A COST-EFFECTIVE COMPUTERIZED INFORMATION SYSTEM FOR EDUCATIONAL ADMINISTRATION FOR UNIVERSITIES LIKE BITS

Thesis

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By

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CERTIFICATE

This is to certify that the thesis entitled "A COST-EFFECTIVE COMPUTERIZED INFORMATION SYSTEM FOR EDUCATIONAL ADMINISTRATION FOR UNIVERSITIES LIKE BITS" submitted by Mr. K.R.VENKATASUBRAMANIAN, ID.No. 82PHXF001, for the award of the Ph.D. degree of the institute, embodies original work done by him under my supervision.

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Dated: 27 Dec 1990

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The last one is usually reserved for the spouse usually more out of custom than anything else. In my case, it is anything but just being customary. Usha, my wife, was instrumental in egging me on in my work on the thesis. Apart from making things lively on the domestic front, she also did the splendid job of making the figures that appear in this thesis on the Xerox Ventura DTP. She also recovered the "database of references" from a floppy that I thought was corrupted and saved me hours of tedious work. I owe her more than just thanks, so ....

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(K R VENKATASUBRAMANIAN)

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CHAPTER 1

INTRODUCTION

1.0 PRELUDE

Since the last two decades, educational administration, like most other office activities, has emerged out of its archaic position of tradition-bound practices to carve a niche of its own as one governed by scientific and modern office automation procedures. Ahmad A. (1977) refers to this emergence as the "management of knowledge workers", thus ushering in a certain respectability to a discipline that professional managers consider not so dynamic to warrant any serious attention and academics shy away from often. The extreme traditional view of educational administration has as its focal point what is usually labeled as the "REGISTRAR's OFFICE" where the day-to-day administrative functions are carried out. As to the policy and decision making activities of educational administration, a traditional educational institution would rely largely upon the "VICE-CHANCELLOR and THE BOARD OF GOVERNORS". It implies that, most of the other personnel are completely cut off from administrative functions, even if the matter concerned academics directly. Further, the task of educational administration gained wider scope and respectability as institutions grappled with problems of budgeting and optimization of scarce resources much in the same way as production units do. Indeed, the educational system has close analogies with the functioning of industrial production units [Mitra C.R.(1982 & 1989)]. Modern day offices are no longer treated as being enclosed within the four walls of a building, but are treated with increased respect as information processing entities [Balagurusamy E.(1988)]. The systems approach, which was used widely with many diverse systems, found its applicability in educational administration also [Backoff R.W. & Mitinik B.M. (1981)]. Educational administration, too, has been increasingly placing its reliance on availability of information, basing its decisions on a foundation of correct, up-to-date information and adapting itself to changing conditions in the environment as evidenced by processed information. Many successful organizations have an undercurrent of a strong well-organized information system. Information systems, mainly connected to production, inventory, marketing, financial functions have usually formed the kernel of 'Management Information Systems'.

What most organizations have traditionally underplayed is the role of Human Resources Management in Organizational Growth and in administration. Recently, however, the emphasis has shifted from production, operations and financial management to the management of human resources. Educational administration, too, has shown a trend towards emphasis on human resources, albeit a little sluggishly. The Government of India itself formed the Ministry of Human Resources Development only in the latter half of the 1980s. Combined with these winds of change, the increased use of computers made deep inroads into all aspects of information processing, including educational administration. The role played by computerized information systems in educational administration goes far beyond the much hyped "modernization" and "efficiency" questions. The next section examines the multi faceted role of computerized information systems in educational administration.

1.1 ROLE OF COMPUTERIZED INFORMATION SYSTEM IN EDUCATIONAL ADMINISTRATION

In order to understand and appreciate the information needs of educational administration, one has to delve deeper into the set of activities that make up educational administration. In the broadest sense, educational administration encompasses all activities of planning, organizing , leading and controlling in the functioning of an educational institution. It has already been stated that an educational system has a close resemblance to the functioning of a production unit. Consequently, virtually every managerial (administration) function within any organization would hold for an educational institute too, except possibly for the "profit generation" motive that controls many organizations. (Today, however, the administrative functions of non-profit organizations are studied with equal seriousness [Kotler P.(1985)]). In educational institutions, the major administrative activities are concerned with the running of the institution, its programs, and the entities like students and faculty.

As the information processing needs to meet the needs of educational administration grows, the personnel involved in such tasks tend to grapple with voluminous amounts of data and perform highly repetitive tasks in a mechanical sort of way. Handling voluminous data through manually maintained files and notes by the various information processing entities (clerks in the offices) have the following disadvantages:

* they invariably lead to duplication of work since different

offices maintain their own records as per their primary needs,

* loss of data through mishandling, incorrect filing or faulty inter-office communication is higher,
* inconsistency surfaces in the reports made by different offices since a data updated in the manual files/notes in one office may not have been communicated/updated in the records of the other, and
* the end result is loss of integrity in the functioning as offices operate on different sets of data.

Apart from these, handling voluminous tasks manually and performing of highly repetitive tasks often results in loss of efficiency and motivation of the personnel, as seen from the human interest angle. One of the primary objectives of office automation is to standardize routine tasks in such a way that the manpower spends little time and energy on repetitive, mundane tasks and spends more time on creative aspects of the profession. Seen from the viewpoint of improving productivity and efficiency, and also from the viewpoint of human interest, a computerized information system would fit the bill neatly.

The primary role of a computerized information system in any activity is to contribute towards increase in productivity (of the information processing entities) and facilitate decision making. In the case of educational administration, the role of computerized information system, specifically, is as follows:

1. Educational systems ought to function with the same zeal towards questions of office productivity and administrative efficiency (despite the lack of a profit making objective).

Information systems form the backbone of efficient functioning of an industry, and so it must be with educational institutions.

2. Information systems usher in a modernised way of functioning and orderly record keeping and retrieval.
3. Educational systems that are not excessively subsidized by some agency or the other need to constantly adapt itself by performing scores of optimization exercises. Such exercises and adaptation requires availability of a good information base and scope for the decision maker to experiment and analyze. Computerized information systems can be designed to allow for such kind of "what if" scenario analysis.
4. Educational institutions that have chosen the path of innovation, experimentation and self-correction as a way of life are forced to constantly analyze the functioning of the various entities in the system, the impact of various stimuli from within the organization and from the environment. Computerized information systems aids in performing these tasks with greater ease and reliability.
5. Information systems, specifically designed with a focus on human resources management, would aid in better utilization of manpower and contribute towards organizational productivity.

1.2 BENEFITS OF COMPUTERIZED INFORMATION SYSTEM VIS-A-VIS HUMAN RESOURCES MANAGEMENT

Much has been talked and written about the benefits of computerized information systems in general. Maish A.M.(1976), in his doctoral dissertation, has surveyed computer based information systems and their uses. Bateman H.H.(1972) reports that a study of 284 four-year colleges in the USA revealed that computerized information systems were primarily used for students records and financial areas predominantly. Personnel management planning was not given much emphasis. Aitken C.E.(1977) developed a model to act as a computerized tool for academic advisors. Beaty J.L.(1975), Beck J.D.(1976), Bell J.C.(1975), Braggins H.A. Jr.(1975), Briney III J.F. (1973), Demb A.B. (1975) and Dicianna T.L.(1974) presents a small cross section of studies that focus on various aspects of computerized information systems. However, until recently, very little has been reported on the benefits of computerized information systems vis-a-vis human resources management.

Among the early literature, Scheetz L.P.(1973) studied the advantages and disadvantages of personnel information storage and retrieval system used at Michigan State University. Piper W.B.(1974) in his dissertation establishes the need for a management information system to aid in the decision making process in several schools at MIchigan, USA. Morales L.E.(1972) presents an evaluation of administrative data processing uses in selected community colleges in the USA. This study lists several benefits of computerization, but specific benefits on account of human resources management do not figure in the thesis prominently. Perhaps the work of McGovern J.J.(1973) was one of the first serious studies on human resources management. This was a Delphi systems analysis for management control and program budgeting. Other studies concerning computerized information systems are reported in Chapter 2 of this thesis. This section outlines some of the major benefits of computerized information systems vis-a-vis human resources management.

1. Removal of duplication of job function is often quoted as the primary benefit of computerized information systems. McNinch J.P. Jr.(1977) reports that human resources management function in educational administration consists of 21 activities. It is very evident that many of these functions have a high content of information processing. Hence the greatest benefit that emerges on having a computerized information system is avoidance (or atleast a reduction) in the duplication of work.
2. A computerized human resources management system would enable the administrator to perform a comprehensive human resources management function. Otherwise what functions would be performed would be in isolated pockets like recruitment, evaluation, etc. which is far from being a comprehensive function.
3. Decision making that has a direct bearing on utilization of human resources would tend to be faster, more data based and objective. This further results in better manpower utilization and productivity. The decision making process itself becomes

more scientific and less whimsical.

4. Usually personnel data is used for clerical and mechanical uses. Using a computerized information system opens up wider horizons of applications. Lyons L.P.(1972) has studied the applications of teacher-personnel information system involving techniques of control and analysis. Furthermore, this plays an important role in comprehensive planning of education itself, as the research of Leader C.E.(1974) reveals.
5. Computerized information systems often lead to better accountability. Lanza L.G.(1976), in his doctoral dissertation, has proposed an "accountability information system", which has as its heart a human resources management system.
6. Computerized information systems lead to a better utilization of manpower, notably educational administrators, who are partly academicians partly administrative as in BITS. LaMarsh B.N.(1968) has shown that computerized information systems can free people of some of the clerical operations or time consuming data analysis for decision making as required by their positions, but which also take them away from their primary objective - educating students.
7. Computerized information systems enable an innovative educational administrator to evaluate alternative educational programs and their consequent requirements, both physical and intellectual. For instance, this is investigated by Karmer D.L.(1972) using a computer simulation model.

In a similar vein, several other benefits can be enumerated. Admittedly, some of these benefits have a dramatic impact within a short span of time, while many do not even show visible or tangible benefits. yet, the benefits that accrue far outweigh the costs incurred, as will be shown later in Chapter 5 of this thesis.

1.3 THE LEGACY OF INNOVATION AND MODERNIZATION IN BITS

Since the formation of BITS from three constituent colleges in 1964, innovation and modernization have been a way of life. Educational innovation took the form of several bold, new schemes like integrated system of education, broad based educational structure, complete internal evaluation, dual degree scheme, university-industry linkage through Practice School programs, collaborative education through the M.E.(Collaborative) degree programs, distance learning schemes, etc. Modernization took the form of administrative restructuring to accommodate functional management of educational administration, doing away with traditional departmentation, centralization of lab facilities, and increased use of computers in both academic and administrative endeavours.

The entire story of this innovation and modernization has been lucidly narrated in a book entitled "An Improbable Achievement". (See References at the end of the thesis). What we shall emphasize in this section are those aspects of innovation and modernization that sowed the seeds of designing computerized information systems with special attention given to the need for system reliance (to changes due to educational innovation or modernization) and keeping the cost overheads low. In short, we shall consider only those factors that were prime motivating factors for undertaking this investigation.

* Some time, in the early part of 1969, BITS ordered its first computer - the IBM 1130 system (a popular machine in its time) for modernizing its curriculum as well as its data processing

functions. In the month of August 1969, the system was installed and a new unit called the "Information Processing Center" was formed. The IPC was expected to take care of the computer aspects of the academic and administrative needs of BITS. This was probably the "seed event" that ushered in an avalanche of activities that pushed BITS on its route of educational innovation and modernization.

* Plans began rightaway in earnest for changing over from traditional practices of record keeping to a computerized system. By the end of 1970, the design for such a system had already been worked out and the first of the computerized grade cards for students emerged from the IPC. What makes this a remarkable event was that (apart from the bold innovations that permitted such a computerization) the software was written entirely by the faculty of BITS, and not through a hired consultant.
* In 1971-72, BITS introduced a bold policy of "Unassigned Admissions with Progressive Branching" on a five-year integrated program. Reacting to this change, the software for Students Records was redesigned. It was only at this stage that it was realized that the software had to be redesigned in its entirety. This entailed two major disadvantages. Firstly, the previous system that was implemented became almost entirely obsolete. Secondly, the redesigning of the entire system made deep inroads into the developer's time (which in the case of BITS was the faculty time).
* Again in 1978, there was an experimental change in the

admissions policy. BITS went in for a "partial assigned and partial unassigned" system of admissions for its five year integrated program. But having had the experience of sudden changes in educational policy in the preceding years, the software designers were somewhat prepared. The redesigning and recording effort was not as debilitating as it was in 1971-72.

* Just a year later, in 1979, reacting to changes in the school education (10+2 scheme), BITS introduced a "Four Year Integrated Program with a Preparatory Semester". Now the entire admissions were on an assigned basis. Evidently, this resulted in a major rehaul of the computer system, since the system had to be capable of handling the new system plus those in the pipeline.
* In 1981, as the school system with its 10+2 stabilized all over India, BITS settled for a "Four Year Integrated Program" with assigned admissions. At this time, there were students on the rolls of the institute belonging to the Five Year Integrated programs, the Four Year Integrated programs with a Preparatory Semester, and the newly introduced Four Year Integrated Program. The complexity of the software system to handle these wide ranging disparate cases may easily be imagined.
* Again, in 1981, a particular event triggered off a spate of computerization of educational administration, now with those aspects directly relating to human resources management, i.e. its staff. The accounts office of BITS delayed payment of salaries to staff on the pretext that it was under staffed and that its workload was unusually heavy. The sequence of events

that led to this has been reported in an internal paper entitled "An Artificial Crisis". The administration promptly countered this "artificial crisis" by getting a full fledged payroll software implemented on the then existing IBM 1130 system within a record 20 days! This was to prove to be a precursor of more daring and innovative computerization efforts to come.

* The mid 1980's saw an upswing in the always popular Practice School program. More organizations were involved were involved and from far flung areas across the country. To meet the academic and administrative challenges posed by this, a computerized system was designed and implemented. Christened COPSIMS, this remarkable software forms the backbone of PS instruction and monitoring even today. [See Dey S.(1989)].

The foregoing paragraphs are by no means exhaustive or complete. It however suffices to emphasize that BITS always had a rich legacy in innovation and modernization that fostered computerization of educational administration. The genesis of the cost effective computerized information system reported in this thesis lies in this legacy.

1.4 OBJECTIVES OF THE THESIS

The objectives of the thesis are mentioned below.

1. To survey the existing scenario as to the state of the technology in relation to computerized information systems.

   { Computer hardware technology has improved by leaps and bounds in the last two decades. Software technology, too, has grown but perhaps not so dramatically as the hardware technology. While prices of hardware are plummeting, the cost of software design, implementation and maintenance are climbing to near unmanageable heights. [For example, see Baber L.(1978), Abbott R.J.(1985), Peters T.J.(1985), Tausworthe R.C.(1979)]. The survey would provide the basis for reinforcing one of the central issues of the thesis - to design a "cost-effective" computerized information system. }

2. To survey the research work on computerized information systems for educational administration, provide a critical appraisal of the state for the art, and study its progress in India.

   { One of the working hypothesis used in this thesis is that while research on computerized information systems for educational administration has been pretty hectic abroad, the situation in India reveals certain yawning gaps. The establishment of this hypothesis would lay the foundation for the importance of this thesis in emphasizing cost effectiveness, modularity, integration, etc. in computerized information system for educational administration. }

3. To show that the laudable principles of structured programming, modularity, maintainability, integration, etc. advocated by software engineering need not necessarily have to break down when an information system evolves rather than when it is designed once and for all.

   { It is the usually accepted dogma that computerized information systems should be "designed" and not let to evolve. This, per se, is not a repugnant principle to follow. However, for universities like BITS, where change and innovation are a way of life, following the dogma rigidly would not be feasible. This is because an ideal design of an information system would almost never emerge in such a dynamic setup. It is the effort of the thesis to show how to preserve modularity, maintainability and integration and a host of other desirable features inspite of letting the computerized information system for educational administration evolve over time. }

4. To design and implement a cost effective computerized information system for educational administration with special reference to management of human resources for a university like BITS, where change and innovation are commonplace, and that which changes the requirements of the information system.

   { Most designers follow the well trodden path for building information systems. [Abbott R.J.(1986), Peters T.J.(1988), Pressman R.S.(1982), Tausworthe R.C.(1979), Boehm B.A. (1976), Ross D.T. et al (1975), Yourdon and Constantine (1979), Stevens et al (1974), De Marco

(1987), Flavin (1981), Katzan Jr. (1976), Peters (1981), Peters and Tripp (1976), Jones (1970), Orr (1977) and Page-Jones (1980) forms a sample cross-section where slight variations in individual approaches exist, but wherein all agree on a well defined set of steps in information systems design]. THis thesis chooses to view the information system requirement as a pyramidal structure consisting of Grassroot Applications and Decision Support Systems - an approach that has been found in this thesis to be enormously resilient to change and is cost effective. }

5. To establish that cost effectiveness, operability, maintainability, modularity, reliance, and integration call all be achieved (within reasonable limits) in an information system for a dynamic university like BITS using modest hardware, least extravagant software development tools, and using manpower upgraded from within the organization.

{ Most computerized information systems designed in the 1980's tend to use enormously powerful and costly equipment in terms of graphic workstations, superminis, LANs, WANs, etc. Software tools employed are often highly extravagant (and expensive) like sophisticated RDBMS, 4GLs, Object Oriented programming Languages, etc. Design and development manpower are usually highly priced consultants, while operational manpower are often to be hired (a high salaries) at the behest of the consultants. It is the contention of this thesis that much of these are not essential ingredients in the Indian milieu. The end result in running a university's administration smoothly and effectively can be achieved with modest hardware, less expensive software development tools, short lead times for design and development, and small recurring expenses in the operation and maintenance of the system. }

1.5 METHODOLOGY

The methodology followed to achieve some of the objectives in this thesis are enumerated below.

1. In order to survey the scenario as to the state of the technology in relation to computerized information systems, an in-depth literature survey was conducted. The literature surveyed included, among other things, textbooks & practioner's guides on Software Engineering, computers and information systems; journals; popular magazines on computers, information systems and software; and news magazines. The results of the literature survey are presented in Chapter 2 of the thesis.
2. In addition to the above, to cater to objective (2) above (mentioned in section 1.4), research work on computerized information systems for educational administration was particularly surveyed. Of specific interest, several doctoral dissertations in this area as has been carried out in the various universities of the USA, UK and Canada between 1965 and 1986 have been considered in the survey. Further, scores of professional journals on higher education, educational administration and information systems published in India were also surveyed. The analysis that stems from this survey is also presented in Chapter 2 of the thesis.
3. A third, and final, aspect to the literature survey was undertaken with a specific motive of studying the various software engineering practices connected with information systems design, implementation, verification, maintenance, etc. Also surveyed were the software development tools ranging

from simple programming languages to sophisticated RDBMS and 4GLs. Due attention was paid to the survey of software systems connected with Grassroot Applications (discussed in Chapter 3 of the thesis) and Decision Support Systems (discussed in Chapter 4 of the thesis). Since, cost effectiveness, resilience to change, and integration are the central issues discussed in the thesis, literature connected with software metrics and software engineering were also studied.

4. At the very outset, the information systems design was initiated with a different beginning. The main conception was that any integrated information system for an organization exists in a pyramidal structure (See Chapter 3 of this thesis). The essence of the thesis was then to design and implement each of the modules from the base of the pyramidal structure upwards in a cost effective manner, preserving integration and providing some resilience to change. Further, the information system so implemented was to have certain desirable properties despite the fact that many of these modules really evolve rather than are apriori designed.
5. The selection of hardware to implement the information system was one by default, i.e. by availability rather than by conscious choice. Again, this has positively contributed to the central theme of the thesis - cost effectiveness without sacrificing quality.
6. As with computer hardware, the software development tools also selected themselves, as what were readily available on the system rather than by conscious choice. This has again

contributed significantly in the support of one of the central hypothesis of the thesis - modular, integrated, resilient software systems can be built using modest software development tools without resorting to esoteric and extravagant tools.

7. All stages in the information systems design & implementation, i.e. from requirements, specifications, detailed design, software implementation, verification, to pilot runs and actual observation of the system in action for 2-3 years were carried out "in house" on available hardware and software.

8. Several interactions with the actual users of the computerized information system were initiated so that "fine tuning" of the system could be done as a result of this feedback.

9. The design and implementation was primarily geared to provide resilience to change, easy maintainability, and above all, integration of modules. Added to these, the central idea was to provide a working model to the satisfaction of the end users, without resorting to expensive gadgets and software gimmickry.

? Example

what was done to achieve this? Examples

1.6 HIGHLIGHTS OF THE THESIS

Some of the major highlights of the thesis are given below.

* The thesis brings into sharp focus the lack of attention / importance given by academicians and practitioners to the study of computerized information systems for educational administration.
* This study also points out some yawning gaps in the study of computerized information system for educational administration in India.
* The usual dogma of information system designers and software engineers is that computerized information systems must be the result of conscious design and not evolution. While not opposing this excellent guiding principle, the thesis argues strongly that in an innovative and dynamic university like BITS, such projects adhering to this dogma would normally not take off at all or would be prohibitively expensive.
* Abhorrence by software engineers for letting an information system evolve is that modularity, maintainability, integration, etc. would be sacrificed. This thesis attempts to demonstrate that the only practical way in which computerized information systems for dynamic universities like BITS can be built (given the normal constraints that most universities would face) would be by natural evolution reacting to innovative changes within the system. Also, the thesis attempts to establish that modularity, integration, etc. need not be sacrificed by adopting skillful design of software that provides resilience to change.
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and equally powerful, but esoteric and extravagant software development tools, the thesis attempts to establish that cost effectiveness and software quality can be maintained for most of the information system requirements for a university like BITS.

* The thesis argues strongly in favour of considering "Grassroot Applications" as the first charge of computerization. It is only on the strong foundation established by the grassroot application modules that sophisticated decision support systems (that administrators obviously would favour) can be built. Consequently, Chapters 3 and 4, are entirely devoted for grassroot applications and decision support respectively.

* Finally, alternate schemes that could have been adopted (if the constraints of having to keep costs low, etc. were relaxed) are also explored in the last stages of the thesis.

CHAPTER 2

A SURVEY OF THE SCENARIO

The foregoing chapter provided a brief prelude to the role of computerized information systems (with special reference to educational administration) and the benefits of computerized information system vis-a-vis human resources management. Since the thesis proposes to study and develop a cost-effective computerized information system, the previous chapter also touched upon the legacy of innovation and modernization at BITS. The objectives of the thesis, the methodology used and the major highlights of the thesis, were also presented. This chapter presents a survey of the scenario - that of the technology and the research work on computerized information system for educational administration. The chapter also attempts to provide a critical appraisal of the state of art as gleaned from the survey of the scenario. Of primary importance, in this chapter, is an incisive study of the progress of the progress of computerized information system for educational administration in India and an exposure of the certain large gaps that exist in that area. The central theme of the thesis is that computerized information system for educational administration for universities like BITS (where change and innovation are frequent) have to be resilient to change for cost-effectiveness. This implies that the most touted priniciple of software engineering that a system must be "designed in its entireity" would break down under the pressure of frequent change. This thesis follows the "software evolution" priniciple which is frowned upon by the software engineering purists. The latter portion of this chapter (section 2.3) provides a critical appraisal of this approach.

2.0 COMPUTERIZED INFORMATION SYSTEMS - THE STATE OF THE TECHNOLOGY

This section provides a survey of the state ofthe following technology of computerized information system. The study of computerized information system involves the following sub-modules.

(a) Computer Hardware

(b) Software Systems

(c) Software Engineering Management

Thus, the state of the technology would be studied in respect of the technological trends in each of the above sub-modules.

2.0.1 The State of the Technology of COmputer Hardware

The computer hardware technology has grown in the last four decades in leaps and bounds. from the development of the first large scale electronic digital computer (the ENIAC) way back in 1946, the computer hardware industry has come a long way. Today's desktop models pack more computing power and rival the power of contemporary supercomputers. Table 2.1 shows a partial view of the chronological development of computer hardware.

The computer hardware technology has been changing rapidly. This has resulted in computer models being available for lesser cost with superior power than what was available months before.

Table 2.1

PARTIAL VIEW OF THE CHRONOLOGICAL DEVELOPMENT OF

COMPUTER HARDWARE

YEAR	EVENT	TECHNOLOGY
1946	First large scale electronic digital computer - The ENIAC	Vacuum Tubes, Plugs & switches; Not a true stored program computer
1946	First transistor	Towards miniaturization; replaced vacuum tubes
1949	First working full scale stored program computer - The EDSAC	Mercury delay lines punched paper tape, teleprinter
1949	First core memory	Reliable memory; dominated 1950s & 1960s
1950	First interactive parallel real time computer - The WHIRLWIND	First computer to use core memory
1951	First commercially available computer - The UNIVAC	First generation
1951	First description of microprogramming	M V Wilkes' concept has a profound effect even today
1954	First transistorized general purpose computer -The TRADIC	Second generation; > 800 transistors
1956	First random access storage system - The RAMAC 305	Magnetic disk technology
1959	First IC	Semiconductor tech. contained 22 transistors on chip
1960	First laser	Based on crystal of synthetic ruby; has impact on communications even today
1963	First minicomputer - The PDP-8	
1964	IBM 360 developed	Third generation; IC tech.; solid

Table 2.1 (continued)

YEAR	EVENT	TECHNOLOGY
		logic tech; ushered in a form of tech. obsolescence
1964	First commercially available super computer - The CDC 6600	
1969	First 16-bit minicomputer - The NOVA	
1970	First commercially produced fibre optic cable	Optical circuits have speed & capacity over conventional cables
1970	First semiconductor laser	Solid state laser; promised cost effective communication when used with fibre optics
1971	First microprocessor - The INTEL 4004	2250 transistors in 1/6 inch by 1/8 inch chip
1971	First personal computer - KENBACK I	Programmable thro switches; LED for screen; SSI chips
1977	First commercial LAN - ARCnet	Coaxial cable
1977	First completely assembled personal computers - Apple, Radio Shack & Commodore	
1980	First 32 bit microprocessor - The BELLMAC 32	LSI
1981	IBM PC	Historical event
1983	First experimental version of optical transistor	Transphases; 1000 times faster than electronic switch crystals & laser technology

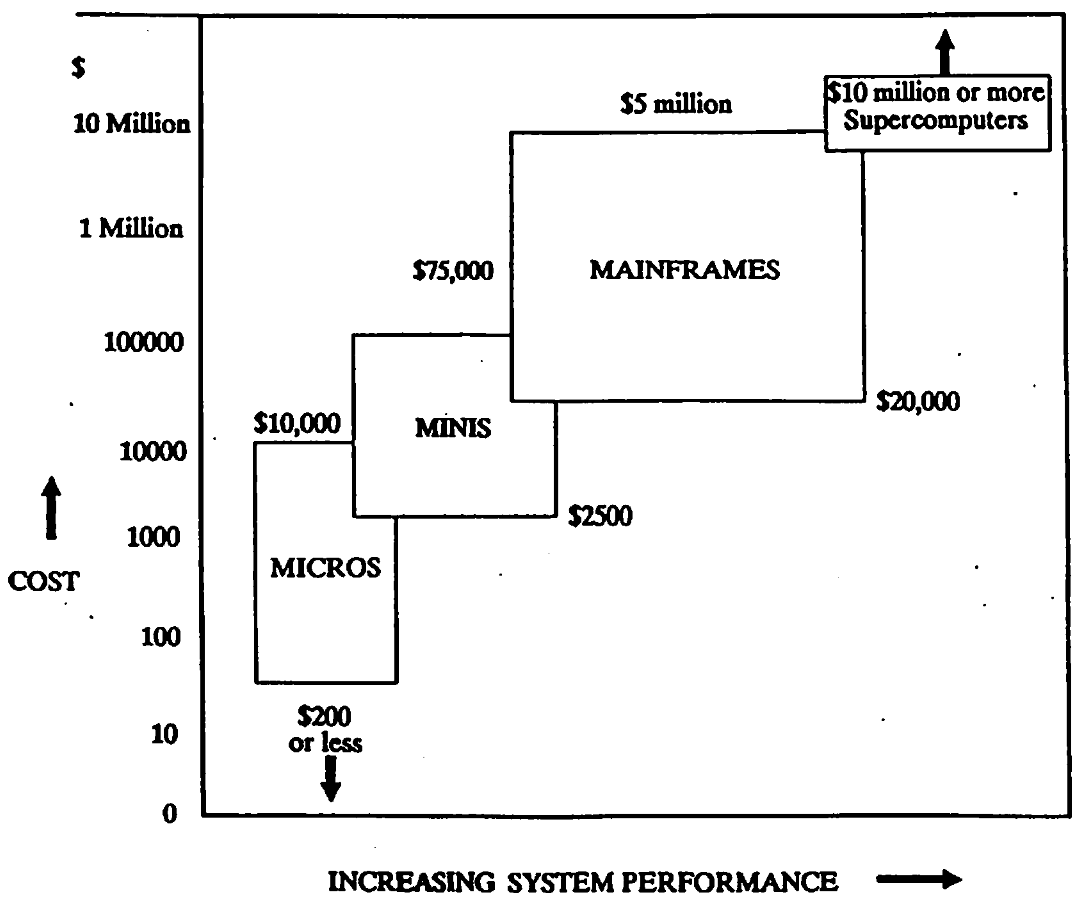
Source:

Eames C.(1973), Eames C.(1981), Ralston A. & Reilley E.D.(1983), Blissmer R.H.(1987) and Zientara M.(1981)

The rapid technological pace creates havoc with classification schemes. Using an arbitrary classification of micros, minis, mainframes and supercomputers, costs and performances may be compared. Figure 2.1 shows such a classification comparing costs and system performances.

FIGURE 2.1

CLASSIFICATION COMPARING COST AND SYSTEM PERFORMANCES



Much of the hardware advances have been dramatic reductions in computer size. Table 2.2 summarizes the hardware advances and gains that have been made. The 1990s hold out an even tantalizing promise in terms of hardware gains. The technological gains in computer hardware are not just restricted to computer systems alone. Input/Output devices and also mass storage devicess have all recorded remarkable technological advances. While keyboard remains the most popular and widely used input device, several outstanding technological advancements have been made in other input devices that are becoming increasingly popular. Figure 2.2 has a diagram showing the different types of input devices. Similarly, output devices have largely emerged from the shell of the conventional VDU and a dot matrix printer. Figure 2.3 shows different output devices that are being increasingly used with computers. Recent technological trends show that mass storages are being developed that packs gigantic amounts of information at relatively low costs. Figure 2.4 depicts the different types of mass storage devices that are currently available.

The field of communications is also experiencing rapid and dramatic technological changes. The advancements have been so rapid that the distinction between "telecommunications" and "data communications" has blurred into an intergrated "information networks". Figure 2.5 shows the convergence of computers and communication.

By far, the greatest impact that computers have had on organizations (medium to small) and people is through the advent of personal computers. The installed base of PCs have even

TABLE 2.2

A SUMMARY OF HARDWARE ADVANCES

Development	1950	1960	1970	1975	1980's
No. of circuits/cubic ft.	1,000	100,000	10 million	1 billion	Many billions
Execution Speed CPU	300 micro-seconds	5 micro-seconds	80 nano-seconds	25 nano-seconds	5 nano-seconds or less
Cost (Cents/million instruction)	2,800	100	2	1	Less than .01
Cost (cent for storage 1 bit)	261	85	5	1	Less than .01
Primary Memory Bytes	20,000	120,000	1 million	10 million	Much greater than 10 million
Secondary Storage Bytes		20 million	Over 100 billion	Virtually unlimited	Virtually unlimited
MTBF CPU	Hours	Tens of hours	Hundreds of hours	Thousands of hours	Years

why?

why?

FIGURE 2.2

DIFFERENT TYPES OF INPUT DEVICES

Redundant

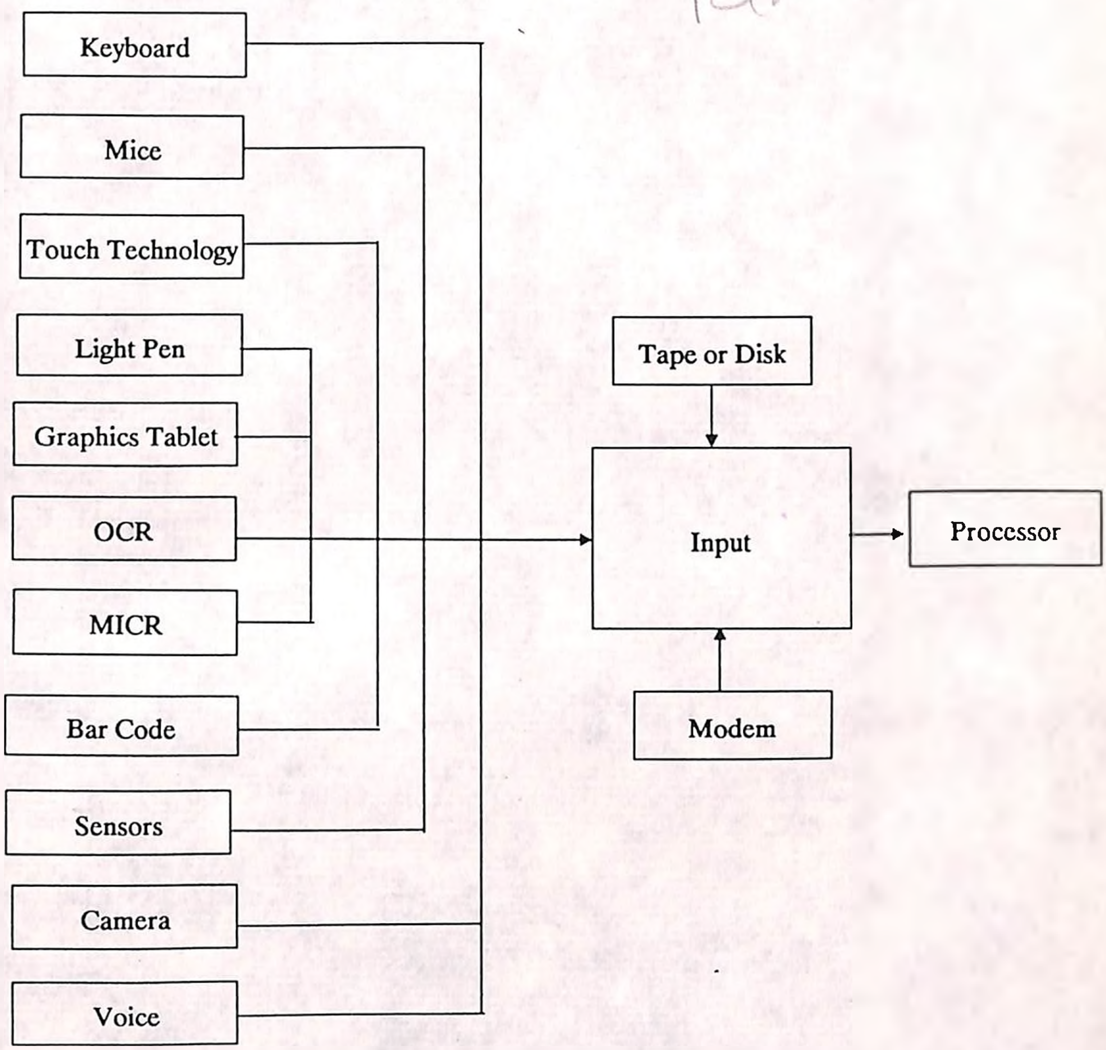


FIGURE 2.3

DIFFERENT TYPES OF OUTPUT DEVICES

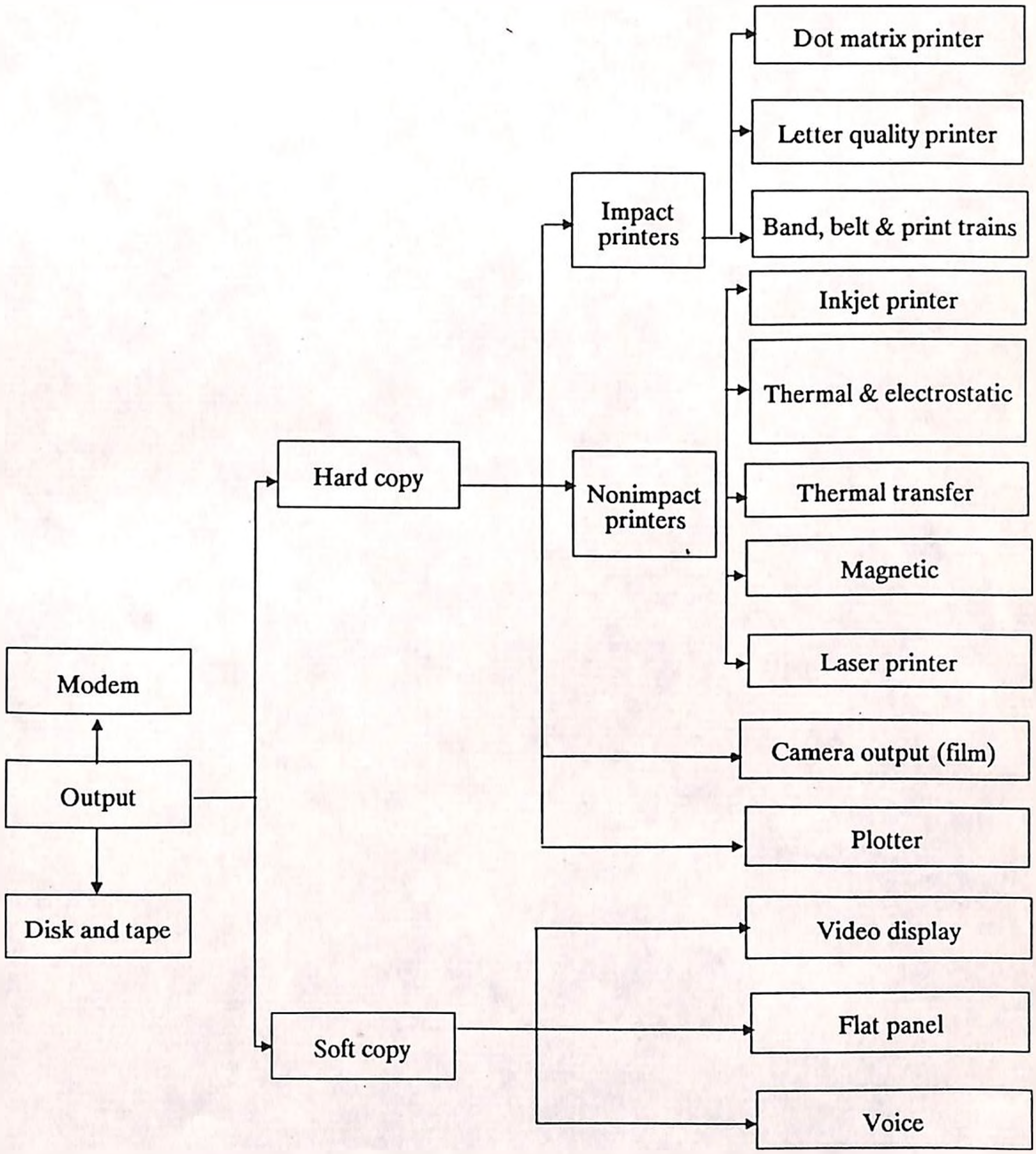


FIGURE 2.4

DIFFERENT TYPES OF MASS STORAGE DEVICES

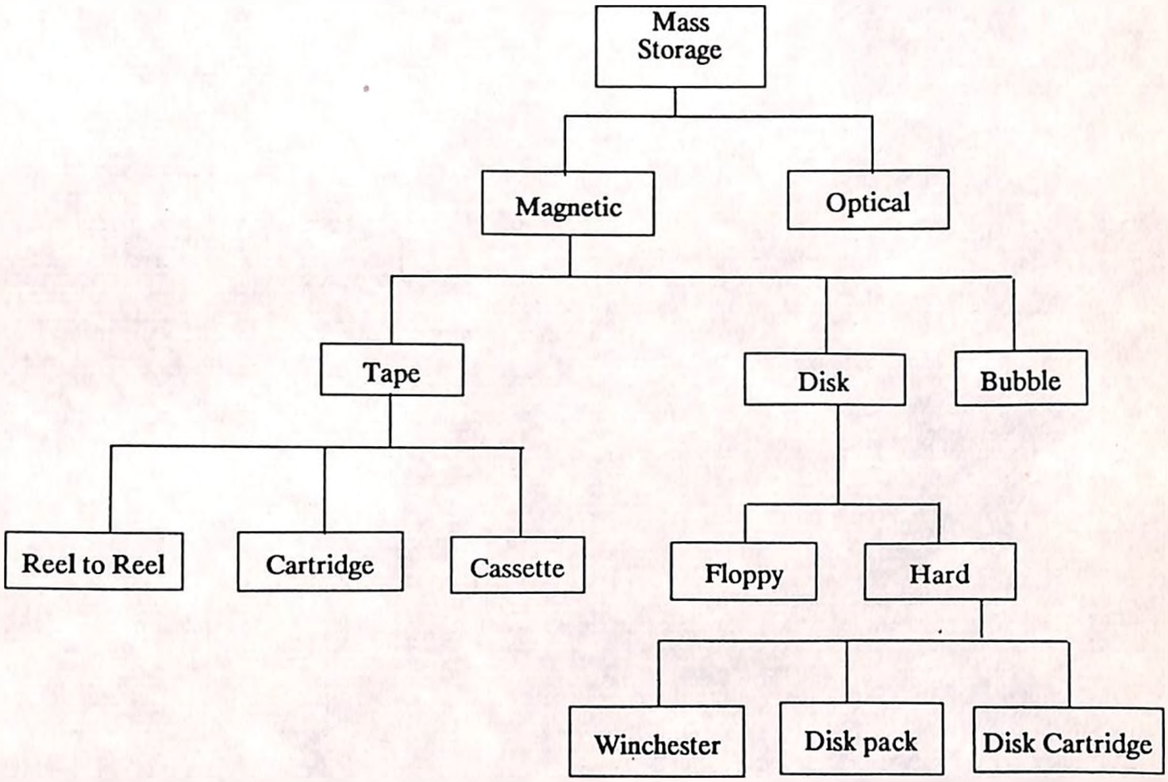


FIGURE 2.5

CONVERGENCE OF COMPUTERS AND COMMUNICATIONS

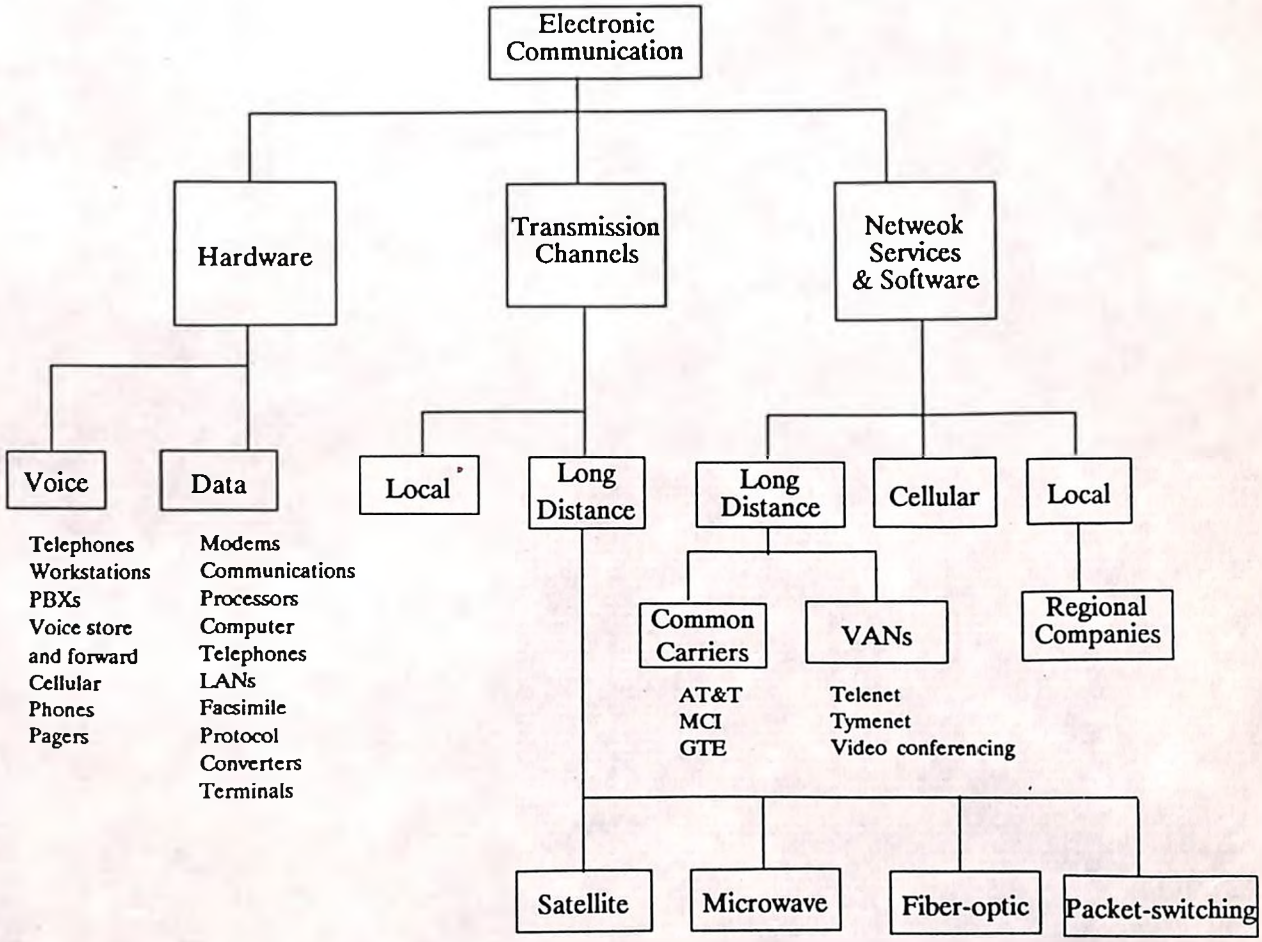


FIGURE 2.6

GROWTH OF INSTALLED BASE OF COMPUTERS

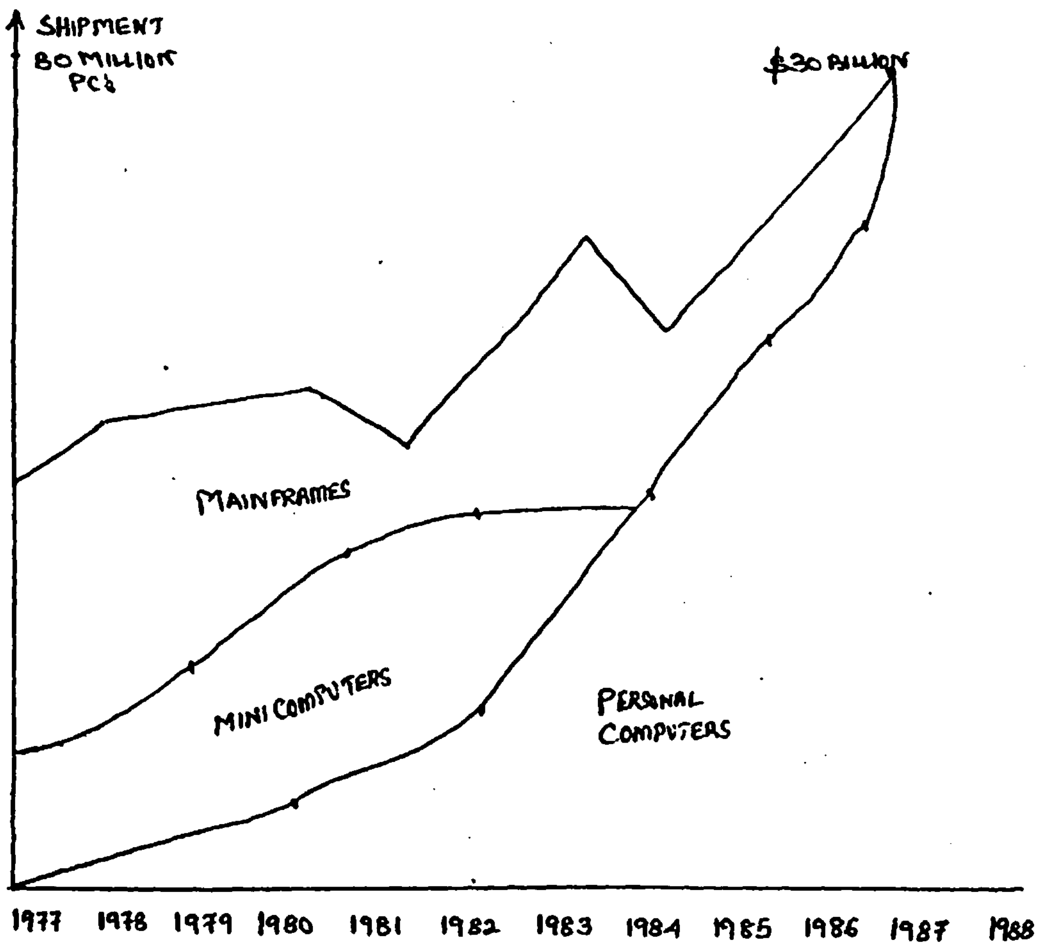
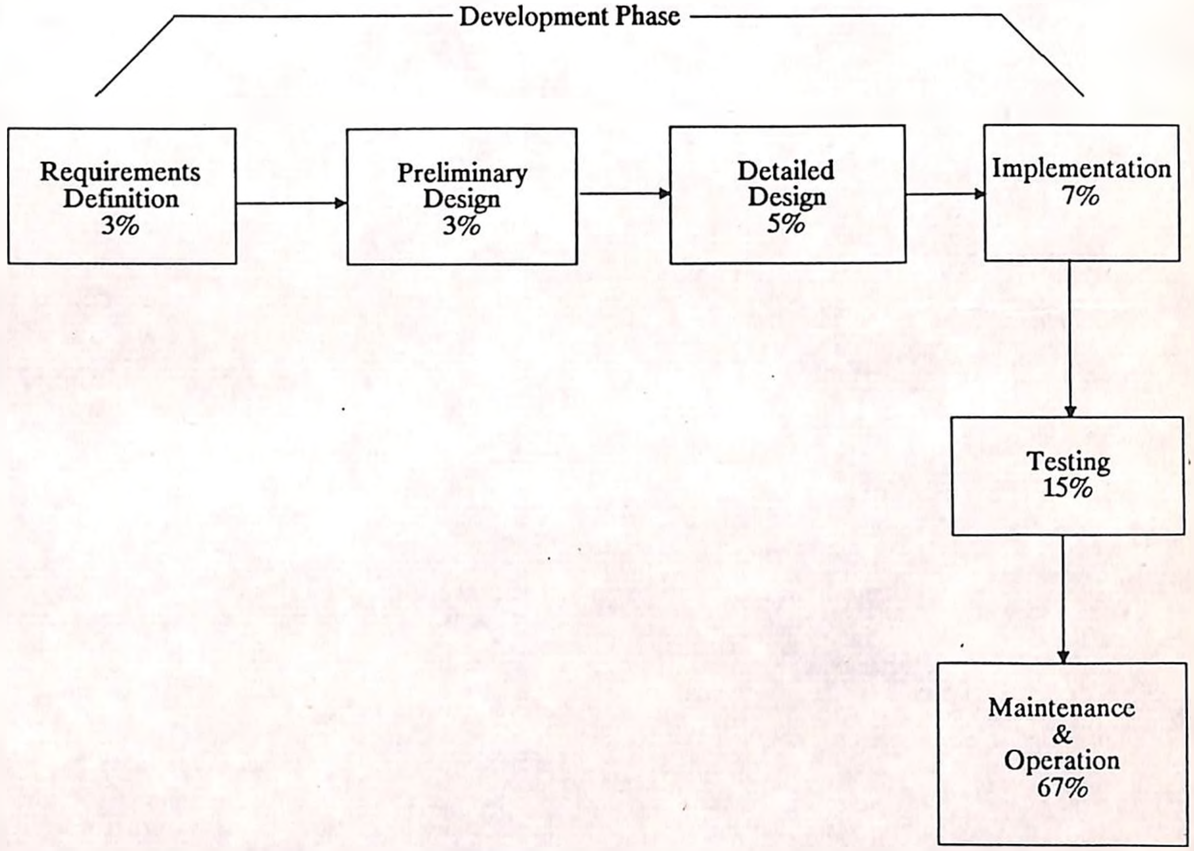


FIGURE 2.6

RELATIVE COSTS IN SOFTWARE DEVELOPMENT



outstripped those of mainframes and minis. This has also contributed significantly to cost-effectiveness of computerization through low hardware costs (one of the themes of the thesis). Figure 2.6 shows the growth of the installed base of personal computers against minis and mainframes.

In summary, the state of the technology of computer hardware reveals a trend towards miniaturization, more power and efficiency packed in, a tendency towards providing ease of use, better reliability, and above all, a trend of falling costs.

2.0.2 The State of the Technology of Software Systems

The technology of software systems have also grown by no less an extent than that of computer hardware. It is in this area that some of the remarkable innovations have taken place. For the purpose of the survey of the scenario, we can consider software systems to comprise of

(a) Operating Systems and Environments

(b) Programming Languages

(c) Systems Development

We shall now present the survey of the state of the technology in relation to each of these areas.

(A) Operating Systems and Environments

The three decades spanning the 1950s to the 1970s was characterized by a domination of proprietary operating systems. One of the most obvious consequences of this was that programs and applications developed on a particular machine (running under particular operating environment) would not run on any other machine. This does not imply that proprietary OS vanished from the scene altogether. Far from it, proprietary OS on IBM/DEC/CDC mainframes, SUN OS and Aegis on SUN and APOLLO workstations reigned supreme in their respective niches. Apple computers, with its highly successful Apple II and Macintosh series have opted to go in for proprietary OS. Yet the trend is clear in that the computer community would like to move towards open systems. Portability of applications and programs became an important consideration. The important thing is that indirectly they were all endorsing cost-effectiveness as a vital issue in software systems development.

Perhaps one of the most far reaching developments in OS was the development of the UNIX OS at AT&T Bell Labs in the early 1970s. UNIX is now available in an enviable range of computers from mainframes to PCs.

One of the remarkable trends in OS technology is a conscious movement towards "user friendliness". People prefer to talk about "operating environments" rahther than operating systems, where a friendlier and easy-to-operate environment is provided. Decades of research at Xerox Corporation's Palo Alto Center ushered in attractive operating environments. This was mainly characterized by a multiple windowing environment with icons, pull down menus and other graphical user interfaces. Apple's Macintosh epitomized this trend and made "user friendliness" a household term. Even in the IBM PC arena, operating environments like Digital research's GEM, DESQVIEW and Microsoft's WINDOWS have made their presence felt.

Even the characteristically cryptic UNIX nowadays sports friendlier environments in the form of Apple A/UX, SCO's Open Look and Open Desktop, and OSF's Motif. The trend is clearly towrds complete graphical operating systems. Years of research in this area has resulted in the formation of the IEEE POSIX and X/OPEN standards.

In summary, the trend in technology of OS is a movement towards open systems, user friendliness, graphical operating systems, portability and compliance with certain standards.

(B) Programming Languages

The overwhelming technological trend in the 1960s and the 1970s was that information systems applications were mainly developed in AUTOCODER (now defunct), COBOL and FORTRAN. The surprising fact is that a large number of organizations in India (and abroad too) still use COBOL and FORTRAn based applications. Structured programming methods were seldom used. Software project costs were usually very high. [For example, see Juran J.M.(1974), Boehm B.A.(1981), Bergland G.D.(1981), Warnier J.D.(1974), Wirth N.(1971), Boehm B.A.(1973) and Brooks F.P.(1975)].

Sometime in the middle of the seventies, the emphasis on structured programming and the need to keep development costs low were made evident. Programming languages like PL/I and Pascal came into prominance. However, their use in information systems development were very low indeed. variations of languages loke BASIC to provide enhancements for better file handling were introduced. The mainstay for information system applications, from procedural languages, was still COBOL and FORTRAN.

Non procedural languages like LISP, SNOBOL and PROLOG were seldom used in information system applications, despite their latent promise. In summary, programming languages, barring COBOL showed no trend towards aiding information systems development. Advances made in fostering structured programming methods made little or no impact on information system developers. System development costs continued to remain at a high level with no signs of reducing.

(C) System Development Tools

The late seventies and the early eighties saw several system development tools being ushered in on a commercially available basis. Unlike the developments in (A) and (B) above, these development tools were specifically designed to cater to information system applications. For the purpose of this thesis, we shall consider the following sub-divisions for software development tools.

(i) Data Base management Systems (DBMS)

(ii) Fourth Generation Languages (4GLs)

(iii) Object oriented programming Systems (OOPS)

Each of these will now be considered for analysis of the state of the art of software technology.

(i) Data Base Management Systems (DBMS)

One of the major areas of software technology that forms the cornerstone of the emergence of the "information age" is the data base management technology [Cardenas A.F.(1979)]. It was in the late 1960s that the need for powerful data structures and file organization capabilities than provided by COBOL, RPG, FORTRAN and PL/I was felt deeply. Of particular interest was the need for "data independence" between application programs, ability to share data amongst various various users, non redundancy of information, high performace, efficiency, security and integrity. In the 1970s, a diverse and diffused body of technology, i.e. knowledge, tools, practices and commercial systems have emerged for structuring integrated data bases and data base oriented systems. [Dodd G.D.(1969), Knuth D.E.(1969), Williams R.(1971)]. The earliest data management software technology was the development of COBOL by the Conference on Data Systems and Languages (CODASYL) in 1960. later in the 1970s, Generalized File management Systems (GFMS), then Generalized Data Base Management Systems (GDBMS) and Genaralized Data Base Data Communications Systems (DB/DC) evolved. CODASYL presented its Data Base Task Group (DBTG) Report in 1971 as the basis for subsequent systems.

The major DBMS developed fell into three main categories:

* The hierarchical model
* The network model
* The relational model

Several hundreds of software houses, universities and vendors were engaged in the development of proprietary DBMS based on the first two approaches. Some examples of these are the SDC/TDMS [Bleir R.F.(1967)], System 2000, ADABAS, METABASE, DATACOM/DB, MARK IV and IMS/VS. [See also Fry J.P. & Sibley E.H.(1976)].

The relational model of DBMS was conceived by Codd E.F.(1970) that started an avalanche of research in data bases. Most DBMS commercially available in the 1980s are based on the relational model. Some of the outstanding experimental data base systems based on the relational approach are reported in Whitney V.K.M.(1972), Held G.D. et al (1975), Chamberlain D.D. & Boyce R.F.(1973), Astrahan M.M. et al (1976), Codd E.F.(1975), Date C.J.(1977), Zloof M.M.(1975). Research on normalization of data bases and functional dependencies [Codd E.F.(1971, 1972, 1974), Heath I.J.(1971) and Date C.J.(1975)] brought about rigour and formalization into the study of DBMS.

The development of System R [Astrahan M.M. et al (1976), Blasgen M.W. et al (1981), Chamberlain D.D. et al (1981), Chamberlain D.D., Gilbert A.M. & Yost R.A.(1981)] was to be a watershed in the technology of data bases as it was to prove to be a forerunner of the popular DB2, INGRES, and SQL [Date C.J.(1984, 1987 & 1988)]. IBM announced in 1981 SQL/DS for the DOS/VSE environment, followed by one for VM/CMS in 1982. In 1983, IBM announced a SQL product for MVS, now called DB2. Over the next few years in the 1980s, numerous vendors also announced SQL based products. Examples of these are DG/SQL by Data General Corp. in 1984, SYBASE by Sybase Inc. in 1986, SQL interfaces for INGRES by Relational Technologies Inc. in 1985 and IDM by Britton Lee in 1985. By 1986, there were some fifty or so products in the market that support some dialect of SQL, running on machines that range from micros to mainframes. In 1986, the ANSI standard of SQL was officially released.

It is true that DBMS revolutionized computerized information systems development. But it would be a hype if we consider that DBMS or SQL are the panacea it appears to be. For example, see Date C.J.(1989), Codd E.F.(1985a, 1985b) and the Turing Award Lecture of Codd E.F.(1982) for some notes of caution.

DBMS would have remained either esoteric or available only on high end minis and mainframes if it were not for the advent of PCs and availability of DBMS like dBASE III on them. The early 1980s witnessed the emergence of micros as a force to reckon with. Consequently, a version of DBMS called dBASE II was made available by Ashton Tate on a variety of micros. When the power of the PC (in the form of the PC/XT, PC/AT and Macintosh) was unleashed, more powerful versions like dBASE III and dBASE IV emerged. Today the software industry id flooded with a variety of DBMS to suit a plethora of uses and purses. A cursory comparison of some of the DBMS available in the 1970s and those available on PCs in the 1980s shows not only a rich variety available on PCs, but also a trend of falling costs of the software. This has contributed to cost-effective computerized information system development in the last decade.

