In offering these services, some of them require high bit rate of data transmission, therefore, the high speed of digital leased circuit or the ISDN primary rate interface is inevitably necessary. Synchronously with the technology development, the introduction plan should be established.

4.6 ISDN Subscription

In Thailand, ISDN is scheduled to be commenced in the near future. With the commencement of ISDN, various services as described in the previous sections can also become available on ISDN. Some of the subscribers will transfer from the existing networks to ISDN. The volume of transition basically depends on the tariff level of ISDN and the price of digital terminals in comparison to those of the existing networks.

1) Tariff Level of ISDN Subscription

In some advanced countries, ISDN have been introduced and the digital interface terminals can be available by way of Digital Service Unit (DSU). The basic rate access interface is composed of two channels of 64 kb/s and one channel o f 16 kb/s (2B+D) in one subscription. Its capability in volume of transmitted data is equivalent to about 2.25 times than the existing telephone service. Taking this capability into account, the tariff level should be settled.

Making reference to the cases in some advanced countries, the tariff levels of ISDN are compared in Table 4.6-1. The monthly fee ratio to the ordinary telephone service is varying, namely, in Japan about 2.3 times, in W. Germany about 2.7 times, in France about 7.7 times etc. Some of these tariff levels might be settled on the trial basis, and may be amended by examining the actual demand in comparison to the supply policy.

Table 4.6-1 Comparison of Tariff Level of ISDN

Country	Tariff of ISDN		Tariff of Ordinary Telephone		Tariff Ratio of ISDN to Ordinary	
	Installation	Monthly	Installation	Monthly	Installation	Monthly
Japan	72,800 Yen	5,400 Yen	72,800 Yen	2,350 Yen	1.00	2.30
W. Germany	130 DM	74 DM	65 DM	27 DM	2.00	2.74
France	675 Fr	300 Fr	250 Fr	39 Fr	2.70	7.69
U. Kingdom	£500 stg.	£43 stg.	£105 stg.	£7.51 stg.	4.76	5.73

Note : Tariff of Basic Rate Access Interface (2B+D) for Business Use

2) Price Trend of Digital Terminals

a) Price Trend of Each Terminal

The price of digital interface terminals are very high at present as shown in Table 4.6-2. In order to cope with the digital interface, Digital Service Unit (DSU) is indispensable in addition for connecting to ISDN network, as is not required in the existing analog interface.

The price trend is one of the key factors for popularization of ISDN. From a long-sighted view, it will surely be becoming lower and lower in future owing to the technology development and mass production. It is considered that the marginal price level for popularization is about one tenth (1/10) of the present price level, namely, 20,000 Yen for digital telephone set and 200,000 Yen for G-4 facsimile.

Table 4.6-2 Price Comparison of Analog & Digital Terminal
(As of Year 1989)

Terminal	Analog Interface	Digital Interface
DSU	-	150,000 Yen
Telephone Set	20,000 Yen	200,000 Yen
Facsimile	(G-3) 200,000 Yen	(G-4) 2,000,000 Yen

b) Relation among Other Media

After the commencement of ISDN, subscribers may connect various kind of terminals to the end of (2B+D) interface. However, most of telephone subscribers may continue to employ analog telephone service after digital telephone service is available.

Supposing that a subscriber will be intending to apply only voice communication service, the digital telephone service may not always be adopted, because the existing analog telephone service satisfy his requirement sufficiently. The degree of requirement to digital interface is considered to be based on primarily data terminal, secondarily G-4 facsimile and thirdly digital telephone. The digital telephone may be adopted in a synthetic communication system composed of various kinds of media. That is, the (2B+D) interface will be shared by Digital telephone, G-4 facsimile, Data terminal etc. as shown in Figure 4.6-1.

Basic Rate Access Interface (2B+D)

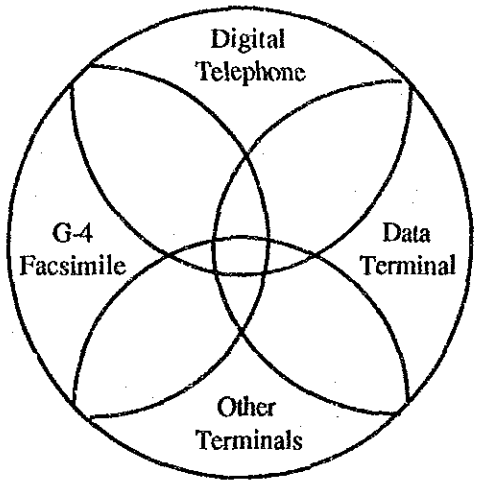


Figure 4.6-1 Composition of Digital Subscription

3) Analysis of Market Segment

Taking account of the above-mentioned key factors, the market segment for ISDN era is analyzed as follows:

a) Tariff Level of ISDN

The market segments as classified by the tariff level of ISDN are analyzed in Table 4.6-3.

Table 4.6-3 Market Segment as Classified by Tariff Level

Tariff Level	Evaluation of Tariff Level	Market Segment
Two Times	Tariff per one B channel is almost the same to one line unit on telephone network. It is economical to adopt ISDN only for telephone (voice) communication.	Subscriber having more than 2 line units on telephone network.
Three to Four Times	Tariff per one B channel is about 2 times as high as one unit on telephone network. It is uneconomical to adopt ISDN only for telephone (voice) communication. The (2B+D) channels will be shared with various kinds of media.	Subscribers having more than 3 line units among telephone network, leased circuits, packet network, etc.
Over Four Times	Tariff per one B channel is over 2 times as high as one unit on telephone network. It is uneconomical to adopt ISDN only for telephone (voice) communication. The (2B+D) channels will be shared with various kinds of media.	Subscribers having more than 4 line units among telephone network, leased circuits, packet network, etc.

b) Digital Terminal

Making reference to the case of facsimile terminal, its price have been coming down to about one tenth (1/10) during the last ten years as shown in Figure 4.1.3-1. And in the case of memory storage for computer facility, its price have also been coming down to about one tenth (1/10) for every five years. There is no official referential guidance for the future price trend. Probably, in a similar way to these cases, the price of digital interface terminals will be coming down to about one tenth (1/10) during the next 10 years.

On the basis of this trend, the price of digital interface terminals is supposed to be coming down as shown in Figure 4.6-2. In accordance with the fall in price, they will become more popular and the market segment will be expanding toward the residential subscribers.

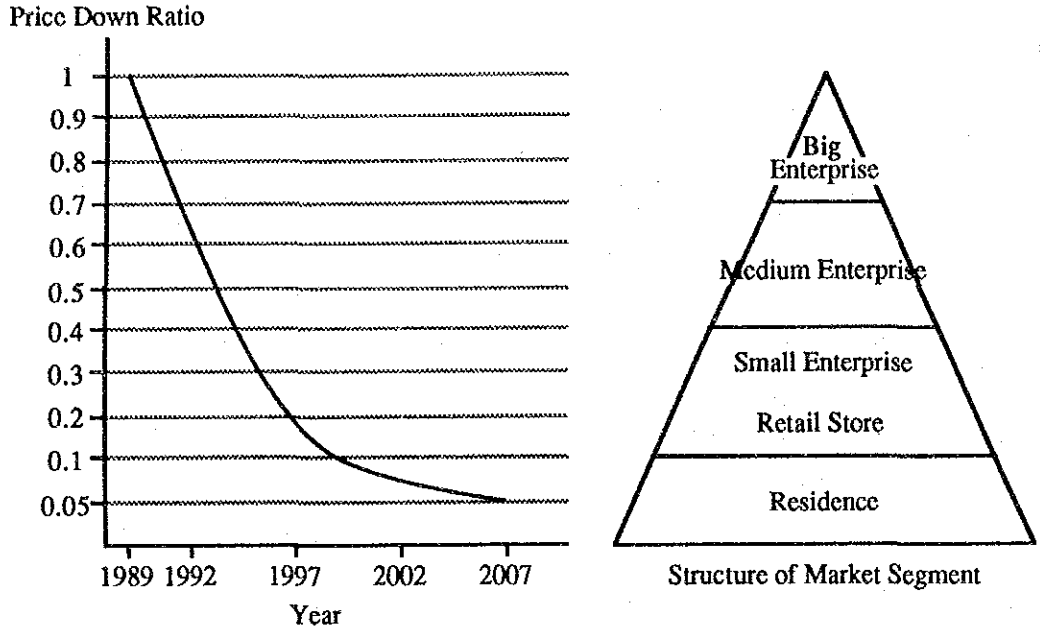


Figure 4.6-2 Supposition of Price Trend and Market for Digital Terminals

c) Analysis as a whole

The analyses in general are summarized in Figure 4.6-3. According to this figure, in case that the tariff level of ISDN is over three times as high as the telephone service and the price of digital terminals does not fall to below one second (1/2), the market segment will be limited to only a specified class. The widespread popularization is considered to be under the condition of below one tenth (1/10) of digital terminal price and within two times of ISDN tariff level.

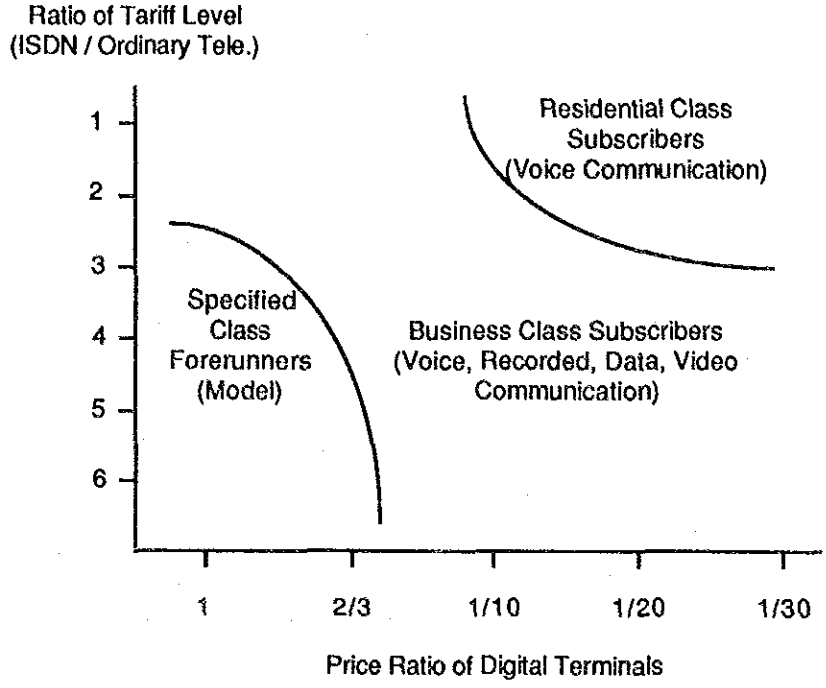


Figure 4.6-3 Market Segment for Tariff Level & Digital Terminal

4) Forecast

Under the above-mentioned analyses, some of the existing network subscriptions will transfer to the ISDN subscription. ISDN integrates not only telephone network but also packet switched data network, circuit switched data network etc., however, at the present stage, there is no suitable methodology for forecast. Therefore, for the time being, it is practical that the volume of transition is estimated on the basis of telephone network. One of the methodologies to be considered is described as in the following.

- Assumption of transition ratio from telephone subscription to ISDN classified by the tariff level of ISDN and the 5 year period.

- Estimation of transition volume from telephone subscription to ISDN multiplying the number of telephones by the above-mentioned transition ratio.

- Assumption of the average number of terminals composed of Digital telephone, G-4 Facsimile, Data terminal etc. in one (2B+D) interface as 4.

- Estimation of ISDN subscriptions dividing the transition volume by 4.

According to this methodology, the number of ISDN subscription is estimated as shown in Table 4.6-4.

Table 4.6-4 Estimation of ISDN Subscriptions

Year			1992	1997	2002	2007
Number of Telephone Demand (x1000)						
		Metropolitan Area	1,467	2,120	2,769	3,376
		Provincial Area	1,060	1,494	2,037	2,791
Ratio of Tariff Level	Transition Ratio to Digital Subscription (%)					
		Metropolitan Area	0.5%	5.0%	10.0%	20.0%
		Provincial Area	0.0%	0.5%	5.0%	10.0%
	Transition Volume to Digital Subscriptions (x1000)					
		Metropolitan Area	7	106	277	675
		Provincial Area	0	7	102	279
Two Times	Digital (ISDN) Subscriptions on the (2B+D) basis (x1000)					
		Metropolitan Area	2	27	69	169
		Provincial Area	0	2	25	70
Ratio of Tariff Level	Transition Ratio to Digital Subscription (%)					
		Metropolitan Area	0.3%	3.0%	5.0%	10.0%
		Provincial Area	0.0%	0.3%	3.0%	5.0%
	Transition Volume to Digital Subscriptions (x1000)					
		Metropolitan Area	4	64	138	338
Three to Four Times		Provincial Area	0	4	61	140
	Digital (ISDN) Subscriptions on the (2B+D) basis (x1000)					
		Metropolitan Area	1	16	35	84
		Provincial Area	0	1	15	35
Ratio of Tariff Level	Transition Ratio to Digital Subscription (%)					
		Metropolitan Area	0.1%	1.0%	2.5%	5.0%
		Provincial Area	0.0%	0.1%	1.0%	2.0%
	Transition Volume to Digital Subscriptions (x1000)					
		Metropolitan Area	1	21	69	169
		Provincial Area	0	1	20	56
Over Four Times	Digital (ISDN) Subscriptions on the (2B+D) basis (x1000)					
		Metropolitan Area	0	5	17	42
		Provincial Area	0	0	5	14

CHAPTER 5

OBJECTIVES AND STRATEGIES OF TELECOMMUNICATIONS DEVELOPMENT

CHAPTER 5. OBJECTIVES AND STRATEGIES OF TELECOMMUNICATIONS DEVELOPMENT

5.1 Present and Future Points at Issue in TOT

Today, telecommunications are considered to be important parts of infrastructure to conduct various social and industrial activities in every country. As described in Chapter 2, Thailand has now been achieving remarkable progress in economy. Therefore, it must be a pressing need for Thailand to expand and reinforce the telecommunications more rapidly than ever before in order to support further overall development of the country as well as to promote prosperity of the people.

Meanwhile, as one of the state enterprises for telecommunications in this country, TOT has been making considerable efforts to render the better telecommunication services to the customers since its inauguration in 1954.

However, the present services offered by TOT do not seem sufficiently matured yet, and also some internal management procedures are yet to be improved.

Main points at issue are considered as follows;

- Large amounts of waiting applicants and remaining non-telephone communities,
- Insufficient telecommunication services,
- Less reliable telecommunication network,
- Under-utilization of telephone traffic data,
- Shortage of management resources.

5.1.1 Large Amounts of Waiting Applicants & Remaining Non-Telephone Communities

There were about 451,000 waiting applicants in the whole country in February 1989. Furthermore, this number of total waiting applicants is expected to increase to 705,000 at the end of FY 1992 according to the telephone demand estimation and the present telephone installation program in TOT.

At the end of FY 1992, on the other hand, there will be 4,200 tambons left as non-telephone communities. It is among the most important matters in telecommunications to resolve these problems from the viewpoint of the nation's prosperity.

5.1.2 Insufficient Telecommunication Services

In spite of TOT's considerable efforts in these years, the service qualities are yet to be improved in comparison with the international standards. Taking ordinary telephone service for example, when people want to make a call, they have to make many unsuccessful calls before achieving a successful call at last. When people are talking through telephone, sometimes they perceive unacceptable noise for a comfortable conversation. And also when in urgent need, they often can not find even a working telephone around them.

One reason of the above situation seems to be that the fault ratio caused by outside plant facilities has been as high as about 50 % of the total faults according to TOT data. Therefore, improvement of outside plant facilities is expected to upgrade the service level to a considerable extent. However, the criteria for replacement of timeworn facilities has not been set up yet.

Thus, it is required to provide some appropriate procedures relating to maintenance and operation work of the telecommunication network and facilities for upgrading the service qualities.

Furthermore, recent tendency of diversification in telecommunication services should be taken into consideration. In addition to the Cellular Mobile service, more derivative telephone services and some enhanced non-telephone services will have to be introduced by means of ISDN and CCS to cope with the demands from every sector.

5.1.3 Less Reliable Telecommunication Network

The reliability of the present telecommunication network of this country is not considered sufficiently high. For example, there are many PCs connected to other PCs with single transmission route only. Route duplication of the network and other measures for enhancing network reliability should be promoted.

5.1.4 Under-utilization of Telephone Traffic Data

Traffic management is the key point of telecommunications operation. However, the application system of traffic data is not completed yet. In principle, capacity of the telecommunication facilities should be determined by the traffic data, and traffic promotion activities for successful call ratio improvement and traffic sales promotion should be carried out depending on the actual traffic data.

5.1.5 Shortage of Management Resources

The present and recommended organizations do not seem suitable to TOT. The organization should be changeable according to the scale and condition of the entity in order to achieve the most efficient operation for meeting the needs of the society. In order to keep the present good financial situation in future, it will be indispensable for TOT to reinforce the management executives and overall personnel and also to reserve or raise reasonable funds.

5.2 Long-Range Development Objectives

Taking the above-mentioned situations in the present telecommunications of this country into consideration, the following four long-range objectives are set forth in formulating the Master Plan for domestic telecommunication network development, as the basic principles to assign various projects for improvement of the telecommunication services both in quantity and in quality to the respective areas and periods.

1) Fulfillment of national telephone demand
2) Upgrade of service qualities
3) Diversification of services
4) Improvement of management

For the sake of formulation, the period of the Master Plan is divided into three phases as follows;

Phase-1: From FY 1993 to FY 1997,
Phase-2: From FY 1998 to FY 2002,
Phase-3: From FY 2003 to FY 2007.

5.3 Development Strategies and Targets

To achieve the four objectives mentioned in the previous paragraph, some strategies are adopted for each of the objectives as in the following.

5.3.1 Fulfillment of National Telephone Demand

Ordinary telephone service has been the principal service in domestic telecommunication services in Thailand, which is now indispensable to overall development and prosperity of this country. Therefore, this objective is considered to be the most important one to proceed with the implementation of the Master Plan. The following three strategies are set forth in order to achieve this objective.

1) Reduction of Waiting Applicants

To satisfy urgent demands for telephone service from every socio-economic sector, telephone installation for the waiting applicants will be promoted to the extent that most of the applicants in any place of the country except rural areas will be able to receive within a few months after the subscription, by the end of Phase-1 period.

2) Dissolution of Non-Telephone Communities

To keep the security of the nation and also to extend the benefits of telecommunications all over the country, this strategy is also very important. Projects for dissolution of non-telephone "tambons", the same as those being carried out in the current 5th ESDP, will be continued by the end of the Phase-2 period.

In the Phase-3 period, rural telecommunication system introduction will be continued for non-telephone villages (muhbahn) in line with the related items of the ITU Kuala Lumpur Declaration in December 1983, namely, "By the year 2000, national planning bodies should aim at the goal of providing access to national telecommunication services within walking distance of no more than 3 km for people in all countries."

3) Increase of Public Telephones

Installation of public telephones is also important to extend the benefit of telephone service into many and unspecified people in need. In this Master Plan, installation of public telephone will be carried out in such a way that installation numbers of public telephone for each phase are proposed aiming at the target of the average number of public telephones per 1000 population as 2.5 at the end of FY 2007.

5.3.2 Upgrade of Service Qualities

In addition to quantitative improvement, upgrade of service qualities is essential to the administration for meeting requirements from the customers. In telecommunications, many facets of service qualities can be defined. However, in this Master Plan, fault ratio and successful call ratio are employed as the principal criteria of the service qualities.

The following strategies are selected for upgrade of service qualities in regard to the above criteria with respective targets. In applying these strategies, comprehensive and continuous efforts in close cooperation among the departments concerned in the administration will be required to achieve the targets.

1) Improvement of Telecommunication Facilities

a) Rehabilitation of Subscriber Cables and Wires

In the installation process of outside plant facilities, replacement of timeworn subscriber cables and wires will be carried out with the installation work from the beginning of Phase-1, aiming at improving fault ratio into less than 1.3 per 100 subscribers per month by the end of FY 2007.

b) Replacement of Analog Facilities

Digitization of the domestic telecommunication network will be completed including all TC, SC and PC level by the end of the Phase-1 period. Besides, all the new LS facilities will be digital system through the whole period.

In the meantime, remove and reuse plan for XB system with replacement of analog transmission system will be carried out from Phase-1 taking service life, new service demand, economical viewpoint etc. into consideration.

2) Enhancement of Network Reliability

As a measure of network reliability enhancement, transmission route duplication will be completed among all of the TCs and SCs by the end of Phase-2. For connection to PCs, duplication will be realized among all the PCs in principle by the end of Phase-3. In addition, introduction of digital transmission switching system will be planned during and after Phase-2.

3) Improvement of Operation and Maintenance

a) Review of Outside Plant Maintenance Center

Vehicles and installation machinery will be rearranged at the existing outside plant maintenance centers, in order to carry out larger quantities of the installation work more smoothly and also to conduct the maintenance work more efficiently.

b) Introduction of Network Management System

The matters relevant to introduction of network management system for switching and transmission facilities will be studied.

5.3.3 Diversification of Services

In studying introduction of various services, the following priorities should be considered;

- To meet the customers' demand,
- To promote the customers' benefit effectively,
- To contribute revenue increase of the enterprise,
- To use network facilities efficiently.

1) Reinforcement of Telecommunication Network

a) Introduction of ISDN

As an essential means toward information oriented society, development plan of Integrated Services Digital Network (ISDN) will be carried out for rendering diversified services in order to cope with the request from the society. As a proposed schedule, ISDN introduction will be continued in Phase-1, and the extension will be promoted by the end of Phase-3.

b) Application of CCS

Application plan of common channel signalling system (CCS) will be adopted for Cellular Mobile network and ISDN trial service by 1992. Then from Phase-1, CCS will be introduced with ISDN commercial service or other new diversified services into the areas concerned.

c) Development of Satellite Communication System

Development plan of satellite communication system will be carried out from Phase-1 for the purpose of reinforcement of the domestic telecommunication network, measures against natural disasters and provision of transmission means for various new services.

2) Introduction and Extension of Various Services

According to the ISDN introduction, the services to be available will become more diversified. Taking account of the recent telecommunication services trend in the other countries and also the customers' demand in this country, introduction and extension plan of some feasible services should be studied for each phase in the Master Plan period.

3) Extension of Cellular Mobile Service

Extension plan of the existing cellular mobile service, which is superior in terms of instantaneity and mobility to the ordinary telephone service, will be completed to cover all over the country by the end of the Phase-1 period.

The second cellular mobile system for TOT using 900 MHz frequency band will be introduced in Phase-1 period in order to cope with the increasing demand.

5.3.4 Improvement of Management

1) Human Resource Issues

a) Manpower Management

When facilities are expanded, the manpower must be also expanded at the same time. Massive facilities will be just wasted without proper expansion and allocation of human resources. Expenses on human resources are the major expense items in business operations; therefore, they must be efficiently and carefully managed.

Each department of TOT has its own staff requirement standard. However, in order to control the total number of the staff properly, the human resource department should have a total manpower plan and staff allocation policies.

b) Reorganization

As the number of subscribers increases, it will become more difficult for the TOT Headquarters to centrally manage the whole organization. Some management functions

should be decentralized to the regional offices. An adaptation of a profit and cost center system should be considered sometime in the later part of the Master Plan.

c) Human Development

Organizations flourish through the efforts of individuals, because people are the most important resource a manager has. It is expected that the operation and management of TOT will become larger and more complicated in the future; therefore, it must develop skills and abilities of its people up to the sufficient level to be able to operate its own complex, massive, and sophisticated facilities. It is quite indispensable for TOT to provide large-scale training programs at the earliest possible time because many new technologies will be introduced in the Master Plan.

d) Promotion and Compensation System

Promotion and compensation systems affect employee motivations and incentives. Hence, they must be formulated and practiced to take out the fullest extent of employees contributions to organizations.

2) Financial Issues

In order to raise enough internal and external capital to carry out the Master Plan, TOT should examine the following issues to improve its financial position.

a) Fund Management

TOT must manage not only large amount but also many kinds of financial funds for many years, once the Master Plan starts. Financial mismanagement will jeopardize implementation of the projects and cause a tremendous loss to TOT and the society. Hence, it is recommended to obtain a help of a professional fund manager who is knowledgeable on both domestic and international money markets.

b) Remittance to the Treasury

In order to increase its internal reserve so that TOT can generate larger amount of own fund for implementing projects, the remittance to the Treasury is a heavy burden. TOT should work more aggressively on being totally or partially excused from paying remittance to the Treasury until at least TOT eliminates the existence of waiting applicants.

c) Depreciation

One good and widely practiced method to increase the available amount of internal reserve is to take the maximum advantage of depreciation, although net income on book decreases. There are three issues to be examined on depreciation. The first is on accounting method of calculating depreciation. The second is on service lives of equipment and facilities. The third is on work in progress and plant under construction.

d) Tariff

Tariff is one of major revenue management tools. Tariff structures of TOT have never been closely examined from either economic theoretic viewpoints or management viewpoints. To establish a sound and effective financial management system, it is recommended for TOT to conduct a tariff review project at the earliest possible time.

e) Marketing and Customer Relations

Marketing and customer relations are one of the least developed management areas in TOT. To improve the marketing and customer relations, the immediate efforts should be primarily concentrated on improvement of the following:

i) Development of the data base on the customers and traffic,

ii) Clear and easy documentation of jobs, tasks, duties, objectives, procedures, rules, and system flowcharts.

After TOT eliminates the existence of waiting applicants and achieves demand-supply balance for the telephone services, marketing efforts must be greatly enhanced in order to create more demands for the telecommunication services and offer customer friendly services. Marketing becomes very important in opening up people's minds to make them being fully aware that modern and sophisticated telecommunication services are not just to transmit voice messages, but to transmit, store, and process all kinds of information and to support people in making intelligent decisions. TOT should lead the industry to promote "Informationization" of the society and become the primary promoter of the telecommunication services.

f) Increase General Work Efficiency

TOT should consider the following measures to increase general work efficiency:

i) Promotion of office automation,

ii) Clarifications, documentation, and mannualization of job definition, purposes, objectives, duties, rules, procedures, standards, and organization-wide education of middle and lower management people,

iii) Promotion of QC circles,

iv) Effective utilization of management information system.

5.4 Strategy Formation and Execution

Figure 5.4 presents a system flow chart which illustrates how the present issues will be incorporated into the objectives and strategies, and how they will be executed in each of three phases.

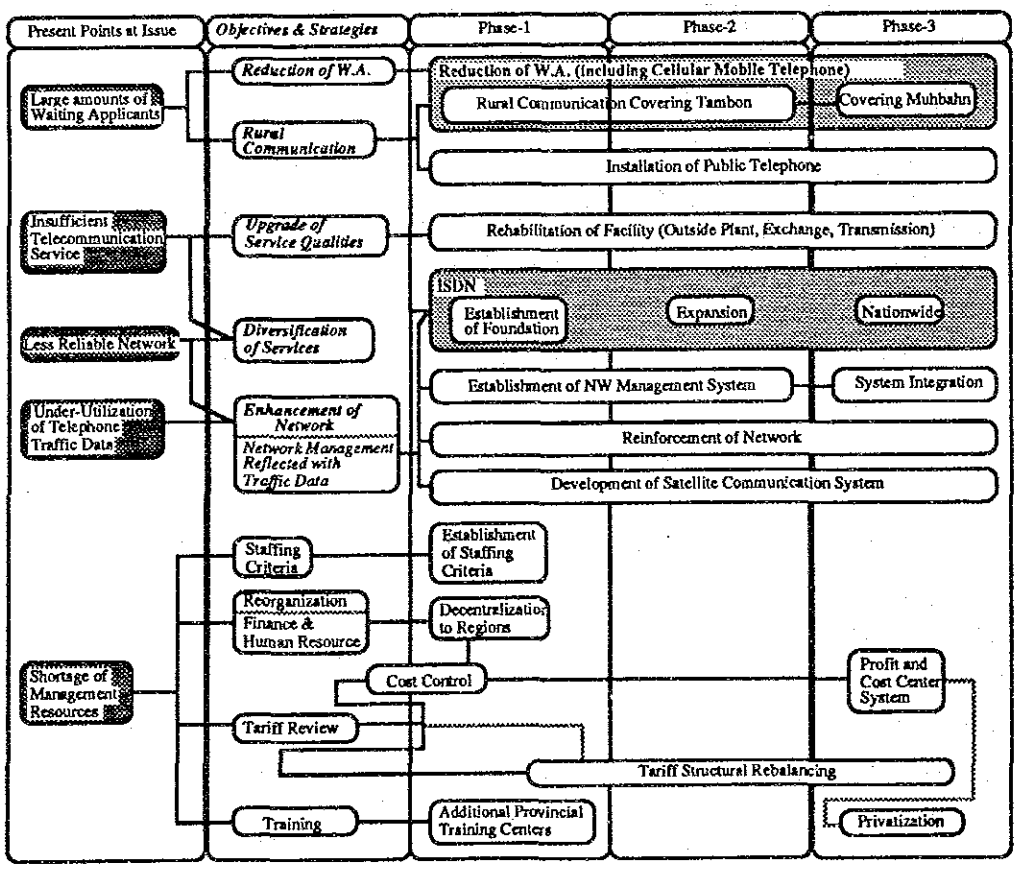


Figure 5.4 Strategy Formation and Execution

5.5 Effects Produced through Implementation of the Master Plan

As the results of implementation of the Master Plan, the following effects will be exerted on the users, the society and the telecommunication sector.

1) On the Users

The users will be offered with faster, cheaper and more versatile services as well as more friendly services.

2) On the Society

The industrial structure will be upgraded, and the financial sector will be reformed. Thus, the society will gradually be evolved into an informationized society according as the development of the infrastructure will progress.

3) On the Telecommunication Sector

In the telecommunication sector, it will become possible to perform more dynamic and innovative business operation toward the customer oriented one with enforcement of fair and efficient regulation. At the same time, telecommunication entities will be providing more and fair career development opportunities to the employees.

In the future, the common carriers of telecommunication sector will provide not only voice transmitting service but also various intelligent services supporting new life styles of the people.

