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BACHELOR´S THESIS

INITIALIZATION OF UMTS WCDMA LABORATORY NETWORK USING NETHAWK RNC/IUB SIMULATOR

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PREFACE

This study was made for Helsinki Metropolia University of Applied Sciences. I want to thank my supervisor Seppo Lehtimäki and my language instructor Jonita Martelius for their guidance and encouragement. Special thanks to my fiancée and family for supporting me throughout this process.

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Jarno Taskinen

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Tämän työn tavoitteena oli UMTS WCDMA -verkon alustaminen Helsinki Metropolia Ammattikorkeakoulun laboratoriossa. Rakennettua verkkoa ja lopputyötä on tarkoitus käyttää ohjekirjana opiskelijoille sekä opetustarkoituksiin.

3G-verkko on kehittynyt nopeasti ympäri maailman ja sitä voidaan pitää yhtenä tietoliikenteen pääverkko teknologiana. Kolmannen sukupolven verkon toteutus Metropolian laboratoriossa mahdollistaa modernin verkkoteknologian tutkimisen ja opetuksen.

Verkko rakennettiin käyttäen Nokia Flexi WCDMA -tukiasemaa, Nethawk RNC/Iub Simulaattoria ja Nokia N73 matkapuhelinta. Verkkoelementit kytkettiin ja alustettiin käyttäen tuotekohtaisia asennustyökaluja. Nethawk RNC/Iub simulaattori on tietokonepohjainen työkalu ja tästä johtuen verkko on osittain simuloitu.

Verkon ylösajo suoritettiin onnistuneesti. Nokia Flexi WCDMA -tukiaseman ja Nethawk RNC/Iub simulaattorin proseduurit alustettiin onnistuneesti ja käyttäjä liitettiin verkkoon. Pakettidatayhteys testattiin ja verkko todettiin toimivan lähellä teoreettista maksimiaan. Piirikytkentäistä puhelua ei onnistuttu luomaan ”paging error” virheen takia.

Avainsanat: 3G, UMTS, WCDMA, Nethawk

Metropolia

ABSTRACT

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The purpose of this study was to initialize the UMTS WCDMA network in the laboratory environment of Helsinki Metropolia University of Applied Sciences. The built network and the report are to be used as an instruction guide for students as well as for teaching purposes.

3G technology has been developing fast all over the world and can be considered as one of the main technologies in telecommunication. Implementing the Third Generation network to Metropolia´s laboratory environment enables more efficient researching and teaching of the modern network technology.

The network was built using the Nokia Flexi WCDMA Base Station, Nethawk RNC/Iub simulator and Nokia N73 user equipment. All required components were connected and initialized using product specific commissioning tools. The Nethawk RNC/Iub simulator is a computer based tool and, therefore, the network was partly simulated.

The configuration process was successful in terms of setting up the network. The Nokia Flexi WCDMA Base Station was commissioned and all the procedures in the Nethawk RNC/Iub simulator were successfully initialized. The subscriber connection was also successfully accomplished. A packet data connection test was carried out and the network was discovered to operate close to its theoretical maximum speed. It was not possible to perform a circuit switched call due to a paging error.

Keywords: 3G, UMTS, WCDMA, Nethawk

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ABREVIATIONS

2G	Second Generation. Second generation mobile technology.
3G	Third Generation. Third generation mobile technology.
3GPP	Third Generation Partnership Project. Group of telecommunications associations for 3G standardization.
AAL	ATM Adaptation Layer. Provides the support for information transfer protocols.
ALCAP	Access Link Control Application Part. Control plane protocol for the transport layer.
APN	Access Point Name. Identifies an IP packet data network.
ATM	Asynchronous Transfer Mode. Digital data transmission technology.
BCCH	Broadcast Control Channel. Point to multipoint channel used in the Um interface.
CCCH	Common Control Channel. Support common procedures required to establish a dedicated link with the network.
CDMA	Code Division Multiple Access. Describes physical radio channels.
CN	Core Network. Integrates the circuit and packet switched traffic.
C-NBAP	Common Node B Application Part. Controls overall Node B functionality.
CRNC	Controlling Radio Network Controller. Responsible for the configuration of a Node B.
D-NBAP	Dedicated Node B Application Part. Controls radio links to specific user equipment.

DRNC	Drifting Radio Network Controller. Routes information between the SRNC and the UE.
FACH	Forward Access Channel. Downlink transport channel used for signaling and small quantities of data.
FDD	Frequency Division Duplex. Uses different carrier frequencies to separate traffic.
FDMA	Frequency Division Multiple Access. Separates multiple users in frequency domain.
GPRS	General Packet Radio Services. Provides packet data service.
IMEI	International Mobile Equipment Identity. Unique identifier allocated to each mobile equipment.
IMSI	International Mobile Subscriber identity. Unique identifier allocated to each mobile subscriber.
LA	Location Area. Defines the number of cells throughout which a mobile will be paged.
MCC	Mobile Country Code. Three digit number identifying a country code.
ME	Mobile Equipment. Hardware element containing keyboard, screen, radio, circuit boards and processor etc.
PCH	Paging Channel. Broadcast paging and notification messages in a cell.
RACH	Random Access Channel. provides initial access into a UMTS system.
RANAP	Radio Access Network Application Protocol. Responsible for setting up a radio access bearers.
RNC	Radio Network Controller. Controls the use and the reliability of the radio resources.

RRC	Radio Resource Control. Controls the configuration of UMTS radio interface layer 1 and layer 2.
SRNC	Serving Radio Network Controller. Responsible for the user´s mobility within the UTRAN.
TDD	Time Division Duplex. Users are allocation to one or more timeslots for up-link and downlink transmission.
TDMA	Time Division Multiple Access. Uses a common channel among multiple users separated by unique time slots.
TMSI	Temporary Mobile Subscription Identity. Ensure subscriber identity for visit-ing mobile subscriber.
UE	User Equipment. Combination of ME and USIM modules.
UMTS	Universal Mobile Telecommunications System. Third generation mobile communication system.
USIM	Subscriber Identity Module. User subscription to the UMTS mobile network.
UTRAN	Universal Terrestrial Radio Access Network. Part of UMTS network consist-ing of RNCs and Node Bs.
WCDMA	Wideband Code Division Multiple Access. Third generation mobile wireless technology.

1 INTRODUCTION

This study was made for Helsinki Metropolia University of Applied Sciences. The purpose of this study was to build and initialize the UMTS WCDMA network in the laboratory of Metropolia. The built network and the study report are to be used as an instruction guide for students and for teaching purposes.

3G technology has been developing fast all over the world and can be considered as one of the main technologies in telecommunication. New frequencies have been adopted to efficiently cover broader areas and more inexpensive devices have been manufactured for a wider variety of users.

Bringing the theory of the 3G network to practice by implementing the Third Generation network to Metropolia´s laboratory environment enables more efficient researching and teaching of the modern network technology. Compared to the already existing 2G network of the Metropolia University, the 3G network makes it possible to gain higher data rates and simultaneous use of speech and data. 3G also enables implementing a variety of advanced services through enhanced spectral efficiency.

The beginning of the study clarifies the basic concept of UMTS WCDMA technology and provides the reader with the essential information for understanding the following chapters. The later chapters describe the used equipment, network structure, initialization of the network and subscriber connection. Calling and packet data connection will be explained briefly as they are not the primary focus of this study.

2 NETWORK ARCHITECTURE

UMTS (Universal Mobile Telecommunications System) network architecture consists of various components and interfaces. The network has been developed over time and thorough standardization has lead to global availability. In this chapter the basic concept of UMTS WCDMA (Wideband Code Division Multiple Access) technology is clarified and the essential information for understanding the study is presented.

2.1 Predecessor Networks

1G (First generation) cellular networks, for example NMT (Nordic Mobile Telephone), TACS (Total Access Communication System) and Radiocomm 2000 were developed in the late 1970s and early 1980s. These systems were similar in terms of features, but their lack of technical compatibility lead to, for example, incapability for roaming. Regardless, the first generation systems lead the way to mass markets.

Second generation (2G) cellular networks GSM (Global System of Mobile communications), PDC (Personal Digital Cellular), IS95 and IS136 were developed towards public standard networking. Ultimately, however, different systems from the United States, Europe and Japan all competed in the global markets. The development towards third generation (3G) networks continued in the form of 2.5G, which already introduced several resources of 3G. Figure 1 shows the theoretical limits of different networks based on GSM specification. [1, s. 14-18]

Service	Time slots	Max. bit rate (kbit/s)
Standard GSM	1	9.6 – 14.4
HSCSD	Up to 8	~ 110
GPRS	Up to 8	~170
ECSD (HSCSD + EDGE)	Up to 8	~330
EGPRS (GPRS + EDGE)	Up to 8	~400

Figure 1. Maximum bit rates in GSM [1, s. 18]

Figure 1 presents the development of maximum bit rates from a standard GSM network to the more advanced EGPRS (Enhanced General Packet Radio Service) network. It also shows how multislotting and a new modulation method enabled higher bit rates in more advanced HSCSD (High Speed Circuit Switched Data Services) and GPRS (General Packet Radio Services) network. [1, s.17-18]

2.2 Standardization

ITU (International Telecommunication Union) is an international organization established to create recommendations to achieve standardized radio and telecommunication networks. A project called FPLMTS (Future Public Land Mobile Telecommunications System), later known as IMT-2000 (International Mobile Telecommunications 2000), was introduced to begin the standardization of undefined Third Generation systems. The purpose of the project was to compose recommendations, which would lead to worldwide compatible network coverage by using different cell sizes from “in building” Picocells to Global Satellite cells. Through this project five radio transmission technologies were approved as potential technologies for third generation network, as shown in Figure 2. [1, s.18-19]

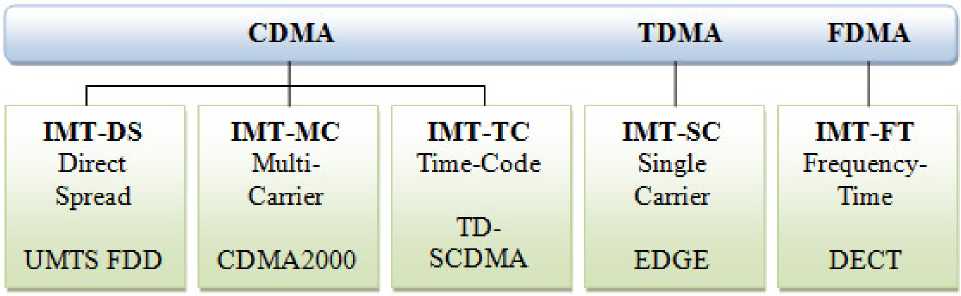

Figure 2. IMT2000 radio transmission technologies [2]

Figure 2 presents the ITU members´ submitted proposals for potential third generation network technologies. As shown in the figure, transmission technologies can be divided into three core technologies: CDMA (Code Division Multiple Access), TDMA (Time Division Multiple Access) and FDMA (Frequency Division Multiple Access) as well as five radio transmission technologies.

