A Study on Managing Traffic by Tadem Swisch

by

Ms. Chantipa Tuschan

A Final Report of the Six-Credit Course
IC 6997 and IC 6999 E-Commerce Practicum

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Internet and E-Commerce Technology
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Project Title	A Study on Managing Traffic by Tandem Switch
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The Graduate School of Assumption University has approved this final report of the six-credit course, IC 6997 and IC 6999 E-Commerce Practicum, submitted in partial fulfillment of the requirements for the degree of Master of Science in Internet and E-Commerce Technology.

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ABSTRACT

The Communication Authority of Thailand (CAT) is the first telecommunication company that provides service in International Telephone. As International Telephone traffic volume continues to grow and the demand for more professional knowledge, technologies and other services is increasing, the telecommunication network is becoming more and more complex. Therefore this project is to develop the high quality product and network solutions for International Telephone System.

The current existing Digital Switching System is based on the technical manual and some computerized systems to control the operation of overall system. The latest technology design is based on Digital Switch called "Tandem Switch". Tandem Switch (Digital Switching System) is one of the major products in providing easy operation and maintenance, Advanced Capabilities and high performance. However the numerical data takes from all real source and make data nearly real data for easier to understand by simplified real data into assume data in comparison all data before and after installation Tandem Switch.

The new proposed Information System will be developed to solve some problems in CAT's Network to manage traffic efficiently. However, in the future Tandem Switch Switch will be vital in the large network. It is easier to expand or to reduce network size and reduce the network cost.

ACKNOWLEDGEMENTS

Several people have made contributions to this project. The writer would like to acknowledge their efforts and thank them for their contributions.

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I. INTRODUCTION

The convergence of voice and data in today's communication network has the potential to change the fundamental way for world communication. In addition, Technology in Digital Switching System is developed dynamically and with high efficiency. Nowadays the Digital Switching System is used in the Telecommunication Network by modifying to many functions. This project aims to provide telecommunication, Technology overview of modern voice and data network focusing on Tandem Switch operation to manage traffic of International Telephone in Communication Authority of Thailand that implemented is by Huawei Technology Co., Ltd.

Information in this document begins with an overview of project and background of the organization including the Tandem Switch Solution that describes more detail in each item (The Existing Network Part). After a brief overview of concept, the Propose System introduces the overall structure and performance characteristic of the Digital Switching System (Tandem Switch) and then review hardware and software requirement. Later this project considers Cost and Benefit Analysis that describes efficiency and effectiveness of Tandem Switch and revenue-generating business service from measuring the traffic of oversea calls.

The rest of this project is the Project Implementation, which describes Configuration and Network Planning, Measurement Traffic and Compare Call complete before and after using Tandem Switch. In the last section is Conclusion and Recommendation; a brief description of some large domestic applications of Tandem Switch System has been presented. Moreover, a brief summary of application in some countries is also described.

1.1 Background of the Project

This project deals with a description of the proposed Tandem Switching System concerning its Configuration, Networking and other relevant parameters. In this project, 2 sets of Digital Switching System (Tandem Switch) are adopted as Tandem Switch for CAT (Communication Authority of Thailand).

As international telephone traffic volume continues to grow and the demand for more professional knowledge, technologies and other services is increasing, the telecommunication network is becoming more and more complex. This growth has forced CAT to build out network quickly nationwide and with more efficiency. Meanwhile, the Digital Switch or Tandem Switch has the latest technology design, providing easy operation and maintenance, Advanced Capabilities and highly - reliable operation. CAT has to reconfigure network and add new Digital Switch in network. The Digital Switch was added and called "Tandem Switch".

Tandem Switch is a switching system in the message network that establishes trunk-to-trunk connections and is a primary gateway between ITSC (International Telephone Switching Center) and distributed local switching. Tandem Switch has only trunks, without subscriber line, this allows faster call transfer nationwide. The results are high efficiency on Network Management, cost saving and gaining access charge revenue. (Figure 1.1. Network Configuration).

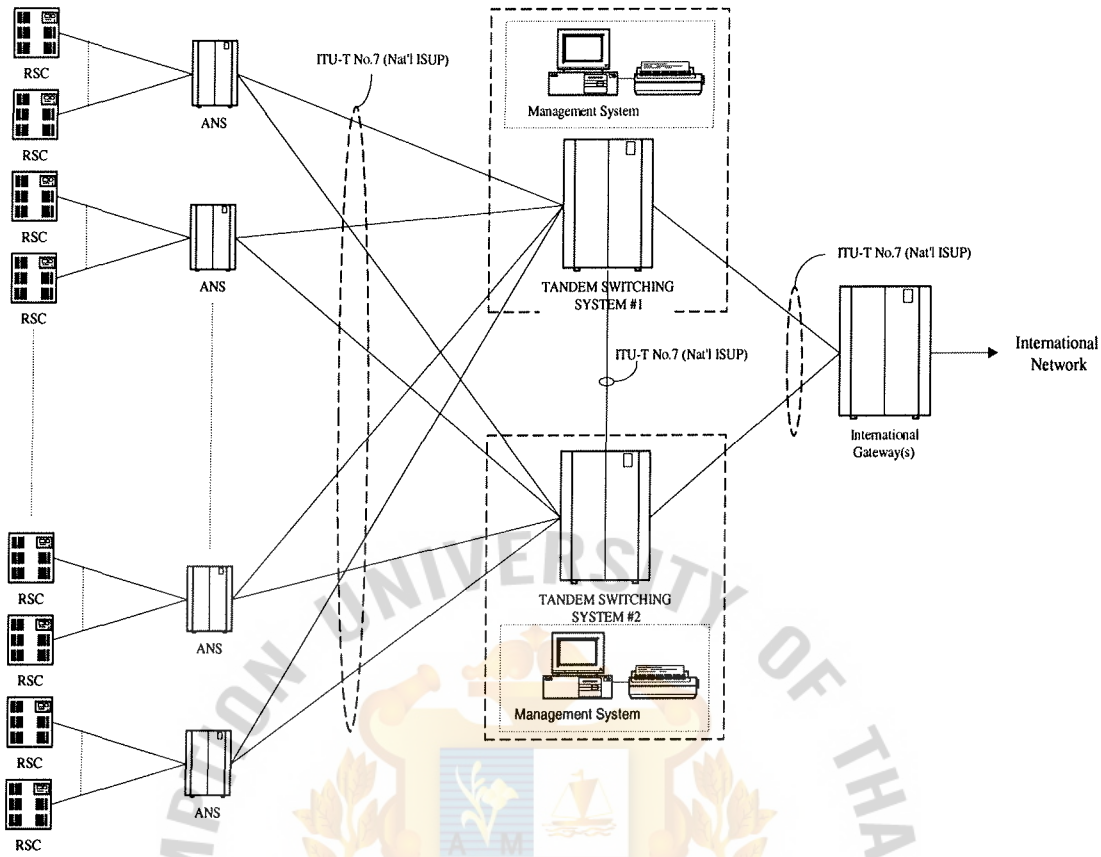


Figure 1.1. New Network Configuration.

In the figure Tandem Switch will be vital in the large network. It is easier to expand or to reduce network size and reduce the network cost.

So previous technologies, having the advantage of advanced technology, high stability, can meet all the demands of the most complicated telephone network system.

1.2 Objectives of the Project

This project aims

(1) To introduce the overall structure and performance characteristic of Digital Switching System (Tandem Switch). It will understand the function of basic composition modules, functions of individual module and inter-connection between modules of Tandem Switch.

(2) To study how Tandem Switch can provide high quality product and network solutions for International Telephone System that can provide abundant service.

(3) To study measuring the traffic of oversea calls of International Telephone after adding Tandem Switch.

The Digital Switching System feature integration of optical and electronic technology, switching and transmitting, wire and wireless accessing, narrow and broad bandwidth, basic and intelligent services, as well as integrated network management. Tandem Switching comprehensively provides services to public telecom network, private telecom network, Intelligent Network (IN), and Integrated Service Digital Network (ISDN).

1.3 Scope of the Project

This term project will cover:

(1) Overview to (Tandem) Digital Switching System' Hardware System

  (a) Hierarchical Structure

  (b) System Architecture

(2) Calculate Percentage Call Complete via Tandem Switching System and send into International Telephone Switching Center.

  (a) Performance Characteristics of Tandem

  (b) Flexible Design

  (c) Wireless Local Loop

  (d) ISDN service

  (e) Intelligent Networking Service

  (f) Business Communication Network Services

  (g) Processing Capability

(h) System Reliability

1.4 Deliverables

(1) Final report in details covering the scope mentioned earlier

(2) Computer Network and Telecommunication System and IT (Internet Technology) will be shown concepts in the report being applied.

1.5 Project Plan

Table 1.1. Research in Tandem Switch.

	Year 2003						
No.	**Job Title**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**
1.	Proposal Submission	*					
2.	Research and Analysis	*	*				
3.	Researching Report and Measurement Traffic		*				
4.	Configuration and Networking Planning			*			
5.	Compare Call complete before and after use Tandem				*		
6.	Report Submission (End of Project)					*	
7.	Review & Defense						*

Detail in Project Plan

Sat. Mar. 1, 2003 Last day to request & submit project IEC

(After checking grammar and format)

Sat. Mar. 22, 2003 Present Project IEC

II. THE EXISTING SYSTEM

For over two decades, organizational structure of postal and telecommunication service had been remodeled from a governmental agency to a state-owned enterprise. The Communications Authority of Thailand was henceforth established as an enterprise under the state ownership with the commitment to provide communications services; be it physical or digital-up to international standards. Since its inception, the CAT has been continually serving the public with efficient, fast, and reliable services with ultimate customer satisfaction as its priority.

International Telephone Service expands and improve International Telephone circuit in order to support future demand growth and to enhance effectiveness in providing advanced telecommunication service, as well as to increase stability of International Telephone Network by constructing three buildings, the 30 - storey Telecommunication Building Postal Building and Parking Building, establishing of 10,000-circuit SPC International Telephone Switching Center (ITSC IV), installing of 10,000 Front End Telephone number, and at the present increasing the Digital Switching System (Tandem) to manage traffic efficiently and to solve some problems in system network.

By year-end 2002, the CAT will be corporatized in response to the government's privatization policy. The pivotal corporate reform is considered as a momentous undertaking, which constitutes the separation of telecommunications and postal services, and the core of this scenario shift and as well-prepared in pursuance of good corporate government, human resource development, technology development, and customer service excellence; the organization reform is aimed to achieve efficiency and optimal public benefits in order to enhance the CAT's competitive, advantage and capabilities for future harsh battles.

2.1 Background of the Organization

CAT's Organizations Structure

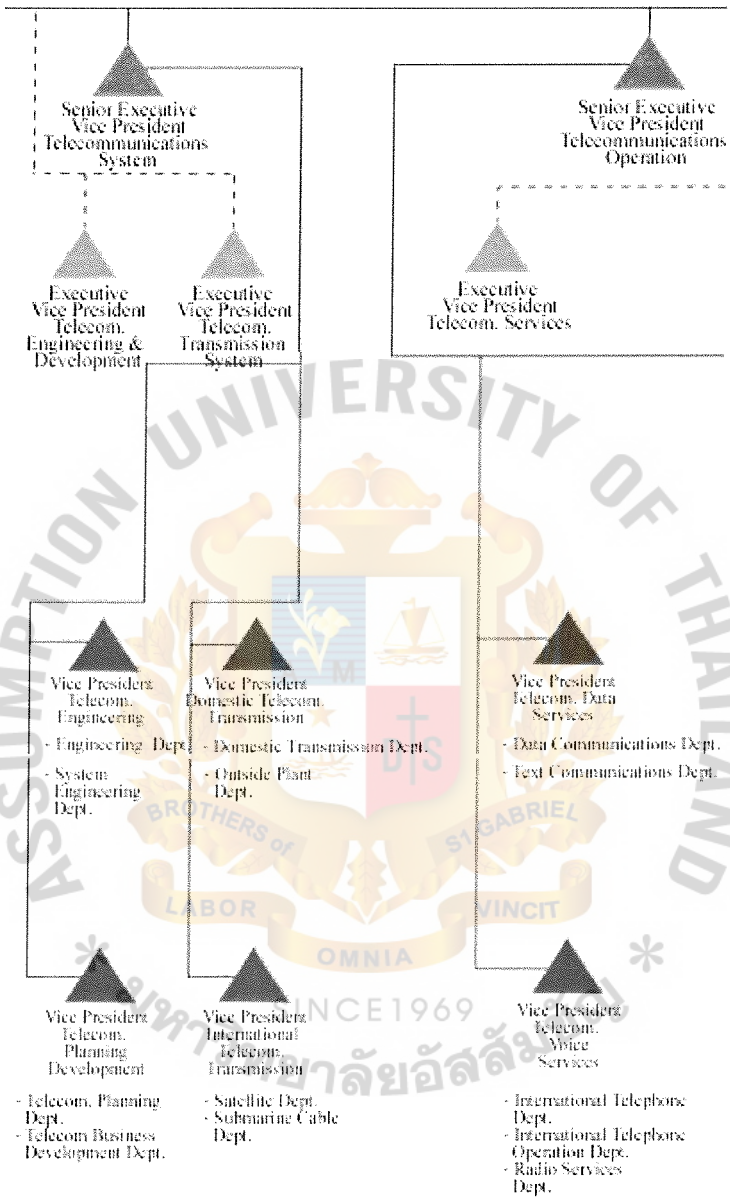


Figure 2.1. CAT's Organization Structure.

CAT's History

CAT was established on the 25th February 1977 by the provision of the Communications Authority of Thailand Act B.E. 2519. CAT bears an essential responsibility for Thailand's postal and telecommunications systems for the benefit of the country and the public.

CAT's Business Activities

As the main communications Hub of the nation, CAT plays an important role in developing and applying the most advanced technology for both postal and telecommunications systems, constructing both optical fiber submarine cable and satellite networks, investing in Intelligent Network of ATM switching system in order to effectively provide a variety of multimedia telecommunications services. CAT ranks among the leading telecommunications service providers in Southeast Asia region.

CAT's Objectives

(1) To enhance and offer high quality service and seek for opportunities in providing other related business.

(2) To apply advanced technology in operational and service development.

(3) To prepare for the privatization in the aspect of business management and financial independence.

CAT's Vision

Post: To become Thailand's postal business leader in providing international standard services to obtain highest customer satisfaction.

Telecommunications: To provide world standard telecommunications services in order to obtain highest customer satisfaction.

CAT's Intention

For long-term success, CAT determines to create high service standard and performance by effective cooperation, readiness and creativity. This strong intention will generate the growth of our organization for business profit and social value.

CAT's Policy

To successfully reach an excellent performance, enhanced policies in services, marketing, finance, investment human resources development, administration and

management, advance technology and welfare have been adopted, while focusing on standard business management for competition in the market. It aims to ensure customer satisfaction and to lay a firm basis for continuous self-development and to take care of our personal staff.

CAT's Mission

To bear an essential responsibility for Thailand's postal and telecommunications and other related business by providing high quality services with reasonable rates for the great benefit of the public.

CAT's Service for Oversea Call

001 Automatic Direct Call service (ISD) direct calls to anywhere in the world by pressing 001.

100 Operator Assisted Call Dial 100 to CAT's operator who will assist you in making a call to every country in the world.

International Prepaid Calling Card – THAICARD is the first international prepaid calling card in Thailand Users could make a call from Thailand to Overseas, in the meanwhile, from Overseas to Thailand and to Others Countries. It's a convenient way without any surcharge from any touch-tone phone in Thailand or mobile phone or from local public phones or disconnected-line phones.

International Toll Free Service (ITFS) Ideal for hotels, travel agencies, airlines, exporters, or international companies who wish to facilitate their customers in making a free connection.

PhoneNET CARD To facilitate international call service user on Internet protocol with Phone Net card: Phone-to-Phone (Phone to Phone: It's economic international calling card via CAT's Internet network. The service is now available for 88 countries around the world).

DATEL Data communications and facsimile service through Front End network. CAT will provide the network and assign special numbers to facilitate international reception and transmission of communication faster, clearer and more economical.

Thailand Direct

Direct line to Thailand from any type of telephone worldwide. With the help of a Thai operator and service charge billed to called party in Thailand, this service helps solve language barrier and voice.

Home Country Direct

International Call from Thailand connected through each country's operator to facilitate foreign businessmen and tourists in Thailand calling home

eFONE

It will be low-cost international calls, using Internet Protocol Network to reduce charges by 20-30%. Nowadays, it's available to 109 countries over the world.

2.2 Current Problems and Area for Improvement

Driven by information technology, customer' s needs and market competition, the telecommunication industry has been developing very fast in the last 10 years. Following these rapid changes, the telecom field has entered into a new era, which is featured by: With the monopoly status of the dominant telecom service provider concluded, lots of operators came in to being. More and more networks are built or are being built, including PSTN, PLMN and Data Network. As a result, a heterogeneous environment of multi-operators and based on multi-networks has formed, and has brought certain complexity for internetworking. One of the important questions raised today is how to interconnect all these networks.

Tandem Switch or Digital Switching System is responsible for transit Remote Switch to support and improve the operation of ANS (Access Node Switching). The

ANSs are installed in many places within Thailand and at the present every switching is connected directly to the ITSC (International Telephone Switching Center) in Figure 1.1. Previous reason is arrangement of incorrect network hierarchy as a result of a waste of traffic in ITSC so Tandem Switch installation will eliminate these problems.

Tandem Switches have trunks, and no lines, which allow faster call transfer nationwide. This multi-use, flexible switch eliminates the need for each and office switch to store multitudes of routing information, provides faster call transfer, and result in cost savings as well as gaining regulatory access charge revenues. They handle both local and long distance services, allowing customers to develop and manage their switch equipment in cost-effective manner, whether these needs are basic long distance, wholesale long distance, international long distance, or a variety of other service options.

2.3 Existing Switching System

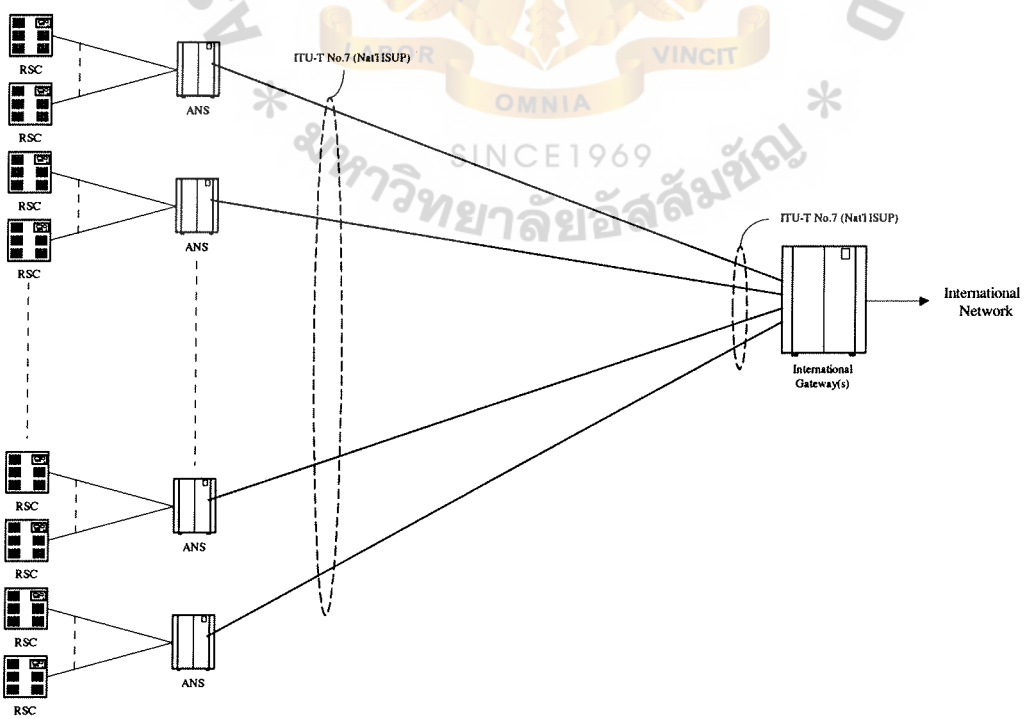


Figure 2.2. The Network Configuration No Tandem Switch.

Formerly the Network Configuration does not have Tandem Switch. All Access Node Switching (ANSs) are connected directly to the International Telephone Switching Center (ITSC). When the number of calls attempted exceeds the capability design, then we say the switching equipment, which is used in this time, is overloaded. The Switching proposed is "Tandem Switch" for the Communication Authority of Thailand.

III. THE PROPOSED SYSTEM

This paper was written to help telecommunication business; nonprofit organizations and other groups of people discover how to use Tandem Switch (Digital Switching System) to promote their organizations. Information is provided for this project to:

(1) Introduce the overall structure and performance characteristic of Digital Switching System.

(2) Study how Tandem Switch can provide high quality product and network solutions for International Telephone System that can provide abundant service.

(3) Study measuring the traffic of oversea call of International Telephone after adding Tandem Switching System.

In addition, this part will separate into each item that involves with Tandem Switching System: System Overview (Briefly introduces the general technical function, the new technologies applied in the system and the future development trend.), System Architecture (Introduces the Tandem Switch hardware and software architecture, typical hardware configuration and networking capabilities, and the six outstanding service aspects of Tandem Switch exchange.), Fully Open Terminal System (The terminal system of Tandem Switching System applies a Client/Server approach, with the BAM acting as Server and WSs as Clients), Performance and Characteristic, and Cost and Benefit Analysis (described in efficiency and effectiveness of Tandem Switch). These topics will be described in more detail.

3.1 System Overview

3.1.1 Brief Introduction

The new century is witnessing the information wave sweeping throughout the world. Telecom operation services and equipment manufacturing industries are facing a severe challenge of market globalization. Geographical distances disappeared due to sufficient transmission bandwidth. The future network will be a telecommunication network based on IP. This is not only a transformation of the telecommunication concept but also a revolution in the field of telecommunications. Following upon the heel, the reform and regrouping of the telecom industries will ensue worldwide. With the blend of telecom and computer technologies as well as the infiltration of various businesses into one another, the IT industry is heading forward to an era of digitalization, individualization, and intelligentization.

