A Migration Path from GSM to GSM/GPRS

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Dedication

I would like to dedicate this thesis to my Family specially my mother, father & wife Abeir and my son Yousif who inspire me to undertake this project and deliver it to the best of my capability.

Acknowledgements

My words fall short of thanking every one who has helped in bringing this thesis to completion.

My first thanks are to Dr. Iman Abuel Maaly who encouraged me to go ahead with the idea of writing a thesis on migration path from GSM to 2.5G and using MobiTel as study case.

My gratitude also goes to Dr. Salah Mubarak for boosting my efforts, helping and enquiring all times for the progress of the thesis.

Many thanks to Ericsson and MobiTel staff specially the planning department for donating their time and sharing with me their vision in the mobile industry.

مستخلص

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تعتبر خدمة الحزم الراديوية ألعامة خدمة جديدة غير صوتية (بيانات) ،وهى خدمة مضافة تسمح للمعلومات أن ترسل وتستقبل عن طريق شبكات الهاتف السيار، كما أنها اضافة الى تطوير مستخدمى الهاتف السيار على استخدام الشبكة المعلوماتية ، ودلك للتحسن الدى طرأ على اتصالات البيانات المتحركة.

الغرض من هدا البحث وضع خطة للتحول من شبكات الهاتف السيار الصوتيه الى خدمات الهاتف السيار الصوتية\البيانية "خدمة الحزم الراديوية العامة" GPRS، هدا التحول سيكون بأستخدام الاجهزة والبنية التحتية الموجودة فى شبكة موبتيل.

تنفيد هدة الخطة يتم فى ثلاثة مراحل: المرحلة الاولى يتم تنفيدها فى منطقة الخرطوم وسط، المرحلة الثانية فى منطقة الخرطوم بحرى و ام درمان، المرحلة الثالثة فى باقى ولايات السودان، هدة الخطة تاخد فى الاعتبار كل من العوامل الاقتصادية بالاضافة الى العوامل التقنية والهندسية.

مسار التحول من خدمات الهاتف السيار الصوتية الى الصوتية\البيانية يحتاج الى اضافة مقسمات للحزم البيانية SGSN&GGSN بالاضافة الى تطوير البرمجيات لنظام المحطة الاساسى (BSS) وقلب الشبكة (NSS).

فى المرحلة الاولى تم اختيار BSC3&6 بالاضافة الى MSC3/VLR3 والتى سيتم توصيلها بالاجهزة الجديدة SGSN و GGSN (CGSN) من شركة اريكسون والتى توجد فى دار الهاتف.

بما ان استخدام الحزم الراديوية المعلوماتية العامة اثناء التحرك من منطقة الى اخرى هو اساس الفكرة، فانة يتم تعريف الهاتف السيار فى كل منطقة جديدة يدخل اليها لضمان سريان المعلومات اثناء هدا التحرك، فانة تم اختيار منطقتين فقط لكى يتم تعريف الهاتف فيهما فى المرحلة الاولى ودلك لتفادى فقدان المعلومات اثناء الحركة.

تم حساب السعة الموجودة فى كل من محطات التحكم الاساسية رقم 3 و6 ووجد من التقارير انه يمكن استخدام هدا النظام فيها.

تم أختيارالنظام من شركة اريكسون لكى تعمل فى المرحلة الاولى من المشروع

Abstract

The General Packet Radio service (GPRS) is a new non-voice (data) value added service that allows information to be sent and received across a mobile telephone networks. GPRS has evolved to cater to the mobile users by enabling them to access the internet world incessantly. It will provide a massive boost to mobile data communication.

The aim of this thesis is to setup a migration path from GSM to GSM/GPRS service (2.5G). The focus is on real world migration plan that can be implemented on the existing infrastructure of MobiTel-Sudan network. The plan can be implemented into three phases, phase1 is to implement the GPRS in the center of Khartoum in which we focus, phase 2 in centre of Khartoum north and Omdurman, phase three is in the rest of Sudan. The plan takes into considerations economical factors as well as technical aspects.

The migration path from GSM to GPRS requires additional packet switching nodes, software upgrade in the base station subsystem (BSS) and Core network. In phase1 we choose BSC3, BSC6 and MSC3/VLR3 which cover the center of Khartoum and located in Dar Elhatif to be connected with the SGSN and GGSN. As the mobility management plays a significant role in the GPRS such as routing area updates we suppose that BSC3&6 connected with SGSN will be in two routing area in Phase1 to avoid inter SGSN routing area updates, however in the following phases different forms of user mobility and their effects on the communication traffic can be will planned.

The traffic in Erlang and hardware has been calculated from the traffic and hardware dimension reports of the network to accommodate the GPRS in these nodes. We use Ericsson SGSN, GGSN, and their specifications to be implemented in this phase In addition to access server and firewalls.

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1 CHAPTER

Introduction

- **Statement of the Problem**
- **Overview and literature review**
- **Objectives**
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1.1 Statement of the Problem:

The conventional GSM limitations in data services as we can see in Chapter2, and the ever increase demand for bandwidth in the mobile service is due to introduction of new applications as MMS (multimedia messaging service), web browsing, moving images, document sharing , remote LAN access ,file transfer ect.(will be discuss in CH4). These facts have led to serious considerations of deployment technologies that can satisfy the need of more bandwidth in the mobile network. The GPRS (described in chapter3) is a very well tested technology worldwide that can be used to tackle such problem. In this thesis, the main task is to deploy GPRS service in MobiTel network in a phased migration plan for deploying GPRS with considerations of coverage, quality of service and costing. The main objective is to obtain a good quality of service while still satisfying the financial constraints.

1.2 Overview of literature review

Global System for Mobile communication (GSM) was capable of providing a data rate of 9.6 kbps on a single time slot (TS). With the advent of high-speed circuit-switched data (HSCSD), the capability of the network was increased multi-fold, to 115.2 kbps(In a GSM network single slots are allocated to each user, which has a standard data transfer rate of 9.6Kbps, although some networks are now being upgraded to 14.4Kbps, an increase of 50%. In HSCSD, users are allocated multiple slots so that if they use the eight time slots it will be 115.2). In practice, however, it was only 64kbps owing to the limitation of the A-interface and the core network. The main benefit of the implementation of the HSCSD was that, with limited upgrading (i.e. minimum investment), the capacity for data transfer was increased to up to four TS on the receiving side and two TS on the transmitting side. Nevertheless, the traffic was still circuit-switched, which meant a long access time to the network. As charging is proportional to the logging time, the subscriber ends up paying more. This led to evolution to the packet-switched network. In this technology, the access time to the network reduced and charging is done solely on the usage of the network; i.e. even when the connection is there but not being used, the subscriber is not charged. Usage of the network resources becomes more dynamic and efficient. They are no longer reserved for a user logged to the network, even when he is not using the resources. This system was known as General Packet Radio System (GPRS).

1.2 Objectives

The aim of this thesis is to setup a migration path from GSM to GSM/GPRS service (2.5G). The focus is on real world migration plan that can be implemented on the existing infrastructure MobiTel-Sudan network. The plan takes into consideration economical factors as well as technical aspects. As GPRS is an additional to the existing GSM system, enabling packet-switched transmission in the network whilst keeping the existing value-added services like SMS, etc. Because of this data, rates increase substantially; the user now can log into the GPRS network, and can make use of all eight TS dynamically and be charged only when using the resources. The packet data can be sent during idle times also, between speech calls, thus making effective use of the network resources and saving money for the subscriber.

1.4 Methodology

Phased approached to develop the system which allow the value added services to pay for itself.

1.5 Thesis Layout

This thesis is structured into 7 chapters under the following heading:

Introduction, GSM architecture, GPRS architecture, GPRS operation, Migration path from GSM (2G) to GPRS (2.5G), Business plan and, Conclusion.

The purpose of the **second chapter** is to give a description of the GSM System. This is remarkably done in the standardization of this system.

Chapter 3 assumes that the GSM service and architecture has already been in operation. The goal of this part is to remind the normal reader what the main ideas and functionality of GPRS are. The chapter analyzes and describes GPRS as a system point of view, which means that no attention will be paid to how functions are implemented but what they provide, for who and why.

In addition to that, the chapter describes the principles entities that need to be added or upgraded to follow the further analysis about migration. In fact, this part is not a complete description of the well-advanced system that GPRS is but much more the basics that need to be mastered so as to understand the further discussions that will appear in the subsequent chapters.

Chapter 4 describes issues and concepts of the operation and mobility in GPRS and various user mobility investigation techniques. As the Mobility, management plays a significant role in the new cellular wireless network standard GPRS, this chapter focuses on functions of routing area updates, and its effects on communication traffic by implementing its algorism.

Chapter 5 outlines the proposed migration plan from an existing GSM to GPRS A case study on MobiTel network is being conducted and a flowchart that illustrates the whole process of migration from existing Mobitel infrastructure GSM to GPRS network.

Chapter6 study analyses of the financial impact of the deployment and operation of the GPRS services on the only one Sudanese mobile operator. MobiTel Sudan has a monopoly on the market share at the moment. This study is trying to drive and discuss initial economic conclusions using key profitability factors such as Net present value (NPV), Internal Rate Return (IRR) and payback period. The techno-economic analysis is followed by a sensitivity analysis in order to identify the impact of the most important parameters such as GPRS penetration, market share, tariff level and usage level.

Chapter 7 concludes the thesis with the description of the findings, a discussion of the limitations of the application, and addition insights for future research.

2 CHAPTER

GSM System Architecture

- **Global System for Mobile Communication (GSM)**
- **GSM Interface**
- **Logical Channels**
- **GSM services**
- **Conventional GSM limitations in data services**

2.1 Global system for Mobile communication (GSM)

The GSM system architecture includes four subsystems (Figure2-1) shows the system architecture of a GSM public land mobile network (PLMN) with essential components [3]: Mobile Station (MS), Base Station Subsystem (BSS), Network and Switching Subsystem (NSS), and Operation Sub-System (OSS).

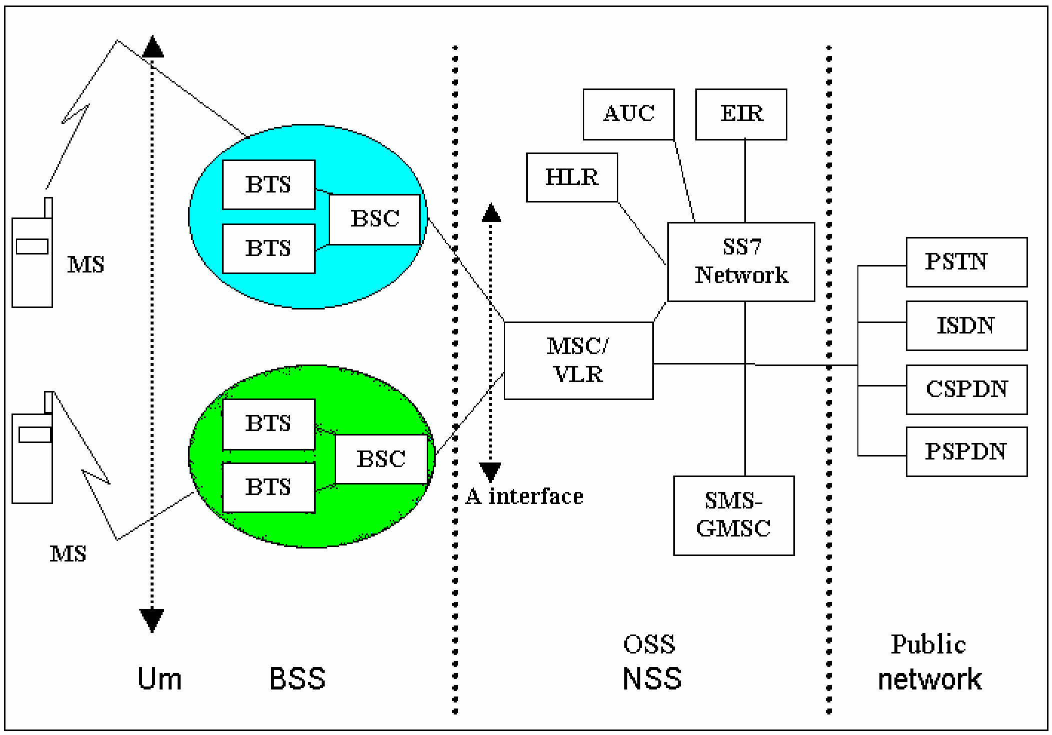


Fig.2-1 GSM System Architecture

The MS subsystem involves a radio part, an interface, and a Subscriber Identity Module (SIM). The radio part carries out all the functions related to the radio interface (Um), e.g. receiving and transmitting radio signals, signal processing, frequency hopping, and channel management. The interface to terminal equipment acts as a gateway between the terminal and the radio part. The SIM contains all the subscriber-related information on the MS side of Um to identify a subscriber and take care of the security. The SIM is implemented as a smart card.

The BSS forms cell structure of GSM network. It includes two types of network elements: the Base Transceiver Station (BTS), and the Base Station Controller (BSC).

The BTS is a transmission component. It carries out radio signal transmission and reception; signal processing, speech encoding and decoding, and transmission rate adaptation. The BSC is a managing component. It is responsible for all the management of the Um, e.g. channel allocation and deallocation, handover, and timing of radio signals. One BTS can implement one or more cells in GSM. A BSC can manage several BTSs.

The NSS comprises the main switching functions of GSM and all the databases needed for subscriber information, mobility management, and interworking. It contains the following databases: Home Location Register (HLR), Visitor Location Register (VLR), Authentication Center (AUC), and Equipment Identity Register (EIR). The MSC performs the basic switching function by setting up calls to/from MSs.

The GSM system also communicates with other networks such as the Public Switched Telephone Network (PSTN), Integrated Services digital Network (ISDN), Circuit-Switched Public Data Network (CSPDN), and packet-switched public data network (PSPDN).

GSM, the most successful digital cellular network, is the European digital cellular standard published by ETSI (the European Telecommunications Standards Institute). There are three phases for GSM technology creation [5]:

1. Introduction of commercial GSM services, including telephony, short message, fax and data services in 1992.

2. In 1996, phase 2 completed the original GSM design task and established a framework for ongoing technology enhancement.
3. GSM standardization is now in phase 2+, in this phase. It includes improved voice coding and advanced data transmission services. Two data services are high-speed circuit-switched data service (HSCSD) and the General Packet Radio Service (GPRS).

2.2 The GSM radio interface

The radio interface [9] is the interface between the mobile stations and the fixed infrastructure. It is one of the most important interfaces of the GSM system.

The Radio Interface (Um) is split into several channels (will be discussing later in this chapter): traffic channels and signaling channels. The traffic channels carry user data. The signaling channels carry management and control information.

2.2.1 Frequency allocation

Two frequency bands, of 25 MHz each one, have been allocated for the GSM 900 MHz system:

- The band 890-915 MHz has been allocated for the uplink direction (transmitting from the mobile station to the base station).
- The band 935-960 MHz has been allocated for the downlink direction (transmitting from the base station to the mobile station).

2.2.2 Multiple access schemes

The multiple access scheme defines how different simultaneous communications, among different mobile stations located in some different cells, share the GSM radio spectrum. A mix of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA), combined with frequency hopping, has been adopted as the multiple access scheme for GSM.

2.2.2.1 FDMA and TDMA

Using FDMA, a frequency is assigned to a user. So, the larger the number of users in a FDMA system, the larger the number of available frequencies must be. The limited available radio spectrum and the fact that a user will not free its assigned frequency until he does not need it longer, explain why the number of users in a FDMA system can be "quickly" limited. On the other hand, TDMA allows several users to share the same channel. Each of the users, sharing the common channel, are assigned their own burst within a group of bursts called a frame. Usually TDMA is used with a FDMA structure.

In GSM, a 25 MHz frequency band is divided, using a FDMA scheme, into 125 carrier frequencies spaced one from each other by a 200 kHz frequency band. Normally a 25 MHz frequency band can provide 125 carrier frequencies. Each carrier frequency is then divided in time using a TDMA scheme. This scheme splits the radio channel, with a width of 200 kHz, into 8 bursts. A burst is the unit of time in a TDMA system. A TDMA frame is formed with 8 bursts. Each of the eight bursts, that form a TDMA frame, is then assigned to a single user.

2.3 Logical Channels

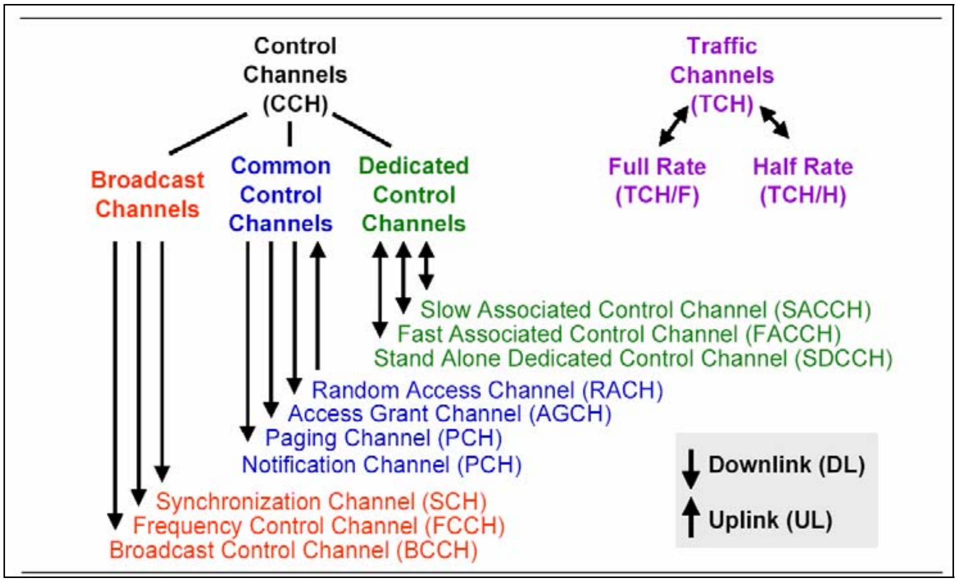


Fig 2-2 Logical Channels

We will focus on the following:

2.3.1 Common Control Channels

Common Control Channels are point-to-multipoint channels used mainly for access control

- Paging Channel (PCH) - downlink only used by the BTS for paging and localizing the MS
- Random Access Channel (RACH) - uplink only used by any MS to request allocation of a signaling channel (SDCCH).
- Access Grant Channel (AGCH) - downlink only used to allocate a SDCCH or directly a TCH
- Notification Channel (NCH) - downlink only used to notify MS of voice group and voice broadcast calls (ASCI feature)

2.3.2 Dedicated Control Channels

Dedicated Control Channels are bidirectional point-to-point channels that allow authentication, signaling, handover and the exchange of measurement values.