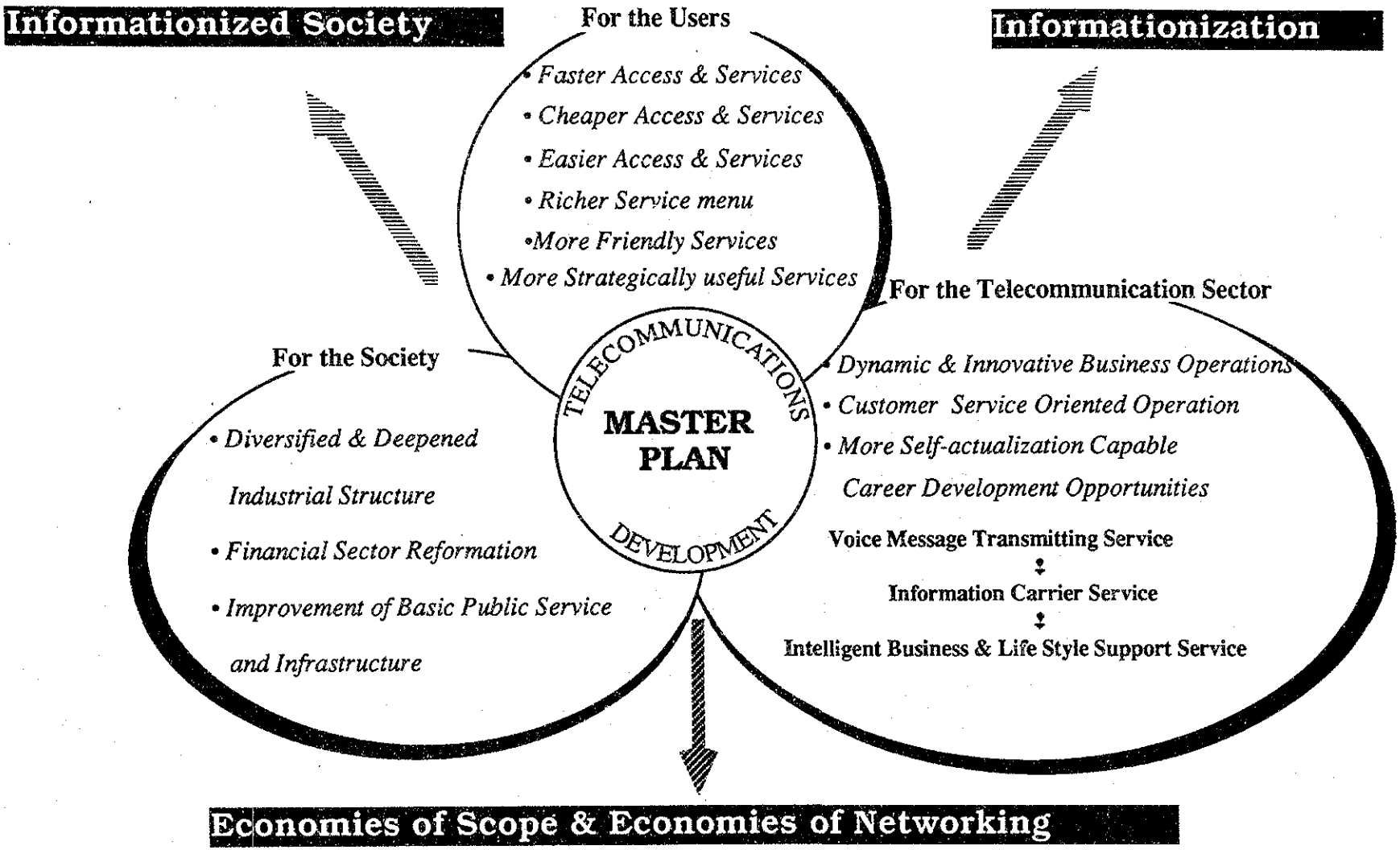


Figure 5.5 Effects Produced through Implementation of Master Plan

CHAPTER 6

TRAFFIC FORECAST

CHAPTER 6. TRAFFIC FORECAST

6.1 Telephone Service

This section presents forecasted results of traffic volume among primary centers in the whole country, and traffic volume among local exchanges in Bangkok multi-exchange area.

6.1.1 PC - PC Traffic Matrix Forecast

The forecast procedure of PC-PC traffic matrixes is illustrated in Figure 6.1.1-1

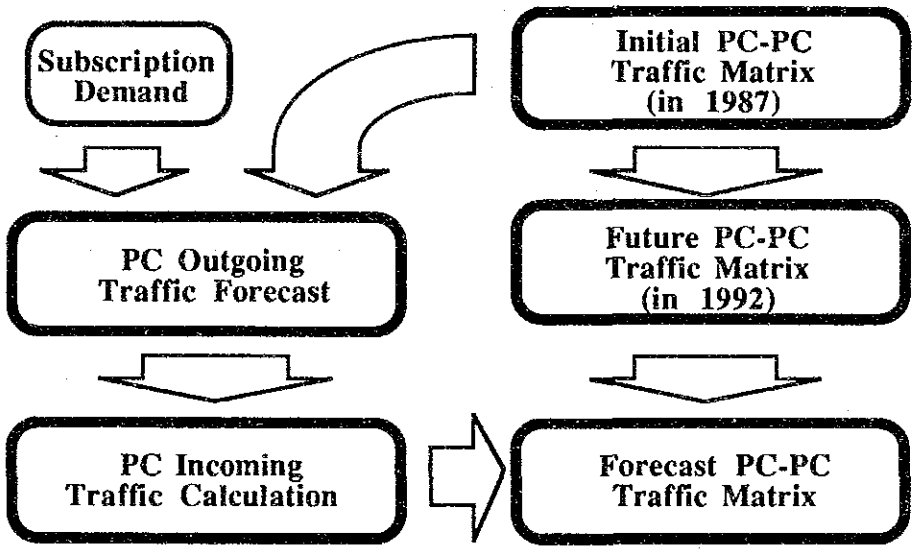


Figure 6.1.1-1 PC-PC Traffic Matrix Forecast Procedure

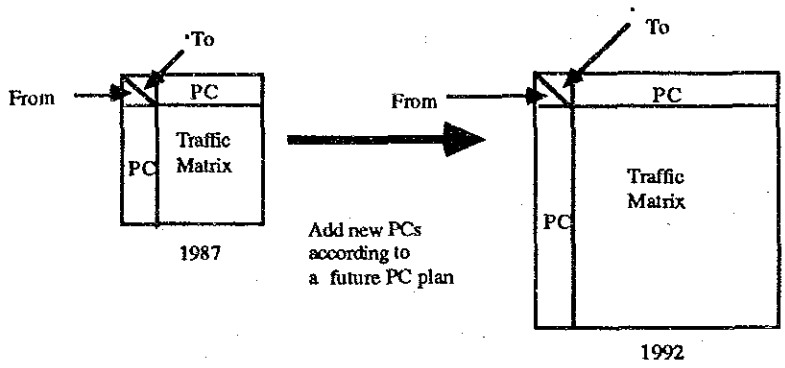
1) Creation of The Future PC-PC Traffic Matrix

The PC-PC traffic matrix in 1992, called the Future PC-PC Traffic Matrix, is basically an expanded and rearranged PC-PC traffic matrix in 1987. The PC-PC traffic matrix in 1987 is expanded according to the primary center expansion plan in "5TH PROJECT NUMBERING PLAN FOR TELEPHONE EXCHANGE IN PROVINCIAL AREA". The PC-PC traffic matrix in 1987, called the Initial Traffic Matrix, is modified in the following two steps:

-- Addition of new primary centers,
-- Redistribution of 1987 traffic between new PC and new PC, new PC and existing PC, and existing PC and existing PC.

The procedure of creating the Future Traffic Matrix is as follows:

a) Expanding the Initial Traffic Matrix by adding new primary centers according to a future primary center plan,



b) Redistributing 1987 traffic among the primary centers in 1992.

Traffic is redistributed according to the following rules.

i) Calculation of traffic volume from a newly operated primary center (called PC: A1) to an existing primary center (called PC : D), not located in the same secondary center area that PC : A1 is located.

The following formula is used:

$$TFa1d = TFad \cdot \left(\frac{Sa1}{Sa}\right)$$

where

Sa1 : The number of subscribers accommodated by PC : A1,

Sa : The number of subscribers accommodated by the primary center (called PC : A) to which PC : A1 used to belong before it becomes a new independent PC in 1992,

TFad: The volume of traffic from PC : A to PC : D,
TFa1d: The volume of traffic from PC : A1 to PC: D.

ii) Calculation of traffic volume from PC : A1 to a newly operated primary center (called PC : C1), not located in the same secondary center area that PC : A1 is located:

The following formula is used:

$$TFa1c1 = TFac \cdot \left(\frac{Sa1}{Sa}\right) \cdot \left(\frac{Sc1}{Sc}\right)$$

where

Sc1 : The number of subscribers accommodated by PC: C1,
Sc : The number of subscribers accommodated by the primary center (called PC : C) to which PC : C1 used to belong before it becomes a new independent PC in 1992,
TFac : The volume of traffic from PC : A to PC : C,
TFa1c1 :The volume of traffic from PC: A1 to PC: C1.

iii) Calculation of traffic volume from PC : A1 to a newly operated primary center (called PC : A2), located in the same secondary center area that PC : A1 is located.

The following formula is used:

$$TFa1a2 = (CRa \cdot Sa1) \cdot \frac{Sa2}{(Sa - Sa1)}$$

where

CRa : Calling rate of intra- A secondary center (called SC: A) area traffic,
= (Total intra-traffic volume in the SC: A area) / (Total number of subscribers in the SC: A area),
Sa2 : The number of subscribers accommodated by PC : A2,
Sa : The number of subscribers in the SC: A area,
TRa1a2: The volume of traffic from PC : A1 to PC : A2.

Figure 6.1.1-2 as described below shows the concept of creating the Future PC-PC Traffic Matrix.

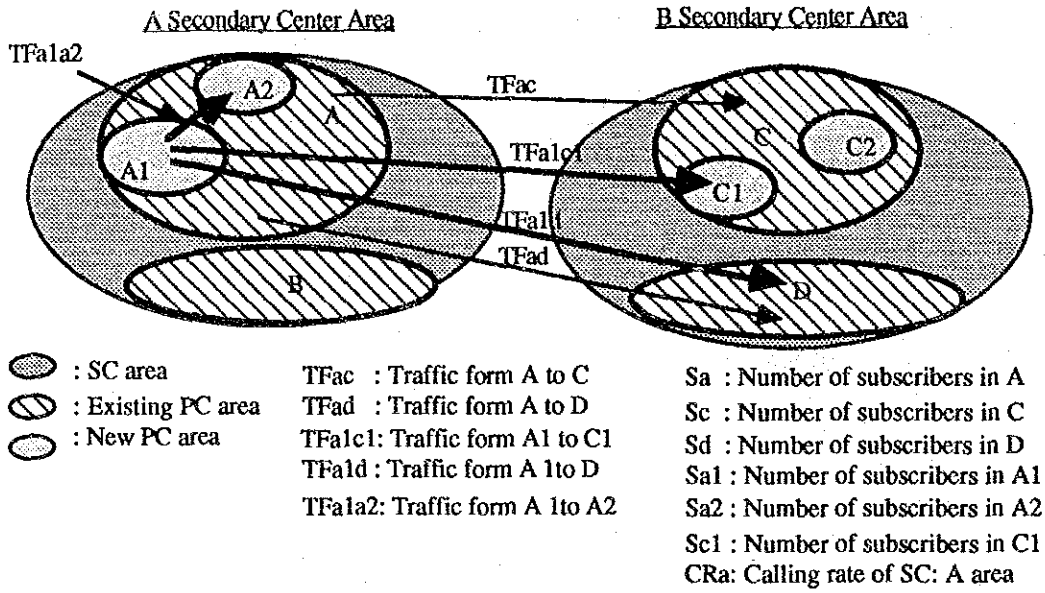


Figure 6.1.1-2 Concept of Creating the Future PC-PC Traffic Matrix

2) Forecast of Outgoing Traffic from Primary Centers

a) Originating Calling Rate for Automatic Exchanges of Japan in 1976[1]

Telephone traffic can not exist, if the called party does not have a telephone. Therefore, generally speaking, the calling rate of a small scale center is lower than that of a large scale center, because the small scale center does not have many subscribers who can be called.

Figure 6.1.1-3 shows the calling rate of centers of each scale classified by the number of subscribers in an accommodation area in Japan. It is obvious that the calling rate, especially that of local traffic, tends to increase in accordance with the scale of the center. There are remarkable differences in frequency of telephone use between a business telephone and a residential telephone.

Among the same category of telephones, for example, the business telephone, most of the old subscribers use the telephone very frequently. However, the new subscribers usually do not use the telephone as frequently as the old subscribers do.

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[1] GP 82-NO. 4 NETWORK PLANNING TRAFFIC FORECASTING, P36~38, NIPPON TELEGRAPH & TELEPHONE CORPORATION, JAPAN INTERNATIONAL COOPERATION AGENCY

Therefore, in early days with a very low telephone penetration rate, subscribers would consist of high traffic subscribers, like business concerns. Therefore, a high calling rate is often shown on this case in spite of the number of subscribers being limited.

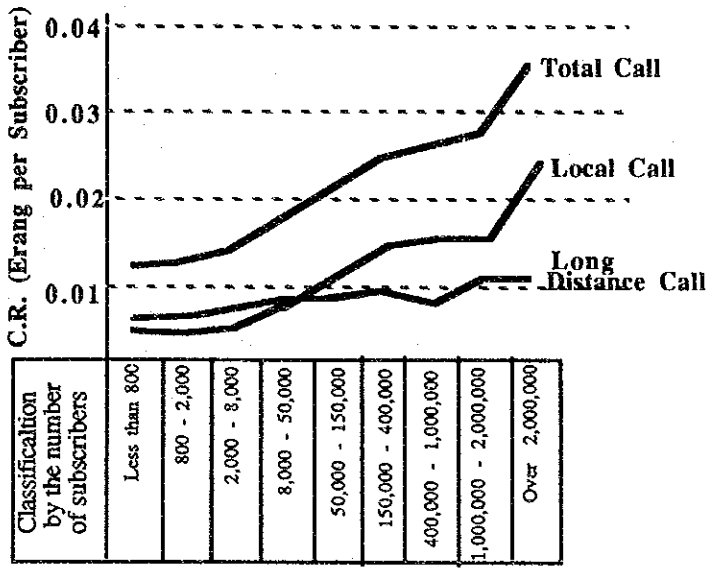


Figure 6.1.1-3 Originating Calling Rate for Automatic Exchanges of Japan in 1976

b) Situation of Outgoing Traffic for Primary Centers in 1987

Figure 6.1.1-4 and 5 show graph of outgoing calling rate for primary centers, in Thailand.

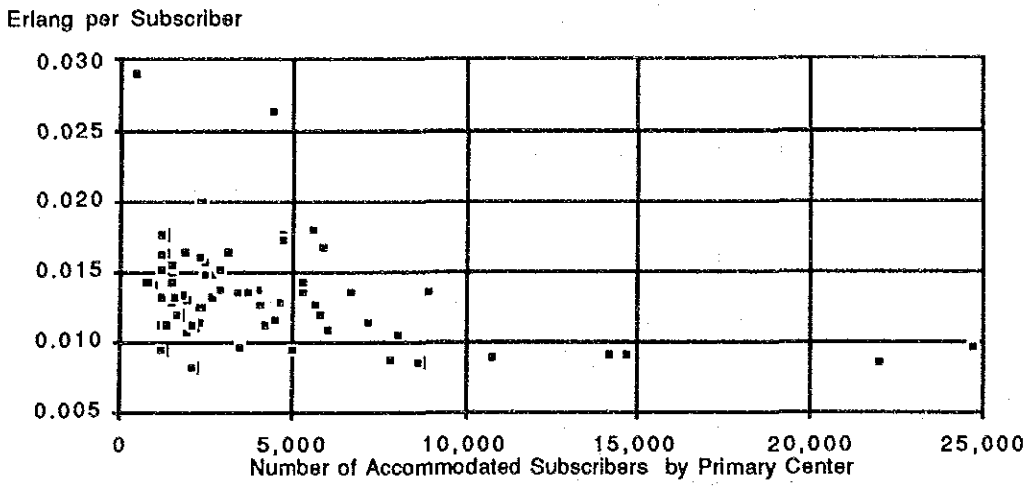


Figure 6.1.1-4 Outgoing Calling Rate for Scale of Primary Center

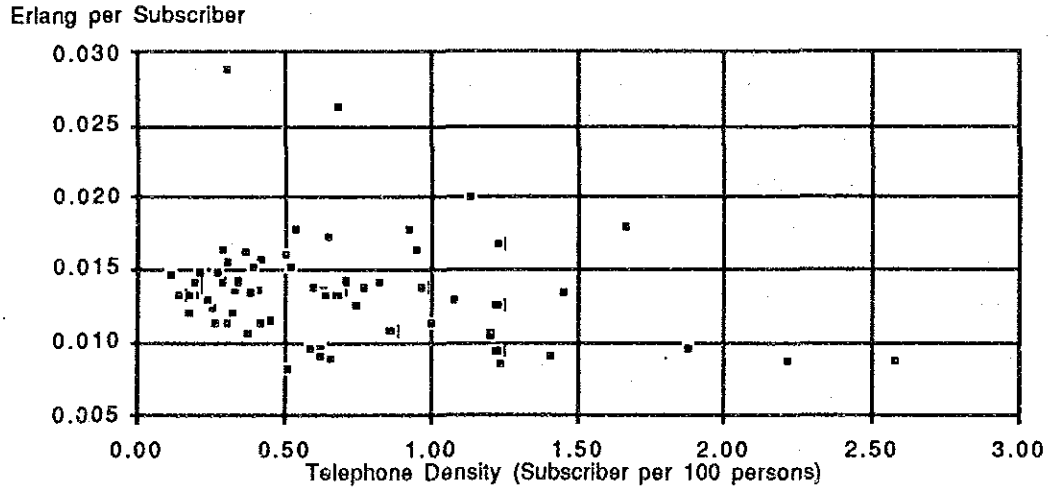


Figure 6.1.1-5 Outgoing Calling Rate for Telephone Density of Primary Centers

Figure 6.1.1-4 and 5 show the calling rates of small scale primary centers or low telephone density primary centers are almost higher than those of large scale primary center or high telephone density primary centers.

It is obvious that primary network in 1987 is starting phase of growth of network.

c) Estimation of the Outgoing Traffic Volume

The volume of outgoing traffic was estimated by a multiple regression model. The model used for this purpose was formulated as follows:

$$Y_{it} = a \cdot GGR_t^{\alpha} \cdot SGR_{it}^{\beta}, \qquad (6.1)$$

where

Y_{it} : Outgoing traffic growth rate from primary center i in period t,

GGR_t : GDP growth rate in period t,

SGR_{it} : Subscribers growth rate of primary center i in period t,

α, β, a : Coefficient.

The formula can be rearranged in the following log-linear form.

$$\ln (Y_{it}) = A + \alpha \ln (GGR_t) + \beta \ln (SGR_{it}) \qquad (6.2)$$

The coefficients were estimated by 24 grouping data of outgoing traffic on the basis of measurement data of 17 XB bar exchanges form 1982 to 1985 and in 1987. The estimated results are shown in the following equation.

$$\ln (Y_{it}) = 1.186 \ln (GGR_t) + 0.499 \ln (SGR_{it}) \qquad (6.3)$$

In this calculation, the following statistical tests of significance were obtained:

T-value (A)	= 0,
T-value (α)	= 2.633,
T-value (β)	= 2.837,
Coefficient of Determination (R^2)	= 0.734,
Adjusted Coefficient ($\overline{R^2}$)	= 0.710,
Standard Error of Estimate	= 0.149,

Degree of Freedom	= 22,
Probability of T-value(α)	= 0.015,
Probability of T-value(β)	= 0.009.

Figure 6.1.1-6 ~ 9 show the graph of the estimated results.

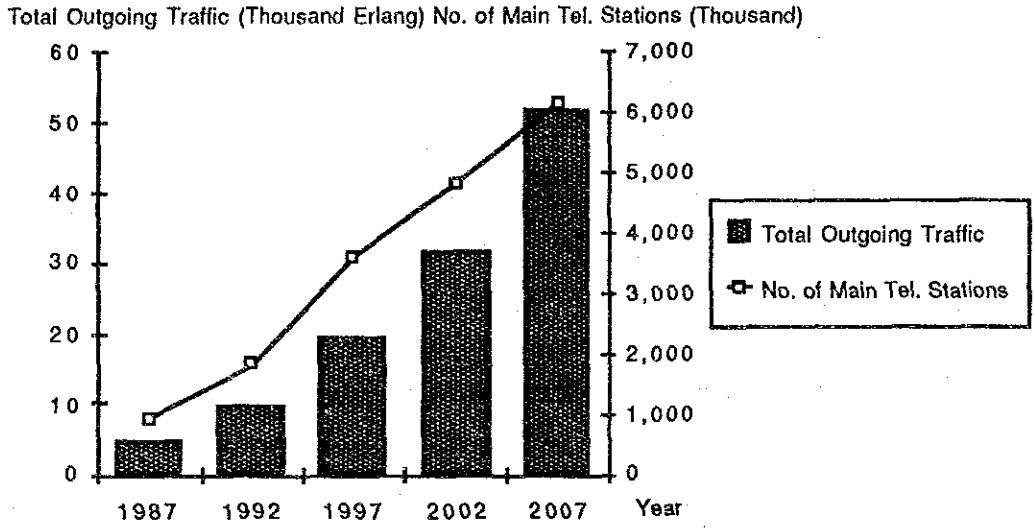


Figure 6.1.1-6 Estimated Total Outgoing Traffic of Primary Centers

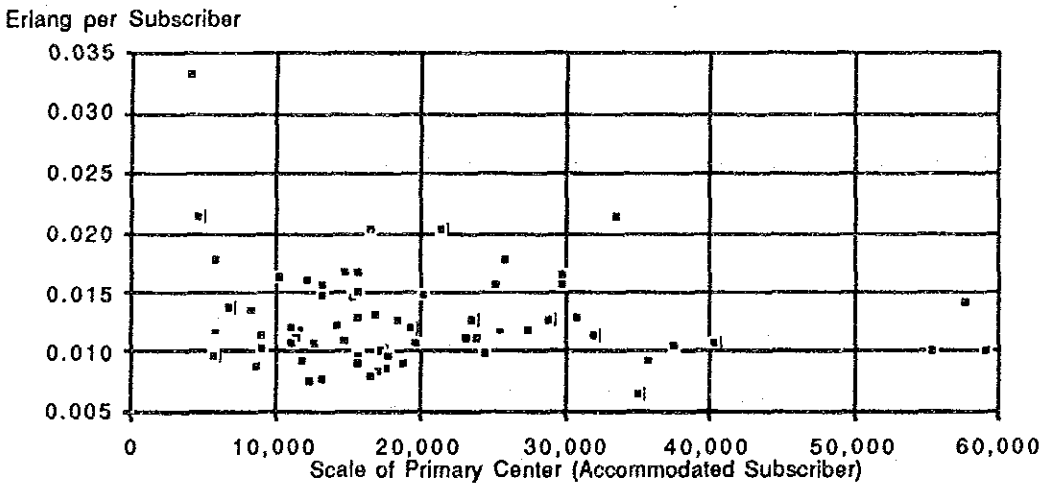


Figure 6.1.1-7 Outgoing Calling Rate for Primary Centers in 1997

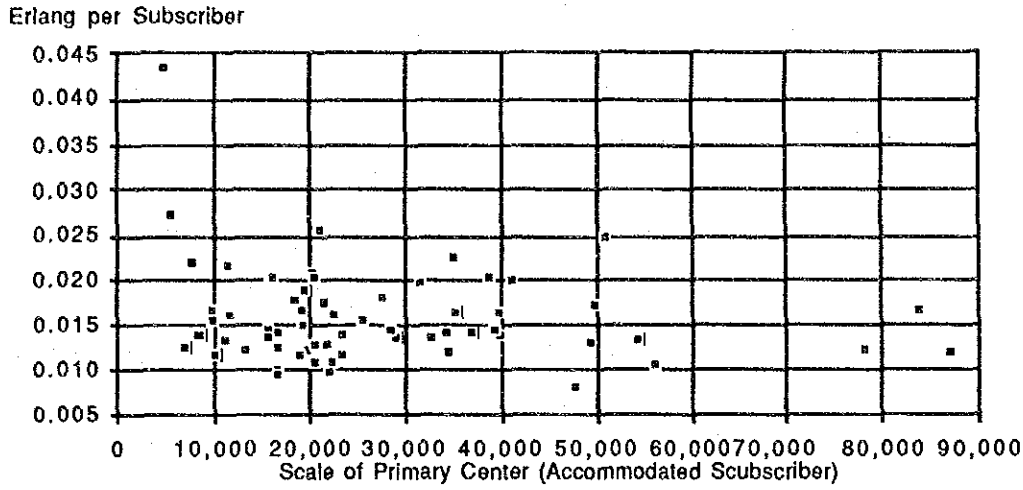


Figure 6.1.1-8 Outgoing Calling Rate for Primary Centers in 2002

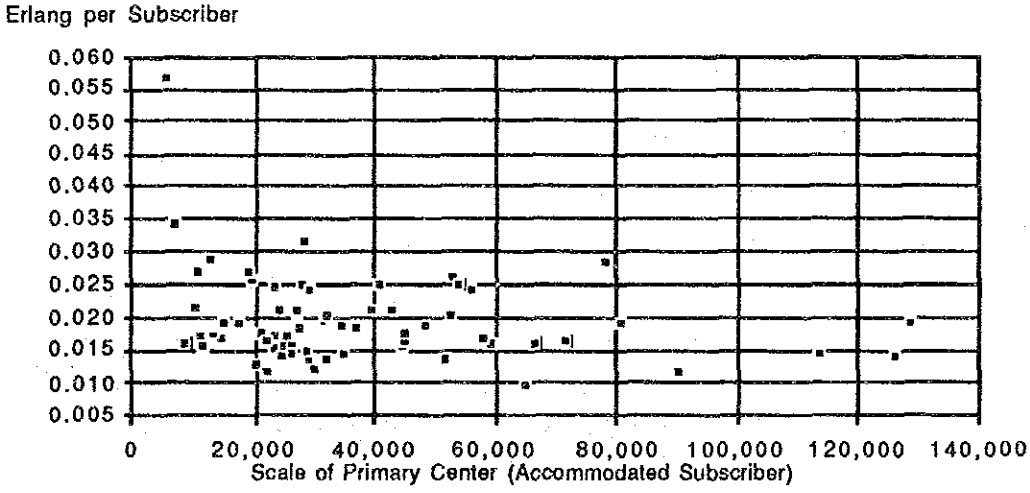


Figure 6.1.1-9 Outgoing Calling Rate for Primary Centers in 2007

d) Examination of The Results of Estimated Outgoing Traffic for Primary Centers

Figure 6.1.1-7,8 and 9, show that the calling rate tendency in future will increase in accordance with increasing accommodated subscribers by primary center. Further the results of estimated traffic in 2007 express that primary centers of higher calling rate than 0.02 will increase.

However, all the people having intention to subscribe will be offered telephone service within a few months by the end of Phase-1 period described in Chapter 5. Therefore, larger portion of telephone installation will be to offer telephone service to new residential subscriber from Phase-2. Accordingly, it can not expected that calling rate will necessarily increase in accordance with subscriber increasing .

e) Revise of the Results of Estimated Outgoing Traffic for Primary Center

From 2002, the results of estimated calling rate for primary centers that over the 1997's value are substituted by the respective values of 1997's calling rate, because of the reason mentioned above.

Further, traffic of network services is estimated on the basis of the ratios shown in Table 6.1.1-1.

Table 6.1.1-1 Traffic Ratio of Network Services to Basic Telephone Service

	1997	2002	2007
Ratio of Network Services for Basic Telephone Service	0.01	0.02	0.04

The ratios shown in Table 6.1.1-1 are assumed as described in the section 6.3.

Generally, in long-term forecast, after forecasting a nationwide macro unit on the basis of social and economic trends, a micro forecast for offices and primary center areas is estimated on the basis of the macro forecast. In this study, however, the forecast a nationwide macro unit does not estimate, because historical total traffic of nationwide was not obtained. Therefore, after estimating outgoing traffic of primary centers by a model, the results of the estimating traffic is revised on the basis of examination result.

Figure 6.1.1-10 shows forecast results of outgoing traffic.

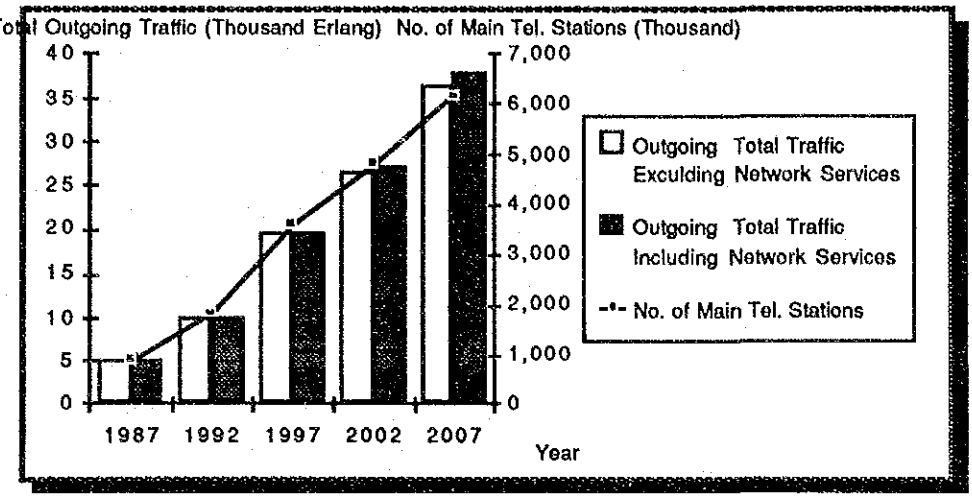


Figure 6.1.1-10 Forecasted Results of Outgoing Traffic

3) Calculation of Incoming Traffic for Primary Centers

The volume of incoming traffic to a primary center from the rest of primary centers is calculated on the basis of incoming and outgoing traffic ratios obtained from the Future PC-PC Traffic Matrix .

4) Forecast of PC-PC Traffic Matrixes for the Planning Years

The PC-PC traffic matrixes are forecasted by using the Kruithof's algorithm on the basis of the forecasted outgoing and incoming traffic for primary centers, and the Future PC-PC Traffic Matrix.

The results of forecast are shown in Appendix.