(ii) Fourth Generation Languages (4GLs)

Computerized information systems, using any of the above mentioned software systems, still required extensive training on computers and data processing.. The emergence of 4GLs in the mid 1980s, called alternatively as "high productivity languages" and "application generators" revolutionized programming languages.

The seed of the idea that application development without professional programmers is possible is quickly gaining ground. [See Martin J.(1982)]. 4GLs were called to specifically meet the following objectives. [Martin J.(1985)]

* to speed up the application building process
* to make applications easy and quick to change, thus reducing maintenance costs
* to minimize debugging problems
* to generate bug free expressions from high level expressions of requirements
* to make languages user friendly so that end users could solve their own problems and put computers to work

Commercially available 4GLs vary greatly in their power and capabilities. Some are merely query languages, others are report generators or graphics generators, others can generate applications while still others are very high programming languages. DATATRIEVE, SQL, QBE, and ADRS are examples of those that are referred to as 4GLs but with limited functionality. MANTIS, IDEAL, NATURAL and APPLICATION FACTORY are genuine complete 4GLs. 4GLs reduce development effort and contribute to cost-effective development.

At present, the technology of 4GLs is in such a fluid situation that no standards exist. 4GLs are mainly used i "information systems" type of applications. The productivity of routine DP work (grassroot applications of Chapter 3 of this thesis) can also be greatly improved. The major conceived uses of

4GLs are

* prottyping rutine applications [Martin J. & McClure C.(1983)]
* building routine applications [Martin J.(1982)]
* prototyping management information systems
* building MIS more felxible than earlier
* making application packages more flexible and hence more practical
* data extractors connected to application packages to facilitate the use of their data
* personal computing
* building decision support systems [Martin J.(1984)]
* reducing maintenance costs
* making systems easy to modify in rapidly changing environments

Cost-effectiveness and productivity tends to go up with the use of 4GLs as the use of 4GLs affect only the programming, testing and maintenance phases.

(iii) Object Oriented programming

Object oriented programming is primarily a system building tool since it puts "modularity" at the centre of the the software development process, making "reusability" the usual way in which new components are built, instead of occasionally calling a function from some library as programmers do now. [Cox B.(1986)]. System building is primarily an organizational activity, not a solitary one. Since it occurs over long periods of time, changes become one of the major threats. {computerized information system development for a university like BITS is one such case}. "encapsulation" becomes essential in compartmentalizing damage, making software malleable enough to avoid destruction by changing requirements.

Object oriented programming can be added to nearly any conventional programming language by grafting a small number of new syntactic features alongside the existing capabilities of the language. The new language retains the efficiency and compatability of the base language, but it provides the reusability and productivity of an object oriented programming language. The hybrid retains both programming styles as tools to be picked up or laid aside according to the problem on hand. Objective-C is one such hybrid language based on the C language. Objective-C is commercially available on a wide range of UNIX, VMS, AOS, and DOS based systems. It is also available n the Macintosh and workstations.

Now in the beginning of the 1990s, OOPS has become a buzzoword. Smalltalk-80, the result of over a decade of research at Xerox PARC, is an object oriented programming language. The language has had a lasting effect on Xerox Star office automation system, Apple's Lisa and Macintosh systems. Cost-effective commercial implementations of Smalltalk-80 are becoming available. Smalltalk's designers emphasized

* personal computing
* interaction
* graphics
* object oriented programming

Smalltalk-80 includes the vital aspects of OOPS such as object, messages, class, method and inheritance. [See Goldberg and Robson

(1983)]. Smalltalk-80 also has an extraordinary integrated programming environment with text editors, linkers, debuggers and even the OS which are tightly coupled.

The language ADA, commissioned by the US Department of Defence, was designed as the state of art replacement for the diverse collection of languages now used to build embedded computer systems. Ada has certain features that support object oriented programming. Encapsulation in Ada is provided by the compiler but vanishes before run time. Ada has the capability of defining a package. However, Ada has been criticized on several counts.

The language C++ is an evolutionary enhancement to the C language [Stroustrup B.(1986)]. C++ is almost a proper superset of C with enhancements for object orientation like classes, friend functions, member functions, derived classes, operator overloading and memory management. Other important OOPS include Flavours and LOOPS which emphasize class hierarchies to organize facts outside a problem domain. languages like Carl Hewitt's Actor and Yanezawa's ABCL provide object orientation alognside concurrency. A number of other OOPS include languages like Object-Pascal, Neon, Modula-2, Mesa and Cedar. For a survey of these languages, one may consult Schmucker K.(1986).

In summary, OOPS provide source code compactness, cost-effective resusability of code, binary code compactness, resilience to change and easy maintainability.

2.0.3 Software Engineering Management

The term "Software Engineering" was first coined in the late 1960s, at one of the conferences to discuss "software crisis. Today, it may sound trivial to know that the so called "software crisis" was a reaction to problems created by the advent of thrid generation computers. Software Engineering was first introduced in the early 1970s, as discipline that encompasses procedures, methods and tools for analysis, design, implementation and testing. Today Software Engineering has evolved into a multidisciplinary field comprising of computer science, management and pragmatic engineering [Fairley R.(1985)]. Software can be developed, according to Pressman R.J.(1988), more productively, with significantly higher quality and more cost-effectiveness when Software Engineering is used. Following Sommerville I.(1985), Software Engineering consists of

* **procedures** for planning, controlling, tracking and assuring technical activities during software development
* **methods** that are applied by technical staff during analysis, design, implementation, testing and maintenance of software
* **tools** that enhance productivity, introduce rigourous discipline and aid in quality assurance

The study of Software Engineering really gained importance when it was realized that large software projects entail spirallingly heavy costs. [Boehm B.W.(1973, 1975 & 1981), Brooks F.P.(1975), Martin J. & McClure C.(1983), Ebert R. et al (1980), Halpern M.I.(1965), Niblett B.(1977), Horowitz E.(1975), and Wolverton

(1974) stress this aspect quite vehemently]. Lehman M.M.(1980) point out that in 1977, software costs in the USA was in excess of $50 billion, more than 3% of its GNP that year. It can be safely expected that similar costs would prevail in developing nations as well. What is more, the costs are likely to have doubled atleast in the last decade.

Software Engineering points out that the costs of software are usually high on account of the high cost of software maintenance. Boehm B.A.(1975) quotes a pathological case where the developmental costs of an avionics system was $30 per instruction while the maintenance cost was $4000 per instruction! In all fairness to developers, it must be admitted that software maintenance costs arise mainly from changing system requirements than on account of erroneous design/coding. [Arthur L.J.(1988)].

One of the central concepts of Software Engineering is the **Software Development Life Cycle (SDLC)**. The initial model of the SDLC is attributed to Royce (1970), which consisted of five stages. Over the years the basic SDLC has undergone innumerable changes and metamorphoses. For example, Bentley C.(1982) proposes a SDLC with 8 stages, King D.(1984) with 7 stages and Simpson W.D.(1987) who simplified it to contain four stages of definition, design, implementation and maintenance. The SDLC is often characterized by the **Waterfall Model**. Though the SDLC forms the central theme in Software Engineering, it is not really without its opponents. McCracken D.D. Jackson M.A.(1982) have pointed out the latent ills in the SDLC concept. Gladden G.R.(1982) criticizes SDLC as a never ending loop from which he wants to get off. **Evolutionary Delivery** has emerged as an alternative to the SDLC in recent times. This has been reported in the path breaking paper of Gilb T.(1985) wherein he compares and contrasts the evolutionary delivery model with the waterfall model. The main motivation for the evolutionary delivery was to make available a useable product at the earliest time. This feature will be further discussed in Section 2.4 of this thesis.

The methodology that one uses depends on the software project sizes. Simpson W.D.(1987) uses LOC (Lines of Code) and KLOC (thousand LOC) as the basis for classification of software project sizes. Table 2.3 presents the classification and suggests the appropriate Software Engineering tools that may be used. Lamb D.A.(1988), Shooman M.(1983), King D.(1984), Gunther R.C.(1978) and scores of Software Engineers have conceptually agreed that the various tools for software development may be classified as

* Planning tools
* Design tools
* Development tools
* Monitoring tools
* Skeletal system design
* Review process

The main planning tool used are specification languages [Stibic V.(1982)], structured analysis and system specification [DeMarco T.(1987)], and tools like PERT/CPM, etc. Gunther R.C.(1978) mentions that the essential tools of management are also used as planning tools.

A plethora of Software Engineering design tools have been in focus for the last several years. Bergland G.D.(1981) provides a guided tour of the program design methodologies in vogue. By and large, the system design tools used vary from simple flowcharts to sophisticated mechanisms. Wirth N.(1971) and Dahl O.J. et al (1972) have emphasized the role of structured programming and stepwise refinement. Peters L.J.(1981) provides a comprehensive summary of software design methods and techniques. Earlier, Peters L.J. & Tripp L.L.(1976) emphasized the importance of design to a lackadaisical DP community in a hard hitting article. The Hierarchical Input Process Output (HIPO) method had a large number of followers in the mid 1970s. Katzan Jr H.(1976) provides a complete reference to the HIPO method. Warnier J.D.(1974), one of the founding fathers of the "data structure oriented design", and Orr K.(1981) developed the now famous Warnier-Orr technique. Data structure oriented techniques had some small variations too. Jackson M.A.(1983) outlined a data structure oriented technique that breaks away substantially from the HIPO and Warnier-Orr techniques. The "Jackson Structured Program" had emerged as a very powerful rival to many design techniques. "Data flow" oriented techniques found favour with the Software Engineering community in the late 1970s. Page-Jones M.(1980) and DeMarco T.(1979) advance lucidly the data flow technique for specification and design. perhaps the most rigorous of the design tools was presented in the form of the HOS methodology by Martin J.(1985). Procedural design tools (PDL) has may followers until this date [Linger R. et al (1979)]. Object oriented techniques

TABLE 2.3

CLASSIFICATION OF SOFTWARE PROJECT SIZES & METHODOLOGIES

Level	Classification	Expected Duration	Expected	Size	Suggested Project Methodology
1	Very Small	few days	<$1000	<500 Loc	Spreadsheet Interpretix Lang
2	Small	1 week	<$5000	500-1999 LOC	DB Very Inter. Lang
3	Low-Medium	few months	<$50000	2000-7999 LOC	4GL
4	Medium	1 year	<$250000	8 to 31 KLOC	Automated design tools 4 GLS, 3GLS
5	High Medium	2 years	$500000 to 1 million	32 to 127 KLOC	Models, prototype, Skel.., 3 GLS
6	Large	< 5 years	$1 to $15	128 to 511KLOC	Resusability models, Proto, skel
7	Very Large	5-10 years	$20 to $50 million	512 to 2000 KLOC	Auto proj plg. proto, skel
8	Super Large	> 10 years	>$50 million	> 2000 KLOC	Auto plg. & monitor All gen. of lans

Source : Simpson W.D. (1987)

seem to emerge as a winner in the arena flooded with a plethora of tools. Booch G.(1983), Goldberg & Robson D.(1983), Robson D.(1981) and Cox B.(1986) epitomize the increasing popular of object orientation. In the process, it seems as though the other structured design methods would slowly be discarded in favour of object oriented programming [Jamsa K.(1984)].

Martin J. & McClure C.(1985) provides a comprehensive survey of structured charts, HIPO, Warnier-Orr, Nassi-Schneidermann diagrams, flowcharts, state transition charts, PDL, decision trees, Jackson method, etc.

The developmental tools are also plenty. It has already been discussed in Section 2.0.2 of this thesis. The monitoring tools used are usually the GANTT charts and CPM/PERT. The software design phase can be greatly benefitted by "prototyping", whose virtues are amply stated in Boar B.H.(1985). However, prototyping of software is not usually cost-effective because the design effort and coding effort are almost equivalent to designing and coding the final product. Further, prototyping slows down the final usability of the product. The situation is fast changing with the emergence of 4GLs using which rapid prototyping is not only possible but also is cost-effective [Jones J.C.(1986a, 1986b), Arthur L.J.(1983) and Mohanty S.N.(1981)]. Additional advantages that 4GLs provide are "disposable prototyping" and "multiple prottype testing" without incurring debilitating costs.

The availability of PC based analysis and design tools have further enriched the scope of Software Engineering. Five of the remarkable products are IEW/WS fromKnowledgeWare Inc., DesignAid from Nastec Corp., Rational R1000 from Rational Development Systems, SPQR/20 from Structured productivity Research Inc. and Transform from Transform Logic Corp.

Computer Assisted Software Engineering (CASE) has become popular in recent times that provides methodology, support, contains project planning, tracking, control, DTP, text and graphics integration, and an integrated programming environment. It greatly eases the job of a Software Engineer. However, few CASE tools are available on the PC range at reasonable prices. The only full blown CASE tools available are on graphic workstations which are by no means cost-effective for small firms! [Case A.F.(1986)].

The other areas in which Software Engineering has shown a burgeoning trend is in software testing. Beizer B.(1983), Myers G.(1979) and hetzel W.(1984) provide a complete, comprehensive survey of all known software testing methods. research in this area has been quite hectic with the emergence of highly parallel but economical computers. The study has grown past its traditional boundaries into Software Quality Assurance. Evans M.W. & Marciniak (1986) surveys SQA methodologies, software metrics and espouses the IEEE SQA standard. SQA encourages the use of formal technical reviews. It has already been mentioned that software maintenance accounts for a major share of the software costs. Over the years, the subject of software maintenance has matured into a practioner's discipline of Software Engineering. [See parikh G.(1986)]. Further, to keep costs low, the need for writing machine independent software becomes critical. [See Niblett B.(1977) for several papers in this vein of thought]. Bowles K.L.(1978) is an example of one such effort to develop machine independent software. While developing machine independent software proved to be time consuming and expensive, focus shifted to software protability. Today software portability has its own standards [Dahlstrad I.(1984)], gained academic respectability [brown P.J.(1977)] and practical applicability [Tannenbaum A.S. et al (1979)].

It is evident that Software Engineering has a major role to play in making software development more productive and cost-effective. Glass R.L.(1977, 1978, 1979 and 1981) brings out this need in a chillingly sober fashion despite the humourous and easy going style of presentation. Parnas D.L. & Clements P.C.(1986) warns against the degeneration of the terms Software Engineering and Rational Design into buzzwords. In summary, Software Engineering holds a promise that remains to be exploited for cost-effective development.

2.1 SURVEY OF THE RESEARCH WORK ON COMPUTERIZED INFORMATION SYSTEM FOR EDUCATIONAL ADMINISTRATION

The role and importance of computerized information system for educational administration has already been pointed out in Chapter 1 of this thesis. In this section, we shall report the survey of the research work done in this area in universities of the USA. Most of these work, surveyed in this section, are doctoral theses (Ph.D. or Ed.D) carried out between the mid 1960s and early 1980s. Over 150 papers have been surveyed as part of the present thesis's requirements. To provide a coherent presentation of the areas in which research has been done, there is a need to classify the hundred odd papers. For the purpose of this thesis, we shall consider the various works of research to be in the following categories:

(a) Computer usage in universities

(b) Development of systems and procedures

(c) Specific applications

(d) Management Information Systems

(e) Modelling simulation and evaluation

2.1.1 Computer Usage in Universities

By the beginning of the seventies, several universities in the USA has installed computers to be used for various purposes. In Indian universities, the momentum picked up much later in the mid 1980s, except for a handfull of universities. Research on the use of computers in universities has been sparse in the 1970s in the USA. In India, research on the use of computers in universities has been virtually non existant. yet another major reason behing the lack of research activity in this area is that it was not considered to be of deep academic merit. The situation remains so until today!

LaMarsh B.N.(1968) was one of the first authenticated works of academic research into the use of computers. The major aim of the project was to compare three methods of utilizing automated DP tools in Colorado schools, USA. It was one of the first papers to stress that use of computers can free school personnel (teachers and academic administrators) of some of the clerical operations required of their positions and take them away from their primary objective -- educating students. The three methods compared in the thesis were (i) owner operated computers, (ii) leased time equipment, and (iii) a combination of the above two. The theis recommended as early as in 1968 a cooperative computer center shared by several school districts. This was the fore runner of the "Regional Computer Center" concept which gained popularity in India in the late 1970s. LaMarsh recommended that leased time use of equipment was the most cost-effective method then. With falling prices in computers today, such a conclusion seems untenable.

Ploughman T.L.(1968) in his doctoral thesis studied the implementation, operation and evaluation of regional DP services provided or anticipated by Michigan's Intermediate School Districts. The major objectives of the thesis were to describe the implementation process, to critique existing operations, and to define evaluation criteria for educational DP programs. The thesis primarily relied on the analysis of questionnaires sent to superintendents of schools and DP directors. One of the main conclusions was that constraints to more rapid developments appeared to be the cost of computerized systems, lack of adequate knowledge and understanding of potential benefits. The research pointed out that the ratio of administrative to teaching staff has been decling while the demand for information has been increasing. The factors (in the 1960s) said to encourage DP are effectiveness, speed, increased information, effective handling of higher volumes of work, ease of access of information and release of personnel for other duties. The thesis showed that the trend towards computerized processes was increasing. Dale C.H.(1968) investigated the status and the relationship of EDP procedures on student scheduling and record keeping. The author metions as advantages that the accuracy of EDP material is improved as a result of the elimination of many purely clerical and manipulative tasks and that EDP enforces a disciplined approach to planning.

Morales L.E.(1972) was one of the aerliest researches into the determination of the administrative uses of computerized DP in colleges of the USA. It also attempted to develop a set of recommendations for improving and installing administrative DP systems in community colleges of the USA. The major findings of the thesis were as follows:

* Of the 117 colleges studied, 73 had computers and Unit Record Equipement (URE), 26 had only URE and 5 had only terminals. One hundred and five campuses had equipment on site and 32 depended

on central offices or service bureaus

* Uses for student information system was low with the exception of entrance testing, class schedules and grade cards
* Uses for financial information was reported to be very low
* Less tha 39% usage was reported regarding inventory and library information in all the installations
* Only about 59% usage was reported for faculty and classified staff information
* Specialized staff were employed for all levels of jobs
* Over 25% owned equipment whose cost was over $4.5 million. The rest pay rental to the tune of $4 million
* Most institutions reported inadequate budget, lack of planning, lack of DP staff, lack of administrative cooperation and lack of faculty cooperation.

Morales's work was one of the major surveys into the use of computers in colleges of USA. A work of that magnitude has not been undertaken in recent times in this area.

Fixel A.R.(1972) was a doctoral research into computer time sharing services in educational administration. The main purpose behind the work was to cost one technique of computerized information retrieval of administrative records. using financial management procedures, the study reported the costs involved as under.

1. Service	$ 2000.00	
2. Storage	$ 800.00	
3. Personnel (3)	$ 2000.00	
4. Terminals (5)	$ 850.00	
5. Leased Lines	$ 800.00	
Total	$ 6450.00	per month
	$ 1290.00	per month per district

Such cost-effective utilization of computers were possible because of networking technology being available as early as in the 1970s. In India, cost-effective computerization has to take a different approach as networking is still in its infancy and available networks like INDONET and NICNET are still far from being economical. Fixel also endorsed the use of APL in programming as it considerably reduces development time retaining flexibility.

Merritt E.T.(1973), in his thesis, provides guidelines for the introduction and implementation of computerized DP in the school districts of Connecticut. One of the purposes of the research was to determine some notion of cost-benefit relationships involved when using EDP for pupil, staff, facility, curriculum and financial applications. Merritt's was a Delphi study backed by surveys through questionnaires. The major findings are as follows:

* school districts with less than 400 students should not introduce EDP
* districts with mre than 4000 students would benefit from EDP if they implement applications in the order of payroll, course scheduling, report cards, accounting, and PPBS
* initial use of computers may be from leased sources

* schools should not wait for development of fourth generation systems and reduced costs
* in-house training in EDP vital

Many of the findings and conclusions do not hold any longer in India too. Hardware has become quite affordable by even small organizations. Bucchino W.A>(1974) in his Ph.D. thesis attempted to develop criteria, test instruments and a methodology to determine whether university computer centers were delivering services they purported to deliver and to evaluate how well these services were being delivered. The research design used was a correlations design with statistical controls but no control groups. The findings and conclusions were quite general. Huxel G.H.(1975) was a study of the future implications of computer technology for higher education using the Delphi technique. It recommended that administrators conduct cost-effectiveness analysis in areas of potential uses of computer technology. It also stresses the need for institutions to enter into cooperative computer services sharing agreements to reduce computing costs and to share available expertise. This recommendation, despite its obvious merit, would find great difficulty in India on account of poor communiation facilities and rigid traditional outlook of mos universities.

Maish A.M.(1976) surveyed computer based information systems and their uses for a doctoral dissertation. It was a study of user attitudes and feelings towards computerization. Terry J.P.(1976) surveyed the use of EDP in public school districts of

Texas. the survey included 383 school districts of Texas which revealed a peak in the use of EDP. Administrative applications were implemented more frequently than instructional applications. The thesis, however, failed to provide a comparative cost of using EDP.

2.1.2 Development of Systems and Procedures

One of the areas which offer adequate scope for research is on the development of systems and procedures that aid computerized information systems. In 1970, the American Association of School personnel Administrators (AASPA) decided that the "1960 Standards for School Personnel Administration" was in need of revision. This required a study to revise the principles and functions designated in the 1960 standard. Obloy T.S.(1971) in his doctoral research undertook this study and incorporated three draft revisions in the 1960 standard. What is notable is that "standards" on personnel administration existed even then in the USA. Equally notable was Obloy's doctoral research in that it found academic merit in what was hitherto considered out of bounds by universities. It is also a sad commentary that in India no such standards existed even in the waning stages of the 1980s.

Noggle F.D.(1972) in his dissertation provided a procedure guide and manual for school plant management. Even though it had nothing to do with computerized information system, it shows a trend that research into systems, standards and procedures were getting increased academic acceptance. Pakel E.D.(1972) made an explorative study of information demands in institutions and administrative response to them. The methodology used in the research was mainly interviews and thematic analysis of the contents of the interviews conducted in colleges of New York and Pennsylvania. The study revealed that the major kinds of data collected relate to space utilization, academic operations, student charateristics, fiscal operations and faculty payrolls. The main purposes these data were being used were for long range planning, improved decision making, facilitation of legislation, assuring accountability, and increasing understanding of higher education. The other major findings are listed below.

* Administrative responses to external information demand tend to focus upon the centralization in one office of the responsibility of coordinatng the collection of information
* Response to internal demands were less formal and there was a tendency to create ad hoc committes to collect the needed information
* Most administrators desire to develop an ideal computerized information system. They are themselves unsure as to how to create such a system
* The outstanding problem facing administrators are lack of money, the need to standardize information forms, the need for consultants to train administrators in information management methods, the belief that such collected information is useless to the institution, and the existance of anxiety concerning the use of computers in administtration of universities.

Research involvng a comparison of personnel information storage and retrieval systems for placement services in selected universities of the USA was undertaken by Scheetz L.P.(1972). The thesis particularly compared the system implemented at Michigan State University with those in selected major universities. It established the cost-effectiveness of the procedures used in Michigan State University. Leach G.(1973) concentrateds on the identification, trial implementation and evaluation of criteria and procedures which may be generally applicable to their resources and activities. McGovern J.J.(1973) in his dissertation attempted to determine the faculty data most needed for management control and program budgeting. The study used the Delphi method involving over 150 administrators. Dunning F.R.(1973) developed a system to collect and analyse data to determine what factors affect Student Persistance In Community Colleges - the SPICC system. It consisted of an admission, enrollment, probability, data base and student data modules. However the study also revealed that the SPICC system was too costly to be implemented in colleges of the New York state.

Martin J.K.(1974) made a departure from the often tread line of research by attempting a heuristic goal structure for information need analysis. It proposes a theoretical framework rather than deriving from experience alone as was the praactice then. Leader C.E.(1974) worked on the development of an algorithmic profile data for comprehensive planning in education for his Ph.D. Leader's information system exists at four levels of data, namely, (i) raw profile data, (ii) algorithmic profile data, (iii) policy environment conditions, and (iv) projected alternative states. leader, however, concentrated on algorithmic profile data alone in his thesis.

Muscat E.J.(1974) made an attempt to locate, identify and describe computerized attendance systems in California schools. It was primarily a survey through questionnaires. What is remarkable about the findings is that schools in California had employed computerized attendance accounting services since 1958! Clark J.E.(1974) developed a program budget format to facilitate decision making and encourage cost analyses. This doctoral work proved to be the precursor to research on computerized PPBS through the seventies. Carter W.E.(1974) conducted his doctoral research on implementation of an information needs and evaluation model at South Carolina. His implementation also facilitated the theoretically strong Ott model to be evaluated in a typical decision making setup. Baltes K.G.(1977) investigated the data needs assessments for higher education administration. The thesis developed a methodology for revealing a relational model of the database which administrators were operating then and are likely to operate in future. The method involves data element collection, normalization in Codd's Third Normal Form [Codd E.F.(1971)], definition of structures, survey of administrators and clustering techniques for analysis. McNinch J.P. Jr.(1977) investigated the personnel management function of Missisippi School Districts. The study reveals 21 activities of the personnel management function that may be considered for computerization.

The survey above shows that much of the research effort has been directed on assessment of information needs, systems, standards and procedures. The general weakness has been that most of the work has relied on questionnaires, interviews and Delphi. Few have undertaken a study of the Software Engineering practices despite its increasing popularity. Fewer still have gone in for full blown implementations of computerized information systems, as in the present thesis.

2.1.3 Specific Applications

Development of specific applications of computerized information system for educational administration has never had the charm to capture the imagination of academics. hence it is not to be expected to find several research papers in this category. This is not to say that such research never took place; they were merely not reported! In this section we shall survey the little research work that got published in this area. Most of these are doctoral theses carried out in the USA in the 1970s.

Love J.W.(1971) worked on the development of an automated inventory information retrieval system of educational facilities in Florida. The system was used extensively by the Department of Education, Florida. Ehin C.(1972) demonstrateds the extent of the gap that emerges as a result of implementing computerized information systems, since system designers are not closely related to genaral systems theory and fail to exploit advanced information technologies. The thesis describes three alternatives, genaral computer based independent study systems design. In effect the research provides a unified knowledge base for the design and application of computerized information systems and extends general systems theory and the techniques of advanced information technology in the field of correspondence education. The present thesis has adopted many of the fundamental procedures followed by Ehin.

Embrey C.L.(1973) has developed an information system for university physical facilities decision making. It has used the Software Engineering life cycle approach in a latent manner without explicitly stating it. Cowand K.P.(1973) has worked on computerized system for reporting disciplinary problems. The major reasn why the thesis considered a computerized system was that of providing accountability. The thesis touches upon reluctance of administrators to the use of computers for fear of violating the personnel rights of the students. This aspect has been hotly contested and debated during recent years. Dicianna T.L.(1974) instructs student personnel administrators in the development and practical application of a student information system in community colleges of Pennsylvania. The thesis develops a model in non technical terms for educational administrators and not systems analysts.

By the mid 1970s the use of computers for school scheduling had become popular in the USA. However no comprehensive effort to provide administrators with information, guidelines or training were provided. Fairley A.K.(1975) underlines this need and develops a manual for administrators on educational decision making and the use of computers. Mellor W.L.(1975) in his excellent doctoral dissertation attempts to analyse the relationship between innovation, environment and patterns of computerized information system for educational administration in use. The study was conducted with school districts contracted with the Oregon Total Information System for the computer services offered by a Full Administrative Package. The thesis found that most information obtained from the computer were operational control decisions. The thesis points out that the most urgent priorities attributed to decision making areas, however, were strategic and management control level issues like budget projections, curriculum development, personnel evaluation, instructional methods, program evaluation, etc. File integration, natural language query, simulation and statistical analysis were proposed as additions to the Oregon Total Information System. the thesis strongly argued that computerized information system for educational administration must become "receiver controled" if they were to maintain a dynamic evolutionary growth. A computer assisted budgetary decision making model for a vocational program was made by Braggins H.A.(1975). It was basically exploratory in nature, modifying the then existing McGWIL model into the McGWIL/HABRAG model. Bolon G.(1976) studies the design and development of a computer model that projects faculty demography, staff variations and cost of alternate programs. The computerized model was developed in FORTRAN for the UNIVAC 1106 computer at the Minnesota State University.

Natale J.L(1976) has developed a PERT model for managing routine administrative and operating procedures in universities. the thesis concentrates on the areas of budgeting, purchasing and facilities planning processes. Longnecker W.D.(1976) presents a staff management system for university residence halls. the thesis does a clear expose of the lack of management systems and practices in the universities of the USA, and provides an initial focus for educational administration interested in establishing management frameworks using a computer. Kaiser R.W.(1977) in his thesis outlines an experimental model computerized information system for use in universities of the USA. The thesis stresses the need for data systems that are both flexible and dependable. kaiser uses a fixed length record with an inverted file dictionary in a common data base of the administrative information system. The stress has been on "less complex" systems and cost-effectiveness - the same as in the present thesis.

Jones B.J.K.(1977) surveys the computer applications in art education research in the USA. Johnson W.R.(1977) has developed a CAI package specifically for educational administration. perhaps this is the first instance of educational administrators being trained through CAI on the theory of educational administration. The CAI package was developed on a HP 2000 in the IDF Author Language. Aitken C.E.(1977) developed a computerized advising tool model for use in academic advising. The model has been used and tested in the University of Denver.

2.1.4 Management Information Systems

MIS applications of computerized information systems are undoubtedly the educational administrator's choice. This emerges as a result of down to earth practicality of MIS applications. They are neither esoteric nor impractical. Consequently doctoral research on MIS applications to educational administration have been quite hectic.

Bass D.A.(1971) studied an operational process of institutional self analysis, integrating selected perceptions of campus environment, factual data, and institutional objectives to objectives to obtain a MIS for small, church related colleges. It was more of a methodological study enhancing the College and University Environment Scales (CUES II) system developed by C.R.Pace at the University of Houston rather than a computerized MIS. The applications of MIS assisted by EDP were burgeoning in the late 1960s in the USA. A systematic study to determine the status of computerized MIS, and the extent to which it role of supporting, planning and decision making in universities in the USA has been inroduced is found in Bateman H.H.(1972). the survey covered about 284 four-year colleges and universities. The predominant administrative applications using computers, according to bateman, were student records, financial areas, personnel, management planning, control and physical facilities in that order. This thesis revealed that few MIS incorporated modelling features. Evans W.K.(1972) points out that computerized MIS is a necessity in universities which face relatively low financial supports. the thesis studies the human implementation process and the man-machine interface.

English W.E.(1972) developed a data base for an educational MIS for schools in Ohio. The study included the areas of student information, staff information, instructional programs information, financial information and facilities information. The need for linkages and integration among the subsystems were stressed. While doctoral research centered around developing MIS, Hall R.E.(1973) worked on an evaluation model for a computerized educational MIS. His model was successfully tested on the computer based vocational testing information system implemented by the Bureau of Educational Planning and Development of the University of New Mexico for its Department of Vocational technical and Adult Education. The research of Harrison H.R.(1973) was on the development of a compuerized MIS for the analysis of direct costs of an instructional program. The work embodies the principles of cost accounting and MIS. Lyons L.P.(1972) attempted to design an integrated, computer based, professional personnel information system, for automating the teacher-personnel information system in Texas. The study culminated in the design of a Texas Education Management Information System (TEMIS). An axial information / report matrix was developed and used to analysis the data elements collected from two districts of Texas. An Educational Personnel Review and Evaluation technique was developed to facilitate the recognition of management information and to determine whether it should or should not be included in the computerized MIS.

Martin R.K.(1973) presented case studies of three american universities in relation to MIS. It brought out the significant point of the need for cooperation among universities so that each may benefit from the experiences of the other. Ivanov K.(1972), in his doctoral work at the Royal Institute of Technology, Sweden, has attempted to evaluate the importance of accuracy and quality of information in data banks and in MIS. Though the thesis attempts to attach a measure of quality to discrete items of information, the end result turns out to be quite non formal. Martin T.H.(1974) proposes an ideology and methodology which enable those individuals who have an interest in the study of information phenomena to focus their efforts for the benefit of society. A payroll system incorporating a MIS was developed by Hostetler R.E.(1974) at Indiana University. Hostetler's thesis is enormously relevant to the present one in that it was conceived in an atmosphere of limited financial resources on one hand and new expenditure mandates on the other (a situation quite the same as in BITS).

Piper W.B.(1974) tried to establish the need for a MIS to aid decision making in schools of Michigan. the methodology employed was mainly a literature survey and interviews. The thesis made a startling recommendation that at present the MIS does not require the use of a computer on aaccount of cost considerations. The general contents of Piper's thesis was quite in variance to other theses of tht period. Jepsen K.J.(1974) describes the extent to which computer is being and will be used for actual decision making of individual student financial awards at post secondary institutes in the USA. It also describes the relative merits and demerits of a computer based system as an analysis of the questionnaire. Bell J.C.(1975) studied the present status and future planning of computerized facilities and future planning with an emphasis on computer based MIS in medium sized public schools in the USA. As with other theses of its time, Bell's thesis also relied on the analysis of a questionnaire circulated to about 560 schools.

Beaty J.L.(1975) developed a conceptual model capable of serving as aguide for educators seeking to improve decision making by utilizing a MIS. It was an online, real time, computerized MIS employing state of art hardware and software systems. The thesis covered five subsystems, namely, financial, facility, pupil, staff and curriculum. Reck J.D.(1976) attempted to determine the utility of systems analysis in the development of computerized MIS in California community colleges. It employed literature survey, interviews and the Delphi technique. Janke R.W.(1976) tries to understand the use made of evaluation informaion by administrators in making decision among instructional programs in the USA. The study employed design of experiments and factorial design.

Whatever be the state of development of computerized MIS, the most important thing is human acceptance. Diran K.M.(1977) examines the reasons underlying the failure of a major MIS in a large university in the USA. the thesis finds that the reasons for failure were not basically technical in nature but, rather, evolved from the manner in which the MIS was received on the campus. A total of 57 reasons were ennumerated as the causes behind the failure.

In summary, the research on computerized MIS for educational administration spanned areas like development of the MIS itself, study of the need of MIS, effectiveness of MIS and attitudes towards MIS. The survey also reveals that many of the MIS still deal with operational and not management information.

2.1.5 Modelling, Simulation and Evaluation

Research on computerized information system for educational administration has involved the areas of modelling, simulation and evaluation. This section surveys the various doctoral research that have been carried out in these broad areas.

Oliver E.E.(1977) has developed a cost accounting model for improved decsion making in higher education. The study demonstrates how newer models may be applied without disrupting the institution's normal accounting system. Briney III J.R.(1973) in his thesis has created a model to analyse and evaluate computer class scheduling. The primary aim of the research was to bridge the communications gap between administrators, computer scientists and the computer itself. Hartley A.C.(1973) employs a linear programming model for the determination of university faculty salaries. Savage G.V.(1973) emphasizes the need for the administration to separate the role and tasks of instructional leader from logistical manager. It proposes such an organizational model. Russell C.R.(1972) involves the development of a theoretical model for the systematic selection of educational programs using computer applications.

Simulation models, too, were a popular choice of researchers. A design for a computer based simulation of master schedule preparation for secondary schools was investigated by Philips E.L.(1973). Shirley M.S.(1974) on the other hand investigated the status of the implementation of comprehensive computer simulation models by institutions of higher education in the USA. Literature survey and questionnaires were the mainstay of the thesis. Kramer D.L.(1972) attempted to incorporate systems analysis and computer simulation into an overall planning concept to enhance the development of educational specifications. he model related to generating and evaluating alternate educational programs and consequently facility requirements was the main focus of Kramer's study. Jones B.J.(1976) adapted a computer simulation model for use in assessing administrative decision making in an elementary school. Huxel L.L.(1973) also adapted the national Educational Finance Project's computer based simulation model for public school finance to New Mexico. The NEFP computer based model simulates the fiscal consequences of alternate decisions relative to financing of schools. Dlug P.W.(1975) developed a computer assisted instruction-simulation-resource forecasting model for training administrators. The study was to help alleviate the administration's problem by developing professional curriculum materials to accompany a computer simulation on school planning.

DeMello E.(1975) adapted EFP's computer based simulation model to Sergipe, Brazil. Chew R.L.(1975) designed a computer simulation model for graduate education planning in a university.

The work was largely based on Forrestor's system dynamics. But the programs were written in FORTRAn rather than in DYNAMO which is normally used for system dynamic models. The GEPM (Graduate Educational Planning Model) so developed has been effectively applied to University of Massachussetts, Amherst. A dynamic stochastic computer simulation model was developed for subsystems of a university by Cawley C.T.(1968). It dealt with academic departments, students, research contracts, personnel, etc.

Salner M.B.(1975) studied the impact of the systems analyst on educational planning. Control and optimization issues involving use of PPBS, MIS and computer simulation are all discussed. In 1968, a Total Guidance Information Support System (TGISS) was in use at the Okhlahoma State University. later another computer assisted counselling called Title III/ESEA was used employing a sophisticated IBM 360/50 with medium range networks. Richardson W.E.(1973) performed an evaluation of this computer assisted counselling using the Clark-Guba model. In stark contrast to usual evaluation studies, Harrisson F.E.(1975) studied the legal and security aspects of computerized public educational information systems.

Garlick L.D.(1975) attempted to create a theoretical model to provide guidelines to successful utilization of consultants in developing educational information systems. The present thesis, in contrast to Garlick's thesis, proposes in-house manpower to be used for cost-effective development of computerized information systems rahther than using external consultants. The organizational impacts of computerized information systems have been studied by Demb A.B.(1975). In large part, the continuing disparity between investment and performance in these operations may be traced to inadequate comprehension of the organzational impacts of computer based information systems, according to Demb. The study focuses on organizational development based on organizational developmental theories. Rodriguez J.A.(1975) studied the retrieval time of student attendance information systems under three methods of record keeping followed in Dallas. the method proposed by Rodriguez was found to be superior to computer based record keeping, an unusual result. Poduska P.R.(1976) surveyed existing methods of using management information by student personnel administrators in universities. Computer facilities were found to be poor for MIS applications by the study.

The survey reveals that research work incorporating rigorous formalisms in modelling, simulation and evaluation have been sluggish. There has been a tendency to stick to non formal interviews, questionnaires and Delphi studies. Computer simulation studies too have been restricted to trend analysis except in stray research work. Optimization and modelling have been virtually absent.

2.2 CRITICAL APPRAISAL OF THE STATE OF THE ART

Based on the foregoing survey of the state of the technology, the survey of doctoral dissertations on computerized information systems, a critical analysis is presented below.

* Hardware technology to support computerized information system have shown a tremendous improvement over the years. The advent of PCs and powerful desktop computers have made computerized information systems for even the modestly endowed universities accessible.
* The trend of falling costs of hardware is likely to fuel cost-effective computerized information systems. The danger is however is one of rapid technological obsolescence.
* The emergence of good communication facilites and networks have contributed to better sharing of resources.
* Cost-effective development of computerized information systems have taken an upsurge iwth the availability of a wide range of DBMS and software tools to cut down on design and development time
* The future hold a great promise for 4GLs that have emerged as a powerful force that would spearhead cost-effective development of computerized information systems. Such 4GLs being available on PCs are an added attraction
* The disciple of Software Engineering has come out of its reticent shell of the 1970s and has carved a niche of respectability on its own. CASE tools hold forth the promise of systematic development of software curbing costs at reasonable levels.

* Object oriented programming systems are likely to emerge as undisputed leaders in software development environments where change is rapid .
* Alternate approaches that break away from the traditional "waterfall model" may contribute more to cost-effective development of computerized information systems. One such approach, the evolutionary delivery approach, is the one followed in the present thesis.
* Doctoral dissertations on computerized information systems for educational administration have been quite modest. It has not attracted the attention that it merits. the most overpowering reason behind this is that computer scientists do not find that the study of computerized information system for educational administration deserves much academic merit
* The survey of doctoral dissertations done in the 1970s in the USA suggests that more researchers are tending to work on computerized information systems more actively than before. Universities like the Michigan State University which have a graduate program on educational research have greatly contributed to this upsurge.
* Yet, the survey reveals a dismal picture wherein no research work has been reported on the use of DBMS, 4GLs, CASE tools, etc. on computerized information system for educational administration. Nor have any reports been made on the use of sophisticated technologies like LANs, WANs, etc. in universities for administrative work. The world at large is moving towards implementation of sophisticated DSS, yet none in connection with educational administration has been reported.

It would be a hasty conclusion if we say that such things are not reported since they don't exist anyway. At least in the universities of the USA, such systems do exist, but do not merit the attention of researchers. It is a dismal situation indeed!

2.3 THE PROGRESS OF COMPUTERIZED INFORMATION SYSTEM FOR EDUCATIONAL ADMINISTRATION IN INDIA

The previous section surveys the research work on computerized information systems in the USA. This section presents a survey of the progress of computerized information system for educational administration in India. At the outset, it must be stated that in India, the state of thetechnology is many years behind that in the USA. WHile studies in this area began in the 1960s in the USA, work in India is sluggish even today. Universities in India have yet to move in for computerization of educational administration in a big way.

Gupta R.(1974) discusses the ways in which the costs of a psychology department are reported by a computer. This modest study is a virtual breakthrough since it reveals two major aspects, namely, (i) that computers are being used in financial management of universities in India, and (ii) that such a sophisticated tool is used by an unlikely psychology department. The study reveals how a cost accounting model has been computerized for monitoring the functioning of the department. Padmanabhan C.B.(1983) analyzes financial managment issues of universities in India. Among one of the issues studied is the need for computerized information systems to provide an MIS for better decision making. A few models of financial management ripe for computerization are also indicated. Padmanabhan C.B.(1982) had earlier suggested a novel approach to financial management specific to Indian universities. An effort to computerize this approach may be of merit.

Chandy P.T.(1971) has espoused the concept of educational administration and institutional planning in India forcefully. The role of computerized information systems are also discussed. In a similar vein, Dhanrasi .(1981) prepares a strong case in favour of adoption of modern management techniques in educational administration of Indian universities. The recommendations are extremely relevant and logical. The asd part is that such recommendations in India hardly find their way out of the paper on which they are made.

Ghosh D.K.(1977) has studied the problem of educational administration in a residential university in India. While not directly referring to the use of computers, Ghosh does mention the role of orderly record keeping, planning functions and decision support. Goyal S.M.(1980) makes a forceful case for systems approach to education in Indian universities. The study is refreshingly free of the usual cliches and analyzes the problem pragmatically. These studies are important despite the fact that they do not refer to computerized information systems directly.

One of the earliest papers that addressed itself directly to computer technology in India is the study of Shankar Narayan D.(1982). It dealt with the role of computer science and technology. The emphasis was on facility requirements and certification of academic programmes. the fact that computer technology has attracted the attention of educational administration is evident from this study. Earlier, Shankar

Narayan D.(1979) had presented a comprehensive report on the structure, function and management of a university centre. Providing educational administration with DP and MIS aids were some of the stated functions. the study also stated that from a survey of 63 universities of India, only 4 were using computers for educational administration purposes. Sharma D.K. et al (1979) also recommend the use of computerized information systems for effective management of universities in India. Financial

Sharma

D.K.(1982) provides a comprehensive summary of decision making models for eduational systems. Many of the models discussed there have applicability in all universities and are not specific just to the Indian system.

Kaul J.N.(1981) has analyzed educational planning and administration as a discipline in Indian universities. The study starts by mentioning that Indian universities don not approach educational administration in a systematic way. Educational planning is mainly ad hoc and often whimsical subject to political pressures. The study provides guidelines as to how to integrate educational planning and administation as a discipline in Indian universities. Khader M.A. & Singhal S.(1983) provide an in depth analysis of institutional quality of student input and output in six Indian universities. Nonetheless, the study makes no mention of the use of computerized information systems to arrive at such measures of quality. The one area in which some computer based information system work has been done in Indian universities is in library information systems. Rao M.K.D.(1979) analyzes the status of computerized bibliographical information systems in Indian universities and compares it with modern trends emerging elsewhere. What emerges from the study, however, is that Indian universities are lagging far behind in the use of computer technology as well as the contemporary state of art. Swaminathan M.S.(1981) attempts to portray a hopeful picture of higher education in the 21 st century. The scenario visualized in the study is quite in contrast with what exists now.

Malhotra S.P. & Panda S.K.(1982) discusses the primary need for adopting a systemsapproach to educational planning in India. Malla Reddy M. & Ravishankar S.(1981), too, endorse a similar view. Various systems, methods and techniques have been mentioned as candidates in the study for adoption in Indian universities in their educational administration and planning. many of these are never likely to take off without a concerted effort at having a computerized information system.

An area like performance budgeting ought to attract the attention of researchers and educational administrators alike in the Indian mileau, since shrinking funds pose an enormous challenge. Padmanabhan C.B.(1976 & 1977) and Shirur R.R.(1981) consider performance budgeting as an innovation in educational administration. the study also discusses several budgetary reforms in Indian universities to improve performance. The demands on operational information and management information for strategic decision making for making performance budgeting a reality are obvious. This further reinforces the need for a computerized information system in Indian universities. Pillai J.K.(1979) and Pillai S.S.(1973) also discuss the need to employ a systems approach to educational administration and the imperative to use modern management techniques. Puri R.P.(1978) in his objective view of university administration roundly criticizes the adhocism, non data based administration, archaic record keeping procedures and resistance to change in face of environmental needs. many of these criticisms can be tackled effectively by using a computerized information system for educational administration. Dube S.C.(1981) bemoans the lack of flexibility in educational management in Indian universities so that educational administration can react better to environmental changes. He poses this as one of the main challenges to educational management. Sharma R.C.(1977) expresses similar views and calls for modernization of educational administration and adoption of computers to aid decision making. Sharma D.K. & Darji D.R.(1981) makes a trend analysis of management of educational systems and research. The results discussed in the study are far from flattering and is an indictment of the failure of educational administration in not choosing the path of modern management of educational systems. It expresses the hope that the increased use of computers, MIS and modelling would reverse this dismal trend.

Seth S.C.(1978) presents a futuristic view of education. Much of what has been expressed in the study are far fetched. For example, the study visualizes the uniformity of educational administration, instruction and performance. Going by what exists today, it seems quite far fetched. However, many ideas like orderly record keeping, increased use of computers, adoption of modern management techniques, fostering accountability are all realizable goals.

The literature survey reveals that Indian universities lag far behind their American counterparts in the area of computerized information system for educational administration. The few paers that touch upon this aspect resort to rhetorics and cliches without much actual development. It must be reiterated once again that it is quite simple to "recommend" development and use of computerized information system for educational administration but not so trivial to get one such system up and running.

Computer magazines like Dataquest and Computers Today occassionally present survey reports on the use of computers by specific segments of the Indian community. The September 1987 issue of Dataquest carried a survey on the use of computers in Indian universities. The report presents a pathetic picture of use of computerized information system for educational administration. many universities have installed computers, especially those funded by the government, have installed expensive powerful ones. A majority of the claim to use them for academic purposes, instruction and research. One of the major areas of the use of computers in universities is for the preparations of examination results. That itself does not sound very impressive when it is known that over 80% of the universities have examinations only once a year! yet another aspect of the use of computers in educational administration is that most of the software have been designed and developed by external consultants. It is true that many universities do not have qualified manpower to develop these systems in-house. But what is truly amazing is that institutions like IIT(K) has to depend on consultants like Softek Pvt. Ltd. for the development of software for administrative purposes. It just shows a lack of participation of computer professionals in modernizing educational administration.

BITS, however, is a refreshing change in that it has chosen the path of computer based information systems to spearhead modernization of administration and foster educational innovation. Section 1.3 has already discussed some of these aspects. The most commendable feature in BITS is that it has judiciously melded the development of computer based information systems for its educational administration into time bound activities with a academic flavour. The list of references at the end of the thesis gives a few of the research and development work in the area of computerized information system for educational administration at BITS.

2.4 INFORMATION SYSTEM FOR EDUCATIONAL ADMINISTRATION - BY DESIGN OR BY EVOLUTION?

Software Engineering provides a systematic body of knowledge to guide the development of computerized information systems for educational administration. A vast majority of the text books on Software Engineering and an equally large number of practitioners endorse the "waterfall model" for delivery. [Gilb T.(1988)]. Although they take various forms, the principal characteristics are

* all planning is oriented towards a single delivery date
* all analysis and esign are done in detail before coding and testing

Figure 2.7 depicts a version of the software life cycle along with the relative costs of each phase. Little or no formal feedback and learning exists. It also requires freezing the requirements and design specifications at an unrealistically early stage. Further, only a fourth or a thrid of the costs are attributed to development while alion's share of effort and costs are spent on operations and maintenance.

The delivery date is usually a year or so after the project begins. One way of improving design is by prototypes. But as already mentioned in section 2.0.3 of this thesis, prototyping entails "throwaway" of prototypes and escalate developmental costs.

This raises the basic question - should one follow the life cycle by design or go in for an alternative?

Figure 2.7

Relative Costs in Software Development

misplaced

McCracken D.D. & Jackson M.A.(1982) consider the life cycle as harmful. Gladden G.R.(1982) provides excellent reasons to get off the eternal life cycle. Gilb T.(1985) and Arthur L.J.(1988) provide an alternative to the conventional life cycle, called as the "Evolutionary Delivery" method.

The Evolutionary Delivery Method (hereinafter to be referred as EDM) is based on the following simple principles:

* **deliver** something to the real end user
* **Measure** the added value to the users in all critical dimensions
* **Adjust** both design and objectives based on observed results

The above concepts are firmly rooted in engineering literature and practice in other disciplines. This thesis attempts to exploit the potential of this method and vindicate its ability. EDM is based on iteration towards clear and measurable multidimensional objectives so characteristic of dynamic and innovative universities like BITS. The following points epitomizes some of the characteristics of the EDM.

* Software projects usually allow for the first practical delivery one or more years ahead. the administration would dearly love to get some results as early as possible. In EDM the concept of selecting the potential steps with the highest user value to development cost ratio for earliest implementation used. It is this high value per cost procedure that distinguishes EDM from other Software Engineering procedures.

* Gilb T.(1985 & 1988) states that one of the greates time wasters in a software project is detailed requirements analysis, followed by detailed design, folloed by full coding and testing phases. This becomes vital if in a lengthy detailed requirements analysis phase, the environment and the requirements constantly change. The EDM avoids this pitfall by spreading out developmental activities and intermixing with phased deliveries.
* The EDM provides a user orientation such that neither budget overruns nor delivery time overruns become a serious problem.
* The EDM imposes a certain result orientation. In the traditional waterfall model, the process of development itself seems to be more than the result. The method is useless under conditions when objectives/requirements are not clearly stated and the project gets blocked.
* In EDM, the emphasis is on creating "open ended systems architecture". This simply means that we try to position ourselves so that any change, no matter how unexpected, is relatively easy to cope up with, without major changes in the system we are evolving.

One of the major attractiveness of the EDM is that it is applicable to both large and small projects in equal measure. Wong C.(1984) and Mills H.(1980) are cases of its applicability in large scale systems. Despite its obvious advantages, the EDM is objected to on the following grounds.

* The system cannot be divided into smaller steps. {Actually, every system can be divided into smaller ones}.

* Speedy development is needed. {EDM actually speeds delivery}.
* The management would not like piecemeal delivery. {Studies like Wong C.(1984) and Mills H.(1980) show that the management would actually love it since they better control}.
* Designers cannot make evolutionary plans. {Designers too may be restrained to make evolutionary plans - Mills H.(1980)}.
* It is not the time tested way of design and planning. {It certainly is not traditional, but worthy of attention}.

Evolutionary delivery, and the feedback that it produces, often lead to management acceptance of revised estimates for time and money at early stages of the project.

We shall now present a survey of literature to show the extent of understanding of the ideas of evolutionary delivery inside and outside of Software Engineering. This is meant to show hat it is not a new or unappreciated idea - it is merely a hitherto widely ignored one.

Altman E. & Stonebaker M.(1982) report on their experiences with evolutionary delivery while leading the development of a 75,000 line C database system, for over 6 years, at the University of California, Berkeley. The product ultimately had over 150 user sites. One of the major advantages attributed by the authors were increased workforce morale (who see results shortly). Balzer R.(1986) points out that "program enhancements" are necessary because, (a) no one has enough insight to built a system correctly the first time (even assuming no implementation bugs!), and (b) the insight gained from the usage of an existing system creates demand for new or altered facilities. Evolutionary delivery provides the process for exporing the unknown. The inevitable interwining of the specification and implementation phases is forcefully brought out by Swartout W. & Balzer R.(1982). The authors consider the waterfall model that separate specifications from implementation naive and contrary to reality. The evolutionary delivery that encourages maintenance by respecification and reoptimization of the altered definition is more realistic. Basili V.R. & Turner A.J.(1975) echo similar feelings. Evolutionary delivery is viewed by them as a combination of function extensions and solutions enhancements. The "Spiral Model" of development and enhancements, proposed by Boehm B.W.(1986) is a variation of the evolutionary delivery ebodying many of the latter's features. the spiral model could be used as a framework for choosing evolutionary delivery as a strategy or one among the many alternatives. Boehm B.W.(1986) says that the spiral model is a risk driven approach for guiding the software process, rather than a strictly specification driven or prototype driven process.

Currit P.A. et al (1986) shows the slow but predictive exploitation of the evolutionary delivery to control factors other than cost and time, which was dominant in IBM those days. Gilb T.(1976), one of the most vociferous supporters of the evolutionary delivery, mentions that evolution is a designed characteristic of a system development which involves gradual stepwise change. The major advantage of evolutionary delivery cited in the study are as follows:

* It provides step results measurement and retreat possibility
* Minimizes failure risk, using feedback, correcting design errors
* Even though the time of the total system operation will be longer, the date of total "successful" system operation will be earlier than otherwise
* The evolutionary method avoids the need to predict requirements and environments in the future

A series of articles on evolutionary delivery appeared in the magazine "Computer Weekly". They are

* Evolutionary Planning and Development: An Alternative, Computer Weekly, 2 Aug 1979
* Realistic Time/Cost Data, Computer Weekly, 16 Aug 1979
* Eleven Guidelines for Evolutionary Design and Implementation, Computer Weekly, 12 March 1981
* The Seventh Principle of Technology Projects: Small Steps will Result in Earlier Success, Computer Weekly, 30 July 1981

One of the earliest, clear, published recognitions of the evolutionary delivery method in the computer business is by Oliver R.L.(1969). McCracken D.D. & Jackson M.A.(1982) denounced the life cycle concept as unrealistic, vacuous, being responsible for perpetuating our failures so far, and obsolete. They do not however suggest any particular remedy. Jahnichen S. & Goos S.(1986) have proposed a network type of an alternative model for software development. In this, nodes represents a product in a state and each edge is a transition from one state to another.

Whenever a state is inconsistent with objectives, a backtracking takes place.

Parnas D.L.(1979) streses the need for designing software for ease of extension and contraction. He contends that design for change is a necessity that can be easily facilitated by the evolutionary delivery method. Quinnan R.E.(1980) describes the process control loop used by the IBM FSD ensuring that the design is cost-effective. The article contains some excellent concepts of cost estimation and control. Radice R.A. et al (1985) proposes a selection of software development languages and tools for use in IBM labs that is evolutionary. Robertson L.B. & Secor G.A.(1986) present a tight case for evolutionary design by spreading releases of a large project over time. Rzevski G.(1984) is s definitive treatise on the superiority of evolutionary information system development. Jonathan Sachs who wrote the best selling Lotus 1-2-3 software cites several evolutionary delivery system viewpoints in an interview in the book by Belay J.I.(1986).

The evolutionary delivery viewpoint has been widely endorsed by management experts and engineers from other disciplines. Since BITS presents a typical case where change is commonplace, the evolutionary delivery was considered to be the atural choice. Its use in the actual design and development of a computerized information system for educational administration will be presented in the following chapters.

CHAPTER III

INFORMATION SYSTEM FOR GRASSROOT APPLICATIONS

3.0 PRELUDE

Computerized Information System for educational administration, like in all systems (be it production or manufacturing or marketing or government) can be seen to contain a wide range of subsystems. These subsystems, while they interact with each other, vary in terms of the quantum and nature of data they act upon, the nature and complexity of processing involved, and the manner in which it aids the administrators in planning and decision-making. Broadly these subsystems that form a conceivably complete information system, can be seen to fall into three categories of applications. They are:

(i) Grassroot applications,

(ii) Decision Support Systems, and

(iii)Expert Systems.

This classification is depicted as a pyramidal structure in Fig. 3.1.

