ASSUMPTION UNIVERSITY (ABAC), BANGKOK
มหาวิทยาลัยอัสสัมชัญ

SERVICE QUALITY ENHANCEMENT THROUGH THE AUTOMATIC INTERNATIONAL ROAMING TESTING SYSTEM

by

Mr. Somsak Sudthiparinyanon

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
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Project Title	Service Quality Enhancement through the Automatic International Roaming Testing System
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Academic Year	July 2002

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.

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ABSTRACT

The objective of this project is to implement the effectiveness and evaluate the efficiency of an Automatic Roaming Test System (ARTS) in the way of enhancing quality of international roaming services for a GSM operator. The chapters in this project will consequently show the introduction, literature review and the set of Quality of Service criteria including the quality enhancement after use of new tool (Automatic Roaming Test System) that can deliver the tangible and intangible benefits for both mobile operators, and valuable international roaming customer.

ITU standard for Quality of Service in Telecommunication industry to be determined as the standard reference of the Quality of service model reflects the majority enhancement quality of International roaming service. The essential aspects for the evaluation of quality of International roaming service are network performance and service performance measurement. This project provides a framework for:

(1) Quality of service measurement criteria

(2) Relating quality of service for network and service performance

(3) Set of performance key measures and reports

For enhancing the Quality of International Roaming Service, we use Automatic Roaming Test & monitor System as an advanced tool to improve quality of International Roaming services.

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Lastly, special thanks to my family for their encouragement to study for this degree and cheer me to complete this project continuously.

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I. INTRODUCTION

An International Roaming Service is a valuable (high revenue services for GSM operators) service of the GSM operator to allow Mobile Stations to use in different national mobile networks. This make an individual GSM Mobile Operator experience tremendous subscriber growth rates during the past decade. Hundreds of millions of mobile subscribers are today using digital mobile phones, and growth is expected to continue unabated. Especially, GSM network subscriber is growing by up to 10 million customers per month.

Ultimately all these trends say one thing about the GSM mobile operator market: to stay competitive, GSM mobile operators must continuously expand and improve their quality of services, meeting subscribers demand while controlling operating costs. And as we will see, Quality of Service plays a major role in network competitiveness and business success.

According to International Roaming Service Quality, it is very difficult to detect availability of services because there are more than two parties involved providing the services such as HPLMN, VPLMN, IGP including all partner operators.

There are only two traditional ways to detect the availability as follows:

(1) Customer Complaints.

(2) The periodic Re-testing.

(3) Signaling Network Monitoring.

Customer complains means dissatisfied services even though it is the feedback of the service unavailability.

The periodic Re-testing is a very time-consuming task, cost-intensive in terms of manpower and administration, and it reduces the reliability of the obtained test results.

The way to keep customer a good service is a preventive test. The periodic Re-testing can be defined a preventive test however it has to done more frequently as short as possible to detect the problem before customer sees and corrects it.

The objective of this project is to assess the effectiveness and efficiency of an Automatic Roaming Test System (ARTS) in the way of enhancing quality of international roaming services for a GSM operator. The chapters in this project will consequently show the introduction, the literature review and the determination set of QoS criterias including roaming quality enhancement after implementation of new tool (Automatic Roaming Test System) that can deliver the tangible and intangible benefits for both mobile operators, and valuable international roaming customer.

For enhancing the Quality of International Roaming Service, we use Automatic Roaming Test & monitor System as an advance tool to improve quality of International Roaming services. We also show the improvement from the old testing process and new system process in order to make further scope of improvement.

The following chapters will describe how these technologies can help the operator to enhance the quality of international roaming services in details.

II. LITERATURE REVIEW

Mass-market mobile telecommunications was certainly one of the major breakthroughs of this new millennium. The possibility to make and receive calls through a small wireless handset, wherever you are, had an obvious appeal. The Business opportunities were tremendous, since one can imagine that every person (and not only every home), including children, could be equipped provided the services was cheap enough. Many people agree that the sociological consequences will be important, much more than for video communications. Wireline telephony allows us to reach a place, if someone is there to answer. Mobile telephony allows us to reach a particular person, wherever almost he or she is. This will greatly increase the accessibility to people, and increase the feeling of security. On the other hand, this increased accessibility can in many cases be a nuisance, and widespread social acceptability of mobile telephony requires that users have a high degree of control on the calls they receive (identification of the calling party, forwarding of calls to a third party, messages banks, etc.)

Mobile telecommunications is not a very recent technology, but it is a rapidly evolving one. Expensive vehicle mounted sets have been available for 30 or 40 years. A major step was made at the beginning of the 1980's, when analog cellular technology was introduced. The GSM system, and its offshoot DCS1800 (Digital Cellular System 1800) are the European contribution to this evolution. This system was designed during the 1980's, and entered operation in various European countries during 1992.

GSM was designed internationally, in standardization committees, by the major European telecommunications operators and manufacturers. The understanding of the gain to be obtained by combining resources, and of the business opportunity offered by mass-market radiotelephony, resulted in a substantial manpower and financial effort from the participants, thus making GSM a very dynamic project.

The design-by-committee had resulted in a public set of detailed specifications encompassing all system areas.

2.1 GSM Overview

2.1.1 The GSM System for Mobile Communication

Public radio-communication requires sophisticated techniques, and therefore its evolution has always followed very closely the progress of electronics. The idea of instant communication regardless of distance is part of man's oldest dreams, and this dream became reality as soon as techniques would allow it. The first implementations of radio waves for communication were realized in the late nineteenth century for radiotelegraphy. Since then, it has been a widely used technique for military communications. The first public applications concerns broadcasting (sound, the images): this is much simpler than radiotelephony as the mobile terminal is only a receiver. The real boom in two-way public mobile radio-communications systems took place right after the Second World War, when the use of frequency modulation and of electronic techniques such as the vacuum valve enabled the implementation of a real-scale telephony service for cars. The first true mobile telephone service was officially born in St. Louis (Missouri, USA) in 1946. Europe, recovering from war, followed a few years later.

The first mobile telephone network was manually operated (that is to say that the intervention of an operator was required to connect the call to the wireline network) and the terminals were heavy, bulky and expensive. The service area was restricted to the coverage of a single emission and reception site (single-cell systems). Little radio spectrum was available for this kind of services, since it was allocated with priority to military systems (this has not changed much!) and broadcasting in particular television). As a consequence, the capacity of the early systems was small and saturation came quickly despite the high cost of terminals, which deterred many a potential customer. Quality of service decreased rapidly with congestion, and the throughput sometimes fell drastically due to near-deadlock situations.

Between 1950 and 1980, mobile radio systems evolved to becomes automatic and the costs decreased due to the introduction of semiconductor technology. Capacity increased a little but remained too small compared to potential demand: public radiotelephony remained a luxury product for a chosen few.

During the 70's, large-scale integration of electronic devices and the development of microprocessors opened the door to the implementation of more complex systems. Because the coverage area of one antenna is mainly limited by the transmitting power of mobile stations, systems were devised with several receiving stations for a single transmitting station. They allowed coverage of a larger area at the cost of additional infrastructure complexity. But the real breakthrough came with cellular systems, where both transmitting and receiving sites are numerous and whose individual coverage areas partially overlap.

Instead of trying to increase transmission power, cellular systems are based on the concept of frequency re-use: the same frequency is used by several sites which are far enough one from the other, resulting in a tremendous gain the system capacity. The counterpart is the increased complexity, both for the network and for network and for mobile stations, which must be able to select a station among several possibilities, and the infrastructure cost due to the number of different sites.

The cellular concept was introduced by the Bell Labs, and was studied in various places in the world during the 70s. In the US, the first cellular system, the AMPS

(Advanced Mobile Phone Service) became a reality in 1979 when the first pre-operational network was opened in Chicago, Illinois. In the North-European countries, the telecommunication administrations together with some manufacturers devised the NMT (Nordic Mobile Telephone) system, which aimed at a Scandinavian coverage. The system started operation in Sweden in September 1981, and shortly afterwards in Norway, Denmark and Finland.

Networks based on these two sets of specifications account for the great majority of mobile networks throughout the world in the early 90's. For example, the TACS, derived from AMPS, was put in service in the UK in 1985. Most European countries have one or more cellular networks today. Table 1.1 shows the major cellular networks in operation in Europe in early 1992.

All these cellular systems were based on analogue speech transmission with frequency modulation. They all used frequency bands either around 450 MHz or around 900 MHz. Their coverage was usually nation –wide and their capacity reaches several hundreds of thousands subscribers. The largest national system in Europe (composed of two country wide coverage networks) was the British TACS with more than one million subscribers by 1990. The highest population penetration was held by the Scandinavian NMT, with more than 6% of the Swedish and Norwegian population having mobile equipment. However, these figures were much higher than the mean European values. For instance, the penetration factor in 1991 in France was about one tenth of the Swedish one.

Mobile equipment evolved very rapidly during the late 80's. At the onset, only vehicle-mounted equipment could be built. In the mid-80's portable equipment appeared, with a weight of a few kilograms and an autonomy of a few hours. Handheld equipment first appeared around 1988; not yet small enough to fit in your pocket, but fitting nicely in your attach-case. In 1990, the smallest terminals on the market were weighing less than 400g, and fitted in a coat pocket

GSM Network Architecture.

Below the GSM network architecture is described. See Figure 2.1.

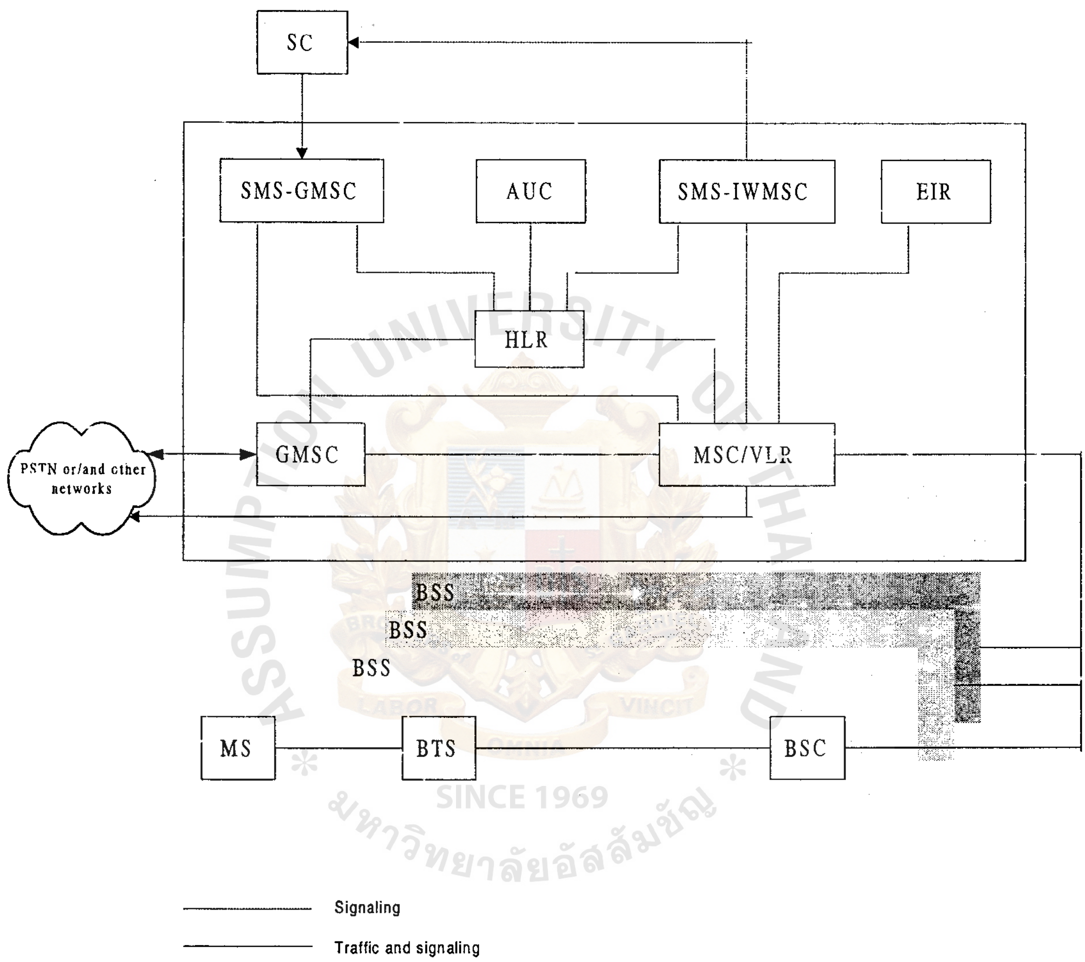

Figure 2.1. GSM Network Architecture.

The SS (Switching System) consists of the network entities MSC/VLR, SMS-GMSC, SMS-IWMSC, HLR, GMSC, EIR and the AUC. It is responsible for setting up and maintaining calls with mobile subscribers within the PLMN, transporting of short messages to and form Mobile Stations (MS) within the PLMN, charging and accounting, handing of the subscriber data and ensuring security and subscriber confidentiality.

The BSS (Base Station System) consists of a BSC and of one or several BTSs connected to the BSC. The BSS is responsible for functions such as managing radio network resources, handling cell configuration data, handling connections to Mobile Stations including handovers, controlling radio frequency power levels in Mobile Stations and BTSs, broadcasting system information and short messages (Cell Broadcast Short Messages).

GMSC

The GMSC (Gateway Mobile services Switching Center) is the point in the PLMN where calls to mobile subscribers enter the GSM network. Therefore each mobile terminating call must be routed via GMSC.

The GMSC has the interrogation facility that is the GMSC has signaling functions for fetching information from the concerned HLR telling how to proceed the call setup. Depending on the interrogation result, the call shall either be re-routed by GMSC to the MSC where the mobile subscriber is located or forwarded according to the forwarder-to number. Charging and accounting functions are also implemented in the GMSC.

HLR

The Home Location Register (HLR) is a database that stores and manages subscriptions. In a PLMN there is one or several HLRs. For each "home" subscriber, the HLR contains permanent subscriber data such as the associated numbers: MSISDN and IMSI, a list of services: tele-services, bearer-services and supplementary-services, which the subscriber is authorized to use and so forth.

The HLR also stores and updates the dynamics data about each subscriber concerned, including subscriber locations (VLR-address), services registered and activated by the subscriber or the operator such as call forwarded numbers, call barring for certain types of calls, and so forth.

The HLR can be integrated in the same node as the MSC/VLR, or can be implemented as a separate node.

The HLR provides functions as defined in the GSM specifications. This involves:

(1) Connection of Mobile Subscribers and definition of corresponding subscriber data using a standard command interface.

(2) Maintenance of a Database of Mobile Subscribers and corresponding subscriber data.

(3) Subscription to Basic Services.

(4) Provision/withdrawal of Basic Services.

(5) Provision/erasure of Supplementary Services.

(6) Activation/deactivation of Supplementary Services.

(7) Interrogation of Supplementary Services Status.

(8) Functions for analysis of Mobile Subscriber numbers (MSISDN, IMSI, additional MSISDN) and other types of addresses.

(9) Handling of Authentication and Ciphering Data for Mobile Subscribers including communication with an external Authentication Center AUC either via a command interface or CCITT No. 7 signaling system interface, MAP-protocol (Both interfaces are optional).

(10) Functions for communication with the other GSM defined entities in the network (that is GMSC and VLR) using the CCITT No.7 signaling system, MAP-protocol (MAP).

(11) Statistical functions for collecting data regarding the performance of the system.

AUC

The AUC (Authentication Center) is a database, which handles triplets. A triplet consists of a Random Number (RAND), a Signed Response (SRES) and a Ciphering Key (Kc). The AUC generates and provides one, or several triplets for certain IMSI at each request from the HLR. At any MS access attempt the MSC may send RAND to the Mobile Station to authenticate the subscriber's SIM. The received SRES is then compared in the VLR with the one originally provided by the AUC (via HLR). The MSC may also command ciphering on the radio path by providing the Kc to the TRX concerned with the traffic. Successful ciphering is only possible if the Kc, which is calculated by the MS during the authentication procedure, is identical with the one originally provided by the AUC and used by the TRX for this particular communication.

EIR

The EIR (Equipment Identity Register) is a database, which, for each Mobile Station equipment, containing a unique number, International Mobile Station Identity (IMEI), Stores this number. At any Mobile Station access, except IMSI-detach, the MSC/VLR verify the IMEI. The main objective is to be able to take measures against stolen equipment or the one with bad technical performance. The classification is as follows:

(1) White listed (permitted for use)

(2) Gray listed (should be tracked for evaluation)

(3) Black listed (stolen)

(4) Unknown equipment

The network shall terminate any access attempt or ongoing call when receiving any of the answers "black-listed" or "unknown equipment".

MSC/VLR

The MSC (Mobile Services Switching Center) and VLR (Visitor Location Register) functionalities are always integrated together. The MSC/VLR is responsible for:

(1) Functions for setting up and controlling calls (involving supplementary services).

(2) Functions for handling of the speech path continuity of moving subscribers (handover).

(3) Functions for updating of the mobile subscriber data.

(4) Provision of functions for signaling to/from the BSC and the mobile stations (using BSSAP) and between other GSM entities (using MAP, TUP or ISUP), as well as, between other networks such as, PSTN or ISDN (using TUP or ISUP).

(5) Administrative function for defining data and handling of the mobile subscribers.

(6) Security related functions, which perform authentication/selective authentication, ciphering, (re) allocation and analysis of the TMSI.

(7) Functions for equipment identity control.

(8) Functions for receiving/delivering short messages from/to the MS.

(9) Charging and accounting.

SMS-GMSC

A SMS-GMSC (Short Message Service Interworking MSC) is an MSC/VLR capable of receiving a short message from an SC (Service Center), interrogation an HLR for routing information and message waiting data, and delivering the short message to the MSC of the recipient MS.

SMS-IWMSC

An SMS-IWMSC (Short Message Service Interworking MSC) is an MSC/VLR capable of receiving a mobile originated short message from the MSC or an ALERT message from the HLR and submitting the message to the recipient SC.

The SMS-IWMSC functionality is normally integrated in the MSC/VLR node.

SC

The SC is responsible for the relaying and store-and–forwarding of a short message between a short message sender and a mobile station. The SC is not a part of the GSM PLMN.

BSS

The BSS (Base Station System) is the system of a BSC (Base Station Controller) and one or several BTSs (Base Transceiver Stations), each including, among other things, one or several TRXs (Transceivers). One BTS provides coverage of one call. The BSS is seen by the MSC through the A-interface, as being the entity responsible for communicating with mobile stations in a certain area.

BSC

The BSC handle all radio related functions, and is the Base Station System's center point. The BSC manages the entire radio network, handling connections to Mobile Stations including handovers, and handles the radio transmission network, as well as BTS remote control

BTS

The main BTS functions are:

(1) Radio transmission, including frequency hopping.

(2) Radio signal reception from Mobile Stations, including equalizing and diversity functions to compensate for fading effects.

(3) Quality measurements (measurements made by the MS of the downlink quality and the signal levels from surrounding BTSs are sent to the BSC. Uplink quality is also regularly reported to the BSC).

(4) Time alignment measurements.

(5) Transceiver and MS power control.

(6) Multiplexing on the radio path, channel coding, interleaving, and encryption/decryption.

(7) Broadcasting system information and paging messages.

(8) Receiving channel requests from Mobile Stations.

The BTS consists of a cluster of autonomous TRXs. The software stored in TRX Random Access Memories (RAMs) in controlled, loaded, and upgraded from the BSC, thus eliminating the need for on-site BTS visits. This remote control capability also includes automatic tuning in the combiners in case control capability also includes automatic tuning in the combiners in case frequency planning is changed. Strict transceiver orientation means that faults will be isolated per TRX and will not affect adjacent TRXs in the same BTS.

2.1.2 Roaming

In telecommunication systems accessed through a fixed link, the choice of which network provides the service is done (when choice is possible!) at subscription, once and for all. When mobility is introduced, new horizons emerge. Because a mobile terminal is not on a leash, different networks can provide service to a given customer, depending on where he is. When different network operators co-operate, they can use this possibility to offer to their subscribers a coverage area much wider than any of them could do on its own. This is what is called roaming, and it is one of the major features of the pan-features of the pan –European GSM, whose subscribers can enjoy European-wide coverage, whatever their national network of subscription.

Roaming can be provided only if some administrative and technical constraints are met. From the administrative point of view, issues like charging, subscription agreements, etc. must be solved between the different operators. The free circulation of mobile stations also requires regulator bodies to agree on the mutual recognition of type approvals. From the technical point of view, some topics are a consequence of the administrative matters, such as the transfer of call charges to the transfer of subscription information between networks. Others are needed simply for roaming to be possible at all, such as the transfer of location data between networks, of the existence of a common access interface.

This last point is probably the most important one. It requires a subscriber to have a single piece of equipment enabling him to access the different networks. To this avail, a common air interface has been specified, so that the user can access all the networks with the same mobile station.

Other GSM-based (or DCS 1800-based) systems will be created. Roaming between these systems and the European GSM may not always be possible with the same mobile station. A possible limitation is bandwidth. European countries have agreed to use a common part of the spectrum, at 911 MHz, Another band is already possible, at 1800 MHz. Roaming with the same mobile equipment is not possible between GSM 900 and DCS 1800, except with dual band mobile station, of as yet unproved commercial interest. Similarly, the European 900 MHz band may not be available in other parts of the world, and using a different bandwidth would preclude using the same mobile equipment for roaming. But in all such cases, it is possible to envisage another kind of roaming, based on using the subscriber-specific part of the mobile station only, in connection with a radio access part specific to each network. Such a combination will enable users to have a single subscription and be reached through the same directory number, whatever network they be roaming into. A way to achieve this aim is already included in GSM and will be expanded upon when the SIM (Subscriber Identity Module) is introduced.

2.1.3 The Subscriber Identity Module (SIM)

A mobile station in any cellular network must be personalized, i.e., associated with a given subscriber is not in a one-to-one correspondence with the physical medium used for access as in a wireline network. The usual approach is to store in a permanent memory of the machine the required information, such as a subscription identifier. This is what is done in most analogue cellular networks (an exception is the German C network). The approach in GSM is different.

A GSM mobile station is split in two parts, one of which contains the hardware and software specific to the radio interface, and another, which contains the subscriber-specific data: the Subscriber Identity Module, or SIM. The SIM can be either a smart card, having the well-known size of credit cards, or alternatively it can be "cut" to a much smaller format, called "plug-in SIM" (See Figure 2) This smaller format was introduced to put less constraints on the design of handheld. The SIM is a kind of key. Once removed from the terminal, the latter cannot be used except for emergency calls (if the network permits), that is to say it cannot be used for any service which will impact the subscriber's bill.

This view must be somewhat qualified, because the insertion and removal of the SIM is not necessarily easy with mobile stations. Since it's small size does not make it easy to manipulate. It is not foreseen that plug-in SIMs will be easy to remove, and in some cases mobile manufacturers have even secured them in the handheld station by a screwed lid. But the possibility still remains for the user to change it.

Figure 2.2. The Two Type of SIMs.

The possibility to remove the SIM presents many advantages for the user beside its role as a key. For instance, if his mobile station fails and must be taken to repairs, another one can be used for the interim period. It suffices to remove the SIM from one equipment and to put it in the other. Another example is the case of urban users, which have only a handheld, for reasons of economy. When needed, they can borrow a more powerful station to be used in the countryside, or rent a car equipped with a vehicle-mounted station. In all cases, they can use their own SIM, in order for calls toward their personal number to be routed to the rented terminal, and for the call charges to be put on the same bill as for the calls made through their handheld.

The SIM is also the custodian of much information involved in the local provision of services to the user. The SIM can be protected by a password, a PIN code (Personal Identity Number), similar to the (typically 4-digit) PINs of credit cards. Unlike much credit card PINs, the GSM PIN may be chosen by the subscriber. The SIM may also contain a list of abbreviated dialing numbers, with the corresponding alphanumerical index (for the name of the correspondent for instance) and the type of call (speech, fax, etc.) The SIM can also be used to store short messages, in particular those received when the user is not present. Amore technical application it the storage for a list of preference for the choice of a network when several are possible. Since the user will have to choose which network he will get service from, for instance when he crosses an international boundary, the SIM stores information to make this choice automatically, taking into account the user's preferences. When real-time advice of charge becomes available on networks, the SIM will also be able to memorize this charging information to keep the subscriber informed of his expenses.

An interesting development for the user is the potentiality to read and modify part of the personal information stored in the SIM. This can of course be done using the keyboard of a mobile station, but a more comfortable approach could also be offered, using a card reader connected to a personal computer, and relevant software to enter abbreviated dialing numbers, to archive short messages on the computer, etc. Of course, this only holds for part of the data stored in the SIM, since most of the information is protected against alterations and in some cases even against reading. The scope of the SIM can even be extended beyond GSM, and the concept of a multi0applicatin cad is emerging The compatibility of the SIM specification with internationally-recognized ISO standards in this domain makes the GSM application a good candidate for inclusion into a multi-application card. The concept of the SIM is yet in its infancy, and will undoubtedly become a basis for a better interworking between a used and a terminal.

Another portentous aspect of the SIM is related to roaming. We have already seen how roaming can be achieved by using the same mobile equipment to get service from two different networks with a single subscription. We will call this kind of roaming "MS-roaming" (MS standing for mobile station), since there is another possibility. The interface between the SIM and the rest of the mobile station is standardized in the Specifications, and this standard could provide a basis for roaming between PLMNs having different Air Interfaces, which will be referred to as SIM-roaming does not offer the fully automatic networked selection as MS-roaming does (except with dual- or multiple-mode mobile stations), but it allows inter-operability at a much larger scale between systems based on different radio techniques. Instead of carrying his mobile station, a user would only take his subscriber card with him and use a different mobile equipment to adapt it to the networks he wants to access.

See Figure 2.3. Moreover, SIM-roaming does not present any technical obstacle to the extension to any kind of telecommunication network, wire-accessed or radio-accessed, since the network aspects of the roaming issue do not depend on the access scheme used in each network The SIM appears then as the technical vector for personal numbering, that is to say a means to provide each user with a single telecommunication number whatever the network the user happens to be connected to. This is an important topic at the date of writing, with the studies concerning UPT (Universal Personal Telecommunications). Undoubtedly, the Specifications in this domain prefigure future worldwide telecommunication systems, in which the user simply equipped with his SIM will be able to access any telecommunication system.

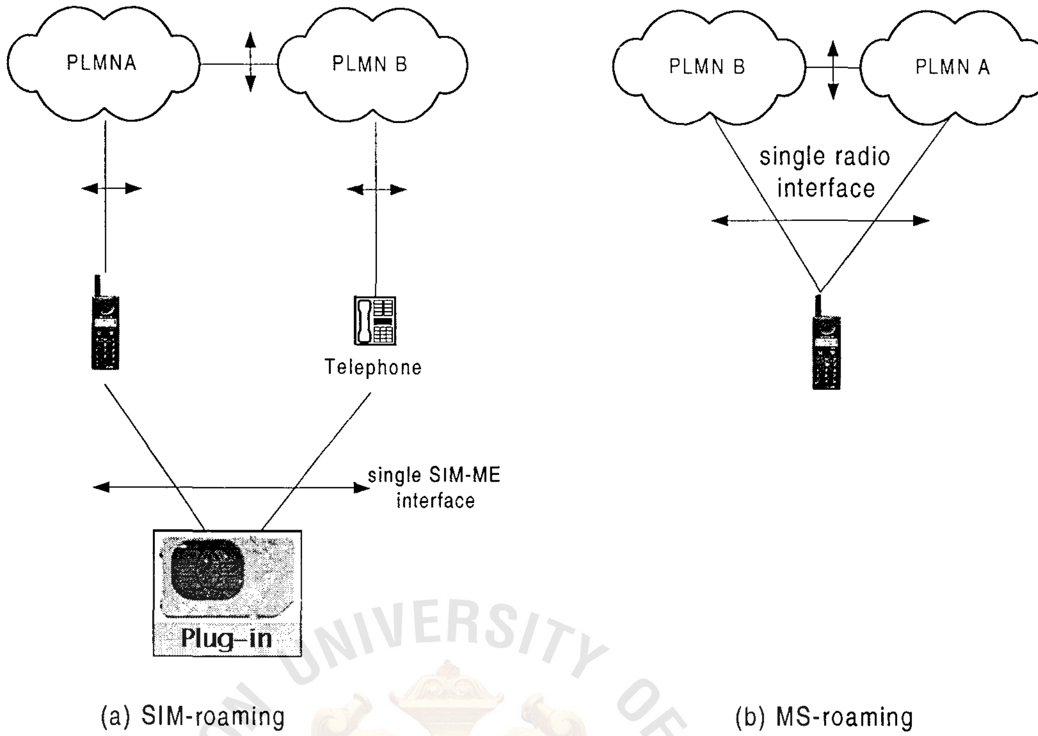

Figure 2.3. PLMN Interfaces.

2.2 International Roaming (IR) Services Overview

Any mobile telephone network exists within the borders of its own country, providing a range of services to its subscribers within the confines of its own boundaries. Once a subscriber has passed beyond those boundaries, the network's services are no longer available to them.

International roaming may be defines (at its simplest) as the ability of a mobile telephone network subscriber to travel to a different country and use the mobile telephony services provided by one or more networks in that country as part of their own network subscription. International Roaming extends the boundaries of the network as perceived by the subscriber.

Automatic Roaming

International roaming can be provided in different ways, but ideally it should be transparent – or automatic – from the subscriber's point of view. That is:

(1) A subscriber should be able to roam to a different network using their own subscription – they should not need a second subscription it the visited network.

(2) They should be able to make and receive calls in a different network using their normal telephone number.

(3) Any calls they make or receive in the different network should be automatically reflected in their normal billing arrangements.

Roaming Requirements

The ability to provide automatic roaming relies on two key features:

(1) SS7 signaling links supporting Global Title routing. When the SIM card is used the VLR must route messages via Global Title translation to the HLR in the home network and vice versa. This requires the existence of a suitable SS7 signaling infrastructure between the two networks. The signaling infrastructure routes the messages to the correct destination by analyzing the address of the message, i.e. its Global Title.

(2) Roaming agreements. Two network operators who wish to provide automatic roaming must implement a roaming agreement which specifies, for example, how call charges will be split, and the mechanism by which MSC call records will be exchanged to allow accurate billing by the home network for roamed subscribers.

To illustrate how automatic roaming works, consider the case of a Vodafone subscriber who is visiting France.

