WCDMA System Overview
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Background and Standardization of WCDMA
Since 1985, ITU (International Telecommunications Union) has been developing IMT-2000, previously termed Future Public Land Mobile Telephone System (FPLMTS).

In 1992, the World Administrative Radio Conference (WARC) of the ITU identified the frequencies around 2 GHz for future 3rd generation mobile systems, both terrestrial and satellite.

Within the ITU, the 3rd generation systems are called International Mobile Telephony 2000 (IMT-2000). In Europe, it is called UMTS (Universal Mobile Telephone Service).


Specification has been created in 3GPP (the 3rd Generation Partnership Project), which is the joint standardisation project of the standardisation bodies from Europe, Japan, Korea, the USA and China.
Within 3GPP, WCDMA is called **UTRA (Universal Terrestrial Radio Access)** FDD and TDD.

In addition to WCDMA, the other air interfaces that can be used to provide third generation services are EDGE and cdma2000.

**EDGE (Enhanced Data Rates for GSM Evolution)** can provide third generation services with bit rates up to 500 kbps within a GSM carrier spacing of 200 kHz.

EDGE includes advanced features that are not part of GSM to improve spectrum efficiency and to support the new services.

cdma2000 can be used as an upgrade solution for the existing IS-95 operators.
Air Interfaces for 3rd Generation Systems

- In Europe and in most of Asia, IMT-2000 (or WARC-92) band uses 1920-1980 MHz (uplink) and 2110-2170 MHz (downlink) for WCDMA FDD mode and 1900-1920 MHz and 2020-2025 MHz for WCDMA TDD mode.
- FDD systems use different frequency bands for uplink and downlink.
- TDD systems use same frequency for both uplink and downlink.
- In China, depending on the regulation decisions, up to 2 x 60 MHz of the IMT-2000 spectrum will be available for WCDMA FDD and the TDD spectrum will also be available.
- In the USA, no new spectrum has yet been made available for 3rd generation systems.
2 GHz Band Spectrum Allocation

Figure 1.2. 2 GHz band spectrum allocation in Europe, Japan, Korea and USA (MSS = Mobile satellite spectrum)

Table 1.1. Existing frequency allocations around 2 GHz

<table>
<thead>
<tr>
<th></th>
<th>Uplink</th>
<th>Downlink</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM1800</td>
<td>1710–1785</td>
<td>1805–1880</td>
<td>2 × 75 MHz</td>
</tr>
<tr>
<td>UMTS-FDD</td>
<td>1920–1980</td>
<td>2110–2170</td>
<td>2 × 60 MHz</td>
</tr>
<tr>
<td>UMTS-TDD</td>
<td>1900–1920</td>
<td>2010–2025</td>
<td>20 + 15 MHz</td>
</tr>
<tr>
<td>Americas PCS</td>
<td>1850–1910</td>
<td>1930–1990</td>
<td>2 × 60 MHz</td>
</tr>
</tbody>
</table>
RACE I (Research of Advanced Communication Technologies in Europe) program started the basic 3rd generation research work in 1988.

RACE II program develops the CDMA-based CODIT (Code Division Testbed) and TDMA-based ATDMA (Advanced TDMA Mobile Access) air interfaces during 1992-95.

European research program ACTS (Advanced Communication Technologies and Services) was launched at the end of 1995 to support mobile communications research and development.

Within ACTS, the FRAMES (Future Radio Wideband Multiple Access System) project was set up to define a proposal for a UMTS radio access system.

- Nokia, Siemens, Ericsson, France Telecom, CSEM/Pro Telecom.
Europe

- FRAMES wideband CDMA and wideband TDMA proposals were submitted to ETSI (European Telecommunications Standards Institute) as candidates for UMTS air interface and ITU IMT-2000 submission.

