COMPARATIVE EVALUATION OF SWITCHING NETWORK PERFORMANCE

by

Mr. Tawatchai Lerksumrand

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
Assumption University

April 2001

COMPARATIVE EVALUATION OF SWITCHING NETWORK PERFORMANCE

by
Mr. Tawatchai Lerksumrand

A Final Report of the Three-Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
Assumption University

April 2001

Project Title	Comparative Evaluation of Switching Network Performance
Name	Mr. Tawatchai Lerksumrand
Project Advisor	Dr. Chamnong Jungthirapanich
Academic Year	April 2001

The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

Approval Committee:

(Dr. Chamnong Jungthirapanich)
Dean and Advisor

(Prof.Dr. Srisakdi Charmonman)
Chairman

(Asst.Prof.Dr. Boonmark Sirinaovakul)
Member

(Assoc.Prof. Somchai Thayarnyong)
MUA Representative

April 2001

ABSTRACT

The fundamental network of Cellular 900 mobile system needs be reconfigurated to a star network. To make this project successful, the concept and related information of the network before and after change are gathered. The background of analog mobile networks is considered because the network in this project is one type of analog mobile network, NMT900. The general principle of two different connections of network elements to be large mobile network in mesh and star is studied respectively. The step to evaluate the traffic performance starts with studying various traffic measurements to find the best one. And then the meaning of three important gains to measure the network usage: traffic intensity, numbers of call attempts and numbers of call completed will be concerned in selecting traffic measurement method.

The process of system evaluation begins after the overall information is enough. To prove that this change is worthwhile or not, the presentation of the results in any conditions is to easily compare the effects of reconfiguration network is the first step. The next step is to describe why the result of the new network changes and to compare its performance in terms of analysis. The overall advantages and disadvantages from analysis will be compared to decide which one is better. And also all objectives should be met their goals, to absolutely complete the project.

ACKNOWLEDGEMENTS

The author would like to take this opportunity to express his gratitude to Dr. Chamnong Jungthirapanich, his supervisor, for his valuable assistance and support during the course of the project. The author would also like to thank all of his friends and staff in CEM, Assumption University, for their helpful information and supporting ideas.

Finally, the author would like to express his deepest gratitude and appreciation for his beloved family who have continually given the encouragement and support throughout his Master Degree course at the Assumption University.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

The development of mobile telephony network is continuously done to improve the service quality, operation and maintenance administration, resource management and also corrective solution for each specific case. Nowadays there are so many companies that run a business of mobile telephone service because the communication industry has a very strong competition in Thailand and the demand of mobile telephone is increasing continuously.

Advance Info Service (AIS) is one of them that has been successful and famous in mobile telephone service. The author has been working in this company since 1996 and responsible for NMT (Cellular 900) switching exchange. In 1999, the author was delegated to be the one member in the project team of Gateway NMT Project. The author was responsible to cooperate and work with the suppliers from NOKIA Company that came from Finland for this project also. At that time, the author didn't know anything about this new equipment and why AIS had to spend a lot of money for this project.

This is the first project that the author had a chance to participate. The author thought of being worthwhile for him to work with the professional team and to advance his work experience. The Gateway NMT equipment passes the steps of installation and commissioning already and now it is on service and we are gradually cutting over the real traffic to connect through this equipment. When the implementation will be finished, the whole configuration of the original network will change from Mesh Network to Star Network.

After implementation Gateway NMT equipment, NOKIA commits to AIS about six benefits that AIS will receive. So the author wants to prove those assumptions if they are true or not. The author knows that it is possible to prove those assumptions by comparative evaluation of the switching network performance between the original network and the new network. The author starts to study the evaluation of the network performance and traffic measurement to use them for this report. The author has done this project to submit in partial fulfillment of the requirements for the degree of Master of Science Computer and Engineering Management of Assumption University.

1.1 Background of the Network

When telephony first began, there were only local exchanges to which subscribers were directly connected. The only task of these exchanges was to switch telephone calls between subscribers who lived in the same village or town and who were connected to the same local exchange.

As the need to communicate outside that village or town increased, it became necessary to interconnect the local exchanges. The more exchanges that were interconnected, the more complicated the network became. In time, the interconnecting cables formed a network that was completely intolerable. See in Figure 1.1, something drastic had to be done to bring order out of the thoroughly mesh-shaped telecommunications network or called mesh network (Ericsson Telecom 1997).

Since the opening of service, Cellular 900 exchanges were interconnected in mesh-shaped network. The first exchange of Cellular 900 system was implemented in the area of TOT exchange at Krungkasem road. With continuous expansion, now there are 28 exchanges and 1,520 base stations for Cellular 900 system in Thailand.

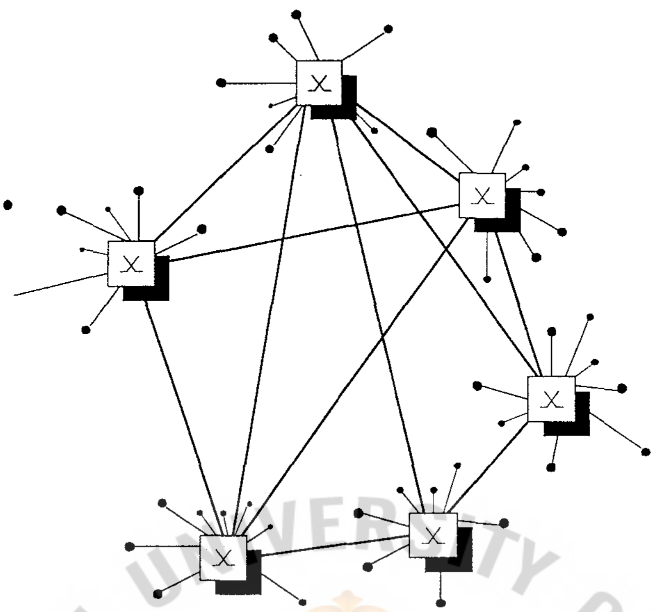

Figure 1.1. Mesh-shaped Network with Direct Connections between Every Node.

In Bangkok, all switching exchanges have direct interconnecting trunks, and the access to the rural area, exchanges are made using one of Bangkok exchanges as a Gateway. The overall configuration of such network since the opening of service until March 1999 is shown in Figure 1.2.

The growth of the network is high, causing demand for more exchanges. The more there are exchanges, the larger portion of subscribers of one single exchange is visiting. Because aerial numbering plan is not used in Bangkok, the subscribers are mixed all over the exchanges in Greater Bangkok area, The incoming calls from PSTN are routed first to home exchange and rerouted to the visiting exchange if the subscriber is not in the service area of home exchange.

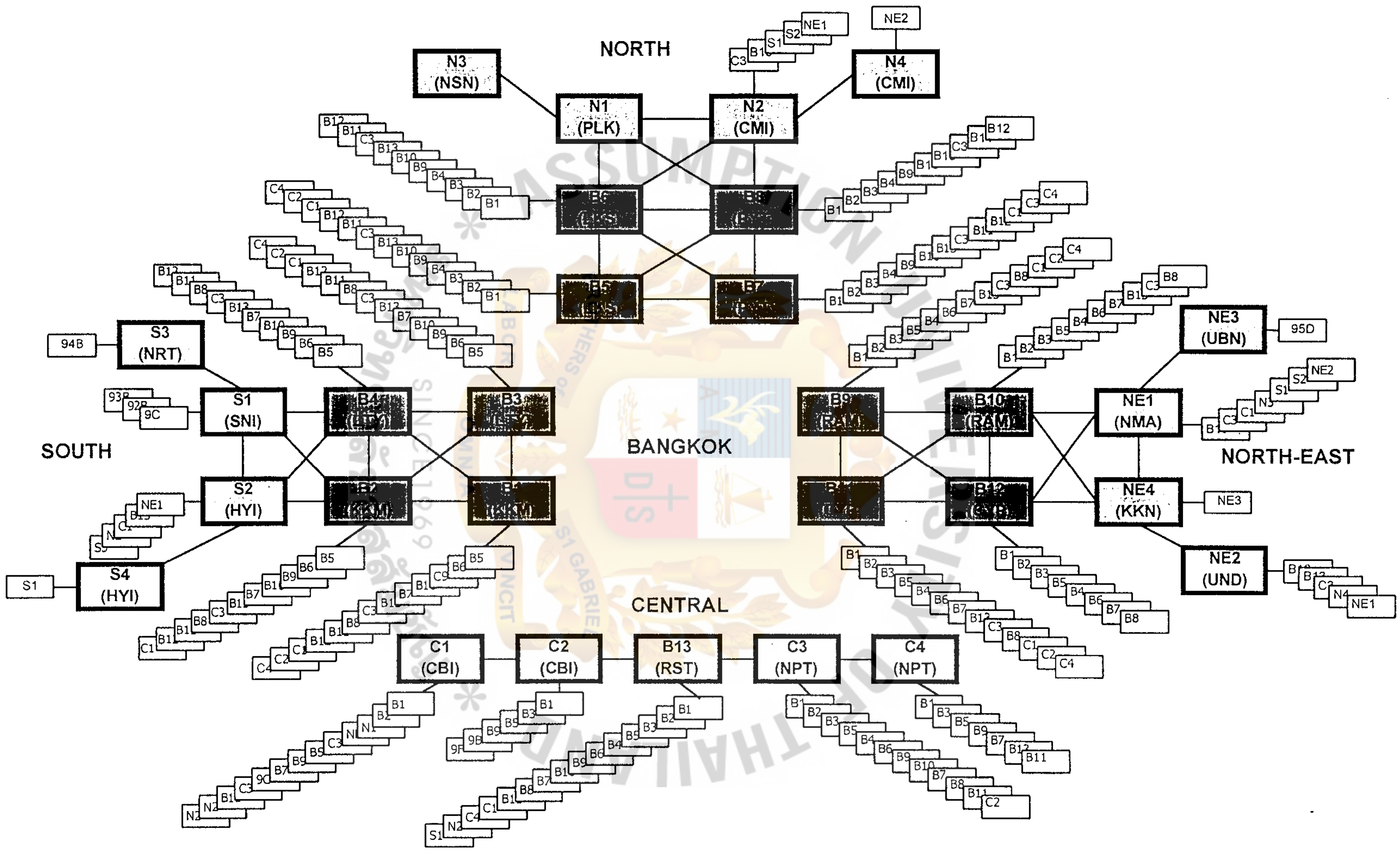

Figure 1.2. Mesh Network Configuration.

According to the traffic measurements, some 70% incoming calls from PSTN are rerouted, and the share is still growing when more exchanges are taken in operation. That will cause the need for trunk capacity between the exchanges. Anyway the relative traffic between two exchanges is decreasing because less subscriber are visiting in one exchange but shared with new exchanges as well. As the result, there is a need for many small circuit groups for handling calls between exchanges. The transmission network will be more complicated to manage, links are needed from every site to the others and circuit groups are small offering less relative capacity per circuit than the circuit in large ones. And from that many small circuit groups, it is difficult to manage in operation and maintenance as well.

The solution to the problem was a network hierarchy. By introducing new node in the network and reconstructing some of the existing ones, a system of nodes was created at different levels. As a result, not all nodes needed their own direct connections (direct routes) to every other node. The network took on a star-shaped structure, complementing the existing mesh-shaped structure.

Advanced Info Service, PCL, or AIS have made a decision to implement the Gateway switching exchange since January 1999. NOKIA had been chosen by AIS for the Gateway solution. When this implementation finished, the whole configuration of the existing network will change from Mesh Network to Star Network as in Figure 1.3.

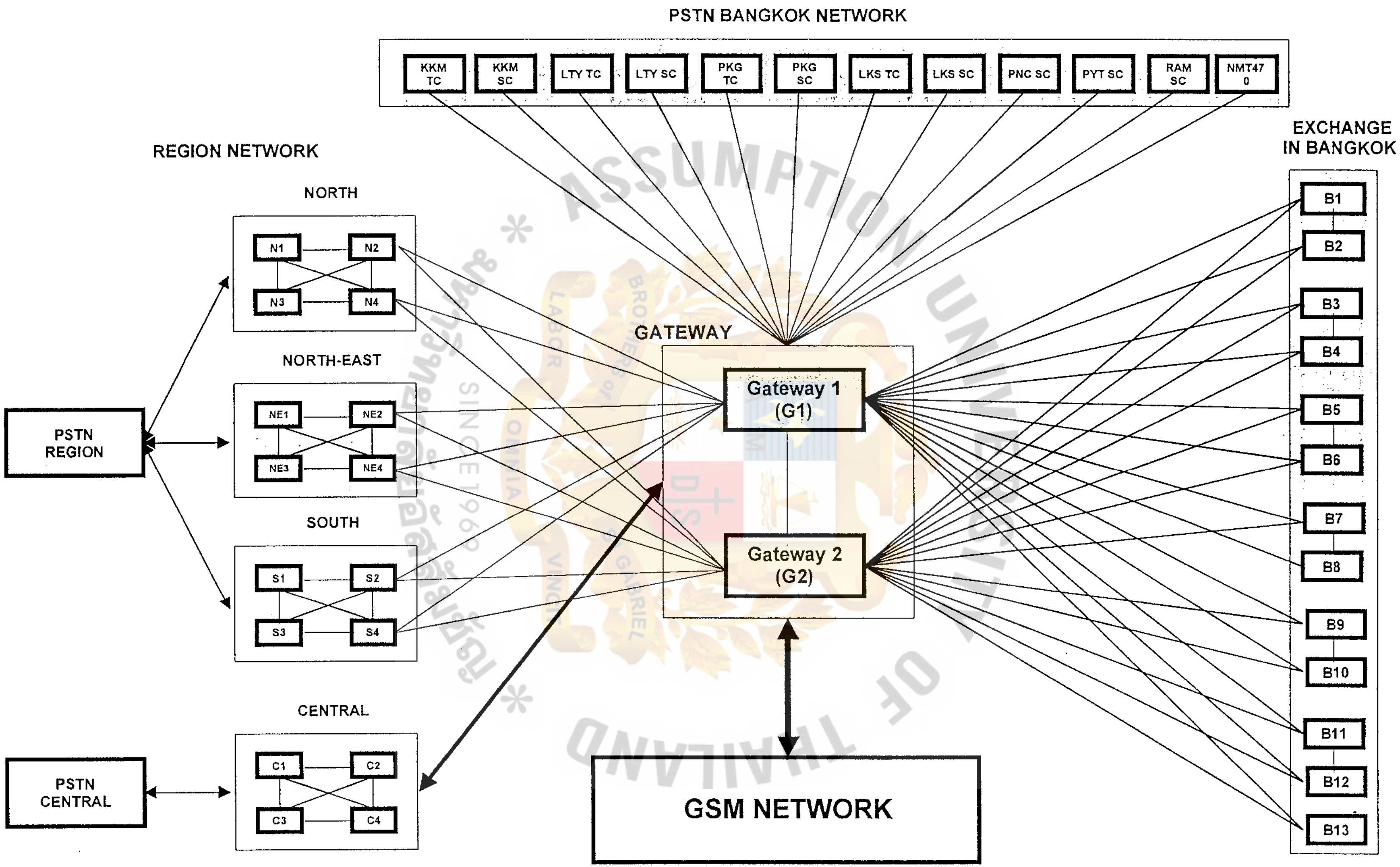

Figure 1.3. Star Network Configuration.

1.2 Objectives

To make a decision which network is better, it is difficult to do because there are both advantages and disadvantages in each type of network. Therefore my report will not present which one is better than the other but it recommends that the purpose and the goal of this change is accepted or not.

The objective of this report is to study the performance evaluation of the new network (star network) compared to the original network (mesh network) after implementation of Gateway solution. The benefits of Gateway solution that NOKIA commits to AIS are in following lists:

(1) Savings in transmission with enhanced call rerouting

(2) Simplifies the PSTN interface and improves the utilization of the limited trunk capacity

(3) Reduces the complexity of network

(4) Increases the connected call ratio

(5) Easy expansion of the network; new exchange is connected only to Gateway

(6) More efficient transmission management

To prove these agreements, it should consider the feasibility of many aspects. In the author's point of view, the author will consider only the technical feasibility of this change. Therefore these objectives will be met if the technical aspects of this solution that the author tries to study shows the result that coincides reasonably with NOKIA's commitment.

1.3 Scope

From my above objectives, I have designed the scope of my project that composes of three main aspects:

(1) Comparative evaluation the traffic performance of each exchange before and after change of network.

(2) Comparative evaluation of transmission utilization before and after change of network.

(3) Conclude the overall results of advantages & disadvantages of the existing and the new network

The details of each one will be explained later in the chapter of system evaluation in this report.

II. LITERATURE REVIEW

2.1 NMT Mobile Network

NMT mobile network in this project is one of analog network standards. The author will mention about NMT mobile network often in this project. Therefore it is interesting to understand briefly the background and concept of this network before. The author will describe about analog mobile network first and after that the author will describe about its network elements (Ericsson Telecom 1997).

2.1.1 The Analog Mobile Network

Analog mobile networks are characterized by the fact that control channels and traffic channels are analog. Both voice (commonly at 3 kHz) and data are frequency-modulated on a carrier. Today's analog network standards are:

(1) NMT – Nordic mobile telephony

(2) AMPS – American mobile phone system

(3) TACS – Total access communication system

Table 2.1. Analog Mobile Network Standards.

