Chapter V

TARGET NETWORK

Contents

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Purpose of this chapter

Why consider a target network?

The business idea of any Public Telecommunication Operator (PTO) is to provide services to the customers for payment. For this, the operator needs a good organisation, competent personnel, a business strategy, and an efficient network. In order to meet the ever-changing and increasing service demand, the network must continuously be developed, altered and modernised. However, telecommunications become more and more sophisticated and complex, necessary investments are often very large, it takes a considerable time to radically change the principal network functions, and there is always a risk that quite recently implemented new technologies or configurations soon become obsolete.

Furthermore, land for future installations has to be procured, ducts to be planned etc. The network must thus continuously develop, but always in the right direction. So we must clearly know what this direction is, in other words, we must have a target network as a framework for the network evolution.

The target network should therefore be very carefully considered and specified. Even so, we must always expect that even the target network may have to be revised from time to time.

Outputs

The outputs should be in the form of alternative scenarios, corresponding to different levels of service provision, network functions and technological sophistication.

Each scenario may be limited to only one point of time, e.g. 15 or 20 years ahead, but should preferably cover some period of time. Each service area should be covered:

- an overview of all different network types and the degree of integration between them;
- a description of the general network architecture, i.e. a plan of the network functions;
- a description of the network structure, i.e. a plan of the transmission systems, transmission media and mode equipment;
- the study may be structured into five network blocks, as shown in Figure 5.13, i.e.:

  access;

  transport;

  switching;

  feature;

  operations support.

Inputs

- Results of and information given in Chapters 3 and 4.
- Guidelines and information provided in this chapter.

Contents of Chapter 5 : This chapter provides guidelines for networks which develop towards configurations and functionalities that can meet the future demand for services and thus become important parts of the infrastructure in a country. For cases with a considerably slower development, the section on digitalisation strategies given in Chapter 4 is more applicable.

Chapter V

TARGET NETWORK

5.1 Network growth and degree of integration

A number of factors will influence the development of the networks, for example:

- the degree of deregulation on the telecommunications market;
- the capital available for investments in telecommunications;
- the general business and socio-economic development;
- the strategy and skill of the network operators;
- the general infrastructure and especially telecommunications policy in the country.

For each network, as well as for the total telecommunications network, resource information on, for example, the following aspects is required:

- the growth over time expressed in approximate amount of end users and traffic;
- the degree and time of integration.

Each area of importance should be studied, considering all existing and future networks. The most complex and also important areas will probably be the metropolitan areas. As an example, Figure 5.1 attempts to illustrate the possible growth over time for the following types of network:

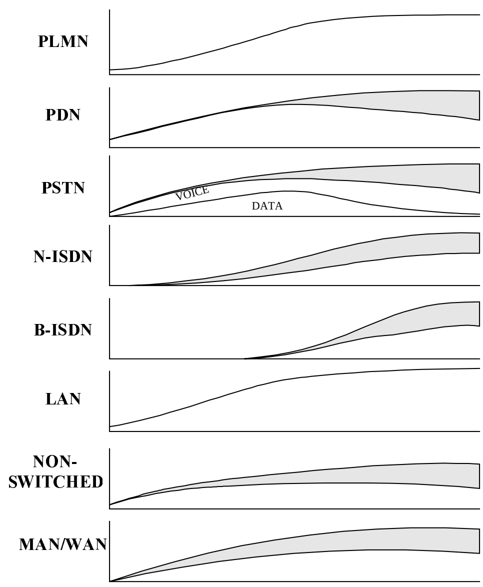

Figure 5.1 : Network growth

PLMN	=	Public Land Mobile Networks
PDN	=	Public Data Networks
PSTN	=	Public Switched Telephone Networks
N-ISDN	=	Narrowband ISDN
B-ISDN	=	Broadband ISDN
LAN	=	Local Area Networks
NON-SWITCHED	=	Non-switched multiplexer network for fixed digital lines. The multiplexers may be DXC's.
MAN/WAN	=	LAN interconnect networks: Metropolitan Area Networks and Wide Area Networks

Local Area Networks (LAN) are or will be a very large source for the provision of data communication, possibly over public networks, such as ISDN, B-ISDN or possibly Non -switched networks. The competition comes from MAN/WAN and private data networks.

Some areas in the graphs are shadowed to indicate that the growth of a particular network will be influenced by the growth of others. There is a complex interdependence or competition between the networks, as shown in Figure 5.2.

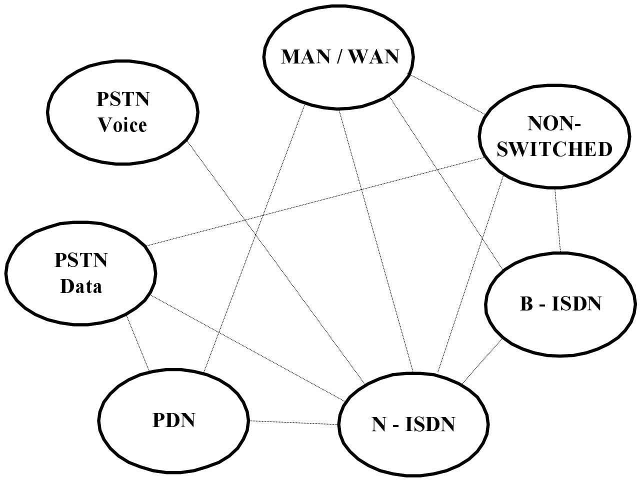

Figure 5.2 : Competition between networks

Integration may radically affect the competition between networks and consequently the growth trend of an individual network.

