TECHNISCHE UNIVERSITÄT DRESDEN

Department of Computer Science Institute for System Architecture, Chair for Computer Networks

Application Development for Mobile and Ubiquitous Computing

1. Introduction

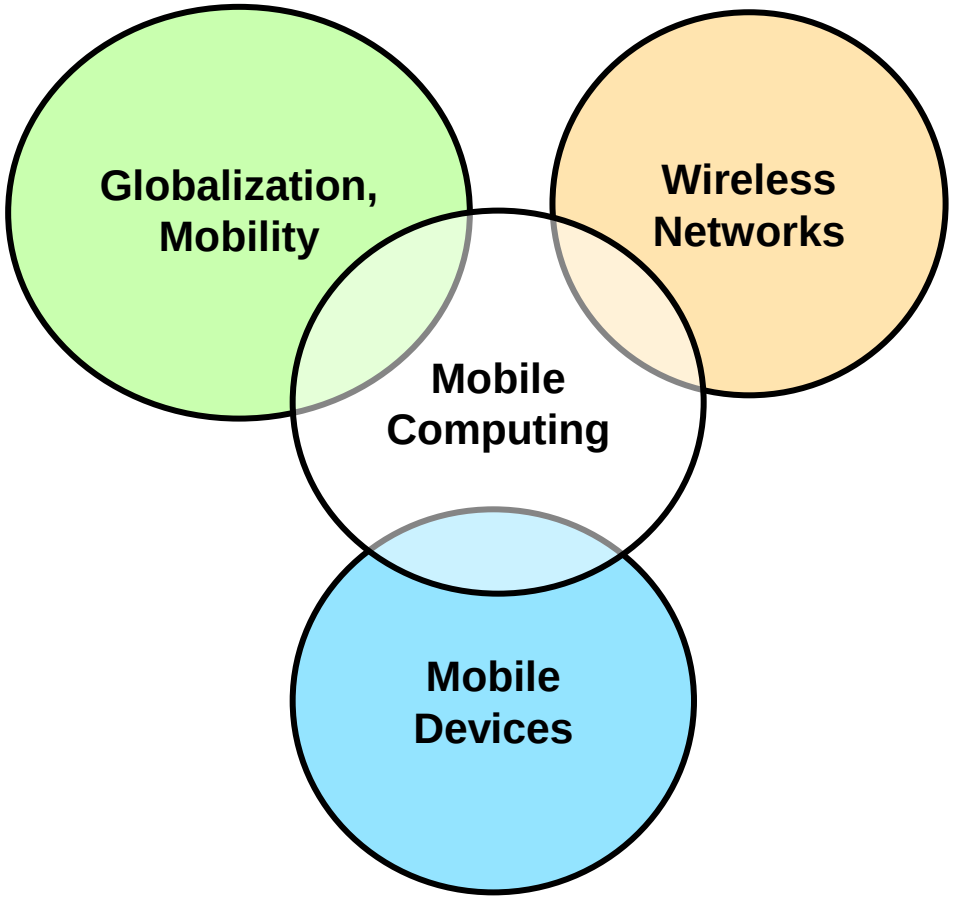
Dr. Ing. Thomas Springer
Technische Universität Dresden
Chair of Computer Networks

Overview

- Why Mobile Computing?
  - What is Mobile Computing
  - Major Driving Forces
  - Application Scenarios
- Future Trends
  - Pervasive and Ubiquitous Computing
  - Ambient Intelligence
  - Context Awareness
- Challenges
- Lecture Organization

WHY MOBILE COMPUTING ?

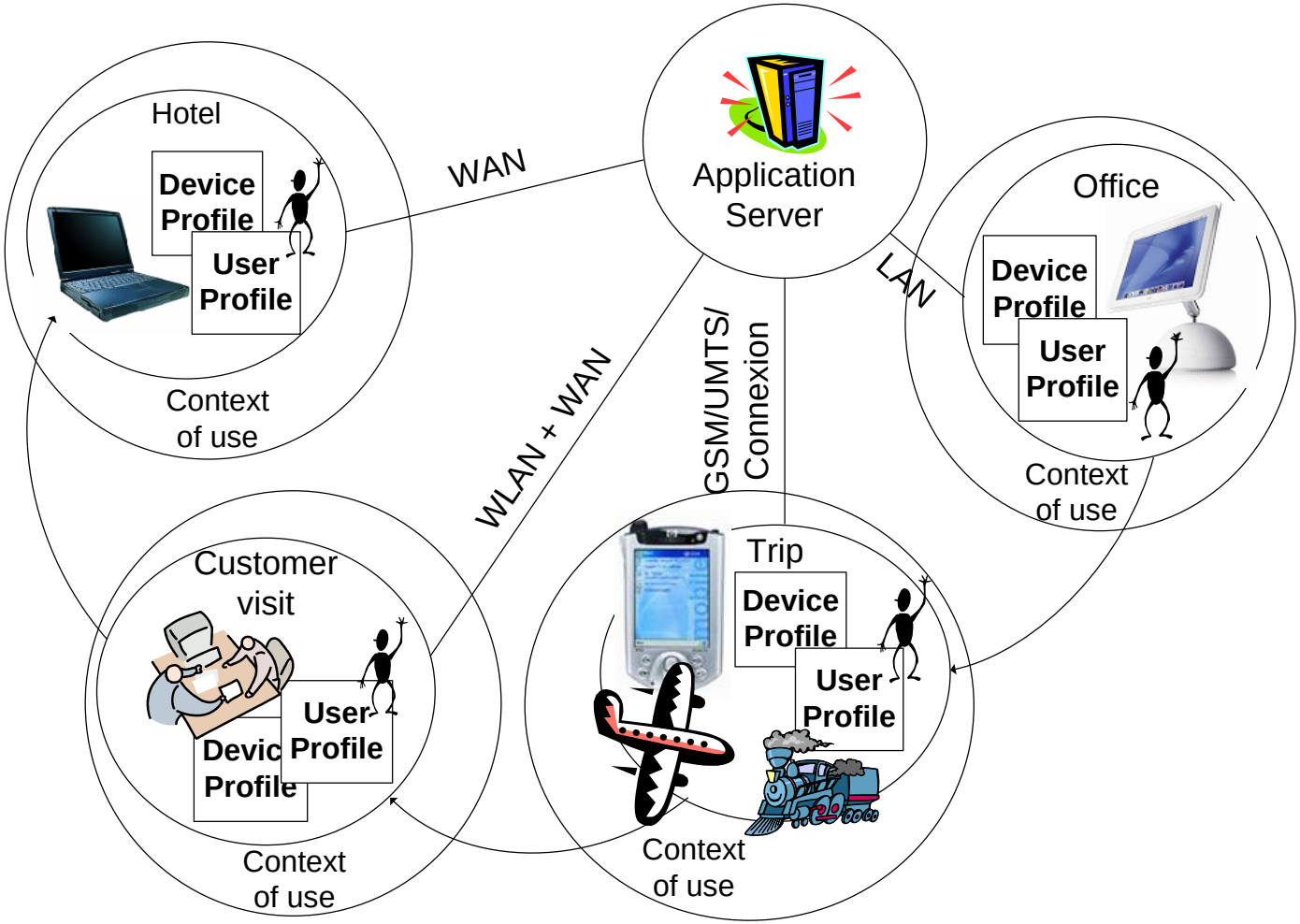
Major driving forces for Mobile Computing



