

THE ORGANISATIONAL EFFECTS
OF INSTALLING A
DISTRIBUTED PROCESSING SYSTEM

by

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SYNOPSIS

Since its introduction to business in 1952, computerised data processing has undergone a number of substantial changes, both in the hardware and the techniques that are used. The introduction of miniaturisation, and the resultant lowering of the costs of circuitry, has led to the widespread use of mini- and micro-computers. There has also been a large increase in the use of communication facilities.

Initially, almost all organisations centralised their computer facilities at the Head Office and systems were run in the batch mode. The need to service the requirements of remote users was resolved by installing on-line facilities and providing unintelligent terminals to those users. Alternatively, stand-alone computers were installed at the remote locations.

However, the requirements of businesses for centralised reporting and control led to the need to instal processing units at the user sites and to connect those computers, via communications links, to a computer facility located at Head Office. In this way distributed data processing evolved.

The provision of this type of processing mode has important implications to the organisation in such areas as costs, staffing, planning, control and systems design.

(ii)

This thesis, therefore, investigates the current (1980) trends in relation to distributed processing. It specifically examines the developments in hardware, software, and data communications. It assesses the criteria that should be considered by an organisation in selecting either the centralisation or distribution of its processing facilities.

Through a field study both successful and unsuccessful distributed installations are examined.

Conclusions are then drawn and recommendations made, to provide management with working guidelines when assessing the feasibility and practicality of distributed processing for its organisation.

The findings of the study are appropriate for both general management and DP management with only centralised computing experience; and for individuals offering professional computer consultancy services to existing or potential users.

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I certify that the thesis is my own work and all references are accurately reported.

Signed by candidate

P.M.Q. LAY

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CHAPTER 1BACKGROUND

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CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

This thesis is concerned with the concept of Distributed Data Processing (DDP) and the factors that should be considered by the organisation in implementing and controlling it.

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DDP represents a form of decentralising the computer power in an organisation, or "Putting computer power where the people and business problems are".¹ It is also a relatively new concept in computer processing :

"When you talk, however, about completely distributed systems . . . you are talking about things that are still largely experimental."²

Apart from the technical reasons for the late development of DDP as a processing concept (examined in Chapter 3) the developments in computers in relation to the business requirements must also be examined, to appreciate why it is only now that DDP is emerging as an alternative mode of data processing.

1.1.1 The Problems of Centralisation

In the 1950s there was a strong trend to centralise business functions as a means of controlling the costs and profits of divisions in an organisation. As the purpose of computers is to serve the needs of business, the computing function was, therefore, also centralised. The computer department was sited at the Head Office and the systems were run in batch mode.

In the 1960s businesses started to decentralise their functions and the response from the manufacturers of computer equipment was to supply on-line facilities (whereby terminals are placed in user departments, giving them access to the data stored in the central computer). As the business grew so did the computer, in terms of memory and data storage capabilities. This suited the policies of IBM, which were to supply larger, more powerful mainframes to existing users.

"IBM has been slow to endorse distributed processing, supporting instead the central computer room and its high-capacity but high-priced large central mainframes, mass storage devices and the like."³

This reference, specifically to the policies of IBM, is elaborated in Section 1.2.

Although economies were being achieved through having a large

mainframe, other factors were beginning to emerge :

- (i) To ensure that the hardware was performing adequately, sophisticated software was needed. The greater the sophistication, the greater the cost and complexity of the software. The machine was required to spend more and more time performing 'housekeeping' tasks at the expense of the users' tasks, which, at times, were not handled at all (a concept known as 'thrashing').
- (ii) The Data Processing department spent more time in maintaining existing systems. Attention was being devoted to tuning the installed systems and the development of new systems became a secondary priority.

These two factors degraded the service that was being provided by the DP department to its users :

Matteis : "In a very real sense, the large, centralized data center approach drained our ability to provide the uniquely tailored services our customers demanded."⁴

Hebditch : "Few people would deny that, although this approach could achieve well defined economies, service to the user department (and, in turn, to their own customers) was often impaired."⁵

1.1.2 EDP as a Corporate Resource

In a large number of organisations EDP equipment was first installed to satisfy the requirements of the accounting and finance divisions. Once those cost-reduction applications were implemented, the DP department then became involved in other areas of the organisation such as production planning, marketing and purchasing.

When this occurred, problems arose such as which system would be developed first and which took priority when being processed. As Schilling stated:

"Managers responsible for a profit centre within an organisation have found that their own particular requests had to be queued with those of other managers before being considered by the central DP department."⁶

Even with Steering Committees and a scheduling function within the DP department, these areas were still problematic and led to conflict between the DP and user departments. As DP traditionally reported to the Financial or Administration Director, other divisions felt that they were being forced to take a lower priority and the computer — a corporate resource — was being used primarily to serve the needs of the accounting divisions.

1.1.3 An Alternative Approach

In the mid-1970s, it became obvious that centralised systems (either on-line or batch) were not satisfying the needs of every user, particularly where he was given autonomy over his costs, and an alternative approach was required. This became available with the advent of the low-cost mini- and micro-computers.

"The mood of greater local autonomy and profit consciousness has coincided with the availability of cost-effective local computers."⁷

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There thus arose an alternative to the centralised mainframe, and that was to provide the user with his own smaller computer and to distribute the processing power in the organisation. This, it was felt, would alleviate the problems described in 1.1.1 and 1.1.2.

(An important point to note is that centralised or decentralised systems are not mutually exclusive in an organisation, and that one can have a mix of the two. Indeed, in large organisations there are inevitably some applications (such as purchasing, credit control, etc.) that are centralised and some (marketing, stock control) that are decentralised. That organisation would then employ both modes of processing. What is important is that it now has the choice.)

However, there are a large number of factors that should be taken into account when considering the choice, such as :

Costs

Staffing

Security

Availability.

The choice between centralising or distributing is not an easy one and the cost of reversing a decision can be extremely expensive. The organisation should thus be aware of the factors that are liable to affect it and should reach a decision only after careful analysis.

This is illustrated by the International Data Corporation :

"The biggest questions, however, are management ones. And most of them centre around control.

Where should the responsibility for DDP decisions lie? Who should do the programming? Who evaluates the success of the project? How far down the line should hardware acquisition decisions be placed? Do many local data files, each perhaps more vulnerable than a single central data file, offer better system security than a single large file? How much change can an organisation dictate to its line units? Must the pressure for change come from within operating units?"⁸

These are all questions which, if not answered before

developing and implementing a DDP system, could materially affect the success of the installation.

The title of the thesis is "The Organisational Effects of Installing a Distributed Processing System". The effects that are analysed are those that are liable to have an impact on the organisation *after* the decision has been taken to distribute its systems. These are summarised in Figure 1.1 (overleaf).

The factors that should be considered when choosing between centralisation and decentralisation are analysed in Chapter 4. The remainder can all have different methods of approach and can affect the organisation in various ways. The main purpose of the thesis is thus to analyse these and to recommend the most favourable approach.

1.2 OBJECTIVES, METHODOLOGY AND LIMITATIONS

1.2.1 Objectives

The objectives of this study have been directed towards :

- (i) Defining the nature and components of a DDP system including such aspects as the networks and the organisation of data.

PHASES IN A SYSTEM	FACTORS TO BE CONSIDERED
Preliminary survey	Centralisation versus decentralisation
Decision in principle	
Feasibility study	Hardware Staffing Network Organisational changes
System proposal and final decision	
Systems development	System design standards Operating techniques Allocation of development teams Final design Programming Education
Implementation	Conversion Implementation On-going control

Figure 1.1 : Summary of the Factors to be Considered in the Development of a DDP System

- (ii) Tracing the technological developments of hardware, software and data communications that have made DDP possible.
- (iii) Examining the implications of DDP on the organisation. These relate to :
 - Factors to be taken into consideration in the centralisation/decentralisation issue.
 - The effects that installing a DDP system may have on the organisation.
- (iv) Recommending the approach to be taken by an organisation that is considering DDP and the factors to be taken into account in ensuring its on-going success.

1.2.2 Methodology

There are seven Chapters in this study, and within each Chapter there are sections and sub-sections separately numbered. All Figures used are shown in the main body of each section, while footnotes can be found at the end of each Chapter.

- Chapter 1 introduces the subject of DDP and gives a background to the study.

- Chapter 2 defines DDP. It describes the components of a DDP system in terms of the hardware and the network. It then analyses how data is to be stored and examines aspects concerning the flow of data. The subject of data bases is dealt with, but on a superficial level only.
- Chapter 3 examines the evolution of hardware, software and data communications. The reason for this is to give the reader an appreciation of the technological developments that have taken place making DDP feasible.

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- In any large organisation there is a choice between centralisation and decentralisation of some or all of its systems. In reaching a decision, several factors should be examined. Chapter 4 itemises these and presents arguments both for and against DDP.
- Chapter 5 is concerned with the field studies undertaken in this thesis. Four companies were selected. The reason for that number is twofold :
 - The study had to be in-depth in order to gain a full appreciation both of the systems and the reasons for choosing DDP as the mode of processing. To contain the size and duration of the field study four companies were considered sufficient.

- As was explained in the Introduction, DDP is still a new concept. There are, therefore, not that many organisations that have selected this mode of processing. In Cape Town there are only five such installations and one had to be excluded as the firm's policy is to not divulge any information concerning their systems to 'outsiders' (the reasons for the selection of the four companies are analysed in Section 5.1.1).

This chapter, then, analyses these companies and describes their environment. The information was obtained from interviews with senior personnel and users in each organisation.

- Chapter 6 analyses the results of the field study and draws conclusions from the facts and opinions gathered.
- Chapter 7 makes recommendations concerning the implementation of a DDP system. These relate to the managerial considerations that must be examined and resolved by the organisation.

While a large number of articles have been written on DDP, they deal with varying aspects on a very superficial level only. The author was able to find only one book dedicated to DDP and this was "Distributed Processing Systems" by Thierauf.⁹

- Staffing
- Logical design
- Relationships
- Data dictionary

are considered too wide to be included in a research topic such as this.

(ii) Network design

Networks are discussed in Chapters 2 and 3, but the technical aspects of networks design (line loadings, queueing theory, etc.) are considered to be beyond the scope of this thesis.

(iii) Statistical inferences

Due to the fact that four companies were selected for the field study, no statistical inferences could be drawn. All conclusions are based on subjective evaluations.

(iv) The references to IBM

A large number of references are made to the IBM company and its equipment. The reasons for this are twofold :

- The worldwide market of computer hardware is dominated by IBM. This domination relates not only to installations of equipment, but to

1.3 ASSUMED KNOWLEDGE OF THE READER

The subject of Data Processing is, by its nature, a specialised one and employs a large number of technical terms and acronyms. It is assumed that the reader has a knowledge of DP in such areas as :

- Systems analysis and design
- Telecommunications
- Computer hardware
- Software tools
- The DP manufacturing industry.

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In the introductory chapters (2, 3 and 4) a glossary of the more complex terms has been included in the introductory sections. However, these are by no means comprehensive and the author assumes that the reader has a knowledge of the more commonly used terms, for example :

- Modems
- Control units
- Data bases
- Mini-computers
- Micro-computers.

This technical knowledge is, however, only required for Chapters 2 and 3. While the remainder of the thesis

FOOTNOTES

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- (2) EDITORIAL. "What the experts Say", Data Processing, November 1976, p.45.
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- (4) MATTEIS, R.J. "The new back office focuses on customer service", Harvard Business Review, March-April 1979, p.153.
- (5) HEBDITCH, D. "The Distributed Computer", Management Today, September 1978, p.128.
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- (9) THIERAUF, R. Distributed Processing Systems. Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1978.
- (10) SAVANT RESEARCH STUDIES. Lancashire, England: Savant Institute, 1979. The titles of the series are :
1. Distributed Data Processing: The Opportunity and the Challenge.
 2. Corporate Strategy for Distributed Processing.
 3. Distributed File and Data Base Design: Tools and Techniques.

4. Computer Networks and Distributed Processing.
 5. Distributed Processing Network Mechanisms, Standards and Recovery.
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CHAPTER 2THE DEFINITION OF DISTRIBUTED DATA PROCESSING

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disjointed pieces (physical or conceptual) at different locations :

- Computing power
- Computing operations
- Hardware system control
- Software systems control
- Data base
- Any one of the above
- Any two or none of the above
- All of the above simultaneously."²

Taylor : "Distributed processing is a new systems design philosophy which involves the processing and/or storage of data by means of two or more similar types of system component within the same system, interconnected via on-line communications links."³

Donaldson : "The definition of distributed processing which seems most appropriate is 'Putting computer power where the people and business problems are'."⁴

Hoffberg : "DDP, in its most basic form, then, is the separation of data processing into appropriate parts and the spreading of them out, generally, among two or more geographic locations."⁵

Graham : "In keeping with the delegation analogy, I see it as the sharing of a workload among multiple, interdependent, semi-autonomous processors so that each processor has the means to handle the

activities in its immediate frame of reference and can call on the central site to deal with more 'global' affairs."⁶

Whilst all of the above definitions indicate that processing power is moved from the central site to the users, the way that this is achieved does not seem particularly clear. Thierauf, Taylor and Graham mention (or imply) that the systems are interconnected by communication lines, while Thierauf's is the only definition that discusses mini- or micro-computers. Furthermore, none of the definitions draws the distinction between distributed and decentralised (or dispersed) computing.

This chapter, therefore, examines the types of systems that are available (centralised, decentralised and distributed) and how they differ. Data bases and DDP are also considered.

In any computer system, one of the critical aspects is the origination, storage and flow of data. This is also examined as it relates to a DDP system, without attempting to draw any conclusions as to the best method.

2.1.1 Glossary of Terms Used

The following technical terms are used in Chapter 2 :

Transmission Control Unit - An item of hardware, situated in the same location as the Central Processing Unit (CPU), that controls the transmission of data in a network. This unit has undergone considerable change in that its capabilities have been improved to include such functions as polling and addressing, error recovery and line switching.

Remote Control Unit - This has the same capabilities as a Transmission Control Unit but is placed at a site remote from the central computer.

Slave Computer - A processor plus related hardware that is subservient to the commands of a larger, central computer. It is normally remote from the central computer.

Intelligent Terminals - These are used for data capture and enquiry. Although they have programming capability, the program is normally sent via the network rather than being entered by the user. The programming language normally requires specialist knowledge (thus development and maintenance of the programs would normally be handled by a trained programmer, rather than a user).

2.2 CENTRALISED, DECENTRALISED AND DISTRIBUTED SYSTEMS

Any computer system will typically fall into one of three categories, centralised, decentralised or distributed.

2.2.1 Centralised Systems

This is one where all the processing power is located at one site in the organisation. The applications are either run in batch mode, or the users are given access to the computer via unintelligent terminals.

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The following aspects characterise a centralised system :

- (i) All processing power in the organisation is located at one geographical point.
- (ii) If terminals are linked to the processor they will be either Visual Display Units, typewriter terminals or printers, or a combination of the three.
- (iii) The terminals will not be user-programmable. They may have limited programming capability but these will either be 'hard-coded' (an integral part of the hardware) or will require a high-degree of technical competence, such as is normally only found in a DP department.
- (iv) There will be no auxiliary storage attached to the terminals.

Figures 2.1 and 2.2 (overleaf) illustrate the principle of centralised systems.

2.2.2 Decentralised Systems

The organisation may have multiple processors in different locations but they will not be connected via transmission lines, i.e. they have no means of communicating with each other, other than by off-line methods. Thus, the only manner in which data may be transmitted from computer to computer is through a manual intervention (e.g. post). An example of a decentralised system is shown in Figure 2.3 (page 28).

A decentralised system has the following characteristics :

- (i) Processing will be performed at more than one site in an organisation.
- (ii) Each site will be responsible for the capture, updating and maintenance of the data used at that location.
- (iii) There will be no communications capabilities between any of the computers in that organisation.
- (iv) Each computer site will have its own operations, development and maintenance staff who will be responsible for the running of that site.

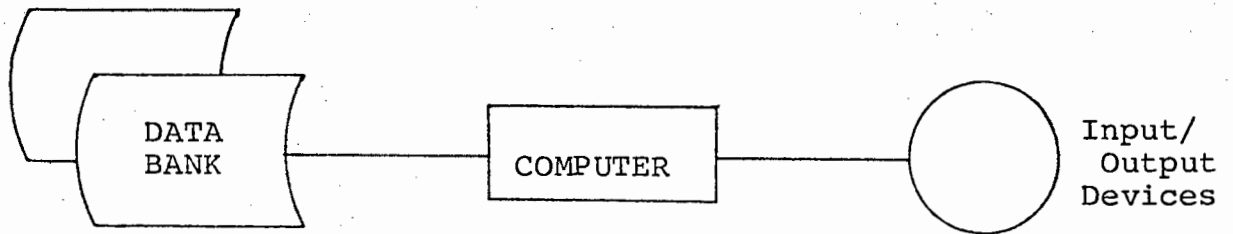


Figure 2.1 : Centralised Layout with Batch Systems

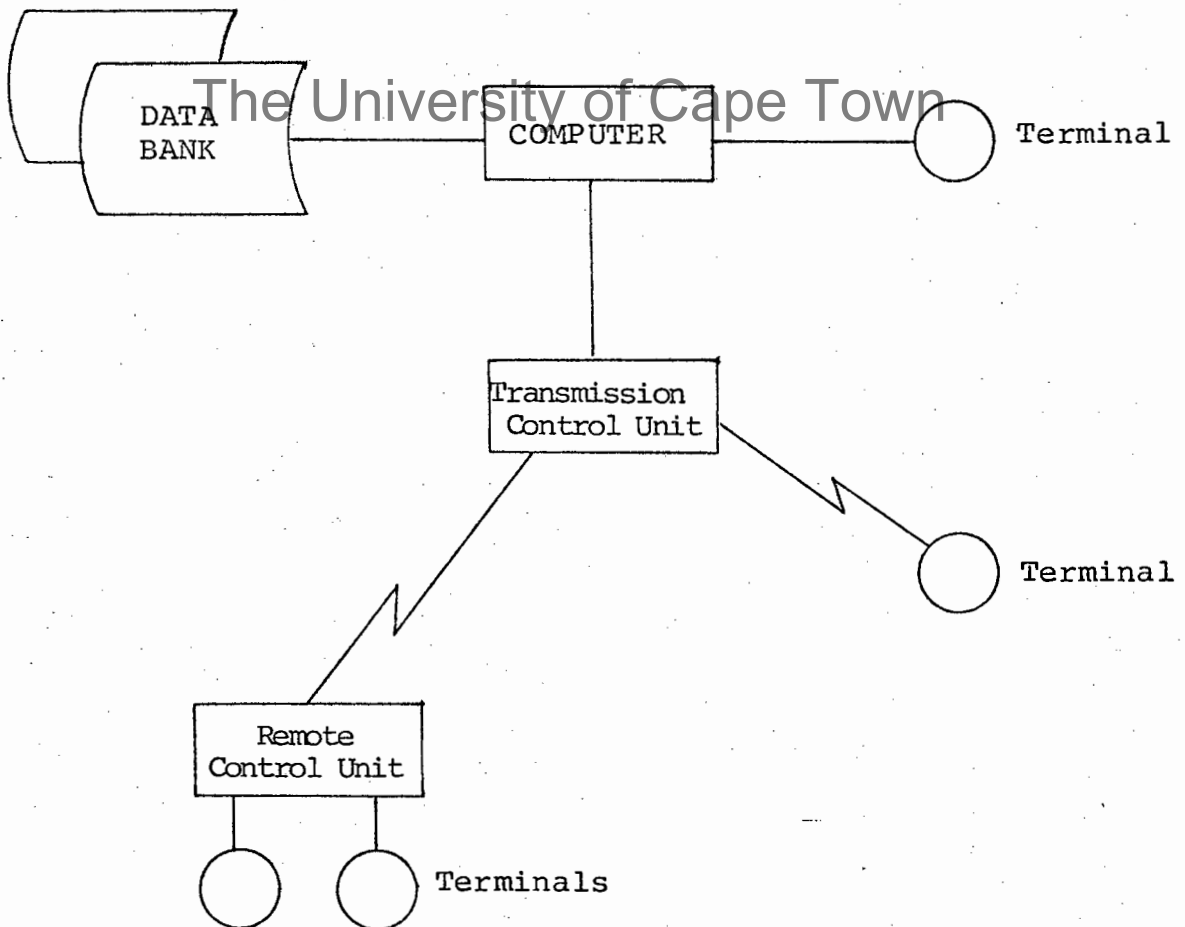
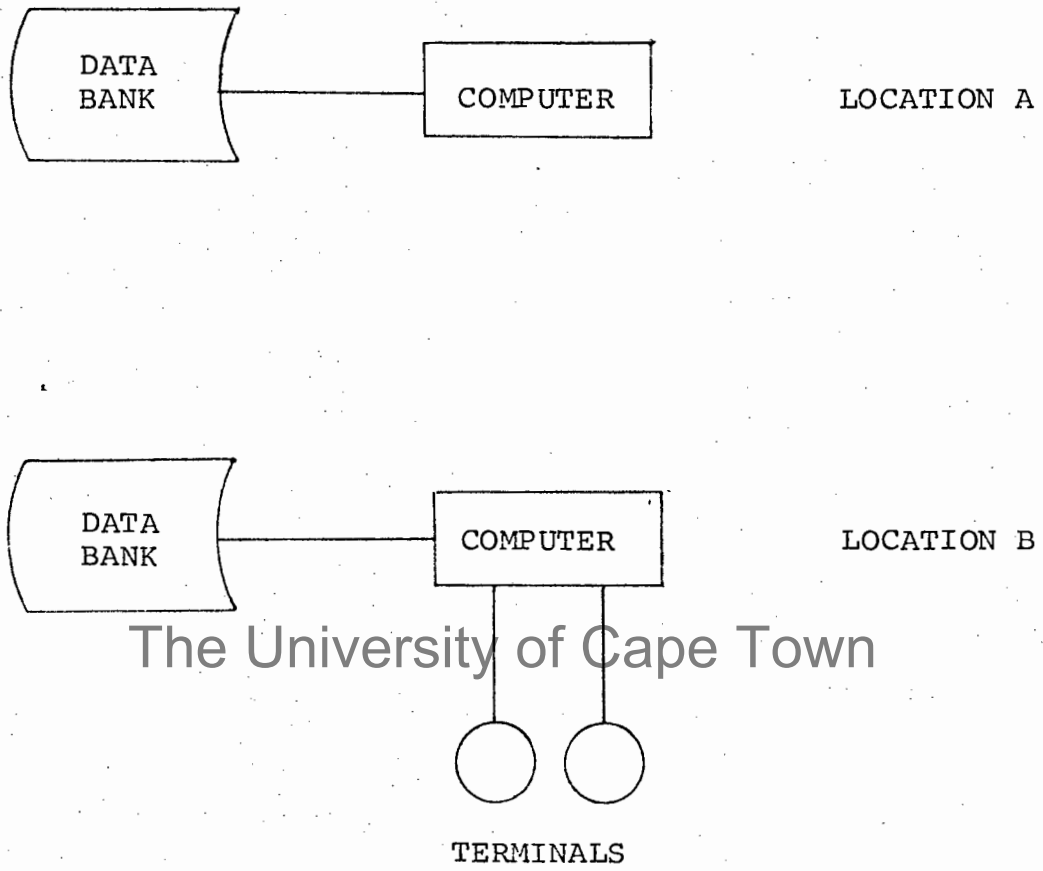


Figure 2.2 : Centralised Layout with Communications Network



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Figure 2.3 : Decentralised Systems

2.2.3 Distributed Systems

The distribution of *processing functions* is not a new concept. In the late 1960s IBM and UNIVAC announced network controllers where the processing of network commands was removed from the Central Processing Unit. Disk input/output routines have also been removed from the CPU. While these are a form of Distributed Processing they represent the technical aspects of a system and are not user related. In a true distributed system the processing power, data storage and program capability are all placed at the user site. Each site where this power is located is capable of communicating either with other sites and/or with a central processor. Figure 2.4 (overleaf) illustrates an example of a distributed system. In this example each 'slave' computer would either be processing its own or a common application. Each could have its own data files, and may be in the same area as the central computer or in a remote location.

The following points will, in general, apply to all distributed systems :

- (i) The organisation will have two or more processors which are geographically separated. This separation applies to the organisational boundaries in that two divisions of a company may be in the

same block of a city but if they have processors that are linked they will form part of a distributed system.

- (ii) These processors must be linked via communication lines (either GPO or direct lines) so that data may be passed between the systems.
- (iii) The processors will be confined within one organisation. This could be a Head Office with multiple branches or divisions, or a Holding Company/ Subsidiary environment. It could equally well apply to a company that places computers in user departments (which could all be in one building).
- (iv) The processors will have the capability of being programmed according to the users' requirements and of storing and processing the data.
- (v) The slave processors will normally, but not necessarily, be application dependent (i.e. they will be used to process one application, for example, credit control).

There are a variety of approaches that may be taken by the organisation when considering distributed systems. In relation to Figure 2.4 (page 30) the hardware discussed below is represented by the 'slave computer'.

Distributed Data Entry - This is the simplest form of distribution where data is captured at a remote site with simple editing and transmitted, via communication lines, to the host computer. There are many systems falling into this category, such as key-to-disk, key-to-tape, key-to-diskette.

Distributed Processing Through Intelligent Terminals - This is the next category in order of complexity. The data is stored at the host processor and intelligent terminals are programmed according to the user's requirements. These might be to

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- Capture transactions entered by the user.
- Perform validation checks (e.g. that fields are numeric, etc.) on the data.
- Access information stored on files.
- Transmit the data to the central computer.

These programs are most commonly transmitted from the central processor and are not usually established directly from the terminal.

Distributed Processing Through Minis/Micros - This is the most complete form of distribution, where the remote computers are capable of storing data, being programmed by the user, and able to transmit data to other computers.

Although distributed data bases are often discussed in this environment, they are more likely to be a collection of files and not a 'true' data base.⁷

There is another category of distribution that is gaining prominence and that is distributed word processing. In this type of system word processing typewriters are connected through communication links and can transmit and receive text. This concept is often discussed when referring to the 'office of the future', however, it is considered to be beyond the scope of this thesis.

2.3 NETWORK ORGANISATION

From the preceding analysis it is evident that one of the more important aspects of a DDP system is the network that links the computing sites. While this study will not examine the technical aspects of network design, such as queueing theory and response time optimisation, it is necessary to show how the networks may be organised in terms of the central and user sites.

There are two types of networks that exist in a distributed environment, horizontal and hierarchical (or vertical).

2.3.1 Horizontal Distribution

"In horizontal distribution all devices co-operate at an equal level, logically, to perform an equal set of tasks."⁸

No one system is subordinate to any other except possibly to the central processor. An example of this type of network is shown in Figure 2.5 (overleaf).

This type of network would typically relate to a Head Office/Subsidiary organisation where each would need a large, central computer, and both may have slave computers handling user applications.

2.3.2 Vertical Distribution

"In vertical distribution the interconnected devices form a hierarchy, sharing tasks in a structured way with each component controlled to some degree by the higher level member(s) of the hierarchy."⁹

A large hierarchically distributed system would thus take the form illustrated in Figure 2.6 (page 36).

