An Evolution Strategy Toward Digitalized Inter-exchange Network structure in Seoul Metropolitan Area

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1. Abstract

This paper analyzes the impact of digitalization on networks in Seoul Metropolitan Area by considering facility investment together with operating costs. A stepwise evolution method toward a digitalized double-homming architecture is proposed to accommodate most efficiently with existing analog-oriented networks.

2. Introduction

Telecommunication networks in Korea have been rapidly changing in the last decades. In the periods of 70's and 80's, the main goal of telecommunication policy was one line per one household and successful execution of the policy resulted in large volume of telephone lines available to general customers. With the change of monopolistic structure of telecommunication business to market economy structure in the beginning of 90's, the telecommunication business environment has to be more competitive than ever with the growth of economy. Enormous demand on various services has been a characteristic trend in early 90's korean telecommunication market. For the period of 90's, number of subscribers per 100 people has been expressed 39 by the end of 1992, will reach at the level of 40 by 1994, and will eventually reach at the level of 50 by the end of this century.

From the view point of telecommunication technology, with the theme of network digitalization, various projects including common channel signaling, intelligent networking, and ISDN pilot services have been actively pursued.

The following summarizes the trends in current telecommunication market: (1) customers want to utilize the existing facility with high quality services at low cost. Customers also try to take advantages of various telecommunication services for their businesses. (2) Operating companies, on the other hand, aim at supplying their customers with valuable services at proper prices, The services include speedy network formation, stable network maintenance, and continuous expansion of facility to meet advanced technological features.

This paper presents and evolution strategy established to solve problems with the current metropolitan networks. The strategy will result in flexibility of future networks and robustness of the managemental capability of Korea Telecom. This paper does indirectly or directly reflect the overall aspects of telecommunication strategy for the modernization of networks.

3. Current Structure of Seoul Metropolitan Networks

3.1 The current network configuration

The Seoul Metropolitan networks have been installed and connected to the toll network, heterogeneous network, and new service network for a large scale local telephone facilities. The networks are evolving with close relationship with networks of neighbor cities.

1) Toll network

Until late 1990, all toll traffics had been transacted through the toll exchange. Since 1991, however, the local exchange has included the toll transaction function between local and the 16 neighbor city areas that have high volume traffic.

2) Inter-local transit network

The transit network areas are classified as 8 areas; from the Area #2 to the Area # 9. The inter-local transit networks are maintained with numbering architecture: direct route for the traffic of the same area and the traffic between different areas.

3) Special number circuitry network and heterogeneous network

Under the circumstance of rapid increase in various services, the special number circuitry network such as 114 or 115 has the low efficiency and high complexity. The measures have taken to resolve these problems with the pure tandem network as a basic structure. Networks for various services are to be integrated and eventually to form fully dual network system in order to improve the stability of the network. In addition, rearrangement of the special number networks are underway as an effort to improve efficiency of the network since it is rather difficult to improve the entire local network by the tandem network alone.

3.2 Trends in subscriber demand and current facilities

1) Trends in subscriber demand

As shown in Table 1, Seoul Metropolitan Area has 4.4 million lines and 16 areas of neighboring city areas have 1.5 million lines as of 1991.

[Table 1] Trends in subscribers demand

(Unit : millions lines)

Class	'92	'93	'94	'95	'96	'97
City	4,430	4,900	5,270	5,560	5,780	5,970
Neigh-boring Cities	1,480	1,830	2,120	2,340	2,480	2,600
Total	5,190	6,730	7,390	7,900	8,260	8,570

2) Existing exchange facilities

Table 2 shows the composition ratios of current exchange facilities as of 1992. The digitalization ratios of exchange facility for the Seoul area and the neighboring city areas are 40.8% and 67.4%, respectively. Overall 47% of all exchange facilities are digitalized. Our goal toward 100% digitalization for exchange facilities is the year 2005.

[Table 2] Existing Exchange Volumes

(Unit : 1 K lines, system)

Class	Mechanical		Analog		Digital	
	Lines	Sys.	Lines	Sys.	Lines	Sys.
City	323 (5.9)	15	2,906 (53.3)	80	2,225 (40.8)	58
Neigh boring Cities	23 (1.4)	3	519 (31.2)	9	1,120 (67.4)	80

Total	346 (4.9)	18	3,425 (48.1)	89	3,345 (47.0)	138

Reference : the bracket is expressed in component ratio

3) Tandem facilities

The tandem network consists of 54 tandem exchanges with 534,000 lines. 11,955 tandem routes are under operation for various functions including local and transit toll traffic handling. Existing facilities of different route types are shown in Table 3. Note that 56.6% of all exchange lines are direct route.