It will for instance take some efforts and capital to start integration of services via the so-called narrow band ISDN, but after some time its use may become more attractive and its development could accelerate.

As far as the B-ISDN is concerned, the initial step will be much more difficult, since it comprises new transmission media, a new transmission hierarchy, new switches, new signalling capabilities and even new terminals.

5.2 Provision of public data communication services

Data processing and communication are today very important parts of society and provide significant means for competition among its different organisations. This importance places stringent requirements on the telecommunication network, which constitutes the base for the evolution towards more effective transport of data information.

The conditions for public data communications differ from country to country, depending on network solutions, user application demands, tariff structure, etc.

Since the user always will, and indeed must, adapt his communication procedures to the network performance, there is no certain way to estimate which network solutions will best serve the various types of user applications. There is often more than one public service alternative which the user has to decide upon when he is creating his application. Besides cost and technical performance he must also judge how flexible the solution is for expansions and functional changes, and how well it is adapted to fulfil future demands.

If we try to structure the wide range of applications, it is useful to group the different types of communication needs according to their traffic pattern. In this way, three types of network solutions can be identified:

- Closed networks

  These are to a large extent implemented as private networks on leased lines, due to the fact that they often have a very high traffic load and often use manufacturer-specified protocols.

- Half-open networks

  The structure of these networks is characterised by a large number of terminals, communicating with a smaller number of central equipments, for example databases. These networks are often dedicated to certain kinds of business, agencies, brokers, various groups of professionals, etc.

- Open networks

These represent "real" public telecommunication and consist of a number of services, each with almost equal numbers of terminals exchanging information, in one, or between several, public networks. Examples are: telex, videotext, teletex, telefax.

These three types of network can be used for a number of different communication types, each one characterised by a number of traffic parameters:

- call set-up time;
- call intensity;
- bandwidth;
- length of messages;
- availability;
- security;
- business;
- busy hour period.

Data services may be publicly provided in a number of ways:

- via modems in the public switched telephone network (PSTN);
- via dedicated data networks (PDN), which may be circuit switched, (CSPDN), or packet switched, (PSPDN);
- via direct leased lines;
- via non-switched networks, i.e. fixed connections through a network of multiplexers, e.g. DXCs;
- via narrowband ISDN, (N-ISDN);
- via broadband ISDN, (B-ISDN).

N-ISDN is circuit switched but can handle packet switched accesses via an interworking unit, IWU.

B-ISDN will eventually be packet switched, using ATM, but may during some years use STM, broadband circuit switching.

5.2.1 Telematic services

An important incentive to implement data networks is the possibility of offering telematic services. The following are examples:

- teletex service over CSPDN, PSPDN or ISDN;
- facsimile service over PSTN, CSPDN, PSPDN or ISDN;
- videotex service over PSTN or ISDN;
- telex service over CSPDN or ISDN.

Introduction of these services requires introducing telematic terminals connected to data networks. The telematic services enhance the utility of data networks and will increase the number of users. Figures 5.3 and 5.4 indicate how to provide these services in an economically feasible way.

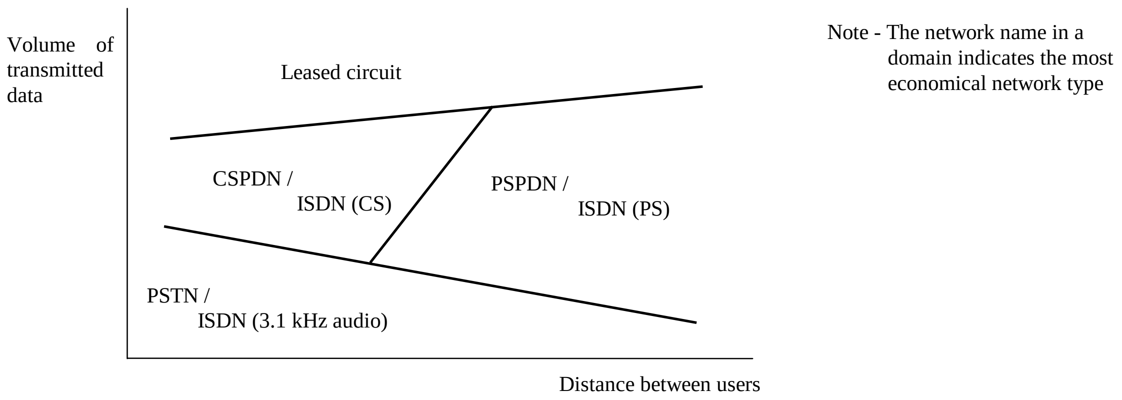

Figure 5.3: Economical comparison of data network types (Volume-Distance)

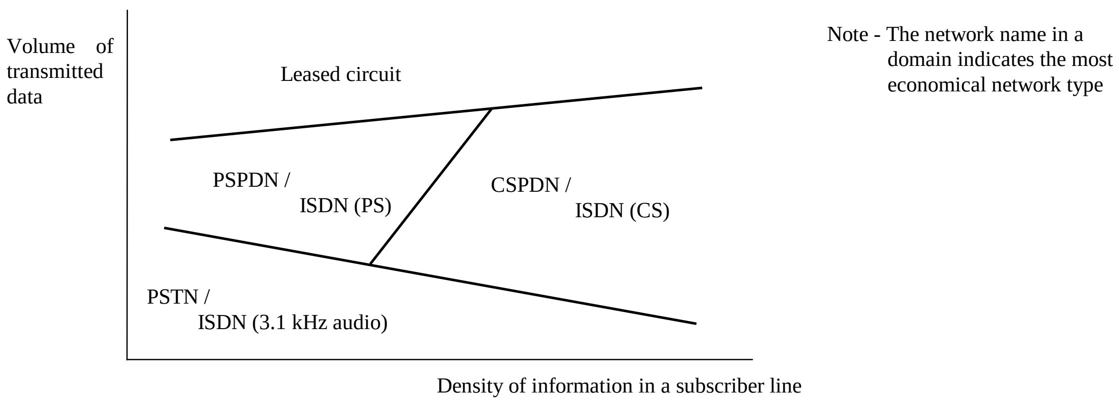

Figure 5.4 : Economical comparison of data network types (Volume-Density)

