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Planning, management operation, and maintenance of telecommunication networks

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Planning, management operation, and maintenance of telecommunication networks

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REPORT ON QUESTION 3/2

Planning, management operation, and maintenance of telecommunication networks

Topic a.1 Prepare a draft list of issues arising from the convergence of information and telecommunication technologies that are of specific relevance to the network planning function within developing countries.

1 New technologies and services

New services which are sophisticated, interactive and concerning any type of data can be created and offered to customers thanks to the implementation of new technologies like:

– ISDN (Integrated Services Digital Network),

– B-ISDN (Broad band ISDN),

– ATM (Asynchronous Transfer Mode),

– data transmission,

– IN (Intelligent Network).

These technologies are presented in detail in the report on Question 2/2: *Handbook on new technologies and services*. They are here recalled for the record. The last concept, IN, illustrates the convergence of computer and telecommunication techniques. The IN term describes a concept of architecture providing a command network to control networks; its objective is to allow for a rapid introduction of new services and to reorganize the elementary functions of information transport in a centralized manner. The long-term objective is to apply the principles of the IN architecture to any kind of network. These include in particular telephone switching networks, mobile networks, data transmission networks and broadband networks. This is quite ambitious as, for the moment, only the Public Switched Telephone Network (PSTN) and, to a limited extent, the ISDN have been studied by the ITU-T.

Concerning data transmission, technological leads consist in techniques implemented on dedicated data networks, like X.25 or Frame Relay (FR) techniques and, for integrated networks, like ISDN or B-ISDN. The Frame Relay is known as Simplified X.25 and offers higher bit rates up to 2 Gbps. The ISDN was created to comply to the idea of a network able to transport at the same time speech signals and computer data. The integration allows a better use of the network resources and a rapid introduction of new services as it is not necessary to develop a new network. It offers a large range of telephone and non-voice applications. Its development is supported by the advantages offered to its users:

– a single connection for every service,

– a unique subscriber number,

– a global bill, and

– a cable installation on which all the terminals are connected via a universal socket.

The ISDN is characterized by three fundamental principles:

– the digital closeness from end-to-end which ensures the transport of digital signals of any kind through the network, from one terminal to another. Indeed, the ISDN is based on digitization up to the subscriber installation. The bit rate is of 144 kbit/s on a basic access 2B+D and 1.5 Mbit/s or 2 Mbit/s on a primary access 23B+D or 30B+D.

– the signalling system being independent of the communication; it uses for the signalling system between switches the ITU-T Common Channel Signalling System No. 7 (CCSS), and for the subscriber signalling system it uses the D protocol being implemented on the D channel. The system is the same as for the common channel signalling: one particular channel (D channel) supports messages between the user and the network, separately from the information channels. Any signalling information can be obtained even if no communication is handled.

– the implementation of various services, which is technically possible as all the information including the signalling data is compacted in one single digital multiplex.

The ISDN, as described above, is implicitly called narrow-band ISDN. The Broadband ISDN (B-ISDN) is now under normalization process; its objective consists in transporting all kinds of information (speech, sound, video, text, image and data, and more particularly any broadband services) on a single network. It is based on the Asynchronous Transfer Mode (ATM) technique which is particularly adapted for providing the multiplexing and switching functions. Indeed, the ATM transfer protocol was developed to meet the following characteristics: ability to handle, with maximum flexibility, bit rates up to megabits per second per communications channel; the ability to satisfy strict real-time constraints; and the ability to return to applications a service suited to their needs without complicating the terminals needlessly.

As for the transmission functions, optical fibre appears to be the unique physical support for providing capacity and performances related to high rates services (B-ISDN). However, in some cases, other supports can be used. For example, xDSL technology (DSL = Digital Subscriber Line, xDSL = HDSL, SDSL, ADSL or VDSL) allows a copper subscriber line to be adapted for high data bit rates (up to 8 Mbps for the ADSL technique) without interfering with the existing services (telephony or ISDN). Synchronous digital transmission (SDH) complements naturally the implementation of the B-ISDN.

Based on these technologies, “new” services are offered in addition to the classical “basic” telecommunication services. Hereinafter are described some of the services that can and must be introduced as they are requested by a growing number of customers. It is, then, becoming more and more important that they be taken into account within the network planning phase of the engineering studies for the construction or enhancement of a telecommunication network. They will impact on the fundamental plans when:

– they generate larger volume of traffic. Consequently, adequate transmission and switching plans have to be revised to ensure a high level of quality of service, even with such a large volume of traffic;

– a decision is taken to implement an Intelligent Network on a national level to provide such services;

– a signalling network of common channel type has to be implemented and dimensioned in consequence, as these new services consume significant signalling resources even if they are not implemented exclusively on the Intelligent Network;

– a numbering scheme needs to be planned to use a large amount of numbers.

1.1 Mobile telephony with roaming capability

Mobile telephony is a technique which is now well known and which is presently implemented in many countries. It is based on the cellular radio concept that can be characterized by three basic principles, namely:

– cellular topography,

– frequency re-use, and

– location management.

The first two principles require signal processing techniques; the third one is based on data management since mobile telephony implies that:

– a subscriber can continue his conversation even though he has migrated from one cell to another; this is called handover, and,

– a subscriber can leave his “home” area and yet receive all the calls intended for him; this is called roaming. A system of registration and location updating has to be implemented so that the subscriber can be contacted anywhere in the network.

This sophisticated system is based on real-time interconnection of databases which exchange the information of the current location of the mobile terminal. It was made possible by the use of the ITU-T Signalling System No.7, which controls this transfer of information.

Mobile telephony makes significant use of the common channel signalling network as large amounts of data have to be exchanged, not only for the roaming, but also:

– for the identification, authentication of the terminals and billing;

– for the transfer of information concerning the rights and/or additional services made available to every individual mobile subscriber, specifically in the case of mobility between networks (roaming agreement between operators).

Generally, a dedicated network for mobile communications is constructed and interconnected to the PSTN. It is supported by a proper signalling network. It can also be implemented on an IN in order to simplify the management of the transfer of data.