[Table 3] Tandem Facilites

(Unit :lines)

Type		DR	HUR	TR	Total
Route	lines	4,301	5,388	2,306	11,995
	%	(35.8)	(45.0)	(19.2)	(100.0)
Trunk	lines	302,377	93,098	138,744	534,219
	%	(56.6)	(17.4)	(26.0)	(100.0)
Average Trunk Per route		70.3	17.3	60.2	44.5

Reference : DR = Direct Route, HUR = High Usage Route, TR = Tandem Route

3. 3 Status Analysis and Improvement

1) Complexity of tandem network

According to the design output of 11,191 tandem route, there are approximately 12,000 routes and 530,000 tandem trunks. This result is derived from the design criterion in which the current method is supplied the terminating tandem, HUR or DR between end offices if the traffic is more than 6 Erlangs or within the same area. This results in several problems including the followings:

- Any changes in design and installation can occur frequently because of the high error rates by complex network plan with the outgoing routes and the lines of tandem network.
- Rapid management is not available because of low network flexibility that is limited by emergency and new service provision.
- The efficiency of trunk lines for the case of small-grouped trunks is in low level. For example, in order to keep 1% grade of services 30 trunks are required as the traffic is 20 Erlangs, 117 trunks are needed as the traffic is 100 Erlangs. It results in the improvement of 0.85% Erlangs per channel in the latter compared with 0.67 Erlangs per channel in the former.
- The direct routes composing 90% of total routes cause a cost increase in operation and maintenance due to a growth route numbers, in comparison with a reduction of initial investments. The network handing cost will increase because of the personnel expenditure. On the other hand, network equipment cost will decrease by technology advance. This fact will make direct route uneconomical in the next 5-10 years.

2) Directions for the improvement of routing and network structure

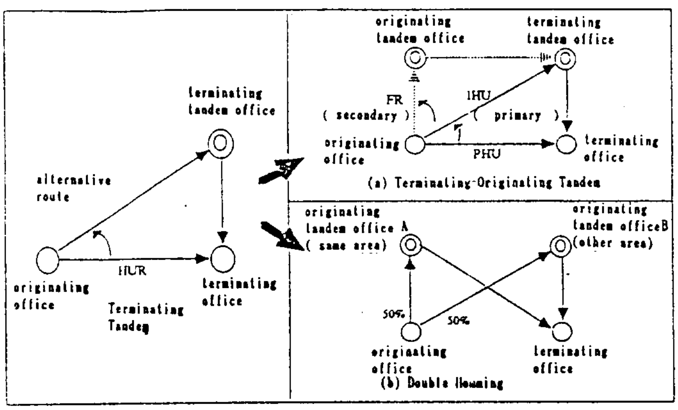
Many problems in current network architecture can be solved by improving present routing methodology.

The improvement in routing methodology can also help network digitalization. The following conditions should be considered when present routing methodology is modified:

- simplicity of network structure

- flexibility of network in future change
- supply of originating tandem function
- tightness of making direct route between end offices

Evolving from the current terminating tandem to future digital tandem network, the alternatives can be summarized as the two methods of terminating-originating tandem and dual homming tandem as shown in Fig.1.



[Figure 1] Two Evolution Strategies of Tandem Routing

In case of Fig. 1-a, the route can be offered to the central office of the region. Primary High-Usage(PHU) route and Intermediate High-Usage(IHU)route can be utilized for improving the network flexibility by admitting the alternate routes twice. It, however, may cost more than before since more routes between end offices and more complex network management are expected.

In case of Fig. 1-b, the several routes can be grouped into one and the number of total routes is reduced. The star network that is a form of grouping method can be also found in many local networks in Japan or Sweden. This methodology will also increase the safety of the networks. The route from a digital end office to a tandem office can cover the 50% of traffics transiting the route from a tandem office to a terminating office while covering the other 50% of traffics trasiting the route from a digital originating office to a terminating office. The dual homming tandem routing has several advantages including minimizing the number of routes and alleviating the burden in network management while showing disadvantages such as introducing the pure tandem exchange for solving overload problem in tandem exchange.

3) A plan for accommodating neighbor cities

The traffics between Seoul areas and neighboring 16 cities are handled by the gateway using 6 pure tandem exchanges (5 ESS, S1240). These exchanges have processed local and tandem functions. The system capacity will be fixed by the condition of customer traffic and tandem traffic per subscriber, the traffic is expected to have sharp increase and a large capacity of tandem exchange as a gateway will be required in the next 10 years. Therefore, the alternatives should be set up to cover the capacity of gateway accommodating huge traffic with the neighboring cities.