In December 1998 the ITU´s competition of different standards was over. All the major organizations decided to gather all their activities under one partnership project. The 3GPP (Third Generation Partnership Project) was born.

The following organizations were involved in the 3GPP project:

- **TTC (Japan)** Telecommunication Technology Committee
- **CWTS (China)** China Wireless Telecommunication Standard Group
- **ARIB (Japan)** Association for Radio Industries and Business
- **ETSI (Europe)** European Telecommunications Standard Institute
- **TTA (South Korea)** Telecommunications Technology Association
- **T1 (USA)** Standards Committee T1 Telecommunication
- **TIA (USA)** Telecommunication Industry Association

Soon after the standardization started the project was split between two separate committees focusing on different network technologies. The original 3GPP concentrated on the UMTS network and a separate committee called 3GPP2 focused on cdma2000. [1, s.23-25]

2.3 WCDMA Air Interface

UMTS network can have various air interface technologies, such as CDMA2000 or WCDMA, and use FDD (Frequency Division Duplex) or TDD (Time Division Duplex) operations. The present study concentrates on the WCDMA FDD technology. [3, s.1-2]

2.3.1 WCDMA Frequency Bands

The third generation network spectrum allocation has been defined at ITU´s Radio Conference (WARC) to be around 2GHz. In North America, however, the spectrum was already in the use of operators using second generation systems before WARC in 1992. Therefore, third generation services and WCDMA had to be implemented using the existing bands of North America. Figure 3 shows the global spectrum allocation for different areas and network technologies. [3, s.2]

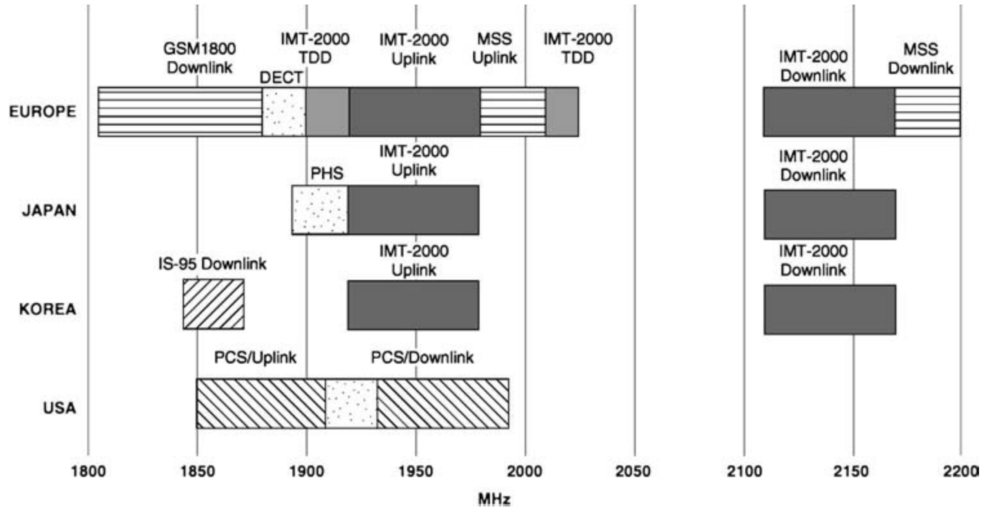

Figure3. 2 GHz spectrum allocation [3, s.3]

As seen in Figure 3, in Europe and most of Asia the WCDMA FDD can be implemented in the 2x60 MHz (1920-1980 MHz plus 2110-2170 MHz) IMT-2000 bands. In FDD systems uplink and downlink have different frequency bands, which are separated by the duplex distance.

In May 2000 the following frequencies were identified in WARC-2000 conference: 1710 – 1885 MHz, 2500 – 2690 MHz and 806 – 960 MHz. [3, s.3]

2.3.2 *Characteristics of WCDMA*

WCDMA is a wideband Direct-Sequence Code Division Multiple Access system. WCDMA can achieve high bit rates, theoretically up to 2 Mbps, by supporting a variable spreading factor and multimode connections as seen in Figure 4. In practice the network can usually reach a bit rate of 384 kbps. [3, s.47]

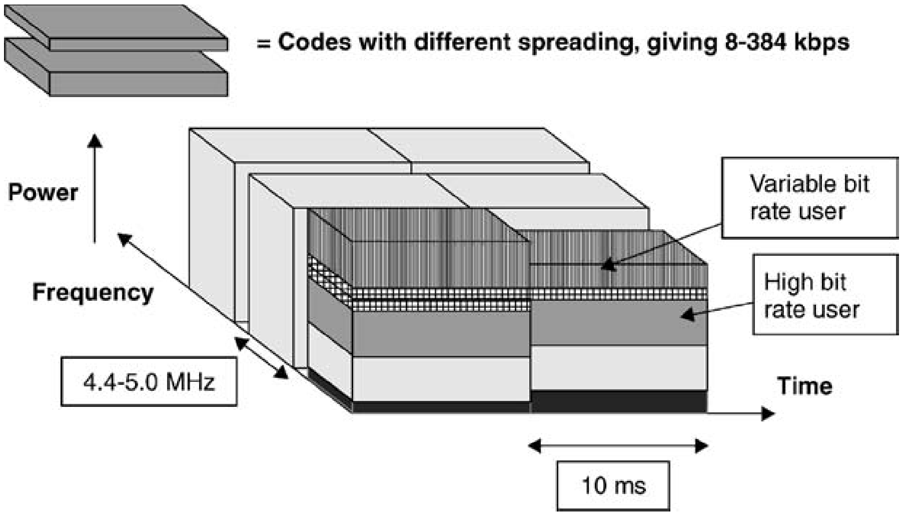

Figure 4. WCDMA characteristics [2, s.48]

The maximum WCDMA chip rate is 3.84 Mcps. As seen in Figure 4, it has been produced by multiplying the narrowband data with quasi-random bits to achieve carrier bandwidth of about 5 Mhz. Bandwidth divisions are updated every 10 ms and the network operator can dynamically change the channel bandwidth on demand (BoD).

In the FDD mode the uplink (from mobile to Node B) and downlink (from Node B to mobile) use separate 5 MHz carrier frequencies, respectively in TDD only one 5 MHz carrier is time shared. [3, s.47-48; 4]

2.4 UMTS Network Architecture

UMTS is one of the third generation mobile systems developed within ITU´s recommendations. It is widely used all over Europe, including Finland. UMTS utilizes a great number of second and first generation systems and aims at reusing all available resources from older technology networks. The UMTS network can be divided into three different systems: UTRAN (Universal Terrestrial Radio Access Network), CN (Core Network) and UE (User Equipment). The UMTS network architecture´s components and interfaces are presented below in Figure 5. [3, s.75; 5, s.9]

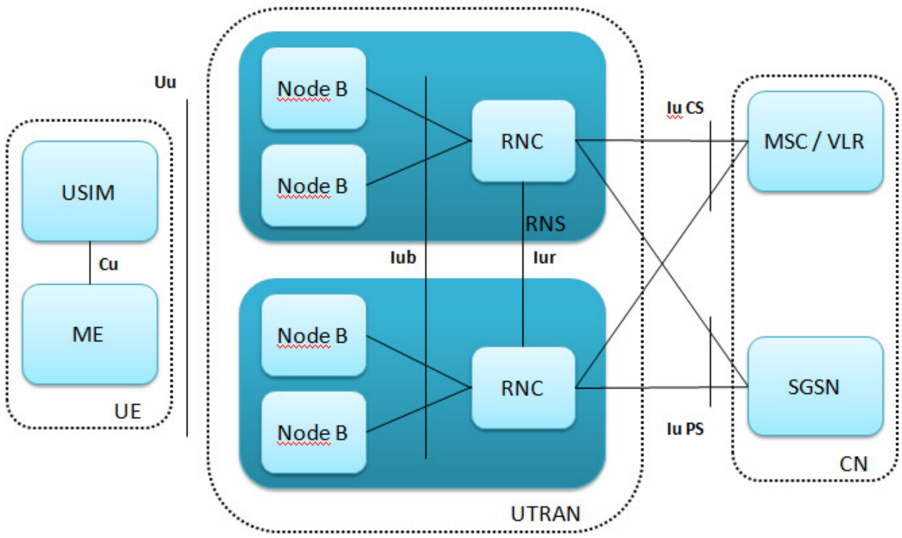

Figure 5. Basic concept of UMTS architecture. [3, s.78]

UTRAN handles all radio-related functions and consists of two parts which together form RNS (Radio Network Sub-system):

- Node B handles the data flow between Iub and Uu interfaces (channel coding, interleaving, rate adaption and spreading). It also performs some radio resource management operations.
- RNC (Radio Network Controller) controls the radio resources in its domain and is an access point between UTRAN and CN. It is similar to GSM´s BSC (Base Station Controller).

