

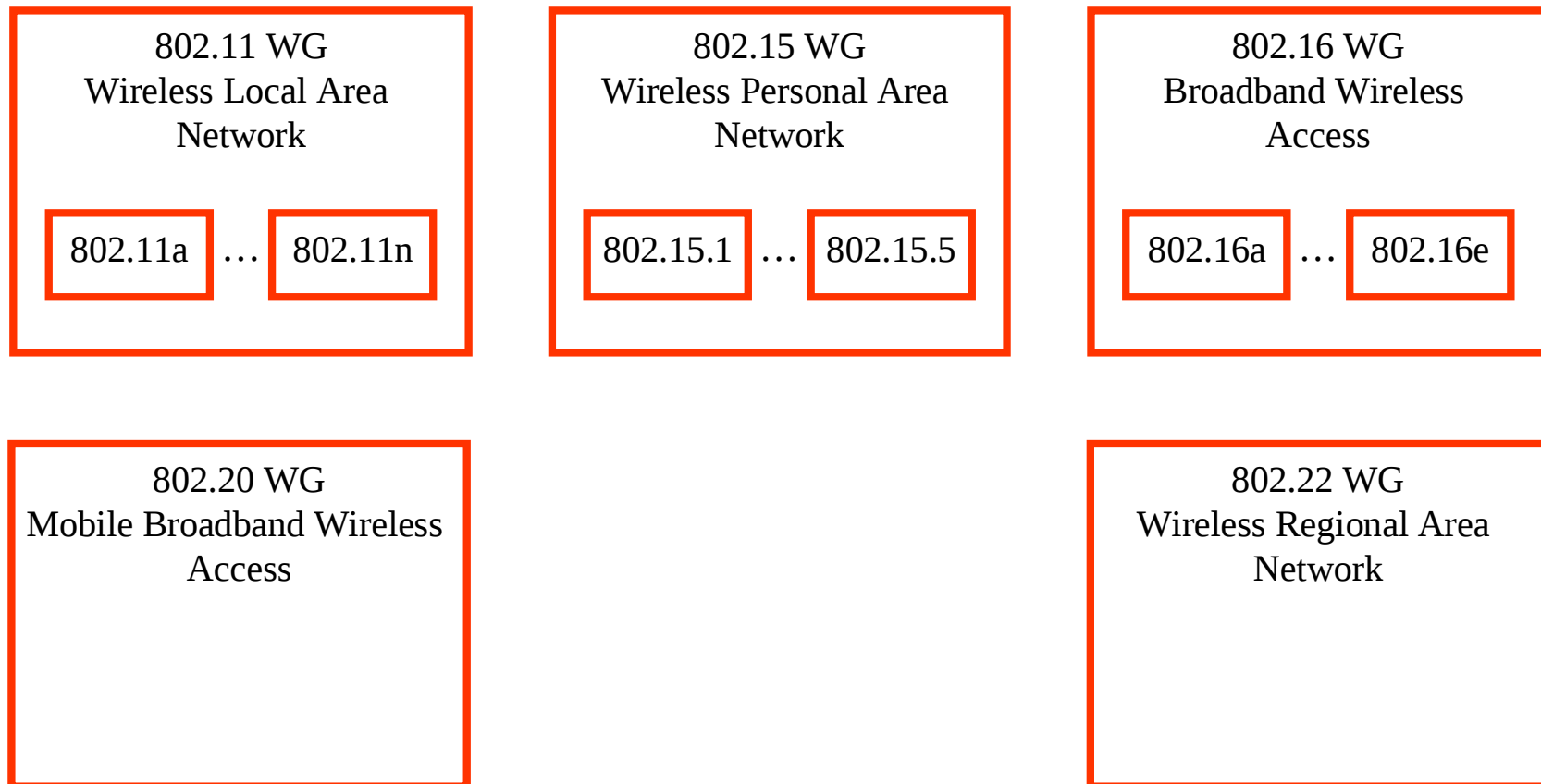
WiFi WiMAX

Robert Bestak



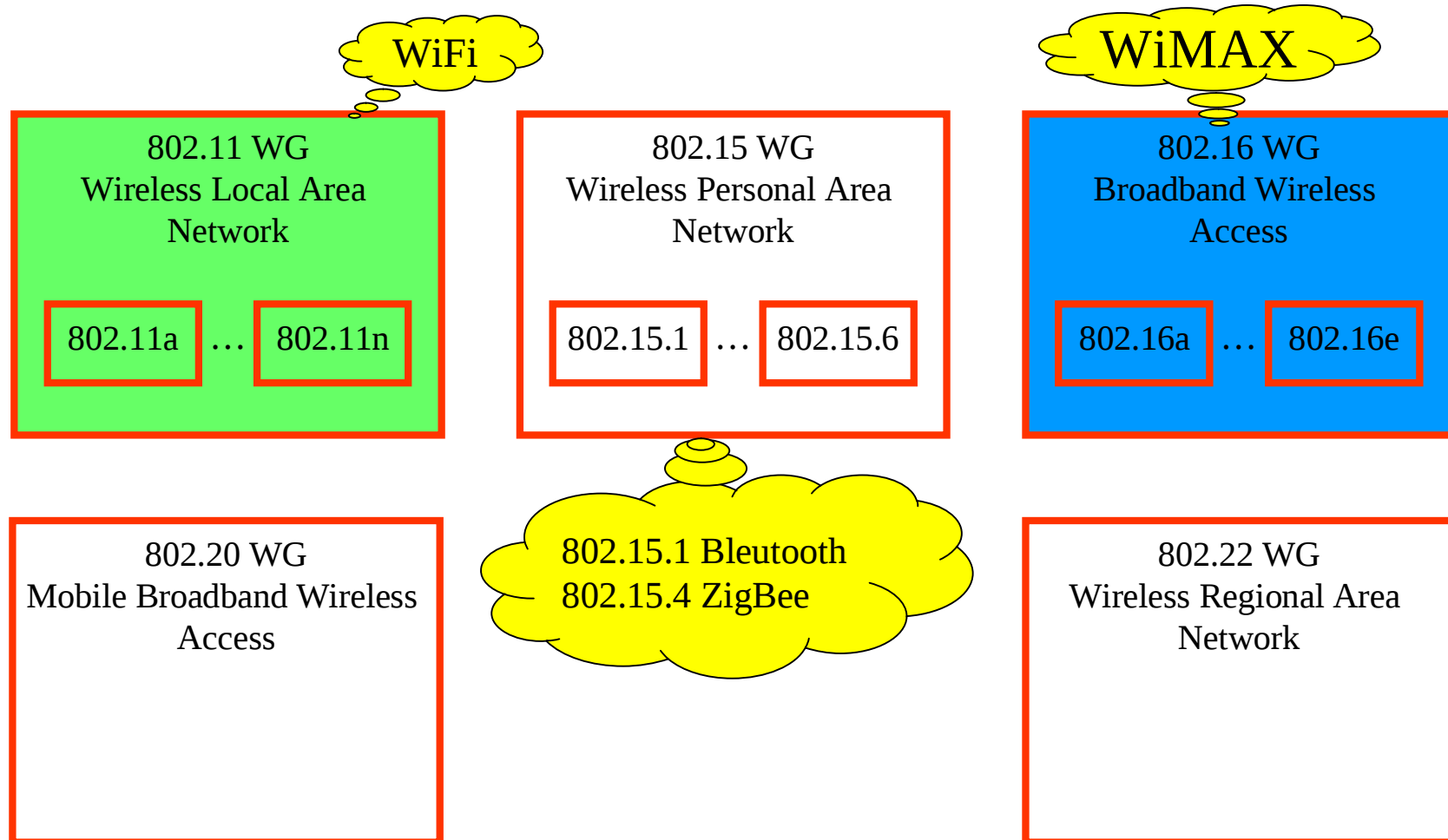
Czech Technical University in Prague
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IEEE wireless standards (1/2)



