mobile business

Lecture 04

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Business Informatics 2 (PWIN)
WS 2022

Information Systems III

Mobile Information Systems

Prof. Dr. Kai Rannenberg

Chair of Mobile Business & Multilateral Security
Johann Wolfgang Goethe University Frankfurt a. M.

Agenda

- What is Mobility?
- Mobile Infrastructure & Ecosystem
- Mobile Information Systems
- Conclusion on Challenges / Benefits of Mobile IS

What is mobility?

Lat. *mobilitas*:

(1) Flexibility, velocity, motion;
and as “mobilitas animi”: (mental) fitness

(2) But also (and quite ambivalent to (1)) changeability,
inconstancy, unstableness

[SkuStowPets1998]

Mobility

- Social implications
  - Mobility not just "*humans' independence from geographical constraints*"
- Spatial mobility
- Temporal mobility
- Contextual mobility

[KakihaSorens2001]

mobile business

Agenda

- What is Mobility?
- Mobile Infrastructure & Ecosystem
  - Mobile Voice & Data Communication Services
  - Mobile Devices
  - Smartcards and Subscriber Identity Module (SIM)
  - Mobile Operating Systems
  - Mobile Web Apps vs. Mobile Apps
  - App Markets
- Mobile Information Systems
- Conclusion on Challenges / Benefits of Mobile IS

Mobile Voice & Data Communication Services

- Mobile device (sometimes named mobile terminal/station)
- Base station responsible for radio cell
- Connection to the Internet

Mobile device

Transmission channel

Base station

Mobile Voice & Data Communication Services

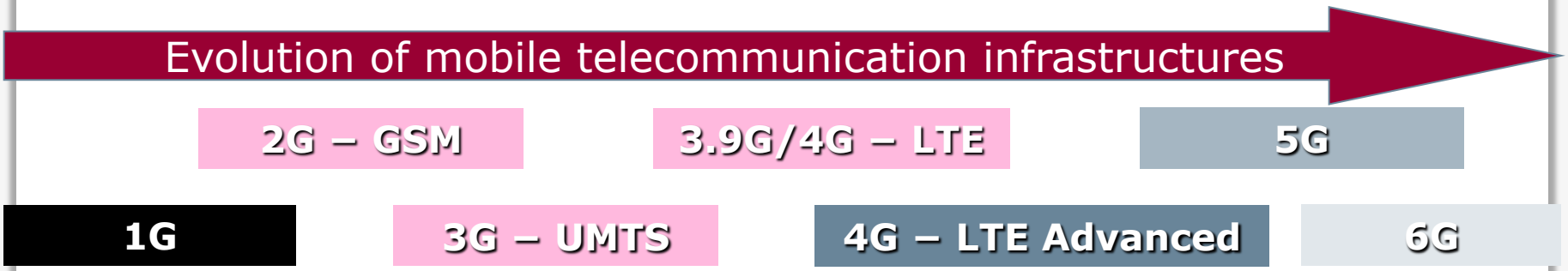
Fundamental mobile communication services

- Mobile voice
  - GSM, UMTS
- Mobile data
  - GPRS, EDGE, 3G networks (UMTS, HSDPA), 4G networks (LTE, LTE advanced), 5G networks (forthcoming)
- Mobile messaging
  - Text messaging (SMS), Multimedia messaging (MMS)
- Mobile Machine-To-Machine
  - GPRS, EDGE, 3G networks (UMTS, HSDPA), 4G networks (LTE, LTE advanced), 5G networks, 6G networks (forthcoming)

→ Lecture focuses on mobile data communications

Mobile Voice & Data Communication Services

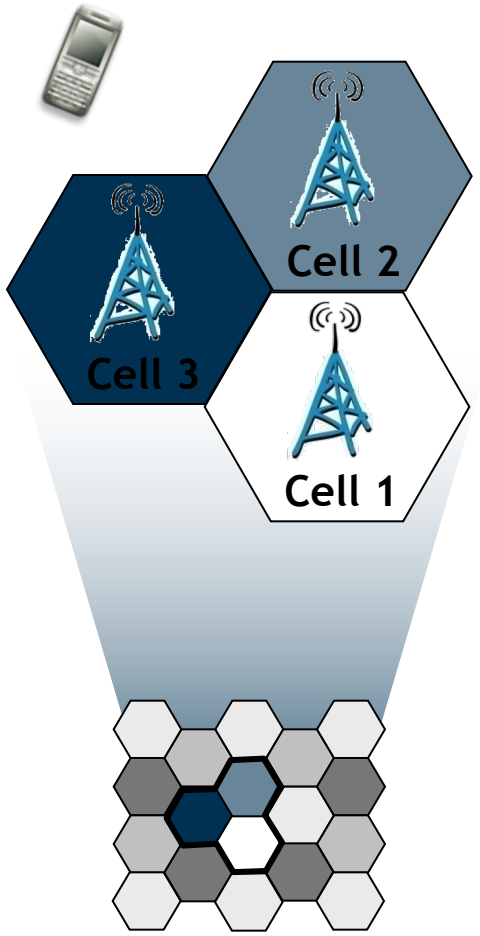
- *1st Generation (1G) - Analogue networks*
- *2nd Generation (2G) - GSM networks*
  Global System for Mobile Communications
- *3rd Generation (3G/3.5G) - UMTS/HSPA/HSPA+*
  Universal Mobile Telecommunications System
  High Speed Packet Access / Evolved HSPA = HSPA+
- *3.9G or 4G - LTE*
  Long Term Evolution
- *4th Generation (4G) - LTE Advanced*
- *5th Generation (5G) - Mobile broadband*
- *6th Generation (6G) - Ubiquitous wireless intelligence [Latva19]*



Cell-Based Communication (CBC)

What is a Cellular Network?

- Cellular networks are radio networks consisting of several transmitters.
- Each transmitter or base station, covers a certain area ➲ ***a cell.***
- Cell radii can vary from tens of meters to several kilometres.
- The shape of a cell is influenced by the environment (buildings, etc.) and usually neither hexagonal nor a perfect circle, even though this is the usual way of drawing them.



[Schiller2003]

Cell-Based Communication (CBC)

Advantages of CBC (1)

- Cellular networks offer a number of advantages compared to centralised radio systems:
  - ***Higher capacity:*** Cells offer the possibility to "*reuse*" the transmission frequencies assigned to mobile devices (e.g. by multiplexing). In order to do so, the networks need a thorough planning of the position of base stations and their frequencies.
    - ➲ More users can use the infrastructure
  - ***Reduced transmission power:*** Reduced power usage for the mobile device, due to the fact that only a limited amount of transmission power is needed in a small cell, compared to a far away base station.
    - ➲ Reduced power consumption for mobile devices

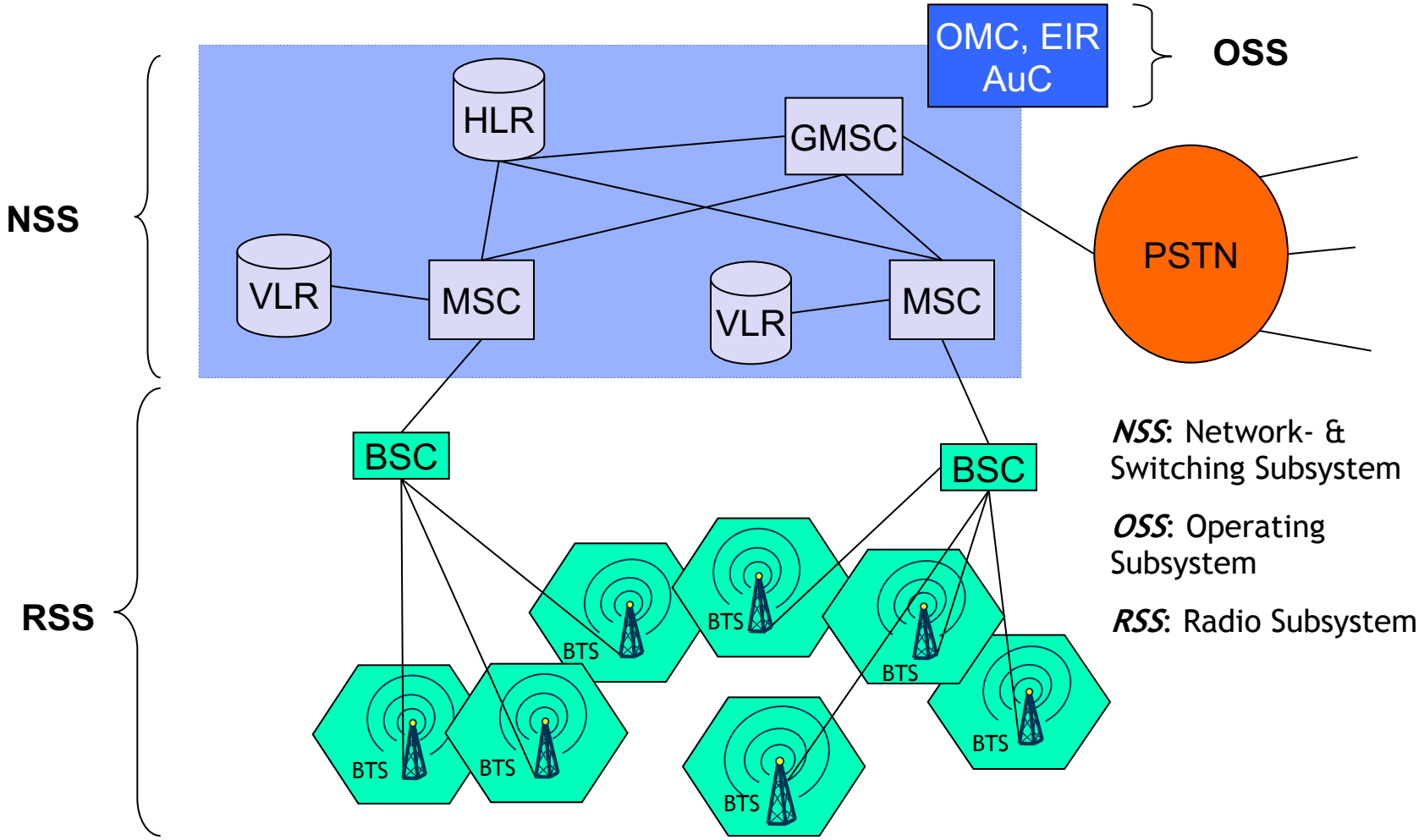
Cell-Based Communication (CBC)

