UNIT – IV WIRELESS WIDE AREA NETWORK

INTRODUCTION

The aim of future networks is to support voice, video and data together. Technology is now geared in the direction towards the development of third generation (3G) networks to support multimedia communications. The success of GPRS networks in providing limited data services is the key driving force needed to deploy the IP-based core network for 3G, fitting into the main components of the GPRS network and the existing global System for Mobile Communication (GSM) infrastructure.

The Universal Mobile Telecommunication System (UMTS) is a third generation (3G) wireless system that delivers high-bandwidth data and voice services to mobile users. UMTS evolved from GSM and has a new air interface based on Wideband Code division Multiple Access (WCDMA).

Release 99 (R99) is the first version of UMTS architecture based on the new multiple access technology WCDMA for increased utilization of radio resources. The Third Generation Partnership Project (3GPP) has specified the R99 standards.

UMTS NETWORK ARCHITECTURE – RELEASE 99

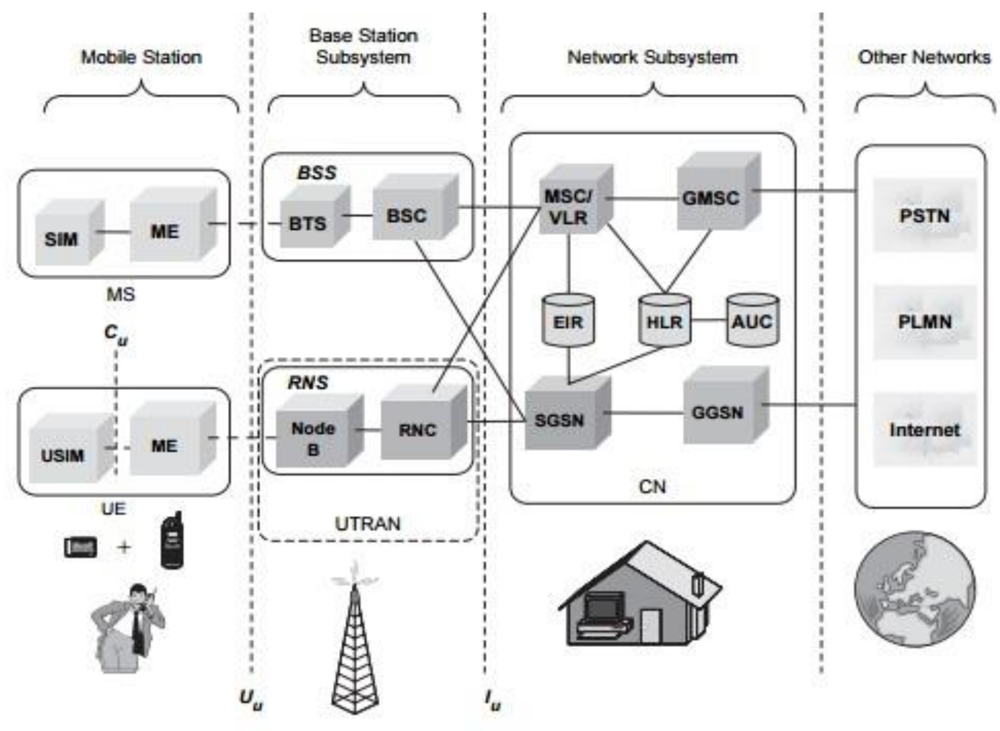

Figure 15.13 UMTS—3G reference architecture.

The first deployment of the UMTSR99 network architecture is shown in the above Figure15.13. The major change is in the Radio Access Network (RAN) based on WCDMA and Asynchronous Mode of Transmission (ATM).

The UMTS architecture defines three main functional entities:

- User Equipment 9UE)
- UMTS Radio Access Network (UTRAN)
- Core Network (CN)

The Core Network (CN) which are again divided into 2 types.

- Circuit-Switched (CS) network
- Packet-Switched (PS) network

User Equipment

UE replaces the MS (Mobile Station) for GSM/GPRS networks. A subscriber must buy a new handset for 3G services with a new SIM called USIM. USIM is a user subscription to the UMTS mobile network and contains all relevant data that enables access onto the subscripted network.

The main difference between a USIM and GSM SIM is that by default, a USIM is downloadable and can be accessed via the air interface and be modified by the network. The USIM is a universal integrated service card having much more capacity than the GSM SIM. It can also store JAVA applications.

Node B

The base station used in UMTS is known as 'Node B' that replaces BTS. It provides that physical radio link between the UE and the network.. It is capable to handle CDMA subscriber on the new frequency bands.

It can also support higher data rates used for 3G. Node B is the termination point between the air interface and the transmission network of the RAN. IT performs the necessary signal processing functionalities for the WCDMA air interface and is more complex than BTS.

Node B is responsible for the following:

1. Power Control: It measures the actual signal-to-interference ratio (SIR), compares it with the threshold value and then may trigger the change of transmitting power of UE.
2. Reports the RNC (Radio Network Controller): The measured values are reported to RNC.
3. Combines the received signals coming from multiple sectors of the antenna that a UE is connected to: It converts the signals into a

single data stream before it transmits to the RNC. This may help to soften the handover procedure for UMTS networks.

Radio Network Controller

The RNC is the main element in the Radio Network System (RNS) and controls the usage and reliability of radio resources. An RNC is similar to a BSC and is interfaced with the CS of a GSM core network (MSC) in order to handle circuit-switched calls along with SGSN for packet data transport.

It also needs to be capable of supporting interconnections to other RNCs, which is a new feature of UMTS. The main tasks for RNC are call admission control, radio bearer management, power control and general management controls in connection to OMC (Operation Management Control).

There are three types of RNCs:

1. Serving RNC (SRNC)
2. Drift RNC (DRNC)
3. Controlling RNC (CRNC)

1. Serving RNC (SRNC)

The SRNC controls a user's mobility within a UTRAN. It is a connection point to the core network towards MSC or SGSN.

2. Drift RNC (DRNC)

The DRNC receives connected UEs that are drifted or handed over from the SRNC cell connected to a different RNS. The RRC (Radio Resource Controlled) is still connected to SRNC.

The DRNC then exchanges the routing information between the SRNC and UE. Thus, the DRNC provides radio resources to the SRNC to allow soft handover.

3. Controlling RNC (CRNC)

CRNC controls, configures and manages an RNS and communicates with the Node B application part (NABP) protocol with the physical resources of all Node Bs connected via the $\mathbf{I_u}$ interfaces. Any access request from the UE is forwarded to the CRNC.

OVERVIEW OF UTMS TERRESTRIAL RADIO ACCESS NETWORK

The UTRAN consists of a set of radio network subsystems (RNSs) (see Figure 15.21). The RNS has two main logical elements:

- Node B
- RNC (Radio Network Controller)

The RNS is responsible for the radio resources and transmission/reception in a set of cells. A cell (sector) is one coverage area served by a broadcast channel.

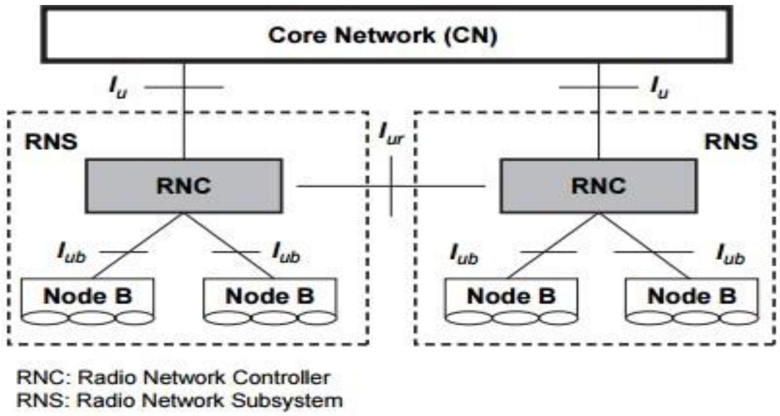

Figure 15.21 UTRAN logical architecture.

RNC (Radio Network Controller)

An **RNC** is responsible for the use and allocation of all the radio resources of the RNS to which it belongs. The RNC also handles the user voice and packet data traffic, performing the actions on the user data streams that are necessary to access the radio bearers. The responsibilities of an RNC are:

- Intra UTRAN handover
- Macro diversity combining/splitting of I_{ub} data streams
- Frame synchronization
- Radio resource management
- Outer loop power control
- I_u interface user plane setup
- Serving RNS (SRNS) relocation
- Radio resource allocation (allocation of codes, etc.)
- Frame selection/distribution function necessary for soft handover (functions of UMTS radio interface physical layer)
- UMTS radio link control (RLC) sublayers function execution
- Termination of MAC, RLC, and RRC protocols for transport channels, i.e., DCH, DSCH, RACH, FACH
- I_{ub}'s user plane protocols termination

NODE B

A **Node B** is responsible for radio transmission and reception in one or more cells to/from the user equipment (UE). The logical architecture for Node B is shown in Figure 15.22.