- Stand Alone Dedicated Control Channel (SDCCH) used for call setup (authentication, signaling, assignment of actual TCH), localization updates and SMS
- Slow Associated Control Channel (SACCH) is always coupled with a SDCCH or TCH and is used for the exchange of measurement values and control parameters
- Downlink : Control of MS Power Level and MS Timing Advance
- Uplink : Measurement reports (MS reception levels) used by the BTS for its handover-decisions
- Fast Associated Control Channel (FACCH) is activated in case of increased signalling demand e.g. during handover. Bandwidth is stolen from associated TCH

2.4 GSM services

GSM has three types of services, teleservices, bearer services, and supplementary services. Teleservices include telephony, fax, emergency calls, teletex, short Message services, fax mail, and voice mail. Supplementary services include call forwarding, call barring, etc. Bearer services are used for transporting user data. Some of the bearer services are listed below:

- Asynchronous and synchronous data, 300-9600 bps.
- Alternate speech, and data, 300-9600 bps.
- Asynchronous PAD (packet-switched, packet assembler/disassembler) access, 300-9600 bps.
- Synchronous dedicated packet data access, 2400-9600 bps.

2.5 Conventional GSM limitations in data services

1. It does not provide direct connection to the Internet. In order to access to the Internet, GSM needs to call Internet Service Provider (ISP).
2. Uplink and downlink channels allocated for a user are for entire call period.
3. It has time-oriented charging, that is, payment is based on connection time, not on data volumes.
4. Connection setup takes about 20-25 seconds.
5. Limited capacity (9600 bps).
6. GSM was designed for speech, not for data, hence 50% radio capacity is wasted, and there is no optimal channel coding for data.

3 CHAPTER

GPRS System Architecture

- **Introduction to GPRS**
- **The GPRS Network Architecture**
- **GPRS Terminal Class**
- **The GPRS System**
- **Packet Control Channels**
- **Channels coding schemes**
- **Protocols**
- **GPRS characteristics**
- **GPRS Services**

3.1 Introduction to GPRS

The General Packet Radio System (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, an occurrence that will, in turn, increase the penetration of data services among consumer and business users. In addition, GPRS will allow improved quality of data services as measured in terms of reliability, response time, and features supported. The unique applications that will be developed with GPRS will appeal to a broad base of mobile subscribers and allow operators to differentiate their services. These new services (will discuss later) will increase capacity requirements on the radio and base-station subsystem resources. One method GPRS uses to alleviate the capacity impacts is sharing the same radio resource among all mobile stations in a cell, providing effective use of the scarce resources. In addition, new core network elements will be deployed to support the high burstiness of data services more efficiently.

In addition to providing new services for today's mobile user, GPRS is important as a migration step toward third-generation (3G) networks. GPRS will allow network operators to implement IP-based core architecture for data applications, which will continue to be used and expanded upon for 3G services for integrated voice and data applications. In addition, GPRS will prove a testing and development area for new services and applications, which will also be used in the development of 3G services.

3.2 The GPRS Network Architecture

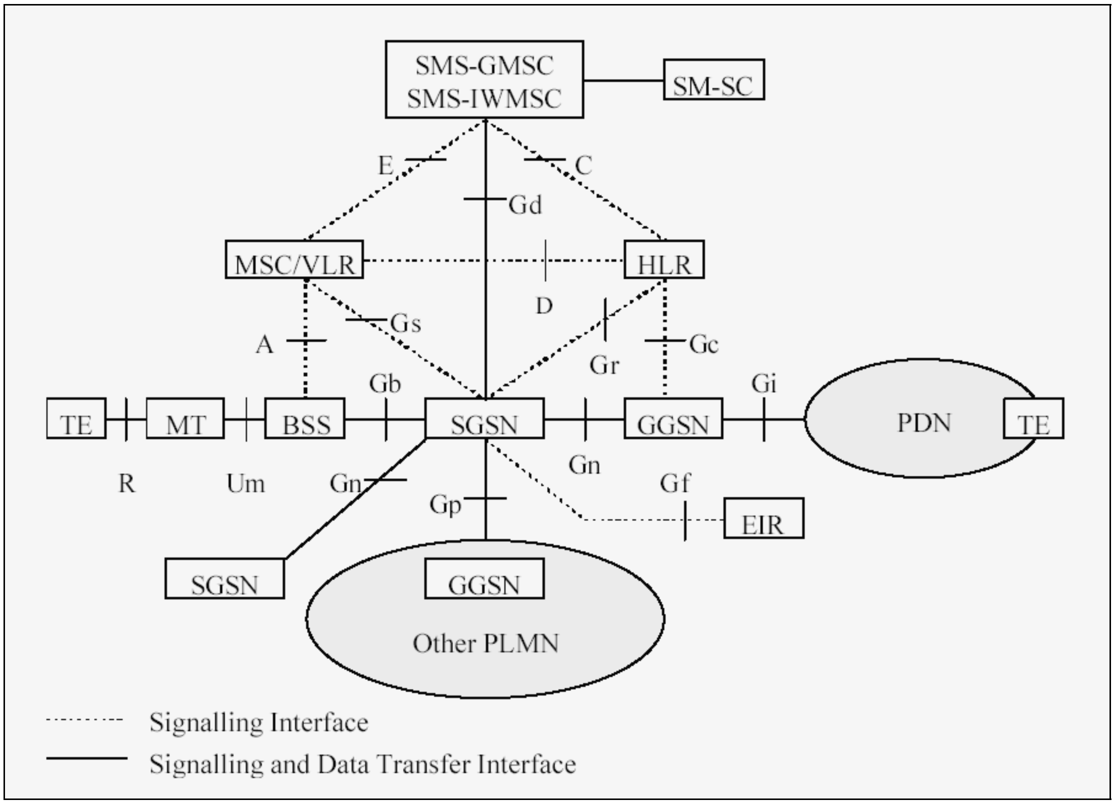


Fig 3-1 GPRS System Architecture and Interfaces [1], [3], [5]

The packet switched GPRS service can co-exist with the circuit switched GSM service and therefore, it can utilize the existing GSM physical nodes (see Figure 3-1). However, additional physical nodes are required to support the GPRS functionality.

GPRS is designed to support from discontinuous and bursty data transfers through to occasional transmission of large volumes of data. GPRS is designed for fast reservation to begin transmission of packets, typically 0.5 to 1 second. Charging will typically be based on the amount of data transferred.

3.3 GPRS Terminal Class

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; terminal classes and types. Depending on the Mobile Station (MS), define the equipment and the network capabilities, GPRS MSs can operate in three different modes [1]:

- Class A mode of operation allows an MS to have a Circuit Switched (CS) connection at the same time as it is involved in a packet transfer.
- Class B mode of operation allows an MS to be attached to both CS and Packet Switched (PS), but it cannot use both services at the same time. However, MS that is involved in a packet transfer can receive a page for CS traffic. The MS can then suspend the packet transfer for the duration of the CS connection and afterwards resume the packet transfer.
- Class C mode of operation allows a MS only to be attached to one service at the time. A MS that only supports GPRS and not CS traffic will always work in class C mode of operation.

The combination of a Terminal Equipment (TE) and Mobile Terminal (MT) is a MS, but TE and MT components could actually be in the same piece of equipment. From the TE point of view e.g. a laptop computer, you could compare the MT to a modem, connecting the laptop computer to the GPRS system.

3.4 The GPRS System

GPRS introduces two new network nodes in the GSM PLMN (Fig.3-1) The Serving GPRS Support Node (SGSN), which is at the same hierarchical level as the MSC, keeps track of the individual MSs' location and performs security functions and access control. The SGSN is connected to the base station controller with Frame Relay (Gb interface). The Gateway GSN (GGSN) provides interworking with external packet-switched networks, and is connected with SGSNs via an IP-based

GPRS backbone network. The HLR is enhanced with GPRS subscriber information, and the SMS-MSC's are upgraded to support SMS transmission via the SGSN. Optionally, the MSC/VLR can be enhanced for more-efficient co-ordination of GPRS and non-GPRS services and functionality: e.g., paging for circuit-switched calls, which can be performed more efficiently via the SGSN, and combined GPRS and non-GPRS location updates.

3.4 .1 SGSN – Serving GPRS Support Node

The Serving GPRS Support Node (SGSN) is a primary component in the GSM network using GPRS and is a new component in GSM. The SGSN forwards incoming and outgoing IP packets addressed to/from a mobile station that is attached within the SGSN service area, and it provides packet routing and transfer to and from the SGSN service area. It serves all GPRS subscribers that are physically located within the geographical SGSN service area. A GPRS subscriber may be served by any SGSN in the network all depending on location. The SGSN also provides the following:

Ciphering and authentication, Session management, Mobility management and Logical link management towards the MS.

3.4 .2 GGSN - Gateway GPRS Support Node

Like the SGSN, the Gateway GPRS Support Node (GGSN) is a primary component in the GSM network using GPRS and is a new component. The GGSN provides:

- The interface towards the external IP packet networks and is therefore contains access functionality that interfaces external ISP functions like routers and RADIUS servers (Remote Access Dial-In User Service), which are used for security purposes. From the external IP network's point of view, the GGSN acts as a router for the IP addresses of all subscribers served by the GPRS network. The GGSN thus exchanges routing information with the external network.
- GPRS session management, communication setup towards external network.

- Functionality for associating, the subscribers to the right SGSN.
- Output of billing data. The GGSN collects billing information for each MS, related to the external data network usage. Both the GGSN and the SGSN collect charging information on usage of the GPRS network resources.

3.4 .3 CGSN – Co-located GPRS Support Node

Co-located GPRS Support Node (CGSN) means that the SGSN and GGSN functionalities are combined in the same physical node (network element), but they may also reside in different physical nodes. SGSN and GGSN contain GPRS backbone network protocol (IP) routing functionality, and they may be interconnected with IP routers.

3.4 .4 Border Gateway

The border gateway interconnects different GPRS operator's backbones, thereby facilitating the roaming feature. It is based on the standard IP router technology.

3.4 .5 Legal Interception Gateway (LIG)

The LIG performs legal functions in the network. Subscriber data and signalling can be intercepted by using this gateway, thus enabling the authorities to track criminal activities. LIG is required when lunching GPRS service.

3.4 .6 Domain Name System (DNS)

DNS Does the translation of IP host names to IP addresses, thereby making IP network configuration easier. In the GPRS backbone, SGSN uses DNS to get GGSN and SGSN IP addresses.

3.5 Radio Interface

A new radio interface is needed to handle packet traffic, new security features for the GPRS backbone and a new ciphering algorithm, new Mobile Application Part (MAP) and GPRS-specific signaling should be added. GPRS interfaces are the following (Fig.3-1):

Gb is a Frame Relay interface connects the BSS and the SGSN, which allows many users to be multiplexed over the same physical resource. Unlike GSM A interface where the resources of a circuit-switched connection are dedicated to a user throughout the whole session, GPRS Gb interface only allocates resources to a user during the periods when data are actually delivered. As shown in Figure 3-4, the Gb interface protocol layers (from the highest to the lowest) include SNDCP, LLC, Base Station System GPRS Protocol (BSSGP), Network Service (NS) Layer, Link Layer 2, and Physical Layer. The Gb link layer 1 establishes Frame Relay virtual circuits between SGSN and BSS. On these virtual circuits, the NS transports BSSGP Packet Data Units (PDUs) between a BSS and an SGSN.

And as shown in Fig3-1:

Gc: Interface between a GGSN and an HLR.

Gd: Interface between a SMS-GMSC and an SGSN, and between a Short Message Service Interworking MSC (SMS-IWMSC) and an SGSN.

Gf: Interface between an SGSN and an EIR.

Gi: Reference point between GPRS and an external packet data network.

Gn: Interface between two GSNs within the same PLMN.

Gp: Interface between two GSNs in different PLMNs. The Gp interface allows supporting of GPRS network services across areas served by the co-operating GPRS PLMNs.

Gr: Interface between an SGSN and an HLR.

Gs: Interface between an SGSN and an MSC/VLR.

3.6 Packet Control Channels

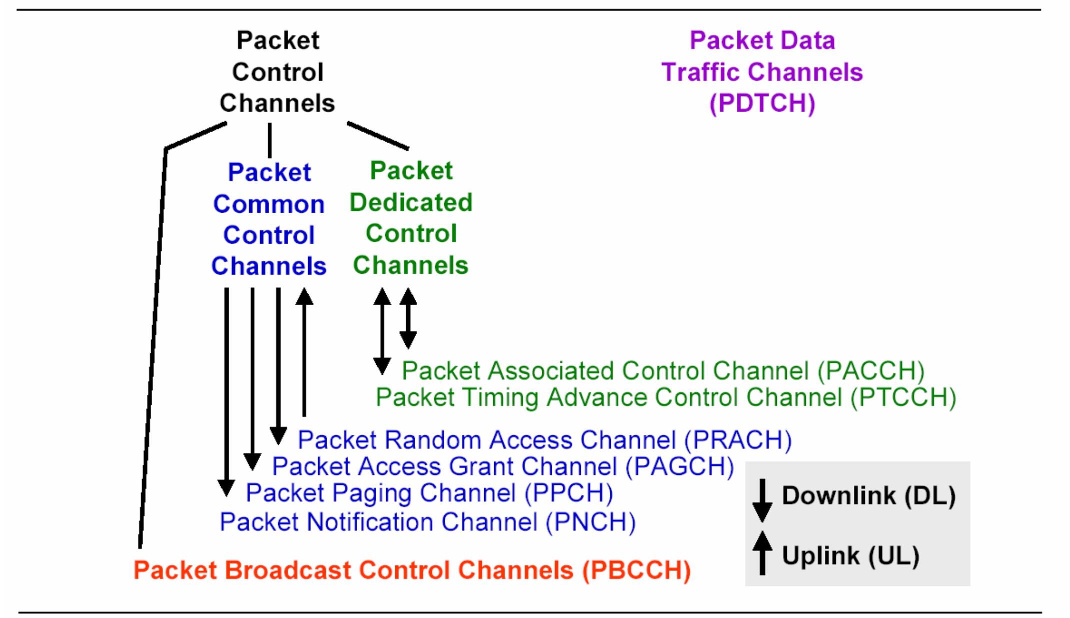


Fig 3-2 GPRS Logical Channels

Fig3-2 lists the packet data logical channels defined in GPRS [2]. As with conventional GSM, they can be divided into two categories: traffic channels and signaling (control) channels. The packet data traffic channel (PDTCH) is employed for the transfer of user data. It is assigned to one mobile station (or in

the case of PTM) can be assign to multiple mobile station or one mobile station can use several PDTCHs simultaneously. The packet broadcast control channel (PBCCH) is a unidirectional point-to-multipoint signaling channel from the base station subsystem (BSS) to the mobile stations. It is used by the BSS to broadcast specific information about the organization of the GPRS radio network to all GPRS mobile stations of a cell. Besides system information about GPRS, the PBCCH should also broadcast important system information about circuit switched services, so that a GSM/GPRS mobile station does not need to listen to the broadcast control channel (BCCH).

The packet common control channel (PCCCH) is a bidirectional point-to-multipoint signaling channel that transports signaling information for network access management, e.g., for allocation of radio resources and paging. It consists of four sub-channels:

- The mobile request one or more PDTCH uses the packet random access channel (PRACH).
- The packet access grant channel (PAGCH) is used to allocate one or more PDTCH to a mobile station.
- The packet-paging channel (PPCH) is used by the BSS to find out the location of a mobile station (paging) prior to downlink packet transmission
- The packet notification channel (PNCH) is used to inform a mobile station of incoming PTM messages (multicast or group call).

The dedicated control channel is a bidirectional point-to-point signaling channel. It contains the channels PACCH and PTCCH:

- The packet associated control channel (PACCH) is always allocated in combination with one or more PDTCH that are assigned to one mobile station. It transports signaling information related to one specific mobile station (e.g., power control information).
- The packet timing advance control channel (PTCCH) is used for adaptive frame synchronization.

The coordination between circuit switched and packet switched logical channels is important. If the PCCCH is not available in a cell, a mobile station can use the common control channel (CCCH) of conventional GSM to initiate the packet transfer. Moreover, if the PBCCH is not available, it will listen to the broadcast control channel (BCCH) to get informed about the radio network. Fig. 3-2 shows the principle of the uplink channel allocation (mobile originated packet transfer)

[2]. A mobile station requests radio resources for uplink transfer by sending a “packet channel request” on the PRACH or RACH. The network answers on the PAGCH or AGCH, respectively. It tells the mobile station which PDCHs it may use. A so-called uplink state flag (USF) is transmitted in the downlink to tell the mobile station whether the uplink channel is free.

