White Paper

Interfacing with interWAVE

General Packet Radio Service • GPRS

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Introduction

General Packet Radio Service (GPRS) is a new service that provides packet radio access for users of Global System for Mobile Communications (GSM) technology. It is truly a monumental step in the evolution of mobile communications towards data centric paradigm. The introduction of GPRS marks the first time a packet data technology is implemented in large scale in the circuit switched world of GSM. It is a key stepping stone in the transition to Third Generation (3G) mobile networks and beyond.

Background

Up until recently, the majority of users were accessing the Internet only through wired networks, for example through Internet Service Providers (ISPs) or corporate Local Area Networks (LAN). The recent and rapid growth of wireless networks coupled with the increase in Internet and Web content has been the driving force for Wireless Internet access.

In recent years, data communication service has been one of the fastest growing sectors in the telecommunication market. In the wireless arena, most of the growth has been attributed to the widespread use of Short Message Service (SMS) and SMS-based Value Added Services (VAS). There are over 20 billion short messages sent each month worldwide and the trend is up.

Other than SMS, there has been limited usage of wireless data services. Circuit Switched Data (CSD) applications have had only very limited use (such as CSD based modem access to content and Wireless Access Protocol -WAP- based services). The Wireless Internet access promised by WAP was generally accepted as a failure for three important reasons: 1) the small display (most text based) on the mobile phone, 2) the not-always on, slow, and expensive CSD data pipe, and 3) regular Internet content needs reformatting or conversion before being suitable for WAP access.

Looking at the history of slower than expected wireless data growth (except SMS), there are a number of generic factors that hinder its growth:

- High cost of connection
- Low data speed (SMS is 160 character per message and CSD is mostly 9.6kbps)
- Long setup time and not always on (in the case of CSD, it is cost prohibitive to leave a connection on at all time).
- Lack of high value data services/applications
- Limitations of terminals (size of display, color rendering, battery life)
- Lack of universal standards (many proprietary schemes have failed)

As a result of the above, there has been a constant desire for an always-on connection that provides higher bandwidth and allows low cost access to the Internet and its vast amount of information, content, and variety of VAS. The advent of GPRS addresses most of the above issues, and therefore, holds the very promise for low cost, ubiquitous access to the Internet and the transition towards a data centric paradigm.

GPRS Benefits

GPRS was developed to enable GSM operators to meet the growing demand for wireless packet data services that resulted from the explosive growth of the Internet and corporate intranet. The tight integration of GPRS with the Internet or intranet revitalizes many of the existing applications and quickly spawns new ones. These applications and services include access to Internet/intranet, email, messaging, information services/WAP, or even wireless telemetry. Furthermore, availability of GPRS will enhance the WAP user experience via an always-on packet data connection, at affordable cost.

The growing popularity of wireless voice services

has resulted in the steady increase of the number of subscribers, most notably in developing markets. However, in mature markets such as Western Europe, penetration has reached more than 70 percent in some countries. The increasing competition among service providers, on a more or less commodity like voice service, has generally led to a steady drop in the per-minute charge and hence the Average Revenue Per User (ARPU). The popularity of prepaid services has exacerbated the problem.

The availability of GPRS to the operators creates a new revenue opportunity (data revenue) and results in more efficient use of the scare wireless bandwidth compared to existing CSD offering, which reduces the cost for supporting wireless data services. This cost reduction, in turn, will reduce the entry barrier to new wireless data subscribers, making GPRS services far more affordable.

The great success of I-Mode in Japan and the rapid increase of SMS-based applications in Europe and Asia have clearly shown that wireless data can indeed increase operators' revenue if the wireless data applications offered meet the dire needs of subscribers. GPRS is widely expected to bring wireless data to new heights.

At the micro level, GPRS gives GSM operators the opportunity to gain next generation experience while building both data and IP skills and gradually fuel the buildup of applications and services necessary for justifying the transition to 3G.

The tight coupling of GPRS and GSM infrastructure ensures maximum reuse of GSM and lowers the incremental cost to add a true packet data service. However, the incremental capability that GPRS offers is far more significant if operators know how to turn it into revenue.