1.2 Services such as Freephone defined in Capability Set-1 of IN

These services are based on call processing functions; they require data handling at the level of the network and then specific functions have to be developed and implemented either on resources of the PSTN in a dedicated manner, or through an Intelligent Network (IN) in a generic manner. When the ITU-T standardized the first architecture of the IN, a set of services to be offered on the IN was defined and called Capability Set-1 (CS-1). This does not mean that only these services can be implemented on the IN, but rather that any service requiring equivalent data-handling capability can be offered.

CS-1 covers, amongst other things:

– Freephones,

– Split charging,

– Universal Access Numbers,

– Call distribution,

– Card calling, which credits the call on the card number and not on the number of the calling party.

– Televoting, which counts the number of calls without setting up communications.

For example, the Freephone service consists in:

– a “universal” number service: one unique number whatever the actual location of the called party, location that can depend on the time of the call, on the geographical location of the calling party etc.; and

– reverse charging of the call.

The introduction of such services requires at least the following functions:

– translation of the number keyed-in by the calling party,

– authentication of the calling party,

– command for routing the calls,

– dialog with the user,

– flexible billing process.

The IN by definition offers these functions which are not implemented normally at the level of the PSTN resources but at the level of independent physical systems. This represents flexibility and rapidity when introducing new services.

1.3 Multimedia service including videotex service

Multimedia services require large bandwidth to transmit on the same support sound, video and data. Video on demand, video conferencing and videotex are common examples. Some of these services are already offered on the PSTN or on the ISDN. But the majority cannot be implemented on such networks due to their requirements in bandwidth and in flexibility. The B-ISDN should be the answer to this growing need in multimedia services.

1.3.1 Videotex

This service offers public access to information which used to be scarcely distributed. It introduces the experience of interactivity which at the beginning was new for users, and offers the possibility of a mail-box system. It requires videotex terminals or computers supplied with a modem; these terminals are connected via the PSTN to local servers, or through the PSTN to an access node to communicate with a packet switched network which provides connection to data servers. The service is also available on the ISDN thanks to equipment integrated in the ISDN terminal or a special terminal. It then provides the transmission of fixed or slightly animated images.

1.3.2 Advanced videotex

Interactive multimedia services, multi-video transmissions, etc., are big consumers of telecommunication resources which also require high levels of flexibility within the network. These types of service can no longer realistically be provided by the PSTN or the ISDN. They will be offered on B-ISDN only.

1.4 E-Mail service, access to Internet, Telecom Information Exchange Services (TIES), etc.

These computer networks provide data transfer and exchange of cultural and scientific information. The largest one in the world is Internet, which is composed of various interconnected networks, on which millions of local networks are connected, gathering tens of millions of users world-wide. The local networks use a common communication language called TCP/IP (Transmission Control Protocol/Internet Protocol). Among the services offered on the Internet, documentary research can be the most important one for operators looking for technical information. Most universities and research centres now have their own connections.

Internet users get connected to the Network thanks to an Internet Service Provider which allocates them a Point of Presence (i.e. Access Node) and an Access Right. Most users use a computer provided with a modem connected to the Access Node through a telephone line. Service providers are interconnected, directly or through a supra-national operator.

Due to the importance of this network, without which the development of a country could be strongly hindered, it is highly recommended to plan, especially in developing countries, at least one access node to Internet.

1.5 Distance learning, telemedicine, teleworking, etc.

The possibility of teleworking, etc., relies on the capability of the network to provide individual and remote sites with telecommunications resources for voice, data, video:

– on a single access, and

– offering a virtual “closeness” with other members of the teleworker’s team or colleagues, which allows for lower costs of telecommunications and interactive work on the same documents or files.

The planning of easy-to-use and efficient teleworking services basically implies planning the deployment of services, relying on the telecommunication networks, meeting the expectations raised by the two aspects mentioned above, which in turn implies:

– ISDN – and of course the corresponding digitization policy of the network and the implementation of the common channel signalling system;

– Virtual Private Network (VPN) services – relying on the advanced functions provided by new technologies like IN, and allowing the creation of virtual private networks between the individual teleworkers, the headquarters of their company, the remote production sites, etc.

1.6 Introduction of data networks

Data networks are at present of two main types:

– circuit switched, implemented, for example, with the ISDN. A circuit is temporarily opened connecting two final users for exchanging data or voice information;

– packet switched, technique generalized, for example, on X.25 networks (public or private). The data bit rate has recently reached 2 Mbps.

The limitations of the classical circuit or packet switched data network are already known, especially for high bit rate and real-time applications; these networks also lack much of the required flexibility.

Other techniques allowing for high bit rates, like Frame Relay (FR) or ATM, have been elaborated; they flow from the X.25 in which network control has been saved.

The Frame Relay (FR) technique, like the X.25, does not support voice or integration of voice and data. The FR is known as the Simplified X.25 since the packets format and the communication procedure have been improved. This was made possible thanks to the growing reliability of the transmission supports. As a consequence, the network controls on flows and errors are not operated in each switching node but are moved to the extremities of the connection. This service is used for high bit rate communications, like the interconnection of distant local networks.

The ATM technique is universal as it supports the integration of voice/data/image. It combines the advantages of circuit switching (real time) and packets switching (bandwidth optimization). It is based on cells of small fixed size. Flow and error controls are operated the same way as the Frame Relay technique, at the extremities. ATM technology was

conceived to meet the need for long distance communications. However, it can be implemented on a site for local networks interconnections.

1.7 Other services

Instantaneous call charge informing system, semi-automatic/automatic telephone directory service and many other services can be considered.

2 General and specialized information network

2.1 Postal saving network and Inter-Banking network

The convergence of information and telecommunication networks will lead to the following two stages.

First stage: For the postal saving network, all post offices in a country could be linked to the national postal saving computer center by dedicated circuits. This network would enable customers to deposit or withdraw their money from any post office in the country. For the inter-banking network, all the computer networks operated by each bank, including that of the national bank, could be linked by dedicated networks for the transfer of money nationwide. For security reasons, it is recommended that this kind of network be built as a dedicated network, avoiding public access.