3.7 Channels coding schemes

The radio block consists of header, data and control information, which are the MAC header, the RLC data block and MAC/RLC control information. In GPRS system, there are four coding schemes that are used for the packet data; the following table describes the different coding schemes:

Table 3-1 Coding scheme in GPRS

Channel coding scheme	Data rate kb/s
CS-1	9.05
CS-2	13.4
CS-3	15.6
CS-4	21.4

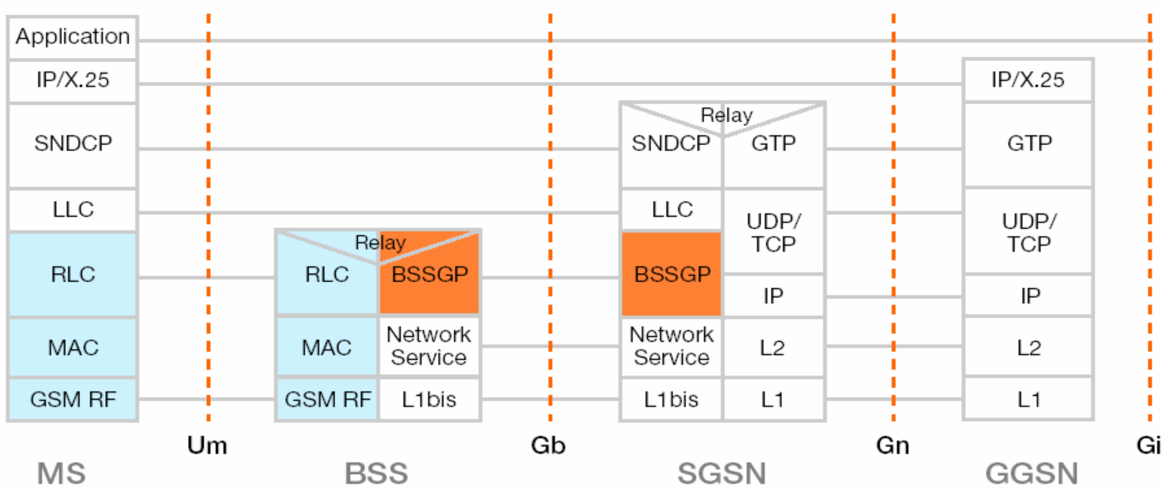
In coding scheme CS-1, half rate convolution code is used for forward error correction (FEC). It has a data rate of 9.05kbps. Coding schemes CS-2 and CS-3 are the same as CS-1 but in punctured format. Puncturing is done to increase data rate but it comes at the cost of reduction in redundancy. Coding scheme CS-4 has "no coding" (i.e. no FEC), so further increasing the data rate to 21.4 kbps.

3.8 Protocols

The GPRS data communication architecture [4], [5], [7] adheres to the principle of protocol layering and has two protocol planes, signaling plane and transmission plane. The signaling plane consists of protocols that control and support the transmission of user information. The transmission plane covers the protocols for user information, and associated control procedures like flow control or error handling. Between SGSN and GGSN (Figure 3-4), the GPRS tunnel protocol (GTP) tunnels the PDUs through the GPRS backbone network. The GTP header contains mobile's identity and PDP context identifier (will be discuss in chapter4). In addition, QoS parameter is included in the PDP context activation and modification. This is not included in every packet.

Below GTP, the Transmission Control Protocol/User Datagram Protocol (TCP/UDP) and IP are used as GPRS backbone network-layer protocols. Any IP based network protocols can be used below IP, e.g. Ethernet cabling, integrated services digital network (ISDN) links, or ATM-based protocols.

Between the SGSN and MS, the Sub network-Dependent Convergence Protocol (SNDCP) maps, network-level protocol characteristics onto the underlying logical link control and provides functionality like multiplexing of network-layer messages onto a single virtual logical link connection. Furthermore, segmentation and compression functionality are covered by SNDCP. The BSS GPRS protocol (BSSGP) has been derived from the BSSAP used in GSM, and conveys routing and QoS-related information between the BSS and SGSN.



Transmission plane protocol architecture. (Legend: BSS, Base station system; BSSGP, BSS GPRS protocol; GGSN, Gateway GPRS support node; GTP, General telemetry processor; IP/X.25, Internet Protocol X.25; LLC, Low-layer capability; L1 and L2, memory caches; MAC, Mobile allocation control; MS, Mobile station; RF, Radio frequency; RLC, Radio link control; SGSN, Serving GPRS support node; SNDCP, Subnetwork-dependent convergence protocol; TCP, Transmission control protocol; UDP, User diagram protocol)

Fig.3-4 Transmission Plane

Radio communication between the MS and the GPRS network covers physical and DLL (data link layer) functionality.

Between MS and BSS the physical layer is split up into a Physical Link sublayer (PLL) and a Physical RF sublayer (PRF). The PRF performs the modulation and demodulation of the physical waveforms. The carrier frequencies, radio channel structures, and raw channel data rates are specified, as well as transmitter and receiver characteristics and performance requirements. The PLL provides services for information transfer over a physical channel between the MS and the network. These functions include data unit framing, data coding, and the detection and correction of physical medium transmission errors.

The data link layer has been separated into two distinct sub layers. The Radio Link Control/Medium Access Control (RLC/MAC) sub layer arbitrates access to the shared medium between a multitude of MSs and the network. The RLC/MAC layer encompasses the efficient multiplexing of data and signaling information, and performs contention resolution, QoS control (limited), and error handling. The MAC itself is derived from a slotted reservation ALOHA protocol, and operates between the MS and BSS. For retransmission of erroneous frames, an automatic selective repeat request (SREJ-ARQ) mechanism is applied.

The Logical Link Control (LLC) layer operates above the MAC layer, and provides a logical link between the MS and SGSN. To allow introduction of alternative radio solutions without major changes to NSS, it is independent of the RLC/MAC protocol as far as possible. Protocol functionality is based on APD as used within the GSM signaling plane, but supports point-to-multipoint transmission [8].

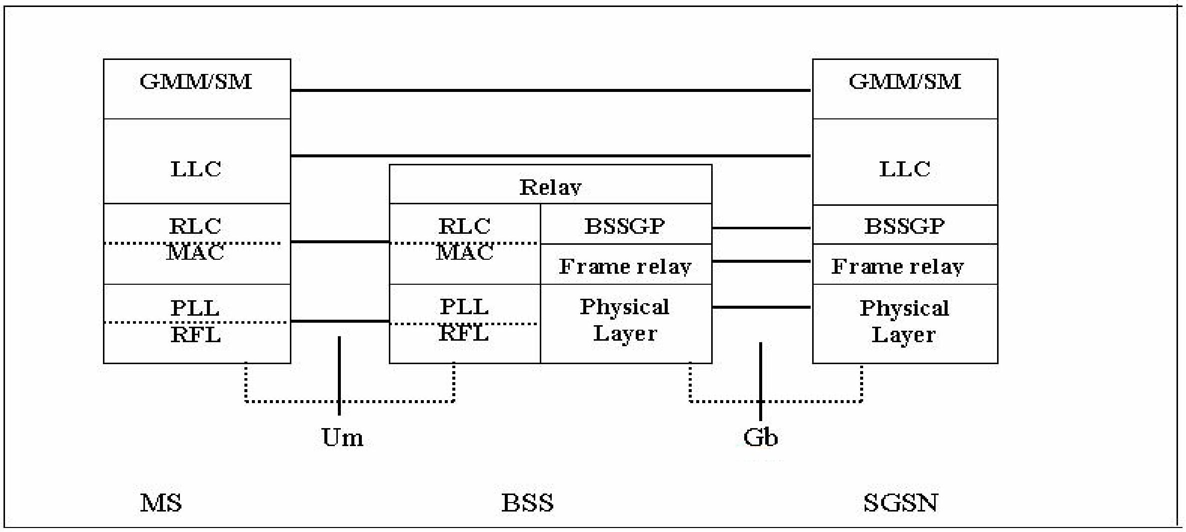


Fig.3-5 Signaling plane

For signaling plane, between the MS, BSS, and SGSN (Figure 3-4), the same protocols are used as for data transmission up to the SNDCP protocol. Only at the network layer, a GPRS-specific mobility management protocol (GMM) is required within MS and SGSN to support the mobility functionality.

3.9 GPRS characteristics

1. Transmission modes: send and receive data in packet transfer mode; cost effective and efficient use of network resources.
2. Traffic characteristics: intermittent, bursty data transmissions; frequent transmissions of small volumes of data; infrequent transmission of large volumes of data
3. Transmission: four level of radio priorities and five classes of QoS supported; point-to-point (PTP) or point-to-multipoint (PTM)

3.10 GPRS Services

From the user's point of view, GPRS is a wireless extension of data networks. It can access to data networks, such as IP-based networks (public internet, private intranet, IPv4 and IPv6 protocols) and X.25 based networks.

GPRS upgrades GSM data services and provides the following services:

1. Point-to-point (PTP) service: internetworking with the Internet (IP protocols) and X.25 networks.
2. Point-to-multipoint (PTM) service: point-to-multipoint multicast and point-to-multipoint group calls.
3. SMS service: bearer for SMS
4. Anonymous service: anonymous access to predefined services
5. Future enhancements: flexible to add new functions, such as more capacity, more users, new accesses, new protocols, new radio networks

The Table below shows us the differences between the GSM and the GPRS services:

Table 3-2 GPRS Vs GSM services

GPRS services	**traditional GSM services**
connection with external packet data networks	connection with circuit switched networks
typical connection can last several hours	typically one call per hour, average call 2 minutes
data transmission bursty	continuous flow of data in both direction
uplink and downlink transmissions independent	
no need to access HLR for every GPRS packet	every MT call causes query to HLR
user can activate services separately	all services activated at IMSI attach
charging is based on amount of transmitted data	charging is based on time
every network element knows where to route packets further	
GPRS support the "service specific attach" principle	
packets are short(typically 500-1000 octets)	
every packet treated as independent entity	

4 CHAPTER

GPRS Operation and Mobility

- **GPRS Operations**
- **Packet Routing**
- **Mobility management**
- **Mobility management functions**
- **GPRS Applications**
- **Quality of Service (QoS)**
- **Protecting the different GPRS parts**

4.1 GPRS Operations and Session Management

In order to send and receive GPRS data, the MS shall activate the packet data address (IP address) that it wants to use, this operation is known as PDP context Activation and lets the corresponding GGSN know the MS, and then interworking with external data networks can start.

The traffic cases in the GPRS are describes as the following:

-MS attach and detach (GPRS attach, IMSI, combined GPRS/IMSI attach)

-PDP context activation and deactivation

-Payload handling

-SMS send and receive

-Cell update

-SGSN routing area update

Before an MS is able to send data to a corresponding host, it has to attach to the GPRS system. During the attachment procedure, the GPRS shall do the following things as shown in Fig 4-1

1. Inform the network for the MS's request to be active.
2. Network checks the MS's identity and initiate ciphering mode for data communication.
3. If SGSN does not already have the MS’s subscription info, download the information from HLR to SGSN update location.
4. Attach Accept.
5. Signal between the MS and SGSN.

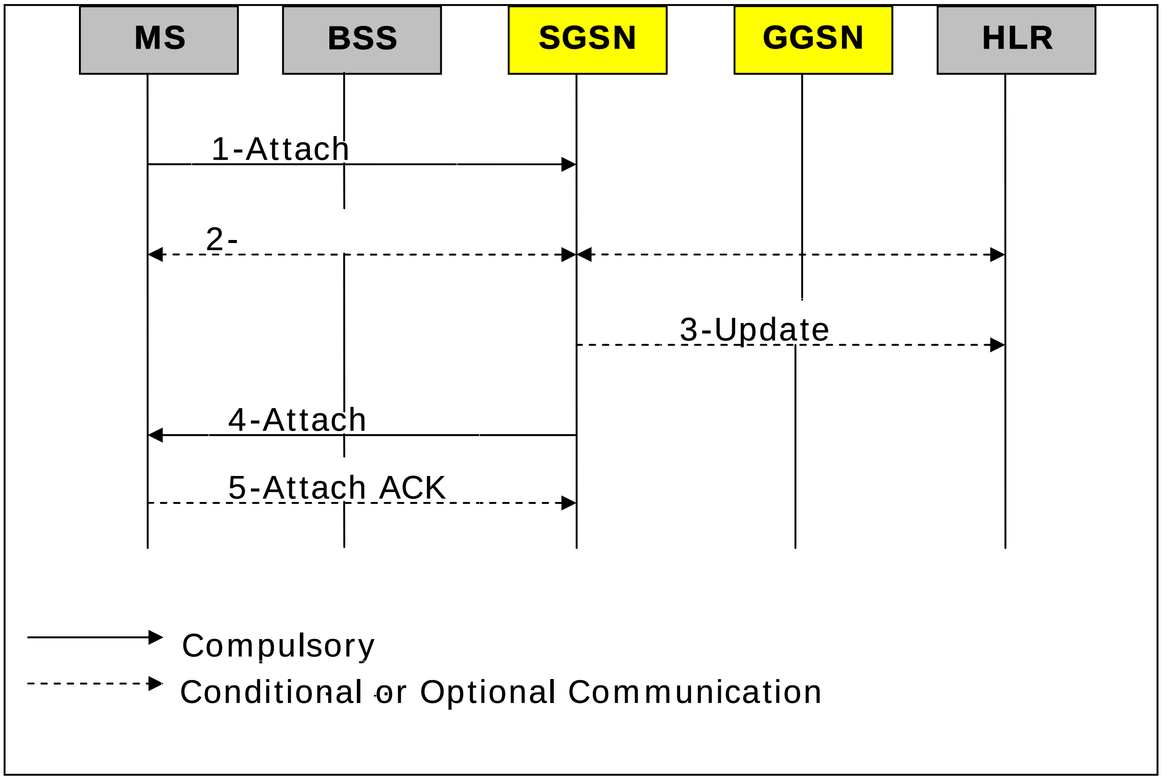


Fig 4-1 GPRS Attach Procedure

PDP context consists of PDP type, PDP address (optional), QoS parameters (optional) and APN, the optional means that when activating a context, these are optional; when context is active; they have some negotiated or subscribed value. Access point name (APN) which is made up of an APN network identifier (look like URL) it will be as the service provider's internet Domain Name (*sdn-mobitel.com*). Moreover, the default APN for MobiTel will be made up using Mobile country code (MCC) and Mobile Network code as located for use in IMSI and it will be as follows:

Sdn-mobitel.com.mnc01.mcc634.gprs

The APN is always resolved to IP address.

GPRS uses the concept of non-anonymous and anonymous PDP contexts. The no-anonymous PDP context means that:

1. MS must have a subscription for this operation.
2. Network verifies that unauthorized PDP context activation is not done.
3. Network knows who holds each PDP context.
4. No limitations on mobility (MS may move freely in the network).

The anonymous PDP context means that:

1. No subscription is needed, no need to attach first.
2. Network does not know who uses PDP context.
3. Limited mobility (only within limited area).

The user may have several subscribed contexts, which are used to access to external data networks. Any of the contexts can be activated or deactivated independently. When context is activated, user can send and receive data packets from MS to fixed network, from fixed network to MS, or form MS to MS. When a context is not activated, the network drops the packets.

The steps of PDP Context Activation procedure are identified in Fig 4-2 the main procedures are:

1. MS send an Activate PDP Context request message to SGSN. This message contains information for the IP address allocation and the requested QoS.
2. SGSN checks that MS is allowed to activate the context. In addition, SGSN fills/defines missing (optional) parameters.
3. SGSN selects GGSN to be used.
4. If the validation was successful, the SGSN sends an Activate PDP Context accept message to the MS.

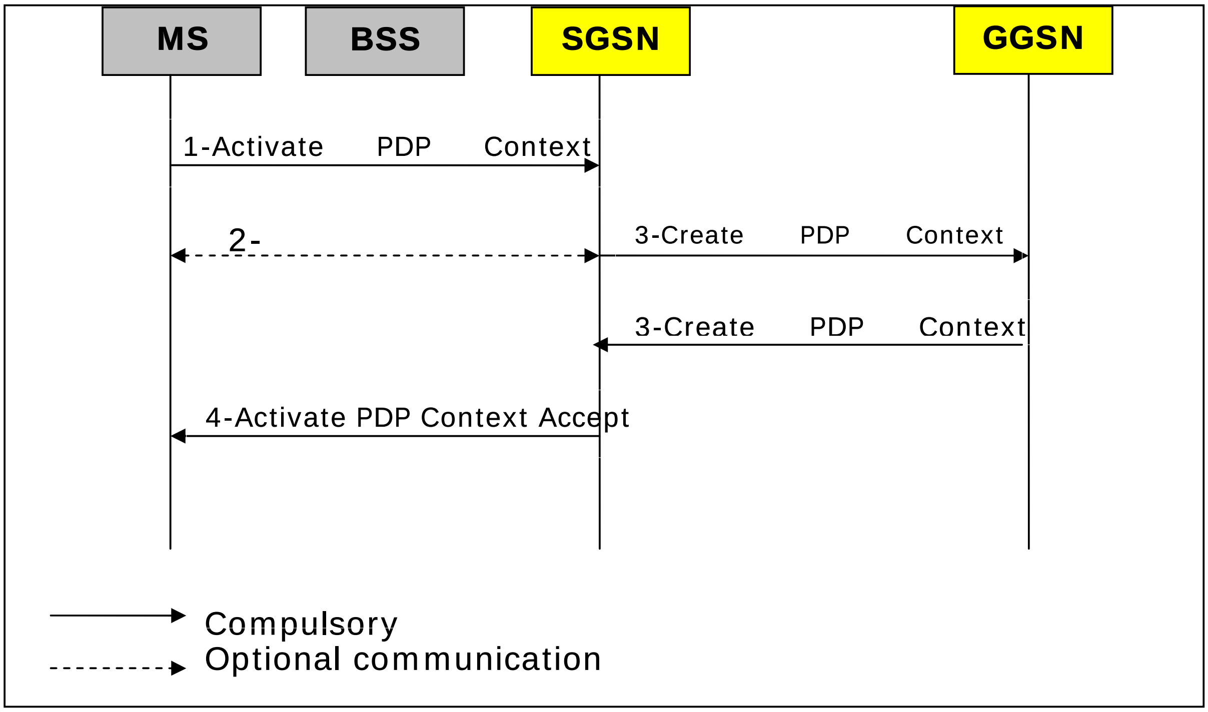


Fig 4-2 PDP Context Activation Procedure (from [GSM 03.60])

In order to communicate with network, the MS shall activate one or more PDP contexts. Once the MS has been attached to the network, the PDP context can be negotiated with the SGSN. If access is permitted, the SGSN informs the GGSN to update the context for the MS. The GGSN context includes the address of the SGSN that is currently serving the MS and tunneling information. The PDP context activation is completed by an acknowledgement from the network to the MS Fig 4-2.