6.1.2 Traffic Matrix Forecast in Bangkok Multi-Exchange Area

The forecast procedure of traffic matrixes in Bangkok multi-exchange area is illustrated in Figure 6.1.2-1

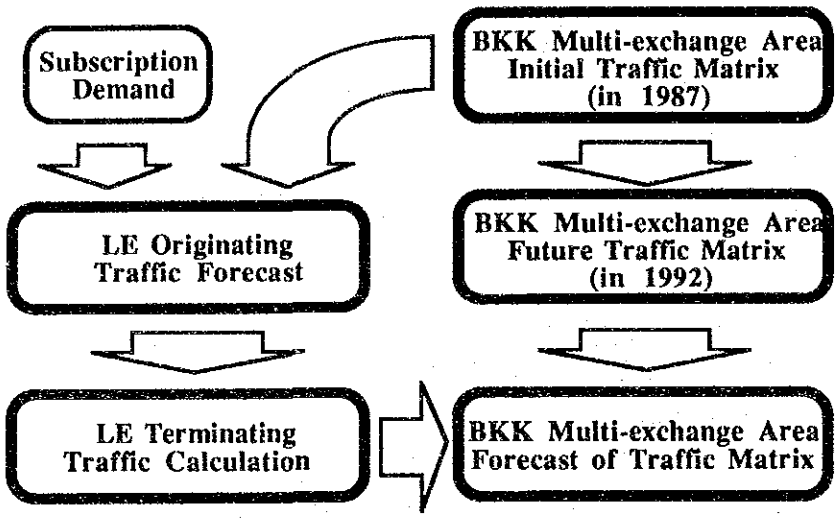


Figure 6.1.2-1 Bangkok Multi-Exchange Area Traffic Matrix Forecast Procedure

1) Creation of The BKK Multi-Exchange Area Future Traffic Matrix

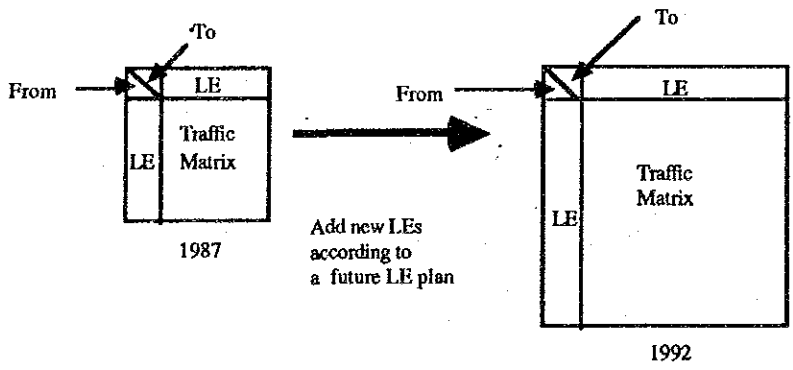
The traffic matrix of Bangkok multi-exchange area in 1992, called the Future Traffic Matrix, is basically an expanded and rearranged traffic matrix of Bangkok multi-exchange area in 1987. The traffic matrix in 1987 is expanded according to the expansion plan of local exchange office (LE) in " NUMBERING OF METROPOLIS (REV 4)". The traffic matrix in 1987, called the Initial Traffic Matrix, is modified in the following two steps:

-- Addition of new local exchange office,

-- Distribution of 1987 traffic between new LE and new LE, new LE and existing LE.

The procedure of creating the Future Traffic Matrix is as follows:

a) Expanding the Initial Traffic Matrix by adding new local exchange office according to a future local exchange office plan,



b) Distributing 1987 traffic among the local exchange office in 1992.

In this study, traffic distribution of new local exchange office are assumed the same as the traffic distribution of nearby existing local exchange office in 1992.

2) Forecast of Originating Traffic from Local Exchange Offices

a) Situation of Originating Traffic for Local Exchanges in 1987

Figure 6.1.2-2 shows originating calling rate for local exchanges in 1987.

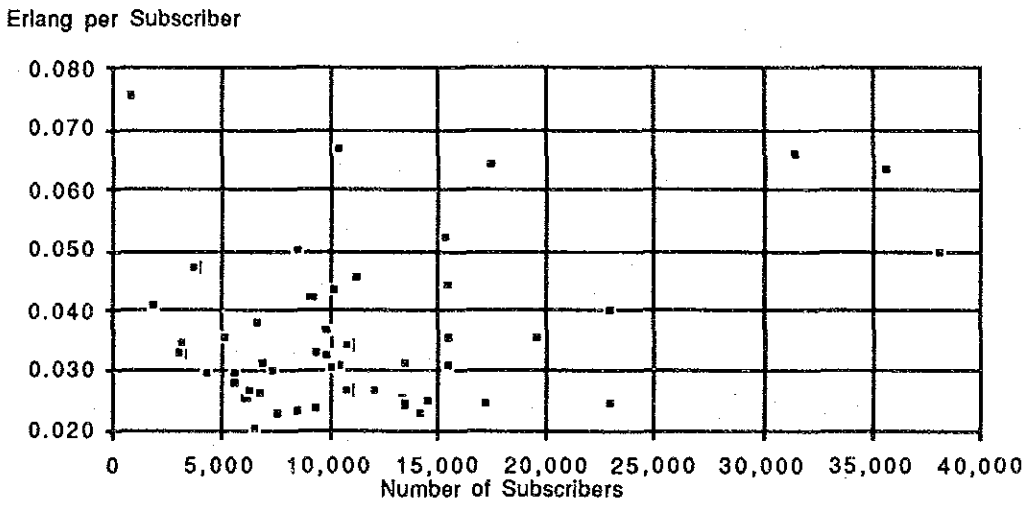


Figure 6.1.2-2 Originating Calling Rate of Local Exchanges in 1987

Figure 6.1.2-2 shows the originating calling rate tendency generally to increase in accordance with the scale of local exchange. However, there are many local exchanges having higher originating calling rate than 0.03 though the accommodating subscriber are less than 5,000. Therefore it is conjectured that in Bangkok metropolitan multi-exchange area, there are many exchange areas of low telephone penetration ratio in 1987.

Further, this Figure is conjectured that four big local exchanges of higher originating calling rate than 0.06 (Phloen Chit, Krung Kasem, Surawong and Sukhumvit local exchange) are accommodated big business areas. Therefore in the near future, these areas will be big market of new services such as ISDN or network services. In this study, however, traffic forecast of telephone service is estimated by a model for Bangkok

metropolitan multi-exchange area. Therefore, for micro unit forecast including the above four exchange areas, it is necessarily to be studied more in detail.

b) Estimating the Volume of Originating Traffic in the Future

The volume of originating traffic in the future is predicted by a regression model. The model used for this purpose was formulated as follows:

$$Y_{it} = a \cdot S_{it}^{\alpha} \cdot \mathrm{Exp}(\beta \cdot D), \qquad (6.4)$$

where

Y_{it} : Originating traffic volume from local exchange office i in period t,

S_{it} : Number of subscribers of local exchange office i in period t,

α, β, a : Coefficient,

D : Dummy variable for local exchange office of high CR more than 0.04.

The formula can be rearranged in the following log-linear form.

$$\ln (Y_{it}) = A + \alpha \ln (S_{it}) + \beta \cdot D \qquad (6.5)$$

The coefficients were estimated by the data of originating traffic in 1987 from the Initial Traffic Matrix. The estimated results are shown in the following equation.

$$\ln (Y_{it}) = -2.9385 + 0.9331 \ln (S_{it}) + 0.6187\ D \qquad (6.6)$$

In this calculation, the following statistical tests of significance were obtained:

T-value (A) = -8.7470,

T-value (α) = 25.2848,

T-value (β) = 10.8333,

Coefficient of Determination (R^2) = 0.9520,

Adjusted Coefficient ($\overline{R^2}$)	= 0.9449,
Standard error of Estimate	= 0.1766,
Degree of Freedom	= 48,
Probability of T -value (A)	= 0.000,
Probability of T -value (α)	= 0.000,
Probability of T -value (β)	= 0.000.

Number of subscribers for each local exchange office from 1997 to 2002 were obtained by proportionating the demand employed in this study for Bangkok metropolitan telecommunication area to percentage figures of local exchange demand to total demand of Bangkok metropolitan area in "TELEPHONE SUBSCRIBER DEMAND FORECASTING IN THAILAND (1987-2002)". Number of subscribers for each local exchange office in 2007 were obtained by proportionating the Bangkok metropolitan telecommunication area demand to the same percentage of 2002.

Further, traffic of network services is estimated on the basis of ratio on the Table 6.1.1-1.

Figure 6.1.2-3 shows a graph of the forecast results.

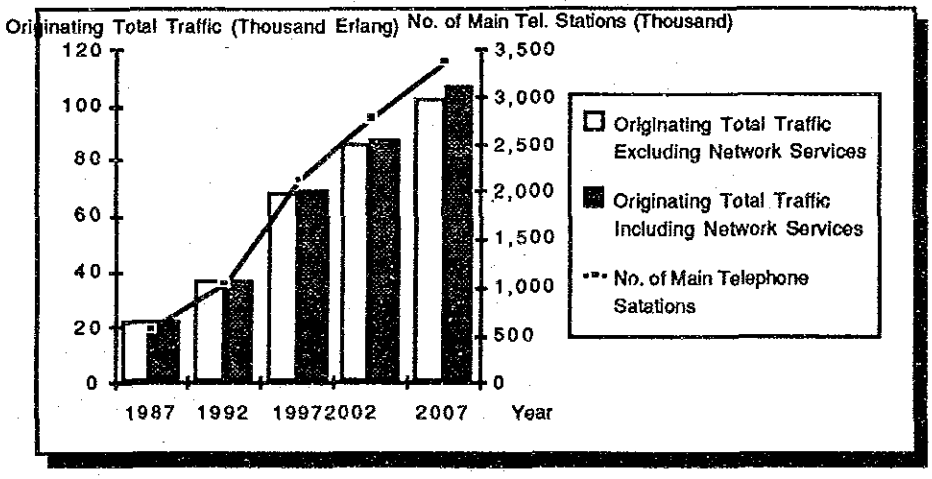


Figure 6.1.2-3 Forecasted Results of Total Originating Traffic

3) Calculation of Terminating Traffic for Local Exchange Office

The volume of Terminating traffic to a local exchange office from the rest of local exchange offices is calculated on the basis of originating and terminating traffic ratios obtained from the Future Traffic Matrix.

4) Forecast of Traffic Matrixes for the Planning Years

The traffic matrixes is forecasted by using the Kruithof's algorithm on the basis of the forecasted originating and terminating traffic for local exchange offices, and the Future Traffic Matrix.

The results of forecast are shown in Appendix.

6.2 Cellular Mobile Service

1) Present State

As regards the traffic state of cellular mobile telephone, the busy hour traffic breaks out about 9 to 11 o'clock and the call duration time per 1 call is about 3 minutes in average similarly to the ordinary telephone service.

According to the actual traffic measurement data as shown in Table 6.2-1, the traffic per subscriber is estimated at about 0.03 Erlang for Bangkok metropolitan area and 0.05 Erlang for provincial areas. The calling rate in cellular mobile service will become lower in future in proportion to the expansion of ordinary telephone service.

Taking reference to the actual traffic data in detail as classified into the directions of traffic at each RBS as shown in Table 6.2-2, the traffic from RBS to MTX is about 4 times as large as that from MTX to RBS. This means that this service is mainly utilized for originating calls from mobile stations.

Table 6.2-1 Traffic Data for Cellular Mobile

Year	Total Traffic			Number of Subscribers			Traffic per Subscriber		
	BKK	EAST	WEST	BKK	EAST	WEST	BKK	EAST	WEST
Sep.1986	22	-	-	781	21	7	0.0282	-	-
Mar.1987	52	30	3	1,612	336	65	0.0323	0.0893	0.0462
Sep. 1987	72	42	14	2,824	976	519	0.0255	0.0430	0.0270
Mar.1988	156	63	41	4,330	1,497	941	0.0360	0.0421	0.0436

Table 6.2-2 Actual Traffic Data at RBS

(Dec. 1988)

Radio Base Station		Number of Cells	Number of Channels	Traffic Density (erl.)	
				MTX to RBS	RBS to MTX
Metropolitan Area		24	364	48.264	178.962
	Asok Din Daeng	6	91	8.201	36.785
	Krung Kasem	3	56	7.940	29.790
	Lat Phrao	2	35	5.447	15.820
	Phra Khanong	2	28	3.980	14.835
	Rat Burara	2	28	4.704	11.498
	Charunsanitwong	1	21	2.613	14.895
	Nontabri	1	14	2.091	8.865
	Laksi	2	28	5.207	14.312
	Khlong Chan	1	14	1.467	8.865
	Bang Na	2	28	4.503	14.010
	Surawong	2	21	2.111	9.287
Provincial Area		13	153	21.772	107.018
	Bang Pakong	1	28	4.865	19.418
	Si Racha	1	12	1.005	9.588
	Ban Khanamrai	1	12	3.779	6.432
	Khao Yaida	2	28	3.297	20.624
	Chantha Buri	1	12	1.166	8.744
	Nakhon Pathom	1	16	2.593	11.498
	Phetcha Buri	1	16	2.915	10.814
	Hua Hin Radio	1	8	0.523	5.447
	Trat	1	5	0.181	3.719
	Ratchaburi	1	8	0.503	5.608
	Suphan Buri	1	8	0.945	5.126

2) Traffic Trends

Based on the result of demand forecast as described in the section 4.2.1, the number of subscribers up to the year of 2007 is estimated. The traffic forecast is carried out by referring to this subscription demand on the basis of 60% share of the total demands and by taking account of the lower of calling rate in future. The result is shown in Table 6.2-3.

Table 6.2-3 Traffic Forecast

Year	1992	1997	2002	2007
Volume of Demands (60% Share Basis)				
Metropolitan Area	25,488	56,802	124,282	203,112
Provintial Area	29,727	63,162	133,219	208,372
Traffic per Subscribers (Erlang)				
Metropolitan Area	0.03	0.03	0.02	0.02
Provintial Area	0.04	0.04	0.03	0.03
Total Traffic (Erlang)				
Metropolitan Area	765	1,704	2,486	4,062
Provintial Area	1,189	2,526	3,997	6,251

6.3 Other Services

In the preceding sections, the traffic forecasts of telephone service and cellular mobile service are described individually. In Chapter 4 as demand forecast, the subscription forecasts for each service are described individually. In this section, however, the traffic forecast of other services is described as a general view because of the following reasons.

- In comparison to the telephone service, the share of traffic by other services is considerably low and the volume is basically in proportion to that of telephone service.

- With the diversification of services and the enhancement of networks, the traffic features will become variable. To cope with this trend, corresponding measures should be studied in general for the traffic management, regardless of services and networks.

- Various kinds of services will be put into operation in the field of telecommunications, and some services will be competitive for each other, for instance, between telegram service and bureau facsimile service, between packet data service and ISDN service etc. Under these situations, the service classification will become more and more complicated, and their boundaries can not clearly be discriminated.

- Taking account of the relation between services and networks, the services to be offered don't systematically correspond to the networks to be employed. Some of the services are realized on plural networks. The relation between services and networks will not clearly be defined.

- In case that the network is dedicated for the exclusive use, for example, as classified into telephone network, telex network, packet data network etc., the individual traffic theory can be adopted for each network. However, all of these networks will be integrated into the ISDN network, and the services are synthetically offered with the (2B+D) interface. The new concept of traffic theory should flexibly be applied to meet the ISDN era.

The relations among services & networks, traffic features and traffic forecast are shown in Figure 6.3, and the detailed explanations are described in the following.

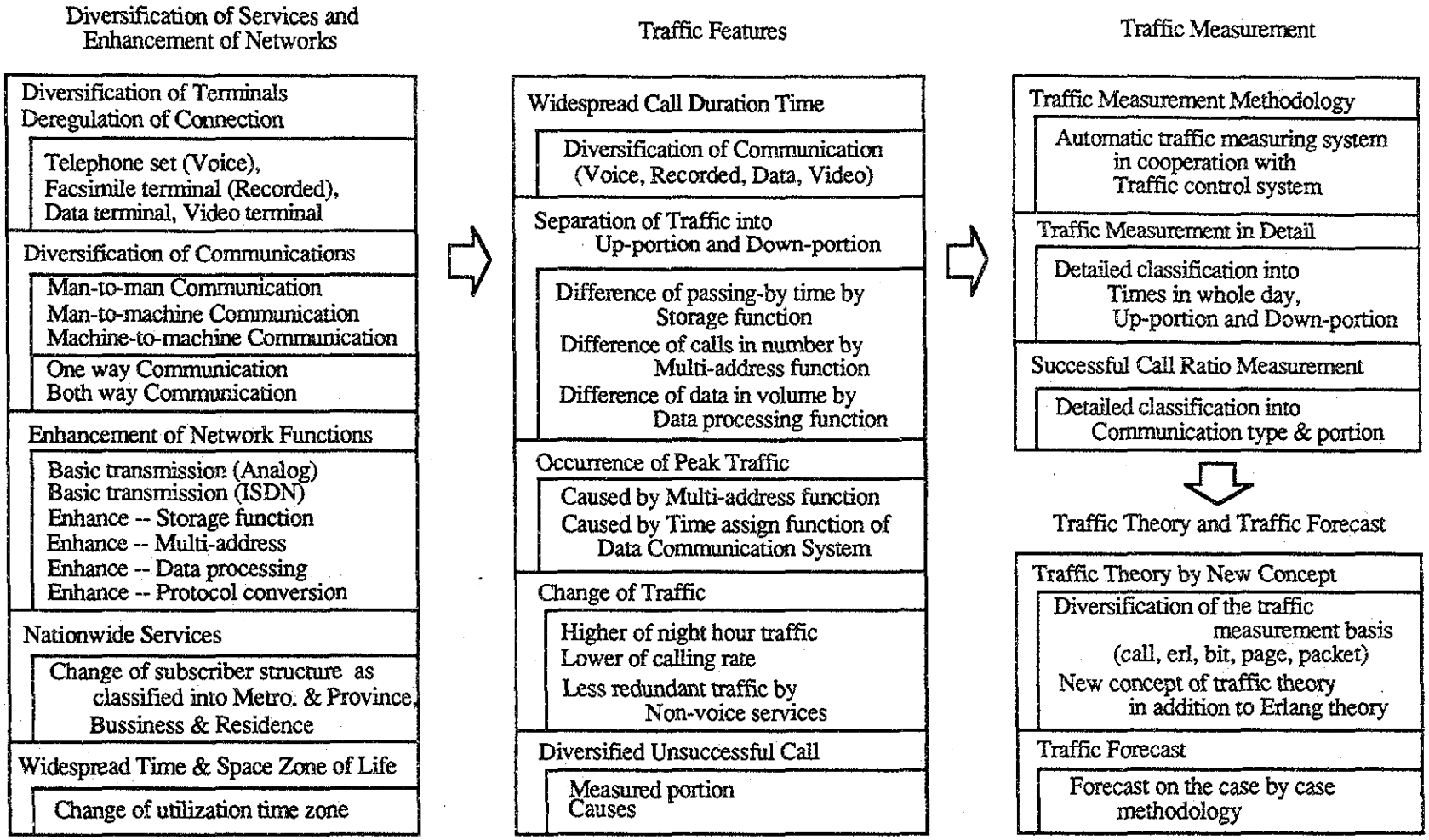


Figure 6.3 Relations among Traffic Factors

6.3.1 Diversification of Services and Enhancement of Networks

1) Diversification of Terminals

Owing to the deregulation of terminal application, various kinds of terminals are accommodated on the public telephone network. At present, the major terminals are telephone set, facsimile terminal, data terminal with analog interface. In the near future, video terminal, the advanced digital terminals will be introduced. This diversification of terminals will affect the change of call duration time.

2) Diversification of Communications

With the accommodation of diversified terminals on the network, the communication form becomes variable. In addition to the existing man-to-man communication, the communications among man and machine are also available. In relation to the above, one way communication is utilized for machine-to-machine communication. As a result, the volume of transmitted information is different between the portions.

3) Enhancement of Network Functions

In addition to the existing network function, the following functions will be realized in the near future.

a) ISDN Interface as Basic Transmission

ISDN basic access rate interface provides two channels of 64 kb/s and one channel of 16 kb/s with one subscription. These channels can be shared with plural terminals, and various types of information are transmitted through this interface. Accordingly, the traffic should be managed in various concepts.

b) Enhanced Function

In utilizing the basic transmission service, data store & forward function and data processing function may be offered in future. Definitely, facsimile mail system, message handling system etc. may be available. This enhancement leads to the separation of traffic into up-portion and down-portion. Namely, up-portion traffic does not always be proportional to down-portion traffic.

Table 6.3.1-1 Service Categorization

Basic Service	Enhanced Service	
Transmission	Data Store & Forward	Data Processing
Telephone Network, Telex Network, Leased Circuit, Packet Data Network, ISDN Network, etc.	Facsimile Mail System, Message Handling System, Database Inquiry, Bulletin Board System, Voice Mail etc.	Data Communication System, Computer Network, etc.

4) Nationwide Services

With the expansion of telecommunication services, the market segment will be enlarging toward covering the whole society. That is, the subscriber structure will be changing in proportion to the expansion. This change of structure is classified into metropolitan and provincial area, and business and residential subscriber, and will affect the traffic trend in quantity and in quality.

5) Widespread Time & Space Zone of Life Style

With the improvement of life style, the time & space zone for usage of telecommunication services will become widespread. At present, the busy hour traffic usually breaks out in the morning of the week day. The busy time traffic will gradually be dispersed to the other time zone.

6.3.2 Traffic Features

1) Widespread Call Duration Time

As regards the voice communication in a form of man-to-man communication, the call duration time is about 3 minutes in average. This trend is not so changeable, wherever the location is and whenever the era is. The deviation is considered to be relatively smaller in voice communication. On the other hand, the call duration times of other communications are varied owing to the difference of procedure, circuit speed etc.

For instance, as regards the facsimile communication, the call duration time per one sheet by G-3 facsimile is about 20 seconds while that by G-4 facsimile is about 4 seconds. As regards the data transmission, that by Basic procedure transmission requires long time period while that by High Level Data Link Control procedure (HDLC) requires short time period.

As a summary, the call duration time is variable according to the followings;

- Caused by communication form as voice, recorded, data, video etc.,
- Caused by kind of media as telephone, facsimile, data etc.,
- Caused by transmission procedure, speed etc.

2) Separation of Traffic into Up-portion and Down-portion

In general, a call is composed of up-portion and down-portion in pair. Up-portion is the call direction from terminal to network while down-portion is the call direction from network to terminal. With the enhancement of network functions as described previously, some of the calls are processed separately into up-portion and down-portion. That is, the content of traffic is different between up-portion and down-portion as follows;

- Passing-by time caused by storage function,
- Number of calls caused by multi-address function,
- Volume of transmitted data caused by data processing function.

3) Occurrence of Peak Traffic

In providing multi-address function on the network or accommodating data communication system having data gathering or distributing functions, peak traffic may occur during the short time period. In some cases, the considerable amount of calls are given to the network. The detailed traffic observation is required for this peak traffic.

4) Change of Traffic in Quantity and in Quality

With the increase of telephone subscriptions, the share of residential subscribers are increasing. As a result, the calling rate will become lower and the traffic in the night time zone will become higher.

In the existing telephone network, the communication is carried out by confirming the partner's intention with both way communication. The density of transmitted information is relatively low in the voice communication, while the density relating to non-voice communication is higher because its communication has less redundancy. The change of traffic in quality requests the new concept of traffic theory.

5) Diversified Unsuccessful Call

In the existing telephone network, the successful call ratio is measured covering the whole procedures from handset off until called party answer, and the unsuccessful call is mainly composed of called party busy, calling party fault, network congestion etc. With the enhancement of networks, the successful call ratio will become different by the measured portions, and the causes of unsuccessful call will be more diversified.

6.3.3 Traffic Measurement

Taking account of the above-mentioned traffic features, the traffic measurement and traffic forecast should flexibly meet the current situations as described in the followings.

1) Traffic Measurement Methodology

After the integration of networks, some of the traffic concentration may break out in the night time or in the holiday, namely, it will not be limited to the morning time zone in a week day. It cannot be anticipated when the busy hour is. As a countermeasure, it becomes necessary to observe traffic during the whole time zone by automatic system in cooperation with the traffic control system such as NCOM.

2) Traffic Measurement in Detail

On the basis of the gathered data, the results should be arranged by classifying the data into time zones, portions, services etc. for reflecting to the analyses and countermeasures.

3) Successful Call Ratio Measurement

In appreciation of the present state of successful call ratio, the ratio is considered too low. In order to utilize the actual traffic data for the analyses rather uniformly, the successful call ratio should be upgraded more and more. That is, the traffic data can be more reliable as the upgrade goes on, because the unsuccessful calls will become to exert less influence to the measurement.

In a similar manner, the cause of unsuccessful call should be measured in detail for planning countermeasures.

6.3.4 Traffic Theory and Traffic Forecast

1) Traffic Theory by New Concept

The traffic has been managed mainly on the basis of the Erlang theory in the existing telephone network. In accordance with the change of traffic features, the traffic management method should be diversified as measured by Bit, Page, Packet etc. On the basis of these traffic measurement units, the new concept of traffic theory should be established.

2) Traffic Forecast

It is very difficult to forecast the traffic for various services. There has been no standard traffic forecast method for the various derivative services, and also from now on, the uniform rule cannot be applied as a whole. It is considered that the traffic forecast of various services can be estimated at most on the macroscopic basis.

The method should be established individually on the case by case basis. However, even if the tentative method is established, its result may indicate one of the guidelines and may not surely forecast the actual trends. Therefore, the results should always be examined and modified according to the actual trend data.

Among the total traffic of ordinary telephone service, the share of various services will be about several percents at most. As mentioned previously, the traffic of non-voice services is non-redundant, namely, the information is condensed, therefore, there will be less influence on the whole traffic. It is considered practical to reflect the traffic to the network by estimating at within 5 percent of the telephone traffic, as described in Table 6.1.1-1.

CHAPTER 7

TELECOMMUNICATION NETWORK PLAN

CHAPTER 7. TELECOMMUNICATION NETWORK PLAN

7.1 Fundamental Network Plan

7.1.1 Network Configuration

1) Present Domestic Network

The domestic network is established with three level hierarchy in the metropolitan area and four level hierarchy in provincial areas as shown in Figure 7.1.1-1. The digitization from primary centers upward will be completed at Phase-1. But the local exchanges will consist of crossbar system with digital system for a while.

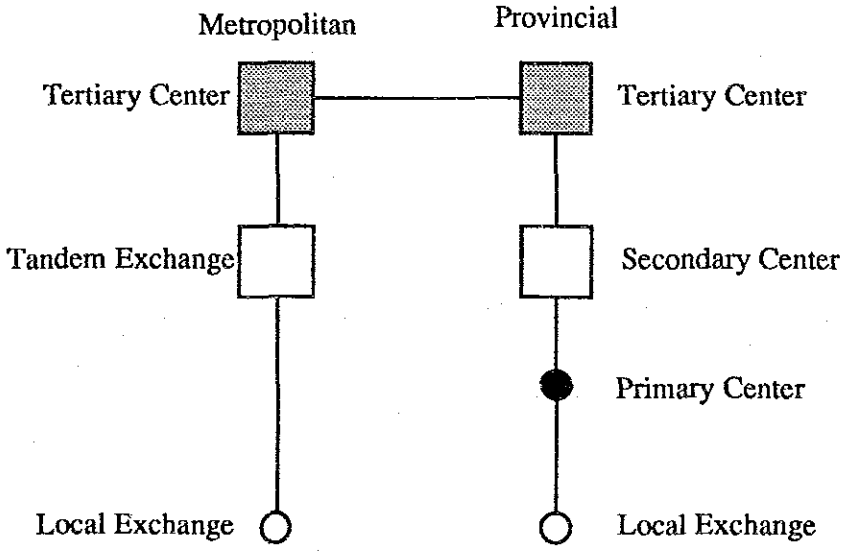


Figure 7.1.1-1 Network Hierarchy

The domestic network in Thailand has 7 Tertiary Centers (TC). 4 TC is installed in Bangkok and 3 TC is installed in provincial areas. Each TC has the final route to International Transit Switching Center (ITSC). Numbering areas in each TC is as follows.

Lak Si (LKS)	02-2xx and 02-5xx numbering areas
Phra Khanong (PKG)	02-2xx and 02-3xx numbering areas
Lat Ya (LTY)	02-2xx and 02-4xx numbering areas
Krung Kasem (KKM)	03-x numbering areas (Central area)
Nakhon Ratchasima (NRS)	04-x numbering areas (North-eastern area)
Phitsanulok (PSN)	05-x numbering areas (Northern area)
Surat Thani (SAT)	07-x numbering areas (Southern area)

The above TC numbering areas are divided into Secondary Center (SC) areas. There are 20 SC areas except Bangkok Metropolitan Area (BMA). Each SC area has SPC trunk exchange and 3 exchanges combine with TC function. Meantime, in BMA, 6 SPC tandem exchanges have SC function.

The SC areas are subdivided into Primary Center (PC) areas and there are 68 PC areas. Among them, SPC exchange and XB exchange in parallel are installed in 7 PC as of 1992 but there are not XB exchange for SC and TC. Figure 7.1.1-2 shows the state of switching locations at the end of 5th project.

Domestic network has many high usage routes according to economic point of view. Basically, routing scheme is employed with high usage routes and final choice routes, adopting far to near rotation method.

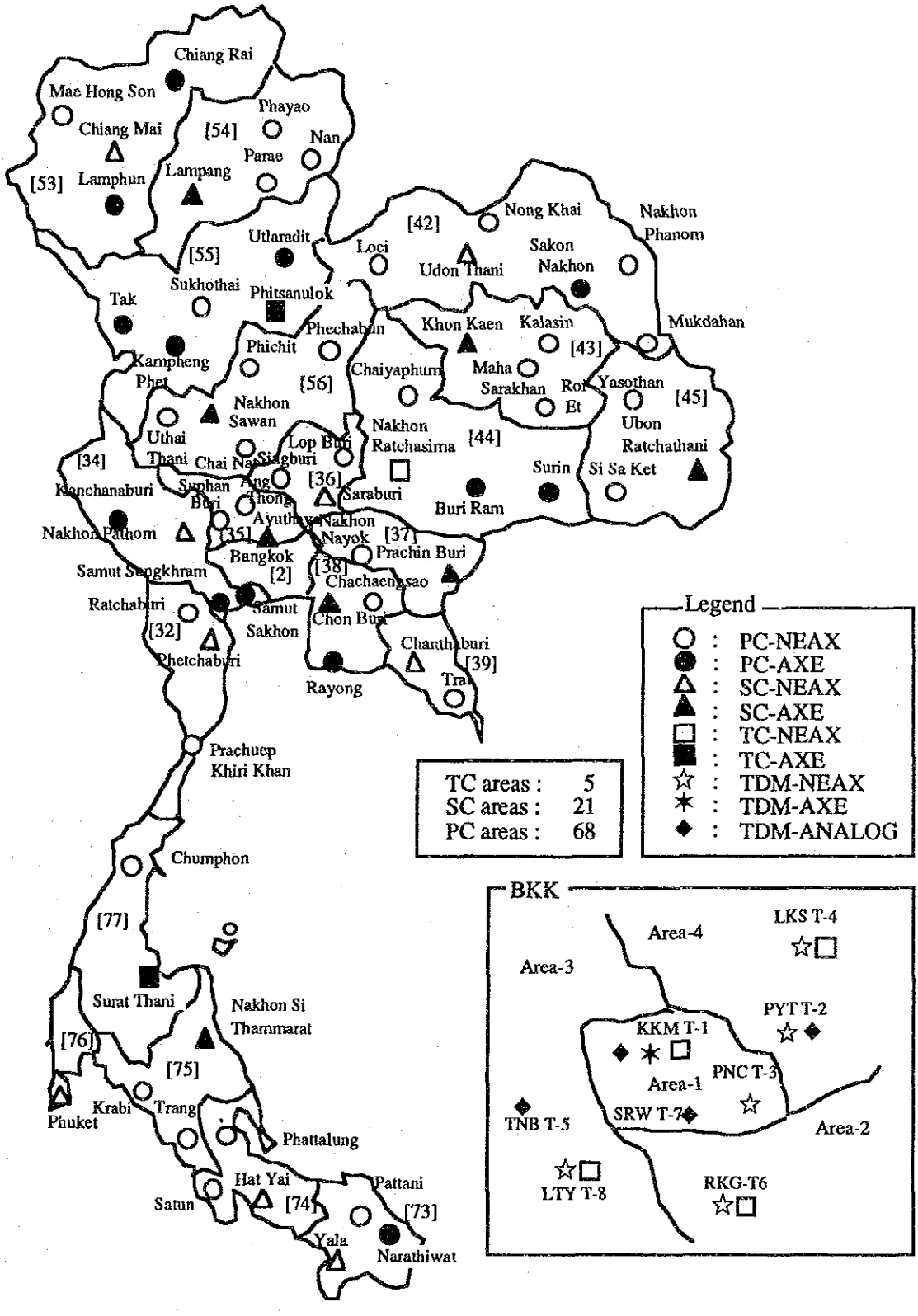


Figure 7.1.1-2 Switching Locations

2) Metropolitan Network

The network in BMA is applied with the dispersed tandem system and there are 4 XB exchanges and 6 SPC exchanges for 8 tandem areas (T1-T8). XB tandem exchanges are connected to XB local exchanges and SPC tandem exchanges are mainly connected to SPC local exchanges for final choice route.