Standard	NMT 450	AMPS	TACS	NMT 900
System start	1981	1984	1985	1986
Frequency band uplink	453-457.5 MHz	824-849 MHz	890-915 MHz	890-915 MHz
Frequency band downlink	463-467.5 MHz	869-894 MHz	935-960 MHz	935-960 MHz
Channel capacity	180/359	832	1000	999/1999

NMT

NMT was specified by the Nordic telecommunications administrations and was the first commercially operated public mobile network (1981). Two variants exist: NMT450 and NMT 900. The numbers relate to the frequency band used. NMT 900, introduced in 1986 as a result of the fact that number of NMT 450 channels was insufficient, also offers some international roaming functionality. NMT has been implemented in Europe, the Middle East and Asia (Ericsson Telecom 1997).

AMPS

AMPS is a notable mobile network standard that was specified by the US consortium TIA/EIA/ANSI. The air interface standard is referred to as EIA/TIA-553. The first AMPS network became operational as early as 1984 in the US, and 1988 the standard was expanded to contain a wider frequency band, E-AMPS. AMPS networks are found in the Americas, Australia and in Asia (Ericsson Telecom 1997).

TACS

TACS is a modified version of AMPS; its frequency band is somewhat higher. The modification was made with the British market in view, where the standard was operational in 1985. TACS also received a wider frequency band in 1988, E-TACS. Since that time, TACS has spread to many countries around the world (Ericsson Telecom 1997).

2.1.2 The Analog Mobile System in Thailand

In Thailand, the first analog system is NMT standard. At the beginning of NMT mobile telephone network, TOT has launched NMT 470 MHz since 1982. NMT 470 MHz mobile telephone isn't popular because of low demand of subscribers and lag of technology. In 1984 CAT (Communication Authority of Thailand) proceeds to service new analog system with different frequency band, AMPS 800 MHz (BAND A), but it sill be not popular and suffers a loss. The government of Thailand realizes that the efficiency of private individual is an important factor to make this project successful so AIS takes a concession of this project from TOT for 20 years. AIS has launched NMT 900 MHz mobile telephone system since 1990 whereas TAC takes a concession from CAT to launch project of AMP 800 MHz (BAND B).

2.1.3 Network Elements in NMT 900 System

The following are 4 necessary network elements in NMT 900 network:

(1) Mobile Telephone exchange – MTX

MTX is a mobile network element that performs the switching functions in its area of operation and controls the interworking with other networks.

(2) Radio Base Station – RBS

RBS is the transceiver equipment used for communicating with mobile stations in a mobile network.

(3) Mobile Station or Mobile telephone – MS

MS is terminal equipment which uses radio connection and which can be used in motion or at unspecified points.

(4) Transmission

All network elements interconnect by using the transmission system.

2.2 Architecture of Large Mobile Network

The various elements of the core network are interconnected in much the same way as local, transit and network-intelligence nodes in PSTN/ISDN. A PLMN core network can be built in accordance with one of the three principles illustrated in Figure 2.1.

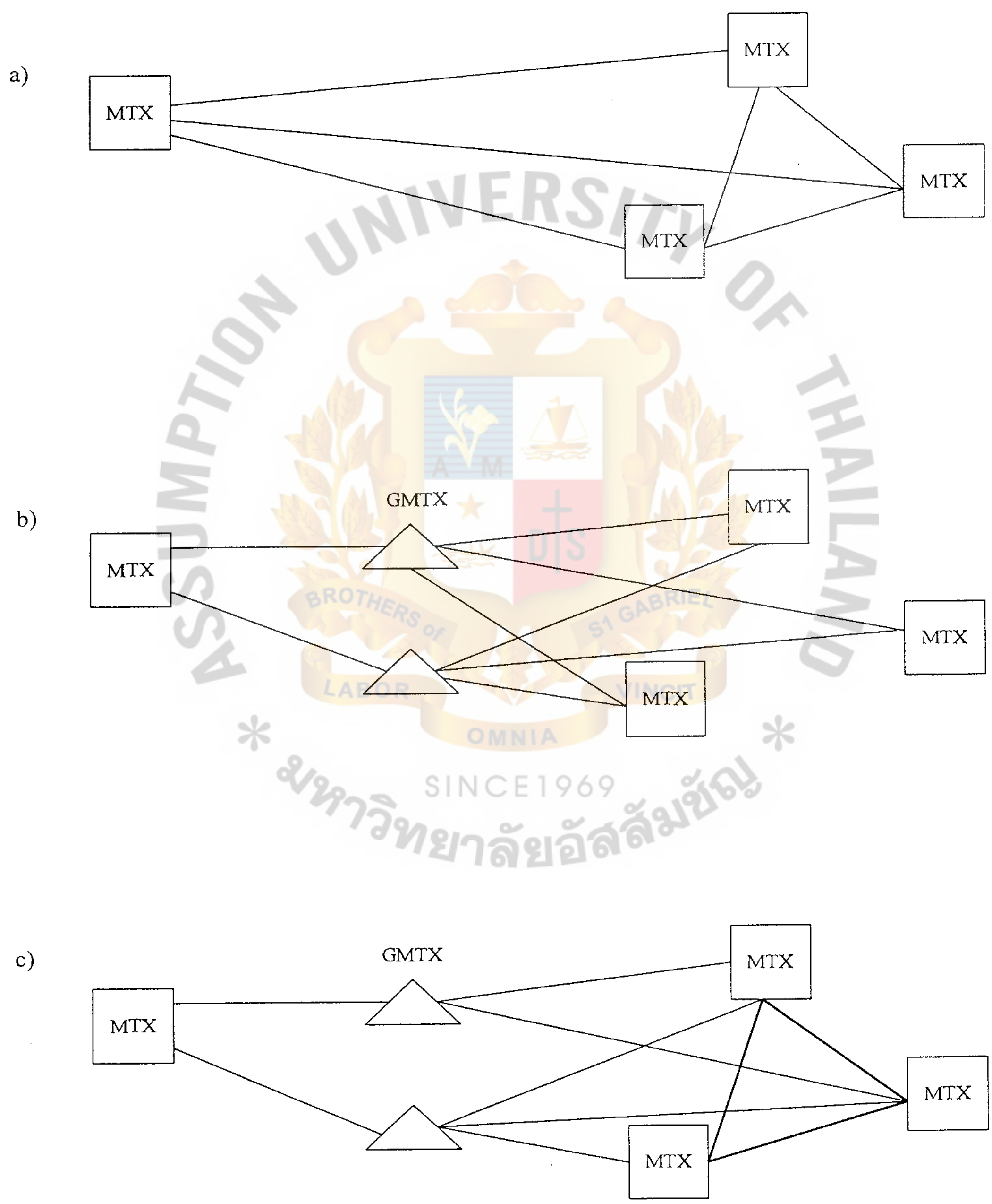

Figure 2.1. PLMN Core Networks – Three Different Solutions.

Alternative a (mesh network) shows a solution in which all MTXs are connected to each other regardless of how their service areas are related geographically. In alternative b (star network), gateway exchanges have been introduced, and all direct routes have been removed to achieve greater flexibility. All inter-MTX traffic is routed over the gateway exchanges – a practical solution in case where traffic demand is uncertain. Alternative c has combined the routing principles employed in a and b and has introduced direct routes between MTXs handling high traffic loads (resulting from frequent handover and great demand for inter-MTX traffic). This is the optimal solution in most cases – providing the greatest flexibility and dependability at the lowest transmission and operating costs (Ericsson Telecom 1997).

2.3 Concept of Mesh and Star Network

2.3.1 Mesh Network

For mesh network, each node needs line to n-1 others. Thus from A to B can also convey calls from B to A, the total number of lines required is $N = ½*n*(n-1)$. If $n>>1$, then N is approximately proportion to n*n. This arrangement is practicable if n is small and the lines are short. It has been used, for example, for small systems serving a number of telephones in the same office. However, as n increases and the lines become long, the arrangement becomes much too expensive (Flood 1995).

A mesh is a completely enclosed region. Nodes directly connected by a mesh component have the ability to decide and select the optimum route for data transfer. Methods for deciding on which route or link to transmit a data segment may be simpler or complex, depending on the level of sophistication required of the network. The simplest routing procedures do no more than establish primary and alternate routes, using the alternate path only when the primary path has failed. Alternate paths can be selected manually or automatically. Routing procedures from this simple algorithm increase with varying complexity. The more complex techniques are able to decide on a path depending on varying load conditions and the user's needs. Optimum routing is therefore loosely defined as routing necessary to satisfy user requirements for timeliness as constrained by implementation cost (Pooch 1991).

The added reliability of mesh switching can only be obtained with additional nodes and associated connecting links. This added reliability is usually dependent upon some (although not elaborate) form of alternate routing, in which not every path is duplicated. Theoretically, however, methods for improving the reliability of networks are not infinite. The number of alternate paths and links can approach infinity, but perfect reliability is achieved only if the supply is infinite. As a result, cost quickly becomes the dominating factor, requiring that reliability be statistically adjusted to a given dollar threshold (Pooch 1991).

2.3.2 Star Network

The network configuration shown in above figure is called a star network. The number of lines is reduced from $N = ½*n*(n-1)$ to only $N = n$. If N is large, the cost of providing the switching center is far outweighed by the saving in line costs. As the area covered by a star network and the number of nodes served by it grow, the line costs increase. It then becomes economic to divide the network into several small networks, each served by its own exchange (Flood 1995).

The star network, in which control functions are centralized. This topological scheme, essentially a star topology, requires that a link be dedicated for communications between the central node and each terminal connected to the node during periods of operation. Star networks are typically used for smaller data communications systems where the node (or switch) is also used for data processing or applications programming. That portion of processing not dedicated to network functions is referred to as host processing. Features allow the switch to detect a failed link and automatically reestablish communications. The latter is in more popular demand where time is critical or where both ends of the link are terminated with some form of automated intelligence, either hardware or software (Pooch 1991).

2.4 Measuring of Network Usage

The parameters commonly used to monitor the usage of circuit-switched or point-to-point (leased) networks are listed below:

(1) The traffic intensity

(2) The total number of calls completed

(3) The total number of calls attempted

The reason for monitoring each of these parameters, and the methods of measurement, are described in the following sections (Clark 1997).

2.4.1 Traffic Intensity

Traffic intensity is the measure of the average number of simultaneous calls in progress on a route between two exchanges, or across an exchange, during a given period of time. It is normally measured during the hour of greatest traffic activity or so-called busy hour and is quoted Erlangs. There are two principal methods of measuring traffic intensity: either by frequent sampling of the number of circuits actually in use and calculation of the statistical average or by using a call logging system which records the start an finish time of each individual call, so allowing the total circuit usage time to be measured accurately. Total usage during the period is divided by the duration of the period to give the average number of circuits in use (Clark 1997).

A check at least once per month of the busy-hour traffic on each route in a network is essential to make sure there are enough circuits on each individual route. Circuit requirement of each route are calculated form these values according to the

Erlang formula, using the forecast traffic and the desired grade of service as inputs to the formula (Clark 1997).

On their sampling days, many network operators are not content to monitor the traffic intensity during the anticipated busy hour though this is an accepted practice; they also monitor the traffic activity profile on each route throughout the whole day. The profile is invaluable as an indicator of overall calling patterns, revealing short or long periods during the day when the traffic on a particular route is either very heavily congested or is under-utilizing the available capacity (Clark 1997).

2.4.2 Number of Calls Attempted

The total number of calls attempted (also called the number of bids) is the best measure of unconstrained customer demand, because unlike the paid minute volume or the traffic intensity actually carried by a network, it is not limited by network congestion. At a time of network congestion, the busy hour call attempt (BHCA) count may continue to increase (as unsatisfied customer demand continues to grow) whereas paid minute volumes and traffic intensities may saturate at the maximum capacity of the network. A very large number of unsatisfied call attempts is an almost certain sign of congestion, either through underprovision of equipment or resulting from short term network failure, and is a good means of spotting suppressed traffic within a network. Unfortunately the exact amount of suppressed traffic is difficult to estimate, because the persistence of customers in repeating call attempts many times over affects the overall bid count (Clark 1997).

The number of call attempts can only be measured accurately by monitoring each individual customer's line. A value measured at any point deeper in the network will not be an accurate measure, as the effects of any congestion at the network fringe (Clark 1997).

Sometimes exchange monitoring limitations make it impossible for network operators to measure accurately the number of call attempts from a given source given destinations. If so, the number of call attempts may be estimated as the number of outgoing circuit seizures (Clark 1997).

2.4.3 Number of Calls Completed

The number of calls completed in a network sense (i.e. reaching ringing tone or answer), when compared with the number of calls attempted gives another measure of the state of network congestion. The proportion of busy hour calls completed, when expressed as a percentage of the number of calls attempted, should equal the design grade of service (Clark 1997).

Hence

$$\text{Grade of service} = \frac{(\text{number of busy hour call attempts}) - (\text{number of busy hour call completions}) \times 100\%}{(\text{Number of busy hour call attempts})}$$

The grade of service is a measure of the frustration that a customer will experience when trying to complete a call during the busiest hour day. We would calculate the average daily percentage of lost call attempts, but this is not so commonly done, because psychological analysis of the customer behavior suggests that it is of no relevance (Clark 1997).

The number of calls completed by the network is a difficult quantity to measure, because not all signaling systems indicate the 'network-completed' state. In the American network a peg-count overflow was used to monitor this value but its absence in other networks means that is also common to measure only the number and proportion of answered calls. The number is clearly lower than the number completed by the network as some calls are bound to encounter either a subscriber busy state or a ring tone-no reply condition. The proportion of answered to attempted calls, and that of answered calls to seizures are shown as the answer bid ratio (ABR) and the answer seizure ratio (ASR), respectively; they are defined mathematically below. Measured over relatively short period of time (5-15 minutes), both are good indicators of instantaneous network congestion. The higher the network congestion, the lower the ABR or ASR. The converse, that the higher the ABR or ASR the greater congestion, is not necessarily true because call may remain unanswered for a range of other reasons (e.g. people are simply not answering their phones). These same uncertainties mean that no conclusion can be drawn from the actual value of the ABR or ASR. A conclusion can only be drawn from the value relative to its 'normal' (Clark 1997).

$$\text{Answer bid ratio (ABR)} = \frac{\text{No. of answers}}{\text{No. of call attempts}}$$

$$\text{Answer seizure ratio (ASR)} = \frac{\text{No. of answers}}{\text{No. of seizures}}$$

2.5 Network Performance Evaluation

2.5.1 Method of Measuring Traffic Performance

To evaluate the traffic performance, we should have a tool to gather the information such as number of call attempts, number of answered calls, number of rejected calls, erlangs and etc. After that such information will be analyzed and compared to the other case and then the final result will tell us which one is better. In the general principle of telecommunication, a tool that I mentioned at first means traffic measurement function.

As a rule, in modern exchange equipment will include functions for traffic measurement, which makes it easy to collect data of the traffic associated with an exchange. This data can be printed out and or stored for later processing. There are many methods and criteria to design the traffic measurement. Before we go to see the detail of each method to design our traffic measurement, it is important to know the operational function called traffic administration. Traffic administration is one function in the operation center for collecting the data from several exchanges. With the traffic administration MML programs we can find out the exchange load and used capacity (Nokia Telecommunications 1995).

Traffic administration consists of:

(1) Traffic measurement

(2) Traffic observation

(3) MTX measurements

(4) Lad observation

(5) Field reporting

(6) Supervision

Each function in traffic administration will be used in different conditions. I study all functions in traffic administration and then I select one specific method in traffic measurement to make my required reports. This chapter presents the concept of my selected method and how to apply it to evaluate the traffic performance. The following includes definitions of certain concepts associated with the traffic measurement.

2.5.2 General Principles of Traffic Measurement

Traffic measurements provide us with information on the traffic intensity and distribution of traffic in the exchange. We can use this information when dimensioning the exchange and the telecommunications network or evaluating the traffic performance.

The most important information produced by traffic measurements is the traffic intensity in the object measured. Traffic intensity is measured by using the reeling principle as follows:

(1) At given intervals, the measurement system takes samples from the traffic in the object under observation.

(2) The system adds the traffic volume data to a temporary meter.

(3) At the end of the result accumulation period, the system divides the value in the meter by the number of samples taken.

(4) As a result, you receive the average traffic intensity, based on sampling, during the results accumulation period.

The principle of sampling causes the measurement results to show some degree of error, as compared to the actual traffic intensity. Generally the error is, however, smaller than the accuracy at which the measurement data is output. See Figure 2.2 (Ericsson Telecom 1997).

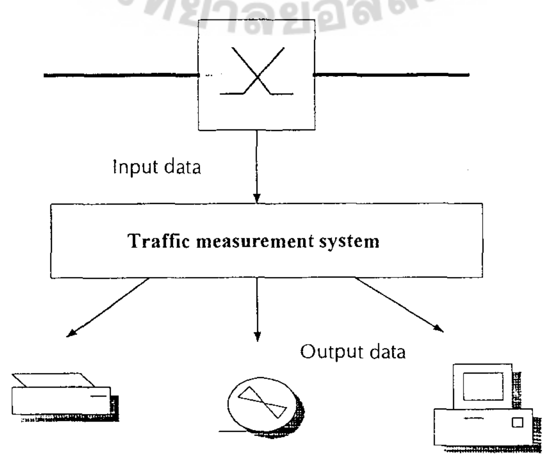

Figure 2.2. The Principle of Traffic Measurement.