4.2 Packet Routing [4], [7]

The procedure that routes the packets in the GPRS system is called packet routing. In order to explain the packet routing, we use the GPRS network scenario depicted in Figure 4-3. Consider that MS1 roamed from its home domain, i.e., GPRS PLMN1, to GPRS PLMN2. Suppose now that a Terminal Equipment (TE) node attached to an external IP Packet Data Network (PDN) wants to communicate with the MS1. TE sends an IP packet to the IP PDN network, i.e., routing step 1. The addresses of the IP packets will have the same subnet prefix as the address of the

GGSN1 that is located in the Home Domain of MS1. Therefore, the IP PDN network will send these IP packets to GGSN1, i.e., routing step 2. GGSN1 queries HLR to find out the RA wherein MS1 is located, i.e., routing step 3. The HLR informs the GGSN about the new location of MS1, i.e., routing step 4. The IP packets are then (GTP) encapsulated by GGSN1 and tunneled through the Inter-PLMN GPRS network to SGSN2, i.e., routing steps 5 and 6. The SGSN encapsulates the GTP encapsulated IP packets and delivers them to BSS, i.e., Routing step 7. The BSS delivers these packets to the MS1, i.e., routing step 8.

The data transmission can be Mobile oriented data transmission, Mobile terminated data transmission, and Mobile originated and terminated data transmission. In the case of a mobile-originated transmission, the SGSN encapsulates the incoming packets from MS and routes them to the appropriate GGSN, where they are forwarded to the correct PDN. Inside PDN, PDN-specific routing procedures are applied to send the packets to the corresponding host.

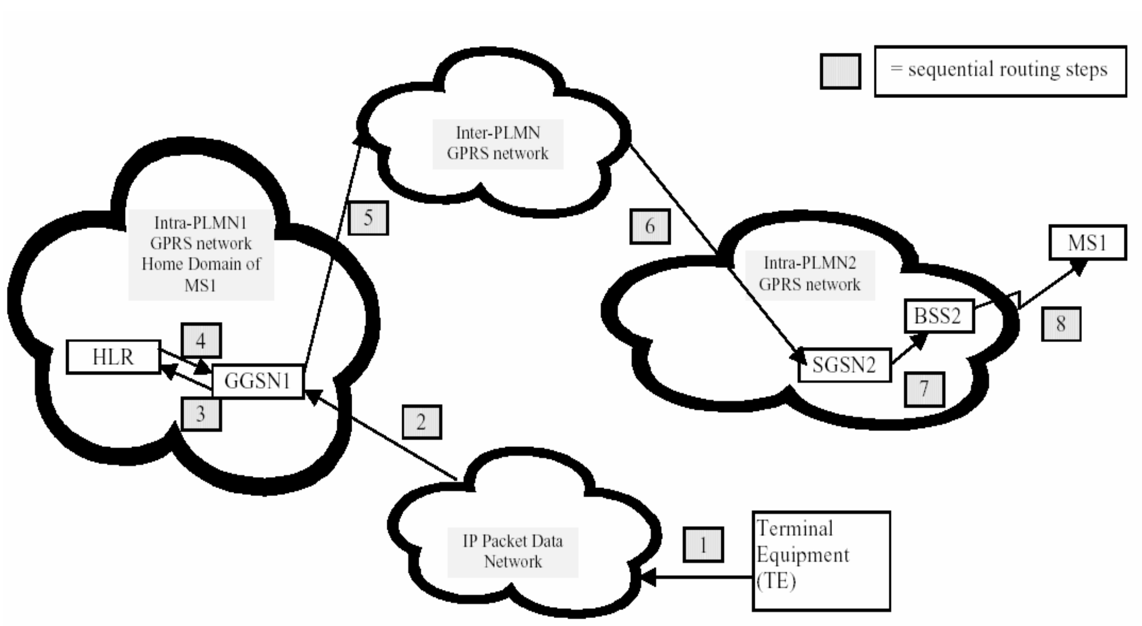


Fig.4-3 Inter Domain Routing

Packets coming from a corresponding host are routed to GGSN through the PDN based on the examination of the destination address. The GGSN checks the routing context associated with this destination address and determines the serving SSGN address and tunneling information. The packet is encapsulated and, forwarded to the SGSN, which delivers it to the mobile station.

4.3 Mobility management

Mobility management[1], [4], [6] within GPRS builds on the mechanisms used in GSM networks; as a MS moves from one area to another, mobility management functions are used to track its location within each mobile network. The SGSNs Communicate with each other and update the user location. The MS profiles are preserved in the visitor location registers (VLRs) that are accessible by the SGSNs via the local GSM MSC (Gs interface). A logical link is established and maintained between the MS and the SGSN in each mobile network. At the end of transmission or when a MS move out of the area of a specific SGSN, the logical link is released and the resources associated with it can be reallocated. The distribution of the RA (routing area) is described in the study case.

There are three activities related to mobility management, that is attach which is discuss early, detach, and location update. Attach means entering/joining the system. Detach means leaving the system. Location update includes routing area (RA) update and cell update.

Because of this attachment, a logical link control context, including a temporary logical link identity (TLLI), is established between the MS and SGSN.

A cell update is performed implicitly on the logical link control level. In cell update, the following information needs to be updated:

1. Specific cell update message
2. Any valid signaling message
3. Any user data sent uplink

4.3.1 Routing Area and Cell Updates

Three different types of updates are possible in GPRS mobility management:

1. Inter-SGSN routing area updates (RAU). This is executed when MS moved into a new routing area (RA) administered by a SGSN different from that of the old RA. The new SGSN realizes that the MS has changed to its area and requests the old SGSN to send the PDP contexts of the user as been discussing earlier. The new SGSN later informs the old SGSN about the user's new routing context. In addition, the HLR, GGSN and, if needed, the MSC/VLR are informed about the user's new SGSN, Fig 4-4. In our case, we plan to have one SGSN in the system, thus the inter-SGSN routing area update will not be handle in this phase.
2. Intra-SGSN routing area update is that the MS has moved to an RA attached to the same SGSN as the old RA. In this case, the affected SGSN has already had the necessary user profile. Since the routing context does not change, there is no need to inform other network elements, such as GGSN or HLR, this will reduce the signaling. However, we have two Routing areas for BSC3 and 6, which will be, discuss in chapter 5.
3. Cell updates. This applies only to MS that is in active state and has moved to a cell that belongs to the same RA; this can work on all the cells connected to BSC3&6 in which the GPRS is deployed as we will see in the following chapter.

However, Inter-SGSN routing update procedure Fig 4-5 is the most complicated procedure among three types of updates described above. As MS changes from one SGSN area to another and it must establish a new logical link context between with the new SGSN, old SGSN, in turn will informs GGSN and HLR about the new location of the MS.

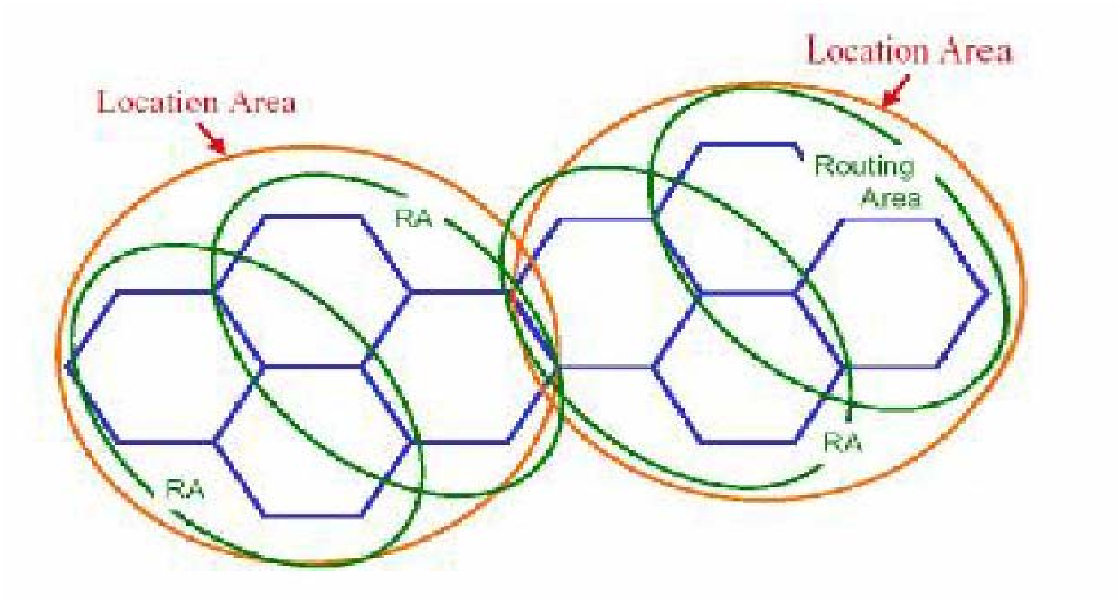


Fig 4-4 Cell, Routing Area and Location Area.

4.3.2 Effect of Changing Routing Area in GPRS

During a routing area update, MS shortly halt its packet transmission and reception. The packet delivery process resumes after completing the routing area
Update procedure i.e. after MS receiving the GMM Routing Area Update Accept message from the new SGSN and after new SGSN receiving GMM Routing Area
Update Request Complete message from MS (see Figure 4-5). This results in delayed packet deliveries, affecting different applications in different ways. In the case of real time interactive application, if packets arrive after play out delay, the packets are dropped. For non real time These ill effects are more prominent for the case of inter-SGSN routing area update, where at least 14 messages are involved, among MS, new SGSN, old SGSN, GGSN, HLR (this does not including security related messages, and is for the case of no combined RA/LA update).

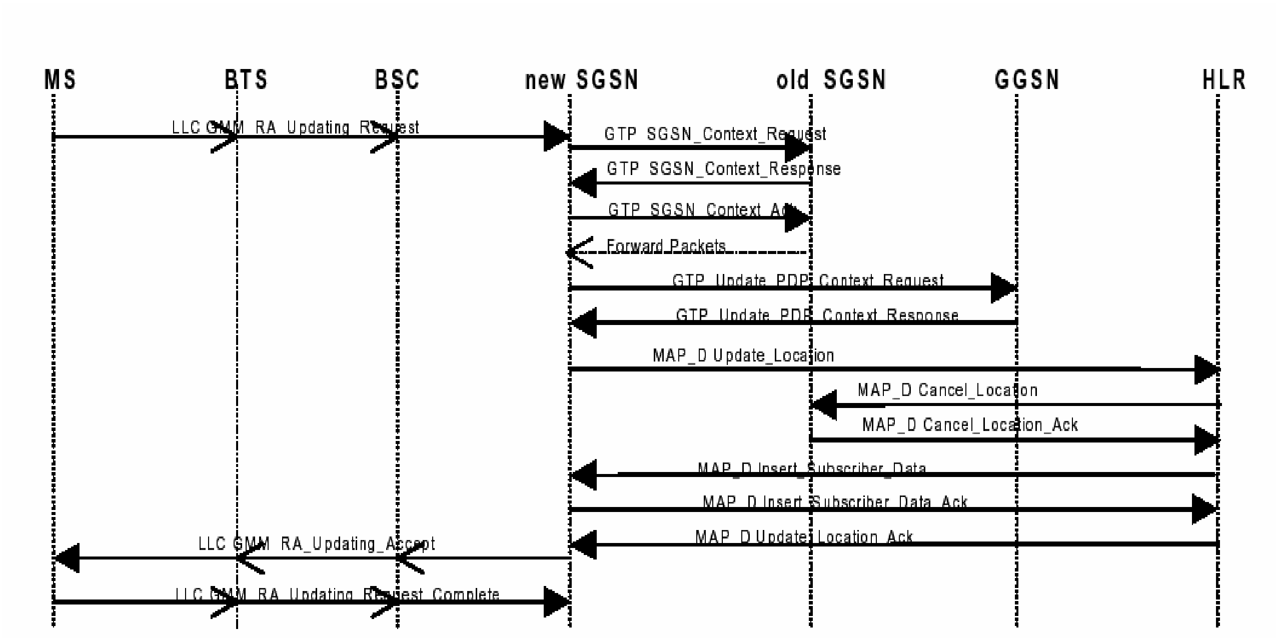


Fig 4-5Inter-SGSN Routing Area Update algorism Procedure

4.4 Mobility management functions

One of the three different MM states characterizes the Mobility Management (MM) activities related to a subscriber. However the MM states for a GPRS subscriber are IDLE, STANDBY, and READY, each state describes a certain level of functionality and information allocated. The information sets held at the MS and the SGSN are denoted MM context.

4.4.1 Mobility Management States for GPRS

By Performing a GPRS attach, the MS gets into READY state and if the MS does not transmit any packet for a long period until the READY timer is expired, the MS will get into STANDBY state. It is possible to transmit data only if the MS is in READY state, thus the MS in STANDBY state can switch back to the READY state, if a PDU transmission occurs and in the same way, at READY state. If the

GPRS detach is performed, the MS will be back into IDLE state and all PDP context will be deleted. The GPRS state model is shown in Figure 4-6.

In the STANDBY state, the MS sends the location update message seldom, so its location is not known exactly and the paging is necessary for every downlink packet, resulting in a significant delivery delay. In the READY state, the MS updates its location frequently. Consequently, the MS's location is known precisely and no paging delay during delivery downlink packet. However, this consumes much more the uplink radio capacity and battery of the MS.

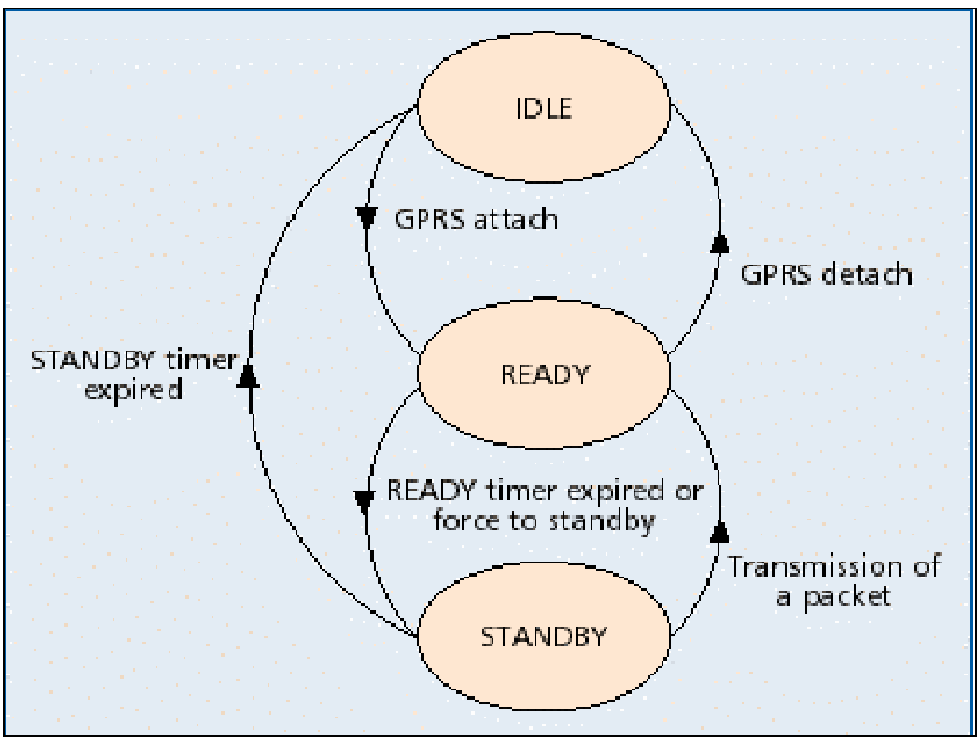


Fig 4-6 Mobility Managements States

5.5 GPRS Applications

GPRS supports standard data network protocol (TCP/IP, X.25) based applications [8], such as www, ftp, telnet, email, video, audio for wireless PCs or mobile offices. There are also GPRS specific protocol based applications, e.g. point-to-point application (Toll road system, UIC train control system, etc.) and point-to-multipoint application (weather info, road traffic info, news, fleet management).

Recently, an important industry trend is remote access, a new technology, referred to as a virtual private network (VPN) [2]. With this new technology, companies will be able to let their remote workers wirelessly access to corporate resources and stay in touch with their work teams.

In general, applications can be separated into two high-level categories: corporate and consumer. These include:

- Communications—E-mail; fax; unified messaging; intranet/Internet access
- Value-added services (VAS)—Information services; games
- E-commerce—Retail; ticket purchasing; banking; financial trading
- Location-based applications—Navigation; traffic conditions; airline/rail schedules; location finder
- Vertical applications—Freight delivery; fleet management; sales-force automation
- Advertising

4.6 Quality of Service (QoS)

- A QoS parameter is associated with each service request primitive received at a Network Service Access Point (NSAP). This is a set of parameters, which collectively specify the, performance of the network service that the network service user expects the network provider in relation this request. In addition, QoS is also used to specify the optional services to be used with this request. The QoS may vary from one network to another.

- GPRS supports Quality of Service. The QoS profile attributes in GPRS are:
  - Precedence class---indicates the importance of the packet with regard to discarding it in case of problems and degradation of QoS when necessary)
  - Reliability class---specifies the mode of operation for various error detection and recovery protocols, how securely the data should be derived.
  - Delay class---the transfer delay includes the uplink radio channel access or downlink radio channel scheduling delay, the radio channel transit delay, and GPRS network transit delay
  - Peak throughput class --- define the maximum allowed transfer rate
  - Mean throughput class --- define long term average transfer rate
- In GPRS, the default QoS profile is defined in HLR. The SGSN and GGSN control QoS in GPRS, but mainly in the SGSN.
- One of the problems of GPRS is relatively low bandwidth and the lack of capability to perform packet multiplexing between LLC packets with different QoS requirement of same PDP context. Another problem is regarding the packets discarding when the MS moves from one BSS to another.