A distributed system may consist of a mixture of horizontally or hierarchically designed networks. For example, in

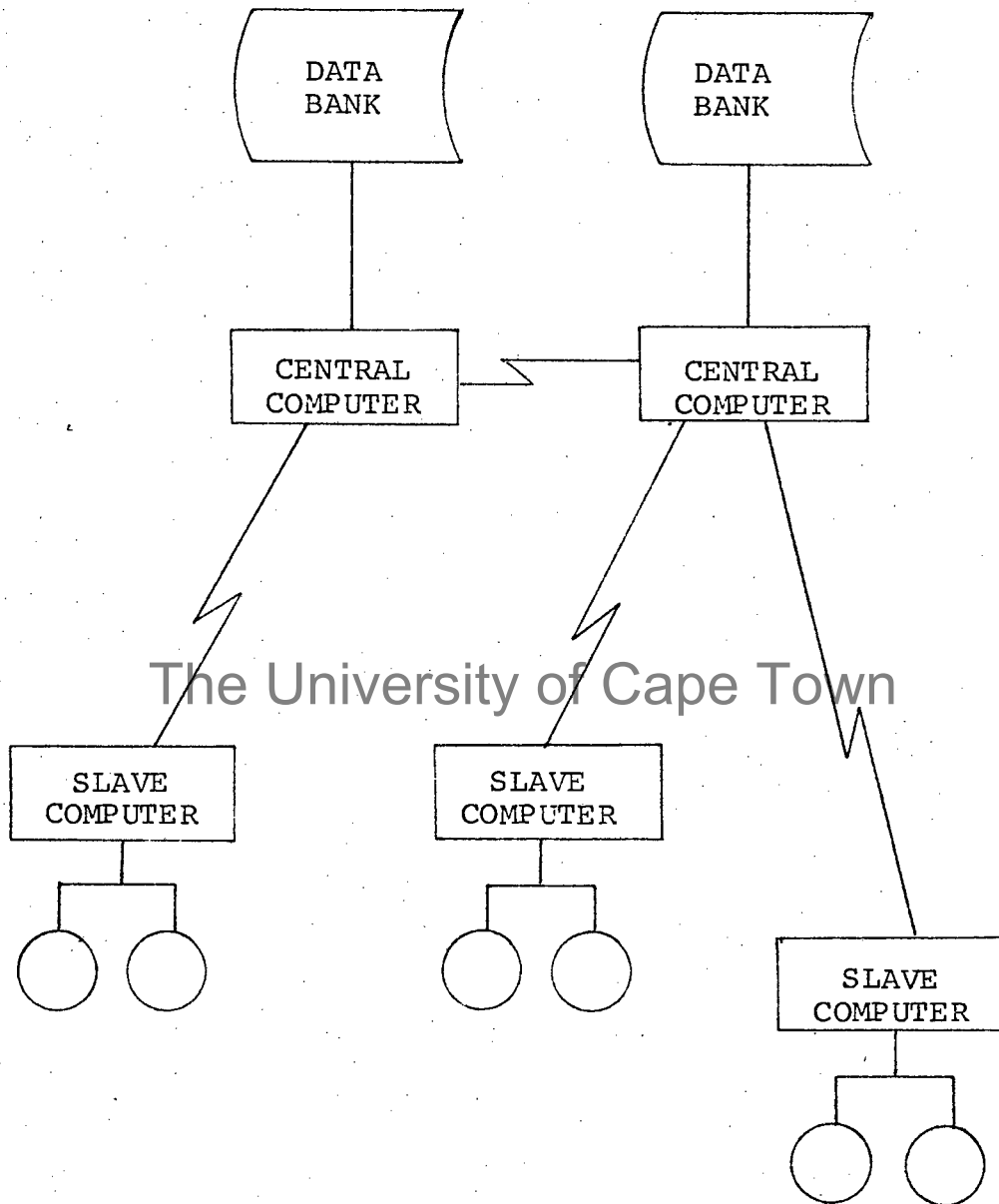


Figure 2.5 : Example of an Horizontally Distributed Network

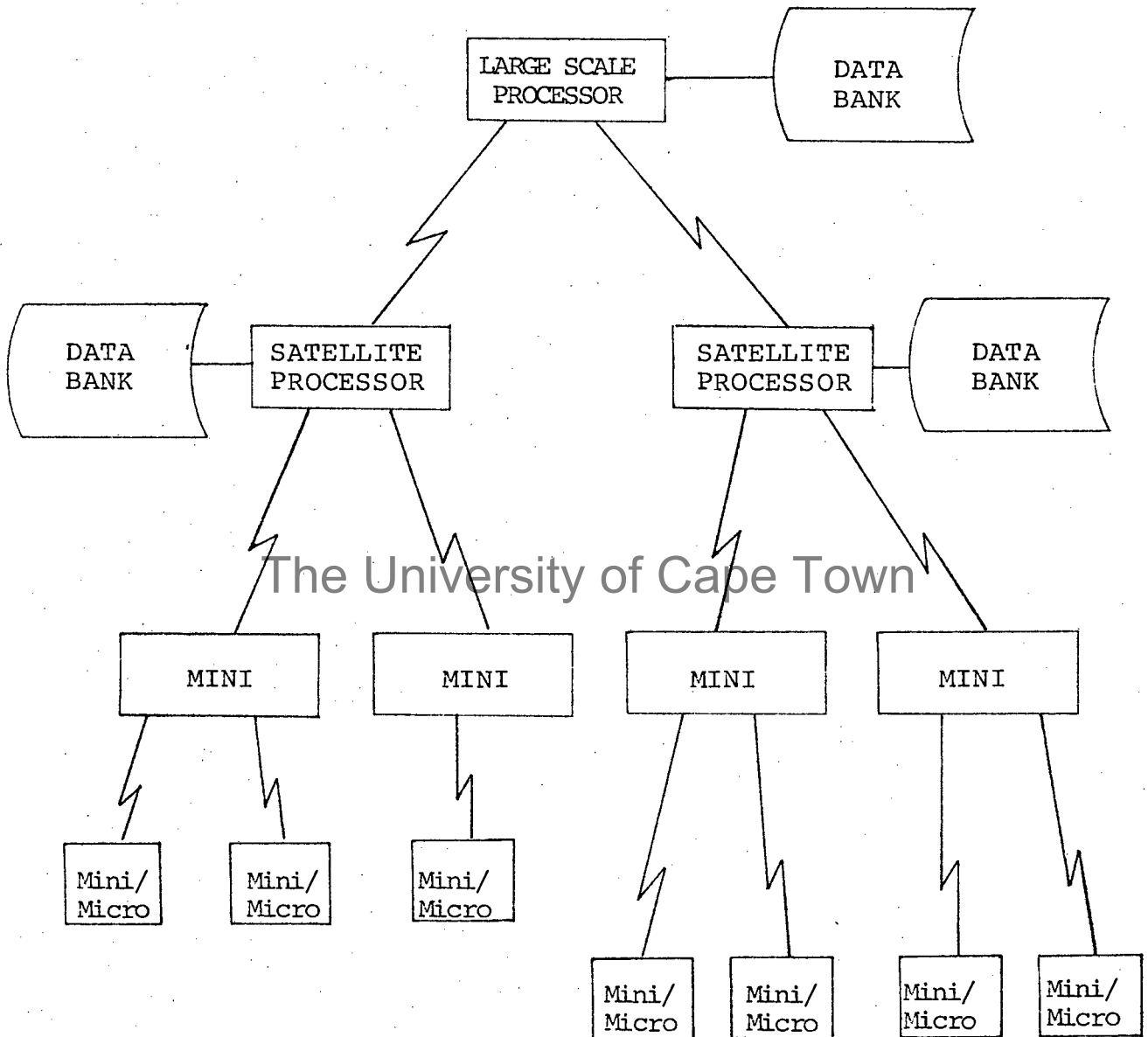


Figure 2.6 : Example of an Hierarchically Distributed Network

Figure 2.5, the large scale processor may be connected via a remote line to another processor which could have the network shown in Figure 2.4 connected to it.

It is important to note that, although all the above examples show slave computers being connected to the central computer, this does not necessarily have to be the case. These could be intelligent terminals provided they are user programmable, and have data storage capabilities.

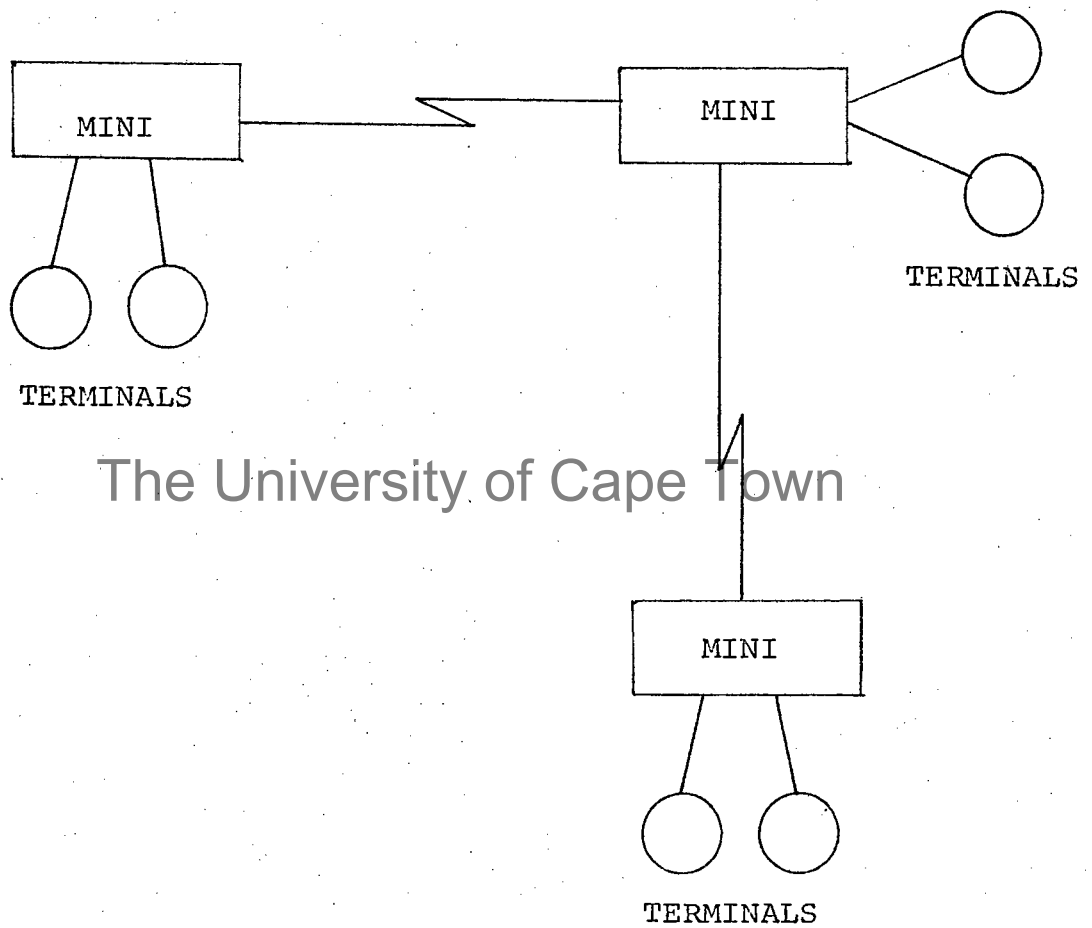
In addition, a distributed system may consist of minis or micros with no large central computer, as in Figure 2.7 (overleaf).

2.4 DATA FLOW IN A DDP ENVIRONMENT

Although the hardware and network configurations are an important aspect of DDP, another consideration is the organisation of data within the company. There are two methods available, i.e. centralised or decentralised data.

2.4.1 Centralised Data

In this method all data is held at the central computer. The purpose of the slave computers is to capture and edit the transactions at source (i.e. at the user sites). The



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Figure 2.7 : Example of a Distributed Network Using Only Minis or Micros

editing may take two forms. In the first case it consists of batching the data and performing 'unintelligent' checks on the data (modulus 11 checks, hash totalling, numeric checks, etc.). In the second case, stripped versions of the master files are held on the slave computers which then, for example, check that account numbers exist.

Having edited the data in both cases, it is sent to the central computer for file update. Reports for each location are then sent back to the user sites for printing.

2.4.2 Decentralised Data

In this case full application processing takes place at the user site. Master files are held at the source, data is captured, edited, and used for update. Reports are also printed at the user location. Only data that is required at the central site is transmitted, usually in summary form.

When deciding which method to choose, due consideration should be given to the following aspects :

- Access time and turn-around time for capture and enquiry.
If the user requires immediate response, then the data should be stored at that user's site.

- The recovery time in the case of system failure. If the data is decentralised, the recovery time is likely to be quicker than if it is centralised.
- Data security. The further the data has to travel to its ultimate storage site, the greater is the likelihood of loss of integrity.
- Conformity to organisational standards. It is far easier to ensure that standard coding structures are maintained if all data is held on a central computer.

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2.5 DATA BASES AND DDP

Distributed Data Processing appears to be moving against one of the leading developments of the 1970s, that of the data base. As has been stated in Section 2.4, one of the alternatives is to store data at each user location.

However, the use of a data base is normally associated with centralised data. Doouss and Collins state :

"The use of distributed intelligence looks as if it is cutting completely across the data base objective. It is even, in some cases, pulling application files away from the centre out to remote locations."¹⁰

However, there are a number of reasons why DDP is not

contradicting the concept of a data base. In a large organisation there is likely to be a vast volume of data to be processed. If this is being held in one logical data base, the updating of information is liable to be slow because of the high software overhead of maintaining indices, etc. If files are held at user locations in a distributed environment, the slave computers can relieve the central computer of a high processing overhead by editing and sorting the data into the sequence that will be most efficient for data base update. Alternatively, summary transactions may be created at the remote location and sent to the central site, again relieving the load of the main computer.¹¹

There is also the possibility of physically distributing the data base. Although sections may be sited at locations remote from the central computer, one could still view all the separate entities as one logical data base. There are two categories of distributed data bases :

- Partitioned data bases; and
- Replicated data bases.

2.5.1 Partitioned Data Bases

"This category of distributed data base exists when a conceptual data base is separated into sections and spread across multiple computers."¹²

In this method the data base is split but is designed as one *logical* entity. It would be split according to the access and update requirements of the various users of the data, as can be shown in the following example :

Consider the case of a company that has a factory and a sales office which are situated in two towns with a computer in each. The production and stock sections of the data base would be located at the factory site but the marketing, debtors and financial information would be located at the sales office. The two together would form the company's logical data base.

2.5.2 Replicated Data Bases

In this situation each computer site would carry copies of the central data base. Any transactions as well as updating the local site, would update the central data base either in real-time or batch mode.

An example of this would be an organisation that has a large number of debtors and has elected to decentralise the credit control function to its branches. Each branch would then have its own debtors stored on a data base at the branch site. The Head Office would have the debtors of *all* the branches on the central computer.

In the latter case, there are obvious problems associated with keeping the replicated data bases in step and should they get out of step, the procedures for synchronising them again may be complex. One solution is always to update the central site prior to updating the local data base. In the event of system failure, copies of the central data base are sent to the remote sites and new versions are created. In this case, recovery is liable to be simple but will be very slow (obviously this is dependent on the size of the data bases).

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2.6 CONCLUSION

From the definition one can conclude that DDP is not a 'revolutionary' concept. The hardware is available and can perform the required functions at each user site. The factor that can inhibit the success of DDP installation is the software required to allow each computer site to communicate with the others. Certain manufacturers (such as Datapoint, General Automation) have concentrated a portion of their efforts towards the development of reliable communicating software. However, a large number of mini/micro suppliers do not have the software to cater for a DDP environment. As the concept becomes more and more accepted by business, these suppliers will, no doubt, improve their range of products.

The other area that is likely to impinge on the success of DDP is data base software technology where those data bases are spread over multiple locations. Again, software suppliers are concentrating some of their efforts towards improving this shortcoming (for instance, TOTAL running on mini-computers in a DDP environment is installed in the United Kingdom, Digital Equipment Corporation has developed DECNET for its mini-computer range¹³).

It is likely that in the near future total DDP software packages will be available which the user may instal with confidence. This does not necessarily mean that there are not DDP installations at present. What it does imply is that where the user instals a DDP system a large section of the communicating and data base software would have to be modified or specially developed to handle that user's requirements.

- (11) RAVENPORT, R.A. "Distributed or centralised data base", The Computer Journal, Vol.21, No.1, p.10.
- (12) AUERBACH PUBLISHERS INC. Op.cit., p.6.
- (13) MILLER, M. "A Survey of Distributed Data Base Management", Information and Management, No.1, 1978, pp.250-251.

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CHAPTER 3THE HISTORICAL DEVELOPMENT TOWARDS DISTRIBUTED
DATA PROCESSING

"Even relatively small computing systems will have to support data management for both batch and on-line situations as a result of likely distribution of processing power and data storage throughout an organisation."¹

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3.1 INTRODUCTION

Following the definition in Chapter 2, DDP represents, firstly, decentralising the information processing capabilities of the organisation, and, secondly, the use of communications capabilities to allow the transfer of data between user sites.

Decentralisation of business functions has been a structural alternative for many years. To quote Vancil :

"Profit centers and decentralised management have become almost a hallmark of the American business organisation. The underlying philosophy is that authority and responsibility should be parallel and that in a complex business the

authority and responsibility must inevitably be delegated."²

DDP was first mentioned as a system solution in the early 1970s and gained prominence in the late 1970s, and yet computers were first introduced into the business world in the early 1950s. The reason for this long delay for a potential solution was that certain developments had to have taken place in the data processing field before DDP could become a reality. These were :

- Computer power should have increased and the price decreased to such an extent that computers could be placed at user locations while not imposing too heavily on those users' budgets. This would imply that the users are paying for the service themselves which in a DDP system is logical, but even if they are not, to have a computer for one application would mean that the price would still need to be low to justify its use.
- The software necessary to drive the networks and data bases should have developed to the point of making DDP feasible. As mentioned in Chapter 2, although the software is still not fully developed, DDP, even now, is a feasible alternative to a centralised system.

- Communications facilities should have progressed to the stage where data could be transmitted reliably over networks and the price of that transmission should be low enough to make it justifiable.

This chapter traces the developments that have taken place concerning the above factors and shows the progress that has been made since the early 1950s - thus describing how it has become possible for DDP to be introduced.

All the figures in Sections 3.2 and 3.3 were taken from "The Waves of Change" by Lecht. They were the result of a study into the computer industry undertaken by the Advanced Computer Techniques Corporation Technology-Analysis Group in the United States of America.

3.1.1 Glossary of Terms

The following is an explanation of the technical terms used in this chapter.

Archival File - A medium for the storage of large quantities of data. These can be accessed on-line but the access times are very slow (measured in seconds or minutes).

Bipolar - A transistor requiring a large amount of power and generating a lot of heat. One of the transistors used in early computers.

FET - Field Effect Transistor. In certain applications within the computer it has replaced the bipolar.

Network Controller - A hardware unit separate from the CPU that performs some of the network control functions such as error recovery, polling, addressing, etc.

Remote Multiplexer - A unit at the end of a high-speed trunk line that can change line speeds and modes for transmission to or from terminals.

Semi-Conductor - A medium for conducting electricity. In computer terms this relates to the development of the silicon chip.

Frequency Division Multiplexing - A division of a line that allows multiple inflowing lines of low speed to be joined to a single higher speed line.

3.2 THE EVOLUTION OF HARDWARE

In 1952 the first commercial computer was installed at Prudential Equity in New York. From that year through the rest of the 1950s the development emphasis by the manufacturers was for bigger and more expensive computers.

"All systems were batch orientated and in most cases the initial business applications were

in the financial area - payroll, billing, accounting - because these were the most formalised of company systems and likely to be the easiest to program; not because they were necessarily the most cost effective."³

The 1960s saw a branch in the development of computers. The main line of development saw the big machines get bigger and more expensive. The incidence of the announcement of new products increased - IBM announced the 1400, 360 and 370 ranges all in the decade and each range was more powerful than its predecessor. However, on the other side, 1961 saw the advent of the first commercially available mini-computer, priced at \$27 000.⁴ This marked the start of what was to become a flourishing market (so much so that it is today considered to be a higher growth area than that of mainframes). From 1961 the mini was to increase in capability and decrease in price.

"A 4K Digital PDP-8 that sold for \$16 500 in 1965 is currently priced at \$2 000. It soon became obvious that this vastly increased power and speed per dollar could be utilised not only for typical applications - specialised, single task, scientific or process control jobs - but as general purpose business computers."⁵

Figure 3.1 (overleaf) shows how the price of a 4K PDP-8 has decreased from 1965 to 1975. The price reductions were

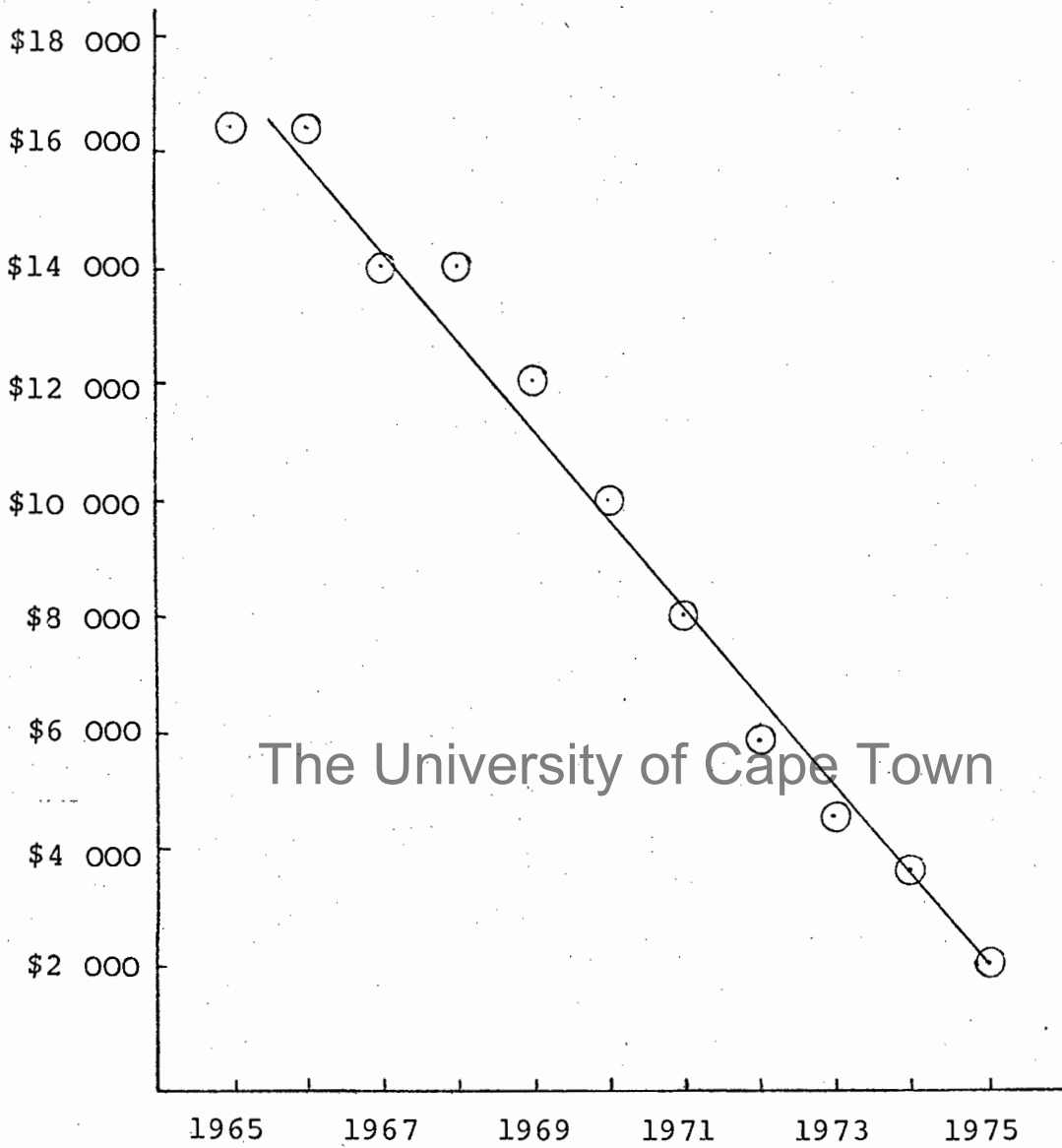


Figure 3.1 : Average Yearly Price of a 4K PDP-8⁶

possible because of technological improvements which were applicable throughout the computer industry. No statistics on the PDP-8 are available after 1975 but the trend line, when applied to all computers, has levelled off in the last five years.

However, much as the mini was a radical development in the 1960s, it was to become overshadowed by the advent of the micro-computer in the 1970s. Priced in the range of a few hundred dollars to \$40 000, the micro was destined to play a revolutionary role in the application of computers to business problems. It was now economically feasible to place computer power, in the form of processors, in user departments.

Peripheral devices were, at the same time, undergoing as much of a change as the central processing units. Disks were holding more and more data, and access times were reducing. Communication controllers (in the form of the IBM 3704 and 3705) were announced in the late 1960s which took much of the network load off the central processor, leaving it free to handle other, more important, tasks.

Figures 3.2 and 3.3 (pages 55 and 56 respectively) show how the price and performance of computers has changed in the last two or three decades. Figure 3.4 (page 57) shows how secondary storage prices have moved and are projected to change.