From the traffic measurement technique of MTX offers the possibility of gathering very accurate and detailed information about traffic offered and lost call attempts. This information may be divided so as to relate to:

(1) Traffic on different circuits

(2) Distribution of outgoing traffic in different directions

(3) Distribution of incoming traffic from different directions

(4) Distribution according to the type of traffic source

(5) Use of different services per customer segment

The traffic measurement system provides the operator with an excellent basis for network planning and evaluation. Traffic in different points in the exchange can be read: number of call attempts, number of lost call attempts, seized devices, holding times, queuing delays, number of calls queued and so forth. This information can then be processed in a computer, together with data from other exchange (Ericsson Telecom 1997).

With the traffic measurement commands it is possible to handle measurement functions with which the user obtains at regular intervals reports on the average exchange load. A measurement can be executed by:

(1) Circuit groups

(2) Base stations

(3) Destinations

(4) Control units

(5) Traffic categories

When I concern the concept of each type of execution. I execute the traffic measurement by destinations object list. It is necessary to understand clearly about it before go to next chapter. The following will describe the definitions of certain concepts associated with the traffic measurements of destinations and how to make the measurement reports from this method.

2.5.3 Traffic Measurement of Destinations

Destination Object List

The destination object list commands are part of the function group called traffic administration. Together with the traffic measurement handling commands they form the basis for traffic measurements of incoming and outgoing destinations. An object list refers to a list of objects to be included in a measurement (Nokia Telecommunications 1995).

Destination is defined on the basis of the first digits of the digit sequence to be analyzed, and it reveals the location of the subscriber A or B in relation to the exchange under observation. If the subscriber in question is a mobile subscriber, the location is found out directly on the basis of the subscriber (Nokia Telecommunications 1995).

Traffic measurement of destination produces information on the traffic intensity on different number destinations. The system measures total number of calls, number of successful calls, number of calls ended in a subscriber error, number of failed calls caused by errors in the own exchange or by other errors and average traffics in erlangs during the measurement interval. In number destination measurement;

(1) Four different destination object lists can be defined for the traffic measurements of destinations.

(2) A maximum of 255 destinations for one measurement can be defined.

(3) The depth of a destination is 16 digits.

(4) Two destinations whose length is the same, i.e. the destinations contain an equal number of digits; can be associated with the concept destination interval (Nokia Telecommunications 1999).

Destination Interval

In connection with the addition of destination, destination interval means the group of destinations, which are in size between the boundary values of the destination interval or of equal size with the boundary values. The numbers of the destinations also have to be of the same length as the boundary values. The beginning and end value of the destination interval is called boundary values. For example, the destinations 23, 24, 25, 26, 27 and 28 are included in the destination interval formed by the destinations 23 and 28 (Nokia Telecommunications 1999).

In connection with the removal of destinations, all the destinations which fulfill the above-mentioned criteria are part of the destination interval and in addition, all the destinations the first part of which is the same as that of the destinations fulfilling the above-mentioned criteria. For example, all destinations whose number depth are at least 2 and which begin with 45, 46, or 47 belong to the destination interval 45...47 (Nokia Telecommunications 1999).

Destination Traffic Measurement Report

A destination traffic measurement report in Table 2.2 contains the following data of each destination included in the measurement (Nokia Telecommunications 1999):

(1) Destination (DESTIN)

(2) Direction (DIR)

(3) Total number of calls (CALLS)

(4) Number of successful calls (ACCEP)

(5) Number of calls ended in a subscriber error (SFAIL)

(6) Number of failed calls caused by errors in the own exchange (IFAIL) or by other errors (EFAIL)

(7) Average traffics in erlangs (ERLANGS) during the measurement interval

Table 2.2. Example of a Destination Traffic Measurement Report.

DX 220 DX 220-NOK 83-06-21 10:18:00

TRAFFIC MEASUREMENT REPORT DESTINATIONS

SOURCE: STU-0 OUTPUT INTERVAL: 60 MIN

SAMPLE DATE: 83-06-21 10:15:00

DESTIN	DIR	CALLS	ACCEP	SFAIL	IFAIL	EFAIL	ERLANGS
4200XX	IN	123	120	3	0	0	13.2
45XXXX	OUT	85	85	0	0	0	7.2

END OF REPORT

From the destination traffic measurement report, the question of how to calculate and measure the average traffic intensity or average traffics in erlangs is described by the following erlang measurement principle.

2.5.4 Erlang Measurement Principle

In traffic measurement, the calculation of traffic intensity is based on samples taken. The traffic volumes in the objects defined for the measurement object lists are added to the temporary counter of each object at sampling intervals. At the end of the result accumulation period, the number of samples taken divides the value in this counter. As a result, you will receive the average traffic intensity based on the number of samples in the object during the results accumulation period (Nokia Telecommunications 1995).

The principle of sampling always causes some degree of error in the erlang values. In continuous traffic, however, the error normally falls below the accuracy at which the erlang fields are printed out. The relative error decreases as the number of calls goes up, the results accumulation period become longer, or the sampling interval becomes shorter (Nokia Telecommunications 1995).

2.5.5 Busy Hour Method

A busy hour is the full hour during a day when the average traffic is at its maximum level. Peak hour method refers to a method where the traffic intensity on each day (24 hours) is measured at each full hour. This method is also known as the "highest full-hour method" (Nokia Telecommunications 1995).

The data during peak hour or busy hour is interesting so I include this method in my traffic measurement as well. Compare in the chapter of system evaluation that the results collected from the peak hour of each day will be reasonable or not (Nokia Telecommunications 1995).

2.5.6 Method of Evaluating Traffic Performance

After measuring the traffic data from exchanges, it is time to evaluate the traffic performance by using the comparative entities. Gathering information about the calls in the exchange that occurred within the measurement period, and sorting them out according to the reasons of releases provide the statistical data on the trafficability performance of the exchange (Nokia Telecommunications 1999).

Entities:

Attempted calls – total number of calls is attempted.

Seized calls – total number of successful calls.

Answered calls – number of calls in which the called subscriber has answered.

Rejected calls – number of calls, which were interrupted in the ring phase and the called subscriber, did not answer.

Each one of entities is expressed as a numerical and as a proportional share (%) of the total number of calls.

To sort the calls according to the above entities, it is necessary to use the application program to manage this complicated work. When referring with the data in mentioned destination traffic measurement report, the formulas of above entities will be applied are following:

Attempted calls = *CALLS*

Seized calls = *CALLS - IFAIL*

Rejected calls = *EFAIL*

Answered calls = *ACCEP*

The number of calls in each entity that are gathered from each exchange will be useful to analyze the traffic performance of the exchange after the change of the configuration of network. Example, if exchange MTX1 has more rejected calls after changing the network configuration, it means that the traffic performance of exchange MTX1 is worse than before. The author will discuss and show the results of the real traffic in detail in part of the system evaluation.

III. RESEARCH METHODOLOGY

The theory and concept of traffic measurement and traffic evaluation was described already. Now the author will present how it was applied to his case study of comparative network performance.

Steps of making my measurement report are as follows:

(1) Select the type of traffic measurement and assign the required parameters

(2) Sampling the exchange for measurement

(3) Dump the raw data from each exchange and keep them in the database

(4) Transform the format of measurement report for evaluating the traffic performance

(5) Represent the results by using the comparative tools such as tables and charts

Select the Type of Traffic Measurement and Assign the Required Parameters

As the author had mentioned early that the author selected the method of traffic measurement on destination for his case study. The concept and theory had been described as well. In this part the author will explain how to apply such measurement method to research the comparative evaluation of traffic performance. To measure the required data, it is necessary to assign some parameters such as name of measurement, type of measurement, measurement day, measurement interval and list of outgoing destinations. The following table shows each parameter in details.

Table 3.1. The Parameter of My Traffic Measurement in Details.

Parameter	**Value**	**Remark**
Type	Destination	
Measurement day	Monday to Sunday	- Capture the raw data from everyday in July and November 1999. - The data from July 1999 (before cutover) as a representative of data of mesh network. - The data from November 1999(after cutover) as a representative of data of star network.
Measurement Interval	24 hours	In each day of measurement, an hour with maximum call attempts will be included in case of busy hour method.
List of outgoing destinations	Compose of many groups of beginning digits that defined within digit table for routing analysis. Example: digit 8 will route to GSM network or to GSM Exchange	- A list from each exchange includes different outgoing destinations. - Destinations in my list are in NMT and GSM networks only because the data of traffic from PSTN aren't stable.

Sampling the Exchange for Measurement

In Thailand, there are 22 NMT exchanges that distribute in each region. But 70% of subscribers are roaming or visiting in Bangkok. Therefore exchanges in Bangkok area are reasonably used in measuring and evaluating the performance of network. There are 13 NMT exchanges in area of Bangkok but the author sampled the raw data from only 11 exchanges for measurement. In his case study, the author denies the data of traffic from 2 exchange because it comes from other vender and the format of data also different.

Exchanges for measurement are MTX1, MTX2, MTX3, MTX4, MT… 11.

Dump the Raw Data from Each Exchange and Keep in Database

The raw data from each exchange will be fetched to store in main compute. See an example of raw data from MTX1in traffic measurement on destination report in Appendix A.

Transform the Format of Measurement Report for Evaluating the Traffic Performance

Referring the method of evaluation of traffic performance, the written application program will transform the format of measurement report to be new form of report for evaluating the traffic performance of network. See an example of this report in Appendix B.

Nowadays the same form of such report in Appendix B is presented in web site www.nmc.ais (AIS 1998) that uses for reporting the network statistics for AIS Company. Figure 3.1 is an example of a daily report of traffic on destination from MTX1 on web page.

Represent the Results by Using the Comparative Tools such as Tables and Charts

The last step of making my measurement report is to represent in comparative results. The results will be divided to 2 cases, one for 24 hours measuring and the other one for peak hour measuring. In each case have two similar sets of data, one for mesh network data and the other one for star network data. The detail of evaluation of these data will be presented and described later in the chapter of system evaluation.

DAILY REPORT: NMT-Call Completion on Destination

Data are taken from 2000.07.19-2000.07.20 (Daily Report)

M... Name		[illegible]						[illegible] Hours				
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	O/G (Erlang)	[illegible]	[illegible]	NCR(%)	ASR (%)
[illegible]	001XXX	19:30	0.60	16	100.00	6.25	93.75	2.20	133	100.00	31.58	61.65
[illegible]	021XXX	09:30	0.10	30	100.00	40.00	36.67	0.20	167	100.00	37.13	34.73
[illegible]	022XXX	15:30	15.80	895	100.00	5.03	90.84	148.40	8770	99.99	5.02	90.73
[illegible]	023XXX	15:30	3.30	155	100.00	3.23	89.03	30.10	1286	100.00	4.74	89.58
[illegible]	024XXX	16:30	5.00	226	100.00	10.62	86.73	46.30	2353	100.00	7.14	87.76
[illegible]	025XXX	14:30	4.40	219	100.00	3.65	92.24	42.80	2035	100.00	6.04	89.29
[illegible]	026XXX	14:30	6.60	321	100.00	0.31	96.26	57.20	3584	100.00	0.67	93.86
[illegible]	027XXX	16:30	3.10	174	100.00	1.15	95.40	24.90	1260	100.00	0.40	93.73
[illegible]	028XXX	13:30	4.30	211	100.00	0.47	92.89	40.10	2210	100.00	0.18	93.30
[illegible]	029XXX	16:30	4.60	248	100.00	1.21	94.76	42.70	2602	100.00	0.31	95.00
[illegible]	032XXX	14:30	1.10	40	100.00	2.50	92.50	7.20	236	99.58	5.51	87.66
[illegible]	034XXX	15:30	1.80	92	100.00	3.26	89.13	14.70	710	100.00	6.76	75.92
[illegible]	035XXX	10:30	1.50	47	100.00	0.00	95.74	11.50	436	100.00	2.06	92.43
[illegible]	036XXX	13:30	1.30	30	100.00	10.00	80.00	10.50	411	100.00	20.44	73.24
[illegible]	037XXX	11:30	0.50	55	100.00	54.55	45.45	1.10	85	100.00	38.82	60.00
[illegible]	038XXX	16:30	2.30	88	100.00	9.09	89.77	19.40	708	100.00	4.80	88.98
[illegible]	039XXX	11:30	0.40	16	100.00	6.25	93.75	2.00	133	100.00	12.03	76.69
[illegible]	042XXX	14:30	0.80	27	100.00	22.22	77.78	6.90	295	100.00	25.42	71.19
[illegible]	043XXX	15:30	0.60	32	100.00	15.62	84.38	2.50	186	100.00	32.26	63.98
[illegible]	044XXX	14:30	1.50	89	100.00	19.10	76.40	12.20	506	100.00	12.65	82.21
[illegible]	045XXX	15:30	0.80	43	100.00	18.60	81.40	5.20	356	100.00	21.91	74.44
[illegible]	053XXX	15:30	1.40	26	100.00	3.85	92.31	9.60	352	100.00	8.81	87.50
[illegible]	054XXX	19:30	0.70	11	100.00	18.18	81.82	3.00	137	100.00	21.90	72.99
[illegible]	055XXX	22:00	1.40	15	100.00	0.00	93.33	7.00	201	100.00	7.46	88.06
[illegible]	056XXX	14:30	1.20	49	100.00	24.49	67.35	7.40	375	100.00	18.67	76.27
[illegible]	073XXX	15:30	0.20	22	100.00	45.45	50.00	0.40	46	100.00	21.74	65.22
[illegible]	074XXX	10:30	1.00	33	100.00	0.00	87.88	4.50	171	100.00	4.68	86.55
[illegible]	075XXX	11:30	1.00	24	100.00	0.00	91.67	1.90	77	100.00	2.60	89.61
[illegible]	076XXX	16:30	0.40	19	100.00	10.53	89.47	0.80	44	100.00	4.55	88.64
[illegible]	077XXX	09:30	0.40	23	100.00	34.78	60.87	2.40	271	100.00	38.38	57.93
[illegible]	09XXXX	16:30	2.70	1071	99.91	0.00	100.00	19.20	7879	99.96	0.01	99.89
[illegible]	19059X	12:30	6.80	312	100.00	0.00	99.68	13.40	568	100.00	0.00	99.65
[illegible]	19069X	11:30	9.70	410	100.00	0.24	99.51	42.00	1683	99.88	0.06	99.76
[illegible]	19209X	11:30	8.20	300	100.00	0.00	99.67	19.60	765	99.74	0.00	99.87
[illegible]	19259X	10:30	7.80	357	99.72	0.00	100.00	34.50	1445	99.79	0.21	99.65
[illegible]	19359X	11:30	6.50	272	100.00	0.00	99.63	23.20	974	99.90	1.85	98.05
[illegible]	19409X	12:30	5.80	315	100.00	1.27	98.73	55.20	2831	99.96	1.17	98.69

Figure 3.1. An Example of Traffic on Destination on Web Page.

