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GRADUATE STUDY

COMPARISON OF PARAMETERS AND LISTING OF MAJOR DIFFERENCES BETWEEN ERICSSON WRAN P6.1 AND WRAN P7 SYSTEMS

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PREFACE

Graduate study has been very educational experience for me. L M Ericsson Oy Ab provided me a great opportunity to do graduate study in one of the leading companies in the field of telecommunications.

I would like to express my deepest gratitude to the supervisor of my study, Seppo Lehtimäki, Senior Lecturer and to my instructor, Aravindan Govindaraj, Services Engineer for giving me guidance throughout the graduate study. And first of all, I would like to thank Ericsson and Jarno Kämppi, my Section Manager, who trusted me and gave me an opportunity to let me show my skills. I hope that I have fulfilled my promises.

And last but not least, I would like to thank my friends and my family, especially my father who helped me to make my dreams come true. And of course my lovely girlfriend, for always being there for me.

Helsinki, October 30th, 2008

Mikko Laine

INSINÖÖRITYÖN TIIVISTELMÄ

Tekijä: Mikko Laine

Työn nimi: Parametrien vertailu ja suurimpien erojen listaaminen Ericssonin WRAN P6.1 ja WRAN P7 järjestelmissä

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Insinöörityön aiheena on esitellä Ericssonin radioverkon uuden P7-järjestelmän etuja, vertailla järjestelmän toiminnallisuuksia ja esitellä toiminnallisuuksien sisältämät uudet parametrit. Päämääränä on luoda Ericssonin henkilökunnan käyttöön tietopaketti muutamasta uuden P7-järjestelmän toiminnallisuudesta. Insinöörityö toimii myös hyvänä tiedonhakulähteenä Ericssonin sisäisessä verkossa.

Insinöörityö sisältää peruskuvauksen nykyisestä laajakaistaisesta 3G-radioverkosta ja antaa tietoa sen rakenteesta sekä toiminnallisuuksista. Työssä esitellään HSPA-tekniikka downlinkissä sekä uplinkissä. Työn varsinaisessa tutkimusosassa perehdytään radioverkon uusiin toiminnallisuuksiin ja toiminnallisuuksien ohjaamiseen sekä valvomiseen parametrien avulla.

Tutkimusosassa listataan lisäksi HSPA-radioverkon uudet toiminnallisuudet ja esitellään näistä keskeisimmät. Keskeisimpien toiminnalisuuksien uusia parametreja selostetaan yksityiskohtaisesti. Lisäksi niiden vaikutusta sekä hyötyjä radioverkon tietoliikenteeseen tutkitaan ja esitellään teorian avulla. Parametreista on tehty myös listauksia verkonhallintatyökalun avulla, missä selostetaan kunkin parametrin sijainti sekä kuvaus parametrin toiminnasta radioverkossa.

Avainsanat: Ericsson, WCDMA-RAN (WRAN), HSPA, HSDPA, EUL, Feature, Parameter

ABSTRACT

Name: Mikko Laine	
Title: Comparison of Parameters and Listing of Major Differences Between Ericsson WRAN P6.1 and WRAN P7 Systems.	
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Graduate study introduce the benefits that could be reached with Ericsson`s new P7 radio network system, compare differences between Ericsson WRAN P6.1 and P7 systems and introduce new and enhanced features and parameters. The goal is to create an information packet for personnel use within Ericsson, where some new features are introduced. This graduate study works as an internal reference library for Ericsson as well.

The study includes basic knowledge of the present wideband 3G network including introduction to its architecture and its features. The HSPA (High Speed Packet Access) technique in the air interface is introduced. The research part of the study introduces new features in the radio access network and describes how these features affect the network and how they are monitored by parameters.

The research part lists all new features and introduces the most essential of them. Parameters inside the significant features are introduced in detail on a theoretical level and their impact and benefits to the network has been studied.

Keywords: Ericsson, WCDMA-RAN (WRAN), HSPA, HSDPA, EUL, Feature, Parameter

TABLE OF CONTENTS

ABBREVIATIONS

16QAM	16 Quadrature Amplitude Modulation
3G	3rd Generation
3GPP	3rd Generation Partnership Project
64QAM	64 Quadrature Amplitude Modulation
AAL2	ATM Adaptation Layer 2
ACK	Acknowledge
AMR	Adaptive Multi Rate
ATM	Asynchronous Transfer Mode
CE	Channel Element
CELLO	System which offers transport services to radio network
CN	Core Network
CP	Connection Point
CPI	Customer Product Information
DTX	Discontinuous Transmission
E-AGCH	E-DCH Absolute Grant Channel
E-DCH	Enhanced Dedicated Channel
E-DPCCH	E-DCH Dedicated Physical Control Channel
E-DPDCH	E-DCH Dedicated Physical Data Channel
EHICH	E-DCH HARQ Information Channel
EL2	Enhanced Layer 2
E-RGCH	E-DCH Relative Grant Channel
EUL	Enhanced Uplink
FDD	Frequency Division Duplex
FP	Frame Protocol Feature Pack
GRAKE	Generalized RAKE Receiver
GSDC	Global Service Delivery Center
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
HSDPA	High Speed Downlink Packet Access
HS-DPCCH	High Speed Dedicated Physical Control Channel
HS-DSCH	High Speed Downlink Shared Channel
HSPA	High Speed Packet Access
HS-DSCH FP	HS-DSCH Frame Protocol
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	High Speed Shared Control Channel
IP	Internet Protocol
ISO	International Organization for Standardization
Iu	3GPP specified interface between WRAN and CN
Iur	3GPP specified interface between RNCs
Iub	3GPP specified interface between RNC and RBS
kbps	Kilobits per second
LTE	Long Term Evolution
MAC	Medium Access Control
MAC-d	dedicated MAC
MAC-ehs	enhanced MAC-hs
MAC-hs	high speed MAC
MBMS	Multimedia Broadcast and Multicast Service
Mbps	Megabits per second
MGW	Media Gate Way
MIMO	Multiple Input Multiple Output
MO	Managed Object
MOM	MO Model

Mu	External interfaces from WRAN to OSS-RC
NACK	Negative Acknowledge
NE	Network Element
Node B	3GPP abbreviation for RBS
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open Systems Interconnection Basic Reference Model
OSS-RC	Operation Service System for Radio and Core
PDU	Packet Data Unit
PQ	Priority Queue
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RAB	Radio Access Bearer
RAN	Radio Access Network
RBS	Radio Base Station
RLC	Radio Link Controller
RNC	Radio Network Controller
RNSAP	Radio Network System Application Part
RXI	Radio Access Network Aggregator
SIR	Signal/Interference Ratio
SMS	Short text Message
SRB	Signalling Radio Bearer
SRNC	Serving Radio Network Controller
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
Uu	Interface between RBS and UE
VC	Virtual Channel
VCI	Virtual Channel Identifier
VP	Virtual Path
VPI	Virtual Path Identifier
WCDMA	Wideband Code Division Multiple Access
WRAN	See WCDMA and RAN

1 INTRODUCTION

Continuously recurrent and improving technology has revolutionized the development of mobile networks. Only the sky is the limit when it is a question of terrestrial radio access networks. New mobile networks offer astonishing connection speeds for the end users providing the access to the internet, besides all the other functionalities. Technology behind these broadband service speeds for the radio networks is WCDMA (Wideband Code Division Multiple Access).

In WCDMA 3GPP (3rd Generation Partnership Project) release 5 and release 6, HSPA (High Speed Packet Access) technique was introduced. HSPA consists of uplink (EUL, Enhanced Uplink) and downlink (HSDPA, High Speed Downlink Packet Access). Among benefits of new feature standards in 3GPP releases, HSPA has reached its speed up to 21 Mbps in downlink and up to 5.8 Mbps in uplink and there is still much to come. In future with MIMO (Multiple Input Multiple Output) technique it is easy to double these transmit speeds, at least in theory.