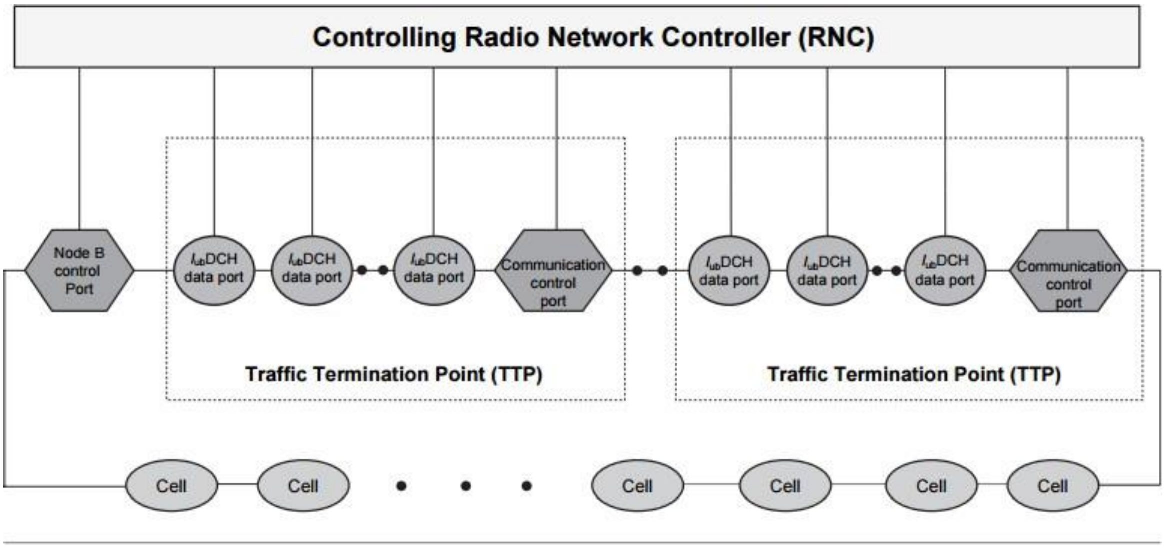

Figure 15.22 Node B logical architecture.

The following are the responsibilities of the Node B:

- Termination of I_{ub} interface from RNC
- Termination of MAC protocol for transport channels RACH, FACH
- Termination of MAC, RLC, and RRC protocols for transport channels: BCH, PCH
- Radio environment survey (BER estimate, receiving signal strength, etc.)
- Inner loop power control
- Open loop power control
- Radio channel coding/decoding
- Macro diversity combining/splitting of data streams from its cells (sectors)
- Termination of U_u interface from UE
- Error detection on transport channels and indication to higher layers
- FEC encoding/decoding and interleaving/deinterleaving of transport channels
- Multiplexing of transport channels and demultiplexing of coded composite transport channels
- Power weighting and combining of physical channels
- Modulation and spreading/demodulation and despreading of physical channels
- Frequency and time (chip, bit, slot, frame) synchronization
- RF processing

A. UTRAN LOGICAL INTERFACES:

In UTRAN protocol structure is designed so that layers and planes are logically independent of each other and, if required, parts of protocol structure can be changed in the future without affecting other parts.

The protocol structure contains two main layers,

- Radio network layer (RNL) – allows communication between UTRAN and Core Network.
- Transport network layer (TNL) - allows communication between UE and UTRAN.

In the **RNL**, all UTRAN-related functions are visible, whereas the TNL deals with transport technology selected to be used for UTRAN but without any UTRAN-specific changes. A general protocol model for UTRAN interfaces is shown in Figure 15.23.

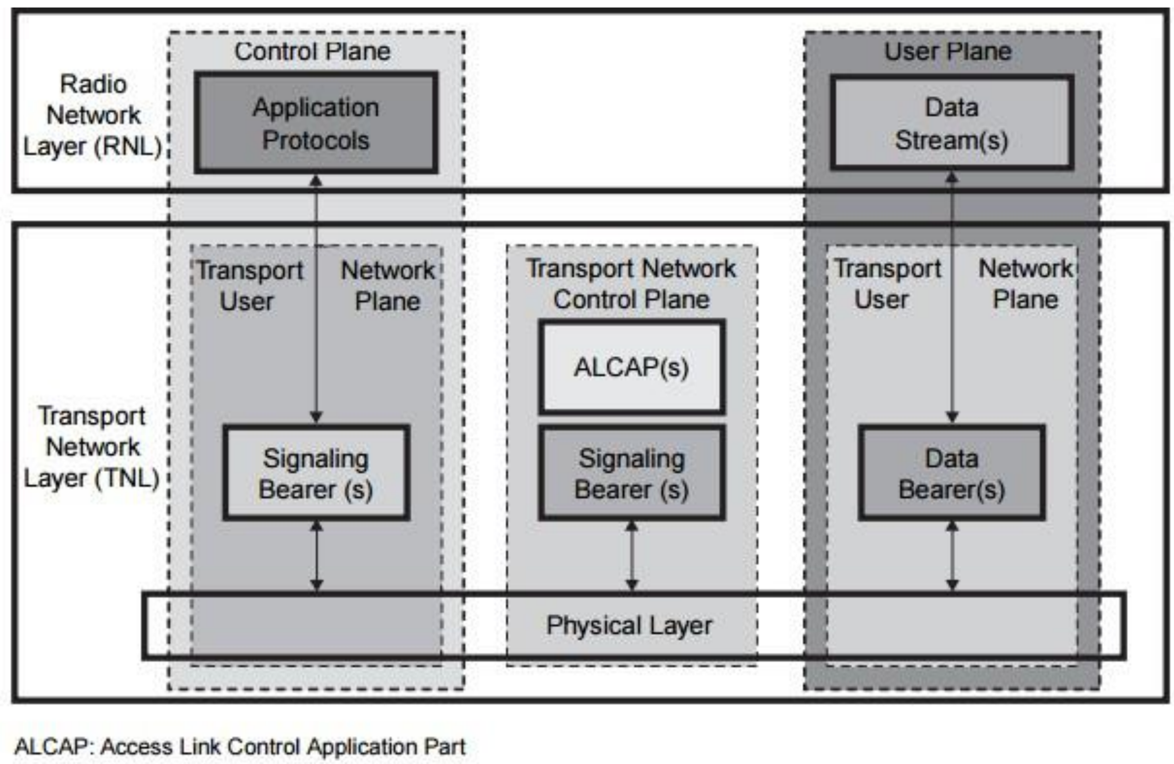

Figure 15.23 General protocol model for UTRAN interfaces.

Each of the layers is again divided into two planes.

- Control Plane
- User Plane

The **control plane** is used for all UMTS-specific control signaling. It includes the

- Application Protocol (i.e., radio access network application part (RANAP) in $\mathbf{I_u}$,
- Radio network subsystem application part (RNSAP) in $\mathbf{I_{ur}}$ and
- Node B Application Part (NBAP) in $\mathbf{I_{ub}}$).

The **application protocol** is used for setting up bearers to the UE. In the three-plane structure the bearer parameters in the application protocol are not directly related to the user plane technology, but rather they are general bearer parameters.

The **user plane** includes data streams, and data bearers for data streams. User information is carried by the user plane. Each data stream is characterized by one or more frame protocols specified for that interface.

The transport network control plane carries all control signaling within the transport layer. It does not include radio network layer information. It contains **access link control application part (ALCAP)** required to set up the transport bearers (data bearers) for the user plane. It also includes the signaling bearer needed for the ALCAP. **The transport plane lies between the control plane and the user plane.** The addition of the transport plane in UTRAN allows the application protocol in the radio network control plane to be totally independent of the technology selected for the data bearer in the user plane.

With the transport network control plane, the transport bearers for data bearers in the user plane are set up in the following way. There is a signaling transaction by application protocol in the control plane that initiates set-up of the data bearer by the ALCAP protocol specific for the user plane technology. The independence of the control plane and user plane assumes that an ALCAP signaling occurs. The ALCAP may not be used for all types of data bearers. If there is no ALCAP signaling transaction, the transport network control plane is not required. This situation occurs when preconfigured data bearers are used. Also, the ALCAP protocols in the transport network control plane are not used to set up the signaling bearer for the application protocol or the ALCAP during real-time operation.

$\mathbf{I_u}$ Interface

The UMTS $\mathbf{I_u}$ interface is the open logical interface that interconnects one UTRAN to the UMTS core network (UCN). On the UTRAN side the $\mathbf{I_u}$ interface is terminated at the RNC, and at the UCN side it is terminated at U-MSC.

The $\mathbf{I_u}$ interface consists of three different protocol planes.

1. Radio network control plane (RNCP)
2. Transport network control plane (TNCP)
3. User plane (UP)

The **RNCP** performs the following functions:

- It carries information for the general control of UTRAN radio network operations.
- It carries information for control of UTRAN in the context of each specific call.
- It carries user call control (CC) and mobility management (MM) signaling messages.

The control plane serves two service domains in the core network.

- Packet-switched (PS) domain
- Circuit-switched (CS) domain.

The **CS domain** supports circuit-switched services. Some examples of CS services are voice and fax. The CS domain can also provide intelligent services such as voice mail and free phone. The CS domain connects to PSTN/ISDN networks. The CS domain is expected to evolve from the existing 2G GSM PLMN

The **PS domain** deals with PS services. Some examples of PS services are Internet access and multimedia services. Since Internet connectivity is provided, all services currently available on the Internet such as search engines and e-mail are available to mobile users. The PS domain connects to IP networks. The PS domain is expected to evolve from the GPRS PLMN.

The $\mathbf{I_u}$ circuit-switched and packet-switched protocol architecture are shown in Figures 15.24 and 15.25.