[redacted]	19459X	10:30	9.00	359	99.72	0.00	100.00	34.10	1380	99.78	0.00	99.78
[redacted]	19489X	18:30	6.10	267	99.63	0.00	100.00	16.70	552	99.64	0.00	99.82
[redacted]	19519X	20:30	2.90	80	100.00	15.00	85.00	24.70	923	100.00	11.16	88.73
[redacted]	19539X	16:30	0.80	37	100.00	0.00	97.30	0.80	37	100.00	0.00	97.30
[redacted]	19549X	19:30	2.20	47	100.00	4.26	95.74	10.30	416	100.00	3.85	95.91
[redacted]	19709X	11:30	1.20	50	100.00	4.00	94.00	11.60	600	100.00	6.00	93.83
[redacted]	19739X	11:30	2.40	87	100.00	1.15	98.85	18.00	899	100.00	2.78	97.00
[redacted]	19759X	14:30	2.50	78	100.00	2.56	97.44	21.50	998	100.00	3.71	96.19
[redacted]	19859X	16:30	4.90	190	100.00	0.00	99.47	4.90	190	100.00	0.00	99.47
[redacted]	19909X	10:30	1.70	56	100.00	5.36	94.64	17.00	726	100.00	8.68	91.05
[redacted]	19929X	10:30	1.70	79	100.00	15.19	84.81	13.10	789	100.00	14.58	85.42
[redacted]	19949X	17:30	5.50	316	100.00	2.53	97.47	65.70	3388	99.91	3.78	96.19
[redacted]	19959X	16:30	4.10	154	99.35	0.00	100.00	4.10	154	99.35	0.00	100.00
[redacted]	19969X	12:30	6.40	306	100.00	1.31	98.69	66.60	3373	99.94	1.66	98.28
[redacted]	19979X	20:30	3.70	115	100.00	6.96	93.04	25.40	1263	100.00	4.12	95.72
[redacted]	19989X	10:30	11.60	590	100.00	2.54	97.46	125.90	6802	99.96	2.73	97.23
[redacted]	19999X	15:30	6.00	298	100.00	1.68	98.32	51.30	2858	99.90	2.45	97.41
[redacted]	21XXXX	09:30	0.30	12	100.00	0.00	83.33	1.00	74	100.00	1.35	89.19
[redacted]	22XXXX	11:30	0.20	12	100.00	0.00	91.67	0.40	58	100.00	0.00	79.31
[redacted]	285XXX	13:30	0.20	8	100.00	12.50	87.50	0.20	30	100.00	30.00	70.00
[redacted]	286XXX	11:30	0.10	16	100.00	0.00	93.75	0.20	34	100.00	5.88	91.18
[redacted]	30XXXX	10:30	0.90	60	100.00	1.67	98.33	7.70	503	100.00	0.99	94.83
[redacted]	31XXXX	16:30	1.80	123	100.00	4.88	86.99	16.20	1139	100.00	3.69	88.94
[redacted]	33XXXX	11:30	1.70	94	100.00	6.38	88.30	14.30	979	100.00	4.09	90.09
[redacted]	34XXXX	17:30	1.00	48	100.00	0.00	95.83	5.00	332	100.00	6.02	89.76
[redacted]	35XXXX	12:30	0.30	26	100.00	0.00	96.15	1.50	142	100.00	2.82	94.37
[redacted]	39XXXX	18:30	0.10	9	100.00	11.11	77.78	0.10	15	100.00	6.67	73.33
[redacted]	46XXXX	12:30	0.10	13	100.00	0.00	92.31	0.10	32	100.00	21.88	65.62
[redacted]	4XXXXX	13:30	5.60	278	100.00	1.08	95.32	55.60	3009	100.00	1.60	93.42
[redacted]	6XXXXX	15:30	12.90	817	100.00	3.55	92.41	138.60	8132	100.00	2.72	93.27
[redacted]	8XXXXX	15:30	15.60	951	100.00	7.68	89.70	172.90	10156	100.00	6.90	89.09

O/G = Outgoing Traffic(Erlang)
Bids = Number of Call Attempts
SBR = Seizure to Bids Ratio
NCR = Next Exchange Congestion Ratio
ASR = Answer to Seizure Ratio

Figure 3.1. An Example of Traffic on Destination on Web Page. (Continued)

IV. SYSTEM EVALUATION

There are three main parts for this chapter. The first part shows the comparative result of traffic performance. Each table shows the data from each type of traffic measurement report. The second part will evaluate the traffic in form of comparative chart. The last part concludes the advantages and disadvantages of both networks.

4.1 Comparative Results of Traffic Performance

Referring to item 2.4 in Literature Review chapter, it is about the measuring network usage. Tables 4.1 to 4.7 show the required entities that are useful for measuring network usage such as traffic intensity in erlang, number of call attempts, and number of call complete. These results can be used to compare the traffic performance between the networks as well. Each table is different according to different condition of traffic measurement.

The results in Tables 4.1 and 4.2 are overall information of traffic gathered by traffic measurement on destination method. The measuring interval in both tables is different. The raw data are gathered 24 hours for Table 4.1 but only busy hour for Table 4.2. The meaning of each entity in Tables 4.1 and 4.2 are listed below:

Erlang :: average traffics in erlangs during the measurement interval

Attempt :: total number of calls is attempted during the measurement interval

Seizure :: total number of successful calls during the measurement interval

Nreject :: number of calls, which were interrupted in the ring phase and the called subscriber, did not answer during the measurement interval

Banswer :: number of calls in which the called subscriber has answered during the measurement interval

Per_seizure :: The percentage of total number of successful calls to total number of call is attempted

Per_reject :: The percentage of number of calls, which were interrupted in the ring phase and the called subscriber, did not answer to total number of call is attempted

Banswer :: The percentage of number of calls in which the called subscriber has answered to total number of call is attempted

The average value of data in July and November are shown in such tables to compare the traffic performance before and after change network. To make it is easily to see the difference of data according to each entity, the following Tables 4.3 to 4.7 will be helpful.

Table 4.3 shows the average erlang in 24 hours before and after reconfiguration of network. After change, the erlang of all exchanges will decrease.

Table 4.4 shows the average erlang at busy hour before and after reconfiguration of network. After change, the erlang of all exchanges will decrease.

Table 4.5 shows the seized calls in percentage before and after reconfiguration of network. After change, the seized calls of all exchanges will increase.

Table 4.6 shows the rejected calls in percentage before and after reconfiguration of network. After change, the rejected calls of all exchanges will decrease.

Table 4.7 shows the answered calls in percentage before and after reconfiguration of network. After change, the answered calls of all exchanges will increase.

All tables in this chapter will relate to the comparative charts in section 4.2 of chapter 4. The assumptions of data changing in each case will be mentioned in such section as well.

Table 4.1. The Information of Traffic on Destinations in 24 Hours (Monthly Report).

Exchange	Erlang	Attemp	Seizure	Nreject	Banswer	Per_seizure	Per_reject	Per_answer
MTX1	59.9	3139	3136	151	2886	[illegible]	4.81	[illegible]
MTX1	*50.5*	*2793*	*2792*	*101*	*2577*	*99.96*	*3.62*	*92.27*
MTX2	56.3	2780	2779	163	2567	99.96	5.86	92.34
MTX2	*47*	*2340*	*2339*	*130*	*2184*	*99.96*	*5.56*	*93.34*
MTX3	70.3	3489	3486	153	3256	99.91	4.39	93.32
MTX3	*59.3*	*3144*	*3143*	*121*	*2948*	*99.97*	*3.85*	*93.77*
MTX4	78.3	4898	4896	203	4595	99.96	4.15	93.81
MTX4	*74.5*	*4637*	*4636*	*168*	*4361*	*99.98*	*3.62*	*94.05*
MTX5	73.2	3787	3784	180	3524	99.92	4.75	93.06
MTX5	*73.1*	*3894*	*3892*	*167*	*3648*	*99.95*	*4.29*	*93.68*
MTX6	82.6	4039	4037	175	3788	99.95	4.33	93.79
MTX6	*75.6*	*3838*	*3836*	*156*	*3624*	*99.95*	*4.06*	*94.42*
MTX7	62.6	3243	3240	171	2987	99.91	5.27	92.11
MTX7	*46.9*	*2562*	*2560*	*131*	*2362*	*99.92*	*5.11*	*92.19*
MTX8	64.7	3115	3114	151	2925	99.97	4.85	93.9
MTX8	*63.2*	*3205*	*3204*	*151*	*3017*	*99.97*	*4.71*	*94.13*
MTX9	69.6	4689	4685	199	4395	99.91	4.24	93.73
MTX9	*54.2*	*3938*	*3937*	*150*	*3704*	*99.97*	*3.81*	*94.06*
MTX10	74.6	3790	3789	175	3552	99.97	4.62	93.72
MTX10	*60.7*	*3147*	*3146*	*143*	*2954*	*99.97*	*4.54*	*93.87*
MTX11	85.7	4262	4258	343	3811	99.91	8.05	89.42
MTX11	*73.6*	*4003*	*4002*	*304*	*3586*	*99.98*	*7.59*	*89.58*

Hint: Jul-99

Nov-99

Table 4.2. The Information of Traffic on Destinations at Busy Hour (Monthly Report).

Exchange	Erlang	Attemp	Seizure	Nreject	Banswer	Per_Seizure	Per_reject	Per_answer
MTX1	4	194	194	10	178	100	5.15	91.75
MTX1	*3.9*	*196*	*196*	*8*	*180*	*100*	*4.08*	*91.84*
MTX2	3.8	156	156	10	143	100	6.41	[illegible]
MTX2	*3.6*	*163*	*163*	*10*	*152*	*100*	*6.13*	*93.25*
MTX3	4.4	196	195	9	182	99.49	4.59	[illegible]
MTX3	*4.2*	*198*	*198*	*8*	*186*	*100*	*4.04*	*93.94*
MTX4	4.8	4898	4896	203	4595	99.96	4.15	[illegible]
MTX4	*4.2*	*4637*	*4636*	*168*	*4361*	*99.98*	*3.62*	*94.05*
MTX5	4.6	211	211	12	195	100	5.69	92.42
MTX5	*4.2*	*250*	*250*	*12*	*234*	*100*	*4.8*	*93.6*
MTX6	5.5	251	251	19	227	100	7.57	90.44
MTX6	*5.2*	*228*	*228*	*11*	*213*	*100*	*4.82*	*93.42*
MTX7	4.1	187	187	12	171	100	6.42	91.44
MTX7	*3.7*	*176*	*176*	*10*	*161*	*100*	*5.68*	*91.48*
MTX8	5.2	246	246	17	226	100	6.91	91.87
MTX8	*4.3*	*179*	*179*	*10*	*167*	*100*	*5.59*	*93.3*
MTX9	4.4	265	265	14	246	100	5.28	92.83
MTX9	*4*	*258*	*258*	*13*	*239*	*100*	*5.04*	*92.64*
MTX10	4.5	210	210	15	192	100	7.14	91.43
MTX10	*4.2*	*205*	*205*	*10*	*191*	*100*	*4.88*	*93.17*
MTX11	5.6	247	247	28	212	100	11.34	85.83
MTX11	*5.2*	*257*	*257*	*27*	*224*	*100*	*10.51*	*87.16*

Hint: Jul-99

Nov-99

Table 4.3. Average Erlang in 24 Hours Comparing between Both Networks.

EXCHANGE	ERLANG(Before change, July 1999)	ERLANG(After change, Nov 1999)
MTX1	59.9	
MTX2	56.3	
MTX3	70.3	
MTX4	78.3	
MTX5	73.2	
MTX6	82.6	
MTX7	62.6	
MTX8	64.7	
MTX9	69.6	
MTX10	74.6	
MTX11	85.7	

Table 4.4. Average Erlang at Busy Hour Comparing between Both Networks.

EXCHANGE	ERLANG(Before change, July 1999)	ERLANG(After change, Nov 1999)
MTX1	4	
MTX2	3.8	
MTX3	4.4	
MTX4	4.8	
MTX5	4.6	
MTX6	5.5	
MTX7	4.1	
MTX8	5.2	
MTX9	4.4	
MTX10	4.5	
MTX11	5.6	

Table 4.5. Comparative Seized Calls (%) of Each Exchange between Both Networks.

Exchange	%Seized calls in 24 hours		%Seized calls at busy hour	
	before change(July 1999)	after change(Nov 1999)	before change(July 1999)	after change(Nov 1999)
MTX1	99.9	99.96	100	100
MTX2	99.96	99.96	100	100
MTX3	99.91	99.97	99.49	100
MTX4	99.96	99.98	99.96	99.98
MTX5	99.92	99.95	100	100
MTX6	99.95	99.95	100	100
MTX7	99.91	99.92	100	100
MTX8	99.97	99.97	100	100
MTX9	99.91	99.97	100	100
MTX10	99.97	99.97	100	100
MTX11	99.91	99.98	100	100

Table 4.6. Comparative Rejected Calls (%) of Each Exchange between Both Networks.

Exchange	%Rejected calls in 24 hours		%Rejected calls at busy hour	
	before change(July 1999)	after change(Nov 1999)	before change(July 1999)	after change(Nov 1999)
MTX1	4.81	3.62	5.15	4.08
MTX2	5.86	5.56	6.41	6.13
MTX3	4.39	3.85	4.59	4.04
MTX4	4.15	3.62	4.15	3.62
MTX5	4.75	4.29	5.69	4.8
MTX6	4.33	4.06	7.57	4.82
MTX7	5.27	5.11	6.42	5.68
MTX8	4.85	4.71	6.91	5.59
MTX9	4.24	3.81	5.28	5.04
MTX10	4.62	4.54	7.14	4.88
MTX11	8.05	7.59	11.34	10.51

Table 4.7. Comparative Answered Calls (%) of Each Exchange between Both Networks.

Exchange	%Answered calls in 24 hours		%Answered calls at busy hour	
	before change(July 1999)	after change(Nov 1999)	before change(July 1999)	after change(Nov 1999)
MTX1	91.94	92.27	91.75	91.84
MTX2	92.34	93.34	91.67	93.25
MTX3	93.32	93.77	92.86	93.94
MTX4	93.81	94.05	93.81	94.05
MTX5	93.06	93.68	92.42	93.6
MTX6	93.79	94.42	90.44	93.42
MTX7	92.11	92.19	91.44	91.48
MTX8	93.9	94.13	91.87	93.3
MTX9	93.73	94.06	92.83	92.64
MTX10	93.72	93.87	91.43	93.17
MTX11	89.42	89.58	85.83	87.16

4.2 Comparative Evaluation of Traffic Performance

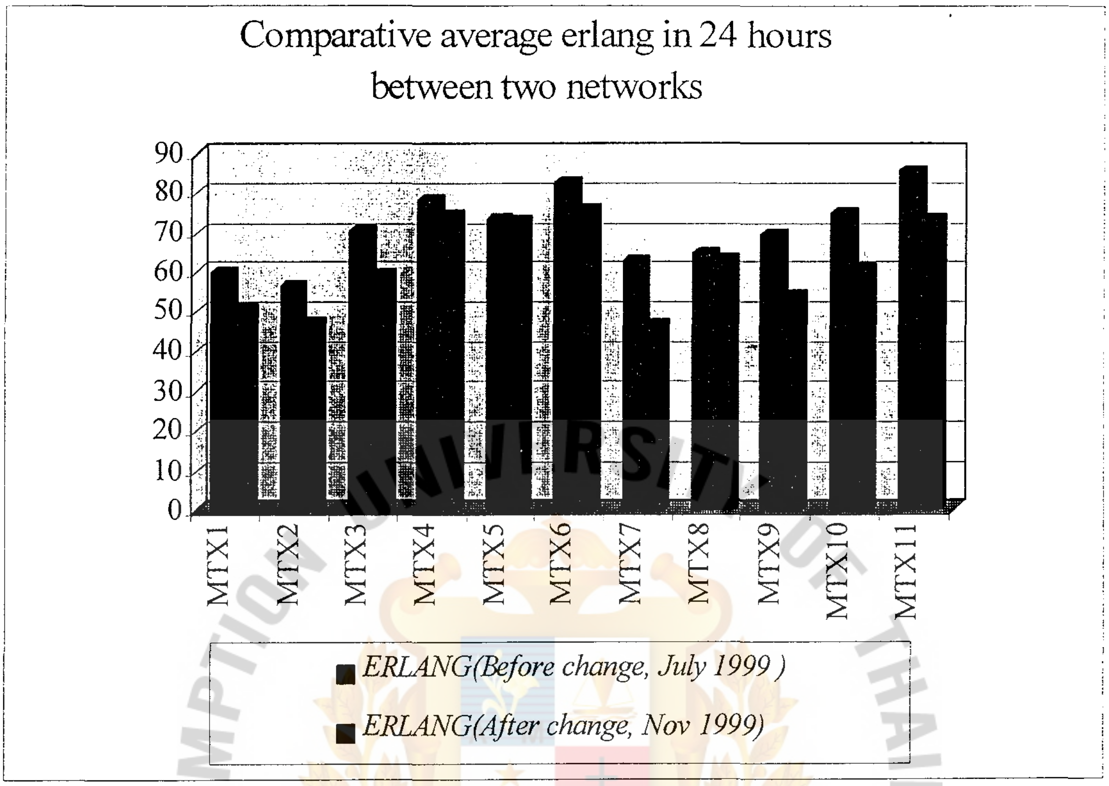

Figure 4.1. Clustered Columns Show Comparative Average Erlang per Month between Two Networks.

From Figure 4.1, the average erlang in 24 hours decreases after the reconfiguration of the network. It means the traffic intensity to each destination is less than before.

Assumptions:

(1) There are more circuits or traffic channels between each MTXs after connecting through Gateway.

(2) The idle time of network resources in star network is more than before.

(3) The traffic through the network is decreasing.