Second stage: Customers could be allowed to access these networks from their terminals through either PSTN or Internet. However, the highest security measures must be included in such a scheme. Already various projects including experimental trials have started and are expected to develop quickly to wider usage. The developing countries are advised to watch the trends closely for their future introduction.

2.2 Specialized telematic networks (meteorological, disaster, environmental, agricultural, medical, etc.) including data collection, processing, and disseminating

As an example, meteorological information networks normally consist of gathering large amounts of data from many, often remote, sites into a central point. These remote sites are often unattended and are linked to the central computer centre through the PSTN via a regular polling mechanism such as automatic dialling and data transfer via modems. The centre processes this data in order to facilitate the weather maps and weather forecasts. These results can also be sent to various other organisations automatically. At an advanced stage, the public could access this centre to receive the information via the PSTN.

Networks covering such areas as disaster forecasting, environment measuring, agriculture market information, medical information for physicians could be planned in a similar manner to the meteorological information network.

3 Configuration of a new telecommunication network

The evolution of the telecommunication network towards a unified information network requires the implementation of additional functions on its existing elements. As seen before, some new services could be obtained by adding terminal equipment or functions in the resources of the PSTN. Some others need deep arrangements, like, for example, the introduction of specialized information networks, ITU-T SS No. 7 network, Intelligent Network, etc.

3.1 ITU-T SS No. 3 network and Intelligent network

The Intelligent Network (IN) must, in the long term, be implemented as it is appropriate for the rational provision of new services. The following considerations must therefore be taken into account.

3.1.1 ITU-T SS No. 7 network (Common Channel Signalling System Network-CCSS Network)

The CCSS network should be introduced as it allows not only for IN but also ISDN or mobile techniques to be implemented. It is basically interesting as:

– it relieves the exchanges of the signalling functions,

– it multiplies them and extends their capability,

– it offers protection for the communications by using error detection or call reconfiguring,

– it strongly decreases the call establishment duration, e.g. for a phone call, and the response delay significantly decreases when moving from the multi-frequency signalling system to the common channel signalling system.

The principle of the ITU-T Signalling System No. 7 is to separate the communication channels from the signalling channels. The PSTN manages the communication channels and the CCSS network manages the signalling channels. This separation offers flexibility for network management.

This separation implies the creation of a signalling network overlaid on the communication network. Each exchange of the PSTN or of a mobile network is supplied with an interface to the CCSS network which is called Signalling Point (SP) and which is identified in the network by an SP number. The SP function uses hardware and software. The ITU-T defines two modes of operation for the CCSS network: the associated and the quasi-associated modes. In the associated modes, a signalling relation exists for each communication relation. In the quasi-associated mode, the transfer of information between the SPs is structured in the CCSS network and transits through dedicated machines called Signalling Transfer Points (STP). These points are totally meshed and each SP has access to the CCSS network through two STPs.

3.1.2 Intelligent network

The long-term objective of the IN is to offer high flexibility for introducing new services in addition to basic services such as the transport of speech, data or animated images. It covers all types of networks: the telephone switching networks on which CS-1 services can be introduced, mobile communication networks for which roaming can be easily implemented, the data networks, and the broadband networks.

It consists in separating the services logic and data from the network resources and current basic services. Software functions are implemented on switching elements of the PSTN and are handled by a set of controlling points. Its conception was made possible thanks to the separation of the signalling function provided by the ITU-T SS No. 7 from the switching function.

The functional architecture of the IN has been defined with functional entities. These entities can be implemented on various physical systems according to various architectures. They consist of:

– Service Switching Function (SSF) to be implemented on the switching points of the telecommunication network, which detects IN calls and which is controlled by the SCF to ensure the progress of the service. This is a basic function which can be implemented either on subscribers' or transit exchanges.

The following four other functions to be implemented on dedicated stations which provide the IN services to the telecommunication network subscriber through the signalling network are as follows:

– Service Control Function (SCF): This function contains the IN service logic and handles service-related processing activity. It has access to centralized data and controls the SSF. It is a centralized server connected to the PSTN through the ITU-T SS No. 7 network.

– Service Management Function (SMF): It involves service management control, service provision control and service deployment control.

– Specialized Resource Function (SRF): It provides the specialized resources required for the execution of the IN-provided services (e.g. digit receivers, announcements, conference bridge, etc.). It is not needed to locate these data in each exchange. This function is contained in the Intelligent Peripheral.

– Service Data Function (SDF): It contains customer and network data for real-time access by the SCF in the execution of an IN-provided service.

For example, a Freephone call requires the following functions:

– the call is routed up to an SSF which analyses the number of the called party and detects a Freephone number. The SSF starts a dialog with the SCF;

– the SCF collects the number of the called party, the identity of the calling party, the time and day when the call was produced in order to select a translated number thanks to translation tables;

– the SCF commands the SSF either to set up the call on the translated number or to send an artificial speech to the calling party;

– the information for billing is transmitted by the SSF to the SCF which transmits it to the SMF.

The IN architecture does not depend on the PSTN network, neither on its architecture nor on its system providers.

3.2 Numbering plan of the Common Channel Signalling System network

Some services, like the Freephone, Videotex or the Internet, are big consumers of numbers. For instance, the operator must plan its numbering scheme for provision of free numbers. A numbering plan is also necessary for the common channel signalling system network as every signalling point is allocated a number. It must take into account:

– multi-operator environment, i.e. the codes of the signalling points should contain an indicator of operator (fixed telephony, mobiles, etc.);

– the possibility of evolution from a structure in associated mode to a quasi-associated mode.

ITU-T elaborates Recommendations for the international signalling points numbers. The world-wide signalling network is structured into two functionally independent levels, namely the international and national levels. This structure allows numbering plans of signalling points of the international network and the different national networks to be independent from each other.

