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

You

- Do you use mobile phones?
  - for what?
- Do you use other mobile devices?
  - what devices?
  - for what?
- Have you ever implemented a mobile application?
  - what kind of application?
  - what platform?
  - what programming language?
  - what tools?

You

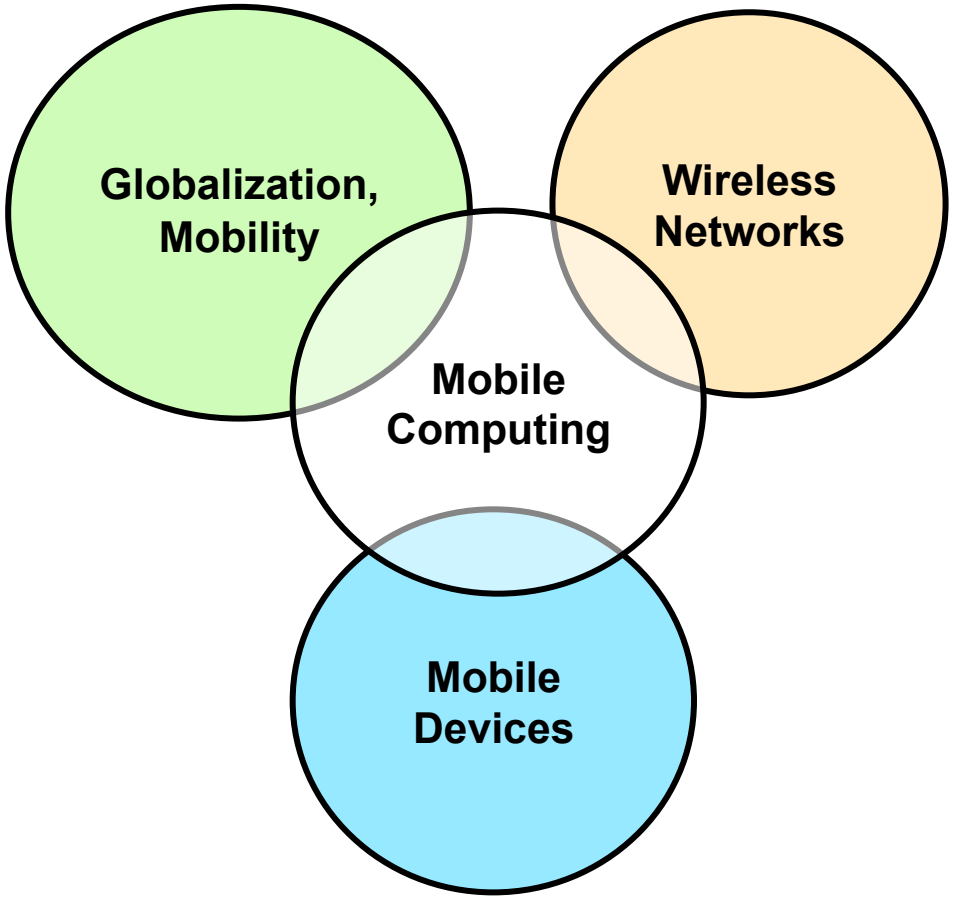
- What do you expect from the lecture?
- What kind of technology do you want to learn about?
- What is your background during the studies?
  - Distributed Systems
  - Mobile Communication and Mobile Computing
  - Other lectures

Overview

- What is Mobile Computing?
  - Major Driving Forces
  - Application Scenarios
  - Definition
- Current Trends
  - Pervasive and Ubiquitous Computing
  - Internet of Things
  - Ambient Intelligence
  - Context Awareness
- Challenges
- Lecture Organization

WHAT IS MOBILE COMPUTING ?

Major driving forces for Mobile Computing

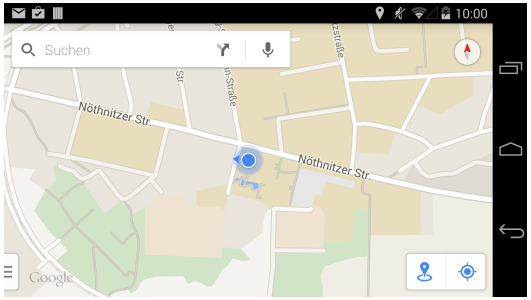


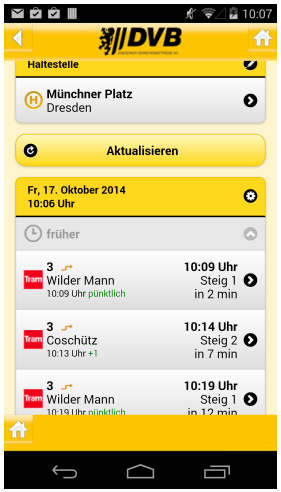
Mobile Computing is already there

- Smartphones
  - Communication
  - Social Networking
  - E-Mail, calendar
  - eTickets for public transport
  - Orientation and Maps anywhere
  - Exchange data and media
  - Control smart home devices
  - …
- Tablets and eBook-Reader
  - Take your library with you
  - Shopping
  - News, ….

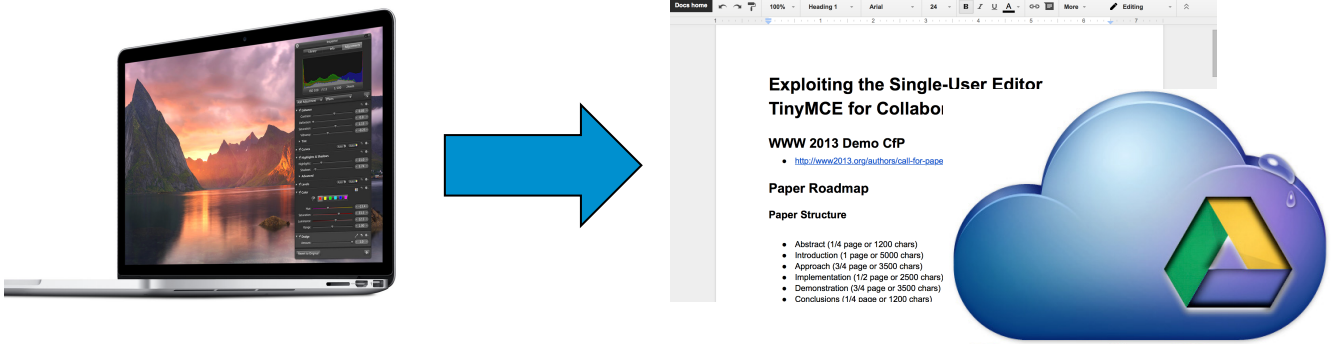
Mobile Computing is already there

- Mobile information and service access





- Location-independent work



Possible Applications of Mobile Computing

- Device control
  - control PowerPoint presentation with mobile device
  - access to smart home devices
- Wireless information / data exchange
  - exchange of data and media between 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

