DAI-Labor
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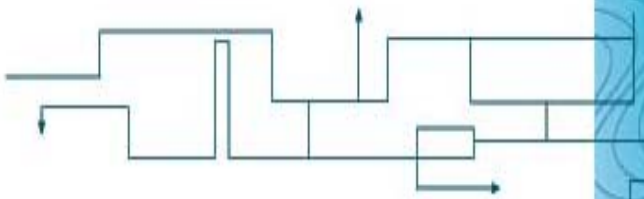


Next Generation Networks

⇨ **Agententechnologien in der Telekommunikation**
Sommersemester 2009

Dr. Fikret Sivrikaya
fikret.sivrikaya@dai-labor.de

Lecture 2 – 06.05.2009

AIOIT

Agententechnologien in
betrieblichen Anwendungen
und der Telekommunikation

Structure of the Lecture

- ⇨ Motivation
  - → Evolution of Networks - Convergent Networks - The all-IP Vision
- ⇨ Definition
  - → 2G, 3G, 3.5G, B3G, 4G, NGN, LTE, SAE
- ⇨ Basic Concepts & Principles
  - → Access networks, core network, QoS, AAAC, IPv4/IPv6, mobility, PSTN-IP integration, etc.
  - → Intelligent combination of wireline, wireless and mobile networks
    - → Traditional networks, open access networks, ad hoc networks, meshed networks
  - → 3GPP, 3GPP2, IMS
  - → Terminal devices

Structure of the Lecture

- ⇨ Beyond-3G Testbed @ DAI-Labor
  - → Motivation
  - → Design Principles
  - → Testbed Overview
- ⇨ References

Motivation

- ⇨ Wired, wireless, and mobile networks are converging to an all-IP heterogeneous network with immense complexity
- ⇨ Underlying access network technologies like UMTS/GPRS, WLAN, and WiMAX are going to be integrated in one overall heterogeneous network
  - → These underlying access networks have a high variance of characteristics
- ⇨ Convergence of PSTN and IP networks – evolution towards the IP Multimedia Subsystem (IMS)

Motivation

- ⇨ Diversity of multi-mode devices is growing rapidly
- ⇨ Mobile network operators have to provide their customers with hassle-free access to communication services while taking into account the best possible resource usage of the deployed infrastructures
- ⇨ Seamless mobility, intelligent network selection and optimal resource usage are key success factors for next generation heterogeneous telecommunication networks or so-called 4G systems
- ⇨ Next generation heterogeneous networks enable ubiquitous access to IP-based services

Motivation

- From the user's perspective the *always best connected* (ABC) paradigm must become a reality.
- The network operator needs an environment which fulfils the requirements for *always best managed* (ABM) infrastructures, networks, and services.

Definitions

- 2G
  - Stands for second-generation mobile phone technology
  - GSM (Global System for Mobile Communications), HSCSD (High-Speed Circuit-Switched Data), iDEN (Integrated Digital Enhanced Network, Motorola), D-AMPS (Digital Advanced Mobile Phone System), cdmaOne (Code Division Multiple Access, Qualcomm), PDC (Personal Digital Cellular, Japan), CSD (Circuit Switched Data), PHS (Personal Handy-phone System)
- 2.5G
  - Packet-switched network based on the 2G infrastructures
  - GPRS (General Packet Radio Service), WiDEN (Wideband Integrated Dispatch Enhanced Network)

Definitions

- 3G
  - Stands for third-generation cellular system
  - W-CDMA (Wideband Code Division Multiple Access) (e.g. UMTS - Universal Mobile Telecommunications System, FOMA - Freedom of Mobile Multimedia Access), CDMA2000 1xEV-DO (Code Division Multiple Access 1x Evolution-Data Optimized, US), TD-SCDMA (Time Division-Synchronous Code Division Multiple Access, China), UMA (Unlicensed Mobile Access, 3GPP)
- 3.5G
  - Extension to 3G networks
  - HSDPA (High-Speed Downlink Packet Access), HSUPA (High-Speed Uplink Packet Access) in case of W-CDMA (UMTS, 3GPP)
  - EV-DO in case of CDMA2000

