Chapter IV

SCENARIOS FOR FUTURE DEVELOPMENT

Contents

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Purpose of this chapter

This chapter aims to provide the background for the preparation of some possible future scenarios which will be required for strategic planning. In particular, the transition from the conventional single service, single technology network towards the concept of multi-service (and therefore probably multi-technology) networks is considered in some detail together with descriptions of the advanced technologies now becoming available. For developing countries, some of these technologies are obviously irrelevant at the present time when priority has to be given to expanding and improving the service quality of their conventional networks but it is nevertheless prudent to be aware of the future possibilities. A more immediate requirement is the transition from an analogue to a fully digital network, strategies for which are also included in this chapter. This is the principal short-term requirement for developing countries.

Finally, the concept of the Telecommunication Management Network (TMN) is introduced. TMNs will be essential items of the future network and must be included in all the scenarios to be considered.

Outputs to be included in this section of the plan

- Definition of some possible future service scenarios;
- Definition of digitalisation strategy;
- Definition of time-scale for the above strategy;
- Possible time-scales for introduction of new services.

Inputs required

- Complete inventory of present network;
- Full description of management organisation;
- Analysis of present network capability;
- Subscriber and traffic forecasts;
- Market surveys of future services;
- Consultations with government on future policies.

Chapter IV

SCENARIOS FOR FUTURE DEVELOPMENT

4.1 Network planning stages

4.1.1. Network structures

As is well known, the basic idea of **Telecommunications** is the exchange of information over relatively large distances or between separate locations. The **Information** may include voice, text, data and image. A **Telecommunications network** is therefore largely a **System** or **Machine** which can provide these **Services** to a number of **End Users**. The business idea is that an organisation - a **Network Operator** - can plan, install, run and maintain such a network and that the **End Users** are connected to the **Network** and can enjoy the **Services** by paying for them. The end users have usually to provide the necessary **Terminals** for the desired communication services.

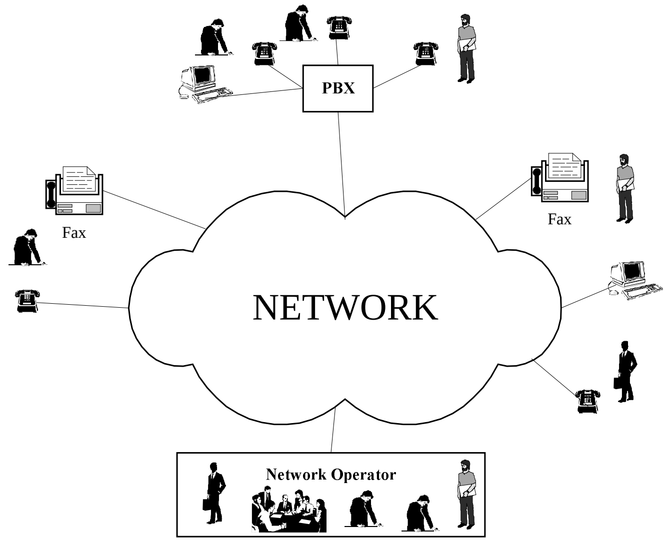


Figure 4.1 : Two kinds of users: End Users and the Network Operator .

From the end users' point of view, the network has some main tasks: to interconnect between end users, to transfer information between them in a form that suits the end users' terminals, to send and receive signals to/from the end users to facilitate the establishing and maintaining of the communication and to provide additional services such as wake-up calls, information about the price of the last call, etc.

The main tasks of interconnecting and transferring information require that the system comprises a number of links between the end users. Each link must consist of a medium to carry the information - the signal - which may utilise electricity, light or radio waves for the transfer, and some transmission system for the organisation of the signal. This indicates that links could be expensive so that they are not provided between all pairs of end users, but are arranged in a network, over which each connection can be established along a path comprising several links in tandem.

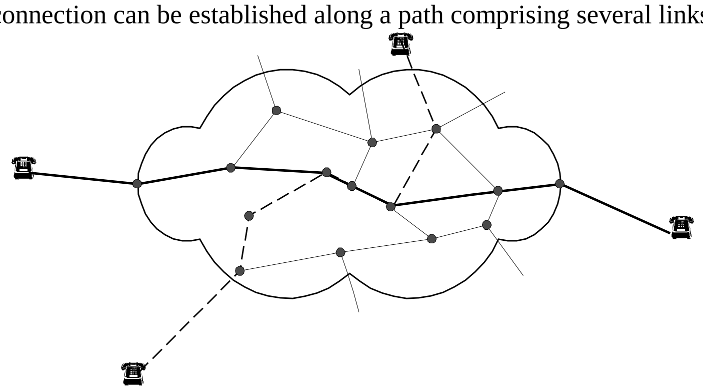


Figure 4.2 :A network comprises nodes and links.
Two connections through the network are shown.

It is obvious that several connections may utilise partly the same links, partly different links so that each link must therefore comprise several channels. Another observation is that links meet in nodes and that each node must be able to select links so that correct connections between end users are established. To do this, a node must be able to co-operate with other nodes, to analyse and use address information. Thus, a telecommunications network comprises **Nodes** and **Links.** Now let us consider three different concepts of the network structures as outlined below:

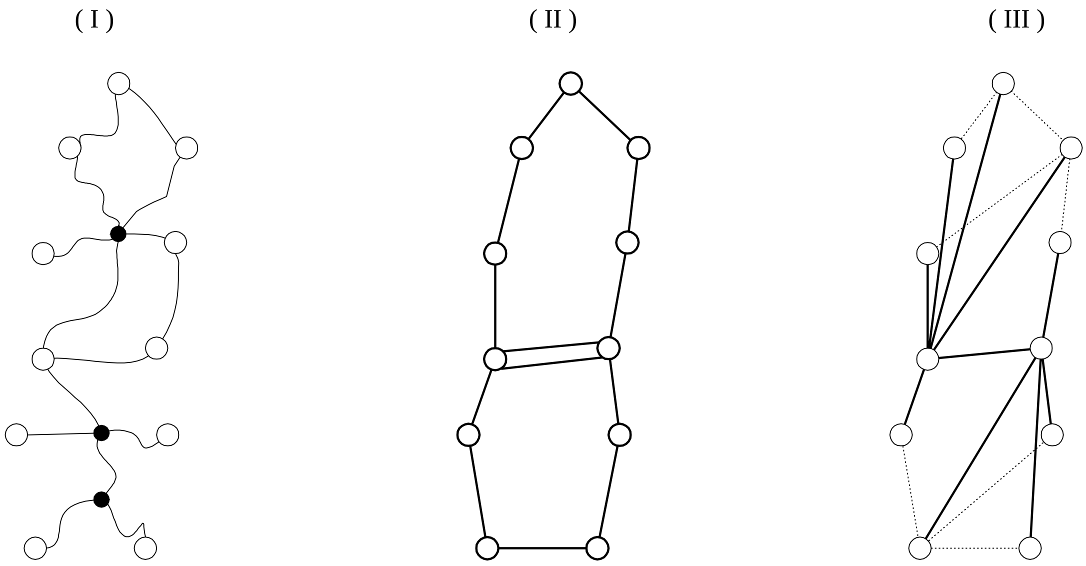


Figure 4.3 : Three different network structures.
Circles and points represent nodes; full or dotted lines are links.

We can identify nodes drawn as small circles and links drawn as lines. In structure I there are also some nodes drawn as points, and in structure III there are some links drawn with dotted lines.

As a matter of fact, all three structures describe one and the same telecommunication network, but illustrate different aspects:

- (I) represents the **Geographical** structure. It refers more or less exactly to the geographical map of the service area. The **Links** are cables, radio relays, etc. and the **Nodes** are buildings and branching points, the latter drawn as points.

- (II) represents the **Physical** structure of the network, showing the transmission resources. The **Links** are thus transmission systems, and the **Nodes** represent main distribution frames, multiplexers, cross connects, etc.

- (III) illustrates the **Logical** structure. The **Links** are traffic routes and the **Nodes** are switches. Low-loss routes are drawn with full lines, high-usage routes with dotted lines.

The **Geographical** structure shows how the actual cables are located. The **Physical** structure shows that the transmission resources are arranged as two complete rings. The **Logical** structure shows that alternative routing is employed, and that there are two tandem points in the network.

When considering the network structure it must be remembered that there is now an increasing trend for the national network (PSTN) to involve several operators. Thus a national long-distance call could be processed by more than one operator. The implications for the network planning in this case are obviously the necessity for a more rigorous coordination between operators, enforced if necessary through regulation, and a strict adherence to unified technical standards by all concerned. Regulators in developing countries in which more than one network operator is envisaged should therefore ensure that the necessary coordination procedures are agreed and in place well before multiple operation commences.

4.1.2 Network properties

The future network must be able to do much more than the present one. It will have to carry not only voice and data, but also text and image. Ultimately, connections between end users might be of **Multimedia** type i.e. comprise all of these single service classes. Besides this, each service class will comprise quite a few different particular services, each requiring a particular minimum bandwidth of transmission. The end users will have the possibility to compose their own set of services and to change the mix of services whenever they wish. At the same time, a number of dedicated networks are being built now - data networks, mobile networks, etc., so that the future main network must be able to bridge between these dedicated networks. Demand and traffic patterns will change faster than they do today. Thus, one important property of the future network is **Flexibility,** which implies:

- Easy and fast implementation of new services.
- Allocation of bandwidth on demand.
- Easy and fast adaptation to large changes in demand and traffic pattern.
- Easy and smooth interworking with other networks.
- Easy updating of transmission, switching, etc.

However, this new network will tend to be much more complex than the present one. It will also require more sophisticated technology and more intelligent control and management functions. Unless we try hard to choose simple solutions, the result could be a network that is complicated to plan, supervise and operate. Thus, **Simplicity** should be the key to the design of the future network, in terms of planning, engineering, supervision,management and operation. Particular attention will have to be given to efficient and simple signalling systems.

It would not be so difficult to build networks which are both **Flexible** and **Simple**, provided that unlimited funds were available, but that is not at all the case. On the contrary, it will be more important than ever before to minimise the cost of the network, including not only the capital cost, but also the cost for installation, maintenance, future replacement, etc. Especially, management costs will be more important than today. Thus, **Cost Effectiveness** will be the third important property.

4.1.3 Network planning

The future situation for the network operator may be one of strong competition, since it will be possible for any competent software house to create new telecommunication services in the form of pure software, which can be loaded into the network from special nodes. Such service providers will sell services to the customers. A customer can sometimes be a single end user but is more often a company with many end users (= employees). Since the general network will carry the traffic, this gives of course an income to the network operator, but the majority of the revenue may go to the service provider. Nothing, however, prevents the network operator from **trying** to be a service provider as well.

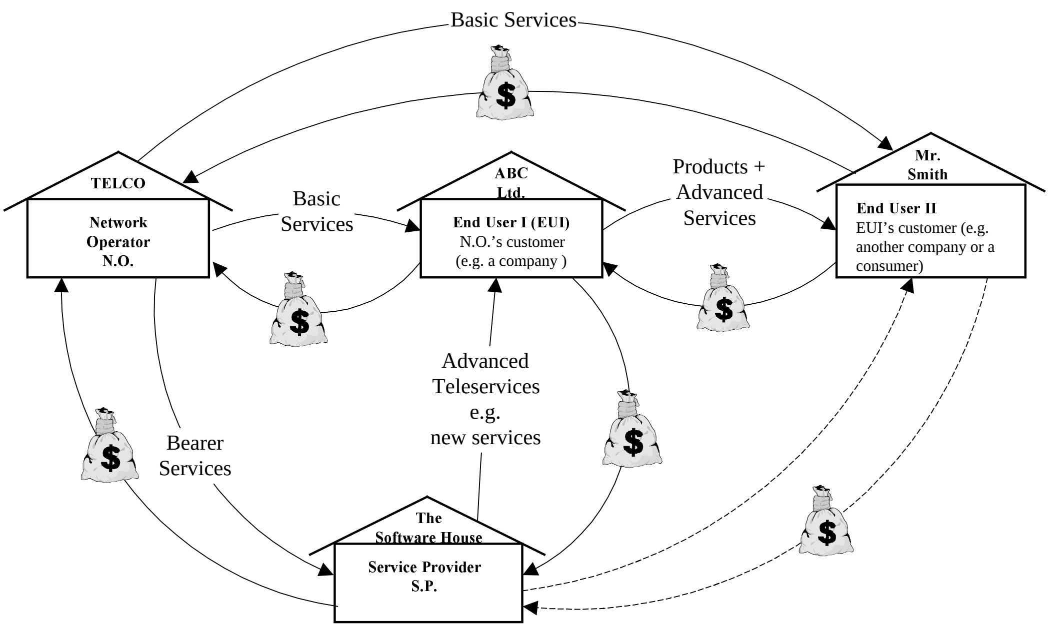


Figure 4.4: Possible future service provision situation.

It will be necessary to have a much more service centred view of the telecommunication network than before, and the planning of the network actually ought to start with a definition of **Service Scenarios.** When possible and needed services are determined for the strategic future points of time, the corresponding **Technical Requirements**, such as use of CCS No.7, intelligent networks, broadband communication etc. should be defined. The next step is to define the distribution and amount of services, i.e. to carry out **Forecasts.** Now it is possible to draw up a **Network Architecture** which describes the network in terms of network functions. After that the **Network Structure** can be planned, which shows how different systems can interact to carry out the network functions. The last step is to define equipment in all nodes = **Node Planning**. To carry out the last two steps, we have to select network elements in the form of switching and transmission equipment.

The process is in reality not very straight-forward but rather more iterative, and each of the different steps may require several revisions. Furthermore, in connection with the first three steps, some kind of service implementation analysis should be done. The last three steps should include network optimisation and dimensioning.

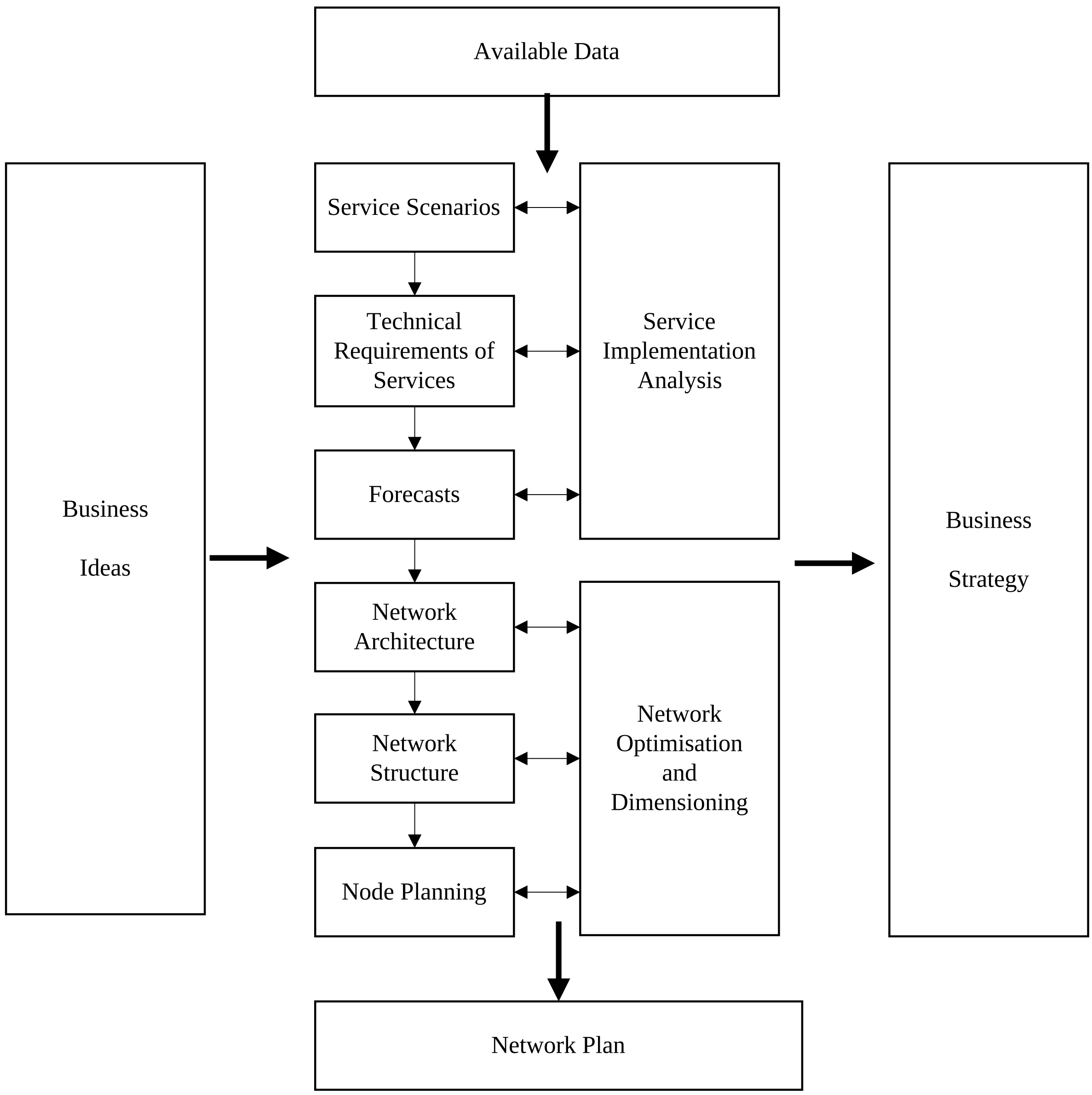


Figure 4.5 : Network planning steps.

4.2 Service development

4.2.1 A service centred view

In the past the telecommunication network was based on single service, single technology. This is now rapidly changing towards the multi-service, multi-technology network. Telecommunication services and technology must therefore be made much less dependent on each other. It must be possible to define services independent of technology and it must also be possible to use service control software designed for one technology for others. We should therefore **not** buy particular products because they offer some particular services, but rather because their **Network Functionality** enables the network to provide the services which are really needed.