This Graduate Study was commissioned by the WRAN (Wideband Radio Access Network) department of Ericsson GSDC Finland and it reviews Ericsson`s radio access network. Ericsson supply systems and services to most of the world’s largest mobile and fixed network operators and it have more than 600 customers in over 175 countries.

The purpose of the study was to introduce the benefits that could be reached with the new Ericsson`s P7 system, to compare differences between present Ericsson WRAN P6.1 and incoming P7 systems, and to introduce new and enhanced features and theirs parameters. New and experienced employees in Ericsson, who are interested in this field, are the target group of the study.

Basically, networks are defined by their different features and features in turn define services that the network offers. Features consist of parameters, variables which define networks behavior. In order to understand all aspects involved, it is good to introduce the basics of radio access network.

In the beginning of the study, in chapter 2, WRAN is introduced on a general level. In chapters 3, 4 and 5, HSPA and its uplink and downlink are introduced. Enhanced and new features in WRAN are introduced, and some of the most significant of them are studied more closely in chapter 6. Subsections in chapter 6 concentrate on behavior of the network and how new parameters affect the network. Finally conclusions are drawn in chapter 7.

2 WCDMA-RAN OVERVIEW

UMTS (Universal Mobile Telecommunications System) is a 3rd Generation mobile network used in Europe. The UMTS includes RAN (Radio Access Network), CN (Core Network), transmission network and service network. RAN, also known as UTRAN (UMTS Terrestrial Radio Access Network), provides connection between CN and UE (User Equipment).

The radio access method used in UTRAN is called WCDMA (Wideband Code Division Multiple Access) where abbreviation WRAN used in Ericsson is derived from. The basic idea in WCDMA is that the users are separated by unique codes. This means that all users in WRAN can use the same frequency and transmit at the same time, which improves performance, capacity, end users´ experience and several other functions within the network. [1.]

WRAN and CN could be maintained and monitored through OSS-RC (Operation Service System - Radio & Core). The following subsections provide more detailed information about what the WRAN consists of.

2.1 Radio Access Network

WRAN consists of NEs (Network Element), such as RNC (Radio Network Controller), RBS (Radio Base Station) and a functionality called RANAG (Radio Access Network Aggregator) located in RBS or in RXI. According to figure 1 on page 4, **Iu** interfaces offer connections between network elements. OSS-RC and RAN are connected with the **Mu** and the **Uu** connects UEs to WRAN.

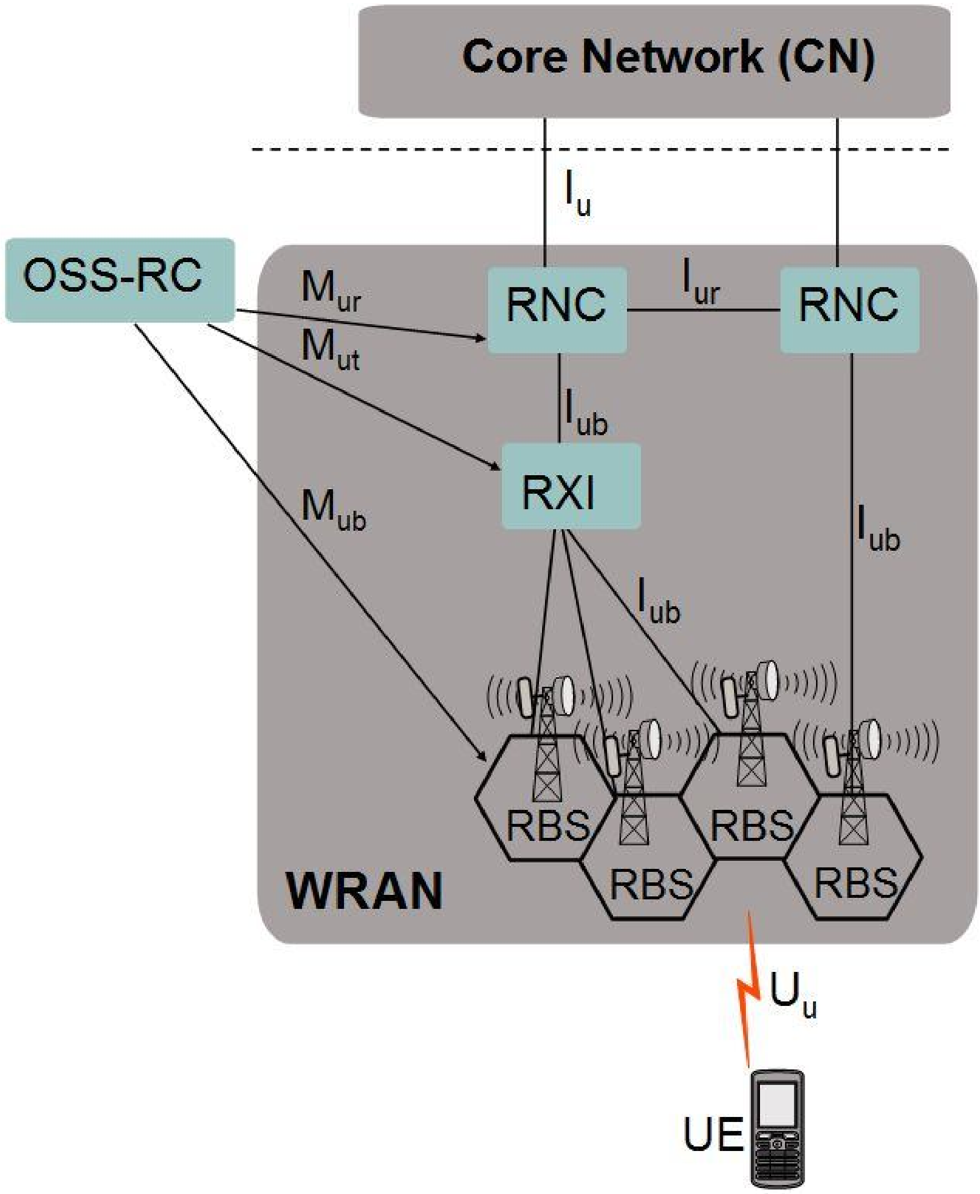

Figure 1. Structure of WRAN. Dash line separates on which area this Graduate Study is concentrating on.

The RAB (Radio Access Bearer), connection segment between UE and Core Network, is the main service offered by WRAN. RAB carries subscriber data through WRAN. The platform used in all WRAN nodes is the CPP (Cello Packet Platform). In figure 1, dash line separates on which area this graduate study is concentrating on, as it is shown the core network fall outside the scope of the graduate study.

2.2 Radio Network Controller

The RNC controls all functions in the WRAN. It operates via **Iu** interface between the CN and the WRAN. What makes a network a real network is the **Iur** interface. **Iur** interface connects two or more RNCs together so they can communicate with each other, thus increasing the capacity and enabling call handovers within the WRAN. RNCs also provide connections to other networks via CN.

RANAG

The RANAG is used as a hub within WRAN, enabling multiple RBS connected to RNC. RNC could have the RANAG function so it could be integrated in RNC or there can be a separated RANAG device called RXI, which aggregates all RBSs for the RNC as shown in figure 1 on page 4.

2.3 Radio Base Station

The RBS handles radio traffic and provides radio resources in **Uu** interface. It includes all physical devices needed, such as antennas and transmitters, enabling radio connection to UE. RBS is connected to RNC via **Iub** interface.

2.4 Interfaces

Interfaces describe how NEs, CN and OSS-RC are connected to each other. Moreover, interfaces are divided in two groups, internal and external. Internal interfaces are located inside WRAN and external interfaces connect WRAN with CN, UE and OSS-RC. All the interfaces are shown in figure 1 on page 4.

