Wireless Architectures

S-72.333 Postgraduate Seminar on Radio Communications

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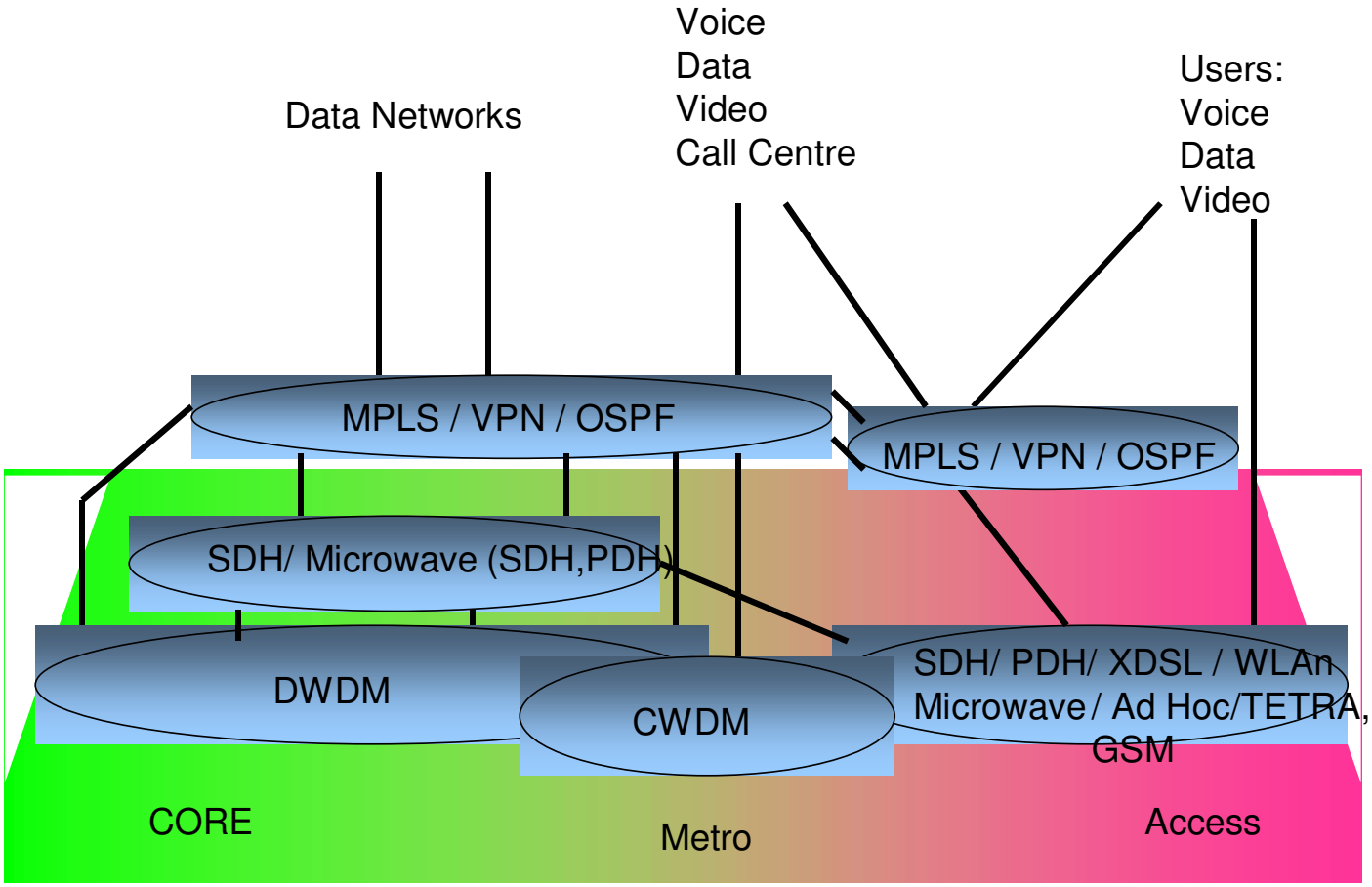
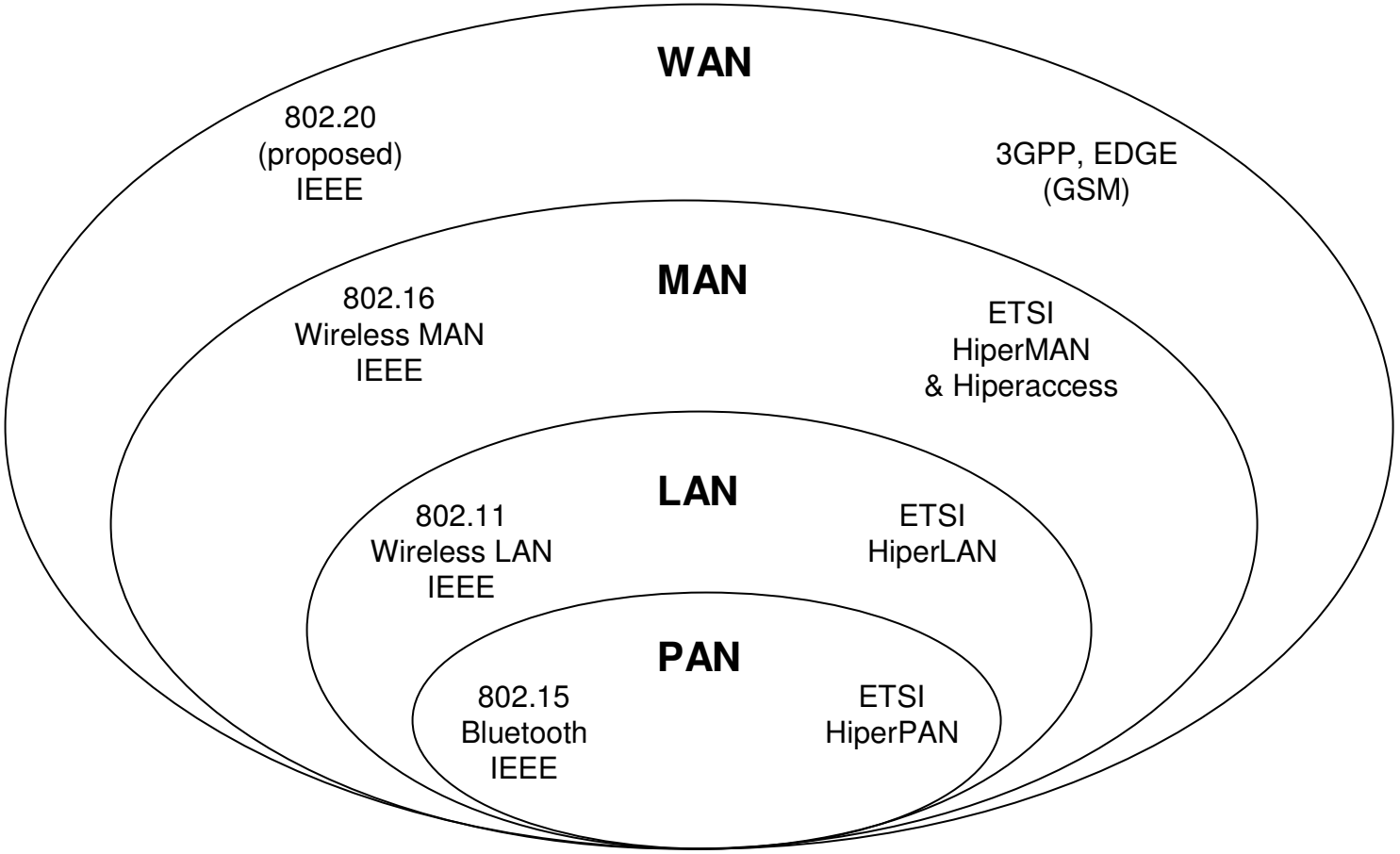
AGENDA

