CBSS4103
DECISION SUPPORT SYSTEMS

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COURSE GUIDE

COURSE GUIDE DESCRIPTION

You must read this *Course Guide* carefully from the beginning to the end. It tells you briefly what the course is about and how you can work your way through the course material. It also suggests the amount of time you are likely to spend in order to complete the course successfully. Please keep on referring to the *Course Guide* as you go through the course material as it will help you to clarify important study components or points that you might miss or overlook.

INTRODUCTION

CBSS4103 Decision Support Systems is a 3 credit hours administered by the Faculty of Science and Technology. This is one semester course for the schedule seeking a Bachelor Degree Information Technology.

COURSE AUDIENCE

Before attending this course, you should understand the content offered in this course. You should also need to understand the requirements of this course and how this course is performed.

STUDY SCHEDULE

It is a standard OUM practice that learners accumulate 40 study hours for every credit hour. As such, for a three-credit hour course, you are expected to spend 120 study hours. Table 1 gives an estimation of how the 120 study hours could be accumulated.

Table 1: Estimation of Time Accumulation of Study Hours

ACTIVITY	HOURS
Understanding the course contents and initial discussions	5
Reading 3 text units and completing the suggested exercises, with a rate of 20 hours per exercise	60
Attending 5 tutorial sessions, with a 2 hour per session rate	10
Access to websites	12
Completion of 1 assignment with the rate of 15 hours	15
Revision	18
TOTAL	120

LEARNING OUTCOMES

By the end of this course, learners should be able to:

1. Review and clarify the fundamental terms, concepts and theories associated with managerial decision-making, Decision Support Systems (DSS), group support systems and knowledge-based DSS;
2. Describe tools for designing and implementing computerised Decision Support Systems (DSS);
3. Discuss about DSS that supports a group of users that need to make a decision collaboratively;
4. Explain three approaches to DSS development and the need of developing data warehouse;
5. Analyse the important concepts of DSS modelling and analysis and describe management science (MS) technique or operational research (OR) technique for developing a model-driven DSS;
6. Apply techniques to develop the foundation of a model-driven DSS, based on solid decision processes and mathematical model by using a spreadsheet; and
7. Discuss the use of Artificial Intelligence techniques in decision-making, especially when it involves a complex DSS.

COURSE SYNOPSIS

This course is divided into 10 topics. The synopsis for each topic is presented below:

Topic 1: Introduces the concept of decision making, and its style. Stages in the decision making process will be introduced in this topic. Evolution of computer based information systems in organisations is presented in this topic. The definition of Decision Support System, its capabilities, taxonomies, architectures, development framework, classification and benefits are also presented in this topic. The topic ends with the description of the applications of DS in real life situations.

Topic 2: The key to building Decision Support Systems is to understand business decision-making and business decision processes. Topic 1, entitled **Human and Managerial Decision-making**, explains fundamental concepts related to business decision-making. This topic provides an introduction, definitions and the process of managerial decision-making. The purpose of this topic is to provide an overview for how business decisions are made, the various types of decision styles, types of decision support systems and the framework of decision support. The principles of choice in decision-making are also emphasised. This topic also describes on how Simon's four-phase decision-making process can be used in the development of decision models. It clearly delineates between types of control that are strategic, operational, and tactical decisions, indicating who makes the decisions and how they are typically implemented.

Topic 3: This topic presents an introduction to decision support systems (DSS). The topic begins with the concept of DSS, configurations, characteristics and capabilities. Then, we focus on the four major sub-systems of DSS and the description of each sub-system: data management sub-system, model management sub-system, knowledge-based management sub-system and user interface sub-system. The roles of user in the development and the use of DSS are also explained. Finally, to appreciate the role of DSS as tool for decision support, we enlighten the success stories of DSS implementations in several organisations.

Topic 4: This topic concerns on DSS that support a group of users that needs to make a decision collaboratively. This topic starts with brief explanation on the need of group decision-making. Then, the different possible situations of collaboration are also discussed, together with the supporting technologies that will help the decision-making process easier. Finally, examples of applications are also given to show how GDSS can enhance the decision-making process and thus benefit the group members.

Topic 5: Topic 4 presents a general DSS development process (DDP) that suite to develop DSS. The DDP shows the 6 phases of DSS development process. Each phase describes activities in each phase. This topic also reviews various traditional Information System development approaches adopted in DDP. Another issue, such as project management, implementation and integration are also discussed in this topic.

Topic 6: This topic begins by explaining the need of a data warehouse for a decision support system (DSS). Then, we define data warehouse and describe the concept of data warehouse. Further on, we describe the two basic approaches in analysing the data in data warehouse: user guided analysis and automated analysis. For user-guided analysis, we focus on understanding OLAP including relational OLAP and multidimensional OLAP.

For automated analysis, we briefly describe the concept of data mining, together with its several techniques and algorithms. Through several examples of data visualisation tools, the use of data visualisation and its typical features are also explained.

Topic 7: This topic named as modeling and analysis describes how unstructured and semi-structured model can be modelled by using influence diagrams, decision table and decision trees. These techniques facilitate the building of models and provide model documentation. You will learn how to construct an influence diagram which is used to visualise the interrelationships of a model. Then, we further your modelling techniques by introducing decision table and decision trees to model a single-goal situation. You will be exposed to uncertain situations which require basic knowledge of probability and elementary mathematics.

Topic 8: This topic is concern over the use of quantitative decision-making model and analysis, with spreadsheet role as tools for the manager. Quantitative analysis is the scientific approach to managerial decision-making. A quantitative modelling and analysis approach includes defining the problem, developing a model, acquiring input data, developing a solution, testing the solution, analysing the results, and implementing the results. However, this topic is only an introductory to quantitative approach (also known as operational research or management science (OR/MS)) in modelling business situation. This topic covers limited number of techniques from the OR/MS field. Three examples, each from deterministic model, stochastic model and simulation will be discussed to introduce the importance of modelling in quantitative analysis.

Topic 9: In this topic, we will learn spreadsheet modelling, primarily by doing a series of short examples. We will learn how to develop and translate a black box representation into a spreadsheet model, how to design the interface and introduce the useful typical features of any spreadsheet for modelling and analysis. 'What-if' analysis, data table command and goal seek are among the analysis tools for exercising with spreadsheet model. This topic's primary objective is to describe examples on how to develop a model-driven spreadsheet-based decision support systems.

Topic 10: This topic discusses on the use of Artificial Intelligence techniques in decision-making, especially in complex DSS context. The concern of this topic is to see how AI techniques are used to enhance the decision-making process. This topic starts with exploring the fields in AI, then emphasising in the area of Artificial Neural Network and Expert System. Finally, some examples of applications that use AI techniques in supporting decision-making process are given to assist the understanding of this topic.

TEXT ARRANGEMENT GUIDE

Before you go through this module, it is important that you note the text arrangement. Understanding the text arrangement should help you to organise your study of this course to be more objective and more effective. Generally, the text arrangement for each topic is as follows:

Learning Outcomes: This section refers to what you should achieve after you have completely gone through a topic. As you go through each topic, you should frequently refer to these learning outcomes. By doing this, you can continuously gauge your progress of digesting the topic.

Self-Check: This component of the module is inserted at strategic locations throughout the module. It is inserted after you have gone through one sub-section or sometimes a few sub-sections. It usually comes in the form of a question that may require you to stop your reading and start thinking. When you come across this component, try to reflect on what you have already gone through. When you attempt to answer the question prompted, you should be able to gauge whether you have understood what you have read (clearly, vaguely or worse you might find out that you had not comprehended or retained the sub-section(s) that you had just gone through). Most of the time, the answers to the questions can be found directly from the module itself.

Activity: Like Self-Check, activities are also placed at various locations or junctures throughout the module. Compared to Self-Check, Activity can appear in various forms such as questions, short case studies or it may even ask you to conduct an observation or research. Activity may also ask your opinion and evaluation on a given scenario. When you come across an Activity, you should try to widen what you have gathered from the module and introduce it to real situations. You should engage yourself in higher order thinking where you might be required to analyse, synthesise and evaluate instead of just having to recall and define.

Summary: You can find this component at the end of each topic. This component helps you to recap the whole topic. By going through the summary, you should be able to gauge your knowledge retention level. Should you find points inside the summary that you do not fully understand, it would be a good idea for you to revisit the details from the module.

Key Terms: This component can be found at the end of each topic. You should go through this component to remind yourself of important terms or jargons used throughout the module. Should you find terms here that you are not able to explain, you should look for the terms from the module.

References: References is where a list of relevant and useful textbooks, journals, articles, electronic contents or sources can be found. This list can appear in a few locations such as in the Course Guide (at References section), at the end of every topic or at the back of the module. You are encouraged to read and refer to the suggested sources to elicit the additional information needed as well as to enhance your overall understanding of the course.

PREREQUISITE

This course requires knowledge of elementary mathematics, statistics and probability theory.

SOFTWARE

Microsoft Excel.

ASSESSMENT METHOD

Refer to myVLE.

REFERENCES

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Sprague, R., & Watson, H. (1996). *Decision support for management*. Upper Saddle River, New Jersey: Prentice Hall.

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Topic 1 ▸ Management Decision Making and Computer Supports

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Provide an overview of the decision making process;
2. Present evolusion of the applications of computer based; information system in organisations;
3. Highlight major characteristics of DSS; and
4. Present examples of applications of DSS.

▸ INTRODUCTION

Manager needs to make decision. Selecting which project should be invested, choosing which shares should be bought are examples of decisions which the manager need to make. Every decision making process produces a final choice. Decision making can be regarded as an outcome of mental processes leading to the selection of a course of action among several alternatives. The output from the decision can be an action or an opinion. Decision making is the subject that has attracted a lot of attentions in the management literature. It can be studied from different perspectives or angles. From a psychological perspective, decision making is examined in the context of a set of needs, preferences an individual has and values he/she seeks. For example different individuals have different needs, preferences and values in life. Individual needs, preferences and values are important inputs to the decision making process. They will affect the way the decision is made. Decision making also can be studied from normative perspective, the analysis of individual decisions is concerned with the logic of decision making and rationality and the invariant choice it leads to. It might be regarded as a problem solving activity which is terminated when a satisfactory solution is found. Therefore, decision making is a reasoning or emotional process which can be rational or irrational, can be based on explicit assumptions or tacit assumptions.

There come the concept of Decision Support System (DSS), which is computer based information system to support decision making process in ill-structured environment. Ill-structured environment lies between unstructured and structured environment. Decision making in unstructured environment relies on human judgment and computer can be used for the decision making in structured environment. In ill-structured environment, computer will provide information to support human decision making, namely computer will provide information to assist in "what if" type of analysis. For example, what if certain decision is made. The concept has evolved from two main areas of research: the theoretical studies of organisational decision making done at the Carnegie Institute of Technology during the late 1950s and early 1960s, and the technical work on interactive computer systems, mainly carried out at the Massachusetts Institute of Technology in the 1960s. It is considered that the concept of DSS became an area of research of its own in the middle of the 1970s, before gaining in intensity during the 1980s. Now, the concept of DSS is well accepted by academics and business community and a number of software tools have been developed to assist in the implementation of DSS in real life situations.

1.1 DECISION MAKING

Basically decision making life cycle can be described in terms of the following stages:

(a) Define the problem or identify the opportunity

(b) Identify the alternative decisions

(c) Select the best alternative

(d) Implement the solution or take the action

(e) Review the decision or consequences and learn from the experience

1.1.1 Define the Problem or Identify the Opportunity

Problems come from a number of sources. When organisation cannot achieve its objectives it generates problems, for example how to meet the sale target next year. Opportunity can be identified from what happen in the environment. Organisation may want to take business opportunities from the increase in the number of tourists to Malaysia. For those involve in hotel or tourisam industry, this opportunity make them want to build hotels and where and how big is the hotel are the problems that need to be solved. Defining problems or identifying opportunities involves gathering and processing of information. Internal information is useful to determine how operational processes perform and objectives are achieved or not. External information is to determine what happen in the environment.

1.1.2 Identify the Alternative Decisions

A number of alternative decisions can be identified to help solving the problem. The amount of money to be spent on advertisement, whether RM $X or RM $Y or RM $Z are examples of alternative decisions organisation need to take to solve the problem of not meeting the yearly sale target. The decision on the type of media to be used for advertisement, for example media X or media Y or media Z, are also examples of the alternative decisions identified to solve problem of not meeting the yearly sale target. Taking the business opportunity from the increase in the number of tourists to Malaysia may involve a number of identified alternative decisions, namely the identified alternative locations where the hotel should be built. You may have to take decision on where to go for your holiday, what car to buy etc. In summary the alternative decisions need to be identified for the problem that has been recognised or opportunity identified. Developing alternatives requires information searching and analysis. There are many sources of information which can effectively be used to obtain useful information. For example information can be obtained from the interview of experts, from observed events, past or present, from the research.

1.1.3 Select the Best Alternative

In order to help in the alternative selection, alternative needs to be put into a form which is useful for selection purpose. A number of techniques are suggested for this purpose. One of them is Suitability, Feasibility and Flexibility (SFF) Matrix. In SFF alternative is evaluated against three criteria: Suitability, Feasibility and Flexibility. Suitability is to measure whether alternative is ethical or practical and feasibility how many resources will be needed by the alternative decision. Flexibility measures our ability to respond to unintended consequences, or openess to new possibility and whether we can control outcomes one we begin. Table 1.1 is used to help in the selection of alternative decision.

Table 1.1: Selection of Alternative Decision

	Suitability	Feasibility	Flexibility	Total
Alternative A				
Alternative B				
Alternative C				
Alternative D				
etc				

We can rate each alternative on the scale 1 — 3, where 1 is no good, 2 is good and 3 is best. Example is given below:

	Suitability	Feasibility	Flexibility	Total
Alternative A	1	3	2	6
Alternative B	2	3	3	8
Alternative C	3	3	3	9
Alternative D	1	2	2	5

Alternative C is the best alternative to be selected as it has a score of 9.

1.1.4 Implement the Decision or Take the Action

Before the implementation of the decision or taking the action, implementation plan should be developed. Plan should contains what need to be done by when and should also contains resources allocation. In order to ensure implementation is carried out successfully, it need to be properly monitored. The implementation plan developed in the previous stage can be used for monitoring the progress of implementation of the decisions, namely what need to be done is implemented accordingly. The use of the resources is according to the plan. The timeline of the implementation should be observed. As we monitor the progress of the implementation, if the results are not what we expected, we review the plan.

1.1.5 Review the Decision or Consequence and Learn from the Experience

Whatever decision we take is to solve certain problem or to achieve certain objective. Therefore, the decision or consequence of the decision need to be reviewed to see whether it solve the problem or achieve the objective. If it does not the decision need to be reviewed and changed, namely we need to go back to the stage of identify the alternative decisions.

1.1.6 Decision Making Style

How the decision makers define the problem or identify the alternative decisions, select the best alternative decision, implement the solution or take the action, monitor the progress and review the decision or consequence and learn from the experience in real life situations depend on many factors. Performing cognitive complex functions of the decision making in demanding situations is a subject that has attracted a lot of attention in the literature. Demanding situations are marked by time pressure, uncertainty, vague goals, high stakes, team and organisational constraints, changing conditions, and varying amounts of experience. For example due to time pressure, alternative formulation of decision may not be carried out. Decision maker may not take the best decision but the decision which seems to be reasonably suffice for the purpose.

Decision making can be studied from normative or descriptive perspective. Most of decision theory is normative or prescriptive i.e. it is concerned with identifying the best decision to take, assuming an ideal decision maker who is fully informed, able to compute with perfect accuracy, and fully rational. Normative decision making is an important part of all science-based professions, where specialists apply their knowledge in a given area to making informed decisions. For example, medical decision making often involves making a diagnosis and selecting an appropriate treatment. The practical application of this normative approach (how people *should* make decisions) is called decision analysis, and aimed at finding tools, methodologies and software to help people make better decisions. But some decision makers do not typically behave in optimal ways. This lead to the study of the decision making from positive or descriptive angle. Positive or descriptive discipline attempting to describe what people will actually do in the decision making. Some research using naturalistic methods shows, however, that in situations with higher time pressure, higher stakes, or increased ambiguities, experts use intuitive decision making rather than structured approaches, following a recognition *primed decision approach* to fit a set of indicators into the expert's experience and immediately arrive at a satisfactory course of action without weighing alternatives. Recognition-primed decision

(RPD) is a model of how people make quick, effective decisions when faced with complex situations. In this model, the decision maker is assumed to generate a possible course of action, compare it to the constraints imposed by the situation, and select the first course of action that is not rejected. It appears to be a valid model for how human decision-makers make decisions. This technique has benefits in that it is rapid, but is prone to serious failure in unusual or misidentified circumstances. In real life situation it is possible to relax the assumptions of perfect information, and rationality in decision making may not be applicable in certain situations.

A person's decision making process depends on a significant degree on their cognitive style. Myers developed a set of four bi-polar dimensions, called the Myers-Briggs Type Indicator (MBTI). These dimensions are classifed into: *thinking* and *feeling; extroversion and introversion*; judgement and *perception; and sensing* and *intuition.*

People with a preference for Extroversion draw energy from action: they tend to act, then reflect, then act further. If they are inactive, their level of energy and motivation tends to decline. Conversely, those whose preference is Introversion become less energised as they act: they prefer to reflect, then act, then reflect again. People with Introversion preferences need time out to reflect in order to rebuild energy. The Introvert's flow is directed inward toward concepts and ideas and the Extrovert's is directed outward towards people and objects. There are several contrasting characteristics between Extraverts and Introverts: Extraverts desire breadth and are action-oriented, while introverts seek depth and are thought-oriented.

Sensing and Intuition are the information-gathering (Perceiving) functions. They describe how new information is understood and interpreted. Individuals who prefer *Sensing* are more likely to trust information that is in the present, tangible and concrete: that is, information that can be understood by the five senses. They tend to distrust hunches that seem to come out of nowhere. They prefer to look for details and facts. For them, the meaning is in the data. On the other hand, those who prefer *Intuition* tend to trust information that is more abstract or theoretical, that can be associated with other information (either remembered or discovered by seeking a wider context or pattern). They may be more interested in future possibilities. They tend to trust those flashes of insight that seem to bubble up from the unconscious mind. The meaning is in how the data relates to the pattern or theory.

Thinking and Feeling are the decision-making (Judging) functions. The Thinking and Feeling functions are both used to make rational decisions, based on the data received from their information-gathering functions (Sensing or Intuition). Those who prefer *Feeling* tend to come to decisions by associating or empathising with the situation, looking at it 'from the inside' and weighing the situation to achieve, on balance, the greatest harmony, consensus and fit, considering the needs of the people involved. Those who prefer *Thinking* tend to decide things from a more detached standpoint, measuring the decision by what seems reasonable, logical, causal, consistent and matching a given set of rules.

A person's decision making style is based largely on how they score on these dimensions. For example, someone who scored near the thinking, extroversion, sensing, would tend to have a logical, analytical, objective, critical, and empirical decision making style.

1.2 COMPUTER SUPPORT OF DECISION MAKING

Computers were first used to help solving scientific problems. Then there were applications of computers in business organisations, such as calculating payroll or simple accounting applications. The earlier applications of computers in business organisations were characterised by stand alone applications and for routinised activities. The advances in hardware and softwares, such in the database management systems, network technologies and the awareness of the business community on the importance of computer based information system in organisations have resulted in proliferation of computer-based applications in orgnisations to serve various functionalities in the organisation, such as marketing, production, finanace, etc. One of the important characteristics of these applications is that they are integrated, namely integrated applications and databases. This is the era of Management Information Systems. But most of these applications are mostly for routinised activities. Further advances in hardware, sofware, and the emergence of concepts and techniques of Artificial Intelligence, Knowledge Based Systems, Decision Support Systems have moved the computer based applications to non routine activities, such as applications to assist the decision makers to make decisions in ill structured environment.

Decision support systems are a class of computer-based information systems that support decision making activities. There are many approaches to decision-making and because of the wide range of domains in which decisions are made, the concept of *decision support system* (DSS) is very broad. A DSS can take many different forms. In general, we can say that a DSS is a computerised system for helping make decisions. A decision is a choice between alternatives based on estimates of the values of those alternatives. Supporting a decision means helping people working alone or in a group gather intelligence, generate alternatives and make choices. Supporting the choice making process involves supporting the estimation, the evaluation and/or the comparison of alternatives. In practice, references to DSS are usually references to computer applications that perform such a supporting role.[1]

The term *decision support system* has been used in many different ways (Alter 1980, Power, 2002) and has been defined in various ways depending upon the author's point of view [2]. Finlay [3] and others define a DSS rather broadly as "a computer-based system that aids the process of decision making" Turban [4] defines it more specifically as "an interactive, flexible, and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making. It utilises data, provides an easy-to-use interface and allows for the decision maker's own insights."

Other definitions fall between these two extremes. For Little [5], a DSS is a "model-based set of procedures for processing data and judgments to assist a manager in his decision-making. "For Keen [6], a DSS couples the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions ("DSS are computer-based support for management decision makers who are dealing with semi-structured problems"). Moore and Chang [7] define DSS as extendible systems capable of supporting ad hoc data analysis and decision modeling, oriented toward future planning, and used at irregular, unplanned intervals. For Sprague and Carlson [8], DSS are "interactive computer-based systems that help decision makers utilize data and models to solve unstructured problems." In contrast, Keen [9] claims that it is impossible to give a precise definition including all the facets of the DSS ("there can be no definition of *decision support systems*, only of *decision support*"). Nevertheless, according to Power [10], the term *decision support system* remains a useful and inclusive term for many types of information systems that support decision making. He humorously adds that every time a computerised system is not an on-line transaction processing system (OLTP, someone will be tempted to call it a DSS. As you can see, there is no universally accepted definition of DSS. [11]

1.2.1 Characteristics and Capabilities of DSS

Because there is no exact definition of DSS, there is obviously no agreement on the standard characteristics and capabilities of DSS. Turban, E., Aronson, J.E., and Liang, T.P. [12] constitute an ideal set of characteristics and capabilities of DSS. The key DSS characteristics and capabilities are as follows:

(a) Support for decision makers in semistructured and unstructured problems.

(b) Support managers at all levels.

(c) Support individuals and groups.

(d) Support for interdependent or sequential decisions.

(e) Support intelligence, design, choice, and implementation.

(f) Support variety of decision processes and styles.

(g) DSS should be adaptable and flexible.

(h) DSS should be interactive and provide ease of use.

(i) Effectiveness balanced with efficiency (benefit must exceed cost).

(j) Complete control by decision-makers.

(k) Ease of development by (modification to suit needs and changing environment) end users.

(l) Support modeling and analysis.

(m) Data access.

(n) Standalone, integration and Web-based.

1.2.2 Taxonomies

As with the definition, there is no universally accepted taxonomy of DSS either. Different authors propose different classifications. Using the relationship with the user as the criterion, Haettenschwiler [13] differentiates *passive*, *active*, and *cooperative DSS*. A *passive DSS* is a system that aids the process of decision making, but that cannot bring out explicit decision suggestions or solutions. An *active DSS* can bring out such decision suggestions or solutions. A *cooperative DSS* allows the decision maker (or its advisor) to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation. The system again improves, completes, and refines the suggestions of the decision maker and sends them back to her for validation. The whole process then starts again, until a consolidated solution is generated.

Using the mode of assistance as the criterion, Power [14] differentiates *communication-driven DSS*, *data-driven DSS*, *document-driven DSS*, *knowledge-driven DSS*, and *model-driven DSS*.

(a) A **model-driven DSS** emphasizes access to and manipulation of a statistical, financial, optimisation, or simulation model. Model-driven DSS use data and parameters provided by users to assist decision makers in analyzing a situation; they are not necessarily data intensive. Dicodess is an example of an open source model-driven DSS generator [15].

(b) A **communication-driven DSS** supports more than one person working on a shared task; examples include integrated tools like Microsoft's NetMeeting or Groove[16].

(c) A **data-driven DSS** or data-oriented DSS emphasises access to and manipulation of a time series of internal company data and, sometimes, external data.

(d) A **document-driven DSS** manages, retrieves and manipulates unstructured information in a variety of electronic formats.

(e) A **knowledge-driven DSS** provides specialised problem solving expertise stored as facts, rules, procedures, or in similar structures.[14]

Using scope as the criterion, Power [10] differentiates *enterprise-wide DSS* and *desktop DSS*. An *enterprise-wide DSS* is linked to large data warehouses and serves many managers in the company. A *desktop, single-user DSS* is a small systems that runs on an individual manager's PC.

1.2.3 Architectures

Once again, different authors identify different components in a DSS. For example, Sprague and Carlson [8] identify three fundamental components of DSS: *(a)* the database management system (DBMS), *(b)* the model-base management system (MBMS), and *(c)* the dialog generation and management system (DGMS). Haag *et al.* [17] describe these three components in more detail:

The Data Base Management Component stores information (which can be further subdivided into that derived from an organisation's traditional data repositories, from external sources such as the Internet, or from the personal insights and experiences of individual users); the Model Management Component handles representations of events, facts, or situations (using various kinds of models, two examples being optimisation models and goal-seeking models); and the User Interface Management Component is of course the component that allows a user to interact with the system.

(a) According to Power [14], academics and practitioners have discussed building DSS in terms of four major components: *(a)* the user interface, *(b)* the database, *(c)* the model and analytical tools, and *(d)* the DSS architecture and network.

(b) Hättenschwiler [13] identifies five components of DSS:

(i) users with different roles or functions in the decision making process (decision maker, advisors, domain experts, system experts, data collectors),

(ii) a specific and definable decision context,

(iii) a target system describing the majority of the preferences,

(iv) a knowledge base made of external data sources, knowledge databases, working databases, data warehouses and meta-databases, mathematical models and methods, procedures, inference and search engines, administrative programs, and reporting systems, and

(v) a working environment for the preparation, analysis, and documentation of decision alternatives.

(c) Arakas [18] proposes a generalised architecture made of five distinct parts:

(i) the data management system,

(ii) the model management system,

(iii) the knowledge engine,

(iv) the user interface, and

(v) the user(s).

Turban E et al have indentified DSS components which include all the components described above. In general Decision Support Systems are computer-based information systems that support the activity 1, activity 2 and activity 3 in decision making life cycle as shown in the following Figure 1.

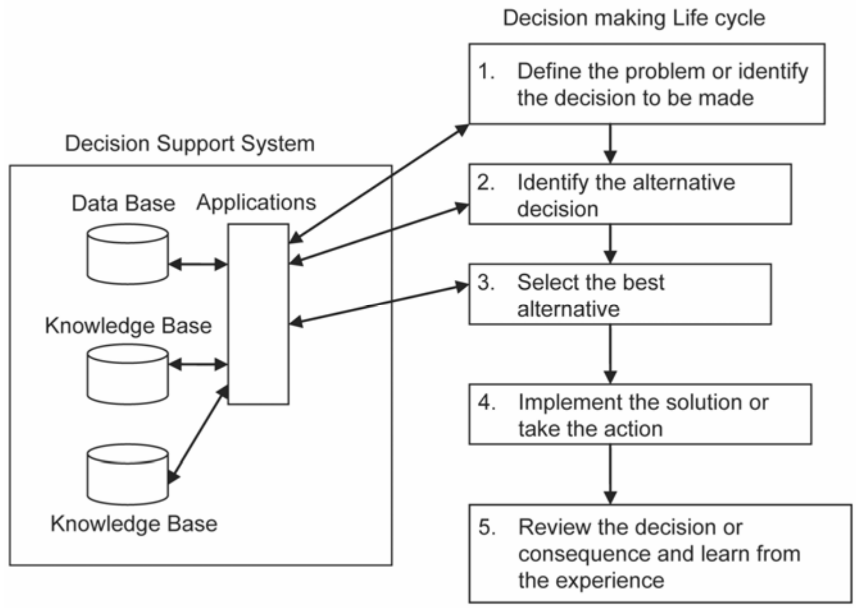

Figure 1: Possible role of decision support system

1.2.4 Development Frameworks

DSS systems are not entirely different to other systems and require a structured approach. A framework was provided by Sprague and Watson (1993). The framework has three main levels: Technology levels, People involved, and the developmental approach.

(a) **Technology Levels**
Sprague has suggested that there are three levels of hardware and software that has been proposed for DSS.

(i) **Level 1 – Specific DSS**
This is the actual application that will be used to by the user. This is the part of the application that allows the decision maker to make decisions in a particular problem area the use can act upon that particular problem.

(i) **Level 2 – DSS Generator**
This level contains hardware/software environment that allows people to easily develop specific DSS applications. This level makes use of case tools or systems like Crystal

(iii) **Level 3 – DSS Tools**
Contains lower level hardware/software. DSS generators including special languages, function libraries and linking modules.

(b) **People Involved**
Sprague suggests there are five roles involved in a typical DSS development cycle.

(i) The end user

(ii) An intermediary

(iii) DSS developer

(iv) Technical supporter

(v) Systems Expert

(c) **Developmental Approach**
The developmental approach for a DSS system should be strongly iterative. This will allow for the application to be changed and redesigned at various intervals. The initial problem is used to design the system on and then tested and revised to ensure the desired outcome is achieved.

1.2.5 Classifying DSS

There are several ways to classify DSS applications. Not every DSS fits neatly into one category, but a mix of two or more architecture in one.

Holsapple and Whinston [19] classify DSS into the following six frameworks: Text-oriented DSS, Database-oriented DSS, Spreadsheet-oriented DSS, Solver-oriented DSS, Rule-oriented DSS, and Compound DSS.

A compound DSS is the most popular classification for a DSS. It is a hybrid system that includes two or more of the five basic structures described by Holsapple and Whinston [19].

The support given by DSS can be separated into three distinct, interrelated categories [20]: Personal Support, Group Support, and Organisational Support.

Additionally, the build up of a DSS is also classified into a few characteristics:

(a) **Inputs:** this is used so the DSS can have factors, numbers, and characteristics to analyse.

(b) **User knowledge and expertise:** This allows the system to decide how much it is relied on, and exactly what inputs must be analyzed with or without the user.

(c) **Outputs:** This is used so the user of the system can analyze the decisions that may be made and then potentially.

(d) **Make a decision:** This decision making is made by the DSS, however, it is ultimately made by the user in order to decide on which criteria it should use.

DSSs which perform selected cognitive decision-making functions and are based on artificial intelligence or intelligent agents technologies are called Intelligent Decision Support Systems (IDSS)[21].

1.2.6 Benefits of DSS

(a) Improving Personal Efficiency

(b) Expediting Problem Solving

(c) Facilitating Interpersonal Communication

(d) Promoting Learning or Training

(e) Increasing Organisational Control

1.3 APPLICATIONS OF DSS

Many DSS applications were developed in real life situations. For example Clinical decision support system for medical diagnosis. Other examples are DSS application to assist a bank loan officer verifying the credit of a loan applicant and DSS application that assist an engineering firm that has bids on several projects to know if they can be competitive with their costs. DSS is extensively used in business and management. Executive dashboard and other business performance software allow faster decision making, identification of negative trends, and better allocation of business resources. A growing area of DSS application, concepts, principles, and techniques is in agricultural production, marketing for sustainable development. For example, the DSSAT4 package[22[23], developed through financial support of USAID during the 80's and 90's, has allowed rapid assessment of several agricultural production systems around the world to facilitate decision-making at the farm and policy levels. There are, however, many constraints to the successful adoption on DSS in agriculture [24]. A DSS application was also developed for Canadian National Railway. The application was used to assist to tests the equipment on a regular basis. A problem faced by any railroad is worn-out or defective rails, which can result in hundreds of derailments per year. Using DSS, CN managed to decrease the incidence of derailments at the same time other companies were experiencing an increase.

An example of the architecture of **model-driven DSS** which was developed for an agency in Malaysia is shown in the Figure 1.2 (Afza 2008). The objective of the DSS is to help this agency in its planning activity. As shown in Figure 1.2, the DSS has five major components: model base, analysis component, user interface, data manipulation and data base (Afza 2008). Model base contains models which are useful for planning. Model base component and analysis component are two major components of model management subsystem of DSS. Basically the functions of analysis component is to select which model to run, and which data to accesss to run the model, based on the user requirements and also to update the models base. User interface component covers all aspects of communication between a user and DSS. Major capabilities of user interface component include provide graphical user interface, accommodate the users with a variety of input devices, provide interactions with the database and model base etc. The database contains strategic data, departmental data and divisional data. The data base and data manipulation components are in the data management subsystem of DSS.

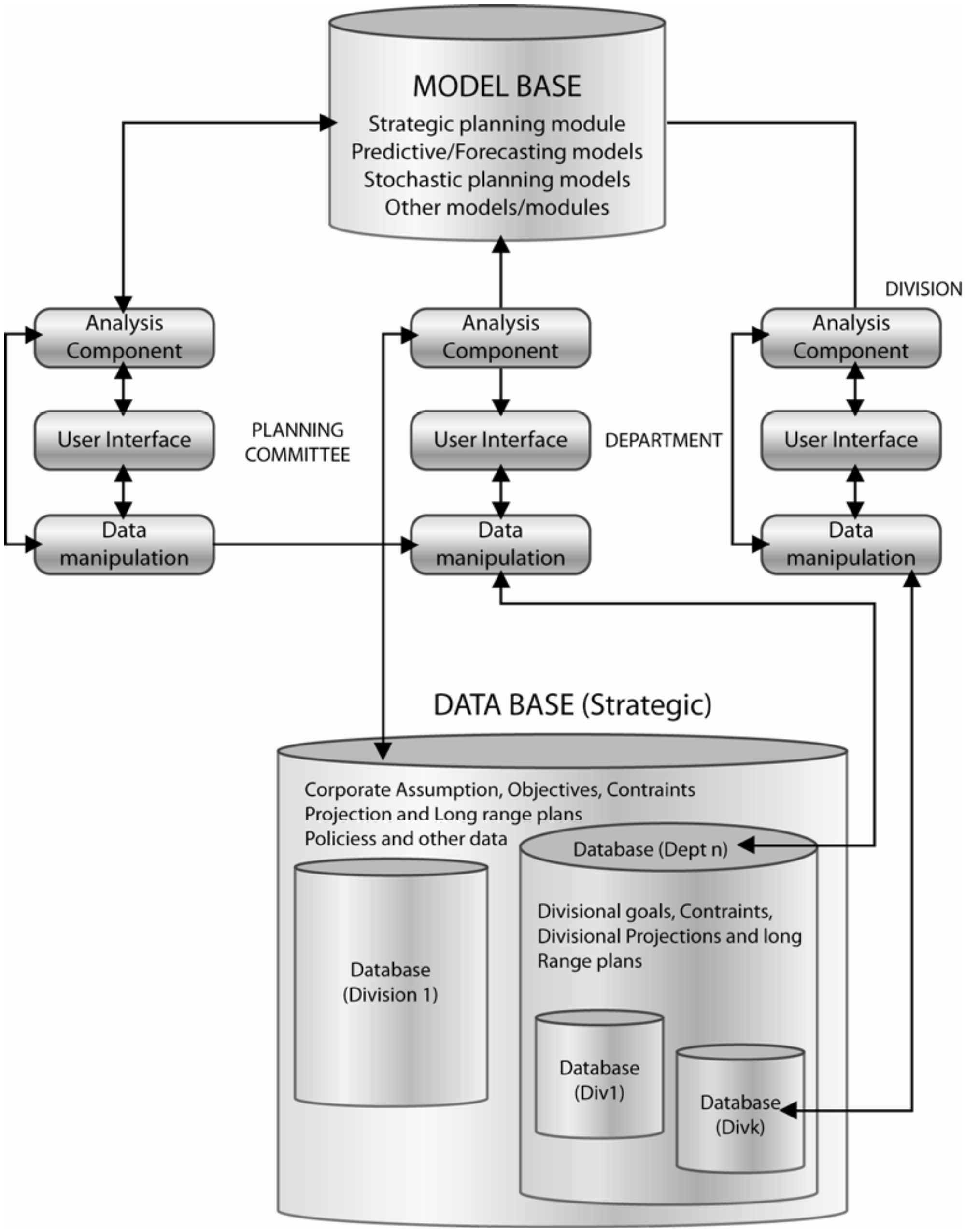

Figure 1.2: DSS architecture (Afza 2008)

SUMMARY

- DSS is a computer-based information system to support decision making activities.
- There are many definitions of DSS proposed in the literatures. This is due to the complexity of the decision making.
- Decision making can be studied from a number of perspectives or angles, from psychological, normative, and descriptive Understanding of the decision making in these perspectives is important to understand the nature of support to be provided to the decision maker.

KEY TERMS

Communication-driven DSS	Decision Support System (DSS)
Data-driven DSS	Document-driven DSS
Decision Making	Knowledge-driven DSS
Decision Making Style	Model-driven DSS

SELF-ASSESSMENT 1

1. Can you think of any other criterion/criteria to add to SFF matrix above? (10 marks)

2. Go to the internet and find other methods or techniques to assist in selecting the best alternative decisions. (20 marks)

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Topic 2 ▶ Human and Managerial Decision-making

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Discuss what decision-making is and how managers make decisions;
2. Describe the processes of decision-making;
3. Discuss and distinguish four categories of decision styles;
4. Express decision effectiveness; and
5. Apply a decision support system to solve a specific type of problem.

▶ INTRODUCTION

Decision-making is an important part of a manager's job and other business professionals. A manager has many responsibilities where they take action on an organisation's behalf. They allocate resources, negotiate agreements, monitor organisation's performance and correct deviations from plans (Power, 2002).

Decision Support Systems (DSS) are built to assist managers when making decisions. The system does not make decisions by itself. Therefore, to design an ideal and successful DSS that fit into the way humans think and make decisions, it is important to initially understand decisions and decision-making processes. This topic emphasizes on the concept of decision-making, the decision-making processes, the decision styles, and characteristics of good decision-making (decision effectiveness).

2.1 INTRODUCTION TO DECISION-MAKING

ACTIVITY 2.1

As normal people, we do make decisions everyday. We tend to set a lot of options to make the best decision. How do you make decision? What are your considerations in making them?

"Somewhere along the line of development we discover what we really are, and then we make our real decision for which we are responsible. Make that decision primarily for yourself because you can never really live anyone else's life."

Eleanor Roosevelt

Before we begin our discussion on decision-making, let us think about a very simple question regarding this subtopic: What is a decision?

A **decision** refers to a conclusion or a reasoned choice among alternatives. We make a number of decisions, personal decisions as well as business decisions in our lives.

Decisions can include what to wear to the office, where to go for the school holidays, which life insurance to purchase, how many tutors to employ for a computer course, how to advertise a new drama centre among countless other things.

Each decision is constructed by a decision statement, a collection of alternatives and a collection of criteria. Although we are not always aware of them, these three subjects always exist. Figure 2.1 (Mallach, 2000) illustrates the relationship among decision statement, alternatives and criteria.

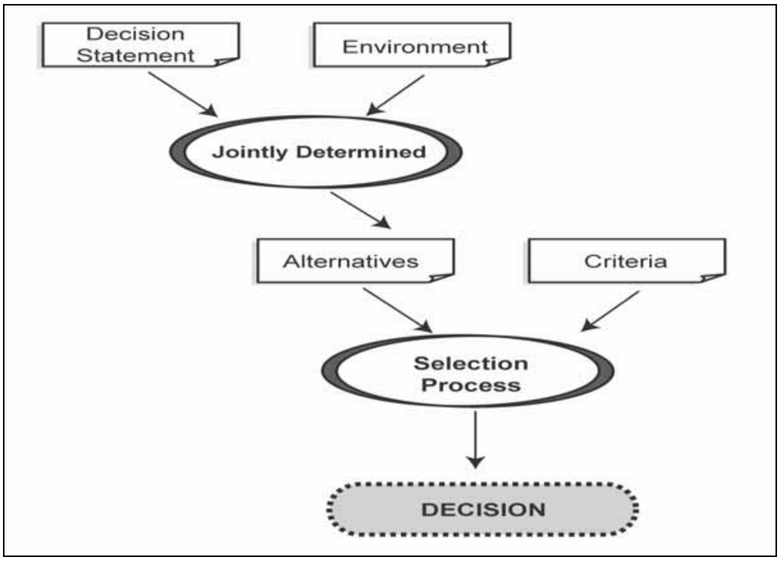

Figure 2.1: Relationship among decision statement, alternatives and criteria
Source: Adapted from Mallach (2000, pg. 38)

What we want or attempt to decide is stated clearly in a **decision statement**. Hence, we can focus our attention and effort only on the key issue. A decision statement is particularly vital to intelligent decision-making.

We all make decisions of varying importance every day, so the idea that **decision-making** can be a rather sophisticated art may at first seem strange. However, studies have shown that most people are much poorer at decision- making than they think. An understanding of what **decision-making** involves, together with a few effective techniques, will help produce better decisions.

A decision usually involves three steps (Arsham, 2005):

(a) A recognition of a need: a dissatisfaction within oneself (a void or need);

(b) A decision to change (to fill the void or need); and

(c) A conscious dedication to implement the decision.

Having understood the meaning of a decision and a decision statement, what is meant by decision-making?

Decision-making is a process of reasoning among alternatives that are available for the purpose of accomplishing a purpose or purposes (Turban, 2005).

Using the example of a decision of how to advertise a new drama centre, the alternatives of methods that can be considered are advertising through e-mails, distributing flyers at housing areas and advertising in newspapers and magazines. In addition to the definition of decision-making, Harris (1998) put forward his definitions as:

> **Decision-making** is the study of identifying and choosing alternatives based on the values and preferences of the decision-maker and the process of sufficiently reducing uncertainty and doubt about alternatives to allow a reasonable choice to be made from among them (Haris, 1998).

Decision-making types may allow for only three unique systems of making decisions (Arsham, H., 2005):

(a) **Individualism**: which access inequity, relishes competition and identifies with the rights and power of the individual.

(b) **Collaboration**: which treats all men as equally important, exalts collaborative efforts, and identifies with unlimited democracy.

(c) **Power and Authority**: which respects power and identifies with controlling authority.

> **Alternatives** refer to possible desicions that can be made.

In some situations, there are few alternatives and in other situations there are thousands. To arrive at a decision of what to wear to the office, there would be 16 alternatives to be considered if you have 4 shirts and 4 long pants. In another case, there are thousands of alternatives if you were to choose an investment of 1 billion Ringgit Malaysia. In this case, a decision-maker has to narrow down the number of alternatives.

In making a decision, we may want to optimise the decision-making criteria. For instance, in purchasing a house, we may be concerned with the location, cost, exterior and interior finishing, built-up area and number of rooms.

However, it is impossible to optimise all criteria at the same time. Thus, a decision-maker has to reach a compromise.

There are several basic **types of decisions** (Harris, 1998) as explained in Figure 2.2 below:

Decisions Whether

Include the yes/no, either/or decision that must be made before selecting an alternative. Should I buy a new car? Should I go to hotel A or hotel B? In order to make this kind of decision, the pro and con have to be weighed.

Decisions Which

Involve a choice of one or more alternatives from among a set of possibilities. The chosen alternatives are based on how well each alternative match a set of predefined criteria.

Contingent Decisions

Decisions that have been made but put on hold until some conditions are met. For instance, I have decided to buy a car if I can get it for the right price; I have decided to take the part time job if I can work the necessary time for it into my schedule.

Figure 2.2: Types of decision

ACTIVITY 2.2

(a) Decision-making is an important part of many professions, where they apply their expertise in a given area to making informed decisions. For example, a medical doctor often involves making a diagnosis and selecting an appropriate treatment. Think what computers can do for doctors in decision-making.

(b) You can read more about decision-making by visiting this website at: http://www.virtualsalt.com/crebook5.htm

SELF-CHECK 2.1

(a) What is a decision?

(b) What is the difference between decisions-whether and contingent-decisions?

2.2 MANAGERS AND DECISION-MAKING

SELF-CHECK 2.2

In an organisation, who will make the most decisions? Does a manager play an important role in making decisions? What are his/her responsibilities in making decisions?

Let us first understand the nature of manager's work. According to Minztberg (1980), managers perform 10 roles, which can be classified into three major categories: interpersonal, informational and decisional (see Figure 2.3).

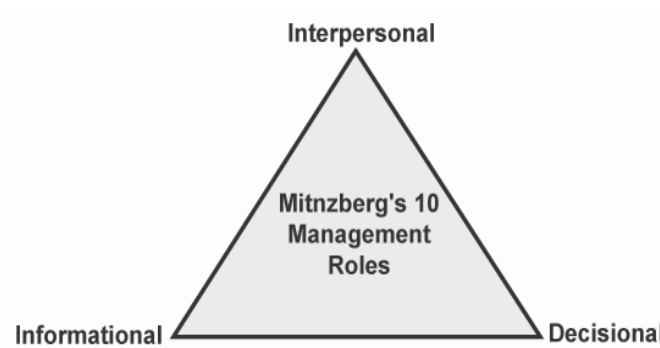

Figure 2.3: Three major categories of Mintzberg's 10 management roles

Each role is explained in Table 2.1 (Mintzberg (1980) and Mintzberg (1993).

Table 2.1: Mintzberg's 10 Management Roles

Interpersonal	
Figurehead	Symbolic head; responsible to perform several routine duties of a legal or social nature.
Leader	Responsible to motivate and activate the subordinates as well as responsible for staffing, training and associated duties.
Liaison	Maintain self-developed network of outside contacts and informers who provide favours and information.
Informational	
Monitor	Seeks and receives a wide variety of special information to develop a thorough understanding of the organisation and environment; emerges as the nerve centre of the organisation's internal and external information.
Disseminator	Transmits information received from outsiders or from subordinates to members of the organisation's internal and external information.
Spokesperson	Transmits information to outsiders on the organisation's plans, policies, actions, results and others; also serves as an expert on the organisation's industry.
Decisional	
Entrepreneur	Searches the organisation and its environment for opportunities and initiates improvement projects to bring about change; supervises design of certain projects.
Disturbance Handler	Responsible for corrective action when the organisation faces important, unexpected disturbances.
Resource Allocator	Responsible for the allocation of organisational resources of all kinds- in effect the making or approving of all significant organisational decisions.
Negotiator	Responsible for representing the organisation at major negotiation.

A manager is primarily a decision-maker. A corporate success depends on its managers' decisions. Thus, decision-making remains as one of the more challenging roles of a manager.

Decisions can be classified according to organisational level. Referring to Figure 2.4, the organisational decisions are strategic planning, management control, operational control and operational performance (Anthony, 1965).

Figure 2.4: Categories of organisational decisions

Generally, **strategic planning** is made at upper levels of organisation management, and the decisions made affect the entire organisation. It involves making decisions in determining objectives, establishing policies, allocating resources, controlling organisational performance and evaluating investment.

Management control, or tactical decision, which is made by middle managers, includes decision processes related to acquisition and use of resources. It affects a part of the organisation for a limited time into the future.

Operational control includes decisions associated with the effectiveness of organisational actions, monitoring the quality of product/service and assessing the needs of product/service.

Operational performance involves making day-to-day decisions in functional units. The decisions are made to implement strategic decisions, functional tactics and operational activities.

Within each level of organisational decision, researchers classify decisions as structured, semi-structured and unstructured (for more explanation, refer to section 2.6).

Structured decisions (programmed decisions) are routine and recurring. Such decisions already have a worked out handling procedure. As they occur, we do not need to figure out from the beginning on how to handle them.

In contrast, **unstructured decisions** (non-programmed decisions) are complex or elusive. Such decisions have no definite or cut-and-dried method of handling them, as they never arise before. They may also be very important, thus they need custom-tailored treatment.

Semi-structured decision has some structured aspects, but cannot be completely structured (Mallach, 2000).

ACTIVITY 2.3

The fear of making serious decisions is a new kind of fear, called **decidophobia**, proclaimed by Walter Kaufmann at Princeton University in 1973. When you decided to continue your study, were you afraid of making mistake in the program you chose? Or have you feared of failing to omplete your study? What kind of decision forces forced you to decide to continue your study with OUM?

2.3 DECISION-MAKING PROCESS

In order to come up with the right decision, it is recommended that one should follow a systematic decision-making process. According to Simon (1960), the process consists of three phases: intelligence, design and choice (refer to Figure 2.5). The process involved problem discovery to solution.

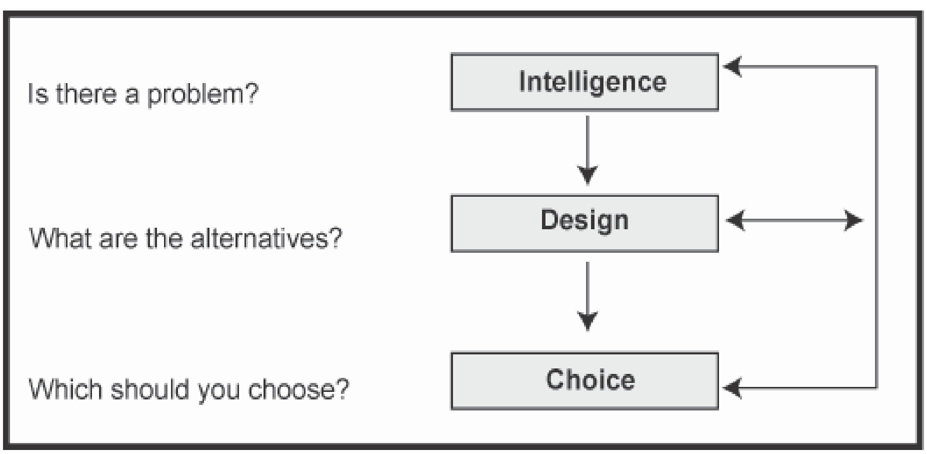

Figure 2.5: The decision-making process
Source: Adapted from Laudon and Laudon (1999, pg. 93)

There is a continuous flow from one phase to another. However, at any phase there may be a return to a previous phase. Every decision should involve all the phases, at least minimally. The emphasis on each phase differs from one decision to another due to the following reasons:

(a) The nature of a decision may require a decision-maker to spend more time in one phase or another.

(b) A decision-maker may emphasise on one phase or another, depending on his/her styles of behaviour.

Being human, we are normally not aware of what we are doing when we make decisions. Nevertheless, all three phases exist in some form in every decision we make.

You can visit this website to read an example of how decision-making process is done: http://www.uuaa.Org/resources/leadership2002/DecisionMaking Process.htm

SELF-CHECK 2.3

(a) Define structured, semi-structured, and unstructured decisions.

(b) List and define the three phases of the decision-making process (according to Simon).

2.3.1 The Intelligence Phase

The intelligence phase is the first phase in the decision-making process. Generally, a decision-maker has to identify and define the problem or situation that requires a decision. The scanning activity may be done periodically or continuously. In order to perform the activity, the decision-maker has to review organisational objectives, search and scan procedures, and gather relevant data. This phase also includes the understanding of why the problem occurs, where it happens and with what effects (Laudon and Laudon, 1999). The end product of this phase is a **problem statement**.

There are several activities to perform in the intelligence phase. They are shown in Figure 2.6 below:

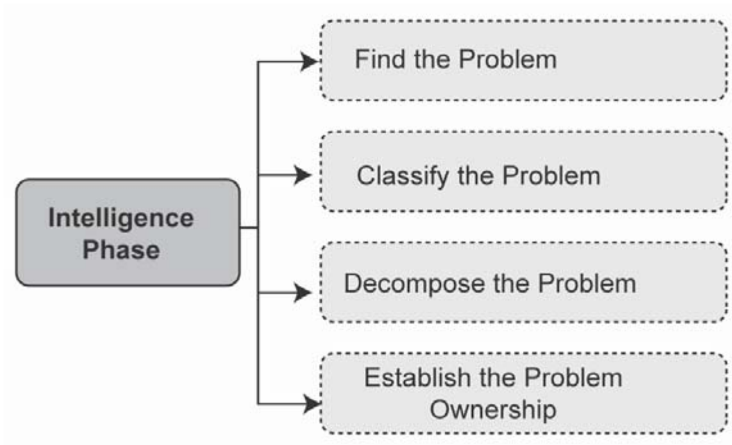

Figure 2.6: Intelligence phase activities

These activities are further explained below:

(a) **Find the Problem**

We begin the intelligence phase with identifying the organisational goals and objectives. We determine whether those goals and objectives are being met or not. Problems arise if there is dissatisfaction with the way things are going. Dissatisfaction is the difference between what we desire and what is (or is not) happening.

In order to appraise the existence of a problem, the organisation's productivity level should be monitored and analysed (Turban et al., 2005). If a problem really exists, one should find out the problem symptoms, determine the problem magnitude and define the problem explicitly.

(b) **Classify Problem**

This activity is to classify a problem into a definable category. An important approach classifies problems according to the degree of structuredness. As defined by Simon (1977), there are two extreme situations regarding structuredness of a decision problem: structured and non-structured problems (please refer to section 2.2). Non-structured and semi-structured problems tend to gain structure as the solving process is being carried out.

(c) **Decompose Problem**

In order to conquer a complex problem, the problem should be divided into sub-problems. Sub-problems are more manageable and thus, solving simpler sub-problems helps in solving a complex problem. When a problem consists of structured and unstructured sub-problems, the problem itself is actually semi-structured. The decomposition approach eases the communication among people involved in the problem solving process.

(d) **Establish Problem Ownership**
Once a problem is detected, the problem should be owned by any individual or any department of an organisation. In other words, a person or a group in the organisation must own the problem as the organisation agrees to take on the responsibility to solve the problem or has the ability to solve the problem.

The intelligence phase ends with a **formal problem statement.**

Should a decision-maker of his/her or her organisation is not able to solve the problem, it is said that the problem cannot be owned. Thus, the situation cannot trigger the next phase of the problem solving process.

ACTIVITY 2.4

(a) Intelligence is a general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language and learn. But in psychology, the study of intelligence is related to the study of personality. Can you explain what the relationship between personality and decision-making is? What kind of personality makes a better decision-maker? How can computers help different types of personality in making decisions effectively?

(b) What do you think executives in many organisations are paid to do? To think or to do routine tasks? Explain.

2.3.2 The Design Phase

Generally, design phase involves developing and analysing possible courses of action to solve a problem. In this phase, proposed solutions to the problem or alternatives are developed. A decision-maker needs to do a lot of research for each available alternative. The objectives of the decision that is about to be made should be clear and well-defined.

The activities to be performed in the design phase are shown in Figure 2.7.

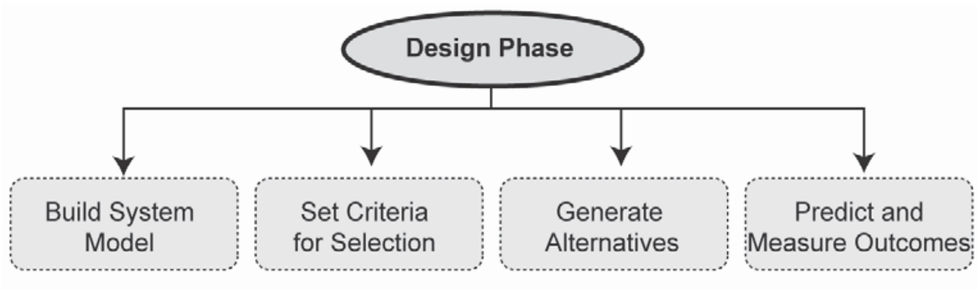

Figure 2.7: Design phase activities

These activities are further explained below:

(a) **Build System Model**
This activity involves building a model of the system or problem situation.

> **System models** are simplified representation or abstraction of systems or problems.

Problem solving is done on the model first rather than on the real problem. This is due to the fact that a real problem is too complex to describe exactly. The complexity of the problem or situation is also sometimes irrelevant in solving the problem.

By modelling, the problem is conceptualised and abstracted to quantitative and/or qualitative form. Models have several variables as in Table 2.2 (Turban et al., 2005).

Table 2.2: Several Variables for Models

Variables	Descriptions
(a) **Decision Variables**	Describe the alternatives a decision-maker must choose among (for example, when to advertise a new product, or how many cars to deliver to each car rental agency).
(b) **A Result Variable or a Set of Result Variables**	Describe the goal of the decision-making.
(c) **Uncontrollable Variables**	Describe the environment. For example: economic condition.

Modelling process will determine the variables and establish the relationships among the variables that may exist in a problem situation.

(b) **Set Criteria for Selection**
In this activity, we determine the criterion or criteria in accepting a solution approach. It involves how a decision-maker establishes his/her decision-making objective(s) and how the objective(s) is/are incorporated into the model(s).

(c) **Generate Alternatives**
After determining the criteria for evaluating the alternatives, a decision-maker searches for alternatives. This activity depends on the availability and cost of information, as well as the availability of expertise in the problem area. An individual or groups sit in a brainstorming session, supported by electronic brainstorming software, to find alternatives. Finally, the outcome of every proposed alternative must be established.

(d) **Predict and Measure Outcomes**
The outcome of each alternative can be expressed in terms of a goal. An outcome like profit maximisation can be measured in terms of Ringgit Malaysia, while an outcome such as customer satisfaction can be measured by the number of complaints or by the ratings found by surveys. Therefore, having predicted the outcome of every proposed alternative allows a decision-maker to determine which alternative will serve as a satisfactory solution.

2.3.3 The Choice Phase

The choice phase is the critical phase in decision-making process, where in this phase a decision-maker actually makes a decision. This phase includes the search, evaluation and recommendation of a satisfactory solution to the model built in the design phase. The end product of this phase is a **decision that can be implemented.**

The boundary between the design phase and the choice phase is not clear. This is because some activities, such as generating alternatives and evaluating alternatives can be carried out during both phases. In addition, a decision maker may return frequently to and from those two phases. The activities to be performed in the choice phase are shown in Figure 2.8.

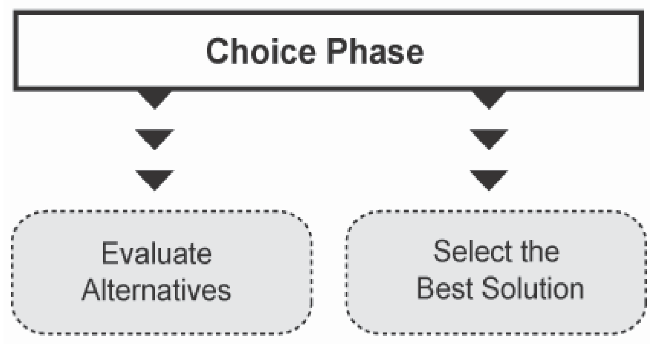

Figure 2.8: Choice phase activities

These activities are further explained below:

(a) **Evaluate Alternatives**

Solving a model yields a recommended solution to the real problem. The proposed solutions are applied to the model to test its feasibility. Thus, to solve the model built in design phase, alternatives are evaluated.

To perform the evaluation of alternatives, a decision-maker needs extensive data on the variety of alternatives and data analysis tools. This is to account for all the costs, consequences and opportunities (Laudon and Laudon, 1999).

(b) **Select the Best Solution**

The best solution must be selected based on the condition that exists at the moment, as well as the expected or estimated condition at the time the solution will actually be implemented (Marakas, 2003).

Solving the problem model is not the same as solving the real problem. However, it gives the idea of feasibility of the proposed solution on the real problem. A problem is considered to be successfully solved only if the recommended solution is successfully implemented.

As explained, there is a general process of decision-making. Values and perception varies from people to people, hence, in reality, the process is not linear. One people may follow the process sequence and one people may not use all the steps. The behaviour, which affects decision-making process, is further explained in the next section.

SELF-CHECK 2.4

What is the end product of the Choice Phase?

2.4 DECISION STYLES

SELF-CHECK 2.5

Can you think of what is the relation between decision styles with the design and implementation of a DSS?

Decision style describes the manner in which a decision-maker makes decision.

The style is reflected in the way the individual reacted to decision-making tasks; which aspect is important, which one is of less value, how information is translated and how to deal with situations. The effect of decision styles on a decision outcome depends on the problem context, the decision maker's perceptions and personal set of values that he/she brings to the situation.

The three factors, which are important in determining a decision-maker's decision style, are shown in Figure 2.9.