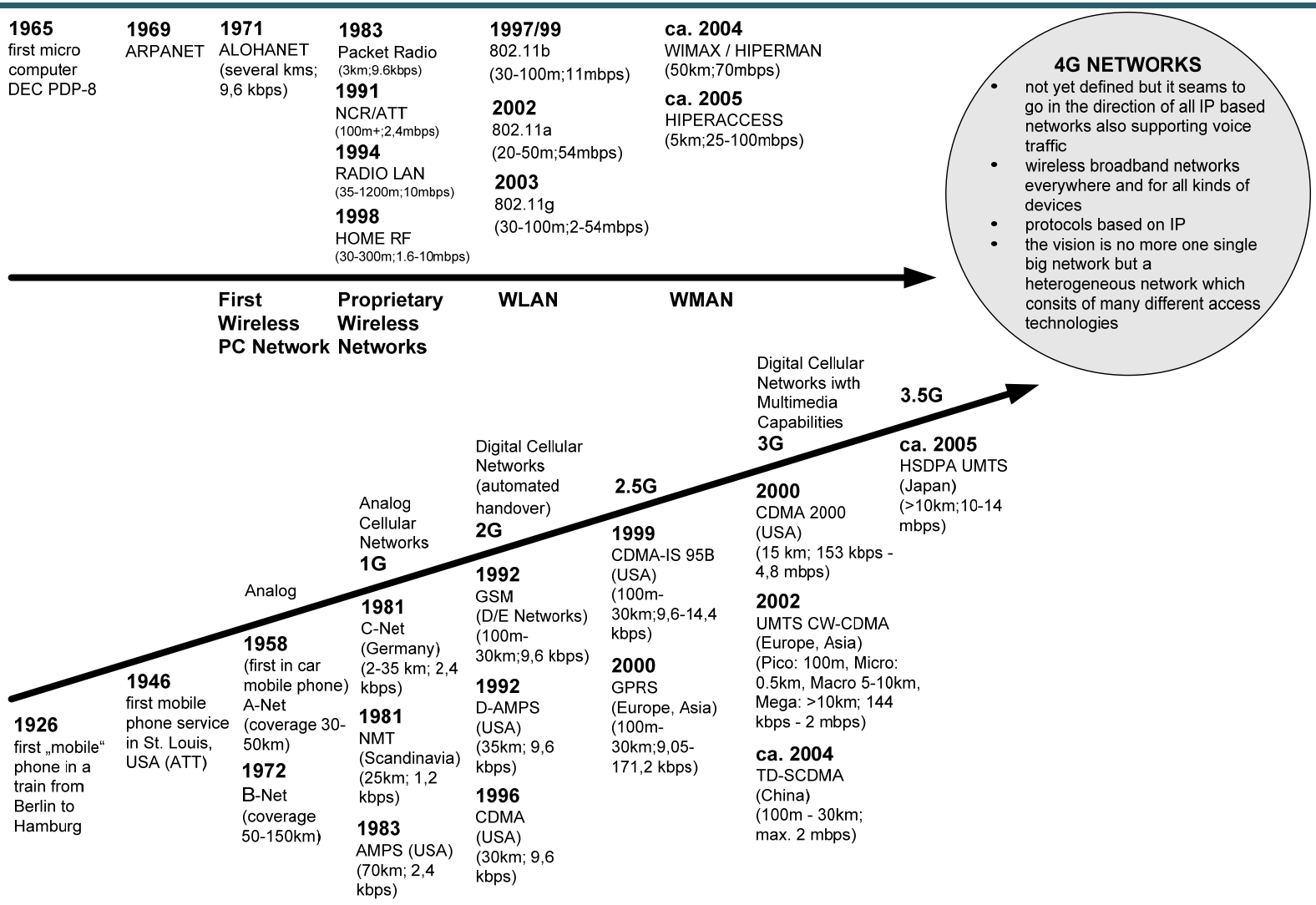
Definitions

- B3G – Beyond 3G
  - Term was created when operators and standardization bodies started to work on 3G – WLAN integration issues
  - Everything after 3G
- 4G
  - Another term
  - Fourth generation system
- NGN
  - Yet another term
  - Next generation networks – often used by fixed network operators → migration towards IP based transport of voice

Definitions

- ⇨ 4G systems
  - → Two different definitions
  1. New air interface with 100Mbit on the move and 1Gbit/s in case of stationary usage
  2. Heterogeneous network consisting of a combination of different wireless access technologies like UMTS, WLAN, WiMAX, FLASH-OFDM etc.