Location Update (Registration)

When the subscriber switches on their handset and selects a network in France to connect to, e.g. SFR (Societe Francaise du Radiotelephone), a registration attempt takes place:

(1) Each SIM card contains a unique IMSI, in a specific range, that can be used to identify the home network. The SFR VLR/MSC analyses the IMSI, sent from the subscriber's Vodafone SIM card and establishes a Global Title address for the UK HLR. This address is used to route a location update request on to the UK network, via the international signaling network.

(2) The international GMSC in the UK receives the request, identifies its destination as the Vodafone network by Global Title analysis, and routes the call on the Vodafone GMSC.

(3) The Vodafone GMSC receives the message and routes it to the subscriber's HLR, again using Global Title analysis.

(4) The HLR now carries out the normal GSM registration procedure (authentication, location update, previous location cancellation) with the SFR VLR, and the subscriber registers successfully.

All the signaling involved in this transaction is passed between the SFR VLR and Vodafone HLR over the international SS7 signaling links, which connect the two countries.

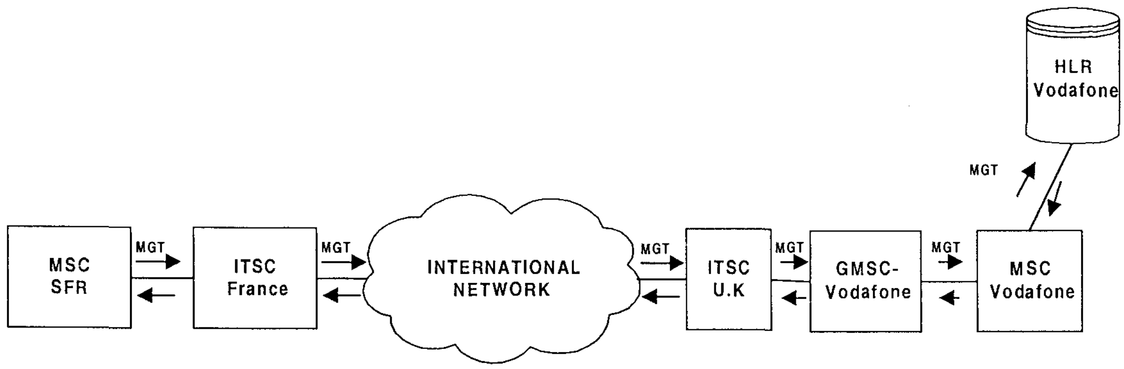

Figure 2.4. Location Update.

Outgoing Calls.

Once the subscriber has location update (registration) they can make speech calls from the same VLR without any further interaction with the home network, except for authentication requests. Any calls they make will generate call records on the serving MSC, which can then be transferred to the home network according to the operators' roaming agreement.

Incoming Calls.

If somebody attempts to call the subscriber while they are roamed:

(1) The call is routed to the Vodafone network by directory number analysis in the local switch.

(2) The Vodafone GMSC requests routing information for the call from the Vodafone HLR.

(3) The Vodafone HLR, knowing that the subscriber is roamed on the French SFR network, interrogates the SFR VLR (MSC) to obtain a roaming number for the subscriber.

(4) The Vodafone HLR return the roaming number to the GMSC, which uses this number to connect the call to the subscriber on the SFR MSC.

Again, all the signaling involved in this transaction is passed between the SFR VLR and Vodafone HLR over the international SS7 signaling links, which connect the two countries.

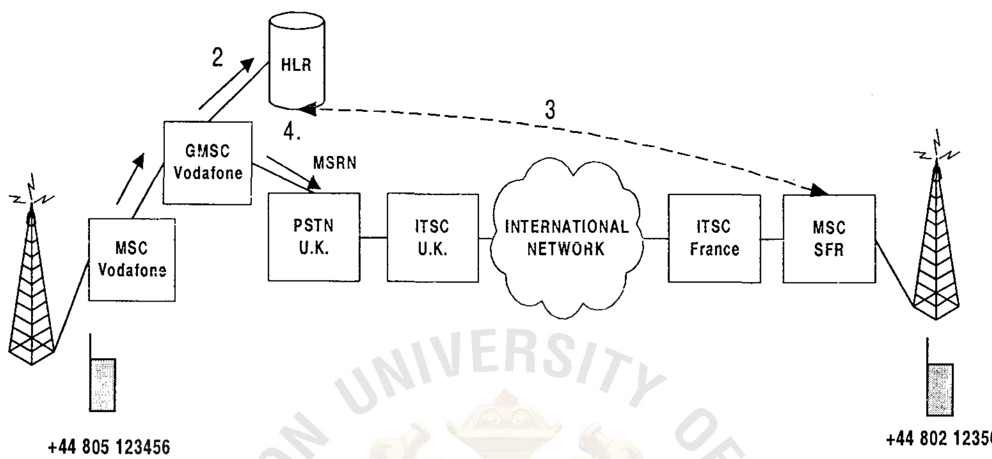

Figure 2.5. Incoming Call.

2.3 International Roaming (IR) Test Process Overview

To maintain the international roaming services, each partner has to re-test the service functionality according to the following events.

Fault management.

It is recognized that maintenance actions must be performed as soon as possible when the international roaming service is failing. The responsibility of controlling the reliability of international roaming is shared by the international carriers and the PLMN operators.

Each international carrier shall be requested to monitor the signaling traffic in its own IGP, for example by counting the number of SCCP messages exchanged (emitted, received) with each foreign IGP. The number of SCCP messages exchanged with each national PLMN operator should be counted as well.

Each PLMN operator should monitor the reliability of its own network acting as a VPLMN, and consider that the control of international roaming service to be provided to its HPLMN subscribers is ensured by the partner PLMN operators. VPLMN should take steps to notify HPLMNs of major service effective faults.

MTP and SCCP Route Verification Tests (MRVT, SRVT) as described in CCITT recommendation Q.753 appear to be a good means to detect routing and translation errors in MTP and SCCP. Unfortunately it will take years until both functionalities are available in most networks. Until this time, a possible solution might be to perform all checks manually. As this method surely is time consuming, it should only be used in a limited number of cases (e.g. after occurrence of routing failures). Therefore an agreement between the PLMN and the PSTN carriers will be necessary.

If the international roaming service becomes faulty, and it becomes clear that the error is at the SCCP level of the signaling relation, the affected PLMN maintenance staff shall contact the maintenance staff of the next SCCP International Gateway Point. Depending on the access solution the two PLMNs are using this means that the maintenance staff of:

(1) The IGP in the corresponding PLMN or.

(2) The IGP of the corresponding fixed network.

And the affected PLMNs maintenance staff will have to make direct contact and will be responsible for the further action.

The affected PLMN maintenance staff shall contact the maintenance staff of the next SCCP IGP, which is responsible to contact the maintenance staff of the next SCCP node. If the error cannot be detected, this method will continue until, at least, the maintenance staff of the partner PLMN is contacted.

If the access solution is in a manner that one or more MTP-STPs are part of the SCCP relation and none of the carriers operating the SCCP nodes is responsible for operation of those STPs, also the maintenance staffs of all STP nodes will be contacted. This will be done by the SCCP IGP node maintenance staff, who contacted its corresponding SCCP IGP node maintenance staff.

Re-testing after Network Changes

When operation is in course, it will be necessary to repeat subsets of the tests related with the above indicated stages, if a major upgrading is introduced in one of the two PLMNs. The evaluation of the necessity of test repetitions is the responsibility of the involved VPLMN operator. Examples of cases that can require test repetition are:

(1) Introduction of new mobility services, data services, supplementary services. All the PRD IR.24 (See Appendix IR24) tests associated to these new services must be performed as soon as possible after the launching of new GSM services provided by the VPLMN operator to its own customers;

(2) Modification of addressing or numbering data;

(3) Change of the national numbering plan in a PLMN country;

(4) Introduction of international STP (I-STP), national STP (N-STP), SCCP International Gateway Point (IGP) whose manufacturer differs from the existing I-STP, N-STP or IGP respectively;

(5) Introduction of MSC or HLR whose manufacturer differs from the existing MSC or HLR respectively;

(6) Introduction of a new software release which involves major changes in a VPLMN or HPLMN node.

The appropriate subsets shall be defined on a case per case basis by the VPLMN operator.

Periodic Re-testing

In order to check that international roaming is available continuously after the commercial opening of the service, periodic test repetition, not triggered by any special event, but for regular service control, shall be performed by the VPLMN operator.

The VPLMN operator will set-up and connect calls periodically with test SIMs of each HPLMN, currently located in the VPLMN. This operation has to be performed weekly in each type of MSC used in the VPLMN, twice if two types of HLR are used in the HPLMN.

The following test cases will be performed:

(1) IR.24, A.2.1.3 (outgoing call+incoming call): MS_1(a) calls MS_2(a), both roamed in VPLMN (b); (See Appendix IR24).

(2) IR.24, A.2.2.4 or 2.2.5 (call forwarding): call forwarding on not reachable. (See Appendix IR24).

However, considering the fact that it is hard and expensive for operators to find a schedule and technical staff to perform these necessary periodical bilateral re-testing, PRD IR.29 (See Appendix IR29) describes the specifications concerning the minimal test equipment for automatic roaming re-testing and test cases in the VPLMN.

In fact AIS International Roaming department test all scenarios according to Fault management, Re-testing after network changes and Periodic re-testing. But in sense of proactive maintenance that focus on this project for enhancing Quality of Service, IR engineer always test the Periodic re-testing scenario with all 200 roaming partners start from beginning of every month. It took time to test Location Update, Mobile Originate Call and Mobile Terminate Call to cover all roaming partners. AIS need hired more employee to take care for these type of test

2.4 Quality Improvement Model

In this chapter, we will use the Quality Improvement Model as a guideline for research methodology to indicate and evaluate how quality of GSM international roaming services improving via Automatic Roaming Test System (ARTS).

The Quality Improvement Model is an eight-step process that is performed in four phases. See Table 2.1. The effectiveness of the improvement activity again depends on judgment in the Planning phase and on execution in the Do-Study-Act phases. Within each step, a logical flow of planning, analysis, study, and action occurs, which repeats the cycle of the overall model. The judgment in Planning is dependent on a customer focus and on using data to make decisions.

Table 2.1. Eight-Step Quality Improvement Model.

Phase	Step
Plan	1. Select Improvement Opportunity
	2. Analyze Current Situation
	3. Identify Root Causes
	4. Select and Plan Solution
Do	5. Implement Pilot Solution
Study	6. Monitor Results and Evaluate Solution
Act	7. Standardize
	8. Periodic Re-evaluation

The model is a guide, or a logical process that have been modified to fit our situation. We will also stop at Step 6 for this project to just only evaluate the pilot project not intent to move onto the cycle of continuous improvement. Then, the process of research for this project can break down into as following step.

STEP 1: Select Improvement Opportunities

The tasks involved in selecting a problem or process improvement opportunity. This step will start with the list of international roaming problem. Then discuss the opportunities to improve task or process that effects quality of roaming services. Finally we will select the opportunities to improve it.

We will focus to improve quality of an international roaming services Network Performance (NP) aspect.

(1) List all roaming problem and improvement opportunities.

(2) Identify each problem into a category that disturbs customer satisfaction.

(3) Describe how the problem effects the quality of international roaming services.

(4) Describe the problem according to improvement opportunities.

(5) Discuss each opportunities issue to clarify a priority of improvement opportunities.

(6) Select improvement opportunity.

(7) Select the highest priority or most critical one and write a statement defining the current "as is" situation and the "desired state" in measurable terms.

(8) Summarize project and define road map. The project summary and road map include the problem or opportunity statement, project scope, roles and responsibilities, other milestone date, and deliverables.

STEP 2: Analyze Current Situation

The purpose of this step is to analyze the current situation of the problem and opportunities that we have selected from previous step to show detail of the problem at this moment. To state the process to be improved in terms of it current configuration, the participants in the process, and the performance measures that define customer expectations and suppliers specifications.

(1) Define process to be improved.

(2) Flowchart the process.

(3) Collect baseline data (time, duration, possibility to detect the problem).

(4) Identify performance gaps.

(5) Validate problem or opportunity statement.

STEP 3: Identify Root Causes

The purpose of this step is to identify potential root causes of poor performance, rather than secondary causes and symptoms, and to ultimately very these root causes.

(1) Analyze causes and effect relationships.

(2) Identify Potential Root Causes.

(3) Collect Data.

(4) Verify cause and effect and root causes.

(5) Validate problem and opportunity statement.

STEP 4: Select and Plan Solution

The overall proposes of this step is to identify and select the solution to solve the problem or improve based on the analysis in Step 3.

(1) Generate list and select best solution.

(2) Define revised process.

(3) Develop implementation plan.

STEP 5: Implement Pilot Solution

The purpose of a pilot implementation is to test the solution on a small scale in order to ensure that the revised process is capable of producing an output with the desired outcomes. The pilot activity verifies the effectiveness of the solution and proves whether or not the solution should be standardized across the organization.

STEP 6: Monitor Results and Evaluate Solution

(1) Monitor Results: results need to be monitored relative to targets, process changes, and controls defined in the implementation plan.

(2) Evaluate Solution.

2.5 Quality of Services (QoS) in Mobile Networks

Quality of Service (QoS) is defined as the quality that subscribers perceive when using any service offered by the telecom network. QoS actually is an indication for the satisfaction of the subscribers and therefore it is very important for network operators to constantly monitor the quality of service and in particular the network performance.

Liberalizations of the telecom market, combined with the fast growing number of mobile subscribers, has made in important to have an efficient and powerful test solution to provide knowledge of Quality of Service (QoS) and network performance at anytime. Due to the great complexity of the mobile network, it is very difficult to isolate internal network problems. In case of international roaming traffic, several networks are involved, which increases the complexity of testing even more.

Then we can define the Quality of the service as the following:

Definition: Usability and reliability of a network and its services. Permanent observation, supervision and adjustment of the various network parameters in a telecommunication system.

GSM Operators must:

(1) Identify errors occur most frequently

(2) Eliminate root causes of these errors

Identification of Quality of Service Aspects of Popular Services

This section identifies QoS aspects for popular services in GSM. For each chosen service QoS indicators are listed, which are considered to be suitable for the quantitatively characterization of the dominant technical QoS aspects as experienced from the end-customer perspective.

The indicators are described by their name and a short description from the customer point of view. Where possible existing ITU-T or ETSI definition are referenced. In some cases ITU-T or ETSI definitions do not exist or are considered as too generic, then a more service and mobile network specific definition is chosen.

Objective of Indicator List

The objective of the indicator list is to have an agreed set of QoS indicators, which allow an easier external and internal benchmarking.

Services are chosen which are considered to be of a high relevance to the end-customer in a national and international market and which are common for most of the network operators.

Indicators are selected which are considered:

(1) To have main influence on the customers satisfaction with the service.

(2) To identify technical QoS aspects, which can be influenced by the performance of the network or terminal.

(3) To be measurable by technical means.

(4) To be relevant for network operators national and international benchmarking.

The QoS indicators will be considered for one service at one time.

QoS Background

For a common understanding of QoS and Network Performance the main principles, which will be reflected in this document, are described.

ITU-T (E 800) definition of Quality of Service:

"The collective effect of service performance which determine the degree of satisfaction of a user of the service."

ITU-T E 800 definition of Network Performance:

"The ability of a network portion to provide the functions related to communication between users"

The relationship between customer satisfaction, QoS and NP is shown in the next figure. The IREG WP QoS has a focus on the technical aspects for customer satisfaction.

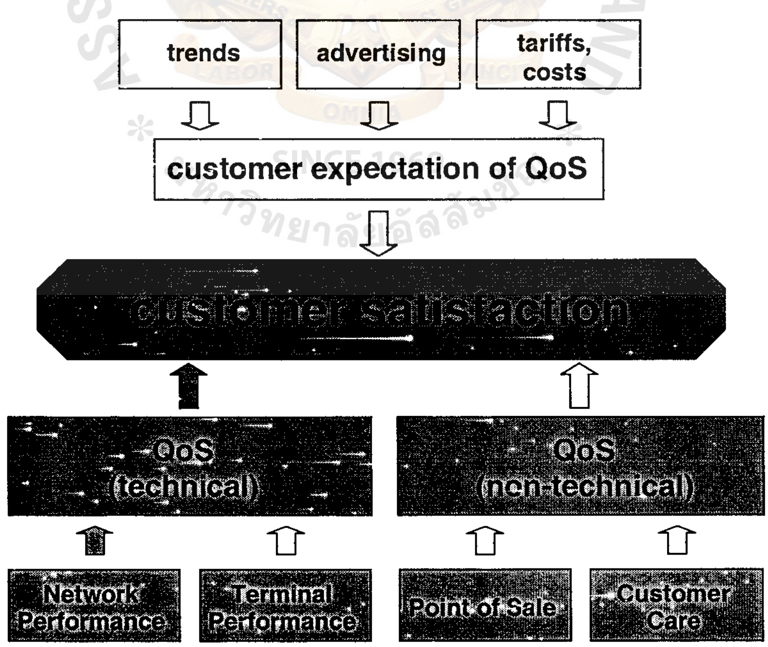

Figure 2.6. Relationship between Customer Satisfaction, QoS and NP.

Definition of Quality of Service Parameters and Their Computation

This section defines QoS parameters, the technical QoS indicators are the basis for the chosen parameter set. The parameter definition is divided into two parts:

(1) The abstract definition.

(2) The generic description of the measurement method with the respective trigger points. Only measurement methods not dependent on any infrastructure provided are described in this chapter.

The harmonized definitions given in this document are considered as the prerequisites for comparison of QoS measurements and measurement results.

General Considerations

All these quality of service parameters and their computations based on field measurements. That means that the measurements were made from customers point of view (full End-to-End perspective, taking into account the needs of testing).

It is assumed that the end customer can handle his mobile and the services he wants to use (operability is not evaluated at this time). For the purpose of measurement it is assumed:

(1) That the service is available and not barred for any reason.

(2) Routing is defined correctly without errors.

(3) The target subscriber equipment is ready to answer the call.

Further preconditions may apply when reasonable.

QoS Indicator List

Overview

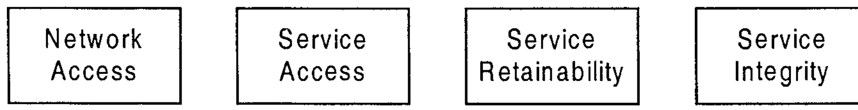

Figure 2.7. Phases of Service Use from Customer Point of View.

Figure 2.7 shows the different phases (Quality of Service aspects) during service use from the customer point of view. The meaning of these QoS aspects is:

(1) **Network Access**: The network indication on the display of the mobile is a signal to the customer that he can use the service of this network operator.

(2) **Service Access**: If the customer wants to use a service, the network operator should access him as fast as possible to the service.

(3) **Service Integrity**: This describes the Quality of Service during service use.

(4) **Service Retainability**: The customer should use a service as long as he wants. Service Retainability describes the termination of services (according or against the will of the user).

2.6 Automatic Roaming Test System

Modern mobile radio, in particular on GSM standards based systems, had become very popular throughout the world. In addition to the accumulating number of subscribers, the available services are expanding as well. To have an efficient and reliable mobile network, constant monitoring and testing are essential. This is the only way to guarantee all services reliably available at all times.

A significant benefit of the GSM System is that it can also be used in foreign countries. Mutual agreements (roaming contracts) among the operators involved are necessary for the purpose to regulate the use of the services agreed. Thus GSM subscribers can use the services to which they subscribe on their own mobile radio network also on the network of the roaming partner using the same SIM-card.

It is in the interests of network operators to be able to constantly monitor and check availability of services on their own network as well as those services contractually agreed with roaming partners. As manual verification is very labor intensive and also not entirely objective, automated testing can be used. Automatic testing provides objective, reproducible results.

The need for cross network tests between operators involves a great deal of discussion and coordination, if a uniform quality and reporting standard has to be achieved. Therefore the entire test process should be standardized and automated. In order to guarantee constant quality of service, STS developed the Automatic Roaming Test System, which fulfills automatic testing of the GSM MoU-IREG specifications.

The purpose of the test calls is to check it the nontracted services are available for all operators and functionality is provided as specified. The Automatic Roaming Test System provides an easy and effective way to implement all the customer-needed test campaigns and let them run at the desired time. Each operator is allocated in the system by reading his SIM-cards and filling in the specific terms.

All basic services like location update, normal calls between PLMN, MS to MS and calls between PLMN and PSTN / ISDN subscribers as well as supplementary services like all types of call forwarding, barring out going call are possible. Furthermore the test system offers a powerful visualization tool for drawing the results of the measurements by standard and operator-defined filters. Every window and report can be printed out on the delivered system printer. The Automatic Roaming Test System specified in this document combines all the facilities and functions required for automating the test and real time monitor procedures.

Automatic Roaming Test System (ARTs) provides also an extensive range of real-time monitoring tools that continuously examine, and report status of the quality of roaming services between PLMN network and interconnected partners. ARTs highlight problems experienced by inbound roamers, using PLMN network, and partner roamers when using other national or international networks. It allows network operations staff to take fast, and appropriate, remedial action to maintain a first-class quality of roaming services. Easy to read graphical displays help identify problem areas quickly and easily. They allow users to drill down to investigate faults in more detail.

ARTs provide comprehensive, robust and accurate information to support roaming customers. RMS helps build up profiles of service performance for roaming services, so resources can be targeted more efficiently. It also helps establish the metrics needed to support formal service level agreements between your network and your roaming partners.

Architecture of the Mobile Service Test System

The Automatic Roaming Test System contains in its standard configuration two main components:

(1) The Test Remote Unit (TRU) which can be equipped with different Test Modules (TM) for either A-interfaces, ISDN Basic Access or analog subscriber lines. Depending on the needed SIM-cards several SIM Server Service Boards (SSSB), each with 56 SIM-cards capacity, can be used. The TRU is constituted of a UNIX system for the communication and a real time kernel required for the execution of the tests in real time.

(2) The Test Control Unit (TCU), as its name indicates, controls and manages the TRU in order to execute correctly the tests. It is also a UNIX system

that, besides the communications control and the TRU control, provides a user friendly Graphical User Interface (GUI).

The following picture (Figure 2.8) shows on the user part a classic GSM network and on the lower part how the mobile services test system is commented to it.

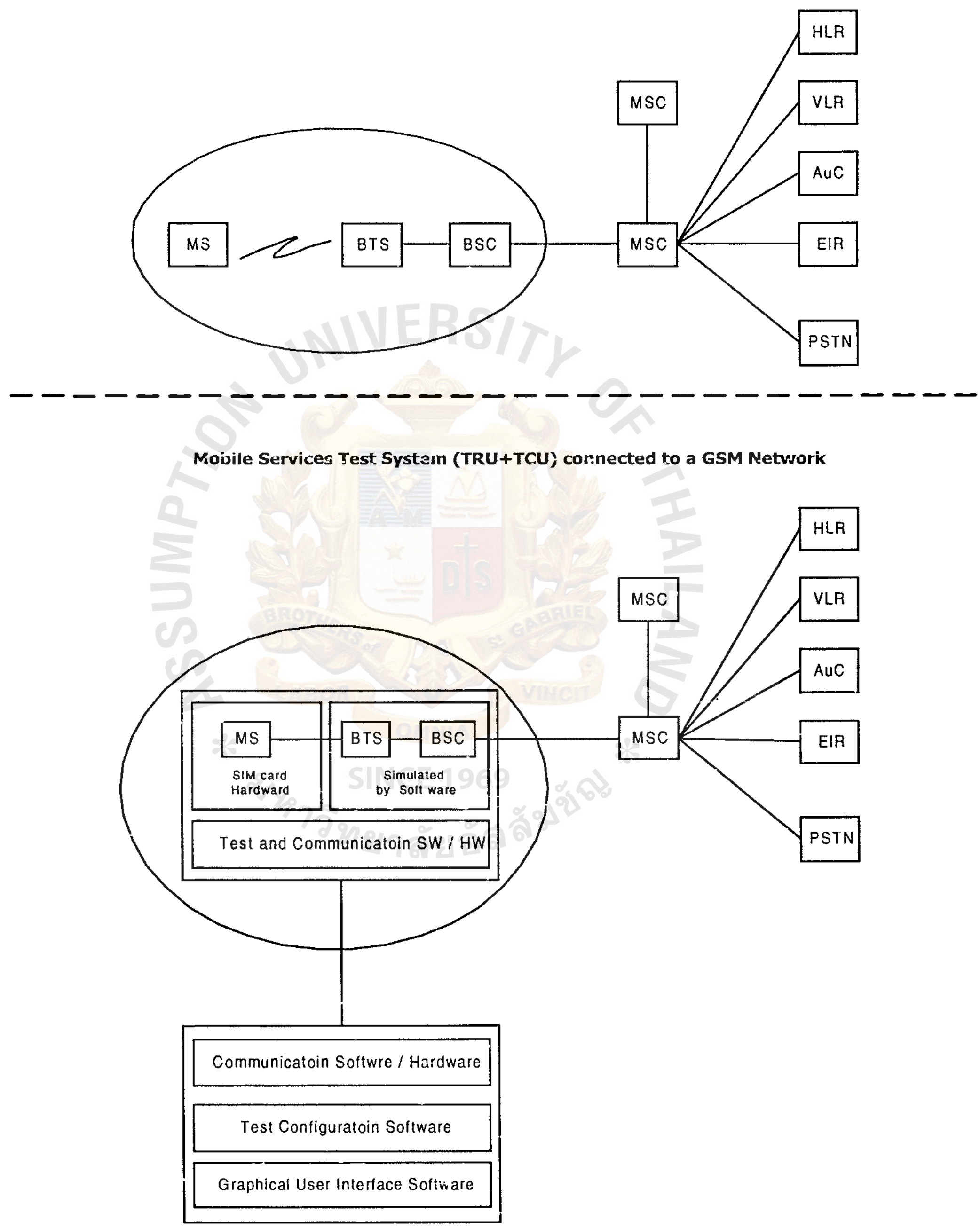

Figure 2.8. Architecture of a Automatic Roaming Test System.

In case of monitoring the international signaling for PLMN as detail in Figure 2.9, there are going to be four remote sites. Central site can be at any place where the operation team in located as long as LAN/WAN connectivity exists.

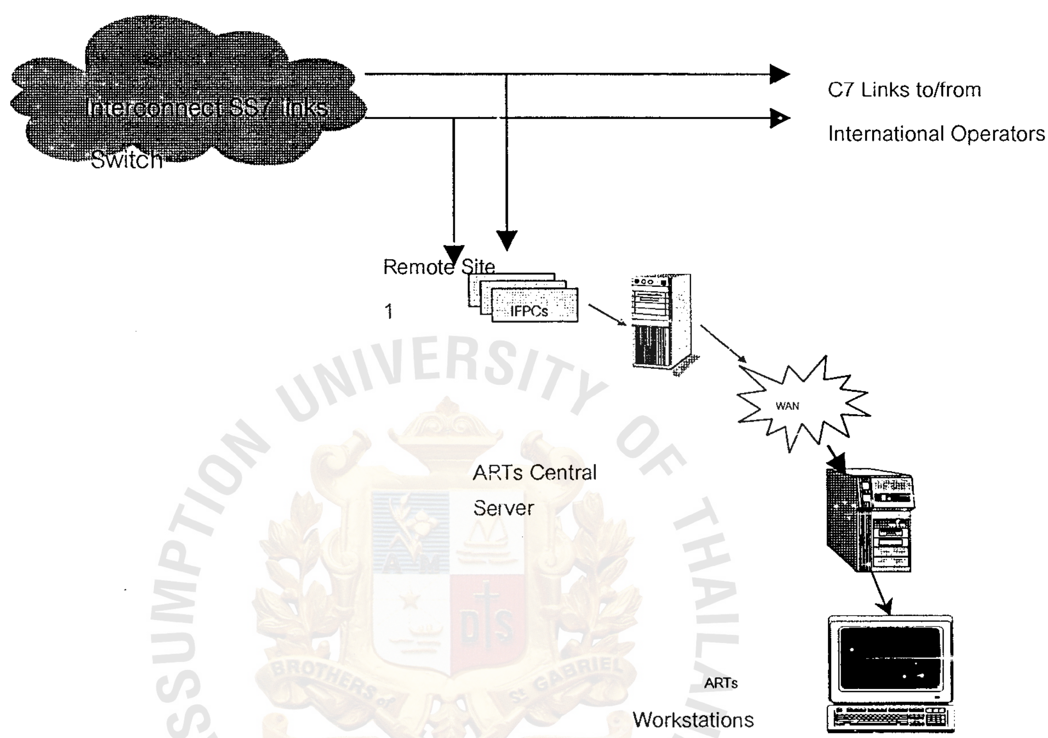

Figure 2.9. ARTs Signaling Real Time Monitor between PLMN and International Operator.

Remote Site Processor and mediation hardware in Figure 2.9 are required to non-intrusively connect the system to C7 links for capturing MAP/ISUP messages. Once the MSUs are captured, they are correlated at the remote site processor. There can be multiple remote sites based on customer network configuration. Then Data is passed on to central site for necessary aggregation and display at Central server. Workstations are used for GUI.

ARTs make extensive use of the WAN links between the remote sites and the RMS Server. Therefore, the WAN must be provisioned with sufficient capacity and reliability. WAN bandwidth requirements are dependent on MAP message volume across the international links.

How Does the Automatic Roaming Test System Work?

The different phases and principle behind the mobile services test system are simple and can be summarized as follows:

(1) A System configuration phase is the first step in order to connect the mobile services test system to the GSM network and make it run. Sum of the system parameters are link parameters (MTP 1, 2, 3 parameters: CRC, signaling time slot, etc.) and more specific GSM parameters (OPC, DPC, LAC, Cell ID, MCC. MNC. Etc.).

(2) An operator definition phase where the user will define operator(s) by entering the relevant associated data such as SIM-card IMSI, MSISDN, any fax or data number associated to the SIM-card, services, locality etc.

(3) A test campaign definition phase when the user defines which executable test campaigns will be performed. The test campaigns are built using pre-defined parts of operators, default configuration foe each test and a set of single tests, the so-called test sequences.

(4) A scheduling phase consisting of telling the system which test campaigns must be executed, when and how many times.

(5) A monitoring phase where the user can monitor the state of the test using an alarm server.

(6) A result visualizing phase where the user can generate and print reports representing statistic on the tests performed before.

(7) A result analyzing phase where the user analyzes the reports and decides what will be the next actions to be performed: defining new test campaigns with specific operators.

The working flow diagram corresponding to all those phases depicted on Figure 2.10 below.