There was also a simple relation between the network operator and the customers, who were the subscribers. Possibly, subscribers were split into classes, e.g. residential and business subscribers. Now we may define the different roles in telecommunications as:

- **Network Operators**
- **Service Providers**
- **Customers**
- **End Users**

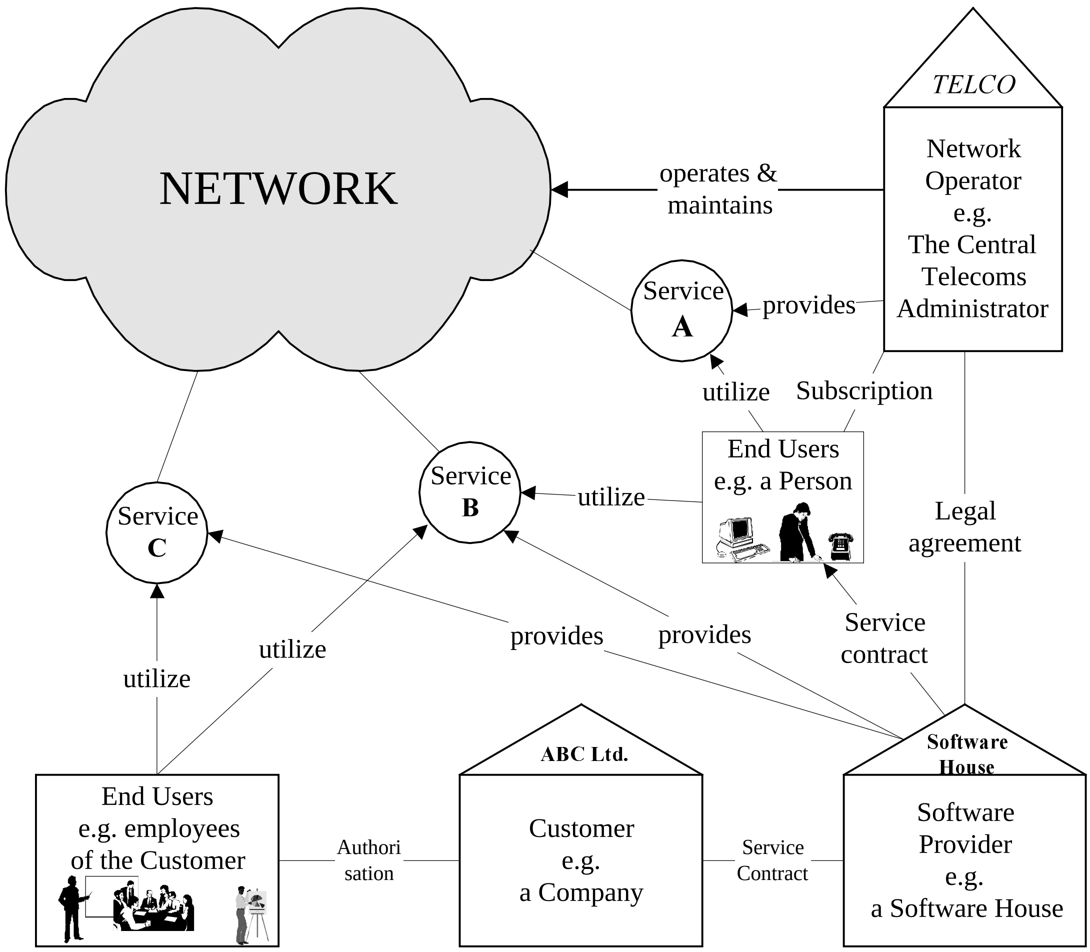


Figure 4.6 : Relation between parts on the telecommunications market in a simple case.

A **Network Operator** operates and maintains the physical network and node equipment that is required to support the services.

A **Service Provider** is an operator offering services to customers, e.g. teleservices, supplementary services, value added services. The service provider may get a particular service from another service provider, so he may be a customer in that situation. Furthermore, an independent service manager may actively manage a particular service on behalf of the service provider.

A **Customer** is a person or an organisation, for example a company, which has a service contract with a service provider. The customer pays the bill and utilises the services. However, the customer may enhance some of the services he pays for, thereby creating value added services which he may sell back to the service provider or offer to his own customers.

An **End User** may be a **General User**, i.e. a user who addresses a specific service by means of for example the directory number, or an **Exclusive User**, who is **associated** to the specific service and is authorised to use it by the customer.

Thus, we see that any particular organisation and even an individual person may play more than one role in telecommunications and that the relation between the parts may be complex.

4.2.2 Service classification

From the end user's point of view, the network should offer:

- **Accessibility**
- **Transparency**

In other words, the end user wants immediate and guaranteed access to persons, terminals, processes, information data bases, etc., and he wants the system to provide this without interference, i.e. the information should be provided with no delay, and arrive crystal clear and completely unchanged. Due to the large number of technical implementations, system concepts and the use of diverse technology a multitude of new services have been defined. The extensive existing service classifications thus depend on technical constraints.

We may classify services from the end users' point of view as:

- **Access to Persons**, such as POTS, video conference services, CAD/CAM conference, EDI, etc.

- **Access to Information**, such as TV, CATV, radio broadcasting, books, magazines, newspapers, data base retrieval, etc.

- **Access to Information Processes**, such as access to computer capacity, distributed processing, etc.

These three groups attract different markets, which may facilitate the planning, since the different user categories have a difference in price elasticity. Business customers, for example, are much less sensitive to tariff variations than residential users, but more sensitive concerning the total cost of using a service.

There are many ways of dividing the services into categories. We may for example use the CCITT classification into five groups by the information type:

- **Multimedia Services**

- **Voice Services**

- **Image and Video Services**

- **Data Services**

- **Text and Document Services**

4.2.3 Current telecommunications services

Many telecommunications services are already available. Unfortunately, they are often based on quite old technology, which sometimes has made them less than user-friendly. The design of these services has been based more on the capability of existing networks and systems to support them rather than on actual users' requirements, with the result that there are often limitations concerning accessibility and transparency. Some of the existing services are described below.

Telephony

- **Call Forwarding**
  This service makes it possible to move the telephone number from the ordinary main telephone set (main line) to another set, which thus temporarily can be reached by two numbers. The service intends to increase the accessibility, but it is not very user friendly. It is for example easy to forget that the phone is in call-forwarding mode and thus lose incoming calls.

- **Automatic Call Distribution**
  Incoming calls will be automatically distributed among different attendants. This may increase the accessibility to services, e.g. information services.

- **Queuing**
  The service gives automatic information of an incoming call during a call already in progress, and allows the called party to switch between the two calls. This increases the accessibility.

- **Call Back**
  If the called line is busy, a second call attempt will be made as soon as the line becomes free, which gives increased accessibility.

- **Hot Line**
  Automatic call to a predetermined number as soon as the handset is lifted. Note that the call is switched and set up after the handset is lifted. This means increased accessibility to a particular user.

- **Freephone**
  The service allows users to call certain numbers without being charged. It is used by commercial companies to stimulate potential customers to call them. The companies can locate their sales or information facilities independently of where the customers are.

- **Terminal Mobility**
  This service is based on mobile telephony and means wireless access. There are two kinds of mobile services. The first one is cellular radio and offers mobility over large areas, e.g. a whole country or a region. The second one is called cordless telephones, where cables between the handset and the wall socket are not needed, so the user can walk around in the immediate vicinity while using the service.

- **Information Services**
  The service is based on speech synthesis and pre-recorded messages. The telephone can be used to get information and advice. Since the service is interactive, they allow for example bank account transfers, ordering of goods and selecting among information topics.

- **Centrex Services**
  Centrex services are business communication services realised for example as virtual PBX functions offered from the ordinary local exchange.

Telefax

Telefax is a pure non-voice service and is thus different from telephony from the transparency aspect. Otherwise, it is a service often used in combination with telephony. The user may have a combined telephone and telefax terminal and can either switch manually between the two services or programme the terminal to do this automatically depending on the type of signal received. Telefax demand developed slowly during a long period but the situation is now radically changed. Some Telefax terminals are low priced, the tariff is usually the same as for telephony, and the ordinary telephone line can be used.

Data communication

In this case, computers are used to exchange or transmit information. There are many different services in addition to services such as Teletex and Videotex which are offered by the public network operators. The only common base is provided by the CCITT bearer service interfaces such as V.24 in the telephone network, X.21 in circuit switched data networks and X.25 in packet switched data networks. Accessibility and transparency varies between different applications.

Mobile data communication offers terminal mobility. Two cases occur, the first one, being based on cellular radio or satellite, gives mobility over large geographical areas; the second one using radio instead of cable between portable computers and the wall socket gives local mobility, for example in offices and factories.

Videoconference

This service combines several media, adding real time video and image communication to telephony and thus offers very good transparency. The drawback is that the equipment is quite expensive. Therefore, there are few customers for this service so far.

4.2.4 Future telecommunications services

The number of available, planned and envisaged services is rapidly increasing. This is due to accelerated technology development, strong competition between telecommunication manufacturers and of course also to demand based on socio-economic and commercial development. Network operators and service providers should attempt to exert more influence on the conception and design of these new services as they could probably define the needs from a more user-centred point of view.

Well defined generic services could often give each individual user the possibility to design a service application that best fulfils his needs. No single specific service could meet all users' requirements. A user may also want to switch between or combine different media and ways of communication on one and the same occasion.

For a service provider, it will be very important to determine what impact on the infrastructure a potential new service will have. Services that rely on a modified infrastructure would probably require a much longer, less certain and thus costly period of introduction. Services designed from a user centred view may of course fit very well into the existing infrastructure, but may at the same time not fit so well into the existing telecommunication network. If a potential service has to be introduced very quickly, it is then important to apply both a user **and** a network centred view for definition of the service.

It is also very important to classify the range of services using some kind of segmentation. Preferably, more than one kind of segmentation should be used, so that the consequences of services and sets of services for the users, for the telecommunication system, for the service providers and for the network operator can be assessed.

The network operators used to plan for the introduction of specific services for years ahead. This will not be possible in the future, since the customers will require tailor-made services for the specific needs of their different users. Customisation will be a very important principle, especially to fulfil the needs of the large customers.

Each service provider and often also the customer must have control of the service definitions which must be easy to make and to implement. This means that service management requirements must be considered when new services are defined.

In general, the single-service, single-technology network will develop into a multi-service, multi-technology network, and the development and support of the very large number of new services has to be much less dependent on the various implementation technologies, otherwise, the service development costs will be too high and the process will be far too slow. Furthermore, one would certainly not arrive at **simple** network solutions.

What is needed is a good **Service Architecture** which can support efficient development and implementation of customised services, cost effective and simple network solutions that are less dependent on the introduction or modification of services and can reduce the total number of software products that are to be operated and maintained. This means that software must be modular and re-useable.

The manufacturers are trying to meet these requirements by developing Intelligent Network Service Platforms. This approach will give service providers and even customers the possibility to define new network services by direct access to special nodes in the network.

Some of the services likely to be important in the future are described below.

Mobility

There are two main kinds of mobility: **terminal** and **personal** mobility. Total **terminal** mobility is offered by cellular radio to mobile users, restricted **terminal** mobility is offered both to mobile and to fixed subscribers via the conventional network. **Personal** mobility enables a user to use any access, fixed or mobile, and offers global or national accessibility to customer specified services. Mobility adds value to the telecommunication services and stimulates new demands and additional services, such as voice mail, calling number identification, call answering services, etc.

Bandwidth on demand

Different types of transfer through the network require different bandwidths and bit-rates. Transfer of images, high quality sound, graphics, etc. require much higher bit-rates than are available over the present conventional networks. Thus, broad-band transmission must be introduced, but flexibility must also be taken into consideration. If a particular user for example needs only 20 Mbit/s he will not be willing to pay for 140 Mbit/s, if that happens to be next modular bandwidth. Furthermore, he may need the 20 Mbit/s only for a month or a few days. To satisfy such needs at a reasonable cost, the network must be very flexible from the transmission resources point of view, and the management of the network must be very easy and fast.

Multimedia

Multimedia will use more than one medium for communication, for example audio, text, graphics, animation, video and still images. Multimedia applications are video conference, education, training, information, entertainment and ordering of goods.

Multimedia will be used more and more for various reasons. In the field of education, for example, multimedia applications are very cost effective, and offer education to distantly located users without time restriction.

The computer industries are very active in the multimedia field and are designing products based on digitally stored and transmitted live video. Multimedia services require large bandwidth and generally broadband communication, even if there are compression technologies offering simpler versions of for example video over narrowband ISDN 2B+D access.

Interaction

The traditional telecommunicative way to interact is by means of conversations. A new way to interact is based on **messages,** where the services offer interaction by message handling functions such as information, editing, processing and conversion or by mailbox, etc. Message handling applications are electronic mail (E-mail), electronic data interchange (EDI), answering services, voice mail and video mail. Another interactive mode is **retrieval**, the applications being retrieval of information stored in information data bases. A very good idea for network operators and service providers is to subscribe for retrieval in data bases where articles on telecommunications are stored. The subscriber can then define search profiles dependent on the area of interest.

Other services

Electronic Signatures will offer protection from unauthorised access to electronic documents, which may also give the possibility of making such documents legally binding.

Distributive Services such as radio broadcasting, TV and video may be integrated with the telecommunication network in order to finance broadband communications, since a common infrastructure could be made much more cost effective.

CCITT service classification

The possible future use of alternative media, multimedia and interactive services, perhaps combined with integration of all kinds of distributive services, will give a very large total number of services. CCITT has proposed two classifications, one being based on media segmentation, and the other being network centred. Figure 4.7 shows a collection of present and future services. The CCITT classifications are used with the media segmentation on the vertical axis and the network centred definitions on the horizontal axis.

	INTERACTIVE	MESSAGE	RETRIEVAL	DISTR.SERV. With User Pres. Contr	DISTR. SERV. Without UPC
TEXT	High Speed Fax 10-150 Mbit/s	Text 64 kbit/s-45 Mbit/s	Document Management		
“	FAX 64kbit/s	Remote Printing	News Retrieval		
“			Education/ Training		
DATA	Bank Transaction 10 Mbit/s	EDI 1-10 Mbit/s (100 Mbit/s), CAD/CAM	Software Library 2-150 Mbit/s, CAD/CAM		
“	Logistics 1-10 Mbit/s	Logistics, Just In Time (JIT) 10 Mbit/s	Database Information Retrieval 2-150 Mbit/s		
“		Remote Printing, Mainfr. File Trans 10 Mbit/s	Technical Design		
IMAGE	HDFAX 100-150 Mbit/s	Graphics, Technical Design 45-150 Mbit/s	Frozen Video Images 2-45 Mbit/s	Pay-TV, Pay Per Channel 45-150 Mbit/s	CATV 45 Mbit/s
“	Medical/Clinical 10-600 Mbit/s	CAD/CAM 100-150 Mbit/s	Videotext 2-45 Mbit/s, Videomail	HDTV, BQTV 45-150 Mbit/s	HDTV, BQTV 45-150 Mbit/s
“	CAD/CAM 100-150 Mbit/s	Doc. mail service 1-10 Mbit/s	Advertising, Home Shopping 2-45 Mbit/s		
VOICE/ AUDIO	POTS 64 kbit/s	Answering service 64 kbit/s	Hifi/Stereo/ Audio 1 Mbit/s	Hifi/Stereo/ Audio 1 Mbit/s	Hifi/Stereo/ Audio 1 Mbit/s
“	Tele. Conference 64 kbit/s	Voice mail 64 kbit/s	Voice Mail		
“	Pers. Tele. System (PTS) 64 kbit/s-2 Mbit/s		Spoken Information Services		
MULTIMEDIA	Video Conference 30-45 Mbit/s	Personal Security Network 64 kbit/s-2Mbit/s	Logistics 1-10 Mbit/s		
“	Video Telephony 2-150 Mbit/s	Video mail 2-45 Mbit/s			
“	Surveillance, Security, Protection 2-45 Mbit/s	Surveillance, Security, Protection 2-45 Mbit/s			
“	CAD/CAM, Logistics 100-150 Mbit/s	CAD/CAM, Logistics 100-150 Mbit/s			

Figure 4.7: Present and future services

4.2.5 Other important services and service aspects

Customer services

The customer has a service contract with the service provider. In many cases he is also the end user, but often is not, for example when the customer is some kind of organisation such as a company, an institution, etc. In this latter case, he may require particular customer services that will not be made available to the end users, such as charging information, service configuration and restriction management and network management. The customer may obtain on-line access to the corresponding inter-active information services via his computer equipment.

Service management services

Network operators, service providers, and in some cases customers, will need efficient, reliable and user oriented services for: **Service Design and Implementation** for the creation of new, especially customised services; **Service Provision** for activation and modification; and **Service Management** for supervision and control of services and service processes.

Network management services

These are on-line services for network status information and management, facility and traffic management, charging information, etc. These services are tailor-made for the use of the network operator, but sub-sets of such services may be made available for service providers and even customers. Such sub-sets are called **Customer Network Management** and offer the customers a way for better and more flexible utilisation of the network.

4.3 Specification of service requirements

This subsection intends to give guidance on how to specify service requirements so that networks which can offer the corresponding services may be designed based on these requirements. Figure 4.8 shows how some future types of service could be implemented in the (future) network.

We see that several different kinds of network may cooperate in such a way that end users can communicate irrespective of where they are connected. Also, we will find the same kind of service in several different networks. We will for instance have **Fax** users in the PSTN, CSPDN, PSPDN and ISDN. We see that in this scenario, ISDN will interface all the other networks, the PSPDN via a Packet Handler, the other networks via Interworking Units (IWU).

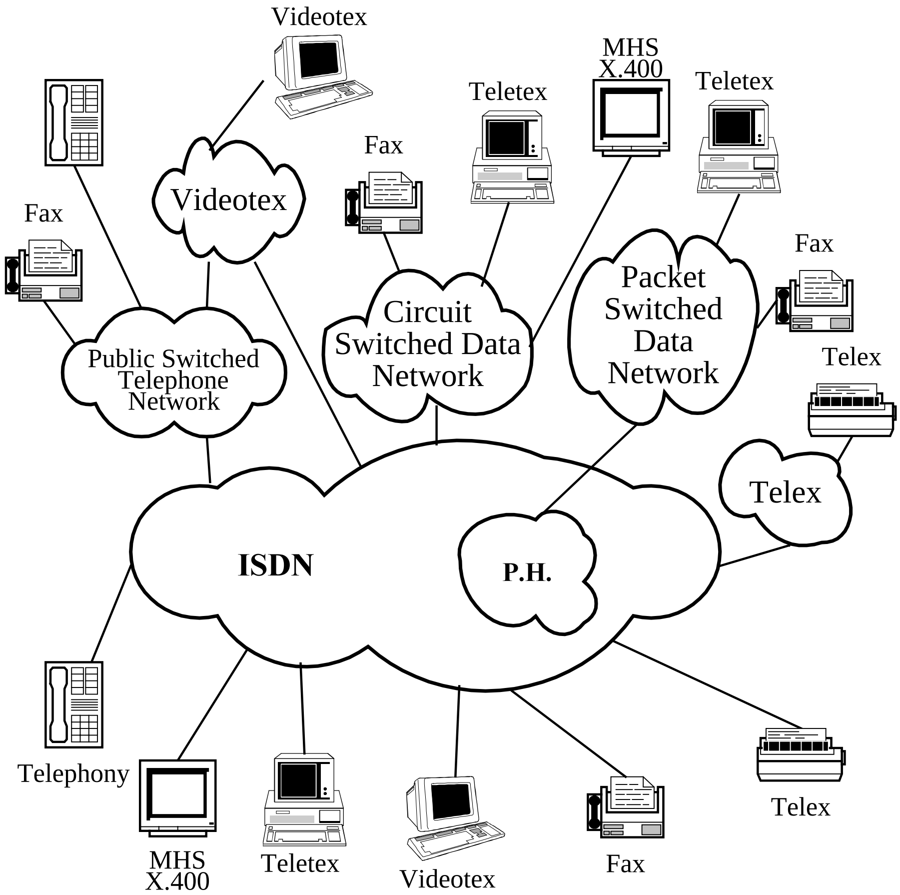


Figure 4.8 : Teleservices and networks

It is possible to design networks which can provide these services in many different ways. Let us consider three main generic possibilities:

1 **Service Specific Developments** in the form of “add-on” service packages. This tends to be a cheap solution, and the services can also be designed specifically for the applications. The potential for further development of a particular service will however be limited;

2 **Network Overlays**. Solutions of this type tend to be much more expensive than add-ons, since they typically depend on special purpose switches engineered to work in the network, but they may offer the capability for further development. The necessary integration into the existing network requires signalling and numbering arrangements which increase the costs and the implementation time-scales;

3 **Integrated Network Capability**. This means incorporating the new service into the switches of the network. This solution involves special switch development and is very costly, time consuming and risky.

With the accelerating number of new services it seems as if the first possibility - add-on service packages - would be preferable. Figure 4.9 aims to illustrate this service development over time.