In 2 tandem areas among the above 8 tandem areas, XB tandem exchange and SPC tandem exchange are equipped together. The dispersed tandem exchange system is shown in Figure 7.1.1-3. And the tandem exchange names are shown in Table 7.1.1-1.

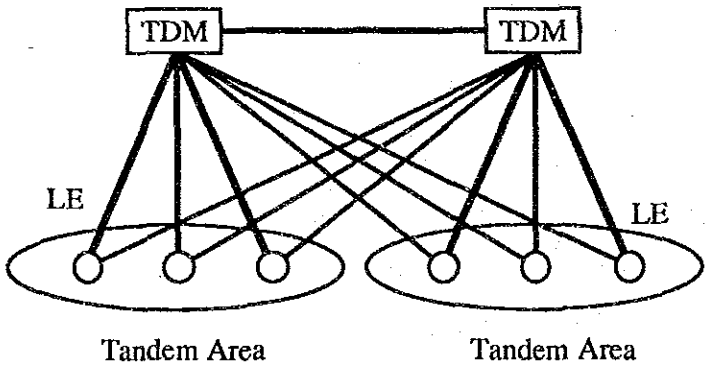


Figure 7.1.1-3 Dispersed Tandem Exchange System

The local exchange in each tandem area has final route to its own superior tandem exchange. In case that the originating and terminating traffic is more than 20 erl, the high usage route is set up to another tandem exchange. And also, the high usage route between local exchanges is set up, if the traffic is more than 20 erl. And the unit of circuits is 30 (1 DTI).

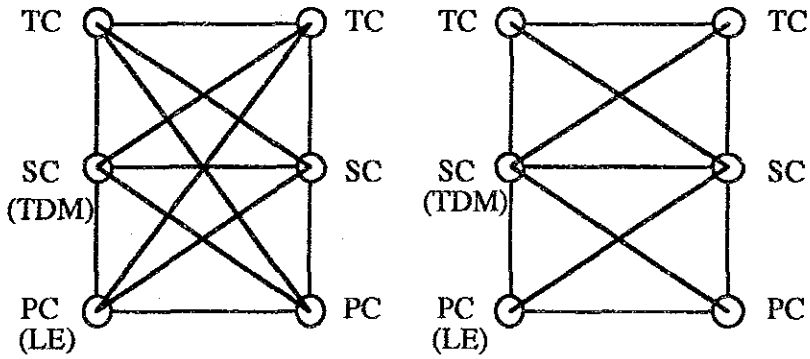
Table 7.1.1-1 Tandem Exchange Name

	Office Name	Exchange Type	Numbering
T1	Krung Kasem	AXE10 (SPC), ARF (XB)	02-2xx
T2	Phahonyothin	NEAX61 (SPC), C400 (XB)	02-2xx
T3	Phloen Chit	NEAX61 (SPC)	02-2xx
T4	Lak Si	NEAX61 (SPC)	02-5xx
T5	Thon Buri	C400 (XB)	02-4xx
T6	Phra Khanong	NEAX61 (SPC)	02-3xx
T7	Surawong	C400 (XB)	02-2xx
T8	Lat Ya	NEAX61 (SPC)	02-4xx

3) Proposed Network

For digital network construction, long distance and local metropolitan routing plans have been formulated in Thailand, and network configuration will be completed in accordance with these routing plans by the end of 1992.

However, this plan is considered to have too many high usage routes to make future network expansion plan efficiently. Therefore, partial revised plan will be proposed aiming at a simpler network from the viewpoints of maintenance and operation. Figure 7.1.1-4 shows the proposed routing plan.



Note: ( ) means in case of metropolitan area

Figure 7.1.1-4 Proposed Routing Plan

On the other hand, exchange reliability enhancement will be necessary in future by duplication of higher rank exchanges taking account of traffic increase, and so forth. Figure 7.1.1-5 shows the example for exchange reliability enhancement.

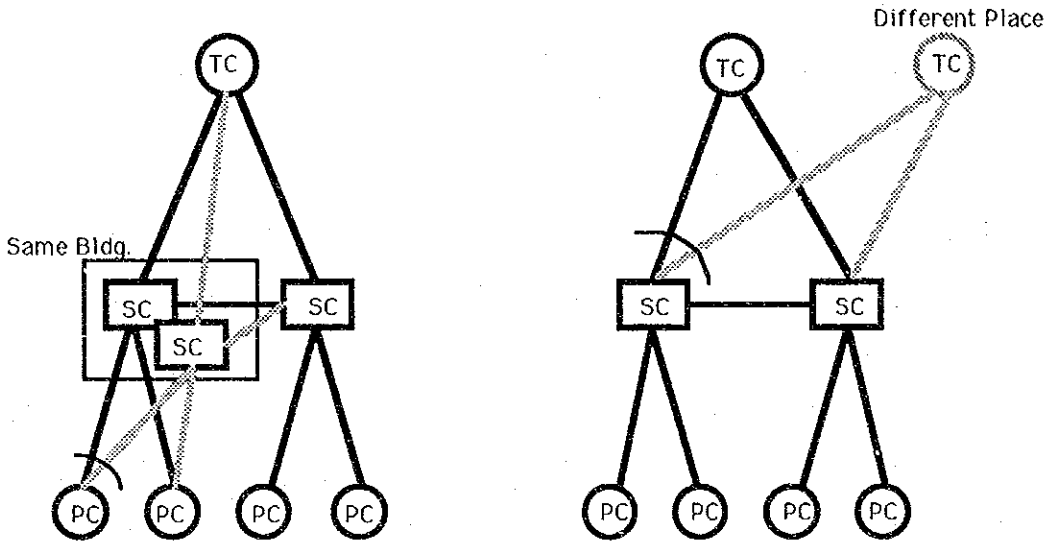


Figure 7.1.1-5 Example of Exchange Reliability Enhancement

7.1.2 Numbering Plan

1) Basic Matters Relating to Numbering Plan (on the basis of CCITT E.163)

The purpose of numbering plan is to give subscribers, connected to domestic telephone network, this own telephone number without conflict. Numbering plan should have the numbering structure which is simple style for subscriber, makes economical telephone network expansion possible and can cope with the fluctuation of demand forecast in future, besides taking international connection into consideration.

The telephone number is used not only for connection control between subscriber and network but also identified for charging. Generally, the following matters are taken into account;

- It is not necessary to change for long term in future, having enough capacity of number for increasing subscribers and new services,
- Wherever a subscriber can call destination partner from, by using the same number. Because, if the telephone number is given different number depending on originating place, it will be very inconvenience,
- The number has simple and easy style to understand for subscriber,
- For function of exchange, the number should be easy to translate routing and charging,
- The maximum figure of telephone number is decided. According to CCITT, the domestic telephone number does not excess total number of (12-N). In TOT case, it is allowed by ten digits because the number of N is two figure.

2) Numbering Plan in Existing System (CCITT E.163)

a) The Number for Existing Services

i) The Number of Ordinary Telephone

The most important factor when domestic telephone number is decided, is fluctuation of telephone demand from each area. The existing numbering plan, however, should be changed to numbering plan of ISDN era because the existing numbering plan for data and telex communication will be integrated to the telephone number in ISDN era.

In examining the number capacity, Table 7.1.2-1 shows number capacity until FY 2022. This figure was not forecasted with demand forecasting method but calculated with linear extrapolation based on the telephone demand in FY 2007.

Table 7.1.2-1 Number Capacity

	Telecom Area	Code	2012	2017	2022
BMA Total			4,004,811	4,633,244	5,261,678
Prachin Buri	Prov. 1	37	59,548	71,216	82,885
Chon Buri	Prov. 1	39	520,286	613,100	705,914
Chanthaburi	Prov. 1	39	75,428	91,570	107,712
Nakhon Ratchasima	Prov. 2	44	234,220	275,055	315,890
Ubon Ratchathani	Prov. 2	45	106,402	121,891	137,380
Udon Thani	Prov. 3	42	160,937	185,017	209,096
Khon Kaen	Prov. 3	43	149,897	172,207	194,518
Phitsanulok	Prov. 4	55	224,108	268,830	313,552
Nakhon Sawan	Prov. 4	56	186,641	222,673	258,704
Chiang Mai	Prov. 5	53	226,543	270,447	314,350
Lampang	Prov. 5	54	150,503	178,258	206,013
Phetchaburi	Prov. 6	32	252,317	310,113	367,908
Nakhon Pathom	Prov. 6	34	246,960	300,920	354,880
Nakhon Si Thammarat	Prov. 7	75	141,874	166,359	190,844
Phuket	Prov. 7	76	56,101	67,008	77,915
Surat Thani	Prov. 7	77	120,569	142,298	164,027
Yala	Prov. 8	73	82,333	95,720	109,107
Songkhla (Hat Yai)	Prov. 8	74	194,039	232,653	271,268
Ayutthaya	Prov. 9	35	91,804	108,547	125,289
Saraburi	Prov. 9	36	159,556	194,962	230,368

Metropolitan Area

The number of subscribers of the metropolitan are in FY 2007 will exceed about 3 millions and will approach about 5 million after 15 years more. From the viewpoint of telephone number capacity, TOT now adopts 8 digits in metropolitan area and it can accommodate up to 8 millions telephone number.

Although it will be enough for number of subscribers in future, it will have to use new office code. And if TOT adopts 9 digits the same as provincial areas, it can accommodate 80 millions telephone number for subscribers. It will be necessary to study which way is preferable for Thailand in the long run.

8 digits A- BCD-EFGH

2-	2XX-XXXX	occupied
	3XX-XXXX	
	4XX-XXXX	
	5XX-XXXX	
	6XX-XXXX	unoccupied
	7XX-XXXX	
	8XX-XXXX	
	9XX-XXXX	

Note: "0" and "1" of B code are not used. Therefore, the capacity is $1 \times 8 \times 10^6 = 8$ millions

9 digits A-BCDE-FGHI
2-XXXX-XXXX

Note: "0" and "1" of B code are not used. Therefore, the capacity is $1 \times 8 \times 10^7 = 80$ millions

In case of 8 digits, the following points should be considered for assignment of new office codes.

- Relation to the metropolitan telecommunication areas and the tandem areas
- Relation to the existing office codes

For example, a proposed of new office code assignment is shown in the followings.

Occupied Office Code	Metro. Area	New Office Code	Metro. Area
2 xx	1,2,4	6 xx	1
3 xx	2	7 xx	2
4 xx	3,4	8 xx	3
5 xx	2,3,4	9 xx	4

If TOT adopts nine digits, present complicated situation which does not correspond to office code and metropolitan area number or tandem areas will be solved. However the telephone network plan about this matter in metropolitan area should be reexamined.

Provincial Area

Table 7.1.2-1 shows the result of examination of number capacity in provincial areas. It seems that all provincial areas have enough capacity. However, "038" area should be noted at near FY 2022. At present, the available area code starting from "3" in provincial area is "30", "31" and "33". If these numbers are used for the same area as "38" area, it will cause confusion about network planning and for subscriber as these are not continuous number from "38".

ii) Cellular Mobile Service

The numbering plan of cellular mobile service is established on the basis of that of ordinary telephone service. For TOT's mobile service, the trunk code "01" is exclusively assigned, while for CAT's mobile service, the exchange code for Bangkok area is occasionally assigned in proportion to the increase of subscribers.

Based on the result of demand forecast as described in the section 4.2.1, the numbering capacity is examined as shown in Table 7.1.2-2, under the condition that each of carriers has the probability of satisfying the 60 % of total demands.

Table 7.1.2-2 Study of Numbering Capacity

Area	Demand (x1000)	TOT		CAT	
		Numbering Capacity (x1000)	Result of Study	Numbering Capacity (x1000)	Result of Study
Metropolitan	203 (338 x 0.6)	1,000	Sufficient	Shared with the number of ordinary telephone service	Sufficient in number Provisional scheme
Provincial	209 (347 x 0.6)	4,000	Sufficient		
(Not Assigned)	-	5,000	-		

According to this study above, the numbering capacity is sufficient for the TOT's service. However, that of CAT's service should be examined in relation to that of ordinary telephone service as studied in Table 7.1.2-1, because the exchange code is to be picked up from the non-engaged codes. At least, 42 exchange codes will be required for this use. In conclusion, the numbering capacity is sufficient in number, however, the followings can be pointed out.

- Provisional numbering scheme,
- Complicated for decording the destination from the side of exchange function,
- Unclear of descriminating the services from the side of subscribers.

iii) Paging Service

The paging service is presently offered by CAT. The numbering structure is regarded as the same to the case of PBX. Namely, to reach a paging station, the radio base station is to be connected first by the ordinary telephone number, then the designated paging station is to be called by the station number. On the basis of this procedure, one telephone number can be shared by many paging stations, because the call duration time per one call is relatively short and standard

Based on the result of demand forecast as described in the section 4.2.2, the demand is estimated at 370,000 stations in 2007. To cope with this demand by paging stations, the number of line units may be sufficient as 2,000 line units of telephone network. Accordingly, there seems to be no problem in the numbering capacity, as far as the present scheme will continue to be applied.

3) The Number for Enhanced Services

In order to cope with the diversification of services, the required numbers are assigned according to service descriptions.

i) 1XY Series

The number started from "1".

This number is used for the services which is regardless dialling way such as emergency call, complaint reception, telephone directory assistance service and etc.

ii) Function Button Series

This number is composed of figure and function button (# or *) and only push button subscriber can use it (i.e. abbreviation dialling service).

iii) "0"ABC Series

The number started from "0".

This number is used for connection with telephone network and other networks. Therefore, this number series makes possible to structure economical network with setting the connection point at superior than PC level. At present, TOT has not adopted this way yet.

4) Numbering Plan for ISDN Era

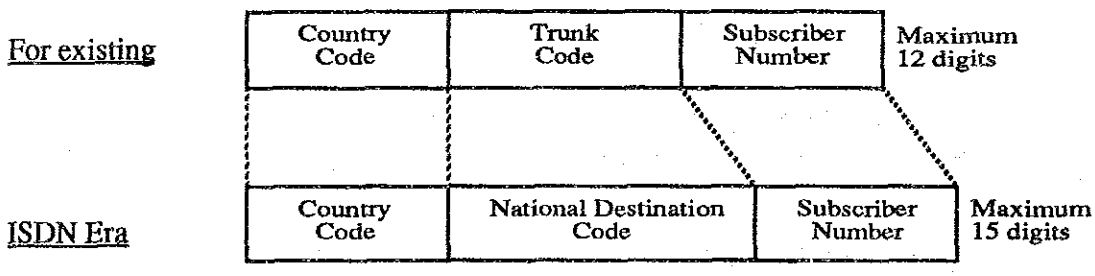
a) Purpose

The existing network services are offered with respective network corresponding to each service and the services were given particular numbering plan, if necessary. ISDN service, however, needs new integrated numbering plan, because ISDN primarily aims at integrating voice service and non-voice service into ISDN services.

b) Consideration

The numbering plan for ISDN era should be able to be adopted with not only ISDN but also the existing networks and terminals. It will basically be an expansion of the contents of CCITT Rec. E.163.

c) Comparison of Numbering Plan for ISDN Era and Existing



Feature

(1) The maximum digits will be changed to 15 digits.
(2) The numbering plan can identify every domestic network.

d) Relation between Selection Logic and Information Signal

The informations concerned to connect to network among of various information in I–interface are following:

i) Identifier of numbering plan

Designation of numbering plan such as telephone network, ISDN network, data network and telex network for connecting to existing network,

ii) Indicator of classified number

Designation of call such as international, domestic and local etc. (correspond to prefix of telephone number),

iii) Called telephone number

Country Code(CC)+National Destination Code(NDC)+Subscriber Number(SN),

iv) Selection of transit network

In case of difference of network or area in which originating and terminating subscriber is accommodated,

v) Sub address

Designation of terminal equipment.

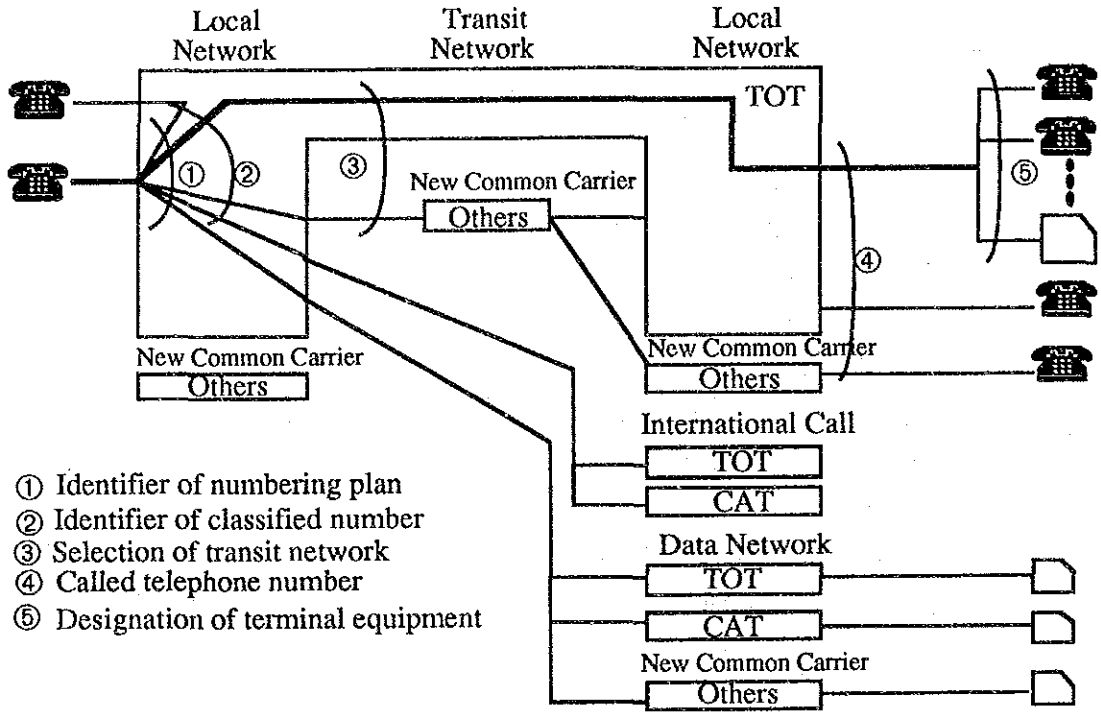


Figure 7.1.2-1 Relation between Selection Logic and Information Signal

These information factors have been defined "number" em bloc up to now. When the signal from a subscriber only depends on dialling figure, there has been no problem. Figure 7.1.2-1 shows the relation between selection logic and information signal on I-interface.

As regards the new numbering plan for ISDN service, however, study on "number" should be started from classifying various meaning of "number".

e) Transition of Numbering Plan for ISDN Era

The new numbering plan for ISDN era is to be based on the existing numbering plan. The numbering plan having 15 digits can not connect to existing network having 12 digits, because the maximum digits of existing network is 12 digits.

Accordingly, in the meantime, the present numbering plan will be followed. CCITT has recommended to change the numbering plan 15 digits in every country. The changing time is decided on December 31, 1996 at 23 h 59 minutes Coordinated Universal Time (UTC).

5) Numbering Plan for ISDN of Thailand

In ISDN era numbering plan, as mentioned already, the concept of identification of destination network (NDC: National Destination Code) to select the plural network in the country. Although at present, TOT has been offering domestic and a part of international telecommunication and CAT has been offering international communication, in future, TOT and CAT may expand each other's business or new common carrier may enter into this market. Therefore the giving principle of NDC should be definite because the concept of NDC will become necessary. Besides, when assigning NDC, as about NDC effects the telecommunication of whole kingdom, it needs to examine it considerably.

CCITT has defined that NDC has both network identification and area identification function, the detailed matter however, depends on the situations of each country, according to CCITT. The basic matters are examined in the following paragraphs.

a) Classification and Definition of Network

The network can be classified into two categories from the viewpoint of utilization form. One is defined as local network accommodating subscriber and another is defined as transit network carrying the call. NDC is to be given to local network because NDC includes a part of destination subscriber's number.

b) NDC Assignment Principle

i) Relation between Common Carrier and Network and Service

Figure 7.1.2-2 shows relation between the common carrier and the network and the service. The connection will be distributed two cases. One of the cases is to offer by using two networks such as network-A and network-B. Besides each network also can offer plural services (as shown service-1 and service-2 in Figure 7.1.2-2).

Another case is that some common carriers offer one service by making one network (as shown service-4 in Figure 7.1.2-2).

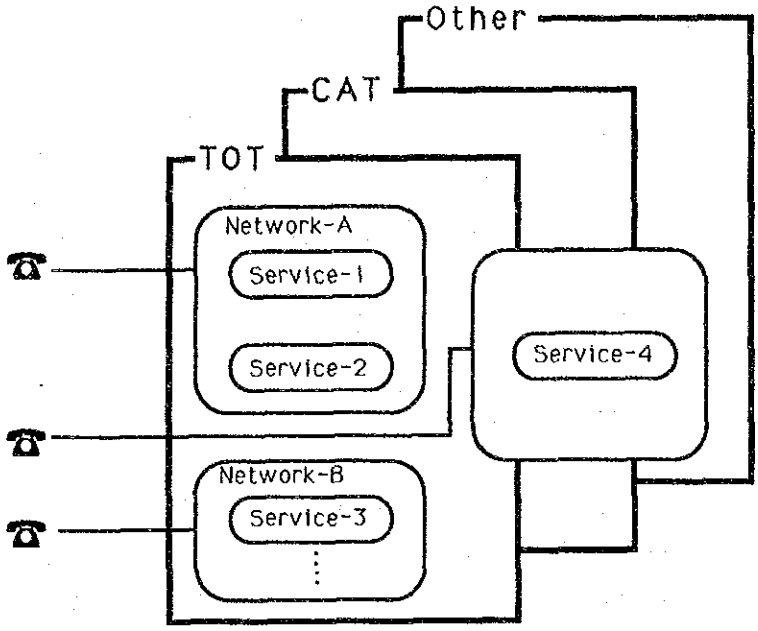


Figure 7.1.2-2 Relation with Network and Service

ii) Classification of Services

The services will be classified into two categories such as Figure 7.1.2-3.

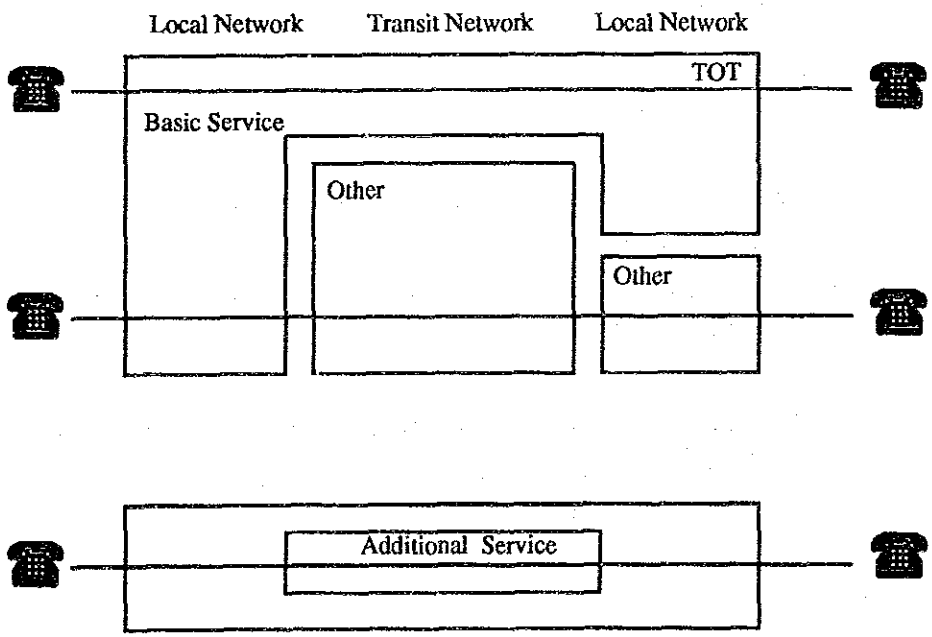


Figure 7.1.2-3 Classification of Services

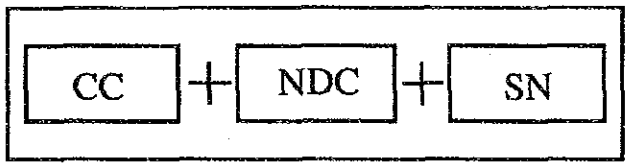
c) Network Assigned with NDC

In case of the above-mentioned item, it can be supposed that TOT offers some similar services through one network but another carrier offers the same services by using plural networks. Besides it may occur that TOT and other common carrier share one network.

Therefore, NDC is not to be assigned to each service or each common carrier including TOT and CAT, but to be assigned to a logical network so that the common carriers can cope with the expansion and integration of enterprises or services flexibly.

Accordingly, NDC is to be given the network offering a basic service, and one NDC is to be shared by some common carriers and one NDC is to be able to offer some services.

d) Composition of NDC



NDC: TC, DN+TC, TC+DN

where:
- CC Country code as defined by Rec.CCITT
- NDC National destination code
- SN Subscriber number
- DN Destination network code
- TC Trunk code

The assignment method of NDC will greatly depend on the telecommunication services offering condition in future. For example, the case of new common carriers enter into the market covered by TOT is different situation from the other case that whole country of Thailand is divided into several areas corresponding to the plural carriers. Therefore, the principle of NDC assignment will become different from each other.

CCITT recommendation has defined the order of NDC (DN+TC or TC+DN) is to be left as a domestic matter for each country. To decide the assignment method for Thailand is not possible for the present, however, comparison between the both methods is described next. Table 7.1.2-3 shows the features of the two NDC orders.

Table 7.1.2-3 Comparison of Order

DN+TC	TC+DN
Easy to recognize about common carriers.	Easy to recognize about the area.
Dialing digits becomes smaller.	Dialing digits becomes longer within same network
Dialing procedure is not the same.	Dialing procedure is always the same.
Setting of area is flexible.	Contradiction will occur about offering service regardless of area.

e) Digit Number of Network Destination Code

The digit number of at present is,

CC	+	**TC**	+	**SN**
two digits		one or two digits		six or seven digits

Therefore, if above numbering plan observes CCITT Rec. E.164, it will be changed as follows;

CC	+	**NDC**	+	**SN**
two digits				six or seven digits

TC 1 digit DN 5 digits
TC 2 digits DN 4 digits

Then, up to five digits seem to be available for DN, but four digits for DN seems to be preferable considering the margin of numbering plan in metropolitan area. However for determination about this matter should be examined considerably because it will effect not only TOT but also the other common carriers. The assignment method of giving NDC is described as follows:

i) Fixed length method

Every common carrier will be assigned with a DN having a definite number of digits.

ii) Apparent fixed length method

Most of the common carriers will be assigned with a DN having a different of digits for each of digits and large scale common carriers will be assigned with plural DN.

iii) Variable length method

A DN of variable length is assigned to each common carrier depending on its scale.

Table 7.1.2-4 shows the comparison about these methods.

Table 7.1.2-4 Comparison of Number of DN

Fixed Length Method	Apparent Length Method	Variable Length Method
Low efficiency of using DN number	High efficiency of using number	High efficiency of using DN number
Not necessary to presume the common carrier's scale previously	Not necessary to presume the common carrier's scale previously	
The number of dialing digits increase		The number of dialing digits can decrease
	In case of addition, DN can not be continual	
	Necessary to presume the common carrier's scale previously for giving one more DN,	Necessary to presume the common carrier's scale

From the above table, it seems to be better that DN is assigned with variable length method and have suitable number of DN digits from one to four corresponding to the common carrier's scale.

6) Numbering Plan for Using Remote Terminal

In case of providing ISDN services through Remote Terminal (RT) to the analog exchange installed area, it is preferable that a vacant office code in the area is used to avoid telephone number change on the occasion of replacing analog exchange with digital

exchange in future. If there is no vacant office code, a vacant thousands of subscriber number should be used. Figure 7.1.2-4 shows the example of numbering plan for using RT.

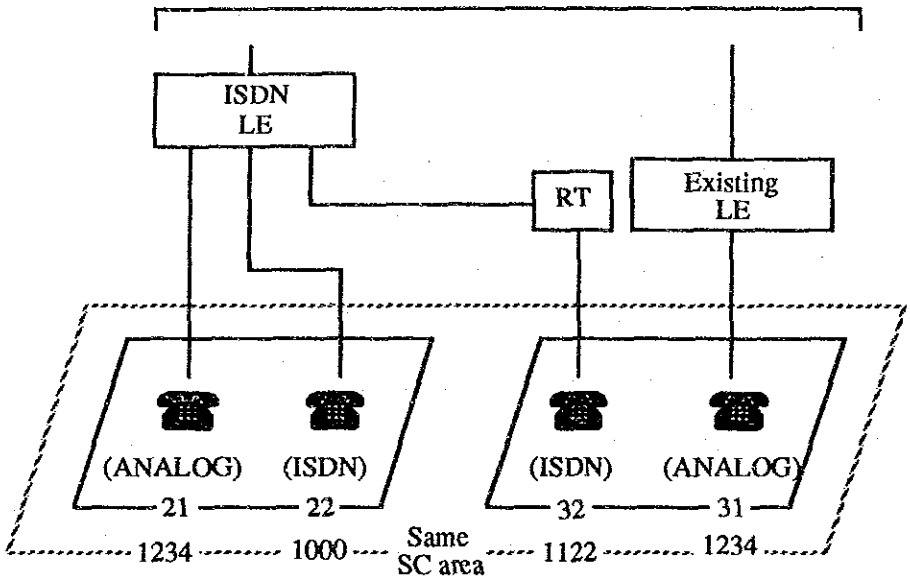


Figure 7.1.2-4 Example of Numbering Plan for using RT

7.1.3 Signalling Plan

1) Examination on Introduction of CCS No.7 Signalling System

a) Present State of Dedicated Network

The locations of the existing telephone offices of primary center level and above are shown in Figure 7.1.3-1.

b) Signalling Network Form

Table 7.1.3-1 shows various signalling network form.

i) Non-hierarchical Signalling Network

In this network, SEPs combine with the function of STP, and have two features except mesh-network: (a) each SEPs have fewer signalling link, (b) the number of signal transit stages increases and consequently, the delay time for signal transfer and the number of signal links increase. On the other hand, mesh-network is uneconomical because SEPs should have many signal links toward all the other SEPs.

ii) Hierarchical Signalling Network

This network is superior than non-hierarchical signalling network from the viewpoints of economy and reliability. Therefore, this study adopted hierarchical network for TOT.

c) Structure of Hierarchical Network

Though only a few SEPs will be set up at the beginning stage of CCS signalling system introduction (Phase-1), it will be increased gradually after Phase-1.