3.0.1 Grassroot Applications

The base of the pyramid consists of all those computerized information subsystems that are called "Grassroot Applications" (hereinafter referred to as GRA). They are so called because these subsystems deal predominantly with data which are rudimen-

FIGURE 3.1

STRUCTURE OF INFORMATION SYSTEMS

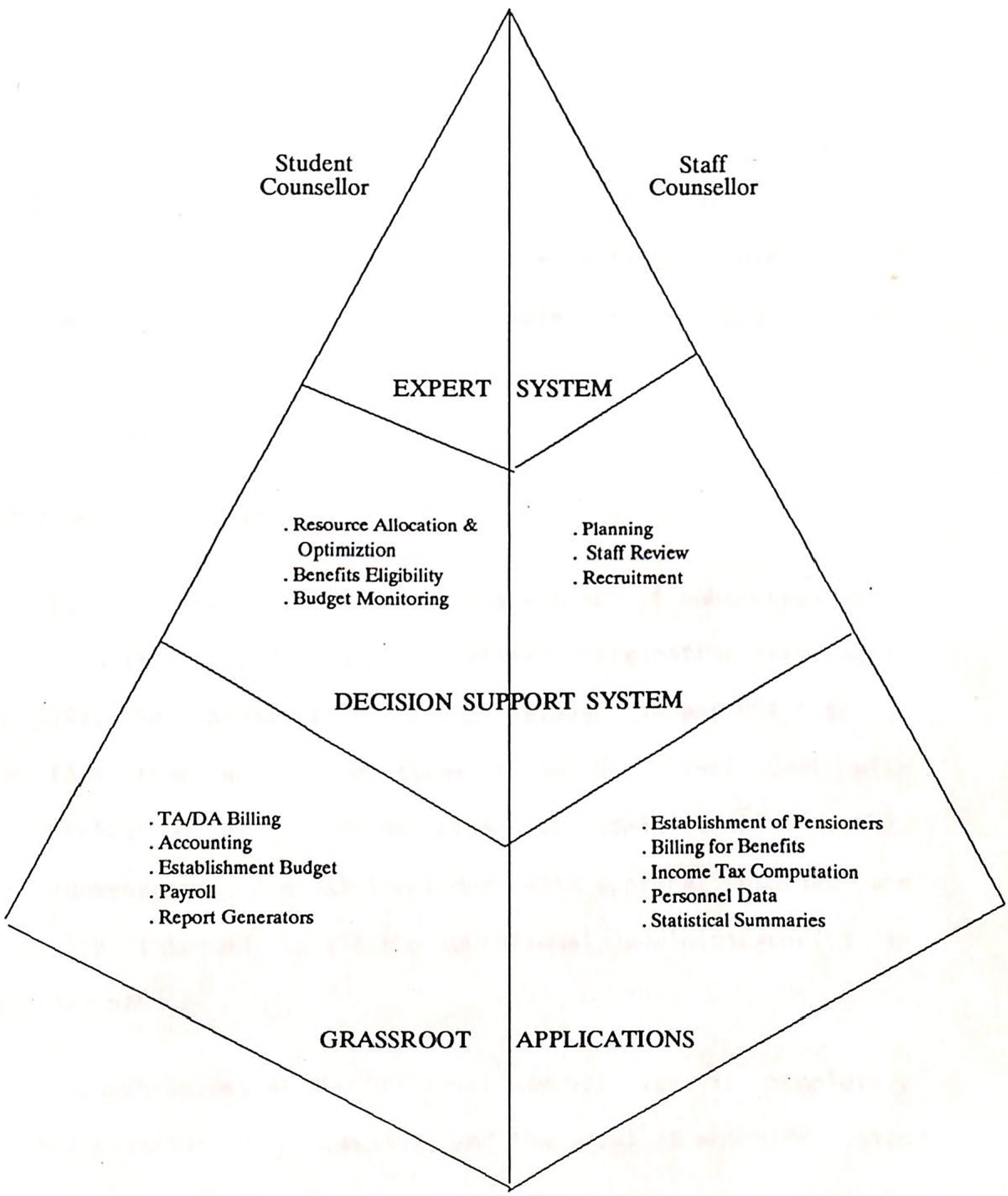
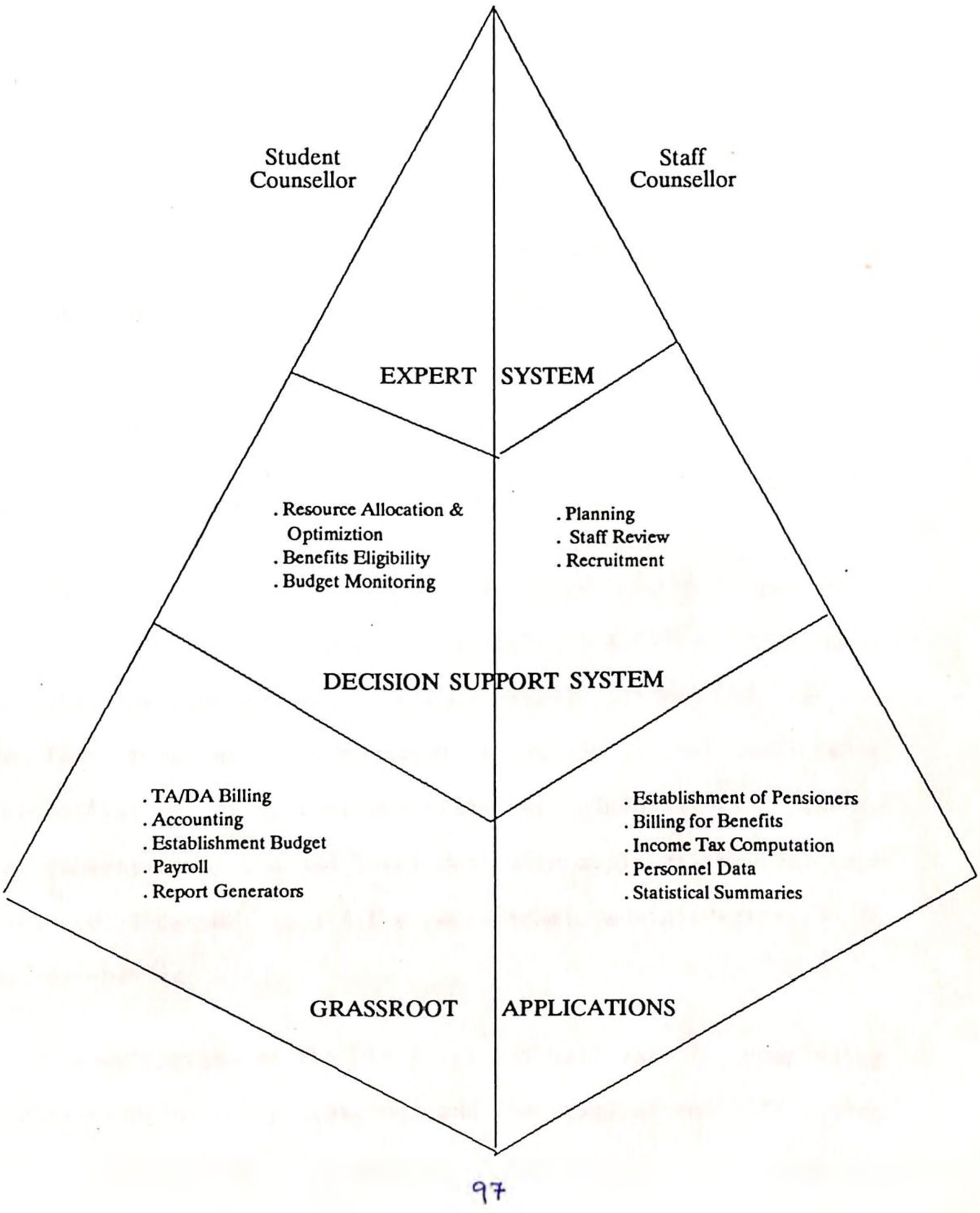


FIGURE 3.1

STRUCTURE OF INFORMATION SYSTEMS



tary, vital and basic in nature, are concerned with operations that are often routine and essential, and provide processing which forms the basis for decision-making. Examples of subsystems at the GRA level are the payrol, establishment budget of staff, faculty records storage and retrieval, routine billing, and other such applications that do rudimentary data processing. It is, however, evident that these GRA are routine but essential operations in the running of an educational institution (or for that matter, any organization). Indeed, they are the foundation on which educational administration rests. Thus Fig. 3.1 depicts GRA with a broad base in the structure, reflecting a plethora of routine administrative tasks they handle. It also suggests the need for primary importance to these subsystems in designing of a computerized information system.

3.0.2 Decision Support Systems

Built on the broad base of GRA are a set of subsystems which may be called **"Decision Support Systems"** (hereinafter referred to as DSS). The fundamental difference between GRA and DSS lies in the fact that while subsystems at the GRA level deal with computerization of routine but essential administrative tasks, the subsystems at the DSS level deal with applications that are primarily intended to aid the educational administrator(s) in decision-making.

The subsystems at the DSS level may well vary in complexity of data handling and processing, and the level at which "decision support" is provided. For example, suppose an employee seeks the administration one year leave of absence. The nature of "decision" required is whether this particular employee is "eligible" for such a leave under the operating rules of administration in the institution. It could be as simple as merely having to check whether the employye has served for the requisite duration as dictated by the rules and regulations. Such a subsystem at the DSS level would be quite elementary. However, note that the application itself is to provide information that aids decision-making, and not routine data processing and "number crunching".

On the other hand, the DSS applications may be quite complex. They be designed not just to support elementary decision-making, but also aid in educational planning, strategic planning, etc. They could involve employment of modelling, simulation and optimization. Budget monitoring, resource allocation (and related optimization effort), space and equipment utilization, etc. are some examples of subsystems at the DSS level.

Evidently, "sophisticated rule checking", modelling, simulation and optimization all require reliable and up-to-date data. These can be easily provided for if one has a strongly engineered GRA. Thus the success and reliability of DSS rests heavily on GRA. Normally, an educational institution in its quest for computerization, would have fewer DSS than GRA. (In a highly automated university administration, DSS may quite approach the wide range of applications in GRA). Thus in Fig. 3.1 DSS occupies a position over the GRA reflecting the fewer number of subsystems but a higher degree of complexity in handling data, processing and algorithms involved.

3.0.3 Expert Systems

At the apex of the pyramid in Fig. 3.1 stands a set of applications which may be called as "Expert Systems". The applications at the GRA and DSS involves predominantly data handling and manipulation, processing in terms of arithmetic calculation and report generation, and a few "conditions checking". But "logical deductions" are the heart of expert systems. To appreciate the fundamental difference between expert systems and GRA or DSS, consider the following example.

Every educational institution will have (or is atleast expected to have) a set of "rules and regulations" governing the manner in which the administration ought to function. Alternatively called "statutes", they provide the framework within which administrators and faculty function. Similarly, every educational institution will have certain "academic regulations". This normally defines the framework in which students, faculty, as well as administrators ought to function. Although these documents are normally made available to everyone, few, if any, peruse it to any depth. (The framework in which citizens and the government ought to function is given in the Constitution. The sad fact is that few peruse it to any depth).

However, what happens often is that a select few from within the organization emerge as "experts" in the statutes or in the academic regulations. Whenever a point of doubt or controversy arises in regard to a situation that requires knowledge of rules and their application, the so-called "experts" are consulted. (It is another matter that the verdict offered by the "experts" may well be incorrect!).

Imagine that a student wants to know what the consequenses would be if in a certain course that he had registered as "optional elective" he failed to clear. Would he have to register in that course again and clear it? Can he graduate having not cleared that course? "Experts" may give different verdicts depending on their grasp of the regulations and the clarity with which deductions are made. A computerized system which enables such a student find answers to such questions as above are called "Expert Systems".

These expert systems are very sophisticated subsystems. To function well, the "facts base" (as opposed to a data base) must be exhaustive and reliable. Fig. 3.1 shows the expert systems at the top of the pyramid reflecting the great sophistication that would be required.

3.0.4 Cost-Effectiveness and Evolutionary Delivery

It is quite evident from the preceding paragraphs that GRA forms the basis on which sophistication may be built into computerized information systems. The "total" computerized information system for educational administration however consists of GRA, DSS and ES. Complete delivery systems based on the life cycle models would tend to be unwieldy to handle. Educational administrators themselves may not be sure as to all their requirements at very early stages in the project. Secondly, the workforce required to carry out a complete delivery would involve immense costs. Thirdly, prototyping of complete systems are expensive options and are not even realistic in the case of universities like BITS where changes take place rapidly. Thus, evolutionary delivery system ought to be employed proceeding from GRA to DSS, and then if need be, to ES.

Since with evolutionary delivery method, GRA would be the first to be tackled, the administration would see working results in marginal increments in time. This enables administration to have a strict control over time and cost overruns. Also, based on the experience gained from working with the GRA, the administration would turn in more coherently thought out requirements of other applications.

This prelude stresses that GRA is the foundation on which any attempt at imbibing sophistication in the information system must rest. GRA will be the central subject of discussion in the rest of the chapter.

3.1 NATURE OF GRA IN EDUCATIONAL ADMINISTRATION

Any educational institution requires a strong administrative setup based on which educational innovations can be attempted. The administrative tasks themselves have a sizeable chunk concerned with data capture, record keeping, routine operations (like accounting, payroll, billing, etc.), and report generation for the higher echelon in administration. An administrative setup based on slovenly record keeping, adhocism in managing routine operations and ineffective reporting system to top administrators is hardly conducive for ventures in educational innovation. Thus strengthening the administrative mechanism at the routine level should be of prime importance.

Computerization of these routine administrative tasks imbibes in the system an orderliness that is seldom found in conventional universities where data management may be expected to be chaotic. Computerization must, therefore, start with certain GRA (See section 3.0 above).

The GRA in educational administration can be seen to have the following characteristics:

(1) They consist mainly of data capture and record keeping. These activities form the kernel of the administrative machinery.

(2) They deal with the practice of information flow within the various subunits of the organization. This forms the backbone of administrative activity.

(3) They are concerned with routine administrative operations that act upon data {(1) above} and use the information flow {(2) above} but involve very little decision-making.

(4) They are concerned with safeguarding the operational logic of educational administration as set down in the "book of statutes" or "rules and regulations". This involves routine operation of rules rather than any decision-making.

(5) They are responsible for communicating routine reports to the operational management.

(6) They are to provide support services to top management in carrying out strategic planning, resource allocation & optimization, etc.

It is very clear from the nature of GRA that computerization of educational administration must start at the GRA, thus strengthening the foundation on which the idea of moving from routine administration of human resources to pioneering educational innovation in various frontiers. The computerization of GRA has largely smoothened the tasks of innovation.

The systems investigation, specification of GRA, system design for computerization of GRA, implementation, results of the pilot runs of the computerized GRA, follow-up actions and a critical study of the benefits and shortcomings of the computerized GRA are discussed in the next few sections.

3.2 IDENTIFICATION OF THE GRA FOR COMPUTERIZATION

Right from the early seventies, BITS has been employing computers in many of its tasks of educational administration. Notable among these is the "Students Records Processing & Monitoring" [See Ananthasubramanian R.(1988), Gupta A.K.(1980), Misra D.K.(1984), Prabhu T.N.(1989), Sethi A.K.(1976), Shridhar (1982), Shukla T.N.(1984), Tavathia S.(1987) and Venkatesh N.(1987) for a cros section of work in this area]. Bits embarked on a pioneering venture into university-industry linkage and off-campus education through the Practice School Programme. Here, the need for uniform instruction, evaluation and co-ordination among various PS stations spread all over the country was acutely felt. This led to a concentrated effort at systematising administrative tasks which had taken an entirely new dimension. An outcome of this was the "Practice School Division Operations Manual" [Mandke V.V.(1982)]. This systematically described the entire information flow and operational logic involved in the administration of the innovative PS program. A Computerized Practice School Instruction Monitoring System (COPSIMS) was developed soon after [S Dey (1984) and (1989)]. Batra M.(1988), Devikumari G.R.(1982), Jain V.(1984), Jha R.M.(1982), Mathews S.(1984), Mitra A.(1984), Nagalingam S.(1983), Nagar A.(1987), Narasimhan S.(1984), Nathan S.S.(1989), Pashupathy K.(1984), Rajan K.(1984), Rajpal S.(1989), Reddy G.S.(1989), Sharma S.(1984) and Trivedi R.K.(1984) are other efforts at computerizing the administrative activities of the PS Division at BITS.

Apart from these, mission oriented research in areas of computerized information system (suggested by the needs of educational administration in BITS) emerged. Agarwal P.(1987), Agarwal A.(1988), Ahuja S.(1984), Babu R.G.(1987), Chatterjee A.H.(1988), Garg A.K.(1977), Gangrade N.K.(1987), Gupta K.C.(1985), Gupta R.(1984), Jamadagneya S.K.(1971), Jayaraman V.(1984), Mohan J.(1988), Kamesh K.(1989), Lakshmanan R.(1989), Mahesh K.(1988), Maniyar D.(1984), Mathur J.(1976) Nene S.A.(1984), Palit A.(1989), Philips Raj Y.(1985), Radhakrishnan A.(1987), Kumar R.(1987), Ramakrishnan C.R.(1986), Ramesh S.(1989), Rangarajan S.K.(1987), Rastogi A.(1985), Sagar R.(1984), Sagar Rao P.P.(1984), Saisreedhar P.V.(1988), Sharma V.R.(1985), Singh A.K.(1981), Sinha A.(1984), Sood S.(1989), Sridhar A.(1989), Sriram D.(1989), Srivastava M.(1984), Subramanian C.(1989) and Usha K.(1978) are some of the diverse types of work carried out in the last two decades at BITS.

The administrative and educational philosophy at BITS has always recognised the importance of computerized information systems. Identifying the GRA for computerization for this study presented very few problems. Such a case would be highly unlikely in a university starting its computerization effort **de Novo**, amidst uncooperative lower level administrative staff with imagined fears of computerization and faculty unwilling to have anything to do with administrative work! [See also Chapter II of this thesis].

Fig. 3.2 shows a schematic diagram representing the various areas of educational administration that can be computerized. Our primary task, as mentioned in Chapter I of this thesis, is to restrict ourselves to those areas of educational administration closely related to the management of human resources. Those modules of administrative activity connected with management of human resources are shown distinctly in the schematic of Fig. 3.2. The figure also shows those modules that are GRA (as opposed to DSS).

For this study, the following areas of GRA expressly concerned with the management of human resources were chosen:

(1) Data capture and design of standardized proformas.

(2) Operation of payroll.

(3) Establishment of teaching, supporting and helping staff.

(4) Routine billing operations.

(5) Rudimentary reporting to various administrative subunits.

Consistent with kepping design and development costs low, the evolutionary delivery scheme was followed.

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(4) Routine billing operations.

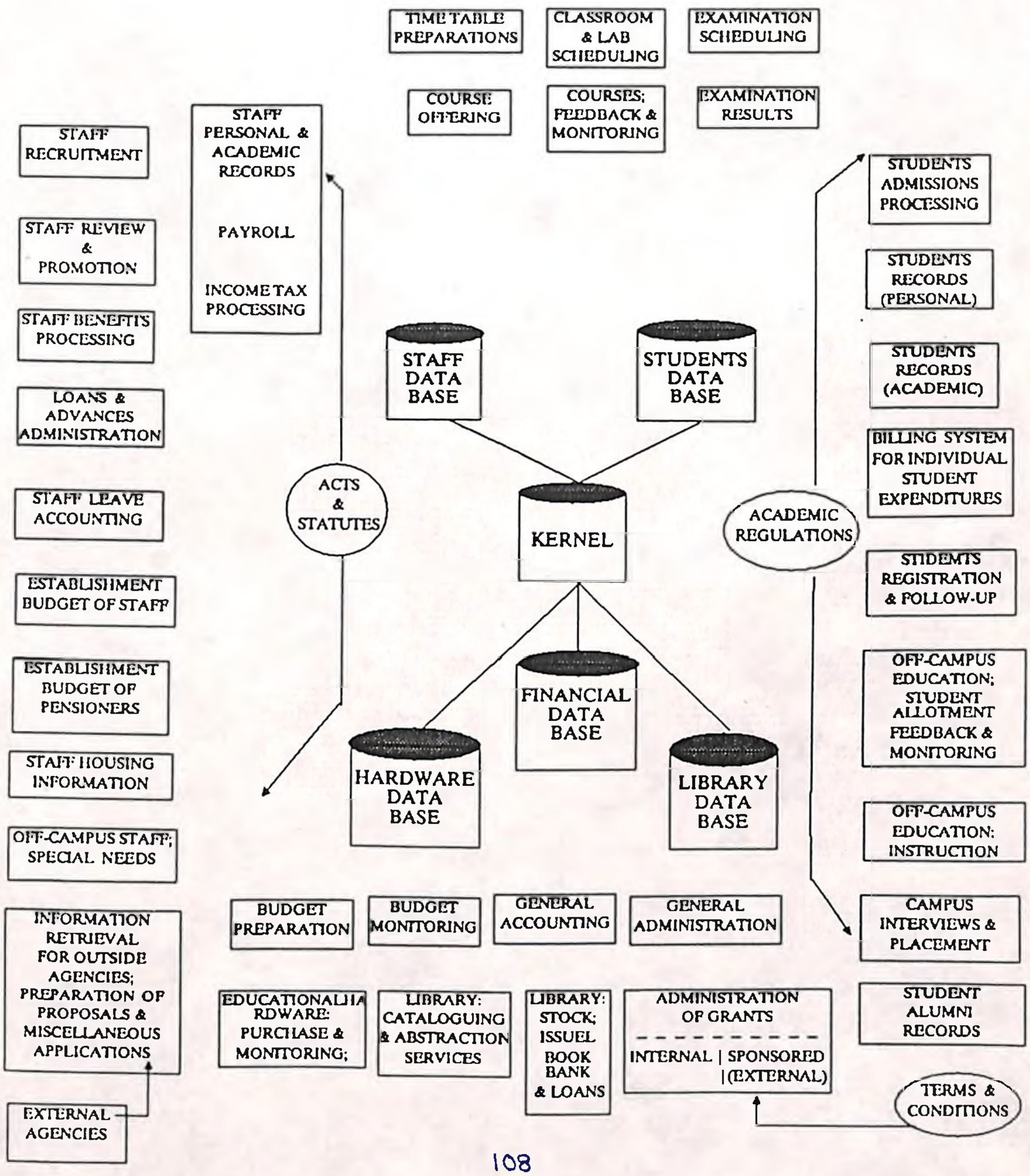
(5) Rudimentary reporting to various administrative subunits.

Consistent with kepping design and development costs low, the evolutionary delivery scheme was followed.

FIGURE 3.2

SCHEMATIC SHOWING AREAD OF EDUCATIONAL ADMINISTRATION

AS CANDIDATES FOR COMPUTERIZATION



3.3 PROBLEM SPECIFICATION

The task on hand is to provide unambiguous specification of the problem. In trying to specify the problem - that of ultimately designing and implementing computerized information system modules for GRA - we must stress once again the following points:

(1) The scope of the current task is restricted to GRA modules only. {It is granted that certain modules cannot be easily and categorically stated to be either GRA or DSS. As with most categorizations, the borderline is very thin}.

(2) The modules of GRA themselves considered are those that mainly deal with human resources management, either directly or indirectly.

Consider Fig. 3.2 once again. Among the various GRA modules highlighted there, our task now reduces to a selection of a particular set of modules for study. The following GRA modules will be considered for study, design and implementation:

(1) Payroll.

(2) Income Tax.

(3) Establishment (budget) of teaching, supporting and helping staff.

(4) Leave Travel COncession - billing.

(5) Elementary Housing Information.

(6) Miscellaneous Report Generation.

Thus the problem consists of the following:

(a) Analysis of the system behaviour mainly from the viewpoint of information flow and operational logic connected with the

3.3 PROBLEM SPECIFICATION

The task on hand is to provide unambiguous specification of the problem. In trying to specify the problem - that of ultimately designing and implementing computerized information system modules for GRA - we must stress once again the following points:

(1) The scope of the current task is restricted to GRA modules only. {It is granted that certain modules cannot be easily and categorically stated to be either GRA or DSS. As with most categorizations, the borderline is very thin}.

(2) The modules of GRA themselves considered are those that mainly deal with human resources management, either directly or indirectly.

Consider Fig. 3.2 once again. Among the various GRA modules highlighted there, our task now reduces to a selection of a particular set of modules for study. The following GRA modules will be considered for study, design and implementation:

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(2) Income Tax.

(3) Establishment (budget) of teaching, supporting and helping staff.

(4) Leave Travel COncession - billing.

(5) Elementary Housing Information.

(6) Miscellaneous Report Generation.

Thus the problem consists of the following:

(a) Analysis of the system behaviour mainly from the viewpoint of information flow and operational logic connected with the

GRA modules above.

(b) Design for a computerized information system of each of the modules of GRA. This includes design of standardized proformas for data capture and data/information communication; design of computer file organizations where the data will be stored and retrieved; design of computer algorithms for data management, processing and report generation; choice of computer system to implement the GRA modules; choice of software system (operating systems, computer language) to code the algorithms designed above.

(c) Implementation of the GRA modules on the computer.

(d) Testing the software that has been implemented.

(e) Performing a "pilot-run" of the software system developed. This is similar to a dress rehearsal where the computerized GRA modules are put to work with real life data and situations.

(f) Operational tuning of the computerized modules. After the pilot run, several hitherto unenvisaged snags that develop are corrected; certain idealized assumptions made during the design and implementation stage turn out infeasible to carryout at the operational stage and so they are ironed out. This stage of operational tuning makes adjustments and/or modifications in the computerized system in order to suit operational administrative requirements.

(g) Manpower training to orient the administrative personnel involved in operations/usage of the computerized GRA.

(h) Finally, documentation of the system developed.

Before proceeding with the discussion of systems analysis, design, etc., a brief overview of the administrative mechanism at the GRA level at BITS would be in order. This systems overview is given in the next section.

3.4 SYSTEMS OVERVIEW

While most universities in India followed a traditional departmentation based on academic subjects (like Mechanical Engineering, Chemistry, Economics, etc.), BITS follows a "functional administration". That is, administrative entities are based on the function that they carry out rather than on traditional departmentation. Among other things, this functional administration attempts to avoid duplication of work, increase efficiency, optimize use of resources and foster accountability. The organizational structure of BITS is given in Fig. 3.4.

At the GRA level, many of the entities interact with each other, are suppliers and consumers of data/information, make routine use of information provided by the GRA and perform routine hosekeeping tasks. The administrative mechanism at the GRA level is depicted in Fig. 3.5

FIGURE 3.3

ORGANISATIONAL STRUCTURE OF BITS

DIRECTOR

ADMINISTRATIVE DEANS (I & II) | DEPUTY DIRECTORS (TWO) | EDUCATIONAL CONSULTANCY DEANS (TWO)

DEAN FACULTY DIVISION I	DEAN FACULTY DIVISION II	DEAN FACULTY DIVISION III	DEAN INSTRUCTION DIVISION	DEAN PRACTICE SCHOOL DIVISION	DEAN RESEARCH & CONSULTANCY DIVISION	DEAN ACAD REGIS-TRATION & COUNSELLING DIVISION	DEAN STUDENT WELFARE DIVISION	DEAN EDUCATIONAL DEVELOPMENT DIVISION	DEAN EDUCATIONAL HARDWARE DIVISION
NUCLEUS ALL GROUP LEADERS	NUCLEUS ALL GROUP LEADERS	NUCLEUS ALL GROUP LEADERS	NUCLEUS OF THE DIVISION	NUCLEUS OF THE DIVISION	NUCLEUS OF THE DIVISION	NUCLEUS OF THE DIVISION	NUCLEUS OF THE DIVISION	NUCLEUS OF THE DIVISION	NUCLUS OF THE DIVISION
BLOCK ADMINISTRATION HOUSEKEEPING & PHYSICAL FACILITIES LAB CLASSROOM & OFFICE MAINTENANCE			TIME TABLE TEACHING ALLOCATION IMPLEMENTATION FEEDBACK & MONITORING GROUPS & GROUP LEADERS	ESTABLISHMENT FACULTY ALLOCATION FEEDBACK & MONITORING STUDENT NEEDS STATION OPERATION STUDENT ASSIGNMENT & EVALUATION GROUPS & GROUP LEADERS	IDEATION OF STATIONS ADMINISTRATION ORGANISATION INTERFACING WITH OUTSIDE AGENCIES SEEKING OUT CON-SULTATION GROUPS & GROUP LEADERS GROUPS & GROUP LEADERS	REGISTRATION PLANNING & OPERATION ACADEMIC RECORDS OF STUDENTS ELIGIBILITY COUNSELLING ACADEMIC COUNSELLING BOARD GROUPS & GROUP LEADERS	HOSTELS, NSS, NCC, NIS, GAMES & ATHELETICS STUDENT ACTIVITIES RAILWAY CONCESSIONS SCHOLARSHIPS & AIDS, SFC STUDENTS PERSONAL FILES & TESTI-MONIALS DISCIPLINE GROUPS & GROUP LEADERS	COURSE & LAB DEVELOPMENT COURSE IMPROVEMENT TEACHING W/S INSTITUTIONAL & EDUCATIONAL RESEARCH EDUCATIONAL TECHNOLOGY TEACHING AIDS IDEATION FEEDBACK GROUPS & GROUP LEADERS	CENTRAL PURCHASE BASIC EQUIPMENT MAINTENANCE GROUPS & GROUP LEADERS
GROUPS & GROUP LEADERS CHEM.ENGG. CIVIL ENGG. ECONOMICS ENGG.TECH. HUMANISTIC STUDIES LANGUAGES MANAGEMENT	GROUPS & GROUP LEADERS EEE MECH.ENGG.	GROUPS & GROUP LEADERS BIO. SCI. CHEMISTRY MATHEMATICS MUSEUM STUDIES PHARMACY PHYSICS SCIENCE & TECHNOLOGY & DEVELOP-MENT							

U N I T S	CHIEF, GENERAL ADMINISTRATION CHIEF, MAINTENANCE (MAINTENANCE OFFICER) CHIEF, ADMISSIONS & PLACEMENT (ADMISSIONS & PLACEMENT OFFICER) CHIEF, ACCOUNTS & FINANCE (BUDGET OFFICER) CHIEF, DISTANCE LEARNING PROGRAMMES

U N I T S	CHIEF, LIBRARY CHIEF, INFORMATION PROCESSING CENTRE CHIEF, WORKSHOP CHIEF, INSTRUMENTATION CENTRE CHIEF, COMMUNITY WELFARE CHIEF, COMPUTER ASSISTED HOUSE KEEPING

3.5 SYSTEMS ANALYSIS AND BEHAVIOURAL SPECIFICATION

Computerization of GRA modules require that a thourough systems investigation be done prior to any attempt at design and implementation of software algorithms. The idea is to investigate the system from the viewpoint of information flow and operational logic (IFOL) leading to a set of unambiguous behavioural specifications. These behavioural specifications arrived at (and expressed in a convenient form) would greatly aid in the process of design of file structures, algorithms that capture the operational logic and implementation of software.

It will be recalled from the discussion in Sec. 3.3 that the following GRA modules would be included in our study:

(a) Payroll

(b) Income Tax

(c) Establishment Budget of Staff

(d) Leave Travel Concession Billing

The selection of the above GRA modules is by no means arbitrary. The following are some of the points that led to the selection of the above modules for study.

* It has been the considered opinion of practising administrators in BITS that operationally, the above modules cover a wide range of routine administrative operations that they (or their staff) spend a large chunk of their time on.

* Some of the GRA like Payroll and Income Tax are operations carried out routinely every month. As such, the effects of

these operations have a visible and tangible effect on staff. Recurring errors in these operations or delays (which lead to late payment of salaries) may have a debilitating effect on staff well-being and morale.

* The range of the data required and used by these GRA modules are so basic, essential and vital that they cover roughly three fourths of the entire data captured, recorded and used by administrators. Evidently, computerizing these GRA would make data available to other modules condidered for computerization later.

* In February 1982, payment of salaries were delayed for 15 days creating a sitaution of discomfort to everyone at BITS. the plea of the accounts section (for the delay) was that they were acutely understaffed and could not produce the required results unless given additional manpoer. The top administration was, however, skeptical of the plea and investigated the problem carefully. the results of the investigation are reported in an internal document entitled "An Artificial Crisis". To counter such recurrence of "artificial crises", computerization of GRA like Payroll and Income Tax were accorded top priority.

Before embarking on a detailed systems analysis, it would be worthwhile to consider some aspects of information flow and operational logic from a macro level. The focus of our study is on the entity "faculty". What information on this entity is generated on this entity when it arrives into the system, how the data is used in the GRA and so on, is our primary concern here.

The IFOL and interaction of various entities in the system were depicted using data flow diagrams and activity charts. [Ross D.T. et al (1975), Yourdon E. & Constantine L.(1979)].

Once the "faculty" becomes an entity of the system, it involves a complicated set of interactions with certain administrative entities. A complete systems diagram depicting the overall interations and IFOL would be neither possible nor desirable. To arrive at behavioural specifications that facilitates development of computerized GRA, it is only necessary to consider in abstraction the relevant subsystems.

The interactions and IFOL concerning the "payroll" subsystem was specified using data flow diagrams. Payroll processing is one of the most routine GRA. The purpose of systems investigation at this level is primarily to understand and specify clearly the IFOL and interactions between the administrative entities.

As soon as the "faculty" becomes an entity in the educational system, he is appointed against a post that is budgeted for. Typically, in most universities, this task of preparation, maintenance and monitoring of the establishment budget for faculty is one routine administrative task usually entrusted to the Registrar's Office. This, then, is a GRA that has opeations so routinised that it suggests itself for computerization.

The faculty entity also interacts with other administrative entities in the system connected with availing of various benefits like LTC, Medical Reimbursement, etc. Availing these benefits is usually a two-step process:

(i) Faculty applies for the benefit, the concerned administrative entity (usually the administrative dean's office) checks the eligibility conditions and a sanction to avail of the benefit is given.

(ii) Faculty avails of the benefit, makes a claim by submitting a bill and the administrative entity checks the validity of the claim as per applicable rules and finally passes the bill for payment.

Task (i) above lies in the realm of decision making and will be discussed in Chapter 4. Here we shall consider the routine aspect of making a bill as per applicable rules when claims are made. The entity interactions and IFOL connected with LTC claims and billing were depicted using data flow diagrams and activity charts.

Having studied the entity interactions and IFOL of these subsystems, we can now arrive at a set of behavioural specifications connected with GRA like payroll, income tax, preparation and maintenance of establishment budget of staff, and LTC claims and billing.

3.5.1 Payroll

Behavioural specification in the context of the payroll subsystem (considerd here as a GRA) involves the following:

(i) Specification of the interactions among the various entities and IFOL.

(ii) Listing of the various items of data used in the preparation of payroll.

(iii) Procedures and proformas used in the communication of administrative and other information to the payroll subsystem.

(iv) Procedures used in preparation of payroll, ledgers, etc.

(v) Listing of the various visible outcomes of the payroll processing.

On the basis of the systems analysis carried out, a list of various items of data connected with individual faculty pertinent to the payroll subsystem has been worked out. The list is presented in a tabular fashion in Table 3.1. The payroll processing involves a visible st of outcomes in the form a ledger, pay-slips and many other reports. A list of all such visible outcomes are given in Table 3.2.

TABLE 3.1

DATA ITEMS IN THE PAYROLL SUBSYSTEM

S.No.	DATA ITEM	WORD	BYTE	REMARKS
1.	PSRN	1	1-2	I
2.	BSRN	2	3-4	I
3.	DELETE/REVIVE FLAGE	3	5	I (0,1)
4.	EMPLOYEE TYPE	3	6	I (1,2,3,4)
5.	NAME	4-13	7-26	A
6.	HOUSE NUMBER	14-15	27-30	
7.	BANK A/C NO.	16-17	31-34	I
8.	DATE OF BIRTH		35-37	I
9.	DATE OF JOINING		38-40	I
10.	DATE OF TERMINATION		41-43	I
11.	DRAFT CODE POSTING		44	I
12.	DESIGNATION CODE		45	I
13.	ADMINISTRATIVE DESIG.		46	I
14.	INTERNAL DIV.		47	I
15.	INTERNAL GROUP		48	I
16.	BUDGET DIVISION		49	I
17.	BUDGET GROUP		50	I
18.	GRADE CODE - 12		51	I
19.	FIXED SALARY CODE 11		52	I
20.	BASIC PAY I4	27	53-54	I
21.	DA I4	28	55-56	I
22.	INCREMENT MONTH		57	I
23.	INCREMENT YEAR		58	I
24.	PF DEDCTIBLE ALLOWANCE	30	59-60	I
25.	NON-PF DEDUCTABLE ALLOWANCE	31	61-62	I
26.	OTHER PAYMENTS	32-33	63-65	I RS. PS.
27.	ARREARS	33-34	66-68	I RS. PS.
28.	PF % OWN		69	I
29.	PF % EMP.		70	I
30.	ACC. PF OWN CURRENT	36-37	71-73	I RS. PS.
31.	ACC. PF EMP. YEAR	37-38	74-76	I RS. PS.
32.	ACC. PF OWN PREVIOUS	39-40	77-79	I RS. PS.
33.	ACC. PF EMP. YEAR	40-41	80-82	I RS. PS.
34.	PF LOAN TOTAL AMOUNT	42-43	83-85	I RS. PS.
35.	PF LOAN REPAYMENT INSTALMENT	43-44	86-88	I RS. PS.
36.	BALANCE OF PF LOAN	45-46	89-91	I RS. PS.
37.	NON REPAYABLE LOAN ON PF	46-47	92-94	I RS. PS.
38.	SPL. LOAN TOTAL	48-49	94-97	I RS. PS.
39.	SPL. LOAN INSTALMENT	49-50	98-100	I RS. PS.
40.	SPL. LOAN BALANCE	51-52	101-103	I RS. PS.
41.	FURT. LOAN TOTAL	52-53	104-106	I RS. PS.
42.	FURT. LOAN INSTALMENT	54-55	107-109	I RS. PS.
43.	FURT. LOAN BALANCE	55-56	110-112	I RS. PS.
44.	OTHER LOAN TOTAL	57-58	113-115	I RS. PS.
45.	OTHER LOAN INSTALMENT	58-59	116-118	I RS. PS.

Table 3.1 (Continued)

S.No.	DATA ITEM	WORD	BYTE	REMARKS
46.	OTHER LOAN BALANCE	60-61	119-121	I RS. PS.
47.	LIP	61-62	122-124	I RS. PS.
48.	TCC	63	125-126	I RS.*100/PS.
49.	HOUSE RENT	64	127-128	I RS.*100/PS.
50.	CTD INSTALMENT	1	1-2	I RS. PS.
51.	CTD REMAINING MONTHS	2	3-4	I
52.	ACC. CTD	3-4	5-7	I RS. PS.
53.	INCOME TAX DEDUCTION	4-5	8-10	I RS. PS.
54.	ACC. INCOME TAX	6-7	11-13	I RS. PS.
55.	FURT. RENT	7-8	14-16	I RS. PS.
56.	METER RENT CODE	9	17	I
57.	STAFF ASSOCIATION	9	18	I
58.	REVENUE STAMP	10	19	I
59.	P.S. ALLOWANCE	10-11	20-22	I RS. PS.
60.	SALARY ADVANCE	12-13	23-25	I RS. PS.
61.	TERM APPOINTMENT INDICATOR	13	26	I
62.	VACATION ELIGIBILITY DAYS	14	27	I DAYS
63.	ELECTRICITY BILL	14-15	28-30	I RS. PS.
64.	ELECTRICITY UNITS	16		I
65.	BITSCOOP MEMBERSHIP IND.	17	33	I
66.	MEDICAL	17-18	34-36	I RS. PS.
67.	LEAVE DEDUCTION AMOUNT	19-20	37-39	I RS. PS.
	OTHER DEDUCTIONS (i)	20-21	40-42	I RS. PS.
	(ii)	22-23	43-45	I RS. PS.
	(iii)	23-24	46-48	I RS. PS.
	(iv)	25-26	49-51	I RS. PS.
68.	TOTAL DED. WITHOUT LEAVE DED.	26-27	52-54	I RS. PS.
69.	TOTAL DED. WITH LEAVE DED.	28-29	55-57	I RS. PS.
70.	BASIC PAYABLE AFTER LEAVE DED.	29-30	58-60	I RS. PS.
71.	DA PAYABLE AFTER LEAVE DED.	31-32	61-63	I RS. PS.
72.	ALLW. WITH PF AFTER LEAVE DED.	32-33	64-66	I RS. PS.
73.	ALLOW. WITHOUT PF " "	34-35	67-69	I RS. PS.
74.	TOTAL PAY WITHOUT LEAVE DED.	35-36	70-72	I RS. PS.
75.	GROSS PAY AFTER LEAVE DED.	37-38	73-75	I RS. PS.
76.	NET PAY	38-39	76-78	I RS. PS.
77.	PF OWN	40	79-80	I
78.	PF EMP.	41	81-82	I
79.	OTHER DEDUCTION (V)	42-43	83-85	I RS. PS.
80.	OTHER DEDUCTION TOTAL	43-44	86-88	I RS. PS.
81.	HPL (HEAL PAY LEAVE)	45	DAYS	I DAYS*100+LEAVE
82.		46	BASICPAY	I
83.		47	DAYS	I
84.		48	BASICPAY	I
85.		49	DAYS	I
86.		50	BASICPAY	I
87.	WPL (WITHOUT PAY LEAVE)	51	DAYS	I
88.		52	BASICPAY	I
89.		53	DAYS	I

Table 3.1 (COntinued)

S.No.	DATA ITEM	WORD	BYTE	REMARKS
90.		54	BASICPAY	I
91.		55	DAYS	I
92.	WPL (WITHOUT PAY LEAVE)	56	BASICPAY	I
93.		57	HPLINDI.	I 1,0
94.		58	WPLINDI.	I 1,0
95.		59	NOTEMPID.	I
96.	NEMPLOYED AMOUNT	60		I RS.
		61	121	I PS.
97.	UNUSED	62		I
98.	UNUSED	63		I
99.	UNUSED	64		I

Table 3.1 (COntinued)

S.No.	DATA ITEM	WORD	BYTE	REMARKS
90.		54	BASICPAY	I
91.		55	DAYS	I
92.	WPL (WITHOUT PAY LEAVE)	56	BASICPAY	I
93.		57	HPLINDI.	I 1,0
94.		58	WPLINDI.	I 1,0
95.		59	NOTEMPID.	I
96.	NEMPLOYED AMOUNT	60		I RS.
		61	121	I PS.
97.	UNUSED	62		I
98.	UNUSED	63		I
99.	UNUSED	64		I

TABLE 3.2

VISIBLE OUTCOMES FROM THE PAYROLL GRA

1.	Base Data of Faculty as input	Internal	As & when
2.	Data Update Sheets	Internal	As & when
3.	List of Faculty receiving increment in a particular month/year	Internal Accts.	Monthly
4.	Staff with Negative Salary	Internal	Monthly
5.	Salary Ledger	Internal Accts.	Monthly
6.	Master Ledger	Internal	Monthly
7.	Payslips	Individual Staff	Monthly
8.	Bank Statement	Internal/ Accts./Bank	Monthly
9.	Cash Disbursement Statement	Internal/Accts.	Monthly
10.	Draft Statement	Internal/Accts. PSD	Monthly
11.	Reports on individual items of deducation		
	* BITS COOP	Internal/Accts./ BITSCOOP	Monthly
	* House Rent	Internal/Accts./ MNTU	Monthly
	* TCC	Internal/Accts./ MNTU	Monthly
	* Cumulative Time Deposits (CTD)	Internal/Accts./	Monthly
	* Special Loan Repayment	Internal/Accts./	Monthly
	* Income Tax	Internal/Accts./ ITU	Monthly
	* Usage of Motor Car of BITS	Internal/Accts./	Monthly
	* Electricity Meter Rent	Internal/Accts./	Monthly
	* Electricity Biils	Internal/Accts./ BET	Monthly
	* PF deduction of employee	Internal/Accts./ BET	Monthly
	* Loan repayment on PF	Internal/Accts./ BET	Monthly
	* Deduction of Life Insurance Premium	Internal/Accts./ LIC	Monthly
	* Furniture Rent	Internal/Accts./ MNTU	Monthly
	* Staff Association Subscription	Internal/Accts./ Staff Assoc.	Monthly
	* Salary Advance	Internal/Accts./ Adm. Deans	Monthly
	* Furniture Loan Repayment	Internal/Accts./	Monthly
	* Other Deduction	Internal/Accts./	Monthly

Table 3.2 (Continued)

S. No.	OUTPUT	USER(S)	FREQUENCY OF PRODUCTION
12.	Reports on individual items of Payment		
	* Arrears	Internal/Accts./	Monthly
	* Other Payments	Internal/Accts./	Monthly
13.	Reports on Miscellaneous Items		
	* List of staff and their Quarters for use as proforma for entering electricity data	BET/Internal	Monthly
	* List of staff as per internal divisions	Adm Deans	As & When
	* List of staff on PS duty	Adm Dean/DDs	As & When
	* List of staff as per employment type	Adm Dean/DDs	As & When
	* List of staff on rolls	Adm Dean/DDs	As & When
	* List of staff with no quarters	Adm Dean	As & When
	* List of staff as per designation	Adm Dean/DDs	As & When
	* List of staff on Summer Duty	Adm Dean	Every Summer
	* List of staff as per Salary Scales	Adm Dean/DDs Registrar	As & When
	* List of staff on Fixed Pay	Adm Dean/DDs	As & When
	* List of staff whose term expires in a particular month/year	Adm Dean/DDs Registrar	Monthly
	* List of staff who have reached the maximum salary in their scale	Adm Dean/DDs Registrar	As & When

NOTE : In addition to the above, faculty exists for generating reports on various aspects of staff with programs written and added to the repertoire on a need basis or adhoc basis.

3.5.2 Income Tax

Strictly speaking, the preparation of income tax for individual faculty entities (to be deducted at source by the concerned administrative subunit - usually the Accounts Office) is not an independent activity. It is a part of the payroll subsystem. However, we shall treat it seperately so as to bring the salient points involving income tax computation to the forefront.

The data on individual faculty needed to carry out this processing is provided in Table 3.3. Procedures to be adopted in the actual computation of income tax for faculty is dictated by the prevailing Income Tax Rules.

3.5.3 Establishment Budget

In every university, the establishment record of faculty are routinely maintained. This consists of preparation and maintenence of data on posts budgeted for, the post against which the faculty is appointed, and other related financial information on the posts. Methods on how the establishment information is maintained, the establishment budget prepared and updated vary from university to university. Given below is a brief description of what establishment information means and how the establishment budget is prepared and used in BITS.

In BITS, the establishment of staff consists of 770 posts (presently, this may be expanded or contracted) sanctioned or

TABLE 3.3

DATA FOR INCOME TAX GRA

File - 1

S.No.	DATA ITEM	WORD	BYTE	REMARKS
1.	PSRN	1		I
2.	NAME	2-16		A2
3.	DIVISION CODE	17		U
4.	BASIC+DA/MONTHLY	18		I
5.	DESIGNATION CODE	19		I
6.	YEARLY SALARY	20-21		I
7.	OTHER ALLOWANCE	22		I
8.	SUMMER ALLOWANCE	23		I
9.	P.S. ALLOWANCES	24		I
10.	HOUSE RENT ALLOWANCE	25		I
11.	ADDITIONAL INCOME	26		I
12.	P.F. % (OWN)	27		I
13.	L.I.C. (PREMIUM YEARLY)	28-29	55-57	RS. PS.
14.	FAMILY PENSION (YEARLY)	29-30	58-60	PS. RS.
15.	C.T.D. (YEARLY)	31-32	61-63	RS. PS.
16.	P.P.F. (YEARLY)	32-33	64-66	PS. RS.
17.	U.L.I.P. (YEARLY)	34-35	67-69	RS. PS.
18.	NATIONAL SAVINGS CERTIFICATE	35-36	70-72	PS. RS.
19.	NATIONAL SAVING SCH. UND. 80CCA	37-38	73-75	RS. PS.
20.	INCOME TAX ALREADY PAID	38-39	76-78	PS. RS.
21.	P.F. AMOUNT	40		RS.
22.	TAX CODE FLAG	41		I
23.	TOTAL INCOME	42-43		REAL
24.	TOTAL DEDUCTION	44-45		REAL
25.	STANDARD DEDUCTION	46-47		REAL
26.	PERMISSIBLE DEDUCTION	48-49		REAL
27.	NSS UNDER 80CCA	50-51		REAL
28.	NET INCOME TAXABLE	52-53		REAL
29.	SURCHARGE	54-55		REAL
30.	INCOME TAX	56-57		REAL
31.	TOTAL TAX	58-59		REAL
32.	REMANING TAX	60-61		REAL
33.	MONTHLY TAX	62-63		REAL
34.	UNUSED	64		

Table 3.3 (Continued)

File - 2

S.No.	DATA ITEM	WORD	BYTE	REMARKS
1.	PSRN	1	1-2	I
2.	DELETE/REVIVE FLAG	2	3	I (0,1)
3.	EMPLOYEE TYPE	2	4	I (1,2,3,4)
4.	NAME	3-12	5-24	A
5.	DESIGNATION CODE	13	25	I
6.	TAX PAID CODE	13	26	I (0,1)
7.	GROSS PAY APRIL	14-15	27-29	I RS. PS.
8.	GROSS PAY MAY	15-16	30-32	I RS. PS.
9.	GROSS PAY JUNE	17-18	33-35	I RS. PS.
10.	GROSS PAY JULY	18-19	36-38	I RS. PS.
11.	GROSS PAY AUGUST	20-21	39-41	I RS. PS.
12.	GROSS PAY SEPTEMBER	21-22	42-44	I RS. PS.
13.	GROSS PAY OCTOBER	23-24	45-47	I RS. PS.
14.	GROSS PAY NOVEMBER	24-25	48-50	I RS. PS.
15.	GROSS PAY DECEMBER	26-27	51-53	I RS. PS.
16.	GROSS PAY JANUARY	27-28	54-56	I RS. PS.
17.	GROSS PAY FEBRUARY	29-30	57-59	I RS. PS.
18.	GROSS PAY MARCH	30-31	60-62	I RS. PS.
19.	TAX PAID APRIL	32		I RS.
20.	TAX PAID MAY	33		I RS.
21.	TAX PAID JUNE	34		I RS.
22.	TAX PAID JULY	35		I RS.
23.	TAX PAID AUGUST	36		I RS.
24.	TAX PAID SEPTEMBER	37		I RS.
25.	TAX PAID OCTOBER	38		I RS.
26.	TAX PAID NOVEMBER	39		I RS.
27.	TAX PAID DECEMBER	40		I RS.
28.	TAX PAID JANUARY	41		I RS.
29.	TAX PAID FEBRUARY	42		I RS.
30.	TAX PAID MARCH	43		I RS.
31.	P.F. AMOUNT APRIL	44		I RS.
32.	P.F. AMOUNT MAY	45		I RS.
33.	P.F. AMOUNT JUNE	46		I RS.
34.	P.F. AMOUNT JULY	47		I RS.
35.	P.F. AMOUNT AUGUST	48		I RS.
36.	P.F. AMOUNT SEPTEMBER	49		I RS.
37.	P.F. AMOUNT OCTOBER	50		I RS.
38.	P.F. AMOUNT NOMBER	51		I RS.
39.	P.F. AMOUNT DECEMBER	52		I RS.
40.	P.F. AMOUNT JANUARY	53		I RS.
41.	P.F. AMOUNT FEBRUARY	54		I RS.
42.	P.F. AMOUNT MARCH	55		I RS.
43.	C.T.D. APRIL	1		I RS.
44.	C.T.D. MAY	2		I RS.

Table 3.3 (Continued)

File - 2

S.No.	DATA ITEM	WORD	BYTE	REMARKS
45.	C.T.D. JUNE	3		I RS.
46.	C.T.D. JULY	4		I RS.
47	C.T.D. AUGUST	5		I RS.
48.	C.T.D. SEPTEMBER	6		I RS.
49	C.T.D. OCTOBER	7		I RS.
50.	C.T.D. NOMBER	8		I RS.
51.	C.T.D. DECEMBER	9		I RS.
52.	C.T.D. JANUARY	10		I RS.
53.	C.T.D. FEBRUARY	11		I RS.
54.	C.T.D. MARCH	12		I RS.
55.	L.I.P. APRIL	13-14	25-27	I RS. PS.
56.	L.I.P. MAY	14-15	28-30	I RS. PS.
57.	L.I.P. JUNE	16-17	31-33	I RS. PS.
58.	L.I.P. JULY	17-18	34-36	I RS. PS.
59.	L.I.P. AUGUST	19-20	37-39	I RS. PS.
60.	L.I.P. SEPTEMBER	20-21	40-42	I RS. PS.
61.	L.I.P. OCTOBER	22-23	43-45	I RS. PS.
62.	L.I.P. NOMBER	23-24	46-48	I RS. PS.
63.	L.I.P. DECEMBER	25-26	49-51	I RS. PS.
64.	L.I.P. JANUARY	26-27	52-54	I RS. PS.
65.	L.I.P. FEBRUARY	28-29	55-57	I RS. PS.
66	L.I.P. MARCH	29-30	58-60	I RS. PS.
67.	OTHER PAYMENT APRIL	31-32	61-63	I RS. PS.
68.	OTHER PAYMENT MAY	32-33	64-66	I RS. PS.
69.	OTHER PAYMENT JUNE	34-35	67-69	I RS. PS.
70.	OTHER PAYMENT JULY	35-36	70-72	I RS. PS.
71.	OTHER PAYMENT AUGUST	37-38	73-75	I RS. PS.
72.	OTHER PAYMENT SEPTEMBER	38-39	76-78	I RS. PS.
73.	OTHER PAYMENT OCTOBER	40-41	79-81	I RS. PS.
74.	OTHER PAYMENT NOMBER	41-42	82-84	I RS. PS.
75.	OTHER PAYMENT DECEMBER	43-44	85-87	I RS. PS.
76.	OTHER PAYMENT JANUARY	44-45	88-90	I RS. PS.
77.	OTHER PAYMENT FEBRUARY	46-47	91-93	I RS. PS.
78.	OTHER PAYMENT MARCH	47-48	94-96	I RS. PS.
79.	GROSS YEARLY SALRY	49-50		REAL
80.	OTHER PAYMENT YEARLY	51-52		REAL
81.	L.I.P. YEARLY TOTAL	53-54		REAL
82.	C.T.D. YEARLY TOTAL	55		I
83.	P.F. YEARLY TOTAL	56		I
84.	TAX YEARLY TOTAL	57		I
85.	HOUSE NUMBER	58-59		I/A
86.	UNUSED	60-64		

budgeted for. These posts are distributed among three types of staff, namely,

(i) Teaching and Academic Staff,

(ii) Supporting Staff, and,

(iii) Helping Staff.

These posts carry a "sanctioned" designation and salary grade. This, in fact, defines the financial implications of the sanctioned posts. Staff are appointed against a santioned post. A staff may be appointed against a santioned designation and salary grade in the same designation and salary grade or in a lower designation and/or salary grade. Thus the staff appointed may have an "actual" designation and salary grade which may well be different from the sanctioned (established) one.

The major routine tasks involved in the establishment of staff are:

(i) Preparation of the establishment budget of staff every year for one financial year.

(ii) Updating and monitoring of information on establishment of staff periodically as staff join/leave the institute.

(iii) Reporting to top administration on vital information like "staff-in-position" and "vacancies" and other matters with financial implications as may be required from time to time.

The actual task, however, can be seen to be mainly of orderly record keeping; updating; routine and repetitive computation in regard of the financial implications of the posts like salaries, dearness allowance, etc.; searching, sorting and collating information for reporting to the top administration according to their needs; and ensure that the provisions in the budget are adhered to in practice. The tasks are of such a basic and vital nature that they can be readily treated as GRA.

The data requirements for carrying out the tasks mentioned above are provided in Table 3.4. The list of reports normally sought by top administrators periodically (that emanates from the data in Table 3.4) is also provided in Table 3.5. It should be noted that the list is not exhaustive by any means but only represents what is usually sought.

3.5.4 Leave Travel Concessions - Claims and Billing

A study of the proformas used for LTC suggests the list of data that are used in the operation of the LTC claims verification and final billing. The list of data are given in Table 3.6. The rules that govern the LTC operations are specified in a booklet on "RUles and regulations". These constitutes the behavioural specifications of the LTC subsystem. It is evident that the data/information requirement, the operation of rules concerning LTC and the actual computation involved in LTC bills are quite rudimentary and repetitive that it readily suggests itself as a candidate for computerization.

TABLE 3.4

DATA FOR ESTABLISHMENT BUDGET GRA

S.No.	ITEM	WORD	BYTE	TYPE
1.	PSRN	1	1-2	I
2.	Vacanay flag	2	3	I (0.1)
3.	Emp. Type		4	I (1,2,3,4)
4.	Division Code	3	5	I (1,24)
5.	Group Code		6	I (0,17)
6.	Name	4-18		15 A2
7.	Sanc. Desig.	19		I (1,120)
8.	Adtual Design	20		I (1,120)
9.	Sanc. Grade	21	41	I (1,14)
10.	Act. Grade		42	I (1,14)
11.	Personal Pay Code	22	43	I (0,1)
12.	Fixed Salary	22	44	I (0,1)
13.	PF Flag		45	I
14.	PS Station		46	I
15.	Inc. Monthly & Year	24		I Month* 100 + Year
16.	Pay in April	25		
17.	Spl. Allowance	26		
18.	All. without PF	27		
19.	Yearly Salary	28-29		Real
20.	Yearly D.A.	30-31		Real
21.	Yearly Allowance	32-33		Real
22.	Total Amount	34-35		Real
23.	PF Total	36-37		Real
24.	Teaching Disc.	38-45		I

TABLE 3.5

LIST OF VISIBLE OUTPUT FROM THE "ESTABLISHMENT BUDGER" SUBSYSTEM

S. No.	OUTPUT	USER(S)	FREQUENCY OF PRODUCTION
1.	Establishment Budget of Teaching Staff	Adm Dean/ Registrar Director/DD Acts,Chairman, Finance Committee	Yearly
2.	Establishment Budget of Supporting Staff	do	do
3.	Establishment Budget of Helping Staff	do	do
4.	Staistical Analysis of Budget * Analysis of Staff in position * Analysis of Vacant posts	do	do
5.	Consolidated breakup of financial aspects of establishment budget divisionwise	do	do
6.	List of Teaching Disciplines of Staff	do	do
7.	List of Special Competence of Supporting Staff	do	do
8.	Additional information on Helping Staff	do	do

NOTE : All outputs except 4 and 5 above, are part of Volume II of the Budget estimates of the Institute.

TABLE 3.6

DATA ITEMS FOR THE LTC CLAIMS & BILLING GRA

S.No.	DATA ITEM	TYPE
1.	PSRN	Integer
2.	Name	Alphanumeric (15)
3.	Division Code	Integer
4.	Basic	Integer
5.	Designation Code	Integer
6.	Home Town declared	Boolean (0 or 1)
7.	Home Town	Alphanumeric (20)
8.	Distance to Hometown	Integer (km)
9.	No. of Dependents	Integer
10.	Name of dependent	Alphanumeric (15)
11.	Relationship	"
12.	Date of Birth of Dependent	Integers (dd/mm/yy)
13.	Sex	Integer
15-35.	Repeat of 10 to 13 above	For rest of dependents (Max. 5)
36.	To Distance to hometown (Road, Rail)	Integer (3 items)
37.	Return Distance from Hometown	Integer
38.	Class Travelled	Integer
39.	Total Claimed	Rs. Ps. Integer

* Other implicitly required data like fares, etc. are not shown here.

Having completed the systems investigation and behavioural specification in regard of the GRA, we can now proceed to the design and implementation of computer software for these GRA. This will be discussed in the next section.

3.6 SOFTWARE DESIGN AND IMPLEMENTATION

The design and implementation of software for the four GRA (payroll, incometax, establishment budget of staff, and LTC claims billing) considered for this study will be discussed in this section. Before the design of software algorithms two main questons must be answered:

(1) On which computer is the software to be developed?

(2) What would be the operating system and programming language used?

These questions may pose considerable difficulty for a university that is embarking on a computerization venture for the first time. However, BITS has a rather long history in having pioneered the use of computers in educational administration. Furthermore, after the "artificial crisis" of 1983 (see section 3.5), computerization of these GRA was a top priority task. The essence was to design and implement the GRA modules swiftly within a time-bound framework. Thus there was no scope of launching on an open-ended study of all available hardware and software systems that may be best suited to the task on hand. The idea was to make do with available hardware and software developmental tools, and make the design and implementation phase a time-bound task. In short, the effort was to launch a cost-effective computerized information system.

Cost-Effectiveness Criterion -- A Digression

Developing a cost-effective computerized information system is one of the central issues tackled by this thesis. The following are some of the visible costs associated with the process of developing a computerized information system for educational administration.

* costs of acquiring and installation of hardware
* costs of setting up infrastructural facilities like dust free atmosphere, air conditioners, etc.
* cost of software development tools like, programming languages, DBMS, etc.
* cost of computer manpower involved in analysis, design, implementation, testing and maintenance
* costs of administrative manpower involved in the process
* costs of training/retraining mainpower for operational purposes

Keeping in mind the need to keep the development process cost-effective, the following steps were taken:

* Consider only the available hardware at BITS for implementing the computerized information system. This entails no new purchase of hardware nor any longwinded selection process. Thus time and money are saved.
* Since no new hardware are proposed to be added, cost of setting up infrastructure woud be minimum.
* Consistent with the evolutionary delivery system, and progressive incremental enhancements, software was to be developed only on available developmental tools. This, too, contributes to keeping development costs low.
* Instead of hiring expensively priced external consultants, BITS decided to make use of in-house manpower for software

development. This meant that the faculty of the Computer Science Department actively participated in the administrative development process, perhaps a unique achievement in its own right.

<End of Digression>

Given the circumstances under which the initial portion of the study was undertaken, the two questions can be readily answered:

(1) The GRA modules were to be implemented on DCM Spectrum-3, a microcomputer based on the Intel 8085. (Actually, the choice was not very wide either. BITS, then, had only an IBM 1130 - a batch processing system, and the DCM Spectrum-3 - a single user interactive system).

(2) The Spectrum-3 then supported the CP/M operating system and the programming languages BASIC and FORTRAN. It was decided to use Microsoft's FORTRAN-80 for implementing the GRA modules. (Once again, the choice was not much. The BASIC compiler version available then was an experimental version riddled with bugs. No database management system was available for use then. The dBASE II implementation under CP/M came much later).

The strategy adopted for design and implementation was that each of the GRA modules would be treated as a distinct entity. Thus each module would be designed as a standalone system capable of handling only that GRA. Interfacing, if any, between these modules were to be carried out in a loosely coupled fashion through seperate software modules.

The software design and implementation phases consisted of the following activities:

(1) Design of the various computer data files and their file structures.

(2) Design of algorithms for processing the data in the files as per the dictates of the operational logic of the GRA.

(3) Coding of the algorithms in (2) above in FORTRAN.

(4) Implementation of the sotware developed.

(5) Testing of the various programs that make up the computerized GRA.

All these activities will be discussed for each of the GRA modules, in turn, in the next sections.

3.6.1 Payroll

The task of design and implementation of software for the payroll system was taken up first. The data required for carrying out the payroll operation has already been given in Table 3.1. The design of the data file structure is of prime importance (as this is the basis on which the programs will have to be developed) and will be discussed below.

Design of File Structure(s)

Fig 3.4 shows a schematic diagram illustrating the various data files used in this GRA module and their relationships. It is clear from the figure that the bulk of the data would be stored in a single file called PAYMASTER. Before we specify the actual structure of the files, a brief digression is necessary to discuss the nature of file organisation under the CP/M operating system and Microsoft's implementation of FORTRAN-80.

* File Organisation in FORTRAN-80 under CP/M - A Digression

Data files on secondary storage (floppy disks, in this case) are organised as having "fixed length" records. In FORTRAN-80 under CP/M, data files can be created and used as having fixed length records with 128 bytes per physical record. Each physical record then has 128 bytes (or 64 words).

It does not however imply that "variable length" records are not possible at all. In fact, the only way we can create variable length records easily is by using the standard editor under CP/M by Digital Research Inc. The problem with this is that the data files of necessity will be stored in ASCII form with each record terminated by the CR and LF characters. This method is highly unsuitable when a large amount of numbers will have to be stored. For example, the integer number 123 will be represented as the ASCII character '1', '2' and '3' in three bytes. Not only does this process use more storage space, but also needs to be converted to binary by user programs before any arithmetic operation can be carried out.

Thus the structure of the data file has to be designed around fixed length records of 128 bytes (or 64 words) each.