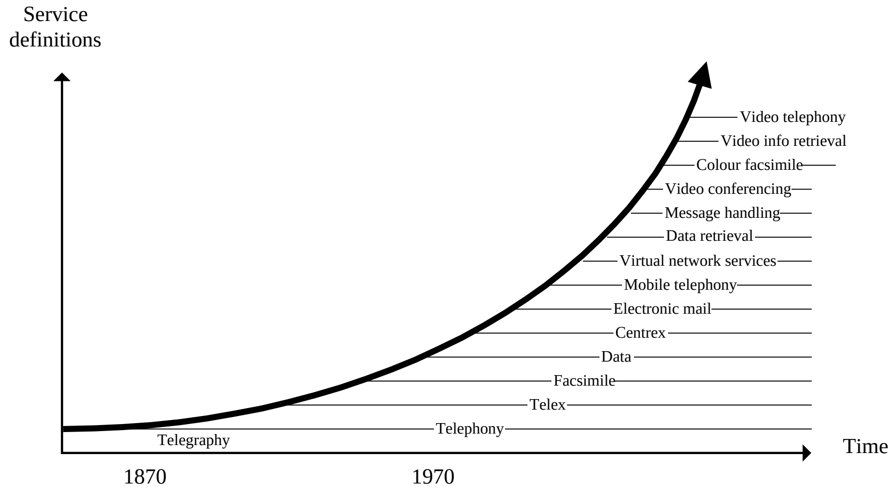


Figure 4.9 : Service development trend

The service explosion in recent years imposes new requirements on network operators and their networks. With a flexible network concept the explosion may result in increased revenues. In order to facilitate the planning of a simple, flexible and cost-effective network which can offer high quality services, it is important to specify these services as well as possible. This applies both for service scenarios and forecasts as well as for specification of the requirements which the services put on the networks.

4.3.1 User's requirements

It is first necessary to consider the **user needs** which can be listed as follows:

RESIDENTIAL

Personal needs
Less time in queues
Less time commuting
Flexible work at home

Remote access to data
Banks
Stock Exchange
Financial Information

Education
Distance learning

Entertainment/amusement
Interactive Games
Movies
International TV

Childcare assistance
Work at home
Remote access to doctors

Remote shopping
Goods
Food

BUSINESS

Business improvements
Increased effectiveness
Faster access to information
Efficient operations
Reduced staffs
Better planning
Records of transactions

Computers
Inquiry

Retrieval
Processing
Analysing
Presentation

Communication
High resolution
High quality
Reliable
Cheap

Information exchange
Voice
Data / Text
Video
Image

Consider also the **GLOBAL INFORMATION SYSTEM**:

END USER SYSTEMS	**NETWORK SYSTEMS**	**INFO PROCESSING SYSTEMS**
Voice	**Fixed Connections (leased etc.)**	**Transaction Processing**
Data		**Scientific Calculation**
Text	**Switched Connections (Packet, circuit, etc.)**	**Development Support**
Video	**Conversions (format speed, protocol, media, etc.)**	**Image Processing**
Combination		**Info Retrieval**
"APPLICATION ORIENTATION"	**"INFO CONTENTS MAINTAINED"**	**"INFO CONTENTS CHANGED"**

TeleServices ← → **Bearer Services**

Telecommunication Services

Value Added Services

Note that an **end user** sees the **tele services** and that a **terminal** sees the **bearer services**.

Figure 4.10 shows the new services which could be implemented on the ISDN.

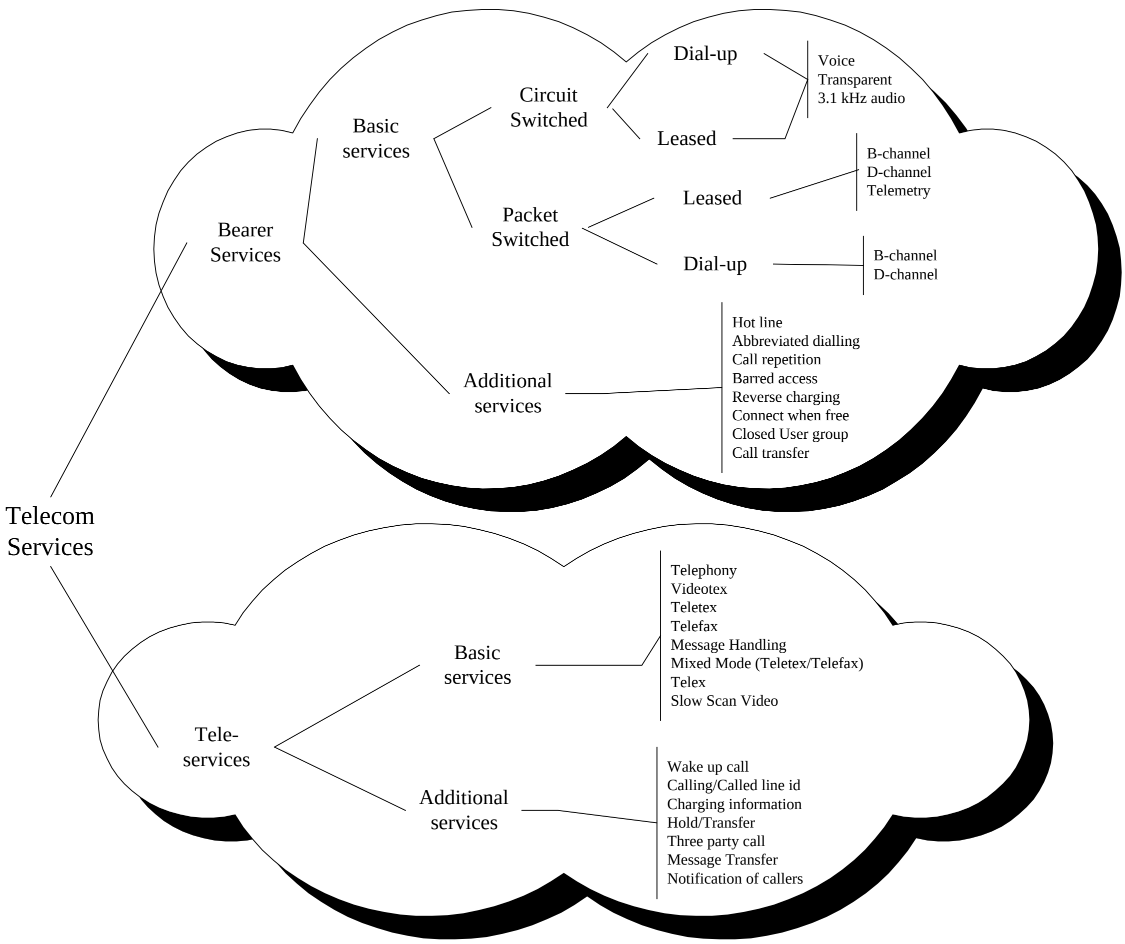


Figure 4.10 : ISDN services

4.3.2 Bandwidth requirements

An important requirement is the **Bandwidth**. Usually, references are made to “Narrowband” ≤ 64kbit/s, “Wideband” ≤ 2 Mbit/s and “Broadband” ≥ 2 Mbit/s. Examples of presently estimated bandwidth requirements - user rates - for various services are listed below:

Voice	POTS	64 kbit/s
	7 khz speech after compression	64 kbit/s
	Voice mail box	≤16 kbit/s
	Packetized speech	< 64 kbit/s
	DCME	(10-20%) x 64 kbit/s
	GSM mobile-base station	13 kbit/s
Text	Telex	50 bit/s
	Teletex	2.4 kbit/s
	Info retrieval	1.2 kbit/s
	Message to database	75 bit/s
	Electronic mail	< 64 kbit/s
Data	Transaction oriented data service	≤ 64 kbit/s
	Normally	2.4 or 4.8 kbit/s
	File transfer	64 kbit/s to 8 Mbit/s
	LAN interconnection	≤ 70 Mbit/s
Image	Facsimile group 1-3	2.4 kbit/s
	Facsimile group 4	2.4 to 64 kbit/s
	CAD/CAM, graphics	64 kbit/s to 34 Mbit/s
	Photovideotex	64 kbit/s to 2 Mbit/s
	Photofax	2 Mbit/s
	Simple videophone compressed	64 kbit/s
	“Normal quality” videophone, compressed	2 Mbit/s
	Slow scan tv	64 kbit/s
	Videoconference compressed	64 kbit/s to 2 Mbit/s
	TV compressed	34 Mbit/s
	High definition TV compressed	140 Mbit/s

Dramatic changes in services can however only come when access to high bandwidth comes to the user site, which probably implies that optical fibre must be connected to the office and to the home. New services and intelligent information systems may mean new ways to work: telecommuting and teleworking could offer some people a better life style, but not all people will welcome such changes. As new services become more complex and more powerful, the investment cost unfortunately increases, which probably means that increasing international cooperation will be necessary to create markets large enough to justify new products. In the future, fewer and fewer corporations will be able to finance the developments of new services on their own.

Figure 4.11 shows the bit rates for some main telecommunication services.

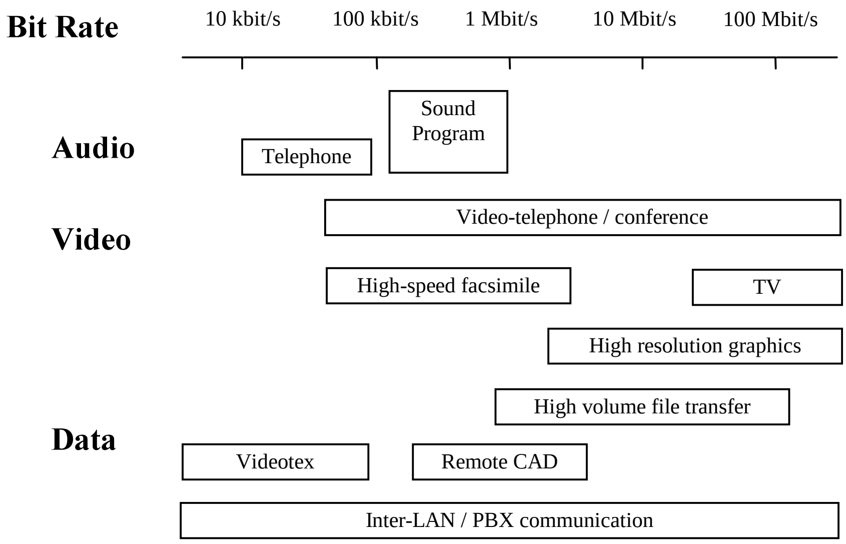


Figure 4.11: Bit rates for telecommunication services

Another important aspect is the nature or usage frequency of the various services. A relatively slow protocol such as X.25 may have difficulties with very "bursty" services. Figure 4.12 shows the estimated usage frequencies of current services.

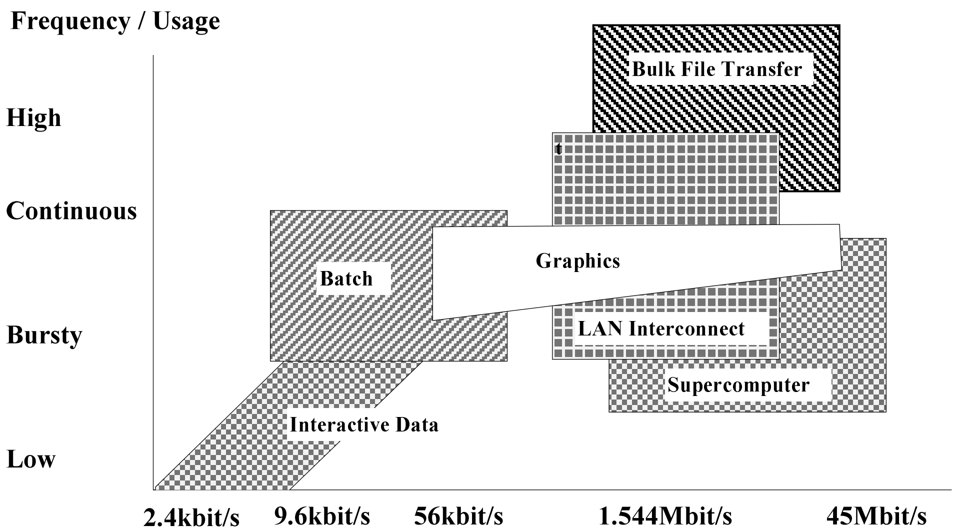


Figure 4.12: Bandwidth requirements for current services

In addition to switched and reserved connections, a new feature known as **Bandwidth On Demand** will be very important in the new network. Figure 4.13 shows a possible scenario for the use of switched connections, reserved connections and bandwidth on demand.

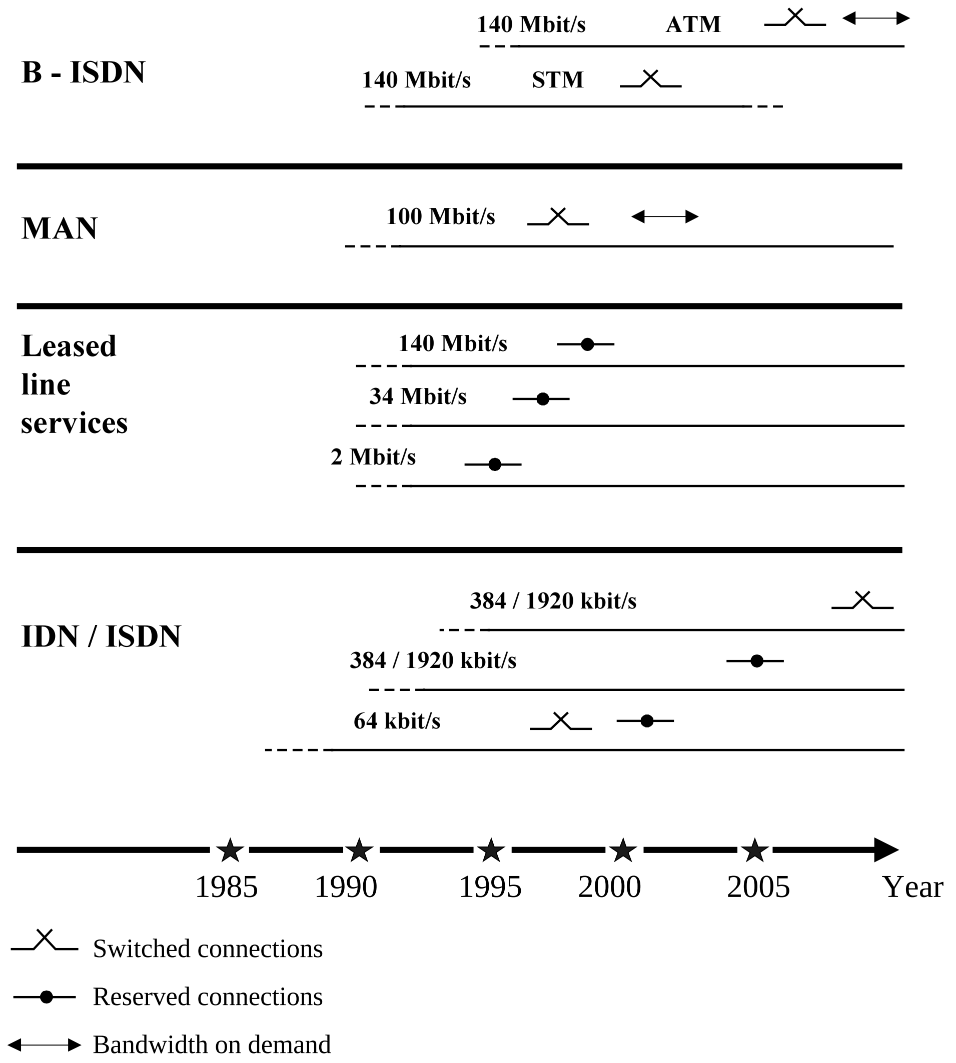


Figure 4.13: Scenario - broadband capabilities

4.3.3 Network requirements

Many requirements will be placed on the network by these services. A distinction is made between the **Transmission Network** and the **Public Switched Network**.

Requirements for the transmission network:

Minimum bandwidth;
Maximum delay;
Quality of transport;
Reliability/availability;
Interface;
Maintainability.

Requirements for the public switched network:

All the requirements put on the transmission network;
Protocols to control the connection (set up, clear etc.);
Acceptable post dialling delay and clearing time;
Grade of service;
Access - connectivity (64 kbit/s, 3,1 kHz etc.).

4.3.4 Service requirements

The specification of service requirements could be structured as follows

a) <u>Minimum range of services for a specified period (example):</u>

POTS
POTS supplementary services such as call transfer, wake-up etc.
Mobile telephony
Telex
Facsimile, group 1-3
Videotex, 1200 bit/s
Transaction oriented data service
File transfer data service
Centrex
800-service
Credit card validation
Private meters
Operator services
Electronic mail X400

b) <u>Highly interesting services during the period (Example):</u>

Slow-scan video
Photo videotex
Videophone 64 kbit/s, Videoconference
CAD/CAM, Graphics
EDI (Electronic Data Interchange)
Calling number display
LAN interconnection (point-to-point, switched)
Facsimile group 4
Digital transport of HDTV, PAL TV

c) <u>Business service forecast</u>

Here, we consider ≥ **2 Mbit/s** sources, which could be high speed services or composed of multiplexed tributary services **< 2 Mbit/s**. They might include business telephony services from PABX, ISPBX, Centrex, LIMs etc.

Example:
RSU (Centrex)
LIM (Remote unit to a PABX)
IMUX
PABX, ISPBX
Video conference, ≥ 2 Mbit/s
PAL TV
HDTV
Frame relay packet traffic 2 Mbit/s
File transfer ≥ 2 Mbit/s
Graphics ≥ 2 Mbit/s
CAD/CAM ≥ 2 Mbit/s
Various multiplexers
LAN interconnect
  Token ring
  Ethernet
Service provider ≥ 2 Mbit/s
MAN
  FDDI
  DQDB
SMDS
ATM based traffic

d) <u>Existing services</u>

Table 4.1 shows the existing services, with provision for recording the number of users of each service connected to each one of the different networks and the total number of each service.

Service	**Network**								Total
	Telephony	Telex	PSPDN	ISDN (PS)	CSPDN	ISDN (CS)	Leased anal.	Leased dig.	
POTS									
POTS supplementary services like call transfer, wake up etc.									
Mobile telephony									
Telex									
Facsimile, group 1-3									
Videotex 1200 bit/s									
Transaction oriented data service, File transfer data service, and other data services									
Centrex									
800-service									
Credit card validation									
Private meters									
Operator services									
Electronic mail X 400									

Table 4.1 : Existing services per network

e) **Required services**

The minimum required services during the planning period should be structured as in Table 1

f) **Main business user locations**

For forecasting and planning, each service area is structured e.g. by definition of basic zones, each such zone being a part of a specific traffic area, and at the same time also being a part of a specific exchange area. This structure should be used also in this case, by indicating the main business user locations, as shown in Figure 4.14.

