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Department of Electrical and Electronic Engineering

General Paket Radio Service

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ABSTRACT

GSM (Global System for Mobile communications) is an European standard for cellular communications developed by ETSI (European Telecommunications Standard Institute). GPRS is a set of new GSM bearer services that provide packet mode transmission within the GSM network and inter-works with external packet data networks. GPRS is a full digital system and is still an evolving standard that spans beyond telephony and circuit switched services.

GPRS services are divided into two categories: Point-to-Point (PTP) and Point-to-Multipoint (PTM) services. Possible PTP services include: data base access and information retrieval; the Internet; messaging and conversational services from user to user; credit card validation, etc. PTM services include: unidirectional distribution of information such as news and weather reports; conferencing services between multiple users,etc.

A formal specification of GPRS has been written in LOTOS, covering the following functions: network access control, logical link management, packet routing and transfer, and mobility management. The abstract GPRS model considered is based on the following assumptions: the GPRS network is composed of four RAs (Routing Areas), each one having two cells; there are one SGSN (Serving GPRS Support Node) and one MSC/VLR (Mobile Switching Center/Visitor Location Register) for each pair of RAs; there is one HLR (Home Location Register) in the network; and two GGSNs (Gateway GPRS Support Node) serve as connections to the external networks.

The methodology adopted for validating the LOTOS specification combines concepts of testing and model-checking. Four test suites were identified (with a total of 35 tests), covering the following aspects: attach and detach procedures; PDP context activation and deactivation procedures; data delivery between MS and external network; routing update procedures and data delivery. The test processes were composed in parallel with the original LOTOS specification and the corresponding LTS models were generated using RTL and reduced using ALDEBARAN. For each test, the execution sequences leading to

may pass results have been extracted using EXHIBITOR and examined by translating them into MSCs (Message Sequence Charts).

Several specification problems were detected using these validation techniques. The two main ones concern: Mobility Management state conflicts (packets that cannot be forwarded properly of the MS); and routing updates and data delivery conflicts (loss of data).

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Introduction

GPRS (General Packet Radio Service) is a step between GSM and 3G cellular networks. GPRS offers faster data transmission via a GSM network within a range 9.6Kbits to 115Kbits. This new technology makes it possible for users to make telephone calls and transmit data at the same time. (For example, if you have a mobile phone using GPRS, you will be able to simultaneously make calls and receive e-mail massages.) The main benefits of GPRS are that it reserves radio resources only when there is data to send and it reduces reliance on traditional circuit-switched network elements.

With GPRS, an IP data transmission protocol, which is characteristic of computer networks, is being introduced to GSM. IP is a data transmission protocol which is used in Internet, the largest computer network in the world today.

Main features of GPRS

Before introduction of GPRS, the radio capacity was used for calls and data transmission within the GSM network in a rather inefficient way. For data transmission the entire channel was occupied and was thus insufficiently used. With the GPRS technology, the channel is used more efficiently owing to the possibility of more than one user sharing the same channel. GPRS telephones user several channels for data transfer thus facilitating greater transfer speeds.

The GPRS infrastructure and mobile phones support a data transmission speed of up to 13.4Kbits per channel.

GPRS signaling and data traffic do not travel through the GSM network. The GSM network is only used for table look up, in the Location Register (HLR and VLR) data bases, to obtain GPRS user profile data.

GPRS Telephone

Owing to the fact that more than one channel is used for downlink, the GPRS mobile phones make possible greater data transmission speeds. There are several types of phones with regard to the number of channels they use for data transmission...

- Type 2+1 – two downlink channels and one uplink data transmission channel
- Type 3+1 – three downlink channels and one uplink data transmission channel
- Type 4+1 – four downlink channels and one uplink data transmission channel

The GPRS mobile phones can be classified into the following three classes in terms of the possibility of simultaneous calls (via GSM) and data transmission (via GPRS)...

- Class A – Simultaneous calls (via GSM) and data transmission (via GPRS)
- Class B – Automatic switching between the GSM and the GPRS mode is possible according to telephone settings.
- Class C – Hand operated switching between the GSM and the GPRS mode

Data Transmission Speeds

The supported data transmission speed per channel is 13.4Kbits. Depending on the type of phone, the following data transmission speeds are theoretically possible...

- Type 2+1: Receive 26.8Kbits and send 13.4Kbits.
- Type 3+1: Receive 40.2Kbits and send 13.4Kbits.
- Type 4+1: Receive 53.6Kbits and send 13.4Kbits.

The Network

In the core network, the existing MSCs are based upon circuit-switched technology, and they cannot handle the GPRS style packet traffic. Thus two new components, called GPRS Support Nodes, are added:

- Serving GPRS Support Node (SGSN)
- Gateway GPRS Support Node (GGSN)

The SGSN can be viewed as a "packet-switched MSC;" it delivers packets to mobile stations (MSs) within its service area. SGSNs send queries to home location registers (HLRs) to obtain profile data of GPRS subscribers. SGSNs detect new GPRS MSs in a given service area, process registration of new mobile subscribers, and keep a record of their location inside a given area. Therefore, the SGSN performs mobility management functions such as mobile subscriber attach/detach and location management. The SGSN is connected to the base-station subsystem via a Frame Relay connection to the PCU in the BSC.

GGSNs are used as interfaces to external IP networks such as the public Internet, other mobile service providers' GPRS services, or enterprise intranets. GGSNs maintain routing information that is necessary to tunnel the protocol data units (PDUs) to the SGSNs that service particular MSs. Other functions include network and subscriber screening and address mapping. One (or more) GGSNs may be provided to support multiple SGSNs. More detailed technical descriptions of the SGSN and GGSN are provided in a later section.

Security

GPRS security functionality is equivalent to the existing GSM security. The SGSN performs authentication and cipher setting procedures based on the same algorithms, keys, and criteria as in existing GSM. GPRS uses a ciphering algorithm optimized for packet data transmission.

Network Protocols Used

There are several protocols used in the network equipment. These protocols operate in both the data and signaling planes. The following is a brief description of each protocol layer:

- Sub-Network Dependent Convergence Protocol (SNDCP): the protocol that maps a network-level protocol, such as IP or X.25, to the underlying logical link control. SNDCP also provides other functions such as compression, segmentation and multiplexing of network-layer messages to a single virtual connection.
- Logical Link Control (LLC): a data link layer protocol for GPRS which functions similar to Link Access Protocol - D (LAPD). This layer assures the reliable transfer of user data across a wireless network.

- Base Station System GPRS Protocol (BSSGP): BSSGP processes routing and quality of service (QoS) information for the BSS. BSSGP uses the Frame Relay Q.922 core protocol as its transport mechanism.
- GPRS Tunnel Protocol (GTP): protocol that tunnels the protocol data units through the IP backbone by adding routing information. GTP operates on top of TCP/UDP over IP.
- GPRS Mobility Management (GMM): protocol that operates in the signaling plane of GPRS and handles mobility issues such as roaming, authentication, and selection of encryption algorithms.
- Network Service: protocol that manages the convergence sub-layer that operates between BSSGP and the Frame Relay Q.922 Core by mapping BSSGP's service requests to the appropriate Frame Relay services.
- BSSAP+: protocol that manages paging for voice and data connections and optimizes paging for mobile subscribers. BSSAP+ is also responsible for location and routing updates as well as mobile station alerting.

1. FEATURES AND APPLICATIONS OF GPRS

1.1 Overview

General packet radio service (GPRS) gives GSM subscribers access to data communication applications such as e-mail, corporate networks, and the Internet using their mobile phones. The GPRS service uses the existing GSM network and adds new packet-switching network equipment. See Figure 1.

1.2 How GPRS Works

GPRS uses packet switching to transfer data from the mobile device to the network and back. This provides significant benefits. On a packet-switched network, a device can be always connected and ready to send information without monopolizing the data channel. Channels are shared in packet switched networks, but in circuit-switched networks each channel is dedicated to only one user. Therefore, that user has to pay for the exclusive use of the channel. Another benefit of packet switching is that there are no call setup or suspend delays.

The mobile device can begin sending packets immediately whenever it is used. By overlaying the GSM network, GPRS is able to take advantage of the world's leading digital phone system, with a global subscriber base of over 646.5 million and growing (GSM Association, 01/02). GSM service is available in more than 150 countries and has become the de facto standard in Europe and Asia. It operates on the 900 and 1800 MHz frequency bands in Europe and Asia Pacific and 1900 MHz in North America. In the near future, North American operators will also begin using the 850 MHz frequency band for GSM/GPRS. GPRS improves on the data transmission capability of GSM while using the existing voice transmission capability. Users can have high quality voice conversations using circuit switched data up to 14.4 kbps and transfer data using packet switched GPRS at up to 53.6 kbps (85.6 kbps with advanced wireless networks).

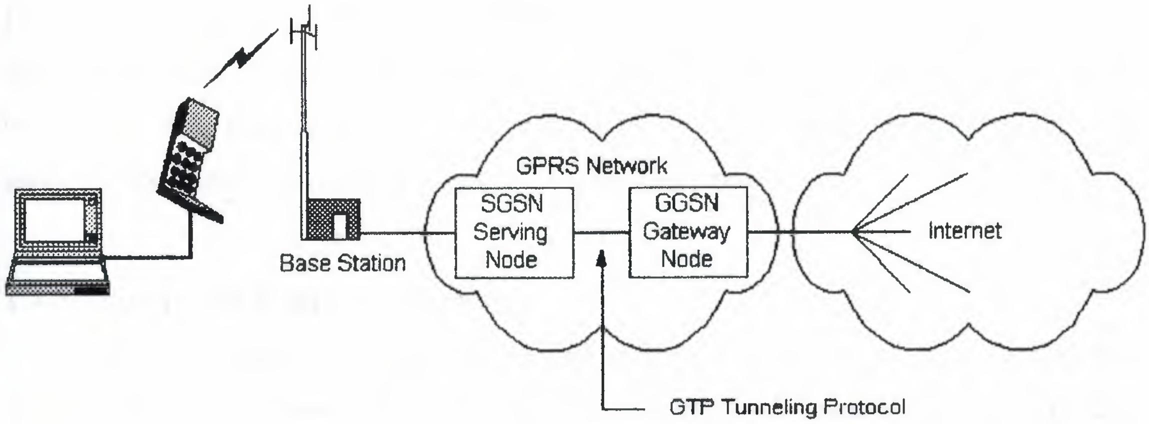

Figure 1.1 GPRS Network

1.3 Applications for GPRS

A wide range of corporate and consumer applications are enabled by no voice mobile services such as SMS and GPRS. This section will introduce those that are particularly suited to GPRS.

1.3.1 Chat

Chat can be distinguished from general information services because the source of the information is a person with chat whereas it tends to be from an Internet site for information services. The "information intensity"- the amount of information transferred per message tends to be lower with chat, where people are more likely to state opinions than factual data. In the same way as Internet chat groups have proven a very popular application of the Internet, groups of likeminded people- so called communities of interest- have begun to use no voice mobile services as a means to chat and communicate and discuss.

Because of its synergy with the Internet, GPRS would allow mobile users to participate fully in existing Internet chat groups rather than needing to set up their own groups that are dedicated to mobile users. Since the number of participants is an important factor determining the value of participation in the newsgroup, the use of GPRS here would be advantageous. GPRS will not however support point to multipoint services in its first phase, hindering the distribution of a single message to a group of people. As such, given the installed base of SMS capable devices, we would expect SMS to remain the primary bearer for chat applications in the foreseeable future, although experimentation with using GPRS is likely to commence sooner rather than later.

1.3.2 Textual and Visual Information

A wide range of content can be delivered to mobile phone users ranging from share prices, sports scores, weather, flight information, news headlines, prayer reminders, lottery results, jokes, horoscopes, traffic, location sensitive services and so on. This information need not necessarily be textual- it may be maps or graphs or other types of visual information.

The length of a short message of 160 characters suffices for delivering information when it is quantitative- such as a share price or a sports score or temperature. When the information is of a qualitative nature however, such as a horoscope or news story, 160 characters is too short other than to tantalize or annoy the information recipient since they receive the headline or forecast but little else of substance. As such, GPRS will likely be used for qualitative information services when end users have GPRS capable devices, but SMS will continue to be used for delivering most quantitative information services. Interestingly, chat applications are a form of qualitative information that may remain delivered using SMS, in order to limit people to brevity and reduce the incidence of spurious and irrelevant posts to the mailing list that are a common occurrence on Internet chat groups.

1.3.3 Still Images

Still images such as photographs, pictures, postcards, greeting cards and presentations, static web pages can be sent and received over the mobile network as they are across fixed telephone networks. It will be possible with GPRS to post images from a digital camera connected to a GPRS radio device directly to an Internet site, allowing near real-time desktop publishing.

1.3.4 Moving Images

Over time, the nature and form of mobile communication is getting less textual and more visual. The wireless industry is moving from text messages to icons and picture messages to photographs and blueprints to video messages and movie previews being downloaded and on to full blown movie watching via data streaming on a mobile device. Sending moving images in a mobile environment has several vertical market applications including monitoring parking lots or building sites for intruders or thieves, and sending images of patients from an ambulance to a hospital. Videoconferencing applications, in which teams of distributed sales people can have a regular sales meeting without having to go to a particular physical location, is another application for moving images.

1.3.5 Web Browsing

Using Circuit Switched Data for web browsing has never been an enduring application for mobile users. Because of the slow speed of Circuit Switched Data, it takes a long time for data to arrive from the Internet server to the browser. Alternatively, users switch off the images and just access the text on the web, and end up with difficult to read text layouts on screens that are difficult to read from. As such, mobile Internet browsing is better suited to GPRS.

1.3.6 Document Sharing/ Collaborative Working

Mobile data facilitates document sharing and remote collaborative working. This lets different people in different places work on the same document at the same time. Multimedia applications combining voice, text, pictures and images can even be envisaged. These kinds of applications could be useful in any problem solving exercise such as fire fighting, combat to plan the route of attack, medical treatment, advertising copy setting, architecture, journalism and so on. Even comments on which resort to book a holiday at could benefit from document sharing to save everyone having to visit the travel agent to make a decision. Anywhere somebody can benefit from having and being able to comment on a visual depiction of a situation or matter, such collaborative working can be useful. By providing sufficient bandwidth, GPRS facilitates multimedia applications such as document sharing.

1.3.7 Audio

Despite many improvements in the quality of voice calls on mobile networks such as Enhanced Full Rate (EFR), they are still not broadcast quality. There are scenarios where journalists or undercover police officers with portable professional broadcast quality microphones and amplifiers capture interviews with people or radio reports dictated by them and need to send this information back to their radio or police station. Leaving a mobile phone on, or dictating to a mobile phone, would simply not give sufficient voice quality to allow that transmission to be broadcast or analyzed for the purposes of background noise analysis or voice printing, where the speech autograph is taken and matched against those in police storage. Since even short voice clips occupy large file sizes, GPRS or other high speed mobile data services are needed.

1.3.8 Job Dispatch

No voice mobile services can be used to assign and communicate new jobs from office-based staff to mobile field staff. Customers typically telephone a call center whose staff takes the call and categorize it. Those calls requiring a visit by field sales or service representative can then be escalated to those mobile workers. Job dispatch applications can optionally be combined with vehicle positioning applications- such that the nearest available suitable personnel can be deployed to serve a customer. GSM no voice services can be used not only to send the job out, but also as a means for the service engineer or sales person can keep the office informed of progress towards meeting the customer's requirement. The remote worker can send in a status message such as "Job 1234 complete, on my way to 1235".

The 160 characters of a short message are sufficient for communicating most delivery addresses such as those needed for a sale, service or some other job dispatch application such as mobile pizza delivery and courier package delivery. However, 160 characters does require manipulation of the customer data such as the use of abbreviations such as "St" instead of "Street". Neither does 160 characters leave much space for giving the field representative any information about the problem that has been reported or the customer profile. The field representative is able to arrive at the customer premises but is not very well briefed beyond that. This is where GPRS will come in to allow more information to be sent and received more easily. With GPRS, a photograph of the customer and their premises could, for example, be sent to the field representative to assist in finding and identifying the customer. As such, we expect job dispatch applications will be an early adopter of GPRS-based communications.

1.3.9 Corporate Email

With up to half of employees typically away from their desks at any one time, it is important for them to keep in touch with the office by extending the use of corporate email systems beyond an employee's office PC. Corporate email systems run on Local Area computer Networks (LAN) and include Microsoft Mail, Outlook, Outlook Express, Microsoft Exchange, Lotus Notes and Lotus cc:Mail.

Since GPRS capable devices will be more widespread in corporations than amongst the general mobile phone user community, there are likely to be more corporate email applications using GPRS than Internet email ones whose target market is more general.