UE connects the end-user to the radio interface. It is connected to Node B through the Uu interface. UE consists of two elements:

- ME (Mobile Equipment) is the radio terminal used for radio communication.
- USIM (UMTS Subscriber Identity Module) holds subscriber identity and performs authentication and encryption functions.

CN is mainly adopted from GSM and is responsible for routing and switching call and data connections to external networks.

- HLR (Home location register) stores the user service profiles, which contain for example service information, roaming areas, location information and call forwarding information.
- MSC/VLR (Mobile Service Switching Centre / Visitor Location Register) handles the Circuit Switched services in UE´s existing location.

MSC handles voice calls and SMS (Short Message Service) as well as other circuit switched transactions. VLR stores a copy of the user profile and location information.

- GMSC (Gateway Mobile Service Switching Centre) connects the UMTS PLMN (Public Land Mobile Network) to the external circuit switched network.
- SGSN (Service GPRS (General Packer Radio Service) Support Node) handles the packet switched services. SGSN is used in early UE handling operations.
- GGSN (Gateway GPRS Support Node) is responsible for the co-operation between GPRS and the external packet switched network.

In UMTS network a large part of Core Network has been inherited from older networks, while UE and UTRAN have been designed to meet the needs of WCDMA technology. The inherited Core Network facilitates the introduction of new technologies and offers advantages, such as global roaming.
[3, s.75-.80]

2.5 Radio Network Controller

The Radio Network Controller is responsible for controlling and switching resources in UTRAN. It is connected to Iub and Iu interfaces. Several RNCs can be connected together with an inter-RNS connection called the Iur interface. The generic architecture of RNC can be seen in Figure 6.
[3, s.79; 5, s.110-111]

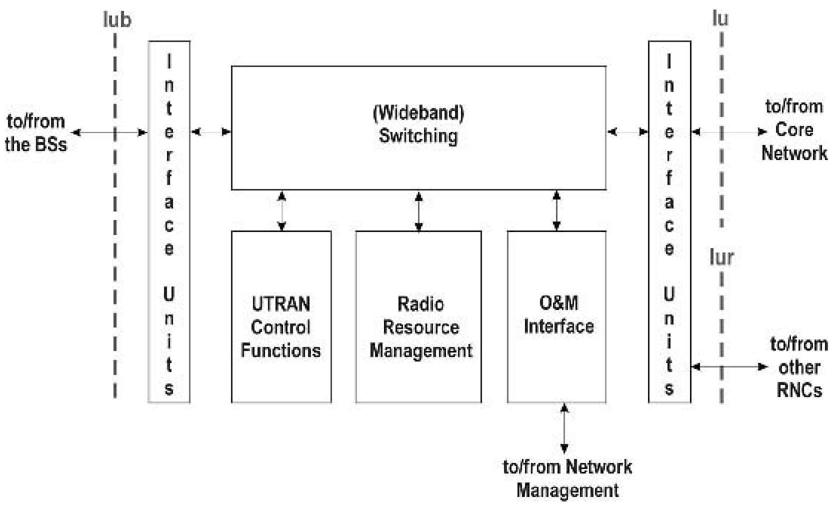

Figure 6. Basic logical architecture of the RNC [5, s.111]

Figure 6 displays the two way traffic between the connected network elements and used interfaces. It also clarifies some of the essential functions on RNC.

UE can connect to the network using several RNCs with different logical roles. These roles are CRNC (Controlling RNC) or, in case several RNCs are used, SRNC (Serving RNC) and DRNC (Drifting RNC). One physical RNC normally contains all logical roles.

CRNC controls one Node B and is responsible for traffic and load control, as well as admission control and code allocation.

The SRNC´s main function is to maintain the Iu interface and terminate RANAP (Radio Access Network Application Protocol) signaling between user equipment and the core network. SRNC is also responsible for the L2 processing of data and RRC (Radio Resource Control) between UE and UTRAN. Basic Radio Resource Management, such as mapping of Radio Access Bearer, handover decisions and outer loop power control, are executed in SRNC. Only one SRNC can be assigned for one UE.

The logical role of DRNC is used when the UE needs to connect to another cell not controlled by SRNC. DRNC routes data between Iub and Iur if the UE is not using common or shared transport channels. One to several DRNCs can be assigned for one UE. [3, s.79; 5, s.11]

2.6 Node B

Node B is located between the Uu and Iub interfaces and corresponds with the GSM Base Station. The main function of the Node B is to perform the air interface L1 processing, such as channel coding, interleaving and spreading etc. It also performs basic Radio Resource Management operations. It implements WCDMA radio access physical channels and, thus, can be considered as the radio edge of the UTRAN. Figure 7 describes the logical model of Node B. [3, s.80; 5, s.101]

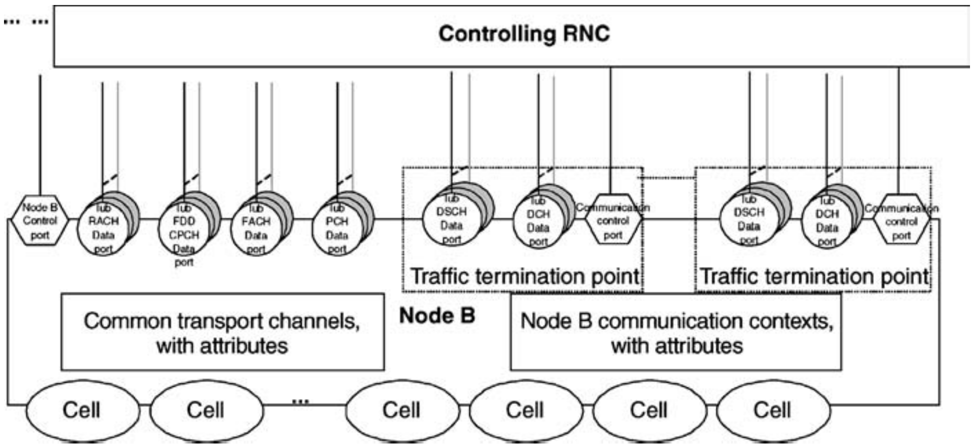

Figure 7. Logical model of Node B [3, s.92]

As seen in Figure 7, the Logical model of Node B consists of a common control port, dedicated control ports and traffic termination points. The common control ports manage the common data ports located outside the traffic termination points. Common data ports are used for controlling transferred information, such as RACH (Random Access Channel), FACH (Forward Access Channel) and PCH (Paging Channel), inside common traffic channels. The traffic termination point controls several mobiles with dedicated resources in the Node B. Traffic corresponding with these mobiles are transferred through data ports. [3, s.91-92]

2.7 UTRAN Terrestrial Interfaces

The structure of UTRAN terrestrial interfaces is described using layers (Radio and Transport Network layer), planes (user and control plane) and protocols within these planes as shown in Figure 8. Layers and planes are logically independent from one another. Protocol structure may partly vary in the future, while other parts remain intact. Horizontally the protocol structure consists of two main layers, the Radio Network Layer and Transport Network Layer. [3, s.80]

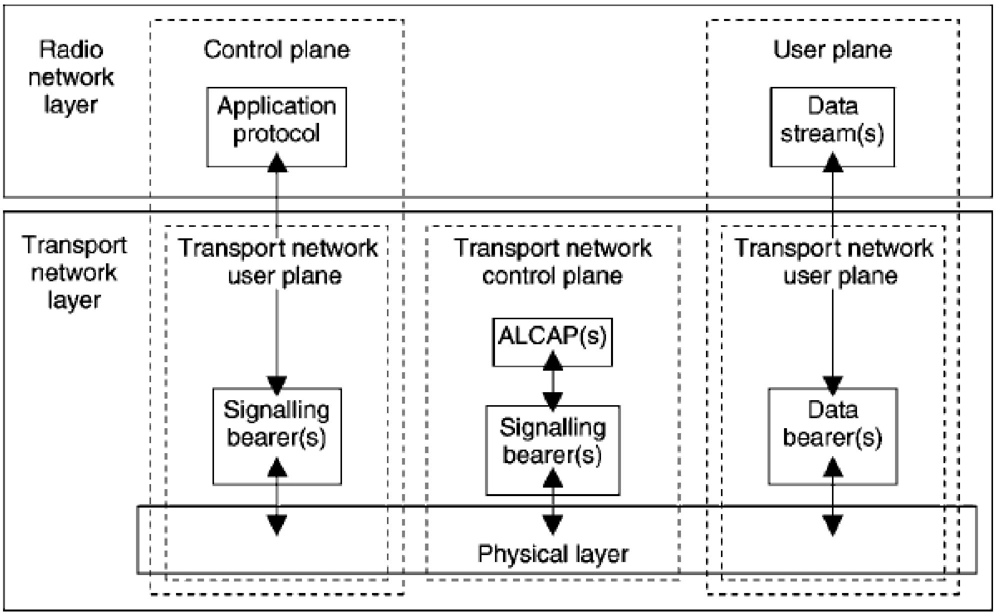

Figure 8. Protocol structure of UTRAN terrestrial interfaces [3, s.81]

The Radio Network layer is divided into a Control Plane and a User Plane. The Control Plane is responsible for control signaling. It consists of Application Protocol and the Signaling Bearer for carrying Application Protocol signaling messages. User Plane carries all the information (i.e. voice calls and packet data) sent and received by the user. It consists of Data Streams, with one or more interface specific frame protocols, as well as Data Bearers for the Data Streams.