For economical construction of signalling network, it is necessary to expand signalling network according to the number of SEPs and traffic condition at the beginning stage and the capability of one STP.

The method of the expansion is as follows:

i) New STP accommodates new SEP regardless of the locations,

ii) When a new STP is installed, existing SEPs locations around there are changed to be accommodated to the new STP.

Figure 7.1.3-2 shows the transitions depending on the methods mentioned above, and the feature of each method are described in Table 7.1.3-2. From these figure and table, it is clear that the signalling network of case a) is more reliable and economical in construction than case b).

d) Accommodation Area of STP and Signalling Area

In order to structure signaling network economically, minimum accommodation area unit of STP must be defined through forecasting the final situation of the signaling network at the beginning stage of the introduction.

Basic factors on defining signaling area are as follows:

i) One signaling area is composed of one contiguous area such as TC, SC or PC area in telephone network and each signaling area should adjoin the others continuously,

ii) From the economical viewpoint, it is desirable that the number of SEPs and the traffic volume in each signaling area are about equal the others,

iii) One STP can accommodate all SEPs installed in the same signaling area,

iv) It is better to apply correspondingly to toll area system of telephone network such as

v) The signalling area need not be changed in future as far as possible.

Thus, taking above mentioned into account, on defining signalling area:

- The location plan of STP can be made easily,

- By conforming with toll area system of telephone network, the transmission route for the signalling network is decided without difficulty, because main object of the signalling network is to support telephone service.

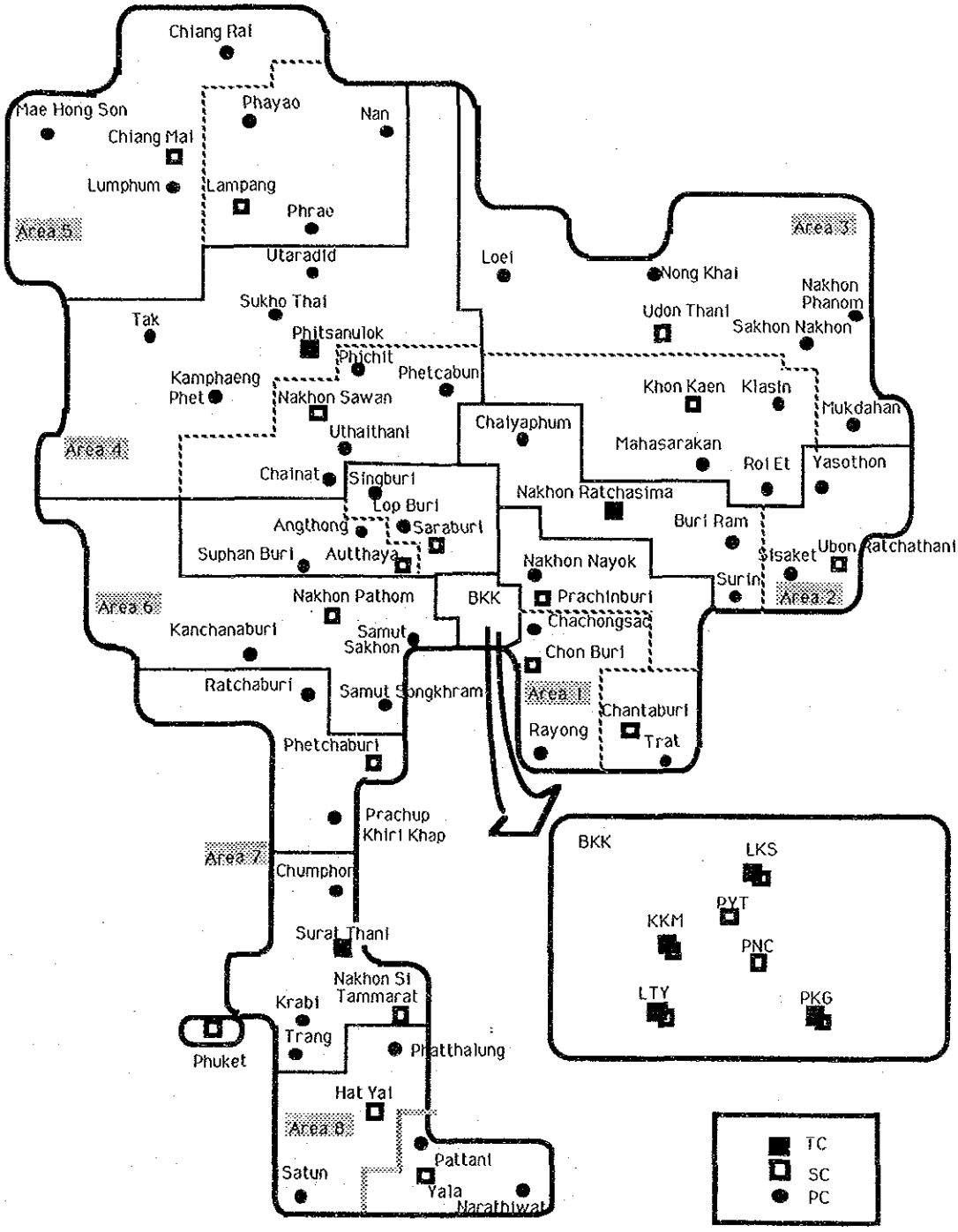
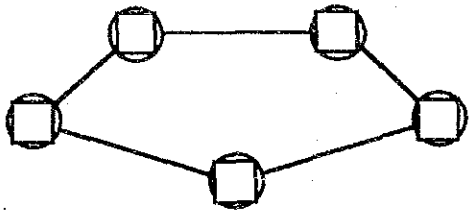
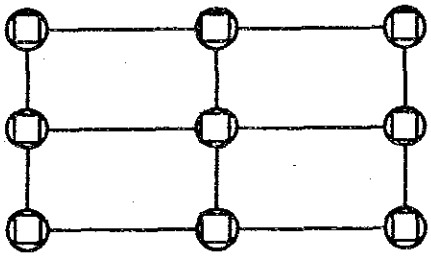
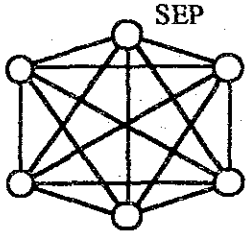
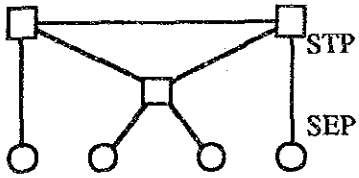
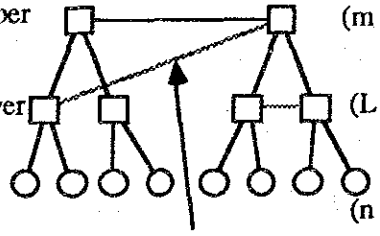
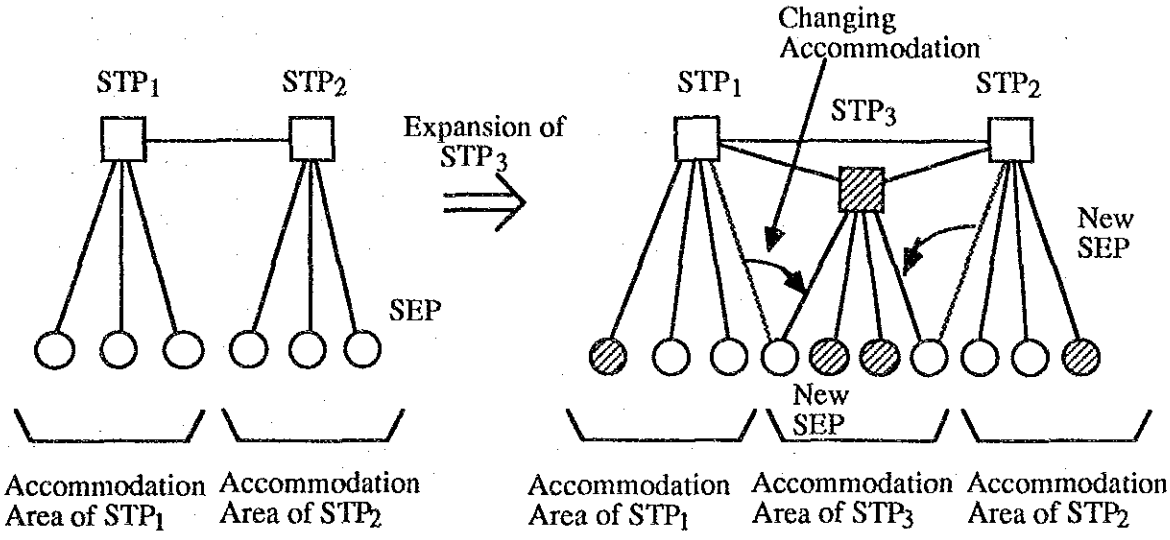


Figure 7.1.3-1 Location of Exchange

Table 7.1.3-1 Signalling Network Form

	Form		Number of Signaling Links	Maximum Number of Junction (SEP no. = n)
Non-hierarchy Network	Direct	SEP + STP 	2	n - 2
	Ring		2	$[\frac{n-1}{2}]$ [ ]: Gauss Symbol
	Grid		4	$2\sqrt{n} - 3$
	Mesh	SEP 	n - 1	0
Hierarchy Network	One Level	 STP (m Offices) SEP (n Offices)	SEP: 1 STP (Average) $= (m - 1) \div \frac{n}{m}$	2
	Two Level	Upper (m Offices) Lower (L Offices)  (n Offices) Traversal link	SEP: 1 STP (Average) = Upper: $(m-1) + \frac{L}{m}$ Lower: $\frac{n}{L} + 1$	4

(a) Changing Accommodation of Exsiting SEP



(b) New STP Accommodates New SEP

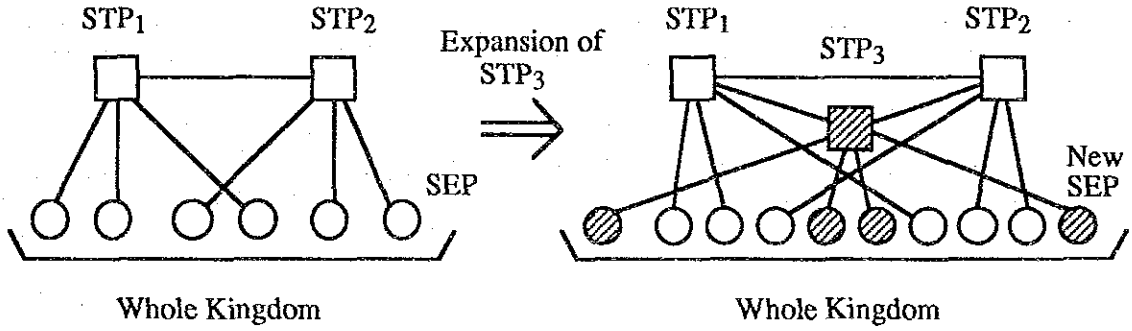


Figure 7.1.3-2 Structure of Hierarchy Network

Table 7.1.3-2 The Feature of Hierarchical Network Structure

Item	(a) Changing Accommodation of Existing SEP	(b) New STP Accommodates New SEP
Signal transit volume	Generally, inter-SEP signal volume of short distance is larger than that of long-distance. Therefore, network structure with STP accommodation gathering adjacent SEP has small signal volume than another method because local signal transmission can be done through only one STP. (o)	Even if two SEP are adjacent, it is not always that the number of transit stages needed for communication is small. Total Signal transit volume of network is larger than case (a). (Δ)
Number of STPs and signaling links	Suitable number of STPs and signaling links because signal transit volume of whole network has no redundancy. (o)	Number of STPs and signaling links increase because signal transit volume is larger than case (a). (Δ)
Signaling circuit length	Preventing to become long signaling circuit length through changing accommodation of SEP. (o)	The circuit length increase more than case (a). (Δ)
Reliability	Low occurrence ratio trouble as signaling circuit length is shorter. (o)	Higher occurrence ratio than case (a). (Apt to occur trouble as signaling circuit length is long.) (Δ)
Connection delay time	Preventing increase the delay time as the number of signal transit stages is small. (o)	The delay time is larger than case (a) as the number of signal transit stages. (Δ)
Maintenance aspect	SEP accommodation changing work is necessary. (Δ)	SEP accommodation changing work is not necessary. (o)

e) Accommodation Capability of Signalling Network

Although, the number of signalling links per a signalling route depends on network configuration, on way of concentration, the number can be calculated roughly as follows;

Assuming that, the signalling network all over the country is structured with about 640 SEPs including forecasted exchanges at FY 2007 and some margin, and the network handles about total of 245,000 circuits.

As the situations are quite different between the metropolitan area and provincial areas, the matter is examined for the respective areas separately.

- Metropolitan area

The number of SEPs is 140 SEPs including 94 exchanges forecasted at FY 2007 and some margin. This network handles about 183,000 circuits.

Average number of outgoing and incoming circuits per a SEP is 1,300 circuits (183,000 circuits/140 SEPs = 1,300 circuits)

- Provincial area

The number of SEPs is 500 SEPs including 426 exchanges forecasted at FY 2007 and some margin. This network handles about 62,000 circuits.

Average number of outgoing and incoming circuits per a SEP is 130 circuits (62,000 circuits/500 SEPs = 130 circuits)

Note; Number of circuits is in Appendix.

From above calculation, one 48 kb/s signalling link which can control up to about 16,000 circuits will be sufficient for signal transmission between an SEP and an STP in both metropolitan and provincial areas.

In order to accommodate 640 SEPs in whole country with STP having capability of 700 signalling links,

Effective ratio of signalling link to STP is 0.7
Number of SEP per STP is,
640 SEPs /490 signaling links = 1.31 STPs

From the above calculation, only two STPs can structure the signalling network for all over the country. The result is obtained assuming that large scale STPs having a capacity of 700 signaling links. However, the other type of STP combined with a telephone exchange seems to be suitable to TOT taking its network scale into consideration. Table 7.1.3-3 shows the calculation result necessary STP numbers according to the signalling channel handling capacity of STPs applied.

Table 7.1.3-3 Number of STP

No. of Signaling Links/1STP	Metropolitan Area	Provincial Area	Total
20	7	25	32
30	5	17	22
40	4	13	17

By means of comparison of calculation result and existing network, STP having 30 signalling links will be most appropriate scale because the number of STPs corresponds to the SC of telephone network.

Average number of trunk speech circuits is calculated as follows;
150,000 circuits / ${}_{22}C_2$ = 649 circuits.

Therefore, the conclusion is expressed in Table 7.1.3-4 (Refer Appendix. Total number of long distance circuits is 15,000.)

Table 7.1.3-4 Estimated Signalling Network

No. of STPs		SEP - STP	STP - STP
Metropolitan Area	Provincial Area		
5 offices	17 offices	1 link/48 kb/s	1 link/48 kb/s

f) Signal Transfer Delay Time

The signal processing time of SEP and STP should be shorten according to increase of the number of transit stage because the delay time is limited by quality of signalling network.

For that reason, it is desirable to structure as simple hierarchy signalling network as possible.

g) Network Reliability

To achieve higher reliability of the signalling network, the following factors should be taken into cosideration.

i) Unavailability of Inter-SEP Network

Most SEPs accommodated the signalling network will be telephone exchange. The case of the signalling network controls the telephone network. Total unavailability includes unavailability of telephone network and that of signalling network. Therefore, unavailability of the signalling network should be limited so that it causes very little effect on telephone network.

ii) Prevention of Decreasing Traffic Volume at Network Trouble

As signalling network is applied for control system of the telephone network, data communication network etc., decreasing of traffic handling capacity of signalling network, when a trouble occurs in it network is considered to lower the capacity of telephone network etc.

Therefore, the signalling network should have the structure which can keep the normal capacity even if trouble occurs on the network.

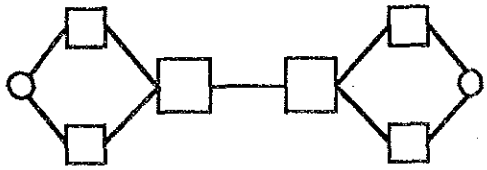
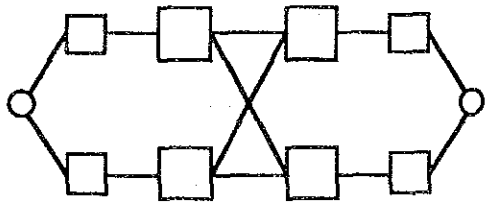
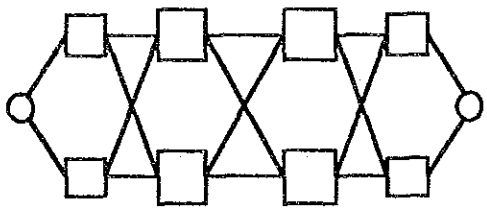
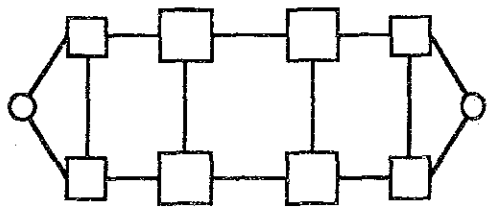
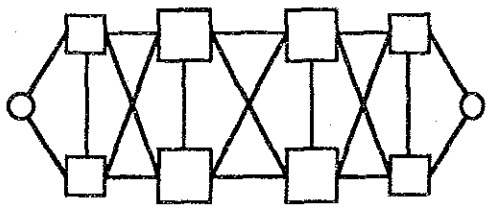
iii) Measure of Disaster

The signaling network should have the structure to keep the functions against a wide-scale natural disaster such as flood etc.

iv) Comparison of Redundancy Structure of Signalling Network

Table 7.1.3-5 shows the comparison of redundancy structure of signalling network.

Table 7.1.3-5 Comparison of Redundancy Structure of Signalling Network

A 	• Non-redundancy. • Mesh-structure between STPs.
B 	• SEPs belong to two different sub-STPs. • Sub-STP belongs to one main STP.
C 	• SEPs belong to two different sub-STPs. • Sub-STP also belongs to a pair of different Main-STPs. • Incomplete mesh-structure between Main-STPs.
D 	• SEPs belong to a pair of different Sub-STPs. • Sub-STPs also belong to a pair of different Main-STPs.
E 	• SEPs belong to a pair of different Sub-STPs. • A pair of sub-STPs belong to each Main-STP paired. • Inter-Plane pass joints paired main STPs.
F 	• Complete mesh-structure between paired main-STPs and Sub-STPs and between main-STPs.

○ : SEP □ : Sub-STP □ : Main STP

2) Introduction Plan

Introduction plan of CCS is examined covering three stages corresponding to Phase-1, 2 and 3.

a) Merit of CCS

The merit of CCS is as follows;

- CCS is able to cope with rendering diversified services as it carries a large volume of signalling information with high speed,
- Total number of circuits can be reduced by using both way trunk.

Besides, in future, the network management and operating system will be improved through utilizing CCS.

b) Introduction Method

For the time being, the signalling network will be structured in the way described before, and will be extended according to expansion of ISDN service. At the final stage, CCS will be introduced into all the exchanges aiming at supporting the new services to be introduced and also various operating and maintenance systems.

Introduction of ISDN is described in Chapter 7.3.

c) Signalling Network Structure

i) The following are preconditions on signalling network structure;

- Number of STPs is five STPs in metropolitan area and 17 STPs in provincial area but, at this time, 6 STPs in metropolitan area and 20 STPs in provincial area were set for correspond to the number of SCs.
- Two-plane structure will be adopted to keep redundancy.
- Telephone network composition is four-level hierarchy.
- Number of maintenance centers is four and located the same place at present.

ii) Location of STPs

The location of STPs is decided taking account of economic comparison, reliability of the network, maintenance aspect and etc.

d) Conclusion

The introduction plan described in this section is shown in Figure 7.1.3-3, 7.1.3-4 and 7.1.3-5.

When ISDN service is introduced in full scale base, the contents of this section will need to re-examine from the viewpoints of technical engineering standard and economic comparison, in conformity with the results of further study in CCITT etc.

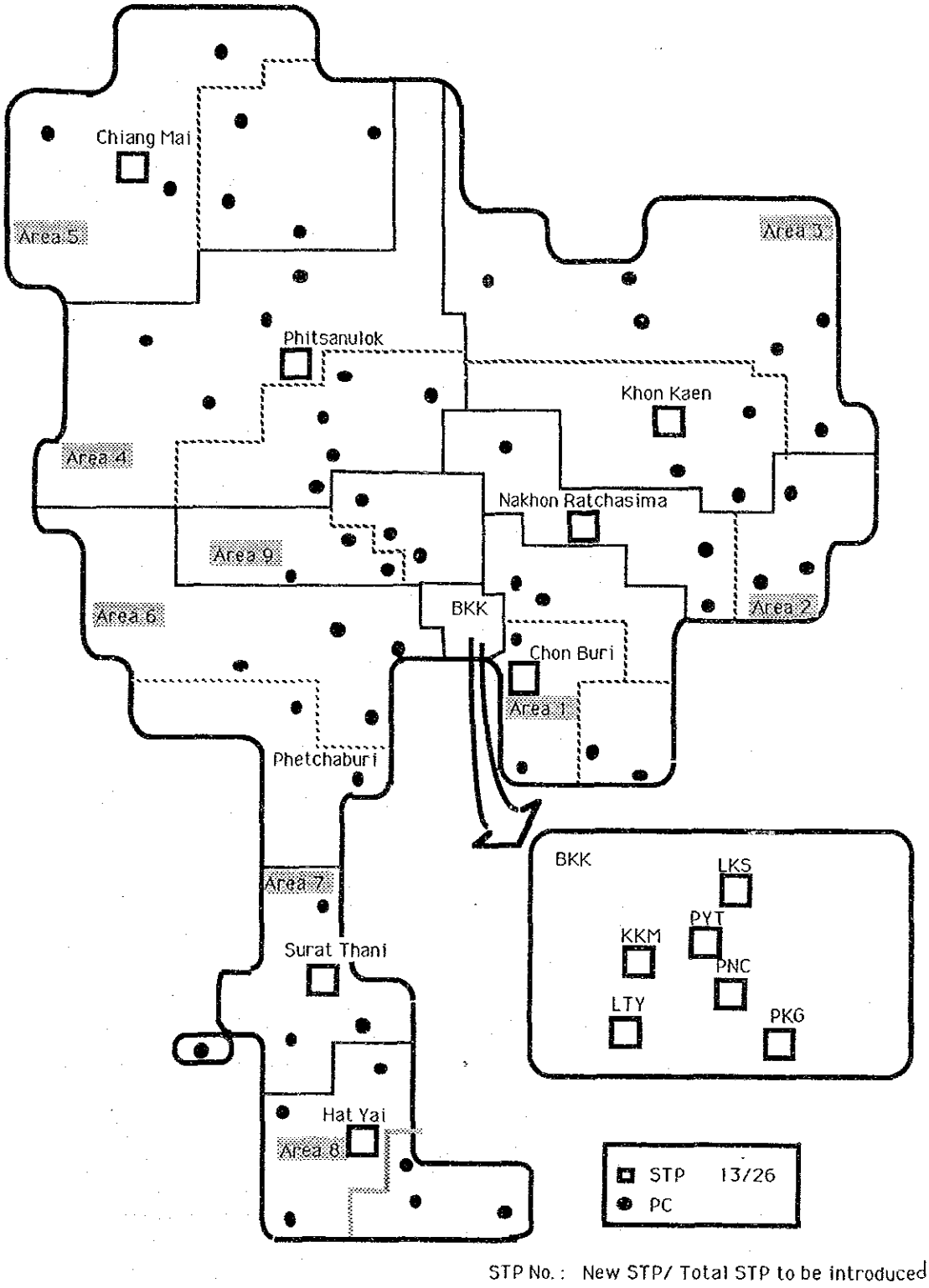


Figure 7.1.3-3 Expansion of CCS (Phase-1)

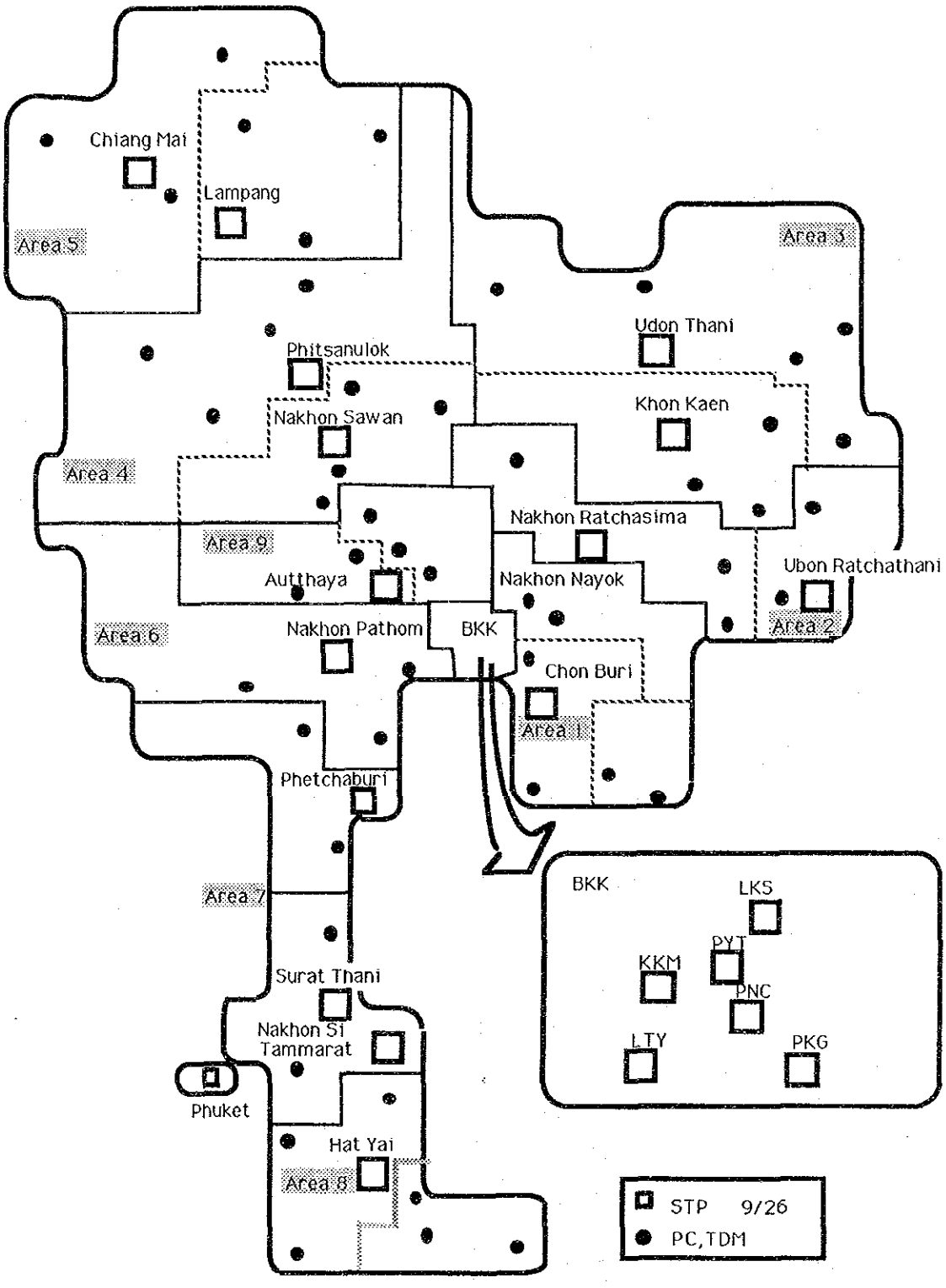


Figure 7.1.3-4 Expansion of CCS (Phase-2)

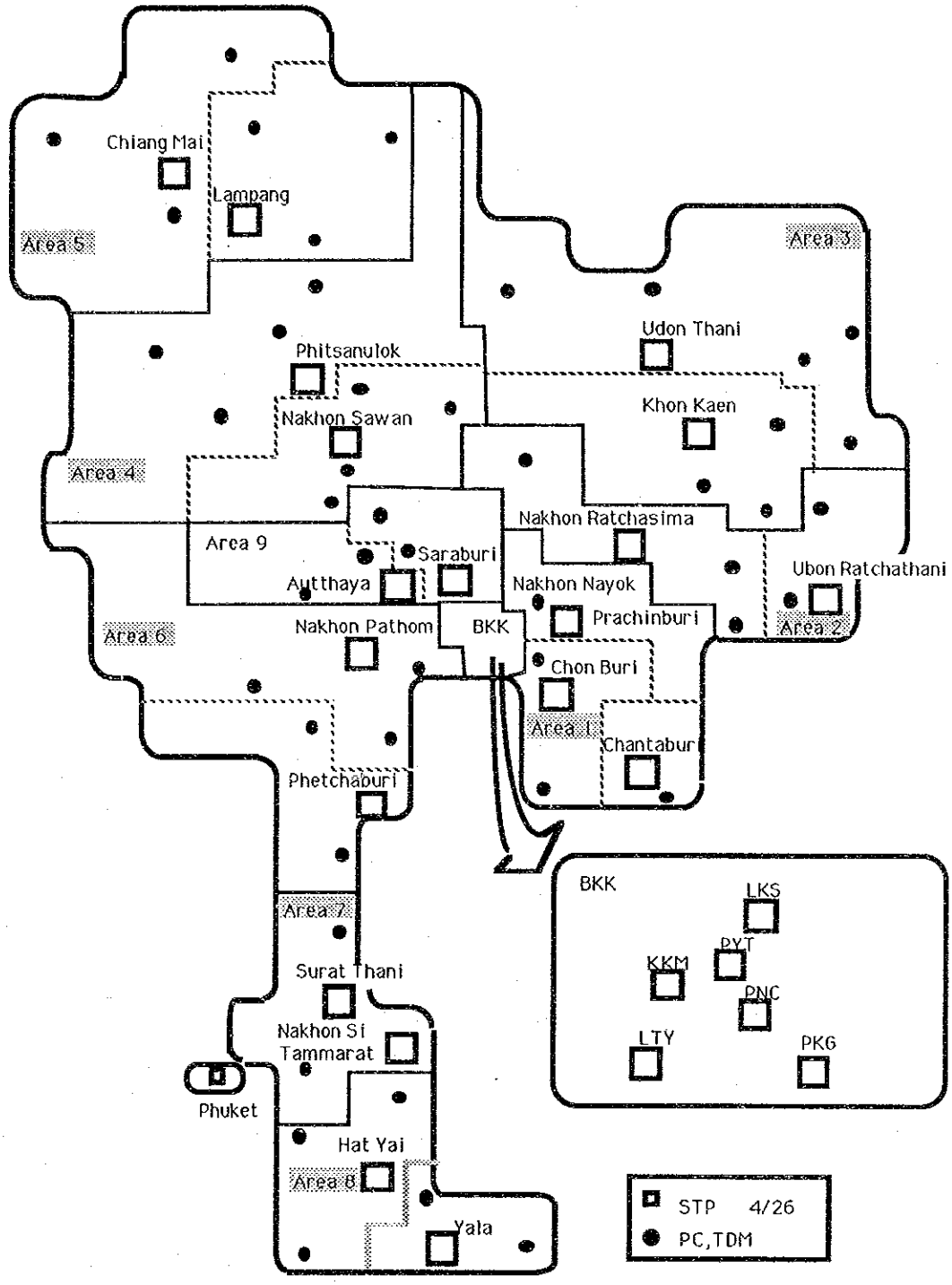


Figure 7.1.3-5 Expansion of CCS (Phase-3)

7.1.4 Network Synchronization

1) Type of Network Synchronization

Network synchronization is the basis for providing the clock of the same frequency to digital switching equipment and transmission links in the digital networks and carrying time slot conversion, circuit setting, multiplexing and separation economically and flexibly.

