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A survey of general packet radio service(GPRS) as it relates to the Global system of mobile communication (GSM) in Nigeria.

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ABSTRACT

GPRS is a wireless data network, designed to be integrated with existing digital networks, to provide an enhanced data network. Advantages include things such as faster connection times, faster data speeds and more accurate billing (to the kilobyte generated and consumed). This paper surveys the GPRS technology providing a high level view of the major components of a GPRS system as it relates to GSM.

INTRODUCTION

Until the late nineteen-nineties, wireless mobile networks focused primarily on voice service having, evolved from the well known "bag telephone" in the late eighties to the clearer digital networks, such as GSM. With the advent of smaller, more powerful devices, user sophistication has grown and with it the demand for faster wireless data services has also grown. In an attempt to address this requirement, the European Telecommunications Standards Institute (ETSI) developed a new wireless data network, the general packet radio service (GPRS) which is designed to integrate with existing digital networks. GPRS offers speeds of from 9 to 115 kilobits/second, and its support for multiple bandwidths make it an ideal solution for carriers on the path to the 3G2. In addition, GPRS can be added to a network incrementally, thereby allowing the total capacity to be increased as needed. This approach has two advantages: (i) it minimizes the risk on the investment required to deploy a GPRS network, and (ii) it allows the users to drive the deployment.

This paper gives an overview of the GPRS architecture, as it relates to existing networks, specifically the GSM4. It also provides an explanation of how a mobile station registers with the network and how those sessions are managed. An example of routing packets to and from, an external network and a GPRS mobile station is also given. Of course packets cannot be routed to a mobile station if its location is unknown. Therefore, tracking the location of a mobile station as it moves is very important.

GSM ARCHITECTURE

An outline of the GSM is required to fully understand the architecture of the GPRS. Fig. 1 gives an illustration of a typical GSM network. A mobile station (MS), as the diagram depicts, is the actual user equipment, identified by an international mobile equipment identity (IMEI). However, this identifier is only for the device; the user of the device is identified by a subscriber identification module (SIM). Multiple MSs connect wirelessly to a base transceiver station (BTS), creating a "cell" of users. The BTS is responsible for translating data coming from ,and destined for, the MSs. From the BTS the data is sent to the base station controller (BSC), which is capable of handling hundreds of cells and is responsible for registration, handover and other functions (all of these combined create a very computationally expensive task).

The next link in the chain is the mobile switching centre (MSC fig 1), an upgraded switch used to bridge networks, to the standard telephone system. Since large numbers of mobile station (MS) may be attached to each base station controller (BSC), there are usually only a few BSCs controlled by a single MSC.

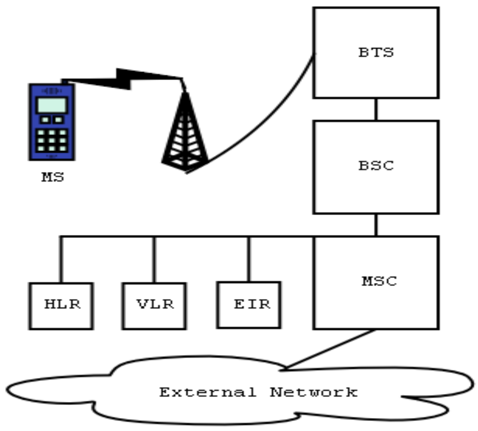

Fig. 1. Generalized view of the MS,BTS etc GSM architecture (Bettstetter et al, 1999).

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Available to the MSC are various databases, such as the equipment identity register (EIR fig 1) used to store the IMEI of each MS on the network. The EIR can also be used to exclude certain MSs from the network and to provide notification when stolen MSs are registering on the network. The two other databases shown in the illustration (fig 1) and the home location register (HLR) and the visitor location register (VLR), meant to track and record the locations of the mobile stations. In the next section, the GPRS will be overlaid on this GSM structure and an elaboration is made on the parts of the GSM system that need to be extended to facilitate GPRS service.