4.7 Protecting the different GPRS parts

The meaning of protecting or preventing different part in the GPRS system is also about avoiding attacks to the system. These can be by:

- The GPRS operator configures a firewall. In general, all applications that are using IP as the underlying protocol are supported, but the GPRS operator may restrict their usage. In most cases, it is necessary to restrict access from external IP networks to the GPRS network.
- A Domain Name Server is managed by the GPRS operator or it can be managed by the of the external IP network operator.

- From the GPRS network's point of view, the allocation of a dynamic IP address is done by the GGSN. The GGSN may allocate these addresses by itself or use an external device such as a DHCP server. This external device may be operated by an external organization such as an ISP or Intranet operator.

Also the security protocol IPSec. IPSec consists of several open standards and its purpose is to ensure security private communication over IP networks. E.g. inside GPRS backbone, between different GPRS Networks and over the Internet. It based on standards developed by the Internet Engineering Task Force (IETF). IP ensures confidentiality, integrity and authentication of data communications across an insecure, public IP network [10].

5 CHAPTER

Migration from GSM to GPRS

- **Introduction**
- **GPRS Network Planning**
- **Case Study (MobiTel-Sudan)**

5.1 Introduction

As it has been described in previous chapters, GPRS is an addition to the existing GSM system, enabling packet-switched transmission in the network whilst keeping the existing value-added services, while migration some factors has to be considered these are:

- 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

5.2 GPRS Network Planning

The main difference between GSM and GPRS networks is the addition of a packet-data handling capability in GPRS. All the differences in network planning are due to this issue. In the following sections, we will explore how the radio network planning, core network planning, and the transmission network planning are affected by the addition of GPRS.

5.2.1 Radio network Planning

Both GSM and GPRS have the same radio-wave propagation principle. The only extra consideration is the addition of data traffic. Three considerations are to be taken when planning the radio network in a GPRS environment:

- **Coverage Planning**

  Coverage in a GPRS network depends on the (signal-to-noise-ratio) and data transmission rates. Each of the coding schemes (table 2) works for a certain range of C/I for a given value of block error rate (BLER). The coverage plans should be made with the objective of providing a balanced *link-budget* (link Power) for both the uplink and downlink directions. The coding scheme used and the channel-to-interference ratio are also factors to consider when planning the coverage of a GPRS network.

- **Capacity Planning**

Capacity planning of a GPRS network may be subdivided into two parts: capacity planning for radio interface and capacity planning for the Gb interface and this is a new interface, we will focus on the capacity planning on radio interface.

The network has three kinds of traffic: voice, CS data and PS data. All these have to be considered when doing capacity planning for radio interface. Circuit-switched traffic is always has priority over PS traffic, but owing to the delay sensitive nature of some PS services, some time slots are dedicated to carry the PS traffic only.

When an existing GSM network is upgraded to a GPRS network, the available capacity falls short for the PS data. Increasing the number of TRX's and the time slots in the GPRS territories (dedicated +default) would be one of the effective ways to tackle the capacity problem.

- **Frequency and Parameter Planning**

Coverage and capacity planning go hand-in hand, and coverage planning is quite related to frequency planning. An effective frequency plan will increase coverage areas significantly and limit interference (as well power control). Thus, in GPRS network, interference reduction becomes quite an important aspect of the whole network-planning scenario.

Parameter planning in a GPRS network can be considered an extension of GSM parameter planning. Signaling, RRM, power control, handover, etc., are still relevant, and extra parameters related to packet data are added. The major enhancements are in the signaling parameters

As seen in chapter3. Lastly, there are parameters related to routing and location area codes, to insure enough capacity is available for paging.

5.2.2 Core Network Planning

Core network planning is subdivided in to two major parts: planning for circuit core and for the packet core. Planning for circuit core consist of switch network planning and signaling network planning these include MSC, VLR, HLR, AC and EIR

5.2.3 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 CGFCDRs to the CCB system for rating. Thus, the charging gateway function is more of a policing function than a charging function this will be located at Dar Elhatif.

5.2.4 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.

5.2.5 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.

5.3 Case Study (MobiTel-Sudan)

5.3.1 Key figures for the MobiTel network

- **Standard**: GSM 900/1800, Phase 2
- **Network size**: 4 MSC's +2 TSC, 9 BSC's, 453BTS the configuration as Fig 5-1 follows:
- MSC1/VLR1+MSC2/VLR2 are located at HQ (Head quarter) serving BSC1&5 connected to MSC1, BSC2&4 to MSC2 while MSC3/VLR3+ MSC4/VLR4 are located at Dar Elhatif and serving BSC3&6,and BSC7,10&11 respectively.
- **Release**: R9.1 upgraded to R10
- **GPRS**: pilot
- **Vendor**: ERICSSON (NSS, BSS, GPRS, MMS)
- **Converse** (SMS, VMS)
- **Transport network:** MW (PDH Ericsson, SDH,DXX Ericsson)
- **VAS:** SMS-email, MMS, Internet, Intranet, GSM Pro, etc.

5.3.2 STRATEGY

- MobiTel strategy is to achieve high-quality GSM network with the GPRS system upgrading Nationwide and to start with GPRS technology at moderate speed starting in Khartoum with high population at the first stage.
- GPRS system requires substantial new investment, since a new Radio Access Network needs to be deployed.
- To make reuse possibility of many of the service network components as well as other peripheral systems.

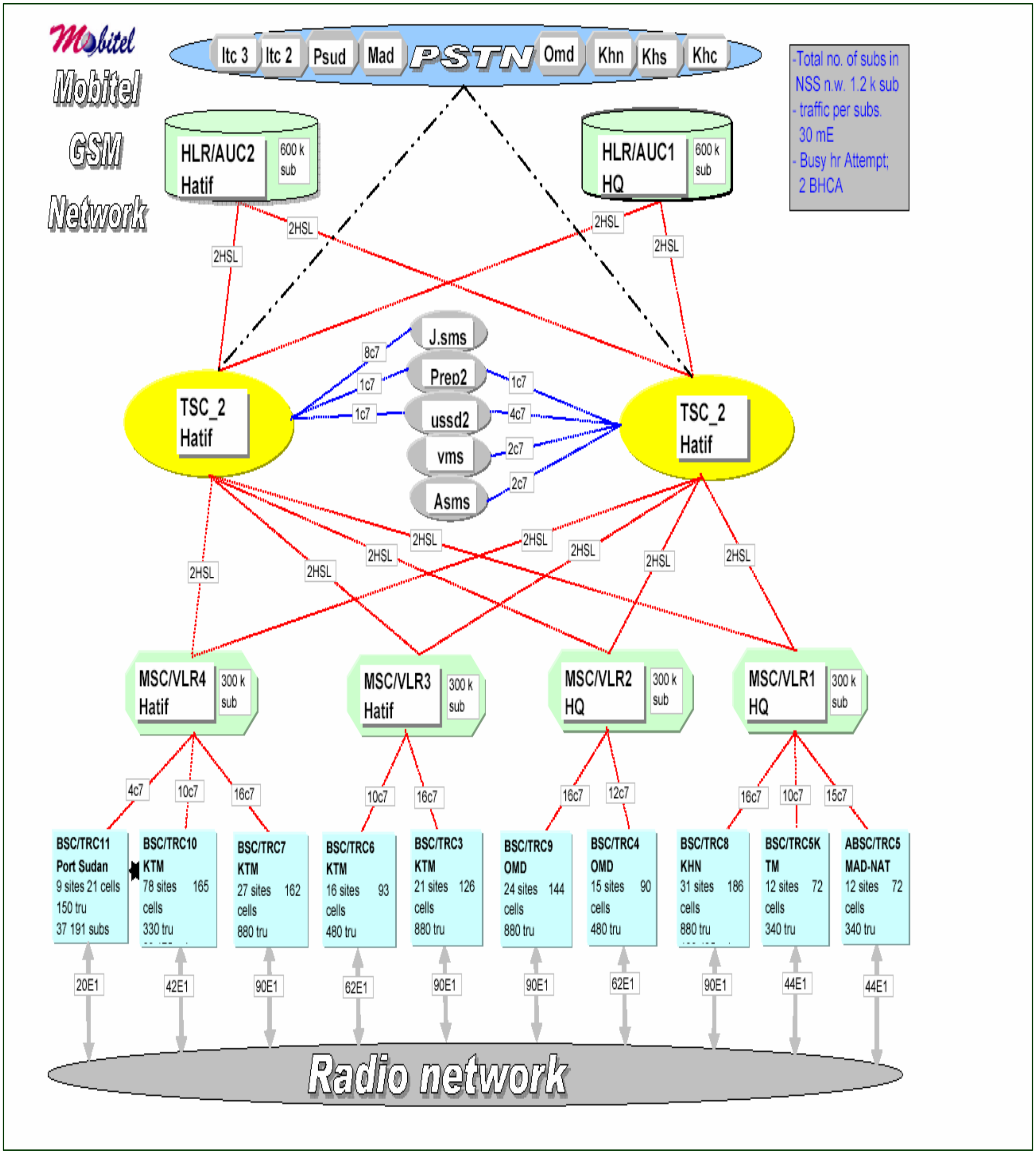


Fig 5-1 MobiTel GSM Network infrastructure

5.3.3Financial Aspects

In order to evaluate the visibility of deploying the GPRS some financial factors are to be taken into consideration. The first consideration is that there is no license purchase required for GPRS. Secondly, we have to take into account an additional percentage of 5% to the annual revenues due to roaming agreements. Thirdly, we have to count in a percentage of at least 15% to the operational costs for content provision as well as $160 per subscriber for terminal subsidiary. Fourthly, Mobitel will have to invest for marketing costs.

Based on the above considerations the net present value, internal rate of return, and payback period can be calculated. The biggest amount of the investment is required in the first two years in order to install GPRS components in urban and suburban areas. This means the addition of new BTSs and software as well as core network infrastructure upgrades for the existing ones. For MobiTel Network this could amount up to $3 million. After deploying the service in the urban area, the cash balance is expected to grow.

4.3.3 Sensitivity Analysis

Three factors are to be considered to conduct a sensitivity analysis for the GPRS in MobiTel:

- GPRS market Penetration
- Market Share – loose of monopoly
- Tariff Level – due to competition

5.3.5 Technical Instillations and Upgrades MobiTel network

The first phase of the project will involve covering the center of Khartoum. The second phase of coverage will include the centers of Khartoum North and Omdurman. The coverage of urban areas and the rest of the country will be included in the final phase of the project. For a detailed migration process, each phase can be broken into three simultaneous processes. :

- Radio Network Upgrade
- Core Network Upgrade
- Transmission Network Upgrade

♦ Radio Network Upgrade

The first phase is to cover center of Khartoum, this area is served by BSC3&BSC6, (Fig5.2) consist of 37 sites/ 180 cells dual band located at DarElhatif to accommodate GPRS, the Base Transceiver Station(BTS) and the Base Station Controller (BSC) in the BSS are modified, and a new component Packet Control Unit (PCU) is introduced. The BTS is modified by software upgrade to support new GPRS channel coding schemes CS1,CS2,CS3&CS4 can be developed depend on the QoS (Table 3-1), however this software upgrade can be remotely downloaded to BTSs so no sites visits are needed. The BSC forwards circuit-switched calls to the MSC, and packet-switched data (through PCU) to the SGSN. BSC3 and BSC6 will be connected to one SGSN through the Gb interface described in Section 3.5 and 3.8 is Frame Relay running across E1 transmission connection implemented to accommodate functions such as paging and mobility management for GPRS. The BSS should also manage GPRS-related radio resources such as allocation of (PDTCH) packet data traffic channels in cells. As described in Section 3.5, the Um radio interface is modified to support GPRS features. To support GPRS traffic, the transmission capacity of the BSS is increased through standard upgrade process. The PCU is viewed as the equivalence of a Transcoder and Rate Adaptor Unit (TRAU) for the packet data services. The PCU is either located locally with the BTS or remotely located in the BSC or the SGSN. Ericsson, follow the remote PCU options so that no hardware modifications to the BTS/BSC are required. In the remote options, existing Abis interface between the BTS and the BSC is reused, and the GPRS data/signaling messages are transferred in modified TRAU frames with a fixed length of 320 bits (20 ms). The PCU is responsible for the Medium Access Control and Radio Link Control layer functions such as packet segmentation and reassembly, packet data traffic channel management (e.g., access control, scheduling, and ARQ), and radio channel management (e.g., power control, congestion control, broadcast control information). Here we will follows one PCU per BSC design. A PCU can cover 512 BTSs and up to 4096 GPRS radio channels (1750 channels practically), which is applicable in this phase as only two channels will be defined for dedicated GPRS traffic. Hence, BSC3 has 833 TRX's and BSC6 has 500 TRX's this can easily work (see the table for the BSC3&BSC6).

The definition of the PDCH on the BSC3&6 will be fixed and on demand, accordingly we will define only two TS in any cell for the fixed PDCH and other two will be on demand for the traffic of GPRS. The table 5-1 shows the capacity of all cells on BSC3&6 after defining two TS for GPRS we can see that the capacity is still not affect in the busy hours.

The present MobiTel radio infrastructure is capable of handling the GPRS needs in terms of Hardware in the BTS's. The only upgrade that is needed is software upgrade to support the coding scheme used.

The following Fig 5-2 shows the geographical area that BSC3 &6 is serving including the location of the sites with their direction, this is done by GIS software Map info

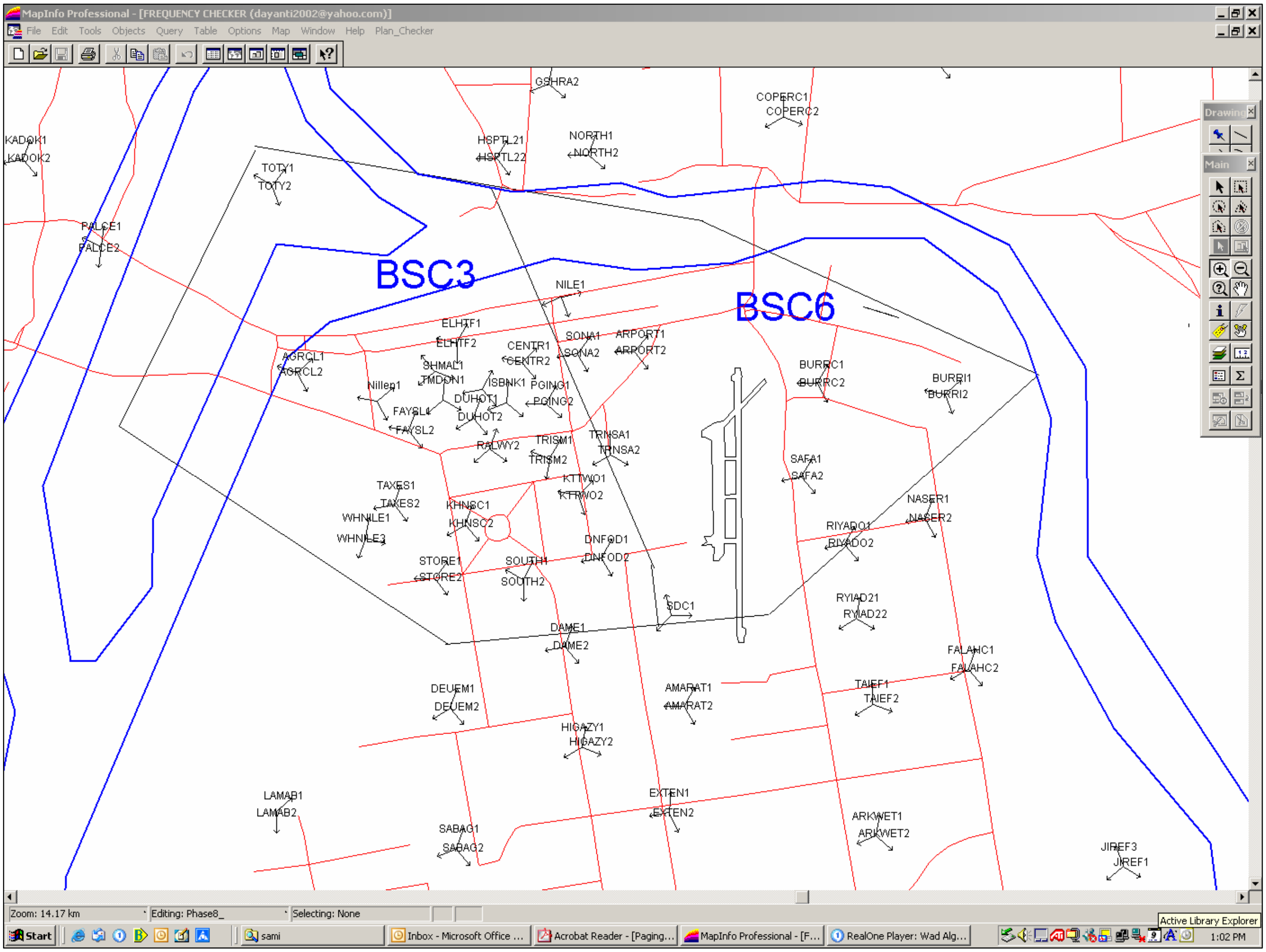


Fig 5-2 BSC3&6 serving area

- **Core Network Upgrade**

Two kinds of GSNs are introduced in GPRS: Serving GSN (SGSN) and Gateway GSN (GGSN). In this phase we can use combined in a physical node (e.g., Symmetry's UWS-GSN [9] and Ericsson's Combined SGSN/GGSN or CGSN [15]). A GSN is typically implemented at multiple processor system

platforms with hardware redundancy and robust software infrastructure that support uninterrupted operation [15]. Ericsson has developed two GSN models. Model GSN-25 is a small-capacity GSN used to enable fast deployment of the GPRS service, which can be deployed in this phase .With the same capability as GSN-25, Model GSN-100 provides larger capacity in terms of throughput and number of attached users.

