

Cutting Edge Technologies

2008 / 2009



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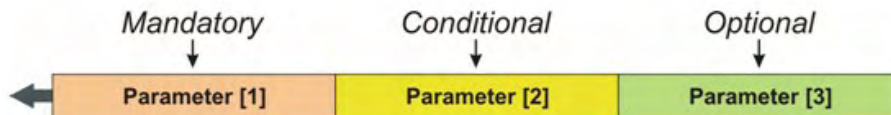
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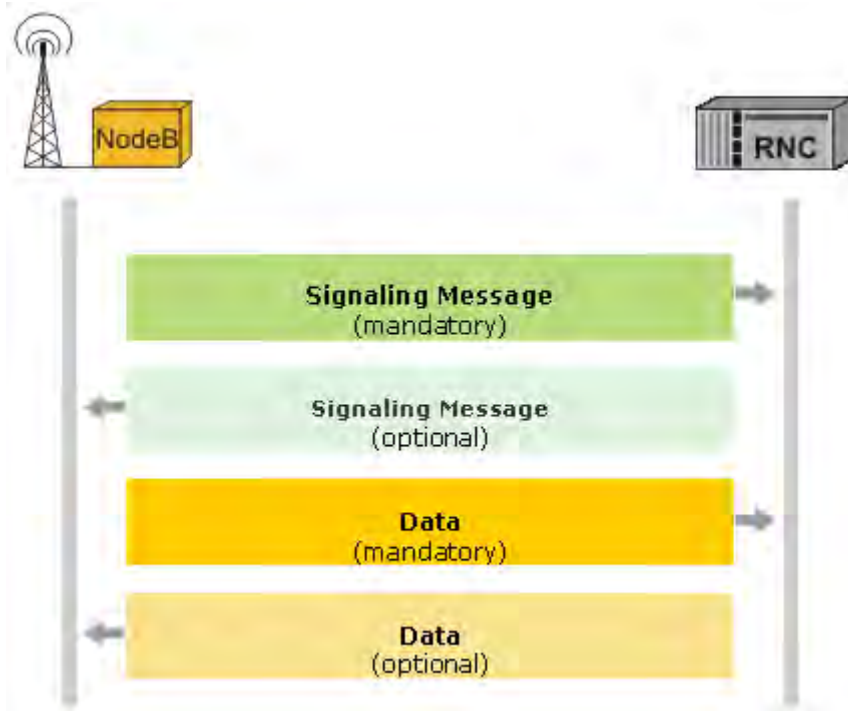
Legend:

All INACON publications use the same color codes to distinguish mandatory from optional or conditional parts in frame formats or optional from mandatory data blocks or signaling messages in scenarios. The different color codes are explained underneath:

- **Color Codes in Frame Formats:**



- **Color Codes in Scenarios:**



Foreword of the Publisher:

Dear Reader:

Note that this book is primarily a training document because the primary business of INACON GmbH is the training and consulting market for mobile communications. As such, we are proud to providing high-end training courses to many clients worldwide, among them operators like Chungwa Telecom in Taiwan, INMARSAT, SWISSCOM or T-MOBILE and equipment suppliers like ALCATEL-LUCENT, ERICSSON and SONY-ERICSSON, MOTOROLA, NOKIA-SIEMENS and RIM.

INACON GmbH is not one of the old-fashioned publishers. With respect to time-to-market, form-factor, homogeneous quality over all books and most importantly with respect to after-sales support, INACON GmbH is moving into a new direction. Therefore, INACON GmbH does not leave you alone with your issues and this book but we offer you to contact the author directly through e-mail (inacon@inacon.de), if you have any questions. All our authors are employees of INACON GmbH and all of them are proven experts in their area with usually many years of practical experience.

The most important assets and features of the book in front of you are:

- **Extreme degree of detailed information about a certain technology.**
- **Extensive and detailed index to allow instant access to information about virtually every parameter, timer and detail of this technology.**
- **Incorporation of several practical exercises.**
- **If applicable, incorporation of examples from our practical field experiences and real life recordings.**
- **References to the respective standards and recommendations on virtually every page.**

Finally, we again like to congratulate you to the purchase of this book and we like to wish you success in using it during your daily work.

Sincerely,



Gunnar Heine / President & CEO of INACON GmbH

Table of Content

Observable Trends & Latest News.....	1
1.1 Current Trends.....	2
1.1.1 Trends within the Domain of the CPE.....	2
1.1.1.1 The i-Phone.....	2
1.1.1.2 Google's Android.....	2
1.1.1.3 The OpenMoko Projcet and the NEO 1973.....	2
1.1.2 Trends within the Domain of the Access Network.....	4
1.1.2.1 WiMAX gains Momentum.....	4
1.1.2.2 Femto Cell Deployment.....	4
1.1.2.3 Access Network Sharing.....	4
1.1.2.4 Municipal Networks.....	4
1.1.2.5 Progress of LTE.....	4
1.1.2.6 GERAN evolves to the next Generation.....	4
1.1.2.7 HSDPA and HSUPA emerge to HSPA+.....	4
1.1.3 Trends within the Application Domain.....	6
1.1.3.1 The Dominance of Voice.....	6
1.1.3.2 Messaging.....	6
1.1.3.3 Mobile Internet.....	6
1.1.3.4 Mobile Payment.....	6
1.1.3.5 Mobile TV / IP-TV.....	6
1.1.4 Trends within the Domain of the Backbone and the ASP.....	8
1.1.4.1 Google & Co enter the Market.....	8
1.1.4.2 IMS comes slowly.....	8
1.1.4.3 Everything becomes IP-centric.....	8
1.2 Latest News	10
1.2.1 Sprint's WiMAX Rollout.....	10
1.2.1.1 Background Information & Interpretation.....	10
1.2.1.2 Conclusions.....	11
1.2.2 The Illusion of free Internet Access.....	12
1.2.2.1 Background Information & Interpretation.....	12
1.2.3 Unlicensed Mobile Access / Generic Access.....	14
1.2.3.1 Background Information & Interpretation.....	14
1.2.3.2 Alternative FMC-Offering.....	15
1.2.4 DVB-H, MBMS and IP-TV.....	16
1.2.4.1 Background Information.....	16
1.2.4.2 Issues.....	18
1.2.4.2.1 Unclear Value Chain and Scarce Resources.....	18
1.2.4.2.2 Legal Restrictions and IPR.....	18
1.2.4.2.3 Handset Liabilities and Screen Size.....	18
1.2.5 The i-Phone.....	20
1.2.5.1 Background Information & Interpretation.....	20
1.2.5.2 Conclusions.....	21