Evolution of Networks



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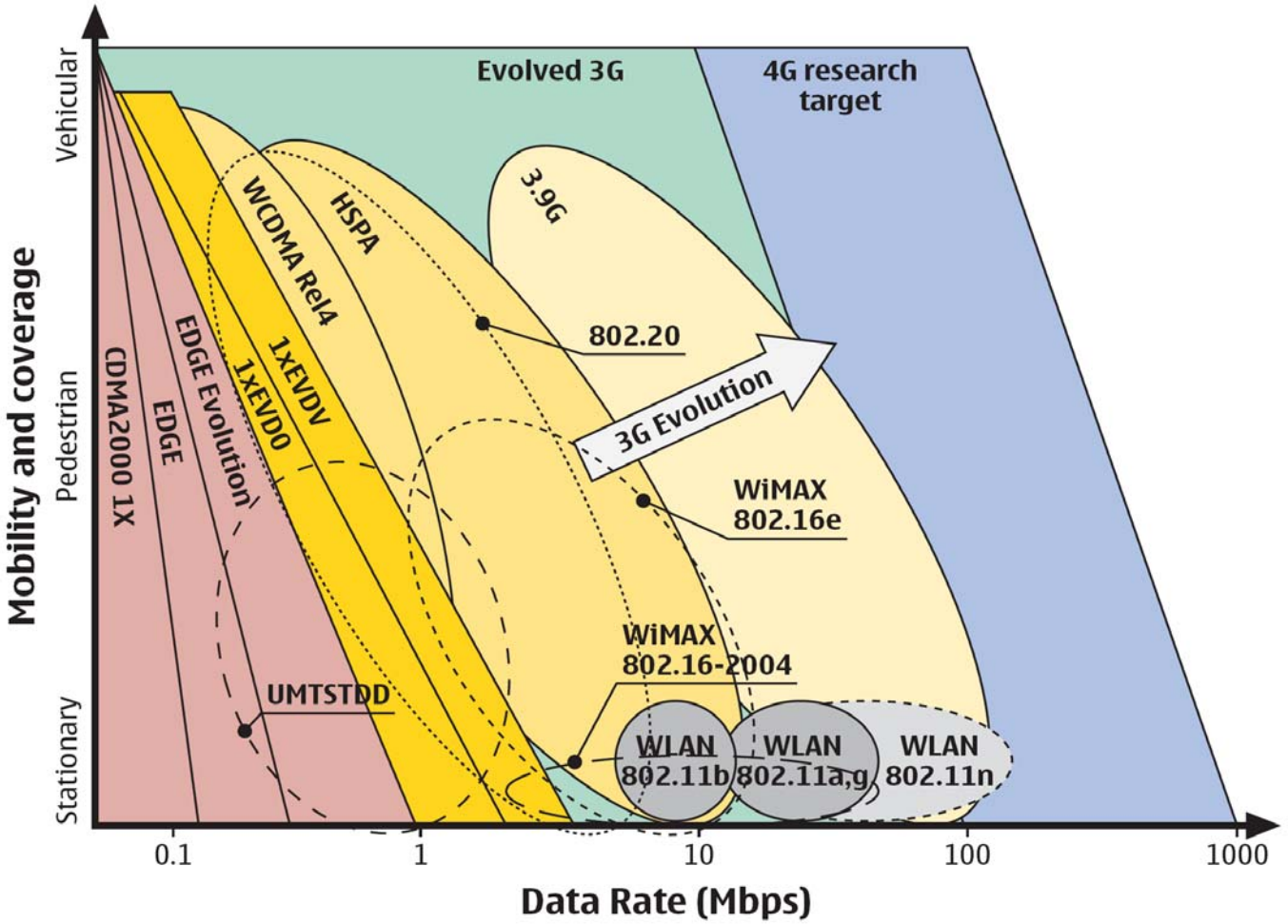
Evolution of Networks



