

Ergänzungen zur Vorlesung „Vernetzte Systeme“
WS 2000/01 – Thema mobile / drahtlose
Kommunikation

F.Ma. 1

Consequences of Device Portability



- **Power** consumption
 - Moore's law does not apply to batteries
 - limited computing power
 - cpu: proportional to clock frequency
 - small and low quality displays
 - smaller and slower disks
- **Data replication**
 - higher probability of loss of data (e.g., theft of device)
 - synchronization with data on other devices
- Limited **user interfaces**
 - e.g., integration of character / voice recognition
- Limited memory and other **resources**

F.Ma. 2

General Issues of Mobile Computing

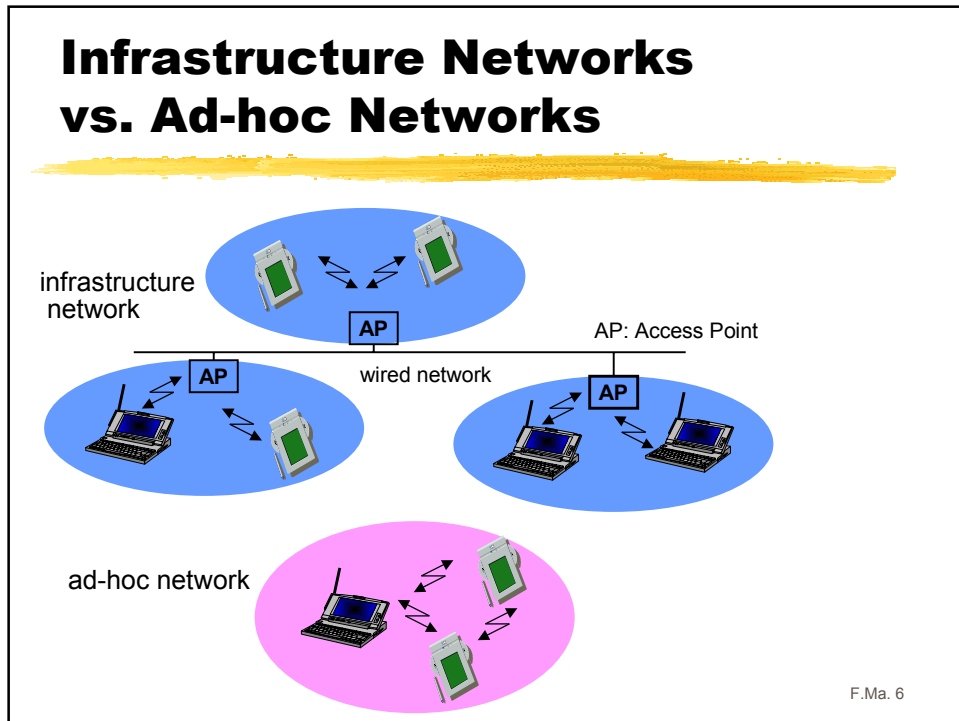
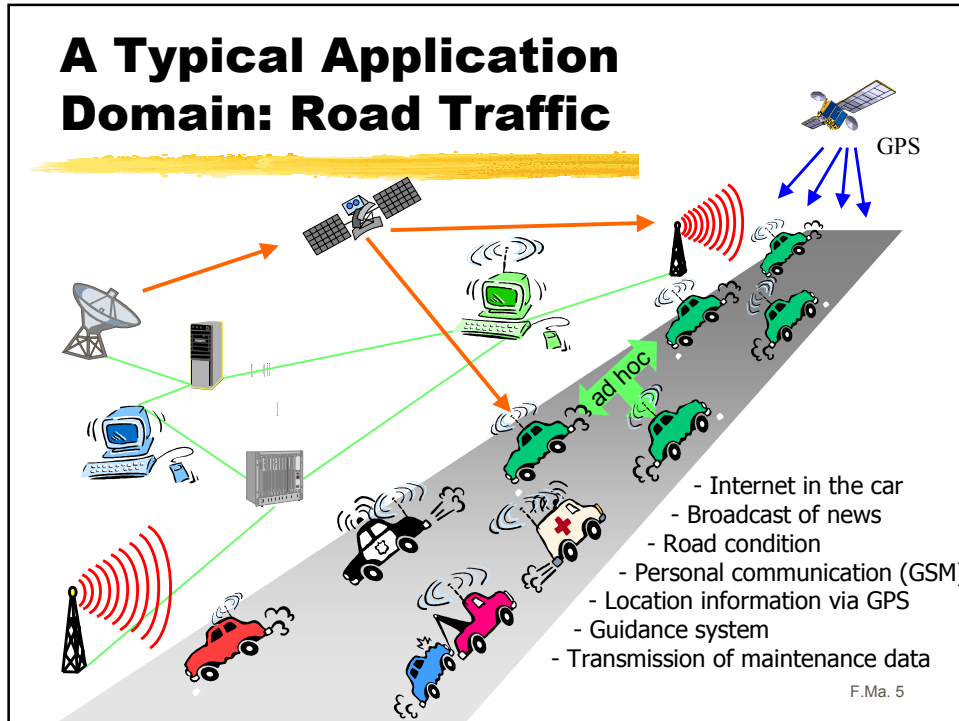
- **Wireless communication**
 - transmission quality (bandwidth, error rate, delay)
 - modulation, coding, interference
 - media access, regulations
- **Portability**
 - power consumption
 - limited resources
 - usability, human computer interface
- **Mobility**
 - service discovery
 - location dependent services
 - location transparency
 - quality of service support
 - disconnection management (also: caching, hoarding)