1.2.6 Google and the Android.....	22
1.2.6.1 Background Information & Interpretation.....	22
1.2.6.2 Conclusions.....	24
1.2.7 The OpenMoko Project.....	26
1.2.7.1 Background Information & Interpretation.....	26
1.2.8 RFID in the Mobile Environment.....	28
1.3 The Value Chains in Telecommunication	30
1.3.1 ... today	30
1.3.1.1 Telecom Operator.....	32
1.3.1.2 Unrelated Services.....	32
1.3.1.3 Money Streams.....	32
1.3.2 ... and tomorrow.....	34
1.3.2.1 Split of the Telecom Operator.....	36
1.3.2.2 New Role of "Content / Services" Domain.....	36
1.3.2.3 Money Streams.....	36
1.4 Standardization Committees	38
1.4.1 ... to be observed.....	38
1.4.1.1 3GPP.....	38
1.4.1.2 IEEE.....	38
1.4.1.3 IETF.....	40
1.4.1.4 NGMN.....	40
1.4.1.5 OMA.....	40
1.4.1.6 WiMAX-Forum.....	40
1.4.2 ... that loose Importance.....	42
1.4.2.1 3GPP2.....	42
1.4.2.2 ITU-T.....	42
1.4.2.3 ETSI.....	43
1.4.2.4 ANSI.....	43
1.4.2.5 CDG.....	43
Shaping & Defining 4G.....	45
2.1 Characteristics and Properties of 4G-Systems.....	46
2.1.1 Criteria Part 1: Performance, Services and Mobility Management	46
2.1.2 Criteria Part 2: Architectural Characteristics.....	48
2.1.3 Criteria Part 3: Procedural and Radio related Characteristics...50	
2.2 On the Way to 4G.....	52
2.2.1 Technology Overview.....	52

2.3 Protocol Stack Comparison 3G / 4G at the CPE.....	54
2.3.1 Details of the 4G-Protocol Stack.....	55
2.3.2 What makes SIP so appealing?.....	56
2.3.2.1 Introduction and Overview.....	56
2.3.2.2 Conclusions.....	57
2.4 Shaping the Target Network Architecture.....	58
2.4.1 Operation within this Environment.....	58
Applications & Services.....	61
3.1 Potentially Important Applications	62
3.1.1 Voice, Voice, Voice	63
3.1.2 e-learning and e-conferencing.....	64
3.1.3 Mobile Payment.....	64
3.1.4 Mobile Gaming.....	64
3.1.5 Mobile TV.....	64
3.1.6 Plain Video Conferencing.....	65
3.2 ... and their Technical Realization (Examples).....	66
3.2.1 E-Learning and E-Conferencing.....	66
3.2.1.1 Conclusions.....	66
3.2.2 IP-TV.....	68
3.2.2.1 Conclusions.....	68
3.2.3 Mobile Payment.....	70
3.2.2.1 Conclusions.....	70
Access Network News.....	73
4.1 Most Important Assets of GERAN with Release 7.....	74
4.1.1 EGPRS2.....	74
4.1.2 Multicarrier Operation.....	75
4.1.3 Reduced Latency Operation.....	75
4.2 Moving on to HSPA+.....	76
4.2.1 Most Important Assets of HSPA+.....	76
4.2.1 Use of MIMO.....	76
4.2.2 New Modulation Schemes.....	76
4.2.3 Advanced Operation.....	76

4.3 Most Important Assets of WiMAX and WiMAX 2.0.....	78
4.3.1 General.....	78
4.3.2 Performance.....	79
4.3.3 Physical Layer.....	79
4.3.4 Network Architecture.....	80
4.3.4.1 Split into ASN and CSN.....	80
4.3.4.2 ASN-Sharing is imperative.....	81
4.3.4.3 BS layout not standardized.....	81
4.4 Most Important Assets of LTE.....	82
4.4.1 Performance.....	82
4.4.2 Physical Layer.....	83
4.4.3 Network Architecture (SAE).....	84
4.5 MIMO demystified.....	86
4.5.1 The Basics: Signal Fading Physics between TX and RX.....	86
4.5.1.1 Scattering.....	87
4.5.1.2 Refraction.....	87
4.5.1.3 Reflection.....	87
4.5.1.4 Diffraction.....	87
4.5.2 Multiplexing Dimensions.....	88
4.5.3 The Multipath Dimension.....	90
4.5.3.1 Detailed Description.....	90
4.5.3.2 Macro- and Micro-Diversity.....	91
4.5.3.1 Zoom into RX1.....	92
4.5.4 And finally: Application in MIMO-Systems.....	94
4.5.4.1 Adding Receive Diversity.....	94
4.5.4.2 Implementation Options.....	96
4.5.4.3 Diversity Combining to improve Quality.....	96
Conclusions & Lessons Learned.....	97
5.1 Conclusions & Lessons Learned.....	98
5.1.1 Conclusions and	98
5.1.2 ... Lessons Learned.....	100

Chapter 1:

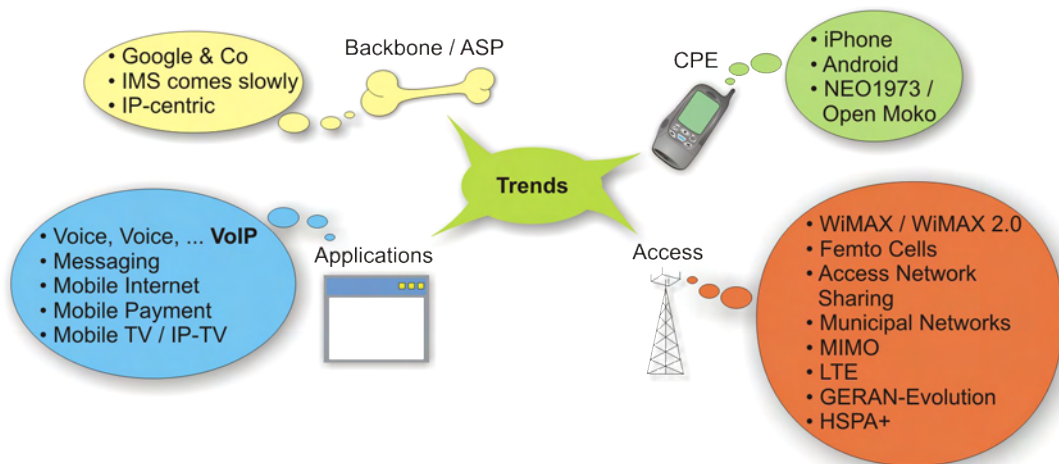
Observable Trends & Latest News

Objectives

Some of your questions that will be answered during this session...

- **Which trends are currently visible in the field of mobile telecommunication?**
- **What are the most recent news about previously announced hypes and technical developments?**
- **Into which direction will mobile telecommunication most likely evolve?**
- **What will be the value chains of tomorrow's mobile networks?**
- **Which standardization committees like 3GPP or OMA will orchestrate tomorrow's mobile telecommunication environment?**
And which ones will not?

1.1 Current Trends



The objective of this section is to introduce the student into the latest trends within the various domains of mobile communications.

Image Description

- The image illustrates in its four angles the different domains of mobile communication.
- Inside the related bubbles, the trend headlines are depicted.

1.1.1 Trends within the Domain of the CPE

1.1.1.2 The i-Phone

- The i-Phone is attracting a lot of attention and reveals the users' interest in high end CPE's with easy to use and easy to access multimedia capabilities.
- Very interesting is the fact that similar CPE's using various different operating systems are on the market already since quite some time but lack broader customer acceptance.

1.1.1.3 Google's Android

- The G-phone is actually a software platform that offers developers the opportunity to design applications on top.
- Google and the other supporters of the Android system hope to prosper from the trend of mobile Internet.

1.1.1.4 The OpenMoko Project and the NEO 1973

- Another remarkable global trend starts affecting the mobile environment: It is the trend of free, open software.

- Open-source software is license-free and becomes more and more important on the standard computer market.
- The Internet is the fundament that enables the open-source community that now also reaches for the mobile environment.
- In that respect, the OpenMoko project is the farthest advanced (which may change due to the Android project).
- The OpenMoko-project is based on a hardware (telephone) that stems from the Taiwanese manufacturer FIC (First International Computers). We will present a photo of the device shortly afterwards.

Legacy mobile phone vendors may be in trouble because of the open-source trend on the mobile market. But history never repeats unchanged...



- **Abbreviations of this Section:**

AN	Access Network	IP	Internet Protocol (RFC 791)
ASP	Application Server Provider	LTE	Long Term Evolution (of UMTS)
CPE	Customer Premises Equipment	MIMO	Multiple In / Multiple Out (antenna system)
GERAN	GSM EDGE Radio Access Network	TV	Television
HSPA	High Speed Packet Access (operation of HSDPA and HSUPA)	VoIP	Voice over IP
HSPA+	Enhanced High Speed Packet Access (operation of enhanced HSDPA and enhanced HSUPA)	WiMAX	Worldwide Interoperability for Microwave Access (IEEE 802.16)
IMS	Internet Protocol Multimedia Core Network Subsystem (Rel. 5 onwards)		

1.2.6 Google and the Android



ANDROID

Open Platform for Mobile Devices

Google Inc., T-Mobile, HTC, Qualcomm, Motorola and others have collaborated on the development of Android through the Open Handset Alliance. By providing developers a new level of openness that enables them to work more collaboratively, Android will accelerate the pace at which new and compelling mobile services are made available to consumers.

The Android platform is the first step to a fully integrated mobile "software stack" that consists of an operating system, middleware, user-friendly interface and applications. The first Android based phones should be available Q3 - Q4 of 2008.



Graphic: <http://www.tomshw.it>

Source: http://www.google.com/intl/en/press/pressrel/20071105_mobile_open.html



The objectives of this section are to discuss the Android platform and to present the goals of the *Open Handset Alliance*.

1.2.6.1 Background Information & Interpretation

- Just a few months ago, the so called G-Phone (for Google) proved to be different from the i-Phone approach.
- While the i-Phone "only" marked the entry of a new competitor into the arena of mobile handsets, the G-Phone or rather the Android-system turns out to offer more potential on one hand and poses more threats for legacy mobile handset vendors on the other hand.

- The ideas of the Android-system or platform is steered to a large degree by Google which focuses the joined efforts under the umbrella of the *Open Handset Alliance* (<http://www.openhandsetalliance.com/>).

The basic underlying ideas of the Open Handset Alliance are:

- **Use of an open source (Linux) operating system**
- **Provision of a free-of-charge SDK to the developers' community**
To develop applications on top of the operating system.
- **Platform (modem) independence**

Room for your Notes:

- **Abbreviations of this Section:**

HTC	High Tech Computer Corporation	SDK	Software Development Kit
------------	--------------------------------	------------	--------------------------

1.2.6.2 Conclusions

- Android inherits and re-uses the idea of "Open Source" software and platform independence from the computer market.
- I am reminded of the old days when personal and home computers were as different as mobile phones (modems) are today.



