Wireless Internet/Advanced Networking

Introduction, Review

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Wireless Business and Markets
State of the Wireless Data Business

Telecommunication World
- 2G Mobile Communication Systems are in place (GSM, GPRS, EDGE)
- 3G Mobile Systems (UMTS incl. HSDPA) are available
- B3G systems (LTE/SAE) are under development
- Wireless voice market is saturating
- Data traffic is growing
- Traditional Telecom Operator and infrastructure provider target the Internet market

Internet World
- Fixed Internet access is getting common (DSL)
- WLAN hot spots are installed at airports, campus areas, coffee shops, etc.
- 802.11a products are standard, 802.11n is establishing
- 802.16 (WiMAX) products are available
- 802.20 (MBWA) standards approved
- Internet Service Providers (ISP) and Internet infrastructure provider target the mobile market
Mobile Networks in Germany
IEEE 802.16/WiMAX Systems

2005: Fixed Outdoor
- E1/T1 level service for enterprises
- Backhaul for hotspots
- Limited residential broadband access

2006 (802-16d): Fixed Indoor
- Indoor ‘last mile’ access for consumers
- Wireless DSL
- Metrozone / Enterprise campus piconet

2008 (16e): Portable/Mobile
- ‘Portable’ broadband access for consumers
- Always best connected
Future Networks/Next Generation Network (NGN)

• is a packet-based network
• provides telecommunication services and more
• uses multiple broadband, QoS-enabled transport technologies
• offers unrestricted access by users to different service providers
• supports generalized mobility
• allows consistent and ubiquitous provision of services to users
• service-related functions are independent from underlying transport-related technologies
Unlicensed Mobile Access (UMA)  http://www.umatechnology.org

Idea:
Access to GSM and GPRS mobile services over unlicensed spectrum (WLAN, Bluetooth)

User View:
- Voice and data services
- Same mobile identity on GSM and WLAN
- Seamless delivery (roaming and handover)
- Security equivalent GSM

Operator view:
- Preserves investment in mobile core network infrastructure
- Independent of underlying unlicensed spectrum technology (e.g. WLAN, Bluetooth)
- Transparent to existing, standard devices (e.g. access points, routers and modems)
- No impact to operations of GSM/UMTS (e.g. spectrum engineering, cell planning, …)

Participants: T-Mobile, Alcatel, BT, Cingular, Ericsson, Motorola, Nokia, Nortel, O2, Siemens, Sony-Ericsson, …
UMA Architecture

![Diagram of UMA Architecture](image)
Fixed Mobile Convergence

FMC Solution: SIP over Wi-Fi

- Centralized Application Server or IP-PBX controls VoIP services
- advanced VoIP services on mobile, enterprise, home, and public Wi-Fi networks
- Enables wireline or wireless replacement

http://www.thefmca.com/
4G Mobile Communication Systems

Reconfigurable Radio

Wireless IP Society

4th Generation

Wireless Broadband

UMTS

Satellite Broadband

S-UMTS

DVB-S

DVB-T

DAB

GPRS/EDGE

GSM

UMTS ++

MBS 40

MBS 60

BROADBAND W-LAN

Bluetooth

DECT IR

Personal Area Networks

Body LANs

Local Area Networks

Wireless Local Loop

Indoor

Quasi-Cellular

Cellular

Broadcasting

Satellite/HAPS

Broadband
5G: Interplanetary Internet
Review of Basic Problems
Efficient Use of Radio Resources

- **Problems**
  - Radio resources are limited
  - Minimize emission
  - Access to the shared radio resources

- **Objectives**
  - Maximize the transport capacity (application and system view)
  - Minimize the radio power needed per bit of transmitted user data (radio technology)
  - Minimize interference to others
  - Avoid collisions (efficient radio usage)
  - Minimize the latency

- **Some basic solutions**
  - Transmit power control
  - Adaptive modulation
  - Adaptive coding
  - Antenna technology
  - Select suitable medium access control mechanism
Efficient Use of Radio Resources – Solutions

How to increase the system capacity?
- Tap new radio resources at higher frequencies
- Adaptive antennas/beamforming
- MIMO and distr. MIMO systems
- Fast transmit power control
- Adaptive modulation
- Adaptive coding and FEC
- Hybrid ARQ
- Multiuser detection
- Cognitive Radio
- Opportunistic scheduling
- Fast radio resource management
- Reduction of cell size and increase number of cells
- Multi-hop support
- Cross-layer optimization
- Common Radio Resource Management (select radio technology with most efficient use of radio resources)
- …