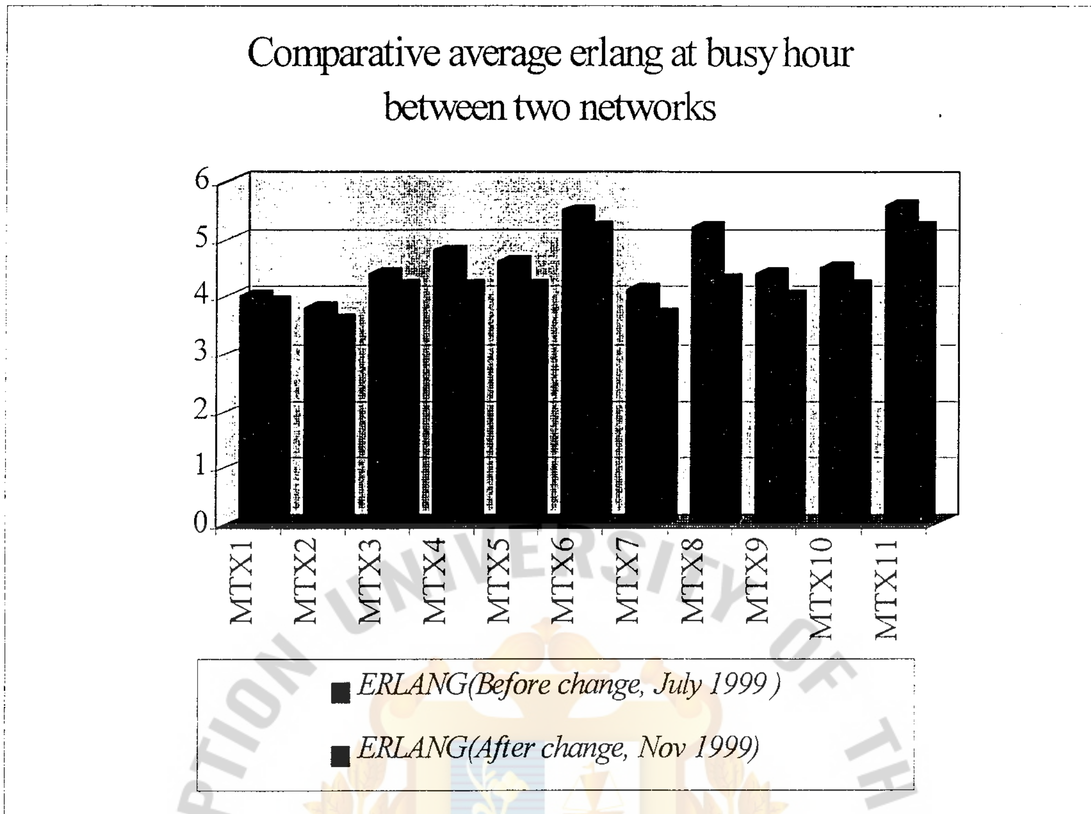

Figure 4.2. Clustered Columns Show Comparative Average Erlang at Busy Hour between Two Networks.

From Figure 4.2, the average erlang at busy hour decreases after the reconfiguration of the network. It means the traffic intensity to each destination at busy hour is less than before. This chart supports the result from previous chart but different in collecting time.

Assumptions:

(1) There are more circuits or speech channels between each MTXs after connecting through Gateway.

(2) The idle time of network resources in star network is more than before.

(3) The traffic through the network is decreasing.

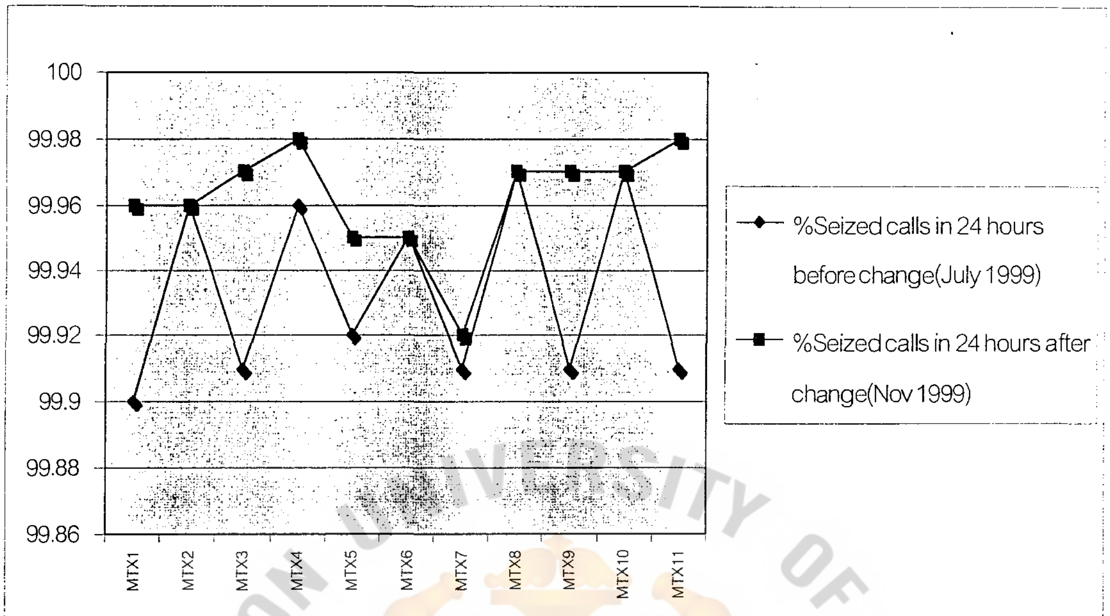

Figure 4.3. Line Chart Shows Comparative Seized Calls in 24 Hours before and after Change.

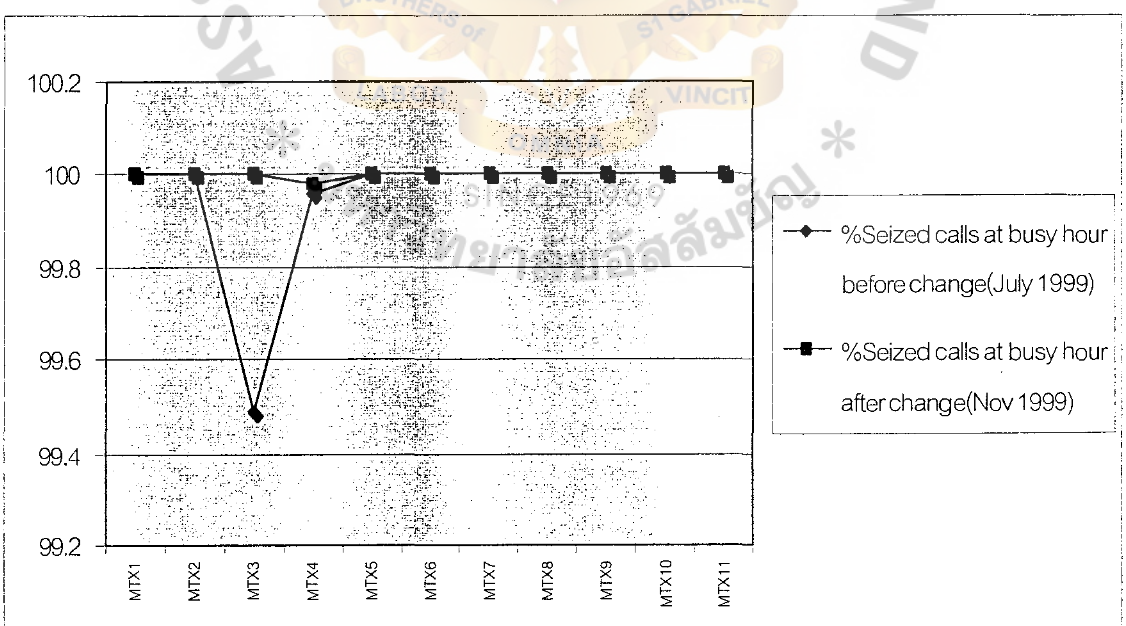

Figure 4.4. Line Chart Shows Comparative Seized Calls at Busy Hour before and after Change.

From Figures 4.3 and 4.4, the percentage of seized calls in star network increases. This means on the same number of calls attempted to the destination, there are more calls that can occupy the circuits than before.

Assumptions:

(1) The network is less complicated than before so more calls can seizure to the destination.

(2) There is no more congestion problem because of more utilization of network resources.

(3) New network configuration increases the utilization of network resources. One circuit can use in several times.

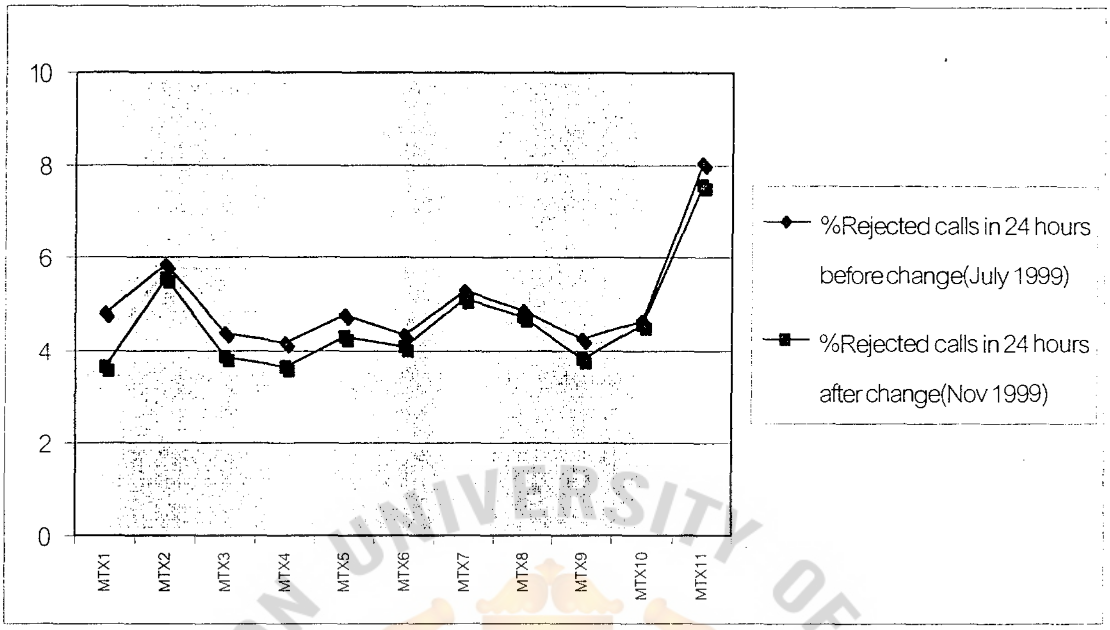

Figure 4.5. Line Chart Shows Comparative Rejected Calls in 24 Hours before and after Change.

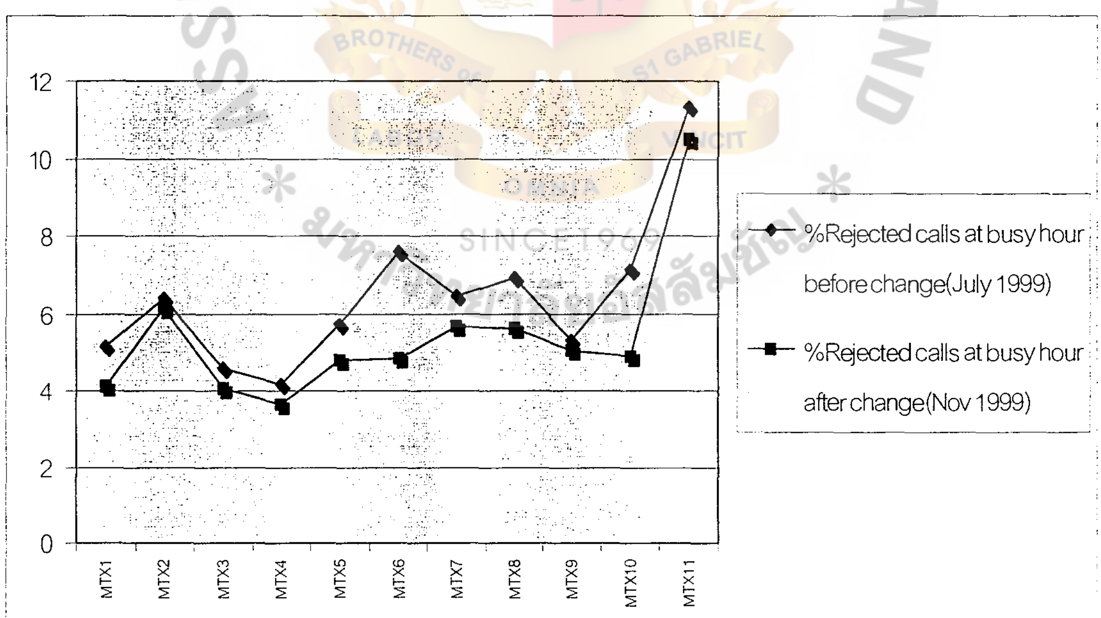

Figure 4.6. Line Chart Shows Comparative Rejected Calls at Busy Hour before and after Change.

From Figures 4.5 and 4.6, the percentage of rejected calls in star network decreases. This means on the same number of calls attempted to the destination, there are lesser calls that should be rejected with various reason during calls processed in the star network.

Assumptions:

(1) The network is less complicated than before so more calls can seizure to the destination. The rejected calls should be decreased as well.

(2) There is no more congestion problem because of more utilization of network resources. So the number of rejected calls for star network is less than mesh network.

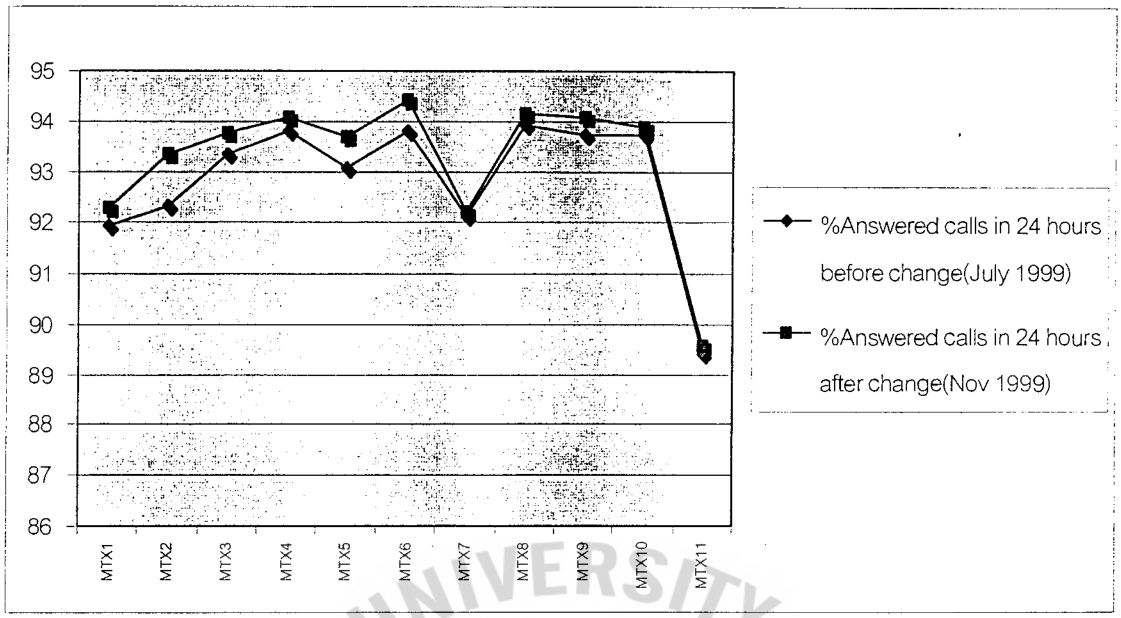

Figure 4.7. Line Chart Shows Comparative Answered Calls in 24 Hours before and after Change.

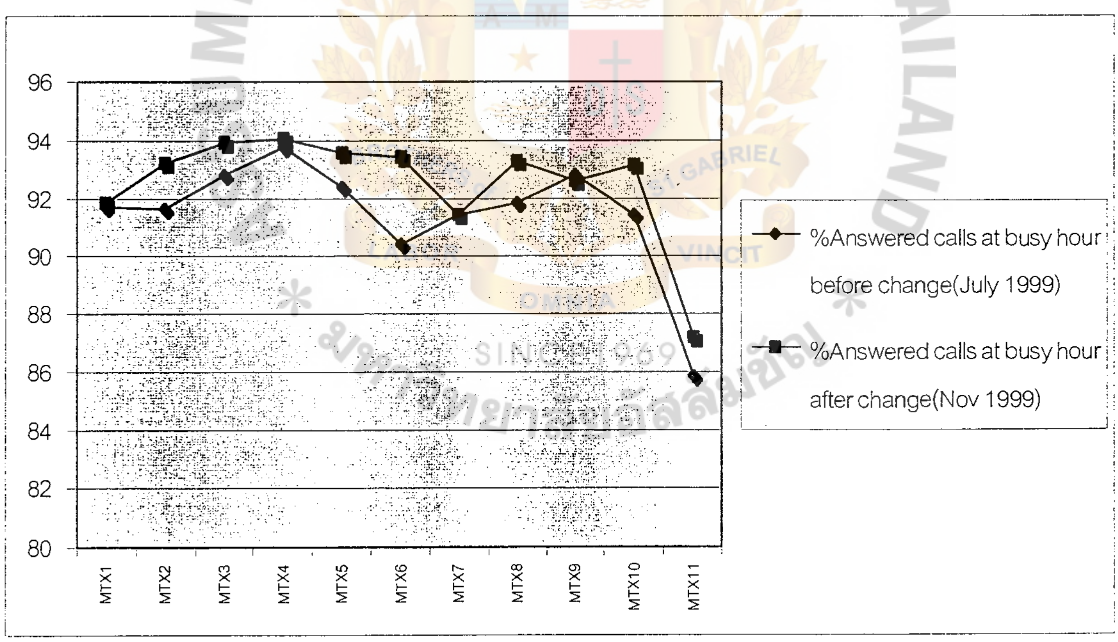

Figure 4.8. Line Chart Shows Comparative Answered Calls at Busy Hour before and after Change.

From Figures 4.7 and 4.8, the percentage of answered calls in star network increases. This means on the same numbers of call attempted to the destination, there are more successful calls processed in the star network.

Assumptions:

(1) The network is less complicate than before so more calls can seizure to the destination. From the same reason, the answered calls are increasing.

(2) If there is no more congestion problem, more calls can process completely.

(3) New network configuration increases the utilization of network resources. One circuit can use in several times. So more calls can process completely.

