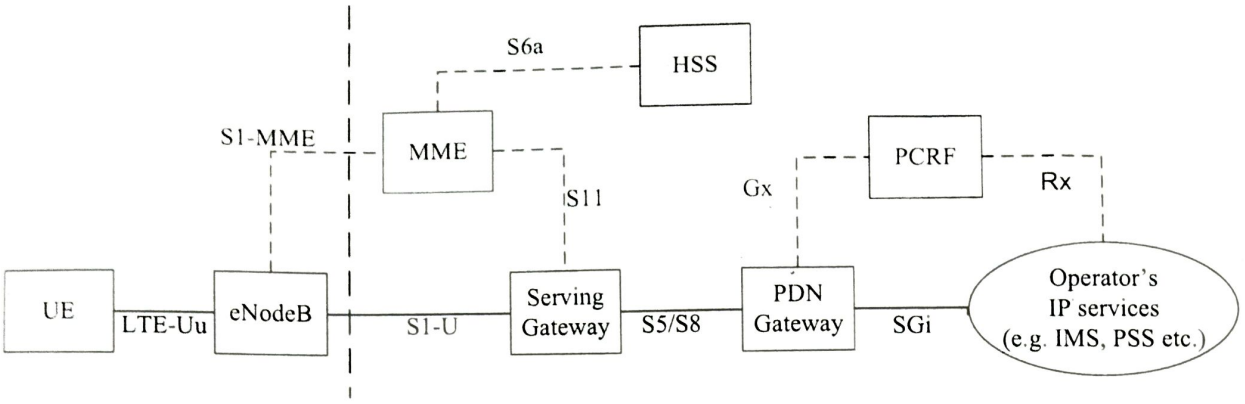



Figure 2.1 The EPS network elements.

## 2.2 Overall Architectural Overview

EPS provides the user with IP connectivity to a PDN for accessing the Internet, as well as for running services such as Voice over IP (VoIP). An EPS bearer is typically associated with a QoS. Multiple bearers can be established for a user in order to provide different QoS streams or connectivity to different PDNs. For example, a user might be engaged in a voice (VoIP) call while at the same time performing web browsing or File Transfer Protocol (FTP) download. A VoIP bearer would provide the necessary QoS for the voice call, while a best-effort bearer would be suitable for the web browsing or FTP session.

The network must also provide sufficient security and privacy for the user and protection for the network against fraudulent use.

This is achieved by means of several EPS network elements which have different roles. Figure 2.1 shows the overall network architecture including the network elements and the standardized interfaces. At a high level, the network is comprised of the CN (EPC) and the access network (E-UTRAN). While the CN consists of many logical nodes, the access network is made up of essentially just one node, the evolved NodeB (eNodeB), which connects to the UEs. Each of these network elements is inter-connected by means of interfaces which are standardized in order to allow multivendor interoperability. This gives network operators the possibility to source different network elements from different vendors. In fact, network operators may choose in their physical implementations to split or merge these logical network elements depending on commercial considerations. The functional split between the EPC and E-UTRAN is shown in Figure 2.2. The EPC and E-UTRAN network elements are described in more detail below.

### 2.2.1 The Core Network

The CN (called EPC in SAE) is responsible for the overall control of the UE and establishment of the bearers. The main logical nodes of the EPC are:

- PDN Gateway (P-GW);
- Serving Gateway (S-GW);
- Mobility Management Entity (MME).

