STADIA
HELSINGIN AMMATTIKORKEAKOULU

FACULTY OF TECHNOLOGY

INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS

Telecommunications

FINAL STUDY

WCDMA HSPA Performance Counters for Monitoring 3G- Radio Access Network

Name: Mika Ruotsalainen
Supervisor: Seppo Lehtimäki
Instructor: Mikko Saarikallio

Approved: __. __. 2007

Seppo Lehtimäki
Senior Lecturer

STADIA
HELSINGIN AMMATTIKORKEAKOULU

PREFACE

The graduate study has been very educational and it has given me a lot of experiences. It has given me an opportunity to be a part of a large telecommunications company and shown how wide and interesting the IT-branch can be.

I would like to thank Ericsson for providing me a subject for my graduate study. I would also like to thank my supervisor, Mikko Saarikallio, for guiding me through the study. Also thanks to Jarno Kämppi and Timi Neuvonen for helping me with some very demanding technical aspects during the study. Furthermore, I would like to thank my instructor – Seppo Lehtimäki – for giving me guidance throughout the writing process and Mrs. Anne Hannila for helping me with the linguistic aspects of the study.

Helsinki, November 23th, 2007

Mika Ruotsalainen

HELSINGIN AMMATTIKORKEAKOULU

TIIVISTELMÄ

Tekijä: Mika Ruotsalainen	
Työn nimi: WCDMA HSPA suorituskykylaskureiden monitorointi 3G-radio verkossa	
Päivämäärä: 23.11.2007	Sivumäärä: 29
Koulutusohjelma: Tietotekniikka	Suuntautumisvaihtoehto: Tietoliikennetekniikka
Työn valvoja: Lehtori Seppo Lehtimäki Työn ohjaaja: Mikko Saarikallio, Insinööri	

Tämän Insinöörityön tarkoituksena oli kerätä kaikki laskurit joita käytetään HSPA suorituskyvyn monitorointiin. Päämääränä oli luoda Ericssonin henkilökunnalle tiivis paketti HSPA suorituskykylaskureista sekä radioverkon monitoroinnista jota he voivat sitten käyttää työssään hyödyksi.

Tämä työ pitää sisällään lyhyen kuvauksen 3G-radioverkosta ja sen arkitehtuurista. HSPA tekniikka ja HSPA suorituskyky on esitelty työssä. HSPA suorituskyky osio pitää sisällään sourituskykylaskureiden ja suorituskykymittareiden toiminnalliset kuvaukset, joita käytetään radioverkon hallinnoinnissa ja monitoroinnissa.

Työn viimeinen osuus pitää sisällään katsauksen suorituskyvyn hallinnointi-työkaluista. Siinä esitellään kuinka laskurit on esitetty hallinnointi-työkaluissa. MOShell ja OSS-RC ovat työssä esitellyt hallinnointi-työkalut. Nämä työkalut on valittu siksi koska MOShell on Ericssonin sisäinen hallinnointi-työkalu ja OSS-RC on asiakkaan käyttämä työkalu.

Avainsanat: Ericsson, HSPA, suorityskyvyn hallinnointi, verkon hallinnointi

STADIA
HELSINGIN AMMATTIKORKEAKOULU

ABSTRACT

Name: Mika Ruotsalainen	
Title: WCDMA HSPA Performance Counters For Monitoring 3G- RAN	
Date: November 23^{th} , 2007	Number of pages: 29
Department: Information Technology and Telecommunications	Study Programme: Telecommunications
Instructor: Seppo Lehtimäki, Senior Lecturer Supervisor: Mikko Saarikallio, Services Engineer	

The objective of this project was to gather all the counters which are used on HSPA performance monitoring. The main purpose was to create a compact packet of HSPA performance counters and radio network monitoring which Ericsson's employees can then use in their daily work.

The study includes a short introduction to the architecture of the 3G-radio access network. The HSPA technology and HSPA performance are presented including a functional description of performance counters and KPIs, which are used for performance management and monitoring. The theory part of the study also covers an overview of performance management in OSS-RC.

The final part of the study covers an overview of the performance management tools, introducing how the counters are represented in these interfaces. MOShell and OSS-RC are tools used in this study. Tools were selected because the MOShell is Ericsson's internal management tool and OSS-RC is a tool designed for customers.

Keywords: Ericsson, HSPA, Performance management, Network monitoring

ABBREVIATIONS

16QAM	16 Quadrature Amplitude Modulation
3G	3^{rd} Generation
3GPP	3^{rd} Generation Partnership Project
ACK	Acknowledgement
A-DCH	Associated Dedicated Channel
ATM	Asynchronous Transfer Mode
CN	Core Network
CPP	Cello Packet Platform
CQI	Channel Quality Indicator
CV	Configuration Version
DCH	Dedicated Channel
Eul	Enhanced Uplink
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FM	Fault Management
GGSN	Gateway GPRS Support Node
GSM	Global System for Mobile Communications
GSDC	Global Service Delivery Center
GUI	Graphical User Interface
HARQ	Hybrid Automatic Repeat Request

HHO	Hard Handover
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	High Speed Shared Control Channel
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access
IF-HO	Inter Frequency Handover
ITU	International Telecommunications Union
KPI	Key Performance Indicator
MAC	Medium Access Control
MO	Managed Object
NACK	Negative Acknowledgement
NE	Network Element
O&M	Operation and Maintenance
OSS-RC	Operations Service System Radio & Core
QoS	Quality of Service
QPSK	Quatrature Phase Shift Keying
RAB	Radio Access Bearer
RAN	Radio Access Network
RBS	Radio Base Station
RLC	Radio Link Controller
RNC	Radio Network Controller
ROP	Report Output Period

TB Transmission Block

TFRI Transport and Format Resource related Information

TTI Transmission Time Interval

UE User Equipment

URA UTRAN Registration Area

UTRAN UMTS Terrestrial Radio Access Network

WCDMA Wideband Code Division Multiple Access

TABLE OF CONTENTS

1 INTRODUCTION

Wideband Code Division Multiple Access-based Third Generation Radio Access Network (WCDMA 3G RAN) is a technology that provides good broadband services to transport information at good data rate. In WCDMA Third Generation Partnership Project (3GPP) Release 5, a technique known as High Speed Downlink Packet Access (HSDPA) was introduced which provides peak data rates up to 14 Mbps in downlink. In Release 6, the Enhanced Uplink (Eul) was introduced which provides peak data rate up to 12 Mbps in uplink. These two techniques combined form High Speed Packet Access (HSPA).

This study was commissioned by L M Ericsson Ab, which operates in more than 140 countries, making it the one of the world's biggest radio network providers. Approximately 40% of all mobile calls are made through Ericsson networks.

Ericsson has already provided HSPA networks in 54 countries with over 100 commercial launches. 47 HSPA networks are powered by Ericsson and over 500 million subscribers use the technique.

This study was done with the help of the global support unit, which is a part of the Ericsson Global Service Delivery Center (GSDC) organization.

The main goal of this study was to create a help guide that helps to manage and analyze radio network with counters. The idea of this guide is to help network monitoring and troubleshooting. When an error occurs in the radio network, the error needs to be located and this guide is a good help to start with.

Network performance can be analyzed by using several different kind of counters. This study only has focus on the HSPA counters. Study will show what kind of counters has added along with HSPA and what the counters are used for.

The study also shows how performance is managed and what kind of tools need to be used when network performance is monitored.

This study contains eight chapters that will explain to the reader what performance counters are. As the 3G-radio network is monitored with the counters in this study, second part of the study describes the idea of 3G-radio network and demonstrates the parts that belong to radio network.

HSPA consists of a combination of two techniques from which the other, HSDPA and it's main characteristics are discussed in chapter three. The second technique, Eul is discussed in chapter four. Chapter five concentrates on HSPA which is the main subject of this study.

As the study concentrates on studying performance counters, chapter six concentrates on HSPA performance which includes statistical mechanisms, counters, KPI's and performance management. Chapter seven demonstrates the tools that are needed to monitor the performance of the radio network. Summary of this study are discussed in chapter eight.

2 WCDMA RADIO ACCESS NETWORK

WCDMA RAN is a radio access network that provides a connection between the User Equipment (UE) and the Core Network (CN). The networks are separate and communicate with each other via Iu interface. The WCDMA RAN and CN are maintained from Operations Service System – Radio& Core (OSS-RC). It communicates via Mu interface. The following subsections describe the parts where a Radio Access Network (RAN) consists of.