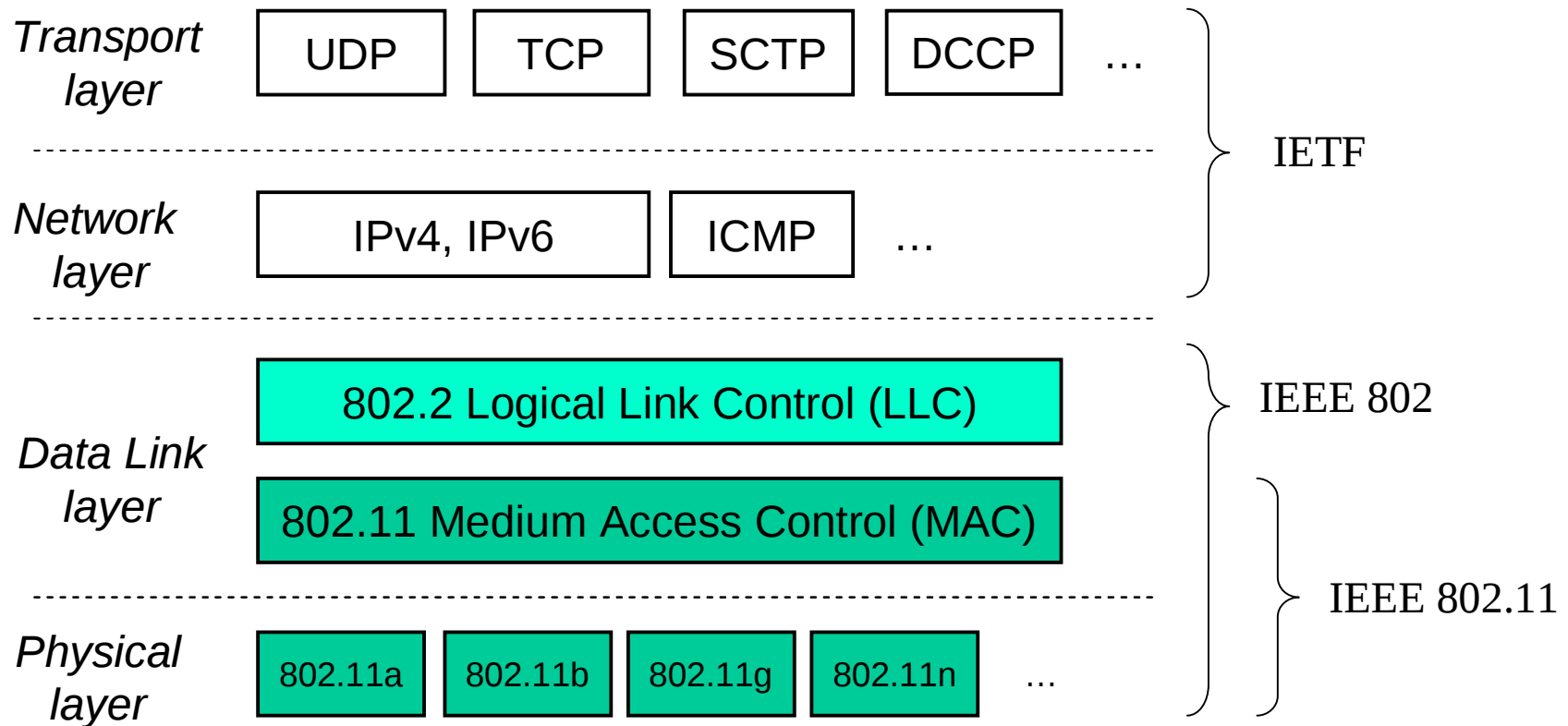
*IEEE: Institute of Electrical and Electronics Engineers

IEEE wireless standards (2/2)



WiFi

IEEE 802.11 protocol model



* IETF: Internet Engineering Task Force

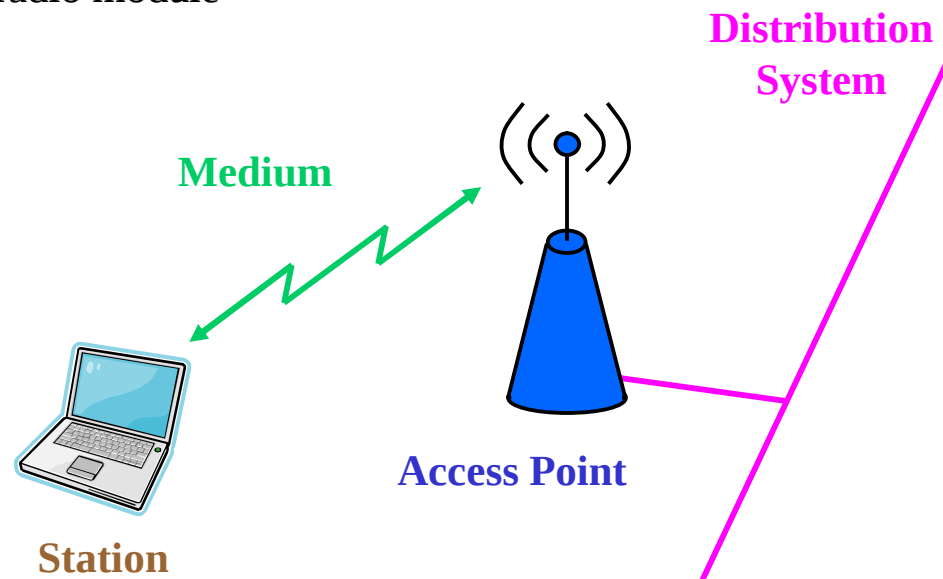
IEEE 802.11

- *Wireless Fidelity*
- IEEE 802.11, Wireless LAN
- Indoor (offices, buildings, ...not well suited for outdoor BWA)
- Originally did not support QoS
- WiFi Alliance
 - Ø Manufactures of WiFi equipments
 - Ø Testing, certification, promotions of technology
- ...Equipments before standard (...problems with interoperability, ...)
- Products certified by WiFi Alliance are provided with logo