3.3 Network synchronization

The convergence of information technology and telecommunication networks, as well as the new technologies allowing rapid transfer of information (data, voice, video), make the need for synchronization more and more crucial. This implies requirement common standards and interfaces. At the same time, the multiplication of the different types of equipment, as well as of the providers, becomes a hindrance for an easy, reliable and efficient synchronization of the whole network. It is thus of the responsibility of the network planning engineer to design a flexible synchronization strategy for the developing network, and to set the standards and requirements of that strategy such that it can be introduced and then managed as the network evolves.

The objectives of a synchronization plan should be to define the main characteristics of the target synchronization network to be implemented, both qualitative and quantitative, and to determine how these characteristics may be achieved. In particular, a synchronization plan should:

- define the main characteristics of a target synchronization network;
- determine the relevant synchronization equipment;
- define the target network architecture;
- define the major steps which should be taken in order to implement the target synchronization network;
- establish an overall reference equivalent for the synchronization network, which takes into account such degradation as jitter and wander, and to distribute the above degradation in the best possible way in the network;
- determine the protection schemes including highly reliable network configuration and algorithms of restoration in the case of synchronization trail failures;
- determine the reference documents and standards relevant to the required synchronization plan (ITU, ETSI, T1, national documents, etc.).

3.4 Implementation procedure of new services and of new technologies

The implementation of these new concepts is not an easy task and has to be considered and included as early as possible in the developing plan of the network. The developing plan defines the steps reached by the network to offer various services at a given time. Its elaboration is of utmost importance as it ensures compatibility between the old remaining parts and the new equipment types and always with the aim of providing an increasing grade of service to the customers. It is part of the network planning activity. Various aspects interfere. The main issues are recalled hereunder:

a) Network digitization

This is the first step towards the implementation of integrated (ISDN), mobile or intelligent (IN) networks, and above all towards a high quality of service. The electromechanical switching equipment provides only basic telephone services, and its operating functions are limited, whereas the electronic switching equipment can offer value-added services, sophisticated operating functions, ISDN and CS-1 IN services. Appropriate equipment has to be selected according to the needs for such services.

The GAS 9 Economic and Technical Aspects of the Transition from Analogue to Digital Telecommunication Networks manual defines the principles for digitalizing the whole network. The two main approaches recommended are:

– **top-down** or overlay – the highest level(s) of the network hierarchy are digitalized and this policy is then "spread" to the lower levels of the network successively; the investment cost is the lowest but this should be used only in the case where a smooth expansion of the service is planned.

– **bottom-up** or island – several digital "islands" are created in the network with the aim of providing new services to selected areas. As these services are proved to be interesting for the whole country, these islands are enlarged until they join together to form the new complete infrastructure. This strategy is used when particular areas have an urgent need for a special service; it rapidly generates high revenue even though the total investment cost, when considering the whole network, is higher than in the top-down approach.

The comparison of the two strategies is covered in the same document, in Chapter IV.

b) Transport

Similarly to the switching network, the transmission network should also be upgraded to offer a high quality of transmission and to support high bit rates. Telecommunication satellites have a growing part in signal transport, and in particular in image transport. Optic techniques are more and more often used for terrestrial supports. The monomode optic fibre has now reached commercial use, and operational links without amplification can exceed 90 km.

The multiplexing technique should also be digitalized as it offers transmission quality, powerful handling capacity, adequacy to technologies and investment costs; it provides data transmission at a higher bit rate, and images transmission. The Synchronous Digital Hierarchy (SDH) is now the technique appropriate to optic fibre cables, to high rates requirements and to the technical management of the network. This technique offers network architectures like self-healing rings which provide highly protected transmission. Two strategies can also be considered to implement it. Either self-healing rings first can be implemented within a point-to-point PDH network, in order to protect the high-traffic areas like cities or business centres, or point-to-point SDH transmission systems can be implemented to support the long-distance traffic.

c) Signalling network

Considering the CCSS network, as a first step, and for a quicker implementation, it is wise to connect in associated mode a few switching points (for reasons of economy and efficiency, this number must be limited) of a specific area of the network where a significant need for new services or ISDN has been identified. Nevertheless, the target architecture of such a signalling network should later be able to be upgraded to a quasi-associated structure.

At each step of development of the network, the planning engineer must thus ensure consistency between:

– the structure and the capabilities of the telecommunication network,

– the architecture of the common channel signalling network,

– the implementation of the IN functions,

– the services to be provided to the customer.

4 Data collection and processing

These two aspects of the network operating function are very important and are the first step before the Telecommunication Management Network (TMN) is implemented.

4.1 Billing data collection and processing

Billing is an important aspect in customer perception of network reliability and quality of service, since it is one of the most sensitive aspects of the relations between an operator and its customers.

Besides the quality of the process of billing data collection and processing, it is wise to plan the possibility of interfacing the billing databases of the various telecommunication operators who provide telecommunication services to the same customers. The advantage of this interfacing feature is to present the customer with one single telecommunication bill although he or she has used various operators to complete calls.

4.2 Traffic data collection and processing

Traffic data collection and processing is a key issue for network management, both from the technical point of view (reliability of the equipment, adaptation of telecommunication capacities to demand) as well as from the service point of view (introduction of certain services, need for other services, marketing policy, etc.).

Monitoring the indicators of traffic and service is an essential activity in order to:

– provide the necessary reliability that is today expected from a telecommunication network by its customers,

– be able to have the minimum basic data necessary for sound network planning activities.

4.3 Application of the Internet

The Internet can be used for transmitting these operating data to the processing centre. However, the operator has to be aware of the issues of security of information and reliability of transmission on the Internet.

5 Telecommunication Management Network (TMN)

Data collection as considered in the former section can lead to storage and processing of redundant information. Nowadays, methods and operating tools follow the same evolution as the equipment which is digitalized, in which software and micro-processors have taken a growing place. Equipment is able to give information on its working state, and its growing reliability leads to remote operation. Hence, a management network is built in parallel, or rather transversely in order to cover the various layers of the network, to the telecommunication network. ITU-T elaborates Recommendations on its implementation.

TMN supports the management needs of the operators in order to:

– plan,

– implement,

– maintain,

– use,

– and manage

the telecommunication networks and the services.