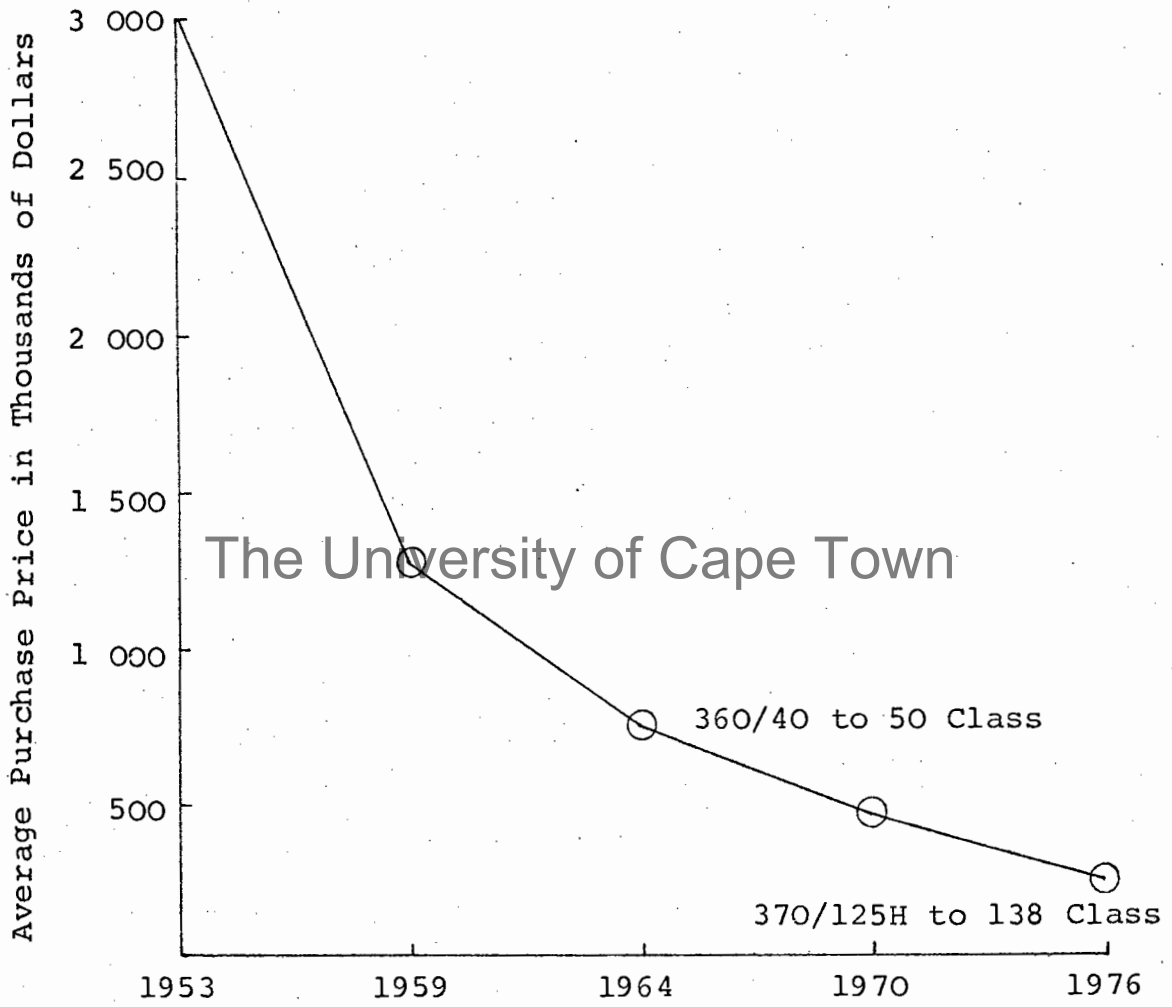


Figure 3.2 : Average Computer Purchase Price

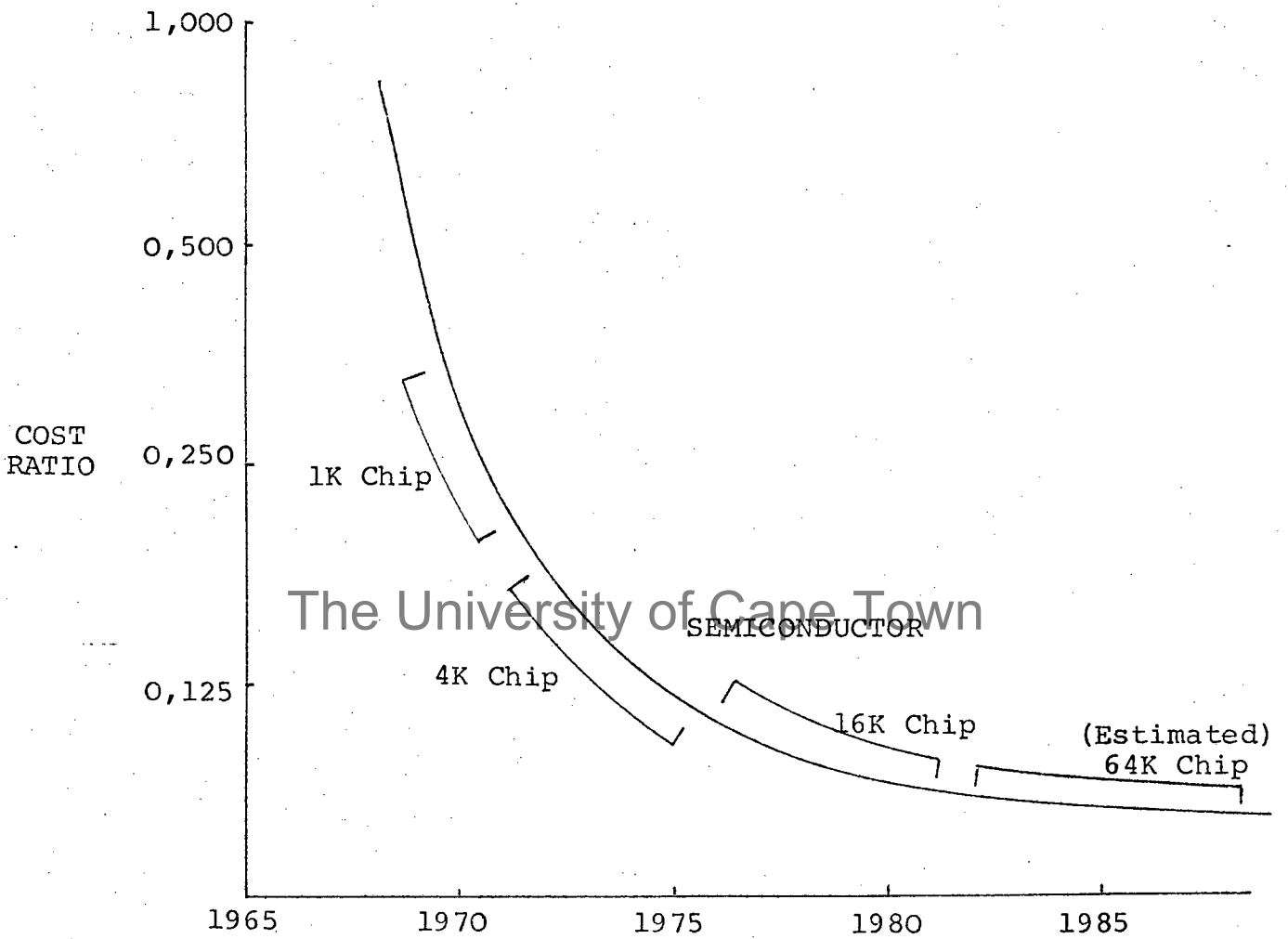


Figure 3.3 : Main Storage Cost Trends

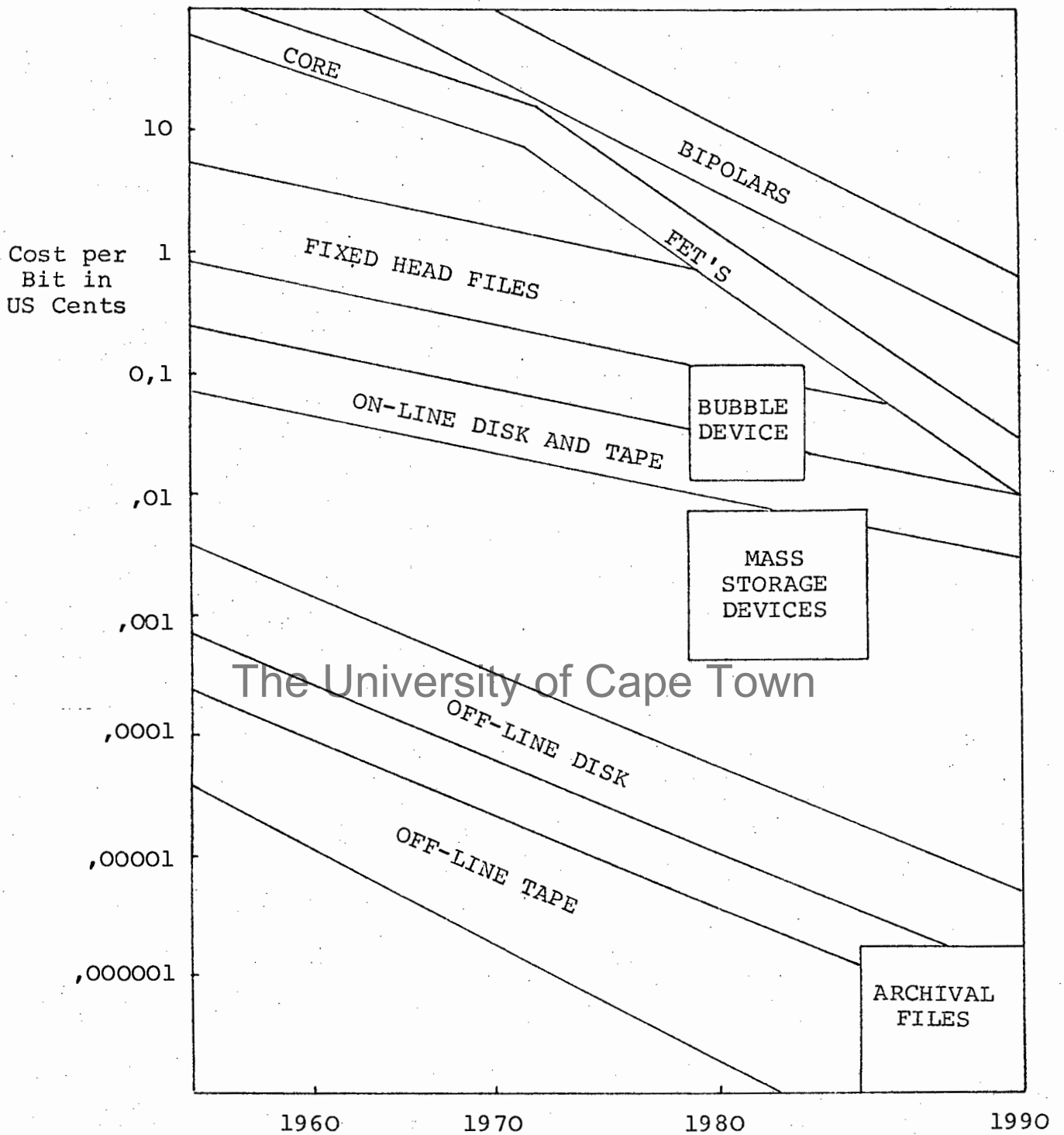


Figure 3.4 : Storage Technologies

In general, the trend in the 1970s was to hold the prices of specific items of computers static. New releases of hardware, however, offered the user improved performance at a decreased price. An example of this was the announcement of the 4300 range of hardware by IBM.

"At the time of its introduction, a 4300 model that exceeded the computing power of an existing \$560 000 machine sold for \$90 000."⁷

There were isolated instances of price-cutting, but this was, in the case of IBM, shortly before announcing new equipment (for instance, the price of the 370/145 was decreased shortly before the announcement of the 148). Other suppliers generally only reduced *their* prices in response to these cuts by IBM.

However, the capacities of computer equipment in terms of memory size and auxiliary storage space increased and the performance improved (measured in cpu cycles and disk access times). The net effect was to improve the price/performance ratio of computers.

3.3 THE EVOLUTION OF SOFTWARE

While the general development of software has been towards more sophistication and more complexity, one must

differentiate between mainframe and minis/micros to trace the growth of computer software and its impact on the organisation.

3.3.1 Mainframe Software

The early commercial computers were characterised by the fact that they could only process one job at a time. However, in the early 1960s operating systems were announced that could improve the processing throughput of a machine by multi-programming. With the advent of interrupt driven computers, the two developments laid the foundation for teleprocessing.

The teleprocessing software was, at first, fairly basic, but, because of the demand for telecommunication facilities, the development towards more sophisticated systems was rapid. This is evidenced by the announcements from IBM of BTAM (Basic Telecommunications Access Method), BATS (Basic Additional Teleprocessing Support) and CICS (Customer Information Control System), all in the period 1966 to 1970 and each more sophisticated than its predecessor.

In the late 1960s, data base software was being introduced to computer users in the form of IMS and DBMS. However, because of the complexity - both of the software and the

applications - its installation was limited to the powerful, more expensive computer.

The trend in the 1970s has been towards more sophistication of the software and improvement of the telecommunicating capabilities of the software. As Foy states,

"Mainframes are characterised by their emphasis on sophistication (alias complexity, alias expense) and on support."⁸

3.3.2 Mini and Micro Software

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In the late 1960s and early 1970s, mini-computers were initially being used as input systems where the data was being captured for later processing on a mainframe. However, it was soon realised that they could be used to process commercial applications and software houses started developing the required software. On the system software side, multi-programming and communications facilities were being developed. The development of these sophisticated techniques had the effect of pushing the mini into the lower mainframe market, as related by Sealy and Nelson :

"But what of the mainframe manufacturers?
Undoubtedly the mini has exerted some pressures here and we have seen the traditional computer market place livened up with the introduction

of database and teleprocessing products with a drift away from batch processing techniques to transaction processing and on-line file interrogation. It must be said, however, that these techniques are also available on the more powerful minis."⁹

The micro-computer was first introduced as the hobbyists' machine. However, it was soon appreciated that it could be used to process commercial applications. Software houses were quick to take advantage of this potential market, for instance, Computer Analysts and Programmers set up CAP MicroSoft, which specialises entirely in micro-computer applications. Today even the small micro-computers are being sold with a full range of commercial packages.

Despite these developments on the minis and micros, they are still a long way behind the software on the mainframe. Hoffberg, when discussing the lack of acceptance by management of DDP solutions, states as one reason, "The lack of tools for use by the user, including vendor support through software".¹⁰ However, there is growing evidence that sophisticated software on minis and micros is being developed (the announcements of such packages as Varian's PRONTO for on-line data base management, and DEC's ASSIST 11 for telephone directory assistance, support this view).

3.4 THE GROWTH OF TELECOMMUNICATIONS

This section analyses the improvements that have taken place in the areas of data communications since the early 1960s. The analysis is divided into four sections, viz. :

- Hardware
- Transmission speeds
- Networks
- Costs.

Although the trends apply to worldwide developments, specific reference is made to the South African environment.

3.4.1 Hardware

The first terminals used in data communications were 'unintelligent' (of the IBM 1050/2740 type). The natural progression was to add memory and storage capabilities. Computer-to-computer communications were introduced to the business world in the mid-1960s. Specialised terminals (such as banking, retailing) were also introduced by the major firms in the late 1960s and early 1970s. Examples of this type are the Burroughs TC500 and the IBM 3600 series.

In a communication based system, the CPU has a high overhead of polling and addressing all the terminals on the network

and of performing error recovery. To reduce this overhead, network controllers (or front-end processors) were announced in the late 1960s. The trend in the 1970s was for the manufacturer to produce more sophisticated specialised terminals, such as the Point of Sale ranges. In addition, the micro-computer was used as a remote terminal.

3.4.2 Transmission Speeds

In South Africa most of the early data transmissions took place at a speed of approximately 115 bits per second (bps). This was a function of the modems that were used on the lines and the quality of the lines carrying the data. However, the GPO introduced several improvements and by the 1970 - 1972 period, transmission speeds of 600 and 1200 bps were commonplace.

With the introduction of the microwave network and higher quality modems, the speed was further increased and today a large number of transmissions between the major centres take place at 9600 bps without a noticeable increase in the error rate. Speeds of 19 200 bps have been achieved in South Africa but these are not over trunk lines (i.e. between, say, Cape Town and Johannesburg); the transmission has been restricted to one geographic area only.

Optical fibres are already under development, as Malan states

"These hair-thin fibres have digital transmission capabilities that are quite outstanding, with theoretical limits in the range of tens of thousands of megabits/bilometre".¹¹

3.4.3 Networks

Initially networks were limited to a simple point-to-point or multi-drop networks as shown in Figures 3.5 and 3.6 (pages 65 and 66 respectively). However, as technology improved, so did the concepts of network configuration; 'star' and 'ring' networks were introduced, as in Figures 3.7 and 3.8 (pages 67 and 68).

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The introduction in South Africa of the SAPONET network has created a lot of opportunities in network configuration not previously available, particularly in the area of 'packet switching'. This involves using one high speed trunk line to transmit blocks of data, each of which may contain packets of data destined for different users.¹⁵ Many users may thus occupy the same high-speed network and effectively reduce their communication costs.

When considering overseas transmission, the use of satellites has greatly improved the quality and speed of transmission. The major developments in the area of network configuration in the 1970s are :

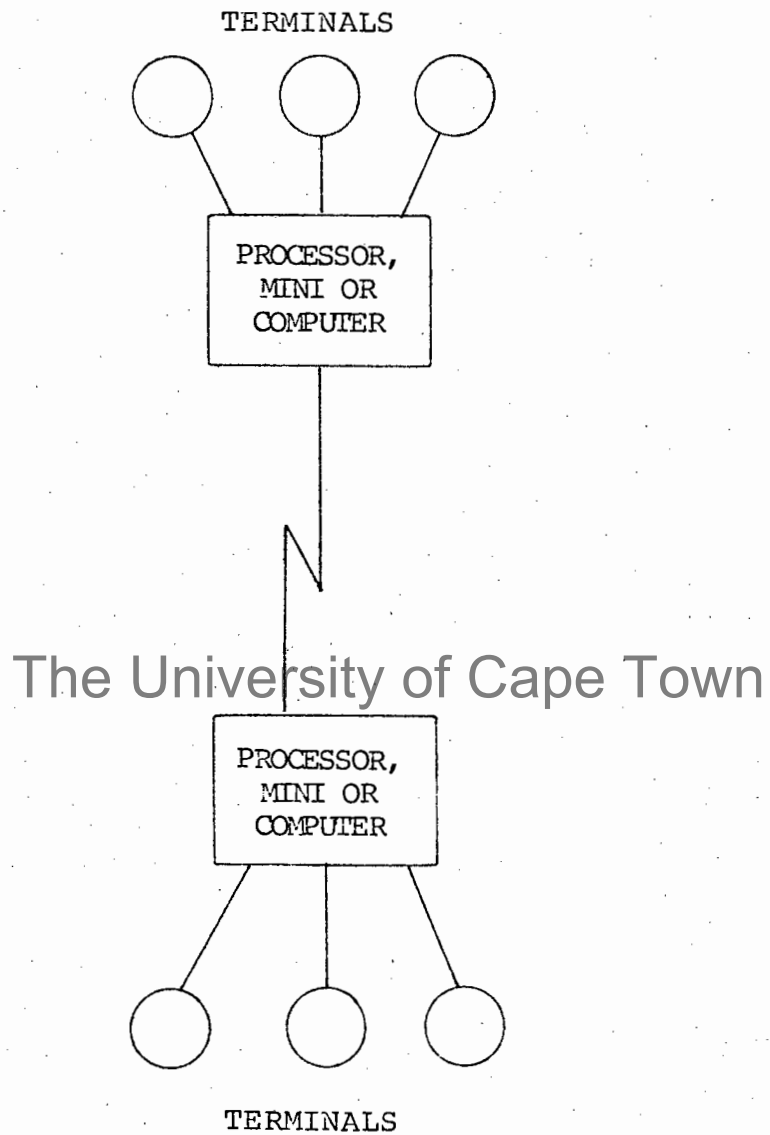


Figure 3.5 : Example of a Point-to-Point Network¹²

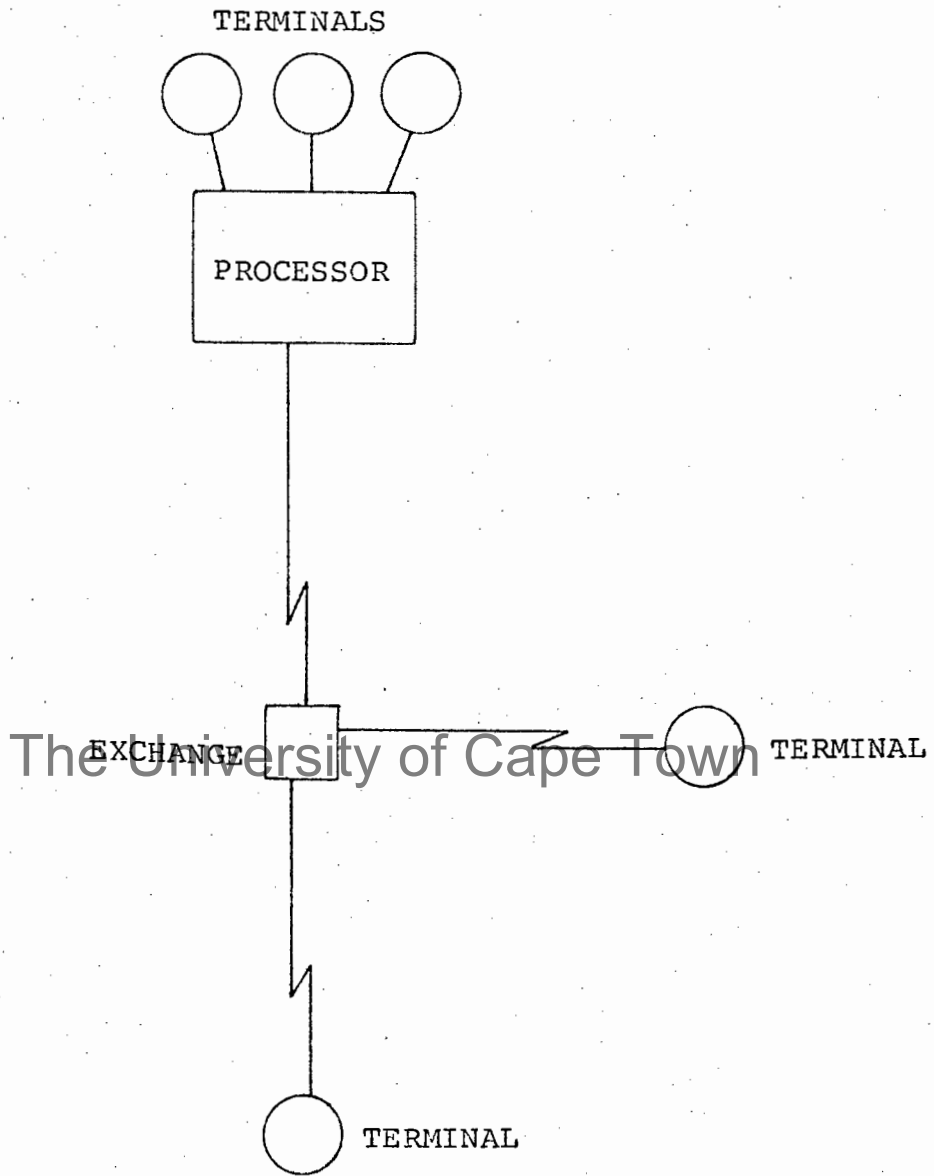
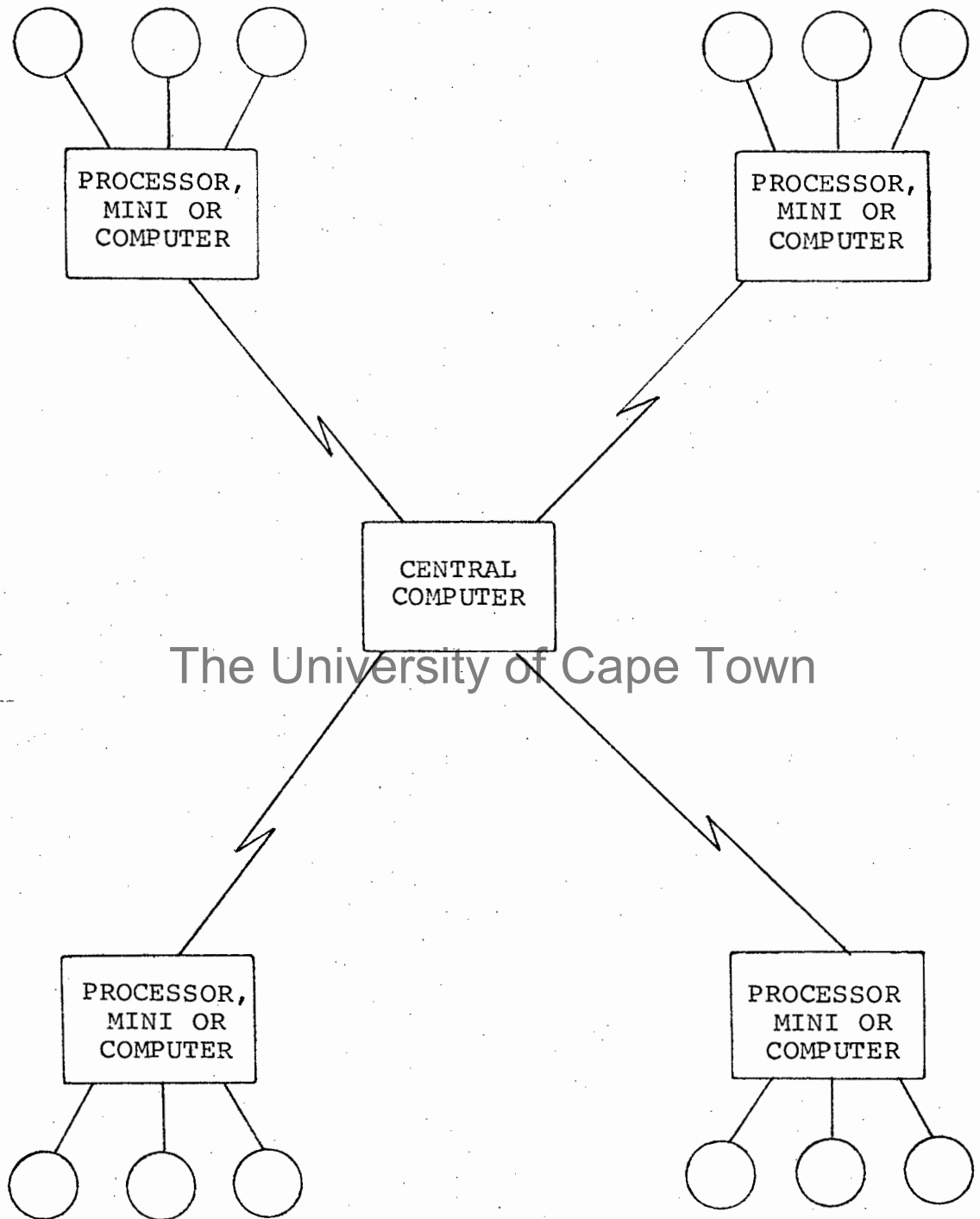


Figure 3.6 : Example of a Multidrop Network



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Figure 3.7 : Example of a Star Network for a Distributed Processing System¹³

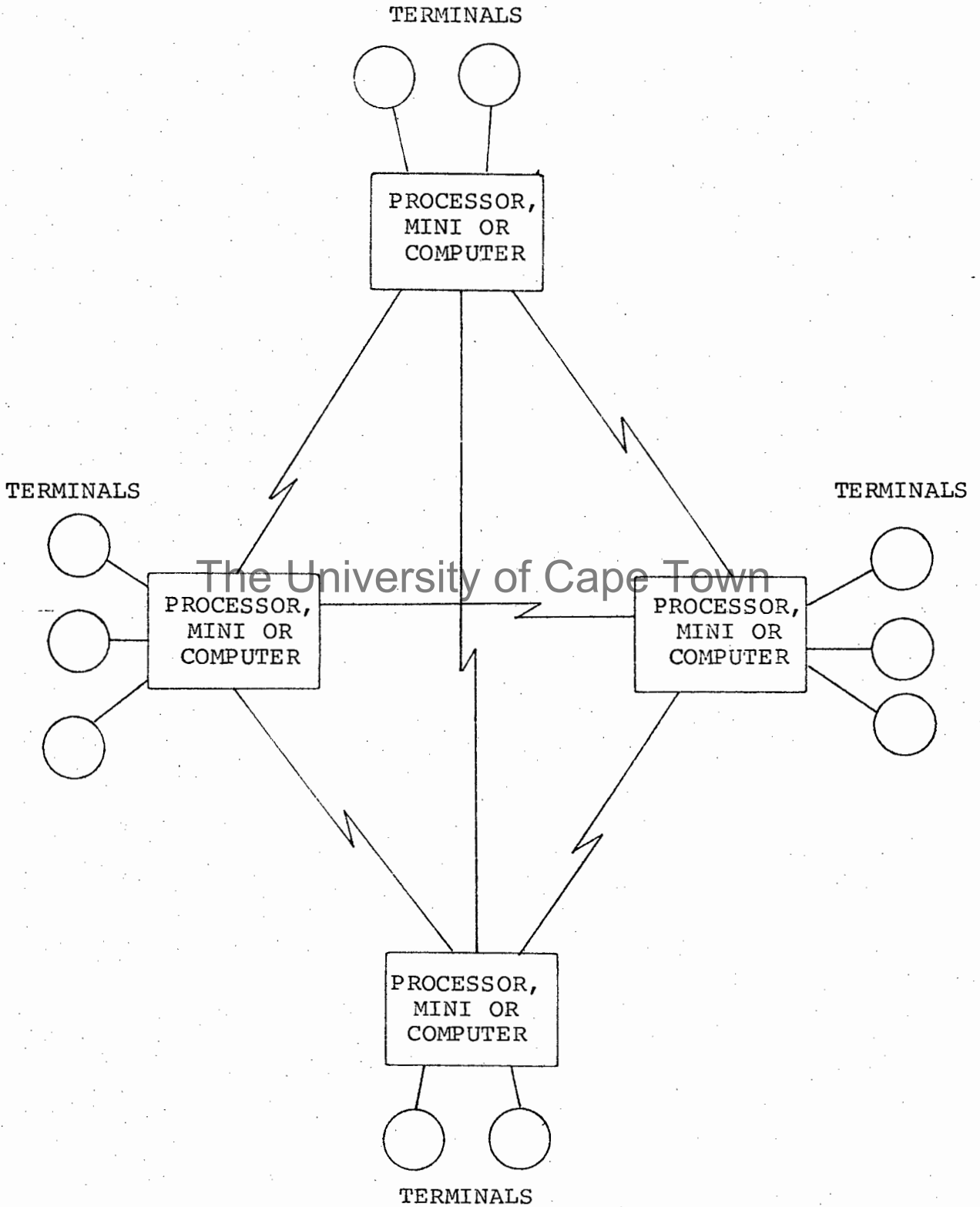


Figure 3.8 : Example of a Loop or Ring Network for a Distributed Processing System¹⁴

- The development of the SDLC (Synchronous Data Link Control) transmission protocol by IBM which improved the throughput of a given network configuration.
- The improvements in multiplexing technology. The first was the Time Division Multiplexor which allowed the use of (effectively) 9 x 1200 bps data streams down one 9600 bps line, thus increasing the capacity of that line. The second was the Intelligent Multiplexor which doubled the number of lines from 9 to 18.

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The trend of the future is continuing towards faster, more reliable networks. The joint venture between IBM, Aetna and Consat to create a United States domestic satellite system, creates important precedents in the field of data communications. With satellite systems, because of their reliable transmission activities, the scope for network configuration design will increase even further.¹⁶

3.4.4 Costs

The line cost of communication in the 1960s was R16 per mile per annum for a 2-wire circuit and R32 per mile per annum for a 4-wire circuit.¹⁷ The current line cost is R10 per kilometre per annum for a 2-wire and R20/kilometre/annum for a 4-wire circuit. There has thus been no change

in the data transmission line cost since its inception in the mid-60s. However, if one discounts the effects of inflation, the cost of data transmission has, in relative terms, decreased substantially.

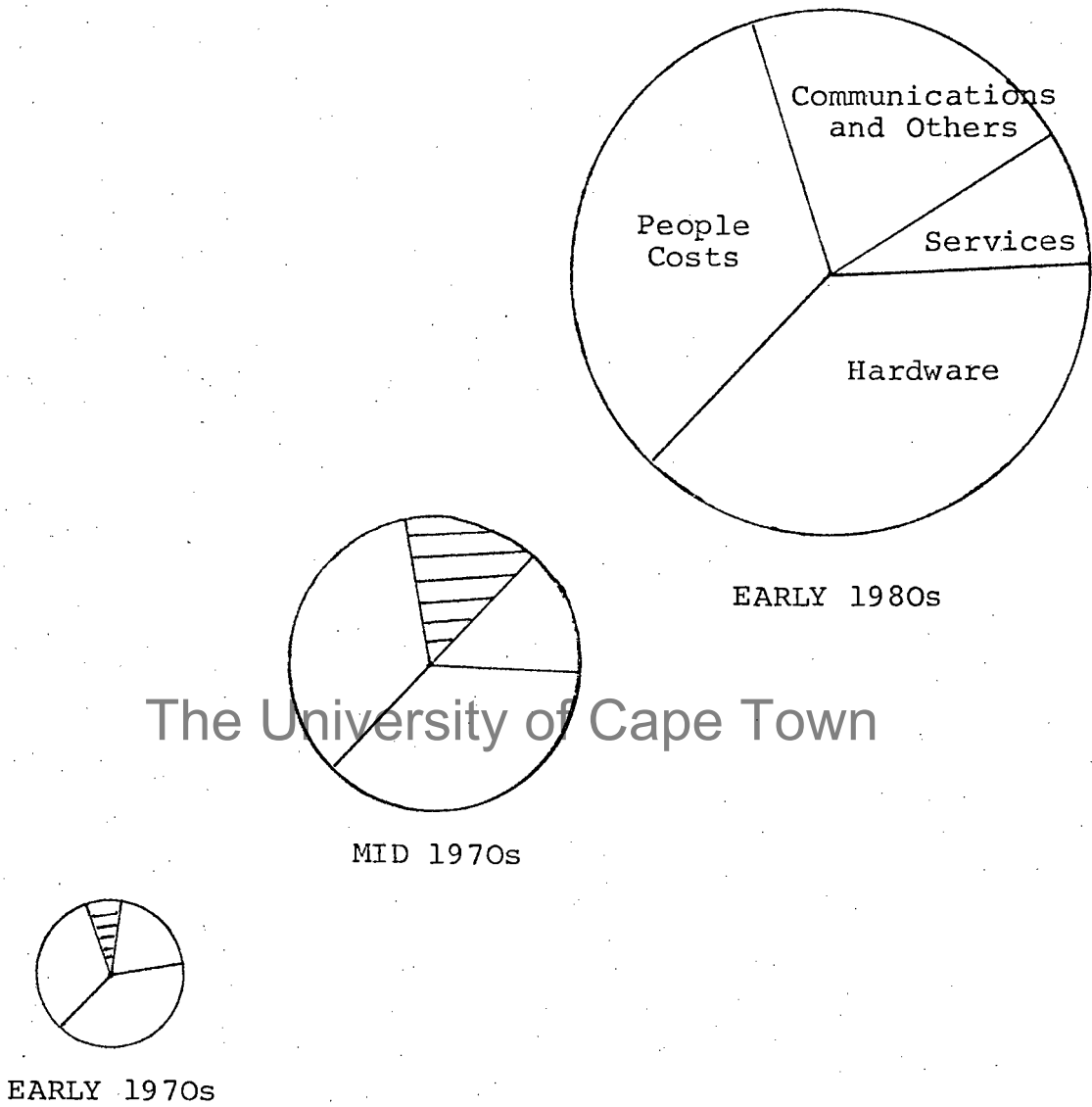
Through the use of remote multiplexors and front-end processors, thus allowing for a more efficient network configuration, the user has been able to effect further reductions in the cost of data transmission.

Although the cost of data communications has decreased, its use has increased, as is shown in Figure 3.9 (overleaf). This shows the trends worldwide, but the distribution is also applicable to South Africa.

3.5 CONCLUSION

This chapter has traced the developments that have taken place in the areas that are crucial to a distributed system as defined in Chapter 2. These are :

- the small computer hardware which is necessary for a user to justify the processing of one or two applications at a cost which can be met by that user's budget;
- the software that is required to drive that computer;



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Figure 3.9 : Worldwide Distribution of EDP Budget Trends¹⁸

- the communications facilities that are necessary for the transmission of data between user sites.