<End of Digression>

Figure 3.10

DATA FILES USED IN THE PAYROLL GRA MODULE

Salary Grades

PAYMASTER

DA Table

Bank Index File

Draft Codes & Captions

Division Captions

PAYROLL MODULE

Designation Caption

POINTERS (Index file on PSRN) & Budget Division

LEDGER

Internal Pointers (Index file on Internal Division)

Thus we shall take complete advantage of the fact that certain data items envisaged to be stored in PAYMASTER can be stored as integer words of 16 bits or as integer bytes of 8 bits. Characters are as usual stored as a byte in ASCII form. Also, storing of financial data in real form presents serious difficulties. For example, we may want to store the net pay of faculty as Rs. 1250.33. If we store this as a real number in the file, there will be certain inaccuracies in the representation of the fractional part. The fractional part .33 cannot be accurately represented in floating point form. We can then conclude that if financial quantities involving a fractional part (i.e. paise) cannot be accurately represented, computations involving these quantities would further compound these inaccuracies, leading to grave problems in operation of algorithms and inconsistencies.

One simple way of overcoming this problem is to store the financial quatities as "integer pair" containing a "rupee part" and a "paise part". Since integers (within a range) can be accurately represented, the financial quantities can be stored, used in computation by considering the rupee and paise part seperately. Special software for carrying out arithmetic operations on financial quantities represented as above will have to be developed, however.

Also one more "data compression" can be achieved. We know that the paise portion can be only in the range [0,99]. These values can be represented in a byte. Thus we can store financial quatities as a pair involving a rupee part, represented as an integer in 16 bits, and a paise part, represented as an integer in 8 bits only.

The file organisation of PAYMASTER incorporates the data compression logic discussed above. It also shows that the logical record corresponding to a faculty consists of two contiguous physical records of 128 bytes each.

Data like designation, division, or salary grade have been codified, while the actual captions corresponding to the codes are made available in seperate files. This organisation is nothing but the indexed file organisation [Wiederhold G.(1979)]. This is also sometimes called as the inverted file organisation.

Another important file in this subsystem is the LEDGER file which contains the ledger information on salary paid during a month. In fact, the ledger module uses the LEDGER file as well as a couple of sattelite files (See Fig. 3.4). The organisation of the ledger file is staightforward. There exists one physical record for every staff member in this file. The other sattelite files are merely inverted files that maintain ledger totals according to employee type and division (as required by the budget of the institute). The organisation of the ledger files are depicted in Table 3.7.

TABLE 3.7

ORGANIZATION OF LEDGER FILES

S.No.	ITEM	TYPE
1.	PSRN	Integer
2.	Name	Alphanumeric (15)
3.	Division Code	Integer
4.	Designation Code	Integer
5.	Bank A/c	Integer (2 items)
6.	House Number	Alphanumeric (8)
7.	PF Deduction	Integer (%)
8.	PF Contribution	Integer (%)
9.	Half Pay Leave Deduction	Real (Rs. Ps.)
10.	Without Pay Leave Deduction	Real (Rs. Ps.)
11.	Basic Rate	Integer
12.	Actual Basic Payable	Real (Rs. Ps.)
13.	DA Rate	Integer
14.	DA Payable	Real (Rs. Ps.)
15.	Allowance Rate	Integer
16.	Allowance Payable	Real (Rs. Ps.)
17.	PS Allowance	Real (Rs. Ps.)
18.	Arrears	Real (Rs. Ps.)
19.	Other Payments	Real (Rs. Ps.)
20.	PF Contribution Amount	Real (Rs. Ps.)
21.	PF Deduction	Real (Rs. Ps.)
22.	PF Loan deduction	Real (Rs. Ps.)
23.	LIP	Real (Rs. Ps.)
24.	CTD	Real (Rs. Ps.)
25.	Furniture Rent	Real (Rs. Ps.)
26.	House Rent	Real (Rs. Ps.)
27.	Electricity Meter Rent	Real (Rs. Ps.)
28.	Electricity Bill	Real (Rs. Ps.)
29.	TC/CH	Real (Rs. Ps.)
30.	Special Loan	Real (Rs. Ps.)
31.	Other deductions	Real (Rs. Ps.)
32.	Staff Association SUbscription	Real (Rs. Ps.)
33.	Revenue stamp	Real (Rs. Ps.)
34.	Salary Advance	Real (Rs. Ps.)
35.	Net Pay	Real (Rs. Ps.)
36.	Total Payable	Real (Rs. Ps.)
37.	Total Deducations	Real (Rs. Ps.)

File Access

Records within the PAYMASTER file has been organised sequentially with each logical record occupying two contiguous physical records of 128 bytes each. Further each employee is given a unique identifying number called PSRN. This actually also denotes the logical number of that staff record in the file. Thus the problem is one of accessing the proper physical record in file given the PSRN (or the logical record number). A straightforward formula has been developed to provide record access:

Physical record number = 2*logical record number - 1

= 2*PSRN - 1

Similarly, records within ledger files are accessed with the mapping of PSRN, employee type and division code into a unique physical reord.

Design and Implementaion of Software

The payroll subsystem requires certain algorithms to be designed that fall into the following broad categories:

(a) Modules connected with data management

(b) Modules connected primarily with computation, like salary payments, deductions and ledger

(c) Modules that are essentially report generators

(a) Modules concerned with data management

Data management is the kernel of any computerized information system. Accordingly, considerable care must be given to the modules concerned with data management so that the kernel on which other modules rely so heavily on is built on a strong foundation. The prime rquirement here is that the data management modules must have the following characteristics:

* The module must be highly interactive and user-friendly since these modules will be used mainly by lower level administrators, clerks or data entry operators.
* The modules must be highly structured and flexible. This enables easy maintenance of the programs, provides for systematic troubleshooting and helps in modification to accomodate changing administrative needs and situations.
* The modules must provide for automatic verification of data in the computer files to the extent possible.

Table 3.8 shows the various modules concerned with data management in the payroll subsystem.

Ideally a user-friendly data management module must provide for attractive screen layouts for data entry and update. The hardware on which the implementation was to take place provided only very few screen attributes/functions. Thus the module employs only a simple interactive method with no on-screen extravaganzas like data entry templates, screen editing and pull-down menus, etc.

TABLE 3.8

MODULES CONCERNED WITH THE PAYROLL GRA

S.No.	MODULE	FUNCTION/REMARKS
1.	PAYLOAD	Data management for new staff.
2.	ECHODATA	Data management for new staff.
3.	UPDATE	General purpose update program.
4.	PAYINIT	Files initializer; startup routine.
5.	MONDATA	Monthly data management.
6.	COMPSALL/ MAKESALL	Payroll computing for all active staff.
7.	COMPSALI/ MAKESALI	Payroll computing for a particular staff. (Special use)
8.	LEDGER/ MAKELED	Ledger computing for month.
9.	LEDPRINT	Ledger printing; with unique power fail restart procedures.
10.	CASHLIST	Checklist for cashier.
11.	BANKLIST	Bank statement.
12.	DRAFLIST	Checklist for draft preparation.
13.	CONSOLID	Diagnostic; consolidator.
14.	MASTLIST	Printing Master Ledger for month.
15.	PAYSLIP4	Payslips printing.
16.	PAYSLIP1	Snoop preview of payslip.
17.	REPORTS	A general purpose report generator. (about 37 reports).
18.	ELECLIST	Information blank for filling electricity data
19.	PROFORMAS	General purpose proforma generator to serve as information blanks.
20.	SUMSAL	Prepares & prints Summer Salaries.

Table 3.8 (Continued)

S.No.	MODULE	FUNCTION/REMARKS
21.	LOANS	Loans monitoring programs (PF,Furniture and Special Loans).
22.	CLEANUP	Cleansup unused spece on disks.
23.	CHEKUP	Checks files for consistency.

FIGURE 3.4

DATA FILES USED IN THE PAYROLL GRA MODULE

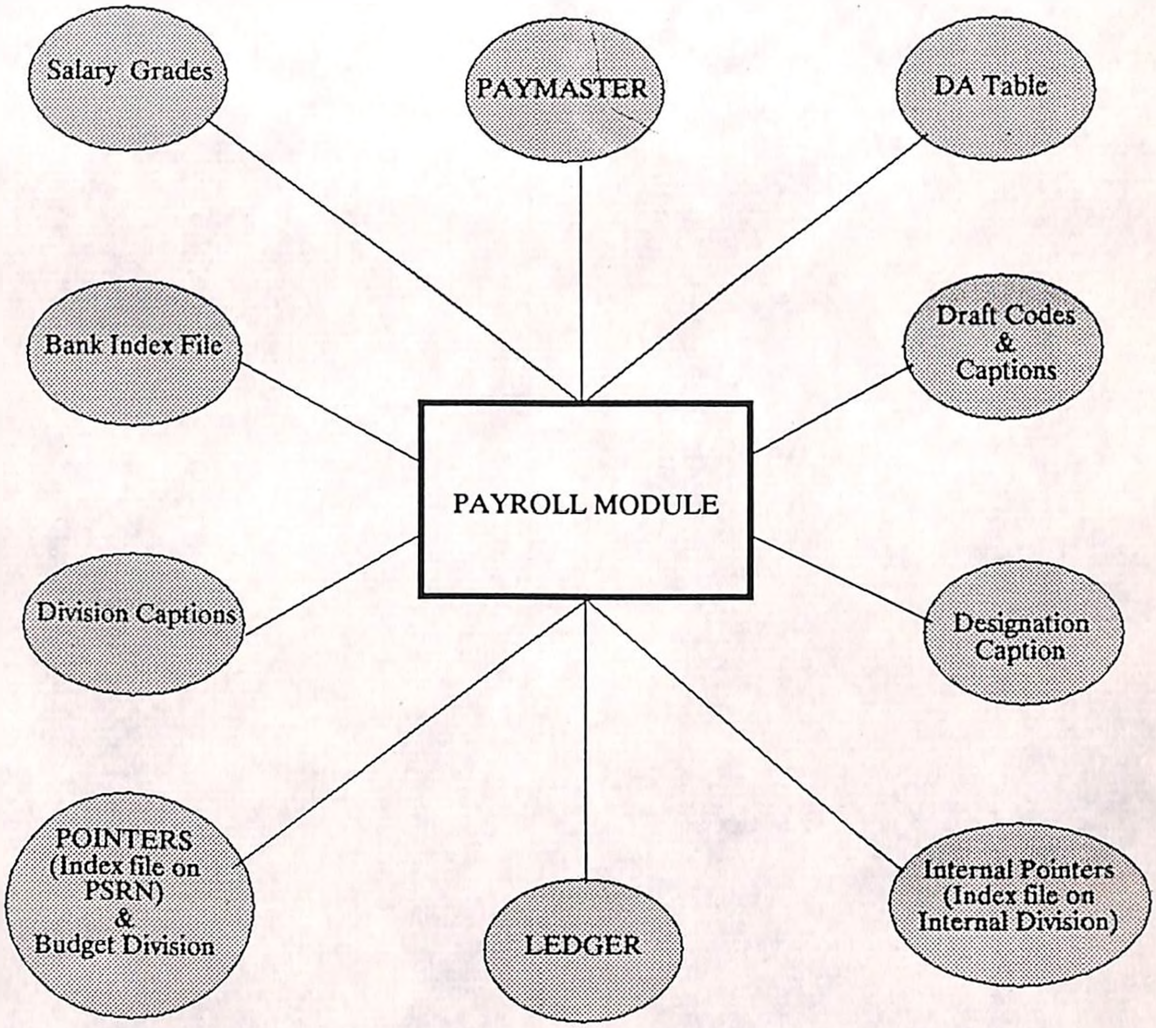


FIGURE 3.4

DATA FILES USED IN THE "PAYROLL" SUBSYSTEM

Salary Grades

PAYMASTER

DA Table

Bank Index File

Draft Codes & Captions

Division Captions

PAYROLL MODULE

Designation Caption

POINTERS (Index file on PSRN) & Budget Division

LEDGER

Internal Pointers (Index file on Internal Division)

(b) Modules concerned with computation of payroll

These modules, listed in Table 3.8, are the central computational ones that perform the computation of salaries; payments and deductions, ledger, etc. Given below is a brief discussion on some of the salient points of the design and implementation of these programs.

The PAYINIT program prepares the PAYMASTER data file for use in computation of salaries of staff during a month. Before any of the other programs can be executed, the PAYINIT program must be run. This program initialises the PAYMASTER data file, sets those fields within the record that are specific to each month processing, checks whether the staff member is due for any increment during the month; if so, calculates the increment due, sets the date on which the next increment would be due, and many such tasks. Naturally, this program should not be run more than once during the month; so there is built-in protection to avoid an incautious operator from running the program more than once.

The MAKESAL program, as the name suggests, computes the salaries of each "active" staff member on rolls according to the computational rules captured in the algorithm designed. One of the central tasks in this, is the calculation of deductions from basic salary, dearness allowance, etc. due to leave taken - either leave with half pay or leave without pay. Practical problems exists in reporting leave figures during the current month itself. Often the leave information is reported by the concerned controlling officers after a month or two. In certain extreme cases, deductions on account of leave have been reported after a whole year! There is nothing wrong with the reporting method; the said staff member could have applied for leave without pay while he was still on probation. Later on, after a year, when he became eligible for "half pay leave", the controlling officer in his discretion may recommend the conversion of the leave without pay earlier sanctioned to leave with half pay. This requires that the data on basic pay and dearness allowance (both may change over time) prevailing then to be present in the data file for proper computation. Storing the data on basic pay and dearness allowance for extended periods like a year or two in the data file is not feasible (i.e. not cost-effective). Thus, the concerned data entry program (LEAVES), apart from interactively inputting leave days, also seeks input on basic and dearness allowance in that month. Presently, the system designed can take only three such leave figures per month per staff member each in the leave with half pay and leave without pay categories. Experience in operation of this GRA shows that this limit does not impose debilitating restrictions.

The program MAKESAL also detects cases where total deductions are in excess of total pay leading to a negative net pay. This actually means that the staff member has to deposit that amount with the institute that is overdue. Since negative net pay figures would create havoc with the salary ledger calculations, the operating staff would have to reduce some deduction item to let the net pay become zero. This step is essentially manual (interactive), and the salary computation for this person has to be done all over again. MAKESAL, however, computes salaries for <u>all</u> active records in the data file. To avoid this, yet another version of the same program called MAKESAL1 has been designed. This enables one to compute salary for any particular staff member by inputting the PSRN.

After MAKESAL has been executed, a number of standard reports can be printed immediately. They are, for example, the cash, draft, and bank statements, statements on deductions like house rent, electriciy bill, etc., and the payslips. Before printing the salary ledger, however, one has to execute the ledger computing program designed (LEDGER). This builds the salary ledger for the month and stores the ledger on the secondary storage (floppy disk, in this case). It also builds a set of index files and pointers that enables faster access of records and speeds up ledger printing. The ledger printing program itself is menu driven which provides for unique startup facilities in case of power breakdown. This feature was added in view of the erratic power situation in this region (Pilani) and to avoid wastage in terms of computer time, stationary and to provide flexibility in operation - all in all, to provide for cost-effectiveness!

(c) Modules concerned with report generation

The payroll system requires a varietyof reports to be generated. The modules concerned with report generation are listed in Table 3.14. Given below is a brief discussion on some of the salient points of the design and implementation of these report generators.

Ideally, in any computerized information system, there must be only one general purpose report generator module. However, in this case, each individual report has to be generated by a specific program designed specifically to do this alone. Thus we have one program to generate each of these reports. Some operator convenience and user-friendliness could have been achieved if the entire spectrum of report generating programs were accessible through a menu driven module. Although not impossible to design, this task was not used as a design consideration since the computer on which it was to be implemented had a paltry 64 Kbytes of main memory. Menu driven modules of such a large number of report generators would require a much larger memory. A preliminary attempt at writing menu drivers using the CP/M BIOS itself was abandoned after a trial run.

This completes the discussion of the design and implementation of the payroll subsystem. Closely connected with the payroll subsystem is the Income Tax subsystem. The design and implementation of the income tax subsystem is described in the next section.

3.6.2 Income Tax

According to the Income Tax Act, tax for individual staff members will have to be deducted at source as part of the salary deduction. The calculation of income tax for those who fall in the taxable income bracket is actually a part of the larger payroll subsystem. In this design, the income tax module is considered as a seperate GRA. There are strong reasons for considering this module seperately.

(1) Not all staff members whose records are present in PAYMASTER data file fall in the taxable income bracket. Thus we need to consider and calculate income tax only for those who are likely to fall into the taxable bracket as per the prevailing income tax rules.

(2) A quick glance at the file structure of PAYMASTER (See Table 3.1) would reveal that there is virtually no space to accomodate fields connected with income tax even if we wanted to handle it as part of payroll. Therefore it was necessary to design and implement this module seperately.

(3) Furthermore, payroll has been designed and implemented on a 8 bit microcomputer with two 8" floppy drives each capable of storing 256 Kbytes. While one floppy is usually used to contain programs and utilities, the other floppy leaves only 256 Kbytes for data storage. If we were to redesign the structure of PAYMASTER to accomodate the files connected with income tax, we would require three physical reords (of 128 bytes each) for every logical record. Conceivably, the entire data would have to be split into two portions accomodated on two floppies. This by itself is not diffult to achieve; in fact, it is fairly straightforward. But the real crunch comes in redesigning the software. it should be recalled that we used the PSRN itself as the key to directly access the proper physical record. This provided a fast

method of direct disk record access. If we split the records across two floppies, the PSRN cannot be directly used to compute the physical record's position. We would have to use a table driven approach to access records. This is substantially slower. Furthermore, the operator will be greatly inconvenienced by having to swap floppies on the drive as directed by the software.

(3) Even if we were to use the approach of splitting the data across two floppies, writing back certain fields by the software on the floppy after floppy switching would not be possible. This because of a quirk in the version of the CP/M being used. CP/M treats any floppy that is swapped as an unusual condition and treats the swapped drive as a "read only" drive. Thus, any attempt to write back records on a swapped floppy would result in the infamous error message "OS error on R/O drive". This quirk has been corrected in later versions of CP/M, but was unavailable for this study.

(5) Admittedly, the above problems can be neatly sidetracked if the computer in question supported a hard disk with a larger storage capacity. But no such mass storage was provided in the configuration available, thus the design limitation in treating income tax as seperate from payroll system. This aspect is further refined in Chapter 5.

Design of File Structure

The income tax data files contain data on individual staff members like PSRN, name, division, total pay for the year, PF deduction percentage, and certain staff specific items like individual's Life Insurance Policy, National Savings Certificate amounts, etc. The files required in the income tax module is depicted as a schematic in Fig 3.5. The file structure organisations are given in Table 3.3. This shows that one physical record (128 bytes) is used for each staff member. The records corresponding to those staff members likely to fall in the taxable income bracket as per prevailing rules would be tagged in the file.

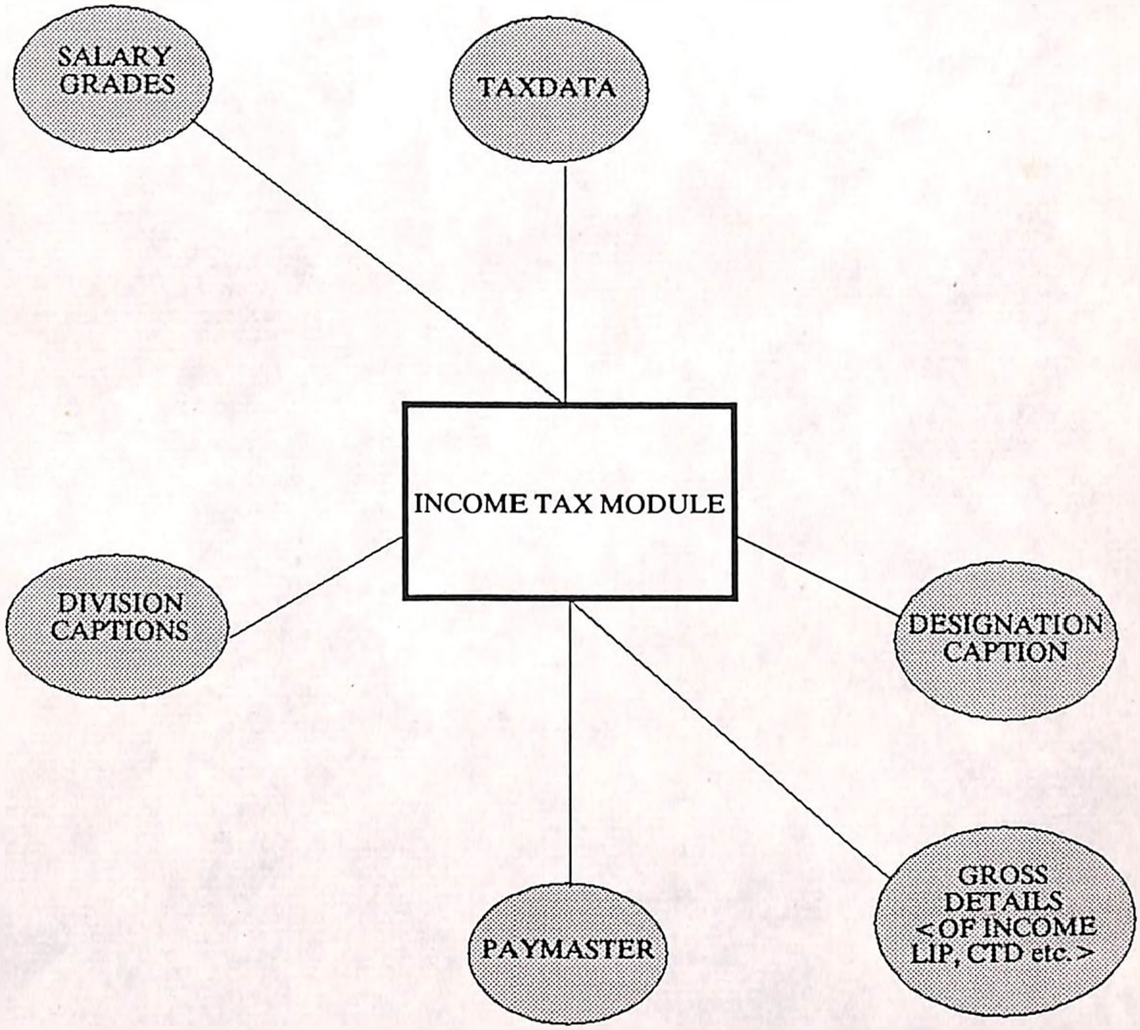
Design and Implementation of Software

At the beginning of a financial year, in the month of April, data records from PAYMASTER with relevant fields will be transferred to the INCOMETAX data file. Thereafter, data records corresponding to newcomers who join afer April would have to be loaded; fields like LIP amount, CTD amount, etc. would have to be updated according to requests from individual staff; income tax payable would have to be recalculated as updates are made; and finally the monthly tax deductionto be made at source would have to be posted in PAYMASTER.

A number of programs have been designed to carry out these tasks. Table 3.9 lists the various programs designed and implemented as part of the income tax subsystem.

FIGURE 3.5

DATA FILES USED IN THE "INCOME TAX" SUBSYSTEM



Given below is a brief discussion on some of the salient points pertaining to the design and implementation of some of the programs that constitute the income tax computation system.

* TRANSFER

It has been mentioned earlier that the INCOMETAX data file wiuld have to be initially created at the beginning of every financial year in April from the PAYMASTER file. A program TRANSFER was specifically designed to perform this task. This program transfers the relevant fields of income tax file already present in PAYMASTER creating a single physical record for every logical record. The total annual income is calculated taking into consideration any annual increment in salary that may fall for a staff member. Using the total estimated yearly salary, staff members who fall in the taxable income bracket as per prevailing rules are flagged in the data file.

* TAXUPDATE

After the data is transferred from PAYMASTER to the INCOMETAX data file, new records may have to be added as new staff join afer April, delete records as staff leave, and update certain fields on staff request such as CTD, LIP and NSC amounts contributed by him. A generalised update program that performs all these tasks has been designed (TAXUPDATE) and implemented. This program is highly interactive and completely menu driven.

* INCOME TAX

This program is an interactive and menu driven one that performs a variety of tasks. It enables computation of income staxes for staff members in accordance with prevailing tax rules (for all records flagged as explained above or for a particular staff member) and also prints out individual income tax assessment reprots (again for all flagged records or fro a particular staff member). The submodule of this program that incorporates the income tax caclculations and embodies the operation of pertaining to the existing tax rules is particularly vulnerable to changes in tax rules. Thus the submodule will have to be modified whenever changes are effected in the income tax rules. To facilitate easy modification and troubleshooting, the program segments that need to be changed are clearly indicated and the software itself documented well. A sample individual tax assessemnt form generated is given in Appendix A.

* SUMMARY

Providing for income tax deductions calculations at source for use by the payroll subsystem and printing indicidual tax assessment sheets (akin to payslips) is just one part of the activity. The administration, at the end of a financial year in March, is also required to file complete details of income tax deduction at source in Income Tax Form 16 of the Income Tax Act. To enable the administrative unit responsible fill these forms easily, a summary report is generated by a separate program. A sample summary report is given in Appendix B.

The next section discusses the design and implementation of yet another GRA, the establishment budget of staff.

3.6.3 Establishment Budget of Staff

It has been discussed in Sec 3.5.3 what an establishment budget of staff is, how it is prepared in the case of BITS and how important it is from the educational administration point of view. For clarity the following important characteristics of this GRA module is repeated below:

1. From the operational point of view, establishment budget of staff involves an orderly record keeping and updating procedure.
2. Estimation of the financial implications of sanctioned posts in the budget.
3. Estimation of the financial implications of having appointed staff in actual designation and salary grade against a sanctioned post.
4. Reporting to top administration on vital matters like "staff in position", vacancies, etc.

In fact, the establishment budget subsystem is (or ought to be) to source of all administrative concern. It is intimately related to the payroll subsystem. All salaries drawn by staff (as processed by the payroll subsystem) must be in accordance with the provisions of the establishment budget. We are forced to design this subsystem seperately for roughly the same reasons provided for the income subsystem in Sec. 3.6.2. Refinements to thise are discussed in Chapter 5.

Design of File Structures

The establishement budget consists of a main data file BUDGET and a number of inverted files. The various files used in this subsystem are shown in Fig 3.6. The BUDGET data file consists of 1 physical record (128 bytes) each for every post budgeted for. Currently, in BITS, 770 posts are budgeted for; thus BUDGET file consists of 770 physical records. Each budget record is identified by a unique integer in the range [1,770] called BSRN. The data items that would have to be stored in the file is given in Table 3.4.

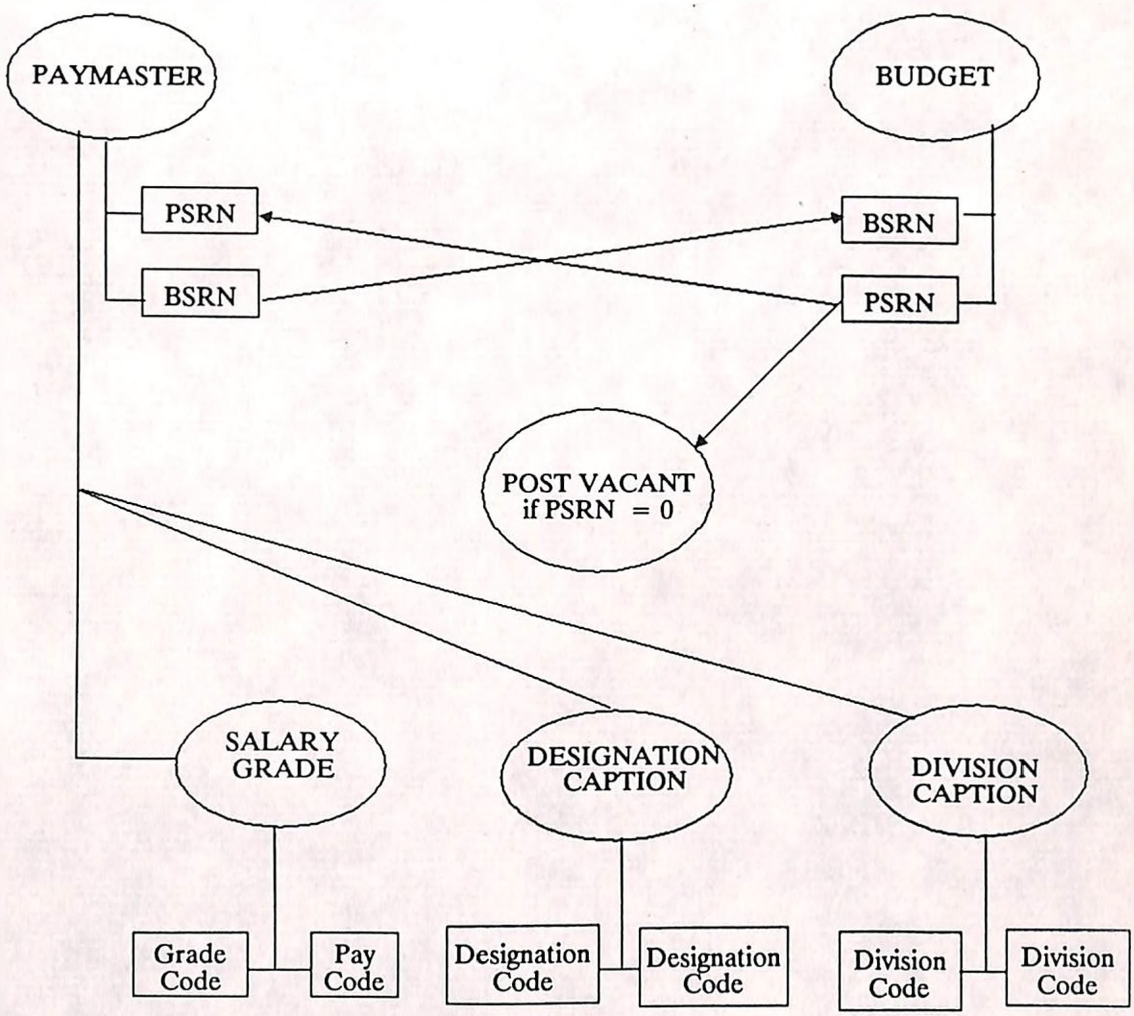
Note that the actual PSRN of the staff appointed against a post is stored as part of the record. A valid PSRN, a positive integer, implies that a staff appointed against the budgeted post at BSRN is drawing salary from payroll subsystem in logical record PSRN against the provisions of budget in thay BSRN record. This provides the vital link to the PAYMASTER file. Similarly, a BSRN entry in PAYMASTER provides the vital link to BUDGET file.

Record Access

The accessing of records in BUDGET are usually sequential with BSRN itself doubling up as the physical record number in the file. Sometimes random access of records in BUDGET is required when BSRN is used as the key item.

FIGURE 3.6

FILES USED IN THE ESTABLISHMENT BUDGET GRA



Design and implementation of software

The software for establishment budget subsystem comprises of a set of interactive, menu driven programs. These programs enable one to manage data in BUDGET file, calculate the financial implications of the establishment of staff, print the establishment budget, abd generate reports as are normally required by the administration. The programs comprising this subsystem are listed in Table 3.10. Given below is a brief discussion on some of the salient points of a few of the programs comprising the computerized establishment budget of staff.

* MAKEBUDG

This program is essentially designed as a menu driven one capable of handling the entire task of preparing the establishment budget of staff. Through this program one can initialise the BUDGET file to begin the record keeping activity afresh. It would be recalled that the PAYROLL file contains as data the BSRN which acts as a link to the BUDGET file. When the file is initialised the data on staff on rolls, i.e. appointed against a post can be directly transferred from PAYROLL. The MAKEBUDG program provides for this crucial faculty. Using the option to transfer data from PAYROLL to BUDGET fills all those records (posts) occupied by staff in position with the corresponding PSRN. The other records will have to be flagged as vacancies. The same program permits one to flag the vacant posts.

The MAKEBUDG program also provides an option for calculating the establishment budget of staff for a financial year. This is

TABLE 3.10

MODULES CONCERNED WITH ESTABLISHMENT BUDGET GRA

S.No.	MODULE	FUNCTION/REMARKS
1.	ESTEACH	Establishment budget of Teaching Staff.
2.	ESSUPP	Establishment budget of Support Staff.
3.	ESHELP	Establishment budget of Helping Staff.
4.	TDISP	Manages & prints tendring disciplines.
5.	CLIST	Prints courewise teaching list.
6.	SCOMP	Manages & prints special competences of Supporting Staff.
7.	HCOMP	Manages & prints special competences of Helping Staff.
8.	PENLIST	Mages & Prints list of pensioners.
9.	BSUM	Budget Summarizer.
10.	GATEACH	Analysis of Teaching Staff gradewise.
11.	GASUPP	Analysis of Supporting Staff gradewise.
12.	GAHELP	Analysis of Helping Staff gradewise.
13.	POSTEACH	Analysis of Teaching Staff in position.
14.	POSSUPP	Analysis of Supporting Staff in position.
15.	POSHELP	Analysis of Helping Staff in position.
16.	VACTEACH	Analysis of Vacancy in Teaching Staff.
17.	VACSUPP	Analysis of Vacancy in Supporting Staff.
18.	VACHELP	Analysis of Vacancy in Helping Staff.
19.	OPEXP	Reports operating expenses.
20.	INCMONTH	Reports increments of staff during budgetary period.
21.	MAKEBUDG	Menu driven program that manages all tasks of establishment budget
22.	BUDGUPDT	General purpose field updater for budget files.

TABLE 3.10 Continued)

MODULES CONCERNED WITH ESTABLISHMENT BUDGET GRA

S.No.	MODULE	FUNCTION/REMARKS
23.	PRNTBUDG	Budget printer with unique power font restart options.
24.	STATIST	Menu driven utility for performing routine analyses of budget.

usually done for a financial starting in April to be approved by the "finance committee". Yet another option in this program permits the user to print the establishment budget. Sample extracts from a printed budget are given in Appendix C.

* BUDGUPDT

It is required to correct or update certain fields of BUDGET file from time to time. For example, in view of a promotion, a staff member's designation and his salary grade might have to be changed. Circumstances and administrative actions would dictate certain fields to be corrected or updated. To cater to such needs, a program that permits the user to update virtually any field of BUDGET file has been designed. The key item use for update is the BSRN. The salient feature of this program is that the user has an overall control over the entire database. While updating certain elementary data validation checks are made before the file entry itself is updated.

* PRNTBUDG

While the MAKEBUDG program has an option to print the estbalishment budget, it must be noted that the entire budget would be printed. However, administrators may often require only a portion of the budget to be printed - PRNTBUDG is such a program that is designed primarily to cater to such needs. This menu driven program permits certain meaningful subsets of the budget to be printed. Thus, one can print the establishment budget of any of the categories of staff (Teaching and Academic, Supporting or Helping) or print the budget corresponding to a division. A salient by-product of this design is the ability to start budget printing without much loss of time when power failures occur.

* STATIST

This program is specifically designed to enable the administration to get crucial reports on staff in position, vacancies, etc. Samples of reports generated by this program are given in Appendix D. Incidentally, the reports themselves are of such a comprehensive nature that it provides in about nine tables a birds eye view of the establishment budget.

Apart from the above programs, a number of programs have been designed to cater to need based report generation and manipulation of the BUDGET file entries. Programs are designed to automatically validate the database and alert the operator when inconsistencies are detected. The programs themselves are reasonably well documented to enable easy modification when situations warrant it.

This completes the discussion on the design and implementation facets of softwzare for establishment budget of staff. In the next section the design and implementation of software for the last of the GRA's considered in this study, that of LTC claims and billing, would be discussed.

3.6.4 LTC claims and billing

Actually, LTC claims and billing is only a subset of the general claims and billing for staff benefits. Staff benefits include medical reimbursement, fee benefit scheme, loans for purchasing furniture, loans on PF account, special loans granted by the Director towards "special circumstances" like towards expenses of one's daughter's marriage, etc., rebate on annual purchased by staff from BITS COOP, and many others. Loans, medical reimbursement are already a part of the payroll subsystem. LTC claims and billing differ from these other benefits in certain respects:

1. The set rules and conditions that apply to LTC claims and billing are more complex than in case of other staff benefits.
2. The range of data required for claims verification and billing in case of LTC is much wider than in other staff benefits. Notably, claims verification require data on dependants.

3. The nature of computation involved is slightly more involved in case of LTC than in other benefits processing.

In view of the above, LTC claims and billing has been selected as a GRA from among the multitude of staff benefits for this study.

Design of File Structures

The set of data required for processing LTC claims have been given already in Table 3.6. It is evident that this should be considered for design and implementation of softwzare seperately. The same reasons ennumerated in Sec.3.6.2 for income tax subsystems hold here also. The structure of files are quite simple, they are mostly sequentially organised with PSRN acting as the primary key. Inverted files are used for storing captions of designations, divisions, etc.

Complex Nature of the LTC claims

Before discussing the design and implementation of software, it would be pertinent to bring out the complex nature of LTC claism. The other GRA modules discussed earlier had, by and large, fairly simple computational rules which enabled the design and implementation of software a reasonably straightforward task. The nature of LTC claims are extremely complex and this has a direct bearing on design of algorithms.

The rules governing the LTC oprations are given in the book of "rules & regulations". While the conditions governing the

TABLE 3.6

DATA ITEMS FOR THE LTC CLAIMS & BILLING GRA

S.No.	DATA ITEM	TYPE
1.	PSRN	Integer
2.	Name	Alphanumeric (15)
3.	Division Code	Integer
4.	Basic	Integer
5.	Designation Code	Integer
6.	Home Town declared	Boolean (0 or 1)
7.	Home Town	Alphanumeric (20)
8.	Distance to Hometown	Integer (km)
9.	No. of Dependents	Integer
10.	Name of dependent	Alphanumeric (15)
11.	Relationship	"
12.	Date of Birth of Dependent	Integers (dd/mm/yy)
13.	Sex	Integer
15-35.	Repeat of 10 to 13 above	For rest of dependents (Max. 5)
36.	To Distance to hometown (Road, Rail)	Integer (3 items)
37.	Return Distance from Hometown	Integer
38.	Class Travelled	Integer
39.	Total Claimed	Rs. Ps. Integer

* Other implicitly required data like fares, etc. are not shown here.

eligibility of a staff member using LTC are quite simple, the operational aspects of billing a claim leaves a wider scope. Given below are a few points that illustrate the complex nature of LTC claims.

* Complex claims can arise from the mode of travel adopted for the outward journey from Pilani. Essentially, the ruel merely states that one must travel by teh shortest route and claim road/rail fare according to the class in which he is eligible to travel (and has actually travelled). Thus one can travel by road from Pilani to Loharu aand then by rail to Delhi. Or alternatively he can travel by road to Delhi from Pilani. This by itself should not create any complexity. Except that is one is to travel 2000 km. altogether, he can easily claim that he travelled x km by road, the next y km by train in II class, the next z km by train in I class, and so on. Evidently the set of possible claims are endless.

* Claims for the inward journey, too, can be made piecewise in a manner similar to the one described above. The real difficulty in such cases is two fold:

  a. Because of piecewise reporting of mode of travel and class of travel, it is clear that one cannot set an upperbound on how many "pieces" the jounery has been completed. Thus, apriori, we have no way of allocating space in the LTC data file (LTCCLAIMS) to take care of all possinle piecewise claims. What is essentially required is a variable lenth file organisation. Difficulties that would arise in software design in case of variable length file organisation has already been discussed in Sec.3.6.1.

b. The computation of overall cost of travel by this piecewise method would be considerably difficult. For example, the rates for travelling the first 100 km by I class, the next 100 km by II class, and the last 100 km by I class is not (and should not) be the same as travelling the entire distance by either I or II class. The rate for the last 100 km by I class claimed would be an overestimated figure.

* Persons eligible to travel often claim fare by going through a circuitous route. Software designed must have the ability to detect claims that are not by shortest route and make a bill based only on shortest route. This requires that the database contain information of shortest route for all staff members whose hometown has been declared. Buidling up such a database is by itself a daunting task.

* Staff members often claim to have travelled by A.C.Sleeper II class, or by AC Chair Car while they are eligible to travel by I class. Software design must take care not to allow any claims to exceed that figure for I class travel.

* As a rule surcharge or charges on reservation on railway travel is inadmissible. However, the operational

administrative practice has been to permit claims on reservation charges if one is eligible for travel by I class but has travelled by II class. Software designed automatically to compute railway fares must then also be aware of what the reservation charges are and the number of nights the journey would take to compute sleeper charges.

* Staff members may embark on the outward journey together with their dependents. While claiming LTC fares, the staff member may only claim for a subset of his dependents and keep the rest in abeyance. This would impose considerable strain on the software designated to flag such cases in the data file.

And so the list goes on. A study of the LTC claims made in the last decade at BITS shows a bewildering variety of claims. The essence of computerization lies in algorithmising the procedures. Algorithms may not be designed correctly when the situations themselves are wide enough to be intractable. Thus, some rationalisation of rules governing LTC would be necessary. This would enable oen to make the variety of claims fall under a tractable, computable algorithm.

Given below is the discussion of design of software for LTC claims and billing considering only the common cases of claims. The software would relegate the extremely complicated claim to amnual verification.

Design and implementation of Software

The software system for LTC claims and billing comprises of a set of programs, each of which are highly interactive and meny driven. The various programs that are part of the system are listed in Table 3.11.

TABLE 3.11

MODULES CONCERNED WITH LTC GRA

S.No.	MODULE	FUNCTION/REMARKS
1.	LTCINIT	Creates & initializes LTC files.
2.	LTCLOAD	Menu driven data management module.
3.	LTCUPDT	General purpose LTC file fields updating utility.
4.	INTERACT	Interactive utility to specify routes used in travel.
5.	LTCCLAIMS	Menu driven module that manages, checks & evaluates individual's claims.
6.	LTCBILL	Modules that evaluates payables by shortest routes.
7.	LTCDIFER	Checks & prints discrepencies between claims and eligibilities.
8.	LTCSUMM	LTC claims & BILLING Summarizer.
9.	LTCPOST	Posts payable values to the payroll GRA directly on request.
10.	LTCCHECK	Checks consistency of LTC files.
11.	LTCCLEAN	Cleans up and salvages space on LTC disks.

As an LTC bill is received for processing the relevant data on travel details and monetary claims are entered as it is found in the claims proforma. The software checks the validity of the route undertaken. If the route undertaken is longer than permissbile by rules, the software computes the bill as permissible by the shortest route. Where the claims are complicated in nature, the software would only report that a manual processing has to be done.

3.7 Computerization of GRA - A Summary

This chapter considered some of the crucial Grass Root Applications in educational administrative that form the base in which sophisticated information systems ought to be built. The nature of data used in are so rudimentary that they readily suggest themselves for computerization. Systems analysis and behavioural specification of the GRA modules were presented in a fairly elaborate scale. The choice of machines and operating environment were discussed as it acted as a constraint to the design of the software. The major aspects involved in desinged of file structures and software are also discussed. No effort was made to arrive at an integrated solution on account of certain fundamental constraints prevailing at the time of the first effort at computerization. However, Chapter 5 of this thesis discusses the design and implementation of an integrated information system for human resources management. Many refinements, enhancements and sophistications which are built into the system are discussed in Chapter 5.

As mentioned in the beginning of this chapter, following the GRA are certain applications which are mainly in the realm of decision support. The next chapter discusses the nature, design and implementation of computerized information systems for decision support in education administration.

CHAPTER 4

INFORMATION SYSTEM FOR DECISION SUPPORT

4.0 PRELUDE

Computerized information system for Grassroot Applications lay the foundation for systematic record keeping, record storage and access. The importance of having sound computerized grassroot applications in educational administration cannot be overstressed. But a smooth, unchanging clockwork does not make for growth of institutions. Educational institutions, notably BITS, has to change constantly and adapt itself to changing environmental factors and pioneer its educational innovation. For BITS, change is a way of life. Wherever such changes occur, "decision making" becomes one of fundamental importance to educational administrators. And, invariably, information is required for the decision making process.

Having built a strudy foundation of a computerized information system for grassroot applications, developing an information system for "decision support" suggests itself. Recent literature on information systems is literally inundated with pathbreaking articles on Decision Support Systems. [J.H Tucker(1981), R.M.Tong et al(1983), P.G.W.Keen et al(1978), P.G.W.Keen (1981), Mintzberg H.(1975), Newman W.(1987), Nutt G.J. & Ricci F.A.(1981), Pilote M.(1982), Uttal B.(1982), Wohl A.(1982), Zisman M.(1977), Zloof M.M.(1981), Cyert R.M.(1981), Evan W.K.(1973), Kassimati K.(1978), Kluczynski J. & Kwiatkowski

S.(1977), Smith H.G.(1973), Theis G.N.(1974), Traegde S.C.(1971) and Wangsotorn T.I.(1974) are some of the selected articles that have appeared in the last two decades].

4.1 ROLE AND CRITICALITY OF DECISION SUPPPORT IN EDUCATIONAL ADMINISTRATION

The decision making function is considered a very vital function in all organizations. Educational institutions are no exceptions. It is also normal that the decision making process involves, among other things, the following activities connected with data:

(1) Data Collection

(2) Data Processing

(3) Information Analysis

(4) Optimization, Modelling, etc.

(5) Information Presentation

The activities of data storage and retrieval, processing and presentation forms the kernel of the decision making process. Information system for decision support is a set of procedures that, when executed, provide information for decision making and/or control of the institution.

Some of the objectives of having an information system for decision support are:

(1) Helps top educational administrators in innovation and strategic management

(2) To provide a flexible mechanism which responds quickly to the decision maker's queries, and,

(3) To provide for an analysis of "What if" scenarios.

It is not as if in the olden days that educational administrators were not performing functions of strategic managemnet and innovation in the absence of such information systems for decision support. Certainly the decisions were made rather slowly and awkwardly in the absence of information, or were rather conservative and not providing for bold educational innovativeness. By providing a computerized information system for decision support, it is hoped that top educational administrators car move boldly into areas of educational innovation with far reaching consequences than hitherto attepted.

Computerized information systems come in various forms, sizes and complexities. Often, the are customized to organizational needs than using a generalized set of procedures. Nonetheless information systems for decision support have the following characteristics in common across diverse organizations:

(1) they usually employ quantitative techniques of model building an optimization techniques,

(2) they usually provide for simulation and exploring unchartered areas,

(3) they provide for statistical analysis of data and summarization of information,

(4) they make a concerted effort to cater to semi-structured or unstructured tasks, and

(5) they are flexible and adptive to changing informational needs of the decision maker.

Computerized information system for decision support are especially useful when

(1) the database that exists is so large that the manager has difficulty accessing and making conceptual use of it,

(2) there is a necessity of manipulating data or performing some computation in the process of arriving at a solution,

(3) there is some pressure on time for arriving at the final decision, and

(4) there is a neccessity of judgement to decide upon available alternative by asking lots of "what if" questions.

It should be clear that decision support, then, is a major area of study within information systems with an emphasis on man-machine interface in relation to decision making process. Their role is to support a decison maker - not make decisons for him. In other words they should provide facilities that are useful in decision making. The facilities usually include data management capabilities for collecting, organizing, and processing data relevant to the decision problem, and modelling capabilities for developing computer-based models for analyzing decision problems.

From the mushrooming literature on decison support systems, we can summarize the various characteristics and role of decision support:

* Decision support systems are information systems whose focus is on decison making. In this sense, they are different from Electronic Data Processing (EDP) which focuses on Data. They are also different from Management Information Systems (MIS) which concentrates on Information.
* They rely heavily on man and machine working together for the decison making effort. In this regard, EDP relies on automating routine processes (See discussion of GRA in

Chapter 3 of this thesis). Of course, it must be admitted that in educational administration, decison support using computers is still in its infancy even in the developed nations and is mostly unheard of in most universities in India. Thus MIS, whose main function is to provide information that can be useful to educational administrators is perhaps more useful in such a context. As a matter of fact, in this thesis, we are considering the bulk of MIS functions for educational administration within the broader framework of decision support.

* Their functional capabilities are oreiented more towards supporting decision making activities through supply of vital information rather than solving decison making problems themselves.
* Thier focus is on improving the effectiveness rather than the efficiency of decison making by the educational administrator.
* Though information systems for decision support may be used for a number of structured problems of decision making in educational administration, they are more suited for semi-structured decision making problems.
* Information system for decision support tend to be extensible and evolve over time rather than being designed and implemented in a "one-shot" affair.

The foregoing discussion of the characteristics of information systems for decision support provided for a reasonable understanding of its role in educational administration. Educational administration, like other organizational activities or of human endeavour, involves data collection, storage, retrieval, processing and presentation to aid decision making. However, what is not obvious is the critical role played by information systems for decision support in educational administration. Below we give certain points which tend to show the critical nature of information systems for educational administration.

* Educational systems also involve certain activities in which decisions would have to be taken with a pressure on time. For example, consider a proposal to change, enhance and modify the salary structure prevailing in a university. Often cursory calculations are made, in most traditional universities, without making an attempt to analyse the effect of such changes in the long run. Usually other alternate proposals, however meritorious they are, are sidelined since performing quantitative comparative evaluation is considered an exercise in drudgery. Above all, in most traditional unversities, micro level record keeping itself is sloopy, redundant and erroneous; thus, making comparative quantitative estimates of a proposal as above would not be made. Under such situations, how do universities make decisions? Harsh though it may sound, decisions under such circumstances tend to be guided by "intuition" of a few administrators (which may be quite fallible), or are whimsical and adhoc (especially when the pressure on time mounts). In other extreme situations, the

decision problem itself is sidetracked, postponed or rejected despite possible merits in the proposal itself. It is precisely under such circumstances that computerized information systems for decision support comes in handy. Using computerized information systems for decision support, the educational adminstrator can work with well-organized micro level data, perform quantitative analysis of alternate proposals in an iterative manner which would not have been possible under face of time pressure.

* Computerized information system for grassroot applications certainly play an important role in systematizing record keeping and automating routine tasks of administration. But this is not enough in the case of a unversity like BITS where change is a way of life and educational innovation is a neccessity rather than a fancy frill. When the system itself is constantly undergoing a change, adptation to changing environmental factors becomes crucial. Decision support, rather than automated routine tasks becomes the focus of attention then. Thus, information systems for decision support is especially critical in institutions where change and innovation are normal, where adapting rapidly to changes in environmental factors is vital for survival, and where decisions would have to be taken after careful analysis without any scope for avoiding the problem itself. In fact, the only place where the criticality of decision support would be minimal is an educational institution where maintenance of "status quo" is considered efficient functioning.

* Sadly enough, information systems for decision support are considered necessary only in industries which transforms inputs into marketable outputs and where accountability is of prime importance. Much of the ailment of educational institutions may be traced to the pathological avoidance of measurement of performance and the paltry requirement of accountability. However, in educational institutions where resource position is a crunch and where innovoation has to be a necessity, the need for measuring performance of the system and the innovations made and the question of accountability cannot be scuttled through lame arguments that education involves transmission of knowledge that is not measurable and any requirement of suggesting accountability is a violation of academic freedom. In fact, the functioning of an educational system has a close resemblance to that of an industrial unit [See Mitra C.R.(1979)]. This analogy itself suggests that what is critical for the industrial system cannot be dismissed outright. Decision support does have a role to play in educational institutions and their role is at least as critical as it is in industrial units.

It would be quite possible to extend the arguments for showing the criticality of information systems for decision support. The foregoing arguments amply illustrate that the reaseons why they have been considered not so necessary in educational administration are mostly those arising out of resistance to change, lack of perception of the role of educational administrators themselves, and similar such untenable factors. The following sections would further reinforce the role of information systems for decision support in educational administration.

4.2 ELEMENTARY FUNCTIONS OF DECISION SUPPORT

It should be recalled that in Chapter 3 of this thesis, we stressed that decision support should be built on a broad base of grassroot applications. It is mainly because data collection, storage and routine processing would be covered, so that information processing for decision support may be made without having to worry about data management functions. The phrase "decision support" normally evokes an expression of awe in most persons who think of them as highly sophisticated design and implementation of complicated algorithms. Nothing can be farther from truth, really. In this section of the thesis, our main objective is to show that information system for decision support neither implies sophisticated design nor complicated algorithms to be used. Much of the decision making requirements of educational administrators tend to be quite simple collection, processing, collation and presentation of data, i.e. selective retrieval and presentation of information.

Hard though it may be to believe, much of the information required for decision making in educational administration emanates from the requirement of a "reminder service" for decisions to be taken on specific dates. The decision, for example, could be as simple as one requiring an educational administrator to take up the matter of extending or terminating the contract of a faculty whose term is expiring on a particular date. Or it could be that budgetary provisions have to be made in pension for faculty likely to retire at the end of a semester/year. Information for decision support of this kind is dealt with in the next section.

4.2.1 Information for Decision Support Emulating a "Reminder Service"

One of the simplest methods of providing information for decision support is to provide "reminders" to the concerned educational administrator of an impending activity on a certain date that requires his express attention. Examples of such activities are numerous in educational administration even in the small subset that is concerned with that of human resources, namely, the faculty. These are summarized in Table 4.1.

Admittedly, many of the activities mentioned in Table 4.1 require decisions which are quite simple to arrive at. But the relevant information required for arriving at a rational decision in each of the cases is more complicated than what the Table 4.1 would have us believe. Many factors hamper the smooth decision making in the absence of information system, even in this supposedly elementary case of requiring decision support. Some of these factors are outlined below:

TABLE 4.1

ACTIVITIES THAT REQUIRE "REMINDERS" FOR CONSIDERATION OF A DECISION BY AN EDUCATIONAL ADMINISTRATOR

Activity	Information to be given	Decision (likely)	Administerial Level
Completion of 1 year of service	Date of Joining Nature of Appointment;Pay	Permission to join the PF Scheme;	Middle
		Confirmation of Service	Top
Expiry of Term in an ad hoc appointment	Date of expiry of term; qualifications & discipline of staff; etc.	Extension	Top
Expiry of Contract	Dates of Joining, birth, designation pay, academic performance	Promotion Fresh tenure	Top
Superannuation	Date, Service length, pay, PF, etc.	Clearing accounts	Middle
		Reappointment	Top
		Provision of pension	Middle & Top
Acquiring Higher Qualification	Degree, date, designation, pay details	Promotion	Top
		Review of nature of appointment	Top
Advances & Loans overdue	Dates, amounts to be recovered	Administrative action to initiate recovery	Middle mostly; Top involved

1. As is clear from the activities presented in Table 4.1, many of the activities involve a systematic recognition of the impending date of an activity. This itself would require the middle level educational administration having meticulous record keeping practices, adequate manpower to wade through multitudes of files to yank out the necessary information required for decision, and above all, a throughly routinized system of detecting dates of such impending activities. It should be clear that the task would be quite gargantuan if done manually by the clerks in a traditionally organized Registrar's Office (the place where traditionally universities keep their records and from where such reminders emanate). Even the best organized Registrar's Office would more likely wilt under the pressure of time and perform inadequately in relation to supplying the administrators with information for decision support.

2. Decision support function, at the middle level too, very often is not completely specified in terms of its data processing and information requirements. Even if it were reasonably well specified, the information retrieval requirements may be such that a clerk may have to refer to several files and do a fair bit of derivation of his own. Thus the data retieval volume itself may be very high and require several cross referencing across files that may be well near impossible to manage under pressures of time. It is not uncommon that in traditionally managed institutions, such information retrieval requirements are either ignored outright or imprecise information (gathered from truncated

data) is used compromising the decision support function. Computerised information systems for decision support, on the other hand, facilitate easy retrival of information and makes compromises in face of pressure of time or in face of voluminous data processing requirements.

3. Manual retrieval of information and reporting for decision support involves, among other things, location of relevant data, processing, collation and typing of the derived information to be given to the decision maker. Evidently, the procedure is very laborious, slow, repetetious and often very error prone. As a result, the human resources involved in this function tend to become rigid in their postures of working with very little motivation to move towards better methods of functioning, and ultimately compromising on efficiency. Personnel involved in this function find the job an unpleasnt chore despite its challenging nature and its vital role in decision making. Computerised information systems for decision making enables the improvement in the functioning of the same human resource without ang compromise in efficiency of functioning by removing the lement of drudgery from the job.

The so called "reminder service" function is a very vital one in any administrative setup, but unfortunately has acquired a somewhat derogatory role in the decision support function. It is only because of a precise and reliable reminder service that many decisions become routinized and the system works smoothly. It is only becuase of reminder service that timely decisions are taken in a routine manner, thereby releasing vital manpower to engage themselves in other hitherto neglected areas of educational administration. Above all, an efficient reminder service enables all administrative decisions to be taken well within time and easily; this creates an environment in which the other employees (not necessarily administrators) are motivated to perform their activities within a time frame. In other words, it sets an excellent example to others in the system by floating the message that time is an crucial element in the working of the system.

A program called DATFLASH has been designed and implemented which would be run every month. The program checks through the entire database for all "reminder" activities mentioned in Table 4.1 and produces a report to aid in the decision making process. Apart from mundane reporting of activities that require reminders for consideration of a decision by an educational administrator, the DATFLASH module of decision support also provides for interactive querying of the database for activities based on dates. Personal interviews with clerks in the registrar's office at BITS has revealed that this function of "dates management" and "reminders" has been one that has occupied roughly 40% of a clerk's working time. For non-routine queries based on dates, the manual process was found to be extremely slow, laborious and error prone. When the DATFLASH module was introduced in the actual working environment, even the skeptical clerks were impressed with the ease with which a mundane, laborious, but yet vital function can be carried out.

4.2.2 Information for Decision Support on "Eligibility Check" Functions

Yet another vital, but simple method of providing information for decision support is through a set of procedures for checking the eligibility of a claimant for a particular benefit or consideration. Usually, in most organizations, an application is made for consideration of the award of the benefit. In educational institutions, the application is routed through the registrar's office where the eligibility of the claim (or "permissibility" of the award) is checked against various data in files and applicable rules and regulations. This requires retrieval of data and processing them as per applicable rules and regulations. This seemingly simple task often proves quite difficult in practice for several reasons. Some of these are listed below.

* Disorderly record keeping practices that either lead to incorrect decisions or postponement of the decsions over extended periods of time.
* Incorrect and/or partial understanding of the rules and regulations to be operated to check the eligibility of the claims.
* An undue emphasis on precedence that requires mentally checking a large number of similar claims made in the past and the decisions made thereof.
* Inability to stick to a mechanical rule checking procedure that would have allowed for a uniformity in the decisions and often swayed by personal convictions of the operating staff.

TABLE 4.2

DECISION SUPPORT ON ELIGIBILITY CHECK FUNCTIONS

Benefit Item	Eligibility Check	Level at which decision is made
Joining PF	Three months continuous service; Completion of period of probation	Middle; Recommendation of controlling officer
Institute's contribution to PF	Five Years of service	Middle
LTC	One year service; Hometown declared; Claim falling in block year	Middle
Travel reimbursement	Class of travel depends on salary grade; Sanction	Middle
Dearness Allowance for outstation jobs	Depends on salary grade; place of work	Middle Prior sanction
Medical reimbursement	Type of appointment; Dependent or self	Middle
Fee Benefit Scheme	Type of appointment For self or dependent Satisfactory performance	Top
Membership to RAF	Self or dependent; Resident with staff	Middle
Membership to Staff Association	Teaching Staff; salary grade	Middle
Furniture Loan	Confirmed appointment; Item asked for; salary	Top
Loan on PF	Valid reasons; No loan outstanding; salary	Middle
Pension	Length of service; Type of appointment; salary	Top

Since these eligibility checks lead to decisions regarding permissibility of staff availing of a particular benefit or not, it is imperative that these decisions are made swiftly, correctly and in a uniform manner. The various types of eligibility check functions that are usually made in a university environment are listed in Table 4.2.

It is quite clear that many of the information that is required for decision support on the eligibility check functions are based on data used by the GRA and need only very simple rules to be operated. These information system modules, despite their apparent simplicity, do bring up several tricky issues that have great bearing on the cost-effectiveness of the implementation. Some of these points are discussed below.

* Many of the eligibility check functions require only a subset of the data used in the GRA (discussed in Chapter 3 of the thesis). Therefore, to build up information system modules for decision support of the "eligibility checking" type is a fairly straight forward process. It must be stressed strongly at this point that the various individual items that form the decision support function are not ennumerated by the users (i.e. the educational administrators) once and for all. Rather, they tend to evolve with time. More decision support functions would be sought for by the educational administrators after some experience at working with existing ones. Thus these decision support modules, of necessity, would have to be incrementally designed, developed and delivered. This is consistent with one of the prime

contentions of the thesis that it is the evolutionary delivery method that is most appropriate for design and development ofcomputerized information system for educational administration. Also, since these decision support modules are implemented at the behest of the direct users, extremely simple, frivolous and esoteric modules do not figure in the development process. This contributes to cost-effectiveness of the developmental process.