From a long-term evolution viewpoint, the introduction of GPRS is a very significant revolutionary step out of the circuit centric world of mobile communications. GPRS is considered a preview of 3G, offering 90 percent of the end user value. It does almost everything 3G promises, except high data rates. It brings packet data to GSM, making GSM/GPRS a powerful standard for voice and packet data services worldwide.

In comparison to GPRS, the 3G investment is much larger. It involves technologies that are superior but far more complex. Some say that 3G offers an evolutionary step (not a revolutionary step since GSM/GPRS can do most of the high revenue services claimed by 3G) towards 3.5G and 4G, emphasizing the importance and revolutionary nature of the GPRS.

Timelines for GPRS

When a new service is introduced, there are a number of stages before it becomes established. GPRS service development includes standardization, infrastructure development, network trials, contracts placed, network roll-out, availability of terminals, application development, etc. A history of GPRS development milestones is located on the following page.

Date	Milestone
1999 - 2000	Network operators placed trials and commercial contracts for GPRS infrastructure. Incorporation of GPRS infrastructure into GSM networks.
Summer of 2000	First trial GPRS services became available. Typical single user throughput was around 20 kbps (2+1 phone running CS-2). For example, T-Mobil had a GPRS trial at Expo2000 in Hanover in the Summer of 2000.
Summer of 2001	Basic GPRS terminals began to be available in commercial quantities for several vendors.
Throughout 2001	Network operators launched GPRS services commercially and rolled out GPRS. Vertical market and corporate GPRS early adopters began using it for data mobile communications.
2001/2	Typical single user throughput has been 20-40kbps. New GPRS specific applications, higher bit rates, greater network capacity solutions, more capable terminals became available, fuelling GPRS usage.
Start of 2002	Typical single user throughput likely to be about 40 kbps (4+1 phone). Over 10 million GPRS phones and terminals were made available globally.GPRS was routinely incorporated into high end GSM mobile phones and was starting to reach critical mass in terms of usage. (This is the equivalent to the status of SMS in 1999).

One of the key limiting factors for the timing of GPRS deployment has been GPRS terminal availability; the same factor is expected to drive the EDGE and 3G deployment schedules in the near future.

GPRS Applications

The business justification for GPRS depends largely on the revenue operators hope to generate from the applications enabled by GPRS. Just as SMS has become a revenue generator for many operators, GPRS as a new generic service is expected to not only revitalize the existing wireless data applications but also enable many unique new applications in the future.

There are many ways to categorize wireless data applications. Perhaps the broadest classification is between corporate and consumer applications. Corporate users are more interested in using applications that help them to efficiently conduct business and work related activities (e.g., email, intranet access, dispatch, document load, etc.) while consumer users have broader interests (e.g., information services, financial/banking access, gaming, etc.) and are far more price sensitive.

In the following discussion, we divide the GPRS applications into the following broad categories for easy understanding:

- Communications (email, SMS, unified messaging, chat, Internet/intranet access)
- Information Services (value-added service based on information, push/pull, entertainment)
- Transaction Services (m-commerce, financial/banking transactions, ticketing, retail)
- Location-based Services (finding area specific interest, location sensitive ads)
- Vertical Applications (job dispatch, sales force management, telemetics)

Communication Applications

Communication applications are characterized by the interest of the users to communicate with each other or to use it as a communication pipe such as remote access to Internet/intranet. These include, but are not limited to email, SMS, fax, voice mails, multimedia messaging, instant messaging, and group chat.

With the proliferation of the Internet and intranet, the ability to remotely access content on the Internet/intranet becomes very important. When mobile workers are away from their desks, they clearly need to connect to the LAN in their office. Remote LAN applications encompass 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 database applications. The mobile terminal such as handheld or laptop computer has the same software programs as the desktop on it, or smaller client versions of the applications accessed through the corporate LAN.

This application area is therefore likely to be a conglomeration of remote access of several different information types such as email, intranet, and databases access. This information may be accessible through web browsing tools or require proprietary software applications on the mobile terminal. The ideal bearer for Remote LAN Access depends on the amount of data being transmitted, but the speed and latency of GPRS make it practically suitable when higher speed alternative access such as 802.11 WLAN and wireline access are not available. For bandwidth intensive activities such as file transfer or data/application downloading, the current GPRS speed (around 40kbps) will be less desirable. This is where EDGE and 3G technologies can help.