External interfaces of the WRAN include:

- **Iu**, interface connects WRAN to Core Network
- **Uu,** interface is the air interface between RBS and UE.

External interfaces from WRAN to OSS-RC include:

- **Mub**, interface from OSS-RC to RBS
- **Mut**, interface between OSS-RC and RXI
- **Mur**, interface between OSS-RC and RNC.

Internal interfaces of the WRAN include:

- **Iub**, interface is between RNC and RBS
- **Iur**, interface is between two or more RNC.

Later on, these interface abbreviations are used clarifying explanations.

2.5 Dual Stack

Dual Stack is a feature which was introduced in Ericsson P6.0 that makes IP (Internet Protocol) and ATM (Asynchronous Transfer Mode) routing possible on all the **Iu** interfaces in parallel. Now operators can use both ATM and IP transport between RNCs and RBS as figure 2 illustrates.

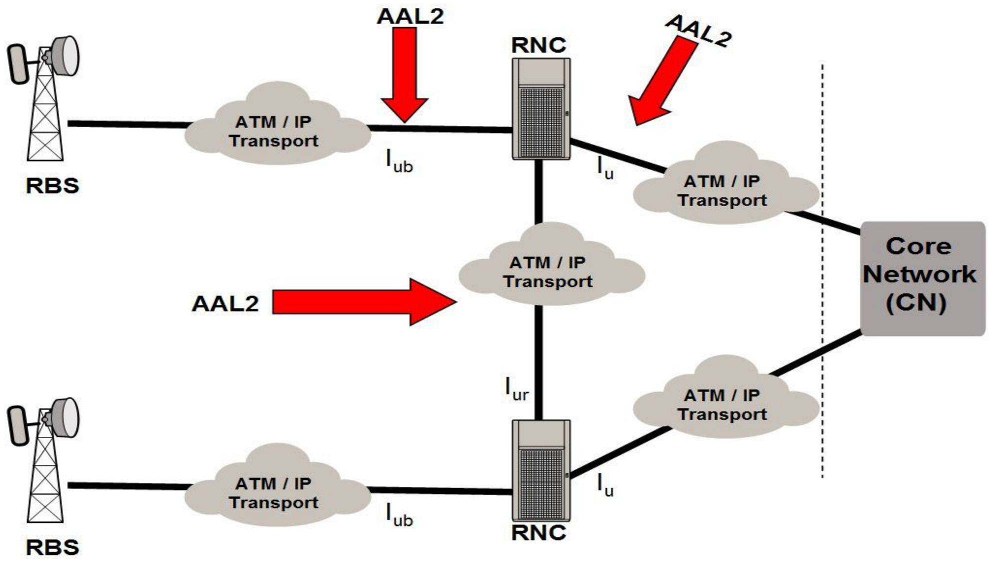

Figure 2. Dual Stack Transport and AAL2.

Dual Stack supported **Iu** interfaces are shown in figure 2. Dual Stack has to be activated in RBS and configured in RNC. The RAB is the one that makes decisions on which transport method is used. It is also possible to modify the transport technique in use between ATM and IP during transmission without any impact on ongoing traffic. During the IP transport, the data have been sent to network by using IPv4/IPv6 addressing and other IP transport based techniques. [2.]

AAL2 Transport

The AAL2 (ATM Adaptation Layer 2) is transport technology on radio network layer introduced by Ericsson in year 1995. The AAL2 protocol operates on a common ATM virtual channel connection between network elements, such as RBS and RNC, enabling several user connections to multiplex efficiently as shown in Dual Stack transport figure 2 on page 6. Figure 3 describes physical layer on **Iu** interface where the AAL2 is more clearly visible.

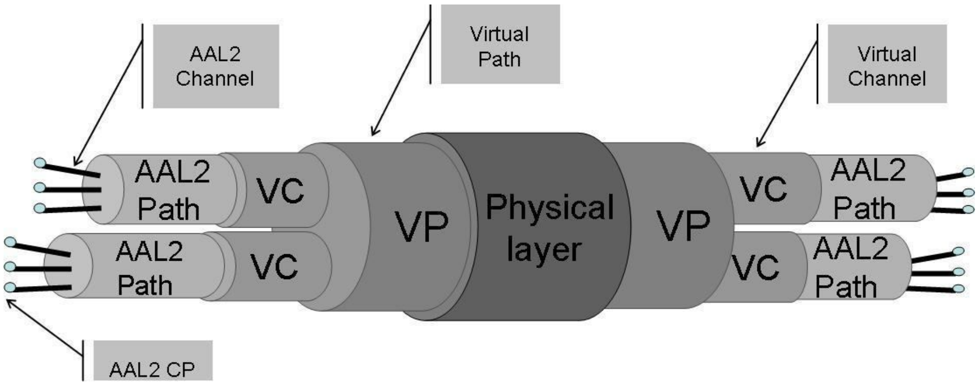

*Figure 3. The AAL2 **Iu** interface. [1.]*

Physical layer connection is imagined as an ATM VP (Virtual Path) in figure 3. This virtual path is a network layer, which has its own network topology and different VPs are distinguishable by VPI (Virtual Path Identifier). VP includes VCs (Virtual Channel), which can be identified with VCI (Virtual channel Identifier). The VCs have AAL2 paths. These AAL2 paths are divided in several AAL2 channels, and within the AAL2 channels, connection has been divided in AAL2 CPs (Connection Point), which is the deepest level in AAL2 transport technology. [3.]

2.6 OSS-RC

The WRAN is controlled by the OSS-RC. It supports operations and maintenance from 2G, 3G and other existing mobile networks, to upcoming mobile networks. OSS-RC makes it easier to get information from different network elements, such as RBS, RNC, and RXI. OSS-RC collects data from the MOs (Managed Object). MO is a database where all information concerning the network behavior is located and gathered. All information for used features and parameters are stored there. OSS-RC is mainly used by operators to monitoring their networks. [1.]

3 HSPA OVERVIEW

HSPA enables wireless broadband connections to mobile user equipment. It is a technique that makes the existing UMTS network to operate faster.

HSPA is divided in two separate technologies, downlink (HSDPA, chapter 4) and uplink (EUL, chapter 5). The HSDPA was introduced in 3GPP release 5, which was the first step towards faster networks. The next step was EUL, introduced in 3GPP release 6, which was complementary to high-performance packet data applications in HSDPA. [4.]

In Ericsson P6/P6 FP systems, the capacity is up to 14 Mbps in downlink direction and up to 5.8 Mbps in uplink direction. With Ericsson WRAN P7, operators can provide downlink speed to their customers up to 21-28 Mbps during the years 2008 and 2009 as figure 4 describes, and in future much more.

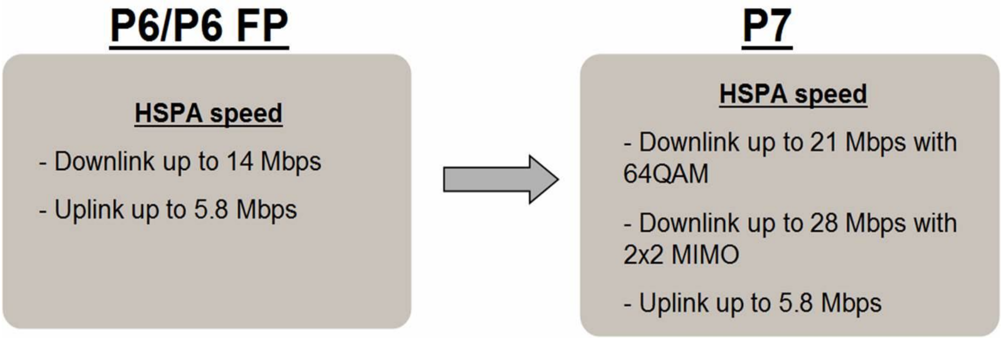

Figure 4. HSPA speed improvements from Ericsson WRAN P6/P6 FP to P7.