* Information systems for decision support that require more data than is present in the GRA would present a few problems. The first of the questions is "where do we maintain those extra data?". There are two straight forward choices, each with their own merits and demerits. One is to expand the primary data base used for the GRA and accomodate the extra data needed for the decision support modules. This means that many of the data management modules connected with the GRA would require modification, enhancement and maintenance. It has already been stated that maintenance and enhancement costs tend to be quite high. [See Arthur L.J.(1986)]. Further, tampering with a smoothly operating GRA to provide for the extra features may introduce complications and bugs that would entail heavy costs in the long run. The second method is to create a secondary data base consisting only of the extra data item the GRA would require modification, enhancement and maintenance. It has already been stated that maintenance and enhancement costs tend to be quite high. [See Arthur L.J.(1988)]. Further, tampering with a smoothly operating GRA to provide for the extra features may introduce complications

and bugs that would entail heavy costs in the long run. The second method is to create a secondary data base consisting only of the extra data item a very interactive environment. Interactive environments often conjure up visions of decision makers with terminals or graphical workstations at their desks. The decision makers are not persons intimately connected with computers, therefore the interface must be friendly. The choice of a suitable user interface is critical as it affects the cost-effectiveness of the information system development.

* A related problem is one of the hardware and the environment in which the information system is developed. Software development tends to become complex when the information system is sought to be developed in a multi terminal environment. It becomes further complex when it is sought to be developed in a LAN environment. Software complexity is lowest when the system is implemented in a single user environment. Since the concern with the thesis is to develop a cost-effective computerized information system, it is evident that solutions involving complicated hardware and complex software systems ought not to be chosen.

The decision support modules are normally designed and implemented with the end user (i.e the decision making educational administrator) in mind. But the reality of the situation in many universities is that educational administrators seldom interact with a computerized information system directly. This certainly takes the punch out the interactive usabilty of the computerized information system decision support modules. Some computerized decision support can always be given in the form of a centralized cell performing the job of running the appropriate program and obtaining a hard copy of the decision support information. Compared to the solution that requires remote terminals at the decision maker's desk or the use of LANs, the hard copy solution is technically primitive. However, it is relatively easy to implement and operate in an environment where educational administrators are still shy of handling computers directly. Above all, such a solution involves the least cost of development since it requires no sophisticated hardware, no complex software systems to be developed, no complicated training given to educational administrators. The hard copy solution is quite primitive technically but does retain the flavour of a computerized decision support environment.

At BITS, the decision support software modules listed in Table 4.2 are implemented as add ons to the GRA (following the evolutionary delivery method) and is of the hard copy type of a primitive implementation (following the maxim of cost-effectiveness of development). Interactive decision support is provided in the computerized information system, but it is normally not used by the educational administrators directly. They can be however used with the help of the staff at the Computer Assisted Housekeeping Unit at BITS. Since the implementations at BITS are in a single user environment, this is the only feasible alternative if cost-effectiveness is one of the primary concerns.

Some of the implementation experiences connected with the decision support modules of the eligibility checking type are discussed below.

* The data items required for decision support of the eligibility checking type were predominantly found to be part of the GRA itself. Those extra data items found necessary to carry out eligibility checks were incorporated in additional databases in the first instance. This, naturally, created some problems of integration. The integration aspects will be discussed in Chapter 6 of this thesis. The advantage of maintaining the extra data items in additional databases manifested itself in the form of rapid development of these software modules. Thus the development, coding and testing phases of this part of computerized information system was cost-effective as less man hours were spent in these phases.
* Certain rules for eligibility as stated in the rules and regulations were found to be quite difficult to be converted into an algorithmic form. The solution that would be ideal under these circumstances would be that these rules are rationalized and simplified sufficiently so that an algorithmic way of checking the rules would not be unduly complex. However, rationalizing and simplification of rules are not easily achieved in many universities. It requires administrative maturity, cooperation, initiative and will that are seldom realized within the development phases of the computerized information system. The BITS experience showed that top educational administrators were always willing to

make simplifications and rationalizations in the rules to facilitate easy development of the computerized information system.

* The eligibility checks were performed in modest environments like a single user micro and using no flashy user interfaces. Costs were thus kept minimum. As far as possible, the hard copy mechanism was employed to set the decision support module in action. At the same time, a few computer operators were trained in operating these modules for interactive decision support if required by the administrators. The strategy was to get the modules up and running with least costs incurred. Sophistications and extravaganzas were left for future enhancements to be taken after feedback was received from the use of the usable modules.

The "reminder service" and "eligibility check functions" thus form some of the most elementary decision support services in the computerized information system for educational administration. By far the most popular mechanism for decision support that finds favour with administrators is the one that supports "what if" scenario analysis. This is discussed in the next section.

4.3 INFORMATION SYSTEMS SUPPORTING "WHAT IF" SCENARIOS

Educational administrators would often like to analyze the impact of a particular decision in their planning process. One of the simplest ways in which the immediate impact of a decision on the overall well being of a system may be analyzed is through the "what if" scenarios. Accountants and financial managers have always been working on "what if" analysis towards tuning the various aspects of an organization. Spreadsheets like Lotus 1-2-3, Visicalc, Supercalc, etc. all provide scope for "what if" analysis. An elementary example of how "what if" analysis manifests itself in educational administration is as follows.

In most universities, the dearness allowance paid to the staff has to be revised periodically. The top educational administrator would like to know the extent to which a particular increase in the DA rate would affect the university's budget. Typically, he may like to know by what levels the operational expenditure would increase by due to an increase in the DA rates by, say, 8%, 10%, 12%, etc. Software modules of the computerized information system that provide for such type of analysis are said to provide decision support of the "what if" variety. Following the elementary reminder service and elgibility check functions, the "what if" analysis provides decision support to the educational administrator by letting him experiment with various scenarios and arrive at an "information based" decision.

The data requirements for carrying out decision support of the "what if" kind often do not extend above that of the data requirements for GRA. That is, a computerized information system that has its strong foundations on well established GRA would already have a majority of the data that this type of decision support would need. It is, indeed, the case with the computerization effort at BITS which started off with strengthening its GRA before going on to decision support. Thus, development of the software modules for decision support of this kind may be treated as "independent" tasks built upon the GRA. This was in fact facilitated by a conscious choice of following the evolutionary delivery scheme in the software development process.

Insofar as computerized information system for educational administration that concentrates on faculty based records only, it must be admitted that the bulk of the "what if" analysis would be based on financial data. Table 4.3 shows the various types of "what if" analysis provisions that have been made in the computerized information system that has been developed for BITS.

The following are some points of discussions that are pertinent towards the design and development of the modules concerned with "what if" type of decision support.

* The software modules concerned with decision support of the "what if" kind must ensure that the primary databases (which are usually used for GRA) must not be modified. Thus "read only" access to the databases of the GRA alone need be specified. In this way the integrity of the databases concerned with GRA are vouched for.

* Testing and validating the modules concerned with decision support need to be restricted to the alogithms mainly, as the GRA databases are not modified at all. Cost-effectiveness of the development of these modules are higher since these are modules are less complex and are easier to validate.
* Where a large portion of data has to be input to the software modules concerned with decision support of the "what if" kind, the thesis has used scratch, temporary databases, instead of tampering with those that are concerned with GRA. Thus, the routine operation of the GRA modules is not affected at all by the development of modules for decision support in an add on fashion nor by operation of these add on modules. Thus, the development of these modules do not pose maintenance problems of the GRA, thereby making it a cost-effective implementation. (It has already been stated that maintenance costs are the highest in any product development).
* Since the evolutionary delivery method is followed, there is no need for the educational administrators to state all types of "what if" analysis that they would like to be provided for right in the beginning of the computerization effort. At BITS, the various modules of decision support surfaced based on needs of the educational administrators from time to time in an evolutionary fashion. This enables rapid development and testing of prototypes. Prototype software development is inherently costly, but since these modules are developed in an evolutionary fashion, the prototypes are not strictly throw away, but are reusable modules. Thus, costs of development and testing are pegged at low levels.

* It is evident that the "what if" analysis are best done by the educational administrator himself, interactively handling the computerized information system for decision support. As already stated in this thesis, this requires a very sophisticated and user friendly interface. This usually tends to hike up the costs of the development process, as specialized equipment, sophisticated software tools, longer development cycles and involved training are all needed. Usually the design and coding phases also tend to be long, and hence more costly. Our primary concern is to achieve a working computerized information system delivering the ability of decision support for the educational administrator in a cost-effective fashion. This rules out employing costly hardware, expensive tools and allowing for the luxurious longer development cycles. Most organizations would abandon provision of these decision support modules under such severe cost constraints. The BITS experience shows that cost-effective decision support modules can be provided using modest hardware, passable tools and with rapid prototyping. For example, all the "what if" modules listed in Table 4.3 were developed and tested within 45 man days.

* The modules listed in Table 4.3 are mostly provided with a hardcopy provision. But limited interactive facilities are built into the various modules. They are "limited" only in the sense that they do not engage the user interface extravaganzas like pull down menus, overlapped and split windows, and icons. A functional user interface is all that is needed in most situations, and that is all that has been provided.

TABLE 4.3

MODULES FOR DECISION SUPPORT OF THE "WHAT IF" KIND

MODULE	FUNCTION
CHANGEDA	Permits analysis of financial implications due to changes in DA structure.
PROMOTE	Permits analysis of financial implications due to changes in individuals Salary Scales due to promotions.
WHATPEN	Permits analysis of pension liabilitie in future.
WINDFALL	Permits analysis of financial implications due to changes in fundamental Salary Scales and calculate arrears payable to faculty if done with restrospective effect.

4.4 INFORMATION SYSTEM FOR DECISION SUPPORT IN THE FACULTY REVIEW PROCESS

Periodic review of faculty is one of the main functions of the top educational administrators that has to be completely information based and the decisions scientific. Information regarding the employment status, academic performance, administrative work undertaken, etc. are to be presented to the top administrators in various collated forms so as to aid in the decision making process. Reports of various forms involving a myriad information are sought for by admnistrators. Specific queries arise based on certain attributes sought to be examined by the administrators. All in all, it is a complex process involving generation of a plethora of reports, collating and organization of information, and performing certain simple statistical analysis.

The review process at BITS is considered to be one of the most scientific methods employed in universities and is highly information based. Some of the reports sought for by administrators for decision support in the review process are lisited in Table 4.4.

The data required for the modules that generate the reports mentioned in Table 4.4 are mostly available in the databases concerned with GRA. There cerainly are a large number of extra data items that are not used in the GRA, but are required in the decision support modules. This is somewhat different from the extra data requirements encountered for the decision support modules discussed in section 4.2 and 4.3. The modules in sections

TABLE 4.4

REPORTS SOUUGHT FOR DECISION SUPPORT IN THE FACULTY REVIEW

S.No.	REPORT	REMARKS
1.	Employment Status	Report of faculty as per employment status, viz., Permanent, contractual, Term Appointment, etc.
2.	Designation wise	List of faculty designation wise viz. Professors, Associats Professors, etc.
3.	Salary grade wise	List of faculty Salary gradewise.
4.	Joining dates	Report of faculty in order of Joining dates to give an idea of length of service.
5.	Superannuation	Report of faculty likely to Superannuate in near future (Specified periods).
6.	Max-chaps	Report on faculty who have reached the maximum levels of their designated salary scale.
7.	Personal-Grades	Report of Staff who are on personal salary grades.
8.	In_position	Report of staff in position vis-a-vis establisment of positions.
9.	Vacancy	Report of vacancies in posts as per establishment budger.
10.	Teaching_Disciplines	Report of faculty and their involvement in teaching disciplines.
11.	Course_wise	Report of faculty who have been involved in specific discipline courses like BIO, CS, CHEM, EEE etc.
12.	Special_competence	Report of Supporting Staff and their Special competences.
13.	Helping_skills	Report of helping staff and their special skills, if any.

4.2 and 4.3 required extra data that is of a relatively small magnitude. They were small in magnitude in the sense that either they could have been interactively input to the software modules or could have been entered in temporary scratch files from time to time. Such is not the case with the extra data requirements for these decision support modules; the extra data requirements are not only large in magnitude but have to be present for access as part of every faculty's record. So these data items would have to be stored in appropriate databases and updated regularly, even though their frequency of use is somewhat limited. Maintenance of satellite databases is implementationally a simple choice, but poses some problems for integration. It has been cost-effective in the early stages of the development of the computerized information system since it involves isolated development of the modules building on GRA. But the integration issue is a thorny one and is discussed in Chapter 5 of this thesis.

Use of the computerized information system for the faculty review process is one of the most concrete examples of its use in decision support. It involves no sophisticated hardware (only a PC), no complicated developmental tolls (only an inexpensive database management system) and no user interface extravaganzas (only hardcopy reports and functional interaction). Thus it is an example of a concrete set of modules that are developed in a very cost-effective fashion.

4.5 INFORMATION SYSTEM FOR DECISION SUPPORT OF THE OPTIMIZATION TYPE

Optimization exercises form a very important part of strategic planning in educational administration. Decisions are consciously sought with optimization as the prime requirement. In educational institutions, optimization exercises take various forms. Educational administrators may be interested in budgetary optimization, optimal resource allocation, space optimization, optimal laboratory equipment utilization, etc. This thesis deals mainly with computerized information system for educational administration with special focus on faculty related information. Thus this section will only deal with information system for supporting decisions of the optimization type connected with faculty as the prime entity.

Any optimization work is essentially based on strong numerical data. Therefore information system for decision support of the optimization kind requires the strong foundation of databases in the GRA. Further, the end users, namely the top educational administrators must be involved at every stage in the development of such decision support modules. Adelman L.(1982) considers the involement of end users in the development of decision support aids as one of the principal factors for successful implementation. Bennett J.L.(1983) contains a series of articles that stress the importance of a broad base of data and the intimate involvement of end users. Carlson E.(1977) presents a scenario where managers themselves develop decision support aids through personal computing services. Hamilton W.F. &

Moses M.A.(1974) discusses optimization issues in a corporate planning system. King W.R. & Clelland D.I.(1973) identify optimization aids as one of the central features of information systems for strategic planning. The literature is surfeit with articles that stress optimization as the central theme in computer based strategic planning aids.

Organizations that work in commercial environments are forced to optimize the use of their resources and show ever increasing performance trends. This situation, sadly, does not happen in the case of universities. Most universities pay scant regard for optimized use of their resources (they are scarce), show increased performance (through better dispensation of knowledge and research output) or are driven by a competetive urge to function in an optimized manner. Mitra C.R.(1982) has proposed that educational institutions must also function in an anologous manner of production units in the sense of optimized planning and execution of its activities. In Indian universities, the urge to go in for optimization does not make itself prominent since most universities are liberally funded by the Government of India and optimization is farthest from the minds of such administrators. As a consequence, decision support of the optimization kind has not received the attention that it dererves.

Like in many other aspects, BITS is a case in exception. It is privately funded and has based all its educational innovations on optimized use of scarce resources and a conscious effort to show improved system performance. Its functioning is quite anologous to the that of a production unit in that budgetary optimization, optimal resource allocation, etc. have been accorded due imprortance. At the time of writing this thesis, BITS has certainly recognized various areas for optimization. Some of these areas where optimization exercises may be performed are listed in Table 4.5.

The data requirements for the development of the software modules for those mentioned in Table 4.6, in the case of BITS, is taken care of by the strong databases that underly the GRA. Since the development will be a sort of an "add on" module, it follows the evolutionary delivery method. The manpower and hardware deployment, too, does not extend beyond that used in the development of GRA. Cost-effectiveness of the development can be thus maintained. These modules have not yet been implemented since administrators have to participate actively in the process, and at present they are still gaining operational familiarity with the GRA and simpler decision support modules.

Many authors consider that the real decision support ought to emanate from modelling and the use of simulation. These aspects will be discussed briefly in the following section.

TABLE 4.5

AREAS OF DECISION SUPPORT USING OPTIMIZATION METHODS

S.No.	AREA	REMARKS
1.	Faculty Recruitment	Tune faculty recruitment with that of teaching research needs and budgetoring constraints.
2.	Faculty Deployment	Deployment of faculty towards various academic administrative tasks with a view to minimize costs.
3.	Course Offering	Optimization of faculty use towards wider course offerings.
4.	Time Table	Optimization of available working hour towards course offering subject to constants like faculty availability and timing, class room, and other constrants.
5.	Space Utilization	Towards better space (Classroom and lab) utilization.

4.6 INFORMATION SYSTEMS FOR DECISION SUPPORT INVOLVING MODELLING

The use of mathematical modelling and simulation are powerful techniques that may be used to arrive at decisions in a scientific manner. Chapter 2 surveyed a few doctoral theses that were concerned with the use of modelling and computer simulation for educational administration. In Indian universities the database itself is so poorly maintained that exercises at modelling and simulation can be at best ad hoc efforts. Theoretical models for decision making in a university set up have been proposed widely.

Moser C.A. & Redfern P.(1965) sketch a computational model of the British eductional system and manpower planning. Stone R.(1965 and 1966) proposes the use of Leontief type of Input-Output matrices for educational planning. Davis R.G.(1966) has surveyed various models, techniques and computational methods for planning human resource development. The OECD Technical Reports of 1967 is a volume containing eight papers on mathematical models in educational planning. Holtmann A.G.(1968) develops a short term planning model for high school districts in the USA using linear programming. Plessner Y. et al (1968) is a parametric linear programming model that determines the optimum number of students in each degree program, the allocation of staff between teaching, research and administration, the allocation of teaching time between undergraduate and graduate courses, and the optimum allocation of resources to new faculty. Markov chain models are used in the works of Psacharopoulos G.(1969), Armitage P. et al (1969) and Johnstone J.N. & Philip

H.(1973). Many manpower forecasting models have been developed for use in educational systems. Linear and dynamic programming models have been used by Bowles S.(1967), De Voretz D.J.(1969) and Benard J. & Versluis J.(1974).

Joshi N.C.(1970) explains ways in which accounting data can help in taking management decisions. It suugests a strong financial database and use of statistical techniques.

Despite the abundance of models that have been proposed, the majority of the studies have been isolated efforts in the sense that the use of models is not integrated with the ongoing administrative activities nor with the normal decision making process. What we are envisaging in this thesis is not the use of these models in a sporadic fashion, but an integrated use in the educational administrative set up. Development of software modules to accomodate modelling and simulation must be done in an unhurried manner to be able to integrate the use of the modules with the entire computerized information system for educational administration.

4.7 SUMMARY

The modules of computerized information system that would be of prime interest to middle and top educational administrators are those of the decision support variety. Apart from reducing the tedium of performing the chores required for systematic decision making, these modules permit for an information based decision making. Timely and scientifically analyzed decisions contribute to organizational health. These modules of decision support require an exhaustive database which would be possible only if the computerized information system has the strong foundation of GRA.

The additional data required for the decision support function can either be integrated with the primary databases or maintained separately. The former has the advantage of binding the various modules in a tightly knit fashion, but is costly (in terms of development time) to build. The latter is cost-effective (again in terms of development time) since it is based on the evolutionary delivery system building upon strong GRA, but tends to make integration difficult. The integration aspects of the computerized information system will be discussed in the next chapter.

Decision support functions need not always be enormously sophisticated in terms of use of complicated mathematical models, simulation and optimization methods. Decision support can begin form extremely elementary functions such as a reminder service for administrative actions. These functions are quite simple but are vital for the smooth functioning of educational administration. Most commercially available software for decision support (PRISM, RISK, ACCENT R, EMPIRE, EXPRESS, SIMPLAN, etc.) concentrate on use of modelling and simulation, but ignore simple but vital functions of decision support. This chapter discussed the progression of developing decision support modules on top of the GRA, from simple functions like a reminder service to rules checking to optimization to use of models and simulation. Cost-effectiveness of developing these software modules were ensured through the use of evolutionary delivery, non reliance on expensive prototyping, keeping the complexity of the modules at low and manageable levels, use of inexpensive hardware, rejection of the need for expensive user interfaces, and simplifying end user training.

The discussion of decision support in this chapter raised a few important points about the integration of the components of the computerized information system. The situation described so far shows a computerized information system in which the components are loosely coupled. The next chapter examines some of the features of integrating the modules into a more tightly coupled system.

CHAPTER 5

A COST EFFECTIVE INTEGRATED INFORMATION SYSTEM FOR HUMAN RESOURCE MANAGEMENT

5.0 PRELUDE

In this thesis, the first chapter introduced the need and benefits of having a computerized information system for educational administration for universities like BITS. The chapter outlined the objectives, scope and methodology of the thesis. In the next chapter (Chapter 2), an elaborate survey of the scenario that has bearing on the design and implementation of a cost-effective computerized information system for educational administration was reported. The survey covered various aspects like historical development of hardware and software, the study of software engineering and the often ignored "evolutionary delivery system". This thesis, in its effort to develop a cost-effective computerized information system, has consciously chosen to adopt the evolutionary delivery scheme. Chapter 3 of the thesis discussed the issues involved in the design and development of GRA that forms the broad base of applications in any computerized information system. The preceding chapter (Chapter 4) discussed the salient aspects of developing decision support system modules on top of the GRA for educational administration.

In the development of GRA and the decision support modules discussed in the preceding two chapters, respectively, the focus in this thesis has been on following the evolutionary delivery scheme and a strict adherence to keeping deveopment and maintenance costs low. The benefits of following the evolutionary delivery scheme has been clearly explained in Chapter 2 of this thesis, and has been sporadically mentioned in the preceding chapters too. The primary benefit of using the evolutionary delivery scheme was to peg the costs of development of the computerized information system at manageably low levels and provide an insulation to rapidly changing requirements as in the case of BITS.

While preliminary costs of developing these modules have been maintained at low levels, this method has an obvious disadvantage. The modules so developed tend to be very loosely coupled. Several other demerits surface, commanding immediate attention. They are mentioned below.

* The GRA and the decision support modules tend to become loosely coupled, which beyond a stage becomes difficult to manage. Thus, the advantages gained in the use of the evolutionary delivery scheme produces diminishing returns (or increasing relative costs) as costs of maintenance tends to go up. [See Arthur L.J.(1988), Boehm B.W.(1981) and Gilb T.(1988) for instances of such cost escalation].
* Redundancy in the databases increases as additional modules are added on to the originally designed system as requirements evolve. Redundancy of data elements in the databses pose

several disadvantages. Apart from the technical problems like updating complexities, the redundancy increases the sizes of the databases and hence the cost of the computerized information system.

* By far the most danagerous thing that occurs with such loosely coupled systems is that "integration" of the databases is sacrificed. The horrors that organizations are likely to face with such systems are discussed in Lipow M.(1979), Baber L.(1979), Nolan R.(1979), Abbott R.J.(1986), Brooks F.P.(1983) and Gilb T.(1988).

The problem of "integration" poses problems of such crucial dimensions that it merits a complete discussion. Cost-effectiveness, as sought to be attained in this thesis, would lose much of its meaning if the computerized information system for educational administration so developed lacks integration of the subsystems (initially developed and delivered through the evolutionary delivery scheme). This chapter discusses the problems, issues and procedures followed in this thesis towards design and development of a cost-effective, integrated information system. Since we are dealing only with "faculty" as the prime entity, the computerized information system is pertinent only from the viewpoint of human resources management.

5.1 INTEGRATION OF SUBSYSTEMS AS A CRITICAL FACTOR

Integration of subsystems in the context of a computerized information system for educational administration takes two facets - integration of the databases and integration of the application modules. The requirement of integration of the databases involved is well understood and is documented widely in the literature. [See Codd E.F.(1970, 1971, 1972, 1974) and Date C.J.(1977]. The requirement of having to integrate the applications has not been given the attention it desrves. Unintegrated applications tend to work in isolation, accessing common databases, modifying them in an unstructured manner, and destroying the very foundations of a cost-effective and reliable computerized information system. The critical role of integration will be discussed in the next few sub-sections.

5.1.1 Requirements of Integration

The requirements of integration of the various databases involved in the computerized information system for educational administration are discussed below.

* Access Path:

  There must be a well-defined access path to the relevant records of the various databases and unque keys linking the databases together. In the case of the GRA where "faculty" is the prime entity, the PSRN serves as the key linking the files together. Further, it provides the unique access path to the various databases. The "establishment budget subsystem" is organized according to sanctioned positions in the institute's budget. Here, the PSRN and another key, BSRN act as linking elements and provide access paths. Provision of a well-defined access path and having a unique key set is one of the first requirements of integration.

* Removal of Redundancy:

An integrated database would have little or no redundancy in the data elements. Redundancy of data elements across databases is one of the prime culprits that lead to destroying of the integrity of databases. For example, if the "salary scale" of a faculty is redundantly stored in more than one database, an updating request to change the salary scale will be done by a particular GRA module in the primary atabase alone. The older salary scale will remain in the redundantly used places, leading to an inconsistency of the databases. Serious errors might result in such cases. SInce this thesis deals only with a single user computerized information system, there is really no need to allow redundancy. Distributed databases however allow redundancy to increase efficieny. In our case, reduction (or even total elimination) of redundancy provides for integration.

* Normalization:

Codd E.F.(1971, 1972) has shown that a normalized database provides for integration and removes redundancy and inconsistencies in the databases. The present thesis has organized its databases into the Third Normal Form of Codd that ensures removal of redundancy and functional dependencies.

The requirements of integrating the application programs involves following of certain disciplined methods of designing the software and a strict adherence to certain standardized coding schemes. These are discussed below.

* The application modules must be "data coupled", in the sense that these modules must recive and modify data only through the modules that invoke them.
* These modules must not modify flags or indicators directly that affect the operation of the rest of the modules of the computerized information system.
* These application modules, as far as possible, must refrain from accessing and/or modifying global data elements. Unconstrained modificaion of global data elements, amekes the modules difficult to test and validate since the side effects of global modifications does not localize the errors.

The various software modules developed for this thesis have scrupulously followed these requirements to provide for integration of the application modules. Integration of databases and application modules enhances the "integrity" of a computerized information system. This integrity requirement imposes several constraints on database design and application development. They are providing limited access to information, maintaining privacy of sensitive information, enforcing limitations on addition and modification of databases and application modules, limitations on functional access to the computerized information system, among others.[Turn R.(1981)]. Additional constraints may come in certain organizations in the form of certain legal and audit requirements.

5.1.2 Benefits of Integration

The benefits of integration in a computerized information system mostly stem up from a highly well knit set of databases. Integrated databases are such that redundancy is removed. The benefits that emerge from this may be as technical as reduction of complexity of updating software to something as simple as saying that less redundancy in databases mean less strain on secondary storage requirement (and hence, less costs in terms of media and maintenance). Integrated databases provide for a unique and well defined access path making the software design and development chore manageable. Date C.J.(1977), Boehm B.W.(1981), Lano R.J.(1979) and Gilb T.(1981) have discussed additional benefits arising from integration of databases and application modules. Some of the specific general benefits that are gained from integration are discussed below.

* It increases the work-ability in the computerized information system as it increases process capacity, responsiveness and storage capacity. [Gilb T.(1981)].
* It increases the reliability of the computerized information system, as it contributes to a tight knit maintenance of databases and structured software modules of reduced complexity.
* It contributes to maintainability of the computerized information system, since database security and integrity can be observed easily. The process of debugging and validating the system is simplified.

* It improves adaptability of the system, in that changes may be accomodated more easily, employing less manpower, time and money.
* It facilitates improvability of the computerized information system, since both databases and applications are more tightly coupled and changes towards improvement are localized and are easily validated.
* It provides for extendability to the computerized information system as requirements evolve over time. Unintegrated applications further worsen as more and more modules are added. Integration provides for a more disciplined way of extending functions to the computerized information system without increasing complexity.
* Finally, it contributes to portability of the computerized information system. Tightly knit systems are more easily ported across various hardware platforms than a myriad loosely coupled applications.

At the time, before the issue of integration was taken up, the individually developed GRA and some of the modules for decision support were being operated. These operations threw up several problems which pointed to the need for operational integration. Some of the points specifically relevant to the case of BITS operation of GRA and decision support modules are discussed below.

* In the beginning, the GRA modules of payroll and establishment budget were implemented at BITS. Operational experience with these two modules suggested that data duplication was creating

an enormous strain on the operational manpower. Updating programmes were being modified the most often, without still ensuring some sort of an integrity of the databases. In providing for integration requirements, the updating modules were becoming more complex.

* During the operational phase of these modules, several new requirements for the educational administrators surfaced. In trying to provide for these requirements, a number of independent report generators were developed. The trouble was that the number of such report generators, developed in such ad hoc fashion, became quite large for maintenance of the software.
* The large number of modules that were required to be developed, then, had certain additional data requirements (not available primarily in either the payroll or the establishment budget databases). The urgency with which the additional requirements were catered to necessitated employment of equally ad hoc measures to accomodate these extra data (either in the original databases in modified form, or in additional satellite databases). Clearly, the operational strain that these unplanned enhancements would pose would be quite heavy. Indeed, the software maintenance job was posing enormous strain andchallenge to software personnel and operational staff alike.

These operational requirements suggested that the procedures be integrated to remove unnecessary strain on operational staff as well as software personnel.

5.1.3 Integration - By Design or By Planned Evolution?

The development of computerized information system for educational administration of a university like BITS is frought with problems.

* BITS is characterized by bold innovations and constant changein educational administration. Thus, the computerized information system must be developed with resilience to change as one of the prime features.
* The computerized information system must be extendible. As operational procedures change, educational administration at BITS would require that the computerized information system reflect such extensions to the procedures. Also, experience on operation with the computerized information system throws up newer demands of functional capabilities to be incorporate in the computerized information system. These require that the computerized information system at BITS be extendible.
* The educational administration at BITS is functional and constantly attempts to adapt to changing conditions. RUles and operational procedures are strreamlined and rationalized. Incorporatin these changes require the computerized information system to be adaptible.

The problem, in the case of BITS, is that change occurs rapidly and surely. This imposes some requirements on the computerized information system like resilience, extendability and adaptability. As the computerized information system is tinkered with, the problem of maintainability assumes importance. Since changes, too, occurs rapidly, the working system must be delivered within a short time span. If the requirement of having to keep development and maintenance costs low is superimposed on the already stiff constraints, there would be little room for maneouverability. Thus the following woud not be possible in the case of development of a computerized information system for BITS.

* Ennumerating all the requirements of the computerized information system and generating a complete requirements document.
* A complete functional requirements specification.
* Specification in a detailed fashion of the compatability requirements, human factors like user sophistication, physical needs/constraints, robustness requirements, failure message and diagnostic requirements, I/O convenience requirements and develiopment environments.
* Unambiguous specification of integrity constraints like access limitations, legal requirements and other policy based requirements.

It becomes clear that the "requirements Specification Phase" itself is fraught with incomplete ennumerations. In a conventional "waterfall model" based software development process, the next phases like system specification, design, coding, etc. will not even take off because the requirements are "incomplete". In the case of BITS, the requirements specification can never be "complete" since innovations in education do bring up newer requirements or change older practices. Therefore, there is no alternative but to follow the evolutionary delivery scheme delivered within a short time span. If the requirement of having to keep development and maintenance costs low is superimposed on the already stiff constraints, there would be little room for maneouverability. Thus the following woud not be possible in the case of development of a computerized information system for BITS.

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Tausworthe R.C.(1979) advocates a process of integration by incrementally accomodating future expansion paths and modifications made to the original system. Stating the integration requiements right at the beginning and designing for the integration of modules developed and yet to be developed is an unrealistic venture. What is realistic is to accomodate expansion plans incrementally with the integration requirements as the focal point [Tausworthe R.C.(1979)].

Arthur L.J.(1988) proposes the strongest case, yet, for software development and integration through an evolutionary process. Educational systems, like all other systems, are in a constant state of flux, changing, growing. The computerized information systems that support these complex organizations and people must evolve. Fig. 5.1 shows the phases in the software evolution process where integration needs to be catered to. In changing environments, the integration needs can only be tackled through a change management system which maintains integration requirements. This is schematically illustrated in Fig 5.2.

A change in computerized information system that appears simple can be much larger than what anyone would expect. Without a proper impact analysis, resource estimates are grossly

FIGURE 5.1

SOFTWARE EVOLUTION PROCESS

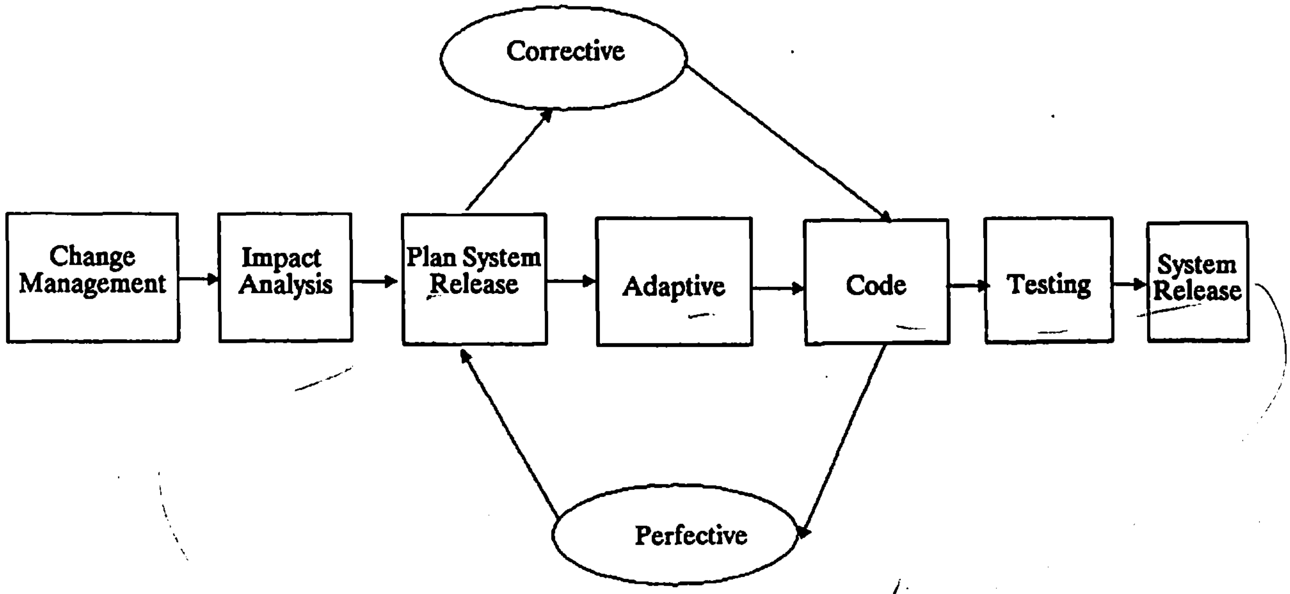
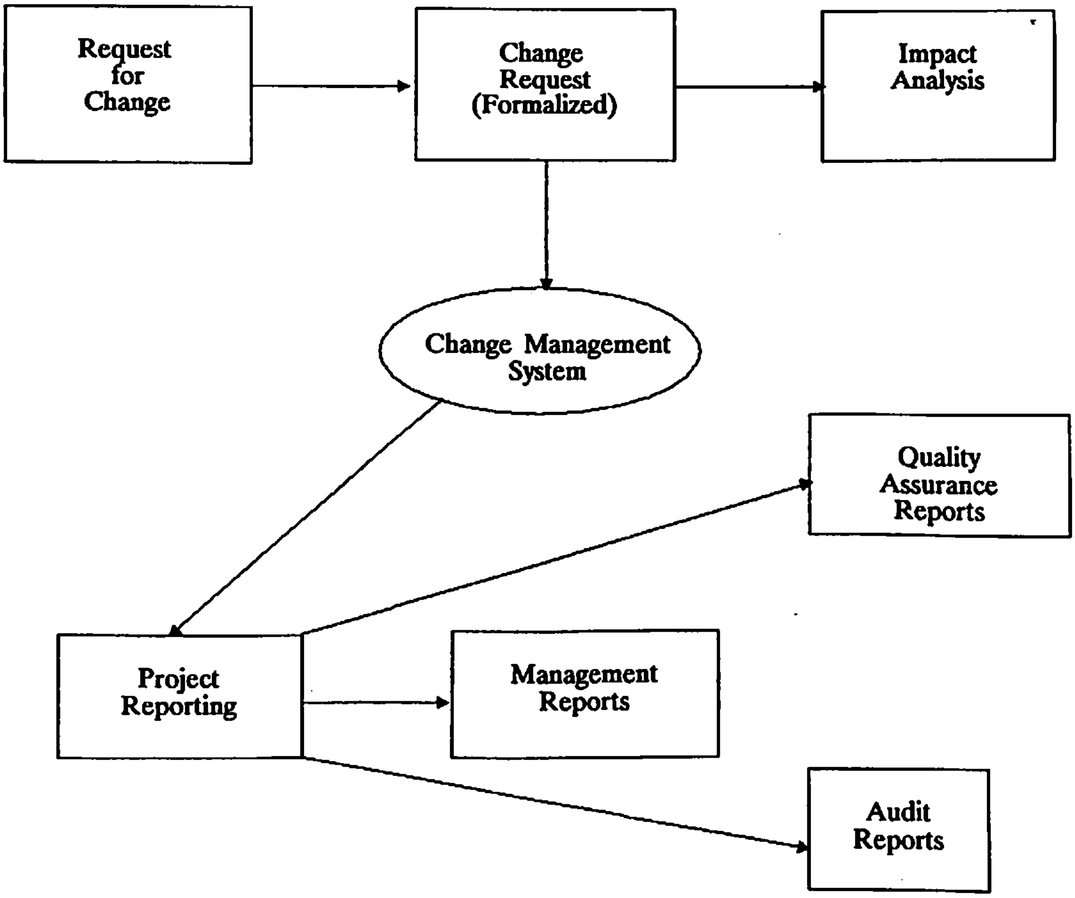


FIGURE 5.2

CHANGE MANAGEMENT SYSTEM



understated, and schedules are jeopardized. It is precisely under such circumstances that integration requirements break down. Fig 5.3 shows the impact analysis data flow as a schematic with phases where integration requirements are considered vital. This, again, reinforces the hypothesis that integration is relistically possible only through planned evolution.

Adaptive maintenance is the key to providing for integration in a planned evolutionary manner. [Arthur L.J.(1988)]. Fig 5.4 shows the adaptive maintenance data flow as a schematic with the areas where integration tests are looked into being superimposed.

Swartout W. & Balzer R.(1982) shows that the specification and the implementation phases are inevitably interwined. Thus the integration requirements have to surface at the specification as well as the implementation phases. Basili V.R.(1975) has pointed out that the only realistic manner in which integration can be brought about is by "iterative enhancement", which is similar to the planned evolutionary process. Other arguments that support the view that integration by planned evolution is reasonable are given in Chapter 2 of this thesis.

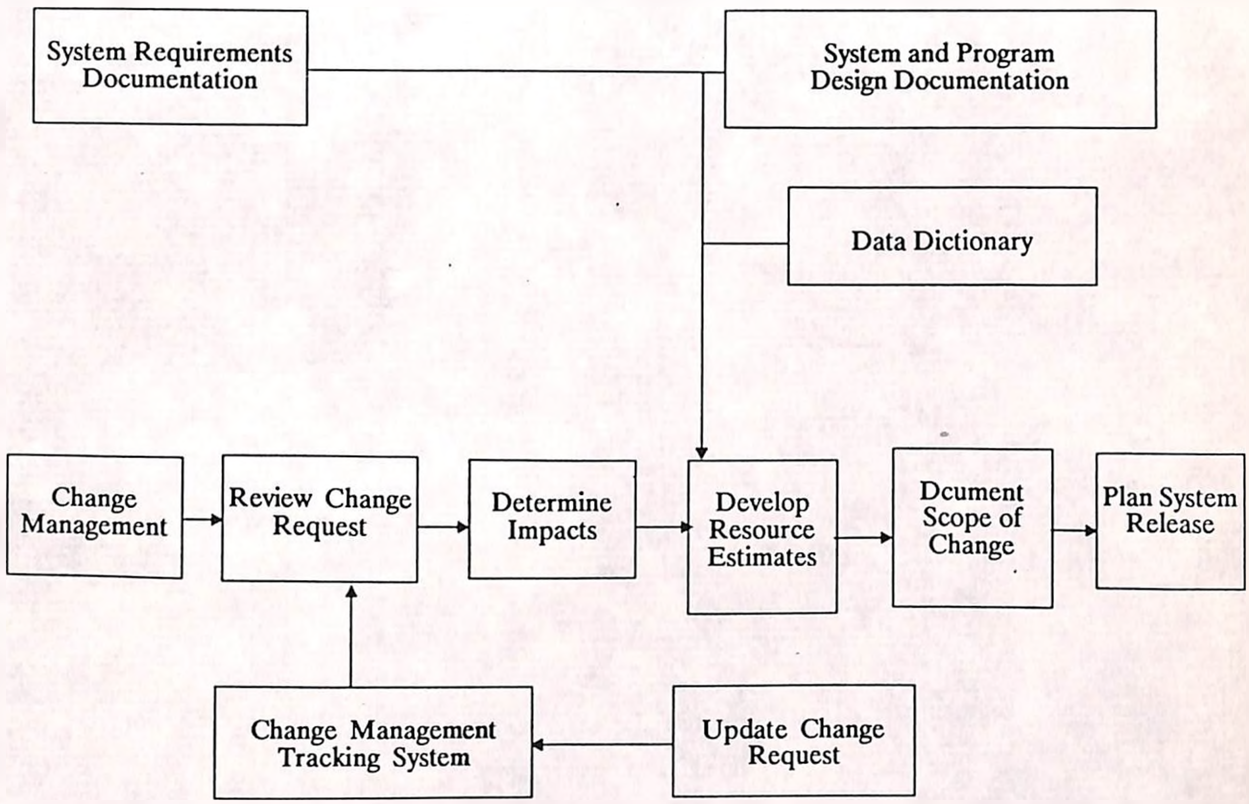
We shall now present a case for considering "cost-effectiveness" as a crucial issue in the development of a computerized information system.

5.1.4 Cost-Effectiveness as a Crucial Issue

Cost-effectiveness of the development process of a computerized information system is considered a very important issue, if not a very vital one. [See Boehm B.W.(1981 & 1973) and

FIGURE 5.3

IMPACT ANALYSIS DATA FLOW



Arthur L.J.(1983 & 1985)]. Cost-effectiveness as a requirement for the software being engineered comes up because of a variety of reasons applicable to typical situations in organizations.

* Software development costs are typically very high. [Boehm B.W.(1973)]. The major reasons cited for this are that developmental effort is specialized and involved, personnel are expensive to hire, and the spread of development time is very wide.
* Arthur L.J.(1988) and Gilb T.(1988) argue that the costs of maintenance of software is the major contributing factor to high costs. Since maintenance is usually an ongoing activity, the recurring costs would have to be controlled effectively.
* The cost of software development does not contribute to increase in organizational performance in commensurate proportions. This is especially true of organizations that have failed to exploit the benefits of computerization in greater degrees.
* The costs involved in changing over from a manual system to a computerized information system is significant. These costs manifest themselves in terms of manpower retraining.

While many of these cost related issues are significant in most organizations, the reasons attributed to the need for a cost-effective development of computerized information system stands out in the case of BITS. These aspects are discussed below.

* The costs of hardware are the most significant reasons. Universities in India are usually poorly funded, and in the case of BITS it is especially significant Since it is privately funded. Diverting the already scarce resources towards computer hardware is a painful issue. In the face of having no additional funds to spearhead the development of computerized information system for educational administration, the need to keep cost of hardware minimum is of paramount importance.

* Most organizations would invest in some development tools for the development of a computerized information system. Such things are compilers, DBMS, debuggers, etc. In BITS, no additional funds are allocated for the development of a computerized information system. So the principle was to to use what was available and not run after the more expensive options.

* The development of a computerized information system for an organization can be done by

  . in house staff employed specifically for that purpose only, or

  . external consultants hired for the purpose

  In BITS, since no additional budget is provided for this purpose, neither can external consultants be hired nor in house staff be specifically employed for this. Manpower employment costs can then take on very significant proportions. The solution adopted by BITS was to involve in house staff for developmental purposes, but not solely for developing computerized information systems.

* Educational administrators at various levels are to use the computerized information system. To aid an educational administrator (who is not an expert on the use of computers), the user interface must be easy to use, flexible and pleasant. To support extravagant user interfaces, special equipment (like color monitors, mouse, etc.) are required. The challenge in the case of this thesis was to provide a functional user interface at no additional cost (in terms of special hardware).
* Change occurs often and with regularity at BITS. Thus the computerized information system has to be maintained, enhanced and modified at intervals. The costs involved here are to provide for adaptive maintenance, resilience to change and extendability. The thesis works on the evolutionary delivery method towards controlling these costs.

Developing a computerized information system for educational administration on expensive hardware, using the state of art tools, employing expert manpower (external or internal) solely for this job, with no stifling budgetary constraints and long development cycles, is no challenge at all. The challenge that this thesis addresses itself is to develop computerized information systems in highly constraining situations. As explained above, costs turn out to be the common denominator that imposes the greatest constraint. Therefore, this thesis focuses on the development of a computerized information system for educational administration, with cost-effectiveness as a prime requirement.

5.2 OVERVIEW OF THE SYSTEM FOR HUMAN RESOURCES MANAGEMENT

The human resources used in a university are the teaching faculty, supporting and helping staff. A computerized information system that is developed for Human Resources Management, therefore, focuses on the prime entity "faculty". Here, "faculty" is used to indicate teaching, research and administrative manpower. Educational administration in a university requires that these human resources be managed in such a way as to enhance system performance. Ahmad A.(1977), Backoff R.W. & Mitink B.M.(1981), Botkin J.W. et al (1981), Bowen H.R.(1973), Graham H.T.(1974) and many others have stressed the need for a shift in focus from "equipment" resource to "human" resources.

The following are a small subset of the broad areas of human resources management as perceived by the educational administrators in universities.

* Faculty recruitment
* Faculty load planning and allotment
* Faculty payroll
* Establishment budget management
* Faculty benefits
* Faculty improvement programmes
* Faculty retirement

Many of the human resource management functions do not operate in isolation from other entities like students, equipment, space, financial resources, etc. The scope of this thesis is restricted to apply to only those that deal with "faculty" primarily.

In chapter 1 itself the development strategy was unfolded in the form of a pyramidal structure consisting of GRA, decision support and expert systems. Chapter 2 unfolded another phase of the strategy in presenting a convincing case for employing the evolutionary delivery scheme. Chapters 3 and 4 presented independent modular development efforts, and brought into sharp focus the problem of integration. The present chapter aims to consolidate all these in a unified form of an integrated computerized information system for human resources management. A pictorial depiction of the system is given in Fig. 5.5. Also, cost-effectiveness is brought in as a crucial design constraint. The various phases from requirements analysis to implementation are presented in this chapter.

The system is a consolidated whole of the GRA (chapter 3) and the decision support modules (chapter 4) with the requirements of integration and cost-effectiveness playing pivota roles.

FIGURE 5.4

ADAPTIVE MAINTENANCE DATA FLOW

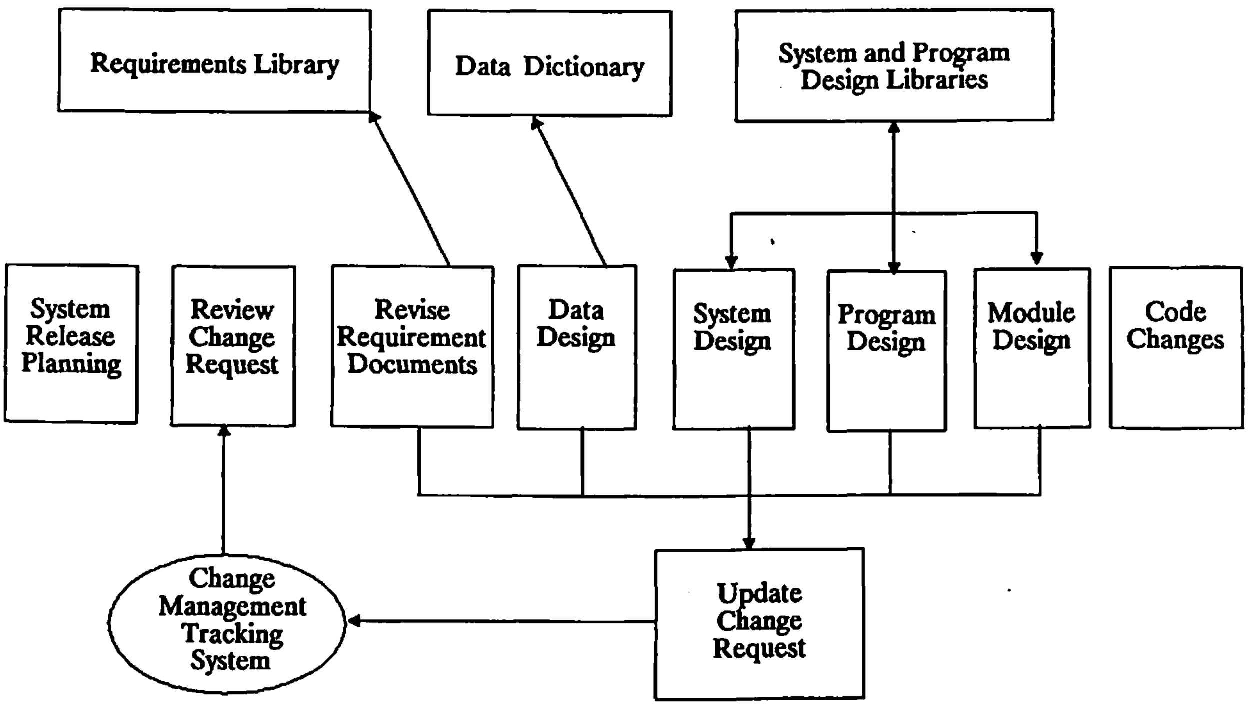


FIGURE 5.5

INTEGRATED COMPUTERIZED INFORMATION SYSTEM FOR HUMAN RESOURCES MANAGEMENT

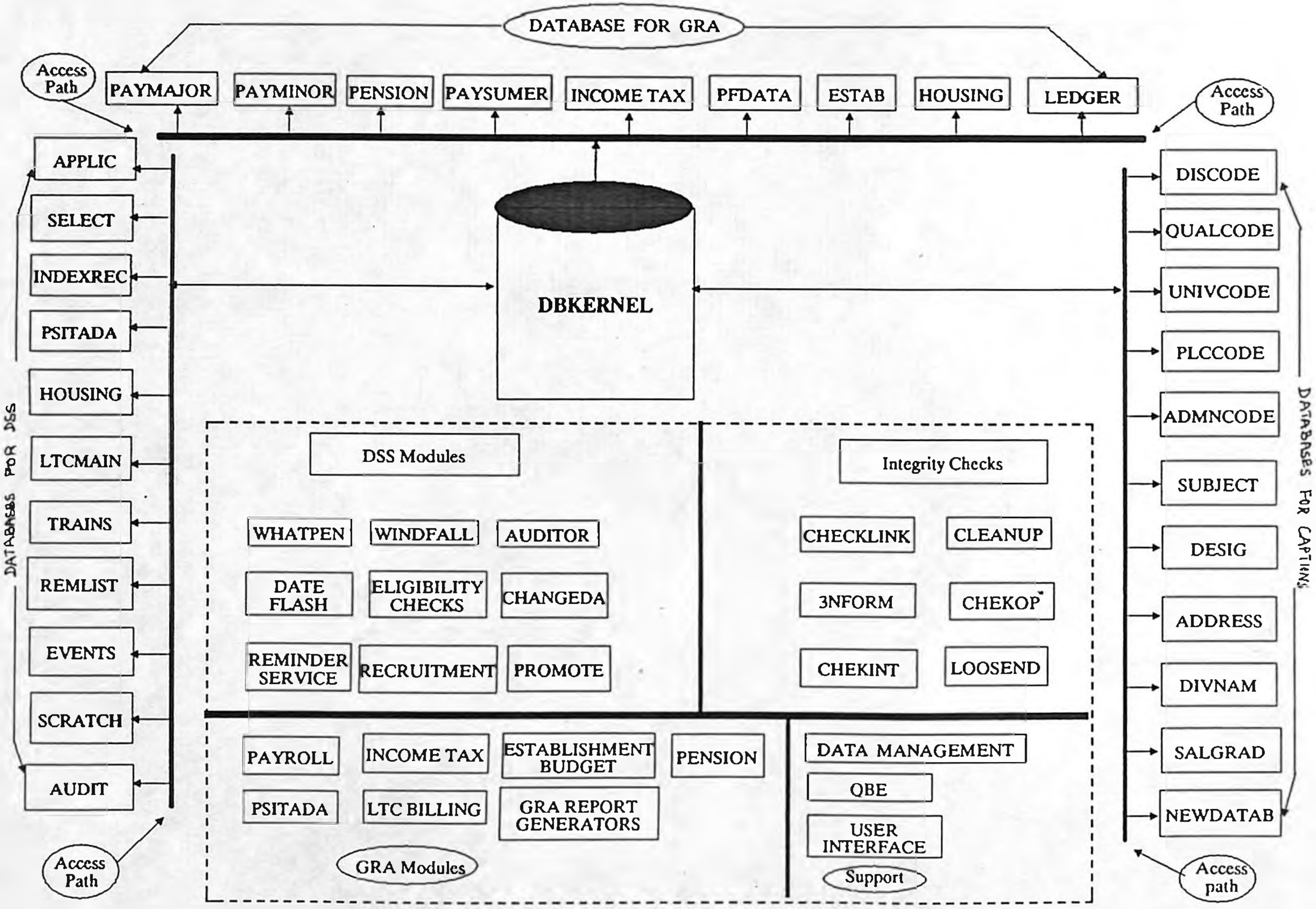
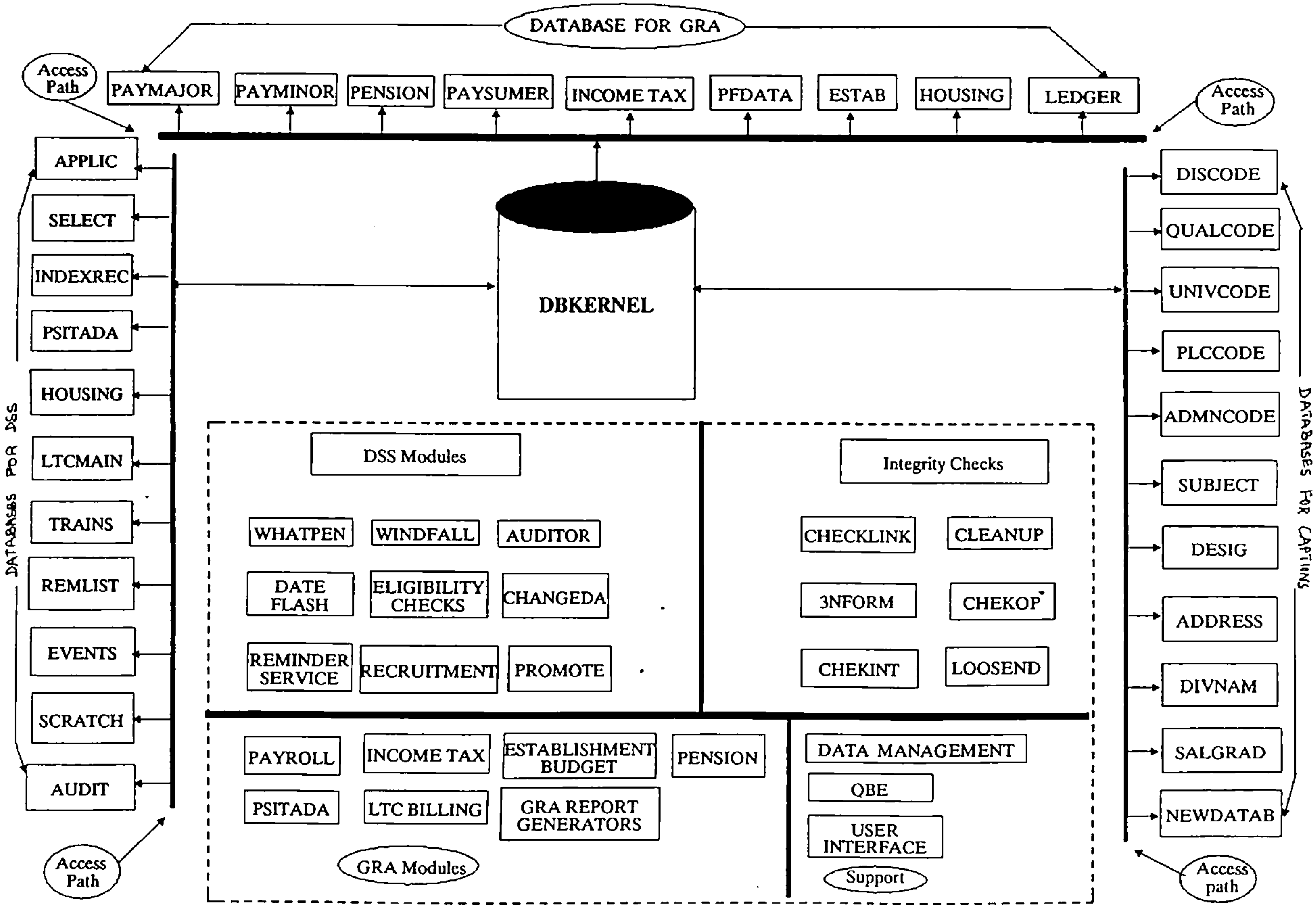


FIGURE 5.5

INTEGRATED COMPUTERIZED INFORMATION SYSTEM FOR HUMAN RESOURCES MANAGEMENT



5.3 REQUIREMENTS ANALYSIS

The requirements analysis is one of the first phases in any systematic design and development of a computerized information system. The purpose is to provide a link whereby the requirements of the user (educational administrator) is communicated to the system designer. The importance of this phase has been clearly stressed in many of the books on software engineering. [See Abbott R.L.(1986), Gilb T.(1988) and Arthur L.J.(1988)]. Many authors advocate the development of a "Requirements Manual" that specifies

* why the user wants the system;the user problem that the system will solve
* how the user intends to use the system
* other systems and procedures that will interface with the planned system
* the technical expertise of manpower who will actually operate the system
* the information the system must be capable of handling
* any integrity constraints the system must enforce; for example access limitations
* any legal constraints; for example privacy, record retention requirements, etc.
* the data processing functions that the system must perform
* the hardware on which the intended system must operate
* the development tools that must be used
* the expected enhancements that the system is likely to undergo after initial use
* auditing requirements; for example the need for an audit trail

* physical constraints, such as airconditioning requirements
* peripheral devices to be used
* anything else that the user musthave that the system developers should know

There is a small problem that we have to contend with. Do we include requirements only or requirements plus rationale? Studies by Alford M.W.(1977), Chen P.(1976 & 1983), Ross D.T. et al (1975) and Tausworthe R.C.(1979) have shown that requirements plus rationale is a sounder choice. This thesis followed the approach of ennumerating the requirements plus the rationale. Once the system has been built, inevitably operating changes are wanted. If the requirements document includes a rationale for the system as built, potential changes can be evaluated in the light of the original reasons for having it as it is.

Then there is the question of how to express requirements. While there are a number of formal and informal methods available, this thesis relied on active dialogue between users and developers and expressed requirements in functional terms. he requirements document, as such, was a collection of informally stated minutes of meetings between the user (educational administrators) and the developers.

5.3.1 User Organization and Currently Used Procedures

In this section, some salient features of the user organization (i.e. the administrative entities within BITS) for which a computerized information system is to be developed and currently used practices will be discussed critically. Since we

TABLE 5.2

AREAS OF COMPUTERIZATION CONSIDERED

S. No.	Area	Usage/Operation
1.	Faculty Records	Regular
2.	Recruitment	As and when required
3.	Payroll	Monthly
4.	Income Tax	Monthly
5.	LTC claims & Billing	As and when required
6.	Benefits processing	Monthly/As and when required
7.	Eligibility checks	As and when required
8.	Establishment Budget	Yearly
9.	Pension	Monthly
10.	Housing Information	As and when required/Regular
11.	Reminder Service	Fortnightly/Monthly
12.	Some "What if" analysis	As and when required
13.	Decision support for Faculty Review	As an when required

are limitinng ourselves, in this thesis, to the prime entity "faculty", only such aspects of the user organization and currently used practices will be discussed here.

The educational administration, and thereefore the user organization, at BITS is centered around functionally organized administrative entities. The various administrative entities that are pertinent to the development of a computerized information system for human resources management are listed in Table 5.1. It is clear that the record keeping effort has been centralized with the GAU. However, administraive operations (like payroll, benefits processing, etc.) are carried out not at the place where records are maintained, but elsewhere. Decisions too are taken up by administrative entities other than the GAU. The record keeping, data processing, routine administrative operations and decision support functions carried out by the various administrative entities are schematically depicted in Fig. 5.6. The need that strongly emerges is to unify these diverse operations under the banner of an integrated computerized information system.