The hardware section illustrated how the price of computers has been reduced substantially in relation to the performance. There are now indications that the prices have stabilised and that technological improvements will not have the effect of decreasing the price still further. As stated by Uttal :

"The rate of inflation is catching up with the rate of technological improvement, so radical price/performance improvements will become elusive".¹⁹

However, even at current levels, the cost of hardware can be borne and justified by user departments (through the introduction of the micro-computer) and DDP systems can be a viable alternative to centralised systems.

Instead of, as in the past, having to make a decision between batch or on-line systems, the organisation may now consider the further alternative of distributing some or all of them. Whilst a number of articles written on DDP state that the business may choose between one or the other, it is entirely feasible (as is shown in the field studies) to centralise a number of the systems in the organisation while distributing others.

FOOTNOTES

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- (2) VANCIL, R.F. Decentralization - Managerial Ambiguity by Design. Homewood, Illinois: Dow-Jones-Irwin, 1978, p.vii.
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- (6) LECHT, C.P. The Waves of Change. 437 Maddison Ave, New York: Advanced Computer Techniques Corp., 1977, p.125. The analysis of the PDP-8 was only performed until 1975.
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- (13) Ibid., p.40.
- (14) Ibid., p.41.
- (15) For an analysis of packet switching, refer to the article "Data Communications", Datamation, July, 1978, written by R.W. Sanders, pp.89 onwards.
- (16) Reference is made to the joint venture in The Waves of Change, by C.P. Lecht, op.cit., p.61.
- (17) The costs quoted in Section 3.4.4 are taken from the article "Data Transmission and the GPO". Date and author unknown.
- (18) LECHT, C.P. Op.cit., p.93.
- (19) UTTAL, B. Op.cit., p.112.

CHAPTER 4THE FACTORS AFFECTING THE DECISION TO
CENTRALISE OR DISTRIBUTE

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CHAPTER 4THE FACTORS AFFECTING THE DECISION TO
CENTRALISE OR DISTRIBUTE

4.1 INTRODUCTION

In Chapter 2 the requirements of a DDP system were defined. Chapter 3 examined those factors and concluded that the hardware, software and communications technology had progressed to the point that DDP now presents itself as a feasible choice when considering the mode of processing.

An organisation thus has three alternatives to consider, viz.

- centralise its DP functions (with on-line or batch systems)
- distribute them to the user sites
- provide a mixture of the above two facilities.

This choice presents itself when an organisation is

- considering the introduction of computerisation
- developing new systems, or
- thinking of changing the entire method of computer processing.

There are a number of issues affecting the organisation that

should be considered prior to making the decision. This chapter examines these and presents arguments both for and against distribution without attempting to arrive at any conclusions as to the suitability of either alternative. Ultimately it is up to the individual organisation to determine which method suits its requirements.

Among the more common reasons for choosing a distributed system are :

- Availability/reliability
- Security
- Providing processing autonomy to decentralised management.

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However, there are many other factors to be considered, each of which could have a bearing on the decision. These will be analysed in the following sections.

4.2 ORGANISATIONAL STRUCTURE AND STYLE

"The logical organization of computers within a company (or group) should match the corporate organization style."¹

Donaldson continues by discussing two building societies that installed centralised systems in the 1960s. One had a highly decentralised management structure and experienced great difficulties in installing the systems. The budget

was exceeded and the system was overdue. The other had a highly centralised structure and the implementation was within the schedule and within the budget. Although one could argue that the former could have been due to incorrectly set budgets and incompetent development staff, it could equally well be due to the fact that a data processing mode was being implemented that did not match the lines of responsibility and control found in the company.

If the structure of the data processing hardware and data flow matches the organisation, then

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"the responsibilities of computing and management can be kept in line, avoiding the conflict between decentralized operation and centralized computing".²

However, this argument only holds true for as long as the structure is static. If, as in a large number of newly-formed companies, the reporting lines and functions of departments are changing, then it is probably easier to change a centralised computer system than it is to change a decentralised one. As Lorin states :

"It is critical, therefore, when mapping systems to organizational charts, that this be done only when there is confidence that the chart will at least endure for the payback period of the system, or that provision for reasonable variations be included in the initial design."³

If an organisation is using this argument to justify a DDP system, it is also important to bear in mind that the functions of a business can rarely be subdivided into the boxes shown on a chart. There are often invisible or implied reporting lines which are not shown which might affect the organisation of a computer system.

Figure 4.1 (overleaf) shows how a distributed system may be organised in such a way as to match the management structure of an organisation.

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4.3 USER EXPERTISE

A critical factor in the evaluation of centralisation versus distribution is the level of skills of the people involved in the systems at each user site.

In a DDP system where computers or intelligent terminals are located at user sites the skill level has to be much higher than in a centralised system which is either batch or on-line with unintelligent terminals. This expertise is required in the computer as well as the business area. In a DDP system each user site will be responsible for, inter alia :

- operating the system - including start-up and end-of-day procedures

- taking securities of master and transaction files
 - performing communication operations between that and the central site (if required)
 - diagnosing faults at the user site (both hardware and software)
 - conferring with the manufacturers for the correction of hardware errors
 - possibly correcting program or system errors
 - designing and developing new systems and maintaining existing systems
 - data preparation, input and correction
- etc.

The user would thus be required to have a high level of understanding, not only of the applications, but also of the hardware at that location. It is also important that more than one person should have the capability of performing the functions listed above (in case of illness, resignation, etc.).

If an organisation is committed to DDP, it will have to examine critically the skills of the people at each site and select those who have the correct aptitudes. If there is nobody available, the organisation would have to employ others. This could be expensive in terms of

training and development of the necessary expertise.

4.4 SECURITY CONSIDERATIONS

In a distributed system there is a supposed anomaly relating to computer security. This is outlined by Dryer. On the one hand

"... distributed processing has lessened the degree of vulnerability by dispersing information - and hence the risk - over a wider area".⁵

Here he is writing about risk in terms of fire, natural disaster or fraud. On the other hand,

"The basic problem is that one is moving from a highly controlled, probably more experienced environment into a smaller, more informal situation".⁶

So while a DDP system tends to promote security by spreading the data (and hence the risk) over multiple machines, it will either increase the exposure to fraud because the users in the remote locations will not be as disciplined as an experienced, centralised site, or it will increase the cost of providing secure systems at the remote sites. This increased cost will come about because of the need to provide security facilities at each computer site, such as :

would be unlikely to have librarians or control groups to ensure that securities are taken and logged.

Thus, if a company is considering DDP, it should bear in mind that it will gain security by spreading its data over multiple user locations but, to achieve the same security as a central system, it may have to instal expensive prevention facilities at each user site.

In a DDP system the user is responsible for data entry, processing and the distribution of reports. He thus has greater opportunity for intentional corruption of files than in a central system where he is remote from the data. All controls (such as software, application, manual, etc.) will thus have to be fairly stringent.

4.5 AUDIT CONSIDERATIONS

When considering centralisation or distribution the organisation should be aware of the audit implications in terms of the roles of the external and internal auditors.

4.5.1 The External Auditor

In a centralised system most DP functions are found at one site. These include, inter alia :

- Systems development
- Programming
- Computer operations
- Librarian functions
- Software support
- Scheduling
- DP management.

As such the external auditor may confine his DP audit to one site. If the system is on-line then terminal procedures will have to be audited but this may be done on a sample basis.

In a distributed environment the auditor might be forced to audit each separate user site to verify such areas as

- The security procedures
 - The operational controls
 - The personnel functions
- etc.

This is especially true if each site is processing a unique application.

The use of audit retrieval packages as a means of auditing the information stored in the files at each site in a DDP

system is unlikely, for as Wardlaw states :

"Because this market is fragmented by many suppliers, the development of audit retrieval packages is not likely. Many vendors are providing an RPG (Report Program Generator) compiler. Auditors will probably find it necessary to use this approach to extract data from files."⁸

The cost of development of specific audit programs will have to be borne by the customer.

4.5.2 The Internal Auditor

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The existence and role of an internal auditor becomes more important in a DDP system than a centralised one. Systems may be developed at each processing node and it is important from the organisation's viewpoint that the controls and security procedures be vetted prior to implementation of the system. This is particularly true if users are developing the systems themselves. The internal auditor would also need to visit the user sites periodically to ensure that the controls are being maintained. Although this would also be required in a centralised system, the time involved would increase with the number of sites where data was being processed.

4.6 AVAILABILITY AND RELIABILITY

In a centralised environment the availability of all systems is dependent on the availability of the central processor. If it for any reason fails then the total data processing capability of the organisation fails. However, in a distributed environment, because the processing is spread across many computers, the failure of one computer will only affect that processing node.

While the above statement would tend to favour a DDP system in terms of availability it should be borne in mind that the most reliable components of a computer system are the memory and storage. If any element in a centralised system is to fail it is more likely to be the communications facility or the applications programs. If the DDP system is, therefore, dependent for its effectiveness on the availability of its teleprocessing capability, then it is in no better position than the centralised system.

On the other hand, if it is critical to the success of the system that the memory and storage section of a system be available at all times, then it is certainly cheaper to duplicate a mini or micro at those critical points than it is to duplicate a mainframe.

Regardless of whether a centralised system be chosen or not,

if availability is important then the speed of recovery is as vital as the reliability of the components (it is always possible that both components of a duplicated system fail simultaneously). Recovery time is a function of the sophistication of system and application software and user procedures. Regardless of which processing mode is used, careful planning and thorough testing of the recovery procedures will ultimately produce a system which is more responsive to failure (from such occurrences as power drops, abnormal program terminations, etc.).

Another aspect to consider is that of bottlenecks occurring at any point in a computer system. In an on-line system, for instance, an overloaded channel will result in increased response times. When this occurs then all applications running on that computer will suffer. In a DDP system, where the workload is spread over multiple locations, the possibility of overloads affecting multiple users is remote. As Statland and Winski state :

"The mini-computer approach, when limited to a few applications per computer, avoids the bottlenecks resulting from the traffic jams and work overloads often encountered as new systems are added to already fully-utilized central computers."⁹

4.7 ECONOMIES OF SCALE

In a centralised environment, greater use can be made of the economies of scale than in a distributed system. It would thus be cheaper to add 1 megabyte to a central computer than to add, say, 10 x 128K bytes to remote processors. This economy of scale applies not only to processors but also to :

- software
- data
- computer floor space
- human resources
- data storage media.

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Software

A centralised system would only need one version of software to maintain and purchase. In a multi-computer site, several copies may have to be bought if standardisation is required. These copies would then have to be individually maintained.

Data

In a centralised system with a data base, data will be held only once. In a distributed system there is liable to be a great deal of duplication.

Computer Floor Space

A distributed system will have multiple processors located at user sites. Each processor will have its own floor space. The sum total is likely to be more than would be required for one large-scale processor in a centralised system.

Human Resources

This relates specifically to computer operators/data input clerks. At each site, people are also required, to prepare and check the data to be used as input to the computer system. If there is only one site there will be less people required than in a multi-computer situation.

Data Storage Media

If data is duplicated in an organisation, larger storage devices (or more storage devices) are required to hold that data. In a multi-computer site there is likely to be more wastage of space than in a single, large site. It is very seldom that a disk pack, for instance, will be utilised to 100% of its capacity. There will normally be some space reserved for future expansion. The more sites there are, the greater will be the wastage of that space.

There are two aspects of the economies of scale argument

that require mentioning. The first is that a large system requires careful tuning of the system software to allow it to operate at its optimum level. This tuning requires an on-going activity from system support personnel. In a DDP network, where the processing nodes are being handled by small computers, this element of tuning is not necessary as the impact on the system's responsiveness will be almost unnoticeable if the machine operates at 80% or 100% of its potential capacity.

The second is that technology has increased the capabilities of the mini-computer to such an extent that it can provide the same processing power as leading maxi-computers (such as the IBM 370/155) but at a fraction of the cost. Some micro-computers are showing even greater cost-performance ratios.¹⁰

4.8 CASH FLOW

DDP systems are developed for a specific application, defined by the end-user and often under his control. The application requirements are thus narrower than in a centralised system and the development time is therefore quicker. As Statland states,

"Distributed systems can be developed more quickly since they primarily address the immediate needs of a specific user group rather than the complex mix of needs of a diverse user population."¹¹

There is thus a shorter time between payment for the computer system and achievement of the benefits of that system.

Allied to this is the fact that payments to the suppliers of mini- and micro-computers are smaller than those of a large central system and can be staggered to meet the required installation dates. This could have a significant effect on the cash flow of the company. Figure 4.2 (overleaf) illustrates the costs involved assuming that the systems are not integrated.

As can be seen from the hypothetical example, although the total hardware cost is approximately the same, in the distributed system the cash outflows have been spread over a year, whereas in the centralised system they have taken place at the start of the project before any benefits have accrued from the systems.

As Doouss and Collins state when analysing the distributed approach :

"Cash flow is often less of a problem. The units of computer power are added in the appropriate location as the systems for that location are

	<u>Centralised</u>	<u>Distributed</u>
1.1.80	IBM 4331	IBM System 38
	<u>To handle :</u>	<u>To handle :</u>
	Creditors	Debtors
	Debtors	Creditors
	Stock	Payroll
	Payroll	
	Production	
	Marketing	
	Total Cost R360 000	Total Cost R85 000
1.6.80		IBM System 38
		<u>To handle :</u>
		Stock
		Total Cost R85 000
1.9.80		IBM System 38
		<u>To handle :</u>
		Marketing
		Total Cost R85 000
1.1.81		IBM System 38
		<u>To handle :</u>
		Production
		Total Cost R85 000

Figure 4.2 : Cash Flow Comparison of Centralised versus Distributed Systems

developed and/or taken on. Thus the benefits can accrue earlier and the absolute size of the minimum cash flow is limited."¹²

4.9 COMMUNICATIONS' COSTS

When data has to be transmitted over large distances, communications can form a large proportion of total DP costs. Where remote users require access to a computer for data entry and enquiry at all times of the day, leased lines have to be installed which are expensive.¹³ Users of a DDP system would only need to send summarised data to the central site at, for instance, the end of a day. This could be transmitted using the dial-up mode of transmission which is substantially cheaper than leased lines as the following example illustrates :

Suppose a company had a Head Office in Johannesburg with branch offices in Cape Town, Port Elizabeth and Durban. Each branch office is autonomous but enquiry and data capture is required at all times of the day.

In the centralised system the communications' costs would be :

Johannesburg-Durban	R500/month
Johannesburg-Cape Town	950/month
Johannesburg/Port Elizabeth	<u>750/month</u>
Total	<u>R2 200/month</u>

In the distributed system, the enquiries and data capture would all be handled at the branches. Summarised data would then be sent using a dial-up transmission mode. Assume that the transmission takes 20 minutes each way from each centre.

The monthly communication costs would be :

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 3 centres x 20 minutes/3 minutes per unit x
 R1 per unit x 2 transmissions x 22 days per
 month

= R880/month

or a saving of R1 400 per month.

Another factor to consider is that although a savings in communications' costs may be achieved, this does not prove that the total cost of a DDP system is cheaper than a centralised configuration. It may be more than offset by the cost of processors, terminals, the cost of additional staff, floor space, etc.

4.10 SOFTWARE AVAILABILITY

As was discussed in Chapter 3, the software available on mainframes is more sophisticated than that of mini- or micro-computers. A significant proportion of this sophistication is directed towards program development.¹⁴ One would therefore assume that systems would be developed faster on a mainframe than on a small computer.

"Sophisticated tools for software development on small computers are available in much less variety than on large machines. Good operating systems, with conveniences for the programmers, are rare."¹⁵

This quotation would suggest that if those software tools *were* available on small machines, then application development would be quicker than it is. However, the following quotation would tend to negate this theory.

"On the other hand, there are opposing factors which tend to reduce the cost of software development on decentralised mini-computers. Perhaps the most powerful factor is that the computer is specialised. . . ., under such circumstances there is no need for a sophisticated operating system with all its mind-boggling complexity. Therefore the programming is straightforward and uncomplicated."¹⁶

From the above one could conclude that a large mainframe with

its complex hardware requires complex software in order to utilise it effectively. However, a small computer would not need sophisticated software since the hardware and applications are not as complicated.

The effect of the above on the organisation is that the more complex the software, the higher the level of skill required to support it. In a large on-line centralised system, the software support effort required to instal and tune the system would be considerable.

As a corollary to this, a centralised system is liable to have only one computer system with only one manufacturer's set of software to maintain. In a DDP system, there could be multiple suppliers requiring multiple ranges of software, all requiring support. Even though the software may be unsophisticated, this may be an enormous task. This situation would become even worse if the mini- and micro-software were to become *really* sophisticated (the trends of development indicate that this is likely to happen).

A further point to consider is the control of software releases and their issuing to remote locations in a DDP environment. As was related by a user :

"We have also found it necessary to control software releases centrally, as suggested earlier. The effects of any laxity in the aspect of control can be exceedingly bizarre - and this means expensive and time-consuming. Different modification levels in the supplier's operating system, local fixes, different compilers, and so on can all have obscure and unpredictable results."¹⁷

4.11 STAFFING AND SYSTEM RESPONSIBILITIES

One of the most important considerations for an organisation that is implementing a DDP system is the development of application systems. In particular, who should perform the development? There are three alternative steps :

- Centralise the function at the Head Office
- Allow the users to develop the applications themselves
- Decentralise development with centralised control.

4.11.1 Centralised Development

The computer programmers and analysts are located at Head Office and all developments are co-ordinated by a DP or MIS manager. This method has the advantage that the process is easily controllable as all resources are sited in one location of the company.

"A critical area of concern of corporate management is control of EDP in the areas of cost, use of resources, and effectiveness."¹⁸

The significant portion of the cost of a system is the development effort. There can be little doubt that it is easier to control this effort if the resources are centralised than if they are spread over multiple locations.

A further advantage of this approach is that standards can be maintained more easily. These relate to :

- The use of coding structures (such as stock codes, branch codes, etc.)
 - Operating procedures
 - Security and recovery procedures
 - Languages used
- Etc.

If systems are being developed at a remote site it is difficult to ensure that standards are maintained.

Centralised development does have one major disadvantage and that relates to user acceptance of the system. A user at a remote site is more likely to accept a system if it has been developed under his management and control than if it has been developed at a distant Head Office by individuals with

whom he had little contact (despite the fact that the user may have been involved in the specification development of a centralised system). Under this mode of development the user is in the same situation as in a centralised system where all development takes place within the DP department at Head Office. This leads to the user not associating himself with his system and not supporting it to ensure its success..

4.11.2 Decentralised Development

The user becomes responsible for developing and maintaining his own systems. This would not be entirely possible without some specialist knowledge, which would be gained by moving 'business analysts' to the user departments. These, having the necessary computer expertise, would then work with the user and advise on the priorities, development methods, etc. This approach is discussed by Brookes, who states :

"However, most of the responsibility for systems design and routine applications programming will rest with the user department. This will mean that many computer specialists will be forced to choose between becoming even more closely associated with the computer, or they will have to transfer this allegiance to one or other of the user departments in the organisation. Thus they will join the

accounting, the marketing, the purchasing, the administration, or some other department and develop systems under the general control of the line managers of those departments."¹⁹

The major advantage is that the user, being in direct control of developing, installing and maintaining his systems, will endeavour to ensure their success.

The disadvantages of this approach are that non-standard systems may be developed - or coding structures may be used - that do not conform to company standards. Another consideration is that the user is not likely to have the expert knowledge of the equipment and its software that may, for instance, be found in a centralised DP department. Systems could, therefore, be implemented that would be inefficient in terms of run time, use of storage facilities, etc. A further factor is that the user may not have the discipline required to instal the system and program controls that are necessary to protect that department from accidental or intentional damage.

4.11.3 Decentralised Development with Central Control

A third approach is possible that combines the best features of the above two options. The main problem of decentralised development is that executive management loses the control discussed under the centralised approach. To overcome this,

an MIS department, as in Figure 4.3 (overleaf) may be established.

This approach was adopted by John Deere and Company, in the United States, where the DP department handles all liaison with the manufacturers of turnkey systems and they put together standards for development, hardware and software within the company. However, they see their prime task as being to educate the users to "understand a little more about what he is getting into, such as project management and computer operations".²⁰ In this case the DP department has assumed the role of the MIS section outlined above.

The functions of the MIS department would embrace, inter alia :

- Quality assurance including
 - systems justification
 - project management
 - acceptance testing
- Technical support in the areas of
 - system software
 - data communications
- Consulting advice covering
 - equipment acquisition
 - technical education
 - specialist application support (in areas such as linear programming, etc.).

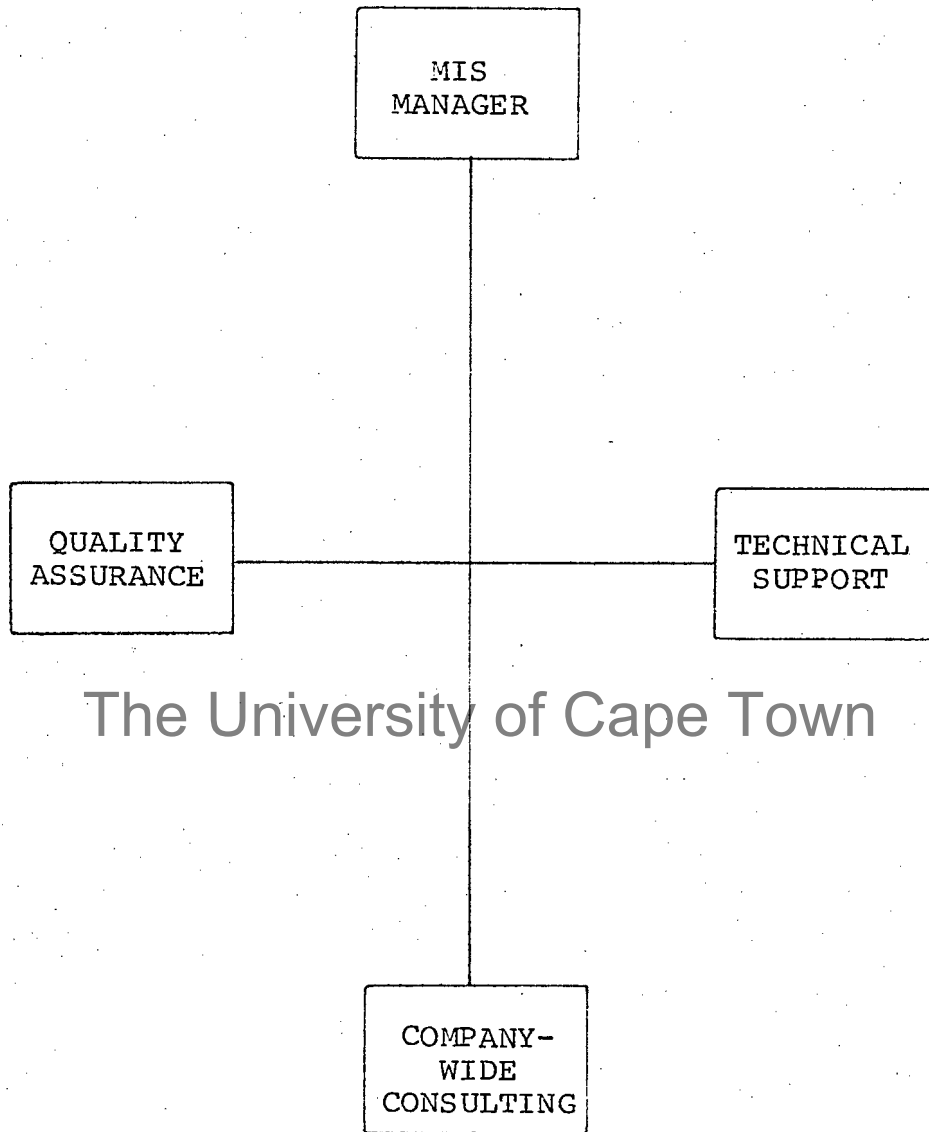


Figure 4.3 : Central MIS Organisation in a Distributed Environment²¹

The role of the MIS department thus embraces the work of a consultant plus the controlling of standards. The latter would be limited to such organisational factors as :

- Standard coding structures
- Documentation standards
- Data compatibility and integrity
- Non-duplication of systems development.

If either of the last two methods is chosen, it must be appreciated that in order to ensure the full benefits of a DDP system there should be a 'spreading' of resources in the organisation.

"One of the problems with decentralisation is that when you decentralise, you also disperse your talent. Subsequently, you have to determine where the people are who know what's going on."²²

4.12 CONCLUSION

The preceding sections in this chapter have analysed the more important criteria that should be examined by an organisation considering the use of DDP. It has served to highlight advantages and disadvantages of distribution as opposed to centralisation of the data processing resource.

Three factors were not considered in the analysis as it is felt that there is insufficient evidence available to form conclusions about them. These are :

- User interfaces

It is not known whether a DDP system will provide a better interface between user and hardware than will an on-line system (the interface being established through the use of prompts, menus, etc.).

- Incremental growth

This is the ability to increase the capacity of a computer to allow for the growth of a system or to add new applications. While a mini or micro can be expanded at a far lower cost than a mainframe, there is a trade-off in terms of programming changes which may not be required on a mainframe but will almost certainly be required on its smaller counterparts.

- Increased installation simplicity

As has been stated

"it is not demonstrable that the planning and design of multinode systems represent more or less effort than the planning and design of single, large systems."²³

The factors mentioned in Sections 4.2 to 4.11 could all have a bearing on the decision by an organisation to

centralise or distribute. It would have to weigh each in terms of its policy regarding data processing and then arrive at a conclusion. If that policy is to have a highly centralised form of management with only clerical functions in the 'field' then, according to many authors, one should choose a centralised approach. If, however, the company's policy is to give autonomy to user management, and allow them to control their data processing activities, then DDP would appear to be the favoured approach. It is important, though, that other factors (such as cost, availability, security, etc.) be considered before final selection is made.

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The authors of various publications appear divided as to the main reasons for selecting DDP :

Doouss and
Collins

: "Perhaps the most obvious reason for using distributed intelligence is the fact that the *pattern of processing and flow of information* much more nearly matches that which is natural to the company."²⁴

Auerbach

: "The president favoured the distributed approach because he wanted the *regional distributing centres to be autonomous*."²⁶

Pollard

: "One of the primary reasons why companies adopt a distributed data processing approach for their branches, depots or subsidiaries is its *low cost of implementation* in comparison with a mainframe computer."²⁷

Furthermore, there are no publications which summarise the factors that will impact the organisation once it has opted for DDP (such as staffing, user training and expertise, etc.). In order to examine further the reasons for selection of DDP, and the effect that it may have on a business, a field study was therefore performed. The details and findings of the study will be presented in the following two chapters.

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CHAPTER 5THE FIELD STUDIES5.1 INTRODUCTION

In Chapter 2 the characteristics of a DDP system were defined. This was followed (in Chapter 3) by an analysis of the developments in the computer industry that have made DDP possible. Chapter 4 then analysed the factors that need to be examined in the centralisation/distribution issue. However, an organisation that is considering the implementation of a DDP system has to take cognizance of other factors that may affect its decision and that may contribute to the success or failure of the project. These include such areas as :

- The implementation plan
- User and DP education
- User training
- Network decisions
- Possible changes to the organisation structure
- The maturity of an organisation in its use of computers.

As the available literature does not deal with these areas

in sufficient depth, it was considered that a field study was necessary.

5.1.1 The Companies Selected

Four companies were selected for the study, each with its Head Office in Cape Town. The reasons for selecting the four are :

- DDP is still a new concept and there are only a few companies in South Africa that have adopted this approach.

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- In addition, certain organisations are reluctant to divulge details of their systems; this limits the choice even further.
- Four companies were considered sufficient to obtain the information necessary to perform an analysis of distributed processing. The selection was made on the basis that the DDP systems were in different stages of maturity, and the organisations had adopted differing approaches to development and implementation. In addition, only two of the four companies selected the same range of hardware (the IBM S/34).
- The fact that the Head Offices of all four are situated in Cape Town does not detract from the

validity of the study as the principles are the same, regardless of where the corporate headquarters are located.

To preserve the anonymity of the participating companies, the author has referred to them as Organisations A, B, C and D. In addition, certain terminology that might have identified the nature of the business and thus might have led to disclosure of the identity of the company has been deliberately avoided.

A brief synopsis of the four organisations follows :

Organisation A

This company has installed a highly successful DDP system. It has an extensive network that has been operational since 1976. All systems were developed using the company's own resources.

Organisation B

The first nodal site to be installed in this company was in June 1980. For them DDP is thus still a relatively new concept. They have, however, been users of DP equipment for many years and have on-line facilities in Cape Town.

Organisation C

This business is similar in many respects to Organisation A but has not been operational for as long a period.

Organisation D

In 1972 the decision was made to adopt decentralisation. Although they had been computerised for approximately 10 years prior to that, all systems were centralised. Progress towards decentralisation was slow and not very successful. In June 1979, after installing three processing nodes, the decision was taken to revert back to a centralised environment. The three nodes were converted back to manual systems in the fourth quarter of 1979 and the centralisation process is now in the development stage.

The four organisations had (and have) different development methodologies and differing aspects relating to such areas as :

- justification
- staffing
- education.

Although many different facets were discussed with representatives from the companies, only those factors relevant to this study are discussed in this chapter.

5.1.2 The Mode of Study

A large number of facts and opinions had to be obtained from individuals within each organisation and it was

decided that a questionnaire would not elicit valid responses. Accordingly, all information was obtained through interviews. These were, in each case, held with senior members of the DP departments and, where possible, with users and senior management. A list of the topics discussed at these interviews is given in the Appendix at the end of this chapter.