At present, each type of telecommunication equipment has to be managed by proprietary systems. The aim of TMN is to overcome this and provide the operator with common management functions for all equipment types and functions within the network.

The concepts of the TMN include not only the management of the PSTN but also:

– public and private networks, including ISDN;

– analogue and digital transmission systems (cables, fibres, microwave links, satellites);

– circuit and packet switched networks;

– signalling systems and real-time databases;

– and even the Intelligent Network and IN services.

6 Reliability of networks

As it is of utmost importance for the various socio-economic activities, telecommunication network reliability should be precisely controlled, which implies:

– reliability monitoring (measurement, quality of service), and

– definition of action plans to maintain or increase network reliability.

This implies the definition of relevant indicators that must be regularly reported, with a level of accuracy that permits the taking of appropriate measures to correct, maintain, or upgrade the reliability of the network.

In addition, in order to ensure the perpetuity of the telecommunication network, planning activities must be aimed at identifying evolutionary solutions which take into account the following:

– the nature of the information to be transported (voice, video, data),

– the different transmission rates of the various types of data,

– the flexibility of the demand,

– the expected availability of the network.

The present trend towards the convergence of information and telecommunication networks must lead to solutions that avoid the multiplication of different types of networks (with different capabilities, different management systems, etc.) dedicated to certain types of traffic.

Topic a.2 Prepare a draft list of issues arising from the emergence of globally harmonized and interconnected networks that affect the network planning function within developing countries.

Different issues concerning the interconnection of conventional Public Switched Telephone Network (PSTN) with various newly offered networks are explained here.

1 Interconnection method within national network structure

1.1 Networks to be connected with PSTN

Regarding new networks to be connected with the existing telephone network, the following networks should be considered:

a) Public switched packet data network;

b) Videotex network;

c) Leased circuits/Private network;

d) Internet;

e) Land mobile communication network;

f) Satellite mobile communication network (GSO, LEO and MEO);

g) Other operators' networks.

1.2 Items to be considered

The dimensioning of the switching and transmission network should be undertaken bearing in mind the following items:

a) Signalling systems including No. 7 signalling systems between networks;

b) Network performance, grade of service, delay grade connection, transmission quality, etc.;

c) Numbering plan;

d) Tariff, recording of charging information, and method of revenue sharing;

e) Avoidance of double hop connection of GEO satellite links.

2 Carrying out interconnection

2.1 Public switched data network

Public Switched Packet Data Network (PSPDN) is served by terminals directly connected to the PSPDN and also accessed from PSTN, preferably ISDN through gateway. For the access from PSTN, the special telephone number or code should be assigned within the national telephone numbering plan. The same can be said for Public Switched Circuit Data Network (PSCDN).

2.2 Videotex network

The access to a videotex network is normally through PSTN and, if the digital path in PSTN can be allocated by using the ISDN subscriber interface, speedier information transmission from videotex source to terminal can be attained.

2.3 Leased circuits/Private network

Large companies are operating huge private networks connecting head offices, branch offices, factories, stores and so on. The PABXs installed in these sites are interconnected with PSTN.

As one of the methods for the introduction of competition in developed countries, a telephone subscriber in PSTN may gain access to this network through PABX in A-location and go from this private network to PSTN via PABX in B-location. If the private network usage charge is set very cheap, this kind of long distance call service attracts many users, even though the transmission quality of voice is not guaranteed. The legal authorization of such connections will spread for the benefit of users, though this service will threaten the lucrative market for the existing operators.

The telecommunication operators should study such trends carefully from various aspects.

2.4 Internet

As many people acknowledge, the Internet will become the most important network and is expected to develop in a revolutionary way in size and variety of usages. Because of the value of the Internet, even Least Developing Countries should seriously consider the availability of the connection to the Internet. The method of connection to the node of the Internet is either through PSTN or the leased circuit. As the largest inconvenience encountered sometimes is the slow transmission speed or the delay of transmission, adequate traffic administration will be indispensable.

2.5 Land mobile communication network

In this category, there are many services and technologies, as shown below:

a) Paging

   a1) Tone only,

   a2) With information display;

b) Analogue type cellular;

c) Digital type cellular (GSM, DCS-1800, D-AMPS, PDC, CDMA, etc.);

d) CT-2 (Telepoint);

e) PCN (DECT-1800) and PHS;

f) PCS in the USA.

As for the interconnection, there exist the following cases:

a) The mobile network and PSTN

The dialling procedure from mobile terminal to PSTN is either the trunk network access code followed by the national telephone number, or the special access code followed by the national telephone number.

As for the tariff, normally the mobile communication charge is higher than the conventional telephone charge for both directions. However, there is a belief that the call charge from the fixed telephone should not be different to the called subscriber's terminal category, and the difference between the call charge of fixed to mobile and fixed to fixed should be borne by the called mobile terminal user. Furthermore, where more than two mobile telephone operators are providing services in the same area, the call tariff is different because of the competition.

b) The mobile network and other mobile networks by direct connection

Where the number of the mobile networks in a country is very limited, this method is simple and easy for the settlement of charges between carriers. The guaranteeing of a good grade of service for connection can be attained if the adequate number of direct connection circuits is provided.

c) The mobile network and other mobile networks through PSTN

This pattern can be easily understood in the case of an international telephone connection where both sides are mobile phones. Within one country, this kind of interconnection will become common along with the increase of mobile networks.

The numbering plan should be carefully implemented, taking into account the ease of understanding for users, future expandability and traffic or charge recording for the settlement of charges among operators. For this last issue, an adequate recording function should be prepared within the network or attached to the network.

To obtain a desirable level of grade of service, very often the performance of PSTN between two mobile networks imposes serious constraint. When the grade of service of PSTN is low, method b) is recommendable rather than c). In terms of obtaining licensing for a mobile service from the Administration, the guarantee of a certain level of grade of service should be included.