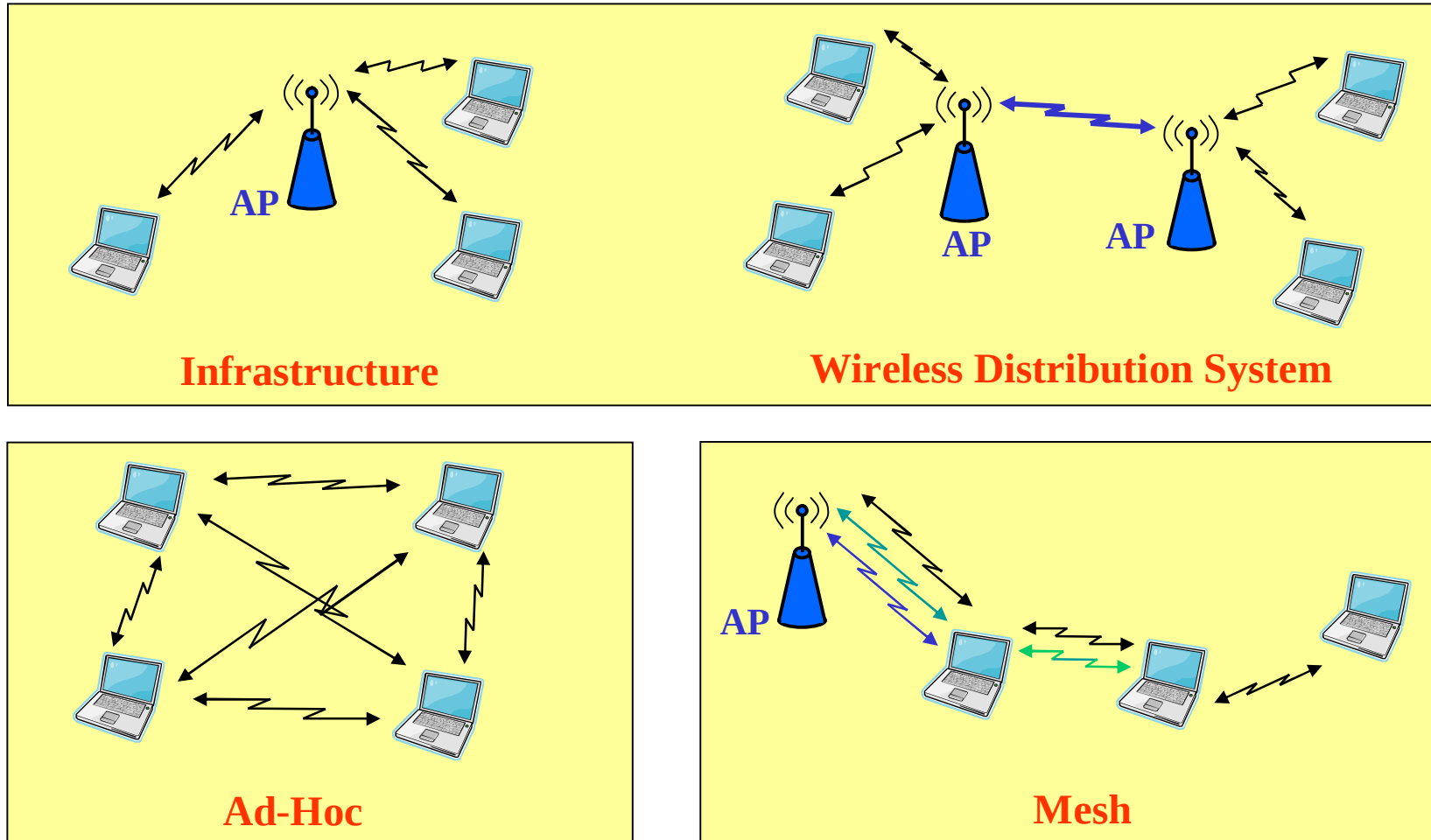


Architecture of WiFi

- **Distribution System**
 - Ø Interconnection of APs
- **Access Point**
 - Ø Provides wireless access to distribution system
- **Station**
 - Ø Terminal equipped with a radio module
- **Medium**
 - Ø Air



Network architecture



Layers

Network layer	IP				
Data Link layer	Logical Link Control (LLC) ... 802.2				
	Medium Access Control (MAC)				
Physical layer	802.11 IR	802.11 DSSS	802.11 FHSS	802.11a,g OFDM	802.11b HR-DSSS