5.2.2 Guidelines for selection of networks

This section deals with the selection of the type of network for data transmission services from the technical and economical points of view. Decision items are elaborated below in parallel with the decision chart in Figure 5.5. In this elaboration, it is assumed that most countries have an operating PSTN, and therefore can already provide data transmission services over the PSTN and leased circuits. The objective of the selection is then to examine the necessity of implementing a new public data network (PDN) and, if found to be required, to evaluate the most suitable type.

- Since the introduction of a dedicated data network requires additional investment, the demand for data services should be carefully examined. If the demand for the services is not high, the use of the existing PSTN or leased circuits for data service is recommended.
- Since a circuit-switched PDN or an ISDN requires a digital transmission system, a packet-switched PDN is the only solution when only an analogue transmission system is available.
- In cases where digital transmission is available, selection of a packet-switched or circuit-switched network is determined from the viewpoints of the application and traffic forecast for data transmission services.
- Introduction of an ISDN may be desirable in cases where a certain degree of digitalisation and synchronisation of the PSTN has already been completed.

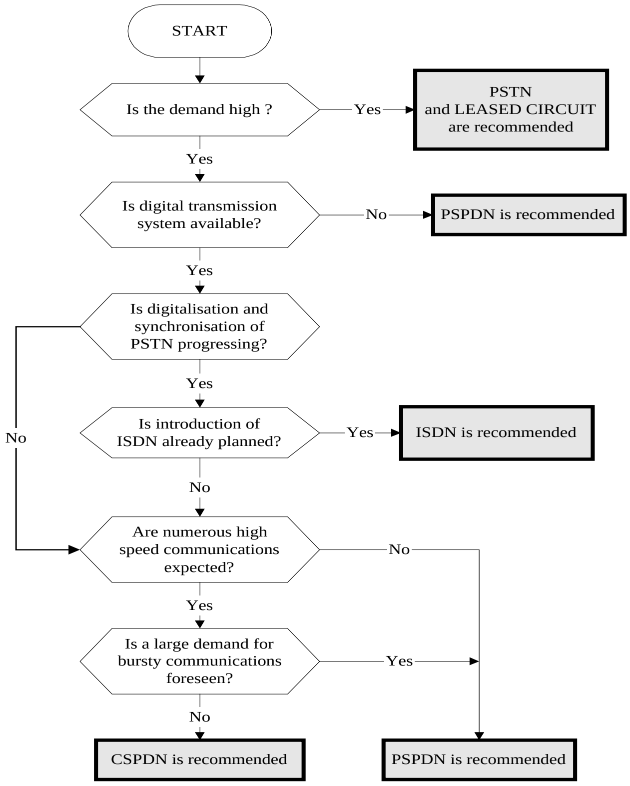

Figure 5.5 : Decision chart of data transmission services

We see that ISDN can provide all the telematic services and is an alternative to other solutions for all distances and for small to large volumes of transmitted data. Only for very large data volumes could leased circuits be a more suitable solution. If digital cross connects (DXC) are implemented as network elements, leased-line connections may become even more attractive because of the fast and easy way of re-arranging transmission resources that DXCs create.

The introduction of ISDN implies integration of existing dedicated public networks. Once the ISDN integration is decided, the ISDN will attract more services.

5.3 Broadband evolution.

Today, the demand for increased bandwidth comes primarily from the business community. In the future, it is expected to become a requirement for residential customers, especially for entertainment services, such as High-Definition Television (HDTV).

Currently, high-bandwidth traffic is carried mostly within the business organisations. However, new services are constantly being introduced increasingly either by new service providers or within highly-distributed service industries, such as the travel industry. This means that traffic between different companies will also grow. (See Figure 5.6.)