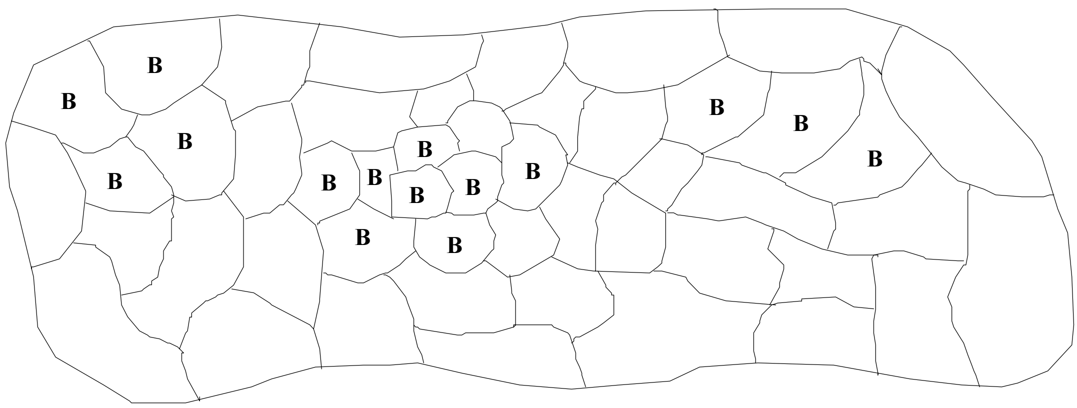


Figure 4.14: Main business user locations

g) **Forecast of business sources ≥ 2 Mbit/s**

The same map may be used to specify the required number of business sources in more detail as shown in Figure 4.15.

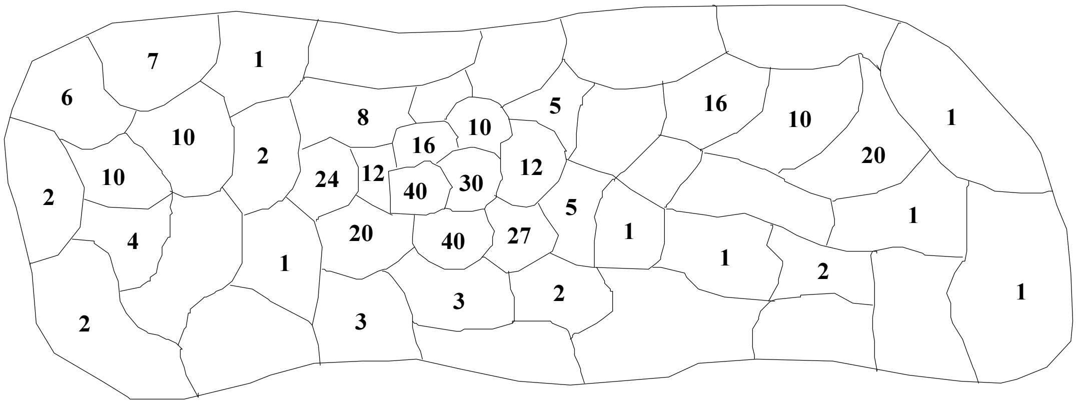


Figure 4.15 : Number of Business Sources ≥ 2 Mbit/s.

h) **Service attributes and requirements**

A table should be prepared showing all interesting services together with their attributes and requirements viz.:

Type	:	Tele, Supplementary, Tele + VANS, IN, Virtual Private, Bearer, Charging, Operation & Maintenance;
Users	:	Residential, Business
Bearer network	:	PSTN, ISDN, PSPDN, Telex, VPN (within PSTN or ISDN);
Max bit rate	:	64 kbit/s, < 2 Mbit/s, ≥2 Mbit/s, 10 Mbit/s etc.;
Allowed call set up time	:	10 ms, 1 s, 10 s, 100s etc.;
Transaction mean length	:	1 s, 100 s, 1000 s etc.;
Peak to mean	:	1, 5, 200 etc.;
Type of distribution	:	1:1, 1:N, N:1, N:N (point-to-point, point-to-multipoint,..)
Switching	:	Circuit-switched, Packet-switched, Non-switched;
Terminals	:	Stationary, Vehicle mounted, Hand held;
Coverage	:	International, National, Regional, Local;
Max bit error rate	:	10^{-3}, 10^{-4} etc.;
Max slip rate	:	As required
Max delay time	:	As required

4.4 Service implementation analysis

When a new telecommunication service is considered for possible future implementation, many questions may be raised, such as:

- What would the significance of the service be for the **end users** and for the **provider** of the service?
- Would the service involve high introduction costs?
- Will the service give a good income for the service provider?
- Will the service adversely affect other services and, if so, to what extent?
- Are there any risks involved?
- etc.

This means that a thorough analysis should be carried out, the result of which should be in the form of a number of different scenarios, coupled with some kind of likelihood parameters, possibly also with recommendations. This output may then be used as a basis for decisions. Decisions are to be taken on whether the specific service should be provided or not, if the own organisation should provide it or an option should be given to independent service providers, etc.

The parameters used in the analysis will be of two kinds: a few parameters may be **crisp data**, i.e. expressed in numbers, while possibly the majority of data is "**fuzzy**", i.e. expressed in linguistic terms, for instance **High-Medium-Low**, **Strong-Average-Mild** or **Optimistic-Medium-Pessimistic**.

Some parameters are of great importance for the expected revenues, such as:

- service penetration over time;
- user traffic;
- tariff

These factors are however inter-dependent. Increased tariffs will decrease penetration and user traffic, increased penetration will increase user traffic, which will again make decreased tariffs possible, etc. However, other factors are also important, such as:

- introduction and promotion strategy;
- service attributes;
- technical level;
- political environment.

An overall scenario would describe these and possibly other factors, for example in the following way:

Service attributes:	:	**STANDARD**
Technical level	:	**MEDIUM**
Political environment	:	**FULL DEREGULATION**
Introduction and promotion strategy	:	**STRONG**
Tariffs	:	**LOW**
Service penetration	:	**HIGH**
User traffic	:	**MEDIUM**
Stability of scenario	:	**HIGH**

To obtain a result, a team of experts could work for instance in a sort of Delphi mode, first defining all directions of dependencies between factors and the strength of each dependency, and then trying to evaluate the resulting dependency matrix by subjective judgement. Software tools exist that can evaluate scenarios based on a complex system of interdependent factors, described by partly crisp, partly linguistic or "fuzzy" data.

4.4.1 Summary of analysis procedure

a) Definition of the service

The service should first be defined in detail, i.e. described in the form of user functions, structure, realisation (software/hardware), location in the network, etc., so that experts and decision makers in all domains - marketing, economy, human resources, technical planning etc. - can understand the service clearly.

b) Significance for target groups

A definition of when and how the service might be used and by which kinds of customers and end users, including an estimation of possible gains for the users, considering time, quality, PR, competition strength, human resources, etc. The question of whether there is already customer pressure for the service, or whether there will be pressure later, has to be considered.

c) Significance for the service provider/network operator

The following questions should be answered:

- What level of income would the service give provided that it succeeds?
- What time would it save?
- What would the influence be on the human resource situation?
- Would it give important PR? Would it stop competition?
- etc.

d) Service requirements

The requirements on the network should be stated clearly and answers provided to the following questions:

- Can the present network be used as it is to implement the service simply by adding a software block, or must slight or possibly larger modifications be carried out?
- Possibly such modifications are already ordered or planned; in that case, when will they take place and how certain are they?

e) Implementation plan

If the service is to be introduced, it must first be developed or acquired, after that be implemented, introduced and promoted, and then put into operation. Even the future cancellation of the service should be foreseen. However, neither the time-scale nor the expected service volume is something fixed and certain. Therefore, optimistic, medium and pessimistic estimations of these parameters should be included (see Figure 4.16). The stability and sensitivity of the plan to various factors should be stated.

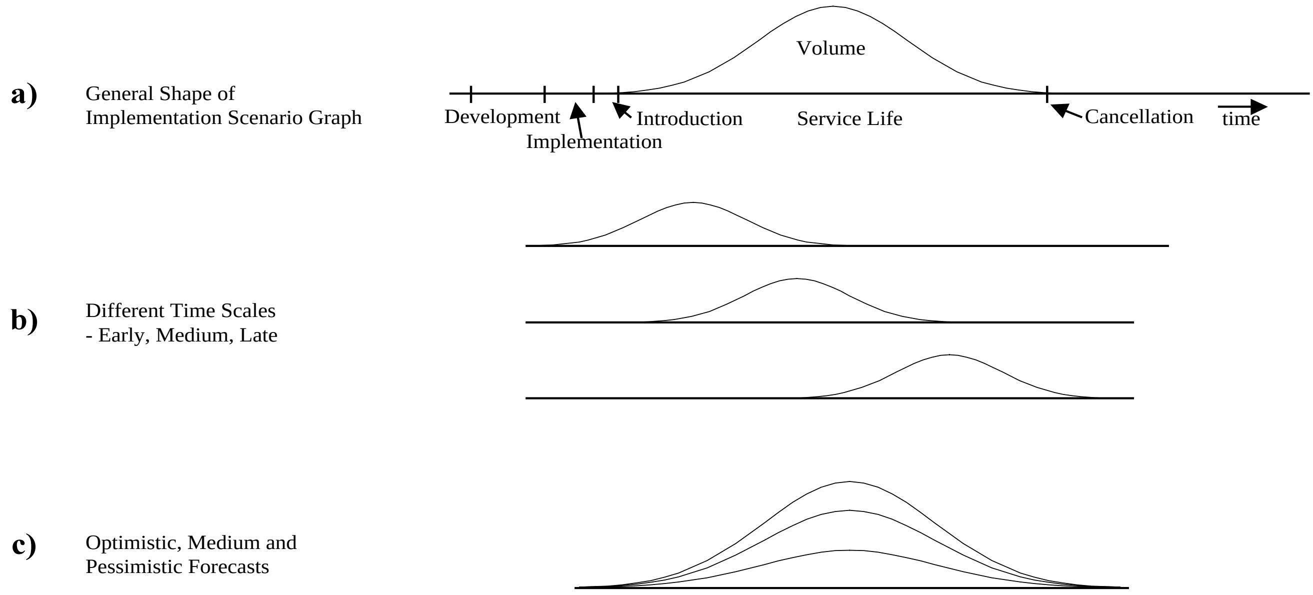


Figure 4.16: Service implementation scenarios

f) Economic analysis

The economic analysis should examine and define the costs for development, implementation and introduction of the service, and the income and resulting profit of selling the service to customers, expressed in monetary units over time, both per time unit and accumulated. as indicated in Figure 4.17.

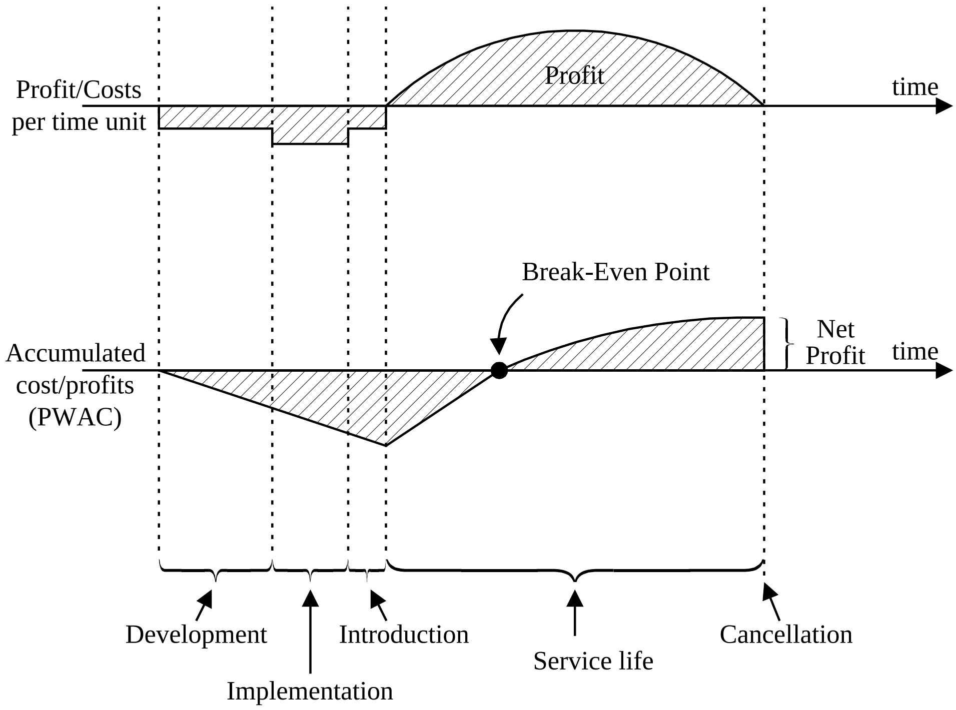


Figure 4.17: Economic analysis

g) **Risk and failure analysis**

Answers should be obtained to the following questions:

- Which factors have the greatest influence?
- What may hold back the propagation of the service?
- Which sequence of events leads to success or failure?
- What is the future evolution and how can it be directed?
- What are the technical, economical and other consequences of a possible failure?
- What will be the effect on other services?
- etc.

4.5. Network and system development

The output of the planning group's work according to the previous subsections comprises service scenarios, technical service requirements and service implementation analysis. Based on this, the group should now prepare possible alternative courses of development in the form of network scenarios showing how the network might evolve to fulfil the service requirements. Alternative **timetables** should be included, indicating important events in the network evolution, for example introduction of concepts such as a digital overlay network, a new transmission hierarchy (SDH), digital cross connects (DXC), asynchronous transfer mode switching (ATM), intelligent networks (IN), a telecommunication management network (TMN), etc. The timetables and scenarios should be given both in general and for each specific network level and particular area. The scenarios should however be **qualitative**, i.e. no exact **quantities** need to be specified. More exact specification should be carried out according to the methods described in the Chapter on "Network Dimensioning and Configuration" (Chapter 7).

The telecommunications network has basically to fulfil four functions:

- **Information Transport**, which is the whole idea of the network. The transported information is of various types, of course user information, but also signalling and management information.

- **Information Processing**, not the type of processing seen by the end users, but processing in order to enhance the reliability of the transparent communication.

- **Signalling**, which is a mechanism for exchanging control information between user and system, between systems and between functional entities.

- **Management**, which is the most intelligent part of the network, controlling the operation of the network, allocating network resources and reporting failures.

Important subjects are:

- **<u>Bearer and Signalling Capabilities</u>**
  Transport media (copper, coax, fibre, radio);
  Transmission types (analogue, PDH, SDH/SONET, WDM);
  Transfer modes (STM, ATM);
  Signalling.

- **<u>Higher Order Capabilities</u>**
  Telephony;
  Data communication (X.25, frame relay, SMDS);
  Mobility;
  ISDN;
  BISDN;
  Multi-connection calls.

- **<u>Intelligent Networks (IN)</u>**

- **<u>Management (TMN)</u>**

4.5.1 Some present and future technical developments

In the following sections, some present and future technical developments and applications are briefly explained.

Traditionally, telecommunications consisted simply of telephony and telegraphy. Today, telephony is just a service, even if it is still a quite dominating one, and telegraphy is practically obsolete. Telephony can be provided in a number of ways, from using a completely analogue network with analogue switches, to a completely digital network with digital switches. In the latter case, transmission could be plesiochronous (PDH) or synchronous (SDH), and switching could be circuit or packet switching. If it is packet switching, there are in principle several switching technologies from which to choose. In this case we have already crossed the border to data communication, and there we have the future of telecommunications; everything will effectively be a form of data communication, not from the end users' point of view, but the transmission and switching technologies will be of that type. All services will be able to be provided by means of data communication technology. Even if many dedicated networks will still exist in one and the same service area, connections between users in such networks will be set up through integrated services networks.

a) LAN, MAN and WAN

A Local Area Network, **LAN**, is a data network within an office, a building or a small area designed to connect intelligent workstations to common servers. Data rates typically between 4 and 16 Mbit/s are used.

A Metropolitan Area Network, **MAN**, was originally designed mainly for interconnecting **LAN**s over a limited geographical area, such as a campus or a city. The MAN is designed for:

- Medium distances;
- High speeds - more than 100 Mbit/s;
- Voice, data, image, video.

A Wide Area Network, **WAN**, is a voice/data facility connecting distant sites. Typically, these networks use 64 kbit/s, but speeds up to 2 Mbit/s are possible.

b) LAN Interconnect: Bridges, Routers and Gateways

A **Bridge** connects two LANs of the same type and protocol, enabling them to form one logically unified network.

Routers can connect LANs of different types and may thus support several protocols; on the other hand, they can not form one logically unified network.

Gateways operate up to OSI level 7 and can thus provide a link between dissimilar architectures by protocol conversion. A user may for instance reach the electronic mail service via a Gateway.

c) Integrating LAN-connections into WAN's

A LAN interconnected backbone network has to take care of bandwidth bursts coming from LANs in an economical way: it must give bandwidth on demand. A positive aspect is that there is less need for error control, since the LAN protocol in itself has proper procedures for error checking. New technologies for such interconnection are **Frame Relay** and **Cell Relay**.

d) X.25 packet switching

X.25 is a very reliable and well proven technology. Error control and error correction is performed in each node in the network, and it offers excellent cooperation between private and public networks. For international data communication, there is hardly any other reasonable alternative as yet. Two properties of X.25, multi-session and multi-destination, are valuable for connection between intelligent workstations, and X.25 is therefore still going to be used to a large extent. X.25 has however some serious drawbacks: The extensive error control creates a large overhead and takes time in the network nodes, so that there is a variable delay. This makes it **slow** when used for transfer of large amounts of data or bursty data, and the **variable delay** makes it next to impossible to use for packetised speech. The human ear is very sensitive to variations in delay, while some errors in shape, or slips are of minor importance. Thus it seems that X.25 solves the wrong problem when it comes to voice communication, which of course also makes it impossible for multi-media applications. The trend is furthermore that the network quality steadily increases, and at the same time error control is included in the user terminals, so that in the future, the X.25 protocol will possibly not be needed even for data communication.

e) Frame Relay

Frame Relay is another packet switching technology which attempts to combine the idea of bandwidth sharing used by X.25 networks with higher speed and lower delay, by letting the packages vary depending on need, from very short to very long packages, and by reducing the error and congestion control to a minimum. The drawbacks are that only high-quality links can be used, since real error correction is performed only by the end points, and, for packetised speech, that the transit delay, even if it is smaller than in X.25 networks, is still variable.

f) Cell Relay

Cell Relay is the technology for the next generation of switches. Again, error control and correction is reduced, which means that the network should be of high quality, and that terminals should contain error control and correction functions. The packet length is fixed, consisting of 48 octets of user information + 5 octets of overhead. Since the length is fixed, switching is performed effectively, and at very high speed. The transit delay is also fixed for the different packages in a message, so there is no longer any problem with packetised speech. There are two different kinds of cell relay switching versions developed in parallel:

- **ATM**, Asynchronous Transfer Mode, which is a real switch intended for broadband ISDN;

- **DQDB**, Distributed Queue Dual Bus, which consists of two data buses with access units; it is consequently a kind of **distributed** switching. **DQDB** is intended for **SMDS**, Switched Multimegabit Data Service, which is a service to interconnect LANs over a metropolitan area.