- COMMUNICATIONS NETWORK ARCHITECTURE
- WIRELESS STANDARDS
- MULTIPLE-ACCESS STRATEGIES
- COMPARISON OF DIFFERENT MULTIPLE ACCESS STRATEGIES
- OSI REFERENCE MODEL
- OSI REFERENCE MODEL, LAYERS
- MAC SUBLAYER
- POWER CONTROL
- POWER CONTROL, OPEN LOOP
- POWER CONTROL, CLOSED LOOP
- HANDOVER
- MULTIPLE-ACCESS CONSIDERATIONS
- MOBILE NETWORK
- WIRELESS LAN with GSM and TETRA
- 802.16a (WIMAX)
- PROBLEMS
- SUMMARY
- HOMEWORK
- REFERENCES

COMMUNICATIONS NETWORK ARCHITECTURE



WIRELESS STANDARDS



MULTIPLE-ACCESS STRATEGIES

Comparison of multiple-access strategies:

1. FDMA

- A quite old technology, in which we divide the frequency band into different frequency channels and users share these channels in order to get access

2. TDMA

- it`s time division multiplexing technology, in which users time-share the used spectrum (e.g. PCM-technology)

3. CDMA

- in this technology all users use the same spectrum simultaneously, but the number of users is limited by multiple-access interference

4. SDMA

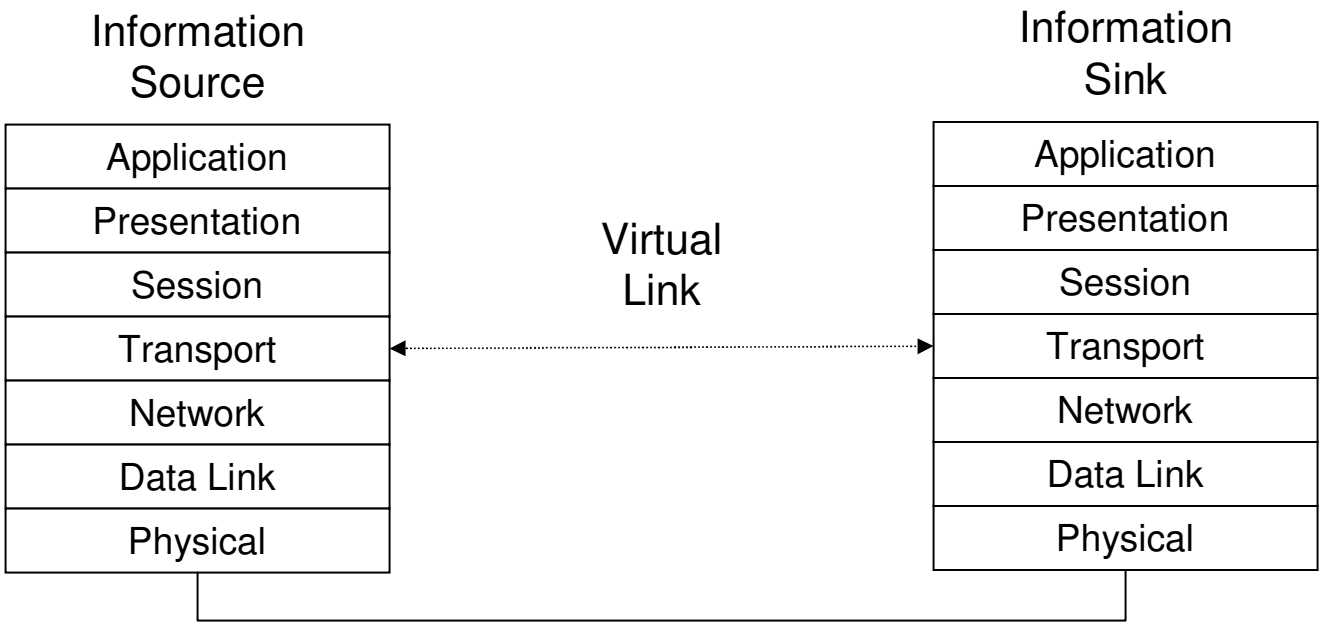
- in this, users share the spectrum in angular direction with the use of smart antennas

