AN ACADEMIC MULTI CAMPUS NETWORK
FOR THE 90s
A SCENARIO FOR THE I T E S M

MIGUEL ANGEL ARREOLA-GONZALEZ

THIS DISSERTATION WAS SUBMITTED IN
PART FULFILMENT OF THE DEGREE
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STRATHCLYDE GRADUATE BUSINESS SCHOOL
DEPARTMENT OF INFORMATION SCIENCE
UNIVERSITY OF STRATHCLYDE

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SEPTEMBER 1990
"The era of personal computing has ended"

Steve Jobs
Chairman of NeXT, Inc.
Palo Alto, California
December 1989
Abstract

ITESM is a private university composed of 26 campuses, with one of the highest standards in education in Mexico and Latin America. The use of computing as an educational tool has been an important aspect of academic management for ITESM since late 1970s.

Nevertheless, ITESM now requires a written and implemented strategy to use networks as tools to obtain and share information within and among its campuses.

This dissertation proposes the creation of an institutional strategy to exploit academic information, the establishment of LANs on each campus, and thus the formation of the ITESM Academic Network as a part of the strategy.

The emphasis of the proposed network is on information services provided by the campus' networks, and on the use of open standards in most of the components.

The author carried out research to find out what type of services are provided by university networks worldwide, and the result is a series of recommended services and technologies that could be used in the development of the ITESM networks.

The dissertation highlights the importance of the participation of all ITESM campuses and departments, and in particular the higher levels of the organisation, to ensure the success of the proposed network. In the same way, a series of organisational changes are suggested to facilitate the planning, development, and management of the networks.
Acknowledgements

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Introduction

The aim of this dissertation is to present a scenario/proposal for the ITESM Academic Multi Campus Network. This work is the result of research into the work done by universities worldwide to exploit modern networks in order to enhance their academic performance and increase the quality of services, education, and research offered.

It is hoped that the work will be a stimulus to establish a formal, long term plan to set up and exploit an institutional academic network, using the existing (and future) university and national telecommunications infrastructure and related services. The work proposes a scenario, discusses how it may be used as a platform for realistic projects, and outlines a comprehensive information strategy for the university.

The emphasis is on types and kinds of information services, and related policies for their use and users within a multi campus environment.

Also, the dissertation is based on the existing and/or future infrastructure of the university but does not make recommendations about specific products or services, although strategic technologies are indicated.

Four chapters form this work: the first describes the ITESM and provides the organisational and technical background required to understand the network services proposed in second chapter.
Chapter two has itself a broader proposal, the establishment of an Academic and Administrative Information Resources Strategy of which the proposed network is an important part. The chapter also describes the minimum or basic services required and identifies advanced services that might be developed in further stages.

Chapter three presents and discusses the main technologies involved in the development of the ITESM network. A special emphasis is placed on Open Systems Interconnection philosophy and standards.

Finally, chapter four introduces a list of some of the organisational changes that, a project of the size of the strategies proposed, requires to ensure successful operation.

It is important to note that the ideas, comments, and observations about ITESM are exclusively the points of view of the writer, who assumes entire responsibility for them. The facts about ITESM are based on published information and are valid at the time of writing this work.
1. THE ITESM UNIVERSITY SYSTEM

The Institute Tecnológico y de Estudios Superiores de Monterrey (ITESM) was founded in 1943 in Mexico by a group of businessmen, to provide higher education with the highest standards.

After 47 years of operations, ITESM is now a multi campus educational system, unique in Latin America in terms of size and complexity. It has 26 university campuses, established in 25 cities in different areas of Mexico and operates with approximately 3,200 professors, and 42,000 students [1].

1.1 MISSION

Since the mission of ITESM as to provide high quality education to its undergraduate and graduate levels, the Institute has developed several programmes which are intended to meet the following requirements:

- To conduct research as a vital part of its graduate programmes;
- To supply programmes of continuing education to keep professionals up to date in their specific areas;
- To provide specialized training for top executives; and
- To run a specialized senior high school to prepare students for its undergraduate courses.
ITESM has adopted the philosophy of continuous improvement in its operations as a means to achieve the level of excellence and quality it seeks [2].

1.2 ORGANISATION

The president of the ITESM System is responsible for the general operation of the Institute. There are also Academic Senates, which are in charge of the establishment of academic policies and regulations, and Academic Divisions with dozens of departments.

The ITESM System is composed of five geographical zones or regions:

- Monterrey Campus,
  Eugenio Garza Sada Campus,
- Northern Zone Campuses,
- Central Zone Campuses, and
- Southern Zone Campuses.

The oldest campus, in Monterrey, is also the most developed. It has 44 buildings in an area of more than 150 acres and represents more than a third of all the activities of the ITESM. Meanwhile the rest of the campuses have been growing accordingly with the needs of each region, each at its own pace and with its own resources.

Each campus has the responsibility and freedom to develop its own plans for infrastructure and services, as well as to
seek sponsorship, research projects, etc., so long as it follows the academic and strategic plans, philosophy, mission, etc. of ITESM as a single, large university system.

The Mexican government, through the Secretariat of Education, recognizes the ITESM System as a whole university and does not make any distinction among their campuses.

1.2.1 Geographical Distribution

The ITESM campuses are located in strategic areas throughout the country in order to respond to regional needs and to see more clearly the problems that Mexico is facing.

With this view, it is possible to present, through high quality higher education, solutions to these problems of development. However, the geographical location of the campuses presents problems for effective coordination of programmes and sharing resources between them.

Figure 1.1 shows the location of each of the ITESM campuses.

1.2.2 Academic and Research Programmes

The Institute currently offers undergraduate programmes in the following areas:

- Architecture.
- Health Sciences, and
- Humanities,
and undergraduate, master's and doctoral programmes in one or more of the following areas:

Administration,
Agricultural,
Animal and Marine Sciences,
Basic Sciences,
Social Sciences,
Computer Science,
Education, and
Engineering.
Moreover, the Institute provides continuing education for college graduates and high school programmes in traditional, bicultural and self-study formats.

During the last years the ITESM campuses have been developing new and innovative ways to respond to the challenges that the country will have in the next century, such as creating an average of one million jobs each year in the next twenty years.

One of the most ambitious programme is the "Advanced Technology for Production" started 3 years ago in the Monterrey campus. Its objective is to provide training and technology development to improve the competitiveness of Mexican goods and services. Five specialized centres support this program:

- Quality Control,
- Manufacturing System,
- Informatics Research,
- Industrial Development, and an
- Informatics Centre.

Each of the centres has specific research and development lines, such as:

- Total Quality Control, Quality Assurance;
- Software Engineering and Expert Systems;
- CAD/CAM;
- Technology Transfer, etc. [3].
1.2.3 National and International Liaisons

The Institute is a founding member of the Asociación de Universidades e Institutes de Enseñanza Superior (Association of Universities and Institutions of Higher Education) in Mexico.

In the U.S. it is a member of the Southern Association of Colleges and Schools, American Library Association, Association of Texas Colleges and Universities (among others), and was the first Latin American institution to join EDUCOM.

1.3 INFORMATION TECHNOLOGY AND ITESM

ITESM has been a leader in incorporating computing within both academic and administrative operations. The Institute sees Information Technology as a strategic asset for competitive advantage and also for fulfilling its objectives of excellence in education. Table 1.1 shows the evolution of IT in the Monterrey campus.

As a result of its size and more developed infrastructure. Information Technology (IT) is concentrated in three campuses: Monterrey, State of Mexico, and Queretaro. In these campuses information is exploited through a number of mainframes, minis, and a huge number (more than 3,000, but the real number is unknown) of personal computers.
Nevertheless, only a small amount of the information generated in such campuses and stored in their computers is shared. Also, if the interchange of academic information among all the 26 ITESM campuses using computers could be measured, the result would be insignificant. The main flow of information is from Monterrey campus to the rest of the campuses.

As was mentioned in the Introduction, this dissertation discusses the actual or future information services of the main campus (Monterrey) for the following reasons:

Firstly, as an example or model of what to do and what not to do in the other campuses. That is, as a research laboratory to investigate, test and develop services and technology that the rest of the System could use and/or have. This does not necessitate centralizing research in this area, but effective use of the experience accumulated through more than 25 years in academic computing of the Monterrey campus.

Secondly, to use the Monterrey campus Information Resources (IR) as a platform to develop the ITESM-Multi Campus Academic Network, which should utilise effectively and efficiently:

The scarce telecommunications facilities Mexico currently offers;

- Maximize the utilization of information, equipment and, human resources of ITESM; and
To minimize the costs of information gathering, manipulation and management for academic purposes.

1.3.1 Information and Technology Management

The major organizational change to have occurred in the information area in ITESM was the merger, in 1982, of two of the most important players in any educational institution (the library and the computer centre) under a common management. The result was the creation of the Informatics Division. Figure 1.2 shows the organisational structure, in which are included the major functions involved in the information and technology planning and decision making in ITESM.

It is important to highlight two new or reshaped departments: one is the Telecommunications and Networks department, whose role has been important to guide the campus towards the use of, and connection to, international networks.

The other department is the Library and Information Centre, which has been in constant change since 1983 taking advantage of the computational resources of the former Computer Centre. The result has been an impressive growth of services and/or improvement in the way that a library operates in Mexico.
<table>
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<th>Year</th>
<th>Event</th>
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| 1963 | IRM-1620  
Creation of the Computer Centre |
| 1967 | The undergraduate course Computational Systems Engineering is offered |
| 1970 | CDC-3300  
Foundation of the Computer Systems Department  
80% of the undergraduates programmes include at least one course about computing |
| 1971 | The undergraduate Computer Systems for Administration programme starts |
| 1975 | IBM-370  
Data Terminals and Express Services, processes Fortran, Cobol, and others programs in 30 seconds or less |
| 1976 | The curricula of Chemical and Computer Systems, and the postgraduate of Information Systems commence  
A system to evaluate exams through computer is inaugurated |
| 1977 | The Electronic System Engineer programme initiates |
| 1980 | Apple II microcomputers  
IDEA Project - Distributed Informatics for Teaching and Administration |
| 1981 | Summer Camp for children with microcomputers is offered |
| 1983 | LAN of 300+ Apple II-Interactive Registration System |
| 1985 | IBM-381 X 4 are installed, two in Monterrey, one in Queretaro, and the other one in State of Mexico campuses |
| 1986 | CADAM Service  
BITNET connection  
IBM-PC and Apple Macintosh microcomputers |
| 1987 | Local Area Networks available to students |
| 1988 | THENET connection  
Campus Area Network begins to operate |
| 1989 | NeXT Computers, a DEC Station, VAX Stations, and a VAX-6310  
INTERNET connection |
| 1990 | Apollo Workstations  
LAN of 250-l- Apple Macintosh-Interactive Registration System |

Table 1.1 The Evolution and Milestones of IT in ITESM
Nowadays, the name Library and Information Centre seems to be inadequate for reflecting the vast amount of services provided to the academic, research, and public sector communities. Perhaps the name "Information Resources Centre" would be a more appropriate label for its actual functions and operations.

The responsibilities (role and main activities) of the Informatics Division were established by the senior officers of the university. The lower levels of the organisation feed the higher with statistical and operational information, as well as with proposals for new services, projects, programmes, etc. At the same time, top-bottom planning is carried out and during the process budgets are assigned. Occasionally these two processes differ in form and/or content, but top-level decisions usually remain.

The departments and divisions have the freedom to invest/expend their budgets, but only in the sanctioned projects and/or activities. When new or additional money is required, a written justification is needed. The President of the campus has the final word as to whether to assign more resources.

The Informatics Division centralizes both academic and administrative information contained and/or manipulated in electronic form, but the owners (or originators) of the data have the liberty to modify their own information through pre-established means such as, limited write access through passwords, written requests using pre-printed forms, etc.
1.3.2 Computing and Communications Infrastructure

The computer power of ITESM is distributed as follows:

Monterrey Campus:
- Two IBM 4381 mainframes
- VAX 6310 minicomputer
- Workstations: VAX Stations, DEC Stations, Apollo, IBM RS/6000
- Microcomputers: Apple II and Macintosh Plus, SE, II: IBM PC XT, AT and PS/2 25, 30, 30, 50, 55, 70 and 80;
- VAX II and NeXT

Other Campuses:
- Two IBM 4381 mainframes
- HP 3000 minicomputers
  - IBM 400 minicomputers
- Microcomputers: Apple II and Macintosh, IBM PC and PS/2

The up-to-date number and type of equipment is unknown, specially with regard to microcomputers. However these microcomputers are known extensively used. For example, in the Monterrey campus there are more than 1500 Apple Macintosh and IBM microcomputers.

Also, there is a certain amount of equipment that is not supported or administered by the Informatics Division such as computers in some academic departments, specialized laboratories, and research centres.
The ITESM communications infrastructure displays a high degree of disparity, in both quality and quantity, among the campuses. For instance, some of the campuses do not have LANs but they have a satellite trans-receiver which provides communication with the other campuses.

The only significant attempt to set up a campus wide network is the project at Monterrey campus. Figure 1.3 shows the basic components of this network.

A backbone of fibre optic cable connects the main buildings. These buildings have token ring LANs which are connected to the backbone by bridges. Network servers, a
3174 communications controller, and Token ring-Ethernet gateways are also attached to the backbone.

The Ethernet bus connects: an Appletalk-Ethernet gateway, the satellite trans-receivers, a MicroVAX that is used as a communications front-end to international networks by means of leased lines to USA (450 kilometres to the north). and a small number of PCs.

During 1988 a Rolm digital PBX was acquired and the entire campus was rewired with new twisted-pair cable. However there was no plan or project to take advantage of this situation for data communications purposes.

Finally, a microwave link exists between the campus and the Medicine School and Hospital located a few kilometres west the campus.

The main problems facing attempts to intercommunicate ITESM campuses are:

• Geographical dispersion, and

The inability to get access to private data lines or even in some cases to have adequate telephone lines.

Kerr [5] reported "... right now, the problem for companies (in Mexico) is that it takes a long time to get a private line, these companies are looking at satellites as an alternative, for example ITESM, a private university which will place the hub at its main computer site near Mexico City and remote terminals at 25 other locations through out the country".
Obviously the paragraph quoted above contain a significant error. Ms. Kerr was misinformed about the location of the main ITESM computer site; it was and still is located in Monterrey, to the far north of Mexico City.

Nevertheless, the ITESM satellite hub was inexplicably located at a site more than 1,500 kilometres from:

- The main computer site.
- The main information resources, and
- The main academic and administrative human resources and offices, which are all located in the Monterrey campus.

As a result, the heavy traffic on the satellite network between Monterrey and the other campuses needs to be sent first to the State of Mexico campus and then re-transmitted to Monterrey, whereas more effective method would be to do the opposite.

Apart from the satellite links, the remaining intercampus communications are made using public telephone lines.

The next sub-section discusses the principal services that use the infrastructure described above.

1.3.3 Computing and Communications Services

According to the ITESM System President Dr. Rangel, Informatics has impacted on ITESM in areas such as:
• Curricula,
• Campus' administration,
• Scholarly services.
• Libraries,
• Exams evaluation systems;

but it has been of little impact as a tool to:

• Obtain remote information and computer services, and
• In the teaching-learning process. [6]

Again, Monterrey campus is the leader in the provision of information and computing services.