When comparing HSPA speed between Ericsson WRAN P6 and P7 in figure 4, in P7 HSPA the carrier efficiency is improved by using 64QAM (64 Quadrature Amplitude Modulation) modulation method, which increases theoretical capacity speed up to 21 Mbps in downlink direction. With the new antenna technique 2x2 MIMO (2x2 Multiple Input Multiple Output), HSPA is capable to increase theoretical capacity up to 28 Mbps. Uplink capacity speed is still 5.8 Mbps in P7 but EUL have been improved with some other features. Together these two techniques (HSDPA and EUL) improve traffic on cell edge and within a cell.

4 HIGH SPEED DOWNLINK PACKET ACCESS IN HSPA

HSDPA is a downlink, a link from RBS to user equipment, in HSPA system. The idea of HSDPA is to reduce round trip delays, increase peak data rate and improve uplink and downlink capacity and its speed in WRAN as figure 5 describes. For the end users, this is demonstrated as enhanced services and faster connections.

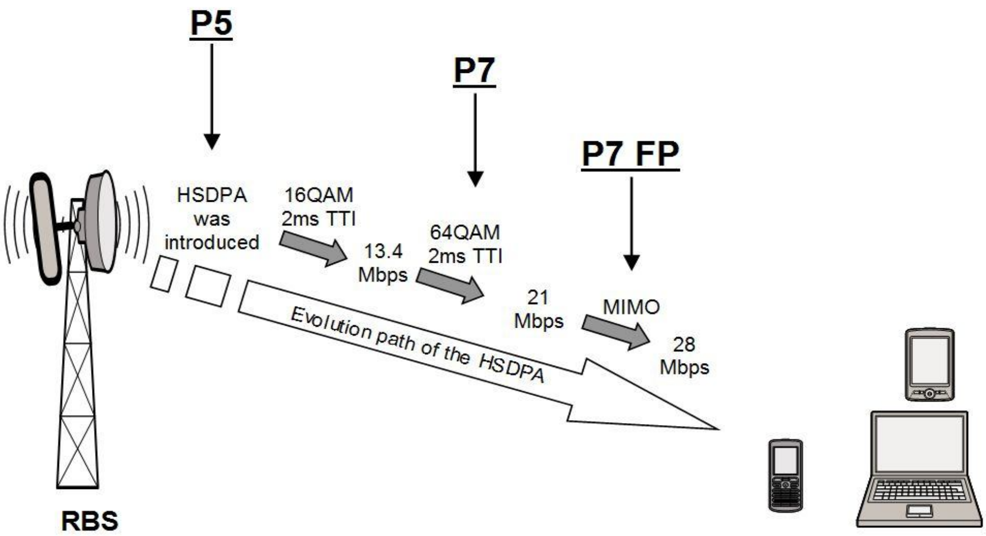

Figure 5. Evolution path of the downlink.

The capacity speed has been improved in HSDPA. When Ericsson P5 was introduced maximum downlink capacity speed was 13.4 Mbps. Now along with P7 features reachable capacity speed is 21 Mbps according to figure 5. HSDPA introduces improvements to WRAN for example a new transmission channel called HS-DSCH (High Speed - Downlink Shared Channel) and the new features in main principles, such as:

- Shared channel and multi-code transmission
- TTI (Short transmission time interval)
- Fast link adaptation
- HARQ (Fast Hybrid Automatic Repeat Request)
- Fast scheduling
- Higher-order modulation.

When creating a connection between RBS and UE all these features are needed. Since HSDPA use a lot of capacity when many users are simultaneously assigned to HS-DSCH transport channel, number of HSDPA users per cell is limited with admission control. So doing, when it is question about used service in cell, the HSDPA service is secondary and speech service is primary. Limiting HSDPA users per cell, sufficient services are guaranteed for all user equipments within a cell. More detailed information could be found in following subsections.

Shared channel and multi-code transmission

In shared channel transmission the radio resources, such as code space and power, are seen as a common resource that is dynamically shared among users within a cell during transmission. An example of how data traffic is handled with one or more users in the HS-DSCH of HSDPA is shown in figure 6. The fourth stack of blocks starting from left shows that the maximum number of the channelization codes is 15. [5; 6, p. 13.]

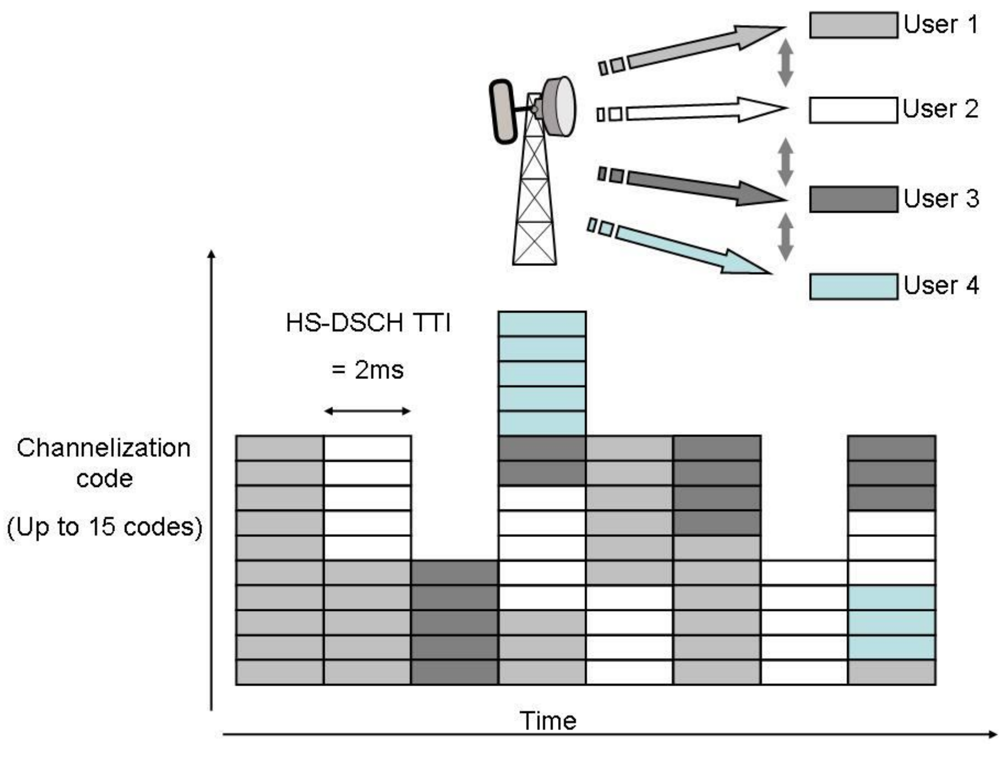

Figure 6. An example of how codes are dynamically allocated per TTI among users in the HS-DSCH. [Amended from reference 6.]

The upper part of the figure 6 illustrates RBS transmission variations among users within the cell. The lower part shows an example of how data resources in 2 ms TTI time frames have been dynamically shared among users. In the first 2 ms TTI time frame, reading from left to right, user 1 is receiving data from all the channelization codes. The second TTI time frame is divided e.g. between users 1 and 2. When looking at the fourth TTI time frame, all the channelization codes are in use and have been divided among the users 1, 2, 3, and 4.

Short TTI (Transmission Time Interval)

In the 3GPP release 5, the HSDPA has defined to use 2 ms short TTI in HS-DSCH as figure 7 describes. Generally it means that, the data sent on the transport channel, is compacted and sent to the radio interface in every 2 ms time interval. It reduces delay on the radio interface **Uu** by reducing RTTs (Round Trip Time). Shorter RTT improves tracking of variations in radio channels, which benefits also fast link adaptation, HARQ and fast scheduling. [5; 6, p. 13.]