The Tandem Switching System is a high capacity digital SPC system designed by Huawei on the basis of the advanced technologies in 1990s, and complies with ITU-T recommendations to offer total solution for the ISDN, intelligent network services and the Internet as well as the SDH optic trunk interfaces.

The Tandem Digital SPC Switching System integrates the switching and transmission, wire and wireless, narrowband and broadband services, and provides an open network platform architecture, which wholly supports all kinds of services by the Public Switching Telephone Network (PSTN), Intelligent Network (IN), and Integrated Services Digital Network (ISDN).

In the Tandem Digital SPC Switching System, high-speed fibers connect the administration module/communication module (AM/CM) and each switching module

(SM). The distance between the RSM and the host exchange can be up to 50 km, which facilitates the establishment of a large local network based on a single exchange, and allows the capacity to be smoothly expanded from 256 lines up to 800,000 lines. The maximum system BHCA value is 6000 k. In the system, the wire and wireless subscribers can be installed simultaneously. The system is possessed of the optic fiber access ability, which, combined with various kinds of remote modules: RSM, RSA, and RIM, can build a multilevel network with remote modules, and achieve the FTTC (fiber to the curb) and FTTB (fiber to the building), which would simplify the structure and maintenance of the local network, thus improving the reliability and reducing costs. The system is capable of all the functions as follows: trunk exchange, combined trunk and local exchange, trunk tandem exchange, terminal exchange, combined trunk tandem and terminal exchange. It is also applicable to most kinds of specific communication networks.

The Tandem system is equipped with a built-in fiber transmission system to achieve the transparent transmission between exchanges. This is a breakthrough in the concept that the transmission is separated from the switching, and the system has integrated the transmission and switching equipment into one entity. Hence, system functions are improved, and equipment and maintenance costs are reduced.

Its trunk networking is very flexible. It can be used in the digital network, analog network, or combined digital and analog network. The Tandem Switching System is equipped with various kinds of digital and analog interfaces, including the E1/T1 interface. Based on the same hardware and minimum replacement in software, different signaling can be supported, such as No.7, V5.2, R2, etc. System can detect 24-digit and

14-digit No.7 signaling coding can be detected automatically.

The Tandem Switch provides various wireless access modes: large area ETS, digital mini-cellular small area ETS1900 and other wireless access devices based on the V5.2 interface. Wire and wireless subscribers can be combined into installation to achieve equal dial digits and functions.

Due to the increasing popularity of the computer applications in communications networks, the Tandem Digital SPC Switching System provides BRI (2B + D), PRI (30B + D), V5.2 and PHI interfaces. It provides the ISDN function; supports TCP/IP, X.2.5 and X7.5 protocols, and can make access to data networks (such as the Internet, etc.), the multi-media communication network and subscriber access network. It has the function of integrated services such as the voice, data, image, etc., and is capable of both narrowband and broadband services such as the data communication, television conference, multi-media communication, CATV, VOD, long distance diagnosis & treatment and long distance teaching.

The architecture of the Tandem Digital SPC Switching System provides a uniform exchange platform for the intelligent network, featured by the separation of the switching from services, intelligence of the whole system and service-customer oriented. It can serve as a Service Switching Point (SSP), and also supports the independent intelligent peripheral IP such as the voice mailbox and voice-activated dialing device. The Huawei TELLIN intelligent network, which is based on Tandem exchange platform, can expand the service scope greatly. It has been able to provide more than 20 types of services such as the Virtual Private Network (VPN), Universal Personal Tele-communications, Franchised Long Distance Service, Mass Call (MAS), etc. The

Tandem integrated network administration platform provides the standard interface for connecting to the software center system of the Telecommunications Office or other Telecommunication Management Network (TMN) systems so as to carry out the monitoring of the entire network traffic, supervising and analyzing of services performances as well as the scheduling of the entire network.

3.1.2 New Technologies in Tandem Switch

On the one hand, the rapid development and application of the Information Technology are now having a profound influence on people's lifestyle, and speeding up people's demands for varied information, which makes it very imperative to provide integrated and diversified services and new functions based on voice, data and image. Therefore, we must take into consideration the practical applications of the new technology to meet people's increasing demands for information. On the other hand, effective solution should be carried into execution to prevent existing traditional local exchanges from being severely impacted by the new Information Technology so as to ensure the sustained development of the communication network as a whole in the process of evolution, and to ensure low costs for its operations and services.

The coming of new Information calls for higher demands on the network competitiveness. But as we can see, the following baffling problems still exist in the local exchange networks:

(1) Conflict between the increasing demand for Internet and traditional communication network.

(2) Conflict between subscribers' increasing demand for new services and the operator's inability to provide the needed services in time due to the constant upgrading .

(3) Conflict between the diversity, specialty and punctuality of the local exchange services and the relative scarcity of services provided by the whole network.

(4) Conflict between the trend of the integration and development of the SDH optic transmission technology & switching technology and the traditional switching / transmission mode as well as their independent interfaces.

(5) Conflict between the demand for the broadband service and the gradual evolution of the existing narrow band exchange system.

The existing communication networks will face market globalization in many aspects, such as technologies, network architectures, service capacities and service standards. With the revolutionary development of the fiber communication technology, microelectronic technology, Internet technology, and computer technology, we are now stepping into a digital world in an information era.

Internet Access Technology

The development of the Internet technology is now changing our life gradually; make us stride into an information society. Nowadays, Internet subscribers in the world are increasing rapidly in number, which doubles every 56 weeks. At the same time, the increase of Internet subscribers has a great effect on the traffic of network. According to statistics, 50% of Internet subscribers spend more than 10 hours online per week on average, 20% spend more than 20 hours, and 30% of subscribers occupy their circuits for more than 3 hours per week on average. The long-time occupation of speech channels by the Internet subscribers has imposed a very heavy burden on the traffic of the

exchange and trunk tandem exchange. If the capacity is not increased, the net congestion is inevitable.

An effective solution to the net congestion is to adopt the Data Bypass technology of the Internet. By introducing bypass techniques for various IP services and through dedicated data lines such as DDN or E1, digital services directly bypass-switching network so that the high Internet traffic imposed on the switching network can be eliminated.

Instead of being connected to an Internet access server via the trunk tandem exchange, the local or exchange subscribers are first connected to the built-in Internet Access module of the Tandem Switch for packet and multiplexing, and then via the special data lines (such as DDN, E1, etc.) are directly connected to the ISP (Internet Service Provider). At the same time, the integration of the high-speed packet switching technology and telephone switching technology on a same platform enables the rapid extension of services and can provide various value-added services. Furthermore, it can also provide supplementary services, such as the IP phone and IP fax so that the interconnection between the PSTN/ISDN network and the Internet can be achieved.

Flexible Service-Providing Capability

The service-providing capability of the network is usually restricted by the existing exchange facilities. The increasing demand for various services by subscribers generally requires that existing network facilities be upgraded or different platforms be added for specified value-added services. For example, to put the Prepaid Card Service into operation, the addition of a set of Prepaid Card Service's platforms is required. More services are put into operation, more platforms are required to be added, which

would result in a situation that the value-added services can be only provided by constant additions of new platforms. However, there exists a conflict between this constant addition of services and the stability of the facilities. With its ability to swiftly provide subscribers and public with more useful intelligent services to meet urgent local needs, the Tandem Switch can not only enhance the competitiveness of the operation but also greatly increase business revenues.

To provide fast and varied services to subscribers, the Tandem Switch intelligent switching network adopts the integration of the switching and Standard Intelligent Network technologies to separate the service provision from switching. Without upgrading the existing network, users can create their own characteristic services on the SCE (Service Creation Environment) in accordance with their own requirements. This localized intelligent network, combining the Standard Intelligent Network and exchange and separating the service provision from switching, is just the Tandem Switch Intelligent Commercial Network. It can provide rapid and diversified services to the sub-scribers and is a solution not only for the conflict between the subscribers' increasing demand for supplementary services and the constant upgrade of facilities, but also for the conflict between the diversity and specialty of local exchange services and scarcity of the network service as a whole. It also ensures the stability and reliability of all network facilities. Typical applications of Tandem Switch-SSCP, such as NP (Number Portable) and Prepaid Card services are now practiced widely.

Open Interface

Larger capacity, fewer exchange administrations, complete and perfect signaling and services are the basic requirements for the new switching system. The switching equipment is required to provide the standard ISDN interface (signaling and services),

standard V5.2 interface, standard No.7 signaling system, caller identification function, capability of being upgraded to SSP, etc. Most of the aforesaid services and requirements have been widely applied in the Tandem Switch ISN (Integrated Service Network).

With the development of the SDH transmission technology and switching technology as well as the combination of the two, mounting the SDH interface on an exchange is not only a requirement by the development of the broadband network but also a means to greatly simplifying the trunk network. It greatly improves the integration degree and stability of the system. It can not only directly connect to the ATM to achieve the integration of the narrowband and broadband, but also can greatly simplify the switching system, thus making it advantage in respects of synthetic costs & profits, extendibility, etc.

As required by development, the Extended Internet Access Module is provided by the Tandem Switch system, which integrates the voice communication and data communication, extends the SDH interface, reduces the system volume & cost, and provides the system with the ability of being upgraded from the narrowband to the Broadband. It extends the generation of supplementary services and intelligent modules for the ISN, achieves the separation of the service provision from switching, provides fast and diversified services and increases incomes of telecomm operations.

Flexible Charging and Authentication Services

It can be foreseen that with the progress of technologies, new equipment and services will be constantly applied, thus making the operation and interconnection of networks more complicated. Due to this complexity in the future, the Tandem

Switching System provides a comprehensive solution for the interconnection of networks. The trunk capacity of a single exchange can reach 180,000. It provides a large-capacity black-and-white list for call authorizations among networks. It also provides a flexibly designed inter-network charging service with a high-degree safety assurance and processing capacity. The Tandem Switch provides an integrated broadband and narrowband switching platform combining the IP access, Internet access, IN services, PSTN, ISDN, V5.2 interface and wireless access.

The Tandem Switching System is in line with trends of data, intelligence, integration and broadband for the development of the modern communication network. It can meet the demand for building a next generation communication network.

3.1.3 Tandem Switch Development Trends

New technology offers a new developing space for telecommunications. Progresses in technologies of the fiber transmission, optic switching, and WDM (Wave Division Multiplex) make it possible to establish a highly transparent, flexible and ultrahigh capacity backbone optic fiber network. The potential immense 30 Hz optic bandwidth means that distance will not be a problem any more. The rapid upgrading in the integration degree of microchips and the research & application of the biochip technology are due to great promotion of the information processing. The concept of Old Network is now springing up. While the traditional network tells data where to go, in the new information network, data tell the network where to go. With the increased popularity of the Internet, the circuit switching technology will eventually give way to the packet switching technology based mainly on IP. From the integration of services to the merge of networks, the 3-in-1 integration of the communication network, computer network and cable TV network has become the trend.

3.2 System Architecture

3.2.1 Overall Architecture of Tandem Switch

Tandem Switch Hardware Architecture

As shown in Figure 3.1, the entire Tandem Switching system is composed of several major parts including the administration module (AM), communication module (CM) and switching module (SM). The AM is further divided into the front administration module (FAM) and back administration module (BAM). The FAM provides the interface between the main processing unit (MPU) and the operations & maintenance terminal. Messaging via FAM carries out establishments of inter-SM connections. All inter-SM speech channels must go through the central switching network on the FAM. The BAM adopts the client server method to provide the connection between the exchange system and the open network system, and is connected to the FAM directly through Ethernet interface/HDLC links. It is the hub for connecting the Tandem Switch exchange with the computer network. The Ethernet interface provided can be connected to a large number of workstations. It also provides X.25/X.35 interfaces for connection to the network administration center. The CM is mainly composed of the central switching network and optic communication interface, responsible for providing inter-modular signaling and speech channels.

The SM is the core of the Tandem Switching System, providing functions such as the distributed database management, call handling, operations & maintenance, etc. The single T switching network in the SM can independently perform the switching function of this module, and can also coordinate with the central switching network on the AM/CM to perform the inter-SM switching function. The SM terminals can be analog subscriber line, analog trunk line, digital subscriber line or digital trunk line. In terms of interfaces provided, it is categorized into three types: user module (USM), trunk

switching module (TSM), and user trunk module (UTM). In terms of locations and functions, the SM can also be categorized into the local and remote types, etc.

Interfaces between the AM/CM and SM include the 40Mbit/s fiber, SDH interface, E1 interface, etc. The CM and SM are connected by two pairs of active/ standby or load-sharing 40Mbit/s fibers. The FAM and BAM are connected by high-speed HDLC links. There are many interfaces, such as LAN, FDDI, V.24, V.35, etc., between the BAM and the operations & maintenance terminal.

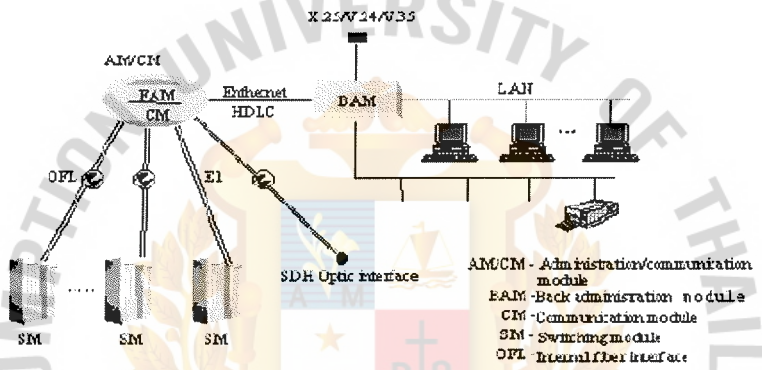


Figure 3.1. Tandem Switch Hardware Architecture.

Tandem Switch Software Architecture

(1) Tandem Switch software system structure

Tandem Switch software system is designed according to the software engineering standard, which uses top-down, modularization layer designing methods to guarantee the manageability of the software by strict file control. Software integration design is abided in the whole process. To guarantee object code manageability and software reliability, maintainability and expandability, SDL and CASE tool are adopted. Tandem Switch software use C language as programming language to make source code easier to read and maintain. Tandem Switch software consists of:

(a) Operating system

(b) Communication task

(c) Resource management task

(d) Call processing task

(e) Database management task

(f) Maintenance task

Figure 3.2 shows the relationship of these tasks.

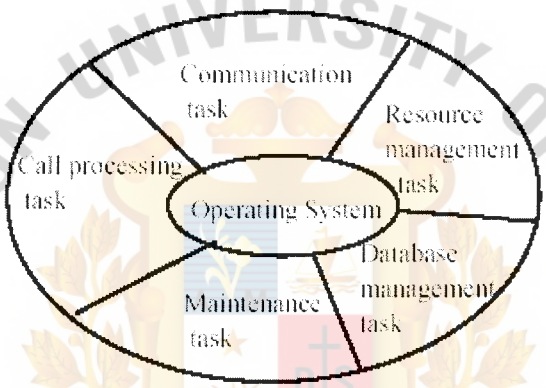


Figure 3.2. Tandem Switch Software Architecture.

Operating system is the core part of the software system. It includes system level processes, other services are application-level processes based on operating system. Software can be divided into multiple levels in concept of virtual machine. Lower level task system is connected with hardware platform, higher level task system is independent of specific hardware platform, the hardware related part is packetted with core codes, thus making software easier to transplant and install. As in Figure 3.3.

(2) Tandem Switch operating system

Operating system refers to the system management program. The program managed by operating system is called application program.

Operating system executes the functions of task dispatch, memory management, file management, peripheral management and user interface management. According to its dispatch strategy, the operating system can be classified as batch-processing operating system, time-division operating system and real time operating system.

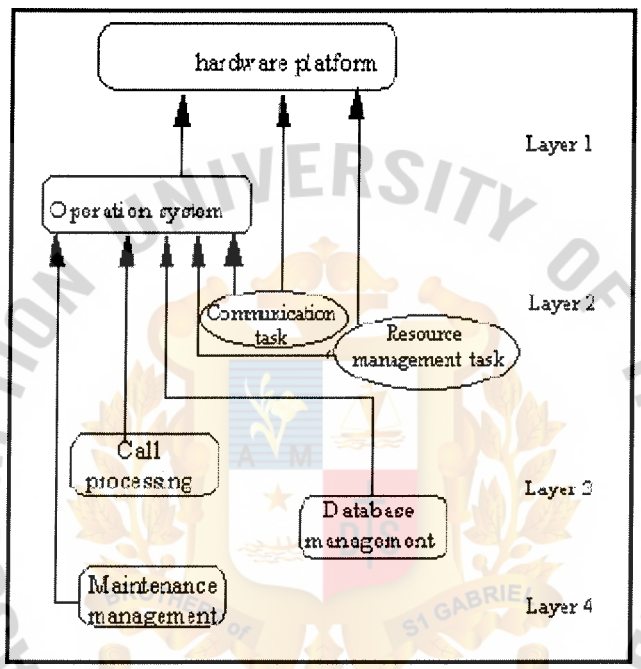


Figure 3.3. Tandem Switch Virtual Machine.

In the field of SPC exchange, the real time operating system must be used to achieve high-speed response to the external events. The so-called "real time" means the system can respond quickly enough to the external events. It also has the ability of priority scheduling, error-detection and preemptive scheduling.

Priority scheduling means that in multitask real time system the processor executes the tasks according to their priority level to guarantee the task of high priority is executed first.

Preemptive scheduling means when external event happens, the processor can stop the current task arbitrarily, then the processor turns to handle another task after site protection.

Error detection means that operating system can supervise status of all tasks. If anything abnormal is detected, it can do fault tolerance processing to keep the system work normally. This kind of task is defined the highest priority.

Tandem Switch operating system is a real time operating system in an embedded application environment. Basic function as follows:

(a) System initialization

(b) Program loading

(c) Interrupt management

(d) Task scheduling

(e) Message packet management

(f) Memory management

(g) Timer management

(h) Clock management

(i) System load control

System initialization: completes whole system software and hardware configu-ration and initialization.

Program loading: downloads the program and data to MPU memory from ter-minal and starts the execution.

Interrupt management: completes interrupt vector configuration and interrupt processing procedures.

Task scheduling: multitask priority scheduling and related resources manage-ment and distribution in multi-real time processing system.

Message packet management: communication entity among tasks in Tandem Switch software system. Any task activation is driven by message packet sent by another task or operating system.

Memory management: completes memory resource dynamic allocation and release management.

Timer management: completes all kinds of timing task initiation, activation and cancellation.

System load control: the operating system supervise and control a processor occupation rate automatically. When system utilization rate reaches the preset upper threshold, lower level tasks will be paused to reduce processor load. When processor occupation rate goes down to the preset lower threshold, overload control is relieved.

Clock management: the management of system time, including year, month, week, day, hour, minute, second.

(3) Tandem Switch communication tasks

Tandem Switch is a multi-processor system. Communications among module processors and second level processors are performed by communication task. Communication task relationship is as in Figure 3.4.

(a) Active /standby processor communication task

To guarantee system reliability, Tandem Switch implements dual processors in one module in active/standby mode. When error occurs in active processor, the standby processor will take the control to support the system's running.

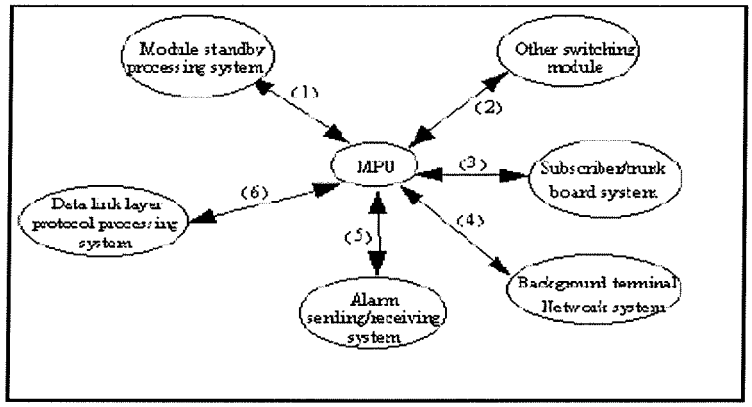
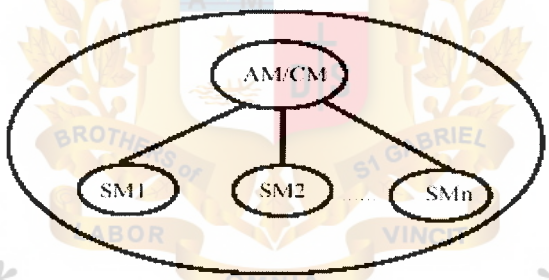


Figure 3.4. Tandem Switch Communication Tasks.

(b) Module communication task

Tandem switching system consists of multiple modules, forming a switching plat-form as in Figure 3.5:



AM/CM: Administration/communication module SM: Switching module

Figure 3.5. Tandem Switching Platform.

(c) Main node communication task

Subscriber/trunk circuit card processing system collects and analyses analog or digital signal and reports to module processor with certain protocol via main node communication task, or send commands to subscriber terminal or opposite exchange after receiving the command from module processor via main node communication.

(d) BAM communication task

BAM communication task provides maintenance management operation to switching system. It is a network system permitting multi-workstation to operate the switch.

(e) Alarming communication task

The alarming communication task responsible for the communication of alarming card and alarming box.

(f) Communication task between MPU and data link layer protocol system Responsible for communications between MPU and other processing systems in Tandem switching platform.

Communications inside the software system are performed by message packet process of the operating system, not belonging to communication task. Communication tasks are at the lower level because they deal with hardware.

(4) Resources management tasks

Resources referred here are hardware resources related with switching services (e.g. switching network, signal tone source, DTMF receiver, DTMF sender and voice mail box, etc.). Resources management task complete hardware resources initialization, applying, releasing, maintenance and test, specifically including:

(a) Switching network management task

(b) Signal tone source management task

(c) DTMF receiver and sender management task

(d) Multi-frequency signal receiver and sender management task

(e) Voice mailbox management task

(f) Operator management task

The above tasks are at lower level of the whole software system because they deal with specific hardware platform. They mainly provide service supporting for the call processing tasks.