- After submission and presentation during 1996 and early 1997, proposals for the UMTS Terrestrial Radio Access (UTRA) air interface were grouped into five concept groups in ETSI in June 1997.
  - Wideband CDMA (WCDMA)
  - Wideband TDMA (WTDMA)
  - TDMA/CDMA
  - OFDMA
  - ODMA
In January 1998, ETSI selects WCDMA as the standard for the UTRA (UMTS Terrestrial Radio Access) air interface on the paired frequency bands, i.e. for FDD (Frequency Division Duplexing) operation, and WTDMA/CDMA for operation with unpaired spectrum allocation, i.e. for TDD (Time Division Duplexing) operation.

The detailed standardization of UTRA proceeded within ETSI until the work was handed over to the 3rd Generation Partnership Project (3GPP).

The technical work was transferred to 3GPP with the contribution of UTRA in early 1999.
ARIB (the Association for Radio Industries and Businesses) was established in April 1993 to evaluate possible 3rd generation systems around three different main technologies based on WCDMA, WTDMA and OFDMA.

The WCDMA technology in Japan was very similar to that being considered in Europe in ETSI.

ARIB selected WCDMA, with both FDD and TDD modes operation, in 1997.

WCDMA was chosen in ARIB before the process was completed in ETSI.

ARIB contributed their WCDMA to 3GPP.
Main standardization activities for wireless systems are carried out in TIA Engineering Committee TR45 and TR46, and in the T1 committee T1P1.

TR45.5 is responsible for the IS-95, TR45.3 for the IS-136, and T1P1 with TR46 are jointly for GSM1900.

Industry forums: UWCC for IS-136, CDMA Development Group (CDG) for IS-95, and the GSM Alliance and GSM North America for GSM.

In April 1997, CDG issued the Advanced Systems initiative to develop the IS-95 based 3rd generation air interface proposal.

In 1997, proposals from Hughes, Lucent, Motorola, Nokia, Nortel, Qualcomm, and Samsung, were submitted to TR45.5 for cdma2000, all backward compatible to IS-95.

In March 1998, TR45.5 agreed on the basic framework for cdma2000: cdma2000 1x has same bandwidth as IS-95 (1.25 MHz) and cdma2000 3x, also called multicarrier CDMA, three times the bandwidth of IS-95.
TTA (Telecommunications Technology Association) adopted a two-track approach to the development of 3rd CDMA technology.


A wideband CDMA proposal has been developed within ETRI, which forms the basis for the TTA I scheme.

SK Telecom (previously KMT, Korea Mobile Telecom) merged with other industrial proposals at the beginning of 1998 and formed the TTA II scheme.

The TTA1 and TTA2 air interface proposals (later renamed Global CDMA 1 and 2) were based on synchronous and asynchronous wideband CDMA technologies respectively.

Korean standardization efforts were later moved to 3GPP and 3GPP2 to contribute to WCDMA and cdma2000.
3GPP (3rd Generation Partnership Project) was founded in 1998.

The standardization organizations involved were ARIB (Japan), ETSI (Europe), TTA (Korea), TTC (Japan) and T1P1 (USA).

The partners agreed on joint efforts for the standardization of UTRA, now standing for Universal Terrestrial Radio Access.

In 1999, CWTS (the China Wireless Telecommunication Standard Group) joined 3GPP and contributed technology from TD-SCDMA, a TDD-based CDMA 3rd generation technology already submitted to ITU-R earlier.
The first version of the common specification, called Release-99, was ready by the end of 1999.

Within 3GPP, four different technical specification groups (TSG) were set up:
- Radio Access Network (RAN) TSG
- Core Network TSG
- Service and System Aspects TSG
- Terminals TSG
Within the TSGs, the one most relevant to the WCDMA technology is the RAN TSG.
Work done in TR45.5 and TTA was merged to form 3GPP2.

Focused on cdma2000 Direct-Sequence (DS) and Multi-Carrier (MC) mode.

This activity has been running in parallel with the 3GPP project, with participation from ARIB, TTC, and CWTS as member organizations.