Real systems use usually a hybrid of two or more of these multiple-access strategies (growth strategy, complexity of systems, existing systems)

COMPARISON OF DIFFERENT MULTIPLE-ACCESS STRATEGIES

- modulation	FDMA and TDMA relies on bandwith efficient modulation, CDMA - simple modulation, SDMA – transparent
- source coding	FDMA and TDMA- improves efficiency CDMA - improves efficiency SDMA – transparent
- diversity	FDMA and TDMA – requires multiple transmitters or receivers TDMA - can be also frequency hopped CDMA - includes frequency diversity when implemented with a RAKE receiver SDMA – single antenna reduces space diversity
- handover	FDMA and TDMA – hard CDMA – soft and SDMA potentially soft
- flexibility	FDMA – fixed data rate, TDMA – data rate variable in discrete steps, CDMA – can provide a variety of data retes without affecting signal in space, SDMA - transparent

OSI REFERENCE MODEL



Seven layers of OSI a model of communications

(OSI – The Open System Interconnection)

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OSI REFERENCE MODEL, LAYERS

1. PHYSICAL LAYER

- includes mechanism for transmitting bits. The module for performing this function is a modem – modulator and demodulator.

2. DATA LINK LAYER

- includes error correction or detections, packets retransmission, orderings of packets. For W-LAN systems data link layer is quite important work to do when multiple nodes share the same media, it`s to allow frames to be sent over the shared media without undue interference from other nodes.
  The part of the data link layer that controls multi-access communications is the medium access control (MAC) sub layer.

3. NETWORK LAYER

- this layer is responsible for routing, to determine the quality of service (QoS) and flow control

4. TRANSPORT LAYER

- this layer separates messages into packets for transmission and reassemblies the packets at the other end. This layer provides also reliable end-to-end communications.

OSI REFERENCE MODEL, LAYERS

5. SESSION LAYER
- this layer determines access rights and finds the right delivery service

6. PRESENTATION LAYER
- data encryption, data compression, and code conversion

7. APPLICATION LAYER
- this layer provides user interface

OSI reference model was developed for computer communications.
Today we are using it also to the wireless communication systems.

MAC SUBLAYER

To the wireless communications MAC-sub layer has many important procedures to do.

The lower level MAC layer functions describe the rules for sharing frequencies, time slots, cells, and codes.
It has also influence on physical layer constructions, in which way it`s designed.

- share the radio spectrum
- voice communications
- cannels for user traffics and also for the signalling purposes

The MAC-sub layer is quite important when we are designing the wireless systems.
The MAC-sub layer assign different MAC-functions to the logical cannels.
Logical cannels may be assigned to the same or different physical cannels.
Logical channels will use an FDMA, TDMA or CDMA strategy for multiplexing.

The different logical cannels for the MAC-sub layer may be divided into four types:

1. Synchronization and broadcast cannels
2. Paging and access channels
3. Control channels
4. Traffic Channels

POWER CONTROL

In the wireless communication systems we try to maximize the number of users and utilization of the radio spectrum.
There is one big problem concerning these goals:
Interferences => the number of users is limited

The near-far problem is a simple example of these interference limits.
=>
Improving spectral efficiency and increasing capacity implies minimizing the interference.
Which, in turn, is directly related to minimizing the transmitted power of each terminals.

The main goal of the power control is to solve near-far problem.
We do it by adjusting each transmitter`s power so that received signal is the acceptable level according to the SLA (Service Level Agreement).