Note that **ATM** and **DQDB** are **Switching Technologies**, while **B-ISDN** and **SMDS** are **Services**, and they all belong to the **Cell Relay Technology**. ATM, for instance, could very well be used as a switch in an SMDS network.

g) <u>ISDN</u>

In the ISDN switching can be carried out in both circuit mode and packet mode. Frame Relay, for instance, can easily travel in the ISDN network. ISDN uses switches at 64 kbit/s, but it can handle either two circuit switched 64 kbit/s data channels plus the signalling channel, or 30 x 64 kbit/s data channels plus the signalling channel. ISDN provides a good cost-saving solution for data communication because of the availability of a switched connection that can be used between nodes in a private network as a back-up. For new services it is excellent, as far as the bandwidth capacity permits.

h) <u>B-ISDN</u>

A mature broadband ISDN will be able to carry any type of traffic: voice, data, image, video and multi-media at speeds of up to several gigabit/s. Crucial for the introduction of B-ISDN is the development of new signalling procedures. ATM-based networks will certainly be in operation before the first B-ISDN.

i) <u>SONET and SDH</u>

SONET (Synchronous Optical Network) and SDH (Synchronous Digital Hierachy) are two new **transmission formats**, SONET being a North American standard, and SDH being the CCITT version. They are high-speed multiplexing standards, based on word interleaving instead of bit interleaving which is used in the previous multiplexing standard, PDH (Plesiochronous Digital Hierarchy). They specify a fixed format which includes management, maintenance and overhead information together with users' data. The basic transport level in SONET is 51 Mbit/s which accommodates 45 Mbit/s users' data = OC-1. Higher speeds are defined as OC-3, OC-12, etc. The basic level of SDH is 155 Mbit/s, which is called STM-1 and accommodates 140 Mbit/s users' data. Higher speeds are defined as STM-4, STM-16 etc. Above 155 Mbit/s, SONET and SDH are identical. SDH is briefly considered in Chapters 5 and 9 and, in more detail, in Reference [1].

j) <u>FDDI and FDDI II</u>

FDDI, Fibre Distributed Data Interface, is the first and only networking standard to make full use of the capability of optical fibres for high-capacity, long distance data communications. The capacity is 100 Mbit/s which by far exceeds the capacity of Ethernet and Token Ring LANs. FDDI stations can be connected with a dual ring, which increases the security. The application is only for data communication. FDDI II is an enhanced version of FDDI which can handle both voice and data.

k) <u>DXC</u>

Digital Cross Connects (DXC) are going to play an increasingly important role in the evolution of the telecommunication networks:

- DXC allows automatic and centrally controlled changes in the configuration of the logical network, without requiring physical changes. The need for manually rewiring network connections disappears.

- DXC allows more efficient utilisation of existing network resources.
- DXC allows an operator to set up and administer leased lines without manual intervention.
- DXC may contain an automated security system that re-routes traffic in the event of service interruption.
- DXC can work as a bridge between PDH and SDH transmission
- Together with DXC, Add and Drop Multiplexers (ADM) can be used, which substantially improves the flexibility and cost effectiveness.

l) Network development

Figure 4.18 shows how broadband capabilities can be introduced in the network. We see that broadband and narrowband switches are integrated via DXC. The driving forces behind the increased use of DXC's are mainly:

- Leased lines.
- Routing administration.
- Network redundancy.
- Broadband switching.
- Synchronous interface.
- Bridge between asynchronous and synchronous networks.

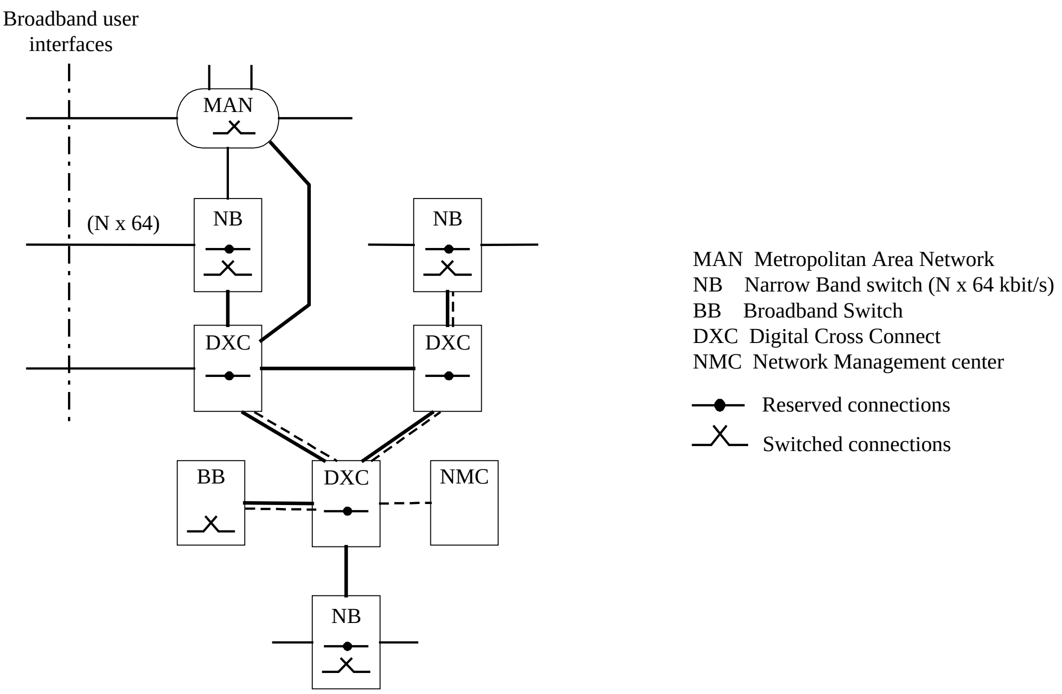


Figure 4.18: Introduction of broadband network capabilities

In the conceptual future network, we will define **nodes** of various **functions**: Access Nodes, Transfer Nodes, Signalling Nodes, Feature Nodes and Management Nodes. Some nodes may contain more than one function. (See Figure 4.19).

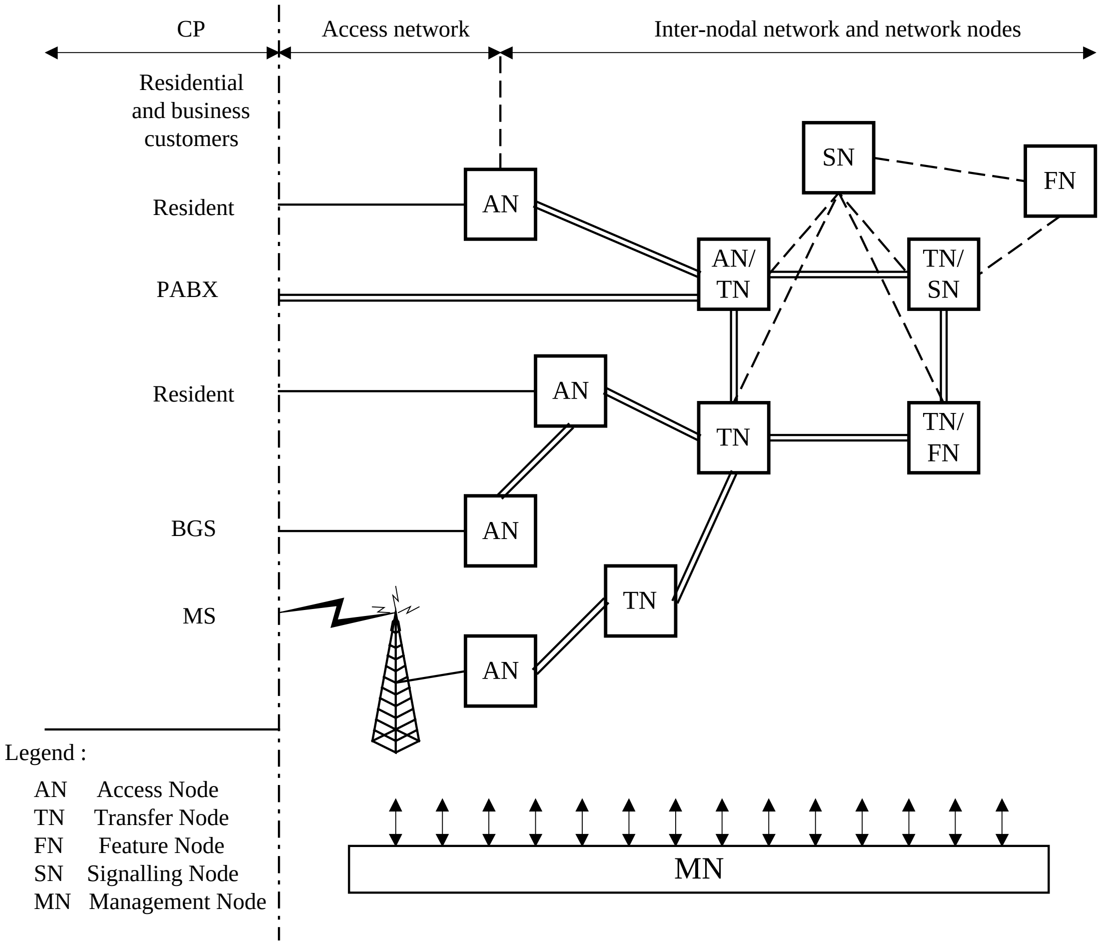


Figure 4.19: The future conceptual network

Figure 4.20 shows that the DXC's play an important role in the future network.

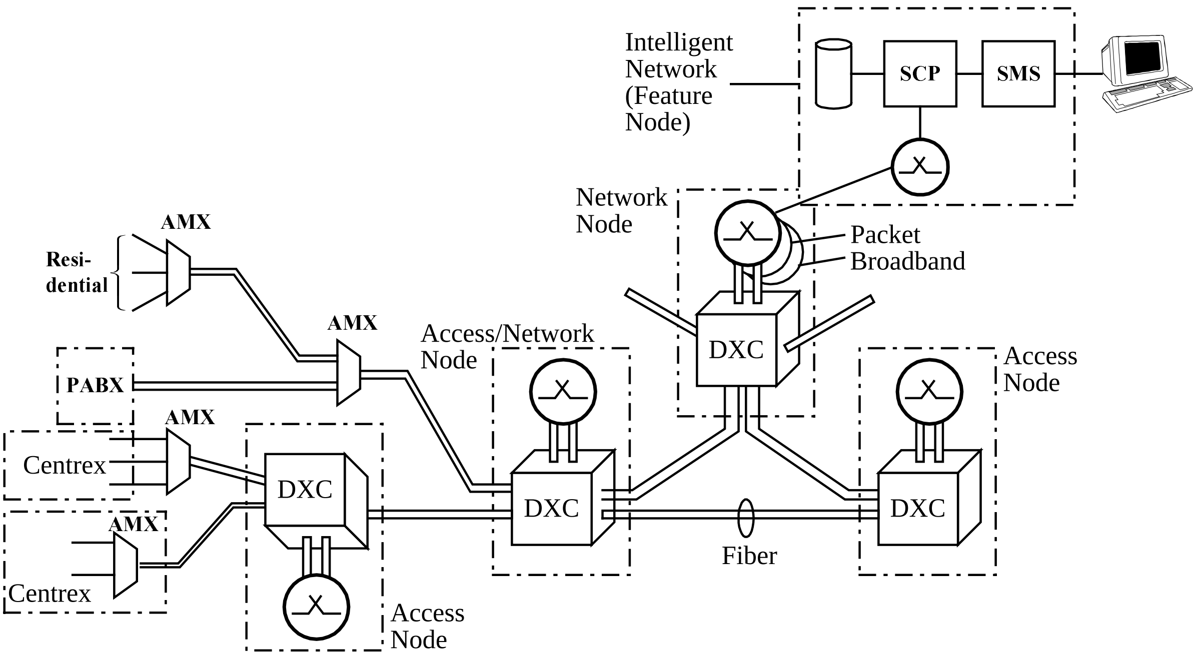


Figure 4.20: The future network

In Figure 4.21, we can see how one and the same network can interconnect LANs, PBX'es and single lines, and also provide leased lines, private switched network functions and virtual private network functions, according to the requirements of the business users.

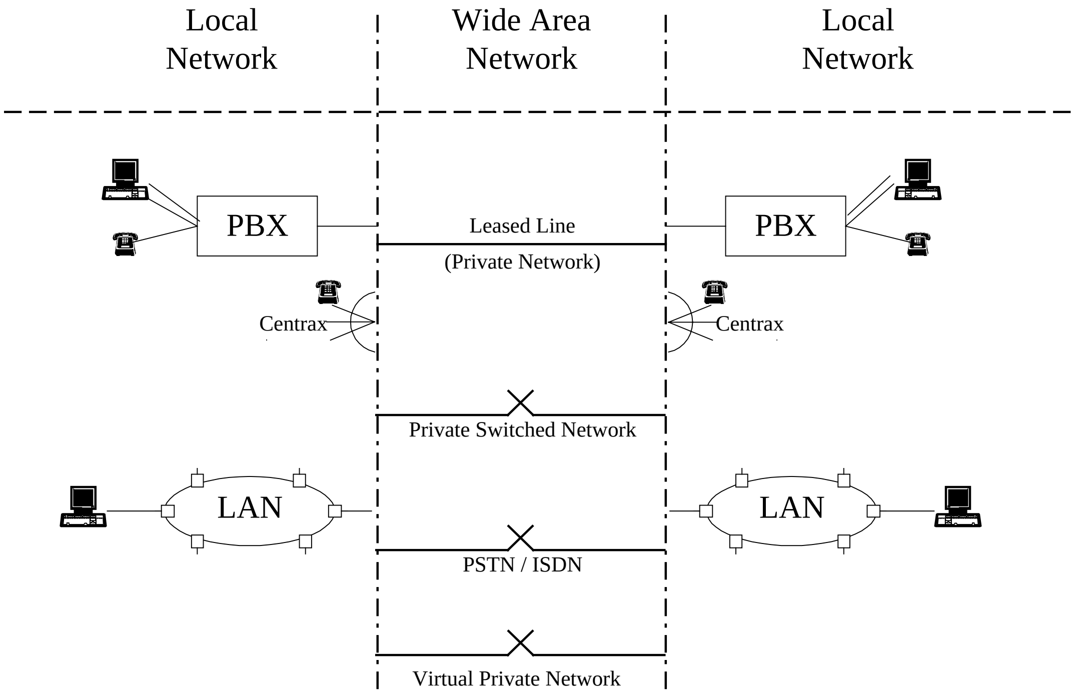


Figure 4.21: The business communication network

4.6 Digitalisation strategy

4.6.1. Introduction

In this section the strategies are explained using an example of an analogue network which is gradually being transformed into a digital one. The planning group should apply these ideas and possibilities to the actual networks which are to be digitalised. The output will thus be in the form of scenarios showing the consecutive steps in the digitalisation process for the specific network levels and areas. One factor which must be added is the **Time Scale**, so that these scenarios can be a real input to detailed service-centred, technical and economical planning.

Digitalisation of a telecommunications network obviously involves the introduction of digital transmission and switching components into the network. The reasons are mainly economical, but there are also other reasons, such as improved and extended services to the subscribers, improved transmission quality, improved operation and maintenance facilities, etc. It should also be remembered that analogue equipment is becoming increasingly difficult to obtain, as are the spares with which existing analogue equipment has to be maintained.

Due to the synergistic effect, the best economy and performance are achieved if both transmission and switching are digital and integrated, since for example no analogue/digital converters are then needed. However, since the existing telephone sets are usually analogue and the costs of replacing them are substantial, the subscriber lines will probably remain analogue while the rest of the network is digitalised. This leads to the Integrated Digital Network IDN, which is the first goal of the digitalisation process (see Figure 4.22).

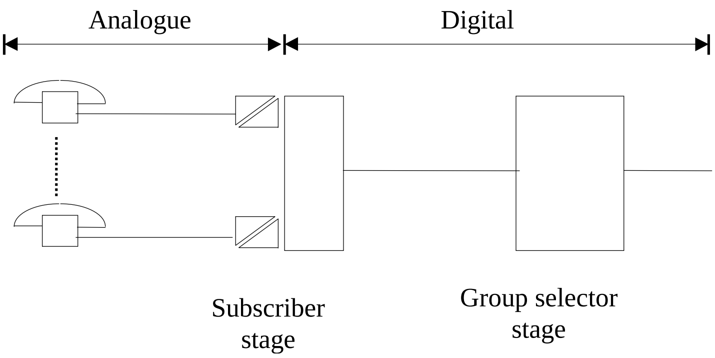


Figure 4.22: First goal IDN

The final digitalisation of the subscriber lines opens up the possibilities of connecting a wide variety of digital equipment at the subscriber's premises, such as data terminals, teletex, etc. We then have an Integrated Services Digital Network ISDN, where telephone services, data services etc. are switched by one integrated telecommunications network (see Figure 4.23).

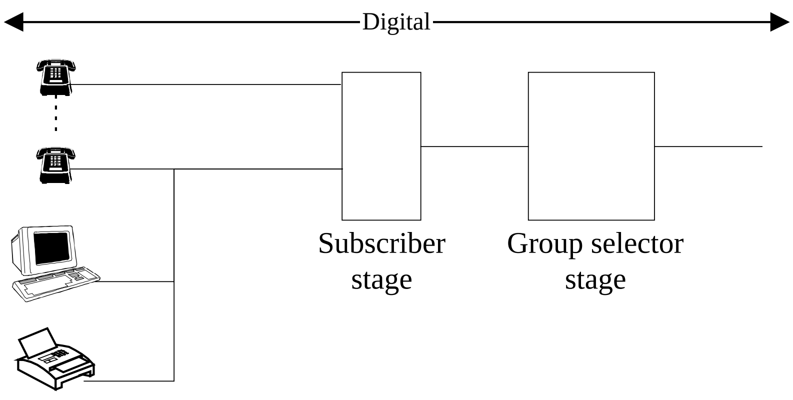


Figure 4.23: Ultimate goal ISDN

Since the existing analogue telephone network is by far the most important network of the various types, telephone, telex, data etc., the development towards IDN/ISDN will start from this network. The following study of digitalisation principles and strategies is therefore based on this fact. The study goes up to the transition into IDN and ends with a comparison between the characteristics of the analogue telephone network and a digital network.

4.6.2 Digitalisation principles

A typical analogue telephone network is shown in Figure 4.24. We will study the digitalisation of various parts of this network.

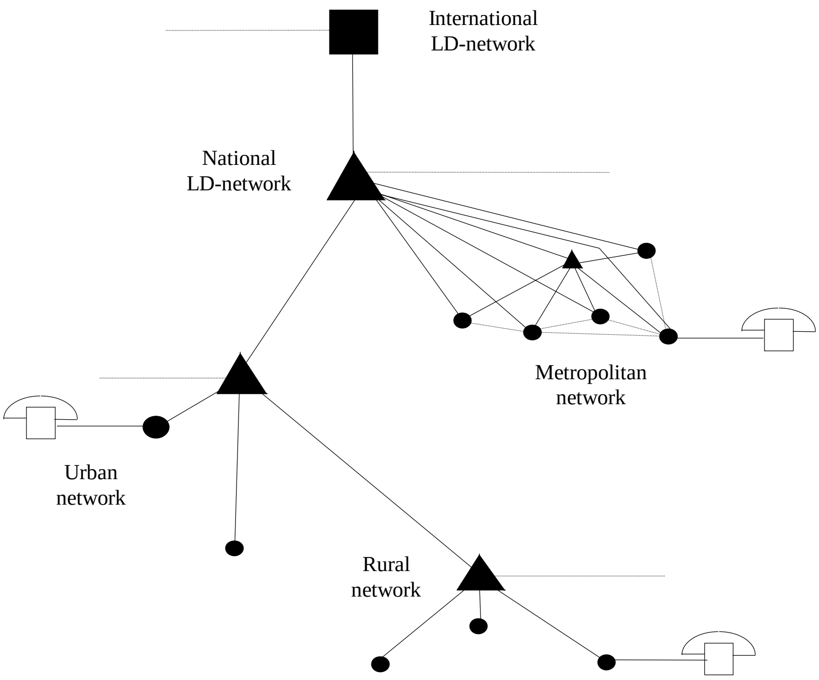


Figure 4.24: Structure of analogue network

a) Digitalisation of subscriber line networks

Subscriber line networks and local exchanges form parts of metropolitan networks, urban networks and rural networks. The digitalisation principles are very much the same in all cases, so let us study the case of the subscriber network in a city area, as shown in Figure 4.25. In this arrangement, 2000 subscribers are connected to the subscriber switch SS. The 2-wire group switch GS has routes to 10 other exchanges, each route with 30x2-wire junction lines. SS and GS are connected with 300 pairs.