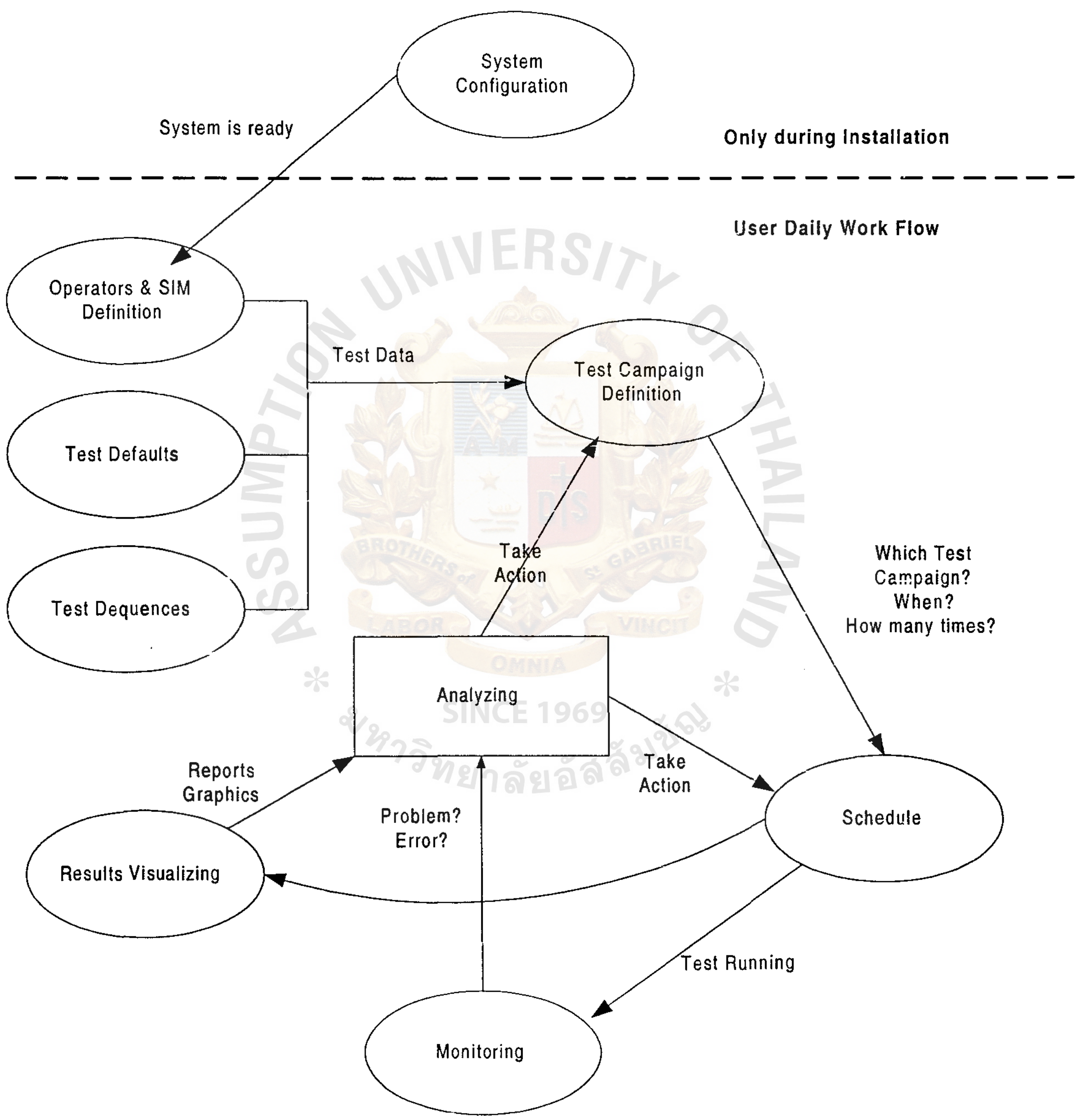

Figure 2.10. Automatic Roaming Test System: Working Flow Diagram.

Moreover ARTs measures, generate alarm and reports, service performance of the fundamental MAP procedures underpinning national and international roaming. ARTs monitor the success and failure of MAP procedures **originating from** and **terminating in** the operator's network. It is non-intrusive and has no SIM card dependencies as present in Figure 2.11 below.

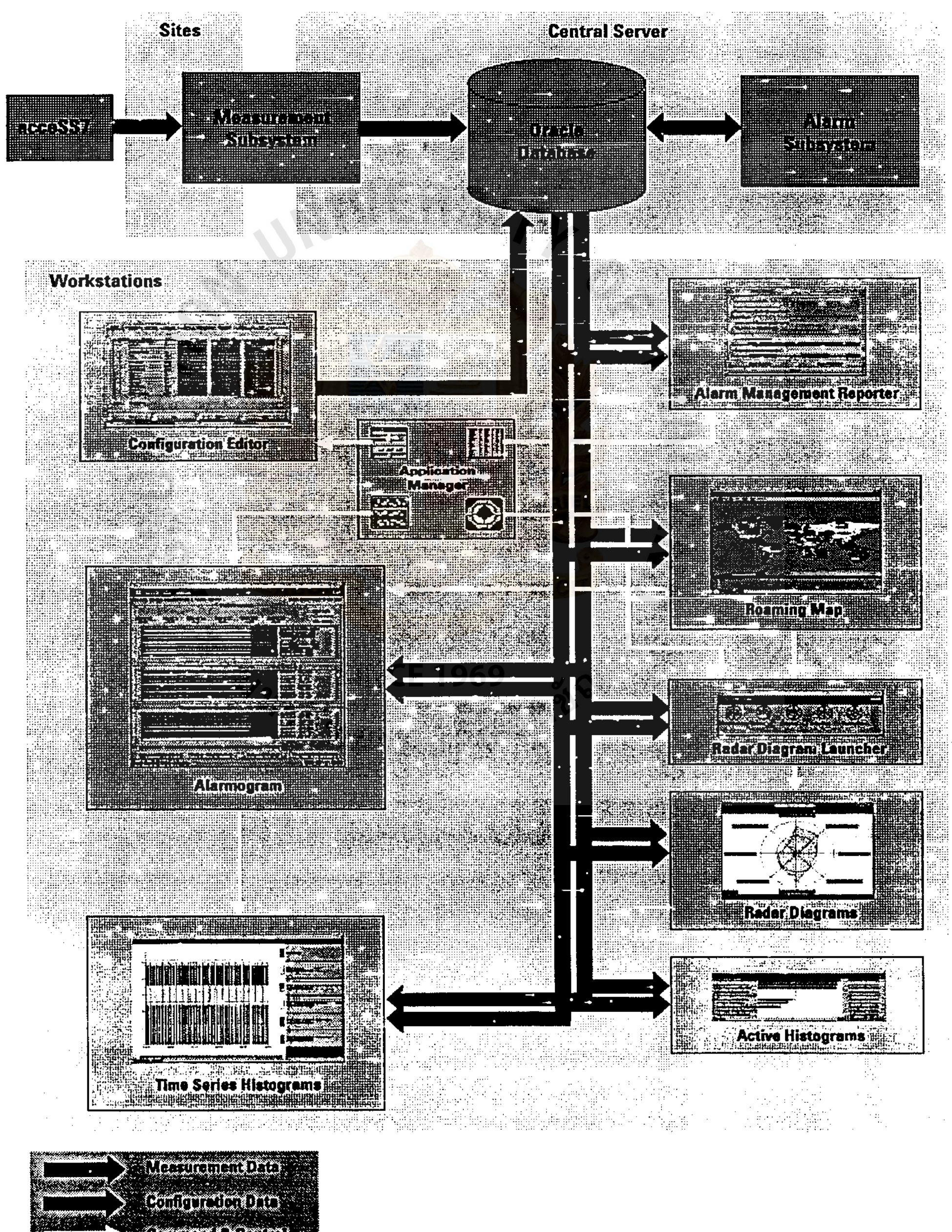

Figure 2.11. Overall of ARTs Operate Architecture.

III. DETERMINATION SET OF QoS CRITERIAS IN ENHANCING AIS INTERNATIONAL ROAMING SERVICE

Reference to ITU standard for Quality of Service in Telecommunication industry Figure 3.1 (Performance Concepts) is a framework intended to provide a general guide to the factors that contribute collectively to the overall quality of service as perceived by the user of a telecommunication service.

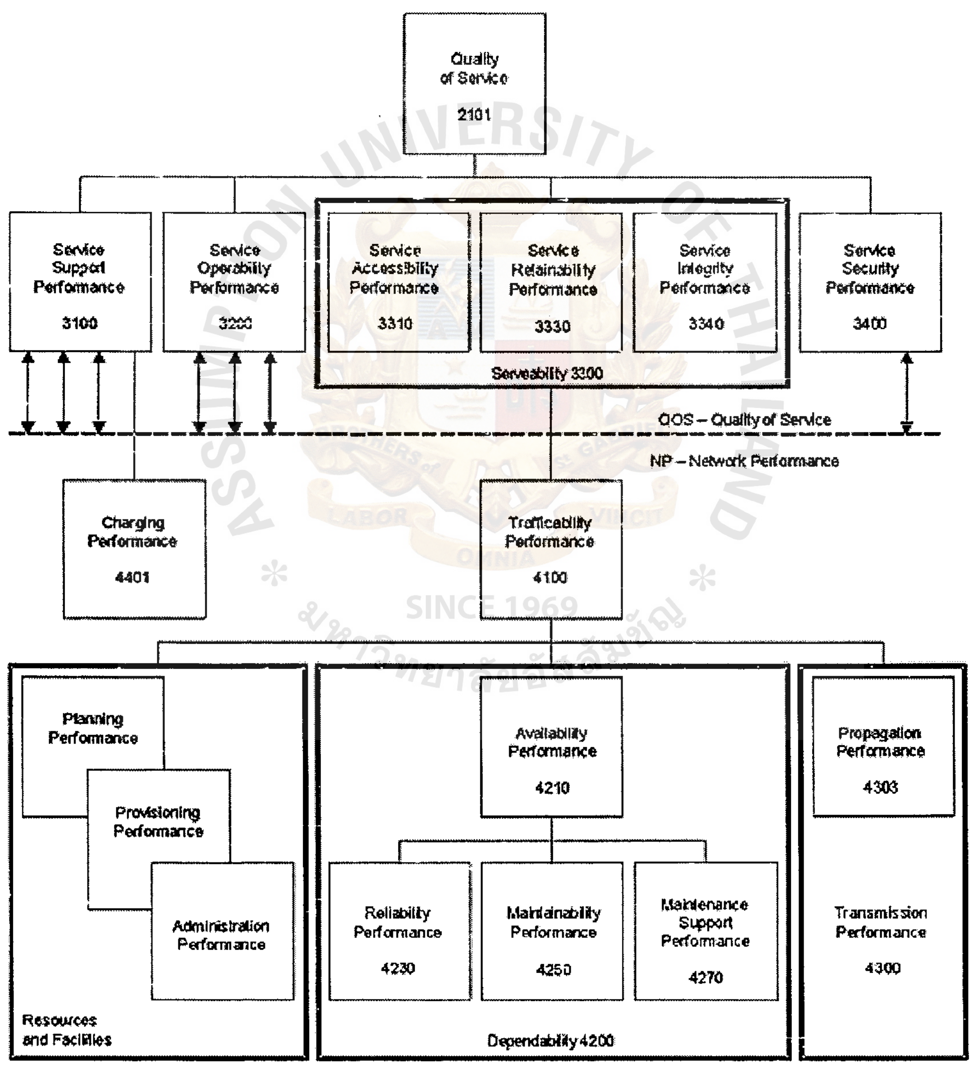

Figure 3.1. Quality of Service Model in Telecommunication Industry.

The terms in the Figure 3.1 can be thought as generally applying either to the quality of service levels actually achieved in practice, to objectives which represent quality of service goals, and to be determined as the standard reference of the Quality of service model reflect the majority enhancement quality of International roaming service.

A Figure 3.1 is structured to show that one quality of service factor can depend on a number of others. It is important to note – although it is not explicitly stated in any of the definitions contained in this document – which value of a characteristic measure of a particular factor may depend directly on corresponding values of other factors, which contribute to it. This necessitates, whenever the value of a measure is given, that all of the conditions having an impact on that value be clearly stated.

The essential aspect of the global evaluation of a service is the opinion of the users of the service. The result of this evaluation expresses the users' degrees of satisfaction. This Recommendation provides a framework for:

(1) The quality of service concept;

(2) Relating quality of service and network performance;

(3) A set of performance measures.

It is obvious that a service can be used only if it is provided, and it is desirable that the provider has a detailed knowledge about the quality of the offered service. From the provider's viewpoint, network performance is a concept by which network characteristics can be defined, measured and controlled to achieve a satisfactory level of service quality. It is up to the Service Provider to combine different network performance parameters in such a way that the economic requirements of the Service Provider as well as the satisfaction of the User are both fulfilled.

In the utilization of a service the User normally identifies the Service Provider only. The User's degree of satisfaction with the service provided depends on quality of service, that is on the latter's perception of the following service performance:

(1) The support;

(2) The operability;

(3) The serveability;

(4) The security.

All are dependent on network characteristics. However, the serveability performance is the most generally affected. It is further subdivided into three terms:

(1) Service accessibility performance;

(2) Service retainability performance;

(3) Service integrity performance.

Serveability performance depends on trafficability performance (Network Accessibility) and its influencing factors of resourcing and facility, dependability and transmission performance (of which propagation performance is a subset), as shown in Figure 3.1. These spotlights are the importance of the key study and define measurement of criteria in each terms including Network accessibility.

The dependability box, resources and facilities box includes planning performance, provisioning performance and the related administrative functions, network planning and provisioning aspects, etc. to the overall quality of service results. These items are for further study.

3.1 Network Access

Network Accessibility

Probability that the Mobile services is offered to an end-customer by display of the network indicator on the Mobile Equipment.

Network Access = {1- (Location Update Success)/(Location Update Request)}

Measurement:

Location Update QoS/ HLR

Location Update QoS/ MSC

Location Update QoS/Visiting Subscribers

Location Update QoS/Roaming Subscribers

Authentication = {1- (Authentication Success)/(Authentication Request)}

Measurement: (separate each report)

Authentication QoS/Intra-network

Authentication QoS/Visiting Subscribers

Authentication QoS/Roaming Subscribers

Criteria of Network Accessibility (shown in terms of error code)

- System Failure
- Data missing
- Unexpected data value
- Unknown Subscriber
- Roaming not allowed

3.2 Service Access & Service Retainability

Service Accessibility

Probability that the end-customer can access the Mobile Telephony Service when requested while it is offered by network indication on the Mobile Equipment.

Telephony:

Service Access Telephony (SAT) = (No of successful call attempts/ No of call attempts) x 100%

Service Non-Accessibility Telephony (SNAT) = (100%-SAT)

Call Setup Time (T2-T1): Time between IAM message (T1) and ACM (T2) message

Mobile Terminated calls = {1- (Provide Roaming No Success)/(Provide Roaming No Request)}

<u>Measurement</u>:

Provide Roaming QoS number/MSC

Provide Roaming QoS number/Roaming Subscriber

Short Message Service:

Service Accessibility SMS = (No of successful SMS attempts/No of all SMS attempts)

Access Delay SMS = T_{recive}- $T_{send\ SMS}$

T_{recive} : Point of time the mobile station receives the confirmation from the SMSC

$T_{send\ SMS}$: Point of time the customer sends his/her SMS to the SMSC

Criteria for Service Accessibility

Access all lists of service below:

Teleservices:	Bearer Services:
Speech	Data Call
Short message Service	Supplementary Service
Emergency Call	Call Forwarding
Voice mail	Call Barring
Fax	Call Waiting

IV. ROAMING SERVICE QUALITY ENHANCEMENT AFTER IMPLEMENTATION OF AUTOMATIC ROAMING TEST SYSTEM

In order to improve Quality of Service in international Roaming service, testing engineer need automatic tool to perform test and generate the report specific for network performance (Location Update, Authentication) and service performance (Telephony, SMS). They found out that the Automatic Roaming Test system was an efficient tool to improve the Quality of IR services in mobile network in terms of preventive maintenance. The test and monitoring system provides an easy and unique way to automatically monitor and continuously check the proper roaming functionality and SIM card validity. This functionality covers mainly the MoU-IREG requirements for automatic re-testing of international roaming. It also can be seen as a support system to generate specific test. Then the result is we can also detect the problem before effect our customer (Inbound&Outbound Roamer). According to prior statement can prove that there will be the great benefit effectively to our customers.

Existing Service Quality

There was a consensus that the serious complaints from customer really meant dissatisfaction and it was the key that shows customer dissatisfaction. It also meant that the number of customer complaints was an identification of our existing quality of services. If the number was high, it means quality of service was low. There is no other key measurement of international roaming service instead of from customer complaint and perform periodic test on the existing service quality measurement. There is also no such report on how the network performance is. The opportunities to improve the quality of IR service from the existing are 3 steps as below.

STEP 1: Selecting an Improvement Opportunities.

To select improvement opportunities, the list of an international roaming problem were shown as the table below.

Table 4.1. Problem/Improvement Opportunities.

Problem/Improvement Opportunities
1. No single network or operators could control the reliability of the network.
2. Poor monitoring system and process to detect the problem.
3. Long time to analyze and solve the problem.
4. Problem could not reproduce.
5. Poor report for tracking the problem.
6. Customer complaint was a good means to detect the problem.

According to Table 4.1 above, the most important problem that effect quality of services was Problem No. 6 “Customer complaint was a good means/measurement to detect the problem” because customer complaint really means poor quality of service. Instead of preventing the customer complaint, we used the customer complaint as a tool to detect the problem. It was not a good thing to do. However, we could not refuse that, for an international roaming services, actually customer usually met the problem before the service provider. Although, customer could accept a temporary problem that happens with in a few minutes or just hours it should be recovered as soon as possible.

Most of the customers will not complain, if they notice that the problem will be recovered. However, most of the problem will be solved after customer had complained because the network operator start solving the problem after customer had complained. It was because of the network just knows that the problem had happened when the customer told them.

It is one of natures of international roaming services. There were 2 reasons that make this happen. The first was shown as the problem no.1 "No single network or operator could control the reliability of the network," because an international roaming customer was always out of their home networks, the network that mobile subscriber register. The service control was shared by international carrier and PLMN operators, both HPLMN and VPLMN. No one could notice that the problem had happened without any notice from one of the parties. However, the notice is usually generated by the customer, if we had no an efficient tool to detect the problem before customer met it. Then it came to the second reason; that is "Poor monitoring system and process to detect the problem."

As we had already stated the traditional way to detect the problem in Literature Review, we used periodic re-testing as a tool to detect the problem. The main reason using the periodic re-testing to detect the problem was because no individual network could control the reliability of the international roaming services. The responsibility of controlling the reliability of international roaming was shared by the international carriers and the PLMN operators. Then, to reduce the gap to detect the problem meant improve the way to do periodic re-testing.

Problem no. 3 "Long time to analyze and solve the problem." came after the problem had already happened and the customer had already complained. It was also a good mean to improve as a corrective maintenance. It might be a step after we could find the process to detect the problem.

Problem no. 4 and 5 were not the root cause of customer dissatisfaction but it is the system to record the problem for our further analysis to understand how the problem happened. After analyzing, the problem/opportunities statement is as follows:

As periodic re-testing once a month is not efficient enough to detect the international roaming problem.

Desired State: Increase frequency of periodic re-testing at least once a day.

Summarize Project and Define Road Map

The way to improve the quality of international roaming services that we focus on was changing the periodic re-testing as is manually tested to automatic test by using ARTS to reduce a gap to detect the problem. Then after we could define and standardize the periodic re-testing we will further focus on the reducing the process to solve the problem. However, this report will only do the first focus.

STEP 2: Analyzing Current Activity.

In 1998 we launched the international roaming services with 80 operators, after we just tried to expand our coverage area since 1995. We confronted customer complaint with a little operation issues because we lack awareness of the roaming problem. Then we started doing the periodic re-testing manually once a month for every MSC during the first week of every month with three basic services Location Update (LU), Mobile Originate Call (MOC) and Mobile Terminate Call (MTC). The process of manual periodic re-testing, See Figure 4.1, shows the sequence of preparation, testing and conclusion.

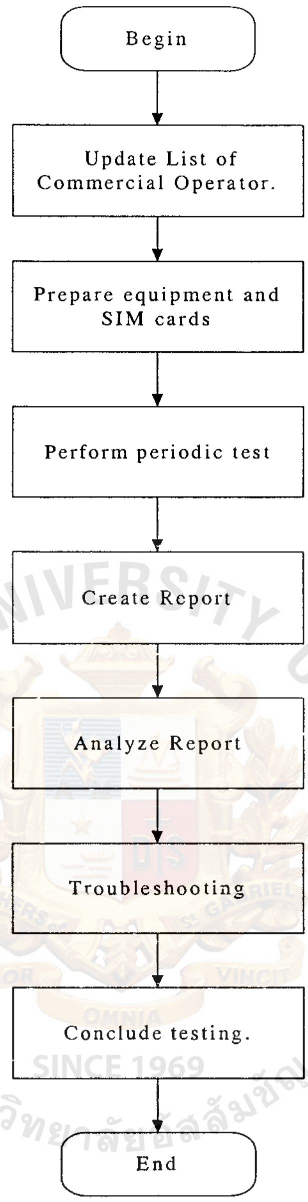

Figure 4.1. Manually Testing Flow Process.

It was a very good mean to do the test because we could check our network to support all the partner operators at that moment over the network and then overcome the operation problem. However, after the number of roaming partners is over 100 operators at the end of 2000, there was a signal that some MSC delayed to send the test results. It needs to follow up to get the test results. Finally, by the mid of 2000, no one did the test and leave checking to customer.

STEP 3: Identify Root Cause.

Why did we make the test more frequent? It was a good question that had to be answered. The answer was because manually re-testing had human concern and limitation.

The list of human concern was:

(1) Time consuming: It took time doing the test manually. The average time to do the test and make report was at least 200 minutes for each operator to cover all IREG24 (see in Appendix IR24) test case (contain 20 test cases/ IREG24). Then it took 20,000 minutes for 100 operators.

20,000 minutes / 60 minutes = 333.33 hours.

It meant that it took about 334 hours for testing 100 operators without eating and resting.

(2) Labor intensive: It was just the repetitive test no creativity.

(3) Manual / individual fault reporting = Normal human errors.

The list of limitation was:

(1) Limited reproducibility of errors and malfunctions

(2) Limited measurement possibilities

(3) Non-standardized fault reporting

(4) Non-unified test cases and procedures

All those concerns and limitations had to be accepted as manual test it was. Anyway, the question has still no answer.

In reality, we could not force the staff to do the test all day all night and it was not practical to do so. Manually testing once a month was just the pilot process and it works for just the beginning. As when humans work repetitively, they feel bored and lack concentration and then come out lacking professionalism.

As we had analyzed the current situation, each MSC tried to fade out the manual test and was finally stopped by mid 2001.

After we find out what is the reason for everyone quits testing, The list below are some main reasons.

(1) It is less priority

(2) Take about weeks to do the test

(3) And most of the test pass.

(4) It is a huge job to detect a problem

(5) And most of the time it has no problem during the test.

Then the Automatic Roaming Test System (ARTS) is an answer to ignore the limitation above because the system does not need to eat and rest and also is not boring. As it is a computer, it can do the task repetitively without lacking professionalism and no human errors.

Quality of Service Report from ARTs Work on Actual Traffic

There was a clear statement for faulty management that "maintenance actions must be performed as soon as possible when the international roaming service was failing". It meant that we started a maintenance action when we knew that the problem had happened. What will happen? If we as a network operator did not know when the problem had already happened, the answer is the customer will tell us by making a serious complaint. There was a consensus that the complaint really meant dissatisfaction and it was customer dissatisfaction. We had already stated the traditional way to detect the problem in Literature Review, we used periodic re-testing as a tool to detect the problem. The main reason using the periodic re-testing to prevent and detect the problem is because of no advance tool implemented on individual network therefore they could not ensure and control the reliability of the international roaming services. The international carriers and the PLMN operators shared the responsibility of controlling the reliability of international roaming. PLMN operators have great benefit after deploying the Automatic Roaming System to monitor and test the International Roaming network and services. Moreover, the new system has capability to detect the problem in real time before the roaming customer knows which has efficient statistic and Quality of service report.

ARTs monitors actually roam signalling traffic between HPLMN and all VPLMNs. From the monitored data ARTS provide information on QoS which inbound and outbound roamers actually experience. That means ARTs gather the information and statistic data from database then do calculation process relying on QoS criteria, which has been set previously. To identify the problem directly on the International Roaming service we have set the criteria monitored Roaming Services as in Table 4.2 below.

Table 4.2. Criteria Monitored Roaming Services.

Monitored Roaming Procedures	
Specific Roaming Services	**GSM-Map Procedures Monitoring**
User Authentication and Connection	***a) Send Authentication Update Location***
User Registration and Connection	***b) Update Location***
Mobile terminated call to roaming user	***b) Provide Roaming Number***
Short Message Service	***d) Forward Short Message***

According to the list of GSM-Map Procedures Monitoring above, ARTs provided the specific criteria, which identify the cause of the problem. Then PLMN operators use these criteria as a standard key to measure the quality of service in terms of network access and service access (QoS of Network, QoS of Service). A and B are the key to determine the Network access QoS. B and D are the key to determine the Service access QoS.

Key Determines Network Access QoS:

(a) Send Authentication: (one of the key measurement of Network access QoS) Authentication is the first operation to give authority for mobile to use the network and to check their identity with their network. ARTs give the Authentication statistic and QoS report to analyze the problem and trace back when the roamer customer encounter the problem on the Authentication process. There are 2 major key measurements that identify the cause of error in the Authentication as below:

(1) User Authentication: these errors appear when the fake roamer customer tries to use the mobile network. This process is used to determine the fraud.

(2) Connection: these errors appear when the signaling link between the mobile operator and their partner fail.

(b) Update Location: (Second of the key measurement of Network access QoS) In general, roamer customer who cannot make the Update Location will not use their mobile phone not only making outgoing calls but also receiving calls. ARTs can collect data and store in the database so that it is the easy way to know what is going on at that moment by setting the threshold & alarm and also ARTs can trace back when the roamer customer encounter the problem on the Location Update. ARTs show the result in terms of statistic and QoS report. There are 2 major key measurements that identify the cause of error in the Location Update as below:

(1) User registration: these errors appear when the roamer customer did not register to use the international roaming service.

(2) Connection: these errors appear when the signaling link between the mobile operator and their partner fail.

Key Determine for Service Access QoS

(c) Provide Roaming Number

Provide Roaming Number is the key to check efficiency of co-roaming partner network that can provide the value of the place where the roamer customer locates in. This operation measures how the co roaming partner operator can provide the service to the roaming customer in their network. ARTs use this key to measure the service access and service retainability. ARTs generate the statistic and QoS report according to the operator performance.

(d) Forward Short message

Actually, forward short message is the key to determine the Short Message Service (SMS) that checks with efficiency of co-roaming partner. Network operator can provide the SMS service. This operation measures how the co roaming partner operator can provide the service to the roaming customer located in their network. ARTs use this key to measure the SMS service access and SMS service retainability. ARTs generate the statistic and QoS report according to the operator performance.

Statistic report consists of detail in each operation which will enhance each mobile operator to improve their efficiency by tracing the problem and solve before their customer experiences and complains. QoS report is the overall network performance determination, which is used for making trend analysis and it is the reference between each operator.

4.1 Quality Enhancement after Deploy Automatic Roaming Test System

The old process of periodic re-testing scenario which tests Location Update, Mobile Originate Call and Mobile Terminate Call was not easy because the significant problem was time and cost consuming. Also the result of the test was fit only to the IREG24 (See Appendix IR24) which was sent to the roaming partner. The test engineer wastes the whole time only to make the Location Update, Mobile Originate call and Mobile Terminate Call but that entire test could not be expressed in terms of improving the quality of IR service. In the mean time, IR department notices that the old procedure taking the test did not give any statistic test details and service report for management to evaluate both roaming network performance and roaming service performance. International Roaming department aims to enhance the Quality of IR service so they decide to deploy advance technology tool instead of hiring more engineers to take the test which causes the time and cost consumption. After the new system started the operation, they can run all processes fluently. After the IR engineer log into the Automatic Roaming Test System (ARTs) via Intranet, he/she has to setup the required test case and also get the result and report. The required information is date, time of schedule for run the test, operator name, the categories of the test case. Then the system ran the test when they reach the schedule time then generate the report from all figures stated earlier. Finally, the system will keep the test result in the form of UNIX database for further requirement.

The engineer who makes the test went into the ARTs and he/she will get the result by directing the test file and opening it. Moreover the system is designed for making the trend analysis that means the result can show the efficiency of the network and service in weekly, monthly and yearly per each Operator Roaming partner or subscriber. This option could also help the IR to analyze the problem and look into the trend for enhancing Quality of IR service. The new system actually not only gives the summary of the Network access, Service access and Service retainability but also generates the statistic report for causes of errors at the end of every day, week and months. Then the new advance tool of testing International Roaming network and service access and retainability is used to dismiss the time and cost consuming problem. Basically, it allows an easy way, to perform automatic mobile services tests, monitors and generate reports on a regular basis:

(1) The system helps the operator by giving relevant information on the kind of errors.

(2) The operator can reproduce the failure most of the time. In fact this is one of the first mandatory steps to successfully correct an error to enhance the Quality of service.

(3) The system can generate results and statistics on the tests performed helping the operator to be more confident in the QoS because QoS is measured on a regular basis and observed a significant period implying much more samples and therefore meaningful statistics.

Those results and statistics of the tests generated in form of Statistic reports and QoS reports correspond to each activity. Also engineer can use QoS report in accordance with the test as judgements to improve quality of home network and service against roaming partners, which are the key to enhance QoS. Moreover, the IR department had to conclude the number of operators that had poor quality of service in terms of network access and service access at the end of each month from QoS reports. Engineer can know the cause of error in each criteria respect to each QoS as follows:

(1) Criteria for Network access QoS

 (a) Location Update

 (b) Request Authentication

(2) Criteria for Service access QoS

 (a) Successful Call

 (b) Provide Roaming Number

Summarize the statistic report makes IR engineer able to analyze the error detail. For the operator performance evaluation in terms of QoS summary report to maintain and set further standards for the Quality of network and service between HPLMN and VPLMN.