POWER CONTROL, OPEN LOOP

Open loop power control is the procedure where the mobile terminal measures its received signal level and adjusts its transmit power accordingly.

Open loop procedure is fast. It`s working without round-trip delay between the base station and the user terminals.

The main disadvantage of the open-loop power control is the limited correlation between received power level on the uplink and downlink.

There is some kind of correlation but variation in these average effects are due to shadowing effects (slow fading) caused by different types of environments.

But e.g. for fast Rayleigh fading, open loop power control is not effective, because down- and uplink transmission usually occur in different frequency bands.

It`s possible to use the open-loop power control procedure in an asymmetric way.
This means that the transmit power should be decreased immediately when there is a high received signal and when received signal is slow, power should be increased slowly.

The purpose of the asymmetric strategy is to minimize the interferences (caused by other users)

POWER CONTROL ,CLOSED LOOP

With closed-loop power control of the mobile terminal, the base station measures the received signal and makes adjustment procedures by sending to the user terminal information about adjust terminal output power.

The delay between measurement and application is a critical parameter there.
- accurate measurement (averaged)
- control information must be multiplexed with the outgoing signal (delay)
  This is the reason for that there are not used forward error-correction encoded or interleaved signals.
-incurs delay in corresponding to the separation between the mobile terminal and the base station.
-because of the power control signals are uncoded, it´s less reliable, and they should use average value over several symbols. That means delay.

There are also outer-loop power control procedures, which are based on frame error rate measurements.

HANDOVER

In the cellular environment mobile terminals will occasionally cross a cell boundary.
In this situation a call must be transfer to the base station of the new cell.
This procedure is known as a handover.

There is also other procedures, which we need there in the cellular environment,
The procedure is known as roaming.
It happens in situations, when mobile terminals are going over operator's network boundary.
There must be roaming agreement between operators before roaming procedure is possible.

A handover is usually based on the received signal strength (old systems).
In new systems, a handover is generally mobile assisted.
In these systems, mobile makes measurements of broadcast channels from the surrounding cells and reports the results to the current base station.
In either case, the measurements are provided to a central processing unit, a mobile switching centre (MSC) that has links to the relevant base stations, which can control the handover.

Handover problems:
- the speed of the mobile terminals
- too many handovers to handle
- there are no free cannels available in the new cell