5.1.3 The Objectives of the Field Study

The objectives were :

- (i) To attempt to determine the reasons and justification for selecting DDP.
- (ii) To ascertain those factors which, through implementing DDP, had an impact on the company.
- (iii) To determine the staffing implications of installing a system - both user and DP staff.
- (iv) To examine the network alternatives that were available and the reasons for each company's selection.
- (v) To determine the procedures that the companies (with the exception of Organisation D) are adopting to ensure the ongoing success of the operation.

The organisations have each been analysed in Sections 5.2 to 5.5 under the following headings :

- Background
- Application description
- Reasons for selecting DDP as a processing mode
- The DDP system description
- Staffing
- Advantages/disadvantages.

Conclusions from the field study will be dealt with in Chapter 6.

The University of Cape Town

5.2 ORGANISATION A

5.2.1 Background

This company has three functions : fishing, fish processing and vegetable processing. The Head Office is in Cape Town and it has three warehouses in Cape Town, Durban and Johannesburg. To handle its 20 000 customers, the company has 20 distribution centres situated throughout the Republic of South Africa. It handles approximately 500 products and has to process one million invoices a year (averaging five line items each).

In 1970 it formed a subsidiary to handle the group's data processing activities. A Burroughs B500 was acquired and sited in Cape Town. In 1971 an additional B500 was purchased for the Johannesburg region (sited at Cazerne) and the following year a third B500 was installed in Durban.

The organisation is split into three regions - Cape, Natal and Transvaal. The B500s were set up to handle the data processing requirements of each region. Although Durban's development was handled by Cape Town, Johannesburg was allowed to follow its own path and develop whatever systems it considered necessary.

The University of Cape Town

Data was placed on magnetic tape at the end of each month and air freighted to Cape Town, where it was processed to produce the monthly management and accounting reports.

In 1974/75 a Singer System 10 was installed in the Pretoria branch.

In 1975 an international firm of auditors was commissioned to analyse the group's data processing activities and to make recommendations as to the approach to be adopted.

After an extensive feasibility study (which took approximately 10 months), the auditors persuaded management to distribute their data processing activities. After evaluation of the tenders, Datapoint equipment was selected and the contract

signed in February 1976. The first computer (a Datapoint 5500) was installed in October 1976 at Clayville in the Transvaal.

5.2.2 Application Description.

The application basically involved invoicing and stock control. Customers are telephoned to obtain their orders. When the order is placed the price is inserted, if available (described later), and invoices produced. These then formed the basis of the picking list. Debtors administration was handled by each of the regional offices.

The problem areas were :

- (i) Certain items could be priced immediately but others were dependent on the weight of the product actually drawn from stock (for example, a customer might order one case of goods, but the price is determined per kilogram; it is only when the case is drawn from stock that the weight can be established as not all cases have the same weight).
- (ii) Controlling the stock was very difficult because of the number of items and the number of invoices. The packing of the ordered stock into delivery trucks was also critical in order to maximise the delivery routes and thus minimise the delivery times.

- (iii) Although computer systems were developed for the regional areas, there was no standardisation. This made transfer of personnel difficult because of the re-training time.

5.2.3 Reasons for Selecting DDP as a Processing Mode

Availability

If the company were to place the invoicing and stock systems on-line, then availability of the systems to the users would be the most important factor to consider. The transaction volume was so high that, despite manual back-up systems being available, the degradation of performance would be so high that the company could not have tolerated extensive down-times. They considered that in a centralised system too much reliance would have to be placed on the central site, and the communications network. A DDP system with multiple computing nodes offered higher availability.

Cost was not an important criterion as far as the organisation was concerned. They were prepared to waive any advantage that a centralised approach may have had in terms of cost and offset this against the increased availability of a DDP system.

5.2.4 The DDP System Description

(a) The Network

Figure 5.1 (overleaf) illustrates how the computer network is organised. The layout is similar to that shown in Figure 2.6 (Section 2.3.2) and would be classed as a vertical or hierarchical distribution. An example of a regional layout is shown in Figure 5.2 (page 124). Neither figure is an accurate representation of the actual network but merely illustrates the communication paths between the branches, regions and Head Office.

The Clayville branch is shown as having a Data point 5500. This is the only exception to the diagram shown in Figure 5.1. The reason for this is that the branch has such a high volume that a more powerful computer was required.

(b) System Description

'Telesellers' are assigned the duty of phoning the customers and obtaining the orders. These are written on to a form and sent, via a conveyor belt, to the VDUs. Here they are entered into the computer and a combined order and picking list is produced. (It would have seemed more appropriate to provide the telesellers with VDUs, but the above represents their actual system.) These are sent to the

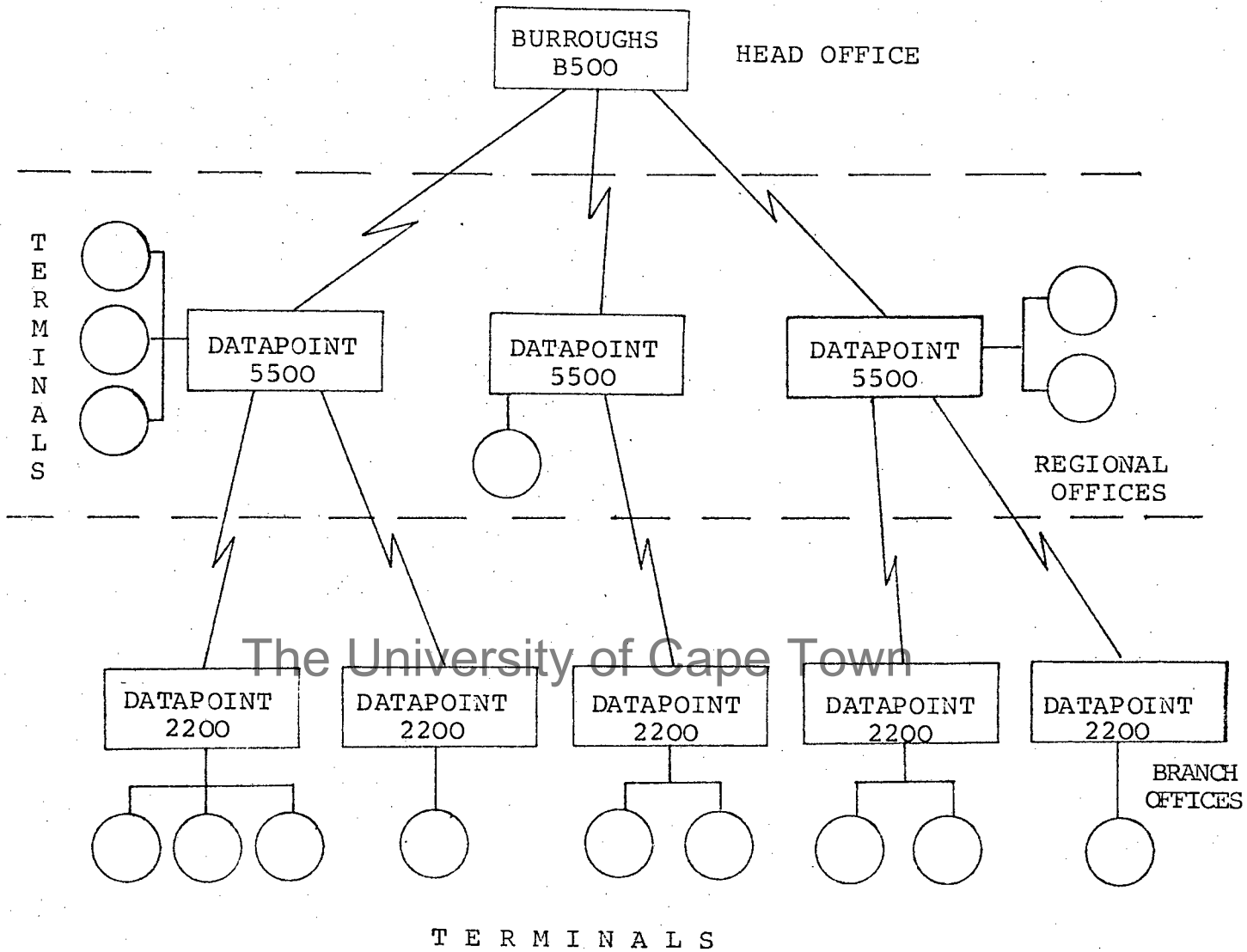


Figure 5.1 : Diagrammatic Representation of Organisation A's Computer Network

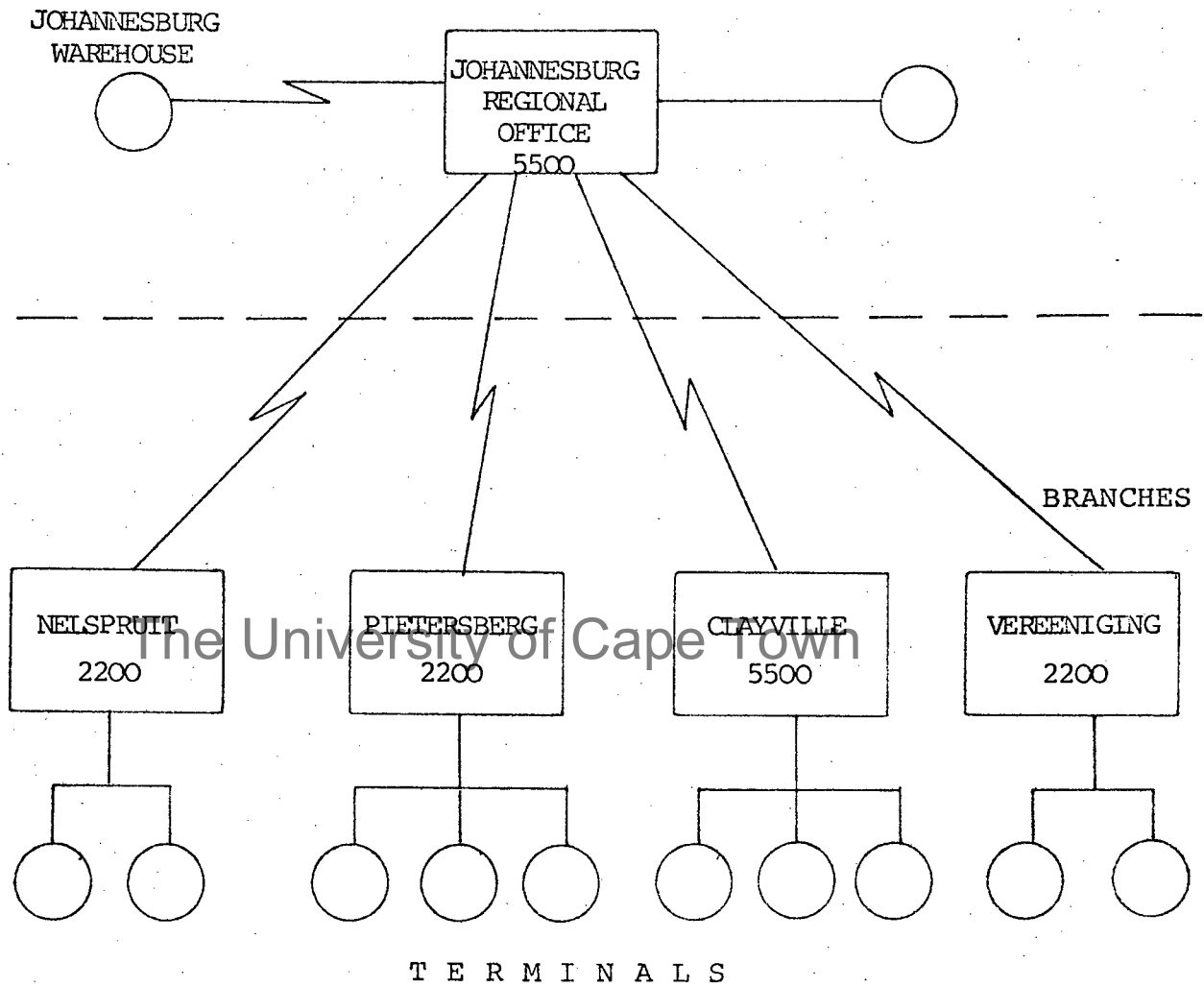


Figure 5.2 : Approximate Layout of the Transvaal Region of Organisation A .

router who groups the orders according to deliveries. After being checked they are given to the pickers. The stock items are placed on a conveyor belt which carries the goods to a delivery section. At this point the weight of the unpriced items is recorded and a final invoice produced. Any stock shortages are recorded and entered into the computer. The goods are then packed into the delivery vehicle according to the delivery schedule (on a first out, last in basis).

The system also performs the following :

- The capture of receipts from customers.
- The production of suggested re-order lists for the stock controllers.
- The recording of stock count information.

On a daily basis the movements are sent to the regional centres for updating of the master files. The branch files hold the stock, customer and pricing details pertinent to that branch only. The regional computer holds information (both unit and financial) applicable to all its branches. Thus, stock details are held at two locations.

Information is sent from each region to the Head Office at the end of every month for the production of monthly

management and accounting reports.

All communications are performed in a dial-up mode with the remote computer being placed in auto-answer status. All transmission of data is from the node computers to the mainframe. The only communication back down the lines is for program updates which are sent, in object form, from the B500 to the minis.

5.2.5 Staffing

(a) User Staff

It was found that, because of the sophisticated nature of the systems, the branches had to be re-organised to cater for computerisation. The function of 'Router' was created and became a 'key' position. Each branch was able to substantially reduce the number of pickers. These people were either laid off or placed in other positions.

Throughout the development phase, emphasis was placed upon making the applications as 'idiot-proof' as possible. The following indicate some of the aspects that were included :

- All securities (daily, weekly, etc.) of files are under program control - the operator does not have to remember to take them.

- Dates that are entered (for instance, in the start of day procedure) are rigorously checked against a date file.
- 'Help' commands are available at any point in the operation to assist the operators.
- It is impossible for the operator to place disk packs on the wrong drives as the serial numbers are checked programmatically.
- Recoveries, in the event of, for instance, power failures, are program controlled.

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This level of sophistication was considered necessary as the user did not wish to have a high level of operator expertise at any of the branches. The organisation's budget for software was exceeded as more and more sophistications were built in. The result was, however, that the branch computers could be handled by clerical personnel.

(b) DP Staff

All systems are developed centrally and sent to the branches via the communications lines when they are ready for installation. The reasons given for developing software centrally are :

- (i) Pooling of expertise. When the organisation had three B500s and Johannesburg was developing its own

systems, the organisation found that application and software expertise was being either duplicated or it was not sited where it was needed most. Now it is in one geographical site and duplication of the areas of expertise has been eliminated.

- (ii) To enforce standardisation. Since all systems are developed in Cape Town, the branches are forced to accept standard systems, otherwise they are not able to computerise.
- (iii) Economics. The organisation found that it was too expensive to develop unique tailor-made systems for each branch. A further factor was that the duplication of expertise at Johannesburg and Cape Town was obviously an unnecessary expense.

When a branch is to be computerised, DP personnel from Cape Town are seconded to instal the hardware and systems. The excellence of the systems and documentation enable them to instal in approximately two weeks.

Each region has a co-ordinator to handle any computer problems that may occur in the branches within that region. He would have a computer background (for instance, an ex-operator) and would be specifically trained by Head Office to perform the task.

5.2.6 Advantages/Disadvantages

- (i) The users are extremely satisfied with the systems and user acceptance is very high. They feel that because the computer is sited in their premises and they are responsible for operating the machine, it is 'their' system (even though they do not have unique application systems).
- (ii) The external audit of the organisation is easier because of the standardisation and the quality of the systems. The audit fees have therefore decreased. (This could possibly be attributed to the fact that the auditors were involved in the feasibility study, and could have also resulted if a centralised system had been recommended and installed.)
- (iii) Major staff savings have been attained.
- (iv) Through the greater internal control that has been achieved at each branch through the computer system, stock losses have been reduced.
- (v) A major problem of the distributed system is that the branch and regional files can get out of step. If this does occur then it is very difficult to synchronise them because the safeguards in the systems prevent master file manipulation. Periodic

audit programs are run to check that the files are correct. If not, because the regional file holds the financial information, it is assumed that that is correct, and the branch file is brought into line.

5.3 ORGANISATION B

5.3.1 Background

In 1966 this company acquired its first computer, an IBM 360/30. The hardware moved through the normal upgrade path to a 360/40 and in 1971 to a 370/145. The core capacity and peripherals of the computer were increased and extended until 1977 when the decision was taken to distribute their invoicing and stock control systems using IBM S/34s.

In the interim period a number of different minis had been obtained; 2 x PDP-11s were installed at remote locations to handle 'stand-alone' applications. Wang mini-computers had also been purchased. These were used as data capture machines by the distribution centres and to run highly specialised computer applications, such as linear programming.

The organisation has on-line facilities, but these are

restricted to their Head Office only, for what is termed 'personal computing' applications (e.g. planning and budgeting, personnel, etc.).

Subsequent to the decision to implement a distributed system the organisation installed an IBM 370/158 in addition to the 370/145. The mainframe upgrades were required to replace the proliferation of the minis (PDP-11s and Wangs), and to cater for the growth in the batch applications. The requirements of the DDP system did not, therefore, in any way affect the decision to upgrade.

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The Head Office is situated in Cape Town and distribution centres (or divisions) are located in all the major centres in South Africa. In addition, there are offices in the smaller towns (such as Caledon), which draw supplies from the larger centres. At the time of writing, all the divisions' daily processing is handled manually.

5.3.2 Application Description

The application that has been computerised comprises an integration of order processing, stock and invoicing.

Orders are phoned into the branches by clients and a local stock file is checked for availability of the required item(s). If available, the stock master is updated and an

invoice produced after extracting the prices from the price master file.

The problem areas for the company are :

- The prices are very variable. Some of the stock items have daily changes in their prices.
- The discount terms are complex, depending on the category of customer, etc.
- There is a requirement that the invoice be produced prior to delivery of the stock items, thus it must be produced in the area where the stocks are held. However, all debtor control and monthly accounting is centralised at the Head Office.

5.3.3 Reasons for Selecting DDP as a Processing Mode

(a) Economics

The organisation has a 370/145 at their Head Office. It was purchased five years ago and is fully depreciated. If they were to have placed the application on their main-frame and to have centralised, a more powerful computer would have been necessary. At the time, the cost of the upgrade was calculated at R1,3 million. The DDP solution, comprising IBM S/34s was estimated to be substantially less

than that figure. It will have been noted from Section 5.3.1 that the organisation has, in the interim, upgraded the 370/145. As was stated, this was independent of any requirements of the DDP system. Had the organisation centralised the divisions, the upgrade might have had to be even bigger (for instance, to a 370/168).

(b) Security

The organisation considers it vitally important for each division to be able to continue processing despite interruptions on the mainframe or the communications lines. Business is dependent on the ability of those divisions to produce invoices. To process the complete operation on the central mainframe would have meant placing too much reliance on one facility. The processor was not the main cause of concern (with the state of technology as it is today, processors are considered the most reliable portion of a total computer system). The more troublesome aspect was the communications facility. This is particularly so in times of civil unrest when communications control centres (such as telephone exchanges) present prime targets for urban terrorism.

Although this factor may be considered an emotional one, it nevertheless must be considered in the light of the organisation's security policy.

(c) Application Justification Philosophy

Organisation B adopted the philosophy that applications may only be computerised using the mini-computer if the savings from computerisation could justify the *total* hardware cost of those minis. Their reason for this is to avoid the situation that could be created in the following example.

Suppose application A is placed on the machine and justifies the cost of that machine.

Application B is computerised but the justification is based on a portion of the cost of that mini.

Application C is also computerised and it cannot justify the cost.

B and C expand to the point where that mini has reached full capacity and a second machine is required but those applications do not justify the cost of that second mini. The organisation is therefore placed in the position of either purchasing an unjustified machine or taking those applications off the computer and reverting to manual methods.

5.3.4 The DDP System Description

The computer operator receives telephoned orders from

customers. He or she therefore is seated at the VDU with a pair of earphones. The customer then gives his name and the system performs a phonetic search based on that name entered by the operator (e.g. if the operator enters 'Thom' the computer will respond with all the full names commencing Thom, such as Thomas, Thompson, etc., and their codes). Having selected the code required, the computer then displays a typical buying pattern for that client, based on his previous order history. If the current order is for goods already displayed on the screen, the operator merely has to enter the quantity. If not, the stock code must also be entered.

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On completion, the prices are retrieved, the order extended and the invoice printed. This is then used for drawing stocks and as a delivery note. If the line item entered reduces the quantity on hand of that stock item below a minimum level, the operator is warned.

At the end of the month, the invoice details are sent to Head Office where statements are produced and the monthly accounts prepared. This is done in dial-up mode. The central computer dials the S/34 which is on auto-answer and the data is transmitted.

The Computer Network

The network at the time of writing consists of a link to a single nodal computer (an IBM S/34) situated at Mossel Bay. From there a line is taken to a user site at Caledon. Figure 5.3 (overleaf) shows a diagrammatic representation of the existing network.

The reasons for choosing Mossel Bay as the initial site were :

- Its proximity to Cape Town. The site was sufficiently close that in the event of a system failure people could be sent from the Head Office to repair the hardware or software fault.
- Although the site is comparatively small, it is performing all of the functions of the major divisions (e.g. Durban, Alberton, etc.). The system could therefore be thoroughly tested on a small user yet still be representative of a larger office.

The intention of the organisation is to expand the DDP operation to eleven other nodal locations. These are situated at :

Port Elizabeth

Durban

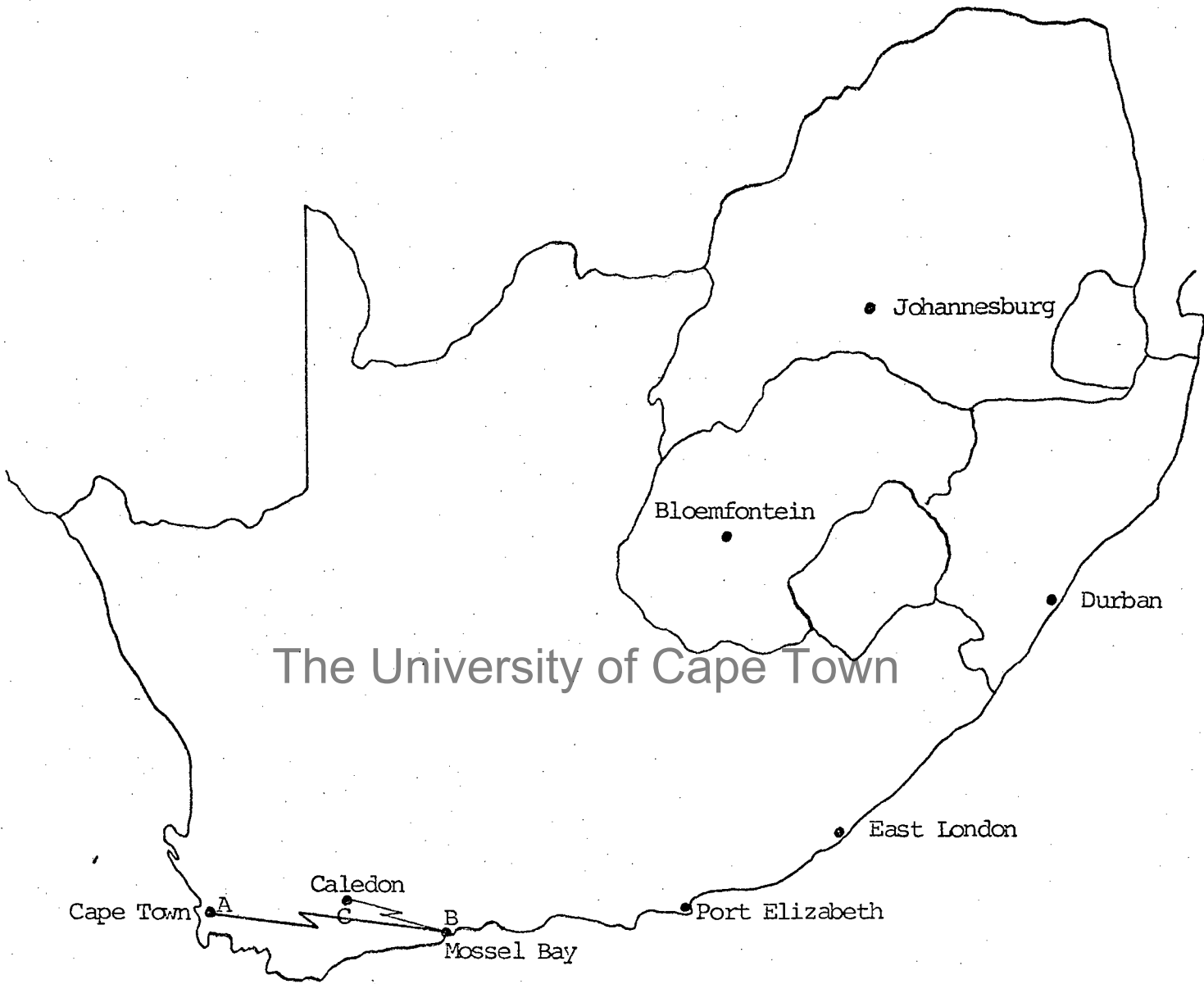


Figure 5.3 : Diagrammatic Representation of Organisation A's Existing DDP Network

- A = S/370 in the Head Office at Cape Town
- B = S/34 at Mossel Bay
- C = Remote Terminal at Caledon off the S/34

Ladysmith

Nelspruit

Pietersburg

Johannesburg

Alberton

Luipaardsvlei (Krugersdorp)

Kimberley

Bloemfontein

Bethlehem.

Each nodal computer will then serve one other remote location, e.g. Caledon is connected via a leased line to the S/34 at Mossel Bay, Queenstown will be connected to the Port Elizabeth S/34, etc. The S/34 only communicates to the mainframe in dial-up mode.

Each S/34 can only communicate with the mainframe. There is no requirement for inter-node communication. Thus in terms of the definition in Chapter 2, the configuration of the network is hierarchical as shown in Figure 5.4 (overleaf).

5.3.5 Staffing

No additional staff is required at the nodal site for operation of the computer. The existing personnel have been trained extensively in the use of the computer in

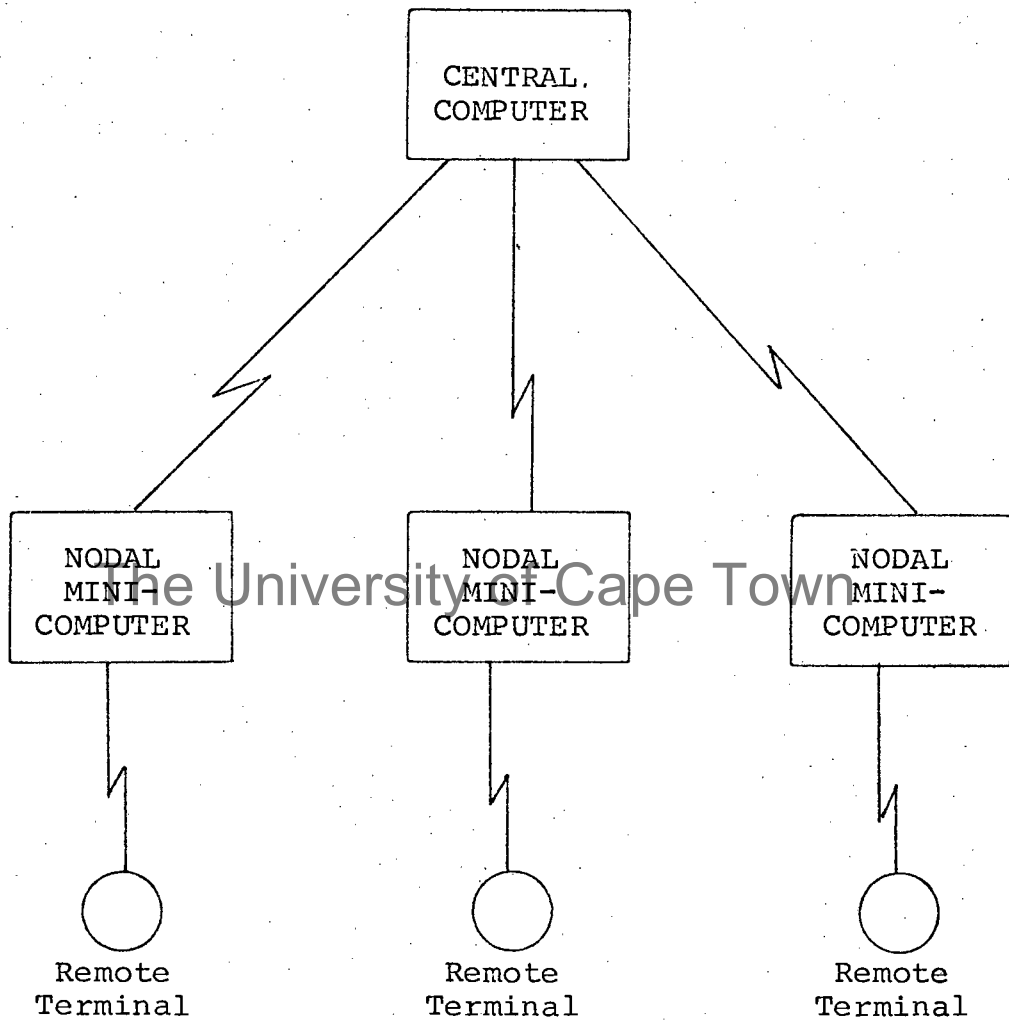


Figure 5.4 : Example of the Hierarchical Network, as Envisaged by Organisation B

such areas as :

- System start-up
- Security/recovery
- Fault diagnosis
- Operating procedures.

All systems are developed at the Head Office by DP personnel.