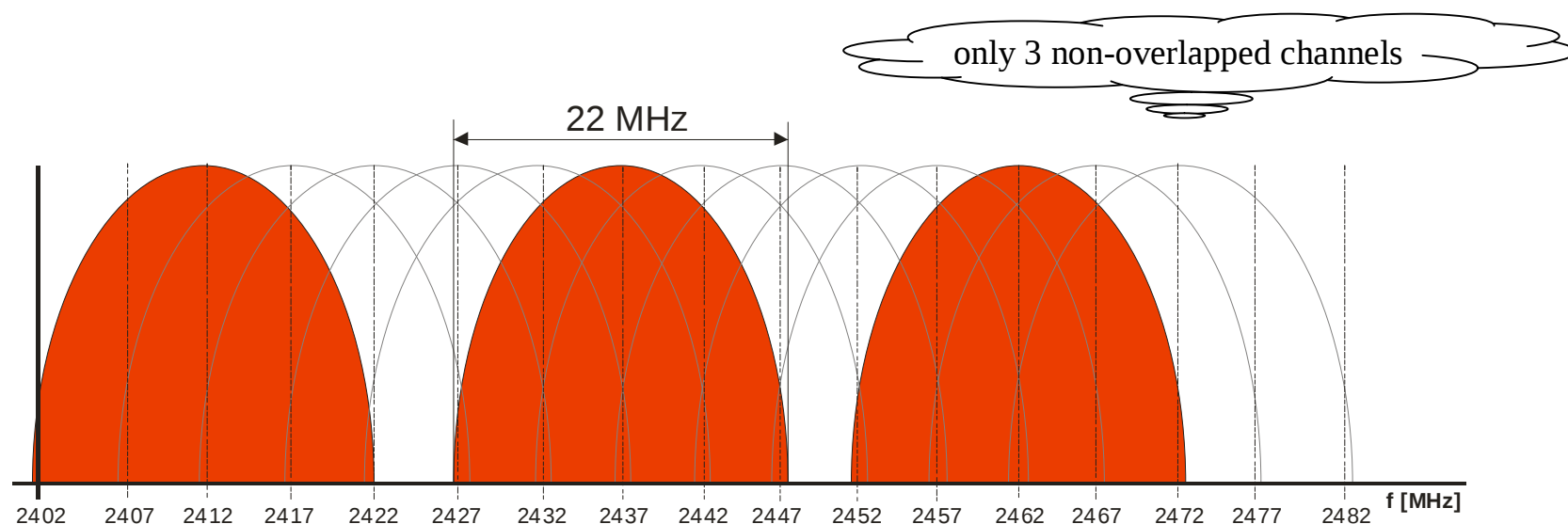
Physical layer

Standard	PHY	Frequency	Data rates [Mbit/s]
802.11	FHSS, DSSS	2,4 GHz; IR	1; 2
802.11b	HR-DSSS	2,4 GHz	1; 2; 5,5; 11
802.11g	OFDM	2,4 GHz	6, 9, 12, 18, 24, 36, 48, 54
802.11a/h	OFDM	5,2; 5,5GHz	6, 9, 12, 18, 24, 36, 48, 54

- Transmission rate
 - Ø Depends on modulation
 - Ø Dynamically varies according to quality of received signal ($\downarrow$ quality $\Rightarrow$ rate $\downarrow$)
- Due to protection, the user data rate is about one half

IEEE 802.11b/g

- Number of channels:
 - Ø CZ → 13 channels (2,412 GHz – 2,472 GHz)
- Channels are shared
- Channel bandwidth: 22 MHz
- Distance between channels: 5 MHz
- EIRP: 100 mW (20 dBm)
 - Ø EIRP (Equivalent Isotropically Radiated Power)