Mobility and coverage vs. the data rates of different radio technologies

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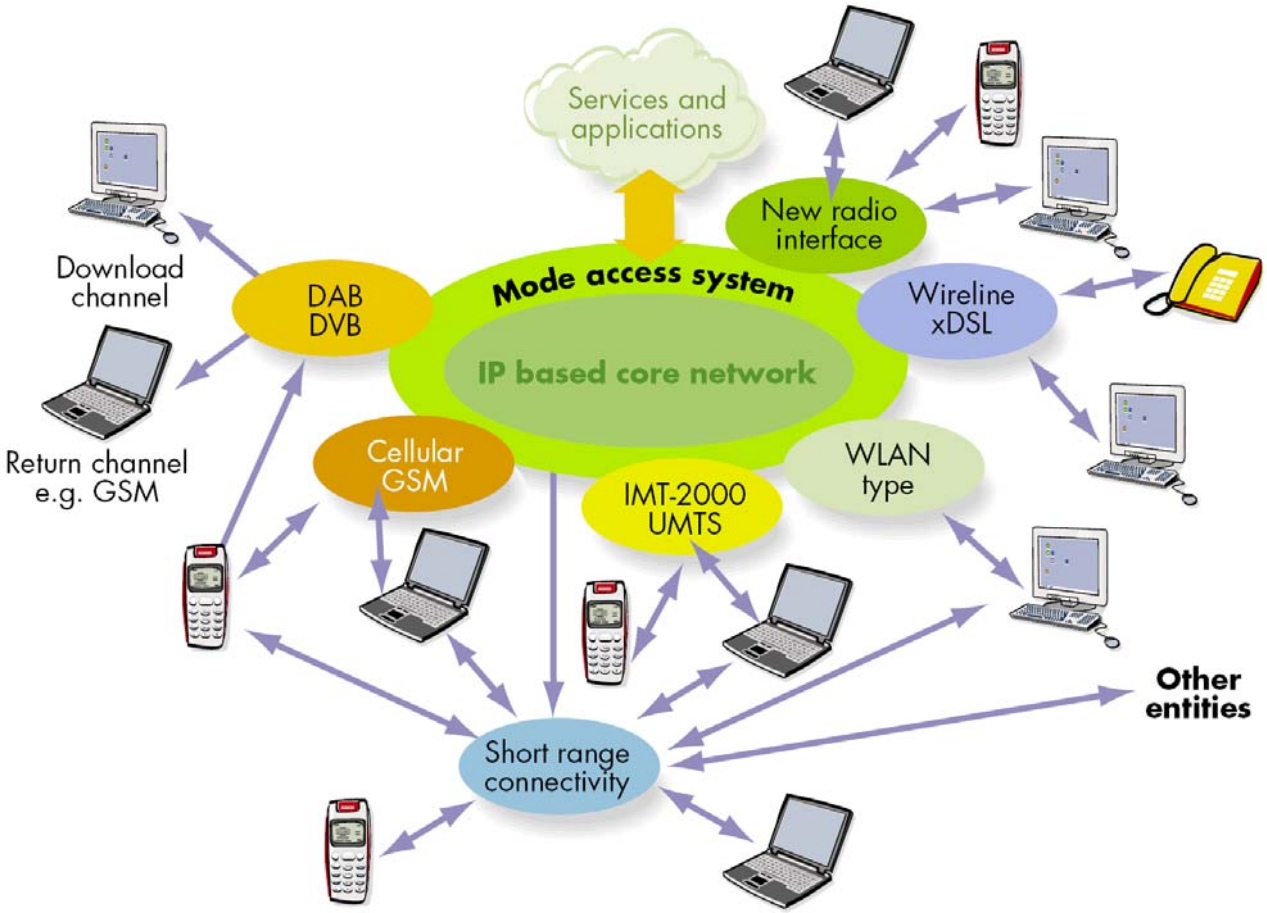
Convergent Networks - The Beyond 3G Vision



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What is NGN?...

- Next Generation Networks (NGN)
  - According to ITU-T the definition is:

    A Next Generation Network (NGN) is a **packet-based** network able to provide services including Telecommunication Services and able to make use of **multiple broadband, QoS-enabled transport technologies** and in which **service-related functions are independent from underlying transport-related technologies**. It offers unrestricted access for users to different service providers. It supports **generalized mobility** which will allow consistent and ubiquitous provision of services to users. [1]

What is NGN?...

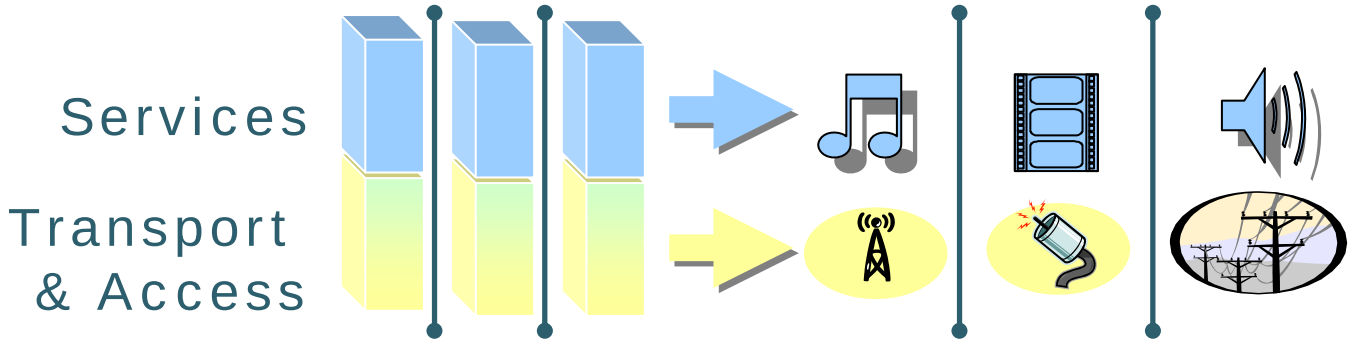
- Practical Description …from ETSI
  - The **convergence** of the public switched telephone network (PSTN) - the voice network, the wireless telecommunication networks (GSM / UMTS / WiMAX) and the data networks (Internet)

    and even broadcasting networks & services...