MULTIPLE-ACCESS CONSIDERATIONS

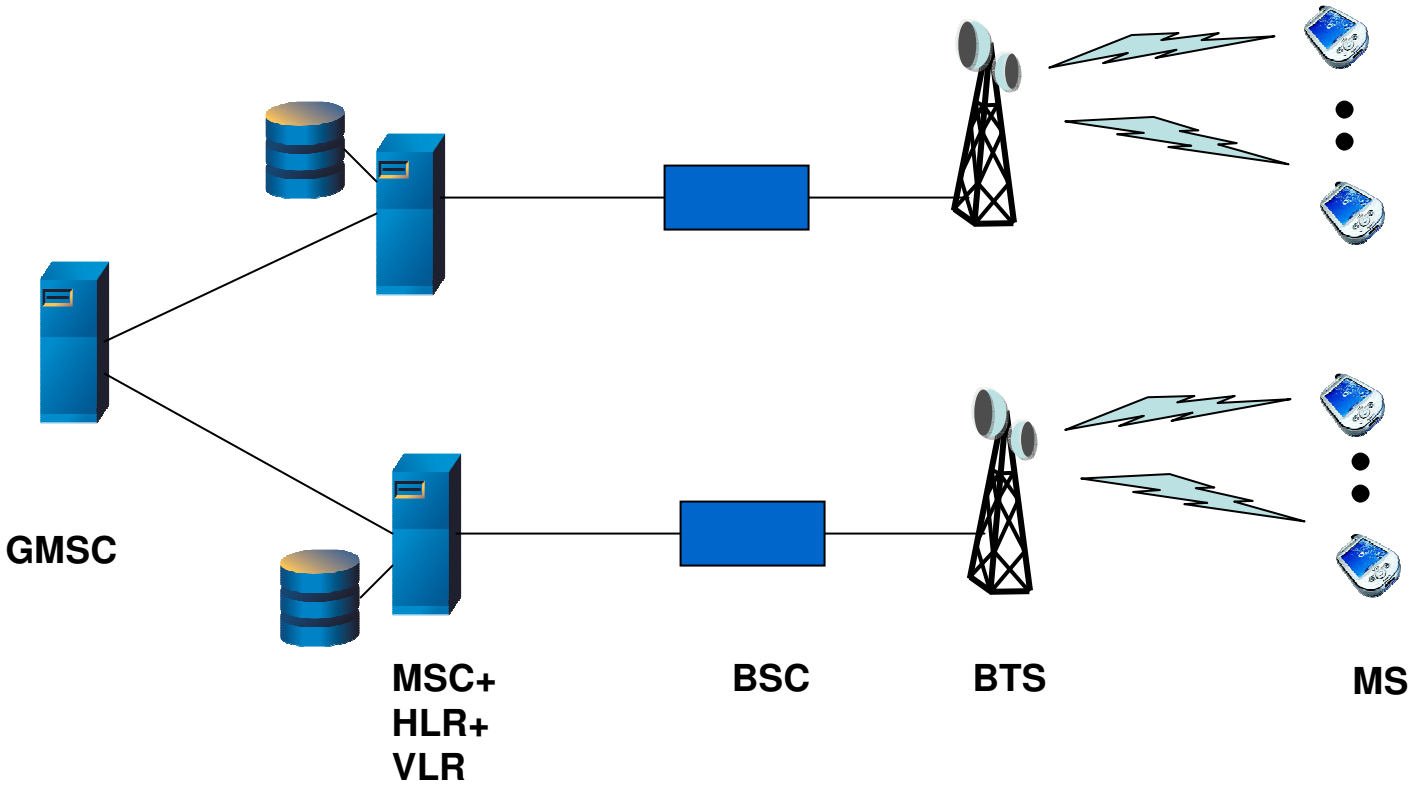
Some special multiple-access considerations with a handover should be observed:

- with FDMA and TDMA/FDMA combination systems, the mobile terminals must change the frequencies of both its traffic channels and signalling channels, as well as synchronization to the new base station.
This process is called as **a hard handover.**

- with CDMA technology, the same process is called as **a soft handover.**
In the CDMA networks we are using the same frequencies in each cell, so there is no need for changing channels when we are going over the boundaries of the cells.

-with SDMA technology, when antenna beams are fixed, a handover is necessary when the mobile terminal goes over a beam boundary. Its also possible, when there are two users occupying same channels.