In summary, the company will get the most benefits from deploying Automatic Roaming Test System as an advance tool to enhance the Quality of International Service. Service engineers have time to do more work in another areas and not interrupt their working. And it is certain that the effectiveness of using the advance tool will bring the efficiency together and also make great service to the roaming customer. The old process of Periodic re-testing scenario which tests Location Update, Mobile Originate Call and Mobile Terminate Call was not easy because the significant problem was time and cost consuming. Also the result of the test fit only the IREG24 (See Appendix IR24) which sends the roaming partner. The test engineer wastes the whole time only to make the Location Update, Mobile Originate call and Mobile Terminate Call but that entire test could not express terms of improving the quality of IR service. In the mean time, IR department notice that the old procedure taking the test did not give any statistic test details and service report for management to evaluate both roaming network performance and roaming service performance. International Roaming department aims to enhance the Quality of IR service so they decide to deploy advance technology tool instead of hiring more engineers to take the test which causes the time and cost consumption. After the new system started the operation, they can run all processes fluently. After the IR engineer log into the Automatic Roaming Test System (ARTs) via Intranet, he/she has to setup the required test case and also get the result and report. The required information is date, time of schedule for run the test, operator name, the categories of the test case. Then the system is running the test when it reaches the scheduled time then generate the report from all figures stated in this chapter. Finally, the system will keep the test result in form of UNIX database for further requirement.

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In summary, the company will get the most benefit from deploying Automatic Roaming Test System as an advance tool to enhance the Quality of International Service. Service engineers have time to do more work in another area and not interrupt their working. And it is certain that the effectiveness of using the advance tool will bring the efficiency together and also make great service to the roaming customer.

4.1.1 Roaming and Interconnection Statistics

PLMN operator has used statistic reports to identify a problem area associated with calls from one of the roaming partners. Now it needs more detailed information to pinpoint the problem, enabling it to fix the problem in the fastest time possible. In real-time it captures, view and decode all of the signaling messages on the links between the network and the roaming partner's network. System allows it to focus on specific types of messages identified by ARTs. ARTs monitor the success and failure of all Location Update procedures, and key user authentication procedures, which flow between operator's network and other national and international wireless operators. Measurement results are grouped and stored by origination direction, and network. This allows accurate reporting of a registration problem to a specific network, and in some cases network element.

Location Management

The update location transaction occurs when a mobile is located on a new VLR. The transaction consists of messages sent from the HLR to the VLR containing the subscription data of the mobile. Statistic of Location management reports express the key measurement of Location Update details. The PLMN operator can identify the number of foreign roamers coming into Thailand and using the network, and vice versa the PLMN operator will know the number of their customers going out of country and where they are located. Also the PLMN operator can measure the efficiency of their network or co-partner operator network by looking at the number of attempts location update compared with the successful location update. In case the number of the success is very low the system can show the cause of error as set in the ARTs. The cause of error can tell PLMN operator how they can solve in the direct way that do not effect the customer as the details below:

Location Update Transactions per Operator, per VLR and/or HLR

The aim of these reports is to measure the location update transactions for the following categories and to give details about Network Elements impacted in the transactions related to:

(1) Roaming IN,

(2) Roaming OUT.

Roaming IN (inbound visitors)

This report concerns Location Update transactions of foreign PLMN customers on internal network. It provides the following values for each foreign PLMN per internal VLR address and the top 10 operators:

(1) Number of LU attempts,

(2) Number of successful LU,

(3) Number of failures,

(4) Number and cause of failure.

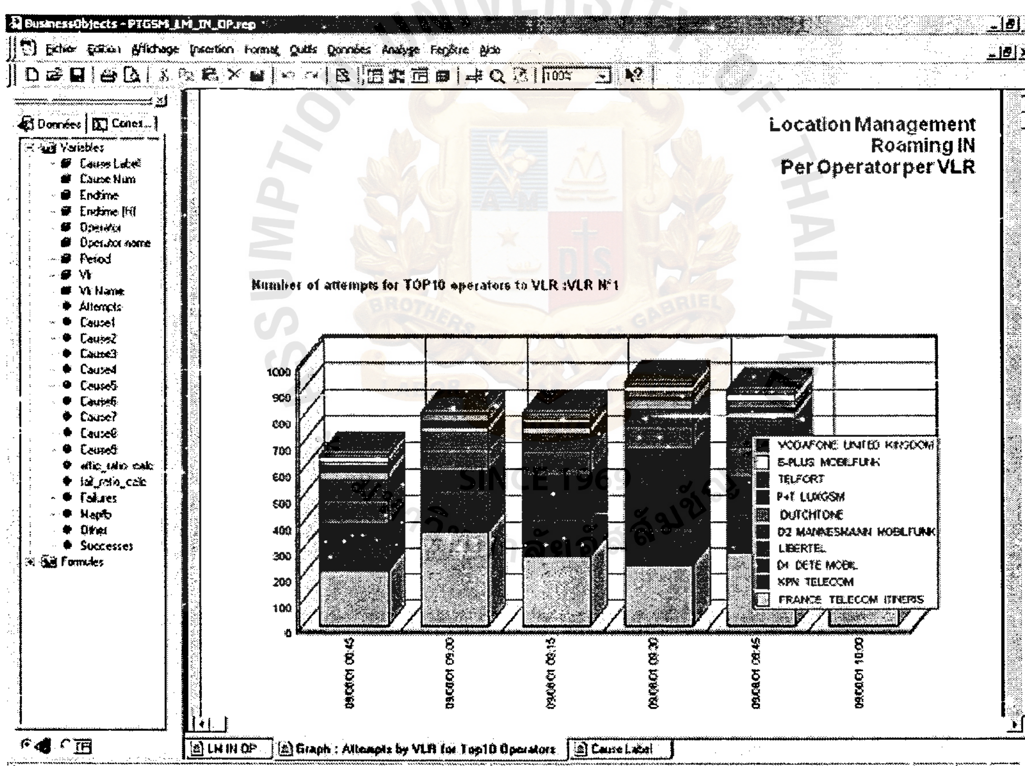


Figure 4.2. Location Update Statistic Report for Inbound Roaming by Area (VLR).

The result from graph in Figure 4.2 represent the 10 most location update attempts at VLR N1 (Samui) of mobile subscriber from partner's operator who is roaming in HPLMN network (Inbound customer) at 9.30 on 09/08/01.

Table 4.3. Result of Inbound Roaming Location Update Statistic Report.

Priority	Operator name	Number of Location Update attempt
1	Vodafone United Kingdom	910
2	Eplus Mobifunk Germany	902
3	Telfort Netherlands	881
4	P&T LuxGSM Luxemburg	852
5	Dutchtone Netherlands	843
6	D2 Germany	817
7	Libertel Netherlands	792
8	D1 Germany	703
9	KPN Finland	408
10	France Telecom France	204

Roaming OUT (Outbound Customers)

This report concerns LU transactions of GSM operators customers abroad. It provides the following values per internal HLR per foreign VLR, and Top 10 operators.

(1) Number of LU,

(2) Number of successful LU,

(3) Number of failures,

(4) Number and cause of failure,

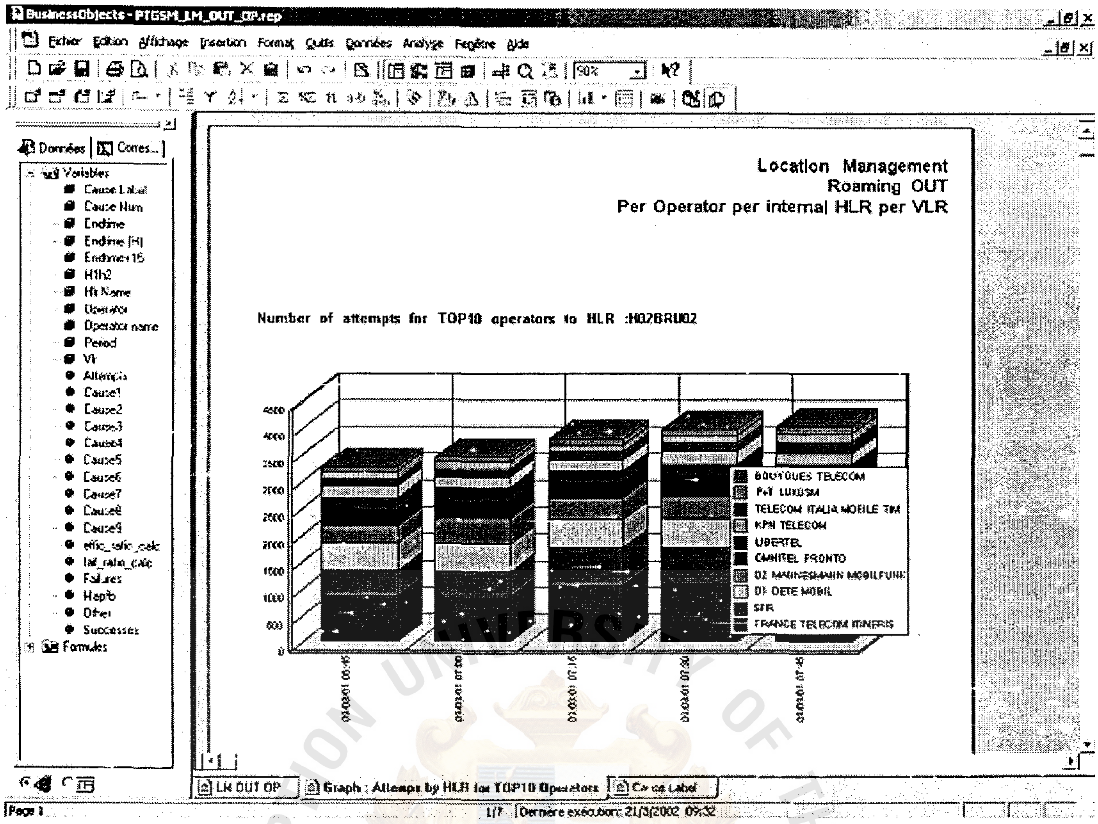


Figure 4.3. Location Update Statistic Report for Outbound Roaming by Area (VLR).

The result from graph in Figure 4.3 represents the 10 most location update attempts of mobile subscriber who is roaming in VPLMN network (Outbound customer) at 7.30 on 09/08/01. This graph represents the result that only corresponds to HLR ID H02BRU02 in HPLMN network.

Table 4.4. Result for Outbound Roaming Location Update Statistic Report.

Priority	Operator name	Number of Location Update attempt
1	Bouyoues Telecom France	4254
2	P&T LuxGSM Luxemburg	4058
3	Telecom Italia Italy	3803
4	KPN Telecom	3710
5	Libertel Netherlands	3508
6	Omnitel Italy	3421
7	D2 Germany	2990
8	D1 Germany	2499
9	SFR France	2002
10	France Telecom	1387

Location Update Transactions per Country

These reports give the location management values per country for the following categories:

(1) Roaming IN,

(2) Roaming OUT.

Roaming IN (Inbound Visitors)

This report gives the following values per country and the top 10:

(1) Number of LU attempts,

(2) Number of successful LU,

(3) Number of failures,

(4) Number and cause of failure,

Roaming OUT (Outbound Customers)

This report gives the following values per country and the top 10:

(1) Number of LU attempts,

(2) Number of successful LU,

(3) Number of failures,

(4) Number and cause of failure,

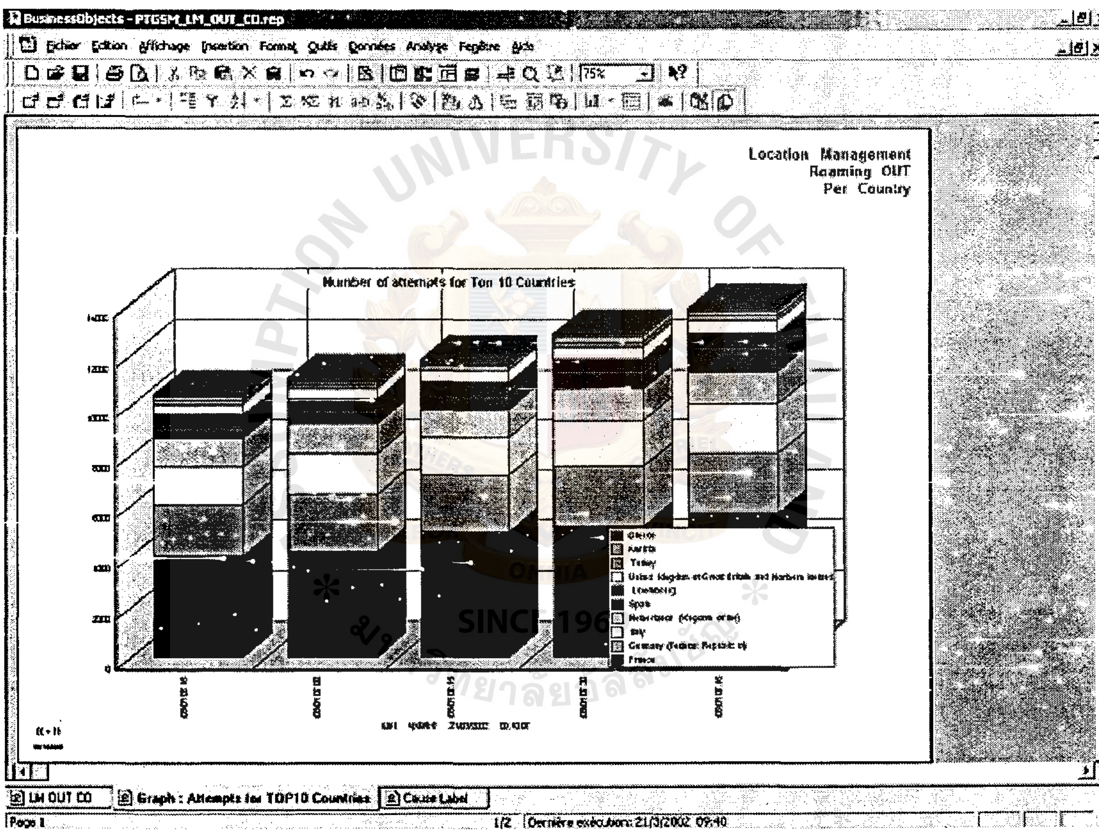


Figure 4.5. Location Update Statistic Report for Roaming Outbound by Country.

The result from graph (Figure 4.5) represents the 10 most location update attempts of mobile subscriber who is roaming in VPLMN network (Outbound customer) at 7.15 on 09/08/01. This graph represents the number of the HPLMN amounts roaming outside.

Table 4.6. Result for Roaming Outbound per Country.

Priority	Country name	Number of Location Update attempt
1	Greece	12100
2	Austria	12099
3	Turkey	11985
4	United Kingdom	11807
5	Luxemburg	11500
6	Spain	11003
7	Netherlands	10495
8	Italy	9308
9	Germany	7893
10	France	5500

From Figure 4.2 to Figure 4.5 shows that ARTS can generate statistic report of Location Updated (Location Update Attempts and successful) of both Inbound Roaming, partner operator subscribers roam in home network, and Outbound Roaming, home subscribers roam in partner operator networks. This report shows the ability of making Location Update in home network by measuring the number of attempts and success. These two numbers can be used to calculate Network QoS. If these two numbers are not too much different, the performance of the network is excellent. Conversely, if those two numbers are very different, it shows that the performance of the network drops and QoS of the network decreases. As a result, the customers cannot use mobile phone in that network. Tracing down from reports, roaming engineer can define cause error value which is cause of unsuccessful Location Updated; therefore, it is easy and convenient for workers to solve the problems. Figures 4.2 and 4.3 show ability of making Location Updated per each VLR (Location area, Bangkok, Chonburi, as define name for individual VLR), which can tell what problems occur in which area when traced down. Moreover, these figures also show top ten of location Updated attempt. Figure 4.4 and 4.5 show ability of making Location Updated of each operator per country, so the problems discriminate each operator by using statistic of Network

QoS calculation. Because of categorization by operator, engineers can define the problems fast and correctly.

Previously statistic reports Figure 4.2 to Figure 4.5 are the ability to provide concise but detailed information that is essential in current working environments. Through its various GUIs, Aautomatic Roaming Test System (ARTs) provides measurement information that can help identify current and potential problems. However, it is often the case that the findings must be reported to others in a less technical way so it is very easy to understand how to solve the problem.

4.1.2 Roaming and Interconnection QoS

Quality of Service report provides information to help PLMN operator improve effectiveness and efficiency in all areas, covering Network Operations and Management, Network Planning, Customer Care, New Services Introduction and Periodic Network Maintenance, while extending the limits of the network's performance and profitability. Managing and troubleshooting International Roaming Quality of Service pro-actively is an on-going issue for PLMN operator business. Of wider concern is the QoS PLMN operators are able to offer on a long-term basis. To do these effectively, it is vital to have a measurement of the sustained performance levels of PLMN operator partner's networks in form of QoS report classify by network access and service access, base on the quality of service criteria that are mention in chapter 3.

Network Access = {1- (Location Update Success)/(Location Update Request)}

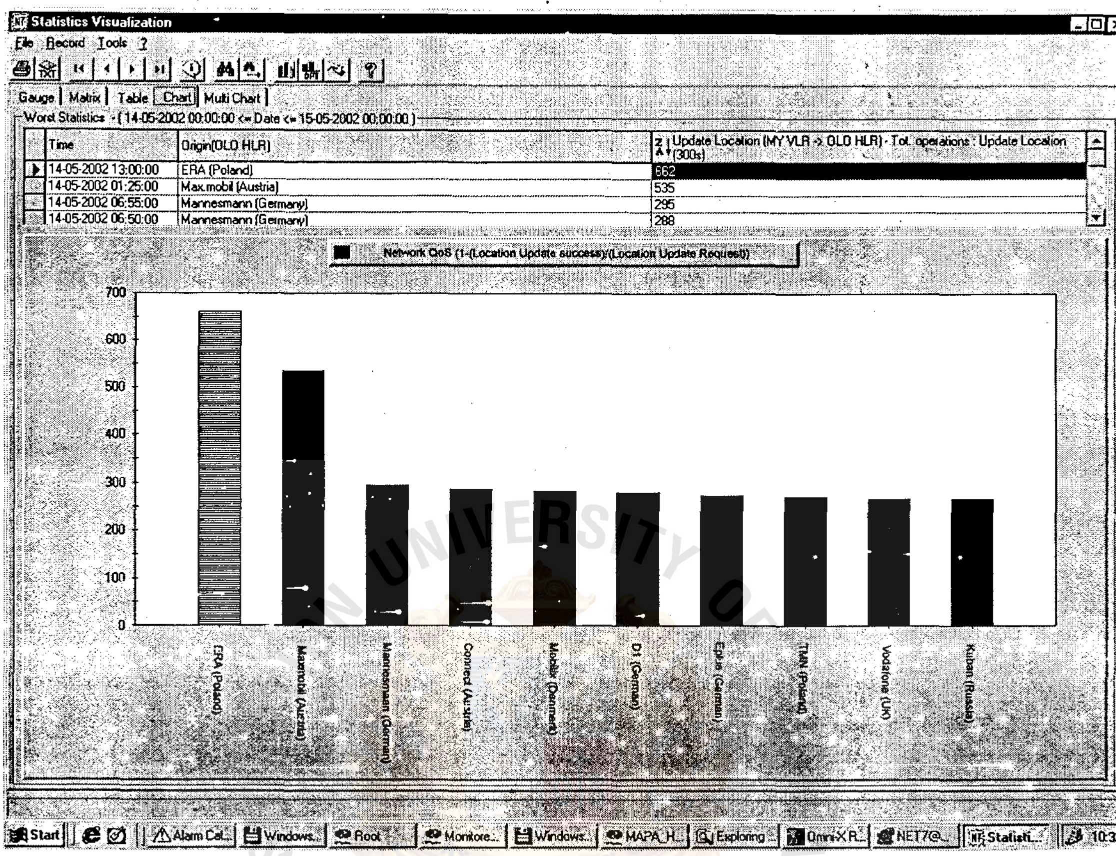


Figure 4.6. Network QoS Report Base on Location Update Operation.

The result from graph in Figure 4.6 show the 10 worst partner operators that QoS of network access represent by location update attempt of mobile subscriber in a period of time.

Table 4.7. Result for Location Update QoS.

Worst Network QoS	Operator / Country	Amount of QoS on error
1	ERA Poland	665
2	MaxMobil Austria	543
3	D2 Mannesmann Germany	300
4	Connect Austria	258
5	Mobilix Denmark	257
6	D1 Germany	255
7	Eplus Germany	253
8	TMN Poland	251
9	Vodafone UK	251
10	Kuban Russia	250

Network QoS report use as the standard performance determination between each operator, which is set by ITU. Firstly of Network QoS report is calculated by the statistic of making Location Updated. The ten worst cases of QoS are shown in Figure 4.6 separated by operator. If the value of QoS equal to 1000, it means that the QoS is worst. If the value of QoS below 1000, there are some presently error according to Location Update operation, which cause the customer to be not easy to make Location Update. However, to find the causes of the problem, one should see the statistic report as in Figure 4.7. It shows why QoS drops. Moreover, it could separate the causes of error correspond to Location Update in terms of amount of error in each period therefore engineer can know what happened at that time and solve it immediately according to each error. In Figure 4.7 also shown the error of roaming not allowed (gray dot and line) in Location Update operation which means those amounts of subscriber cannot make Location Update because they do not register the Roaming service from their operator. Second, the graph that show the black dot and black line, which means there are some amount of system failure. Then the blue dot and line present the total amount of errors in the period of time.

Summaries, Location Update Network Access is one of major network QoS that allows network engineer to monitor the relative performance of each partner's network availability in real time instead of doing a test once a month in the traditional location update test. QoS report gives more detail on the error cause of Location Update operation that correlates to number of non-successes as in Figure 4.7.

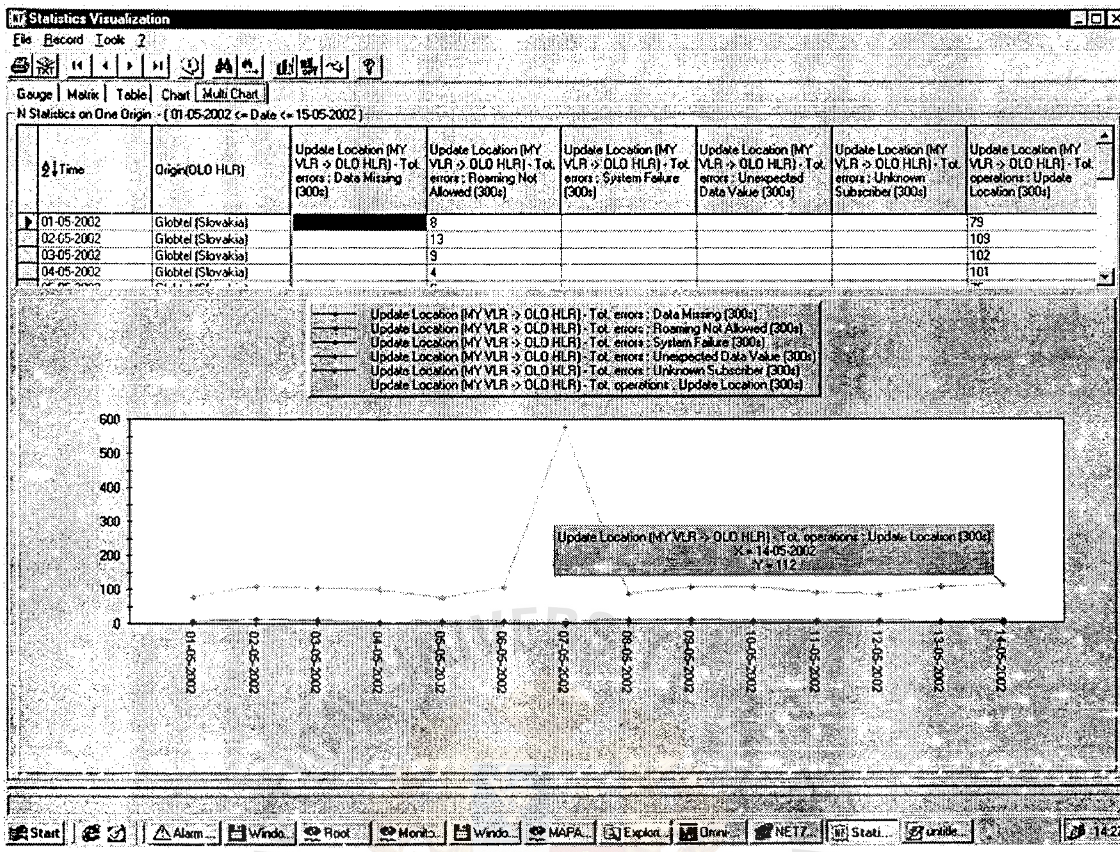


Figure 4.7. Error Cause Details of Location Update Statistic Report.

Authentication = {1- (Authentication Success)/(Authentication Request)}

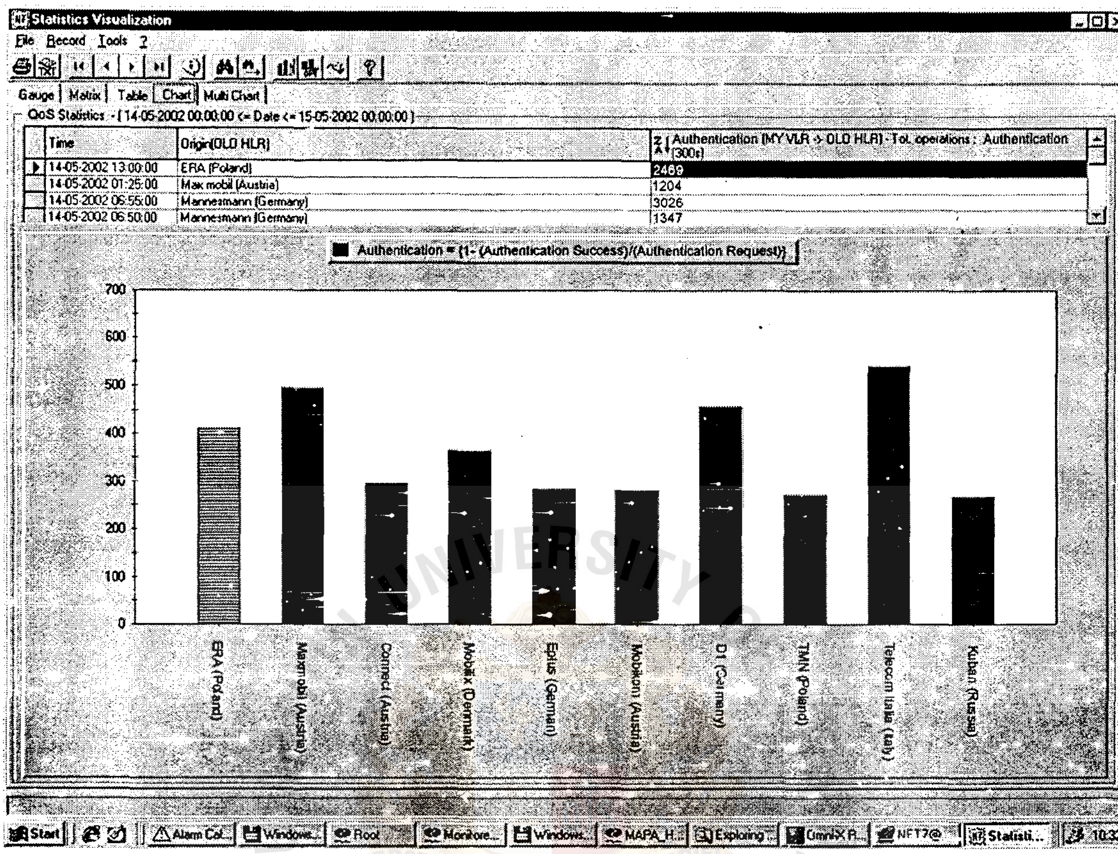


Figure 4.8. Network QoS Report Base on Authentication Operation.

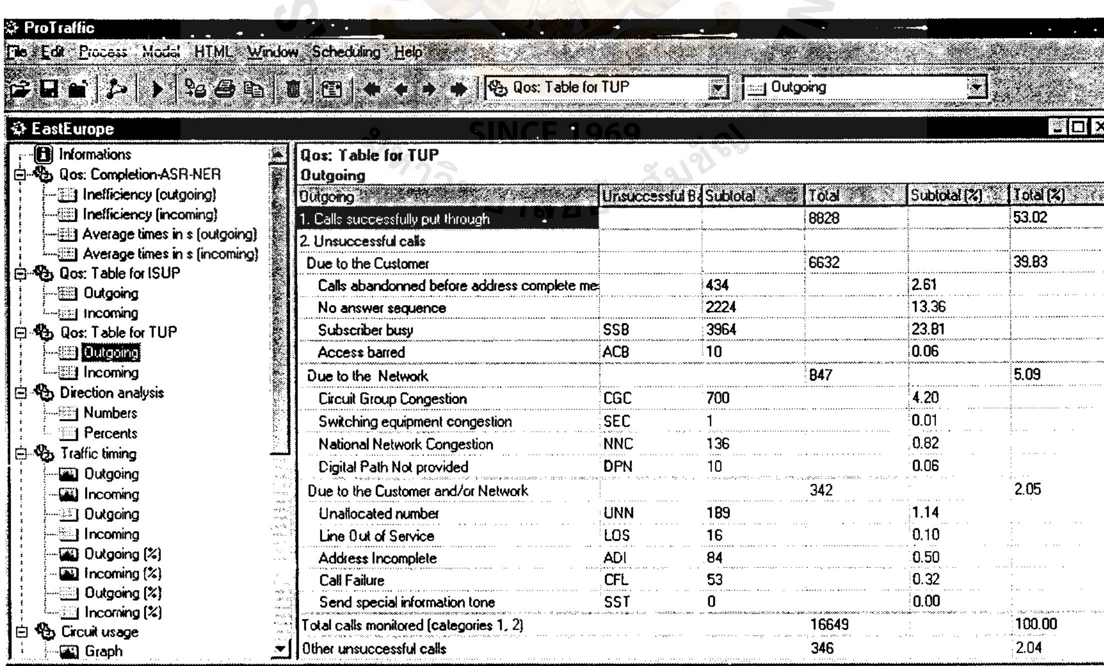
The result from graph in Figure 4.8 show the 10 worst partner operators that QoS of network access represented by Authentication request attempt of mobile subscriber in a period of time.

Table 4.8. Result for Authentication QoS.

Worst Network Qos	Operator / Country	Amount of QoS on error
1	Telecom Italia	547
2	MaxMobil Austria	499
3	D1 Germany	462
4	ERA Poland	402
5	Mobilix Denmark	353
6	Connect Austria	300
7	Eplus Germany	286
8	Mobikom Austria	284
9	TMN Poland	279
10	Kuban Russia	278

Secondly Network QoS is calculated by the statistic of request Authentication operation. The ten worst cases of QoS are shown in Figure 4.8 separated by operator. If the value of QoS equals to 1000, it means that the QoS of service is worst. If the value of QoS Present in the report, there is an error cause which represents the customers do not request authentication in short period of time from each operator. However, to find the causes of the problem, IR engineer should see the statistic report as in Figure 4.7. Authentication Network Access is the second major key of network QoS that allows network engineer to monitor the relative performance of each partner's network availability compared with the location update. The amount of both results are close but this QoS report give more detail on the error cause of Authentication operation that correlate to number of non-successes. The automatic report shows instead of using engineer doing the test once a month in the traditional location update test.