Objectives of the NGN (from ITU-T)

- NGN should
  - promote fair competition;
  - encourage private investment;
  - define a framework for architecture and capabilities to be able to meet various regulatory requirements;
  - provide open access to networks;
- while
  - ensuring universal provision of and access to services;
  - promoting equality of opportunity to the citizen;
  - promoting diversity of content, including cultural and linguistic diversity;
  - recognizing the necessity of worldwide cooperation with particular attention to less developed countries.

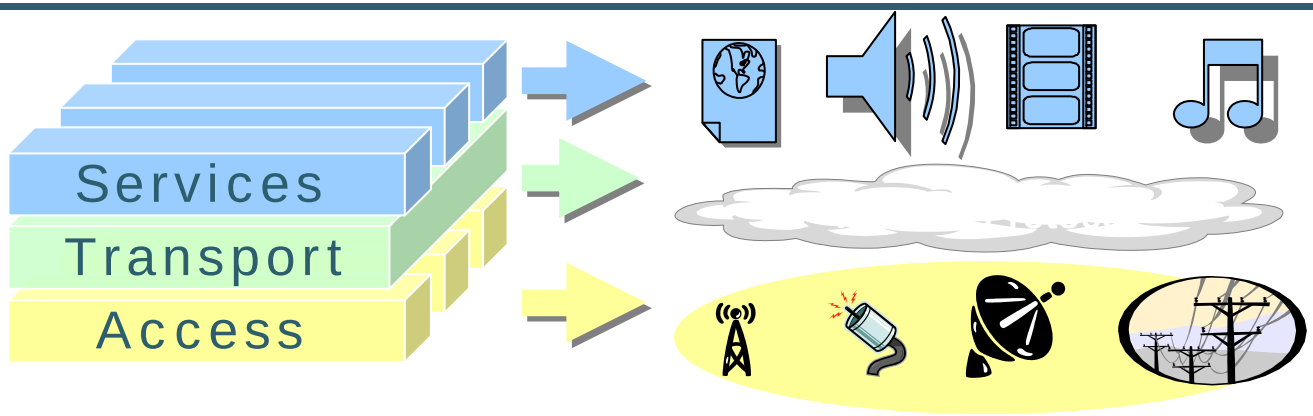
Existing Telecommunications



- Benefits:
  - Worked well for stand-alone systems
- Challenges:
  - Many Networks = High Operational and Interworking Costs
  - Slow to introduce new services
  - Users require different devices for different services

Difficult to integrate new services or technologies

Emerging Telecommunications



- Benefits:
  - Rapid Service Deployment = New Service Revenues
  - Allow continued growth of the network
  - Flexible architecture for future growth and new technologies
  - Allows for competition at individual layers
- Challenges:
  - Legacy policy frameworks are challenged by the emerging telecommunications model throughout the world

Services and access technologies only need to interface to the common transport layer (IP)

NGN

Basic Concepts & Principles

Basic Concepts & Principles

- ⇨ Easy integration of different access networks
- ⇨ Support for different IP versions (IPv4, IPv6)
- ⇨ Authentication, Authorization, Accounting, Auditing, Charging and Security
- ⇨ Mobility support
- ⇨ QoS support
- ⇨ PSTN – IP integration
- ⇨ Support for multi-mode devices
- ⇨ Efficient and effective development and deployment of next generation services based on an all IP heterogeneous network

Basic Concepts & Principles

- ⇨ Easy integration of different access networks
  - → There will be more than just one access technology
  - → Development cycles are getting very short
  - → Users want to get connected – anywhere with any device at any time
  - → New access technologies have to be integrated – always taking into account already existing and widely deployed infrastructures
    - → Example: 3G-WLAN integration from a 3GPP point of view
      - → Loose vs. tight coupling
  - → Meshed networks, open access networks, ad-hoc networks, mobile networks will be part of the future networks as well

Basic Concepts & Principles

- ⇨ Support for different IP versions (IPv4, IPv6)
  - → Today, IPv4 is the protocol of choice in packet-based networks
  - → Tomorrow, IPv6 will probably be deployed
    - → Countries with a small IPv4 address space will drive this evolution
    - → Improved mechanisms e.g. for security and mobility, larger address space, etc.
  - → It will be an evolutionary not a revolutionary approach
  - → The hassle-free coexistence of both protocols has to be guaranteed