4. Comparison among the alternatives of evolution strategies

4.1 The proposed alternatives

1) Alternative 1 (Terminating Tandem : Current Routing Rule)

This rule has been used with forming pure terminating tandem routes since the exchange cannot cover the alternative routing functions due to the operation from most of electromagnetic exchanges in the period of 1960-1970. The traffic zones were split and operated individually by the numbers of the areas. The electronic exchange introduced later made it possible to cover the alternate routing within exchange module. In order to improve the line efficiency in section handling, two routing rules are introduced and used optimally to minimize the cost of network equipment. The two routing rules are: (a) direct route for large volume traffic and (b) tandem route for small volume traffic. This rule is currently used in metropolitan network.

2) Alternative 2 (Terminating-Originating Tandem)

The terminating-originating tandem is a routing rule designed to improve the trunk line efficiency of the alternative route. This rule has been used commonly to minimize overall costs including physical network cost which is proportional to the distance between the two end offices.

3) Alternative 3 (Double Homming)

Double Homming is a routing rule for distributed processing individually to the two tandem exchanges dealing with all transit traffic between the end offices. While this rule suffers from the additional cost for the equipment, the simplicity of the network structure makes it more flexible in future expansion and its maintenance of facilities.

Other routing rules such as dynamic non-hierarchical routing and dynamic alternate routing are excluded from alternatives because of real time data and their complexity.

4.2 Qualitative analysis

Concept of telecommunication is continuously changing with the environment of globalization and advancing technologies in the field. The following summarizes the current trends:

- reduced equipment cost and shortened life cycle in technology
- increase of personnel expenditure
- rapid change of telecommunication market

In order to cope with the above challenges, telecommunication networks are required to satisfy several conditions. First of all, a flexible network structure is to be set up easily enough with minimum disturbance on the present networks as the facility expansion of change is required. The installation work can be restricted to the applicable end offices as the new facility is required. Secondly, the telecommunication structure should be able to be improved to the suitable network architecture according to the size of the network.

For the case of large scale networks, irregularity and complexity are another dimensions to be considered. A systematic analysis of operating condition and the position of office is a troublesome task especially in large scale networks. Since the level of operation should be quantified and well equipped with an automatic processing, it is not easy to adopt the centralized operation and maintenance system. The network architecture is an important factor to be considered in the case of large scale networks.

Another factor to be considered in deciding an optimal routing plan is the amount of installation labor work since the portion of personnel expenditure out of total cost is growing while the portion of equipment cost is comparatively shrinking as time goes by.

4.3 The results of alternative configurations

1) Comparison of network configuration with alternatives

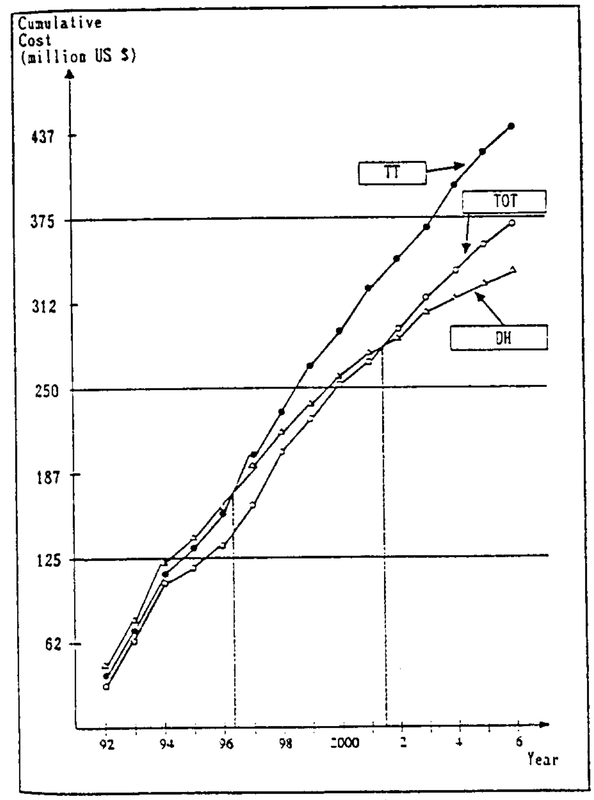
Table 4 shows the expenditure analysis among the alternatives for next 15 years. During this period, the subscriber lines are expected to reach 7.6 million lines and the offered traffic is expected to 0.51 million Erlangs. However, the number of systems will decrease to 112 systems because new digital exchanges with large capacity will replace the electromagnetic and analog exchanges. In the aspects of route numbers, the double homming have the simplest structure due to the reduction in route numbers by removing the analog exchanges.

On the other hand, the double-homming requires the largest amount of trunks in order to offer the tandem routes except the same end office. The average numbers of trunks per route are 58 lines, 63 lines, and 171 lines for the terminating tandem, terminating-originating, and double homming, respectively. This results in 0.919 Erlang of the offered traffic in case of double hommintg depending on the large-grouped effect.

