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КЛЮЧОВИЯТ МОМЕНТ В ГЕНЕЗИСА НА МОБИЛНИТЕ КЛЕТЪЧНИ СИСТЕМИ. КОНТРОЛ НА РАДИОВРЪЗКИТЕ В УНИВЕРСАЛНИТЕ МОБИЛНИ КЛЕТЪЧНИ СИСТЕМИ.

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THE KEY MOMENT IN THE GENESIS OF MOBILE CELLULAR SYSTEMS. CONTROL OF RADIO LINKS IN UNIVERSAL MOBILE CELLULAR SYSTEMS.

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Резюме: Най-важният момент в генезиса на мобилните клетъчни системи е внедряването на универсална телекомуникационна система, като един от най-важните й аспекти е да интегрира съществуващите клетъчни стандарти от второ поколение в една платформа. Универсалните мобилни системи са базирани на няколко различни стандарта, един от които е WCDMA. Той е съвместим с широко разпространената GSM технология и използва честотна лента между 5 MHz и 10 MHz, като по този начин създава стабилна платформа за внедряване на приложения, използващи широка честотна лента. Целта на настоящата статия е да представи основните акценти в управлението на радиокомуникациите в универсалните мобилни клетъчни системи. Да се систематизират протоколите, използвани в слоевете, свързани с радиоуправление и да се обобщят основните им функции. Засегнати са процеси на управление като измервания на радиоинтерфейс, предаване, заемане, преконфигуриране и освобождаване на радиоресурси, необходими на една радиовръзка и други.

Ключови думи: WCDMA, RLC, RRC, BMC, PDCP.

Abstract: The most crucial moment in the genesis of mobile cellular systems is the implementation of a universal telecommunications system, as one of its most important aspects is to integrate existing second-generation cellular standards into a single platform. Universal mobile systems are based on several different standards, one of which is WCDMA. It is compatible with the widespread GSM technology and uses a bandwidth between 5 MHz and 10 MHz, thus creating a stable platform for deploying applications using wide bandwidth. The purpose of this article is to present the main emphasis in the control of radio communications in universal mobile cellular systems. To systematize the protocols used in the layers related to radio control and to summarize their basic functions. Control processes such as radio interface measurements, handover, borrowing, reconfiguring, and releasing radio resources needed by one radio link and others are affected.

Key words: WCDMA, RLC, RRC, BMC, PDCP.

1. Introduction

The key moment in the genesis of mobile cellular systems is the implementation of a universal telecommunication system, as one of its most important aspects is the intention to unify the existing cellular standards of the other generation on a single platform and to introduce the power of mobile internet and high transfer speeds leading to unprecedented personal subscriber experiences. Universal mobile systems are based on several different standards, one of which is WCDMA. It is compatible with the widely used GSM technology and uses a frequency band with a width between 5 MHz and 10 MHz, thereby realizing a stable platform for the implementation of applications using a wide frequency capacity. The Universal Mobile Telecommunications System is a variant of WCDMA that was developed by ETSI and standardized for Europe. This system can also be considered as a European version of the IMT-2000 system, developed by the ITU with the same goal - building a unified international telecommunications network for mobile connections, which offers its subscribers a capacity significantly greater than the capabilities of the current cellular systems . The universal mobile system offers significant benefits to the end user, which include high-quality wireless multimedia services in a converged environment of fixed, cellular and satellite networks. It delivers information directly to end users and enables them to access new services and applications. The activity of developing universal mobile telecommunication systems started in Working Group 8 (SG8) of the International Radiocommunication Union (ITU-R) through the program FPLMTS (Future Public Land Mobile Telecommunications) in 1986. With the development of the global Internet network and mobile systems, it is necessary to review the requirements to the system in terms of the offered range of services and transmission speeds. In their original form, they are significantly inferior to already the existing mobile networks and not correspond to the increased demand for Internet services. The main goal of the program, which received a new name – International Mobile Telecommunications-2000 (IMT-2000) or UMTS, is the creation of a global system for mobile multimedia communications. The system must provide multimedia services, high-speed transmission of information, video and voice, facsimile messages and data to the subscriber regardless of its location and service network, with the help of a terminal having a single universal number. The range of services provided by UMTS systems, approaches the services in fixed networks - high-speed Internet access and multimedia. Achieving the global nature of UMTS services is possible only with the availability of a system of common standards and general frequency range of operation. The standardization of mobile systems of the third generation is conducted under the auspices of the ITU in two directions - ITU-T network technologies and ITU-R radio technologies. Working groups from ITU-T consider conceptual aspects of the creation of a UMTS – network architecture and protocols (group SG11), services, addressing and routing (SG2), multimedia services and coding (SG16). ITU-R includes working groups SG8, which is responsible for the radio interface of UMTS, and SG1, which is engaged in frequency assignments and efficient use of the radio spectrum.