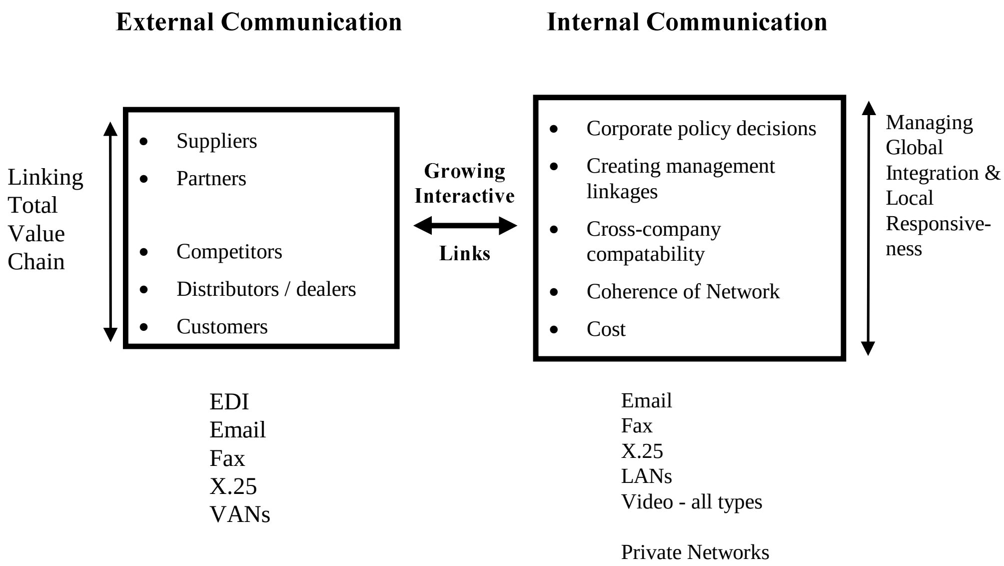

Figure 5. 6 : Example: relationship between inter-company and intra-company communications

One should also bear in mind that the amount of data traffic will always depend on the technology and cost of public networks. The introduction of digital networks will bring about more capacity at lower costs.

The provision of greater bandwidth over the public network will probably be accomplished in a step-by-step fashion. (See Figure 5.7.)

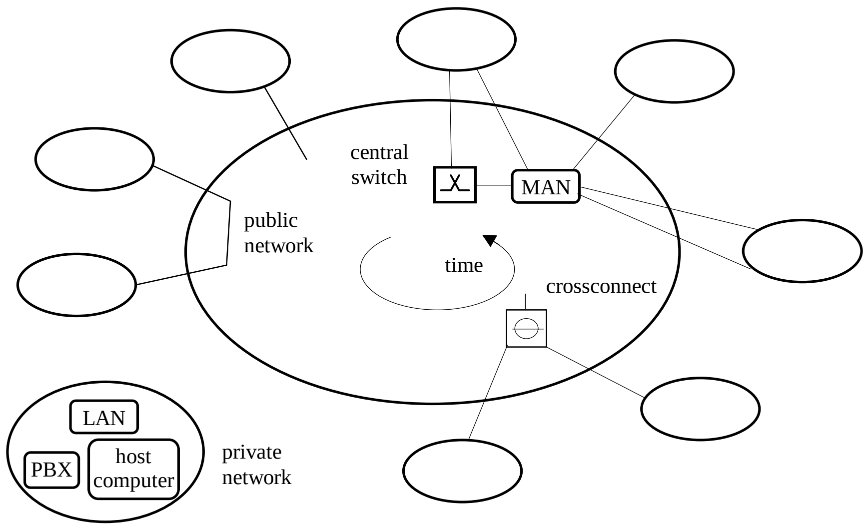

Figure 5.7 : Bandwidth provisioning

The first step, which is already taking place, is for Local Area Networks (LANs) or host computers to be linked together, using leased lines of up to 2 Mbit/s capacity.

Later on, these leased-line connections between distributed organisations will be provided by means of digital cross-connects instead of hard-wire connections. This will shorten delivery times and reduce labour costs by the use of the state-of-the-art operation support systems.

The third step is the introduction of a switched multi-megabit service which could be provided by a public Metropolitan Area Network (MAN). The feasibility of this technology in the public network is under discussion, especially the security, operation and maintenance aspects as well as the distinction between user and network in a multi-user environment.

It is therefore more likely that private or possibly public MANs will be linked together by means of Asynchronous Transfer Mode (ATM), broadband and narrowband switches for the nationwide provision of switched multi-megabit services -thus moving into the B-ISDN era.

Thanks to this step-by-step network evolution, the public network will support broadband communication by using DXC, MAN and ATM technology. In parallel, switched n x 64 kbit/s communication will be offered as an enhanced narrowband ISDN service. Moreover, B-ISDN broadband communication will be developed by encompassing entertainment services such as HDTV.

As far as local networks are concerned, the first optical fibre links are being introduced in high-density areas. The use of optical fibre allows the traffic-handling capacity of the local network to be increased dramatically with the help of existing ducts. It also makes it possible to satisfy the growing demand for higher bandwidth from business customers.

It is assumed here, that the ATM technology to a high degree will eventually be used to a great extent for switching and transmission. However, the introduction of ATM will be costly, and it may therefore take a considerable time before a substantial part of the network is transformed to that concept.

The introduction of broadband services will depend on the end users' demand rather than on political decisions and technical feasibility. The user demand will usually be expressed as desired applications rather than as a need for general bearer capability. In some cases, however, large customers may require bearer bandwidth as a specific service. For the network operator, bearer capability is highly interesting, since it enables the provision of all types of services in one single network.

It is to be expected that investments in broadband communications will be made in areas where the profitability is high. As the need for broadband communications will come mainly from business users, it is probable that many metropolitan areas will be the first to adopt ATM technology. Especially the “bursty” services will require ATM or MAN communication, while services with more continuous bit streams may be provided over STM accesses.

B-ISDN may become a type of ultimate network concept, encompassing all aspects of future telecommunications, but this is by no means certain to come true. It may be that B-ISDN will be economically feasible rather early in some countries dependent on very large demand from the business sector, while in other countries only parts of the new technology for broadband communication will be profitable.

B-ISDN is not just an extension of the ISDN functionality, accommodating high-speed communications, imaging services, etc. An upgrade from an ISDN access to a B-ISDN access is not easily carried out, since B-ISDN requires a completely different infrastructure.

A very much simplified example of evolution toward B-ISDN follows. Terminals, interfaces and protocols are not considered.