The business model of Android appears to be the crucial issue for its success:

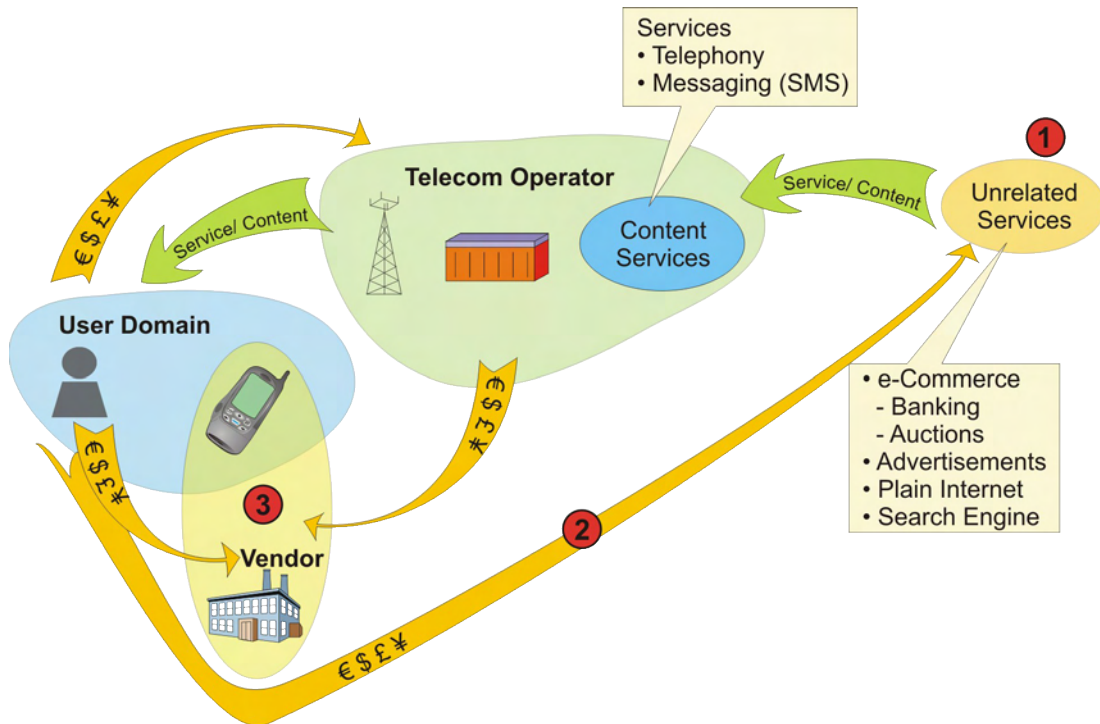
Which revenue justifies the development effort of software applications running on the Android platform?

- The answer to that question was simple for the computer: People had to purchase the software running on generic hardware and operating systems.
- The answer to the same question for the Android is much more difficult to find, esp. in an environment of free open-source software.
- Perhaps, only those applications that are related to the so called "Unrelated Services" (see section 1.3.2) can be commercially viable as they are charged for through different channels.
- Typical examples are advertisements or e-banking software that is sponsored by a bank.

Room for your Notes:

1.3 The Value Chains in Telecommunication ...

1.3.1 ... today ...



The objective of this section is to illustrate the value chains of services and the related payments that are typical for today.



Key point of this section is the dominating position of the telecom operator which is due to the following main reasons:

1. Providing the only means of connectivity/access between user and services.
2. The telecom operator being and controlling the main source of services towards the user.

Image Description

- The image is based on the horizontal axis consisting of the user domain and the telecom operator's domain.
- The green arrows indicate the way that services take to be delivered to the end user. The yellow arrows depict the related money streams.

1.3.1.1 Telecom Operator

- The main services telephony and messaging are provided by the telecom operator and to the user.

1.3.1.2 Unrelated Services

1

- Important for the future considerations is the fact that (so called) unrelated services are also delivered the same way through the network operator's network to the user.
- Unrelated services are Internet services of any kind like access to e-commerce, database accesses (e.g. Wikipedia) or advertisement provision to the mobile user which typically occurs non-voluntary, unsolicited and implicit.