Although this may appear to be in conflict with one advantage of DDP as stated in Chapter 4, viz. that of being able to develop a unique system for each user, in the case of this organisation each nodal site has a system identical with the others. As there are no qualified DP personnel

at the mini-computer locations, it is important that each system be thoroughly tested prior to implementation. The organisation therefore deemed it wise to have this done at the Head Office by skilled programmers and analysts. The company has created the positions of specialist DDP coordinators based at their Head Office. Their tasks are to :

- train the personnel at each user site
- check on the administration of each location
- assist with the take-on and conversion of each site
- act as internal auditor by periodically checking the activities of each site.

5.3.6 Advantages/Disadvantages

The organisation sees the following advantages accruing from its approach.

- The lead time for delivery of items of equipment is shorter for the minis than for the mainframe; therefore there is more flexibility with a DDP approach.
- The cash flow of the DDP system is more advantageous to the company than a centralised approach. With the latter, R1,3 million would be required at the outset of the project, whereas they now only have to pay for each nodal mini-computer as and when it is installed.

5.4 ORGANISATION C

5.4.1 Background

This company acquired its first computer, an ICL 1301, in 1965. From that point on they followed the path of almost all DP departments, viz. expanding the size of the mainframe. In June 1968 they purchased an ICL 1901. This was upgraded in 1973 to a 1902. In 1975/76 they acquired an additional 1901 to provide relief for the overloaded 1902.

In April 1978 the organisation took the fairly radical step

of changing suppliers. The 1901 and 1902 were replaced by an IBM 370/145. The reason given for the change was that both the 1901 and 1902 had, by that time, run out of capacity. The natural upgrade path was to ICL's newly announced 2950. As the organisation did not wish to be 'guinea-pigs', they decided to examine alternative suppliers. The IBM was the best alternative in lieu of its capability to emulate the 1901 and was thus chosen.

In 1979 the decision was taken to distribute the data processing function to the organisation's distribution centre at Epping in Cape Town. A System 34 was acquired for this purpose and the system 'went live' early in 1980.

A Datapoint 2200 is also situated at a warehouse in Johannesburg. This system was installed in 1976 and was later given communicating capabilities for the transmission of data to the Cape Town office.

The organisation has a highly decentralised management structure. The following figure (Fig. 5.5 overleaf) illustrates how the company has been structured.

Each operating division has its own structure which is independent of the group's, and they have full autonomy in terms of their operating decisions (both short- and long-term). They also perform different functions, for instance,

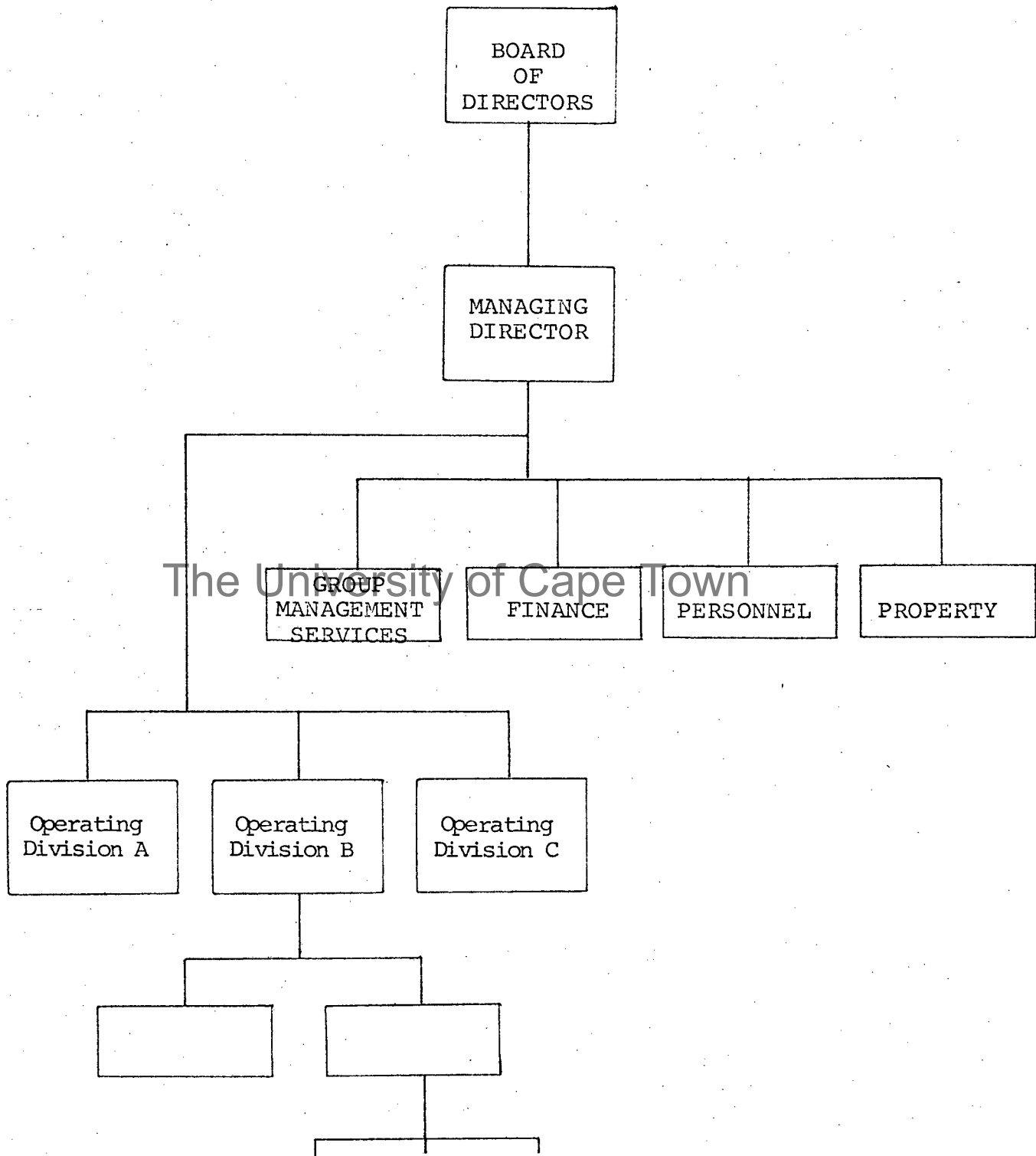


Figure 5.5 : Management Structure of Organisation C

Division A manufactures, B retails and C is a distribution centre.

5.4.2 Application Description

The application that the company distributed to its warehouse was a purchase order management system. They have an extremely large number of stock items that are split into size, colour and style. As each item enters the warehouse, it has to go through the following stages prior to distribution :

- A check for quality control
- Labelling
- Storage
- Picking
- Packing.

Every article has to be tracked through each of the steps. In addition, they have to be matched against orders, to keep track of those that are outstanding or partial deliveries.

Credit control offices are situated in the major centres of South Africa (Cape Town, Port Elizabeth, Durban, Johannesburg and Pretoria). The branches receive microfiche copies of debtor balances and every credit sale is checked against

the balance and the limit of the customer. If there is a problem (over limit or a new customer), it is referred to the central credit office for resolution. The administration of the debtors and the collection of funds is handled at each of the centres. Although the DP plan includes distributing processing power to the credit control centres, the major development effort was towards the warehouse system. The analysis of Organisation B was thus directed towards that area.

5.4.3 Reasons for Selecting DDP as a Processing Mode

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(a) Flexibility

In 1979 the organisation considered both the centralisation and the distributed options. It rejected the former. The 370/145 was being used to run batch systems only. To implement an on-line system would have involved the company in a considerable investment in the purchase of, and training for, such products as CICS (Customer Information Control System), VSAM (Vertual Sequential Access Method), NCP (Network Control Program). They also considered that if they followed this path they would be 'locked in' to IBM and its equipment. DDP, on the other hand, could be implemented without any of the above. The tele-communications capability could be achieved through the use of RTAM (Remote Telecommunications Access Method).

Furthermore, the distributed approach allowed them more flexibility in that if they decided to change mainframe supplier at a later date, they could do so without affecting the remote locations.

(b) Implementation Schedules

The organisation was in the position where they had to instal a system for the warehouse at very short notice. They endeavoured to purchase a suitable package but could not find one that matched their requirements. They considered that the development time on a mini would be much shorter than on a mainframe. (Having developed and installed the system, and in the light of their considerable experience, they still consider this to be the case.)

5.4.4 The DDP System Description

(a) The Network

Figure 5.6 (overleaf) illustrates the installed network layout of Organisation C. All the remote locations communicate with the central mainframe in dial-up mode.

A terminal, connected to the S/34 at the Epping warehouse, has been sited in the Head Office. This is so that members of the development team can enquire into the master

- A = IBM 370/145 at the Company's Head Office
B = S/34 at the warehouse in Epping
C = S/34 in the Credit Control Office in Cape Town
D = Datapoint 2200 at a warehouse outside Johannesburg
E, F, G, H = Credit Control Offices in Port Elizabeth, Durban, Johannesburg and Pretoria. These are handled manually at present, but the DP plan includes distributed systems at these sites

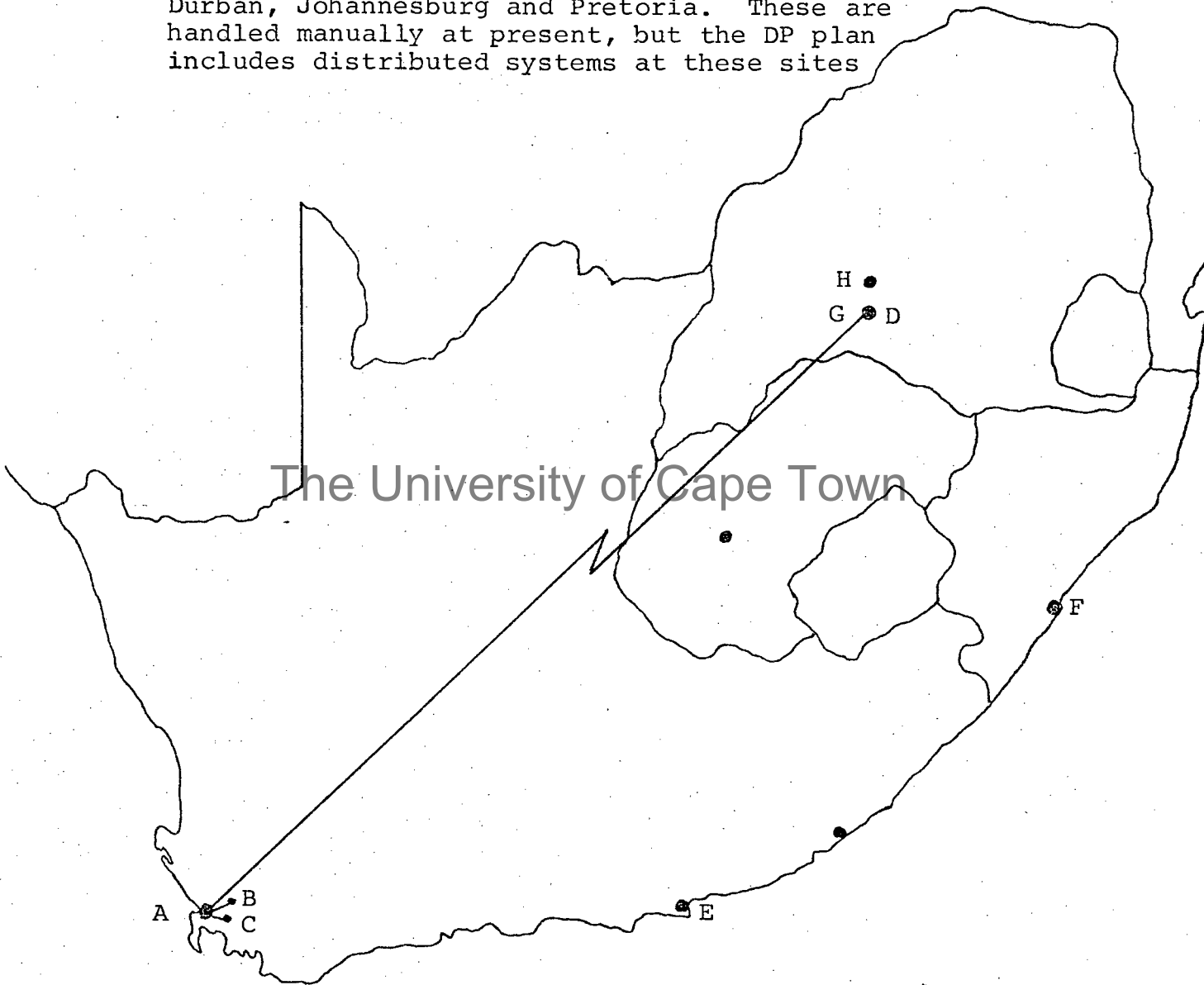


Figure 5.6 : Network Layout of Organisation C

files of the warehouse and correct the data in the event of the master file on the mini getting out of step with the mainframe.

None of the remote computers can communicate with each other.

(b) System Description

Orders are captured at Head Office and update the order file on the 370/145. At a convenient time of the day, the orders (excluding financial information) are sent, using dial-up data transmission, to the S/34 to update its files.

As deliveries are received by the warehouse, so they are entered into the system for matching against the order. A delivery is always entered per stock item (not as, say, 20 items of Product X), so the data capture load can be high when a number of deliveries are received. Using the remote screen that is connected to the S/34, Head Office staff may enquire into the status of orders.

As each item (after delivery) is checked for quality control or is packed, so that information is entered and logged against each item. Exception reports will highlight any articles that have been missed.

At the end of each day shipments to the retail outlets are transmitted back to the Head Office to update the 370 files.

The 370 files are always considered to be correct as that is where the source of all information (the order) is held in its full form (i.e. with financial details). Thus, if the files get out of step, the S/34 files are brought into line with the 370 files.

5.4.5 Staffing

(a) DP Staff

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The systems were developed by members of the Head Office DP staff. During this phase the team was situated at Epping so that there could be as much contact between themselves and the users as possible. Once the development was complete, and the systems installed, the team was then moved back to the Head Office.

The user site at Epping is handled on a Facilities Management basis by members of the Head Office DP staff. Their duties, inter alia, are :

- Recruitment of data capture staff
- Training of the remote computer staff
- Education of the users

- Providing on-going systems advice
- Maintaining the existing systems.

(b) User Staff

At first the organisation considered training the Warehouse Manager to use the computer. However, after an analysis of the amount of time that would be required versus the amount of time that he had available, they realised that it would not succeed. Therefore they opted for the Facilities Management approach.

The University of Cape Town

5.4.6 Advantages/Disadvantages

- (i) The organisation made a very quick decision to move to DDP. They admitted that it was not very carefully planned. They feel that, in retrospect, it was the correct decision and that, given the same choice, they would not change it.
- (ii) Even though the systems were developed by the Head Office staff and the site was managed by non-warehouse personnel, the warehouse manager felt that it was 'his own' system. The users had a very positive attitude towards the computer (this was in contrast to the fear that they felt when initially discussing the DDP system).

- (iii) The budget for the program development was significantly exceeded. This was due to two factors. Firstly, they under-estimated the effort involved and the training and education time of the programmers. Secondly, they found that there were a large number of modifications that were required to reduce the possibility of the operators corrupting the data.
- (iv) The organisation at first attempted a distributed data capture only system at the Johannesburg office. This, it was found, did not function very well but the problem was a managerial one in that the control over the staff and operating procedures was lax.

5.5 ORGANISATION D

5.5.1 Background

This organisation's Head Office is in Cape Town with operating divisions in all the major centres in South Africa.

In 1974 a feasibility study was performed by the DP department in conjunction with the user management. The results favoured DDP. After a protracted period, the equipment was selected and the contracts for Burroughs B/80s

were signed in 1976. All the application programs were to be developed by the manufacturer. In June 1978 the application was installed at the first nodal site in Woodstock, Cape Town. In October of the same year Durban was installed and in February 1979 the largest site at Isando in Johannesburg 'went live'.

In June 1979 a Business System Plan (BSP) was performed by IBM and the results favoured a change back to a centralised approach. In the last quarter of that year the nodes were converted back to manual systems and the B/80s were returned to the manufacturers. A three year project was initiated to instal a centralised Data Base/Data Communication system.

At the time of the decision in favour of DDP (in 1974) the organisation was decentralised in terms of its management structure as the following figure (Fig. 5.7 overleaf) indicates.

The Marketing Manager was situated at Head Office, but the Regional Managers were situated at each region. They had autonomy for marketing within their areas within the confines of the policies laid down at Head Office. There were informal reporting lines from the regions back to Head Office functions (represented by the dotted lines). This structure was subjected to a number of changes and in

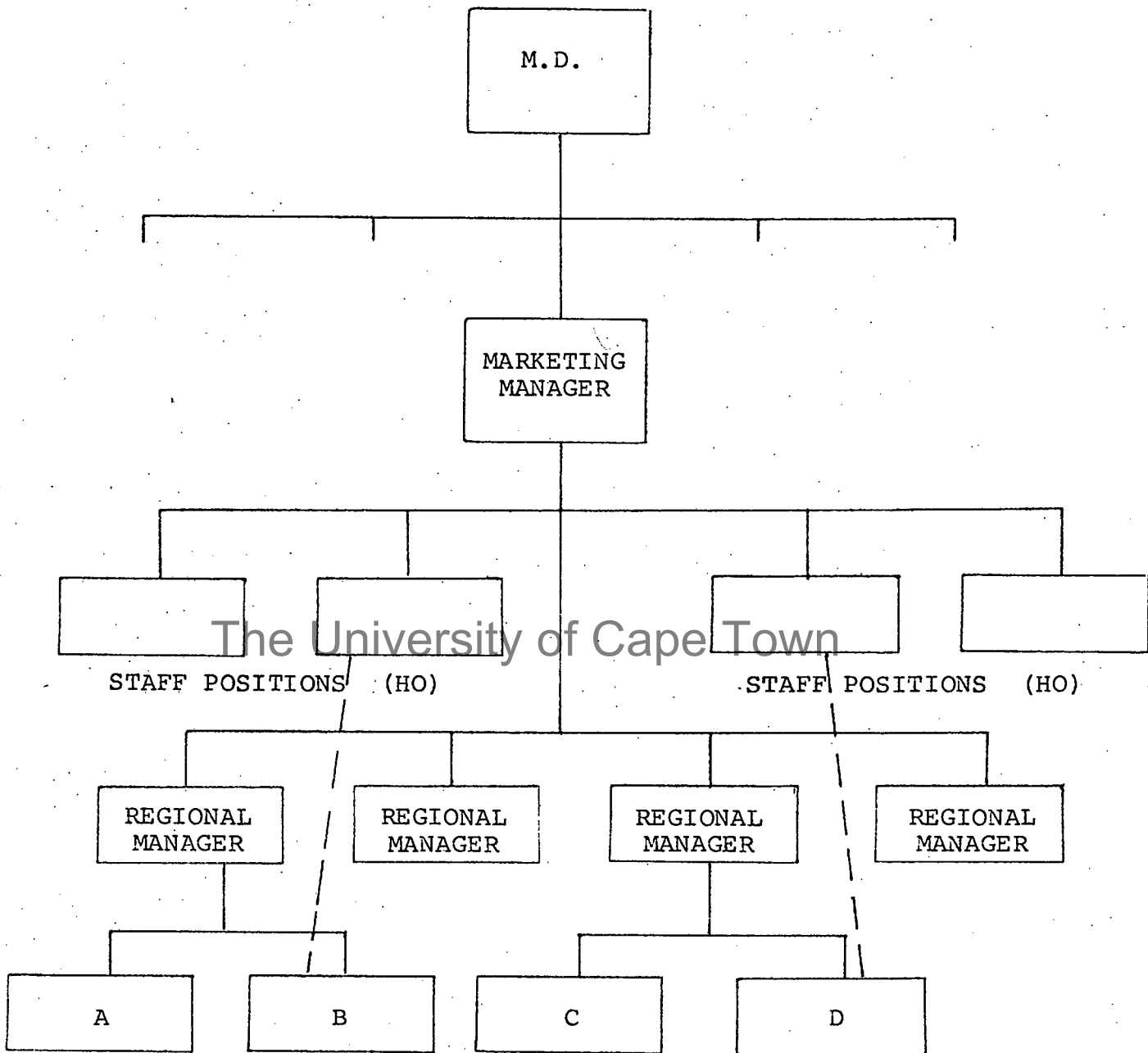


Figure 5.7 : Management Structure of Organisation D

1979 the Regional Managers no longer existed. It was replaced by a highly centralised layout where the field functions (A, B, C and D in Fig. 5.7) reported directly to Head Office staff.

5.5.2 Application Description

The applications selected for computerisation were similar to those of Organisation B, being invoicing and stock control. The problem areas and details of the system are as described for Organisation B (Section 5.3).

5.5.3 Reasons for Selecting DDP as a Processing Mode

The organisation performed an extensive feasibility study of the distributed versus the decentralised approach. This was commenced in 1974 and took almost a year to complete. It was a formal evaluation as the following extract indicates.

Selection Approach

The organisation was faced with four choices :

- On-line to a central mainframe
- Independent networks
- A cluster mix (clusters of terminals around a remote controller)

- Distributed intelligence.

To assist in the selection of the favoured approach, weightings of 1 to 4 were assigned to each factor (if it were considered important it would be assigned a 4, if unimportant a 1). The factors were assigned after proposals had been received and evaluated from several suppliers. Therefore the assignment of weightings was based on known costs.

The following table (overleaf) illustrates the results of the analysis performed by Organisation D. The bracketed items refer to supplier-related factors.

The results clearly favoured DDP. In addition, further financial analysis showed a favourable Discounted Cash Flow and that the payback period was within that prescribed by the company in its investment policy.

5.5.4 The DDP System Description

Figure 5.9 (page 157) illustrates the network that existed in the fourth quarter of 1979. The B/80s were connected via dial-up mode to the mainframe. They were used to capture details of orders from clients and produce invoices. Stock items were updated at the time of capturing the order.

	Score	On Line to Main Frame	Independent Networks	Cluster Mix	Distributed Intelligence
OPERATION	20	6	7	8	17
Hardware simplicity	2	2	2	-	1
Interactive order entry	4	-	-	4	4
Overlapping VDU/printer	(1)	-	(1)	(1)	(1)
Reliability (independence)	4	-	-	2	4
Staff motivation	1	-	-	-	1
Centralised control	4	4	3	1	2
Total cost	4	-	1		4
DEVELOPMENT/IMPLEMENTATION	20	-	4	2	20
Existing proven software	(4)	-	-	-	(4)
Application development support	(2)	-	-	-	(2)
Probability of success	4	-	1	-	4
Maximum exposure	2	-	1	-	2
Speed/Ease of implementation	4	-	1	1	4
Total cost	4	-	1	1	4
MAINTENANCE	14	12	6	6	5
Engineering support	(4)	(4)	(1)	(2)	(1)
Software support	(2)	(2)	(2)	(2)	(2)
One language	2	2	-	-	-
Vendor financial stability	(4)	(4)	(3)	(2)	-
Systems programming resources/cost	2	-	-	-	2
EXPANDABILITY	8	7	7	6	6
All depots	2	2	2	1	1
Limited additional depots					
- incremental hardware cost	4	4	4	3	3
- incremental software cost	2	1	1	2	2
SYSTEMS & COMPUTER DEPT.	16	14	3	2	2
Upgrade to 370	2	2	-	-	-
TP capability	2	2	-	-	-
Staff motivation	4	4	-	-	-
DOS/OS operation	2	-	2	2	2
One supplier: IBM	4	4	-	-	-
Leased line Durban/CT	1	1	1	-	-
Interface - other system	1	1	-	-	-
Approach-related		29	20	17	40
Supplier-related		(10)	(7)	(7)	(10)
Total	78	39	27	24	50

Figure 5.8 : Analysis of the Evaluation of the Four Processing Modes Selected by Organisation D

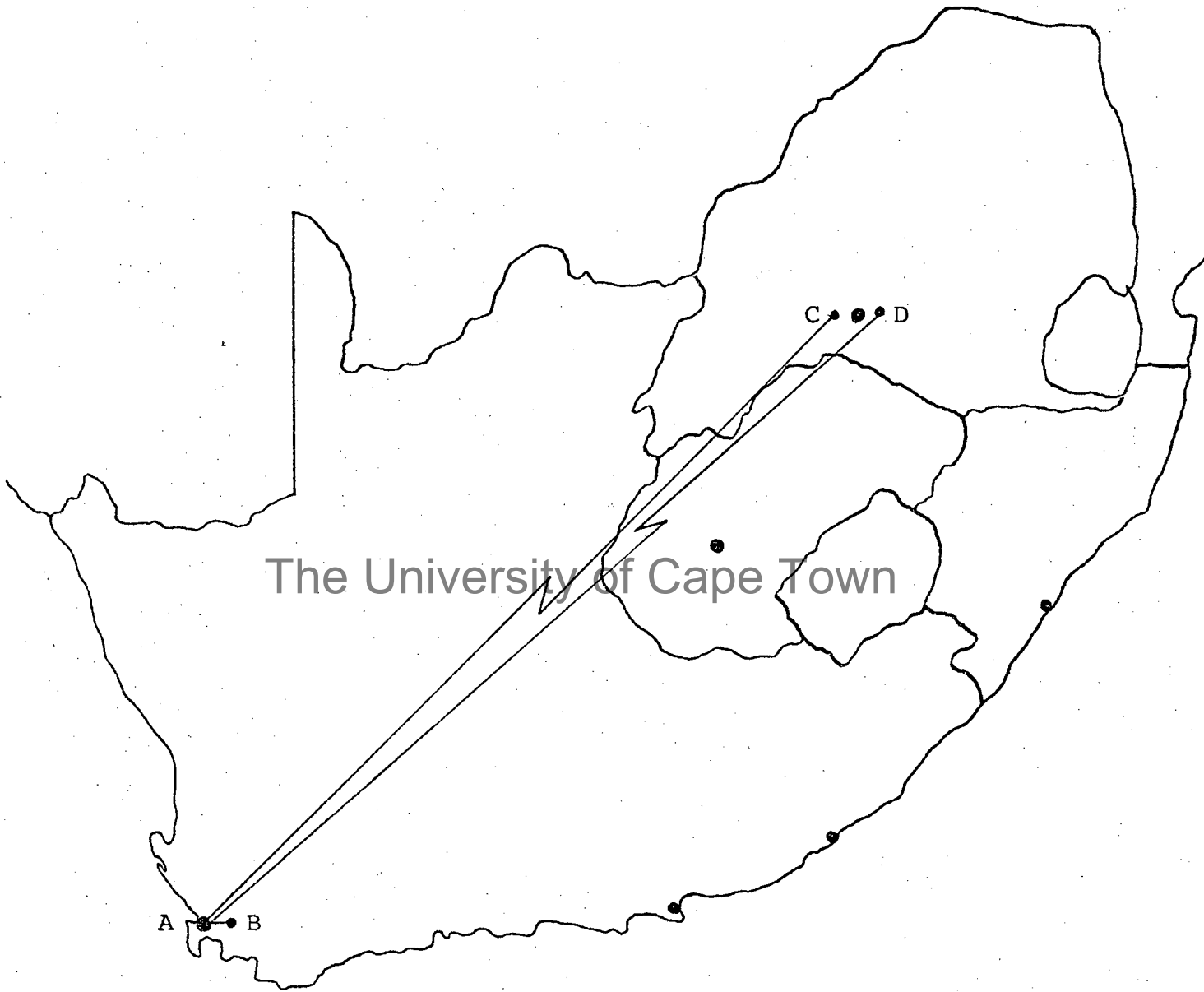


Figure 5.9 : Network Layout of Organisation D as it Existed in 1979

- A = IBM Mainframe at the Head Office in Cape Town
- B = Burroughs B/80 at Woodstock
- C = B/80 at Isando
- D = B/80 at Langlaagte

A master file was held on the mainframe with subsets at each of the nodal sites.

New customer details and special price changes were batched at each region and sent by post to Head Office. There they were batched and entered on to the mainframe. Only at that stage were they sent down the communication line to the regions for updating of the nodal files. As was related, this could have been anything up to three or four weeks after receipt of the new client details by the region. This delay presented problems to the regions in terms of processing orders for new customers. Until such time as the details were loaded (pertaining to the customer), the order had to be handled manually.

5.5.5 Staffing

The organisation believed that the B/80s could be operated by the users with no additional staff. They totally underestimated the amount of training required and found that there was a continuous effort needed to answer user queries and to rectify the errors. Had they not decided to centralise their systems, it was felt that they would have had to consider placing trained computer personnel at each regional site.

The applications were developed by the manufacturer of the

computer equipment. A group was established to confer with the supplier on application details, enhancements to the systems and potential problem areas.

5.5.6 Advantages/Disadvantages

- (i) As was stated, the training required at each remote site was underestimated. There was thus a large commitment required from the central DP department for on-going support.
- (ii) The organisation considered that the maintenance load in terms of back-ups, security procedures, recovery, etc. was too high (vis-a-vis a centralised system).
- (iii) The users were discouraged by the initial problems encountered when installing the systems. However, at the time of the reversal of the decision, they were enthusiastic about the systems and were unhappy to lose them.
- (iv) There was no integration of the DP plan into the corporate plan. Thus, the re-organisation of the company structure into a more centralised form was performed without taking cognizance of the long term plans of the DP department.

5.6 CONCLUSION

While all the organisations were extremely helpful in supplying information concerning their DDP systems, and were keen to describe the technical aspects such as the hardware and the systems operation, they were reluctant to talk about non-computer related aspects (the organisation structure and the corporate plan). There is thus an element of non-standardisation when analysing the organisations; for instance, organisational charts were only available for Organisations C and D. However, the author considers that the information given was sufficient to obtain a good understanding of their applications.

As can be seen from the preceding sections, each organisation had a widely differing approach and methodology in establishing and operating its DDP system. The information gathered in the course of the study provided a sufficient foundation from which to draw numerous conclusions. A summary of these will be presented in the following chapter before presenting the recommendations for implementing a DDP system (Chapter 7).