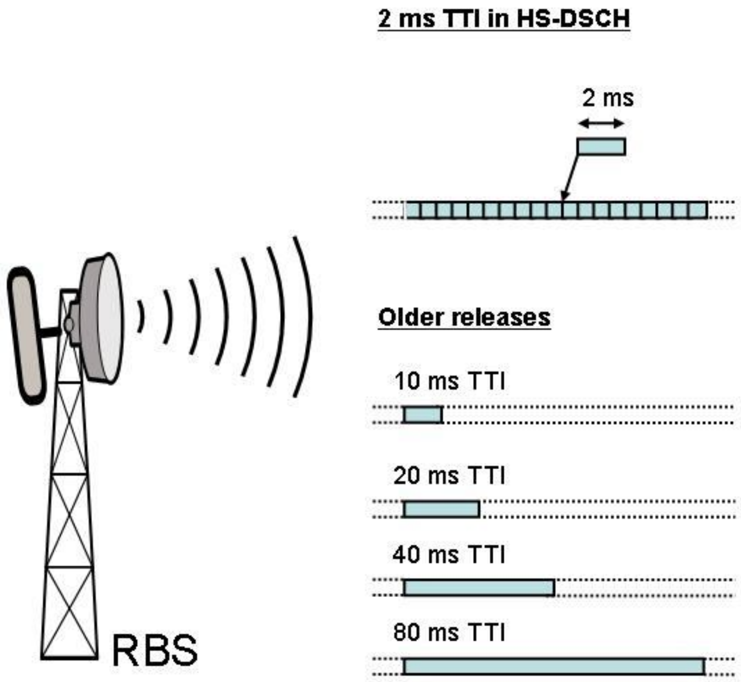

Figure 7. Comparison of the TTI time frames between older and newer versions.

Compared to older 3GPP releases in figure 7, on new HS-DSCH data have been sent to radio interface more often in 2 ms TTIs. Shorter TTIs enable faster networks.

Fast link adaptation

HSDPA uses fast link adaptation instead of power control, which makes downlink faster. The basic idea is to ensure similar service quality to all communication links, despite variations and differences in the radio channel conditions within the cell. In other words, the fast link adaptation adapts data rate to radio conditions. When scheduling and link adaptation decisions are taken every 2 ms TTI, fast link adaptation is capable of track rapid variations in the HS-DSCH channel. [5; 6, p. 17.]

Channel conditions define which one of the modulation methods is in use. When channel conditions permit the efficient modulation method, method up to the 64QAM can be used and unfavorable channel conditions offer lower data rate by using the QPSK modulation as figure 8 illustrates. Modulation methods used in the HSDPA are introduced in this chapter.

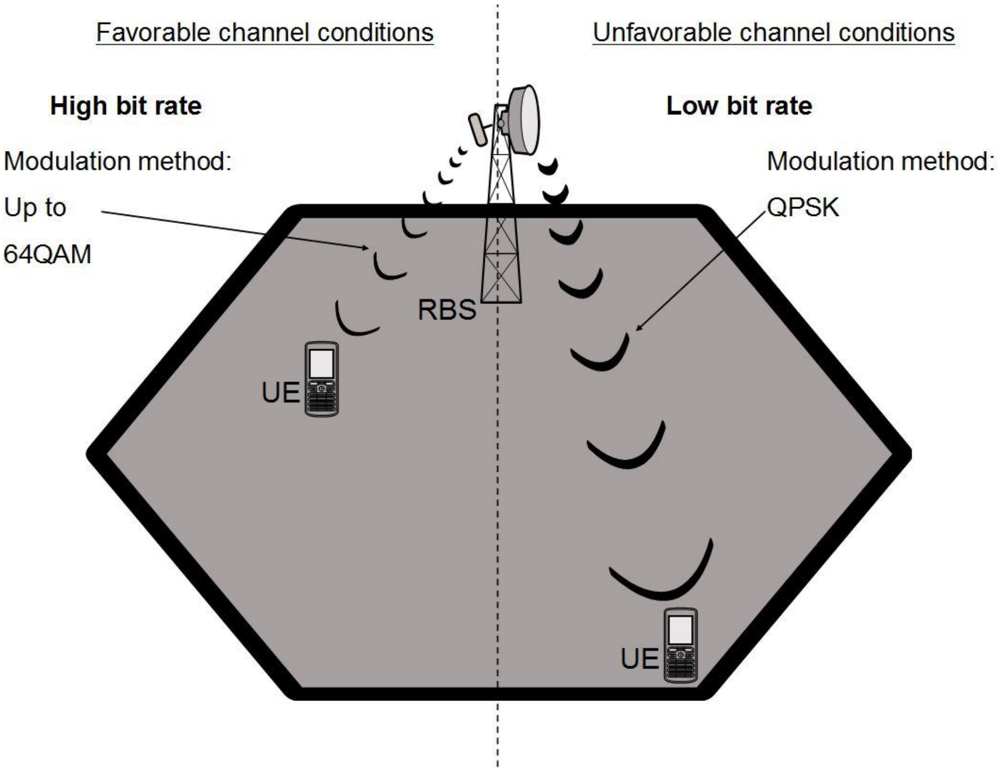

Figure 8. Fast link adaptation under favorable and unfavorable conditions.

Unfavorable channel conditions do not always come with longer distance to the RBS as figure 8 shows. Reason can be the multi-path fading depending on the speed or the blocks which come ones way of the user equipment. Other reasons can be distance-dependent path loss, location-dependent shadowing and variations in interference level, which depend on the position within the cell and the instantaneous activity of neighbour cells. [5; 6, p. 17.]

Fast link adaptation exploits the dynamic power allocation. This means that HS-DSCH adjusts the data rate to match instantaneous radio conditions and available transmission power in RBS by maximizing throughput in downlink. [5.]

HARQ

There can be many reasons why packet loss occurs during the transmission trough the radio interface. That is why the HARQ is needed to offer more robustness to the link adaptation leading to higher capacity and decreased delay. A demonstration of HARQ functionality when erroneous data occurs is shown in figure 9. [5; 6, p. 21.]

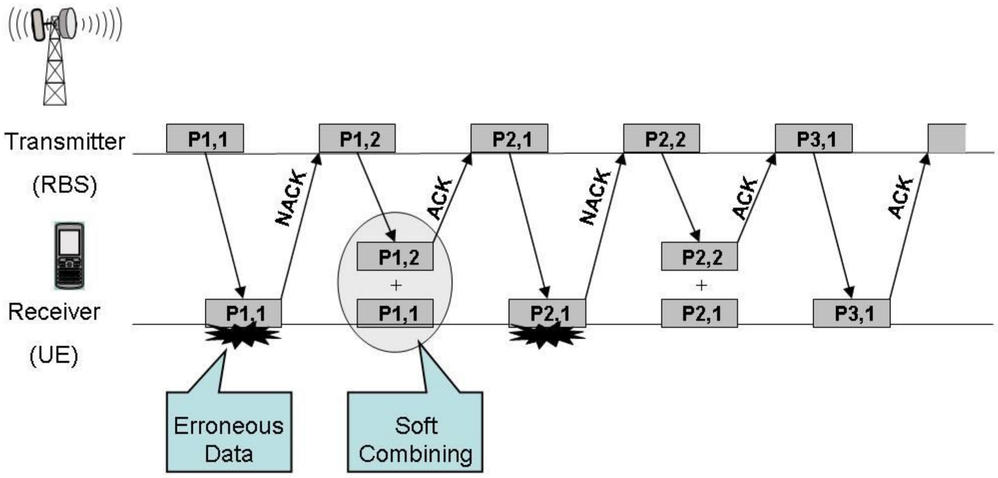

Figure 9. How to increase robustness with the Fast Hybrid ARQ. [Amended from reference 6, p. 43.]

