

Radio Frequency Analysis of UMTS System

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Abstract--This paper deals with the RF characteristics of the WCDMA network, the main concern being how to optimize the radio network so as to enable the network operation more reliable and economical, improve the network service quality and resource utilization, which is of great importance to network carriers.

Keywords—UMTS, RAN, RNC, RNS, RBS, NE, CPICH, FACH, RSCP

I. INTRODUCTION : 3G OVERVIEW

The use of 3rd Generation (3G) technology increases the capabilities compared to earlier mobile communication systems. Systems based on 3G technology integrate all present services, such as speech and future multimedia services, into one system.

The circuit-switched and packet-switched traffic carries the necessary subscriber data. This adopts multimedia applications and saves spectrum resources. The very high data rates allow the transmission of different types of information simultaneously. These information types include graphics, photos, text and figures, video clips, sound tracks, and software applications. The applications in a 3G system are depicted in the Fig.1 below

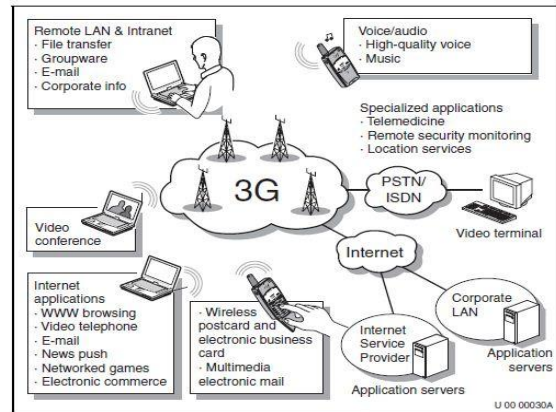


Fig.1: Functions in 3G System

II. WCDMA RAN ARCHITECTURE

WCDMA RAN is the Radio Access Network for UMTS that connects the Core Network (CN) and the User Equipment (UE). The WCDMA RAN also comprises interfaces towards different external management systems.

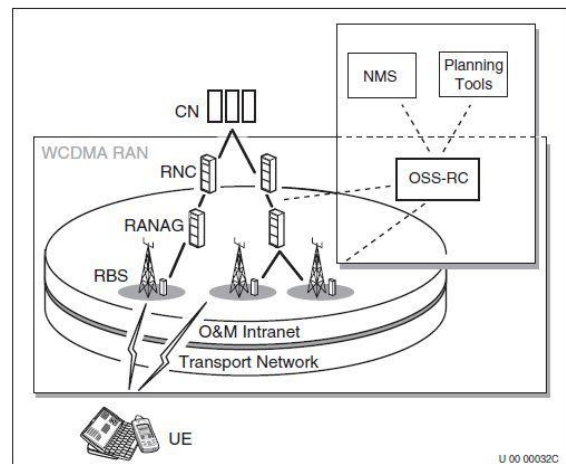


Fig.2: WCDMA RAN Architecture

The different Network Elements (NEs) and interfaces in the WCDMA RAN are:-

a. Core Network (CN)

The CN is responsible for switching and routing calls and data connections to external networks. The WCDMA CN has evolved from the GSM CN. The CN is the same for both UMTS and GSM. The CN contains the physical entities that provide support for the network features and telecommunications services. It is also responsible for providing the mobility and location on the highest level of the UE. The CN handles both packet-oriented services (such as data) and circuit-oriented services (such as speech).

b. WCDMA RAN

The WCDMA RAN handles all radio-related functions and Subnetwork Management Systems (OSS-RC and Planning tools). The network contains the physical entities that manage the resources of the access network and the NEs that provide the subscriber with access to the CN.