<u>Service Access & Service Retainability QoS</u>



Outgoing	Unsuccessful B	Subtotal	Total	Subtotal (%)	Total (%)
1. Calls successfully put through			8828		53.02
2. Unsuccessful calls					
Due to the Customer			6632		39.83
Calls abandonned before address complete me		434		2.61	
No answer sequence		2224		13.36	
Subscriber busy	SSB	3964		23.81	
Access barred	ACB	10		0.06	
Due to the Network			847		5.09
Circuit Group Congestion	CGC	700		4.20	
Switching equipment congestion	SEC	1		0.01	
National Network Congestion	NNC	136		0.82	
Digital Path Not provided	DPN	10		0.06	
Due to the Customer and/or Network			342		2.05
Unallocated number	UNN	189		1.14	
Line Out of Service	LOS	16		0.10	
Address Incomplete	ADI	84		0.50	
Call Failure	CFL	53		0.32	
Send special information tone	SST	0		0.00	
Total calls monitored (categories 1, 2)			16649		100.00
Other unsuccessful calls			346		2.04

Figure 4.9. Call Statistic Report.

Service access statistic reports in Figure 4.9 show the detail of every call that is stored in the ARTs database, in the figure presents the successful call, unsuccessful call and each error cause concern to non-successes. These data are used as the baseline to calculate the service access QoS in the next figure. Also international roaming engineer use statistic report to analyze and trace the problem. The statistic data are grouped according to incoming and outgoing call.

Service Access Telephony (SAT) = (No of successful call attempts/ No of call attempts) x 100%

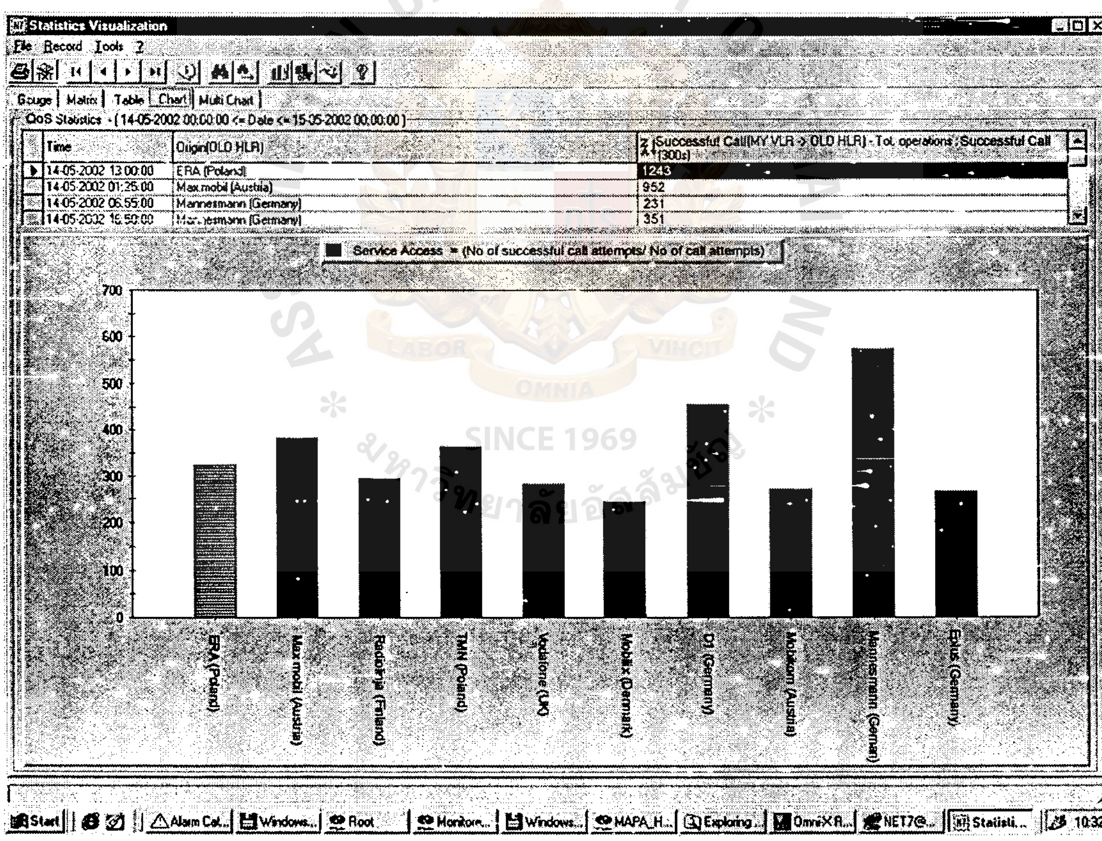


Figure 4.10. Service Access QoS Report Base on Call Statistic.

The result from graph in Figure 4.10 show the 10 worst partner operators that QoS of Service access represent by successful call of mobile subscriber in a period of time.

Table 4.9. Result for Call Statistic QoS.

Worst Service Qos	Operator / Country	Amount of QoS on error
1	D2 Mannesmann Germany	562
2	D1 Germany	450
3	MaxMobil Austria	382
4	TMN Poland	357
5	ERA Poland	325
6	Radiolinja Finland	300
7	Vodafone UK	297
8	Mobikom Austria	275
9	Eplus Germany	266
10	Mobilix Denmark	248

Firstly service access QoS report is calculated by the statistic of Successful and Unsuccessful call. The ARTs show ten worst cases of service QoS shown in Figure 4.10 separated each operator. If the value of QoS equals to 1000, it means that the QoS of service is worst. If the value of QoS Present in the report, there is an error cause which represent the customers do not make call in short period of time by each operator. However, to find the causes of the problem, IR engineer should see the statistic report as in Figure 4.9 above.

Call Setup Time (T2-T1): Time between IAM message (T1) and ACM (T2) message

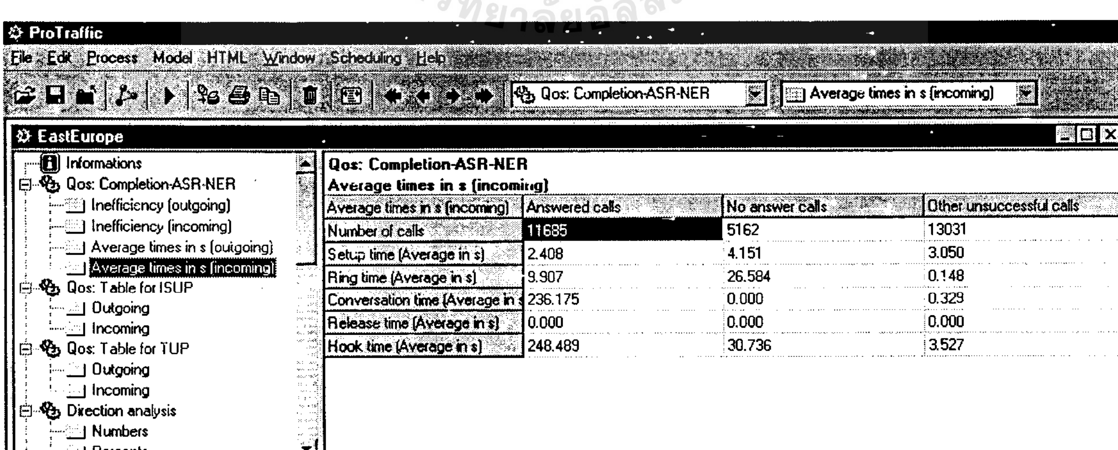


Figure 4.11. Service Retainability Report Represent by Call Setup Time.

For call setup time in Figure 4.11 show the timing detail of each call, ARTs can record timing of single call according to subscriber in each partner's network (operator). Call setup statistic data used as service retainability measurement which means any detail corresponding to the duration of call, completion of call, error cause of drop call then international roaming engineer can trace this report.

Mobile Terminated calls = {1- (Provide Roaming No Success)/(Provide Roaming No Request)}

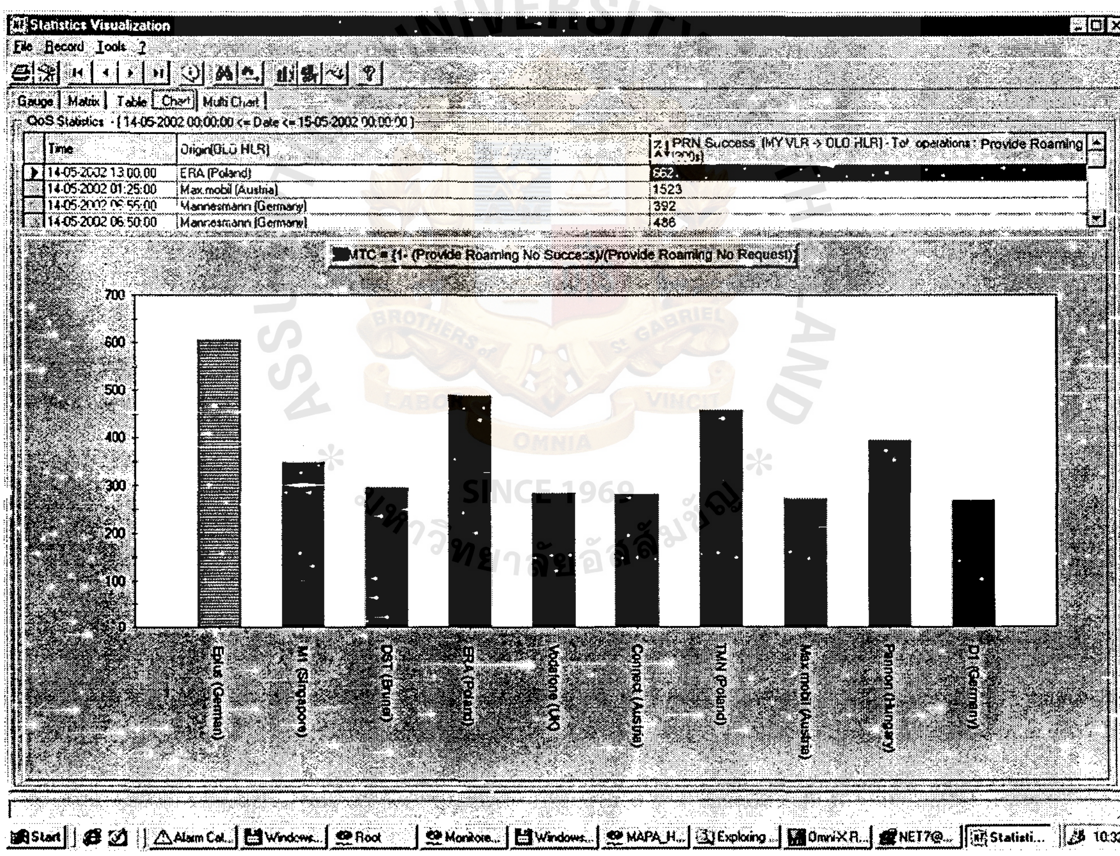


Figure 4.12. Service Access QoS Report Represent by Provide Roaming Number Operation.

The result from graph in Figure 4.12 shows the 10 worst partner operators that QoS of Service access represented by Provide Roaming Number of mobile subscriber in a period of time.

Table 4.10. Result for Provide Roaming Number QoS.

Worst Service QoS	Operator / Country	Amount of QoS on error
1	Eplus Germany	602
2	ERA Poland	490
3	TMN Poland	450
4	Pannon Hungary	393
5	M1 Singapore	350
6	DST Brunei	300
7	Vodafone UK	290
8	Connect Austria	287
9	Max mobil Austria	264
10	D1 Germany	259

Secondly service access QoS report is calculated by the statistic of Provide Roaming Number operation. The ARTs show ten worst cases of service QoS are shown in Figure 4.12 separated by each operator. If the value of QoS equal to 1000, it means that the QoS of service is worst. If the value of QoS Present in the report, there is an error cause which represents the customers do not receive call in short period of time to each operator. However, to find the causes of the problem IR engineer should see the statistic report.

For mobile terminate call used as key measurement of service QoS while any customer would like to receive a call but in this report measures the performance of the partner's operator how much they can provide the service to their customer roaming in their network use the service. In other words the value of mobile terminate call which represents the Service access QoS mean how mobile subscriber tend easy to receive their call in each partner operator.

Short Message Service QoS (SMS)

These reports will measure the traffic delivered by INTERNAL SMS-C and by VPLMN SMS-C.

SMS Delivered by Internal SMS Centre to Foreign VLR

This report measures the SMS sent by the internal SMS-C to a customer abroad and to FPLMN customers located on foreign VLR. It provides the following values per operator and per VLR:

(1) Total number of SMS delivered by the internal SMS-C,

(2) Total number of successful SMS delivered,

(3) Cause and number of failure

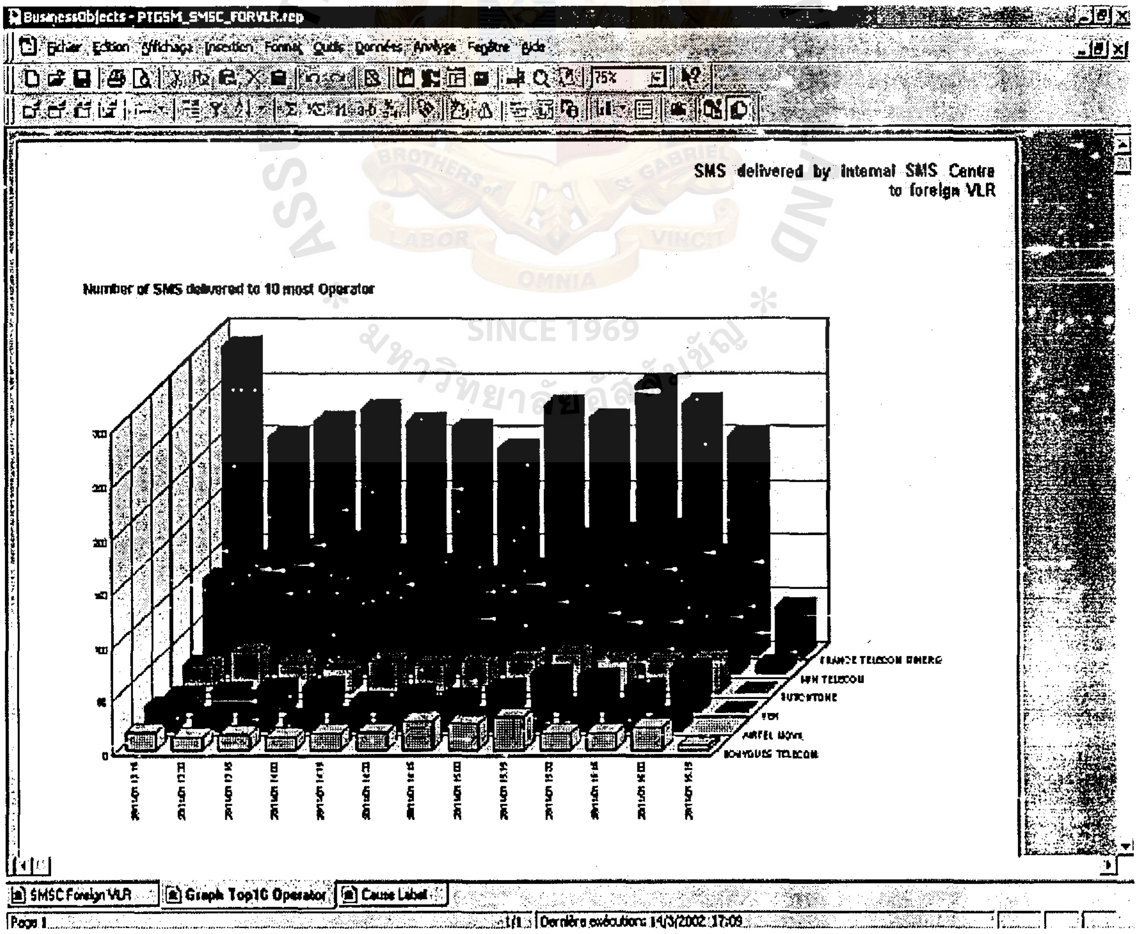


Figure 4.13. SMS Deliver by Internal SMSC Statistic Report by Visiting Area (VLR).

SMS Delivered by Foreign SMS Centre to Internal VLR

This report gives a measurement of SMS sent by foreign SMS-C to a mobile located in the local network. It provides the following values per internal VLR and per operator:

(1) Total number of SMS delivered by the internal SMS-C,

(2) Total number of successful SMS delivered,

(3) Cause and number of failure,

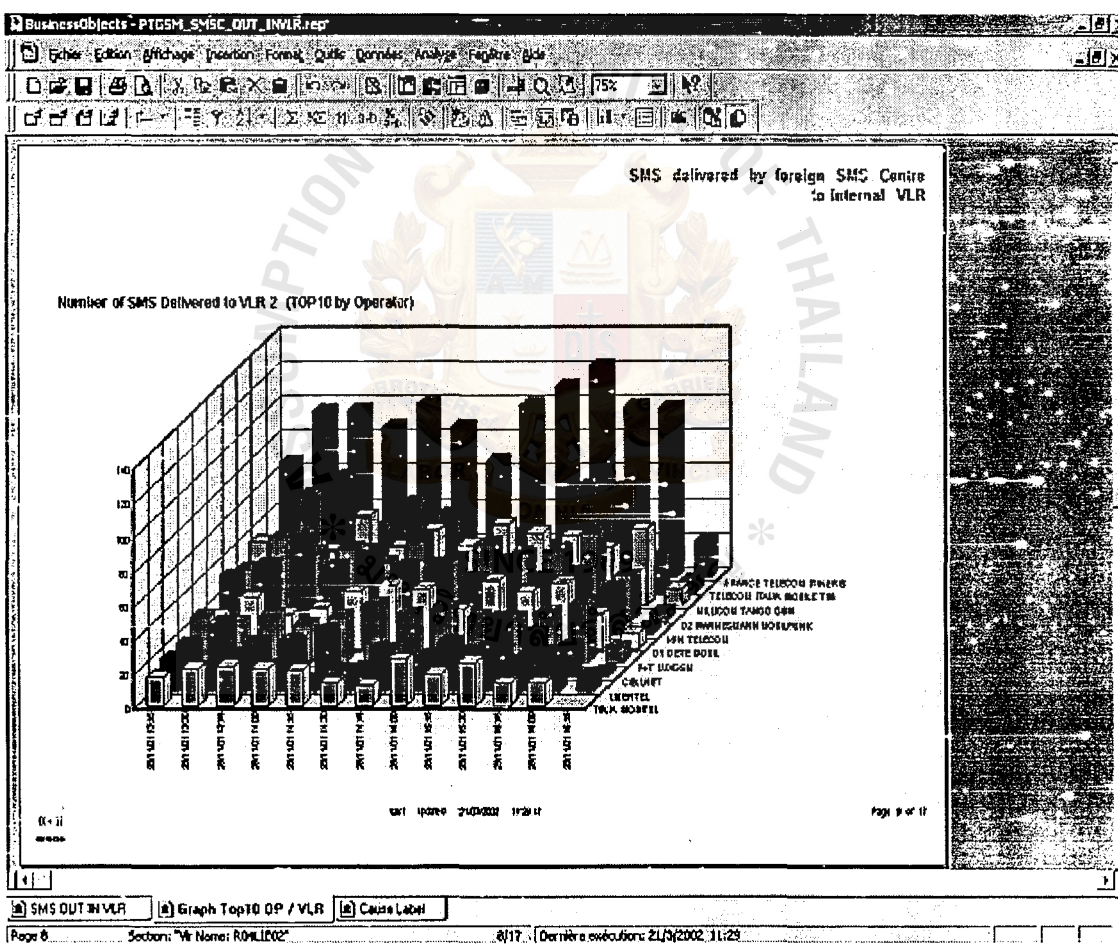


Figure 4.14. SMS Deliver by Foreign SMSC Statistic Report by Visiting Area (VLR).

SMS Service Accessibility = (No of successful SMS attempts/No of all SMS attempts)

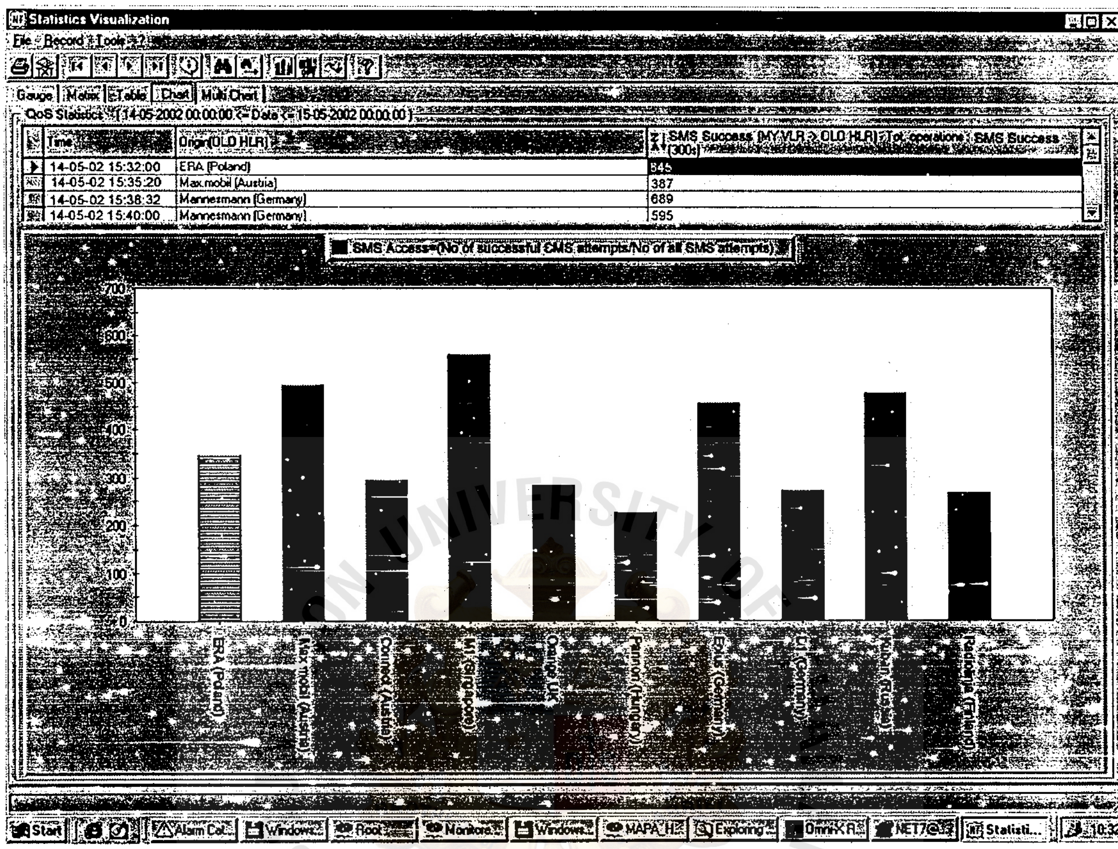


Figure 4.15. SMS Service Access QoS Report.

The result from graph in Figure 4.15 show the 10 worst partner operators that QoS of SMS Service access represent by SMS Success deliver of mobile subscriber in a period of time.

Table 4.11. Result for SMS QoS.

Worst SMS Service Qos	Operator / Country	Amount of QoS on error
1	M1 Singapore	552
2	Max mobil Austria	498
3	Kuban Russia	463
4	Eplus Germany	450
5	ERA Poland	349
6	Connect Austria	299
7	Orange UK	284
8	D1 Germany	270
9	Radiolinja Finland	268

SMS Service QoS report is calculated by the statistic of Successful and SMS attempt as shown from Figure 4.13 to Figure 4.14. The ARTs show ten worst cases of SMS QoS shown in Figure 4.15 separated by each operator. If the value of QoS equal to 1000, it means that the QoS of SMS service is worst. That meant subscriber can send/receive SMS as they want to. If the value of QoS Present in the report mean, there is an error cause which represents the customers do not send/receive SMS in short period of time in each operator.

Reports from Schedule Test & Monitoring

The major types of reports that can be generated are:

(1) Quality of Service (i.e. Total error volume divided by total volume)

(2) Network availability (i.e. Total error volume divided by total volume)

(3) Service availability (i.e. Uptime divided by uptime plus downtime)

These can obviously be broken down into less general, more useful reports

Daily Data

Network Quality of Service

ARTs provide Volume and Error Volume measurement data from each measurement interval. This information can be used to provide details of the Quality of Service being offered by particular networks by country, best performing networks and worst performing networks.

The data provided includes information about the particular procedures involved. This information can be used to provide high-level detail concerning how the service being provided by the network is being affected and when.

Data aggregated over a day will provide information that will allow the following types of reports to be produced:

(1) Worst performing foreign network for roaming subscribers.

(2) Calculated using highest error rate for particular date in the "to Home" direction.

(3) Reports based on country, error category (type of problem) or top 10 worst performing.

(4) Best performing foreign network for roaming subscribers.

(5) Calculated using lowest error rate for a particular date in the "to Home" direction.

(6) Reports based on country or top 10.

(7) Quality of service being provided by home network to foreign subscribers.

(8) Calculated in the "from Home" direction.

(9) Reports based on highest error rate.

(10) High Transaction Volume Network QoS.

(11) The volume for a particular network may be calculated and used to determine the networks with the highest transaction volume, in both directions, for a particular day. The associated QoS may be calculated and Displayed.

Network Availability

Within a GSM network it can be assumed that if there are no MAP messages being exchanged between networks then there is either connectivity problem or the amount of traffic exchanged between the two networks is low.

Reporting on the low volume networks is a lower priority whereas interconnectivity issues with higher volume networks can have a major effect on customer satisfaction and thus revenue. If an interconnectivity problem exists for an extended period, customers will become unhappy as it not only will they not be able to receive calls but they also will not be able to make calls either.

Uptime and downtime is therefore recorded in the aggregation tables. Reports such as the following can therefore be generated.

(1) Interconnectivity between HPLMN and VPLMNs.

(2) For all networks with total MAP volumes above a certain level to and from home.

(3) For worst 10 networks with total MAP volumes above a certain level to and from home.

Weekly Reports

Weekly reports highlight issues of high importance that may occur only once. However, the focus of weekly reports is to provide a short-term trend analysis of network performance. The weekly extended aggregation data is extrapolated from the daily aggregation data allowing reports generated from this information to provide a more concise, longer-term view of network performance.

Network Performance

As stated, the focus of the weekly reports is to provide longer-term trend analysis of the data to highlight reoccurring issues that affect the service provided to the customer. The data used to provide daily reports for the Quality of Service being provided by other networks to subscribers and to foreign subscribers can be used to provide a weekly quality report for selected networks. The focus of this may be to review the performance of the larger roaming partners where the majority of subscribers are roaming, or simply a network under investigation.

By using the weekly report data, Quality of Service reports may be produced for a particular network. The data can be broken down into reports such as:

(1) Problems per Error Category.

(2) Problems per Country.

(3) Problems per specific networks.

Network Quality of Service

The daily extended aggregation information used to provide daily network quality of service reports is aggregated again to provide a weekly view of the overall service provided as follows:

(1) By network to foreign subscribers.

(2) By the foreign networks to roaming subscribers.

Network Volume

A report that indicates the volume of traffic to and from a particular network can be produced daily or weekly. This can be particularly useful when tracking changes in SMS traffic through a network. A substantial increase from one week to the next could indicate fraudulent activity.

Monthly Reports

Monthly reports allow the long-term trends of the network to be established. This can be particularly useful when dealing with peak periods of the year when the network traffic is at its highest level.

The level of service being provided can be compared between months to not only establish if the performance of your own network is being improved but also the performance of your roaming partners networks. Transaction volumes over an extended period of a month can indicate if there is a major change in the networks being used by the roamers abroad or how many foreign roamers are using the network.

Network Quality of Service

The weekly report information used to provide weekly network quality of service reports is aggregated again to provide a monthly view of the overall service being provided as follows:

(1) By network to foreign subscribers.

(2) By the foreign networks to roaming subscribers.

Monthly "Network Quality of Service" reports can be produced, similar to the daily and weekly reports.

Network Volume

A report that indicates the volume of traffic to and from a particular network can be produced daily, weekly or monthly.

Detecting Problems with ARTs

ARTs give immediate indication of the following problems:

(1) Roamers registration problems.

(2) Authentication failures associated with groups of subscribers roaming in remote networks or "foreign" subscribers roaming in the home network.

(3) Properly registered roaming subscribers unable to received mobile terminated calls.

(4) Major connectivity failures, probably due to incorrect routing, between home network and external networks.

(5) Handoff failures between home network and neighbouring networks.

ARTs monitors the success and failure of all Send Authentication Request, and Location Update requests exchanged between operator's network and its external roaming partners. ARTs measures Vol, Error Vol, Error Rate, Absence, and Avg, Trans Length (ms). These measures are grouped by procedure direction (originating or terminating in the home network) and external network. ARTs measurement (Test) resolution is typically set to 5-min, this serves to smooth out measurement spikes, and provides an accurate basis on which to make accurate operational decisions.

ARTs builds data collected across network interconnects between operator's network and all its external wireless partners. The success and failure of these transactions are measured and reported to the user via the alarm function of ARTs in Figure 4.16.