What is „Mobile Computing?“

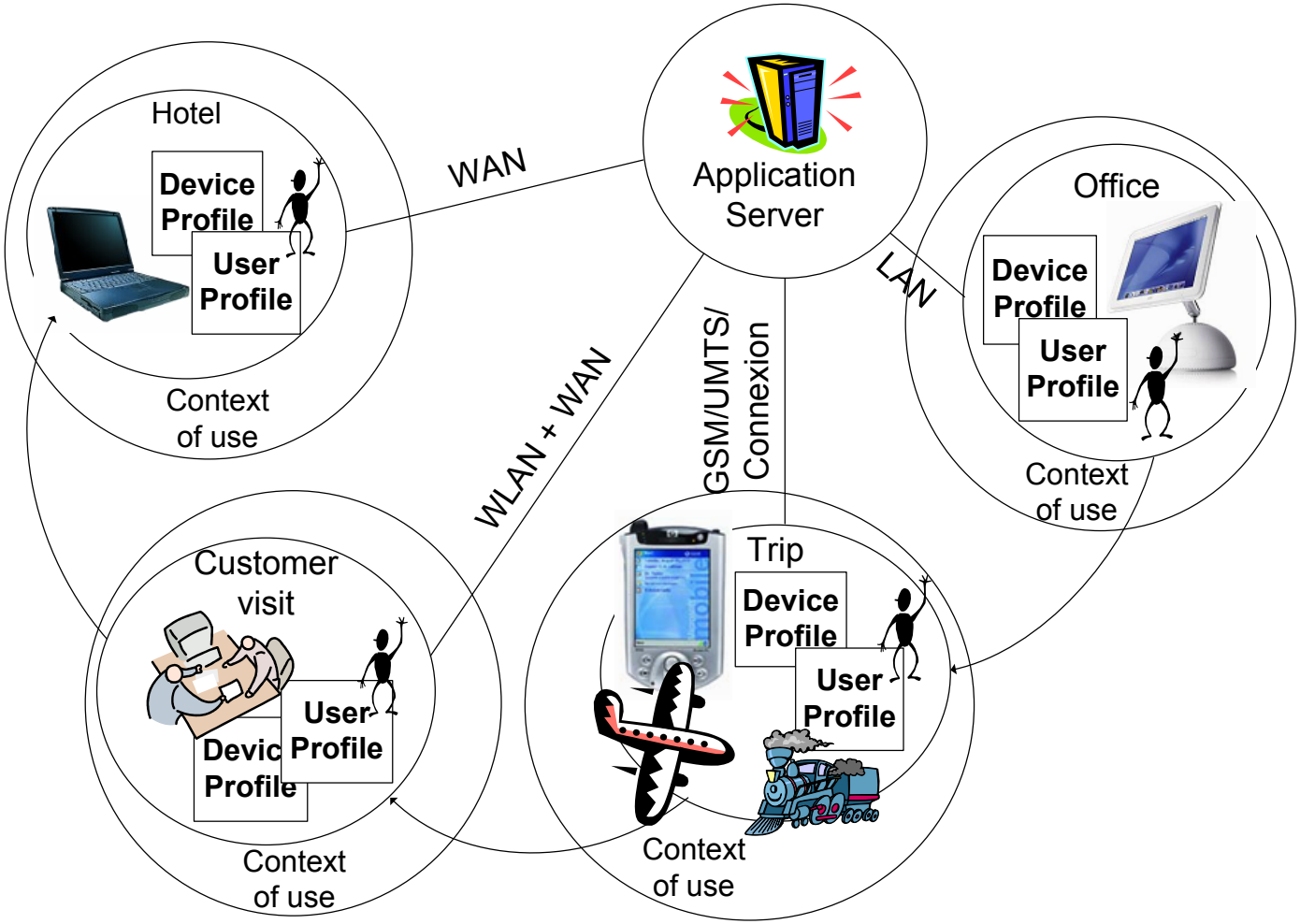
- Mobile Computing
  - integration of wireless networks into existing wired infrastructures
  - usage of portable/mobile devices
  - location-transparent work
  - similar work experience like with stationary devices

- Mobile Computing Paradigm:

  “information anytime, anywhere“

- aspects of mobility:
  - *user mobility*: users communicate (wirelessly) “anytime, anywhere, with anybody”
  - *device mobility*: end user devices may be (wirelessly) connected “anytime and anywhere” to other devices or the network
  - *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 device to another

Is that all?


Hotel
Device Profile
User Profile
Context of use
WAN
Application Server
LAN
Office
Device Profile
User Profile
Context of use
WLAN + WAN
GSM/UMTS/ Connexion
Customer visit
Devic Profile
User Profile
Context of use
Trip
Device Profile
User Profile
Context of use

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

Ubiquitous Computing – The 3rd Wave

„The "UC" era will have lots of computers sharing each of us. Some of these computers will be the hundreds we may access in the course of a few minutes of Internet browsing. Others will be imbedded in walls, chairs, clothing, light switches, cars - in everything. UC is fundamentally characterized by the connection of things in the world with computation.“ [Mark Weiser, 1996]

- users own multiple personal devices (e.g. laptop, smartphone or wearables)
- devices can be shared by multiple users (e.g. cloud server, public displays or sensors)

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]

- each computing device is able to interact and cooperate

- Ubiquitous Computing Paradigm:

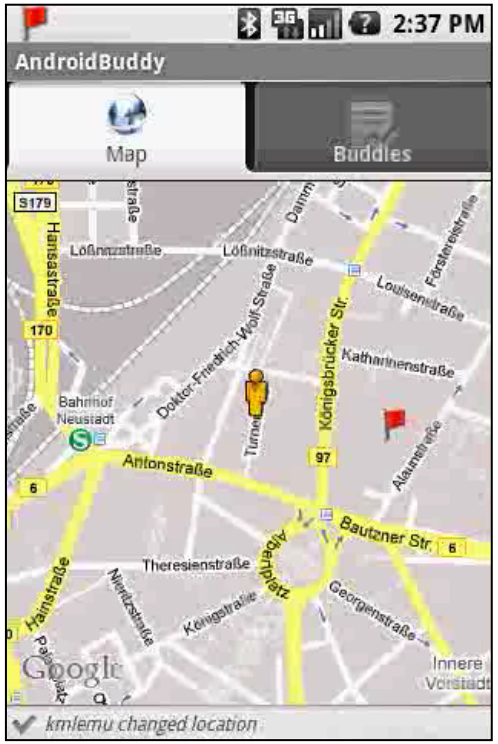
"the right service, at the right place, at the right time"

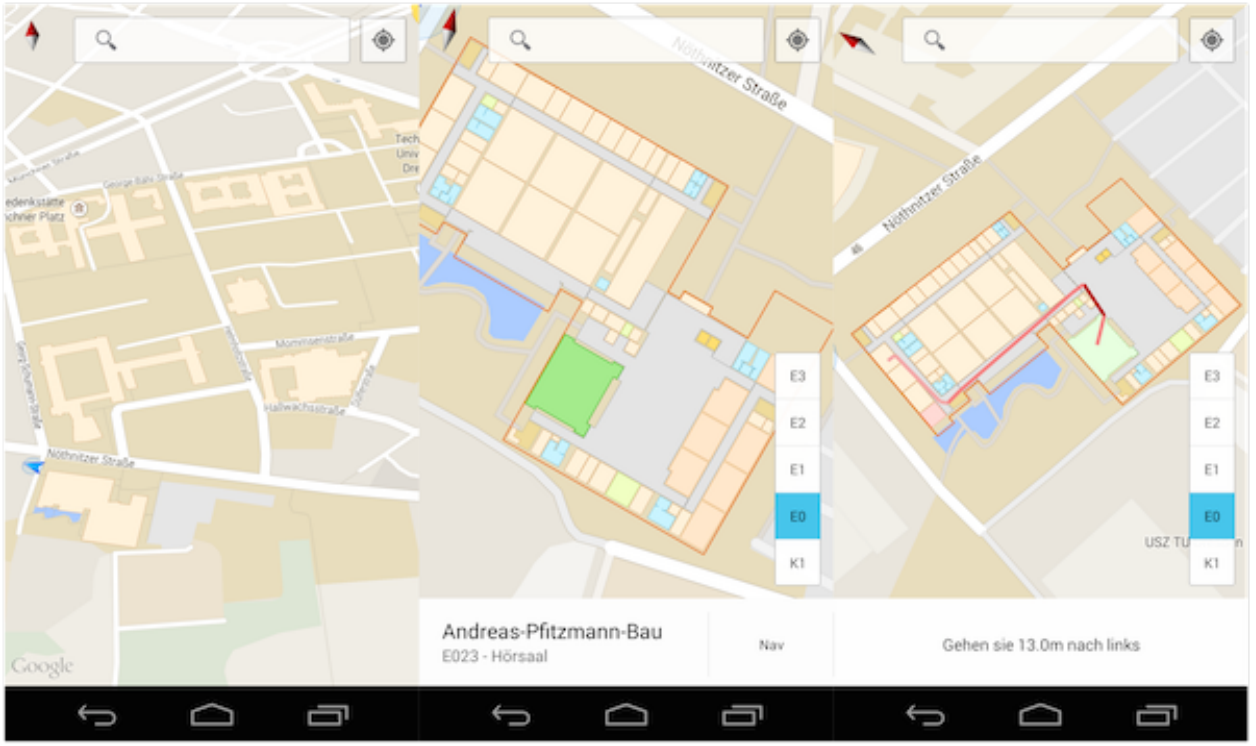
Pervasive Computing

"A billion people interacting with a million e-businesses through a trillion interconnected intelligent devices..."
[Lou Gerstner, IBM Chairman, 1997]

- Pragmatic, Industry-driven perspective
- integration of computing technology into business processes (i.e. mobile devices, RFID)
- new application areas (mobile business)
- today Pervasive Computing and Ubiquitous Computing are used synonymously

