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)

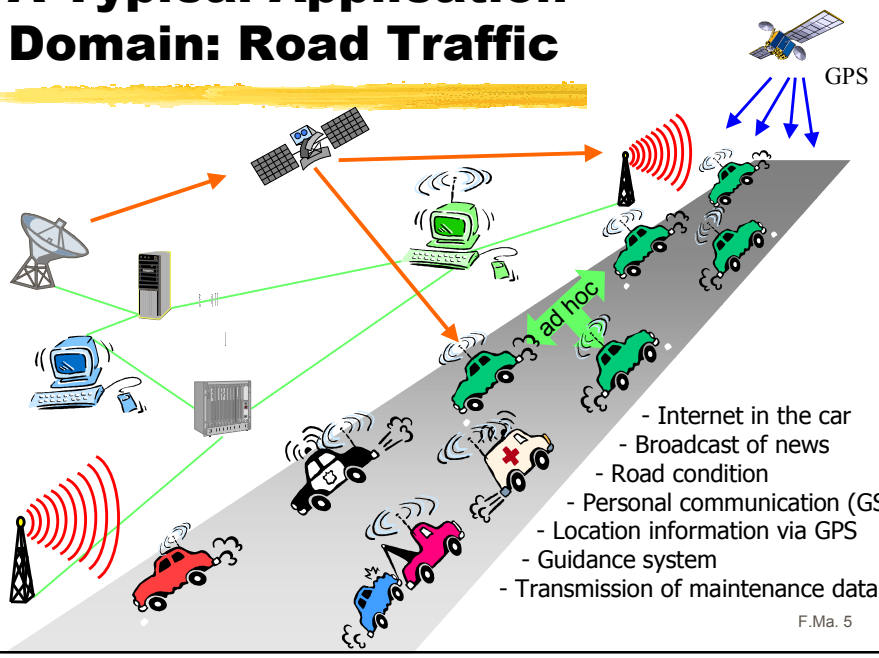
F.Ma. 3

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

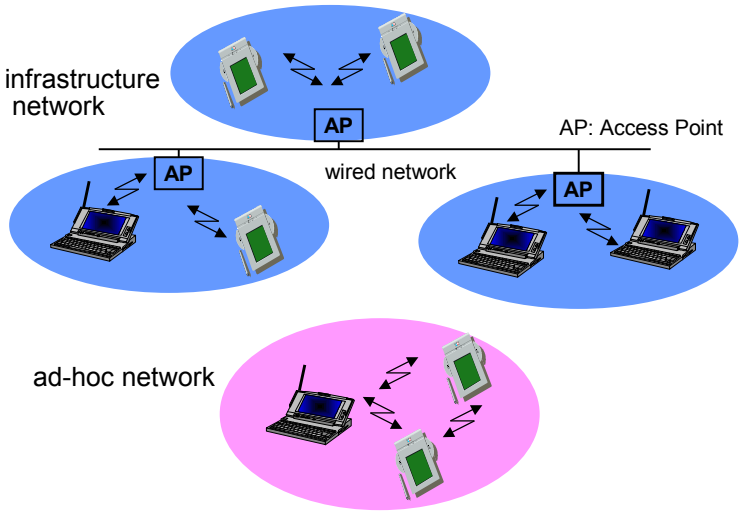
A Typical Application Domain: Road Traffic



- Internet in the car
- Broadcast of news
- Road condition
- Personal communication (GSM)
- Location information via GPS
- Guidance system
- Transmission of maintenance data

F.Ma. 5

Infrastructure Networks vs. Ad-hoc Networks

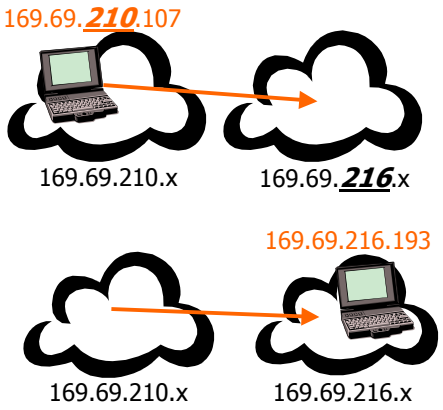


F.Ma. 6

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

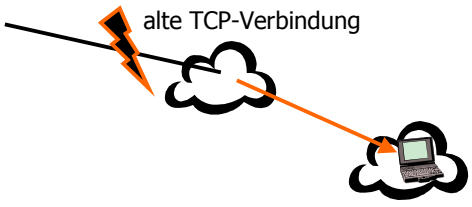
⇒ bei Subnetzwechsel muss die IP-Adresse des Endgerätes angepasst werden: keine Transparenz!