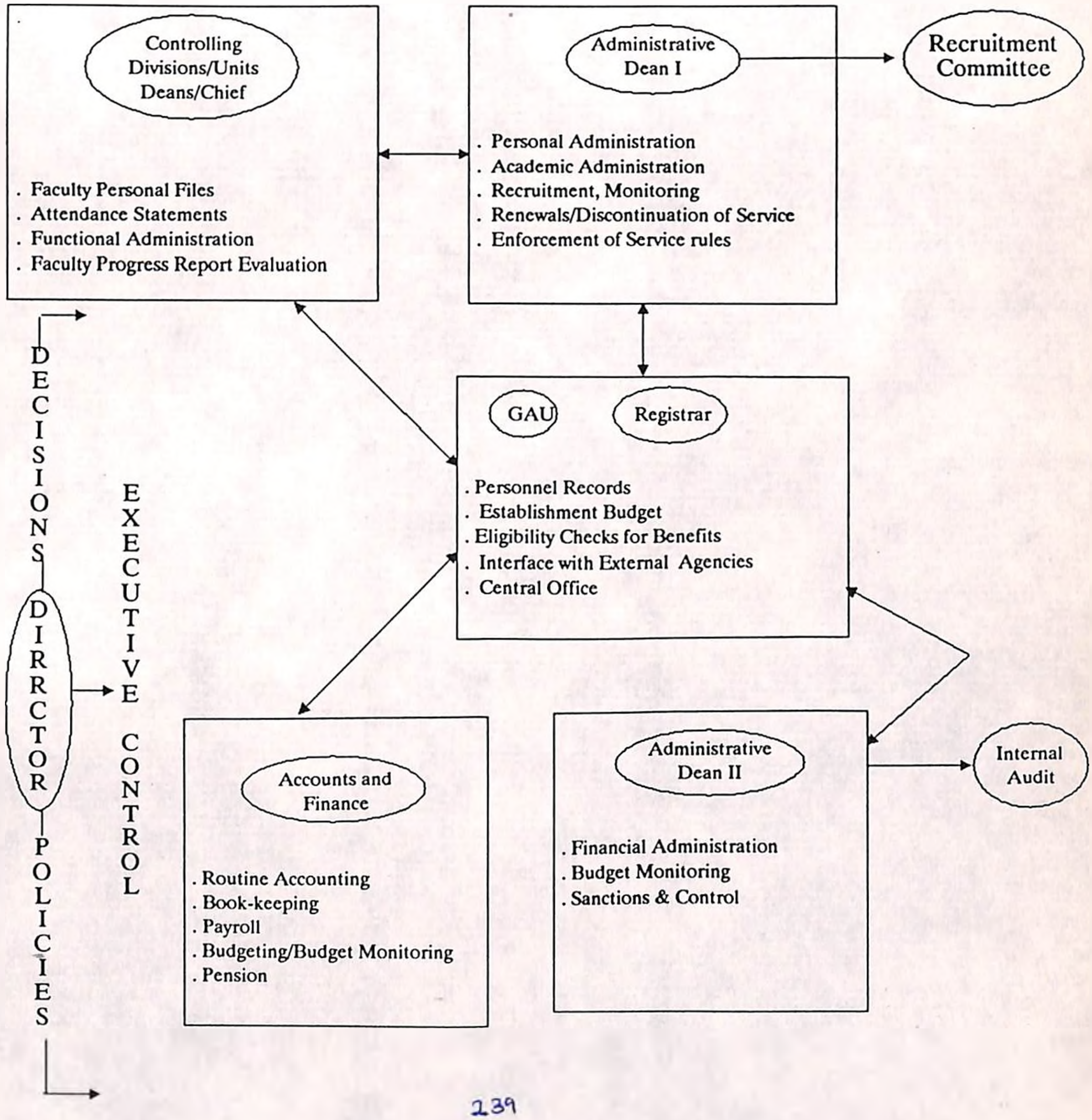
The "currently" (i.e. prior to the development and use of a computerized information system) used practices that are somewhat archaic, inefficient and of a duplicating nature. the following discussion critically comments on some of the currently used practices that has a direct bearing on the development of a computerized information system.

* Most of the GRA that have been identified (chapter 3) have two

FIGURE 5.6

FUNCTIONS CARRIED OUT BY ADMINISTRATIVE ENTITIES

(Pre Computerization Period)



main components - orederly record keeping and data processing functions. For the sake of uniformity, removal of redundancy and duplication of effort, these GRA must be centred around a single administrative entity. At present, these functions are being carried out by diverse administrative entities. Therefore, duplication of effort, loss of integrity of information and inability to fix accountability are some of the problems that are likely to arise.

* The GAU that has been in charge of the personnel records used manual record keeping procedures. data that gets modified (updated) through an operation (routine or administratively triggered) by other entities has to be communicated to all entities that maintain and use that data. This is usually effected through notification, telephonically conveyed instructions or minutes of decisions. All these involve a time lag that is large enough so that data processing functions of other entities are affected crucially.

* Routine data processing functions are carried out by various entites. Each operate within their (manually maintained) data files and procedures. This leads to much duplication of effort. More serious is the fixing the responsibility of a particular information on an entity. Data or information is scattered that often leads to the administrative malady popularly known as "passing the buck".

* Even simple things like knowing what payments and deuctions are made to faculty take on major magnitudes. For example, when the payroll system was being operated manually by the BITS accounts office, personnel had to go and verify these

figures from a ledger. Many of the faculty never did this for a variety of reasons. This leads to major problems. In one such case, a faculty believed that a certain percentage of his salary was being cut towards PF, while the accounts office was not making any such deduction. It was only after three years that the error was discovered. Apart from indiividual hardship and institutional embarassment, certain legal procedures are likely to be sidetracked.

* It was never clear where to obtain requisite information towards a particular decision support function. Prior to the computerization era at BITS, it was discovered much to the dismay of the administration that the data on dependents of faculty (on which many benfits related decisions rest) had not been updated for years
* Worse, data had been maintained incorrectly. For example, the "age" of a faculty's dependent is essential to the award of benefits like LTC, FBS, etc. The manual records maintained this "age" in years and months. retrieval of data would sufffer severely since it ought to have been correctly record as the "date of birth". The period prior to computerization revealed many such gaps in data recording.
* Many of the data items were found missing in the case of personnel. In one such glaring case, the "date of birth" of quite a few personnel was not recorded in their personal files. The obvious troubles are that their date of retirement cannot be effected correctly, among other things.
* procedures were being talked about as though only a few clerks

were competent to operate them. For instance, the operation of the LTC benefits was long shrouded in mystery and complication that few faculty found the process of claiming LTC easy to handle. Much streamling and simplification of procedures suggested themselves as applications/claims got stuck at a point over a procedural wrangle.

* Information retreval usually took inordinately long periods of time. For instance, suppose the administration wanted a list of faculty members who have been serving the institute for over 20 years. This seemingly simple information retrieval took days instead of minutes since it necessitated that over 500 manual files containing papers were to be scanned, the information noted and then finally typed out. It is evident that more complicated queries would have taken up much greater times, delaying decisions and often being of little to administrators.

The discussion above shows that the practices followed prior to computerization were chaotic, redundant and inefficient. One of the first steps in the computerization process were to provide for better record keeping and retrieval methods.

5.3.2 Anticipated Operational Strategy

Apriori knowledge of the operational strategy of the integrated information system for human resource management is useful during the requirements analysis phase. Operational strategy provides many clues that influence design of an information system. For example, is the system meant for use in a single user environment or in a multi-user environment? If the operational strategy is such that it is to be employed in a multi-user environment, is the conceived database a centralized, shareable database or a distributed one? What is meant by operational strategy in this section is limited to such types of queries.

At the very outset of an institution embarking on a design, implementation and use of a computerized information system, it is perhaps premature to talk in terms of a firmly laid out operational strategy. It is for this reason that we settle for an anticipated operational strategy. {If, however, there is a substantial departure from the anticipated operational strategy, the entire requirements analysis may have to be undertaken all over again!}. The following are some of the relections on the anticipated operational strategy that has a prime bearing on the design and implementation of a cost-effective computerized information system.

* The conceived computerized information system is anticipated to work in a single user environment.
* The entire task of cordinating the operation of the information system would be in the hands of a single functional entity in the administrative hierarchy of the institution.
* The operation of the GRA modules would be handled largely by operating staff, supervised by the competent head of the functional entity. In the case of BITS, the functional entity is anticipated to be the Computer Assisted Housekeeping Unit, headed by a Unit Chief.

* As far as the decision support modules are concerned, none of the educational administrators are expected to work directly on the computerized information system. They are expected to work through the Chief, CAHU (mentioned above) or together in an interactive sense.
* In the initial stages of the implementation of the computerized information system, the manual process is expected to continue along with the operation of the computerized information system. After the applications in the computerized modules stabilize in operation, the manual process would be discontinued.
* The operational manpower would be the same clerical manpower who would be retrained to work with the computerized information system.
* It is not anticipated that the entire plethora of applications would be implemented and then only the system declared operational. Instead, the computerized information system will be set operational in a modular fashion consistent with the evolutionary delivery principle.

5.3.3 Functional Requirements

The normal procedure for arriving at the functional requirements of the computerized information system is to interact with the end user directly. But as stated in the previous section, the term "end user" is a bit hazy in this context. It actually refers to personnel (or even entire divisions/units) that have been processing the GRA manually and also the decision makers who seek to get decision support out of the information system. Given this broader definition of the end user, the functional requirements were arrived at after a series of meetings with all concerned administrative entities and the end users. In a dynamic system like BITS, it will be near impossible to specify all the functional requirements in any sense of completeness. The outcome of the process was an ennumeration of the preliminary functional requirements. Some of the most significant functional requirements ennumerated in these discussions are described below.

* In the early stages of the project, the information system is expected to streamline the data handling procedures or the various administrative entities in the institute.
* Rather than have a prolonged wait for a "complete" system to be functional, the GRA modules were to be made available in stages.
* Among the GRA, a certain priority was indicated through the frequency of operation of the GRA and the extent of data requirements for the GRA. The requirement was that those GRA that were operated more frequently or those GRA that spanned a large section of the data that were common across applications were to be accorded higher priority.
* Only after the making the GRA operational, the decision support modules were to be considered for implementation.
* The GRA's data handling procedures were to closely follow the ones used in the manual process to the extent that efficieny is not sacrificed. This is to make the existing data easily adaptible to a computerized information system and also to

make the transition less arduous.

* The outputs of the GRA emanating from the computerized information system were to not depart from the existing manual process without affecting efficiency. Where reducdancies are detected, they are to be eliminated.
* Economy of storage, easy retrievability and provision of scope for expandability were to be given due concern.
* Detection of inconsistencies and gaps in the database were to be detected through an algorithmic process and not through a manual verification cycle.
* The operability of the software must be conducive to manpower of the clerical genre with only a minimal training in handling computerized information systems and worse, only a bare minimal working knowledge of the english language.
* The software on the whole must be conducive to maintainability, expandability and modifiability as the system itself is highly dynamic.

5.3.4 Human Factors in the Design Process

Human factors play a very important role in the design of a computerized information system for eduational administration. Specifically in the case of a university like BITS, where cost-effectiveness is a chosen objective, the costs of training (or retraining) manpower, cost of a suitable hardware, costs of development and maintenance and costs of providing an operating environment are all greatly influenced by certain human factors. Some of these factors that have a specific bearing on achieving cost-effectiveness are discussed below.

* The preparatory level of the operational manpower is quite rudimentary in so far as using a computerized information system is concerned. Thus, the user interface that is provided must be simple to use and easy to learn. Cox B.(1986) and Schneiderman B.(1983) have argued the case for the employment of a graphical user interface with icons resembling the existing work environment and a "point and choose" philosophy. But such user interfaces require expensive hardware and the development costs are rather high. Since they do not contribute to the cost-effectiveness endeavour, a simpler user interface is to be designed.
* The menu screens that are displayed must be simple and functional. Extravagantly designed screens (with pop up menus and overlapped windows) may actually be counter productive in a situation as in BITS where the operational manpower has only rudimentary capabilities.
* The text must be designed in as simple a fashion as possible, since the operational manpower are not expected to even be highly conversant in the english language. Interative commands and options must be terse without being cryptic, and self-explanatory without being verbose.
* Since the GRA modules are by and large routine aspects, the computerized information system must carry out the execution of the various constituent modules in as automatic a fashion as possible (i.e. with the least operator intervention). So much so that all the modules from installation to processing to backup procedures must be carried out with the least

operator intervention.

* Since the operational manpower ar expected to follow a fixed set of procedures, no expensive online help (context sensitive or otherwise) need be provided. Instead, a short, crisply written user's command summary that gives a bird's eye view of the entire options available on the computerized information system would do.
* The decision support modules are usually operated by the educational administrators themselves. In the present case, it is expected to be used with the help of trained personnel. Thus there is little need to overstress the "user friendliness" requirement which usually tends to increase the costs of development.
* Finally, the system must be made sufficiently adaptible to change. Requirements change either because the users originally understated their needs or because the system itself has undergone sufficient change. In BITS, both these factors are likely to demand a modification in the original system. Thus resilience to change as well as adaptability are both fundamental requirements.

5.3.5 Integrity, Reliability and Failure Requirements

The integrity, reliability and failure requirements vary from system to system but have some common concerns. Those features that are specific to the computerized information system for educational administration in a university like BITS are discussed below.

* The integrity of the databases is a prime requirement from the

procedural viewpoint since there are certain statutory requirements as well as certain legal bindings. For example, the modules that are concerned with areas like provident fund, pension, billing, etc. have to be in conformity with certain statutory requirements while income tax deductions and reporting have certain legal implications. Of course, the requirement of integrity, if violated would have a catastrophic effect in terms of individual hardships, loss of faith in the administration and low morale.

* Since cost-effectiveness of usage is a stated objective, the manual process (wherever employed) would be discontinued once the computerized information system gets stabilized in operation. Reliability is vital in this case since there is no "fall back" option in case of failure. Reliability takes on a wider scope to include insulation from hardware failure, corruption of the databases (either by malicious intent or by accident) and ill conditioned software, among other things.
* In a dynamic system like BITS, it is expected that the software would undergo various degrees of modification or enhancement alongside drastic changes in procedures. The task of ensuring integrity and reliability therefore becomes a continuous one during the entire product's existence. It is thus imperative that algorithms be devised that check the integrity of the databases (at predefined intervals of time) and reliability of the system (atleast whenever a maintenance or enhancement task has been concluded).
* The nature of the applications in educational administration are such that the system has to be fully robust all the time.

No degree of "fault tolerance" can be conceived to be provided for.

* The failure requirement is that the system must be regeneratable within a short period of time and by employing a simple set of recovery procedures. Although the failure requirements are not so constraining as in real time applications or in OLTP, the time lag for recovery cannot be excessive nor the procedures be complicated.
* To enable the rudimentarily endowed operating staff perform the necessary recovery procedurs in the case of a failure, the system must be designed in such a fashion as to provide simple and interactive online help. What would be ideal is to provide the entire recovery procedure in software that automatically gets invoked in case of a failure and interacts with the operator only for the barest minimum.

5.3.6 Constraints in the Choice of the Development Path

Several constraints emerge in the choice of the development path of the computerized information system for educational administration for a university like BITS. These constraints manifest themselves in various forms and in various degrees of severity, influencing the way in which the system is designed, implemented and operates. Some of these constraints merely curb the level of sophistication of the computerized information system that could be designed for cost-effectiveness. There are other constraints that necessitate the use of certain unconventional methods and techniques in the development strategy. These constraints are discussed below.

* The cost-effectiveness criteria imposed one of the serious constraining effects on the choice of hardware as a developmental platform. A conscious choice was made to limit the choice to one of the available hardware at BITS so as to cut the overall costs of development. Thus instead of going in for a multi user system or expensive workstations, the choice was restricted to the use of available PCs.
* The determination to keep costs low also gave rise to the constraint that the software development tools be restricted to the bare necessities that are already available at BITS. This constrained the choice to the use of a popular and already available RDBMS on the PCs. The employment of user interface generation toolkits were avoided for the reason of keeping the investment in software low. For a similar reason no program or application generators were employed in the developmental process. This has the constraining effect of requiring a software engineer develop all the applications in the computerized information system.
* The need to keep the development venture cost-effective removed the possibility of commissioning a team of consultants to carry out the development from the reckoning. As with the hardware and software tools employable, the existing manpower at BITS had to be used in the developmental process. The teaching faculty of BITS also perform the jobs of academic administration. In a similar fashion, the faculty who are qualified computer professionals were to be roped in for this task. For the supportive role of data entry, operation, etc.

the existing clerical cadre were to be retrained. In short, the entire developmental process was to be carried out with no extra manpower employed specifically for this purpose. As will be shown later in Chapter 6, this turns out to be one of the greatest strengths of the effort in a cost-effective development of a computerized information system.

* The modules of GRA and decision support that were to be implemented had to be done in the order of a priority conducive to the educational administrators. This priority need not necessarily be conducive to effective software development.
* The databases and the software modules were to implemented within strict time bound framework. This strict time schedules were necessary since non adherence to these schedules would often invalidate the purpose of designing the module in a dynamic set up like BITS where change is routine.
* The operating manpower, of necessity, had to be from the existing clerical cadre with whatever educational background and tecnical skills that they possessed. Thus the software had to be developed keeping in mind the limitations of the operating personnel.
* For reasons of economy, the decision support modules were not initially considered to be of direct interactive use by the educational administrators themselves. Also because the system is conceived to be a single use one, for reasons of integrity, direct operation of the decision support modules by the decsion makers were not encouraged. Instead, the softer option of operating it through trained manpower was chosen. Thus, the

complexity and sophistication of the decision support modules are pegged at moderate levels.

* A fixed, "once and for all" design was not possible since a system like BITS constantly spawns newer demands on the computerized information system for educational administration. This forced the twins constraints of having the computerized information system having the attribute of being resilient to change and also being adaptable to changing requirements. Clearly, the two requirements have certain elements of incompatability.
* The design and implementation of the initial proto types of the modules of the computerized information system had to be undertaken with the existing procedures as the basis. A working module had to be implemented with the existing procedures followed as it is. Simplifying procedures and rules of educational administration would no doubt enhance the efficiency of the computerized information system. The initial working version had to be made with procedures in situ rather than waiting for procedural changes to take place. If such changes indeed took place, this had to be incorporated through the process of software maintenance or modification.

5.4 DATABASE REQUIREMENTS AND APPLICATION SUBSYSTEMS

The computerized information system for educational administration for a university like BITS has a myriad data items that are candidates for incorporation into the databases. The existing GRA were being operated by a number of administrative entities, each with its own manually maintained data records. In attempting to develop an integrated information system, one of the primary tasks is to get a consolidated list of data items that need to be part of the databases. One way is to get the union of all the data items individually required by the GRA as well as those modules of decision support conceived for implementation in the first instance. The requirements analysis showed that the various administrative entities at BITS were enlightenened enough to see the benefits of such a computerized integrated information system, that it was decided to build a "universe" of data items pertaining to the various activities of educational administration at BITS. Accordingly, all conceivable data items were pooled together through brain storming sessions and a universe of data items pertaining to educational administration at BITS was prepared. A selected set of sections of the six part document is given in Appendix E. This was the first tangible move in the effort to develop an integrated information system for human resource management.

5.4.1 The Plethora of Applications

Educational administration, in its general form, throws up a plethora of applications conducive for incorporation into an integrated information system. Table 5.1 provides the list of administrative entities concerning human resource management in a university. Table 5.2 provides a listing of applications that surface in the case of universities like BITS.

The applications that are candidates for the first consideration of incorporation into the information system are those that deal primarily with record maintenance and upkeep. The GRA are routinized aspects of educational administration that ought to get the initial priority. In the case of BITS, it was discovered that the existing record keeping procedures were so disarrayed that many of the data items listed in Appendix E were not even available. The major task was to select a reasonable subset to create the initial database on which the first of the GRAs may operate upon. This task necessitated the design of data capture proformas, filling up of data items from existing records, circulation of portions of these to individual staff members to fill up gaps and build the initial databases.

5.4.2 Database Usage Across GRA and Decision Support Applications

Table 5.2 shows the variety of applications, both GRA and of decision support, that have been considered in this thesis. The various databases that are used by these applications are depicted schematically in Fig. 5.7. It should be noted that there are a set of data items which are common to most GRA applications are even used by the decision support applications. Such common data items form the kernel of the databases. The main characteristic of the data items in the kernel are that they are common to a variety of applications and that they are almost unchanging in nature.

The advantage of building up this kernel comprising of common data items that are mostly static in nature is that integrity is better and that redundancy is avoided. Further, such crucial data items can be protected from accidental or intentional damage by restricting its usage to a "read only" form. The access path to these large set of kernel data items is made uniform across applications. This provides for resilience to change on the one hand (since modifications are localized to those that provide the access path to the kernel) and enhancability of applications.

The ability to keep grafting applications to the information system mainly stems from the strength it derives from the kernel. Data items local to the applications are built around a local database (or databases) accessible only to that application. This encourages modular enhancement of the databases without having to modify other applications. This also provides for development of applications (GRA or decision support) in an incremental fashion according to the evolutionary delivery scheme.

One of the rewarding features of this approach is that changes that neccesitate modification of an application needs only the local portion of the application and its local databases to be looked into. Thus the cascading effect of a small change in an application to others is avoided. This makes the software maintenance a manageable and cost-effective process.

5.4.3 Designing for an Integrated System

The main task of this thesis is two fold: one to design an integrated information system for human resource management and the other to ensure that the design is cost-effective. This section deals with the task of designing for an integrated system. The question of integration has two aspects, one dealing with the databases and the other dealing with the applications . The major concerns of integration are discussed in the following paragraphs.

* The primary task in the integration of an information system lies in the integration of the underlying databases. In its simplest form, integration takes the form of removal of redundancies and provision of integrity. Fig. 5.7 shows that the approach of keeping all common data items of a static nature in a kernel is a step in the direction by removing redundancies.
* Integration can be provided for by providing a well defined set of access paths to the databases for the myriad applications. This regulates access to the databases through a well defined set of procedures, thereby localizing its effect and providing for easy maintainability.
* Integration of applications that constitute the information system implies that the applications are to be more closely coupled (as opposed to being loosely coupled or even being independent). Since maintanability of the plethora of applications under dynamic situations is a daunting factor, a closer watch is made over those modules of the applications that modify common database items by explicit documentation fo

this fact. This makes the task of modifying applications a more structured task that if the aplications were not closely coupled.

* A library of information system access utilities are to be developed so that duplication of effort is reduced. It is an integration of sorts, too, since making use of a common library of utilities across applications reduce the ripple effect of a change in one of the modules in a particular application.

* The system designed for integration must be capable of being examined periodically for consistency and integrity checks. This requirement is of vital importance in a university like BITS. This is so because changes occur periodically to necessitate modifications to the databases and applications, and there is a greater danger that the maintainance procedures inject inconsistencies into the databases. Further, since the nature of the applications do not allow for a fault tolerance, there is a greater need to ensure consistency of the databases. There is not even the fall back option of going in for a manual process of carrying out the task of educational administration. Thus procedures that periodically verify the health of the databases are a must to ensure integrity.

5.4.4 Providing for a Planned Growth of Databases and Applications

A university like BITS is characterized by innovations in educational administration. Such being the case, it is necessary to provide for a modification of the databases, enhancements of the databases and addition to the list of applications. Adhoc procedures used for the modification of databases and applications due to changing needs slowly eat away the edifice of integration. Soon the myriad databases and the plethora of applications would turn into a patch work that tend to increase the cost of maintenance.

Thus it is necessary to provide for a planned growth of databases and of applications. Some of the issues connected with the provision for a planned growth of databases and applications are discussed below.

* Enhancements emanate from a need to change. Change management provides the basis of uniquely identifying, describing and tracking the status of a request or need for a change. Change management can be effected by a manual system or by an automated system. Since the nature of change is to be more deeply investigated for a case like BITS, a manual change management system ha been adopted in this thesis.
* A good basis for having an enhanceable system lies in its GRA. This thesis develops a kernel of common data items across applications and the strong foundation of GRA. Localized databases and access paths provide the avenue for growth in a structured fashion.

* Linkage to the various databases is provided through a small set of keys. Using the small set of keys, additional local databases can be created without having to tamper with existing running applications.
* Enhancements or modifications to the kernel do not create a ripple effect, since it is through a common set of access procedures, all applications access the kernel. Thus as changes occur ushering in a need to include new data items in the kernel, the maintenance task is localized to the access path procedures. This insulates the other applications from experiencing a ripple effect of modifications in the structure of the kernel.
* Usually the entire gamut of GRA gets implemented first. Once operational, they remain so until the underlying procedures and rules of educational administration change. But it is the decision support modules that tend to keep growing as newer needs are felt by educational administrators. These applications must be developed with the use of the kernel as a read only database for the common data items and having separate local databases for the decision support function.

5.5 SOFTWARE DESIGN AND IMPLEMENTATION

Some aspects of the software design and implementation have been discussed in detil in Chapters 3 and 4. In this section, the software design and implementation aspects specific to the question of integration, provision for planned growth and being cost-effective would be touched upon. The structure of the databases and applications would be dealt with. The testing methodology that was employed in this thesis would be discussed briefly.

5.5.1 The Environment of the Implementation

The hardware environment of the implementation was chosen to be a modest IBM compatible PC/XT with 640 Kb RAM, a 20 Mb hard disk, a monocrome monitor and dot matrix printers. The total hardware expenditure is roughly Rs. 45,000 (about $2700). The infrastructural requirements for the system consists of a voltage stabilizer, furniture, and an optional air conditioner. The software development environment consists of the MS DOS 3.2 operating system, Ashton Tate's dBASE III Plus and a few utilities. the expenditure on the environment of the implementation is given in Table 5.3.

TABLE 5.3

EXPENDITURE ON THE ENVIRONMENT OF THE IMPLEMENTATION

S.No.	ITEM	COST (Rs.)	NATURE
1.	IBM Compatable PC/XT 640Kb RAM 20 Mb Hard Disk, 360 Kb Floppy Drive	32,000	Fixed
2.	FX-105 Dot Matrix Printer	12,000	Fixed
3.	EX-1000 Dot Matrix Printer	18,000	Fixed
4.	MS DOS 3.2	4,000	Fixed
5.	dBASE III Plus	13,000	Fixed
6.	Utilities	5,000	Fixed
7.	Site Preparation & Infrastructure	20,000	Fixed
8.	Furniture	4,000	Fixed
9.	Programmer/Analyst	5,000*	Recurring
10.	Data Entry Operators/ Clerks (4 Nos.)	6,000*	Recurring
11.	Consumables (Floppies, Stationary, etc.)	12,000	Recurring

* Per month figures.

The fixed, setup costs usually constitute a major chunk of the total expenditure incurred in the design and implementation of a computerized information system. Cost-effectiveness has two facets: one to keep the monetary expenditure low and the other to ensure functionality of the system. That is, cost effectiveness is not at the cost of functionality or of low performance. Some of the pertinent points connected with the choice of the implementation environment and the objective of cost-effectiveness are mentioned below.

* The system is conceived to be in a single user environment, thus making the choice of the hardware (mentioned above) a functionally sound one.
* The need for a multiuser environment would have escalated costs, not only in terms of the increased costs of the hardware, but also in terms of development costs of a distributed information system.
* The applications were conceived to be completely developed by a small team of developers. The educational administrators themselves who are the end users, are only expected to provide inputs necessary for the generation of requirements. They are not expected to develop applications on their own. This precluded the use of program and application generators.
* Since the user interface requirement is quite elementary, there was no need of employing expensive user interface generation toolkits.
* The only requirements were a good RDBMS and a few utilities

for disk management.

5.5.2 The Structure of the Applications and Databases

The nature of the databases used in the computerized information system for human resource management have been discussed in various degrees of detail in Chapters 3 and 4. Fig. 5.5 also shows a schematic of the database usage across the GRA and decision support modules.

A list of all the databases and some of the characteristics of these are summarized in Table 5.4. The structure of the various databases used in the information system are given in Appendix F. From the structure of the databases it must be clear that the linkages among them are achieved through a small set of key data items. Strong linkages make the databases actually more closely coupled than is evident from their structure. This brings about an integration of the various databases used in the computerized information system. The databases used in this implementation belong to several broad categories. They are

* the kernel consisting of all common data items that are mostly static
* the local databases concerned with the GRA
* the local databases concerned with the modules for decision support
* the databases resembling inverted files for storing captions, titles, etc.
* the miscellaneous scratch databases

TABLE 5.4

LIST AND CHARACTERISTICS OF VARIOUS DATABASES

S.No.	DATABASE	CHARACTERISTICS/REMARKS
1.	PAYMAJOR	Main database for Payroll GRA; Doesn't change often
2.	PAYMINOR	Secondary database for Payroll GRA; Data fields change monthly and one initialized.
3.	PENSION	Database of pensioners.
4.	NEWDATAB	Mapping table for finding DA rates given basic salary in ranges.
5.	SALGRAD	Table of Payscales with increments.
6.	DIVNAM	Tabhle of captions relating division codes with name of divisions.
7.	PAYSUMER	Database used for processing Summer Salaries; Active only once in August every year.
8.	INCOMETAX	Consolidated database of Income tax subsystem; Includes fields both of a monthly changing nature and annual summaries.
9.	PFDATA	Database of PF related items; used mainly in Loans Monitoring.
10.	ADDRESS	Database of various addresses connected with staff.
11.	DESIG	Table of captions relating designation codes to expansions.
12.	SUBJECT	Table of cations relating subject codes to expansions (mainly teaching disciplines).
13.	ADMNCODE	Table of captions relating administrative designation codes to expansions, like, Dean, Group Leader, etc.
14.	PLCCODE	Table of captions relating place of posting code to expansions.
15.	UNIVCODE	Table of captions relating university code (where staff graduated from) to expansion of university name.
16.	QUALCODE	Table of captions relating qualification code and expansion of the degree/diploma name.

TABLE 5.4 (Continued)

LIST AND CHARACTERISTICS OF VARIOUS DATABASES

S.No.	DATABASE	CHARACTERISTICS/REMARKS
17.	DISCODE	Table of captions relating primary discipline code to expansion.
18.	DBKERNEL	The database kernel consisting of mostly immutable (for reasonable period of time) fields of data used by a plethore of applications.
19.	APPLIC	Database of applications for recruitment (teaching positions only).
20.	SELECT	Database of candidates shortlosted/selected for recruitment.
21.	INDEXREC	Indexing of applications for faster access path.
22.	ESTAB	Database of establishment of teaching, supporting and helping staff positions.
23.	PSITADA	Database of PS I faculty for processing of PS I TA/DA; used only once in August every year.
24.	HOUSING	Information on houseing (on campus only).
25.	LTCMAIN	Main database for processing LTC claims.
26.	TRAINS	Database of shortest routes used in processing LTC claims.
27.	REMLIST	Database of dates for reimmders.
28.	EVENTS	Database of events recording while processing GRA & DSS; used movaly for consolidation and errior recovery.
29.	SCRATCH	General purpose database used mainly as temporary one for carrying out "what if" trials.
30.	AUDIT	Used for logging database usage activities; Mainly used for security and auditing.

Integration, as stated above, is mainly achieved through strong linkages established through a small set of keys and access path provisions. Sufficient care has been taken while designing the structure of the databases so that modifications, enhancements to them or to the applications do not create a ripple effect across a large number of applciations in the computerized information system. Indeed, this was one of the prime requirements if development and maintenance costs are to be pegged at low levels.

Redundancy of the databases are removed through transforming the databases to be in the Third Normal Form of Codd. The only potential danger is that as the databases get modified/enhanced, or newer ones get created, checks have to be initiated to see that they are in Third Normal Form.

The applications that form part of the computerized information system for educational administration fall into the following broad categories, in this implementation.

* database building utilities
* utilities that aid in editing and browsing through the databases
* utilities that provide a set of structured access paths to the databases
* applications for processing GRA
* report generators for GRA
* query processors for GRA
* applications for decision support functions
* miscellaneous utilities that aid in the housekeeping functions

like backup, recovery procedures, etc.

The integrated computerized information system for educational administration that has been designed and implemented in this thesis with special reference to human resources management has over 15 applications (covering both GRA and decision support), consisting of over a 150 programs running into source code lines in excess of 45,000 lines. The applications discussed in chapters 3 and 4 are essentially Fortran programs with a loosely coupled file system and little integration. They spanned about a dozen applications, covering about a 100 programs, running into roughly 27,000 lines of code. The integrated software developed herein is far more structured, the databases more closely coupled and spans a wider dimension of applications.

5.5.3 Support Routines for Checking Integrity Requirements

There are a few reasons why there is a periodic, if not continuous, need to check the integrity of the databases in the computerized information system for educational administration for a university like BITS. The software development process has been consciously chosen to be on the lines of the evolutionary delivery scheme. Thus existing databases tend to get modified or enhanced and new databases come into existence. Evolutionary development of software ought not to disturb the integrity of the system. In such a situation of software evolution, if integrity is lost, it would be extremely difficult, if not impossible, to extricate oneself from the situation.

In BITS, the various applications are developed according to the evolutionary delivery scheme. Further changes do occur frequently necessitating many changes in the database structures and application programs. Therefore it is necessary to check the integrity of the databases periodically. Support programs for checking the integration and and integrity requirements have been developed that are executed periodically. Here, periodically implies whenever changes are made by relatively newer applications to existing databases, existing database structures modified, newer databases grafted to the system, and in similar such situations. The support routines that have been developed for checking the integrity of that databases are listed below in Table 5.5.

TABLE 5.6

SUPPORT ROUTINES FOR CHECKING THE INTEGRITY REQUIREMENTS

S.No.	SUPPORT ROUTINE	FUNCTION
1.	CHEKLINK	Checks links & access pointers for consistency
2.	CLEANUP	Cleans up unwanted/defunct records and conserves space
3.	3NFORM	Checks whether the databases are in Third Normal Form
4.	CHEKUP	Checks whether the GRA processing is in designated order
5.	CHEKINT	Checks integrity of databases after every update cycle
6.	LOOSEND	Checks for loose ends like dangling pointers, uninitialized fields, etc.
7.	AUDIT	Keeps a log of database access and usages to be used for monitoring.

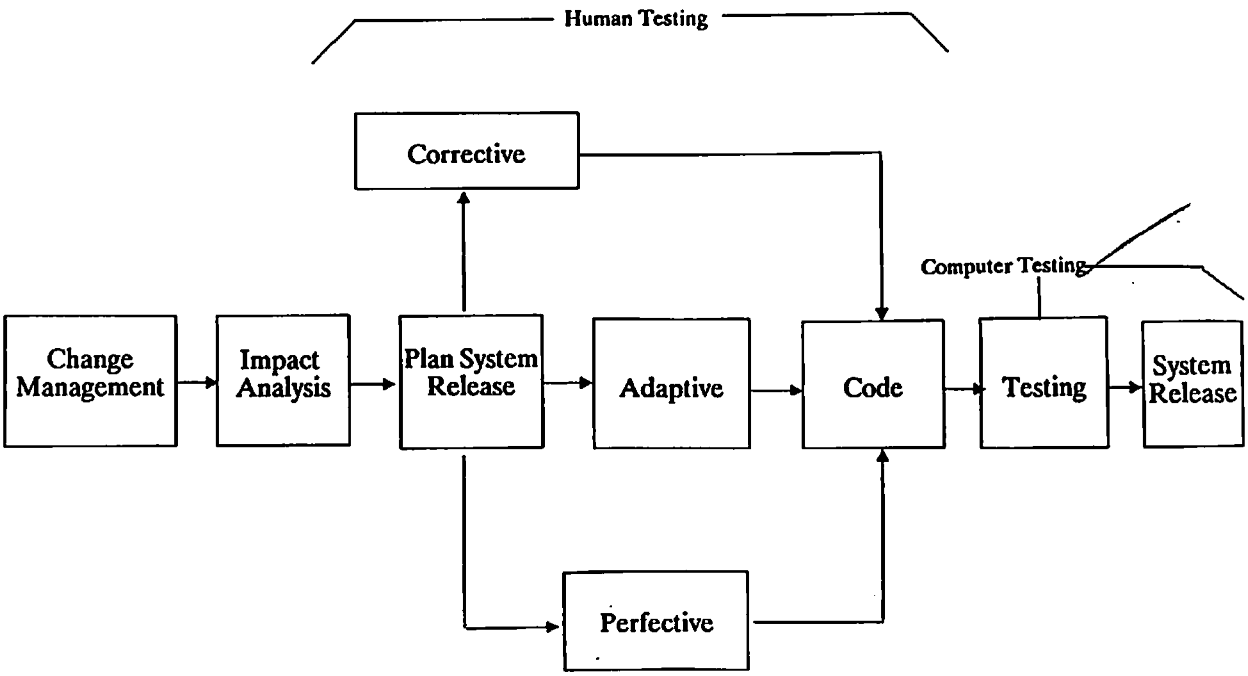
5.5.4 Testing Methodology and Validation Notes

The integrated computerized information system for educational administration that was implemented has been subjected to rigorous testing. In this thesis testing has been employed in the maintenance phase as well as in the development phase. Mostly, a form of incremental testing [Myers G.J.(1979)] has been used. Some of the taspects of testing as has been employed in this thesis are reported below.

* The thesis considered testing as a process of executing a program with the intent of finding errors. [See Myers G.J.(1979)]. The main objectives of testing the computerized information system are to ensure compliance with the original requirements and approved changes. It is also to ensure a quality product that is operational.
* Brooks F.P.(1975) states that testing may take up over 50% of the developmental budget. In this thesis, the aim was to construct a cost-effective system without sacrificing quality. Therefore, a planned testing process essential for the succes of the effort. A form of maintenance testing was followed with less than 10% maintenance allocated during the planning and design phases, about 40% during the coding phase, about 25% during component and early system testing, and about 25% with the entire system functional.
* It was soon realized that maintenance testing was not at all an easy chore, as designs, programs and code all got revised considerably in a rapidly changing environment. Thus, in the latter stages of development in the thesis, incremental

FIGURE 5.7

SCHEMATIC OF THE INCREMENTAL TESTING PROCESS



testing was followed. Incremental testing is a more natural form when the evolutionary delivery scheme is used.

* Basically, test planning is based on the principle of incremental testing. Incremental testing integrates human ad computer testing to test the software in smaller portions. [See Fig. 5.7].

* One of the major advantages of the incremental testing, as employed in this thesis, is that many defects in the edsign and requirement phases itself got eliminated. By integrating the system in stages, a narrow set of interfaces were required to be tested one at a time. This aided in keeping the development and maintenance costs low.

* Some of the other advantages of the incremental testing method are as follows:
  - it requires less work, as testing is spread over the maintenance process and not merely at the very end of the project; reliability gets enhanced.
  - programming errors were detected and removed during the design and coding phases; it would be difficult to correct errors at the time of integration testing or final system testing.
  - it reduces the extent or domain of the problem; during a unit test, only the revised modules need to be examined; during integration test, only the interfaces between modules and programs need to be examined; during final system test, only the man-machine interface and the interfaces between one program and another need to be examined.

* The specific items considered during the test plan are
  - testing specifications
  - list of program and databases
  - new test cases
  - documentation of test results
  - testing procedures
* Walkthroughs or inspections were also employed in the design and coding phases. Sufficient cost savings resulted because of this since
  - there were fewer computer runs
  - there were less modifications required
  - there were less scope for complicated future changes

  Brooks F.P.(1975) mentions that over 80% of all defects in the system can be caught using walkthroughs and inspections.
* Apart from the human testing using walkthroughs or inspections, computer testing was also performed at the program unit, integration and final system levels. A form of bottom-up testing was employed, with the lowest level programs and working incrementally backwards up the hierarchy.
* Much of the time, online testing with systematic documentation procedures were followed.

As of today, many of the modules of the computerized information system are functional on a regular basis at BITS, with end users as well as consumers of the outputs of the system not reporting any serious errors.

5.5.5 Avenues for Future Expansion

Educational administration at BITS is constantly researching on educational innovation that brings about change. Such changes inevitably place newer demands on the integrated computerized information system for educational administration. As such, the thesis has demonstrated that using the evolutionary delivery scheme, a cost-effective computerized information system can be designed, implemented and made functional. The system, as described in the thesis, has been operational for the last 6 years.

In the last few years, the system has undergone numerous changes, enhancing the database coverage and that of applications. As always, integration and cost-effectiveness has been the prime concerns. The experience of operating the system has shown that software maintainability is easy and is quite a structured process. Avenues for future expansion has been designed into the system in the following ways.

* The using of the kernel portion of a database renders a uniform access path to diverse applications. Thus, adding applications exploit the common data elements in the kernel.
* The method of employing local databases provides a simple way of grafting newer applications that require additional data, over and above what is hitherto available across the databases.
* Provision of support routines that check the integration requirements also ensure that redundancies are eliminated by having all the databases in third normal form.

* Since the evolutionary delivery scheme is employed, expansion avenues are only limited by the physcal constraints such as availability of secondary storage, etc.

As a matter of fact, at the time of writing this thesis, adhoc applications are evolved, tested and used in the system for a trial run. As its functionality is demonstrated to a degree of satisfaction, it is integrated into the entire computerized information system.

CHAPTER 6

POSTSCRIPT

The foregoing chapters described the design and implementation of a cost-effective integrated computerized information system for educational administration using the evolutionary delivery scheme. In this chapter, the pilot runs of the system that were undertaken at BITS and the experiences gained thereof are briefly described. The entire thesis concentrated on the design of a cost-effective system that sacrifices neither functionality nor the integration requirements. Thus, a brief discussion of the cost-effectiveness aspect of the system will be reiterated in this chapter. Concluding remarks and suggestions improvement and for future work form the latter portions of the chapter.

6.0 PILOT RUNS AND EXPERIENCES

The entire study has spanned a period of six years, involving development on different types of hardware platforms and on different operating environments using different development tools. A schematic diagram showing the chronological evolution of the entire computerized information system is given in Fig. 6.1. Table 6.1 lists the time spent in each of the developmental activities, manpower involved and man hours employed. This gives a fair idea of the "costs" involved in the

FIGURE 6.1

CHRONOLOGICAL EVOLUTION OF THE COMPUTERIZED INFORMATION SYSTEM

STAGE 1	IBM1130	FORTRAN II	. PAYROL . ESTABLISHEMENT BUDGET . FACULTY RECORDS
STAGE 2	SPECTRUM/3 INTEL 8085 BASED MICRO	MICROSOFT FORTRAN PASCAL	. FACULTY RECORDS . ESTABLISHEMENT BUDGET . PAYROLL . INCOME TAX . LEAVE TRAVEL CONCESSIONS . BILLING . HOUSING INFORMATION . BENEFITS PROCESSING
STAGE 3	IBM COMMTABILE PC XTs	dBASE II PLUS FORTRAN 77 C	. FACULTY RECORDS . ESTABLISHMENT BUDGET . BUDGET MONITORING . PAYROLL . INCOME TAX . LTC CLAIMS & BILLING . BENEFITS PROCESSING . HOUSING INFORMATION . INTEGRATED STAFF DATA BASE . REMINDER SERVICE/DATE FLASH . ELIGIBILITY CHECKS . PENSION . SOME "WHAT IF" ANALYSIS . DECISION SUPPORT FOR FACULTY . REVIEW
STAGE 4	UNIX BASED SUPERMINI	RDBMS; AGL C with EMBEDDED	. ALL OF ABOVE . DSS OF OPTIMIZATION TYPE . DSS INVOLVING MODELLING . DSS INVOLVING SIMULATION

Useful data

TABLE 6.1

DEVELOPMENTAL ACTIVITIES AND MANPOWER INVOLVEMENT

STAGE	ACTIVITY	MANPOWER INVOLVEMENT IN PHASES (MAN MONTHS)				
		SYSTEMS ANALYSIS	DESIGN	CODING	FINE TUNING	TOTAL
1	FACULTY RECORDS	1.0	1.0	0.5	1.0	3.5
	PAYROLL	1.5	1.0	1.0	2.0	5.5
	ESTABLISHEMENT-BUDGET	3.0	2.0	3.0	3.0	11.0
2	FACULTY RECORDS	0	0	0.5	0.5	1.0
	PAYROLL	0	0.5	1.5	2.0	4.0
	ESTABLISHMENT-BUDGET	0	0.5	1.5	1.5	3.5
	INCOME TAX	2.0	2.0	2.0	2.0	8.0
	LTC CLAIMS & BILLING	3.0	3.0	2.0	2.0	10.0
	HOUSING INFORMATION PROCESSING	2.0	1.0	4.0	2.0	8.0
3	FACULTY RECORDS	0	0	1	1	2.0
	PAYROLL	0	0.5	0.5	4.0	5.0
	INCOME TAX	0	0	0.25	1.0	1.25
	LTC CLAIMS & BILLING	2.0	1.0	1.0	1.0	5.0
	BENEFITS PROCESSING	1.0	0.5	0.5	0.5	2.5
	HOUSING INFORMATION	0	0	1.0	0.5	1.5
	INTEGRATED SDB	10.0	6.0	12.0	8.0	36.0
	ESTABLISHMENT BUDGET	2.0	1.0	1.0	0.5	4.5
	REMINDER SERVICE/DATE FLASH	1.0	0.5	1.0	1.0	3.5
	ELIGIBILITY PROCESSING	3.0	1.0	3.0	2.0	9.0
	PENSION	1.0	0.25	1.0	1.0	3.25
	SOME "WHAT IF" ANALYSIS	2.0	1.0	3.0	0.5	6.5
	DECISION SUPPORT FOR FACULTY REVIEW	1.0	2.0	2.0	3.0	8.0

developmental effort. What would be required is to to merely state the figures using a monetary conversion factor. The following points briefy summarize the experiences of the pilot runs of some of the crucial units of the system.

* The building up of a kernel of a database with common elements of a static nature was one of te most daunting tasks. Not simply because of the volume of the data involved. SOme data were not even available, and are not available even today. For example, there are some staff members (especially in the helping staff category) who had joined the erstwhile Birla colleges which later on merged into the present BITS. Due to the sloppy record keeping practices in the early days, the "date of birth" of quite a few employees are not recorded anywhere. Worse, when the kernel database was being built, the concerned staff could not produce a certificate of birth or any such proof of age. What is required is a rationalizing of the gaps in the database. However, a rationale seems to be elusive!
* The kernel building process was time consuming only insofar as recording the data items in a proforma suitable for entry into the database and obtaining the gap information from the staff directly through specially designed proformas. The data entry and verification themselves were performed within a week, employing only about 85 man hours for data entry and about 45 man hours for verification.
* COnsistent with our philosophy of building on the strong base of the GRA, payrool, establishment budget, income tax, billing

and benefits processing were accorded top priority. Only later were the decision support modules designed.

* The pilot runs involving the GRA suggested that updating the massive databases was the most troublesome aspect. It was not out of a want in the software concerned with updating the databases. The proformas and procedures employed by the various administrative entities were found lacking to provide a smooth path to updating. Thus a methods study to improve the paper handling and procedures were suggested to be undertaken to streamline the functioning of the administrative entities.

* While the pilot runs of the GRA were being carried out, notably with respect to payroll, benefits processing and billing, some of the operating rules were found to be unduly complex without being productive. Many of them were shown to be archaic and are capable of being rationalized into a simpler set of rules. Many of the suggestions to simplify certain operating rules were immediately considered, approved and incorporated into the computerized information system. Many others are in the process of being discussed for simplification.

* The training of the operational manpower turned out to be the most uncomplicated of the jobs. The personnel found the user interface quite pleasing, easy to understand and operate withour undue difficult. Feedback from the operators were used to suitably modify the user interfaces.

* Getting the administrative entities which traditionally operated the GRA to accept the computerized information system was a more difficult task. While many have accepted the

functioning of the system, they have not been able to use the system in a highly productive manner. Constructive feedback from these entities were also not forthcoming.

* Many elementary decision support modules that were implemented, notably those connectde with eligibility processing and for faculty review, were highly appreciated. More and more such requirements are surfacing regularly.
* A few administrative entities, having seen the experiences of the pilot runs and the functionality of the system, have given the feedback that more structured decision support modules that they can directly operate would be appreciated.
* The overall feeling that was expressed was that the computerized information system lessened routine jobs, streamlined the functioning and in cases, made the tasks even interesting.

6.1 COST-EFFECTIVENESS ACHIEVEMENT

Cost-effectiveness of the design, development, implementation, functioning and maintenance of the computerized information system was achieved through a combination of factors. Some of these are briefly discussed below.

* The decision to use available hardware set the tone for the entire development cycle. The investment on hardware was kept at abare minimum level employing existing modest hardware. No fancy features were sought nor provided.
* Similarly, the costs incurred in the software development tools were kept low by choosing to use an existing RDBMS. The use of expensive toolkits and 4GLs were avoided.
* The development manpower was to be from the faculty of BITS. The persons were expected to conribute to the developmental effort in addition to his teaching, research and other responsibilities. Thus the costs of software development manpower was pegged at a ridiculously low figure by not employing external consultants.
* The operating manpower was chosen rom among the existing clerical staff. Thus the only costs involved are in the training of the rudimentarily endowed manpower.
* Productivity showed improving trends from the viewpoint of orderly record keeping, operation of the GRA and releasing manpower to do other tasks. Table 6.2 attempts to provide a comparative picture of manpower time spent in the manual process of performing the GRAs and that while operating the computerized information system.

Traditionally universities, even the more static ones, have not embarked on computerization ventures often on the plea of not being able to bear the costs of design, development and operation. Dynamic universities like BITS (there are very few of them in India), have taken the refuge of saying that the rapid changes that occur in the system makes a computerized information system costly to design and maintain. The effort of the thesis has been to show methodology whereby a cost-effective computerized information system may be designed, implemented and made functional in a highly dynamic university like BITS. Functionality and integration requirements, too, need not be sacrificed. the thesis shows that what is essential is an

TABLE 6.2

COMPARATIVE PICTURE OF MANPOWER TIME SPENT IN MANUAL AND COMPUTER ASSISTED PROCESS

GRA	TIME SPENT (MAN DAYS) DATA COLLECTION	UPDATION	GRA PROCESSING	VERIFICATION	REPORT	CONSOLIDATION	TOTAL
MANUAL SYSTEM							
. FACULTY RECORDS	20	5	12	10	15	10	73
. PAYROLL	25	15	5	5	15	20	85
. ESTABLISHMENT BUDGET	90	100	180	180	100	30	680
. INCOME TAX	60	20	15	15	30	10	150
. LTC	-	5	5	3	2	1	16
. ELIGIBILITY	-	3	3	2	1	1	10
. PENSION	10	5	2	1	1	1	20
COMPUTER ASSISTED							
. FACULTY RECORDS	3	0.25	*	0.5	0.25	1	3
. PAYROLL	5	2	1	1	2	1	12
. ESTABLISHMENT BUDGET	20	30	3	10	3	10	76
. INCOME TAX	10	5	1	5	1	1	23
. LTC	-	0.25	0.25	1	*	0.5	3
. ELIGIBILITY	-	0.25	*	0.25	*	0.5	1
. PENSION	2	0.25	*	0.25	*	*	2.5

* Time spent on this activity is neglible in terms of 1 man hour and is of a magnitude of just a few man-minutes.

administrative will and a conscious choice of following the evolutionary delivery scheme for software engineering.

6.2 CONCLUDING REMARKS

The following are some of the conclusions that emerge from the thesis.

* Rapid change presents a veritable software maintenance challenge. In a university like BITS where change is commonplace, maintenance of software presents the single daunting aspect in the design and implementation of a computerized information system for educational administration.
* Adoption of the evolutionary delivery scheme for the engineering of software for educational administration is an insulating factor to the dynamic forces that presents changing requirements.
* Inspite of the challenge posed by the dynamic nature of educational administration in universitieslike BITS, yet another crucial objective, namely, cost-effectiveness can also be achieved.
* Cost-effectiveness of the design, implementation, operation and maintenance of the computerized information system may be achieved through a variety of factors available to almost all universities. Some of these are choosing low cost hardware as the implementation platforms, shunning fancy features, exploiting the use of available resources, including software development manpower from within the university (as opposed to the employment of external consultants which is a soft option but an expensive one), internal manpower training, etc.
* Cost-effectiveness as chosen path to development does not constrain the computerized information system from being

functionally efficient or to satisfy integration requirements.

* Cost-effectiveness, integration ad functionality are necessarily opposing objectives, as is normally believed.

* The use of a kernel database containing common data items of a static nature, and using local databases for specific applications makes the software modular, easy to develop and easier to maintain.

* A judicious combination of evolutionary delivery scheme for engineering software and incremental testing reduces the load on the software maintenance phase. This also contributes to cost-effectiveness since it is a well known fact that software maintenance costs form a sizeable portion of the overall costs.

* The implementation path would be smooth if a broad base of GRA are chosen first to be incorporated into the computerized information system for educational administration. Only then, does implementation of modules for decision support make sense in terms of easy of implementation and maintainability.

* Useful decision support functions may be provided to the educational administrators in the form of elementary functions like a reminder service, simple rule checking, eligibility checks and the provision for the analysis of "what if" scenarios. Sophisticated decision support modules involving modelling and simulation are inappropriate to universitites that are grappling with a fledging computerized information system.

* The experiences gained in the last six years with the operation of the computerized information system for educational administration at BITS has shown that only now is the system poised to move towards the implementation of sophisticated decision support systems.
* The system that has been implemented is capable of being expaned and enhanced in terms of the databases as well as the applications. Modifications due to changes have effects that are localized to few areas. They do not create a ripple effect across a plethora of applications.

6.3 SUGGESTIONS FOR FUTURE WORK

Based on the design, implementation, operation and maintenance experiences gained with the computerized information system for educational administration at BITS, the following suggestions for future work are made below.

* As the utility of such systems increase, there would be an increased demand for decision support from the system by many educational administrators. Instead of considering a multiuser implementation, it it suggested the feasibility of a LAN solution built over the existing system be studied. In this way, many of the existing software can be salvaged.
* Decision support modules for educational administration involving modelling and simulation may be built over the strong foundation that exists.
* The operational experiences have shown that the most pressing need is for a "query by example" interface to aid the tenderfoot user in using the computerized information system. A SQL interface would be a reasonable solution within the existing framework.
* The possibility of providing a 4GL interface so the educational administrators may develop their own applications would have to be worked out. Cost-effective solutions are now within reach employing modestly priced 4GLs.