(5) Call processing task

Call processing task completes specific call services. It can be divided into two levels according to Q.931, subscriber side and network side. Subscriber side has following tasks:

(a) Analog subscriber management

(b) Analog trunk management

(c) No.7 signaling management TUP, ISUP, SCCP, TCAP, MTP, etc

(d) An subscriber management

(e) Packet network interface

(f) CAS signaling management

(g) Digital subscriber management

(h) Digital trunk management

(i) PRI interface

(j) Operator management

The state definition, state transition and message packet format at subscriber side and network side are designed strictly according to ITU Q.931 instructions and realized by protocol engineering method to guarantee the completeness and correctness. Their relationship is as in Figure 3.6.

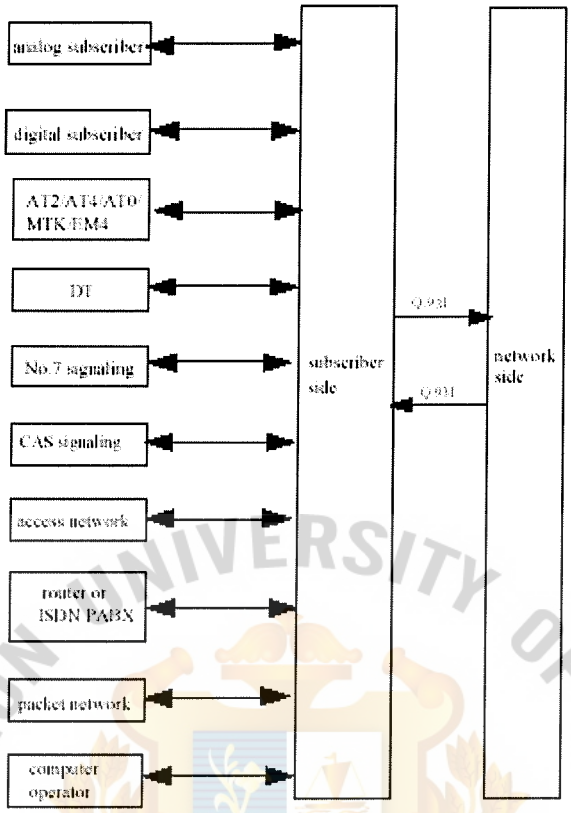


Figure 3.6. Call Processing Task.

(6) Database management

Database management tasks are responsible for data management of the whole switching system (including configuration data, subscriber data, office data, network management data and charging data). Tasks include: data storing and inquiring, data maintenance, data update, data copy and data restoration. Database in Tandem Switching system is a distributed relational database. Each relational table is in- dependent and describes a group of related data. Tandem database provides multi-level index mechanism and structure searching algorithm to provide quick service for other application tasks.

Tandem Switch database management systems are divided into two layers: RDBMS and Tandem Switch application data, as in Figure 3.7.

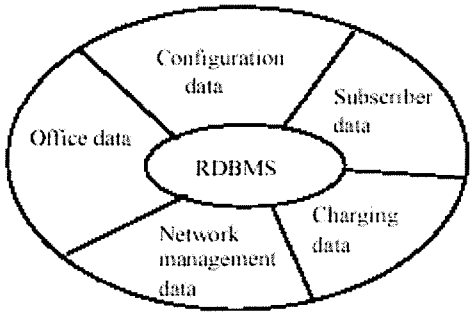


Figure 3.7. Database Management Tasks.

(7) Maintenance tasks

Maintenance tasks enable the maintenance personnel to monitor and operate Switching equipment, which including:

(a) Equipment management

(b) Charging and ticket management

(c) Line signaling supervision

(d) Subscriber/trunk testing

(e) Alarming management

(f) Traffic statistics

(g) Call connecting process tracing

(h) General message tracing

3.2.2 Tandem Switching System Configuration

The Tandem Switch is an open system platform with integration of the switching, optic communication and computer technologies. It adopts the modularization concept in design. The switching module (SM) is connected with the communication module (CM) and administration module (AM) via two pairs of tertiary block fibers. The expansion of capacity is conducted in the form of block building, which facilitates flexibly building the capacity as needed. The SM can be used not only as a module

exchange, but also as an independent exchange. Typical configurations of the Tandem Switch are indicated as in Table 3.1.

The configuration of the Tandem Switch system is flexible and its adjustability is good. For example, modules can be smoothly piled up to 128 SMs at the most. The proportion between the number of subscribers within a module and that of trunks can be set flexibly. Subscriber interfaces and trunk interfaces can be equivalently and mutually substituted. Addition of 60 trunk lines can be enabled by every reduction of 304 analog subscriber lines. The DSL and ASL slots are compatible with each other. Each card providing eight 2B+D interfaces. With the combination of the digital trunk module (DTM) card and different LAP's, the 30B +D interface, V5.2 interface and packet

Table 3.1. Tandem Switch Typical Configurations.

Types	Module Exchange			Independent Exchange		
	Number of DS Line	Number of Trunk Line	Number of Rack	Number of AS Line	Number of Trunk Line	Number of Rack
Subscriber	6688		4			
Trunk		1440(DT)	1		1920(DT)	1
Subscriber/Trunk Combination	4256	480(DT)	3	5169 3648 1824	480(DT)	4 3 2
IN module				512 (console) + 512 VP	1500(DT)	2+2(19")

Where : DT- Digital trunk VP - Voice processing station

handling interface (PHI) can be achieved respectively. According to the traffic, the number of inter-modular speech channels can be adjusted in the unit of 32 channels.

When the expansion of capacity is on a small scale and does not require the addition of switching modules (SM), it is only necessary to add the subscriber shelves and get them connected to the pre-reserved node communication lines and the switching network HW lines. If new SM switching modules are to be added, these new SM modules can be configured independently without affecting other modules. It is only

necessary to add a pair of optic interface cards on the AM/CM module with their optic links connected in series. In short, the design of the Tandem Switch system adopts the modularization technology by which the smooth expansion of capacity can be carried out. See Figure 3.8.

One single SM module can serve as an independent exchange. The capacity of the Tandem Switch can be smoothly expanded up to 800,000 lines

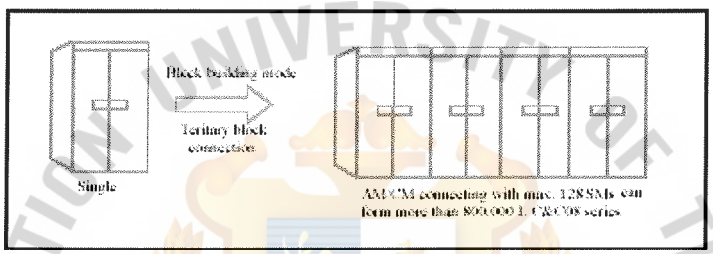


Figure 3.8. Smooth Expansion of Tandem Switch.

In addition, at the outset of the design of the Tandem Switching System, preparations were made for the future extension of new services.

(1) Extendible service functionality

Each hardware card only provides the internal and external interfaces, and actual Operations are executed by software. Therefore, only software upgrading is necessary for the updating of services instead of the replacement of any card. Loaded with different software, many cards of same hardware can be configured as cards for different services.

(2) Extendible intelligence services

The Tandem Switch integrates the switching and computer technologies. It is equipped with a special card, MEM, to provide the

Ethernet interface, which offers a good platform for developing intelligent services such as the Tandem Switch Campus Card System.

3.2.3 Tandem Switch Network Construction

The Tandem Switching system can meet the demands for the transition from the public switching telephone network (PSTN) and special communication network to the integrated services digital network (ISDN), and for developments of the multi-media, intelligent network and broadband services. The Tandem Switch applies to the trunk exchange, combined trunk and local exchange, tandem exchange and terminal exchange. It also can serve as an exchange for all the special communication networks (such as those in the Power, Railway, Oil, Colliery, Military and Police administrations or industries). See Figure 3.9.

Generally, the Tandem Switch has three setups: (1) large and medium capacity, (2) small independent exchange, (3) various remote modules. Among them, (1) applies to local exchange, trunk tandem exchange, trunk exchange and gateway exchange in big and medium-sized cities; (2) applies to terminal exchange in medium-sized and small cities and rural areas; and (3) applies to network construction in areas with a relatively scattered subscriber population.

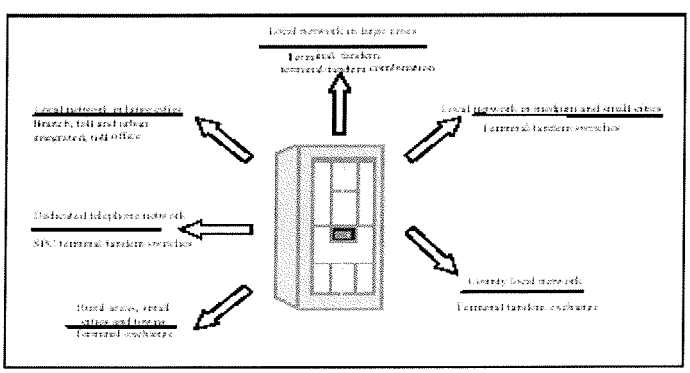


Figure 3.9. Flexible Tandem Switch Configuration.

In the Tandem Switch exchange, each SM, connected with the AM/CM via two pairs of fibers, can be co-located in a same equipment room with the AM/CM. Depending within the range of 50 km from the AM/CM module, which then is referred to as the remote switching module (RSM). In addition to the RSM, the Tandem Switch can provide various types of remote modules: remote subscriber, remote subscriber unit (RSU), RSA. Refer to Figure 3.10.

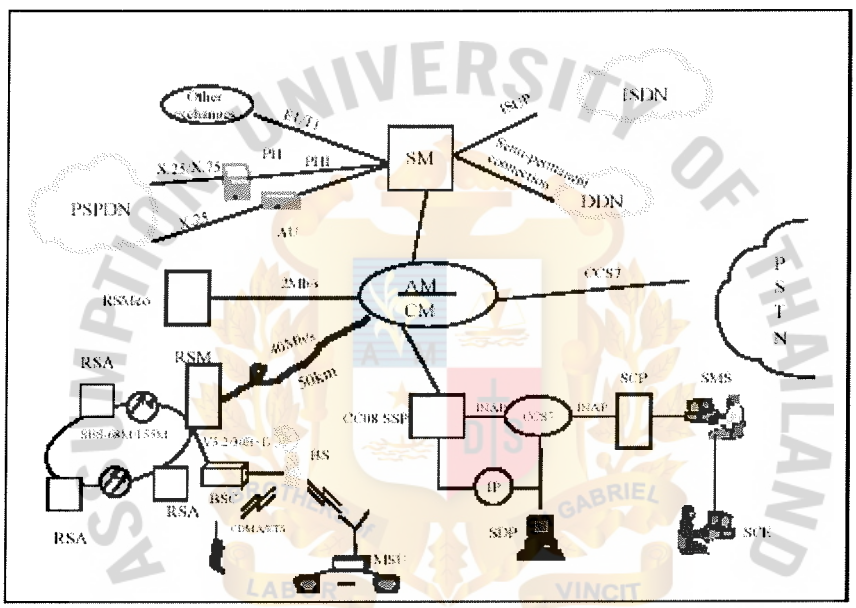


Figure 3.10. Tandem Network Construction Based on the Integrative Network Platform.

3.2.4 Tandem Switch Designing Ideas

Reliability Design

Comprehensive and systematic measures have been adopted to ensure the reliability of the software and hardware in the Tandem Switching System.

(1) Key parts adopt the active/standby mode to ensure the reliability.

(2) Multi-processor redundancy technology is adopted to further improve the

(3) System reliability and Distributed processing.

(4) Mutually assisting mode.

(5) Flash memory is used for permanent storage of programs and static data. Data Restoration takes less than 3 minutes.

(6) ASIC technique is adopted for cards to simplify the system and enhance the Stability of parts.

(7) Object-oriented software designing.

(8) Perfect card test function, supporting card online test.

Reliability Assurance

It is necessary to note that the reliability design of the Tandem Switch is based on the following reliability guarantee systems:

(1) Strictly conforming to Software engineering Control Development Test

(2) ISO 9001

(3) Strict and careful validation and selection of parts

(4) 72-hour aging of cards and the entire machine.

(5) Advanced workmanship and strict quality control

(6) Five-star after-sale service

3.2.5 Features and Advantages of Tandem Switch

In general, the Tandem switch is possessed of the following main features and advantages:

(1) Powerful processing capacity with the maximum BHCA value reaching 6,000k, which supports a maximum traffic volume of 100k Erlangs. The BHCA of a single module can reach 210K. Figure 3.11 illustrates the relationship between the number of calls per hour and the CPU occupancy rate during the call test in single module.

(2) Service Processing Module (SPM) utilizes multi-processor technology and enhances its processing capability by piling up more processors.

(3) Providing various modules and flexible network construction capabilities. Adaptable to varied network construction requirements.

The modules include the SM, RSM, RSM of E1 Interface, RSA and RIM.

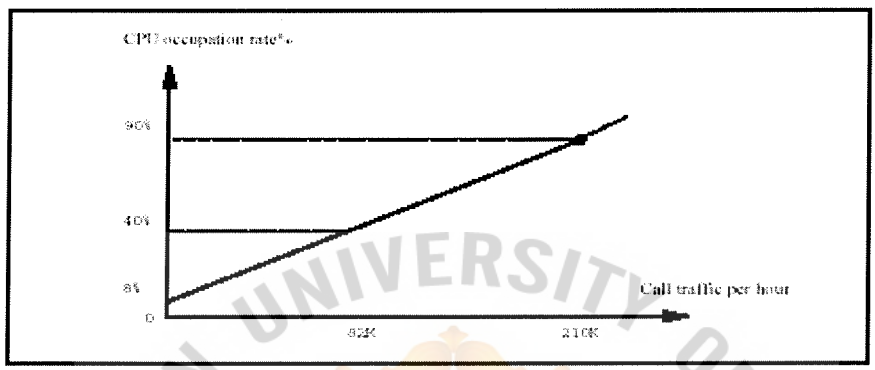


Figure 3.11. Relationship between the CPU Occupation Rate and Calls per Hour.

(4) Providing one-telephone-multi-network function for the special network subscribers, as well as a variety of inter-network interfaces adaptable to varied network construction requirements.

(5) Providing graphic user interface (GUI) and the man-machine language conforming to the ITU-T standard (MML).

(6) Access to the workstation is through the TCP/IP protocol which makes available the multi-location maintenance and remote dial-in maintenance.

(7) The powerful billing & charging system is provided.

(8) The alarm system is capable of accurate faults locating as well as real-time reflection of the system operation status.

(9) The traffic statistic system is powerful, in conformity with the ITU-T standard, service-oriented, user-oriented, and comprehensive in statistic operations.

(10) Both the internal test interface and the standard centralized test interface are provided.

(11) Abundant in service functions. New services and supplementary services are 100% applicable.

(12) The powerful function extensibility can facilitate introducing new services.

(13) Internet access handling unit is provided to meet the demand of the rapid Development of digital communication.

(14) Intelligent business service solutions are provided. It can be upgraded to SSP by changing software.

(15) The SDH interface is provided to support the large-capacity network construction requirements such as the trunk/trunk tandem exchange, etc.

(16) Power consumption of the system is low.

(17) In addition, the Tandem Switch processes the following advantages:

(18) The consummate signaling system, with the number of its links reaching up to 4096, can reliably achieve the interconnections among different types of signaling.

(a) The consummate ISDN services, including route selection, billing & charging, basic services, supplementary services, PSTN services, etc.

(b) Providing specific services such as the hotel function interface.

(c) Varied module interface types, which supports the DDN access (sub rate, N>64K)

(d) Supports the requirements by the interface exchange in respects such as signaling, billing & charging, route selection, etc.

Various Supplementary Services Provided

The Tandem Switching System provides the following supplementary services:

(1) Listening to pre-recorded automatic announcements before the ring tone.

(2) Single-call-multiple-ring service, namely, when a call arrives, all unengaged phones in the same group would ring, and once the call is answered by any of these subscribers, all other phones would stop ringing. This function is only available on a same module.

(3) Supporting the third party charging and the UUS charging.

(4) Supporting measuring platforms.

(5) Toll call handling surrogated by the operator.

(6) Supporting the ring-back and re-ring functions for the operator.

V5 Interface

The standard V5 interface is provided between the Tandem system and its access Network. The V5 interface is categorized into the V5.1 and V5.2 interface. The V5.1 interface supports 2Mbit/s access (e.g. wireless access loop). The V5.2 interface supports n 2Mbit/s access (n=2~16).

Features of Tandem Switch interfaces are:

(1) Standard, open, and able to connect to any access network device equipped with this kind of interface.

(2) High reliability. The V5 protocol has protection rules. Besides, two active/standby signaling links can be mounted on a same interface.

(3) High signaling load capacity. Each protocol card possesses two microprocessors, which are able to handle 8 HDLC links simultaneously. Each link can handle a traffic load of 3,000 circuits.

(4) High maintainability. The V5 interface is able to carry out the maintenance management both locally and remotely with the real-time monitoring of the V5 signaling and connecting processes.

The standard V5 interface provided by the Tandem Switch can be connected to the AN device equipped with the standard V5 interface through the 2M port on the DTM card. The processing of the V5 protocol is carried out by the LAP. The digit receiving function for the AN subscribers is performed by the DTR card. The architecture of the V5 interface unit is illustrated in Figure 3.12.

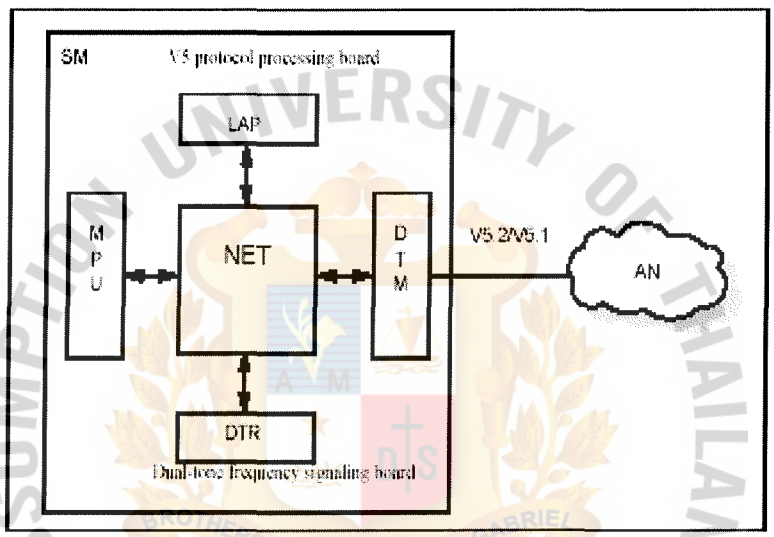


Figure 3.12. V5 Interface Unit.

Internet Interface

The Internet access functional frame is introduced in the Tandem Switch SM module to add an Internet access handling unit, which can simultaneously handle services such as voice communications, Internet access, IP phone service, etc. Each access functional frame can provide 240 access terminals, and the total capacity can reach up to 11,520 access terminals (in the case of No.7 Signaling) or 7,680 access terminals (in the case of ISDN, PRA). Figure 3.13 shows the architecture of the Internet access-handling unit.

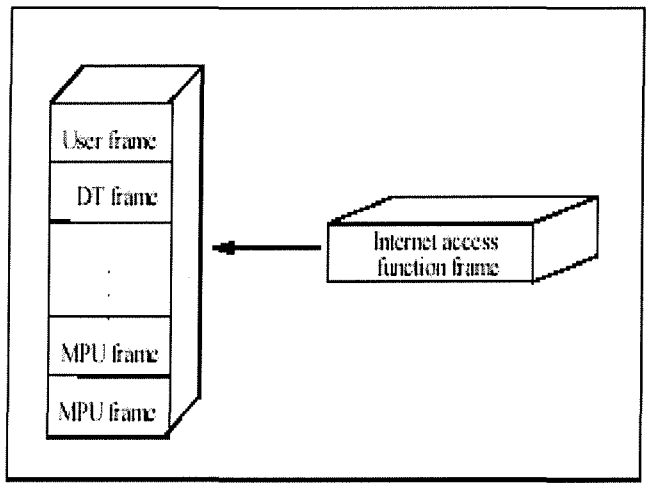


Figure 3.13. Internet Access Handling Unit.

ISDN Services

The ISDN has become a main way to provide integrated services of voice, data, image, etc. The Tandem Switch provides three kinds of ISDN interfaces: 2B+D basic rate interface (BRI), 30B+D primary rate interface (PRI) and packet handling interface (PHI).

The 2B+D BRI conforms to the ITU-T G.960 standard. Each DSL (Digital Subscriber Line) card provides 8 ports. The processor on the card handles the first layer and second layer protocols, while the MPU on the SM handles the third layer protocol.

The 30B+D PRI interface conforms to the ITU-T G .703 standard. The D signaling channel connects to the LAP via the switching network, which can be activated after the SM module processor has downloaded the PRA protocol handling Software packet.

The design principles of the PHI interface are similar to those of the 30B+D interface. The difference is that the downloaded protocol handling software packet is the PHI protocol in conformity to the ETSI300-099 standard.

The Tandem Switch ISDN supports the circuit and packet switching services as well as various ISDN supplementary services and user terminal services. It is applicable to the TV conference, live broadcasting, desktop conference system, multiple-user screen sharing, high-speed file transmission, extension and inter-connection of Intranets, Internet access, G4 fax machine, long distance diagnosis & treatment, and can also serve as a reserve for the DDN private line, etc. See Figure 3.14.

The fundamental task of the ISDN is to provide integrated, comprehensive and varied services to subscribers. The ISDN service must be complete, able to guarantee the terminal-to-terminal compatibility, and use standard service processes to achieve the high quality communications between terminal subscribers both domestically and internationally.

For detailed descriptions of the ISDN, please refer to the ISDN specific chapter in this manual.