1.3.10 Internet Email

Internet email services come in the form of a gateway service where the messages are not stored, or mailbox services in which messages are stored. In the case of gateway services, the wireless email platform simply translates the message from SMTP, the Internet email protocol, into SMS and sends to the SMS Center. In the case of mailbox email services, the emails are actually stored and the user gets a notification on their mobile phone and can then retrieve the full email by dialing in to collect it, forward it and so on.

Upon receiving a new email, most Internet email users do not currently get notified of this fact on their mobile phone. When they are out of the office, they have to dial in speculatively and periodically to check their mailbox contents. However, by linking Internet email with an alert mechanism such as SMS or GPRS, users can be notified when a new email is received.

1.3.11 Vehicle Positioning

This application integrates satellite positioning systems that tell people where they are with no voice mobile services that let people tell others where they are. The Global Positioning System (GPS) is a free-to-use global network of 24 satellites run by the US Department of Defense. Anyone with a GPS receiver can receive their satellite position and thereby find out where they are. Vehicle positioning applications can be used to deliver several services including remote vehicle diagnostics, ad-hoc stolen vehicle tracking and new rental car fleet tariffs.

The Short Message Service is ideal for sending Global Positioning System (GPS) position information such as longitude, latitude, bearing and altitude. GPS coordinates are typically about 60 characters in length. GPRS could alternatively be used.

1.3.12 Remote LAN Access

When mobile workers are away from their desks, they clearly need to connect to the Local Area Network in their office. Remote LAN applications encompasses access to any applications that an employee would use when sitting at their desk, such as access to the intranet, their corporate email services such as Microsoft Exchange or Lotus Notes and to database applications running on Oracle or Sybase or whatever. The mobile terminal such as handheld or laptop computer has the same software programs as the desktop on it, or cut down client versions of the applications accessible through

the corporate LAN. This application area is therefore likely to be a conglomeration of remote access to several different information types- email, intranet, and databases. This information may all be accessible through web browsing tools, or require proprietary software applications on the mobile device. The ideal bearer for Remote LAN Access depends on the amount of data being transmitted, but the speed and latency of GPRS make it ideal.

1.3.13 File Transfer

As this generic term suggests, file transfer applications encompass any form of downloading sizeable data across the mobile network. This data could be a presentation document for a traveling salesperson, an appliance manual for a service engineer or a software application such as Adobe Acrobat Reader to read documents. The source of this information could be one of the Internet communication methods such as FTP (File Transfer Protocol), telnet, http or Java- or from a proprietary database or legacy platform. Irrespective of source and type of file being transferred, this kind of application tends to be bandwidth intensive. It therefore requires a high speed mobile data service such as GPRS, EDGE or 3GSM to run satisfactorily across a mobile network.

1.3.14 Home Automation

Home automation applications combine remote security with remote control. Basically, you can monitor your home from wherever you are- on the road, on holiday, or at the office. If your burglar alarm goes off, not only do you get alerted, but you get to go live and see who are perpetrators are and perhaps even lock them in. Not only can you see things at home, but you can do things too. You can program your video, switch your oven on so that the preheating is complete by the time you arrive home (traffic jams permitting) and so on. Your GPRS capable mobile phone really does become like the remote control devices we use today for our television, video, hi-fi and so on. As the Internet Protocol (IP) will soon be everywhere- not just in mobile phones because of GPRS but all manner of household appliances and in every machine- these devices can be addressed and instructed. A key enabler for home automation applications will be Bluetooth, which allows disparate devices to interwork.

1.4 Optimal Bearer by Application

Currently, corporate applications that use the Short Message Service are few and far between. The reasons are the relatively older age of corporate mobile phone users and their lower price sensitivity, particularly since the employer usually pays mobile phones bills. Corporate users are less willing to learn how to and make the effort to send a short message- they tend to use voice as their primary communications method. Instead, the vast majority of SMS usage is accounted for by consumer applications. It is not uncommon to find 90% of the total SMS traffic accounted for by the consumer applications that have been described. Until GPRS terminals are consumer oriented, SMS will continue to be bearer for most consumer applications. However, since GPRS will be incorporated into high end mobile phones initially, it will be used more for corporate applications.

Whatever the application, the Internet will become the primary communications interface. Previously, application developers wrote proprietary applications that worked with proprietary host terminals and often proprietary rugged terminal operating systems. For example, instead of corporate applications such as service engineering using platform and software specific interfaces, the mobile workers such as service engineers will access an intranet page using their GPRS capable terminal and fill in an electronic form. People increasingly use a web browser to access publicly available data on the Internet itself, the extranet for access to the data of business partners and other external collaborators and the intranet to access internal employee information. As such, all work will be carried out through the web interface.

Often, by designing applications to minimize the effects of the limitations of existing mobile services- such as the length of a short message or the speed of a Circuit Switched Data call- existing no voice mobile services can be successfully used for mobile working. However, many no voice applications are graphics intensive and the new faster data services will allow BETTER VERSIONS of today's existing no voice applications. For example, instead of occasional information messages with SMS, information services via GPRS or 3GSM will be more akin to the "push" Internet channels we see on Active PC Desktops today. Instead of the slow transmission of small video images, real-time broadcast quality images will be transmittable. Instead of using SMS to notify Internet users of new email, the whole email will be sent, and full-blown Internet access will be possible. The same applications will be more immediate and convenient for users.

The use of SMS has prepared customers for no voice applications using GPRS and other no voice services and most of the applications envisaged for GPRS already exist in some form today. It is therefore an important question to consider what the preferred bearer for each application will be- GPRS, Circuit Switched Data or SMS.

1.5 GPRS Terminals

A complete understanding of the application availability and GPRS timeline requires understanding of terminal types and availability. The term "terminal equipment" is generally used to refer to the variety of mobile phones and mobile stations that can be used in a GPRS environment; the equipment is defined by terminal classes and types. Cisco Gateway GPRS Serving Node (GGSN) and data network components interoperate with GPRS terminals that follow the GPRS standards.

1.5.1 GPRS Terminal Classes

A GPRS terminal can be one of three classes: A, B, or C. A Class A terminal supports GPRS and other GSM services (such as SMS and voice) simultaneously. This support includes simultaneous attach, activation, monitor, and traffic. As such, a Class A terminal can make or receive calls on two services simultaneously. In the presence of circuit-switched services, GPRS virtual circuits will be held or placed on busy rather than being cleared. A Class B terminal can monitor GSM and GPRS channels simultaneously, but can support only one of these services at a time. Therefore, a Class B terminal can support simultaneous attach, activation, and monitor, but not simultaneous traffic. As with Class A, the GPRS virtual circuits will not be closed down when circuit-switched traffic is present. Instead, they will be switched to busy or held mode. Thus, users can make or receive calls on either a packet or a switched call type sequentially, but not simultaneously. A Class C terminal supports only no simultaneous attach. The user must select which service to connect to. Therefore, a Class C terminal can make or receive calls from only the manually (or default) selected service. The service that is not selected is not reachable. Finally, the GPRS specifications state that support of SMS is optional for Class C terminals.

1.5.2 Device Types

In addition to the three variables, each handset will have a unique form factor. Some of the form factors will be similar to current mobile wireless devices, while others will evolve to use the enhanced data capabilities of GPRS. The earliest available type will be closely related to the current mobile phone. These will be available in the standard form factor with a numeric keypad and a relatively small display. PC Cards are credit card-sized hardware devices that connect via a serial cable to the bottom of a mobile phone. Data cards for GPRS phones will enable laptops and other devices with PC Card slots to be connected to mobile GPRS-capable phones. Card phones provide functionality similar to that offered by PC Cards, without needing a separate phone. These devices may need an earpiece and microphone to support voice services. Smart phones are mobile phones with built-in voice, non voice, and Web-browsing services. Smart phones integrate mobile computing and mobile communications into a single terminal. They come in various form factors, which may include a keyboard or an icon drive screen. The Nokia 9000 series is a popular example of this form factor. The increase in machine-to-machine communications has led to the adoption of application-specific devices. These "black-box" devices lack a display, keypad, and voice accessories of a standard phone. Communication is accomplished through a serial cable. Applications such as meter reading utilize such black-box devices. Personal digital assistants (PDAs) such as the Palm Pilot series or Handspring Visor are data-centric devices that are adding mobile wireless access. These devices can either connect with a GPRS-capable mobile phone via a serial cable or have GPRS capability built in. A final category of GPRS terminals is handheld communications. Again, these are primarily data-centric devices that are adding mobile wireless access. Access can be gained via a PC Card or via a serial cable to a GPRS-capable phone

1.6 GSM & GPRS Network Management

In GSM network management today, Operations Support Systems (OSS's) have managed both the voice services and the circuit switched data services. With the introduction of GPRS and the subsequent availability of new wireless data services, the new requirements on the GSM OSS's will need to reflect the importance on the wireless data service management, as this will be a key revenue growth area for mobile operators. The issues outlined below highlight just some of the areas where there will be an impact on network management.

- GPRS requires the operators to integrate additional equipment and software into their network. This substantially increases the complexity of their networks, i.e. the number of managed elements, vendor suppliers and management systems.

- The usage of bandwidth needs to be monitored carefully in order to handle the uptake of new services by mobile consumers. The management of bandwidth demand increases the complexity of the system. For instance, how do you effectively configure the network to ensure that subscribers have access to the services they ordered?
- Subscriber usage patterns can also have a key impact on the network. What operational data is available to effect the necessary changes to deal with how subscribers use the network?
- With the introduction of data services via a wireless device, users will be subscribing to a variety of new wireless services. The current usage-based pricing will become just one of the number of pricing models available to the carrier of wireless data services.
- The introduction of new equipment and services also increases the complexity of fault management. New alarms will be produced and the network operator will need to be able to isolate and deal with network faults quickly and efficiently to minimize the impact on their customers.
- The past has proven that total interface interoperability between different vendors or carriers does not exist. It is very likely that a total interoperability will never exist. Therefore, mediation and integration between interfaces is always required. In the subsequent sections we will look at the network management integration issues that face existing GSM networks and the new GPRS networks. We will look at some approaches that will allow the equipment vendors, network operators and service providers to overcome these problems.

1.6.1 GSM & GPRS OSS'S

GSM infrastructure is typically managed via a mandated Q3 network management standard. Most existing OSS software is heavily based on this standard Q3 protocol. GSM operators need to maintain this OSS software, while also managing the new equipment added as part of GPRS network infrastructure. GPRS network elements are inherently different from the circuit switched equipment. They are IP-based and predominantly use a different network management protocol: SNMP. All of this activity has created new challenges in the management of the wireless network itself:

- Carriers face the challenge of integrating GPRS into the pre-existing GSM OSS infrastructure.
- Network equipment manufacturers find that they now need to integrate data equipment into the GSM network infrastructure.
- Network equipment manufacturers also need to meet the Carrier requirements for access to certain information sets from their management platforms.
- Network engineers find that they need to coordinate various architectures that encompass a variety of interface protocols.

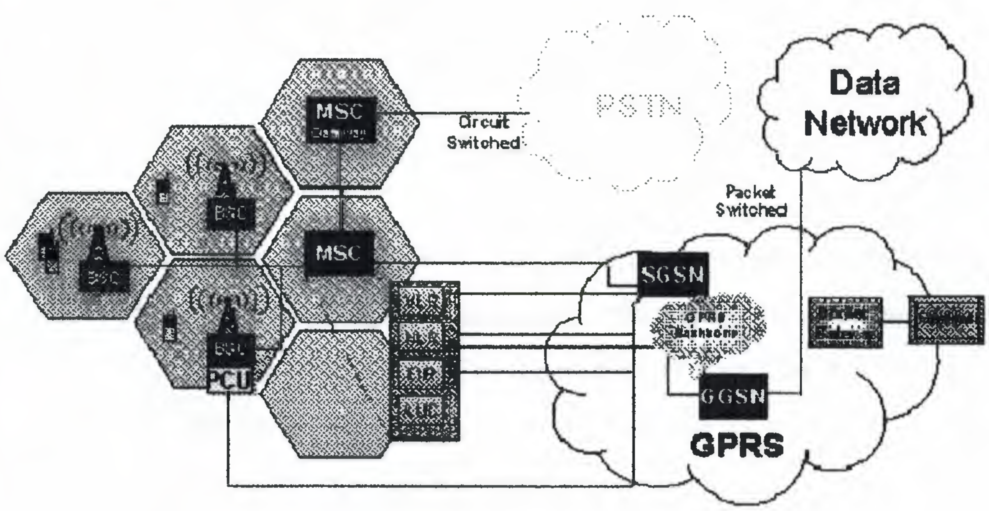

Figure 1.2 Network Architecture of GSM and GPRS

1.6.2 GPRS Components

- SGSN: Serving GPRS Support Node.
- GGSN: Gateway GPRS Support Node.
- GPRS Backbone: IP routing and switching equipment (intranet)
- Firewall: IP software/hardware to restrict GPRS infrastructure access from intruders
- BG: Border Gateway used to connect two different GPRS operators
- Data Networks: IP and X.25 external public networks, accessing GPRS via Firewall/GGSN.

1.6.3 The Issues

The introduction of GPRS now poses several network management integration issues for network equipment manufacturers and carriers.

1. The first area is the introduction of primarily SNMP based equipment to support GPRS. This now has to be managed through an existing EMS (Element Management System) or OMC (Operations and Maintenance Center) or a new EMS to manage the GPRS components.

2. The northbound interface that the network equipment provider exposes to the OSS carrier now needs to be extended to allow access to the GPRS portion of the network. This may require the integration of one or two EMS's into the existing OSS infrastructure.

3. It may also be the case that the operator has different types of OSS's. For example, one set which is used to manage the preexisting voice infrastructure and one set that is used to manage the data or IP infrastructure. The equipment vendor now has to work with the mobile operator and solve the problem of mediating one or two EMS's into different carrier OSS's.

4. Equipment vendors are also required to meet specific interface requirements laid out by the carrier. These can vary from carrier to carrier and, as a result, a flexible and efficient way of managing the northbound carrier interface requirements is needed.

5. In the midst of all of this activity, mobile operators also need to be aware of their future OSS requirements. This may involve new systems or updates to existing ones. A

migration path to allow an operator to gradually switch on new OSS systems is also vital in the preservation of established service levels with their existing customers. Because churn is one of the key challenges facing each operator, any potential impacts to the customer experience must be carefully managed.

1.7 Migration from GSM to GPRS

The migration path from GSM to GPRS requires:

- Additional packet switching nodes (routers between the base stations and the Mobile switch center)
- Software upgrades in the base station subsystem (the base station and base station controller). The existing GSM nodes to be upgraded with GPRS functionality. Further more, the same
- Transmission links can be reused, for example, between Base Transceiver Stations (BTSs) and Base.
- Station Controllers (BSCs) for both GSM and GPRS.
- Commercial data services to provided, for this a GPRS operator needs to deploy other elements like Access servers and Firewalls.

Since the migration path from GSM to GPRS is not too onerous, telecommunications providers can quickly and easily provide GPRS services to existing GSM coverage areas. Thus, there should be minimal changes to the circuit switched GSM network, except where this confers a benefit to the GSM network. The GPRS architecture will demonstrate to the marketplace that packet switched technology and services for the wireless environment are viable, and will also stimulate marketplace demand for wireless data services.

1.8 Leveraging the GSM infrastructure for GPRS

The GPRS cost model provides incremental cost results, which does demonstrate that it's relatively cheap for GSM services providers to provide GPRS services in addition to their GSM service offerings for their existing subscribers. The GSM providers incur a relatively low incremental cost in providing GPRS services because the resources allocated to developing the GSM infrastructure subsidizes the development of the GPRS network. Thus the GSM providers can afford to leverage their existing infrastructures to provide wireless data.

1.9 Factors to be considered during the Migration

1.9.1 To Meet GPRS Requirements

– Fast Setup/Access Time

– Efficient use of scarce radio resources

– Connectivity to other data networks

– Flexible service

– Efficient transport of packets

– Reuse of GSM functions/Network

– Co-existence of both GSM and GPRS without disturbance

1.9.2 Mediation

1.9.2.1 Charging Gateway Functionality:

Transactions over a GPRS network generate CDRs from both the Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN).

The SGSN CDR (S-CDR) provides the Radio Network Billing Information:

1. Subscriber identity – International Mobile Subscriber Identifier (IMSI)
2. Location (Cell ID)
3. QoS, Data Volume
4. Link/Downlink duration

The GGSN CDR (G-CDR) provides the Data Network Billing Information:

1. Subscriber identity (IMSI)
2. External Address - Access Point Network (APN)
3. Data Volume
4. Link/Downlink duration

The Charging Gateway Functionality (CGF) in a GPRS network provides the first level of mediation, consolidating the S-CDRs and G-CDRs into a meaningful format for the external Customer Care & Billing (CCB) system. The CGF passes the mediated CGF

CDRs to the CCB system for rating. Thus, the charging gateway function is more of a policing function than a charging function.