Location-based Services



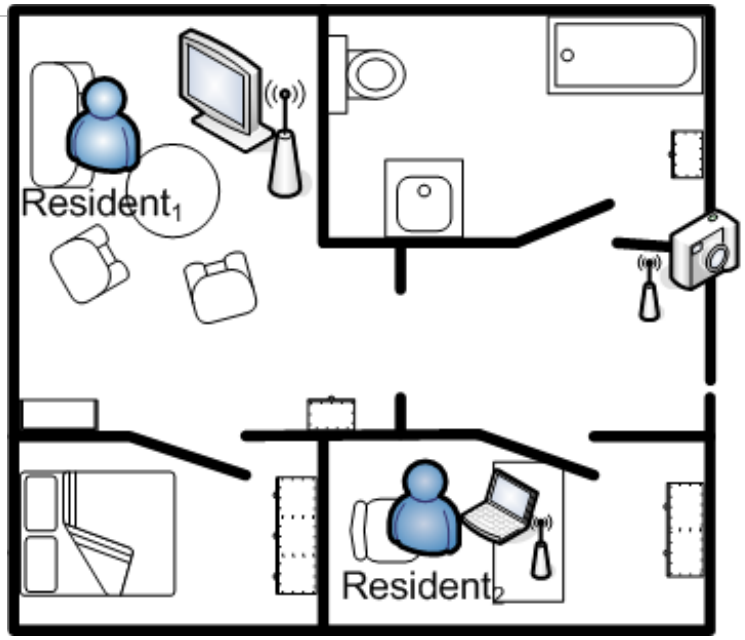


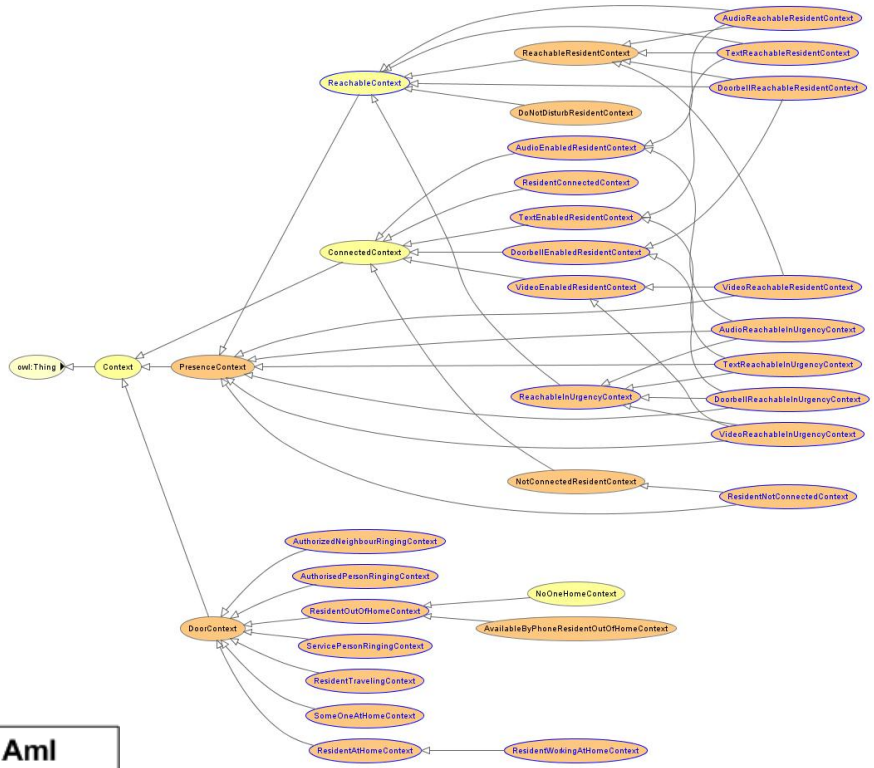
Ambient Intelligence

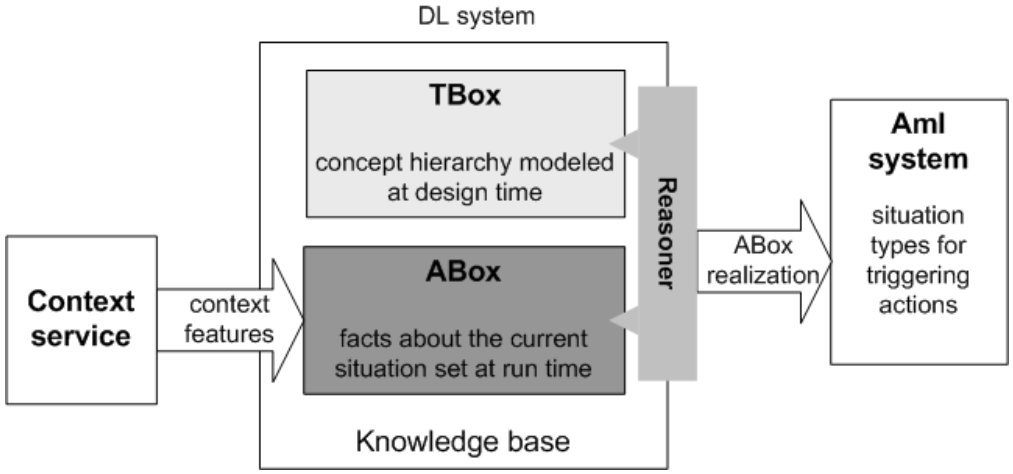
- *"A vision of the future where we are surrounded by electronic environments, sensitive and responsive to people"* [defined by the Advisory Group of the 6th Framework of the EU]

- 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

Intelligent Environments

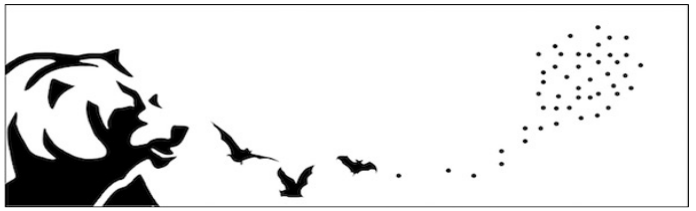






Internet of Things (IoT)

- IoT Vision [Kevin Ashton]:
  - Traditional WWW is user-centric -> humans create data
  - IoT: devices/objects provide data about physical world
- Internet becomes more diverse
  - Bears
    - Multi-purpose interactive devices
    - Interconnected
    - Share data and media
  - Bats
    - Special purpose devices
    - Need bear device for user interaction
    - Can be interconnected (smart home)
  - Bees
    - Active sensing devices (sensors)
    - Passive tagged objects (product with RFID)
    - „interactive" objects provide information and services via bears

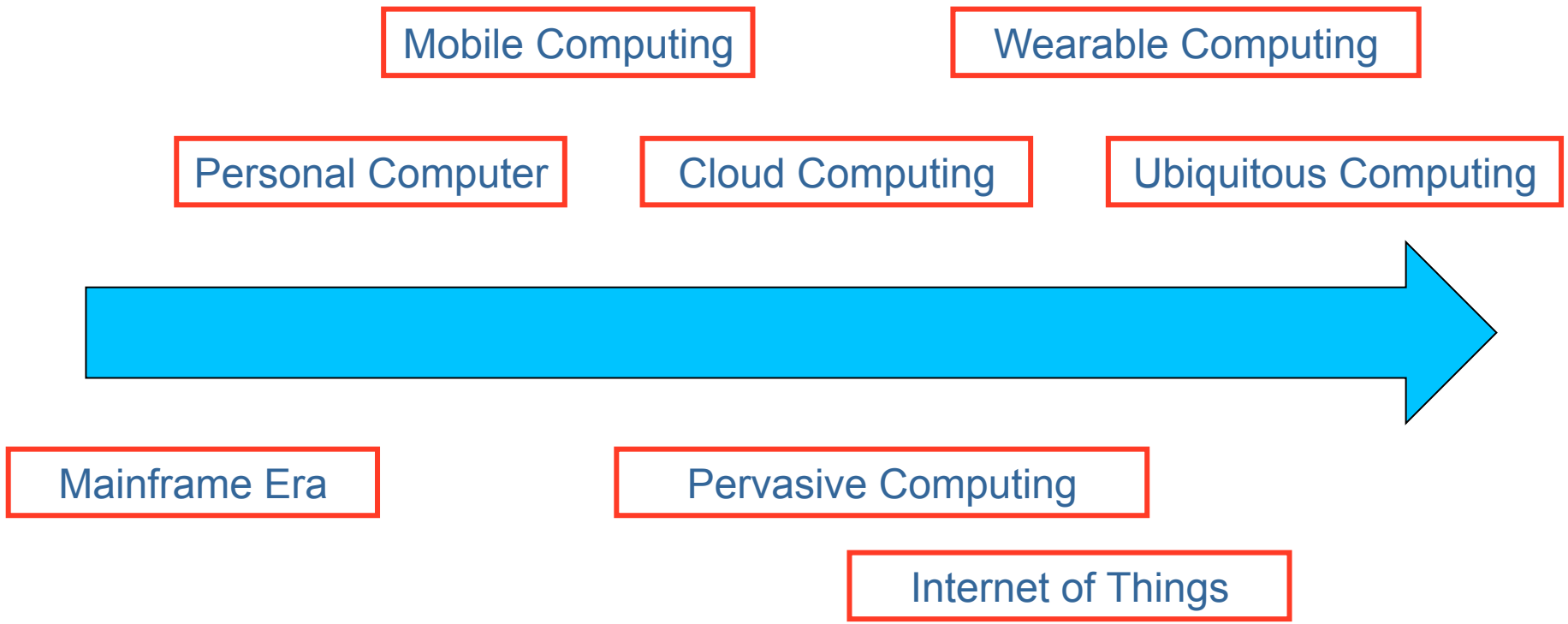


[Scott Jenson]