2) Engineering economy

The investment costs for the alternatives are estimated. As a result, Terminating-Originating Tandem(TOT) shows the most economical alternative with 117 million U.S.Dollors(USD) while the Terminating Tandem (TT) and the Double Homming (DH) with 139 million USD and 161 USD, accordingly. From the view point of maintenance cost, the DH is the most economical routing rule with 171 million USD. When we consider the total cost including the investment cost and maintenance cost to the net present value at 1991, the followings are the cost for three alternatives; 334 million USD for DH,371 million USD for TOT, and 438 millions USD for TT.

The trend graph shown in Fig. 2 illustrates the cumulative cost with alternatives. The DH has the highest investment cost in the beginning of the period. However, the increasing trend will level off as time goes and the yearly cost will reach the point where the DH is the least expensive alternative in the year 1995. In the year 1997, the DH will surpass the TT even in cumulative cost. Finally, the DH will be the best alternative among the three alternatives in the year 2001 for the cumulative cost.



[Figure 2] The Cumulative Cost Comparison with Alternatives

5. An Evolution Strategy Toward the Digital Networks

5.1 The conversion plan of the tandem network

In order to cope with rapidly varying telecommunication environment, the formation of tandem network should be initiated as soon as possible. During the conversion plan toward the digital networks, the two alternatives of routing methodologies will coexist and the conversion plan including network design and installation should be extremely complex. Therefore, the conversion should be completed within minimum period of time, say, in one year. However, there exist certain problems such as budget problem and traffic control if we try to finish the conversion in to short period of time.

After considering all the pros and cons of different time schedule in conversion plan, a two phase plan was proposed: Phase 1(1992-1993) and Phase 2(1993-1994). Four tandem offices were installed and preparation of network conversion was performed in the Phase 1 period. In the Phase 2, additional four tandem office was installed during 1993 and switching of tandem networks was conducted during 1994.

5.2 Network configuration during the conversion process

Since the network conversion should be conducted in parallel with yearly supply of facility and two different network architectures coexist, several complex conditions including proper switching of current tandem lines and tandem network configuration of new exchanges should be cardfully considered.

The conversion plan of pure tandem have prepared with the two phases accommodating the existing and new systems during the installation of pure tandem exchanges. Otherwise, the existing tandem rule is applied as an alternate rule. Considering these conditions the tandem network is formed with the types of exchanges and the installation conditions of pure tandem exchanges.

5.3 Priority in the installation of tandem exchanges

Since the pure tandem exchanges will be installed on top of already existing networks and double homming architecture is conceptually over the numbering areas, no explicit installation priority exists. Only practical components such as growth of toll lines, the amount of required lines, and the provisions of installation space are considered in selecting tandem offices.

5.4 Accommodation of regional end offices

The double homming does not depend on the area and accommodates the regional end offices by existing facilities with areas as much as possible. Therefore, the pure tandem exchanges accommodates 50% of outgoing trunk traffic and the exchanges of other areas takes over the other 50% of traffic.

5.5 Supply scheduling of pure tandem exchanges

The tandem exchanges are basically facilities used for forming service networks of local end offices with transmission equipment. Currently, supply of local exchanges is performed as following: a plan, design of tandem networks, and design and construction of tandem exchanges are done usually two years, one and half year, and one year before the sale.

5.6 Generation of surplus facilities

Centralization of alternate trunks to the pure tandem exchanges produces surplus facilities. The inter-office trunk lines will increase the tandem lines even though lines in other offices are increased unlike subscriber lines. Therefore, new equipment can be still utilized even though the inter-office trunk lines are removed. Since the existing Time Division (TD) facilities require T1 trunk lines, the existing TD facilities can be accommodated by rearranging the surplus facilities out of TD systems. The toll lines will be handled by the TD exchanges for the time being.

5.7 Network switching and traffic control

In order to minimize the surplus facilities and to maximize the existing trunk lines, a certain amount of lines are reserved for switching among pure tandem offices and systems in end offices. The switching should be determined after considering whether the traffics can be handled by the already installed lines.

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5.8 Conversion of CEPT transmission method

After considering the amount of the existing T1 facilities and the required amount of E1 facility in the future, we decide to install the tandem exchanges which have dual funcion of T1 and E1.

6 Concluding Remarks

The telecommunication networks have close relationship with various fields ranging from detailed execution of plan to management, equipment investment, and operations. The pure tandem networks have planned to gain such advantages in overall areas of telecommunication business over the existing network structure. The expected advantages include construction of regional network management, improvement of traffic construction of intelligent networks, and flexible conversion toward ISDN.

References

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