2. Architecture of universal mobile telecommunication systems

The architecture of universal mobile telecommunication systems can be represented in a generalized scheme, illustrated in fig. 1. Interfaces between mobile stations and the radio access network (Uu interface) and between the radio access network and the backbone network (Iu interface) are standardized, which ensures network operators compatibility of radio equipment from different manufacturers.

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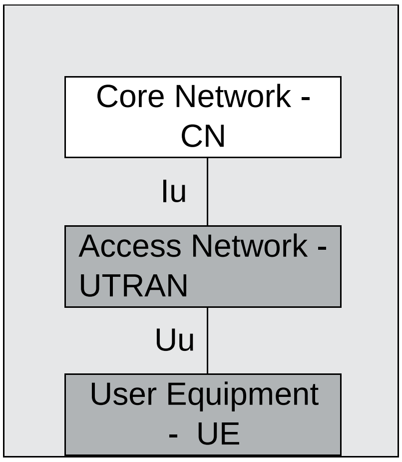

Fig. 1. General scheme of the architecture of universal mobile telecommunication systems

The Universal Telecommunication Radio Access Network (UTRAN) is represented by the base transmission stations and the controllers managing them, which implement radio transmission to the mobile subscriber devices (User Equipment, UE). Core Network (CN) is the network with which the base stations connect to each other internally and through which information is transferred at high speeds. The UMTS architecture also includes an intelligent network responsible for charging operations, the localization of the subscriber, roaming and the transfer of the connection (handover). In fig. 2 presents a detailed architecture of universal mobile telecommunication systems, together with basic network elements and interfaces.