The campus Administration side runs its systems on one IBM mainframe. Including payroll, accounting, financial and budgeting, personnel and registry. These applications are file based systems developed by the Informatics Division staff.

The campus network has the following services:

- Electronic mail,
- CD-ROM servers.
- Library catalogue,
- TABCO, and
- Full text documents for academic and general use.

It also provides a budgeting and purchasing system for the administration.

Last July the library put its catalogue on-line, not just on the campus network but also on the INTERNET network. The catalogue can now be accessed by means of the ITESM satellite network, by telephone, by Telepac (the Mexican packet switched network), or using the telnet facility of INTERNET (TCP/IP protocols).[7]

Another service is TABCO (Selective Dissemination of Tables of Contents Service) which was developed in 1987 and has been evolving as a networked service. The TABCO database contains: title, date, number and volume of each journal and title, author(s) name(s), abstract and page of the articles of each issue. [8]

The indexed full text documents services are recent additions to the network. They are installed in a NeXT computer and consist of: Informatics and Library Guides, the Monterrey Campus telephone directory, and a dictionary. [9]

Twice a year a special purpose LAN is set up in the library to carry out the registration of more than 10,000 students. When the registration process finishes, the network is dismantled.

In 1983 a Ethernet-like network (a Nestar's Cluster/One Model As) was used to interconnect more than 300 Apple II Plus microcomputers [10]. Last year the network was changed and now has more than 250 Apple Macintosh as "clients", IBM
PS/2 Models 50 and 70 as "servers" with TCP/IP, Appletalk and Ethernet protocols [11].

In addition, Monterrey campus offers terminal emulation for time sharing on its IBM 4381 mainframes and its VAX 6310 minicomputer.

The only other campus that provides computer services is the State of Mexico: It offers terminal emulation for its IBM 4381. [12]

The satellite trans-receivers are also used for telephony. They interconnect the offices of the campuses' directors and sometimes other offices. It is an expensive service and it seems that voice communications are taking a significant amount of the available bandwidth. On the other hand, while there is a low level of data traffic compared with voice, this service is justifiable. The main reason behind the use of satellite links for voice communications is the poor telephone service in Mexico. The next subsection highlights the principal problems of Mexico's telecommunications and the plans to improve such services.

1.3.4 Mexico's Telecommunications

In June 1985 [13] Telmex (the Mexican PTT) announced:

"In 1990, 36% of the total amount of the telephone plant shall be digital and by 2000 it will reach 70% of all digital lines in service".
Three months later a series of severe earthquakes struck Mexico City, Telmex suffered the most catastrophic damage in its history with an estimated $25.74m loss. [14, 15]

This situation, and the "unbearable price for the title of model debtor" [16], have resulted in an archaic telephone system. The Mexican government regards the existing public switched telecommunications network as inadequate and believes Telmex, its operator, should be sold. [17]

Last year it was announced that the privatization of Telmex would proceed and an aggressive strategy has been adopted to attract foreign investment in telecommunications and other areas.[18,19,20]

Also, during 1985 and 1986 Mexico acquired two satellites which were built by Hughes Aircraft Corp. and launched on NASA's space shuttle. The aim of the Morelos satellites is to improve the country's telecommunications but have so far been underutilized, according to Borrego and Mody [21], because of:

- A lack of interagency cooperation,
- A lack of indigenization,
- A lack of private sector flexibility, and
- A lack of vision in the public sector.

Currently the main data users of the Mexican satellites are: ITESM, government institutions, banks [22], and brokerage firms [23] using VSAT equipment.

Satellite technology therefore has helped but it is not enough to improve telecommunications.
Recent reports [24.25,26] assess the telecommunications situation as follows:

Telmex provides service to more than eight million telephones;

The national density as 10.8 telephones per 100 inhabitants;

- Telmex has been adding lines at a rate of 8% per year;
  Almost all local exchange centres are electromechanical;

and future actions as being:

- Build a $250-million dollars digital overlay network in Mexico City;
- Increase installed telephones to 35 million;
- Increase long distance capacity to 3.4 billion calls;
- Increase long distance circuits to 412,000; and
- Develop ISDN in Mexico.

Observers expect that Telecommunications imports and services to double in Mexico during 1990 and 1991. Thus also expect that VADS would be liberalized together with the privatization of Telmex.

If the plans to modernize Mexican telecommunications succeed, ITESM should take advantage of the opportunity to improve its actual services in particular it may be able to improve its network interconnections with all campuses using both terrestrial and satellite technologies, taking advantage of price and characteristics of each technology.
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2. THE ITESM MULTI CAMPUS ACADEMIC NETWORK

ITESM has been a leader in educational innovations in higher education in Mexico, which has been a strategic advantage in gaining the privileged place that it already has in the Mexican higher education market. Among the innovations, it is the intensive use of computers as a means and/or tools to help the instructional and the research programmes. Today with 26 campuses, new technology available, and more competence, ITESM needs to take a further and decisive step:

Create, write, plan and establish a whole, formal and institutional Academic and Administrative Information Resources strategy, using the most advanced techniques and technologies that permit ITESM conserve and augment its standards to reach "world class" university status through innovative origination, storage, delivery, manipulation, etc of information resources.

The past decade was characterized by strategic mergers, and this trend seems to be continuing during the 90s. Thus alliances and co-operative work are critical factors for success in the highly competitive markets that are to be found today. To survive and progress, organisations need to recognize their weaknesses and may be able to combat them with the strengths of a partner. In other words, to use alliances to obtain a synergetic effect and fulfil the mission and objectives of both parties.
This lesson must be learned by ITESM: it should increment its alliances with other organisations, and especially within its own campuses.

The proposed strategy should consider among others, the following aspects:

- Setting up of a formal organisation at higher level within ITESM, to lead a representative group, which could plan and coordinate the strategy in the whole ITESM;
- Development of policies and objectives that will govern the strategy, organisation and services created during the formalisation of such a strategy;
- Development of a complete planned strategy with mission and objectives, goals, budgets, projects, etc. for the short and long term.

This dissertation outlines a scenario for just a part of the strategy proposed above. It has as an objective the provision of some initial ideas and directives for a formal development of the strategy.

The writer proposes the creation of an academic network that links all ITESM campuses in the first stages, and in further steps with other Mexican and overseas universities.

Also, the Multi Campus Academic Network could serve as an example to other Mexican or Latin American (or any developing country) university, as a means of helping the development of a country in the form of technology transfer through education and research, as well as serving as an
information generator and supplier for both private sector and government.

As sub-section 1.2.2 mentioned above, it is important to highlight the efforts of ITESM to increase research in Mexico. Here research can be viewed as the generation of knowledge and teaching as its dissemination. Thus networking technology can affect positively the way research and dissemination of knowledge is carried out.

How could a computer network help in this aim? Harden and Golden [1] provide an answer to this question:

"The mission of education institutions is the creation, storage, and dissemination of information. Communication networks are tools to be used in accomplishing these tasks more effectively, as they facilitate fast, reliable information exchange and resources sharing".

But the network's "real" value will result from the information resources and services available [2] and will not reside simply in the "physical" computer and communications hardware.

With these ideas in mind, computing and telecommunication technology should be considered as an institutional priority with a strong emphasis on open standards (discussed in detail in the next chapter) to establish a common computing environment among ITESM campuses. This objective/goal will, of course, offer several challenges to the institute,
perhaps the most important of which are the financial and technical aspects.

Figure 2.1 illustrates the directions in which data networking is going and which should be considered as a guide for the proposed network.

Figure 2.1 Networking Directions


One of the most important lessons of Figure 2.1. is also one of the major strategic decisions: Everybody (students, staff, researchers, etc.) in the university, have (or should have) the same services.

Byrne and Brown [3] propose the following characteristics for computing in an education environment:
"It should be accessible to all, in offices, laboratories, classrooms, and public clusters;

• The interface between the user and computer should be non-threatening, friendly, and easy to use;
• Programming the computer to do one's bidding should be a simple task; and
• Computer resources should be as available to faculty, students and staff as books in the library".

• The above characteristics could be described as part of the challenges that must be mastered in the information resources strategy.

But, why do we need a network? There are several reasons, the most important are:

ITESM has a large number of personal computers and their computing power, if they are interconnected, easily exceeds the total processing capacity of the campus computer centre, thus ITESM must take advantage of this, leaving local processing power but increasing user's access to others information resources;

ITESM has an important set of information resources scattered across the country, which a network would allow users to share and access relatively easily;

A versatile and high-speed network is essential to realize the full benefit of computers as a tools in teaching and research [4]; and
• An ITESM network could "create a truly competitive form of education", not only among ITESM campuses but also in national and international arenas [5].

• In the long term as Siegman and Yundt [6] affirm, a network that grows and improves its response time and quality is seen as a "great asset" and Runyan [7] describes it as a "utility", to the university's community.

• Proof of the penetration of networking in universities is the example of the pace of this trend in the U.S.A. In a 1988 survey [8] 35% of the universities were using this technology, and in the 1989 survey [9] the percentage had grown to 76%. These figures must be accepted as firm evidence that "higher education is one of the first societal segment to be affected by the rapid expansion of the information age" [10], this time in the form of computer and communications networks.

    The ITESM Multi Campus Academic Network could help to take a definitive step towards fulfilling important issues which are being discussed among the most influential universities in Mexico [11], these are:

    • A national system of higher education information;
    • Coordination and improvement of research and post graduate education;
    • Training of academic and administrative personnel;
    • Diffusion of culture;
• Continuing education; and
• Library services.

• Finally, state-of-the-art computing in the form of a multi campus network with access to worldwide information could represent for ITESM a means "to attract and keep the best faculty and staff as well as "students, specially for research" [12,13]. This is another strategic reason for networking.
• This chapter has five further sections where some specific objectives for the ITESM network, services, policy, management, security, and administrative issues are revised.

2.1 OBJETIVES

The objectives for the setting up of a university network are numerous, but those that best fit the ITESM mission and objectives are presented in Chapter One, the strategy for Academic and Administrative Information Resources excellence, and the characteristics for computing in educational environment presented in the past section, can be summarised as:

• Broaden the distribution of scholarly opportunity and creativity by connecting faculty, students, and professional staff;
• Advance the quality of teaching and research to collaborate and share scholarly work;
• Increase university productivity by improving access to information resources;
• Shorten the time to transmit basic research results to productive sectors and thus enhance national research and product development with international capability [14];
• Consolidate the usage of computers and other information resources as basic tools for ITESM programmes;
• Obtain scale economies through providing the means to buy and share information resources as a whole university and not 26 separate entities;

Generate technical expertise at the time of planning, using, managing and maintaining advanced computer and communication equipment;

Share human resources, knowledge and information resources as a means of competitive advantage;

Increase communication among the ITESM community and thus enhance the sense of unity to the institutional mission and principles; and finally

• Help the country, through sharing knowledge generated and manipulated in ITESM as a means of technology transfer from research and academic centres to the private sector, government bodies, and other universities.
The ten objectives cited above must be shared by the whole ITESM community on the 26 campus, though each one of the objectives may have different weights at the time of establishing regional (or zonal), campus, and departmental networks according to their own priorities, gaps, budgets, etc.

The important issues are to have a clear policy and strategy and consensus of the objectives and benefits of networks.

Perhaps some departments and/or campuses will not need or require all the services available in the network or perhaps some do not require the same proportion of work stations or the same speed.

Thus, it is essential to develop strategies, projects and programmes for the short and long terms such as:

- Equipment acquisition and replacement;
- Maintenance and improvement of network media, - Monitoring usage levels and introduction of new services;
- Students, faculty and staff training;
- Interconnection with other organisations, etc.

Finally, it is vital to use the enthusiasm of the computer/information literate about concerning the benefits of networking to influence all levels of ITESM. This will help to identify their requirements, expectations, fears and dreams and to obtain a consensus of the importance of
the strategies and subsequently their cooperation, ideas, and involvement.

2.2 CAMPUS LANs

Intentionally the words network and networking have been used to describe either a departmental network with a small number of workstations, or a national, wide area network with thousands of nodes. This is a major characteristic of a strategic network plan: that all users have access to the same services regardless of where they are. In short, services (information resources) are the most important element, not the hardware or the interface.

Nevertheless the designing of a successful network is a critical factor that requires a great amount of resources.

Figure 2.2 shows a simple and typical university LAN layout. There are no two identical networks, since every one is developed according to the needs of the organisation.

In a university there perhaps exist one or more mainframes, or minicomputers, file servers, tape backups units, bridges, routers, gateways, and several local area networks such as departmental, public clusters, specialized laboratories, library, etc., usually interconnected by means of a common bus or ring, in spite of being different in topology and/or access protocols.
Individual ITESM campuses are different in priorities, size and maturity, but ITESM cannot wait until all of them reach some (or the same) maturity level to interconnect their information resources in a national multi-campus network.

Each campus must initiate a high priority plan to set up its own academic LAN which offers at least an agreed minimum of services and performance levels. Also, it is desirable that soon after it has implemented its LANs each campus provides a means of interconnecting it to the ITESM network and through this, to worldwide academic networks and other information sources.
All the campuses responsible for academic information must be aware of and understand the lessons learned by the most advanced campuses (i.e. Monterrey and State of Mexico campuses) to avoid mistakes and repeat the successes.

Paraphrasing Bigelow [15], small staff and small budgets need not keep a campus from joining the ITESM network. What is required is the willingness and determination to strike out in independent directions, the resolution to seek and accept counselling and guidance concerning the benefits, complexities, anxieties, etc. of networking.

All developments and/or plans should conform to the following requirements:

- To be accredited and approved by the proposed institution authority in information resources strategies;
- To be locally funded in basic infrastructure and centrally funded for services;
- To emphasise OSI products; and
- To be interconnected to the ITESM network as soon as possible.

Each campus networking plan should consider one or more of the following strategic issues: [16,17]

Provision of reasonable services at reasonable cost instead of costly solutions for a few users;
• Hire, retain, support and develop a capable staff of telecommunications engineers and technicians for installations and maintenance duties;
• The networking strategy should be a subset of each campus overall strategy;

   Establish, from three to five years' planning horizon and recognise that the plan is not static but in constant change and development:
• Determine basic campus information such as:

   The number and location of sites/buildings to be covered;
• Number and skill level of users;

   Number and types of equipment, types of services and applications required;

   Traffic profiles at each level (departmental, campus, national, and international wide), desired quality of service (performance, response time, storage capacity, etc.). etc.
• Provide flexibility to manage changes without service disruption when people, workstations, applications or offices move;
• A single system or two different for academic and administrative computing accordingly with local requirements;
• A complete purchasing, replacement and maintenance plan for workstations and peripherals: and
• A funding and budget plan.
Some of the above issues are complementary and others are independent of each other; they are presented to serve as an initial guide for ITESM.

Arms [18] provides the information contained in Table 2.1, which shows three levels of networking options. For each of them there are a number of suitable commercial products, some of which conform to OSI standards.

The decision of the type of option or options is important, because networks are long term major research and development projects and in fact are expected to provide high-quality services despite that they could be in constant evolution.