1.9.2.2 WAP Server

In order to provide a rate for GPRS transactions, additional information is required. Data services over GPRS will rely on WAP servers to convert HTML content from Web servers into a suitable format for mobile devices .WAP servers generate transaction information that would be necessary to effectively provide a rate for data services such as content from the Internet. Service providers will want to offer different pricing plans, depending on the value of the content they are providing. Distinguishing content will require information from WAP servers such as the URLs for an Internet session. Therefore, in addition to CGF-CDRs, there will be the need to use WAP-CDRs for rating.

1.9.2.3 Radius Server

Access (authentication & authorization) to a GPRS network is controlled at the SGSN. A Radius server may control access to external networks. The Radius server allocates IP addresses for a GPRS transaction and as a result, provides the necessary information to relate International Mobile Subscriber Identifier (IMSI) numbers from a mobile subscriber and the associated IP address for rating. Therefore, in addition to mediating CGF-CDRs and WAP-CDRs, there is a requirement to mediate information from Radius - CDRs.

Network Mediation = CGF-CDR + WAP-CDR + Radius-CDR

GSM CCB systems are not capable of mediating event records from these various sources.

1.9.2.4 Business Mediation

In addition to Network Mediation requirements, there are Business Mediation requirements to enable services such as Revenue Sharing and Sponsored Billing that are common business models within the IP environment.

1.9.3 Billing

Since GPRS is an "always-on" technology, the time-based pricing models of the Current GSM world are not appropriate for GPRS. Hence GPRS would require:

- Content
- Application Volume
- Quality of Service
- Transactions.
- And location based pricing models to appeal to users. To support the collection of billable application and content usage data, the data will need to be collected directly from CGSN/SGSN and enhanced and merged with the IP-based applications, servers and network elements.

1.10 Upgrading the existing Mediation set up in WIPRO to suit the Framework of GPRS

Wipro has its GSM customers spread all over India, where the Mediation application has been implemented. Hence the existing framework for GSM can be improvised to meet the GPRS requirements. The following are some of the suggested enhancements:

- An existing Mediation setup to support HTML formats to decipher the information obtained from WAPSERVER and RADIUS Server.
- The output format obtained from the Mediation application be of a common format that could be understood by any OSS end-user application
- Re-designing the mediation application such that it acts like a black box, thereby reducing the customization at the interfaces.
- It is envisaged that the volume of accounting data would greatly increase, in the order of 50 CDRs per person per day and hence the Mediation application to be improvised, in order to process a multitude of records from different elements, as otherwise it would have a direct hit on the performance of the system.

- In the context of GPRS, provisioning of services would include both GSM and IP services.
- Direct Provisioning of the IP should take place at the centralized LDAP servers and for the GSM at the HLR/MSC.

1.11 GPRS Features

Some cooperation still exists between elements of the current GSM services and GPRS. On the physical layer, resources can be reused and some common signaling issues exist. In the same radio carrier, there can be time slots reserved simultaneously for circuit-switched and GPRS use. The most optimum resource utilization is obtained through dynamic sharing between circuit-switched and GPRS channels. During the establishment of a circuit-switched call, there is enough time to preempt the GPRS resources for circuit-switched calls. The GPRS provides a bearer service from the data network to a GPRS terminal. The physical radio interface consists of a flexible number of TDMA time slots (from 1 to 8) and thus provides a theoretical raw data rate of 150 kbps. A Media Access Control (MAC) utilizes the resources of the physical radio interface and provides a service to the GPRS Logical Link Control protocol between the MS and the serving GSN (SGSN). Logical Link Control protocol is a modification of a High-Level Data Link Control based Radio Link Protocol with variable frame size. The two most important features offered by Logical Link Control protocol are the support of point-to multipoint addressing and the control of data frame retransmission. From the standpoint of the application, GPRS provides a standard interface for the network layer.

One of the main issues in the GPRS network is the routing of data packets to/from a mobile user. The main functions of the GGSN involve interaction with the external data network. The GGSN updates the location directory using routing information supplied by the SGSNs about the location of a MS and routes the external data network protocol packet encapsulated over the GPRS backbone to the SGSN currently serving the MS. It also de capsulate and forwards external data network packets to the appropriate data network and collect charging data that is forwarded to a charging gateway.

Three different routing schemes are possible: mobile-originated message, network-initiated message when the MS is in its home network, and network-initiated message when the MS has roamed to another GPRS operator's network. In these examples, the operator's GPRS network consists of multiple GSNs (with a gateway and serving functionality) and an intra-operator backbone network. GPRS operators will allow roaming through an inter-operator backbone network. The GPRS operators connect to the inter operator network. It is also foreseeable that GPRS operators will implement QoS mechanisms over the inter-operator network to ensure service level agreements. The main benefits of the architecture are its flexibility, scalabilility, interoperability, and roaming.

The GPRS network encapsulates all data network protocols into its own encapsulation protocol, called the GPRS Tunneling Protocol (GTP). This is done to ensure security in the backbone network and to simplify the routing mechanism and the delivery of data over the GPRS network. The operation of the GPRS is partly independent of the GSM network. However, some procedures share the network elements with current GSM functions to increase efficiency and to make optimum use of free GSM resources (such as unallocated time slots). An MS has three states in the GPRS system: idle, standby, and active. The three-state model represents the nature of packet radio relative to the GSM two-state model (idle or active). Data is transmitted between a MS and the GPRS network only when the MS is in the active state. In the active state, the SGSN knows the cell location of the MS. However, in the standby state, the location of the MS is known only as to which routing area it is in. When the SGSN sends a packet to a MS that is in the standby state, the MS must be paged. Because the SGSN knows the routing area in which the MS is located, a packet paging message is sent to that routing area. After receiving the packet paging message, the MS gives its cell location to the SGSN to establish the active state. Packet transmission to an active MS is initiated by packet paging to notify the MS of an incoming data packet. The data transmission proceeds immediately after packet paging through the channel indicated by the paging message. The purpose of the packet paging message is to simplify the process of receiving packets. The MS has to listen to only the packet paging messages, instead of all the data packets in the downlink channels, reducing battery use significantly. When an MS has a packet to be transmitted, access to the uplink channel is needed. The uplink channel is shared by a number of MSs, and its use is allocated by a BSS. The MS requests use of the channel in a packet random access message. The transmission of the packet random access message follows Slotted Aloha procedures. The BSS allocates an unused channel to the MS and sends a packet access grant message in reply to the packet random access message. The description of the channel (one or multiple time slots) is included in the packet access grant message. The data is transmitted on the reserved channels.

The main reasons for the standby state are to reduce the load in the GPRS network caused by cell based routing update messages and to conserve the MS battery. When a MS is in the standby state, there is no need to inform the SGSN of every cell change only of every routing area change. The operator can define the size of the routing area and, in this way, adjust the number of routing update messages. In the idle state, the MS does not have a logical GPRS context activated or any Packet Switched Public Data Network (PSPDN) addresses allocated. In this state, the MS can receive only those multicast messages that can be received by any GPRS MS. Because the GPRS network infrastructure does not know the location of the MS, it is not possible to send messages to the MS from external data networks. A cell-based routing update procedure is invoked when an active MS enters a new cell. In this case, the MS sends a short message containing information about its move through GPRS channels to its current SGSN. This procedure is used only when the MS is in the active state. When an MS in an active or a standby state moves from one routing area to another in the service area of one SGSN, it must again perform a routing update. The routing area information in the SGSN is updated and the success of the procedure is indicated in the response message. The inter-SGSN routing update is the most complicated of the three routing updates. In this case, the MS changes from one SGSN area to another and it must establish a new connection to a new SGSN. This means creating a new logical link context between the MS and the new SGSN, as well as informing the GGSN about the new location of the MS.

GPRS does impact a network's existing cell capacity. There are only limited radio resources that can be deployed for different uses. Use for one purpose precludes simultaneous use for another. For example, voice and GPRS calls both use the same network resources. The extent of the impact depends upon the number of timeslots, if any, that are reserved for exclusive use of GPRS. However, GPRS does dynamically manage channel allocation and allow a reduction in peak time signaling channel loading by sending short messages over GPRS channels instead. Achieving the theoretical maximum GPRS data transmission speed of 170 kbps would require a single user taking over all eight timeslots without any error protection. Clearly, it is unlikely that a network operator will allow all timeslots to be used by a single GPRS user. Additionally, the initial GPRS terminals are expected be severely limited supporting only one, two or three timeslots. The bandwidth available to a GPRS user will therefore be severely limited. As such, the theoretical maximum GPRS speeds should be checked against the reality of constraints in the networks and terminals. The reality is that mobile networks are always likely to have lower data transmission speeds than fixed networks, around 120 kbps. Relatively high mobile data speeds may not be available to individual mobile users until Enhanced Data rates for GSM Evolution (EDGE) or Universal Mobile Telephone System (3GSM) are introduced. GPRS is based on a modulation technique known as Gaussian Minimum Shift Keying (GMSK). EDGE is based on a modulation scheme that allows a much higher bit rate across the air interface this is called 8 Phase Shift Keying (8 PSK) modulation. Since 8 PSK will also be used for 3G, network operators will need to incorporate it at some stage to make the transition to third generation mobile phone systems.

2. GPRS TECHNOLOGY

2.1 Overview

GPRS is offering end-to-end package switched services based on the GSM infrastructure. GPRS can tunnel data transparently from the mobile terminal to the internet, giving the terminal the same status as an IP host on a local area network.

Main benefits of GPRS are:

- Wireless access to Internet and intranets
- More efficient use of the air interface as timeslots can be shared among
- several users.
- Fast session set-up, "always online"
- Charging can be based on amount of data instead of time

2.1.1 Capacity versus hype

In GPRS, users are able to use several timeslots and several users may share the same timeslots over a time period. The time slots are shared between GPRS and GSM and most likely the operator will use a dynamic solution where GPRS are allowed to use several timeslots as long as all GSM traffic gets the resources asked for.

In theory the maximum data transmission speed is 171.2 kbps GPRS and in marketing of GPRS the capacity is stated as well over 100 kbps. Unfortunately, these figures are not realistic. One reason is that operators will hardly allocate all resources for GPRS; another reason is that not all coding schemes will be implemented. A realistic estimation on transfer is between 5 and 40 kbps. Conclusively, the main advantage of GPRS is not the transfer speed. More interesting is that GPRS "packetises" the GSM network, allowing the handset to stay connected and use the GPRS network only when sending or receiving information. There is no cost connected to being online, only for data transfer and temporary loss of connection does not stop downloading of data. Handset

A GPRS handset is rather similar to the GSM handset, but naturally there are some differences as the GPRS phone requires software to support GPRS services. The SIM used in a GPRS phone can be a regular GSM SIM or a new SIM that is GRPS aware.

Network changes GPRS adds two new network nodes (support nodes) to the GSM infrastructure:

- . Serving GPRS Support Node, **SGSN**, that supports packet routing within the network
- . Gateway GPRS Support Node, **GGSN**, that connects to Packet Data Networks such as the Internet and to other GPRS networks through GPRS Roaming Exchanges to facilitate roaming.

2.1.2 Security

Most of the algorithms, keys and criteria specified in existing GSM are reused in GPRS. Authentication and cipher mode setting procedures are performed by the SGSN. For the transport of information SmartTrust platform ensures security by the use of GSM 03.48.

2.1.3 SIM card

The SIM card used in GPRS can be GPRS aware or not. The difference is the ability to store two elementary files, EFKcGPRS and EFLOCIGPRS. The Kc file holds the ciphering key and a sequence number while the LOCI file stores parameters describing the location and identity of the mobile station. If a GPRS session is set up with an ordinary SIM those files may be stored in the handset

2.2 SMS over GPRS

A GPRS Mobile Station (MS) can send and receive short messages over GPRS radio channels. The MSC node and its functionality are replaced by a SGSN. The end-user experience does not change, but the transfer speed may be higher. Sending SMS over GPRS requires a mobile phone supporting GPRS and a SMSC that has an interface towards the SGSN. SMS over GPRS can also be used as the bearer for SIM residing applications such as Smart Trust WIB. Also in this case, the end user experience does not change.

2.2.1 GPRS as Bearer/Data Channel

The combination of a new packet switched channel and the increased bandwidth offers both opportunities in the VAS and SIM File Management area. SIM management is enhanced by the possibility to perform OTA management of the SIM files using GPRS as a high bandwidth bearer for the update of large files.

2.3 Time Slot Aggregation

Still another benefit of GPRS is the ability to use more time slots, and therefore assign more data packets, into each transmission frame to a particular user. Since GPRS can combine multiple slots in a single transmission, the effective bandwidth is increased (see Figure 2.1). The theoretical limit for GPRS is eight time slots. GPRS assigns a .5-millisecond time slot to each data packet. The system is notified at the time of transmission as to how many time slots or kbps are needed on both the sending and receiving devices. The ability to combine only the required number of time slots for each transmission gives GPRS the flexibility to support both low speed and high-speed data applications in a single network. Not only does GPRS combine multiple time slots, it also varies the transmission speed of the time slots based on the coding scheme selected. The selection of coding schemes is transparent to the user and determines the level of error correction the network uses to send the data. The better the link is between the user and the network, the less error correction is needed. Less error correction means higher throughput.

(Coding scheme 1 has the highest level of error correction.) For example, Coding Scheme 2 provides a rate of 13.4 kbps per slot. The number of slots is simply multiplied by 13.4 kbps to determine the aggregated speed (see Figure 2.1). Four coding schemes have been specified for GPRS, CS-1 to CS-4. As of March 2002, only CS-1 and CS-2 had been deployed on commercial GPRS networks.

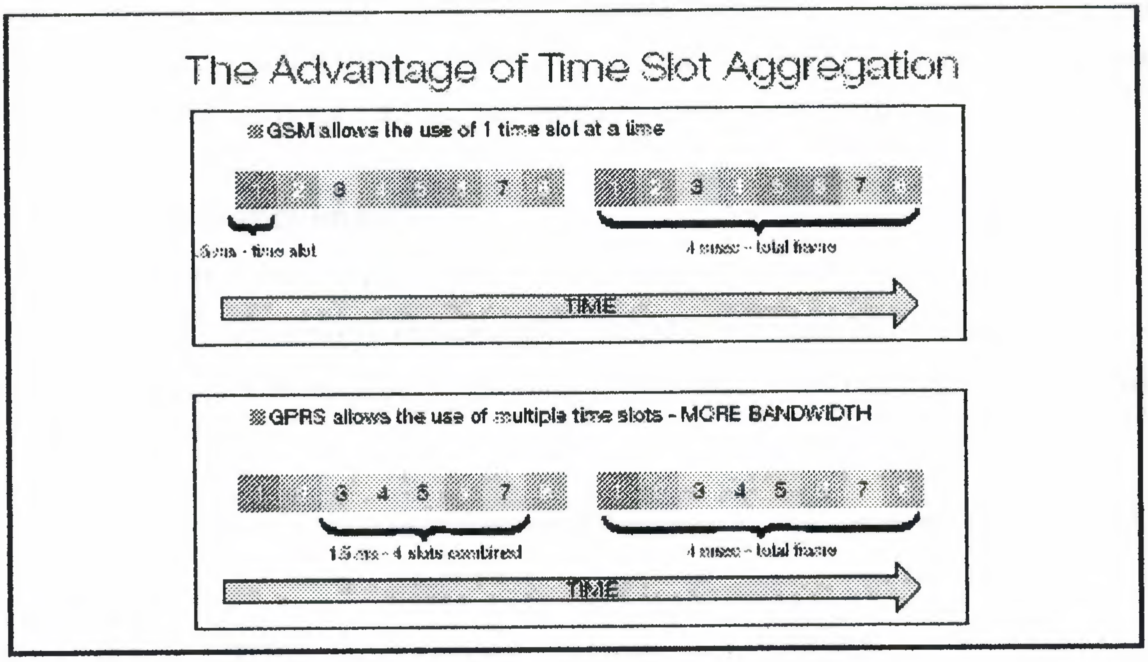

Figure 2.1 Time Slot Aggregation

2.3.1 Classifications

Multi-Slot Classes With GPRS, devices are classified by the number of time slots that they can combine for data transfer, both upstream (from the mobile terminal to the network) and downstream (from the network to the mobile terminal). There are a total of 29 classes, defined by the number of time slots that they combine for uplink and downlink. For example, Class 10 GPRS devices use a total of 5 time slots—the combination can consist of a maximum of 4 slots for receiving data and up to 2 slots for transmitting, with the total not to exceed 5 slots.