Advantages of CBC (2)

- Cellular networks offer a number of advantages compared to centralised radio systems:
  - ***Robustness:*** Cellular systems are decentralised with regard to their base stations. In the case that one antenna fails, only a small area gets affected.
    - ➲ Failure of one base station does not affect the complete infrastructure
  - ***Better coverage:*** Cells can be adapted to geographic conditions (mountains, buildings, etc.).
    - ➲ Better availability of the infrastructure

But: A complex and costly infrastructure is required, in order to link all base stations. This includes switches, antennas, location registers, etc.

GSM (2G)
System Architecture



NSS: Network- & Switching Subsystem

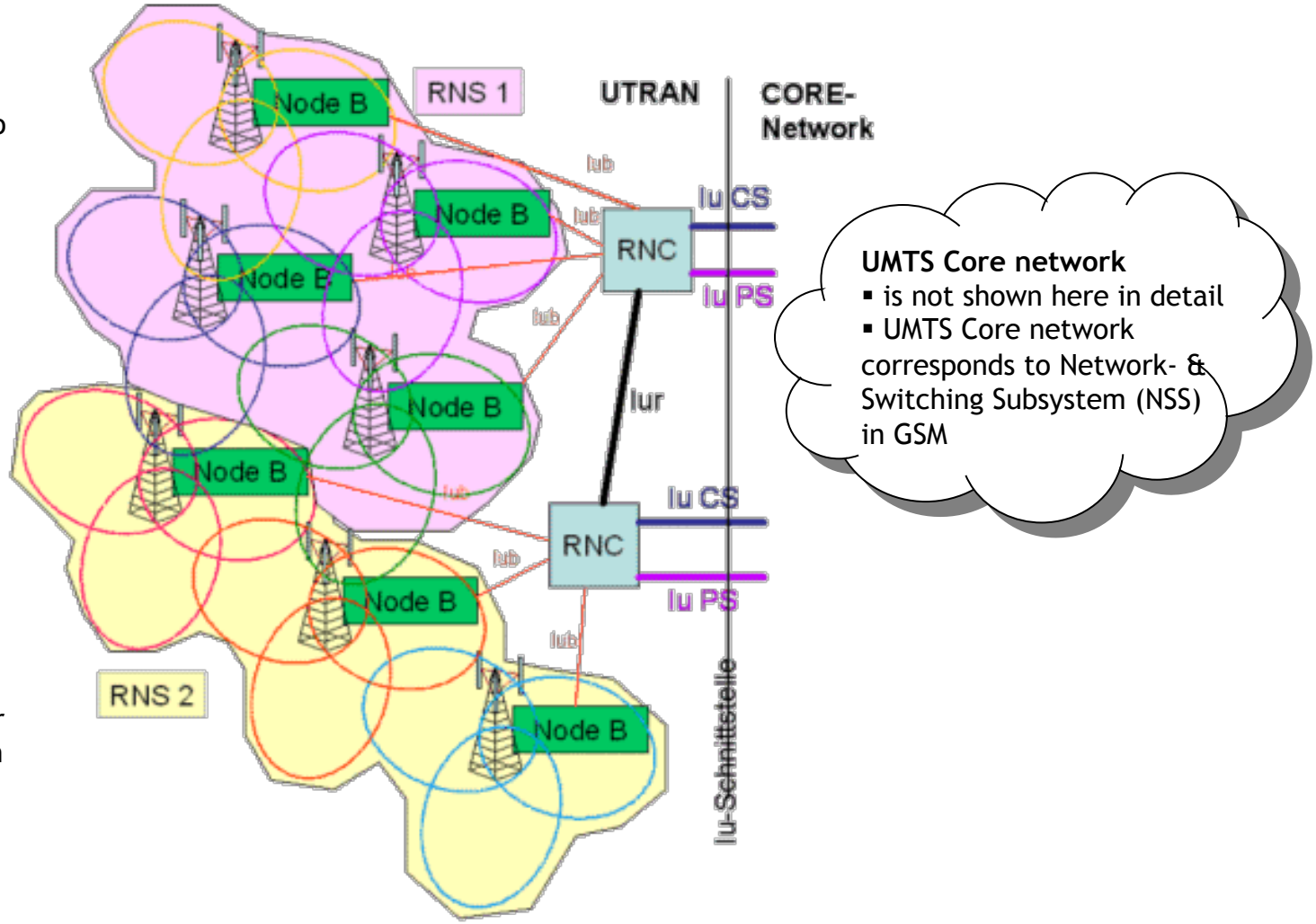
OSS: Operating Subsystem

RSS: Radio Subsystem

Based on [Schiller2003]

CBC using the example of UMTS (3G) System Architecture

- ***UTRAN:*** UMTS Terrestrial Radio Access Network
- ***RNS:*** Radio Network Subsystem
- ***RNC:*** Radio Network Controller (controls the Node Bs)
- ***Node B:*** UMTS base stations (equivalent to base transceiver stations (BTS) in GSM



Source: UMTSlink.at (2011)

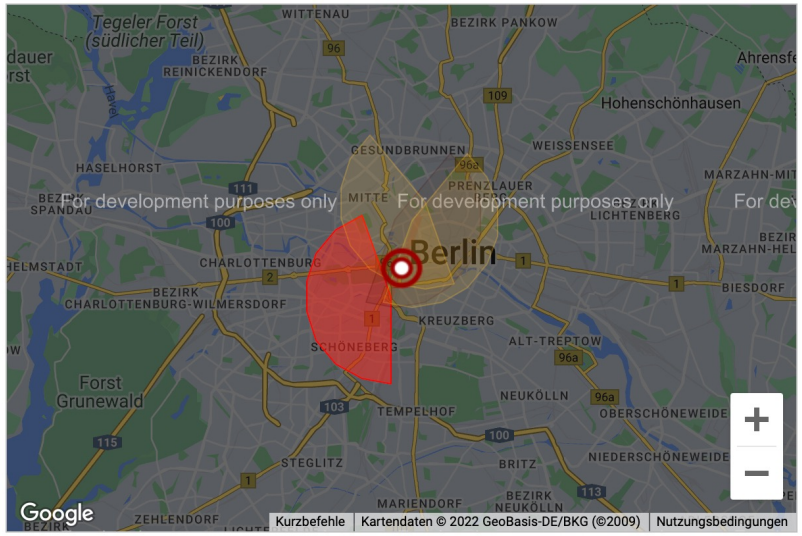
Data retention of cell-based location data

Verräterisches Handy

deutsch | english

Sechs Monate seiner Vorratsdaten hat der Grünenpolitiker Malte Spitz von der Telekom eingeklagt und ZEIT ONLINE zur Verfügung gestellt. Auf Basis dieser Daten können Sie all seine Bewegungen dieser Zeit nachvollziehen. Die Geodaten haben wir zusätzlich mit frei im Netz verfügbaren Informationen aus dem Leben des Abgeordneten (Twitter, Blogeinträge und Webseiten) verknüpft.

Mit der Play-Taste startet die Reise durch Malte Spitz' Leben. Über den Geschwindigkeitsregler können Sie das Tempo anpassen oder an beliebigen Punkten mit der Pause-Taste anhalten. Zusätzlich zeigt der darunter stehende Kalender, wann er noch an diesem Ort war – gleichzeitig kann darüber jeder beliebige Zeitpunkt angesteuert werden. Jede der vertikalen Spalten entspricht einem Tag.