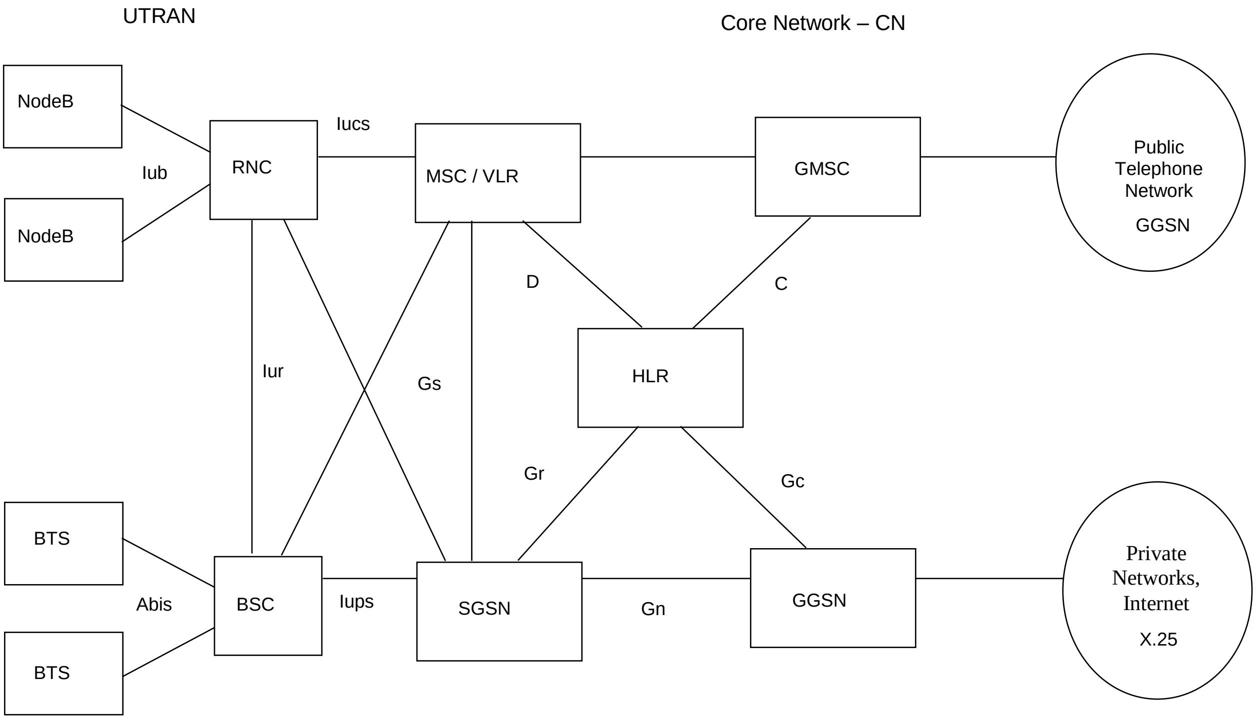

Fig. 2. Architecture of universal mobile systems

The UMTS backbone network includes the same components as the second generation networks (GSM and GPRS), supporting both GSM and UMTS access networks. In universal mobile cellular systems, however, a completely new network interface (Iu) to the UTRAN radio access network has been introduced. The Iu interface has two different physical implementations:

- Iucs – to that part of the backbone network that supports data transmission with channel switching;
- Iups – to the part of the backbone network supporting data transmission with packet switching.

The universal mobile telecommunication system access network (UTRAN) shown in fig. 3, contains several radio network subsystems (RNS) as well as mobility management functions. A radio subsystem consists of a radio controller (Radio Network Controller, RNC) and base stations (Node B). The RNS radio subsystem manages the handover at the cell level, applies the coding functions and manages the radio interface resources.

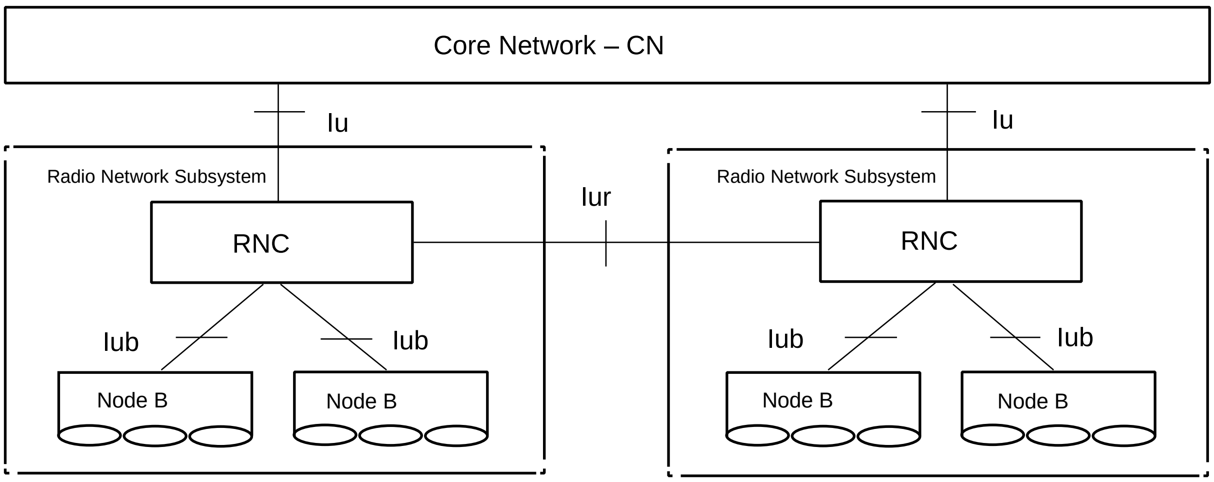

Fig. 3. Universal Telecommunication Radio Access Network (UTRAN)

The base station serves one or several cells in one of the two UMTS operating modes (FDD or TDD). Base stations establish the connection of mobile stations to the network through the radio interface (Uu), and at the same time transform the data flows between the Uu-interface and the interface that connects them to the radio controller. Base stations perform the following basic functions:

- broadcasting and reception of radio signals;
- transmission of official information in accordance with the parameters set by the radio controller;
- separation/collection of internal data flows and implementation of a smooth transfer of the connection (soft handover);
- periodic report of measurements of the line between base stations and mobile stations and power data in the right direction;
- noise-resistant encoding/decoding of transport channels;
- detecting errors and providing an indication to the upper layers;
- unification of the transport channels and separation of the component transport channels;
- coordination of data speeds in transport channels;

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- arrangement of the composite transport channels on the physical channels;
- combining physical channels;
- modulation/demodulation and expansion/contraction of the spectrum in the physical channels;
- time and frequency synchronization; • management of the radiated power.

The radio controller controls one or several base stations and is connected to each of them using the Iub interface internal to the radio subsystem. The radio controller is the access point for all bearer services for the transfer of user data and management information to the backbone network, with which it is connected via the Iucs and Iups interfaces to the mobile switching center (Mobile Switching Center, MSC) and the supporting GPRS node, respectively (SGSN). In this sense, the radio controller performs the following basic functions:

- management of resources for data transport on the Iuinterface;
- management of the logical resources of the base stations that are subordinate to it;
- management of system-wide information provided to base stations;
- traffic management on common channels;
- traffic management on shared channels;
- separation/combination of data flows from different base stations, each of which is engaged in the procedure of smooth transfer of the connection;
- distribution of spectrum-expanding codes for the signal transmitted to the mobile station;
- power management in external cycle;
- permission for distribution of newly declared resources;
- management of radio parameter measurement reports.

The individual radio controllers are connected via the Iur interface. Its introduction is required by the adopted principle for the implementation of radio mobility management procedures, which are carried out entirely in the radio access network, without the need for the participation of the backbone network. As is known, when the connection is transferred, the mobile switching center (MSC), which is part of the backbone network, is engaged in GSM systems.

The use of the Iur-interface in UTRAN is required by the need to split/combine the data streams from one link in several cells and the concept of smooth handover of the link. The characteristics of the WCDMA radio interface allow more than one base station to participate in the active connection, which can be managed by different radio controllers. For each connection between the mobile station and the network, the main management functions are taken over by one radio controller, called serving (Serving RNC, SRNC). The other potentially engaged controllers (Drift RNC, DRNC) are managed by the serving controller through the Iur-interface and receive the data flows corresponding to the specific connection. These flows are transmitted over the Iub interface of the base stations managed by them. The serving controller performs the power management functions for the specific connection, including for cells that are not under its direct control. For each connection between the mobile station and the network, there is only one information flow on the Iu interface to the backbone network. In the process of a built radio connection, it is possible to change the serving radio controller. The procedure is initiated by the current serving controller, as a result of which its connection with the supporting network is released and a new connection is organized in the IU interface between the supporting network and the new serving radio controller.

3. Control of radio links in universal mobile cellular systems.

3.1 Radio Control Sublayer

In general, the Radio Link Control (RLC) sublayer is responsible for the actual transmission of the data packet with control or user information over the radio interface. It ensures that the data to be carried over the radio interface is of the appropriate packet size. It also maintains a buffer of a certain size to serve in cases of packet retransmission, performs encryption and routes incoming data packets to the correct destination - RRC, BMC, PDCP or voice codec. It can work in three modes: transparent mode, unconfirmed mode and confirmed mode. Different modes are used to transfer different types of data. If the data is important, needs a lot of protection and should not receive errors, confirm mode is used. On the other hand, other types of data are not suitable for this mode - for example, it is not suitable to be used for voice transmission, since it can guarantee that some packet will not be lost, but a lost and later retransmitted packet will already be unusable due to the delay created.
Transparent mode is used when carrying BCCH, PCCH, DCCH, DTCH and CCCH. It does very little data processing at the RLC level. The non-acknowledgement mode is used on DCCH, DTCH, CTCH, and in forward direction on CCCH. In this mode, RLC adds a header to the information and encrypts it. Acknowledgment mode can be used to carry the DCCH and DTCH channels. It segments or combines data packets to produce a packet (PDU) of fixed length.