2.1 Radio Access Network

Radio access network is a network providing interface for mobile terminals or mobile phones to access 3G networks. This interface is called Uu. The Radio access network consists of three network elements: Radio Base Stations (RBS), Radio Network Controllers (RNCs) and ATM-switch which is called RXI. Radio Access Bearers (RABs) are used to provide services between the core network (CN) and mobile terminals. All the RAN nodes are based on the same platform which is called Cello Packet Platform (CPP). Figure 1 illustrates the WCDMA Radio Access Network structure.

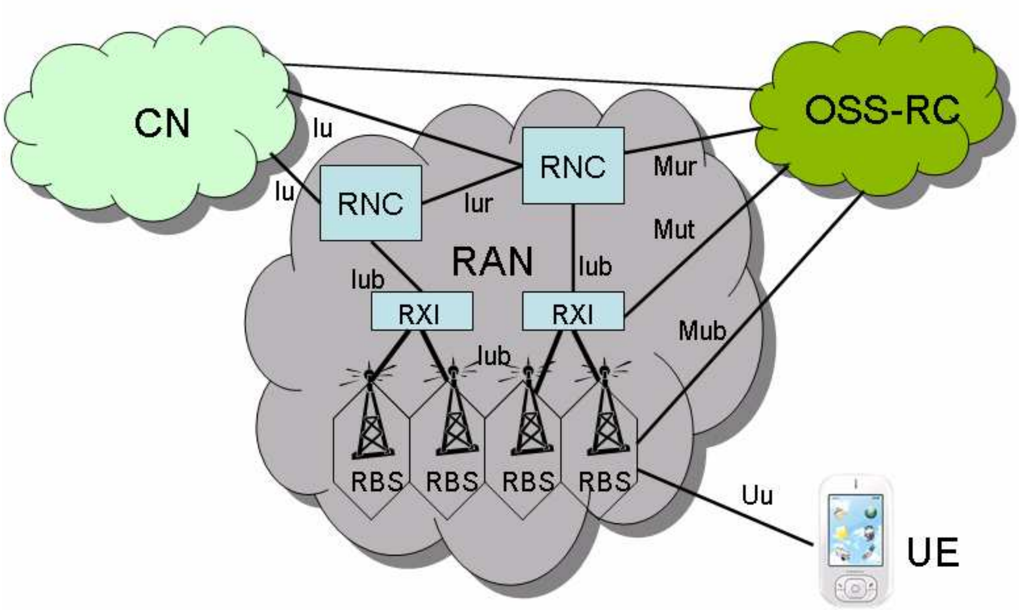


Figure 1. Structure of WCDMA Radio Access Network

Radio Base Station

Radio Base Station (RBS) provides radio resources for mobile terminals. It has radio equipment such as transceivers and antennas, which are needed to serve cells in the network. Radio Base Station works between the user

Equipment (UE) and the Radio Network Controller (RNC), serving radio transmission over the air interface. The main functions of the Radio Base Station are power control, channel coding, spreading and scrambling and modulation.

Radio Network Controller

The Radio Network Controller (RNC) handles Radio Access Bearers (RABs) for the radio network and user data. RNC is connected to the core network with Iu interface. RNC provides a control message bearer service between mobile terminals and the core network. It also controls call handovers within the Radio Access Network (RAN). The Iur interface is used to communicate from RNC to other RNC. The Iub interface is used to communicate from RBS to RNC.

ATM-Switch RXI

RXI handles the switching between RNC and RBS. RXI enables multiple RBS connected to the RNC. It is controlled by OSS-RC via Mut interface.

2.2 Operations and Support System- Radio & Core (OSS-RC)

Operations Service System – Radio & Core (OSS-RC) is a system that provides the performance management, network monitoring and network statistics from the RAN. RAN is controlled by the OSS-RC. It collects information and counter data from the RNC, RXI and RBS and that information can be analyzed by MoShell which is Ericsson's internal system tool or by Operation and Support System Graphical User Interface (OSS GUI) that customer use to manage Network Elements (NEs).

OSS-RC is a customer tool which operators use for alarm handling, cellular network administration and for mobile subscribers. OSS-RC contains applications for performance management, configuration and supervision in RAN.

3 HIGH SPEED DOWNLINK PACKET ACCESS

In this chapter are introduced a HSDPA (High Speed Downlink Packet Access) generally and all the key features that HSDPA introduces. Also chapter describes the radio interface protocol architecture and new channels that comes along with HSDPA.

3.1 Overview of HSDPA

High Speed Downlink Packet Access, HSDPA, is standardized as part of 3GPP Release 5 WCDMA specifications. The new modulation method of HSDPA greatly improves the peak rate and throughput which enhances efficiency. In addition to these benefits, users will perceive faster connections to services through shorter round trip times. [2]

High performing data services will result in increasing traffic volume and data speed. It means more subscribers, more traffic, more usage and higher capacity requirements.

Higher capacity requirements are:

- Higher peak rates and high probability of high bit rates
- Lower latency
- Reduction of cost per Gbit

HSDPA adds a new transport channel to WCDMA, the High Speed Downlink Shared Channel (HS-DSCH) that supports interactive, streaming and background services. This enables an increase in capacity with peak rate of up to 14 Mbps and it also reduces round trip delays [2]. It provides enhanced support for high performance packet data applications in downlink.

A new Transmission layer, High Speed Medium Access Control (MAC-hs) is introduced in HSDPA. MAC-hs enable a functional split to be retained between layers and nodes from Release 99 and 4. [3]

Minimizing architectural changes enables a smooth upgrade to HSDPA, and ensures HSDPA operation in an environment where not all cells have HSDPA functionality. In WCDMA, both voice and data services can run simultaneously on the same frequency carrier. Services that run on HSDPA can also use the same frequency carrier.

3.2 Key Features of HSDPA

There are six key features in HSDPA:

- Shared channel and multi-code transmission
- Short Transmission Time Interval (TTI)
- Higher-order modulation
- Fast link adaptation
- Fast scheduling
- Fast Hybrid Auto Repeat request (HARQ)

Shared Channel and Multi-code Transmission

HSDPA uses channel transmission, which means that some of channel codes and transmission power in the cell are seen as a common resource which is shared between users in the time and code domains [3].

HSDPA uses High Speed Downlink Shared Channel (HS-DSCH) and consists of up to 15 codes. The actual number of used codes employed depends on the number of codes supported by the terminal of system, operator settings and system capacity. Figure 2 shows an example of how codes are dynamically allocated per TTI to one or more users [3].

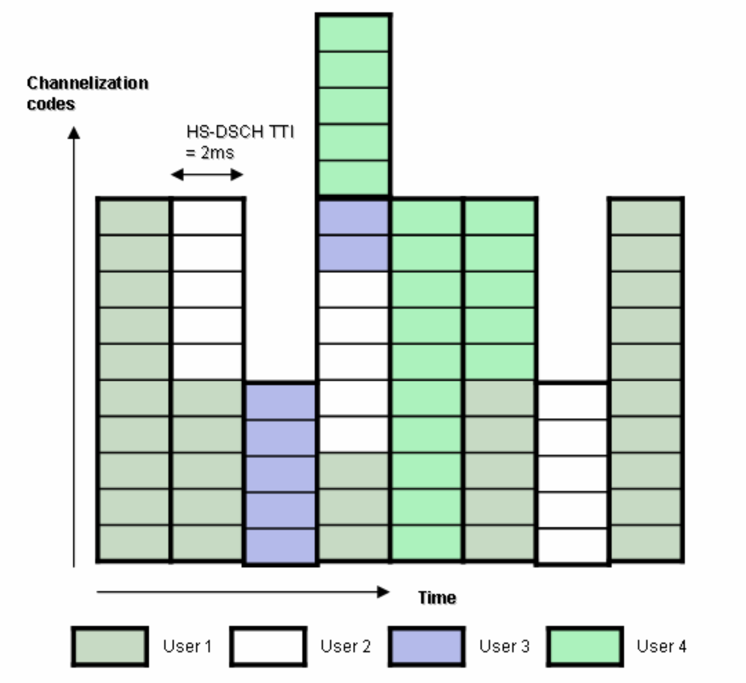


Figure 2. Code and time structure in HS-DSCH

Short Transmission Time Interval

In Release 5, HSDPA was introduced where the TTI is reduced to 2 ms in the downlink. Channel codes that are inside the shared code resource are dynamically allocated every 2 ms's time interval, which improves the tracking of channel variations. TTI also reduces round trip times. Link Adaptation and Fast Scheduling are functions that exploit the TTI feature. The primary way of sharing resources among users is time but resources can also be shared code domains by using different parts of the total HS-DSCH code set, as illustrated in Figure 2 [3].