The following are the description of each advantage that NOKIA commits to AIS for Gateway solution implementation from my study.

4.2.1 Saving in Transmission with Enhanced Call Rerouting

What is the concept of call rerouting?

Call rerouting is a call transfer in which subscriber B's exchange sends a diversion request message to the originating exchange. After the request, the original connection is cleared and the call is transferred again from the originating exchange.

As the result, when a call is set up by the originating exchange to mobile subscriber who roaming in the visiting exchange (not existing in its home exchange area), the originating exchange will send signaling message to inquire the location of such subscriber from its home exchange. Then the originating exchange will reroute or reconnect that call to the visiting exchange for making complete conversation.

The Technical Aspect of Call Rerouting in NMT Network

Analyzing a redirection number if it is received within the release message or otherwise by reanalyzing the original number in a new analysis tree can do rerouting of a call. The routing alternatives of the original destinations can also be used.

The technical aspect of call rerouting in NMT network in at the moment based on Mobile Subscriber Location Inquiry Feature of the Nokia DX 220 High Capacity Gateway.

Mobile Subscriber Location Inquiry Feature

To develop the functionality of the Gateway Switch to better meet network demand, Nokia is going to include selected limited functionality of MUP (Mobile User Part) into the fixed switch release road map. MUP signaling is actually used for interrogation purpose. Somehow, the gateway has an "Improve Rerouting" which can be used full in the "star" configuration network.

This subset of MUP covers the functionality by which the Gateway can with signaling inquire the location of the mobile subscriber from the Home MTX and then forward the call directly to the Visitor MTX. In other words, when a call to a Mobile subscriber comes from PSTN to the Gateway, the Gateway:

(1) Sends a Roaming Number Inquiry message to the Home MTX (MTXH)

(2) Receives the Roaming Number Message from the MTXH

(3) Routes the call according to the roaming number

The picture in Figure 4.9 will describes the Mobile Subscriber Location Inquiry solution:

NOKIA DX 220 Gateway Solution

With "Mobile Subscriber Location Inquiry"

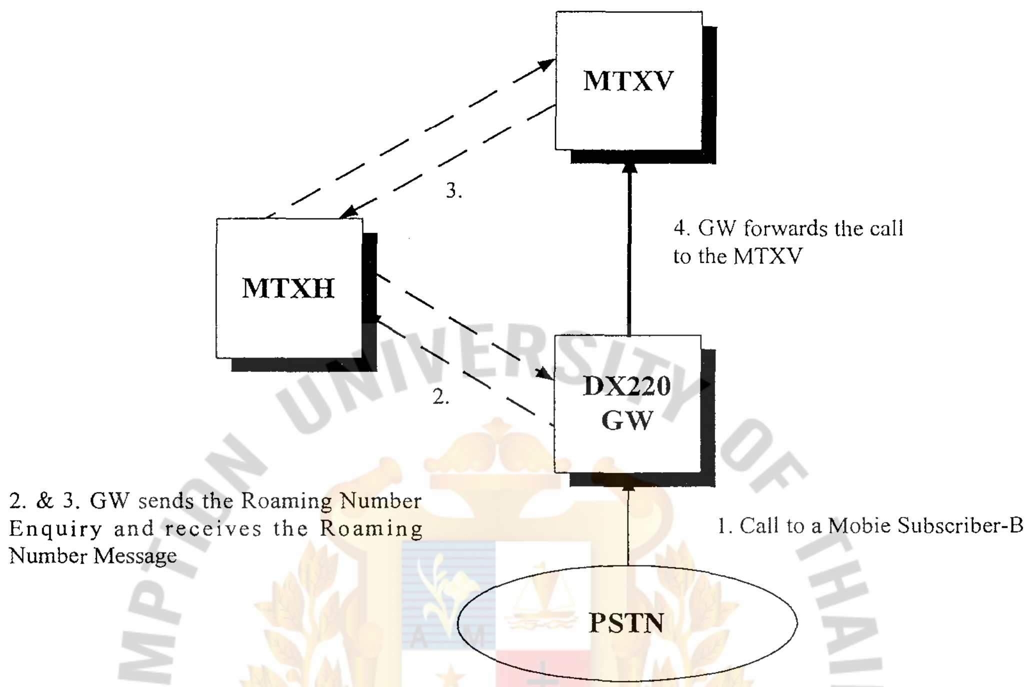

Figure 4.9. Mobile Subscriber Location Inquiry Solutions.

How Does It Save Transmission When the Network Is Star-shaped?

The solution of mobile subscriber location inquiry doesn't change although the network configuration will change. Call rerouting feature of both networks is the same. In mesh-shaped network, the path of call rerouting is shorter than current path in star-shaped network because each exchange in same region will have direct routes to the others. But how it saves transmission when the network changes to star-shaped network will be discussed later.

In fact, there are many cases of calls rerouting in the network, several different originating exchanges reroute calls to several different Home MTXs and Visitor MTXs.

These diverse cases should be possibly happened all or some in real traffics. But it is complicate work and high investment for network planning to cover all possible cases. To cover most possible cases of calls rerouting, in the past the mesh-shaped network had to interconnect all exchanges directly and that required so many transmissions as well. Even so, the routes to other long distance regions are not enough to interconnect in full mesh. Such cases, the calls should route to same regional exchange that has a direct transmission line for making a call connection to the exchanges in other regions. As the result, in mesh-shaped required more transmission than in star-shaped network.

4.2.2 Simplifies the PSTN Interface and Improves the Utilization of the Limited Trunk Capacity

Simplifies the PSTN Interface

PSTN network interfaces with Cellular 900 network before and after reconfiguration are shown in Figures 4.10 and 4.11.

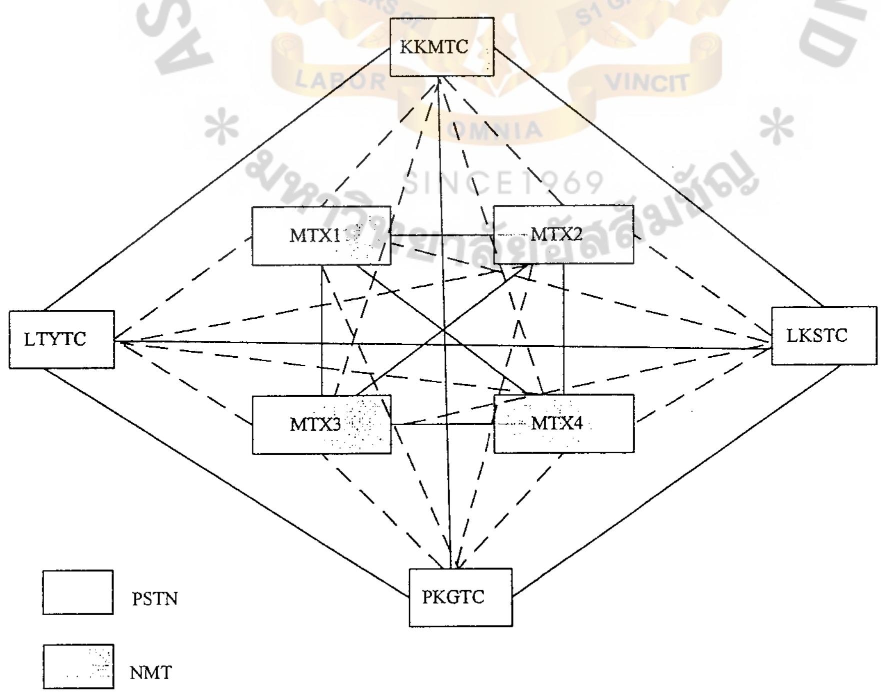

Figure 4.10. PSTN Interfaces to Mesh-shaped Network.

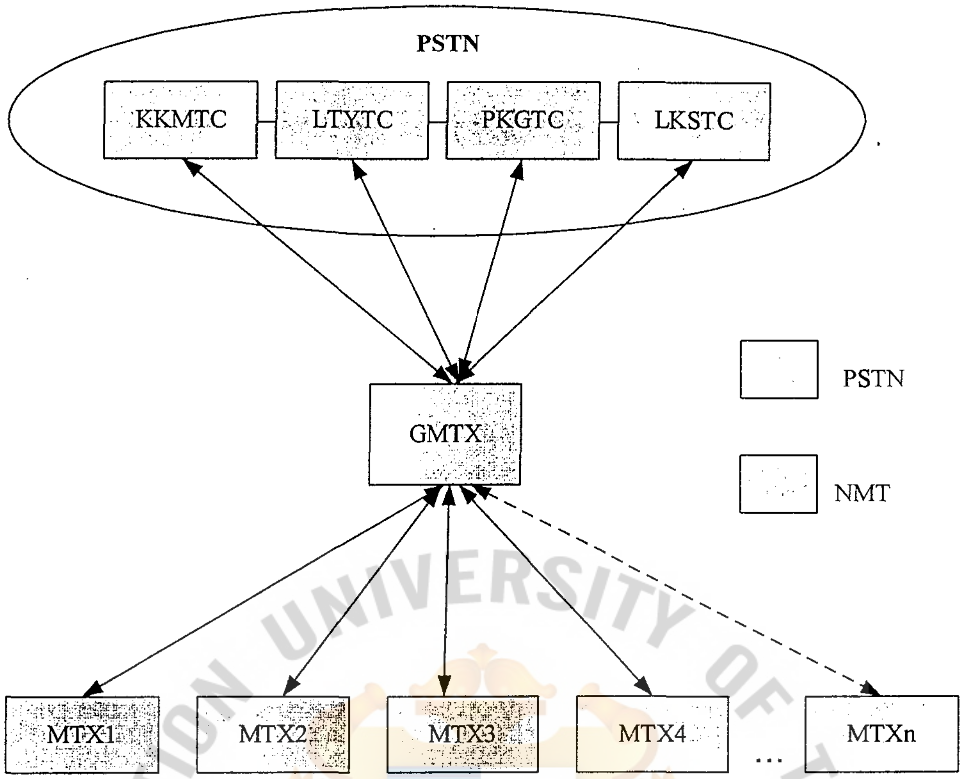

Figure 4.11. PSTN Interfaces to Star-shaped Network.

From Figures 4.10 and 4.11, when the configuration of cellular 900 network changes to be star-shaped network, the complicate interfaces to PSTN network will simplified to be only one interface via Gateway MTX.

Improves the Utilization of the Limited Trunk Capacity

For star-shaped network, more trunk circuits are grouped in one circuit group routing to Gateway exchange. The utilization of each circuit is better than in mesh-shaped network that divide traffic to many small circuit groups and some circuits are useless. So this reconfiguration can improve the utilization of the limited trunk capacity. See Figure 4.12.

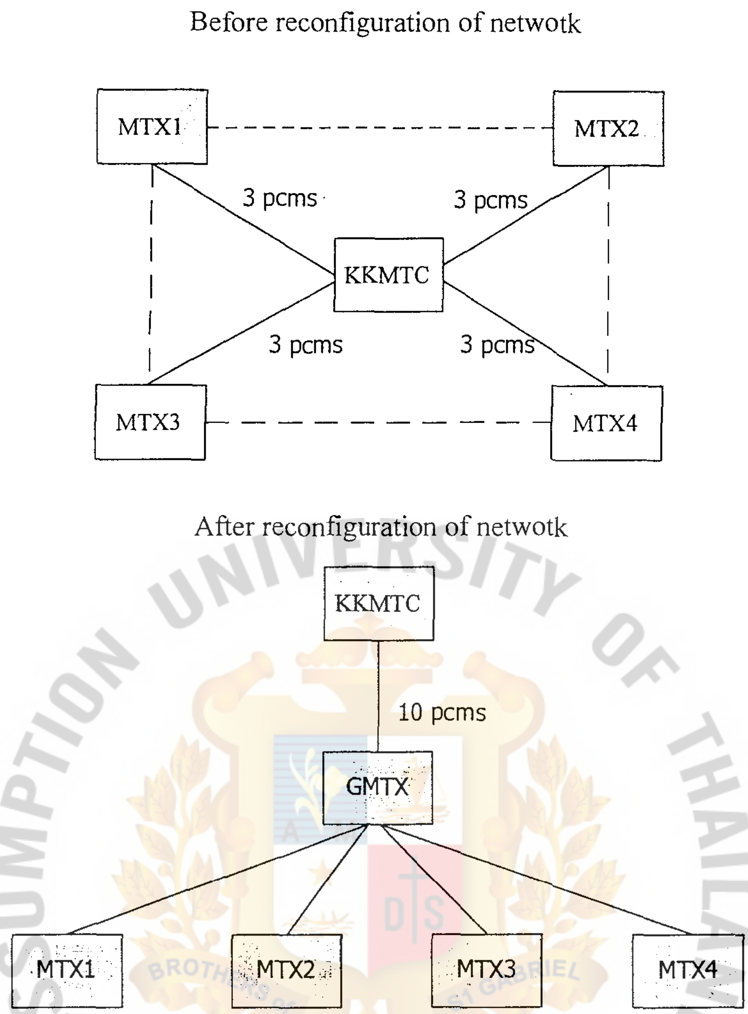

Figure 4.12. Improve the Utilization Limited Trunk Capacity.

4.2.3 Reduce the Complexity of Trunking the Networks

Reduce Many Small Circuit Groups

Some 70% incoming calls from PSTN are rerouted, and the share is still growing when more exchanges are taken in operation. That will cause the need for trunk capacity between the exchanges. Anyway the relative traffic between two exchanges is decreasing because less subscriber are visiting in one exchange but shared with new exchanges as well. As the result, there is a need for many small circuit groups for handling calls between exchanges.

The transmission network will be more complicated to manage, links are needed from every site to the others and circuit groups are small offering less relative capacity per circuit than the circuit in large one. And from that many small circuit groups, it is difficult to manage the operation and maintenance as well.

To solve the above problem, we need one exchange as a gateway to handle all calls between networks. The networks will communicate through this gateway exchange. The new defined circuit groups will be larger and can offer more capacity per circuit than the old ones. The utilization of pool circuits in each larger circuit group will increase when all exchanges are connected in star-shaped. Therefore, this solution will decrease numbers of circuit groups in each original exchange and also reduce the complexity of trunking the networks.

Centralized Access to Voice Mail

To centralized access to Voice Mail Service (VMS) and probably some other Value Added Services, these services will connect to the Gateway Exchange. The solution requires additional trunking capacity to Gateway interfaces but simplifies the trunking network as the trunks from every exchange to the VMS would not needed anymore.

4.2.4 Increases the Connected Call Ratio

The increasing connected calls ratio will increase revenues and customer satisfaction. Therefore good network should have high-connected call ratio. Referring to the comparative results from mesh and star network, the percentage of seized call, rejected call and answered call are the important indicators to compare the connected call ratio between both networks. The following tables conclude the percentage of seized call, rejected call and answered call depending on network shape.

Table 4.8. The Percentage of Seized Calls, Rejected Calls and Answered Calls of Each Network.

EXCHANGE	%Seized call		%Rejected call		%Answered call	
	Mesh network	Star network	Mesh network	Star network	Mesh network	Star network
MTX1	99.9	99.96	4.81	3.62	91.94	92.27
MTX2	99.96	99.96	5.86	5.56	92.34	93.34
MTX3	99.91	99.97	4.39	3.85	93.32	93.77
MTX4	99.96	99.98	4.15	3.62	93.81	94.05
MTX5	99.92	99.95	4.75	4.29	93.06	93.68
MTX6	99.95	99.95	4.33	4.06	93.79	94.42
MTX7	99.91	99.92	5.27	5.11	92.11	92.19
MTX8	99.97	99.97	4.85	4.71	93.9	94.13
MTX9	99.91	99.97	4.24	3.81	93.73	94.06
MTX10	99.97	99.97	4.62	4.54	93.72	93.87
MTX11	99.91	99.98	8.05	7.59	89.42	89.58

From Table 4.8, the increasing of percentage of seized call and answered call can approximately confirm that star network increases the connected call ratio. To make sure, the author will show the increasing percentage of the connected call ratio refers to each exchange after changing the configuration of network by using the information of answered call. See Table 4.9.

Formula:

$$\%\text{ Increasing connected call ratio} = \frac{\{\%\text{Answered call (Star)} - \%\text{Answered call (Mesh)}\}*100}{\%\text{Answered call (Mesh)}}$$

Table 4.9. Increasing Connected Call Ratio.

EXCHANGE	% Increasing connected call ratio
MTX1	0.36
MTX2	1.08
MTX3	0.48
MTX4	0.26
MTX5	0.67
MTX6	0.67
MTX7	0.09
MTX8	0.24
MTX9	0.35
MTX10	0.16
MTX11	0.18

The comparative results confirm that after changing the configuration of network, the connected call ratio in star network with gateway solution has increase reasonably.

4.2.5 Easy Expansion of the Network; New Exchange Is Connected Only to Gateway

This issue is easy to understand. The mesh network requires many connections when expanding to new exchange to the network. Because of many connections, each connection should be reconfigured for the new exchange. So there are many works at for expansion of the network. It will be very difficult to configure new exchange to the mesh network.

But for the star network, the new exchange is connected only to the Gateway when it is expanded. Only new exchange and the Gateway exchange are required to reconfigure.