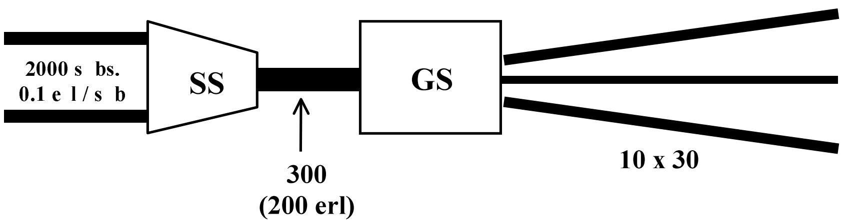


Figure 4.25: Local exchange

Figure 4.26 shows that the 2000 subscribers are connected with a 2000 pair primary cable from the exchange to a cable distribution cabinet (simplified to one cabinet only in the figure), from where 10 secondary cables with 200 pairs each lead further towards the subscribers.

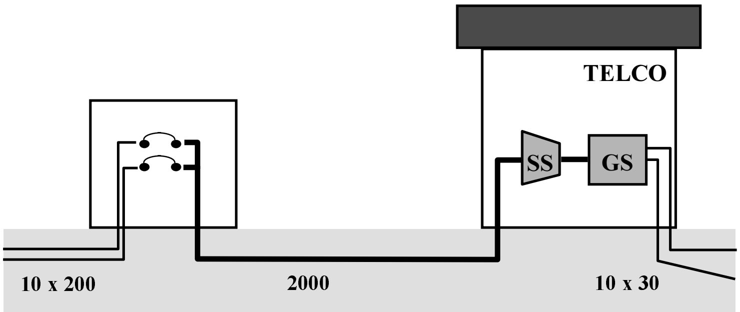


Figure 4.26: Connection of subscribers

A dramatic reduction in the primary cable size is achieved by introducing PCM and a remote subscriber switch, (see Figure 4.27.) 20 pairs for 10x30-channel PCM-systems (2 pairs for each system, 1 pair per transmission direction) give approximately 300 speech channels between the remote SS and GS, which is actually more than enough for the offered traffic of 200 erlangs. The number of pairs is reduced from 2000 to 20, which is a factor of 100.

In Figure 4.27, we have also introduced a 30-channel PCM system on each junction route, resulting in a reduction in junction cables from 30 pairs to 2 pairs per route, which is a factor of 15. The pair gain factor is less than for the primary cable, because a junction pair carries more traffic originally than a subscriber pair (0.7-0.8 erlangs compared to 0.05-0.15 erlangs). The digitalisation of the junction network is considered later.

As can be seen, the pair gain we obtain by introducing PCM is substantial. It is of course to a certain degree counterbalanced by the cost of the PCM equipment.

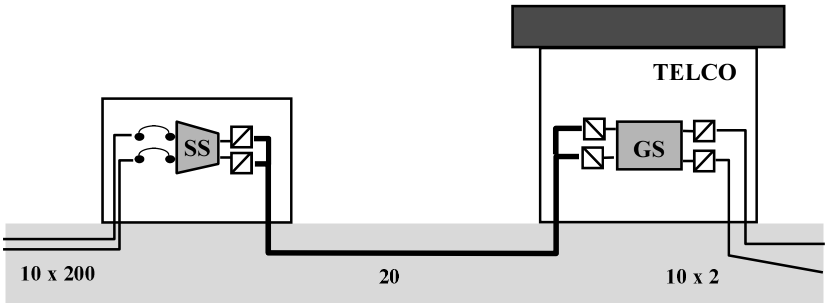


Figure 4.27: Introduction of digital transmission

By introducing digital switches as shown in Figure 4.28, A/D converters are only needed on the subscriber lines which are still analogue, since the telephone sets are analogue. Thus, we have the characteristic structure of an Integrated Digital Network, IDN.

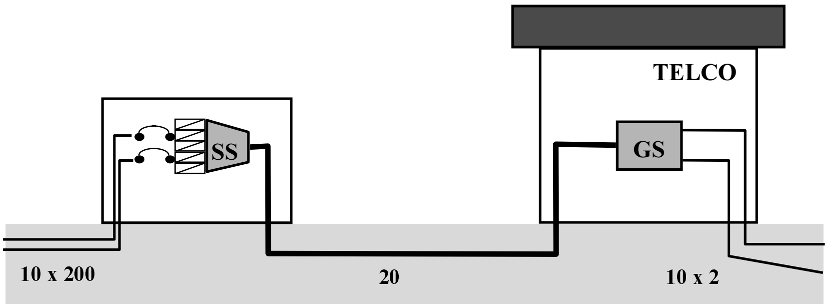


Figure 4.28: Introduction of digital switching

b) Digitalisation of junction networks

Junction lines are connections between local exchanges, and connections between a local exchange and a local transit exchange.

Consider a 2-wire junction route between two local exchanges, as shown in Figure 4.29. The route consists of 300 junctions or 300 pairs. The cost of the route is distance dependent as shown, and is the sum of the fixed cost of the group switch and a varying cable cost dependent on the distance.

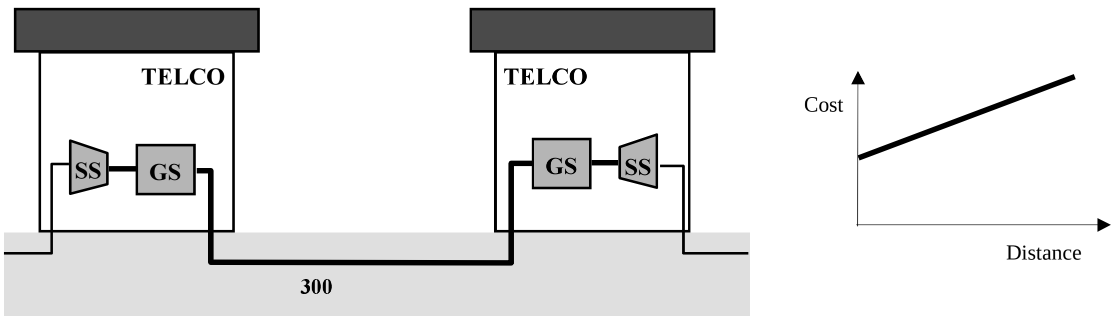


Figure 4.29: Junction route

In Figure 4.30 we have introduced PCM on the route. 10 systems of 30-channel PCM still give 300 connections, but need only 20 pairs. The costs of the PCM terminals will increase the fixed cost while the cable cost is reduced, and the route is economical above a certain distance.

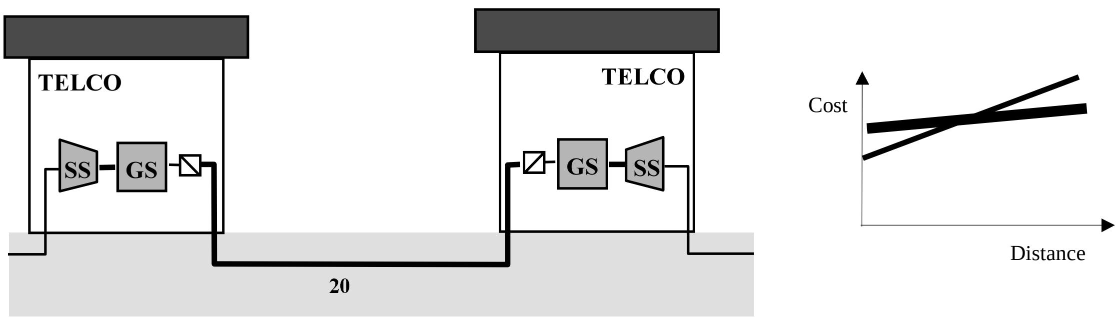


Figure 4.30: PCM on the Route

As in the case of the subscriber line network, the best economy is achieved when the exchanges are digitalised and the PCM terminals integrated into the exchange, as in Figure 4.31. The method is cost effective from 0 km.

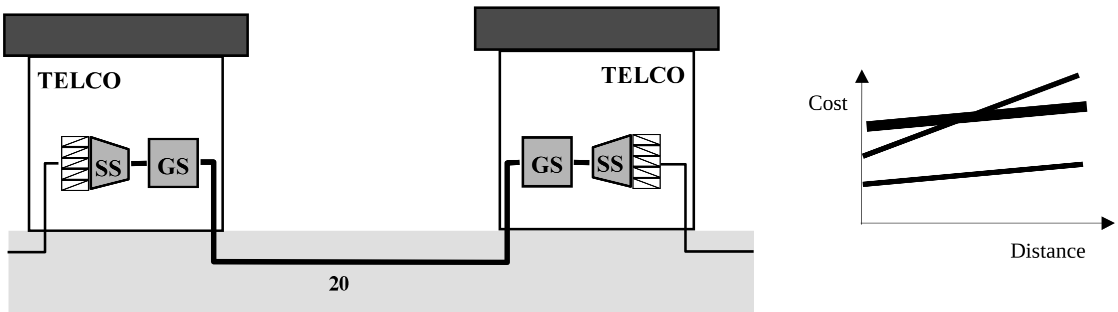


Figure 4.31: PCM on the route and digital exchanges

c) Digitalisation of trunk networks

Trunks are connections between transit exchanges in the long distance network. These connections are, even today, often established by highly efficient FDM systems, and the immediate savings by introducing PCM might be less compared to those in the local networks. Even if that were the case, it would probably still be well worth digitalising the trunk routes, since it would prepare for a completely digital country-wide network. However, by possibly retaining analogue transmission in the long distance network, digital exchanges could still be introduced with good economy, particularly if the cooperating local exchanges and/or junction lines are digital.

4.6.3 Digitalisation strategies

Although it is proved that digitalisation is economical, it is seldom possible to digitalise the whole network in one step, because the initial investments and resources needed would be enormous. Digitalisation will usually have to be a stepwise, evolutionary process, possibly over decades if the starting point is a fully analogue network. It is therefore important that each Administration formulates its own digitalisation strategy as to where, when and how the various steps of digitalisation have to be taken.

However, it must also be remembered that the production of analogue switching and transmission equipment has virtually ceased so that spares to maintain existing systems are no longer available for example. Thus it is becoming increasingly difficult to maintain the analogue systems in service and network operators often have little choice but to replace them by digital systems.

There are three different basic strategies:

- Overlay strategy;
- Island strategy;
- Pragmatic strategy.

The overlay strategy is to create a fairly thin digital network spread over a wide geographical area, overlaid the existing analogue network, as shown in Figure 4.32.

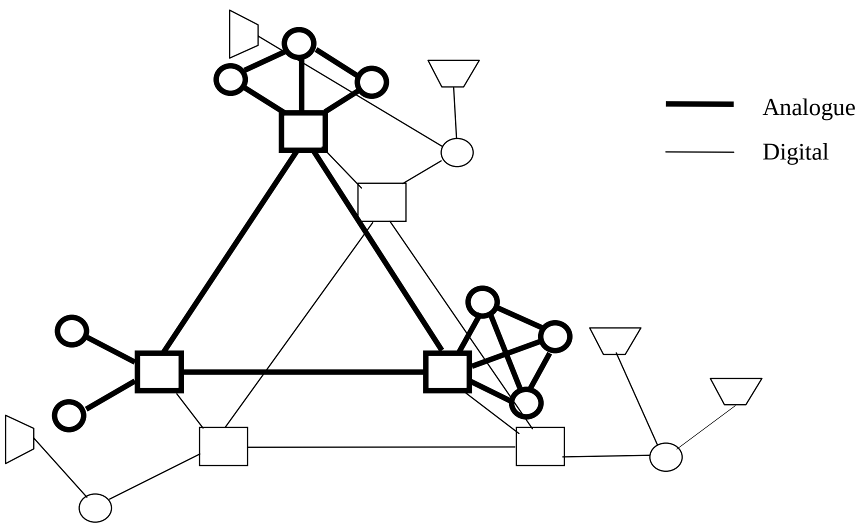


Figure 4.32: Overlay strategy

The island strategy involves the full digitalisation of certain limited geographical areas, which then become known as digital islands, as shown in Figure 4.33.

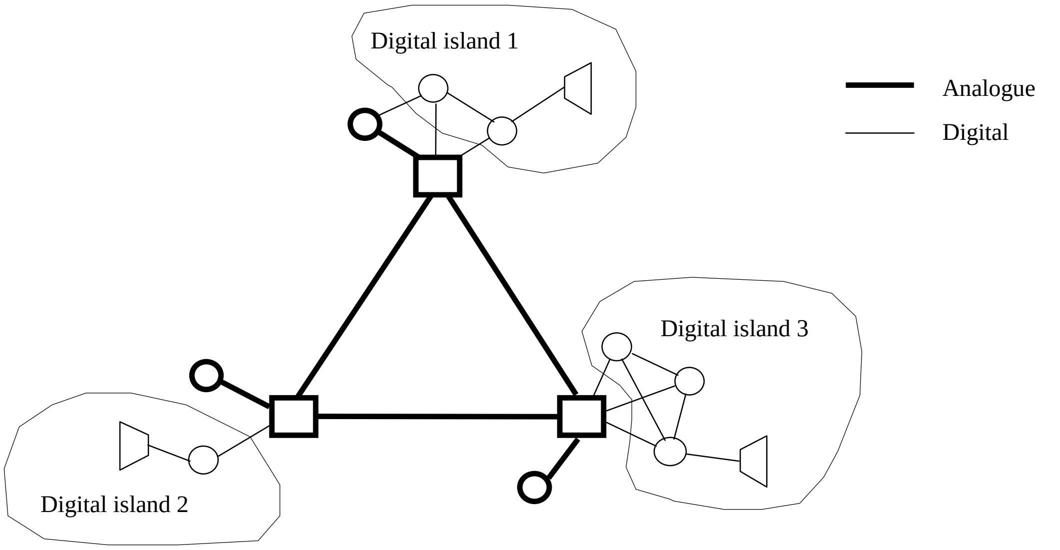


Figure 4.33: Island strategy

The overlay strategy and the island strategy are the two principal strategies. The pragmatic strategy is a practical compromise between the two, as indicated in Figure 4.34.

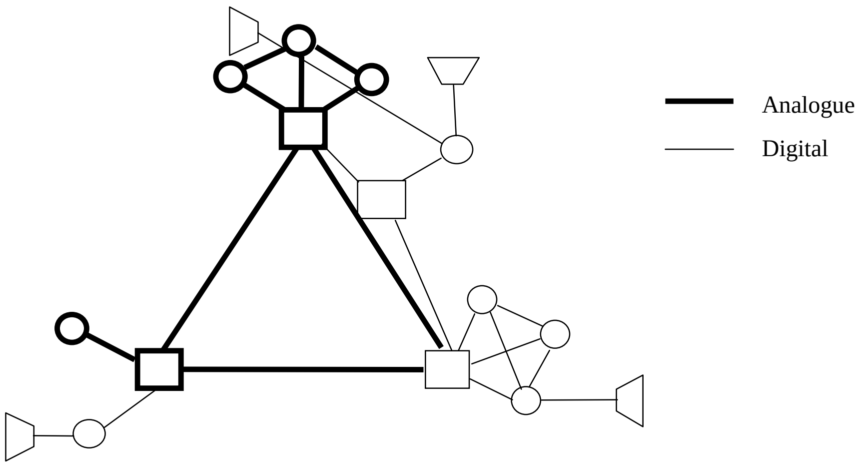


Figure 4.34: Pragmatic strategy

Some guidelines in the choice of strategy are considered in the following brief description of the various strategies.

a) Overlay strategy

The characteristics of the overlay strategy are:

- Rapid provision for digital services on a nation-wide basis.
- High initial investment costs, compared to the low initial capacity provided. This is because certain digital long distance switching and transmission facilities are needed initially.
- Additional operation and maintenance staff and equipment on a nation-wide basis, meaning increased operation and maintenance costs.
- Limited alternative routing in the initial phase, due to the thin network.
- Different treatment and services provided to subscribers with access to the overlay network compared to other subscribers in the same geographical area.

The early provision of end-to-end digital services makes the overlay strategy most suitable in countries with a high and urgent demand for new and enhanced telecommunication services and where the existing network has a relatively long projected useful life. The overlay strategy is also applicable to create a separate, dedicated network for non-voice services in countries where such a network does not exist today but where the demand is pressing.

The overlay strategy could also be dictated by an Administration's policy to meet the growth of subscribers and traffic by digitalisation. This could for instance be achieved by connecting new subscribers to remote subscriber switches of a few new digital exchanges rather than extending existing analogue exchanges. The digital exchanges could then be interconnected in a nation-wide overlay network.

New and improved services imply new revenues, which have to be traded off against the high initial investment costs which penalise the overlay strategy. The limited alternative routing possibilities in the initial stage should also be considered and the routes engineered accordingly. Finally, the different treatment and services provided to subscribers with access to the overlay network compared to other subscribers in the same geographical area may cause some policy explanatory problems to an Administration and should be carefully considered before a decision is taken to adopt the overlay strategy.

The demand for new and enhanced telephone services and/or improved non-voice services emanates to a large extent from the business sector, which normally contributes to the major part of an Administration's income. Business activities are mainly concentrated to metropolitan and city areas. Combined with the fact that digitalisation savings are largest in the subscriber and junction network, the start of the digitalisation process becomes very attractive in such areas. Also, if the same strategy is set by an Administration's policy to meet growth by digitalisation, the city and metropolitan areas seem the most suitable starting points, because these areas generally show the highest growth rates.

b) Island strategy

The characteristics of the island strategy are:

- Provision of complete digital services within certain, limited geographical areas by replacing existing analogue switching and transmission equipment. Nation-wide service is not necessarily an immediate goal.
- Full advantage of integrated digital switching and transmission for the island area from the start. Digital equipment can be concentrated in areas where it is most needed and can be most effectively utilised. Availability of digital long distance switching and transmission capabilities are not needed initially. Waiting for economy to be achieved in digital long haul facilities is therefore possible.
- Additional operation and maintenance staff and equipment only needed for the digital islands and not on a nation-wide basis.
- Alternative routing possibilities not affected, neither within a digital island nor between digital islands.
- Same treatment and services provided to all subscribers within the digital island.

The island strategy is best suited for countries with the growth localised to areas with a relatively large amount of old exchanges which are at the end of their economical lifetime, have reached their maximum switching capacity or cannot be extended unless the buildings are extended. These exchanges are replaced with exchanges of larger switching capacity and/or smaller physical size. Dismantled old exchanges in relatively good condition could conceivably be reconditioned and redeployed. Others which are practically worn out and expensive to maintain at an acceptable level, are scrapped.

A candidate for a digital island is also often characterised by already existing digital transmission to a relatively large extent. By introducing digital switching, the economy of integrated digital switching and transmission is achieved within the digital island.

The island strategy may also be advantageous when large geographic distances separate growth areas and the present cost of digital long distance interconnection is high.

City and metropolitan areas seem to be the best starting points also for the island strategy, because these areas normally have the highest growth rate. These areas also often show the highest percentage of existing digital transmission in the junction and feeder networks

c) Pragmatic strategy

As seen from the previous text, the digitalisation strategy to be adopted will vary from country to country depending on the demand of the present network, the policy of the Administration, the geographical shape of the country, etc. However, in the end there is the trade-off between economy and services provided which dictates the strategy. In most cases neither the pure overlay strategy nor the pure island strategy shows a satisfactory trade-off. Instead, a compromise will have to be used; the pragmatic strategy.