The Transport Network Layer is divided into two different planes: Transport Network User Plane, which includes Data and Signaling Bearers from Control and User Plane, as well as Transport Network Control Plane for control signaling inside Transport Layer. The Transport Network Control Plane includes ALCAP (Access Link Control Application Part) Protocol and the required Signaling Protocol for setting up Data Bearers. [3, s.80-82]

2.7.1 Iu Interface, UTRAN-CN

The open Iu interface connects the radio-specific UTRAN to CN, which performs switching, routing and service control. Iu has two different main interfaces: Iu CS (Circuit Switched) and Iu PS (Packet Switched). The Iu CS is responsible for circuit switched connection between UTRAN and CN and Iu PS for packet switched connection between UTRAN and CN. The additional third interface is called Iu BC (Broadcast) and it connects UTRAN to CN´s Broadcast Domain. [3, s.82-87]

2.7.2 Iur Interface, RNC-RNC

The Iur interface has four functions in addition to the initially designed inter-RNC soft handover:

- Support of basic inter-RNC mobility
- Support of Dedicated Channel traffic
- Support of Common Channel traffic
- Support of Global Resource Management

Due to these functions, RNSAP (Radio Network System Application Part) signaling protocol is also divided into four different modules. A modular structure enables the operators to use only a part of the modules according to their specific needs. [3, s.88-89]

2.7.3 Iub Interface, RNC-Node B

The Iub interface transfers information between RNC and Node B. The Iub interface signaling procedure NBAP (Node B Application Part) is divided into two components: Common and Dedicated NBAP.

Common NBAP (C-NBAP) is used for signaling procedures across the common signaling link. The main functions of the C-NBAP are:

- Set-up of the first radio link of one UE, and selection of the traffic termination point.
- Cell configuration.
- Handling of the RACH/FACH/CPCH (Common Packet Channel) and PCH channels.
- Initialization and reporting of Cell or Node B specific measurement.
- Location Measurement Unit (LMU) control.
- Fault management.

Dedicated NBAP (D-NBAP) is used for signaling procedures across the dedicated signaling link. The main functions of the D-NBAP are:

- Addition, release and reconfiguration of radio links for one UE context.
- Handling of dedicated and shared channels.
- Handling of softer combining.
- Initialization and reporting of radio link specific measurement.
- Radio link fault management.

[3, s.90-93]

The aim of this chapter was to clarify the basic concept of UMTS WCDMA technology and provide the reader with the essential information for comprehending the various stages of the study. The next chapter will introduce the network components used specifically in this study bringing the theoretical information to a practical level.

3 LABORATORY NETWORK COMPONENTS

The laboratory network was set up using the Nethawk RNC/Iub Simulator, Nokia Flexi WCDMA Base Station and Nokia N73 Mobile Equipment, as described in Figure 9. USIMs were provided by Orga Test Systems.

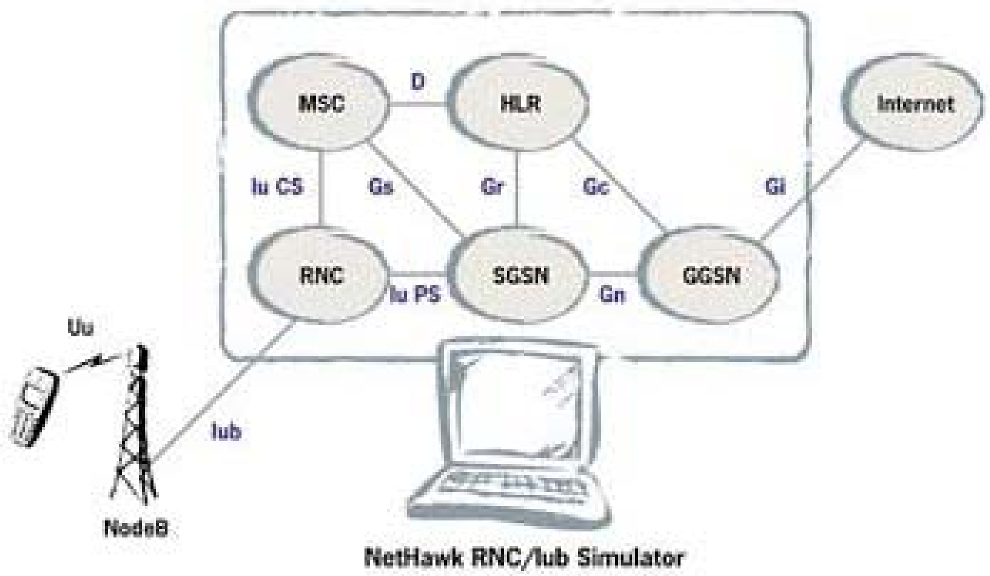

Figure 9. Laboratory Network architecture [7]

Figure 9 shows the used network components and indicates the simulated elements. The laboratory network did not contain all physical network elements since it was partly simulated. The Nethawk RNC/Iub Simulator provides a flexible and cost efficient way for setting up a network without a real RNC or Core Network infrastructure.

3.1 Nethawk RNC/Iub Simulator

The Nethawk RNC/Iub Simulator is a PC based tool for simulating signaling and traffic on UMTS WCDMA UTRA-FDD network. The simulator uses an Open Iub interface standardized by 3GPP. An automated simulator response for incoming messages enables signaling transactions to be monitored without user input. The simulator also enables creating and modifying scripts as well as analyzing 3G protocols in various formats.

3.1.1 Procedures and Protocols

The simulator supports common 3G signaling procedures in the Iub interface and all control commands can be easily inserted from the user interface. Procedure sequences can also be recorded and run as scripts.

The supported procedures are the following:

- FACH/PCH and RACH setup and release,
- radio link setup and release,
- radio bearer setup and release
- RRC connection setup and release
- AAL2 (ATM Adaptation Layer 2) signaling and location update
- mobile originated call setup and mobile terminating call setup
- Packet-switched call and call release.

The simulated protocols use message template files to generate / update protocol messages at run-time. Some parameter values are set by the protocol emulator and some of the values are fixed. Protocols supported by RNC/Iub simulator are AAL5 (ATM Adaptation Layer 5), UNI (User to Network Interface), AAL2 Signaling, Frame Protocol, MAC (Medium Access Control), RLC (Radio Link Control), NBAP, RRC (Radio Resource Control), MM (Mobility Management) and CC (Call Control). Figure 10 clarifies the structure of the simulator and indicates the protocols listed above. [6, “Introduction”, “Protocol engine sub-system overview”]

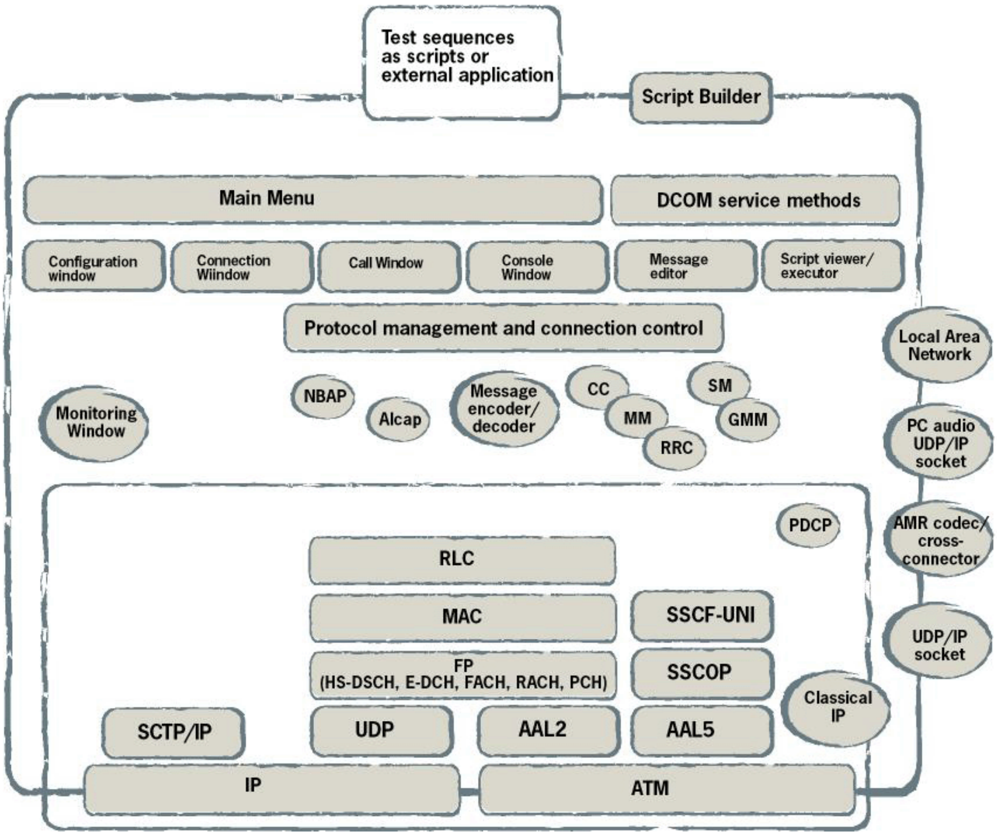

Figure10. RNC/Iub Simulator Structural overview [6, “Introduction”]

Figure 10 shows the Nethawk RNC/Iub simulator structure at a highly abstract level. The upper section of the figure presents the user components and the lower section describes the protocol management and connection control functions.

3.1.2 Simulator Components

The Nethawk user interface is a PC based commissioning software included in the simulator sales package along with the N2/N3C CardBus adapter, D3 PCI bus adapter and required cables or fibers. Nethawk N2 CardBus adapter is shown in Figure 11.

Electrical values	
Power supply	3.3 V
Current consumption	650 mA
CardBus	
PC Card Standard 1995 release compatible CardBus host interface 68-pin connector	
ATM over E1/T1 interface	
According to E1/T1 (ITU-T G.703/ANSI T1.403) specifications Input impedance >> 120	

Figure 11. Nethawk CardBus N2 Adapter [6, "Specifications and performance"]

The present study concentrates on the Nethawk N2 adapter shown in Figure 11, used for constructing the network. The adapter uses a CardBus slot for PC connection and contains two RJ45 style PCM (Pulse Code Modulation) connectors for base station connection.