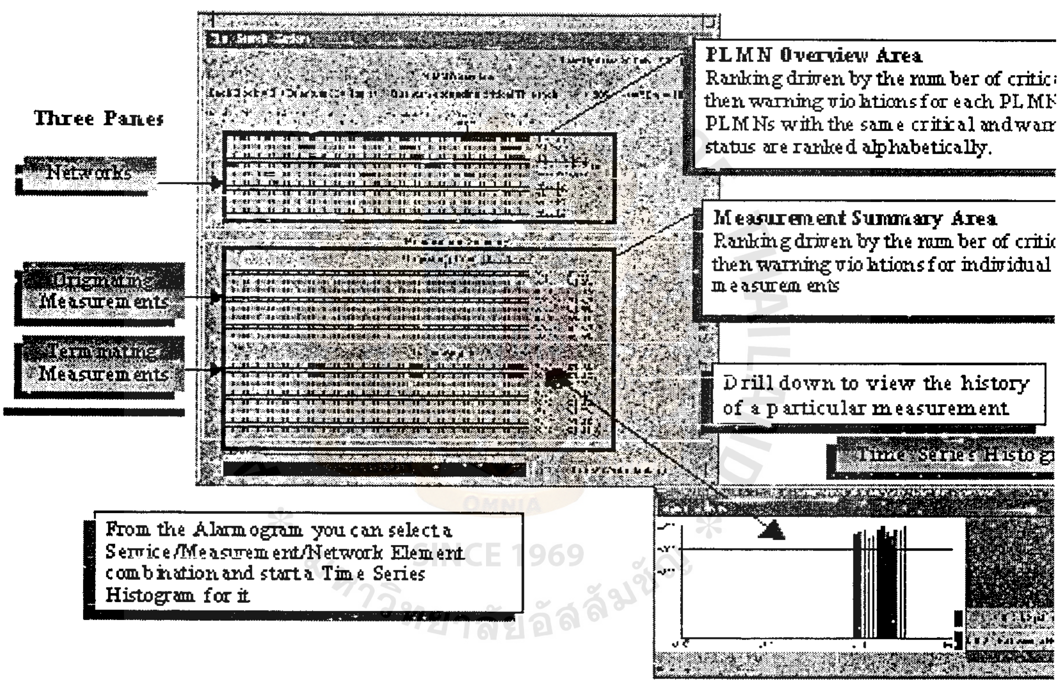


Figure 4.16. Drill Down Problem of the ARTs.

PLMN operator has used ARTs to identify a problem area associated with calls from one of your roaming partners. Now it needs more detailed information to pinpoint the problem, enabling you to fix the problem in the fastest time possible. real-time and will capture, view and decode all of the signaling messages on the links between your network and roaming partner's network. PA allows it to focus on specific types of messages identified by ARTs.

ARTs monitor the success and failure of all Location Update procedures, and key user authentication procedures, which flow between operator's network and other national and international wireless operators. Measurement results are grouped and stored by origination direction, and network. This allows accurate reporting of a registration problem to a specific network, and in some cases network element.

Both Inbound and Outbound Roaming QoS.

With ARTs it is possible to ascertain the QoS being received by both inbound and outbound roamers. Many time Operators have visibility on inbound roamers only. They do not have much visibility on the QoS being received by their own customers abroad. This is generally where Operators get exposed. In today's, mobile network, problems can occur for any number of reasons without the control of the home network. However, subscribers tend to blame the people to whom they pay the bill. RMS is able to provide the Volume, source, destination and QoS for even SMS also.

Entire Network Coverage

ARTs monitors all the transactions between AIS Gateway to International partners by just monitoring the CCS7 link carrying MAP traffic. With this we can have the visibility on entire roaming operation in AIS Network. There is no need to have any infrastructure at any of the BTS, BSC, and MSC sites.

4.2 Performance Evaluations

Operation Benefits

Reference to our using experience, ARTS system is a unique solution helping the mobile network operator to maintain not only the quality of services of international roaming but also national and local mobile service. The main advantages that need to be expanded the Automatic Roaming Test system are:

Time Saving:

Testing in GSM environment is time and labor intensive task. The ART System ables to perform repetitive tasks automatically, save the stuff and operation time drastically.

Money Saving:

The test of roaming (international, national and local) and the GSM functions helps to discover system weaknesses. Thus, the lost of revenue resulting out of network low performance can be discovered fast and accurate then the corrective measures can be implemented in time.

Saving of Manpower:

The alternative to automatic QoS testing is the manual test. The following alternative compares both methods in terms of time for testing of IREG24 (See Appendix IR24) for example of 50 roaming partners

Remarks: (IREG24 (See Appendix IR24) specifies 20 test cases for each roaming partner)

Manpower for manually testing of IREG24 (See Appendix IR24)

(1)	Time consume per test case (average 5 min)	=	100 min
(2)	Reports (5 min per report)	=	100 min
(3)	Man power per each roaming partner	=	200 min
(4)	Man power for complete entire IREG24 test	=	10,000 min =167 hrs

Manpower for ART System testing of IREG24

(1)	Create test campaign	=	2 min
(2)	Insertion test campaign	=	2 min
(3)	Definition of IREG report	=	2 min
(4)	Manual completion of report	=	15 min

(5) Man power per Roaming Partner = 21 min

(6) Man power for entire IREG24 = 1,050 min= 17.5 hrs

The presented calculation is to understand as estimation only. The real time requirement may be different from this, but the level of time saving will be significant. Saving time means potential for quality increase.

Generate of Standard Reports:

Every mobile operator (being the member of MoU IREG group) is obliged to report the Quality of Service figures of their network. The ART System now IR department applies their function to generate the standard test report for signaling availability that we can improve the QoS of our IR services.

Comparable Results:

The automatic testing allows the user to execute tests regularly (repeatable). The obtained results show the development of overall network quality in a very impressive way. The user is able to plan the network development in sense of proactive instead of reactive task. In IRIT, we apply to monitor international links, which are connected to CAT. The standard results show that it does not have enough capacity to maintain the huge amount of traffic so they should be expand the capacity of link that now make consideration phase.

Business Benefits

Helping to Safeguard Most Valuable Asset – International Roamers

ARTs helps Mobile Operator maintain the high level of service expected by international roamers. It provides an extensive range of monitoring tools that continuously examine the international roaming services and provide real time status information. This lets you take pro-active steps to rectify problems, plan strategically and maximize your network revenues.

The Intelligent Way to Look after Roamer Customers

GSM operators value their business customers. This small subset of users makes extensive use of mobile phones in whatever part of the world they happen to be, and depend on other high value services such as voicemail and short message services. With international services contributing from 20% to 30% of operator revenues, business customers generate a significant proportion of the network profit. They are people to be cherished at all costs.

In their turn, business users expect excellent service. They depend on adequate capacity, reliability and good supplementary services, moving immediately to another network if this is not forthcoming. The weekly loss of revenue resulting from this instant churn has been conservatively estimated at many hundreds of thousands of revenues.

Better Strategic Planning

ARTs provide Mobile Operator with comprehensive, robust and accurate information to support their roaming customers. Trend analysis of long-term statistics in service behavior helps you to make informed decisions on network planning and negotiate Service Level Agreements (SLA).

Improved Quality of Service

ARTs lets mobile operator create international roaming profiles of customers as well as visitors to network. By targeting marketing more effectively one can make substantial cost savings. Profiles also enable one to work with preferred international operators, basing roaming agreements upon sustained performance or shareholder requirements. Preferential tariffing could also be negotiated for roaming customers.

Greater Network Security

Instances of SMS (Short Message Service) waves have caused enormous disruption to customers, damaging the reputation of the operators affected. ARTs can detect any sudden unexpected upsurge in SMS activity and pinpoint its source.

Faster Fault Detection

ARTs is intuitive and easy-to-use, helping to boost testing engineer productivity and reduce training costs. It cuts down the time taken to identify and fix problems, both within and outside the control of the home provider. For example, a simple typographical error made during an update to the routing tables could cause complete loss of connectivity. ARTs identifies and locates faults like these as soon as they occur - and before subscribers are aware of them.

Improved Service Management

ARTs trouble-shooting capability is backed up by a 24-hour view of the overall service performance (Optional 7 days view). This is presented in an easy-to-read ordered display that highlights potential problems as well as monitoring the level of service provided by interconnect carriers.

In Summary, ARTs Helps Mobile Operator to:

(1) Increase roaming service availability.

(2) Improve end to end service quality.

(3) Detect and resolve problems quickly.

(4) Maintain high levels of customer satisfaction.

(5) Reduce roamer churn rates.

(6) Improve strategic planning.

Overall Enhancement of QoS

Details from Figure 4.2 to Figure 4.15 can conclude that there are 2 kinds of reports. First, Statistic reports used to prioritize the essential of each partner operators that we have to take action immediately when the ARTs show the error. The report in Figure 4.2 shows the operator priority of roaming in (other operators use our network) per operator, which means subscriber of Vodafone (UK) mostly use our network that is the first priority operator. EPLUS Mobifunk is the second priority, which we have to closely take care and maintain the highest quality of service. Figure 4.3 shows the operator priority of roaming out (our subscriber use other operator network) per operator, which means our subscribers mostly use Bouyoues Telecom which is the first priority operator. P&T LuxGSM is the second priority operator. Actually, we set the ARTs monitor all operators that generate the statistic report that indicate the top ten priority operators. Moreover, ARTs monitor the errors that correspond to each statistic report and store in the database for further calculation in QoS. Second, QoS reports are used to determine the performance of each partner operator. Additionally, QoS reports are related with statistic report by tracing down the cause of error that is stored in the statistic database. We separate the QoS report base on criteria that we have set in chapter 3 as detailed below.

Network QoS Report

Base on Location Update procedure

Base on Request Authentication procedure

Service QoS report

Base on Successful Call

Base on Provide Roaming Number

SMS Service QoS report

For more details, when we see the top ten priority operators from statistic report as mentioned earlier, the ARTs monitor the performance of each partner operator then calculated in terms of QoS value. For instance, we can see that the Figure 4.6 which is network QoS report based on Location Update operation. The report shows ERA Poland has the worst quality of network access because there are most errors for making location update operation (688 times in test period time) but fortunately in the Statistic report ERA Poland is not in the top ten prioritized operator list. That means, it is not the major critique that impacts on the overall QoS of network access. QoS of network access show ten worst QoS. We have to urgently resolve those ten worst QoS that rely on location update operation by looking at the cause of error in statistic report in Figure 4.7 so we can easily pin point and solve the problem. Another scenario is QoS Service access. Form Figure 4.10 roaming out QoS report, we see that D2 Mannesmann Germany is the worst Service access QoS value which relies on successful call operation. This is the major critique that directly impact to overall Quality of IR service because D2 Mannesmann Germany is presented in the Top Ten priority operator list in the Roaming Out statistic report as shown in Figure 4.3. D2 Mannesmann Germany is the 7^{th} most prioritized operator. We need to overcome the problem immediately by looking at Figure 4.9 Call statistic report by tracing down what is the error causing D2 Mannesmann Germany to cannot complete call. Circuit group congestion (700 times) due to network title cause D2 Mannesmann Germany cannot complete call. So we solve it by contacting the partner operator to setup secondary circuit to support those call capacity. The rest of QoS reports use the similar way to maintain the Quality of IR service corresponds in each operation. All earlier scenarios represent how we enhance the quality of IR service by deploying Automatic Roaming Test System to test monitor and generate those kind of reports which IR department never had before.

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

As we have analyzed and selected the improvement opportunity to improve an international roaming service quality and come up with the selected solution to improve the way to detect the problem before customer complaints that improves the testing process by using an Automatic Roaming Test system instead of using manpower. With periodic re-testing we can know only the problem that happened during the test. If the problem occurred for a while and has gone, we will not know. It means that we could not get the whole picture of the quality of the service using a customer complaint and periodic testing by humans. We can know only the problem that we can detect and been informed by operator partners. It means only the fault report or corrective maintenance report. It can not provide the picture of QoS. An Automatic Roaming Test System, ARTS, does the test instead of humans. As we have compared the performance of human testing for 50 operators, the test will be done in 167 hours, or about 7 days without eating and sleeping but ARTS use only 17.5 hours or within a day. This performance is just the comparison. It does not happen in the real work condition with human because no human can work 24 hours continuously for 7 days and continuously working. It is only a system can do that instead. Then only ARTS can complete the task. From the previous chapter "Roaming service quality enhancement after implementation of Automatic Roaming Test System," we can observe that this new system is much more powerful and beneficial in terms of preventive maintenance for enhancing quality of the international roaming service than the old process of periodic re-testing and also the key to measure the QoS of roaming services in three main criteria according to ITU recommendation that is Network Accessibility, Service Accessibility and Services Retainability.

For Network Accessibility, the system provides percentage of successful and unsuccessful Authentication and Location Update for both inbound and outbound roamer. This can show the number of roaming subscribers on both sides trying to access each other. It shows the outstanding network and operator that is the most effective network access and least effective network access. Then we can have the picture of the quality of network access for each partner operator. The most unsuccessful network access have to be analyzed how it happened. Then, we know what is the cause of the problem and correct it. Network Accessibility is the gateway for the customer to access the service. If customer can not access the network, it is not possible to get any service. Then, it is the most potential criteria for quality of services that we have to consider to be improved first.

After the customer can access the network, it means ready to use the service. Services Accessibility is the second potential of quality of service criteria that is beneficial for operator to measure and improve. ARTS can monitor the percentage of successful and unsuccessful incoming calls and SMS services that are two key points that we can monitor the service when our outbound customer is roaming.

The system can also provide the measurement of Service Retainability for inbound roamer. After customer can access network and service, they want to use the services and as long as they want without interruption. Service retainability is the measurement of the failure of the services without customer intension. If we can eliminate this problem, the customer will be fully satisfied with the services. It means the quality of service have been improved.

Moreover, the statistic report can also be used to analyze the operator quality of services for each operator and correct it as a history then it can be used to do trend analysis in the future.

At this point, without ARTS we will have no total report of the periodic retesting and no measurement of quality of services criteria to analyze the total of quality of international roaming report.

Then, an implementation of an Automatic Roaming Test System is the tool to measure quality of international roaming services. Without measurement tools we do not know the baseline of quality of existing services. Without the baseline we do not know the improvement. Then ARTs is the tool that initiate the quality improvement cycle. However, it is only the first cycle. The outcome of the first cycle is quality baseline. We have to move on the quality improvement cycle by doing an analysis of the baseline results by beginning the improvement cycle with the step 1 "select and improvement opportunities" and move on until finished planning phase. At step4 we will get the improvement solution and plan at step 4 and keep moving on until finish the cycle. At the second cycle we will see the improvement gaps and the effectiveness of the ARTs to improve quality of international roaming services. An intangible benefit of the project will show up

In conclusion, ARTS is the step measuring the existing quality of services in three criteria Network Accessibility, Services Accessibility and Services Retainability. It is used to show actual quality of service for international roaming service and using it as the baseline to improve the total quality of roaming services in the future.

5.2 Recommendations

From the improvement of the Quality of an International Roaming Services after implementing an Automatic Roaming Test System, it shows the steps of clarifying quality of the services by doing preventive maintenance and monitoring. It is very beneficial for an GSM operator to know what is their quality of services and the network. Normally, every network and operator have their own Operation and

Maintenance Center (OMC) taking care of preventive and corrective maintenance including quality statistic and standard. However, an international roaming service is quite special because their own subscribers use the services of outside network. The services usage and application is fully controlled by visiting operator including quality of services. However, the responsibility of service availability and quality are fully responded by home network.

It is quite difficult for GSM operator to control quality of this service as the nature of the services is. Initially, when the GSM Association designed this international roaming service, it means to jump out beyond the barrier of cellular phone roaming within the network. The concept is mobile phone is not fixed in the place as the fixed line, why does it have to be fixed in the network? At that time, an engineer succeeded designing GSM network with an international roaming capability. However, they left the responsibility of taking care of the subscriber when roaming with the visiting network without thinking of the barrier to control quality of the service when roaming by home network. At the beginning, it works because there are not many subscribers using international roaming service. The subscribers are not familiar using the services of outside network and the price is very expensive. Low quality of service at the beginning become acceptable or quality mean is beyond customer expectation.

At this time, the services become popular. Overall GSM customers use it as usual and the growth rate of GSM subscriber over the world is magnificent. Then quality of international roaming service become significant. To be the leader in this market, Customer satisfaction is the key to success. Quality of service of an international roaming service is the outstanding topic among the GSM operators.

Automatic Roaming Test tools is the key to measure the overall quality of services for home network monitoring their subscriber using the service outside network

(Outbound roamer) and overall roaming subscriber in side the network (Inbound Roamer) as it has been shown in this project. However, as the phase of developing an quality improvement, we begin with three quality criteria according to ITU standard and recommendation, Network Accessibility, Service Accessibility and Service Retainability. The first priority among those criteria that we have to consider is Network Accessibility because without network access the subscriber can not access any services.

To use the Automatic Roaming Test System is the beginning step of improving the quality of service of an international roaming service. Without the system, we can just set up the roaming operation team to support customer when the problem occurs even if the problem is minor, major or critical problem. The team has to stand by for the complaint from the customer and the operator then doing the corrective maintenance and fix it as soon as possible. However, roaming customers can not wait for any minute. This process means customer dissatisfaction and no quality of services because the customer will be always dissatisfied.

The system is the key measurement of quality of services. The first cycle of measurement we get the baseline of existing quality of service level. Then we have to collect all the data and analyze following the quality improvement model by selecting improvement opportunities, analyze current situation, identify root causes, select and plan solution, implement pilot solution, monitor result and evaluation, standardize and periodic re-evaluation. For example, from the results of network accessibility we see that the accessibility of our outbound subscriber roaming into D1/Germany was low for trying to do the location update and the statistic show that D1/Germany is in the list of the top ten operator that has high value of our customer. We can select this event as the improvement opportunity. Then we have to analyze the current situation of the problem how critical they are. Then we have to analyze the problem in the step of identify root causes to find out the actual cause of the problem. Then we can plan the solution to correct the problem. This problem may and may not be the problem in our network. If it is the problem in our network, we have to fix it and monitor the result. If it is not the problem in our network we have to plan to negotiate with D1/Germany to correct the problem by sharing the situation and actual problem.

Now we can see that the cycle of improvement is running again and again until each of the criteria is saturated. Then we come to the point of limitation of quality improvement for all those criteria. We may have to find out the new quality criteria for international roaming service.

Without an initiation of implementation of the Automatic Roaming Test System, the cycle or quality improvement can not be run. It is the starting point of improving quality of an international roaming service for any operator that would like to be leader in this market.

From the recommendation, we can see that the Automatic Roaming Test system is very useful. The operator can develop or expand for more services quality criteria to enhance the quality of an international roaming services. Then all benefits will be with the operator.

APPENDIX A

GSM ASSOCIATION PERMANENT REFERENCE DOCUMENT

PRD IR.23

GSM

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Title	**Organisation of GSM International Roaming Tests**
Version	**3.4.1**
Date	**18 February 1999**

GSM Association Classifications

Binding

Security Classification Category:	
Unrestricted - Industry	X
Information Category	Roaming - Technical

Reference

Document History

Version	Date	Brief Description
3.4.1	17 February 1999	CR#5 Additional Annex for SCCP testing. Approved at Plenary 41
3.5.0	17.02.99	Additional Annex for SCCP testing
Changes Since Last Version		

Table of Contents

1. GENERAL DESCRIPTION

1.1 Scope

The scope of this document is to define a methodology for testing, and maintaining in the presence of faults, the inter-PLMN international roaming facility. The structure for testing international roaming with MAP version 1 is recommended to follow a four step approach:

(1) Stage 1 - MAP interface self certification testing.

(2) Stage 2 - SCCP protocol testing.

(3) Stage 3 - Exchange of numbering and addressing data, procedures for operation and maintenance, fault reporting, etc.

(4) Stage 4 - End-to-end functionality / capability performance testing.

Detailed description of stage 2 is provided in annex at the end of this document Detailed description of stage 4 tests is provided in the IR.24 document. The purpose of breaking down the testing into Stages is that Stage 1 requires to be done once only for each type and manufacturer of Network Entity: it can therefore be a very complex and thorough test. Stage 4 must be repeated with each PLMN. It must therefore be a high level functional test stage, and hence be able to be completed in a few man hours.

In each of the following sections (section 2 to section 5) the different stages will be described with respect to their general contents, their applicability and their evolution to cope with new features of higher MAP versions.

Section 6 gives a summary of Stages and Responsibilities for international roaming tests. Requirements for re-testing are described in section 7 below.

1.2 Document History

Draft Issue:	ER.D for IREG discussions	May 91 to May 92
IR.23, Issue 3.00.00 :	Approved at MoU 20	3rd June 1992
IR.23, Issue 3.01.00 :	Includes CR.1	29th October 1993
IR.23, Issue 3.02.00 :	Includes CR.2	1 September 1994
IR.23, Issue 3.03.00 :	Includes CR.3	10 September 1995
IR.23, Issue 3.04.00 :	Includes CR.4	23 April 1996
IR.23, Issue 3.05.00 :	Includes CR.5	18 February 1999

1.3 Abbreviations

The following abbreviations are used:

(1) ISDN ("Integrated Services Digital Network");

(2) PLMN ("Public Land Mobile Network");

(3) VPLMN ("Visited PLMN");

(4) MTP ("Message Transfer Part"), a C7 protocol layer;

(5) I-STP ("International Signaling Transfer Point"), a MTP entity;

(6) N-STP ("National Signaling Transfer Point"), a MTP entity;

(7) MRVT ("MTP Route Verification Test"), defined in CCITT Q.753;

(8) SCCP ("Signaling Connection Control Part"), a C7 protocol layer;

(9) IGP ("International Gateway Point"), a SCCP entity;

(10) SRVT ("SCCP Route Verification Test"), defined in CCITT Q.753;

(11) ISUP ("ISDN User Part"), a C7 protocol layer;

(12) ISC ("International Switching Center"), an ISUP entity;

(13) MAP ("Mobile Application Part"), a C7 protocol layer;

(14) HLR ("Home Location Register"), a MAP entity;

(15) VMSC ("Visited Mobile services Switching Center"), including the always co-located entities MSC ("Mobile services Switching Center") and VLR ("Visitor Location Register");

(16) GMSC ("Gateway Mobile services Switching Center");

(17) MS ("Mobile Station").

2. Stage 1

A PLMN operator achieves self-certification of the MAP interface by one of the following methods:

(1) Conformance testing, according to the International Standard ISO DIS 9646. It is recommended to use the test cases described in CO.34.

(2) Acceptance testing, assuming that PLMN operators will have the MAP interface proven as part of their final acceptance tests. Special attention must be payed to the conformance of the MAP-operations necessary for International Roaming.

(3) Compatibility testing between all combinations of different MAP implementations operational in the PLMN.

Stage 1 tests or a subset of tests shall be repeated according to each PLMN specific needs whenever a relevant situation occurs:

(1) New category of Network Entity introduced in the network;

(2) New manufacturer;

(3) Major software upgrade which affects MAP functionality.

3. Stage 2

This stage is intended to cover the SCCP protocol testing in all signaling links involved in the PLMN interconnection excluding those links belonging to the international network and as so already tested by the different fixed network operators. Depending on the PLMN access situation (see PRD IR.22)) those links are established between each PLMN and a SCCP IGP entity, operated by the national PTT operator, the PLMN operator itself, or a national PTT operator in another country.

Stage 2 SCCP protocol tests should be performed according to ETSI EN 301 008 document. The detailed description has been included in an annex at the end of this document. Stage 2 tests or a subset of tests shall be repeated according to each PLMN specific needs whenever a relevant situation occurs.

4. Stage 3

Exchange of numbering and addressing data needs to take place between PLMN-A, ISC-A, PLMN-B, and ISC-B. The international carriers have been operating a STP network between various countries, both inside and outside Europe, for some time now. Their knowledge of signaling routes, capacity contact points etc., is essential. Therefore, they should be brought into negotiations at this stage to ensure that the PLMN's requirements can be met in the most efficient, and reliable manner.

It is anticipated that signaling traffic forecasts will be exchanged between the PLMN and International Operators to ensure sufficient capacity is available on the international routes to accommodate this increased signaling load. The issue of MTP maintenance messages also needs to be addressed - to ensure that a PLMN nodal failure does not cause excessive loading to every signaling connection.

Prior to any roaming taking place between two PLMNs, covering procedures must be established for Operation and Maintenance, for example contact points for fault reporting and notification of planned works. There is also a need to include the local International carriers' contact points. It is noted however that such responsibilities may change from an initial setup phase to the ordinary operational phase.

Exchange of this data will be made in a centralized way under the responsibility of the GSM Association Permanent Secretariat in charge of the maintenance of PRDs and in particular of PRD IR.21, where the relevant information is contained.

The highest version of each MAP application context which is supported in each PLMN on the responding side is indicated in PRD IR.21.

5. Stage 4

PLMNs shall perform end to end functionality tests. This section not only tests the functionality, but more importantly, the customer perception of roaming and its associated facilities.

Reference should be made to CONIG and SMG if unresolved problems are identified: it is mandatory that any test failure or discrepancy, should be clarified against the procedures laid down in the CONIG documentation and GSM standards, i.e. the CONIG output and the ETSI-SMG specifications are considered the base reference documents.

The tests are described in PRD IR.24, PRD IR.26, PRD IR.27. They are split into several parts:

(1) Those related to location update/cancellation and telephony basic service (IR.24).

(2) Those related to barring and call forwarding supplementary services (IR.24).

(3) Those related to SMS MT/PP and SMS MO/PP basic services (IR.24).

(4) Those related to phase 2 supplementary services and ODB (IR.26).

(5) Those related to circuit oriented (fax, asynchronous or synchronous), (audio ex-PLMN or fully digital) data services (IR.27).

Exchange of billing and accounting data can also be performed in conjunction with these tests if required for the testing associated with PRD TD.06.

Stage 4 tests or a subset of tests shall be periodically repeated according to each PLMN specific needs whenever a relevant situation occurs.

Stage 4 tests shall be updated according to the additional needs of each new MAP Version.

6. Summary

Table 1 gives a summary of those stages, and their respective areas of responsibilities, for international roaming tests.

Table 1 - Summary of Stages and Responsibilities

Stage	Activity	Responsibilities
1	MAP interface self-certification testing	PLMN Operator
2	SCCP protocol testing	PLMN-A and IPTT-A or PLMN-A and IPTT-B or PLMN-A and PLMN-B
3	Exchange of numbering and addressing data, procedure for O-M, fault reporting, etc	PLMN-A/IPTT-A/ /PLMN-B/IPTT-B
4	End to end functional/capability performance testing	PLMN-A and PLMN-B

7. Re-Testing

7.1 Fault Management

It is recognized that maintenance actions must be performed as soon as possible when the international roaming service is failing. The responsibility of controlling the reliability of international roaming is shared by the international carriers and the PLMN operators.

Each international carrier shall be requested to monitor the signaling traffic in its own IGP, for example by counting the number of SCCP messages exchanged (emitted, received) with each foreign IGP. The number of SCCP messages exchanged with each national PLMN operator should be counted as well.

Each PLMN operator should monitor the reliability of its own network acting as a VPLMN, and consider that the control of international roaming service to be provided to its HPLMN subscribers is ensured by the partner PLMN operators. VPLMN should take steps to notify HPLMNs of major service effective faults.

MTP and SCCP Route Verification Tests (MRVT, SRVT) as described in CCITT recommendation Q.753 appear to be a good means to detect routing and translation errors in MTP and SCCP. Unfortunately it will take years until both functionalities are available in most networks. Until this time, a possible solution might be to perform all checks manually. As this method surely is time consuming, it should only be used in a limited number of cases (e.g. after occurrence of routing failures). Therefore an agreement between the PLMN and the PSTN carriers will be necessary.

If the international roaming service becomes faulty, and it becomes clear that the error is at the SCCP level of the signaling relation, the affected PLMN maintenance staff shall contact the maintenance staff of the next SCCP International Gateway Point. Depending on the access solution the two PLMNs are using (see IR.22) this means that the maintenance staff of:

(1) the IGP in the corresponding PLMN or;

(2) the IGP of the corresponding fixed network.

and the affected PLMNs maintenance staff will have to make direct contact and will be responsible for the further action.

The affected PLMN maintenance staff shall contact the maintenance staff of the next SCCP IGP, which is responsible to contact the maintenance staff of the next SCCP node. If the error cannot be detected, this method will continue until, at least, the maintenance staff of the partner PLMN is contacted.

If the access solution is in a manner that one or more MTP-STPs are part of the SCCP relation and none of the carriers operating the SCCP nodes is responsible for operation of those STPs, also the maintenance staffs of all STP nodes will be contacted. This will be done by the SCCP IGP node maintenance staff, who contacted its corresponding SCCP IGP node maintenance staff.

7.2 Re-Testing After Network Changes

When operation is in course, it will be necessary to repeat subsets of the tests related with the above indicated stages, if a major upgrading is introduced in one of the two PLMNs. The evaluation of the necessity of test repetitions is the responsibility of the involved VPLMN operator. Examples of cases that can require test repetition are:

(1) Introduction of new mobility services, data services, supplementary services. All the PRD IR.24, IR.26 or IR.27 tests associated to these new services must be performed as soon as possible after the launching of new GSM services provided by the VPLMN operator to its own customers.

(2) Modification of addressing or numbering data.

(3) Change of the national numbering plan in a PLMN country.

(4) Introduction of international STP (I-STP), national STP (N-STP), SCCP International Gateway Point (IGP) whose manufacturer differs from the existing I-STP, N-STP or IGP respectively.

(5) Introduction of MSC or HLR whose manufacturer differs from the existing MSC or HLR respectively.

(6) Introduction of a new software release which involves major changes in a VPLMN or HPLMN node.

The appropriate subsets shall be defined on a case per case basis by the VPLMN operator.

7.3 Periodic Re-Testing

In order to check that international roaming is available continuously after the commercial opening of the service, periodic test repetition, not triggered by any special event, but for regular service control, shall be performed by the VPLMN operator.

The VPLMN operator will set-up and connect calls periodically with test SIMs of each HPLMN, currently located in the VPLMN. This operation has to be performed weekly in each type of MSC used in the VPLMN, twice if two types of HLR are used in the HPLMN. The following test cases will be performed:

(1) IR.24, § 2.1.3 (outgoing call + incoming call): MS_1(a) calls MS_2(a), both ro amed in VPLMN (b).

(2) IR.24, § 2.2.4 or 2.2.5 (call forwarding): call forwarding on not reachable.

However, considering the fact that it is hard and expensive for operators to find a schedule and technical staff to perform these necessary periodical bilateral retesting, PRD IR.29 describes the specifications concerning the minimal test equipment for automatic roaming retesting and test cases in the VPLMN.

The document PRD IR.28 specifies the requirements the HPLMN has to fulfil in order to allow other operators to perform end-to-end functional capability tests.

ANNEX

1. Guidelines for SCCP testing

This annex gives the details of the stage 2 testing as mentioned in chapter 3 stage 2. It is intended to give a common basis for testing of the SCCP functions, which are necessary to route MAP messages to the international partners.

The choice of test cases to be adopted for SCCP compatibility checking between PSTN and PLMN in the national as well as in the international network needs to take into account the following points:

(1) the testing procedure should be simple enough to be carried out in a reasonable time.

(2) tests cases should be available on testing equipment.

The reference document is EN 301 008.

1.1. Pre-test conditions.

It is assumed that the SCCP of PSTN refers to ETS 300 009. For the SCCP of PLMN no assumptions are made

1.2. Test configuration

Optimum results with minimum testing efforts are achieved if a test configuration (Figure. 1) is used. This test configuration depends on the specificity of each operator's SCCP provider (e.g., stand alone SCCP gateway, integrated in one Network Element of the PLMN, etc.) It is recommended is possible to simulate both local and remote SCCP user nodes (e.g, HLR, VLR).The monitors at the interface between the different nodes help to follow the message flows.