The **control plane protocol stack consists of RANAP** on the top of signaling system 7 (SS7) protocols. The protocol layers are,

- Signaling Connection Control Part (SCCP)
- Message Transfer Part (MTP3-B)
- Signaling Asynchronous Transfer Mode (ATM) Adaptation Layer for Network-to-Network Interface (SAAL-NNI).

The **SAAL-NNI** is divided into 3 layers

1. Service-Specific Coordination Function (SSCF)
2. Service-Specific Connection-Oriented Protocol (SSCOP)
3. ATM Adaptation Layer 5 (AAL5)

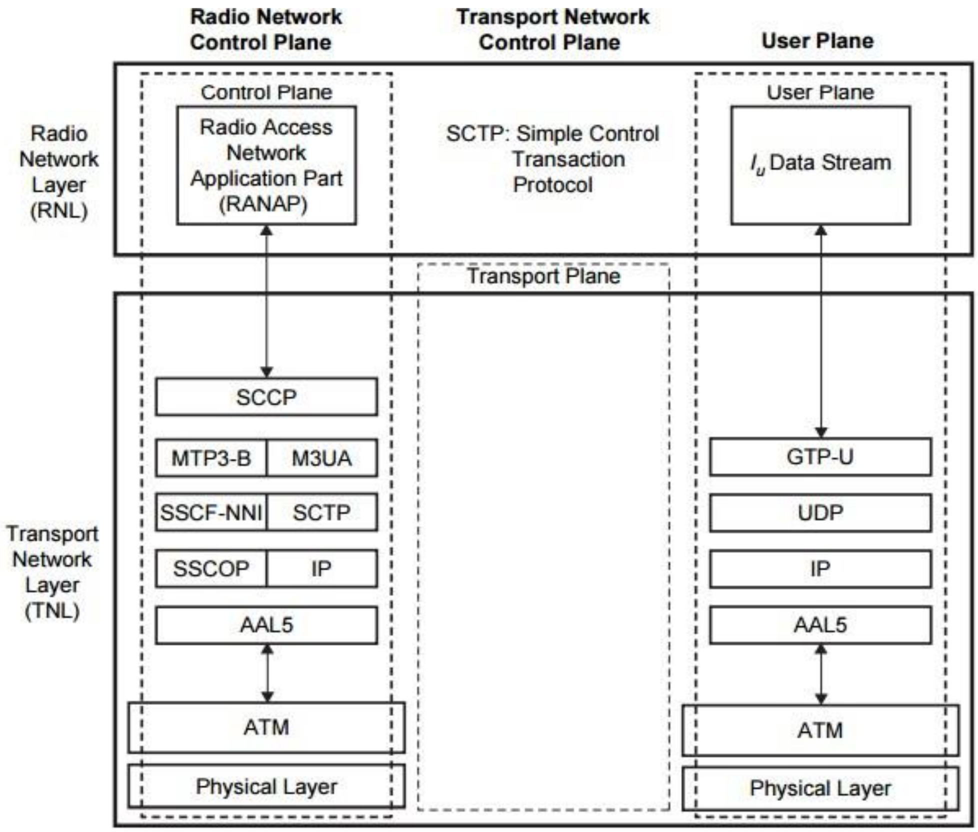

Figure 15.24 PS protocol architecture on I_u interface.

The SSCF and SSCOP layers are specifically designed for signaling transport in ATM networks, and take care of signaling connection management functions. AAL5 is used for segmenting the data to ATM cells.

As an alternative, an IP-based signaling bearer is specified for the $\mathbf{I_u}$ PS control plane. The IP-based signaling bearer consists of SS7-MTP3—user adaptation layer (M3UA), simple control transmission protocol (SCTP), IP, and AAL5. The SCTP layer is specifically designed for signaling transport on the Internet.

The **transport network control plane (TNCP**) carries information for the control of transport network used within UCN.

The **user plane (UP)** carries user voice and packet data information. AAL2 is used for the following services: narrowband speech (e.g., EFR, AMR); unrestricted digital information service (up to 64 kbps, i.e., ISDN B channel); any low to average bit rate CS service (e.g., modem service to/from PSTN/ISDN). AAL5 is used for the following services: non-real-time PS data service (i.e., best effort packet access) and real-time PS data.

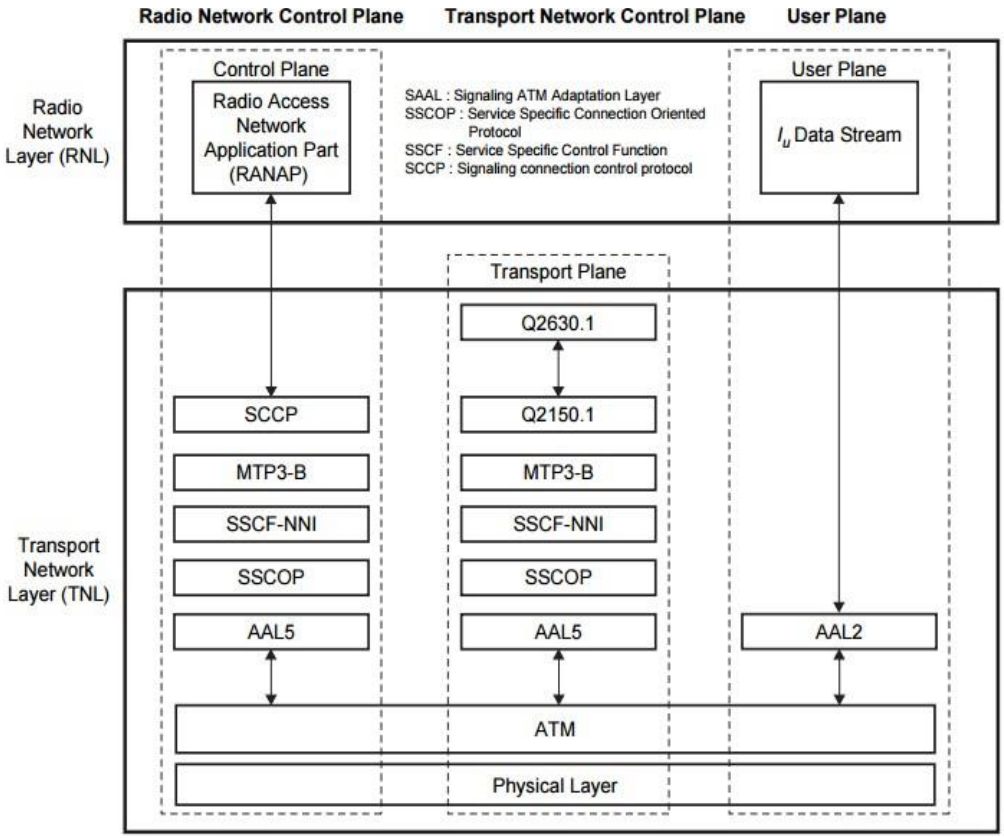

Figure 15.25 CS protocol architecture on I_u interface.

I_{ur} Interface

The connection between two RNCs (serving RNC (SRNC) and drift RNC (DRNC)) is the **I_{ur}** interface. It is used in soft handoff scenarios when different macro diversity streams of one communication are supported by Node Bs that belong to different RNCs. Communication between one RNC and one Node B of two different RNCs are realized through the **I_{ur}** interface.

The **I_{ur}** interface consists of three different protocol planes.

1. Radio network control plane (RNCP)
2. Transport network control plane (TNCP)
3. User plane (UP)

The **I_{ur}** interface is used to carry:

- Information for the control of radio resources in the context of specific service request of one mobile on RNCP
- Information for the control of the transport network used within UTRAN on TNCP
- User voice and packet data information on UP

The protocols used on this interface are:

- Radio access network application part (RANAP)
- DCH frame protocol (DCHFP) RACH frame protocol (RACHFP)
- FACH frame protocol (FACHFP)
- Access link control application part (ALCAP)
- Q.aal2
- Signaling connection control part (SCCP)
- Message transfer part 3-B (MTP3-B)
- Signaling ATM adaptation layer for network-to-network interface (SAALNNI) (SAAL-NNI is further divided into service specific coordination function for network to network interface (SSCF-NNI), service specific connection oriented protocol (SSCOP), and ATM adaptation layer 5 (AAL5))

The bearer is AAL2. The protocol structure of the I_{ur} interface is shown in Figure 15.26

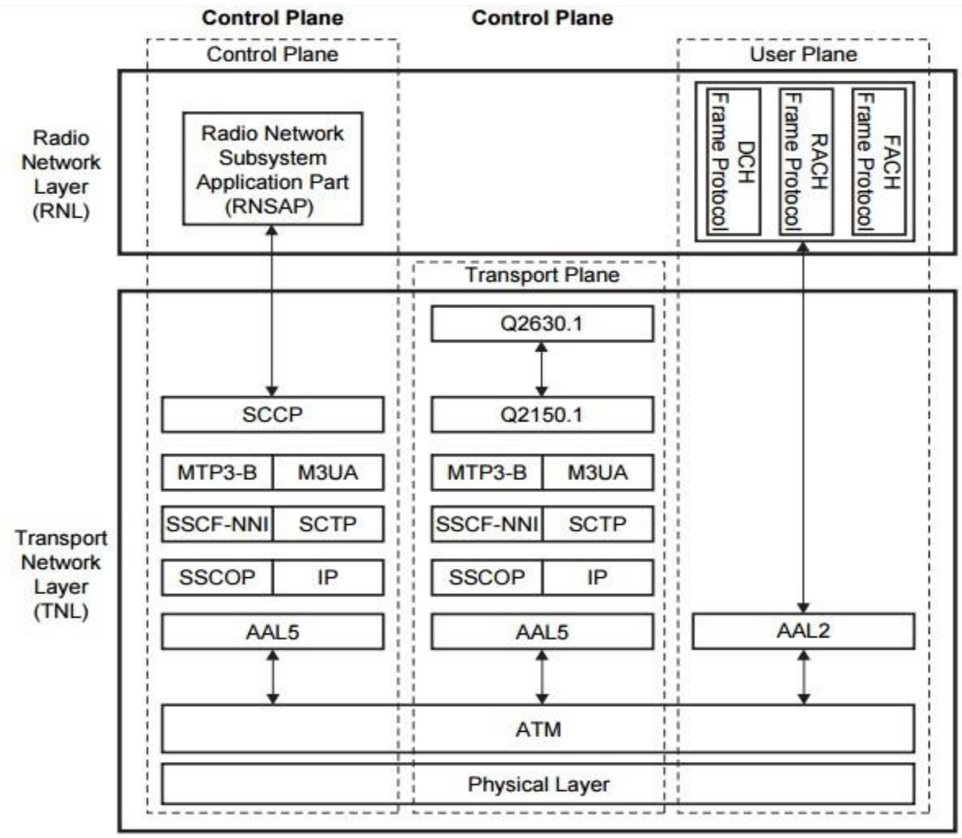

Figure 15.26 Protocol structure of I_{ur} interface.