Higher-order Modulation

Two kinds of modulations are used in HSDPA: Quadrature Phase Shift Keying (QPSK) modulation and 16 Quadrature Amplitude Modulation (16QAM). 16QAM provides twice as high peak rate capability as QPSK and that is why it makes more efficient use of bandwidth than QPSK. However, it also requires better radio channel conditions than QPSK. QPSK uses two bits per symbol and 16QAM uses four bits per symbol, as illustrated in Figure 3.

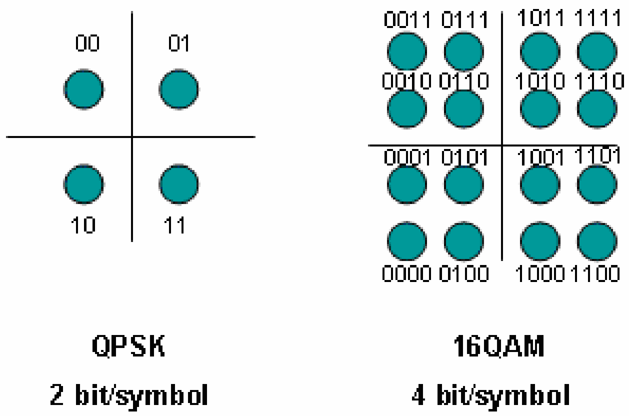


Figure 3. Modulation schemes used with HSDPA, binary numbers are only for demonstration

Fast Link Adaptation

The purpose of fast link adaptation is to adjust transmission parameters to match instantaneous channel conditions. It is located in RBS. UE or terminal which uses HS-services, transmits regular channel quality reports to the RBS. RBS adjusts the transmission parameters using fast link adaptation and when channel conditions permit, enables the use of high order modulation (See Figure 4).

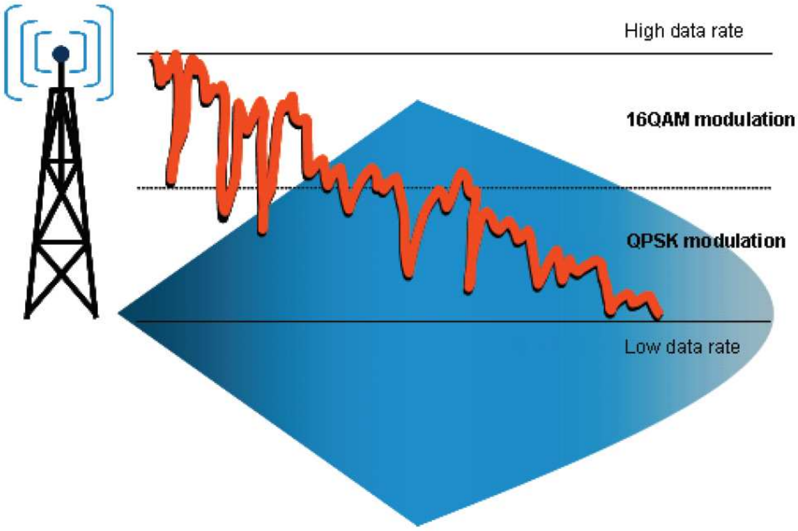


Figure 4. Radio conditions when data rate changes [2]

HSDPA relies on bit rate adjustment instead of using power control. This means that transmission power is constant while it adjusts data rate. Adjustment of data rate is called link adaptation. The link adaptation is more efficient than power control for services that tolerate short term variations in the data rate. HSDPA can use 16QAM modulation to increase peak data rates when channel conditions permit, as illustrated in Figure 4. [3]

Fast Scheduling

Fast scheduling is a feature that is used to maintain the best possible data rate by using channel-dependent scheduling, also called as multi-user diversity, which is illustrated in Figure 5.

For each TTI, the scheduler decides to whom the HS-DSCH should be sent at any specific moment. Task of the scheduler is to decide how many codes and what kind of modulation techniques should be used in the transmission. For this reason, fast scheduling is an essential part of HSDPA performance.

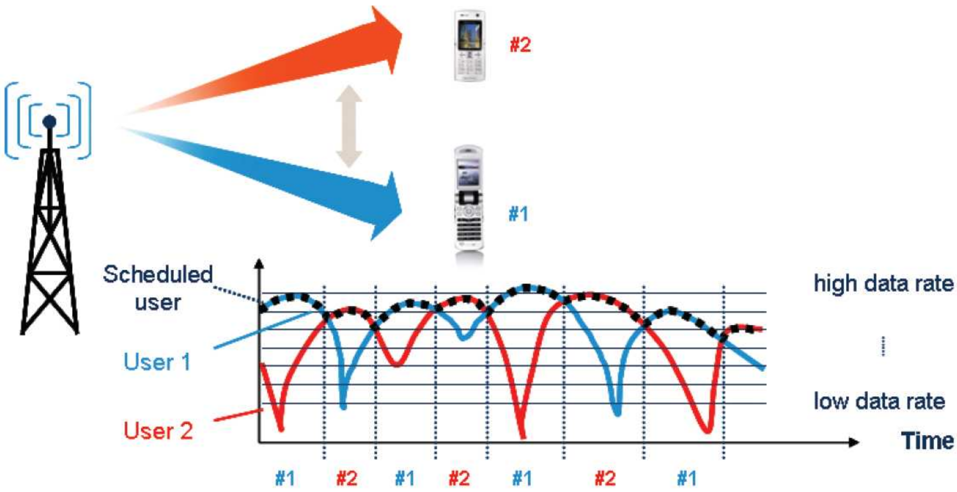


Figure 5. Multi-user diversity [2]

The use of fast scheduling increases cell load, which then increases the number of waiting users online. For this reason, also the probability to distribute good channel quality to the users increases.

Hybrid Automatic Repeat Request

Hybrid Automatic Repeat Request (HARQ) forms an error control strategy by combining Automatic Repeat Request (ARQ) and Forward Error Correction (FEC). It is used at the MAC-hs layer to detect and correct erroneously received transmission blocks (TBs). The user equipment indicates successful or unsuccessful reception of TB by sending an Acknowledgement (ACK) or Negative-Acknowledgement (NACK). The general principle of HARQ is illustrated in Figure 6.

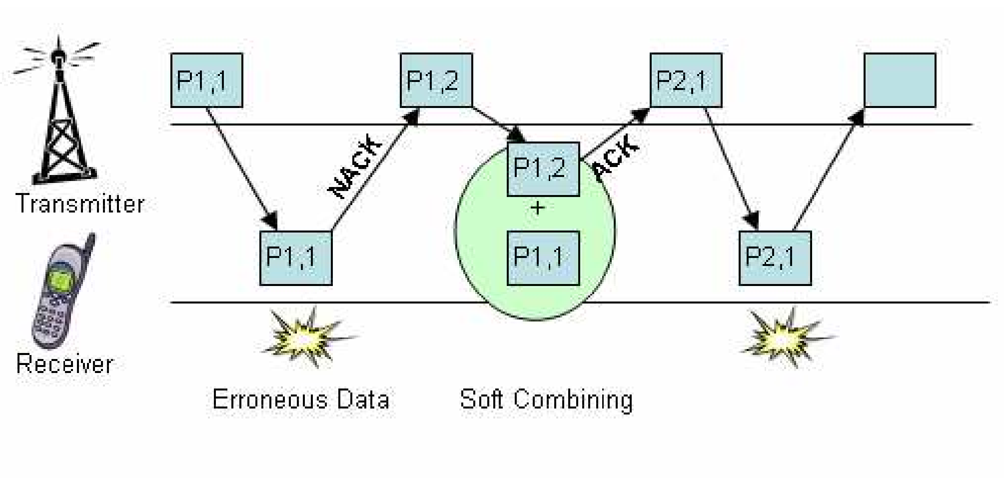


Figure 6. Rapid request of transmission of missing data

The Hybrid ARQ functionality is located in the MAC-hs entity of the RBS. The transport block retransmission process is considerably faster than RNC-based RLC layer retransmissions because the Iub interface is not involved. [5]