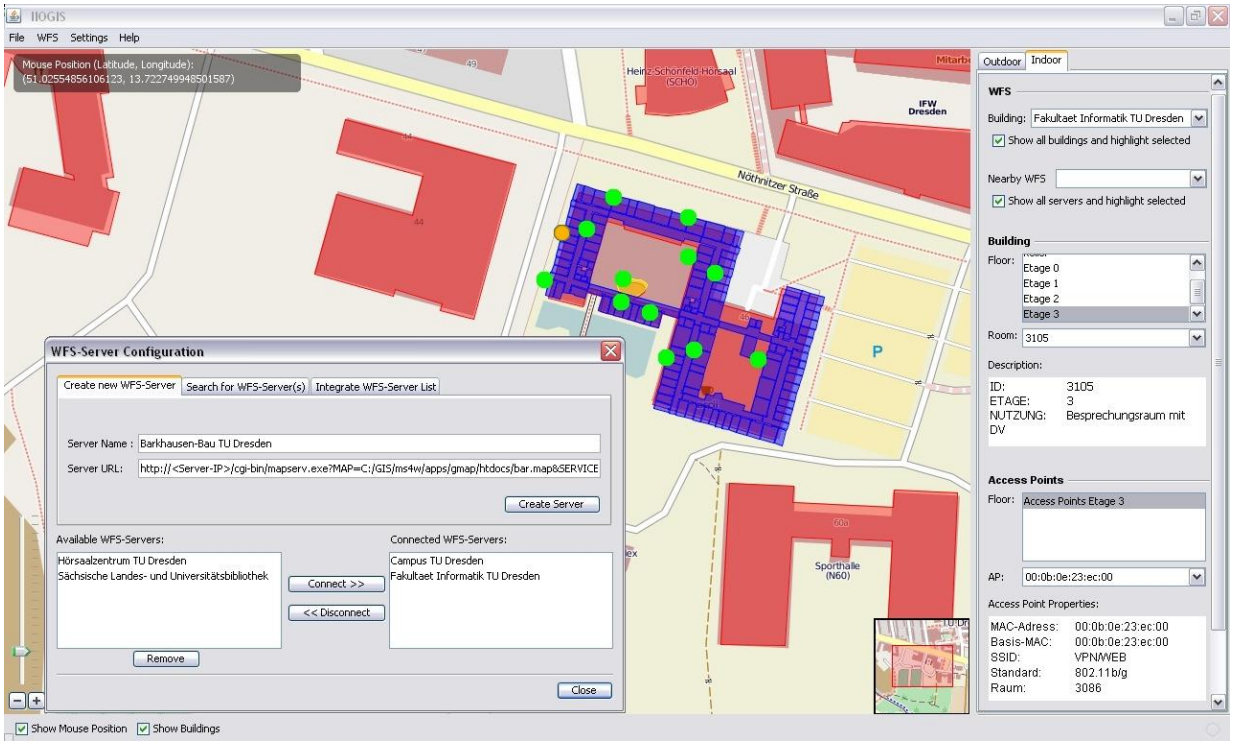
Possible Applications of Mobile Computing

- remote control (devices, applications)
  - local area -> control PowerPoint presentation with mobile device
  - wide area -> access to home devices
- wireless information / data exchange
  - exchange of vCards between two mobile devices
- remote access to information and services
  - internet search and download
  - mobile use of internet services
  - access of enterprise applications
  - location-based services
- local / disconnected work
  - disconnect from network and work autonomously (e.g. robot)

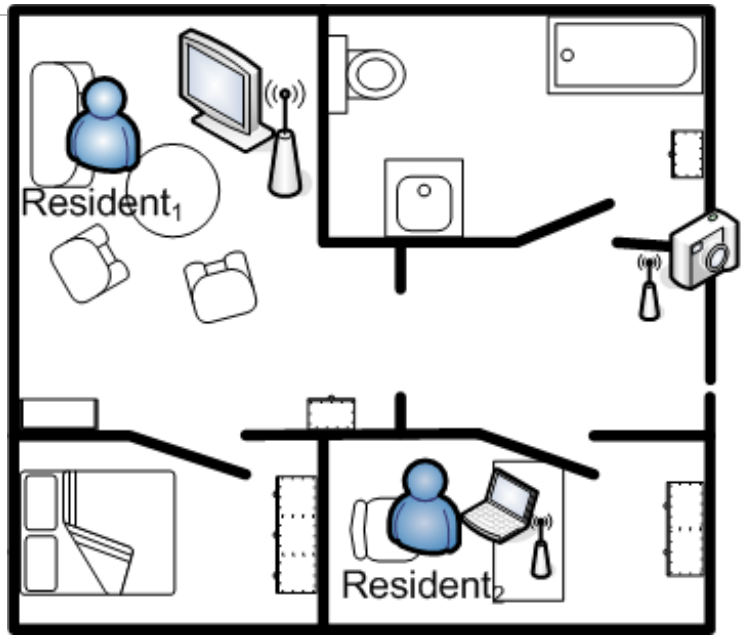
Mobile Workers

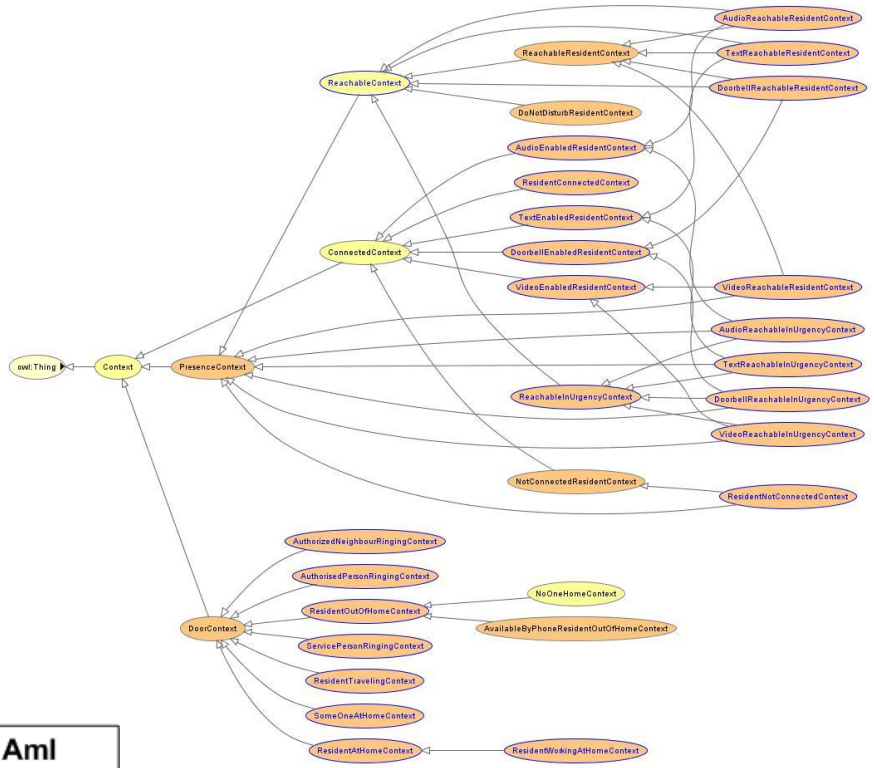


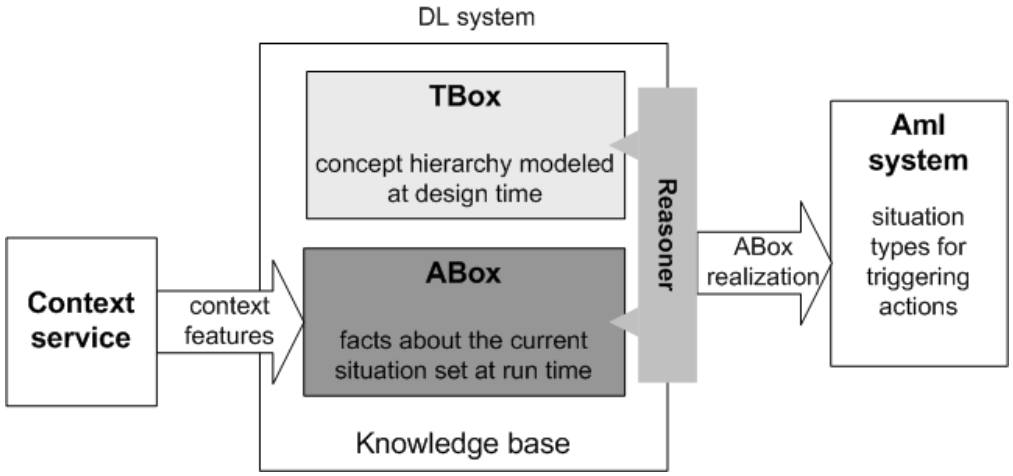
Location-based Services



Intelligent Environments







What is „Mobile Computing?“

- Mobile Computing
  - integration of wireless networks into existing wired infrastructures - wireless (voice and data) communication
  - usage of mobile devices
  - location-transparent work
  - similar work experience like with stationary devices
  - “Mobile Computing Paradigm”:
    - “information anytime, anywhere“

- two main aspects of mobility:
  - *user mobility*: users communicate (wirelessly) “anytime, anywhere, with anybody, at any cost”
  - *device mobility*: enduser devices may be (wirelessly) connected “anytime and anywhere” to other devices or the network
- other aspects of mobility:
  - *data mobility*: data may move “anytime and anywhere” from one node to another
  - *service / application mobility*: services and applications may move “anytime and anywhere” from one node to another