4.2.6 More Efficient Transmission Management

In the past, the transmission team works hard every day. There are many alarms related to the transmission problem sent to the transmission department. It is very sensitive to solve each alarm because of the complicated connection for mesh network. So that it is difficult to analyze the exact solution and also used many people in transmission team to go to each site for testing and solving the problem.

In the planning department, it is also sensitive to work with this network. There are two main problems about the transmission. One is the congestion problem that means transmission lines between related nodes are not enough. The other is less utilization of some transmission lines that means waste money for those resources.

Now it will change. When the new network (star network) is used, the utilization of transmission line will be better than before. The connection isn't complex any more. And the analysis can solve the problem in correct point.

For the transmission planning, each transmission line can be easily increased or decreased depending on the traffic measurement data. We can conclude that this new network is more flexible and efficient in term of transmission management.

4.3 Advantages & Disadvantages of Each Network

From the information the author studies both networks, there are different advantages and disadvantages. The author concludes them from his work experience and some technical references. The following table summarizes the advantages and disadvantages of each network. After that the author will describe each advantages that NOKIA commits to AIS for Gateway solution implementation.

Table 4.10. Advantages & Disadvantages of Mesh Network.

Mesh Network	
Advantages	**Disadvantages**
1) Faster call set up	1) Difficult for expansion: modify to all node
2) More alternative route for routing	2) High expensive cost of transmission line connecting to all nodes
3) No need Gateway exchange	
4) Direct connection to all node so it's more reliable	3) Difficult to crate the routing and digit analysis to cover overall network

Table 4.11. Advantages & Disadvantages of Star Network.

Star Network	
Advantages	**Disadvantages**
1) Savings in transmission with enhanced call rerouting	1) Less reliability
2) Simplifies the PSTN interface and improves the utilization of the limited trunk capacity	2) Requires high capacity of switching Gateway Exchange
3) Reduces the complexity of network	3) Requires more time for call set up
4) Increases the connected call ratio	4) In case of signaling to the node failure, it can't communicate to that node
5) Easy expansion of the network; new exchange is connected only to Gateway	5) Few alternative route for routing
6) More efficient transmission management	

V. CONCLUSIONS

The main purpose of this project is for the evaluation of the performance of the new network (star network). Each chapter in this report will give the information to compare the network performance. The first step of this project is setting up the proposal that concludes the objectives, scopes, and the project schedule. It requires long hours to find the best method to compare the network because there are so many methods and items to consider when we want to compare the performance of the network. Until the best method is discovered, the work of collecting the necessary information starts.

From existing measuring tool in NOKIA exchange, it is very useful to collect the required data. But the data from each exchange is cumbersome so the hard and tedious work of calculation and analysis of the data is needed. This is also use for a long time to finish completely because some exchanges have uncertain measurement processing. When this work is completely finished, the proper evaluation method is selected from many textbooks. To make this comparative evaluation easily understandable, the simple gains of network comparison such as number of call attempts, number of call complete and traffic intensity are selected from the traffic measurement report. And to confirm that this evaluation is fair and correct, it is divided to two sets of data. One is 24 hours measuring data and the other is busy hour measuring data. The result from comparative both sets are in the same direction so it is more confident to trust in this evaluation.

The last and hardest work is needed after receiving all results. To analyze how the result of the evaluation is different and what network is better. The author tries his best to answer that question by referring to his three years work-experience in mobile telecommunication service and the theories in many sources. Some mobile telecommunication techniques for comparative evaluation are required so it may be not easily understood. The solution for this problem is adding some involving knowledge to this project report.

Refer to the results in the system evaluation chapter, the rate of network usage of the star network is better than the mesh network. From many tables in the comparative network result item, they shown that the traffic intensity of new network decreases. This condition shows that there are idler trunk circuits to handle the traffic because the star configuration will enhance the utilization of each circuit for making a call connection. It also reduces the problem of congestion. And the number of calls in each category in the tables also aids us to evaluate the performance of the network. The increase of the number of calls attempted, call seizures and call answered for the star network means that it has better traffic performance in the new network.

But in the author's opinion, the commitment from the supplier to invite AIS to change the network configuration is interesting to concern. Those items are following:

(1) Saving in transmission with enhanced call rerouting

(2) Simplifies the PSTN interface and improves the utilization of the limited trunk capacity

(3) Reduce the complexity of trunking the networks

(4) Increases the connected call ratio

(5) Easy expansion of the network; new exchange is connected only to Gateway

(6) More efficient transmission management

So the six items in the objectives are deeply considered. Each item is also described in the chapter of system evaluation. Some theories of telephone communication are used to describe by the content and figures. The result of each item is accepted that means every thing that Nokia Company commits to AIS is correct and the new network can solve many problems that the original network has faced.

All information that is presented in this report may be not be perfect to consider which network is because there is no issue about economic point of view. But in the author's point of view, the technical issues in this report is enough to confirm that it should be better to change the network configuration of this mobile telephone system to the star network.

VI. RECOMMENDATIONS

As it is mentioned in the conclusion chapter that this project is only for technical comparison aspect to evaluate the performance of the mobile telephone network. For this recommendation, it also refers to the technical issues. In this chapter, it concludes the decision of the author to point that which network is better and what are the reasons.

At the beginning of Cellular 900 mobile telephony, there are a few exchanges called MTX in the network. At that time the transmission lines are connected to all exchanges to make high reliability and capacity for mobile telephone system. All links and nodes in the system form a network called mesh network. Refer to the concept of the mesh network, this network is a good choice for small mobile telephone system because it has enough reliability for routing to others with the simple network structure. But when more traffic demand increases, more exchanges and transmission lines are needed. The cost of expansion of the network is increasing and mostly it spends for the transmission lines. When the time changes, the network becomes complicated and more difficult to expand, some solution is needed. Until 1998, the solution of Gateway NMT launches and requires some changes to the original network configuration. The cost of implementation of Gateway exchange is preferred to accept instead of the cost of transmission lines expansion in the future.

In the author's point of view, It is nearly impossible to compare the cost. But one thing that is possible to compare now is the technical benefits of the new network beyond the original network. For this idea, the project of comparative evaluation performance of the network has begun. The meaning of network performance may have so many gains to measure but the author chooses the simpler ones to evaluate. Traffic measurement on destination, one of the measurement types in NOKIA DX200 Exchange, is selected to measure the author's requirement parameters. Referring to the method of measuring and evaluating traffic measurement items, the detail and process are included.

The mentioned technical benefits in above paragraph are presented in comparative terms between the new and original networks in the system evaluation chapter. From the measurement report, the nature of traffic performance for the Star network looks better than Mesh network. The value of traffic intensity in erlang unit from the network decreases, it indicates that less congestion in the network than before. The reason is its more utilization of the transmission line and less via paths for a call processing. The percentage of the number of call attempted, call seized and call completed from Star network is nearly more than from Mesh network. Conversely, the percentage of rejected call or lost call decrease. These results show that there is some better quality of service for the new network beyond the original network. But it should be noted that this evaluation is possible to consider on the network in Bangkok region only. So it isn't cover to the other region which still have less traffic. The author recommends that mesh network is still cope with the other regions. It is no need to waste the cost for reconfiguration. The overall network structure is shown in Figure 6.1.

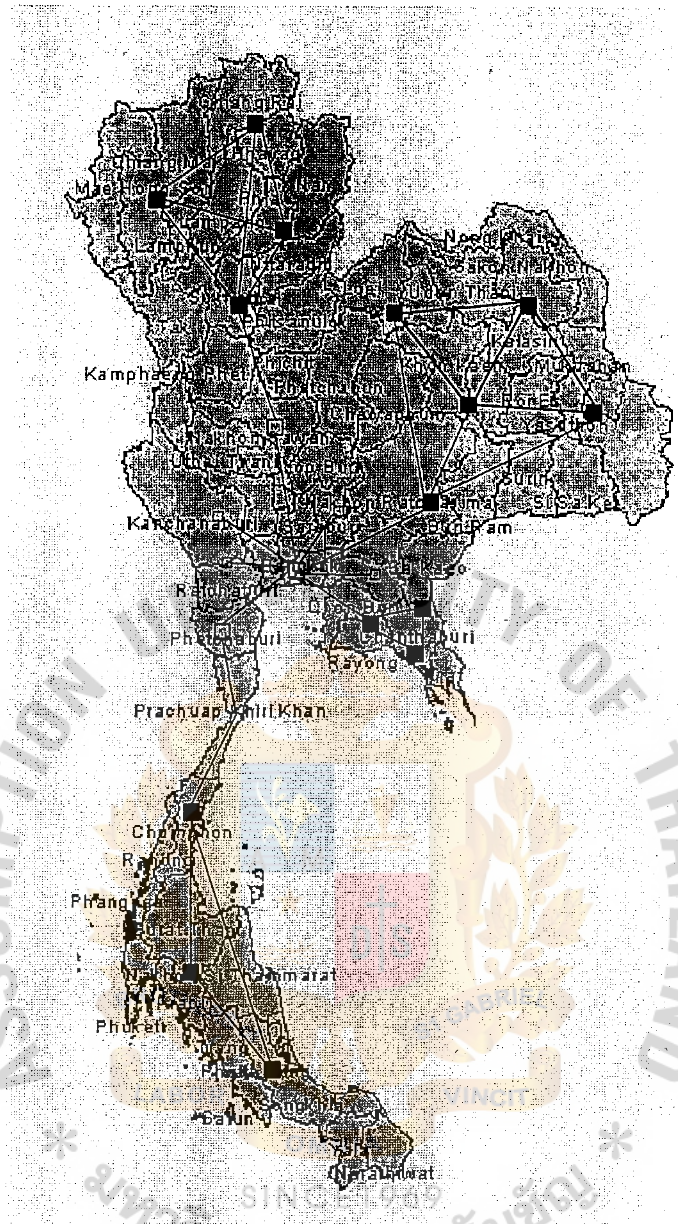

Figure 6.1. Network Structure in All Regions.

The reliability of the network is a distinguished deficiency of the star network type because the centralization process should be done through the Gateway exchange. For this problem the cost of redundant Gateway exchange should be suffered. In the author's opinion, this is one issue to see that new network is worse than the original network. But when compare with its benefits and the future expansion of network. This will be worthwhile to investment this reconfiguration network project. In the future the author thinks to make it more reliable the ring network is additional choice for solving the less reliability of star network. See Figure 6.2.

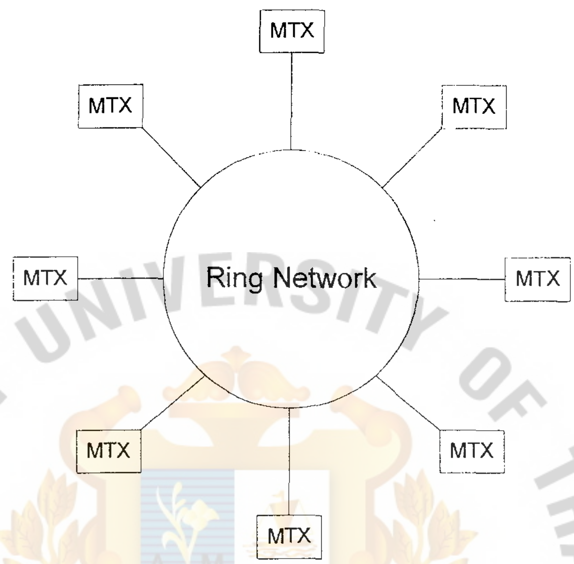

Figure 6.2. Ring Network.

Some technical issues are discussed to prove the benefits commitments by NOKIA for the Gateway solution. This discussion also adds in the objectives of this project report. Some technical examples from the real network are used for supporting this proof. All commitments from NOKIA compose of savings in transmission with enhanced call rerouting, simplification of the PSTN interface and improving the utilization of the limited trunk capacity, reduces the complexity of network, increases the connected call ratio, easy expansion of the network; new exchange is connected only to Gateway and more efficient transmission management are accepted so that my objectives for this project also success.

Due to the continuous development in communication technology to satisfy the customer demand and the increasing number of mobile subscriber every year, the network planner has to deliberately configure the existing network topology so that he does not need to waste his time in reconfiguration the network topology every time the new application introduced. Not only to reconfigure the existing network configuration, but also to plan for a new hardware needed in order to serve a new technology and new coming subscribers as mentioned.

APPENDIX A

AN EXAMPLE OF RAW DATA FROM MTX1 TRAFFIC MEASUREMENT ON DESTINATION REPORT

APPENDIX A

Glossary

DESTIN	::	Destination
DIR	::	Direction
CALLS	::	Total number of calls
ACCEP	::	Number of successful calls
SFAIL	::	Number of calls ended in a subscriber error
IFAIL	::	Number of failed calls caused by errors in the own exchange
EFAIL	::	Number of failed calls caused by other errors
ERLANGS	::	Average traffics in erlangs during the measurement interval

An example of raw data from MTX1 traffic measurement on destination report

DX 220 MTX1 NI.21-11 00-08-01 00:41:21

TRAFFIC MEASUREMENT REPORT DEST1 DESTMEASUREMENT

DATA FROM STU-0 OUTPUT INTERVAL: 60 MIN SAMPLE DATE: 00-08-01 00:30:00

DESTIN	DIR	CALLS	ACCEP	SFAIL	IFAIL	EFAIL	ERLANGS
001XXX	OUT	0	0	0	0	0	0.0
007XXX	OUT	0	0	0	0	0	0.0
09XXXX	OUT	122	122	0	0	0	0.2
021XXX	OUT	1	1	0	0	0	0.0
022XXX	OUT	59	52	2	0	5	0.9
023XXX	OUT	5	5	0	0	0	0.0
024XXX	OUT	18	16	2	0	0	0.4
025XXX	OUT	13	12	1	0	0	0.1
026XXX	OUT	15	15	0	0	0	0.2
027XXX	OUT	2	2	0	0	0	0.0
028XXX	OUT	14	13	1	0	0	0.1
029XXX	OUT	44	38	6	0	0	0.2
032XXX	OUT	2	2	0	0	0	0.0
034XXX	OUT	1	1	0	0	0	0.0
035XXX	OUT	1	1	0	0	0	0.1
036XXX	OUT	3	3	0	0	0	0.0
037XXX	OUT	0	0	0	0	0	0.0
038XXX	OUT	4	4	0	0	0	0.0
039XXX	OUT	0	0	0	0	0	0.0
042XXX	OUT	0	0	0	0	0	0.0
043XXX	OUT	1	1	0	0	0	0.0
044XXX	OUT	2	2	0	0	0	0.0
045XXX	OUT	6	6	0	0	0	0.0

DX 220 MTX1 NI.21-11 00-08-01 00:41:21

TRAFFIC MEASUREMENT REPORT DEST1 DESTMEASUREMENT

DATA FROM STU-0 OUTPUT INTERVAL: 60 MIN SAMPLE DATE: 00-08-01 00:30:00

DESTIN	DIR	CALLS	ACCEP	SFAIL	IFAIL	EFAIL	ERLANGS
053XXX	OUT	0	0	0	0	0	0.0
054XXX	OUT	1	1	0	0	0	0.0
055XXX	OUT	0	0	0	0	0	0.0
056XXX	OUT	3	3	0	0	0	0.1
073XXX	OUT	0	0	0	0	0	0.0
074XXX	OUT	0	0	0	0	0	0.0
075XXX	OUT	1	1	0	0	0	0.0
076XXX	OUT	0	0	0	0	0	0.0
077XXX	OUT	1	1	0	0	0	0.0
084XXX	OUT	0	0	0	0	0	0.0
00760X	OUT	0	0	0	0	0	0.0
007855	OUT	0	0	0	0	0	0.0
007856	OUT	0	0	0	0	0	0.0
19059X	OUT	17	17	0	0	0	0.5
19069X	OUT	23	23	0	0	0	0.7
19159X	OUT	0	0	0	0	0	0.0
19209X	OUT	14	14	0	0	0	0.6
19259X	OUT	28	28	0	0	0	0.8
19359X	OUT	24	24	0	0	0	0.6
19369X	OUT	8	8	0	0	0	0.1
19409X	OUT	24	24	0	0	0	0.4
19459X	OUT	25	25	0	0	0	1.1
19489X	OUT	10	10	0	0	0	0.3
19519X	OUT	2	2	0	0	0	0.0
19539X	OUT	0	0	0	0	0	0.0
19549X	OUT	1	1	0	0	0	0.4