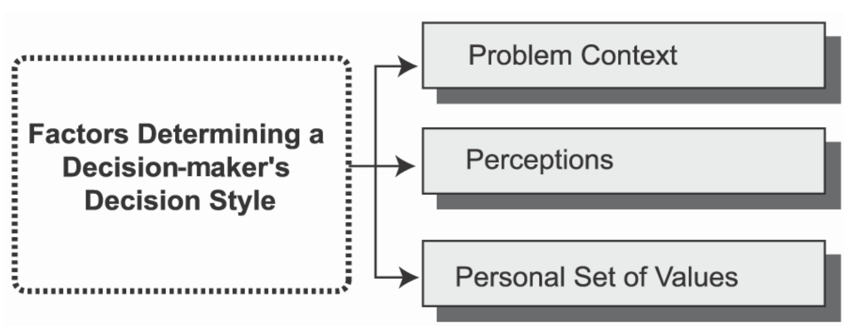

Figure 2.9: Three factors of decision style

Each factor varies from one person to another and from one situation to the next. These activities are further explained below:

(a) **Problem Context**

This factor refers to the forces that act on the decision-maker who is in the act of making a decision. **Forces of organisational and environmental** include government regulation, new technologies and market competition, while **forces of individual nature** include skill set, motivation and perceived abilities. The instances of forces may shape the problem context. Hence, a decision-maker must be able to balance all these forces during decision-making process.

(b) **Perceptions**

This refers to the perceptions of a decision-maker. A decision-maker brings personal bias to the problem context. Therefore, the problem should match its reality. Many studies reveal that managers tend to perceive a problem situation and its possible outcomes bias to their personal goals rather than the realities. As a result, in determining the approach of a decision-maker to solving a problem and whether the approach is effective, perceptual biases will interrelate with the problem context.

(c) **Personal Values**

This factor refers to the personal values of a decision-maker. Values, which consist of views and beliefs, are acquired at an early age and are likely to remain strong throughout a person's lifetime. These values guide a person's judgements, actions and looked-for outcomes.

In order to design a successful DSS, the system should fit decision situation as well as the decision style. The system has to be flexible and adaptable to different users.

However, the three factors explained above are complex in a way that they are interconnected in the formation of decision style. Carl Jung, a knowned psychoanalyst came up with a **decision style classification scheme**, as shown in Figure 2.10 (Marakas, 2003).

The scheme classifies decision styles using two component parts: cognitive complexity and value orientation. These two parts are further used to distinguish four well-defined categories of decision styles; **analytical, directive, conceptual** and **behavioural**.

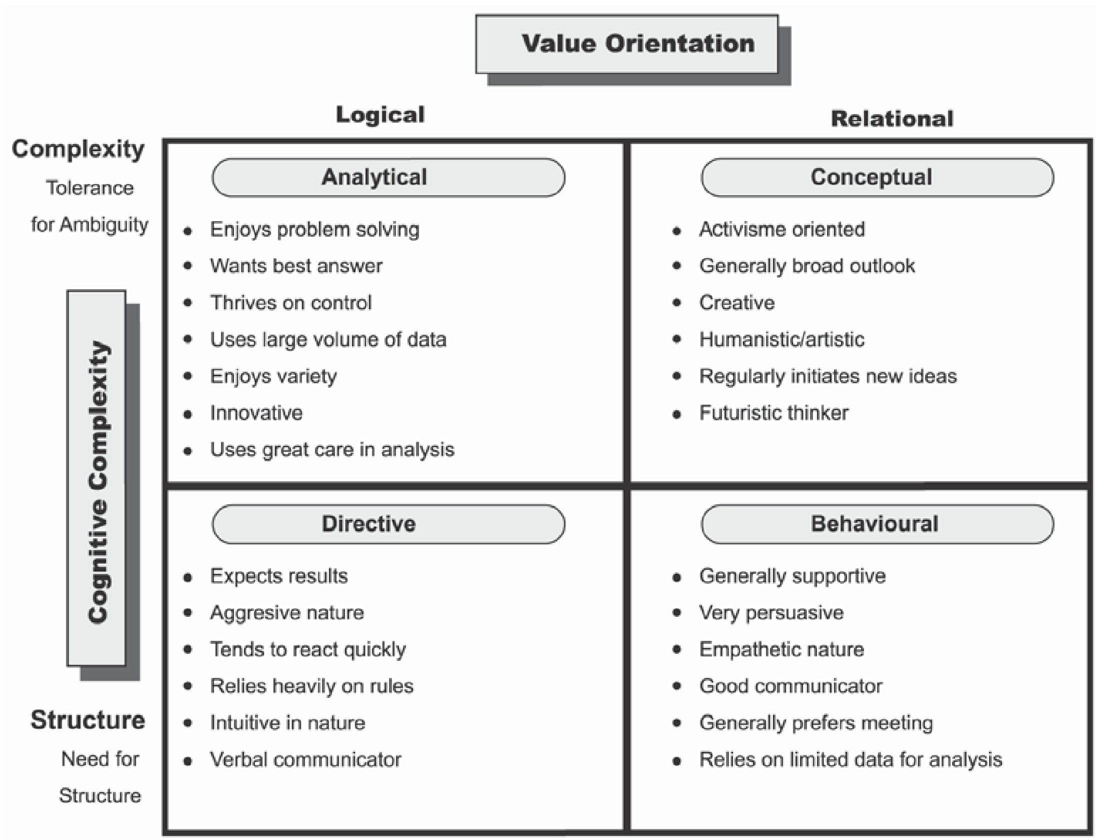

Figure 2.10: Decision style model
Source: Adapted from Marakas (2003, pg. 43)

Analytical decision-makers can better tolerate context ambiguity, need a lot of information and consider a large collection of options. Due to this fact, they may not be able to reach a decision fast. As they enjoy solving problems, this type of decision makers, can cope with new, unforeseen situations and problems. Analytical decision makers also prefer written communication.

On the other hand, **directive** decision style has less tolerance for ambiguity but a high need of structure in the problem context. Such decision-makers prefer to concentrate on decisions with technical nature. These decision-makers do not need a large amount of information and do not consider a large collection of options. Generally, they are considered efficient managers, yet they require notable security and status. In contrast to analytical decision-makers, directive-style decision-makers act best when communicating verbally.

Conceptual decision-makers are much like the analytical decision-maker. They can tolerate ambiguity. They socialise well with subordinates. In addition, conceptual decision-makers are really committed to the organisation. These decision-makers are thinkers rather than doers, and tend to be achievement-oriented.

Behavioural decision style has low tolerance to ambiguity. Decision-makers with this style show high commitment to the organisation. They need low amount of data input and tend to rely on meetings for communicating and organising subordinates. Such classifications of decision styles do not reflect completely the complexity of human beings. Rather than set a single category of decision style to a manager, Marakas (2003) suggested that you will need to determine a manager's dominant as well as backup decision styles. Thus, this helps in the design of interfaces and the levels of directiveness.

2.5 DECISION EFFECTIVENESS

SELF-CHECK 2.6

How do we describe an effective decision? Can it be measured? Is it qualitative or quantitative?

Decision effectiveness refers to the successfulness in producing the desired or intended decision.

A definition of a good decision (Marakas, 2003) is, "a good decision results in the attainment of the objective(s) that gave rise to the need for a decision within the boundaries and constraints imposed by the problem's context. "In other words, we make a good decision if we solved a problem without causing other problems. However, the problem is we have to wait and see after we make a decision to see if it is a good decision. This section explains the various forces that influence the problem context, decision process as well as its outcomes.

All the forces that act upon a decision-maker are referred to as **decision forces** (Marakas, 2003). These forces that affect the formulation and implementation of a final decision are shown in Figure 2.11.

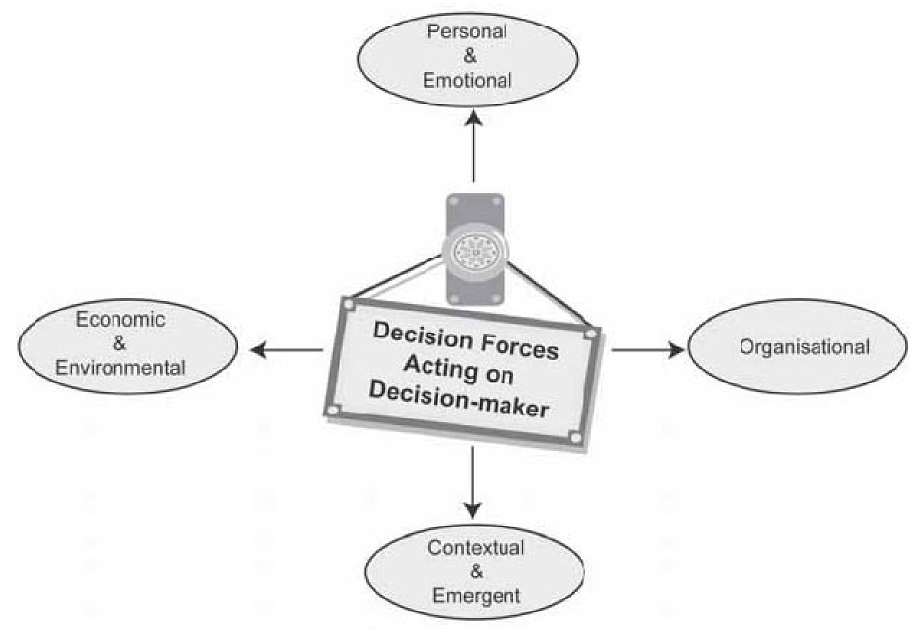

Figure 2.11: Decision forces

These forces are further explained below:

(a) **Personal and Emotional Forces**
A decision-maker's feelings, health, security, rewards, frustrations, anxieties and the most significant, cognitive limitations, are considered as **personal and emotional forces**. These forces have an effect on the process of deciding on the suitable alternative. The human mind does have limitation in the ability to store and process knowledge. Studies also demonstrate that human mind has limited capacity to process the knowledge it possesses.

(b) **Economic/Environmental Forces**
Resources, government policy, marketplace competitive pressure, technology advancement and stakeholders' demands are several examples of **economic/environmental forces**. A decision-maker has to take these forces into account. In other words, individual or combination of forces will shape the final decisions.

(c) **Organisational Forces**
Examples of **organisational forces** include policies and procedures, organisational culture and staffing coordination. If an organisation instills the culture of not accepting new idea to the organisation, then the decision to be made by superiors as well as the subordinates will be constrained.

(d) **Contextual and Emergent Forces**

These forces root from the problem context itself. Several instances of issues related to the forces are skill, motivation, perception and the most important is time requirement. Time limits create stress and pressure on a decision-maker. Although a decision-maker is able to cope with all the forces, time limits could result in poor-quality decision.

Thus, to attain effective decisions, a decision-maker must balance the forces. Power (2002) outlined several obstacles, which a decision-maker has some control, to effective decisions. These are shown in Figure 2.12.

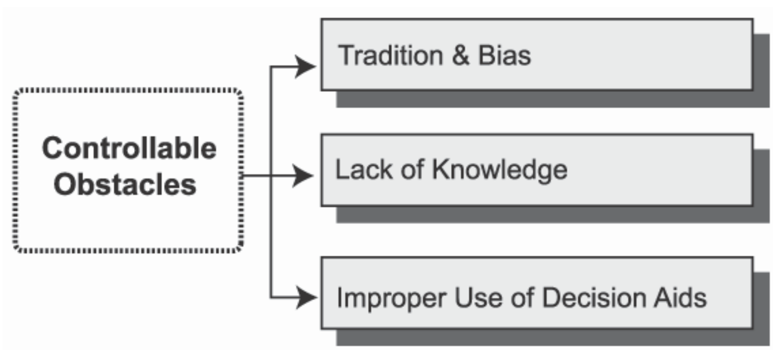

Figure 2.12: Decision-making obstacles

These obstacles are further explained below:

(a) **Tradition and Bias**

It is generally agreed that biases can creep into our decision making processes, calling into question the correctness of a decision. It could exist due to fear of change and fear of failure or because of tradition. A tradition is a set of custom or practice taught by one generation to another. It can cause decision-maker reluctantly to change his/her thought patterns that he/she have used in the past in the face of new circumstances.

(b) **Lack of Knowledge**

Capturing decision knowledge and experience, especially for recurring situations, can reduce this obstacle.

(c) **Improper Use of Decision Aids**

Completeness and accuracy of information in a DSS are not guaranteed. A DSS must be designed to provide positive impact on an individual's or a group's decision behaviour. When and how a DSS will be used in decision-making process must also be clear before it is designed and implemented.

2.6 A FRAMEWORK FOR DECISION SUPPORT

A framework for decision support (see Figure 2.13) was proposed by Gorry and Scott Morton (1971) after combining the work of Simon (1977) and Anthony (1965). As illustrated in Figure 2.13, Simon's idea is demonstrated along the continuum, where **decision types** range from highly structured (programmed) to highly unstructured (non-programmed). The differences between structured, unstructured and semi-structured decisions are described in Table 2.3.

Table 2.3: Differences between Structured, Unstructured and Semi-structured Decisions

Structured	Unstructured	Semi-structured
Decision is focused on routine and repetitive problems. A standard solution exists to solve the problem. Technology supports that can be used to support decision-making are management information system, management science model and data processing.	Decision aims at indistinct and complex problems. There are no standard solution methods. Examples of unstructured problems are considering staffs to promote, choosing a set of new projects and planning for service improvement. Part of the problem can be supported by technologies like expert systems (ES), group support systems (GSS) and knowledge management systems (KMS). However, human intuition is often the basis for decision-making.	Decisions solve the combination of structured and unstructured problems. Thus, both standard solution and human judgment are required to make such decision. DSS offers models for a portion of structured problem. This technology can improve the quality of the information on which the decision is based by providing a set of alternative solutions as well as their potential impacts.

Apart from that, as described in Section 2.3, Simon explained the three-phase decision-making process of intelligence, design and choice. Relating both ideas, the unstructured problem is one that not a single phase of the three phases is tructured. In semi-structured decisions, some but not all of the phases are structured.

	Type of Control			Technology Support Needed
Type of Decision	Operational Control	Managerial Control	Strategic Planning	
Structured	Accounts Receivable, Order Entry 1	Budget Analysis, Make-or-buy, Personnel Reports, Make or Buy 2	Financial Management, Warehouse Location, Distribution Systems 3	Management Information Systems, Management Science Models, Transaction Processing
Semi-structured	Production Scheduling, Inventory Control 4	Credit Evaluation, Budget Preparation, Plant Layout, Project Scheduling 5	Building new Plant, Mergers and Acquisitions, New Product Planning, Compensation Planning 6	DSS, GDSS, KMS
Unstructured	Selecting a Cover for Magazine, Buying Software, Approving Loans 7	Negotiating, Recruiting an Executive, Buying Hardware, Lobbying 8	R & D planning, New Technology Development, Social Responsibility Planning 9	DSS, ES, GDSS Neural Network
Technology Support Needed	Management Information System, Management Science	Management Science, DSS, ES, EIS, GDSS	GDSS, EIS, ES, Neural Networks	

Figure 2.13: Decision support framework
Source: Adapted from Turban et al. (2005, pg. 13)

Anthony's (1965) taxonomy of **managerial activities**: strategic planning, management control and operational control, is demonstrated in the second half of the framework:

(a) **Strategic planning** defines long-range goals and policies for resource allocation. Generally, it is made at upper levels of organisational management.

(b) **Management control**, also known as tactical, ensures the accomplishment of organisational goals by means of the acquisition and efficient use of resources. In contrast to strategic planning, management control concentrates on the goals of a limited time. It is generally made by middle managers.

(c) **Operational control** executes specific tasks efficiently and effectively. It confines within the activities whose tasks and goals have been defined in strategic planning and management control. This type of control is managed by lower level managers.

The bottom row and the right hand column list out the technologies that are needed to support various decisions. The more structured and operational control-oriented tasks (cells 1, 2 and 4) which are performed by low-level managers, are supported by management information systems (MIS) and management science (MS).

> **Management science**, or **MS**, is the discipline of using quantitative analysis (mathematics), and other analytical methods, to help make better business decisions.

The tasks (cells 6, 8 and 9) which are less structured, complex and performed by high-level managers are supported by KMS, neural computing and ES. Combination of technologies can be used to solve a task.

Thus, the framework provided helps by suggesting the appropriate tools or technologies to solve different types of problems.

ACTIVITY 2.5

(a) Some of the decision support techniques that we use in everyday life include:

- (i) Listing the advantages and disadvantages of each option.
- (ii) Flipping a coin or other random methods.
- (iii) Acquiesce to a person in authority or an "expert" like your father or employer. For group decision-making, never forget the ultimate decision support technique in group, traditional but yet efficient; the *lat ta lilat tali tamplom*.

Please compare our "current" decision-making techniques with Turban's decision support framework (Figure 2.3). What are the similarities and the differences?

(b) Discuss the difference between decision-making and problem-solving.

2.7 DECISION-MAKING PROCESS VS. DSS SUPPORT

Section 2.3 discussed the three-phases of decision-making process, while the rest of the topics in the module provide explanation on the various support system technologies. Thus, this section explains how a specific DSS technology provides support to the activities within each phase of decision-making processes (intelligence, design and choice).

A DSS cannot replace a decision-maker. It is not meant to support all the aspects that need to be addressed in the decision-making process. However, a DSS can provide the decision-maker with focused support to one or more activities within the process of decision-making. Marakas (2003) lists the common types of support that a DSS can provide, in Table 2.4.

Table 2.4: Common Types of Support Provided by a DSS

Common Types of Support Provided by a DSS	
(a)	Explore multiple perspectives of a decision context.
(b)	Generates multiple and higher quality alternatives for consideration.
(c)	Explores and tests multiple problem-solving strategies.
(d)	Facilitates brainstorming and other creative problem-solving techniques.
(e)	Explores multiple analysis scenarios for a given decision context.
(f)	Increases decision-maker's ability to tackle complex problems.
(g)	Improves response time of decision-maker.
(h)	Discourage premature decision-making and alternative selection

The types of support listed above are not always fit for a particular problem context. If a DSS is properly applied, it really helps a decision maker formulate a good decision.

In relating appropriate DSS technologies to the decision-making process, let us look at Figure 2.14 and the explanation that follows (Turban et al., 2005).

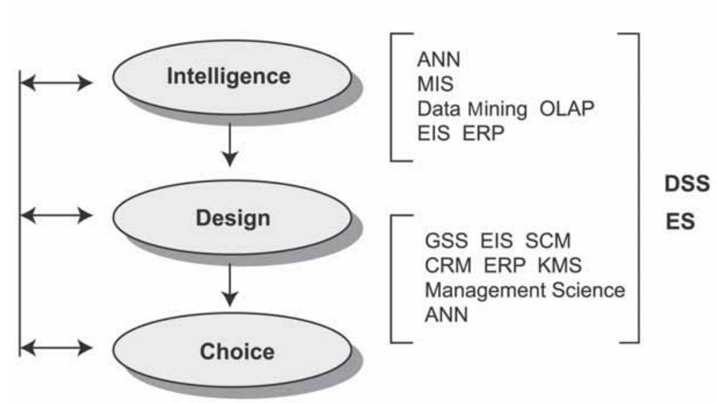

Figure 2.14: DSS support
Source: Adapted from Turban et al. (2005, pg. 72)

These activities are further explained below.

(a) **Support for the Intelligence Phase**

The areas of support for the intelligence phase are:

(i) to **identify** problems and opportunities;

(ii) to **interpret** information; and

(iii) to produce **reports**.

The DSS technologies that can be used to support the intelligence phase are shown in Table 2.5.

Table 2.5: DSS Technologies that Can be Used to Support the Intelligence Phase

DSS Technologies	Detail of Supports
Enterprise Information System (EIS)	• Monitor internal and external information. • Look for early signs of problems & opportunities.
Data Mining, ANN, CRM & ES	• Identify relationships among activities & other factors.
Knowledge Management System (KMS)	• Identify similar past situations & how they were handled.
GDSS	• Share information. • Brainstorming.

ES	• Provide advice on nature of problem, its seriousness and so on. • Provide advice on solution approach.
Web-based OLAP Tools	• Design regular reports to assist problem-finding activity.

(b) **Support for the Design Phase**

The areas of support for the design phase are:

(i) to **generate alternatives**;

(ii) to **discuss criteria of choice** & their relative importance; and

(iii) to **forecast the future consequences** using various alternatives

The DSS technologies that can be used to support the design phase are shown in Table 2.6.

Table 2.6: DSS Technologies that Can be Used to Support the Design Phase

DSS Technologies	Detail of Supports
DSS (by using its standard or special models; example: forecasting & financial models)	• Generate alternatives for structured problems
ES	• Generate alternatives for complex problems.
OLAP & Data Mining	• Identify relationship that can be used in models.
Knowledge Management System (KMS)	• Determine if a problem has been encountered before. • Find out if there are experts on hand who can give quick understanding and answers.
Customer Relationship Management (CRM), Supply Chain Management (SCM), Enterprise Resource Planning (ERP)	• Provide models of business processes that can test assumptions and scenarios.
GDSS	• Provide brainstorming tools to help identify important issues and options.

(c) **Support for the Choice Phase**

The area of support for the choice phase is **to identify satisfactory alternatives**. The DSS technologies that can be used to support the design phase are shown in Table 2.7.

Table 2.7: DSS Technologies that Can be Used to Support the Choice Phase

DSS Technologies	Detail of Supports
DSS (by using its models)	• Identify the best or good enough alternatives by 'what-if' and goal seeking analyses. • Test different scenarios for selected option.
KMS	• Identify similar past experiences.
CRM, ERP, SCM	• Test the impacts of decisions.
ES	• Assess the suitability of certain solutions. • Recommend an appropriate solution.
GSS	• Support to lead to consensus (if decisions are made in a group).

ACTIVITY 2.6

(a) Discuss the relationships among EIS, ERP/ERM, SCM, and CRM.

(b) Discuss the difference between decision-making and problem-solving.

SUMMARY

- The purpose of this first topic is to provide the conceptual foundations regarding decision-making and the framework of decision support, and how support is provided.
- Decision-making is the cognitive process of selecting a course of action from among multiple alternatives.
- Cognitive is the decision-Maker's mental ability to gain knowledge, including perception, and reason.
- However, a person's decision-making process depends to a significant degree on their cognitive style, and personality (temperament) influences decision-making.

- In order to come up with the right decision, a decision-maker should follow a systematic decision-making process. We have discussed the decision-making process which consists of three phases: intelligence, design and choice.
- Decision style describes the manner in which a decision-maker makes decision.
- The impetus of DSS is effectiveness. Decision effectiveness refers to the successfulness in producing the desired or intended decision. A framework for decision support was proposed by Gorry and Scott Morton (1971) after combining the work of Simon (1977) and Anthony (1965).
- Simon's idea is demonstrated along the continuum, where decision types range from highly structured (programmed) to highly unstructured (nonprogrammed). From this topic, we can conclude that human decision styles need to be recognised in designing a DSS.

KEY TERMS

Artificial Neural Network

Customer Relationship Management (CRM)

Data Mining

Decision Support System (DSS)

Enterprise Information System (EIS)

Enterprise Resource Planning (ERP)

Executive Information System (EIS)

Expert System (ES)

Group Decision Support System (GDSS)

Knowledge Management System (KMS)

On-line Analytical Processing (OLAP)

Supply Chain Management (SCM)

SELF-ASSESSMENT 1

Instruction: Answer all questions in 30 minutes.

1. What is a DSS? (4 marks)
2. Categorise managerial activities (according to Anthony's taxonomy). (6 marks)
3. Describe how hybrid systems might help a manager in decision-making. (10 marks)

SELF-ASSESSMENT 2

Instruction: Answer all questions in 1 hour.

1. Define decision-making. (4 marks)

2. Define the phases of intelligence, design, choice, and implementation. (10 marks)

3. What is the difference between a problem and a symptom? (6 marks)

4. Define structured (programmed) versus unstructured (non-programmed) problems and give **ONE** example for each type of decision. (10 marks)

5. How can a DSS support the implementation of a decision? (6 marks)

6. What is a decision style? (4 marks)

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Topic 3 ▶ DSS: Tool for Decision Support

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Describe the concept of decision support systems (DSS);
2. Explain DSS characteristics, capabilities and its five components;
3. Review the roles of data and model management systems;
4. Express the functionality of a DSS knowledge base;
5. Explain the need of the user interface in a DSS;
6. Define the roles of the user in the development and the use of a DSS; and
7. Describe how DSS enables the success of several of organisations.

▶ INTRODUCTION

Decision support systems are information systems that assist people in making decisions. Since the early 1970s, DSS technology and applications have evolved significantly. The study of DSS is not just about computers. It is more than that.

During the early years, DSS only utilised limited database, modelling and user interface functionality. Today, a number of disciplines provide the substantial functionalities. Management Science has developed mathematical models for use in DSS and provided evidence on the advantages of modelling in problem solving. Cognitive Science has provided descriptive information that assist in DSS design and has generated hypotheses for DSS research.

This topic presents an introduction to decision support systems (DSS). The topic begins with the concept of DSS, configurations, characteristics and capabilities. Then it focuses on the four major sub-systems of DSS and the description of each sub-system: data management sub-system, model management sub-system, knowledge-based management sub-system and user interface sub-system. The roles of the user in the development and the use of DSS are also explained. At the end, we share with you the success stories of DSS implementations in several organisations.

3.1 THE CONCEPT OF DECISION SUPPORT SYSTEMS

SELF-CHECK 3.1

Why do you think we need a system that can support our decision? How reliable and accurate is the system to be used by us?

What is meant by decision support systems? As there is no universally accepted definition of DSS, Turban and Aronson (1998) introduced a general term of DSS: any and every computerised system used to support decision-making.

In the early years of DSS, it was defined as a model-based set of procedures for processing data and judgments to assist a manager in his/her decision-making (Little, 1970). DSS was assumed as a computer-based system that extends the user's capabilities. DSS was intended to support managers in semi-structured decision situations, where decision-making could not be fully supported by algorithms.

Later, there are many definitions on DSS. However, the various definitions refer to some common ideas. Some definitions from various authors are:

Moore and Chang (1980) defined DSS as:
Extendible systems that are capable of supporting ad-hoc analysis and decision modelling oriented toward future planning and used at irregular and unplanned intervals.

Bonczek et al. (1980) defined DSS as:
Computer-based system consists of three interacting components:

(a) a language system and a mechanism to provide communication between the user and other DSS components;

(b) a knowledge system and a repository of problem domain knowledge embodied in DSS as either data or procedures; and

(c) a problem-processing system.

Keen (1980) defined DSS as:
The product of a developmental process in which the DSS user, the DSS builder and the DSS itself are all capable of influencing one another; resulting in system evolution and patterns of use.

All the definitions are compared and contrasted in Table 3.1 (Turban et al., 2005). DSS is defined based on the perceptions of DSS functions and the implementation of DSS (such as components required, appropriate usage pattern and necessary development processes).

Table 3.1: Concepts Underlying DSS Definitions

Source	DSS Defined in Terms of
Gorry and Scott-Morton (1971)	Problem Type; System Function (Support)
Little (1970)	System Function; Interface Characteristics
Alter (1980)	Usage Pattern; System Objectives
Moore and Chang (1980)	Usage Pattern; System Capabilities
Bonczek et al. (1989)	System Components
Keen (1980)	Development Process

Source: Adapted from Turban et al. (2005, pg. 104)

In a nutshell, a DSS is an interactive, flexible and adaptable computer-based information system, specially developed to support the solution of a non-structured management problem for improved decision-making. It utilises data, provides easy user interface and allows for the decision-maker's own judgements. DSS may also use models and knowledge sub-systems to support all the phases of decision-making.

Furthermore, although the target users of DSS are middle and senior managers, DSS can actually be designed to support decision-makers at any level of management. This system can also be categorised as vertical system or industry-specific. This is due to the fact that DSS are often designed for specific organisation types, for example hospitals, banks or academic institutions.

Summing up all the ideas mentioned above, the definition of DSS that will be used in this module is:

> A **computer-based information system** whose primary purpose is to **provide decision-makers with information to rely on, in the activity of decision-making**. This is done by providing a set of tools, data, models and other resources that are required by decision makers to improve the effectiveness of the decision outcome in solving semi-structured and unstructured problem.

ACTIVITY 3.1

Why do people attempt to narrow down the definition of DSS?

3.2 DSS CONFIGURATIONS

DSS can be implemented in various configurations. The configurations depend on the situation of management-decision and the specific technologies to be used for support. All the technologies from four basic DSS sub-systems are (which will be explained in section 3.4): data, models, user interface and knowledge. They are assembled and deployed over the Web. Each sub-system will be managed by a software or program.

The major capabilities of a DSS are defined from the approach of components assembly. For instance, a model-oriented DSS emphasises models. Likewise, in a data-oriented DSS, database and its management are accentuated.

3.3 CHARACTERISTICS AND CAPABILITIES OF DSS

SELF-CHECK 3.2

Can you think of how do characteristics and capabilities of DSS are being defined? What are the parameters being set to define them?

There are several connotations of characteristics and capabilities of DSS that are highlighted in pioneering DSS researches. In spite of that, there is no consensus of what DSS should have and should be able to do. Thus, a collective idea (from Turban et al. (2005), Marakas (2003), Holsapple and Whinston (1996) and Alter (1980)) of primary DSS characteristics and capabilities are put forward in this module. These characteristics and capabilities are listed below:

(a) DSS provides support for decision-makers, primarily in **semi structured** and **unstructured situations** by bringing together human judgement and computerised information (Turban et al., 2005). Due to the nature of the half-structured and unstructured contexts, such problems cannot be solved or cannot be solved conveniently by other computerised systems, standard quantitative methods or tools. The role of DSS is providing support to the 'structurable' portion of a problem while human decision-makers focus their resources and efforts to the highly unstructured portion of the problem. The partial support in addressing the unstructured decision situation can be thought of as the employment of human decision processes, which have not yet understood well enough to effectively simulate via automation.

(b) DSS supports the **effectiveness of the decision-making process** (accuracy, timeliness, quality) rather than its efficiency (the cost of making decisions). The decision effectiveness, or degree to which the decision attains its objectives successfully, is a vital element in the decision-making process.

(c) DSS **facilitates decision processes**. They support all phases of the decision-making process: intelligence, design, choice and implementation.

(d) They are able to support various decision-making processes and styles.

(e) DSS supports the decision makers, but cannot replace them. Thus, the **decision-maker has complete control** over all steps of the decision-making process in solving a problem. DSS provides support to the selection process but the final selection is to be made by managers who are directly responsible and accountable for the decision outcomes.

(f) DSS provides **support to various managerial levels**, ranging from top executives to line managers.

(g) DSS provides **support to individuals and to groups**. The involvement of several individuals from different departments and organisational levels or even from different organisations is often needed for less structured problems.

(h) DSS emphasises **flexibility and adaptability** to accommodate changes over time, in the environment and the decision-making approach of the user. As DSS should be flexible, users can add, delete, combine, change or rearrange basic elements.

(i) They focus on features of **user friendliness**, strong **graphical** capabilities and interactive human-machine interface. These characteristics can greatly increase the effectiveness of DSS.

(j) In addition to traditional data access and retrieval functions, DSS usually **utilise models** for analysing decision-making situations. The modelling capability enables experimenting with different strategies under different configurations.

(k) A DSS can be operated as a **stand-alone tool** used by an individual decision-maker in one location, or can be **distributed** throughout an organisation and in several organisations along the supply chain. It can also be **integrated with other DSS and/or applications** and it can be **distributed internally and externally**, using networking and Web technologies.

Well-defined characteristics and capabilities of DSS can guide the development, application and use of DSS and thus allows decision-makers to make better, more consistent decisions in a timely manner.

Those characteristics are provided by the major components of DSS, which will be described in the next section.

ACTIVITY 3.2

Can we measure the capabilities of DSS? How do we measure them?

3.4 COMPONENTS OF DSS

A DSS application consists of the components shown in Figure 3.1 (Turban et al., 2005).

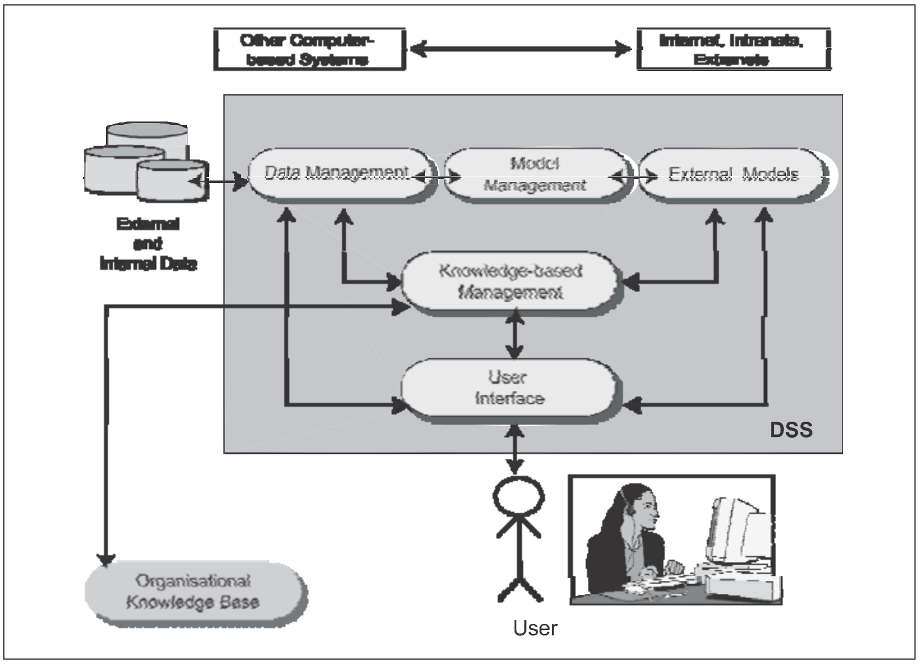

Figure 3.1: A schematic view of DSS
Source: Adapted from Turban et al. (2005, pg. 109)

The **data management** component of a DSS retrieves, stores and organises the relevant data for the particular decision context. It also provides security functions, data integrity procedures and general data administration associated with using the DSS. All the tasks are managed by several components: database(s), database management systems (DBMS), data repository and data query facility.

The **model management** component provides the analytical capabilities for a DSS. It allows the retrieval, storage and organisational activities associated with various models (includes financial, statistical, management science or other quantitative models). This component can be connected to corporate or external models storage. The component comprises the model base, model base management system, model repository, model execution processor and model synthesis processor.

The **knowledge-based management** component provides the 'brains' to supplement the decision-maker's intelligence. It can be interconnected with the organisation's knowledge repository (organisational knowledge base). Besides supporting other components or sub-systems, this component can act independently.

The **user interface** component enables communication between the user and the DSS. This component must allow easy access and manipulation of data, models and processing components of DSS. Its design and implementation is an important element in DSS functionality. It is crucial to the effectiveness of a DSS, to ease the user-DSS communication, whether for specifying parameters or examining the problem space. The user is also considered part of the system.

It is important to consider the role of the user to ensure the effectiveness of a DSS. User's knowledge domain, pattern of use and skill set are among the necessary elements in applying a DSS to a decision context successfully. As mentioned before, a user controls a DSS.

The five basic components of DSS are explained further in section 3.5 until section 3.9. Four of these (data management, model management, knowledge-based management and user interface) are major components of DSS which are mostly discussed in this topic.

ACTIVITY 3.3

Is there any possibility that a new component could be added in these components in the future? Discuss this with your friends.

3.5 DATA MANAGEMENT SUB-SYSTEM

The data management sub-system consists of the following elements:

(a) database;

(b) database management system;

(c) query facility; and

(d) data directory.

Figure 3.2 (Turban et al., 2005) demonstrates the interconnection between these elements as well as the interaction of the data management sub-system with the other sub- systems of the DSS and with several data sources.

(a) **Database**

A **database** is a collection of interrelated data, organised and stored to allow easy data retrieval. The database structure should meet the needs of the organisation.

It should allow for access by multiple users and for use by more than one application. Configurations for a database include porting data from the data warehouse and constructing a special database.

One DSS application can use a number of databases. Data in a database come from several sources. As shown in Figure 3.2, data are extracted from internal and external data sources and also from personal data of individual users of the DSS. The extracted data go to a specific DSS database and to corporate data warehouse.

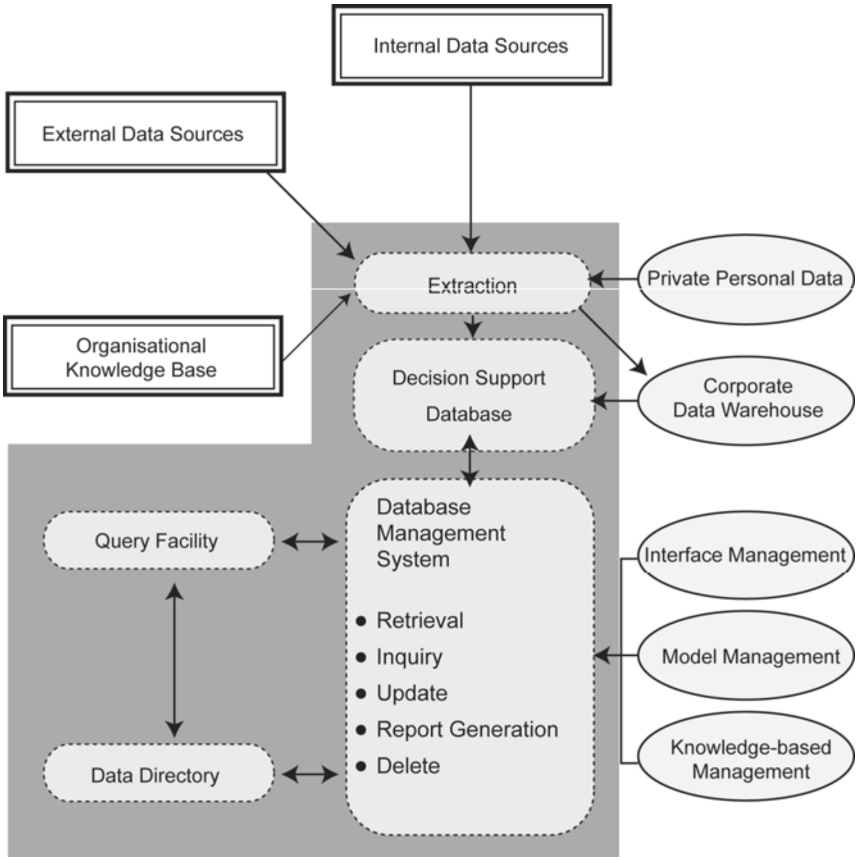

Figure 3.2: The structure of the data management sub-system
Source: Adapted from Turban et al. (2005, pg. 112)

Internal data comes from various business units of an organisation.

The data are generated mainly by the organisation's transaction processing systems, such as from payroll systems, production management systems and sales transaction systems. Transaction-level data are a major source of information regarding the operations of an organisation. Other internal data include budget allocation, sales forecast and maintenance scheduling. Typically, internal data are made available over an organisation's intranet.

External data include government regulations, employment data, crime rate, geopolitics, economics and much more.

External data can come directly from external organisations such as the Malaysian government, research institutions and trade associations, or they can come from the organisation's collection of external data. External data are obtained over the Internet and they can be available both from computerised online services and search engines. Furthermore, data delivery services such as Dow Jones News Retrieval and Compuserve enable the downloading, integration as well as the analysis of external data.

Private or individual-level data owned by the users can also be included in the database. These data include their guidelines used for specific data and/or situations, individual heuristics, queries and the various combinations of data for particular problem context. In addition, personal assessment of past situations or certain data can also be stored as private data in the DSS database.

(b) Database Management System (DBMS)

> A **database management system (DBMS)** creates, accesses and updates a database.

Most DSS are constructed with a standard commercial relational DBMS such as Sybase, Oracle and IBM. Marakas (2003) lists out the capabilities of a DBMS.

Table 3.2: Major Functions of the DBMS

Data Definition	• Provides a data definition language (DDL) that allows users to describe the data entities and their associated attributes and relationships. • Allows for the interrelation of data from multiple sources.
Data Manipulation	• Provides the user with a query language to interact with the database. • Allows for capture and extraction of data. • Provides rapid retrieval of data for ad hoc queries and reports. • Allows for the construction of complex queries for retrieval and data manipulation.

Data Integrity	• Allows the user to describe rules (integrity constraints) to maintain the integrity of the database. • Assists in the control of erroneous data entry based on the defined integrity constraints.
Access Control	• Allows identification of authorised users. • Controls access to various data elements and data manipulation activities within the database. • Tracks usage and access to data by authorised users.
Concurrency Control	• Provides procedures for controlling simultaneous access to the same data by more than one user.
Transaction Recovery	• Provides a mechanism for restart and reconciliation of the database in the event of hardware failure. • Records information on all transactions at certain points to enable satisfactory database restart.

In addition, an effective database and its DBMS should support activities, for instance, general navigation among records, creating and maintaining a diverse set of data relationships and report generation. The power of a DSS as a decision support tool is boost with the integration of its data and the models.

Extraction refers to the process of capturing data from various sources.

This process, which is frequently managed by DBMS, is necessary in creating a DSS database or a data warehouse. During this process, files are imported, summarised and go through a standardisation filtration before compacting the data. Apart from that, extraction also occurs when user generates reports from data in DSS database.

As this extraction process is very important, effort is being made to structure the process. The user has to make an exact query to several related databases that may extend over a number of independent databases in order to extract data. A properly structured process can simplify an important process, so that users do not have to deal with complex details.

(c) **The Query Facility**

To build and use DSS, the user needs to access and manipulate and query data. These tasks are performed by the query facility. When other DSS components request for data, the query facility determines how to fulfill those requests. If necessary, it refers to the data dictionary. After putting together the detailed request, it returns the results to the request issuer. This query facility uses a special query language such as Structured Query Language (SQL). Important functions of a DSS query system are selection and manipulation operations. It means, a DSS query system should be able to follow a computer instruction such as, 'Search for students' exam results in faculty B during year 2004 and summarise the results by CGPA. The user may enter a simple data request on a screen. After a click of a button, the results are neatly displayed in a table.

(d) **The Data Directory**

The **data directory** refers to a catalogue of all the data that is available in the database.

The directory consists of data definitions. Its key function is to answer questions about the availability of data items, their source and their exact meaning. The support of the directory is important in the intelligence phase of the decision-making process. It facilitates in data scanning and identification of problem areas or opportunities. The directory also allows the addition of new entries, deletion of entries and retrieval of information on specific objects.

ACTIVITY 3.3

(a) What is extraction?

(b) What is the function of a query facility?

(c) What is the function of a data directory?

3.6 MODEL MANAGEMENT SUB-SYSTEM

The model management sub-system consists of the following elements:

(a) model base;

(b) model base management system;

(c) model directory; and

(d) model execution, integration and command processor.

These elements and the interrelation with other DSS sub-systems are illustrated in Figure 3.3 (Turban et al., 2005). The next part discusses on every element of model management sub-system.

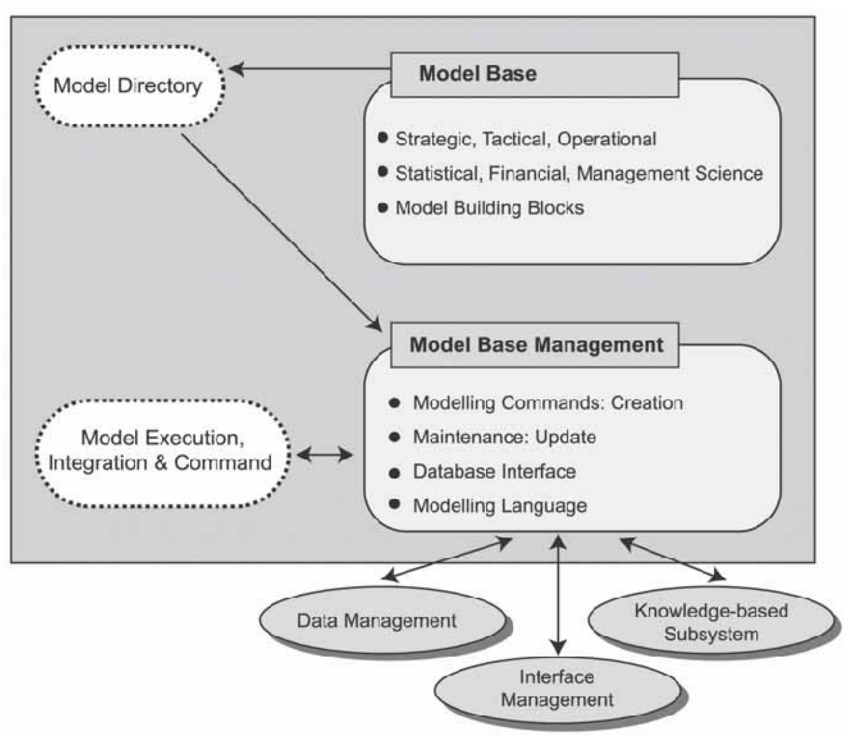

Figure 3.3: The structure of the model management sub-system

(a) **Model Base**

A **model** is a simplified form of some real event or process.

A model is constructed to enable the study and to develop a better understanding of an event or process, without having to actually experience or recreate the event under study (Marakas, 2003). It is intended to be similar to the actual event or process as closely as possible. Even though it does not contain the same level of details as reality, it is possible to determine many characteristics of an event or process.

Imagine the cost of building a car to see if it is safe to drive and how fast it will move. Also imagine the effort and time it would take to determine how popular a new TV channel is going to be if you have to ask everybody's opinion about it before you begin airing it. Thus, modelling can be an effective source of information for the decision process.

Just as the DSS database stores the data used by the DSS, the model base contains the various models that the DSS uses to perform a variety of analysis. The model base is what differentiates a DSS from other computer-based information systems. Accordingly, a model base provides the analysis capabilities in a DSS. It contains routine and special statistical, financial, forecasting, management science and other quantitative models. There are four categories of models in the model base: strategic, tactical, operational and analytical. These models are described in Figure 3.4.

Figure 2.4: Four categories of models in the model base

Apart from categorising the models as above, the models in the model base can also be categorised by functional areas (such as financial models or production control models) or by discipline (such as statistical models or management science allocation models). There can be a few to several hundreds of models in a DSS. As models in DSS are basically mathematical, they are expressed by formulas. These formulas can be pre-programmed in DSS development tools such as Excel. They can be programmed for future use, or they can be programmed for only one use.

In addition to the four categories of models described above, there are **model building blocks** and routines. Model building blocks and routines are used for data analysis and can be used as components of larger models. Some are used to determine the values and parameters in a model. Such building blocks are available in DSS commercial development software.

(b) **Model Base Management System**

Model base management system (MBMS) manages the various analytical tools of DSS. The models in a DSS can vary in number, size and complexity. Table 3.3 lists out the major functions of MBMS (Marakas, 2003).

Table 3.3: Major Functions of the MBMS

Modelling Language	• Allows for the creation of decision models from scratch or from existing modules. • Provides a mechanism for the linking of multiple models to allow for sequential processing and data exchange. • Allows the user to modify models to reflect specific preferences.
Model Library	• Stores and manages all models and solver algorithms for easy access and manipulation. • Provides a catalogue and organisational schema of stored models along with brief descriptions of their individual functions or applications.
Model Manipulation	• Allows for management and maintenance of the model base with functions similar to those found in a DBMS (For examples: run, store, query, delete, link and others).

(c) **The Model Directory**

The Model Directory is a catalogue of all the models and other software in the model base.

The directory contains model definitions and its main function is to answer questions about the availability and capability of the models.

(d) **Model Execution, Integration and Command**

Model execution is the process of managing the actual running of the model.

Model integration involves combining the operations of several models when needed (such as directing the output of one model to be processed by another model) or integrating the DSS with other applications.

A **model command processor** is used to accept and interpret modeling instructions from the user (through user interface component) and route them to MBMS, model execution or integration functions.

Selecting models to match situations cannot be done by the MBMS. Selection process requires expertise and therefore it is done manually. This is a potential automation area for a knowledge-based sub-system to assist the MBMS.

3.7 KNOWLEDGE-BASED MANAGEMENT SUB-SYSTEM

SELF-CHECK 3.4

Review the role of knowledge-based management sub-system in DSS development. Can you explain it?

Knowledge-based management sub-system is the 'brain' of a DSS. The data and the models jointly operate with the knowledge-based sub-system to provide the user with a useful application that supports the decision context at hand. It provides the necessary expertise for solving some aspects of complex unstructured and semi-structured problems. This sub-system, which comprises of one or more intelligent systems, provides knowledge that can enhance the operation of other DSS components. A DSS that are equipped with this component are called an intelligent DSS, a DSS/ES, an expert support system, active DSS or knowledge-based DSS. The knowledge of a DSS is stored in the knowledge base.

Knowledge refers to the rules, heuristic, boundaries, constraints, previous outcomes and other related knowledge that have been programmed into the DSS or acquired by the DSS through repeated use.

The DSS knowledge base component differs uniquely, in terms of information content, from the database or model base component (refer to Table 3.4).

Table 3.4: The Scope of Information Content

DSS Component	Scope of Information Content
Knowledge Base	Specific to a problem domain.
Database	Not limited to a particular problem-solving domain (Useful across several domains or tasks).
Model Base	Not limited to a particular problem-solving domain (Useful across several domains or tasks).

The DSS knowledge base contains most of the knowledge required by a domain expert, for example:

(a) descriptions of various objects or entities and their relationships;

(b) descriptions of various problem solving strategies or behaviours; and

(c) domain-related constraints, uncertainties and probabilities.

The knowledge in the knowledge base can be classified into two groups:

Facts: what is known to be true at a given time?

Hypothesis: rules or relationships that is believed to exist between the facts.

Having described the content of a knowledge base, let us look at how knowledge is acquired and retrieved.

(a) **Knowledge Acquisition**
How does all the required knowledge get into the DSS?

One or more people known as knowledge engineers (KEs), gather the necessary knowledge from the domain experts for the knowledge base. Knowledge engineers are specially trained to interact with domain experts and hence acquire all of the knowledge the expert has in a specific domain. The various knowledge acquisition techniques that are used to get all the knowledge out of the expert's mind include interviewing, modelling, protocol analysis (thinking out loud), among others.

(b) **Knowledge Retrieval**

How do we get all the facts and relationship gathered in the knowledge base back out in an organised and useful manner?

Inference engine (IE) is the part of knowledge base component that facilitates the knowledge retrieval process. The IE, a program module, activates all the collected domain knowledge and performs basic reasoning (inferencing) to work toward a solution. Solutions are derived based on the values and relationships or rules associated with the facts. Due to this fact, the inference engine is equipped with rules on how to apply the rules, strategies for conflict resolution when two rules oppose each other, as well as with methods to determine the probability that a conclusion derived from a set of facts and rules is reliable.

The three components of DSS: data management, model management and knowledge management cannot accomplish much by themselves. The DSS user must be able to access those components in a way that can support the decision-making process. Thus, to enable the interaction between a DSS and a user, an interface is an essential component.

ACTIVITY 3.4

Have you ever heard about knowledge management system? What is the difference between knowledge management system and knowledge-based Management system?

3.8 USER INTERFACE SUB-SYSTEM

> **User interface** includes all aspects of communication between a user and a DSS or any support system.

DSS experts regard the user interface as a crucial element in DSS functionality.

(a) **User Interface Management System (UIMS)**

> **User Interface Management System (UIMS)** is a software that manages the user interface sub-system.

UIMS comprises several programs that provide these **capabilities**:

(i) Provides a graphical user interface.

(ii) Allows the user to use various input devices.

(iii) Presents data in various format and through various output devices.

(iv) Provides interactions with the database and the model base.

(v) Stores input and output data.

(vi) Supports communication among and between users and builders of DSS.

(vii) Provides flexibility and adaptiveness to accommodate different problems and technologies.

(viii) Interacts in multiple, different dialogue styles.

(ix) Tracks dialogue usage to improve the dialogue system.

(b) **The User Interface Process**

The user interface system is illustrated in Figure 2.5 (Turban et al., 2005). The user communicates with the computer via an action language processed by the UIMS. The user interface component may also include a natural language processor. The user can also use standard objects like menus, buttons and Internet browser through a graphical user interface (GUI). UIMS enables the user to interact with data management and model-management sub-systems.

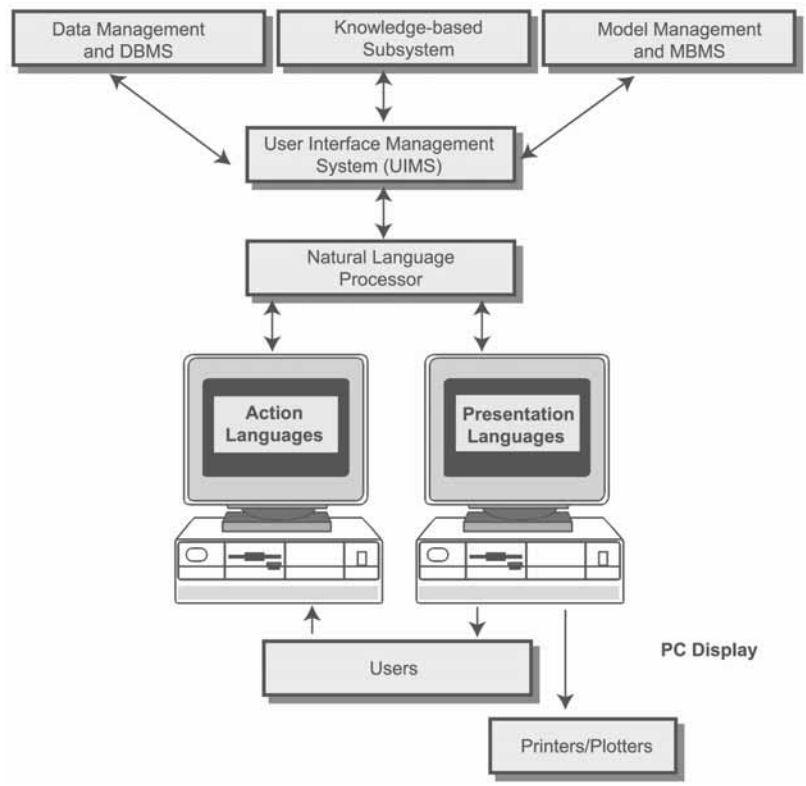

Figure 2.5: Schematic view of the user interface system
Source: Adapted from Turban et al. (2005, pg. 120)

The **action language** is a component that handles users' direct dialogue activities with the DSS.

The action language serves as the basis for the user to transmit information and commands to the DSS. This component facilitates the various modes of data entry via the conventional methods (examples: keyboard, mouse and touchpad) and via the not-so-common methods (examples: retinal scanners, biophysical gloves and voice recognition).

Examples of dialogue styles include menu driven, question and answer and natural command language.

The **presentation language** is what the user actually sees, hears and experiences while he/she is using a DSS.

This component serves as the basis for the DSS to communicate with the user. It presents information via output devices (example: display monitor, printer, voice synthesisers and audio monitors). It allows the creation of various on-screen information presentation styles, for instance graphs, charts, tables, icons, audio triggers and messages. Researches have shown that the method by which information is presented to a user have a significant effect on how valuable that information is perceived to be and how accurately it is interpreted. A user-friendly DSS is where both the action language and the presentation language work together harmoniously.

ACTIVITY 3.5

Action language provides two ways to input data for DSS: conventional methods and biological identification methods. Can you compare these methods by using SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis? Which one is the best and why?

3.9 THE USER

A DSS is not functional without the user. The involvement of user is very critical to the entire system life cycle.

The user refers to the person who is responsible for making decisions, provides expertise in the development and use of a DSS. The user can be an individual or a group.

There are two broad categories of DSS users (also relevant to any Management Support Systems (MSS)) as explained in Figure 3.6.

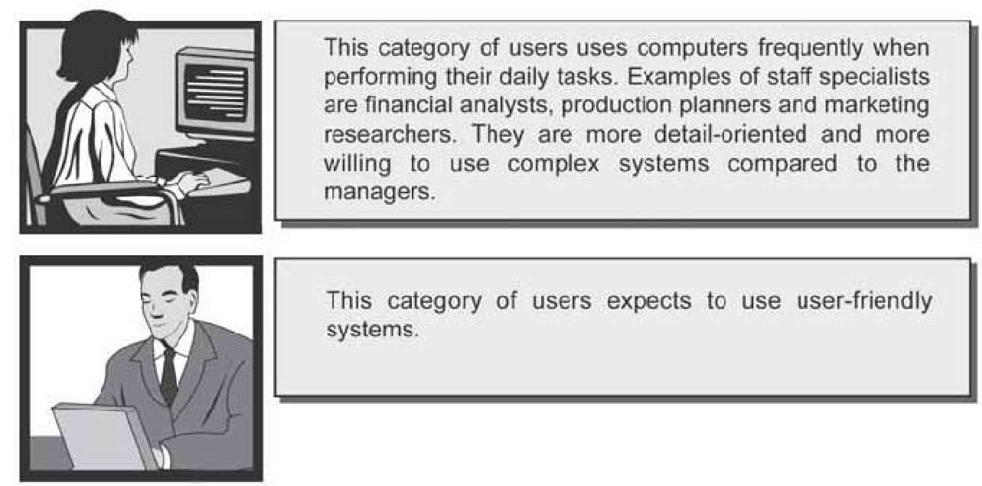

Figure 3.6: Two broad categories of DSS users

Due to the characteristics of DSS users explained above, there are staff analysts that serve as intermediaries between the managers and the DSS.

> An **intermediary** is an analyst that enables the managers to benefit from the DSS without the managers having to interact directly with the system.

There are several types of intermediaries and each type provides different kinds of support (Turban et al., 2005):

(a) **Staff assistants:** They are knowledgeable in managing problems. They can use decision support technology.

(b) **Expert tool users:** They are skilled in using one or more specialised problem solving tools.

(c) **Business (system) analysts:** They have a general knowledge of the application area, a formal business administration education and can use DSS construction tools.

(d) **Facilitators in a group support system:** They manage and guide the use of software to support the work of people working in groups. They also conduct the work group sessions.

ACTIVITY 3.6

(a) Search for a ready-made DSS. What type of industry is its market? Why is it a ready-made DSS?

(b) Compare a custom-made DSS with a ready-made DSS. List the advantages and disadvantages of these DSSs.

3.10 THE SUCCESS STORIES OF DSS

DSS has been implemented by many organisations in various sectors. This section will review some of the success stories of DSS implementation in the case of Bank Rakyat, Time Life Publisher and Whirlpool Corporation.

(a) **Bank Rakyat of Malaysia**

(i) **Background**

Bank Kerjasama Rakyat Malaysia Berhad (Bank Rakyat) was incorporated on 28 September 1954. As the largest cooperative bank in Malaysia, Bank Rakyat provides complete Islamic Banking facilities for the cooperative movement besides being a stable financial institution capable of providing a full range of banking and financial services not only to its cooperative members but also for the general public. As a financial institution, its main aim is to improve the economic status of its cooperative members while the objective of Bank Rakyat is to make profit and expand further. As to date, there are 95 branches throughout Malaysia.

(ii) **Challenge**

Bank Rakyat is improving product performance and strengthening customer relationships with MicroStrategy. Approximately 300 employees located in the bank's headquarters, regional offices and branch locations will use MicroStrategy Web™ to perform product revenue and customer profitability analyses.

(iii) **Solution**

Quad Consulting, with proven expertise in implementing MicroStrategy software and services in Malaysian businesses, will leverage MicroStrategy Web as an important component for Bank Rakyat's web-based analytical reporting solution. Using MicroStrategy technology, Quad Consulting will help Bank Rakyat provides its employees with strategic information to aid in decision-making and planning, with the end goal of improving product performance and strengthening customer relationships quickly and easily.

"We chose this MicroStrategy technology because of its superior offering in the business intelligence industry and Quad Consulting for its expertise in developing and implementing the chosen MicroStrategy platform," said Mohamed Salim Mohd Kassim, Head, Information & Communication Technology Sector at Bank Rakyat.