A pragmatic strategy aims at an optimal trade-off between economy and services by:

- Optimising the usefulness of existing equipment;
- Optimising the effectiveness of new investment.

A controlling characteristic of pragmatic strategies is a tendency to follow the natural driving forces for network evolution such as growth in demand, the desire to provide a capability for new services, and the need to modernise the telecommunication plant, all appropriately weighted through the overall economics. This means that there are at least as many distinct pragmatic strategies as there are countries which are candidates for IDN/ISDN evolution.

In general, pragmatic strategies suggest a more detailed technical and economical analysis of numerous potential combinations of islands and/or overlay flavoured strategies as applied to all segments of the network, to achieve an optimal solution. Various computerised forecasting and network planning optimisation methods have been developed for these purposes.

4.6.4 Examples of a stepwise, pragmatic solution

a) Introducing digital local transit and local exchanges

Let us assume that we have decided to start the digitalisation in a metropolitan area by introducing a digital local transit exchange, as shown in Figure 4.35. In this case, all existing routes are analogue from the start. In other cases, some of them might be digital already.

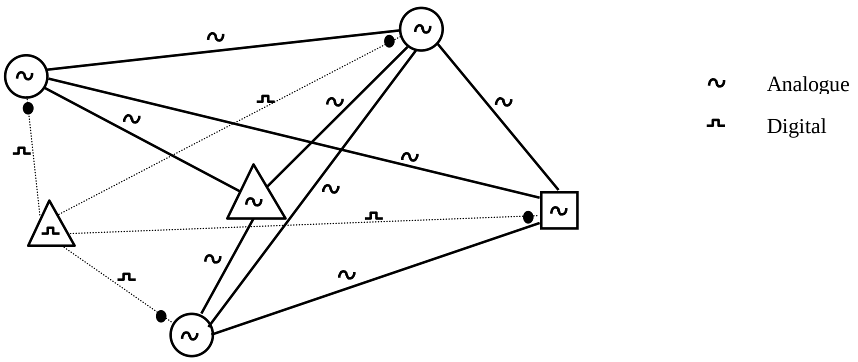


Figure 4.35: Introduction of digital local transit exchange

In Figure 4.36, the analogue local transit exchange has been phased out, but this is not always necessary.

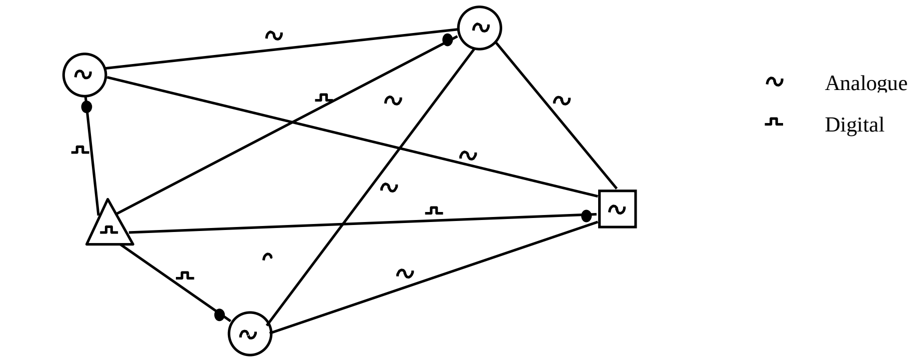


Figure 4.36: Analogue local transit phased out

The network could be extended with new local exchanges which are connected to local transit and existing local exchanges if economical, as shown in Figure 4.37.

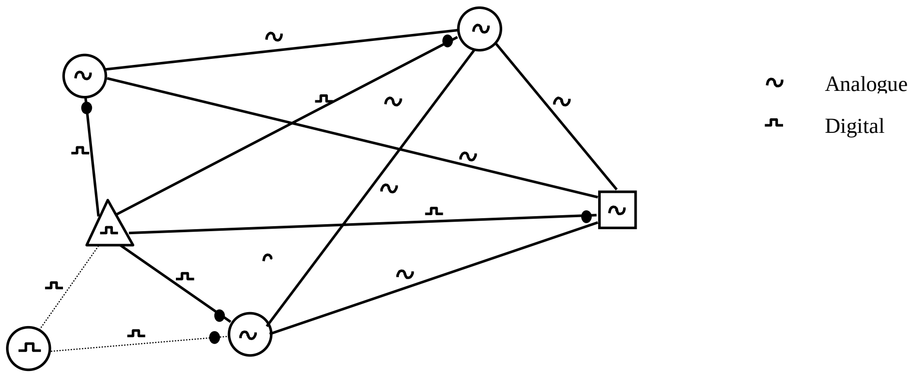


Figure 4.37: Extension with new local exchange

Let us study a direct route between two local exchanges to see whether PCM is interesting, (see Figure 4.38). If the PCM systems on the routes up to the local transit exchange from the two exchanges have spare capacity, this capacity could be utilised for a direct route between the exchanges, by-passing the local transit , as shown in Figure 4.39.

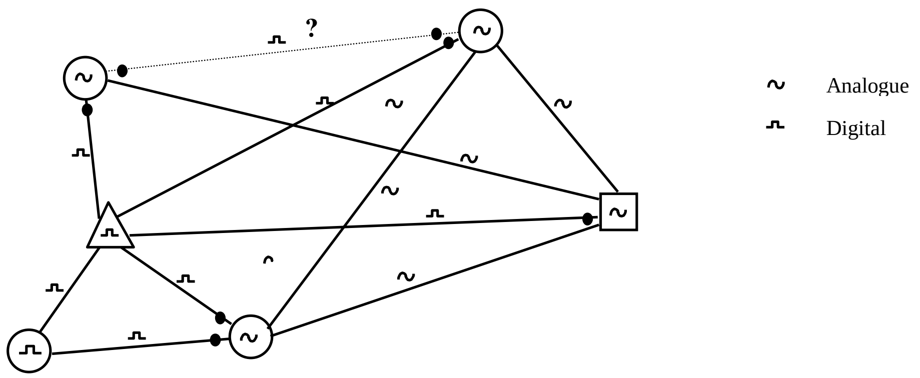


Figure 4.38: Is PCM on indicated route interesting?

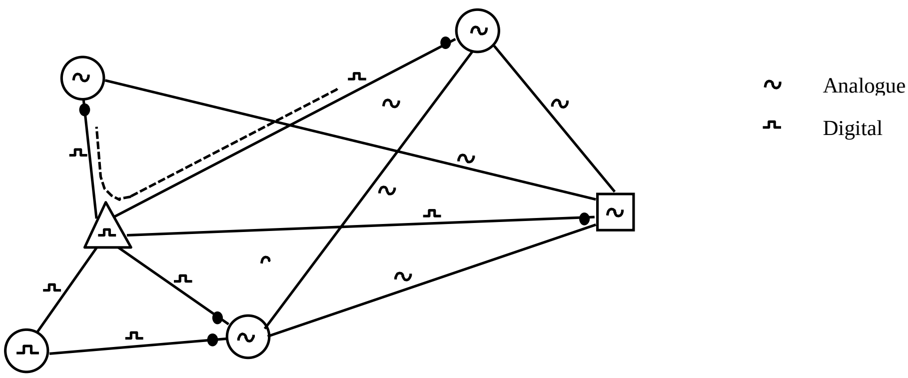


Figure 4.39: Direct Route by-passing local transit exchange

Figure 4.40 shows an example of extending an analogue exchange with a remote subscriber switch connected to the digital local transit exchange. A more detailed picture of this situation is shown in Figure 4.41. Growth in the analogue exchange is taken up by a digital, overlay network.

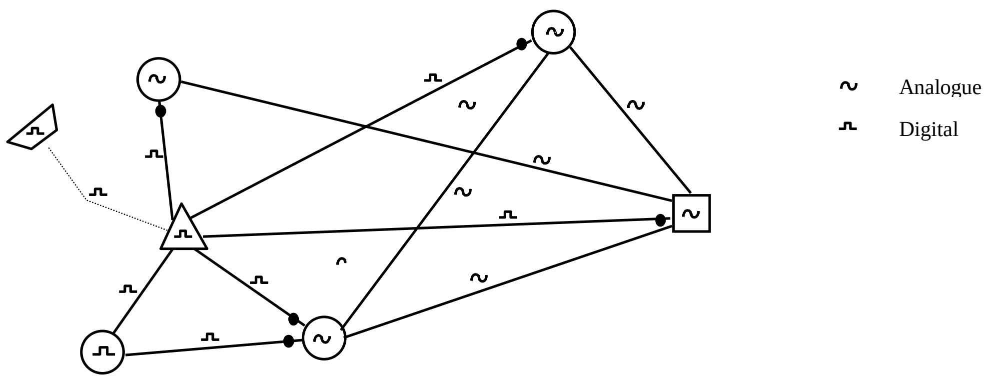


Figure 4.40: Extending an analogue exchange with a remote subscriber switch

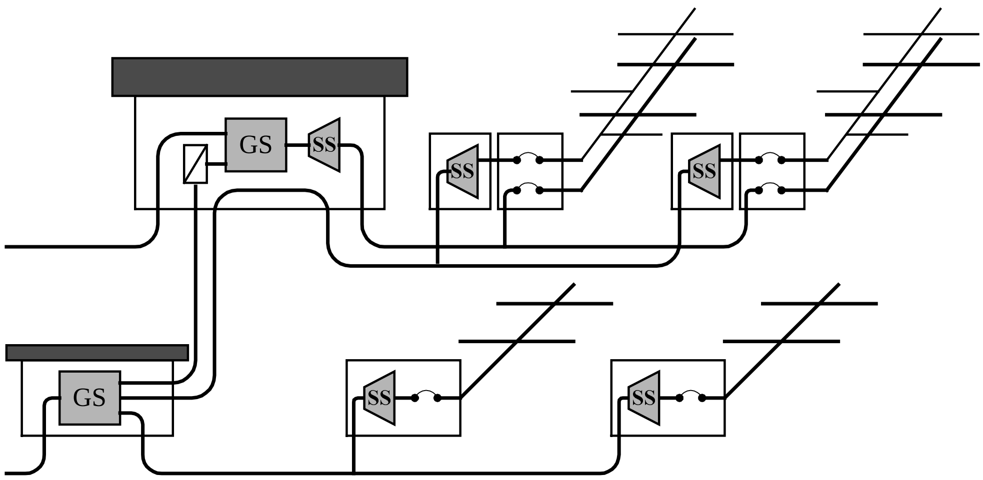


Figure 4.41: Digital overlay network

Figure 4.42 shows the replacement of an analogue local exchange with a digital local exchange. The arrows indicate re-use of PCM terminals.

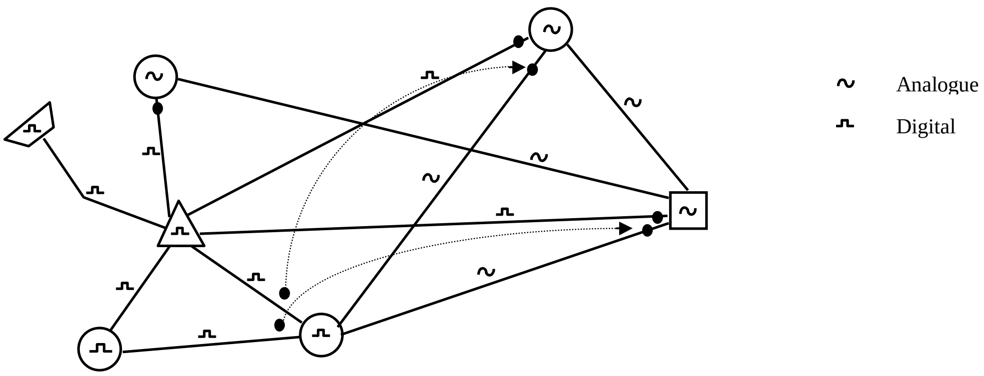


Figure 4.42: Replacement of analogue exchange.
(arrows indicate re-use of PCM terminals)

Figure 4.43 shows in more detail the procedure used to replace an analogue exchange by a digital exchange while both exchanges are in service.

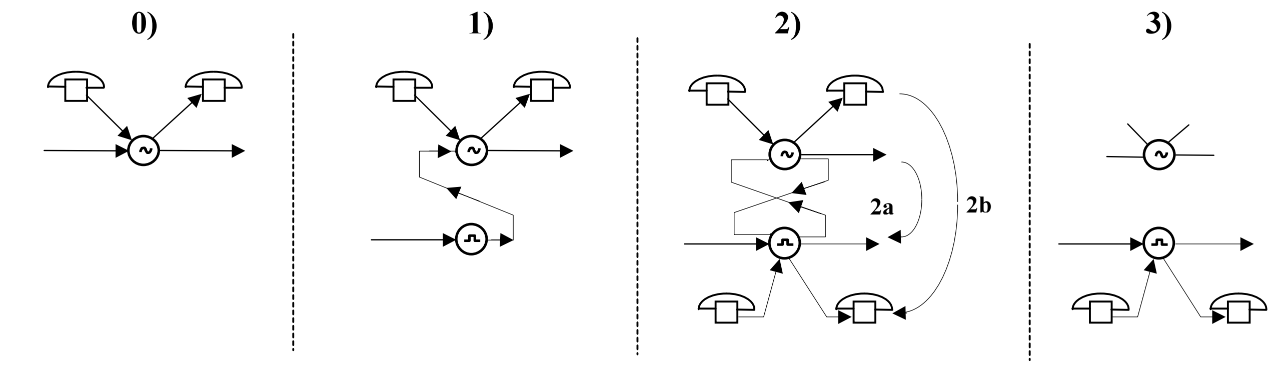


Figure 4.43: Replacing an analogue exchange by a digital exchange

b) Introducing LD transit functions in the existing digital local transit exchange

Figure 4.44 shows an example of introducing long-distance transit functions in the existing digital local transit exchange. The cost of extending the existing analogue transit exchange as the long distance traffic increases was in this case not justified in the long run compared to introducing long-distance transit functions in the existing local transit exchange, which could easily be converted to a combined long-distance and local transit exchange.

The previous local transit routes are extended to carry long distance traffic as well. The long distance route between the analogue transit exchange and one of the digital local exchanges is removed. This creates free ports in the analogue transit exchange, ports that can be used for the now necessary extension of the route to the combined local transit LD transit exchange.

All new trunk circuits, both digital and analogue, are connected to the digital local transit LD transit exchange, because the hardware is cheaper and the expensive rewiring and restrapping work in connection with extensions of trunk routes connected to the analogue exchange is avoided.

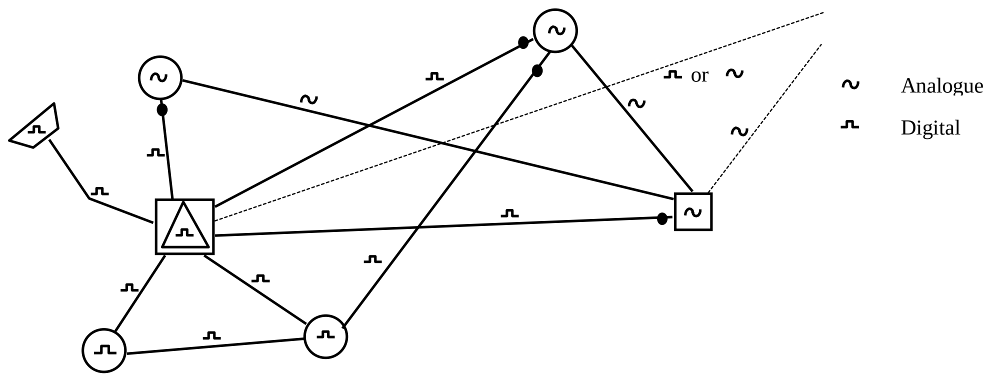
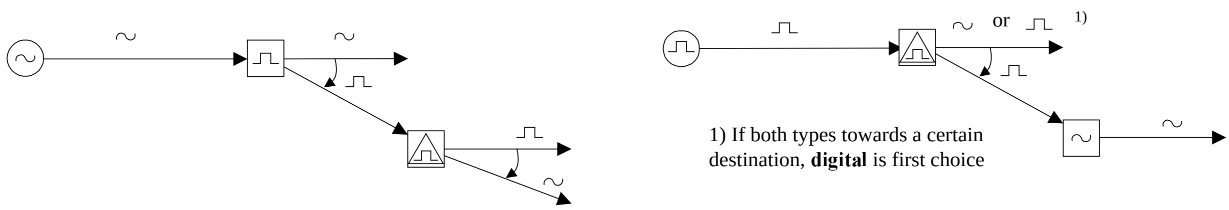


Figure 4.44: Introduction of transit functions in an existing digital local transit exchange

Figure 4.45 shows the routing of long distance traffic in this mixed analogue/digital network. The main principle is to separate digital and analogue traffic as much as possible so as to minimise the number of analogue/digital conversions. Only in the case of congestion is traffic from the digital “path” allowed to overflow to the analogue “path” and vice versa.

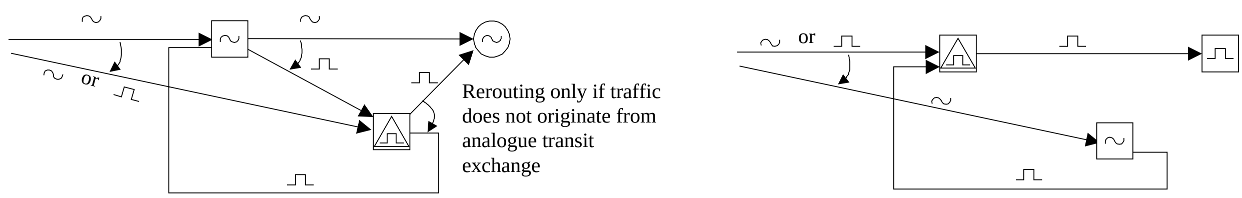
1. Outgoing LD traffic



2. Incoming terminating LD traffic

2.1 To analogue local exchanges

2.2 To digital local exchanges



3. Transit LD traffic

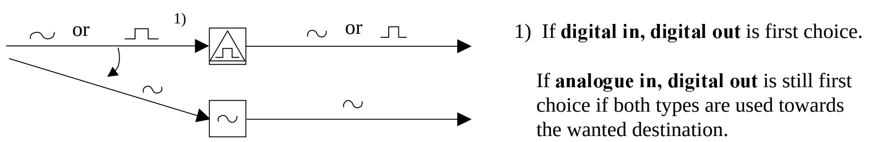


Figure 4.45: Routing of LD-traffic

Figure 4.46 shows the situation after the analogue transit exchange has been dismantled.

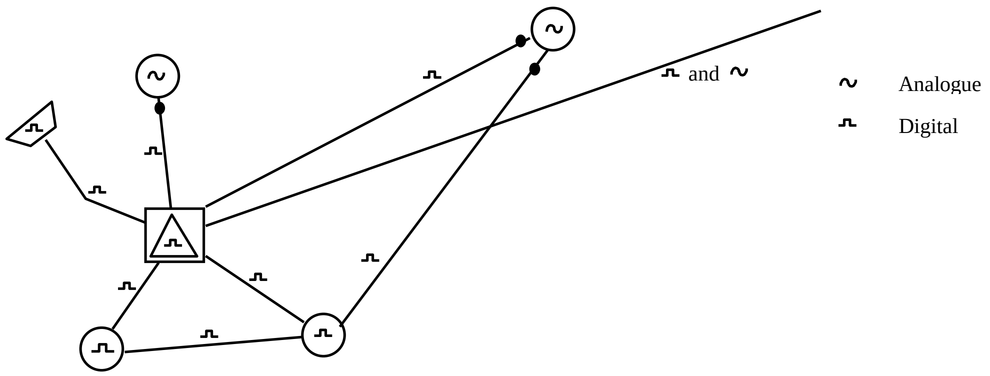


Figure 4.46: Analogue transit exchange dismantled

Figure 4.47 shows the final network structure with the combined local transit / LD exchange.