According to figure 9, first data packet has been transmitted from RBS to UE. The UE receives the packet but there occurs an error. Now the UE sends NACK (Negative Acknowledgement) response to RBS. The RBS response to this NACK message by sending packets P1.1 and P1.2 to the UE. Two packets retransmission is called soft combining. Soft combining makes possible that the correct data packet, where had occurred an error, are not discarded. After receiving the soft combined data, UE sends ACK (Acknowledgement) to RBS and so on.

Fast scheduling

Fast scheduling defines to which UE the shared channel transmission should be directed at a certain moment from RBS. The data has been sent through the radio interface in 2ms TTIs as figure 10 on page 14 illustrates.

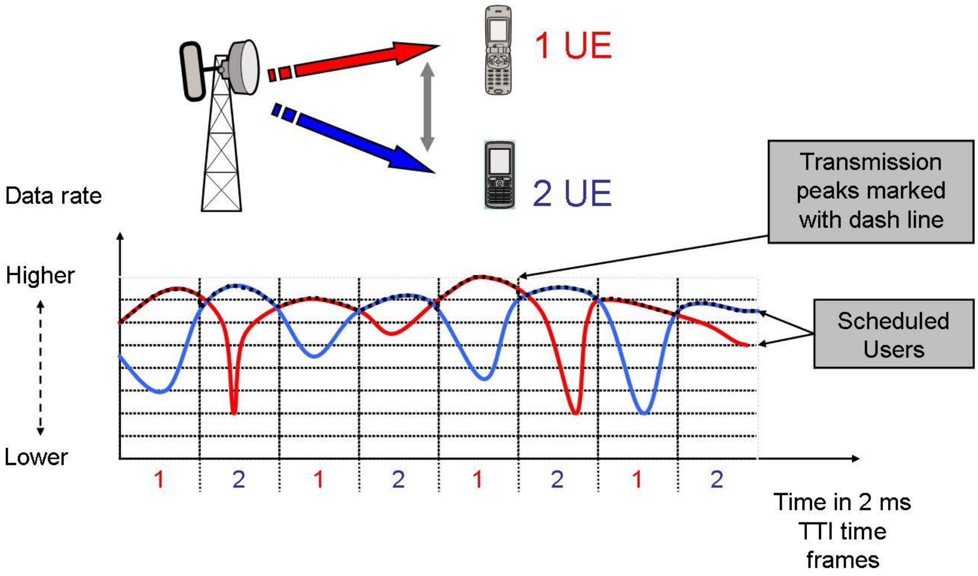

Figure 10.Illustration of the shared channel transmission with fast scheduling. [Amended from reference 6, p.19.]

The transmission peaks marked with dash line in figure 10 illustrates when the UE and which one of the UEs are receiving data. Fast scheduling enables to offer data more often to the UEs which in turn improve channel quality.

Higher-order modulation

Modulation means a known way to transmit digital data through the network by using radio waves. With modulation it is possible to represent variations in transmitted RF (Radio Frequency) signal between its properties. These properties which varied in RF carrier signal are:

- AM (Amplitude Modulation), where amplitude of carrier signal is varied
- PM (Phase Modulation), where phase of carrier signal is varied
- FM (Frequency Modulation), where frequency of carrier signal is varied.

There are different kinds of modulation methods in use. For example QPSK (Quadrature Phase Shift Keying), 16QAM (16 Quadrature Amplitude Modulation) and 64QAM are used by the HSDPA. The differences between these methods are that QPSK carries only two bits per each symbol when 16QAM carries four bits per each symbol. 64QAM in turn carries six bits per symbol. Constellation diagrams in figure 11 on page 15 graphically illustrate the quality and distortion of a digital signal.

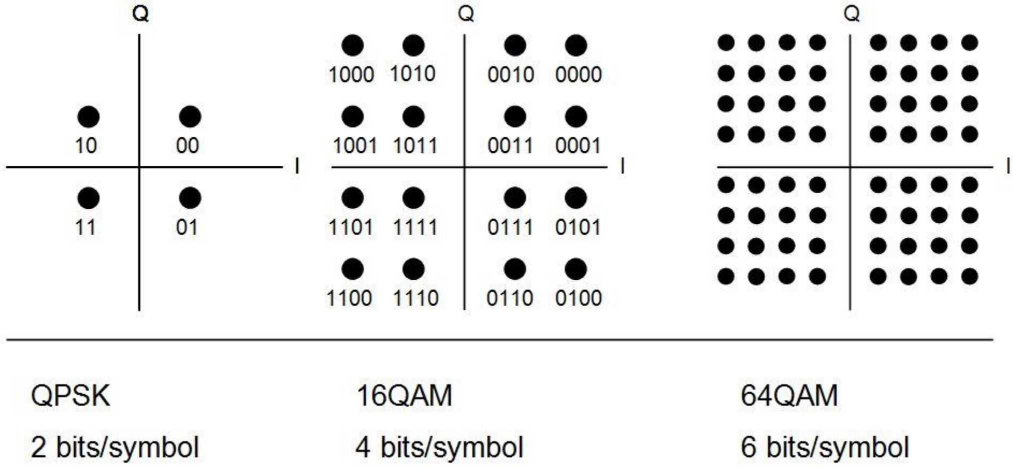

Figure 11. Constellation diagrams of modulation methods, such as QPSK, 16QAM and 64QAM. Modulation methods QPSK and 16QAM are shown with imagined order of binary numbers and in 64QAM there are shown symbols only. [Amended from reference 6.]

Benefits of different modulation methods are shown in figure 11. QPSK has only four symbols where all symbol can carry two bits whereas 16QAM has sixteen symbols and each symbol can carry four bits. This makes 16QAM faster than QPSK, but on the other hand, 16QAM needs better radio network conditions in order that the bits could be decoded correctly. [5.]

In Ericsson WRAN P7, the 64QAM is also introduced. It is faster than aforementioned modulation methods, because there are 64 symbols where each symbol carries six bits. This increase the peak bit rate. Only problem is that, when there is a lot of symbols so close each other in the constellation diagram, the code might be decoded incorrectly. [7.]

MAC-hs

Because of the HS-DSCH, new transport layer functionality in radio interface is introduced. This functionality is called MAC-hs (High Speed Medium Access Control), which is new MAC sublayer shown in figure 12 on page 16. According to ISO (International Organization for Standardization) standard, MAC layer transport data packets over shared network in data link layer of OSI (Open Systems Interconnection Basic Reference Model) model. For new features the MAC-hs is mandatory since the idea is to reduce the impact of HSDPA features to the existing radio interface protocol architecture. MAC-hs makes possible to achieve desired signaling speed for features in HSDPA, which was mentioned earlier. MAC-hs is located in RBS node. [5.]

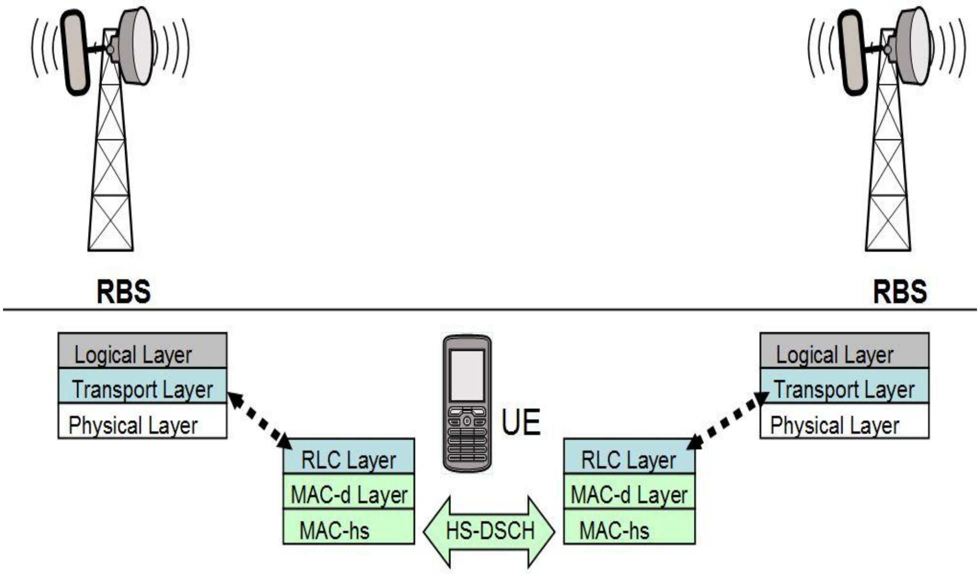

Figure 12. MAC-hs layer between RBSs.