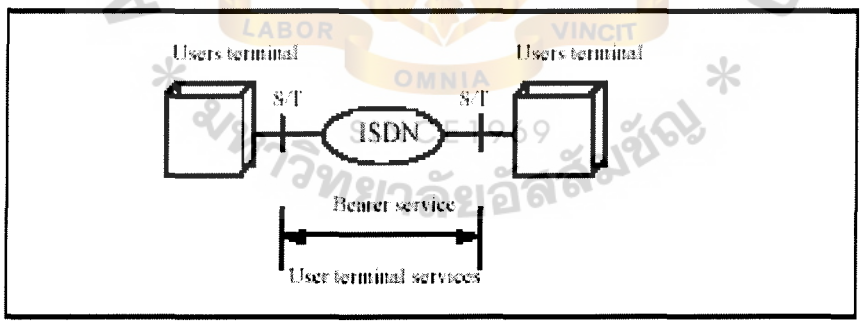


Figure 3.14. Illustration of ISDN Services.

Intelligent Business Service

The Tandem Switch can introduce more local intelligent services, which are more suitable to fulfill the requirements of the telecommunications sector. The system structures and interfaces all conform to the standard intelligent network specifications. It

can quickly enhance the service capacity and intelligence level of local networks without constant upgrading of exchanges. It is an ideal solution for the economic and rapid provision of local special services. Please refer to the IN specific chapter in this manual.

3.3 Fully Open Terminal System

By adopting the client/server scheme, Tandem Switch BAM provides the system with fully open interfaces, which makes it possible to extend the system in an LAN mode, to operate in parallel with multiple processors and to fulfill the requirements of multi-point maintenance. Figure 3.15 illustrates the network architecture of the BAM.

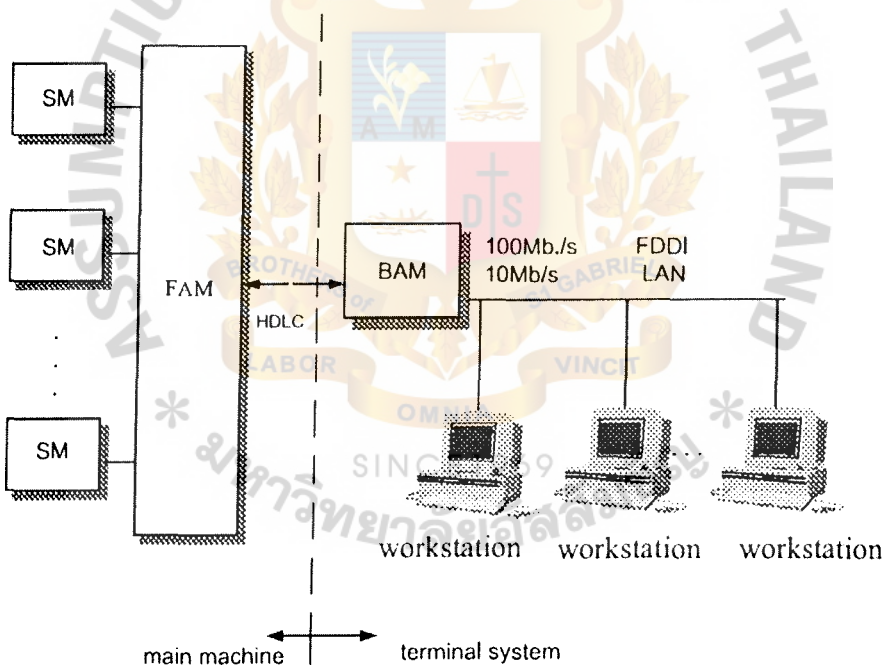


Figure 3.15. The Terminal Architecture of the Tandem Switch.

The LAN-based terminal system is capable of providing data communications at 10 Mbps. High reliability and network file servers ensure security of data. Using LAN-based open decentralized database, the Tandem Switch terminal system can interconnect with third party's devices or systems, serve as a third network management

center or a charging center, and interwork higher rank network management center via X.25 data networks.

The Tandem Switch terminal operation platform is Windows based, with advanced multi-window interfaces. It offers complete functions relating to traffic statistics, billing, data management, maintenance, testing, etc.

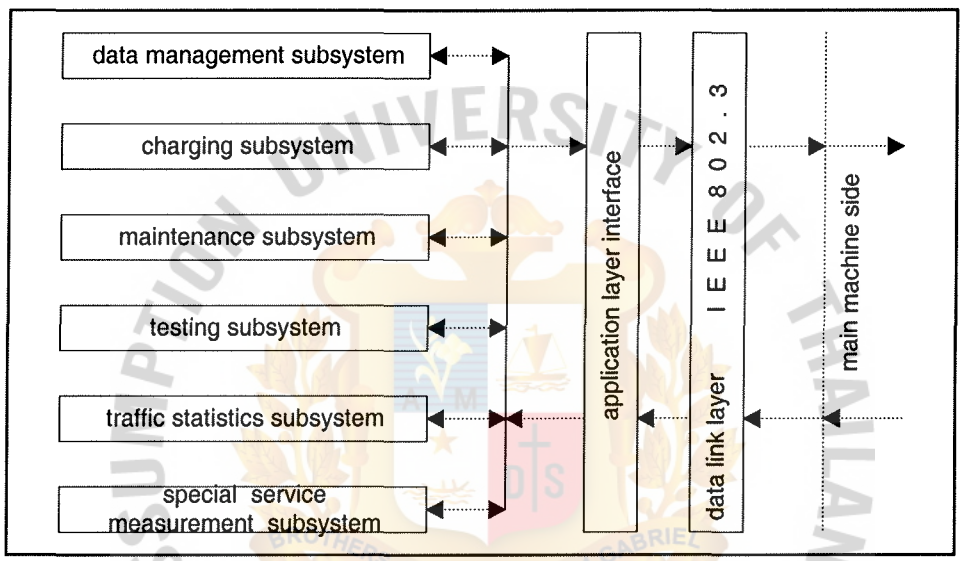


Figure 3.16. Software Architecture of the Tandem Switch Terminal Workstation.

Figure 3.16 shows the software architecture of the Tandem Switch terminal system. The Tandem Switch terminal system introduces the ideas of open design and OOP (Object - Oriented Programming) software design concept, and employs decentralized database technique and the C++ and OOP database languages in its development. By further providing the forth generation SQL (Structured Query Language), it greatly enhanced the inquiry speed.

3.4 Performance and Characteristics of Tandem Switch

The Tandem Digital Switching System features integration of optical and electronic technology, switching and transmitting, wire and wireless accessing, narrow

and broad bandwidth, basic and intelligent services, as well as integrated network management. Tandem Switch comprehensively provides services to public telecom network, private telecom network, intelligent network (IN), and integrated service digital network (ISDN)

3.4.1 Modular Design

SM gets connected with AM/CM through 2 pairs of optical fiber (Third Order Group). SM is able to expand capacity in modular and stackable mode, and therefore, can be flexibly configured to meet the required capacity. SM can be used either in a multi-modular exchange or in a single modular exchange. The typical configurations of Tandem Switching System are shown in Table 3.2.

Table 3.2. Typical Configuration of Tandem Switch.

Type	Multi-modular Exchange			Single Modular Exchange		
	Number of Analog Subscriber Lines	Numbers of Trunks	Numbers Of racks	Number of Analog Subscriber Lines	Numbers of Trunks	Numbers Of racks
Pure Subscriber	6688	-	4	-	-	-
Pure Trunk	-	1440(DT)	1	-	1920(DT)	1
Subs/Trunk Mixed	4256	480(DT)+64(AT)	3	5168 3048 1824	480(DT)+ 64(AT)	4 3 2
Intelligent Module	-	-	-	512(Seats)+512(VP)	1500(DT)	2+2(19"Racks)

Note : AT - Analogue Trunk; DT – Digital Trunk; VP – Voice Processing

The Tandem Switching System provides flexible configuration. Each digital truck board and each user frame takes up some system resources. So they can be replaced by each other as long as the system resource is enough. In fact, every decrease of 304 analog subscriber lines (the maximum lines a user frame can provide) implies capability of an increase of 60 digital trunks (the trunk circuits a digital trunk board can provide). The DSL (digital subscriber line) board and ASL (analog subscriber line) board have

the compatible slots. Each DSL can provide eight 2B+D interfaces. Together with different protocol processing boards, the DTM (digital trunk module) can provide 30B+D interface, V5.2 interface or PHI interface respectively.

For a small-scale capacity expansion with no need to increase any SM, the only work left to do is to add subscriber frames or whole racks, which will then be simply connected to the switch through the reserved node communications lines and HWs. But if new SMs are indeed added, such new SMs can be independently installed without any influence on other SMs. And then, using a pair of newly added optical interface boards and optical fiber links, we can easily connect such new SMs to the AM/CM. Figure 3.17 depicts the smooth expansion of capacity.

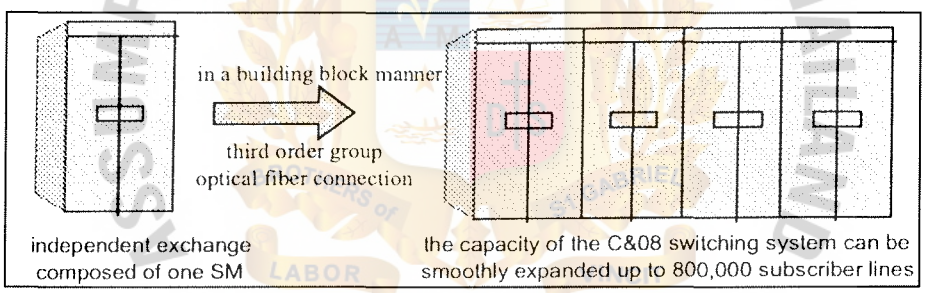


Figure 3.17. Smooth Capacity Expansion of the Tandem Switching System.

In a word, since it adopts the modular design technique, the Tandem Switching System can easily realize smooth capacity expansion.

3.4.2 Flexible Networking

The Tandem Switch digital SPC switching system meets the requirements of the development of public and private telecom networks, transmission, ISDN, wireless communications, multimedia communications, access network, intelligent network, and broadband services. It can be used in public telecom networks, such as in international office, toll office, combination of toll and local switch, tandem office, end office, local

office, and can also be used in various private telecom networks, such as those of electricity, railway, oil, army, and public security.

Tandem Switch posses various digital and analogue interfaces supporting E1/T1 interface. It could support CCS7, V5.2, and R2 signaling protocols by running different software on the same hardware basis. R2 signaling board and CCS7 signaling board have compatible slots, and for CCS7 signaling system 24 bits and 14 bits coding could be automatically distinguished. Keeping pace with proliferation of digital communication network and computer technology, at the present stage Tandem Digital Switching System can provide BRI (2B+D), PRI (30B+D), V5.2 and PHI interfaces; has ISDN functions; supports TCP/IP, X.25 and X.75 Protocols; is able to access data communication network (Internet, PSPDN, ATM for example), multimedia communication network, subscriber access network, and has integrated service function for voice/data/imagery transmission. Therefore, Tandem Switch can realize data communications, conference TV, multimedia communications, CATV, telemedical treatment and remote education by means of both narrowband and broadband services.

As shown in Figure 3.18, the Tandem Switching System has three modes of configuration: A) large or medium capacity switch; B) single module exchange with small capacity: C) using various remote modules in configuration. Of which, mode A is provided for the local and exchange, tandem exchange, toll exchange, and gateway in large and medium cities, mode B for the SPC end exchange in medium and small cities or in country seats, and mode C for networking in areas where the subscribers are relatively scattered.

For a multi-modular Tandem Switch, the basic SMs, which are connected to the AM/CM via two pairs of optical fibers, are placed in the same machine room of the AM/CM, therefore constituting a centralized large capacity exchange. And at the same

time Tandem is also able the access remote subscribers with such methods as RSM (Remote Switching Module) and RSA.

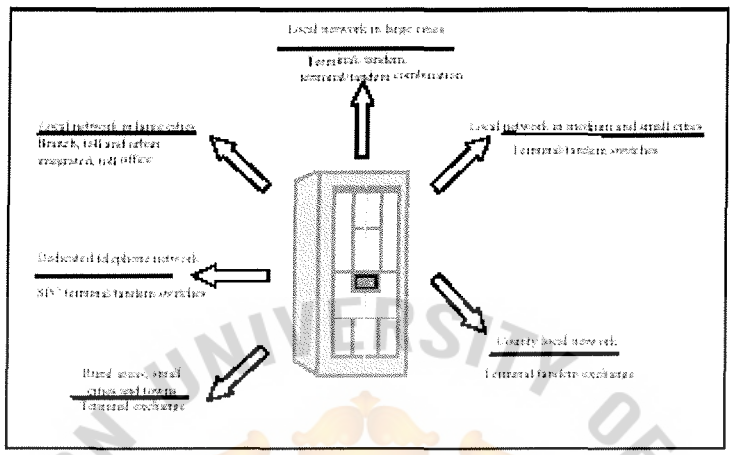


Figure 3.18. Flexible Configuration Modes of the Tandem Switching System.

RSM: The RSM is an SM used as remote module connecting to host exchange via E1/T1 interface utilizing a special protocol. The functions and interfaces of RM is same as those of local SM so that it can implement the intra-module switching.

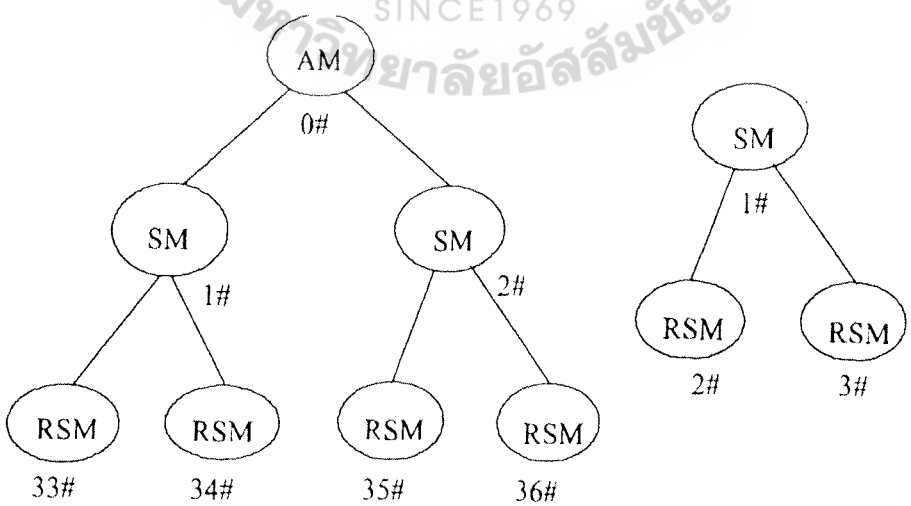


Figure 3.19. Typical Networking of RSM.

RSM' s main advantages are as follows:

(1) Fully utilizing the existing transmission network;

(2) Easy to construct large area high-capacity local networks with fewer exchanges;

(3) The host (AM/CM) exchange can implement central maintenance, charging statistics, data management to all of the RSMs;

(4) The internal switching function ensures higher reliability and security when emergency.

RSA: RSA is the subscriber shelf of SM or RSM used a single unit in remote area, connecting with SM or RSM via E1/T1 interface. The unit capacity is 256/304L per shelf. The compact unit integrates the internal E1/T1 interface into subscriber shelf. Simply adding subscriber shelves can smoothly expand its capacity.

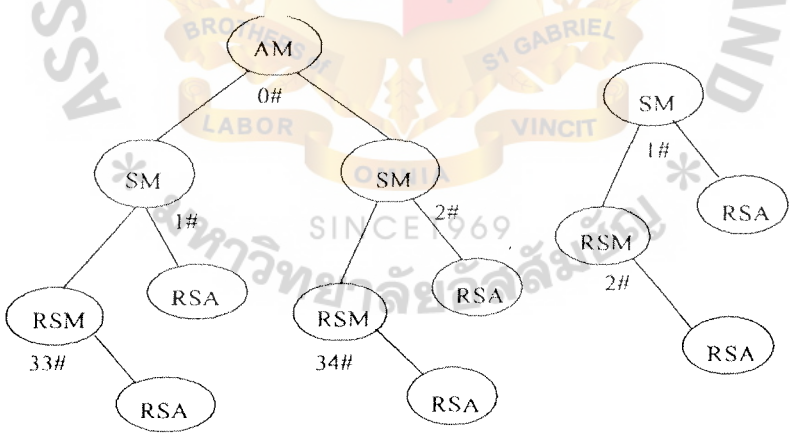


Figure 3.20. Typical Networking of RSA.

RSA has the comprehensive access capability. It not only provides interfaces for analog subscriber line, ISDN 2B+D, V.24/V.35/n × 64 kbps/sub-rate DDN, but also provides the environment monitoring hardware interface. RSA can be accessed via

optical transmission system or PCM system, as well as through 2 pairs of telephone lines by utilizing the technology of HDSL (high-speed digital subscriber line). RSA does not have independent switching ability but have function of line concentration with variable convergence ratio. The switching, maintenance and billing functions will be realized in the USM, UTM and/or RSM, which the RSA is connected to. The Tandem Switch Remote Modules are listed in Table 3.3.

Table 3.3. Remote Modules of Tandem Switch.

Remote Module/ Unit	Capacity per Module/ Unit(L)	Concentrations Ratio	With / without Independent switching Function	Links with the host exchange
RSM	2000 - 6688	4:1,6:1or 8:1 according to requirement	Yes	E1/T1 transmission system
RSA	304	4:1 or according to requirement	No	Optical fiber or E1/T1 Transmission system 30B+D, HDSL

3.4.3 Wireless Local Loop

The Tandem Switch wireless access system is an effective approach to realization of personal communications. The Tandem Switching System integrates wired/wireless switching functions. The wired and wireless subscribers can be concurrently installed in and served by the same switch exchange, as illustrated in Figure 3.19

The Tandem Switching System provides a number of wireless access modes: ETS450/150, ETS450 and ETS1900. Of which, ETS450/150 is a cross-band duplex system, while ETS450 is a co-band duplex system. Both of them are macro-cellular based wireless trunk systems with a coverage radius of 20 ~ 60 km, and therefore are pplicable to the communications in medium and small cities, remote suburbs and countryside areas.

ETS1900 is a DECT technology based digital micro cellular system with a coverage radius of 0.2 ~ 0.5 km, applicable to commercial areas and the areas of high density of subscribers in large and medium cities.

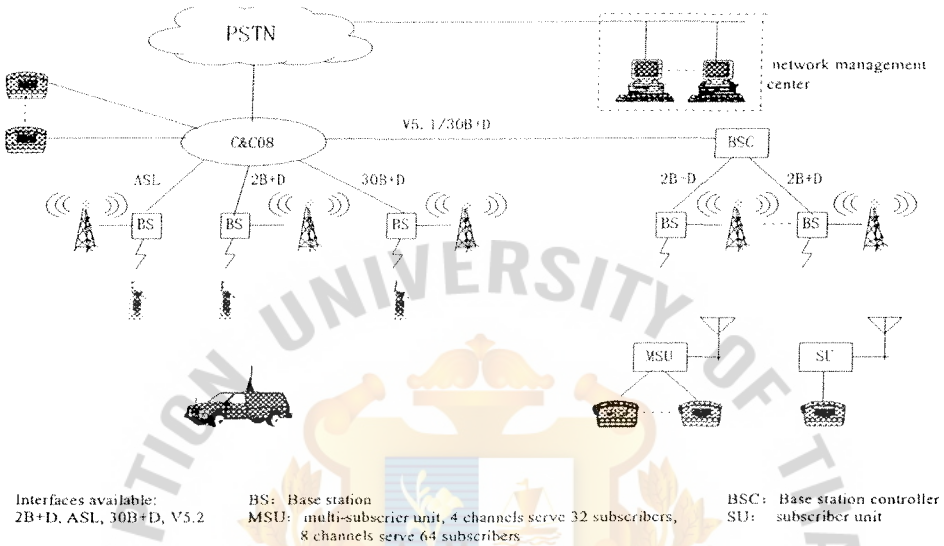


Figure 3.21. Network Architecture of the Tandem Switch Wireless Access System.

The wire-line and wireless subscribers can be installed in a same module and bear identical length of phone number and providing identical functions.

3.4.4 V5 Interface

V5 standard interfaces (classified as V5.1 and V5.2 interface) are installed between Tandem Switch Digital Switching System and access networks, in which the V5.1 interface supports access at 2 Mbit/s rate and V5.2 n × 2Mbit/s (n = 2-16) rate.

The V5 interface of Tandem Switch features as:

(1) Standardized and open. It is capable of interconnecting with any access network equipment equipped with V5 interface.

(2) Highly reliable. V5 protocol has protection regulations, and two signaling links working in active/standby mode are equipped on each interface.

(3) Large signaling processing capacity. Two microprocessors are installed on each protocol handling board for simultaneous processing 8 HDLC links, and each link can handle the voice traffic for 3000 circuits.

(4) Easy for maintenance. V5 interface may be maintained locally or remotely. V5 signaling and connection process can be supervised on real time.

3.4.5 ISDN Services

ISDN has become one of the major means in providing integrated services such as voice, data and images. The Tandem Switching System provides three kinds of ISDN access modes, namely, BRA (basic rate access 2B+D), PRA (primary rate 30B+D) and PHI (packet handling interface).

The base rate interface 2B+D is designed in compliance with the ITU-T recommendation G960. Each DSL board, the processor on which fulfills the processing of layers 1 and 2 protocols, while the main processor of SM carries that of layer 3 out, can provide eight such interfaces.

The primary rate interface 30B+D is designed in compliance with the ITU-T recommendation G 703, its D channel is connected to an LAP via switching network, and is activated by SM downloading PRA protocol handling software package.

PHI is designed with the same principle of 30B+D. The difference is that its downloaded protocol handling software package is a PHI protocol of standard.

The Tandem Switch ISDN system supports circuit-switched and packet-switched bearer services, as well as ISDN supplementary services and user terminal services. It is applicable to such fields as video conferencing, live broadcasting, desktop conferencing system, screen sharing, high bit-rate file transmission, expansion and interconnection of LANs, Internet access, G4 fax, tele-diagnosing, and severing as a backup of DDN dedicated lines.