Despite many improvements in the quality of voice calls on mobile networks, with features such as Enhanced Full Rate (EFR), broadcast quality still does not exist. There are scenarios where journalists or undercover police officers with portable professional broadcast quality microphones and amplifiers conduct and capture interviews with people or radio reports, 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.

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

In recent years, email has gained tremendous popularity. As result, wireless access to email is becoming more and more important for both the corporate and consumer markets. Email on mobile networks may take one of two forms. Emails may be sent to a mobile user directly (email gateway service), or users can have an email account/mailbox provided by their network operator or their ISP. In the latter case, it would be very nice if a notification could be forwarded to their mobile terminal; the notification should include the subject line and the first few lines of

the email as well as details of the sender, the date/time. However, 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.

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 LAN and include Microsoft Mail, Outlook, Outlook Express, and Microsoft Exchange. Since GPRS terminals will be more widespread in corporations than amongst the general mobile phone user community initially, there are likely to be more corporate email applications using GPRS.

In developing countries, email is also gaining popularity and becoming a cost effective and time efficient way to communicate instead of using postal services that are often slow, unreliable, and costly. For example, many Pacific Island countries have large numbers of islands where some of the residents may not have the luxury of frequent and prompt postal or carrier services. Email via GPRS provides instance communication anywhere on the islands. Fax attachments may also accompany emails. For tourists, instead of sending a post card home from the islands and risk it not being received before they themselves return home, they can send short email over GPRS connections and receive replies instantly.

Similarly, developing countries, in general, have little or no existing wireline infrastructure to reply on for Internet/intranet access or electronic communications. Many users' first experience of a telephone call was with a GSM handset instead of a wireline telephone. In these areas, the best hope for any Internet access, for instance for students to do school projects, is to rely on a GPRS connection which is relatively inexpensive compared with the traditional circuit switched GSM data service. In these cases, GPRS may be the only affordable data connection available.

Information Services

Information services are value-added services offered and controlled by the operators or service providers that provide information or content of high value to the end users. There are two forms of information services categorized based on the direction of the information flow: push and pull.

Push is defined as a type of service where information/content is delivered to the end users at predetermined time or under predetermined conditions. Examples of push services may include pre-subscribed weather report, traffic report, headline news, important events, schedule changes, unsolicited advertising, and emergency warnings. However, most of the initial GPRS implementations today do not support mobile terminated GPRS connection establishment due to handset limitations.

Pull is defined as a type of service where information/content is requested in real time by the end user and delivered in near real time. This may include checking flight/train/bus schedules, requesting specific types of news, checking stock quotes, instant opinion polling, or obtaining scores for sport events - all in real time.

A wide range of other content can be delivered to mobile phone users using either push or pull depending on applications and user preference ranging from lottery results, jokes, horoscopes, location sensitive services, etc. This information need not necessarily be textual; it may be maps, 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, sports score or

temperature. When the information is of a qualitative nature however, such as a horoscope or news story, a 160-character message either tantalizes or annoys 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 terminals.
However, SMS will continue to be used for delivering most quantitative information services because of the current SMS success that draws a lot of followers and because of the store and forward function, which is part of the SMS service.
In developing countries where information sharing is largely constrained by communication infrastructure, GPRS based information services designed with the local users' needs in mind, can really improve quality of life.
Again in the case of the Pacific islands, both locals and tourists may benefit from information services such as weather reports, storm/Tsunami warnings, fish reports, boat schedules, tourist information, medical information (local doctors, clinics/drug stores, and hospitals), and tide schedule.