Terminal Classes GPRS devices are also classified by their ability to handle voice and data calls. There are three such classifications:

Class A devices provide complete support of simultaneous voice and GPRS. To ensure faster time-to-market with more devices available for consumers, hardware manufactures and wireless network operators have opted to develop Class C and B initially, with Class A devices to be offered at a later time. Class B devices can be registered on both the GSM (voice) and GPRS (data) networks, but only one connection can be active at a time. The user can select to put data delivery on hold while they receive phone calls and vice versa. Class C devices require that voice calls must be cleared before GPRS can be used and vice versa. Thus, the device will not automatically switch between voice and data—a hard switchover is required.

2.4 Network Functionality

Although GPRS reuses existing GSM network elements, some new protocols, interfaces and other network elements are required (see Figure 2.2). These include two major core network elements, the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN).

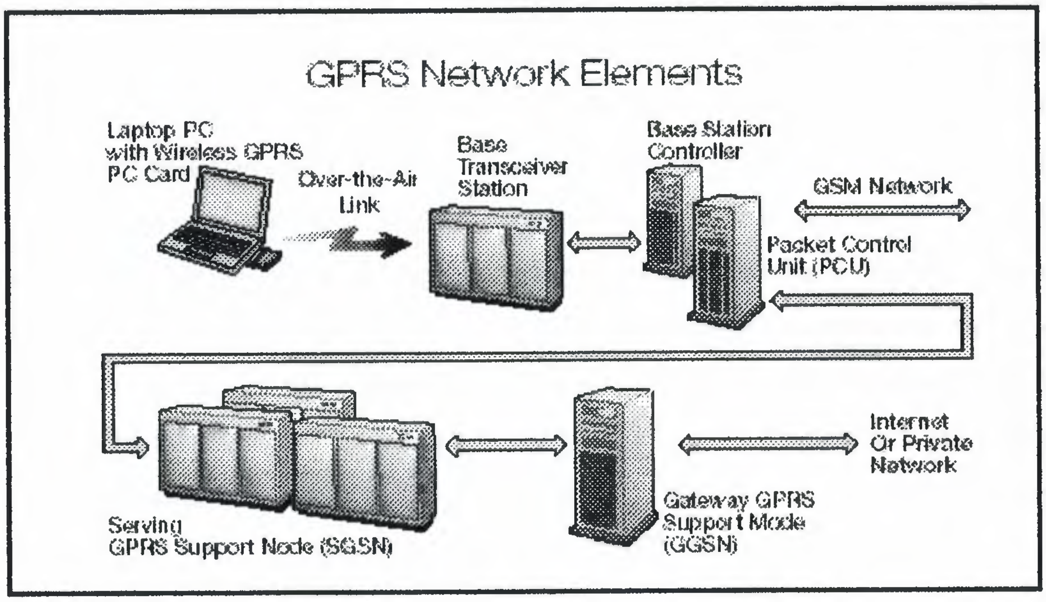

Figure 2.2 GPRS Network Elements

2.4.1 Serving GPRS Support

Node (SGSN) The SGSN is responsible for tracking the state of the mobile station and its movements as it roams in a geographical area. It also handles the data connection between the mobile device and the network.

2.4.2 Gateway GPRS Support Node (GGSN)

The GGSN handles the link between the GPRS network and other data networks, i.e. the Internet and enterprise networks. Each of those networks is given an Access Point Name (APN). The APN directs the link between the GPRS user and the destination network. Other pieces of the network consist of:

- Base Station Subsystem (BSS) that has been upgraded to support the GPRS connections on top of the GSM connections. The BSS consist of a Base Transceiver Station and a Base Station Controller.
- Packet Control Unit (PCU) that has been added to the GSM network as part of the BSC to control and manage the allocation of radio resources to the mobile users. Each user has a record of their GPRS subscription containing an indication of the network(s) to which access is required (indicated by one or more APNs), the quality of service level and potentially, a static IP address. This subscription allows the mobile station to become attached to the GPRS network. The SGSN, which is the driver of this process, continues to track the user from the moment the connection is established. It also loads the networks and services to which the particular user has access. Packet Data Protocol (PDP) context activation follows, initiated by the SGSN. This procedure enables the user to transfer data and to log onto the destination network. The SGSN looks up the APN in the Domain Name Server (DNS) and attempts to connect to a GGSN that connects to the destination network. When completed successfully, this procedure establishes a virtual connection between the mobile station and the GGSN, and data can now flow between the two. From the GGSN, a physical link connects to the destination network.

2.5 Service Delivery

2.5.1 SMS over GPRS

Just as SMS over GPRS can be used for standard SMS text messaging it can be used as the bearer for SIM residing applications such as SmartTrust WIB. And just as SMS over GPRS should be transparent to the end user, short messages sent to WIB over GPRS are transparent for SmartTrust Transport Server, see picture below. The end-user experience of SmartTrust Browser and WIG services will be no different apart from that messages may be sent and delivered faster when short messages are sent over GPRS. Whether the message will be sent over GSM or GPRS is decided by the SMS.

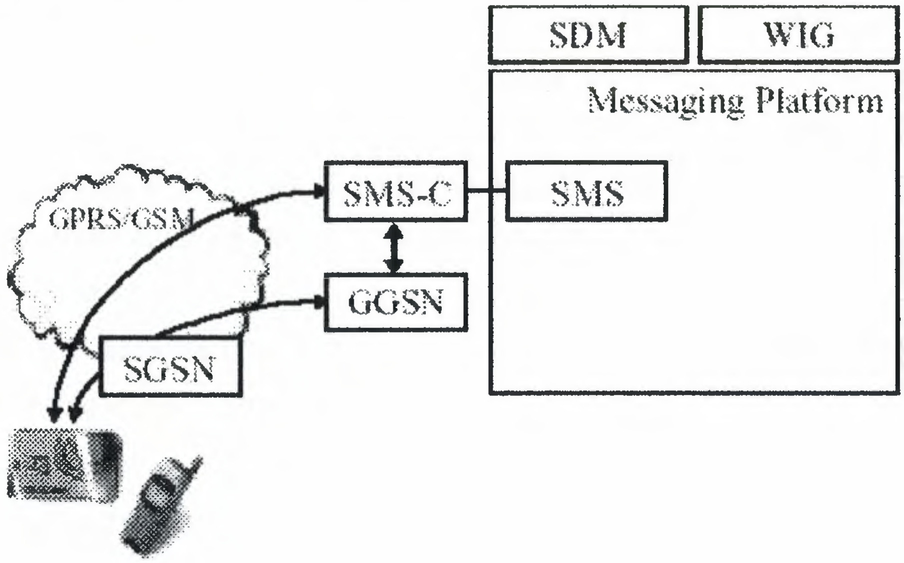

Figure 2.3 Service Delivery

2.5.2 Service Delivery in GPRS

One argument for the WIB based services has been that there is no connection time (as for Circuit Switched WAP) – however, this is not valid in the same sense for GPRS phones. On the other hand – GPRS does not have the same roaming and coverage as GSM. Thus, in order to reach the whole customer base it becomes even more important to offer services across technologies. Authentication and payments will be more important as the value of the VAS increases – and the WIB has a big advantage and future in this area.

2.6 Trusted Operator

The need for authentication and signing is likely to increase with the increased bandwidth and the new usage areas. VPN wireless authentication and digital distribution are two examples of such areas. These technologies are still young, meaning that standards and protocols are not fully defined. However, SmartTrust's products have a natural and significant role to play in theses areas and test and prototypes will be designed as the standards evolve. When VAS of higher value and larger sizes are sent the price (and value) of the services will increase. To ensure the payment of such Value Added services user authorizations will be needed and the SmartTrust WIB and security solutions will be able to ensure these authorizations.

2.7 Limitations of GPRS

It should already be clear that GPRS is an important new enabling mobile data service which offers a major improvement in spectrum efficiency, capability and functionality compared with today's no voice mobile services. However, it is important to note that there are some limitations with GPRS, which can be summarized as:

2.7.1 Limited Cell Capacity for All Users

GPRS does impact a network's existing cell capacity. There are only limited radio resources that can be deployed for different uses- use for one purpose precludes simultaneous use for another. For example, voice and GPRS calls both use the same network resources. The extent of the impact depends upon the number of timeslots, if any, that are reserved for exclusive use of GPRS. However, GPRS does dynamically manage channel allocation and allow a reduction in peak time signaling channel loading by sending short messages over GPRS channels instead.

result: need for SMS as a complementary bearer that uses a different type of radio resource.

2.7.2 Speeds Much Lower In Reality

Achieving the theoretical maximum GPRS data transmission speed of 172.2 kbps would require a single user taking over all eight timeslots without any error protection. Clearly, it is unlikely that a network operator will allow all timeslots to be used by a single GPRS user. Additionally, the initial GPRS terminals are expected be severely limited- supporting only one, two or three timeslots. The bandwidth available to a GPRS user will therefore be severely limited. As such, the theoretical maximum GPRS speeds should be checked against the reality of constraints in the networks and terminals. The reality is that mobile networks are always likely to have lower data transmission speeds than fixed networks.

RESULT: Relatively high mobile data speeds may not be available to individual mobile users until Enhanced Data rates for GSM Evolution (EDGE) or Universal Mobile Telephone System (3GSM) are introduced.

2.7.3 Support of GPRS Mobile Terminate By Terminals Is Not Ensured

At the time of writing, there has been no confirmation from any handset vendors that mobile terminated GPRS calls (i.e. receipt of GPRS calls on the mobile phone) will be supported by the initial GPRS terminals. Availability or not of GPRS MT is a central question with critical impact on the GPRS business case such as application migration from other no voice bearers.

By originating the GPRS session, users confirm their agreement to pay for the delivery of content from that service. This origination may well be performed using a Wireless Application Protocol (WAP) session using the WAP micro browser that will be built into GHPRS terminals. However, mobile terminated IP traffic might allow unsolicited information to reach the terminal. Internet sources originating such unsolicited content may not be chargeable. A possible worse case scenario would be that mobile users would have to pay for receiving unsolicited junk content. This is a potential reason for a mobile vendor NOT to support GPRS Mobile Terminate in their GPRS terminals.

However, there is always the possibility of unsolicited or unwanted information being communicated through any media, but that does not mean that we would wish to preclude the possibility of any kind of communication through that means altogether. A network side solution such as GGSN or charging platform policing would be preferable rather than a non-flexible limitation built into all the GPRS handsets.

When we asked Nokia about this issue, it commented: "Details of the Nokia GPRS terminals are not available at this time. It is too early to confirm whether MT will be supported in the first Nokia GPRS terminals". The company's policy is not to make details available about products before they are announced. Readers should contact the GSM Association, Mobile Life streams Limited and/ or the vendors directly to encourage them to incorporate support for GPRS MT in their initial terminals.

RESULT: GPRS usability and therefore business case is threatened if GPRS MT is not supported by GPRS terminals.

2.7.4 Suboptimal Modulation

GPRS is based on a modulation technique known as Gaussian minimum-shift keying (GMSK). EDGE is based on a new modulation scheme that allows a much higher bit rate across the air interface this is called eight-phase-shift keying (8 PSK) modulation. Since 8 PSK will also be used for 3GSM, network operators will need to incorporate it at some stage to make the transition to third generation mobile phone systems.

RESULT: NEED FOR EDGE.

2.7.5 Transit Delays

GPRS packets are sent in all different directions to reach the same destination. This opens up the potential for one or some of those packets to be lost or corrupted during the data transmission over the radio link. The GPRS standards recognize this inherent feature of wireless packet technologies and incorporate data integrity and retransmission strategies. However, the result is that potential transit delays can occur.

Because of this, applications requiring broadcast quality video may well be implemented using High Speed Circuit Switched Data (HSCSD). HSCSD is simply a Circuit Switched Data call in which a single user can take over up to four separate channels at the same time. Because of its characteristic of end to end connection between sender and recipient, transmission delays are less likely.

2.7.6 No Store and Forward

Whereas the Store and Forward Engine in the Short Message Service is the heart of the SMS Center and key feature of the SMS service, there is no storage mechanism incorporated into the GPRS standard, apart from the incorporation of interconnection links between SMS and GPRS.

2.8 Related GPRS Challenges

2.8.1 Billing

GPRS is a different kind of service from those typically available on today's mobile networks. GPRS is essentially a packet switching overlay on a circuit switching network. The GPRS specifications stipulate the minimum charging information that must be collected in the Stage 1 service description. These include destination and source addresses, usage of radio interface, usage of external Packet Data Networks, usage of the packet data protocol addresses, usage of general GPRS resources and location of the Mobile Station. Since GPRS networks break the information to be communicated down into packets, at a minimum, a GPRS network needs to be able to count packets to charging customers for the volume of packets they send and receive. Today's billing systems have difficulties handling charging for today's no voice services. It is unlikely that circuit switched billing systems will be able to process a large number of new variables created by GPRS.

GPRS call records are generated in the GPRS Service Nodes. The GGSN and SGSN may not be able to store charging information but this charging information needs to be processed. The incumbent billing systems are often not able to handle real time Call Detail Record flows. As such, an intermediary charging platform is a good idea to perform billing mediation by collecting the charging information from the GPRS nodes and preparing it for submission to the billing system. Packet counts are passed to a Charging Gateway that generates Call Detail Records that are sent to the billing system.

However, the crucial challenge of being able to bill for GPRS and therefore earn a return on investment in GPRS is simplified by the fact that the major GPRS infrastructure vendors all support charging functions as part of their GPRS solutions. Additionally, a wide range of other existing non-GSM packet data networks such as X.25 and Cellular Digital Packet Data (CDPD) are in place along with associated billing systems.

It may well be the case that the cost of measuring packets is greater than their value. The implication is that there will NOT be a per packet charge since there may be too many packets to warrant counting and charging for. For example, a single traffic monitoring application can generate tens of thousands of packets per day. Thus the charging gateway function is more a policing function than a charging function since network operators are likely to tariff certain amounts of GPRS traffic at a flat rate and then need to monitor whether these allocations are far exceeded.

This is not to say that we will end up with the free Internet Service Provider model that has become established on the fixed Internet in which users pay no fixed monthly charge and network operators rely on advertising sales on mobile portal sites to make money. There is a premium for mobility and there is frankly a shortage of mobile bandwidth that limits the extent to which that bandwidth is viewed as a commodity. And given the additional customer care and billing complexity associated with mobile

Internet and no voice services, network operators would be ill advised to reduce their prices in such a way as to devalue the perceived value of mobility.

2.8.2 Tarffing

Decisions on charging for GPRS by packet or simply a flat monthly fee are contentious but need to be made. Charging different packets at different rates can make things complicated for the user, whilst flat rates favor heavy user's more than occasional ones.

We believe that the optimal GPRS pricing model will be based on two variables- time and packet. Network operators should levy a nominal per packet charge during peak times plus a flat rate, no per packet charge during non peak times. Time and packet related charging will encourage applications such as remote monitoring, meter reading and chat to use GPRS overnight when spare network capacity is available. Simultaneously, a nominal per packet charge during the day will help to allocate scarce radio resources and charge radio heavy applications such as file and image transfer more

than applications with lower data intensity. It has the advantage that it will automatically adjust customer charging according to their application usage.
As such the optimal charging model could well be a flat rate charge during off-peak times along with a per packet charge during peak times.

2.8.3 Customer Service

Value-added network services such as mobile data, mobile Internet and unified messaging all generate certain specific customer problems and requirements, thereby requiring customer service personnel to be aware of these issues and know how to solve them.
No voice services are surprisingly complex- involving unique configurations of phone types, data cards, handheld computers, subscriptions, operating systems, Internet service providers and so on. Some network operators require customers to opt into certain value added services rather than including them as part of the core subscription- necessitating a customer service process. It is even possible to write a 350 page book about the SHORT message service (it is called "YES2SMS")!
In theory, the need for dedicated customer service for Circuit Switched Data, SMS and other no voice mobile services will decrease in the future as terminals and services become easier to use and as the services themselves are used more widely for customer service purposes.
The reality in the short and medium term is that the need for customer support for value-added services will increase not decrease as awareness of services and their usage increases, and as new services and terminals come onto the marketplace.
Rather than keeping everything in-house or outsourcing everything, we are a proponent of an approach that keeps first line support and customer contact in-house, whilst outsourcing the difficult specific customer service problems arising from connectivity issues and so on. In this way, the network operator is aware of and in control of the kinds of questions and problems its customers are asking.
It is well worth incurring the cost to get the customer aware, educated and initially set up with data services, because, for example, once the PC data card has been successfully

connected to the laptop to the Internet software and so on, the same configuration can be repeatedly used. The one-off customer requirement leads to ongoing usage.