<table>
<thead>
<tr>
<th>Option Level</th>
<th>Speed</th>
<th>No. of Stations Supported</th>
<th>Cost per Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low end</td>
<td>&lt; 1Mbits/sec</td>
<td>10-20</td>
<td>$50 - $200</td>
</tr>
<tr>
<td>Medium speed</td>
<td>1-4Mbits/sec</td>
<td>50-100</td>
<td>$200- $700</td>
</tr>
<tr>
<td>High speed</td>
<td>10-20Mbits/sec</td>
<td>100-200</td>
<td>$700-$1000</td>
</tr>
</tbody>
</table>

Table 2.1 Networking Options

Finally, Gallagher and Porter's [19] remarks make a suitable conclusions for this section:

It takes team work to build a campus network that integrates all user's groups;

On a networked campus IT function and its cost cross all organisational boundaries; thus

Upper administration must work well and actively to ensure excellent cooperation among the units and personalities involved;
Physical geography, funding autonomy, personality conflicts, and lack of foresight and leadership can make implementation and effective use of a network difficult even if it has broad support at all levels; and

Solutions for one university of campus do not necessarily turn into solutions for others.

2.3 SERVICES

During 1986 three complete surveys [20,21,22] of academic computing facilities and services in computer intensive campuses, were carried out in U.S.A. One conclusion from them illustrate the significance of the computing services.

"The real importance of an academic computing facility is not measured in terms of budgets, personnel, and equipment but by the quality of services rendered to the institution's students and faculty".

This affirmation supports the idea that selection and planning of the services in the proposed ITESM network should be the result of the consensus of every university group and/or potential network's users.

The services should have a strong emphasis in pragmatism to ensure their success, and reflect users' requirements and not personal preferences of the Computer Centre staff, or administrative gurus, or self-interested suppliers.
The network services must then fulfil the objectives described in the section 2.1. These services could be divided in two groups: basic services or short term services, and advanced services or long term services.

As has been seen, ITESM campuses display a significant amount of disparity in size and, in consequence, in needs. Thus some of them will require just basic services for long time, meanwhile others will demand advanced services immediately.

Definitions, classifications, and examples of basic and advanced network services vary widely in the specialised literature available. Basic services for some universities are advanced or sophisticated for others. Usually these differences are related to the technology and communication protocols in use.

The next two sub-sections present the basic and advanced services proposed for the ITESM network.

2.3.1 Basic Services

The basic services of any ITESM campus network should be in operation in no more than two years from the set up of the basic infrastructure. They are: [23,24]

Connectivity: In the form of transparent access to devices such as printers, plotters, modems, etc., and facilities to allow users to login remotely to any
computer/application, regardless of the location of both user and application;

- File Transfer: Between all users, computers and applications attached to the campus area network and the ITESM network;
- Mail: To provide immediate communication between users.

Connectivity should allow users to share scarce and/or expensive input and output devices, such as high speed laser printers, colour plotters, magnetic tape and disc drives, etc. Also connectivity means login facilities to remote computers (i.e. minicomputers and mainframes) as if users were at a terminal connected directly to those computers and not to their own workstations.

In a network, users should be able to share disc drives and as a consequence share files. The advantages of sharing files are the opportunity to distribute and exploit knowledge within a networked community. Also multiple copies and different versions of the same file are most of the times avoided, there are savings in storage, and users usually do not have to worry about keeping a back up of such files.

- The disadvantage is the risk of loss of integrity if any user has authority to alter common files, thus a protection mechanism is required to permit "read-only" access to files, impeding any user manipulation. This aspect should not be a high risk if a UNIX environment is chosen as there are sufficient protection features.
The main idea behind connectivity is the optimization of the use of resources. Costs of expensive devices can be shared among several departments and this, in the long term, brings "technological democracy" to organisations such as ITESM with scattered locations each with dissimilar requirements.

However there are advanced forms of connectivity and related issues that take advantage of more complex hardware and software to enhance the quality and performance of a network. Such forms of connectivity are discussed in the Advanced Services sub-section.

File Transfer facilities allow users to copy a file from one computer to another. File Transfer is different from sharing files because the user has a copy of the file on his own workstation to freely work with data. The first service to set up in a campus network may be local File Transfer and eventually, when connections become available, with the ITESM network and the whole world.

The Importance of a mail facility is illustrated by the NCC [25] as follows:

"One of the most frustrating problems when using the telephone network is finding that the person that you want to contact is either out of the office, or his/her phone is constantly engaged. The problem of "telephone tag" can be eliminated by the use of electronic mail (e-mail) via a local area network".
A user on the network can prepare and send a message from his/her workstation to either one or more users within or outside the campus network. The message is stored and can be read by the receiver(s) at any (convenient) time. Furthermore messages can be stored locally or be printed out if desired, and an acknowledgement that the message has been received can usually be sent automatically.

A number of universities have said that e-mail is a major benefit and/or service of their networks, [26,27] because it provides "incredible" opportunities to share expertise with colleagues within a university and across the world. The former might never have been encountered through traditional communications means.

The next sub-section outlines higher levels of these basic services and describes others that should be implemented in the long term or in more developed campuses.

2.3.2 Advanced Services

For advanced services this dissertation presents such services based on the client-server concept. In a network, "servers" provide specific services for all users or "clients", both servers and clients are software that run on the network computers.

The servers' computers support compute intensive processing while the clients' computers run front-end programmes or applications.
The characteristics of the client-server concept are.

Computing processing is dispersed between server and client computers:
• Data is centralized;
  Servers require powerful computers to support multi user access;
  Servers could be microcomputers, workstations, minicomputers or mainframes;
• Servers require big and faster data storage devices;
  Servers need multitasking Operating Systems (i.e. UNIX);
  A client will often be a programme run by a user on a workstation, but server and client can both run on the same computer or a server can use another service and act as a client.

This concept has advantages and disadvantages. Van Name and Catchings [28] present the most important:

Advantages:
• Easy back-up process;
• High degree of data security;
  Take advantage of the principal characteristics of different hardware and software: and
  Clients and servers could use different Operating System.
Disadvantages:

Servers are critical resources;

Server software is complex and require an expert administrator:

Server performance tends to vary widely depending on the network traffic; and

Servers are seem to restrict personal computing and move back to centralized control.

The generic client/server application is the database server. It is a database system that supports multiple simultaneous users accessing the same information thereby avoiding data inconsistency and redundancy.

The most widely used applications of this concept in academic networks environment are:

File Server: This kind of server permits access to files on any computer in the network as if they were in the user's workstations. In addition users can store their own files which can be centrally backed up;

• Mail Server: Is a computer which is always active and can receive, send and store all the messages in a network. Users can read or send mail at any time as if it were always held on their workstations;

• Print Server: Permits users to access many printers of any type, located in remote sites as if they were connected directly to their computers;
Terminal Server: Allows communication between clients and host computers as if they were connected by a dedicated cable.

- CD-ROM Server: It is a computer with one or a series of CD-ROM drives containing various types of data or information;
- Name Server: It is an essential service that allows any computer on the network to communicate with any other. There are two sets of data contained in a name server: user names and computer names. Without this facility each client workstation would have to keep its own directory of names and addresses which has disadvantages such as extra storage capacity, "instant" obsolescence, inconsistency, etc. A national, regional, and campus name server are required to automatically update the directories;

Computation Server [29]: "Allows a user to have computationally demanding subsidiary calculations performed by the more powerful computer, even though the main program is running on the user's own computer.

The only limitation of server applications is the imagination and requirements of users and providers of information services in a university. The next section provides specific applications for some of the basic and advanced services described above.
2.4 SELECTED SERVICES PROPOSED

This section contains the descriptions of services already available on university networks; improvements and/or modifications of applications already in service on the Monterrey Campus of ITESM; and finally new and practicable services that could be developed in the actual and future telecommunications plans and strategies in ITESM.

2.4.1 Software Servers

These may be defined as a server or servers containing the software supported by the Computer Centre and the software used as a part of curricular courses.

Several surveys in academic computing in U.S.A., such as those conducted by The American Council of Learned Societies [30] and EDUCOM and Peat and Marwick [31] clearly show the type and applications of software and applications which are more frequently used by faculty, students and researchers in computer-intensive universities.

Figure 2.3 shows the results of the first survey, and Table 2.2 the findings of the more recent assessment.
Chart 1. How computers are used. Percentage of computer users at colleges and universities who rate each application as very important or somewhat important.

<table>
<thead>
<tr>
<th>Application</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wordprocessing</td>
<td>95</td>
</tr>
<tr>
<td>Maintaining note files</td>
<td>55</td>
</tr>
<tr>
<td>Test preparation</td>
<td>55</td>
</tr>
<tr>
<td>Compiling a bibliography or index</td>
<td>49</td>
</tr>
<tr>
<td>Statistical analysis</td>
<td>37</td>
</tr>
<tr>
<td>Graphics</td>
<td>22</td>
</tr>
<tr>
<td>Accessing online databases</td>
<td>18</td>
</tr>
<tr>
<td>Accessing library's online catalogue</td>
<td>18</td>
</tr>
<tr>
<td>Computer-assisted instruction</td>
<td>18</td>
</tr>
<tr>
<td>Preparing budgets</td>
<td>17</td>
</tr>
<tr>
<td>Preparing a concordance, editing letters or editions, thesauri, etc.</td>
<td>14</td>
</tr>
<tr>
<td>Grading tests or papers</td>
<td>14</td>
</tr>
<tr>
<td>Electronic mail within institution</td>
<td>11</td>
</tr>
<tr>
<td>Electronic mail to outside colleagues</td>
<td>10</td>
</tr>
<tr>
<td>Textual analysis</td>
<td>10</td>
</tr>
</tbody>
</table>

Maximum N = 1960

Figure 2.3 Software Used in Universities


<table>
<thead>
<tr>
<th>Software Application</th>
<th>Percentage of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>60%</td>
</tr>
<tr>
<td>Spreadsheets</td>
<td>58%</td>
</tr>
<tr>
<td>Statistical packages</td>
<td>35%</td>
</tr>
<tr>
<td>Database manager</td>
<td>51%</td>
</tr>
<tr>
<td>Communications</td>
<td>49%</td>
</tr>
<tr>
<td>Graphics</td>
<td>36%</td>
</tr>
</tbody>
</table>

Table 2.2 Institutional Availability of Software

The surveys cited above show the importance and penetration of at least six complementary software packages: word processing, spreadsheets, graphics, database managers, statistical, and communications.
They are used to: develop course materials, write articles and books, keep class records, prepare project budgets, write conference papers, etc. [32,33].

A software server conveys others advantages apart from accessibility and sharing applications, such as:

- More control over potential software problems like privacy, viruses, updates, etc.;
- Standardization of file types; and
- Easy training programmes.

The disadvantages are essentially economical because software suppliers often insist on charging a sum per workstation in a network. This position is difficult to justify as it is almost impossible that all users in a network will want to use the same application at the same time.

This situation is changing however with the expansion of networks. However there is also the possibility of using public domain software, and there are a reasonable number of excellent and well documented software packages in the categories mentioned above whose costs are minimal or, in some cases, free for educational purposes.
2.4.2 Bibliographic Information Servers

This sub-section covers all the feasible possibilities of bibliographic databases servers in the proposed ITESM network, except those databases contained in CD-ROM format, which are discussed separately.

The library is the major academic information centre in a university, and as a result one of the first and most widely used information resources in a networked campus is the library catalogue. [34,35,36,37,38].

The on-line library catalogue, in addition to monograph information, should contain bibliographic data for: journals and periodicals, software, videos, audio tapes and discs, and material held in the reserve section of each campus' library and/or information centre.[39]

The server or servers may have access to the ITESM union catalogue (this could be an option in a general ITESM wide bibliographic system) which per se constitutes a good motivation to start the multicampus academic network proposed.

Besides if the bibliographic server could function as a client for the mail server, new services could be developed, such as those described in the sub-section 2.4.5.

The TABCO database is another service in this server category. Today, the Monterrey Campus library is working to optimise the value of such service. In the future TABCO would contain only information of journals and periodicals not indexed in other bibliographic resources (i.e. CD-ROM.
Indexes) especially Mexican and Spanish language publications.

This service could help ITESM to be an information broker for other universities and research centres in Mexico. Also this type of services could be used to open access to other networks by means of reciprocal agreements.

In spite of the proliferation of Full Text databases, bibliographic information servers have an important role in academic institutions and research centres, and thus it is worthwhile investing in them, as universities would have a rapid return of investment.

Finally, universities must be alert to recent developments [40,41] such as:

The increasing interest in the Z39.50 standard for searching multiple bibliographic databases that are in the same network using a single query transmission; and

The use of the Standard Generalized Markup Language (SGML), Post Script languages, etc., which could be used to standardize storage and display formats.

2.4.3 Full Text Databases Servers

Again, this section does not cover those databases contained in CD-ROM media which are discussed later. Full Text databases have been gaining acceptance worldwide, for the following reasons:
• The drop in cost of data storage;
• The fact that almost all of the scientific and academic information produced is in electronic form; and
• The need to have complete information "instantaneously" through telecommunications (this tendency is easily verifiable by checking the huge lists of full text databases in Dialog, BRS or Data Star services).

The full text databases servers proposed are:

ITESM Publications: Containing all the university magazines (i.e. Tetla-ni and Transferencia), newspapers (i.e. Panorama and Cr6nica Intercampus), newsletters (i.e. Cursor and Bibliotec). All the information contained in these publications is nowadays written, manipulated and stored in floppy discs, then it could be fed into a database manager to be accessed in the network;

ITESM Official Public Domain Documents: Such as policies, mission, regulations, curricula, etc., which is available today in paper editions with the inherent limitations of printed materials such as rapid obsolescence, slow dissemination process, high costs, etc. This server could be the means to always have common criteria in the 26 campuses without any doubt of validity and actuality.
Course Information: In the form of assignments databases, past exam papers, professors counselling time table, courses' pre-requisites, course contents, etc. [42.43]

Symposia Proceedings: ITESM organize more than a dozen symposia each year with national and international participants but the proceedings are almost always never disseminated or even published. Here is an opportunity to preserve an important piece of knowledge.

Students Information: To provide students with a complete set of up to date personal information such as academic records, financial reports, etc. An enhanced security system is required to keep privacy of these data [44].

- Academic, Research and Professional Staff Information: The equivalent of an ITESM Who's Who containing not only basic information (such as bibliographic data, academic and professional trajectory, department, etc.) but areas of interest and research or consultant subjects. The advantages of having access to such information in a university environment are enormous, eg. they provide an easy way to find: project and research partners, consultants, lecturers, etc. [45]

Reserve Documents: The Monterrey campus library actually handles more than 2000 documents each term in the Reserve collection, and most of this material belongs to professors. The Reserve section is frequently criticized for its service level because it is in high
demand. Besides, almost all the material in its collection is photocopied, adversely affecting the photocopy service through over demand. To solve this situation the library bought an OCR unit and started a plan to set up a full text database of the most frequently demanded documents. This database, if it is feasible to operate, could be resident on a network server. Each professor could have access to his/her own material to maintain its currency.

The list presented above is representative but not exhaustive of the services that could contain full text databases servers in the ITESM network.

2.4.4 CD-ROM Servers

The tremendous success of information dissemination in CD-ROM media has reach the networking arena. Nowadays the campus Monterrey library has two CD-ROM servers with four drivers on the network and it is predicted that in the near future it will need extra servers or a jukebox to completely exploit its library CD-ROM collection.