APPENDIX

TOPICS DISCUSSED AT INTERVIEWS IN THE
FIELD STUDY

DP MANAGER

1. STAFFING

Hiring or replacing

Training

Motivation

2. FINANCE

Justification

Equipment selection

Systems development

Alternatives

3. PLANNING

Agreement

Budgets

Control

Feasibility study

Integration with corporate plan

4. CONTROLS

Physical

System

Auditor role - external

- internal

5. IMPLEMENTATION

Error correction

Problems with - suppliers
- Post Office

6. EFFECTS ON COMPANY

User motivation

Management co-operation

Security

Communication lines

7. BENEFITS

To the company

To the individual department

8. WEAKNESSES

9. FUTURE DIRECTION

Hardware developments

Software developments

Systems developments

Changes in organisational structure

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USER

1. EFFECTS ON COMPANY

User motivation

Management co-operation

Security

Communication lines

2. BENEFITS

To the company

To the individual department

3. WEAKNESSES

SENIOR MANAGER

1. FINANCE

Justification

Equipment selection

Systems development

Alternatives

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2. PLANNING

Agreement

Budgets

Control

Feasibility study

Integration with corporate plan

3. EFFECTS ON COMPANY

User motivation

Management co-operation

Security

Communication lines

4. BENEFITS

To the company

To the individual department

5. WEAKNESSES6. FUTURE DIRECTION

Hardware developments

Software developments

Systems developments

Changes in organisational structure

USER MANAGER1. STAFFING

Hiring or replacing

Training

Motivation

2. CONTROLS

Physical

System

Auditor role - external
- internal

3. EFFECTS ON COMPANY

User motivation

Management co-operation

Security

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4. BENEFITS TO THE COMPANY

To the company

To the individual department

5. WEAKNESSES

6. FUTURE DIRECTION

Hardware developments

Software developments

Systems developments

Changes in organisational structure

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CHAPTER 6ANALYSIS OF THE FIELD STUDIES AND THE
CONCLUSIONS REACHED

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CHAPTER 6ANALYSIS OF THE FIELD STUDIES AND THE
CONCLUSIONS REACHED

6.1 INTRODUCTION

Chapter 5 provided a background to the companies that were analysed in the field study, the purpose of which was to examine the practicalities of installing a DDP system and its effects on the organisation.

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This chapter is devoted to examining the results of the field study in relation to the development and implementation of a DDP system.

The sequence in which each topic is handled is the same as that of the development of any computer system, viz. :

- The feasibility study and justification phase
- The development phase
- Implementation
- The post-implementation phase.

6.2 THE COMPANIES THAT ARE ELIGIBLE

It is evident that not every organisation can instal a DDP system; there are restraints on the size and the structure of the business.

6.2.1 Size of the Organisation

Each of the companies surveyed in the field study was a large company (the turnover of each is in excess of R50 million per annum), yet the question must be asked whether there is a lower limit to the size of the company that wishes to instal a DDP system. A common method of determining the amount to be spent on DP is by relating the cost of the hardware and associated products to the turnover of that company. With the advent of micro-computers, the entry point is obviously lower since the cost of the hardware has declined. A minimum cost breakdown would be :

Hardware

Two communicating micro-computers comprising 128K memory, 10MB hard disk, printer and screen	R15 000/annum
---	---------------

Software

It is unlikely that the software will be available in packaged form, so it will have to be developed. Assume that one analyst and two programmers are required	R40 000/annum
--	---------------

Ancilliary Costs

Operators, communication costs, stationery,
etc.

R20 000/annum

The total annual cost per annum of a minimum DDP system is thus approximately R75 000 per annum. If one assumes that DP costs should be 1% - 2% of turnover, then sales of approximately R5 million would be required to allow the cost of that minimum system. However, turnover cannot be the sole criterion in deciding the amount to be spent on DP. Other factors that must be considered include :

- The number of personnel available. This is particularly relevant in a DDP environment where users are required to operate and control the computer system.
- The profitability of the company in relation to the turnover. Some companies may be making in excess of a 20% return whereas others may only be making 2% - 3%. The latter would experience difficulties in justifying an expenditure of R75 000 per annum on profits of R100 000.
- Prior experience of the organisation with data processing tools and methods. DDP requires a high level of expertise in the areas of operational control and the probability of a new user succeeding with a DDP system is very low.

From the above factors, it is exceedingly difficult, if not impossible, to set a minimum size for the company that may consider DDP and the author does not feel that a conclusion can be justified.

6.2.2 Structure of the Organisation

Not only should a business be of sufficient size to warrant a DDP system, but it should also have a structure that necessitates the processing of data at multiple sites and the transfer of data between those sites. Organisation C was a Head Office/Subsidiary business, whereas the rest were Head Office/Branch relationships. Both would seem the logical structure, but DDP systems have not been restricted solely to those types of companies. Although it is outside the survey, there is an organisation in South Africa that has a mainframe to handle corporate applications. It then has minis to process its debtors. This would not seem untoward except that the mini is in the same building as the mainframe. A distributed mini was chosen in this case because of loadings on the mainframe and the incremental cost of an upgrade to the mainframe would have been more than the cost of the mini.

The main consideration then is that the organisation should be sub-divided into processing components such that a branch/subsidiary/division of the company that wishes to

instal a computer, should be able to process all the data pertaining to that component.

To summarise, therefore, eligibility would appear to be based on the following :

- The organisation should be divided into self-contained processing units.
- It should have experience in the data processing field, preferably through a centralised mainframe.
- It should have sufficient personnel with the necessary skills to operate and control the DDP system or should be able to afford employing the additional required staff.
- It must be able to justify the costs of hardware, software and personnel.

The structure of the company, in terms of either centralised or decentralised management, does not appear to be important. The DDP decision depends more on the *philosophy* of the management in their approach to the centralisation/decentralisation issue.

6.3 THE FEASIBILITY STUDY

A system that embraces a distributed solution is liable to be more complex in terms of systems design and programming than one that is centrally developed. The areas that are liable to add complexity are :

Technical - The design of the master files (incorporating such factors as duplication at central and remote sites, and the recovery procedures)

- The transfer of data between sites

Managerial - Control of the development process

- Control of the conversion process

It therefore follows that the feasibility study is likely to be more complex than for a centrally developed system. An analysis of the times devoted to the feasibility studies by the four organisations surveyed shows the following :

A spent 9 months on the study

B spent 14 months on the study

C spent 2 months on the study

D spent 16 months on the study

Organisation C's short period may be explained by the fact that they were 'forced' into a quick decision (as was related in the previous chapter). Apart from Organisation C it is evident that a considerable investment was made in

the feasibility study. There are certain aspects that are of special importance.

6.3.1 Justification

An analysis of the four companies surveyed shows that the following reasons were given for choosing DDP :

Reason for Selecting DDP	Organisation			
	A	B	C	D
Security		x		
Availability/Reliability	x			x
Cost		x		x
Flexibility			x	
Speed of implementation			x	x

Table 1

Reasons for Selecting DDP as a Processing Mode

Factors such as user motivation, cash flow, software availability were not considered important by any of the organisations (only Organisation D considered them, and, in fact, concluded that these were *not* advantages to be gained from DDP, see Section 5.5.3).

The results would indicate that there is not a common factor which favours DDP and that the reason for its selection is

entirely dependent on corporate circumstances, such as :

- The capacity of the mainframe (assuming there is one installed) at the time of making the decision
- The importance (determined by the organisation's policy) placed on the security of the processing system
- The schedule that has to be met for implementation of the system.

The latter point is of special interest. Organisation C stated that one of their reasons for selecting DDP was that the applications could be developed more quickly on a mini than on a mainframe. Their reasons for this conclusion were :

- On a mini it is easier to make program changes than on a mainframe where rigorous hardware and software controls may be installed to inhibit programmers from making changes.
- In a mini environment the programmer has closer contact with the user and programming and testing is performed on his premises. The programmer will thus develop a system that is closer to the user's actual requirements than on a mainframe.

Thus, despite the lack of sophisticated tools for program

development (such as ROSCOE) it would seem as though the mini is still more powerful for developing programs than its counterpart, the mainframe. This conclusion was also drawn by Pollard who, after analysing the cost of a system in terms of the speed of its development, states :

"One of the primary reasons why companies adopt a distributed data processing approach for their branches, depots or subsidiaries is its low cost of implementation in comparison with a mainframe computer."¹

In this regard, the cost of implementation was derived from the length of time required to program the system and the ease of maintenance of written programs.

6.3.2 Budgets

Organisations A, B and C all exceeded their budgets for program development, in one case by as much as 150%. The reasons for this were :

- The budgets were ill-conceived. Each organisation admitted that the targets were set too low initially. This was in part due to over-optimism and also due to the fact that they had no familiarity with the environment they were entering and thus no yardstick by which to measure their objectives.

- They found they had under-estimated the level of sophistication that had to be built into the programs to make them 'as fool-proof as possible'. Organisation A stated that the level of user expertise at the remote site was in inverse proportion to the level of program sophistication, i.e. the higher the level of expertise the less the programs had to cater for operator error and vice versa. Sophistication, in this context, refers inter alia to :

- Operator prompts
- Menu selection
- Automatic restart procedures
- Programmed securing of data
- Rigorous validation checks, such as the data entered at start of day
- Automatic disk pack checking when loaded at the commencement of any processing run.

It was only after the budgets had been set for the project and development commenced that the organisation appreciated the requirement for the above facilities. These then had to be developed at the expense of the budget, but as was stated by a user in Organisation C, "If it was a choice of exceeding the budget or having a secure system, we would obviously choose the latter".

6.3.3 Planning

Not one of the companies integrated their DP plans with the

corporate plan. Their choice of data processing mode would thus be especially vulnerable to changes in the organisation that might be included in the corporate plan but not in the DP plan. This could include such changes as :

- The restructuring of sales and operating divisions
- The method of distribution of products (from a central warehouse to local warehouses, etc.).

A further aspect is that Organisation C's decision to instal a DDP system was taken very quickly indeed (after a period of two months). This would seem to tie in with the editorial comment in Data Systems :

"At the present time, distributed processing systems are evolving rather than being planned".²

6.4 EQUIPMENT SELECTION

The following computers were installed at nodal sites :

- Organisation A - Datapoint 2200s and 5500s
- B - IBM System 34s
- C - IBM S/34s and Datapoint 2200
- D - Burroughs B/80s.

It is the opinion of the author that one of the contributing

factors to Organisation D's decision to revert to centralised DP was the selection of their equipment. The fact that two years elapsed between commencement of the development effort and installation of the first computer must have contributed greatly to user dissatisfaction with the system. In that period difficulties were experienced with the software which delayed the project.

Organisation B initially selected the same equipment but, unlike D, did not persevere when difficulties were encountered. They decided instead to cancel the contract and select another supplier.

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A, B and C all expressed satisfaction with their equipment and stated that if they had to make the decision again, they would all make the same choice.

6.4.1 Equipment Standardisation

Each of the organisations standardised on a single supplier for their nodal sites. Organisation A installed two models from the same supplier (Datapoint 2200 and 5500), but only for the reasons of providing larger capacity to these sites. The reason stated was that each machine required specialist knowledge and as programming skills are in short supply in South Africa it was safer to select one supplier and, if possible, one model from the range.

Organisation B has another application that is being processed on Wang mini-computers but the plan is to phase these out and replace them with IBM S/34s. C is also tendering for a replacement for their Datapoint 2200 (which was installed in 1976, three years prior to the development of their DDP system), and there is a likelihood that it, too, will be replaced with an IBM S/34.

6.5 NETWORK CRITERIA

All the surveyed organisations selected dial-up as their mode of data transmission with auto-answer at the remote site. The only reason for the selection was cost, as the volumes to be transmitted did not justify the use of dedicated lines. This can be seen as one of the areas of cost advantage over a centralised system (which requires leased lines).

When questioned on the use of SAPONET (South African Post Office Network), all the businesses answered that it would have been more expensive than their existing mode of transmission.

Not one of the organisations allowed for inter-node communication. The primary reasons given were :

- It would have added considerable complexity to the system design in the areas of file maintenance and additional control facilities
- The benefits that might have been derived from its implementation were not considered sufficient to offset the cost of development.

6.6 THE DEVELOPMENT PHASE

6.6.1 Staffing

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(a) Development Staff

Organisations A and B established central development teams. These developed the systems at Head Office. On completion of acceptance tests, the machine and systems were installed at the user's premises.

Organisation C selected a team from the Head Office DP staff who still reported to the DP manager but were moved to the remote user's premises. They developed the systems with very close consultation with the user.

Organisation D employed the hardware supplier to develop the systems. Although the reason was not stated, the

author believes it to have been a lack of confidence by D to instal the systems themselves, as the hardware had only recently been released. D established a central team of users and DP personnel to liaise with the suppliers to handle queries concerning the system.

The author has not been able to find any evidence of the concepts put forward by authors such as Brookes and Kelsch :

Brookes : ". . . most of the responsibility for systems design and routine applications programming will rest with the user departments."³

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Kelsch : "Since the end user has both the application know-how and responsibility, he should also be responsible for application selection (with established guidelines) as well as the actual programming of selected non-technically complex local applications."⁴

All the organisations surveyed, plus others that were contacted, stated most strongly that the user should *not* have the responsibility for the development of systems on distributed computers. The reasons put forward were :

- The user does not have the time to devote to be actively involved at a detailed level in the development process (this is particularly true for the

user management)

- The user does not have sufficient technical expertise or systems training to develop a conceptual solution to an application or to convert that solution to a computerised system
- They felt that if the user were given total responsibility and control over the development of his computer systems, there would be a strong temptation to build his own DP department. This would lead to a duplication of analytical and programming skills which would involve the organisation in unnecessary expenditure.

(b) User Staff

In the case of Organisations A, B and D the user was responsible for the on-going control of his mini-computer.

This included :

- Deciding the priority of running his systems
- Selecting the operating staff and training them
- Liaising with suppliers concerning machine malfunctions.

In the case of Organisation C, these functions were all handled by the Head Office's DP department on a Facilities Management basis. It was admitted that this was only

possible because of the close proximity of the user to the DP section. It does seem logical that at a remote location the user should be able to take his own decisions concerning the on-going running of his data processing department. Excessive dependence on the DP department must be considered 'unhealthy' in the long term, leading to a breakdown in the level of service provided by the central facility.

6.6.2 Data Base versus Files

In all cases the systems utilised standard file structure and accessing techniques - there was no evidence of data base software being used at the remote sites, simply because it was not available on the level of machine that was being installed. Even if it had been available, all the organisations stated that they would not have utilised it for the following reasons :

- Contrary to what was expected by the author, they stated that the use of a Data Base Management System (DBMS) would have extended the development period of the applications due to such factors as the training of programmers and analysts and the increased analytical time to build the data relationships
- The use of DBMS software would have added complexities to the systems which would have made it more difficult

for the user to operate (for instance, if the links in the data base were to be destroyed the processes required to re-build them can be complex)

- The number of people required to support the locations would have to be increased. Individuals with the necessary DB skills are in short supply in South Africa and the training period is too long to justify the expense of expanding that department (Data Base Administration).

In all cases the companies opted for an approach that kept the file structures as simple as possible.

Duplicate copies of the files were held at both the remote locations and the central sites. The purpose of this was twofold :

- The central site maintained its records of information for corporate reporting
- In the case of data being lost or corrupted, the files could be brought into line by matching the data of one file against the other.

The only exception to this was Organisation A. As was shown in Section 5.2.4, copies of the files were held at the regional centre rather than on the Head Office mainframe

machine. When information is stored at two sites, one of the major problems is to determine which site had the correct data when the two sites lose synchrony. This was solved in two different methods by Organisations A and C.

Organisation A's Solution

The regional centre held complete information concerning customer orders, i.e. the volumes and the financial details of the order (prices, discounts, etc.), whereas the distribution centre merely held the number of items ordered by the customer broken down by product type. Since the regional site's information was more complete, it was considered that the information stored at that site was correct. If a discrepancy occurred, the distribution centre's files were brought into line with the regional files.

Organisation C's Solution

Data pertaining to orders is captured at the Head Office site and transmitted to the remote mini-computer, but deliveries and receipts of stock are captured at the remote site and transmitted to the mainframe. There are thus two sources of information. Should the remote site's data not agree with that stored on the mainframe, the site which originally captures the data is considered correct. Thus, if there is a discrepancy with orders, the mainframe updates

the remote files, but if the deliveries or receipts disagree, the mini's files are used to bring the mainframe back into line.

Since both methods appear to function well, no conclusion can be drawn as to which is preferable. A point to note, however, is that both organisations stated that a large amount of time was required to bring the files into line when an error occurred and that this was one of the disadvantages of DDP.

6.6.3 Security Procedures

It was found that the organisations all had similar security arrangements, but that Organisation A's procedures were the most comprehensive. These will, therefore, be analysed in detail.

(i) Physical Security

As with the other companies, A's physical security was generally lax. The mini-computers are housed in open offices except for three sites where separate rooms have been set aside for the hardware.

(ii) File Security

Their file security is excellent. Two backups of

the updated master files are taken during the day. These are under program control and the operator may not proceed with other tasks until it has been performed. At the end of each working day, the daily transactions are secured to a specific file. This is on a 31-day cycle so that any day's transactions in the last 31 may be restored. In addition, all files at the end of the day are secured.

As the transactions are transmitted to the regional centre on a daily basis, it is not considered necessary to store any of the security files in off-site premises. They are, however, locked in a fire-proof safe.

(iii) System and Program Access

Nine levels of password control exist. The highest level is used to access the program source code. The organisation found that one of the major control problems in a DDP system was to prevent the users from accidentally or intentionally accessing and changing programs. To prevent this, a password procedure was implemented. It is under the control of the DP department at Head Office in that the algorithm for its generation is only known to certain of the DP staff. It is changed daily.

The next eight levels are all under the control of the user in that he may access and change the passwords. It may only be changed or loaded from certain screens on a configuration. The first level may access all functions in the system. The second level may only use certain functions (such as enquiries, eliminating the use of updates, etc.). As one moves higher in the level, so more and more functions are barred to the user.

Screen access is also limited to specific systems. Thus Screen 1 may only be used for entering order information, Screen 2 may only handle distribution functions, etc.

Passwords are used extensively in this Organisation and have been found to work satisfactorily. The users accept them as a method of system security.

6.7 IMPLEMENTATION

6.7.1 Training

Training of the users was, in all cases, carried out by the Head Office staff initially. However, each organisation adopted different procedures.

Organisation A

Members of the Head Office staff are seconded to the site that is installing a computer system. An intense training session is held and the users are taught all aspects of the system. The period of this is approximately two weeks. After this time, if the users have any problems, they contact the regional co-ordinator who has been given specialist training in all aspects of the system.

Organisation B

The method was similar to that of A except that the period of training was longer (3 - 4 weeks). There were also no regional co-ordinators, so that problems had to be resolved telephonically, or if this did not suffice, members of the Head Office staff had to fly to the remote site.

Organisation C

The systems were developed at the user site and training was performed while the systems were being developed. On completion of the system, the user was thus in a position to commence operation without any formal sessions.

Organisation D

In this company the users were brought to Head Office for

training. This was fairly extensive (3 - 4 weeks) and on returning to the remote site, queries were handled on the telephone.

6.7.2 Conversion

All the organisations converted to their DDP systems in the same manner - by selecting a pilot site, developing the systems for that site, installing and noting the problems. These were then corrected before installing the next site.

The selection of the initial location needs to be performed with care. If only some of the users will be running the same systems, then the pilot site must have a representative mix. It should also be relatively close to the central mainframe so that teething problems can be resolved quickly. If it is not then the development team should be moved to the remote location. Organisation C chose this approach even though the site was close to the Head Office (approximately 20 kilometres). Organisation B chose a location that was approximately 250 kilometres distant, but that had a representative mix of system requirements of the other locations that were to be installed.

Apart from the above factors, the procedures for implementing a DDP system are similar to any other computer system and do not warrant analysis in this study.

6.8 ON-GOING CONTROL

One aspect relating to the on-going control of a DDP system that requires careful consideration is the decision to computerise new branches or divisions. The questions that need to be answered are :

- Is the site large enough to warrant linking into the DDP network?
- Can it justify the cost of the machines?
- Does it have the resources required to operate and control the system?
- Should it have similar hardware to other sites, or is a subset sufficient? (An example of this is Organisation B, where a terminal was installed at Caledon, connected to the node computer at Mossel Bay.)

Organisation A adopted the following procedure. A feasibility study was performed by the DP staff. During this study they analysed the size of equipment required and the costs of the hardware and associated staff were defined (including the associated costs such as stationery, etc.). Against this the benefits to be derived were weighed. A report was then submitted to the user who was then theoretically able to accept or reject the proposal. In practice he would not reject it as the benefits of fast

transmission of data for corporate reporting usually outweigh the costs of the data processing function. Having decided, allowance for the costs was then made in his budget.

With regard to other aspects of on-going control, only Organisations A and D have DDP systems that have been operational (or were operational, in the case of D) for a sufficient period of time to formulate conclusions. The procedures for each is as follows :

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Any errors in the system are reported by the regional co-ordinators (who are trained to recognise hardware and software faults) to the DP department. Steps are immediately taken to correct them and distribute the updates to all affected users (who may or may not have had difficulties with the same problem).

The regional co-ordinator holds regular meetings with the users in his region. If concensus is reached on the requirement for new reports or functions in the existing systems, these are sent to the Head Office DP staff for scheduling and implementation.

The DP staff visit the divisions in the Cape Region frequently to gain first-hand knowledge of the successes

or failures of the systems.

Quarterly meetings are held between the data processing staff and the Head Office administration to discuss major enhancements or new systems. The minutes of these meetings are sent to the users to gain their approval for any decisions reached.

Organisation D

Their procedures for monitoring the performance of installed systems were less formal than A's. Members of the DP department would merely visit the computer installations on an infrequent basis (depending on the number of calls for assistance, in the event of system failures, made by the users).

A schedule of which divisions were to be computerised was drawn up as part of the initial DDP study and this was being followed up to the point when the decision was made to centralise.

Informal meetings were held between the DP staff and the regional management to discuss problems that had occurred at user sites.

6.9 CONCLUSIONS

In this chapter certain aspects relating to the field studies were analysed to determine whether the findings of the authors of various books and articles really reflected the experiences of selected South African companies. In general they did.

One impression was strong in every organisation visited : the users were extremely happy with their systems. The acceptance of, and association with, the computerised solutions was evident at every site.

Another aspect was that all organisations processed both centralised and decentralised systems. Organisation C processed a batch system at its remote mini and Organisation B had an on-line system at its Head Office as well as the distributed system, all evidence of the flexibility of processing that can be provided through a DDP system.

The conclusions to be drawn concerning the implementation of a DDP system are presented in the following final chapter.

FOOTNOTES

- (1) POLLARD, J. "What does a system need?", Data Systems, February 1976, p.19.
- (2) EDITORIAL. "Talking about Distributed Processing", Data Systems, February 1976, p.8.
- (3) BROOKES, C. "The Future of EDP Technology and Impact on Organisations", The Australian Computer Journal, July 1976, p.46.
- (4) KELSCH, A.L. "Dispersed and Distributed Data Processing", Journal of Systems Management, March 1978, p.34.

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CHAPTER 7RECOMMENDATIONS FOR IMPLEMENTING A DDP SYSTEM

7.1 INTRODUCTION

The previous chapter detailed the findings of the field study. This, the final chapter, makes recommendations on those aspects that might affect the organisation arising from the decision to distribute its data processing function. As stated in the introduction, the technical aspects of file and network design have not been included.

Previous chapters have suggested that there has been no evidence to indicate that distributed processing is an *alternative* to the centralised approach and that the one excludes the other. All the organisations surveyed had a centralised mainframe on which central batch systems were being processed and, in some cases, supported an on-line network.

The question of which mode to choose would therefore only arise when considering the requirements of remote users or, perhaps, if there were a requirement to provide autonomy over the processing of specialised applications to local users.

The selection of either approach cannot be decided merely on cost or security but must be based upon the policies of the company concerning flexibility for future DP decisions and upon the level of autonomy to be given to the remote users.

The recommendations put forward in this chapter concern those aspects to be considered *after* the decision has been made to opt for DDP and which will, if not correctly planned and organised, severely prejudice the success of the installation.

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7.2 PLANNING FOR DDP

Many authors are stressing an evolutionary approach to distributed processing.

Vickers : "An evolutionary approach offers immediate benefits and speeds the organisational adjustment because people understand more clearly when they see something rather than only hear about it."¹

James : "If it is done as an evolution of computing techniques rather than a revolution, the undoubted benefits will be gained in a controlled manner which will be to the benefit of both

the users and the DP professionals."²

When referring to evolution, these writers are implying that the organisation should not attempt to instal all user sites at once but to start with one user, resolve any problems and then move on to the next site. This has the advantage of visibility in that the users can see operational systems, and results can be obtained in a relatively short period. The disadvantage is that the total system (with all users computerised) will take that much longer to instal, and the planning time-frame will extend over years rather than months.

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 "Indeed, one of the fundamental facts about DDP is that it usually takes several years to plan; most users operating in a DDP mode today started planning in the late 1960s."³

The longer the time-frame, the more difficult it is to plan; the likelihood increases that factors such as competitors, environment, change of strategy, etc. will affect the organisation, and therefore the plan. However, this does not mean that one should then do away with planning, rather the opposite. "The planning phase is vitally important and must be exhaustive and informed."⁴

The importance of the plan can be seen by the amount of time that Organisations A (nine months) and D (14 months) devoted to the task. The time-frame for final implement-

ation is confirmed by Organisation C, who estimate that the full benefits of the system will only be realised by 1985 (a total period of six years).

If the organisation feels in any way diffident about tackling the planning phase itself, then it should consider employing outsiders to perform the task - as was done by Organisation A, who used their auditors. It should be noted that the auditing firm themselves had to bring in specialists from their overseas branches, such was the importance they placed on the process.

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7.3 THE SYSTEMS ARCHITECTURE

7.3.1 Vendor Selection

As was mentioned previously, a major factor in the failure of the DDP system at Organisation D was (in the author's opinion) their choice of hardware. The first reason that Doouss and Collins state when examining why DDP fails in an organisation is "The use of relatively untried equipment which was insufficiently evaluated before a decision to proceed was taken".⁵ At the time of D's decision the Burroughs B/80 was new on the market. Through perseverance all the problems were eventually resolved, but the efforts to reach that state reduced the morale and enthusiasm of

all the personnel involved. Thus, when an alternative solution was recommended, it was adopted with eagerness as 'a way out of a mess'.

The following checklist indicates some of the more important questions that should be asked when evaluating hardware. Whilst the author considers that all the factors are of consequence, the organisation should attach its own weightings prior to selection (for instance, it might consider reliability more important than price).

Criteria for Hardware Selection

Hardware

1. Is the supplier stable and likely to be able to provide the necessary support over a number of years?
2. Is there a sufficient range of peripherals available to facilitate future expansion?
3. Are incremental increases possible and reasonably priced, and can they be field-installed?
4. Are the mean-time-to-failure and mean-time-to-repair at acceptable levels?
5. Can hardware failures be readily detected by a relatively inexperienced user?

6. Does an adequate growth path exist to more powerful, compatible computers?
7. Does a common I/O mechanism exist between all nodes so that, if necessary, data and programs can be transported?
8. Is the product acceptable in terms of its heat and noise output and power requirements?
9. Is the hardware compatible with that installed at the central site and/or other processing centres or nodes?
10. Is the hardware realistically priced in relation to similar offerings by other suppliers?

Software

1. Is a uniform programming language available across all nodes assuming that different models will be installed?
2. Is the software cost effective in terms of its resource usage (memory required, disk space usage, etc.)?
3. Are utilities available for normal system support functions, such as sorts, copies, etc.?
4. Does the software have proven data communications capability?

5. Is the software easy to use and designed to interface with the user rather than DP professionals?

General

1. Does the hardware and software have a proven record at other user installations?
2. Does the hardware and software perform to the levels required by the user?⁶

In the author's view, the only two suppliers that are able to satisfy the above questions are Datapoint and IBM (the former through their 2200 and 5500 systems, and the latter with the S/34 and 8100).

An important factor in the buying decision is made by Doouss and Collins :

"In deciding the policy it is worth remembering the cost benefits which can come from the buying power resulting from standardization of hardware across the company, to only a few types of equipment. Suppliers are often more willing to give bulk discounts, performance guarantees, and to provide extra services like training and provision of spares."⁷

In this respect, two points emerge :

- IBM is the only supplier who will definitely not give discounts. The hardware should not, therefore, be evaluated on the price of a single machine, but on the price of the total hardware requirement at all user sites.

- There seems to be no rationale for mixing suppliers of equipment *within the same application or group of applications*. The benefits are to be derived in many ways, such as decreased training time, standard systems and hardware leading to the easier movement of personnel, quicker development time through better familiarity of equipment by the programmers, etc. Where minis/micros are to be installed that are to process applications with differing requirements (e.g. accounting functions on one and process control on another), different suppliers may certainly be considered.

7.3.2 Network Selection

The organisation has a choice of three modes of transmission :

- Dial-up
- Leased line
- Use of SAPONET.

Since one of the objectives of a DDP system is to process the data at the user's site and only transmit summarised data to a regional or central site at the end of a period, there is no advantage to be gained from installing a costly leased-line network. One has therefore to choose between the use of dial-up transmission or SAPONET. Under the current rate structure dial-up is certainly favourable and is the recommended mode (this is substantiated by the fact that all organisations in the field study made use of dial-up facilities).

The design of the network and the choice between, for instance, a hierarchical system (as was adopted by Organisation A) or a star network (as is used by Organisation C) is dependent on the reporting requirements at each of the nodes.

7.3.3 Software

At the time of writing there are no universal packages available that specifically address distributed processing. As was stated in Chapter 6, attempts are being made by software houses and suppliers to fill this gap. In South Africa, in particular, no suppliers are offering a comprehensive hardware and software solution.