Donnerstag, 24. September 2009

13 eingehende Anrufe
25 ausgehende Anrufe
Gesamtdauer: 0h 49min 43s

11 eingehende Nachrichten
8 ausgehende Nachrichten

Dauer der Verbindung mit dem Internet: 21h 55min 5s

[www.zeit.de/datenschutz/malte-spitz-vorratsdaten]

Mobile Devices

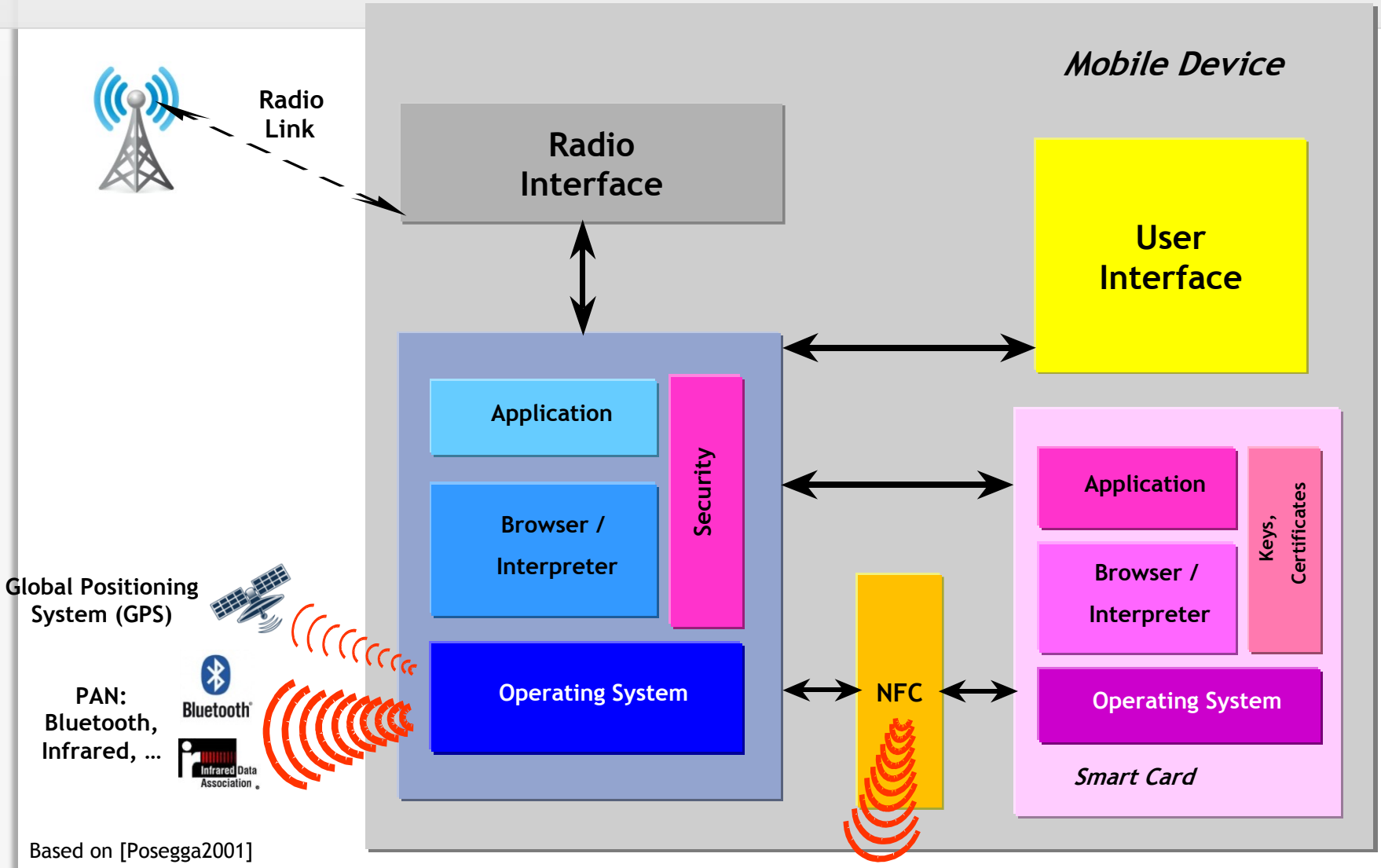
- Categories of mobile devices
  - Mobile phones (low-end „feature phones“)
  - Smartphones
  - Smartwatches
  - Tablet PCs
  - Netbooks
  - Notebook

Source: Nokia Booklet 3G (2010)

Mobile Device Characteristics

- Terminals of users differ in technical specifications
  - Heterogeneous and fragmented system landscape
    - Display resolution
    - Different web browsers
    - Keyboard
    - Mobile operating systems
    - Application software that can be installed
    - Other features

Mobile Device & Operating Systems – Functional Architecture



Based on [Posegga2001]

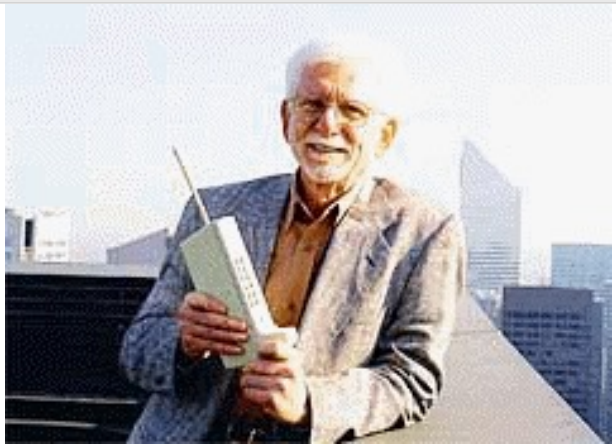
Evolution of Mobile Devices

Time

- Augmented Reality (AR) capabilities
- Near Field Communication (NFC)
- Sensors (accelerometer, gyroscope, etc.)
- Possibility to execute 3rd party software
- Multimedia applications (MP3, radio, camera, video, TV, etc.)
- Data services (GPRS, UMTS, LTE, Wi-Fi)
- Bluetooth
- Interactive Voice Response (IVR)
- Short Message Service (SMS)
- General telephony capabilities

Evolution of Mobile Devices

Examples



© New York Times

1973

2001

© Microoptical

2005

© IBM

2006

2007

2010

© Google

2013

© Samsung

2017

Device Manufacturers and Brands

(Including some historic ones)

- Alcatel
- Apple
- Asus
- (Audiovox)
- Benefon
- BenQ
- Blackberry
- (Bosch)
- (Ericsson)
- Fairphone
- Google
- HTC
- Huawei
- LG Electronics
- Microsoft
- Motorola
- (NEC)

- Nokia
- OnePlus
- Oppo
- (Sagem)
- Samsung
- (Sendo)
- (Siemens)
- Sony
- TCL Communication
- (Telit)
- Telme
- (Toshiba)
- (Trium)
- Vivo
- (Windhorst)
- Xiaomi
- ZTE

Smartcards for Mobile Communication

- **SIMs** are **smartcards:**
  - **SIM cards** serve as security medium.
  - Tamper-resistance prevents counterfeiting.
  - Robust design
- Contain **International Mobile Subscriber Identifier (IMSI)** for subscriber identification and the key $\mathbf{K_i}$ provided by the mobile operator
- Reliably execute computational functions for the mobile device

Based on [EffingRankl2008]

The Subscriber Identity Module (SIM)

- In GSM since 1991, and used in all further mobile networks
- **Represents** contract **between subscriber & network operator**
- Authorises **a "phone"** to **use** the network by linking it to a **subscription**
- By 2018 around **5.1 billion** mobile broadband subscribers (forecast to grow to **5.9 billion** by 2025) with $**1.03 trillion** mobile operator revenue [GSMAI2019]
- More countries with SIM infrastructure (ca. 240, 2019-Q2) than McDonalds (121, 2019-Q2) and UN-members (193, 2019-Q2) [GSM2019, Wiki2019, UN2019]
- More and more called "Subscriber **Identification** Module" to reflect progress in the general field of **Identity Management**

Mobile Operating Systems

What is a mobile operating system (OS)?

- An OS is a program that serves as a mediator between the user and the hardware.
- It enables the users to execute programs
- *Other properties:* Multi-user, multi-thread, high availability, real-time, …

- ***Primary goal of an OS***: Easy usage of the actual hardware
- ***Secondary goal of an OS***: Efficient usage of the hardware

[Silberschatz, Galvin 1999]

Functions of the Mobile OS

- Controlling and sharing of resources
  - Computation time, real-time processing
    “Who is computing how much? How long does it take?”
  - Memory (RAM, Disk)
    “Who gets which part of the memory?”