Initially, this interface was designed to support the inter-RNC soft handoff, but more features were added during the development of the standard. The $\mathbf{I_{ur}}$ provides the following four functions:

1. Basic inter-RNC mobility support
    - Support of SRNC relocation
    - Support of inter-RNC cell and UTRAN registration area update
    - Support of inter-RNC packet paging
    - Reporting of protocol errors
2. Dedicated channel traffic support
    - Establishment, modification, and release of a dedicated channel in the DRNC due to hard and soft handoff in the dedicated channel state
    - Setup and release of dedicated transport connections across the $\mathbf{I_{ur}}$ interface
    - Transfer of DCH transport blocks between SRNC and DRNC
    - Management of radio links in the DRNS via dedicated measurement report procedures and power setting procedures
3. Common channel traffic support
    - Setup and release of the transport connection across the $\mathbf{I_{ur}}$ for common channel data streams
    - Splitting of the MAC layer between the SRNC (MAC-d) and DRNC (MAC-c and MAC-sh); the scheduling for downlink data transmission is performed in the DRNC
    - Flow control between the MAC-d and MAC-c/MAC-sh
4. Global resource management support
    - Transfer of cell measurements between two RNCs
    - Transfer of Node B timing between two RNCs

$\mathbf{I_{ub}}$ Interface

The connection between the RNC and Node B is the $\mathbf{I_{ub}}$ interface. There is one $\mathbf{I_{ub}}$ interface for each Node B. The $\mathbf{I_{ub}}$ interface is used for all of the communications between Node B and the RNC of the same RNS.

The $\mathbf{I_{ub}}$ interface consists of three different protocol planes.

1. Radio network control plane (RNCP)
2. Transport network control plane (TNCP)
3. User plane (UP)

The $\mathbf{I_{ub}}$ interface is used to carry:

- Information for the general control of Node B for radio network operation on RNCP

- Information for the control of radio resources in the context of specific service request of one mobile on RNCP
- Information for the control of a transport network used within UTRAN on TCNP User CC and MM signaling message on RNCP
- User voice and packet data information on UP

The protocol structure for the interface **I_{ub}** is shown in Figure 15.27.

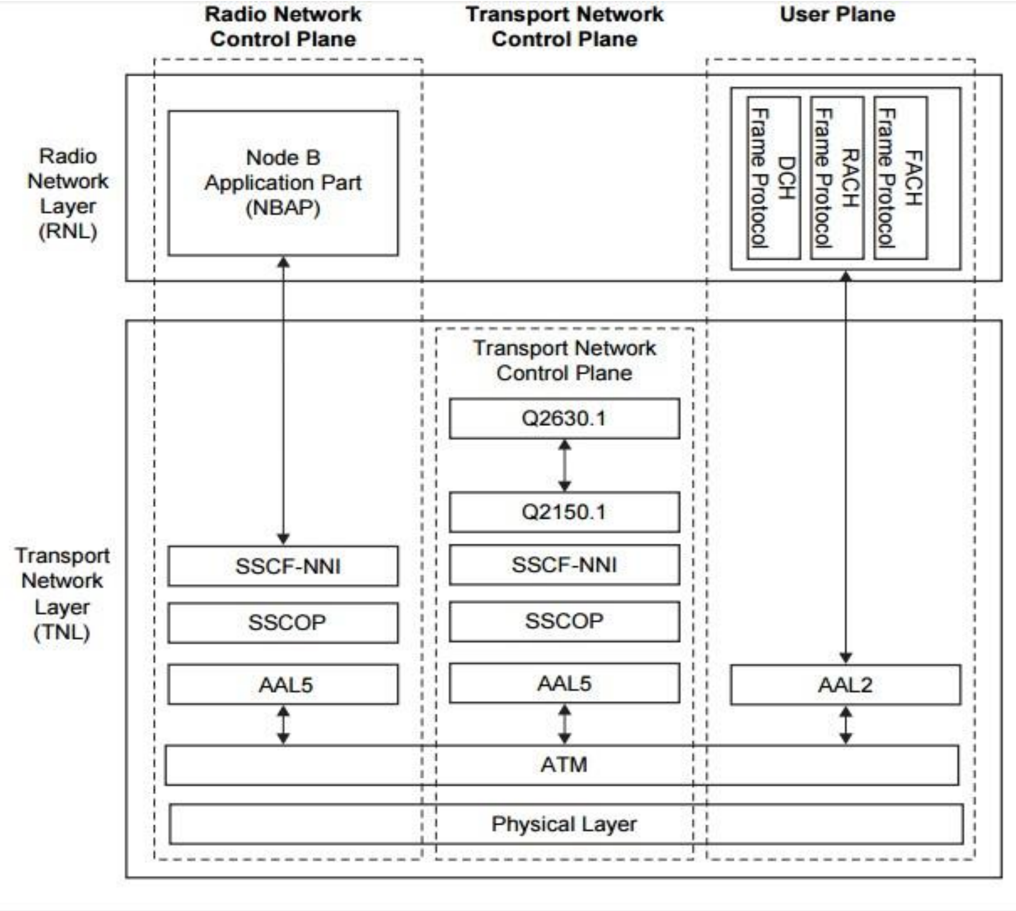

Figure 15.27 Protocol structure of I_{ub} interface.

The protocols used on this interface include:

- Node B application part protocol (NBAP)
- DCH frame protocol (DCHFP)
- RACH frame protocol (RACHFP)
- FACH frame protocol (FACHFP)
- Access link control application part (ALCAP)
- Q.aal2
- SSCP or TCP and IP
- MTP3-B
- SAAL-UNI (SSCF-UNI, SSCOP, and AAL5)

When using multiple low-speed links in the **I_{ub}** interface, Node B supports inverse multiplexing for ATM (IMA). The bearer is AAL2.

U_u Interface

The UMTS **U_u** interface is the radio interface between a Node B and one of its UE. The **U_u** is the interface through which UE accesses the fixed part of the system.

B. DISTRIBUTION OF UTRAN FUNCTIONS:

Located in the RNC

- Radio resource control (L3 Function)
- Radio link control (RLC)
- Macro diversity combining
- Active cell set modification
- Assign transport format combination set (centralized data base function) Multiplexing/demultiplexing of higher layer PDUs into/from transport block delivered to/from the physical layer on shared dedicated transport channels (used for soft handover)
- L1 function: macro diversity distribution/combining (centralized multipoint termination)
- Selection of the appropriate transport format for each transport channel depending upon the instantaneous source rate — collocate with RRC
- Priority handling between data flows of one user

Located in Node B

- Scheduling of broadcast, paging, and notification messages; location in Node B — to reduce data repetition over **I_{ub}** and reduce RNC CPU load and memory space
- Collision resolution on RACH (in Node B — to reduce nonconstructive traffic over **I_{ub}** interface and reduce round trip delay)
- Multiplexing/demultiplexing of higher layer PDUs to/from transport blocks delivered to/from the physical layer on common transport channels

UMTS CORE NETWORK ARCHITECTURE

Figure 15.28 shows the UMTS core network (UCN) in relation to all other entities within the UMTS network and all of the interfaces to the associated networks.

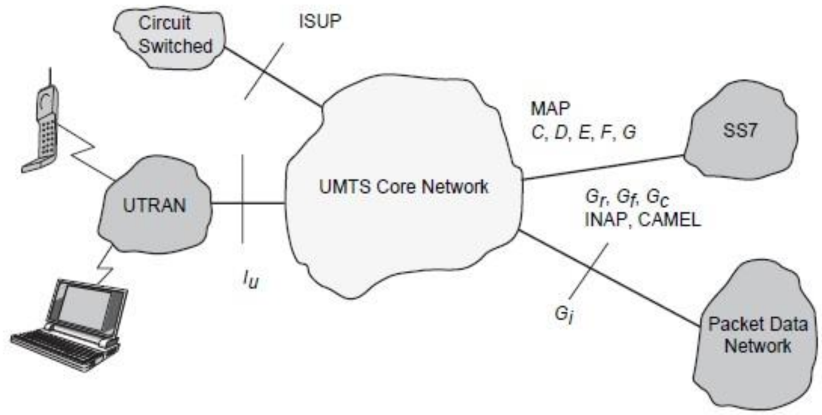

Figure 15.28 UMTS core network architecture.