3.3 High Speed Medium Access Control

To support fast interactions between the network and the UE, a new high-speed MAC layer (MAC-hs) has been implemented into the RBS's. MAC-hs controls the data transfer over HS-DSCH and is hence responsible for many functions related to HSDPA. As Figure 7 illustrates, the MAC-hs is consisted of four different functional entities:

- *Flow Control*
- *Scheduling/Priority handling*
- *HARQ*
- *Fast Link Adaptation*

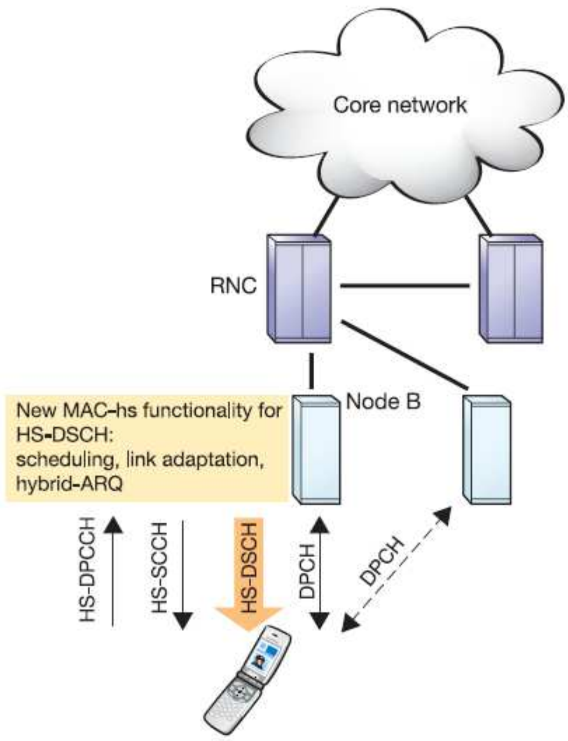


Figure 7. MAC-hs functionality presented in RBS

More information regarding MAC-hs can be found in [6].

3.4 HSDPA Radio Interface Protocol Architecture

Radio interface protocol architecture of HSDPA is shown in Figure 8. It demonstrates a MAC-hs and MAC-d layers location in the architecture.

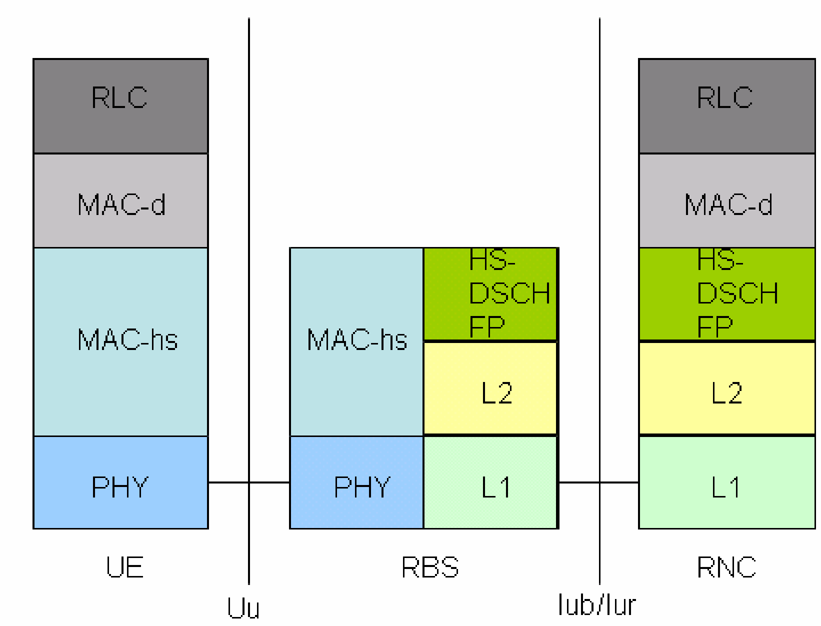


Figure 8. Radio interface protocol architecture

The MAC-hs is the layer which communicates between UE and RBS. The MAC-hs is in charge of handling HARQ of every HSDPA users. It distributes the MAC-d according to their priority and selects the appropriate transport format for every TTI. The HS-DSCH FP layer is a flow mechanism that aims at keeping the buffers full.

3.5 HSDPA Channels

The HSDPA information sharing is done with new HS-channels which enable a fast data transmission in downlink direction. There are four new High-Speed channels added in HSDPA (See Figure 10), which are listed below:

- HS-DSCH (High Speed Downlink Shared Channel)
- HS-DPCCH (High Speed Downlink Physical Control Channel)
- HS-SCCH (High Speed Shared Control Channel)
- A-DCH (Associated Dedicated Channel)

Figure 9 illustrates how the channels transport data in the radio network.

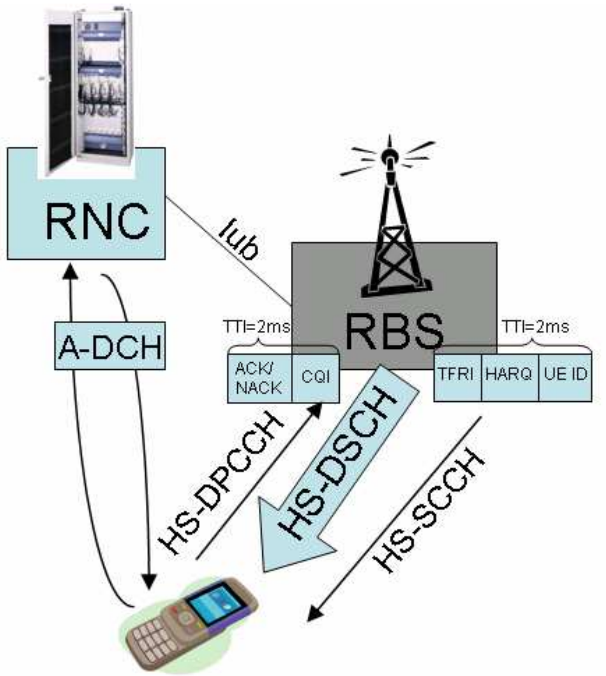


Figure 9. HSDPA channels

The RBS's HSDPA functionalities are Scheduling, HARQ and Fast Link Adaptation, which communicates with UE by using the HS-DSCH channel. UE transmits an ACK/NACK response and Channel Quality Indicator (CQI) information to the RBS through a HS-DPCCH channel. HS-DPCCH uses spreading factor of 256 in transmission (See Table1).

Table1: HS-DPCCH channel data rates

Slot Format	Channel bit rate (kbps)	Channel symbol rate (ksps)	SF (Spreading Factor)	Bits/subframe	Bits/Slot	Transmitted slots per Subframe
0	15	15	256	30	10	3

Table 1 shows data rates which channel use when the UE transmits ACK/NACK and CQI information to the RBS.

The HS-SCCH channel is control channel which control signaling related to HS-DSCH transmission. HS-SCCH allows the UE to listen to the HS-DSCH at the correct time and use the correct codes to decode successfully the UE data. RBS sends a TFRI (transport and Format Resource related Information), HARQ and UE identification information to UE via HS-SCCH channel.

4 ENHANCED UPLINK

Enhanced Uplink (Eul) was introduced in 3GPP Release 6, which was released in 2004. One of the key features of Enhanced Uplink is that it has capability to operate without HSDPA in downlink direction. Enhanced Uplink makes it possible to use the same 5 MHz uplink bandwidth more efficiently providing higher peak data rates and reduced round trip times compared to earlier releases. Where the maximum uplink peak data rate in Release 5 is 384 kbps, the Enhanced Uplink can provide peak rates up to 12 Mbps [7]. See Figure 10.

Figure 10. Development of Eul data rate

Features of Enhanced Uplink

Enhanced Uplink supports several new features, which makes it faster than earlier uplink. It can use the same frequency carrier as Release 99 so it is compatible with earlier networks. The new features are:

- Multi code transmission
- Short Transmission Time Interval
- Fast Hybrid Automatic Repeat Request
- Fast Scheduling

Multi code transmission

New uplink channel that is introduced for Enhanced Uplink is not shared between users, but is dedicated to a single user. Up to four codes can be used to increase the uplink data rate.

Short Transmission Time Interval

Eul operates with TTI of 2 ms or 10 ms in the uplink. A short Transmission Time Interval enables remarkable reduction in overall latency and provides the means for the other features to adapt rapidly.