- Security functions
  - Protection of the data (memory, hard disk):
    “Who is allowed to access resources?”
  - Process protection (computation time, code, isolation):
    “Who is allowed to compute?”
  - Security module support

- Communication
  - Allocation of I/O-resources
  - Processing of the communication
  - User interface (UI)

Manufacturer-dependent Mobile OS

- Originally, most mobile phone manufacturers used their own "closed" operating systems for their mobile devices.
  - *Palm OS (Garnet OS)*
    - *Latest release: Palm OS Cobalt 6.1*
  - Apple *iOS* (Unix-based)
    - Latest release: iOS 16.1
  - *BlackBerry OS*
    - Latest release: BlackBerry OS 10.3.3 (EOL January 4, 2022)
  - *LuneOS* (formerly WebOS, initially developed by Palm, later HP)
    - Latest release: LuneOS Eggnog Latte (2019)
    - Not to be confused with Palm OS (now: Garnet OS) that was also initially developed by Palm
  - *Samsung bada*
    - Latest release: v2.0, e.g. on Samsung Wave 3 S8600 (discontinued 2013)
- ***Advantage:*** Tend to be not as much affected by malware than "open" operating systems
- ***Disadvantage***: Less flexible, as 3rd-party software cannot be easily installed and executed
- Later, more and more platforms switched to more open and interoperable operating systems (e.g. Windows CE, Symbian OS, Android).

Manufacturer-dependent Mobile OS Example: iOS

- Developed by Apple for iPhone, iPod Touch, iPad, and Apple TV
- Latest release: iOS 16
- iOS derived from Mac OS X, a Unix-based operating system
- Apple does not permit the OS to run on third-party hardware
- User-interface uses multi-touch gestures

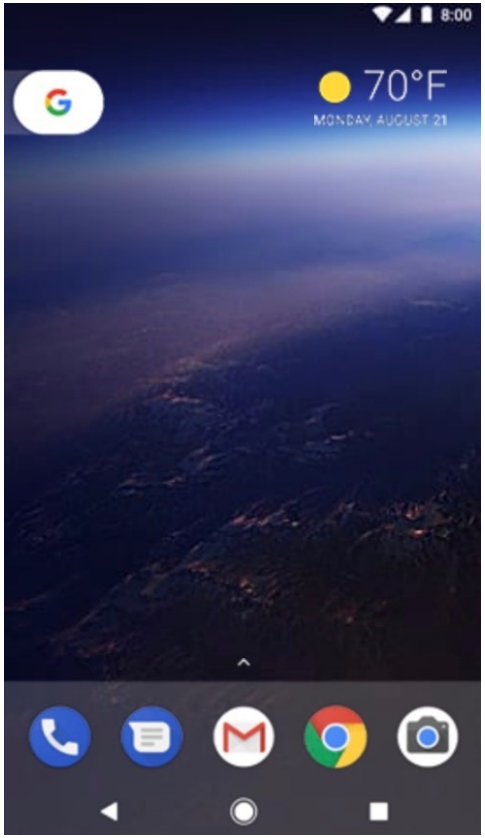
Manufacturer-independent Mobile OS

- Linux: LiMo (Linux Mobile), Openmoko Linux, Qt Extended (Qtopia)
- Symbian platform
  - Latest release: “Nokia Belle Feature Pack 2“ for Symbian^3 devices
- Android (by Open Handset Alliance)
  - Latest release: 12
- Windows Mobile
  - Latest release: Windows 10 Mobile 1709
- Windows Phone
  - Latest release: Windows Phone 8.1 Update 2
- Maemo (by Nokia) → MeeGo (by Nokia, Intel) → Sailfish OS (by Jolla)
  - Latest release: Sailfish 4.4.0.72 (Vanha Rauma) / 30 (Sept. 2022)
- Tizen (by Samsung, Intel, Linux Foundation)
  - Latest release: 6.5 Public M1 (May 2021)
- Firefox OS (by non-profit organisation Mozilla)
  - Latest release: 2.2.0 (April 2015) – Cancelled in September 2016
- KaiOS (by Boot to Gecko)
  - Latest release: 3.0 (August 2021)
- HarmonyOS (by Huawei)
  - Latest release: 3.0 (27. Juli 2022)

= Linux-based

Manufacturer-independent Mobile OS Example: Android

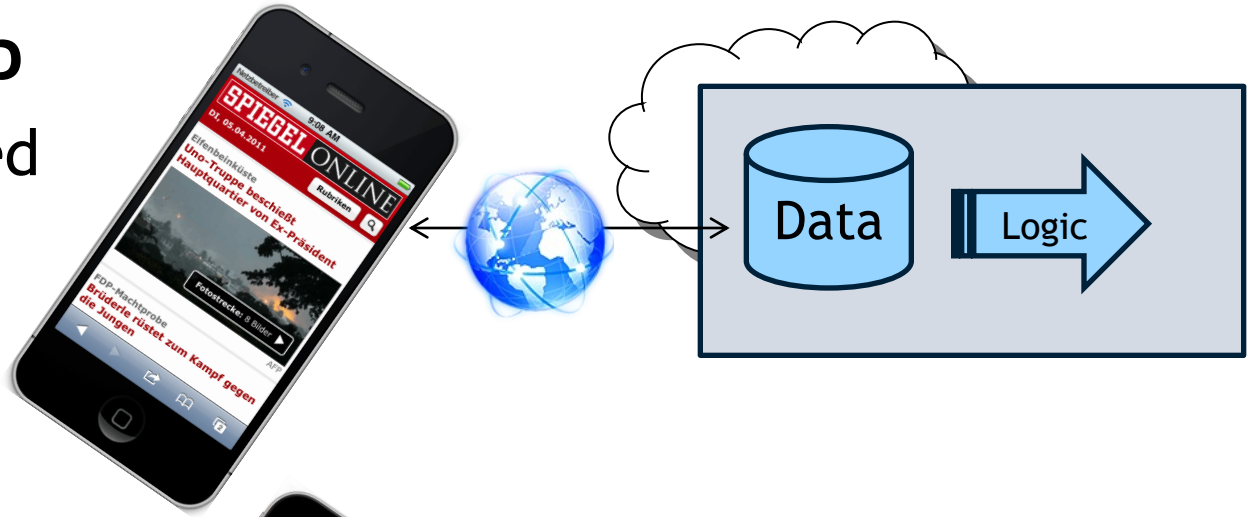
- Google and other members of the **Open Handset Alliance** collaborated to develop and release Android.
- Open Handset Alliance (OHA) established in 2007
- Android based on modified version of Linux kernel
- October 2008: First commercially available phone running Android (T-Mobile G1)
- February 2021: Version 12



Types of Mobile Apps

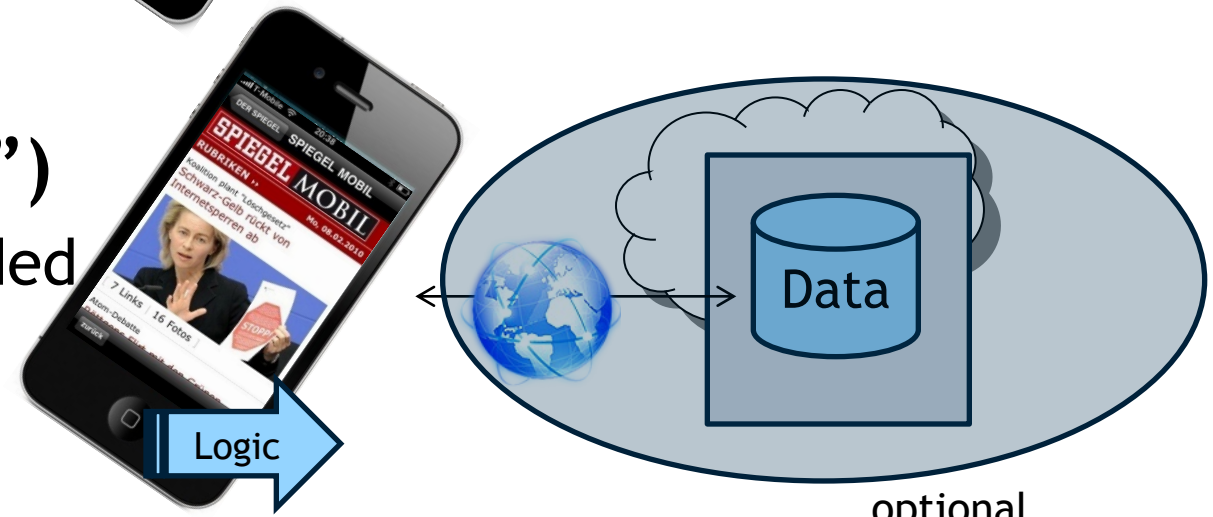
Mobile web app

- App not installed on the device



Mobile app ("native App")

- App is downloaded and installed



Mobile Web Apps vs. Mobile Apps

Mobile app ("native App")	Mobile web app
Supports offline use	Needs constant internet connectivity (network coverage)
Can be found easily in app store(s)	Distribution via URL, e.g. QR-codes
Business model: Sold in app store(s)	Difficult to implement payment and authentication system
Can make use of all OS and device functions	Cannot access OS core functions (e.g. 3D graphic processing or access to locally protected storage)
Needs to be platform-specific (native code)	Using web browser of the device, hence manufacturer-independent multi-platform support possible; also porting to other devices/platforms is less expensive
Based on Objective-C, C#.Net, Java	Based on HTML5, CSS, Javascript
Updates/versioning through app stores	Easy updates as they are done on the server, not on every client device