If it's not possible to use simulators, most of the test cases may anyway be performed *in situ*.

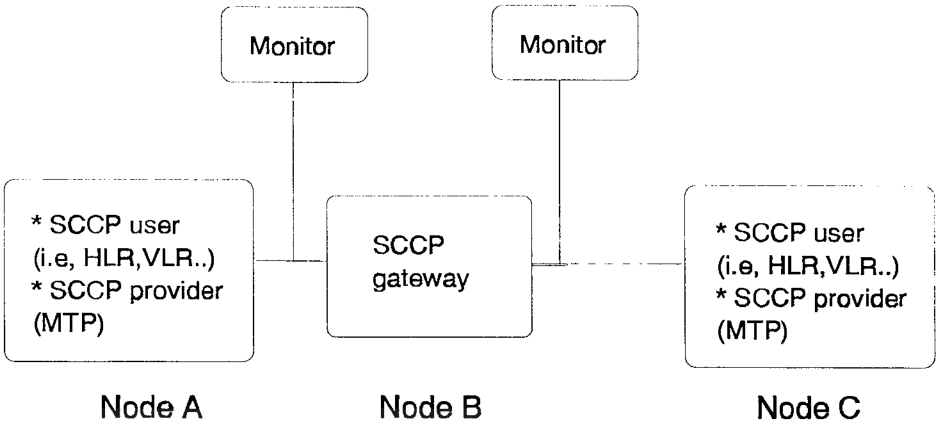


Figure A.1. Example of SCCP Test Configuration.

Node A and Node may be simulated.

2. Test cases

The numbering of tests cases refers to the EN 301 008 document « Integrated Services Digital Network (ISDN); Signaling System n° 7; Signaling Connection Control Part (SCCP); Interoperability test specification ».

The test 7 concerning segmentation (XUDT) needs SCCP White book additional features and is for further study.

Test number 1

(1) Title : GT translation

(2) Subtitle : Correct operation of signaling route

(3) Purpose : To verify correct Global Title translation and a correctly functioning signaling route exists between nodes under test

(4) Pre-test Conditions :

(a) Arrange the generation of a UDT message from Node A to Node B with :SCCP address information :

GT ; route on GT (routing indicator = 0)

(b) Arrange the SCCP routing control data at Node B as follows :

GT translated to DPC of Node C.

5) Expected message sequence:

Node A	Node B	Node C
UDT ⟶	UDT ⟶	

Test number 2

(1) Title : GT translation

(2) Subtitle : Updating of translation table status based on information of SCCP temporary unavailability and subsequent availability

(3) Purpose : To verify correct GT translation, message return and SCCP management functionality following temporary SCCP unavailability

(4) Pre-test Conditions :

(a) Arrange the generation of a UDT message from Node A to Node B with :

(i) SCCP address information :

(ii) GT ;

(iii) route on GT (routing indicator = 0) ;

(b) return on error option set

(i) Arrange the SCCP routing control data at Node B as follows :

(c) GT translated to DPC of Node C.

(i) Expected message sequence:

Node A Node B Node C

UDT ⟶

UDT ⟶

at this point, arrange that SCCP at node

C becomes temporarily unavailable

UDT ⟶

UDT ⟶

⟵ - - - - - - - - MTP UPU

timer stat.info started (on receipt of MTP UPU)

UDT ⟶

⟵ UDTS

timer stat.info expires

SST ⟶ SSN= 1

timer stat.info restarted (on sending SST)

UDT ⟶

⟵ - - - - - - - - MTP UPU

⟵ UDTS

timer stat.info expires at this point, arrange that

SCCP at node C becomes available

again

SST ⟶ SSN= 1

timer stat.info restarted (on sending SST)

SSN= 1 ← SSA

timer stat.info restarted (on sending SST)

UDT →

UDT →

Test number 3

a) Title : GT translation

b) Subtitle : GT translated to remote but inaccessible DPC and/or unavailable SSN/SCCP (return on error option not set)

c) Purpose : To verify that UDTS is not returned when the GT translates to an inaccessible DPC and/or unavailable SSN/SCCP and the return on error option is not set

d) Pre-test Conditions :

- Arrange the generation of a UDT message from Node A to Node B with :
  - SCCP address information :
  - GT ;
  - route on GT (routing indicator = 0) ;
  - return on error option not set
- Arrange the SCCP routing control data at Node B as follows :
  - GT translated to DPC of Node C.
  - new or same SSN
- DPC inaccessible and/or SSN and/or SCCP of Node C unavailable

e) Expected message sequence:

Node A Node B Node C

UDT ⟶

<u>Test number 4</u>

a) Title : GT translation

b) Subtitle : GT translated to remote but inaccessible DPC and/or unavailable SSN/SCCP (return on error option set)

c) Purpose : To verify that UDTS is not returned when the GT translates to an inaccessible DPC and/or unavailable SSN/SCCP and the return on error option is set

d) Pre-test Conditions :

   * Arrange the generation of a UDT message from Node A to Node B with :

     - SCCP address information :

     - GT ;

     - route on GT (routing indicator = 0) ;

     - return on error option set

   * Arrange the SCCP routing control data at Node B as follows :

     - GT translated to DPC of Node C.

     - new or same SSN

   * DPC inaccessible and/or SSN and/or SCCP of Node C unavailable

e) Expected message sequence:

Node A   Node B   Node C

UDT ——————→

←—————— UDTS

UDTS Return Cause: 05 « network failure » if Node C not accessible

03 « subsystem failure » if SSN not available

11 « SCCP failure » if not SCCP available

<u>Test number 5</u>

a) Title : GT translation

b) Subtitle : Message contains GT for which no translation table can be selected in Node B (Return on error option set)

c) Purpose : To verify that UDTS is returned when the GT is of a type that cannot be translated and the return on error option is set

d) Pre-test Conditions :

* Arrange the generation of a UDT message from Node A to Node B with :

- SCCP address information :

- GT ;

- route on GT (routing indicator = 0) ;

- return on error option set

* Arrange the SCCP routing control data at Node B as follows :

No translator table is selectable for the received GT from Node A. Global Title is valid but some inputs are not selectable by the translator table of the Node B (c.g., Translation Type, Numbering Plan, nature od address Indicator)

e) Expected message sequence:

Node A Node B Node C

UDT ——————>

<—————— UDTS (Return cause = 0 « no translation for an address

of such nature »

Test number 6

a) Title : GT translation

b) Subtitle : Message contains GT Address Information which does not exist in the selected translation table of in Node B (Return on error option set)

c) Purpose : To verify that UDTS is returned when unknown GT Address digits are received and the return on error option is set

d) Pre-test Conditions :

* Arrange the generation of a UDT message from Node A to Node B with :

- SCCP address information :

- GT ;

- route on GT (routing indicator = 0) ;

- return on error option set

*	Arrange the SCCP routing control data at Node B as follows :

*	No Global Title translation for specific address.

e)	Expected message sequence:

Node A			Node B			Node C

UDT ——————>

<—————— UDTS (Return cause = 0 « no translation this specific address «)

PRD IR.24

GSM

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Title **End-to-End Functional Capability Specification for Inter-PLMN Roaming (Stage 4 Testing).**

Version **3.6.1**

Date **4 November 1998**

GSM Association Classifications

Binding

Security Classification Category:	
Unrestricted - Industry	X
Information Category	Roaming - Technical

Document History

Version	Date	Brief Description

Changes Since Last Version

Table of Contents

The Scope of this issue of the document extends to GSM Association Phase 1 services only.

1.2. Abbreviations

The following abbreviations are used:

(1) PLMN ("Public Land Mobile Network") including RSS ("Radio Sub-System") and NSS ("Network Sub-System"). PLMN (a) indicates the "a_{th}" PLMN.

(2) VPLMN ("Visited PLMN").

(3) HPLMN ("Home PLMN").

(4) HLR ("Home Location Register").

(5) VMSC ("Visited Mobile Services Switching Centre"), including the always co-located entities MSC ("Mobile Services Switching Centre") and VLR ("Visitor Location Register").

(6) GMSC ("Gateway Mobile Services Switching Centre").

(7) MS ("Mobile Station"). MS (b) indicates that the MS subscription is managed by PLMN(b).

(8) PSTN telephone (b) indicates a PSTN telephone in the country which contains PLMN (b).

(9) DN ("Directory Number").

The terms "visitor" and "roaming" are equivalent through the document.

1.3. Objective of Tests

The fundamental objective of this testing is to confirm the capability, and sample the quality of service which GSM users will receive when roaming from their Home PLMN (a) to PLMN (b). Consequently the tests are restricted to top-level capability testing. There is no provocative or inopportune behaviour testing: this type of testing forms part of the Stage 1 testing [see IREG PRD IR23].

Because the testing is at a top-level, its scope includes checking the correct working of user features and any network features required by the HPLMN (e.g. Barring). The scope also includes the confirmation of acceptable quality of transmission, absence of echo and call set-up delay.

The overall objective of the tests is to confirm that the functions and features, which are already known to operate correctly within each separate PLMN, will also operate correctly for Inter-PLMN roaming.

When there is no difference in a PLMN's operation between Home and Visiting MSs, then there is no requirement to confirm successful operation during Stage 4 testing. An example of this is "handover". In addition where a feature involves only the Gateway MSC and HLR, (both located in the HPLMN), then there is no requirement to test during Stage 4.

The specific objectives are to prove that:-

(1) "Location updating" and the associated "Inserting of Subscriber data" can be successfully completed for MS (a) roaming to PLMN (b). In addition, that the "cancel location" service operates correctly.

(2) Incoming speech calls to MS (a) can be handled by:

    (i) HPLMN (a) asking for Roaming Number from VPLMN (b)

    (ii) HPLMN (a) successfully routing the call

    (iii) VPLMN (b) connecting the call

(3) Outgoing speech calls by MS (a) to the VPLMN (b) are handled for:

    (i) Emergency calls

(ii) Calls to VPLMN (b) country (i.e. local calls)

(iii) International calls

(iv) Calls to any other/relevant "Operator Services" on VPLM(b)/PSTN(b)

(4) Supplementary Services can be registered and activated, and their status interrogated by the MS (a).

(5) Specific Supplementary Services can be invoked successfully:

(i) Call Barring : All Outgoing Calls

(ii) Call Barring : Outgoing International Calls

(iii) Call Barring : Outgoing International Calls except to Home Country

(iv) Call Forwarding on Not reachable (Before IMSI detach)

(v) Call Forwarding on Not reachable (After IMSI detach - If Attach/Detach supported by VMSC)

(vi) Call Forwarding on Busy

(vii) Call Forwarding on No Reply

(6) Specific Supplementary Services can be activated by a MS which is roamed.

(7) Barring of Incoming Calls when roamed

(8) Short Message Service is available between Home Country Service Centre and roamed mobile station.

If either the HPLMN or VPLMN contain GSM Network Entities which are supplied by more than one manufacturer, then the test cases should be repeated for each manufacturer. Therefore if HPLMN(a) contains HLR and GMSC from "m" suppliers, and the VPLMN(b) contains VMSC from "n" suppliers, then potentially the tests should be performed m*n times. The actual number of repeats of the test cases is for bilateral agreement between the HPLMN and VPLMN. However if agreement is not straightforward, it is for the HPLMN to decide the scope of the repeating of test cases, because it is ultimately responsible to its customers for the service supported when roaming.

An associated optional objective is to use the Toll Ticketing function of the VMSC to generate a live data file, which is used by the TADIG Stage 3 testing. After transfer to the HPLMN via TADIG processes, the HPLMN may use the information from the test results to validate the details of the Toll tickets, however this is not part of the GSM Association IREG roaming testing.

1.4. Strategy for Testing

In order to maximise the efficiency of testing, the test cases have been drawn up so as to minimise the requirement for simultaneous joint activity by both PLMN (a) and PLMN (b).

Accordingly, the program of testing forms three distinct components.

(1) HPLMN (a) issues pre-programmed SIMs and programmes HLR

(2) PLMN (b) performs tests

(3) PLMN (b) and HPLMN (a) discuss results.

It is recognised that some parts of this specification are of greater priority than others. The test cases concerning the " Basic Service" (Section 2.1) are of greater priority than those for the "Supplementary Services" (Section 2.2).

1.5 Document History

Draft Issues:	For Ad Hoc group discussion	October-December 1991.
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Version 2.00.00 :	Incorporates comments from 27th July 1992.	
	GSM AssociationPlenary June 1992	
Version 2.01.00 :	Incorporates comments from	25th August 1992.
	IREG August 1992	
Version 2.01.01 :	Editorial Corrections	7th September 1992.
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Version 3.02.00 :	Approved MoU 24	
	Includes CRs 5,6,7 and 8	30th June 1993.
Version 3.03.00 :	Approved MoU 25	15th February
	Includes CRs 9 and 10	1994
Version 3.04.00 :	Approved MoU 30	
	Includes CR11	24th March 1995
Version 3.05.00 :	Approved MoU ??	
	Includes CR.12	
Version 3.06.00 :	Approved MoU 40	20th October 1998
	Includes CR.13	

It is anticipated that further updated issues will be made in response to IREG comments and following experience of testing.

It is anticipated that further Issues will be needed to extend the testing beyond GSM phase 1.

2. TEST CASES

The test cases are in three groups:

(1) Basic Service (Mobility Management and Telephony)

(2) Supplementary Services

(3) Short Message Service (Point to point)

The test configuration is shown in Figure 1 below. It is anticipated that it may be necessary to monitor both signalling messages and voice calls on any of the Network Entity interfaces shown in the diagram. However this is not a firm requirement for this test specification.

The results of the test cases shall be recorded in Appendix A.

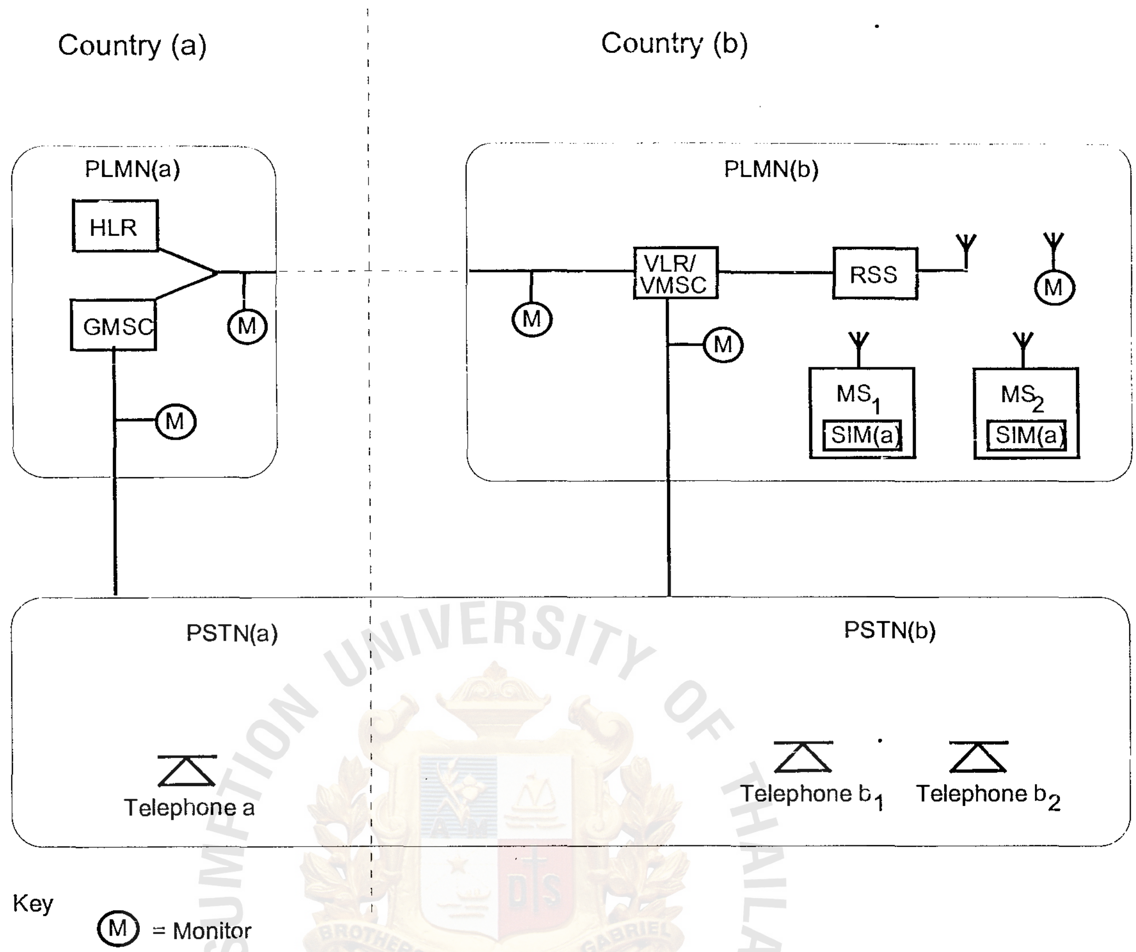

Figure A.2. Test Case Configuration.

To provide valid toll ticketing recording, then both the clock used to note call start and finish times for the test result sheets, and the internal VMSC clock must be checked against each other and set to an accuracy of better than five seconds. Note the VMSC clock must only be altered in conjunction with local operating rules and procedures because all Toll Tickets will be affected by any alteration.

2.1 Basic Service Test Cases

It should be noted that no supplementary services are active during the Testcases which are described in Section 2.1.

2.1.1 Location Update by MS(A) in VPLMN(B)

Preconditions:	MS_1 contains SIM of HPLMN(a) No VLR record exists for MS. HLR record contains basic and supplementary service information.
Action:	Power-up MS_1(a) and perform location registration on VPLMN(b) Check VLR record for the IMSI/MSISDN of MS_1.
Result:	Successful result if VLR record is identical to the pre-testing information supplied by PLMN(a). Unsuccessful result if any of the basic and supplementary services tested by this document or all of the information is missing.
Comments:	This testcase confirms operation of Update Location and Insert Subscriber Data procedures. It checks the support of the relevant MAP operations, TCAP processes and SCCP addressing for both E214 and E164 Global Titles, between the HLR(a) and VMSC(b).

2.1.2 Operator Control of Service

(1) Location Cancellation for MS(a) Subscription held in VPLMN(b).

Preconditions: VLR in VPLMN(b) contains subscription information for MS(a)

Action: HPLMN(a) personnel deletes MS(a) subscription from HLR either using HLR's Man-Machine Interface or via Administrative Data Centre (ADC) input to HLR.

Check VLR for record of MS(a).

Result: Successful result if VLR record for MS (a) has been erased.

Comments: This test case confirms that the "cancel location" procedure operates correctly.

(2) Operator Determined Barring (ODB) for All Outgoing Calls and All Incoming Calls when on Roaming of MS(a)

Preconditions: VLR in VPLMN(b) contains subscription information for MS(a)

Action: HPLMN(a) personnel activates ODB for All Outgoing Calls and All Incoming Calls when on Roaming for MS(a) from HLR either using HLR's Man-Machine Interface or via Administrative Data Centre (ADC) input to HLR.

Check VLR for record of MS(a).

Try to call MS(a) and try to make a call from MS(a).

Result: Successful result if VLR record for MS(a) contains ODB information and non of the call attempts is successful.

Comments: This test case confirms that ODB procedures operate correctly.

2.1.3 MS_1(a) Calls MS_2(a), Both Roamed In VPLMN (b).

Preconditions: MS_1(a) and MS_2(a) have location updated successfully in VPLMN(b).

Action: MS_1(a) establishes call to MS_2(a).

Call answered and held for one minute.

Quality assessed.

Result: Successful result if call is established in 30 seconds, and call is stable in unanswered and answered phases, and there is no perceptible echo to either user, and call remains in intelligible/high quality conversation phase for one minute. See CCITT Rec P.84 Annex D for instructions on use of Quality Scales.

Comments: This test case confirms Mobile Originated and Mobile Terminated call sequences for roamers. It checks the support of the Provide Roaming Number MAP operation between PLMN(a) and PLMN(b). It checks the ability to establish international call between the two PLMNs using roaming numbers. It implies the ability of the PLMNs to disable excessive instances of echo control devices.

2.1.4 PSTN Telephone In Country Containing PLMN(b) Calls MS_1(a), Which Has Roamed To VPLMN(b), But The VLR Has Lost The Record For MS_1(a).

Preconditions:	MS_1(a) does not have a record in VMSC(b) but HLR(a) indicates that MS_1 (a) is roamed to VMSC(b).
	MS_1(a) is active, but has not location updated in (periodic, normal or IMSI attach) since VLR record was removed.
Action:	PSTN telephone(b) calls MS_1(a).
	If call is successfully established, then maintain answered call for one minute. Assess quality.
	If call attempt returns "System Failure" message, then make MS_1(a) perform a location update, and repeat this test case.
Result:	Successful result if either first call-attempt is established, or "System Failure" message is returned within 30 seconds. In addition the answered call, whether establish on the first attempt or after the location update, has no perceptible echo to either user, and that an acceptable quality connection can be maintained. See CCITT Rec P.84 Annex D for instructions on use of Quality Scales.
Comment:	This test case confirms the VLR recovery mechanism, which may use the Send Parameters MAP operation. It also checks that the Gateway MSC (in PLMN(a)) correctly inserts an echo cancellation device, and implies that other instances of echo control devices have been correctly configured.

2.1.5 PSTN Telephone In Country Containing PLMN(B) Calls MS(A), Which Has Roamed To VPLMN(b), But Has Performed IMSI Detach.

Precondition: MS(a) is detached or deregistered in the VLR in VPLMN (b) but VLR(b) contains a record for MS(a)

Action: Check that the subscriber is detached in the VLR, if possible.

Attempt a call from PSTN telephone(b) to MS(a)

Result: Successful result if PSTN telephone(b) receives an announcement that MS(a) cannot be reached or is unavailable.

Comments: This test case confirms that the "absent subscriber" reason is given as the result of a roaming number enquiry to the VLR(b) where the MS(a) has performed an IMSI detach. The detach status of the subscriber should be checked in the VLR, because the switching-off procedure of a Mobile does not guarantee that the subscriber will be detached, because no acknowledgement message is sent from the VLR to the MS. Note that the announcement will be in the language of PLMN(a), as it should be raised at the GMSC(a).

2.1.6 PSTN Telephone In Country Containing PLMN(b) Calls MS(A), Which Has Roamed To VPLMN(b), But Is Not Able To Respond To Paging

Precondition: MS(a) is attached.

Action:	Disable MS(a) so that it is unable to respond to paging [Note MS(a) must not send IMSI Detach message, while being disabled]. Check that the subscriber is attached in the VLR, if possible. Immediately attempt a call from PSTN telephone(b) to MS(a)
Result:	Successful result if PSTN telephone(b) receives an announcement that MS(a) cannot be reached.
Comments:	This test case confirms that the correct response is given when a call is made to a roamed mobile that does not respond to paging. Note that there wiii be some delay before the failure announcement is given while the paging is performed. The announcement will be in the language of PLMN(b).

2.2 Supplementary Service Test Cases

Test cases 2.2.1 to 2.2.8 require that the MS(a) is able to manage its own Supplementary Service registration and activation status.

The Call Forwarding testcases should be performed by using the "+" key.

It should be noted that only those Supplementary services referenced in the "Preconditions" notes are to be active.

2.2.1 Barring of All Outgoing Calls

Preconditions:	HLR entry contains "SS : BAOC : Active".[Set by MS]
Action:	MS(a) attempts Emergency Call [112 keyed on MS]

MS(a) attempts call to PSTN.

Result:	Successful result if call "i" succeeds and call "ii" fails.
Comment:	This test case confirms the support of this Supplementary Service by the VPLMN (b). It also indicates that Emergency Services are available to visitors from HPLM (a).

2.2.2. Barring of Outgoing International Calls

Preconditions:	HLR entry contains "SS : BOIC : Active". [Set by MS]
Action:	MS(a) attempts call to PLMN(b) or PSTN(b) General Operator Service [The call should be made to an Operator Position, which uses a signalling system to obtain the identity of the Calling Party]
	MS(a) attempts outgoing call to Home PLMN Country.
Result:	Successful result if call "i" succeeds and call "ii" fails.
Comment:	This test case confirms the support of this Supplementary Service by the VPLMN(b).
	It also indicates that General Operator Services are available to visitors from HPLMN(a), that any special routing operates successfully, and that any Calling Party information displayed to the operator is appropriately presented.

2.2.3 Barring Of Outgoing International Calls Except To Home PLMN Country

Pre-Check Check if the VPLMN does support the SS:BOICexHC. (YES/NO)

If: YES continue with A.

NO continue with B.

(1) Preconditions: HLR entry contains "SS : BOIC ex HC : Active". [Set by MS]

Action: (i) MS(a) attempts an outgoing call to Home-PSTN-telephone(a).

(ii) MS(a) attempts a call to the country, where the MS is presently located by making use of the international number format.

(iii) MS(a) attempts an international call to any other country than mentioned in (i) or (ii).

Result: Successful result if calls of testcases "i" and "ii" succeeds, and the call of testcase "iii" fails.

(2) Preconditions: HLR entry contains "SS : BOIC exHC : Active".[Set by MS]

Action: (i) MS(a) attempts a call to local PSTN.

(ii) MS(a) attempts outgoing call to Home PLMN country.

Result: Successful result, if the call (i) succeeds and call (ii) fails.

Comment: This test case confirm the support of this Supplementary Service by the VPLMN(b). In the case VPLMN(b) does not support the SS: BOICex HC then the switch makes a Functional fallback because it supports BOIC.

2.2.4 Barring Of All Incoming Calls (BAIC / BAICroaming)

Pre-Check: Check if the VPLMN does support the SS: BAICroaming. (YES/NO)

If: YES continue with A.

NO continue with B.

(1) Preconditions: HLR no entry for Barring of all incoming calls when roaming in VPLMN.

Action: MS(a) in VPLMN (b) activates the SS: BAICroaming PSTN (b) calls MS(a)

Result: Successful result, if calls fails

(2) Preconditions: HLR no entry for Barring of all incoming calls.

Action: MS(a) in VPLMN (b) activates the SS: BAIC PSTN(b) calls MS(a)

Result: Successful result, if calls fails

Comment: This test case confirms the support of the activation of this Supplementary Service when roaming inside VPLMN.

2.2.5 Call Forwarding on Not Reachable (Before IMSI Detach)

Preconditions: HLR entry for MS(a_1) contains "SS : CFNRc : Active "Forwarded -to-address is PSTN telephone(b_1). [Set by MS]

In some PLMNs there are HLR restrictions on registering a forwarded-to-address which is outside the HPLMN country. There are also some PLMNs in which MSCs prevent the invocation of a call forward towards a distant country. In these cases the forwarded-to-address shall be MS(a_2). If MS(a_2) cannot be used, then the forwarded-to-address shall be PSTN telephone(a).

MS (a_1) is attached. If used, MS(a_2) is attached.

Action: Disable MS(a_1) so that it is unable to respond to paging [Note MS(a_1) must not send IMSI Detach message, while being disabled. This can be achieved by removing the battery while the phone is switched on].

Immediately attempt a call from PSTN telephone(b_2) to MS(a_1). Answer resultant call to PSTN telephone(b_1), MS(a_2) or PSTN telephone(a).

Result: Successful result if the call is completed to PSTN(b_1), MS (a_2) or PSTN(a) and the call quality is acceptable. See CCITT Rec P.84 Annex D for instructions on use of Quality Scales. Optionally, PSTN(b_2) may receive an announcement that the call is being forwarded.

Comments: This test case confirms that CFNRc (before IMSI detach) operates correctly and implies that echo cancellers are correctly configured.

Note the announcement could be in the language of PLMN(b), as the call was forwarded by the VMSC(b).

2.2.6 Call Forwarding on Not Reachable (After IMSI Detach)

Preconditions: HLR entry for MS(a_1) contains "SS CFNRc: Active:Forwarded-to-address is PSTN telephone(b_1)". [Set by MS]

In some PLMNs there are HLR restrictions on registering a forwarded-to-address which is outside the HPLMN country. There are also some PLMNs in which MSCs prevent the invocation of a call forward towards a distant country. In these cases the forwarded-to-address shall be MS(a_2). If MS(a_2) cannot be used, then the forwarded-to-address shall be PSTN telephone(a).

MS (a_1) is detached or deregistered in the VLR, but the VLR contains a record for MS(a_1).

If used, MS(a_2) is attached.

Action: Check that the subscriber MS(a_1) is detached in the VLR, if possible.

Attempt a call from PSTN telephone(b_2) to MS(a_1).

Answer: resultant call to PSTN(b_1), MS(a_2) or PSTN(a).

Result: Successful result if the call is completed to PSTN(b_1), MS (a_2) or PSTN(a) and the call quality is acceptable. See CCITT Rec P.84 Annex D for instructions on use of Quality Scales. Optionally, PSTN telephone(b_2) may receive an announcement that the call is being forwarded.

Comments: This test case confirms that $CFNR_c$ (after IMSI detach) operates correctly and implies that echo cancellers are correctly configured.

The detached status of the subscriber should be checked in the VLR, because the switching-off procedure of a Mobile does not guarantee that the subscriber will be detached, because no acknowledgement message is sent from the VLR to the MS.

Note the announcement will be in the language of PLMN (a) as the call was forwarded by GMSC(a).

2.2.7 Call Forwarding on Busy

Preconditions: HLR entry for MS (a_1) contains SS : CFB : Active : Forwarded-to-address is PSTN telephone (b_1). [Set by MS]

In some PLMNs there are HLR restrictions on registering a forwarded-to-address which is outside the HPLMN country. There also some PLMNs in which MSCs prevent the invocation of a call forward towards a distant country. In these cases the forwarded-to-address shall be MS(a_2). If MS(a_2) cannot be used, then the forwarded-to-address shall be PSTN telephone(a).

MS (a_1) is in conversation state.

If used, MS(a_2) is attached.

Action: Attempt a call from PSTN telephone(b_2) to MS(a_1). Answer resultant call to PSTN(b_1), MS(a_2) or PSTN(a).

Result: Successful result if indicate the call is completed to PSTN (b_1), MS(a_2) or PSTN(a) and the call quality is acceptable. See CCITT Rec P.84 Annex D for instructions on use of Quality Scales. Optionally, PSTN telephone(b_2) may receive an announcement that the call is being forwarded.

Comments: This test case confirms that CFB operates correctly.