GPRS ARCHITECTURE

An overview of the extended GSM system which function as a GPRS is shown in Fig. 2. Two new components, have been added : the serving GPRS support node (SGSN) and the gateway GPRS support node (GGSN). Both the SGSN and the GGSN belong to the class of nodes known as GPRS Support Nodes (GSN) which collectively, are responsible for delivering packets from the MSs to external networks, such as the Internet. The SGSN is also responsible for tracking the location of the MSs as they move within the network. It is a proxy between the MS and the GPRS backbone, responsible for delivering packets to, and from the MS and monitoring traffic for billing, location tracking, and other functions (not addressed in this paper). The SGSN also represents the main integration point between the GSM network and the GPRS addition although the integration occurs with both the BSC and MSC.

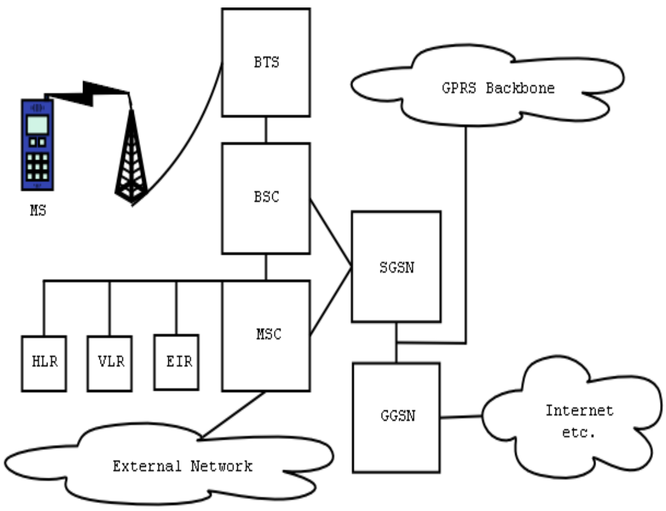

Fig. 2. GPRS architecture overview (Cai and Goodman, 1997)

The GGSN, like any gateway, acts as a bridge between external networks and the MSs, via the SGSN; delivering packets from the MSs to the external network and vice versa. As part of this task, the GPRS standard defines a GPRS tunneling protocol (GTP) that is used to forward the Internet protocol (IP) packet onto the MS intact. The roles of the two GSNs are discussed in more detail in subsequent sections.

Mobile station classes and quality of service

GPRS provides for three classes of mobile stations. These are:

1. Class A: the most robust device class, which is able to use GSM and the GPRS services simultaneously.
2. Class B: able to register for both services simultaneously, but uses only one service at a time.
3. Class C: could register for only one service at a time, either GSM or GPRS.

In addition to a choice of device types, there is also the provision for a choice of quality of service (QoS). A QoS profile is negotiated between the mobile station and the network during registration (explained later). The required QoS depends on the intended use. For example, checking your e-mail can be accomplished using the so-called "best-effort", meaning that the packets are delivered as quickly and reliably as possible, but that other data may take precedence. However, a live data feed, such as audio/video, will require timely delivery of in-sequence packets, otherwise the user experience is diminished.

During the negotiation of a QoS profile four criteria are considered: precedence, reliability, delay and throughput. The MS will notify the network with the requested QoS parameters which will either be accepted or the network will offer another profile (if the requested parameters cannot be accommodated). All of the GSNs are involved in providing QoS throughout the transmission of the data. It should be noted here that traffic bound for external networks is subject to the QoS available on that network, regardless of the negotiated profile. In addition the higher the QoS requested the more costly is the connection and this gives the carrier the opportunity to properly assign charges to those users placing the most demand on the network (GSM 03.60, GPRS).

Registration

Before a MS can use the GPRS functionality on a given network it must first attach to the SGSN. When an attachment request is received from a MS, the SGSN will check to make sure the user is authorized. If authorization succeeds, the user's profile is then copied from the HLR to a temporary location on the SGSN. This process can only be initiated by a MS, and can happen (for those devices that support it) at the same time as registration on the GSM network. Conversely, when a MS is finished using the network it must send a detach request to release allocated resources on both sides of the connection. Unlike the attach process, the detach process can be initiated by both sides; the SGSN or the HLR can initiate the detach process, if required.