3.4.6 Intelligent Networking Services

The architect structure of Tandem (Digital Switching System) provides unified switching platform for IN, the platform featured in the separation of service from switching, intelligent capability for whole network and subscriber-oriented. It can act as Service Switching Point (SSP), Service Control Point (SCP), and Service Management Access Point (SMAP), Service Creation Environment (SCE) and Service Data Point (SDP) supporting stand-alone intelligent peripherals, such as voice mailbox and voice initiated dialing device etc. Through adopting intelligent network, Tandem is able to expand service coverage, such as No. 600 virtual networking service, No. 700 personal communications service, No. 800 call accounting and No. 900 public information service etc.

Intelligent network (IN) provides intelligent service. "Users" of IN include the telecom network's subscribers and telecom network carriers (such as those who want to obtain the services specified in IN "Capacity Set (CS)", to obtain the support for network management, etc.). IN separates service logic from switching logic, strengthens software functions and uses network-wide shared service control equipment and intelligent peripherals. This makes it possible not only to introduce new services without increasing hardware investment, but also to popularize new services promptly, and thus create excellent economic returns for the users.

The Tandem Switch IN is designed with "user" oriented concept, taking into consideration the omni bearing requirements of the "user". The Tandem Switch IN is mainly composed of SSP, SMS, SMAP, SCE and IP.

(1) Service switch point (SSP)

The Tandem digital SPC switching system also incorporates all SSP functions, and its software has CCF (call control function) and SCF (service

control function) functions, thus it can interwork with the SCP to carry out service logic. It supports 13 service independent building blocks (SIBs) of IN Capacity Set – 1 (CS-1) and some self-defined SIBs. It is also equipped with SRF (specialized resource function) functions (such as number receiver, voice announcement, conference bridging circuit, voice recognition, voice synthesis, protocol conversion, etc.). The Tandem IN (Intelligent Network) also supports independent IP. In addition, it provides tandem circuits for access of switches without SSP function at transitional stage.

(2) Service control point (SCP)

Each SCP can control and complete the provision of various services. To use SCP, specific services under jurisdiction of each of the SPCs within an IN should be defined one by one according to the SCPs within an IN should be defined according to the service classes available to "users" and the traffic of each service in use. The Tandem SCP employs high performance fault-tolerant computer and offers the choosing, invoking and action management of various service logic processing instances (SLPIs). It provides No.7 signaling and X.25 interfaces, which are used to connect it with SSP, IP, SMS and other SCPs.

(3) SMS and SMAP

SMS (service management system) and SMAP (service management access points) are a service data management platform to perform the management of SCP, SSP and IP, to load tested GSL (global service logic) definition files onto the SCP and SSP, and to provide IN "users" with multiple point remote management interfaces.

(4) Intelligent peripheral (IP)

IP provides specialized resources for IN services. It is connected to SSP via INAP/DSSI, and connected to SCP via INAP.

(5) Service creation environment (SCE)

SCE is an UNIX operating system based interactive operation platform, providing functions needed for the definition, verification, testing of GSL. The Tandem IN may define and create new services at any time according to the development and the user's demands.

3.4.7 Business Communications Network Services

The Tandem Switch business communications network (BCN) is based on ISDN and IN technologies, optical communications and computer technologies, aimed to satisfy the requirements of users for voice, data and image communications, and used to provide a technical solution to the integrated service network combining three networks of telecom network, computer network and CATV network.

BCN is superimposed on the PSTN in an overlay network mode, making full use of existing network resources and without reforming the existing network in a large scale. Since business subscribers are widely scattered, therefore most of the BCN services are required to provide over different areas. The Tandem Switching System network uses the Tandem Switch as its node, making full use of its advantages in multi-level networking with remote modules. The connection of AM/CM between respective SMs is made with optical fiber links; with the remote modules of RSM, RSA and RSU, different network architectures such as chain, ring, or tree one can be formed according to the actual networking situation, so as to cover the majority of local business subscribers in a large or medium city. Abundant signaling systems and interfaces offered by the Tandem Switch System facilitate the flexible interworking and

interconnection of the business communications network with other networks. BCN uses the CCS7 TUP (telephone user part) to interwork with PSTN, uses the CCS7 ISUP (ISDN user part) to interwork with ISDN nodal switches, uses the PHI interface to interwork with PSPDN, uses INAP to interconnect with IN, uses the V5.1 interface to access wireless equipment, uses the 30B+D interface of V5.2 to access ISDN PBX or Internet, uses 2B+D interface of V5.2 to access ISDN users, and so on and so forth, thus realizing integrated wired/wireless, fixed/mobile, narrow/broad band voice, data, and image services.

The commercial network of Tandem Switch can provide multiple services, such as ISDN service, IN service, Corporate Card service, and calling number display etc.

3.4.8 Processing Capabilities

The BHCA of each SM is 171 k (Occupation rate of CPU is 52%) evaluated by State Telecommunication Administration. For the whole system, the BHCA value reaches up to 6000k and traffic processing capability reaches up to 45,000 Erl.

The system provides CPU overload control mechanism. And when the system enters into overload or blocking status emergency warning messages will be issued, then after the system has restored to normal condition, the restoring event-warning message will also be issued.

In Tandem Switch the dialed number storage capability reaches 24 digits and analysis capability to 16 digits. The man-machine interactive command setting could define whether the area code should be appended or not when sending the caller' s subscriber number (the default setting is "Not append").

3.4.9 System Reliability

Tandem Digital Switching System takes comprehensive and systematic measures for reliability to ensure the system running reliability in both hardware and software.

(1) The board level hot-standby structure is adopted for important components.

(2) Multi-processors and multi redundancy technology are utilized.

(3) Distributed processing.

(4) Cross assistance work mode.

(5) Program and static data are permanently stored in the flash memory components so that the restore time of a module is less than 3 minutes.

(6) Adopting ASIC technology to single boards to reduce system complexity and upgrade components stability.

(7) Object oriented software design methodology.

(8) Sophisticated board testing function supports online testing.

3.5 Cost and Benefit Analysis

3.5.1 Network Solution and Efficiency

Tandem Switch is a switching system of the message network that establishes trunk-to-trunk connections. A method of interconnecting Central Office by tandem office when the end office does not have trunks directly to each other, or as an alternate route if direct trunks are busy. There are Local Tandems, Access Tandem and Packet Tandem. The Tandem Switching application provides an administrative interface to configure and provision the Tandem Switching feature within the system as well as to manage the day-to-day switching operations.

Key factor for developing solution: Tandem Solutions provide a wide range of functions to provide full control over the business. Tandem Switch provides authorization codes to identify subscribers, determine their class of service and features and collect call details by specific user within subscriber's organization.

As shown in Figure 3.22, Network Configuration without Tandem Switch show how to make a call from Thailand to oversea which has two kinds of traffic as follows:

(1) TOT Traffic comes from TOT Gateway 1 and TOT Gateway 2 so called New Secondary Center (13 NSCs) via CAT Gateway 1 and CAT Gateway 2 into the destination.

(2) CAT Traffic, CAT (International Telephone Service) has Remote Switch which are installed in many places within Thailand for providing International Telephone Service. Many subscribers make an international call pass through PBX (Private Branch Exchange), ANS (Access Node Switch), CAT Gateway 1 or CAT Gateway 2 and finally to the destination.

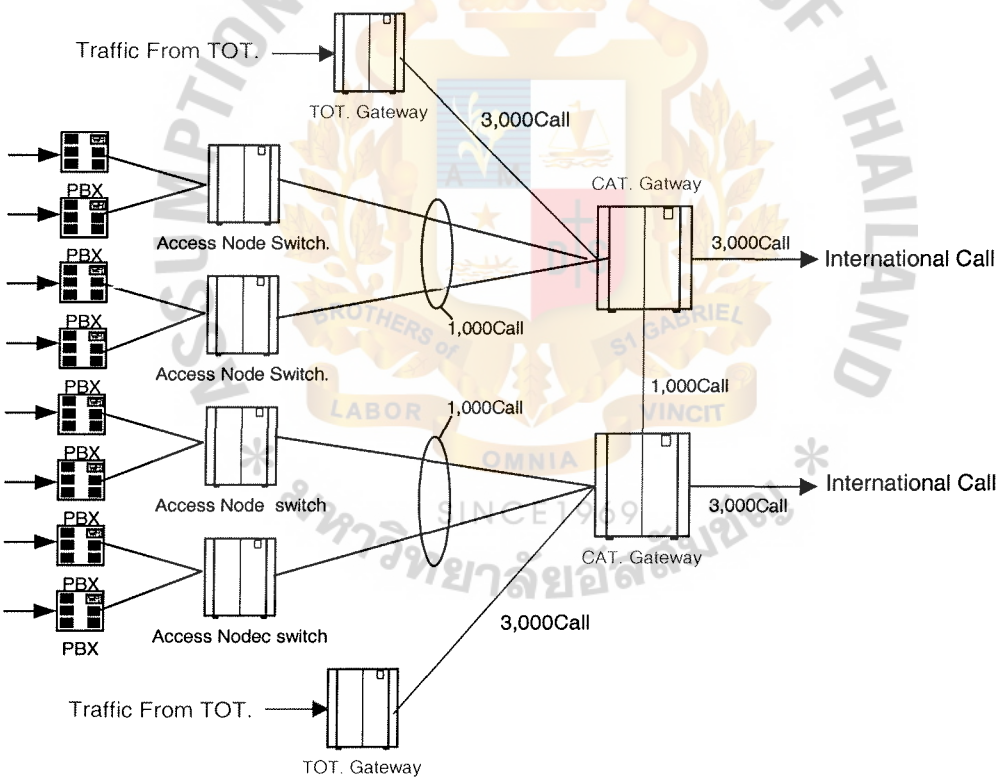


Figure 3.22. Network Configuration without Tandem Switch.

However, CAT Gateway 1 and CAT Gateway 2 have transmission that connects to some country as a result of technical reason and transmission system.

Table 3.4. Transmission in CAT.

CAT Gateway 1	CAT Gateway 2
Australia	Australia
Canada	Bangladesh
China	Cambodia
German	Canada
Hawaii	Denmark
Hong-Kong	Finland
India	Greece
Iran	India
Italy	Israel
Japan	Japan
Jordan	Korea
Korea	Macao
Malaysia	Norway
Myanmar	Pakistan
Nepal	Philippines
Netherlands	Russia
New Zealand	Saudi Arabia
Nigeria	Singapore
Norway	Spain
Oman	Switzerland
Poland	U.S.A
Singapore	United Arab Emirates
South Africa	Vietnam
Spain	
Sweden	
Taiwan	
U.S.A	
U.K	

List of countries, which are linked to both CAT Gateways. When you make an international call by passing CAT Gateway there is no transmission with the country that you make a call. So the mentioned call will be transmitted to another gateway that we call overflow call. The overflow call is sent into Tie Line via CAT Gateway that has transmission with the destination country that you dial to.

For instance, when a customer makes a call from PBX 1 via ANS and CAT Gateway 1 into Norway, so called destination oversea, from Table 3.4, CAT Gateway 1 has no transmission into Norway. So the mentioned call becomes an overflow call and

is sent into Tie Line and CAT Gateway 2 and its transmission is connected with the destination

In case, the customers of TOT want to make a call to Germany by passing TOT (Telephone Organization of Thailand) Gateway 2 which connects CAT Gateway 2 but it has no transmission with Germany, the mentioned call becomes an overflow call which is sent into Tie Line and CAT Gateway 1 and its transmission is connected with the destination.

While it may not be obvious to people who are not involved in telecommunications, there are limits to the traffic handling capacities of every carrier. No one, including CAT, is immune to occasional blockages. If you don't believe it, make a call on New Year's Day in Thailand - you can be assured that every network has periodic overloads. From all previous reasons, CAT Gateway must check all incoming calls as a result of overload on CAT Gateway (International Telephone Switching Center). In addition, CAT Gateway can support maximum capacity of 3,000 calls at the same time; and Tie Line that links between both CAT Gateway has only 1,000 circuits. Finally we can summarize the technical data for each CAT Gateway as follows:

(1) It can support a maximum capacity of 3,000 calls.

(2) Transmission between CAT Gateway and TOT Gateway is 3,000 calls.

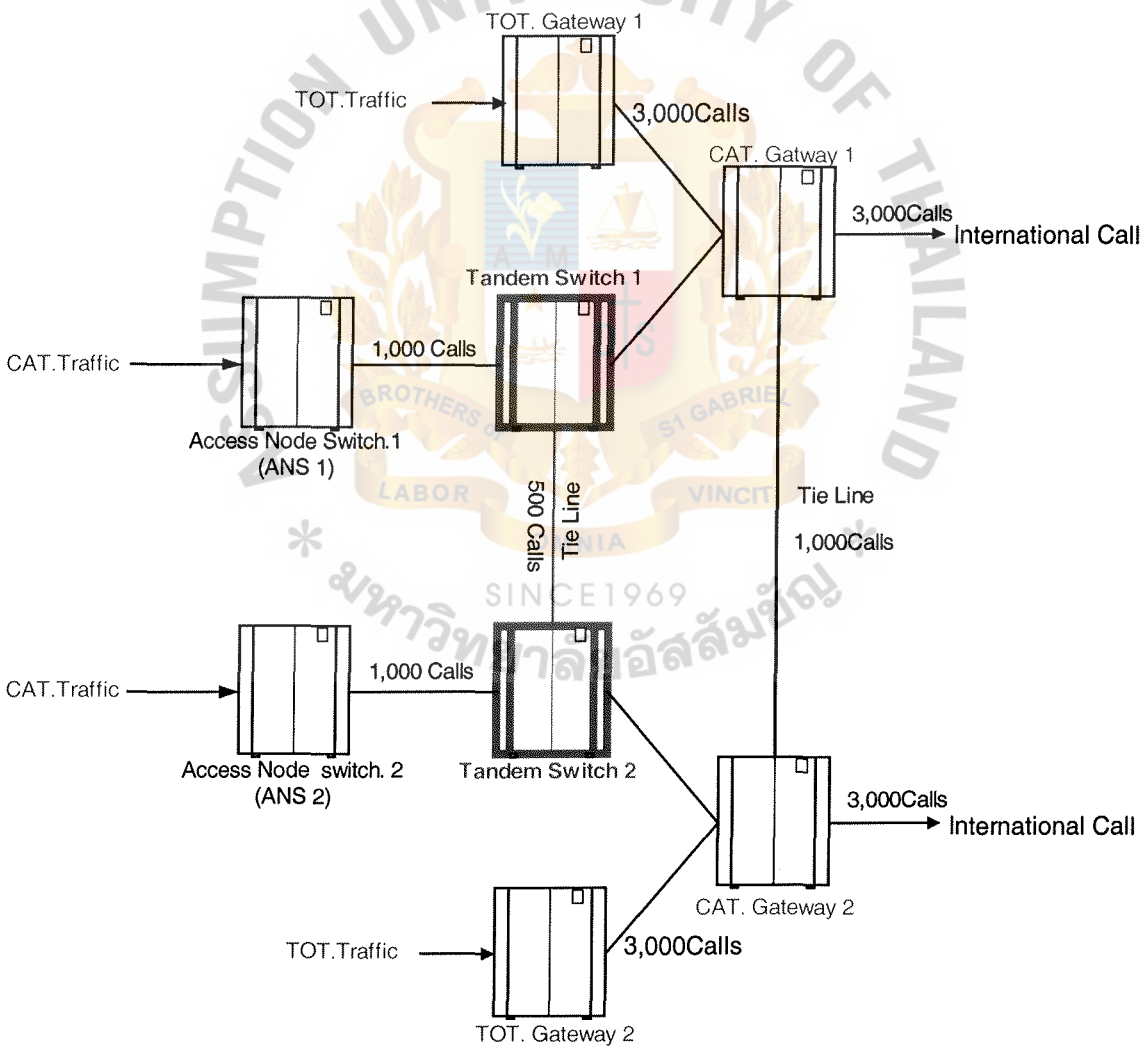
(3) Transmission between ANSs and CAT Gateway is about 1,000 calls.

(4) Transmission between CAT Gateway1 and CAT Gateway 2. (Tie Line circuit) is about 1,000 calls.

If incoming calls to CAT Gateway exceed 3,000 calls then the exceeding calls can not be handled, i.e. it reduces CPU ability. This is called Call Attempt. Because of Tie Line circuit of 1,000 circuits, if numbers of calls between CAT Gateway are sent to Tie Line more than 1,000 calls, the rest of the calls are called Call Attempt.

At first, CAT does not have Tandem Switch to increase the efficiency of CAT Network. So CAT loses annual revenue very much because of high quantity of Call Attempts.

To solve these problems and to increase the efficiency of CAT Network is to support more traffic and to reduce Call Attempts. CAT does improve Network Configuration, see Figure 3.23 by increasing Digital Switch, so called Tandem Switch; therefore it is easy to implement transmission in CAT Network.



CAT : Communication Authority of Thailand TOT : Telephone Organization of Thailand

Figure 3.23. Network Configuration with Tandem Switch Describe Number of Calls.

Are you beginning to see that whenever you engineer a telecommunication circuit, you have certain requirements that have to be arranged? Talk paths, signaling, control – these are the fundamentals of any communications circuit. If you are still curious and want more detail, just visit the Appendix B on. Tandem No.7 Signaling System

Figure 3.23, Network Configuration with Tandem Switch, describes the number of calls. The architecture was enhanced by adding "Tandem Switch" between CAT Gateway and ANSs. When you connect the call to overseas by passing PBX and ANSs into Tandem Switch, Tandem Switch examines this call whether its destination and transmission are to any country and any CAT Gateway respectively. After we send call into the target CAT Gateway which helps reduce CPU operation in CAT Gateway the officer will be responsible to check call that comes from TOT Gateway.

But there is no doubt, as the CAT Network efficiency is increased to conclude that Tie Line circuit is operated especially for TOT Traffic but for CAT Traffic, subscriber is defined the destination using only Tandem and call transmission that will take place on Tie Line between both Tandem Switch.

All in all, telecommunication has a bright future; having said that, the results are high efficiency by adding two sets of Tandem Switch in CAT Network which is decrement in Call Attempt, increment in Call Complete and cost saving including gaining access charge revenues.

3.5.2 Effectiveness

The comparison example shows that the efficiency of network is better after installing Tandem Switch by measuring the number of Call Complete before and after installation. The Network Configuration is adapted from the illustration in Figure 3.23. In addition, this figure shows the direction of traffic send from National Gate Way (TOT) into International Gateway (CAT).

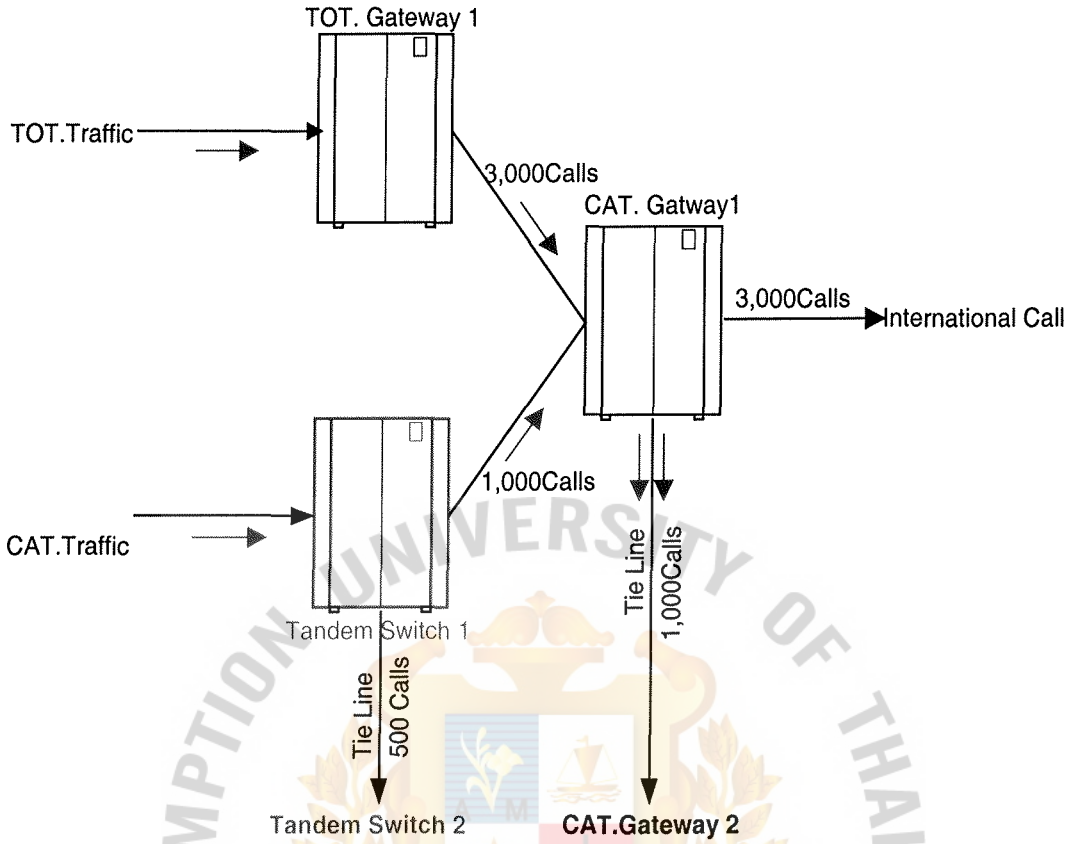


Figure 3.24. Traffic Flow after Adding Tandem Switch.

It is easy to describe this example, as shown in Figure 3.24; we suppose that there is traffic from Tandem Switch 1 and TOT Gateway 1. This traffic is sent into the destination by passing through Tie Line into CAT Gateway 2.

When we define the TOT traffic by given fixed call number at 500, 750, 1000 then CAT traffic vary call number. Finally Call Attempt is derived from both call number by focusing on Tie Line, see Table 3.5.

It is simple in order to understand traffic measurement. Let' s look at Table 3.5, as shown in the different comparison.

All data in Table 3.5 are adapted into Table 3.6; we use only the different Call Attempt numbers for easy to understand.

Table 3.5 Comparison Number of Call before and after Adding Tandem Switch.