In SGSN solution, the number of attached users is 20000- 40000, the number of SS7 signaling links is eight, the max number of E1 links to Gb interface is 10 we will use 2 E1 in this phase. Configuration of Gb interface will be shown in the appendix, and the throughput is 20 Mb/s This design is suited for this phases.

As we will use CGSN, a border gateway (BG) shares the GGSNs physical interfaces to external networks and the backbone network. One border gateway can handle multiple public land mobile networks (PLMN). The GGSN sets up communication with external networks and manages GPRS sessions. It also includes functionality for associating subscribers to the SGSN. For each mobile subscriber, the GGSN also collects charging data—use of the external data network and use of GPRS network resources in HLR and VLR4

To accommodate GPRS subscription and routing information, new fields in the MS record are introduced in HLR, which are accessed by SGSN and GGSN using the IMSI as the index key. These fields are used to map an MS to one or more GGSNs, update the SGSN of the MS at attach and detach, and store a fixed IP address and QoS profile for a transmission path. In the HLR, the GSN-related information includes:

- IMSI and MSISDN.
- SS7 address of the SGSN that serves the MS.

- IP address of the SGSN that serves the MS.
- MS Purged for GPRS flag that indicates if the MM and PDP contexts of the MS are deleted from the SGSN.
- MNRG (Mobile not reachable in GPRS) that indicates if the MS is not reachable for GPRS service.
- GGSN-list that provides a GGSN IP address list to be contacted for MS activity when MNRG is set.

In MSC4/VLR4, a new Gs interface is connected to SGSN number is added to indicate the SGSN currently serving the MS. The MSC4/VLR4 may contact SGSN to request location information or paging for voice calls this will reduce the signaling in the GSM A-interface. It also performs signaling coordination for class B mobile through the Gs interface and suspends/resumes GPRS activities through the A and Gb interfaces.

- **Transmission Network Upgrade**

The most important aspects of GPRS packet core network is the dimensioning of a number of main interfaces:

1. The interface between the BSS and SGSN. Normally such a connection is performed via a Frame Relay network connections discuss earlier. Its estimated one SGSN will be needed during the initial phase of the deployment. Only the BSC3&6 that correspond to the areas of coverage will be connected. The SGSN should support SS7 (Gs interface) for synchronization with MSC4.

2. MobiTel Ethernet LAN can be regarded as the GPRS IP backbone; this might need an upgrade to the existing LAN capacity. The interface

   between SGSN and GGSN is connected through the GPRS IP backbone (Ethernet Switch).

3. The interface between GGSN and external networks. In the Ericsson GGSN, a border gateway (BG) shares the GGSNs physical interfaces to external networks and the backbone network. One border gateway can handle multiple public land mobile networks (PLMN) in case of the new GSM operator .The GGSN sets up communication with external MobiTel ISP (Mobinet) and manages GPRS sessions. It also includes functionality for associating subscribers to the appropriate SGSN in the upcoming phases. For each mobile subscriber, the GGSN also collects charging data—use of the external data network and use of GPRS network resources. Since different type of data will be flowing through GGSN, this interface can be regarded as a reference point. We recommend that connection to external or corporate networks.

4. All the other network elements inside the GPRS packet core such as NMS, firewalls, DNS, BG, and any other future expansions of SGSN and GGSN are connected through GPRS IP backbone.

The table below describes all elements in GSM network to be upgraded to GPRS network, we can see that the only new elements are SGSN, GGSN in the core network and in the BSC site there is new PCU component that is added, however in the BTS, HLR &VLR software upgrade is only need.

A very new subscriber terminal is needed to access the GPRS; survey has been made for the MS's in MobiTel network given that 75% of the subscribers are able to use the GPRS service with their terminals.

Table 5-2 Modifications Required for GPRS

GSM Network Element	Modification or Upgrade Required for GPRS
Subscriber Terminal (TE)	A totally new subscriber terminal is required to access GPRS services. These new terminals will be backward compatible with GSM for voice calls.
BTS	A software upgrade is required in the existing base transceiver site (BTS).
BSC	The base station controller (BSC) will also require a software upgrade, as well as the installation of a new piece of hardware called a packet control unit (PCU). The PCU directs the data traffic to the GPRS network and can be a separate hardware element associated with the BSC.
Core Network	The deployment of GPRS requires the installation of new core network elements called the Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN).
Databases (VLR, HLR, and so on)	All the databases involved in the network will require software upgrades to handle the new call models and functions introduced by GPRS.

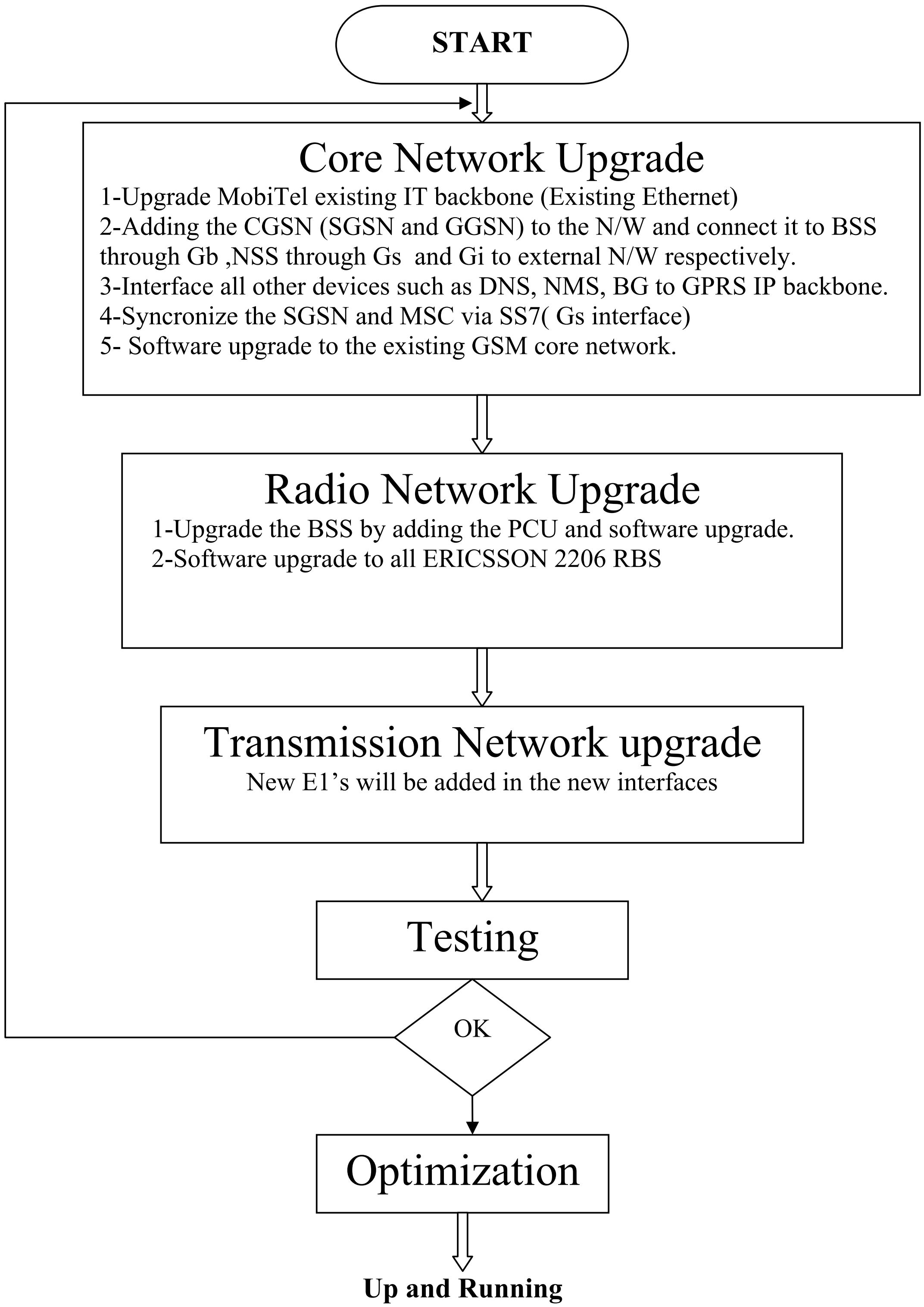


Fig 5-3 Migration Path Flow Chart

6 CHAPTER

Business Plan

- ***The Enterprise***
- ***The Offering***
- ***Market and Strategy***
- ***Finical Projection***
- ***Finical Charts***

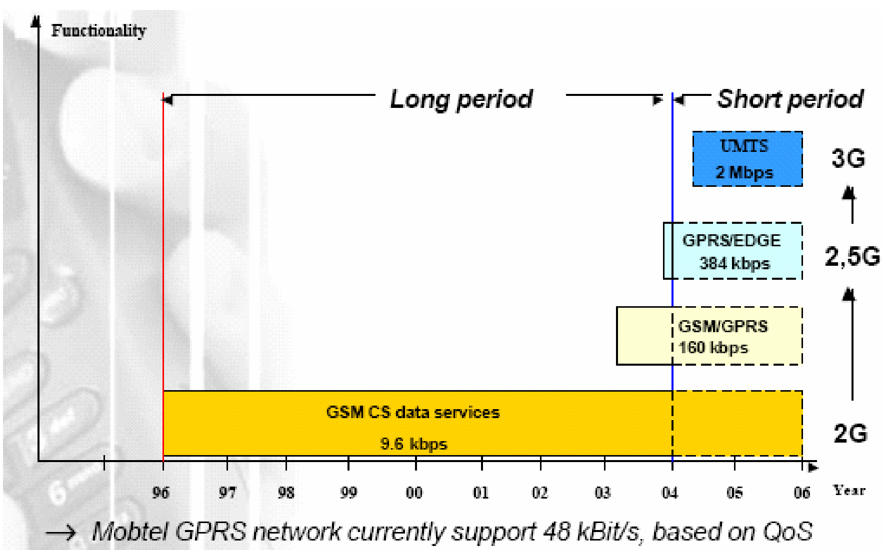
6.0 The Enterprise

6.1 Objectives

We have a number of business objectives, including;

MobiTel strategy to provide complete, quality wireless Internet solutions through the mobile to our clients by incorporating sensible and cost-effective technologies GPRS. This product will be supported by a team of customer-oriented quality staff whose overriding priority is to provide professional service to our customers resulting in complete customer satisfaction.

The analysis is based on the current mobile operator as a monopoly. It is assumed that MobiTel owns and operates a GSM network. The operator starts with 50% of the market share in 2006 and maintains this share until 2020. Since MobiTel already maintains and operates a GSM network it has been taken into consideration how current and future technologies can be merged in one common network, utilizing many of the GSM network elements and reducing network set-up costs. The technical data and network architecture will be held in this version of the study.



→ Mobtel GPRS network currently support 48 kBit/s, based on QoS

6.2 History

MobiTel owns and operates a GSM network since 1997, utilizing many of the GSM network elements and reducing network set-up costs. The technical data and network architecture will be held in this version of the study. However this monopoly will be lost according to the market share

6.3 Future

Based on the present rate of growth announced by MobiTel, and assuming a subscription penetration of 120% until 2020, we can estimate the demand for mobile services. The actual traffic analysis and estimation results are withheld in this version of the study. Based on these results and assuming that the percentage of subscribers holding more than one mobile station starts from 0% and saturates to 20%, the subscriber penetration can also be derived.

6.4 The Offering

6.4.1 Market Segments

For promotional purposes we define our market segments as follows:

Postpaid subscribers

Prepaid subscribers

Corporate

Many companies can use LAN and WAN while they are away from the offices and can accept their e-mails

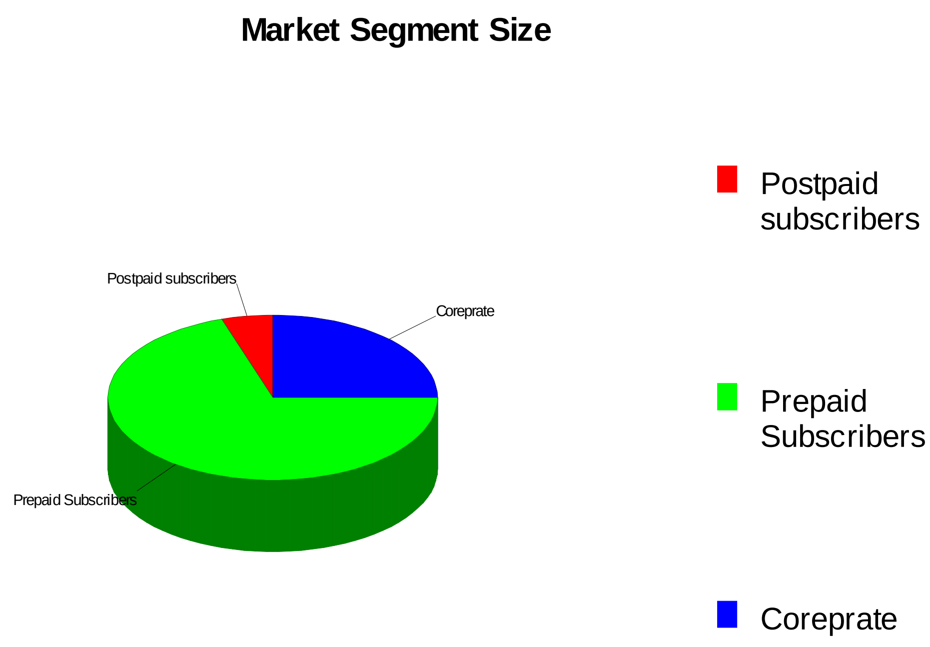


Fig (1) Market Size

▪ Objectives

The majority of our subscribers are prepaid. They want to be able to use the internet and send MMS messages and be able to connect to the GPRS at the any time.

▪ Size

The market consists of prepaid 800000, postpaid 200000, and corporate 400000. we expect to sell at minimum 500000 prepaid subscriber using GPRS with subscription fee of $2 per month and 100000 postpaid with $5 a month and 100000 corporate with $50 per month

How fast is GPRS?

GPRS generally operates at speeds between 30-50 KB/s - similar to a land-line dial-up connection. All traffic across the GPRS network is optimized; that is, the data for email and web browsing is compressed into packets and "accelerated". This lifts actual performance to between 60-120KB/s, except where data is already heavily compressed or is being sent over a Virtual Private Network (VPN).

GPRS data plans with more choice

Whether you're just getting started or you're a frequent user, MobiTel has pricing options to help you get the most value out of your GPRS mobile phone. You're free to choose the option that best suits your needs and budget.

If you're just getting started or you're a low user, you may be better suited to the Pay-As-You-Go (PAYG) option. The plan options are detailed below.

If you frequently access information you may be better suited to one of our GPRS monthly packs. The packs reward frequent users who make an up-front monthly commitment, with lower data volume rates and no session fees. Just call 0912300000 to select the right pack for you.

6.4.2 Description

- **The good things about GPRS are:**

It is faster for sending data than simple dial-up: about three times as fast. You pay for the data transferred, not for the time you have a connection, which means you can leave a connection open in the background. Connection set-up time is shorter than simple dial-up. For example, 2G wireless users that must dial in to the Internet to check e-mail can, on GPRS networks, be prompted as messages arrive. In addition, 2.5G data usage is measured by the kilobyte, rather than by the minute, which should result in lower wireless data costs.

You can now use the MMS to send and receive multimedia messages, in addition to other VAS.

- **How would I use it?**

Like other phones, GPRS-enabled phones are capable of accessing the Internet directly and checking for email or viewing WAP pages, they just do it faster. However, it is arguably more useful to connect a laptop or Pocket PC through your phone, using a cable or Bluetooth. It is also possible to connect to a corporate network using GPRS, either by using a dedicated GPRS link or through a VPN.

A significant number of mobile phones that have appeared over the last two years have GPRS capability built-in. There are also GPRS cards available for laptops and

Pocket PCs that include their own SIM. The only other requirement for connecting to the Internet is to have GPRS set up on your mobile phone account by your network provider.

The services we deliver are accessible to our subscribers for prepaid and postpaid. From the time the customer calls for subscription until they have completed their access the service, our objective is to offer them quality service before they have to ask for it.

We start with service activation. A subscriber can register with our system, providing us with name, address, telephone number we can over up to 5 MB download for free upon subscription. Once the subscriber is using the services, our objective is to make their usage both fast and pleasant.

6.4.3 Market Status

The total subscriber penetration can be split into two different mobile system generations, namely GSM or 2G in which the number of subscriber is 1400000 subscribers, and GPRS or 2.5G. When the period of study starts in 2005 only GSM users are considered to be in the mobile market.

The first GPRS user is expected to appear by July 2005.and we expect to have 50% in the first year, 70 in the second year up saturation level of 80% and is expected to be reached by 2007. Following that period there will be decline in the demand down until the 3G takes over.

6.4.4Value

For the above services specific tariffs are to be assigned based on tariffs of existing fixed services plus 60% premium for mobility. A 5% reduction per year in the tariff prices has to be taken in consideration. This will result in 20% price cut-down by 2010 when this service is expected to be withdrawn. The actual prices and calculations have been omitted from this version of the report.

6.5 Marketing Strategy

6.5.1 Target(s)

As stated earlier, we are targeting the "prepaid subscribers for whom price is a major influencer for where they use the service. Most of these subscribers fall in the 'pay as you go' category.

6.5.2 Promotion

We intend to promote our service and our image in a variety of ways. We expect to advertise in local newspapers, have posters at streets and shops, send direct mail promotions to the human resources director of area businesses and to social and political leaders, and distribute special offer flyers to our customers.

6.5.3 Pricing

Our objective is to achieve the maximum income possible from each service while leaving the subscriber with the feeling that they definitely received their money's worth in service and entertainment.

To do this we want to offer our service at a price that is consistent with the customer's perception of the value received. We believe this is done by creating the proper mental image in each customer's mind about the GPRS experience. This image starts with subscription (500KB up to 5MB free), followed by the other services like MMS email, etc.