The organisation is therefore required to devote a large

proportion of its budget to the development of appropriate software. There are two factors that are of particular importance, both arising out of the field study :

- (i) The application software should cater for the untrained, undisciplined user. Controls will have to be built in, which may possibly be overlooked in the system design phase. All the organisations surveyed under-budgeted for the development of application programs. This was mainly due to 'last minute' modifications to protect the system from operator misuse. It is advisable, therefore, to set a very lenient budget or to ensure that these controls are incorporated in the design stage of the system.
- (ii) The file structure and general system functions should be kept as simple as possible. If this policy is adopted, the organisation will avoid the problem of maintaining complex systems (with a high staff turnover the re-education time of replacement programmers can be costly). In addition, changing user requirements can be more easily implemented if the structure is simple. As Vickers states :

"A manager should insist on simplicity. The source data processing (or DDP) system is,

or should be, a tool. More like a personal computer than some faraway mainframe, it is important that it be simple because so many people in the organisation need to understand it - the bigger the organisation, the greater the need for simplicity. Top management and auditors need to understand it. And, most importantly, line managers must understand it at a more superficial level."⁸

7.4 STAFF ORGANISATION

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There are three considerations of importance when deciding on staff functions and organisation in a DDP environment.

- (i) To centralise or decentralise the systems development function;
- (ii) The role of the user in the design, development and implementation phases; and
- (iii) The need for overall control of the DDP system.

7.4.1 The System's Development Function

An organisation has two alternatives : to disperse its systems and programming expertise to the user departments, or to centralise it at the Head Office. There is a third

choice, that of allowing the user to develop his own system, but, as was stated in Chapters 4 and 6, this is excluded from the analysis as there is no evidence of its being a practical solution.

Dispersing the Technical Expertise

This option was partially adopted by Organisation C in that the programmers and analysts were moved to the user site during development. It is also advocated by Withington :

"Spread the programmers, systems analysts, and other information technicians around. Arrange for them to work with the increasing numbers of 'interested amateurs' among professional, supervisory, and middle management ranks. The amateurs will learn some technical aspects and be able to do increasing functions of the work, thereby making wider use of the technicians' expertise. The technicians, in turn, will learn more about the organisation and its people."⁹

This approach has two major disadvantages. Firstly, the organisation is at risk of duplicating expertise if the talents are distributed too widely (which obviously has cost implications). Secondly, control over the development function will be exceedingly difficult if systems are being developed at multiple remote sites.

Centralising the Technical Expertise

All systems and programming are located at one central point in the organisation and the development and maintenance of systems is performed under the control of Head Office management. This approach was adopted by Organisations A, B and D and is recommended by a number of authors :

Doouss and Collins : ". . . maintenance and enhancement of the systems needs to be centrally administered. In this way, best use of relatively scarce skills can be made and co-ordination of maintenance of systems and enhancement of the systems can be accomplished."¹⁰

James : "All applications development work for the transition to distributed processing should remain the responsibility of the central DP department."¹¹

A number of writers are, however, divided as to how the systems development should be organised. In the author's opinion, the centralised approach is the safer option in terms of greater control and is therefore the one to be selected.

However, as Vickers states :

"Computer knowledge, and programming knowledge in particular, is much more widespread than it was 10 years ago; students are taught programming in most high schools and colleges. Also, the computer has trained a lot of people, and thus there is much less fear of computers and a willingness to use them to solve problems."¹²

There can be little doubt that when computer knowledge becomes more generally widespread, there will be more pressure from the users to develop their own systems. When this happens a good case may be made for allowing them to do so.

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7.4.2 The Role of the User

If one accepts, then, that the user is not responsible for systems development, there must be other functions for him to perform as he cannot be excluded entirely from the development process. These can be categorised as follows :

System Selection

The user should, through a user committee, be able to select which applications should be computerised and the order of development. Once this has been set, the proposed schedule will be handed to the central DP staff. This does not signify that there will be a lack of control over the development of systems. This will be examined

in the next section.

Systems Development

It is vital that the user perform a project management during systems development. This will achieve two important benefits.

- The user will be involved in the system from the outset thus reducing the education and training time prior to installation.
- The user will develop a sense of ownership, in that it is 'his' system being developed under his control. This will contribute to his enthusiasm for, and acceptance of, the system.

Conversion and Implementation

The user will continue in his role of project manager, ensuring that interest in the system does not flag during this period.

Post-Implementation

This will be analysed in Section 7.7 under "On-Going Control of the DDP System".

If the development team moves to the user site during development, then the role of project manager is easily filled by the user. If, however, the system is being developed at the Head Office, and the divisional manager is situated some distance away, difficulties may be encountered in his role. In this case regular progress reports should be sent to the manager and meetings between him and the development team should be held as frequently as is possible. Above all, it must be represented as 'his' system.

One aspect that needs careful attention during the development phase is the morale of the user. It is important to maintain it throughout. A reduction of motivation should be detected as early as possible and the necessary steps taken. This could be due to :

- A lack of involvement in the system.
- A lack of confidence by the user in his ability to perform the project management function because of insufficient training in the necessary techniques.
- A lack of confidence through an inadequate understanding of the system or the hardware.

The first can be solved by involving the user through frequent meetings (assuming he is not the project manager).

The last two points can be rectified through an education programme.

7.4.3 The Need for Management Control

There can be little doubt that as in all computer systems, there is a need for management control. The problem in a DDP system is that the controlling function would be centralised yet the resources that require controlling may be situated at remote locations. Woods suggests the organisational structure detailed overleaf in Figure 7.1.

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In the author's opinion the structure is weak unless the Distributed Processing Manager has regional controllers reporting to him. Organisation C, with its regional coordinators, would tend to offer greater control than the structure in Figure 7.1. A more favoured layout is illustrated in Figure 7.2 (page 217).

The responsibilities of the Distributed Systems (DS) manager would be :

- To monitor the hardware and software of all nodes.
- To check on the standards of development and operations.
- To liaise with the users (via their user committee) concerning application developments.

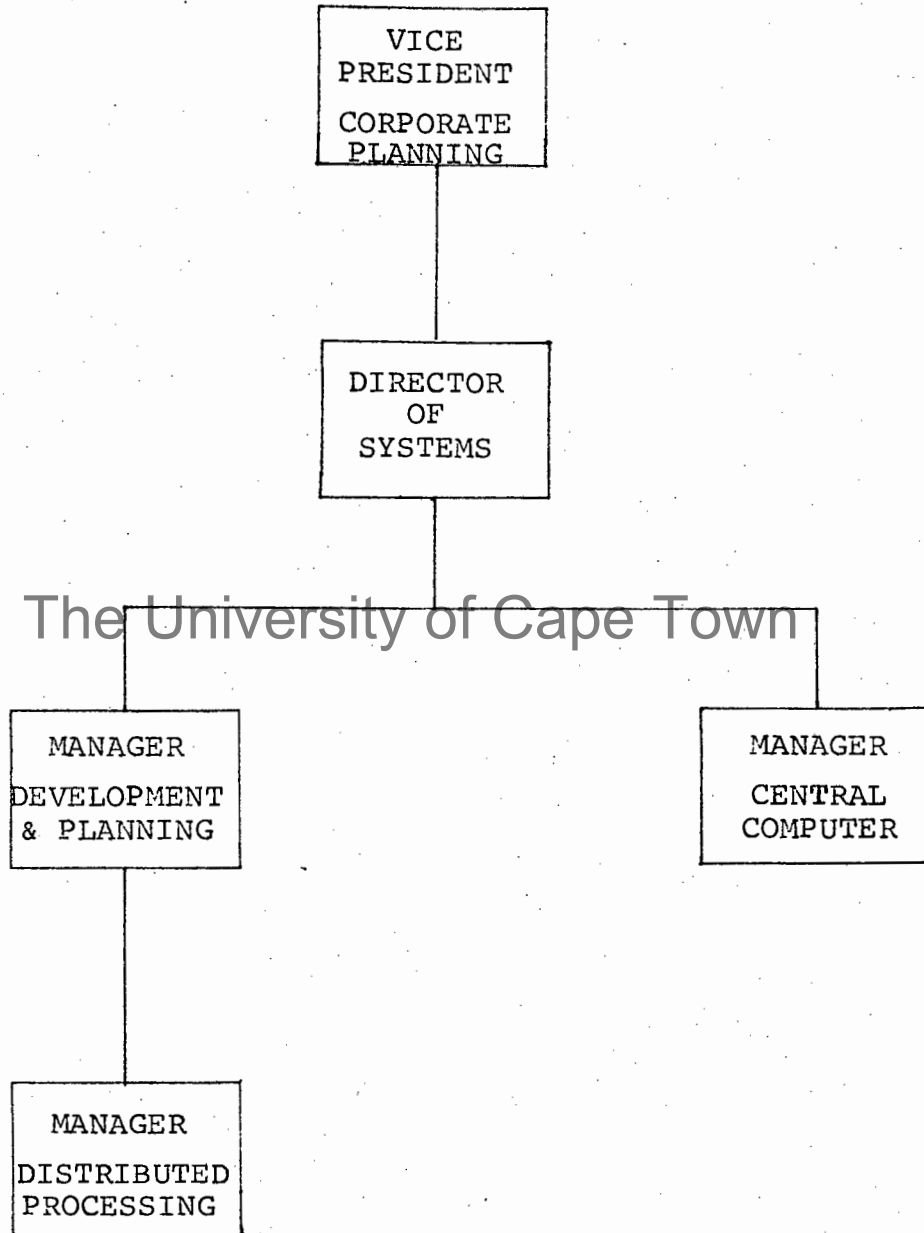


Figure 7.1 : Organisational Structure at John Deere for Controlling the DDP Function¹³

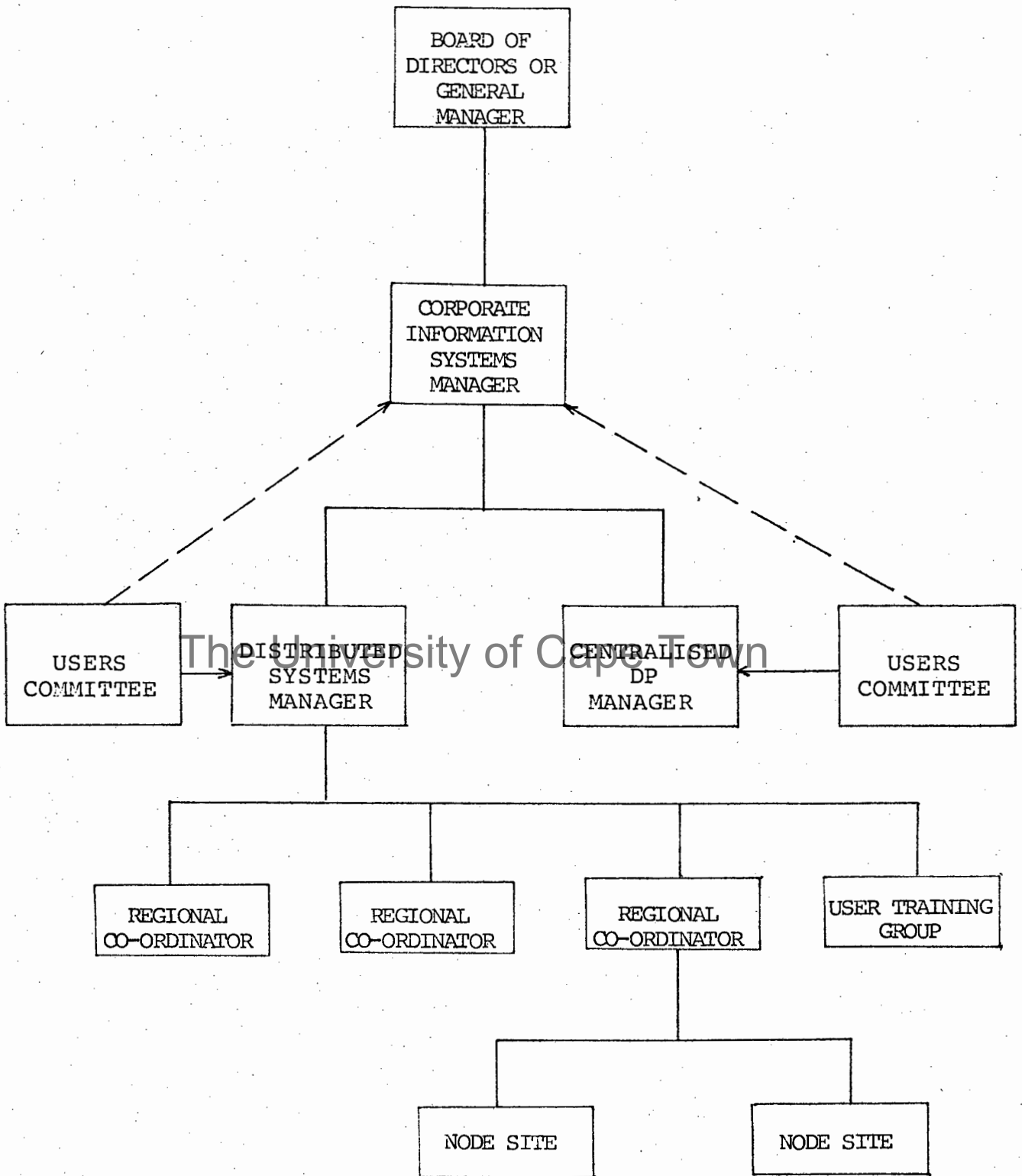


Figure 7.2 : Proposed Structure to Ensure Effective Control of the DDP System

- To liaise with suppliers concerning the acquisition of new equipment and the performance of installed hardware.
- To forecast the projected work-loads at each node and thus the requirements for future upgrades of hardware.
- To co-ordinate the training and education of all personnel involved with the computers at each node.
- To monitor and control the activities of the regional co-ordinator.

The regional co-ordinators would, inter alia :

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- Provide support to the nodes in such areas as operating problems, data communications, errors, etc.
- Log all hardware and system software failures in their regions and report these on a regular basis to the DS manager.
- Monitor application program failures and report these to the DS manager.
- Assist in the education of new users or the training of new operators.
- Assist the users in the hiring of personnel (data capture clerks, operators, etc.)
- Check on the use of standards laid down concerning

environment control, password usage, etc.

An area that requires special attention by the DS manager is requests for computer staff by the nodal sites or the regional co-ordinators. The motive could be based on 'empire building'. Any requests should therefore be justified by increased volumes or the installation of additional systems.

With the structure detailed in Figure 7.2 there is both a central and remote controlling function which will ensure continuous management of all nodes in the DDP system.

While the titles and locations may change (the user training group and regional co-ordinators may be situated at Head Office), the recommendation is that the functions and reporting lines should be adopted by every company installing DDP.

There should still be the normal corporate steering committee which would review and approve the DP budgets, approve major projects and expenditure decisions. It would review the progress of major projects and decide when to terminate them.¹⁴

7.5 SYSTEM DESIGN CRITERIA

7.5.1 Design Objectives

When designing systems in a DDP environment, the objectives that the organisation expects to achieve should be clearly defined. This is so of any computer system or, indeed, any project. However, in DDP it has special significance when systems are being developed by multiple teams that will be installed in many locations but have a common focal point, at Head Office.

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Whilst a large number of these objectives are implied and may relate only to particular systems (e.g. an objective of a stock system may be to reduce the level of inventories held by that division), there are objectives that may be generally applied, such as :

- (i) Performance. The system should be able to process transactions within a specified time limit. This should be set at such a level as to cater for the required growth of the organisation.

- (ii) Economy. The cost of the total DDP system and any one of its nodes should be acceptable in terms of the organisation's DP budget. The cost can be expressed in terms of the data transmission links,

the support personnel, the cost of hardware and software.

- (iii) Implementability. The system should be designed in such a way that it is as easy to implement as possible. Specific aspects to consider are the use of prompts and menus and the use of training manuals.
- (iv) Recoverability. The design should be such that the procedures to recover files, in the event of system failure, is simple. This requirement includes such factors as the detection of errors, the mean time to recovery from failures, etc.
- (v) Flexibility. In this context, flexibility refers to the ability of the system to
- Cater for future increases in volumes.
 - Incorporate new application areas.
 - Allow for changes in the organisational structure (the changing of responsibilities, changed reporting lines, etc.).¹⁵

Although a number of writers have stressed that performance and economy are the overriding objectives, the author believes that the others are as important, in particular

the ability to be easily implemented, and the recovery capability.

7.5.2 The Need for Standards

One of the most important aspects that could contribute to the success or failure of a DDP system is the use of standards.

Foy : "One experienced user points out that you can't decentralize until you've centralized - to establish the common languages, standards, codes and information structure which enable different parts of the company to keep in touch and use each other's data. Without strong attention to such standards, distributed systems could turn into a nightmare for the computer department, and perhaps for general management as well."¹⁶

Van Rensselaar : "As our use of computers has evolved, we have faced a number of continuing challenges, some of the most important of which are . . . establishing, maintaining, and promoting the use of standards for hardware, software, documentation, project management, data, and auditability and control as a foundation for well-coordinated worldwide applications systems."¹⁷

As the above quotations suggest, it is extremely important when developing systems that are to be used in many sites, to develop standards before the DDP project begins. These should relate to :

- The use of common programming languages to facilitate the movement of programs from one hardware system to another.
- The use of standard coding techniques. This will ease the maintenance load after installation.
- The writing and use of documentation such as procedure manuals, system and program documentation, operator reference manuals, etc. If they are in a standard format and their use is encouraged, the training time of operators and programmers will be vastly reduced.
- Project management and reporting techniques. This will aid the steering committee in evaluating project progress on a common basis.
- Data storage, access and security (through back-ups, passwords, etc.). If common methods are in use, the diagnosis of errors will be more rapid than if each node has its own, non-standard procedures.
- Operating procedures relating to such areas as report shredding, data flow, etc.

One problem is highlighted by Byles : "How can the group's DP standards be gently enforced on the enthusiastic users?" He offers no solution but they can be easily implemented if decided on prior to the commencement of the DDP project. If they are left until some time after the systems have been installed, the user will develop his own standards and will be reluctant to change.

7.6 TRAINING

Training is another factor that is more important in a distributed than in a centralised system. Not only do programmers have to be trained but many users have to learn both the systems and the operational aspects of the computer.

7.6.1 Programmer Training

Designing and writing programs for mini-computers requires different skills from those for a mainframe installation. Organisation C, in fact, found it necessary to screen their staff very carefully when selecting the team for DDP system development. They were forced to employ additional staff when insufficient talents were found in the company. The reasons for this are :

- The programmer has to be more aware of the skill level of the user and has to build in controls that may not be in the specification. He has to be able to place himself in the position of an untrained user and say "What will happen if I do A instead of (the correct procedure) B?" As a DDP system will have more hardware than, say, a terminal based network, the programs will need to have more controls in such areas as checking of disks or diskettes and the recognition of the latest files.
- The analysts and programmers will have a closer liaison with the user during development than they would in a centralised system. They will thus have to be more people-orientated and be aware of the users' shortcomings, their fears, and so on.

Organisation C is in the process of establishing two distinct development teams, one that programs only on the mainframe and another to develop systems on the minis.

Whichever way the development team is structured the training of the programmer should embrace more than merely the hardware and the programming languages (as is so often the case in a centralised system). His training should be extended to such areas as :

- The requirement for, and use of, controls and how to

implement them.

- How to handle requests for changes during development (in all the organisations surveyed, the programmers were continually being requested to include changes, both major and minor).

Note : In mini-computer systems it is not unusual for the programmer to perform analytical work as well. However, if the functions are split and systems analysts are utilised, then the factors mentioned in 7.6.1 would apply to them as well.

7.6.2 User Training

User training should consist of :

- Informal user groups.
- Courses run by the suppliers.
- Sessions internally designed and handled by the central DP staff.¹⁸

(i) User groups. A valuable interchange of ideas is achieved by establishing user group meetings. The purpose is to allow them to meet on an informal basis to exchange their experiences in running the systems, the problems they have encountered, or suggestions for enhancements. The groups should

consist of users from multiple sites and could be held on a regional or national level. This is for each organisation to decide, as a national group meeting may be too costly. The author therefore considers that regional meetings would achieve the required purpose.

- (ii) Supplier courses. These are given to any new users to familiarise them with the equipment and the systems software.
- (iii) Internal courses. These are given to users, from the operators to user managers. The objective is to teach them the details of the new system. The emphasis will vary from the operator to manager with the former being taught at a very detailed level. The manager will have been shown the systems at a more conceptual level, with the emphasis on control and the interface to other systems.

Some of the topics covered in the operator course would be :

- System security and recovery
- Data communications
- System start-up and shut-down
- Application operation
- Error detection and recovery.

Hands-on training is vital for the operator during this phase.

If possible, the organisation should establish a central training division whose job it would be to handle all the education of new users.

7.7 ON-GOING CONTROL OF THE DDP SYSTEM

A DDP system will only operate effectively for as long as there is constant management control and supervision. This applies as much to control of the total network by the Head Office staff as it does to that provided by the remote user management. The success of the system is as much dependent on the skills of the developers and users as it is on the structure and reporting lines that are established to monitor its progress.

7.7.1 The Structure

This should be established in the way recommended in Section 7.4.3 so that there is both central co-ordination of the total network and regional control of the user sites. The former will provide the direction for future developments and act as the liaison point with the user committee. The latter will provide the day-to-day control

needed to support the users. They will also perform a quality control function to ensure that standards of operating are being maintained by the users.

The user committee will perform a vital function in ensuring that they have a voice in the development of new systems and can point out weaknesses in the existing ones.

7.7.2 The Skills of Involved Personnel

Only through continuing education and training programmes can the organisation ensure that the standard of user skills is maintained at a high level. There is certainly a greater need than in a centralised system, since the functions performed in a DDP system are more varied and complex (such as machine operation, etc.).

7.8 A SUMMARY OF THE RECOMMENDATIONS

This section summarises the recommendations made, and conclusions reached, in Chapters 6 and 7. A reference is made, after each, to the relevant section(s) in the thesis. They are listed under four main headings, viz.:

- Hardware and software
- Systems design

- Staffing
- Management considerations.

7.8.1 Hardware and Software

- (i) *A single manufacturer should be chosen to supply all the processing units to be installed at user locations (where those sites are to implement common systems). Sections 6.4.1 and 7.3.1*
 - (ii) *The hardware should be proven. Section 7.3.1.*
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- (iii) *All sites must be compatible in terms of programming languages and operating procedures. Section 7.3.1.*
 - (iv) *The use of data base software packages should be avoided until such time as a universal, proven package is available. When it is, the organisation should ensure that it has sufficient skills, at regional and central levels, to implement and maintain it. Sections 6.6.2 and 7.3.3.*
 - (v) *The dial-up mode of transmission should be used. Section 7.3.2.*

- (vi) *The need for inter-node communication should be examined and justified very carefully. Section 6.5.*

7.8.2 Systems Design

- (i) *The major design objectives of the system should be performance, economy, implementability, recoverability and flexibility. Section 7.5.1.*
- (ii) *Standards should be set for programming, operating and documentation prior to the commencement of development. Once set, they should be strictly enforced. Section 7.5.2.*
- (iii) *The systems should cater for unskilled operators and should be rigorous in their edit/validation checks. They should be easy to implement and self-explanatory (through prompts and menus). Section 7.3.3.*
- (iv) *System security should be enforced through the use of passwords. Section 6.6.4.*
- (v) *Users should not be given the ability to modify their files except through normal transaction procedures. Any modifications required (after program, hardware or power failures) should be handled by the regional*

co-ordinators after express permission from the DS manager. Section 6.6.4.

7.8.3 Staff

- (i) *The structure (as shown in Figure 7.2) should be established with regional co-ordinators situated in their respective regions and a user training group at Head Office. Section 7.4.3.*
- (ii) *The systems development staff should be located at the Head Office. A specific team should be established which is not connected in any way with the development staff for centralised systems. Section 7.4.1.*
- (iii) *A user training group should be established at Head Office. Their responsibility will be to instal the system and provide initial and on-going training at all user locations. Section 7.4.3.*
- (iv) *A user manager should be appointed as project manager, and, if necessary, be given special training in project management techniques to allow him to fulfil this role. Section 7.4.2.*

- (v) *A user committee, consisting of senior user personnel, should be formed to recommend enhancements and future developments of the DDP system to the DS manager. Section 7.4.3.*

- (vi) *A user group (consisting of node manager and operators) should meet at least quarterly on a regional or national level to discuss problems and improvements to the systems. Section 7.4.3.*

7.8.4 Management Considerations

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- (i) *The decision to centralise or distribute should not be based solely on hardware or the requirements of the users but on the philosophy of management and its policies towards such aspects as security and autonomy. Section 6.3.1.*

- (ii) *The plan for DDP must be an integral part of the corporate plan. Section 6.3.3.*

- (iii) *The planning of the system must be thorough at all levels (equipment selection, systems design and development, and implementation). It is likely to take man-years rather than man-months. Section 7.2.*

- (iv) *The budget for systems development must be lenient. Due allowance must be made for unplanned program changes. Section 7.3.3.*
- (v) *The organisation should opt for quick visibility of the systems. This can be achieved by phasing the development and installing at a pilot site. Section 7.2.*
- (vi) *The pilot site should be representative of both the systems to be installed and the skills of the personnel involved in the systems. Section 6.7.2.*
- (vii) *The organisation must be prepared to invest considerable amounts of time and money in the training of its systems development staff, the user training group, the user managers and operators. Sections 7.6.2 and 7.7.2.*
- (viii) *The user should not be responsible for equipment selection or systems development but should decide the priorities of running his own systems. Section 6.6.1.*
- (ix) *Special attention should be given by the DS manager to requests for staff by the regional co-ordinators or the node computer managers. Section 7.4.3.*

- (x) *The morale of the users should be watched very carefully during the evolution of the system.*

Section 7.4.2.

7.9 THE FUTURE OF DDP

As was stated in the Introduction, no analysis of computer trends and the future direction of DP can be complete without examining the role of IBM and its development path :

"IBM has been slow to endorse distributed processing, supporting instead the central computer room and its high capacity but high priced large central mainframes, mass storage devices, and the like.

IBM hasn't really 'blessed' the distributed processing concept - but it may be adopting it."¹⁹

That statement was made in 1977 and since that time IBM has announced the 8100 system, billed as its distributed processing solution. Even though they, in the past, have so obviously favoured the centralised approach, the announcement of their low priced 4300 series and 8100s may indicate a move away from the central computer system. Although the new Synchronous Data Link Control (SDLC) protocol for data transmission has improved the reliability

of communications networks, it has not removed the high cost of the attendant products (NCP, VTAM, etc.). SNA (Systems Network Architecture) which, for a few years now, has been IBM's offering in the data communications area, has a high cost overhead. As Sherwood states :

" . . . the user must evaluate the conversion costs, increased capital costs, personnel costs, and equipment resources demanded by a conversion to the SNA environment."²⁰

As well as being expensive the centralised offering of IBM does not offer the flexibility of DDP. However, through its vast range of models (the S/34, S/38, etc.) IBM still has the capacity to offer many different hardware solutions to the organisation considering DDP (as adopted by Organisations C and D). It would seem then, that despite IBM's slow acceptance of DDP principles, the mode will continue to find favour in the marketplace.

7.10 CONCLUSION

This study has analysed the implications of installing a DDP system. It has described the components of the system and why it has only recently become a viable alternative to be considered by the organisation. Factors to be considered in the centralisation versus decentralisation

issue were then examined - these would be taken into consideration by an organisation when considering the processing mode. The study then proceeded to examine, through field studies, the aspects that must be planned for and controlled when planning and implementing a DDP system.

Accepting the computer maturity of an organisation and its management, the success of a DDP system will ultimately depend on the planning, the attention that is paid to the requirements of the users during development, and the control over the system after implementation. To this extent, this study has attempted to highlight the major areas likely to affect the business. Only through being aware of them may the organisation plan effectively and thus ensure a successful installation.

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FOOTNOTES

- (1) VICKERS, W.H. "Source data processing", Datamation, March 1980, p.160.
- (2) JAMES, C. "Evolution, not Revolution", Data Processing, November 1976, p.49.
- (3) INTERNATIONAL DATA CORPORATION. "Distributed Processing/ Data Communications", Fortune, March 1977, pp.77-80.
- (4) EDITORIAL. "Talking about Distributed Systems", Data Systems, February 1975, p.8.
- (5) DOOUSS, B.M. & COLLINS, G.L. "Distributed Intelligence", Management Decision (UK) No.6/76, p.312.
- (6) KELSCH, A.L. "Dispersed and Distributed Data Processing", Journal of Systems Management, March 1978, p.35. Most of the questions were extracted and adapted from the above article.
- (7) DOOUSS, B.M. & COLLINS, G.L. Op.cit., p.309.
- (8) VICKERS, W.H. Op.cit., p.160.
- (9) WITHINGTON, F.G. "Coping with computer proliferation", Harvard Business Review, May-June 1980, p.153.
- (10) DOOUSS, B.M. & COLLINS, G.L. Op.cit., p.311.
- (11) JAMES, C. Op.cit., p.49.
- (12) VICKERS, W.H. Op.cit., p.158.

- (13) WOODS, L.D. "Distributed Processing in Manufacturing", Datamation, October 1977, p.62.
- (14) WITHINGTON, F.G. Op.cit., p.161.
- (15) DAVENPORT, R.A. "Distributed or centralised data base", The Computer Journal, Vol.21, No.1, p.11.
- (16) FOY, N. "The Great Small Computer Change", Management Today, October 1976, p.104.
- (17) VAN RENSSELAER, C. "Centralize? Decentralize? Distribute?", Datamation, April 1979, pp.90-91.
- (18) FALOR, K. "'Distributed' doesn't mean 'Random'", Datamation, September 1978, p.227.
- (19) INTERNATIONAL DATA CORPORATION. Op.cit., p.52.
- (20) SHERWOOD, H.F. "IBM's Strategy in Terminals and Distributed Processing", Datamation, October 1978, p.98.

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