The simulator requires Microsoft Windows XP Professional with Service Pack 1 or Windows 2000 Professional with Service Pack 4 installed on the PC. Also MSXML, WinPCap and CardBus or PCI (Peripheral Component Interconnect) bus slot are required. [6, "Preparing for Installation"; 7]

3.2 Nokia Flexi WCDMA Base Station

The Nokia Flexi WCDMA Base Station was used in the study to provide the connection between RNC and UE (cf. Figure 12). The Flexi WCDMA offers high capacity data transfer with decreased power consumption. It can also be installed both indoors and outdoors and it supports distributed base station architecture. [8]

Figure 12. Nokia Flexi WCDMA Base Station

The Flexi WCDMA has a modular structure and it is compatible with Open Base Station Architecture Initiative (OBSAI) specifications. These features enable Flexi WCDMA to be deployed with future technologies within the network. [8]

3.3 User Equipment

In the study the Nokia N73 mobile device was used for testing cellular calls and data transfer (cf. Figure 13). It is a quad band GSM/WCDMA device with GSM 850/900/1800/1900 and WCDMA 2100 supported. The N73´s maximum WCDMA data transfer speed for uplink and downlink is 384kbit/s. [9]

Figure 13. Nokia N73 Mobile Device

Two USIMs, manufactured by Orga Test Systems, were used for subscriber authentication. The USIM´s specifications are:

1. Orga SIM number: 8949000409290006074 (23.1)
   IMSI: 234881000000007
2. Orga SIM Number: 8949000409290006082 (23.1)
   IMSI: 234881000000008

The purpose of this chapter was to explain and present the used network components in more detail and give the reader a clear view of the laboratory network structure. The next chapter describes the initialization of the laboratory network. It presents the used tools and configurations needed for successful network initialization.

4 CONFIGURATION OF THE NETWORK

The laboratory network was mainly setup beforehand in terms of hardware and wiring. Therefore, in this study the main task was the configuration of all the equipment used in the network environment. The Nokia WCDMA Base Station and Nethawk RNC/Iub Simulator were provided with a specific commissioning tool for this purpose. The aim of this chapter is to give the reader a clear view concerning the needed tools and commands for configuration, as well as how these affect the network.

4.1 Configuration of WCDMA Base Station

A Microsoft Windows based computer with a Nokia WCDMA BTS Site Manager installed was used for commissioning the Nokia Flexi WCDMA Base Station (cf. Figure 14).

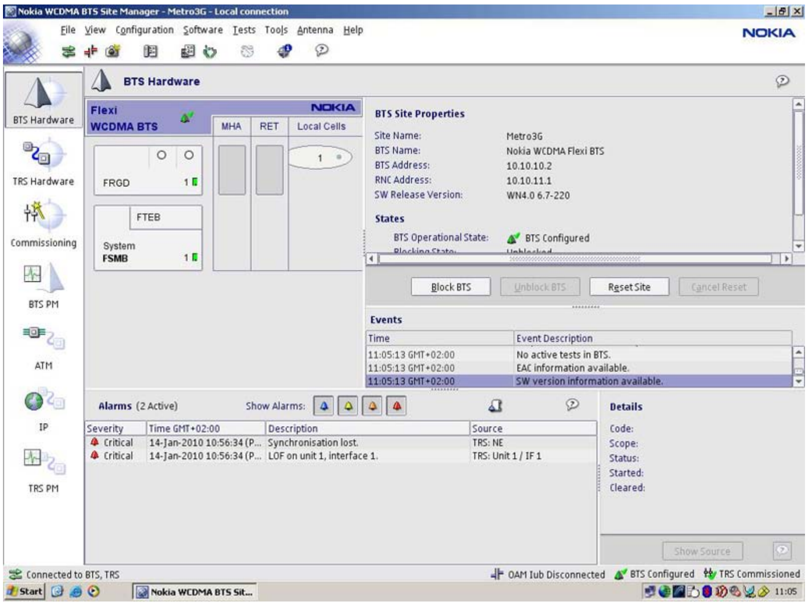

Figure 14. Nokia WCDMA BTS Site Manager

The Base Station LED (Light Emitting Diode) indicator was verified to be in “Power on” state and the local connection was established from PC to LMP port on the System module with twisted pair Ethernet cable. The computer network settings were changed as follows:

- IP address: 192.168.255.130
- Subnet mask: 255.255.255.0

The Nokia BTS Site Manager requests login before connecting to Nokia Flexi WCDMA. The default username was Nemuadmin and the password nemuuser.

Template commissioning was performed during the practical phase of the study. This feature enables the use of predefined configurations to be stored as templates. It reduces the number of parameters which have to be inserted and makes commissioning significantly faster. The template file used for configuring BTS was defined beforehand.

4.2 Configuring Nethawk RNC/Iub Simulator

The Nethawk RNC/Iub Simulator software was installed to a computer running Windows 2000 operating system (cf. Figure 15). Software installation was very straightforward and mainly automatic.

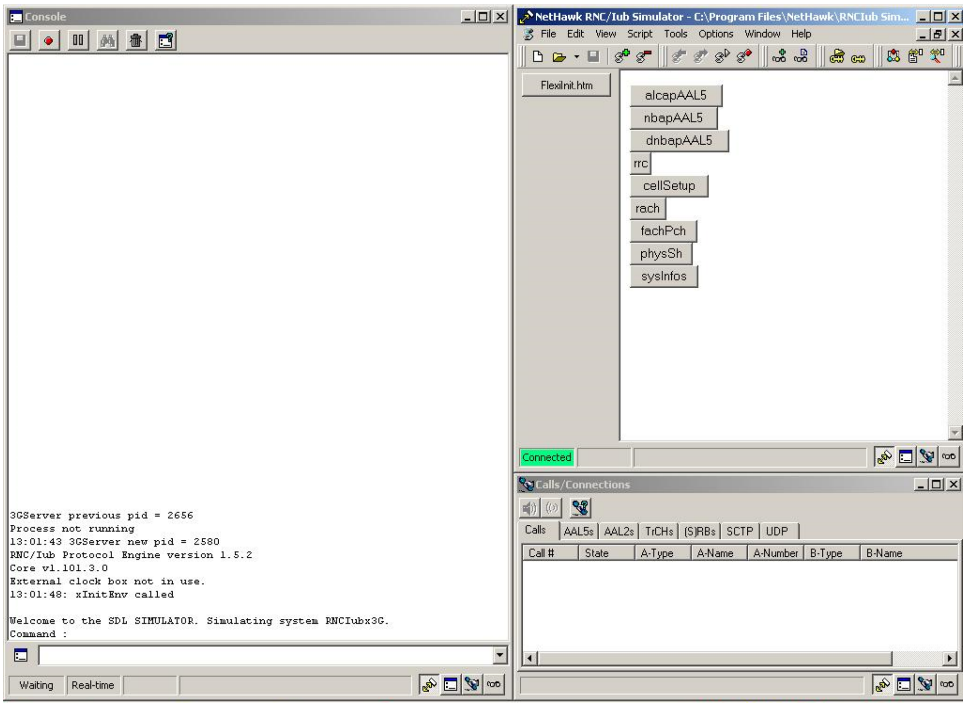

Figure 15. Simulator user interface

The Nethawk simulator requires allocated IP addresses from a local LAN (Local Area Network) network to support Internet connections from User Equipments. The allocated IP addresses in the laboratory network were: EU1 10.80.84.51 and EU2 10.80.84.52.

The Nethawk N2 adapter consists of three parts: PCC, pod with physical interface and connection cables. The PCC part was fit into the computer CardBus slot with the impedance selector positioned at ‘L’ (low) after which Windows automatically detected the required drivers and resources. The connection cables were set between the RJ45 connectors in the N2 adapter and Rx1 Tx1 connectors in the Base Station. Through this ATM (Asynchronous Transfer Mode) based connection the user can input, monitor and analyze transactions over the E1/T1 interface. [6, “Installing Adapters”]

The Simulator configurations are stored in a XML (Extensive Markup Language) file presented in Figure 16. The configurations are arranged into sections containing parameters. The user can define these sections using e.g. XML Notepad editor. The configuration file is selected and loaded on to the simulator at startup.

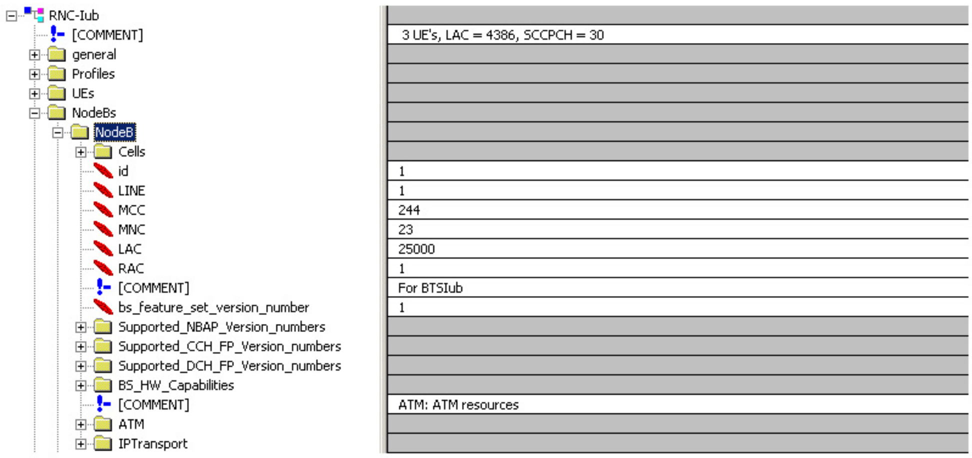

Figure 16. Node B node

As shown in Figure 16, the configuration file consists of several nodes. The General descriptions of these nodes are described below:

- General node contains parameters concerning PC and data network as well as simulator and application interfaces.
- Profiles node can be used to create system information blocks and setup channels. Changes in these section´s ids can affect several other sections containing the same ids.
- UE nodes contain the required parameters for identifying User Equipments. It also defines the connection and location parameters.

These configurations must correspond with the ones defined in Mobile Equipment.