"Our bank managers will have the technology at their fingertips to track product performance and customer profitability. Once implemented, we expect the MicroStrategy platform will help us to make critical business decisions that increase revenue."

MicroStrategy, Inc (2005). Success Story: Bank Rakyat. Retrieved Sept. 2005 from http://www.microstrategy.com/Customers/Successes/bankrakyat. asp

(b) **Time Life Publisher**

TIME LIFE

(i) **Background**

Time Life is a publisher of CDs, videos and book series. It depends fully on promotion and distribution for the sales of its products and reserves considerable amounts for this purpose. The television commercials, advertisement, flyers and direct mailings are among others that are used to advertise its various series of CDs, videos or series of books.

Customer loyalty is rewarded with special offers and discounts. It does not affect their success. In the Netherlands alone tens of thousands of people buy a full or part product series every year. According to Marketing Analysis Manager, Maarten Prejide, this is down to the unique range — the products are not available in the shops — in combination with the repeated automatic dispatch of new issues.

(ii) **Challenge**

Time Life needs marketing analysts to calculate the yield on the investments on promotion and distribution of sales.

Together with his fellow analysts Prejide studies the entire process a new series goes through. "Everything is registered in detail in four source systems," he explains. "One for the promotion and one for the variable costs, such as packaging and distribution; a system for complete overviews of price and customer lists and product offers and one for processing an order, which includes the customer's payment history and the number of returns."

To determine and predict a product's success are the average take (the average number of parts that are sold per series) and the cost per order, because exact data usually only becomes available months after the end of a product campaign. The inevitable revaluation of for instance the promotion budget and the product's total profit had to be done manually and could take days. It is not really an accurate basis for an organisation whose success very much depends on timely and correct information.

"We also wanted to get rid of the manual work, because the analyses did not go deep enough," Prejide explains. "People cannot do what computers can do and certainly not as fast." Another argument for extensive computerisation was that the various reports were rather difficult to compare, since all analysts had their own method of working. Neither was there enough contact between the different marketing areas within Time Life International (Europe, Asia, Latin America and South Pacific) and Time Life USA; comparing the results of similar products in different regions was not possible.

(iii) **Solution**

In the European region, Prejide was put in charge of the computerisation project. "We started by checking the present data. Of course these appeared to be incomplete and a devil of a job subsequently followed collating all data per product campaign. Sometimes these could only be dug up from aged administrations,"as the marketing analysis manager recall.

The second step was setting up an Essbase database. One with nine dimensions that provides a complete overview in various cross-sections of all crucial positions in a product campaign: the development of a product, the dispatch and the margin on the order costs including the turnover, promotion costs and ultimately the profit.

They constructed the database, developed the reading-in programs and wrote the calculation script. However, their solutions appeared to be inefficient, as they wanted to put far too much information in the database. This is where Temtec helped them with the layout and the installation for an advanced system.

The data from the four source systems are downloaded into the database every week and they become available to the marketing analysts, product managers, financial and area management. Executive Viewer is used to produce fast, simple and accurate management reports, while the marketing analysts work with the Excel Essbase Add-in every day.

Prejide dares to say that the investments in the Essbase database were reclaimed within three months. "If only because we no longer conduct product campaigns that are not profitable." The results are even so hopeful that Time Life will also implement the system in America.

(c) **Whirlpool Corporation**

(i) **Background**

Whirlpool Corporation, which was established in 1911, is now the world's leading manufacturer and marketer of major home appliances. The company manufactures in 13 countries and markets products in more than 170 countries under major brand names such as Whirlpool, KitchenAid, Roper, Estate, Bauknecht, Ignis, Laden, Inglis, Brastemp and Consul. Whirlpool Corporation is also the principal supplier to Sears, Roebuck and Co. of many major home appliances marketed under the Kenmore brand name. Its achievement as a world leader in the appliance industry is particularly impressive when considered in the context of the worldwide appliance industry. Whirlpool competes in an environment made up of more than 235 million major home appliances, worth approximately $70 billion. Yet, in the home appliance industry, Whirlpool holds the leading market positions in North America and Latin America, third place in Europe and the top spot among Western companies doing business in Asia.

(ii) **Challenge**

Becoming a world leader in the competitive home appliance market is tough enough. But sustaining that position is even more challenging, requiring a dedication to efficiency that can save the company capital that could better be used to allow cutting. How does a large company like Whirlpool, which must manage numerous manufacturing sites, product partners and vendors, balance efficiency and cost-savings with superlative customer service and brand loyalty? That balance can only come from careful analysis of business data analysis, which is only useful when done with a powerful, yet simple tool, which turns data into knowledge and knowledge into instantand empowering, business insight.

(iii) **Solution**

In 1993, Whirlpool turned to Teradata ® to find even more insight. Recognising the need for a sophisticated, enterprise decision support environment, Whirlpool first installed a Teradata Ware-house in 1993. Over the years, the company's Teradata Warehouse has grown as the company's needs increased, incorporating data from functions all across the company, including finance, sales, customer service, logistics and manufacturing. Now, across the company, more than 600 users tap into the power of the company's applications, using the Teradata Warehouse each month. Over eight years, Whirlpool has opted for several performance-based upgrades and feature functionality expansions to its Teradata Warehouse. Teradata has not only helped Whirlpool meet the challenges that inspired the company to employ a data warehouse in the first place, but has significantly added value to Whirlpool's efficiency and bottom-line revenues. "The concept of information use for decision-making is strategic and has the potential to add significantly more value than automation/work flow, such as ERP projects," says Gil Urban, Lead Director, Global

Enterprise Management Systems. "Also, the 2000's seem to me to be trending toward managing knowledge (such as sharing it, acting on it and making it available) versus processing data (such as amassing inputs and outputs and transaction data). The transaction foundation, ERP, has been addressed and now companies are looking to mine the data and create more effective, professional and better decisions."

Conservatively, Whirlpool estimates that over just the past three years, its Teradata Warehouse has yielded the corporation several million dollars in savings per year and a high return on investment. Whirlpool puts Teradata to use by tracking and managing the quality of its products, a process that has empowered the company to reduce defects in the design and development of its products.

This Teradata-powered initiative has contributed to reduced warranty costs by 10 percent annually. Teradata has also enabled Whirlpool to perform promotional analysis and eliminate the worst 10% of trade deals. Whirlpool, through Teradata-based analysis, tracks its base sales, as well as the incremental sales driven by trade promotions and deals. This business insight has given Whirlpool a 5% reduction in promotional spending.

NCR Corporation (2001). Whirpool Corporation.
Retrieved from http://www. teradata.com/t/pdf.aspx?a=83673&b=87619

ACTIVITY 3.7

After you have read these success stories of DSS, what can you conclude about DSS? Make your conclusion by using SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) about DSS.

SUMMARY

- There are several definitions of DSS. DSS can simply be defined as computerised information systems that support all phases of the decision-making process for all managerial levels.
- The four major components of DSS are data management sub-system, model management sub-system, knowledge management sub-system and user interface sub-system.

- The data management sub-system handles data through database, DBMS, data repository and data query facility. The model management sub-system provides the analysis capabilities in a DSS through model base, MBMS, model execution processor and model synthesis processor.
- Knowledge management sub-system, which enhances the operation of other sub-systems or operates on its own, serves as the brain of a DSS.
- The user interface sub-system is of utmost importance to a functionality of a DSS. It is managed by UIMS to enable the communication between the user and the DSS and to provide the needed capabilities.
- The user, which is also considered part of the DSS provides the intellect to the development and use of DSS.

KEY TERMS

Data
Extract
Information
Intermediary
Knowledge

SELF-ASSESSMENT 1

Instruction: Please answer all questions in 30 minutes.

1. Give your own definition of a DSS.
2. What are the major components of DSS?
3. What are the major functions of DBMS?
4. Database stores data from various sources. What are the possible sources of data collected in a database?
5. There are four categories of models in a model base. One of them is the tactical model. Briefly define the tactical model with an example.
6. A ______________ is constructed to enable the study and develop a better understanding of the event or process, without having to actually experience or recreate the event under study.

7. The major functions of MBMS are _____________, model library and _____________.

8. In a user interface system, a component that handles users' direct dialogue activities with the DSS is known as _____________.

SELF-ASSESSMENT 2

Instruction: Answer all questions. Please answer each question in 30 minutes.

1. Shasha Ahmad was promoted to be a director of the transportation department in a medium-sized university. She controlled the following vehicles: 17 sedans, 15 vans and 4 lorries. The previous director was fired because there were too many complaints concerning not getting vehicles when needed. Shasha was told not to expect any increase in budget for the next two years (no replacement or additional vehicles). Shasha's major task is to schedule vehicles for employees and to schedule the maintenance and repair of the vehicles. All this should be accomplished manually. Your job is to consult Shasha regarding the possibility of using a DSS to improve this situation. Shasha has a top-end PC and the latest version of Microsoft Office, but she is using the computer only as a word processor. She has an access to the University's intranet and to the Internet. Prepare:

   (a) A justification for the development and use of the DSS (namely, what the DSS can do to support Shasha's job).

   (b) What will be included in the data management, model management and interface?

   (c) What type of support do you expect in this DSS to render? (d) How would you classify this DSS?

   (e) Does it make sense to have a knowledge component?

   (f) Should the DSS be built or should one be rented online? Why?

   (g) Should she disseminate the DSS to others on the intranet? Why or why not? (Source: Turban et al., 2005)

2. Answer these questions:

   (a) There are several characteristics and capabilities of DSS. Review them by relating to the major components of DSS.

   (b) List some internal and external data in a DSS that would be constructed for a decision regarding a school expansion.

(c) Provide a list of possible strategic, tactical and operational models for a university and a restaurant.

(d) Explain why the user is considered a component of the DSS.

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Topic 4 ▶ Group Decision Support System

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Describe groupware technologies;
2. Define group decision support system, discuss its five characteristics and its four components;
3. Explain computer-supported cooperative work;
4. Differentiate four types of collaboration framework; and
5. Discuss the application of group decision support system (gdss) in distance learning and virtual workplace.

▶ INTRODUCTION

In the previous topics, we have discussed what DSS is all about, which basically tell us on how to develop a system that has the ability to support a user on making his decision. This topic will discuss DSS that support a group of users that need to make a decision collaboratively. Group decision-making can become more productive with the application of network technology as the usual conventional face-to-face meeting has too many limitations, including the need to travel in the hike of gas and oil price, coordination of schedules, the risk of disorganisation, the tendency of some participants to dominate or not to become

fully involved in discussions, and the need for a sequential processing of information since participants cannot express their opinions simultaneously.
By using group support systems (GSS), these and other problems associated with conventional face-to-face meetings can be avoided. A GSS uses computer hardware, computer software and network technology to allow meeting participants to exchange ideas without the fear of rejection, to achieve consensus that is free from political influence and to express their opinions simultaneously without the risk of miscommunication or perhaps misunderstanding. The location will be in a meeting room or decision room or in remote locations, as the team members might be geographically distributed. We need a DSS that will take into account all factors, so that all team members can fully be involved in making the decision. This kind of DSS is called Group Decision Support System, or simply (GDSS), which we will be further discussed in this topic.

4.1 AIDS FOR GROUP DECISION-MAKING

ACTIVITY 4.1

In your opinion, does making decisions in groups increase the productivity of an organisation? Why?

During the industrial era, group activities are economically necessary. The necessity for group over individual activity has been assured by the modern industrial state, which could not survive on individual effort alone. The belief in the efficiency of group work was reinforced by research in the 1930s that showed groups could solve problems in larger numbers and with greater speed than could isolated individual (Kraemer and King, 1988).

However, new problems and dilemmas emerge as people work in groups. Kraemer and King (1988) illustrate the need through the following dilemma:

Decision-makers find themselves faced with an increasing number of lengthy meetings needed to discuss information-laden issues, but decision-makers are beginning to resist attending such meetings because they take time away from other critical activities. 'Losses' of productivity in group decision-making occur because discussions are dominated by certain individuals, low-status members defer to high status members, group pressures lead to conformity of thought, miscommunication among members is common, and insufficient time is spent in problem exploration and generation of alternatives.

(Kraemer & King, pg. 117)

Therefore, social and computer scientist solutions to this dilemma are to make meetings more productive, which is the key concept behind the Group Decision Support System (GDSS). Operationally, this means increasing the speed at which decisions are reached without reducing, but it is hoped, enhancing, the quality of resulting decisions. In other words, GDSS is mainly about developing a technology that a group of people can use to make decisions effectively and efficiently. However, effective group decision-making requires meeting the need of the situation, ensuring that members are satisfied with the process, and enabling members to meet and work successfully in the future.

But a new question arose, how can the GDSS accomplish these worthy goals? Kreamer and King (1988) report that Huber (1982) provides the following suggestion:

GDSSs can help alleviate these problems by providing a personal computer terminal for each participant, a public display screen for all, computing and communication capabilities that allow for accessing databases and communicating with the group leader and the public display, and software for word processing, data access and management, graphics, and 'controls' to permit communications with others or the group.

(Kraemer & King, pg. 117)

Since then, over the past decade, computer-based systems have been proposed as tools for group decision support. The result has been the creation of a new area of research in GDSSs. For example, let us take a look at the use of GDSS in a company.

There are two departments in the company, the IT Department and the Human Resource Department. The senior executives need to monitor the company requirements from time to time such as software, hardware, trainings for their staff and budgeting plan for each department. Therefore, the managers from each department need to gather all information about their requirements and input them into the system. The system can produce appropriate reports for each department along with the budget. The executives of the company can access these reports so that they can decide which requirements will be the top priority. The report can also assist them to plan their monthly or yearly budget. Figure 4.1 shows the flow of information in each department that finally assists the executives to make decisions.

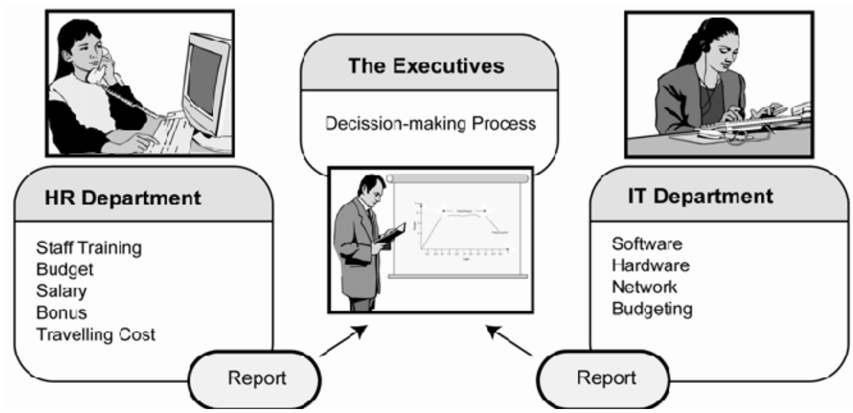

Figure 4.1: Decision-making in an organisation

Now, let us take a look at another example: a decision process made by a group of researchers who are geographically distributed from one another.

The researchers are from a local university in Selangor. They are developing a system that can automatically diagnose paddy diseases. In this research, they have to collaborate with paddy experts from Malaysian Agricultural Research and Development Institute (MARDI), located in Penang. In order to get precise information about paddy, the researchers need to get in touch with the experts from time to time, so that the experts can make a decision and verify that the system they developed are precise and satisfactory. In order to save travelling cost, they can set up a teleconference or video conference meeting to communicate and make decisions appropriately among each other, like the following Figure 4.2.

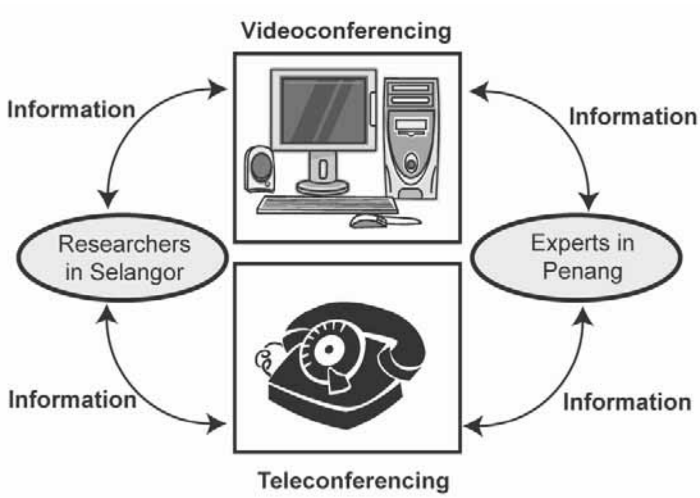

Figure 4.2: Geographically dispersed decision-making

The GDSS has become more important these days because of the factors in Table 4.1.

Table 4.1: GDSS's Important Factors

Factors	Descriptions
The Need of Decision That Comes From a Group	Sometimes, the organisation needs a decision that comes from a group. This is because none of the staff in the organization has enough experience to make a decision of a particular problem. In this case, brainstorming is done within the group members to get the idea of solving the problem. In addition, the burden will be shared by the group and not by an individual.
The Need to Hear Every Member's Idea	There are also times that the decision-makers would wish to hear the idea or comment that comes from each member of the group. In certain situations, it may be important to protect the anonymity of individual sources. The decision maker can use GDSS technologies that support this kind of circumstances.
The Need to Communicate in Distributed Environment	Consider that a company has become bigger and has successfully initiated branches in different places. The manager in each branch will now have to communicate with each other in order to work in parallel. Therefore, many organisations have started to work collaboratively.

For these reasons, the managers have learned the need of group decision-making. GDSS can be used to support the decision-making process that can enhance group performance and decision-making process.

4.2 AN OVERVIEW OF GDSS

In the previous topic, we have discussed Decision Support System for an individual decision-maker. GDSS efforts initially grew out of a desire to expand the concept of decision support systems (DSSs) to encompass group decision-making (Kraemer & King, 1988).

Now, consider that in an organisation, we have a project team. Generally, in a team like this, a big project will be divided into subtask and each subtask will be distributed among all group members according to their area of expertise. Starting from these subtasks, every member will produce an output. These outputs will be integrated and from there, every member must work together and make an appropriate decision as to make the integration possible. This kind of activity does not exist with single decision maker.

Every team member needs to communicate with each other in an efficient way. A member also needs to know the other members' skills and expertise. Sometimes in a particular situation, they need to contact other group members immediately to get help. In this situation, they need a system or tool to allow them to easily get in touch and therefore the decision-making process can be performed well. One way to solve this problem is to use GDSS, to support their activities.

Group Decision Support System (GDSS) can be defined as technologies that help and support a group of decision-maker in terms of designing, structuring or modelling the required outcomes in any organisation. It also accommodates tools needed by the members to communicate with each other.

For Power & Power (2001), the name (GDSS) is very descriptive and defines GDSS as a hybrid system that uses an elaborate communications infrastructure and heuristic and quantitative models to support decision-making. A GDSS must be an interactive, computer-based system that helps a team (or group) of decision-makers to solve problems and make choices (to decide).

ACTIVITY 4.2

Can Decision Support System (DSS) that is being used by many managers be considered as Group Decision Support System (GDSS)? What are the differences between DSS & GDSS?

SELF-CHECK 4.1

(a) What is GDSS?

(b) Why do you think GDSS is important in an organisation?

4.2.1 The GDSS Main Characteristics

Important characteristics of a GDSS can be summarised as shown in Figure 4.3 (DeSanctis and Gallupe, 1985).

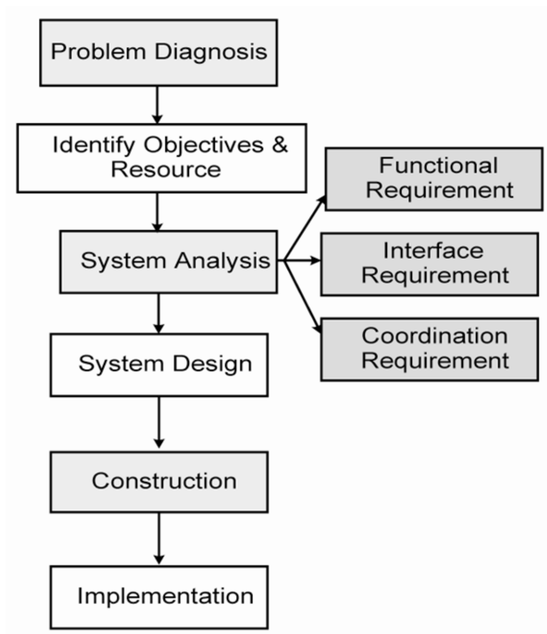

Figure 4.3: Important characteristics of a GDSS

4.2.2 The GDSS Components

SELF-CHECK 4.2

You have learnt the components of DSS in Topic 2. Could you think of the components of GDSS? Are the components similar to DSS components?

As with many other technologies, it is useful to conceive of a GDSS as a socio-technical 'package' comprised of:

(a) Hardware;

(b) Software;

(c) Organisationware; and

(d) People.

These components are illustrated in Figure 3.4.

Socio-technical package in GDSS context means that neither the society (group) is determined by GDSS technology, nor is GDSS technology determined by the society.

Both emerge as two sides of the socio-technical coin, during the construction processes of artifacts, facts and relevant social groups.

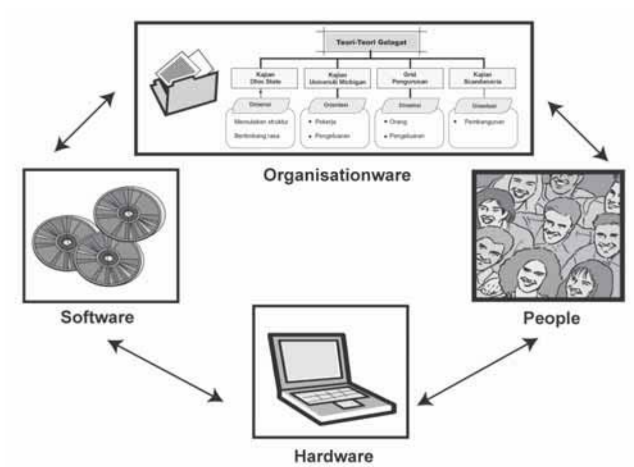

Figure 4.4: GDSS components

(a) **Hardware**

Hardware includes the conference facility (for example: decision room), computing resources, telecommunications facilities, printers and audiovisual equipment.

The computing equipment includes a computer processor with graphics capability, central server for managing communications among members and storing common databases and models, an information display (for example: large projection screen, plasma or projection widescreen television).

(b) **Software**
Software is the key distinguishing technological feature of GDSSs and may be used for the support of general information processing, decision modelling, or communications.

Sometimes, intelligent agents (such as smartbots) can function as facilitators in GDSS. General information processing software could be used for either individual or group work and includes database management systems and high level programming languages, as well as generalised application packages such Microsoft Office, Adobe Photoshop or Paint for graphics, spreadsheets, and statistical analysis such as SPSS. There are several software packages that can help stimulate creativity like ThoughtPath, Creative WhackPack, GoldFire and IdeaFisher. GoldFire, for example, reads, understands and extracts key concepts from the company databases and creates a problem solution tree or knowledge index.

Decision modelling software is specifically aimed at supporting group decision-making and includes modelling languages such as SIMSCRIPT and DYNAMO.

Communications software is specifically aimed at supporting the collaborative aspects of group work and includes tools for text, data, voice, and video transmission (for example: electronic whiteboard, workflow management systems, e-mail, V-mail, computer/audio/video-conferencing).

(c) **Organisationware**

Organisationware includes the organisational data, idea (for example: opinion, or judgement), group processes, and management procedures for collaborative group work.

GDSSs involve the use of internal and external databases. These databases might include a number of distributed databases from local and remote information systems like Human Resources Information System, Students Information System, Marketing Information System and perhaps the Executive Information System.

(e) **People**

People include the participants in the group and the support staff who facilitate the group's activities.

4.3 COMPUTER-SUPPORTED COOPERATIVE WORK

SELF-CHECK 4.3

Why do we need computer-supported cooperative work? What is the importance of computer-supported cooperative work (CSCW) in group collaboration?

Computer supported cooperative work (CSCW) refers to applications of groupware technology that allows group collaboration.

As this requires all members to be present concurrently, the specific activities include online file transfer to the group members, chatting, sharing whiteboard as well as performing audio and video conferencing. In addition, any notification or announcement can be made through emails. The main objective of CSCW is to provide work group applications, which require multi-user application access and control, and coordination of all users' activities.

CSCW is known as group support systems (GSS) or groupware (Turban & Aronson, 2004).

However, a lot of confusion in the field of CSCW rises from the different interpretations of the terms collaboration and cooperation. Dillenbourg et. al. (1995) draw a distinction between them:

Cooperation and collaboration do not differ in terms of whether or not the task is distributed, but by virtue of the way in which it is divided; in cooperation the task is split (hierarchically) into independent subtasks; in collaboration cognitive processes may be (heterarchically) divided into intertwined layers. In cooperation, coordination is only required when assembling partial results, while collaboration is ...a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.

4.3.1 Types of Collaboration

DeSanctis and Gallupe, stated that there are four types of collaboration as shown in the Figure 4.5 below:

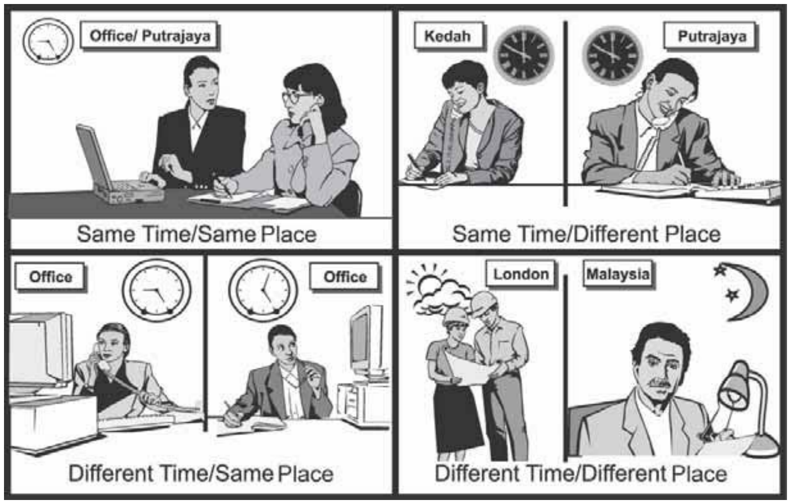

Figure 45: Types of collaboration

(a) **Same Time/Same Place**

In this type of collaboration, all group members attend a meeting at the same time and place such as a meeting held in a meeting room. The communication support can be added at minimum condition such as computer projection system with a smart board and touch panel on the screen. The smart board is connected to the computer. The person in charge of the meeting can simply touch the panel to control what is on the screen. In addition, there can be many computers for each member in the meeting room. With GDSS tools, all members can share the same information on their own screen. The technology also supports anonymity so that each member can give his/her idea anonymously. The supporting technologies for same time/same place are shown in Figure 4.6.

GDSS Technologies
1. Decision Room 2. Whiteboard 3. Document-sharing 4. Web-based GSS 5. Multimedia Presentation Systems

Figure 4.6: Same time/same place supporting technologies

(b) **Same Time/Different Place**

In this type of collaboration, the members are at different places. For example, the managers at different branches can organise a meeting at a specific time to discuss upon a problem. In this case, they need a technology to support their communication activities. The most popular way is to use conference telephone call where the group members can discuss over the phone. Another alternative is to use chatting tools in a forum/conference room. The members can type their ideas or comments on a space provided. In addition, they can talk to each other by using microphones and speakers. Another technology that supports this type of collaboration is teleconferencing. The members can talk/listen to each other, as well as share their information. The supporting technologies for same time/different place are shown in Figure 4.7.

GDSS Technologies	
1. Video-conferencing 2. Whiteboard 3. Document-sharing	4. Web-based GSS 5. Audio Conferencing 6. E-mail, V-mail 7. Computer Conferencing

Figure 4.7: Same time/different place supporting technologies

(c) **Different Time/Same Place**

In an organisation that practices different shift of working time, the managers have to communicate with each other to make sure all operations in the organization are working properly. There are supporting communication tools that allow decision to be shared among them. For example, when the first manager finishes the first shift and leaves a message, the next manager can read the message and carries on with the tasks. Therefore the work can be done continuously, without having both persons present at the same time. The supporting technologies for different time/same place are shown in Figure 4.8.

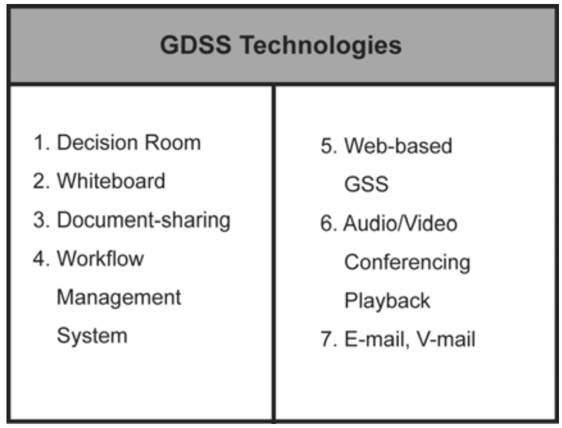

Figure 4.8: Different time/same place supporting technologies

(d) **Different Time/Different Place**

This kind of situation always occurs in an international company. The members of the team are separated in different places and might be in different time zone too. They must be connected to the Internet so that they can send email or use conferencing software that enables information and resource sharing. They can also share information via forum where one can broadcast a question and later be answered by the other team members. The supporting technologies for different time/different place are shown in Figure 4.9.

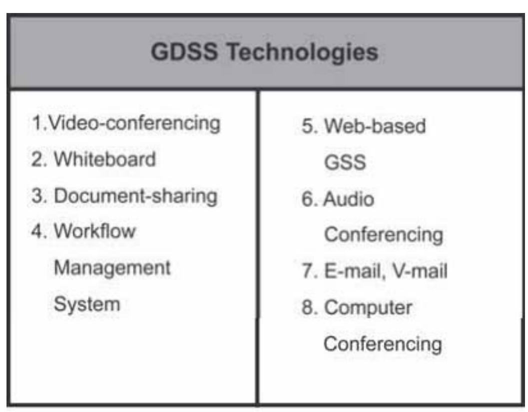

Figure 4.9: Different time/different place supporting technologies

In certain situation, an organisation may have all the above types of collaboration. This is to make sure that they are always connected with each other and have the information shared. In order to do this, they need tools to support their activities, which will be discussed further in the next section.

ACTIVITY 4.3

Create the table of advantages and disadvantages between same time/same place, same time/different place, different time/same place and different time/different place. From the table, which one do you think will be simple and easy to implement?

SELF-CHECK 4.4

(a) What are the four categories of group decision support situations?

(b) For each situation, give a scenario on how collaboration can occur.

4.4 THE GROUP SUPPORTING TOOLS

4.4.1 Email, Mailing List and Newsgroup

These types of supporting tools are used for communications. Each member of the group can share information or discuss problems via email or mailing list. Similar to the mailing list is the newsgroup, where a member can sign up to a particular group. Once he/she has signed up, he/she can have access to all messages sent by other members and the user can send messages to the group as well. A decision-maker can create a group and assign tasks on what to do to the other members. They can also brainstorm and share ideas on a particular problem.

4.4.2 Electronic Conferencing

There are several tools to can support electronic conferencing and they are:

(a) **Whiteboard**
Whiteboard is one of the communication-supporting tools, which allows concurrent communications in the group.

Whiteboard is an application that allows users to collaboratively make simple or complex drawings.

The shared whiteboard application provides users an area on a display screen that multiple users (from different places) can write or draw on. Whiteboards are a principal component of teleconferencing applications because they enable visual as well as audio communication. Each participant can add text, make drawings or paste pictures on the whiteboard. Other participants can immediately see the result on their workstation. Each participant can make a local printout or save the contents of the whiteboard to a disk file for later reference. There is a special type of whiteboard known as **application sharing**.

An **application sharing whiteboard** is a whiteboard that will run a computer application in a window, which can be seen by all participants.

The group members can share the same interface of the whiteboard. Other members can view any changes in the screen made by a user. Figure 4.10 shows an example of a smart interactive whiteboard.

Figure 4.10: A smart interactive whiteboard

(b) **Telephone Conferencing**

Telephone conferencing or simply **teleconferencing** is a technology used as a way of communication for two or more people in different locations at the same time.

The users can discuss on a particular problem with other members of the conference by using speakers and microphones.

(c) **Video Conferencing**

This technology uses a similar concept with teleconferencing. However, it provides additional features. It allows users to share text, audio and video. This application can transmit static as well as motion pictures to the other members.

Video conferencing is an interactive tool that combines the use of video, computing, and communications technologies to allow people in different locations to meet face-to-face to conduct a conference in real-time.

Video conferencing allows students, faculty, and staff to communicate with one another while staying close to their home campus. The example of video teleconferencing is the Microsoft NetMeeting, which is supplied in Windows 2000. Figure 4.11 illustrates a point-to-point video conference. The video user who is initiating the conference (room A) dials the video phone number(s) of the far end site (room B).

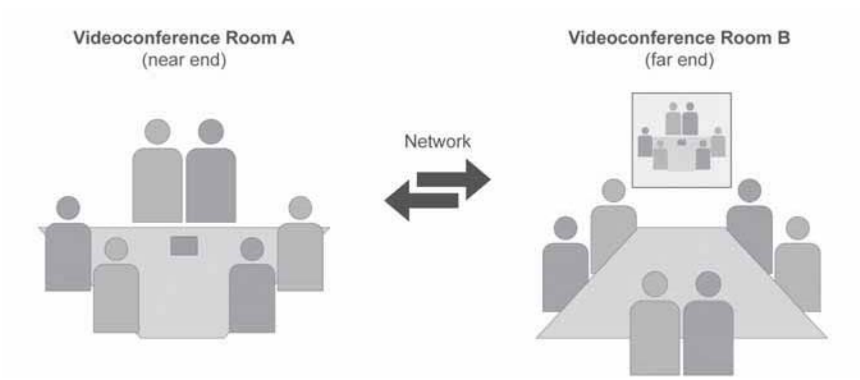

Figure 4.11: Point-to-point video conferences
Source: www.hsph.harvard.edu/ it/dl/E_Learning_Guide.html

A **multi-point video conference** is a conference involving more than two sites.

All participating sites are linked through a multi-point bridging device. A bridge connects four or more telecommunications sites so that they can all communicate together. Figure 4.12 illustrates a multi-point video conference.

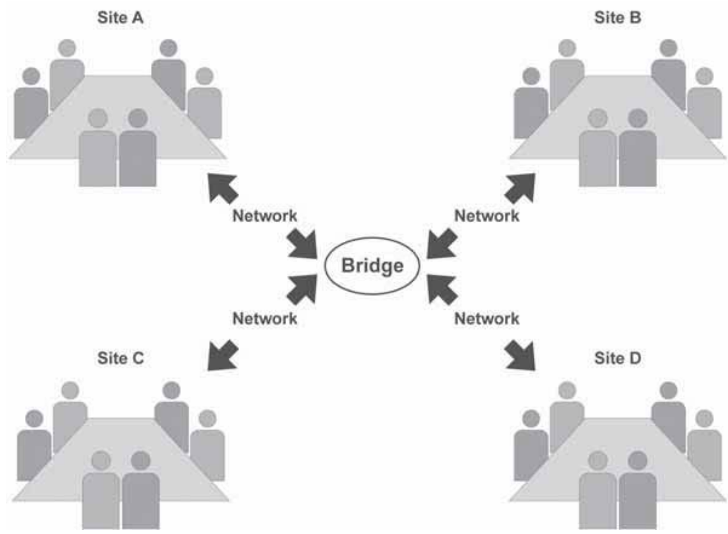

Figure 3.12: A multi-point video conference
Source: www.hsph.harvard.edu/ it/dl/E_Learning_Guide.html

(d) **Chatting Tools**

This tool has become so popular nowadays. It can sometimes be helpful in working with remote members. Each member can type any message as well as exchange files with the other members. For example, Yahoo! Messenger (www.yahoo.com) or Skype (www.skype.com). Figure 4.13 shows the interface of a popular chatting tool (Yahoo Messenger).

Figure 3.13: A voice conference interface with Yahoo Messenger
Source: http://www.carnet.hr/cimages/606406/yahoo1.gif

4.4.3 Decision Room

A **decision room** refers to the physical arrangement for using a GDSS in a high-tech, electronic conference room and each participant has his/her own workstation.

Participants can brainstorm ideas, discuss them, and evaluate them in a mediated setting via their workstation. Organisations using the facility have the ability to brainstorm, simultaneously and anonymously, generating more ideas in less time. The objective in using a Decision Room is to enhance and improve the group's decision-making process. Figure 3.14 shows an example of decision room's environment.

Figure 3.14: Participants discuss and make decisions using a workstation in a decision room
Source: http://www.evaluate-europe.net/Members/admiraal/

The system provides three main advantages over conventional and verbal-only meetings:

(a) A full transcript is automatically generated from participant interaction.

(b) All participants may 'talk' at once.

(c) All participant input through the system is anonymous.

Characteristics of a Decision Room include (Power & Power 2001):

(a) Each participant has a computer workstation.

(b) A leader (facilitator) coordinates the meeting.

(c) The room has a display screen that all participants can view.

(d) Computers are networked and client/server architecture is used.

(e) Specialised software is available to all participants.

ACTIVITY 4.4

Most managers are senior people that are not so familiar with these kinds of technologies. What are your recommendations so that GDSS can be used effectively by them?

4.5 GROUPWARE

Groupware is a technology used by the team as a communication support.

Groupware is an application programs that assist a group of people (multi-user) in geographically distributed location.

Generally, it can consist of calendars, messages, and emails. It also allows database sharing, and electronic meeting. The calendar program allows a member of a team to set any dateline of a particular task where other members can see it. With this program, members can set their own work schedule. Any meeting can be arranged by looking at each other's schedule without having to ask other members about their available time. In brief, it provides a mechanism that helps users coordinate and keep track of on-going projects by assisting people to work together through computer-supported communication, collaboration, and coordination.

The meeting can be set up in a meeting room where each member is provided with a computer and connected to the network. The groupware also supports group tasks such as brainstorming, generating and organising ideas, and even make a vote anonymously. In addition, this application also supports electronic conferencing for geographically distributed members.

Lotus Notes, Microsoft Exchange, Communicator, Novell GroupWise, Netscape SuiteSpot, Eclipse, Team Talk, and Internet Explorer/NetMeeting are some examples of groupware products.

(a) **Lotus Notes**

Lotus Notes for example is a proprietary, client-server collaborative software and email system owned by Lotus Software, of the IBM Software

Group. This software allows users to share many different types of unstructured and semi-structured information, collaborate with colleagues, customers, business partners and suppliers, and generate results. Lotus Notes users can use presence awareness to see who is on-line and available to converse from their desktop or favourite wireless devices. Participants in a workgroup can utilise the instant messaging application to converse in real-time or use web conferences to share a document, application or your entire desktop or conduct a **whiteboarding** session. Figure 4.15 shows the interface for Lotus Notes application.

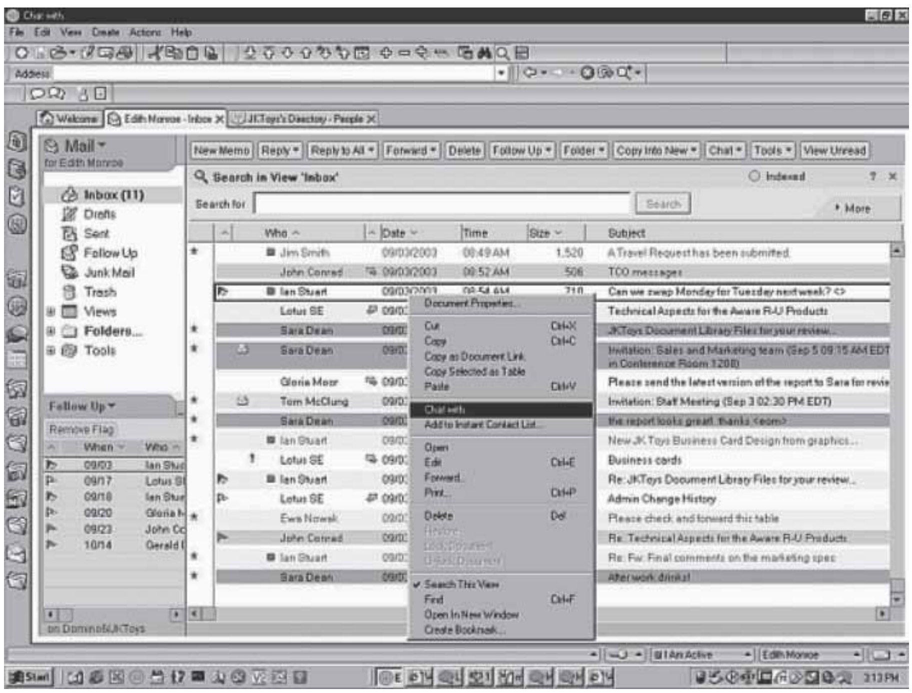

Figure 4.15: Lotus Notes interface
Source: http:// www-5.ibm.com/es/ press/fotos/software/

(b) **GroupSystem and VisionQuest**

GroupSystem is another popular product of GDSS, which is developed in the University of Arizona. Nokia, which is known as one of the leading telecommunication companies has been using GroupSystem in designing their product. The GroupSystem helps the company to set up a meeting where workstation computers are plugged in for each group member in a meeting room. Each computer is connected to a local area network. In order for them to share information, a large screen video monitor is placed in the room so that everyone can get a view of what is going on in the meeting. The software installed in the computers enables them to generate ideas, brainstorming and evaluating every idea so that they will get a list of accepted ideas at the end of the meeting. The software also allows members to make a vote anonymously.

VisionQuest is another GDSS product developed by Collaborative Technologies Corporation in Austin, Texas. This product supports meetings in which the group members are not at the same place or at different time. Among other software products that also support this type of communications are Microsoft NetMeeting, Netscape Collabra Server, and TCBWorks.

(c) **Netscape Collabra Server and TCBWorks**

Netscape Collabra Server that is developed by Netscape enables team members to make 'virtual meeting'. Users can create their own discussion group, and share information through any media such as text, audio and video. This software also enables secure collaboration by setting up a user name and a password, a domain name security as well as certificates.

TCBWorks is developed at the Terry College of Business at The University of Georgia. It is the first generation web-based groupware. This software used to enhance group performance of decision-making. Indisputably, there are many types of groupware available in the market today that assist group members in making decision process more efficient.

ACTIVITY 4.5

(a) Can you make comparisons between Lotus Notes, GroupSystem, VisionQuest, Netscape Collabra Server and TCBWorks? Which one is the best and why?

(b) Visit Groupsystem website to learn more about collaboration at: http://www.groupsystems.com

SELF-CHECK 4.5

(a) Give three examples of group supporting tools.

(b) What is Groupware?

(c) What are the main criterias of Groupware in order to support group collaboration?

(d) What is Computer Supported Cooperative Work (CSCW)?

4.6 DISTANCE LEARNING

SELF-CHECK 4.6

As a student of OUM, your learning method is open distance learning (ODL). How about distance learning? Do you know what distance learning is? Can you find the differences between ODL and distance learning?

The GDSS concept is not only applied in the industrial sector but also applied in the educational sector. For example, GDSS is applied in distance learning Program or virtual university. Students from all over the place will take a particular program that contains specific subjects. There are many ways of conducting this learning method. The popular approach is the electronic learning (or simply e-learning).

E-learning is learning that does not require the student to be physically present in the same location as the lecturer or tutor.

E-learning may occur by correspondence (surface mail), video, interactive or cable TV, satellite broadcast, or any number of Internet technologies such as message boards, chat rooms, e-whiteboards and desktop video or computer conferencing.

The students can obtain lecture notes and assignments via websites. Communication among students and lecturers are done electronically. Distance learning is one of the solutions for people who are still interested in furthering their study but having restrictions in terms of time and place.

Nowadays, there are many web-based tools that support distance learning. In general, students from different places will use the tool for communication purposes. The tool provides e-mails, chatting function and electronic forums. Figure 3.16 shows general overview of distance learning. The figure indicates a group of students and a lecturer are using the same web-based learning tool. They are attached to the network and all forms of communication are done electronically. The communication can be done synchronously by setting up a virtual classroom. This is done via electronic conferencing just like we have discussed before in Section 4.4.

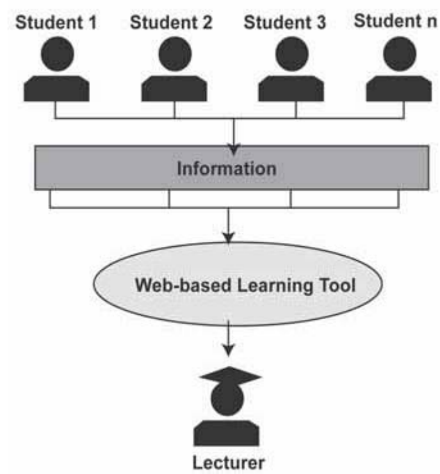

Figure 4.16: General overview of distance learning

An example of this tool is the Learning Care Portal used in National University of Malaysia (UKM). In this portal every user is provided with an account. The lecturer who acts as the moderator can set up a portfolio for a particular course. All lecture materials and announcements can be uploaded into this portfolio. The students who subscribe to this portfolio can access the teaching materials. The students can also access to online quizzes and get the result at the end of the quiz session. The students can communicate with the lecturer using email or alternatively, they can use a forum utility. They can post a question in the forum and it can be read by others. Not only the lecturers can answer to that question, the other students can also give feedback as well. Through this forum, they can brainstorm any idea or topic, which is related to their course.

ACTIVITY 4.6

(a) Based on your experiences, can you give some limitations of distance learning and suggest solutions to them.

(b) Explain how GDSS concept can be applied in education sector.

4.7 VIRTUAL WORKPLACE

SELF-CHECK 4.7

How do you define a virtual workplace? How is it being conducted? Is it similar to the sci-fi movies such as 'Minority Report' and 'The Matrix'?

In this section, we will discuss on a virtual workplace where we do our work virtually from home or somewhere else that is not formally in the office as technology has made it possible for many of us to work outside the standard office environment.

A **virtual organisation** is an organization that uses technology to virtually construct working places for those who are involved in the company transactions such as employees, suppliers, customers, and others.

This is to build less cost and more efficient opportunities (Vine 1995). All communications are done electronically without any restriction in term of place and time. The employees who work in a virtual organisation communicate through emails, electronic conferencing and other form of information sharing tools or system. The employees do not have to think of working in the office, parking spaces or even traffic jam. They only need to be self-motivated and only have to worry about the datelines especially when they are working from home. They can send memos by emails and they might as well subscribe to the company's mailing list to get responses from other members.

4.7.1 Collaborative Virtual Workspace (CVW)

The Collaborative Virtual Workspace (CVW) is a prototype collaborative computing environment, designed to support temporary and geographically dispersed work team.

The CVW original developer is Mitre Corporation. From the user's point of view while using CVW, it provides a persistent virtual building (space) within which applications, documents and people are directly accessible in rooms, floors and buildings. From a technical point of view, it is a framework for integrating diverse collaborative capabilities. To a user, a CVW is a building that is divided into floors and rooms, where each room provides a context for communication and document sharing (sourceforge.net, 2005). CVW allows people to gather in rooms to talk through chat or audio/video conferencing and to share text and URLs with one another (Figure 4.17).

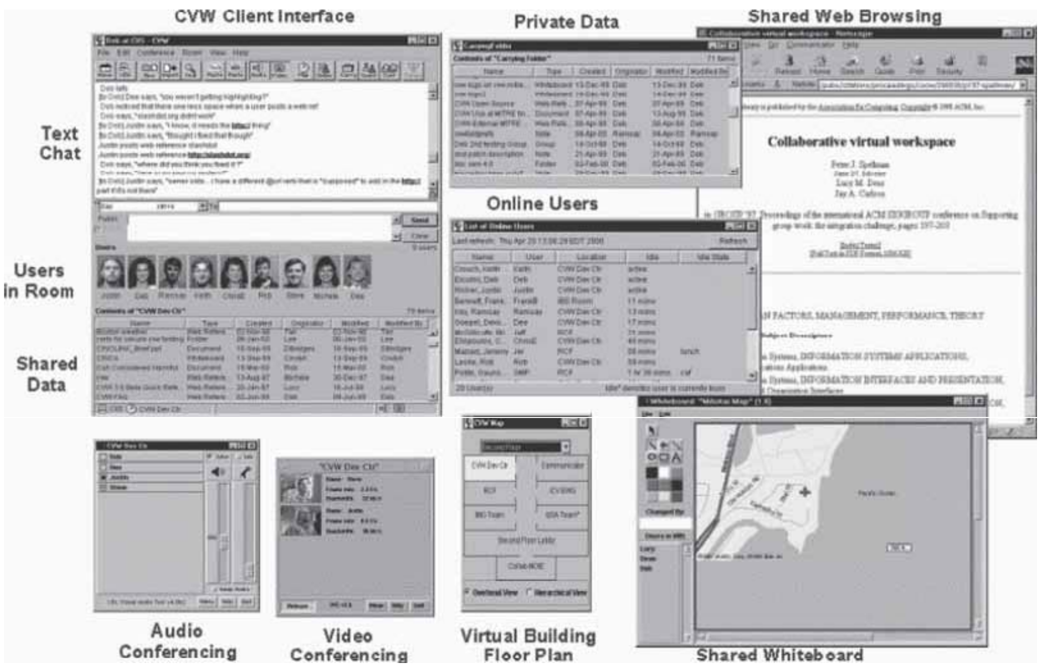

Figure 4.17: Collaborative virtual workspace (CVW) client interface
Source: http://cvw.sourceforge.net

ACTIVITY 4.7

For further information on CVW, please visit this website at:
http://cvw.sourceforge.net

4.7.2 Virtual Workplace Advantages

Virtual organization concept is designed in such a way so that an organisation can get major advantages from it. The most apparent result of practicing this concept is cost reduction. An organisation needs employees who are highly motivated and can access to the Internet. An employee does not have to spend much on the everyday lunches and travelling costs, clothes, car maintenance as well as petrol costs. In addition, he would feel more relax and flexible in doing his/her job. He/she will also have the ability to attend distance-learning course anywhere possible because of the flexibility of time. Moreover, he can make extra pocket money by doing other job as well. This kind of job is also suitable for disabled people, as this job does not require them to travel much.

The company on the other hand, can reduce cost especially on office rental. This will save money on the company budget. They can reduce paper usage as well as stationery. The company might as well hire staff from any part of the country. The employee can also be the company representative when communicating with a clientor suppliers at a particular place, particularly places that are near to the employees.

This can enhance the interaction between both parties and at the same time increase the company's productivity.

However, there are some challenges. It is more difficult to maintain a corporate culture in a virtual environment. There is a greater chance of alienation. Brainstorming sessions are more difficult to do when people are not in a face-to-face environment. In short, collaboration is more difficult to do virtually. As we move towards virtual offices, researchers are still doing more researches and development to explore new innovative ways of communicating and doing business in virtual environment to overcome the basic limitations of the non-face-to-face environment.

ACTIVITY 4.8

(a) A virtual workplace is a new phenomenon especially in Malaysia. Can this technology be implemented in Malaysia and what are its strengths, weaknesses, opportunities, and treats of this technology?

(b) Explain the GDSS concept in a virtual workplace.

SUMMARY

- So far, you have learned about GDSS concept and its supporting technologies. This topic is a survey of computer-based technologies designed to support group activities and the group dynamics involved in the use of those technologies.
- When people work together in a team, and each or some of the members in the same and some may be working at different places and time, they need to communicate, collaborate, and access a diverse set of information sources. They usually will use a GDSS.
- GDSS technologies are used to enhance group performance and decision-making process.
- There are four type of collaboration in decision-making.
- Collaborative computing is known by a number of terms, including groupware, group support systems, and computer-supported collaborative works (CSCW).
- The decision process can be performed in a meeting room, where all members can meet at the same time. It can also occur among geographically distributed members through appropriate GDSS groupware.
- GDSS concept can be applied not only in the organisation, but also in education. Distance learning occurs when learning is performed with tools or technologies to overcome the restrictions of same time and same place learning.

KEY TERMS

Computer-supported Cooperative Work (CSCW)
Decision Room
Distance Learning
Group Decision Support System (GDSS)
Groupware
Virtual
Voice Mail (V-mail)
Whiteboard

SELF-ASSESSMENT 1

Instruction: Answer all questions in exactly 15 minutes.

1. Describe **FOUR** types of collaboration. (4 marks)

2. Give **THREE** examples of group supporting tools. (3 marks)

3. When would you use various group support tools? (4 marks)

4. How can videoconferencing and groupware help in an organization that has few branches? (4 marks)

5. What is the definition for a 'Virtual Organisation'? (5 marks)

SELF-ASSESSMENT 2

Instruction: Answer all questions in exactly 30 minutes.

1. In what condition do managers need the support of GDSS? (5 marks)

2. What advantages can managers get from the support provided by GDSS? (5 marks)

3. What type of technologies used in order to make a 'Virtual Workplace' possible? (5 marks)

4. What is the advantage and disadvantage of working in a virtual organisation? (5 marks)

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Topic 5 ▶ Constructing DSS

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Explain three approaches to DSS development approaches that can be adopted to DSS such as SDLC, prototyping approach and end-user development approach;
2. Describe a general development process for DSS development process (DDP);
3. Apply the decision-oriented approach in DDP;
4. Identify the DSS development tools that can be used; and
5. Explain the various DSS implementation issues needed to be considered when developing DSS.

▶ INTRODUCTION

By now, you should already understand what DSS is, the importance of DSS, know various types of DSS and how DSS helps in decision-making. In this topic, we will learn how to develop DSS.

In order to produce a successful DSS, you need an appropriate development methodology not unlike that of the Information System's (IS) development do. A development methodology provides guidelines on how to develop DSS. The guidelines are developed by the practitioners based on their experiences and later put as a step by step process that other developers can follow. Even though, various approaches been proposed for the development of DSS, but every one does not agree what methodology is the best for building different types of DSS. It is difficult to come out with a general methodology that suits all types of development for DSS. This is because DSS involves a wide range of DSS types, from a very simple to a very complex DSS. Most DSS developers, designs and development is based on personal experiences, case studies or follow the general IS development literature. The earliest approach is following the general IS development as the community argued that DSS is a system similar to Information System. However, in most situations, DSS is nothing like the traditional IS. DSS may be developed on top of the current IS, or integrated with many IS systems or as an ad-hoc system. We cannot completely follow the IS development approach, but we can adopt and enhance it.

TIPS FOR STUDENTS

A **methodology** is like a recipe to make a cake. It shows a step by step process to make a cake. A good recipe provides precise steps, if any bakery follows the same recipe, they will produce a similar product. If you have a recipe to make 1kg of chocolate cake, can you use the same recipe to make 1kg of chocolate banana cake? A good methodology allows non experienced baker to follow the steps that will produce the same cake quality. An experienced baker can use any recipe, which he/she knows in order to make a good chocolate banana cake. Nevertheless, a recipe guides you how to make a cake. It may work or at the very least you produced a cake and not a pancake. This is similar in constructing DSS, where we can adopt and enhance IS development approach to suit with DSS development.

This topic reviews the three popular approaches that can be adopted for DSS development: the traditional SDLC, Rapid Prototyping and End-user Approach. This topic also presents a general DSS development process which is the enhanced version from the traditional IS development. This topic also presents a decision-oriented approach used during the development process while the rest of the topic discusses arious kinds of DSS development tools that can be used and discusses the issues that should be considered in implementing a DSS.

5.1 SYSTEM DEVELOPMENT LIFE CYCLE (SDLC)

SELF-CHECK 5.1

SDLC is a popular development approach. Can you define what are the reasons that make this approach widely used in software development?

System Development Life Cycle (SDLC) approaches known as a waterfall model is based on a series of formal steps. SDLC is a popular approach for IS development that you learn in SSDM (Structured System Design Methodology) or Introduction Management Information System courses (Kendal & Kendal, 2003, and Shelly, et. al. 2002). Figure 5.1 shows the typical series of steps. It shows the development process and outputs produced in each step. Each SDLC step culminates in a written document which must be reviewed and approved before you go the next begin step. Both user and developer review the document. Users are involved in the early and last stage in defining the requirement and verify the system to meet their needs. The middle part involves the technical task performed by the developer who is normally system analyst.

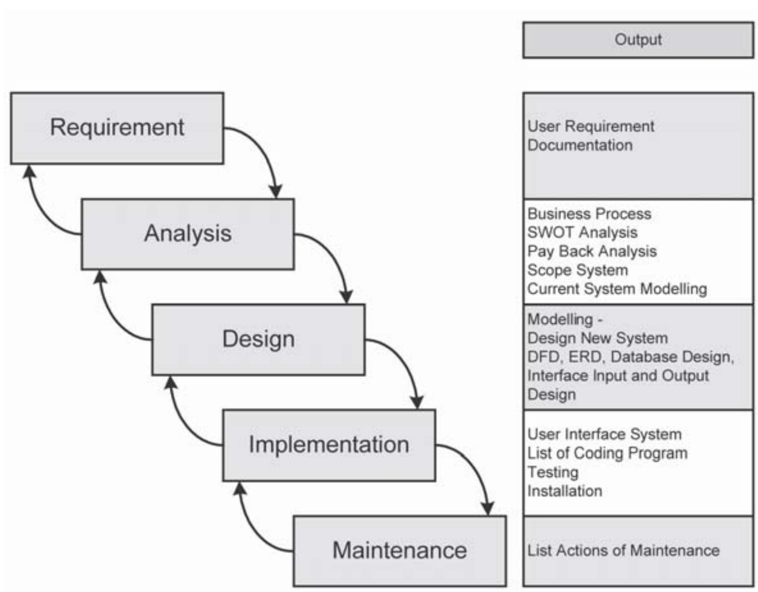

Figure 5.1: SDLC development approach

5.1.1 The Advantages of SDLC

The advantage of SDLC is the fact that it shows a step-by-step process that can allow the other developers to follow and understand easily. It is good for maintenance because it is well documented. SDLC ensures no important area has been overlooked. It has normal contractual relationship between developers and the user.

5.1.2 The Disadvantages of SDLC

SDLC is not suitable for systems that change rapidly. The user agrees at the first stage of the process. When changes happen, the entire development process has to be restarted. This will cause an increment in cost of development. Another drawback of SDLC is poor medium communication between the user and the developer. Users are hard to articulate what they need in a system, while the system analyst produces hundred pages of technical description that is hard to elicit and most likely not to be read.

Following the whole SDLC is less appropriate. However, it still makes sense for large DSS development which involves many people in the development. SDLC offers structured modelling techniques which is good for decomposing the large complex module into small sub-modules. Thus, large DSS development may apply this technique. SDLC is also suitable for DSS development from scratch, which involves programming to construct the whole DSS. SDLC is not suitable for development of an ad-hoc DSS. Hague and Waton (1985) reported that 25% of organisations are using SDLC approach.

5.2 PROTOTYPING

Prototyping preserves the SDLC development steps but it is evolved in response to deficiencies of the SDLC. In the prototyping approach, system analyst sits down with a potential user and develop a system that appear to work using any tools such as fourth generation languages (4GLs) that support rapid development. The prototype system appears as the end of product but omit the error checking, access to real database, connection to real network and so forth which is mostly used by most of development time. Figure 5.2 shows the proptotyping development process. The figure shows the recursive process to produce a prototype system. Once approved, the prototype becomes a specification to perform the design modelling for the development of the system.