Figure 5.8 illustrates a possible beginning with two main network components:

- a switch that can support large volumes of services with a bandwidth requirement of up to 2 Mbit/s, such as POTS and other telephony, low speed video, low to medium speed data services including telefax, teletex, videotex etc. In addition, a circuit switch with parts having sufficient capacity for bandwidths up to 34-45 Mbit/s could be provided for relatively small volumes of services such as video conference with standard TV quality;
- a digital cross connect system with the DXCs distributed in the transit network. Suitable locations would be together with switches. The DXC in a asynchronous network provides for the setting up of semi-permanent connections between different channels, enabling routing to be performed down to a VC level (see § 8.4.4). The fundamental difference between switching and cross-connecting lies in the duration of the connection. In switching it is temporary, in cross-connect it is semi-permanent.

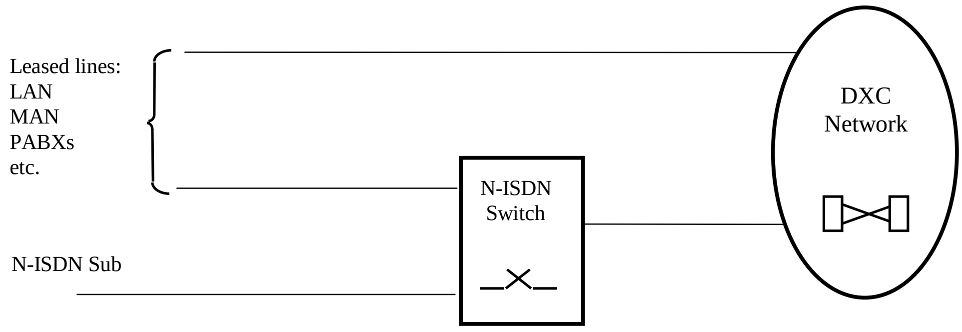

Figure 5.8: **Initial broadband system structure**

When the demand for high bit-rate data services for business users increases, this initial configuration would probably become insufficient. Real broadband switching capability for data services such as Switched Multi-megabit Data Service (SMDS) must be added to the network.

Figure 5.9 shows that this new switching capability will be reached via the DXC network. The use of DQDB, Distributed Queue Dual Bus is just an example. Alternatively, a solution based on ATM or STM (Synchronous Transfer Mode = Circuit Switching in broadband networks) may be used. This alternative would actually give a higher throughput, and would of course also be more in line with the possible longer term network development.

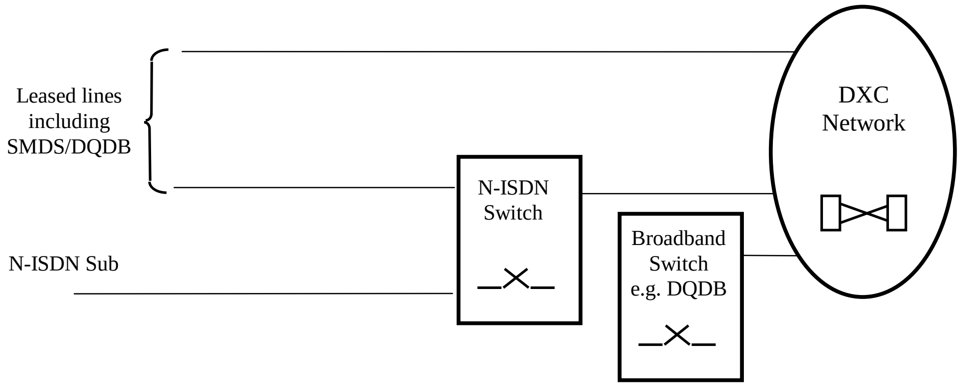

Figure 5.9 : Real broadband switching is introduced

Figure 5.10 shows how on-demand switching of broadband channels and provision of full bandwidth flexibility is obtained by including the ATM-switch in the network. In the beginning, only a few of the switching modes may be equipped with ATM switches. Broadband customers who are connected to switching nodes without ATM will still be able to access ATMs via the DXC network on semi-permanent paths.

When the demand for on-demand connectivity increases, it might be feasible to modify some of the DXCs to customer controlled 155 Mbit/s space switches.

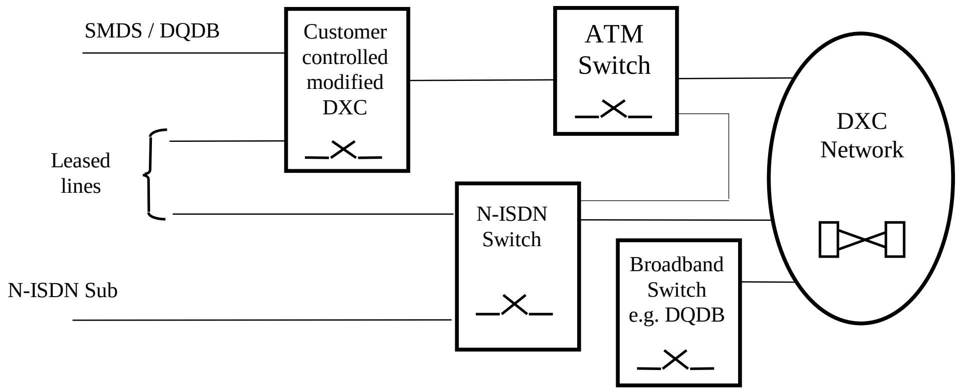

Figure 5.10: On-demand switching by introduction of ATM

The last step may be to introduce dedicated B-ISDN access, which allows for a single integrated access for all services, via modified DXCs capable of handling 622 Mbit/s. (See Figure 5.11.)