How to handle all this?
- Adaptive control and self-organization …
Mobility Management

- Problem
  - Locate a mobile user

- Solutions
  - Mobile registers with each visited cell
  - Support Paging

Solution 1: Large paging area
Solution 2: Small paging area
Mobility Management

• **Problem**
  – Change the cell during an ongoing session (handover)

• **Reasons for handover:**
  – Quality of radio link deteriorates
  – Out of coverage
  – Overload in current cell

• **Solutions**
  – Measurements of current and neighboring cells
  – Proactive handover

![Diagram of cell 1 and cell 2 connection](image-url)
Quality of Service (QoS)

- **Problems**
  - Provide a defined minimum of quality (throughput, delay, etc.)
  - Quality during handover (seamless handover)

- **Solutions**
  - Resource reservation
  - Overprovisioning
  - Priorisation

- **Examples**
  - GSM voice – explicit reservation
  - IntServ (RSVP) – explicit reservation (soft state)
  - Diffserv – service differentiation (priority-based)
Security and Privacy

- **Problems**
  - Confidentiality
    - privacy of content (eavesdropping of communication content by others)
    - privacy of location
    - privacy of identity
  - Misuse of mobile station or network
    - rerouting of traffic
    - unauthorised access to services

- **Solutions**
  - Authentication (who am I?)
  - Authorisation (what am I allowed to do? which services?)
  - Ciphering
  - Location hiding from others
  - Identity hiding from communicating partner
Review of Wireless Transmission
see Course on Mobile Communication Networks (B.Sc.) for details
Signal representations

- Composed signals transferred into frequency domain using Fourier transformation
- Digital signals need
  - infinite frequencies for perfect transmission
  - modulation with a carrier frequency for transmission (analog signal!)
Signal propagation

Propagation in free space always like light (straight line)

Receiving power proportional to $1/d^2$
  
  $(d = \text{distance between sender and receiver})$

Receiving power additionally influenced by
  
  – fading (frequency dependent)
  – shadowing
  – reflection at large obstacles
  – scattering at small obstacles
  – diffraction at edges
Multipath propagation

Signal can take many different paths between sender and receiver due to reflection, scattering, diffraction.

Time dispersion: signal is dispersed over time
- interference with “neighbor” symbols, Inter Symbol Interference (ISI)

The signal reaches a receiver directly and phase shifted
- distorted signal depending on the phases of the different parts
Effects of mobility – Fading

Channel characteristics change over time and location
- signal paths change
- different delay variations of different signal parts (frequencies)
- different phases of signal parts

→ quick changes in the power received (short-term fading or fast fading)

Additional changes in
- distance to sender
- obstacles further away

→ slow changes in the average power received (long-term fading or slow fading)
Review of Media Access Control

see Course on Mobile Communication Networks (B.Sc.) for details
Hidden and exposed terminals

Hidden terminals
- A sends to B, C cannot receive A
- C wants to send to B, C senses a “free” medium -> CS fails
- collision at B, A cannot receive C -> CD fails
- A is “hidden” for C

Exposed terminals
- B sends to A, C wants to send to another terminal (not A or B)
- C has to wait, CS signals a medium in use
- but A is outside the radio range of C, therefore waiting is not necessary
- C is “exposed” to B
Near and far terminals

Terminals A and B send, C receives
- signal strength decreases proportional to the square of the distance
- the signal of terminal B therefore drowns out A’s signal
- C cannot receive A

If C for example was an arbiter for sending rights, terminal B would drown out terminal A already on the physical layer
Also severe problem for CDMA-networks – precise power control needed!
TDMA: RTS/CTS

RTS/CTS scheme avoids the problem of hidden terminals
- A and C want to send to B
- A sends RTS first
- C waits after receiving CTS from B

RTS/CTS scheme avoids the problem of exposed terminals
- B wants to send to A, C to another terminal
- B sends RTS, A replies with CTS
- C does not receive CTS from A
  => C concludes that it is not within receiving range of A
- C can start its transmission

Disadvantage:
- overhead where data packets are small
FDD vs. TDD

**Frequency Division Duplex (FDD)**
Separate frequency bands for up- and downlink

+ separation of uplink and downlink interference
- no support for asymmetric traffic

Examples: UMTS, GSM, IS-95, AMPS

**Time Division Duplex (TDD)**
Separation of up- and downlink traffic on time axis

+ support for asymmetric traffic
- mix of uplink and downlink interference on single band

Examples: DECT, WLAN, UMTS (TDD)