- Node B node describes the parameters used for corresponding cells. It defines the available resources and the connection methods.
- PSTN (Public Switched Telephone Network) Subscribers node distinguishes the subscribers.
- RNC node defines the SRNC_identity, which refers to the whole system, including Node B. (Nethawk Help)

After the Nethawk simulator is switched on the network needs to be initialized. For this purpose the simulator offers either “ConsoleUserInput” method or scripting engine. The scripting tool uses HTML (Hyper Text Markup Language) language and the scripting engine supports both VBScript and JScript. The present study an automated script template was created with Script Builder for facilitating future use. [6, “Simulator Scripting Overview”; “Overview of configuration”]

4.2.1 ALCAP

RNC is responsible for establishing the AAL5 (ATM Adaptive Layer Protocol 5) link. Node B´s VPI and VCI parameters need to be set for AAL5 connections. These connections are later used for ALCAP and NBAP signaling. Usually at least three AAL5 links are needed: Common NBAP, Dedicated NBAP and ALCAP. [6, “Configuring AAL5 links for ALCAP and NBAP communication”]

ALCAP is a control plane protocol for the transport layer. It is needed to setup transport bearers for the user plane as well as multiplexing multiple channels into one AAL2 (ATM Adaptation Layer Protocol 2) transmission path. To take care of AAL2 signaling, related to AAL2 link establishment during transport channel setup, the ALCAP entity has to be initialized in the simulator.

Figure 17 shows the initialization process between Node B and RNC. The ALCAP protocol can be initialized using a script template or by following commands from the user console:

out-i ALC_INIT_REQ 1 1 alcap_cm management
go-

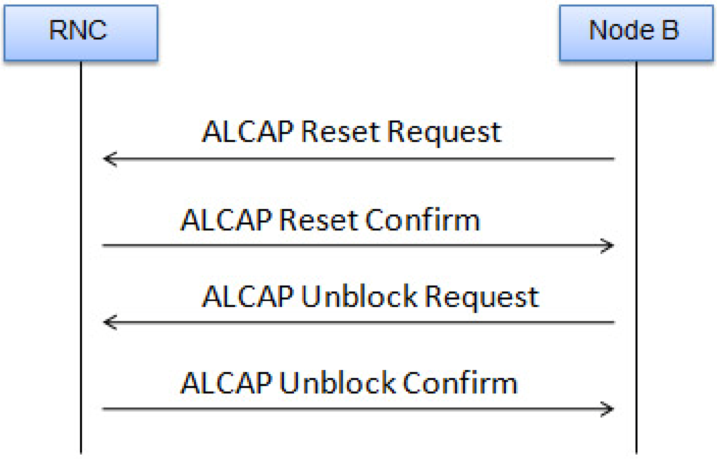

Figure 17. ALCAP Initialization

After initialization the simulator starts an AAL5 link establishment for AAL2 signaling for cell 1 in Node B 1. The establishment acknowledging message is received when the link in completed. [6, “Setting up ALCAP”; 10, s.69]

4.2.2 Common and Dedicated NBAP

The Simulator can only have one common NBAP or several dedicated NBAP signaling links simultaneously. These protocols can be defined by a script template or by the user console. The following commands initialize the common NBAP protocol as shown in Figure 18:
[6, “NBAP signalling link establishment”]

out-i NBAP_AAL5_EST_REQ 1 nbap_cm management
go-

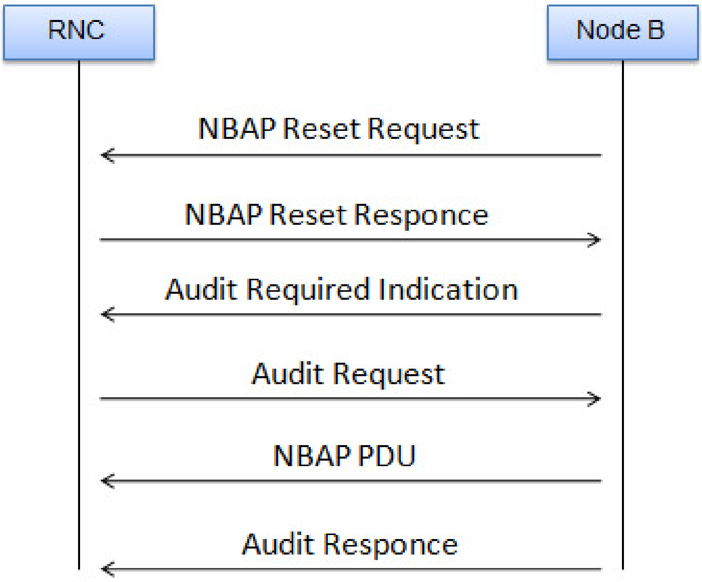

Figure 18: Common NBAP Initialization

The command signal retrieves the parameters for AAL5 link from the Simulator configuration file and activates the AAL5 link for common NBAP use. Both the common and dedicated NBAP connections are established through ALCAP signaling. After the common NBAP, the dedicated NBAP is initialized (Figure 19) with the following command:
[6, “Protocol engine signals”]

out-i NBAP_D_AAL5_EST_REQ 1 nbap_cm management
go-

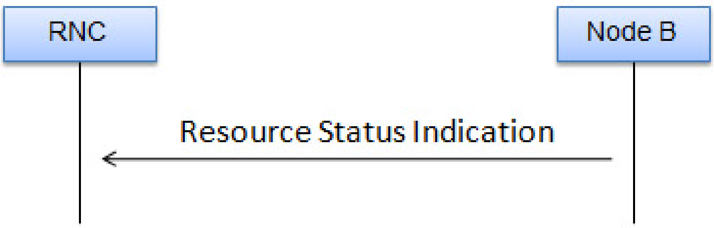

Figure 19. Dedicated NBAP Initialization

The main functions of common and dedicated NBAP are presented in Chapter 2.7.3.

4.2.3 RRC and Common Control Channel

RRC is responsible for controlling the radio resources in Layer 3 between UTRAN and the UE. Therefore Radio Resource Control Messaging composes a major proportion of control signaling. These messages handle the higher layer signaling (MM, CM and SM(Session Management)) and are required to convert and release Layer 1 and Layer 2 protocol entities. [3, s.79, 149, 164]

CCCH (Common Control Channel) is a two way channel for transmitting the control signaling between UTRAN and UE. This channel is always connected to RACH and FACH transport channels. [3, s.153]

Common Control Channels are set up using the following commands:

out-i RRC_CCCH_EST_REQ 1 1 rrc_cm management
go-

After executing the command the RRC initiates NBAP procedures and configures the FP (Frame Protocol), MAC (Medium Access Control) and RLC (Radio Link Control) layers for signaling transport. [6, “Setting up Common Control Channels”]

4.2.4 Cell Setup Request

The Cell Setup Request is used to set up a cell through a control port in the Node B, as shown in Figure 20. Node B reserves the needed resources and initializes the new cell using parameters defined in the message. The cell setup commands, presented below, execute the cell setup process:
[11, s.37-38]

out-i NBAP_CELL_SETUP_REQ 1 1 nbap_cm management
go-

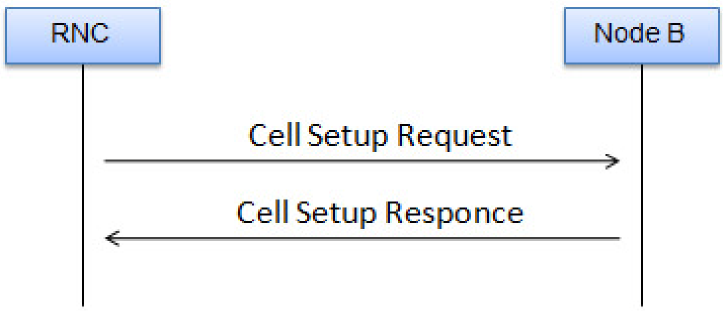

Figure 20. Cell Setup Request

After receiving the message the Node B reserves the necessary resources and configures the cell according to the parameters in the message. [11, s.38]

4.2.5 CTCH Setup

The Common Traffic Channel is a point-to-multipoint downlink channel for transferring dedicated user information. This procedure is executed to enable the needed resources concerning FACH, RACH PCH etc. in Node B. [3, s.153; 11, s.29]

Random Access Channel

The Random Access Channel (RACH) is an uplink channel for transporting control information from terminals. RACH operates with low data rate since it has to cover the whole cell coverage area. RACH initialization is shown in Figure 21. [3, s.102]

Random Access Channel is established with following commands:

out-i NBAP_CTCH_SETUP_REQ 1 1 1 0 0 0 2 nbap_cm management
go-

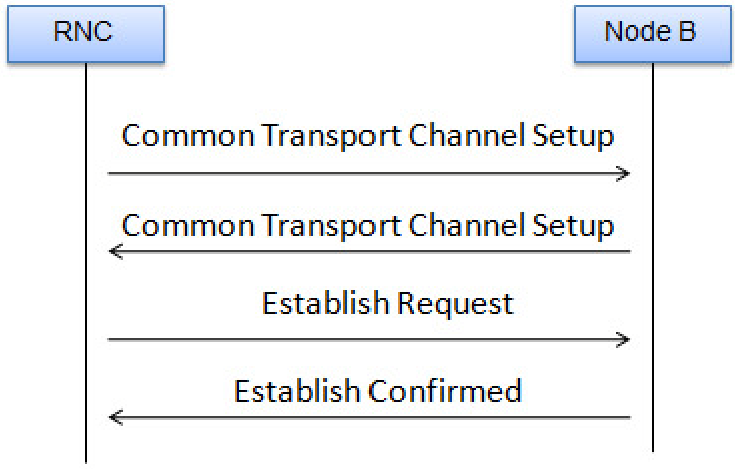

Figure 21. RACH Setup

Forward Access Channel and Paging Channel

The Forward Access Channel (FACH) is a downlink transport channel for carrying control information to terminals. Several FACHs can exist in one cell and at least one of them has to have low bit rate in order to be accessible to all the terminals in the area.