Call			Call Complete			
TOT.Traffic	CAT.Traffic	Call Attempt (Total)	Before		After	
			Complete	%	Complete	%
500	0	500	500	100	500	100
500	250	750	750	100	750	100
500	500	1000	1000	100	1000	100
500	750	1250	1000	80	1250	100
500	1000	1500	1000	66	1500	100
750	0	750	750	100	750	100
750	250	1000	1000	100	1000	100
750	500	1250	1000	80	1250	100
750	750	1500	1000	66	1500	100
750	1000	1750	1000	57	1500	87
1000	0	1000	1000	100	1000	100
1000	250	1250	1000	80	1250	100
1000	500	1500	1000	66	1500	100
1000	750	1750	1000	57	1500	87
1000	1000	2000	1000	50	1500	75

Call Attempt = TOT Traffic + CAT Traffic Call Complete is call that can connect to the destination number.

Table 3.6. Different Call Attempt Number for Easy to Understand.

Call			Call Complete			
TOT.Traffic	CAT. Traffic	Call Attempt (Total)	Before		After	
			Complete	%	Complete	%
500	0	500	500	100	500	100
500	250	750	750	100	1000	100
500	750	1250	1000	80	1250	100
500	1000	1500	1000	66	1500	100
1000	750	1750	1000	57	1500	87
1000	1000	2000	1000	50	1500	75

Let's look at an example, as shown in Table 3.7 and Figure 3.25, the comparison between Call Attempt and Call Complete before and after adding Tandem Switch.

Table 3.7. Comparisons between Call Attempt and Call Complete.

Call Attempt	Call Complete	
	Before	After
500	500	500
750	750	750
1000	1000	1000
1250	1000	1250
1500	1000	1500
1750	1000	1500
2000	1000	1500

Remarkable From all data in table are simplified to easy for understanding because numerical data rather confusion. The real data in APPENDIX D.

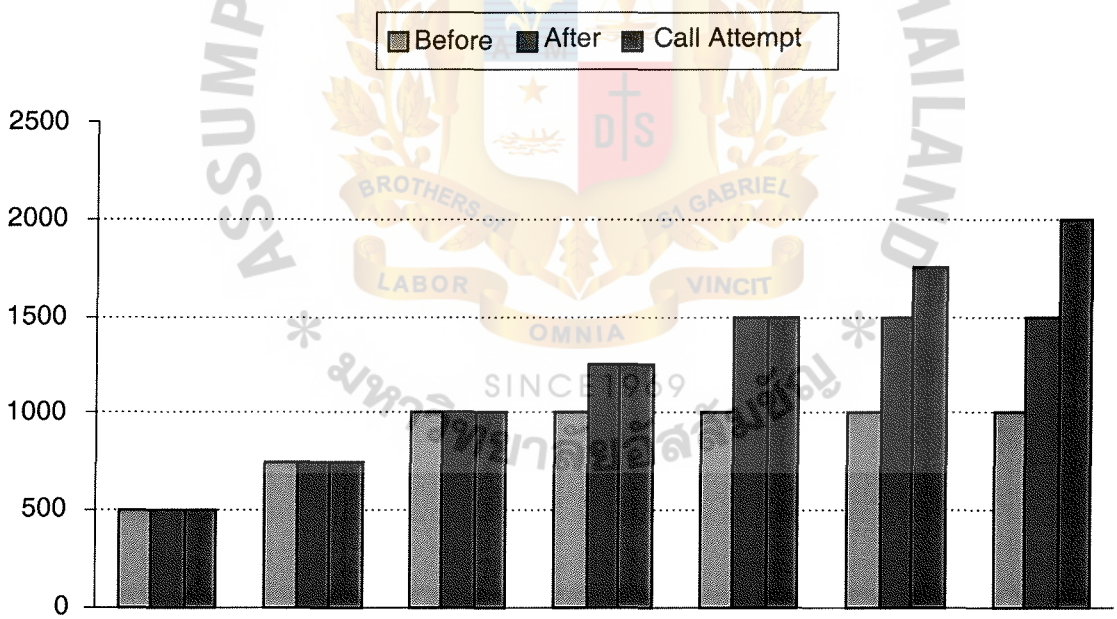


Figure 3.25. Comparison between Call Attempt and Call Complete.

So it is obvious that the description in both Call Attempt and Call Complete before and after adding Tandem Switch. Call Attempt is compared with Call Complete in percentage to show efficiency.

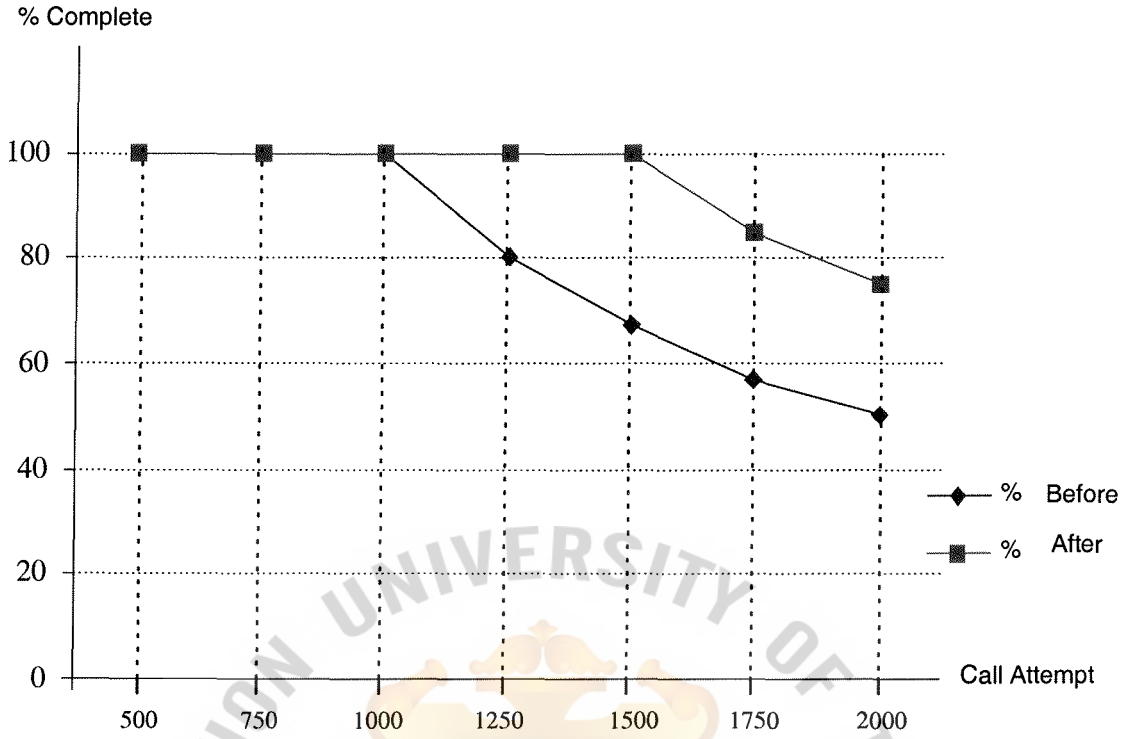


Figure 3.26. Comparison Call Attempt and Call Complete in Percentage.

As can be seen in Figure 3.26, when the Call Attempt is less than 1,000 calls the Call Complete is still stable at 100% complete. When Call Attempt is higher than 1,000 calls, the number of Call Complete before having Tandem Switch decrease slope. But if Call Attempt is higher than 1,500 calls, the number of Call Complete after having Tandem Switch will start to decline together. It is also important to note that Tandem Switch effects the efficiency of CAT Network Configuration as a result of decrement in Call Attempt and increment in Call Complete.

To increase the efficiency of International Telephone Service by upgrading or adding new hardware or installing new gateway is rather higher cost than using Tandem Switch by at least 10–20 times. The previous method may get the same effectiveness. To install an entirely new gateway system requires several complex procedures and takes a long implementation time.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The convergence of voice and data in today's communications network has the potential to change the fundamental way that the world communicates. The demand for the inter-working of the telecommunication network in domestic and international level is increasing. Through the use of all this technology, CAT had built the biggest and most powerful-switched network in the organization so called "Tandem Switch". This trend has made the system an extremely complicated one. So, to provide reliable service to the subscribers, the telecom service providers of the world require a switching system that can provide lots of services together with high reliability and strong interconnection capability. Tandem switching system of Communication Authority of Thailand (CAT), having the advantages of advanced technology, high stability, adaptability and revenue, can meet all the demands, of the most complicated telephone network system all over the world.

4.2 Recommendations

Spearheading Our Future Success

We believe that our Tandem switch is specifically designed for the next-generation of switching system networks requiring increased reliability, performance, scalability, interoperability and flexibility. Our strategy is to manage traffic and to increase the efficiency of International Telephone Switching Center (ITSC), utility companies and telecommunication service providers who are willing to develop network system of the telecommunications business. We believe that we have an early mover advantage in this network performance. Digital switching systems can use fiber optic or digital wireless transmission, which enables developing countries to

easily and rapidly deploy telecommunications services to consumers within months rather than years.

Leveraging Our Proprietary Technology

Our digital switching systems are based on our proprietary operating system software, which provides high performance, reliability and functionality. We regard our software technology and certain components of our system hardware as proprietary. We believe the development of comparable systems that would require too much cost and take several years to complete.

Solidly Positioned for Success

We are entering 2003 with a clear identity and direction in the fields of data and voice communications. We believe that our services will enhance the value of our organization. Our vast array of both Internet systems and advanced digital switching systems should provide a diverse revenue stream as well as solid growth prospects in the future.

APPENDIX A

TANDEM NO.7 SIGNALING SYSTEM

Tandem No.7 Signaling System

1. Tandem No.7 Signaling System Architecture

Tandem No.7 signaling system may provide message transfer part (MTP), signaling connection control part (SCCP), telephone user part (TUP), ISDN user part (ISUP) and translation capabilities application part (TCAP), etc. MTP, TUP, ISUP are Tandem Switch basic configuration. SCCP, TCAP and related parts can be configured by necessity. The distribution of these functional modules in Tandem Switch is as in Figure A.1 MTP second-level process is completed in NO7/LAP card. MTP third-level and MTP user part are completed by MPU in SM. The function processes in each module are independent.

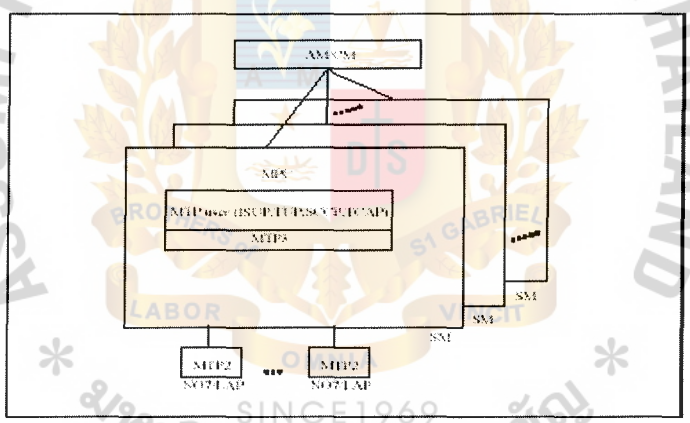


Figure A.1. Distribution of Functional Modules in Tandem Switch.

2. Signaling Data Links (MTP First Level)

Signaling data link is the channel for signaling transmission, which transmits signaling data in dual direction. Tandem Switch connect NO7 or LAP card link to TS of PCM system by building a switchable semipermanent connection through switching network to provide 64kbit/s signaling data link. Link connection mode of Tandem Switch No.7 Signaling data is as shown in Figure A.2.

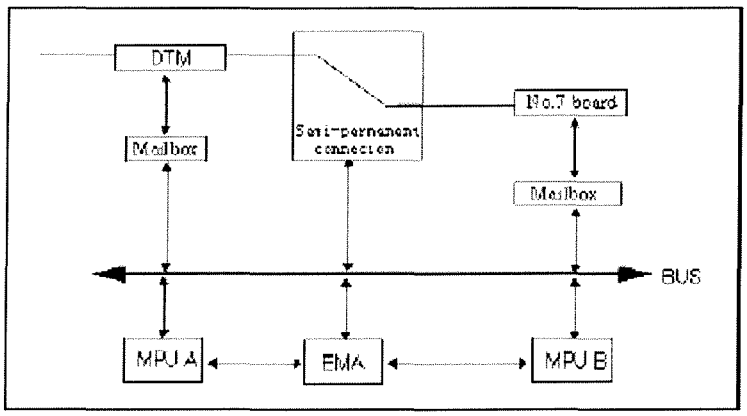


Figure A.2. Tandem Switch Signaling Data Link Connection.

Tandem Switch data trunk module (DTM) performs the first level function of MTP. The advantage of semipermanent connection is that any TS can be set as signaling data link (except synchronization TS) by man-Machine command.

3. Signaling Link Function (MTP Second Level)

Signaling link level defines the function and process to transmit signaling to data link. It, together with first level, guarantees reliable signaling link transmission between two direct connected signaling points. Tandem Switch No.7/LAP card completes the second level functions, including signal unit delimitation, signal unit alignment, error detection, error correction, initial alignment, signaling link error monitoring, flow control.

Tandem Switch may be configured the specific error correction method by satellite flag in MTP link data table in office data. The basic error correction method is suitable for signaling link using non-intercontinental terrestrial transmission means or intercontinental signaling links where the one-way propagation delay is less than 15ms. While preventive recycle retransmission method is fit for intercontinental signaling links where the one-way propagation delay is greater than or equal to 15ms and for all signaling links established via satellite.

4. Signaling Network Function (MTP Third Level)

Signaling network function (third level) defines function and process to transmit the signaling message between signaling points to guarantee the reliable signaling message transmission even if some signaling link or point become faulty in the network. Signaling network function can be divided into signaling message processing and signaling network management.

4.1 Signaling message processing

Signaling message processing function ensure that the signaling messages originated by a particular User Part at a signaling point (originating point) are delivered to the same User Part at the destination point indicated by the sending User Part. Signaling message handling function consists of 3 sub-functions: message routing, message discrimination and message distribution. Tandem Switch also has the following sub-functions besides:

(1) Tandem Switch can perform message shielding function with signaling message being processed. Before message is authenticated, Tandem Switch will compare the DPC, OPC and SLS in the routine flags with the shielding items in the office data to justify the validity of the message. For example, whether the message is invalid or from a wrong routine, or whether the destination point is allowed, only the legal message can be sent for message distribution or routine selection.

(2) One exchange can be configured to own multiple signaling points to satisfy the operation requirement in a multiple signaling network.

(3) Provides 14/24 bits signaling point coding.

(4) Provides signaling transfer function

(5) Link load-sharing can be realized through data configuration.

Can sends various kinds of pseudo message through maintenance operation.

Can monitor from maintenance console the sent and received message on signaling

link. And the monitored messages of MTP, TUP or ISUP can be saved on maintenance console.

4.2 Signaling network management

Signaling management function is to reconfiguration of the signaling network in the case of failure and to control traffic in case of congestion. Signaling management function consists of three parts: signaling traffic management, signaling link management and signaling route management. Tandem Switch can provide:

(1) Signaling traffic management: changeover, change back, inhibiting, forced rerouting, controlled rerouting ,signaling traffic flow control and MTP restart.

(2) Signaling link activation, restoration, deactivation and test functions in signaling network.

(3) Signaling data link and signaling terminal are connected with basic signaling link management mode, that is, the non-automatic mode.

(4) Transfer - prohibited, transfer- allowed, transfer- restricted, transfer-controlled, signaling-route-set-test and signaling-route-set-congestion-test.

5. Signaling Connection Control Part (SCCP)

One of the designing purposes of signaling connection control part is to provide perfect network layer function coordinating with MTP level 3. Corresponding to SCCP network service, there are four protocol classes.

class 0 Basic connectionless service.

class 1 In-sequence no connectionless services.

class 2 Basic connection-oriented class.

class 3 Flow control connection-oriented class.

Tandem Switch now has realized class 0, class 1 and class 2 protocols. Class 1 relies on the cooperation of Signaling Link Selection (SLS) code and MTP to guarantee orderly

message transmission. Now UDT and XUDT can be used to transmit user data. UDT message hasn't message data segmenting and (reassembling) capacity, it can transmit maximum user data up to 256 octets. XUDT message has segmenting and reassembling capacity. It can transmit user maximum data up to 2K octets.

For (connection-oriented) service, the basic three phases are connection establishment, data transfer and connection release. Tandem Switch may couple connection and provide local reference freezing when releasing local connection reference resource to prevent connection confusion.

The route function of SCCP can realize all types of GT code (translation). Following message addresses can be (translated) based on necessity: DPC+SSN, DPC+ old GT, DPC+ new GT, DPC. Tandem Switch may realize SCCP network management function, including management of signaling point status and sub-system status, active/standby real time switchover, status message broadcasting and sub-system status testing.

6. Telephone User Part (TUP)

TUP defines necessary telephone signaling function when No.7 signaling system is used as control signaling of telephone call. It can be used for control and connection of all kinds of circuit switching, including voice circuit and satellite circuit. Tandem Switch TUP part satisfies all the requirements of semi-automatic and automatic telephone services defined by ITU-T. When used in digital telephone circuit, the connection of the circuit is guaranteed by internal transmission quality monitoring and error detecting means provided by the digital circuit system.

6.1 Basic telephone services

Tandem Switch TUP can provide basic telephone services:

- Support E1, T1 circuit.
- provide circuit selection mode of maximum/minimum, master/slave according to standard.
- provide semi-permanent connection.

6.2 Supplementary services

Tandem Switch TUP may provide part of the subscriber supplementary services:

- Malicious call identification (MCID)
- Calling line identification presentation / Restriction(CLIP/CLIR)
- Call forwarding (CFU, CFB, CFNR)

Tandem Switch TUP part can provide circuit or circuit group maintenance functions by man-machine commands, such as block, open, reset, state inquiry. As for circuit hardware fault or recovery it can automatically conduct hardware blocking and recovery processing, it also supports signaling congestion control, automatic congestion control and continuity test.

Tandem Switch TUP part can realize signaling interworking of TUP.R2, TUP.ISUP, TUP.No.5.

7. ISDN User Part (ISUP)

ISUP is the ISDN user part of No.7 signaling system. It defines necessary signaling message, function and procedure of voice service and non-voice service control. (such as circuit switched data communication). ISUP can complete all functions of TUP and DUP, and can realize wide range of ISDN services. It is used widely.

7.1 Basic bearer services

Tandem Switch supports basic bearer services, that is, to setup, monitor and release the

64kbit/s switching network connection between exchange. It can satisfy:

- occupy multiple 64kbit/s B channels (from 1 to 30 channels) in one call.
- support E1, T1 circuit.
- provide circuit selection modes of maximum/minimum and master/slave .
- provide message and parameter compatibility processing.
- provide circuit semi-permanent connection.

7.2 Supplementary services

Tandem Switch supports following supplementary services:

- Call line identification presentation / restriction (CLIP/CLIR)
- Connected line presentation / restriction (COLP, COLR)
- Call forwarding (CFU, CFB, CFNR).
- Call holding (HOLD)
- Call waiting (CW)
- Malicious call identification (MCID)
- Direct dialing in (DDI)
- User to user signaling (UUS1)
- Conference call (CONF)
- Three party communication (3PTY)

Tandem Switch ISUP part can provide circuit or circuit group maintenance functions by man-machine commands, such as block, open, reset, state inquiry. As for circuit hardware fault or recovery it can automatically conduct hardware blocking and recovery processing, it also supports signaling congestion control, automatic congestion control, continuity test and Fallback function.Tandem Switch ISUP part can realize signaling coordinating and interworking of ISUP.R2 , ISUP.TUP, ISUP .No.5.

8. Transaction Capabilities Application Part (TCAP)

Transaction capabilities are a set of communication capabilities that provide an Interface between applications and a network layer service, it provides a public specifications and has nothing to do with specific application.

Tandem Switch TCAP part can provide:

(1) The addressing options supported by the SCCP.

(2) Structural and non-structural dialogue by connectionless network service.

(3) Support multiple TC users at same time.

(4) Support the transfer of session control PDU and user information.

(5) Background maintenance terminal provides friendly man-machine interface, direct status inquiry for session status machine, TC user and SCCP communication tracing.

APPENDIX B

TANDEM IN THE TELECOM FIELD AND APPLICATION

1. Tandem in the Telecom Field

As the demand for more professional knowledge. Technologies and other services is increasing, the telecom network is becoming more and more complex. With our new technologies and rich practical experience in telecom industry, we can provide high quality products and network solutions that can provide abundant services.

Tandem digital switching system is one of the major products of Huawei Technologies Co., Ltd. Now it is widely in use in the telecommunication network all over the world besides China. Until now, Huawei has set up dozens of joint ventures and representative offices all over the world.

China itself has an extremely big telecom network. Total capacity of fixed networks is152 million lines. Huawei Tandem switching system occupied 32% of the total market. In 1997, Huawei sold 4.115 million lines of Tandem Switch, while in 1998 Huawei sold 6.88 million lines. By the end of October 1999, more than 28 million lines of Tandem Switching System have entered more than 20 countries and regions.

In the following sections, brief descriptions of some large domestic application of Tandem Switching System have been presented. Moreover, a brief summary of application in other countries is also described.