2.6 Satellite mobile communication network

a) Geostationary satellite

The network configuration is similar to the land mobile communication network, as the satellite links used are the same as the surface radio wave. However, special consideration will be needed for the range of interconnection or selection of the transmission route in order to avoid the double hop connection between calling and called subscribers.

b) Low and medium earth orbit satellites

The interconnection with the national network needs special arrangements for the network configuration, the numbering plan, the charging plan and the recording of charge information. In the case of the gateway for satellite communication not being available in the country, the real interconnection of a GMPCS terminal with its national network might be established in the following way: Mobile terminal (also portable or fixed) – Satellite – Gateway in neighbouring country – International gateway switch (in the neighbouring country) – International telephone circuit – International gateway switch of the country – National network – Called terminal.

2.7 Networks of other operators

Besides the above-mentioned networks, various network operators can be expected in the environment of regionally divided telephone service operators or competition. The former case is not new and will have no problems, but the latter case will be new in many countries and should be dealt with carefully. Here the latter case will be studied.

a) International network

First of all, the access code should be studied as to whether a new access code only should be given to the newcomers without changing the access code given to the existing operator, or whether a new equal access system should be introduced by changing the access code used by the existing operator. An adequate recording system of call charges should be implemented.

b) Trunk network

The interconnection with a new trunk network has the same problems as the international network.

c) Local network

This interconnection is more complicated than the former two cases, especially as subscriber number allocation is an important subject. As the recent world trend, number portability is regarded as a very important premise for fair competition between local telephone operators.

3 Numbering plan

One of the forecasts on telephone demand indicates that the number of the total world wireless telephones will equal wired telephones by the 21st century. Many developed countries are studying or have introduced a new national telephone numbering plan to cope with such a rapid increase in demand for mobile telecommunications. As similar phenomena can be expected in developing countries, the future numbering system should be studied in each country and future numbering plans in developed countries could be used as useful references.

4 Tariff and charging plan

First of all, the important issue is to establish the country's tariff policy. The introduction of various new services and competition will bring many new tariffs which should be carefully studied and compared so as to attain harmonization among them. Also, necessary information for each call should be collected so as to settle call charges among related operators.

Among the Questions under study in SG-3 of ITU-T are included policy issues and economic impact in telecommunication development, the charging and accounting principle and costs study. Close attention should therefore be paid to the progress of studies.

Topic a.3 Study if there is a need for guidelines, handbooks or additional data collection and dissemination on these issues for the benefit of the developing countries.

Besides technological matters, the regulatory organisations corresponding to each country should be studied from the privatization and competitive environment point of view. Typically, there will be two cases:

a) Within the ministry,

b) Outside the ministry, such as the Federal Communications Commission (FCC) in the U.S.A., Oftel in the U.K. or the Directorate of the European Union.

Within the domain of Question 2/2, a new Handbook on new technologies will be produced paying due attention to the planning, management operation and maintenance of telecommunication networks. Furthermore, a liaison statement will be sent to ITU-T asking for a study on guidelines regarding the numbering plan of the national No. 7 common channel signalling system network.

Topic b.1 Prepare draft relevant issues to technical maintenance.

1 Service grade measurement, evaluation and target setting

1.1 Call completion rate: Local, Trunk and International

a) Call completion rate should be measured periodically during busy hours by either the specially designed equipment for this purpose, connected to subscriber terminals in local exchanges and outgoing international circuit terminals in international exchanges, or the software function stored in electronic switches in these exchanges. The reason for not considering the trunk exchanges is that a sufficient number of calls to evaluate trunk call completion could be obtained from observation at the subscriber stages of exchanges.

b) The results of call completion observation should be classified: with regard to local calls, preferably by classification within the same switch and towards other local switches in the same local area; trunk calls should, where possible, be identified as follows:

– Complete with answering by the called subscriber.

– Called subscriber busy.

– Congestion within network.

– Fault of network.

– Abandonment by the calling subscriber during dialling or due to no answer.

The reason for such detailed classification is that, by analyzing the causes, many action plans could be implemented for the improvement of call completion rate. Also, such detailed classification will help in the evaluation of each action taken.

c) The statistics of these items should be examined over a long period to evaluate improvement trends, and could be used for international comparison.

1.2 Fault rate for subscribers

a) The fault rate as a figure for 100 subscribers is the most important figure for evaluating the quality of service. In order to reduce faults, the details of each fault should be recorded exactly to analyze the causes of such faults. Sometimes the fault clearance result is not reported in the belief that the repair is, after all, the final target, but the importance of result reporting should be expressed to all maintenance staff.

b) The cause of the faults should be classified so that action can be taken. For example, a faulty cable section which should be replaced by a new one, or a specific subscriber terminal which needs repair or replacement, can be found by these statistics.

c) The future target value should be decided based on the present value. International comparison with other countries is very useful for this work.

d) Various action plans targeting specific objectives should be made and carried out for the reduction of faults, and the result of each action plan should be evaluated.

e) Long-term statistics should be taken to know the trends of the fault decline as a result of action plans.

1.3 Fault clearance time for subscribers

Another important item for evaluating of the quality of service for subscribers will be fault clearance time. As the fault-reporting subscriber will be anxious to know the repair time, the operator needs to try and undertake the following:

– When the breakdown complaint is received, inform the subscriber at what time the repairman will be dispatched.

– Shorten the duration of inconvenience as much as possible.

– Include details of the fault clearance time in statistics which can be used in preparing an action plan to shorten the duration of breakdowns.

– Set the future target value for fault clearance.

1.4 Reliability of network

a) Dependence on telecommunication infrastructure is becoming significant for various economic, political and social activities and, as a consequence, reliability should be raised to respond to such high expectations of telecommunications.

b) The outage of the network should be recorded in detail for an analysis of the cause and establishing an adequate action plan.

There can be various measures in an action plan to raise reliability, as shown below:

- Ring configuration of transmission route, with adequate network protection technology.
- Ring or new configuration for important subscribers, with supervision and switching functions.
- Introduction of national and regional network management centres.
- Preparation or storage of various backup or emergency equipment such as:
  - Transportable telephone switch.
  - Transportable earth station for satellite communications.
  - Transportable radio system for transmission link.
  - Transportable radio system for subscriber link.
  - Transportable power unit, and so on.