The Paging Channel (PCH) is a downlink transport channel for carrying relevant paging procedure data. The paging channel is used when communication between network and terminal is initialized e.g. speech calls. A paging massage can be transferred to one or several cells and the terminals must be able to receive the information in the whole cell area. The paging channel design also effects the power consumption of the terminal. [3, s. 102]

The establishment of FACH and PCH channels, presented in Figure 22, is conducted with the following commands:

out-i NBAP_CTCH_SETUP_REQ 1 1 0 1 1 1 4 nbap_cm management
go-

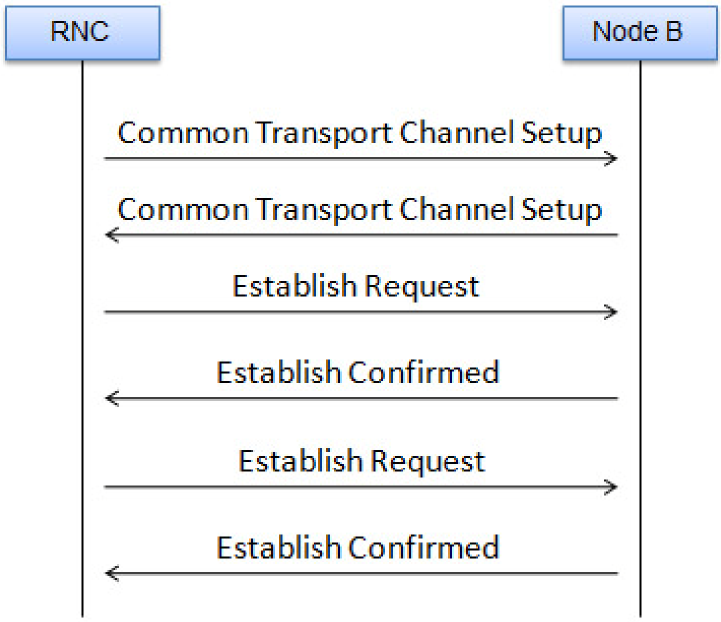

Figure 22. FACH and PCH channel setup

Figure 22 shows the successful setup procedure for Transport Channels. These channels have to be established in order for UE to gain connection via the radio interface.

4.2.6 Physical Shared Channel and System Information Update

Physical Shared Channel Reconfiguration

Physical Shared Channel Reconfiguration (PSCH) is used for assigning HS-DSCH (High Speed Downlink Shared Channel) related resources for Node B. It also handles PDSCH (Physical Downlink Shared Channel) and PUSCH (Physical Uplink Shared Channel) sets in Node B. PSCH procedure is shown in Figure 23. [11, s.75]

The PSCH is executed using a hexadecimal command string:

var strSysInfoDump="00 25 22 04 43 20 00 00 05 00 19 00 02 00 01 00 2b 00 01 d5 02 0a 00 02 00 fa 02 0c 00 02 4b 40 02 0d 00 02 00 08";

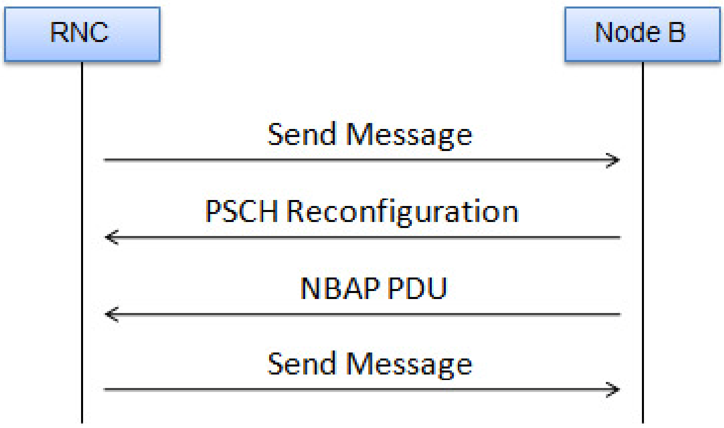

Figure 23. PSCH Reconfiguration

System Information Update

The System Information Update, shown in Figure 24, performs operations to enable Node B to apply the correct scheduling and content for the system information segments. This information is broadcasted through BCCH (Broadcast Control Channel). [11, s.61]

The System Information Update is executed using a hexadecimal command string:

```
var strSysInfoDump="00 20 42 00 50 81 5a 00 00 02 00 19 00 02 00 01 00
86 00 81 4c 18 00 04 20 01 0a 00 23 07 00 00 00 50 80 de 00 91 04 45 00
00 62 10 32 10 19 90 c8 d4 40 0c 1c a8 0e 80 00 00 00 00 00 00 00 00 03
03 26 01 0a 00 23 07 00 00 02 50 80 de c4 00 f5 08 00 0b 23 d0 10 07 ff ff
fa 54 d9 33 0c 7a 07 51 06 73 a0 00 00 00 00 00 04 03 26 01 0a 00 23 07
00 00 04 50 80 de 00 00 40 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 05 03 26 01 0a 00 23 07 00 00 06 50 80 de
00 04 00 04 44 02 00 20 47 ff ff f0 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 07 03 26 01 0a 00 67 27 00 00 0a 00 80 de c2 38 0e 80 03 c0 ff ff
14 84 3c 0a 43 02 a0 06 00 03 03 3e 85 f8 40 fc 00 00 0f cd c0 00 0c 20 80
de 28 7f f0 32 02 03 89 02 63 c0 80 80 08 86 43 00 04 08 8b 45 81 00 0f 10
c0 2c 76 19 c0 00 0e 30 80 de 03 80 a0 40 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 09 03 06 01 0a 00 04 04 00 00
12 0d 03 26 01 0a 00 23 07 00 00 14 50 80 de 01 bf 0c 08 22 88 01 4c 00
85 05 15 40 4a 05 d0 32 98 84 00 30 14 9f 48 ca 40 00 00";
```

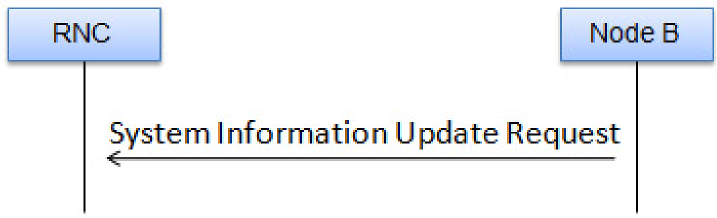

Figure 24. System Information Update Request

After System Information Update the RNC/Iub simulator configuration is completed. The needed protocols and channels are established, after which the network is capable of establishing subscriber connections.

4.3 Configuring and Connecting User Equipment

The aim of this chapter is to describe the configuration of the User Equipment and procedures used for subscriber network connection. The network configuration must correspond with USIM and Mobile Equipment information. The needed procedures for a standardized mobile subscriber connection must also be carried out.

4.3.1 Configuring UE

The network connection can be established by using any device with 2100 MHz 3G capability. In this study the Nokia N73 Mobile Equipment was used, further described in Chapter 3.3.

The SIM module containing identity information is to be inserted into the Mobile Equipment. The SIM module specification is described in Chapter 3.3. The SIM module contains IMSI information, which can be divided into three segments: MCC (Mobile Country Code), MNC (Mobile Network Code) and MSN (Mobile Subscriber Number). The Nethawk RNC/Iub Simulator´s UE identity and Node B segment information have to correspond with the information stored on the SIM module. [5, s.155]

In order to gain access to available services and packet data networks, such as Internet access, the corresponding APN (Access Point Name) configuration is required. Access points of this kind can be created or edited within Mobile Equipment. The configuration used in this study is shown below:

Connection name: Metro3G
Data bearer: Packet data
Access point name: internet
User name: None
Prompt Password: No
Password: None
Authentication: Normal
Homepage: https://www.google.com

Advanced settings

Network type: IPv4
Phone IP address: 10.80.84.51
DNS address:

Primary DNS address 193.167.197.100
Secondary DNS address 193.167.197.100

Proxy server address: None
Proxy port number: 0

One Mobile Equipment can have multiple APNs. When for example using available services or establishing the packet data connection, the corresponding APN must be selected.

4.3.2 Connecting UE

After successful network initialization, described in Chapters 4.1 and 4.2, the configured User Equipment can be connected to the network. During this connection procedure the network accomplishes a series of standardized procedures, which can be divided into eight transaction steps.

RRC Connection Setup

In order to establish a radio connection between UE and RNC over the Uu interface the RRC Connection Setup messages are sent over the CCCH channel, as shown in Figure 25. The RRC Connection Request, the message that starts the connection setup, contains information concerning requested radio connection, terminal identity and subscriber identity. The RRC Connection Request message consists of e.g. IMSI (International Mobile Subscriber identity), TMSI (Temporary Mobile Subscription Identity), IMEI (International Mobile Equipment Identity), LAI (Location Area Identity) and RAI (Routing Area Identity).

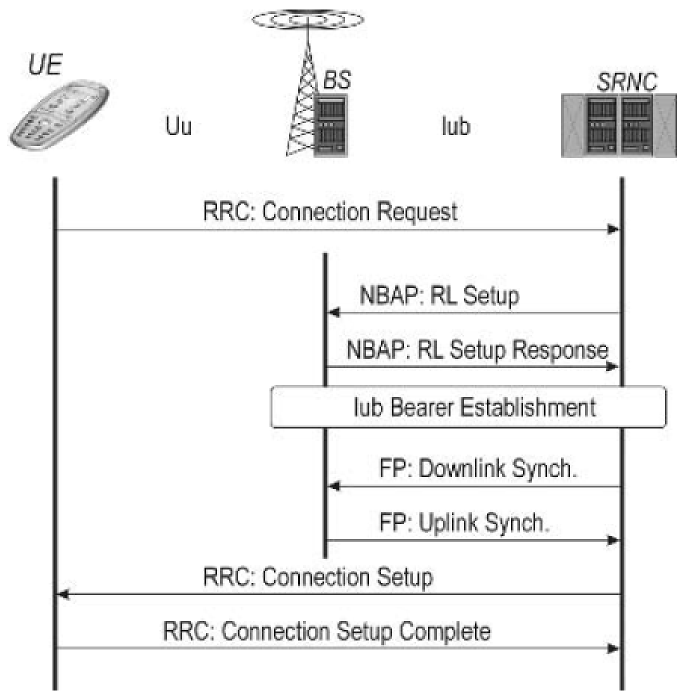

Figure 25. RRC Connection Setup Procedures [5, s.355]

RNC sends the Radio Link Setup message containing the transport format description, power control information and code information. The BS replies with the Radio Link Setup Response message containing transport-layer addressing information and reference information about the Iub bearer establishment.