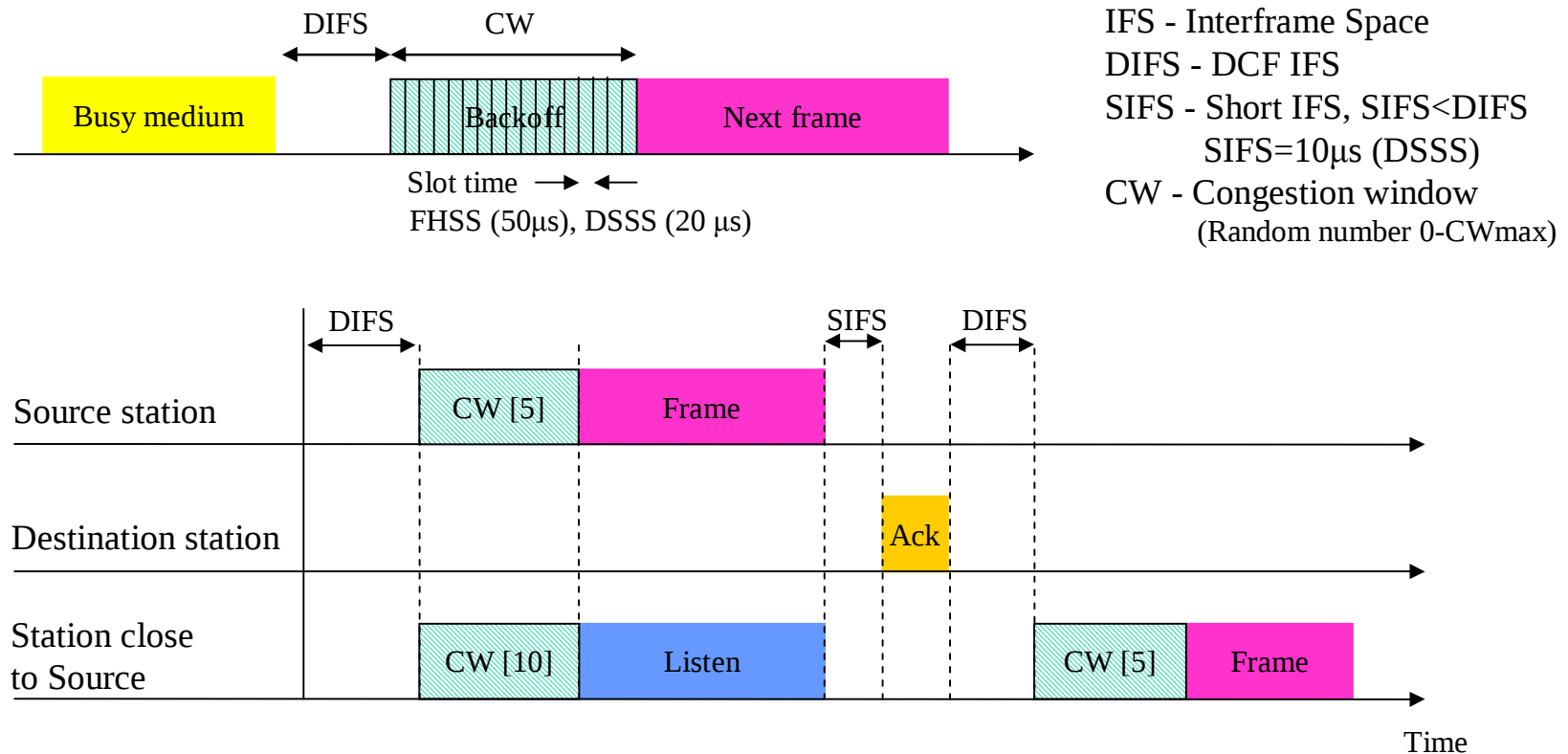
MAC

MAC implements
access methods

Network layer	IP				
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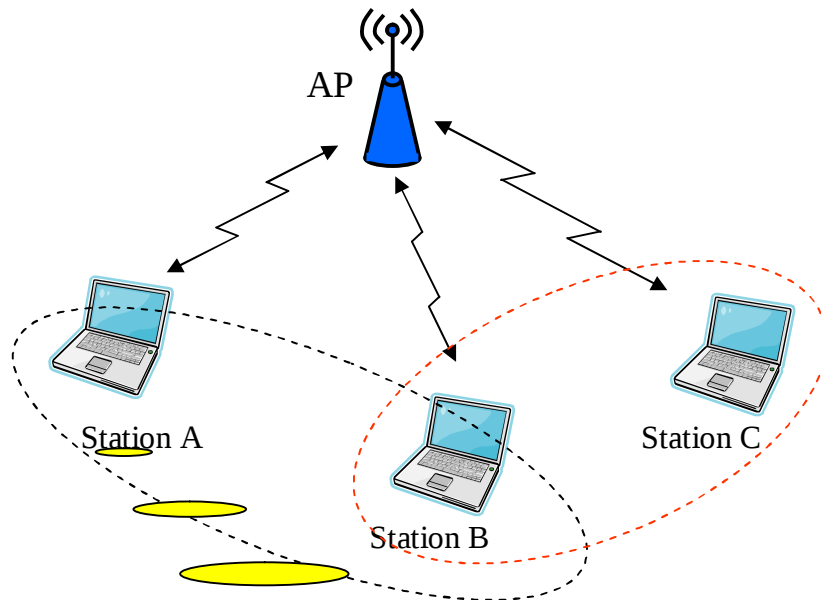
- CSMA
 - Ø Carrier Sense Multiple Access
 - Ø Rules:
 - Carrier ==> do not transmit
 - No carrier ==> OK to transmit
 - Ø But the above rules do not always apply to wireless environment
 - Solution: RTS/CTS
- Collision detection (CD)
 - Ø Ethernet
 - Ø Does not work over wireless (stations can not hear each other)
Therefore, 802.11 family uses CA
- Collision avoidance (CA)
 - Ø Random backoff
 - Ø Priority ack protocol

DCF (Distributed Coordination Function)

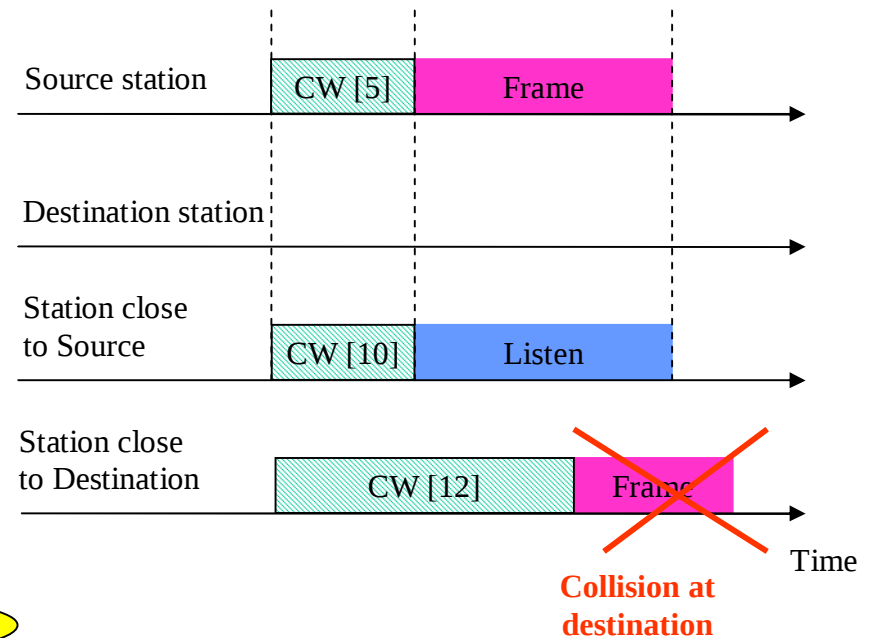


Problem of DCF

- CSMA/CA – problem of **hidden node**
 - Ø Reduction of communication about 40%
 - Ø Mainly case of large area and use of omni-directional antennas

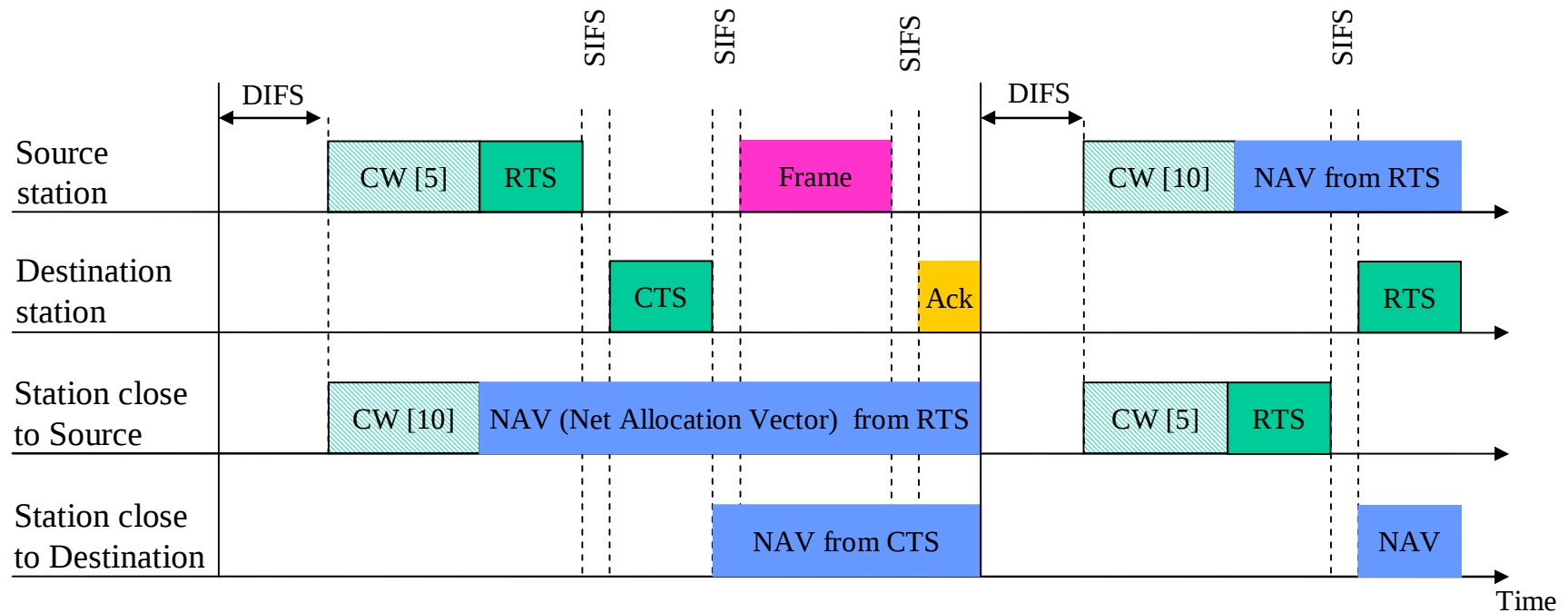


Station A does not hear the communication
AP/Station C (...hidden node)