If such broadband services are provided for residential users, the bandwidth will probably be used mainly for entertainment broadcast services such as High Definition TV etc. Only a small part of the bandwidth will then be used for communicative services, so the corresponding traffic needs to be concentrated before extending the network.

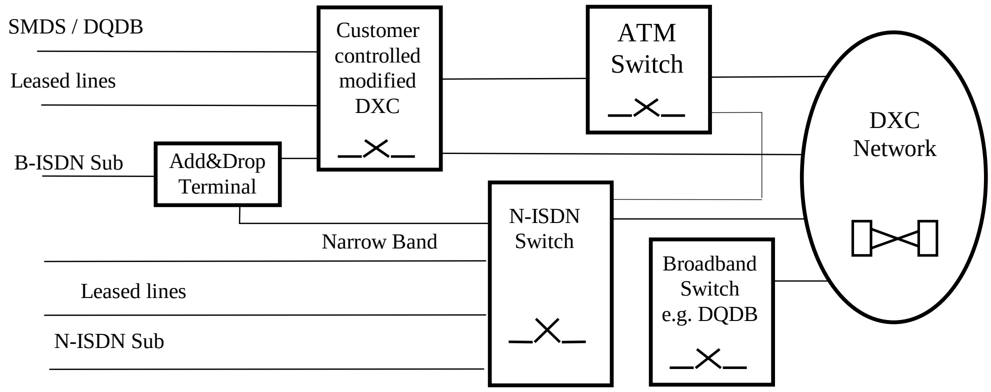

Figure 5.11: Full B-ISDN structure

A picture of the ultimate, fully integrated future network is given in Figure 5.12 and Figure 5.13 illustrates how the whole network may be structured into five blocks.