Fast Hybrid Automatic Repeat Request

The fast hybrid ARQ protocol used is similar to the one used for HSDPA. HARQ can be seen as a combination of ARQ and Forward Error Correction (FEC). The basic idea of FEC is to add redundancy to transmissions in such manner that decoding of data can be done successfully in the receiving end and even though the transmission would not be error free.

Fast HARQ in Enhanced Uplink uses Stop and Wait (SAW) algorithm, meaning that after a data block is sent, the sending party waits for ACK or NACK to be received before the next data block is sent or the retransmission of previous data block is performed (See Figure 6 on page 8). [8] There are also other algorithms, but SAW is most commonly used.

Fast scheduling

In Enhanced Uplink the scheduling is done in RBS, instead of performing it in RNC like it was done in the earlier releases. This change brings the scheduling closer to the air interface and cuts away the signaling delay that scheduling messages have in the Iub interface. When the scheduler performs resource allocation, it has two objectives.

The first objective is to keep the system in stable state by avoiding interference peaks and to adapt rapidly to the interference variations enabling more efficient use of the air interface resources. The second one is to provide sufficient capacity to UE to meet associated Quality of Service (QoS) profile requirements.

Enhanced Uplink scheduling in RBS is based on scheduling requests received from UEs and QoS information received from RNC. 3GPP has no specified scheduling algorithm to be used in the Eul scheduling, which gives flexibility to vendors and operators to design and implement different kind of scheduling algorithms depending on the environment or the used network characteristics.

5 HIGH SPEED PACKET ACCESS (HSPA)

Combined HSDPA and Eul is known as High Speed Packet Access (HSPA) (See Figure 11). High Speed Packet Access covers both traditional mobile terminals and personal consumer devices such as cameras, ultra mobile PCs, portable game consoles and music players.

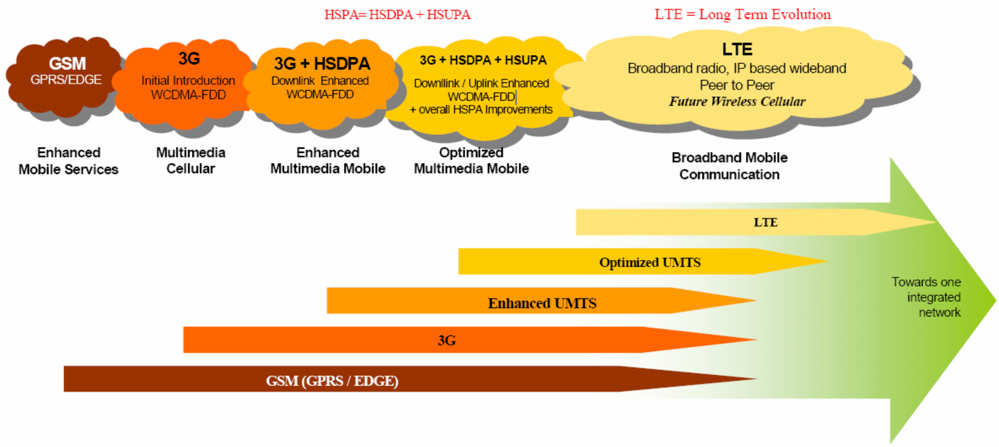


Figure 11. HSPA evolution [9]

HSPA is based on direct-sequence spread spectrum system and today its bit-rate goes up to 14 Mbps and will increase to 42 Mbps in the near future. HSPA is a Frequency Division Duplex (FDD) technology, in which the uplink and downlink are in separate frequency channels (usually denoted as 2 x 5MHz).

HSPA supports soft handover in the uplink, which provides macro-combining gain and it also helps increase the network capacity by reducing intra-cell interference. Hard handover is also supported in HSPA and is used for intra-frequency handover and for intersystem handover in GSM.

With the advantage of HSPA, WCDMA makes it possible for operators to provide end-users with more advanced mobile/wireless broadband applications, with wide-area coverage and mobility. Right now over 100 operators in more than 50 countries use HSPA technology and it is predicted that HSPA will be the technology behind over 70% of mobile broadband connections in future.

6 HSPA PERFORMANCE

HSPA performance measurement is done with HSDPA and Eul counters and with Key Performance Indicators (KPIs). KPIs are formulas which give performance statistics from the radio access network to the operating system. KPIs are results of different counter formulas.

6.1 Overview of Counters

Performance statistics are generated from live traffic from the radio part and from the transport network. The performance statistics data consists of a number of predefined counters. Counters are components which can be used to monitor a performance and processes in the network (See Figure 12).

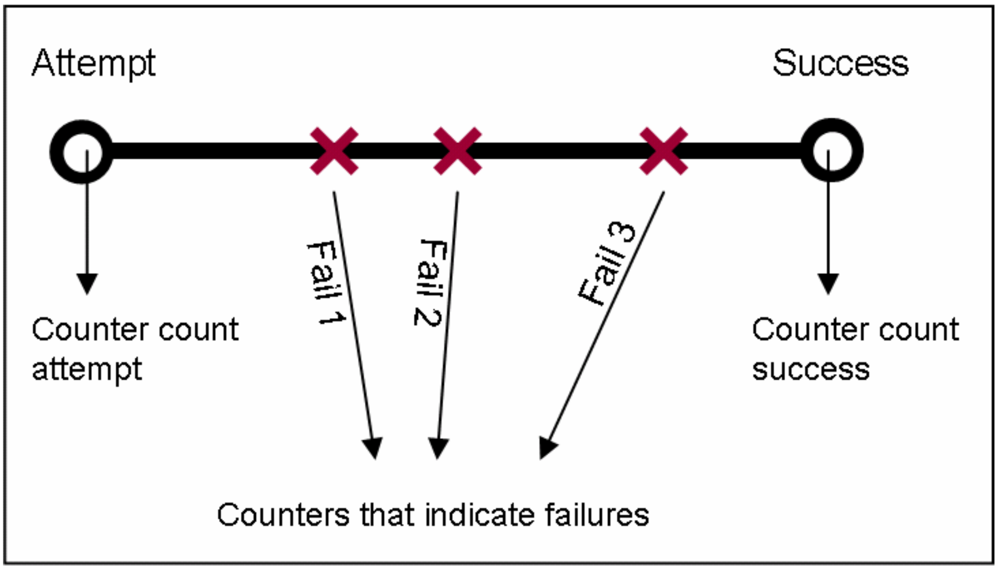


Figure 12. Demonstration of counters location in process

Figure 12 illustrates where counters can be located in process. There are counters that count when data attempt, fail or succeed in process. If expected counter does not increment, there might be a problem in that area. Counters are a good help in troubleshooting, improving and managing the network. Focus of this study is on HSPA counters which are located in RAN nodes Radio Base Station (RBS) and Radio Network Controller (RNC).

There are seven different types of counters which are used in performance statistics mechanisms in WCDMA.

6.2 Performance Statistics Mechanisms

Performance statistics are used to create a general statistic data collection and processing system for all types of traffic handling and maintenance application in the system. Performance statistics contains general information about network performance and is generated from the radio and the transport network live traffic. [11]

The performance statistics data is made up of a number of predefined counters. Performance is monitored by the Operations Service System Radio & Core (OSS- RC). OSS-RC fetches statistical data from NE every Report Output Period (ROP) and creates an xml-file. Once OSS-RC has retrieved the result, it saves the data for a maximum of ten days unless the statistics database is present, in which case the data can be stored permanently. [11]

Counter groups

Counters can be grouped depending on where they are generated, i.e. in which NE they are located (RNC counters, RBS counters, RXI counters, OSS-RC counters). Counters have to be active so that values can be collected and analyzed. The most used groups in HSPA are RNC and RBS.

Statistics Scanners

The statistics profiles are only visible in Operations Service System Graphical User Interface (OSS GUI) and the actual communication between OSS-RC and NE is performed by statistics scanners. Normally, the users are controlling the performance statistics administration through profiles in the network. Figure 13 shows the concept of profiles, scanners and counters on the example of an RNC node.