F.Ma. 3

Wireless Networks in Comparison to Fixed Networks

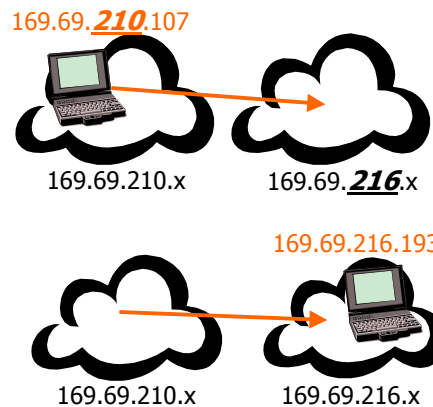
- Higher **loss rates** due to interference
- Restrictive regulations of **frequencies**
 - useable frequencies are almost all occupied
 - national and **international coordination** necessary
- Lower **transmission rates**
- **Lower security**
 - radio interface accessible for everyone, base station may be simulated (e.g., "IMSI catcher")
 - shared medium (requires secure access mechanisms)
- **Integration of wireless networks into existing fixed networks**
 - e.g., GSM as an "extension" of classical telephony
 - e.g., mobile IP (extension of the Internet protocol IP)

F.Ma. 4



Mobile Internetworking

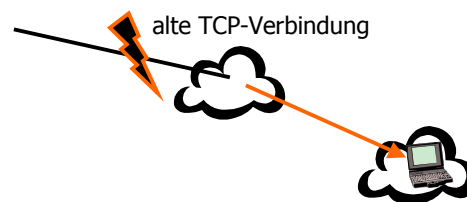
- Ohne Unterstützung ist mit IP-basiertem Protokoll keine Mobilität zwischen verschiedenen Subnetzen möglich
 - Grund: IP-Routing verwendet Adresse des Subnetzes für das Routing
- ⇒ bei Subnetzwechsel muss die IP-Adresse des Endgerätes angepasst werden: keine Transparenz!



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Ändern der IP-Adresse?