App Markets

- Mobile app distribution through **app markets** (“app stores”)
- App markets are two-sided markets, a base where people can publish their apps
- Payment, hosting, maintenance and marketing through App Market

Users

€€€

App

App markets

€€€

App

App developers

Mobile Strategy of Apple and Google (1)

- Mobile platform for selling content, services (apps) and hardware
- Offering channels against the *everything is free* culture of the internet
- Entering advertising market with iAd since iOS 4

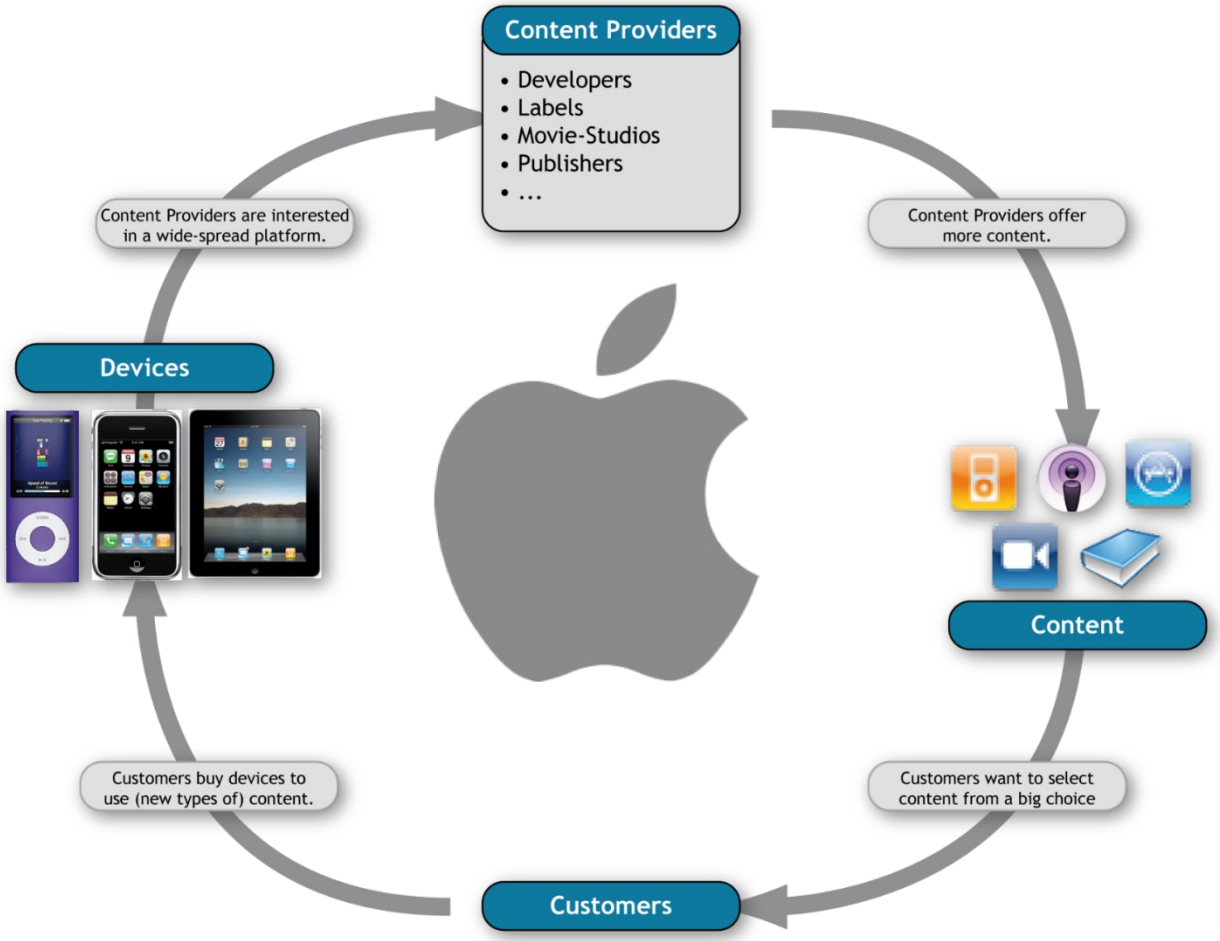
Google Deutschland

- *„Mobile first“*
  - Eric Schmidt, CEO Google
- Having control over which search engine is used on mobile devices
- Making the mobile web attractive to build new *advertising pillars*

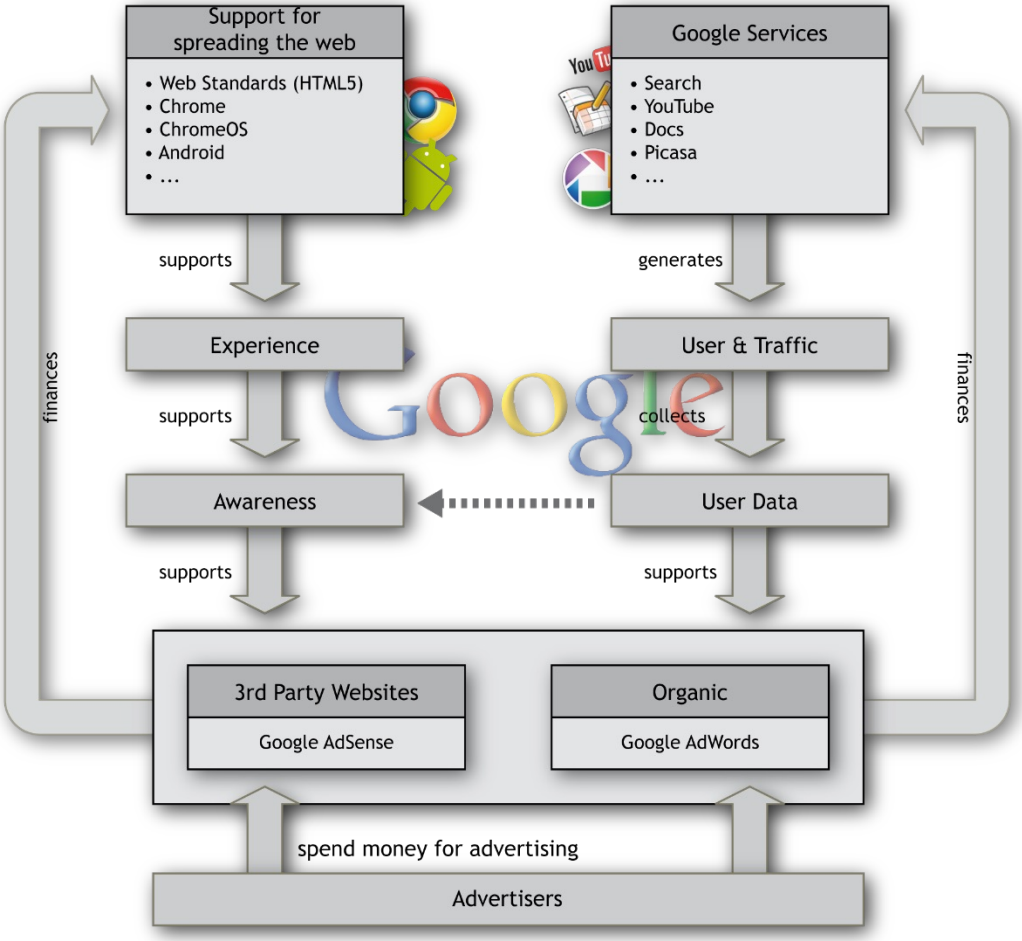
Mobile Strategy of Apple and Google (2)

- Like Microsoft for desktop computers, Android as a rather non-restrictive platform became a major player on the mobile market.
- Android can profit from Apple‘s restrictive strategy, but can also be affected by Google’s bad image.
- There will not be a monopoly or duopoly on the mobile OS market.
- With the rising complexity of mobile devices and technologies, the challenge will be recognisable trustworthiness.

Apple‘s Economic Cycle



Google‘s Economic Cycle



Future of Mobile (Web) Apps

- Mobile browsers are likely to gain access to more OS core functionality (e.g. 3D graphics processing; location API already available)
- The trio HTML 5, CSS, JavaScript was strongly expected to further improve the graphical user interfaces (GUIs) towards native mobile apps as well as to provide more platform independence
- Consequently, it is likely that mobile web apps will be the future dominating application type in the mobile ecosystem
- Possible consequences for the mobile ecosystem
  - Specific mobile platforms and app markets become less relevant in the mobile market
  - Reduced market power of app market operators such as Apple
- How would/will Apple, Google & Co. react to this scenario?

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Agenda

- What is Mobility?
- Mobile Infrastructure & Ecosystem
- Mobile Information Systems
  - Mobile Information System
  - Unique Characteristics of Mobile Data Communications
  - Infrastructure of Mobile Applications
  - Mobile Office
  - Mobile Marketing
  - Mobile CRM Systems
  - Mobile Communities
- Conclusion on Challenges / Benefits of Mobile IS

Mobile Information System

- **Information System (IS):**
  A system which was built to be used in a part of an enterprise. It contains all relevant application systems and is embedded into the organisation and management of an enterprise.