Transaction Services

Transaction services are particularly suited to run over GPRS. Transaction applications are generally defined as services in which users complete one or more business transaction on the Internet or over a data pipe such as the purchase of goods or services. For this reason, it is also referred to as mobile eCommerce or m-commerce, which normally requires authentication and secure transmission of sensitive data.
Banking services are becoming popular in many cities/countries, where people can perform account balance checking, money transfer between accounts, bill payment, and overdraft alert. Banking and financial services have a large interest in adopting wireless data services. Banks have a vested interest in keeping you away from their branches because branches are an expensive way for the banks to process routine transactions such as checking account balances, bill-payment and transfers. More cost-effective methods include ATMs, telephone banking, Internet banking and now mobile banking services, especially in developing countries where there is low penetration of fixed-line telephone but there may be reasonable GSM penetration. With the immediacy and security that comes with GPRS, financial trading will become more efficient and secure.
There are many goods or services that are suitable to be booked or transacted on a mobile terminal. Examples include airline and hotel bookings, purchase movie or shows tickets, buy flowers or pizza and have them delivered to where you are, purchase of lottery tickets, or getting a soda from a vending machine on a hot summer day.

Location-Based Services

Location-based services provide the ability to link push or pull information services with a user's location or provide some other value added aspect to an end user based on location information. The key characteristic of location-based services is that the information or services provided is highly tailored to the location of the end user.
Common examples of location-based services include finding the location of an establishment such as a hotel, a restaurant, nearest ATM or vending machine, roadside assistance, and city-specific news and information. Location-based services also have ample applications in the enterprise vertical applications space such as workforce dispatch and vehicle tracking.
Other location specific services can be highway traffic reports based on the current location of your vehicle, weather report of your island or your area at this hour, advertising of discount or other sales information for area business establishments (stores, restaurants, theaters).

Vertical Applications

Vertical applications are those designed for enterprises to perform specific tasks using mobile infrastructure or services within their value chain. The key difference here is that it is tailored for enterprises as opposed to mass-market consumers.

Common examples of vertical applications include:

- Sales information provisioning
- Order entry and management
- Job dispatch - job details such as location and scheduling
- Fleet management - control of a fleet of delivery or service staff, monitoring their locations and scheduling work
- Parcel delivery - tracking the locations of packages for feedback to customers and performance monitoring
- Vehicle location tracking and management
- Telemetics or telemetry applications

Mobile data services can be used to communicate and dispatch new jobs from office-based staff to mobile field-staff. Customers typically telephone a call center whose staff takes the call and categorizes it. Those calls requiring a visit by field sales or service representatives can then be escalated to those mobile workers. Job dispatch applications can optionally be combined with vehicle positioning applications so that the nearest available suitable personnel can be deployed to serve a customer. Mobile data services can be used not only to send the job out, but also as a means for the service engineer or sales person to 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 limited bandwidth of SMS (160 characters) are sufficient for communicating most delivery addresses such as those needed for a sales, service or other job dispatch applications, such as mobile pizza delivery and courier package delivery.

However, that limitation does require manipulation of the customer data such as the use of abbreviations such as "St" instead of "Street." Also, that limitation does not 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.
Vehicle location tracking applications integrate satellite-positioning systems that tell people where they are via mobile data services or 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/determine 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. SMS is ideal for sending GPS position information such as longitude, latitude, bearing and altitude. GPS coordinates are typically about 60 characters in length. GPRS could alternatively be used.
Telemetics applications, when used as vertical applications, are, roughly speaking, those involving communications to/from or between systems instead of between people. It is ideally suited for remote monitoring, industrial processes, tracking and control of assets/resources, etc. Examples include embedded GPRS terminal in motor vehicles to monitor vehicle operations, provide value-added services such as navigation, emergency help, remotely lock/unlock or start vehicles, track and control movable assets (boats, machines), monitor water level, dam, pipelines and