F.Ma. 7

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

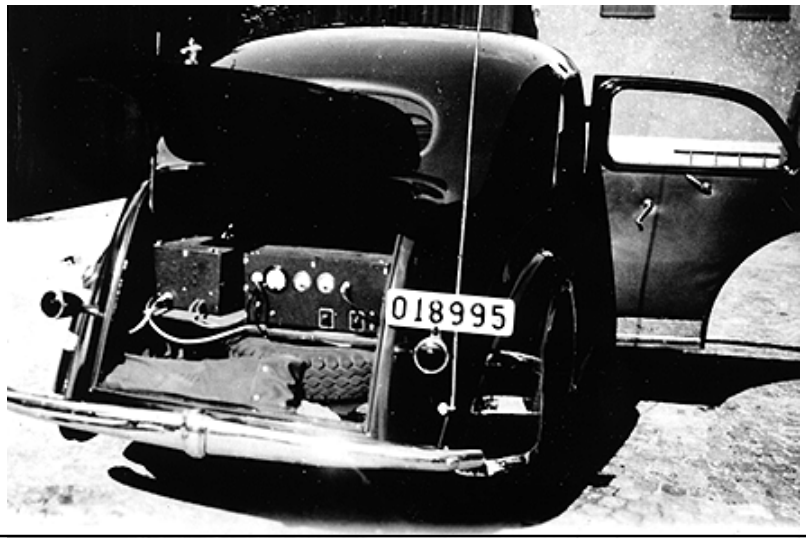
Mobile Internetworking: Anforderungen

- 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?

F.Ma. 9

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

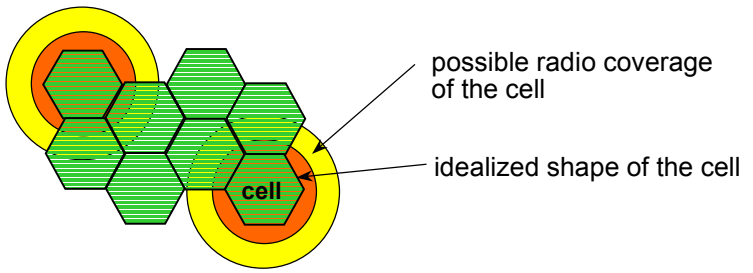
1992: Start of GSM

- 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)

F.Ma. 12

Segmentation of the Area into Cells

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

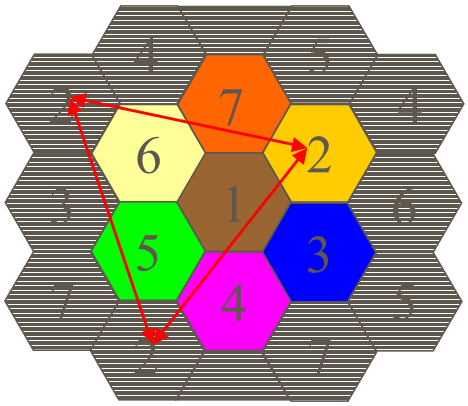


- Cell sizes vary from some 100 m up to 35 km depending on user density, geography, transmitter power,...
- Hexagonal shape of cells is idealized (cells overlap, shapes depend on geography)

F.Ma. 13

Frequency Reuse

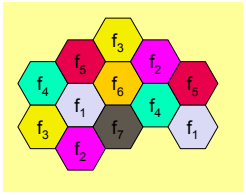
- Frequency reuse only with a certain distance between the base stations
- Standard model using 7 frequencies



F.Ma. 14

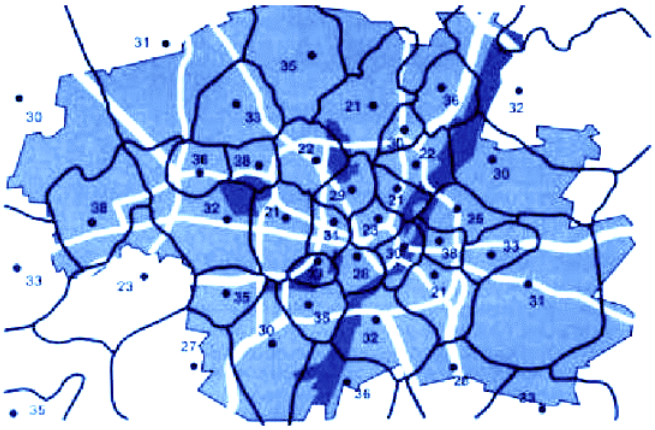
Frequency Planning

- 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



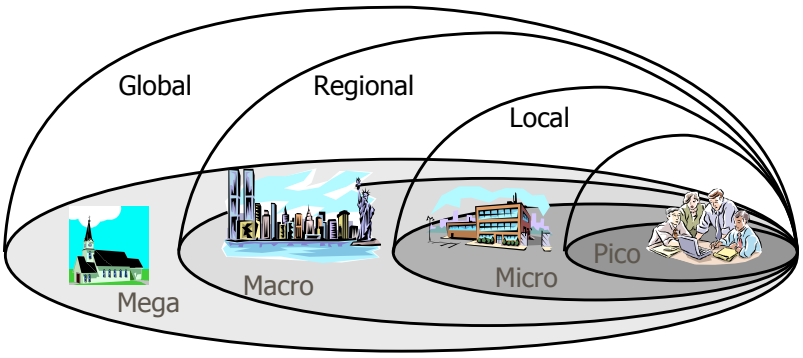
F.Ma. 15

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

F.Ma. 17