Session management

After a MS has “attached” to the GPRS network and made itself known to the SGSN it is still unable to communicate with external packet data networks (PDN), such as the Internet. Before using a PDN the MS needs to create a session for that specific PDN, obtaining a packet data protocol (PDP) address in the process. Incidentally, a MS is not limited to one session; it may have several sessions to multiple PDNs. For each session, a PDP context is created containing the PDN type, such as IPv4, the PDP address assigned to the MS, the QoS parameters (as negotiated) and the address of the GGSN, necessary to access the PDN. Once this context is created the MS is free to exchange data with the PDN.

The PDP address obtained during session creation can be either statically or dynamically assigned, depending on the user account. This type of address assignment is prevalent in many other networks, and is nothing new. If the address is statically assigned to the user account, it will receive the same PDP address every time a session is created. Otherwise, the address will be dynamically assigned from a pool of available addresses, similar to dynamic hoist control protocol (DHCP) in an IP based network.

GPRS also supports the notion of anonymous and non-anonymous context creation. The preceding paragraphs assume non-anonymous access, meaning that the user has a subscription and is known to the network. However, anonymous access does not require a subscription. There are anonymous access cases, such as pre-paid services for which the MS is not required to attach to the SGSN before creating a PDP context. In such cases, the mobility of the MS is limited to the current routing area (RA) and the network has no knowledge of the user (but does obviously know the IMEI of the MS). Thus, regardless of the address type or access method, all MSs with an active session are able to send and receive data packets and the interface between the network and the PDN remains the same.

POCKET TRANSMISSION

Routing

An illustration of the routing of packets between an external PDN and a mobile station on a GPRS network is provided by the case of a mobile browser communicating with a server on the Internet, as in Fig. 3. First, the MS attaches to the GPRS network and obtains a PDP address, in this case ,an IP address accessible on the internet. Once the context has been created, the MS sends IP packets to the web server. Clearly, IP packets can not pass though the GPRS network without some assistance. Hence the SGSN intercepts the outgoing IP packets, checks the PDP context, encapsulates the IP packet (using GTP) and routes it through the GPRS network to the GGSN. Once at the GGSN, the packet is decapsulated and forwarded to the Internet and onto the server. After the server has processed the request, it sends the response back to the mobile node using the IP (PDP) address of the MS. Since the GGSN and MS share the same subnet, the packet will be routed to the GGSN. When the packet arrives, the HLR is consulted to find the current location of the MS. The packet is then encapsulated and forwarded the appropriate SGSN, where it is decapsulated and the original IP packet is sent to the MS (Salkintzis, 1999).

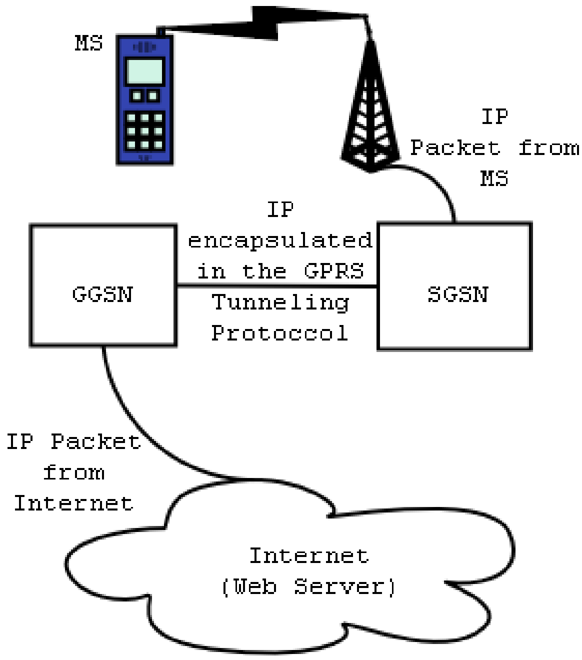

Fig.3. Packets being routed from the Internet to a mobile station.