1.3.1.3 Money Streams

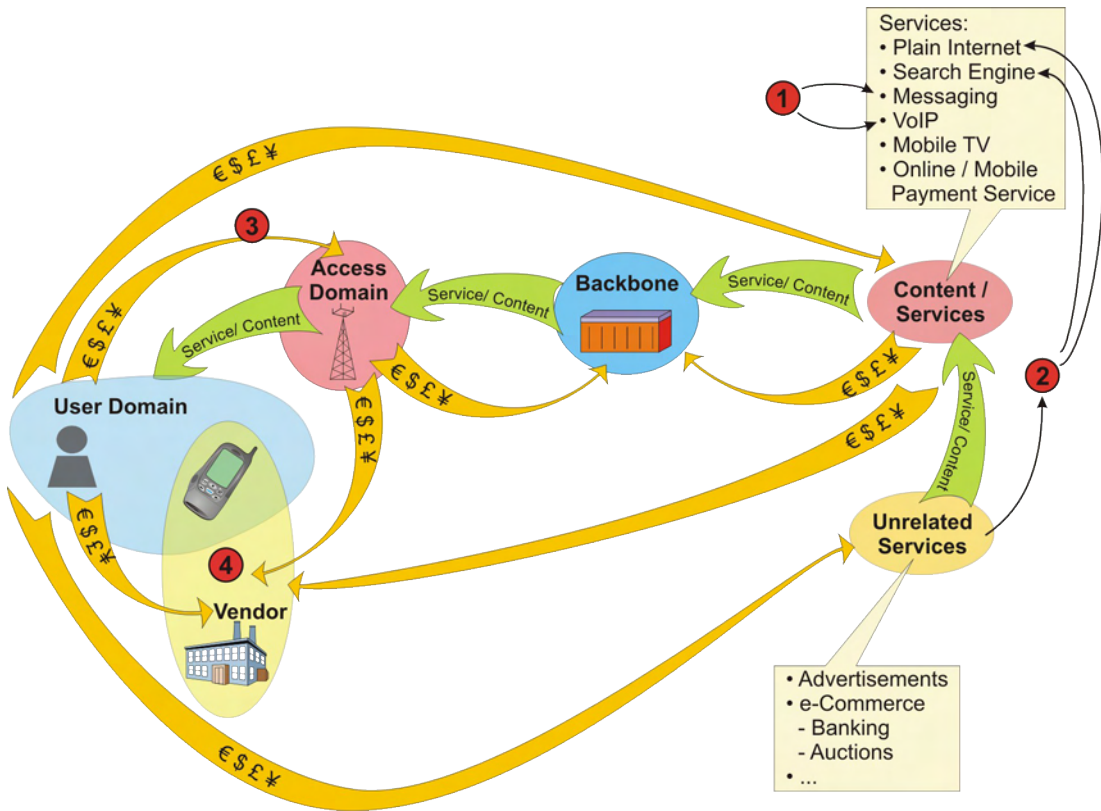
2

- It is essential to recognize the money stream from the user to the unrelated services domain.
- The term "unrelated" means that these services are out of scope and out of control of the telecom operator.
- This money stream represents all revenue that is gained from the user using the Internet to perform functions like e-banking or e-shopping.

3

- Yet another money stream is the one that the mobile handset vendor is targeting at: The mobile handset vendor today is receiving money either from the telecom operator through subsidized handsets or from the end user. The "or" in the previous sentence is frequently an "and/or".

1.3.2 ... and tomorrow



The objective of this section is to present in contrast to the previous section the main value chains of tomorrow's blended telecom and Internet environment.



Key point of this section is that the "Content / Services" domain may or may not be part of the legacy telecom operator.

Image Description

- As in the previous section, the image is centered around the horizontal axis consisting of the user domain and the telecom operator's domain.
- The green arrows indicate the way that services take to be delivered to the end user. The yellow arrows depict the related money streams.

Chapter 2:

Shaping & Defining 4G

2

Objectives

Some of your questions that will be answered during this session...

- **What are typical characteristics of 4G systems?**
These characteristics will also distinguish 4G systems from 3G.
- **What are the technical performance characteristics of 4G-systems?**
- **How will the network architecture look like in 4G-mobile networks?**
- **How will the 4G CPE's internally differ from today's devices?**

2.1.3 Criteria Part 3: Procedural and Radio related Characteristics

Feature / Property	3G	4G
Session / Call Control	Access network specific protocols (e.g. UMTS Call Control)	IP-based (SIP)
Security Architecture	Access network specific (e.g. Ki-based)	IP-based (adaptive, flexible, expandable)
Spectral Efficiency	≤ 1 bit/s/Hz	≤ 8 bit/s/Hz
Multiple Access	WCDMA	OFDMA

 = Procedure related  = Radio related



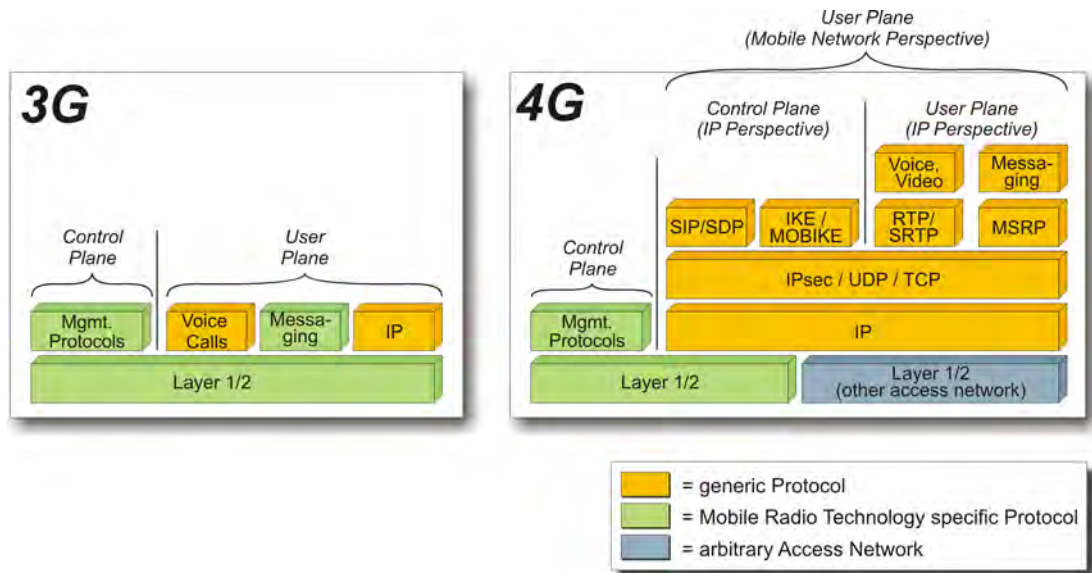
The objective of this section is to list the most important procedure and radio related differences between 3G and 4G mobile radio.



Key points of this section are:

1. The most impressive increased spectral efficiency of 4G mobile radio.
2. The transition away from an access network specific protocol architecture towards an IP-based architecture.

2.3 Protocol Stack Comparison 3G / 4G at the CPE



The objective of this section is to illustrate the difference between the protocol stack implementation of a typical 3G user device and a 4G user device.