The Coming Age of Calm Technology

- *"What matters is not technology itself, but its relationship to us."* [Mark Weiser, 1996]

- major trends in computing:
  1. Mainframe Era - many people share a computer
  2. Personal Computer Era - one computer, one person
  2.5 Internet - Widespread Distributed Computing . . . transition to . . .
  3. Ubiquitous Computing Era - many computers share each of us

Pervasive Computing

- *"A billion people interacting with a million e-businesses through a trillion interconnected intelligent devices..."* [Lou Gerstner, IBM Chairman]

- integration of computing technology into business processes (i.e. mobile devices, RFID)
- new application areas (mPayment, mCommerce)
- mobile business

Ubiquitous Computing

- *"... only when things disappear in this way are we freed to use them without thinking and so to focus beyond them on new goals."* [Mark Weiser, 1991]

- small, sensor equipped devices - become "smart"
- embedded into things of daily live
- sense and react on the environment (context-aware)
- technology moves into background of users attention
- focus on the task not the technology

- *"The real power of the concept comes not from any one of these devices; it emerges from the interaction of all of them."* [Mark Weiser, 1991]

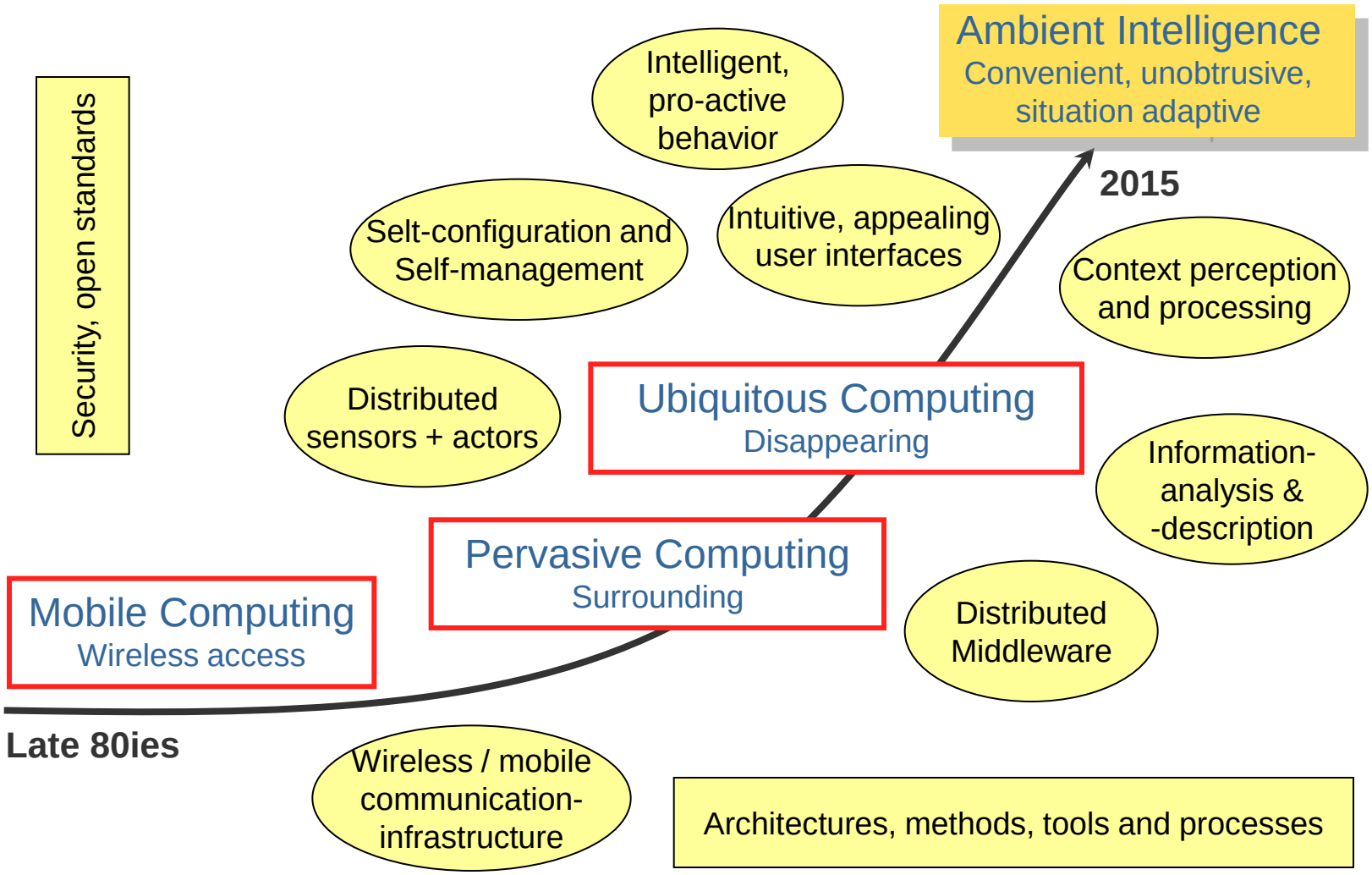
- interconnection of everything, each computing device is able to communicate
- Ubiquitous Computing Paradigm:
  - the right service, at the right place, at the right time, (at the right cost)

Ambient Intelligence

- *"A vision of the future where we are surrounded by electronic environments, sensitive and responsive to people"* [defined by the Advisory Group of the 6th Framework of the EU]

- goal is the "intelligent" interaction of the environment with the user
- three main areas:
  - Ambient Technology: basic technologies (materials, sensors, power supply, multi-modal i/o systems, adaptive software systems)
  - Intelligence: intelligent processing of context and multi media data, natural interaction, emotional computing, privacy and trust
  - Platforms: design, development and integration of service oriented architectures
- research is:
  - prototype-driven
  - based on innovative concepts of software engineering like aspect and service orientation