TNINF enables communication between the different NEs in the WCDMA RAN and between the WCDMA RAN and the CN. The Radio Network is the interface between, for example, the WCDMA RAN and the UE or the WCDMA RAN and the CN. O&M is supported by the O&M Intranet.

c. User Equipment (UE)

The UE includes all the equipment types (terminals) used by subscribers. The UE can have a dual-mode feature to access both 2G and 3G mobile networks. The UE consists of two parts:

- The Mobile Equipment (ME)
This is the radio terminal used for radio communication.
- The UMTS Subscriber Identity Module (USIM)
This is a smart card that holds the subscriber identity, performs authentication algorithms, and stores authentication and encryption keys together with subscription information for the UE.

d. Radio Network Controller (RNC)

A traffic NE that manages radio links, radio resources and controls mobility. The RNC is also the interface between CN and WCDMA RAN. An RNC, together

with its connected RBSs, is called a Radio Network Subsystem (RNS).

e. Radio Access Network Aggregator (RANAG)

A traffic NE responsible for aggregation of traffic, from low-speed transmission links from RBSs to high-speed transmission links to the RNC.

f. Radio Base Station (RBS)

A traffic NE responsible for radio transmission and reception in one or more cells to and from the UE. The RBS corresponds to Node B in 3GPP specifications.

g. Operation Support Subsystem -- Radio and Core (OSS—RC)

The collection of all functions that provides support for network management of the WCDMA RAN. The target groups for these tools are the operators in the network management centre. OSS-RC has constant and direct access to the different Nodes in the WCDMA RAN via the O&M Intranet.

It gives a consolidated view of WCDMA RAN information, such as alarms, configurations and basic performance. OSS-RC also provides several interfaces for easy integration with the existing management environment.

The Supporting Infrastructure for WCDMA RAN includes:-

a. O&M Intranet

All NE in the WCDMA RAN system are interconnected by the O&M Infrastructure.

It includes equipment used in the infrastructure for the O&M network, for example routers and servers.

b. Transport Network Infrastructure (TNINF)

TNINF handles the communication between the NEs within WCDMA RAN and between CN and WCDMA RAN.

III. LOGICAL INTERFACES IN WCDMA RAN

The WCDMA RAN uses two different kinds of interface; traffic interfaces and management interfaces. These two types of interface can be both internal within the NEs in the WCDMA RAN and external towards other networks or systems.

The interfaces support a variety of functions, such as transmitting traffic and managing data between NEs. They represent logical interfaces or reference points, rather than physical paths.

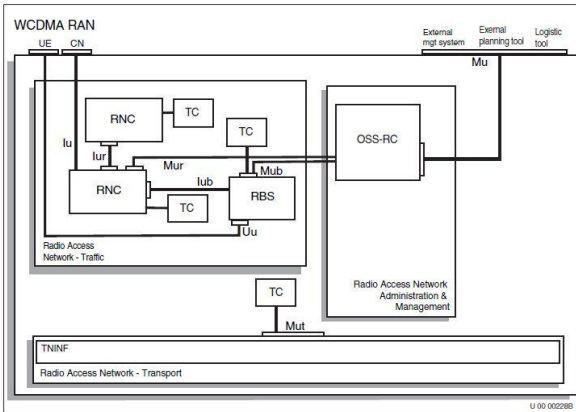


Fig. 3: Logical Architecture of WCDMA RAN

a. External Traffic Interfaces

The WCDMA RAN has a number of external interfaces, some of which are used for the external traffic and radio signaling. The following external traffic and radio interfaces are provided:

- *Lu Interface*

The Lu is an open, standardized interface providing multi-vendor equipment to be supplied for the CN and the WCDMA RAN respectively. This interface comprises the reference point between the RNC node and the two different parts of the CN, MSC (circuit-switched part of CN), and SGSN (packet-switched data part of network).

The Lu is layered into several protocol layers: the physical layer, the ATM and the ATM Adaptation Layers and the Network Layer. It is also divided into a Control Plane part and User Plane data transport part.

- *Uu Interface*

The air interface (Uu) is the WCDMA RAN external radio interface towards the UE. The Uu is an open, standardized interface. Uu is layered into three protocol layers: the Physical Layer, the Link Control Layer, and the Network Layer.

b. Internal Traffic Interfaces

The WCDMA RAN uses a number of internal interfaces between the different NEs to handle the traffic and radio signaling. The following interfaces are provided:

- *Lur Interface*

The Lur is a WCDMA RAN internal interface for the communication between two RNC nodes or between two Radio Network Subsystems (RNS).

The Lur is layered into several protocol layers: the Physical Layer, the ATM Layer, the ATM Adaptation Layers and the Network Layer.