To ensure the various measures, periodical drill is indispensable.

c) Software tools which are dedicated to network planning could help operators to improve their network reliability.

2 Productivity of maintenance staff

The most popular figure used to show the productivity of the telecommunication operator's staff is the number of telephone main lines per employee. As for the productivity of the maintenance staff, this can be evaluated, for example, in addition to the above category, by the number of fault clearances per maintenance staff. The future target setting is very important, and its achievement could be easier than within other industries as the number of subscribers will increase year by year; the increase in the number of staff can be minimized by taking the following measures:

- Introduction of more reliable telecommunication equipment.
- Automatization of various telecommunication facilities.
- Introduction of a computerized customer information system such as plant record.
- Enhancement of training.
- If possible, the introduction of a salary or bonus system related to the increase of productivity.

In addition, the restructuring of the organization so as to gain higher efficiency could play an important role in attaining these objectives.

3 Billing

a) Accuracy of contents of bill

The conventional billing process needs human intervention at various stages, from reading the subscriber meters, or recording call information, to mailing the bill. Because of the nature of the procedure, there are possibilities of reoccurring errors. On the other hand, the modern billing system can handle electronically various charge-related information with the least possibility of error during many process steps. However, as the processing information is not visible, once the mis-setting of the processing system occurs, the consequences have a significant effect. For this reason, checking function setting and following the individual stages as indicated below becomes very important:

- Recording charge information in the electronic switch.
- Verification of the charge information from the electronic switch on magnetic tape/other media, or data transmission to billing centre.
- Matching of individual calls and charge information to individual subscribers.

– Collection and updating of charge-related information for each subscriber such as the basic monthly charge, surcharge for special services, etc.

– Collection and updating of the mailing address.

– Printing of the bill.

– Insertion of the bill in the envelope.

Furthermore, as the electronic recording might be lost due to system trouble or human error, frequent recording of the charge information for backup purposes is very important.

As for itemizing the bill, producing detailed bills has become easier thanks to progress in call information recording technology. The detailed bill can play quite an important role in the settlement of a dispute on charges between an operator and subscribers. The operator should make an effort to send a detailed bill to all subscribers.

b) On-time delivery of bill

The telecommunication bill should be issued monthly or quarterly to subscribers. The bill should be sent on schedule to gain the subscriber's trust. In some countries, for the purpose of work balance in the billing centre, subscribers are divided into several groups and the bill to the first group is dispatched on the first week of the month, and for the second group on the second week, and so on.

c) On-time collection of telecommunication charge

For the operator, the collection of the telecommunication charge by the specified deadline is a very important matter. The operator should seriously watch how much percentage of expected payment has been settled by this date. Every conceivable collection method should be put in practice for acquiring the payment. Notification by telephone call, subscriber visit by the operator's staff, suspension of originating calls, suspension of telephone service, etc., should be considered successively.

d) Storage of bill information

A subscriber's complaint regarding a bill should be dealt with most carefully. During discussions with the complaining subscriber, evidence should be presented by the operator to satisfy the customer. All detailed records should be kept for long periods, preferably more than one year. When legal disputes occur, a much longer period will be essential.

4 Maintenance centres, telemaintenance and remote operation

In order to raise the telecommunication operator's productivity, the introduction of these kinds of facilities and the reorganization of the operation should be considered. Even though the conventional system has various functions for remote maintenance and operation, recent electronic telephone switch and transmission systems have much more advanced facilities which can send more detailed information of operating status or trouble, and can control more varied functions. The operator may introduce more and more operations and maintenance based on non-attendance. Accordingly, restructuring the organization at the same time will become necessary.

However, regarding the designing of the maintenance centre, information items and controlling functions between centre and exchanges should be unified as much as possible regardless of the type of switches and related equipment, otherwise the efficiency of centralisation will not be increased. To achieve these objectives, an in-depth study on the necessary functions should be carried out in close cooperation with the manufacturers concerned, and due attention should be paid to the specifications of the equipment to be purchased.

5 Network management centres

Because of the increase in the role of telecommunications in various economic, political and social activities and also the increase of network complexity, the importance of network managing centres is being recognized as the natural trend. When the network size is small, a unique national network management centre could be sufficient. However, along with the expansion of the network, the installation of additional regional network management centres supervised by the national network management centre, as a two-hierarchy structure, becomes the adequate structure. The major functions of the centre could be the following:

a) Supervision of the fault in switch and transmission systems (international and national trunk networks).

b) Changing the routing pattern to minimize the fault effect. An appropriate recorded announcement should be inserted to let the subscriber know about the connection difficulty.

c) Supervision of traffic flow and changes to the routing pattern to cope with unusually high traffic. If the traffic is extremely high, the outgoing traffic from the local switch should be suspended except for urgent/important calls, and a suitable announcement should be inserted for the cancelled calls.

As in the case of the maintenance centre, the supervision and control of the national network both require unified specification – regardless of the differences in type of switches or transmission of traffic systems – concerning the information received about the breakdown of a network element (switch or transmission system) and about the real-time traffic volume at every network node, as well as concerning instructions to the network element about cancelling traffic to a specific destination, or about a change of routing pattern.

As the number of subscribers grows in the large cities, the setting-up of a third lower hierarchical level local network management centre in large cities will become indispensable. As a consequence, three levels of hierarchical network management centre will be established.

Topic c.1 Assess the needs of developing countries for telecommunication specific management.

1 Types of organizations of telecommunication operator to cope with new trends

Globally, there will be two types of organization for telecommunication operators. One is organized on the basis of technical speciality, and the organization will be structured accordingly: Switching division, Transmission division, Outside plant division, Supply division, etc.

The other type is based on the work flow: Planning division, Plant designing division, Installation division, Operation division, Maintenance division, Supply division, etc.

The recent development of technology or services implies that the integration of various technologies is becoming common and important for ISDN, Intelligent Network, Multimedia services, etc., and cooperation among various experts is indispensable. The operator's organization should be structured based on these changes, preferably according to the latter type. However, where the number of technical specialists is scarce, adapting to the latter type will be difficult because of the need for the same speciality, say a switching engineer, in various divisions.