The Way towards Ambient Intelligence

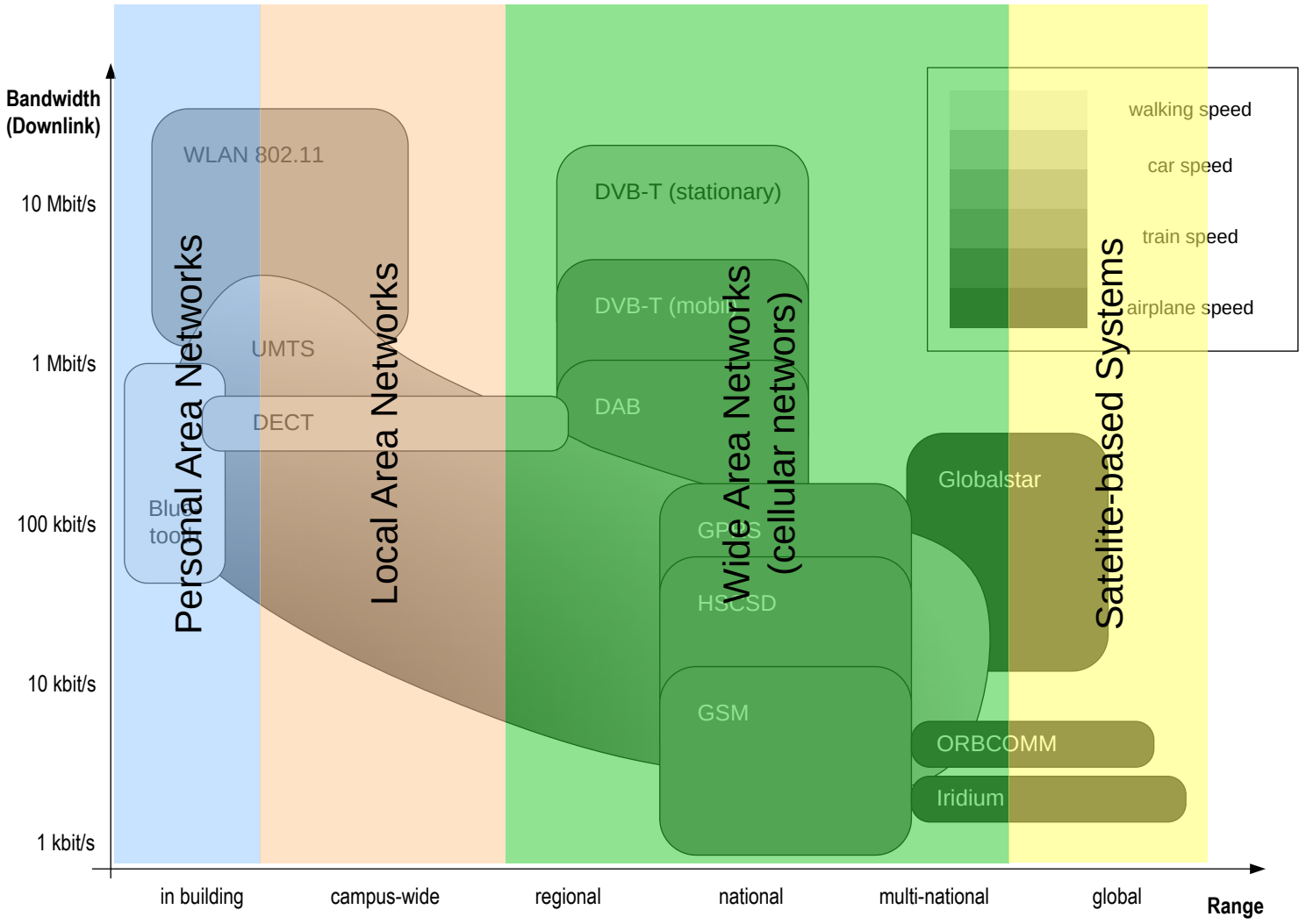


Characteristics of Wireless Communication

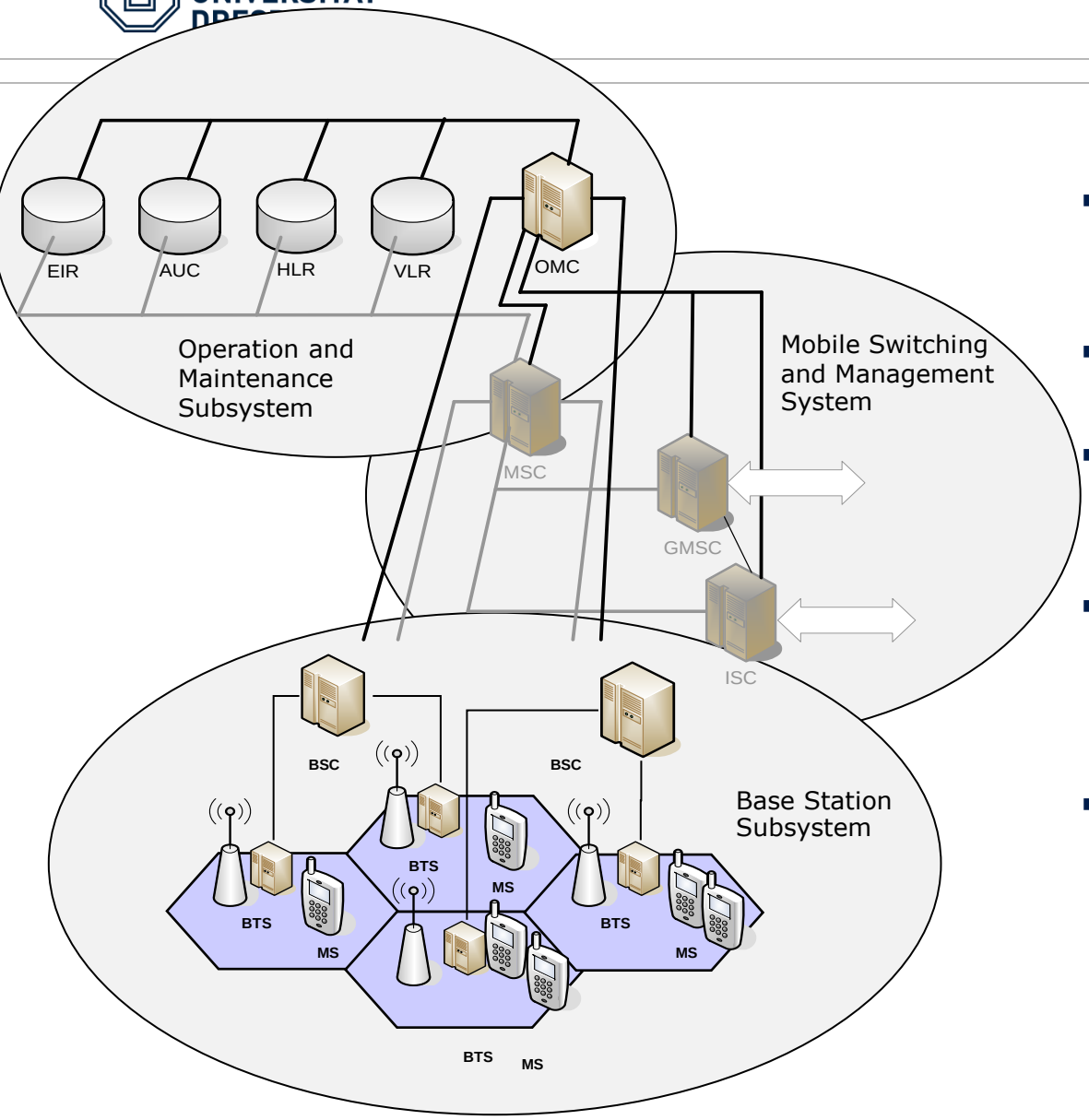
- More Interference-prone
  - no cable protecting signal from interferences
  - each interference decreases signal quality significantly
  - caused by multi-path propagation and other propagation effects
- Lower data rates
  - limited availability of frequency
    - regulation (country-specific)
    - shared medium
    - higher frequencies require more energy for transmission, technologies more costly, complex and error-prone
    - the higher the frequency, the higher effects of scattering and refraction (line-of-sight required)
- Security issues
  - eavesdropping easily possible
- Limited coverage
  - due to degradation of signal power
  - distortion due to interferences, shadowing, reflection, refraction, and scattering
    - effects depend on signal frequency and wave length

CHALLENGES

Network overview



Cellular Networks



- Cellular structure to provide nation wide coverage
- Hierarchical system architecture
- Management of Handovers and Roaming
- Connection to public telephony networkm other cellular networks and Internet
- Separated pathes for circuit switched and packet switched traffic

GSM and Extensions

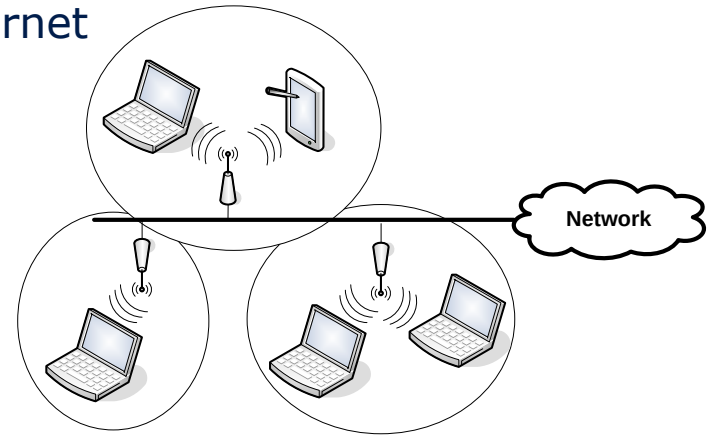
- GSM (Global System for Mobile Communications)
  - Primary build for telephony services
  - data communication up to 9600 Bit/s
- HSCSD (High Speed Circuit Switched Data)
  - Circuit switched, pay per usage time
  - Parallel usage of several time slots (TCH – traffic channel)
  - Data rates from 9,6 up to 53,8 kbit/s
  - Asymmetric transmission (1TCH Uplink /3TCH Downlink)
- GPRS (General Packet Radio Services)
  - Paket oriented data service, pay per volume
  - Parallel usage of existing ciruit switched services
  - Data rates up to 171,2 kbit/s (theoretical) – in practice 53,8 kbit/s
  - Extension of GSM specification & network structure required
- EDGE (Enhanced Data Rates for GSM Evolution)
  - Higher bit rates by modified modulation mechanisms (up to 384 kbit/s)
  - Enhances HSCSD and GPRS
  - Moderate modifications of GSM technology (updata of software in BTS)