- *Lub Interface*

The Lub is a WCDMA RAN internal interface between the RNC and the RBS. It transmits radio application-related signaling, radio frames and quality estimation of uplink radio frames and synchronization data.

The Lub has several protocol layers: the Physical Layer, the ATM Layer, the ATM Adaptation Layers and the Network Layer.

- *c. External Management Interfaces*

The WCDMA RAN includes a number of management interfaces that handle the external communication to other networks and systems. All management interfaces are IP-based. The following interfaces is provided: Mu

- *d. Internal Management Interfaces*

The WCDMA RAN includes a number of management interfaces that handle the internal communication between the different NEs. The following interfaces are provided:

- *Mur Interface*

The Mur is the management interface provided by the RNC. It is used for Network Management and Element Management. Mur also allows the Information Service to access RNS information.

- *Mub Interface*

The Mub is the management interface provided by the RBS. It is used for Network Management and Element Management.

- *Mun Interface*

The Mun is the management interface provided by OSS-RC. OSS-RC collects data from the RNC and RBS nodes and makes it available through the Mun interface.

- *Mut Interface*

The Mut is the management interface provided by the RANAG. It is used for Element Management^[1].

IV. RADIO FREQUENCY ISSUES

The frequency allocations for different radio systems have a major effect on possible interference scenarios. If another system is operating next to the Wideband Code Division Multiple Access (WCDMA) system, there is the possibility of signal power leakage due to imperfect transmitter filtering of the other system and receiver filtering of the WCDMA system. Frequency usage around 2GHz in the different parts of the world is shown in Figure 4.

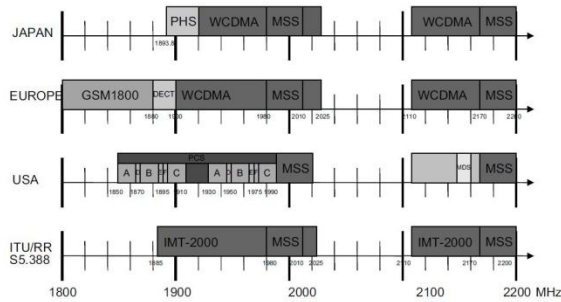


Fig. 4: Frequency usage around 2GHz in different parts of the world

In the case of larger frequency separation, intermodulation can be an issue. When co-siting WCDMA with GSM900 (Global System for Mobile communication at the 900MHz band), special attention should be paid to the second harmonics that can fall into the WCDMA uplink band. Third-order intermodulation products can be problematic when GSM1800 (GSM at the 1800MHz band) and WCDMA networks operate in the same area.

a. Thermal Noise

In a practical system there is always some minimum detectable signal level determined by the noise floor. The noise floor depends mainly on the thermal noise power and the excess noise generated inside the system. Thermal noise is caused by the random movement of atoms in material and its spectrum is white.

b. Man-made Noise

Man-made noise can be classified as either intentional or unintentional. Intentional emissions come mainly from radio transmitters, such as radars, mobile networks and broadcast systems. Unintentional sources include, for example, motor traffic, industrial equipment, consumer products and lighting systems. The main sources that contribute to background noise are traffic, other radio systems, industrial machinery, power lines and lightning.

c. Interference Scenarios

Interference can originate in a system itself or it can come from external sources, mainly from other radio systems. At a WCDMA NodeB all the received power other than the desired mobile power can be treated as interference power. Besides thermal noise power, this interference power consists of adjacent channel power, leaked transmitted power through the duplexer, transmissions from other mobiles and radio systems, and unintentional external noise sources such as radio emissions from traffic. If systems are not operating in adjacent frequency bands, the most probable interference sources are system non-linearities^[2].

d. HandOver

The term **handover** or **handoff** refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another. Handovers are needed when the mobile station moves from the coverage area of an old cell to the coverage area of a new cell. Moreover, handovers are needed to support multilayer networks as well as multi mode operations, e.g., using WCDMA and GSM networks together. The handover which creates trouble in the WCDMA network are:-

- *Intra-Frequency HandOver*
- *IRAT HandOver*

V. OPTIMIZATION OF THE WCDMA RAN

RAN Optimization is starting when the radio network has been tuned. RAN Optimization identifies and solves radio network problems in live networks together with the rising of subscribers in the network. RAN Optimization^[3] can result in changes in the parameter setting for the different functionalities such as idle mode, radio connection supervision, power control, capacity management, handover and channel switching.