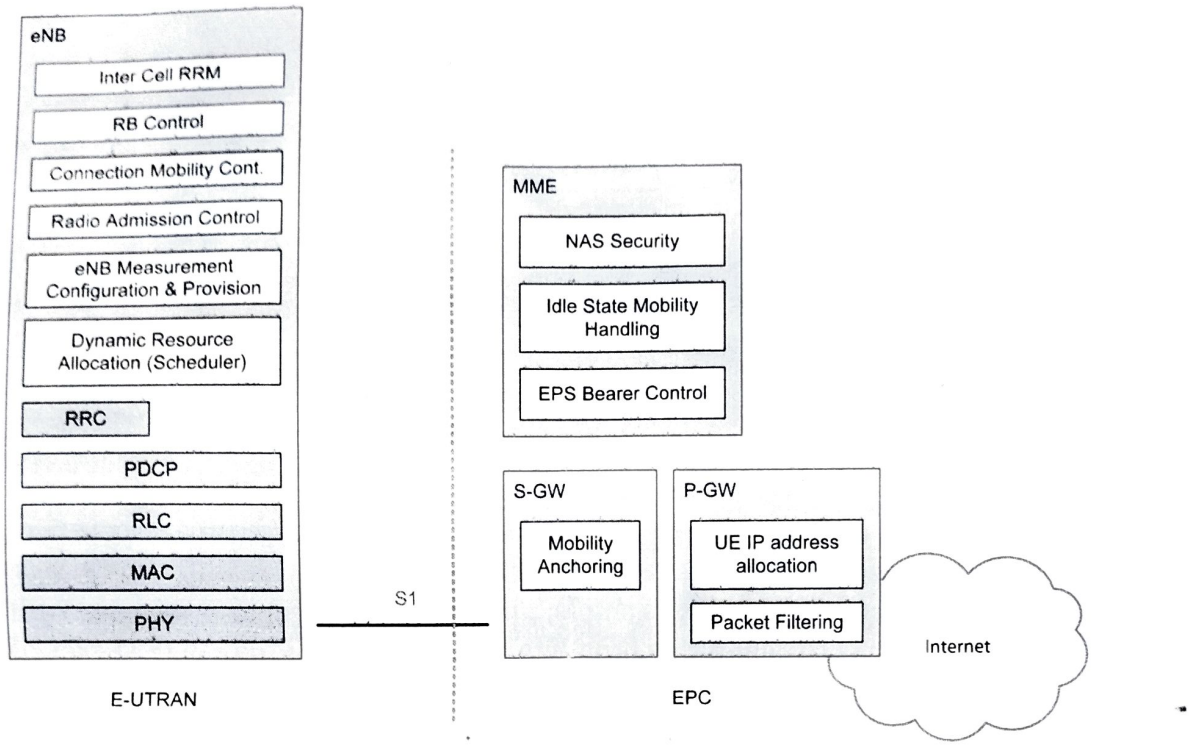



Figure 2.2 Functional split between E-UTRAN and EPC. Reproduced by permission of © 3GPP.

In addition to these nodes, EPC also includes other logical nodes and functions such as the Home Subscriber Server (HSS) and the Policy Control and Charging Rules Function (PCRF). Since the EPS only provides a bearer path of a certain QoS, control of multimedia applications such as VoIP is provided by the IP Multimedia Subsystem (IMS) which is considered to be outside the EPS itself.

The logical CN nodes (specified in [1]) are shown in Figure 2.1 and discussed in more detail in the following.

- **PCRF.** It is responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF) which resides in the P-GW. The PCRF provides the QoS authorization (QoS class identifier and bitrates) that decides how a certain data flow will be treated in the PCEF and ensures that this is in accordance with the user's subscription profile.

Home Subscribes Server HHS

- **~~Home Location Register~~ (HLR).** The ~~HLR~~ contains users' SAE subscription data such as the EPS-subscribed QoS profile and any access restrictions for roaming (see Section 2.2.3). It also holds information about the PDNs to which the user can connect. This could be in the form of an Access Point Name (APN) (which is a label according to DNS[1] naming conventions describing the access point to the PDN), or a PDN Address (indicating subscribed IP address(es)). In addition the HLR holds dynamic information such as the identity of the MME to which the user is currently attached

[1] Domain Name System

or registered. The HLR may also integrate the Authentication Centre (AuC) which generates the vectors for authentication and security keys.

- **P-GW.** The P-GW is responsible for IP address allocation for the UE, as well as QoS enforcement and flow-based charging according to rules from the PCRF. The P-GW is responsible for the filtering of downlink user IP packets into the different QoS based bearers. This is performed based on Traffic Flow Templates (TFTs) (see Section 2.4). The P-GW performs QoS enforcement for Guaranteed Bit Rate (GBR) bearers. It also serves as the mobility anchor for inter-working with non-3GPP technologies such as CDMA2000 and WiMAX networks (see Section 2.2.4 and Chapter 13 for more information about mobility).

- **S-GW.** All user IP packets are transferred through the S-GW, which serves as the local mobility anchor for the data bearers when the UE moves between eNodeBs. It also retains the information about the bearers when the UE is in idle state (known as ECM-IDLE, see Section 2.2.1.1) and temporarily buffers downlink data while the MME initiates paging of the UE to re-establish the bearers. In addition, the S-GW performs some administrative functions in the visited network such as collecting information for charging (e.g. the volume of data sent to or received from the user), and legal interception. It also serves as the mobility anchor for inter-working with other 3GPP technologies such as GPRS and UMTS (see Section 2.2.4 and Chapter 13 for more information about mobility).

- **MME.** The MME is the control node which processes the signalling between the UE and the CN. The protocols running between the UE and the CN are known as the *Non-Access Stratum* (NAS) protocols.

  The main functions supported by the MME are classified as:

  **Functions related to bearer management.** This includes the establishment, maintenance and release of the bearers, and is handled by the session management layer in the NAS protocol.

  **Functions related to connection management.** This includes the establishment of the connection and security between the network and UE, and is handled by the connection or mobility management layer in the NAS protocol layer.