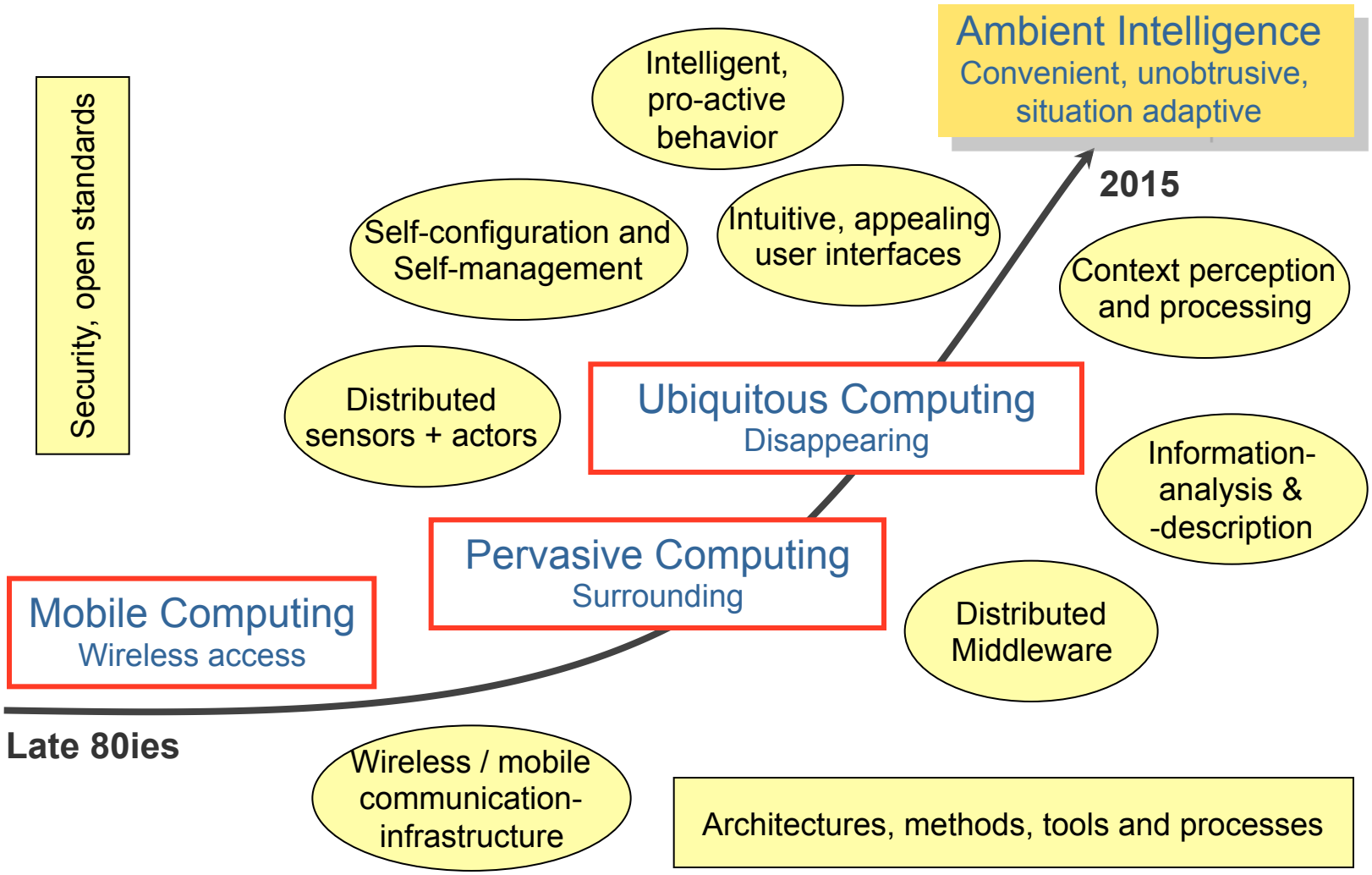
Manufacturing

- Mobile Goods based on RFID (Radio frequency Identifier)
  - tagging of objects and goods with RFID technology
  - position tracking

Timeline

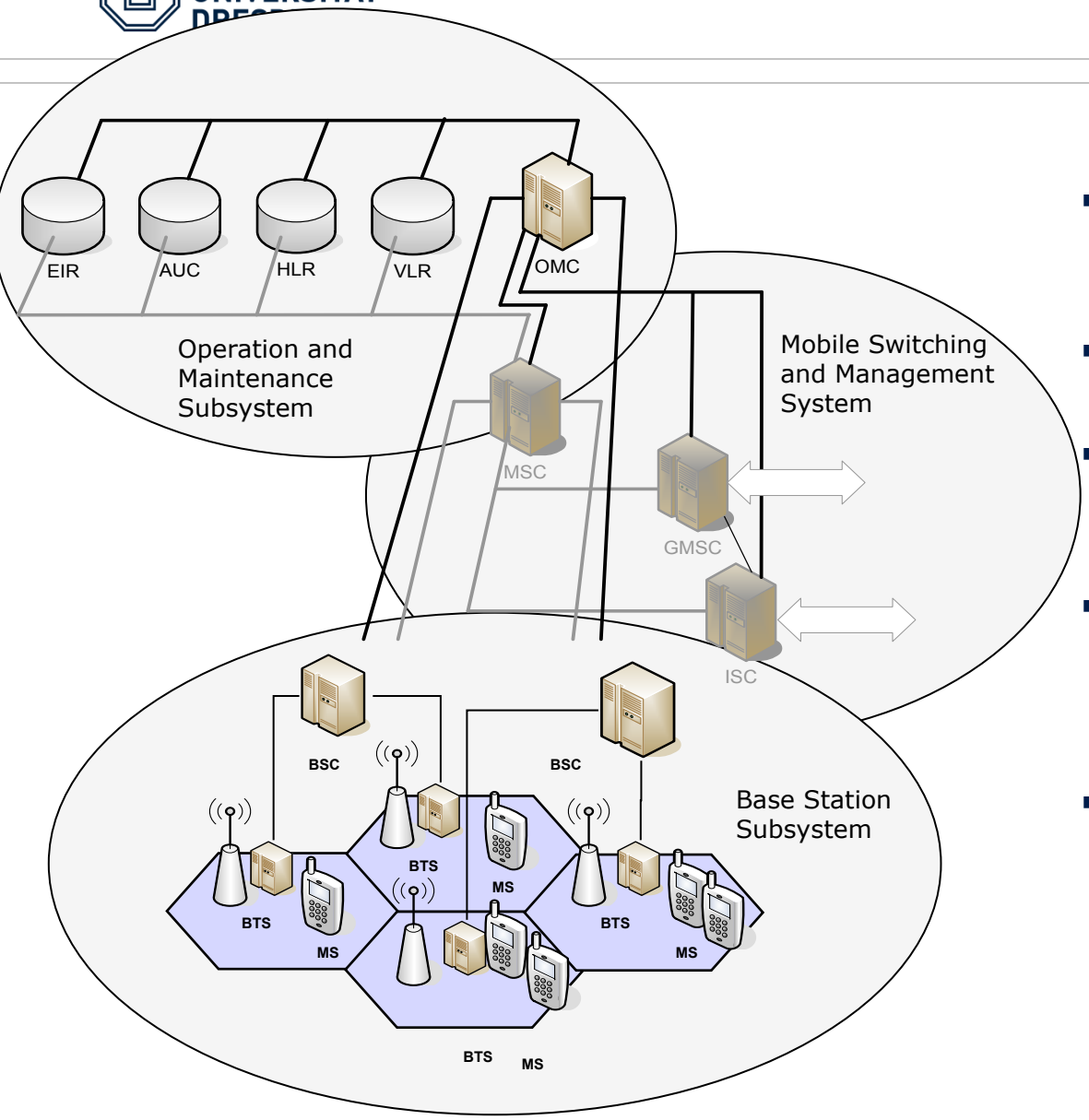

Mobile Computing
Wearable Computing
Personal Computer
Cloud Computing
Ubiquitous Computing
Mainframe Era
Pervasive Computing
Internet of Things