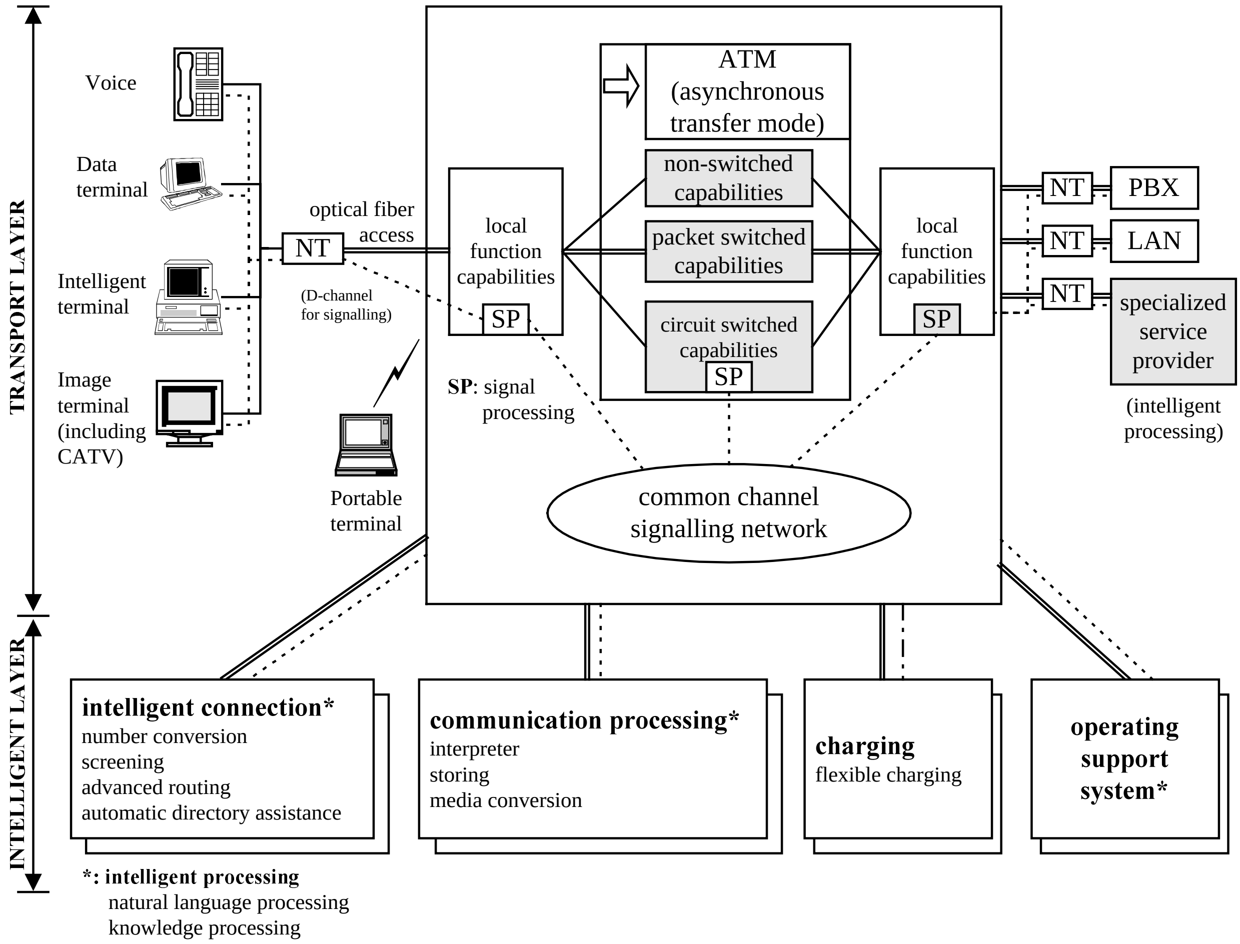

Figure 5.12: Future network architecture

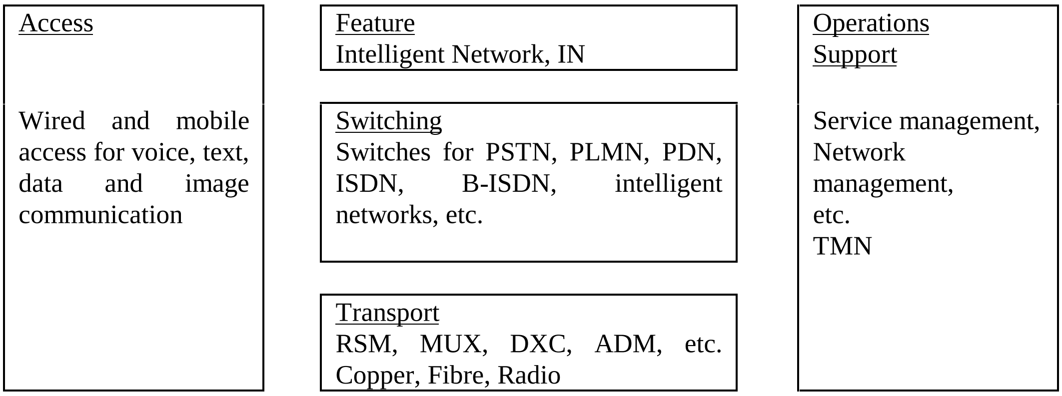

Figure 5.13: Functional structure of the telecommunication network

5.4 Access networks

5.4.1 Physical structure

The infrastructure of the access network comprises ducts, cable and localities and represents a considerable capital investment for a network operator. To change this infrastructure requires long-term decisions. Available funds for investment in the access network are usually quite limited; so that it is it is important to use the capital in the most effective way. Investments in new ducting for example must be carefully planned to support the development towards the target network.

The ducts in the access network are a strategic resource. New operators often buy or lease land for this purpose rather early. One solution to avoid the development of a new initially costly infrastructure is to use radio access. However, to serve a more demanding market, cable oriented solutions are required for two reasons: long run costs are lower, and capacity is higher. That means in practice optical fibre. By using sophisticated coding techniques, bit rates in the order of 2 Mbit/s can be carried on copper, offering the possibility that a number of future services requiring increased bandwidth will be delivered over the copper network. In the longer term, however, only optical fibre and radio have the bandwidth capability that can deliver an access network which will meet all future service requirements.

Unfortunately, the fixed costs of fibre systems are high, and the associated terminal equipment requires high fill rates in order to be economic.

Developments in Passive Optical Networks (PONs) offer the imminent possibility that fibre systems can be deployed economically not only to small and medium businesses, but also to residential customers requiring broadband (for example, entertainment) services. Relative to copper and present fibre systems, the fixed costs of PONs are much lower, allowing them to be deployed initially with much lower fill rates. Moreover, a single fibre can be used to serve a number of customers in contrast to existing systems, such as copper which require dedicated pairs for each customer site. As a result, by using PONs, requests for service can be met on demand, and the pre-investment costs minimised. Technology always delivers its promises - eventually. New developments do not always go according to plan and today’s access network cannot be planned using tomorrow’s technology.

In the meantime, it is vital that the infrastructure for building tomorrow’s access network be built today to enable the timely deployment of fibre in the future. Fibre can be installed either as cable in ductwork or as bundles in blown fibre tubing. While the copper access network continues to grow over the next few years, the reservation of duct space for subsequent fibre cable installation on the primary side, and provision of blown fibre tubing on the secondary side, possibly in a composite distribution cable, will ensure that the infrastructure required for fibre will be ready when it is needed.

5.4.2 Transmission

Digital technique was applied to the access network relatively recently. Typical digital applications in the access network consist of:

- connection of digital business exchanges;
- connection of remote subscriber units;
- interconnection of LANs.

The technique used is point-to-point connection via 2, 8, 34 or 140 Mbit/s lines. 2 Mbit/s connections may be made over pair cable; higher speeds over optical fibre; a few cases via radio link. The traditional digital transmission technique, using the plesiochronous digital hierarchy (PDH), will be replaced by SDH, the advantages offered by SDH being:

- quality data;
- maintenance data;
- control;
- modularity.

Many network operators base the network planning on the use of SDH also in the access networks.

5.4.3 Distribution

SDH in the access network can be considered as an automated distribution frame, whether it is realised as a distributed Add and Drop Multiplexer (ADM), or a centralised Digital Cross Connect (DXC). The advantages of establishing SDH far out in the access network are that the service quality can be supervised near the subscribers and that faults can be by-passed near the source of error due to redistribution functions in the system.

Another redistribution takes place at the channel level. Traditionally, this is a physical relocation of copper pairs in a distribution frame. The advantage of the introduction of an effectively automised redistribution functionality in the digital access network is the fact that there are quite a few extensions which are not handled by the public telephone network, for example Datex, leased lines, etc. These may in the beginning be realised over separate copper pairs into the local exchange. In the future it will not be economically and practically feasible to have a copper network in parallel with the optical one for this type of access.

In the future, some of these services will be withdrawn, and others will be implemented in a form suitable for digital transmission, for example via the ISDN. With the traditional techniques, some kind of separate multiplexer is required in the access network if copper is not available to the exchange. These multiplexers would preferably be connected to a digital cross connector for 2 Mbit/s terminations and 64 kbit/s internal distribution.