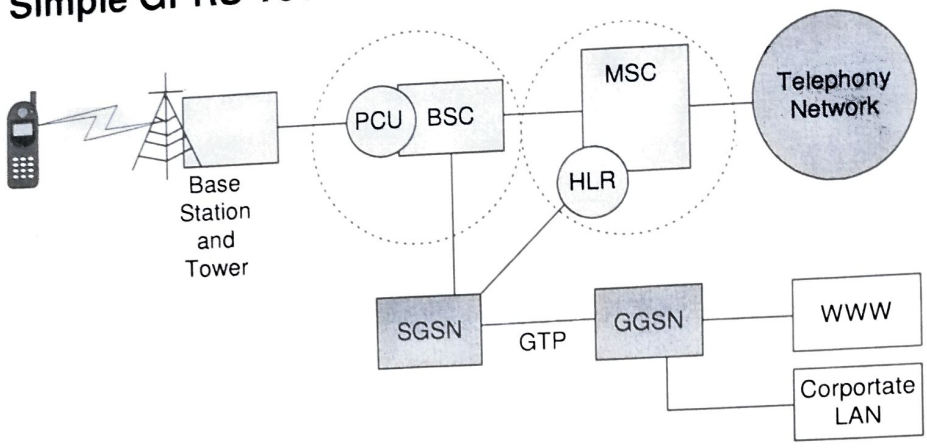
  NAS control procedures are specified in [1] and are discussed in more detail in the following section.

#### 2.2.1.1 Non-Access Stratum (NAS) Procedures

The NAS procedures, especially the connection management procedures, are fundamentally similar to UMTS. The main change from UMTS is that EPS allows concatenation of some procedures to allow faster establishment of the connection and the bearers.

The MME creates a *UE context* when a UE is turned on and attaches to the network. It assigns a unique short temporary identity termed the SAE-Temporary Mobile Subscriber Identity (S-TMSI) to the UE which identifies the UE context in the MME. This UE context holds user subscription information downloaded from the HSS. The local storage of subscription data in the MME allows faster execution of procedures such as bearer

# 2 Simple GPRS Technical Overview




As mentioned earlier GPRS is not a completely separate network to GSM. Many of the devices such as the base transceiver stations and base transceiver station controllers are still used. Often devices need to be upgraded be it software, hardware or both. When deploying GPRS many of the software changes can be made remotely.

There are however two new functional elements which play a major role in how GPRS works. The Serving GPRS Support Node (SGSN) and the Gateway GPRS support node (GGSN). These 2 nodes are new to the network with the other changes being small if any.

Before explaining what these 2 new members of our network do it is important to ask how does the network differentiate between GSM (circuit) and GPRS (packet)?

In simple terms there are in practice two different networks working in parallel, GSM and GPRS. In any GSM network there will be several BSC's (Base Station Controllers). When implementing GPRS a software and hardware upgrade of this unit is required. The hardware upgrade consists of adding a Packet Control Unit (PCU). This extra piece of hardware differentiates data destined for the standard GSM network or Circuit Switched Data and data destined for the GPRS network or Packet Switched Data. In some cases a PCU can be a separate entity.

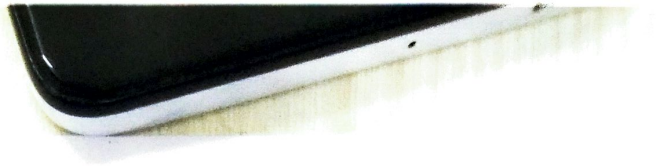
From the upgraded BSC there is a fast frame relay connection that connects directly to the newly introduced SGSN.

## *2.1 SGSN*

The Serving GPRS Support Node, or SGSN for short, takes care of some important tasks, including routing, handover and IP address assignment.

The SGSN has a logical connection to the GPRS device. As an example, if you where in a car travelling up the M1 on a long journey and were browsing the Internet on a GPRS device, you will pass through many different cells. One job of the SGSN is to make sure the connection is not interrupted as you make your journey passing from cell to cell. The SGSN works out which BSC to "route" your connection through.

If the user moves into a segment of the network that is managed by a different SGSN it will perform a handoff of to the new SGSN, this is done extremely quickly and generally the user will



not notice this has happened. Any packets that are lost during this process are retransmitted. The SGSN converts mobile data into IP and is connected to the GGSN via a tunnelling protocol.

## 2.2 GGSN

The Gateway GPRS Support Node is the "last port of call" in the GPRS network before a connection between an ISP or corporate network's router occurs. The GGSN is basically a gateway, router and firewall rolled into one. It also confirms user details with RADIUS servers for security, which are usually situated in the IP network and outside of the GPRS network.

## 2.3 Connectivity Between the SGSN & GGSN

The connection between the two GPRS Support Nodes is made with a protocol called GPRS Tunnelling Protocol (GTP). GTP sits on top of TCP/IP and is also responsible for the collection of mediation and billing information. GPRS is billed on per megabyte basis unlike GSM. In practice the two GSN devices may be a single unit.

## 2.4 HLR

The HLR or Home Location Register is a database that contains subscriber information, when a device connects to the network their MSISDN number is associated with services, account status information, preferences and sometimes IP addresses.