The main thing to remember from this section is the GGSN acting as “proxy” for the MSs on the external PDN. Obviously, this example can be extrapolated to provide access to multiple networks, of differing types. In fact, many carriers use this functionality as a way to provide companies secure access to their VPN.

Mobility management

As with all mobile networks, tracking a mobile station as it moves within the network is imperative to the proper routing of traffic. The GSM network handles the physical detection of cell change. It is therefore sufficient here to say that the MS “knows” when it has changed cells and so on since this paper is focused on the updates required for GPRS rather than the detailed explanation of GSM: However, it is important to know how often the cell change occurs.

It has been estimated that a typical user may change cells every thirty to forty seconds or almost a thousand times in an eight hour work day (Salkintzis 1999). As a MS moves around it periodically sends “location update” messages to its current SGSN. If these messages are to frequent, it wastes valuable resources such as bandwidth and battery power. However, if the location update messages are infrequent, the current SGSN will send paging packets for finding the exact location of the MS, before delivering the actual packet, thereby causing unnecessary overhead. To avoid there situation, the GPRS specification is equipped with a state machine (fig.4) which controls the transmission of location messages as a compromise of the two extremes.

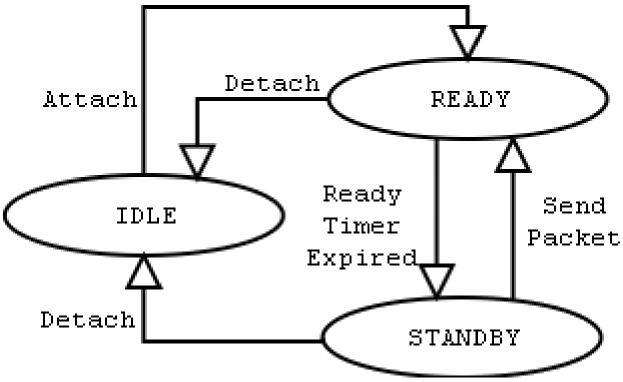

Fig. 4. Illustration of the MS state machine used to determine location update messages.

Starting in the “idle” state, when data is ready to be sent a MS attaches to the network and transitions to the ready state. In the READY state, a timer is created. If data is sent/received before the timer expires it is reset, otherwise, the timer runs out and the MS transitions to the standby state. From the STANDBY state, a timer is once again created. If the MS transmits data before the timer runs out the MS moves to the READY state once again, otherwise, the MS detaches from the GPRS network and goes to the IDLE state.

So how do all these states help with the location message problem? Simple. The frequency of the location update messages is determined by the current state of the MS. In the IDLE state, location update messages are only sent if the MS is moving between areas controlled by differing SGSNs. Conversely, in the READY and STANDBY states, the location is updated for every cell change, providing location information with cellular precision, and avoiding the need for paging while the MS is receiving packets. During the MS handover process, from one SGSN to another, the old SGSN is required to forward any packets sent for the MS (it also buffers all packets until they are acknowledged). This guarantees delivery of all packets, even during handover.

CONCLUSION

When integrating with GSM, the GPRS requires a few additional equipment. A SGSN is required to provide logistic and encapsulation support for the MSs while a GGSN is needed to provide a gateway to external packet data networks, such as the Internet. Routing of external packet types through the network is facilitated by the GTP or GPRS tunneling protocol, and occurs between the two types of GSNs, SGSN and GGSN. Finally, the importance of mobility management was discussed as it relates to the delivery of packets. If a MS moves between SGSNs while transmitting data, the system needs to be able to deliver the packets seamlessly and reliably. This happens on two levels. First, if the MS is in the READY or STANDBY state, all movements trigger a location update message. However, if the MS is in the IDLE state, a location update message will only be sent if the MS moves between cells controlled by differing SGSNs.

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