DS mode was abandoned.
Manufacturers and operators agreed to adopt a harmonized global 3rd generation CDMA standard consisting of three modes: Multi-Carrier (MC) mode based on the cdma2000 multi-carrier option, Direct Spread (DS) mode on WCDMA (UTRA FDD), and the Time Division Duplex (TDD) mode on UTRA TDD. UTRA FDD and TDD mode chip rate were changed from 4.096 Mcps to 3.84 Mcps.
Parameters of WCDMA

- Channel Bandwidth: 5 MHz
- Duplex Mode: FDD and TDD
- Spread Spectrum Technique: Direct Spread
- Chip Rate: 3.84 MHz
- Frame Length: 10 ms (38400 chips/sce)
- Slot Length: 15 Slots per Frame (2560 chips/slot)
- Spreading Modulation: Balanced QPSK (downlink) and Dual-Channel QPSK (uplink) with complex spreading circuit.
- Data Modulation: QPSK (downlink) and BPSK (uplink).
Parameters of WCDMA

- Channel Coding: Convolutional code, Turbo code, and no coding.
- Spreading Factors: 4-256 (uplink) and 4-512 (downlink).
- Modulation symbol rates vary from 960 k symbols/s to 15 k symbols/s (7.5 k symbols/s) for FDD uplink (downlink).
- Spreading (downlink): OVSF sequences for channel separation. Gold sequences $2^{18}-1$ for cell and user separation (truncated cycle: 10 ms).
- Spreading (uplink): OVSF sequences for channel separation. Gold sequences $2^{25}-1$ for user separation (truncated cycle: 10 ms).
<table>
<thead>
<tr>
<th></th>
<th>WCDMA</th>
<th>GSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier spacing</td>
<td>5 MHz</td>
<td>200 kHz</td>
</tr>
<tr>
<td>Frequency reuse factor</td>
<td>1</td>
<td>1-18</td>
</tr>
<tr>
<td>Power control frequency</td>
<td>1.5 kHz</td>
<td>2 Hz or lower</td>
</tr>
<tr>
<td>Quality control</td>
<td>Radio resource management algorithm</td>
<td>Network planning (frequency planning)</td>
</tr>
<tr>
<td>Frequency diversity</td>
<td>Multipath diversity with RAKE receiver</td>
<td>Frequency hopping.</td>
</tr>
<tr>
<td>Packet data</td>
<td>Load-based packet scheduling</td>
<td>Time slot based scheduling with GPRS</td>
</tr>
<tr>
<td>DL transmit diversity</td>
<td>Supported for improving downlink capacity.</td>
<td>Not supported by standard but can be applied</td>
</tr>
</tbody>
</table>
## WCDMA vs. IS-95

<table>
<thead>
<tr>
<th>Feature</th>
<th>WCDMA</th>
<th>IS-95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier spacing</td>
<td>5 MHz</td>
<td>1.25 MHz</td>
</tr>
<tr>
<td>Chip rate</td>
<td>3.84 Mcps</td>
<td>1.2288 Mcps</td>
</tr>
</tbody>
</table>
| Power control                | 1.5 kHz for both uplink and downlink. | UL: 800Hz  
DL: slow control |
| Base station synchronization | Not needed                 | Needed (typically GPS)       |
| Inter-frequency handover     | Yes                        | Possible but not specified   |
| Radio resource management    | Yes, provides required quality of service. | Not needed for speech only network |
| Packet data                  | Load-based packet scheduling | Transmitted as short circuit-switched calls |
| DL transmit diversity        | Supported                  | Not supported                |
Core Network Relation to the 3rd Generation Air Interface Alternatives
WCDMA System Architecture
Basic Architecture of GSM

**Base Station Subsystem (BSS)**

- BTS (Base Transceiver Station)
- BSC (Base Station Controller)
- MS (Mobile Station)