The UCN consists of a CS entity for providing voice and CS data services and a PS entity for providing packet-based services. The logical architecture offers a clear separation between the CS domain and PS domain.

The CS domain contains the functional entities:

- Mobile switching center (MSC)
- Gateway MSC (GMSC)

The PS domain comprises the functional entities:

- Serving GPRS support node (SGSN)
- Gateway GPRS support node (GGSN)
- Domain name server (DNS)
- Dynamic host configuration protocol (DHCP) server
- Packet charging gateway
- Firewalls

The core network can be split into the following different functional areas:

- Functional entities needed to support PS services (e.g. 3G-SGSN, 3G-GGSN)
- Functional entities needed to support CS services (e.g. 3G-MSC/VLR)
- Functional entities common to both types of services (e.g. 3G-HLR)

Other areas that can be considered part of the core network include:

- Network management systems (billing and provisioning, service management, element management, etc.)

- IN system (service control point (SCP), service signaling point (SSP), etc.) ATM/SDH/IP switch/transport infrastructure

3G - MSC:

The 3G-MSC is the main CN element to provide CS services. The 3G-MSC also provides the necessary control and corresponding signaling interfaces including SS7, MAP, ISUP (ISDN user part), etc. The 3G MSC provides the interconnection to external networks like PSTN and ISDN.

The following functionality is provided by the 3G-MSC:

- **Mobility management**: Handles attach, authentication, updates to the HLR, SRNS relocation, and intersystem handover.
- **Call management**: Handles call set-up messages from/to the UE.
- **Supplementary services**: Handles call-related supplementary services such as call waiting, etc.
- **CS data services**: The IWF provides rate adaptation and message translation for circuit mode data services, such as fax.
- **Vocoding**
- **SS7, MAP and RANAP interfaces**: The 3G-MSC is able to complete originating or terminating calls in the network in interaction with other entities of a mobile network, e.g., HLR, AUC (Authentication center). It also controls/ communicates with RNC using RANAP which may use the services of SS7.
- **ATM/AAL2 Connection** to UTRAN for transportation of user plane traffic across the I_u interface. Higher rate CS data rates may be supported using a different adaptation layer.
- **Short message services (SMS):** This functionality allows the user to send and receive SMS data to and from the SMS-GMSC/SMS-IWMSC (Interworking MSC).
- **VLR functionality**: The VLR is a database that may be located within the
- **3G-MSC** and can serve as intermediate storage for subscriber data in order to support subscriber mobility.
- **IN and CAMEL.**
- **OAM** (operation, administration, and maintenance) agent functionality.

3G – SGSN

The 3G-SGSN is the main CN element for PS services. The 3G-SGSN provides the necessary control functionality both toward the UE and the 3G-GGSN. It also provides the appropriate signaling and data interfaces including connection to an IP-based network toward the 3G-GGSN, SS7 toward the HLR/EIR/AUC and TCP/IP or SS7 toward the UTRAN.

The 3G-SGSN provides the following functions:

- **Session management**: Handles session set-up messages from/to the UE and the GGSN and operates Admission Control and QoS mechanisms.
- **I_u and G_n MAP interface**: The 3G-SGSN is able to complete originating or terminating sessions in the network by interaction with other entities of a mobile network, e.g., GGSN, HLR, AUC. It also controls/communicates with UTRAN using RANAP.
- **ATM/AAL5 physical connection** to the UTRAN for transportation of user data plane traffic across the I_u interface using GPRS tunneling protocol (GTP).
- **Connection across the G_n interface** toward the GGSN for transportation of user plane traffic using GTP. Note that no physical transport layer is defined for this interface.
- **SMS**: This functionality allows the user to send and receive SMS data to and from the SMS-GMSC /SMS-IWMSC.
- **Mobility management**: Handles attach, authentication, updates to the HLR and SRNS relocation, and intersystem handover.
- **Subscriber database functionality**: This database (similar to the VLR) is located within the 3G-SGSN and serves as intermediate storage for subscriber data to support subscriber mobility.
- **Charging:** The SGSN collects charging information related to radio network usage by the user.
- **OAM** agent functionality.

3G – GGSN

The GGSN provides interworking with the external PS network. It is connected with SGSN via an IP-based network. The GGSN may optionally support an SS7 interface with the HLR to handle mobile terminated packet sessions.

The 3G-GGSN provides the following functions:

- **Maintain information locations** at SGSN level (macro-mobility)
- **Gateway** between UMTS packet network and external data networks (e.g. IP, X.25)
- **Gateway-specific access methods** to intranet (e.g. PPP termination)
- **Initiate mobile terminate** Route Mobile Terminated packets

- **User data screening/security** can include subscription based, user controlled, or network controlled screening.
- **User level address allocation**: The GGSN may have to allocate (depending on subscription) a dynamic address to the UE upon PDP context activation. This functionality may be carried out by use of the DHCP function.
- **Charging:** The GGSN collects charging information related to external data network usage by the user.
- **OAM** functionality

SMS – GMSC/SMS – IWMSC

The overall requirement for these two nodes is to handle the SMS from point to point. The functionality required can be split into two parts. The SMS-GMSC is an MSC capable of receiving a terminated short message from a service center, interrogating an HLR for routing information and SMS information, and delivering the short message to the SGSN of the recipient UE.

The SMS-GMSC provides the following functions:

- Reception of short message packet data unit (PDU)
- Interrogation of HLR for routing information
- Forwarding of the short message PDU to the MSC or SGSN using the routing information

The SMS-IWMSC is an MSC capable of receiving an originating short message from within the PLMN and submitting it to the recipient service center.

The SMS-IWMSC provides the following functions:

- Reception of the short message PDU from either the 3G-SGSN or 3G-MSC
- Establishing a link with the addressed service center
- Transferring the short message PDU to the service center

FIREWALL

This entity is used to protect the service providers' backbone data networks from attack from external packet data networks. The security of the backbone data network can be ensured by applying packet filtering mechanisms based on access control lists or any other methods deemed suitable.

FIREWALL

A firewall is a network security system, either hardware- or software-based, that controls incoming and outgoing network traffic based on a set of rules. This entity is used to protect the service providers' backbone data networks from attack from external packet data networks. The security of the backbone data network can be ensured by applying packet filtering mechanisms based on access control lists or any other methods deemed suitable.

Introduction

Firewalls are computer security systems that protect your office/home PCs or your network from intruders, hackers & malicious code. Firewalls protect you from offensive software that may come to reside on your systems or from prying hackers. In a day and age when online security concerns are the top priority of the computer users,

Firewalls provide you with the necessary safety and protection. Firewalls are software programs or hardware devices that filter the traffic that flows into your PC or your network through a internet connection. They sift through the data flow & block that which they deem (based on how & for what you have tuned the firewall) harmful to your network or computer system.

When connected to the internet, even a standalone PC or a network of interconnected computers make easy targets for malicious software & unscrupulous hackers. A firewall can offer the security that makes you less vulnerable and also protect your data from being compromised or your computers being taken hostage.

Firewalls are setup at every connection to the Internet, therefore subjecting all data flow to careful monitoring. Firewalls can also be tuned to follow "rules". These Rules are simply security rules that can be set up by the network administrators to allow traffic to their web servers, FTP servers, Telnet servers, thereby giving the computer owners/administrators immense control over the traffic that flows in & out of their systems or networks.

Rules will decide who can connect to the internet, what kind of connections can be made, which or what kind of files can be transmitted in out. Basically all traffic in & out can be watched and controlled thus giving the firewall installer a high level of security & protection.

Firewall logic

Firewalls use 3 types of filtering mechanisms:

(i) Packet filtering or packet purity

Data flow consists of packets of information and firewalls analyze these packets to sniff out offensive or unwanted packets depending on what you have defined as unwanted packets.

(ii) Proxy

Firewall in this case assumes the role of a recipient & in turn sends it to the node that has requested the information & vice versa.

(iii) Inspection

In this case Firewalls instead of sifting through all of the information in the packets, mark key features in all outgoing requests & check for the same matching characteristics in the inflow to decide if it relevant information that is coming through.

DNS/DHCP

The DNS server is used, as in any IP network, to translate host names into IP addresses, i.e., logical names are handled instead of raw IP addresses. Also, the DNS server is used to translate the access point name (APN) into the GGSNIP address. It may optionally be used to allow the UE to use logical names instead of physical IP addresses. A dynamic host configuration protocol server is used to manage the allocation of IP configuration information by automatically assigning IP addresses to systems configured to use DHCP.

DHCP (Dynamic Host Configuration Protocol)

DHCP is a network protocol that is used to assign various network parameters to a device. This greatly simplifies administration, since there is no need to assign static network parameters for each device separately. DHCP is a client-server protocol. A client is a device that is configured to use DHCP to request network parameters from a DHCP server. DHCP server maintains a pool of available IP addresses and assigns one of them to the host. A DHCP server can also provide some other parameters, such as:

- Subnet mask
- Default gateway
- Domain name
- DNS server

DHCP process explained: DHCP client goes through the four step process:

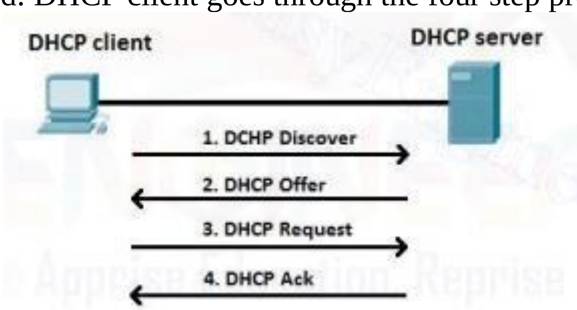

Fig: DHCP

1: A DHCP client sends a broadcast packet (DHCP Discover) to discover DHCP servers on the LAN segment.