2.2.8 Call Forwarding on No Reply

Preconditions: HLR entry for MS (a_1) contains "SS : CFNRy : Active : Forwarded-to-address is PSTN telephone (b_1). [Set by MS]

MS(a_1) is attached and idle.

If used, MS(a_2) is attached.

Action: MS(a) initiates an "Interrogate Call Forward Information". MS(a) displays information. Attempt a call from PSTN telephone(b_2) to MS(a_1). After a period of time during which MS(a_1) "rings", call is diverted to PSTN(b_1), MS(a_2) or PSTN(a) where it is answered.

Result: Successful result if MS(a) displays equivalent information to that stored in HLR and if MS(a_1) "rings" for length of time equal to "No Reply Timeout" value stored in HLR, and call is completed to PSTN(b_1), MS(a_2) or PSTN(a), and the call quality is acceptable. See CCITT Rec P.84

Annex D for instructions on use of Quality Scales. Optionally, PSTN telephone(b_2) may receive an announcement that the call is being forwarded.

Comments: This test case confirms that CFNRy operates correctly. It also confirms that the procedure "Interrogate Call Forward Information" operates correctly.

2.3 SMS Test Cases

2.3.1 Mobile Originated and Terminated SMS

Preconditions: SMS-MO/MT is provisioned in HLR subscription. MS_1(a) and MS_2(a) are registered in VPLMN(b).

Action: Switch on MS_1(a). Switch off MS_2(a).

Use MS_1(a) to transmit a 160 character Short Message to MS_2(a) via the Home Country SMS - Service Centre with Message Waiting priority selected.

Switch on MS_2(a)

Await delivery of Short Message to MS_2(a)

Check contents of Short Message with those transmitted.

Result: Successful result if Short Message is correctly delivered within [2] minutes of switching MS_2(a) on.

Comments: This test case confirms correct operation of SMS - Mobile Originated / Terminated Services including "Message Waiting" and "Note MS Present" procedures.

3 EQUIPMENT REQUIREMENTS

The Equipment described in this Section is necessary for undertaking the test cases described in Section 2.

3.1 User Equipment

(1) Two Mobile Equipments supplied by VPLMN(b)

(2) Two PSTN telephones in PSTN(b)

(3) Two SIMs supplied by HPLMN(a).

The supply of additional SIMs may be agreed by the HPLMN(a) and VPLMN(b), typically for the purposes of:

i) spare cards in case of failure

ii) allocation from different HLRs

(4) Two SIMs supplied by VPLMN(b)

It is expected that manual selection will be used to select VPLMN(b) when using the SIMs supplied by HPLMN(a). To facilitate subsequent automatic selection it is required that bits b6 and b5 of byte 2 of the SIM Service Table (Data-field 38) be set to "1", and the chosen VPLMN is in the PLMN Selector (Data-field 30)

In order to replicate the service that general roamers will encounter, it is required that any SIM used in the tests shall have one access class out of the classes 0-9 defined. No other access class (e.g. 10 or 11-15) shall be defined.

It is recommended that on any new SIM the Location Update Status field is set to "Status not updated" before the tests start (bit b2 set to "0" and bit b1 set to "1", of byte 11 of Data-field 7E).

3.2 Test Equipment

(1) The availability of a CCITT # 7 tester able to decode SCCP, TCAP and MAP is highly advisable, but not strictly necessary for these tests. However it is essential for any analysis of test case failures.

(2) Clock capable of being used to allow testing personnel to record call start and chargeable start (i.e answer) time of calls to an accuracy of better than five seconds. If possible, the clock shall be adjusted to be in alignment with the internal MSC clock which is used for theToll Ticketing function.

(3) Stopwatch capable of measuring perceived chargeable duration of calls to an accuracy of one second.

4 PRE-TESTING DATA EXCHANGE

It is necessary for the two PLMNs to have exchanged the Pre-Testing data defined in this Section prior to the commencement of testing.

4.1 Testing Contact Information

The following information should be exchanged by both PLMNs.

(1) Test Co-ordination contact names, telephone numbers and fax numbers.

4.2 PLMN addressing, numbering and routing data

Confirmation of the PLMN addressing numbering and routing data as referenced in the Stage 3 [IREG PRD IR23], is regarded as advisable. Such information includes:

(1) E212-E214 translation.

(2) MSC/VLR and HLR E164 addresses.

(3) MSRN number ranges.

(4) International Signalling Point Codes (if applicable)

(5) SMS Service Centre E164 address

4.3 SIM associated data supplied by PLMN (a)

The following information as stored in the SIM and/or HLR is required individually for each of the four SIMs.

(1) PIN, PUK/(SUPER PIN).

(2) IMSI

(3) MSISDN

(4) Basic Service Subscription Information

(5) Initial Supplementary Service Configuration Information, including Call Barring, Password and Call forwarding information. (These will be modified by the tests, but initial settings are required for Testcase 2.1.1)

4.4 PSTN information supplied by PLMN (b)

The following is required individually for each PSTN telephone.

(1) PSTN Directory Numbers, for telephones used for call forwarding tests.

END OF SPECIFICATION

APPENDIX A

IREG Stage 4 Test Results for Mobile Stations of PLMN(a) Roaming to PLMN(b)

A.1.1 Network Operator Information

HPLMN (a) ....

VPLMN (b) ....

Date of Tests ....

Testing personnel PLMN(a) ....

Tel/Fax: ....

Testing personnel PLMN(b) ....

Tel/Fax: ....

HLR Identity/Identities ....

....

HLR Manufacturer(s) ....

....

HLR Software Build Level(s) ....

....

GMSC Identity/Identities ....

....

GMSC Manufacturer(s) ....

....

GMSC Software Build Level(s) ....

....

VMSC Identity/Identities ....

....

VMSC Manufacturer(s) ....

....

VMSC Software Build Level(s) ....

SMS-SC Identity / Identities ....

....

SMS-SC Manufacturer(s) ....

....

SMS-SC Software Build Level(s) ....

....

Comments

A.1.2 Toll Ticket Configuration

Call Toll Ticketing in use at VMSC? [Yes/No] ....

Supplementary Service activity Toll Ticketing in use at VMSC ?

[Yes/No] ....

Toll Ticketing in use at GMSC for Roaming call legs ? [Yes/No] ....

Will VMSC Toll Ticket file be transfered to VPLMN Computing Centre ?

[Yes/No] ....

Will VMSC Toll Ticket file be transfered to the HPLMN from VPLMN ?

[Yes/ No] ....

Method of transfer of TollTicket File to HPLMN

[via TADIG mechanism/other] ....

Comments

Notes:

(1) If Toll Ticketing is not in use then the line items marked with an asterisk (*) may be omitted from these Test Result Sheets.

(2) If Supplementary Service activity Toll Ticketing is not in use there is no need to write the time at the lines marked with a plus (+).

A 2.1 Basic Test Results

The numbering of the test result sections within this appendix is identical to the associated Test case from section 2 of the main document.

A 2.1.1Location Update by MS(a) in VPLMN(b)

(a) VLR Record contents:

MSISDN ....

IMSI ....

Teleservices Speech [✓=Yes/X=No]..............................

SMS MO [✓/X]............. SMS MT [✓/X].............

Fax[✓/X]...

Bearer Services ....

Supplementary Services

BAOC [✓/X].......................

BOIC [✓/X]........................

BOIC exHC [✓/X]...............

CFB [✓/X].......................C Number..

CFNRy [✓/X].................C Number..

CFNRc [✓/X].................C Number..

CW [✓/X]..........................

CH [✓/X]..........................

MPTY [✓/X]......................

AOCC [✓/X]......................

AOCI [✓/X]......................

Others ....

HLR E164 Address ....

(b) Comments

(c) Testcase Result [Pass/Fail/Not performed]..

Signature of Tester......................Time................. Date.....................

A 2.1.2 Operator Control of Service

A) Location Cancellation for MS(a) Subscription held in VPLMN(b)

(a) VLR Record contents prior to cancellation

MSISDN ....

IMSI ....

(b) VLR record erased ? [Yes/No] ....

(c) Time delay between HLR deleting subscription and VLR erasing record

.... secs

(d) Comments

(e) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester...............................Time................. Date ....

B) Operator Determined Barring (ODB) of All Outgoing Calls and All Incoming Calls when on Roaming of MS(a)

(a) MSISDN of MS(a) ....

(b) Operator performed barring from HLR [Yes/No] ....

(c) VLR record contains barring tags [Yes/No] ....

(d) Perform a call from MS(a). Is it successful? [Yes/No] ....

(e) Call MS(a). Is it successful? [Yes/No] ....

(f) Comments

(g) Testcase Result [Pass/Fail/Not Performed] ....

Signature of Tester ....Time ....Date ....

A 2.1.3 MS_1(a) Calls MS_2(a), Both Roamed To VPLMN (b)

(a) MSISDN of originating MS (i.e.MS_1(a)) ....

(b) Number keyed into MS_1(a) ....

(c) Time of start of call (i.e. SEND key operation)........hrs .....mins ....secs

(d) Delay between SEND key operation at MS_1(a) and MS_2(a) alerting

.... secs

*(e) Time of perceived answer of call .... hrs .... .mins .... secs

*(f) Chargable Call Duration (i.e. perceived answer until end of call. Duration must be 60sec or more.) .... secs

(g) Quality of call [Excellent, Good, Fair, Poor, Bad] ....

(h) Echo present ? [Yes/No] ....

If Yes, to which MS ? [MS_1(a) / MS_2(a)] ....

(i) Comments

(j) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date ....

A 2.1.4 PSTN Telephone(B) Calls MS_1(A)

(a) Directory Number (DN) of PSTN telephone(b) ....

(b) Number dialled by PSTN telephone(b) ....

(c) Time of start of successful call (i.e. SEND key operation)

...........hrs ....mins ....secs

(d) Delay between dialling last digit of MSISDN of MS_1(a) at PSTN

telephone(b), and MS_1(a) alerting ....secs

*(e) Time of perceived answer of call ....hrs..........mins..........secs

*(f) Chargable Call Duration (i.e. perceived answer until end of call. Duration must be 60sec or more.) ....secs

(g) Was first call successful? [Yes/No] ....

(h) Was location update sequence originated from the Mobile Station necessary? [Yes/No].............

(i) Quality of successful call [Excellent, Good, Fair, Poor, Bad] ....

(j) Echo present ? [Yes/No].............

If Yes, to which party ? [PSTN/MS_1(a)] ....

(k) Comments

(l) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date ....

A 2.1.5 PSTN Telephone(B) Calls MS(A) Roamed To Country(B) - IMSI Detached

(a) Directory Number of calling PSTN telephonc(b) ....

(b) Number dialled by PSTN Telephone(b) ....

(c) Time of start of call (i.e. last digit dialled) ....hrs ....mins ....secs

(d) Time of start of "not reachable" announcement

...........hrs............mins...........secs

(e) Duration of announcement ....secs

(f) Language of announcement ....

(g) Text of announcement ....

....

....

(h) Comments

(i) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date ....

A 2.1.6 PSTN Telephone(B) Calls MS(A) Roamed To Country(B) - No Response To Paging

(a) Directory Number of calling PSTN telephone(b) ....

(b) Number dialled by PSTN Telephone(b) ....

(c) Time of start of call (i.e. last digit dialled) ....hrs ....mins ....secs

(d) Time of start of "not reachable" announcement

............hrs............mins..........secs

(e) Duration of announcement... secs

(f) Language of announcement ....

(g) Text of announcement ....

....

....

(h) Comments

(i) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date........................

A 2.2 Supplementary Service Test Results

A 2.2.1 Barring Of All Outgoing Calls.[BAOC]

(a) MSISDN of MS(a) ....

+(b) Time of activation of BAOC ....hrs ....mins ....secs

(c) Emergency code keyed [i.e.112] ....

(d) Time of start of emergency call (i.e. SEND key operation)

..................hrs..............mins.............secs

*(e) Time of perceived answer of call ....hrs.............mins............secs

*(f) Chargable Call Duration (i.e. perceived answer until end of call) ....secs

(To be measured irrespective of charging policy for emergency calls in VPLMN)

(g) Emergency Call successful ? [Yes/No] ....

(h) PSTN number keyed ....

(i) PSTN call successful ? [Yes/No].............

+(j) Time of deactivation of BAOC ....hrs ....mins ....secs

(k) Comments

(l) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date ....

A 2.2.2 Barring Of Outgoing International Calls [BOIC]

(a) MSISDN of MS(a) ....

+(b) Time of activation of BOIC ....hrs ....mins ....secs

(c) Operator Service number or PSTN(b) number keyed

....

(d) Time of start of national PSTN call (i.e. SEND key operation)

............hrs............mins.........secs

(e) Delay between SEND key operation and MS(a) receiving alerting indication

.......secs

*(f) Time of perceived answer of call ....hrs............mins.........secs

*(g) Chargable Call Duration (i.e. perceived answer until end of call)

......................secs

(h) Call routed to correct Operator position?

[Yes/No].............

(i) Home PLMN Country number keyed ....

(j) Home PLMN Country call successful ? [Yes/No]............

+(k) Time of deactivation of BOIC ....hrs ....mins ....secs

(l) Comments

(m) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester... Date ....

A 2.2.3 Barring Of Outgoing International Calls Except To Home PLMN Country [BOIC-exHC]

I) General:

(a) Method of Supplementary Service Configuration

[MS User/HLR operator].................................

(b) Does the switch support the SS:BOICexHC? [Yes/No] ....

(c) MSISDN of MS(a) ....

II) Split into different cases if VPLMN(b) supports (i.e.A) or does not support (i.e.B) the SS:BOICexHC.

A) Activated Service is BOICexHC (VPLMN supports SS:BOICexHC)

A.1) Call to Home-PSTN-telephone(a):

(d) Home PSTN Country number keyed ....

(e) Time of start of Home PSTN Country call (i.e. SEND key operation)

.............hrs............mins.........secs

*(f) Time of perceived answer of call ....hrs............mins.........secs

*(g) Home PSTN Country call Chargable Call Duration

(i.e. perceived answer until end of call) ....secs

A.2) Call to country where the MS is presently located:

(h) PSTN number of the country keyed, where MS(a) is presently located

....

(i) Time of start of call within the country where the MS(a) is presently located (i.e. SEND key operation) ....hrs............mins.........secs

*(j) Time of perceived answer of call ....hrs............mins.........secs

*(k) Chargable call duration, to the country where the MS(a) is presently located (i.e. perceived answer until end of call) ....secs

A.3) International Call, not to Home PLMN country and not to country where the MS is presently located:

(l) International (Non Home PLMN Country and non country where MS(a) is presently located) number keyed ....

(m) International (Non Home PLMN Country and non country where MS(a) is presently located) call successful [Yes/No].............

B) Activated Service is BOICexHC (VPLMN does not support SS:BOICexHC):

B.1) Call to country where the MS is presently located:

(n) PSTN number keyed ....

(o) Time of start of national PSTN call (i.e. SEND key operation) ....hrs............mins.........secs

(p) Time of perceived answer of call ....hrs............mins.........secs

(q) PSTN Chargable Call Duration (i.e.perceived answer until end of call) ....secs

B.2) Call to Home-PSTN-telephone(a):

(r) Home PSTN Country number keyed ....

(s) Home PSTN Country call successful ? [Yes/No]............

III) Results of this testcase and comments:

(t) Comments

(u) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester... Date ....

A 2.2.4 Barring Of All Incoming Calls [BAIC / BAICroaming]

(a) MSISDN MS(a) ....

+(b) Time of activation of [BAIC / BAICroaming] ......hrs ....mins ....secs

(c) PSTN number ....

(d) Number keyed by PSTN ....

(e) Call successful ? [Yes/No] ....

+(f) Time of deactivation of [BAIC/BAICroaming] ....hrs ...mins ....secs

(g) Comments

(h) Testcase result [Pass/Fail/Not performed] ....

Signature of Tester .... Date ....

A 2.2.5 Call Forwarding On Not Reachable (Before IMSI Detach, TAKE BATTERY OFF WHILE PHONE IS SWITCHED ON).[CFNRc]

(a) MSISDN of MS(a_1) ....

+(b) Time of activation of CFNRc ....hrs .... mins ....secs

(c) Directory Number(i.e.DN) of calling PSTN telephone(b_2) ....

(d) DN of forwarded - to - PSTN telephone(b_1). Note 1 ....

(e) Time of start of call ....hrs........mins.......secs

(f) Delay between dialling last digit of MSISDN of MS(a_1) at PSTN telephone (b_2) and PSTN telephone(b_1) ringing Note 1 ....secs

*(g) Time of perceived answer of call ....hrs........mins.......secs

*(h) Chargable Call Duration (i.e. perceived answer until end of call) ....secs

(i) Was an announcement that call was - being - forwarded received by PSTN telephone(b_2)? [Yes/No].............

(j) Language of announcement [If applicable] ....

(k) Text of announcement [If applicable] ....

....

....

(l) Quality of call [Excellent, Good, Fair, Poor, Bad] ....

(m) Echo present? [[Yes/No].............

If Yes, to which party? [caller/called] ....

(n) Comments.

Note 1. If forwarding to PSTN telephone (b_1) is restricted by HPLMN or VPLMN, then use MS(a_2). If MS(a_2) cannot be used then choose PSTN telephone(a).

(o) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester... Date ....

A 2.2.6 Call Forwarding On Not Reachable (After IMSI Detach, SWITCH THE PHONE OFF) [CFNRc]

(a) MSISDN of MS(a_1) ....

(b) DN of calling PSTN telephone(b_2) ....

(c) DN of forwarded - to - PSTN telephone(b_1) Note 1 ....

(d) Time of start of call ....hrs..........mins........secs

(e) Delay between dialling last digit of MSISDN of MS(a_1) at PSTN telephone(b_2) and PSTN telephone(b_1) ringing. Note 1

...............secs

*(f) Time of perceived answer of call ....hrs............mins...........secs

*(g) Chargable Call Duration (i.e. perceived answer until end of call)

.... secs

(h) Was an announcement that call was - being - forwarded received by PSTN telephone(b_2)? [Yes/No].............

(i) Language of announcement [If applicable] ....

(j) Text of announcement [If applicable] ....

....

....

(k) Quality of call [Excellent, Good, Fair, Poor, Bad] ....

(l) Echo present? [Yes/No].............

If Yes to which party? [caller/called] ....

+(m) Time of deactivation of CFNRc ....hrs ....mins ....secs

(n) Comments

Note 1. If forwarding to PSTN telephone (b_1) is restricted by HPLMN or VPLMN, then use MS(a_2). If MS(a_2) cannot be used then choose PSTN telephone(a).

(o) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester... Date ....

A 2.2.7 Call Forwarding On Busy [CFB]

(a) MSISDN of MS(a_1) ....

+(b) Time of activation of CFB ....hrs ....mins ....secs

(c) DN of calling PSTN telephone(b_2) ....

(d) DN of forwarded - to - PSTN telephone(b_1) Note 1 ....

(e) Party with which MS(a_1) is in conversation [DN] ....

(f) Time of start of call ....hrs........mins.......secs

(g) Delay between dialling last digit of MSISDN of MS(a_1) at PSTN telephone (b_2) and PSTN telephone(b_1) ringing. ....secs

*(h) Time of perceived answer of call ....hrs...........mins..........secs

*(i) Chargable Call Duration (i.e. perceived answer until end of call) ....secs

(j) Was an announcement that call was - being - forwarded received by PSTN telephone(b_2)? [Yes/No].............

(k) Language of announcement [If applicable] ....

(l) Text of announcement [If applicable] ....

....

....

(m) Quality of call [Excellent, Good, Fair, Poor, Bad] ....

(n) Echo present? [Yes/No].............

If Yes to which party? [caller/called] ....

+(o) Time of deactivation of CFB ....hrs ....mins ....secs

(p) Comments:

Note 1. If forwarding to PSTN telephone (b_1) is restricted by HPLMN or VPLMN, then use MS(a_2). If MS(a_2) cannot be used then choose PSTN telephone(a).

(q) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date ....

A 2.2.8 Call Forward On No Reply [CFNRy]

(a) MSISDN of MS(a_1) ....

+(b) Time of activation of CFNRy ....hrs ....mins ....secs

(c) Interrogate Supplementary Service at MS(a) by pressing *#61#SEND

(d) Time of start of SS activity (i.e. SEND key operation)

.....hrs ....mins ....secs

(e) Delay between SEND key operation and receipt of Display information

.......secs

(f) Information displayed on MS(a) ....

(g) Does MS(a) displays correct status of the call forwarding service?

[Yes/No] ....

(h) DN of calling PSTN telephone(b_2) ....

(i) DN of forwarded - to - PSTN telephone(b_1) Note 1 ....

(j) Time of start of call ....hrs......mins....secs

(k) Delay between dialling last digit of MSISDN of MS(a_1) at PSTN telephone (b_2) and PSTN telephone(b_1) ringing. Note 1 ....secs

(l) Length of time for which MS(a_1) "rings" ....secs

*(m) Time of perceived answer of call ....hrs...........mins...........secs

*(n) Chargable Call Duration (i.e. perceived answer until end of call)

..... secs

(o) Was an announcement that call was - being - forwarded received by PSTN telephone(b_2)? [Yes/No].............

(p) Language of announcement [If applicable] ....

(q) Text of announcement [If applicable] ....

....

....

(r) Quality of call [Excellent, Good, Fair, Poor, Bad] ....

(s) Echo present?

[Yes/No].............

If Yes to which party? [caller/called] ....

+(t) Time of deactivation of CFNRy ....hrs ....mins ....secs

(u) Comments

Note 1. If forwarding to PSTN telephone (b_1) is restricted by HPLMN or VPLMN, then use MS(a_2). If MS(a_2) cannot be used then choose PSTN telephone(a).

(x) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester.. Date ....

A 2.3 SMS Test Results

A 2.3.1 Mobile ORIGINATED AND Terminated Short Message Service

(a) MSISDN of $MS_1(a)$ ....

(b) E164 address of HPLMN SMS - Service Centre ....

(c) Time of transmitting to SMS - Service Centre ....hrs.......mins........secs

(d) MSISDN of $MS_2(a)$ ....

(e) Time of switching on $MS_2(a)$ ....hrs ....mins ....secs

(f) Time of receipt of SMS at $MS_2(a)$ ....hrs ....mins ....secs

(g) Was message correctly received? [Yes/No] ....

(h) If the message was not received, repeat test with $MS_2(a)$ switched on. Was message correctly received this time? [Yes/No] ....

(i) Comments

(j) Testcase Result [Pass/Fail/Not performed] ....

Signature of Tester .... Date...................

A 2.4 Completion Certificate for IREG Stage 4 Testing for Inter-PLMN Roaming

This certificate confirms the successful completion of IREG Stage 4 Tests for Mobile

Subscribers of................................PLMN visiting.......................PLMN.

The Services tested were:-

Telephony Basic Service [Pass / Fail / Not applicable]....................

Call Barring Supplementary Services [Pass / Fail / Not applicable]....................

Call Forwarding Supplementary Services [Pass / Fail / Not applicable]....................

Short Message Services [Pass / Fail / Not applicable]....................

Other comments..

....

Toll Ticket file is being forwarded from .... PLMN to ....PLMN via TADIG procedures.

(Delete if not applicable)

The tests were completed on...................(date).

The testing team in PLMN................................

were:..

The testing team in PLMN................................

were:..

Signed..

Date..

of PLMN....................

Signed...

Date...

of PLMN.....................

End Of Appendix

PRD IR.29

GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS

Title	**Proposal of a minimal requirement on an automatic test equipment for roaming**
Version	**3.0.0**
Date	**April 1997**

GSM Association Classifications

Non-Binding

Security Classification Category:	
Unrestricted - Industry	X

Information Category	Roaming - Technical

Document History

Version	Date	Brief Description
Changes Since Last Version		

Table of Contents

1 Scope

This document describes specifications concerning the minimal test equipment for automatic Roaming Retesting and test cases, that rely on the infrastructure as described in IR.28.

Due to high number of GSM operators in the world it is more and more difficult to perform efficient periodic retesting on time as required in the roaming agreements.

To perform more than one single test for each operator with a small operation staff, an automatic test equipment is useful for

(1) Performing the tests several times, in order to guarantee the network quality

(2) Performing several type of tests (data, SMS, CF.. CB .. MO, MT)

(3) Performing tests at any time, for instance during heavy traffic hours or off peak hours

(4) Performing test calls for periodical billing data tests.

The minimal requirement on the infrastructure of a PLMN to be tested is defined in the document IR.28.

Only some common tests scenarios are described here. Every operator is free to define more detailed tests.

2 Abbreviations

Abbreviations according to the GSM specification ETR 100:1993 (GSM 01.04 Version 4.0.2).

3 Test Configuration

TS: Automatic Roaming Test System

CU: Control Unit

MS/SIMa: Mobil Test Equipment with SIM from PLMN a

MS/SIMb: Mobil Test Equipment with SIM from PLMN b

PSE: PSTN Subscriber Emulator

AAC: Automatic Answering Circuit (Voice)

DAAC: Data Automatic Answering Circuit (incl. Fax Gr. 3)

4 Test Method

The shown test configuration allows to perform the roaming test fully automatically. The roaming test is carried out by establishing test calls from:

(1) MS to MS

(2) MS to AAC

(3) MS to PSE

(4) MS to DAAC

(5) and vice versa.

The test scenarios can be created by the CU. For each roaming feature to be tested a dedicated scenario has to be created. The test scenarios can be stored on the CU. On request by the operator the scenarios will be downloaded to the involved MS or/and PSE. The number of repetition can be predetermined. The start time of a test can be programmed, as well.

The ARTS consists of:

(1) CU

(2) MS

(3) PSE

(4) AAC

(5) DAAC

CU

The CU is the central unit of the test system. The main functions are:

(1) Generate Test Suites

(2) Store Test Suites

(3) Load test suites to TE

(4) Control the Test run

(5) Get and store results

(6) Present results

MS

The MS is/simulates a mobil station which is controlled remotely by the CU. The MS is able to handle outgoing and incoming calls.

MS/SIMa

MS/SIMa is/simulates a roaming mobil station from HPLMNa.

MS/SIMb

MS/SIMb is/simulates a mobil station of the VPLMNb.

PSE

PSE

Emulates either an analogue subscriber or an ISDN subscriber for incoming and outgoing calls.

5 Test scenarios

This document specifies 5 test cases for international roaming test. As location update can be tested with each call, it will not be tested by a specific test case.

5.1 Basic Service Test Cases

5.1.1 Location update by MS/SIMa1 and MS/SIMa2 in VPLMN and MS/SIMa1 calls MS/SIMa2

Preconditions:

(1) MS/SIMa1 and MS/SIMa2 are roaming in the VPLMN.

(2) The registration of MS/SIMa1 and MS/SIMa2 must be deleted in the VLR before.

(3) HLR record contains basic and supplementary service information.

(4) Authentication and encryption are enabled in VMSC.

Actions:

(1) Location update for MS/SIMa1.

(2) Location update for MS/SIMa2.

(3) The time needed for location update is measured and compared against a set time specified in the test Case.

(4) MS/SIMa1 calls MS/SIMa2

(5) MS/SIMa1 measures the time for call establishing and compares it against a set time specified in the test case.

(6) MS/SIMa2 answers the call

(7) MS/SIMa1 and MS/SIMa2 check the speech path during a programmable time for stability.

(8) MS/SIMa1 releases the call.

Results:

Call OK:

(1) The location update could be done within the set time.

(2) The call could be established within the set time.

(3) The call remains without call cut off and call drop during the set time.

Call faulty:

(1) Location could not be done within the set time.

(2) The call could not be established within the set time.

(3) The call was not stable during call hold time.

5.2 Supplementary Service Test Cases

5.2.1 BARRING OF OUTGOING INTERNATIONAL CALLS

Preconditions:

(1) Location update request for MS/SIMa1

Actions:

(2) MS/SIMa1 activates BAIC

(3) MS/SIMa1 calls to AAC of HPLMN(a)

(4) MS/SIMa1 checks for busy tone or the non-detection of the DTMF signal of the AAC.

(5) MS/SIMa1 releases the call.

(6) MS/SIMa1 deactivates BAIC

Results:

Call OK:

(1) DTMF signal was not recognized or busy tone was detected.

(2) The quality of the transmission is highly dependent of the PSTN line and of the modem equipment used; therefore it is foreseen to do only a functionality and not a quality test. For this reason any file transfer protocol can be used to send the files.

5.3.2 DATA TRANSMISSION, BEARER SERVICE 26

MS/SIMa1 roamed in VPLMN(b) calls the DAAC in HPLMN(a) with a speed of 9600 bits/s in asynchronous mode.

Preconditions:

Bearer service 26 is provisioned in HLR subscription. MS/SIMa1 is registered in VPLMN(b).

Actions:

(1) MS/SIMa1 establishes a call to the auto-answer modem station in PLMN (a) with the configuration 9600 bits/s, 8 bits, No parity, 1 stop bit and transparent or not transparent.

If call is successfully established, then upload (send) a file, using the Z-modem file transfer protocol (overwrite-mode in both ends).

If the file is successfully sent, then download (receive) the same file, using the Z-modem file transfer protocol (overwrite-mode in both ends).

If the file is successfully received, then check whether the two files are identical.

Results:

Successful:

(1) If the two transmissions are successful, and if the sent and received files are identical.

Comments:

This test case confirms the support of this data service by the VPLMN(b). The test is done with a file transfer protocol because this is a functionality and not a quality test.

5.4 Short Message Service

5.4.1 SMS MOBILE ORIGINATING - MOBILE TERMINATING

Preconditions:

(1) MS/SIMa1 and MS/SIMa2 both roaming in VPLMN (b).

(2) MS/SIMa2 is detached or switched off (if SMSC supports the waiting state).

Actions:

(1) MS/SIMa1 sends a MO SM with 40-160 characters towards MS/SIMa2 via the SMSC (a).

(2) After 1 minute MS/SIMa2 is switched on or attached again and receives the SM.

Results:

Successful:

(1) The SM received by the MS/SIMa2 matches the SM sent by MS/SIMa1.

Comments:

This test confirms the availability of the routing of SM's from the HPLMN-SMSC to and from the VPLMN.

5.5 Telefax services

5.5.1 MS/SIMA1 CALLS TELEFAX IN HPLMN(A) (MOBILE ORIGINATING FAX)

Preconditions:

(1) Location update request for MS/SIMa1

Actions:

(1) MS/SIMa1 calls the telefax.

(2) Call is answered by the telefax.

(3) ARTS sends a telefax (one page).

(4) MS/SIMa1 releases the liaison.

Results:

Successful:

(1) The call is answered and the acknowledgement of end of transmission (protocol T30) has been received.

Comments:

The quality of service is not controlled because this quality is depended on the telefax equipment or telefax software.

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