2.9 The Mobile Value Chain

The no voice mobile value chain shows the various parties, along with their interdependence and activities that are involved in realizing the full potential of no voice mobile services. There will be differences between the voice and no voice value chain- need for IT channels,

These parties are network operators, customers, IT/ mobile channels, terminal and infrastructure vendors and application developers. All of these players in the value chain are essential to deliver the overall success of the no voice services- if any one is underdeveloped or not present, the entire value chain can break down. Each has a distinct role to play, which will now be discussed.

2.9.1 Customers

Without customer interest in the no voice mobile services, there is little need for any of the other players in the value chain to be present. If customers don't see a compelling requirement for a no voice service such as GPRS that can be delivered at a reasonable cost to them, there is little point in network operators offering services, GPRS terminal vendors manufacturing product, channels for product purchase being established or applications developed. Customer interest is the business case that supports any investment in the no voice market, as in any other.

Customers tend to interface with network operators to buy service- either directly or indirectly through designated channels depending on the size of the business and importance of the customer to the network operator. Customers may also have links with application developers if their application requires some specific software.

2.9.2 Terminal/ Infrastructure Vendors

Terminal and infrastructure vendors supply the equipment and technology that turns a service such as GPRS that has been set down on paper as a standard in theory into something that can be implemented in practice. Clearly, without network infrastructure to enable the service in a cost effective way, it cannot be widely implemented in practice. Equally, availability of terminals in commercial quantities at reasonable prices can hinder or halt market take up. There is little point in a network supporting a service if the clients to connect to that network are not available. Delays in widespread terminal availability have often hindered the successful deployment of new technologies and initiatives- most recently with SIM Application Toolkit and the Wireless Application

2.9.3 Protocol

Terminal and infrastructure vendors need to have links to the people who buy their products such as network operators to buy the network infrastructure and mobile channels that distribute and sell their terminals. Terminal and infrastructure vendors may well also have links to application developers to encourage applications to be ported to their infrastructure and terminal solution and interfaces and operating systems. The vendors may also have direct contact with large corporate end users- helping enable the no voice mobile opportunity in a network independent way.

2.9.4 Application Developers

Application developers- software developers, systems integrators and the like- are an essential part in the no voice mobile value chain. Customers are interested in what the no voice services can be used for- GPRS and other such services are a means to an end and not and end in themselves- they facilitate applications.

Applications are the end that will generate high usage of no voice services. They will generate regular and ongoing use of the no voice mobile services. Even given standardized elements in the other parts of the mobile value chain, some systems integration is likely to be necessary to deploy the application, such as integration with the host systems. However, once deployed, these applications will rapidly become an indispensable part of the daily life of the user that they will be loath to give up and keen to use frequently. Because they will make that person's life easier- they will help that person get their job done well and keep in touch with their family, friends, colleagues and customers.

Application developers may develop off the shelf shrink-wrapped no voice products such as a chat software program designed for volume sales, customized products developed specifically to meet one customer's requirement, or a hybrid in which a generic product such as a database is customized with application specific data. Some products or services have a "killer application" that is overwhelmingly popular- such as spreadsheets for PCs or desktop publishing for the Apple Macintosh- or a raft of different applications that all build on the underlying technology.

Application developers may have links to terminal and infrastructure vendors- in many cases, these vendors have application development forums and programs such as the GPRS Application Alliance from Ericsson and the Nokia Developer's Forum. Application developers should also have contacts with the network operators since networks have different levels of tariff plans, hardware and network infrastructure and services availability. This interface between application developers and network operators is ideally in the form of a business partners program. Application developers may also sell their products directly to mobile channels by concluding packaging and bundling deals with those channels.

2.9.5 IT/ Mobile Channels

The customer needs to be able to find out about and sign up for a service in a convenient and easy way. The market channels are what facilitates this- different customer groups prefer to use different channels. For example, if you only sold a product through Internet channels, you would preclude all those people who are not connected and those who are unwilling or uncomfortable to purchase online. In some cases, customers for no voice services such as GPRS will contact and contract with the network operator directly to purchase service- this could be a retail outlet or sales person or telesales type operation. In other cases, they will buy from an Information Technology (IT) channel such as a computing magazine or retail outlet. Just as consumer oriented propositions such as prepay are available from chemists and newsagents, corporate oriented IP based services such as GPRS are likely to lead to a further evolution in channels for mobile telephony products. Such smart terminals and other devices will be available from IT superstores such as Office World, management consultancies such as Anderson Consulting, business facilities outlets such as Mailboxes Etc., in airline business lounges and the like.

The channels have links to the customers that buy from them, the vendors who supply terminals to them and the network operators who try to get them to sell equipment connected to their particular network. The channels may also connect with application developers if their customers require a specific software solution.

2.9.6 Network Operators

Clearly, the sum of activities that a network operator carries out is essential in determining the success of no voice services. From fundamental prerequisites such as deciding to invest in network infrastructure to support no voice services to investing resources in educating customers about their availability and uses, network operators are an essential part of the process.

Network operators tend to have links with customers that are managed by account managers and customer service staff, channels such as service providers and retailers, application developers through business partner programs and network infrastructure and terminal suppliers who they contract with for the underlying technology. As such, given its central role and relations with all of the other players in the value chain, network operators are of central importance and need to systematically and deliberately manage relations with these different groups through setting up concrete programs and mechanisms to communicate with them.

We can therefore see the various parties that make up the no voice mobile services value chain and the importance of each. If any one of the five core elements of network operators, customers, application developers, terminal and infrastructure vendors and channels was NOT present, the entire value chain would be damaged and the success of the no voice service delayed or entirely precluded.

3. GPRS NETWORK ARCHITECTURE

3.1 Overview

3.1.1 GPRS Architecture

GPRS is not a completely new system instead it is an upgrade of existing GSM networks. Therefore the same function for telephone calls will still be used, and it will also be possible to use voice and data simultaneously on some handsets. Since the GSM system will be used it is the same coverage for GPRS as it is for the present network. This is possible since GPRS is introduced with a software upgrade of the base stations in the present GSM network. Accordingly most operators do not have to send technicians to each cell site. Instead it can be done with a central software upgrade. The functionality added to GSM to get GPRS has no influence on the already existing GSM services. The already existing infrastructure will be used as much as possible. Existing base stations and antennas for GSM was expensive to build, so it is appreciated by the operators that they can use the same base stations, since they save money this way. If the infrastructure had to be built from the beginning it would take a long time to get the same coverage for GPRS as we have for GSM has today. By getting GPRS functionality into mobile networks the users gets to see the real advantages with the mobile Internet, and it also creates a need for more. So that the users create a need for the 3G system before it exists.

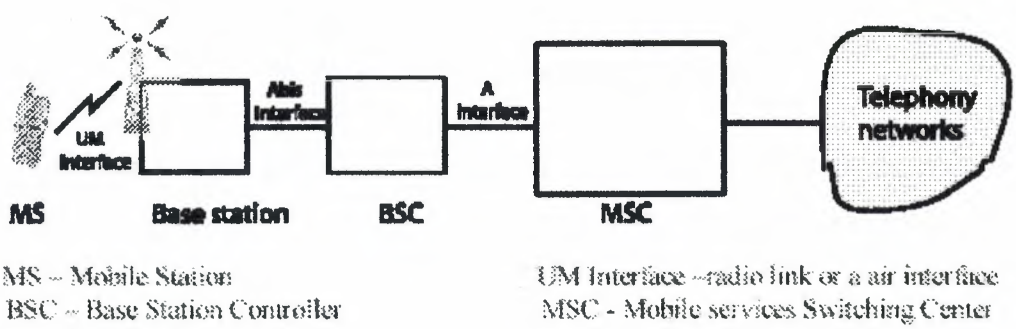

Figure 3.1 GPRS Network

In GSM, the Abis interface is standardized to facilitate connectivity between multiple base stations and BSC (fig 2.2). When GPRS is introduced this interface can remain unchanged. GPRS packet data and GSM voice share the same interface, the Abis interface (fig 2.2). To achieve efficient packet data handling, different core networks are needed. The existing GSM core network for circuit-switched data and a new GPRS core network for packet data.

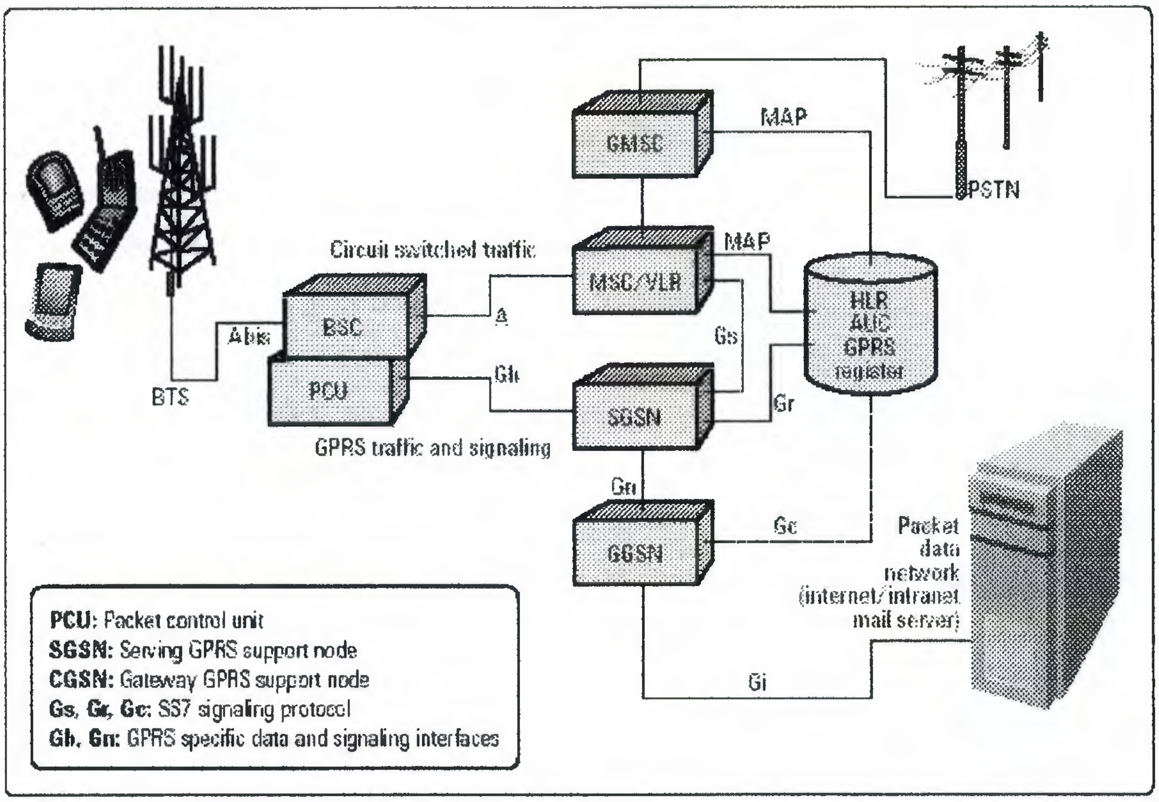

Figure 3.2 GPRS network architecture

The BSC have to separate the different data flows and direct them to the right network. This new functionality requires new hardware in the BSC, the Packet Control Unit (PCU). The PCU multiplexes the different data streams from circuit switched and packet switched core networks into common streams down to the cells. The PCU also separates circuit switched data and packet data when it is received from the MS. The PCU is a separate entity and it could be located physically separated from the BSC. The BSC also gets its software upgraded for GPRS in order to enable it to handle the new logical packet data channels, the paging of GPRS handsets, and other packet data-specific functions of the air interface. Most of the new functionality that is added is implemented in the BSC. One BSC is connected to several base stations, one MSC, and one Serving GPRS Support Node(SGSN) The GPRS core network has two main nodes: SGSN and Gateway GPRS Support Node (GGSN), together they are called the GSN nodes. To connect these nodes to the radio network, a new open interface, Gb, is introduced. Gb is a high-speed Frame Relay link that is built running on an E1 or T1 connection. The connection between the different GSN nodes and other components of the core network is called the GPRS backbone. The backbone is a regular IP network that has access router, firewalls etc. The backbone usually connects to the operators billing system via a billing gateway. The backbone can also be use to connect to other GPRS operators. The SGSN have the main responsibility for mobility of packet data users. When you are connected to a GPRS network, MS have a logical connection to its SGSN and can perform a handover between different cells without changing in the logical connection. The SGSN keeps track of which BSC to use when sending packets from an outside network to a MS. It has the same functionality as an ordinary IP router, but it has some added functions since it is a mobile network. It has to verify the user, distribute IP addresses, perform ciphering, etc. Since it is a radio link you have to consider that packets get lost, and handle it in some way. Between the MS and the base station the protocol RLC (Radio Link Control) is used, it resends data that is lost over the air. The Logical Link Control (LLC) protocol, between MS and SGSN, can be configured to give similar functionality. When a MS is connected to an Internet site it is much easier to handle lost packets with a fast retransmission protocol instead of using a high layer protocol like TCP. The retransmission protocol then only handles the wireless part and hides the loss for TCP, which then can concentrate on what that protocol was aimed for. GGSN is similar to a combined gateway, firewall and an IP router. GGSN handles interfaces to external IP networks, Internet Service Providers (ISP), routers, Remote Access Dial-In User Service (RADIUS) servers, and other contiguous nodes. To the external networks, GGSN is like an ordinary gateway that can route packets to a user within its domain. The GGSN keeps track of which SGSN a specific MS is connected to and forwards packets accordingly.

GGSN and SGSN can either be close in a GSN or placed far apart connected via the backbone. Since the backbone can be shared with other operators, a tunnelling protocol called GPRS Tunneling Protocol (GTP) has been developed (fig 2.4). Packets that are traveling over the GPRS backbone have a stack with IP and TCP as two levels. This makes it secure and easy to implement but it is not the most efficient solution

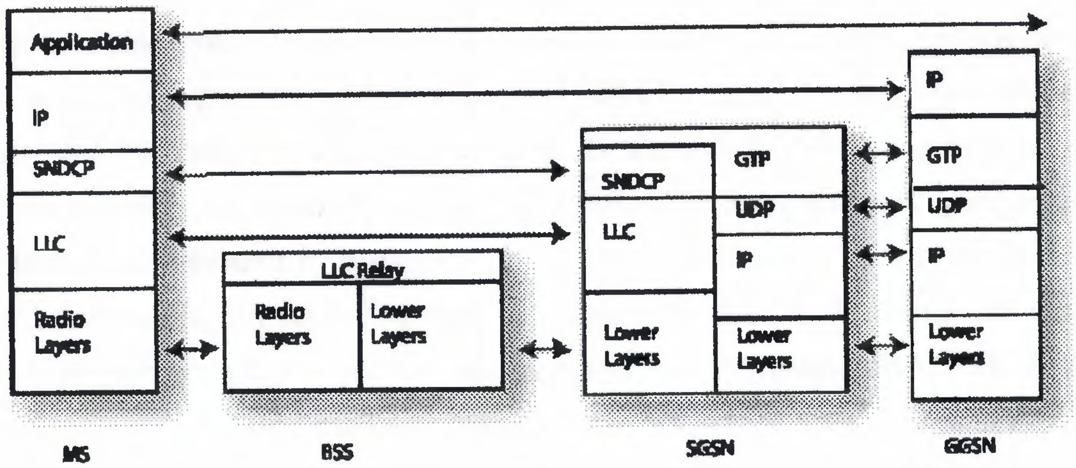

Figure 3.3 GPRS Network

BSS = Base Station System
MS = Mobile Station
GGSN = Gateway GPRS Support Node
SGSN = Serving GPRS Support Node
GTP = GPRS Tunnelling Protocol
SNDCP = Sub Network Dependent Convergence Protocol
IP = Internet Protocol
UDP = User Datagram Protocol

3.2 GPRS Handsets

To be able to use GPRS you need a handset that handles GPRS. Handsets can be divided into three classes. Class A terminals can handle packet data and voice at the same time. Two transceivers are needed because the handset have to send and/or receive data and voice at the same time.

Class B terminals handle both packet data and voice, but not at the same time. You can use the same transceiver for both, keeping the cost of the terminals down. In practice, the GPRS session is suspended when a GSM voice call is started. The user could have a choice of if they want to receive the incoming call or if they want to maintain the data session.