2: The DHCP servers receive the DHCP Discover packet and respond with DHCP Offer packets, offering IP addressing information.

3: If the client receives the DHCP Offer packets from multiple DHCP servers, the first DHCP Offer packet is accepted. The client responds by broadcasting a DHCP Request packet, requesting network parameters from a single server.

4: The DHCP server approves the lease with a DHCP Acknowledgement packet. The packet includes the lease duration and other configuration information.

DNS (Domain Name System)

DNS is a network protocol used to translate hostnames into IP addresses. DNS is not required to establish a network connection, but it is much more user friendly for human users than the numeric addressing scheme. Consider this example. You can access the Google homepage by typing 74.125.227.99, but it's much easier just to type www.google.com!

To use DNS, you must have a DNS server configured to handle the resolution process. A DNS server has a special-purpose application installed. The application maintains a table of dynamic or static hostname-to-IP address mappings. When a user request some network resource using a hostname, (for example by typing www.google.com in a browser), a DNS request is sent to the DNS server asking for the IP address of the hostname. The DNS server then replies with the IP address.

The figure below explains the concept:

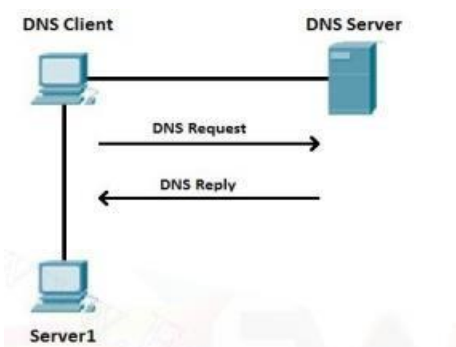

Fig: DNS

Suppose that the DNS Client wants to communicate with the server named Server1. Since the DNC Client doesn't know the IP address of Server1, it sends a DNS Request to the DNS Server, asking for Server1's IP address. The DNS Server replies with the IP address of Server1 (DNS Reply).

DNS/DHCP

The DNS server is used, as in any IP network, to translate host names into IP addresses, i.e., logical names are handled instead of raw IP addresses. Also, the DNS server is used to translate the access point name (APN) into the GGSN IP address. It may optionally be used to allow the UE to use logical names instead of physical IP addresses.

A dynamic host configuration protocol server is used to manage the allocation of IP configuration information by automatically assigning IP addresses to systems configured to use DHCP.

HIGH-SPEED DOWNLINK PACKET ACCESS (HSDPA)

In third-generation partnership project (3GPP) standards, Release 4 specifications provide efficient IP support enabling provision of services through an all-IP core network.

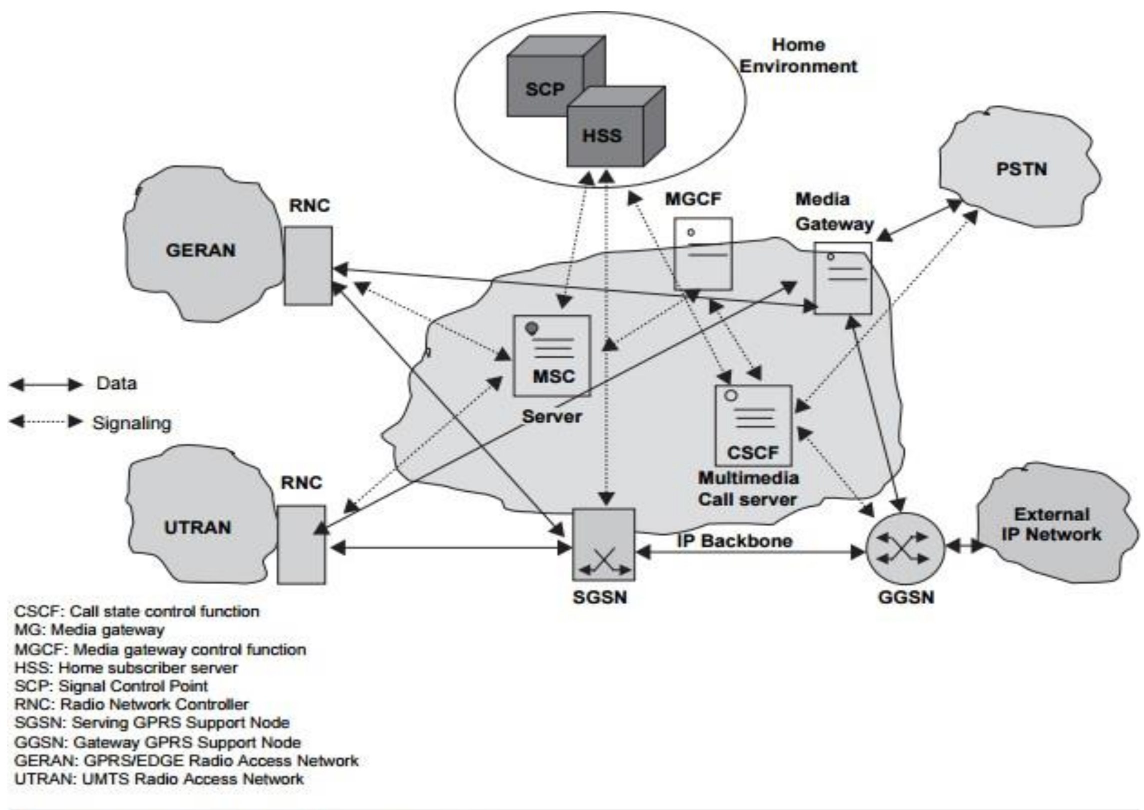

Figure 15.32 A simplified all-IP UMTS architecture.

Release 5 specifications focus on HSDPA to provide data rates up to approximately 8–10 Mbps to support packet-based multimedia services. Multi input and multi output (MIMO) systems are the work item in Release 6 specifications, which will support even higher data transmission rates of up to 20 Mbps.

HSDPA is evolved from and backward compatible with Release 99 WCDMA systems. HSDPA is based on the same set of technologies as high data rate (HDR) to improve spectral efficiency for data services - such as shared downlink packet data channel and high peak data rates - using high-order modulation and adaptive modulation and coding, hybrid ARQ (HARQ) retransmission schemes, fast scheduling and shorter frame sizes.

HSDPA marks a similar boost for WCDMA that EDGE does for GSM. It provides a two-fold increase in air interface capacity and a five-fold increase in data speeds in the downlink direction. HSDPA also shortens the round-trip time between the network and terminals and reduces variance in downlink transmission delay. The improvements in performance are achieved by:

- Bringing some key functions, such as scheduling of data packet transmission and processing of retransmissions (in case of transmission errors) into the base station that is, closer to the air interface.
- Using a short frame length to further accelerate packet scheduling for transmission.
- Employing incremental redundancy for minimizing the air-interface load caused by retransmissions.
- Adopting a new transport channel type, known as high-speed downlink shared channel (HS-DSCH) to facilitate air interface channel sharing between several users.
- Adapting the modulation and coding scheme according to the quality of the radio link.

The primary objective behind HSDPA is to provide a cost-effective, high bandwidth, low-delay, packet-oriented service within UMTS. HSDPA is particularly suited to extremely asymmetrical data services, which require significantly higher data rates for the transmission from the network to the UE, than they do for the transmission from the UE to the network.

HSDPA introduces enablers for the high-speed transmission at the physical layer like the use of a shorter transmission time interval (TTI) (2 ms), and the use of adaptive modulation and coding. HS-DPCCH is used to carry the acknowledgment signals to Node B for each block. It is also used to indicate channel quality (CQI) used for adaptive modulation and coding. HS-DSCH uses 2 ms TTI to reduce trip time, to increase the granularity in the scheduling process, and to track the time varying radio channel better.

The RNC routes data packets destined for a particular UE to the appropriate Node B. Node B takes the data packets and schedules their transmission to the mobile terminal over the air interface by matching the user's priority and estimated channel operating environment with an appropriately chosen coding and modulation scheme (that is, 16-QAM vs. QPSK).

The UE is responsible for acknowledging receipt of the data packet and providing Node B with information regarding channel condition, power control, and so on. Once it sends the data packet to the UE, Node B waits for an acknowledgment. If it does not receive one within a prescribed time, it assumes that the data packet was lost and retransmits it.