Key point of this section is that with 3G there are still mainly mobile radio technology specific protocols while with 4G generic protocol dominate.

Image Description

- The left part of the image depicts the protocol stack of a typical 3G user device. There is a distinction into control plane protocols and protocols within the user plane.
- Most important is the different color used for the different protocol types. Orange color represent generic, so to say "off-the-shelf" protocols.
- Green protocols on the other hand represent protocols which have specifically been defined and designed for this mobile system. This relates obviously to the layer 1 but in 3G it typically also relates to layer 2 and above.



GSM as a 2G system looks like 3G. The protocol stacks are quite similar.

2.3.1 Details of the 4G-Protocol Stack

There are two decisive differences compared to the 3G-protocol stack:

1. The 4G-protocol stack is only partially based on the green mobile radio technology specific layer 1 and 2. However, the CPE can also be operated using other alternative access networks (blue).
2. The protocol stack is mostly orange colored which means that mostly generic IP-based protocols are used.

Room for your Notes:

• Abbreviations of this Section:

4G	4th Generation ...	RTP	Real-time Transport Protocol (RFC 3550, RFC 3551)
CPE	Customer Premises Equipment	SDP	Session Description Protocol (RFC 2327, RFC 3266, RFC 3264)
IKE	Internet Key Exchange (RFC 2409)	SIP	Session Initiation Protocol (RFC 3261)
IP	Internet Protocol (RFC 791)	SRTP	Secure RTP (RFC 3711)
IPsec	Internet Protocol / secure (RFC 4301)	TCP	Transmission Control Protocol
MOBIKE	IKEv2 Mobility and Multihoming Protocol (RFC 4555)	UDP	User Datagram Protocol (RFC 768)
MSRP	Message Session Relay Protocol (draft-ietf-simple-message-sessions-XX)		

Chapter 3:

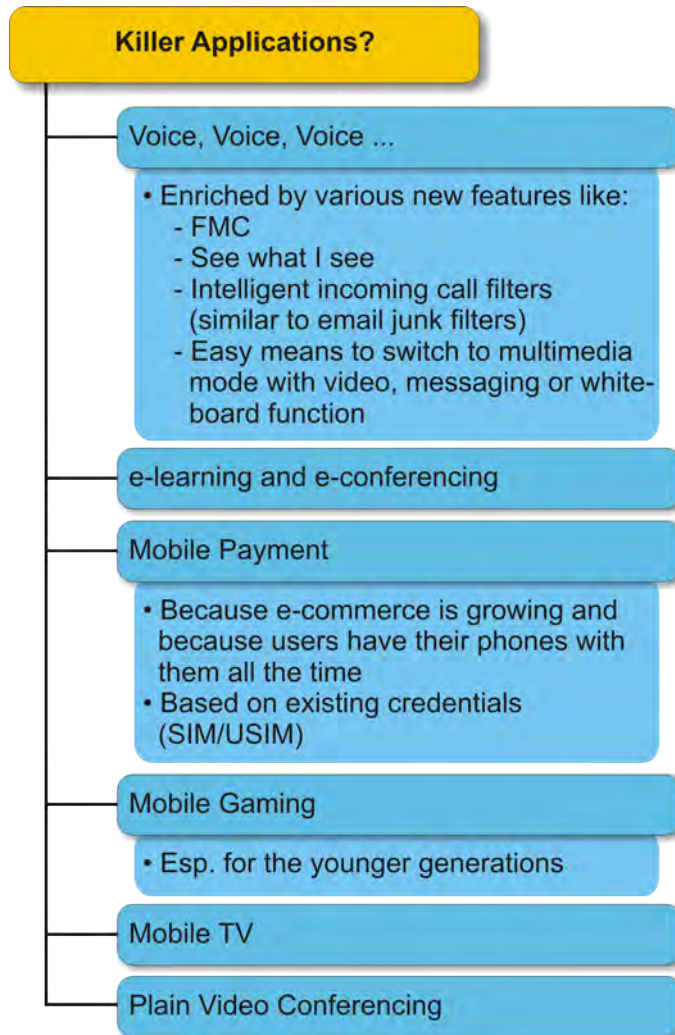
Applications & Services

Objectives

Some of your questions that will be answered during this session...

- **Which applications may become killer applications within a 4G network environment?**
The emphasis is on "may become"...
- **How can my organization possibly prosper from this development?**
- **Which media streams need to be blended together to enable a certain application?**

3.1 Potentially Important Applications ...



The objective of this section is to provide a fast overview of the potential killer applications with 4G.



Key point of this section is that all listed applications can be realized on top of an IP-bearer combining more or less many media streams.

3.1.1 Voice, Voice, Voice ...

- There is little doubt that plain voice communication will account for the majority of sessions also in a 4G environment. If counted by numbers, only IM-transactions will exceed the number of voice calls.
- However, today's plain voice calls will be enriched by various accompanying features that can be added on demand like text messaging or "See what I see".
- "See what I see" allows two peers to share visual information about local attractions, files or similar. Think about being in vacation and showing somebody the beautiful scenery and your beach.
- Another "must have" application is presence information. But no operator should hope to be able to charge for such service. It comes implicitly.
- One feature that will become increasingly important is the defense against incoming blind calls. And probably, users will be willing to pay for such service.
- Another "must have", yet implicit feature is FMC. People will roam around and their device will pick the most suitable access network available. In that respect, suitability relates to price and quality.

Room for your Notes:

- **Abbreviations of this Section:**

4G	4th Generation ...	SIM	Subscriber Identity Module
FMC	Fixed Mobile Convergence	TV	Television
IM	Instant Messaging	USIM	Universal Subscriber Identity Module
IP	Internet Protocol (RFC 791)		

3.1.2 e-learning and e-conferencing

- Terrorism, time constraints, travel expenses; none of these issues was so far able to make the long announced hype of e-conferencing real.