power transmission.
Home automation is becoming a popular domain for telemetics. Home automation applications combine remote security with remote control. This enables you to 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 immediate access to see who the 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 or switch/turn your oven on so that the preheating is complete by the time you arrive home. Your GPRS capable mobile phone really does become an extension of the remote control devices we use today for our televisions, videos, and stereos. As IP will soon be everywhere - not just in mobile phones because of GPRS but also in all manner of household appliances and in every machine- these devices will be capable of being addressed and instructed. A key enabler for home automation applications will be Bluetooth, which allows disparate devices to interwork.
Traditionally, telemetics is done via proprietary radio infrastructure over smaller pipes. Some used SMS and had reasonable success for very low bandwidth telemetry services. With the always-on and pay-for-the-bit-shipped characteristics, GPRS may find popular applications in this space. Particularly with its increased bandwidth, GPRS may be used for providing visual information such as web cam with streaming. 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, from picture messages to photographs, from blueprints to video messages and movie previews being downloaded to complete movie watching via data streaming on a mobile terminal.
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. Another area where GPRS can fill the gaps is the self-professed document sharing applications, many of which fall under the vertical application domain. GPRS may facilitate document sharing and remote collaborative working, i.e., allowing different people in different places work on the same document at the same time, such as document sharing on the Internet. 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, medical treatment, advertising copy setting, architecture, journalism and so on. These applications will excel anywhere somebody can benefit from having and being able to comment on a visual depiction of a situation or matter. By providing sufficient bandwidth, GPRS facilitates these multimedia applications.

GPRS Architecture

GPRS has been designed as an extension to the existing GSM network infrastructure to provide a connectionless package data service. It introduces a number of new functional elements that support the end-to-end transport of IP based package data. GPRS has been developed by the GSM standards bodies, resulting in a system with defined functionality, interfaces and inter-network operation for global roaming support.

GPRS Reference Model, Functions, and Interfaces

GPRS Reference Model and Functions

Figure 1 below shows the standard GPRS reference model in a GSM network context. In addition to the network components defined in a voice-based GSM network, such as Home Location Register (HLR), Mobile Switching Center (MSC), Base Station

Controller (BSC), and Base Transceiver Station (BTS), some additional network functions are required to support GPRS.
Two new core network functions are introduced: the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). The SGSN monitors the state of the mobile stations and tracks their movements within a given geographical area. It is also responsible for establishing and managing the data connections between the mobile users and the destination network.
The GGSN provides the point of attachment between the GPRS domain and the external data networks such as the Internet and the corporate intranets. Each external network is given a unique Access Point Name (APN), which is used by the mobile user to establish the connection to the required destination network.
The GSM Base Station Subsystem (BSS) has to be adapted to support the GPRS connectionless packet mode of operation. A new functional node called Packet Control Unit (PCU) is the interface between the packet based GPRS core network and the circuit based GSM air interface. The PCU manages the transmission and reception of data to/from the mobile terminals. In addition, it provides radio link layer functions, radio resource management, etc.
Similar to the GSM voice architecture where interfaces between elements are clearly labeled, the GPRS functional diagram below shows the GPRS interfaces between the elements.