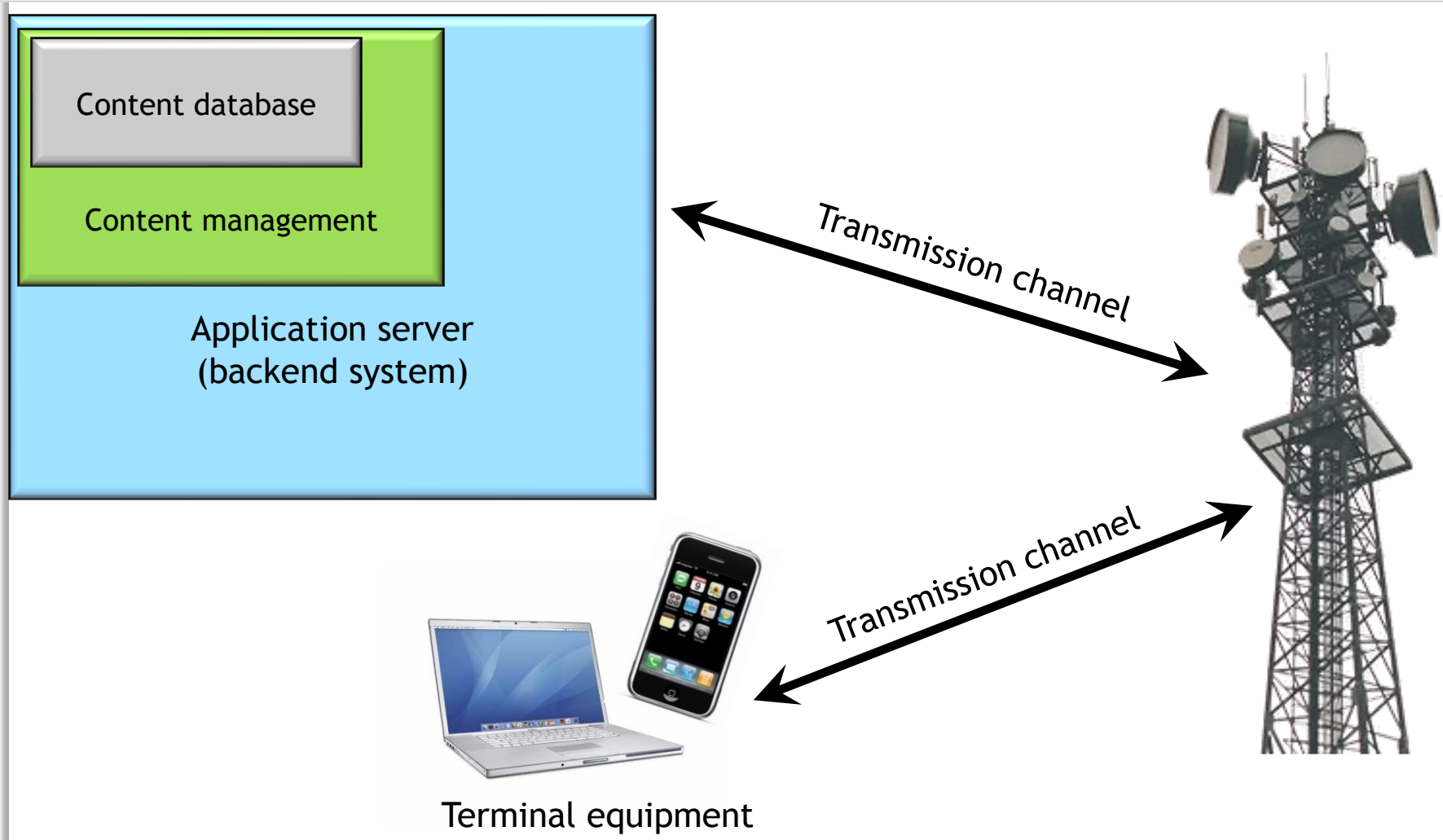
- **Mobile Information System:**
  Information systems in which access to information resources and services is gained through end-user terminals that are easily movable in space, operable no matter what the location, and, typically, provided with wireless connection.

Source: Pernici (2006)

Unique Characteristics of Mobile Data Communications

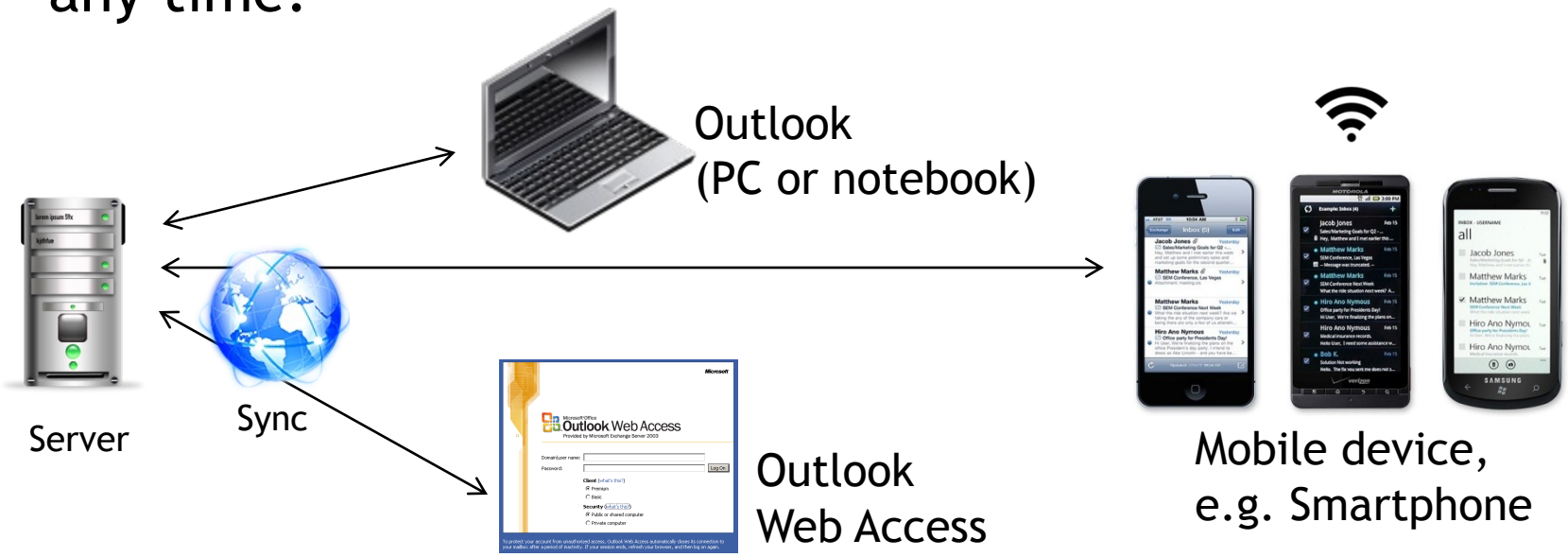
- Time and location independence
- Instant on of mobile devices
- Limited I/O capabilities
- Location awareness
- Personal nature of the medium
- Identification of mobile user
- 1:1 communications
- High penetration in the population

Infrastructure of Mobile Applications



Mobile Office (Mail, Calender, Tasks, Notes, Files)

- Mobile devices, e.g. smart-phones, allow access to emails, calendar, tasks, notes and files via wireless networks from centralised server.
- Additional mobile channel, which enables users to access and use an office infrastructure anywhere and at any time.



Mobile Marketing

- *Mobile marketing is a set of practices that enables organisations to communicate and engage with their audience in an interactive and relevant manner through any mobile device or network.*

Source: Mobile Marketing Association (2009)