UMTS, HSPA and LTE

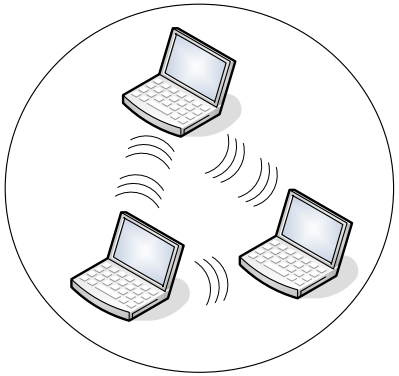
- UMTS (Universal Mobile Telecommunications System)
  - Data rates: 144 kbit/s mobile, up to 2 Mbit/s in close range
  - Asymmetric data rates for Up-/Downlink
- HSPA (High-speed Packet Access) = HSDPA+HSUPA
  - HSDPA (High-speed Downlink Packet Access) for download
  - HSUPA (High-speed Uplink Packet Access) for upload
  - Data rates up to 14,4 Mbit/s (10,8 Mbit/s with error-correction encoding) on downlink channel
- LTE (Long-term Evolution)
  - high data rates: up to 100 Mbit/s in local area (even up to 300 Mbit/s with extensions)
  - optimized for travelling speeds of up to 15 km/h (up to 500km/h possible)
- Coverage and quality varies between urban and rural areas

WLAN and WPAN

- Infrastructure
  - like a star-network
  - Access-Point (AP) is a central point
  - AP coordinates the network nodes and communicates with other networks
  - Infrastructure planning required required, low flexibility
  - Network functionality mainly contained in Access points
  - Access to other networks and Internet



- Ad-Hoc
  - Like Peer-to-Peer Network
  - no central Station or higher-level infrastructure available
  - All network nodes are equivalent
  - No infrastructure planning required, high flexibility
  - Network functionality contained in device, complexity of devices increased
  - No access to other networks



Comparision of WPAN/WLAN-technologies

FUNCTION	Bluetooth	IrDA Data	IEEE802.11 (WLAN)
Range:	10 meter max.	1 meter max.	50-100 meter
Angle:	omni-directional	ca 30° (line-of-sight required)	omni-directional
Frequency Band:	ISM Band, 2.4 GHz	Infrared Radiation	ISM Band, 2.4 GHz
Mobility:	mobile, walking speed	stationary, LoS	mobile, walking speed
Data rate:	up to 723 kBit/s	Varying (kBit/s – MBit/s range)	11 MBit/s, 54 MBit/s
Security level:	High	Low (but very limited range)	High

Source: http://www.okisemi.com

Further Technologies

Personal Area Networks

- Blue-tooth
- ZigBee
- Near-Field Comm.
- Wireless USB, 1394
- Ultra-Wide Band

Local Area Networks

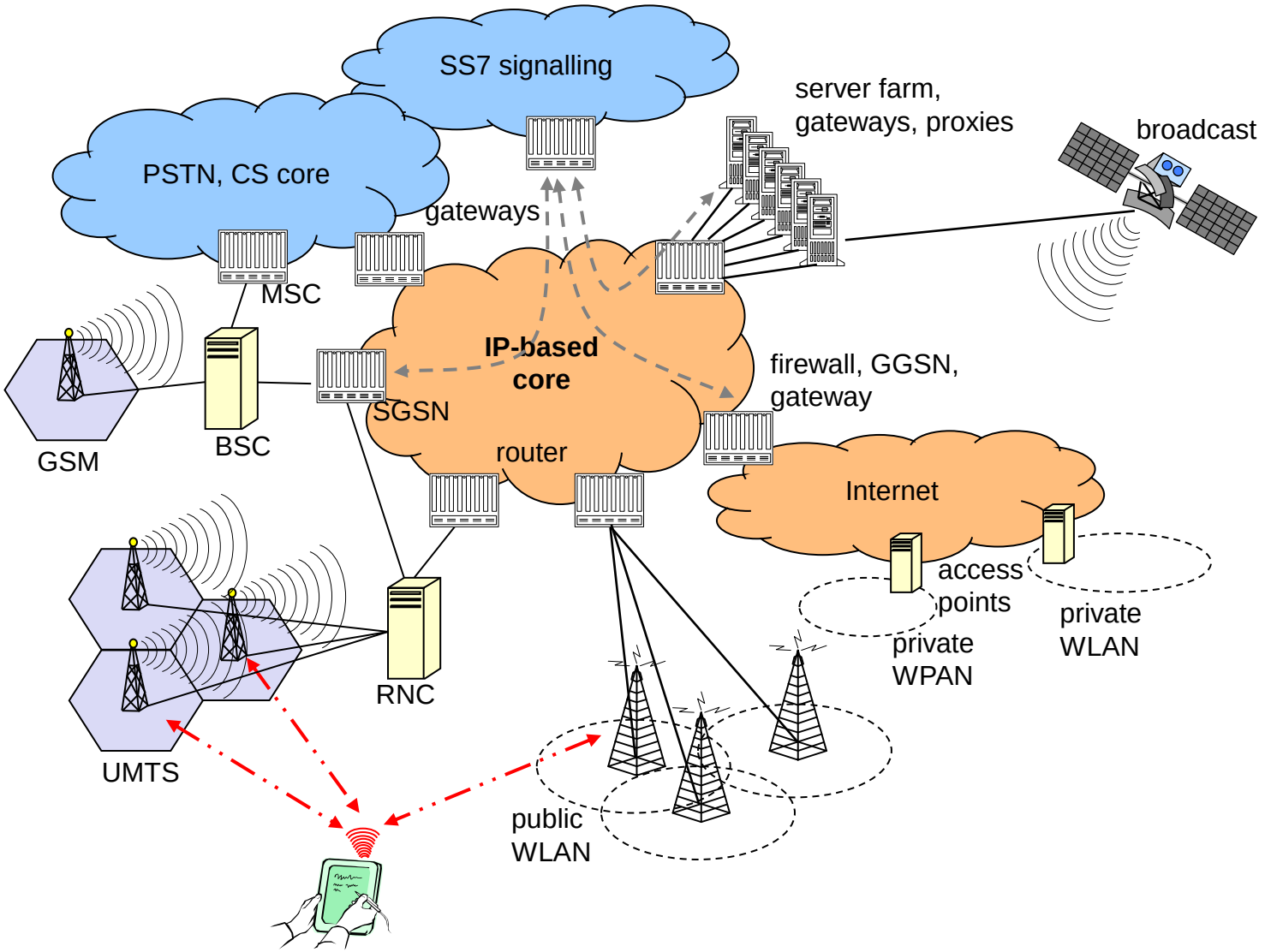
- WLAN (WiFi)
- DECT

Wide Area Networks

- GSM
- GPRS
- EDGE
- CDMA 2000
- UMTS
- LTE
- WiMax

emerging established

Example IP-based 4G network infrastructure



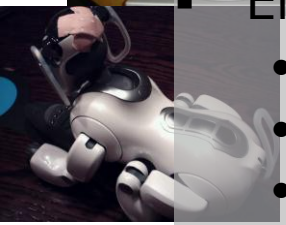
Challenges of Connectivity

- Wireless Access issues
  - more interference and error prone
  - limited bandwidth and coverage
  - security
- Access technologies are
  - heterogeneous (frequency, technology, bandwidth, delay, jitter, error rates, cost, …)
  - Limited coverage, availability changing over time
  - made for different purposes
    - GSM (and extensions) – Mobile Communication
    - UMTS (and extensions) – Mobile Communication and Data Exchange
    - IEEE802.11 – wireless LAN data communication
    - Bluetooth – integration of peripherical devices

Four Device Categories

According to Hansmann, U.: Pervasive Computing Handbook. The Mobile World.