Some of the databases held on the CD-ROM servers are bibliographic, full text or a mixture of both. In the future, the number of bibliographic databases will diminish while the full text data bases will grow.
Meanwhile the library has plans to provide more comprehensive support to the ITESM academic community and especially to researchers through a fully indexed periodicals collection. This will be held either in CD-ROM databases or in its local database TABCO, both on network servers and supported by extra services such as photocopy requests, automatic periodic searches following personal and specific profiles, etc.

The campus network plans should consider CD-ROM drives or servers as an important technology for the local dissemination of information. General interest databases such as dictionaries, encyclopedias, etc., ensure an immediate success, and acceptance of an academic network.

2.4.5 Electronic Mail Servers

Basic e-mail capabilities have been described above. In this sub-section advanced or innovative uses for e-mail are discussed. There are a large number of e-mail applications for libraries/information centres which extend traditional services to levels which would be difficult to achieve using telephone or paper based communications. Applications of e-mail services which might improve the educative process in universities are also described.
The utility of e-mail is dependant on factors such as:

- Easy procedures for sending/receiving mail;
- Transparent access to local, intercampus and international mail systems;
- A service completely accessible by the entire community: students, faculty, staff, etc.; and
- An exhaustive standardized, and up-to-date directory of users.

The e-mail interface should be friendly and free of complicated commands, procedures and intricate addressing requirements. For any user, the process for sending/receiving messages from another network (in Mexico or elsewhere) should be as easy as sending/receiving messages from his/her own campus network.

The importance of a complete users' directory is vital for the success of e-mail. In a university environment such as ITESM users can be classified by: name, campus, department, academic and/or research areas of interest, association membership, city/state of origin (for students), etc.

Also, addresses and postal addresses and telephone may be included [46].

A complete study of privacy requirements of such information is suggested to ensure a correct use of the directories' information. However an "open mind" view is recommended in spite of the possible inherent risks.
advantages of heavy use of e-mail outweigh than the disadvantages.

Also, any attempt to use or develop an institutional e-mail service and directory should follow the international standards X.400 and X.500 [47] set up for such proposes.

Electronic mail could facilitate communications between students and professors, students and other students, professors and other professors, students and the university administration.

The applications of e-mail in the ITESM network could be:

- Registration or pre-registration for courses;

- Requests for instructional material (i.e. text books lists);

- Completion of scholarship or research application forms;

- Exchange of commentaries (to extend classroom discussions) [48];

- Submission and grading of assignments [49];

- Post courseware (in addition or as a complement of courses via satellite, and normal courses);

- Booking and control of facilities such as audiovisual equipment, conference facilities, etc.;

- Distributing information such as minutes, periodical reports, etc.;

- Conference support: communication with speakers, planning, etc.;

- Lists of interests; and
Exchange of documents and draft papers.

Electronic mail reduces the amount of paper and provides an effective, cheaper and quicker distribution of academic related material between students and faculty as a result of the facility to send the same message to several people with minimum effort.

A server with templates for e-mail purposes could help to facilitate and standardize electronic communications.

Library uses of e-mail deserve a separate place to cater for the number of potential applications [50,51,52.53] such as

- Interlibrary loans,
- Reference queries,
- Online search requests,
- Photocopy requests,
- Books and other materials acquisition requests,
- Reservation requests,
- Document requests.

Transmitting purchase orders, invoices and claim information to suppliers. This implies the use of EDI standards and perhaps some changes of the ITESM administrative procedures are required to allow and accept "electronic documents" instead of paper based records.
Computer conferencing is an electronic forum within which authorized members are brought together in a network to discuss a specific topic [56]. Computer conferences are also known as lists of interests, and it differs from electronic mail which is "the simple exchange of messages over computer networks". In electronic conferencing all participants see the questions, replies and information sent to the group.

There are a lot of users of electronic conferencing in the ITESM network, some ideas are:–

- To provide on line education. Oriented to faculty and staff attending an "electronic university" [57] to take short courses such as use of word processing, spreadsheet, new educative techniques, etc.;
- To manage projects that require matrix management. With an electronic conference all the campuses/departments heads would keep informed;
- To produce institutional documents such as policies, reports and proposals with the participation of multiple campus' members; and
- To develop academic electronic conferences with subjects such as evaluation techniques, multimedia in education, fund raising, library issues, etc.
The major advantages of electronic conference are:

- Encourage communications between people who are distant;
- Improve group communications;
- Cut travel costs;
- Reduce meeting times.

Electronic Bulletin Boards are also a good media for disseminating information in a network. The ITESM network could use them to provide current awareness information services such as:

- New books in the libraries;
- Journals and Books table of contents [59];
- Electronic suggestions "box";
- Career services [59,60] such as calendar orientations, workshops, special events, jobs advertise, etc.;
- Conferences and Alumni meetings calendar;
- ITESM official calendar; etc.

Again the applications of bulletin boards in an academic network are large and it seems that there are always are new subjects to open a new board. ITESM could obtain huge benefits through their use, in the form of large, continuous and wide communication among all the ITESM community distributed in the whole country.
2.4.7 Front End Servers

A user friendly front end is almost automatically achieved when the client/server model is used, and well implemented. Here the emphasis is on the use of front ends to obtain transparency in operation for users.

Users do not have to known that instead of a single network they are using a series of interconnected networks [61] or that a database is located on another campus or outside of Mexico. Also users need to have a standardized front end and commands regardless of the application or service they are using.

This approach has various advantages such as:

• Friendly network environment;
• Facilitate users' training;

Users would be encouraged to use network services as a communications means and as an important information source;

New services can be introduced without disturbing actual services or operation.

Specific applications for front ends servers are:

• Communications: for local, intercampus, BITNET [62,63], ARPANET, etc. electronic mail access. For use of computer conference and bulletin boards;
On line databases: for ITESM, national and international on line databases search, and information download; and

File Transfer: between departments, campus or international networks.

The advantages of front end implementation are mainly for users but network managers and libraries can also gain through the use of intelligent networks. With the use of on line databases front end servers it is possible to increase the use of commercial databases (i.e. Dialog, BRS) among the faculty and researchers, but now as end-users (without the library as intermediary).

The front end can control access to only authorized databases and for the maximum time available for an individual, a department or a campus. Also ITESM can obtain substantial savings by negotiating a single account to on line information suppliers acting as a single big user instead of one big and 25 small users.

The use of simple to understand and use front-ends for e-mail would enable a large number of "communication messages" among ITESM community with the inherent improvement in productivity.
2.5 NETWORK POLICIES

Another important component in the ITESM network are the policies set that will govern its planning, development, use, management, and funding.

Continuing with the "transparency" concept introduced in the last section, policies must be:

Written, and accessible to everyone (perhaps in a database server);
Updated continuously to reflect any change; and
Covering every issue related with ITESM network.

The responsibility to produce the policies resides with the organisation in charge of the planning and operation of the network. However every campus authority and the ITESM president should support them.

The proposed policies are in the following areas: Users, Management, Usage, and Funding.

In the list the use of OSI standards is omitted because such standards should be a necessary requisite for the network and are widely discussed in Chapter 3. OSI standards use is a fundamental part of the ITESM network policy.

Finally, all the policies for the proposed network should be carried out by taking account of ITESM mission, principles and objectives.
2.5.1 Network Users

An ITESM network user could be any registered student or employee (faculty, staff, etc.) of any ITESM campus. The network management organisation should provide a network account for all users.

The generation of the accounts should be automatic, for employees at the moment of joining (or signing a contract with) ITESM and for students at the registration session of each term.

The expiration of a network account should take place immediately after the user leaves ITESM under any circumstance. Thus a communication mechanism is required between academic registry, personnel department and the network administration.

The automatic "right" and assignment of a network account is an initial motivation to use the network. While a clerical process is an inhibitor that must be avoided.

Another principle that should apply to the network is that all users should have access to the same services at the same level, otherwise the differences will create useless confrontations, complicated control mechanisms and, in extreme situations, fraud attempts.

All the information contained and/or conveyed in an academic network should be non-confidential. Perhaps the only exception is the personal academic and financial information contained in the server suggested in the previous section.
In addition to ITESM members, if it is technically and economically feasible, third party organisations could join the network.

Other universities, research institutions, private sector companies and government agencies are some of the potential "external" users of the information services available on the network. For these parties, the same or special rules or usage conditions could apply.

The membership acceptance of third party users should be the responsibility of each campus network authority and ratified by the central management organisation in charge of the ITESM network.

All users must be clearly informed of their responsibilities and their rights and also of the legal obligations of ITESM as a purveyor of information for academic and research purposes and as a non-profit organisation.

In the same way third parties should be notified of copyright and restrictions in the use of the information contained, extracted, conveyed, etc. on the network, regardless of special conditions or contracts such as temporary connections, reciprocity service for equal treatment in other networks, etc.

Finally a users' training programme must be established. This programme could have two levels: normal user, for any new user; and technical or advanced user, for new network support staff. The latter could also be divided in software.
hardware, and communications, depending on the area within which the technical user will work.

Network training is a function of the organisation in charge of each campus' network, but following a common instruction material set to ensure that all users can operate the network in any site where the network would accessible in the same basis.

2.5.2 Network Management

The management of the network is an important issue that should have a high priority from the start of the planning process of the ITESM network. This section explains the main subjects involved, answering the following questions:

- Who should manage the networks?,
- What responsibilities should networks managers have?,
- What staff are required to manage the networks?,
- Is it desirable to merge academic and administrative computing in the networks?,
- What kind of security should the network have?, and
- Is there any software tool to manage networks?

Who should manage the networks?

This is not an easy question to answer because the implications of setting up a multi campus network presuppose a series of changes in the organisation of ITESM, Chapter 4 presents the most significant.
Nowadays the trend is towards [64,65]:

The establishment, in universities, of a Chief Information Officer (CIO) with control of computer and telecommunications functions, libraries, and campus printing, mail, video, photographic, etc. services. The CIO should have direct access to the highest executive level of the university.

The CIO thus is a leader of the information resources development and management, one of which is the ITESM network. It should be run by a network manager who has a team of people with appropriate technical, managerial and academic skills.

The network management group is thus a heterogeneous body with representatives of every campus and/or department and students.

The way in which such a group could work is by means of "broadly based planning, consensus-generating committees and task forces" [66], and an established network management staff for day-to-day operations.

The ITESM network group (or whatever name the organisation obtain) should have authority to preserve the institutional goals and objectives with respect to the network.

A critical success factor (CSF) for the network is the requirement for all ITESM campuses to participate in the
planning, development, and operation of the network in one way or another.

Each campus could appoint its own CIO and/or a network manager who may have the same or similar functions and equivalent responsibilities as ITESM's CIO and network manager.

Finally there follows a short list of people that should be involved in any network planning, development and management group: Computer Centre and Library staff. Buildings Manager, Faculty, Administrative Staff, Students' Representatives, etc. [67]

What responsibilities should network managers have?

The typical duties of a network manager in a university are:

- Test and install hardware and software;
- Train users in how to use the network;
- Enforce network usage policies;
- Support equipment, network connections, and software;
- Secure, maintain, and back up network files;

Encourage faculty to find new ways to use network applications;
- Deal with day-to-day operational issues;

Plan and propose new networks, services, improvements, etc.;
- Supervise external contractors' work;
- Assure the use of OSI products and philosophy;
Negotiate the purchase of hardware and software, telecommunications contracts, access to other networks, etc.;

Document and update manuals, procedures, configurations, and operational databases (i.e. name servers):

Investigate for new applications, hardware, software, technologies, etc. to enhance the quality and number of services and the overall performance of the network; and

• Represent ITESM in network forums

What staff are required to manage the network?
The requirements of staff for a campus network vary accordingly with the size and complexity of the network, hardware installed, services available, network traffic, etc., the most advanced networks would require:

• Telecommunications engineers to address technological problems;
• Operational staff to deal with day-to-day operations;
• Planning managers to plan the growth and/or changes in the network;
• Support engineers to maintain hardware and software;
• Researchers to do research in networking;
• Instructors to attend users' queries and training sessions; and
• Services administrators to maintain files, databases, servers, etc.
Unfortunately there is a lack of adequate tools to manage heterogeneous, complex, multi-vendor networks as well as a lack of network managers [68] with broad technical experience in the field. The knowledge required to be a network manager is usually gained through experience rather than through formal education. Thus a university environment with intensive use of networks is a good place to develop such managers.

Is it desirable to merge academic and administrative computing in the network?

There are no correct and definitive answers for that question. In some situations it could be a wise or de facto decision, and in others it could be a disastrous one.

A rule that can be applied is: If administrative computing is well established, developed, and traditionally does have not have any relation with its academic counterpart, the best decision is not to merge them.

The separation would reduce the complexity and physical scale of the network but could also represent the loss of a unique opportunity to improve both areas in a common computing environment.

On the other hand, "bringing them together has brought economies of scale for some and caused a decline in service for others" [69].

If the network facilities could provide precise information for the university administration and could also reduce the burden of essential bureaucratic procedures on
students and university personnel, then the decision should be to merge them with the goal of improving the overall productivity in the campus.

What kind of security should the network have?

Again, the opinions of experts in the subject are divided. Some want to have 100% security (that is virtually impossible in practice) others that the recognition of the risks and taking the necessary actions to minimize the threats is the best decision.

Crocket [70] opines that "even though most security experts agree that managing people is the most difficulty part of securing a network, organisations still spend more time and money implementing technological measures to secure networks than dealing with people...the key to keeping a network secure is to make sure that only authorized users gain access to critical data...common sense is the best rule to apply to network security matters".

In a university, with a high density of creative and inquisitive users, common sense seems not to be enough. Gateways, routers, and bridges can partition the information traffic within a campus or department and serve as an extra measures for protecting sensitive and/or administrative data against unauthorized access.

Also, ITESM should look for a free access network, open dissemination of knowledge and free exchange of ideas as an information matters philosophy; strict security measures could limit this freedom.
Nevertheless if security appears to be a critical factor, the OSI architecture could provide some degree of security through a series of mechanisms.

Table 2.3 [71] shows a sample of the mechanisms developed or in developing process for the OSI layers.

<table>
<thead>
<tr>
<th>MECHANISM</th>
<th>OSI-RM LAYERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Encipherment</td>
<td>X X X X - X -</td>
</tr>
<tr>
<td>Digital Signature</td>
<td>- - X X - X X</td>
</tr>
<tr>
<td>Access Control</td>
<td>- - X X - - X</td>
</tr>
<tr>
<td>Data Integrity</td>
<td>- - X X - X -</td>
</tr>
<tr>
<td>Authentication Exchange</td>
<td>- - X X - - -</td>
</tr>
<tr>
<td>Traffic Padding</td>
<td>- - X - - - X</td>
</tr>
<tr>
<td>Routing Control</td>
<td>- - X - - - -</td>
</tr>
<tr>
<td>Notarization</td>
<td>- - - - - X X</td>
</tr>
</tbody>
</table>

Key: X = Applicable mechanism; - = No Applicable mechanism

Encipherment: Implies the use of a key management mechanism.
Digital Signature: Implies the use of some cryptographic process.
Access Control: Passwords, tokens, etc.
Data Integrity: Involves block checking codes or cryptographic check functions.
Authentication Exchange: Passwords, cryptography and hand shaking techniques.
Traffic Padding: Protection against traffic analysis.
Routing Control: Intended to ensure that only physically secure sub-networks or links are chosen.
Notarization: Involves a trusted third party notary and trusted communications channels to assure integrity, origin, time and destination of data

* Table 2.3 Relationship of OSI Layers and Security Mechanisms
Is there any software tool to help manage networks?