When the network has been rolled out and put into operation, it has to be optimized for best performance. The major concerns for optimizing the WCDMA RAN are:

a. Coverage Problem

The coverage of a radio network deals with the following issues:

- *Signal Dead Zone*

A signal dead zone generally refers to the area where the pilot signal is less than the lowest access threshold (such as RSCP threshold is -115dBm , Ec/Io threshold is -18dB)^[4], and the area can be a concave area, hill rear, elevator shaft, tunnel, underground garage or basement, and internal part in a tall building.

- *Coverage Hole*

A coverage hole refers to the coverage area where the pilot signal is lower than the lowest value required by full-coverage services such as voice, VP and PS 64K service, but higher than the lowest access threshold of mobile phones.

For example, if the traffic is even but the sites locations are unevenly distributed, RSCP will not be able to meet the lowest requirement for full-coverage services in some areas. Still, if RSCP of the pilot signal in some areas can meet all requirements, but the intra-frequency interference increases, the pilot channel Ec/Io will not meet the lowest requirement for full-coverage services.

- *Trans Regional Coverage*

The trans-regional coverage usually refers to the coverage of some base stations exceeds the planned scope. The trans-regional coverage can cause discontinuous dominant areas in the coverage of other base stations if the strength of trans-regional signal meets the requirement for the full-coverage services.

b. CPICH

The Primary Common Pilot Channel (CPICH) is one of the continuously transmitted downlink Physical Channels. It is the reference signal used by the UE to make radio related decisions for:

- Cell Selection,
- Cell Reselection,
- Soft (intra-frequency) Handover and
- Hard (inter-frequency) Handover
- InterRAT Handover.

All signal level and quality measurements are made based upon or relative to the Primary Common Pilot Channel.

The power of Primary Common Pilot Channel is set to an absolute value per cell at the Reference Point (antenna connector) through the primary CPICH Power parameter. Currently it is defined 35dBm for our system^[5]. All other downlink Physical Channels

on the cell are set relative (dB) to the Primary Common Pilot Channel.

c. Pilot Pollution

The pilot pollution means that too many pilots are received on a point, in which there has not a dominant pilot. The following method is used to judge the existent of the pilot pollution: the number of the pilots that meet the condition $CPICH_RSCP > -95\text{dBm}$ is more than 3, with $(CPICH_RSCP 1^{st} - CPICH_RSCP dB 4^{th}) < 5\text{dB}$ ^[6]. The reason of adding the judgment to the absolute threshold of pilot RSCP is to distinguish coverage hole from no dominant call in the edge of the target coverage area.

In general, the possible reasons for pilot pollution may be the unreasonable site distribution, too high the location of the base station or too high antenna, unreasonable directional angle of the antenna, and the influence caused by the back radiation of the antenna, unreasonable setting of pilot power and the influence of around environments.

Therefore, besides adjusting the distribution and antenna parameters, combining the sectors of the base station or deleting redundant sectors can reduce the pilot pollution without affecting the capacity condition.

d. Swapped Feeder

The Feeder Cable which is connected from the RBS to the antenna might not get swapped for the sectors. This must be ensured to be correct while installing the radio network as the sector swapping causes irregular signals.

e. Neighbor List

Missing Neighbor Analysis is a fundamental aspect to WCDMA network optimization. It should be performed as part of the rollout phase of a network to construct and/or optimize the adjacency lists of each cell; and throughout the life of the network as changes to traffic and tilt affect the coverage pattern and interference interaction between the cells.

f. Resolving Call Drops

Neighbor list analysis can also be used verify the reason behind a dropped call. This method uses the process of combining the scanner and UE together and checking the Active and Monitored Sets for the UE against the scanned measurements at the point of a dropped call. This requires the scanner and UE traces to be collected at the same time, and for the resulting collection files to be super streamed together (and correcting any time offset between the collection devices).