The SRNC establishes the Iub bearer based on the information provided by BS. RNC sends the RRC Connection Setup message to UE over the common control channel with the required parameters for establishing DCH.

After UE establishes the radio link, the Radio Link Restore Indication message is send from Node B to SRNC.

RRC connection setup is completed with the RRC Connection Setup Completed message sent by the UE. [5, s.354-356]

<u>Initial Direct Transfer Message</u>

The RRC Initial Direct Transfer message, presented in Figure 26, contains the transaction´s first system network message sent from UE to the network.

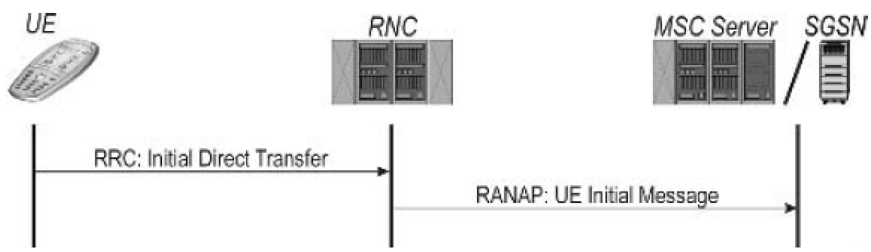

Figure 26. Direct Transfer Message [5, s.357]

RNC receives the message and combines it with the parameters from the first system network message, before forwarding it to CN. [5, s.356-357]

<u>Authentication and Security Messages</u>

The network and UE authenticate each other with an Authentication Request message. The message is sent in the payload of RANAP and RRC Direct Transfer messages to UE. USIM, within UE, executes authentication algorithms and responds with an Authentication Response message.

The Security Mode Command message indicates whether the transaction should be encrypted and which security algorithms are selected. It also transfers the integrity and encryption keys to the UTRAN. The authentication and security procedures are presented in Figure 27.

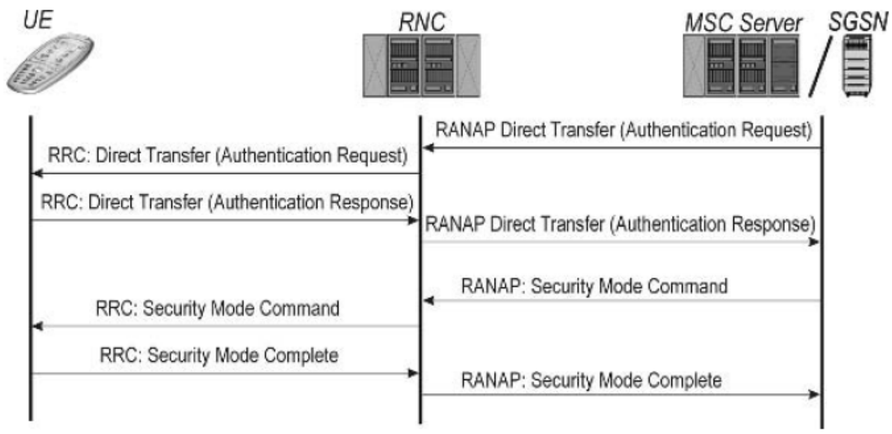

Figure 27. Authentication and Security Procedures [5, s.357]

UE starts the encryption using corresponding keys and algorithm. It sends the Security Mode Complete message to indicate the successful use of integrity and encryption algorithms. [5, s.357-358]

<u>Location Update and TMSI Reallocation</u>

LA (Location Area) information stored in the USIM is compared to the system´s LA information. In case differences occur, the Location Update Request message is sent to indicate the current location. This message contains the new and the old LA identity as well as subscriber identity information, most commonly a TMSI number. After the subscriber information is updated the CN domain sends the Location Update Accepted message to UE.

The Location Update Accepted message also contains a new TMSI number for the subscriber. RNC forwards this message to UE, which replies with a TMSI Allocation Complete message as a confirmation of acceptance. [5, s.373]

<u>RRC Connection Release</u>

A RRC Connection Release message is sent to UE after the RNC identifies the releasable RRC connection. The UE confirms the RRC connection release by sending RRC Connection Release Complete message. The RRC connection release procedure is shown in Figure 28.

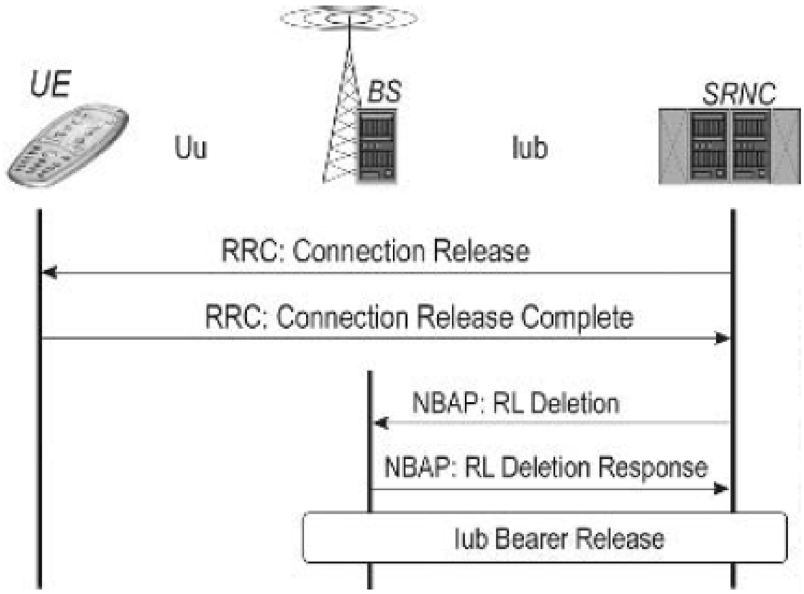

Figure 28. RRC Connection Release [5, s.363]

RNC clears the Iub interface resources with NBAP Radio Link Deletion and NBAP Radio Link Deletion Response messages. [5, s.364]

This chapter described the initialization of the laboratory network. Within this chapter the network components were configured and connected with each other, thus, forming a functional UMTS network.

The next chapter will concentrate on describing the calling procedure and packet data connection within the network. These operations are brought to a practical level by presenting the basic testing procedures.

5 PACKET DATA CONNECTION AND CALLING

Calling and forming packet data connections are the most common procedures carried out through the network. This study focuses on network initialization, rather than testing the functional network. Both of these procedures were, however, tested with a simple visual approximation.

In addition to the network initialization, an APN configuration was required for the user equipment. The packet data connection was tested using the Nokia N73 user equipment, as presented in Chapter 3.3. A simple visual test was conducted in the form of browsing the Internet with the built in Internet browser of the device. Network data transfer speed was measured by using Speedtest.net and was discovered to be close to the theoretical maximum of 384 kbps.

Circuit switched calling was tested by using two 3G capable user equipments with Orga Test Systems USIM. The calling procedure was begun by calling the “Party numbers” defined in the simulator configuration XML file’s UE node. During network testing it was not possible to perform a successful circuit switched call due to a paging error. The cause of the inoperability was analyzed with the TEMS Investigation WCDMA analyzer and a possibly incorrect mobile country code was discovered.

Although the testing of two basic network procedures was not the main focus of this study the chapter points out that the set up of the network was successful. The next chapter summarizes the results of this study and how they responded to original objectives.

6 RESULTS AND CONCLUSIONS

The purpose of this study was to initialize the UMTS WCDMA network in the laboratory environment of Helsinki Metropolia University of Applied Sciences. All required components were to be connected and initialized using product specific commissioning tools. The built network and the study report were to be used as a manual for students as well as for teaching purposes. The study was, therefore, partly written in the form of a user guide for future network setup.

During network configuration the lack of information and offered support led to the use of the trial and error method. This resulted in running into several incorrect configuration options in the process. Eventually the elimination process led to the correct combination of parameters and a successful network configuration was established.

All the procedures in the Nethawk RNC/Iub simulator were initialized using the built-in scripting engine. The needed protocols and channels were also established. The Nokia Flexi WCDMA Base Station was successfully commissioned, although, good base station stability could not be achieved and any error can cause the need for a restart. The commissioning tools in both equipment support the use of pre-defined templates derived from the used configuration, enabling fast and easy setup in the future.

Subscriber connection was established using Nokia N73 user equipment. Only minor configurations were made for user equipment. The subscriber connection was successfully accomplished in the form of a series of standardized procedures. A simple packet data connection test was made and the network was discovered to operate close to its theoretical maximum speed. Circuit switched calling was unsuccessful due to a paging error possibly caused by an incorrect mobile country code.

The development of the Nethawk RNC/Iub simulator has been ended and therefore no new future improvements are to be expected from the Nethawk. However, the modular structure and Open Base Station Architecture of Nokia Flexi WCDMA enable deploying new technologies and therefore can be considered as a foundation for future improvement in the Metropolia Laboratory. In order to improve the network functionality, e.g. stability and particularly the circuit switched calling procedure, a broader investigation with TEMS Investigation WCDMA analyzer or BER Tester would be required.

In order to successfully integrate the study to the existing study program, a shorter summarization of the main stages and a clear laboratory assignment description should be produced.

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