Transmission between RBSs could be imagined in three layers to help understand where different kinds of functions take their place. Basic idea of logical layer, transport layer and physical layer and where MAC layer is positioned is illustrated in figure 12. In transport layer there are RLC (Radio Link Controller) layer and MAC layer. Under MAC-d (dedicated MAC) layer there is MAC-hs protocol, which operates between RBSs through the HS-DSCH channel. RLC layer operates between UE and RNC as it is shown in protocol architecture in figure 13.

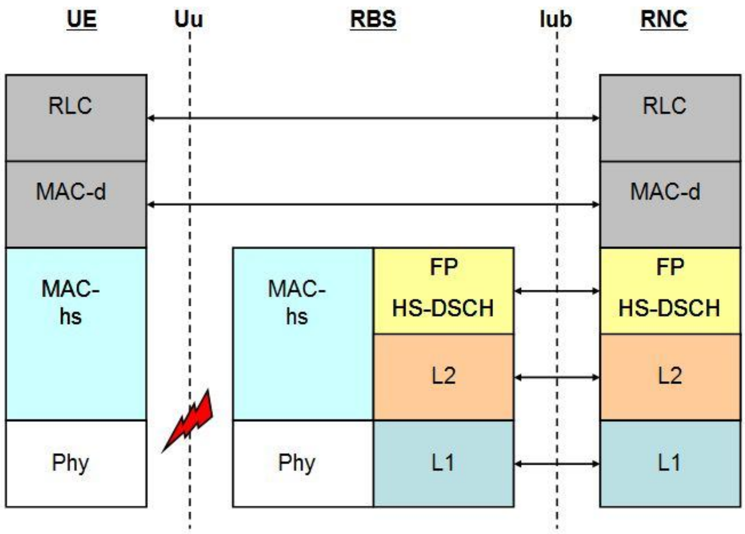

Figure 13. Protocol architecture of the transport layer. [Amended from reference 6, p. 51.]

The more detailed protocol architecture under RLC layer is described in figure 13 on page 16. There are shown which protocols are used in **Uu** and **Iub** interfaces between UE and RNC.

Channels in HSDPA

Transmission channel **HS-DSCH** is based on the shared channel transmission. It supports the use of higher order modulation which in turn allows higher peak data rate and increased capacity speed. **HS-DSCH** supports features, such as:

- Fast link adaptation
- Fast channel dependent scheduling
- Fast hybrid ARQ with soft combining.

New high speed channels introduced in HSDPA are:

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

Of the preceding channels, **A-DCH** is a new transmission channel, and the three other channels are physical channels. These channels are shown in figure 14 on page 18. [5; 6, p. 31 - 32.]

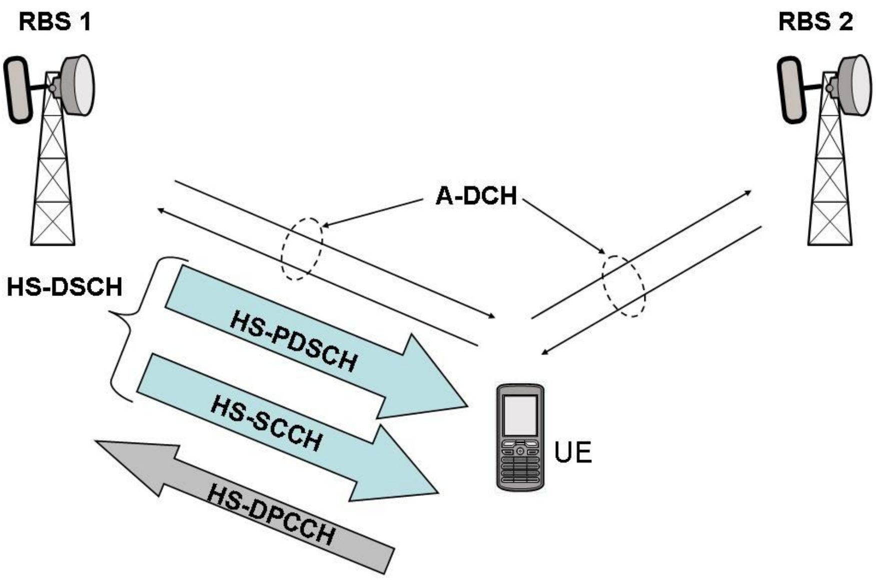

Figure 14. HSDPA Channels. [Amended from reference 6, p. 31.]

The **HS-DSCH** is transport channel which carries the user data between RBS and UE. **HS-DSCH** is divided in two channels, **HS-PDSCH** (High-Speed Physical Downlink Shared Channel) and **HS-SCCH** (High-Speed Physical Shared Control Channel) as shown in figure 14 on page 17. The **HS-PDSCH** channel is used to carry the user data and the overhead bits of the layer 2 over the radio interface. The **HS-SCCH** channel carries the control information how to decode and which user decodes the information on the **HS-PDSCH** channel. The **HS-DPCCH** is physical uplink channel, which is used in sending ACK/NACK messages and channel quality reports.

Each one of the connection has the **A-DCH** channels between RBS and UE allocated in the cell. The **A-DCH** channel is used for user data and control signaling of the layer 3. [6, p. 31.]

5 ENHANCED UPLINK IN HSPA

EUL is an uplink, a link from UE to RBS, in HSPA system. When WCDMA was introduced, it offered uplink speed up to 0.64 kbps proceeding step by step up to 0,384 Mbps. Nowadays, there is need to send bigger files from the user equipment to another, such as: send a pictures, videos or e-mails with attachments.

In Ericsson WRAN P5 release and 3GPP release 6, EUL was introduced. EUL bring along new transport channel E-DCH (Enhanced Dedicated Channel). Transport channel makes it possible to reduce delays, increase capacity and data rates.

EUL improves uplink speed by reducing TTI to 2 ms, offering peak data rate up to 5.8 Mbps as shown in figure 15. By using shorter TTI, latency could be reduced, and it becomes possible to create faster interactive connections what network services require these days. When modulation method is changed to 16QAM, it is possible to reach uplink speed up to 12 Mbps. And in the future releases with other techniques it could be imagined how fast uplink could be.

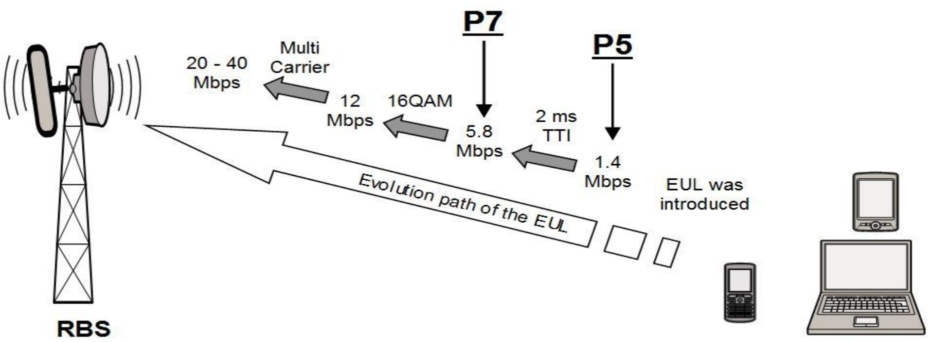

Figure 15. Evolution path of the uplink.