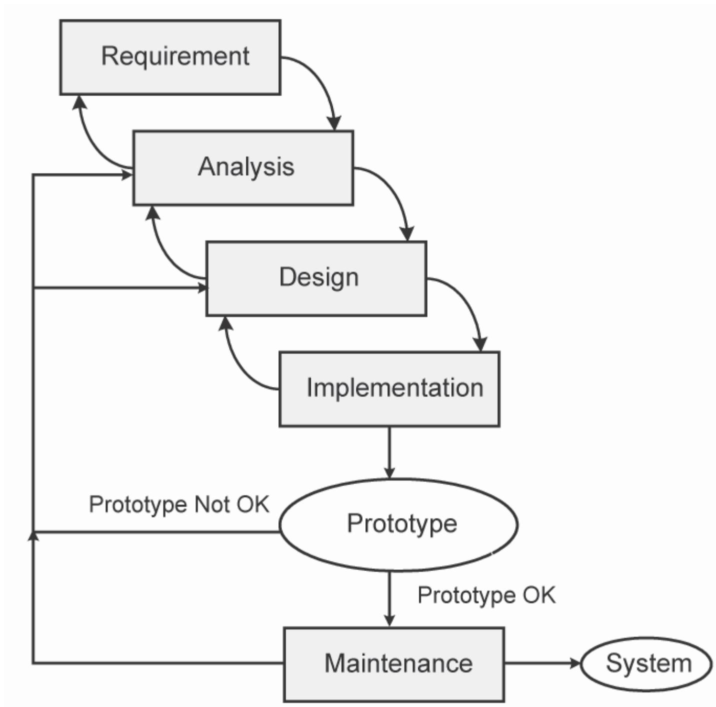

Figure 4.2: Prototyping development approach
Source: Adapted form Turban (2001, 328)

There are two prototype approaches:

(a) Throwaway; or

(b) Evolutionary prototyping (known as rapid application development).

The first approach is less suitable for the DSS development especially that involves purchasing to host data warehouse and upgrading a new platform. This will increase cost of development and implementation.

The second approach is more suitable for DSS. The prototype becomes the foundation of application and continues to use a high-level development tools. This is due to the fact that time is important in the DSS development and usually the manager needs a DSS as soon as possible. Prototype has some advantages and disadvantages. These are explained in Table 5.1.

Table 5.1: Advantages and Disadvantages of the Prototype Approach

Prototype Approach	
Advantages	**Disadvantages**
It clearly shows that prototyping approach improves the user-developer communication. Therefore, the proposed system is more likely meets the user's needs.	this approach increases the schedule of development DSS, especially by using throwaway approach or choosing the wrong tools in a wrong way. The developer must understand the limitation of screen packages, 4GL or any rapid development tools.

ACTIVITY 5.1

Who do you think will be involved in prototyping? What are their roles?

5.3 END-USER DEVELOPMENT

SELF-CHECK 5.2

What is the end-user development approach? What are the roles of the users in this approach?

As discussed above, prototyping has high level of cooperation between users and developers. The end-user development approach gives full responsibility of development to the user as a decision-maker. The development environment platform is developed in such a way that is affordable for the end-users to develop their own DSS.

This development approach is often associated with desktop microcomputers. However, nowadays, there are many end-users oriented packages or tools available in minicomputers and even for mainframes. These tools are also available in both single-user and large multi-user computers. The most popular end-user development tool is the spreadsheet such as Lotus 123 and Microsoft Excel. After analysis, the decision makers select the best alternative solution that meets their business needs. For example, a manager uses Microsoft Excel to analyse the issues like the impact of different budget options. It is proven that spreadsheets are useful tools to develop DSS as a college business curriculum. Managers and professionals can carry out such analysis on their own by using this software. Table 5.2 describes the advantages and disadvantages of this approach.

Table 5.2: The Advantages and Disadvantages of the End-user Development Approach

End-user Development Approach	
Advantage	**Disadvantage**
The major advantage of end-user development is that the person who needs computer support will be involved in creating it. Sometimes the results are faster development and cost saving. The developer controls all the situation and option solution.	This approach is less desirable for the development of a complex DSS. At some points, specialist can do work much better, much faster and cheaper. This is because managers are normally not trained to manage the system such as testing the system, create documentation, provide back-up and security and design sophisticated user interface, which may cause problems on the system.

The best solution of end-user approach is that the DSS analyst should help the manager to build document and test the system. However there are many controversial issues on this approach as listed below, which needs to be considered such as:

(a) End-users select an appropriate software product as development environment.

(b) End-users have limited expertise while IT group has limited resource to support end-user.

(c) Errors happen frequently due to lack of checking formulas.

(d) Unnecessary and redundant databases that may occur which cause inaccurate result.

(e) Poor construct databases can cause some difficulties to maintain.

A complex end-user project should be aided with professional support. Many firms provide such support and it is usually called 'information centre'. With such services, the managers can explore the use of database accessing tools such as 4GLs to satisfy their own needs. The information centre normally provides regular training classes, telephone help and appointment or walk-in consultation. To ensure compatibility among the DSS systems, an organisation should have a standard software and hardware for the development personal DSS.

The SDLC approach is suitable for the DSS development on which the system is developed from scratch and involves programming to construct the system. Normally, end-user is less knowledgeable about IT and the analyst have to take a lot of afford to analyse and design the system. Therefore SDLC produces documentation in each stage and agreement from team in each stage as well. Besides that, SDLC is also suitable for development of a large and complex DSS which involves a lot of people in the development.

Developing DSS is very expensive; adopting the SDLC may guarantee the success of DSS development. The prototyping approach is suitable for middle-scaled system. Designer translates the user requirement into a prototype system and shows it to the user. This method needs a tight involvement between user and analyst in the development. The Rapid Application Development approach is normally used for DSS development.

The end-user approach is used when the user knows IT and the development of DSS by using any DSS tool which the user can use to develop by himself/herself, without the help of the analyst. However, this approach is suitable for small-scaled DSS.

ACTIVITY 5.2

Create a comparison table for SDLC, prototyping and end-user development approach. From this table, which approach do you think is the best and why?

SELF-CHECK 5.3

(a) Explain the advantages of SDLC?

(b) Explain the limitation of end-user approach?

5.4 DSS DEVELOPMENT PROCESS

SELF-CHECK 5.4

(a) Listed below are **SIX** stages in a DSS development process. Can you determine the order of these stages?

(b) Implementation, construction, system analysis, system design, identify objectives and resources, and problem diagnosis.

Throughout the above discussion, we have shown that there are many similarities between DSS development and the development of IS application. The unique nature of DSS development which deals with semi-structured or unstructured problem makes it different with IS development. This section discusses a DSS development process proposed by Marakas as he declares a general approach for the DSS development (Marakas, 1999).

Figure 5.3 shows the generalised DSS Development Process (DDP), which contains six stages or steps and they are:

(a) Problem diagnosis;

(b) Identifying the dss objectives and resources;

(c) System analysis;

(d) System design;

(e) Construction; and

(f) Implementation.

In DSS development, there will always be problems of getting complete user requirement. At early stages, the managers are not clear with the requirements because of unclear identifying user requirement. Marakas (1999) proposed to use prototype approach as we see at the last stage of DDP as increment adaptation. Each stage in prototype approach will be discussed further in the next section.

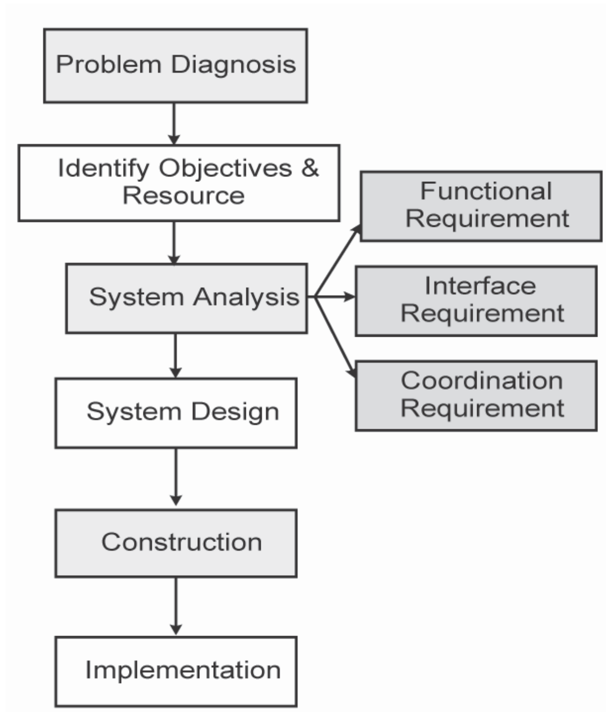

Figure 5.3: A general approach for DSS development

5.4.1 Problem Diagnosis

Problem diagnosis stage is quite similar to problem definition phase in SDLC. The analyst is responsible to assess the nature of the organisation and develop documentation describing the problem context and the organisation environment, which needs decision support, then later stated in preliminary feasibility report.

This stage looks at the opportunities of decision support for identification problem within the organisation. The system analyst should be an expert and well known in DSS, thus he/she can critically support the manager for identifying organisation problems, which involves DSS.

In Topics 1 and 2, we have discussed various problems that manifest themselves as a collection of symptoms that leads to the identification of the needs of DSS within an organisation. Topics 8 and 9, will also discuss various techniques which managers can exploit in their market decision-making. At the end of this stage, a problem statement is produced.

5.4.2 Identifying Objectives and Resources

Once opportunity for decision support has been identified, the objective and key decision that has to be supported by the DSS must be recognised. The available resources support the DSS developments such as hardware, software, current technology and knowledge that must be made should be identified. System analyst or designer must carefully identify the objective of the DSS. The objective should clarify the function of proposed DSS depending on:

(a) the types of knowledge;

(b) the capacity of knowledge to be available to the decision maker; and

(c) the general performance characteristic of the system.

Besides that, he/she must determine the exact role of DSS that will be expected to play within the identified problem context. For examples: enhance user creativity, imagination or insight, solve or assist in solving problems, provide assistance in the form of advice, analysis or evaluation. The examples of objectives are as follows:

(a) Increase the market share for product gloves.

(b) Improve the quality of a particular raw material by more than 12 percent.

(c) Improve the quality of decisions made within the organisation.

Throughout this module you will learn more about DSS. After that, you will find out more possible examples of DSS objectives. While identifying objectives, the analyst also needs to identify the methods by which the objectives of proposed DSS can be evaluated in term of the success.

At the end of this stage, there should be a list of set objectives that are associated with possible resources that are needed to develop DSS. The objectives are then analysed which can be accurately accessed and become the exact objectives of DSS within the problem context, within the organisation. This defines as initial determination of feasibility with regard to the resources conducted.

5.4.3 System Analysis

In traditional SDLC, analysis phase focuses on determination, collection and documentation of specific requirements for a new system. The activities are similar to the analysis phase of DSS development. It is intended to produce in detail the set of requirements for the DSS. Techniques getting requirements introduces in SDLC can be applied. However, what kind of information needs to be gathered to produce the set of DSS requirements will become the issue.

Holsapple, Park and Whiston (1993), in Marakas (1999) categorised three types of requirements for DSS that can be established as:

(a) **Functional Requirements**
This requirement describes the specifications of DSS capacity storage, recall and production of knowledge are useful to the problem context. For example, a requirement that describes the capability of a particular DSS to store a variety of product sales projections, specifies the components or characteristics of one or more projections and estimate the effects on sales volume of one or more changes to the underlying assumptions or variables that are involved in it.

(b) **Interface Requirements**
Interface plays important roles producing a quality and useful DSS. The interface requirement focuses on the communication capabilities of DSS in the problem context.

Developer should identify various channel and methods of communication that will be made available to the DSS and the condition underneath to make it available. It may involve identifying menus, report structures, command interface and output formats. The developer should also identify the various types of requests that might be made of DSS by decision-maker. For example, the interface should provide a graph that should be able to show the company projections product sales variety. This graph can be used by decision-makers to predict the company budget.

(c) **Coordination Requirements**
These requirements describe the timing of events associated with the performed decision-making process, facilitates the access to the relevant information and the integration of various modelling tools contained in the DSS. In similar method of scenario techniques which describes the necessity of one event to be occured before another action can be performed. For example, needs to update the actual figure of the sales projections for prior fiscal periods before initiating a future projection process.

5.4.4 System Design

In traditional SDLC, this stage uses the user requirements from the previous phase to create various model system components processes and data as well as their interactions such as DFD model, ERD, database design and architecture design. While in the design phase of development, DSS needs to determine the physical components, structure and development platform. So, the primary activities are selected as a set of development tools to be used in the construction of DSS. Once the development tools have been determined, the design process can be performed. What kinds of modeling are appropriate to use? It depends on the strengths and features of those tools. Later, in the development tools section, discussion on various platforms will be defined.

5.4.5 Construction

In SDLC, constructions are allocated in implementation phase. The phase consists of code generation that uses any programming language followed by testing of the system, which later tests the performance of the system in relative to the stated requirement. Meanwhile, Marakas separates the construction phase as a phase before implementation. This phase is responsible to construct the system according to the tools that have been decided in the design phase. The construction uses an interactive prototyping approach that allows for a small system to be refined based on feedback from testing and user involvement so that it will be implemented into the real system. This process is continuously being performed, but there is a significant change in the initial requirement specification.

At the early stage, a manager cannot imagine what DSS is, but as soon as he/she sees how DSS helps him/her in decision-making by using the DSS prototype, it will generate more ideas and requirements from the manager. However, the manager or user can request anything as long as it is not reflected to the design specification. The prototype is also used to determine more requirements associated with interconnecting the DSS with other existing software application in the organisation.

5.4.6 Implementation

This phase is to test, evaluate and deploy the DSS system. All functionality of the DSS should meet a degree of satisfaction from the user. The system test has to fulfill the objectives of a decision-maker. Any modification can be performed by going back to design stage. Some DSS implementation activities are:

(a) obtaining and installing the DSS hardware;

(b) installing the DSS and making it runs in its intended hardware;

(c) providing user access to the system; and

(d) creating and updating the databases.

Some other activities that are similar to traditional IS development are:

(a) Giving training to the DSS user groups in terms of capabilities, function and structure of the system. The advantage is that the users can be involved in maintenance and refinement the system from time to time.

(b) Documenting the system for its users and for those who will be responsible for maintaining the DSS.

(c) Making arrangements to support the users.

(d) Transferring on-going responsibility for the DSS from developers to MIS group who will maintain the system.

(e) Evaluating the operation and the use of the system.

DSS Development is never-ending. It is an incremental adaptation process. The system always upgraded until the users realised that the system is out-dated and not useful and has to be maintained. The developer is responsible to get response from the users from time to time, to enhance the capabilities of the DSS based on the result of its use. There are two main reasons why incremental adaptations are needed. First, new needs are manifested by the users or developers. New innovative functions are developed from time to time in response to their needs. Secondly, the changes of the current and future technology will support better DSS. It may have major revisions or may restart.

ACTIVITY 5.3

If a manager can specify that the DSS requirement in advance to develop a small-scale DSS system and the development tools are available. What development approach is appropriate? Give your reasons.

5.5 APPLYING DECISION-ORIENTED APPROACH IN DSS DEVELOPMENT PROCESS (DDP)

DSS covers various types of system, from simple to complex system. Therefore, no specific methodology can be applied. The DSS development as previously discussed shows that the developer involves a lot of decision-making in each stage of development. The right decision plays an important role and the decision-making at the consequence stage depends on the result of the previous stage. Therefore, each stage of DSS development involves decision-making as we call it decision-oriented approach. Following sub-section discusses the kind of decisions needed, which involve the users and developers. The DSS developer's experience plays an important role of the success of the DSS development. Nevertheless, the novice has advantages if she/he knows what the right action should be taken in each stage of DSS development.

5.5.1 Decision-oriented to Problem Diagnosis

As discussed before, problem diagnosis involved determining potential DSS to define problem context within an organisation. It needs thorough understanding of problem domain. In some situations, it is enough to have some general knowledge of problem domain, while in some cases domain expertise is needed. The user and developer must be in the same stream of specifying the interest in the problem domain. DSS developer must be well knowledgeable not only on the knowledge to develop computer application but also the knowledge of surrounding problems. The developer needs to decide how to increase his/her knowledge on these subjects. In certain cases, DSS experts in the domain should be invited in the development team. The novice developer may consult the DSS consultant, in order to make sure you will be able to diagnose the right problem in the organisation.

5.5.2 Decision-oriented Identifying Objectives and Resources

At this phase, a set of objectives asscociated with the resources within the organisation are identified. Developer must understand the problem context and identify the needs of DSS to the user. The set of objectives provides the scope of the DSS. The objectives should be analysed to produce a concrete and realistic objectives. The set of objectives should be prioritised. Developers have to decide which objectives most likely going to success and which set objectives are urgent and which can be delayed. The prioritized set of objectives is useful for identifying resource that is needed. This will make sure the resources can be used for long period of time by using incremental development approach. By making a list of objectives, prioritising them, utilising the existing resource or identifying appropriate resources all need good decision-making skills.

5.5.3 Decision-oriented Strategic System Analysis and Design

In order to have general methods of DSS development, Marakas (1999) classifies various approaches for DSS development into two common strategies:

(a) programming a customised DSS; and

(b) employing a DSS generator.

The choice of the approach is often contigent to the organisation setting or problem context. Applying both approaches are quite impossible. Developers have to choose the appropriate approach after the objectives have been defined and before performing the system analysis stage. This is because both approaches provide different methods of DSS development.

(a) **Programming a Customised DSS**

This strategy normally develops the system either by using general-purpose programming language (GPL) such as C, Java or Pascal, or by using a fourth-generation language (4GL) such as Visual Basic, Visual C++, Power Builder or ASP. Early DSS was developed by using the GPL approach, but most of modern system uses combination of 4GL and other components and tools to decrease development time. Large DSS may need interface with other various DSS and other operating systems which employ commercial programming product to allow for development of the DSS.

(b) **Employing a DSS Generator**

A **DSS generator** is an application system that eliminates the need for programming that contains thousands of lines of coding. It is a software tool that provides functionality to the developer to easily develop his/her own DSS.

The most popular DSS generator is an electronic spreadsheet such as Excel, Lotus 123 or Quattro Pro. In Topic 8, we will discuss more details on how to develop DSS by using this approach. However, the limitation of using this DSS generator is the fact that it is less flexible and suitable for the less complex DSS.

Another improvement of DSS generator is called domain-specific DSS generator. It is classified as a highly structured DSS that is intended for use within a specific functionality area. The examples are SAS (use for complex statistical application) and Commander FDC (for financial analysis).

Figure 5.4 shows the hierarchy of decision strategic approach for DSS system design for DSS development (Power, 2001). The decision is made after producing feasibility study at the end of system analysis phase. The decision of approach influences various issues such as eliminates certain processes, additional people who are involved in the development, risk management, consultation, training and outsourcing. For example, the developer as the end-user will be using the end-user development approach that may eliminate the training and outsourcing activities, but need support for testing.

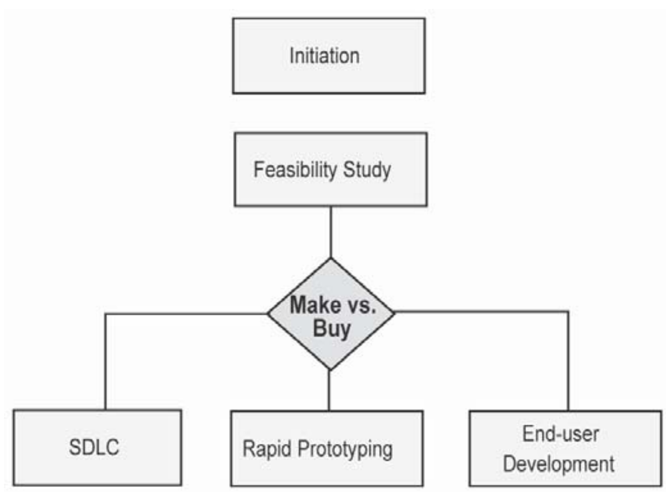

Figure 5.4: A DSS system design development approach
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ACTIVITY 5.4

(a) Can SDLC be fully used for DSS development? Why?

(b) When is SDLC approach suitable to be used for DSS development?

(c) What are the differences between SDLC and the DSS development processes?

5.5.4 Decision-oriented System Design

Design phase is the most critical phase of making decisions in order to ensure the success of DSS development. Developer should decide the appropriate physical components, structure and development platform in relation to problem context and objectives of DSS development. Developers need to understand the available development technologies to ensure that they choose the right DSS development platform or tools. For example, a spreadsheet is more appropriate for 'what-if' analysis, whereas rule management platform is suitable for corrective action in a complex manufacturing process. The developer should know when it is appropriate to use data mining, expert system, case based reasoning, neural network and others. Choosing an appropriate user interface design, architecture, database design and output design are also important at this stage.

Decision-making in construction phase is involved in testing activities. The developer should identify an appropriate method to test the DSS. While in the implementation phase, the developer needs to make sure that the system fulfills the users' needs, which will later innovatively enhance the system.

ACTIVITY 5.5

Imagine that you never read any of the DSS development approach before; do you think you can manage to develop DSS? What is your opinion of the above DSS Development Process? Did it provide guidelines for you on how to develop DSS?

SELF-CHECK 5.5

(a) List at least FOUR developer's skills that are needed in order to develop a successful DSS.

(b) Company 'A' wants to perform 'What-if' analysis. Which development approach is most appropriate for this analysis?

(c) Which development approach works better for Enterprise-wide DSS and which one is better for ad-hoc DSS?

5.6 DSS DEVELOPMENT TOOLS

SELF-CHECK 5.6

Can you explain what is the role of DSS development tools? How important is it?

Nowadays, a powerful DSS development tool is for implementing DSS to become more common to support various kinds of DSS. These tools support techniques for the DSS development. For example, tools for specific decision techniques such as spreadsheet, tools that support multiple techniques such as corporate spreadsheet with graphical presentation and also tools that support highly sophisticated DSS so called DSS generators.

Marakas (1999) and Turban (2001) classify development tools into three levels of technology: DSS primary tools, DSS generator and Specific DSS.

(a) **DSS Primary Tools**
It is the lowest of DSS technology. It provides fundamental development either for a DSS generator or specific DSS application. Examples of these DSS tools are programming languages, graphics, editors, database query system, coding and random number generators.

(b) **DSS Generators**
DSS generator is a package of hardware/software that provides a set of capabilities to develop specific DSS in a quick, easy and inexpensive way (Sprague and Carlson, 1982). There are various ranges of DSS generators that are available from Microsoft Excel such as a simple spreadsheet package to highly sophisticated software such as MicroStrategy's DSS Agent.

The advantage of DSS generator is convenience. A DSS generator is an integrated tool that provides functionality to create decision modelling, reports design and generation and presents graphics and manages basic data based, without having difficulties integrating between multiple tools such as to import and export data. This is the most common tool used for DSS development.

(c) **Specific DSS**
Specific DSS application is used for certain domain knowledge, which the decision-maker faces the most problems. It has been developed as a commercial DSS application development. For example, in the medical

profession, which has vast knowledge base of medicine coverage for all human races, the DSS can assists in diagnosis of medical condition or illness hence replacing a doctor.

The relationships of the classification are shown in Figure 5.5. DSS tools can be used to construct a DSS generator, which can be used for a single DSS or multiple DSS applications. A commercial DSS generator can be used to develop a specific DSS application. The choice depends on the specific needs of the decision-maker and the nature of the problem.

The decision issues always rise when choosing DSS development tools. Among these include which tools to use and which hardware, operating system and network to run on them. If you choose the DSS generator, these are the following criterias for DSS generators that need to be considered (Marakas, 1999):

(i) Data management functions.

(ii) Model management functions.

(iii) User interface capabilities.

(iv) Compatiblity and degree of connectivity.

(v) Available hardware and platforms.

(vi) Cost.

(vii) Quality and availability of vendor support.

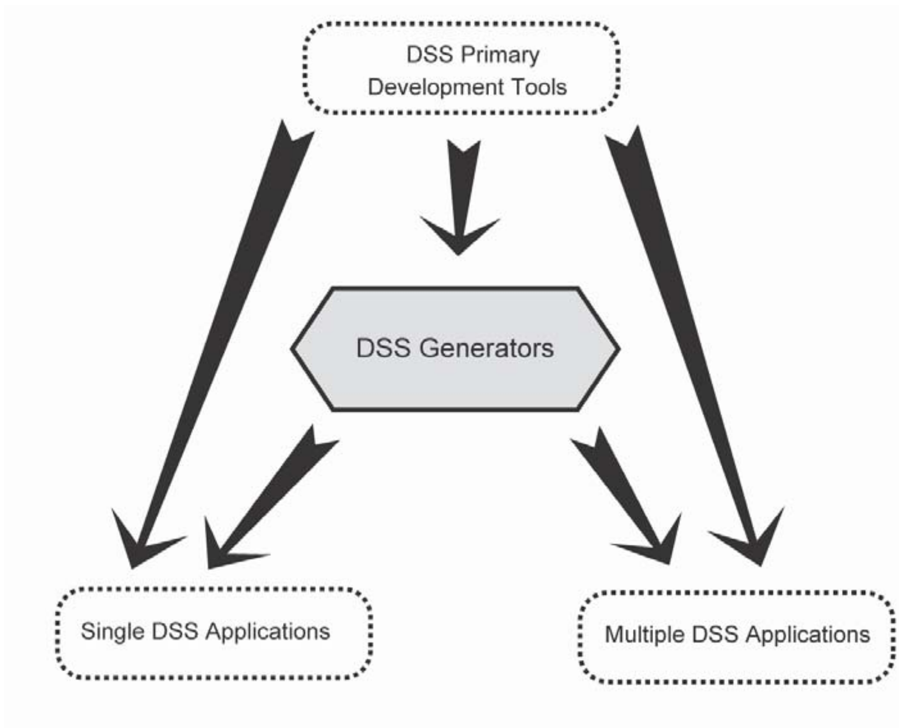

Figure 5.5: Classification of DSS development tools

SELF-CHECK 5.7

(a) List **THREE** categories of DSS development tools. Which one is less popular and why?

(b) Why integrated DSS generators are so popular and are used for DSS development?

(c) List **FOUR** issues that need to be considered when choosing DSS Development tools.

5.7 DSS DEVELOPMENT ISSUES

In spite of discussing the DSS development process, there are several issues that should be considered when developing DSS such as implementation, project management and DSS project participation, as further discussed in the next section.

5.7.1 DSS Project Management

In order to make sure DSS development succeeds, it needs to be managed by a project manager. The issues that should be considered for DSS project management are explained in Table 5.3.

Table 5.3: DSS Project Management Issues

Issues	Descriptions
Funding	Funding is the key of the DSS development. The sponsor can be the decision-maker, an organisation, or executive sponsor as part of business and information system planning or part of research and development.
Identify Project Leader	Project leader is assigned based on the size of the project. Project leader is a person who handles all the projects from beginning to end. In large DSS developments, it may benefit having co-project managers including a business and technical manager.
Project Team	DSS development needs project team. It involves person who gives sponsor, project manager, users, DSS builder or system analyst, technical support person such as head of IT and the expertise of DSS area. Project manager needs to select the right person in the project team.
Outsource vs. In-house	The decision of DSS development is to outsource vs. develop of in-house influence on the project team. If outsourced, then the evaluation proposal should be performed. If development in-house, then feasibility analysis should be determined.
Specify DSS Architecture	In large DSS project DSS architecture needs to be specified. Any changes or addition to the current information system or information technologies infrastructure must be planned.

The responsibilities of DSS project leader is shown in Figure 5.6.

The Responsibilities of DSS Project Leader

- Diagnoses problem, produces a feasibility study, defines objectives and scope of the project.
- Once the project is approved, project leader need to develop an appropriate DSS development methodology and assigned project team.
- Identifies tasks that must be completed and resources that are needed.
- Delivers progress of project.
- Defines project plan and manages daily activities associated to the project.
- Coordinates project resource, budget, status reporting, change requirement tasks, relation with vendor, sponsor and MIT staff.

Figure 4.6: The responsibilities of DSS project leader

5.7.2 DSS Implementation Issues

There are various issues that should be considered when implementing the DSS as we classify them into two categories: technical issues and user-related issues. The technical DSS implementation issues are responsible to make sure that the DSS operates as its supposed to, in term of performance, reliability and the accuracy of the results.

The performance is measured according to response time. Even though it has been measured while testing, it may not represent the real result. This is because, the developers may use a lightly loaded system or high-performance workstations, while in real implementation it content may include heavier load on the server, slower computer, network traffic or integration with full scale database that will cause different result of response time.

Reliability measures how stable the system operates. The system may crash unpredictably at frequent intervals. Therefore, the system is used to measure the reliability in many conditions. For example, how reliable is the system if the database has to be reorganised during working hours? What will happen to the system if the network fails?

The accuracy of the results is an issue in implementation as well. The accurate result may influence from the quality of data input, especially data that are collected from several resources and some are from external data warehouse. Therefore, the data should be monitored carefully.

The user-related issues are harder to face compared to the technical issues. The implementation becomes problematic when the user and management are not supporting the implementation process. The user is the core person that is involved in the DSS development. When the user is not truly committed, the problem will rise. Besides that, an unstable user community is also causing implementation problems. This is because the new user group may have different backgrounds, different problems solving styles or different views of technology. Therefore it causes implementation not to be performed smoothly. Involvement from the top management is also important to send memo to both users and developers to make sure they have the commitment from all of them.

The issue of response time also becomes an implementation issue. This is because the users may have different expectation of response time with one another. Several studies show that users accept response time for several minutes if they carry out certain complex task. The studies show that the response time of performing routine tasks should not be more over than two seconds (Power, 2000).

5.8 DSS FEASIBILITY OUTLINE

Feasibility study report is used to report about the status project of DSS development project whether to be proceed, postponed or cancelled. Feasibility study report addresses some issues including the project's benefits, cost, effectiveness, alternatives considered, analysis of alternatives, opinions of potential users and other factors. The contents depend on the purpose of the report being produced. It may be an early feasibility report. Detailed feasibility report is produced after the system analysis phase; before system design phase is started. The following is an example of feasibility outline proposed by Power (Power, 2001):

(a) **Executive Summary**

- (i) Key Business Needs
- (ii) Issues
- (iii) Solutions
- (iv) Benefits and Costs
- (v) Critical Success Factors
- (iv) Project Management

(b) **Introduction**

- (i) Background and Definitions
- (ii) Key Questions

- **Site Readiness**: To what extent is the company ready for and interested in implementing a new Decision Support System? What needs to change to facilitate successful implementation?
- **Technical Feasibility**: Is it possible to develop or adapt software to perform the proposed types of analyses. If so, can the technical solution be implemented efficiently and effectively with present technical resources?
- **Financial Feasibility**: What are the projected costs of implementing the DSS and do potential benefits justify these costs?
  (iii) Feasibility Study Approach

(c) **Background Needs and Assessment**

(i) Goals

(ii) Constraints

(iii) Related Projects

(iv) Business Decision Support Needs

(v) Decision Support Diagnosis

(d) **Objectives**

(e) **DSS scope and Target Users**

(i) Scope and Decision Process Definition

(ii) Scope Recommendation

(iii) Scope Issues

(f) **Anticipated DSS Impacts**

(g) **Proposed Solution**

(i) System Integration Issues

(ii) Major Functions Provided

(iii) Technology Tools/Infrastructure Used

(iv) New Organisational Structure and Processes

(h) **Major Alternatives**

(i) **Conformity with Current is/it Plan**

(j) **Project Management and Organisation**

(k) **Estimated Time Frame and Workplan**

(l) **Incremental Costs**

(m) **Benefits**

(n) **Risks and Mitigating Factors**

(o) **Draft Conceptual Design**

SUMMARY

- This topic mainly discusses various approaches for DSS development. Decisions of selecting an appropriate approach becomes an easy task as we follow the past experience of other DSS developments.
- Jack Hogue and Hugh Watson (Power, 2000) in their survey found that 2/3 of organisastions had built DSS using an evolutionary or prototyping approach, while the remaining organisation uses SDLC approach. It shown that the SDLC approach is used when the proposed DSS supported managers throughout the company or when required company-wide data.
- The evolutionary approach is used for smaller-scale DSS or when the development tools are available.
- The result also shows that 9 out 18 companies used DSS generators to develop their own DSS. This finding is quite similar to what we have discussed in this topic.
- Power stated that if the managers can specify the DSS requirement in advance then the SDLC approach was most likely to be used. Similarly, if DSS is developed by the IS specialists.
- SDLC is also suitable for large development of complex system, network, enterprise-wide and data-driven DSS.
- When using evolutionary and prototyping design, the managers or users have to get involved in design and development process. The willingness of their involvement is very important. The end-user of DSS can be satisfactory and inexpensive, but it needs MIS staff to support the development which may discourage it.

- In the development of the new DSS, the selection approach depends on the amount of data needed and its sources, the number of users, any model and analytical tools used and the amount of anticipated use. Usually, specialised DSS or ad-hoc DSS are built using end-user development or rapid prototyping. In general, Model-driven and Knowledge-driven DSS are built using rapid prototyping.
- However, Data-driven DSS is built using either rapid prototyping or SDLC depending on the situation as we have discussed throughout this topic.
- Besides selecting appropriate approaches, the MIS professionals should use decision-oriented approach throughout the development phase. He/she should know what elements to use in each stage and know what is the consequence of a wrong decision for the development.
- The right decision needs professional skills of DSS development. Othman (2004) states that a good software development methodology should have these following criteria:
  - (i) Covers certain phases of development process. Each phase provides techniques and modelling notation that facilitates representation of the system.
  - (ii) Should be general for particular context of development.
  - (iii) Possess clear guidance on movement from one phase to another phase.
- We conclude that the DSS development presented here is not full scale DSS development methodology but rather a guideline on how to develop DSS.
- The disadvantage of the current DSS development is that it just has general modeling techniques. Many researchers have proposed several kinds of modelling techniques but very seem tied to a particular type of DSS.

KEY TERMS

Computer-aided Software Engineering (CASE)

Data Flow Diagram (DFD)

DSS Generator

End-user Development

Entity Relationship Diagram (ERD)

Outsource

Prototyping

Rapid Application Development (RAD)

System Development Life Cycle (SDLC)

SELF-ASSESSMENT 1

Instruction: Answer all questions in 1 hour.

1. Name **THREE** software development approaches that can be used for DSS development? (5 marks)

2. What is the strength of SDLC and prototyping approach that can be adopted for DDP (DSS Development Process)? (5 marks)
3. What are the disadvantages of end-user development approach? (5 marks)
4. Explain what the requirements of decision-making is needed by the developer at the following DSS development phases:
   (a) Problem diagnosis.
   (b) Analysis.
   (c) Design.
   (d) Implementation.
   (10 marks)

SELF-ASSESSMENT 2

Instruction: Answer all questions in 45 minutes.
(This question can be given to you when you have learned Topic 9)

1. You are assigned by Company XYZ to build an expert system for buying a car. This expert system is used by the car sales executives.
   (a) List questions that you need to answer before developing the system.
   (b) Show the development process of the expert system by using the DSS development process stated in this topic.
   (c) List the activities in each stage.

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Topic 6 ► Data Driven DSS

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Discuss the need of developing data warehouse;
2. Describe the concepts of the data warehouse;
3. Explain two basic ways to analyse data in data warehouse; user-guided analysis (olap) and automated analysis (data mining);
4. Describe the features of online analytical processing (olap);
5. Explain data mining techniques, the applications and technologies; and
6. Describe data visualisation and its tools.

► INTRODUCTION

Data is crucial raw material in the information age. Relevant data is stored and managed in operational databases. We can track sales, inventories or other variables through these operational databases. Such databases are critical to the success of almost any organisation. The ultimate reason for data collection, storage and management is to create information. Information is used to make decisions. However, information needs for decision-making are becoming more complex. The process of extracting data from operational databases into decision support systems (DSS) is not an easy process. Thus, data warehouses are developed to overcome the difficulties that may be caused by operational databases. Having all necessary data integrated in data warehouses, these data are analysed using either the user-guided analysis (online analytical processing or OLAP) approach or the automated analysis (data mining). Data visualisation is applied to understand data along data processing chain. For example, during data extraction process or to dig/search in data in a data warehouse. This topic begins by defining data warehouse and describing the concept of data warehouse. Next, it focuses on understanding OLAP, including relational OLAP and multidimensional OLAP. Data mining, together with its several techniques and algorithms are also explained briefly. Finally, data visualisation and its typical features are explained through three examples of data visualisation tools.

6.1 INTRODUCTION TO DATA WAREHOUSE

SELF-CHECK 6.1

How do you describe data warehouse? Is it similar to general warehouse that stores goods? How is data being organised in the warehouse?

In order to shed light on the need of data warehouse for a decision support system (DSS), let us look at the differences between operational data and DSS data.

DSS is used for decision-making at strategic and tactical managerial levels within an organisation. The effectiveness of a DSS relies on the quality of data collected at the operational level. Operational data and DSS data serve different purposes (Rob and Coronel, 2004). Thus, their formats and structures differ.

The differences of DSS data from operational data are explained in Table 6.1 (Rob and Coronel, 2004).

Table 6.1: The Differences between DSS Data from Operational Data

Differences	Descriptions
Data Currency	Operational data represent transaction as they occur. DSS data represent operational data at a given point in time, for example, weekly product sales.
Transaction Type	Operational data are characterised by update transactions. DSS data characterised by query transactions. DSS data require periodic summarisation and loading up from operational data.
Summarisation Level	Operational data represent information about a given transaction and are stored in many tables. DSS data do not have the details of each operational transaction, but represent transaction summaries.

Data Model	Operational data in a relational transaction system require normalised structure. With normalised structure, many tables are yielded, with each table consists of minimum number of attributes. On the other hand, DSS databases are non- normalised. The focus of DSS database is not on transaction updates, but on query capability. Thus, DSS database has a few tables, and each of them contains a large number of attributes.
Query Activity	Queries on operational database are narrow in scope, low in complexity and speed-critical. Queries on DSS data are broad in scope, very complex and less speed-critical.
Data Volumes	The volume of operational data might be from hundreds of megabytes up to gigabytes. The volume of DSS data can be of hundreds of gigabytes to terabytes. The large volume of data is due to two factors. First, data are stored in non-normalised structures and thus displays data redundancy and duplication. Second, the same data are stored in different ways to represent different snapshots. For instance, sales are stored in relation to region, product, customer and many more.

The differences between operational data and DSS data indicate the need of DSS databases. Due to the complex information requirements and growing demand for better data analysis, they initiate the creation of a new type of datarepository, known as data warehouse.

Data warehouse has become the main data source for modern decision support systems (DSS). It obtains its data from various operational databases as well as external sources. The data in the data warehouse are organised in format and structures that facilitate data extraction, data analysis, and decision-making.

6.2 DATA WAREHOUSE CONCEPT

Data warehouse is a large database containing business information that end users can get (Mallach, 2000).

A data warehouse may contain, for example:

(a) sales information by product, region and time period;

(b) credit card usage information by cardholder income, age, sex and marital status; or

(c) insurance claim information by city, age, sex, occupation and type of policy.

Bill Inmon, the acknowledged father of the data warehouse defines data warehouse as an **integrated**, **subject-oriented**, **time-variant** and **non-volatile** database that provides support for decision-making.

The highlighted components of the given definition are explained in Table 6.2.

Table 6.2: The Definitions of Data Warehouse Components

Components	Definitions
Integrated	It refers to the common format of describing all business entities, data elements, data characteristics, and business metrics throughout an organisation. For example, the marital status of a staff might be indicated as 'married' or 'single' in Human Resource Department and as 'MRD' or 'SNG' in Computer Information System Department. Thus, to avoid format problem, the data in the data warehouse must have a standard format.
Subject-oriented	Data in data warehouse are organised and summarised by topics, such as sales, marketing and finance. Each topic contains specific subjects like products, customers and regions. In other words, summarised sales data are recorded by product, by customer and by region.
Time-variant	Data in data warehouse represent the flow of data through time (Rob & Coronel, 2004). When the previous weekly sales data are uploaded to the data warehouse, the entire weekly, monthly, yearly and other time-dependent aggregates for products, customers, and other variables are also updated. Data warehouse can also contain projected data.
Non-volatile	The data in the data warehouse are never removed. New data are always added and data warehouse is always growing. As no changes to data are allowed when data are properly stored, the data environment is relatively static.

Table 6.3 presents the differences between data warehouse and operational databases (Rob & Coronel, 2004 and Marakas, 2003).

Table 6.3: The Different Characteristics of Operational Database and Data Warehouse

Characteristics	Operational Database	Data Warehouse
How is it Built?	One application or subject area at a time.	Multiple subject areas at a time.
Normalised Data?	Must be normalised to support business processes.	Not normalised. Data can be and often are redundant.
Area of Support	Day-to-day business operations.	Decision support for managerial activities.
Data Retention Period	Retained as necessary to meet daily operating needs.	Retention period not determined. Must allow historical reporting, comparison and analysis.
Availability of Data	Require high and immediate availability.	Immediate availability is less critical.
Volume of Data	Similar to typical daily volume of operational transactions.	Much larger than typical daily transaction volume, especially time series data sets.
Integrated	All data elements have common definition and representation.	Similar data can have various definitions and representations.
Subject-oriented	Data are stored functional-orientated or process-orientated.	Data are stored with a subject orientation that provides different views of the data and assists decision- making.
Time-variant	Data are recorded as current transaction, for instance, the product sales of a given date is RM3216 on 5-FEB-2005.	Time dimension is used to facilitate data analysis and time comparisons.
Non-volatile	Data updates are frequent. Thus, data environment are fluid.	Data cannot be changed. Thus, data environment are quite static.

In order to build a data warehouse, data are extracted from various sources and then are transformed and integrated before being loaded into the data warehouse. It is difficult to create a high quality data warehouse. This is due to the fact that data are derived from various sources that use different data formats and structures. Figure 6.1 illustrates the process of creating a data warehouse from data contained in operational databases (Rob & Coronel, 2004).

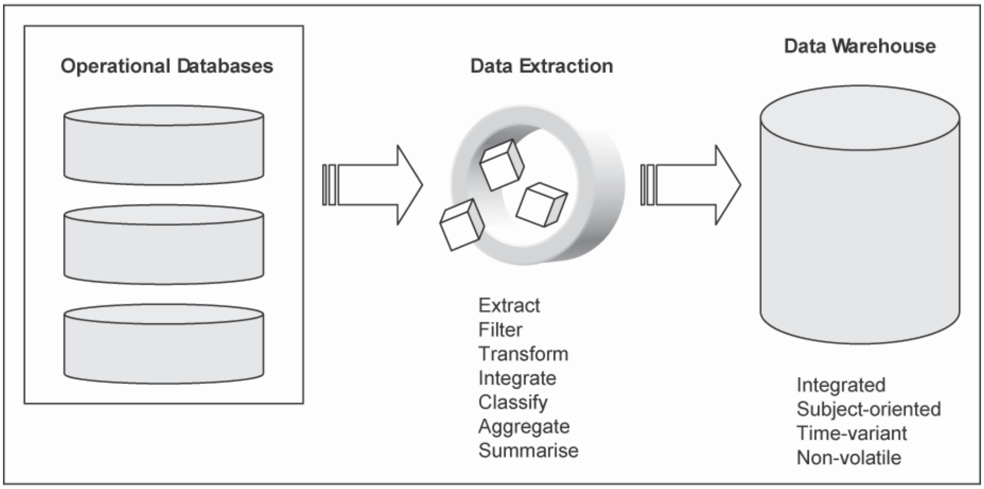

Figure 6.1: Creating a data warehouse from operational databases

ACTIVITY 6.1

Why should a data warehouse store data summary?

SELF-CHECK 6.2

(a) What provides input to the data warehouse? What is the usage of output from the data warehouse?

(b) What must be done to data before loading them into a data warehouse?

(c) What is the function of a directory?

6.3 ANALYSING DATA WAREHOUSE CONTENTS

SELF-CHECK 6.3

Why do we need to collect data? What do we do with the data?

The content of a data warehouse would be useless if users are not able to find answers to their questions. Therefore, there are two approaches that can be used to get insights out of data in data warehouse.

The first approach is user-guided analysis or active analysis. The user asks a question and the computer will find the answer. After getting the answer, the user will ask further until he or she reaches the desired level of insights of the data. As mentioned by Turban et al. (2005), the user drives OLAP.

The second approach is automated analysis or data mining. In contrast to the first approach, computer does all the work. The user tells the computer what he or she wants to find out from the analysis.

Both approaches are explained further in sections 6.3.1 and 6.3.2.

6.3.1 User-guided Analysis: OLAP

(a) **The Concept**

On-line analytical processing (OLAP) refers to the mode of operation where data in the data warehouse are sliced and diced to answer questions.

In other words, after analysing the results of precedent questions, the user looks for more and more details (drilling down) until a required decision have been made.

Pendse (2004) summarised several OLAP definitions and features, including Codd's 12 rules for OLAP into five keywords, Fast Analysis of Shared Multidimensional Information (FASMI). Table 6.4 explains the details of these keywords.

Table 6.4: OLAP Five Keywords (FASMI)

Keywords	Descriptions
Fast	An OLAP system should deliver most responses to users within about five seconds, with the simplest analysis in not more than one second and only a few analyses taking more than 20 seconds. This feature is still a developing technology as speed is the most often cited technical problem with OLAP products (Pendse, 2004). This is due to the fact that databases grow very large. Thus, it is difficult to achieve fast speed especially if users required on-the-fly and ad-hoc calculations.
Analysis	An OLAP system must allow user to do analysis easily. It should be able to handle any business logic and statistical analysis required by the application and the user. Putting it in another way, the user, and the application must be provided with all the necessary analysis features like ad hoc multidimensional structural change, currency translation, exception alerting and many more without having to program. Such analysis features may be provided in the vendor's own tools or in linked external product.
Shared	An OLAP system should be equipped with security controls for confidentiality. It should also has concurrent update locking for handling multiple writes and updates access.
Multidimensional	This is the most important requirement in OLAP system. An OLAP system must allow a multidimensional view of the data. (This feature is further explained in the next section).
Information	Information refers to all of the data and derived information needed, wherever it is and however much is relevant for the application. It is defined in terms of how much input data an OLAP system can handle.

Rob & Coronel (2004) stated four main characteristics of OLAP systems. They are:

(i) **Use Multidimensional Data Analysis Techniques**
This is the most important characteristic of OLAP tools. In this type of analysis, data are processed and viewed as part of a multidimensional structure. Data can be viewed as data that are related to other data. For instance, an analyst of a hotel management would like to see how hotel sales relate to customers' country and month. Figure 6.2 shows how multidimensional differ from one-dimensional.

A. One-dimensional View of Sales

Table INVOICE

INV_NO	INV_DATE	CUS_NAME	COUNTRY_RESIDENCE	INV_TOTAL
101	5 /1/ 2004	Rebecca	United Kingdom	RM1400
102	10/1/2004	David	France	RM900
103	12 /6/ 2004	Tony	Australia	RM1820
104	13 /6/ 2004	Cory	Australia	RM780
105	23 /11/ 2004	Matt	United Kingdom	RM1050

Table INVOICE_LINE

INV_NO	LINE_NO	ROOM_DESC	ROOM_PRICE	NO_OF_DAY	LINE_AMT
101	1	DELUXE	RM280	5	1400
102	1	TWIN	RM180	5	900
103	1	STANDARD	RM200	7	1400
104	1	DELUXE	RM280	10	2800
105	1	DELUXE	RM280	3	840
105	2	DELUXE	RM280	3	840

B. Multidimensional View of Sales

Customer Country Dimension	Month Dimension			Totals
	January	June	November	
United Kingdom	RM1400		RM1050	RM2450
Australia		RM2600		RM2600
France	RM900			RM900
Totals	RM2300	RM2600	RM1050	RM5950

Figure 6.2: One-dimensional view and multidimensional view

In Figure 6.2(A), the tabular view of separate tables does not provide a business perspective of sales data. The multidimensional view in Figure 6.2(B) allows users to combine data at different levels: total sales figure by customers' country of residence and by month. Users can also switch dimensions from sales by customers' country of residence to probably sales by hotel branches, sales by room type, and others.

(ii) **Provide Advanced Database Support**

The features include:

- access to many different kinds of DBMSs, flat files and various data sources;
- access to aggregated data warehouse data and the details in operational databases;
- advanced data navigation features like drill down;
- rapid query response;
- map user requests to appropriate data source and then to appropriate data access language; and
- very large databases support.

(iii) **Provide Easy-to-use End-user Interface**
With easy-to-use interface, all the tools provided in OLAP can be accessed easily. Most of the interface features in OLAP are the ones which are already familiar to users.

(iv) **Support Client/Server Architecture**
In client/server architecture, OLAP system can be divided into several components. All the components can be placed on the same computer or can be distributed among a number of computers.

(b) **Relational OLAP and Multidimensional OLAP**

SELF-CHECK 6.4

Why do you think online analytical processing is being called online analytical processing? What does each of the word in this term contribute to its meaning?

Multidimensional data must be used for OLAP. There are two approaches of how the multidimensional data can be stored and managed, and hence allow user to conduct analysis. The two approaches are relational OLAP and multidimensional OLAP.

(i) **Relational OLAP (ROLAP)**
ROLAP provides OLAP functionality by using relational databases, relational query tools to store and analyse multidimensional data (Rob & Coronel, 2004). The organisations which have been using relational database can easily extend their traditional relational DBMS (RDBMS) with several features like optimise data access language and query performance for multidimensional data and the ability to support very large database.

The relational database contains detailed and summarised data, thus enable users to drill down large data sets. With ROLAP, there is a trade-off between flexibility and performance. Vendors can build portable and scalable tools due to the fact that the implementation of ROLAP uses robust administration tools and open structured query language (SQL) interfaces. However, ROLAP needs a large number of relational tables to handle the huge volume of data and dimensional relations. Tables have to be combined and indexes have to be created to manage and to allow the analysis of multidimensional data. These processes result in degraded performance of ROLAP.

(ii) **Multidimensional OLAP (MOLAP)**

MOLAP provides OLAP functionality by using multidimensional databases. The stored data can be viewed as three dimensional data or also known as a data cube. The data cubes can expand to n-dimensional cubes or hypercubes. Data cubes are static. In other words, they cannot be changed and must be created before they can be used. Queries can only be made on pre-created cubes with defined axes. Once users created an A cube with X, Y and Z dimensions, they can only query on those dimensions. The addition of a new dimension requires users to recreate a new cube. The creation of data cubes is a time consuming process. Due to this fact, MOLAP is best suited to small and medium data sets. This limits MOLAP scalability.

Apart from that, MOLAP is also affected by sparsity (the density of data held in the data cube). As the dimensions of data cubes are predefined, some cells are populated and some cells are empty. Often, less than fifty percent of the data cube's cells are populated (Rob & Coronel, 2004). Therefore, multidimensional databases must handle sparsity effectively to reduce processing overhead and resource requirements.

ACTIVITY 6.2

Can you list the advantages and disadvantages between ROLAP and MOLAP in a table? From the table, what can you conclude about ROLAP and MOLAP?

ACTIVITY 6.3

(a) What kinds of databases can OLAP software use?

(b) Explain ROLAP, and give the reasons you would recommend its use in a relational database environment.

6.3.2 Automated Analysis: Data Mining

SELF-CHECK 6.5

Why do we call this technique as data mining? Is this technique similar to mining activities in the normal mines (coal, tin or mineral mines)?

(a) **The Concept**

Data mining is a process, which extracts information from databases that the user did not know existed (Thearling, 2004).

This process discovers information within data warehouses that queries and reports that cannot be effectively reveal (Turban et al., 2005). Data mining refers to finding pattern in data and inferring rules from the recognised pattern (these patterns can be rules, affinities, correlations, trends or prediction models). In other words, data mining is applied to discover knowledge in databases. Using the data in data warehouses, data mining can provide answers to questions about an organisation that a decision-maker had previously not thought to ask (Marakas, 2003), such as:

(i) Which of our product should be promoted to this customer?

(ii) What is the probability that a certain customer will respond to a planned promotion?

(iii) Which clients are most likely to respond to my next promotional mailing?

(iv) What medical diagnose should be assigned to this patient?

Before exploring deeper into data mining, let us look at the most basic terms in data mining: data and knowledge.

Data are items about things, events, activities and transactions that are recorded, classified and stored, but cannot give any specific meaning.

Example of data is shown in Figure 6.3. This data set presents the values for variables 'Studies', 'Education', 'Work', and 'Income'.

	Studies	Education	Work	Income
1	Poor	SPM	Poor	None
2	Poor	SPM	Good	Low
3	Moderate	SPM	Poor	Low
4	Moderate	Diploma	Poor	Low
5	Poor	SPM	Poor	None
6	Moderate	Diploma	Poor	Low
7	Good	MSC	Good	Medium
.				
.				
99	Poor	SPM	Good	Low
100	Moderate	Diploma	Poor	Low

Figure 6.3: Example of data

Knowledge consists of data items and/or information organised and Processed to convey understanding, experience, accumulated learning and expertise that are applicable to a current problem or activity.

In decision-making, knowledge can be the application of data and information.

In relating both terms of data and knowledge, please refer to Figure 6.3 and Figure 6.4. After mining the data in Figure 6.3, the rules in Figure 6.4 are inferred. Relationships between the four variables, which are 'Studies', 'Education', 'Work' and 'Income', are examples of the 'jewels' that data mining hopes to figure out.

studies(Poor) AND work(Poor) => income(None)

studies(Poor) AND work(Good) => income(Low)

education(Diploma) => income(Low)

education(MSc) => income(Medium) OR income(High)

studies(Mod) => income(Low)

studies(Good) => income(Medium) OR income(High)

education(SPM) AND work(Good) => income(Low)

Figure 6.4: Examples of knowledge (the inferred rules)

In another example, consider a catalogue retailer who needs to decide who should receive information about a new product. The data mining process operates on information contained in a historical database of previous interactions with customers and the features associated with the customers, such as age, postal code and their responses. The data mining software would use this historical information to build a model of customer behaviour. This model could then be used to predict which customers would be likely to respond to the new product. By using this information, a marketing manager can select only the customers who are most likely to respond.

(b) **Data Mining Techniques**

We already gathered all the data in the data warehouse, so how are we going to identify patterns in the data?

There are several techniques to mine the data. Data mining techniques are classified according to the classes of problems they can be applied to or they are able to solve. Each class is supported by a set of algorithmic approaches. The classes are classification, association, clustering, sequencing and regression. In order to allow better understanding of each class of data mining technique, each technique is described with several examples of applications.

(i) **Classification**

Classification is an approach to discover rules that define if an item belongs to a particular subset or class of data.

The technique aims to assign a class as accurately as possible to previously unseen records. This technique works well with categorical data or a mixture of continuous numeric and categorical data. Examples of typical questions of classification are "Which households will likely respond to a forthcoming direct mail campaign?" and "Which insurance claims currently under process are most likely fraudulent?" The following are several examples of applications.

Application 1: Direct Marketing
The goal of application is to reduce cost of mailing by targeting a set of consumers likely to buy a new cell-phone product.

The approach taken to achieve the goal:

- Use the data for a similar product introduced before.
- Identify which customers decided to buy and which decided otherwise. The buy/don't buy decision forms the class attribute.
- Collect various demographic, lifestyle and company-interaction related information about all such customers (for instance, type of business, where they live and how much they earn).
- Use this information as input attributes to learn a classifier model.

Application 2: Fraud Detection
The goal of application is to predict fraudulent cases in credit card transactions. The approach taken to achieve the goal:

Use credit card transactions and the information on its account-holder as attributes (when does a customer buy, what he/she buys and how often he/she pays on time).

- Label past transactions as fraud or fair transactions. This forms the class attribute.
- Learn a model for the class of the transactions.
- Use this model to detect fraud by observing credit card transactions on an account.

Application 3: Customer Attrition/Churn
The goal of this approach is to predict whether a customer is likely to be lost to a competitor. The approach taken to achieve the goal:

- Use detailed record of transactions with each of the past and present customers, to find attributes (for example, how often the customer calls, where he/she calls, what time of day he/she calls most, his financial status and marital status).
- Label the customers as loyal or disloyal.
- Find a model for loyalty.

(ii) **Clustering**

Clustering identifies groups of items that are similar to one another.

In other words, all items in one cluster share a certain characteristic. In contrast to classification technique, this technique can be used when it is difficult to define the characteristics or the parameters of a class. The following are several examples of applications.

Application 1: Market Segmentation
The goal of application is to subdivide a market into distinct subsets of customers where any subset may conceivably be selected as a market target to be reached with a distinct marketing mix.

The approach taken to achieve the goal:

- Collect different attributes of customers based on their geographical and lifestyle related information.
- Find clusters of similar customers.
- Measure the clustering quality by observing buying patterns of customers in same cluster vs. those from different clusters.

Application 2: Document Clustering
The goal of this application is to find groups of documents that are similar to each other based on the important terms appearing in them.

The approach taken to achieve the goal:

- Identify frequently occurring terms in each document.
- Form a similarity measure based on the frequencies of different terms. Use it to cluster.

(iii) **Association**

Association identifies relationships between events that occur at one time.

This technique discovers dependency rules that will predict occurrence of an item based on occurrences of other items. Example outcomes of association technique is "Twenty-nine percent of the time that the brand A blender is sold, the customer also buys a set of kitchen tumblers" and "Eighty-three percent of all records that contain items R, S and T also contain items U and V". The following are several examples of applications.

Application 1: Marketing and Sales Promotion
The goal of this application is to plan strategies of marketing and sales promotion based on the rules discovered.

For example, the rule discovered is *{Bagels................} à {Potato chips}*.

Potato chips as consequent: Can be used to determine what should be done to boost its sales.

Bagels in the antecedent: Can be used to see which products would be affected if the store stops selling bagels.

Bagels in antecedent and Potato chips in consequent: Can be used to see what products should be sold with Bagels to promote sale of Potato chips.

Application 2: Supermarket Shelf Management
The goal of this application is to identify items that are bought together by sufficiently many customers.

The approach taken to achieve the goal:

- Process the point-of-sale data collected with barcode scanners.
- Find dependencies among items.

There is a popular classic rule during Hari Raya where, if a customer buys a butter and flour, then he/she is very likely to buy eggs in order to make biscuits.

Application 3: Inventory Management
Taking a consumer appliance repair company as an example, the goal of this application is to anticipate the nature of repairs on its consumer products and keep the service vehicles equipped with right parts to reduce on number of visits to consumer households.

The approach taken to achieve the goal:

- Process the data on tools and parts required in previous repairs at different consumer locations.
- Discover the co-occurrence patterns.

(iv) **Sequencing**
Sequencing is similar to association technique, except that the relationship occurs over a period of time. Example of application is to predict stock performance, based on a series of preceding events.

In direct mail industry, sequences are analysed as they relate to a specific customer or group of customers. Knowing the sequence of purchases, a catalogue containing specific products can be target mailed to associated customers. For example, when parents rent a movie, they tend to buy the toys associated with a particular movie within two weeks after renting the movie. This sequence suggests that a flyer campaign for promotional toys should be linked to customer lists created as a result of movie rentals.

Other examples include; in point-of-sale transaction sequences:

- Computer Bookstore: (Intro-To_Visual_C) (C++_Primer)(Perl_for_dummies)
- Athletic Apparel Store: (Shoes) (Racket, Racketball)(Sports_Jacket)

(v) **Regression**
Regression is used to map data to a prediction value. This technique takes a numerical data set and develops a mathematical formula that fits the data. To predict a future behaviour, new data is plugged into the developed formula. This technique works well with continuous quantitative data (for example, weight, age or speed). Examples of applications include:

- Predicting sales amounts of new product based on advertising expenditure.

- Predicting wind velocities as a function of temperature, humidity, and air pressure.
- Time series prediction of stock market indices.

(c) **Data Mining Technologies/Algorithms**

We already looked at various techniques to assist in mining the data. Before mining the data, it is appropriate to build mining models. How are we going **to build the mining models**?

There are several data mining technologies that are used to build mining models. The technologies that are covered briefly in this section are statistical analysis, neural networks, genetic algorithms and decision trees. These technologies/algorithms are explained in Table 6.5.