RTS/CTS method

- RTS/CTS (Request To Sent / Clear To Sent)
 - Ø Eliminates problem of hidden node
 - Ø Collision can only occur when sending RTS packet
 - Ø Effective only for long packets (for short packet is used the basic mechanism)



Standards

Standard	Release date	Frequency [GHz]	Max. data rate [Mbit/s]	Notes
802.11	1997	2,4	2	Original version
802.11c	1998			Bridge operation procedure; this work is now part of 802.1D-2004
802.11a	1999	5	54	OFDM
802.11b	1999	2,4	11	
802.11d	2001			For countries that don't support 2,4 GHz frequency bands
802.11F	2003			Provides wireless access point communications among multi-vendor systems; trial use recommendation – withdrawal in 2006
802.11g	2003	2,4	54	HW is compatible with 802.11b
802.11h	2003			Spectrum Management of 802.11a for European compatibility; dynamic frequency selection and transmit power control
802.11i	2004			Security
802.11j	2004	4,9 - 5		FFor Japanese market
802.11e	2005			QoS enhancements (EDCA, HCCA, etc.)
802.11m	2007			Maintenance of the standard → 802.11-2007
802.11-2007	2007			Includes amendments a, b, d, e, g, h, i & j
802.11k	2007?			Radio resource management enhancement
802.11r	2007?			Fast Roaming / Fast BBS Transition
802.11n	2008?	2,4 and/or 5	74	MIMO.
802.11p	2009?			Wireless access in the vehicular environment
802.11s	2008?			Mesh topology
802.11u	2009?			Interworking with non-802 networks (e.g., cellular network)
802.11w	2008?			Increase of security of management frames
802.11y	2008?	3,65 -3,7		For U.S. market

WiMAX

Access networks (last mile)
... metallic cables, optical cables, radio

WiMAX

- a) Substitution of cables
- b) ...Mobile network

Wireless Access

- WiMAX

- Ø Worldwide Interoperability for Microwave Access
- Ø IEEE 802.16 (... 2001 - 1st version of standard)
- Ø BWA
- Ø Outdoor (...metropolitan access network)
- Ø Support of QoS



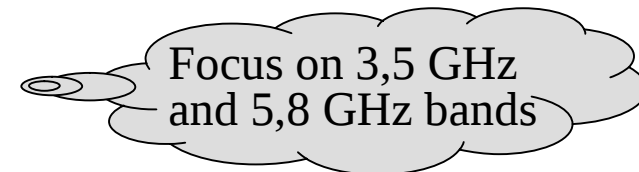
- WiMAX Forum

- Ø Founded 2001
- Ø Non-profit industry trade organization
- Ø Around 350 members (e.g., Alcatel, Intel, Nortel, Alvarion, etc.)
- Ø Goal
 - Promotion & certification of equipments
 - Specification of tests (...according to standards, interoperability)
 - Selection of labs for certification
- www.wimaxforum.org



Frequency bands (1/2)

- Unlicensed / licensed spectrum
- 10-66 GHz
 - Ø Line of Sight (LOS)
 - Ø Cell radius - up to 40÷50km
- 2-11 GHz
 - Ø Non Line of Sight (NLOS)
 - Ø Cell radius - up to 7÷9 km
 - Ø ...power management, MIMO

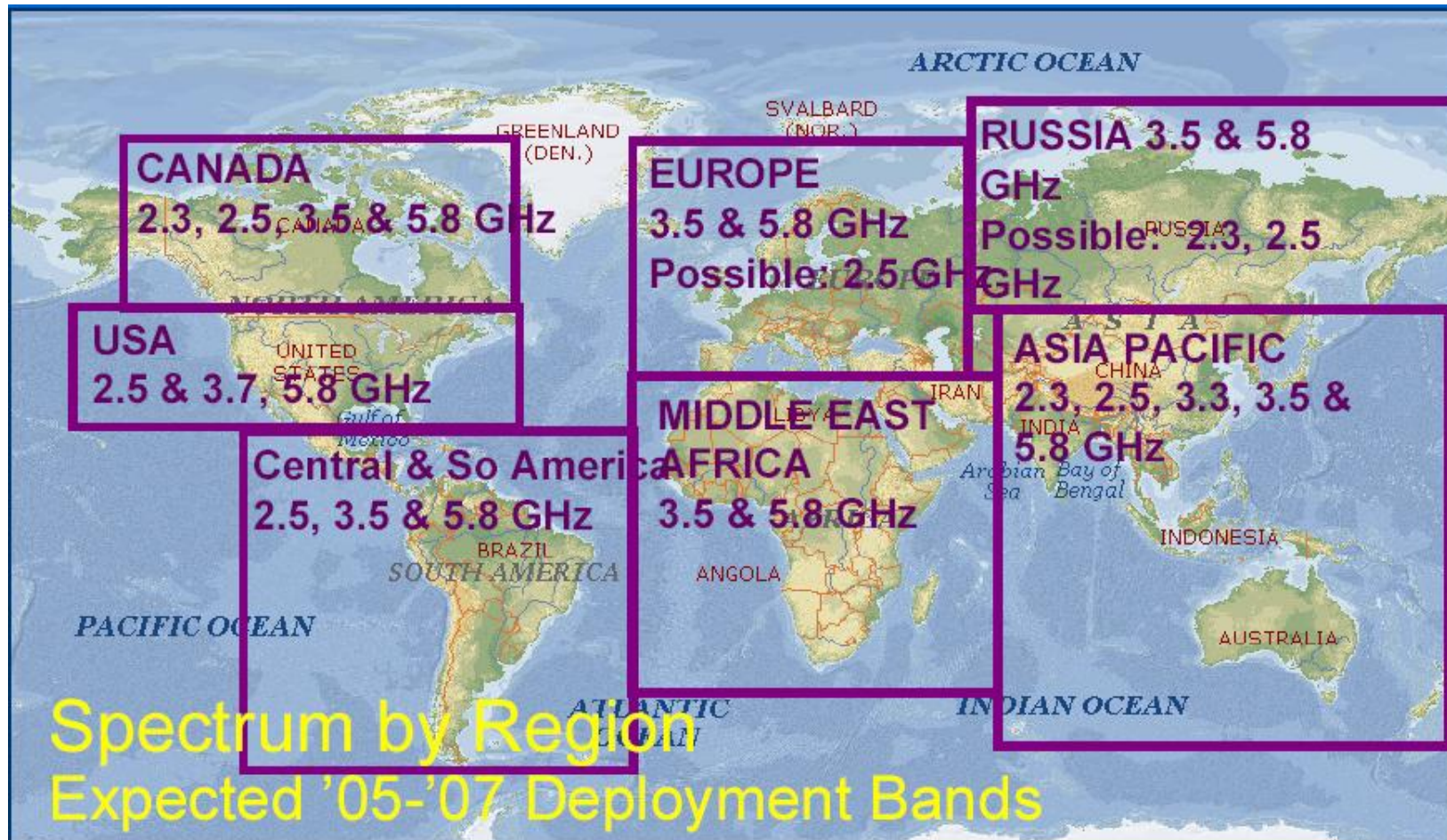


Note: Unlicensed spectrum

+ Free, allows quickly meet the needs of users

- To eliminate interferences, arrangement between providers is needed

Frequency bands (2/2)