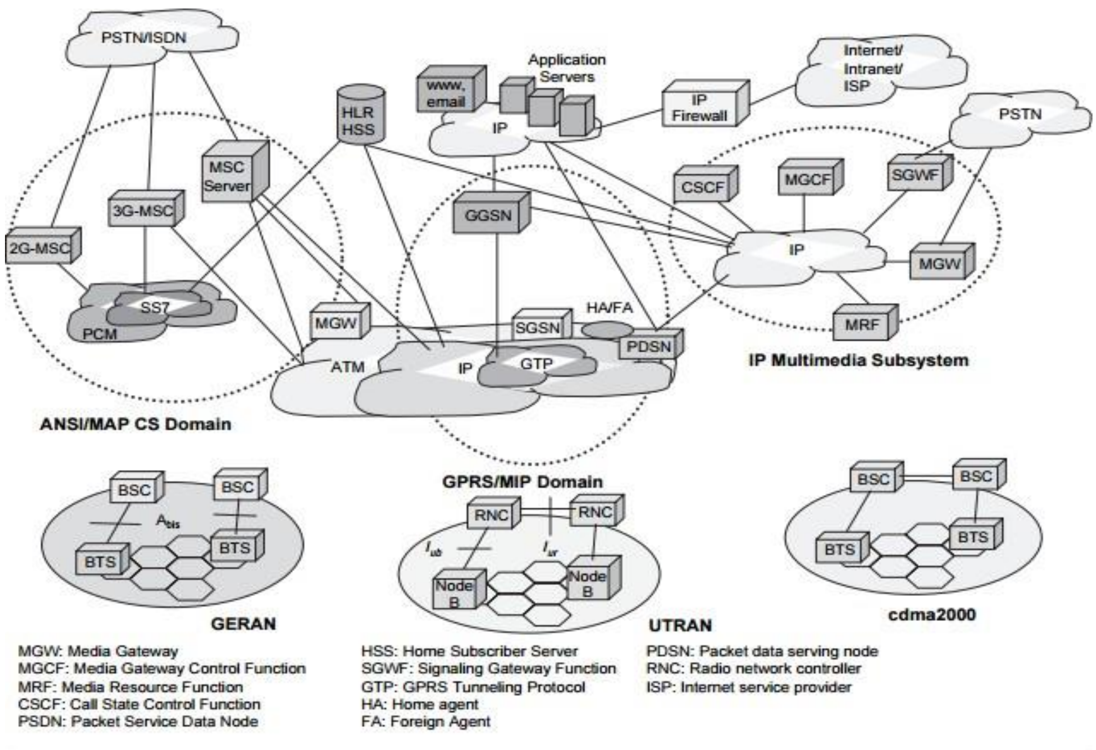

Figure 15.33 All-IP core network architecture for UMTS.

The data rates achievable with HSDPA are more than adequate for supporting multimedia streaming services.

The Node B radio cabinet sits in proximity to the radio tower and the power cabinet. For indoor deployments the radio cabinet may be a simple rack, while in outdoor deployments it may be an environmental-control unit.

The guts of the radio cabinet are an antenna interface section (filters, power amplifiers, and the like), core processing chassis (RF transceivers, combiner, high performance channel cards, network interface and system controller card, timing card, back-plane, and so on), plus mechatronics (power supply, fans, cables, etc.) and other miscellaneous elements.

The core processing chassis is the cornerstone of Node B and bears most of the cost. It contains the RF transceiver, combiner, network interface and system controller, timing card, channel card and backplane. Of the core processing chassis elements, only the channel card needs to be modified to support HSDPA.

The typical UMTS channel card comprises a general-purpose processor that handles the miscellaneous control tasks, a pool of digital signal processor (DSP) resources to handle symbol-rate processing and chip-rate assist functions, and a pool of specialized ASIC (application specific intergrated circuit) devices to handle intensive chip-rate operations such as spreading, scrambling, modulation, rake receiving, and preamble detection.

To support HSDPA, two changes must be made to the channel card. First, the downlink chip-rate ASIC must be modified to support the new 16-QAM modulation schemes and new downlink slot formats associated with HSDPA. In addition, the downlink symbol-rate processing section must be modified to support HSDPA extensions.

The next change requires a new processing section, called the **MAC-h$_S$**, which must be added to the channel card to support the scheduling, buffering, transmission, and retransmission of data blocks that are received from the RNC. This is the most intrusive augmentation to the channel card because it requires the introduction of a programmable processing entity together with a retransmission buffer. Since the channel card already contains both a general-purpose processor and a DSP, one can make convincing arguments that the **MAC-h$_S$** could be effectively realized using either of the two types of devices.

The new channels introduced in HSDPA are **high-speed downlink shared channel (HS-DSCH), high-speed shared control channel (HS-SCCH), and highspeed dedicated physical control channel (HS-DPCCH).**

The **HS-DSCH** is the primary radio bearer. Its resources can be shared among all users in a particular sector. The primary channel multiplexing occurs in a time domain, where each TTI consists of three time slots (each 2 ms). TTI is also referred to as a sub-frame. Within each 2 ms TTI, a constant spreading factor (SF) of 16 is used for code multiplexing, with a maximum of 15 parallel codes allocated to HS-DSCH. Codes may all be assigned to one user, or may be split across several users. The number of codes allocated to each user depends on cell loading, QoS requirements, and UE code capabilities (5, 10, or 15 codes).

The **HS-SCCH** (a fixed rate 960 kbps, SF 128) is used to carry downlink signaling between Node B and UE before the beginning of each scheduled TTI. It includes UE identity, HARQ-related information and the parameters of the HS-DSCH transport format selected by the link-adaptation mechanism. Multiple HS-SCCHs can be configured in each sector to support parallel HS-DSCH transmissions. A UE can be allocated a set of up to four HS-SCCHs, which need to be monitored continuously.

The **HS-DPCCH** (SF 256) carries ACK/NACK signaling to indicate whether the corresponding downlink transmission was successfully decoded, as well as a channel quality indicator (CQI) to be used for the purpose of link adaptation. The CQI is based on a common pilot channel (CPICH) and is used to estimate the transport block size, modulation type, and number of channelization codes that can be supported at a given reliability level in downlink transmission.

UE capabilities include the maximum number of HS-DSCHs supported simultaneously (5, 10, or 15), minimum TTI time (minimum time between the beginning of two consecutive transmissions to the UE), the maximum number of HS-DSCH transport block (TB) bits received within an HS-DSCH TTI, the maximum number of soft channel bits over all HARQ and supported modulations (QPSK only or both QPSK and 16-QAM).

LTE NETWORK ARCHITECTURE AND PROTOCOL

INTRODUCTION

In contrast to the circuit-switched model of previous cellular systems, Long Term Evolution (LTE) has been designed to support only packet-switched services. It aims to provide seamless Internet Protocol (IP) connectivity between user equipment (UE) and the packet data network (PDN), without any disruption to the end users' applications during mobility.

While the term "LTE" encompasses the evolution of the Universal Mobile Telecommunications System (UMTS) radio access through the Evolved UTRAN (EUTRAN), it is accompanied by an evolution of the non-radio aspects under the term "System Architecture Evolution" (SAE), which includes the Evolved Packet Core (EPC) network. Together LTE and SAE comprise the Evolved Packet System (EPS).

EPS uses the concept of EPS bearers to route IP traffic from a gateway in the PDN to the UE. A bearer is an IP packet flow with a defined quality of service (QoS) between the gateway and the UE. The E-UTRAN and EPC together set up and release bearers as required by applications.

NETWORK ARCHITECTURE

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 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 high-level network architecture of LTE is comprised of following three main components:

- User Equipment (UE)
- Evolved UMTS Terrestrial Radio Access Network (E-UTRAN).
- Evolved Packet Core (EPC).

The evolved packet core communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. The interfaces between the different parts of the system are denoted Uu, S1 and SGi as shown below:

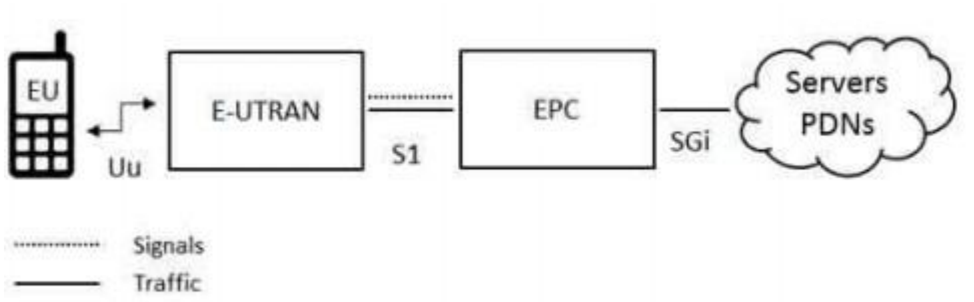

Fig: The LTE network Architecture

(i) User Equipment (UE):

The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM which is actually a Mobile Equipment (ME).

The mobile equipment comprised of the following important modules:

- **Mobile Termination (MT):** This handles all the communication functions.
- **Terminal Equipment (TE):** This terminates the data streams.
- **Universal Integrated Circuit Card (UICC):** This is also known as the SIM card for LTE equipments. It runs an application known as the Universal Subscriber Identity Module (USIM).

A **USIM** stores user-specific data very similar to 3G SIM card. This keeps information about the user's phone number, home network identity and security keys etc.