The Way towards Ambient Intelligence



COMPUTING INFRASTRUCTURE

Cellular Networks



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

GSM and Extensions

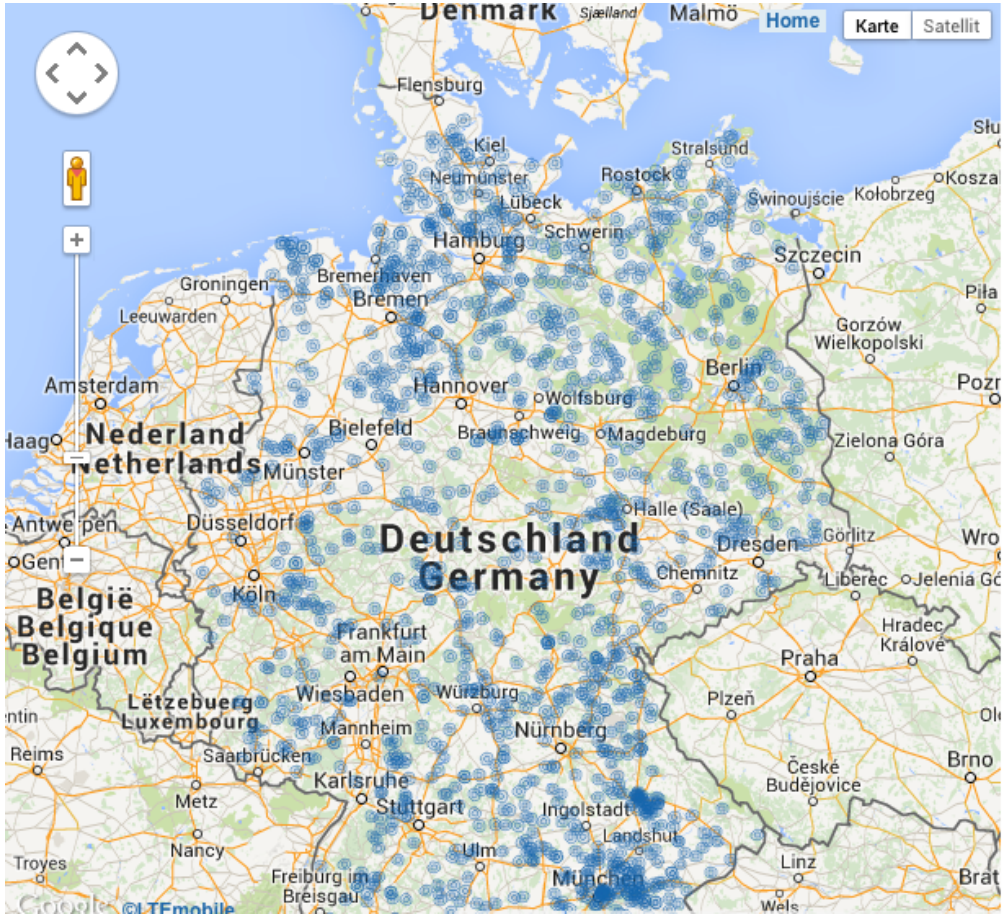
- GSM (Global System for Mobile Communications)
  - Primary build for telephony services
  - data communication up to 9600 Bit/s
- HSCSD (High Speed Circuit Switched Data)
  - Circuit switched, pay per usage time
  - Parallel usage of several time slots (TCH – traffic channel)
  - Data rates from 9,6 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

Coverage of LTE in Germany

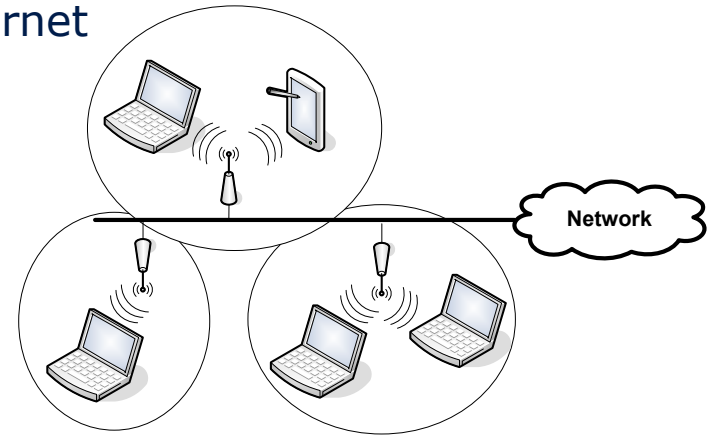
- degration of wireless access due to:
  - uncovered regions
  - limited contingent in flat rate



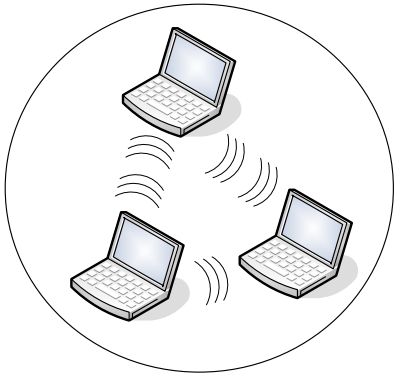
Source: http://www.ltemobile.de/lte-verfuegbarkeit/

WLAN and WPAN

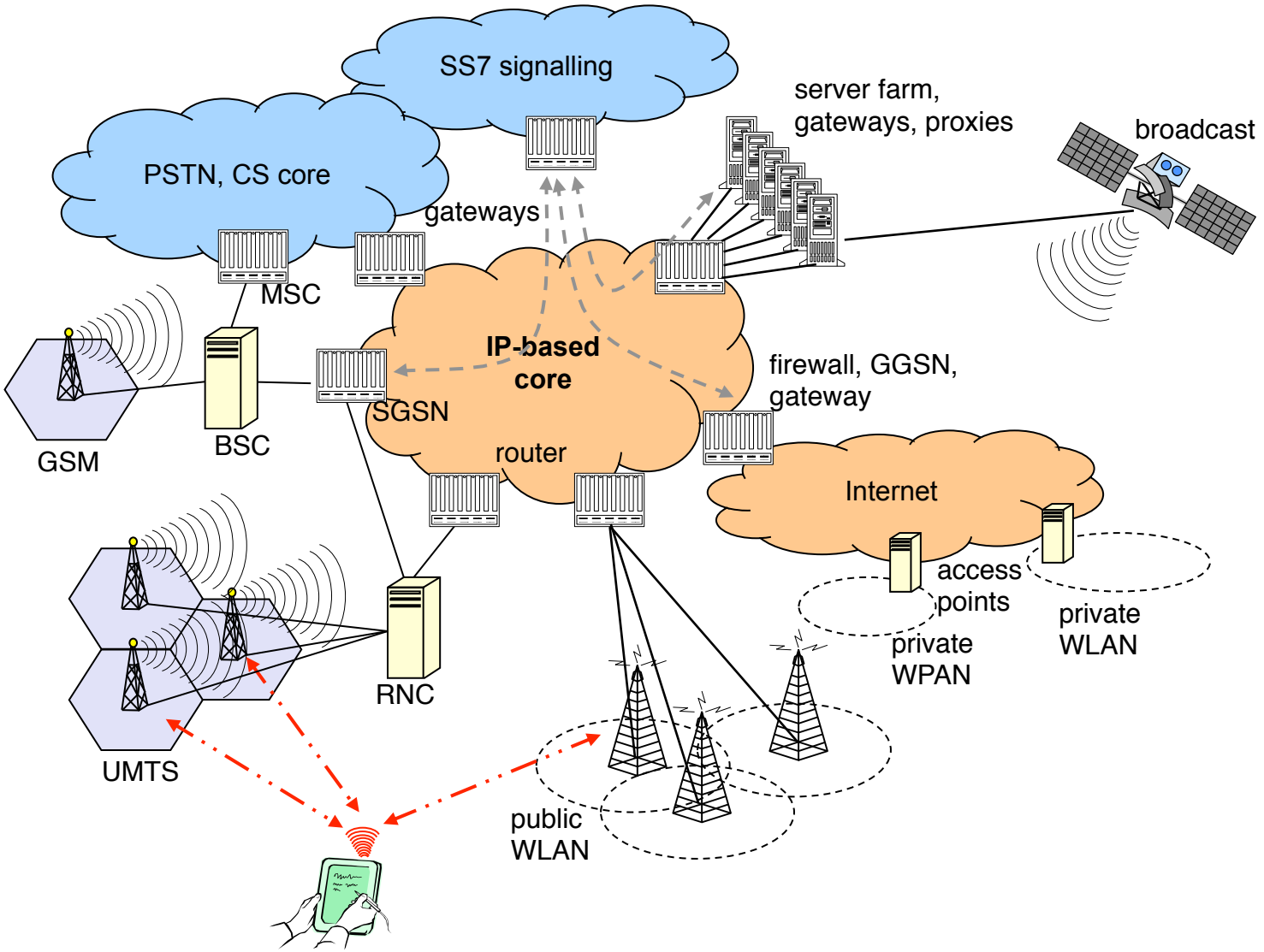
- Infrastructure
  - like a star-network
  - Access-Point (AP) is a central point
  - AP coordinates the network nodes and communicates with other networks
  - Infrastructure planning required required, low flexibility
  - Network functionality mainly contained in Access points
  - Access to other networks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