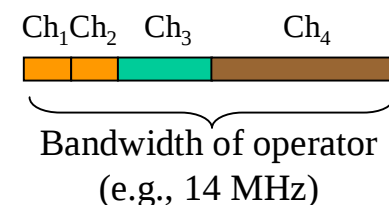


802.16 versions (1/2)

- 802.16 2001/12
 - Ø LOS (10-66 GHz), up to 135 Mbit/s
- 802.16c 2002
- 802.16a 2003/01
 - Ø NLOS (2-11 GHz), up to 75 Mbit/s
- 802.16REVd (802.16-2004) 2004/10
- 802.16e 2005/12
 - Ø NLOS (to 6 GHz)
 - Ø *Mobility*

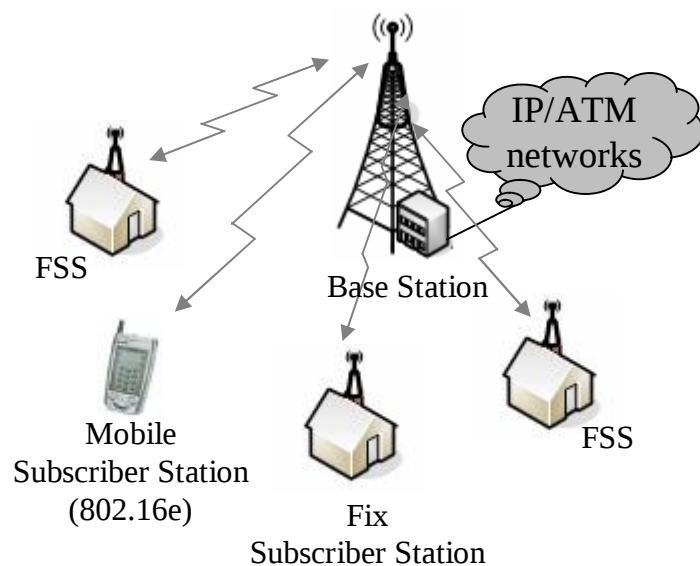
Features

- Flexible channel size
 - Ø 1,75 MHz ÷ 20, 28 MHz (...1,75; 3,5; 5; 7; 10;...)
 - Ø ...increase of cell capacity in the network
- High data rates
 - Ø Over 100 Mbit/s (depends on the channel bandwidth)
- QoS support
 - Ø ..support low latency applications (e.g., voice or video)
- Support of tents of users under one Base Station



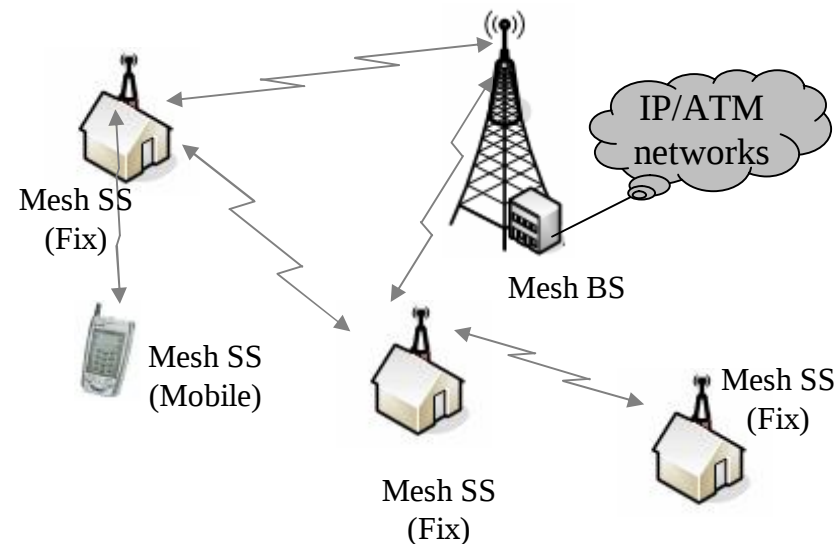
Topologies

Point-To-Multipoint



Communication between SSs through BS

Mesh



Communication between SSs with/without BS

Modes (1/2)