(ii) E-UTRAN (The access network)

The architecture of evolved UMTS Terrestrial Radio Access Network (EUTRAN) has been illustrated below:

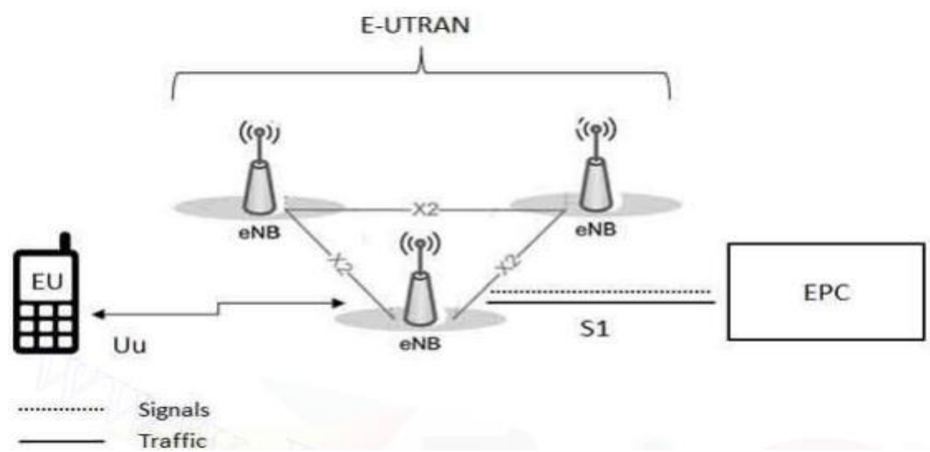

Fig: The architecture of E-UTRAN

The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called eNodeB or eNB. Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.

LTE Mobile communicates with just one base station and one cell at a time and there are following two main functions supported by eNB:

- The eBN sends and receives radio transmissions to all the mobiles using the analogue and digital signal processing functions of the LTE air interface.
- The eNB controls the low-level operation of all its mobiles, by sending them signalling messages such as handover commands.

Each eBN connects with the EPC by means of the S1 interface and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signalling and packet forwarding during handover.

A home eNB (HeNB) is a base station that has been purchased by a user to provide femtocell coverage within the home. A home eNB belongs to a closed subscriber group (CSG) and can only be accessed by mobiles with a USIM that also belongs to the closed subscriber group.

(iii) Evolved Packet Core (EPC) (The core network):

The architecture of Evolved Packet Core (EPC) has been illustrated below. There are few more components which have not been shown in the diagram to keep it simple. These components are like the Earthquake and Tsunami Warning System (ETWS), the Equipment Identity Register (EIR) and Policy Control and Charging Rules Function (PCRF).

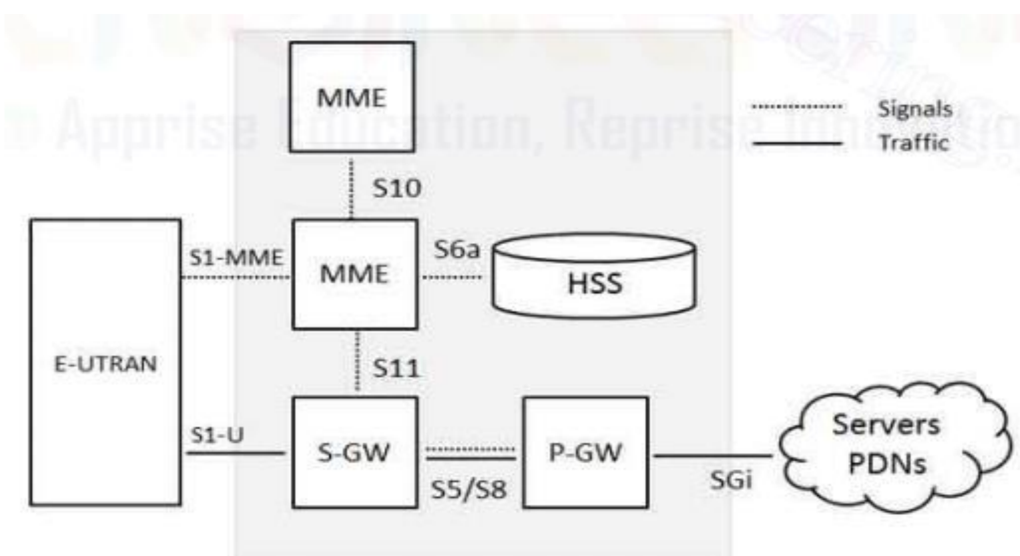

Fig: The architecture of Evolved Packet Core

Below is a brief description of each of the components shown in the above architecture:

- The Home Subscriber Server (HSS) component has been carried forward from UMTS and GSM and is a central database that contains information about all the network operator's subscribers.
- The Packet Data Network (PDN) Gateway (P-GW) communicates with the• outside world ie. packet data networks PDN, using SGi interface. Each packet data network is identified by an access point name (APN). The PDN gateway has the same role as the GPRS support node (GGSN) and the serving GPRS support node (SGSN) with UMTS and GSM.
- The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.
- The mobility management entity (MME) controls the high-level operation of the mobile by means of signaling messages and Home Subscriber Server (HSS).
- The Policy Control and Charging Rules Function (PCRF) is a component which is not shown in the above diagram but 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 interface between the serving and PDN gateways is known as S5/S8. This has two slightly different implementations, namely S5 if the two devices are in the same network, and S8 if they are in different networks.

LTE PROTOCOL STACK LAYER

Physical Layer (Layer 1)

Physical Layer carries all information from the MAC transport channels over the air interface. Takes care of the link adaptation (AMC), power control, cell search (for initial synchronization and handover purposes) and other measurements (inside the LTE system and between systems) for the RRC layer.

Medium Access Layer (MAC)

MAC layer is responsible for Mapping between logical channels and transport channels, Multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels, demultiplexing of MAC SDUs from one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels, Scheduling information reporting, Error correction through HARQ, Priority handling between UEs by means of dynamic scheduling, Priority handling between logical channels of one UE, Logical Channel prioritization.

The below diagram shows the layers available in E-UTRAN Protocol Stack.

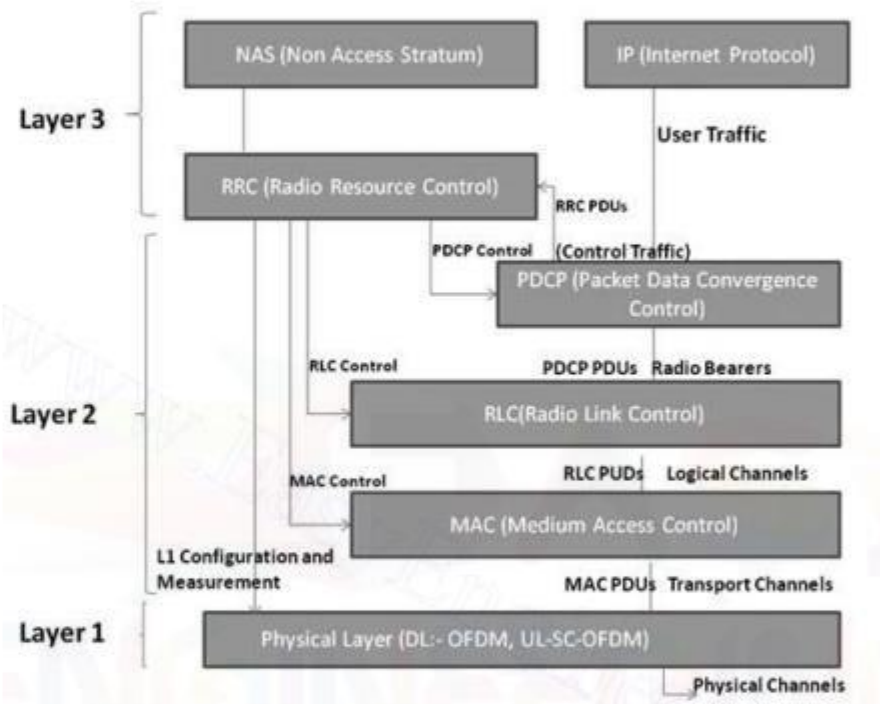

Fig: E-UTRAN Protocol Stack

Radio Link Control (RLC)

RLC operates in 3 modes of operation:

- Transparent Mode (TM)
- Unacknowledged Mode (UM)
- Acknowledged Mode (AM)

RLC Layer is responsible for transfer of upper layer PDUs, error correction through ARQ (Only for AM data transfer), Concatenation, segmentation and reassembly of RLC SDUs (Only for UM and AM data transfer).

RLC is also responsible for re-segmentation of RLC data PDUs (Only for AM data transfer), reordering of RLC data PDUs (Only for UM and AM data transfer), duplicate detection (Only for UM and AM data transfer), RLC SDU discard (Only for UM and AM data transfer), RLC re-establishment, and protocol error detection (Only for AM data transfer).

Radio Resource Control (RRC)

The main services and functions of the RRC sublayer include broadcast of System Information related to the non-access stratum (NAS), broadcast of System Information related to the access stratum (AS), Paging, establishment, maintenance and release of an RRC connection between the UE and E-UTRAN, Security functions including key management, establishment, configuration, maintenance and release of point to point Radio Bearers.

Packet Data Convergence Control (PDCP)

PDCP Layer is responsible for Header compression and decompression of IP data, Transfer of data (user plane or control plane), Maintenance of PDCP Sequence Numbers (SNs), In-sequence delivery of upper layer PDUs at re-establishment of lower layers, Duplicate elimination of lower layer SDUs at re-establishment of lower layers for radio bearers mapped on RLC AM, Ciphering and deciphering of user plane data and control plane data, Integrity protection and integrity verification of control plane data, Timer based discard, duplicate discarding, PDCP is used for SRBs and DRBs mapped on DCCH and DTCH type of logical channels.

Non Access Stratum (NAS) Protocols

The non-access stratum (NAS) protocols form the highest stratum of the control plane between the user equipment (UE) and MME. NAS protocols support the mobility of the UE and the session management procedures to establish and maintain IP connectivity between the UE and a PDN GW