2 Modern management techniques

Recently, the importance of the Management Information System (MIS) has become obvious for every business operation. The variety and amount of information needed for telecommunication operation and maintenance are growing and becoming increasingly important. During a telecommunication operation, an abundance of information will be produced, and only adequate processing of this information can ensure an efficient operation. An MIS will include such information as:

– Trends in revenue and expense.

– Increase in subscribers.

– Increase in international telecommunication traffic.

– Trends in faults categorized by major failure and minor failure.

– Categories of customer complaints.

– Trends in call completion rate for local, trunk and international networks.

– Progress of facility expansion or renewal work.

– Employees' attendance and overtime work statistics, etc.

3 Major points of short-, medium- and long-term planning and strategic planning

First of all, the fundamental telecommunication plans such as network structure with office hierarchy, the numbering plan, the transmission standard, the charging plan, etc., should be established. The major important points should be as follows:

a) Long-term planning

– Size of demand (with an additional new exchange scheme).

– Automatization and digitalization of network (with a future new transmission route).

– Improvement of subscriber access network.

– Introduction of new services.

– Land acquisition plan for a new exchange, maintenance centre or office.

– Staff requirements.

– Financial plan.

b) Medium-term planning

– New or extension of building.

– New transmission route.

– Civil work plan for local network.

– Power supply plan to meet the network extension.

– Financial plan.

c) Short- term planning or annual planning

– Increase of number of subscribers at each exchange.

– Expansion of capacity of exchange, transmission system, power system, etc.

– Time-scale plan for various work assignments.

– Recruitment plan.

– Financial plan.

Besides such planning, strategic planning should be considered. This involves targeting the achievement of increased numbers of subscribers, the improvement of services, etc., with due consideration of the planned number of employees and financial plans. Typical strategic planning would be a **Five-year expansion plan** or **Year 2010 plan**, and so on.

4 Introduction of new technologies and new services

The following items should be considered:

a) Adequate planning for the introduction of new technology and new services, as very often both are closely related. Consideration will be needed as to whether the new service should be introduced from the business area to other areas or from the capital to local cities on a year-by-year basis, etc.

b) Careful study of tariffs for new services, considering cost and revenue and comparison with similar services.

c) Systematic training to all staff concerned.

d) Adequate organization should be studied for the following alternatives:

- Present status.
- Joint venture.
- Subsidiary company.
- Private company.

5 Project management

Telecommunication networks are made up of various elements and also inter-linked to form a single large system. The expansion or renewal project should be carried out by administrating all work, and it is particularly important to meet target dates so that the undertaking to the customer is honoured and so that revenue can be raised from the usage of the new facility.

The target date for cutover should be fixed, and all related work such as the building, outside plant, transmission system, telephone switch, power system, contract work with new subscribers, including payment of deposit or connection charges, main distribution frame jumpering and subscriber tests should be scheduled accordingly in order to meet the target date. The periodic meeting of all relevant groups should check the progress and adjust if necessary. In this case, not only engineering action but also the commercial activity is important.

6 Management of change (Introduction of competition, and/or new technologies, and/or new services)

The introduction of competition requires many actions by the operator. These are as follows:

a) Cost analysis of the present services. Concerning the telephone service, the cost corresponding to the connection charge, monthly rental charge, local communication charge and trunk call charge versus distance should be analyzed to counter competitors' tariffs.

b) In studying the interconnection method and the modification plan of the existing network, the new national telephone numbering plan should be studied for easy dialling.

c) New call charge tariffs, call charge sharing scheme between operators and call charge information recording plan.

d) Adequate regulatory body for regulation and dispute settlement.

e) Various efficiency-raising measures.

When introducing new technologies or services, the training plan, the recruitment plan, the reorganization plan, monitoring the stability of a new technology or the usage trend of a new service, etc., should be taken into consideration.

f) Changing of the mentality of employees and encouraging proper motivation.

7 Harmonization of maintenance procedures

The most important aim of maintenance is customer satisfaction, and all maintenance policies and procedures should start from this aim. Upon receipt of the report, each technical problem should be investigated and the customer should be informed of the date and time of repair, either inside the exchange or on the customer's premises. The telecommunication operator should study, in collaboration with the test section, switching section, outside plant section, store section and personnel section, how to implement this kind of service as well as how to shorten the breakdown time.

8 Human resources management

Human resources management should include the following items:

a) Planned recruitment.

Annual recruitment should have a stable and consistent policy. Consideration should be given to long-term productivity improvement, future new technology introduction, number of new recruits among technical university/college graduates, number of new recruits from economics or law university/college graduates, number of other categories, and so on.

b) Evaluation for all staff should be carried out for appropriate promotion and work allotment.

c) A long-term individual promotion and rotation plan for future executives should be put into practice.

d) Various appropriate training courses should be given to all staff systematically.

e) Detailed personal files should be precisely and timely updated.

f) Information on organizational strategy and activities should be given to all employees.

9 Budget control

The long-term financial plan should be established taking into account the necessary funds for investment, expected annual revenue and method of obtaining the difference. As for the annual budget, detailed itemizing of expenses should be studied along with expected revenue and borrowing. After fixing the annual budget, monthly control of payment and income becomes extremely important.

10 Monitoring of new technologies, Research and Development, etc.

An adequate business plan ought to refer to a variety of information available worldwide, for the timely decision to introduce new technologies and new services, and to modify tariffs. Fortunately, many informative and useful monthly and weekly publications are now available. The operator needs to keep up to date with such publications in order to be aware of the world trends.

If developing countries wish to plan Research and Development activities, careful study will be needed. For example, the Research and Development cost of an electronic switching system amounts to billions of US dollars and is comparable to that of a middle to large size jet passenger aircraft. Therefore R&D items should be concentrated on national needs only. Now scale merit is becoming significant, and regional or across-the-countries cooperation will be more beneficial for R&D and manufacturing sectors.