Class C terminals can only handle either voice or data. Examples of class C terminals are GPRS PCM/CIA cards, embedded modules in vending machines, and so on. Theoretically the throughput of GPRS is said to be 170Kbps. This value assumes that all eight available time slots are used, that no other users are sharing them, and that there is no protective coding. In reality, the terminal will often limit the throughput. There are many defined configurations of GPRS terminals that indicate how many time slots will be for downlink and uplink. Hence, a 2 + 1 terminal can receive data by using two time slots but can only send by using one. The capacity per time slot varies from 9Kbps to 20Kbps depending on the coding used. It is difficult to build an 8 + 8 handset, because the power consumption would be very high and the heat generation would require a massive cooling fan. There are also physical limitations on the number of timeslots used. In the beginning it is likely that only one transceiver will be used, since it will save cost and complexity. If one transceiver is used, the cellular phone cannot send and receive data at the same time. Initially, it is likely that terminals will be of class B and between 2+1 and 4+1. The reason is because there are only eight time slots per frame. This gives the terminal eight chances per frame to send four time slots and to receive one if a 4+1 terminal wants to achieve maximum speed. Thus a 1+2 terminal must be capable of using three time slots in that one frame for user data (1 + 2 = 3). That gives five slots left in the frame for the terminal to make control signaling with the base station, to maintain a connection, and to monitor other cells to see whether a handover is necessary (fig. 2.5).

Having this in mind, one realizes that it would be impossible making a 6 + 2 terminal using all eight time slots and only one transceiver. Since at least one time slot will be used for control data, the terminal cannot be used in order to get maximum speed. This terminal would need to have two transceivers in order to send and receive at the same time. This functionality adds a significant cost to the handset. If you want the handset to be class A and to handle voice at the same time, a third transceiver need to be added or the situation will be back at square one.

R-REFERENCE POINT INTERFACE the R-reference point interface is used when the mobile terminal and the terminal equipment are physically separated. A Bluetooth enabled laptop that communicates with network services via a GPRS and a Bluetooth enabled phone is an example of a configuration that uses the R-reference point interface. The cellular phone serves as a modem and acts like an Internet bridge for the laptop. In order to establish such a connection, you first connect the devices on the physical layer. If a cable is used you just hook up the devices. With infrar ed connections, the infrared hardware has to be enabled and the devices have to be held close enough and pointed toward each other. When Bluetooth is used the devices do not have to be as close as with infrared and the devices do not have to be pointed toward each other. In any case, a physical connection between the TE (Terminal Equipment) and the MT (Mobile Terminal) is established. The next step is to set up a Point-to-Point Protocol (PPP) connection between the communicating devices. PPP creates a communications interface with the lower layers and enables the IP layer to seamlessly communicate with the network.

3.3 Attaching the Cellular Phone to the Network

When we did our testing with GPRS we used an Ericsson R520 cellular phone and a Motorola Accompli 008. We will go trough the connection procedure with the R520 cellular phone. MT and TE are both inside this phone, R520 is a combined GSM and GPRS phone (class B). This means that it needs to tell the network that it can handle both GSM and GPRS connections. This procedure is called Attach and is similar in GSM and GPRS. A GPRS Attach creates the logical link between the SGSN and the MS. This task is done in the following way:

1. The MS sends an Attach request message to the SGSN.
2. The SGSN checks to determine whether it knows the MS and tries to find its unique

1. IMSI (*International Mobile Subscriber Identity*) identification number. If the MS is not known, it asks the recent SGSN for IMSI and authentication triplets.

2. If the old SGSN does not know the MS, it sends an error message. The new SGSN
3. then asks the MS for its IMSI. It would be more efficient to ask the MS right away, but sending the unique IMSI number over the air is generally avoided for security reasons.
4. The SGSN performs an authentication of the MS.
5. If the MS is found to be in a new service area, the *Home Location Registry* (HLR) is
6. Updated.
7. If the MS currently is in a new location area, the Mobile Switching Center (MSC)/Visitors Location Registry (VLR) is updated.

The SGSN informs the MS about its assigned *Temporary Location Link Identifier* (TLLI). TLLI is used throughout the GPRS session as an identifier for the MSSGSN logical link. To register the GSM part the International Mobile Subscriber Identity (IMSI) Attach is done. It is possible to perform a combined GPRS/IMSI Attach and make the phone visible to both voice and packet data at the same time. A GPRS Detach is done to remove the GPRS terminal from the network, this procedure is usually done when the phone is turned off.

After the MS-SGSN link has been established, the cellular phone needs to get an IP address and other connection parameters. This task is done through *Packet Data Protocol* (PDP) context activation. The PDP context can be viewed as a software record that holds parameters that are relevant to a certain connection. This information includes the protocols that are used (IP or X25), the IP address (if IP is used), the QoS (*Quality of Service*) profile, and information about whether to use compression. The PDP context activation makes the GPRS cellular phone visible to the concerned GGSN, which makes external connections possible. After the GPRS Attach we did previously we are now going to do a PDP context activation procedure:

1. The MS sends a PDP context request to the SGSN.
2. Security functions can be executed between the MS and the SGSN, which validates the request.
3. The SGSN:

- Checks the subscription
- Checks the QoS, which affects the pricing of the service
- Sends information to the GGSN about how to reach the MS
- Configures a logical link to the GGSN by setting up a tunnel

4. The GGSN contacts a RADIUS within the operator network and gets an IP address for the MS
5. The IP-address is sent back to the MS. The GPRS user is now ready to send and receive packets

3.4 Connection to Internet and Other PDN

One of the most important functions with GPRS is that you can connect to other PDN (*Packet Data Network*), like Internet or X.25 . When X.25 is used as transport, GGSN should handle the translation between MS that uses GPRS and the network that uses X.25. MS is in this case a DTE – *Data Terminal Equipment* and the network is DCE- *Data Communications Equipment*. When using IP as transport, the transport with IP-routers is done via the Gi interface. From the external network the GGSN is like an ordinary IP-router. GPRS offers two different ways of connecting to the Internet or an Intranet. Transparent connection directly to the network and Non-transparent connection where GGSN has an active role. Transparent connection:

- MS gets an address belonging to the operators address space. The address can either be static with the subscription or dynamic being given via PDP Context Activation.
- MS does not have to send any authentication request to GGSN at the activation and GGSN does not take part in the qualifying control.

Non-transparent connection:

- MS gets an address belonging to Intranet/ISP. The address can be static with the subscription or dynamic being given via PDP Context Activation.
- MS sends an authentication request at PDP Context Activation and GGSN asks for an authentication from the server, for example via RADIUS or DHCP (*Dynamic Host Configuration Protocol*).

- Information about the protocol being used is gathered from the server.
- The communication can be done over any network, including Internet.

3.5 HSCSD – High Speed Circuit Switched Data

HSCSD is a technique in parallel to GPRS, as GPRS higher bandwidth can be reached by letting a user use more of the radio network. Opposite to GPRS, HSCSD is circuit switched. The connection is as for GPRS, that a user can use more time slots and traffic channels. The difference is how the timeslots/traffic channels are handled and how it is handled in the network. Since HSCSD is circuit switched the nodes SGSN and GGSN do not exist. The major difference is that there are more channels between MS and BTS, and between BTS and BSC. At most HSCSD can have eight channels, and GSM can normally only use one channel. The channels in HSCSD can be allocated either symmetric or asymmetric as the time slots can be allocated in GPRS. Normally asymmetric is used and if you have 4 channels you have one channel from the cellular phone to the network and three from the network to the cellular phone. HSCSD is released in 27 countries for over 100 million GSM users, Sweden is one of the countries. The technology is supported by many different mobile devices with transmission speeds between 28.8 kbit/sec to 43.2 kbit/sec for sending and receiving data.

3.6 Security

When people use new technology they are very skeptical, they don't know if it is secure enough, to use it. It could be difficult to convince them that something is secure before they have used it themselves. People are not so careful with their credit cards but they are reserved about giving out their credit card number online. The risk is normally not to use the credit card online the risk lays in that after the credit card has been used online, the credit card number is stored on a server and that server can be hacked. Thus, it is much easier to hack a server and to steal credit card numbers, than to eavesdrop on encrypted SSL (*Secure Sockets Layer*) connections.

3.6.1 Securing the Transmission

Powerful security mechanisms are needed for wireless networks, in order to ensure that high level layers can rely on secure transmission properties of the networks. Encryption is used to prevent eavesdropping; the integrity is kept by using checksums, authentication codes, and digital signatures. AUTHENTICATION authentication is used to verify the identity of communicating parties. In a wireless network, this procedure is commonly done both at the network layer and by higher level layer protocols that applications use. A public key or a secret key can be used for authentication.
ENCRYPTION Encryption is used to protect information from eavesdropping; the message is coded in a way that only the sender and receiver can access the data. PROTECTING THE MESSAGE INTEGRITY To keep message integrity, Checksums and Message Authentication Code (MAC) fields are used. The MAC field works like a regular checksum, where bits are added at the end of the message by applying an algorithm to the message. The recipient then uses the same algorithm in order to ensure that the message has not been altered.

3.6.2 GSM/GPRS/3G Network Security

In GSM and the following systems, the operator controls all the security keys and authentication methods. The *Subscriber Identity Mechanism* (SIM) card holds all the vital subscriber information and the keys that are needed. The traffic (voice and data) is encrypted and thus securely protected. The authentication codes are only calculated in two places: by the SIM card and the *Authentication Center* (AUC), this means that the operator has full control over the security. As a result, the wireless link of these systems provides one of the most secure transmission mechanisms available. The problem is that the users may not rely on this; they do not trust the wireless communications to be secure, because it is a new technique.

3.6.3 Enabling Security in Higher Layers

When a communication session starts or when a secure application is initiated, the communicating parties decide on a common set of algorithms to use throughout the session. This decision includes the encryption algorithms and data integrity protection as well as how to exchange keys. When symmetric keys are used, exchanging keys is especially sensitive, because if someone finds out what one key is, it means finding out what the other key is.

3.6.4 Security Issues

Even though mobile Internet networks generally are more secure than wired networks, there are some issues that need to be considered. One issue involves the protocol transaction in the WAP gateway. The WAP gateway converts the TCP/IP protocols into WAP protocols; this includes a translation of the security features. Between the WAP gateway and the content server, Transport Layer Security (TLS) is used. Between the WAP gateway and the WAP mobile device, *Wireless Transport Layer Security* (WTLS) is used. When this conversion is done the data have to be decrypted for a brief period of time during the translation. This means that someone could potentially hack the WAP gateway and gain access to the information. WAP gateway manufactures have to take this in consideration when designing the WAP gateways. This include doing both decryption and encryption in the same process internally, thus not storing the unprotected data in persistent memory and minimizing the time that the data is unprotected. Therefore it is a matter of how much the application developer trusts the owner of the WAP gateway (for example the mobile operator), and how much control the user wants to have over it. Some applications developers who use applications that have high security requirements are solving this problem by hosting the application themselves for example mobile banking.

3.7 3G and Systems of the Future

The upgrade to 2.5G such as GPRS was a big difference compared to 2G. New applications and services could be developed and new types of using areas for cellular phones have been introduced. Promising words about high bit rate were heard from media but the fact is that this is not really the case. One important feature is to be "always online". Neither the speed nor the *Quality of Service* (QoS) with various downlink speed and losses of packets are that impressive. Other important features that are missing in today's GPRS systems, even if only developers and operators see it, are open API's and architectures. The 3G systems will include all the functionality from 2G and 2.5G. Handover from 3G to 2G and 2.5G can be done from day one; this means that the operator can start building the new system in cities and urban areas. As the new 3G standard grows in popularity and the more money operators earn the result will be, that more base stations can be built in rural areas.

3.7.1 EDGE

EDGE (*Enhanced Data Rates for Global Evolution*) was developed by Ericsson to enable the transmission of a large amount of data at a high speed. It is a technology that gives GSM the capacity to handle services for the third generation of mobile telephony. In other words, EDGE is *not* a 3G technique, just a way of making GSM more effective. When all eight timeslots are used it allows data transmission speeds up to 384 kbps. This means a maximum bit rate of 48 kbps per timeslot, higher per timeslot than any other previously available mobile data service. It was initially developed for GSM mobile network operators that would not get any third generation spectrum. Then it was realized that EDGE also worked on TDMA networks. EDGE is a cost-effective way of migrating to 3G by implementing the changes in modulation that will be necessary for implementing 3G later. EDGE does not change much of the core network, which still uses GSM/GPRS. Rather, it concentrates on improving the capacity and efficiency over the air interface by introducing a more advanced coding scheme where every time slot can transport more data. In addition, EDGE adapts this coding to the current conditions, which means that the speed will be higher when the radio reception is good. New operator licenses are not needed for EDGE. To make the modulation upgrade, hardware upgrades will be needed to the radio interface. Each cell will need one new EDGE transceiver hardware unit. The new EDGE transceiver can also handle GSM and will switch over to EDGE mode when needed. Some operators who have acquired 3G licenses will still invest in EDGE to gain some competitive advantages. In the beginning when 3G is introduced it will have limited coverage. The fall back solutions in rural areas will be GPRS or EDGE, where EDGE provides significantly higher bit rates and capacity. EDGE uses nine different coding schemes to send the data information over the air. As the mobile user moves from the base station and the signal quality gets weaker, EDGE switch to a more robust coding scheme but with lower bit rates per time slot.

3.7.2 The Definitions of 3G

Higher speeds and multimedia services are often being used in presentations of 3G in media. 3G are based on the Universal Mobile Telecommunications System, UMTS, standard which is the standardization group ETSI:s definition of how the system are going to be constructed, in addition to Wideband Code Division Multiple Access, WCDMA, which concentrates upon the technique of the data traffic connections. The proper definitions of 3G, or International Mobile Telecommunication *2000* (IMT- 2000), are set by the *International Telecommunication Union* (ITU) in their recommendation (ITU-R M687-2). The recommendation includes the following items:

- A QoS that is comparable to fixed voice networks
- A phased development, with the first phase supporting bit rates of up to 2Mbps
- The capability to build terminals that have many different form factors ranging in size from what 2G phones offer up to what you can carry in vehicles
- A flexible architecture where you can easily add additional applications

3.7.3 Standardization Groups

As the Internet grows, users and companies get more depending on it. The information and the services shall be available to anyone, anywhere and on any device. New kinds of services pop up when Internet gets common on wireless devices and more people need to be connected twenty four seven. The plans for the frequency bands which 3G use was determined by ITU as early as 1992 on the World Administrative Radio Conference 1992 (WARC-92). The suitable frequency was around 2GHz, which then could be used both for satellite and terrestrial mobile systems. The original target was to have a single 3G or IMT 2000 standard, but this goal proved to be very difficult to reach. In 1997, three different standards were promoted separately, in Europe, United States and in Japan. Some big companies were represented in all these groups, working toward different goals instead of one global standard. In the first half of 1998, Europe made several decisions in the direction of WCDMA while the United States supported EDGE and cdma2000. Japan was also working toward standardizing WCDMA, but there were some key differences between its work and the European standard. In 1998, the ITU called for proposals for IMT -2000, and 10 proposals were submitted for the terrestrial part. These proposals spurred several standards to work toward harmonization and the Japanese standardization body, ARIB/TTC, and the European counterpart, ETSI, T1P1 (United States), and TTA (Korea) to join forces in the strive toward a global standard. The result was one WCDMA standard, and the *Third-Generation Partnership Project* (3GPP) formed. U.S. standardization bodies then created 3GPP2, which standardizes the cdma2000 system. Also 2000, GERAN (GSM EDGE Radio Air Interface) was added to 3GPP.

3.7.4 Key Features

A common feature for all different 3G systems is that their applications will run over the *Internet Protocol* (IP) and work independent of the bearer. Higher bit rates in 2.5G than in the 2G is something that the user not always can count on. This depends of the number of users in the cell and the distance to the base station. Because of this the developer have to design their application in a way that accept lower speed sometimes and maybe even loss of connection. The bit rates and QoS will be much higher in 3G, these will be the biggest differences comparing to older standards. Both uplink and downlink stream of data will have bit rates of hundreds of Kbps. QoS can be guaranteed for a user, and depending on what kind of agreement the user has with the operator, a limit of lowest bit rate for the user is promised. This is a QoS that was not applied on 2.5G where the speed could be as slow as zero. The connection can of course be lost in a 3G network as well if a user moves out of range of the coverage are.

3.7.5 Open Architecture

Services on the mobile Internet become more and more advanced; the ways of building a network exceeds, it is therefore important to have a flexible architecture. The 3G architecture is layered. This type of architecture enables the user to access an application in a service network from the fixed Internet as well as from a 3G handset. The application server and the core transport network can be the same. Data is routed to the right access network. The developer can therefore develop applications that work independently of the underlying bearer. By this, almost any IP-based application will run on the 3G networks. There will be APIs between the layers and these underlying layers can be accessed through open and standardized interfaces.