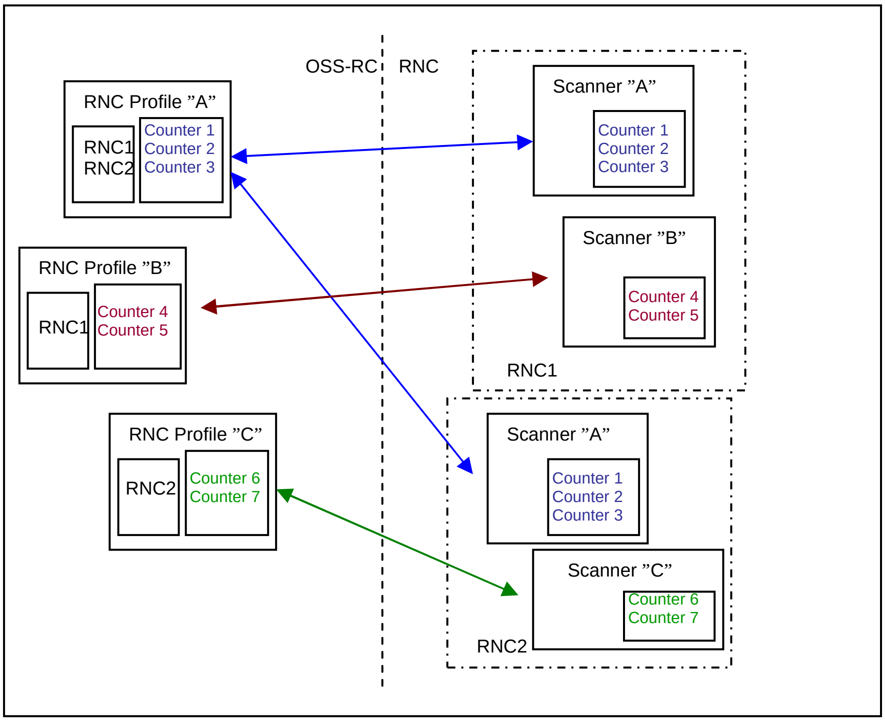


Figure 13. Example of profiles, scanners and counters- RNC point of view

Predefined scanners will come up after node restart but user-defined scanners will not, unless they have been saved to Configuration Version (CV) backup.

6.3 Performance Counters in HSPA

Along with the HSPA technique, new counters are added into the radio network. They are used to monitor network performance and network statistics. Only the counters that concern the HSDPA and EuI are discussed in this study. Key Performance Indicators (KPIs) are an essential part of monitoring performance.

Admission Control

Admission control is a mechanism that controls admission of users into the system and makes sure that system does not exceed the maximum system load. The function of admission control is to keep cell power as high as possible all the time.

Channel Switching

The main factor in monitoring quality is channel switching, which is illustrated in Figure 14.

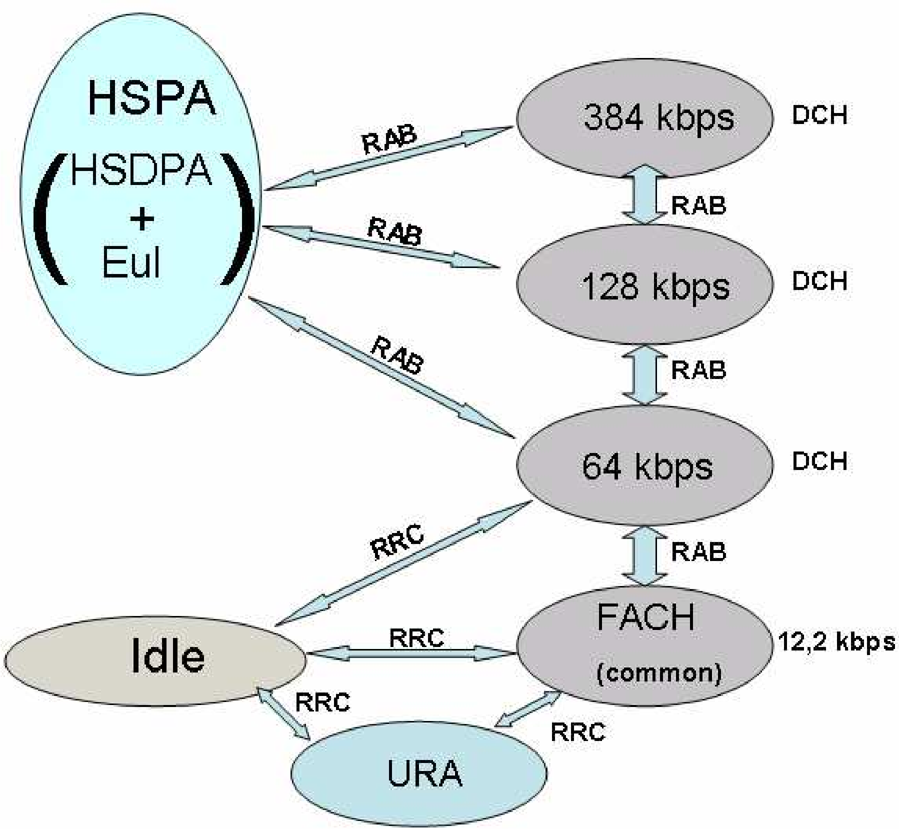


Figure 14. Channel switching state diagram

Figure 14 shows the purpose of channel switching in general. Channel switching can be done with:

- Common (FACH) to dedicated channel (DCH)
- DCH to FACH
- DCH to DCH
- DCH to HSDPA/Eul channel
- FACH to idle mode
- FACH to UTRAN Registration Area (URA)

Channel Switching common to dedicated counters:

The up-switch from common to dedicated channel is based on buffer load, i.e. the UE will be switched to dedicated channel in case the buffer exceeds a configurable threshold value. The down-switch from dedicated to the

FACH common channel will occur in case of low user data volumes, i.e. when the throughput falls below configurable threshold value during a settable time period on both the uplink and downlink.

When the UE is on the FACH common channel, the switching to UTRAN Registration Area (URA) state is performed when there has been no throughput for a settable time period.

Channel Switching dedicated to dedicated counters:

Channel Switching handles the switching of UEs between dedicated channels with different bit rates (e.g. 64, 128, 384, HSDPA/Eul). The DL/UL up-switch to higher throughput is triggered if the throughput on the DL/UL is above a configurable threshold for a settable time.

Handovers in HSPA

HSPA need good channel conditions so that connection does not disconnect when UE moves from one cell to another. HSPA uses Inter-Frequency Handover (IF-HO) and Hard Handover (HHO) to move between cells.

Hard handover means that before a new radio link is established, all the earlier radio links must be released. Inter frequency handover is done between cell which use different carriers. IF-HO is HHO between different carriers that provide data transmission even then if there are other carriers or HS HHO does not succeed between cells. Both handovers cause temporary RAB switch off and try to do it without interference.

HSDPA statistics counters in RBS

Radio Base Station is the essential part of HSPA performance. Counters in RBS give information concerning data transmission between RBS and UE, e.g. how many NACK's are received in case of HARQ functionality. The following counters are valid for measuring traffic actions between RBS and UE.

6.4 Key Performance Indicators (KPIs) for HSPA

Key Performance Indicators (KPIs) are formulas that operators use to collect network performance reports. These KPIs are inherently part of network monitoring and they enable end-to-end solution observation that the network supports. Beside that, KPIs are important indicators when operating network. KPIs measure accessibility, retainability, Integrity, utilization, mobility and availability.

6.5 Performance Management

Performance Management is one of the OSS-RC features. Operators use the Performance Management feature to monitor traffic situations in the network. This feature consists of two functions that are performance statistics and performance recording.

Performance Statistics was explained in chapter 7.1. Performance Recordings can be used to troubleshoot, tune and optimize the network by inspecting the variety of network recordings.

7 MONITORING THE NETWORK PERFORMANCE

Monitoring the network performance is very important part of large telecommunication system. Monitoring is executed with large amount of counters which are located in network areas that have meaning for performance or needs to be monitored.

In Ericsson performance monitoring is executed with MoShell and OSS network graphical interface tools.

7.1 MOshell

The Ericsson has developed a tool called MoShell for network management. The MoShell is a network tool used by Ericsson employees and it is the most important tool when there is need to integrate, upgrade, tune, troubleshoot or monitor the Radio Access Network. This chapter explains the Managed Object (MO) concept and main functionalities of MoShell.