- Ändern der DNS-Einträge
 - langwierig, aufwendig
 - skaliert nicht
 - Routing-Probleme
- Unterbrechung aller aktiven Verbindungen (TCP beruht auf IP-Adressen)
- Bei manchen Betriebssystemen ist ein Neustart erforderlich



F.Ma. 8

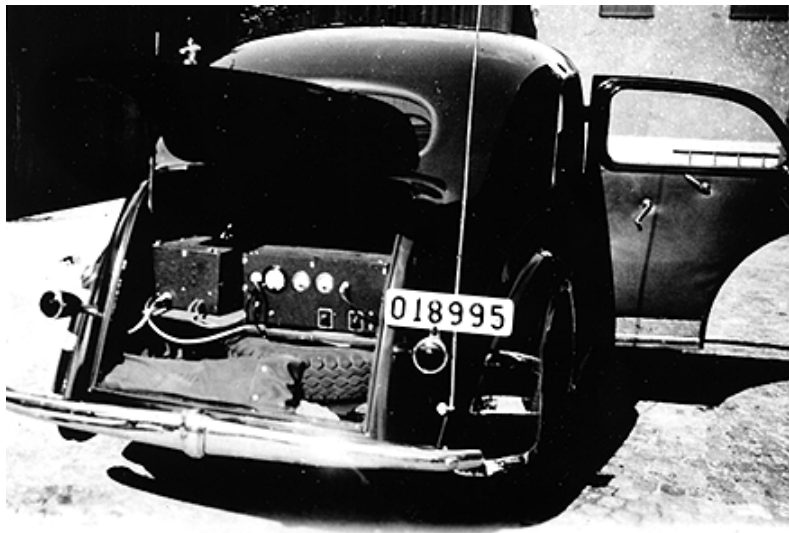
Mobile Internetworking: Anforderungen

- **Transparenz**
 - mobile Endsysteme behalten ihre IP-Adresse
 - Mobilität ist für höhere Schicht nicht sichtbar
 - ⇒ Fortsetzung der Kommunikation auch nach Unterbrechung
- **Kompatibilität**
 - Unterstützung existierender Protokolle anderer Schichten
 - keine Änderung an Routern und anderen Geräten
- **Idee**
 - **temporäre IP-Adressen** („care of address“)
 - **Forwarding** vom alten zum neuen Subnetz (mittels „encapsulation“)

- Overhead?
- Effizienz?
- Skalierbarkeit?

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One of the First Mobile Phones...



F.Ma. 10

Evolution of the Public Mobile Phone Network (Example: Germany)

- 1958 "A-Net"
 - analog, 160 MHz, connection setup only from the mobile station, no hand-over, 80% coverage
 - "mobile" phone: 16 kg, DM 15000
 - 1971: 11000 customers
- 1972 "B-Net"
 - analog, 160 MHz, connection setup also from the fixed network (but location of the mobile station has to be known)
 - available also in some other countries (e.g., A, NL)
 - 1979: 13000 customers in D
- 1986 - 2000 "C-Net"
 - analog voice transmission, 450 MHz, hand-over, digital signaling, automatic location of mobile device
 - services: FAX, modem, X.25, e-mail, 98% coverage
 - public phones in trains until end of 2000



F.Ma. 11

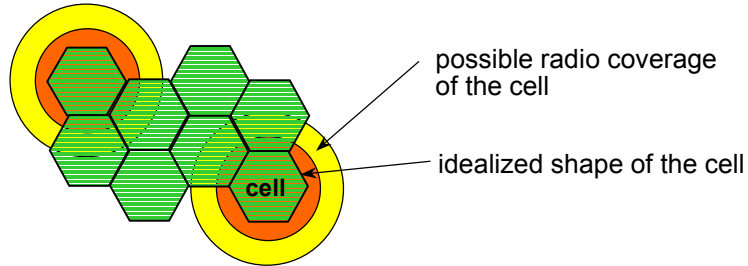
1992: Start of GSM

- Automatic location, hand-over, cellular
- Services: voice, data with 9.6 kbit/s, FAX, ...
- Germany:
 - "D1" and "D2", fully digital, 900 MHz, 124 channels
 - customers: D1 15 Mio (Oct. 2000), D2 13.8 Mio (June)
 - 1994 "E-Net" (1800 MHz, smaller cells, 1997: 98% coverage of the population, 5 Mio customers in 1999)
- Roaming in Europe - now almost worldwide
- Evolution:
 - GPRS (2000/01: packet oriented, IP support, 28.8 – 171 kbit/s, volume tariffing)
 - UMTS (2002-05)