**Mobile Services Switching Centre (MSC)**

- AUC (Authentication Centre)
- HLR (Home Location Register)
- VLR (Visited Location Register)
- OMC (Operation & Maintenance Centre)
- EIR (Equipment Identity Register)

**Signalling Links**

- A-bis
- Um

**Interconnections**

- PSTN
- ISDN
- CSPDN
- PSPDN
GSM Network Architecture

- **MS**
  - Layer 3: CM, MM, RR
  - Layer 2: LAPDm
  - Layer 1: physical layer

- **BTS**
  - RR
  - LAPDm
  - LAPD
  - physical layer
  - Um Interface

- **BSC**
  - RR
  - BTSM
  - LAPD
  - physical layer
  - A-bis interface
  - SCCP
  - MPT
  - BSSAP

- **MSC**
  - CM
  - MM
  - BSSAP
  - SCCP
  - MPT
  - A interface
GPRS Architecture

**Channel Codec Unit (CCU)**
- Channel Coding
- Radio Channel Measurements

**Packet Control Unit (PCU)**
- Channel access control
- Radio channel management
- Data packet segmentation and re-assembly

**Serving GPRS Support Node (SGSN)**
- Functions comparable to VMSC/VLR

**Gateway GPRS Support Node (GGSN)**
- Functions comparable to GMSC

**HLR Extension**
- GPRS subscriber data
- Routing information

**Visited MSC / VLR**

**Gateway MSC / VLR**

**External Data Network**

**PSTN**
GPRS Transmission Planes

MS | Um | BSS | Gb | SGSN | Gn | GGSN | Gi | Router

Application/Higher level protocols

- BSSGP: BSS GPRS Protocol
- FR: Frame Relay
- GTP: GPRS Tunnelling Protocol
- IP: Internet Protocol
- LLC: Logical Link Control
- MAC: Medium Access Control
- RLC: Radio Link Control
- SND: Sub-Network Dependent
- TCP: Transmission Control Protocol
- UDP: User Datagram Protocol
- L1: Layer 1
- L1': Layer 1'
- L2: Layer 2
- L2': Layer 2'
- IP/X.25

Relay

Router
GPRS Signaling Planes

SGSN  Gr, f, d  HLR, EIR, SMS-GMSC
GGSN  Gc  HLR

SGSN  Gs  MSC /VLR

GPRS-specific MAP extension

MAP  Mobile Application Part
TCAP  Transaction Capabilities Application Part
SCCP  Signaling Connection Control Part
MTP L3
MTP L2
L1

BSSAP+
BSS Application Part +
SCCP
MTP L3
MTP L2
L1

Subset of BSSAP functionalities
UMTS Network Architecture
Network Elements in a WCDMA PLMN

- PLMN: Public Land Mobile Network.
- One PLMN is operated by a single operator.
The UE consists of two parts:

- The *Mobile Equipment (ME)* is the radio terminal used for radio communication over the Uu interface.
- The *UMTS Subscriber Identity Module (USIM)* is a smartcard that holds the subscriber identity, performs authentication algorithms, and stores authentication and encryption keys and some subscription information that is needed at the terminal.
UMTS Terrestrial Radio Access Network -- UTRAN

- UTRAN consists of two distinct elements:
  - The *Node B* converts the data flow between the Iub and Uu interfaces. It also participates in radio resource management.
  - The *Radio Network Controller (RNC)* owns and controls the radio resources in its domain (the Node Bs connected to it). RNC is the service access point for all services UTRAN provides the core network (CN).
UMTS system utilizes the same well-known architecture that has been used by all main 2nd generation systems.

The network elements are grouped into:

- The Radio Access Network (RAN, UMTS Terrestrial RAN = UTRAN) that handles all radio-related functionality.
- The Core Network (CN) which is responsible for switching and routing calls and data connections to external networks.

Both User Equipment (UE) and UTRAN consist of completely new protocols, which is based on the new WCDMA radio technology.