The following content lists the radio configuration parameters that may be adjusted for solving the coverage problem:

1) *CPICH TX Power*

This parameter defines the PCPICH transmitting power inside a cell. The setting of this parameter must be combined with the actual environment condition, such as the cell coverage range (radius) and geographical environment. The cell needs to be covered, subject to the uplink coverage. In the cell with the soft handover demand, the parameter setting should ensure the rate of the soft handover area required in the network planning. In general, it is 10% of the total downlink transmitting power in the cell.

2) *MaxFACHPower*

This parameter defines the maximum transmitting power of FACH, relative to CPICH TX Power. If the parameter is set too low, it will cause that the UE will not receive the FACH packets, or the rate of the received wrong packets is very high; if it is set too low, it will lead to the power waste. If the accessed E_c/I_0 on the cell edge is -12dB, the parameter can be set to -1dB, (relative to pilot).

3) *Sintrasearch, Sintersearch and Ssearchrat*

The three parameters are the start threshold for intra-frequency cell reselection, also known as Sintrasearch, the start threshold for inter-frequency cell reselection, known as Sintersearch, and the start threshold for inter-system cell reselection. Sintrasearch has higher priority than that of Sintersearch or Ssearchrat, so the value of Sintrasearch should be larger than that of Sintersearch or Ssearchrat. Sintrasearch is set to 5 (i.e. 10dB) by default, Sintersearch to 4 (i.e. 8dB) by default, and Ssearchrat to 2 (i.e. 4dB) by default, which can be set according to different conditions. For example, in an area with dense cells, Sintrasearch can be set to 7.

4) *PreambleRetransMax*

The parameter is the maximum times of an UE retransmitting preamble during a preamble escalating period. If the value is

set too low, the preamble power may not rise to the required value, so an UE cannot access successfully; if the value is too high, the UE will increase the power continuously, and make access attempts repeatedly, which will cause interference to other user. This parameter is set to 8 by default. If the connectivity is low, the default value can be increased.

5) *RLMaxDLPwr and RLMInDLPwr (service-oriented)*

RLMaxDLPwr and RLMInDLPwr respectively means the maximum and minimum transmitting power of downlink DPDCH symbol, represented by the relative value of CPICH. The range between the maximum and minimum power is the dynamically adjusted range of power control, and can be set to 15dB. If RLMInDLPwr is set too low, it will cause that the transmitting power is very low due to wrong SIR estimation; if it is set too high, it will influence the downlink power control [7].

VI. CONCLUSION

WCDMA network deployment can be simplified by following a simple methodology that focuses on one set of variable at a time. By following this simple process, the main issues that have been observed in previous WCDMA deployment could be alleviated. Namely:

- RF planning and optimization: by focusing on both qualitative and quantitative metrics, the main RF issues (cell overshoot, lack of dominant server, frequent change of best server) are minimized.
- Parameter setting: by isolated parameters in groups (reselection, access, handover ...) that can be isolated, the tuning process is simplified.
- Inter-system performance: planning boundaries will be the first key to prevent inter-RAT issues.

As a result, the network performance of deployed WCDMA network would be, right from the start, meeting the subscriber expectations.

VII. REFERENCES

- [1] *WCDMA RAN Optimization Student book*– Ericsson, 2006.
- [2] Jaana Laiho, Achim Wacker and Tomas Novosad, *Radio Network Planning and Optimisation for UMTS*, John Wiley & Sons Ltd.

- [3] Christophe Chevallier, *WCDMA (UMTS) Deployment Handbook: Network planning and optimization consideration*, Wiley and Sons, June 2006.
- [4] *WCDMA-RAN-Planning-and-Optimization-Basic Guidelines Handbook*, Huawei Technologies Co.
- [5] Raj Sandhu, Allan Bispo and Daniel Platero, *WCDMA Basic Concept & Optimization – Nokia Siemens Networks*, Aug 2007.
- [6] Tero Isotalo, Jarno Niemelä, Jakub Borkowski and Jukka Lempiäinen, “*Impact of Pilot Pollution on SHO Performance*”, (WPMC'05), Aalborg, Denmark, September 2005.
- [7] Christophe Chevallier, Christopher Brunner, Andrea Garavaglia, Kevin Murray, Kenneth Baker, *WCDMA (UMTS) Deployment Handbook*, John Wiley & Sons Ltd, July 2006.