Basic Concepts & Principles

- Authentication, Authorization, Accounting, Auditing, Charging and Security
  - Very, very important
  - Integration with Operations Support System (OSS) and Business Support Systems (BSS)
    - Today, almost all mobile operators have their own system – grown over time, proprietary
  - RADIUS (RFC 2865) and Diameter (RFC 3588) are the protocols of choice

  (One of the first questions in case of presentations of research approaches in the field of next generation networks and services quite often is: how is the accounting done? (especially if operators are present))

Basic Concepts & Principles

- Mobility support
  - Personal mobility
    - e.g. SIM card or SIP URI
  - Session / service mobility
    - service is seamlessly transferred between devices
  - Terminal mobility
    - e.g. handover from 3G network to WLAN access point
  - Key success factor for the realization of next generation heterogeneous networks
    - Hassle free access
    - Seamless handovers between networks
      (also between circuit switched networks and packet switched networks; e.g. GSM – WLAN)
    - Pervasive access to services – no matter what network or device is used

Basic Concepts & Principles

- ⇨ QoS support
  - → Support for end to end QoS over different bearers and the core network is one key requirement
  - → Precondition for the provisioning of multimedia services (VoIP, video telephony, multimedia streaming applications, IPTV, etc.)
  - → Precondition for the implementation of different user classes, SLAs (service level agreements)

Basic Concepts & Principles

- ⇨ PSTN – IP integration and evolution towards the all-IP vision
  - → The public switched telephone network will have to be integrated and interoperability has to be guaranteed for a very long time frame
  - → Key success factor for the evolution towards an all IP network
  - → Evolutionary path could look like:
    - → PSTN-IP integration (e.g. Cisco Callmanager in enterprise setups)
    - → SIP based infrastructures (e.g. sipgate, truephone)
    - → SIP based infrastructures evolving towards the IP Multimedia Subsystem (IMS) (e.g. T-Online, T-Mobile, BT → 21CN)

Basic Concepts & Principles

- ⇨ A broad range of different end devices will be used in future networks
  - → PDAs, laptops, smartphones, mobile phones supporting one or different access technologies will be used to access the services using multi-modal interfaces (HTML, WML, Voice, J2ME-midlets, etc)
  - → Multi-mode devices (support different access technologies)
    - → SDR – software defined radio
  - → Single purpose devices (e.g. traffic monitoring)

What is IMS?

- IP Multimedia Subsystem as defined by 3GPP
  - 3GPP IMS standards define a network domain dedicated to the control and integration of multimedia services.
  - IMS is defined by 3GPP from Release 5 onwards (2002)
  - 3GPP2 equivalent of IMS is the MMD (MultiMedia Domain), fully interoperable with 3GPP IMS
- IMS builds on IETF protocols
  - Based upon SIP, SDP, COPS and Diameter protocols
  - 3GPP have enhanced these IETF protocols for mobility
- IMS in short
  - Open-systems architecture that supports a range of IP-based services over the PS domain, employing both wireless and fixed access technologies

What does IMS provide?

- Services and Control
  - adds call session control to the packet network
  - enables peer-to-peer real-time services - such as voice, video – over a packet-switched domain
  - scalable common service control (based on SIP) gives the ability to manage parallel user services
- Media Mixing
  - Ability to pick and mix various multimedia flows in single or multiple sessions
  - Can handle real-time voice, video, data
- Connectivity Network Independence
  - Provides access to IP based services independent of the underlying connectivity technology (mobile / fixed)
- IMS is based upon an open standard with a strong evolutionary advantage
  - IMS architecture & SIP may be easily extended to provide new services

Why IMS in NGN? - ETSI's view

- The IP Multimedia Subsystem generally fulfills the NGN requirements for conversational services
  - For managed, carrier operated telecom. networks
  - With Release 6, IMS becomes applicable to a range of access network types (3G RAN, WLAN)
- For the benefit of the whole telecommunications industry
  - IMS is being proclaimed as the architecture of choice for converging networks (mobile – fixed), as well as voice and multimedia
  - It is predicted that IMS will enable IP to gradually replace circuit switched voice
  - Operators who own both fixed and mobile networks want to consolidate their networks
  - Growing IMS market, will encouraging greater usage and creation of new IP based services
  - Open interfaces allow for a wider choice of IMS suppliers
  - Market stimulation, decreasing costs (thanks to shared development/deployment costs)

Source: ASTAP05-WP.IP&NGN-08_ETSI

IMS - How does it work?