The definition of CN is adopted from GSM.
Main Elements of the GSM Core Network

- **HLR (Home Location Register)** is a database located in the user’s home system that stores the master copy of the user’s service profile.
  - The service profile consists of, for example, information on allowed services, forbidden roaming areas, and Supplementary Service information such as status of call forwarding and the call forwarding number.
  - It is created when a new user subscribes to the system.
  - HLR stores the UE location on the level of MSC/VLR and/or SGSN.
MSC/VLR (Mobile Services Switching Center / Visitor Location Register) is the switch (MSC) and database (VLR) that serves the UE in its current location for circuit switched services.

- The MSC function is used to switch the CS transactions.
- The VLR function holds a copy of the visiting user’s service profile, as well as more precise information on the UE’s location within the serving system.
Main Elements of the GSM Core Network

- **GMSC (Gateway MSC)** is the switch at the point where UMTS PLMN is connected to external CS networks.
  - All incoming and outgoing circuit switched connections go through GMSC.
- **SGSN (Serving GPRS (General Packet Radio Service) Support Node)** functionality is similar to that of MSC/VLR, but is typically used for Packet Switched (PS) services.
- **GGSN (Gateway GPRS Support Node)** functionality is close to that of GMSC but is in relation to PS services.
**Interfaces**

- **Cu Interface**: this is the electrical interface between the USIM smartcard and the ME. The interface follows a standard format for smartcards.
- **Uu Interface**: this is the WCDMA radio interface, which is the subject of the main part of WCDMA technology. This is also the most important open interface in UMTS.
- **Iu Interface**: this connects UTRAN to the CN.
- **Iur Interface**: the open Iur interface allows soft handover between RNCs from different manufacturers.
- **Iub Interface**: the Iub connects a Node B and an RNC. UMTS is the first commercial mobile telephony system where the Controller-Base Station interface is standardized as a fully open interface.
UTRAN Overall Description
The protocols over Uu and Iu interfaces are divided into two structures:

- **User plane protocols**
  - These are the protocols implementing the actual radio access bearer service, i.e. carrying user data through the access stratum.

- **Control plane protocols**
  - These are the protocols for controlling the radio access bearers and the connection between the UE and the network from different aspects (including requesting the service, controlling different transmission resources, handover & streamlining etc.).
User Plane

The radio access bearer service is offered from service access point (SAP) to SAP by the Access Stratum. The following figure shows the protocols on the Uu and Iu interfaces that link together to provide this radio access bearer service.
The following figure shows the control plane (signalling) protocol stacks on Iu and Uu interfaces.
UTRAN Architecture

- UTRAN consists of one or more *Radio Network Sub-systems (RNS)*, which are connected to the core network through the Iu.

- An RNS is a sub-network within UTRAN and consists of one *Radio Network Controller (RNC)* and one or more Node Bs.

- A Node B can support FDD mode, TDD mode, or dual-mode operation.

- RNCs may be connected to each other via Iur interface.
UTRAN Architecture

- RNCs and Node Bs are connected with an Iub interface.
- The RNC is responsible for the Handover decisions that require signaling to the UE.
- A RNC may include a combining/splitting function to support combination/splitting of information streams.
- Inside the UTRAN, the RNCs of the Radio Network Subsystems can be interconnected together through the Iur.
Main Characteristics of UTRAN

- Support of UTRA and all the related functionalities.
- UTRAN has to support soft handover and the WCDMA-specific Radio Resource Management algorithms.
- Maximization of the commonalities in the handling of packet-switched and circuit-switched data, with a unique air interface protocol stack.
- Use of the ATM transport as the main transport mechanism in UTRAN.
Radio Network Controller (RNC)

- RNC is responsible for the control of the radio resources of UTRAN.

- RNC interfaces with the core network (normally to one MSC and one SGSN).

- RNC terminates the RRC (Radio Resource Control) protocol that defines the messages and procedures between the mobile and UTRAN.