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APPENDIX A

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE
PILANI (RAJASTHAN)

PAYSLIP FOR THE MONTH OF FEB 1990

Name V P Gaur CONFIDENTIAL
Designation ASTP
Div/Unit FD1
PSRN 8 Net Pay 2932.36

Bank a/c No. 02088 /02

PAYMENTS	Rs Ps	DEDUCTIONS	Rs Ps		Rs Ps
Basic Pay	4075.00	HRent	17.00	Stf Asn	3.00
D.A.	325.00	TC-CH	7.00	PF Loan	0.00
Spcl Alwnc	0.00	Meter	1.00	Furn Ln	40.00
Other Pmnt	0.00	Elect	73.80	Stf Adv	0.00
Arrears	0.00	PF	704.00	Fur Rnt	0.00
PS ALnc	0.00	Inctx	163.50	R Stamp	0.20
Medical	55.60	LIP	0.00	Oth Ded	6.40
		CTD	50.00	Spcl Ln	0.00
		Leave	0.00	Not Emp	0.00
		FP	0.00	BITSCOP	457.34
Total	4455.60	Total			1523.24

Employers Contribution to PF 440.00
Employers Contribution to FP 0.00

Electricity Units : 60

Prepared By
Staff Data Centre

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE
PILANI (RAJASTHAN)

PAYSLIP FOR THE MONTH OF FEB 1990

Name S N Prasad CONFIDENTIAL
Designation LECT
Div/Unit FD1
PSRN 10 Net Pay 2787.21

Bank a/c No. 09718 /03

PAYMENTS	Rs Ps	DEDUCTIONS	Rs Ps		Rs Ps
Basic Pay	3200.00	HRent	0.00	Stf Asn	3.00
D.A.	275.00	TC-CH	0.00	PF Loan	0.00
Spcl Alwnc	0.00	Meter	1.00	Furn Ln	0.00
Other Pmnt	0.00	Elect	92.25	Stf Adv	0.00
Arrears	0.00	PF	319.00	Fur Rnt	0.00
PS ALnc	0.00	Inctx	65.00	R Stamp	0.20
Medical	24.10	LIP	36.60	Oth Ded	165.84
		CTD	0.00	Spcl Ln	0.00
		Leave	0.00	Not Emp	0.00
		FP	29.00	BITSCOP	0.00
Total	3499.10	Total			711.89

Employers Contribution to PF 319.00
Employers Contribution to FP 29.00

Electricity Units : 75

Prepared By
Staff Data Centre

CTD Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	CTD
1	8	V P Gaur	50.00
2	9	SureshChandra Sharma	200.00
3	15	G D Tripathi	100.00
4	43	S P Gupta	100.00
5	44	SurendraKumar Sharma	200.00
6	74	V P Goel	100.00
7	89	Rup Datta	50.00
8	97	K R Chandhoke	50.00
9	159	G R Nagaraj	100.00
10	168	P S V S K Raju	100.00
11	202	Brij Lal	50.00
12	204	Brij Lal Saini	100.00
13	207	P P Mehta	10.00
14	212	Rama Kant Prasad	10.00
15	217	M P Soni	100.00
16	270	S N L Srivastava	40.00
17	286	K Gopalan	100.00
18	289	Sagar Mal	20.00
19	295	Sardararam Saini	100.00
20	299	Dwarka Prasad	20.00
21	316	H C Pant	50.00
22	319	R A Soni	150.00
23	326	Ram Swaroop	100.00
24	396	G R Bhomia	50.00
25	402	Ram Nivas	20.00
26	446	Jagdish Rana	50.00
27	447	Bhagwanaram	150.00
28	494	Jagdish Pd	30.00
29	497	Mahabir Pd Saini	10.00
30	538	Maliram Mali	30.00
31	695	Brij Lal Saini	30.00
32	736	Ram Murthy Bhomia	100.00
33	891	Pawan Kumar Sharma	10.00
34	900	Duli Chand Verma	200.00
			2580.00

SALARY NOT DRAWN

-- NIL --

Consolidated PF Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	PFC	PFD	PFLOAN	TOTAL
1	2	R K Saksena	471.00	771.00	335.00	1577.00
2	4	J V S Mani	449.00	449.00	500.00	1398.00
3	5	H S Moondra	456.00	456.00	0.00	912.00
4	7	G P Avasthi	471.00	771.00	0.00	1242.00
5	8	V P Gaur	440.00	704.00	0.00	1144.00
6	9	SureshChandra Sharma	440.00	440.00	0.00	880.00
7	10	S N Prasad	319.00	319.00	0.00	638.00
8	12	Krishna Mohan	471.00	771.00	0.00	1242.00
9	13	P D Chaturvedi	500.00	800.00	500.00	1800.00
10	15	G D Tripathi	391.00	643.00	0.00	1034.00
11	16	J P Verma	391.00	391.00	0.00	782.00
12	20	S K Jain	391.00	391.00	0.00	782.00
13	22	Ravindra Roy	329.00	329.00	0.00	658.00
14	26	S C Rastogi	449.00	735.00	193.00	1377.00
15	28	K E Raman	269.00	269.00	400.00	938.00
16	31	Shri Dayal	471.00	471.00	0.00	942.00
17	34	H Subramanian	471.00	471.00	420.00	1362.00
18	35	Mrs S Mitra	310.00	513.00	0.00	823.00
19	36	M C Joshi	500.00	800.00	0.00	1300.00
20	37	S C Rastogi	471.00	771.00	625.00	1867.00
21	41	R S Rai	500.00	500.00	1000.00	2000.00
22	42	K P Srivastava	471.00	471.00	0.00	942.00
23	43	S P Gupta	471.00	771.00	0.00	1242.00
24	44	SurendraKumar Sharma	456.00	456.00	300.00	1212.00
25	46	L K Singh	371.00	371.00	0.00	742.00
26	47	K C Sud	420.00	672.00	0.00	1092.00
27	48	A N Pant	269.00	269.00	0.00	538.00
28	49	S K Arya	254.00	254.00	0.00	508.00
29	51	P K Raman	471.00	471.00	450.00	1392.00
30	52	V P Mainra	471.00	771.00	0.00	1242.00
31	53	B S Tavathia	471.00	471.00	450.00	1392.00
32	56	Satya Prakash	384.00	384.00	0.00	768.00
33	57	M V Tamhankar	384.00	384.00	300.00	1068.00
34	59	Mrs P Mandke	371.00	371.00	0.00	742.00
35	61	M K Kashiramka	236.00	395.00	0.00	631.00
36	62	S S Mathur	500.00	500.00	0.00	1000.00
37	64	J S Verma	471.00	771.00	0.00	1242.00
38	65	H M Ghule	471.00	471.00	0.00	942.00
39	66	Shri Krishna Sharma	500.00	500.00	0.00	1000.00
40	67	G P Srivastava	371.00	371.00	0.00	742.00
41	68	T N R.K Kurup	400.00	400.00	1000.00	1800.00
42	69	Rakesh Mehrotra	254.00	254.00	0.00	508.00
43	70	P C Pandey	371.00	371.00	0.00	742.00
44	71	Ved Prakash	351.00	351.00	0.00	702.00
45	74	V P Goel	456.00	456.00	212.00	1124.00
46	75	M S Radhakrishnan	411.00	499.00	500.00	1410.00
47	76	S N Pathak	440.00	440.00	675.00	1555.00
48	77	M C Datta	286.00	286.00	300.00	872.00
49	79	R K Mittal	269.00	269.00	300.00	838.00
50	81	S Venkateswaran	581.00	581.00	375.00	1537.00

Birla Institute of Technology & Science Pilani
Computer Assisted Housekeeping Unit

BANK Statement for the month of February 1990

SNO	PSRN	NAME	BANK A/C NO.	NET PAY	SIGNATURE
1	194	K N Sharma	06229/01	859.43	
2	399	D R Sunar	06430/01	1822.43	
3	337	Shyam Lal	06889/01	836.60	
4	183	K M Sharma	06898/01	785.54	
5	219	Matu Ram Saini	06975/01	437.15	
6	270	S N L Srivastava	07514/01	1079.17	
7	48	A N Pant	07647/01	2639.51	
					8459.83
8	96	I J Nagrath	01005/02	4270.50	
9	129	S C Mittal	01374/02	3795.38	
10	286	K Gopalan	01584/02	4742.93	
11	82	Birbal Singh	02052/02	1988.54	
12	105	J N Jaitly	02054/02	3232.09	
13	26	S C Rastogi	02087/02	3655.81	
14	8	V P Gaur	02088/02	2932.36	
15	66	Shri Krishna Sharma	02110/02	4619.46	
16	90	K C Gupta	02157/02	3871.47	
17	46	L K Singh	02559/02	2587.10	
18	42	K P Srivastava	02999/02	3777.01	
19	308	M M Narang	03100/02	1459.38	
20	65	H M Ghule	03550/02	4028.79	
21	186	A P Rastogi	03557/02	1856.39	
22	89	Rup Datta	04490/02	4048.48	
23	200	J P Sharma	04516/02	883.63	
24	111	Devi Prasad	05583/02	3114.91	
25	172	L K Maheshwari	05631/02	4479.69	

FURN RENT Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	FURN RENT
1	825	G Sundar	4.00
2.	828	S K Ray	6.00
3	857	R C Gummadi	5.00
4	874	Sunil Kumar	2.00
5	877	Santosh Kumar Singh	4.00
6	937	Abhimanyu Mohapatra	2.00
7	948	R C Jain	4.00
8	958	V K Devarayalu	4.00
9	960	G S Rao	4.00
10	963	V K Deshpande	4.00
11	984	J K Basu	4.00
12	991	Anil Rai	4.00
13	1000	Miss T Sreedevi	2.00
			49.00

SALARY NOT DRAWN

-- NIL --

FAMILY PENSION Statement for the month of FEB , 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	SALARY	FPC 1 1/6%	FPD 1 1/6%
1	2	R K Saksena	5000	29	29
2	4	J V S Mani	4775	29	29
3	5	H S Moondra	4850	29	29
4	7	G P Avasthi	5000	29	29
5	10	S N Prasad	3475	29	29
6	12	Krishna Mohan	5000	29	29
7	15	G D Tripathi	4200	29	29
8	16	J P Verma	4200	29	29
9	20	S K Jain	4200	29	29
10	22	Ravindra Roy	3575	29	29
11	26	S C Rastogi	4775	29	29
12	28	K E Raman	2975	29	29
13	31	Shri Dayal	5000	29	29
14	34	H Subramanian	5000	29	29
15	35	Mrs S Mitra	3387	29	29
16	37	S C Rastogi	5000	29	29
17	42	K P Srivastava	5000	29	29
18	43	S P Gupta	5000	29	29
19	44	SurendraKumar Sharma	4850	29	29
20	46	L K Singh	4000	29	29
21	48	A N Pant	2975	29	29
22	49	S K Arya	2825	29	29
23	51	P K Raman	5000	29	29
24	52	V P Mainra	5000	29	29
25	53	B S Tavathia	5000	29	29
26	56	Satya Prakash	4125	29	29
27	57	M V Tamhankar	4125	29	29
28	59	Mrs P Mandke	4000	29	29
29	61	M K Kashiramka	2650	29	29
30	64	J S Verma	5000	29	29
31	65	H M Ghule	5000	29	29
32	67	G P Srivastava	4000	29	29
33	69	Rakesh Mehrotra	2825	29	29
34	70	P C Pandey	4000	29	29
35	71	Ved Prakash	3800	29	29
36	74	V P Goel	4850	29	29
37	75	M S Radhakrishnan	4400	29	29
38	77	M C Datta	3150	29	29
39	79	R K Mittal	2975	29	29
40	81	S Venkateswaran	6100	29	29
41	82	Birbal Singh	5000	29	29
42	87	K R V Subramanian	2575	29	29
43	89	Rup Datta	4850	29	29
44	90	K C Gupta	4775	29	29
45	91	V N Sharma	4400	29	29
46	92	P R Marwadi	4125	29	29
47	97	K R Chandhoke	4850	29	29
48	100	J C Pant	5000	29	29
49	101	R K Patnaik	4850	29	29
50	105	J N Jaitly	4400	29	29

Birla Institute of Technology & Science Pilani

DRAFT Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	NET PAY	BANK NAME
1	44	SurendraKumar Sharma	3492.30	NAGDA
2	64	J S Verma	4125.60	GHAZIABAD
3	106	D P Mittal	3696.55	STATE BANK OF INDIA, VIRBHADRA
4	116	R P Bhatnagar	40.97	CHURCHGATE, BOMBAY
5	124	Arjun Badlani	3495.80	PARLIAMENT STREET, NEW DELHI
6	128	Ramesh Chandra Garg	3699.80	CHANDIGARH
7	133	A K Chatterjee	1284.80	PARK STREET, CALCUTTA
8	135	Anjan Ghosh	0.00	CHURCHGATE, BOMBAY
9	137	N C Mishra	4299.32	PARK STREET, CALCUTTA
10	138	B R Natarajan	1990.76	PARK STREET, CALCUTTA
11	146	Samarendranath Saha	2350.80	PARK STREET, CALCUTTA
12	148	R Bandyopadhyay	2299.30	PARK STREET, CALCUTTA
13	150	Murali Dhar Arora	2136.80	DEFENCE COLONY BRANCH, NEW DELHI
14	151	B V Prasad	2309.80	PARK STREET, CALCUTTA
15	152	B N Sharma	2530.30	NAGDA
16	231	V Jayraman	2215.59	UCO Bank, Adyar Branch, Madras
17	624	B G Saha	6.00	ULHASNAGAR, BOMBAY
18	655	Mrs Kusum Lata	2192.94	UCO Bank, Adyar Branch, Madras
19	658	S K Khandelwal	145.00	CHURCHGATE, BOMBAY
20	676	Mrs Uma M Mokashi	2099.80	RICHBOND CIRCLE, BANGALORE
21	681	Dr Suresh C Sharma	2663.30	PARLIAMENT STREET, NEW DELHI
22	738	S C Banerjee	530.00	CHURCHGATE, BOMBAY
23	740	Sangeeta Pruthi	2099.80	PARLIAMENT STREET, NEW DELHI
24	760	H S Jabbal	984.80	PARK STREET, CALCUTTA
25	761	Mrs Alka Mitra	2099.80	PARK STREET, CALCUTTA

Birla Institute of Technology & Science Pilani

PF LOAN Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	PF LOAN
1	2	R K Saksena	335.00
2	4	J V S Mani	500.00
3	13	P D Chaturvedi	500.00
4	26	S C Rastogi	193.00
5	28	K E Raman	400.00
6	34	H Subramanian	420.00
7	37	S C Rastogi	625.00
8	41	R S Rai	1000.00
9	44	SurendraKumar Sharma	300.00
10	51	P K Raman	450.00
11	53	B S Tavathia	450.00
12	57	M V Tamhankar	300.00
13	68	T N R K Kurup	1000.00
14	74	V P Goel	212.00
15	75	M S Radhakrishnan	500.00
16	76	S N Pathak	675.00
17	77	M C Datta	300.00
18	79	R K Mittal	300.00
19	81	S Venkateswaran	375.00
20	82	Birbal Singh	625.00
21	91	V N Sharma	500.00
22	92	P R Marwadi	300.00
23	97	K R Chandhoke	500.00
24	101	R K Patnaik	425.00
25	108	R P Vaid	250.00
26	109	S R Yadava	1000.00
27	122	J L Arora	500.00
28	130	V Panduranga Rao	500.00
29	131	V S Rao	350.00
30	150	Murali Dhar Arora	220.00
31	154	S Kumar	450.00
32	155	Mrs Aparna Gupta	250.00
33	161	B K Nema	525.00
34	165	S D Misra	425.00
35	176	D M Mishra	275.00
36	177	M R Jangira	68.00
37	178	Durga Lal	225.00
38	180	Udai Pal Singh	210.00
39	181	J P Gaur	160.00
40	182	Ramswaroop	120.00
41	183	K M Sharma	100.00
42	184	Shankar Mal	300.00
43	186	A P Rastogi	210.00
44	187	Jagdish Kumar	180.00
45	192	C L Saini	320.00
46	194	K N Sharma	360.00
47	197	Bhagwan Das	125.00
48	200	J P Sharma	170.00
49	208	V P Agochiya	275.00
50	209	Ram Kumar	200.00

Birla Institute of Technology & Science Pilani

HOUSE RENT Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	HOUSE	RENT	TCC	METE
1	2	R K Saksena	B326B	75.00	15.00	1.00
2	4	J V S Mani	066C	30.00	10.00	1.00
3	5	H S Moondra	A323B	75.00	15.00	1.00
4	7	G P Avasthi	B297B	75.00	15.00	1.00
5	8	V P Gaur	218D	17.00	7.00	1.00
6	9	SureshChandra Sharma	136D	17.00	7.00	1.00
7	12	Krishna Mohan	168B	45.00	15.00	1.00
8	13	P D Chaturvedi	169B	65.00	15.00	1.00
9	15	G D Tripathi	065C	30.00	10.00	1.00
10	16	J P Verma	215D	17.00	7.00	1.00
11	20	S K Jain	B317D	25.00	7.00	1.00
12	22	Ravindra Roy	266D	17.00	7.00	1.00
13	26	S C Rastogi	237D	17.00	7.00	1.00
14	28	K E Raman	B327C	40.00	10.00	1.00
15	31	Shri Dayal	224C	50.00	10.00	1.00
16	34	H Subramanian	A326B	75.00	15.00	1.00
17	35	Mrs S Mitra	B296B	85.00	15.00	1.00
18	36	M C Joshi	287B	57.50	15.00	1.00
19	37	S C Rastogi	B328C	40.00	10.00	1.00
20	41	R S Rai	303C	30.00	10.00	1.00
21	42	K P Srivastava	186C	30.00	10.00	1.00
22	43	S P Gupta	D327C	40.00	10.00	1.00
23	46	L K Singh	264D	17.00	7.00	1.00
24	47	K C Sud	D313D	25.00	7.00	1.00
25	48	A N Pant	D310D	25.00	7.00	1.00
26	51	P K Raman	300B	55.00	15.00	1.00
27	52	V P Mainra	298B	55.00	15.00	1.00
28	53	B S Tavathia	D328C	40.00	10.00	1.00
29	56	Satya Prakash	D309D	25.00	7.00	1.00
30	57	M V Tamhankar	D304D	25.00	7.00	1.00
31	59	Mrs P Mandke	B322B	75.00	15.00	1.00
32	62	S S Mathur	301B	55.00	15.00	1.00
33	65	H M Ghule	233D	17.00	7.00	1.00
34	66	Shri Krishna Sharma	188C	30.00	10.00	1.00
35	67	G P Srivastava	B325B	75.00	15.00	1.00
36	68	T N R K Kurup	190C	35.00	10.00	1.00
37	69	Rakesh Mehrotra	217D	22.00	7.00	1.00
38	70	P C Pandey	D317D	25.00	7.00	1.00
39	71	Ved Prakash	234D	17.00	7.00	1.00
40	75	M S Radhakrishnan	A304D	25.00	7.00	1.00
41	76	S N Pathak	267D	17.00	7.00	1.00
42	77	M C Datta	219D	17.00	7.00	1.00
43	81	S Venkateswaran	289B	72.00	22.00	2.50
44	82	Birbal Singh	223C	30.00	10.00	1.00
45	87	K R V Subramanian	D311D	25.00	7.00	1.00
46	89	Rup Datta	162C	35.00	10.00	1.00
47	90	K C Gupta	284C	30.00	10.00	1.00
48	91	V N Sharma	229C	30.00	10.00	1.00
49	92	P R Marwadi	209D	17.00	7.00	1.00
50	96	I J Nagrath	A322B	75.00	15.00	1.00

Birla Institute of Technology & Science Pilani

List of Staff Whose Term Expires in MAR 1990
Prepared by Computer Assisted Housekeeping Unit

SNO	PSRN	NAME	Basic	Desig	Div	Joining Date	Term Expiry Date
1	279	R N Varma	1420	CSHR	A/CU	18/03/89	16/03/90
2	938	N B Venkateswarlu	2200	LECT	EDD	31/03/89	29/03/90

Birla Institute of Technology & Science Pilani

List of Staff Whose Term Expires in MAR 1990
Prepared by Computer Assisted Housekeeping Unit

SNO	PSRN	NAME	Basic	Desig	Div	Joining Date	Term Expiry Date
1	279	R N Varma	1420	CSHR	A/CU	18/03/89	16/03/90
2	938	N B Venkateswarlu	2200	LECT	EDD	31/03/89	29/03/90

SPECIAL LOAN Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	SPECIAL LOAN
1	68	T N R K Kurup	42.00
2	82	Birbal Singh	625.00
3	116	R P Bhatnagar	2518.57
4	135	Anjan Ghosh	1770.04
5	188	M K Sharma	150.00
6	243	O P Runthla	42.00
7	268	N K Sharma	200.00
8	311	M P Saini	120.00
9	326	Ram Swaroop	42.00
10	624	B G Saha	2450.80
11	658	S K Khandelwal	704.80
12	711	Jugal Kishore	42.00
13	713	Bajrang Lal	42.00
14	738	S C Banerjee	2639.80
15	928	S N Kulkarni	2181.80
16	932	Durai Rajan M	699.80
			14270.61

SALARY NOT DRAWN

-- NIL --

TAX Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	TAX
1	2	R K Saksena	247.00
2	4	J V S Mani	570.50
3	5	H S Moondra	1244.50
4	7	G P Avasthi	250.50
5	8	V P Gaur	163.50
6	9	SureshChandra Sharma	3.50
7	10	S N Prasad	65.00
8	12	Krishna Mohan	250.50
9	22	Ravindra Roy	207.00
10	26	S C Rastogi	167.50
11	28	K E Raman	52.50
12	34	H Subramanian	615.00
13	37	S C Rastogi	340.00
14	41	R S Rai	187.50
15	42	K P Srivastava	469.00
16	43	S P Gupta	316.50
17	44	SurendraKumar Sharma	351.50
18	46	L K Singh	494.00
19	51	P K Raman	599.50
20	53	B S Tavathia	53.00
21	57	M V Tamhankar	148.50
22	64	J S Verma	92.00
23	65	H M Ghule	289.50
24	66	Shri Krishna Sharma	35.50
25	67	G P Srivastava	230.50
26	68	T N R K Kurup	160.00
27	69	Rakesh Mehrotra	21.00
28	70	P C Pandey	85.00
29	71	Ved Prakash	116.50
30	74	V P Goel	582.50
31	75	M S Radhakrishnan	464.50
32	76	S N Pathak	167.50
33	77	M C Datta	115.50
34	81	S Venkateswaran	900.00
35	82	Birbal Singh	412.00
36	89	Rup Datta	76.00
37	91	V N Sharma	333.00
38	96	I J Nagrath	1015.50
39	97	K R Chandhoke	1845.00
40	100	J C Pant	103.50
41	101	R K Patnaik	150.50
42	105	J N Jaitly	414.00
43	106	D P Mittal	27.50
44	107	K S Subudhi	580.00
45	108	R P Vaid	598.00
46	109	S R Yadava	106.00
47	111	Devi Prasad	291.00
48	116	R P Bhatnagar	46.00
49	122	J L Arora	537.00
50	124	Arjun Badlani	316.00

Furniture Loan Balance at the end of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	Previous Amount	Instalment	Remaining
1	2	R K Saksena	212.00	104.00	108.00
2	7	G P Avasthi	424.00	208.00	216.00
3	8	V P Gaur	350.00	40.00	310.00
4	9	SureshChandra Sharma	3128.00	208.00	2920.00
5	22	Ravindra Roy	2088.00	208.00	1880.00
6	28	K E Raman	2750.00	125.00	2625.00
7	51	P K Raman	996.00	63.00	933.00
8	57	M V Tamhankar	4376.00	208.00	4168.00
9	74	V P Goel	2750.00	125.00	2625.00
10	75	M S Radhakrishnan	216.00	216.00	0.00
11	81	S Venkateswaran	632.00	208.00	424.00
12	82	Birbal Singh	4000.00	167.00	3833.00
13	90	K C Gupta	2088.00	208.00	1880.00
14	91	V N Sharma	4376.00	208.00	4168.00
15	97	K R Chandhoke	3328.00	209.00	3119.00
16	107	K S Subudhi	424.00	208.00	216.00
17	109	S R Yadava	6000.00	250.00	5750.00
18	122	J L Arora	1858.00	89.00	1769.00
19	130	V Panduranga Rao	1880.00	208.00	1672.00
20	131	V S Rao	424.00	208.00	216.00
21	135	Anjan Ghosh	3336.00	208.00	3128.00
22	150	Murali Dhar Arora	1750.00	125.00	1625.00
23	173	R P Khare	6000.00	250.00	5750.00
24	176	D M Mishra	3128.00	208.00	2920.00
25	177	M R Jangira	701.00	33.00	668.00
26	178	Durga Lal	832.00	103.00	729.00
27	182	Ramswaroop	1682.00	112.00	1570.00
28	187	Jagdish Kumar	1288.00	61.00	1227.00
29	188	M K Sharma	1875.00	125.00	1750.00
30	203	Leela Dhar Varma	720.00	81.00	639.00
31	207	P P Mehta	297.00	99.00	198.00
32	208	V P Agochiya	250.00	125.00	125.00
33	212	Rama Kant Prasad	164.00	88.00	76.00
34	214	B K Gupta	2250.00	150.00	2100.00
35	216	Shri Gopal Sharma	1682.00	112.00	1570.00
36	217	M P Soni	4000.00	167.00	3833.00
37	219	Matu Ram Saini	3000.00	125.00	2875.00
38	227	Mohan Lal Sharma	300.00	100.00	200.00
39	228	Prem Kumar	200.00	100.00	100.00
40	232	S C Sharma	2292.00	104.00	2188.00
41	233	Banwari Lal Soni	144.00	73.00	71.00
42	234	Radhey Shyam	2891.00	214.00	2677.00
43	243	O P Runthla	3455.00	165.00	3290.00
44	245	Jamna Dhar Saini	2835.00	135.00	2700.00
45	249	N M Soni	308.00	156.00	152.00
46	250	H S Kulhari	2224.00	149.00	2075.00
47	257	S M Soni	188.00	96.00	92.00
48	262	B D Paul	326.00	162.00	164.00
49	264	S S Tandon	327.00	82.00	245.00
50	267	S S Redu	912.00	92.00	820.00

PS ALLOWANCE Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	PS ALLOWANCE
1	44	SurendraKumar Sharma	100.00
2	64	J S Verma	100.00
3	106	D P Mittal	100.00
4	116	R P Bhatnagar	100.00
5	124	Arjun Badlani	100.00
6	128	Ramesh Chandra Garg	100.00
7	135	Anjan Ghosh	78.57
8	138	B R Natarajan	58.18
9	146	Samarendranath Saha	100.00
10	148	R Bandyopadhyay	100.00
11	150	Murali Dhar Arora	100.00
12	151	B V Prasad	100.00
13	152	B N Sharma	100.00
14	231	V Jayraman	100.00
15	624	B G Saha	100.00
16	655	Mrs Kusum Lata	100.00
17	676	Mrs Uma M Mokashi	100.00
18	740	Sangeeta Pruthi	100.00
19	761	Mrs Alka Mitra	100.00
20	768	D Basava Raju	100.00
21	812	T Srinivas	100.00
22	853	S G Bhat	100.00
23	910	Sonia Nath	100.00
24	930	Dinesh Kumar Gupta	100.00
25	953	M N Rao	100.00
26	992	Anoop Kumar Singh	100.00
			2536.75

SALARY NOT DRAWN

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LIP Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	LIP
1	5	H S Moondra	199.46
2	7	G P Avasthi	112.90
3	9	SureshChandra Sharma	55.10
4	10	S N Prasad	36.60
5	12	Krishna Mohan	118.29
6	13	P D Chaturvedi	36.88
7	15	G D Tripathi	30.68
8	37	S C Rastogi	47.60
9	43	S P Gupta	79.50
10	44	SurendraKumar Sharma	224.80
11	46	L K Singh	87.70
12	49	S K Arya	139.20
13	51	P K Raman	91.92
14	52	V P Mainra	141.80
15	53	B S Tavathia	185.80
16	64	J S Verma	79.20
17	65	H M Ghule	69.35
18	66	Shri Krishna Sharma	29.89
19	68	T N R K Kurup	29.74
20	70	P C Pandey	35.31
21	71	Ved Prakash	33.54
22	75	M S Radhakrishnan	64.71
23	82	Birbal Singh	125.03
24	87	K R V Subramanian	279.00
25	89	Rup Datta	34.10
26	90	K C Gupta	20.03
27	91	V N Sharma	309.50
28	92	P R Marwadi	147.35
29	97	K R Chandhoke	67.09
30	107	K S Subudhi	29.89
31	109	S R Yadava	86.22
32	111	Devi Prasad	78.00
33	122	J L Arora	24.58
34	129	S C Mittal	15.39
35	130	V Panduranga Rao	984.30
36	131	V S Rao	431.10
37	132	Mrs M Banerjee	44.30
38	135	Anjan Ghosh	229.40
39	147	Pratap Singh	580.24
40	160	Pratap Singh	54.80
41	165	S D Misra	24.10
42	168	P S V S K Raju	94.50
43	172	L K Maheshwari	127.30
44	173	R P Khare	141.30
45	176	D M Mishra	26.80
46	177	M R Jangira	118.00
47	178	Durga Lal	19.50
48	179	Raghuveer Singh	148.90
49	181	J P Gaur	17.90
50	185	Mali Ram Soni	145.40

MEDICAL Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	MEDICAL
1	2	R K Saksena	94.15
2	4	J V S Mani	388.75
3	5	H S Moondra	136.10
4	8	V P Gaur	55.60
5	10	S N Prasad	24.10
6	15	G D Tripathi	54.35
7	16	J P Verma	180.45
8	20	S K Jain	388.30
9	22	Ravindra Roy	49.45
10	26	S C Rastogi	135.60
11	28	K E Raman	6.15
12	31	Shri Dayal	27.20
13	37	S C Rastogi	69.95
14	41	R S Rai	37.10
15	44	SurendraKumar Sharma	103.80
16	48	A N Pant	33.15
17	49	S K Arya	81.25
18	53	B S Tavathia	45.10
19	65	H M Ghule	13.70
20	66	Shri Krishna Sharma	293.70
21	67	G P Srivastava	24.30
22	71	Ved Prakash	89.10
23	89	Rup Datta	17.70
24	92	P R Marwadi	41.65
25	96	I J Nagrath	375.45
26	97	K R Chandhoke	40.90
27	105	J N Jaitly	60.25
28	109	S R Yadava	93.30
29	111	Devi Prasad	181.90
30	129	S C Mittal	30.65
31	130	V Panduranga Rao	38.00
32	138	B R Natarajan	49.90
33	157	B M Mithal	45.20
34	160	Pratap Singh	196.75
35	161	B K Nema	280.15
36	165	S D Misra	67.50
37	172	L K Maheshwari	38.20
38	180	Udai Pal Singh	10.75
39	195	S K Sinha	81.45
40	197	Bhagwan Das	15.90
41	201	S S Sharma	6.85
42	208	V P Agochiya	46.90
43	209	Ram Kumar	29.15
44	212	Rama Kant Prasad	27.20
45	214	B K Gupta	21.80
46	216	Shri Gopal Sharma	50.70
47	217	M P Soni	109.10
48	218	V N Sharma	300.55
49	219	Matu Ram Saini	9.45
50	224	T C Sood	266.00

ARREARS Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	ARREARS
1	137	N C Mishra	2114.52
2	762	Miss Sangeeta Shah	589.52
3	824	S Gurunarayanan	527.83
4	979	Mrs Neelam Bhatia	5.00
5	1001	Bishwajit Sen	2262.10
6	1002	K V S N Jawaharbabu	1548.39
			7047.36

SALARY NOT DRAWN

-- NIL --

BITS COOP Statement for the month of FEB , 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	AMOUNT
1	7	G P Avasthi	274.82
2	8	V P Gaur	457.34
3	9	SureshChandra Sharma	357.96
4	13	P D Chaturvedi	244.69
5	15	G D Tripathi	228.33
6	20	S K Jain	301.04
7	22	Ravindra Roy	411.36
8	28	K E Raman	302.78
9	31	Shri Dayal	75.31
10	34	H Subramanian	282.96
11	35	Mrs S Mitra	348.12
12	37	S C Rastogi	50.01
13	41	R S Rai	47.40
14	46	L K Singh	239.41
15	47	K C Sud	83.53
16	49	S K Arya	56.00
17	51	P K Raman	436.41
18	52	V P Mainra	131.35
19	56	Satya Prakash	340.11
20	59	Mrs P Mandke	61.30
21	75	M S Radhakrishnan	236.90
22	77	M C Datta	370.84
23	81	S Venkateswaran	621.29
24	82	Birbal Singh	268.30
25	91	V N Sharma	981.40
26	97	K R Chandhoke	45.32
27	107	K S Subudhi	50.02
28	108	R P Vaid	161.75
29	109	S R Yadava	976.35
30	122	J L Arora	23.45
31	129	S C Mittal	41.90
32	130	V Panduranga Rao	441.30
33	131	V S Rao	231.92
34	132	Mrs M Banerjee	139.25
35	160	Pratap Singh	355.92
36	165	S D Misra	334.79
37	178	Durga Lal	295.87
38	180	Udai Pal Singh	97.99
39	181	J P Gaur	246.46
40	182	Ramswaroop	105.29
41	183	K M Sharma	180.40
42	187	Jagdish Kumar	389.84
43	192	C L Saini	131.11
44	194	K N Sharma	339.36
45	195	S K Sinha	68.75
46	197	Bhagwan Das	327.00
47	200	J P Sharma	614.48
48	201	S S Sharma	208.08
49	203	Leela Dhar Varma	199.45
50	210	Puran Mal	178.24

ELECTRICITY Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	ELECBILL
1	2	R K Saksena	126.69
2	4	J V S Mani	222.63
3	5	H S Moondra	63.96
4	7	G P Avasthi	43.05
5	8	V P Gaur	73.80
6	9	SureshChandra Sharma	46.74
7	10	S N Prasad	92.25
8	12	Krishna Mohan	125.46
9	13	P D Chaturvedi	259.53
10	15	G D Tripathi	78.72
11	16	J P Verma	41.82
12	20	S K Jain	46.74
13	22	Ravindra Roy	62.73
14	26	S C Rastogi	102.09
15	28	K E Raman	132.84
16	31	Shri Dayal	47.97
17	34	H Subramanian	136.53
18	35	Mrs S Mitra	5.00
19	36	M C Joshi	88.56
20	37	S C Rastogi	293.97
21	41	R S Rai	40.59
22	42	K P Srivastava	212.79
23	43	S P Gupta	150.06
24	46	L K Singh	163.59
25	47	K C Sud	49.20
26	48	A N Pant	34.44
27	49	S K Arya	45.51
28	51	P K Raman	156.21
29	52	V P Mainra	82.41
30	53	B S Tavathia	94.71
31	56	Satya Prakash	67.65
32	57	M V Tamhankar	60.27
33	59	Mrs P Mandke	79.95
34	61	M K Kashiramka	40.00
35	62	S S Mathur	94.71
36	65	H M Ghule	100.86
37	66	Shri Krishna Sharma	67.65
38	67	G P Srivastava	201.72
39	68	T N R K Kurup	99.63
40	69	Rakesh Mehrotra	166.05
41	70	P C Pandey	79.95
42	71	Ved Prakash	76.26
43	74	V P Goel	15.99
44	75	M S Radhakrishnan	173.43
45	76	S N Pathak	59.04
46	77	M C Datta	99.63
47	81	S Venkateswaran	473.61
48	82	Birbal Singh	234.93
49	87	K R V Subramanian	87.33
50	89	Rup Datta	127.92

STAFF ASSOC. Statement for the month of FEB 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	AMOUNT
1	2	R K Saksena	3.00
2	4	J V S Mani	3.00
3	5	H S Moondra	3.00
4	7	G P Avasthi	3.00
5	8	V P Gaur	3.00
6	10	S N Prasad	3.00
7	12	Krishna Mohan	3.00
8	13	P D Chaturvedi	3.00
9	15	G D Tripathi	3.00
10	16	J P Verma	3.00
11	20	S K Jain	3.00
12	22	Ravindra Roy	3.00
13	26	S C Rastogi	3.00
14	28	K E Raman	3.00
15	31	Shri Dayal	3.00
16	34	H Subramanian	3.00
17	35	Mrs S Mitra	3.00
18	36	M C Joshi	3.00
19	37	S C Rastogi	3.00
20	41	R S Rai	3.00
21	43	S P Gupta	3.00
22	46	L K Singh	3.00
23	48	A N Pant	3.00
24	49	S K Arya	3.00
25	51	P K Raman	3.00
26	52	V P Mainra	3.00
27	53	B S Tavathia	3.00
28	56	Satya Prakash	3.00
29	57	M V Tamhankar	3.00
30	61	M K Kashiramka	3.00
31	62	S S Mathur	3.00
32	64	J S Verma	3.00
33	67	G P Srivastava	3.00
34	68	T N R K Kurup	3.00
35	69	Rakesh Mehrotra	3.00
36	74	V P Goel	3.00
37	75	M S Radhakrishnan	3.00
38	76	S N Pathak	3.00
39	77	M C Datta	3.00
40	79	R K Mittal	3.00
41	82	Birbal Singh	3.00
42	87	K R V Subramanian	3.00
43	91	V N Sharma	3.00
44	92	P R Marwadi	3.00
45	96	I J Nagrath	3.00
46	97	K R Chandhoke	3.00
47	100	J C Pant	3.00
48	101	R K Patnaik	3.00
49	107	K S Subudhi	3.00
50	108	R P Vaid	3.00

WORK ORDERS Statement for the month of FEB , 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	AMOUNT
1	8	V P Gaur	6.40
2	34	H Subramanian	3.45
3	75	M S Radhakrishnan	47.40
4	96	I J Nagrath	28.80
5	180	Udai Pal Singh	14.90
6	258	D S Varma	4.20
7	259	R S Shekhawat	34.35
8	284	S M Sharma	5.50
9	289	Sagar Mal	32.65
10	291	A N Bhargava	6.45
11	293	V S Srivastava	11.00
12	357	Bajrang Lal	0.75
13	359	B P Singh	9.45
14	362	Banwari Lal Darji	5.95
15	366	Raghubir Prasad	4.85
16	370	Mai Lal	792.65
17	385	B D Sharma	4.00
18	452	Shreeram Saini	2.40
19	594	Rewat Singh	4.00
20	725	Mahabir Singh	16.55
21	877	Santosh Kumar Singh	5.50
22	890	Mohan Lal Saini	4.50
23	976	B Chandrasekhar	7.90
			1053.60

SALARY NOT DRAWN

-- NIL --

MESS BILL Statement for the month of FEB , 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	AMOUNT
1	10	S N Prasad	165.84
2	49	S K Arya	57.30
3	59	Mrs P Mandke	12.20
4	97	K R Chandhoke	17.00
5	108	R P Vaid	17.00
6	122	J L Arora	220.00
7	129	S C Mittal	161.60
8	131	V S Rao	369.35
9	132	Mrs M Banerjee	110.00
10	160	Pratap Singh	42.50
11	787	S Srinivasa Rao	633.40
12	819	G Raghurama	5.05
13	855	CH Seshavadhani	54.00
			1865.24

SALARY NOT DRAWN

-- NIL --

MISCELLANEOUS Statement for the month of FEB , 1990
Prepared by Staff Data Centre

SNO	PSRN	NAME	AMOUNT
1	75	M S Radhakrishnan	1.00
2	90	K C Gupta	1.00
3	91	V N Sharma	1.00
4	132	Mrs M Banerjee	1.00
5	147	Pratap Singh	1.00
6	208	V P Agochiya	1.00
7	315	K C Gupta	2.00
8	327	S N Vyas	3.00
9	366	Raghubir Prasad	3.00
10	375	Brij Mohan	1.00
11	389	M L Jangira	1.00
12	444	Mange Ram	1.00
13	846	Chhotu Ram Rao	1.00
14	865	Tara Chand	201.00
15	1002	K V S N Jawaharbabu	16.50
			235.50

SALARY NOT DRAWN

-- NIL --

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE
PILANI (RAJASTHAN)

SALARY STATEMENT FOR THE MONTH OF FEB 1990 -LEDGER CAHU - TEACHING & ACADEMIC Prepared By Staff Data Centre

S NO PSRN	NAME BASCRT DA RT ALWNCRT	 BASIC DA ALWNC	 PSAL ARRS OTHP	D/U PFC PFD PFL	 FPC FPD	DSG	BNKa/c LIP CTD TAX	HS No HSRNT FURLN FURNT	PFDDP TC/CH MTRNT ELCTR	PFCNP MEDIC SPCLN OTHDD	 STFAS RSTMP	 TTLPAY TTLDDN NETPAY
1	R K Mittal			CAHU		LECT	07678/02		10	10		
79	2725.00	2725.00	0.00	269.00	29		0.00	0.00	0.00	0.00		3175.00
	250.00	250.00	0.00	269.00	29		0.00	0.00	0.00	0.00	3.00	601.20
	200.00	200.00	0.00	300.00			0.00	0.00	0.00	0.00	0.20	2573.80
2	CH Seshavadhani			CAHU		LECT	25903/83	WSK	10	10		
855	2275.00	2275.00	0.00	221.00	29		221.30	0.00	0.00	0.00		2500.00
	225.00	225.00	0.00	221.00	29		0.00	0.00	1.00	0.00	3.00	556.56
	0.00	0.00	0.00	0.00			0.00	0.00	27.06	54.00	0.20	1943.44
	5000.00	5000.00	0.00	490.00	58		221.30	0.00	0.00	0.00	6223.00	5675.00
TTL	475.00	475.00	0.00	490.00	58		0.00	0.00	1.00	0.00	6.00	1157.76
	200.00	200.00	0.00	300.00			0.00	0.00	27.06	54.00	0.40	4517.24

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE
PILANI (RAJASTHAN)

SALARY STATEMENT FOR THE MONTH OF FEB 1990   Prepared By Staff Data Centre

LEDGER CAHU SUMMARY

TYPE	BASCRT DA RT ALWNCRT	BASIC DA ALWNC	PSAL ARRS OTHP	PFC PFD PFL	FPC FPD	LIP CTD TAX	HSRNT FURLN FURNT	TC/CH MTRNT ELCTR	MEDIC SPCLN OTHDD	GRSAL STFAS RSTMP	TTLPAY TTLDDN NETPAY
	5000.00	5000.00	0.00	490.00	58	221.30	0.00	0.00	0.00	6223.00	5675.00
TS	475.00	475.00	0.00	490.00	58	0.00	0.00	1.00	0.00	6.00	1157.76
	200.00	200.00	0.00	300.00		0.00	0.00	27.06	54.00	0.40	4517.24
	4085.00	4085.00	0.00	90.00	12	136.40	28.00	12.00	11.60	4612.00	4521.60
SS	425.00	425.00	0.00	90.00	12	20.00	0.00	2.00	0.00	0.00	774.67
	0.00	0.00	0.00	125.00		0.00	0.00	84.87	263.40	1.00	3746.93
	600.00	600.00	0.00	60.00	8	8.60	0.00	0.00	13.25	743.00	688.25
HS	75.00	75.00	0.00	60.00	8	150.00	59.00	0.00	0.00	0.00	415.80
	0.00	0.00	0.00	130.00		0.00	0.00	0.00	0.00	0.20	272.45
	9685.00	9685.00	0.00	640.00	78	366.30	28.00	12.00	24.85	11578.00	10884.85
GTL	975.00	975.00	0.00	640.00	78	170.00	59.00	3.00	0.00	6.00	2348.23
	200.00	200.00	0.00	555.00		0.00	0.00	111.93	317.40	1.60	8536.62

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE
PILANI (RAJASTHAN)

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05/03/90

SALARY STATEMENT FOR THE MONTH OF FEB 1990 Prepared By Staff Data Centre

LEDGER DIVISIONWISE SUMMARY

TYPE	BASCRT DA RT ALWNCRT	BASIC DA ALWNC	PSAL ARRS OTHP	PFC PFD PFL	FPC FPD	LIP CTD TAX	HSRNT FURLN FURNT	TC/CH MTRNT ELCTR	MEDIC SPCLN OTHDD	GRSAL STFAS RSTMP	TTLPAY TTLDDN NETPAY
	139323.00	138062.73	200.00	9047.00	739	871.81	913.00	271.88	1585.30	160485.83	152485.13
FD1	9925.00	9925.00	2262.10	10528.00	739	350.00	863.00	33.00	0.00	72.00	29457.29
	450.00	450.00	0.00	4210.00		3668.50	14.00	2739.45	4171.25	12.40	123027.84
	88228.00	84801.21	100.00	5527.00	552	454.34	581.50	163.34	1019.85	97680.21	92721.06
FD2	6350.00	6350.00	0.00	6150.00	552	150.00	1029.00	21.00	150.00	48.00	17908.07
	450.00	450.00	0.00	1743.00		1195.00	8.00	1474.77	4178.72	9.40	74812.99
	178170.00	176557.10	100.00	15504.00	1088	2386.09	1246.00	364.34	2291.50	209627.49	195426.99
FD3	14400.00	14400.00	1548.39	17646.00	1088	260.00	1733.00	41.00	625.00	78.00	45691.77
	530.00	530.00	0.00	6156.00		5162.00	13.00	3805.19	5074.15	14.00	149735.22
	36320.00	36320.00	0.00	2589.00	191	256.61	205.00	60.00	189.95	42275.00	39684.95
ARCD	2925.00	2925.00	0.00	2677.00	191	100.00	686.00	8.00	0.00	24.00	11613.21
	250.00	250.00	0.00	3087.00		1793.50	0.00	720.78	1801.12	3.20	28071.74
	10849.00	10849.00	0.00	1105.00	86	6.50	109.00	29.00	24.30	13340.00	12173.30
EDD	1050.00	1050.00	0.00	1105.00	86	10.00	308.00	3.00	0.00	3.00	2586.42
	250.00	250.00	0.00	70.00		230.50	0.00	353.01	272.21	1.20	9586.88
	15795.00	15795.00	0.00	1529.00	113	218.24	30.00	11.00	89.55	19087.00	17534.55
EHD	1400.00	1400.00	0.00	1529.00	113	0.00	102.00	2.00	0.00	9.00	3802.96
	250.00	250.00	0.00	750.00		91.50	0.00	157.44	788.38	1.40	13731.59
	36166.00	35380.29	0.00	2634.00	225	257.52	213.50	61.84	600.70	41753.81	39495.51
ID	2675.00	2675.00	589.52	2898.00	225	0.00	609.00	7.50	42.00	15.00	9813.93
	250.00	250.00	0.00	1800.00		1253.00	0.00	888.06	1540.51	3.00	29681.58
	109745.00	108906.95	2036.75	6081.00	574	1955.34	284.00	79.33	382.45	124451.47	120215.67
PSD	6525.00	6525.00	2114.52	6799.00	574	200.00	763.00	11.50	13007.61	33.00	31141.02
	250.00	250.00	0.00	2320.00		2298.00	0.00	815.65	1990.59	10.00	89074.65
	15171.00	15171.00	0.00	1530.00	160	127.30	80.00	22.00	128.30	18838.83	17277.13
RCD	1200.00	1200.00	527.83	1530.00	160	0.00	179.00	4.00	0.00	15.00	3148.12
	250.00	250.00	0.00	400.00		0.00	0.00	168.59	460.83	1.40	14129.01
	56635.00	56635.00	0.00	5610.00	493	1280.04	214.00	81.72	941.65	68563.00	63401.65
SWD	5575.00	5575.00	0.00	5874.00	493	140.00	1151.00	13.50	0.00	24.00	18893.36
	250.00	250.00	0.00	5580.00		661.50	0.00	810.65	2560.95	9.00	44508.29
	23561.00	23561.00	0.00	1647.00	148	297.83	67.50	32.00	210.00	27056.00	25471.00
[illegible]CU	1700.00	1700.00	0.00	1647.00	148	40.00	196.00	3.00	200.00	6.00	6340.01
	0.00	0.00	0.00	1610.00		524.50	0.00	426.81	1138.57	2.80	19130.99
	11750.00	11750.00	0.00	1131.00	76	216.30	65.50	23.00	1142.30	14257.00	14192.30
ADMU	1100.00	1100.00	0.00	1465.00	76	170.00	140.00	2.00	0.00	0.00	4302.87
	200.00	200.00	0.00	780.00		0.00	0.00	134.07	1229.60	1.40	9889.43

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE
PILANI (RAJASTHAN)

SALARY STATEMENT FOR THE MONTH OF FEB '1990 **Prepared By Staff Data Centre**

LEDGER GRAND SUMMARY

TYPE	BASCRT DA RT ALWNCRT	BASIC DA ALWNC	PSAL ARRS OTHP	PFC PFD PFL	FPC FPD	LIP CTD TAX	HSRNT FURLN FURNT	TC/CH MTRNT ELCTR	MEDIC SPCLN OTHDD	GRSAL STFAS RSTMP	TTLPAY TTLDDN NETPAY
	651405.00	643481.28	2536.75	46970.00	3358	7309.39	4286.00	1211.05	5665.20	753101.64	710975.59
TS	45500.00	45500.00	7042.36	53942.00	3358	1150.00	4260.00	141.50	13632.61	381.00	154837.85
	6750.00	6750.00	0.00	16365.00		22048.50	45.00	12316.26	14348.14	43.40	556137.74
	261815.00	261746.61	0.00	22035.00	2617	4534.78	1487.50	504.00	6860.25	312578.61	294786.86
SS	26175.00	26175.00	5.00	22476.00	2617	1110.00	6626.00	69.75	554.00	27.00	86774.75
	0.00	0.00	0.00	17909.00		805.00	4.00	5565.99	22445.73	39.00	208012.11
	100436.00	100436.00	0.00	8786.00	1160	628.10	152.50	90.24	2306.00	122687.00	115047.00
HS	12225.00	12225.00	0.00	8786.00	1160	320.00	3440.00	20.00	84.00	0.00	34696.75
	80.00	80.00	0.00	11974.00		0.00	0.00	700.72	7308.39	32.80	80350.25
	1013656.00	1005663.89	2536.75	77791.00	7135	12472.27	5926.00	1805.29	14831.45	1188367.25	1120809.45
	83900.00	83900.00	7047.36	85204.00	7135	2580.00	14326.00	231.25	14270.61	408.00	276309.35
	6830.00	6830.00	0.00	46248.00		22853.50	49.00	18582.97	44102.26	115.20	844500.10

SALARY STATEMENT FOR THE MONTH OF FEB 1990 MASTER-LEDGER   Prepared By Staff Data Centre

S NO PSRN	NAME BASCRT DA RT ALWNCRT	BASIC DA ALWNC	PSAL ARRS OTHP	D/U PFC PFD PFL	FPC FPD	DSG	BNKa/c LIP CTD TAX	HS No HSRNT FURLN FURNT	PFDDP TC/CH MTRNT ELCTR	PFCNP MEDIC SPCLN OTHDD	STFAS RSTMP	TTLPAY TTLDDN NETPAY
1	R K Saksena					PROF	10457/02	B326B	16	10		
2	4650.00	4650.00	0.00	471.00	29		0.00	75.00	15.00	94.15		5294.15
	350.00	350.00	0.00	771.00	29		0.00	104.00	1.00	0.00	3.00	1714.89
	200.00	200.00	0.00	335.00			247.00	0.00	126.69	8.00	0.20	3579.26
2	J V S Mani					ASTP	05824/02	066C	10	10		
4	4450.00	4450.00	0.00	449.00	29		0.00	30.00	10.00	388.75		5163.75
	325.00	325.00	0.00	449.00	29		0.00	0.00	1.00	0.00	3.00	1815.33
	0.00	0.00	0.00	500.00			570.50	0.00	222.63	0.00	0.20	3348.42
3	H S Moondra					ASOP	06228/02	A323B	10	10		
5	4500.00	4500.00	0.00	456.00	29		199.46	75.00	15.00	136.10		5186.10
	350.00	350.00	0.00	456.00	29		0.00	0.00	1.00	0.00	3.00	2095.12
	200.00	200.00	0.00	0.00			1244.50	0.00	63.96	8.00	0.20	3090.98
4	G P Avasthi					ASOP	09717/03	B297B	16	10		
7	4650.00	4650.00	0.00	471.00	29		112.90	75.00	15.00	0.00		5200.00
	350.00	350.00	0.00	771.00	29		0.00	208.00	1.00	0.00	3.00	1791.47
	200.00	200.00	0.00	0.00			250.50	0.00	43.05	282.82	0.20	3408.53
5	V P Gaur					ASTP	02088/02	218D	16	10		
8	4075.00	4075.00	0.00	440.00	0		0.00	17.00	7.00	55.60		4455.60
	325.00	325.00	0.00	704.00	0		50.00	40.00	1.00	0.00	3.00	1523.24
	0.00	0.00	0.00	0.00			163.50	0.00	73.80	463.74	0.20	2932.36
6	SureshChandra Sharma					ASTP	01216/03	136D	10	10		
9	4075.00	4075.00	0.00	440.00	0		55.10	17.00	7.00	0.00		4400.00
	325.00	325.00	0.00	440.00	0		200.00	208.00	1.00	0.00	0.00	1366.50
	0.00	0.00	0.00	0.00			3.50	0.00	46.74	387.96	0.20	3033.50
7	S N Prasad					LECT	09718/03	WRP	10	10		
10	3200.00	3200.00	0.00	319.00	29		36.60	0.00	0.00	24.10		3499.10
	275.00	275.00	0.00	319.00	29		0.00	0.00	1.00	0.00	3.00	711.89
	0.00	0.00	0.00	0.00			65.00	0.00	92.25	165.84	0.20	2787.21
8	Krishna Mohan					ASOP	11636/02	168B	16	10		
12	4650.00	4650.00	0.00	471.00	29		118.29	45.00	15.00	0.00		5000.00
	350.00	350.00	0.00	771.00	29		0.00	0.00	1.00	0.00	3.00	1358.45
	0.00	0.00	0.00	0.00			250.50	0.00	125.46	0.00	0.20	3641.55
9	P D Chaturvedi					ASOP	05167/03	169B	16	10		
13	4650.00	4650.00	0.00	500.00	0		36.88	65.00	15.00	0.00		5000.00
	350.00	350.00	0.00	800.00	0		0.00	0.00	1.00	0.00	3.00	1925.30
	0.00	0.00	0.00	500.00			0.00	0.00	259.53	244.69	0.20	3074.70
10	G D Tripathi					LECT	02511/03	065C	16	10		
15	3900.00	3900.00	0.00	391.00	29		30.68	30.00	10.00	54.35		4254.35
	300.00	300.00	0.00	643.00	29		100.00	0.00	1.00	0.00	3.00	1153.93
	0.00	0.00	0.00	0.00			0.00	0.00	78.72	228.33	0.20	3100.42
11	J P Verma					LECT	22574/03	215D	10	10		
16	3900.00	3900.00	0.00	391.00	29		0.00	17.00	7.00	180.45		4380.45
	300.00	300.00	0.00	391.00	29		0.00	0.00	1.00	0.00	3.00	490.02
	0.00	0.00	0.00	0.00			0.00	0.00	41.82	0.00	0.20	3890.43

APPENDIX B

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
STAFF DATA CENTRE
INCOME TAX ESTIMATES
Assesment Year 1990 - 91

DATE : 22/02/90

PSRN : 2
NAME :R K Saksena
DIVISION :WSU

Monthly Basic Salary + DA	: Rs.	5000			
Provident Fund Percentage	:	16			
Yearly Salary (Estimate)			: Rs.	63675	
Other Allowances			: Rs.	2390	
Practice School Allowances			: Rs.	0	
House Rent Concession			: Rs.	0	
Additional Income			: Rs.	0	
Total Annual Income				: Rs.	66065
Claimed Deductions:					
Contribution to provident fund			: Rs.	9194	
Contribution to Family Pension fund			: Rs.	232	
Life Insurance Premium			: Rs.	797	
Cummulative Time Deposits			: Rs.	0	
Public Provident Fund			: Rs.	0	
Unit Linked Insurance plan			: Rs.	0	
National Savings Certificate			: Rs.	0	
Total Deductions Claimed under 80 (c)			: Rs.	10223	
Total Deductions claimed under 80CCA			: Rs.	15000	
Permissible Deductions:					
Standard Deductions	: Rs.	12000			
Permissible Deduction under 80 (c)	: Rs.	8112			
Permissible Deductions under 80 cca	: Rs.	15000			
Total Deductions				: Rs.	35112
Net Taxable Income (rounded off)				: Rs.	30950
Income Tax Payable	: Rs.	3185			
Surcharge	: Rs.	0			
Total Tax Payable				: Rs.	3185
Uptodate TAX PAID	: Rs.	2691			
Remaining Tax Payable	: Rs.	494			
Monthly Tax Deductions	: Rs.	247			

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
STAFF DATA CENTRE
INCOME TAX ESTIMATES
Assesment Year 1990 - 91

DATE : 22/02/90

PSRN : 2
NAME : R K Saksena
DIVISION : WSU

Monthly Basic Salary + DA	: Rs. 5000			
Provident Fund Percentage	: 16			
Yearly Salary (Estimate)		: Rs. 63675		
Other Allowances		: Rs. 2390		
Practice School Allowances		: Rs. 0		
House Rent Concession		: Rs. 0		
Additional Income		: Rs. 0		
Total Annual Income			: Rs.	66065
Claimed Deductions:				
Contribution to provident fund		: Rs. 9194		
Contribution to Family Pension fund		: Rs. 232		
Life Insurance Premium		: Rs. 797		
Cummulative Time Deposits		: Rs. 0		
Public Provident Fund		: Rs. 0		
Unit Linked Insurance plan		: Rs. 0		
National Savings Certificate		: Rs. 0		
Total Deductions Claimed under 80 (c)		: Rs. 10223		
Total Deductions claimed under 80CCA		: Rs. 15000		
Permissible Deductions:				
Standard Deductions	: Rs. 12000			
Permissible Deduction under 80 (c)	: Rs. 8112			
Permissible Deductions under 80 cca	: Rs. 15000			
Total Deductions			: Rs.	35112
Net Taxable Income (rounded off)			: Rs.	30950
Income Tax Payable	: Rs. 3185			
Surcharge	: Rs. 0			
Total Tax Payable			: Rs.	3185
Uptodate TAX PAID	: Rs. 2691			
Remaining Tax Payable	: Rs. 494			
Monthly Tax Deductions	: Rs. 247			

APPENDIX C

BUDGET 1990-91

ESTABLISHMENT OF TEACHING AND ACADEMIC STAFF

Data as of 07/01/90

SNO	BSRN	PSRN	NAME	ACTUAL POST IF DIFFERENT FROM BUDGET	BUDGET POST DESIG NATION	GRADE	PAY IN APRIL	INCR. DUE	SALARY	YEARLY DA	ALW	TOTAL AMOUNT	PF
1. DIVISION/UNIT FD1													
21	32	15	G D Tripathi		LECT	2200-4000	3900	Jul 90	47700	3825	0	51525	5152
22	33	16	J P Verma		LECT	2200-4000	3900	Jun 90	47800	3850	0	51650	5165
23	34	166	Mrs V Varma		LECT	2200-4000	3100	Jul 90	38100	3300	0	41400	4140
24	36		VACANT		ASTP	3700-5700	3700		44400	3600	0	48000	0
25	37		VACANT		PROF	4500-7300	4500		54000	4200	0	58200	0
26	38		VACANT		ASTP	3700-5700	3700		44400	3600	0	48000	0
27	39	911	P N K Rao	ALEC 2200-2950	ASTP	3700-5700	2200		26400	2700	0	29100	0
28	43	762	Miss Sangeeta Shah	TA 2000	LECT	2200-4000	2000		24000	0	0	24000	2400
29	44	20	S K Jain		LECT	2200-4000	3900	Jun 90	47800	3850	0	51650	5165
30	45	745	Mrs Usha Jain	ALEC 2200-2950	LECT	2200-4000	2350	Aug 90	28800	2700	0	31500	3150
31	49	972	R Sriram	TA 2000	LECT	2200-4000	2000		24000	0	0	24000	0
32	60	850	N K Mandal		LECT	2200-4000	2275	May 90	28125	2700	0	30825	3082
33	88	984	J K Basu	LECT 2200-4000	ASTP	3700-5700	2200		26400	2700	0	29100	0
34	136	950	Rakesh Kumar	ALEC 2200-2950	LECT	2200-4000	2200		26400	2700	0	29100	0
35	142	877	Santosh Kumar Singh	ALEC 2200-2950	LECT	2200-4000	2275	Oct 90	27750	2700	0	30450	3045
36	149	719	Pulak Kumar Das		LECT	2200-4000	2425	Jun 90	29850	2950	0	32800	3280
37	206	10	S N Prasad		LECT	2200-4000	3300	Apr 91	39600	3300	0	42900	4290
38	255	161	B K Nema		LECT	2200-4000	3900	Jun 90	47800	3850	0	51650	5165

SALARY TOTAL	Rs.	1546600
DEARNESS ALLOWANCE TOTAL	Rs.	119425
ALLOWANCE TOTAL	Rs.	3000
PROVIDENT FUND TOTAL	Rs.	102154
GRAND TOTAL	Rs.	1771179

BUDGET 1990-91

ESTABLISHMENT OF SUPPORTING STAFF

Data as of 07/01/90

SNO	BSRN	PSRN	NAME	ACTUAL POST IF DIFFERENT FROM BUDGET		BUDGET POST DESIG NATION	BUDGET POST GRADE	PAY IN APRIL	INCR. DUE	SALARY	YEARLY DA	ALW	TOTAL AMOUNT	PF
1. DIVISION/UNIT FD1														
1	291	177	M R Jangira			TYPT	725-1225	1125	Jun 90	13750	1500	0	15250	1220
2	292	210	Puran Mal			GESO	725-1225	1125	Jun 90	13750	1500	0	15250	1525
3	293	179	Raghuveer Singh			TYPT	725-1225	920	Jun 90	11240	1200	0	12440	1244
4	294		VACANT			TCHS	1800-3750	1800		21600	2400	0	24000	0
5	295		VACANT			TCHA	1300-2350	1300		15600	1800	0	17400	0
6	296	180	Udai Pal Singh			DEM	1000-1790	1520	Aug 90	18520	2100	0	20620	2062
7	297	181	J P Gaur			STKR	725-1225	1125	Jun 90	13750	1500	0	15250	1525
8	298	182	Ramswaroop			BM	725-1225	1125	Jun 90	13750	1500	0	15250	1525
9	299	183	K M Sharma			GB	725-1225	1125	Jun 90	13750	1500	0	15250	1525
10	300	184	Shankar Mal			MENC	725-1225	1125	Jun 90	13750	1500	0	15250	1525
11	301	185	Mali Ram Soni			TYPT	725-1225	1125	Jun 90	13750	1500	0	15250	1525
12	302		VACANT			TCHA	1300-2350	1300		15600	1800	0	17400	0
13	303		VACANT			DEM	1300-2350	1300		15600	1800	0	17400	0
14	304	187	Jagdish Kumar			ASK	850-1495	1460	Apr 91	17520	1800	0	19320	1932
15	306	216	Shri Gopal Sharma	TYPT	725-1225	C/T	850-1495	1125	Jun 90	13750	1500	0	15250	1525
16	307		VACANT			OSER	1000-1790	1000		12000	1500	0	13500	0
17	308		VACANT			DEM	1000-1790	1000		12000	1500	0	13500	0

SALARY TOTAL	Rs.	249680
DEARNESS ALLOWANCE TOTAL	Rs.	27900
ALLOWANCE TOTAL	Rs.	0
PROVIDENT FUND TOTAL	Rs.	17133
GRAND TOTAL	Rs.	294713

BUDGET 1990-91

ESTABLISHMENT OF HELPING STAFF

Data as of 07/01/90

SR.	BSRN	PSRN	NAME	ACTUAL POST IF DIFFERENT FROM BUDGET	BUDGET POST DESIG NATION	GRADE	PAY IN APRIL	INCR. DUE	SALARY	YEARLY DA	ALW	TOTAL AMOUNT	PF
	DIVISION/UNIT FD1												
1	537		VACANT		ATDT	675-1125	675		8100	900	0	9000	0
2	538		VACANT		ATDT	675-1125	675		8100	900	0	9000	0
3	539		VACANT		ATDT	500- 740	500		6000	900	0	6900	0
4	540	403	Jugal Kishore		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
5	541	404	Matu Ram		ATDT	500- 740	620	Apr 91	7440	900	0	8340	834
6	542	405	Ramkaran		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
7	543	406	Amarlal		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
8	544	407	Asharam		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
9	545	408	Balchandra		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
10	546	409	Gopiram		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
11	547	410	Rameshwar Prasad		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
12	548	411	Ram Kumar		ATDT	500- 740	728	Apr 91	8736	900	0	9636	963
13	549	500	Satyanarain		ATDT	500- 740	610	Apr 91	7320	900	0	8220	822
14	550		VACANT		ATDT	500- 740	500		6000	900	0	6900	0

SALARY TOTAL	Rs.	112848
DEARNESS ALLOWANCE TOTAL	Rs.	12600
ALLOWANCE TOTAL	Rs.	0
PROVIDENT FUND TOTAL	Rs.	9360
GRAND TOTAL	Rs.	134808

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI
BUDGET 1990-91
ESTABLISHMENT OF SUPPORTING STAFF

LEGEND

DESIGNATIONS		DESIGNATIONS	
ACD	ACADEMIC DEAN	I A	INTERNAL AUDITOR
ACCO	ACCOUNTANT	KPOR	KEY PUNCH OPERATOR
A C	ACCOUNTS CLERK	LABT	LABORTORY TECHNICIAN
ATPO	ADMISSION TRANING & PLACEMENT OFFICER	LIB	LIBRARIAN
		LBAT	LIBRARY ASSISTANT
AFO	ASSISTANT FINANCE OFFICER	L S	LIFE SAVER
ALB	ASSISTANT LIBRARIAN	M O	MAINTENANCE OFFICER
AOS	ASSISTANT OFFICE SUPERINTENDENT	MATN	MATRON
A R	ASSISTANT REGISTRAR	MENC	MECHANIC
ASK	ASSISTANT STOREKEEPER	M I	MISTRY INSTRUCTOR
BAG	BAGWAN	MOMC	MOTOR MECHANIC
B M	BOILER MISTRY	MUNM	MUNEEM
B O	BUDGET OFFICER	OFAT	OFFICE ASSISTANT
CTR	CARETAKER	OFST	OFFICE SUPERINTENDENT
CSHR	CASHIER	OPR	OPERATOR
C A	CHIEF ACCOUNTANT	OSER	OVERSEER
CLER	CLERK	PSTD	PERSONAL SECRETARY TO DIRECTOR
C/T	CLERK/TYPIST	PSYD	PHYSICAL DIRECTOR
CMPR	COMPOUNDER	PPFR	PIPE FITTER
DOS	DEAN OF STUDENT	PDO	PLANNING DEVELOPMENT OFFICER
DEM	DEMONSTRATOR	PFAT	PROFESSIONAL ASSISTANT
D D	DEPUTY DIRECTOR	PRGR	PROGRAMMER
DRG	DEPUTY REGISTRAR	LO'	LIAISON OFFICER
DIRO	DIRECTOR	RDM	RADIO MECHANIC
DRAF	DRAFTSMAN	REGR	REGISTRAR
DRVR	DRIVER	SECO	SECURITY OFFICER
EEGR	ELECTRICAL ENGINEER	SEDR	SENIOR DEMONSTRATOR
ELEC	ELECTRICIAN	SHC	SENIOR HOSTEL CLERK
LOC	LESION OFFICER COOP	STNO	STENO
FAR	FINANCIAL ADVISIOR	STNT	STENO TYPIST
FRMN	FOREMAN	STKR	STORE KEEPER
GAST	GARDEN SUPERINTENDENT	SRAU	SUPERVISIOR AUTOMOBILES
GSMY	GAS MISTRY	STOR	SYSTEM OPERATOR
GMC	GENERAL MANAGER CATERING	TXMT	TAXIDERMIST
GESO	GESTNER OPERATOR	TA	TEACHING ASSISTANT
G B	GLASS BLOWER	TCHA	TECHNICAL ASSISTANT
HCLK	HEAD CLERK	TCHL	TECHNICIAN LANGUAGE LAB
H A	HERBARIAN ASSISTANT	TCHS	TECHNICAL SUPERINTENDENT
HOLK	HOSTEL CLERK	TRCR	TRACER
HOST	HOSTEL SUPERINTENDENT	TYPT	TYPIST
INST	INSTRUCTOR	LOC	LIAISON OFFICER COOP