- Entertainment Systems
  - easy integrateable
  - simple interactions
  - more powerful devices
  - higher data rates

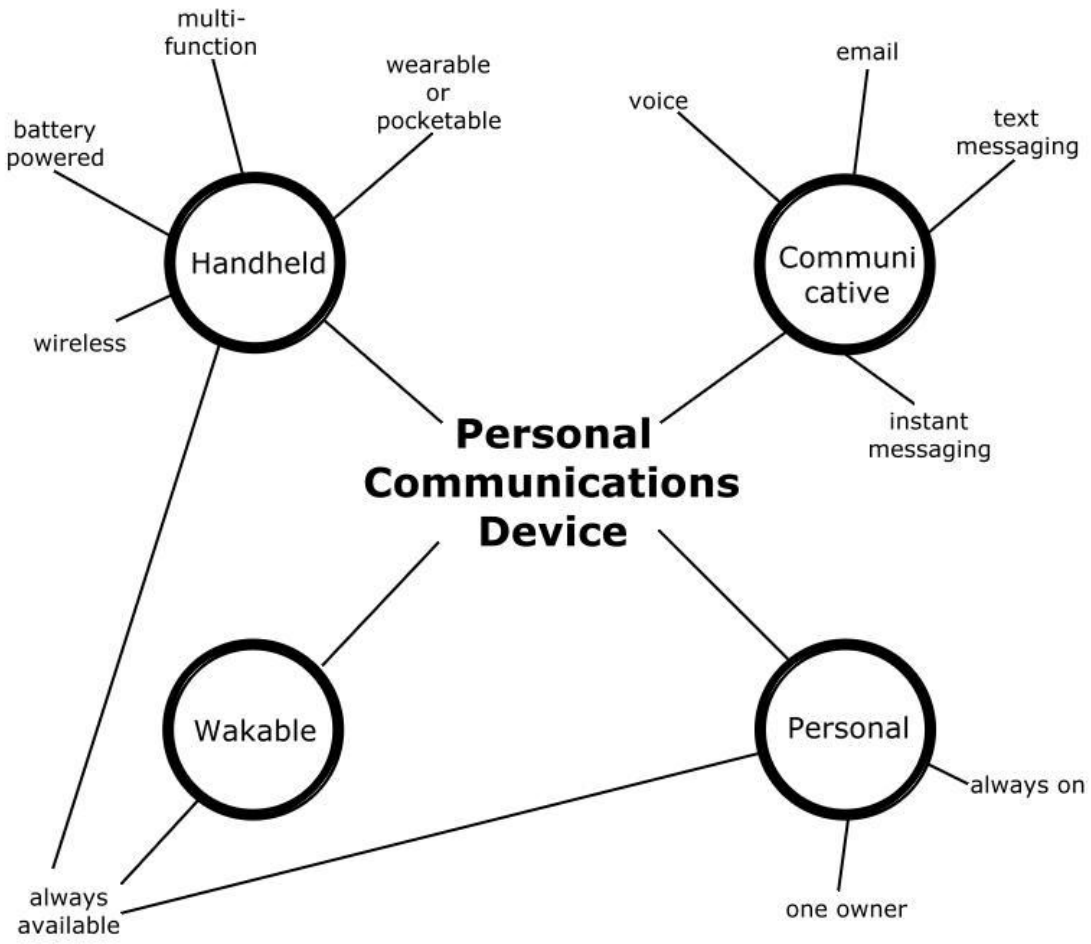


- Sensors and Smart Controls
  - highly specialized and integrated
  - limited connectivity
  - sensor integration
  - contraint energy sources

- Information Appliances
  - easy integrateable
  - simple interactions
  - more powerful devices
  - higher data rates

- Intelligent Appliances
  - computing power embedded into things of daily life
  - extend capabilities of appliences
  - integration and cooperation

Information Appliances = Personal Communication Devices



- Belongs to one person, „always with you“
- Different channels for voice/data communication
- Low weight, simple to carry
- Quickly wakable with one touch, active also in sleep mode

Ballard, B.: Designing the Mobile User Experience, Wiley, 2007

Information Appliances

Basic phones
- SMS and speech
- Add ons: flashlite

Smartphones/PDAs
- speech, data, WLAN
- graphical UI, touch
- small keyboards
- Apps

netbooks/laptop
- fully functional
- standard applications

feature phones
- SMS, speech, data
- camera
- JavaME, BREW

pads/ebook-reader
- WLAN, 3G
- graphical UI, touch
- Apps

capabilities and resources

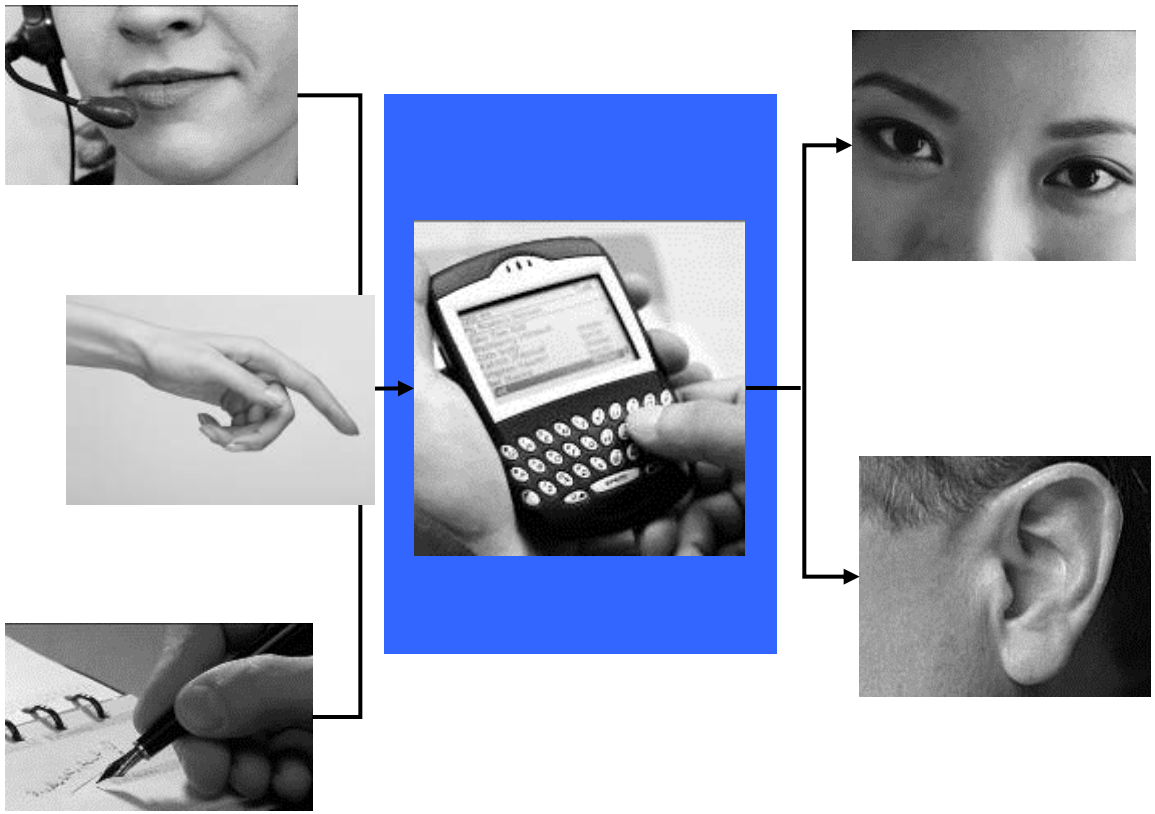
Interactions are different

- full qwerty keyboard
- restricted qwerty keyboard
- phone keypad
- character recognition
- on screen keyboard

- arrow keys pointer
- mouse
- trackball
- touchpad
- pointing stick
- pen

Multimodal Interactions

- Multimodality: parallel, sequential or alternative usage of visual, speech, gesture, …
- More natural interactions between humans and computers
- use can concentrate on the task
- dependence on environmental settings
  - available modalities
  - noise level
  - light level
  - user activity



Different Operating Systems

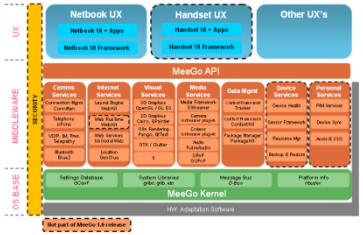
- Windows Mobile (Microsoft)
  - intended for resource rich PDAs (pen-based) and embedded devices
  - applied by manufacturers like Casio and HP
  - office and multimedia features, desktop like "look and feel"
  - Development Environment for C++ and Basic, also Java

- Android
  - layered platform for mobile devices based on Linux
  - Programming in Java, but with special VM implementation (Dalvik VM)
  - Complete development environment with large set of libraries, services and UI framework

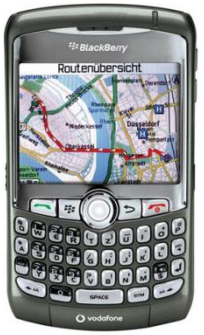
- iOS (Apple)
  - Proprietary platform for iPhone and iPad based on Mac OS X
  - Development with Objective C, Cocoa API
  - Multitouch gestures
  - No Multitasking, with version 4 support for several background tasks