- A short high level view:

  http://www.youtube.com/watch?v=hWGm4060azo

ALL-IP NGN Testbed @ DAI-Labor

Motivation

- ⇨ Provide our research projects with an environment to study challenging aspects of upcoming heterogeneous networks on all layers
- ⇨ Take into account the today widely used technologies and solutions (mobile operator's existing infrastructures) as well as upcoming protocols, technologies and enable us to work on innovative ideas
- ⇨ Enable an easy integration of new access technologies to be able to extend the system as new network technologies are emerging in very short time frames

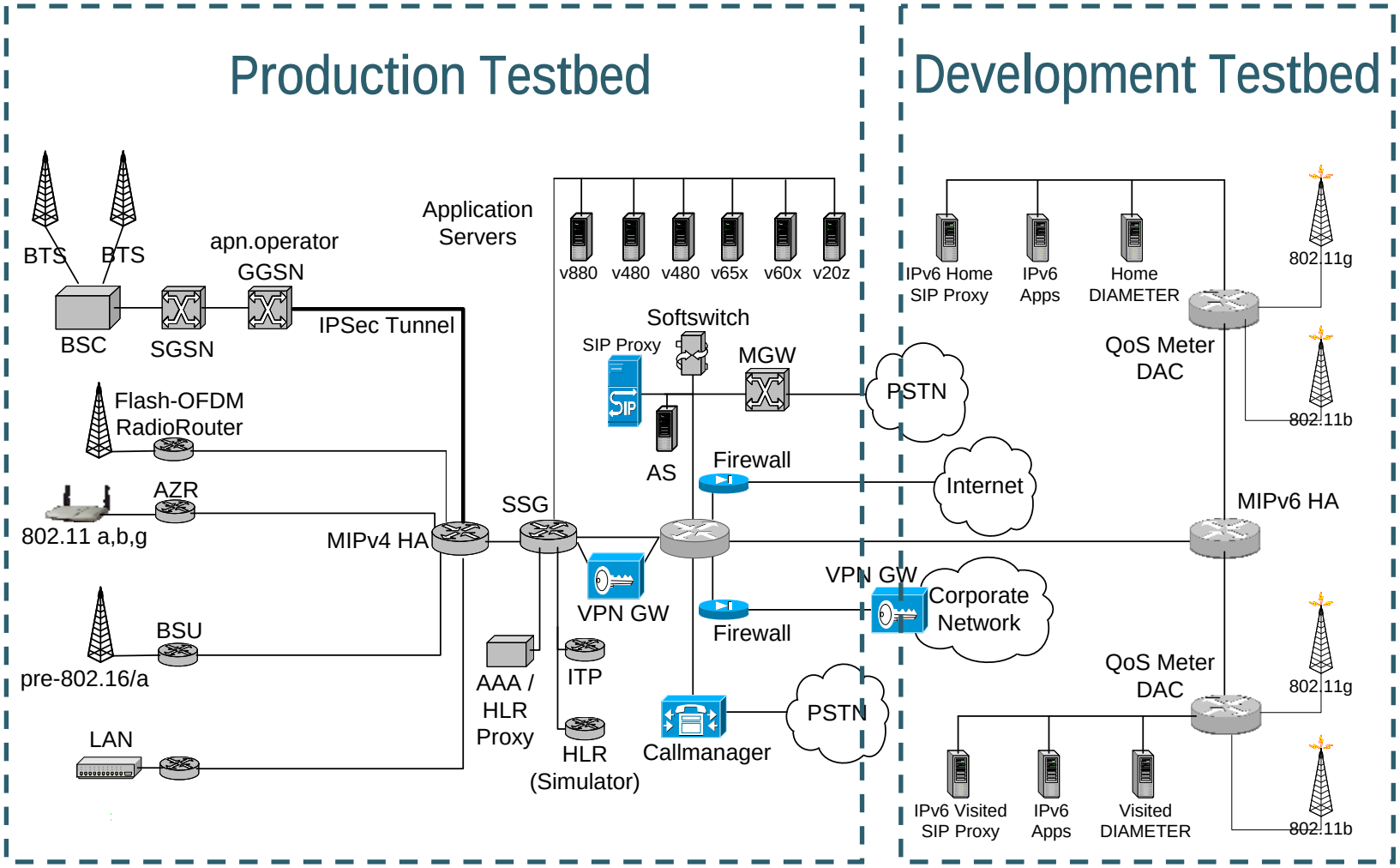
Testbed Design Principles

- Integration of Various Access Networks
  - The mini mobile network operator testbed should support an easy integration of new access technologies and access technology independent mechanisms have to be used for that purpose.
- Support for IPv4 and IPv6
  - The mini mobile network operator testbed should support both Internet protocol versions and serve as en environment for coexistence and migration studies.
- Mobility Support
  - The mini mobile network operator testbed should support different candidate mobility management protocols and multiple administrative domains to enable research on inter-technology vertical handovers, intra-technology, inter-domain handovers, and roaming.