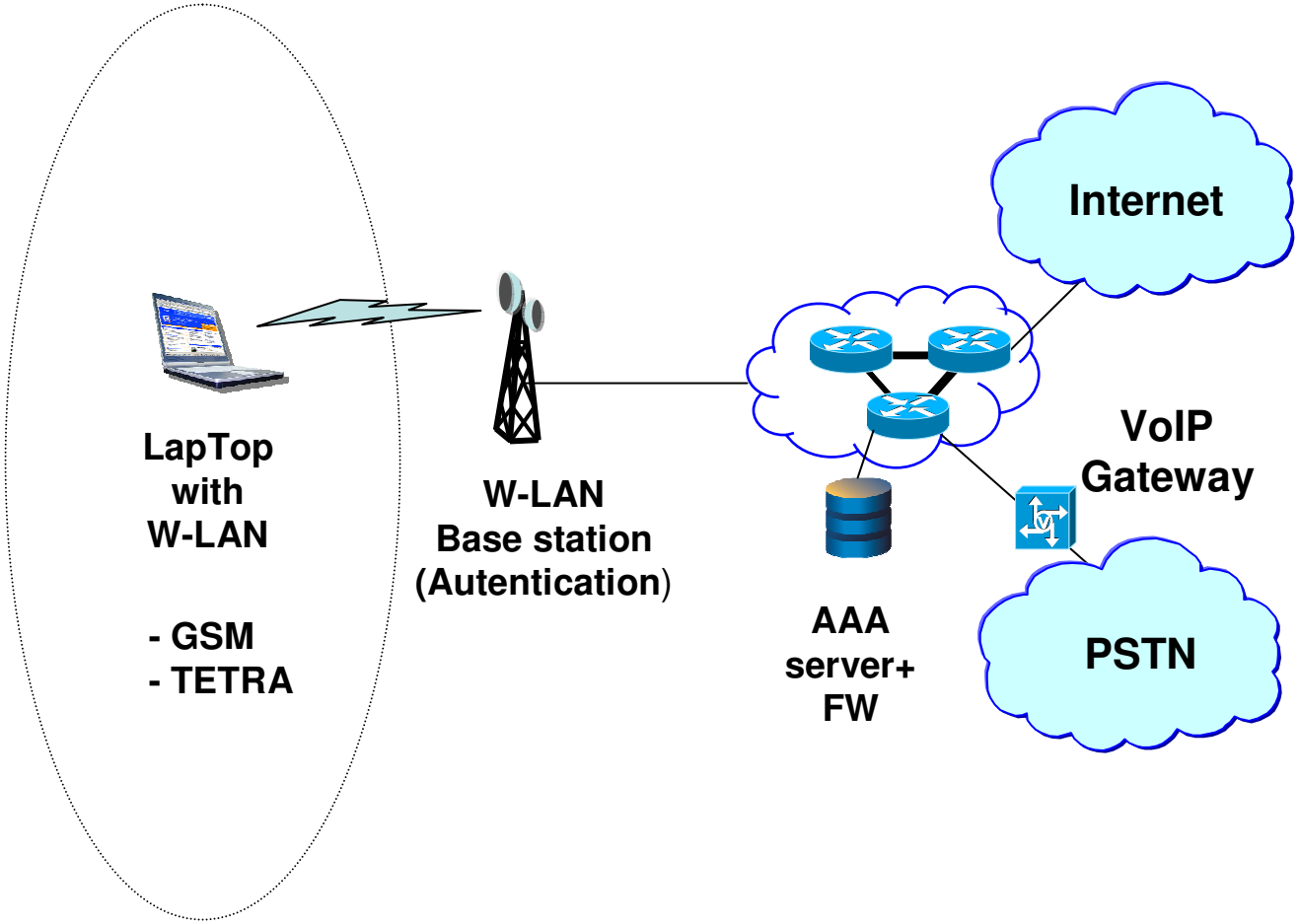
MOBILE NETWORK



MS = Mobile Station
BTS = Base Transeiver Station
BSC = Base Station Controller
MSC = Mobile Switching Center
GMSC = Gateway Mobile Switching Center
HLR = Home Location Register
VLR = Visitor Location Register