Integrated Communication Infrastructure



Further Technologies

Personal Area Networks

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

Local Area Networks

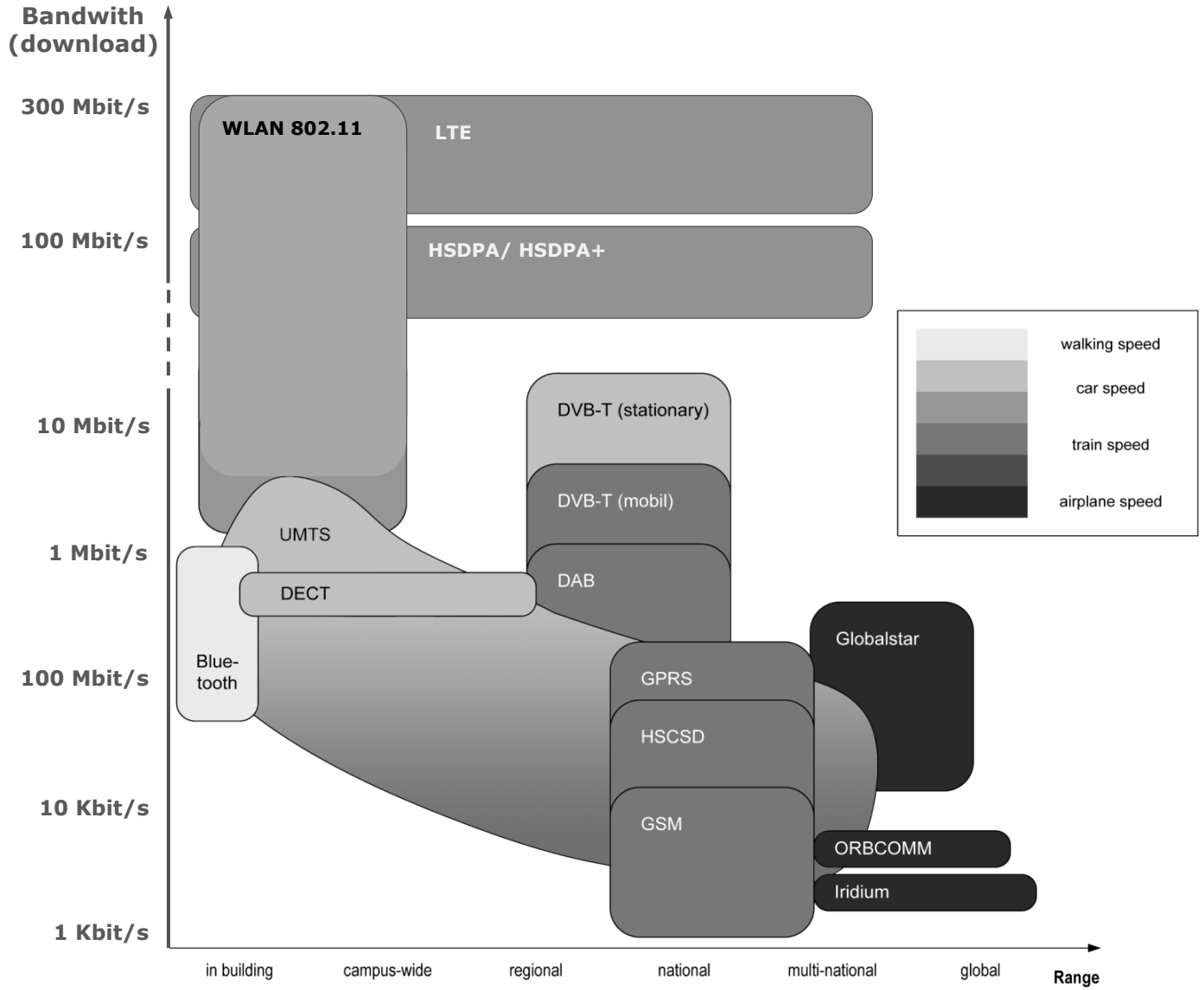
- WLAN (WiFi)
- DECT

Wide Area Networks

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

emerging established

Wireless Communication Technologies



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

Information Appliances

Basic phones
- SMS and speech
- Add ons: flashlite

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

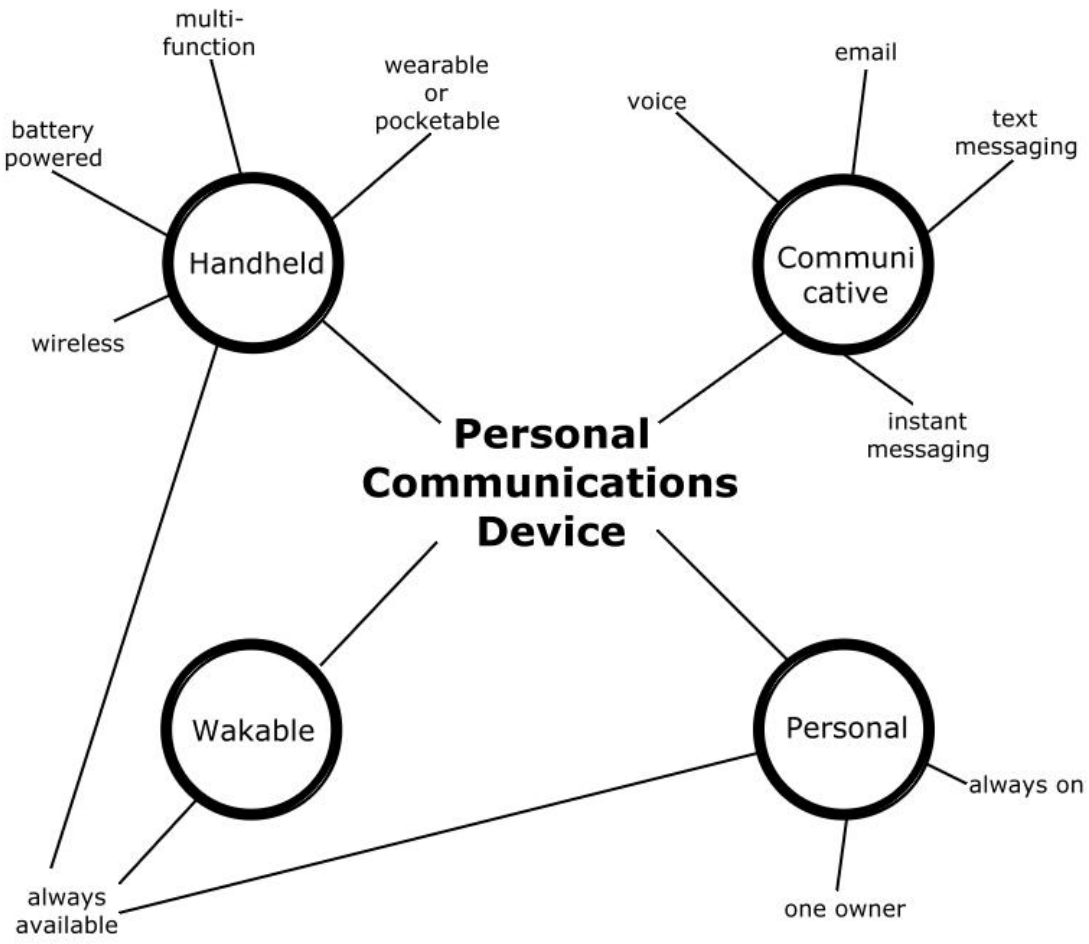
netbooks/laptop
- fully functional
- standard applications

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

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

capabilities and resources

Information Appliances = Personal Communication Devices

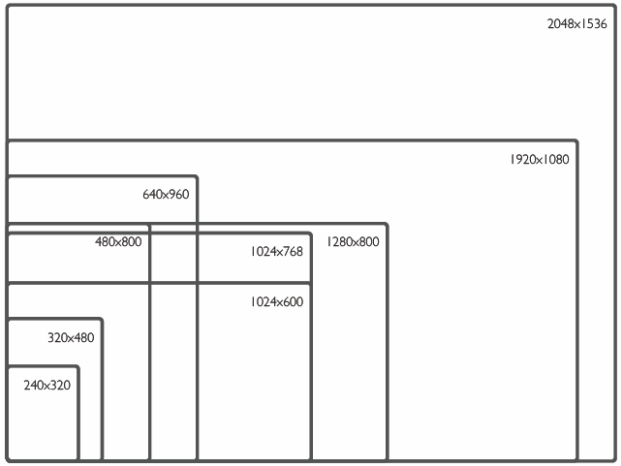


- Belongs to one person, „always with you“
- Different channels for voice/data communication
- Low weight, simple to carry
- Quickly wakable with one touch, active also in sleep mode