The answer is yes. Moreover, there exist two OSI standards which will allow some inter-operability between management systems [72], Also a numerous group of vendors have founded the OSI Network Management Forum.

The two OSI standards are: OSI's Common Management Information Services (CMIS) and the Common Management Information Protocol (CMIP). These standards include a "filtering" mechanism that allows problems to be resolved and captured at the "element" management system level. The "element" is defined as "anything in the connecting chain which will impact user service if something goes wrong, i.e. a modem.

The objectives of network management are defined from two points of view. For a user, the objective is to design and operate "fault-tolerant" networks, and to have the means to assess their performance. In the other hand, a vendor objective is to provide a system that allows single (and/or central) monitoring and control. In general, network management aim is to find, isolate, and repair any fault in the shortest time possible.

Network management software should detect at least:

- Protocol errors,
- Traffic jam,
- Data collisions,
- Bad routing.
Misdirection output.
Multiple ACKS,
Incompatible software.
Buffer overflow, etc.

The generic functions of network management software are the following:

• Performance management,
• Throughput measurement,
• Remote diagnosis and test,
• Remote configuration,
• Administrative data base,
• User accounting and billing,
• Centralized or distributed control, etc.

The importance of a good network management software is enormous, ITESM should take this into account to guarantee a reliable network service.
2.5.3 Network Funding and Charges

Charge or don't charge for network services?

Who should pay?

Central, campus or external network funding?

These and other financial questions have been discussed in universities worldwide without a clear agreement of which are the best answers. Each university has its own answers according to its goals, administrative style and resources.

Taking first the charging issue, Neff [73] predicts that all computer facilities in a university will become a no-charge item following the "library model" and that libraries and computer centres will charge for extraordinary services.

But what is an extraordinary service? It is perhaps the example exposed by Bigelow [74] "free dot matrix printers but charge for laser printer output to cover paper, toner, and maintenance, and to discourages the use of printers as copiers". Thus, extraordinary services should be those with an added value, or those used by a small and/or specialized users, etc.

Some think network costs should be part of a university's overhead budget (such as electrical power), but others insist on operating networks on a cost recovery basis, although this means complex control mechanisms which increases the university's administrative burden.

Marks affirms: [75] "the installation of a telephone service is actually rather similar in cost to that of a data network (in U.S.A.), but people accept telephone charges,
and their budgets already have a corresponding line item" but not to cover network installation and use.

The proposal for ITESM is to try to avoid any network charge for the use of in-house developed or centrally funded services, and charge simple, easy to understand and easily computed rates for external or commercial services (i.e. online databases).

The funding issue is a similar situation. Some universities want networks as cost-recovery projects or services. This is an almost impossible goal for a campus network with the required characteristics described in this dissertation. Some other propose the opposite, 100% centrally funding.

The right combination of the two approaches seems to be a successful solution. This point of view can also be combined with other pragmatic decision such as: central funding for construction, operation and service infrastructure; and departmental or campus funding for wiring and connections within their offices and laboratories [76].

A similar approach can work for the ITESM network: common infrastructure and services centrally funded and particular campus or departmental networks or services locally funded.

Also a reciprocity formula could be introduced to compensate those campuses providing a large number or heavily used services, which may require large expenditures to maintain them.
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3. STRATEGIC TECHNOLOGIES

Instead of providing a list of products—hardware and software—needed to take the Academic Network from a proposal or plan to a reality, the writer has concentrated on identifying a series of standards which are heavily used in universities worldwide.

A list of specific products has the advantage of giving important information such as names and addresses of vendors and characteristics and prices of articles. This kind of information is vital when a project or programme is seeking support and finance, but has the disadvantage of being obsolete by the time that it is compiled. This disadvantage is the result of the speed of changes and innovations that characterise the IT market and is the major reason for presenting a framework of standards.

Also, the writer recommends the development of a purchasing policy that uses written operational requirements for the supply of IT. The operational requirements should contain at least the following:

- A general background of the procurement;
- An outline of the functions which the equipment is expected to fulfil;
- The detailed requirements, such as: minimum requirements, desirable requirements, etc.;
- Instructions to suppliers, such as: timetable, conditions of contract, evaluation criteria, etc.
The writing of this policy and the operational requirements should be a task for the organisation responsible for developing the strategy proposed in the past chapter.

This chapter contains information about one of the most important efforts in IT—the Open Systems Interconnection Reference Model (OSI-RM) and also examines some of the more widely used standards established by either formal organizations or by the acceptance of vendor products as de facto standards.

In some cases, the description of a given standard is more complete than in others, as a rule, the extent of each section is relative to the actual importance of the particular topic. The range of standards discussed is wide, from the relatively old and well established IEEE 802.X Series and the CCITT X-Series, to likely industry standards such as FDDI, TCP/IP, and NFS.

The importance of OSI is highlighted since it represents insurance against rapid obsolescence of hardware, and the associated adverse monetary and credibility consequences [1].

In particular, for the proposed services/network, open systems have a vital role since the ITESM Academic Network necessarily needs to be a network of interconnected networks (or an internet). However each campus, or even each department, can choose the standard that best fits its requirements and usually the one that can be met by its budget. This means that a number of standards (protocols)
should be supported, but only if they have common communication means (i.e. TCP/IP protocol) [2].

The open systems idea allows freedom of decision for the decision makers in every organisation to try to maximize their investment in IT using broad frameworks, and ensures the means for interconnection and sharing of resources of other organisations with as little effort as possible.

Nowadays, professional bodies, governments, vendors and user's groups are promoting open systems' standards. With these kind of standards the communication between equipment made by different vendors can be more easily achieved, and if this philosophy is applied to operating systems, languages, utilities, interfaces, etc. the dream of total hardware-software interdependence will be a reality.

The advantages of using standards, and particularly open standards, are varied. Perhaps the most important is that users will be able to use different systems with almost no new training when they change from one system (hardware or software) to another. For the suppliers of equipment and information this is also an advantage because most of the people will be capable to use their services "instantaneously" after buying them.

Nevertheless, companies which have invested in R&D, marketing, etc using their proprietary and usually closed, systems are trying to obtain a return on their investment, sometimes offering huge discounts and/or gifts to universities. and others promising means to allow communication and interconnection of their products.
Fortunately, hardware and software have a life cycle, and it is just before the cycle ends when open systems philosophy should be "sold" to the decision makers. Open architecture and protocol products tend to cost more, but also present more advantages and the guarantee of being able to participate with the global networks that have been taking shape during recent years. This will be an important success factor for universities and research centres in the 90's.

The adherence to standards is voluntary for both user and producer and for this reason some standards are most popular or used than others [3].

The next section examines the history, evolution and components of the Open Systems Interconnection Reference Model, and finally discusses its implications for the future.

3.1 OPEN SYSTEMS INTERCONNECTION REFERENCE MODEL

During 1977, the International Standards Organisation (ISO) recognized the necessity of specifying an architecture that allowed the interconnection of different systems made by different companies, and maybe in different countries. The importance for such data network intercommunication is comparable with the telephone communication networks that exist worldwide nowadays [4,5].

The ISO subcommittee developed a model known today as the seven layer model. Figure 3.1 shows the OSI model.
Using a layered model any system is divided into sub-systems or modules, thus facilitating the development of the whole system by dividing it into supposedly manageable projects.

The functions and relationships of each sub-system are specified and each of the layers has at least two important functions. The first is to make possible communications with the contiguous layers in both directions, above and below in the hierarchy, and the second to provide logical peer-to-peer communication with its counterpart in other systems which also conform to the layered model.

The seven layers are divided into three groups according to their major role. The Physical, Data Link and Network (1, 2, and 3) layers afford both the interconnection and, the data transmission, between systems (networks). The Session, Presentation, and Application (5, 6, and 7) layers are responsible for the interaction between application systems independent of the means of the network interconnection. They also deal with the meaning of information and how dialogues are conducted. Finally, the Transport (4) layer is the connector between the two sets of layers: with its function both of the other groups can work independently.

Among these layers, the Network and Transport play a key role when a decision is required about which protocols (software) should be supported by a given network.
Figure 3.1 Open Systems Interconnection Reference Model

A brief description of each layer with the most representative standards is presented as follows [6,7]:

I. Physical Layer: Is concerned with the transmission of bits over a physical medium (i.e. twisted pair, coaxial, or fibre optic cable) between the network and the data terminal equipment (DTE). This layer indicates physical connectors, transmission rates, voltage levels, etc. The IEEE 802.X Series, equipment interfaces V.24, and 1.430/431 standards represents some of the standards developed for the layer.

II. Data Link Layer: Also concerned with transmission, but now at the level of bytes or data. In this layer transmission errors are checked and notified, as well as recovered when it is possible. Standards for this layer are: HDLC, 1.440/441, etc.

III. Network Layer: This layer deals with the connections and routes information to flow through the network in the form of groups of bytes or packets. Some standards in this category are the X.25 and the 1.450/451

IV. Transport Layer: Concerned with end-to-end sequence control, flow control, error recovery, and multiplexing. The standards ISO 8072/8073 achieve this task.

V. Session Layer: Deals with the dialogue between systems, for example set-up and termination of sessions, synchronisation, etc. The ISO 8326/8327 were developed to cover this layer.
VI.- Presentation Layer: Responsible for data formatting and code conversion to allow communication between incompatible devices. The series ISO 8822-25 are the main standards.

VII.- Application Layer: The layer that specifies the nature of the task to be performed over the network. It also provides the interface for the user's applications, such as, file transfer access and management (FTAM), electronic mail, etc. The X.400 series is a representative standard for the last layer.

The OSI-RM layered structure allows a high degree of transparency when heterogeneous networks and even LANs and WANs are interconnected using a common transport layer.

This approach has been successfully implemented by General Motors Co. in the Manufacturing Automation Protocol (MAP) and by Boeing Co. in the Technical and Office Protocol (TOP).

Figure 3.2 shows one view of the possible relationship between networking standards [8].

Finally six remarks about OSI that should be taken into account at the moment to develop the proposed strategy:

First, staying vendor independent but compliant with open systems specifications, permits working with different equipment and systems;
Second, it is necessary to recognize the need for different hardware and software, portability, and interconnection features among different groups of people, departments, campus, or universities. Then, OSI is the first step to fulfill those requirements in the near future;

Third, real OSI products conforming to international standards for complete interconnection and operability may take some time to be a reality;
Fourth, adopting actual standards, even with some degree of customization can result on considerable savings in resources;

Fifth, OSI-RM is not a directly applicable solution: technical decision-makers have to choose the products to buy and the means to "glue" them to work in a real network, with real services for real users; and

• Sixth, with the constraints in time and capital, ITESM should not take the risk to adopt proprietary or non-standard technologies: ITESM must follow a strict policy in this issue. [9]

The next section examines and explains some of the more important standards related with networks.

3.2 SPECIFIC NETWORK STANDARDS

According to Fortier [10], "a degree of standardization is always necessary for any industry or product line to be economically and technically feasible", and as the previous section showed, these days standards also play a strategic role for users: functionality in the form of interconnectivity and compatibility, and economically in the assurance of longer life cycle of hardware and systems.

A great number of standards for internetworking have been developed from specific to general definitions, a standard could be defined as a series of criteria and guidelines to produce a good or system.
Manufacturers take a standard and implement such a standard partially or completely in a system. For this reason the specification of two products developed under a given standard may be or not be compatible. This is particularly important when the selection of the parts for the network is taking place. Vendors should demonstrate "in situ" one hundred percent compatibility of their products with the products of others when they are putting them to work together in a network. Written specifications and claims of connectivity are not enough, a clause of this issue should be part of any request of proposal and every purchase agreement.

The Corporation for Open Systems (and other bodies) is developing procedures to test the conformance of products to the OSI standards. In the future the market will consist of products which are fully OSI compatible, semi or partially OSI compatible, or non-OSI.

The decision as to which type of item should be bought, will be complicated, lengthy, important and painful.

The sources of standards could be bodies, such as IEEE or ISO, or companies whose products are adopted as de facto standards (e.g. IBM and XEROX).

The motivation for developing a standard is to give order in an industry, and professionals organisations (such as IEEE) have this objective in mind while developing standards. On the other hand, large companies and/or successful products (i.e. IBM-PC, Hayes modems) create "de facto" standards.
However this acceptance has often acted against users/consumers interests by tying them to a product line for years (a practice in which IBM is a master) without or very limited possibility to interconnect using third party components.

This threat has been disappearing with the advent of the open system philosophy. Though should be noted that a number of the unofficial standards have developed because of the lack of standards, consumer needs, or the comprehensive delay of professional/official organizations to set up public domain standards.

In the next sections the major players in networks standards are reviewed. Some of them are "de jure" standards such as the series X, I and 802.X, and others are "de facto" such as TCP/IP and UNIX.

3.2.1 IEEE 802.X Series Standards

A Local Area Network (LAN) interconnects a number of different devices together, i.e. hard disks, printers, modems, and of course computers. Obviously each LAN component may have been manufactured by a different company, following their own strategy to support software and the connection to/with other hardware, but if each of these items has a common interface, the communication or transfer of data between them will be possible.
Interconnectivity opens up a large number of possibilities for the design of a LAN, with the flexibility to satisfy the needs of a two device LAN, to a LAN with thousands of nodes. Nevertheless, this characteristic could work against the designers if they do not develop a plan that ensures the purchase of devices that support a common standard.

The most important series of standards for LANs were developed by a committee of the IEEE during 1984-1985. They constitute the IEEE 802.X Series, a set which was later endorsed internationally by ISO.

This series of standards deals with the Physical and Data Link layers of the OSI Model.

Figure 3.3 shows how the 802.X Series is organised. From the bottom to the top, the first layer is the Physical, that deals with base and broadband, coaxial and twisted-pair cables, etc.; above it is the Medium Access Control represented by CSMA/CD Bus, the Token Bus, Token Ring, and Metropolitan Area Network Protocols; and finally the Logical Link Control and the 802.1 document that relates the relationship of the series with the OSI-RM [11].

Using these standards not only can the problems of connectivity of devices be resolved but also the challenge of providing a flexible wiring system and the interconnectivity of LANs by means of bridges can be met [12].
Figure 3.3 EEE 802 Series Standards

Relation with OSI
802.1

Logical Link Control
802.2

CSMA/CD Bus
802.3
- Baseband-Coax. 10Mbps
- Broadband

Token Bus
802.4
- Broadband 1, 5, 10Mbps
- Single channel

Token Ring
802.5
- Twisted pair 1-4Mbps
- Baseband coax 4-40Mbps

Metropolitan Area Net.
802.6
Among the 802.X Series, two of them have received both users' acceptance and manufacturers' support. Descriptions of these (802.3 CSMA/CD Bus and the 802.5 Token Ring), are provided below (13).

IEEE 802.3 Carrier Sense Multiple Access/Collision Detection

It is almost self described by its long name, and in the commercial arena the products developed under this standard are known as Ethernet. The CSMA/CD media access method is the means by which two or more stations (nodes) share a common bus transmission medium.