- **GPRS Pricing Options**
- **Pay-As-You-Go**

22 cents	Session fee
2.2 cents	Volume rate (per KB)

1. A flat session fee of 22 cents is payable every time you access the service. After 24 hours of continuous connection, we will charge you an additional session fee if our systems can detect that you are still active in that session.

2. Data you send and receive is charged at 2.2 cents per KB transferred. In calculating data volumes, where the volume of data transferred is not a whole number of kilobytes, it is rounded up to the nearest KB at the end of each session.
3. These charges may be included as part of your voice call plan's "included calls" component. To find out, call our Customer Service Centre on 012300000.

Table 6-1 GPRS Pricing Options

Usage charges (per KB) over the included data	Included Data in Monthly Subscription*	Monthly Subscription fee
2 cents	0.5 MB	$2
1.5 cents	1 MB	$5
1.25 cents	2 MB	$10
1.1 cents	5 MB	$25
0.8 cents	10 MB	$50

*Unused included data in a month is forfeited and will not roll over for use in the next month.

Monthly Subscription Plan

1. The monthly subscription fee cannot form part of your voice plan's "included calls" component however data volume charges that exceed the included data component of a selected GPRS monthly subscription may form part of the "included calls" component of voice call plans. For further details call our Customer Service Centre on 0912300000.
2. In calculating data volumes, where the volume of data transferred is not a whole number of kilobytes, it is rounded up to the nearest KB at the end of each session.

3. No other discounts or special pricing options apply.
4. MobiTel accepts no responsibility for any content accessed by customers using the GPRS and is not liable for loss or damage suffered by any person as a result of using information obtained using the GPRS or the Internet. Customers must accept full risk and responsibility for their use of the GPRS and must not use the GPRS for any illegal or inappropriate purpose.
5. Transmitted data includes packet data payload plus the packet header

6.6 Financial Projections

6.6.1 Year One Income/Expenses

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	TOTAL
Revenue:													
													0
													0
Cust. Dep./Sale of Assets	0	1,520,000	1,100,000	1,320,000	3,840,000	2,565,000	3,710,000	0	0	0	0	0	14,055,000
Total revenue	$0	$1,520,000	$1,100,000	$1,320,000	$3,840,000	$2,565,000	$3,710,000	$0	$0	$0	$0	$0	$14,055,000
Expenses:													
Cost of goods sold													
													0
													0
Gross margin	$0	$1,520,000	$1,100,000	$1,320,000	$3,840,000	$2,565,000	$3,710,000	$0	$0	$0	$0	$0	$14,055,000
Depreciation	0	-4,274	-4,530	-4,915	-5,342	-5,833	-6,474	26,870	26,880	26,891	26,902	26,912	103,088
Loan Payment Interest	0	0	0	0	0	0	0	0	0	0	0	0	0
													0
													0
													0
Total Operating Expenses	$0	($4,274)	($4,530)	($4,915)	($5,342)	($5,833)	($6,474)	$26,870	$26,880	$26,891	$26,902	$26,912	$103,088
Pre-Tax ($)	$0	$1,524,274	$1,104,530	$1,324,915	$3,845,342	$2,570,833	$3,716,474	($26,870)	($26,880)	($26,891)	($26,902)	($26,912)	$13,951,912
Pre-Tax (%)	0.00%	100.28%	100.41%	100.37%	100.14%	100.23%	100.17%	0.00%	0.00%	0.00%	0.00%	0.00%	99.27%
Fed. Tax Provision													1,395,191
													0
Net Profit	**$0**	**$1,524,274**	**$1,104,530**	**$1,324,915**	**$3,845,342**	**$2,570,833**	**$3,716,474**	**($26,870)**	**($26,880)**	**($26,891)**	**($26,902)**	**($26,912)**	**$12,556,721**

6.6.2 One Year Cash flow

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	TOTAL
Source of Funds													
Beginning cash	**1,000,000**	**3,010,685**	**8,194,247**	**10,929,863**	**13,849,315**	**19,730,000**	**23,209,726**	**27,924,110**	**28,940,000**	**28,940,000**	**28,940,000**	**28,940,000**	**1,000,000**
Sales/Svcs Income	**10,685**	**783,562**	**1,035,616**	**719,452**	**680,685**	**729,726**	**714,384**	**1,015,890**	**0**	**0**	**0**	**0**	**5,690,000**
Sale of Assets	**0**	**4,200,000**	**1,600,000**	**2,200,000**	**5,200,000**	**2,750,000**	**4,000,000**	**0**	**0**	**0**	**0**	**0**	**19,950,000**
Customer deposits	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Loans	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Contributed Capital	**2,000,000**	**200,000**	**100,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,300,000**
Available Cash	**$3,010,685**	**$8,194,247**	**$10,929,863**	**$13,849,315**	**$19,730,000**	**$23,209,726**	**$27,924,110**	**$28,940,000**	**$28,940,000**	**$28,940,000**	**$28,940,000**	**$28,940,000**	**$28,940,000**
Tax Payments			**0**			**0**			**0**			**2,295,191**	**2,295,191**
Total Cash Out	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$2,295,191**	**$2,295,191**
Net Cash Flow	**$3,010,685**	**$8,194,247**	**$10,929,863**	**$13,849,315**	**$19,730,000**	**$23,209,726**	**$27,924,110**	**$28,940,000**	**$28,940,000**	**$28,940,000**	**$28,940,000**	**$26,644,809**	**$26,644,809**

6.6.3 Year Two Cash Flow

	Q1	Q2	Q3	Q4	Totals
Source of Funds					
Beginning cash	26,644,809	31,644,809	34,644,809	38,144,809	26,644,809
Sales/Svcs Income	0	0	0	0	0
Sale of Assets	4,000,000	3,000,000	3,500,000	4,000,000	14,500,000
Customer deposits	0	0	0	0	0
Loans	0	0	0	0	0
Contributed Capital	1,000,000	0	0	0	1,000,000
Available Cash	$31,644,809	$34,644,809	$38,144,809	$42,144,809	$42,144,809
Use of Funds					
Salaries	0	0	0	0	0
Other oper. expenses	0	0	0	0	0
Loan payments	0	0	0	0	0
Capital Expenditures	0	0	0	0	0
Dividends	0	0	0	0	0
Tax Payments	0	0	0	1200532	1200532
Total Cash Out	$0	$0	$0	$1,200,532	$1,200,532
Net Cash Flow	**$31,644,809**	**$34,644,809**	**$38,144,809**	**$40,944,277**	**$40,944,277**

6.6.4 Five Years Cash flow

	Year 1	Year 2	Year 3	Year 4	Year 5
Source of Funds					
Beginning cash	1,000,000	26,644,809	40,944,277	43,718,507	43,718,507
Sales/Svcs Income	5,690,000	0	0	0	0
Sale of Assets	19,950,000	14,500,000	3,500,000	0	0
Customer deposits	0	0	0	0	0
Loans	0	0	0	0	0
Contributed Capital	2,300,000	1,000,000	0	0	0
Available Cash	$28,940,000	$42,144,809	$44,444,277	$43,718,507	$43,718,507
Use of Funds					
Salaries	0	0	0	0	0
Other oper. expenses	0	0	0	0	0
Loan payments	0	0	0	0	0
Capital Expenditures	0	0	0	0	0
Dividends	0	0	0	0	0
Tax Payments	2,295,191	1,200,532	725,769	0	0
Total Cash Out	$2,295,191	$1,200,532	$725,769	$0	$0
Net Cash Flow	**$26,644,809**	**$40,944,277**	**$43,718,507**	**$43,718,507**	**$43,718,507**

6.6.5 Balance Sheet

	Year 1	Year 2	Year 3	Year 4	Year 5
Current Assets:					
Cash	26,644,809	40,944,277	43,718,507	43,718,507	43,718,507
Accounts Receivable	0	0	0	0	0
Inventories	0	0	0	0	0
Historical Other	0	0	0	0	0
Total Current Assets	$26,644,809	$40,944,277	$43,718,507	$43,718,507	$43,718,507
Fixed Assets:					
Buildings & Equipment	-1,005,000	-2,770,000	-2,970,000	-2,970,000	-2,970,000
Non-depreciable assets	-80,000	-65,000	-48,000	-30,000	-10,000
Less Accum Deprec.	-103,088	-567,767	-1,014,690	-1,461,613	-1,908,536
Total Fixed Assets	($1,188,088)	($3,402,767)	($4,032,690)	($4,461,613)	($4,888,536)
Other Assets	0	0	0	0	0
Total Assets	$25,456,721	$37,541,510	$39,685,817	$39,256,894	$38,829,971
Current Liabilities:					
Accounts Payable	0	0	0	0	0
Short Term Loans	0	0	0	0	0
Other short term liabilities	2,500,000	2,780,000	2,747,000	2,765,000	2,785,000
Historical Other	0	0	0	0	0
Total Current Liabilities	$2,500,000	$2,780,000	$2,747,000	$2,765,000	$2,785,000
Cust. Dep. Liability	0	0	0	0	0
Long-term Liabilities	0	0	0	0	0
Total Liabilities	$2,500,000	$2,780,000	$2,747,000	$2,765,000	$2,785,000
Stockholder's Equity:					
Contributed Capital	2,300,000	3,300,000	3,300,000	3,300,000	3,300,000
Retained Earnings	20,656,721	31,461,510	33,638,817	33,191,894	32,744,971
Total Stockholder's Equity	$22,956,721	$34,761,510	$36,938,817	$36,491,894	$36,044,971
Liabilities + Equity	**$25,456,721**	**$37,541,510**	**$39,685,817**	**$39,256,894**	**$38,829,971**

6.6.6 Financial Alternatives

Best Case

	% Chg	2005	2006	2007	2008	2009
Revenue:						
Product/Service sales	20%	6,600,000	750,000	0	0	0
Maintenance	10%	165,000	100,000	0	0	0
Interest	10%	0	0	0	0	0
Other	10%	44,000	50,000	0	0	0
Cust. Dep./Sale of Assets	20%	20,838,000	14,964,000	4,020,000	0	0
Total revenue		$27,647,000	$15,864,000	$4,020,000	$0	$0
Expenses:						
Cost of Goods Sold						
Management Salaries		100,000	120,000	200,000	0	0
Non-management Salaries		50,000	70,000	100,000	0	0
		0	0	0	0	0
		0	0	0	0	0
Production Expenses		100,000	150,000	100,000	0	0
Other		50,000	40,000	50,000	0	0
		0	0	0	0	0
		0	0	0	0	0
Gross margin		$27,347,000	$15,484,000	$3,570,000	$0	$0
Management Salaries		0	0	0	0	0
Non-management Salaries		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
Operating Expenses		0	0	0	0	0
Bad Debt		0	0	0	0	0
Contributions		0	0	0	0	0
Other Expenses		0	0	0	0	0
Depreciation		103,088	464,679	446,923	446,923	446,923
Loan Payment Interest		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
Total Operating Expenses		$103,088	$464,679	$446,923	$446,923	$446,923
Pre-Tax Income		$27,243,912	$15,019,321	$3,123,077	($446,923)	($446,923)
Pre-Tax (%)		98.54%	94.68%	77.69%	0.00%	0.00%
Fedl Tax Provision		2,724,391	1,501,932	780,769	0	0
Net Profit		$24,519,521	$13,517,388	$2,342,308	($446,923)	($446,923)

6.7 Financial Charts

6.7.1 Five Years Profit & Loss

Figure below shows five years profit and loss; we can see that the revenue is good in the first year of the project.

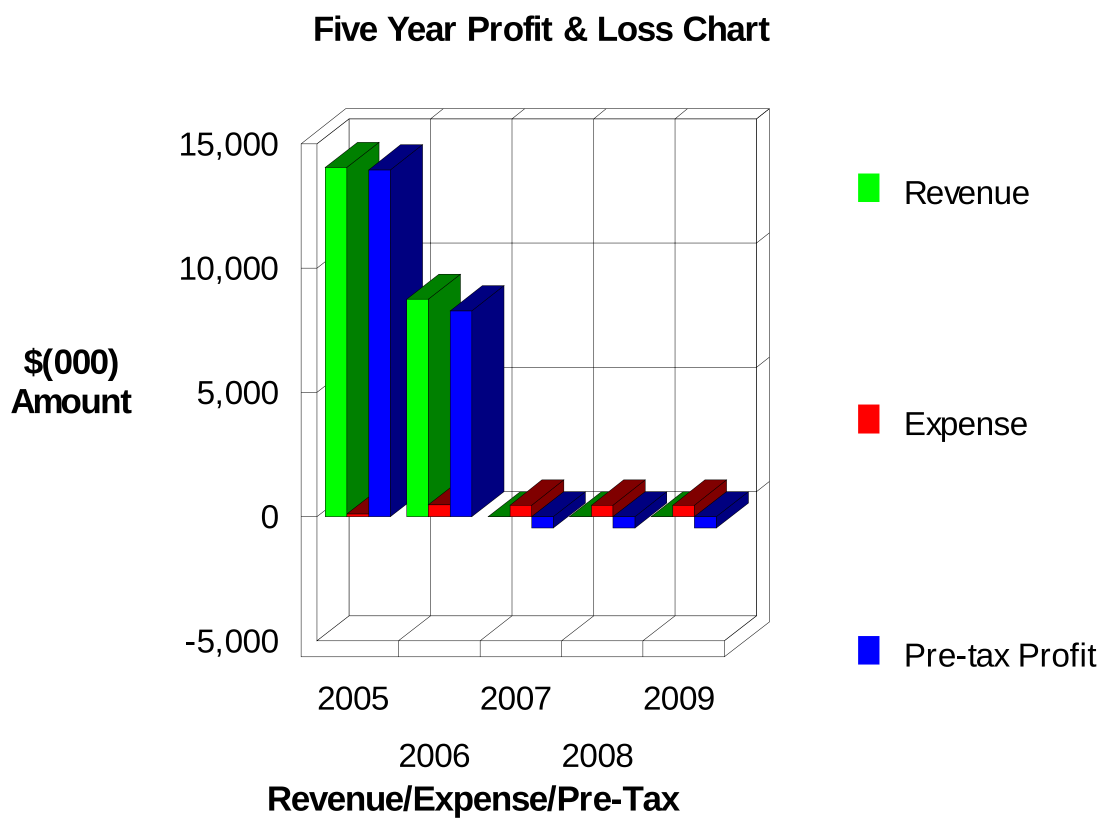


Fig (6.7.1) Five Years Profit & Loss

6.7.2 Year One Break Even

The Figure below shows one year break even, we can see the cash in versus the cash out in the first year.

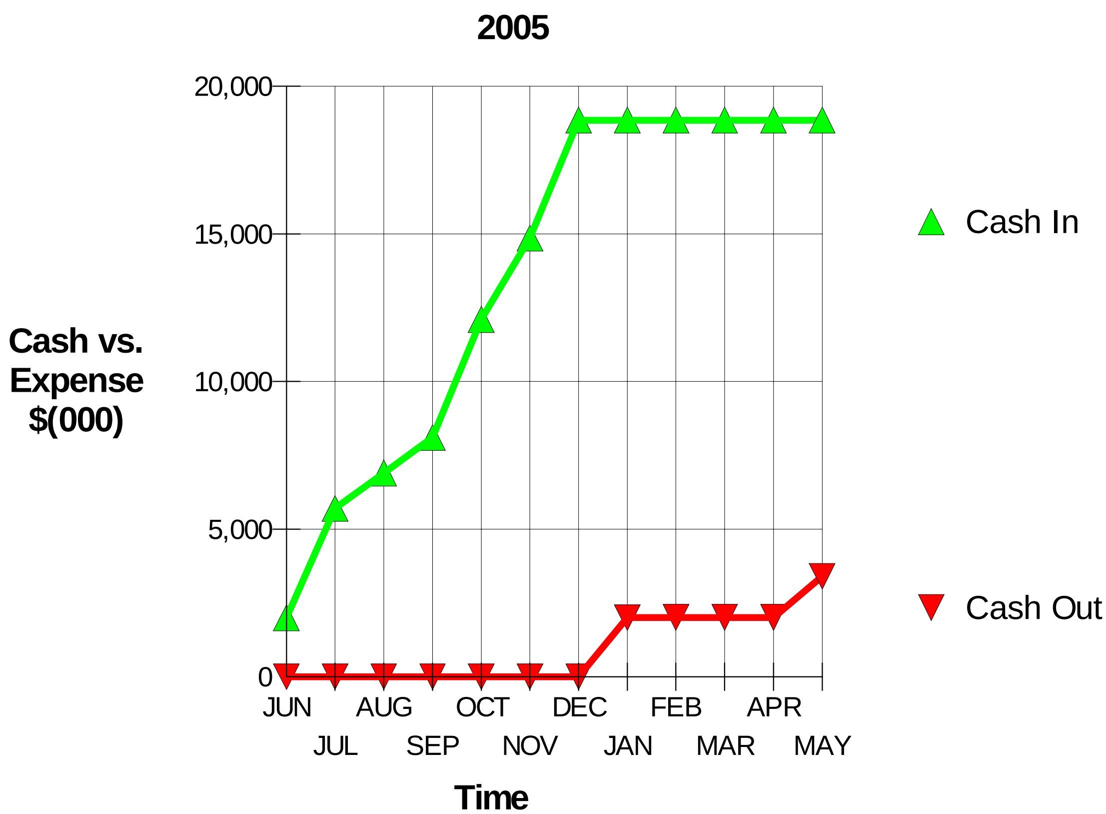


Fig (6.7.2) Year One Break Even

6.7.3 Two Years Break Even

Figure below shows the two years break even; it describes the amount in cash in and out in the eight quarters in the two years.