Mobile Portal

Personalised Service-Offering

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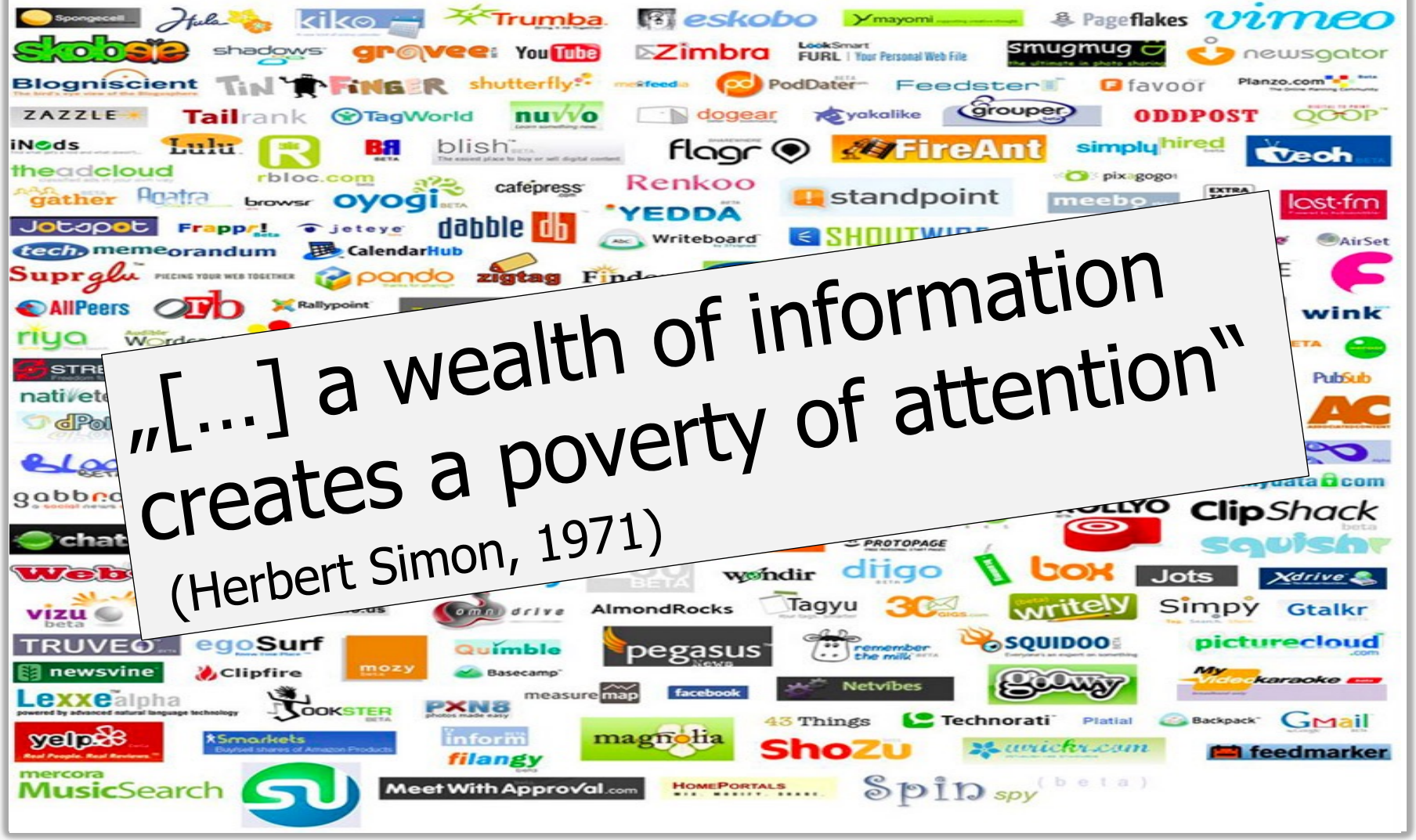
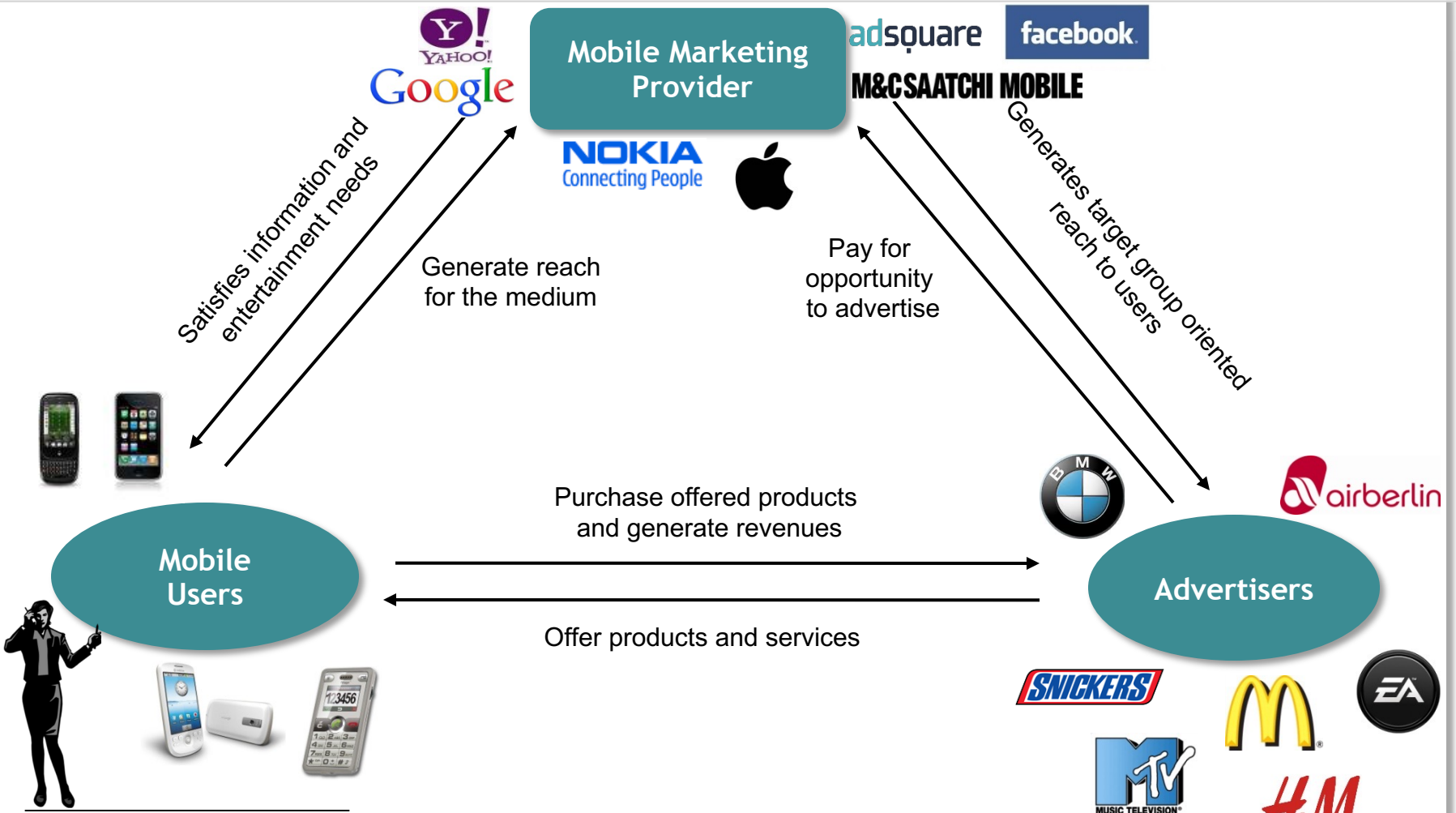
Mobile Marketing

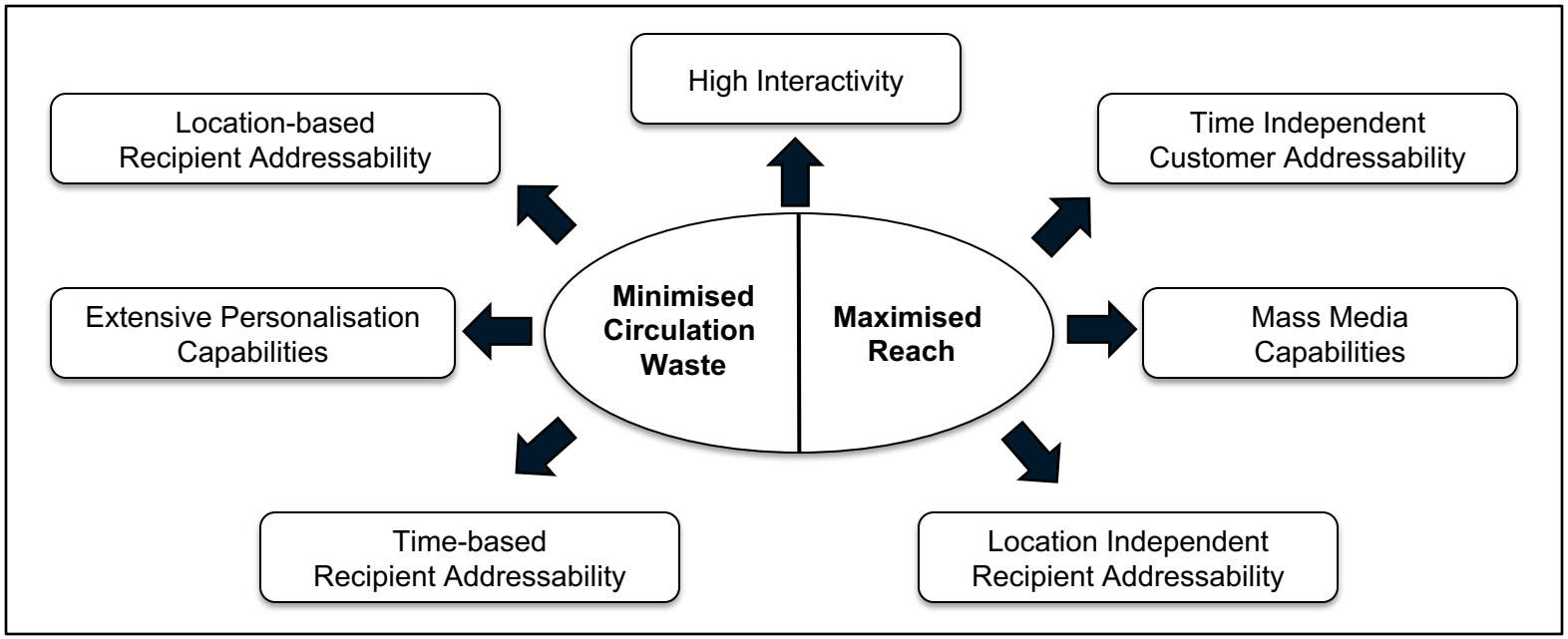


Idealised Two-Sided (Mobile) Media Market



Based on Zerdick, Picot, Schrape, and Artopé (2001)
Die Internet Ökonomie - Strategien für die digitale Wirtschaft.