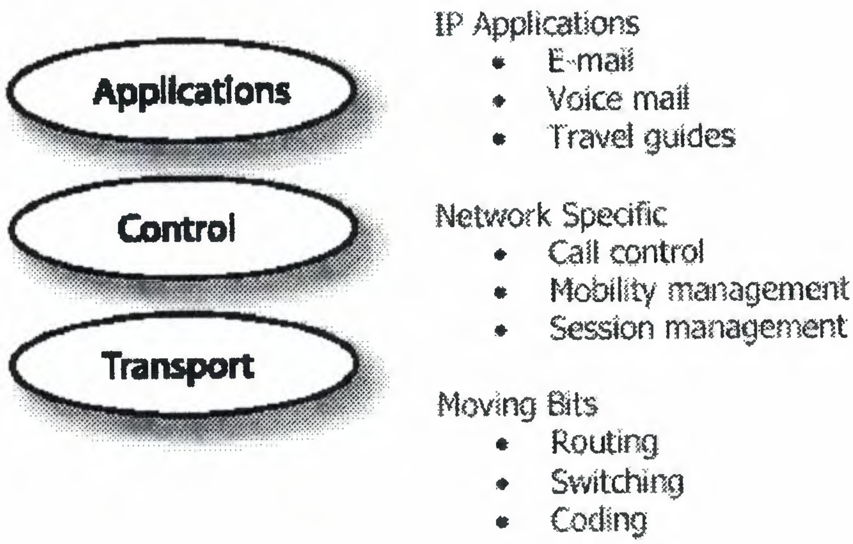

Figure 3.4 GPRS Architecture

3.7.6 4G

The definitions of what 4G will be are not decided yet, everyone you ask will give you different answers. One thing is for sure, the speed will increase considerably to between 20- 100 megabit. No frequency spectra are reserved yet and no one knows how the network will be build. But with today's services, few need that fast speed. This is an interesting thing, because this means that services of the future need to be planned before the network will be built. Because if no services are presented, no one needs the fast system. [29] A problem is that the speed depends a lot of how close the user are to the nearest base station, the highest speeds can only be reached if a user is next to a base station and all alone in the cell. This is a dream scenario that hardly never will be reached, but to make the chance bigger and the QoS higher, a lot of new base station needs to be built. That is a big problem, because only to upgrade from GPRS to 3G a lot of new stations (around 5.000 – 10.000 in Sweden) need to be built, and the next phase when 4G shall be introduced we need to double that number. This forces to change the way of how masts and stations are constructed, if not, our surroundings will look like a pincushion. Operators need to think about this and find practical solutions. One thought is to design the mobile devices as small base stations, a peer-to-peer net with devices that both sends and receives signal that can be picked up from other end work as a bridge between the ordinary mobile station and the one who wants to make a call or use the mobile internet. Experts in the area believe that 4G will be introduced around the year of 2010. This depends of course of the future use of 3G and if the need for an upgrade is interesting for the operators and the users.

4. GPRS and UMTS

4.1 Overview

Hughes Software Systems GPRS and UMTS solutions enable "always on" mobility offering new ways to communicate, transact business, find information and be entertained. Find out more... GPRS (General Packet Radio Service) and UMTS (Universal Mobile Telecommunications System) are changing the face of communications offering new ways to communicate, transact business, find information and be entertained. This entails managing more capacity for voice services and meeting customers' increasing need for seamless data connections. HSS spearheads the evolution to the 3rd Generation of mobile communication - UMTS, which will deliver high-value broadband information, commerce and entertainment services to mobile users via fixed, wireless and satellite networks.

Our GPRS and UMTS products and solutions provide your business with a competitive edge and the time to market advantage.

4.2 GPRS (General Packet Radio Service)

General Packet Radio Services or GPRS is the mobile networking industry's answer to enabling pervasive mobile data networking and mobile commerce. GPRS is a technology that is the bridge between the current GSM-based mobile networks and the next generation UMTS - based mobile networks. With data rates of 115 KBPS, the GPRS (GSM 9.6 KBPS) data transmission technology is optimized for "bur sty" dotcom services such as wireless Internet/intranet, multimedia services, instant messaging, and mobile Internet access and connects users directly to Internet Service Providers. GPRS therefore offers a smooth add-on to integrate into existing networks and supplements today's Circuit Switched Data and Short Message Service, providing users with "always on" connectivity and greater bandwidth. For new operators, it is also attractive to launch

GPRS networks to provide competitive dotcom services.

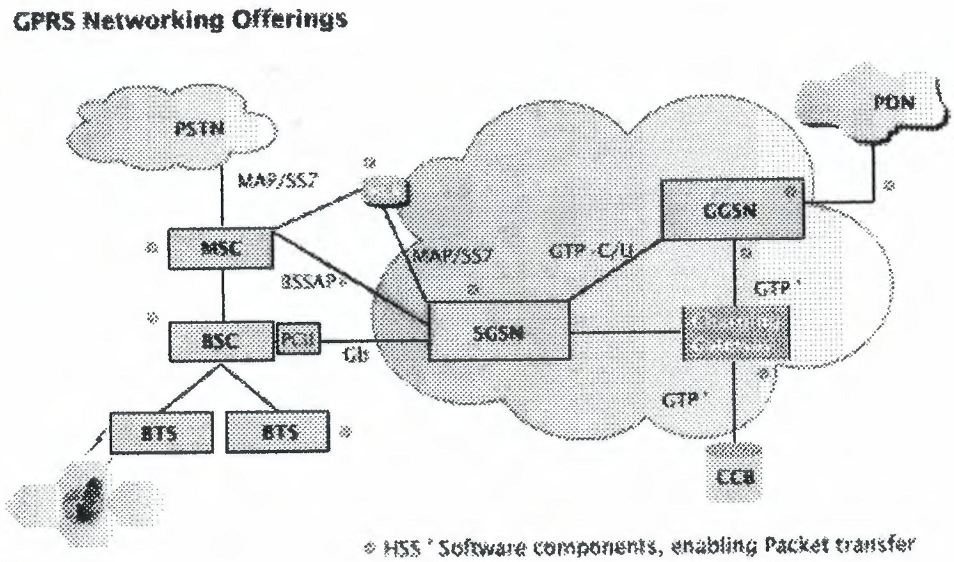

Figure 4.1 GPRS Network

4.3 UMTS (Universal Mobile Telecommunications System)

3G or third generation of mobile communication - UMTS is wideband wireless connectivity, which will usher in true convergence of technology. With data rates up to 2MBPS, UMTS seeks to build on and extend the capability of today's mobile, wireless and satellite technologies by providing increased capacity, data capability and far greater range of services using an innovative radio access scheme and an enhanced, evolving core network.

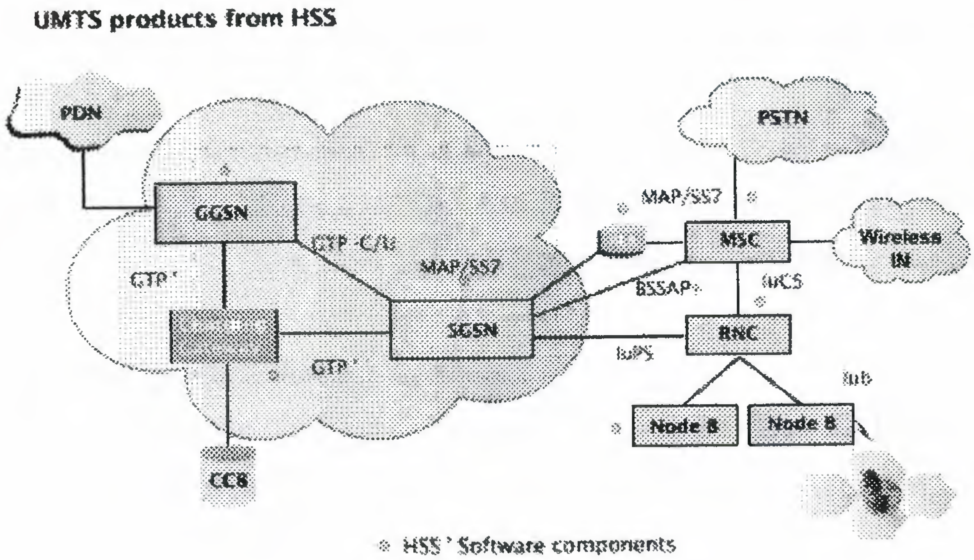

Figure 4.2 UMST Products From HSS

UMTS allows extremely high bandwidth multimedia applications and m-commerce opening a New World of possibilities. From customized infotainment, streaming video, video messaging to location based services; UMTS offers a unique opportunity to create a market for highly personalized and truly unique mobility services.

4.4 GPRS and UMTS Stacks

Our GPRS and UMTS protocol stacks are reliable, efficient and are proven building blocks for deploying exceptional GSM, GPRS and UMTS terminal products.
HSS is the first company to offer unique Integrated Stacks as value added software solutions for the In interface of the 3G networks. The Cups and IuCS integrated software products provide distributed and highly scalable architecture offering higher reduction in time to market for 3G nodes.
HSS has the domain expertise and comprehensive product portfolio to deliver Next-Generation products, solutions and services. Also see Service Creation Environment.
Utilizing this rich experience set, HSS has built software products enabling seamless transition from GSM to GPRS via EDGE and finally UMTS.

The HSS framework for GPRS is a scalable solution that can be configured as an SGSN, GGSN or a combined GSN and has interfaces to the HLR, Charging gateway, MSC/VLR and PDN.

HSS also offers high performance, interoperable and versatile Protocol Stacks like - Gb stack, GPRS Tunneling Protocol, MAP, IPoA, BSSAP+ Stack, AAL2 Signaling Stack (ALCAP), ATM SAAL Stack, Core Network Ranap Stack for rapid network roll out.

4.4.1 GPRS Gb Interface Stack

The GPRS Gb Interface Stack from HSS has been developed for both the SGSN and BSS/PCU nodes. The BSS - Gb product can be used to upgrade existing GSM BSS equipment and provide GPRS based packet data services.

The use of GPRS technology facilitates the provision of packet mode data services to GSM networks and speeds up data transfer rates up to 115 kbps. It provides new and superior applications for mobile users, by supporting different packet data protocols (IP, X.25) and offering select services to users through different Quality of Service. OEMs benefit through GPRS, as it enables shared use of radio resources, data volume dependent charging and offers higher efficiency of radio resources.

The GPRS Gb Interface Stack from Hughes Software Systems (HSS), has been developed for both the SGSN (Serving GPRS Support Node) and BSS/PCU (Packet Control Unit) nodes. The BSS -Gb product can be used to upgrade an existing GSM BSS equipment and provide GPRS based packet data services. On the other hand, SGSN vendors can use the SGSN-Gb product to build their equipment. This support will help GSM networks provide packet-data based services and applications like mobile Internet, mobile e-mail access and wireless VPNs. Both the stack products are equally attractive for use by Test & Measurement tool vendors.

4.4.1.1 HSS' GPRS Gb Stack consists of the following layers:

- SNDCP
- LLC
- BSSGP (both BSS and SGSN sides)
- NS (both BSS and SGSN sides)

4.4.1.2 HSS' GPRS Gb Stack: Architecture

The Gb stack has the following architecture on the SGSN side:

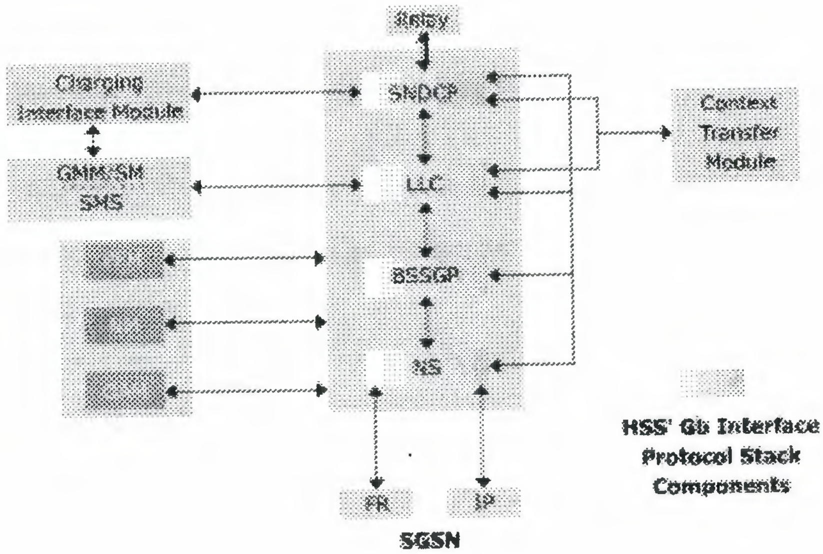

Figure 4.3 GPRS Architecture

The Gb stack has the following architecture on the BSS side:

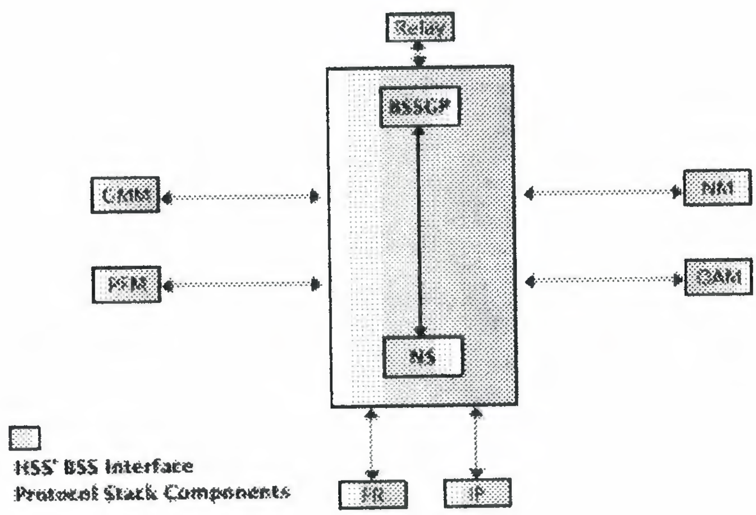

Figure 4.4 GPRS Architecture

4.4.1.3 HSS' GPRS Gb Stack: Subsystems

SNDCP

- Transmission and reception of N-PDUs in Acknowledged and Unacknowledged LLC mode
- Multiplex several packet data protocol packets for same MS
- Multiplex several instances of a packet data protocol for same MS
- Segmentation and Re-assembly of network packets to/from LLC frames
- Header Compression(RFC1144 and RFC 2057)
- Data Compression(V.42bis)
- Transmission and reception of variable length N-PDUs
- Parameter Negotiation
- Buffers N-PDUs for acknowledged mode services

LLC

- Provides reliable logical MS-SGSN link
- Variable length frames
- Acknowledged and Un-acknowledged transfer
- Protected and Unprotected payloads
- Permits communication between one SGSN and multiple MS over same medium
- Parameter Negotiation
- User Data Confidentiality using Ciphering
- Supports Multiple LLEs per TLLI
- Provides flow control in the Asynchronous Balanced Mode (ABM)
- Error Detection, Recovery and Notification
- Provide Sequence Control to maintain the sequential order of frames across a logical link connection

BSSGP

- Separate BSSGP-SGSN and BSSGP-BSS software modules
- Efficient implementation of flow control algorithm provides support for features like:
    - Delay class

- QoS
  - Priority and frame lifetime
  - Dynamic BVCI learning
  - Pluggable customized flow control algorithms
- Transfer of LLC Frames between BSS and SGSN
- Transfers GPRS Mobility Management (GMM) Protocol Data Units (PDUs) between BSS and SGSN
- Transfers Network Management (NM) PDUs between BSS and SGSN
- Flow Control on the down-link
- LL-FLUSH procedures
- Auto Flush

NS

- Designed to accommodate a wide variety of boards/hardware configurations
- Provides support for:
  - Hash based load sharing
  - Identifying a frame relay link as foreign or local. This helps in avoiding traffic on the back plane bus in case the hardware design involves NS-VCs belonging to one NSEI spanning multiple Gb boards
  - FR or IP based sub network services (SNS) layer
- Transmission of NS SDU
- Encapsulation of NS SDU
- Load Sharing across NSVC
- Congestion Detection and Reporting
- Block/Unblock procedures for NSVC
- Reset and Test procedures for NSVC
- Status Indication

4.4.1.4 Operation and Management Support

GPRS Gb Product provides extensive operation and management support as well as debugging assistance via:

- Run-time control of capacity and configuration parameters

- Extensive statistics collection (API protocol, internal events and error statistics)
- Error/alarm reporting
- Multi-level tracing supports (detailed and brief traces)

4.4.2 GPRS Tunneling Protocol (GTP)

The GPRS Tunneling Protocol (GTP) software from Hughes Software Systems (HSS) enables communication between GPRS Support Nodes in a GPRS network (both GSM Phase 2+ and UMTS). GTP is defined for the Gn interface, i.e. the interface between GSNs within a PLMN, and for the Gp interface between the GSNs in different PLMNs. In addition, the GTP software at the SGSN, provides the user data transmission on the IuPS interface.