GRADES		GRADES	
7300-7600	7300-7600 or any other specified scale	675-1125	675-12-735-15-840-20-1000-25-1125
5700-7300	5700-200-7300	725-1225	725-15-860-20-1000-25-1225
4500-7300	4500-150-5700-200-7300	850-1495	850-20-1010-25-1210-30-1390-35-1495
4500-6300	4500-150-5700-200-6300	1000-1790	1000-25-1200-30-1380-35-1590-40-1790
3700-5700	3700-125-4950-150-5700	1300-2350	1300-30-1450-35-1660-40-1860-50-2110-60-2350
2200-4000	2200-75-2800-100-4000	1800-2750	1800-50-2000-60-2300-75-2750
2200-2950	2200-75-2950	1800-3700	1800-50-2000-60-2300-75-2750-100-3700
2000	2000 consolidated	2900-4750	2900-100-4000-125-4750
500-740	500-8-580-10-680-12-740	4000-5950	4000-125-4750-150-5950

BUDGET 1990-91

List of Pensioners

NO.	PSRN	Name	Designation	Date of Retire-ment	Pension up to	Amount of Pension Rs. p.m.	Total Amount for the Year Rs.
51	88	Dr. H L Kundu	Professor	20.07.89		712.50	8544.00
52	93	Shri P L Sharma	Lecturer	20.07.89		540.00	6480.00
53	351	Shri F S Kamboj	Foreman	20.07.89		242.50	2910.00
54	466	Smt. Shanti Bai	Attendant	20.07.89		82.50	990.00
55	441	Shri Bajrang Lal	Attendant	20.07.89		65.10	781.20
56		Mrs.K Mathur w/o SN Mathur 164	Asst. Professor	14.10.89	14.10.93	303.00	3636.00
57		Mrs. Sushila w/o D Nath 321	Clerk	03.12.89	03.12.94	118.15	1417.80
58		Mrs PL Sharma w/o DN Sharma191	Asst. Registrar	09.12.89	09.12.94	547.50	6570.00
59	274	Shri Murli Dhar Sharma	Chief Accountant	19.07.90		802.50	6730.65
60	159	Shri G R Nagaraj	Asstt. Professor	20.07.90		1000.00	8354.85
61	41	Dr. R S Rai	Associate Professor	20.07.90		1000.00	8354.85
62	160	Dr. Pratap Singh	Assistant Professor	20.07.90		1000.00	8354.85
63	129	Dr. S C Mittal	Assistant Professor	20.07.90		1000.00	8354.85
64	8	Dr. V P Gaur	Asst. Professor	20.07.90		1000.00	8354.85
65	9	Dr. S C Sharma	Asst. Professor	20.07.90		1000.00	8354.85
66	47	Dr. K C Sud	Lecturer	20.07.90		1000.00	8354.85
67	52	Dr. V P Mainra	Associate Professor	20.07.90		1000.00	8354.85
68	66	Dr. S K Sharma	Associate Professor	20.07.90		1000.00	8354.85
69	68	Shri T N R K Kurup	Lecturer	20.07.90		1000.00	8354.85
70	107	Dr. K S Subudhi	Asst. Professor	20.07.90		1000.00	8354.85
71	259	Shri R S Sekhawat	Physical Director	20.07.90		1000.00	8354.85
72	264	Shri S S Tandon	Hostel Clerk	20.07.90		448.50	3747.15
73	278	Shri S K Sharma	Accountant	20.07.90		537.00	4486.55
74	308	Shri M M Narang	Demonstrator	20.07.90		618.00	5163.30
75	357	Shri Bajrang Lal Sharma	Instructor	20.07.90		438.00	3659.45
76	419	Shri Mag Lal	Attendant	20.07.90		218.40	1824.70
77	427	Shri Chiman Lal	Attendant	20.07.90		136.40	1139.60
78	530	Shri Asha Ram	Attendant	20.07.90		158.60	1325.10
79	345	Shri B S Kudesia	Steno	21.07.90		561.75	4675.20
80	291	Shri A N Bhargava	Registrar	21.07.90		1000.00	8322.60
81	13	Dr. P D Chaturvedi	Associate Professor	21.07.90		1000.00	8322.60
82	36	Dr. M C Joshi	Associate Professor	21.07.90		1000.00	8322.60
83	76	Dr. S N Pathak	Asstt. Professor	21.07.90		1000.00	8322.60
84	62	Dr. S S Mathur	Professor	23.07.90		1000.00	8258.10
				TOTAL			403993.85

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
BUDGET 1990-91

Details of Operating Expenses
(FOR THE WHOLE INSTITUTE)

I. MISCELLANEOUS

S.No.	ITEMS		Amount in lac
(1)	Stationary (Ordinary and Computer)		2.102
(2)	Printing and Binding		2.450
(3)	Postage and Telegrams		1.574
(4)	Telephones		0.760
(5)	Bank Commission		0.025
(6)	Insurance		0.160
(7)	Audit Fees and Expenses		0.292
(8)	Legal Expenses		0.106
(9)	Advertisement		1.927
(10)	Expenses on Guests		0.316
(11)	Motor Car expenses		1.050
(12)	Travel Expenses (TA & DA)		1.570
(13)	Leave Travel Concession		0.277
(14)	Servants Uniforms		0.235
(15)	Contribution to:		
	Community Centre	0.037	
	Kalyani Club	0.013	
	Staff Assoc.	0.032	
	Children Benefit	0.005	
		-----	0.087
(16)	Tuition Fee Reimbursement		10.755
(17)	Electricity Charges		6.165
(18)	Water Charges		5.077
(19)	Reduction in water charges		1.640
(20)	Upkeep of office machines, furniture etc.		0.874
(21)	Upkeep of Swimming Pool		0.085
(22)	Upkeep of Infant Care Centre		0.003
(23)	Contingency		0.940
(24)	Semester Tests and Exam. Expenses		1.053
(25)	Meeting and Founder's Day		0.887
(26)	Lab. and Class Room Consumables		2.201
(27)	Chemicals and Glass Wares		0.885
(28)	PS outstation Local conveyance		0.486
(29)	Upkeep of PS Centres		0.076
(30)	PS outstation house rent		1.254
(31)	Games materials and Equipment		0.661
(32)	Grant to Athletic Club		0.050
(33)	N.C.C. and Sports		0.020
(34)	Maintenance Contracts		2.542
(35)	Maintenance of Tools and Spares		0.226
(36)	Workshop Training Materials		0.316
(37)	Stipend for Workshop Apprentices		0.292
(38)	Upkeep of Auditorium		0.158
(39)	Gas Plant Fuel		0.190
(40)	Contribution to Students Union		0.750

			50.517

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
BUDGET 1990-91

Details of Operating Expenses
(FOR THE WHOLE INSTITUTE)

I. MISCELLANEOUS

S.No.	ITEMS		Amount in lac
(1)	Stationary (Ordinary and Computer)		2.102
(2)	Printing and Binding		2.450
(3)	Postage and Telegrams		1.574
(4)	Telephones		0.760
(5)	Bank Commission		0.025
(6)	Insurance		0.160
(7)	Audit Fees and Expenses		0.292
(8)	Legal Expenses		0.106
(9)	Advertisement		1.927
(10)	Expenses on Guests		0.316
(11)	Motor Car expenses		1.050
(12)	Travel Expenses (TA & DA)		1.570
(13)	Leave Travel Concession		0.277
(14)	Servants Uniforms		0.235
(15)	Contribution to:		
	Community Centre	0.037	
	Kalyani Club	0.013	
	Staff Assoc.	0.032	
	Children Benefit	0.005	
		-----	0.087
(16)	Tuition Fee Reimbursement		10.755
(17)	Electricity Charges		6.165
(18)	Water Charges		5.077
(19)	Reduction in water charges		1.640
(20)	Upkeep of office machines, furniture etc.		0.874
(21)	Upkeep of Swimming Pool		0.085
(22)	Upkeep of Infant Care Centre		0.003
(23)	Contingency		0.940
(24)	Semester Tests and Exam. Expenses		1.053
(25)	Meeting and Founder's Day		0.887
(26)	Lab. and Class Room Consumables		2.201
(27)	Chemicals and Glass Wares		0.885
(28)	PS outstation Local conveyance		0.486
(29)	Upkeep of PS Centres		0.076
(30)	PS outstation house rent		1.254
(31)	Games materials and Equipment		0.661
(32)	Grant to Athletic Club		0.050
(33)	N.C.C. and Sports		0.020
(34)	Maintenance Contracts		2.542
(35)	Maintenance of Tools and Spares		0.226
(36)	Workshop Training Materials		0.316
(37)	Stipend for Workshop Apprentices		0.292
(38)	Upkeep of Auditorium		0.158
(39)	Gas Plant Fuel		0.190
(40)	Contribution to Students Union		0.750

			50.517

Details of Operating Expenses (Continued)

II. HOSTEL

(1) Water charges	2.662
(2) Contingencies	0.510
(3) Utensils	0.170
	3.342

III. LIBRARY

(1) Stationery, Library Cards etc.	0.158
(2) Printing and Binding	0.243
(3) Postage and Telegrams	0.025
(4) Maintenance of Furniture and Fixtures	0.035
(5) Upkeep of Reprography	0.035
(6) Chemicals for Reprography	0.110
(7) Insurance	0.010
(8) Journals and Magazines	5.387
(9) Books	2.047
(10) Book Bank	0.912
(11) Research Journals	0.145
(12) Contingency	0.060
	9.167

IV. REPAIRS	3.540
V. GARDEN	1.136
VI. SCHOLARSHIPS	
(1) Merit and Merit-cum-need scholarships	11.873
(2) Postgraduate Scholarships	4.457
(3) Fulltime Fellowships & Research Scholarships	5.000
	21.330

LIST OF STAFF MEMBERS TEACHING AND ACADEMIC IN 1990-91

LEGEND

1. BIO BIOLOGICAL SCIENCE
2. CE CIVIL ENGINEERING
3. CHEG CHEMICAL ENGINEERING
4. CHEM CHEMISTRY
5. CS COMPUTER SCIENCE(INCLUDING ALL COMPUTER APPLICATION COURSES AT THE 3 TIERS
6. ECON ECONOMICS(INCLUDES SOCIAL ENGG.II, CDP
7. EEE ELECTRICAL ELECTRONICS ENGINEERING
8. ENGL ENGLISH
9. ET ENGINEERING TECHNOLOGY INCLUDING COURSES WITH ENGG & TOC NUMBERS (EXCEPT INTRO TO SYSTEMS ?)
10. INST INSTRUMENTATION(INCLUDING ALL SPECIAL COURSES AT THE 3 TIERS)
11. MATH MATHEMATICS(INCLUDES PROB. STAT, NUM. ANAL.
12. ME MECHANICAL ENGINEERING
13. MGTS MANAGEMENT(INCLUDES SOCIAL ENGG.I & MANAGEMENT ORIENTED CDP & SKILL COURSES
14. MSMS MUSEUM STUDIES
15. PHAR PHARMACY
16. PHY PHYSICS
17. STD SCIENCE TECHNOLOGY DEVELOPMENT

TWO YEAR HIGHER DEGREES - ME COLLAB

18. ERD EDUCATION AND R D SYSTEMS
19. IDEV INDUSTRIAL DEVELOPMENT
20. IP INDUSTRIAL PRODUCTION
21. PE PROJECT ENGINEERING

ADDITIONAL SUBJECTS

22. HIND HINDI
23. HIST HISTORY
24. PHIL PHILOSOPHY/LOGIC
25. POL POLITICAL SCIENCE
26. PSY PSYHOLOGY
27. SAMS SANSKRIT
28. SOC SOCIOLOGY
29. RUSS RUSSIAN
30. FRE FRENCH
31. GFER GERMAN

OTHER AREAS

32. EA ENGINEERING AREAS
33. EG ENGINEERING GRAPHICS
34. ES ENGG. SCIENCE & MEASUREMENT TECH. II
35. HUM ALL COURSES WITH HUM LABEL
36. LANG LANGUAGES(COMPARATIV INDIAN LITERATURE & REPORT WRITING
37. MSAR MUSIC & ARTS(GRAPHIC ATRS,PAINTING ETC)
38. OTOR OPTIMIZATION & OPERATION RESEARCH
39. PROJ PROFESSIONAL SKILL DEV. ELECTIVE PROJECTS AND ENTREPRENERSHIP
40. PSON PRACTICE SCHOOL-I
41. PSTW PRACTICE SCHOOL-II
42. SC COURSES WITH SCI MEMBERS, MEASUREMENT TECH.I, INSTR. METHODS OF ANALYSIS
43. SEM SEMINAR
44. SYST SYSTEMS,CONTROL SYSTEMS, INTRO. TO SYSTEMS
45. TIC TIC PROJECTS
46. THES THESIS (AT ALL THREE TIERS)
47. WS WORKSHOP PRACTICE

PROF	PROFESSOR
ASOP	ASSOCIATE PROFESSOR
ASTP	ASSISTANT PROFESSOR
LECT	LECTURER
ALEC	ASSISTANT LECTURER
TA	TEACHING ASSISTANT
VPF	VISITING FACULTY
DIR	DIRECTOR
DD	DEPUTY DIRECTOR
LIB	LIBRARIAN
M O	MAINTENANCE OFFICER
ALB	ASSISTANT LIBRARIAN
ATPO	ADMISSIONS PLACEMENT OFFICER
PRGR	PROGRAMMER
DEM	DEMONSTRATOR
TCHA	TECHNICAL ASSISTANT
INST	INSTRUCTOR
ADJN	ADJUNT FACULTY
ASOF	ASSOCIATE FACULTY

DIVISIONS/UNITS

(1) FDI FACULTY DIVISION I
(2) FDII FACULTY DIVISION II
(3) FDIII FACULTY DIVISION III
(4) ARCD ACADEMIC REGISTRATION AND COUNSELLING DIVISION
(5) EDD EDUCATIONAL DEVELOPMENT DIVISION
(6) EHD EDUCATIONAL HARDWARE DIVISION
(7) ID INSTRUCTION DIVISION
(8) PSD PRACTICE SCHOOL DIVISION
(9) RCD RESEARCH & CONSULTANCY DIVISION
(10) SWD STUDENT WELFARE DIVISION
(11) A/CO ACCOUNTS FINANCE
(12) ADMU ADMISSION PLACEMENT
(13) CWC COMMUNITY WELFARE
(14) GAU GENERAL ADMINISTRATION
(15) IPCU INFORMATION PROCESSING CENTRE
(16) IU INSTRUMENTATION CENTRE
(17) LIBU LIBRARY
(18) MNTU MAINTENANCE
(19) DLPU DISTANCE LEARNING PROGRAMMES
(20) CAHU COMPUTER ASSISTED HOUSEKEEPING
(21) WSU WORKSHOP
(22) DB DIRECTOR BRANCH
(23) DDB DEPUTY DIRECTOR BRANCH

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJASTHAN)

BUDGET 1990-91

LIST OF TEACHING DISCIPLINES OF TEACHING & ACADEMIC STAFF

DATA AS OF 07/01/90

DIVISION/UNIT FD1

SNO	BSRN	PSRN	NAME	DESIGNATION	HIGHEST QUALIFICATION	WORKING FOR HIGHER DEGREE	TEACHING DISCIPLINES
1	4	4	J V S Mani	ASTP	Ph.D.		CHEG PSON ES THES ET PROJ
2	23	8	V P Gaur	ASTP	Ph.D.		POL
3	24	9	SureshChandra Sharma	ASTP	Ph.D.		POL HUM HIST THES
4	206	10	S N Prasad	LECT.	Ph.D.		HIST HUM PSON
5	28	12	Krishna Mohan	ASOP	M.A.		ENGL THES LANG
6	29	13	P D Chaturvedi	ASOP	Ph.D.		ENGL LANG HUM THES
7	32	15	G D Tripathi	LECT	Ph.D.		HIND LANG HUM THES
8	33	16	J P Verma	LECT	M.A.		ENGL LANG THES
9	44	20	S K Jain	LECT	M.Com.		MGTS PSON PROJ THES
10	1	34	H Subramanian	PROF	Ph.D.		MATH STD THES CS PROJ OTOR
11	255	161	B K Nema	LECT	M.A.		PHIL
12	30	165	S D Misra	ASTP	Ph.D.		LANG PSON HUM SOC SAMS THES
13	34	166	Mrs V Varma	LECT	Ph.D.		PSY SOC
14	149	719	Pulak Kumar Das	LECT	M.S.		ECON PSON MGTS THES PROJ
15	45	745	Mrs Usha Jain	ALEC	POST-GRADUATE DIPL.	M.Phil.	MGTS PROJ PSY THES
16	17	747	Mrs Koneru Aruna	ALEC	POST-GRADUATE DIPL.		ENGL LANG PSON
17	20	790	Rajiv Gupta	ALEC	M.E.	Ph.D.	CE ES SYST EG PROJ THES PSON
18	10	847	D S Prakash Rao	ASOP	Ph.D.		CE PROJ PSON ES THES
19	60	850	N K Mandal	LECT	M.Tech.	Ph.D.	EEE SYST ES PROJ
20	15	861	S Ghoshal	ASTP	Ph.D.		CE CS ES PROJ THES EG
21	13	876	B Prasad	LECT	M.Tech.		CHEG ES PROJ
22	142	877	Santosh Kumar Singh	ALEC	M.Tech.	Ph.D.	CE PROJ ES THES EG
23	39	911	P N K Rao	ALEC	M.E.	Ph.D.	CE PROJ ES THES
24	840	913	R Siddique	ALEC	M.E.	Ph.D.	CE PROJ ES THES
25	136	950	Rakesh Kumar	ALEC	M.E.	Ph.D.	CE ES EG
26	9	957	V V Swamy	TA	M.Sc.(Hons.)	M.E.	ECON
27	22	962	C V Prasad	TA	B.E.(Hons.)	M.E.	CE OTOR PROJ
28	49	972	R Sriram	TA	B.E.	M.E.	CHEG PROJ
29	48	976	B Chandrasekhar	TA	B.E.(Hons.)	M.E.	CHEG
30	161	981	T V A Subramanian	VFAC	M.E.		MGTS
31	88	984	J K Basu	LECT	M.Chem.Engg.		CHEG ES PROJ

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJASTHAN)

BUDGET 1990-91

LIST OF TEACHING & ACADEMIC STAFF TEACHING BIOLOGICAL SCIENCES

DATA AS OF 07/01/90

SNO	PSRN	BSRN	NAME	DEGREE	DESIGNATION	PRIMARY DISCIPLINE	DIVISION/UNIT
1	35	75	Mrs S Mitra	Ph.D.	PROF	BIO	FD3
2	36	76	M C Joshi	Ph.D.	ASOP	BIO	FD3
3	37	77	S C Rastogi	Ph.D.	ASOP	BIO	FD3
4	43	85	S P Gupta	D.Phil.	ASOP	CHEM	FD3
5	91	87	V N Sharma	Ph.D.	ASTP	BIO	FD3
6	97	257	K R Chandhoke	Ph.D.	ASOP	BIO	CWU
7	813	99	Mrs Anuradha Tandon	Ph.D.	LECT	BIO	FD3
8	828	279	S K Ray	Ph.D.	LECT	BIO	DLPU
9	952	268	J P Mishra	M.E.	ALEC	INST	IU

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE PILANI

BUDGET 1990-91

ADDITIONAL INFORMATION OF SUPPORTING STAFF

LEGEND

ACMG	ACCOUNTS MANAGEMENT	ACPO	A C PLANT OPERATION
ACWK	ACCOUNTS WORK	ANHM	ANIMAL HOUSE MAINTENANCE
AUMT	AUTOMOBILE OPT. MAINTENANCE	AVEO	AUDIO VISUAL EQUIPMENT OPERATION
BOBI	BOOK BINDING	BOGA	BOTANICAL GARDENING
BOOP	BOILER OPERATION MAINTENANCE	CARP	CARPENTRY
CKNG	COOKING	CLWK	CLERICAL WORK
COMP	COMPOUNDING	COOP	COMPUTER OPERATION
COST	COSTING	CPRJ	CINE PROJECTION
CSWK	CASH WORK	CYCL	CYCLOSTYLING
DAEN	DATA ENTRY	DESP	DESPATCH WORK
DRIV	DRIVING	DRTG	DRAUGHTING
ELRP	ELECTRICAL REPAIRS	ELTN	ELECTRICIAN
EOMT	ENGINE OPERATION & MAINTENANCE	EPLG	ELECTROPLATING
FRDE	FRANKING & DESPATCH	FTFX	FITTINGS & FIXTURES
GAAC	GAMES ACTIVITIES	GAPO	GAS PLANT OPER. & MAINTENANCE
GEMT	GENERAL OPERATION & MAINTENANCE	GLBO	GLASS BLOWING
GNHL	GENERAL HELP	GNSU	GENERAL SUPERVISION
GOCO	GOURMENT COOKING	HOSE	HOSTEL SECURITY
INCM	INTERCOM MAINTENANCE	INMT	INVENTORY MAINTENANCE
INRP	INSTRUMENT REPAIR	KEPG	KEY PUNCHING
LAWK	LABORATORY WORK	LBCL	CLASSIFICATION LIBRARY
LBCR	CIRCULATION LIBRARY	LBCT	CATALOGUING LIBRARY
LBMG	LIBRARY MANAGEMENT	LBPR	PERIODICALS LIBRARY
LBRS	READER SERVICES LIBRARY	LBTS	TECHNICAL SERVICES LIBRARY
LLWK	LANGUAGE LAB. WORK	MATR	MATRON
MCNG	MACHINING	MECA	MEDICAL CENTRE ASSISTANCE
MOLD	MOULDING	MTMC	MOTOR MECHANIC
MTWN	MOTOR WINDING	OFMG	OFFICE MANAGEMENT
PAMK	PATTERN MAKING	PASO	P.A.SYSTEM OPERATION
PHED	PHYSICAL EDUCATION	PHMO	PHOTOSTAT MACHINE OPERATION
PLUM	PLUMBING	PPFT	PIPE FITTING
PRIN	PRINTING	PSAC	P S ACTIVITIES
PSMG	PROVISION STORE MANAGEMENT	PTNG	PAINTING
RDPH	REGISTERED PHARMACIST	REFN	REFRIGATION
REKP	RECORD KEEPING	REPO	REPROGRAPHY OPERATION
SMTY	SMITHY	STEN	STENOGRAPHY
STKG	STORE KEEPING	STLT	STAGE LIGHTING
SUPR	SUPERVISION	SWCH	SWIMMING COACH
TCWK	TEACHING WORK	TURN	TURNING
TYPG	TYPING	WDPR	WORD PROCESSING
WELD	WELDING		

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJASTHAN)

BUDGET 1990-91

MORE INFORMATION ON SUPPORTING STAFF

DATA AS OF 07/01/90 PAGE

DIVISION/UNIT FD1

SNO	BSRN	PSRN	NAME	DESIGNATION	QUALIFICATION	SPECIAL COMPETENCE			
1	291	177	M R Jangira	TYPT	HIGHER SECONDARY	ACWK	TYPG	WDPR	
2	296	180	Udai Pal Singh	DEM	DIPLOMA	AUMT	BOOP	GEMT	LAWK
3	297	181	J P Gaur	STKR	B.Com.	ACWK	STKG	TYPG	
4	298	182	Ramswaroop	BM	CERTIFICATE	BOOP			
5	299	183	K M Sharma	GB	SCHOOLING	GLBO			
6	300	184	Shankar Mal	MENC	SCHOOLING	PPFT			
7	301	185	Mali Ram Soni	TYPT	HIGHER SECONDARY	TYPG	WDPR		
8	304	187	Jagdish Kumar	ASK	INTERMEDIATE	STKG	TYPG	WDPR	
9	292	210	Puran Mal	GESO	SCHOOLING	CYCL			
10	306	216	Shri Gopal Sharma	TYPT	MATRICULATION				

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJASTHAN)

BUDGET 1990-91

MORE INFORMATION ON HELPING STAFF

DATA AS OF 07/01/90 PAGE

SNO	BSRN	PSRN	NAME	DESIGNATION	QUALIFICATION	DIV/UNIT	SPECIAL COMPETENCE		
1	565	424	Chajju Ram	ATDT	SCHOOLING	FD2	PPFT		
2	570	429	Shiv Narain	ATDT	SCHOOLING	FD3	LAWK		
3	576	436	Shankar Lal	ATDT	SCHOOLING	FD3	GAPO		
4	579	439	Hari Ram	ATDT	SCHOOLING	FD3	ANHM		
5	587	445	Nathu Ram	ATDT	SCHOOLING	ARCD	DAEN	GESO	REKP
6	590	449	Karan Singh	ATDT	HIGH SCHOOL	EDD	CYCL	REKP	
7	598	457	Jeeta Ram	ATDT	SCHOOLING	DLPU	GESO	REKP	
8	600	458	Jhuntha Ram	ATDT	SCHOOLING	PSD	REKP		
9	603	461	Banwari	ATDT	SCHOOLING	IPCU	CYCL		
10	604	462	Jailal	ATDT	SCHOOLING	SWD	GAAC		
11	605	463	Magharam	ATDT	SCHOOLING	SWD	GAAC		
12	638	495	Prabhu Dayal	ATDT	SCHOOLING	ADMU	FRDE		
13	644	497	Mahabir Pd Saini	ATDT	SCHOOLING	DIRB	CYCL		
14	549	500	Satyanarain	ATDT	SCHOOLING	FD1	CYCL		
15	664	523	A C Sonania	ATDT	HIGH SCHOOL	IPCU	ACPO		
16	667	526	Rameshwar Daroga	ATDT	SCHOOLING	IPCU	ACPO		
17	668	527	Ramjilal	ATDT	SCHOOLING	IPCU	ACPO		
18	672	528	Surajbhan Singh	ATDT		IU	PASO		
19	674	529	R N Singhathia	ATDT	HIGHER SECONDARY	IU	ELTN		
20	591	587	Gulab Singh	ATDT	SECONDARY	EDD	CYCL		
21	758	600	Chhajuram Saini	ATDT	SCHOOLING	WSU	TURN		
22	759	601	Jhindu Ram	ATDT	SCHOOLING	WSU	CARP		
23	760	602	P R Singh	ATDT	SCHOOLING	WSU	EPLG		
24	761	603	R A Soni	ATDT	SCHOOLING	WSU	FTFX	MTMC	
25	764	606	Jas Bahadur	ATDT	SCHOOLING	WSU	CARP		
26	765	607	Manik Chand	ATDT	SCHOOLING	WSU	TURN		
27	680	885	Daya Ram Saini	ATDT	SECONDARY	LIB	LBCL	LBCT	
28	681	886	Liladhar Nayak	ATDT	HIGHER SECONDARY	LIB	LBCL	LBCT	
29	679	887	Ami Lal	ATDT	SCHOOLING	LIB	PHMO	REPO	
30	596	888	Shyam Sunder Saini	ATDT	SCHOOLING	PSD	CYCL		
31	551	898	Vijay Mohan	ELEC	SCHOOLING	MNTU	ELTN		
32	646	988	Banwari Lal	ATDT	SCHOOLING	CWU	MECA		

APPENDIX D

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI

BUDGET 1984-85

GRADEWISE ANALYSIS OF TEACHING STAFF

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DIVISION/UNIT

GRADE	FDI	II	III	ARC	EDD	EHD	ID	PS	RC	SWD	ACO	ADM	COM	GA	IPC	INS	LIB	MAIN	PDU	PRO	WS	DB	CDB	TOTAL
1500-2500	7	5	9	2	5	1	1	2	1	2	0	0	0	0	1	1	0	0	0	0	1	0	0	38
1500-2000	5	3	12	1	1	1	5	2	1	0	0	0	1	0	2	0	0	0	0	0	0	0	0	34
1200-1900	14	7	10	5	0	5	12	10	2	3	0	0	3	0	1	1	0	0	0	0	0	0	0	73
700-1600	24	8	20	8	1	3	23	14	3	1	0	0	1	0	1	2	0	0	0	0	0	0	0	109
700-1100	0	0	0	0	0	0	2	7	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	13
NO GRADE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPL.ALLWN.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	50	23	51	16	7	10	43	35	9	6	0	0	6	0	5	5	0	0	0	0	1	0	0	

GRAND TOTAL 267

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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI

BUDGET 1984-85

GRADEWISE ANALYSIS OF SUPPORTING STAFF

DIVISION/UNIT

GRADE	FDI	II	III	ARC	EDD	EHD	ID	PS	RC	SWD	ACD	ADM	COM	GA	IPC	INS	LIB	MAIN	PDD	PRJ	WS	DB	DDB	TOTAL
2000-3000	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	3
1500-2500	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	1	1	1	0	0	0	0	5
1500-2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1200-1900	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	0	1	1	0	0	0	0	0	5
700-1600	1	1	0	0	0	0	0	0	0	5	0	0	0	2	0	0	1	1	0	0	0	0	0	9
700-1100	1	1	0	2	1	0	0	1	0	0	1	0	0	0	1	0	1	0	2	0	1	0	1	13
550-850	3	5	1	1	1	0	9	4	1	0	3	1	0	3	1	1	1	1	0	0	4	1	0	41
450-760	3	4	5	1	0	0	1	5	1	1	5	0	0	0	3	1	4	2	1	0	5	0	0	42
380-610	1	5	0	3	0	2	0	2	1	4	4	2	0	2	2	1	2	4	0	0	18	0	0	[illegible]
300-450	9	5	8	2	1	1	2	2	1	5	2	1	0	6	1	2	8	6	0	0	23	0	1	87
250-450	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	4
5500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
PT ALLW	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	3
TOTAL	18	21	15	10	[illegible]	3	12	13	4	[illegible]	19	5	0	[illegible]	8	5	19	19	4	1	51	[illegible]	[illegible]	

GRAND TOTAL 259

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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI

BUDGET 1984-85

GRADEWISE ANALYSIS OF HELPING STAFF

DIVISION/UNIT

GRADE	FOI	II	III	ARC	EDD	EHD	ID	PS	RC	SWD	ACO	ADM	COM	GA	IPC	INS	LIB	MAIN	PDD	PRD	WS	DB	DDB	TOTAL
215-290	12	14	21	3	1	4	2	4	1	32	3	1	0	45	7	2	11	46	1	0	5	2	1	219
250-450	2	1	1	1	0	0	0	0	0	0	0	0	0	2	1	1	0	2	0	0	4	0	0	15
300-450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380-610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450-760	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
550-850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
700-1100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	14	15	22	4	1	4	2	4	1	32	3	1	0	47	8	3	11	48	1	0	10	2	1	

GRAND TOTAL 234

APPENDIX E

Appendix E

The Universe of Data for Human Resources Management

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

PROFORMA
FOR
COMPUTERISATION
OF
STAFF PROFILE

This Profile has six Sections :

SECTION 1 : VITALS

SECTION 2 : BENEFITS

SECTION 3 : PROFESSIONAL

SECTION 4 : PERIODIC REVIEW

SECTION 5 : COMMUNITY LIFE

SECTION 6 : PAST PROFILE

000 : STAFF RECORD NUMBER

001 : LAST DATE THIS PROFILE WAS UPDATED

SECTION 1

101 NAME IN FULL

______________________ ______________ ____________________
(Last name or Surname) (Middle) (First or Maiden)

102 SEX

Male Female

103. DATE OF BIRTH

104 NATIONALITY

Indian Non-Indian

105. SC ST OTHERS

106. PERMANENT ADDRESS

________________________________ House No., Street

________________________________ Village, Town, District

________________________________ State. Pin Code

________________________________ Telephone No., if any

107. DATE OF FIRST APPOINTMENT WITH BITS

108. DATE OF CURRENT APPOINMENT WITH BITS

SAME AS 107

109 BREAK OF SERVICE AT BITS, IF ANY :

FROM

TO

FROM

TO

110. CATEGORY OF STAFF AS PER BUDGETARY PRACTION

TEACHING SUPPORTING HELPING

If suporting staff, say whether he is formally required to do teaching and academic duties.

111. CATEGORY OF STAFF AS PER CLASSIFICATION IN RULES

ACADEMIC TECHNICAL ADMINISTRATIVE AND OTHERS

112. MARITAL STATUS

SINGLE MARRIED WIDOW OR WIDOWER OR DIVORCES

113. TYPE OF CURRENT EMPLOYMENT

01	PERMANENT
02	TEMPORARY AGAINST PERMANENT POST
03	TEMPORARY, OTHER THAN 02
04	CONTRACTUAL
05	SUBSTANTIVE POST PERMANENT LATEST POST CONTRACTUAL
06	ON DEPUTATION OR LEAVE FROM BITS AND STATIONED ELSEWHERE
07	VISITING AT BITS
08	ADJUNCT FACULTY
09	ASSOCIATE FACULTY
10	PART TIME
11	ON EXTENSION AFTER RETRIEMENT DATE
12	RE-EMPLOYED AFTER RETIREMENT
13	NONE OF THE ABOVE, SPECITY ___________

114. EARLIEST DATE FROM WHICH THE TYPE OF CURRENT EMPLOYMENT (See 113) APPLIES, WITHOUT BREAK

115. SCHEDULED LAST DATE OF CURRENT EMPLOYMENT

1. Termination Date, if Term is known

2. Retirement date, if applicable

3. No Termination or Retirement Date Known

116. NOTICE PERIOD

One month

Three months

Six months

No notice necessary

Any other to be specified

117. a) Designation of Post

b) Effective from

c) Primary Discipline

118. a) Administrative Rank, other than the Designation, if any

b) Effecgive from

119. a) Division/Unit attached to

____

b) Group attached to, if any

____

120. a) JOB LOCATION

On Campus

Off Campus

b) If off-campus, which station

____

121. Pay Scale

____

122. a) BASIC SALARY ______________

b) DA ____________

c) DATE OF NEXT INCREMENT

d) If already a pensioner, amount of pension

123. PERSONAL GRADE, IF ANY

____

124. PERSONAL PAY, IF ANY

____

125. a) CURRENTLY ON EXTRAORDINARY LEAVE

YES NO

b) IF, YES, PERIOD OF LEAVE

FROM

TO

c) STATUS OF SALARY DURING LEAVE

FULL HALF NONE OTHERS, Specify

126. RESIDENTIAL ADDRESS AT PILANI

______________________________ Qr. No./House No. and Street

______________________________ Telephone No., if any

127. OFF-CAMPUS RESIDENTIAL ADDRESS (if any)

________________________________ House No., Street

________________________________ Village, Town District

________________________________ State, Pin code

________________________________ Telephone No., if any

128. EMERGENCY CONTACT ADDRESS

Same as # 106
Same as # 126
Same as # 127

________________________________ Name

________________________________ House No., Street

-------------------------------- Village, Town, District

-------------------------------- State Pin code

-------------------------------- Telephone No., if any

129. DATE WHEN RETIRED (to be filled after retirement)

130. (To be filled after the Staff leaves service)

DATE WHEN HE LEFT THE SERVICE OF BITS

SECTION 2

200 : DETAILS OF MEMBERS OF FAMILY. FOR EACH SUCH MEMBER, THE INFORMATION IS TO BE RECORDED IN THE ITEMS 201 TO 213. NUMBER OF SUCH MEMBERS WHO ARE LISTED

201.xx : NAME ____

202.xx : SEX MALE FEMALE

203.xx : DATE OF BIRHT

204.xx : RELATIONSHIP WITH STAFF MEMBER

205.xx : DEPENDENT : YES NO

206.xx : LIVING WITH STAFF MEMBER YES NO

207.xx : WHETHER ELIGIBLE FOR LTC YES NO

208.xx : WHETHER ELIGIBLE FOR MEDICAL REIMBURSHEMENT YES NO

209.xx : WHETHER THE RELATION IS STUDYING YES NO

210.xx : AT WHAT LEVEL IS THE RELATION STUDYING :

SCHOOLING BELOW & INCLUDING STD X

STANDARDS XI AND XII

FIRST DEGREE AT UNIVERSITY OR EQUIVALENT

HIGHER DEGREE AT UNIVERSITY

OTHERS, SPECIFY ______________________

211.xx : WHETHER ELIGIBLE, AS A RELATION, FOR FREE TUTION FACILTITY YES NO

212.xx : WHETHER THE PLACE, WHERE THE RELATION STUDIES, IS AN ELIGIBLE PLACE FOR THE FREE TUITION FACILITY

YES NO

213.xx : WHETHER THE PERFORMANCE OF THE RELATION IN STUDIES IN THE PREVIOUS COMPLETED ACADEMIC YEAR IS

SATISFACTORY

UNSATISFACTORY

214.xx : ENTITLEMENT OF TYPE OF CAMP'S QUARTERS

B C D E F OTHERS NONE

215 : OCCUPATION OF TYPE OF CAMPUS QUARTERS

B C D E F OTHERS NONE

216. : QUARTERS NUMBER OCCUPED, IF ANY

---

217 : VACATION ENTITLEMENT

YES NO

218. : IF YES TO NO. 331, NOW NAME DATE IN THE CURRENT ACADEMIC YEAR ?

TWO MONTHS ONE MONTH NUMBER OF DATE

219 : NUMBER OF DAYS OF HALF PAY LEAVE ACCUMULATED :

233 : NUMBER OF DAYS OF HALF PAY LEAVE DEBITED

234 : NUMBER OF FULL DAYS OF OUT OF THE NO IN 233

236 : NUMBER OF DAYS OF EARNED LEAVE ACCOMULATED :

330 : EARNED LEAVE USED :

241 : ENTITLEMENT FOR LTC

EVERY YEAR

ONCE IN TWO YEARS

NO ENTITLED

242 : YEAR LAST AVAILED OF :

243 : HOMETOWN, DISTRICT AND STATE

________________________________ TOWN

________________________________ DISTRICT, STATE

244 : HAS THE HOMETOWN BEEN CHANGED ON AN EARLIER OCCASION?

YES NO

245 : SHORTEST DISTANCE TO HOME TOWN

a) From Pilani

TOTAL DISTANCE TO BE COVERED BY BUS OR ROAD

TOTAL DISTANCE TO BE COVERED BY RAIL

b) FROM OFF-CAMPUS STATION, IF RELEVANT

NAME OF OFF-CAMPUS STATION ______________

TOTAL DISTANCE TO BE COVERED BY BUS OR ROAD

TOTAL DISTANCE TO BE COVERED BY RAIL

____

246 : DATE OF JOINING

262 : FULL NAME OF NOMINEE OF THE PF FUND

____________ ______________ ________________
LAST MIDDLE FIRST

263 : ADDRESS OF NOMINEE

____________________________ Hourse No., Street

____________________________ Village or Town, District

____________________________ State, Pin Code

264 : RELATIONSHIP OF NOMINEE TO STAFF MEMBER __________

265 : PERCENTAGE OF SALARY CONTRIBUTED BY EMPLOYEE TO PF

266 : PERCENTAGE OF SALARY CONTRIBUTED BY EMPLOYER TO PF OF EMPLOYEE

267 : CUMULATED AMOUNT IN THE FUND :

Rs. Ps.

As of 31st March

Year

268 : AMOUNT IN RUPEES OF REPAYABLE
PF LOAN TAKEN, IF ANY

270 : DATE ON WHICH LOAN IN ITEM 258 WAS GRANTED

271 : AMOUNT OF MONTHLY DEDUCTION FOR RECOVERY OF
LOAN (See Item 268)

Rs.

272. : NUMBER OF MONTHLY INSTALMENTS OF DEDUCTION

273 : CUMULATED AMOUNT OF NON-REPAYABLE OF LOAN
AVAILED OF FOR PAYMENT OF LIC PREMIAM

Rs. Ps.

AS OF

274 : AMOUNTS IN RUPEES OF NON-REPAYBLE PF LOANS TAKEN FOR
PURPOSES OTHER THAN PAYMENT OF LIC PREMIA IF ANY

FIRST FIME Rs. Ps.

SECOND TIME Rs. Ps.

275 : DATE OF LOANS IF NO. 262

---

371 : ANY OTHER LOAN, FROM INSTITUTE, WHICH IS YET TO BE
CLEARED, SPECIFY.

01 ____________________

02 ____________________

03 ____________________

372 : THE AMOUNT OF SUCH LOANS (ITEM 271) AND DATES ON WHICH GRANTED

01

02

03

373 : AMOUNT OF MONTHLY INSTALMENTS AND NO. OF INSTALMENTS, FOR THE RECOVERY OF LOANS IN ITEM 371 :

01

02

03

(TO BE FILLED WHEN PENSION BECOME DUE, IF ANY)

360 : AMOUNT OF PENSION APPROVED

Rs. Ps.

361 : TO WHOM IS THE PENSION PAYABLE ?

________________ NAME

________________ RELATIONSHIP

________________ ADDRESS

____

362 : HOW LONG?

UNTIL

FOR LIFE

SECTION 3

300 : DEGREES OBTAINED, FROM FIRST DEGREE ONWARD.

For each degree the information from No. 301 to No. 306 is to be recorded. Number of degrees in this list is

301.xx : Degree ________________________________

302.xx : Discipline (Major) ____________________________

303.xx : Division (if any) ____________________________

304.xx : Year ____________________________

305.xx : University ____________________________

306.xx : If the entry under 305.xx is BITS, say whether the degree was acquired by studying for the same.

While being a staff member at BITS

or As a whole-time student at BITS

307 : Candidate for a higher degree at BITS?

YES NO

308 : If answer to No. 307 is Yes, specify the degree at BITS :

____

309 : If answer to No. 308 in 'Ph.D.', the following information is to be recorded; whenever available

a) Date of passing Qualifying Examination :

b) Date of approval of Thesis Topics :

c) Date of Submission of Thesis :

310 : Candidate for a higher degree at a university other than BITS?

YES NO

311 : If answer to No. 310 is Yes, specify the degree and University :

312 : Estimated (according to the staff member) date of completion of degree mentioned in No. 311.

NOTE : Items 320 to 331 are applicable only to teaching staff or supporting staff who are formally required to discharge teaching and academic duties.

320 : a) Was any teaching assignment completed in the previous semester?

YES NO

b) If Yes to No. 320(a), list all courses with calsseroom (and/or laboratory) contact. For each such course, the information from No. 321 toNo. 324 is to be recorded. Number of such courses listed in No. 321 to No. 324 is

321.xx : Course Number :

322.xx : Title of Course : ______________________________

323.xx : Single Section course

Multisection Course

324.xx : Number of students in your section

Less than 25 26-50 51-75 76-100 above 100

325 : Instructor for PS Courses, in the previous completed academic year.

PS I PS II

______________________ ______________________

Name of PS I Station Name of PS II Station

326 : Instructor for courses other than those listed in No. 321 to No. 325 in the completed previous semester. Record the information in No. 327 to No. 329 below. Number of such courses listed is :

327.xx : Course Number :

328.xx : Name of course ______________________________

329.xx : Number of students

Less than 25   26-50   51-75   76-100   above 100

330 : In the <u>completed</u> <u>previous</u> <u>semester</u>, has the staff member been

a) Instructor-in-charge for multisection course?

YES   NO

If Yes, specify the following :

Course No.   Name of course

------------------   ------------------------------

------------------   ------------------------------

b) Seminar Coordinator

YES   NO

c) Supervisor for completed first degree thesis

YES   NO

If Yes, for how many?

d) Thesis Examiner for first degree theis

YES   NO

If Yes, for how many?

e) Supervisor for completed Ph.D. Thesis.

YES   NO

If Yes, for how many?

f) Thesis examiner for BITS Ph.D. Thesis

YES   NO

If Yes, for how many?

331 : Categories the involvement in teaching and academic duties, in the completed previous academic year, in one or more of the following discipline groupings.

BIO	BIOLOGICAL SCIENCES
CE	CIVIL ENGINEERING
CHE	CHEMICAL ENGINEERING
CHEM	CHEMICAL
CS	COMPUTER SCIENCE (INCLUDING ALL COMPUTER APPLICATION COURSES AT THE THREE LEVELS)
ECON	ECONOMICS
EEE	ELECTRICAL ELECTRONICS ENGINEERING
ENGL	ENGLISH
ET	ENGINEERING TECHNOLOGY
CD	CENTRAL
INSTR	INSTRUMENTATION (INCLUDING ALL SPECIAL COURSES AT THE THREE LEVELS)
MATH	MATHEMATICS
ME	MECHANICAL ENGINEERING
MGTS	MANAGEMENT
MSMS	MUSEUM STUDIES
PHAR	PHARMACY
PHY	PHYSICS
STD	SCIENCE TECHNOLOGY DEVELOPMENT
EG	ENGINEERING GRAPHICS
ENGG	ENGINEERING SCINCE, ANALYSIS AND APPLICATION ORIENTED COURSES, MEASUREMENT TECHNIQUES II, TECHNIQUE ORIENTED COURSES
HSS	HUMANITIES AND SOCIAL SCIENCES
LANG	LANGUAGES (HINDI,SANSKRIT,RUSSIAN,FRENCH, GERMAN, COMPARATIVE INDIAN LITERATURE)
MA	MUSIC & ARTS
PS	PRACTICE SCHOOL - I & II
SC	CORE SCIENCE, CORE MATHEMATICS, SCIENCE APPLIED SCIENCE, MEASUREMENT TECHNIQUES - I INSTR. METHODS OF ANALYSIS
TPG	THESIS/PROJECT GUIDE (INCLUDES GUIDING FREE ELECTIVE PROJECTS AND ENTREPRENEUR-SHIP COURSES)
PCK	TECHNICAL REPORT WRITING, PROF. COMMUNICATION, TEACHING PRACTICE, SEMINAR LIBARY SEARCH
WS	WORKSHOP PRACTICE

341 : This item is applicable only for supporting staff who are not usually required to discharge teaching & academic duties. Mark areas of competence in which the staff has been involved in the completed previous academic year :

1. A.C. Pant
2. Accounts Work
3. Animal House
4. Artisan
5. Audio Visual
6. Boiler Work
7. Book Binding
8. Botanical Gardening
9. Carpentry
10. Cataloguing
11. Computer
12. Computer Sc.
13. Cooking
14. Costing
15. Cyclostyling
16. Despatch
17. Draughting
18. Driving
19. Electrician
20. Electrical Work
21. Electroplating
22. Fitting
23. Franking
24. Games Activities
25. Gas Plant
26. Courmet Cooking
27. Green House
28. Hostel Security
29. Intercom
30. Inventory
31. Language Lab. Work
32. Machining
33. Machine Shop
34. Medical Centre
35. Motor Mechanic
36. Moulding
37. Office Management
38. P.A. System
39. Painting
40. Pattern making
41. Photostat
42. Physical Education
43. Pipe Fitting
44. Practice School
45. P.S. Allocation
46. Punching
47. Record Keeping
48. Refrigeration
49. Reprography
50. Smithy
51. Stage Lighting
52. Steno
53. Store
54. Swimming Coach
55. Swimming Pool
56. Tabla
57. Teaching Work
58. Typing
59. Turning
60. Welding

350 Statistics* of Publications during the previous completed academic year.

NUMBER OF PUBLICATIONS (Give the total number of pages in brackets)		Publi-shed	In Press	Accepted for pub-lication	Commu-nicated for pub-lication	In Pre-para-tion
Printed book of the Text-book type	Independently					
	Jointly					

Reprographed notes, supported by the EDD	Independently
	Jointly
Research Papers	Independently
	Jointly
Research monographs printed or otherwise	Independently
	Jointly

* All details of each entry should be filed separately.

351 : Professional meetings or conferences attended and/or invited to attend with with details of papers presented, if any

352 : Talks delivered, with title, and auspices under which delivered.

353 : Details of work done, such as :

a) Abstracting
b) Reviewing
c) Refereeing
d) Editorship of Scholarly publications
e) Industrial Consultation
f) _______________ (specify)

354 : Work other than teaching and research at BITS, such as:

a) Committee work
b) Extra-curricular work
c) Administrative control
d) Public Relations
e) ____________________ (Specify)

355 : Offices held in professional and non-professional organisations.

356 : Any other professional work which does not fall into categorisations so far made.

357 : Honours and Commendations obtained.

APPENDIX F

Appendix F

Structure of the Databases

STRUCTURE FOR DATABASE : SDCMAIN.dbf

Field	Field Name	Type	Width	Dec.
1.	PSRN	Character	4	
2	FNAME	Character	12	
3	LNAME	Character	1	
4	PAY_SALARY	Character	8	
5	JOIN_DATE	Character	8	
6	BIRTH_DATE	Character	7	
7	BANK_AC	Character	3	
8	BUD_IND_NO	Numeric	3	
9	NATIONALTY	Character	4	
10	EX_ACYR_SP	Character	1	
11	SC_ST	Character	1	
12	SEX	Character	1	
13	MAR_STATUS	Character	12	
14	SPOUS_NAME	Character	30	
15	FATH_NAME	Character	4	
16	QUALIF1	Character	4	
17	YR_QUALIF1	Character	4	
18	UNIV_QUAL1	Character	4	
19	SUB_QUAL1	Character	4	
20	QUALIF2	Character	4	
21	YR_QUAL2	Character	4	
22	UNIV_QUAL2	Character	4	
23	SUB_QUAL2	Character	4	
24	QUALIF3	Character	4	
25	YR_QUALIF3	Character	4	
26	UNIV_QUAL3	Character	4	
27	SUB_QUAL3	Character	4	
28	QUALIF4	Character	4	
29	YR_QUALIF4	Character	4	
30	UNIV_QUAL4	Character	4	
31	SUB_QUAL4	Character	4	
32	QUALIF5	Character	4	
33	YR_QUALIF5	Character	4	
34	UNIV_QUALIF5	Character	4	
35	SUB_QUAL5	Character	4	
36	SPECIALIS	Character	30	
37	PR_TCH_DIS	Character	4	
38	TCH_DIS2	Character	4	
39	TCH_DIS3	Character	4	
40	TCH_DIS4	Character	4	
41	TCH_DIS5	Character	4	
42	TCH_DIS6	Character	4	
43	SPL_TRG	Character	4	
44	SPL_COMP1	Character	4	

45	SPL_COMP2	Character	4
46	SPL_COMP3	Character	4
47	SPL_COMP4	Character	4
48	SPL_COMP5	Character	4
49	ADM_DESIG1	Character	3
50	DT_ST_ADS1	Character	8
51	DT_EN_ADS1	Character	8
52	ADM_DESIG2	Character	3
53	DT_ST_ADS2	Character	8
54	DT_EN_ADS2	Character	8
55	ADM_DESIG3	Character	3
56	DT_ST_ADS3	Character	8
57	DT_EN_ADS3	Character	8
58	WH_PERM	Character	1
59	DESG_PERM	Character	4
60	DATE_PERM	Character	8
61	WH_CONTR	Character	1
62	DT_ST_CONT	Character	
63	DT_EN_CONT	Character	8
64	WH_TEMP	Character	1
65	DT_ST_TEMP	Character	8
66	DT_EN_TEMP	Character	8
67	WH_EXT	Character	1
68	DT_ST_EXT	Character	8
69	DT_EN_EXT	Character	8
70	PAYSC_DESG	Character	2
71	DT_ST_PRGR	Character	8
72	DT_EN_PRGR	Character	8
73	SERV_RECOD	Memo	10
74	MED_ENT	Character	1
75	FBS_ENT	Character	1
76	LTC_ENT	Character	1
77	HOME_TOWN	Character	3
78	NRT_RLY_ST	Character	12
79	WH_CHANGED	Character	1
80	DT_LST_LTC	Character	2
81	PF_ENT	Character	1
82	DT_PF_PERM	Character	5
83	DT_PF_JOIN	Character	5
84	PENS_ENT	Character	1
85	VAC_ENT	Numeric	2
86	NOTICE_PD	Numeric	1

STRUCTURE FOR DATABASE : SDCMONTH.dbf

Field	Field Name	Type	Width	Dec.
1	PSRN	Character	4	
2	FNAME	Character	12	
3	LNAME	Character	20	
4	BUD_DIV	Character	4	
5	DESIG	Character	4	

6	PLACE_POST	Character	3	
7	CAT_STA	Character	1	
8	INTRNL_DIV	Character	4	
9	HOUSE_NO	Character	5	
10	PAYSCALE	Character	2	
11	FIX_SAL_CD	Character	1	
12	BASIC	Character	4	
13	NX_INC_MNT	Character	4	
14	DA	Character	4	
15	ALL_WUT_PF	Character	4	
16	PF_OWN	Character	2	
17	PF_EMP	Character	2	
18	EL_BALANCE	Character	3	
19	HPL_BALANCE	Character	3	
20	COMPLV_AVLD	Character	3	
21	WH_HDEGREE	Character	1	
22	HD_NAME	Character	4	
23	DT_HD_PERM	Character	5	
24	DT_HD_STAT	Character	5	
25	DT_HD_DISC	Character	5	

STRUCTURE FOR DATABASE : SDCADDS.dbf

Field	Field Name	Type	Width	Dec.
1	PSRN	Character	4	
2	FNAME	Character	12	
3	LNAME	Character	20	
4	PERM_ADDR	Character	120	
5	EMERG_ADDR	Character	120	
6	CONT_ADDR	Character	120	

STRUCTURE FOR DATABASE : SDCADDS.dbf

Field	Field Name	Type	Width	Dec.
1	PSRN	Character	4	
2	STATUS	Character	1	
3	ISTTIM_FLG	Character	1	
4	ARREARS	Numeric	7	2
5	OTHER_PAY	Numeric	7	2
6	PSALLW_PAY	Numeric	6	2
7	BENIFT_PAY	Numeric	7	2
8	PFLOAN_DED	Numeric	7	2
9	SPLOAN_DED	Numeric	7	2
10	FRNLON_DED	Numeric	7	2
11	OTRLON_DED	Numeric	7	2
12	LIP_DED	Numeric	7	2

13	STAFAS_DED	Numeric	7	2
14	INCTAX_DED	Numeric	7	2
15	CTD_DED	Numeric	7	2
16	HRENT_DED	Numeric	7	2
17	TCC_DED	Numeric	6	2
18	FRNRNT_DED	Numeric	6	2
19	MTRRNT_DED	Numeric	4	2
20	REVSTP_DED	Numeric	4	2
21	ELEC_DED	Numeric	7	2
22	SALADV_DED	Numeric	7	2
23	BITSCP_DED	Numeric	7	2
24	MOTOR_DED	Numeric	7	2
25	OTRTOT_DED	Numeric	7	2
26	LEAV_DED	Numeric	7	2
27	BSC_PAY_CL	Numeric	7	2
28	DA_PAY_CL	Numeric	7	2
29	ALL_NPF_CL	Numeric	7	2
30	NET_PAY	Numeric	8	2

STRUCTURE FOR DATABASE : PAYSCCD.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Numeric	2	
2	B_ONE	Numeric	4	
3	IN_ONE	Numeric	3	
4	YR_ONE	Numeric	2	
5	B_TWO	Numeric	4	
6	IN_TWO	Numeric	3	
7	YR_TWO	Numeric	2	
8	B_THR	Numeric	4	
9	IN_THR	Numeric	3	
10	YR_THR	Numeric	2	
11	B_FORTH	Numeric	4	

STRUCTURE FOR DATABASE : SDCADDS.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	30	

STRUCTURE FOR DATABASE : QUALCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	20	

STRUCTURE FOR DATABASE : PLCCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	3	
2	EXPANSION	Character	12	

STRUCTURE FOR DATABASE : UNIVCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	20	

STRUCTURE FOR DATABASE : COMPCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	30	

STRUCTURE FOR DATABASE : DISCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	30	

STRUCTURE FOR DATABASE : DESIGCD.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	30	

STRUCTURE FOR DATABASE : DIVCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	35	

STRUCTURE FOR DATABASE : SUBJCODE.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	20	

STRUCTURE FOR DATABASE : BUDDESIG.dbf

Field	Field Name	Type	Width	Dec.
1	CODE	Character	4	
2	EXPANSION	Character	30	

STRUCTURE FOR DATABASE : BUDSTRU.dbf

Field	Field Name	Type	Width	Dec.
1	PAYAPRIL	Numeric	4	
2	INC_MON	Numeric	2	
3	INC_YEAR	Numeric	2	
4	ANNSAL	Numeric	6	
5	ANNDA	Numeric	6	
6	ANNALW	Numeric	5	
7	PF	Numeric	4	

STRUCTURE FOR DATABASE : BUDGET.dbf

Field	Field Name	Type	Width	Dec.
1	BSRN	Numeric	4	
2	BDIVCODEN	Character	4	
3	CAT	Character	1	
4	DESIG	Character	4	
5	GRDCODE	Numeric	2	

STRUCTURE FOR DATABASE : TCH_DISP.dbf

Field	Field Name	Type	Width	Dec.
1	BIO	Character	4	
2	CE	Character	4	
4	CHEG	Character	4	
4	CHEM	Character	4	
5	CS	Character	4	
6	EA	Character	4	
7	ECON	Character	4	
8	EEE	Character	4	
9	EG	Character	4	
10	ENGL	Character	4	
11	ERD	Character	4	
12	ES	Character	4	
14	ET	Character	4	
14	FRE	Character	4	
15	GRE	Character	4	
16	HIND	Character	4	
17	HIST	Character	4	
18	HUM	Character	4	

19	IDEV	Character	4
20	INST	Character	4
21	IP	Character	4
22	LANG	Character	4
23	MATH	Character	4
24	ME	Character	4
25	MGTS	Character	4
26	MSAR	Character	4
27	MSMS	Character	4
28	OTOR	Character	4
29	PE	Character	4
30	PHAR	Character	4
31	PHIL	Character	4
32	PHY	Character	4
33	POL	Character	4
34	PROJ	Character	4
35	PSON	Character	4
36	PSTW	Character	4
37	PSY	Character	4
38	RUSS	Character	4
39	SAMS	Character	4
40	SC	Character	4
41	SEM	Character	4
42	SOC	Character	4
43	STD	Character	4
44	SYST	Character	4
45	THES	Character	4
46	TIC	Character	4
47	WS	Character	4

STRUCTURE FOR DATABASE : BUDSTAT.dbf

Field	Field Name	Type	Width	Dec.
1	DIVISION	Character	4	
2	G11	Numeric	3	
3	G12	Numeric	3	
4	G13	Numeric	3	
5	G14	Numeric	3	
6	G15	Numeric	3	
7	G16	Numeric	3	
8	G17	Numeric	3	
9	G18	Numeric	3	
10	G19	Numeric	3	
11	G20	Numeric	3	
12	G21	Numeric	3	
13	G22	Numeric	3	
14	G23	Numeric	3	
15	G24	Numeric	3	
16	G25	Numeric	3	
17	G26	Numeric	3	

18	G27	Numeric	3
19	G28	Numeric	3
20	G29	Numeric	3
21	ROWTOT	Numeric	3

STRUCTURE FOR DATABASE : BUDTDISP.dbf

Field	Field Name	Type	Width	Dec.
1	QUAL	Character	20	
2	WF	Character	1	
3	T11	Character	4	
4	T12	Character	4	
5	T13	Character	4	
6	T14	Character	4	
7	T15	Character	4	
8	T16	Character	4	
9	T17	Character	4	
10	T18	Character	4	

STRUCTURE FOR DATABASE : PAGE3.dbf

Field	Field Name	Type	Width	Dec.
1	DIVISION	Character	4	
2	TNUMB	Numeric	3	
3	TAMT	Numeric	12	
4	SNUMP	Numeric	3	
5	SAMT	Numeric	12	
6	HNUMB	Numeric	3	
7	HAMT	Numeric	12	