Another possibility would be to introduce flexible multiplexers in the access network. Such a multiplexer would include a small DXC and would give the same functionality as the first solution, but closer to the customers.

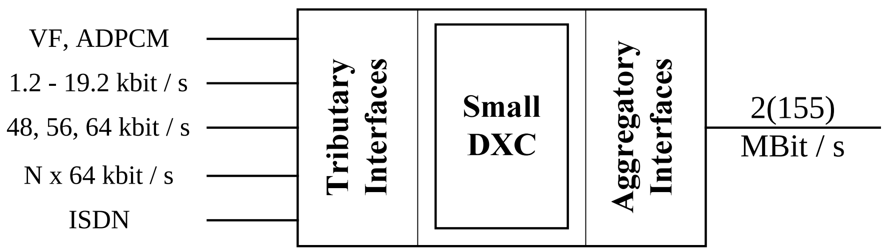

Figure 5.14 : Example of a flexible multiplexer

5.4.4 Customers

A new infrastructure should support future telecommunication business better than before, and the planning should therefore be carried out considering the market and customer conditions.

The ordinary residential user is still the basis for the activity of a telecommunication operator. The continued growth of the demand for telephony is relatively uncertain as more and more residential demands become 100% satisfied. There will for instance be a competition between second and third fixed line and cellular or other radio subscriptions. The characteristics of residential users can be summarised as follows:

- dominate in number;
- use analogue telephony and TV;
- low but stable requirements on functionality, security and quality;
- price sensitive;
- poor profitability in the access network.

The business customers will be of great importance for the future profitability of the telecommunication market and their characteristics can be summarised as:

- relatively few in number;
- use telephony and data;
- high and non-stable requirements on functionality, security and quality;
- less price sensitive;
- high profitability in the access network.

Since mobile and personal telephony has a very strong growth, we may also consider these customers in terms of radio base stations in the access network. Their characteristics are:

- relatively few in number;
- high growth rate;
- use telephony and data;
- high requirements on security and quality;
- less price sensitive in the beginning, but with higher penetration they will become more price sensitive;
- good profitability in this first phase.

5.4.5 The primary network

The primary network based on optical fibres may be built in the form of fibre rings (see Figure 5.15). A ring structure offers the possibility of diversity for the customers, e.g. by connecting their own remote subscriber units, (RSUs). Each ring contains RSUs and Active Nodes = General Access Nodes. An Active Node may contain:

- cable terminations;
- cable joints;
- distribution frames;
- Add and Drop Multiplexers, (ADMs);
- Remote Subscriber Units, (RSUs);
- multiplexer;
- fibre-optic am-receiver (cable TV);
- power and cooling.

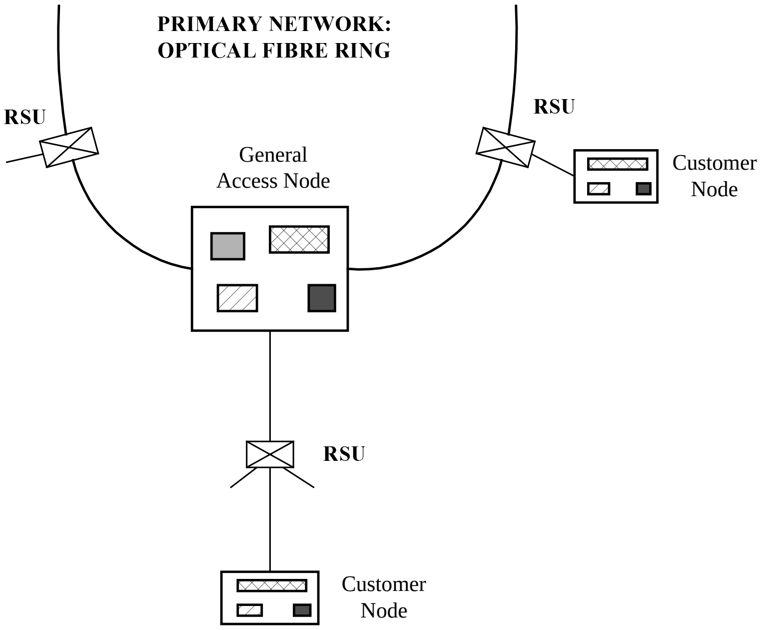

Figure 5.15 : Optical fibre access network

Especially for metropolitan areas active nodes may be needed solely for the provision of fibre and 2 Mbit/s links to large customers, i.e. without RSU in the node.

The SDH technique offers the access of 2 Mbit/s from ADMs, which are located in each Active Node. An SDH ring with 155 Mbit/s can handle up to 126 Mbit/s accesses. If that capacity is not enough, a parallel SDH ring can be activated, or the ADMs can be upgraded to 622 Mbit/s (STM-4).

The introduction of new techniques in the access network will take place at different rates dependent on the market demand and the technical possibilities.

Large customers with particular requirements will probably be served by more or less overlay-like solutions. Through the establishing of a basic structure of optical fibres, these customers may be integrated in the access network.

The digitalisation and the introduction of optical fibres in the access networks in metropolitan and urban areas will first reach large RSUs and business customers. The second step may be to establish small nodes serving buildings with many households plus some smaller business customers. A third step might be to extend the optical fibre “to the curb”, (FTTC), and connect a few subscribers to a node. The last step would then be to continue with the fibre “to the home”, (FTTH).

Two important factors which will influence this development are:

- the growth of wireless personal telephony;
- will high definition TV (HDTV) be transmitted via radio broadcasting instead of via cable?