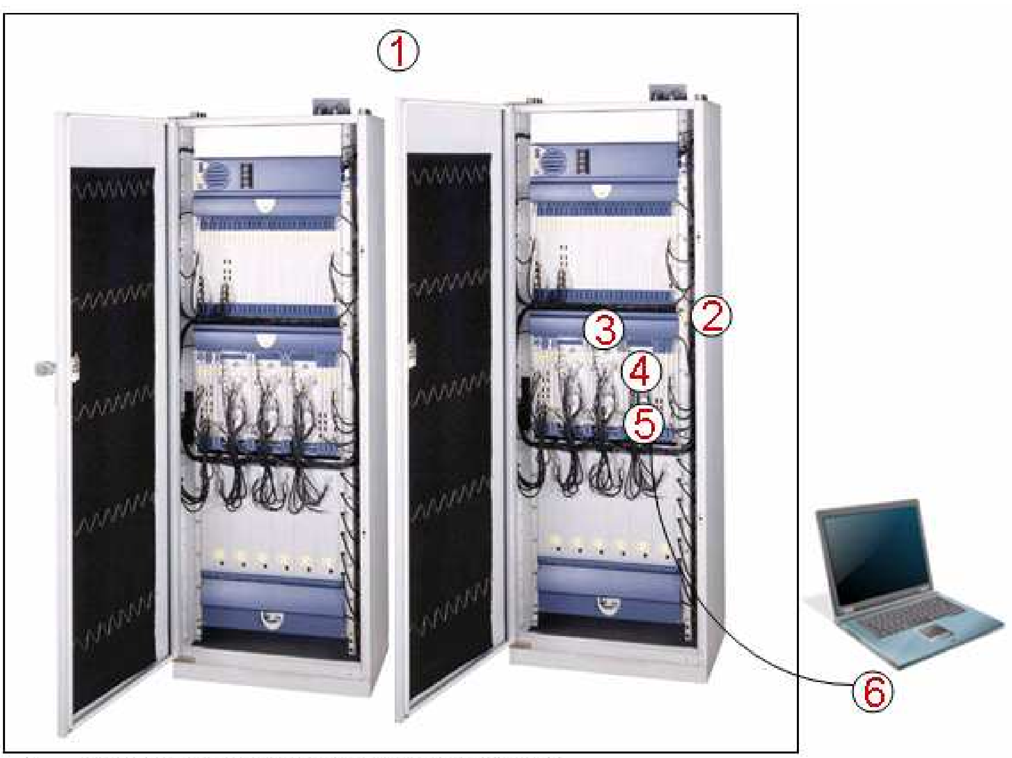
7.1.1 Managed Object MO

MOs are small units for certain functionality in the Node. MOs are organized in a hierarchical tree structure. The Highest MO is so called ROOT MO and it represents the whole Node. Figure 15 illustrates ManagedElement as ROOT MO with some of it's child MOs. [11]

```
ManagedElement=1
ManagedElement=1,Equipment=1
ManagedElement=1,Equipment=1,Subrack=MS
ManagedElement=1,Equipment=1,Subrack=MS,Slot=19
ManagedElement=1,Equipment=1,Subrack=MS,Slot=19,PlugInUnit=1
ManagedElement=1,Equipment=1,Subrack=MS,Slot=19,PlugInUnit=1,Program=DbmFpgaLoader
```

Figure 15. Example of MO tree

In this example the lowest MO is a Program and it contains the address of all parents of that MO all the way up to the ManagedElement. Figure 16 illustrates this example of MO tree disassembled into node positions [11].



1. ManagedElement=1 (Highest MO=Root MO,Node)
2. Equipment=1
3. Subrack=MS
4. Slot=19
5. PlugInUnit=1
6. Program (lowest MO)

Figure 16. MOs in the Node

Managed Object Model (MOM) explains the dependency and functions of managed objects [10]. MOM is a list of all the MOs, their types, attributes, references and actions.

7.1.2 MOShell functionality

MOShell is used for radio access network management by including many useful services. Figure 17 shows the basic look of MOShell.

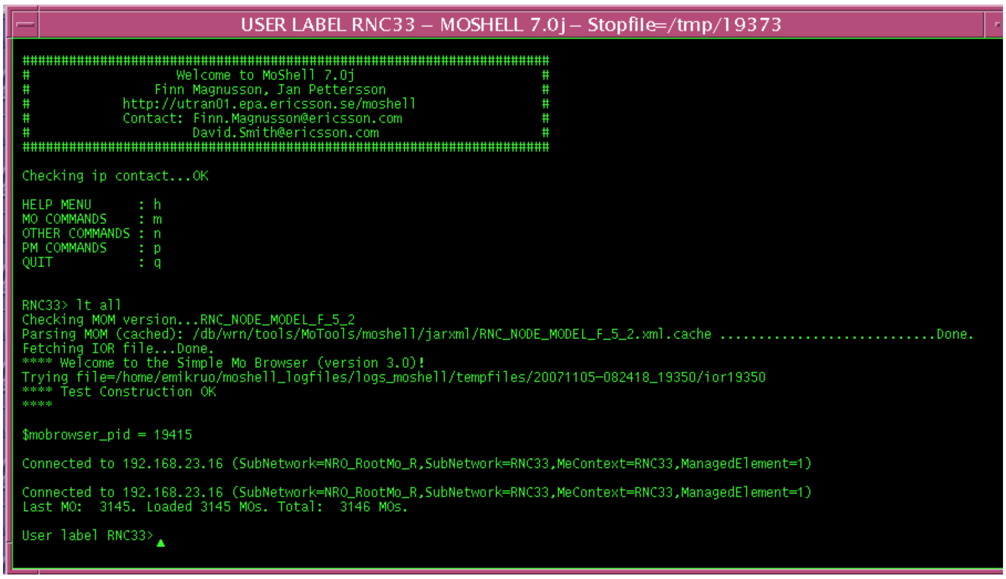


Figure 17. User interface of MOShell

In Figure 17 command ‘lt all’ has been executed. “Lt all” loads all the MOs from the node for user to observe or edit the node parameters.

MoShell is text-based O&M (Operation and Maintenance) client providing access to the following services:

- Configuration Service (CS)
- Alarm Service (AS)
- File Transfer (ftp/http)
- Log Service (LS)
- OSE shell (COLI) (Command Line Interface)
- Performance Management service (PM)

Configuration Service

The configuration service provides specifications and produces the configuration data and software adaptations needed for the network elements to secure high quality in network functions and end-user-services. Functions are e.g. upgrade or integration of the nodes.

Alarm Service

Alarm service lists all active alarms from the network. The service indicates the severity of the alarm, what specific problem is, what is causing it and where the problem is located. The list of active alarms can be retrieved with the commands ‘al’ or ‘ala’. Command ‘ala’ gives more detailed information of alarms.

File Transfer (ftp/http)

Files and directories can be downloaded or uploaded to/from node by using http, ftp of sftp protocol.

Log Service (LS)

The log service is function which enable to read log-files from the node. Log-files indicate all the alarms and failures which have occurred in RAN in certain time period. It is possible to see all the logs from the node, or at certain period of time. Minimum of time period is 30 minute, which includes two ROP xml-files.

Log-files can be found from MOShell by typing the command:

- Lgs (displays the system log from the whole period stored in system log. It can be several months)
- Lgs year-month-day (displays logs from the following date)
- Lgasmi 30 (displays the last 30 days of the alarm and system logs)
- Lgaevs 5h (displays the last 5 hours of the alarm/event/availability/system logs)
- Lgac 30m (display the last 30 min of the alarm log and print the output into a default csv file)

Performance Management Service

All the main performance statistics information can be found with pmr command, which lists performance statistics from the node. The statistics are numbered from 1 to 25 and by entering the wanted number user can see desired counter values.

7.2 OSS GUI

OSS is a network management tool which is designed for customers. Its graphical interface provides statistical data for the RAN. With the OSS statistic data can be formed into charts, which demonstrate the performance graphically. OSS includes the Alarm handling feature (See Figure 18), which indicates all the errors that occur in the network.