To transmit, a station waits for a quiet period on the medium (that is that no other station is transmitting) and then sends the intended message in bit-serial form. If, after initiating transmission the message collides with that of another station, then each transmitting station intentionally sends a few additional bytes to ensure propagation of the collision throughout the system.

The stations remain silent for a random amount of time (back off) before attempting to transmit again.

IEEE 802.5 Token Ring

This standard specifies the formats and protocols used by the token passing ring medium access control (MAC) sub-layer, the physical layer and the means of attachment to the token passing ring physical medium.
A token ring consists of a set of stations serially connected by a transmission medium. Information is transferred sequentially, bit by bit, from one active station to the next. Each station generally regenerates and repeats each bit and serves as a means for attaching one or more devices (terminals, work-stations) to the ring for the purpose of communicating with other devices on the network. A given station transfers information to the next.

The addressed destination copies the information as it passes. Finally, the station that transmitted the information removes the information from the ring.

A station gains the right to transmit its information onto the medium when it detects a free token passing on the medium. Any station, upon detection of free token, may capture the token and modify it. At the end of its information transfer, and after appropriate checking for proper operation, the station initiates a new token which provides other stations with the opportunity to gain access to the ring. A token holding timer controls the maximum period of time a station shall use the medium before passing the token.

Although the electrical topology of a token ring network is a ring, the physical layout is best described as a "chain of stars", the architecture that allows the use of bridges to interconnect different LANs (rings). This characteristic is widely used as a strategic feature when wiring plan is required, because individuals floors are wired and operated as independent networks but also allowing the integration of
wide/campus area networks with flexibility and an extra measure of management and security.

### 3.2.2 TCP/IP Protocols

The TCP/IP protocols were created by the U.S. Department of Defense as a part of the first packet-switched network, ARPANET. The origin of these protocols is military but the architecture provided made them very popular, specially among universities. Nowadays more than 200 companies manufacture products following TCP/IP specifications [14].

Without any doubt TCP/IP are the most widely accepted standards for internetworking worldwide [15,16].

The reasons for its popularity are several. Among the most important are:

- Firstly, it is a vendor independent protocol, that is, it allows the interconnection between diverse type of equipment. As it is software based, it can then be loaded and run on virtually any kind of computer;

  Secondly, it is a public-domain protocol but it is fully documented with source code included; and

  Thirdly, it is a "logical" choice towards full open standards. As the ISO protocol series is still not complete, TCP/IP is a de facto network protocol.
Nevertheless, TCP/IP is not the panacea for communications. There are some criticisms against the utilisation of these specifications that should be taken into serious consideration before taking any decision. The major detractions against TCP/IP are:

- It can take a considerable amount of memory running under DOS [17];
- It uses complex protocols that require significant processing time and interrupts; and
- The overhead headers of TCP/IP unable cheap off-LAN (off-campus) connections [18].

However, recent studies [19] report that "TCP is in fact not the source of the overhead often observed in packet processing, and that it could support very high speeds if properly implemented".

In addition to these allegations, in the long run OSI protocols may well succeed over TCP/IP. Till [20] gives these three reasons:

1) OSI protocols are designed to be comprehensive;
2) There are real, strong, and growing pressure to move to international standards; and
3) ISO upper layer programmes are more powerful than those of the TCP/IP.
In spite of these disadvantages, TCP/IP is still the best current choice for communications protocols. In addition, new developments around TCP/IP are preparing a smooth path between TCP/IP and OSI protocols, such developments are:

The issue of the RFC 1001/1002 specifications that defines the interaction between NetBios and TCP/IP [21];

The emergence of TCP-4 and the CLNS (Connectionless Network Service) [22], which was recently issued as an ISO protocol under the name ISO-IP or ISO 8473 [23].

With all these, the future of TCP/IP is assured at least until the finishing of the OSI suite protocols and its acceptation and development of products that couldn't happen before the mid 90's. Two proposals to pass from TCP/IP to OSI are depicted in the Figure 3.4.

![Figure 3.4 TCP/IP Protocols and OSI-RM](source: Till, J., Standards Protocols Bridge LAN Islands as Networks Go Global, Electronic Design. May 26, 1988, Vol.36 No.12. p.82)
TCP/IP consists of four layers and five protocols, they are:

I. Network-Access Layer: That provides access to a network through its communications protocol, i.e. X.25, IEEE 802.X, etc.

II. Internet Layer: That supplies the routing functions to convey data through different networks. Here the IP or Internet Protocol resides, providing interconnection between multiple LANs and/or networks;

III. Transport Layer: Is where the TCP, Transmission Control Protocol is, providing the logic to ensure a reliable delivery of data exchange between hosts: It is also responsible for directing data to its application;

IV. Application Layer: Contains specific protocols for user applications, TCP/IP contains, Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP), and Telnet. The features of SMTP are: mailing lists, return receipts and forwarding, but requires a native electronic mail facility. FTP. sends files between systems and Telnet, permits remote log-in onto a remote computer, was designed to work in simple scroll-mode terminals [24, 25]. Figure 3.5 shows the four layers of TCP/IP.

The TCP/IP protocols features can be summarised as: being independent of the physical medium, they work on baseband, broadband, and fibre optics cable; use cyclical redundancy checks as means for error detection; are incorporated into the kernel of Berkeley UNIX [26].
TCP/IP allows the internet concept to be possible (the best examples are ARPANET, CSNET and NSFNET in U.S.) without expensive hardware (eg. gateways, protocol converters, etc.) and with a very high degree of openness. It is definitely the architecture to choose for any academic network that need to support diverse hardware and software requirements with a large amount of information to share.
3.2.3 UNIX Operating System

The success of UNIX as a strategic operating system is the result of its features and characteristics:

- It is portable to many computers;
- It does not require a lot of memory;
- It is multitasking; it has built-in network capabilities;
- It is general-purpose, interactive and time sharing;
- It is device-independent for managing I/O;
- It is built up of a series of primitives, i.e. list, sort, copy file, move, etc.;
- It is free for universities, etc.[27]

Figure 3.6 shows the importance of UNIX which together with DOS and OS/2 are considered as the operating systems for Open Systems. They are estimated to have 48% of the total U.S. market and this Figure could be considered as a global trend [28].

UNIX was the operating system chosen to implement TCP/IP protocols by the Department of Defense. The system was originally developed by the Bell Labs in U.S. but its popularity began to grow since the University of California at Berkeley received the code and the permission to alter it and distribute it freely among universities.
1991: Open Systems Surge to 48% of the U.S. Market

Figure 3.6 UNIX U.S. Market

Nowadays, the importance of UNIX as a de facto operating system standard for workstations, minis and mainframes in universities and in scientific and manufacturing areas in industry worldwide has divided the users, developers and vendors into two sides.

The two "UNIX groups" are:

UNIX International, formed by AT&T in association with other vendors and users. They recently launched the release named System V.4.

The other group, the Open Software Foundation, was formed in 1988 by vendors such as: IBM, Digital Equipment, Hewlett-Packard, Groupe Bull, Siemens AG, etc., they expect to release a UNIX version before next year [29].
This "battle" among the two UNIX different standards seems to be a vendors' competition to control the development of the operating system. In the arena of industrial standards, IEEE has appointed the POSIX committee that is developing the IEEE 1003.1 POSIX standard, the other initiative is the X/Open's Portability Guide III (XPG 3) [30,31].

These essential standards can be visualised as the core of in the UNIX world (see Figure 3.7). These are the specifications that make UNIX software portable from machine to machine. The next rings could be the different implementations and/or proprietary UNIX versions such as, AIX(IBM), ULTRIX (DEC), UX (HP), SunOS (Sun), XENIX (Microsoft), and BSD (Berkeley).

A major battle is taking place between vendors and professional associations, the former adding new features to its proprietary versions and the latter expanding the bull's-eye. The vendors are trying to differentiate their systems while associations are trying to conserve UNIX as an open operating system.

In spite of all these disagreements there are few differences among the UNIX implementations/vendor specific versions, and UNIX remains as a key player in the OSI initiative.
3.2.4 Fibre Distribution Data Interface

The physical medium of a network is an important issue for two major reasons:

- Firstly, it is a costly and painful process. The installation and the cable itself represents a major investment but also the process is annoying specially when ducts do not exist in the campus and buildings.

  Secondly, the decision of which wiring system to install will limit or facilitate future developments and improvements of the network.
For these reasons, careful consideration as to whether to install fibre optics cable is fundamental. Currently an important standard is under development: the Fibre Distribution Data Interface (FDDI).

The FDDI development is an initiative by the American National Standard Institute (ANSI), specifically the committee X3T9.5, formed with the support of more than eighty telecommunication and computer manufacturers worldwide [32,33].

The FDDI follows a token-passing access scheme based on the IEEE 802.5 standard [34]. It is intended to achieve speeds up to 100 mbps on fibre optic media. The standard is formed by four parts:

- **Physical (PHY)** that deals with cable and connectors:
  
  Physical Media Dependent (PMD) that describes the link protocol;
  
  Media Access Control (MAC) which deals with the protocol for communication between nodes; and finally
  
  Station Management (SMT), that describes the network management.

The FDDI standard is completed with the exception of the SMT component which is expected to be ready next year.

The major applications for FDDI are: as a LAN backbone and as a high-speed link between graphics workstations and mainframes.
The advantages and disadvantages of fibre optics are appreciated when it is compared against traditional wiring system, Bryce [35] provide the following comparison table (see Table 3.1) between, twisted-pair, coaxial and fibre cable.

<table>
<thead>
<tr>
<th></th>
<th>Twisted-Pair</th>
<th>Coaxial</th>
<th>Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Rate/Km.</td>
<td>16 Mbits</td>
<td>500 Mbits</td>
<td>1000+ Mbits</td>
</tr>
<tr>
<td>Accessibility to Being Tapped</td>
<td>easy</td>
<td>easy</td>
<td>difficult</td>
</tr>
<tr>
<td>Signal Radiation</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Potential for Explosion</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Bit Error Rate</td>
<td>1 in $10^6$</td>
<td>1 in $10^6$</td>
<td>1 in $10^9+$</td>
</tr>
<tr>
<td>Static Problems</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Grounding Problems</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Size &amp; Weight by Data Rate</td>
<td>large</td>
<td>large</td>
<td>small</td>
</tr>
<tr>
<td>Cable cost/ft.</td>
<td>$0.50-1.00</td>
<td>$0.50-1.00</td>
<td>$0.50-1.00</td>
</tr>
<tr>
<td>Installation</td>
<td>In</td>
<td>In</td>
<td>2n</td>
</tr>
<tr>
<td>Design</td>
<td>In</td>
<td>In</td>
<td>2n</td>
</tr>
<tr>
<td>Testing</td>
<td>In</td>
<td>In</td>
<td>1.5n</td>
</tr>
<tr>
<td>Electrical to Optical</td>
<td>none</td>
<td>none</td>
<td>+50% to 100%</td>
</tr>
</tbody>
</table>

NB: "n" represents a money unit required to carry out a work

Table 3.1 Fibre VS Metal

(Source: Adapted from Bryce, J.Y., Fiber VS Metal. Byte, January 1989, Vol.14 No.1, p.254, 258)
The major advantages are:

- High degree of security,
- Extremely low error rate,
- High data rate, and
- Small size and weight.

On the other hand, the disadvantages are:

- Installation is expensive,
- Design and testing for the wiring system cost twice the conventional, and finally
  Requires special cards at each node to convert electrical signals into optical and vice versa.

The typical node connection today costs approximately $10,000 which is expensive for almost any university. Nevertheless, the price is expected to drop in the next four years until a reasonable price of under $1000 is reached during the mid 90's.

There is no doubt that FDDI will take an important role in future network developments. In fact, the four components of the standard fit into the two first layers of the OSI-RM which is a warranty for interconnection. In addition, FDDI-2, the next foreseeable step, will add voice and video to the actual standards, to open a gate to broadband fibre optics networks [36]. Finally, Figure 3.8 shows an example of the utilization of FDDI in a typical LAN installation.
3.2.5 X Series Standards

The X family standards is an international suite of more than 35 specifications issued by the CCITT. The Table 3.2 shows some of the most important documents.

The X.21 standard specifies the electrical and procedural characteristics for digital communications circuits, the X.21bis does the same but for the operation of analog lines used for data transmission. The X.21bis is also compatible with the V.24 specification (see section 3.2.4) for physical interface between the DTE and the modem [37].

Figure 3.8 A LAN with FDDI Backbone

X.3 Packet assemble/disassembly facility (PAD) in a public data network.

X.21 Interface between the data terminal equipment (DTE) and the data circuit-terminating equipment (DCE) for synchronous operation on public data networks.

X.21bis Use on public data networks of DTE which is designed for interfacing to synchronous V-Series modems.

X.25 Interface between the DTE for terminals operating in the packet mode and connected to public data networks by dedicated circuit.

X.30 Support of X.21 and X.21 bis based DTEs by an ISDN

X.31 Support for packet mode terminal equipment by an ISDN

X.200 Reference Model for Open Systems Interconnection for CCITT Applications.

X.250 Formal description techniques for data communications protocols and services.

X.400 Message handling systems: system model-service elements.

X.500 Directory systems: information framework.

Table 3.2 Selected X Series Standards

The X.25 recommendation defined by the CCITT is the "Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment for Terminals Operating in the Packet Mode and Connected to Public Data Networks by Dedicated Circuit". 
Under the X.25 standard there are two modes of access for a user, via direct lines or via dial-up connection. The advantages of using dial-up communications is that users can use their ordinary telephone lines and then dial-up to a Public Packet Switched Network (PPSN), the maximum data rate is of only 2400 bps.

Direct lines can be for data-only or voice-data, using this mode, the host computers are interconnected by a packet switch that provides speeds up to 56 kbps for data-only lines and 19.2 kbps for multiplexing voice-data [38,39]

The X.25 standard has three layers:

- The Physical Layer;
- The Link Layer, where a subset of the ISO Higher Data Link Control (HDLC) is incorporated; and
- The Packet Layer which specifies how data is sent using a framework of preestablished size blocks or packets [40].

The importance of the X.25 is due to its "transparency", because a network developed under its specifications is open and can support the interconnection of different equipment from different vendors. It can also allows different protocols with traffic such as: SDLC, bisynchronous and asynchronous.

Also, the layered configuration of X.25 permits separate applications from the communications function. This allows
flexibility for improvements or changes, and thus can rapidly change to accommodate new developments [41].

This standard is important when a LAN or WAN is under design and interconnection and flexibility is required.

Another X series family standard which is assuming greater importance nowadays, is the X.400 series for messaging handling systems. This series defines:

- Message Transfer Agents (or MTA that could be a company or a bureau of messaging services), and
- User Agents (or UAs) that can be any type of terminal such as teleprinters, teletex of facsimile machines.

The applications of X.400 are related to messaging, e.g. mailboxes definitions, send/retrieval messages, etc. The most important feature is the facility to interconnect different messaging systems under the X.400 specifications.

The X Series of standards could be considered as "basic" recommendations that play a vital role in any network development. regardless of the size of the network or the traffic expected [42], thus decision makers should demand its use and application.

3.2.6 Network File Systems

The Network File Systems (NFS) is a development of Sun Microsystems Inc. it is considered a de facto standard.
NFS is a file server protocol software that is placed over TCP/IP, it allows any workstation in a network (i.e. IBM-PC, Apple Macintosh) to open and use files contained in any other computer in the network, that is, a dynamic sharing of files [43].