Testbed Design Principles

- Quality of Service
  - The mini mobile operator network testbed should provide mechanisms for QoS reservations, QoS metering, and measurements.
- Authentication, Authorization, Accounting
  - The mini mobile operator network testbed should support both protocols - RADIUS and diameter - and integration and migration issues have to be studied. The testbed has to support different authentication methods to enable us to study the impact of heterogeneous network authentication mechanism and their integration with AAA architectures.

Testbed Overview



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Testbed Overview

- ⇨ The testbed provides an ideal environment for design and development of next generation services and solutions for future networks
- ⇨ The testbed is extended over time and it is and will be extensively used for our ongoing and future research activities as a base for the evaluation and validation of results
- ⇨ The testbed is available for industry partners and other research institutions
- ⇨ The testbed is available for student projects, diploma theses etc.

Testbed Overview

⇨ The testbed has been established within the research project BIB3R (Berlin's Beyond-3G Testbed and Serviceware Framework for Advanced Mobile Solutions, funded by the BMBF)

⇨ The testbed became operational on May 2003

In closing…

- ⇨ NGN is a concept, not just a technology.
- ⇨ NGN is an attempt by operators to provide a single technology platform into the future to support converged services
- ⇨ NGN is a global initiative, coordinated by the ITU-T
- ⇨ Robust and open standards are essential to the long term success of IMS and NGN
- ⇨ Not everyone likes or agrees with the NGN concept – especially large parts of the ‘internet community’
- ⇨ Regulators will have an interesting time trying to manage what is likely to become a standards/systems battle between various players

First assignment – Due May 15th. (midnight)

- ⇨ **Read** the white paper by David Clark et al. “Developing a Next-Generation Internet Architecture” (will be emailed to you)
- ⇨ **Write** a 2-page summary in your own words
- ⇨ **Find** & choose a paper that cites this one and read it. Summarize it in a single page by explaining how it tries to address the points raised in Clark’s paper.
- ⇨ **Submit** the 3-page document altogether. Include the explicit title and publication details of the second paper you have chosen within the document.

Next Week...

Date	Title of the Lecture
22.04.2009	Overview of the Course and Organizational Issues
29.04.2009	Introduction to Telecommunications and Current Trends
06.05.2009	Next Generation Networks (NGN)
13.05.2009	Service Control - IP Multimedia Subsystem (IMS)
20.05.2009	Heterogeneous Networks and Mobility - User Perspective
27.05.2009	Heterogeneous Networks and Mobility - Network Operator Perspective
03.06.2009	IPv4 / IPv6 & Mobile IP
10.06.2009	Authentication, Authorization and Accounting (AAA) Protocols
17.06.2009	Network Management
24.06.2009	Game Theory in Telecommunications
01.07.2009	Standardization Bodies & Activities in Telecommunications
08.07.2009	Written In-Class Exam

References

- ⇨ The 3rd Generation Partnership Project (3GPP): http://www.3gpp.org/
- ⇨ The Third Generation Partnership Project 2 (3GPP2): http://www.3ggp2.org/
- ⇨ The Internet Engineering Task Force (IETF): http://www.ietf.org/
  - → IPv4, IPv6, MIPv4, MIPv6, RADIUS, diameter, SIP, MPLS, IPFIX, RIP, etc pp
- ⇨ International Telecommunication Union (ITU): http://www.itu.int/
- ⇨ Next Generation Mobile Networks Alliance (NGMN): http://www.ngmn.org/

[1] http://www.itu.int/ITU-T/studygroups/com13/ngn2004/working_definition.html

[2] http://www.alcatel.com/doctypes/articlepaperlibrary/pdf/ATR2003Q4/T0312-Mobile-Evolution-EN.pdf

[3] 3GPP TR 23.882, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7), 2006-01

[4] IP Multimedia Subsystem (IMS) Service Architecture, http://www.lucent.com/livelink/090094038005df2f_White_paper.pdf

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[6] Nokia, Whitepaper, Radio Network Evolution - The roadmap towards multi-access networks

[7] Sacha Mattke, Die drahtlose Zukunft, Technology Review, September 2003

[8] 3GPP TR 23.882 V1.15.0 (2008-02), 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7)