Thus, synchronization in a digital network is a means to minimize the rate of controlled slips occurring in the network to such an amount that the degradation of service caused by the remaining slip rate can be kept to an acceptable amount with respect to the particular services provided in the network.

There are three network synchronization systems as follows:

- Plesiochronous synchronization,
- Master-slave synchronization,
- Mutual synchronization.

Concept of them are shown in Figure 7.1.4-1.

2) Present State of Network Synchronization

TOT has adopted hierarchical master-slave synchronization system for national network as shown in Figure 2.3.1-5. For national reference frequency, a cesium clock with frequency accuracy of 10^{-11} is used. This figure is in conformity with the CCITT Rec. G.822. The digital clock is located at national toll center in Krung Kasem.

Additional paths has been constructing in the 5th project. Configuration of long distance clock path, at the end of 1992, is shown in Figure 7.1.4-2. The clock path for each TC is not yet duplicated.

It is planned that clock paths are duplicated for TCs and SCs, and for the network in metropolitan area.

3) Network Synchronization Plan

a) Introduction

The main objectives of this synchronization plan is to ensure that the rate of controlled slip in a world wide digital connection to be used for enhanced services (e.g., high speed data transmission service etc.) meeting the requirements prescribed in CCITT Rec. G.822.

In the recommendation, the end-to-end slip rate performance required for an international ISDN with reference to the Standard Digital Hypothetical Reference Connection is stated. Namely, the slip rate objectives are allocated to the different sections of an international connection.

The slip rate objectives for national network are automatically improved by that.

In the light of the consideration above, TOT has already adopted hierarchical master-slave synchronization system and used a cesium clock with frequency accuracy 10^{-11} .

Therefore, in this paragraph, measures against both the master clock failure and the failure in master clock distribution are described.

b) Consideration of the Security of the Clock (Master clock failure)

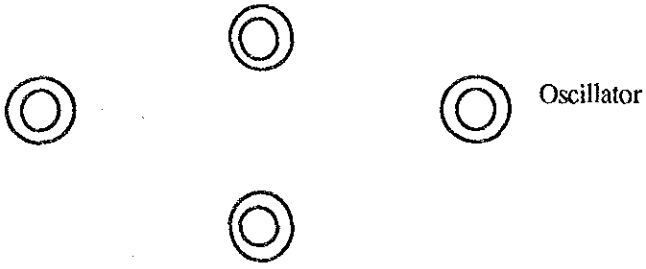
The clock for network synchronization is located in Krung Kasem, and has two back up clocks in its frame. When it will be failed by power failure, fire and other accidents (included natural disasters accidents e.g., flood etc) for long time, however, the digital network will become confused.

Therefore, to avoid such confusion of the network, a standby clock should be provided in another place separated from Bangkok (another TC e.g., Nakhon Ratchasima).

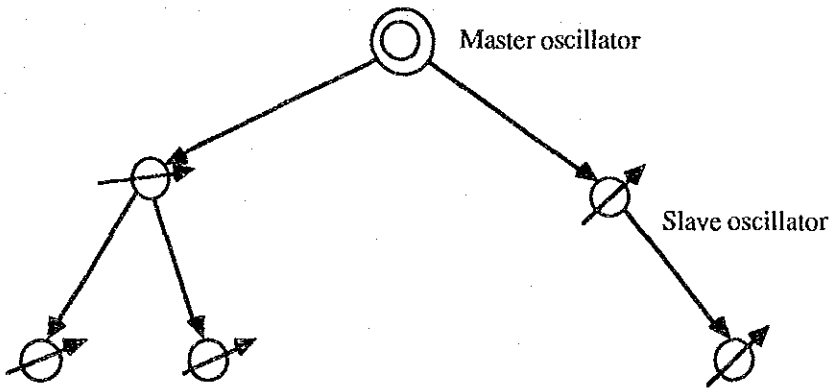
c) Enhancement for the Reliability of Synchronous Path (Failures in master clock distribution)

For enhancing the reliability of synchronous path link, many transmission systems will be installed in this plan. All TCs and SCs will be connected with looped or duplicated synchronous path links in Phase-2.

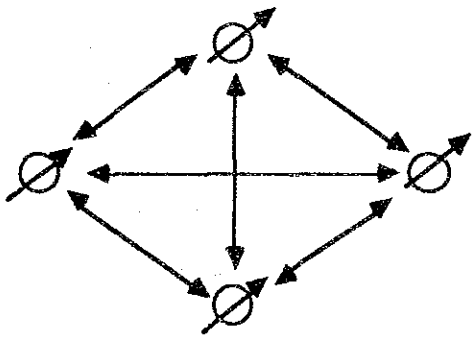
In addition to this, the second (back-up) incoming clock path should be chosen as separatedly from the first one as possible. Figure 7.1.4-3 shows the long distance digital synchronous path link in 1992. And a configuration of the clock path link is shown in Figure 7.1.4-4.



(a) Plesiochronous synchronization



(b) Master-slave synchronization



(c) Mutual synchronization

Figure 7.1.4-1 Method of Synchronization

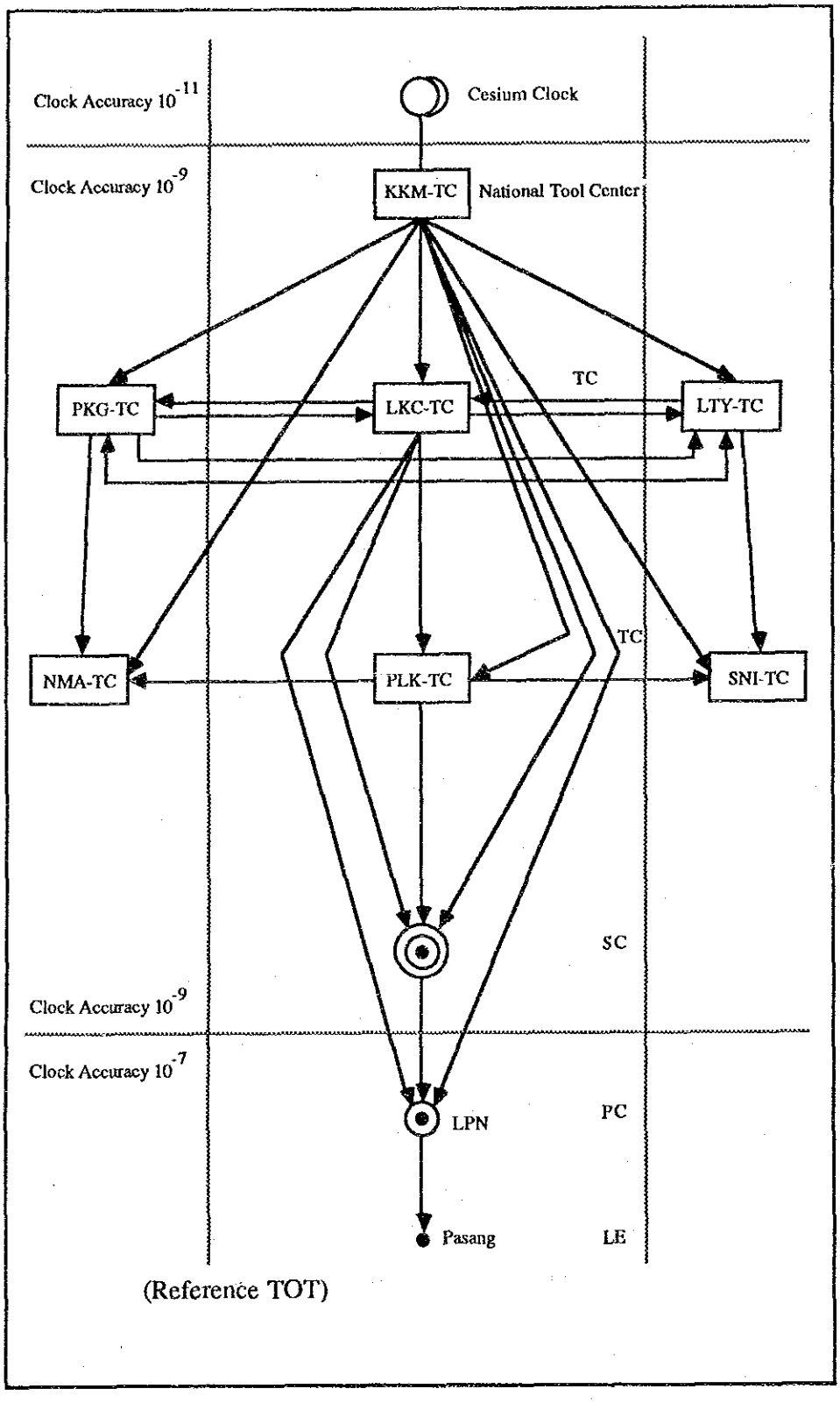


Figure 7.1.4-2 Network Synchronization Plan (End of 1992)

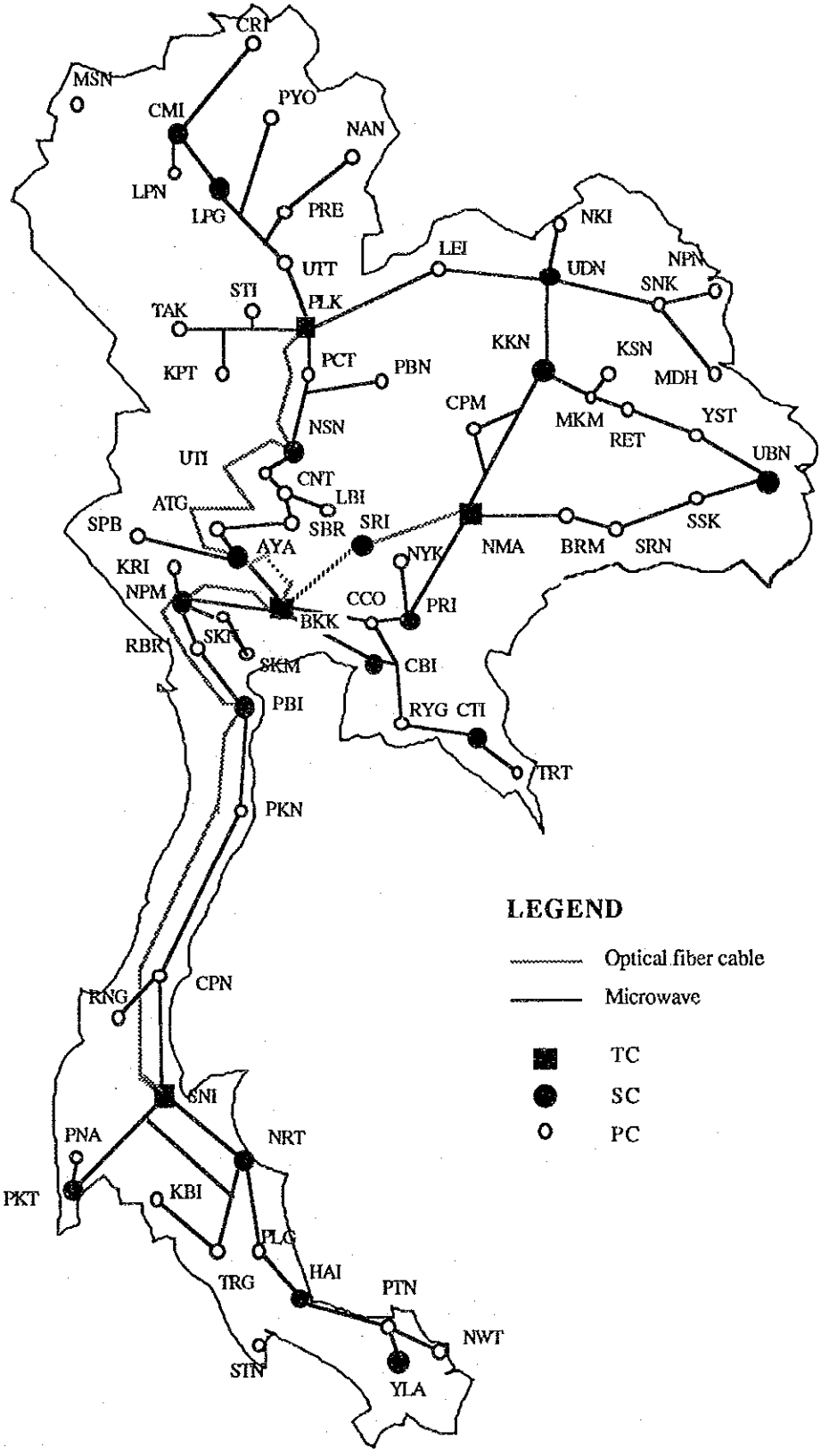


Figure 7.1.4-3 Long Distance Digital Synchronous Path Link (End of 1992)

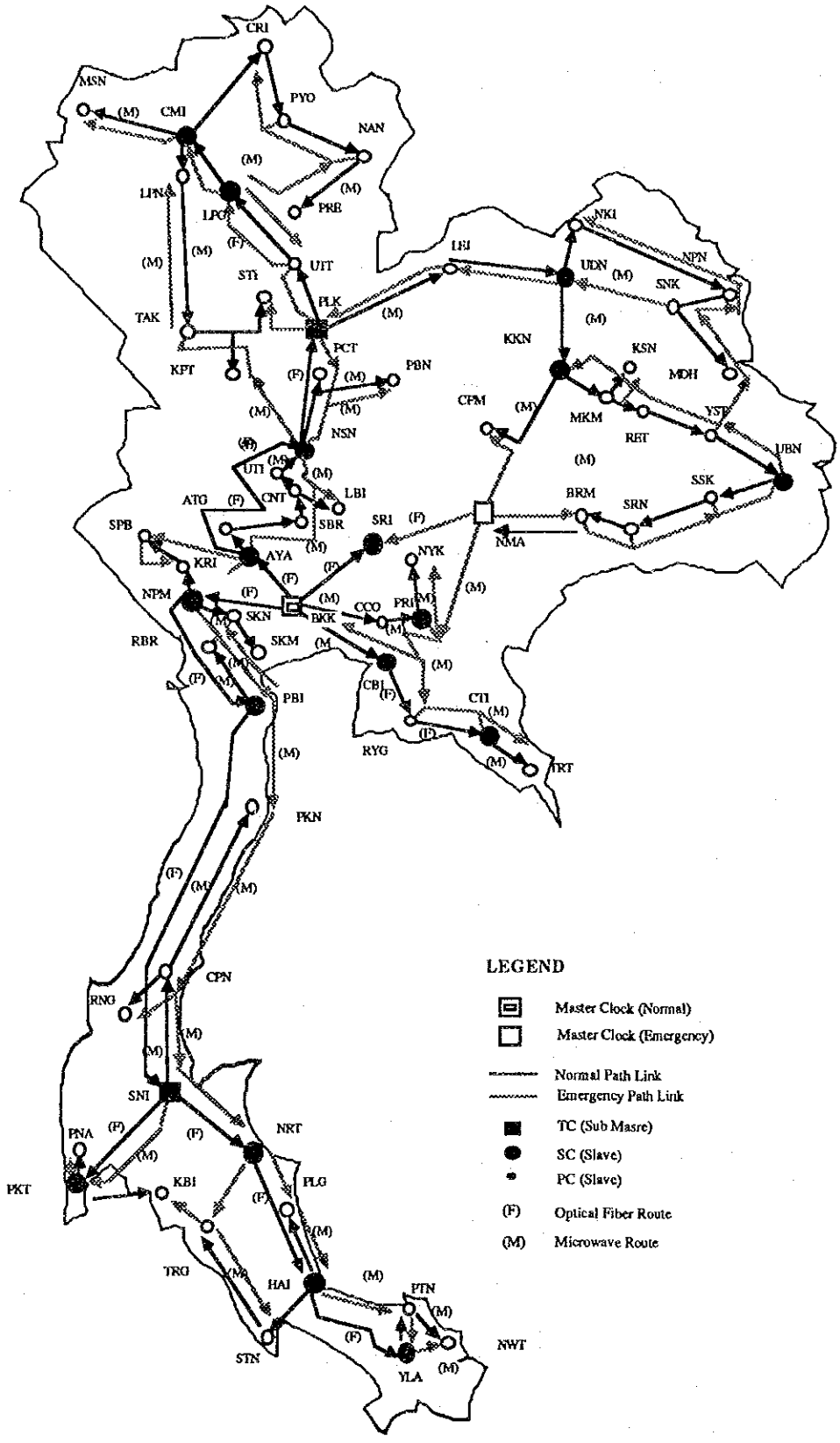


Figure 7.1.4-4 Configuration of Synchronous Path Link (End of 2007)

7.2 Engineering Standard

7.2.1 Introduction

In this section, the present state of Engineering Standard is reviewed, and some engineering standards in the digital telecommunication network are proposed because digitization of the network has already progressed up to about 75 percent by the end of FY 1988 as follows:

Generally, there are three fundamental engineering standards for telephone service bellows;

- Traffic Engineering Standards,
- Transmission Engineering Standard,
- Reliability Engineering Standard.

In this section, some concepts of new traffic and transmission engineering standards are proposed.

7.2.2 Present State of Engineering Standard

The present engineering standards are prescribed according to CCITT recommendations. They are outlined in the following.

1) Loss Probability

Loss probability of each connection of switching system is assigned on the basis of CCITT Recommendation E.520. It is shown in Figure 7.2.2-1.

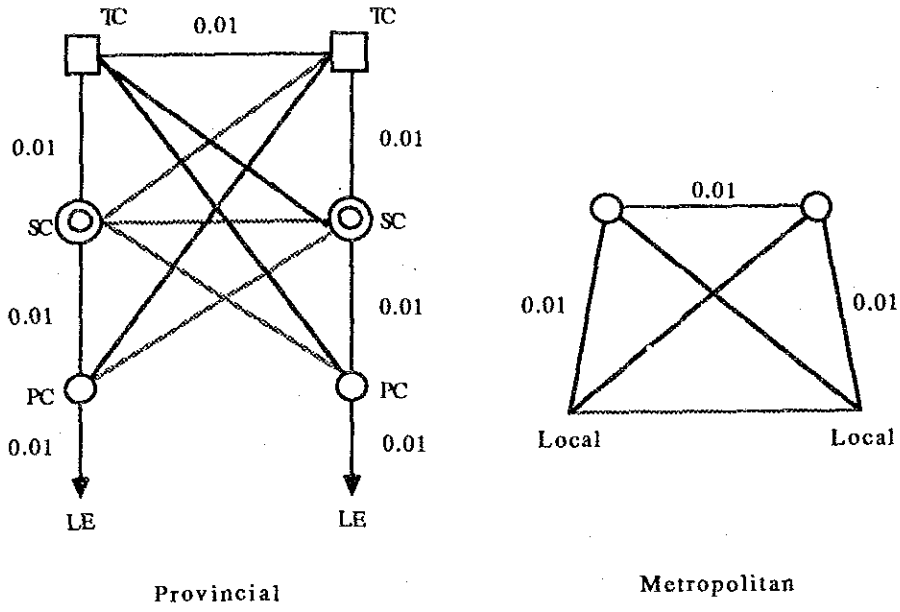
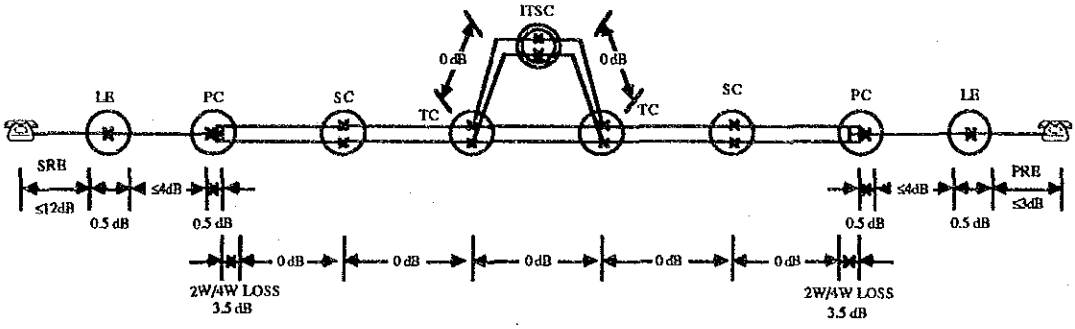


Figure 7.2.2-1 Present Loss Probability Allocation

Switching loss = 0.005
Grade of service on final route (each link) = 0.01
Grade of service for intra office trunk = 0.002
(within the same switching)

2) Transmission Engineering Standard

For transmission quality, TOT has adopted Reference Equivalents. Present attenuation allocation, based on RE, are shown in Figure 7.2.2-2.



Max Sending 20.5 dB

Max Receiving 11.5 dB

Note
- The Variations with time of 4W equipment are not included in the above figures
- It is assumed that the standard deviation of one 4W section (σ) shall not be more than 1 dB. Therefore, for the maximum of 5 - 4W sections, total shall be $\sqrt{5}$ or 2.236.

LE = Local Exchange
PC = Primary Center
SC = Secondary Center
TC = Tertiary Center
ITSC = International Transit Center
Two-Wire Circuit
Four-Wire Circuit
Switching Point
Hybrid Network

Figure 7.2.2-2 Transmission Loss Allocation

The domestic telecommunication network system will have been digitized by the end of the fifth project. Therefore, the engineering standard should be revised in accordance with the CCITT Recommendations.

7.2.3 Engineering Standard Plan to be Recommended

1) Traffic Engineering Standard

a) Loss Probability

Loss probability in circuit groups is allocated as shown in Table 7.2.3-1 on the basis of CCITT Recommendation E.520.

Table 7.2.3-1 Loss Probability (Circuit Groups)

Condition	Loss Probability
Normal load (per link)	0.01
High load (per link)	0.07

Note; 1. Normal load: Mean of the 30 highest working days during a 12-month period.
2. High load: Mean of the five highest days in the same period.

Loss probability of each connection of digital transit switching is allocated as shown in Table 7.2.3-2.

Table 7.2.3-2 Digital Switching Loss Probability

Connection Stage	Loss Probability
Transit Connection	0.001

Note; Terminating connection loss includs the circuit group loss between PC and LE.

In the table, the transit connection loss probability is based on CCITT Recommendation Q.504. And the terminating connection loss probability is proposed at this time.

CCITT recommends the loss probability as 0.05 (one side) for domestic data switching network (Rec. X.131). Therefore, end-to-end loss probability of digital switching (including group and connection loss) should not exceed 0.1.

Figure 7.2.3-1 shows an example of loss probability, allocation mentioned above. In the figure, the loss value between end-to-end is 0.078, so it has value 0.022 as the margin which can be distributed for the mixed network with analog and digital switching.

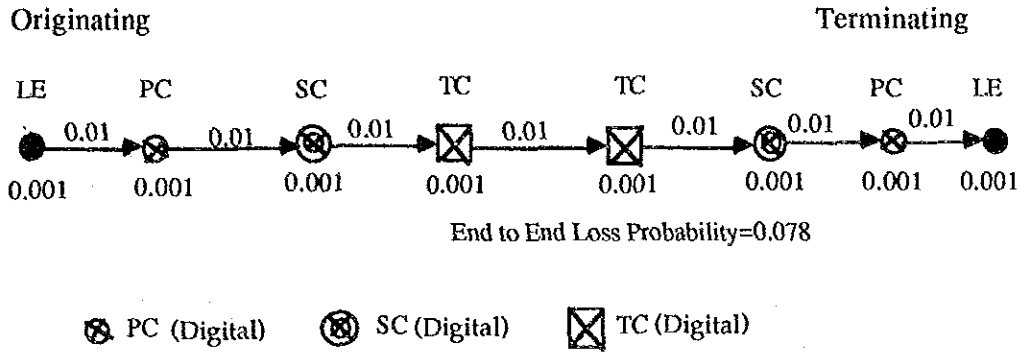


Figure 7.2.3-1 Proposed Loss Probability Allocation

b) Post Dialling Delay

CCITT has not recommended concrete values of Post dialing delay yet. Therefore, the values of the items are proposed on the basis of the experience in Japan. Post dialing delay nominal values are assigned as shown in Table 7.2.3-3 as the objectives under the condition when SPC switching facilities and a common signaling system are used.

Table 7.2.3-3 Post Dialling Delay

Item	Measure	Nominal Value
Audible tone	mean time	5 seconds
Non-audible tone	mean time	6 seconds

Note: Non-audible tone is used in ISDN.

2) Transmission Engineering Standard

As described before, TOT has adopted Reference Equivalent (RE). However, most of switching and transmission facilities will be digitized by the end of Phase-3. The main purpose of this standard plan is to provide appropriate transmission quality distribution to the digitized national telecommunications network, and to provide economically and secure the quality of national and international call.

a) Error Performance Objective for Bearer Service

The performance objectives are stated for each direction of 64 kb/s circuit switched connection used for voice traffic or as a bearer channel for data type service. The values of

condition is defined between T-point on the basis of CCITT Recommendation G.821 as shown in Figure 7.2.3-2.

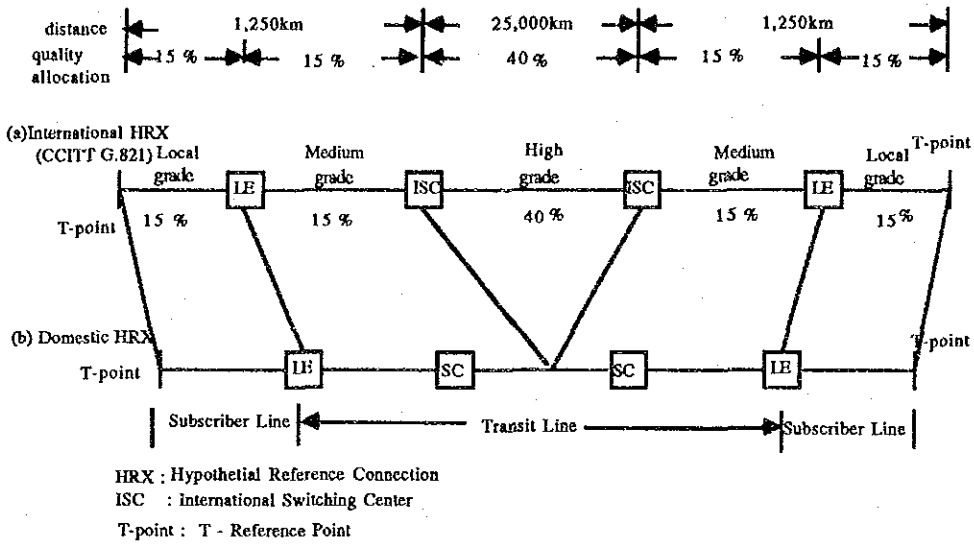


Figure 7.2.3-2 International and National HRX

i) Performance Objectives

Performance objectives for international ISDN connection are shown in Table 7.2.3-4. International connections should meet all of the values of the Table 7.2.3-4 concurrently. (CCITT Recommendation G.821)

Table 7.2.3-4 Error Performance Objectives for International ISDN Connections

Performance classification	Objective
Degraded Minutes (DM)	Fewer than 10% of one-minute intervals to have a bit error ratio worse than 1x10^-6
Severely Errored Seconds (SES)	Fewer than 0.2% of one-second intervals to have a bit error ratio worse than 1x10^-3
Errored Seconds (ES)	Fewer than 8% of one-second intervals to have any errors (equivalent to 92% error-free seconds)

ii) Allocation of Overall Objectives

Three distinct quality classifications have been identified to represent practical digital transmission circuits and are independent of the transmission used. These classifications given in Table 7.2.3-4 are termed local grade, medium grade and high

grade and their usage generally tends to be dependent on their location within a network.

The circuit quality model of HRX is shown in Figure 7.2.3-2.

The allocation of the permitted degradation, i.e. 10% degraded minutes and 8% errored seconds, is given in Table 7.2.3-5. The located network performance objectives are given in Table 7.2.3-6.

Table 7.2.3-5 Allocation of the Degraded Minutes and Error Seconds Objectives

Circuit Classification	Allocation of the degraded minutes and errored seconds objectives given in Table 7.2.3-4.
Local grade (2 ends)	15% block allowance to each end *1
Medium grade (2 ends)	15% block allowance *2
High grade	40% (equivalent to conceptual quality of 0.0016% per km for 25,000 km) *3

Note *1, *2, *3 See at Figure 7.2.3-2.

Table 7.2.3-6 Allocation of % Degraded Minute Intervals and Error Seconds Objectives

Circuit Classification	Network performance objectives at 64 Kb/s	
	% degraded minutes	% errored seconds
Local grade	1.5	1.2
Medium grade	1.5	1.2
High grade	4	3.2

The total allocation of 0.2% severely errored seconds is subdivided into each circuit classification (i.e. local, medium, high grade) in the following manner.

0.1% is divided between the three circuit classifications in the same proportions as adopted for the other two objectives. This result in the allocation is shown in Table 7.2.3-7.

The remaining 0.1% is a block allowance to the medium and high grade classifications to accommodate the occurrence of adverse network conditions occasionally experienced (intended to mean the worst month of the year) on transmission systems. Because of the statistical nature of the occurrence of worst month effects in a world wide connection, it is considered that the following allowances are consistent with the total 0.1% figure.