This type of software has an invaluable role in a heterogeneous network because it allows each kind of computer to be used for its optimal task eg. a NeXT computer indexing text, a VAX doing number crunching, etc.

This importance is augmented especially when it is used in combination with Berkeley "sockets" or Sun's Remote Procedure Call (RPCs) which make it possible to perform interprocess communications [44].

Even though NFS is not an industrial standard its popularity and functionality will push itself into international arena to develop a truly and complete network file system with worldwide and public consensus.

3.2.7 Other Standards

There are a large number of standards for networking, of which the most important are mentioned and explained above. Nevertheless there are others, such as the ISDN Series, the V.X Series, and those issued by ISO and the CCITT. Some of them are highly technical, specific, and/or are more immature in this moment, but it may be also important to take them into account at the time of design and purchase.
Table 3.3 shows some examples of these category of standards.

In the near future the I Series for ISDN will increase in its importance when network products emerge for this technology.

ISDN promises all digital communications to anyone who has at least a twisted pair connection (typically an existing telephone line).

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.300</td>
<td>Videotex service</td>
</tr>
<tr>
<td>T.0-T.5</td>
<td>Classification and standardisation of facsimile apparatus for document transmission over the public networks</td>
</tr>
<tr>
<td>V.21-V.23 and V.26bis-V.32</td>
<td>Modem standardised for use in the global switched telephone network at different speeds</td>
</tr>
<tr>
<td>V.24</td>
<td>List of definitions for interchange circuits between DTE and data circuit-terminating equipment</td>
</tr>
<tr>
<td>I.120</td>
<td>Integrated Service Digital Network</td>
</tr>
<tr>
<td>I.430-1.431</td>
<td>ISDN Basic and primary rate user-network interface</td>
</tr>
<tr>
<td>I.440-1.441</td>
<td>ISDN Data link layer specifications</td>
</tr>
<tr>
<td>I.450-1.451</td>
<td>ISDN User-network interface layer 3 specifications</td>
</tr>
</tbody>
</table>

Table 3.3 Selected CCITT and ISO Standards

However its development is still in its first commercial stage and it will take some years to reach a mature level. Even so, universities and other large scale users, especially those in areas with high volume of voice and data telecommunications needs will have access to ISDN sooner than home subscribers.

For this reason, any attempt to develop a serious network should take ISDN as a near possibility, or in the best of the cases, as an viable alternative [45,46].

3.3 VSAT TECHNOLOGY

A relative new technology. Very Small Aperture Terminals (VSAT) is opening up new opportunities to develop first class networks, specially in regions and/or countries with poor telecommunications infrastructure (see section 1.3.4).

VSAT technology is seen as a "natural choice" to develop Satellite Wide Area Networks (SWANs) with a high degree of flexibility, wide coverture, and according with experts, with an overall economy.[47]

Figure 3.9 shows a typical SWAN architecture with its characteristic (but not unique) star topology, where the central node or hub can establish communication with many "low cost" remote stations. These stations also can be a node for LANs, resulting in a series of LANs interconnected by VSATs. forming a SWAN.
The hub is where the central information and organisation resides. At that location the central management resides as well as the main information resources, i.e. library and information centres, computer centres, etc.

The traffic or data volume handled in this type of network connections is divided into classes [48,49]:

- Business Oriented, which is adequate for low rate data traffic. In it exist three kind of data transactions, such as Interactive, eg. on-line services, real-time message exchange, etc.;
- Query-Response, eg. library queries, personnel records, budget-credit, etc.;
- Narrative-Record, for electronic message or word processed documents transactions.

The other type of traffic is known as Corporate or Bulk data traffic, it handles data in the form of facsimile, teleconferencing (video), electronic mail, data collection, file transfer, etc.

In the case of a university both types of traffic are present, and ITESM presents an ideal opportunity to exploit VSAT technology efficiently because of its geographical dispersion, dissimilar needs and size of each campus, Mexico's telecommunications infrastructure, etc.
Figure 3.9 SWAN Architecture

References


2. ibid. p.80


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11. Lefkon, D., op. cit. p.150-151


15. Arms, C., op. cit. p.239


18. Arms, C., op. cit. p.51


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44. Glass, L.B., op. cit. p.236


4. ORGANISATIONAL RESTRUCTURING

"With the emergence of the computer, the most powerful educational tool since the printing press, the university is potentially a new creature. The issues are three-fold: curriculum must be redefined, institutional structure must be redefined, and the relationship of the institution to other institutions and society at large must be redefined" [1]

This chapter assesses just a part of the redefinitions discussed in the quotation above, ITESM has been in a state of constant change since its beginning: adopting and innovating, changing and redefining roles and structures, all with the objective of fulfilling its mission.

This thesis is a proposal or perhaps more correctly an outline for a formal proposal, that could lead to the development of an important strategy with high priority and the participation of all ITESM campuses.

The chapter is divided into three parts to highlight the importance of the appointment of a Chief Information Officer for the ITESM System, the formation of an ITESM Networking Group to make a reality of this proposal, and finally some recommendations to integrate, in a logical fashion and with the idea of making strategic changes of some functions, services, departments, etc.
The "changes" proposed are not exhaustive but represent the core of the remodelling needed to confront the "information or knowledge age" which presents the challenge of optimizing its main raw material: information resources.

4.1 CHIEF INFORMATION OFFICER

The idea behind a Chief Information Officer is simple: his/her position would reflect the importance of the information as a strategic resource for ITESM. The CIO should be at the highest level possible within the organisation's structure.

The main role of the ITESM CIO is to be a leader. Who will firstly set up an Institutional Information Strategy and then develop a series of policies to properly carry out such a strategy. Secondly, (s)he will lead all projects and programmes that ITESM create as actions towards its mission through widespread, intelligent and decisive use of information resources as tactical resources.

To fulfill his/her duties the CIO should be in charge of at least the following:

- Information Resources of Monterrey Campus;
- ITESM Networking Group;
- Research Group in information usage and management;
  ITESM representation at national and international information and telecommunication bodies.
The Research group is indispensable to ensure that ITESM is up-to-date in the field. That it can test new technologies, and that it can develop or adapt new techniques. The members of this group could be any person working in ITESM or in any private sector organisation in joint ventures; a matrix organisation is the form method suggested to manage this group.

The representation of ITESM at information and telecommunications forums is important to present a single vision including the background situation of all campuses, projects, plans, etc. In such forums he/she will be able to negotiate joint projects, interchange ideas, etc. on behalf of and to the benefit of all ITESM campuses.

The Networking group and the Information Resources issues are discussed in the next sections.

4.2 ITESM NETWORKING GROUP

This group was outlined in sub-section 2.5.2 Network Management, basically is a group with representatives from all the campuses. This group should establish the projects and plans to:

Develop an academic network in each campus, and;
Interconnect them to form the ITESM Multi Campus Academic Network.

Both objectives should follow the directives laid down by the suggested Institutional Information Strategy of ITESM.
The modus operandi of the Networking Group could be as task-force, consensus committees or whatever style accommodates the requirements of the strategy and level of involvement required from each member of such a group. The definition and appointment of the group is a responsibility of the CIO.

4.3 INFORMATION RESOURCES INTEGRATION

A first step towards an Institutional Information Strategy should be the integration of the information resources in each campus. Because Monterrey campus is the most complex case it will be assessed as an example for the other ITESM campuses.

4.3.1 Computing Resources

Computers and their peripherals as information resources should be under a single administration. Bringing together Academic and Administrative computing will produce a number of benefits, the main are being the effective and efficient use of the hardware to maximize the quality of computing services and minimize their costs.

If both areas are separated, a lot of money and effort could be wasted. As Academic and Administrative computing on Monterrey campus are already merged this point is not discussed, but appeared here to highlight the importance of such a merger.
4.3.2 Communications Resources

This is an important issue for discussion because almost all communications resources in ITESM are scattered across various departments, and the synergy is nil.

The proposal is to merge under one management:

- Computer communications,
- Telephony,
- Telex,
- Facsimile,
- Mail,
- Massaging, and
- Parcel services.

All these items are forms of communication. All have the same objective: to convey messages from the transmitter to the receiver, so why then are they separated?

Today a trend is towards the convergence of all communications technologies, and so it is timely to merge all communications systems before technology forces this movement. In this way the merger should be carried out in a planned way.
4.3.3 Information Dissemination Resources

These kind of resources are used to disseminate information but also are information themselves in the majority of the occasions.

The proposal is to merge the following resources:

- Libraries: specialized, departmental, central, etc.;
- DeskTop Publishing and photocopy bureaux;
- Printing and binding workshops; and
- Digital Publications;

Again, scattered and duplicated offices and functions in the form of specialized or departmental libraries cause a waste of resources. The proposal is not to eliminate those libraries but put them under one management to optimize resources.

The desktop publishing, printing, photocopying, and binding workshops should be together as they form a logical production line, there is no reason to separate them as bringing them together could improve the service and cut the cost of production and duplication of paper based information.

Finally, digital publications in the form of databases; should be managed by a single organisation. Expensive equipment such as OCRs, magnetic and optical media players/recorders need to be under strict control to
maximize their use for the benefit of the majority of the ITESM community.

In the same way, as was mentioned in the past subsection, technology is converging the resources mentioned above. It is better to move forward the future, instead of being overtaken by it, the benefits could be exploited immediately.
References

Conclusions:

"When two elements approached each other in such way that the scope of what they can achieve surpasses the total of what they could achieve separately, they acting with Synergy. These synergetic interactions will provide ideas and inspirations, generate surplus energy for continued growth, and refine communications and perceptions"

I CHING (Book of Change)

After research into the requirements of ITESM and writing the four chapters that constitute this dissertation, a large list of conclusions and/or recommendations for the setting up of a multi campus network was generated. The most significant are listed below, both for the purposes of this work and, from the point of view of the writer, for ITESM.

The conclusions are grouped to emphasize four important aspects:

First, the requirements for setting up the proposed network;

Second, the characteristics that the network should have;

• Third, the expected benefits of the network; and
• Fourth, the technical issues that should be taken into account to set up the network.
The proposal of this dissertation is to provide a scenario for the ITESM Multi Campus Academic Network. Such a scenario has the following pre-requisites:

It is necessary to: create, write, plan and establish a whole, formal and institutional Academic and Administrative Information Resources Strategy to reach world class status through innovative creation, storage, delivery and manipulation of information;

The first step for the strategy should be the integration of: computing resources, communications resources, and information resources;

Upper administration should work committedly and actively to ensure the necessary cooperation among the units and personalities involved in the strategy;

• ITESM should have a Chief Information Officer who coordinates and leads at least: the Information Resources of Monterrey campus, the ITESM Networking Group, and the Information Research Group;

• There is insufficient awareness of the potential of network applications and the network concept should therefore be marketed to the entire ITESM community;

The ITESM Networking Group should have representatives from all campuses;
• The mission of ITESM should be the mission of the ITESM network: to provide high quality educational services;
• ITESM cannot wait until all of its campuses reach some level of maturity or size to interconnect them with academic information services; and

All ITESM campuses should participate in the planning, development and operation of the network in one way or another.

The ITESM Multi campus Academic Network should:

• Use Monterrey campus information resources as a developing platform;
  Pursue the following goal: 100% availability, 24 hours a day, seven days a week;
• Have written, and accessible to everyone, current and complete policies;
  Look for free access, open dissemination of knowledge and free exchange of ideas;
• Try to avoid any charge for in-house or centrally funded services, and only charge for external and/or commercial services;
  Provide the same basic services to the entire ITESM community;
• Have the following minimum capabilities: connectivity, file transfer, and mail;
• Establish a plan to initiate the setting up of academic LANs on each campus;

• Have advanced services such as: software servers, bibliography, information servers, full-text databases servers, CD-ROM servers, e-mail servers, bulletin board and conferencing servers and intelligent front-end servers; and

• Recognise libraries and information centres as primary information resources.

The ITESM Multi Campus Academic Network could:

• Increase the impact of informatics as a tool to obtain and use remote information resources;

  Represent a means for attracting and keeping the best faculty, staff, and students;

  Broaden the distribution of creativity by connecting ITESM members;

  Increase productivity by improving access to information resources;

• Shorten the time to transmit basic research to productive sectors;

• Serve to obtain scale economies through providing means to buy and share information resources;

• Increase communication among the ITESM community and thus enhance the sense of unity to the institutional mission and principles.
Be used locally for special purposes during predetermined dates, to carry out: registration process, yearly training sessions, open house/demo sessions, etc.; and

Act as an example to other universities, as a means of technology transfer and as an information generator/supplier for the country.

The technical aspects to keep under consideration for setting up the ITESM Academic Multi Campus Network are:

The Information Resources Strategy proposed should have a strong emphasis on open standards;

Open Standards represent an insurance against rapid obsolescence of hardware;

ITESM can join or start an Open Systems User group in Mexico to promote the open standards philosophy;

ITESM should not seek donations from a single company in order to retain control over design, services, and equipment selection;

New and renovated buildings in ITESM should include network wiring in their plans; and

The hub of the satellite network as part of the future ITESM network should be re-located where the central management and the main information resources reside.
Appendix—Glossary:

Advanced Research Projects Agency Network, see ARPANET

American National Standards Institute, see ANSI

American Standard Code for Information Interchange, see ASCII

ANSI American National Standards Institute. This body approves U.S. standards for many areas, including communications. It is a member of the International Standards Organization

Application Layer The layer of the OSI LAN model concerned with application programs such as electronic mail, database managers, and file-server software

ARPANET Advanced Research Projects Agency Network. An experimental network linking universities and other organizations involved in networking research. Part of the unclassified segment of the Defense Data Network, it was established under the auspices of the Defense Advanced Research Projects Agency (DARPA), which provides basic research, development, and technology transfer for the Department of Defense

ASCII American Standard Code for Information Interchange. A character code used by microcomputers

Asynchronous communication Communication in which streams of characters are sent in sequence but at no set intervals. Transmission is controlled by start and stop elements at the beginning and end of each character. Most of the common non-IBM terminals use asynchronous communication, at speeds up to 19.2 Kbits/second. This is the form of communication supported by the serial ports on personal computers

Backbone A high-speed central network that links independent sub-networks. On many campuses, local area networks are linked to a backbone to form an integrated campus wide network

Bandwidth The frequency range available on a communication system. For instance, the cable used for television distribution has a bandwidth of 300 to 400 megahertz and can support fifty 6-megahertz television channels. The term is often used more generally to refer to the capacity of throughput of a communications link. High bandwidth implies high data throughput, which can provide very high speed communications to a few users at a time or lower data rates to many users
Baseband A transmission system in which signals are transmitted at their original frequency. Typically, a baseband system supports a single communication channel. In contrast, a broadband system can support several data or video channels.

Bibliographic data base A data base that contains information about references to documents, abstracts of documents, and sometimes also contains texts or text extracts of at least some of these documents.

bit rate, see bps.

BITNET Because It's Time Network. A cooperative academic network providing mail, information, and file-transfer services among 360 member institutions, with links to similar networks in Canada, Europe, the Far East, and South America.

bps the number of bits transferred in unit time, usually expressed in bits per seconds.