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Segmentation of the Area into Cells

- Space division multiplex: base station covers a certain transmission area (cell)

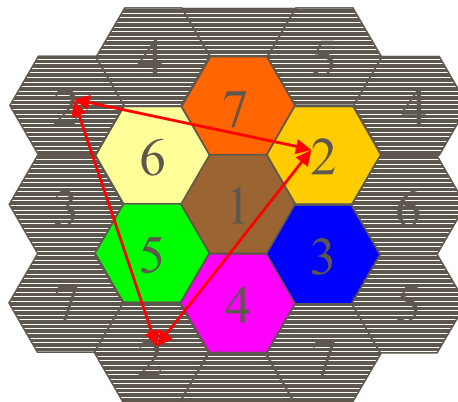


- Cell sizes vary from some 100 m up to 35 km depending on user density, geography, transmitter power,...
- Hexagonal shape of cells is idealized (cells overlap, shapes depend on geography)

F.Ma. 13

Frequency Reuse

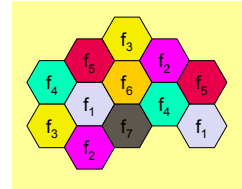
- Frequency reuse only with a certain distance between the base stations
- Standard model using 7 frequencies



F.Ma. 14

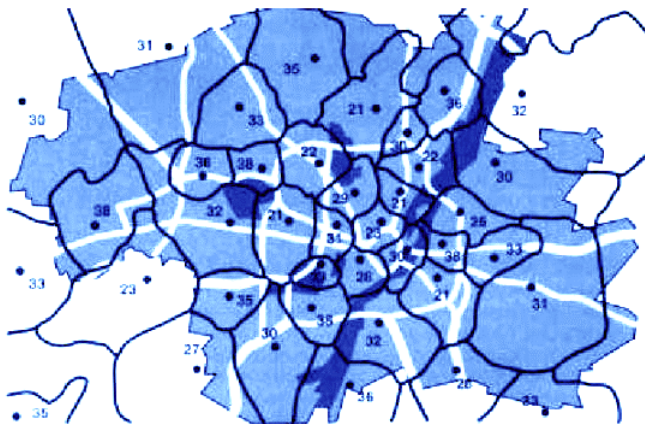
Frequency Planning

- **Fixed frequency assignment:**
 - problem: different traffic load in different cells
- **Dynamic frequency assignment:**
 - base station chooses frequencies depending on the frequencies already used in neighboring cells
 - more capacity in cells with more traffic
 - assignment can also be based on interference measurements



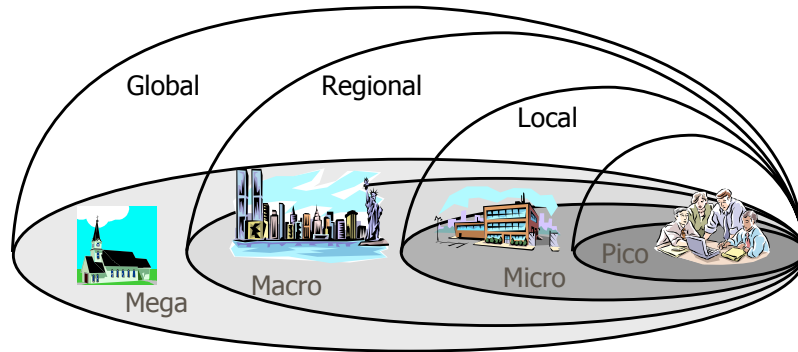
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Sizes of Cells (Example)



F.Ma. 16

UMTS (Universal Mobile Telecommunication System)



- Mega cell > 10 km 144 kbit/s
- Macro cell 5 - 10 km 385 kbit/s
- Micro cell 0.5 km 2 Mbit/s
- Pico cell 100 m > 2 Mbit/s