Table 6.5: Data Mining Technologies/Algorithms

Technologies	Descriptions
(i) **Statistical Analysis**	This method includes linear and non-linear regression, point estimation, Bayes's theorem (probability distribution), correlations and cluster analysis. This technology is typically used by association and sequencing.
(ii) **Neural Networks**	This technology works in a manner similar to how neurons of human brain function. It needs to examine a massive amount of historical data to recognise patterns. For example, we can look through large databases to identify potential customers for a new product. This technology is typically used by classification and clustering.
(iii) **Genetic Algorithms**	This technology is an example of machine learning technologies. It is able to derive meaning from complicated and imprecise data. It works on the principle of expansion of possible outcomes. Given a fixed number of possible outcomes, this technology seeks to define new and better solutions. Clustering and association typically use this technology.
(iv) **Decision Trees**	It is a tree-shaped structure that represents sets of decisions (Thearling, 2004). This technology builds predictive model by breaking data sets down into separate, smaller groups. It works from generalised information to increasingly more specific information (Turban et al., 2005). A decision tree contains a root or parent node followed by nodes. Each node is labelled with a question. The arcs associated with each node represent all possible responses or outcomes.

ACTIVITY 6.4

Can you make a comparison table between OLAP and data mining? Compare these techniques by using SWOT (strengths, weaknesses, opportunities and threats) analysis.

ACTIVITY 6.5

(a) What are the different approaches that data mining software uses to find relationships in its data? Describe each approach briefly.

(b) Using the web, identify **FIVE** data mining products from different suppliers. Find out which data mining methods each of them support.

(c) Visit this website to read additional information about data mining.
http://www.thearling.com/text/dsstar/interaction.htm

6.4 DATA VISUALISATION

SELF-CHECK 6.6

We tend to visualise objects to enhance our understanding on the objects. We can visualise how a car looks like, a hand phone, a PC does and so on. How about data? Can we visualise them in physical form?

Based on New Oxford Dictionary of English, visualisation refers to the activity that goes on in the human mind. The result of visualisation is insight and understanding (Spence, 2001). Turban et al. (2005) defines data visualisation as the technologies that support visualisation, and sometimes the interpretation of data and information at several points along data processing chain (refer to the Mind Map of Topic 6).

While data mining extracts information from a database that the user did not know existed, data visualisation translates the extracted information. Data visualisation allows the user to dig into the extracted information until they understand them. It can also be used to look through data in a data warehouse.

The old saying of a picture worth a thousand words must be appreciated. This is due to the fact that human mind can convert pictures or objects into information very quickly. Data visualisation manipulates human visual system by presenting complex data sets through objects. These objects often represent significant insights and conclusions that are not normally discovered without extensive, time-consuming data analysis. Hence, data visualisation technology lets decision-makers use data to make better decisions. To assist human in visualising data, objects will have the characteristics like lighting effects, colour, direction and size of shadow, relative sizes of and distance between objects, curvature, and transparency (Marakas, 2003).

6.4.1 Data Visualisation Tools

We will look at several data visualisation tools and their applications to appreciate data visualisation.

(a) **Newsmap**

Newsmap is originally a product of Cartia, Inc. By using treemaps technology, Newsmap visualises the Google news aggregator's most relevant news, in a topographic map, as shown in Figure 6.5. While glancing through what the world is talking about, this map can also be explored interactively.

Newsmap's objective is to demonstrate visually the relationships between data and the unseen patterns in news media. It divides information into bands. When these bands are presented together, it reveals underlying patterns in news reporting across cultures and within news segments in constant change around the globe (Weskamp, 2003).

Newsmap uses several visual variables to visually code every piece of news (Dürsteler, 2005):

(i) **Colour:** different news sections use different basic colours. For example, green is reserved for technology and blue for business. Most recent news exhibits brighter colours while older ones appear darker.

(ii) **Shape:** each piece of news is shown within a rectangle.

(iii) **Size:** The size of the rectangle is proportional to the relevance of the news.

(iv) Each piece of news is expressed textually as a clearly legible headline, particularly if the news is important and recent. In that case characters are big, since the size of the rectangle allows for it, and the colour is saturated accordingly to the age of the news.

In addition to the above visual variables, Newsmap retains the important quality of data visualisation, focus, and context. In other words, in Newsmap, the user can still view other news (context) while concentrating on news that he or she is interested in (focus). It is also possible to filter the news by country and by its typology.

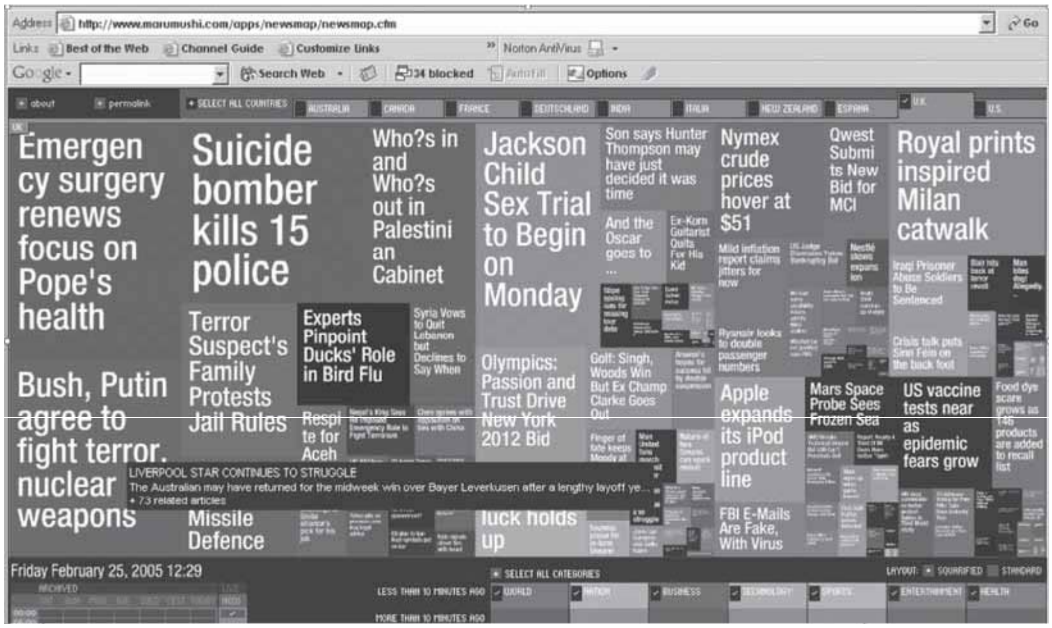

Figure 6.5: Newsmap filtered for United Kingdom, on February 25, 2005

ACTIVITY 6.5

You should try to use the Newsmap by visiting this website.
http://www.marumushi.com/apps/newsmap/index.cfm.

(b) **TableLens**

TableLens is a software development kit (SDK) provided by Inxight. This SDK allows programmers to integrate a patented visual data analysis technique into their software application and web sites.

This technology provides graphical displays of tabular data to represent and to allow the exploration of very large data sets. A graphical representation of over 1000 columns and 65000 rows of data on the same screen enables user to see data trends and relationships among data.

TableLens uses several end-user key features such as:

(i) **Sort** by clicking on columns.

(ii) **Rearrange** columns by drag-and-drop.

(iii) **Promote** columns to create sub-groups.

(iv) **Focus** by clicking on a cell or by clicking and dragging to 'focus' a whole row or multiple rows.

(v) **Filter** sub-sets to create smaller more specific datasets.

(vi) **Spotlight** data (rows/columns) to track particular information as you sort.

Figure 6.6 shows an example of TableLens application. The TableLens represents a data set consisting of 11 columns and over 4000 rows of nutritional data of various foods.

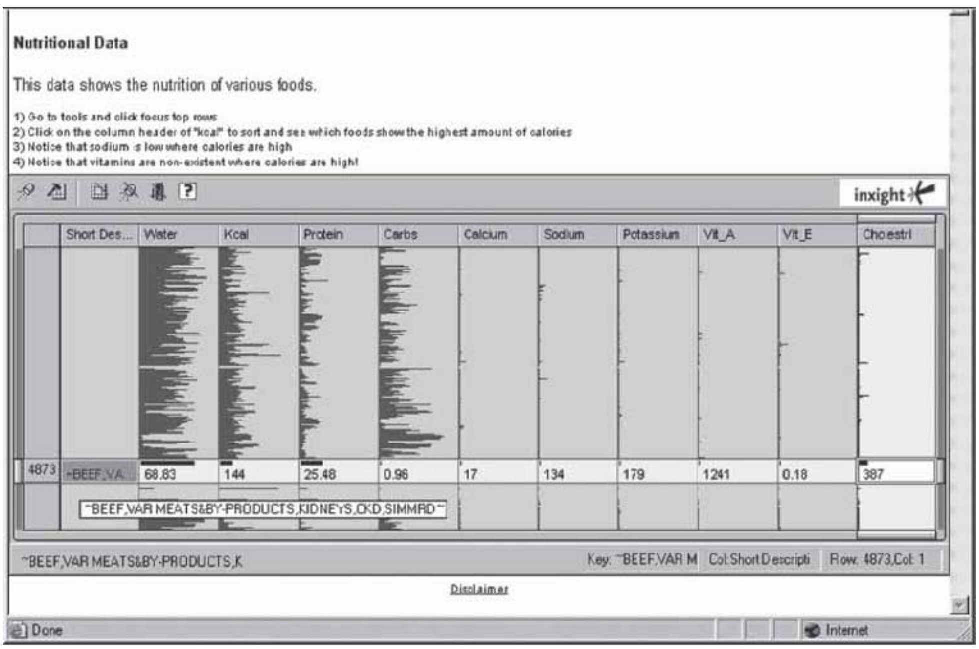

Figure 6.6: TableLens to represent nutritional data

ACTIVITY 6.6

What is the difference between data visualisation and charting?

(c) **AVS Software**

AVS software is a data visualisation software provided by Advanced Visual Systems (AVS). It has an unlimited data visualisation technique.

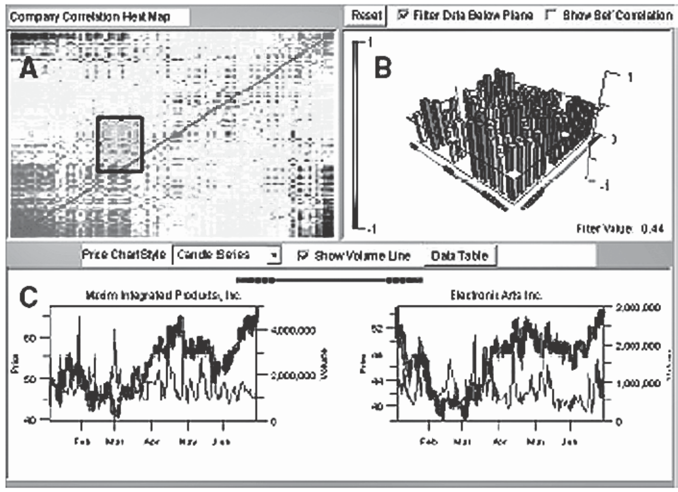

Figure 6.7: Examples of AVS visual analytics

Referring to Figure 6.7(A), 50,000 data points are represented in a heat map. The user can choose a sub-set of data by using a selector. The selected sub-set is then represented in a 3-dimensional bar chart, as in Figure 6.7(B). With a single point-and-click selection, stock charts are displayed. In a few seconds, the user can visually mine a large data set and reach conclusions about the data.

Con Edison, a company which provides a wide range of energy-related products and services, uses a power network monitoring application provided by AVS. The application enables Con Edison to monitor the status of Manhattan power distribution system (from substation to transformers that then deliver power directly to customers) in real time. The application combines information provided from several legacy systems, which in the past have reported information in separate ways. Such integration allows manipulation and utilisation of corporate data in ways that were previously not possible (OpenViz, 2005).

SUMMARY

- Data warehouse is an integrated, subject-oriented, time-variant and non-volatile database that provides support for decision-making. It is developed to satisfy the complex information requirements of decision-makers to make high quality decisions.
- In addition, data warehouse is developed to overcome the flaws in data extracting process from operational databases.
- Several characteristics of data warehouse, as compared to operational database are normalisation of data, area of support, data retention period, data availability and many more.
- Data in data warehouse are then analysed with two basic approaches. The first approach is OLAP, a set of tools for data analysis. Using this approach, the user plays its role actively to understand the data. The second approach is data mining, the process of discovering knowledge in databases. It involves very large data sets.
- Data visualisation is used to understand large data sets by manipulating the ability of human mind to translate pictures or object quickly.

KEY TERMS

Data	Drill Down
Data Extraction	Information
Data Model	Knowledge
Database	Normalisation

SELF-ASSESSMENT 1

Instruction: Please answer all questions in 30 minutes.

1. Define data, information and knowledge. Identify two examples of each. (8 marks)

2. What are the differences between a data warehouse and a database? (5 marks)

3. Describe ROLAP and MOLAP. (6 marks)

4. Define data mining and list its major technologies. (6 marks)

SELF-ASSESSMENT 2

Instruction: Please answer each question in 30 minutes.

1. The issue of data quality is very important to an organisation. Explain why. Provide some of the measures one can take to improve data quality. (4 marks)

2. Discuss the relationship between multiple sources of data, including external data, and the data warehouse. (6 marks)

3. What is a data warehouse, and what are its benefits? (6 marks)

4. Describe the role that a data warehouse can play in DSS. (4 marks)

5. What is OLAP? (2 marks)

6. Describe multidimensionality and explain its potential benefits for DSS. (4 marks)

7. Relate data warehousing to OLAP and data visualisations. (4 marks)

8. Explain the relationship between OLAP and data mining. (3 marks)

9. How does data mining differ from traditional DSS tools? (2 marks)

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Topic 7 ▶ Modelling and Analysis

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Define model and model management in DSS context;
2. Describe and differentiate three types of models;
3. Define static and dynamic analysis;
4. Describe model building and model building life cycle;
5. Explain the roles of influence diagram in modelling process;
6. Explain decision analysis and its approaches namely decision tables and decision trees;
7. Discuss three techniques for DSS modelling and analysis (analytical techniques, blind search and heuristic search); and
8. Explain modelling system.

▶ INTRODUCTION

In the previous topics we have discussed in detail about data-driven DSS which is used to analyse enormous sum of data to find patterns of information that hidden in the data using a special technique or technology like OLAP. However, in certain situations, business decision-making needs a DSS that can facilitate the use of data, models, and structured decision processes in decision-making.

The purpose of this topic is not for the learners to master the topics of modelling, but is engineered towards gaining familiarity with the important concepts of modelling and analysis as they relate to DSS. We walk through some basic concepts of modeling and type of models before discussing the model representation and creation such as influence diagram, decision tree and payoff table. We also will discuss two search techniques used in problem solving.

7.1 MODEL MANAGEMENT

SELF-CHECK 7.1

Why do we have to manage model? What are the reasons?

A model is a formal abstract representation of reality and constitutes an important component of decision support system (Krishnan & Chari, 2000). Taylor (199) defined model as a functional relationship including variables, parameters and equations.

Model (in DSS context) is like a processor that allows DSS to effectively process an input to produce an answer for the user.

Model-driven DSS (MDDSS) relies heavily on certain models to produce or display results to end-users. Therefore, decision models, like stored data, are crucial as an organisational information resource that should be managed effectively.

A model is like a data that must be managed and analyse to maintain their integrity. Model management is concerned with the representation and manipulation of models. However, a model base management system (MBMS) is used to provide (automated) support for various phases of the decision modelling life cycle as a Model-driven DSS may include several types of model, each represents a different part of the decision-making problem. For example, a specific Model-driven DSS may include:

(a) A demand management model such as forecast.

(b) Simulation.

(c) A financial model of a break-even analysis.

(d) An optimisation model such as linear programming.

Some models are standard components in DSS development packages and some must be custom-programmed.

TIPS FOR STUDENTS

Good decision-making and problem solving skills are the keys to developing effective information and decision support systems.

ACTIVITY 7.1

What does standard components and custom-programmed mean? What are their differences?

7.1.1 Types of Models

The representation of management situation can be modelled and viewed in various levels of abstractions (Turban and Aronson, 1998). Therefore, the models can be classified into three groups: iconic, analogue and mathematical.

(a) **Iconic (Scale) Models**

Iconic model is a type of a linear transformation, which transforms the configuration of objects like a physical replica of a system, in different scale from the original objects.

Iconic models may appear in two dimensions or three dimensions. A replica of an F1 car is an example of a three-dimensional iconic model. A photograph of KLCC for example represents a two-dimensional iconic-scale model.

(b) **Analogue Models**

An **analogue model** is a model that represents the behaviour of the system rather than represents the real system itself.

Analogue models are usually two-dimensional charts or diagrams. A blueprint of a building, animations of a cat, a stock-market charts, sales and revenue charts, maps and even an organisation chart of your company are examples of analogue models. An analogue model is not like an iconic model because the shape of an analogue model differs from the real system.

(c) **Mathematical (Quantitative) Models**

A **mathematical model** is an abstract representation of an existing problem situation. It uses mathematical languages to describe the behaviour of a system such as managerial, biological, economic, physics or finance.

This model can be in the form of a graph or chart, but most frequently a DSS model consisting of a set of mathematical relationships. These mathematical or quantitative relationships are made up of numbers and symbols. As an example, consider a chef that cooks and sells pizza. The product (pizza) costs RM6.50 to produce and sells for RM22. A model that can be used by a DSS that computes the total profit that will accrue from the item sold is:

$$\boxed{Y = \text{RM}22x - 6.5x}$$

In this equation, x represents the number of pizzas that are sold, and Y represents the total profit that results from the sale of the product. The symbols x and Y are variables. They are called variable because no set numerical value has been specified for these items. x (number of pizza sold) and Y (Profit), can be any amount. x is an independent variable, because in this case, the number of pizzas sold is not dependent on this equation. However, Y is a dependent variable because profit is dependent on the number of pizzas sold. We will discuss quantitative models more in Topic 8.

7.2 CATEGORIES OF DECISION MODEL

We have learned that a DSS application can be composed of four sub-systems which is data-management sub-system, user interface sub-system, knowledge-base management sub-system and a model management sub-system. A model management sub-system contains routine and special quantitative model like statistical, financial, forecasting and operational research/management science (OR/MS).

The models in the model management sub-system can be classified into four major types; strategic, tactical, operational and analytical model (Turban and Aronson, 1998).

Table 7.1: Types of DSS Model

Type of Models	Supports	Example of Decisions
Strategic	Top Management (CEO, CFO and CIO)	• Planning for mergers and acquisition. • Factory or new branch location selection. • E-business venture. • Non-routine/special budgeting.
Tactical	Middle Management (Example: Manager of a unit or department in a organisation)	• Selecting vendor to service company's server farm. • Sales promotion planning. • Factory layout determination. • Routine (annually) capital budgeting.
Operational	Management That Support The Day-to-day Activities.	• Staff scheduling. • Production scheduling. • Inventory control (Determine the economic order quantities)
Analytical	All Level	• Quality control. • Used to perform some analysis of the data. For example: data mining and management science) Integrated with other models. For example: strategic or tactical.

Despite classification according to the level of organisation, Turban and Aronson (1998) also have classified the DSS models into seven groups according to the representative techniques used. Table 7.2 shows the lists of several representative techniques in each category.

Table 7.2: Categories of Model

Categories	Processes and Objectives	Representative Techniques
Optimisation of Problems with Few Alternatives	Find the best solution from a small number of alternatives.	Decision tables and decision trees.
Optimisation via Algorithm	Find the best solution from a large or an infinite number of alternatives using a step by step improvement process.	Linear and other mathematical programming models and network models.
Optimisation via Analytical Formula	Find the best solution, in one step, using a formula.	Some inventory models.
Simulation	Finding a good enough solution or the best among the alternatives checked by using experimentation.	Several types of simulation.
Heuristics	Find a good enough solution using rules.	Heuristic programming and expert systems.
Other Models	Finding 'what if' using a formula.	Financial modeling and waiting lines.
Predictive Models	Predict future for a given scenario.	Forecasting models and Markov analysis.

Source: Adapted from Turban & Aronson (1998, pg. 148)

Each technique may apply either as a static or dynamic model, which we will discuss further in the following sections. The selection of each model depending on the assumption of the environment being made whether as certainty, uncertainty or risk. Table 7.3 explains the factors of selecting model.

Table 7.3: Factors of Selecting Model

Factors	Descriptions
Decision-making under Certainty	The degree to which we are sure that some result is significant; that is, not due to chance. In this situation, we assumed that complete knowledge is available so the the decision-maker knows the consequences or the outcome of each course of action. Models based on this assumption are easy to work with and can yield optimal solutions. Many financial models are constructed under assumed certainty.
Decision-making under Uncertainty	Uncertainty means doubt: the state of being unsure of something. A condition, event, outcome or circumstance of which the extent, value or consequence is not predictable or estimated. In this kind of situation, several outcomes are possible for each course of action. DSS analysts should attempt to avoid assuming uncertainty because it is very difficult to model that type of situation. We should try to acquire more information so that the problem can be modelled assuming a risk situation. In contrast to decision-making under risk, we cannot estimate or know the probability or chance of occurrence of the possible outcomes.
Decision-making under Risk (Risk Analysis)	Risk is uncertainty concerning loss. Risk is also known as the probabilistic or stochastic decision-making situation. However, we can measure risk. Risk analysis can be performed by calculating the expected value of each alternative and selecting the one with the best expected value. Several techniques can be used to deal with risk analysis. 'What-if' analysis is the primary means of considering risk. As previously noted, 'What-if' analysis is the capability of 'asking' or manipulating a Model- Driven DSS to determine what the effect will be of changing some of the input data or independent variables (Power, 2000).

7.2.1 Static and Dynamic Analysis

As we mentioned before that a model can be classified either a static or dynamic analysis.

Static analysis is a model that represents a single snapshot of a situation in a single interval (Turban & Aronson, 1998).

A static model extracts from the process by which an equilibrium or an optimum might be reached only over time, as well as from the dependence of the variables in the model itself on a changing past or future (Deardof, 2001). It contrasts dynamic model.

> **Dynamic analysis** is a model that is a time dependent model.

A dynamic model uses to evaluate a situation or scenario that change over time. Dynamic models are important because it can show the trends and patterns of demand, production or sales over the time. To be meaningfully dynamic, however, it should include variables and behaviour that, at one time, depend on variables or behaviour of another time. Models may be formulated in discrete time or in continuous time (Deardoff, 2001).

7.3 MODEL BUILDING

DSS development always begins when an individual or group recognise a need for a system that can support the decision-making process. Such individual have a stake in the development of the system. A manager at an airline company, for example, can initiate a DSS development project when he decides that his organisation needs a DSS to summarise and forecast the airline's financial performance. The development team and the manager need to work together to develop the 'model' that will be the 'engine' of the DSS.

A typical modelling process begins with identification of a problem and analysis of the requirements of the situation. This process atempts to answer the question "What is the problem?", "Is it worth solving?" and "What is the scope of the problem domain?" The next step is to identify the variables for the model. The identification of variables and their relationship is very important. This step seeks to answer "Is it appropriate to use a model?", "What variables and the relationships involve?" and "What type of modelling tool should be use?"

Then we start programming to transform the mathematical model into a computer model: a prototype of a model-driven DSS. When the prototype is complete, the model which is being used in the DSS need to be validated, evaluated and managed.

> **Model validation** is the process of comparing a model's output with the actual behavior of the phenomenon that has been modelled.

Validation attempts to answer the question "Have we built the right model?" The modelling life cycle is summarised in Table 7.4.

Table 7.4: Modelling Life Cycle

Tasks in the Modelling Life Cycle		
Tasks	**Goals**	**Mechanisms**
Problem Identification	Clear, precise problem statement.	Argumentation process.
Model Creation	Statement of the model (s) required to mathematically describe the problem.	Formulation. Integration. Model selection and modification (if necessary). Composition.
Model Implementation	Computer executable statement of the model.	Ad-hoc program development. Use of high-level specialised languages. Use of specialised model generator programs.
Model Validation	Feedback from validator.	Symbolic analysis of attributes such as dimensions and units syntax rules.
Model Solution	Feedback from solver.	Solver binding and execution. Solver sequencing and control script execution.
Model Interpretation	Model comprehension. Model debugging. Model results analysis.	Structural analysis. Sensitivity analysis.
Model Maintenance	Revise problem statement and/or model to reflect changes/insight.	Symbolic propagation of structural changes.
Model Versions/ Security	Maintain correct and consistent. Versions of models. Ensure authority to access.	Versioning. Access control methods.

Source: http://www.coba.usf.edu/departments/isds/faculty/hari/model/doc.html

ACTIVITY 7.2

(a) List the tasks in the modelling life cycle.

(b) What are the differences between decision-making under certainty and under risk?

7.4 INFLUENCE DIAGRAM

Usually a manager likes to see results that are easy to understand (with little or no prior experience with computers), easy to use and do not need many clarifications. In order to do this, we need a tool and technique to build models that describe their experience and understanding in decision-making. Therefore, Howard and Matheson (1998) introduced an influence diagram (ID) as formal tools to model decision problems for decision-makers & an analyst. The **flowchart** is graphic representation uses to present a programming flow during analysis and design process.

What is an influence diagram? You may be familiar with a flowchart. Influence diagram is quite similar to flowchat.

Influence diagram is a modelling technique used when you do programming. It is used to map a model's design which is a graphical representation of a model used to assist in model design, development and understanding. While;

There are many kinds of notations of influence diagrams. However, in this section, we only study the convention proposed by Turban et. al., (2004). Table 7.5 explains the notation of ID modelling languages/tools.

Table 7.5: Notation of ID Modelling Languages/Tools

ID Modelling	Descriptions
(a) Certain Influence (b) Uncertain Influence	An arrow denotes an influence. Variables in an influence diagram are connected by an arrow that indicates the direction of influence. The influence arrow means that the value of the influencing variable is set first and is used in determining the level of any variable that it influences. A certain influence show by straight arrow, while uncertain influence shows by a squiggly arrow.

Downpayment	A decision variable is represented by a rectangle. Decision-makers have the power to control other variables.
Tax	The circle notation represents as uncontrollable or intermediate variable. The symbol defines a variable which is uncertain and decision-maker cannot control it directly. For example, tax rate.
Monthly Installment	An oval (or ellipse) signifies an attribute or result variable.

7.4.1 Certainty Influence (Relationship)

An influence diagram has to show the direction of the influence (relationship) between variables with arrows. A straight arrow indicating a certainty influence may apply even if the influencing variable is a random variable. Figure 7.1 demonstrates a situation where a downpayment influences monthly installment, which means that knowing downpayment would directly affect our belief or expectation about the value of monthly installments. Turban et. al (2004) stress that an influence expresses knowledge about relevance and it does not necessarily imply a causal relation, or a flow of material, data, or money. Figure 7.1 also illustrates the type of relationship which is a certainty relationship.

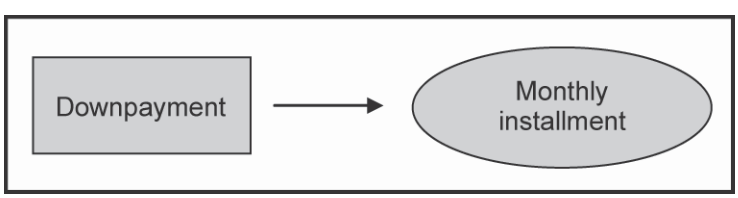


Figure 7.1: Certainty relationship (influence)

7.4.2 Certainty Influence with Random (Risk) Variable

However, there are two situations that students need to understand. We need to differentiate a situation in which all uncertainty in a variable is due to uncertainty in a predecessor variable (no wavy line in the arrow) from one in which a variable known with certainty has an uncertain influence on another (a squiggly arrow). For example, as Figure 7.2 explains a straight line of influence between them indicates that, if the level of Variable Expenses were discovered, revenue would be known too.

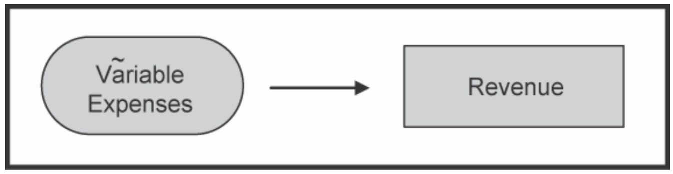


Figure 7.2: Random variable with certain influence

7.4.3 Uncertainty (Risk) Relationship

There are important situations where randomness in a variable is due both to randomness in some influencing variable and an uncertain influence. For example, choosing a price for a new Proton model is a decision variable. However, the effect of one decision on car sales or demand is not certain (Figure 7.3).

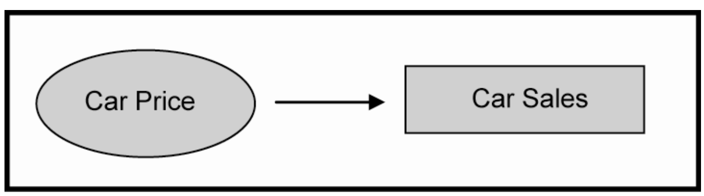


Figure 7.3: Uncertainty relationship

7.4.4 Uncertainty (Risk) Relationship with Random Variables

Figure 7.4: Perodua Myvi
Source: http://star-motoring.com/research/specs.asp?id=439

Figure 7.4 is an example of a business condition where demand for Perodua MyVi may be random and influence car sales. But how many cars could be delivered is still uncertain because even if demand were known with certainty, there would still be additional uncertainty in the number of shipments. For instance, may be it depends on uncertain number of car produced by Perodua which may depend on detailed quality test and inspections. Perhaps one or more cars failed the safety test and definitely will affect the number of car that can be consigned to a sales agent and later to the customer. This would suggest that some variables are related through an uncertain influence (see Figure 7.5).

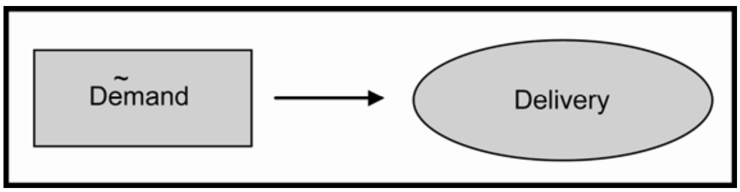


Figure 7.5: Random (risk) variable: place a tilde (~) above the variable's name

Note that in Figure 7.5, the variables 'Demand' and 'Delivery' will be uncertain because influencing variable is random or an influence is random. But we do not mark 'Delivery' with a tilde (~) as tilde's are used only on variables where randomness originates. When you analyse a decision model, you must identify any randomness anywhere along a path of influence leading up to a variable, that variable will be random. After one variable is recognised to be random, and if it influences any other variable in your model, it will results them all to be random.

So far, the influenced relationships that have been described may relate decision variables to intermediate variables or to outcome attributes. They may also relate intermediate variables to outcome attributes or they may simply relate one intermediate variable to another.

A variable in the influence diagram can be binary (0 or 1; True of False), discrete, or continuous. The variable may also be random. Any variable influenced by a random variable is also a random variable. Any random variable will be noted with a tilde (~) above the variable as illustrated at Figure 7.5.

7.4.5 Influence Diagram Examples

An outcome attributes or intermediate variables produced by a set of decision variables may influence other decisions. For example, Figure 7.6 shows an influence diagram having two decisions. You may have decide on the 'Level of Effort' to put into your studies, perhaps to study at least two hours a day after working hours. A resulting outcome attribute is your grades. But grades influence your CGPA and in turn influence the decision made by your education sponsorship whether to transform your education loan status into scholarship. This decision, in future influences your every month remaining cash, as you have to pay back your education loan after graduation if your loan status is not affected by your performance.

Figure 7.6: An attribute may influence other decisions

Figure 7.7 illustrates a two-way dependency between the variables 'Tax Expenses' and 'Product Price'. For example, a business man might use this model to set his product price and the equations might be as follows:

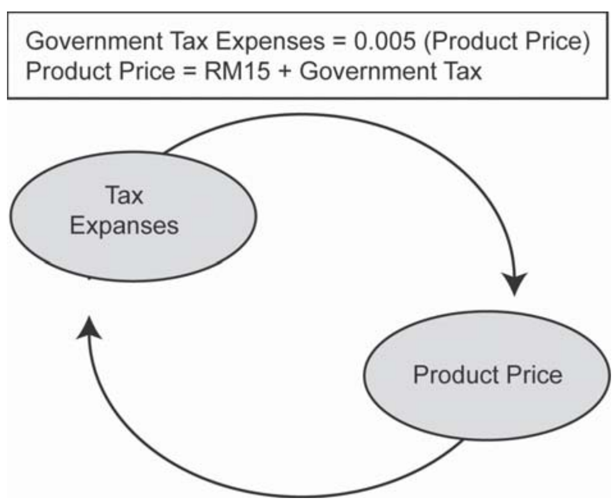


Figure 7.7: Two-way influence diagram

Figure 7.8 shows how decisions about the marketing budget and product price influence expectations about its uncertain market size and market share. These in turns influence costs and revenues, which affect unit sales. Unit sales will then influence the overall.

What we can understand here is the influence denoting a dependency of a variable on the level of another variable? Figure 7.8 shows an influence diagram for selecting a bank to finance your car. By choosing Bank A, the choice made influences the downpayment percentage that influences the downpayment, which in turn influences the buyer's cash position. If a bank insists that a buyer need to pay 15% of the car price which is equivalent to RM100,000.00, a buyer will need to draw RM15,000.00 from his savings. This decision will influence his remaining cash. The decision also influences the percentage rate on the loan. This example has two outcome attributes: the applicant's cash remaining and the actual percentage rate on the loan.

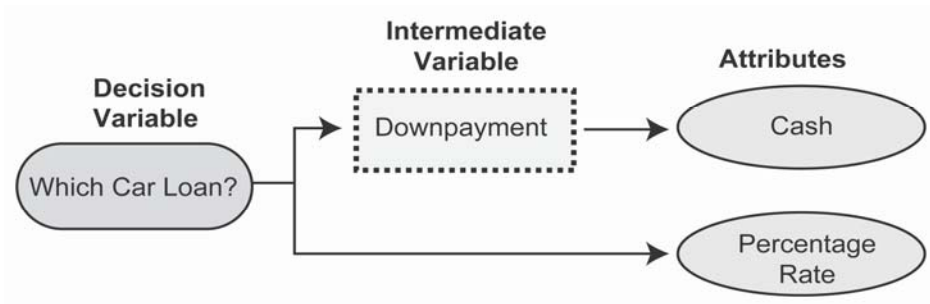


Figure 7.8: 'Which car' loan decision model

ACTIVITY 7.3

How do you present a condition in a flowing chart? What is the difference in presenting a condition in an influence diagram and a flowing chart? Or do we 'read' the influence diagram as we try to understand the flow of a process?

SELF-CHECK 7.2

(a) What is an influence diagram? What is it used for?

(b) What does a straight arrow indicate?

7.5 DECISION ANALYSIS

Complexity in the globalisation and information age, along with information overload, uncertainty and risk, make it necessary to provide a decision-maker a rational decision-making framework. Decision analysis is a popular and important approach to learn. It provides a framework for analysing decision model. The framework provides quantitative support for the decision-makers in all areas including scientists, engineers, systems analyst, financial analysts and experts.

What is decision analysis?

> **Decision analysis** is the discipline of evaluating complex alternatives in terms of values and uncertainty.

Usually, values are expressed monetarily because this is a major concern for any business organisation. The goal of a decision analysis is to give guidance, information, insight and structure to the decision-making process in order to make better, more 'rational' decisions. Any decision-maker must have a number of alternatives and must choose one from them. Decision-makers have to choose the best alternative.

Therefore, we need a tool to represent the alternatives and decision tree and decision table illustrate these situations and add structure to the decision problems.

There are two different approaches in decision analysis: a single goal and multiple goals. In this section, we will study single goal situations by using decision tables and decision trees.

7.5.1 Decision Trees

In this section, we will study a technology known as Decision Trees. Decision tree is a very simple but effective tool to represent the options facing the decision-maker. Decision trees are slightly like a flow chart in that at each node there is a decision to make, having made that decision a particular path is followed which will eventually lead to conclusions. Therefore it is a common tool for building support systems as whitepaper (2000) recognise the extensively use of decision trees as a foundation in building diagnostic aids by a wide range of industries.

In the rest of this section, we will examine what a decision tree is, its structure, how to read it, examine few examples and how it works as well as consider some of the downsides to the decision tree approach. However, for your information, a different type of decision tree also known as classification and regression tree is also being used in data mining which we will not cover in this course as the aim of this section is to give you experience on one of the normative technique in decision-making.

Why decision trees?

According to Whitepaper (2000), **decision trees** are a convenient way of representing and processing classification knowledge.

One of many reasons is a decision tree is easy to develop and understand by the decision-maker. Even a person who has not seen a decision tree before can understand or interpret the decision trees by examining or trace one option (nodes) benefit or loss by working out the total profit for each of the paths from the initial node to the terminal node.

7.5.2 Decision Tree Example: KTM

Figure 7.9: KTMB
Source: http://www.ktmb.com.my/

Figure 7.9 portrays a management situation where a decision has to be made: If a number of KTM locomotives have worn out, should KTM rebuild the locomotive's engine, or perhaps just do nothing to the locomotive or just replace the locomotive with a new one?

As we can see, the KTM decision problem is represented by a typical decision tree possess a single root or node, a set of branches from that node, interior nodes that also have branches and terminal nodes which present the classification information. Each node within the tree represents a decision point that determines which subsequent branch is followed.

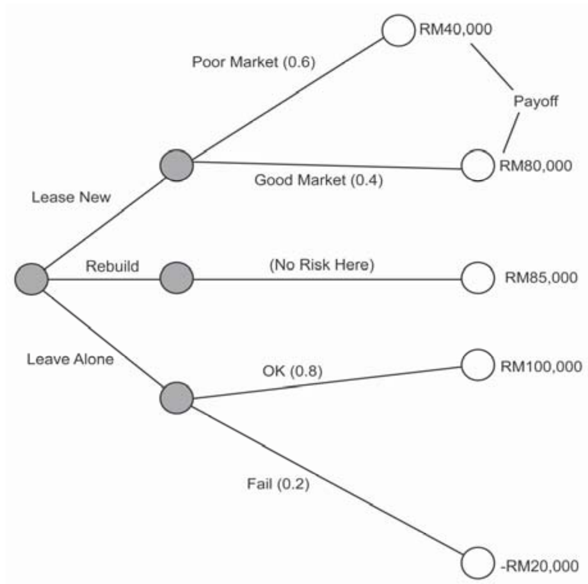


Figure 7.10: Decision tree for locomotive decision

Figure 7.10 has two levels. The first represents the management decision. The second represents the possible outcomes, sometimes called states of nature, which can result from choosing each of the options at the first level. A decision tree may have more than two levels but will always have an even number of them. It always starts with a decision, the two types of nodes always alternate and states of nature are always at the ends of the branches (at the 'leaf nodes').

Again, should KTM rebuild a locomotive's worn out engine, leave it as is, or replace the locomotive? Before we process the decision tree, you must know how to read the decision tree. To 'read' or understand the tree you must start from the tree's root (first node). Then follow each link (path or branch) until you reach a decision point. At each decision point, try to answer the question posed. For example, "Should we lease a new locomotive?" If your answer (pretend to be the decision-maker) is "Yes" then we should follow the 'Yes' branch to the next node.

If the answer is "No", then we should follow the 'No' branch to the next node or consider the next question: "Should we rebuild a new one?" If the next node is a leaf node then it would contain the classification information, for example, 'Poor market' or 'Good Market', 'No Risk', 'Ok' or 'Fail'. Otherwise, you should repeat the above steps until you do reach a leaf node.

Let us go back to the KTM management problem.

A new locomotive will cost KTM RM350,000 to lease for two years but it will enable KTM to earn RM430, 000 profits during the two years because it will be faster and more economical to operate than our present one. Therefore, profit minus the cost, KTM net profit would be only RM80K. However, KTM has 60% probability of downturn cause by turmoil in the global economies which may cause KTM to lose 50% of the profit. Hence, if the economy is poor then KTM profit would be (RM80K × 0.5 = RM40K).

Rebuilding the locomotive's engine will cost KTM RM100,000 but in return, this decision ensures a RM185,000 operating profit. So KTM net profit would be RM85,000 (185K – 100K = 85K as KTM loses a potential RM100,000 in profits because the KTM has to leave that locomotive off the railway to have its engine rebuilt.)

Do nothing and leave the worn locomotive alone will incur no costs to KTM. This decision will enable KTM to make a profit of $100,000 as there are 80 percent chances of everything being fine (no engine breakdown) for two years. However, if there is 80% of good fortune it means there will be 20 percent chance of incurring a $20,000 loss due to unexpected breakdown or failure railway systems.

Remember, we may know the exact cost of rebuilding an engine, but the profit the locomotive will earn is just an educated guess. The actual profit will depend on many factors such as cost of labor and fuel.

The decision tree allows us to evaluate the probable payoff of each option. The probable payoff of rebuilding the engine is RM85,000, in that we have assumed that no chance misfortunes can befall that choice. The probable payoff of letting nature take its course with the engine is (0.8 × $100,000) + (0.2 × ($20,000)) = RM76,000. A similar calculation, working back from the end nodes and their probabilities, shows that the probable pay off of leasing a new locomotive is RM56,000. Accordingly, a rational manager will decide to rebuild the locomotive engine because the probable payoff is the highest among the options.

As can be seen from this KTM's locomotive example, apparently this example is very simple as it is intended for introduction purposes only. A real management problem would need to allow for a wider range of question fashion, including questions that took a numeric value, allowed for a range of options or allowed a level of belief to be supplied. For example, the tree might contain questions such as "What is the maximum number of locomotive that can be leased?", "What is the maximum price KTM would like to pay for a new locomotive?" or "How enthusiastic are you to finish your work before the deadline"?

7.5.3 Payoff Table

Decision analysis is a process that enables decision-maker to understand the nature of the situation, and the risks and allows the decision-maker to decide at least and at most one option from a set of possible decision alternatives. The elements of decision analysis problems are:

(a) Only one person is designated as the decision-maker. For example, the CEO, COO or manager of a company.

(b) A finite number of possible (future) events are called the 'States of Nature' (a set of possible scenarios).

(c) A finite number of possible decision alternatives (for example, actions) are available to the decision-maker.

(d) Payoff (return or outcome of a decision) is an element whereby different combinations of decisions and states of nature (uncertainty) generate different payoffs. Payoffs are usually shown in tables. In decision analysis payoff is represented by positive (+) value for 'net revenue', 'income', or 'profit' and negative (—) value for 'expense', 'cost' or 'net loss'.

Analysts have to be extra careful because it is not easy to construct the matrix. Common errors in a decision analysis are (Arsham, 2005):

(a) false assumptions;

(b) not having an accurate estimation of the probabilities;

(c) relying on expectations;

(d) difficulties in measuring the utility function; and

(e) forecast errors.

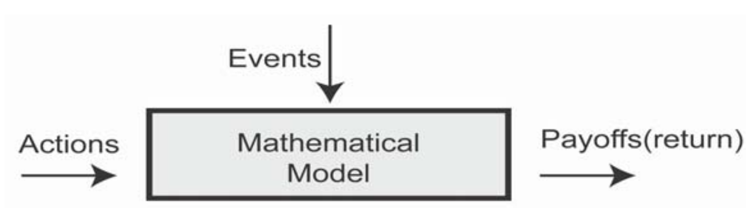


Figure 7.11: Components of probabilistic models

Consider the following Investment Decision-making Example:

The Cik Wan *Kuih*

Figure 7.12: Cik Wan's kuih stall
Source: http://umami.typepad.com/umami/2004/10/berbuka_puasa.html

ACTIVITY 7.4

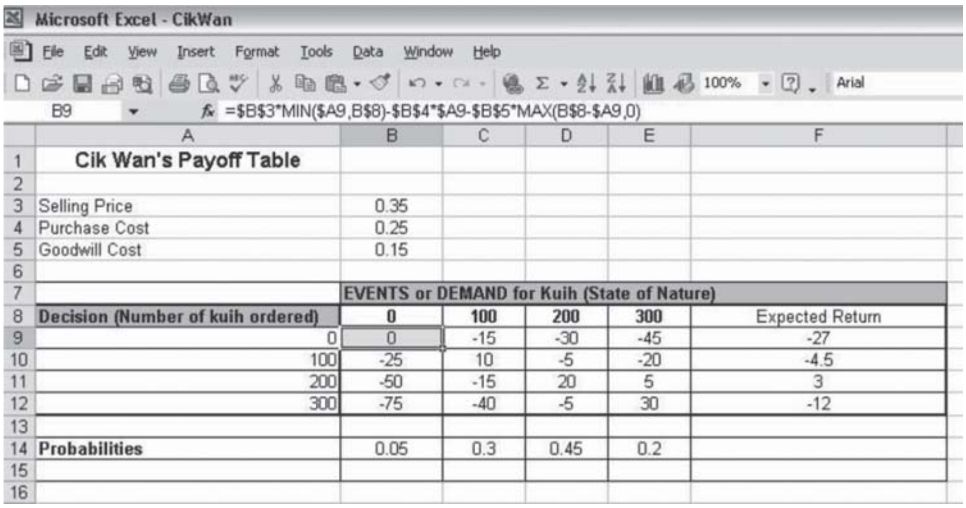
You can download Cik Wan.xls from the OUM website in your myLMS portal to do this exercise.

Cik Wan can buy *kuih* or baked cakes from her supplier (her neighbouring friends) for 25 cents each and sell them for 35 cents. However, she must buy the *kuih muih* before she knows how many she can actually sell. If Cik Wan buys more than she can sell, she can return the *kuih* to its supplier at no additional cost. But if she does not buy enough *kuih*, she loses potential to make profit and perhaps in future, losing her loyal customers. The loss of future customer causes a cost of goodwill of 20 cents per disappointed customer. For this example and ease of computation, we suppose that demand distribution for Cik Wan's *kuih* is:

$$P_0 = Prob\ \{demand = 0\} = 0.05$$
$$P_1 = Prob\ \{demand = 100\} = 0.3$$
$$P_2 = Prob\ \{demand = 200\} = 0.45$$
$$P_3 = Prob\ \{demand = 300\} = 0.2$$

In Cik Wan's model, each of the four different values for demand is a different event (state of nature), and the number of *kuih* ordered is the decision. The return (payoffs), for Cik Wan's model is shown in Figure 7.13.

Payoff = 0.35 (number of *kuih* sold) – 0.25 (number of *kuih* ordered) – 0.15 (unmet demand)



	A	B	C	D	E	F
1	Cik Wan's Payoff Table					
2						
3	Selling Price	0.35				
4	Purchase Cost	0.25				
5	Goodwill Cost	0.15				
6						
7		EVENTS or DEMAND for Kuih (State of Nature)				
8	Decision (Number of kuih ordered)	0	100	200	300	Expected Return
9	0	0	-15	-30	-45	-27
10	100	-25	10	-5	-20	-4.5
11	200	-50	-15	20	5	3
12	300	-75	-40	-5	30	-12
13						
14	Probabilities	0.05	0.3	0.45	0.2	
15						
16						

Figure 7.13: Payoff table for Cik Wan (cikwan.xls)

The entries in Cik Wan's table represent the cash flow associated with demand (event), number of *kuih* ordered and cost of goodwill. Remember that sales (number of *kuih* sold) is the minimum of two quantities. For example in cell D10, even the demand for *kuih* is 200 but Cik Wan only ordered 100 *kuih*. Therefore, the number of *kuih* sold is not 200, but 100 *kuih*. If no *kuih* are ordered, then no *kuih* can be sold, and the unmet demand will equal the demand. For example, in cell E11:

Number of ordered	=	200
Number of demand	=	300, hence
Number of *kuih* sold	=	200 and
Number of unmet demand is 300 – 200 therefore	=	100,

Payoff = 0.35(200) – 0.25 (200) – 0.15 (100)
Cell E11 Payoff = RM70 – RM50 – RM15
Cell E11 Payoff = RM5.00 per day.

Once all the data are assembled as in Figure 7.13, we need to calculate the expected return (ER) for each decision (or alternative) which is ER1 ER2 ER3 ER4. We will first demonstrate this process manually and then we will discuss how to do it in a spreadsheet.

For example, if Cik Wan orders 200 *kuih*:

ER2 = (–50 (0.05)) + (–15 (0.3)) + (20 (0.45) + (5 (0.2))
ER2 = –2.5 + (–4.5) + 9 + 1
ER2 = 3

Based on the spreadsheet results, ER2 is the largest of these four values, therefore the optimal decision is to order *200 kuih* from her neighbours.

Please develop Cik Wan Payoff table similar to Figure 7.13 or you can download the Excel file from OUM's website. If you want to try it at your computer, please type this formula in cell B9.

```
=$B$3*MIN($A9,B$8)-$B$4*$A9-$B$5*MAX(B$8-$A9,0)
```

Now please copy cell B9 and then highlight (click and drag) from cell B9 to E12, and click the right button on your mouse, a pop up menu window will appear, and click paste. Now enter the next formula in cell F9 and then copy cell F9 and paste to cell F10 until F12.

```
=SUMPRODUCT(B9:E9,$B$14:$E$14)
```

Now we can see that ER2 has a high probability (0.45) of generating the second highest payoff of all which is RM20.00 a day. This section provided the basic theoretical foundation on which the rest of the decision analysis is based. We have discussed that a decision model can be described by a payoff table in which the return (payoff) to the decision-maker depends on the decision selected and the event or demand (state of nature) that subsequently occurs.

7.5.4 Decision Table

ACTIVITY 7.5

Your father is interested in one goal: maximising the yield of his investment. He asks you for advice. The problem is to select one best investment alternative. How do you convey your message or ideas to your father? How do you visualise the risk and uncertainties to your father?

Turban et. al. (2004) describe decision tables as a convenient way to organize information in a systematic manner. So decision table is a table which is used to model complicated logic. Decision table is like the control structures that you have learned in programming courses like **if-then-else** and **switch-case** statements (conditions with actions to perform). But unlike control structures, decision tables can associate many independent conditions with several actions in a simpler manner.

You need to build a DSS to help end-user diagnose their printer problems on-line. Therefore, you interview a computer technician (expert) to get information and rules on how to diagnose printer problems based upon his vast experience or heuristics. Then you realise that this kind of decision situation is simple because the **condition alternatives** are simple True or False (Boolean) values, and the **action entries** could be just check-marks or Y/N, representing which of the actions in a given column are to be performed. Table 7.6 shows an example of decision table for printer troubleshooter.

Table 7.6: Printer Troubleshooter Decision Table

Printer Troubleshooter									
Conditions	My document does not print at all.	Y	Y	Y	Y	N	N	N	N
	Printing is unusually slow.	–	–	–	N	Y	Y	N	N
	Fonts are missing or do not look the same as they do on the screen.	–	–	–	N	Y	N	Y	N
Actions	Check the power cable (on/of switch)				X				
	Check or change the printer-computer cable				X	X	X		
	Ensure printer driver is installed and not corrupted				X	X	X	X	
	Check/replace laser jet powder cartridge					X			
	Check for paper jam				X				

Printer troubleshooter is just a simple decision-making situation but what we can learn from this example is the organisation of rules in tabular form. As you can see, we put a hyphen ('do not care' symbol) at column 1, 2 and 3. Why? Because we want to simplify the table; look condition number 1; if a printer is failing to print at all, logically condition number 2 and 3 do not matter at all. Later we can delete column 1, 2 & 3. If we represent conditions with simpler code you can imagine how easy the program of this control structure will look like:

```
IF
                    My printing is unusually slow
          THEN
                    Check or change the printer-computer cable
          ELSE
                    Ensure printer driver is installed and not corrupted
END IF.
```

ACTIVITY 7.6

(a) What is a decision table?

(b) What will you do when you start your car or motorcycle? Develop a decision table to illustrate your steps in solving your car problem. If you know nothing about car/motorcycle engine, get help from the experts or from the net.

7.6 PROBLEM SOLVING METHODS

ACTIVITY 7.7

We often face problems in our daily life, ranging from simple to difficult problems. How do you solve your problems? For example, when doing your assignment that needs to be submitted in just two days. How do you handle this kind of problem?

In this section we will be looking at very general techniques that are important throughout DSS modelling and analysis. In particular, we will look at how we can use search techniques to find a solution to a problem. The general idea is that if you know the available actions that you could take to solve your problem, but do not know which ones will get you to a solution; you can search through all the possibilities to find one that will give you a solution. In artificial intelligence, the term 'problem solving' is given to the analysis of how computers can be made to find solutions in well-circumscribed domains. The process is quite similar when a decision-maker tries to 'solve a problem', the process involves a search for an appropriate course of action (among the alternatives or options founded) that can solve the problem. Many of these problems, possibly expressed in terms of trying to get from 'initial state' (for example: unsolved problem and decision-situation) to a 'target state' (for example: solved problem and decision made). As an analyst, we have to search through all possible actions that could be taken to find a sequence of action that can solve a problem. The definitions for these states are explained in Figure 7.14.

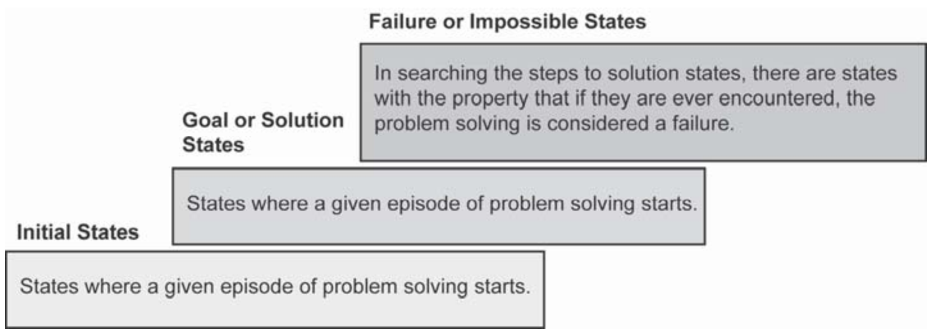


Figure 7.14: Three states of problem solving

Generally, there are three search approaches that can be used for searching, depending on the type of problem (to solve) and the type of modelling approach. The three approaches are:

(a) Optimisation or Analytical Technique.

(b) Blind Search.

(c) Heuristic Search.

7.6.1 Analytical Techniques

Analytical techniques use mathematical formulas to find an optimal solution to predict a result.

> **Analytical techniques** are techniques being used mainly for solving structured problem such as estimation, forecasting, time-series analysis and modelling.

Estimation, forecasting and time-series analysis are usually based on linear regression techniques. EIS/DSS tools that support modelling generally provide estimation, simulation and forecasting techniques that operate on nonlinear variables. Forecasting and time-series analysis differs from simpler estimation techniques in that with the former, future trends are predicted based on existing historical data. When the problem is not structured (more complex), blind or heuristic search approaches are employed. We will discuss more on analytical techniques in Topic 8.

7.6.2 Blind Search

SELF-CHECK 7.3

Why does this search being called blind search? What is the significant of its name?

A **blind search** (also called an **uninformed search**) is a search that has no information about its domain.

The only thing that a blind search can do is distinguish a non-goal state from a goal state. In this section, we examine the simplest search technique known as breadth-first search (Figure 7.15).

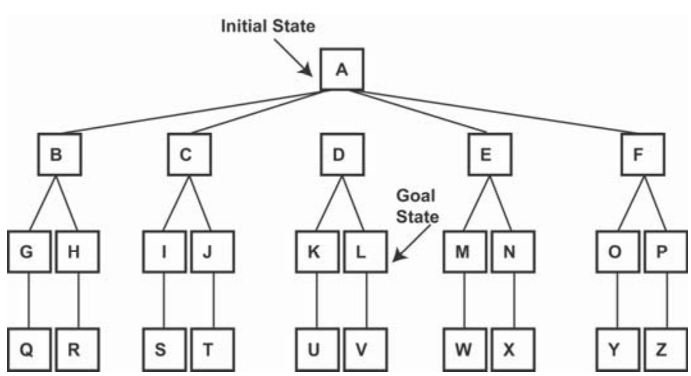


Figure 7.15: Breadth-first search

The algorithm of breadth-first search (BFS) involves using a queue for searching.

A **queue** is a list where nodes are always added to the end of the list but removed from the front.

At the beginning, the queue of BFS contains just the initial state which is A. BFS search involves repeatedly taking the first node of the queue, finding that node's successor and putting them on the end of the queue. This continues until either the first node on the queue is the goal or target state (in this case is L) or the queue is empty. If the BFS algorithm finds the target state, the algorithm will return a signal of success (for example: return TRUE or 1). Otherwise the search will fail.

In our example (Figure 7.15), initially the queue is empty; as stated in the first row of Table 7.7.

Table 7.7: Searching for Goal State using BFS

Step	Size of Queue	Queue (List)	Nodes Expand	Status	Current Level
0	0	Empty	0	n/a	n/a
1	1	A	0	n/a	0
2	1	A	0	Expanding & removing A from the queue. The revealed nodes (B, C, D, E and F) are added to the end of the queue.	0
3	5	B, C, D, E, F	1	Node B is expanded then removed from the queue. The revealed nodes (G, H) are added to the end of the queue. Then backtracking to expand node C.	1
4	6	C, D, E, F, G, H	2	Node C is expanded then removed from the queue. The revealed nodes (I, J) are added to the end of the queue. Then backtracking to expand node D.	1
5	7	D, E, F, G, H, I, J	3	Node D is expanded then removed from the queue. The revealed nodes (K, L) are added to the end of the queue. Then backtracking to expand node E.	1
6	8	E, F, G, H, I, J, K, L	4	Node E is expanded then removed from the queue. The revealed nodes (M, N) are added to the end of the queue. Then backtracking to expand node F.	1

7	9	F, G, H, I, J, K, L, M, N	5	Node F is expanded then removed from the queue. The revealed nodes (O, P) are added to the end of the queue. Then backtracking to expand node G.	1
8	10	G, H, I, J, K, L, M, N, O, P	6	Node G is expanded then removed from the queue. The revealed nodes (Q) are added to the end of the queue. Then backtracking to expand node H.	1
9	10	H, I, J, K, L, M, N, O, P, Q	7	Node H is expanded then removed from the queue. The revealed node (R) is added to the end of the queue. Then backtracking to expand node I.	2
10	10	I, J, K, L, M, N, O, P, Q, R	8	Node I is expanded then removed from the queue. The revealed node (S) is added to the end of the queue. Then backtracking to expand node J.	2
11	10	J, K, L, M, N, O, P, Q, R, S	9	Node J is expanded then removed from the queue. The revealed node (T) is added to the end of the queue. Then backtracking to expand node K.	2
12	10	K, L, M, N, O, P, Q, R, S, T	10	Node K is expanded then removed from the queue. The revealed node (U) is added to the end of the queue. Then backtracking to expand node L.	2
13	Empty	Find L and then empty the queue.		Node L is located and the search returns a solution.	2

The algorithm can be stated more formally as follows:

```
1.   Start with queue = [initial-state] and found=FALSE.
2.   While queue is not empty and not found do:
          a.   Remove the first node N from queue.
          b.   If N is a goal state then found= TRUE.
          c.   Find all the revealed successor nodes of X,
               and put them on the end of the queue.
```

From the example, we can conclude that blind search techniques are arbitrary search that are not guided. This kind of search approaches are not suitable or practical for solving complex and larger problems because too many solutions (path, route or alternatives) must be examined before the target goal (solution) is found.

SELF-CHECK 7.4

(a) What is a decision tree?

(b) Explain the differences between static and dynamic models. How can one evolve into the other?

7.6.3 Heuristic Search

Heuristic search algorithm or programming is a branch of artificial intelligence, which uses **heuristics** (common-sense rules drawn from experience to solve problems).

This is in contrast to algorithmic programming or blind search approaches, which is based on mathematically procedures. Heuristic programming is characterised by programs that are self-learning; they get better with experience. Heuristic programs do not always reach the very best result but usually produce a good result. Many expert systems use heuristic programming. We can define heuristic search as the process of solving problems by evaluating each step in the progress, searching for satisfactory solutions rather than optimal solutions. It comprises a form of problem solving where the results are determined by experience or intuition instead of by optimisation.