Bridge A network link at the data link layer of the OSI Reference Model for network architectures, usually used to join two physical local networks into a single communications sub-network, thereby overcoming the physical constraints that limit a single physical network. Remote local networks can sometimes be joined using a leased telephone line with a bridge at each end. Many bridges act as filters, passing only the traffic that needs to move across the physical boundary, and thus reducing unnecessary traffic.

Broadband A transmission system with a wide frequency range, in which many different sets of signals (channels) are on the transmission medium simultaneously. Each set of signals is translated to a particular frequency range. An example is cable television, where many channels are broadcast at once on a single coaxial cable.

BRS Bibliographic Retrieval Services, is a host system based in New York offering access to online databases.

Bus A local area network topology in which all stations attach to a single cable such that all stations are equal and all stations hear all transmissions.


CCITT International Telegraph and Telephone Consultative Committee, which sets international standards for the communication industry.

CD-ROM Compact Disc-read Only Memory.
Circuit switching A method of communication where a dedicated connection is established between any pair or group of users and maintained until the communication is terminated. Traditional telephone communication uses circuit switching.

Client A computer with special software that requires access to a network to obtain resources of other computers (servers).

CLNS Connection-Less Network Service

Coaxial cable A type of electrical cable in which a piece of wire is surrounded first by insulation and then by a tubular piece of metal whose axis of curvature coincides with the centre of the price of wire.

Computer Conferencing Is the use of networks communications by a group of interested parties who may be scattered geographically.

Connectivity the flexibility of a network in providing connections to a number of different systems.

Cryptography A technique of concealing the content of a message by means of a secret transformation, which only the intended recipient(s) should be able to decode.

CSNET A national network linking computer science and engineering researchers at around 200 member institutions in the United States, with links to other networks around the world.

DARPA Defense Advanced Research Projects Agency. This agency has sponsored many projects in basic computer science research, as well as the development of the ARPANET and of the non-proprietary UNIX operating system.

Data Terminal Equipment, see DTE.

Data Link Layer Layer defined by OSI-RM concerned with ensuring transmission errors across a data link are detected and connected.

Data Star European host system based in Berne offering access to online databases.

Data switch A device comparable to a telephone exchange but designed to handle data rather than voice communications. Based on the technique of circuit switching, data switches have been used for some years at many universities.

DCE Data Circuit-Terminating Equipment.

Defense Advanced Research Projects Agency, see DARPA.
Dialog Dialog Information Systems, is host system offering access to a wide number of online databases

DOS Disk Operating System

DTE A computer or terminal that provides data in the form of digital signals at its output

EDI Electronic Document Interchange Is a common language for the transfer of data

EDUCOM Cooperative activity of several universities that have decided to investigate how the computing needs of their institutions can best be met

Electronic Publishing Application of computing, information technology and electronics to the dissemination of information that would previously have been distributed by conventional methods of printing or reproducing paper documents

Electronic Bulletin Board System An online message system that is issued for general information and is available to all users of a network

Electronic Mail, see E-Mail

Ethernet A popular protocol at the data link layer of the OSI network model. Developed at Xerox Corporation, standard Ethernet operates at 10 Mbits/second over coaxial cable

E-Mail Any form of electronic or computerised communication which is an alternative to at least one of the ordinary postal services. It allows users of computer networks to exchange messages

Facsimile (telefacsimile, Fax) The transmission of information about a document along a telephone line or other communications channel, in such a way that the received signals are reconstructed into a representation of the original page

FAX see. Facsimile

FDDI Fibre Digital Data Interface. A 100 Mbits/second token ring network protocol, designed to connect local area networks over fibre-optic cables and proposed as a standards by ANSI

Fibre Digital Data Interface, see FDDI

Fibre optics A transmission technology based on light pulses through thin glass fibres. The light source may be a light-emitting diode (LED) or laser. The interface equipment for using fibre optics is expensive, but the technology offers advantages for links between local networks
File transfer A network service that allows files to be transmitted from one computer to another

Front-end computer A small computer, between a large computer and computer network, that is used to handle communication between them

FTAM File Transfer Access and Management

FTP File Transfer Protocol, part of TCP/IP

Gateway A device that provides translation between sets of protocols, including translation of protocols above the network layer of the OSI model for network architectures

Handshaking Exchange of predetermined codes and signals between two data terminals to establish a connection

HDLC Higher Data Link Control, a protocol adopted by ISO for the data link layer of the OSI network model

Higher Data Link Control, see HDLC

Host A computer system that provides services for a number of users, usually through time-sharing, or an individually addressable computer on a network

I/O Input/output

IDEA Project-Distributed Informatics for Teaching and Administration, ITESM Mexico

IEEE Institute for Electrical and Electronics Engineers. One of the activities of this professional organization is the development of standards, particularly in the area of local area networking

Information retrieval The process whereby a user extracts required information from a data base

Information Resources

Institute for Electrical and Electronics Engineers, see IEEE

Integrated Services Digital Networks, see ISDN

Intelligent terminal A terminal that contains some local computing power inside its hardware

Interconnection The mechanism of providing a channel for data transfer between two communication users or devices

Interface A shared boundary defined by common physical interconnection characteristics, signal characteristics and meaning of interchanged signals
International Standards Organization, see ISO

International Telegraph and Telephone Consultative Committee, see CCITT

Internet A network of linked networks. Capitalized, the term refers to the linked networks that use the networking protocols developed on the ARPANET and share a common addressing scheme. The INTERNET includes ARPANET and NSFNET

ISDN Integrated Services Digital Networks A future offering designed to provide an universal digital network that will permit the integration of voice and data on a common telephone company facility

ISO Reference Model for Open Systems Interconnection, see OSI Reference Model

OSI Reference Model A specification for network architecture and layers of protocols, that has become so widely adopted that it has become an international standard. It has seven Layers of protocols, which are, from the lowest to the highest: Physical, Data Link, Network, Transport, Session, Presentation, Application

ISO International Standards Organization. This organization, composed of national standards-setting bodies, establishes international standards in many areas. In the networking area, ISO developed the Open Systems Interconnection (OSI) model for networking architectures. Using this layered model as a framework, ISO is gradually adopting one or more standards protocols for each of the layers

IT Information Technology

ITESM Institute Tecnológico y de Estudios Superiores de Monterrey, a Mexican university

Kbits/sec Kilobits per second, i.e. a thousand bits per second

LAN Local Area Network A communications network limited to a small area, usually a single site

Local Area Network, see LAN

MAC Medium Access Control, part of IEEE 802.5 standard. Responsible for salving issues of contention for the medium

Mainframe A large or very large computer
MAN Metropolitan Area Network A computer network, typically covering whole or part of a city or conurbation, whose size is larger than that of a local area network, but smaller than that of most wide area networks. Usually it is situated within a compact area, whose largest dimensions range from about a mile to a few dozen miles.

Manufacturing Automation Protocol, see MAP

MAP Manufacturing Automation Protocol developed by General Motors Co.

MB see Megabyte

Mbits/sec Megabits per second, i.e. a million bits per second

Medium Access Control, see MAC

Megabyte (MB) About a million bytes; precisely defined as 1,024 KB, i.e. as 1,048,576 bytes

Menu A set of choices that is presented to the user, inside a single frame, i.e. screen of displayed information

Message A block of text or data that the user of a communications network or computer network wishes to have transferred as a whole

Message Transfer Agents, see MTA

Metropolitan Area Network, see MAN

Modem A device used to convert the digital signals used by computers into analog signals for transmission over conventional telephone equipment, and vice versa

MTA Message Transfer Agents, part of X.400 standard

Multiplexer A device combining the signals from several communication channels into a common channel, of greater bandwidth or data rate, for the purpose of data transmission

Multiplexing The process of sending several signals over a single transmission medium and separating them at the destination

National Science Foundation Network- see NSFNET

NetBios Network Basic Input/Output System

Network File Systems, see NFS

Network Layer The layer of the OSI LAN model that establishes protocols for packets, message priorities, and network traffic control
NFS Network File Systems, proprietary file server protocol. by Sun Micro Systems Inc.

Node A point in a network where several communication channels come together. It may incorporate a network device such as a terminal server, gateway, or router

Noise Extra signals. superimposed on the modulated information signal in a transmission medium, that can cause errors in the received information

NSFNET A three-level network sponsored by the National Science Foundation to support research. The NSF is responsible for operation and management of a high-speed backbone network. Linked to the backbone are mid-level network, which can be discipline-specific or regional

OCR Optical Character Recognition

OSI Open Systems Interconnection, see OSI Reference Model

Packet A group of bits that is transmitted over a network link as a single unit. A packet includes both data and control information (including source and destination addresses), arranged in a special format. Large messages are broken down into sequences of packets

Packet switching A method of communication in which a channel is occupied only for the time necessary to transmit a single packet, after which the channel is free to transmit a packet from another communication session

Packet-switched network A computer network or data network that uses packet switching

PAD Packet Assembler/Disassembler

Password A unique string of characters that a program, computer user must supply to meet security requirements before gaining access to a system and/or data

PBX Private Branch Exchange, a telephone exchange used within an organization for switching its internal and external telephone traffic

Peripheral(s) is the term used to describe an I/O device which can be connected to a network

PHY Physical, part of FDDI standard

Physical layer The lowest layer (layer 1) of the OSI model for network architectures, which provides the mechanical and electrical interface for the transmission of streams of bits over a network link

PMD Physical Media Dependent, part of FDDI standard

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Portability Is the ease with which a piece of software can be run on a variety of machines or under the control of a variety of operating systems

POSIX IEEE 1003.1 that defines basic functions of UNIX

Presentation layer Layer 6 of the OSI model for network architectures, which provides services such as encryption and translation between different data-representation codes

Private Branch Exchange, see PBX

Protocol A set of rules regulating information flow in a communication or telecommunication system

PSSN Public Packet Switched Network

PSTN Public switched telephone network A network, provided by a PTT or some other common carrier, to link together a large number of telephones through telephone lines and telephone exchanges. More generally, the world-wide networks of interconnected national PSTNs, provided by PTTs and other common carriers

PTT A (usually national) public telegraph, telephone, and telecommunications authority

Public switched telephone network, see PSTN

Remote Procedure Call, see RPC

Remote login The ability to log in to a computer across a network, rather than through a terminal attached directly to that computer

Repeater A hardware device linking network segments at the physical level (layer 1) of the OSI network model. Its function is usually to amplify signals to allow transmission over longer distances than are possible over a single piece of cable

Ring A local area network topology in which computers are linked in sequence, with the last computer linked to the first to complete the loop

Router A device linking network segments at the network level (layer 3) of the OSI network model. Usually implemented in a combination of hardware and software on a small dedicated computer, a router links local area networks and handles addressing across networks

RPC Remote Procedure Call, software that permits interprocess Communications, proprietary of Sun Microsystems, Inc.
Server A program or a dedicated computer that provides a service to other computers or users on a network

Session layer Layer 5 of the OSI network model, which controls the sequences of messages that constitute a networking session, which is like a conversation between two or more computers

SGML Standard generalized Markup Language

Simple Mail Transfer Protocol, see SMTP

SMT Station Management, part of FDDI standard

SMTP Simple Mail Transfer Protocol, the text mail protocol in the ARPANET family of protocols, based on TCP/IP

Standard A generally accepted, or at least widely adopted, formulation, specifying some particular aspect of the operation of a system or network

Station Network node, to which a device is attached, or a combination of network node and attached device

Store-and-forward A technique that stores packets or messages in node memories, while they are waiting for the next stage of their journey across the network

SWAN Satellite Wide Area Network

Synchronous communication Communication in which data is transmitted at a fixed rate, with the transmitter and receiver synchronized. By avoiding the need for start and stop elements, higher transmission speeds can be achieved more efficiently than with asynchronous communication

T1 A digital service offered by telephone operating companies, usually using fibre optics or microwave, to provide data speeds of 1.544 Mbits/second

TABCO A database containing bibliographic information, developed by ITESM

TCP/IP Transmission Control Protocol/Internet Protocol. TCP is a protocol in the transport layer of the OSI network model, and IP is a protocol in the network layer. The two are the basis for the ARPAnet family of protocols; it has been widely adopted by government agencies and universities and is supported on many types of equipment

Technical and Office Protocol, see TOP

Telenet A commercial packet-switching network
Teletext The form of videotex! where information stored in a computer is broadcast, usually in conjunction with television signals, to the user's TV set or terminal; it is usually one-way, not allowing any feedback from the user.

Telmex Telefonos de Mexico, Mexican PTT

Telnet The protocol in the ARPANET family that allows users to log in to a remote computer over a network.

Terminal An input/output device without general-purpose processing capabilities, designed for use with a host computer. A terminal usually consists of a screen display and a keyboard, with an interface for connecting to a computer or network.

Terminal emulation A technique for communication between a personal computer and a host time-sharing computer. A program runs in the personal computer, emulating the functions of a particular type of terminal.

Time-sharing A method of allowing many people to use a computer simultaneously by allocating slices of time to each user in turn.

Token ring A network protocol (in the data link layer) that uses a token to control access to a ring. The token circulates with other messages on the network. When a station receives the token, it may append a message to the sequence of messages circulating and then reinsert the token in the sequence. The station also takes a copy of any message addressed to itself and removes any messages that it has sent.

Token A distinguishable unit in a sequence of characters.

Token bus A network protocol (in the data link layer) that uses a token to control access to a bus. A station receiving the token transmits a message if desired and then forwards the token to the next station.

TOP Technical and Office Protocol developed by Boeing Co.

Topology The "topology" of a network is the geometrical specification of its configuration, showing which connections link which nodes and devices; strictly, this term should not specify the lengths, geography or physical nature of these connections, but it sometimes does so in practice.

Transparent A transmission path is "transparent" to some property of the data stream if that stream passes through it without change of that property.
Transport Layer The layer of the OSI LAN model concerned with protocols for error recognitions and recovery as well as regulation of information flow

Twisted pair Two thin insulated copper wires that are twisted around each other. Twisted pair is the most economical form of network wiring, since the wires are inexpensive and simple to connect

Tymnet A commercial packet-switching network

UA User Agents, part of X.400 standard

UNIX A computer operating system developed originally at AT&T's Bell Laboratories. Unlike most operating systems, UNIX was not kept proprietary. For a small license fee, it can be used, modified, and distributed among academic institutions

V Series Standards for PSTN data transmission, including those dealing with modems

Videotext The whole class of electronic systems that use a modified television set or visual display terminal to present computer-based information in a user-accessible visual form

Virtual circuit service A service in the network layer (layer 3) of the OSI model for network architectures, in which a transmission path is set up for a communication session

VSAT Very Small Aperture Terminals

WAN Wide Area Network A computer network, covering larger regions than those handled by local area networks, typically having distances between its nodes ranging from a few miles to hundreds or even thousands of miles. Thus its coverage is often national, sometimes international and continental, occasionally worldwide

Workstation A personal computing device on a network. In the context of university computing in the late 1980s, the term is used more specifically, referring to a personal computer considerably more powerful than an IBM PC running DOS or a regular Apple Macintosh. Typically, a workstation has an operating system capable of running several processes at once (multitasking), often a version of UNIX

X Series Standards for protocols and other specifications for new data networks. For example, the widely used X.25 and its allied protocols
X.25 A network interface standard for virtual circuit service at 56K bits/second over long-haul packet-switching networks. It is used by commercial networks such as Telenet

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