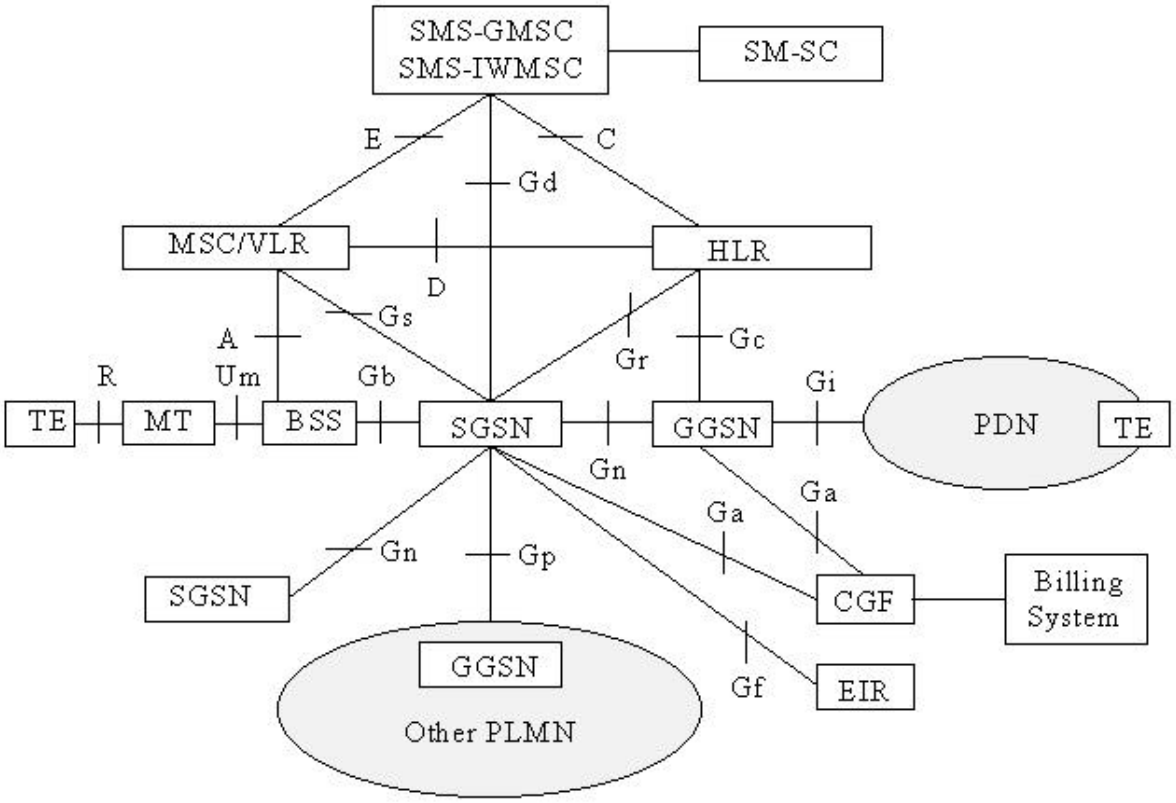

Figure 1: GPRS functional reference model with major interfaces

GPRS Interfaces

The GPRS specifications have introduced a number of new interfaces to the GSM network:

- Gb: the Gb interface is the link between SGSN and PCU and is carried by a Frame Relay network according to the GPRS standard.
- Gn: the Gn interface connects two GPRS Support Nodes (GSNs) and its primary function is the tunneling of data packets between the GGSN and the SGSN. In case of handoff during an active data session, the Gn interface is also used for tunneling data packet from the old SGSN to the new SGSN of the mobile terminal. The Gn interface is carried by an IP based network.
- Gp: the Gp interface is used primarily to support roaming when a mobile terminal is traveling in a foreign Public Land Mobile Network (PLMN) and its data packets are still handled by a GGSN in its home PLMN. The Gp interface is similar to the Gn interface except that additional security is provided through external border gateways.
- Gi: the Gi interface is the link between the GPRS network and the external Packet Data Network (PDN). All packets to/from the supported PDN enter or leave the GPRS network through the Gi interface.
- Gr: the Gr interface carries Mobile Application Part (MAP) messages between the SGSN and the HLR.
- Gs: the Gs interface carries BSSAP messages between the SGSN and the VLR. It is primarily used for performing combined GPRS/GSM procedures such as paging.
- Gd: the Gd interface carries MAP messages between the SGSN and the Gateway MSC (GMSC). It is primarily used for connecting to an SMSC for SMS services.
- Gf: the Gf interface carries MAP messages between the SGSN and the Equipment Identity Register (EIR).
- Gc: the Gc interface (optional) carries subscriber information between the GGSN and the HLR.
- Ga : the Ga interface carries the billing information from the GSN nodes to the Charging Gateway Function (CGF).

In order for GPRS to correctly bill for its use, a CGF is required. CGF serves as a Call Data Record (CDR) collector from the SGSN and GGSN nodes, a CDR aggregation agent, and billing data distributor. The CGF connects to a billing system. For global GPRS roaming, additional network nodes are required. One that is particularly important for GPRS roaming is the GPRS Roaming Exchange (GRX), which acts as a gateway between the individual PLMN/GPRS networks. Last but not the least, the Terminal Equipment (TE) and the Mobile Terminal (MT) are critical elements in providing GPRS service.

GPRS Terminals

The understanding of GPRS will not be complete without the understanding of the GPRS terminals. 'Terminal equipment' is generally used to refer to the variety of mobile phones and mobile stations that can be used in a GPRS environment. Terminal classes and types define the GPRS terminals.

GPRS Terminal Classes

As defined by the GPRS standards, a GPRS terminal can be categorized in one of three classes: A, B, or C.