Theoretical Potential of Mobile Marketing



Context Information to Alleviate Information Overflow

- Mobile network allows determination of
  - subscriber's **identity** (i.e. MSISDN)
  - subscriber's **physical location**
  - **time of usage**
- This *context information* can be **compiled into a situation description** of a mobile subscriber
  - Example: Mobile User is 24 years old, student, currently in Munich, at lunchtime …
- Benefits of context-sensitive mobile marketing campaigns
  - **Mobile users: Personalisation of advertisements** according to immediate needs in current usage situation
  - **Advertisers: Individual selection of relevant mobile users** with highly likelihood consumption need
  - **Mobile marketing provider:** Generation of **additional revenues** and **differentiation from competition**

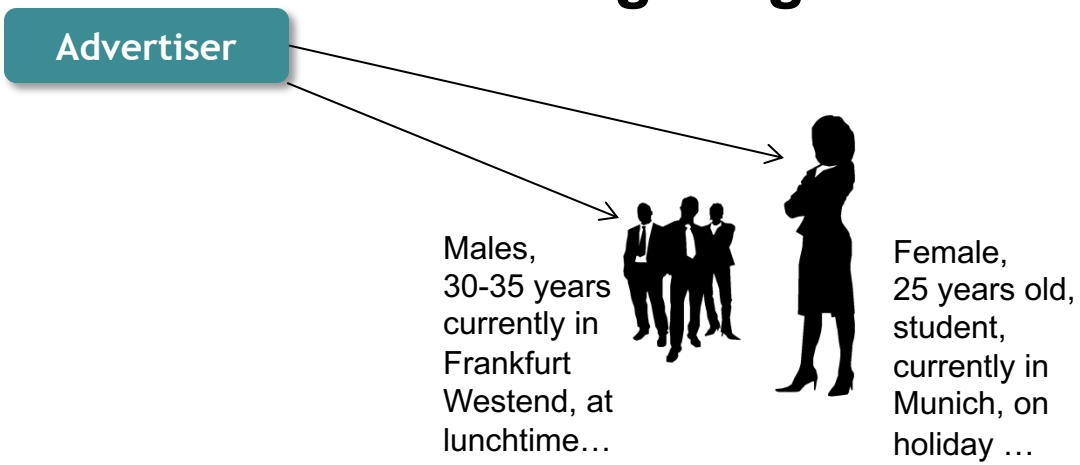
Traditional vs. Context-Sensitive Targeting

Traditional targeting of mobile marketing campaigns

Traditional Information
- Implicit information about preferences of mobile users
- Typically acquired without mobile user's knowledge

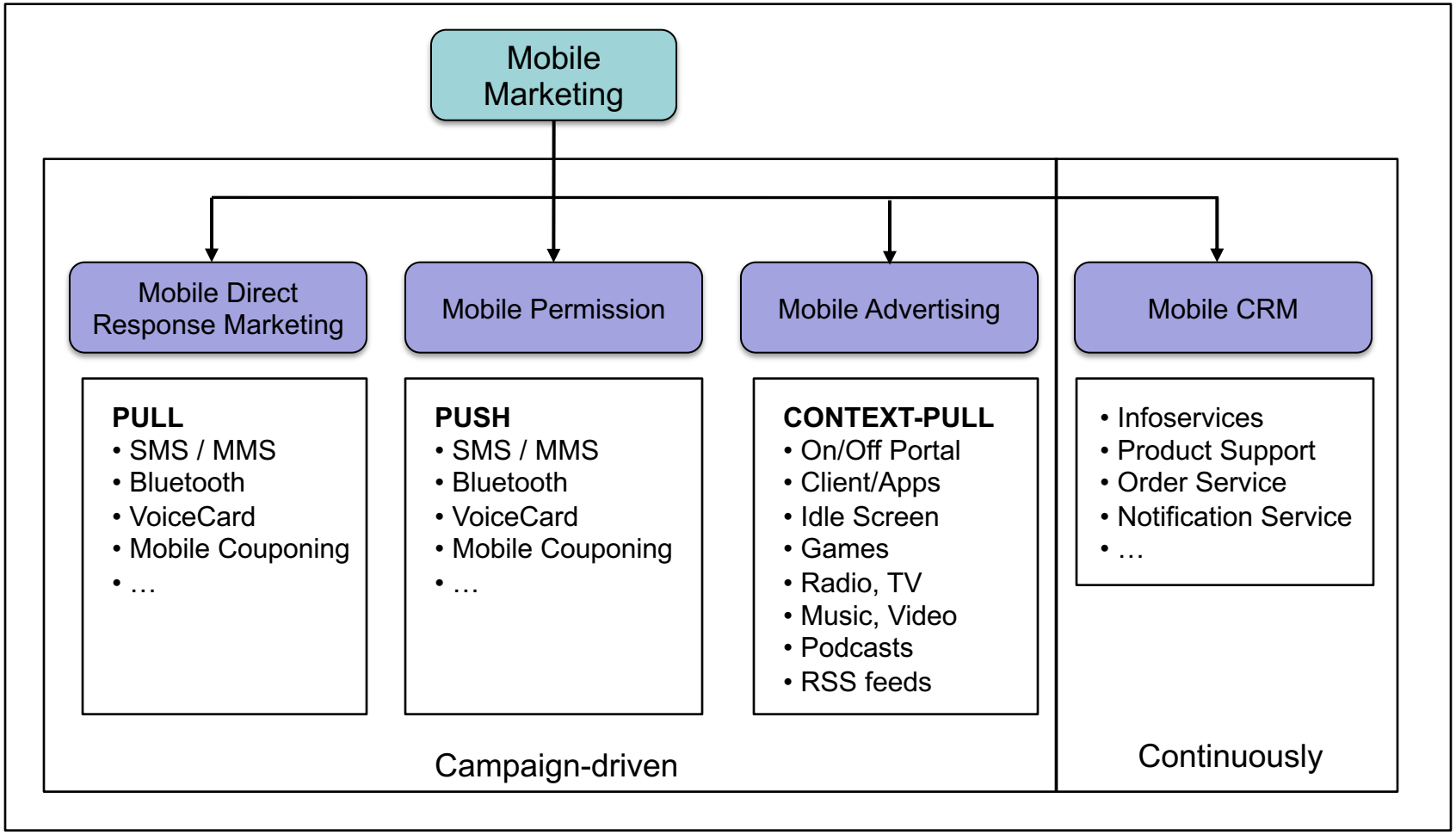
≠

Context-sensitive targeting of mobile marketing campaigns



Context Information
- Explicit information about the usage situation of mobile users
- To be actively disclosed by mobile users

Spectrum of Mobile Marketing Campaigns



Mobile CRM Systems

Mobile CRM (mCRM) services aim at

- Nurturing customer relationships
- Acquiring or maintaining customers
- Support marketing, sales or service processes
- Use wireless networks as the medium of delivery to the customer. (Camponovo et al., 2005)

- Sales representatives, e.g. insurance agents, bank employees and other field staff, can access customer data during on-site consultations.

Mobile Communities

- Definition of mobile community:

A mobile community is a group of people generally united by shared interests or goals who interact:

- *considering their context (e.g. time, space, social),*
- *by means of location-independent information technology,*
- *and also including mobile access to existing community infrastructures.*

Mobile Community Example

What to do

Share what's going on

Check in to places.

Share updates and photos with friends on Facebook or Twitter.

Mobile Community Privacy Issues and Privacy Concepts

- Importance of context information, e.g. **location** information
- Participating users leave private information **traces**.
- Providers of community services need to
  - Handle **trust and privacy**
  - Meet the participants' needs
  - Comply with regulation
- Infrastructure needs to be opened for **marketing activities.**

Agenda

- What is Mobility?
- Mobile Infrastructure & Ecosystem
- Mobile Information Systems
- Conclusion on Challenges / Benefits of Mobile IS

Challenges and Benefits of Mobile IS

- Benefits of mobile IS on business & society
  - Mobile devices increasingly become the digital identity of a user
- Challenges
  - How to further improve the utilisation of unique mobile communication characteristics for mobile applications and services?
  - How to maintain privacy and security?
  - Coping with device & platform fragmentation
  - Coping with limited mobile network bandwidth

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