DX 220 MTX1 NI.21-11 00-08-01 00:41:21

TRAFFIC MEASUREMENT REPORT DEST1 DESTMEASUREMENT

DATA FROM STU-0 OUTPUT INTERVAL: 60 MIN SAMPLE DATE: 00-08-01 00:30:00

DESTIN	DIR	CALLS	ACCEP	SFAIL	IFAIL	EFAIL	ERLANGS
19559X	OUT	4	4	0	0	0	0.9
19579X	OUT	5	5	0	0	0	0.2
19599X	OUT	0	0	0	0	0	0.0
19709X	OUT	5	5	0	0	0	0.1
19739X	OUT	12	10	0	0	2	0.0
19759X	OUT	3	3	0	0	0	0.1
19859X	OUT	14	14	0	0	0	0.2
19909X	OUT	0	0	0	0	0	0.0
19929X	OUT	1	1	0	0	0	0.0
19949X	OUT	30	29	0	0	1	0.4
19959X	OUT	5	5	0	0	0	0.1
19969X	OUT	12	12	0	0	0	0.0
19979X	OUT	0	0	0	0	0	0.0
19989X	OUT	39	39	0	0	0	0.9
19999X	OUT	26	26	0	0	0	0.5
21XXXX	OUT	0	0	0	0	0	0.0
22XXXX	OUT	0	0	0	0	0	0.0
230XXX	OUT	0	0	0	0	0	0.0
231XXX	OUT	0	0	0	0	0	0.0
239XXX	OUT	0	0	0	0	0	0.0
284XXX	OUT	0	0	0	0	0	0.0
285XXX	OUT	4	4	0	0	0	0.0
286XXX	OUT	0	0	0	0	0	0.0
288XXX	OUT	0	0	0	0	0	0.0
30XXXX	OUT	6	6	0	0	0	0.0
31XXXX	OUT	15	12	3	0	0	0.1

DX 220 MTX1 NI.21-11 00-08-01 00:41:21

TRAFFIC MEASUREMENT REPORT DEST1 DESTMEASUREMENT

DATA FROM STU-0 OUTPUT INTERVAL: 60 MIN SAMPLE DATE: 00-08-01 00:30:00

DESTIN	DIR	CALLS	ACCEP	SFAIL	IFAIL	EFAIL	ERLANGS
32XXXX	OUT	0	0	0	0	0	0.0
33XXXX	OUT	8	8	0	0	0	0.5
34XXXX	OUT	1	1	0	0	0	0.0
35XXXX	OUT	1	1	0	0	0	0.0
39XXXX	OUT	0	0	0	0	0	0.0
4XXXXX	OUT	19	19	0	0	0	0.3
46XXXX	OUT	1	1	0	0	0	0.0
6XXXXX	OUT	61	57	3	0	1	2.0
8XXXXX	OUT	89	78	4	0	7	2.1

END OF REPORT

APPENDIX B

AN EXAMPLE OF MEASUREMENT REPORT FOR EVALUATING THE TRAFFIC PERFORMANCE

APPENDIX B

Glossary

destid	::	destination digit
erlang	::	average traffics in erlangs during the measurement interval
attempt	::	total number of calls is attempted during the measurement interval
seizure	::	total number of successful calls during the measurement interval
nrejected	::	number of calls, which were interrupted in the ring phase and the called subscriber, did not answer during the measurement interval
banswer	::	number of calls in which the called subscriber has answered during the measurement interval
ph	::	peak hour or busy hour by referring with number of attempted call.
p_erlang	::	average traffics in erlangs at peak hour
p_attempt	::	total number of calls is attempted at peak hour
p_seizure	::	total number of successful calls at peak hour
p_nrejected	::	number of calls, which were interrupted in the ring phase and the called subscriber, did not answer at peak hour
p_banswer	::	number of calls in which the called subscriber has answered during the measurement interval

An example of measurement report for evaluating the traffic performance

when				exchange	destid	period	erlang	attempt	seizure	Nreject	banswer	ph	p_erlang	p_attempt	p_seizure	p_nreject	p_banswer
Jul	1	1999	12:00AM	MTX1	001XXX	780	4.3	706	706	221	466	16:30	0.5	99	99	33	61
Jul	1	1999	12:00AM	MTX1	022XXX	780	227	13763	13763	682	12010	16:30	29.3	1596	1596	51	1432
Jul	1	1999	12:00AM	MTX1	023XXX	780	55.8	2526	2526	43	2308	16:30	7.4	307	307	2	287
Jul	1	1999	12:00AM	MTX1	024XXX	780	85.5	4283	4283	65	3800	11:30	10	502	502	17	437
Jul	1	1999	12:00AM	MTX1	025XXX	780	70	3514	3514	128	3179	11:30	8.8	458	458	12	423
Jul	1	1999	12:00AM	MTX1	026XXX	780	76.6	4340	4340	155	3839	14:30	10.2	603	603	28	508
Jul	1	1999	12:00AM	MTX1	027XXX	780	38.4	1809	1808	44	1483	16:30	5.3	259	259	6	216
Jul	1	1999	12:00AM	MTX1	028XXX	780	63.2	2906	2905	96	2562	14:30	8.2	391	391	5	334
Jul	1	1999	12:00AM	MTX1	029XXX	780	77.5	3398	3398	141	2991	16:30	8.7	382	382	6	348
Jul	1	1999	12:00AM	MTX1	032XXX	780	11.9	898	898	360	483	9:30	1.2	62	62	0	62
Jul	1	1999	12:00AM	MTX1	034XXX	780	24.3	1046	1046	86	884	11:30	3.1	160	160	11	145
Jul	1	1999	12:00AM	MTX1	035XXX	780	16.4	639	639	22	554	11:30	2.1	66	66	1	62
Jul	1	1999	12:00AM	MTX1	036XXX	780	11.6	551	551	39	485	14:30	1.4	66	66	0	61
Jul	1	1999	12:00AM	MTX1	037XXX	780	6.6	263	263	12	227	17:30	1.1	43	43	0	40
Jul	1	1999	12:00AM	MTX1	038XXX	780	22.6	1035	1035	85	852	16:30	2.9	123	123	4	106
Jul	1	1999	12:00AM	MTX1	039XXX	780	5.7	202	202	3	174	14:30	0.9	31	31	0	30
Jul	1	1999	12:00AM	MTX1	042XXX	780	9.3	370	370	66	286	9:30	1.1	49	49	1	39

when				exchange	destid	period	erlang	attempt	seizure	Nreject	banswer	ph	p_erlang	p_attempt	p_seizure	p_nreject	p_banswer
Jul	1	1999	12:00AM	MTX1	043XXX	780	7.5	346	346	45	288	20:45	1	39	39	28	10
Jul	1	1999	12:00AM	MTX1	044XXX	780	15.5	543	543	93	420	11:30	2.6	83	83	5	70
Jul	1	1999	12:00AM	MTX1	045XXX	780	6.7	251	251	42	202	17:30	1.4	23	23	0	21
Jul	1	1999	12:00AM	MTX1	053XXX	780	17.5	648	648	66	497	20:45	3.1	49	49	5	42
Jul	1	1999	12:00AM	MTX1	054XXX	780	5.2	198	198	12	177	11:30	0.7	26	26	0	24
Jul	1	1999	12:00AM	MTX1	055XXX	780	8.1	398	398	73	311	11:30	1.4	46	46	6	40
Jul	1	1999	12:00AM	MTX1	056XXX	780	12.8	1047	1047	544	396	14:30	2.5	247	247	109	85
Jul	1	1999	12:00AM	MTX1	073XXX	780	2.6	116	116	8	107	11:30	0.6	34	34	1	33
Jul	1	1999	12:00AM	MTX1	074XXX	780	6.1	201	201	12	181	16:30	1.2	20	20	0	20
Jul	1	1999	12:00AM	MTX1	075XXX	780	5.9	282	282	21	199	20:45	1.2	38	38	7	29
Jul	1	1999	12:00AM	MTX1	076XXX	720	2.5	135	135	23	100	14:30	0.5	22	22	5	15
Jul	1	1999	12:00AM	MTX1	077XXX	780	7.1	250	250	4	227	11:30	1.2	33	33	0	30
Jul	1	1999	12:00AM	MTX1	09XXXX	780	37.6	11047	11044	29	10988	11:30	3.6	1038	1038	4	1025
Jul	1	1999	12:00AM	MTX1	1905XX	780	114.4	4738	4726	0	4719	13:30	12.5	508	508	0	508
Jul	1	1999	12:00AM	MTX1	1906XX	780	141.6	5285	5269	9	5256	11:30	16.9	626	625	0	623
Jul	1	1999	12:00AM	MTX1	1910XX	780	114.6	4720	4713	0	4705	11:30	12.2	548	547	0	546
Jul	1	1999	12:00AM	MTX1	1920XX	780	112.7	4466	4461	0	4457	11:30	13	516	515	0	515
Jul	1	1999	12:00AM	MTX1	1925XX	780	123.6	4544	4531	1	4528	11:30	13.1	489	485	0	485
Jul	1	1999	12:00AM	MTX1	1935XX	780	98.1	3755	3745	0	3743	11:30	11.1	442	440	0	439
Jul	1	1999	12:00AM	MTX1	1936XX	780	76.6	2826	2820	0	2820	11:30	8.9	350	350	0	350

when				exchange	destid	period	erlang	attempt	seizure	Nreject	banswer	ph	p_erlang	p_attempt	p_seizure	p_nreject	p_banswer
Jul	1	1999	12:00AM	MTX1	1940XX	780	98.7	4630	4625	606	4016	18:30	10.3	490	490	62	428
Jul	1	1999	12:00AM	MTX1	1945XX	840	137.4	5829	5822	7	5809	16:30	14.2	570	570	0	570
Jul	1	1999	12:00AM	MTX1	1948XX	840	133.7	5116	5109	0	5105	17:30	14.7	487	487	0	486
Jul	1	1999	12:00AM	MTX1	1951XX	840	19.8	710	708	76	632	18:30	2.2	68	68	2	66
Jul	1	1999	12:00AM	MTX1	1953XX	840	15.3	508	506	2	504	20:45	2.1	62	62	0	62
Jul	1	1999	12:00AM	MTX1	1954XX	840	30.5	1213	1212	193	1019	20:45	4.2	125	125	18	107
Jul	1	1999	12:00AM	MTX1	1955XX	840	39.9	1274	1270	0	1269	10:30	4.3	135	134	0	134
Jul	1	1999	12:00AM	MTX1	1957XX	840	29.5	890	888	0	887	21:45	3.2	48	48	0	48
Jul	1	1999	12:00AM	MTX1	1959XX	840	3.7	148	148	22	126	16:30	0.6	9	9	0	9
Jul	1	1999	12:00AM	MTX1	1970XX	840	19.3	928	928	125	802	11:30	2.4	136	136	13	123
Jul	1	1999	12:00AM	MTX1	1973XX	840	25.8	1396	1392	171	1220	20:45	3.1	75	75	3	72
Jul	1	1999	12:00AM	MTX1	1975XX	840	26.6	1071	1070	114	955	20:45	2.9	97	97	12	85
Jul	1	1999	12:00AM	MTX1	1985XX	840	79.8	2775	2769	2	2765	10:30	8.4	292	290	0	289
Jul	1	1999	12:00AM	MTX1	1990XX	840	21.1	802	802	75	727	21:45	2.4	41	41	1	40
Jul	1	1999	12:00AM	MTX1	1992XX	840	19.5	894	894	179	713	20:45	2.3	67	67	16	50
Jul	1	1999	12:00AM	MTX1	1994XX	840	263.7	13039	13035	1088	11946	11:30	24.7	1231	1231	119	1112
Jul	1	1999	12:00AM	MTX1	1995XX	840	86.1	3117	3112	0	3110	20:45	9.1	243	243	0	243
Jul	1	1999	12:00AM	MTX1	1996XX	840	93.9	5403	5396	1474	3922	17:30	9.7	472	471	121	350
Jul	1	1999	12:00AM	MTX1	1997XX	840	19.3	872	871	88	782	8:30	2.1	83	83	7	76
Jul	1	1999	12:00AM	MTX1	1998XX	840	152.8	8905	8890	638	8248	11:30	16.2	888	885	54	831

when				exchange	destid	period	erlang	attempt	seizure	Nreject	banswer	ph	p_erlang	p_attempt	p_seizure	p_nreject	p_banswer
Jul	1	1999	12:00AM	MTX1	1999XX	840	130.3	7496	7488	143	7334	11:30	14	824	824	14	807
Jul	1	1999	12:00AM	MTX1	21XXXX	840	3.1	273	273	5	253	22:45	0.7	6	6	0	6
Jul	1	1999	12:00AM	MTX1	22XXXX	840	1.1	134	134	13	94	8:30	0.3	16	16	0	16
Jul	1	1999	12:00AM	MTX1	230XXX	180	0.1	3	3	0	2	20:45	0.1	1	1	0	1
Jul	1	1999	12:00AM	MTX1	239XXX	720	0.7	82	82	2	77	11:30	0.2	9	9	0	9
Jul	1	1999	12:00AM	MTX1	30XXXX	840	25.8	1672	1672	16	1509	11:30	2.8	188	188	4	167
Jul	1	1999	12:00AM	MTX1	31XXXX	840	30.7	2184	2184	124	1938	16:30	3.5	269	269	36	223
Jul	1	1999	12:00AM	MTX1	33XXXX	840	5.2	502	502	20	446	13:30	0.8	69	69	1	64
Jul	1	1999	12:00AM	MTX1	34XXXX	540	0.7	111	111	11	87	15:30	0.2	10	10	0	10
Jul	1	1999	12:00AM	MTX1	35XXXX	840	5.8	554	554	31	494	17:30	1	54	54	1	51
Jul	1	1999	12:00AM	MTX1	39XXXX	840	1.6	190	190	35	143	14:30	0.4	20	20	2	18
Jul	1	1999	12:00AM	MTX1	40XXXX	840	14.5	1128	1128	62	990	16:30	2	112	112	6	104
Jul	1	1999	12:00AM	MTX1	43XXXX	840	12.2	863	863	11	798	10:30	1.5	97	97	1	91
Jul	1	1999	12:00AM	MTX1	441XXX	840	3.2	188	188	8	166	13:30	0.6	30	30	0	23
Jul	1	1999	12:00AM	MTX1	442XXX	840	2.7	260	260	7	224	13:30	1	40	40	0	40
Jul	1	1999	12:00AM	MTX1	443XXX	840	2.9	267	267	8	225	16:30	0.5	32	32	3	27
Jul	1	1999	12:00AM	MTX1	44XXXX	840	19.8	1280	1280	31	1137	13:30	3	141	141	1	132
Jul	1	1999	12:00AM	MTX1	45XXXX	840	14.8	1027	1027	8	926	16:30	1.9	110	110	1	94
Jul	1	1999	12:00AM	MTX1	46XXXX	780	0.2	71	71	18	36	11:30	0.1	14	14	8	5
Jul	1	1999	12:00AM	MTX1	47XXXX	840	4.2	334	334	7	307	10:30	0.8	29	29	1	25

when				exchange	destid	period	erlang	attempt	seizure	Nreject	banswer	ph	p_erlang	p_attempt	p_seizure	p_nreject	p_banswer
Jul	1	1999	12:00AM	MTX1	48XXXX	840	16.3	1183	1183	26	1110	11:30	1.9	140	140	3	133
Jul	1	1999	12:00AM	MTX1	49XXXX	840	12.4	945	945	16	845	14:30	1.9	115	115	3	101
Jul	1	1999	12:00AM	MTX1	60XXXX	840	7.7	388	388	12	370	11:30	1.5	50	50	1	48
Jul	1	1999	12:00AM	MTX1	61XXXX	840	29	1955	1955	78	1764	16:30	3.4	232	232	29	186
Jul	1	1999	12:00AM	MTX1	62XXXX	840	26.7	1799	1799	67	1636	14:30	3.2	192	192	3	178
Jul	1	1999	12:00AM	MTX1	63XXXX	840	29.3	2090	2090	79	1921	16:30	3.7	317	317	36	265
Jul	1	1999	12:00AM	MTX1	64XXXX	840	48.7	3728	3728	539	2983	16:30	5.9	472	472	116	323
Jul	1	1999	12:00AM	MTX1	650XXX	540	0.1	48	48	0	44	9:30	0.1	14	14	0	14
Jul	1	1999	12:00AM	MTX1	65XXXX	840	21.8	1463	1463	97	1271	14:30	2.5	137	137	10	115
Jul	1	1999	12:00AM	MTX1	66XXXX	840	7.9	459	459	4	423	16:30	1	49	49	0	48
Jul	1	1999	12:00AM	MTX1	67XXXX	840	5.4	352	352	22	313	14:30	0.8	35	35	0	33
Jul	1	1999	12:00AM	MTX1	69XXXX	780	0.2	45	45	0	37	22:45	0.2	7	7	0	7
Jul	1	1999	12:00AM	MTX1	8XXXXX	840	164.4	10958	10957	773	9368	16:30	18.1	1211	1211	77	1026

END OF REPORT

BIBLIOGRAPHY

1. AIS. www.NMC.ais. Thailand: Advanced Info Service, 1998.

2. Clark, P. Martin. Networks and Telecommunications Design and Operation, Second Edition. England: J.Wiley, 1998.

3. Ericsson Telecom, Telia and Studentlitetteratur. Understanding Telecommunications 1. Sweden, 1998.

4. Ericsson Telecom, Telia and Studentlitetteratur. Understanding Telecommunications 2. Sweden, 1998.

5. Flood, J. E. Telecommunication Switching, Traffic and Networks. N.Y.: Prentice–Hall, 1995.

6. Nokia Telecommunication. DX 200 Release Description, AIS Gateway Release1.0, DX 220 Release Level. Finland: Nokia Telecommunication, 1997.

7. Nokia Telecommunication. DX 220/210 Nokia Documentation. Finland: Nokia Telecommunication, 1999.

8. Pooch, W. Udo, Denis Machrel, and John Mccahn. Telecommunication and Networking. Forida: CRC Press, 1991.