However, heuristic search algorithm (also known as informed search methods) such as best-first search and hill-climbing search are best when it is important to find a solution fast, and not necessarily to find the best solution. As we have seen, breadth-first search, although slow, is guaranteed to find a solution with the smallest possible number of operators. Figure 7.16 shows a heuristic search with a goal state is to reach G.

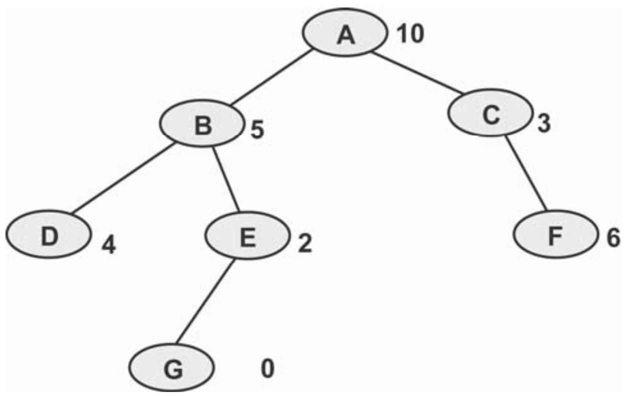


Figure 7.16: Goal state is G

The basic algorithm is as follows:

```
Best-First-Search [Nodes]
    IF there are no more nodes THEN FAIL
    ThisNode <— Most-Promising(Nodes)
    IF ThisNode is the goal
        THEN return ThisNode
        ELSE
        ChildNodes <— Children(ThisNode)
        Best-First-Search
            Append-to-Front
                ChildNodes
                Remove-Node(ThisNode Nodes))
```

Let us examine among the simplest heuristic search technique known as best-first search. We have the search tree in Figure 7.10. Links between nodes shows possible successor states. Node C with number 3 means that the node name is A and it has an estimated cost to solution of 3 (the lower the better). In our example, the goal state is G and the initial state is of course A with an estimated cost to solution of 10.

If we searched G with breadth-first search for example, the nodes would search in the following order: A, B, C, D, E, F and G. If we use the best-first search (search the node with the lowest cost first) then the order would be: A, C, B, E and G. Now we understand that, the algorithm has information which is finding a node with the lowest cost. From A (the 0 level), it scans the 1 level and choose node C (because $3 < 5$). However, the successor of node C is not G. Therefore, it moves to node B and searches the most promising node at the second level of the tree and finds that E has a smaller cost than D. So it moves to E and later finds G.

What we can conclude from this simple example is best first search drastically cut the amount of search. Actually, best first search is a combination of depth first and breadth first searches. Depth first is good because a solution can be found without computing all nodes and breadth first is good because it does not get trapped in dead ends. The best first search allows us to switch between paths thus gaining the benefit of both approaches. At each step the most promising node is chosen. If one of the nodes chosen generates nodes that are less promising it is possible to choose another at the same level and in effect the search changes from depth to breadth.

So far we have discussed two examples of search algorithm but not how they are used in solving real problems. This section is just an introduction to search algorithm as a problem solving approach. Search techniques are used to find a sequence of actions that will get us the solution to our problem. There are many other search techniques that can be used to solve problems such as hill-climbing, A*, recursive best first search, iterative deepening A*, simplified memory-bounded A*, simulated-annealing and so on.

ACTIVITY 7.8

Make a table of comparison between blind search and heuristic search. Compare between their definitions, objectives, algorithms, advantages and disadvantages.

SELF-CHECK 7.5

(a) Define heuristics?

(b) What is the role of heuristics in modelling?

7.7 MODELLING SYSTEM

A **modelling system** is a computer system that accepts a user requirement model, translates it into a form acceptable to a solver, invokes the solver and translates the output of the solver back into a form that can be interpreted by the modeller (Kin, 2004).

For example, AIMMS developed by Paragon Decision Technology is a development environment for building optimisation based decision support applications and advanced planning systems. The AIMMS development environments allow users to build and maintain decision support applications and advanced planning systems efficiently than conventional programming tools. Figure 7.17 provides a top-level overview of the components available in AIMMS.

Numerous modelling languages such as AMPL (http://www.ampl.com/) and General Algebraic Modelling (GAMS) (http://www.gams.com/) are now commercially available. AMPL is a computer language for describing production, distribution, blending, scheduling and many other kinds of problems known generally as large-scale optimization or mathematical programming while the General Algebraic Modelling System (GAMS) is specifically designed for modelling linear, nonlinear and mixed integer optimisation problems.

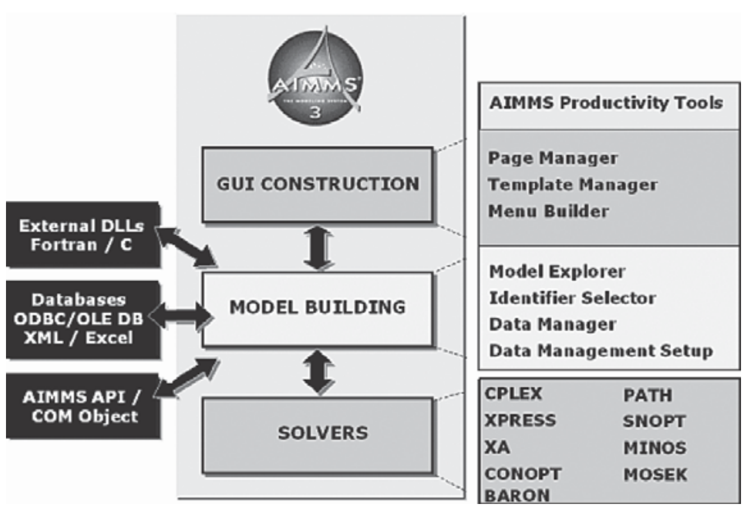


Figure 7.17: Components of AIMMS
Source: http://www.aimms.com/aimms/index.cgi

ACTIVITY 7.9

Visit this website to read more about AIMS.
http://www.aimms.com/aimms/.

SUMMARY

- A model is a formal abstract representation of reality and constitutes an important component of decision support system.
- A model is used in DSS as a prototype or a replacement of a complex situation.
- DSS uses models such as forecasting, simulations, portfolio analysis and many other operational research/management sciences (OR/MS) models to help decision-makers evaluate situations by using different sets of values.
- A major characteristic of decision support systems is the inclusion of at least one model.
- All DSS models are fabricated of three variables which are decision variables, uncontrollable variables, and result (outcome) variables.
- We also have been exposed to the influence diagram; a technique as a formalism to build models that describes decision-makers experience and understanding in decision-making. An influence diagram has the capability to express the manager's beliefs and fit the manager's cognitive style.
- An addition to the influence diagram is an approach called decision analysis to model a problem.
- Decision analysis is different compared to influence diagram which we identify and describe the relationship (influence) between a number of variables or parameters in one particular decision problem.
- A decision tree is a very simple but effective tool in decision analysis used to represent the options the decision-maker faces. Decision trees are slightly like a flow chart in that at each node there is a decision to make. Having made that decision, a particular path is followed which will eventually lead to conclusions.
- Another approach to audit control logic in decision analysis is having a decision table. Decision tables demand us as DSS analyst to think of all possible conditions. With traditional control structures, it is easy to forget about corner cases, especially when the else statement is optional. Since logic is so important to programming, decision tables are an excellent tool for designing control logic.

KEY TERMS

Decision Support	Modelling Language
Management Science	Parameter
Model	Physical Model
Model Base	Problem

SELF-ASSESSMENT 1

Instruction: Answer all questions in 25 minutes.

1. What is a model base management system? (5 marks)

2. Explain why solving problems under uncertainty sometimes involves assuming that the problem is to be solved under conditions of risk. (5 marks)

3. Explain the differences between static and dynamic models. How can one evolve into the other? (5 marks)

4. Explain why an influence diagram can be viewed as a model of a model. (5 marks)

SELF-ASSESSMENT 2

Instruction: Answer all questions in 30 minutes.

1. What is the difference between decision analysis with a single goal and decision analysis with multiple goals (criteria)? (4 marks)

2. Given the following search tree (Figure 1.0), state the order which the nodes will be searched for best first search until a solution (goal state of L) is reached. The numbers on the nodes indicate the estimated cost to solution.

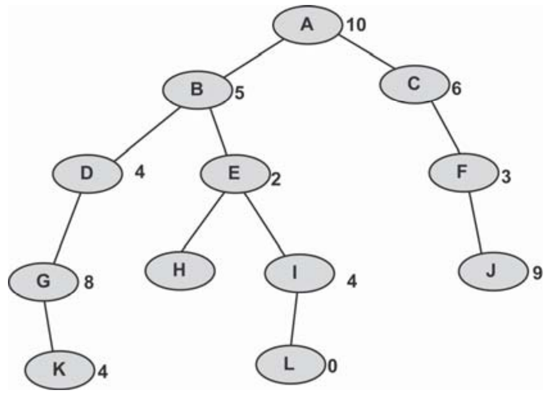


Figure 1.0: Search tree

(8 marks)

3. Given the following search tree (Figure 1.0), state the order which the nodes will be searched for breadth-first search until a solution (goal state of L) is reached. (5 marks)

4. Explain the difference between Analytical Technique and Search Technique? (3 marks)

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Topic 8 ▶ Quantitative Analysis and Modelling

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Explain basic foundations of decision science;
2. Describe mathematical model; its role, classification and components;
3. Explain when does sensitivity analysis is conducted and describe two types of sensitivity analysis;
4. Analyse break even point as deterministic model and apply spreadsheet to facilitate mathematical analysis model;
5. Describe queuing management in stochastic model and its characteristics;
6. Describe simulation and monte carlo simulation;
7. Discuss six forecasting method and its categories in demand management; and
8. Explain mathematical modelling advantages.

▶ INTRODUCTION

Turban & Aronson (2001) asserts that one of the major characteristics of a DSS is the inclusion of at least one model. Mathematical and analytical models are the dominant component in a Model-Driven DSS (MDSS) because models are used by the decision-maker to understand the nature of the problem. A decision-maker can perform test and analysis on a model of reality rather than on the real system/world.

In general, model-driven DSS usually use mathematical model such as businesses, finance, simulation, optimisation or multi-criteria models to provide decision support. Therefore, the ultimate goal of this topic is to introduce students to management science/operational research (OR/MS) technique for use in developing a model-driven DSS. This will be achieved by using a case-study oriented approach. Electronic spreadsheets such as Excel will be used to model. Throughout this topic, we are going to study several OR/MS techniques, each with different objectives and limitations. The ultimate goal of this section is crucial: to build a model that can be manipulated and tested. From here, we examine the general quantitative modelling phases by detailing the steps required for a successful analysis. It is important for you as an analyst plus programmer to be more of the particulars of this process. It is a difficult topic ahead as it demands proper and careful analysis in supporting managerial decision-making. There are more advanced ORMS models than what we have discussed throughout this topic because this exposure is meant to familiariase you with one of the many ORMS models. This section is just only 'a tip of OR/MS iceberg'.

8.1 DECISION MODEL

When decision-making is too complex and the interests at stake are too risky, quite often we are not sure what to decide. In many instances, we resort to informal decision support techniques such as asking our friends. The simplest decision-making process which produce **decision model** with only two alternatives, is known as **Manicheanism** (Arsham, 2005). Manicheanism divides everything in the world into discrete either/or and opposite polar, such as good and bad. However, since the Industrial Revolution of the 19th century, Manicheanism as a decision model was no longer sufficient. In the industrial era, large factories with mass production created a need for managing them effectively and efficiently. Therefore, in 1911, Frederick W. Taylor published **The Principles of Scientific Management** which marked the beginning of **Decision Science**.

Decision Science (DS) which is also known as Operations Research (OR), Quantitative Analysis (QA) and Management Science (MS), is the science of making decisions. Therefore quantitative analysis or OR/MS is the application of quantitative methods to decision-making. Quantitative means that this approach is based on mathematical modelling. It is the scientific approach to automate portions of managerial decision-making.

ACTIVITY 8.1

According to Taylor (1999), an airline company would purposely allow overbooking on flight seats. Without overbooking, there will about 15% of vacant seats because of cancellations and no shows. What happens if everybody turns up? How are the airline company so sure that for each flight, approximately 15% of the customers will cancel they flight?

8.2 MATHEMATICAL MODEL

(a) **What is a Model?**

A **model** is an abstraction or a **summarise/synopsis** of the real-world decision situation.

An abstract decision model focuses on the mathematical representation with which various outcomes can be predicted. However, a model is not a complete representation of a real-world situation since certain element of the real system is loss. The loss of information is taken away during **modelling** process because we are trying to create a simplified representation of reality and to achieve this simplification we have to eliminate certain pieces of information from the abstraction (model).

(b) **Mathematics as a Universal Language of Modelling**
Mathematics can be used as a universal language of modelling. The most widely used models are spoken languages or known as narrative model. For example, verbal reports or written document are the central model for human consciousness.

A **verbal model** is a translation of the mental model.

Therefore, a verbal model expresses all of the functional relationships between the variables in a word passage (Arsham, 2005). Speaking and written document like an interview transcript, case studies, manual and others are models. Therefore, model building involves a great deal of verbal model. However, because of human varieties and limitations of communication and writing skills, the scientists uses mathematics and logic to enable human to express and therefore communicate effectively their ideas. Mathematic is the only language shared by all human beings regardless of race, culture or gender (Arsham, 2005).

(c) **Modelling**

Modelling involves transforming the business problem into an appropriate prototype structure such as a mathematical model. The transforming process involves processing and manipulating raw data into meaningful information. It starts with raw data and these data are manipulated or processed into information that is valuable to decision maker. However, once an analyst produced a mathematical model, we still need an effective and efficient way to use the model. Therefore, mathematical model is transformed into an electronic version or computer model using either statistical software packages, forecasting software, modelling packages or even an end-user tools like Microsoft Excel. However, it is often necessary to customise models using programming tools and languages such as C++, Java or Visual Basic. Then, the decision variables can be manipulated easily and directly by end-users. No matter what kind of MDDSS we try to build, the first goal is the same: to build a model that can be manipulated and tested.

(d) **The Role of Mathematical Models**

Mathematical models are used for analysis. The values of key variables or parameters of the model can be changed repeatedly. Changes are made to reflect changes and uncertainty in any decision situation such as demand and supply, queuing system, production, economy, costs and benefits, and so on. It is the model that produces outputs displayed for users. However, the outputs or results from using the model still need to be analysed and evaluated by decision-makers because Model-driven DSS (MDDSS) is not a decision-making system; it's only just support the decision-making process by human. This capability found only on DSS is named 'What if?' analysis or sensitivity analysis.

(e) **Model Base**

One of the core components of MDDSS is model base. Model base provides decision-maker access to the variety of models and assist them in decision-making. Ultimately, it is the component that assists them in the decision-making process.

ACTIVITY 8.2

Visit this website to read additional information about mathematical modelling a real and complex world.
http://www.math.montana.edu/frankw/ccp/modeling/topic.htm#contents

8.2.1 Mathematical Model Classification

Mathematical models can be divided into four sub-systems, each displaying unique characteristics (see Table 8.1) (Marakas, 1999).

Table 8.1: Decision Model Classification

Type of Models	Characteristics
Simulation	• Incorporate uncertainty into its structure. At least one of the variables is uncertain and described by some probability function. • When constructing a stochastic model, the decision-maker distributes the input value of one or more variables around some mean value and the output variables take the form of a frequency distribution rather than a discrete set of values. • Common stochastic modelling techniques include game theory, queuing theory, linear regression, time series analysis, path analysis and logistical regression or logic analysis.
Deterministic	• This model is used when a problem context are hybrid; which mean the some component of a decision context are deterministic, some are stochastic and some are a combination of both. • A technique developed to allow the combination of multi-model. • A technique for conducting one or more experiments that test various outcomes resulting from the combining of modelled sub-systems into a dynamic environment. • Imitate reality. • Common simulation models are production modelling, transportation and logistic and econometrics.

Domain Specific	• A model which its variable can only take one value at any given time. • Common deterministic models include linear programming, nonlinear programming and differential equations.
Stochastic	• A set of abstract mathematical modelling techniques developed to serve one particular field. • For example, models of supply and demand are unique model used by economists. Other recognised domains such as operations research, sociology, ecology, medicine and meteorology have each developed its own unique abstract modelling techniques.

ACTIVITY 8.3

Make a table of advantages and disadvantages between stochastic, simulation, deterministic and domain specific models.

SELF-CHECK 8.1

(a) Define quantitative analysis. Name **TWO** organisations that support the use of quantitative analysis?

(b) What is a mathematical model? Develop **TWO** examples of a mathematical model.

8.2.2 Components of a Mathematical Model

Generally a mathematical model consists of three components:

(a) Decision Variables.

(b) Uncontrollable Variables ('and'/'or' parameters).

(c) Result (outcome) Variables.

The relationships of the components are shown in Figure 8.1. These variables are linked with each other using mathematical relationships. The values of result variable are determined by three components which are the input value of decision variables, values or parameters of the uncontrollable variable and the relationships among variables.

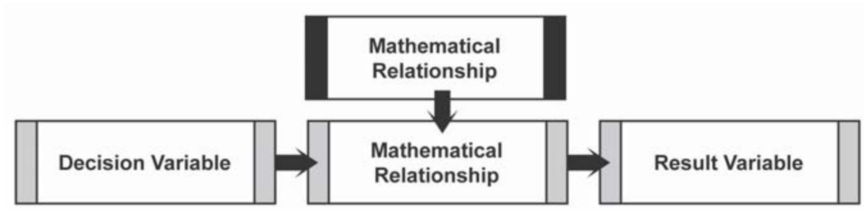

Figure 8.1: The general structure of a quantitative model
Source: Adapted from Turban & Aronson (1998, pg. 164)

Table 8.2 shows some examples of common variables are used in a particular area such as financial investment, manufacturing, selecting a car and scheduling class.

Table 8.2: Example of Variables

Area	Decision Variables	Result Variables	Uncontrollable Variables & Parameters
Financial Investment	• Investment alternative • Investment amount • How long to invest • When to invest	• Total profit • Rate of return • Earnings per share • Liquidity level	• Inflation rate • Prime rate • Competition
Manufacturing	• What to produce • How much to produce • Inventory levels • Compensation programs	• Total cost • Quality level • Employee satisfaction	• Machine capacity • Technology • Material and nature sources prices
Selecting a Family Car	• Car type • Car brand • Car purchase price • Repayment period • Financing institution	• Monthly installment	• Tax rate • Interest rate
Scheduling Class	• Number of student • Lecturer • Venue • Time	• Class schedule	• Number lecture hall • Number of class

Source: Adapted from Turban & Aronson (1998, pg. 165)

(a) **Result & Decision Variables**

Result variables are the variables that reflect the level of effectiveness of the systems and decision variables describe the alternative course of action (Turban & Aronson 1998).

For example, an individual chooses a car, by first, making a decision on how much he/he is willing to pay its monthly installment (result variable). Thus, he/she can set a range of alternative brand (decision variable) to be analysed. Suppose he/she determined to pay for RM900 to RM1200 per month for a car but can only afford to pay 10% (another decision variable) of the car price, hence, perhaps only Proton Perdana or Toyota Altis would be in his/her list of potential cars. The user will definitely avoid choosing a Mercedez Benz, BMW or a Lotus.

(b) **Uncontrollable Variables or Parameters**

Uncontrollable variables or **parameters** are the factors that affect the **result variables**, but are not under the control of the decision-maker.

These factors can be either fixed (called parameters) or they can repeatedly change (called variables). For example, in selecting and buying a car which is financed by the government car loan scheme, the buyer may have a set of cars to choose from like Proton, Toyota or Honda. However, the interest rates are uncontrollable variables because the buyer does not have any power to change the government policy.

(c) **Intermediate Result Variables**

Intermediate result variable is the variable that reflects result of intermediate outcomes.

For example, a manager has to decide a professional course fees (result variable). The manager's decision can affect the total of potential learners that enroll (intermediate outcome), which later determines the net profit (final result).

ACTIVITY 8.4

A DSS developer is a person skilled in the application of quantitative analysis and modelling technique. The first step in this technique is the identification of a problem that exists in the organisation. How would you differentiate a symptom and a problem?

SELF-CHECK 8.2

(a) Explain the role of the model in MDDSS.

(b) List the major components of a mathematical model?

8.3 SENSITIVITY ANALYSIS

SELF-CHECK 8.3

Why does this analysis being called sensitivity analysis? What is the rotionale behind its name?

Sensitivity analysis is an analysis performed to assess the impact of a change in the input data or parameters on the result variable.

For example, what is the impact of changes in petrol and diesel price (uncontrollable variable) to a retailer nett profit (result/outcome variable). Sensitivity analysis is very important in DSS because it provides a better understanding of the decision model. There are two types of sensitivity analysis: automatic sensitivity analysis and trial-and-error.

(a) **Automatic Sensitivity Analysis**
This type of analysis is performed in standard Operational Research/Management Science (ORMS) model implementation such as linear programming. Linear programming is a mathematical model for optimal solution of resource allocation problems. We will learn more on optimisation later.

(b) **Trial and Error (Experiment)**

The impact of changes in any or several variables can be analysed via simple trial-and-error or experiment approach. Users change some inputs or the expected result several times and the consequences of the changes can be directly accessed. When the changes are repeated a number of times, users will understand the nature or the problem as the solutions getting better and better. Such experimentation can be done using Excel. There are two types of experiment: 'what-if' analysis and goal seeking.

> **'What-if' analysis** is structured as "**What will happen to the solution if an input variable, or assumption, or a parameter value is changed?**" (Turban & Aronson, 2001).

A 'what-if' analysis is useful if you do not have complete data or if you want to explore the effect of various changes to your decision problem. For example, income, liability, or available funds that are used in your financial analysis. Azman's sample questions in section 8.4 are good examples. BEP analytical tool has the appropriate user interface. It is easy for Azman to ask the computer model these types of questions and get immediate answers. Furthermore, he can perform multiple cases and thereby change the percentage, or any other data in the question, as desired. All this is done directly, without hassle.

> **Goal seeking analysis** calculates the values of the inputs necessary to achieve a desired level of an output (goal).

Goal seeking analysis represents a backward solution approach (Turban & Aronson, 2005). Some examples of goal seeking are:

- What is the minimum grade needed for each remaining courses in order to increase my CGPA from 3.02 to 3.5?
- How many counters are needed to reduce the average waiting time of a customer in the food court to less than 5 minutes?

Figure 8.2 simplifies sensitivity analysis and its subcomponents.

Figure 8.2: Sensitivity analysis

8.4 DETERMINISTIC MODEL: BREAK EVEN POINT

In building a MDDSS we rely on mathematical modelling, a process that translates observed or desired phenomena into mathematical expressions. For example, suppose we need to use the following mathematical model, which represents profits:

Profits = Revenue – Expenses

In many decision contexts, we express revenues as **price per unit x number of units sold**. Expenses can often be expressed by **fixed costs + variable cost.** And, variable cost is often expressed as **variable costs per unit x number of units**. Thus, we can also express profits as the following mathematical model:

```
Profits = (Price per Unit)*(Number of Units Sold) – Fixed
Costs – (Variable Costs per Unit)*(Number of Units Sold)
```

Let us use the Azman Remote Toys (ART) example to demonstrate the use of mathematical models. Azman's company buys, sells and repairs remote control cars and parts. The 'Break-even Point' is the point of sales volume where total revenue and total expenses are equal; that is, where there is neither a profit nor a loss. Azman sells rebuilt engine for a price per engine of RM100. The fixed cost of the equipment and materials needed to renovate or build a remote car's engine is RM1,000. These fixed costs are costs that do not change over a wide range of sales volume. Apart from equipment needed to customise a car, shop rent is also a fixed cost. How much Azman sells, does not affect shop rent over a wide range of sales volume. However, fixed cost does not necessary remain constant at certain point; fixed cost will 'step up' to a new fixed level. The variable cost per unit is RM50 for an engine. Variable costs are costs that go up or down in direct proportion to sales volume. The more Azman sells the more components and spare parts are used. If we represent the number of engines (units) as the variable *X*, we can restate the profit model as follows:

```
Azman Profits = RM100X – RM1,000 – RM50X
```

Therefore, if sales are 0, Azman will lose RM1,000. If sales are 100 units, Azman will gain a profit of RM4,000. How does he get RM4000? Well, let us see:

X	=	Units sale
Profits	=	RM100*X* – RM1,000 – RM50*X*, if X = 100 (units sale)
Profits	=	(RM100) (100) – RM1,000 – (RM50)(100))
Profits	=	RM10,000 – RM1000 – RM5,000
Profits	=	RM4,000.00

In addition to the profit models shown here, decision-makers are often interested in the **break-even point (BEPs)**. The break-even point for a product, brand, or company is the point where **total revenue equals total costs (TR = TC)**. When a price or quantity is greater than BEP, you (or a firm) are making a profit but when the number of sales or price drops below BEP, your firm suffers a loss. It is calculated by:

Total fixed costs / (price – average variable costs)

It is particularly useful in comparing the profit consequences of alternative prices. By inserting different prices into the formula, you will obtain a number of break even points.

Back to Azman's case, the break even point is also the number of units sold that will result in RM0 profits. Azman sets profits equal to RM0 and solves for X, the number of units at the breakeven point:

Price per Unit	=	A
Number of Units	=	X
Fixed Costs	=	C
Variable Costs per Unit	=	D

0 = AX – C – DX	This can be rewritten as
AX – DX = C	then
X(A-D) = C	
When BEP = X = 0	then dividing both sides by (Price per Unit – Variable Costs per Unit), we can compute the BEP as follows:

Break Even Point (X = 0)	=	C / (A – D) or
Number of Units (BEP)	=	Fixed Costs / (Price per Unit – Variable Costs per Unit)

For the Azman's Remote Toys example, the BEP can be computed as follows:

** BEP = RM1000 / (RM100 – RM50) = 20 units of engine at the break even point

As we can see, mathematical models translate important business problems into a form suitable for determining a good or, in many cases, a 'best' or optimal solution by use of spreadsheets or other computer software. For example, using an appropriate solution technique for the above mathematical model, Azman realises now that he has to continuously promote his company services in order to get more than 20 customers or he will experience loss, as the fixed cost to run his business is RM1,000. So, he needs more than 20 customers a month to make a profit.

We hope you understand that some mathematical models, like the profit and break-even models previously discussed, do not involve risk or chance. We assume that we know all values used in the model with complete certainty. That is why we are calling it **deterministic models.**

8.4.1 Spreadsheet Based BEP

There is another good example of mathematical modelling on the Web. Newberry, Cathey & Co. is a Certified Public Accountants and consultants company servicing individuals, families and businesses with all their financial needs in many industries including manufacturing, construction, real estate, wholesale, retail and non-profit organisations.

ACTIVITY 5.5

How do you think the decision-makers learned about the real system through model development? As a consequence, do you think decision-makers will be able to focus better on the structure of the real system? Do you think their involvement in model building helped them in accepting the results? Yes or no? Why?

SELF-CHECK 8.4

(a) What are the basic components of break-even analysis?

(b) Explain how the break-even point is determined in the break-even model.

8.5 STOCHASTIC MODEL: QUEUING MANAGEMENT

SELF-CHECK 8.5

What do you understand about queuing system? How about queuing management? Do these similar?

Understanding waiting lines and how-to manage queues is one of the most important area in operation management. Queuing management theory is important to creating schedules, job design, inventory management and so on. Every day, it seems we spend some amount of time waiting in lines when we shop or we go to the bank. We wait in line to see a teller or cashier; we frequently wait for service. The study of waiting lines, called the queuing theory, is one of the oldest and most widely used quantitative analysis techniques. In this section, we discuss the basic elements of waiting line problems and provide standard formulas for managing them and show examples of how they are used. We discuss how analytical models of waiting lines can help managers evaluate the cost and effectiveness of service systems.

For example, a company may be able to lower staffing costs by reducing the number of clerks. But this action may also increase the time customers must wait in line. If the waiting time becomes too long, customers may take their business elsewhere, which could result in lower revenues and potentially lower profits for the store. We begin with a look at waiting line costs and then describe the characteristics of waiting lines and the underlying mathematical assumptions used to develop queuing models.

8.5.1 Characteristic of Queuing Systems

In this section we take a look at the components which form a queuing system:

(a) the arrivals or inputs to the waiting line system;

(b) the waiting line itself; and

(c) the service facility.

These three components have certain characteristics that must be examined before mathematical queuing models can be developed.

(a) **Arrival Characteristics**
Arrivals of customer (or packet in data communication systems) for the service system has three major characteristics as explained in Table 8.3.

Table 8.3: Three Major Characteristics of Service System Arrival

Characteristics	Descriptions
Size of the Calling Population	Population sizes are considered to be either **unlimited** (essentially **infinite**) or **limited** (**finite**). Examples of unlimited populations include cars arriving at any PLUS highway tollbooth. Cyber café is an example of a finite population because if there are only six PCs, one or all of them may be affected by a worm or virus and break down. Customers will go to another cyber café if there are no other operational PCs are availabe.
Pattern of Arrivals at the System	Customers either arrive at a service facility according to a schedule (for example, a lecturer sets a schedule that only one student can be advised every half hour) or else they arrive **randomly**. Arrivals are considered random when they are independent of one another and their occurrence cannot be predicted exactly. Frequently in queuing problems, the number of arrivals per unit of time can be estimated by a probability distribution known as the **poisson distribution**.
Behaviour of the Arrivals	We have to make assumption on people's behaviour towards waiting lines. Usually, we have to assume that customers do not balk or renege. Balking happens when a customer walks into a post office, for example, once upon seeing the long waiting line, he/she decides to leave the post office immediately. Maybe he/she is too busy to wait. Reneging happens when some people join the waiting line, but within a few minutes or to a few hours, some decide to leave.

(b) **Waiting Line Characteristics**

The second component of a waiting line is the waiting line itself. First, is the length of a waiting line can be either limited or unlimited. We have discussed this before on the size of population. A second waiting line characteristic is the waiting line discipline. Most of the waiting lines employ **First-In-First-Out (FIFO)**. But sometimes, like at any private clinic, critical patients (customers) will be the first priority to get treatments. Some patients will see the doctors earlier from you because you might only be suffering a minor headache caused by 'exam fever'. Even if you were the first customer that walked in into the clinic, but while waiting to be called, six people who were involved in a bus accident walked in, therefore, the waiting line discipline will change immediately from FIFO to **FILO (First-In-Last-Out)**.

(c) **Service Facility Characteristics**

The third component of a waiting line is the service facility. There are two properties:

(i) the configuration of the service system; and

(ii) the pattern of service times.

- **Examples of Waiting Line Configuration**

Figure 8.3: Single-channel, single phase system

Figure 8.4: Single-channel, multi-phase system

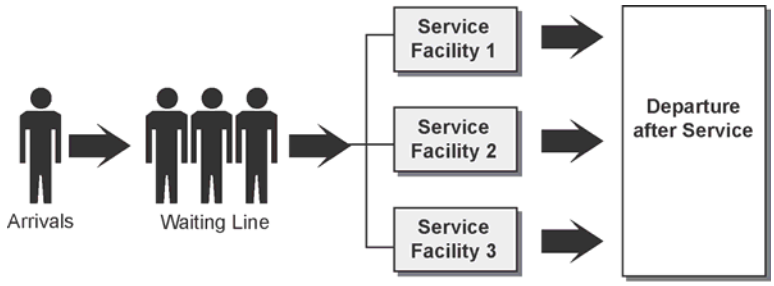

Figure 8.5: Single-channel, single phase system

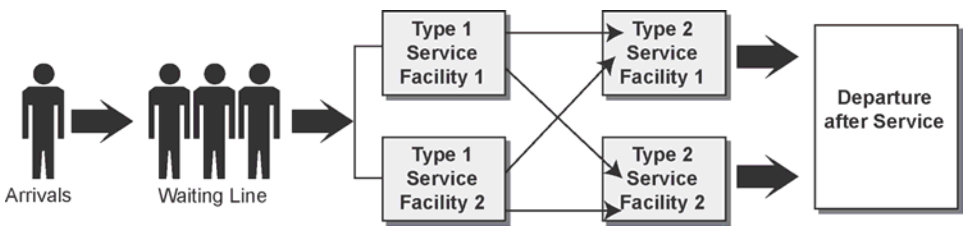

Figure 8.6: Multi-channel, multi-phase system

Table 8.4 explains the examples for these four waiting line configuration.

Table 8.4: Four Waiting Line Configuration Examples

Configurations	Examples
A Single Channel System	Only one server available; McDonald's drive-through that has only one open counter is a good example.
Multi-channel Service System	Have multiple channels; banks usually have more than one teller on duty and each customer waits in one common line for the first available teller.
A Single Phase System	A 'mamak' stall in which the person who takes your order also brings you the food and takes your bills.
A Multi-phase System	A health center. You have to register yourself at registration counter, then wait your name to be summoned by the nurse; see the doctor for diagnose or treatment (for example: minor operation room); then pick up the medicine from the clinic's dispensary and pay the bills at another counter.

(ii) **Service Time Distribution**

Service patterns like how long a doctor diagnoses a patient or how long a mechanic installs a new radio in your car, are like customer arrival patterns. Usually, service times are randomly distributed. Computer technicians need more time to install an operating system such as Windows XP than installing a spell checker on your PC. However, service time for a typical waiting line is exponentially distributed (Render & Stair 2000). For example, when an average service time for a technician to repair a computer is 30 minutes, rarely does the same technician take an hour to repair the same problem. We have to make sure that a waiting line system we are trying to model possess these characteristics. The determination of distribution type on customers arrivals and service times is vital because we have to use different queuing equations if the arrival is not Poisson and the service time is not exponential. The Poisson arrival distribution is illustrated in the following scenario faced by Muthu Barber Shop.

8.5.2 Poisson Distribution Example: Muthu Barber Shop

Poisson Arrival Distribution

For any given arrival rate, such as two customers per hour, a discrete Poisson distribution can be established by using the formula:

Probability of *k* arrivals within time t:

$$P(X = k) = \frac{(\lambda t)^k e^{-\lambda t}}{k!}$$

λ = the mean arrival rate per time unit
t = the length of the time interval
e = 2.7182818
k! = k(k-1)(k-2)(k-3)… (3)(2)(1)
P(X) = probability of X arrivals

Figure 8.7: Muthu's barber shop

Customers arrive at Muthu Barber Shop according to a Poisson distribution. Arrivals of customer are not always Poisson, perhaps they may follow some other distribution. It was his son, Ramasamy an OUM learner who told him that customers' arrival process at his barber shop satisfies Poisson's conditions which is orderliness, stationarity and independence. Orderliness mean, in any time, at most one customer will arrive to Muthu's shop for a hair cut. Stationary at Muthu's shop is satisfied when the probability of an arrival at Muthu's shop on Sunday afternoon between 3:38 pm and 3:39 pm is the same as the probability of an arrival between 3:40 pm and 3:41 pm. Independence condition means customers arrive independently of one another. For example, if Ahmad decides to go to the Muthu Barber Shop, his action will not affect when Tom Cruise will go to the same barber shop.

Muthu's shop usually opens daily at 10:00 am and on Sunday mornings between 10:00 am and 11:00 am, an average of four customers arrive at his shop. Muthu thinks of spending more time at Bangi's Temple to serve his community. He is thinking of working an extra half hour more than usual on Sunday. He is concerned, however, that if he opens the store a half hour late, he might lose too much business. Hence, Muthu would like to know the probability that 0, 1, 2, 3 or more customers will arrive between 10:00 am and 10:30 am on Sunday morning. Muthu wishes to seek advice from you.

To find the probability that a specific number of customers will arrive during the half-hour interval in question, we use the Poisson distribution with l = 4 per hour and t = 0.5 hour (30 minutes). This gives a value for lt = 4(.5) = 2. The spreadsheet in Figure 8.8 shows how we generate the Poisson probabilities for lt = 2.

ACTIVITY 8.6

You can download muthu.xls from the OUM website in your MyLms portal to do this exercise.

As shown in cell B 18, the probability that more than 10 customers arrive during this period is very low: only .00000831 and the probability of two or more customer are 0.594. Muthu is quite concerned about missing two or more customers, so he decides to open on time.

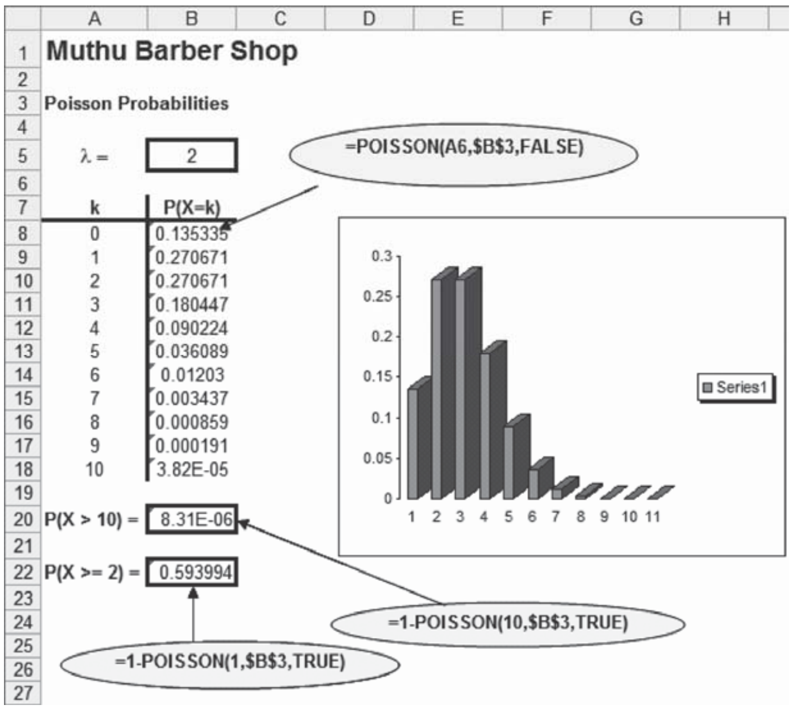

Figure 8.8: Poisson distribution

ACTIVITY 8.7

".. Computer modelling works; it allows us to examine many different alternatives and it forces the examination of the entire problem" – Federal Express CEO. (Source: Eppen. et. al. 1998). Which phase of the Simon decision model can be supported by a computer?

SELF-CHECK 8.6

(a) Why must the utilisation factor in a single-server model be less than one?

(b) List **FOUR** characteristics that define a queuing system.

8.5.3 Cost and Effectiveness of Services

The basic objective of waiting line management is to balance the cost of waiting with the cost of adding more resources (Chase et. al. 1998). For example, MobileVending Sdn. Bhd. (MVSB) supplies vended top-up services for telecommunication companies like Maxis, Celcom, Digi and TMNet to local universities around the Klang Valley where students can buy top-up card from the machine. However, management has a constant repair problem. The vending machine breaks down on an average of five times per hour and the breakdowns are distributed in a Poisson manner. Downtime costs MVSM RM27/ hour per machine and each technician gets RM6 per hour. One technician can service machines at an average rate of seven machines per hour, distributed exponentially; and a team of two workers can do nine machines per hour, distributed exponentially; and a team of three technicians can do eleven machines per hour. The management decision situation is to identify the optimum number of technician for servicing the vending machines.

Case I: One Technician
λ = 5/hour Poisson, μ = 7/hour exponential There is an average number of machines in the system of $L = \frac{\lambda}{\mu - \lambda} = \frac{5}{7 — 8} = \frac{5}{2} = 2.5$ machines Downtime cost is RM27 x 2.5 = RM67.50 per hour ; repair (labour) cost is RM6.00 per hour; and total cost per hour for 1 technician is: Downtime cost (2.5 × RM27) = RM67.50 Labour (1 Technician × RM6) = RM6.00 **Total = RM73.50**

L = Average number in system (including being served)

SELF-CHECK 8.7

(a) Based on MobileVending Sdn. Bhd. problem, please find the optimum maintenance crew size for serving the machines. Compare the costs for one, two, three or perhaps four technicians. Find the optimal decision.

(b) What is meant by an exponential service time?

8.6 SIMULATION

ACTIVITY 8.8

Have you ever heard about simulation? From Wikipedia, the free encyclopedia in the Internet, a simulation is an imitation of some real device or state of affairs. Simulation attempts to represent certain features of the behaviour of a physical or abstract system by the behaviour of another system. How about simulation in DSS context? Can you define it? Is it similar?

Source: http://en.wikipedia.org/wiki/Simulation

We have learned that DSS only deals with semi-structured or unstructured situation which in reality, is complex, which may not be easily represented by optimization or other models. In addition to this, already complicated problems, is having a structure which does not fall into either a strictly deterministic or probabilistic realm. To make this scenario worse, some of the element or sub-systems of a problem context are deterministic, some are stochastic and perhaps some are a combination of both. To solve this problem, a technique called **simulation model** is introduced. In DSS context, simulation is a technique for conducting an experiment that tests various outcomes resulting from the combining of modeled sub-systems into a dynamic environment. Another simple definition is

Simulation generally refers to a technique for imitating the real word mathematically, then conducting experiments on it with a computer.

Why cannot other models do that? If you look in an optimisation model, the values of the decision variables are outputs while in a simulation model, the values of the decision variables are inputs.

In this section, we show how to simulate a business or management system by building a mathematical model that comes as close as possible to representing the real system which is the core of a model-driven DSS. The goals of each model are different; for instance we use simulation models to create an environment in which information about possible alternative actions can be obtained through experimentation (Eppen et.al 1998). One way of doing so is to use a technique known as Monte Carlo simulation. This simulator is designed so that the simulated events can both occur randomly and reflects the theoretical frequencies being modelled.

ACTIVITY 8.9

Sometimes models are built and presented to the decision-makers but never implemented. Why do these situations happen?

8.6.1 Monte Carlo Simulation

SELF-CHECK 8.8

Have you ever heard about Monte Carlo? Why does this simulation being called Monte Carlo? What is the significance behind its name?

When a system contains elements that exhibit chance in their behaviour, the **Monte Carlo method** of simulation may be applied. The basis of Monte Carlo simulation is experimentation on the chance (**probabilistic**) elements through random sampling. We assume you have studied statistic and probability while at secondary school or had succeeded in related courses in OUM. The technique breaks down into five simple steps (Render & Stair 2000):

(a) Setting up a probability distribution for important variables.

(b) Building a cumulative probability distribution for each variable in Step (i).

(c) Establishing an interval of random numbers for each variable.

(d) Generating random numbers.

(e) Actually simulating a series of trials.

ACTIVITY 8.10

Visit this website to read more interesting facts about Monte Carlo Simulation at: http://www.decisioneering.com/monte-carlo-simulation.html

8.6.2 Kelisa Services Case Study

Figure 8.9: A Kelisa car
Source: http://www.wynnesmotorservices.co.uk/kelisa.html

Leong is the owner of the Kelisa Services Sdn. Bhd (KELISA). Apart from tyre and air conditioning experts, KELISA is also famous for its special engine treatment which was specifically designed for Kelisa cars. Leong's Engine Treatment, was designed to reduce friction and wear in Kelisa or any small compact cars like Kancil or Daihatsu. Leong wants to know what the future is for his product because if the demand continues to rise, he needs to decide whether to expand KELISA storage area to accommodate more boxes of lubricant or not. Knowing you who are currently studying DSS, he asks you for help to predict the demand for this lubricant. What should you do?

Before we proceed to more formal steps in simulation, you need to ask Leong for data. Ask him the daily demand for this lubricant over the past 365 days. Then, organise the data in a table like Table 8.5. Why do we organise it this way? One common way to establish a probability distribution for a given variable is to examine historical outcome. We need to know the relative frequency (probability), by dividing the frequency of observation by the total number of observation.

Table 8.5: Historical Daily Demand for Lubricants

Demand for Lubricant (Bottle)	Demand Frequency in Days
0	25
1	50
2	80
3	75
4	90
5	44
	Total = 364

Step 1: Establish Leong Lubricants Probability Distributions

The basic idea in Monte Carlo simulation is to generate values for the variables making up the model being studied. Convert these data (Table 8.2) to a probability distribution based on assumption that past demand rates will hold in the future, by dividing each demand frequency by the total demand, 364. This is illustrated in Table 8.6.

Table 8.6: Probability of Demand Occurred

Demand Variable	Probability of Occurrence
0	25/364 = 0.07
1	50/364 = 0.14
2	80/364 = 0.22
3	75/364 = 0.21
4	90/365 = 0.25
5	44/365 = 0.12
Total	364/364 = 1.0

Probability distributions, we should note, need not be based solely on historical observations. Do not estimate based on judgement or experience to create a distribution. And the distributions themselves can be either empirical, as in Table 8.5, or based on the commonly known normal, binomial, Poisson, or exponential patterns.

Step 2: Build a Cumulative Probability Distribution for Each Variable

Cumulative probabilities are found by summing all the previous probabilities up to the current demand. In Table 8.8, we see that the cumulative probability for each level of demand is the sum of the number in the probability column (middle column) added to the previous cumulative probability (rightmost column). The cumulative probability can be graphed and used in Step 3 to help assign random numbers.

Table 8.7: Cumulative Probabilities for Leong's Lubricants

Daily Demand	Probability		Cumulative Probability
0	0.07		0.07
1	0.14	0.07 + 0.14	0.21
2	0.22	0.21 + 0.22	0.43
3	0.21	0.43 + 0.21	0.64
4	0.25	0.64 + 0.25	0.89
5	0.12	0.89 + 0.12	1.00

Step 3: Setting Random Number Intervals

After you have established a cumulative probability distribution for each variable included in the simulation, assign a set of numbers to represent each possible value or outcome. These are referred to as random number intervals.

First row of Table 8.8, 0.07 probability means there is 7% chances that demand for a lubricant is 0 bottle per day. Therefore 7% of the random numbers are available to correspond to a demand of 0 units. In this case, a total of 100 two-digit numbers (from 00 to 99) is used in the simulation (think of them as being numbered chips in a bowl). We assign a demand of 0 bottle to the first five random numbers: 00, 01, 02, 03, 04, 05 and 06. Look at row 2 column 4 of Table 7.8. Then a simulated demand for 0 units would be created every time one of the numbers 00 to 06 was drawn (later in Step 5).

This is similar for the probability of 0.14 (or 14%). The next 14 random numbers (07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20) represent that demand and so on for other demand levels. Build a table similar to Table 8.8 to organise the random numbers.

Table 8.8: Assignment of Random Number Intervals for Leong's Lubricant

Daily Demand	Probability	Cumulative Probability	Interval of Random Numbers
0	0.07	0.07	00 to 06
1	0.14	0.21	05 to 20
2	0.22	0.43	21 to 43
3	0.21	0.64	44 to 64
4	0.25	0.89	65 to 89
5	0.12	1.00	90 to 99

Step 4: Generating Random Numbers

Random numbers can be generated for simulation problems by computer programs or, if we do not have it, we can simply use what gamblers do at casino such as at Monte Carlo or Genting Highlands, where you can spin a roulette wheel with 100 slots, hence the simulation named Monte Carlo? However, in this module, instead of a roulette wheel, perhaps you can prepare 100 pieces of small paper and write on each paper a number between 00 and 99 to be placed in a hat or a bowl. Please make sure each paper has a unique number. Then, grab any numbered paper out of a hat blindly which demonstrates the act of **random selection**. On the other hand, we can use the most commonly technique which is by choosing numbers from a table of random digits such as Table 8.10. The tables of random numbers in this module have become a standard reference in engineering and econometrics textbooks and have been widely used in gaming and simulations that employ Monte Carlo trials.

Step 5: Simulating the Experiment

We now illustrate the concept further by simulating 30 days of demand for special lubricant at Leong Kelisa Services. It means we have to select 30 numbers from Table 8.10.

" There are so many numbers on the table, how do I start?"

Table 8.10 was itself generated by a computer program. It has the characteristic that every digit or number in it has an equal chance of occurring. Because everything is random, you can select numbers blindly, anywhere in the table. However, in this case, in any use of the table, we should first find a random starting position. A common procedure for doing this is to select the random numbers needed from Table 8.10 blindly. Let us say, we randomly choose the number starting in the upper right-hand corner and (to make this process easier) continuing down the first column. The first number in the upper right-corner of Table 8.9 is 07 (Random number for Day 1). Number 07 is in the interval of 07 to 20 which represents a daily demand for 1 bottle (referring to Table 8.8). The second random number is 60 and the interval 44 to 64 represents a daily demand for 4 bottles. And the same process continues until day 30.

Table 8.9: 30-days Simulation of Demand for Leong's Lubricant

Day	Random Number from Table 8.7 (Look Table 8.5)	Simulated Daily Demand	Day	Random Number from Table 8.7	Simulated Daily Demand (Look Table 8.5)
1	07	1	16	42	2
2	60	3	17	52	3
3	77	4	18	39	2
4	49	3	19	73	4
5	76	4	20	89	4
6	95	5	21	88	4
7	51	3	22	24	2
8	16	1	23	01	0
9	14	1	24	11	1
10	85	4	25	67	4
11	59	1	26	62	3
12	85	4	27	51	3
13	59	3	28	57	3
14	85	1	29	17	1
15	40	2	30	36	2
			Total Demand Per Month		**78**
			Average Daily Demand for Special Lubricant		**78/30 = 2.6**

Let us compare the daily demand of this simulation with expected daily demand, which can compute from the data in Table 8.5.

Expected daily demand = $\sum_{y=0}^{5} y$ = 0 (probability of y bottle) X (demand of y bottle)

= (0.07) (0) + (0.14) (1) + (0.22) (2) + (0.21) (3) + (0.25) (4) + (0.12) (5)
= 0 + 0.14 + 0.44 + 0.63 + 1 + 0.6
= 2.81 Bottle of Lubricant

It is interesting to note that the average demand of 2.6 bottles of special lubricant in our 30-days simulation differs significantly from the expected daily demands, which are 2.81. Why? Actually, we need to have this simulation repeated hundreds or thousands of times; then it is much more likely that the average simulated demand would be nearly the same as the expected demand. The goal of this example, a simulating manual, is to demonstrate the important principles involved and is only useful in small-scale studies. As you might expect, the computer can be a very helpful tool in carrying out the tedious work in larger simulation undertakings which is what we will explore in our next topic. What will you suggest to Mr. Leong? Does he need to expand his store? Will you suggest repeating another simulation? Or perhaps you think otherwise? Is there any better solution? Yes indeed, Monte Carlo simulation is just only a tip of OR/MS iceberg. There are more advanced forecast and simulation technique that can be used. What we discussed in this module is an introduction to the world of Quantitative Analysis to build a decision model in developing a model-driven decision support system.

Table 8.10: Table of Random Numbers

52	06	50	88	53	30	10	47	99	37	66	91	35	32	00	84	57	07
37	63	28	02	74	35	24	03	29	60	74	85	90	73	59	55	17	60
82	57	68	28	05	94	03	11	27	79	90	87	92	41	09	25	36	77
69	02	36	49	71	99	32	10	75	21	95	90	94	38	97	71	72	49
98	94	90	36	06	78	23	67	89	85	29	21	25	73	69	34	85	76
96	52	62	87	49	56	59	23	78	71	72	90	57	01	98	57	31	95
33	69	27	21	11	60	95	89	68	48	17	89	34	09	93	50	44	51
50	33	50	95	13	44	34	62	64	39	55	29	30	64	49	44	30	16
88	32	18	50	62	57	34	56	62	31	15	40	90	34	51	95	26	14
90	30	36	24	69	82	51	74	30	35	36	85	01	55	92	64	09	85
50	48	61	18	85	23	08	54	17	12	80	69	24	84	92	16	49	59
27	88	21	62	69	64	48	31	12	73	02	68	00	16	16	46	13	85
45	14	46	32	13	49	66	62	74	41	86	98	92	98	84	54	33	40
81	02	01	78	82	74	97	37	45	31	94	99	42	49	27	64	89	42
66	83	14	74	27	76	03	33	11	97	59	81	72	00	64	61	13	52
74	05	81	82	93	09	96	33	52	78	13	06	28	30	94	23	37	39
30	34	87	01	74	11	46	82	59	94	25	34	32	23	17	01	58	73
59	55	72	33	62	13	74	68	22	44	42	09	32	46	71	79	45	89
67	09	80	98	99	25	77	50	03	32	36	63	65	75	94	19	95	88
60	77	46	63	71	69	44	22	03	85	14	48	69	13	30	50	33	24
60	08	19	29	36	72	30	27	50	64	85	72	75	29	87	05	75	01
80	45	86	99	02	34	87	08	86	84	49	76	24	08	01	86	29	11
53	84	49	63	26	65	72	84	85	63	26	02	75	26	92	62	40	67
69	84	12	94	51	36	17	02	15	29	16	52	56	43	26	22	08	62
37	77	13	10	02	18	31	19	32	85	31	94	81	43	31	58	33	51

Source: Adapted from Render & Stair (2000, pg. 662)

ACTIVITY 8.11

Simulation has become a standard tool in business. In manufacturing, simulation is used to determine production schedules, inventory levels and so on. Usually, when a mathematical technique fails, decision analyst will use simulation technique. Why?

SELF-CHECK 8.9

(a) Explain the Monte Carlo simulation.

(b) What is the difference between real time and simulated time?

8.7 DEMAND MANAGEMENT: FORECASTING

The purpose of demand management is to coordinate and control all of the sources of demand so the productive system can be used efficiently and the product delivered on time (Chase et al 1998). Forecasts are vital to every business organisation and for every significant decision either it is operational, tactical and strategic.

Forecasting is the estimation of the value of a variable (or set of variables) at some future point in time (Beasley, 2005).

Render & Stair (2000) assure us that forecasting exercise provides an aid to the decision maker and in planning the future. Typically all such exercises work on the premise that **if we can predict what the future will be like, we can modify our behaviour now to be in a better position than we otherwise would have been, when the future arrives** (Render & Stair, 2000). There are so many applications for forecasting such as forecasting the demand for a product; forecasting financial information such as interest rates, exchange rates, share prices; forecasting economic information such as the growth in the economy, unemployment and the inflation rate. There are many types of forecasting methods and therefore, these methods can be classified into several different categories as in Table 8.11 (Beasley, 2005).

Table 8.11: Different Types of Forecasting Methods

Methods	Descriptions
Qualitative Methods	When there is no qualified data that can be used to predict the future; it means there is no formal mathematical model. It is a methodology which tries to explain the phenomena to be studied without quantitative methods by using. For example, stories or citations from discussion.
Regression Methods	A data analysis approach that is used to predict one variable by knowing one or more other variables. Regression analysis is used to answer such questions as "How well can I predict the values of one variable, such as frequency of demand (Y), by knowing the values of another variable, such as expenses on marketing (budget) and/or the wholesale price (X)?"
Multiple Equation Methods	Where there are a number of dependent variables that interact with each other through a series of equations (as in economic models).
Time Series Methods	Where we have a single variable that is dynamic (changes over time) and whose future values are related in some way to its past values.

We shall consider only one method here which falls into the regression method categories, the causal method.

8.7.1 Causal Forecasting Method

The **causal forecasting method** is a technique for us to investigate one or more variables association with a variable being predicted.

For example, the sales of new newspaper might be related to the promotion which is the advertising budget plus good advertising strategy, the price which is 20 cents cheaper than its closest competitors and even the economy and sensational issues. In this case, **sales** of the newspaper would be called the **dependent variable** and the other variables would be called independent variables. So, when we found out these related variables, we need to build a statistical model to forecast the variable of interest, which in this case is a sale. Your job as a DSS analyst is to develop the best statistical relationship between sales and the set of independent variables. The most common mathematical causal forecasting model is regression analysis.

(a) **The New Peninsular Times**

New Peninsular Times or NPT is an English medium local newspaper. Over time, the NPT has found that its revenue (sales) is dependent on the advertising budget. They noticed that the figures for NPT's revenues and the amount of money spent on advertisement for the past six years are presented in Table 8.12. NPT wants to establish a mathematical relationship that will help predict sales. We are going to do least squares regression analysis (also known as method of least square) to establish the statistical model. Next, the basic model applies:

$Y = a + bX$

where

Y = Value of the dependent variable which is Sales

a = Y-axis intercept

b = slope of the regression line

X = independent variable (payroll)

Table 8.12: NTP's Sales

NTP's Sales Amount (RM Millions a year)	Spent on Promotions (RM Hundred Thousands a Year)
1.5	1.2
3.2	3.2
2.2	3.4
2.6	1.5
2.1	3
4.5	6.5

The calculations for a and b are shown in Figure 8.10.

ACTIVITY 8.12

You can download npt.xls from the OUM website in your MyLms portal to do this exercise.

File Edit View Insert Format Tools Data Window Help

K5

	A	B	C	D	E
1	New Peninsular Times				
2					
3		SALES	PROMOTION BUDGET		
4	RM	1,000,000	100,000		
5	Variable	Y	X	X^2	XY
6		1.5	1.2	2.25	1.8
7		3.2	3.2	10.24	10.24
8		2.2	3.4	4.84	7.48
9		2.6	1.5	6.76	3.9
10		2.1	3	4.41	6.3
11		6	4.2	36	25.2
12	Σ	17.6	16.5	64.5	54.92
13					

Figure 8.10: npt.xls interface

$$\bar{X} = \sum X/n = 16.5/6 = 2.75$$

$$\bar{Y} = \sum Y/n = 17.6/6 = 2.93$$

$$b = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2} = \frac{54.92 - (6)(2.75)(2.93)}{64.5 - (6)(2.75^2)} = 0.344$$

$$a = Y - bX = 2.93 - (0.344)\ (2.75) = 1.984$$

The estimate regression equation therefore is:

$$\hat{Y} \text{ (pronounced y hat)} = 1.984 + 0.344X$$

What we have done here is to get Y hat which is the computed value of the variable to be predicted (called the dependent variable). In NPT case, the dependent variable is sales. X is the independent variable which is the promotion budget. It means:

NPT sales = 1.984 + 0.344 (promotion budget)

Now back to NPT, if the board of directors' wants to predict what the sales are is going to be if they allocate RM 500,000 (5.0) next year into the promotion budget. Hence, an estimate of sales for NPT is found with the regression equation:

NPT next year sales = 1.984 + 0.344(5) = 3.41 million

However, take note that this case portrays a central weakness of causal forecasting methods such as regression. We need to get the best estimates of the independent variable which in this case is a payroll. It is very difficult to predict future values of dependent and independent variables with some common independent variables (such as Government economic policies, global trend, oil price and gross national product). However, this is just an introductory to mathematical forecasting method. There are so many advanced and far more complex equations that can be used to forecast the future of anything, with the exception of when you will fall in love, which is a very qualitative model. The message here is, to be a good DSS analyst to build a Model-Driven DSS, you need to have reasonable knowledge of operational research/management science (OR/MS). We hope you can understand, what makes DSS differ from other types of information systems like Management Information Systems (MIS) or a Transaction Processing Systems (TPS). MIS force is efficiency while for DSS, its force is the effectiveness or the quality of the model being used to support decision-making.

ACTIVITY 8.13

Which one is easier to build? A MIS, TPS or a DSS? "The difficult managerial situations are those for which symbolic models or even analogue models do not exist." What do these questions and statements mean to you? What is missing? Give examples.

8.8 THE ADVANTAGES OF MATHEMATICAL MODELLING

There are six advantages of using mathematical models as explained in Figure 8.11.