Traffic capacity speed is enhanced in EUL during past few years and it is going to increase in future as figure 15 illustrates. Features which provide capacity enhancement for EUL are:

- Short TTI
- Multi Code Transmission
- Fast Scheduling
- Fast HARQ.

Short TTI

In EUL it is possible to use 2 ms or 10 ms TTI, depending on the radio conditions. Short TTI reduce latency in the uplink which improve traffic speed in the network. When traffic is faster, it helps other features to adapt rapidly. This impacts to the downlink direction as well. For further information see chapter 4.

Multi Code Transmission

Unlike in HSDPA, EUL dedicate its new uplink channel to a single user and it is not shared between other users. It is possible to use up to four codes to increase capacity in the uplink. [8; 9.]

Fast Scheduling

Fast scheduling defines to which UE shared channel transmission should be directed to, by exploiting the burst in packet data transmissions. In earlier releases these decisions was made in RNC but now with EUL, decisions are made in RBS. The principal reasons for this are, to use air interference more efficiently and provide enough capacity for QoS (Quality of Service). Fast scheduling operates between RBSs. [8; 9.]

Fast HARQ

In EUL, fast HARQ works in a same way it does in HSDPA, as told in chapter 4. With HARQ, RBS can rapidly request retransmissions when error occurs during data transmission by using soft combining. This increase robustness and reduce retransmission delays which benefits other features to operate efficiently. Fast HARQ operates between RBSs. [8; 9.]

New Channels in EUL

EUL has been divided in uplink and downlink and there are also new channels introduced, such as:

- **E-DCH**, Enhanced Dedicated Channel
- **E-DPDCH**, E-DCH Dedicated Physical Data Channel
- **E-DPCCH**, E-DCH Dedicated Physical Control Channel
- **E-AGCH**, E-DCH Absolute Grant Channel
- **E-RGCH**, E-DCH Relative Grant Channel
- **EHICH**, E-DCH HARQ Information Channel.

Two of aforementioned channels are for transport and three are for the signaling. These channels are introduced in figure 16.

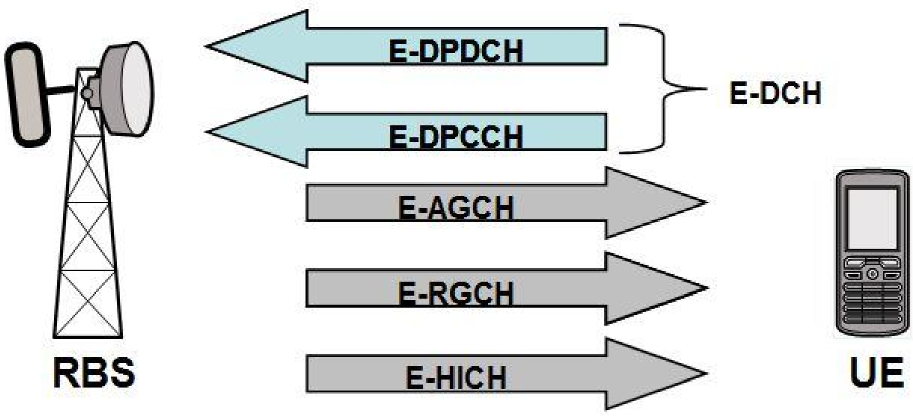

Figure 16. New channels in EUL. [Amended from reference 19.]

Transport channel **E-DCH** consists of data and control channels. E-DCH channels constitute the uplink in EUL and other channels constitute the downlink as shown in figure 16. In uplink, the **E-DPDCH** carries the user data and the **E-DPCCH** carries control information between MAC layers. EUL downlink channels take care of **E-DCH** signaling e.g. user identifying, rate selection and HARQ acknowledgements. [19.]

6 FEATURES AND PARAMETERS IN ERICSSON WRAN P7

There are many kinds of networks which are defined by their different features. Features in turn define the services that the network offers. These features consist of parameters. Parameters are variables and basically define the network functionality. With parameters, it is possible to optimize the network to work in a certain way by tuning them. There are a hundreds of different kinds of parameters whose impacts have to be known before making any changes in the network. A small modification can have huge impacts. In the 3GPP specifications could be found the definitions of the parameters for different releases. According to these definitions, network designers, such as Ericsson, supply systems and services to the network

MoSHell, Network Management

MoShell is a text-based Network Element Manager for Ericsson Cello Nodes, such as RNC, RBS, RXI and MGW (Media Gate Way) in UMTS network. In WRAN, MoSHell is used for radio network monitoring, troubleshooting, integrating, upgrading and tuning.

MoShell gathers up its data from MOs (Managed Object) which includes all the information of the network. There is a simple example how to check MO class of the known parameter in figure 17. Later on, parameters are introduced with their MO classes. [12.]

```
RNCXX> mom . maxMacdPduSizeExtended

081028-11:01:08 rncXX 7.1 RNC_NODE_MODEL_K_9_5 stopfile=/tmp/1700

####################################################################################################
MO Class              Attribute                        Type                             Flags
####################################################################################################
IurLink               maxMacdPduSizeExtended           long
----------------------------------------------------------------------------------------------------
Maximum size of flexible MAC-d PDUs used by the Enhanced Layer 2 feature.
Dependencies: The MAC-d PDU will have the maximum length defined by the minimum of the parameter and the
system value for the RAB. Setting this parameter to a value smaller than the default value can be useful
for multi vendor interoperability.
Unit: bytes
Change takes effect: New connections
Range: 1 to 1504, Default=1504
****************************************************************************************************
```

Figure 17. An example of how to check a MO class via MoShell.

When command "**mom . maxMacdPduSizeExtended**" for parameter check have been typed in MoSHell, the output is like in figure 17. Output shows about parameter MO class and other important information with short description of the parameter itself.

7 CONCLUSIONS

The main goal of the study was to introduce the basics of Ericsson WRAN and new features with their benefits along with Ericsson P7. The study works as a guide to WRAN for the new employees in Ericsson and for the experienced employees, as a reference bank to locate Ericsson and 3GPP documentation, which comes with the new features in Ericsson P7 system.

The study introduces the HSPA techniques of Ericsson`s WRAN in downlink (HSDPA) and in uplink (EUL) with their new features. All new and enhanced features in Ericsson P7 are listed with a short description of the function of the feature. The essential features are introduced in more detail with their parameters.

Benefits that the end user can experience with the new features in Ericsson P7 are significant. Before the study was started, it was possible to achieve mobile connection speed up to 13.5 Mbps in downlink, considering that user equipment corresponds to 3GPP standards. Based on this study it can be concluded that, with the help of EL2 feature, the 64QAM can be taken in use by offering connection speeds up to 21 Mbps, at least in theory. In real life, when radio conditions are favorable and user equipment is nearly plugged with cable into the RBS, there might be a chance to get close to these speeds. When 2 ms TTI is used in the EUL, speed is increased up to 5.8 Mbps, by offering possibility to faster interactive user services.

Initially, documentation regarding to the new P7 system was hard to locate and the detailed information was hard to find since everything was shattered in different databases. When it was time to release P7, documents became available and it was easier to do the research. Because it was not possible to test P7 software in Ericsson GSDC Finland, the study was mainly theoretical based on 3GPP standards and Ericsson documentation and network material. Some parameters in the enhanced features were found from P6.1 but most of the parameters were introduced along with new features.

As a result of the study, an information package was compiled for Ericsson internal use, including concise information of new features and their parameters in Ericsson WRAN P7 collected from several databases. In the future new releases of Ericsson WRAN are coming out. By introducing new techniques and features, these releases improve newest existing networks.

When the time comes, it is needed to create similar kind of document to get familiar with new improvements in a user-friendly way. For the writer, there were and there still are, a lot of new things to learn about the radio networks.

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