- 0.05% to 2,500 km HRDP for radio relay systems which can be used in the high grade and the medium grade portion of the connection.
- 0.01% to a satellite HRDP.

Table 7.2.3-7 Allocation of Severely Error Seconds

Circuit Classification	Allocation of Severely Errored Seconds Objectives
Local grade	0.015 % block allowance to each end
Medium grade	0.015 % block allowance to each end
High grade	0.04 % (note 1)

Note 1: For transmission systems covered by the high grade

b) Transmission Quality for Telephone Service

i) Loss Allocation Plan

CCITT recommends both Corrected Reference Equivalent (CRE) and Loudness Rating, as measures for loudness loss, the most important factor affecting transmission quality of telephone network. As mentioned before, TOT has adopted Reference Equivalent (RE) as a measure for transmission quality in conformity with the quality measure for telephone network.

Above all, the LR seems to be superior to the other measures in accuracy of measurement and additivity of separately measured sending and receiving path LRs to estimate the overall LR of a connection. This measure is single-valued to the loudness with which the listener perceives speech emitted by the talker at a fixed level so that the listening level dependence of the RE can be excluded.

The additivity is achieved by simultaneous use of an Intermediate Reference System (IRS) which defines the sending and receiving ratings and more closely approximates actual circuits than the high quality NOSFER.

Furthermore, the positioning of artificial mouth and ear according to the actual position of the human mouth and ear relative to a telephone set enables the accurate objective measurement of loudness loss. Previously, the LR was affirmable just for subjective assessment, but recently, an objective LR assessment procedure has been established in CCITT so that it has become one of the most useful measures evolving telephone network (CCITT Recommendation G.121).

Overall transmission quality is evaluated according to the characteristics of the telephone stations, the vocalization and auditory characteristics of talkers and listeners in acoustic environment and the transmission performance of telecommunications facilities.

Therefore, the value of attenuation allocation will be determined taking account of the matters mentioned above.

ii) Echo

In a telephone network, there are many factors contributing to degradation of transmission quality, such as loudness loss, echo noise and attenuation distortion. Since echo, second to loudness loss, is an important factor in specifying transmission quality.

Echo, mostly caused by two-wire/four wire conversion, will be reduced by introducing electronic converters in subscriber systems to achieve fine impedance matching and will finally disappear when the fully digital customer interface is implemented.

Echo impairment, affecting to customers, is reduced by the value of loudness loss. Although if the attenuation allocation is determined to a big value, echo will actually not affect to customers conversation, the increasing value of loudness loss affect the quality of the telephone service.

The condition in the basic formula of Echo Loudness Rating (ELR) shown as follows:

$$SLR + RLR + JLR + ME \geq ELR + K_e\sqrt{sSLR^2 + sRLR^2 + sJLR^2 + sE^2 + sELR^2}$$

Note:

SLR	:	Sending Loudness Rating (Sending telephone station),
RLR	:	Receiving Loudness Rating (Receiving telephone station),
JLR	:	Junction LR (nominal Transmission loss),
ME	:	Terminal Echo Loss,
ELR	:	Echo LR,
K_e	:	A Coefficient,

sSLR : Standard deviation of SLR,
sRLR : Standard deviation of RLR,
sJLR : Standard deviation of JLR,
sE : Standard deviation of ME,
sELR : Standard deviation of ELR,

Therefore, the values of Echo Loudness Rating should be determined taking attenuation allocation into consideration.

7.3 Introduction of ISDN

7.3.1 General

1) Feature of ISDN

Recently, the construction of Integrated Services Digital Network (ISDN) is expected in many countries as a part of infrastructure of the information society. ISDN which is recommended by CCITT makes the synthetic telecommunication network through combining transmitting functions of typical communication media such as voice, data, picture, etc. Features of ISDN are as follows :

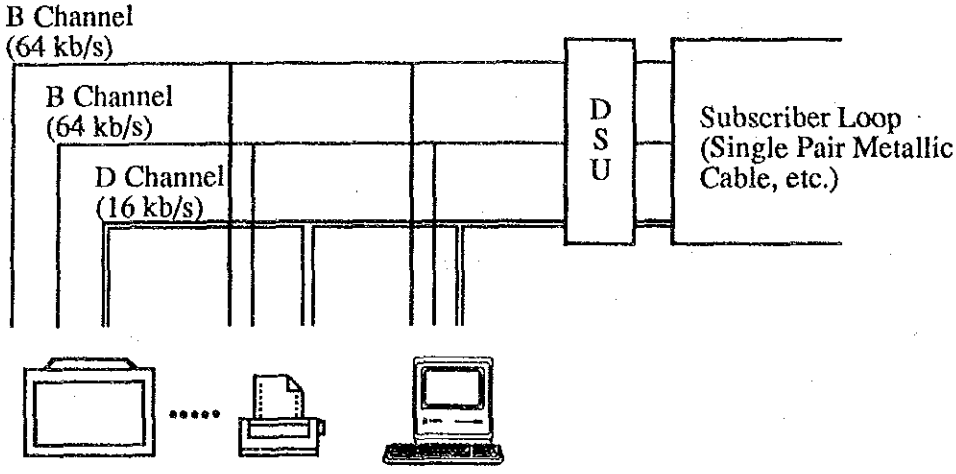
a) Provision for circuit-switched service and packet-switched service with one interface
b) Switching service to communicate with any other party
c) Provision for high quality and high speed digital signal transmission
d) Provision for plural channels by one interface
e) Separation between information channel and signalling channel

2) Outline of ISDN

ISDN has the basic interface provided through the existing telephone line and the primary rate interface provided through the subscriber optical transmission system or the subscriber radio system for bunched or higher speed communications such as composite PBX etc. The interface configurations are shown in Figure 7.3.1-1 and Figure 7.3.1-2.

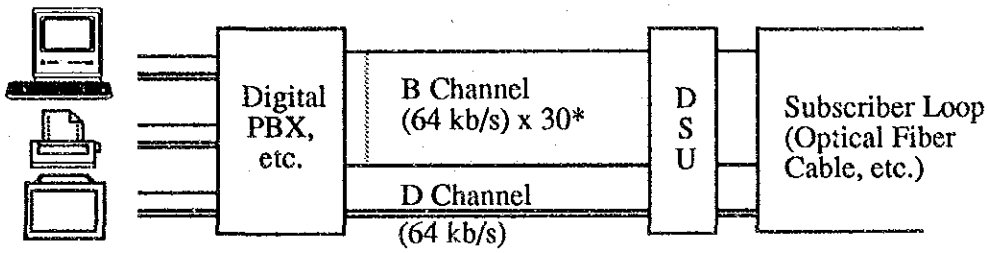
The basic interface has 2 information channels (B channel: 64 kb/s) and one signalling channel (D channel: 16 kb/s). The B channel is used for circuit-switching and packet-switching. The D channel is used for carrying signalling information and packet-switching.

Meanwhile, the primary rate interface is used for 30 B channels and one D channel (In this case, D channel is 64 kb/s) separately through a 2 Mb/s tributary, and also H_0 (384 kb/s) and H_{12} (1920 kb/s) are recommended by CCITT for high speed facsimile, high speed data and teleconference etc.



Channel Type \ Information Transfer Mode	Circuit Mode	Packet Mode	Signalling
B	○	○	
D		○	○

Figure 7.3.1-1 Basic Interface



* With joint use of the D channel of another interface, it becomes possible to supply 31 B channels.

Channel Type \ Information Transfer Mode	Circuit Mode	Packet Mode	Signalling
B	○	○	
H_0 (384 kb/s)	○		
H_{12} (1920 kb/s)	○		
D		○	○

Figure 7.3.1-2 Primary Rate Interface

3) ISDN Services

The ISDN services are classified into bearer services and teleservices. And by combining additional functions with these services, supplementary services are provided some supporting convenient services. These services menu are shown in Table 7.3.1-1.

The provision of supplementary services have to be studied taking CCITT recommendations, the trend of technical development and user's request, etc. into considerations. The present supplementary services in Japan are calling line identification, advice of charge, sub-addressing, direct dial in, terminal portability etc. and recently, call waiting, three-party service, call transfer and call deflection has started.

Table 7.3.1-1 ISDN Service Menu

Service Classification	Service Menu
Bearer Services	• Circuit-switched service • Packet-switched service
Teleservices	• G4 facsimile • Video telephone • Digital telephone • Adopter for analog terminal • Videotex • Video conference, etc.
Supplementary Services	• Calling line identification • Connected line identification • Call waiting • Advice of charge • User-to-user signalling • Three-party service • Call transfer • Call forwarding busy • Call forwarding no reply • Call forwarding unconditional • Call hold • Conference calling • Closed user group • Line hunting • Multiple subscriber number • Direct dial in, etc.

4) ISDN Application Examples

ISDN application will be realized many kind of the utilization style by means of combining ISDN services with various telecommunication terminals step by step. ISDN application examples are shown in Figure 7.3.1-3.

Large-scale corporate network

▼ This large-scale corporate network links headquarters, regional branches and large branches via primary rate interface services. Small branch offices are linked using basic interface services.

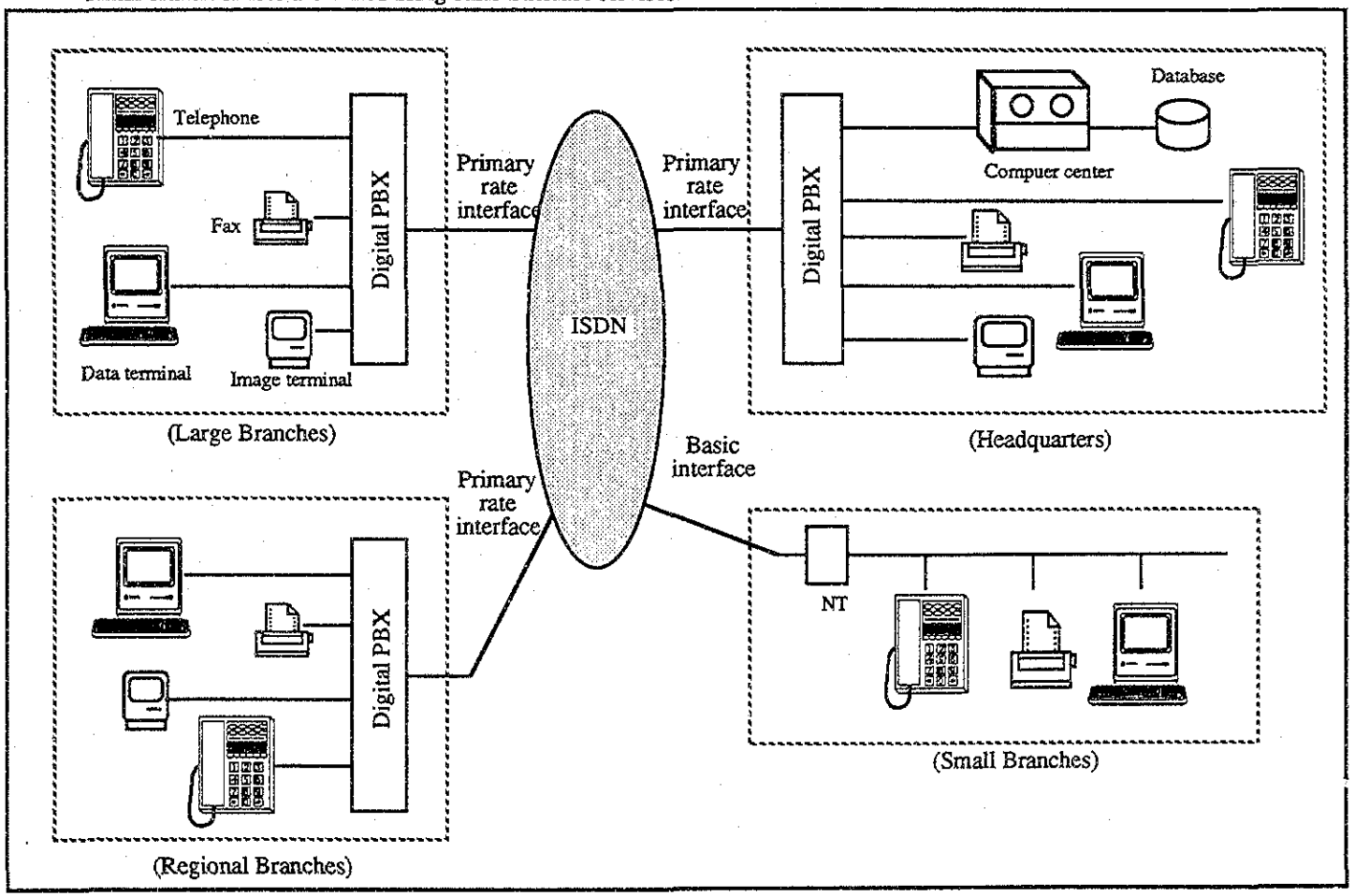


Figure 7.3.1-3 ISDN Application Examples (1)

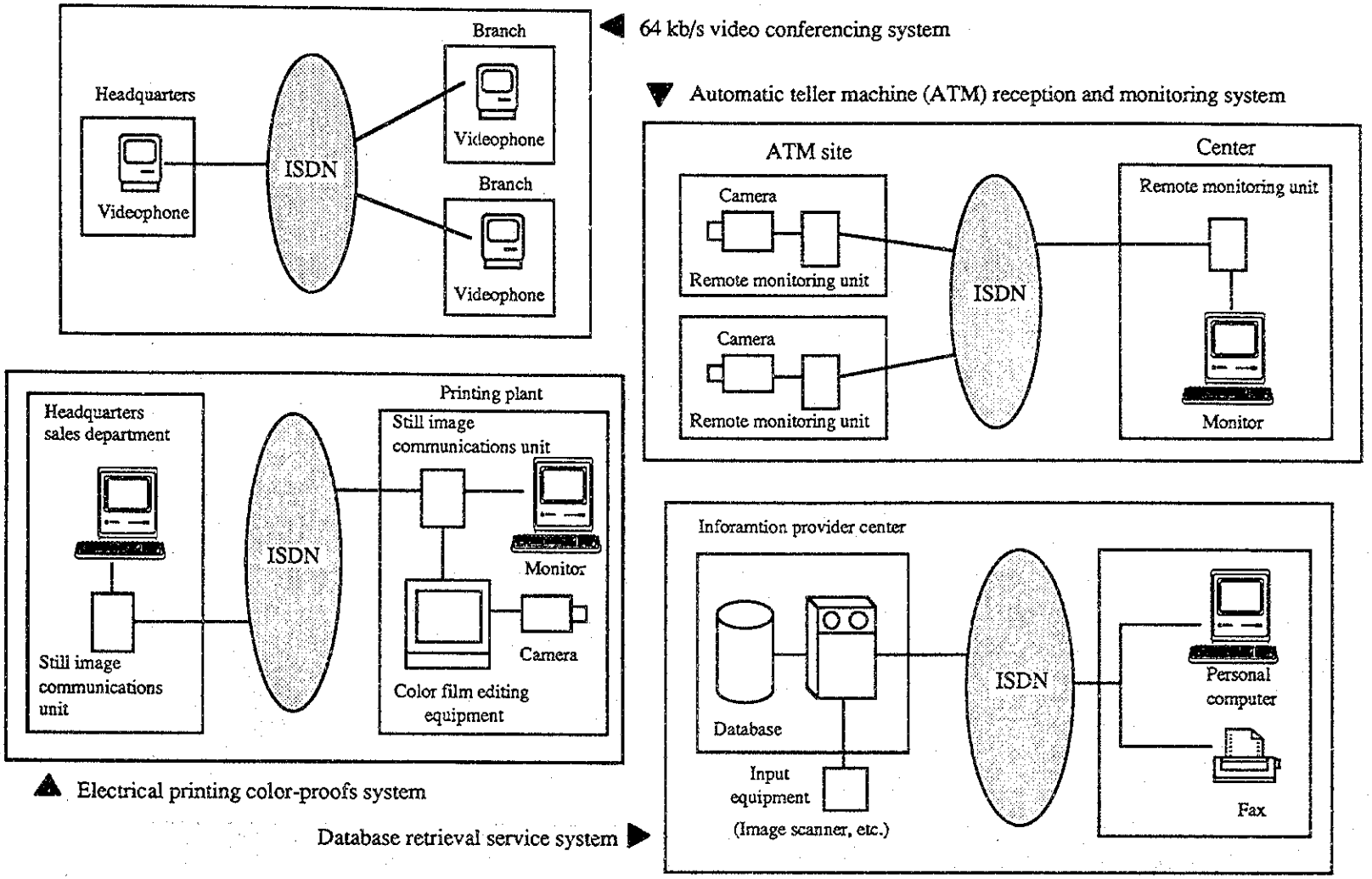


Figure 7.3.1-3 ISDN Application Examples (2)

5) Services Classified by Transmission Speed

The ISDN provides 64 kb/s service corresponding to the voice 1 ch. However, it is possible to transmit some visual information such as drawings, still picture and some data information such as magnetic tape, floppy disc in a short time. Table 7.3.1-2 shows 64 kb/s transmission example and Figure 7.3.1-4 shows transmission service classified by transmission speed.

Table 7.3.1-2 64 kb/s Transmission Example

Items	Information quantity per unit	Information quantity per 1 second	Call duration per unit information
Videotex	2 kbyte/picture	4 picture/sec	0.25 sec/picture
FAX (G4)	35 kbyte/sheet (Average)	0.23 sheet/sec	4 sec/sheet
Japanese Newspaper	39 kbyte/page	0.21 page/sec	4.8 sec/page
FD (2 HD)	1 Mbyte/piece	0.008 piece/sec	125 sec/piece
MT (1600 BPI 2400 Feet)	46 Mbyte/volume	0.00017 volume/sec	5,760 sec/volume (1.6 hour/volume)

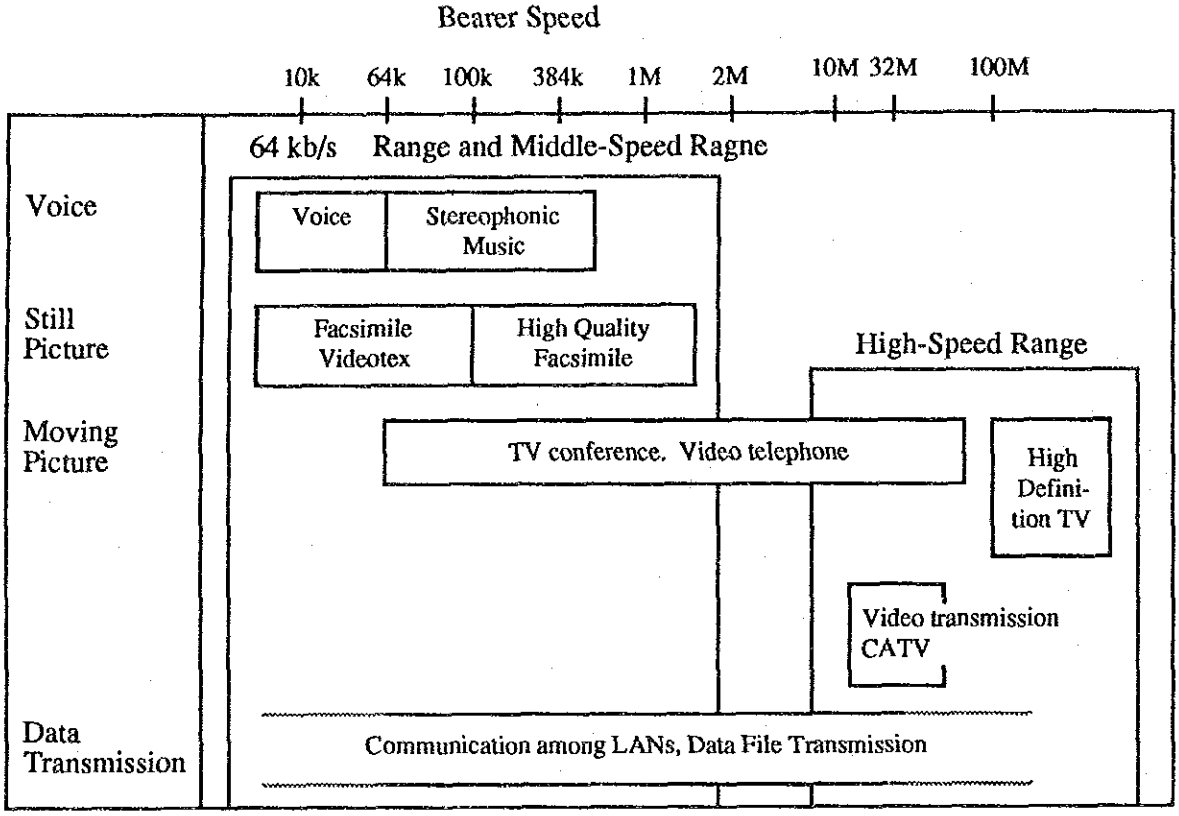
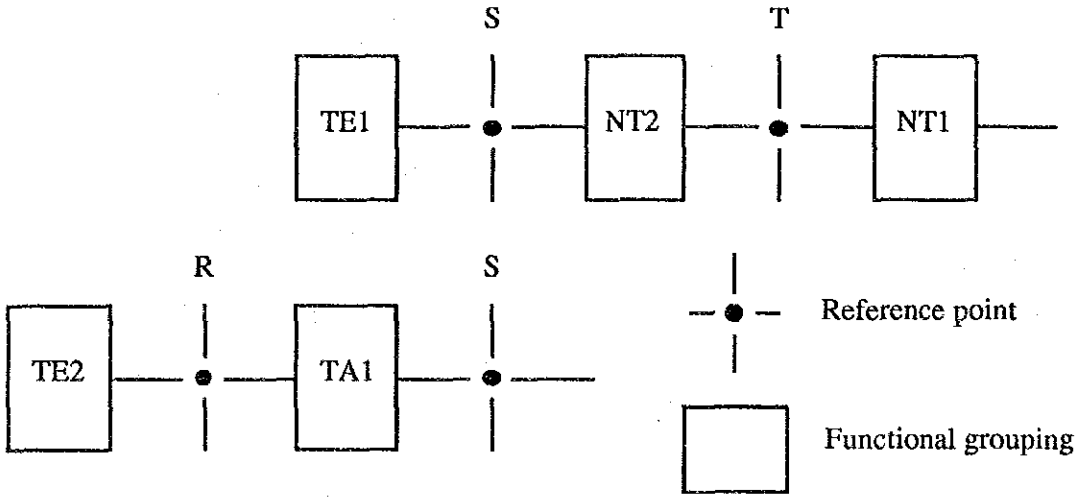


Figure 7.3.1-4 High-Speed and High-Quality Transmission Service

6) User-Network Interfaces

For connecting between user's terminal equipment and network, it is necessary to clarify the reference point. For this purpose, the ISDN user-network interface conditions are defined as described in CCITT recommendation I.411. The reference configurations for the ISDN user-network interfaces are shown in Figure 7.3.1-5.



Note: NT (Network Termination)
TA (Terminal Adaptor)
TE (Terminal Equipment)

Figure 7.3.1-5 Reference Configuration for the ISDN User-Network Interfaces

Point T is the standard reference point for the ISDN user-network interfaces. The connection with PBX etc. is standardized as point S. And also non-ISDN interface terminal equipment is used point R.

7) Broadband Aspects of ISDN

The broadband aspects of ISDN (B-ISDN) is the new telecommunication network to provide multimedia telecommunication service for customers including not only voice, data and still picture but also moving picture, etc.

For new information transfer system which has the feature of both circuit switching and packet switching covering from low speed to high speed, a concept of asynchronous transfer mode (ATM) is studying in CCITT. The B-ISDN will be standardized with the concept of ATM.

7.3.2 Introduction Plan

1) Services Introduction Policy

ISDN will be introduced to form an important part of the infrastructure of the advanced information society. The introduction areas should be decided taking account of the benefit of ISDN on the promotion of socio-economic activities in the specific areas. It seems, however, to be very difficult to estimate the demand of the new services to be introduced with ISDN.

On the other hand, the center of the social and economic activities in Thailand is Bangkok. In this connection, the disparity between Bangkok and other areas is conspicuous. However, as described about the prospects of socio-economic development in Chapter 3, it is expected to develop not only Bangkok Metropolitan Region but also Northeastern Region, Southern Region and Northern Region. Figure 7.3.2-1 shows the circumstances relating to ISDN introduction. As for the present state of telecommunication, provincial areas seem to be still behind. However, the ISDN services should be introduced in some provincial areas where higher demand is expected in the earlier stage such as the main developing areas as well as the Metropolitan Region.

The introduction policy is as follows:

(a) ISDN introduction areas are provided with 2B+D, 30B+D services.

(b) ISDN services are extended through the whole country in Thailand at Phase-3.

(c) Ho (384 kb/s) and H12 (1,920 kb/s) in the primary rate access interface have to be considered separately taking the trend of demand into consideration.

(d) B-ISDN commercial service will be commenced at Phase-3.

2) Introduction Target

According to the introduction policy, the ISDN services will be introduced from large cities and then middle cities, and the remaining areas in the country will follow one after another. The each phase target for the service introduction is set taking account of the sixth national economic and development plan and the number of subscribers in each area. The targets are as follows:

Phase-1: ISDN services will be introduced in regional urban growth centers and the areas which is more than 10,000 subscribers.

Phase-2: ISDN services will be introduced in second-generation regional urban growth centers and the areas which is more than 5,000 subscribers.

Phase-3: ISDN services will be introduced in the areas which the demand occur in the whole country. B-ISDN services are introduced the areas which is more than 10,000 subscribers.

ISDN introduction areas based on the target are shown in Table 7.3.2-1. ISDN services will be expanded to main areas by the end of Phase-2 through the above target. After that, the service will be expanded to the whole country taking account of expressed demand and anticipated revenue, etc. Further, ISDN will be introduced changwat by changwat. However, ISDN exchanges will be introduced to booming industrial and business major cities at frist. Figure 7.3.2-2 shows evolution of ISDN services and Figure 7.3.2-3, Figure 7.3.2-4 and Figure 7.3.2-5 show ISDN introduction areas at the end of each phase.

Table 7.3.2-1 ISDN Introduction Area

Phase	Areas to be provided
Phase-1	BMA (Bangkok, Nontaburi, Pathum Thani, Samutprakan) Chiang Mai, Chon Buri, Nakhon Ratchasima, Songkhla (Hat Yai), Khon Kaen
Phase-2	Nakhon Pathom, Ratchaburi, Udon Thani, Phuket, Nakhon Sawan, Surat Thani, Ayutthaya, Phisanulok, Ubon Ratchatani*, Samut Sakhon*, Nakhon Si Thammarat, Lampang
Phase-3	Whole country (ISDN) BMA, Chiang Mai, Chon Buri, Songkla (Hat Yai), Nakhon Ratchasima, Khon Kaen (B-ISDN)

Note: * sign means PC combined exchange area, the others are TC or SC combined exchange areas.

3) Transition to ISDN

The network digitization which has been progressed at present in Thailand should be coordinated with ISDN network introduction. As for outside plant, the present subscriber cable can be applied in case of the basic interface. However, in case of the primary rate interface, optical subscriber cable or digital microwave subscriber system should be applied.

On the basis of the above-mentioned matters, the following items should be considered:

(a) Establish the ISDN network which is used No.7 CCS,

(b) Secure the same service quality for the present network,

(c) Connect the present network terminals with the ISDN network terminals,

(d) Take over the present telephone numbering plan to ISDN telephone numbering plan.