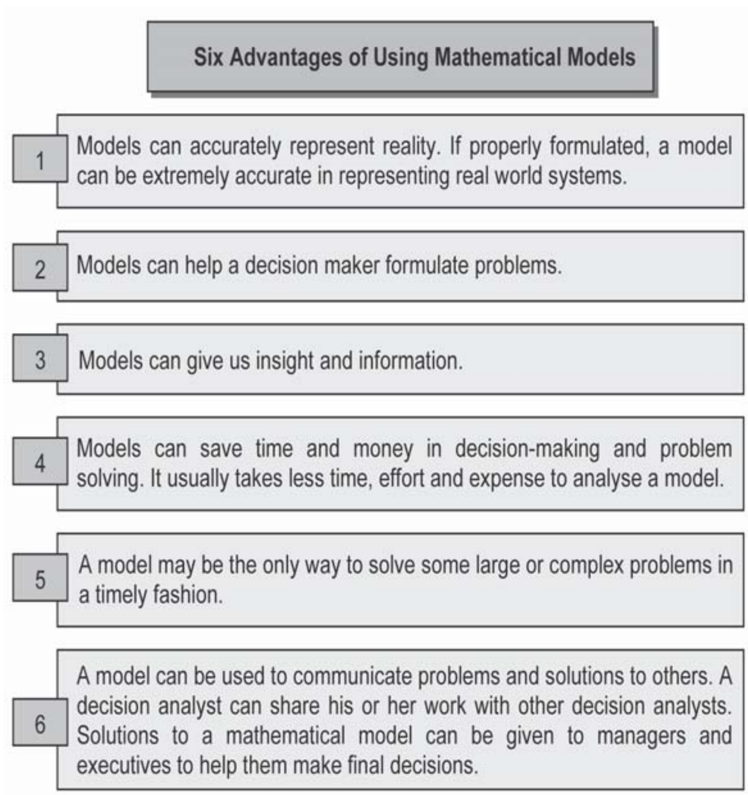

Figure 8.11: Six advantages of using mathematical models

SELF-CHECK 8.10

(a) List some of the operations and functions in any hypermarket that you think are dependent on a forecast for product demand.

(b) What is the difference between quantitative forecast methods and qualitative forecast methods?

SUMMARY

- Throughout this topic, we have discussed on how the steps of the quantitative analysis approach are used to help a manager make a decision based on knowledge which is gained from information processed by a model. That is why our government is making an effort to transform our country so that its economy, military, agencies, schools and private sectors are administered by knowledge workers which will create a knowledge-based organisation and society.
- Learning to build models and Model-Driven DSS is a complex task that requires extensive preparatory work.
- MIS professionals who want to build models need a strong background in management science and operations research.
- Once again, what we have learned here is just a tip of the iceberg. We have studied model type which are deterministic, stochastic, static and dynamic. Models are very important components in Model-Driven DSS, but just remember 'bad' models result in 'bad' decisions.

KEY TERMS

Analogue Model	Random Number Interval
Monte Carlo Simulation	Simulation
Random Number	Symbolic Model

SELF-ASSESSMENT 1

Instruction: Answer all questions in 20 minutes.

1. Name **TWO** major types of models used in DSS? (4 marks)

2. Distinguish between a static model and a dynamic model. Give an example for each. (6 marks)

3. Compare the methodology of simulation to Simon's four-phase model of decision-making. Can the methodology of simulation map be placed directly into Simon's model? Please explain. (6 marks)

4. What is the waiting line problem? (4 marks)

SELF-ASSESSMENT 2

Instruction: Answer all questions in 45 minutes.

1. Chief of Police is considering setting up a police traffic information desk which will be managed by one policeman at Alamanda Putrajaya. Based on information obtained from information desk near the shopping complex. It is believed that people will arrive at the desk at the rate of 20 people per hour. It takes an average of two minutes to check summons on computer. It is assumed that arrivals are Poisson and service times (check summons) are exponentially distributed.

   (a) Find the probability that the policeman is idle.

   (b) Find the proportion of the time that the policeman is busy.

   (c) Find the average number of people receiving and waiting to receive information on their summons.

   (d) Find the average number of people waiting in line to get information.

   (e) Find the average time a person seeking information spends at the desk.

   (f) Find the expected time a person spends just waiting in line to have a query answered. (24 marks)

2. Describe the general process of simulation. (6 marks)

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Topic 9 ▶ Decision Modelling with Spreadsheet

LEARNING OUTCOMES

By the end of this topic, you should be able to:

1. Describe electronic spreadsheet and its importance in DSS;
2. Apply simulation technique in modelling decision situation through spreadsheet exercise;
3. Apply business analysis for determistic model through spreadsheet exercise;
4. Apply optimisation technique and 'Goal-seek' command through spreadsheet exercise; and
5. Generate a report by using Solver report mechanism.

▶ INTRODUCTION

Topic 7 was significantly organised to demonstrate the use of influence diagram in assisting developer in model design, development and understanding. Decision analysis has also been taught to model a decision situation. Then, Topic 8 was designed to include the topics of quantitative analysis to build a mathematical model as an abstraction of the decision situation. After a model has been constructed, a model can be implemented in a variety of programming languages or applications. However, due to the dominance of electronic spreadsheet as a desktop application in both industry and academia, there is a level of familiarity with electronic spreadsheet such as Excel that eases transition into the course for students. This allows them to begin the development (and learning) process fairly quickly, even if they have minimal previous computer programming experience.

The primary goal of this topic is to provide an opportunity for students as the future of IT professionals with hands-on experience in creating and managing a decision-support system. This topic will introduce the techniques to develop the foundation of a model-driven DSS, based on a solid decision process and mathematical model. You will learn to use a spreadsheet to create custom business applications for decision-making support. Thus, you will gain a better idea of the process and work involved in developing DSS. However, the discussion of this topic will focus on how-to build a simple model- driven DSS. Most notable advantage in using an electronic spreadsheet is the fact that it has modelling capability; users can write their own models. You will also conduct the ''What-if' analysis, scenario analysis and goal seeking throughout the exercises in this topic.

9.1 ELECTRONIC SPREADSHEET

"Quantitative methods and spreadsheet-based computation for numerous kinds of decision problems [build] the kind of analytic and problem-solving skills that employers want." Geoffrion, A. (2003). *OR/MS Today*. California: UCLA.

SELF-CHECK 9.1

Have you ever used a spreadsheet before? How about ledger book? Can you define what is an electronic spreadsheet?

An **electronic spreadsheet** is a software that enables the user to type information in a column format which is based on the structure of an accounting spreadsheet consisting of a column-and-row pad.

The electronic spreadsheet is an application program designed to manipulate numerical data. (For example: financial data, stocks exchange and time records). Common examples would include Lotus 1-2-3, MS-Excel and Corel Quattro Pro. It is the fact that the spreadsheet is one of the major forces behind the personal computer revolution in the 1980s. The first spreadsheet originated with VisiCalc in 1978 for the Apple II, followed by SuperCalc, Multiplan, Lotus 1-2-3, Microsoft Excel and others. The current trend of DSS is to integrate spreadsheets with development and utility software, like database management and graphics software like ChartFX. The most notable quality about spreadsheets is the modeling capability (See Figure 9.1). We can write or develop our own models, conduct 'What-if' analysis, Scenario analysis and 'Goal-seek' more efficiently rather than developing an application using any 4th Generation Programming Languages. Electronic spreadsheet is an ideal application used to analyse data but not suitable to collect and manage data. Other applications such as Oracle Performance Manager Data, IBM Red Brick Warehouse or Microsoft Business Solutions Analytics are more suitable to collect and manage the data.

(a) **Why Electronic Spreadsheet as a DSS?**

A primary strength of using spreadsheet such as Excel for generating DSS is that it was specifically created to handle numerical data manipulation. As a DSS generator it enables us to integrate the data analysis and model analysis (simulation or optimisation) in a single workbook. Excel for example has enormous number of built-in functions for financial, statistical and numerical analysis. You can program using Visual Basic for Applications (VBA) to create new algorithms and models based on these functions. Add-in programs such as Solver for mathematical programming also extends the inherent capabilities of Excel. End-users do not have to wait for such a long time for the system analyst and programmer to build a DSS application using .NET or Java technology that needs longer period of development. By using spreadsheet it allows you to build your own DSS application without help from the experts.

These capabilities enable the spreadsheet to become an important, efficient and effective tool for analysis, planning and modelling. From a pedagogical standpoint, this gives you the opportunity to see the practical application for many of the models and solution approaches which you have previously learned.

9.1.1 Components of Spreadsheets

The main component of spreadsheets is called **cells**. It is represented as intersections of the columns and rows in a spreadsheet. The user places numeric data or text in these cells. The user writes formulas using functions to manipulate the data. A spreadsheet layout is very similar to a table. Some terms we use to describe components of a table (such as columns, rows and cells) are used to describe parts of a spreadsheet, with slightly different meanings. Figure 9.1 shows parts of spreadsheets.

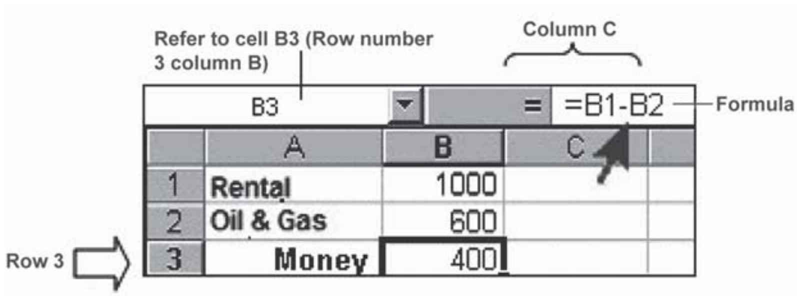


Figure 9.1: Labels, values and formulas

(a) **Labels, Values and Formulas**

Figure 9.1 is an example of an electronic spreadsheet (Microsoft Excel). The labels are in cells A1, A2 and A3 and numeric values are in B1 and B2. The formula in B3 is "subtract B2 from B1". In Excel, typing the equals sign starts the formula creation. The vertical sections with letters (A, B and C) are **columns** and they are placed horizontally with numbered sections called **rows**. The boxes intersect within columns and rows called **cells** which contain the information.

An **active cell** is the cell that you can enter information which highlighted with bold border.

The active cell can move by pressing an arrow key, pressing Tab, or clicking the mouse. The formula bar displays a number, text, or formula of a cell. The name box displays the location of an active cell. Notice that in Figure 8.1, it shows that "B2" is displayed in the name box when the active cell is currently cell B2 (column letter B, row number 2). A combination of column letters and row numbers, such as B2, is called **cell reference**. The thin lines that surround each cell are called **gridlines**. These lines appear on the screen but will not be printable. However, a spreadsheet can be formatted like a table with various kinds of format such as shadeborders and gridlines.

9.1.2 Data, Graph and Charts

Although spreadsheet and tables are similar in many ways, spreadsheets have more features than tables. One of these features is the ability to automatically create bar charts using spreadsheet data. Figure 9.2 shows an example of a bar chart created using the spreadsheet named **pencilsales.xls**.

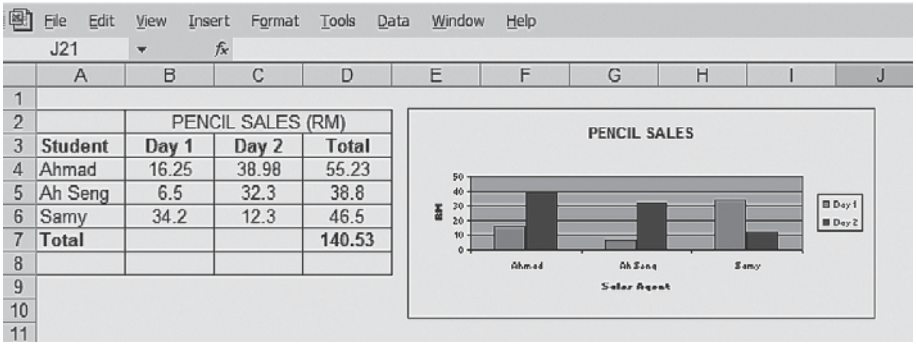


Figure 9.2: A spreadsheet and a bar chart created from the data

ACTIVITY 9.1

You can download pencilsales.xls from the OUM website in your MyLms portal.

9.1.3 Adding Formula

Another feature of spreadsheet component is manipulating formulas. A formula can be assigned into spreadsheet cell that allows the computer to perform the calculation automatically accordingly to the formula. Figure 9.2 shows the value in the **Total** column (column D4-D6) generated as result of formula Day 1 and Day 2. Without formula, users have to calculate manually. Similarly, the total sales of all the students for both weeks can be calculated by adding the total sales for each student (D4 + D5 + D6). This can be done by adding the formula D4 +D5 +D6 in the **Total** cell (D7). But the numbers you see in the Total column in Figure 9.2 were not manually typed. Instead, formulas were typed in each cell of the Total column, telling the computer to automatically add the Day 1 and Day 2 sales.

Once the formulas were entered in the cells, the numbers appeared automatically in the Total column. The column total you see is also the result of a formula. When you use formulas in a spreadsheet, you can replace any number without changing the formulas and the computer will automatically perform new calculations by using the new data. By using **pencilsales.xls** which you can download from the course website, you can change the data (for Day 1 or Day 2) and the computer would automatically change the results in the Total column. For example, if you changed RM16.25 to RM25.00 under Day 1 for Ahmad, the total for Ahmad would automatically change to RM63.98 and the column total would change to RM149.28. You will learn more about formulas later in this lesson.

As mentioned above, you can enter formulas in cells to perform calculations automatically. When creating a formula, always type the equal sign first. This defines the entry as a formula. Then type the needed cell references and operation symbols. The cell references tell the computer where to get the values that you would like to use in the formula. Operation symbols instruct the computer to mathematical operations are needed to perform. Figure 9.3 shows a formula that contains two cell references and one operation symbol. The formula instructs the computer to add the contents of cell B2 and the contents of C2.

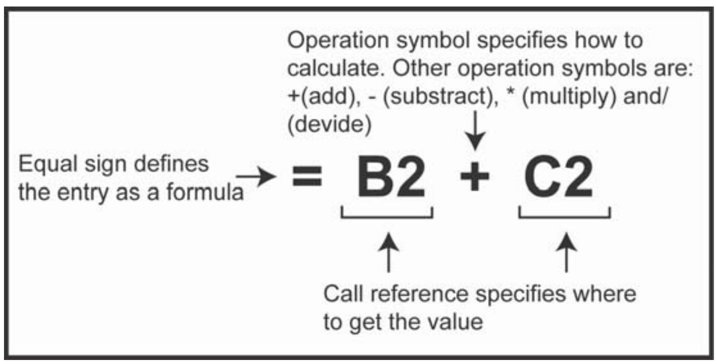


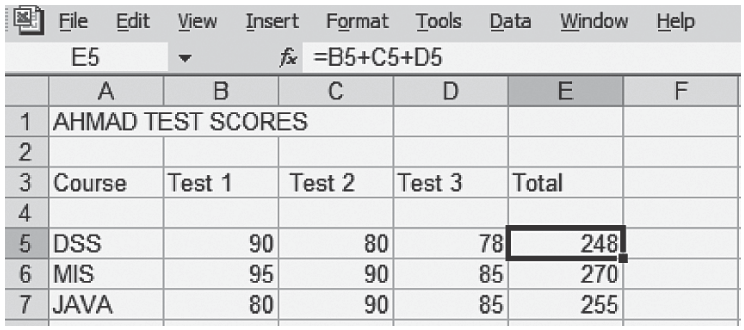
Figure 9.3: Formula to add the contents of B2 and C2

Figure 9.4 shows a spreadsheet to calculate the amount of the test scored. A formula can be added in cell E5 by entering the value = **B5 + C5 + D5**. When the data **Test1, Test2** and **Test3** are entered, the result of the formula (248) appears in cell E5. Notice that the formula still appears in the formula bar in Figure 9.4.

ACTIVITY 9.2

(a) You can download score.xls from the OUM website in your MyLms portal.

(b) Visit this website to read a brief history of spreadsheets. http://dssresources.com/history/sshistory.html



File Edit View Insert Format Tools Data Window Help

E5 =B5+C5+D5

	A	B	C	D	E	F
1	AHMAD TEST SCORES					
2						
3	Course	Test 1	Test 2	Test 3	Total	
4						
5	DSS	90	80	78	248	
6	MIS	95	90	85	270	
7	JAVA	80	90	85	255	

Figure 9.4: score.xls

SELF-CHECK 9.2

(a) What is a spreadsheet?

(b) What is an active cell? What types of information can be typed in an active cell?

(c) How do you display formulas and its value on a worksheet? Please use MS Excel's Help to find the solution.

9.2 HANDS-ON EXERCISE 1: SIMULATION

This exercise will discuss how a spreadsheet is used to model Mr. Leong's decision situation. As you may remember from a previous topic, Kelisa Services Sdn. Bhd. is a small workshop with one mechanic. Kelisa is famous for its special engine oil treatment lubricant. Mr. Leong as the manager wants to know the future sales or demand for lubricant.

A spreadsheet is used as a simulator because Excel has functionality to generate random numbers and then create a 'look up' of these numbers in a table in order to associate them with a specific event.

The spreadsheet is shown in Figure 8.5. It guides you with the solution of this exercise. The objective of the exercise is to learn how to use Excel's Random Number Generator, **VLOOKUP** and **FREQUENCY** function to simulate eight days of Kelisa's data sales.

Three tables are needed to simulate the sales which are **lookup**, **random** and **results** (frequency) table. Lookup table contains probability table and associate a probability range with a value of demand. Random table is where we will code a

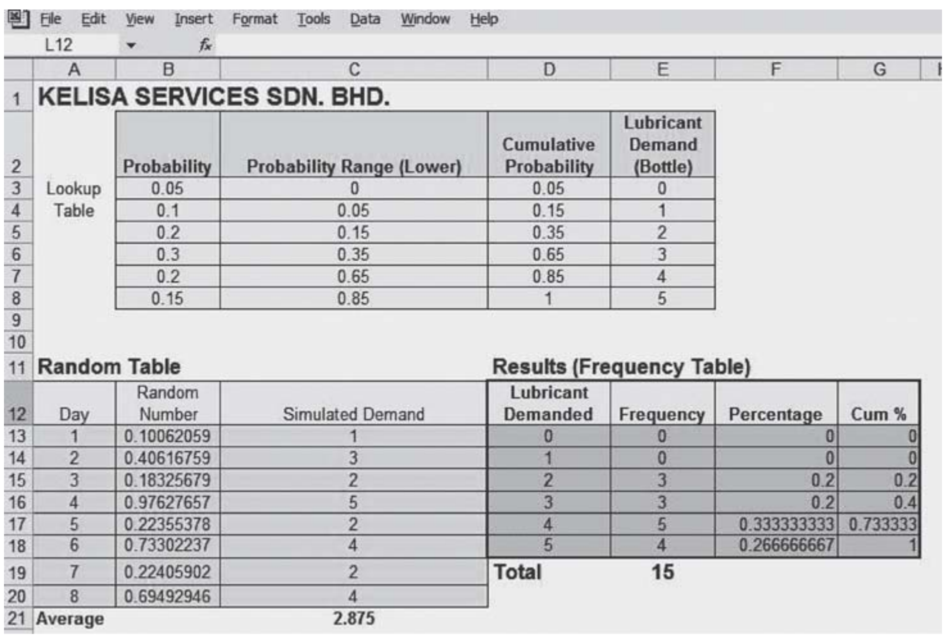
RAND function to generate random numbers between 0 and 1. Result (Frequency) table is where we use the FREQUENCY function to create a frequency table based on the random table.

ACTIVITY 9.3

You can download Kelisa1.xls from the OUM website in your MyLms portal.

The following is the step-by-step process of the solution:

STEP 1: Design the Initial Spreadsheet and Enter the Cell Formulas
Start Excel. Design a spreadsheet that is equivalent to Figure 9.5.



	A	B	C	D	E	F	G
1	KELISA SERVICES SDN. BHD.						
2		Probability	Probability Range (Lower)	Cumulative Probability	Lubricant Demand (Bottle)		
3	Lookup Table	0.05	0	0.05	0		
4		0.1	0.05	0.15	1		
5		0.2	0.15	0.35	2		
6		0.3	0.35	0.65	3		
7		0.2	0.65	0.85	4		
8		0.15	0.85	1	5		
9							
10							
11	Random Table			Results (Frequency Table)			
12	Day	Random Number	Simulated Demand	Lubricant Demanded	Frequency	Percentage	Cum %
13	1	0.10062059	1	0	0	0	0
14	2	0.40616759	3	1	0	0	0
15	3	0.18325679	2	2	3	0.2	0.2
16	4	0.97627657	5	3	3	0.2	0.4
17	5	0.22355378	2	4	5	0.333333333	0.733333
18	6	0.73302237	4	5	4	0.266666667	1
19	7	0.22405902	2	Total	15		
20	8	0.69492946	4				
21	Average		2.875				

Figure 9.5: Excel simulation demand for lubricant

Enter the formula in the specified cell:

(a) cell C2 type Probability Range (Lower)

(b) cell C3 type = 0

(c) cell C4 type = D3

(d) cell C5 type = D4

(e) cell C6 type = D5

(f) cell C7 type = D6

(g) cell C8 type = D7

(h) Take note that the cumulative probabilities are calculated in cell D3 to D8. This procedure reduces the chance of error and is useful in larger simulations involving more levels of demand. Now, enter this formula:

- cell D3 type = B3
- cell D4 type = D3 + B4
- cell D5 type = D4 + B5
- cell D6 type = D5 + B6
- cell D7 type = D6 + B7
- cell D8 type = D7 + B8

(i) Please complete Lubricant Demand column (Column n) exactly as shown in Figure 9.5.

(j) In the Random Table, The = VLOOKUP function looks up the random number (generated in Lookup Table in cell B13 through B20) in the leftmost column of the defined lookup table which is from C3 to C8. It moves downward through this column until it finds a cell that is bigger than the random number. It then goes to the previous row and gets the value from column E of the Lookup Table. Now, enter this formula into the specified cell:

- Cell B13 through B20 please type = RAND()
- Cell C13 type = VLOOKUP(B13,$C$3:$E$8,3,TRUE)
- Cell C14 type = VLOOKUP(B14,$C$3:$E$8,3,TRUE)
- Cell C15 type = VLOOKUP(B15,$C$3:$E$8,3,TRUE)
- Cell C16 type = VLOOKUP(B16,$C$3:$E$8,3,TRUE)
- Cell C17 type = VLOOKUP(B17,$C$3:$E$8,3,TRUE)
- Cell C18 type = VLOOKUP(B18,$C$3:$E$8,3,TRUE)
- Cell C19 type = VLOOKUP(B19,$C$3:$E$8,3,TRUE)
- Cell C20 type = VLOOKUP(B20,$C$3:$E$8,3,TRUE)
- Cell C21 type = SUM(C13:C20)
- Cell D13 to D18, please refer to Figure 8.5.

(k) In the Frequency Table

- Cell E13 type = FREQUENCY(C13:C20, D13:D18)
- Cell E14 type = FREQUENCY(C14:C21, D14:D19)
- Cell E15 type = FREQUENCY(C15:C22, D15:D20)
- Cell E16 type = FREQUENCY(C16:C23, D16:D21)
- Cell E17 type = FREQUENCY(C17:C24, D17:D22)
- Cell E18 type = FREQUENCY(C18:C25, D18:D23)
- Cell E19 type = SUM(E13:E18)
- Cell F13 type = E13/$E$19
- Cell F14 type = E14/$E$19
- Cell F15 type = E15/$E$19
- Cell F16 type = E16/$E$19
- Cell F17 type = E17/$E$19
- Cell F18 type = E18/$E$19
- Cell G13 type = F13
- Cell G14 type = G13+F14
- Cell G15 type = G14+F15
- Cell G16 type = G15+F16
- Cell G17 type = G16+F17
- Cell G18 type = G17+F18
- Average: In cell C21 type = SUM (C13:C20)/8. Save the workbook.

STEP 2: Simulate the Sales
Click the [F9] key on your computer keyboard and you will see that the numbers in the column change whenever you press the key.

In the output screen (see Figure 9.5) for example, the first random number shown in cell B13 is 0.10062059. Excel then look down the left-hand column of the lookup table (C3 through C8) until it finds 0.15. This is because as mentioned earlier, this function moves downward through the column (C3 to C8) until it finds a cell that is bigger than the random number it holds (0.1006). From the previous row (in this case is cell C4 = 0.05) it retrieves the value in column E row number 4 which is 2. Pressing the [F9] function key regenerates the random numbers and the simulation.

STEP 3: Result

The spreadsheet output shows that Kelisa's average sales is 2.875 bottle of lubricant a day. You may have a different output. This is because the random number generated for each simulation is different.

Try to think how we can interact with the computer. It is difficult to find a textbook that satisfies our needs concerning the development of decision-support systems using Excel and Visual Basic for Application (VBA). There are variety of other references that can be used as supporting material for an Excel-based DSS course. The following is a partial list of such resources:

1. Reed Jacobson, "Microsoft Excel 2000 VBA Fundamentals," Microsoft Press, 1999.
2. John Walkenbach, "Microsoft Excel 2000 Power Programming with VBA," IDG Books, 1999.
3. Peter Aitken, "Developing Solutions with Office 2000 Components and VBA," Prentice-Hall, 2000.
4. "Microsoft Office Programmer's Guide," (http://www.microsoft.com/officedev/articles/Opg/toc/PGTOC.htm)

SELF-CHECK 9.3

(a) What are the limitations of simulation models?

(b) List **TWO** ways in which random numbers may be generated for use in a simulation.

9.3 HANDS-ON EXERCISE 2: BUSINESS ANALYSIS

Exercise 1 has introduced to you some basic concepts of solving a simple decision situation by using a spreadsheet. Now, we are going to build worksheets for determistic model which is more challenging. In this case study, we will discuss:

(a) steps to develop black box;

(b) steps to develop an influence diagram;

(c) the transition process from graphical model (influence diagram) to mathematical model; and

(d) the useful features of spreadsheet for modelling decision.

Mrs. Lim sells homemade extended size curry puffs to hypermarkets and grocery stores. She realised that she is not making enough profit to expand her family business. Mrs. Lim asks her friend, Ali, to find a way to maximise her profit. Ali's strategy is to build a model based on Mrs. Lim situation with an influence diagram and spreadsheet to visualise her business situation and explore any options.

There are three phases to achieve Ali's goal, which are:

(a) Phase 1: Build the conceptual and mathematical model.

(b) Phase 2: Apply the model by using an electronic spreadsheet.

(c) Phase 3: Explore the options by altering the variables ('What-if' analysis).

9.3.1 Phase 1: Building the Conceptual and Mathematical Model

There are three important steps to build a business model for Mrs. Lim:

Step 1: Analyse the Decision Situation & Environment
Ali and Mrs.Lim investigate '**what**' the causes influences Mrs. Lim's profit. Ali must identify what is the **critical decision** and what are the **decision variables.** To support this task, Ali uses a **black box diagram** to specify cost parameters. The black box diagram will visualise Mrs. Lim's and Ali's understanding of the situation. What Ali must do is to identify the inputs and outputs of Mrs. Lim's business system.

An **input** is the variable or parameter to be processed by the model and the output is the model's result produced by the model.

At this stage, the model is called a **black box** as we still do not know the association between variables or parameters involved. This diagram enables them to work backward which is from **profit** to find its conceptual elements that influence the profit level.

After hours of discussion and brainstorming through the situation with Mrs. Lim, she and Ali conclude that setting the wholesale curry puff price is Mrs. Lim's most **critical decision** in maximising Mrs. Lim's profit. Ali has discovered that Mrs. Lim has never considered the idea of changing the size or the quality of its curry puffs. This causes the profit to shrink as the production cost is getting more expensive.

Price and **cost** of the curry puffs per unit is the '**decision variable**' that influences Mrs. Lim's profit. They have also identified the cost parameters which consist of:

(a) Monthly fixed cost (Rent, electricity and gas).

(b) Cost per curry puff of chicken and flour per unit.

(c) Cost of curry puff processing per unit (Cooking, packaging and delivery).

Step 2: Identify the Association between Variables or Parameters

During Step 1, Ali has identified five variables input influencing the profit. The logic of the black box model is shown in Figure 9.6. Now, what Ali must do is build the model which is the logic inside the black box (see Figure 9.6). To make this task easier, Ali structures his thoughts by developing an influence diagram. **Influence diagrams** provide a good way to picture the connections between the model's input/output variables without the need to define the model's mathematical logic.

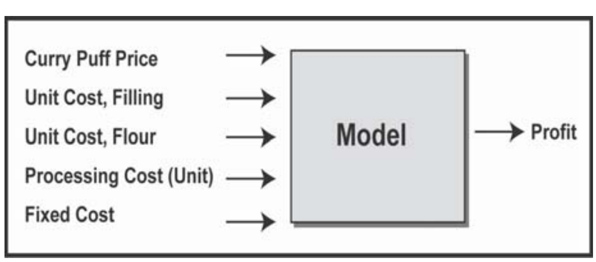


Figure 9.6: Black box view of Mrs. Lim's curry puff model

Starting with the **performance measure** which is to increase Mrs. Lim's profit, Ali defines its two possible influence components that is revenue and total cost. Then, Ali decomposes each of these into two intermediate variables into constituent parts and in turn, each of them into parts and so forth. Ali's diagramming process stops when the entire model's input variables are defined as shown in Figure 9.7.

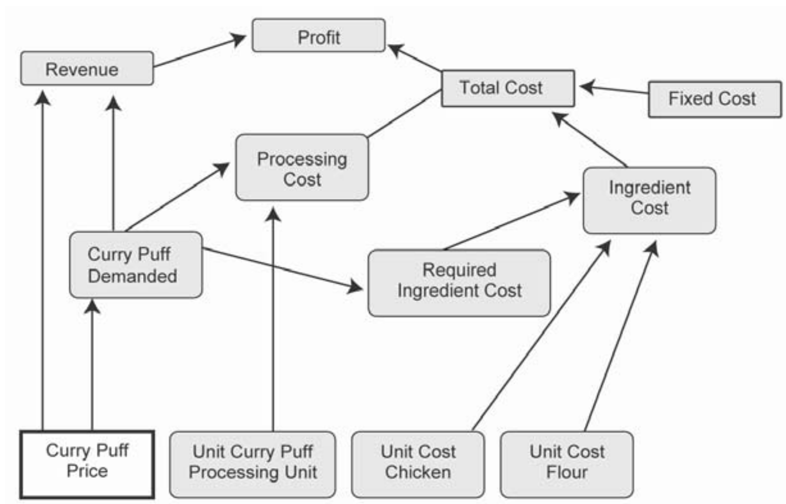


Figure 9.7: Mrs. Lim curry puff model influence diagram

Figure 9.6 and Figure 9.7 is a model of Mrs. Lim business. It also identifies all factors that influence the profit of Mrs. Lim's business. Upon inspection of Figure 9.6 and Figure 9.7, much is revealed about Mrs. Lim's business nature. They include the factors that we consider relevant in maximising Mrs. Lim's profits.

In Mrs. Lim's case study, we need to realise that the diagram makes clear that neither government policy nor the general economy are relevant to her payoff in the short run. There is no working capital, increasing toll rates, new electricity tariffs and other cash flow variables; these are still missing in the diagram. In reality, we have to consider these and other factors in the black box and into the influence diagram during the modelling process. But in order to simplify the model for educational purposes, we exclude other factors as the initial or pre-mature model.

Step 3: Model Construction

Based on the previous influence diagram, now Ali can create the equations relating to the variables to be specified in the spreadsheet. This process requires the equations in relating the variables to be specified. For example, from the first node of the influence diagram, we can easily translate the association as in Figure 9.8.

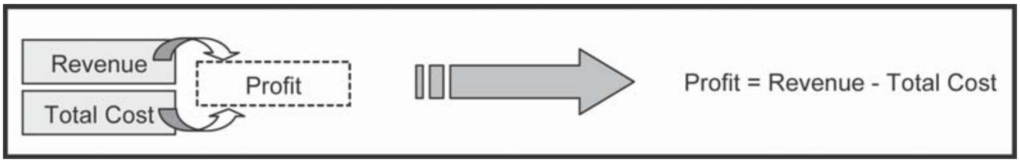


Figure 9.8: Profit's formula

Now, we can understand how Ali formulated the mathematical representation.

Revenue	=	Price * Demand
Total Cost	=	Processing Cost + Ingredients Cost + Fixed Cost
Ingredients Cost	=	(Filling Cost per Unit) + (Flour cost per unit) * Demand
Processing Cost	=	Demand * Processing Cost

However, Curry Puffs Demanded's equation requires more thought. It is similar to Break Even Points which we have studied earlier. Mrs. Lim believes that higher prices will cause a lower demand (sales). Mrs. Lim believes that if she fixes the price at RM3 per unit, no customer would demand for her curry puffs. If the price is below than RM3, she would sell about 2000 curry puffs per week by reducing the price RM0.50 each.

9.3.2 Phase 2: Design and Building the Model on Spreadsheet

Ali needs your help by designing and building Mrs. Lim's business model using a spreadsheet such as MS Excel to analyse Mrs. Lim's business situation.

ACTIVITY 9.4

You can download MrsLim.xls, Trendline.xls and Mrs Lim1.xls from the OUM website in your MyLms portal to do this exercise.

Step 1: Finding the Linear Equation
Design a spreadsheet that is equivalent to Figure 9.9. The spreadsheet shows a linear equation relationship between the price and demand of selling Mrs. Lim curry puff.

Lim Tat Linear Relationship Between Price and Demand

Finding Demand Equation With XY(Scatter) Diagram

RM	Curryf Puff Demand
3	0
2.5	2
2	4
1.5	6
1	8
0.5	10
0	12

Figure 9.9: Finding demand equation

Following are the steps to draw the linear relationship of price versus demand using XY graph:

(a) Click and drag cells A5 through B11.

(b) Click the Chart Wizard button  and the Chart Wizard dialogue box will be displayed.

(c) Choose XY (Scatter) Chart and Click the next button and fill in the necessary configurations until you get the same diagram as in Figure 9.10.

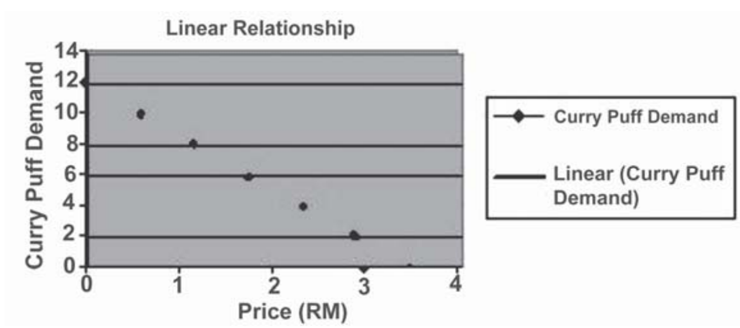


Figure 9.10: Initial XY (scatter) chart

However, Figure 9.10 did not show the linear line. Following are the steps on how to draw the line.

(a) Point to the tabulated point on the chart and right click your mouse. A pop up menu will appear as shown in Figure 9.11.

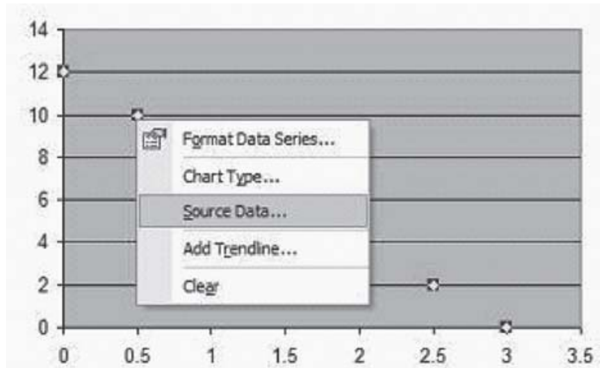


Figure 9.11: A pop up menu to add a trendline in finding the equation

(b) Click Add Trendline. A pop up dialogue window will appear as in Figure 9.12.

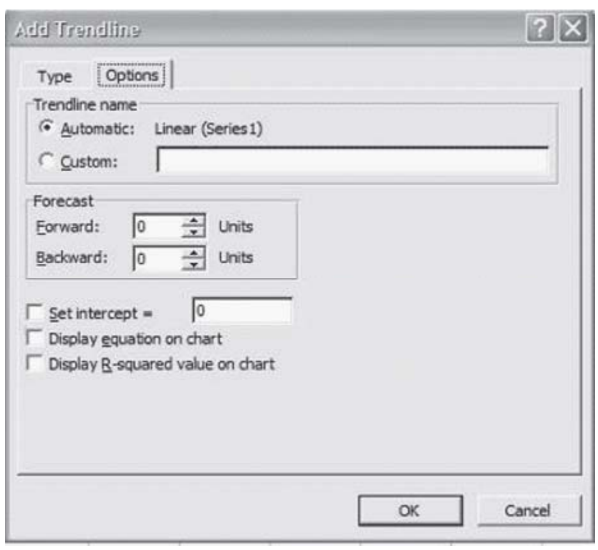


Figure 9.12: Add trendline dialogue box

(c) Click on Linear on the Trend/Regression type frame.

(d) Click Options and click on 'Display equation on chart' option.

(e) Click the OK button.

(f) A linear equation will be generated on the XY chart which is y = — 4x + 12 as in Figure 9.13. This equation results in the following equation for Mrs. Lim's weekly curry puff demand which is only valid for Curry puff Prices between RM0 and RM12:

Demand Equation = 12 – (4 * Curry puff Price)

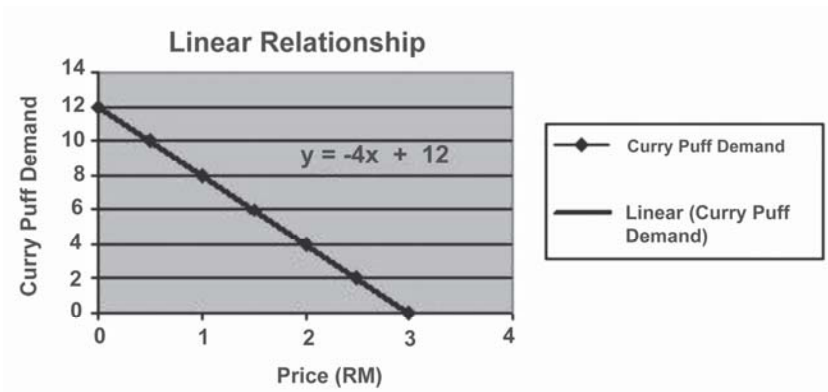


Figure 9.13: Demand equation

Step 2: Developing the Initial Weekly Profit Model
Design a spreadsheet that is equivalent to Figure 9.14. (See Mrs Lim1.xls).

	A	B	C	D	E
1	**Mrs.Lim Weekly Profit Model With Demand Equation**				
2					
3	**Decision Variable:**				
4	Curry Puff Price (RM)	2		If Demand Is:	Total Cost Based on Model
5				0	=0.38*D5
6	**Parameters:**			1	=0.38*D6
7	Unit Processing Curry Puff Cost (RM per curry puff)	0.38		2	=0.38*D7
8	Unit Cost, Chicken Filing (RM per curry puff)	0.1		3	=0.38*D8
9	Unit Cost, Flour (RM per curry puff)	0.03		4	=0.38*D9
10	Fixed Cost (RM000's)	0.6		5	=0.38*D10
11	**Curry Puff Demand Equation: y = - 4x + 12**			6	=0.38*D11
12	Intercept	12		7	=0.38*D12
13	Slope (Linear Coefficient)	-4		8	=0.38*D13
14				9	=0.38*D14
15				10	=0.38*D15
16				11	=0.38*D16
17				12	=0.38*D17
18	**Physical Results (000's)**				
19	Curry Puff Demanded and Sold (in thousands)	=B4*B13+B12			
20					
21	**Financial Results (RM000's)**				
22	Revenue	=B19*B4			
23	Processing Cost	=B7*B19			
24	Ingredients Cost	=(B8+B9)*B19			
25	Overhead Cost	=B10			
26	Total Cost	=SUM(B23:B25)			
27	**Profit (before tax)**	**=B22-B26**			
28					

Figure 9.14: Initial Mrs. Lim weekly profit model

Figure 9.14 presents the Excel worksheet of Mrs. Lim's weekly profit model. The results are computed for Mrs. Lim's current parameter values and its current curry puff price of RM2.00.

Step 3: Examines Actual Processing Cost
In addition to previous analysis, Ali and Mrs. Lim want to investigate the actual processing cost and compare them with the model's processing cost. Please design a worksheet using Excel that is equivalent to Table 9.1.

Calculate the Processing Cost using the model's equation.

> **Processing Cost** = [(Cost of processing a unit of curry puff) * demand] or 0.38 cents * Demand.

Compare the model's processing cost and the actual processing cost. As you can see, the model's processing cost produced is similar with the actual processing cost when the number of curry puff is at 6000 (cell A8).

Table 9.1: Mrs. Lim's Actual vs. Projected Processing Cost

	A	B	C
1	Number of Curry Puff (000's)	Processing Cost (Model) (RM 000's)	Processing Cost (Actual) (RM 000's)
2	0	0	0.4
3	1	0.38	0.50
4	2	0.76	1.00
5	3	1.14	1.35
6	4	1.52	1.60
7	5	1.9	1.70
8	6	2.28	2.28
9	7	2.66	3.00
10	8	3.04	4.00
11	9	3.42	5.00
12	10	3.8	7.00
13	11	4.18	9.00
14	12	4.56	13

Generate an XY chart (Processing Cost vs. Quantities):

(a) Click and drag cells A2 through C14.

(b) Click the Chart Wizard button  and Excel will display a Chart Wizard dialogue box.

(c) Choose XY (Scatter) Chart and Click the next button and fill in the necessary configurations until Excel generates a diagram as in Figure 8.10.

(d) In Figure 9.15, you can see that the model's Processing Cost formula provides a 'poor fit' to the actual data, but the chart of Processing Cost data suggests a nonlinear equation which is more appropriate for us to use. To develop an equation of the processing cost, we will use Excel's Trendline capability again to fit an equation to the data.

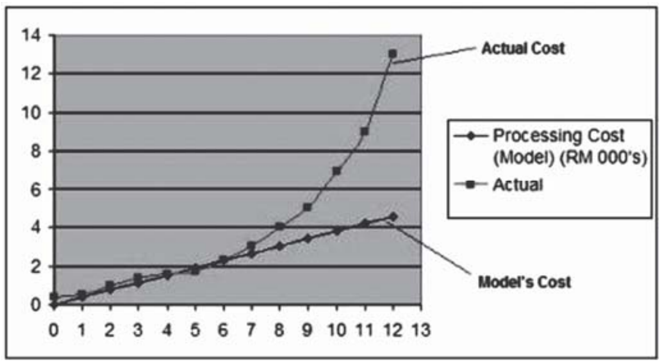


Figure 9.15: Curry puff quantities (X) vs. processing cost (Y)

(e) Select the actual processing cost data points on the chart (right click your mouse button) as shown in Figure 9.11 and choose the Trendline menu item from the pop up menu as shown in Figure 9.12.

   (i) After clicking **Add Trendline**, a dialogue box will open. Click on polynomial trend/regression type and on 'Based on Series', click on Processing Cost (Actual (Series 2)).

   (ii) Click the Options tab and click 'intercept option' to 0 and 'display the equation on chart'.

   (iii) In the same tab, select Custom as the Trendline Name which will allow you to enter Polynomial Fit.

   (iv) Click OK. You should produce a chart and an equation as shown in Figure 9.16.

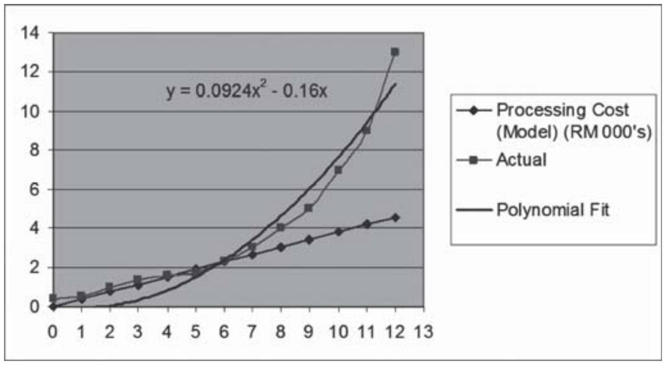


Figure 9.16: Actual processing cost vs. model (projected) processing cost

Step 4: Revised Mrs. Lim's Weekly Profit Model

(a) Design a spreadsheet that is equivalent to Figure 8.17.

(b) Replace the 'Unit Processing Cost' with the new processing cost equation which is $y = 0.0924 \times 2 - 0.16$.

Figure 9.17 shows Mrs. Lim has revised her model incorporating the new Processing Cost equation which is $y = 0.0924 \times 2 - 0.16$.

	A	B
1	Weekly Profit Model	
2	**Decision Variable:**	
3	Curry Puff Price (RM)	2
4	**Parameters:**	
5	Unit Cost, Chicken Filing (RM per curry puff)	0.1
6	Unit Cost, Flour (RM per curry puff)	0.03
7	Fixed Cost (RM000's)	0.6
8	Equation Coefficient	
9	Curry Puff Demand Equation	
10	Intercept	12
11	Slope (Linear Coefficient)	-4
12	**Processing Cost Equation**	
13	**Intercept**	**-0.16**
14	**Slope (Linear coefficient)**	**0.0924**
15	**Physical Results (000's)**	
16	Curry Puff Demanded and Sold (in thousands)	4.00
17	**Financial Results (RM000's)**	
18	Revenue	8
19	Processing Cost	0.2096
20	Ingredients Cost	0.52
21	Overhead Cost	0.6
22	Total Cost	1.3296
23	**Profit (before tax)**	**6.6704**

Figure 9.17: Revised Mrs. Lim's model

ACTIVITY 9.5

You need to download Exercise 8p3.xls from the OUM website in your MyLms portal to do this exercise.

(a) What happens when you replace Mrs. Lim's processing cost with the new one? Please explain.

(b) Now, Mrs. Lim believes that at a price of RM4, no customer would demand for her curry puffs and that below RM4 price he would gain about 2500 curry puffs sold per week for each RM1.00 reduction in price. Model a new demand equation for Mrs. Lim.

(c) What are Trendlines?

9.3.3 Phase 3: Exploring the Options using 'What-if' Analysis

'What-if' analysis is a type of sensitivity analysis. Sensitivity analysis is a technique for determining how much an expected payoff will change in response to a given change in an input variable (in Mrs. Lim's case this would be the curry puff price). Therefore, the 'What-if' analysis is a process of changing the values in cells (cell B3 in Figure 9.17) in order to see how those changes affect the outcome of formulas (Cell B23: Profit) on the worksheet. We use the 'What-if' analysis because Mrs. Lim (as the decision maker) wants to know her profit if some characteristic of her operating environment like processing cost, ingredient cost, or the whole sale price changes in a specified way. Obviously, such questions are fundamental to any management task.

We introduce 'What-if' analysis because one of the major benefits provided by DSS is that it permits 'What-if' analysis quickly and objectively. This allows several different strategies and conditions to be analysed by the end-user. An analytical decision maker like Mrs. Lim will be happy to see precise results, 'What if' analysis, cost benefit (tangible) and a mathematical financial model. Mrs. Lim now may examine the Profit consequences of changes in her assumptions and/or decisions. Figure 9.18 shows seven weeks of different snapshot results of Mrs. Lim's 'What-if' questions.

	A	B	C	D	E	F	G	H
1	Mrs.Lim Weekly Profit Model	WEEK						
2	**Decision Variable:**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3	Curry Puff Price (RM)	0.5	1	1.5	2	2.5	3	3.5
4	**Parameters:**							
5	Unit Cost, Chicken Filing (RM per curry puff)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	Unit Cost, Flour (RM per curry puff)	0.03	0.03	0.03	0.03	0.03	0.03	0.03
7	Fixed Cost (RM000's)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
8	Equation Coefficient							
9	Curry Puff Demand Equation							
10	Intercept	12	12	12	12	12	12	12
11	Slope (Linear Coefficient)	-4	-4	-4	-4	-4	-4	-4
12	Processing Cost Equation							
13	Intercept	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16
14	Slope (Linear coefficient)	0.0924	0.0924	0.0924	0.0924	0.0924	0.0924	0.0924
15	**Physical Results (000's)**							
16	Curry Puff Demanded and Sold (in thousands)	10.00	8.00	6.00	4.00	2.00	0.00	-2.00
17	**Financial Results (RM000's)**							
18	Revenue	5	8	9	8	5	0	-7
19	Processing Cost	0.764	0.5792	0.3944	0.2096	0.0248	-0.16	-0.3448
20	Ingredients Cost	1.3	1.04	0.78	0.52	0.26	0	-0.26
21	Overhead Cost	0.6	0.6	0.6	0.6	0.6	0.6	0.6
22	Total Cost	2.664	2.2192	1.7744	1.3296	0.8848	0.44	-0.0048
23	**Profit (before tax)**	**2.336**	**5.7808**	**7.2256**	**6.6704**	**4.1152**	**-0.44**	**-6.995**

Figure 9.18: Seven weeks 'what-if' analysis for Mrs. Lim

The result of the 'What-if' analysis (Figure 8.18) shows that the largest profit can be made at the price of RM1.50, in which the return profit before tax is RM7225.60 a week.

ACTIVITY 9.6

FINANCIAL MODELLING

Rahul's salaries amount to RM70,000 a year and he is very confident that his annual income grows at 2.5% a year. So Rahul decided to keep a tight budget and peg his expenditures to a fixed percent at 85% of his salaries. However, under the government tax law – single tax payer has a deduction of RM8000 and the tax rate is 9% for all income above this base of RM8000. Furthermore, 35% of all capital gains are taxed as as regular income. Recently, Rahul received RM200,000 as a gift from his loving father. Rahul is concerned on how to use the money.

Rahul has the option of investing any amount of his money in a real estate venture or money market fund investment. Mutual funds pays interest rate of 7.5% per year and the interest income is taxable. In a real estate venture introduce by Rahul's cousin, for each RM1000 invested, the following are the various factors: Annual tax loss is RM150, Annual Income is RM50 and are not taxable, capital gain tax liability at end of year 3 is RM700 and amount return at end of year 3 RM1,500. Develop a financial model on a spreadsheet for Rahul.

Questions

(a) Where and how much should Rahul invest in the real estate and/or mutual fund?

(b) If Rahul's salary growth rate is 10%. How does this affect Rahul's wealth at the end of 3 years?

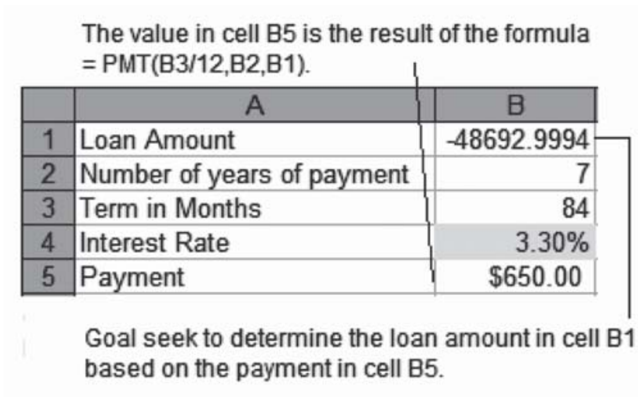
9.4 HANDS ON EXERCISE 3: OPTIMISATION

ACTIVITY 9.7

You can download loan.xls from the OUM website in your MyLms portal to do this exercise.

The use of a spreadsheet in decision-making has been emphasised throughout the module. This section will discuss the **Goal Seek** command. This command allows you to set a value into a target cell and then determine the input needed to reach the target value. Goal Seek is also part of a suite of commands called

'What-if' or Sensitivity analysis tools. When you know the desired result of a single formula but not of other variables, we can use the Goal Seek feature available. (Please download loan.xls or design a worksheet as illustrated on Figure 9.19). When goal seeking, spreadsheet varies the value in one specific cell until a formula that depends on that cell returns the result you want. Let us say Mr. Wai wants to buy a car but he can only pay RM650 per month. So, use the loan.xls and then use Goal Seek commands to change the loan amount in cell B1 until the monthly payment value in B5 equals RM650.00, which
we can afford to pay monthly for a car.



	A	B
1	Loan Amount	-48692.9994
2	Number of years of payment	7
3	Term in Months	84
4	Interest Rate	3.30%
5	Payment	$650.00

Figure 9.19: 7 weeks 'What-if' analysis for Mrs. Lim

You can change the number of years of payment and interest rate easily. The Goal Seek command is useful but it is limited to a **single** input variable. Therefore, **Solver** is used as a powerful 'add in' mechanism that is designed to solve problems involving **multiple variables**.

(a) **What is an 'add-in'?**

> **'Add-in'** is a supplemental program that is added as a custom command of custom features in to Microsoft Office.

There are a few 'add-in' programs already built-in in Microsoft Excel. Table 9.2 shows an example of 'add-in' function that is available in your spreadsheet. However, there are commercial 'add-in' programs that can be used for a specific purpose like Crystal Ball for simulations.

Table 9.2: Add-in Programs Included with Excel

Add-in	Descriptions
Analysis ToolPak	Adds financial, statistical and engineering analysis tools and functions.
Analysis ToolPak VBA	Allows developers to publish financial, statistical and engineering analysis tools and functions using Analysis ToolPak syntax.
Internet Assistant VBA	Allows developers to publish Excel data to the Web by using Internet Assistant syntax.
Lookup Wizard	Creates a formula to look up data in a list by using another known value in the list.
Solver Add-In	Calculates solutions to 'What-if' scenarios based on adjustable cells and constraint cells.

Solver is an add-in program incorporated with Microsoft Excel. It is an optimisation and resource allocation tool that helps you achieve a desired goal.

You can specify a goal, such as maximising profit or minimising cost. You can also indicate the constraints (conditions) that must be satisfied for a solution to be valid and you can specify the cells which we can change the values in order to reach the goal. The solver then determines the values of the adjustable cells (for example: it will tell you how to allocate your resources) in order to reach the desired goal.

9.4.1 Installing Solver

First, open your Excel and then pull down the Tools menu. Can you see any 'Solver' on the menu? If yes, the following is a step-by-step instruction on how to install an 'add-in':

(a) First, pull down the **Tools** menu.

(b) Click the **Add in** command. Check or click the box for Solver, then click OK to close the Add in dialogue box.

(c) Click 'Yes' when asked to install Solver.

(d) Depends on your Microsoft Office version, earlier versions need the Microsoft Office installer to install Solver.

9.4.2 Maximising BONY's Profit

This section introduces the use of Solver through an example on how to maximise a profit. You are the operation manager for Bony factory that manufactures televisions. The factory's product line is divided into two basic categories which are Plasma TVs and Flat Screen TVs. Each product is sold under two labels which are festive-line and first-rate line. As a manager, your job is to determine the quantity of televisions of each type and of each product line, to produce each week. The decision is subject to various constraints that must be satisfied during the production process as listed in Table 9.3 below.

Table 9.3: Number of Hours Needed for Assembly

Package	Product Line	Hours
Festive	Plasma	4
	Flat Screen	3
First-Rate	Plasma	6.5
	Flat Screen	3.5

Bony's Chief Operating Officer (COO) tells you that the maximum hours of production line labour you can have is 5,500 hours per week. The labour cost is RM30 per hour. However, due to limited resources and storage area in your warehouses, the maximum production cannot exceed 750 plasma units per week and 850 flat-screens per week. You have the information from Sales manager that the total demand for the festive television package is 600 televisions per week and first-rate television package is 900 televisions per week.

In the festive package line, the unit profit of flat screen and plasma television are RM900 and RM700 respectively, whilst the first-rate package consists of flat-screen and plasma televisions which have unit profits of RM1,500 and RM1,100 respectively.

Board of directors evaluates your annual work performance based on the profit gained by your factory. Your goal is to maximise BONY's profits. Please design a spreadsheet that is equivalent to Figure 9.20 or you can download from OUM website.

ACTIVITY 9.8

You can download BonyStep1.xls, BonyStep2.xls and BonyStep5.xls from the OUM website in your MyLms portal to do this exercise.

Next is the step by step process on how to maximise the Bony's profit:

Step 1: Design the Initial Spreadsheet and Enter the Cell Formulas

Start Excel.

Design a spreadsheet that is equivalent to Figure 9.20. If the text in the image is unreadable, please download BonyStep1.xls.

Enter the formula shown in Figure 9.19 in the specified cell:

(a) Cell E8 (Total numbers of hours used) = **B2*C2+B3*C3+B4*C4+B5*C5**

(b) Cell E10 (Number of plasmas produced) = **B2+B4**

(c) Cell E12 (Number of flat-screens produced) = **B3+B5**

(d) Cell E14 (Number of festive televisions produced) = **B2+B3**

(e) Cell E16 (Number of first-rate televisions produced) = **B4+B5**

(f) Cell E19 (Profit) = **B2*D2+B3*D3+B4*D4+B5*D5 EI8*E8**

(g) Save the workbook.

File Edit View Insert Format Tools Data Window Help formula

E21 fx

	A	B	C	D	E
1		Quantity	Hours	nit Profit (RM	
2	Festive Plasma		4	900	
3	Festive Flat-Screen		3	700	
4	First-Rate Plasma		6.5	1500	
5	First-Rate Flat-Screen		3.5	1100	
6					
7	Constraints				
8	Total number of hours used				=B2*C2+B3*C3+B4*C4+B5*C5
9	Labor hours available				5500
10	Numbers of plasma tvs produced				=B2+B4
11	Max production for plasma tvs				750
12	Number of flat-screen tvs produced				=B3+B5
13	Max production for flat-screen tvs				850
14	Number of festive tvs produced				=B2+B3
15	Total demand for festive computers				600
16	Number of first-rate tvs produced				=B4+B5
17	Total demand for first-rate computers				900
18	Hourly cost of labor				30
19	Profit in RM				=B2*D2+B3*D3+B4*D4+B5*D5-E18*E8

Figure 9.20: Enter the cell formula (Step 1)

Step 2: Set the Target and Adjustable Cells
You can check whether the formula in cell E19 that you typed just now is entered correctly as shown in Step 1 by pulling down the **Tools** menu and click **Solver** to display the Solver Parameters dialogue box shown in Figure 9.21.

Then, click in the text box for Set Target cell and click in cell **E19** to set the target cell. Do not change the '**Equal to**' option button which is set to Max by default.

Click in the '**By Changing Cells**' text box. Click and drag cells **B2 through B5** in the worksheet to select these cells.

Click the **Add command button** to add the first constraint as described in Step 3.

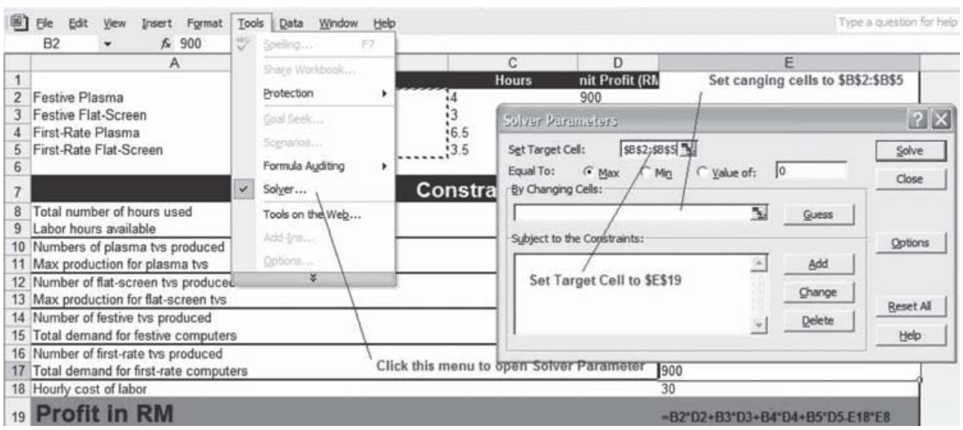


Figure 9.21: Set the target and adjustable cells (Step 2)

Step 3: Add the Constraints

Click the Add button on the Solver Parameter dialogue box and the Add Constraint dialogue box. The dialogue box is shown in Figure 9.22 will pop up.

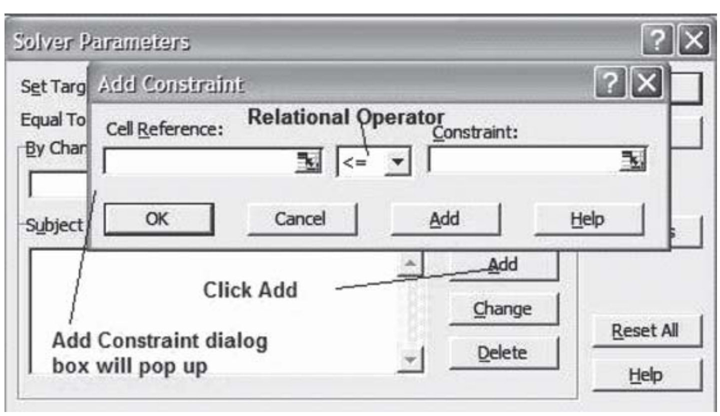


Figure 9.22: Add constraint dialogue box

At the Add Constraint dialogue box, click in **Cell Reference** text box and type **E8** or point to cell E8 (the cell containing the formula to compute the total number of hours used).