- FDD

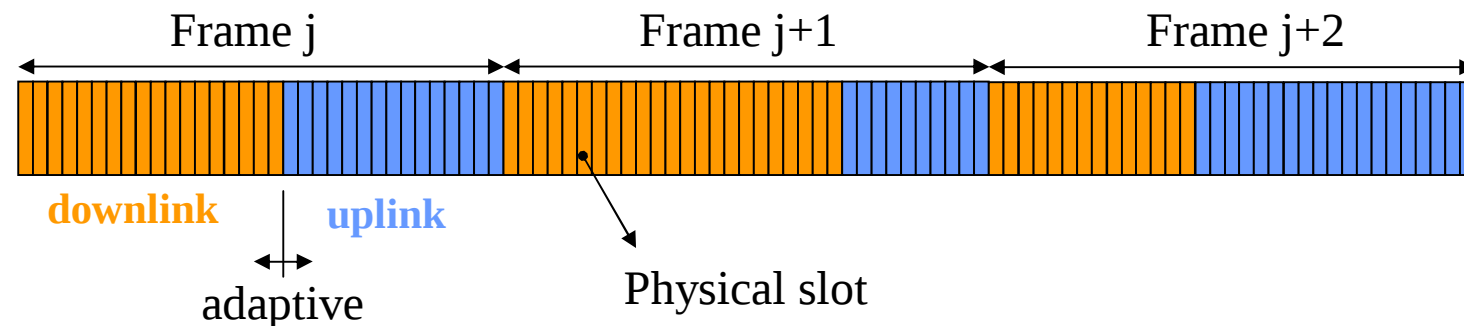
- Ø f_x for downlink, f_y for uplink

- Ø Fixed duration frame

- TDD

- Ø f_x for both downlink and uplink

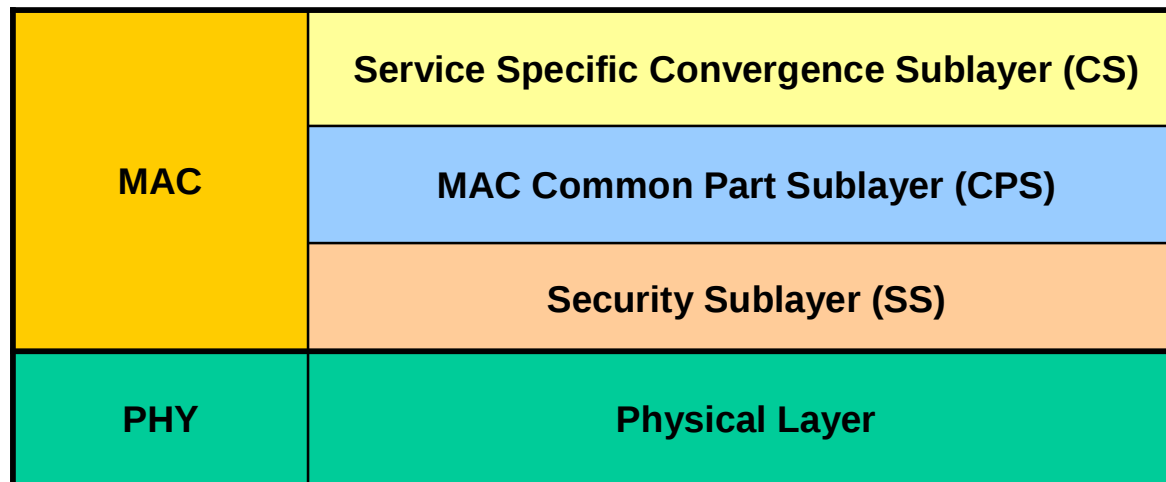
- Ø Fixed duration frame, variable size of downlink & uplink sub-frame



Services

Type		Description	Ex.
<i>Unsolicited Grant Service</i>	UGS	Real-time data transmission - fixed packet size, periodic transmission	Voice, VoIP
<i>real-time Polling Service</i>	rtPS	Real-time data transmission - variable packet size, periodic transmission	MPEG video
<i>Extended rtPS</i>	ErtPS	Real-time data transmission	Detection of voice activity
<i>non-real-time Polling Service</i>	nrtPS	Non real-time data transmission - variable packet size, min. transmission rate	FTP
<i>Best Effort</i>	BE		Web-browsing

Layers in WiMAX



Physical layer (1/3)

2-11 MHz

- i) OFDM (256 carriers)
- ii) OFDMA (2048 carriers)
- iii) Single carrier

10-60 MHz

- i) Single carrier

802.16e

...

SOFDMA (Scalable OFDMA)

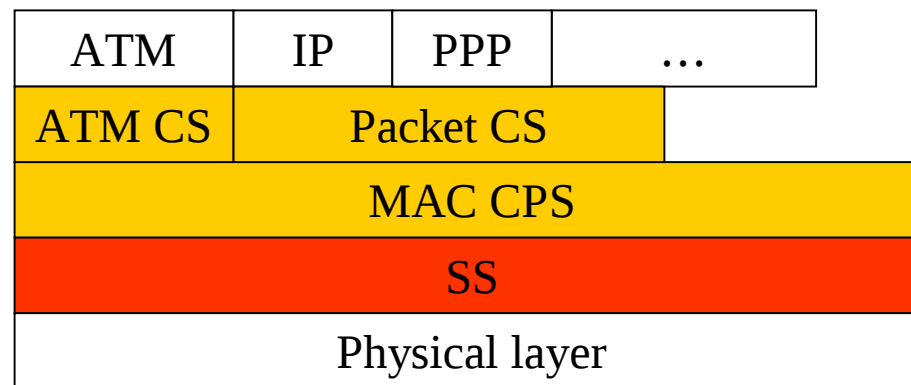
Physical layer (3/3)

- Adaptive Modulation & Coding (AMC)
 - Ø QPSK, 16QAM, 64QAM
 - Ø Convolution code
 - Ø Turbo code
- Hybrid ARQ (HARQ)
 - Ø N x Stop&Wait
 - Ø Chase combining, Incremental redundancy
- Advance antennas techniques
 - Ø Beamforming
 - Ø STC (Space Time Coding)
 - Ø MIMO (Multiple Input Multiple Output)



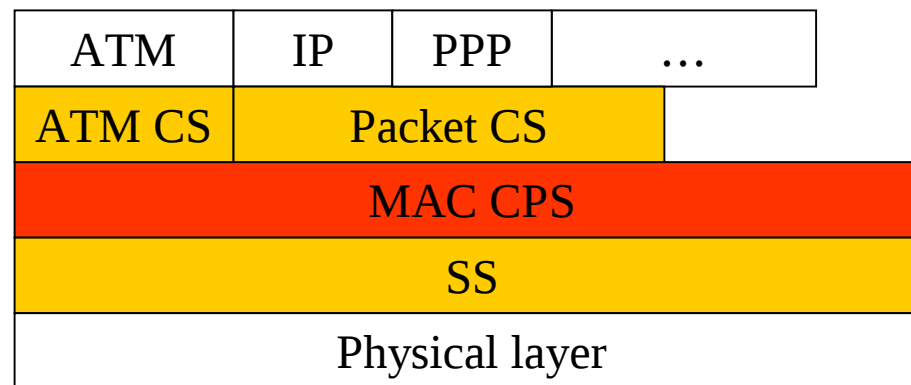
SS (Security Sublayer)

- Identification of user/equipment
 - Ø EAP (Extensible Authentication Protocol)
 - Ø ...SIM, USIM, login + password
- Ciphering of data
 - Ø AES (Advanced Encryption Standard)
- Secure key exchange
 - Ø PKMv2 (Privacy and Key Management Protocol version 2)



MAC CPS (MAC Common Part Sublayer)

- Connection establishment/maintenance/termination
- Assignment of radio resources
 - Ø Transmission of data (voice, audio, video) over the radio interface
- HARQ
 - Ø N x Stop&Wait



CS (Service specific Convergence Sublayer)

- Interface between CPS and upper layers (IP, ATM, etc.)
- Transformation and mapping of upper layer data
 - Ø Classification of upper layer data into appropriate flows (CID)
 - Ø Payload header suppression/restoration (...option)
- Types
 - Ø ATM CS
 - Ø Packet CS (IP, PPP, Ethernet, etc.)