2. Application of Tandem Switch

2.1 Application of Tandem Switch in Hong Kong

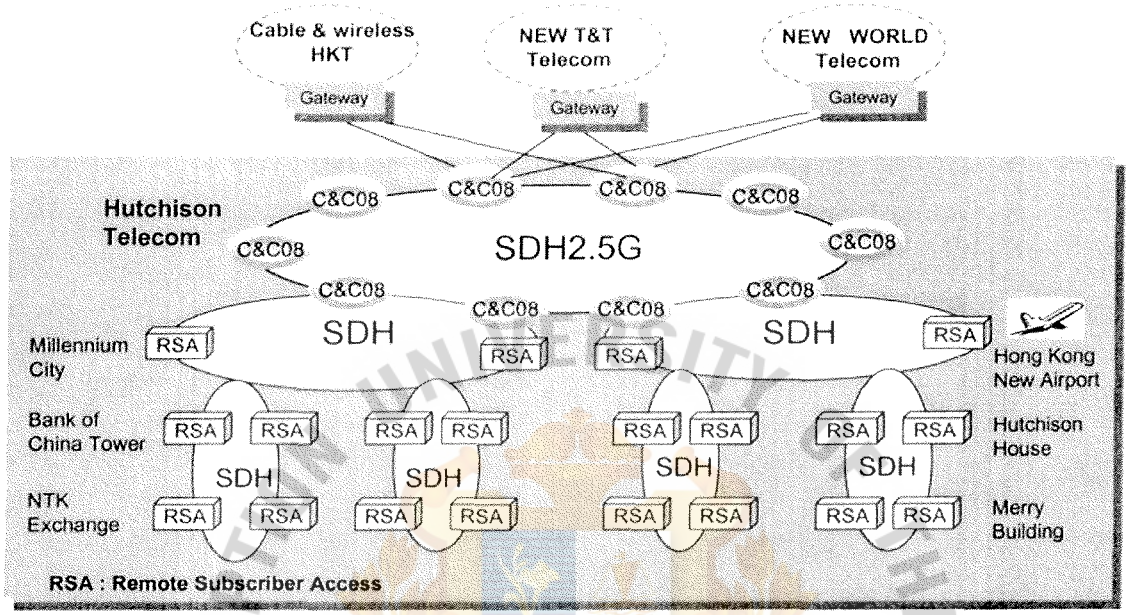


Figure B.1. Tandem Switch in Hong Kong.

Hong Kong is one of the busiest business and financial centers in the world. Hutchison telecom is one of the giants in Hong Kong telecom industry. Since, 1996 Hutchison Telecom has been providing the most attracting functions and best services to big business groups using our Tandem Switching System.

Hutchison Telecom has constructed exchanges with SSP and NP functions located at the SDH backbone network. The tandem exchange of Hutchison Telecom lies in Kowloon International Distribution Center. Four hundred switching modules were built to support up to 260,000 subscribers covering all the places of Hong Kong. Hutchison Network provides the NP (Number Portability) service, Centrex, CID (Caller ID) and other services.

2.2 Application of Tandem Switch in Russia and Other Countries

In Russia, Huawei established a telecom joint venture with Russia Telecom and Beto Company in June 1997, which provides technology support as well as after-sales service. Tandem Switches produced by this joint venture are widely in use in Russian telecom networks. They are highly praised and have won Russian Network Entry Certificate.

☞ In 1998, Huawei signed a frame agreement of 110,000 lines of switching equipment with Russia Telecom.

☞ 6000 lines of Tandem Switch are in use in Sterletamark and 2288 lines are in Daflikaroff

Besides Europe, our switching product is also in use in South America. Brazil, a fast developing country, has also adopted Tandem digital Switching System to provide reliable telecom services to its people. The present capacity of the system is 10000L/960DT. Soon it will be extended to 60,000L. Moreover, our Tandem Switching System is in use in Colombia, another country in South America. The capacity of the system is 5008ASL, 104DSL, and 600DT.

The market of Tandem Switching System is expanding at an extremely high rate. Besides the success of switching products in Russia and Brazil, Tandem Switching System has succeeded in gaining trust and confidence of other countries such as Bulgaria, Iraq, and Lithuania etc.

2.3 Application of Tandem Switch in Beijing

Since the end of 1997, two Tandem Switching Systems have been put into service in the telecom network of Beijing, the capital of China. The main purpose of this system is to provide rich business oriented services. In this system, over thirty sub-services of

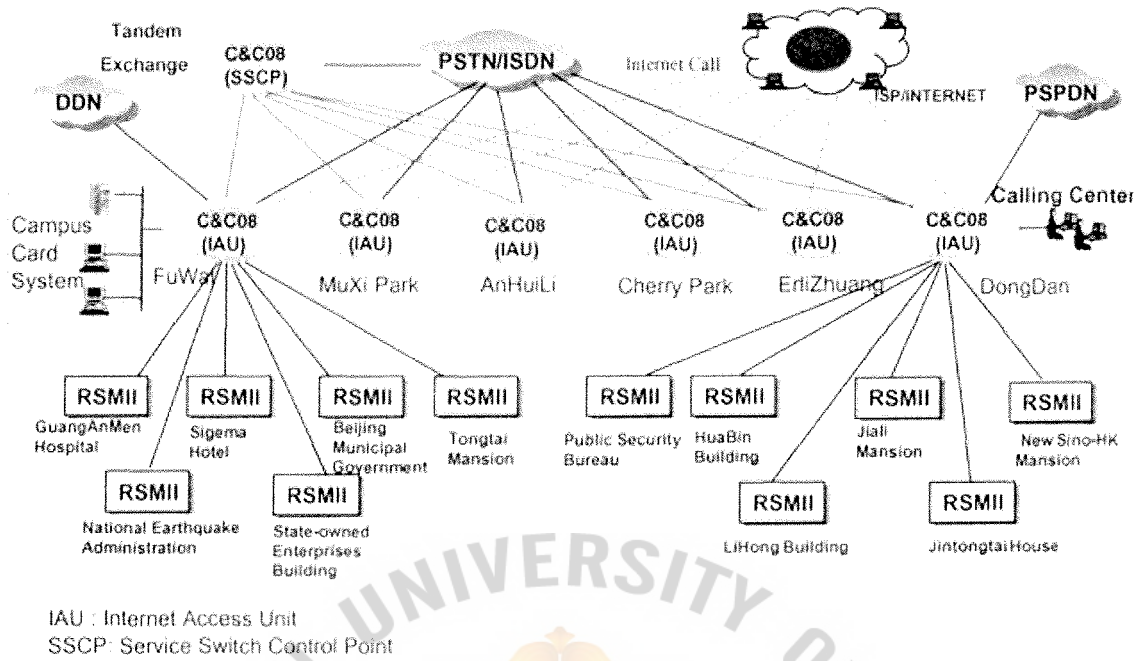


Figure B.2. Tandem Switch in Beijing.

CENTRX have been used to replace traditional PABS. Also some special services such as Call Center and prepaid calling card service were also provide to bring convenience to the customers.

Another five systems came into operation in Feb, 1999. The SSCP (Service Switch Control Point) and IAU (Internet Access Unit) have been introduced in this project. The SSCP system is capable of accommodating ten million cards of prepaid services. The IAU in the Tandem Switch provides IP phone and IP fax. Moreover, it supports Internet connection through IP Bypass.

By the end of 1999, 170,000 ports of Tandem Switch have been in use in the telecom network of Beijing. Besides providing POTS (Public Ordinary Telephone Service), our system can provide interconnection with PSPDN, DDN, Internet, providing plenty of practical services such as Centrex, ISDN, Campus Card, IP Phone, IP Fax, etc.

2.4 Application of Tandem Switch in Guangzhou

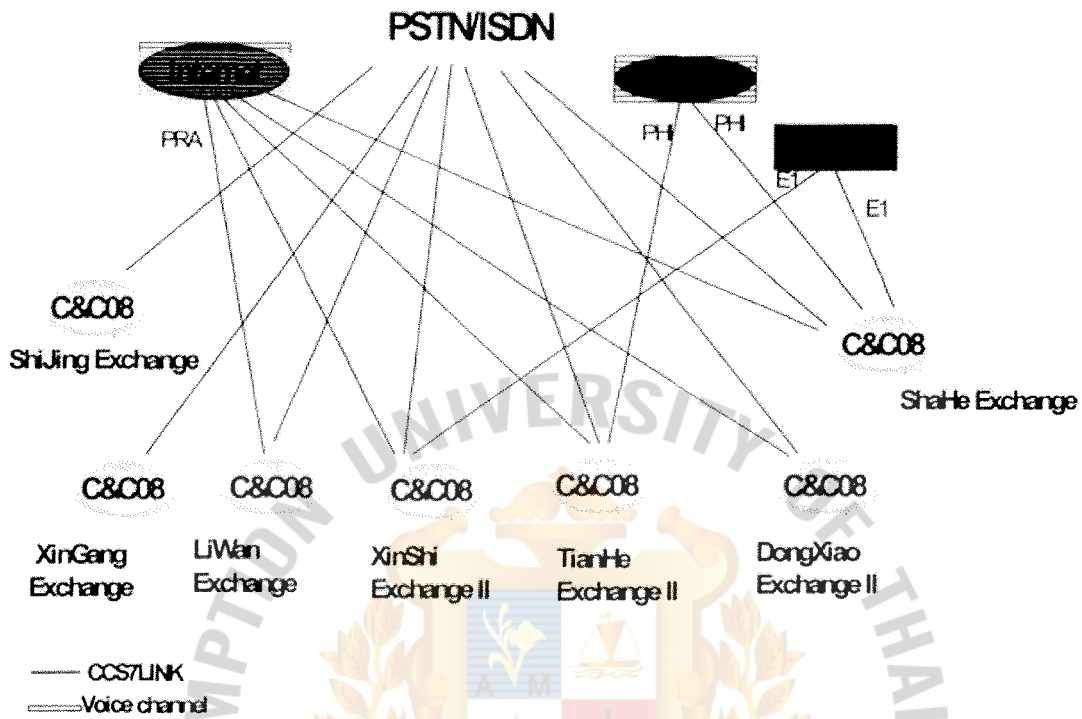


Figure B.3. Tandem Switch in Guangzhou.

In recent years, the growth of Guangzhou Telecom is extremely fast. As a result, the demand for various information services has increased even faster. Considering the technical trend, Guangzhou Telecom has adopted Tandem Switch to develop its telecom network. Through the flexible organization of RSM, RSA and RIM, it has been possible to decrease the installation cost and increase the reliability of the network.

Up to March 1999, there have been over 450,000 ports of Tandem Switch serving on the telecom network of Guangzhou. Among the exchanges, the Xinshi Exchange II connects to thirty-sever remote modules and has a record of stable running for a long time. With the advantages of high stability and reliability, Tandem Switch has been installed in many important places such as international banks, government

organizations, airports etc. Moreover, abundant services provided by Tandem Switch have brought rich revenue to Guangzhou Telecommunication Office.

2.5 Application of Tandem Switch in Shenzhen

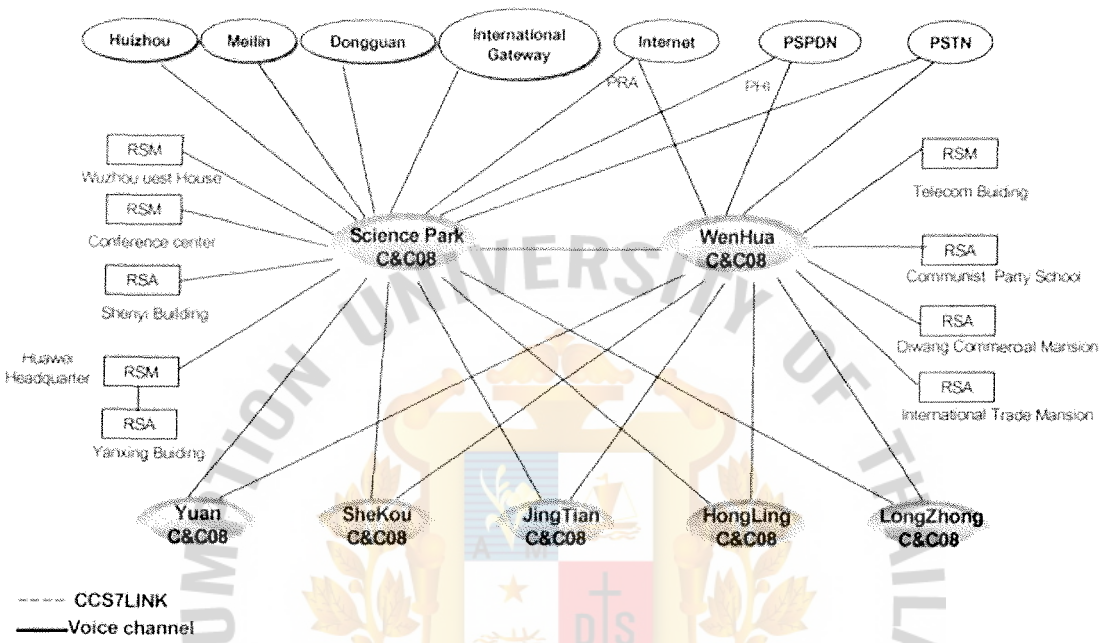


Figure B.4. Tandem Switch in Shenzhen.

Shenzhen is one of the oldest special economic zones of People's Republic of China. Under the pressure of fast economic growth, Shenzhen Telecom has selected Tandem Switch. Choosing Tandem Switching System has enabled Shenzhen Telecom to meet the demands aroused by rigorous customers and technical evolution.

After the return of Hong Kong to China, the business network of this area has been expanded demanding better telecommunication facilities between Shenzhen and Guangzhou. So, in June 1997, Tandem Switch has been connected to the Guangzhou international gateway to provide ISDN service to for the intercommunication between Shenzhen and Hong Kong.

By the end of Dec. 1998, there has been seven Tandem Switch local switches with the total capacity over 330,000 ports (including over 6,000 ISDN subscribers) in service, providing such services as CID, ISDN, Centrex, hotel interface and so on.

Until the end of 1999, nine Tandem Switch exchanges have been in service at Shenzhen commercial network with the capacity totaling more than 1,200,000 lines.

2.6 Application of Tandem Switch in Tianjin

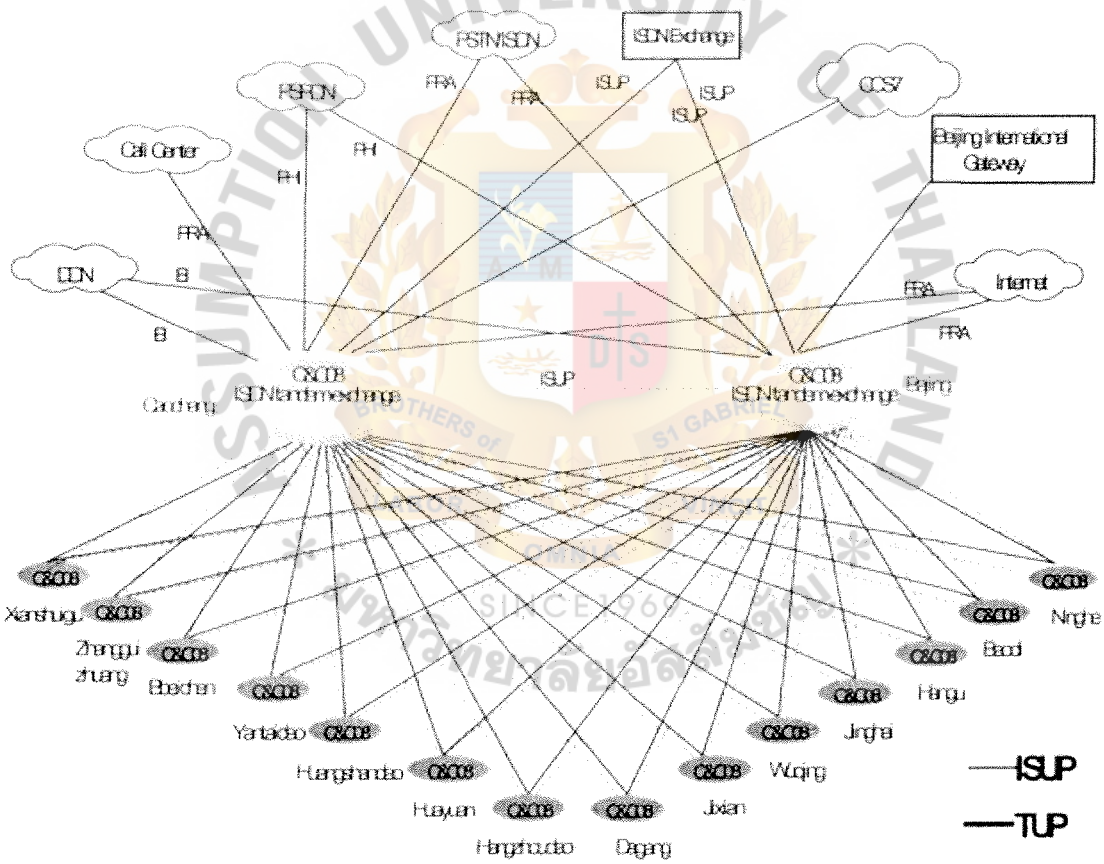


Figure B.5. Tandem Switch in Tianjin.

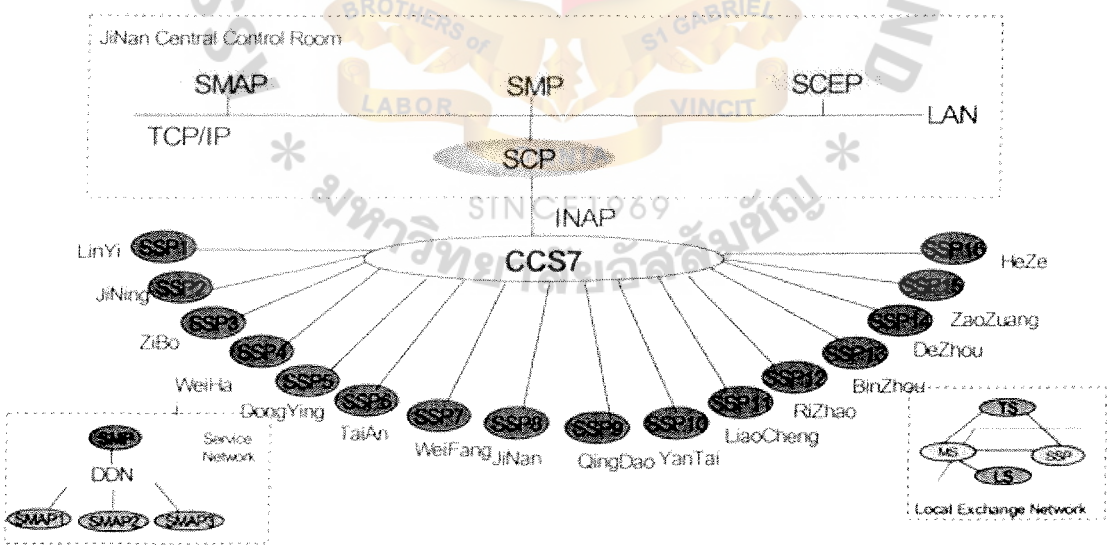
In 1996, Tandem Switching System entered the telecom market of Tianjin, one of the busiest cities in China and a famous port. As a manufacturer, Huawei responded quickly

to the customer's demand and developed Campus Calling Card platform to solve the communication problem of students. Due to perfect social and economical effect, this service was introduced widely into other cities, more and more telecom office gained the benefit from it.

In 1997, HONET access network was used to construct the user-end of the telecom network. Now Tandem Switching System together with HONET access network has simplified the network structure, promoted the access of all kind of services and shortened the construction time.

By the end of March 1999, there are sixteen Tandem Switching Systems in service (with over 300,000 ports) in Tianjin Telecom network.

2.7 Intelligent Network of Shandong Province



Note:

SCP: Service Control Point
SSP: Service Switching Point
SMP: Service Management Point
SMAP: Service Management Access Point
SCEP: Service Creation Environment Point

Figure B.6. Intelligent Network in Shandong Province.

The main purpose of IN (Intelligent Network) system is to provide various services to the subscribers while acting as a sub-layer of telecom network SSP is one of the most important equipments of this system. Tandem Switching System can be easily migrated to SSP through software upgrading. Tandem Switch SSP totally complies with ITU-T standards of IN and has the specialties of big capacity, powerful processing capability, standard signaling system, integrated billing and maintenance functions.

Tandem Switching System, including SSP, SCP, SMP, SMAP and SCE, was selected to build the Intelligent Network for Shandong province in May 1998. The sixteen independent SSPs were set up to process IN services. SSP and SCP are connected to STP via CCS7 signaling network. At present the following services are provided by this network: ACC, UPT, NP, FPH, VOT, WAC, MAS, etc.

2.8 China Mobile Signaling Network

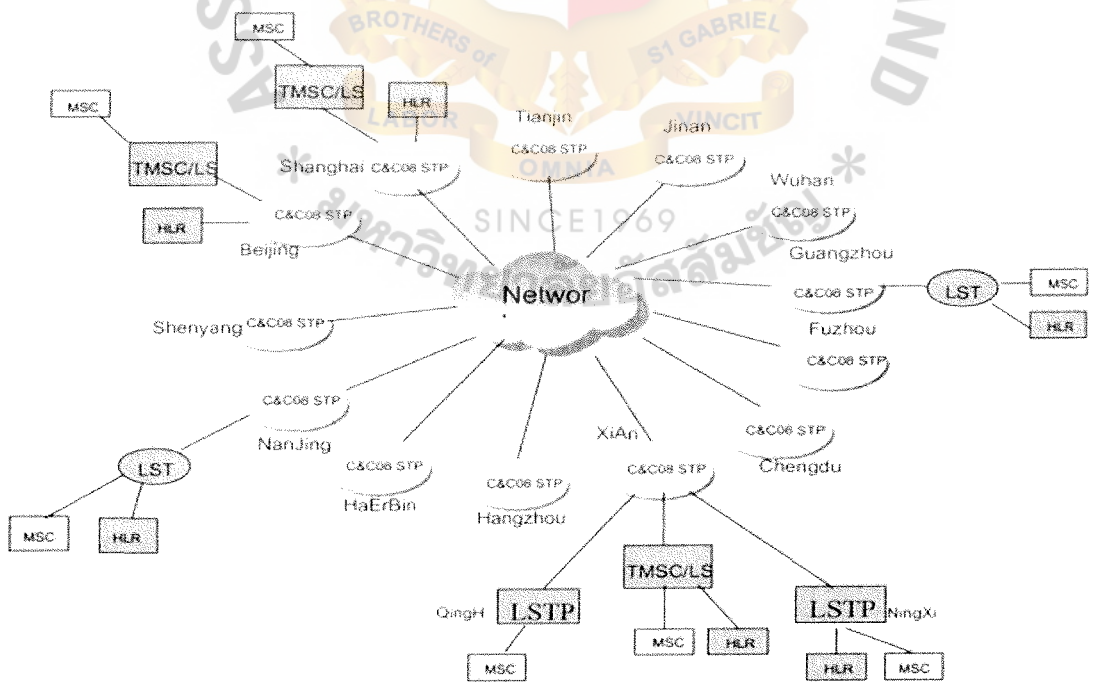


Figure B.7. China Mobile Signaling Network.