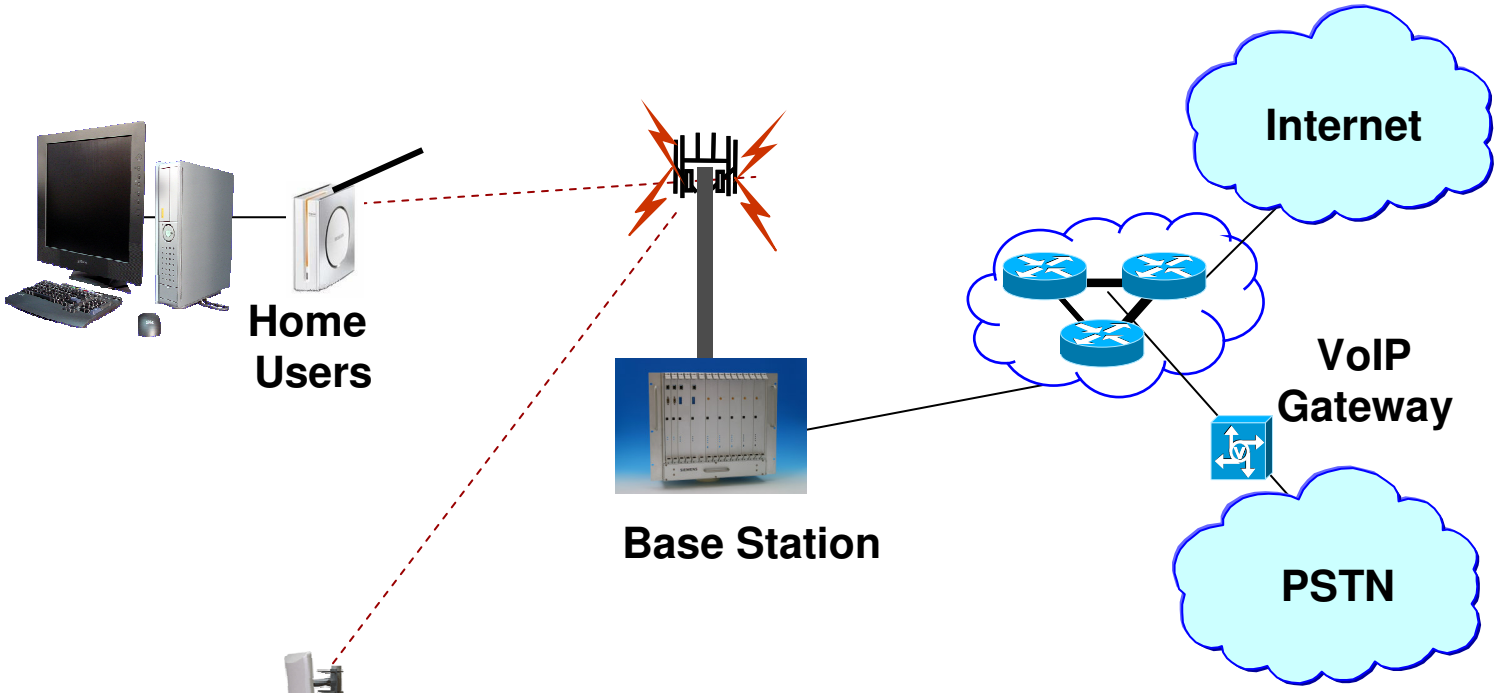
Ob. Round-trip delay

WIRELESS LAN with GSM and TETRA



Ob. Round-trip delay

802.16a (WIMAX)



WIMAX freq. today:

(802.16a)

- 2500 – 2690MHz, 2700 – 2900 MHz

- 3400 – 3600 MHz

- 5725 – 5860 MHz

Ob. Round-trip delay

PROBLEMS

Wireless network:
- MAC-sub layer
- handover procedure (delay)
- roaming between mobile networks and W-LAN-networks (delay)
- power control procedures
- network security
- access procedures in the W-LAN networks

Special wireless networks:
- interferences (used frequencies)
- jamming problems (broadband, narrowband, pulsed)
- security problem
- users terminal movements (handover)

SUMMARY

This representation:
- We have seen advantages and disadvantages of the different multiple-access strategies
- OSI-reference models are also used for the wireless communications purposes
- the use of specialized signalling channels as part of the MAC protocol (needs for voice communications)
- power control procedures
- handover strategies
- wireless telephone networks
- wireless data networks

REFERENCES

[1] Simon Haykin, Michael Moher, Modern Wireless Communications, Prentice Hall, USA 2004.

[2] Jorma Jormakka, Catharina Candolin, Military Ad Hoc Networks Edita Prima Oy, Helsinki 2004

HOMEWORK

What are those biggest problems (3) in the IP-level in the wireless networks.