- RNC logically corresponds to the GSM BSC.
Logical Role of the RNC

- **Controlling RNC (CRNC):** the RNC controlling a given Node B (i.e. terminating the Iub interface towards the Node B).

- CRNC is responsible for the load and congestion control of its own cells.

- CRNC executes the admission control and code allocation for new radio links to be established in those cells.
Logical Role of the RNC

In case one mobile-UTRAN connection uses resources from more than one RNS, the RNC involved have two separate logical roles (with respect to this mobile-UTRAN connection):

- Serving RNC (SRNC).
- Drift RNC (DRNC).
Serving RNC (SRNC)

- One UE connected to UTRAN has one and only one SRNC.
- The SRNC for one mobile is the RNC that terminates both the Iu link for the transport of user data and the corresponding RANAP (RAN application part) signaling to/from the core network.
- SRNC also terminates the Radio Resource Control Signaling, that is the signaling protocol between the UE and UTRAN.
- SRNC executes basic Radio Resource Management operations, such as handover decision, outer loop power control, and the mapping of Radio Access Bearer parameters into air interface transport channel parameters.
- SRNC performs L2 processing of the data to/from the radio interface.
Drift RNC (DRNC)

- One UE may have zero, one or more DRNCs.
- DRNC is any RNC, other than the SRNC, that controls cells used by the mobile.
- DRNC may perform macro-diversity combining.
- DRNC does not perform L2 processing of the user plane data.
- DRNC routes the data transparently between the Iub and Iur interface, except when the UE is using a common or shared transport channel.
UTRAN Functions List

- Transfer of User Data
- Radio channel ciphering and deciphering
- Integrity protection.
- Synchronization.
- Functions related to broadcast and multicast services.
- Overall system access control:
  - Admission Control.
  - Congestion Control.
  - System information broadcasting.
Functions related to mobility:
- Handover;
- SRNS Relocation;
- Paging support;
- Positioning.

Functions related to radio resource management and control:
- Radio resource configuration and operation.
- Radio environment survey;
- Combining/splitting control.
- Connection set-up and release;
Functions related to radio resource management and control (continue):

- Allocation and deallocation of Radio Bearers;
- Radio protocols function;
- RF power control.
- Radio channel coding;
- Channel coding control;
- Initial (random) access detection and handling.
- CN Distribution function for Non Access Stratum messages.
Serving RNS Relocation

Before SRNS Relocation

After SRNS Relocation
Main Functions of Node B

- Node B perform the air interface L1 processing (channel coding, interleaving, rate adaptation, spreading, modulation, etc.).

- Node B performs some basic Radio Resource Management operation such as inner loop power control.

- Node B logically corresponds to the GSM Base Station.
For radio resource management functionality:

- The CRNC owns the radio resources of a cell.
- The SRNC handles the connection to one UE, and may borrow radio resources of a certain cell from the CRNC.
- Dynamical control of power for dedicated channels, within limits admitted by CRNC, is done by the SRNC.
- Dynamic control on smaller time-scale for some radio links of the UE connection may be done by the Node B. This "inner loop" control is controlled by an "outer loop", for which the SRNC has overall responsibility.
- Data scheduling for dedicated channels is done by the SRNC, while for common channels it is done by CRNC.
Function Distribution Principles

- For management of node-internal resources:
  - Each UTRAN node is considered a network element on its own. The knowledge about the equipment of a network element is kept within the network element itself and its management system. The node itself always manages node-internal resources.

- For transport network resource management:
  - Management of transport network resources belong to the Transport Layer. Mechanisms relevant for the selected transport technology are used. No functional split between UTRAN nodes is specified what regards the Transport Layer.