More …

- Maemo/MeeGo (The Linux Foundation)
  - Several device classes (Netbook, in-Vehicle, Netbook, Connected TV, Handset)
  - Open, Linux based platform
  - Development with C as official programming langugage, also support for Phyton
  - Maemo SDK sets up on Scratchbox cross compiling platform



- Blackberry OS (Research in Motion)
  - Proprietary multi-tasking platform for smartphones
  - Development with C++ and Java ME (MIDP)

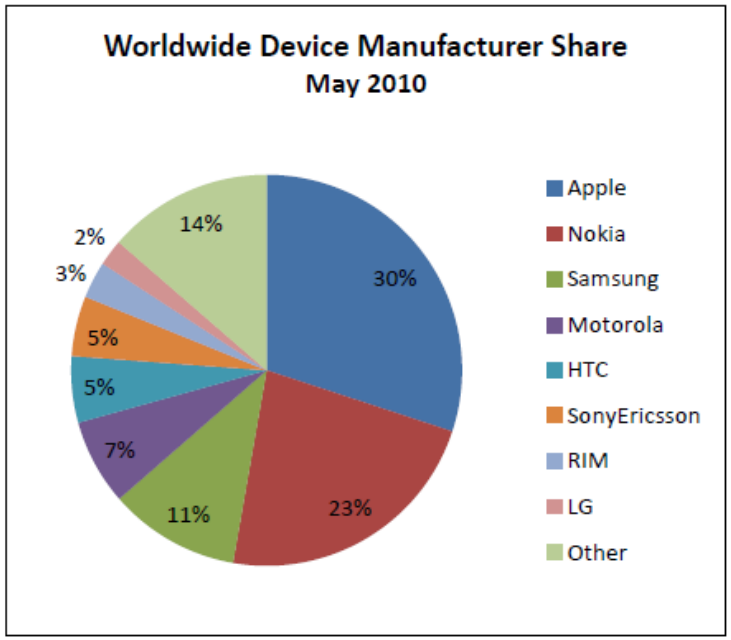


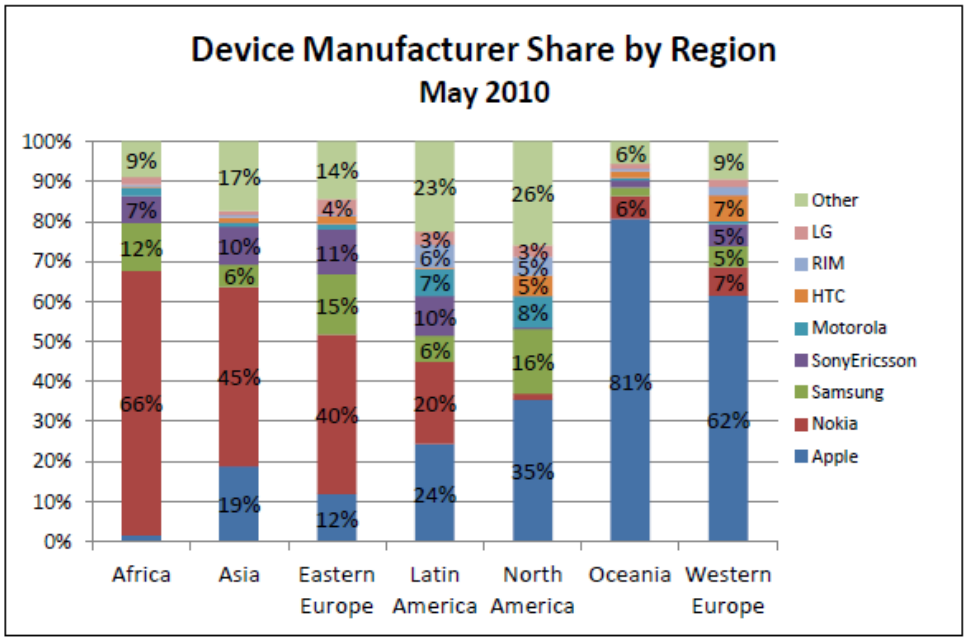
- OpenMoko
  - family of open source mobile phones
  - Linux-based
- LiMo
  - Mobile Linux platform
  - provides large set of middleware services and UI framework
- Even more …

openmoko

Device Manufacturer Share

- Nokia is the leading device manufacturer in Africa, Asia and Eastern Europe, while Apple leads in North America, Oceania and Western Europe
- Many of the top devices in 2010 have touchscreens and are WiFi capable

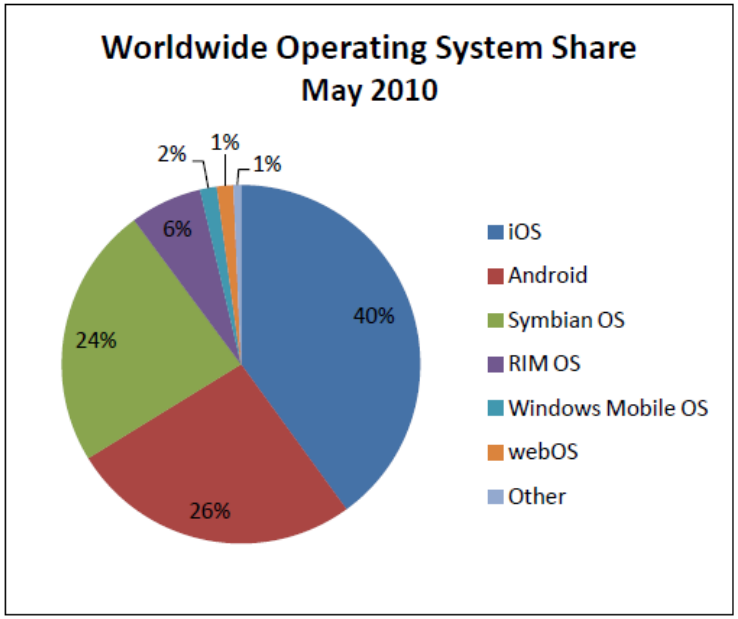


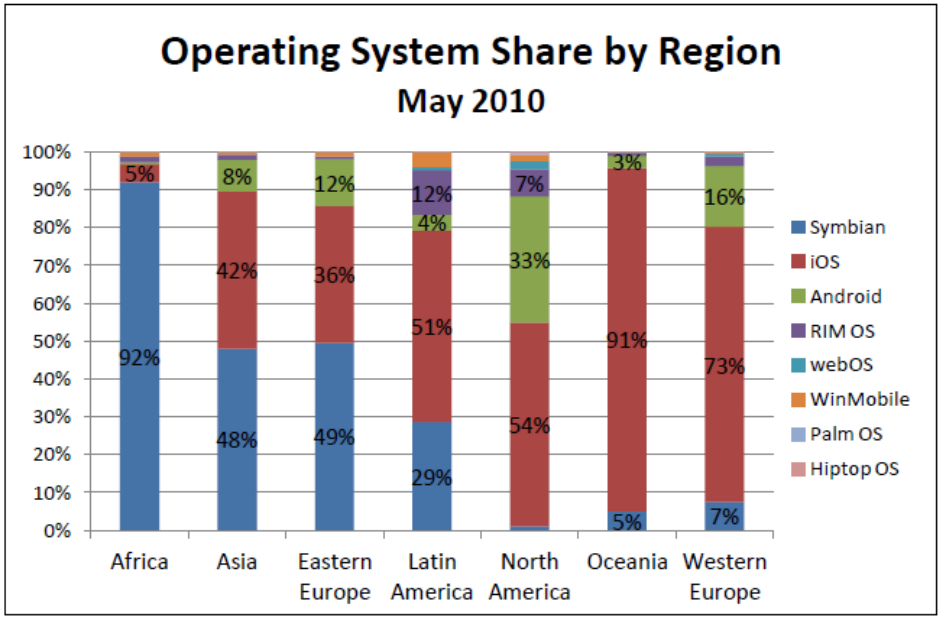


AdMob's Mobile Metrics Report, May 2010 (metrics.admob.com)
AdMob stores and analyzes data from each ad request to serve the most relevant ad possible

Operating System Share (by internet traffic)

- Mobile Internet usage is global
- 92 countries generated more than 10 million requests in May 2010, up from 27 countries in May 2008
- 90% of worldwide smartphone requests were generated by iOS, Android and Symbian