There are certainly various reasons for this but the most important ones are:

- **Lacking customer acceptance**

Which in turn is due to reasons like difficult handling of the related applications, limited usability due to lacking features and, most importantly, increased requirements on the discipline of the users.

- **Lacking Broadband Capabilities**

Only recently, the majority of the people is connected to the Internet through some kind of broadband connection.

This enables the use of e-conferencing systems.

- **Lacking Device**

Formerly, a specific videophone was required for any type of e-conferencing system. Nowadays, the device-question has been resolved: The device is yet another software application on your generic hard- and software running for instance on top of a web browser.

3.1.3 Mobile Payment

- Mobile payment systems will play an increasingly important role in the future. We see the following supporting reasons:
- Most people own a personalized mobile phone and have it with them.
- The mobile phone is accompanied by user credentials (SIM/USIM) which avoid fraud to a certain degree.
- Clients all over the place got used to e-commerce and to shopping without cash.

3.1.4 Mobile Gaming

- Similarly to e-conferencing, mobile gaming will most likely become very important in the future.

3.1.5 Mobile TV

- The success of mobile TV is largely in question. Reasons have been suggested in chapter 1 and are due to the unclear value chain, to IPR-problems and to plain bandwidth.
- The assumption is that mobile TV can only be successful, if people are willing to pay money for the very content they get and this only works in case of pay-TV.

3.1.6 Plain Video Conferencing

Plain video conferencing or plain video calls will probably never become a major part of the business.

Room for your Notes:

- **Abbreviations of this Section:**

4G	4th Generation ...	RFC	Request for Comments (Internet Standards)
FMC	Fixed Mobile Convergence	SIM	Subscriber Identity Module
IM	Instant Messaging	TV	Television
IP	Internet Protocol (RFC 791)	USIM	Universal Subscriber Identity Module
IPR	Intellectual Property Rights		

Chapter 4:

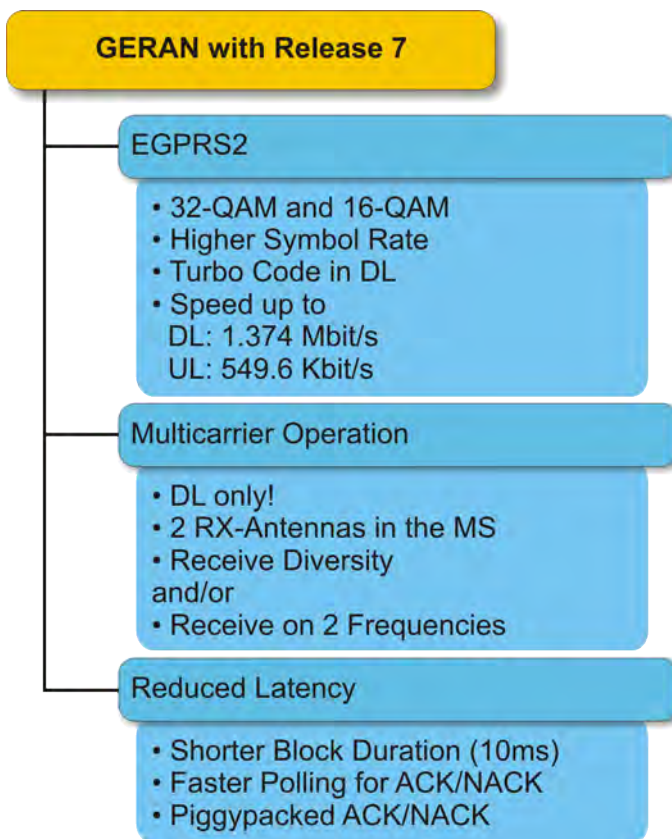
Access Network News

Objectives

Some of your questions that will be answered during this session...

- **What are the enhancements that are included in evolved EDGE?**
- **Which improvements does HSPA+ provide?**
- **What are the key features of LTE?**
- **What are the key features of WiMAX?**
- **Which differences exist between LTE and WiMAX?**

4.1 Most Important Assets of GERAN with Release 7

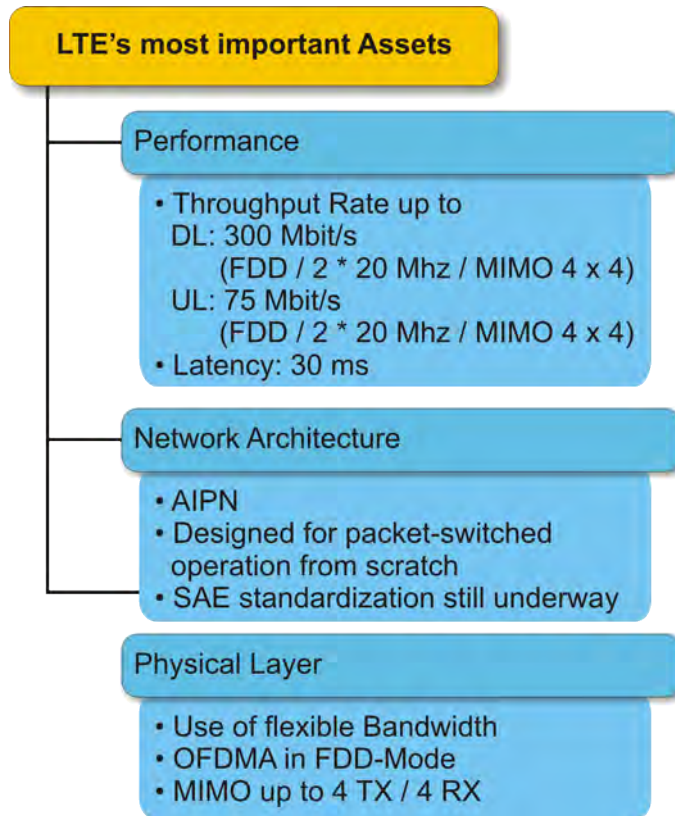


The objective of this section is to provide an overview of the most important features of evolved EDGE, also known as GERAN-evolution.