3.1.1 Functions of the radio control sublayer

The functions of the radio control sublayer can be systematized into:

- segmenting or combining packets coming from higher layers into packets of fixed length;
- padding an RLC packet that is not completely filled due to segmentation/combination with padding bits;
- transfer of user data using three modes of operation - transparent mode, mode without confirmation and mode with confirmation.
- error correction – error detection and correction is supported by retransmission when using confirmation mode;
- transmission of packets coming from higher layers in the same sequence when using mode with confirmation;
- data flow control – the speed with which the opposite RLC sublayer, with which it is communicated, can transmit is controlled;
- checking the sequence number of the packages in non-confirmation mode.
- detection and recovery of errors in the operation of the RLC protocol;
- encryption – performed in non-confirmation mode and confirmation mode.

3.2 Protocol – PDCP (Packet Data Convergence Protocol)

This protocol exists only at the subscriber plane and only for packet-switched services. It contains compression algorithms that are needed to optimize the transmission of IP packets over the radio interface. Algorithms are also defined for compressing the packet header, since

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sometimes (for example in VoIP services) its size can be comparable or even larger than the useful data in a packet.
Its main functions are:

- compression of control information (header) of higher level protocols;
- user data transfer – receiving user data from higher layers and forwarding it to the RLC - sublayer.

3.3 Protocol - BMC (Broadcast/Multicast Control Protocol).

This is a service-specific layer 2 protocol. It exists only in the user plane. It is designed to adapt broadcast services from higher layers to the radio interface. In 3GPP version 99, the only such service is the so-called - SMS cellular broadcast service. It is directly borrowed from GSM. This service is text messages that are distributed to all subscribers in a given cell or group of cells.
Its main functions are:

- storage of SMS cellular broadcast messages and their sending under the control of RRC;
- monitoring the volume of traffic - on the part of the radio access network, the BMC calculates the necessary speed for the transmission of SMS broadcast messages and declares the necessary resources of the RRC;
- arrangement of SMS broadcast messages in a certain order for sending;
- sending BMC messages to user terminals;
- sending the SMS broadcast messages received via the radio interface to the upper layers in the subscriber devices.

3.4 Radio Resource Control Layer

Much of the control signaling between user equipment and the operator's radio network is carried as - RRC (Radio Resource Control) messages. These messages contain all the information needed to establish, modify and tear down connections at the physical and channel level. RRC messages also carry signaling of protocols from higher layers. Mobility of end-user devices is controlled by RRC – these are measurements in the radio interface, handover, change of serving cell, etc.
The functions of this sublayer are:

- dissemination of system information;
- paging;
- initial selection of a service cell and reselection in initial operation mode;
- establishing, maintaining and breaking down an RRC connection between the UTRAN and the end terminals;
- building, reconfiguring and breaking down of the radio carriers;
- control of transport and physical channels;
- control of data security functions - encryption and integrity protection;
- preparation and implementation of handover procedures;
- control of the requested quality of service (QoS);

  - occupying, reconfiguring and releasing the radio resources needed for an RRC connection - this includes allocating extension codes and defining a CPCH channel;
  - protection of the integrity of signaling messages;
  - sending and control of measurements by end user terminals;
  - supporting power control of end user terminals;
- functions in relation to cellular broadcasting services.

4. Conclusion

The purpose of writing the article is to present the most crucial moment in the genesis of mobile cellular system, namely UMTS. One of its most important aspects is to integrate existing generation cellular standards into a single platform and to introduce the power of mobile internet and high transfer speeds leading to unprecedented personal subscriber experiences. The article focuses on the main highlights of radio link control in universal mobile telecommunication systems. Systematize the protocols used in the layers related to the management of radio links and summarize their main functions. Control processes such as measurements in the radio interface, handover, occupation, reconfiguration and release of radio resources needed on a radio link and others are affected. Also presented is the control signaling between the user equipment and the operator's radio network, which is carried as control resource radio messages containing all the necessary information for the establishment, modification and breakdown of connections at the physical and channel level in the mobile cellular network.

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