In China, two planes have been set up for the mobile signaling network: H1 and H2. Huawei Technologies has been constructing H1 plane. At the first stage of the project, thirteen independent Tandem Switch STPs were set up to cover the whole country. The total capacity of this project is 4,096 links. The designed traffic load of each link is 0.4 Erl, and the designed capacity of GT translation is 120,000. Because of its high stability and reliability, Huawei Technologies has also got the contract for the construction of the second stage in May 1999.

The mobile communication-signaling network has a very complicated structure, as it requires big capacity. Averagely, there are 315 signaling links per STP in this project.

APPENDIX C

DATA DICTIONARY

DATA DICTIONARY

Access Node

A connecting point for a data transport or data-packet network. Access nodes usually reside in a central office environment or are a part of a leased space agreement. Connections to access nodes are provided by local carrier loops. Access devices at the end of the customer loop are generally provided by the data-network service provider or by the customer.

Area Code

An area code is a three-digit code that designates a toll center in the North American Numbering Plan. To call outside of your toll center, you first dial 1, then the area code for the toll center or "area" you wish to call.

Basic Rate Interface (BRI)

The small size ISDN line (the other size is a primary rate interface). It consists of two bearers or "B" channel and one data or "D" channel. The B channels are 64 Kbp/s each. With the appropriate service package from the Phone Company and correct terminal adapter, you can talk on one B channel while using your computer modem on the other B channel. When your phone conversation ends and you hang up the terminal adapter will send a message back to the phone company through the D channel that connects both B channel together for a total transmission bandwidth of 128 Kbp/s for your computer automatically.

Blocked Call

A call that cannot be completed because the Central Office or PBX switching capacity is full at the time the call was attempted. Blocking can occur at any point in a network where a call is switched (from CO to CO or from local to long distance). The caller with

a blocked call either hears a fast busy or an intercept message that says "I'm sorry, all circuits are busy now. Please try your call again later".

Blocking

When a central office of PBX has fully utilized its capacity to connect calls, it blocks them. Callers trying to call in or out of a switch that is blocking calls will get a fast busy signal.

Busy Hour

The hour of the day or month when a central office or PBX connects the most calls. The busy hour is an important factor in designing a switch for blocking. See also Erlang.

Call Attempt

An uncompleted call because of blocking, where callers cannot get through because all lines are busy. This is a report statistic of central office switches as well as PBX systems.

CAS (Channel Associated Signaling)

In IP telephony circles, another name for in - band T1/E1 signaling. Within the 64 Kbps DSO channel, 8 Kbps are robbed from the data

stream to provide on-hook, off-hook, and dialed digit information. This is true for all 24 channels of the T1 and all 32 channels of the E1. For more information on T1 Signaling.

CCS7 (Common-Channel Signaling No.7)

1. A centum call second is 100 seconds of telephone conversation. 36 centum call seconds is one Erlang, which is one call hour (one hour of phone conversation). Erlangs are measurements of telephone switch traffic.

2. Common Channel Signaling: Another term for out-of-band signaling on a T1/E1 circuit. In IP telephony circles, T1 signaling is often referred to as *CCS (Common Channel Signaling) or CAS (Channel Associated Signaling).* CCS uses one channel in a T1 to carry signaling information such as on-hook or off-hook and touch tones for the remaining 23 channels (also called DSOs). E1 CCS uses 2 of the 32 channels for carrying the same type of signaling information.

Central Office (CO)

A building that houses a telecommunications switching or trafficking system. Typical switching systems installed in central offices in North America are Lucent Technologies' 5ESS and Northern Telecom's DMS family of switches. There are five classes of central offices and five major parts to a central office. As s whole these parts are referred to as *inside plant*

Central Processing Unit (CPU)

The device within a computer (or switch or other machine that performs complex tasks) that controls the transfer of the individual instructions from one device connected to its bus (the data or I/O bus) to another, such as ROM, RAM, sub controllers, decoders, and I/O ports. Some communications equipment manufacturers actually call a certain card or portion of the system the CPU. That is because they include all of the RAM, sub processors, buffers, clocking circuitry, and ROM as a part of the CPU. This is OK because we know that a real CPU is actually a small integrated circuit.

Circuit

An electronic device that receives a given input and converts it into a desirable output. For instance, a TV converts a transmission input into a picture and sound. A TV can be regarded as one giant circuit or many small circuits.

Client-Server Environment

A type of network environment with requesters (clients) and providers (servers). A service requested could be for processing, a file, or an application.

Completed Call

A call that is connected to its destination. When someone calls a number and someone picks up the end, the call is completed. You would think that a call would be completed when the people were finished talking, but in regard to call routing and switching, that is not the case.

Connection Oriented

A protocol model of interconnection that has three phases: connection, transfers of data, and disconnect. Some connection-oriented protocols are X.25, TCP, and a regular telephone call. Many protocols are a mixture of connection/connectionless, such as ATM, TCP/IP, and frame relay.

Country Code

A code used in international dialing for countries that are not a part of the North American Number Plan (NANP). To dial international long distance from the United States, dial :

011 + country code + city code + number.

For a listing of country codes

To dial the United States from another country that is a part of the NANP, simply dial the area code the same way you would call long distance to another state. To call the United States from another country that is not a part of the NANP, consult, your long distance company. The United States has a different country code/access code for almost every country that is not a part of the NANP.

E1

A European standard that is the counterpart to an American T1. The E1 and T1 are not completely the same. They both use 64 Kbps channels, but the T1 has 24 and the E1 has 32. The following table compares E1 and T1. The European standards are used in all countries, except the United States, Japan, and Singapore.

Erlang

A one-hour unit of telephone traffic. This can be one phone call that lasts for one hour, or two phone calls that last for 30 minutes each, etc. Erlangs consist of CCS *(Centum Call Seconds)*

Exchange

The area that a single central office services. Soon, when number portability is fully implemented, an exchange will not be associated with a central office. It will be associated with an area and the legal regulations imposed on communications companies in that area. Currently, each central office is assigned a group of numbers that it can use. The numbers are the first three digits (not including the area code). The numbers (801)-355-xxxx, (801)-237-xxxx, and (801)-575-xxxx are assigned to the Qwest Salt Lake City, Utah, main central office.

Gateway

In IP telephony, that point at which a circuit-switched call is encoded and translated into an IP packet stream. Gateways are hardware devices that may be incorporated into routers. Stand-alone gateways only perform layer 2 (bridge) functions from a data standpoint. Gateway connects PSTN (Public Switching Telephone Network) services such as ISDN (Integrated Service Digital Network), POTS lines, and T1 channelized voice circuits to IP telephony networks. Gateways incorporate protocols such as MGCP

and H.323 to communicate with central control devices on a respective IP telephony network, such as an IP telephony server.

IEEE (Institute of Electrical and Electronics Engineers)

A professional organization whose activities include the development of telecommunications and networking standards. IEEE LAN standards, such as the Ethernet 802 family, are the predominantly implemented LAN standards today.

INE (Intelligent Network Element)

A network element, such as a router, node or hub, which has the ability to be electronically reconfigured (manually or remotely) or perform additional functions, such as protocol conversions.

Integrated Services Digital Network (ISDN)

ISDN is a service that first evolved in 1979. It brings the features of PBX systems and high-speed data-transfer capability to the telephone network. The only thing that makes ISDN complicated is the many available features. The two kinds of ISDN lines are *Primary Rate Interface (PRI)* and *Basic Rate Interface (BRI)*. Two types of channels are contained within an ISDN circuit. The B (bearer) channel carries the customer's communications, and a D (data) channel provides control and signaling for the B channels. The *BRI (Basic Rate Interface)* ISDN line has two B channels and one D channel. A PRI has 23 B channels and one D channel.

International Gateways

International telecommunications are done through gateway central offices. Gateway central offices (class 5 central offices) connect communications to other countries. The gateway does the translation from T1 to E1, T3 to E3, and vice versa.

International Telecommunication Union (ITU-T)

A worldwide standards organization through which public and private organizations develop telecommunications standards for hardware and software. The ITU was founded in 1865 and became a United Nations agency in 1974. It is responsible for adopting international treaties, regulations, and standards governing telecommunications. A group within the ITU called CCITT formerly performed the standardization functions. After 1992 reorganization, the CCITT no longer exists as a separate body.

Kbps (Kilobits per Second)

A reference to how fast data is being transferred on a communications path.

Lost Call

A call that did not complete or was blocked because of a lack of switching facilities. Lost Call is different from Attempt Call.

Network

A group of devices that communicates back and forth using a set of rules or a set of protocols (called a *protocol stack* in data communications). The medium that the devices communicate through can be copper wire (UTP), fiber optic, coax, fiber optic, air/vacuum (radio), or light (infrared).

Network Element (NE)

A device attached to a network via hardware or software that performs a service or function to the network. A network element can be a router, a host, a workstation, a hub, a central office switch, a private branch exchange switch, a voice-mail system, a firewall/security program, or any other network servicing entity.

Private Branch Exchange (PBX)

A telephone system used to maximize use of telecommunications services purchased from a telecommunications company. A PBX simply takes telephone lines from the outside world and makes them accessible to extensions within a certain building, home, or office. PBX systems are available in many sizes, with many software and feature options. PBX features include call forwarding, speed dial, internal/external paging, and call-detail recording (call accounting). The larger PBX manufacturers are AT&T, Northern Telecom, Siemons, Toshiba, Iwatsu, NEC, and Rolm. PBX system have six main parts: the cabinet-backplane (also called a KSU, Key Service Unit), the station/telephone connectivity, the trunk/telco connectivity, the power supply, the telephones/extensions, and the administrative access.

Switching Center

Another name for a telecommunications company's central office. A location for switching equipment/electronics and transport equipment/electronics.

T1

A T1 ("T" one) is a standard 1.544-Mbps carrier system used to transport 24 telephone lines or various broadband services from one point to another. T1 is the standard carrier for the United States, Canada, Japan, and Singapore. All other countries use the E1 standard (30 channels on four wires). The T1 is a four-wire circuit, two wires for transmit and two wires for receive. The T1 line voltage is -135 V. The T1 circuit can carry voice or data. Its use determines the variables of T1 service, framing format, and line format.

Telecommunications

To exchange information across a distance.

Tandem Switch

A central office that carries ("Links") a call, but does not connect it with the end customer, it switches ("sends") the call to the central office from which the customer is fed.

Terminal

1. A closure where a telephone cable is terminated. It is usually a green box if it terminates buried cable or silver box if pole mounted.

2. A video I/O device with a keyboard that is used to enter and retrieve information (data) from computers.

Tie Line

A tie trunk that is dedicated to one phone. Tie trunks are telephone lines that connect PBX systems together.

Traffic

A measure of the amount of call attempts and active calls on a telephone switch. Traffic is measured in centum call seconds (*CCS*, one phone call for one second) or Erlangs. Many larger PBX (*Private Branch Exchange*) telephone systems and central office switches now have *CTI (Computer Telephony Integration)* applications that will calculate traffic, CPU % utilization, busy hours, and other useful information.

Traffic Engineering

In voice networks, the process of calculating how much equipment and what equipment will be needed. How much the equipment costs and how to allocate the resources of that equipment to keep call blocking to a minimum are also concerns for traffic engineers. Telephone switches and *Private Branch Exchange (PBX)* systems are engineered

according to the "busy hour" of the network, which is the time when the network has the most traffic. The busy hour can be for the day, month, or year. Traffic is measured in *centum call seconds (CCS)*, one phone call for one second, or Erlangs. Many larger PBX telephone systems and central-office switches now have *Computer Telephony Integration (CTI)* applications that calculate traffic, CPU percentage utilization, busy hours, and other useful information.

Trunk

There are various types of trunks. A trunk in all cases is a *link between switches* that carries traffic between various switch end ports. This is true in packet switches and circuit switches. Trunk types for circuit switches (voice) include Loop Start, Ground Start, ISDN, and E&M. For more information about LAN trunking between switches.

X.25

A widely implemented packet service provided by telecommunications companies that runs at speeds up to 56/64 Kbps. X.25 data-packet transfer services are named after the protocol that they are provided through. This service is usually billed by the byte (i.e., x dollars per million bytes transferred). This is good for short and bursty transmissions, such as those made by automated teller machines, credit card transactions, terminal-to-host, or other similar traffic-producing applications. X.25 is also capable of reliably transporting TCP/IP and other protocols. Regarding operability, X.25 is a third-layer connection-oriented protocol. Error detection is performed at level two (LAPB) and three (X.25). This gives x.25 and advantage in areas where telephone facilities are of poor integrity. Because X.25 is responsible for detecting and discarding damaged packets, the customer only pays for packets received, rather than paying for a bandwidth, as in frame relay (Committed Information Rate). X.25 was developed from

the LAPB *(Link-Access Procedure Balanced mode)* protocol. X.25 has remained a viable service for many because of modifications and additions to the protocol family, such as LAPBE, X.28, and X.75. Frame relay is commonly used as a higher-speed backbone enhancement to X.25 networks. Several illustrations of the X.25 frame structure are within this book under *X.25 Data Packet, X.25 Control Field, and X.25 Packet Control Header.*

APPENDIX D

NUMERICAL DATA OF TRAFFIC IN ITSC

Incoming and Outgoing Traffic example in International Telephone Switching Center including detail in number of call.

incoming route (code)	incoming route	yy	mm	call	min	io	int_dom
1AIB4AB	AIS	02	11	36	1022.54	I	National
1AIRSTI	AIS	02	11	10	132.4	I	National
1AISCHI	AIS	02	11	14	135.89	I	National
1AIW4AB	AIS	02	11	35	303.55	I	National
1CFBRKB	FRONTEND/ANS ISDN	02	11	4	90.6	I	National
1INCCSI	IN SERVICE	02	11	5	36.89	I	National
1INFREI	IN SERVICE	02	11	6	135.87	I	National
1ORB42B	CPOrange/TAO	02	11	5	163.8	I	National
1ORMTGI	CPOrange/TAO	02	11	8	86.22	I	National
1ORNPBI	CPOrange/TAO	02	11	10	91.97	I	National
1TAL2TB	Telecom Asia	02	11	17	327.11	I	National
1TAL2TI	Telecom Asia	02	11	3	60.87	I	National
1TCB42B	TAC	02	11	14	166.72	I	National
1TCW42B	TAC	02	11	6	72.32	I	National
1TOKKMI	TOT	02	11	2	2.4	I	National
1TOPK2I	TOT	02	11	1	50.28	I	National
1TOT4AB	TOT	02	11	53	1767.12	I	National
TI40I1I	TIE LINE ROUTE	02	11	20	483.14	I	National
TI42I1I	TIE LINE ROUTE	02	11	23	251.87	I	National
1AIRSTI	AIS	02	12	424901	812771.9	I	National
1AISCHI	AIS	02	12	520872	997772.54	I	National
1AISL2I	AIS	02	12	408	1266.36	I	National
1AISSPI	AIS	02	12	2615	6111.9	I	National
1CCBKAI	CDMA	02	12	74	45.21	I	National
1CCBKBI	CDMA	02	12	23	25.67	I	National
1CFBRKI	FRONTEND/ANS ISDN	02	12	3799	7634	I	National
1INCCSI	IN SERVICE	02	12	128112	363440.15	I	National
1INFREI	IN SERVICE	02	12	217782	833004.93	I	National
1ORMTGI	CPOrange/TAO	02	12	137023	307035.58	I	National
1ORNPBI	CPOrange/TAO	02	12	120050	268521.26	I	National
1TAL2TI	Telecom Asia	02	12	32079	125107.33	I	National
1TALL2I	Telecom Asia	02	12	340	634.73	I	National
1TCLL2I	TAC	02	12	40	145.58	I	National
1TCPSCI	TAC	02	12	318	648.74	I	National
1TCYNVI	TAC	02	12	5	8.69	I	National
1TOKKMI	TOT	02	12	155997	444237.64	I	National
1TOLKSI	TOT	02	12	24801	68182.07	I	National
1TOLT2I	TOT	02	12	2	3.3	I	National
1TOLTYI	TOT	02	12	2121	8547.42	I	National
1TONMAI	TOT	02	12	399	1161.22	I	National
1TOPK2I	TOT	02	12	11420	28357.85	I	National
1TOPLKI	TOT	02	12	1100	4015.12	I	National
1TOTL2I	TOT	02	12	35	141	I	National
1AIRSTI	AIS	03	01	1066	1501.56	I	National
1AISCHI	AIS	03	01	1301	1750.02	I	National
1AISSPI	AIS	03	01	3	5.27	I	National

incoming route (code)	incoming route	yy	mm	call	min	io	int_dom
1ORNPBI	CPOrange/TAO	03	01	197	322.6	I	National
1TAL2TI	Telecom Asia	03	01	19	37.15	I	National
1TCPSCI	TAC	03	01	376	549.05	I	National
1TCYNVI	TAC	03	01	495	813.59	I	National
1TOKKMI	TOT	03	01	321	511.58	I	National
1TOLKSI	TOT	03	01	12	29.06	I	National
1TOLTYI	TOT	03	01	4	5.76	I	National
1TONMAI	TOT	03	01	1	1.17	I	National
1TOPK2I	TOT	03	01	1	1.7	I	National
1TOPLKI	TOT	03	01	1	0.98	I	National
1AIRSTI	AIS	03	01	25	178.64	I	National
1AISCHI	AIS	03	01	25	127.61	I	National
1INCCSI	IN SERVICE	03	01	10	75.45	I	National
1INFREI	IN SERVICE	03	01	11	251.52	I	National
1ORMTGI	CPOrange/TAO	03	01	13	97.17	I	National
1ORNPBI	CPOrange/TAO	03	01	19	213.11	I	National
1TAL2TI	Telecom Asia	03	01	1	12.08	I	National
1TOKKMI	TOT	03	01	13	75.62	I	National
1TOPK2I	TOT	03	01	1	0.6	I	National
TI40I1I	TIE LINE ROUTE	03	01	72	828.16	I	National
TI40N1I	TIE LINE ROUTE	03	01	1	0.5	I	National
TI42I1I	TIE LINE ROUTE	03	01	38	207.99	I	National
TI42N1I	TIE LINE ROUTE	03	01	1	6.17	I	National
1AIRSTI	AIS	03	02	403828	742250.84	I	National
1AISCHI	AIS	03	02	534085	989662.9	I	National
1AISL2I	AIS	03	02	555	1486.62	I	National
1AISSPI	AIS	03	02	3152	6713.92	I	National
1AIW4AB	AIS	03	02	660159	1639731.24	I	National
1BFBRKI	BFKT(CDMA)	03	02	29	34.48	I	National
1CCBKAI	CDMA	03	02	19	28.92	I	National
1CCBKBI	CDMA	03	02	21	66.45	I	National
1CFBRKI	FRONTEND/ANS ISDN	03	02	4180	6396	I	National
1INCCSI	IN SERVICE	03	02	89604	265888.06	I	National
1INFREI	IN SERVICE	03	02	219288	819659.03	I	National
1ORMTGI	CPOrange/TAO	03	02	167878	393895.43	I	National
1ORNPBI	CPOrange/TAO	03	02	157634	368776.64	I	National
1ORTL2I	CPOrange/TAO	03	02	31	86.38	I	National
1TAL2TI	Telecom Asia	03	02	9099	33202.46	I	National
1TALKTI	Telecom Asia	03	02	9210	33489.47	I	National
1TALL2I	Telecom Asia	03	02	5	18.14	I	National
1TCLL2I	TAC	03	02	5	11.9	I	National
1TCPSCI	TAC	03	02	1511	2462.98	I	National
1TOKKMI	TOT	03	02	197397	572863.33	I	National
1TOLKSI	TOT	03	02	26598	80764.61	I	National
1TOLTYI	TOT	03	02	1957	6717.35	I	National
1TONMAI	TOT	03	02	547	2626.33	I	National
1TOPK2I	TOT	03	02	9102	26739.09	I	National
1TOPLKI	TOT	03	02	591	1713.06	I	National
1TOTL2I	TOT	03	02	195	492.48	I	National
TI40I1I	TIE LINE ROUTE	03	02	487155	1399877.72	I	National

incoming route (code)	incoming route	yy	mm	call	min	io	int_dom
TI40N1I	TIE LINE ROUTE	03	02	31287	33794.22	I	National
TI42I1I	TIE LINE ROUTE	03	02	443328	1099186.13	I	National
TI42I2I	TIE LINE ROUTE	03	02	136	303.29	I	National
TI42N1I	TIE LINE ROUTE	03	02	12641	25309.57	I	National
TI42O1I	TIE LINE ROUTE	03	02	2	7.85	I	National
1AIRSTI	AIS	03	03	3	0.63	I	National
1AISCHI	AIS	03	03	2	0.59	I	National
1ORMTGI	CPOrange/TAO	03	03	1	0.02	I	National
1ORNPBI	CPOrange/TAO	03	03	1	0.05	I	National
1TOKKMI	TOT	03	03	1	0.07	I	National
TI40I1I	TIE LINE ROUTE	03	03	2	0.52	I	National
TI42I1I	TIE LINE ROUTE	03	03	1	0.13	I	National

The revenue of Overseas Telephone Service, we can calculate from call duration charge and then is charged in block of 1 unit, (6 seconds). Tandem Switch is installed into the mention network as a result of increasing call complete from 1,000 calls into 1,500 calls. So the increasing call will be calculated into minute per month by following equation.

500 * 60 * 24 * 30 * 0.4 = 8,640,000

500 is number of increasing call complete

60 is number of minutes per hour

24 is number of hours per day

30 is number of days per month

0.4 is Utilization

Result from calculation we can convert all minutes into revenues. In case you want to make an oversea call (USA) that service rate in USA is 22 bahts/minute so the increasing revenue is 190,080,000 baht/month (8,640,000 * 22). Each country will use different service rate that depends on Rate for OVERSEAS CALL. From the previous reason it is difficult in presentation all details because the objective of this project is to increase network efficiency in CAT not focus on detail in revenue.

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