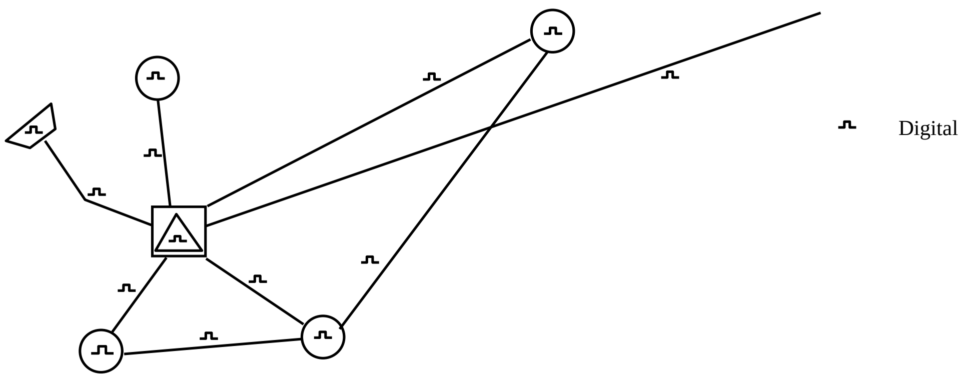


Figure 4.47: Final network structure with combined local transit /transit exchange

c) Introducing a separate, digital LD transit exchange

There are cases when local traffic and long distance traffic cannot be combined in the same exchange, for instance in countries where local traffic and long distance traffic are handled by different administrations. In other cases the same administration handles both local and long distance traffic, but wishes to separate the two types of traffic for policy and/or administrative reasons.

In all these cases a separate, digital LD transit exchange will have to be introduced in the same background situation as described in Figure 4.48. The routes from the local exchanges to the transit exchange carry transit traffic only. The previous direct route from one of the digital exchanges to the analogue transit exchange has been moved to the new digital transit exchange, so as to separate analogue and digital traffic as much as possible.

There is no difference in the routing principles compared to the case when the long-distance and local functions are combined in the same exchange.

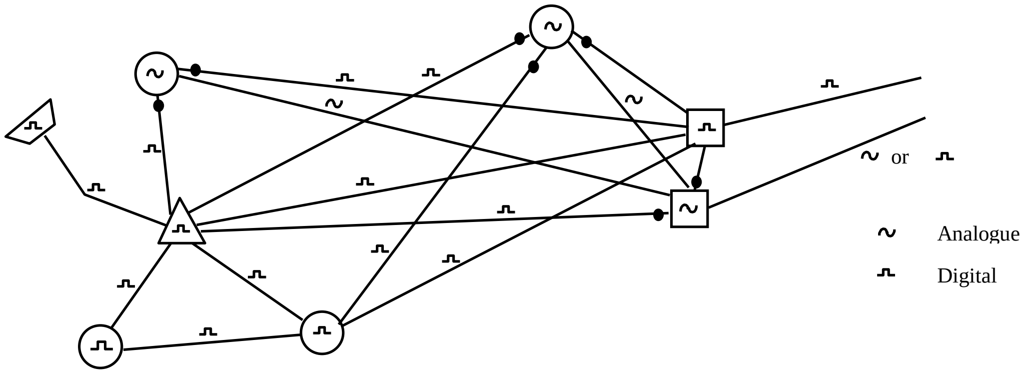


Figure 4.48: Introduction of a separate digital transit exchange

Figure 4.49 shows the situation after dismantling the analogue transit exchange and Figure 4.50 shows the final network structure with the separate transit exchange.

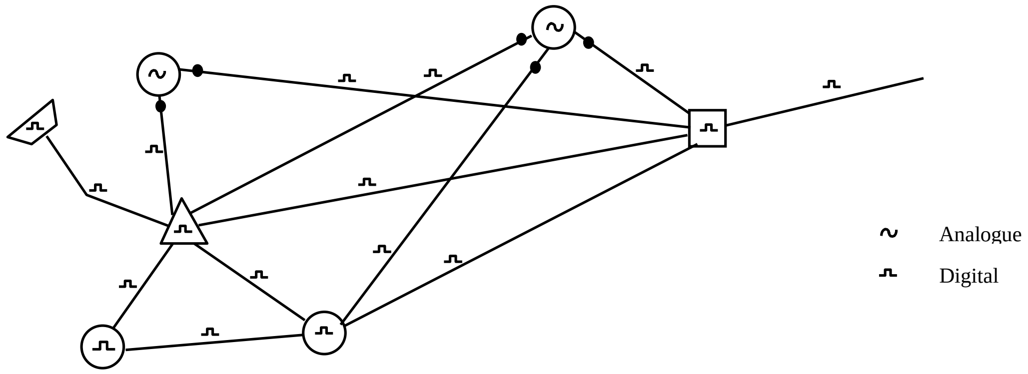


Figure 4.49: Analogue transit exchange dismantled

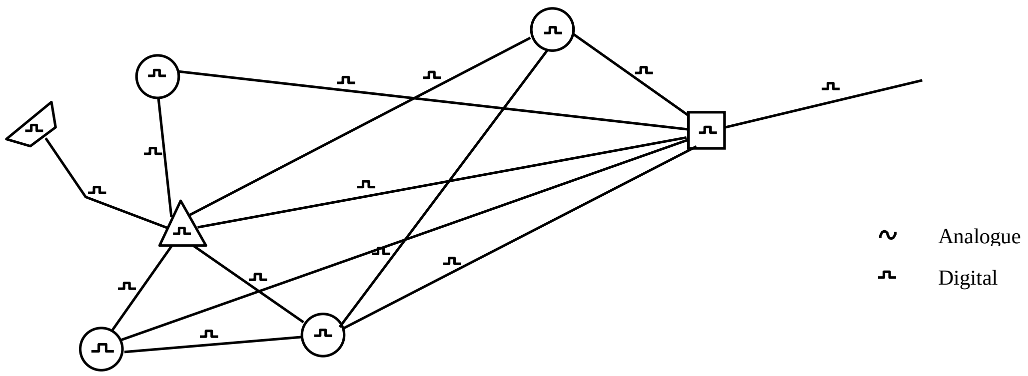


Figure 4.50: Final network structure with separate transit exchange

4.6.5 Comparison of analogue and digital networks

Figure 4.51 shows the traditional network hierarchy of an analogue network. The hierarchical structure of a digital network in Figure 4.52 contains fewer levels because the primary exchanges could be used as local transit exchanges. Furthermore, the level with tertiary exchanges is in most cases not needed because the new digital exchanges have larger switching capacity.

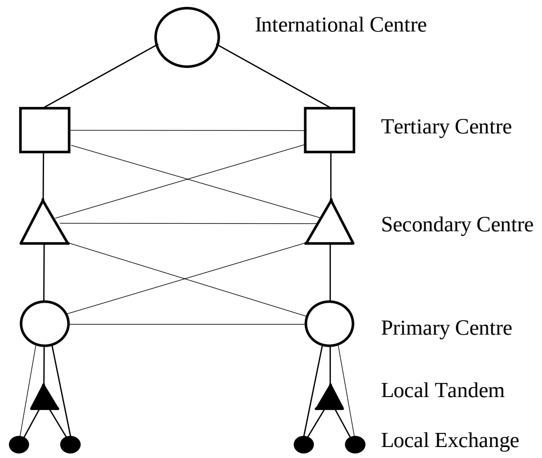


Figure 4.51: Hierarchy of analogue network

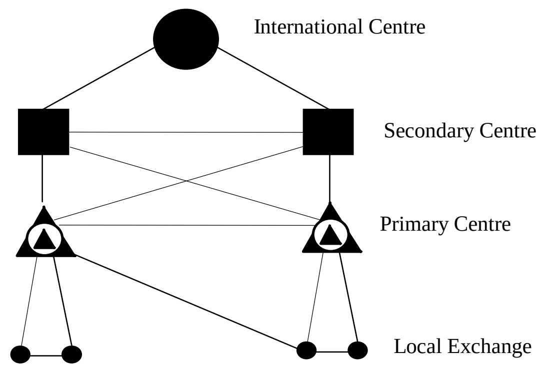


Figure 4.52: Hierarchy of digital network

Figure 4.53 shows the structure of a fully digitalised network. Compared to the analogue network structure in Figure 4.51, the metropolitan network contains fewer exchanges because of the possibility to cover larger subscriber areas by using remote subscriber switches and because of the larger switching capacity of the digital exchanges. Fewer but larger exchanges lead to fewer but larger exchange areas and larger routes.

The tendency is the same in urban and rural networks, where existing smaller exchanges are replaced by remote subscriber units and remote subscriber multiplexers connected to larger digital exchanges.

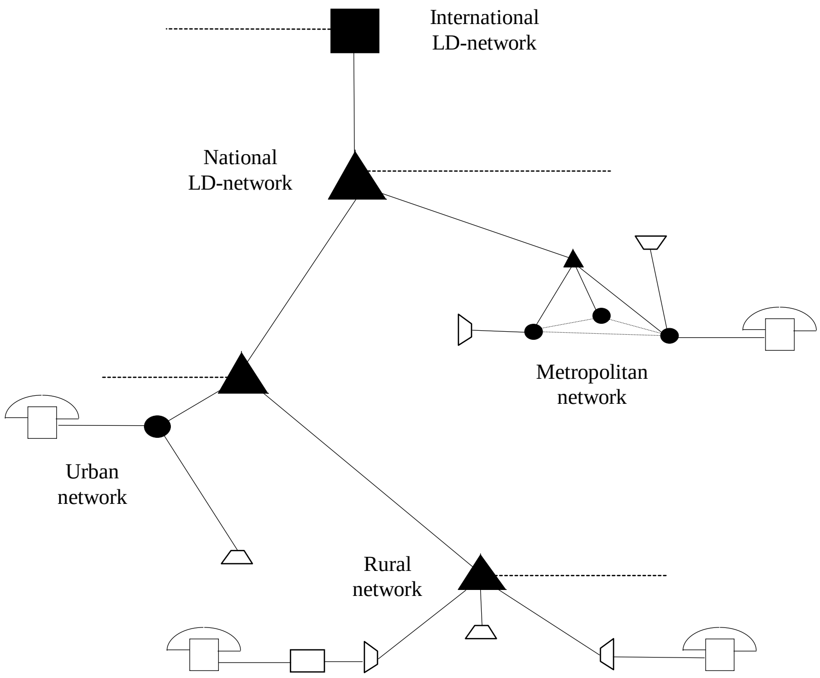


Figure 4.53: Structure of digital network

To summarise, the digital network structure is characterised by:

- Integrated transmission and switching;
- Extensive use of remote subscriber switches;
- Use of combined exchanges (local/LD/transit).

This leads to:

- Lower average cost per subscriber line;
- Reduced number of levels in the network;
- Reduced number of exchanges;
- Larger exchanges;
- Larger exchange areas;
- Larger routes.

The trends are towards:

- Increased use of optical fibre technology;
- Introduction of SDH;
- ISDN-type configurations.

4.7 Impact of new techniques on network operation

Already today, many customers demand a high quality telecommunication service without interruptions around the clock, and are also prepared to pay for such a service. Competing providers' ability to guarantee high quality connections will be an important criterion for customers when they come to choose among different available telecommunications options.

Technical evolution resulted in an upgrading of the equipment, in particular the transmission resources which became of higher and higher capacity. A fault on a large transmission route can thus result in a large number of customers being cut off from service.

Increased demand and customer requirements together with enormously increased capacity, often concentrated in single groups of equipment, puts much more stringent requirements on forecasting, planning, operation and maintenance of the network.

The complexity of the telecommunication market is also increasing. Small and large competing operators will be established, the services provided will be many and customised, and each individual service will possibly have a very short life before it is withdrawn. New services must be created and implemented quickly, and bandwidth on demand will be absolutely necessary.

The way of invoicing customers and sharing the revenue between competing operators and service providers will be an intricate problem, especially since traffic of many origins will share the same network resources. Special agreements with large customers may make a number of different tariffs necessary.

To complicate things even more, we will, for a more or less long period, often have a mixture of analogue and digital technology in the networks, separate networks for different services and many old support systems for operation, dimensioning and data storage running in parallel with modern support systems. The management will therefore be even more complicated than before, and will require manpower, competence, support systems and capital. Thus, management development might very well determine the success or otherwise of network operators and service providers.

The management of the telecommunication networks will be strongly influenced by the deregulation of the service market and the increasing competition. A very important factor is the rapid **technological** development. This development creates a range of new service possibilities which is the factor that makes the market so interesting for new operators and service providers. However, the same technological development also makes new, fast, flexible and cost-effective systems for the management of telecommunications possible.

The development of the management of the network will need the implementation of a highly automised, integrated and standardised, **Telecommunications Management Network**. **TMN** includes systems and standards for **all management** of the network and connected equipment and intends to make the management more effective through increased automisation, integration and **remote handling**.

The handling functions are realised in a new way by dividing the support systems into **application** and **common information** with standardised interfaces.

Figure 4.54 shows the structure of a TMN; **Q** being an interface between the support system and the network elements, **X** between the support system and other TMNs, e.g. other operators, and **F** between the support system and users' systems, i.e. terminals and work stations.

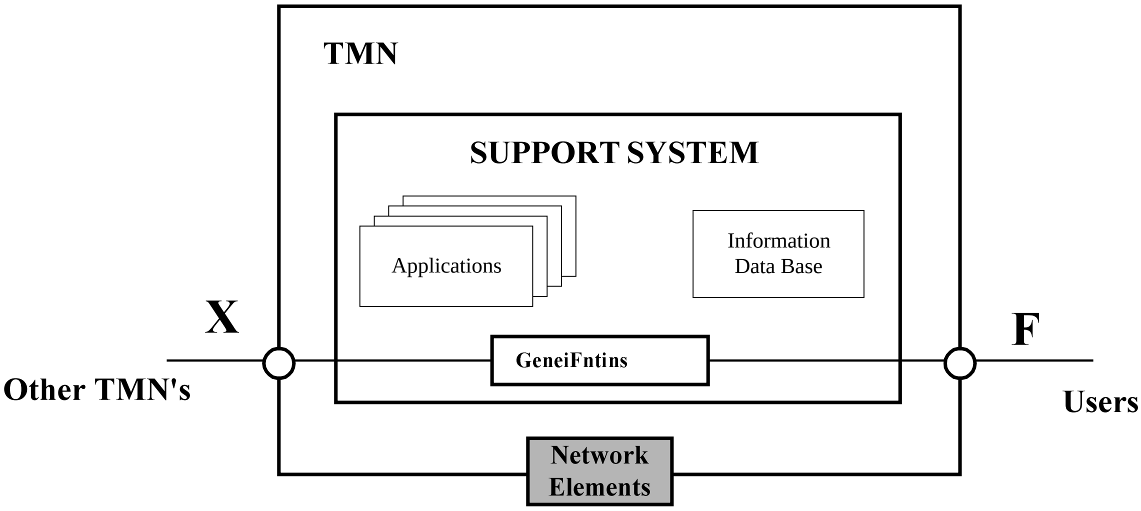


Figure 4.54: Telecommunication Management Network (TMN)

The management functions which are realised in the support or operations systems concern practically all management fields including:

- Design;
- Planning;
- Installation;
- Sales/Provisioning;
- Performance;
- Fault/Maintenance;
- Security;
- Accounting;
- Customer query and control

All these fields are rather interdependent through their need for common information and competence; the management system should therefore be structured in such a way so as to enable common information to be reached and updated from theses fields.

Different operators run their own TMNs. At the same time, each operator has a need for information of **all** customer services running. Thus, standardised interfaces are provided between TMNs for different bearer networks, connected equipment and teleservices as shown in Figure 4.55.

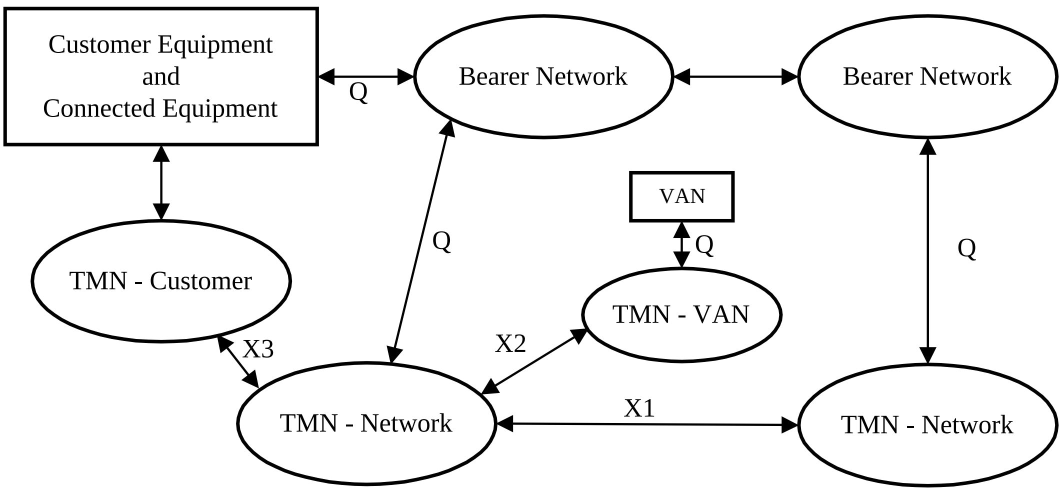


Figure 4.55: Inter-TMN interfaces

Together with properly designed exchange equipment, the new support systems will give more information about the traffic flow in the network, i.e. how the traffic is distributed geographically and over time, for each service and for each customer segment. This information should be stored in network registers which are available for several applications through the application of the TMN-standard.

The network registers thus always contain both historical and fresh data, which gives an excellent basis for service forecasts and for studies of for example how the development of market shares is influenced by various services, promotional activities, competitors activities etc.

Data bases can show the exact and up-to-date state of the network, with an interval between up-dates of not more than a few seconds. The network can be controlled and manipulated from these data bases via direct connection to the different network elements. Network faults and temporary resource problems can thus be handled within a very short time. The information data bases may be connected to the customers' data bases to enable customer control.

Data from and to the network will be needed for all types of activities from marketing to supervision of service quality, operation and maintenance. The border between planning and operation will be thus become less distinct.

The development of support systems for management may be based on the **Platform Concept**. These are composed of combinations of hardware and software, following established industry standards, for example X/Open, Common Application Environment, OSI Communication Protocol = ISO/CCITT, SQL-Oriented Relation Data Base etc.

By the platform concept, it is possible to distinguish clearly between Information, Definition of Systems, Interfaces, Network Design Rules, Products etc. This means that different operation support systems can cooperate using exactly the same information, new software and hardware products can be developed faster, products from different suppliers can be integrated more easily, etc.

The planning group should carefully examine the need, technical possibilities and capital and running costs for a TMN system, in the form of scenarios. Alternative time tables for implementation steps must be included. Consequences of various courses of development should be estimated in terms of costs, losses, revenues, competence and manpower needs. Note that the introduction of TMN in the beginning will probably require **more** personnel than before, but that after some years, probably **less** personnel will be needed. This means that **new** personnel must be recruited and trained for the TMN system, at least to some extent.

4.8 References

[1] Synchronous Transmission Systems. Northern Telecom Europe, London, 1993.