(a) The '<=' operator constraint is selected by default.

(b) Click in the **Constraint** text box, which will contain the value of the constraint, then click cell E9 in the worksheet to enter the cell reference.

(c) Click Add to complete this constraint and add another.

Then you will see a new (empty) Add Constraint dialogue box, which enables you to enter additional constraints. You can type in or use your mouse to point a cell in order to enter each of the constraints shown below:

(a) Enter the constraint **E10<=E11** and click Add.

(b) Enter the constraint **E12<=E13** and click Add.

(c) Enter the constraint **E14<=EI5** and click Add.

(d) Enter the constraint **E16<=EI7** and click Add.

(e) Enter the last constraint. This time you need to click and drag to select the cells **B2** through **B5** or you can just type **$B$2:$B$5** and change the **relational operators** to the '>=' operator. Type 0 in the constraint text box to indicate that the production quantities for all televisions must be greater than zero. Click OK to return to the Solver Parame-ters dialogue box.

(f) Remember! Click the Add button to add another constraint and when you complete adding the constraint then click OK. It will return to the Solver Parameters dialogue box in order to solve the problem.

Step 4: Solve the Problem
Check and change your work if necessary. Check that the contents of the Solver Parameters dialogue to make sure that there is no typing error and it was entered correctly.

(a) If you want to do correction or to change the Target cell, click the **Set Target Cell** text box, then click the appropriate target cell in the worksheet.

(b) To edit or change a constraint, select the constraint and then click the **Change** button.

(c) To delete a constraint, select the constraint and click the **Delete** button.

If everything is fine then you can click the **Solve** button to solve the problem.

Now let us do some analysis. The problem is to determine the values of cells B2, B3, B4 and B5, which represent the quantity of each television to produce. When you click the Solve button, Excel might or might not solve the problem. If Excel fails to solve the problem what you can do is find the solution manually through trial and error, by substituting different values and seeing the impact on profit.

That is exactly what Solver will do for you, only it will do it much more quickly. Solver uses various optimisation techniques that are beyond the scope of this discussion.

(a) Based on the spreadsheet you design, the solution shows the value of the target cell at E19 (which is the profit) that is subject to the constraints (which is E9, E1, E13, E15, E17 and E18).

(b) As you can see at Figure 9.23 (BonyStep5.xls), the solution that will maximise Bony's profit is to manufacture 550 festive plasma televisions, 50 festive plasma televisions, 850 first-rate flat-screen televisions and stop the production line of festive flat-screen television which will generate a profit of RM1,340,000 weekly or RM 4,320,000 yearly.

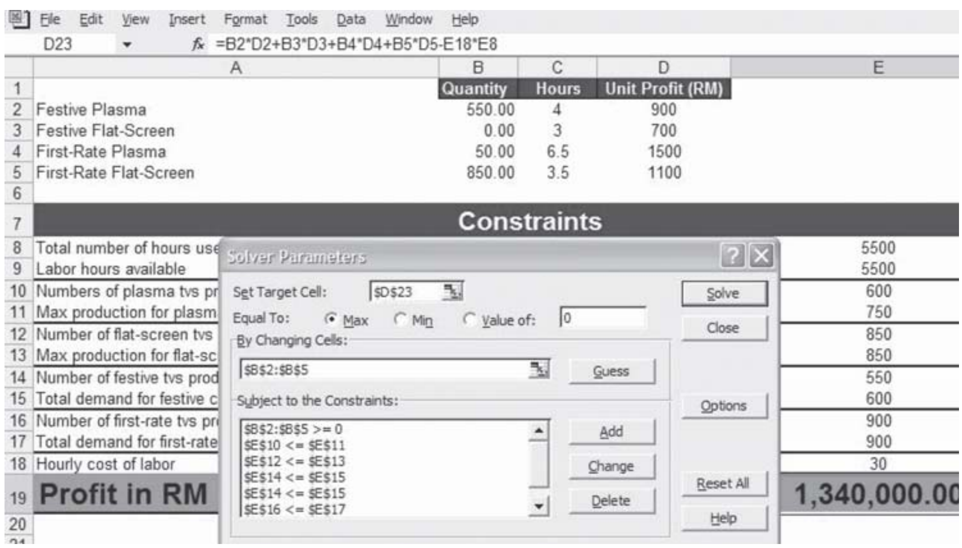


Figure 9.23: Result

Once Solver arrives at a solution, assuming that it can find one, you can create a report.

Step 5: Create the Report

You should see the Solver Results dialogue box in Figure 9.24, indicating that Solver has found a solution.

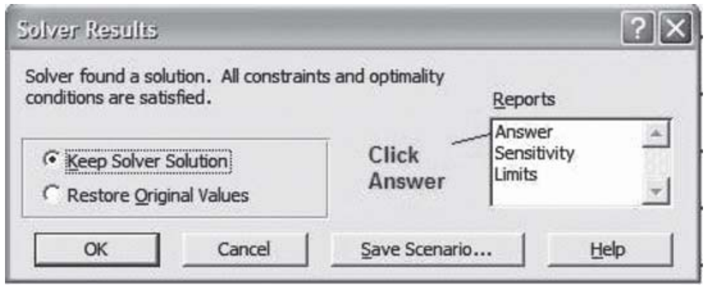
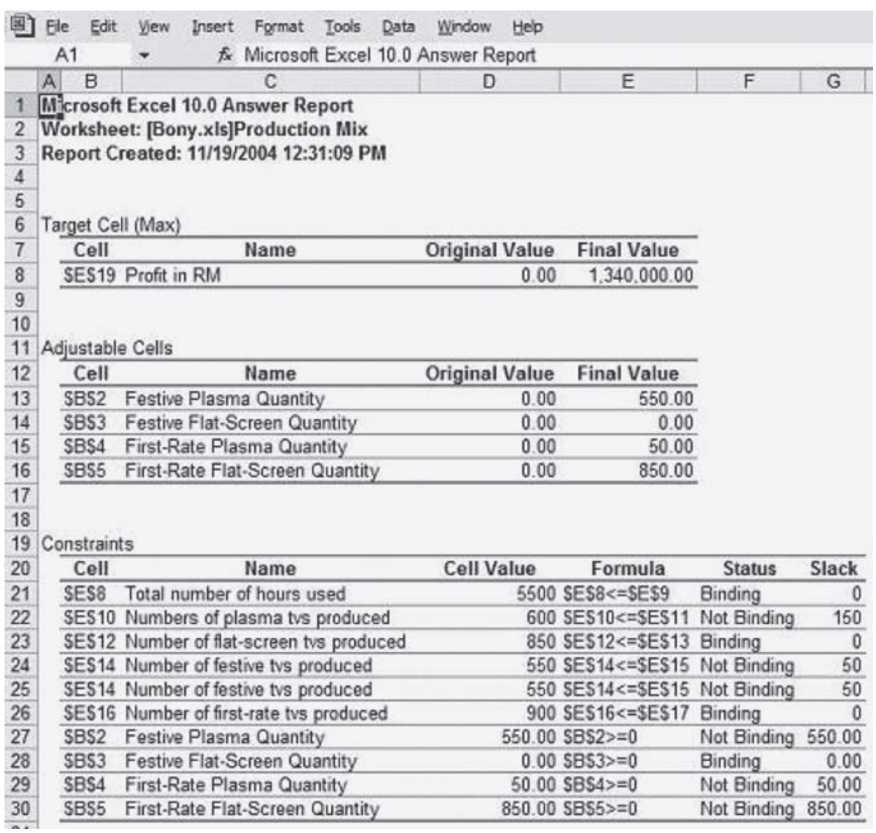


Figure 9.24: Solver results dialogue box

(a) Click **Answer in** the Reports list and then click Ok to generate the report. Excel will add a new worksheet and name it Answer Report 1 as shown in Figure 9.25.

(b) Click the Answer Report 1 worksheet tab to view the report (Open BonyStep5.xls).

(c) Please remember to save your file.



File Edit View Insert Format Tools Data Window Help

A1 Microsoft Excel 10.0 Answer Report

Microsoft Excel 10.0 Answer Report
Worksheet: [Bony.xls]Production Mix
Report Created: 11/19/2004 12:31:09 PM

Target Cell (Max)

Cell	Name	Original Value	Final Value
$E$19	Profit in RM	0.00	1,340,000.00

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	Festive Plasma Quantity	0.00	550.00
$B$3	Festive Flat-Screen Quantity	0.00	0.00
$B$4	First-Rate Plasma Quantity	0.00	50.00
$B$5	First-Rate Flat-Screen Quantity	0.00	850.00

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$E$8	Total number of hours used	5500	$E$8<=$E$9	Binding	0
$E$10	Numbers of plasma tvs produced	600	$E$10<=$E$11	Not Binding	150
$E$12	Number of flat-screen tvs produced	850	$E$12<=$E$13	Binding	0
$E$14	Number of festive tvs produced	550	$E$14<=$E$15	Not Binding	50
$E$14	Number of festive tvs produced	550	$E$14<=$E$15	Not Binding	50
$E$16	Number of first-rate tvs produced	900	$E$16<=$E$17	Binding	0
$B$2	Festive Plasma Quantity	550.00	$B$2>=0	Not Binding	550.00
$B$3	Festive Flat-Screen Quantity	0.00	$B$3>=0	Binding	0.00
$B$4	First-Rate Plasma Quantity	50.00	$B$4>=0	Not Binding	50.00
$B$5	First-Rate Flat-Screen Quantity	850.00	$B$5>=0	Not Binding	850.00

Figure 9.25: View the report

ACTIVITY 9.9

You need to download Exercise 8p5.xls from the OUM website in your MyLms portal to do this exercise.

(a) What is the difference between 'What-if' analysis and 'Goal-seek' function?

(b) For the 'Bony' example in this topic, if the requirement that "you cannot produce more than 750 plasma units" was changed to "must produce exactly 750 plasma TVs". How would this affect the maximisation solution?

9.4.3 Understanding Solver Report

The report worksheet shown in Figure 9.24 generated by Excel contains various formulas that relate to the resources and quantities produced. For example, cell E8 contains a formula that computes the total number of hours used to produce a quantity of each television. The report also examines each constraint and determines whether it is binding constraint or nonbinding constraint.

A **binding constraint** means that resource is fully utilised (for example: the slack is zero).

The number of available hours is an example of a binding constraint. It is a binding constraint because every labour hour is used and hence the value of the target cell (profit) is limited by the amount of this resource (the number of labour hours). Or which means that an increase in the number of available hours (above 5,500) will also increase the profit.

A **non binding constraint** is just opposite to binding constraint. It has a non zero slack (for example: the resource is not fully utilised). It does not limit the value of the target cell.

The festive plasma demand is an example of a non binding constraint. Only 550 festive plasma flat-screens are produced with maximum 600 televisions demanded. In other words, there is a slack value of 50 festive plasma flat-screens for this constraint and increasing the allowable demand will have no effect on the profit.

ACTIVITY 9.10

Snackven Business Strategy (Case Study)

SnackVen new business plan is to place self service snacks vending Machines onto customer premises like schools, clinics, hospitals, libraries and cyber café, among others. SnackVen strategy is to keep capital costs to a minimum by leasing vending machines. SnackVen will also pay a fee to any customer who is willing to provide a space for the machines. This fee would consist of a fixed monthly space rent. As part of their business plan for SnackVen, they have made the following estimates:

Number of Vending Machine Leased (decision variable):	20
Price Charged per Snack (decision variable):	RM1.50
Variable Cost per Snack (supplies, packaging, etc.):	RM0.20
Monthly Vending Machine Space Rental Rate (decision variable)	RM1.25
Other Monthly Expenses:	
Lease Cost of Each Vending Machine:	RM75.00
Coin Collection Labour per Machine:	RM8.00
Miscellaneous Fixed Costs per Machine:	RM25.00

Figure 9.26 is the initial spreadsheet model for SnackVen (suggestion) but you can design your own spreadsheet model based on your understanding and creativity.

File Edit View Insert Format Tools Data Window Help

B20 fx

	A	B	C	D	E	F
1	**SnackVen Sdn. Bhd.**					
2	**Average Monthly Expense per Copier**				No. of Vend. Machine Leased	20
3	Monthly Least Cost	75				
4	Machine Service Cost	8			Price per Snack	1.5
5	Other Fixed Cost	25			Variable Cost per Snack	0.2
6	Fixed Expense per Machine	=SUM(B3:B5)			Margin per Snack	=F4-F5
7	Space Rental Rate	100				
8						
9	Monthly					
10	Snacks/Month/Machine	250				
11	Revenue	=$F$2*B10*F$4				
12	Cost of Snacks Sold	=$F$2*B10*F$5				
13	Contribution Margin	=B11-B12				
14	General & Admin. Costs	=$F$2*($B$6+$B$7)				
15	**Net Income**	=B13-B14				
16						
17						

Figure 9.26: SnackVen initial spreadsheet model

However, SnackVen is considering several alternative arrangements for vending machine space rental payments.

Alternative 1: Offer a fixed space rent of RM100 per vending machine per month only.

Alternative 2: In addition to offering the fixed monthly space rent, SnackVen is thinking of paying their customers a lower space rent and per sale commission payment for each sale made. For example, OUM might prefer to receive RM50 per month per vending machine and a commission of RM 0.30 per sold snack than what is offered in Alternative 1.

Alternative 3: A fixed monthly rent of RM75 plus a per sold snack commission payment of 20 cents, paid only for that portion of the monthly volume that exceeds a predetermined cut-off, such as 200 snacks per month.

SnackVen wants to know the break-even volumes of each alternative for comparisons. Which alternative will result the highest revenue for SnackVen? Please develop a worksheet for ease of building, debugging and analysis of SnackVen decision situation.

SUMMARY

- Throughout this topic, we have learned the basic technique on how to design a spreadsheet based on a set of initial conditions and assumptions.
- This topic has also introduced spreadsheet modelling, by using a series of short examples.
- First, we introduced the components of a spreadsheet, how to type a formula and organise your data. We also showed how the black box diagram is used in addition to the influence diagram and how to translate a black box representation into a model-driven application of DSS which is based on spreadsheet.
- We have learned how to design an interface and use some of the tools available in Excel for modelling and analysis like Goal Seek and Scenario.
- The layout of the model in the spreadsheet is critically important in developing models that are understandable. Try to make the logic clear, avoiding numbers in formulas, labelling variables and use properly variable names all of which contribute to good spreadsheet modelling practice.

- The instructions series in this module and the analysis of the spreadsheet show that there is no shortcut in developing a DSS.
- We also have practised 'What-if' analysis, 'Goal-seek' and charting features of Excel. However, there are many other useful tools which can be used to help a decision maker rationalised various alternatives. Remember that this topic is an introductory topic on how to apply a model-driven DSS application.
- There are many other useful and complex management and decision science model which can be used in a model-driven DSS. If a compact spreadsheet models can assist people effectively, imagine what an advanced DSS technology and complex mathematical model can do. This is among the major reasons why approximately 100% of the Fortune 500 companies and probably Fortune 2000 companies are using DSS (Power 2003).

KEY TERMS

'What-if' Analysis	Model Base
Decision Variables	Model-driven DSS
Goal-seeking	Modelling Tools
Linear Programming	

SELF-ASSESSMENT 1

Instruction: Answer ALL questions in 20 minutes.

1. The numbers of lorries arriving at a workshop during the last 50 hours of operation are as follows:

Numbers of Lorries Arriving	Frequency
16	10
27	12
18	20
29	8

The following random numbers have been generated: 12, 20, 36, 90, 45, 32, 43, 99, 73 and 67. Simulate 10 hours of arrivals at this workshop. What is the average number of arrivals during this period?

(15 marks)

2. What is the relationship between data and models? (5 marks)

SELF-ASSESSMENT 2

Instruction: Answer ALL questions in 30 minutes.

1. Idaho Woods produces tables. The fixed monthly cost of production is RM8000 and the variable cost per table is RM65. The tables sell for RM180 a piece.

   (a) For a monthly volume of 300 tables, determine the total cost, total revenue and profit.

   (b) Determine the monthly break-even volume for Idaho Woods.

   (8 marks)

2. What is the use of Goal Seek Command? List **TWO** limitations of goal seek. (6 marks)

3. Briefly describe **THREE** steps used in model building. (6 marks)

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Topic 10 ▶ Intelligence Decision Support System

LEARNING OUTCOMES

At the end of this topic, you should be able to:

1. Describe the basic idea of what is artificial intelligence (AI);
2. Discuss the various fields of AI;
3. Explain the importance of AI in the decision-making process;
4. Describe what is an expert system and its usage in making decisions;
5. Apply the usage of AI in various areas of DSS through some examples of AI applications used in decision-making; and
6. Describe neural network and its usage in decision-making.

▶ INTRODUCTION

In the previous topic, you are shown how a simple DSS is developed. DSS can be developed easily using end-user development approach. In this topic we are going to discuss the use of Artificial Intelligence (AI) techniques in decision-making, especially when it involves with a complex DSS. The use of spreadsheet in DSS solution as shown in the previous topic can no longer be used anymore.

AI is concerned with enhancing a decision support system, especially one that involves huge chunks of rules, knowledge, data or pattern in the decision-making process. These kinds of problems will cause difficulty to anyone making a decision. This is because only certified experts can make a decision. For example, when making a decision on the type of medicine needed to be provided to a patient, with DSS, surely it can help a patient to choose the right medicine when a doctor is unable to assist him/her. The system stores all expert doctor recommendations.

Besides that, AI can also store the past experience of the expertise and use in future decision-making, therefore the system can gradually provide better decision-making. Furthermore, AI provides learning and reasoning capability. The strength of AI is the capability to make prediction according to the large past data. This prediction is useful for a certain decision-making such knowing the future share market price to make highest profits in a company.

In this topic, we will explore briefly what is AI and the various fields that are categorized under AI. In later sections, we will discuss more detail of some particular fields of AI that are mostly used in DSS. For example, artificial neural network and expert system. In order to let you understand easily, some examples of applications that use AI technique in supporting decision-making process are also given.

10.1 ARTIFICIAL INTELLIGENCE (AI): CONCEPT AND DEFINITION

SELF-CHECK 10.1

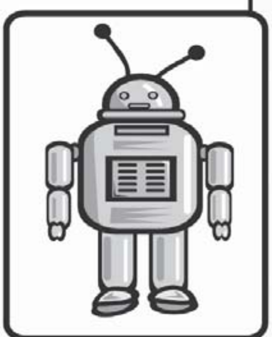
You sure have heard about Artificial Intelligence (AI). How can you describe AI?

Artificial Intelligence (AI) is a technique that makes a system or a machine imitates a human being's way of thinking.

In other words, AI makes a system to be intelligent like a human being.

The AI research tries to come up with techniques that can make a computer system mimics human intelligence. This is the promise of the AI thread, as the research in AI is continually finding out the best feature of human intelligence that can imitate into artificial intelligence. The most popular research in AI is robotics.

The AI techniques which will be discussed in the following sections are part of the techniques that have been found. These AI techniques have several important commercial ICT advantages. The use of AI in DSS has some of the advantages as explained in Figure 10.1.



The Advantages of AI

- AI can be cheaper than natural intelligence. For example, having a diabetic expert system can reduce a doctor's job in giving routine advice to diabetic patients.
- AI is more permanent. Changing expert workers will cause the natural intelligence perishable in a company. Having a new employee may not have similar expertise.
- Easy to duplicate experts. Transformation process of an expert to other people is a long process. With such expert, this transformation process will be reduced.
- AI can be documented. Documentation allows process tracing the activities.
- AI sometimes can execute certain tasks faster than a human can.
- AI sometimes can perform a task that humans cannot do.

Figure 10.1: AI advantages in DSS

Why do we need AI elements in implementing DSS? Computers are designed to perform a task from the easiest to the most highly complicated one, based on people's needs. However, computers are not able to learn from experience like humans do. Whenever a decision is made, computers cannot simply 'think' or assess any consequence out of it. Artificial Intelligence aims to enhance machine behaviours so that an intelligent element can be embedded into the computer during the decision-making process and problem solving. Therefore, the computer will imitate humans by taking into account every factor presented to it. Furthermore, with AI added in, computers can learn from experience like humans do and this criterion will assist in making a better decision.

Let us consider a scenario. You want to invest your RM200,000 money within 10 years with maximum benefits. The steps would be as below:

Decision-making 1 : Find out what kinds of investments are offered in the market.

Decision-making 2 : Make an assumption that since you want to invest as the share market holder, you need to find out the prediction of the share market price.

Decision-making 3 : Find a good company to invest by looking which company has good finance performance history.

In order to have the right decision-making skills for all the steps given, you need a significant amount of knowledge. Even in Decision-making 1, in order to make a right decision, you may need to meet consultant or read more. If we have a system that provides all this information that can assist DSS for Decision-making 1, it will prove very useful. The Decision-making 2 and 3 are the crucial decision stages. The wrong decision-making at this stage may cause money loss. An experienced person or an expert can make a right decision due to sufficient knowledge in the area. The common way is to meet a finance analyst. He/she can suggest to you the right company and the right time to invest. However, you may not trust it or it may involve cost. Even the finance analyst himself/herself will need AI DSS to help him/her make the right decision. The huge data are out of human's capability to remember. Putting an artificial intelligence in the DSS will enhance the user to make the right decision.

In the next section, we will discuss various fields of AI that can be used in DSS development for a particular domain of a problem. Having understanding of these various fields of AI will initiate to you the usage of the AI in various domains of decision-making.

ACTIVITY 10.1

Visit this website to read an article entitled Artificial Intelligence: Realising the Ultimate Promises of Computing at:
http://www.cs.washington.edu/homes/lazowska/cra/ai.html

10.1.1 Some Artificial Intelligence Fields

This section discusses some areas of Artificial Intelligence. These areas of systems or applications apply AI techniques. These applications are applied in various domains of problems.

(a) **Natural Language Processing**

> The **Natural Language Processing** (NLP) is a technology used by a system that allows users to communicate with computer using natural languages such as the English language.

The users can communicate with the computer like they communicate with a person. The NLP is invented to solve the user's problem of having difficulty dealing with various jargon, syntax and command needed by the computer. NLP research divides NLP into two parts:

(i) investigates methods on how computers can understand commands given in standard English; and

(ii) inventing a computer that produces output in ordinary English, so that people can easily understand its command.

ELIZA (Weizenbaum, 66), is an example that uses NLP. ELIZA is a famous computer program, which largely rephrases many of the patient's statements as questions and posing them to the patients as what Rogerian therapists do. The computer system does not provide any special intelligence but rather rephrases the work until the patient feels that he/she is speaking to a human being. For example, the user can ask "I got headache." Then ELIZA will answer "What gave you the headache?" The user then will answer "My mum scolded me." ELIZA in turn, asks "Who else is angry with you?"

(b) **Speech Recognition**

This technology provides the ability of the computer to recognise and understand the spoken language that involves voice. The system must be able to recognise somebody's speech and react to voice commands. This technology is used in various fields, like in medical practice to help people with hearing loss, or when used as a password in computer applications, where the system will look for the exact frequency of the user's voice. Speech recognition is also used in mobile phones, where you can just say the name of the person you want to call. Then your mobile phone will make the call to that person for you.

(c) **Expert System**
This system stores human expertise. It is stored in the system as knowledge of particular expertise, such as knowledge of diabetes diseases. The knowledge represents a collection of knowledge rules, not like a traditional database. The system will interact with users to get information and solve the problem based on the knowledge. A good design of an expert system is that it can imitate the reasoning process of an expert while solving specific problems, for example MyCIN. MyCIN is an interactive program that diagnoses certain infectious diseases, prescribes antimicrobial therapy and can explain its reasoning in detail. The test result shows that its performance equaled that of specialists. MYCIN program also incorporated several important AI developments. MYCIN extended the notion that the knowledge base should be separated from the inference engine, and its rule-based inference engine was built on a backward-chaining, or goal- directed, control strategy. Since it was designed as a consultant for physicians, MYCIN was given the ability to explain both its line of reasoning and its knowledge.

(d) **Fuzzy Logic**
This technique deals with the fuzziness of a fact. In other words, it deals with uncertainties by simulating the process of qualitative human reasoning, allowing the computer to behave less precisely and logically rather than having the basic logic of 'true' and 'false' value. Fuzzy logic goes further than Boolean true/false. It will extend the fact to be partially true (or partially false) with certain degrees. For example, most people say you are tall if you are more than 6 feet and considered short if your are less than 5 feet. Not only that, you can also say that you have less probability in being tall if your height is between 5.7 to 6 feet and less probability in being short if your height is between 5 to 5.2 feet. So you may also be considered as short or tall. These ranges may be different among ethnics. For example, the range value of height for English people is different compared to Japanese or Malaysians.

(e) **Neural Computing**
Most of AI techniques stated above have limitations due to the restricting knowledge and logic storage. Neural computing provides an intelligent system that uses an architecture that imitates human brain functionality in terms of processing capabilities, by transforming it into mathematical model. The result of knowledge representation and processing are based on a huge parallel process rather than traditional sequences process. It has the

ability to retrieve large amounts of information and ability to recognise patterns based of experience. This is the criteria of where the system can imitate humans. The value of neural technology is the fact of the usefulness of pattern recognition, learning, fault tolerance, generalisation, adaptability, forecasting capabilities and the interpretation of incomplete inputs. This will be discussed further in a later section.

(f) **Intelligent Agent**

Agent is a program that will be released to an environment (such as network) to do certain tasks automatically.

A very simple example of an agent system is an antivirus program that automatically detects any unwanted programs in a computer.

The main criterion of an agent system is autonomous, which means that it works on behalf of the user.

The antivirus system provides the criteria of what needs to be captured and act accordingly without having intervention from its user. A certain knowledge is given to the antivirus system in such a way it allows them to act and react on its own. So the criterion of AI techniques given to such a system is called an intelligent agent.

An **antivirus** is a program that runs in our computer system; while it runs it captures something.

An intelligent agent is suitable for environment which distributes, fast changing data or information, is mobile and needs social ability. Intelligent agent is the most critical limitation of the Internet due to information overload and it is facilitated on electronic commerce such as buying and selling.

The used of intelligence agent techniques in DSS will provide the latest information, which will cause better results for decision-making. Some areas of intelligent agents are:

(i) Information retrieval and navigation especially search information from the Internet.

(ii) Intelligent agent is used to support the knowledge worker while making decision.

(iii) Search and retrieval. The complex and routine task of getting information from Internet can be delegated to agents.

(iv) Distributed domain experts, where the expert agents in particular domains can negotiate among themselves in order to make decision.

ACTIVITY 10.2

By now you have already know what AI is. Is it similar to what the Hollywood's movies portrayed such as in the Bicentennial Man, I Robot, Star Wars and Terminator? Discuss this interesting issue with your classmates.

SELF-CHECK 10.2

(a) Why do we need AI techniques in implementing Decision Support System?

(b) Give **FIVE** fields that are currently using AI.

(c) What AI techniques can be used in DSS for stock market exchange and when are these techniques used?

10.2 HOW AI IS USED IN DSS

The varieties of AI areas stated above can be used in various ways of decision-making. It may support human on decision-making, or it may be used as part of a decision support system itself with particular objectives such as better suggestion. An expert system as discussed in previous section is an expert system that helps the user in making decisions. It provides expertise rather than part of DSS database or model of DSS itself. There are various possible areas that AI can be used in DSS as explained in Table 10.1 (Turban 2002).

Table 10.1: Various Possible Areas for AI in DSS

Possible Areas	Descriptions
Support Uncertainty	The AI is useful to support the analysis of uncert ainty. It is used for predicting uncertain conditions according to expertise or large amounts of past data. For example, to predict what kinds of student (define the variables) gets a first class in his/her result. The fuzzy logic to neural network computing is an AI technique that is useful for an expert to predict the uncertainty. Nowadays, uncertainty is one of the major characteristics of the current modern business environment. Predicting the variables that influence the price of shares in the stock market is another example of the use of AI for analysis uncertainty.
Support User Interface	The user interface plays an important role in implementing a DSS. The use of AI such as natural language processing or voice technologies can certainly make the interface very easy and natural. In certain situations it can increase the accuracy of capturing data which are related to high risk issues such as crime by using the thumb print. In this condition the use of pattern recognition is important.
Making DSS Intelligent	The various areas of AI stated above can be used to enhance the DSS to be more intelligent. In this situation, AI is used to support the building, storing and managing of models in multiple models of DSS. This method will enhance the capabilities of models based on the management system.
Support Decision Process	AI can also be used to support the step in decision process which is not addressed by mathematics. For example, it provides various features to provide an appropriate input data required by the expertise. This is the role of an expert system.

Among the above area of the first, the third and the fourth are the most area used in DSS which may be involved in a lot of expert system and neural computing. Therefore, in the next section, we will explain more deeply about expert system and neural computing and hope you will have more understanding of the areas and use it in DSS.

10.3 EXPERT SYSTEM

SELF-CHECK 10.3

What does expert system means? Why do we need this kind of system?

An expert system is a popular technique in AI that can enhance a decision-making process.

An **expert** is a person with special skills or knowledge that will 'give' his/her knowledge to the system so that the system will 'think' like a human when making decisions.

This section discusses about the general architecture of an expert system, specifically in knowledge-based system.

10.3.1 A General Architecture of Expert System: Knowledge-based System

Figure 10.2 shows the architecture of an expert system. An expert system is divided into two major environments; the development environment and consultation environment, an inference engine and the knowledge base.

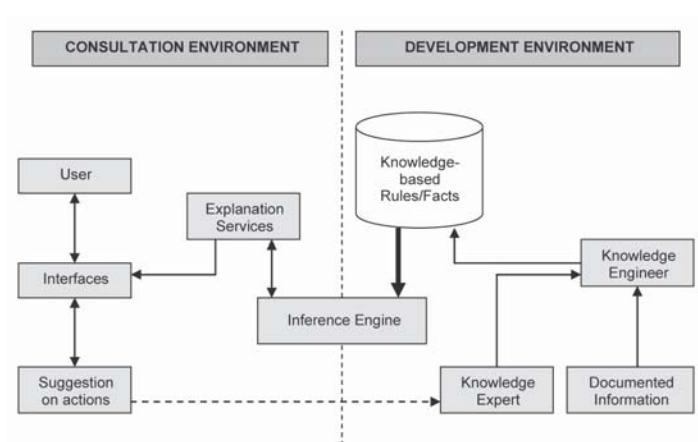


Figure 10.2: Structure of an expert system

(a) **Development Environment**

In the development environment, the knowledge obtained from the expert, together with other documented information will be transferred to a set of rules by knowledge engineers. The rules will be kept in the knowledge base.

(b) **Knowledge Base**

Knowledge base contains rules from experts as well as facts related to the domain problem. Table 10.2 shows an example of rules describing **ischaemic heart disease** depicted from (Arieff, 2004). All facts about this disease will be collected from heart experts and then transformed into rules.

Table 10.2: Rules Developed to Describe Inflammatory Heart Disease

Rules for *Ischaemic* Heart Disease
IF You have high blood pressure. AND You have diabetes. AND You have hypercholesterolemia. AND You feel pain in the chest for a few minutes. AND You have nausea/vomiting. THEN *Ischaemic* heart disease.

(c) **Inference Engine**

An inference engine is used to infer the rules in the knowledge base during the decision- making process. The engine will infer the rules according to the fact given by users and will then come out with a conclusion.

(d) **Knowledge Engineer**

Knowledge Engineer is a person who transformed knowledge from experts as well as from documented information (such as books and articles) to rules and facts that will be stored in the knowledge base.

(e) **Consultation Environment**

In the consultation environment, experts in the domain-specific problem will assist the non-experts, or the target user. The explanation service will explain in further detail how the system comes out with a particular solution. The interaction between end-user and the system is done through the interface.

(f) **Development Process**

The development of an expert system is followed by the rapid prototyping development process during their development.

ACTIVITY 10.3

Visit this website to read more about expert system.
http://en.wikipedia.org/wiki/Expert_system

10.3.2 Applications on Expert System

Which areas do you think expert system is widely used? Have you ever seen or used this system?

There are many expert system applications applied in various kinds of field. Table 10.3 explains some examples of applications that are developed by using expert system technique. Most of the following systems are used as consultation, which helps the process of decision-making faster or more accurate.

Table 10.3: Examples of Expert System Applications

Applications	Descriptions
R1/XCON	This system was developed by John McDermott et. al. in late 70's (John 1982). The system is said to be the most successful commercial expert systems. It is developed to help in setting configuration in VAX computer system at Digital Equipment Corporation. The configuration is on the basis of customer's need. The input of the system is the computer characteristics required by users. The output would be a suggested decision on the computer specification, so that users can make decisions to buy computer specification according to their requirements. However, the system has a few shortcomings where the rules have expanded from time to time. New rules will be simply added in the rulebase and after a while the rulebase becomes very large. Consequently, the system is no longer reliable and the company needs to rewrite the system to get better results.
MYCIN	MYCIN is another application in expert system specifically in medical areas. It is developed using LISP programming language by Edward Shortliffe in the late '70s. This application helps diagnose infection in blood diseases. The input of the system is the symptoms of the specified disease and the output is the diagnosed disease together with the degree of certainty and the suggested therapy. The system will ask a series of questions to the user as inputs. This application uses more complex questions to get inputs from users. The inference engine uses the rules in the rulebase during the diagnosing process based on the inputs given by the user.
E-Paddy	E-Paddy is a diagnosis and advisory system developed by a group of researchers in National University of Malaysia (Rossilawati et. al. 2003). The system covers paddy diseases and pest control diagnosis on paddy plant. Up to now, the system is able to diagnose 18 possible diseases, using production rules and frame approach. The system will request input from the user, to get symptoms of a specific disease by presenting series of questions to the user. The input given will be matched to the set of rules in the knowledge base to produce the specific output regarding the disease.

There are many other examples of applications that use expert system technology. Expert system technology has been widely used to assist and improve the decision-making process. Table 10.4 describes some generic categories of expert system and its usage (Turban, 2002).

Table 10.4: Generic Categories of Expert System

Categories	Problems Addressed
Interpretation	Interfering situation description from observations.
Prediction	Inferring likely consequences of given situation.
Diagnosis	Inferring system malfunctions from observation.
Design	Configuring objects under constraints.
Planning	Developing plans to achieve goals.
Monitoring	Comparing observations to plans, flagging exceptions.
Debugging	Prescribing remedies for malfunctions.
Repair	Executing a plan to administer a resented remedy.
Instruction	Diagnosing, debugging and correcting student performance.
Control	Interpreting, predicting, repairing and monitoring system behaviours.

ACTIVITY 10.4

Analyse expert system by using SWOT analysis.

Strengths	Weaknesses
Opportunities	Threats

SELF-CHECK 10.4

(a) What is the role of an inference engine in an expert system?

(b) Give **TWO** examples of applications that use the expert system technique and describe how it helps in making decisions.

10.4 MACHINE LEARNING (ML)

SELF-CHECK 10.5

Can machines learn from us? Why and how does it happen?

Another popular AI technique that can be used in DSS is Machine Learning. This technique allows machines to learn or acquire knowledge from experience (such as historical data). With such a technique, the DSS can provide a more accurate decision. This is because a DSS with machine learning imitates humans suggesting better decisions according to past experiences. The better DSS provides the right decision and influences the right decision for the user.

There are two types of ML; supervised and unsupervised learning.

Supervised learning indicates a process of learning that induces knowledge from a set of data, which the final outcomes are known.

For example, we induce a set of rules from historical paddy diseases data. We already know all possible cases of diseases that might occur.

Unsupervised learning is used to obtain knowledge from a set of data, which the final outcomes are unknown.

For example, we can do classification on users' preferences of different products. We do not know what kind of choices the user might select. Figure 9.3 indicates taxonomy of ML, depicted from (Turban 2004). The details for these methods and algorithms are explained in Table 10.5.

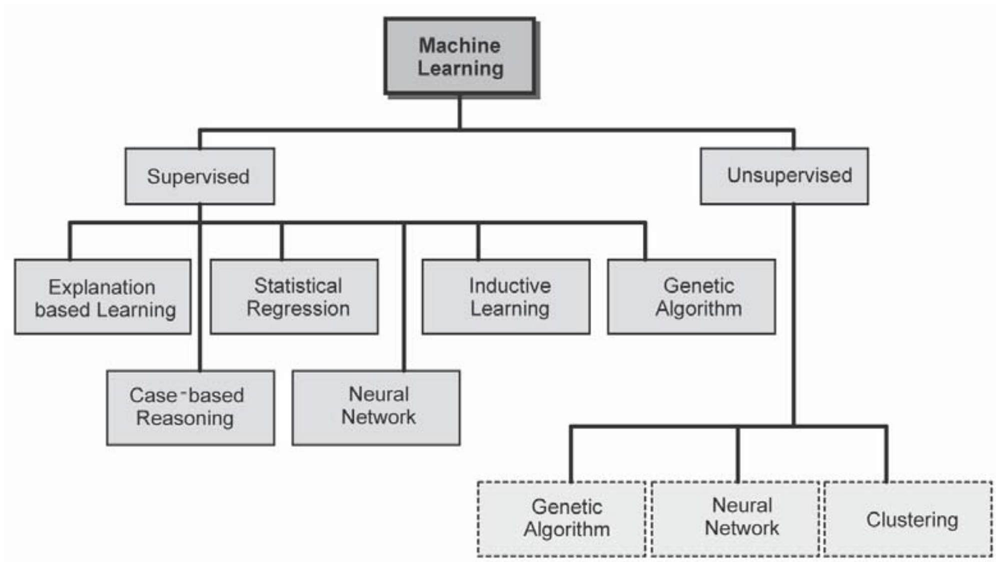


Figure 10.3: Taxonomy of learning methods

Table 10.5: Taxonomy of Learning Methods

Methods	Descriptions
Inductive Learning	Inductive learning involves a learning process performed by example. The system performs generalisation from a specific observation. The generalisation can be used for explanatory or predictive purposes. For example, in explanatory purpose, the system produces a set of similarities from a given set of data. For instance, a customer buying-behaviour study discovers that if customers buy sausages and bread, it is likely that they will also buy butter. In predictive purposes, the system learns from a set of data that is classified into two or more classes. For example, the system is required to classify different types of animals.
Case-based Reasoning	A case-based reasoning (CBR) system works by finding solution to new problems from a historical database and then adapting successful solutions from the past to current situations. For example, if a computer does not start, CBR can be used to match the characteristics of the problem with a database.
Neural Computing	Neural computing is a technique that attempts to imitate the structure and functionality of the human brain. The system that uses this technique will be presented to a set of training data so that the system can learn to solve a specific problem. More on this will be further explained in Section 10.5.

Genetic Algorithm	This technique is used in searching for pattern from a set of data. This technique is based on biological evolution of genetic variation. This technique is often used in optimisation process such as telecommunication network in finding shortest route or in scheduling.It is inspired by Darwin's theory of evolution. This technique solves problem by using evolutionary process. Initially the system is given a set of solutions represented by chromosomes. The set is also called population. The system will try to find the right solution from the population. The chosen solutions will be used to form a new population, which is possibly better than the previous one. The selected solutions are based on their fitness. This process is evolving until some condition is satisfied.
Clustering	Clustering is a technique often used to group data based on their characteristic and often used to discover unknown structure in some given data. For example, in the business area, this technique is used to distinguish or classify customers based on their similarities such as their age, monthly income, or any other factors that affect their buying activities.
Statistical Methods	This method, as the name suggests, uses the basic statistical method such as means, correlation coefficient and variance. This method is suitable for analysing data at the initial stage. This is usually to get the main idea of the structure and relationship of the data.

We have discussed so far that there are many methods and algorithms used under machine learning, which can aid decision support. In the next section, we will be discussing about neural network method in detail and how it can be used to support decision-making.

ACTIVITY 10.5

You can download and read a text book entitled Introduction to Machine Learning by visiting this website at:
http://ai.stanford.edu/people/nilsson/mlbook.html

SELF-CHECK 10.6

(a) What is Machine Learning? List **FOUR** techniques being categorised as Machine Learning.

(b) What benefits does Machine Learning provide?

10.5 ARTIFICIAL NEURAL NETWORKS

Artificial Neural Network (ANN) is one of the AI techniques that can support decision-making. The term 'neural network' comes from a biological term, which is a collection of neurons that form our brain cells. ANN can learn from experience like humans do. In general, neural networks are used in pattern recognition, generalisation, and prediction. Neural networks are trained by showing examples data or historical data repeatedly. The data contain the input and the desired output for a particular problem. The network uses the input data during the training phase, which is to learn to achieve the desired output. When the network has succeeded in mastering the learning process, the network can be tested by a new test data and the result should prove that the network should still be able to predict the correct output. Neural network software packages are widely used in business areas especially in stock market prediction and credit card fault detector, to name a few. In the medical area, neural networks are also used in health monitoring and diagnosing diseases. It clearly shows that the capability of ANN is useful in various areas of DSS.

10.5.1 Basic Components of ANN

ANN represents as several interconnected simple perceptron as a parallel computing procedure. Each perceptron (referred to as 'node' or 'neuron') and only concerned with signals that it sends to, and signals it receives from other perceptrons. Each perceptron cooperates with other perceptrons in a large network to perform the required task. For example, in the business area neural network can be used to help us decide whether a candidate is qualified for a bank loan, or forecast the stock market prices.

(a) **The Perceptron**

Figure 10.4 presents a single perceptron in a network. The neuron receives several signals as input from other connected perceptron as well as sending its signal to the other perceptrons in the network as an output. For every input unit in a perceptron (including the bias) there will be a corresponding **weight**, like the following:

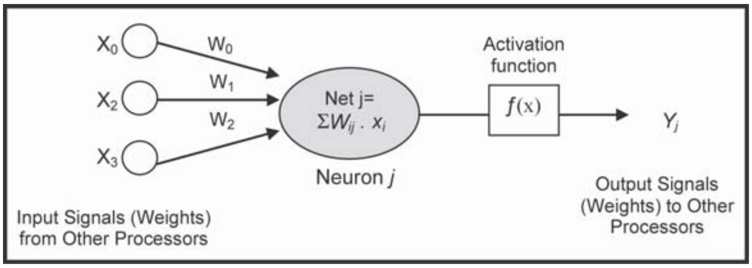


Figure 10.4: A single processor in a network

X_0 is the bias, while x_1 and x_2 are the inputs with the respective weights values of W_0, W_1 and W_2. Bias is a numeric value typically between -1 and 1 or -0.5 and 0.5. Bias is added to the sum of the weighted inputs to a neural network layer.

Each perceptron is capable to compute the output signal to the other perceptron. To get the combining input value, we multiply the inputs with the corresponding weights as the following:

$$Net_j = \sum_{i=1}^{n} wij.xi \qquad W_{ij}.xi....(1)$$

where

Net$_j$, is the summation of multiplication of input values *xi* with the respective weights *Wij*; and n is the number of connected neurons.

There is also another function to calculate the output signal, called the activation function, *f(x)*. This function is to normalise the value of combined input value *Net$_j$*, that later becomes the final output value for the neuron. This output value will either be sent to the other neurons as input or it might be the final output for the network.

The value *Net$_j$* is used as an input to an activation function to determine the final output signal. For example, the activation function might be a binary threshold function such as 1 as YES and 0 as NO according to the value of *Net$_j$*.

(b) **Activation Functions**

An activation function in a network will determine the output signal of a neuron. The calculated output signal is sent to the other neurons as input. The final output could be a real number, or real number within a tolerance interval [0-1], or a discrete number like {0, 1} or {-1, +1}. A simple example of activation function is the binary threshold function. This function limits the value of Y_j (the final output) to 0 or 1 depending on the value of Net_j relative to a particular threshold value, q. This is illustrated in Figure 10.5.

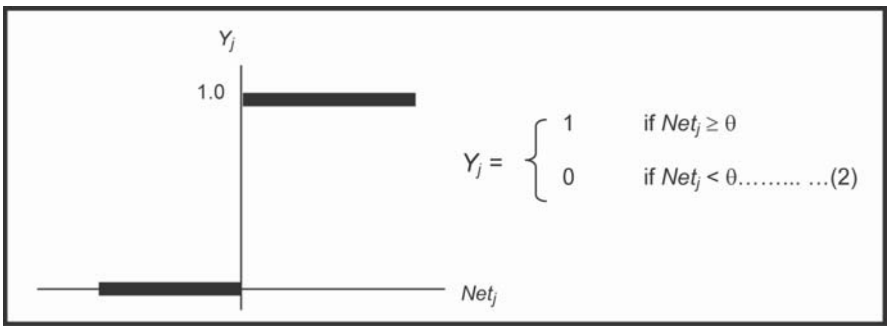


Figure 10.5: The binary threshold function

Next, we will see an example of calculating the output signal of a perceptron.

Example 10.1

Figure 10.6 shows how the calculation of combined input Netj for neuron j illustrated in:

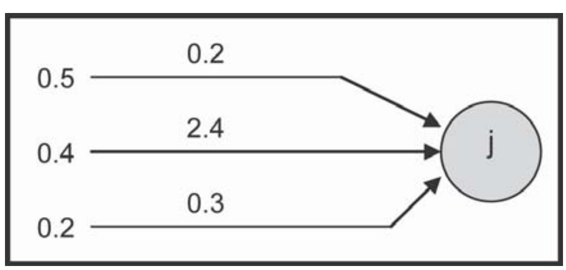


Figure 10.6: An example of calculating the combining input in a neuron

$$\begin{aligned} Net_j &= \sum_{i=1}^{n} W_{ij}.x_i \\ &= (0.5 \times 0.2) + (0.4 \times 2.4) + (0.2 \times 0.3) \\ &= 1.12 \end{aligned}$$

or alternatively, we can use matrices like the following:

$$[0.5 \quad 0.4 \quad 0.2]\begin{bmatrix}0.2\\2.4\\0.3\end{bmatrix} = 1.12$$

(c) **A Learning Rule to Adapt the Weights**

The neural network must be trained to adapt the weight, which means that the network must calculate the weights so that the desired output is as close as the actual output. Therefore, training the perceptron requires us to modify the weights every time the calculation is made. A simple and effective learning rule is the Delta rule. According to this rule, the difference between the desired output and the actual output is calculated, and then used to adjust the weights. The following is the formula to adjust the weights.

Calculate the difference, δ:
δ = *desired output – actual output;*

adjust the weight:
$\Delta w_i = x_i \; . \, \delta;$

and the new weight is calculated as:
$w = w + \Delta w_i$

The main goal of the learning process is to decrease the value of δ so that the actual output is as closed to the desired output as possible by adjusting the weights.

(d) **ANN and Classification**

Following is an example that shows us a network that learns the AND relationship. Table 10.6 shows the AND operator's truth table, where the output can only be true if either x1 AND x2 is true (value = 1).

Table 10.6: The AND Relationship

INPUT		DESIRED OUTPUT
X_1	X_{2x}	
1	1	1
1	0	0
0	1	0
0	0	0

Suppose that we run the network using the sequence of four input patterns according to the table. Figure 10.7 shows the result of the network that correctly draw a line based on the input value of x1 and x2. This line shows how the outputs are classified. The shaded area represents output of 1, which occurrs when x_1 and x_2 are equal to 1. The other part that is not shaded indicates the output of 0.

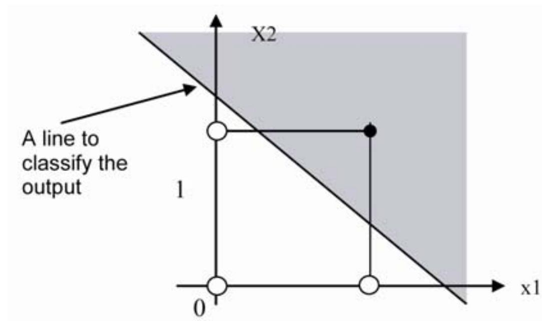


Figure 10.7: Graph plotting for the AND operation

To calculate the Net_j we use the equation (1) like the following:

$$Net_j = \sum_{i=1}^{n} w_{ij} . x_i$$

and then *Net* is used as an input to the activation function, as in the equation (2). The value of Y equal to 1 only if the Netj is greater or equal to the value q; otherwise Y is equal to 0. Therefore, we can see that the input can be split into two parts (less then q, or greater or equal to q). This condition can be explained by:

x1w1 + x2w2 = q …………..(3)

assuming that is 0.2, and w1 and w2 are both 0.1, therefore

$0.1 \times 1 + 0.1 \times 2 = 0.2$ or

x1 + x 2 = 2 which represents the line in the graph.

The main drawback of a perceptron is that it can only classify data that is linearly-separable. If the perceptron is trained on data; it cannot be classified with a line, the weights will not be able to achieve the desired output. Therefore, we must enhance the perceptron to be multilayered. This will be further discussed in the next section.

(e) **Multilayer Perceptron**

A multiplayer perceptron has at least three layers of neurons, the input layer with the input units, middle layer that is also known as hidden layer, and output layer with the output unit. Input unit takes input directly from the environment like keyboards, sensors and so on. Similarly, the output unit sends output directly to the environment. Meanwhile, middle layer or the hidden layer consists of hidden units and they are not directly connected to the environment.

Each neuron is connected to the other neurons in the adjacent layer. There can be more than one hidden layer depending on how we model our network. The neurons can be connected to one another in various ways. Each neuron can be connected to every other neuron, or each neuron can only be connected to the adjacent neuron on the other layer. Also, there are models that allow feedback connection to the other neuron on the adjacent layer and so on.

As discussed in the previous section, multiplayer perceptron can be used to solve the nonlinearly-separable problem. For example on this problem is the Exclusive-OR (XOR) problem. The truth table of the XOR problem is shown in Table 10.7.

Table 10.7: The XOR Relationship

INPUT		DESIRED OUTPUT
X1	X2x	
1	1	0
1	0	1
0	1	1
0	0	0

The XOR relationship only gives the output equal to 1, when only one input is set to 1. We cannot use a perceptron to handle this problem, because it cannot classify the two inputs using a line, which is illustrated in Figure 10.8.

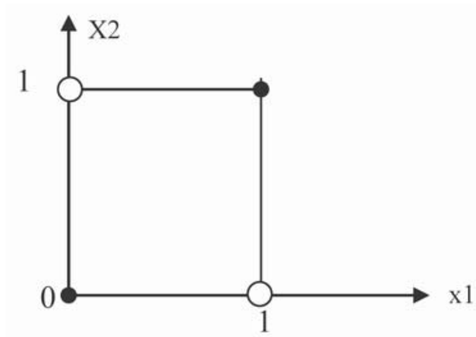


Figure 10.8: Exclusive-OR relationship

The black dots represent the output of 1 and the white dots represent the output of 0, according to the input value of x1 and x2. There is no separation or boundary to distinguish the two outputs. We can use multiplayer perceptron with hidden layer to solve this problem. Here, we will use a model suggested by McCulloch-Pitts (McCulloh, 1943). The network will use two input units; a hidden layer with two units representing the two lines and one output unit as shown in Figure 10.9.

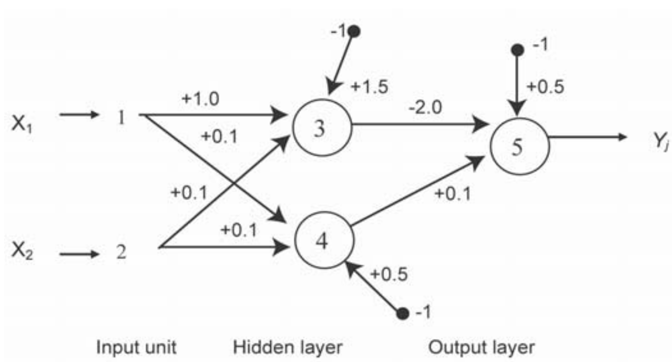


Figure 10.9: The network represented by McCulloch-Pitts for solving the XOR problem

As indicated in Figure 10.9, the network has 3 layers that are the input layer, the hidden layer and the output layer. The input layer contains 2 input units, which are labelled with 1 and 2. This unit will take inputs from X_1 and X_2. The hidden layer contains another two units labelled with 3 and 4. This output layer will contain the final output of the network. After training the network, the lines created by this network can be illustrated like Figure 9.10 (a — c). In Figure 10.10 (a), the line is created by perceptron labelled '3' while Figure 10.10 (b) shows the line created by perceptron '4'. Perceptron '5', which is in the output layer will compute a linear combination of the two inputs from the hidden layer that finally solve the XOR problem, as shown in Figure 10.10 (c).

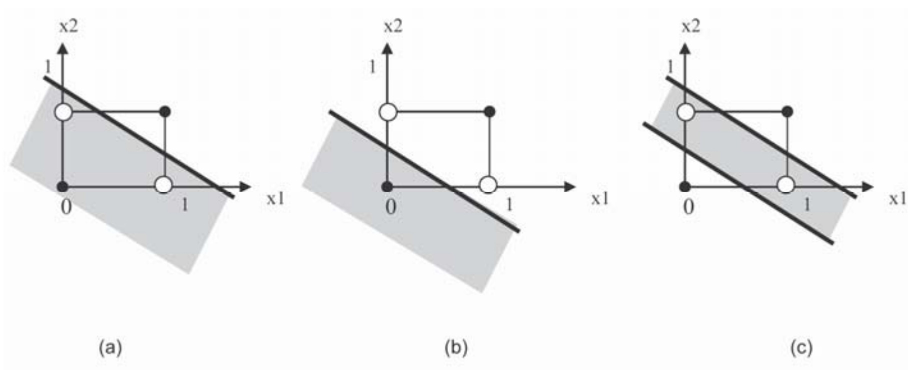
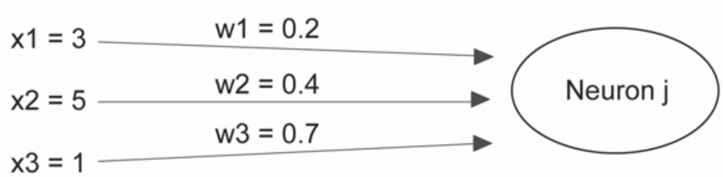


Figure 10.10 (a): The first line constructed by perceptron '4';
Figure 10.10 (b): The second line constructed by perceptron '5';
Figure 10.10 (c): The complete constructed line performed by the network

ACTIVITY 10.6

Calculate the combined input for the following neuron:



10.5.2 Examples of Applications using ANN Technique

So far, we have discussed briefly on ANN. Let us discuss on some common applications that use ANN technique to support decision-making. The ANN is not like the expert system DSS. The ANN is a technique of AI that embedded DSS. It is part a DSS model.

Following are some problem areas where ANN is used:

(a) **Capture Hidden Fact or Pattern**
ANN technique is popular in data mining mainly to enhance the process of discovering hidden fact or pattern from huge data stores. The hidden fact

and pattern are very useful to an organisation in decision-making process. For example, an organisation wants to discover the spending pattern of their consumers, so that classification on the customers can be built based on their history of spending. ANN is also used in identifying and finding irregularities in tax fraud.

(b) **Make Prediction**
ANN is also used in making prediction, decision-making using data mining in various areas such as medical, business and transportation (Table 10.8).

Table 10.8: Areas of ANN Usage in Decision-making

Areas	Descriptions
Business World 	• A bank can use the application to predict and determine any chances that specific companies will likely file for bankruptcy, if given the historical data of that particular company. The result will help the bank in making better decisions. • Sales forecasting and targeted marketing evaluation in airline managements. • Prediction of customer behaviour in order to plan e-commerce advertising by predicting customer behaviour on the Internet. • Sales forecasting and targeted marketing evaluation in a new product analysis. Technique analysis of a new product in previous topic is not done using large past data. It influences the accuracy of decision-making. • Analysing in various investment alternatives including pricing of initial public offerings in stocks, bonds and commodity selection and trading. • Assessing the strengths and weaknesses of corporations and prediction of possible failure in financial analysis. • Predicting employee performance and behaviour and analysing personnel requirement.
Medical 	• Prediction on what is the best treatment needed to be done for the heart disease using the past data of heart disease treatment. Similarly in other areas of medical treatment such as high blood, diabetes, cancer, to name a few.

<table>
<tr><td>Transportation
</td><td>ANN can be used in airline management system by forecasting the seat demand and crew schedulling.
Prediction on how many transportations are needed and the frequency of the services in particular time, route and areas.</td></tr>
</table>

(c) **Approval Process**

ANN is also used in the approval process of credit card application. This application is able to detect any fraud done by the cardholder. It is not an easy task to detect frauds, as there is massive users' information stored in large databases. ANN is used to enhance the process of detecting the frauds by finding hidden pattern and evaluating it with the information stored in the database. This is because ANN is very powerful in handling massive data. Other usage of ANN in approval processes are:

(i) Used in decision-making on loan application evaluation. It is used when judging the worthiness of loan application based on the patterns of previous application.

(ii) Used to evaluate the personnel and job candidates by matching personnel data with job requirement and performance criteria.

(iii) Used in signature validation by matching with the previous signatures.

(d) **Classification of Complex Data**

In biotechnology area, ANN is used in Human Genome Project, to classify the DNA of the human body. There are billions of DNA sequences in the human body. This project aims to classify new genes according to their respective proteins. The application integrates ANN technique to help in analysing the data.

There are many other applications that use ANN to enhance a decision-making process, regardless of the tasks specified. Indisputably, this technique has helped people in achieving better results and thus making a decision process even better.

ACTIVITY 10.7

(a) You have learnt about intelligence decision support system throughout this topic. Now, make a conclusion about AI by using SWOT analysis.

Strengths	Weaknesses
Opportunities	Threats

(b) You can gain additional information about Artificial Neural Networks by visiting this website. http://www.dacs.dtic.mil/techs/neural/neural_ToC.html

SELF-CHECK 10.7

(a) What is Artificial Neural Network?

(b) What is hidden layer in multilayer perceptron? Why is it called *hidden* layer?

(c) How do we calculate the combined input value of Net_j?

(d) List three applications that use the ANN technique and how ANN helps in decision-making.

SUMMARY

- This topic has shown a lot of techniques to produce a better, faster and more accurate decision-making which paved the way to the development of decision support system.
- Researches have integrated Artificial Intelligence (AI) elements in the system so that the decision-making process can be improved to produce better results.
- Today, AI embedded in DSS has dominated our world, which shows the importance of AI in assisting decision-making processes.
- Besides that, the use of intelligent agent surely enhances the DSS while facing the fast changing dynamic information of this decade.

KEY TERMS

Artificial Intelligence (AI)
Expert System
Fuzzy Logic
Genetic Algorithm
Inference Engine
Knowledge Base
Knowledge Engineer
Machine Learning
Neural Network

SELF-ASSESSMENT 1

Instruction: Answer all questions in exactly 15 minutes.

1. What is Artificial Intelligence (AI)? What makes AI important in making decision? (5 marks)
2. Give **THREE** examples of AI fields. (3 marks)
3. What is the Expert System? (2 marks)
4. Explain briefly how neural network uses historical data. (5 marks)
5. Describe the main component of Artificial Neural Network. (5 marks)
6. Explain how neural network is used in prediction of today's price stock market price. (5 marks)
7. How are agents used to get information on the best buy of a plane ticket? (5 marks)

SELF-ASSESSMENT 2

Instruction: Answer all questions in exactly 30 minutes.

1. Describe the general architecture of the Expert System. (6 marks)
2. List **FIVE** technologies used in Machine Learning. (5 marks)

3. Give **THREE** examples of applications that use Expert System in decision-making. (3 marks)

4. Describe the benefits of integrating ANN in Credit Card Fault Detector. What will happen if this is not implemented? (6 marks)

5. What is the role of an activation function in Neural Network? (5 marks)

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