- Class C terminals support either voice or GPRS mode, but not simultaneously. In other words, the user must select which service to connect to, either GPRS or voice. Therefore, a Class C terminal can only make or receive calls from the manually (or default) selected service. The service that is not selected is not reachable. Additionally,

the GPRS specifications state that support of SMS is optional for Class C terminals.
- Class B terminals can monitor GSM and GPRS channels simultaneously, but can support only one of these two modes at a time.
- Class A terminals support GPRS and GSM voice services simultaneously. As such, a Class A terminal can make or receive calls on two services concurrently.

Of the three types of terminals, Class A terminals are the most complex and expected to lag behind the other classes. To date, all the GPRS terminal product announcements have been for Classes B and C. No vendor has declared making a GPRS Class A terminal.

GPRS Multislot Terminal

GPRS multislot classes are defined as different capabilities to transmit and receive on different combinations of multiple time slots. A total of 29 classes are defined. These classes range from one receive and one transmit time slot of class 1, to eight receive and eight transmit time slots of class 29. These terminals fall into two types:

- Type1: terminals not required to transmit and receive at the same time
- Type2: terminals required to transmit and receive at the same time

Again, type 2 requires more radio resource, consume more power, and have higher radiation emission.
The following terminals are some of the common multislot terminal classes available, all of which are type1 terminals:

- Class 1: 1+1 (one receive and one transmit)
- Class 2: 2+1
- Class 3: 2+2 (mostly PC card)
- Class 4: 3+1
- Class 6: 3+2 (mostly PC card)
- Class 8: 4+1

As the GPRS technology matures, new class phones will be brought to market.

Terminal Form Factor

In addition to the above characteristics, each GPRS terminal has a unique form factor, such as size of display and keypad. Some of the form factors will be similar to the current mobile phone devices, while others will evolve to use the enhanced data capabilities of GPRS. The earliest available type has been closely related to the current mobile phone in form factor with a numeric keypad and a relatively small display.
PC cards are credit card-sized hardware devices that can either plug directly into a laptop's PC card slot or connect via a serial cable to the bottom of a mobile phone. The GPRS PC card provides 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, SMS, and web-browsing services. Smart phones integrate mobile computing, PIM, 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 an example of this form factor.
The increase in machine-to-machine communications (or telemetics applications, as described earlier) 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 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 modules, such as the 'Treo' device from Handspring. Research In Motion's Blackberry handheld devices, famous for email access and Personal Information Manager (PIM), are also

extending their mobile wireless access capabilities. These devices can either connect with a GPRS capable mobile phone via a serial cable, with a plug in GPRS extension module or simply with GPRS capability built in.

interWAVE GPRS Solution

interWAVE announced the availability of its GPRS capability in 2002. interWAVE's GPRS solutions are well suited for small to medium size community networks, small to large enterprise networks, and all types of specialty networks.

GPRS for Community Market

For the community market, the availability of GPRS capability in a traditional PLMN coverage area (home zones, WLL, remote villages, or dense urban districts) can be critical for the operators as the GSM ARPU is generally declining. GPRS is considered to be one of the key solutions for providing Internet or information services to communities where there is little established wireline infrastructures. Various messaging and information services are also suitable for capturing the local interests of the subscribers.
interWAVE's GPRS solution is custom built for the small to medium density community market: it offers a turnkey service for both GSM voice and GPRS data. interWAVE's GPRS solution can be self-contained so that all the major elements necessary for running a GPRS network are included in the interWAVE's GPRS offering. Our BSC/PCU supports both the standard Gb over Frame Relay interface for connecting to a third party SGSN as well as the Gb over IP interface for connecting to the interWAVE's GPRS Support Node (GSN). interWAVE's compact GSN node, called WAVE GSN, provides a competitive feature set and matches the capacity required for our GPRS markets while keeping the GPRS core network cost effective.

The initial GPRS penetration for the community market is projected to be fairly low and increase gradually over time. We expect the penetration for GPRS in a small to median size GSM network in a developing market to be approximately 5 to 10 percent in the first 12 months of GPRS deployment, depending on applications and whether the GPRS is used in a home zone/WLL application in homes for internet access. Therefore a 10,000-subscriber GSM network will likely have 500-1,000 GPRS subscribers. A 50,000 subscriber GSM network with 10 percent penetration will have 5,000 GPRS users.