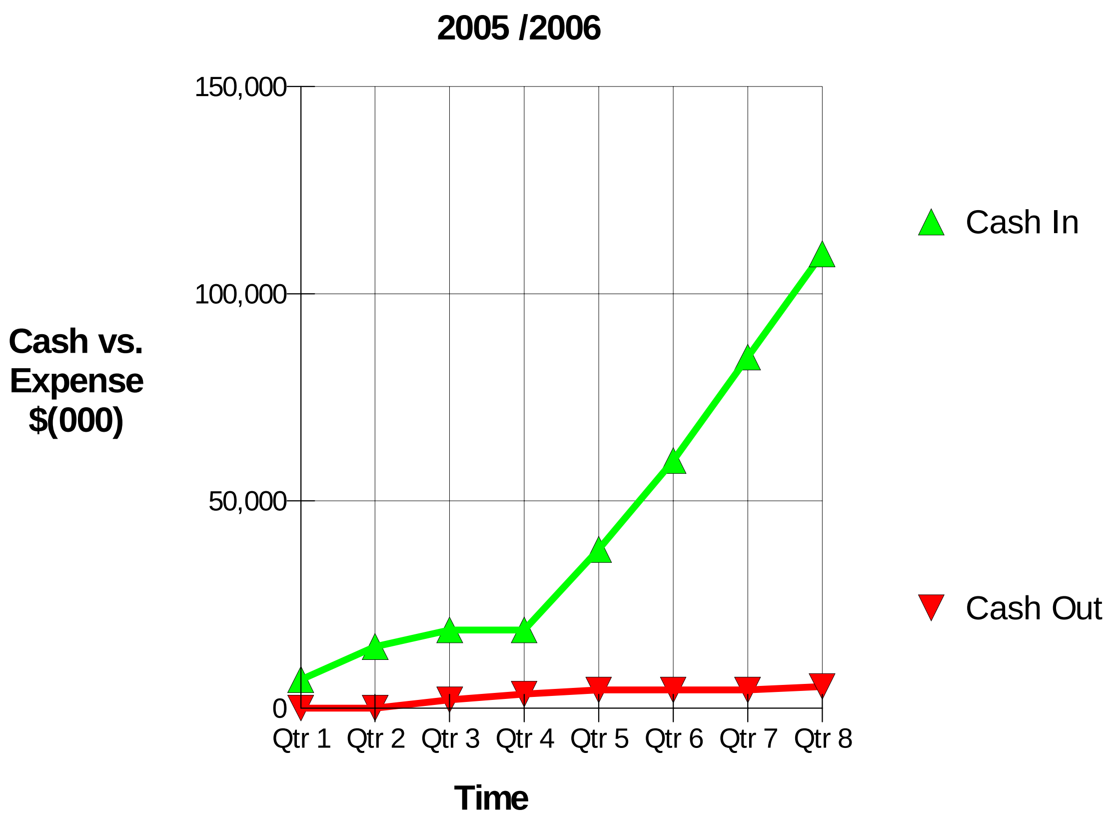


Fig (6.7.3) Two Year Break Even

6.7.4 Five Years Break Even

Figure below shows the five years break even; it describes the amount in cash in and out in the eight quarters in the five years.

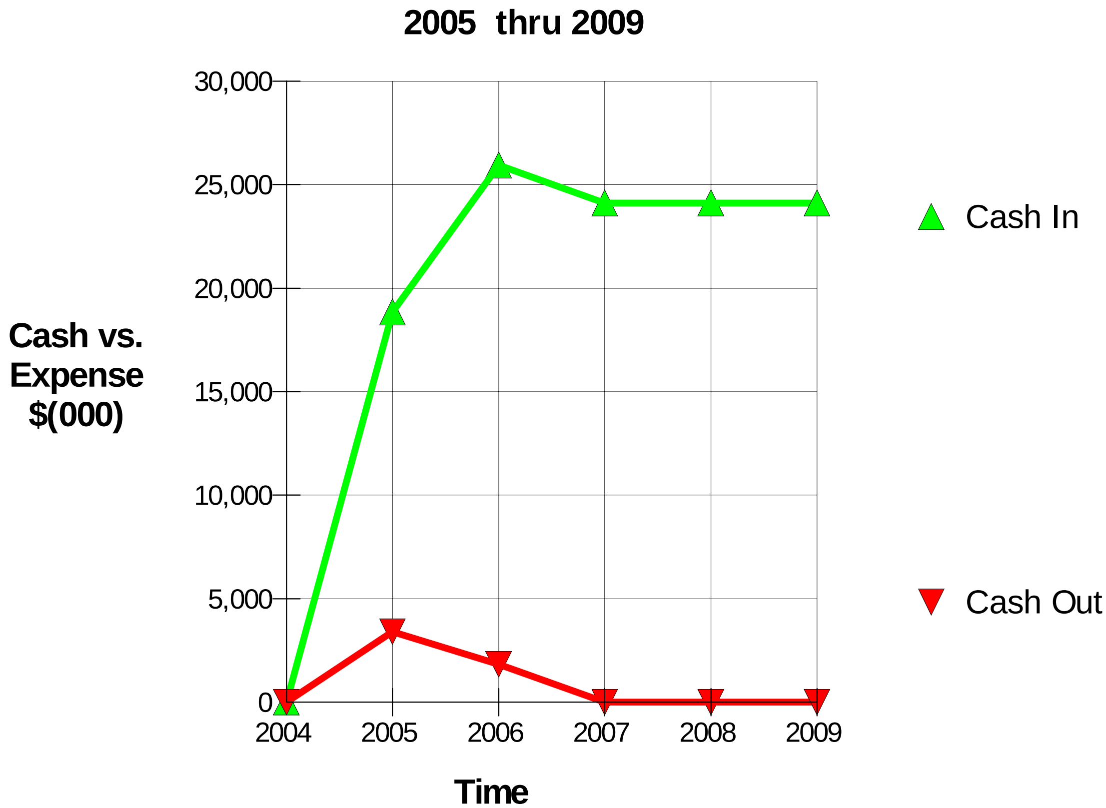


Fig (6.7.4) Five Years Break Even

6.7.5 Year One Cash Flow

The figure below depicted year one cash flow.

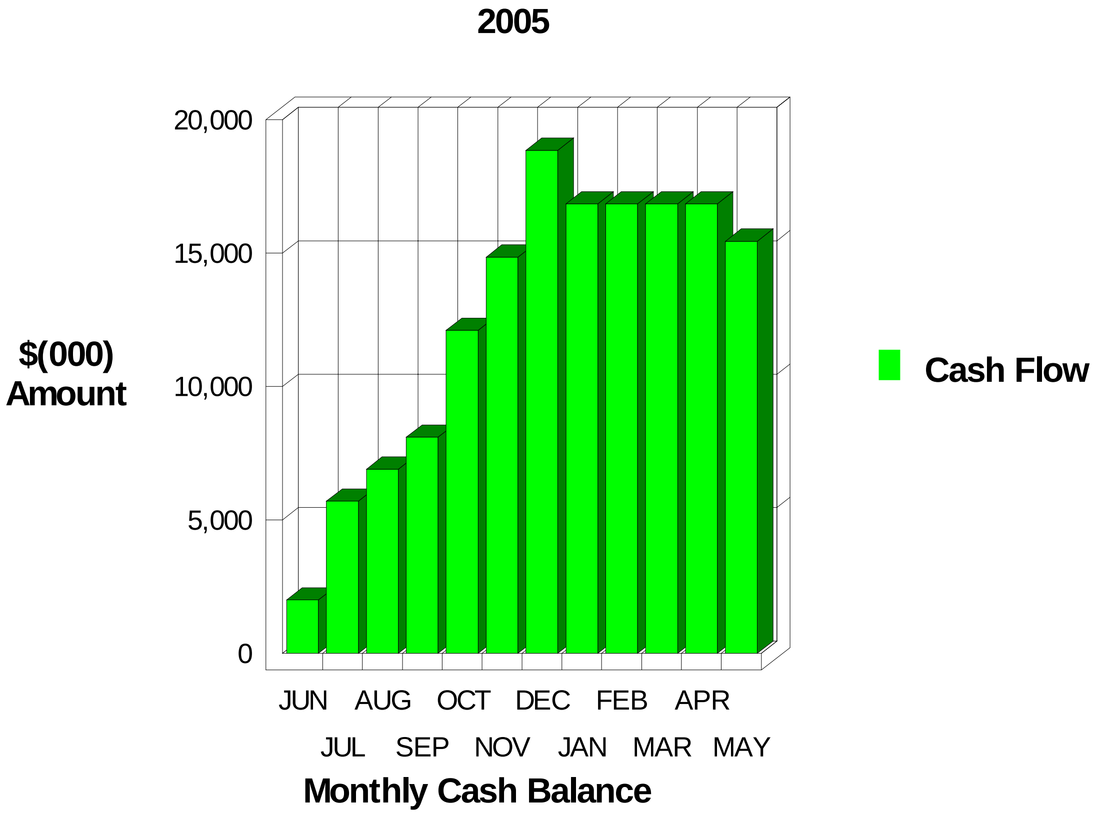


Fig (6.7.5) Year One Cash Flow

6.7.6 Two Years Cash Flow

Figure below shows two years cash flow; the Y-axis shows the amount in thousands dollars and X-axis the quarterly cash balance.

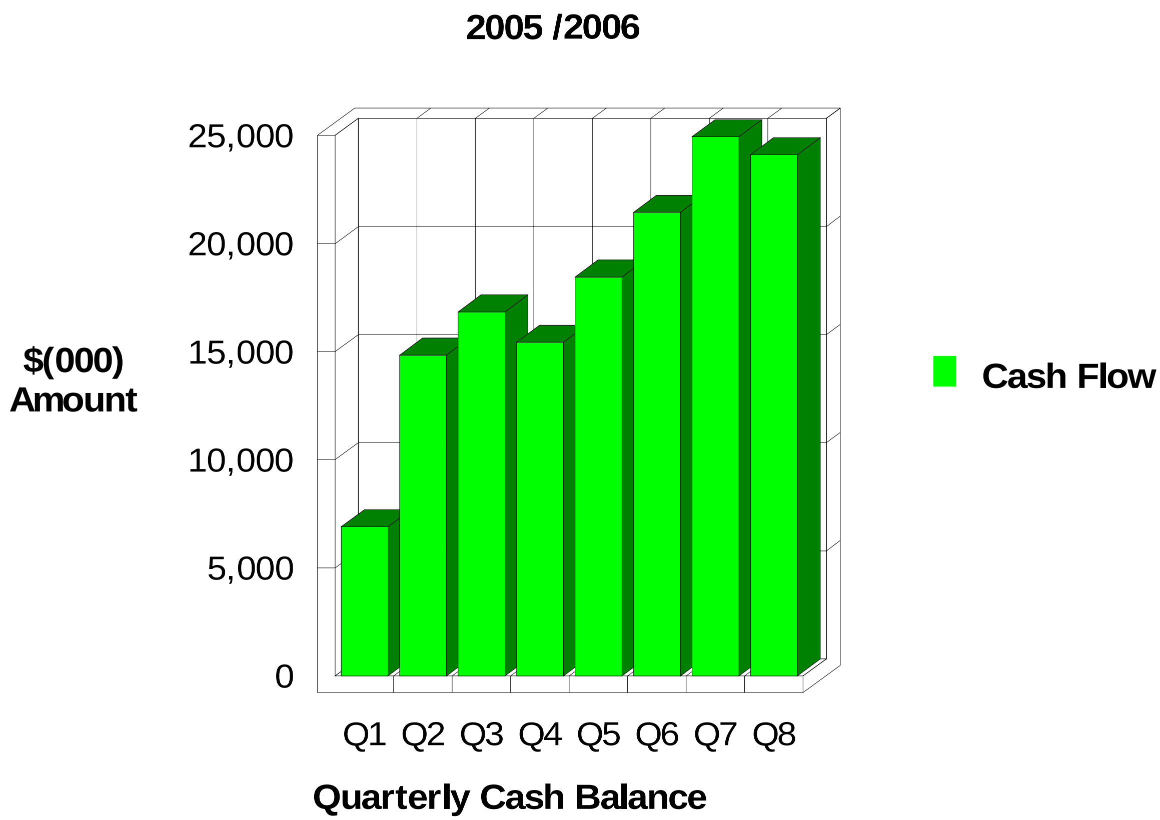


Fig 6.7.6 Two Years Cash Flow

7 CHAPTER

Conclusion

- Introduction
- Conclusion
- Limitation and Future work

7.1 Introduction

The General Packet Radio System (GPRS) is a new service that provides actual packet radio access for 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.

Although GPRS is an emerging technology driven by the equipment suppliers instead of the push from the customers, it has generated strong interest among service providers. Owing to the explosive growth of Internet applications, it is believed that data access is an important trend for mobile services. An obvious advantage of GPRS is that no dial-up modem connection is required to access data. After PDP context activation, the MS becomes an 'always-on' device that facilitates instant connections. This feature is required for mobile computing where information should be sent or received immediately as the need arises. Several potential GPRS applications have been identified, since a mobile phone can be an always-on device, a GPRS MS can always be connected to deliver information. Examples include traffic management (e.g., fleet management, vehicle tracking, vehicle control and guidance) and monitoring automation (e.g., telemetry and security). Other examples are Horizontal applications for individual users in which the mobile phone is used as a media device so that the moving users can receive services such as entertainment (e.g., games and music), location information (e.g., restaurants, cinema, hotels, and parking), and so on. GPRS also allows commerce transactions when the customers are in motion. Examples include on-line banking transactions, stock transactions, ticketing (e.g., for cinema, flights, and trains), online shopping, and so on. However, the limitation here is due to poor infrastructure of the banking system, and information infrastructure.

7.2 Conclusion

MobiTel strategy to provide complete, quality wireless Internet solutions through the mobile to our clients by incorporating sensible and cost-effective technologies GPRS. This product will be supported by a team of customer-oriented quality staff whose overriding priority is to provide professional service to our customers resulting in complete customer satisfaction.

From MobiTel point of view, packet switching is a key functionality because this technology splits information into separate yet related packets before transmitting and reassembling the data at the receiving end. Packet switching means that GPRS radio resources are used only when the users are actually sending or receiving data. This efficient use of scarce radio resources means that large numbers of GPRS users can potentially share the same bandwidth and be served from a single cell.

By reusing GSM infrastructure, most GPRS implementation costs of the existing GSM nodes are software related. As illustrated in Table 5-1, major hardware impact on the GSM network is limited to the addition of a PCU-model to BSC3&BSC6 and the introduction of two new node types: SGSN and GGSN connected with MSC3 in Dar Elhatif. GPRS software upgrade can be performed efficiently. In our proposal by Ericsson solutions, GPRS software can be remotely downloaded to BTSs which are located in the center of Khartoum, so that no site visits are needed which will be more economical in the upcoming phases. In the MS development, a major challenge is to resolve power consumption issue. To support data-related features (e.g., multiple timeslots transmission), GPRS MS consumes much more power than a standard GSM MS. GPRS is typically deployed in two phases. Phase A deployment implements basic GPRS features including:

Standard packet services delivery, i.e., to point packet bearer service, Support for CS-1 and CS-2 channel schemes. GPRS internal network interfaces such Gp, and Gs. Flexible radio resource allocation, i.e., users per timeslot and multiple timeslots Support for Classes B and C MSs. GPRS charging, e.g., packet-based billing QoS-based billing. GSM-based services such as SMS over IP and X.25 interfaces to packet data network.

And from Financial point of view we can see that from chapter6 business plan this project is profitable and it can pay back the money that is invested , as a conclusion GPRS is key factor for evolution to new technology and with granted revenue .

7.3 Limitation and Future work

GPRS data rate is probably too low for many data applications. This problem can be resolved by introducing the EDGE or the third generation radio technologies. Enhanced Data Rates for GSM Evolution (EDGE) can be introduced under the same GSM frame structure. Based EDGE, Enhanced GPRS (EGPRS) provides user data rates two to three times higher than GPRS (to 470 Kb/s for indoor and 144 Kb/s for outdoor) and its spectrum efficiency is two-to-six times higher than GPRS.

However, in EDGE, the BTS in the existing GSM standard should be modified. Specifically, the transceiver units should be enhanced to accommodate new power amplifiers in the transmitter and new equalizers in the receiver. Furthermore, transmission capacity between BTS and BSC must be increased.

The next stepping-stone would be moving towards 3G including UMTS (Universal Mobile Telephone System), WCDMA (Wideband-CDMA) and TD/CDMA (Time Division/Code Division Multiple Access) that are being developed to address 3G networks. In conclusion, the GPRS is the key transition phase and is a fundamental requirement for EDGE and Third Generation Mobile Communications.

Glossary

Ciphering
Ciphering is a method of encrypting text, in which a cryptographic key and an algorithm are applied to a data stream to produce chipertext.

Session management

Session Management. A user may have several subscribed contexts, any of the Contexts can be activated or deactivated independently

DHCP - Dynamic Host Configuration Protocol

DHCP is a communications protocol that lets network administrators manage centrally and automate the assignment of IP addresses in an organization's network [12].

LLC - Logical Link Control

LLC is a protocol which is responsible to maintain communication channel between an individual mobile station and the GPRS core network across the radio Interface [10].

PDP - Packet Data Protocol

PDP is any protocol which transmits data as discrete units known as packets, e.g., IP [10].

PDP address - Packet Data Protocol address

PDP address is used to point a particular PDP entity. In GPRS PDP address may be dynamic or static. The operator gives dynamic address during PDP context activation. Static address is assigned permanently at subscription time [10].

PDP context - Packet Data Protocol context

Each PDP address is described by an individual Packet Data Protocol context in the MS, SGSN, and GGSN. Every PDP context exists independently in the states active or inactive. The PDP context must be active for data transmission using that PDP address [10].

RADIUS – Remote Authentication Dial-In User Service

RADIUS is a client or server protocol and software that enable remote access servers to communicate with a central server to authenticate dial-in users and authorize their access to the requested system or service. RADIUS allows a company to maintain user profiles in a central database that all remote servers can share. It provides better security, allowing a company to set up a policy that can be applied at a single administered network point [12].

2G	Second generation; generic name for second generation of digital mobile networks (such as GSM, and so on)
3G	Third generation; generic name for third-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, 2.5G.

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

TDMA Narrowband digital TDMA standard; uses same frequencies as AMPS, thus is also known as D-AMPS or digital AMPS

TE Terminal equipment

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

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