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

Device Resources

- iPhone 6 Plus
  - Up to 128 GB memory
  - 1920 x 1080 pixel with 401 pixel/inch
  - A8 chip with 64-bit architecture + M8 motion coprocessor
  - Wi-fi, GPS, 3G+, LTE, NFC Sensors
- iPad Air 2
  - up to 128 GB memory
  - Dual-Core Apple A8X with quad-core graphics + M8 motion coprocessor
  - 2048 x 1536 Pixel with 264 pixel/inch
  - Wi-fi, GPS, 3G+, LTE, Sensors
- Google Nexus 6
  - up to 64 GB memory
  - 2560 x 1440 Pixel with 493 pixel/inch
  - Qualcomm SnapdragonTM 805 - Quad Core 2,7 GHz + GPU Adreno 420
  - Wi-fi, GPS, 3G+, LTE, NFC, Sensors



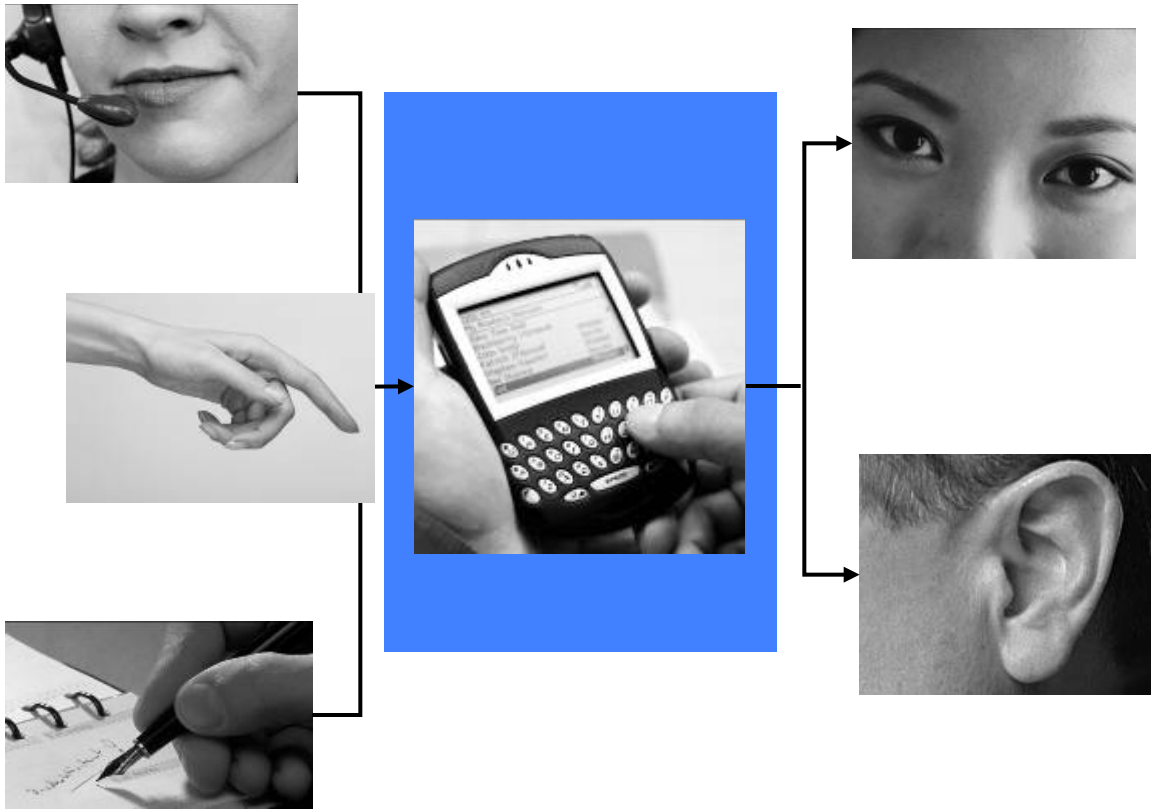
Interactions are different

- 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



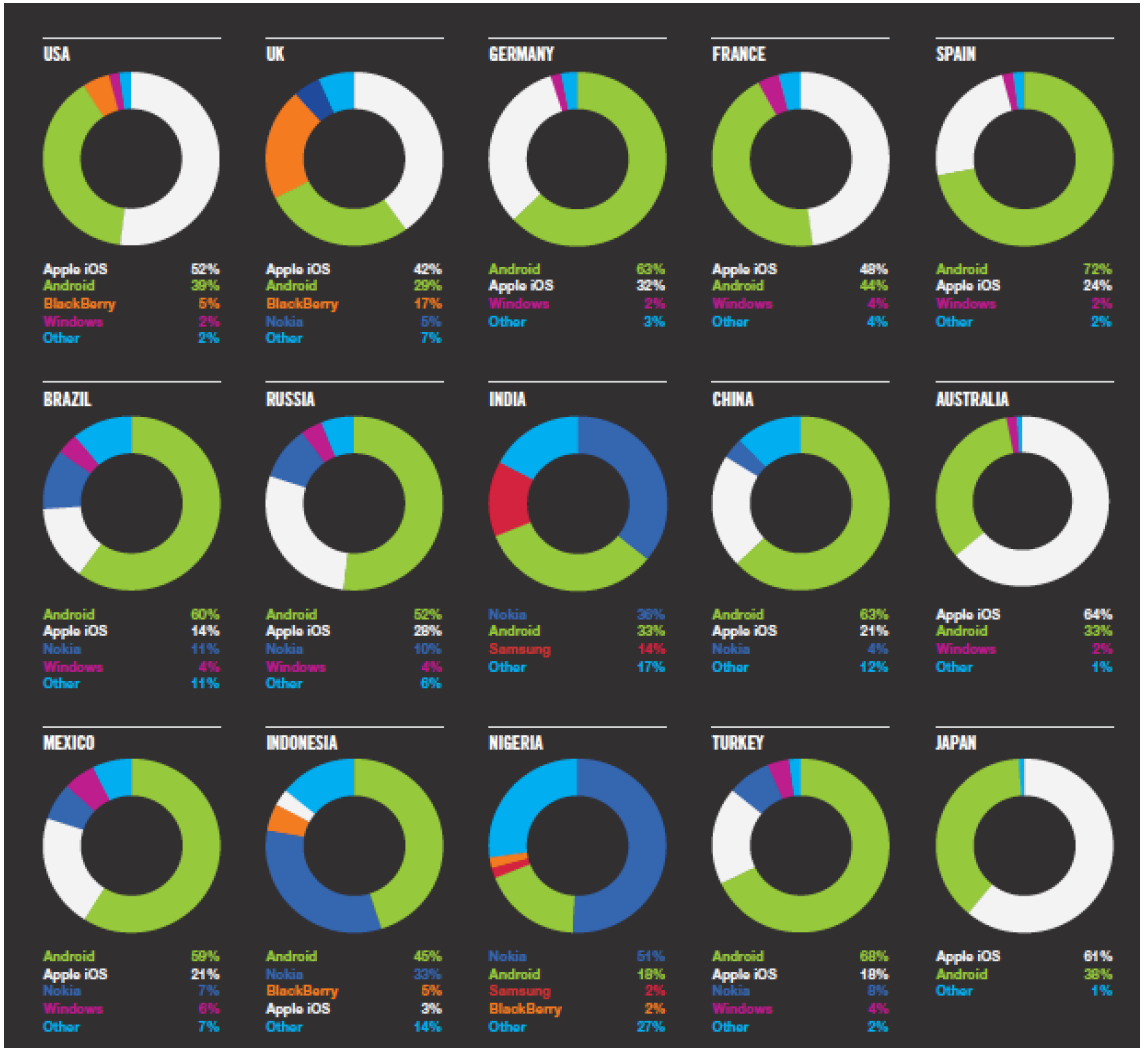
Different Operating Systems

- Android
  - platform for smartphones, tablets and embedded devices
  - development with Java, but with special VM (Dalvik VM)
  - Runs on devices of multiple vendors (e.g. Samsung, Motorola)
- iOS
  - device platform for smartphones and tablets
  - Development with Objective-C, xCode
  - Restricted to Apple devices
- Windows Phone
  - platform for smartphones, converging with Windows
  - development with C#, Visual Basic for Silverlight
  - runs on devices of multiple vendors (e.g. Nokia and HTC)
- Even more…
  - Firefox OS/Chrome OS
  - SymbianOS
  - Blackberry OS