AdMob's Mobile Metrics Report, May 2010 (metrics.admob.com)

Challenges - Devices

- Heterogeneity and limitation of resources
  - Energy, memory, processor speed
  - Available peripheral devices
- Heterogeneity of input and output devices:
  - Input: keyboard, numeric keyboard, pen, speech, …
  - Output: display size, color depth, resolution, built-in UI, …
- Heterogeneity of software:
  - Operating system/device platform
  - Browser type and supported multimedia formats
- Heterogeneity of network connectivity:
  - Supported bearer types
  - Migration between different wireless networks

Challenges - Energy Consumption

- communication consumes energy
- computation consumes energy
- unplugged energy sources are an enabler for mobility
- limited energy
- better energy source
  - energy aware communication
  - energy aware computation

Challenges – Customer Satisfaction

- usability
  - special form factor of mobile devices
  - highly dynamic environment
    - mobility of users and devices (applications)
    - changes of devices and connection technology at runtime
    - sequential and parallel usage of different input and output devices
  - heterogeneity in user requirements
    - personalization
    - individualization
  - heterogeneous usage scenarios
    - different user tasks and roles
    - varying location
  - variability of input and output modalities
  - new forms of interaction

Challenges – Security and Privacy

- portable computers are more vulnerable to loss, damage or theft
- changing domains of trust due to mobility
- limitations for standard security concepts due to limited resources
- wireless communication technologies are easier to attack

Challenges - Summary

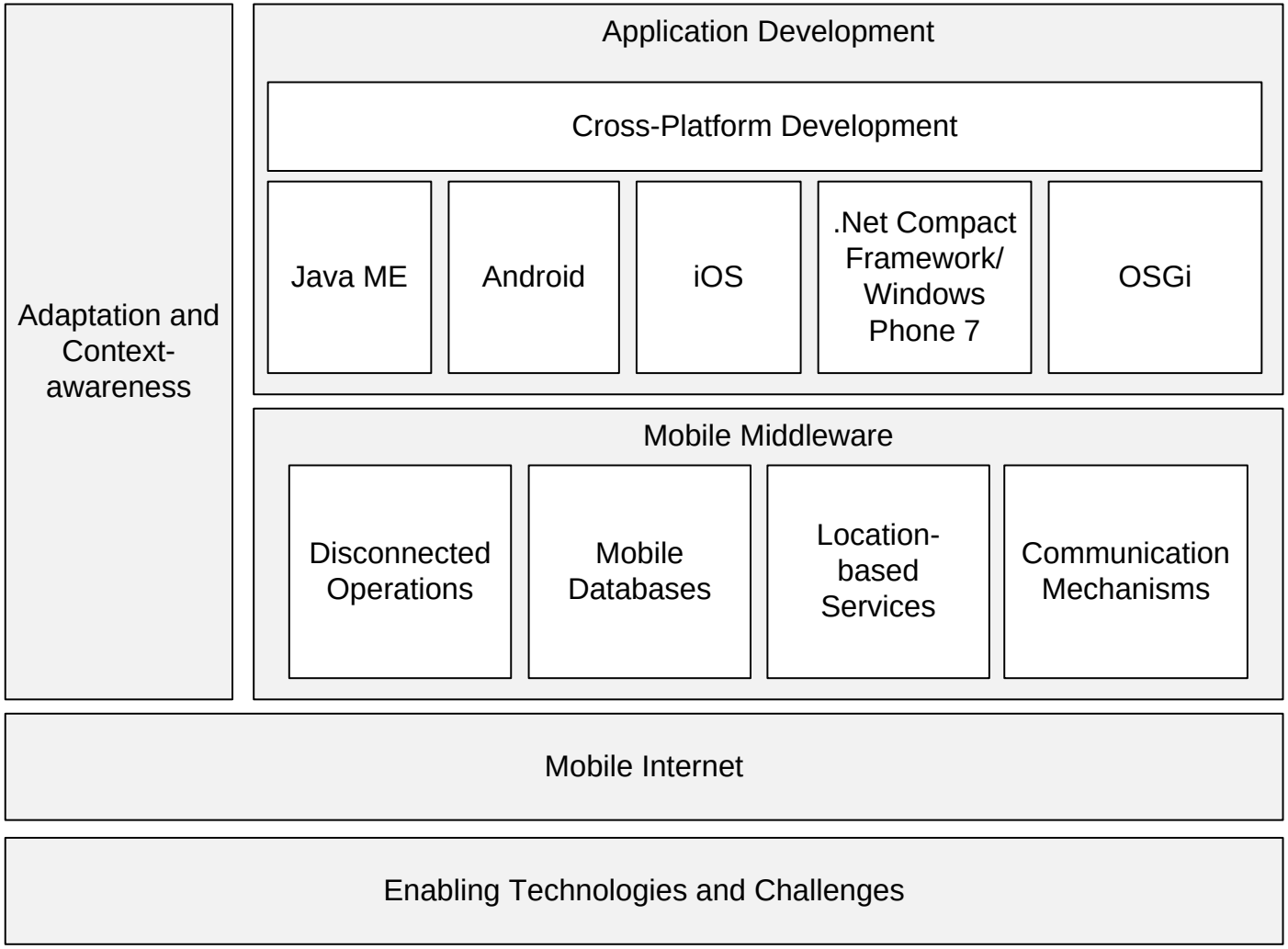
- technological challenges
  - heterogeneity of
    - of network connections
    - of devices
    - programming platforms
    - user preferences
  - resource restrictions: power consumption, storage, interaction and UI capabilities, bandwidth
  - dynamic computing environment
    - data management, disconnected work / synchronization
    - functions for right time and right place
  - form factor of mobile devices
  - energy

- customer satisfaction
  - usability
  - security and privacy

Goals of this Lecture

- understand the notion, challenges and solutions for Mobile Computing, Pervasive Computing, Ubiquitous Computing and Ambient Intelligence
- get a broad overview about technologies and research activities in these technologies
- understand general scope of these applications
- get in contact with research and industrial applications projects
- build your own (first) mobile application!

Lecture Structure



Related Lectures offered by Chair for Computer Networks

- Distributed Systems (Prof. Schill)
- Mobile Communication and Mobile Computing (Prof. Schill)
- Wireless Sensor Networks (Dr. Dargie)
- Practical Exercise: Development of Mobile and Ubiquitous Systems (Dr. Springer)

Organizational Details

- lecture
  - winter term, lecture 2/2/0 - 6 credits
  - integration into
    - CE/DSE Modul: Ubiquitous Information Systems
    - Informatik: Architektur verteilter Systeme
    - Medieninformatik: Systemarchitektur und -techniken
- form of certification:
  - examination: (Teilfachprüfung)
  - certificate (Leistungsnachweis)
- homepage
  - http://www.inf.tu-dresden.de/index.php?node_id=2568&ln=de&lv_id=48
- any suggestions are always welcomed
  - Thomas.Springer@tu-dresden.de

Literature

- Jochen Schiller – Mobile Communications / Mobilkommunikation
- Ivan Stojmeniovic – Handbook of Wireless Networks and Mobile Computing
- Uwe Hansmann – Pervasive Computing Handbook. The Mobile World.
- Andrew Tanenbaum – Computer Networks, and other books
- James D. Solomon – Mobile IP, the Internet unplugged
- Charles E. Perkins – Ad-hoc networking
- Mühl, Fiege, Pietzuch - Distributed Event-Based Systems
- Finkenzeller – RFID Handbook
- Schill, Springer - Verteilte Systeme: Grundlagen und Basistechnologien

- and tons of other books on specialized topics
- papers, papers, papers, …

References

- George H. Forman, John Zahorjan: The Challenges of Mobile Computing. IEEE Computer, Volume 27, Issue 4, April 1994
- M. Satyanarayanan: Pervasive Computing: Vision and Challenges. IEEE Personal Communications, Volume: 8, Issue: 4, 2001
- Weiser, M., Brown, J. S.: The Coming Age of Calm Technology. Revised version of: Weiser & Brown. "Designing Calm Technology", PowerGrid Journal, v 1.01, http://powergrid.electriciti.com/1.01 (July 1996)
- Friedemann Mattern: State of the Art and Future Trends in Distributed Systems and Ubiquitous Computing. http://www.vs.inf.ethz.ch/publ/papers/DisSysUbiCompReport.html