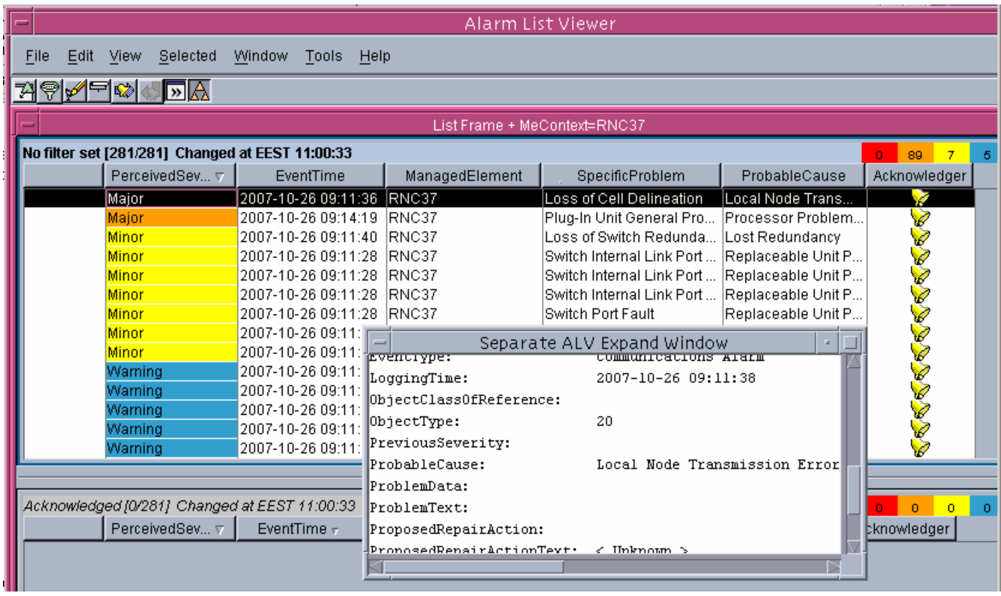


Figure 18. OSS alarm table

Different colors indicate the severity of alarms. The red color indicates that alarm is critical and orange indicates that alarm is major. Yellow color indicates minor alarm and blue color indicates warning. If user needs to see more detailed description of the fault, double click alarm and smaller window appears where alarm details are listed.

OSS-RC can be used to read performance data to monitor the whole RAN with one tool. Figure 19 shows the OSS-RC user interface with open performance menu.

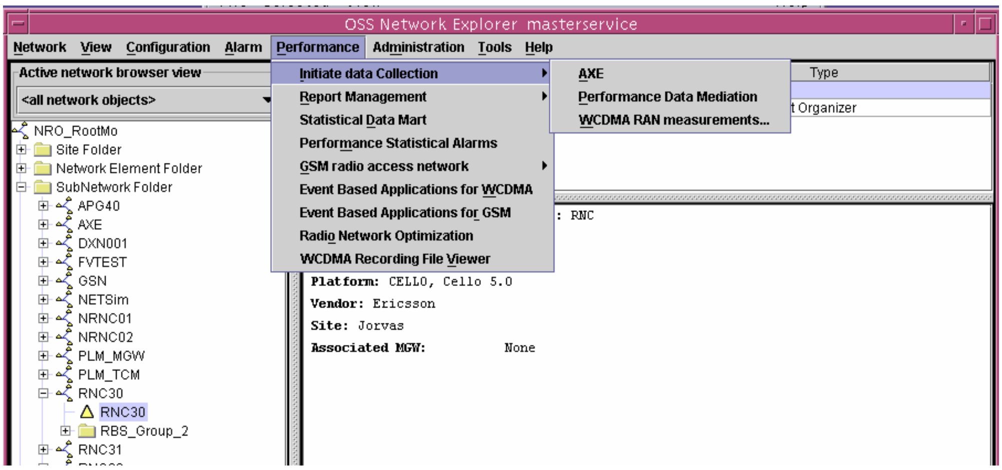


Figure 19. OSS-RC user interface

Initiation of data collection from the WCDMA RAN measurements (See Figure 20) enable user to monitor NEs performance and see all the counters and scanners which operates in the Nodes.

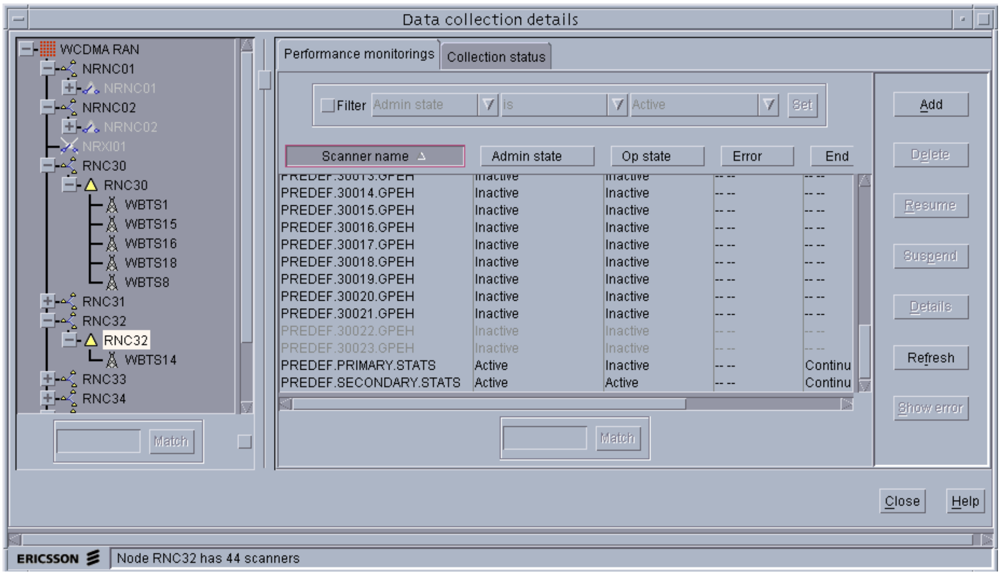


Figure 20. Data collection from WCDMA RAN measurements

Figure 20 shows data collection details from the selected RNC and all the scanners which are either in active or inactive state. By double-clicking the active scanner it is possible to browse scanner profile and see all the counters which are selected to be represented in this profile.

Statistic chart establishment of performance measurements are done with user-defined or pre-defined scanner reports. Statistic charts are called Business Objects.

8 SUMMARY

The main focus of this study was to explore and demonstrate which new counters were added along with HSDPA and Eul techniques, and to produce a compact packet for people who work with performance management at Ericsson. This study has only focused on HSPA Radio Access Network counters which include either Hs or Eul abbreviations, or which otherwise hold an important position in HSPA performance.

The study introduces HSPA technology and lists all the Hs and Eul counters and KPIs in a readable form and explains their purpose. The purpose of this study was also to introduce MOShell and OSS graphical user interfaces which are Radio Access Network graphical interface tools. The MOShell is Ericsson’s internal radio network management tool and OSS GUI is a network management tool used by customers.

The final part of this thesis, monitoring of network performance, was not completely successful since presenting the tools of monitoring would have required real traffic load within node. While Ericsson Finland's test conditions were concerned, there were no nodes available that would have supported HSDPA or Eul technique. For this reason, it was not possible to present any statistical diagrams of the results. However, presentation of manifestation of the counters in management tools was successful and that was the main point. Otherwise everything went as planned and the study was carried out commendably. For the writer, this study gave new points of view about the importance of managing radio access network and its functioning.

REFERENCES

[1] Ericsson AB, Introduction of WCDMA, LZU 108 5199 R2A, Internal course material

[2] Ericsson HSDPA System Techniques, LZU 108 6723, Internal document

http://wbl.eei.ericsson.se:7890/eeonline/course_material/wbl/ericsson_hsdpa_system_techniques.shtml

[3] Ericsson AB, Basic Concepts of HSPA, 284 23-3087RevA, February 2007.

[4] Ericsson AB, WCDMA Evolved, The first step-HSDPA, 284 23-2958 revA, May 2004

[5] P.Ameigeiras, "Packet Scheduling and Quality of Service in HSDPA", PhD Dissertation, Department of Communication Technology, Institute of Electronic Systems, October 2003

[6] 3GPP. TS 25.308 – High Speed Downlink Packet Access: Overall Description, Technical Report 6.3.0, Technical Specification Group Radio Access Network, December 2004, 28 pages.

[7] 3G Americas, The Evolution of UMTS/ HSDPA 3GPP release 6 and Beyond, July 2005, 44 pages.

[8] 3GPP Technical Specification 25.309, FDD Enhanced Uplink Overall Description, version 6.6.0, March 2006, 33 pages.

[9] ITU Next Generation mobile Networks-Opportunities and Spectrum Implications, January 2007, 16 pages.

[10] Ericsson AB, Managed Objects (Cello Hands-on), internal document,v.1.1, June 2002

[11] Ericsson AB, System Performance Statistics, 85/1553-HSD 101 02/5 Rev F, Internal document, January 2007, 77 pages.

[12] John Wiley, Radio Network Planning and Optimization for UMTS, Second Edition, 2006, 619 pages.