4.1.1 EGPRS2

- EGPRS2 is the term under which the stated features are summarized.
- The downlink throughput rate relates to operation in HSR with DBS-12 and with Downlink Dual Carrier Operation and 10 receive timeslots (signaled multislot class 8 / equivalent multislot class 30).
- The uplink throughput rate relates to operation in HSR with UBS-12 and with 4 transmit timeslots (multislot class 12 operating in extended dynamic allocation).

4.4 Most Important Assets of LTE



The objective of this section is to illustrate the most important assets of LTE.

4.4.1 Performance

- The envisaged throughput rates are convincing, yet, they require extensive MIMO-operation and optimum conditions.
- The really low latency is much more important and its prominent mentioning illustrates how important 3GPP considers the latency to be.

4.4.2 Physical Layer

- **Use of flexible Bandwidth**
This feature is vital for 4G access networks. It allows operation in almost any frequency niche.
In case of LTE, various frequency bandwidths and frequency bands have been defined already.
- **OFDMA in FDD**
Note that LTE from scratch was intended to operate in FDD-mode.
- **MIMO up to 4 TX / 4 RX**

Please note the similarity of the physical layers of WiMAX and LTE.

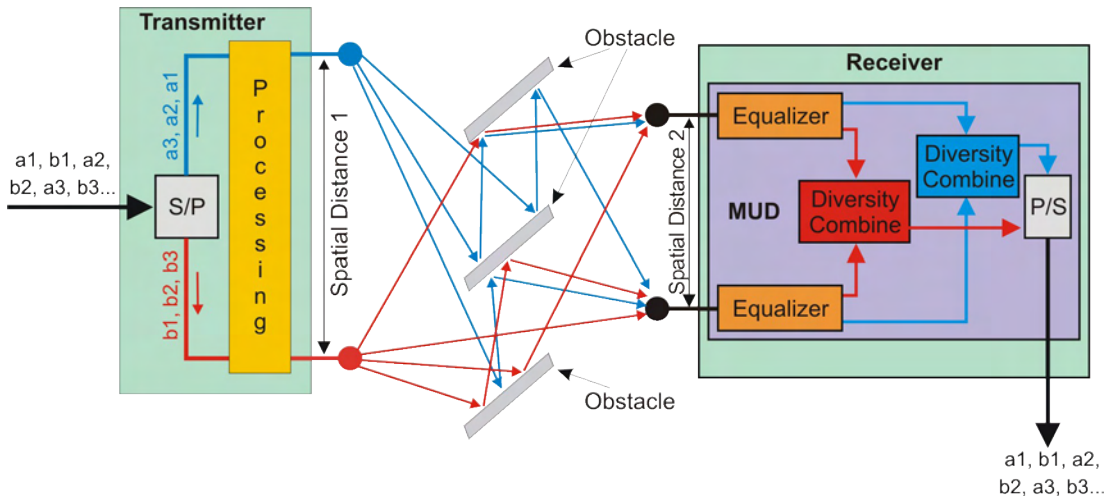


Room for your Notes:

• Abbreviations of this Section:

4G	4th Generation ...	OFDMA	Orthogonal Frequency Division Multiple Access
AIPN	All IP Network	RX	Receive
FDD	Frequency Division Duplex	SAE	System Architecture Evolution
LTE	Long Term Evolution (of UMTS)	TX	Transmit
MIMO	Multiple In / Multiple Out (antenna system)	WiMAX	Worldwide Interoperability for Microwave Access (IEEE 802.16)

4.5.4 And finally: Application in MIMO-Systems



The objective of this section is to illustrate how the aforementioned multipath effects are used in MIMO-systems. S/P P/S



Key point of this section is that MIMO enables the multiple use of the same frequency and time resources through multipath effects. Commercial MIMO-systems support up to 4 TX x 4 RX configurations.

Image Description

- The image illustrates the implementation of a MIMO-system with 2 TX-antennas and 2 RX-antennas (MIMO 2 x 2).
- The figure continues using two colors (red and blue) to ease the identification of the two independent data streams.

4.5.4.1 Adding Receive Diversity

- We previously presented multipath reception at a single Rx-antenna and we have seen that the distance between the more than one Tx-antenna allows for micro diversity (distance between antennas app. = wavelength) or even macro diversity (distance between antennas \gg wavelength).
- To further increase the performance of such a system it is desirable to also deploy more than a single Rx-antenna. The reason for this is the gain of reception diversity.

Example: Consider the old use-case of your car stopping at a traffic light. At your position, the radio reception quality is really bad but if you move your car (the single receive antenna) forward or backward by just half a meter the quality is excellent again. Physically, this effect is caused by local signal extinctions through 180°-phase shifted versions of the radio transmission.



- Increasing the reception quality by moving the car can be achieved also by installing two receive antennas which are situated sufficiently apart from each other.
- The combinations of multiple receive antennas and multiple transmit antennas leads to MIMO (Multiple-Input / Multiple-Output). Any other antenna combination like SISO (Single Input / Single Output), MISO or SIMO (SAIC / DARP) is also possible but has nothing to do with MIMO.

Room for your Notes:

• Abbreviations of this Section:

DARP	Downlink Advanced Receiver Performance (3GTS 45.015, 3GTS 24.008)	S/P	Serial to Parallel
MIMO	Multiple In / Multiple Out (antenna system)	SAIC	Single Antenna Interference Cancellation
MISO	Multiple In / Single Out (antenna system)	SIMO	Single In / Multiple Out (antenna system)
P/S	Parallel to Serial	SISO	Single In / Single Out (antenna system)
RX	Receive	TX	Transmit