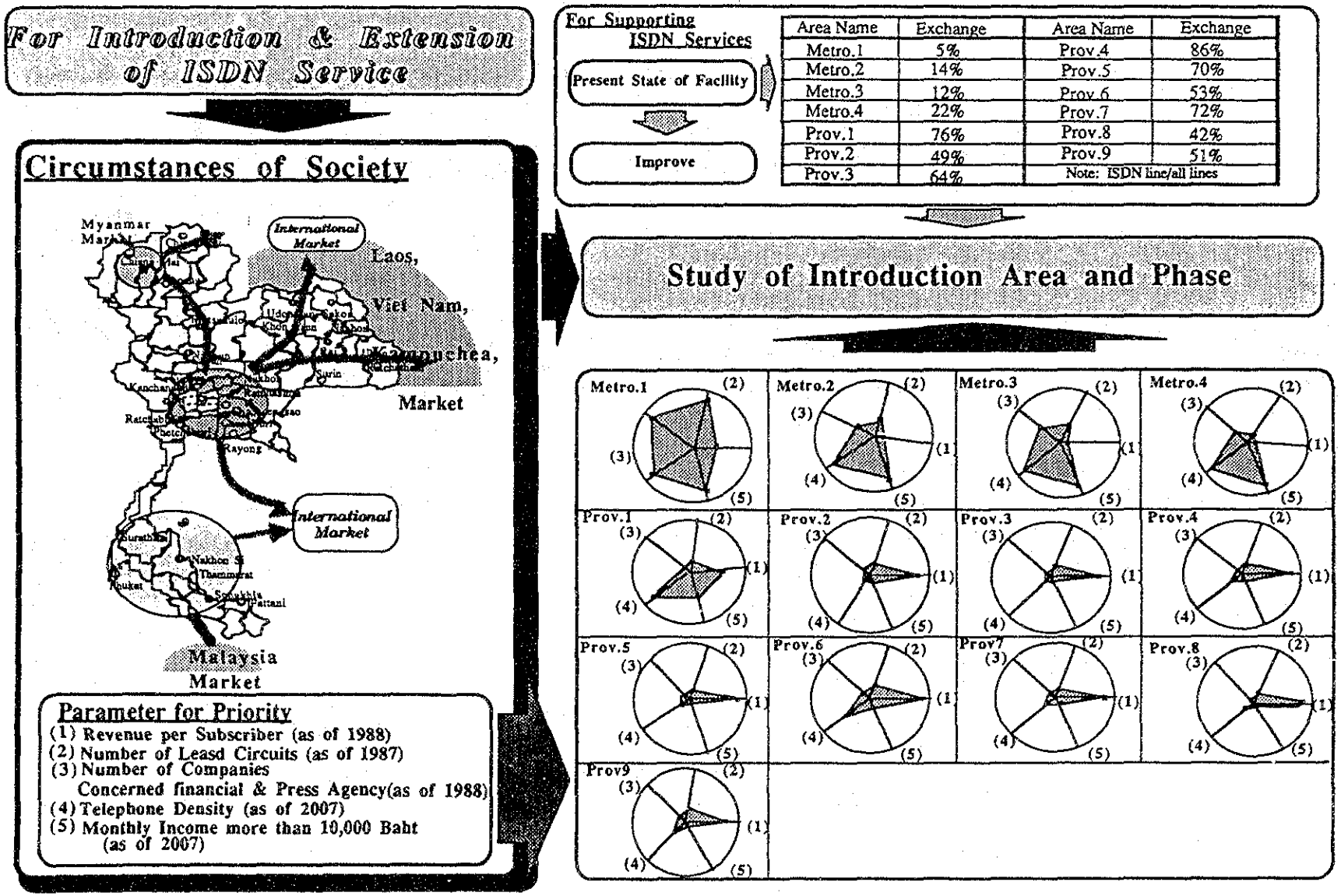


Figure 7.3.2-1 Circumstances Relating to ISDN Introduction

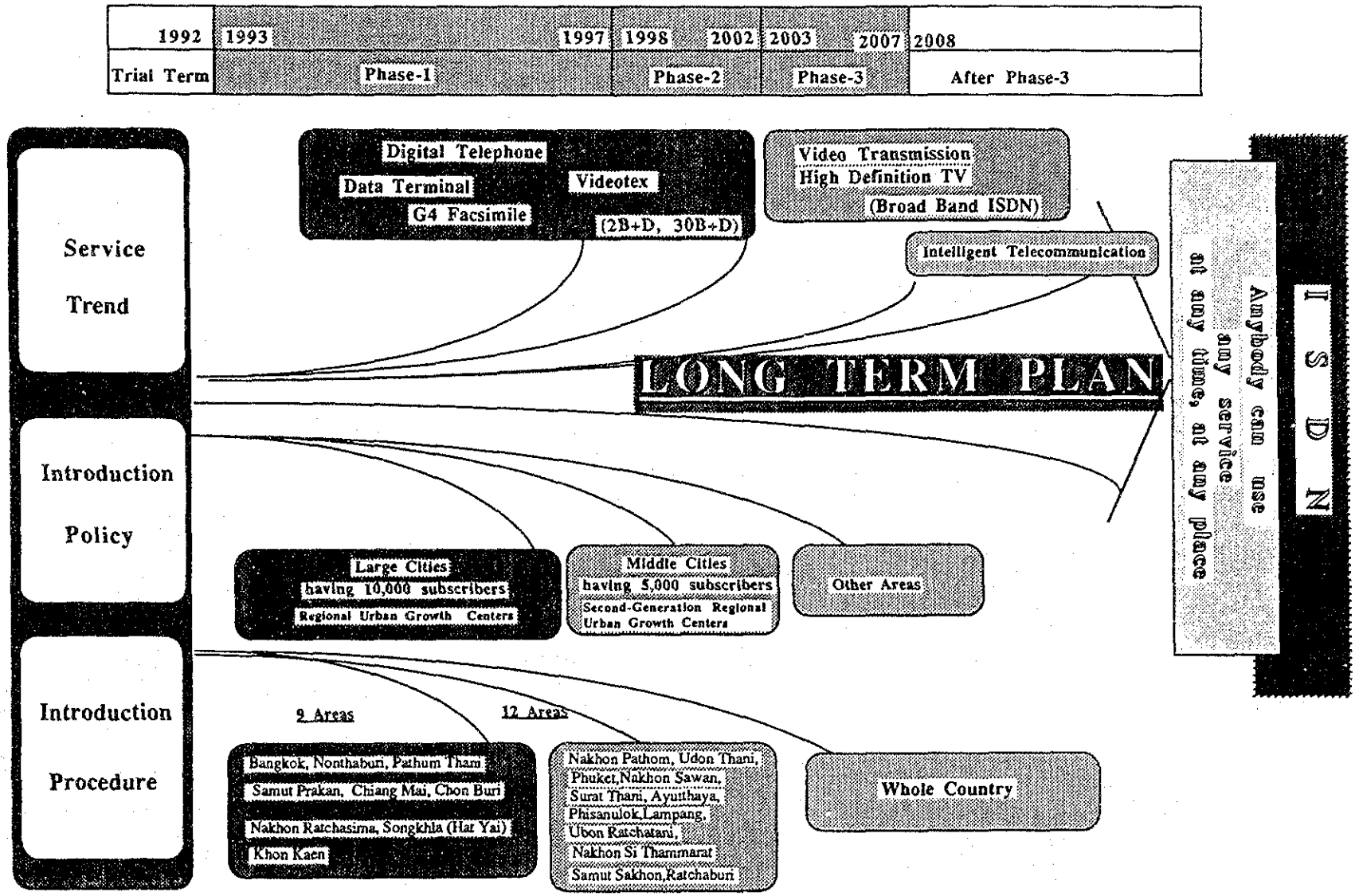


Figure 7.3.2-2 Evolution of ISDN Services

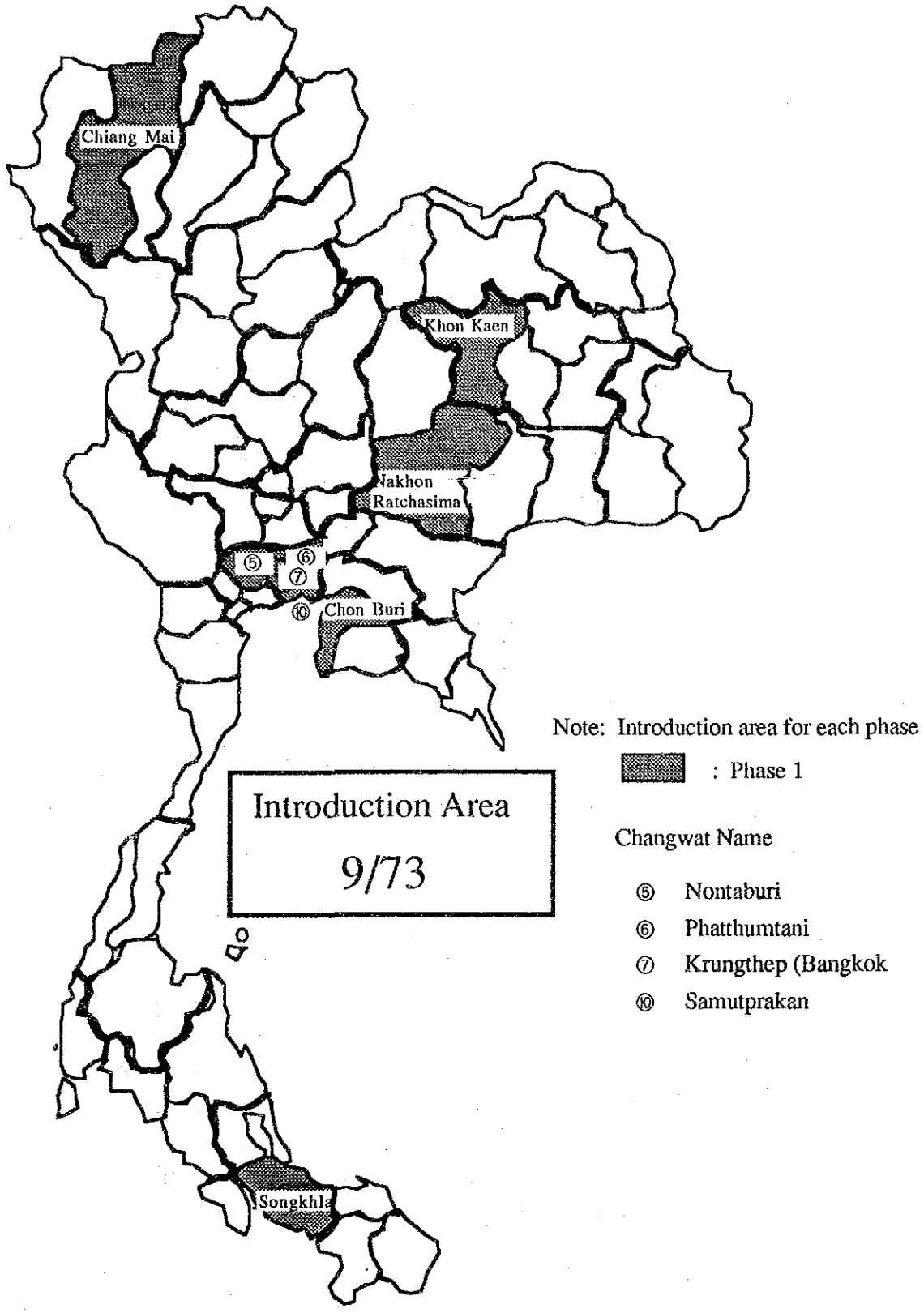


Figure 7.3.2-3 ISDN Introduction Area (End of Phase-1)

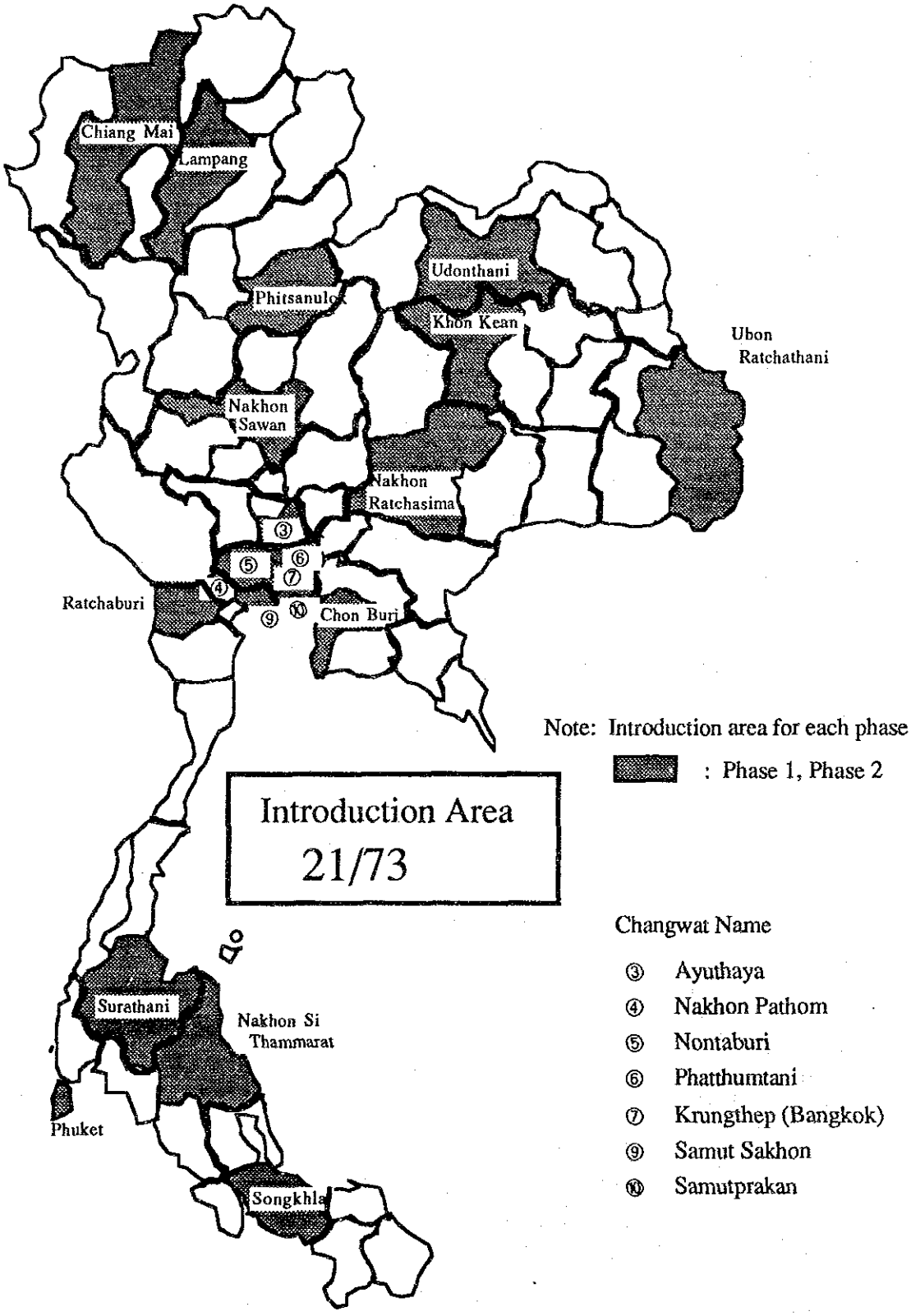


Figure 7.3.2-4 ISDN Introduction Area (End of Phase-2)

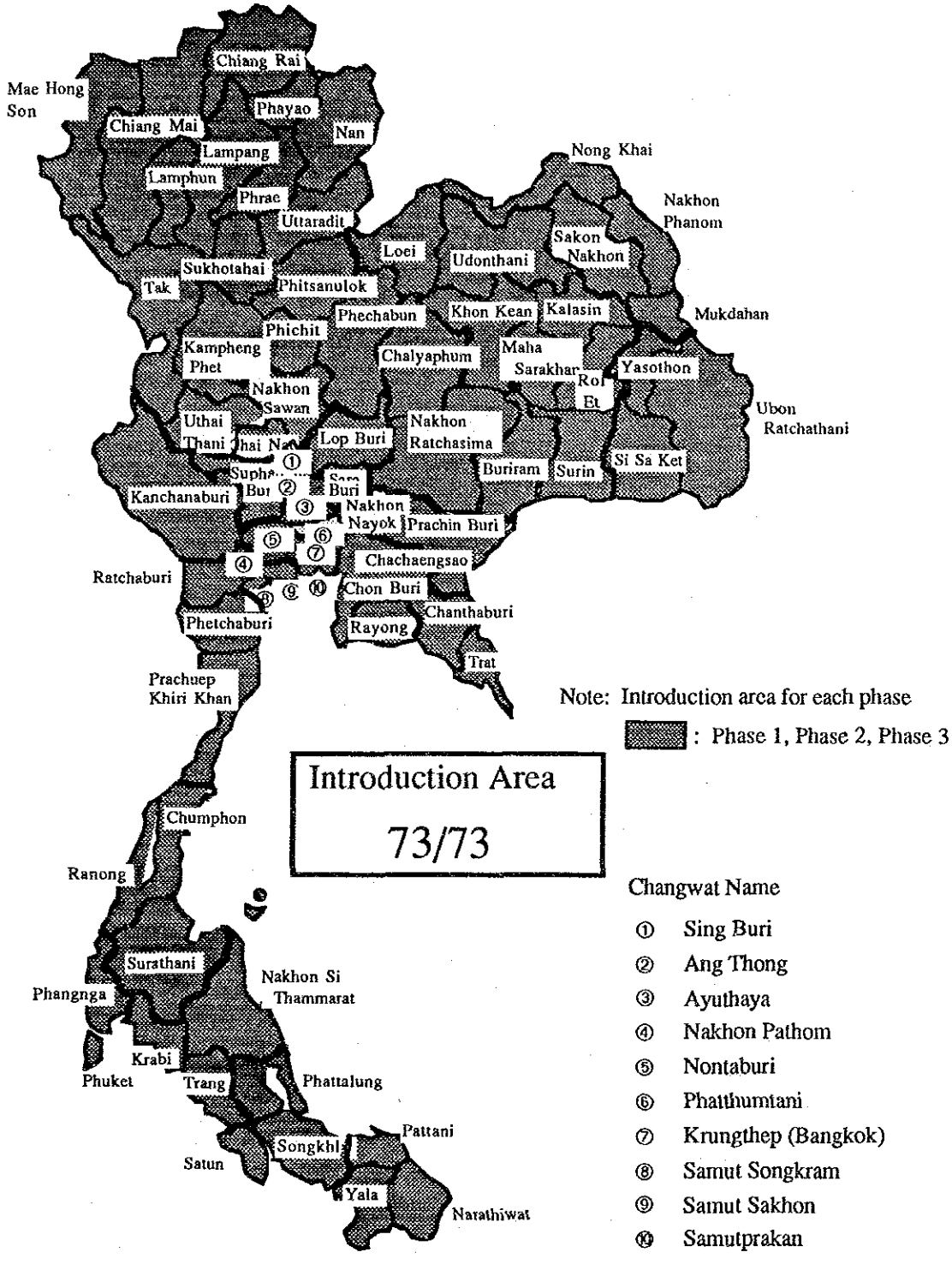
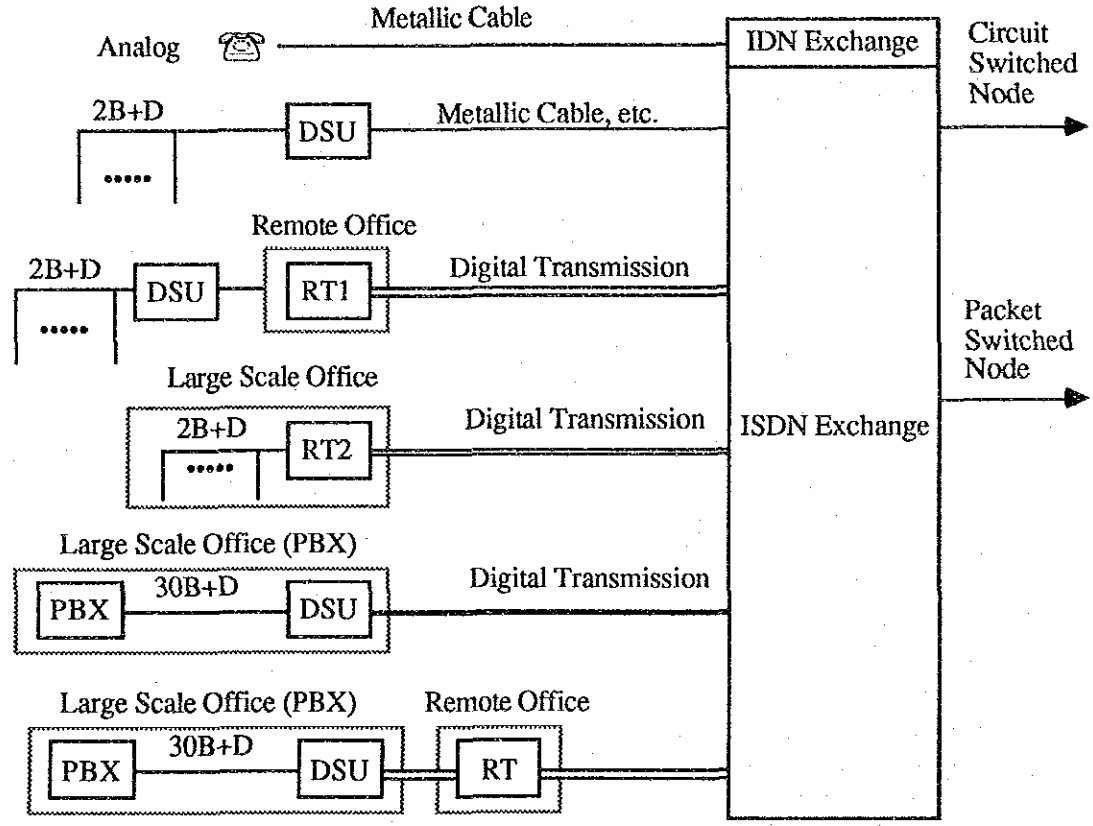


Figure 7.3.2-5 ISDN Introduction Area (End of Phase-3)

4) Network Plan

a) System Configuration

For providing with ISDN services, ISDN exchange is installed to accommodate the ISDN subscribers in the service area. Meanwhile, for small sized demand in the other area, Remote Terminal (RT) is used to provide with basic and primary rate interface services economically. Figure 7.3.2-6 shows the example of ISDN system configuration.



Note : DSU (Digital Service Unit)
RT (Remote Terminal)

Figure 7.3.2-6 Example for ISDN System Configuration

b) Network Configuration

i) Basic Policy

ISDN service will expand the whole country on the basis of ISDN introduction target. In Thailand, the digitization for the levels of PC and above will complete by the end of 1992. However, it is necessary to coordinate the digitization with ISDN

introduction plan. And ISDN exchange will be installed to the transit and local combined exchange which is located in ISDN introduction area at first.

Where a large demand is expected, such as Bangkok, ISDN exchanges will be installed as local exchanges. Meanwhile, small demand area will be equipped with RT which is subordinated to the ISDN parent exchange and then, if the demand increase, RT will be replaced with the exchange.

ii) Centralized Area for ISDN Exchange and its Network

Upon introducing ISDN service, it is necessary to construct a network in which the connection between any subscribers will be assured. Bangkok Metropolitan Area is a single message area. Therefore, ISDN local exchange can provide the service to the other service area through RT. However, as provincial areas are very wide, the centralized area has to be considered.

At present, provincial major cities in Thailand have the transit and local combined exchanges. Taking account of the present numbering areas and message areas, in principle ISDN exchange will be SC combined exchange at first. Small demand area in the same SC area will be provided with the service through RT and when demand increase, the PC combined exchange will have ISDN function. If a large demand is expected in some PC area, however, PC combined exchange will have ISDN function from the beginning stage. On the other hand, small demand SC area will be connected with ISDN exchange in the other SC area through RT as tentative action after investigating the particular technical matters. Figure 7.3.2-7 shows network configuration.

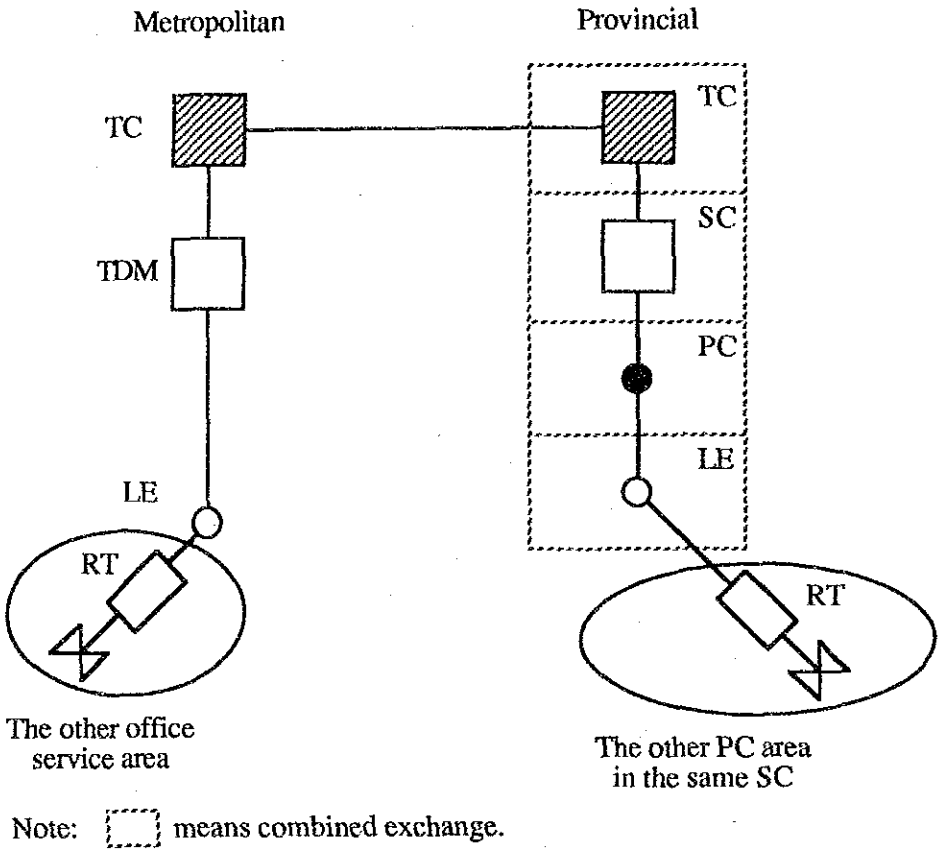


Figure 7.3.2-7 Network Configuration

5) For the Introduction of Digital Network into Local Network

In order to introduce the digital network in local network smoothly toward the advanced information society, it is very important how to expand efficiently and economically the digital network in local areas taking existing facilities and services grade into consideration.

The digitization of subscriber loops is indispensable for realizing the ISDN which provides various end-to-end digital services. Subscriber loop systems can provide various user-network interface services economically. Therefore, the systematization of subscriber loop transmissions has become and important matter.

There are 3 kind of subscriber digital transmission systems, namely, metallic cable, optical fiber cable and digital microwave system.

a) Metallic Subscriber Transmission System

This transmission system, which supports basic rate access interface of ISDN services, provided through metallic cable are economical and efficient, because a large amount of metallic cable has already been installed for the present telecommunication network as a local network.

There are two methods to realize a digital circuit through a metaric cable pair. They are Time Compression Multiplexing (TCM) method and Echo Canceller (EC) method. The TCM method divides the time between the sending and receiving signals to accomplish both-way transmission. The EC method is a method to realize both-way transmission using hybrid circuits. And, this method generally uses a echo-canceler to prevent echos of sending signals from disturbing the receiving side.

In order to introduce these metallic subscriber transmission system into local network as a digital transmission system, there are some technical problems to be solved as follows.

a. Impluse Noise
b. Crosstalk Noise
c. Short Interruption
d. Induced Noise
e. Bridged Tap

To cope with the questions mentioned above, the following items should be examined.

a. Influence of impluse noise arising from analogue telephone lines
b. Crosstalk noise characteristic of copper wires insulated with plastic or paper
c. Splicing method of copper wire wich is connected by manual twisted method or connector splicing method with regard to immunity against short interruption noise
d. Distance from broadcast station for induced noise
e. Reflections brought about distribution system with bridged tap

Therefore, in selecting the transmission system, full consideration should be given to those factors. Figure 7.3.2-8 shows transmission impairment of existing subscriber loop plant.

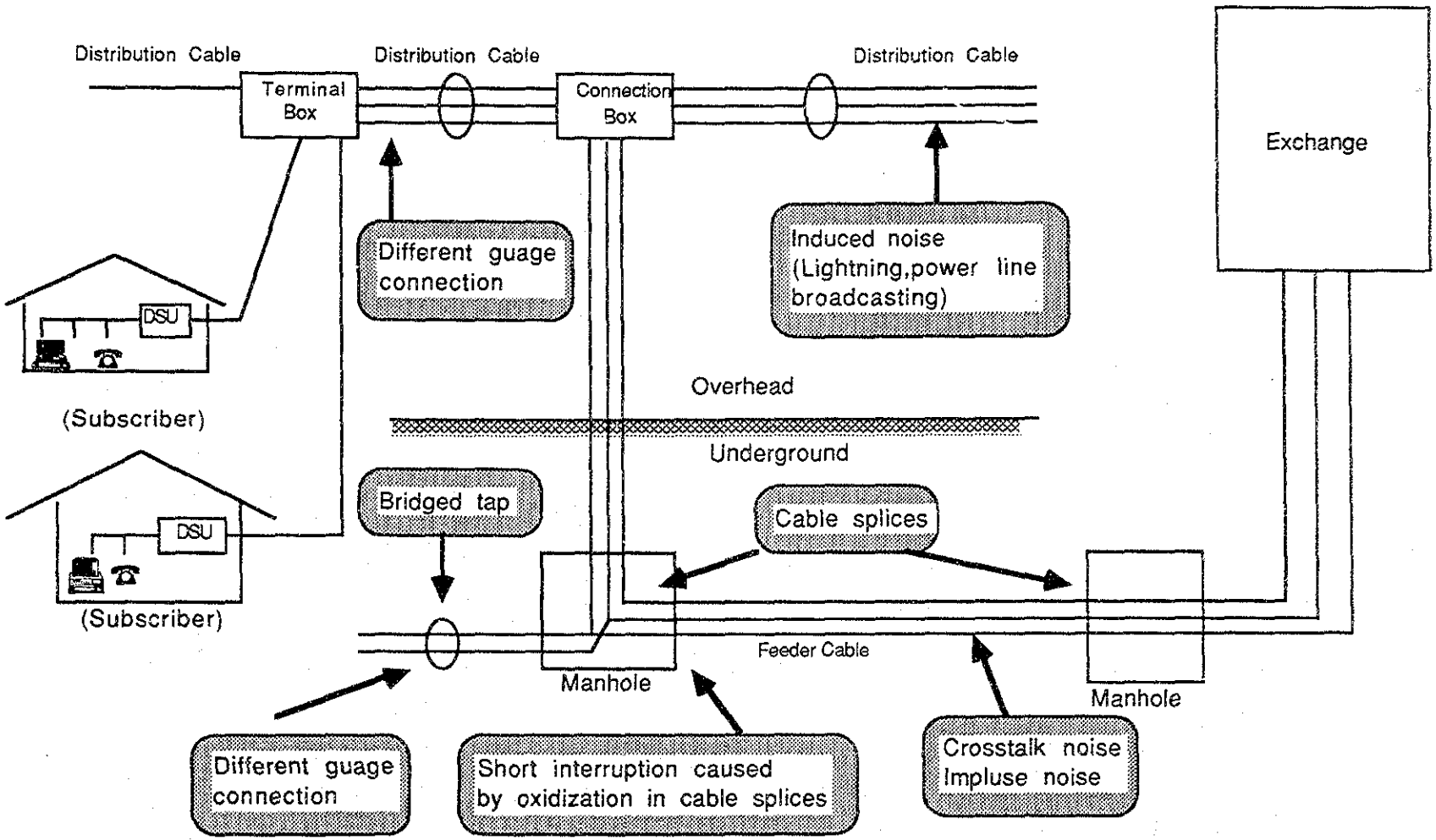


Figure 7.3.2-8 Transmission Impairments of Existing Local Network

Table 7.3.2-2 shows the research and development of digital subscriber transmission system in the world.

Table 7.3.2-2 Research and Development in the World

Country	System
W.Germany	EC
Netherlands	EC
STC	EC
U.Kingdom	
BT	EC
France	Four Wire
	TCM
	EC
Sweden	EC
Italy	EC
Japan	TCM

b) Fiber Optic Subscriber Transmission System

Existing metallic pair cable cannot meet the requirement of broadband services such as high-speed data, primary rate access interface of ISDN and video transmission. Consequently, it is necessary to install optical fiber cable as a subscriber loop to provide above services. It is preferable to consider introduction of fiber optic subscriber networks taking the following three steps according to demand increases.

i) Step-1 Star distribution method

In this stage, optical fiber cables are installed in a radial manner from central office as point to point to cope with the demand individually.

ii) Step-2 Loop distribution method

The network will form loop configuration of the physical network without reduction in the number of fiber to keep reliability, better flexibility to demand fluctuations and diversified circuit assignment.

iii) Step-3 Advanced subscriber networks

In this stage, optical fiber cable forms loop network, moreover it replaces metallic cable.

In construction of optical fiber network, the demand in the future should be considered in order to prevent excessive investment in a same area.

c) Subscriber Radio System

There are two access configurations to the subscriber radio stations or radio outstations, namely, point-to-point access and point-to-multipoint access.

In the case of point-to-pint access, a central radio station and a radio outstation are connected individually. In the case of point-to-multipoint access, many outstations can be connected to a single central station through TDMA and multi-beam antenna of the central station, enabling to design flexibly for user distribution and traffic condition.

The subscriber radio system is economical for quick setting up of subscriber link to offer the services with a certain range of bit rates, or digital telephone channels. Therefore, this system is considered to be suitable to the metropolitan area or rapidly developing areas for establishing permanent or temporary subscriber link for a bunched demands, or a circuit group connecting to a PABX, in a big building or a condominium.

The radio frequency band to be assigned to this system should be selected taking account of 1) radio frequency assignment plan in Thailand, and 2) evaluation of radio propagation loss caused by precipitation.