- As a general guideline, the UTRAN protocols should be designed in such a way that they minimize the need for a DRNC to interpret the user plane frame protocol information other than for the combining/splitting purpose.
Mobility Management

- All cell level mobility should be handled within UTRAN.
- The cell structure of the radio network should not necessarily be known outside the UTRAN.
- The UE may either have or not have a signaling connection:
  - When a signaling connection exists, the CN can reach the UE by the dedicated connection SAP on the CN side, and the UTRAN has a context with the UE and CN for this particular connection.
  - When a dedicated connection does not exist, the CN must reach the UE via the Notification SAP. The message sent to the UE can be a request to the UE to establish a dedicated connection.
When there is a signaling connection exists:

- Depending on the activity of a UE, the location of the UE is known either on cell level (higher activity) or in a larger area consisting of several cells (lower activity). This will
  - Minimize the number of location update messages for moving UEs with low activity.
  - Remove the need for paging for UEs known on cell level.
- The UTRAN shall handle the radio interface mobility of the UE, including procedures such as soft handover.
Where there does not exist a dedicated connection between the UTRAN and the UE:

- No UE information is needed in UTRAN.
- Mobility is handled directly between UE and CN outside access stratum (e.g. by means of registration procedure).
- When paging the UE, the CN indicates a ‘geographical area’ that is translated within UTRAN to the actual cells that shall be paged.
Mobility Management

- When a dedicated connection is released, the UE performs a new registration to the CN when needed.
- The UTRAN does not contain any permanent 'location registers' for the UE, but only temporary contexts for the duration of the dedicated connection.
- This context may typically contain location information (e.g. current cell(s) of the UE) and information about allocated radio resources and related connection references.
Different synchronization issues are identified within UTRAN:

1. Network Synchronisation;
2. Node Synchronisation;
3. Transport Channel synchronisation;
4. Radio Interface Synchronisation;
5. Time Alignment handling.
Synchronization Issues Model
General Protocol Model for UTRAN Interface

The structure is based on the principle that the layers and planes are logically independent of each other. Therefore, as and when required, the standardisation body can easily alter protocol stacks and planes to fit future requirements.

Access Link Control Application Part: generic name for the transport signaling protocols used to set up and tear down transport bearers.

All UTRAN related issues are visible only in the Radio Network Layer.

The Transport Network Layer represents standard transport technology that is selected to be used for UTRAN, but without any UTRAN specific requirements.
Control Plane:

- The Control Plane includes the Application Protocol and the Signalling Bearer for transporting the Application Protocol messages.

- Among other things, the Application Protocol is used for setting up bearers for (i.e. Radio Access Bearer or Radio Link) in the Radio Network Layer. In the three plane structure the bearer parameters in the Application Protocol are not directly tied to the User Plane technology.

- The Signalling Bearer for the Application Protocol may or may not be of the same type as the Signalling Protocol for the ALCAP. The Signalling Bearer is always set up by O&M actions.
**User Plane:**
- The User Plane includes the Data Stream(s) and the Data Bearer(s) for the Data Stream(s).
- The Data Stream(s) is/are characterised by one or more frame protocols specified for that interface.

**Transport Network Control Plane**
- Used for all control signaling within the Transport Layer.
- Does not include any Radio Network Layer information.
- It includes the ALCAP protocol(s) that is/are needed to set up the transport bearers (Data Bearer) for the User Plane.
- It also includes the appropriate Signalling Bearer(s) needed for the ALCAP protocol(s).
Transport Network Control Plane: (continue)

- The Transport Network Control Plane is a plane that acts between the Control Plane and the User Plane.
- The introduction of Transport Network Control Plane makes it possible for the Application Protocol in the Radio Network Control Plane to be completely independent of the technology selected for Data Bearer in the User Plane.
Transport Network User Plane

- The Data Bearer(s) in the User Plane, and the Signalling Bearer(s) for Application Protocol, belong also to Transport Network User Plane.

- The Data Bearers in Transport Network User Plane are directly controlled by Transport Network Control Plane during real time operation, but the control actions required for setting up the Signalling Bearer(s) for Application Protocol are considered O&M actions.