4.4.2.1 GTP STACK OFFERINGS

GPRS Tunneling Protocol (GTP) software enables GPRS Support Nodes in a GPRS network (both GSM Phase 2+ and 3G) to communicate with each other.
HSS provides protocol stack software packages for GTP-C/U on SGSN and GGSN, GTP-U on RNC and for GTP' on GSN and Charging Gateway. The GTP-C module is for signaling while the GTP-U is for user data transport. GTP' is used to transfer the Call Data Records (CDRs) from SGSN/GGSN to the Charging Gateway.

4.4.2.2 GTP Offerings

The HSS' GTP stack is available for SGSN, GGSN and CGF. Separate packages are available for

- 3G GGSN GTP-C/U with backward compatibility to 2.5G across Gn and Gp interface
- 2.5G SGSN GTP-C/U across Gn and Gp interface
- 3G SGSN GTP-C/U with backward compatibility for 2.5G across Gn and Gp interface
- GTP' for SGSN/GGSN across Ga interface
- GTP' for Charging Gateway Functionality (CGF) across Ga interface
- GTP-U for RNC across Iu-PS Interface

4.4.3 MAP Stack

The GSM / 3G PP compliant MAP Stack from Hughes Software Systems (HSS), enables signaling between different network entities such as HLR, MSC/VLR, SGSN and GGSN. This stack is built on top of the Transaction Capabilities Application Part (TCAP) layer, which is the top most layer of the Signaling System Number 7 (SS7) stack.

4.4.3.1 HSS' MAP Stack: Capabilities

The HSS MAP Stack provides extensive layer management features via APIs which:

- Initialize stack entity
- Provision/improvising data
- Collect/initialize statistics and enable/disable statistics collection
- Log trace messages, enable or disable tracing, and configure different trace levels
- Support error and alarm reporting

The diagram below depicts the MAP interfaces in a GSM network:

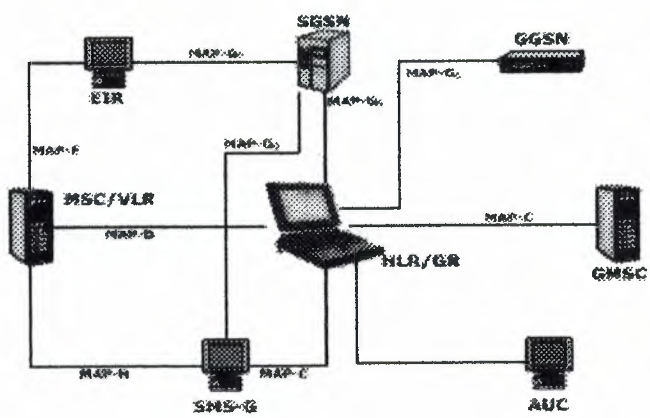

Figure 4.5 GPRS HSS' MAP Stack

4.4.3.2 HSS' MAP Stack: Architecture

HSS' MAP Stack provides individual packages for specific MAP users, which include:

- HLR
- SGSN
- GGSN

- MSC/VLR
- SCF
- Combined SGSN, GGSN and MSC

HSS' MAP stack has a multi-threaded architecture to take advantage of a multi-processor environment. This ensures that independent tasks are performed in different threads. HSS MAP stack can also support single-threaded execution, if required. The stack has wrapper functions for encoding or decoding which eliminates dependency on an ASN compiler.

4.4.5 BSSAP+ Stack

The BSSAP+ protocol stack is responsible for conducting non-GPRS procedures over the Gs interface, between the SGSN and the VLR. The BSSAP+ protocol stack from Hughes Software Systems (HSS), has been developed for the SGSN (Serving GPRS Support Node) side.

4.4.5.1 HSS' BSSAP+ stack supports procedures like:

- Paging for non-GPRS services
- Location update for non-GPRS services
- Non-GPRS alert
- Explicit IMSI detach from GPRS and non-GPRS services
- Implicit IMSI detach from non-GPRS services
- VLR failure
- SGSN failure
- HLR failure
- MS Information
- MM Information
- Error handling
- Tunneling non-GSM Signaling

4.4.5.2 Operation and Management Support

GPRS BSSAP+ product provides extensive operation & management support, and debugging assistance:

- Run-time control of capacity and configuration parameters
- Extensive statistics collection (API protocol, internal events and error statistics)
- Error/alarm reporting
- Multi-level tracing support (detailed and brief traces)
- Tracing levels can be modified at run-time to enable appropriate support for field level debugging
- Multi-level error reporting (critical, major and minor errors)

4.4.6 AAL2 Signaling Stack (ALCAP)

AAL2 Signaling is the signaling protocol employed for dynamic establishment, release and maintenance of AAL2 point-to-point connections between nodes, in an AAL2 network.

The AAL2 signaling stack (ALCAP) from Hughes Software Systems (HSS) is a field-proven building block for developing telecom equipment, network components as well as applications.

4.4.6.1 HSS' AAL2 Signaling (ALCAP) Stack finds applications in:

- Node B, RNC and MSC equipment of 3G networks
- Loop Emulation Service (LES)
- Voice over ATM implementations

Architecture

The following interfaces are provided by the AAL2 stack:

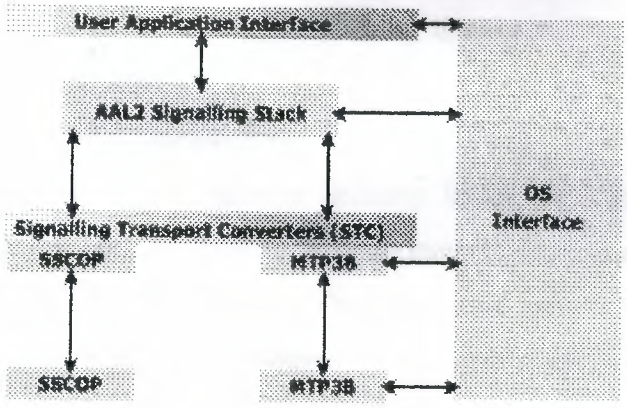

Figure 4.6 AAL2 Signaling Stack

4.4.6.2 HSS' AAL2 Signaling Stack: Subsystems

AAL2 signaling

- Extensive statistics collection – internal events and error statistics
- Error/alarm reporting
- Multi-level tracing support – detailed, medium and brief traces
- Flexibility for the signaling entity to operate over MTP3B and/or SAAL
- Provides support to interface a third party routing engine
- Provides flexibility to the user to perform resource management (CID/link management)
- AVL tree based search algorithm to expedite lookup

STC for SSCOP

- Provides well-defined interfaces to support plug-in of customized modules

STC for MTP 3B

- Provides well-defined interfaces to support plug-in of customized modules

4.4.7 ATM SAAL Stack

The SAAL layer is used for reliable signaling between ATM endpoints. ATM Signaling AAL (SAAL) stack from Hughes Software Systems (HSS), provides efficient and reliable solutions to signaling components.

HSS' ATM SAAL stack is a field proven building block for developing telecom equipment, network components as well as applications. It has been integrated with protocols like Broadband V5, ATM SVC etc. The equipment manufacturers can reduce their time-to-market by using this standards-based off-the-shelf stack from HSS.

4.4.7.1 HSS' ATM SAAL Stack finds application in:

- 3G and GPRS equipment – Used in Node B, RNC, SGSN and MSC for providing Iub, Iur, Iu-PS and Iu-CS interfaces
- ATM switches
- Interworking network devices
- Test and Measurement devices

4.4.7.2 HSS' ATM SAAL Stack: Offering

HSS offers both SAAL-UNI and SAAL-NNI:

- UNI side offering
  - SSCOP conforming to ITU-T Q.2110
  - SSCF at UNI conforming to ITU-T Q.2130
- NNI Side Offering
  - SSCOP conforming to ITU-T Q.2110
  - SSCF at NNI conforming to ITU-T Q.2140

4.4.8 RANAP Stack

RANAP (Radio Access Network Application Part) is the Radio Network Layer signaling protocol for the Iu interface. It resides in the UTRAN & the Core Network (CN).

RANAP handles signaling for the following:

- Iu-PS - RNC and 3G SGSN

- Iu-CS - RNC and 3G MSC

It also provides signaling channel to transparently pass messages between the User Equipment (UE) and the CN.

Over the IU interface, RANAP is used to:

- Facilitate general UTRAN procedures from the Core Network such as paging
- Separate each User Equipment (UE) on protocol level for mobile specific signaling management
- Transfer transparently non-access signaling
- Request and manage various types of UTRAN Radio Access Bearers
- Perform the Serving Radio Network Subsystem(SRNS) Relocation

4.4.8.1 HSS' CN RANAP Stack

The CN RANAP Stack protocol implementation from Hughes Software Systems (HSS) provides support for all RANAP Elementary Procedures (EPs) for accomplishing Radio Access Bearer Management Serving.RNS.Relocation, and Transport of NAS Information between UE and CN, Paging UE and Release of Iu resources.

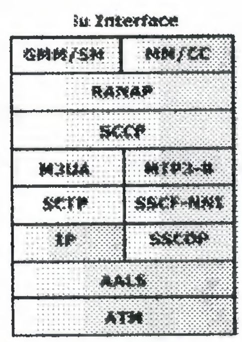

Figure 4.7 HSS' CN RANAP Stack

4.4.8.2 HSS' CN RANAP offering includes:

- Encoding/Decoding for all Iu-CS and Iu-PS messages in RANAP
- Iu connection management on top of SCCP for all connection-less and connection-oriented messages

- Error Indication procedures for Protocol errors detected during message validation
- Timers for elementary procedures
- Implementation for complete handling of Overload, Reset and Reset Resource Elementary procedures.

4.4.8.3 API Primitives

- Provide procedural means to specify how a service user can invoke the RANAP service
- The various primitives offered include:
    - Service User/Upper Layer APIs
    - RANAP-GMM, RANAP-SC (Service Co-ordinator)
    - Lower Layer APIs
    - RANAP-SCCP
    - Layer Management Entity (LME) APIs related to initialization/provisioning of RANAP, statistics collection/reporting, tracing, stack error reporting

4.4.8.4 Conformance to Standards

- Full compliance to 3GPP TS 25.413 V 3.2.0, release 1999

4.5 GPRS and UMTS Solutions

Shorten your time to revenue and build future-safe solutions that meet the carrier-class requirements of scalability, reliability and performance. The Hughes Software Systems Frameworks are source code technologies, which can be easily customized to meet specific requirements. Low implementation and operating costs and customization services ensure a perfect-fit to the customer on their platform of choice.

4.5.1 Integrated Iu Interface Solution for 3G Networks

The integrated Iu interface product from HSS, is unique, as it goes beyond the traditional protocol stack. The UMTS Iu interface enables interconnection of Radio

Network Controllers (RNCs) with Core Network nodes. Hughes Software Systems (HSS) has introduced industry's first distributed and highly scalable Iu interface solution. This solution enables OEMs to build high capacity 3G nodes faster. A value added software solution, the Iu interface is available in two separate packages Iu-Ps and Iu-Cs for Packet Switched and Circuit Switched domains respectively. The Iu-Cs interface interconnects between the MSC/VLR and the RNC network nodes while the Iu-Ps interface provides interconnection between the SGSN (Serving GPRS Support Node) and the RNC network nodes in UMTS/3G networks. The Iu is offered as an integration of standards-based RANAP (CS and PS), SCCP (Signaling Connection Control Part), implemented over either SIGTRAN (for IP network nodes) or Broadband SS7 (ATM transport). The ALCAP (AAL2 Signaling Stack) and GTP-U are also offered as optional elements. The product offering includes RANAP (Radio Access Network Application Part) encoding/decoding, Iu connection management for all connection-less and connection-oriented messages, error Indication procedures, as well as complete handling of reset and reset resource elementary procedures. This solution is extensible and portable, and is ideal for implementation on an embedded platform, host based system - ranging from high-end to low-end systems.

4.5.2 GSN (GSN-Lite)

The GSN-Lite solution from HSS is a GPRS Support Node targeted towards small-sized GPRS networks. It is a fully manageable, cost-effective platform engineered to facilitate easy deployment in corporate and community GPRS networks. HSS' GSN-Lite also supports all its signaling and data interfaces over the Internet Protocol (IPv4) to provide seamless integration with packet-based networks.

4.5.3 3G SGSN

The HSS 3G SGSN Software Offering is targeted towards OEMs, to help them build, test and deliver their 3G solutions faster and at lower cost to their Service Provider customers.

The 3G SGSN integrates industry-leading interface stack solutions, viz., the GMM, SM, IuPS, MAP /SS7, BSSAP+ & GTP.

4.5.4 HSS Value Proposition:

- Standard based software, which is interoperable
- Assured timely enhancement of products keeping up with international standards
- Reduced time to deploy
- Reduced time to market
- Significant cost advantages
- Allows customer to meet external commitments

List of Abbreviation

2G	Second generation; generic name for second generation of digital mobile networks (such as GSM, and so on)
3G	Third generation; generic name for next-generation mobile networks (Universal Telecommunications System [UMTS], IMT-2000; sometimes GPRS is called 3G in North America)
3GPP	3G Partnership Project
BG	Border gateway
BGP	Border Gateway Protocol
bps	Bits per second
BSC	Base Station Controller
BTS	Base transceiver station
CS	Circuit switched
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
EDGE	Enhanced data rates for GSM evolution; upgrade to GPRS systems that requires new base stations and claims to increase bandwidth to 384 kbps
ETSI	European Telecommunications Standards Institute
Gb	Interface between a SGSN and a BSS
Gc	Interface between a GGSN and a HLR
Gd	Interface between a SMS-GMSC and a SGSN, and between a SMS-IWMSC and a SGSN
Gf	Interface between a SGSN and an EIR
GGSN	Gateway GPRS Support Node
Gi	Reference point between GPRS and an external packet data network
GIWU	GSM interworking unit

GMSC Gateway mobile services switching center
Gn Interface between two GSNs within the same PLMN
Gp Interface between two GSNs in different PLMNs
GPRS General Packet Radio Service; upgrade to existing 2G digital mobile networks to provide higher-speed data services
Gr Interface between a SGSN and a HLR
Gs Interface between a SGSN and a MSC/VLR
GSM Global System for Mobile Communications; most widely deployed 2G digital cellular mobile network standard
GSN GPRS Support Node (xGSN)
GTP GPRS Tunneling Protocol
GW Gateway
HDLC High-Level Data Link Control
HLR Home location register
HSCSD High-speed circuit-switched data; software upgrade for cellular networks that gives each subscriber 56K data
IP Internet Protocol
ISP Internet service provider
L2TP Layer two Tunneling Protocol
LLC Logical Link Control
MAC Medium Access Control
MM Mobility management
MS Mobile station
MSC Mobile services switching center
NAS Network access server
OA&M Operations, administration, and management
OSS Operations Support System
PCU Packet control unit
PDA Personal digital assistant
PDN Packet data network
PDP Packet Data Protocol
PLMN Public Land Mobile Network; generic name for all mobile wireless networks that use earth base stations rather than satellites; the mobile equivalent of the PSTN
PSPDN Packet Switched Public Data Network
PSTN Public Switched Telephone Network
PVC Permanent virtual circuit
QoS Quality of service
RADIUS Remote Authentication Dial-In User Service

RLP	Radio Link Protocol
SGSN	Serving GPRS Support Node
SLA	Service-level agreement
SMS	Short message service
SMSC	Short message service center
SS7	Signaling System Number 7
TCP	Transmission Control Protocol
TE	Terminal equipment
TDMA	Narrowband digital TDMA standard; uses same frequencies as AMPS, thus is also known as D-AMPS or digital AMPS
TS	Time slot
Um	Interface between the MS and the GPRS fixed network part
VAS	Value-added services
VLR	Visitor location register
VPN	Virtual private network
WAP	Wireless access Protocol; important protocol stack (Layers 4 through 7 of the OSI model), used to send simplified Web pages to wireless devices; uses IP but replaces TCP and Hypertext Transfer Protocol (HTTP) with UDP and WTP, and requires pages to be written in WML rather than in HTML

Conclusion

GPRS enables GSM operators to offer efficient mobile access to external packet switched networks, such as the Internet and corporate intranets. Several users can share the same network resources at the same time and enjoy transfer rates of up to 115 kbit/s. To support GPRS, two new nodes—the SGSN and the GGSN—must be added to the GSM network

GPRS is a new service that provides actual packet radio access for mobile Global System for Mobile Communications (GSM) and time-division multiple access (TDMA) users. The main benefits of GPRS are that it reserves radio resources only when there is data to send and it reduces reliance on traditional circuit-switched network elements. The increased functionality of GPRS will decrease the incremental cost to provide data services In addition, GPRS will allow improved quality of data services as measured in terms of reliability, response time, and features supported.

GPRS is a step on the way to the next generation of mobile systems, 3G. If GPRS does not get the popularity that the telecom industry hope for, the building of a 3G network is jeopardized. A lot of money needs to be spent on the new network and it is important that the user needs and wants 3G in order for it to be a success.

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