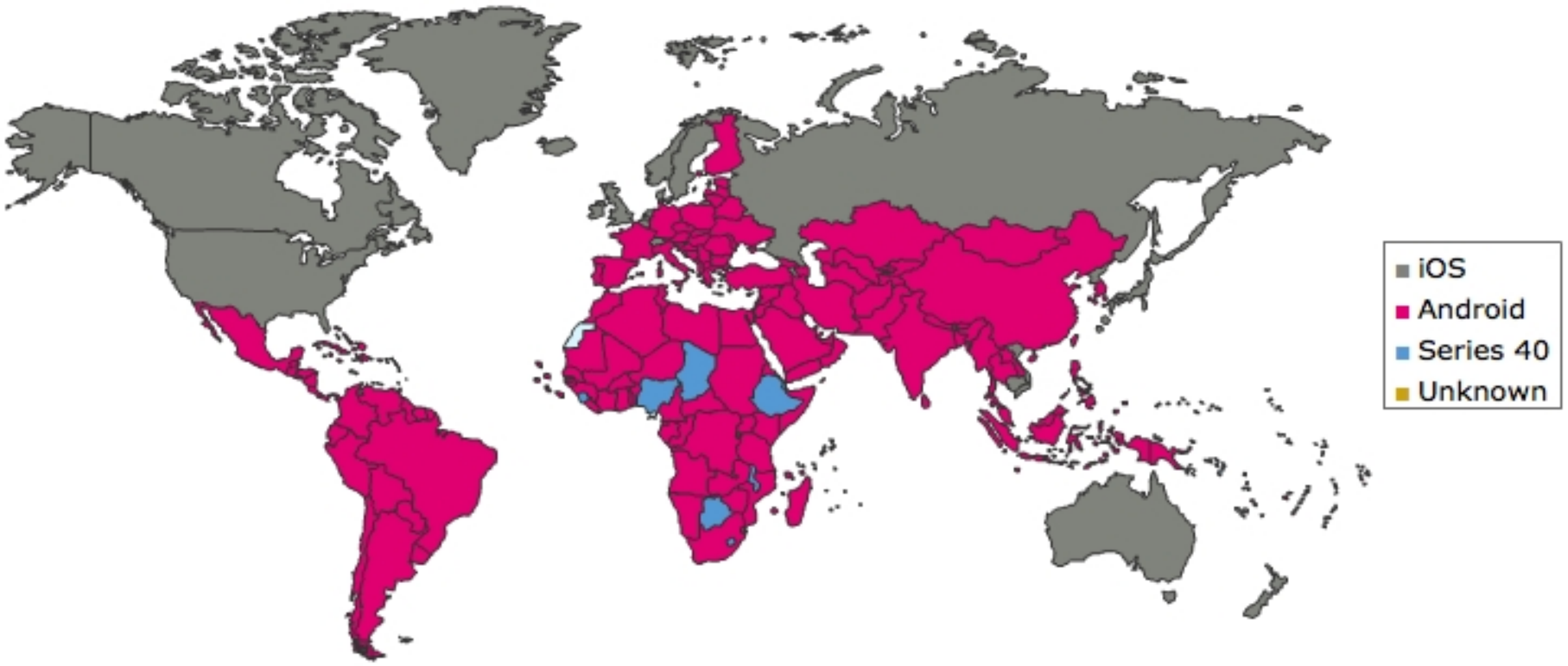
Mobile OS Market Share 2014

- StatCounter FAQ: "We track over 15 billion page views per month across the StatCounter network of over 3 million websites."
- Page views tracked by analyzing useragent string send with every page request
- Tracked OS:

  Android, iOS, Windows Phone, SymbianOS + Series 40, Samsung, Unknown, Nintendo 3DS, Other



Most popular device platforms



Source: http://www.statista.com/chartoftheday/Operating%20Systems/

CHALLENGES

Connectivity Challenge

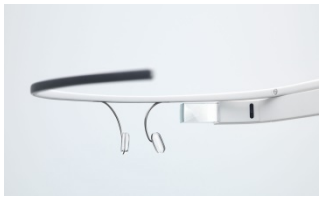
- Access technologies are
  - heterogeneous (frequency, technology, bandwidth, delay, jitter, error rates, cost, …)
  - Limited coverage, availability changes over time
  - made for different purposes
    - GSM – Mobile Communication
    - UMTS – Mobile Communication and Data Exchange
    - LTE – Mobile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

Offline Challenge

- Different reasons for disconnections
  - foreseeable (due to energy saving, communication costs, location changes)
  - unforeseeable (uncovered regions, unavailability of servers, network congestions)

- Challenge: providing data and services anyway
  - Make data and functionallity locally available
  - Track changes and creation of new data
  - Synchronize with backend
  - Resolve conflicts due to concurrent changes

Form Factor challenge







- 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

Energy challenge

- 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

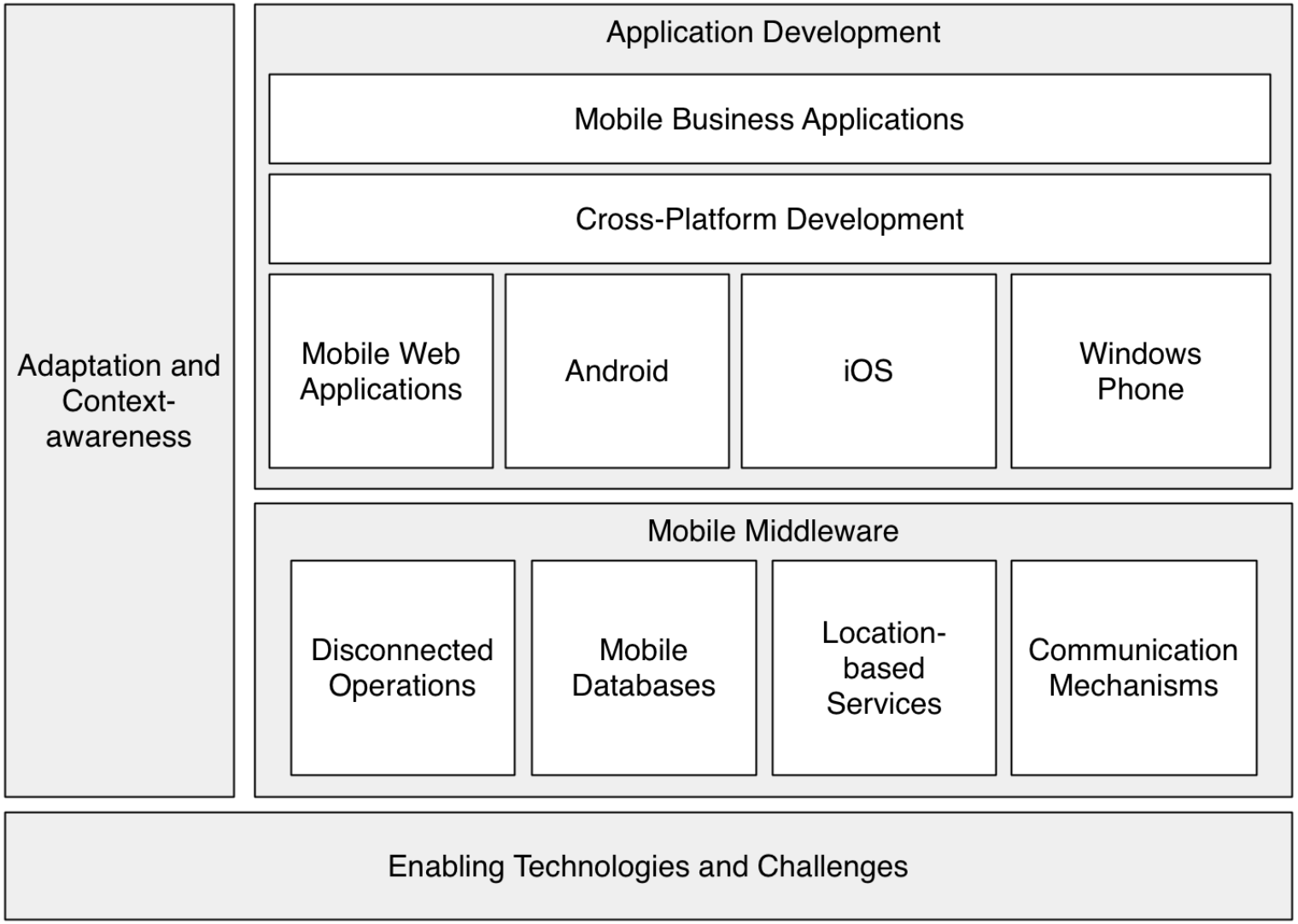
Usability challenge

- 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 - Summary

- technological challenges
  - heterogeneity of
    - of network connections
    - of devices
    - programming platforms
    - user preferences
  - resource restrictions:
    - 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
  - usability
  - efficient development
  - cross-platform apps

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 Course and Seminar: Development of Mobile and Ubiquitous Systems (Dr. Springer)
- Practical Course and Seminar: Internet of Things (Dr. Schuster)

Organizational Details

- lecture
  - winter term, lecture 2/2/0 - 6 credits
- modules:
  - CE-E11, CE-E6, DSE-E11, DSE-E6, DSE-M2, FG AvS, FG SyA, INF-B-510, INF-B-520, INF-B-530, INF-B-540, INF-BAS-4, INF-BI-1, INF-VERT4, WI-MA-01
- exam:
  - oral exam (30 min)
  - successful participation in the seminars is necessary prerequisite to take the exam
- 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

Use Auditorium!

- For questions and discussions use Auditorium
- https://auditorium.inf.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, …

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