GPRS for Enterprise Market

In GSM wireless enterprise applications, our GPRS solution offers unique differentiations. Because of the superior indoor GSM/GPRS coverage, for instance via a Distributed Antenna System (DAS), a Wireless Enterprise GPRS network will be able to offer higher data rate (up to about 80kbps as opposed to about 40kbps) than the macro PLMN/GPRS network. This will provide added incentives for corporate GPRS users who tend to have more bandwidth consumption. With interWAVE's compact GSN deployed in the enterprise, security may be greatly improved as the GPRS data may be kept on the enterprise GSN and the intranet, and therefore will not have to leave the enterprise. These benefits may be multiplied for enterprise consisting of multiple locations or sites across a city, a country, or even across the ocean.

GPRS for Special Market

For the specialty market, interWAVE's GPRS enables a wide spectrum of high value services. The GSM Network-On-Wheels solution (including communication van, military applications, containerized solution, etc.) is greatly enhanced with the addition of GPRS, especially when global deployment of GPRS is in full swing.
Due to the compact size and lower cost of the

smaller interWAVE GSM/GPRS network, it can also be very attractive to many third party developers who desperately need fully functioning GSM/GPRS networks in order to test or develop their products or services. These may range from GPRS testing equipment developers to value-added GPRS application developers.

Standard Compliance and GPRS Upgrades

interWAVE's GPRS solution interoperates with all GPRS terminals provided by the large vendors that follow the GPRS standards. Our solution also interoperates with selected large vendors of GPRS components. For instance, interWAVE's BSC/PCU currently interoperates with some of the large GPRS vendors in the industry, and interWAVE continues on-going testing with a growing list of vendor's equipment.

interWAVE's GSM hardware is GPRS and EDGE ready so that if a particular customer is planning to bring GSM voice first to a new market and then enhance it later with GPRS/EDGE, the upgrade will only involve a software change on the existing system plus the addition of GSN and some core GPRS network supporting elements (such as DNS, DHCP, RADIUS servers, etc.)

List of Acronyms

2G . . . . . Second Generation (wireless technologies or services)
2.5G . . . . . Two and Half Generation (wireless technology or services)
3G . . . . . Third Generation (wireless technology or services)
3.5G . . . . . Three and a Half Generation (wireless technology or services)
4G . . . . . Fourth Generation (wireless technology or services)
APN . . . . . Access Point Name
ARPU . . . . . Average Revenue Per User
ATM . . . . . Automatic Teller Machine
BSC . . . . . Base Station Controller
BSS . . . . . Base Station System
BSSAP . . . . . Base Station System Application Part
BTS . . . . . Base Transceiver Station
CDR . . . . . Call Data Record
CGF . . . . . Charging Gateway Function
CS-2 . . . . . Coding Scheme 2
CSD . . . . . Circuit Switched Data
DAS . . . . . Distributed Antenna System
DHCP . . . . . Dynamic Host Configuration Protocol
DNS . . . . . Domain Name System
EDGE . . . . . Enhanced Data Rate for GSM Evolution
EFR . . . . . Enhanced Full Rate
EIR . . . . . Equipment Identity Register
GGSN . . . . . Gateway GPRS Support Node

GMSC	Gateway Mobile Switching Center
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPX	GPRS Roaming Exchange
GSM	Global System for Mobile communication
GSN	GPRS Support Node
HLR	Home Location Register
ISP	Internet Service Provider
IP	Internet Protocol
LAN	Local Area Network
MAP	Mobile Application Part
MSC	Mobile Switching Center
MT	Mobile Terminal
PCU	Packet Control Unit
PDA	Personal Data Assistant
PDN	Packet Data Network
PIM	Personal Information Manager
PLMN	Public Land Mobile Network
RADIUS	Remote Authentication Dial In User Service
SGSN	Serving GPRS Support Node
SMS	Short Message Service
SMS-C	Short Message Service Center
TE	Terminal Equipment
VAS	Value-Added Services
VLR	Visitor Location Register
WAP	Wireless Application Protocol
WAVE GSN	interWAVE's GSN product name
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop