HiperLan 2 for FWA Below 11 GHz

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Purpose:

Information

HiperLAN Type 2:
A Candidate for Fixed Wireless Access Systems Below 11 GHz & Wireless HUMAN

A Presentation to

IEEE 802.16 BWA.3 Task Group & BWA HUMAN Group

July 11, 2000, San Diego

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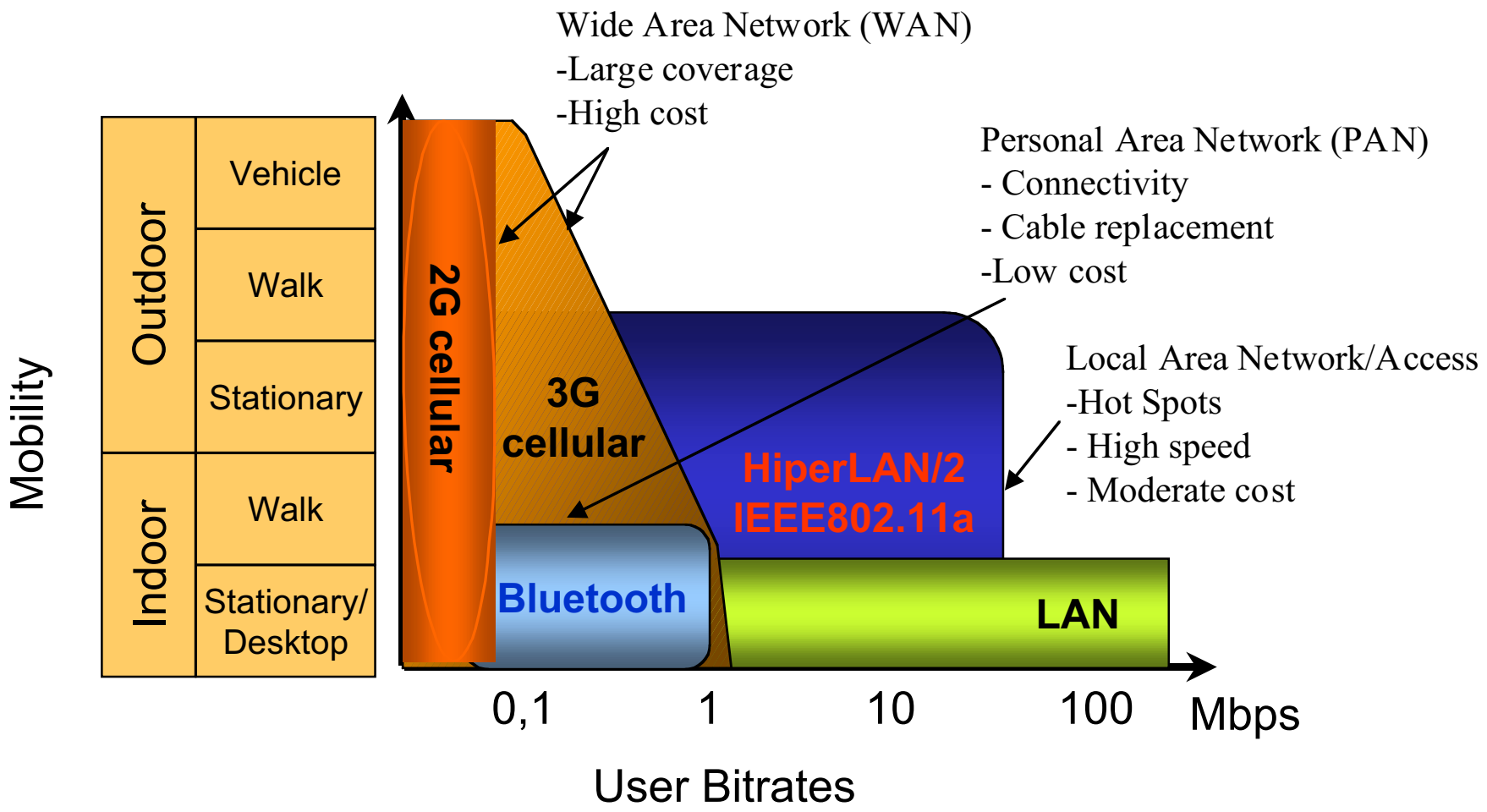
Agenda

- Wireless “Data” Solutions
- HiperLAN/2
  - Requirements
  - Spectrum Allocation
  - Operation Modes
  - Application Scenarios
  - Protocol Architecture
    - Convergence Layer
    - DLC
    - PHY
  - Security
- Conclusions

Wireless “Data” Solutions



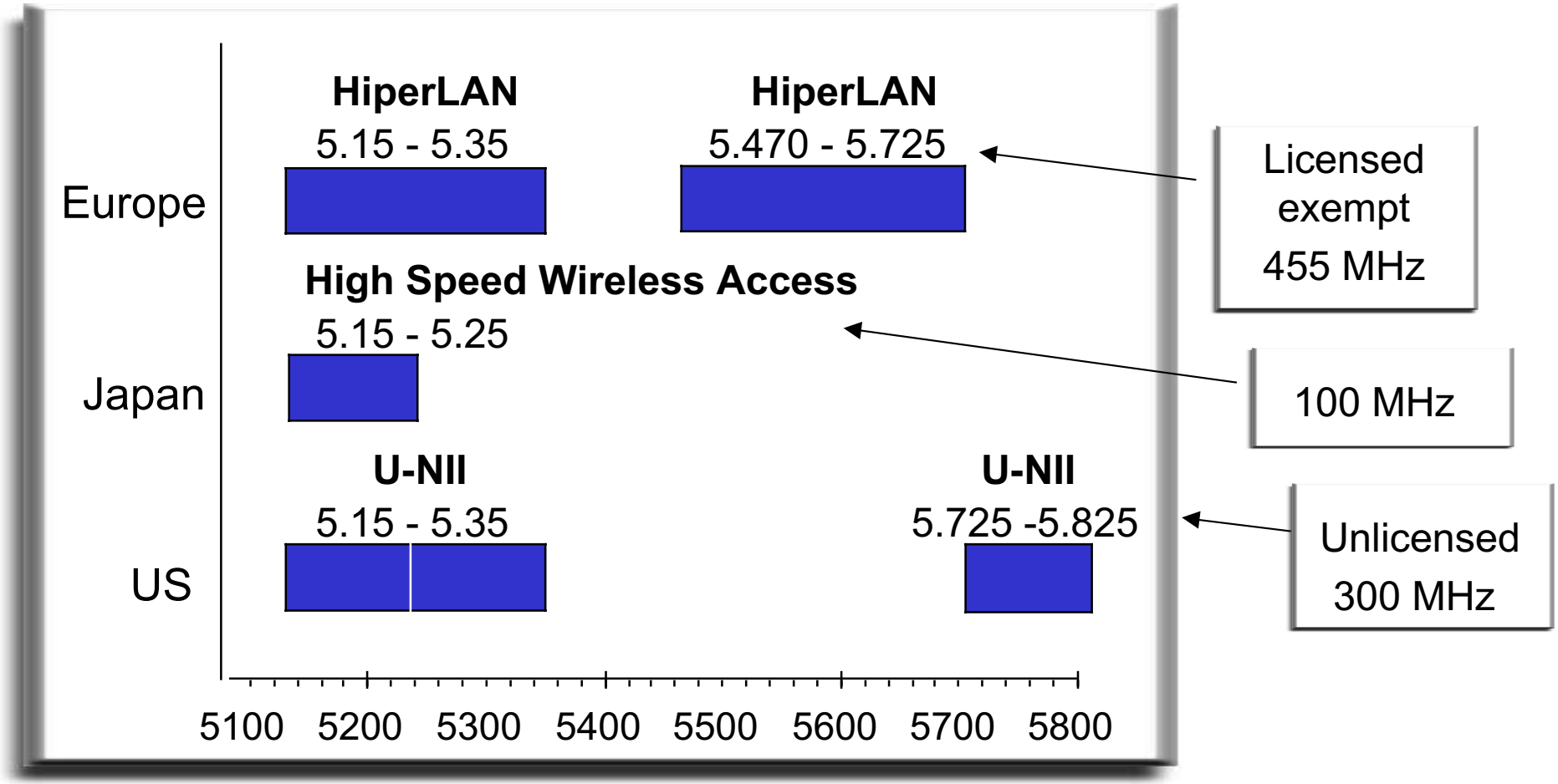
Requirements - 1

- Core network independent with QoS support for real time services (VoIP, Video)
  - Support of IP transporting networks, ATM networks, 3rd Generation, Firewire, etc.
  - Packet network based on connection-oriented wireless link
- Radio access network specifications (physical layer, data link control layer and convergence layer)
  - Interoperability standard with conformance test specifications
- No frequency planning
  - Dynamic Frequency Selection
- Capable of handling different interference and propagation situations
  - "Link Adaptation" with multiple modulation and channel coding schemes Supporting asymmetrical traffic load fluctuating in uplink and downlink as well as for different users

Requirements - 2

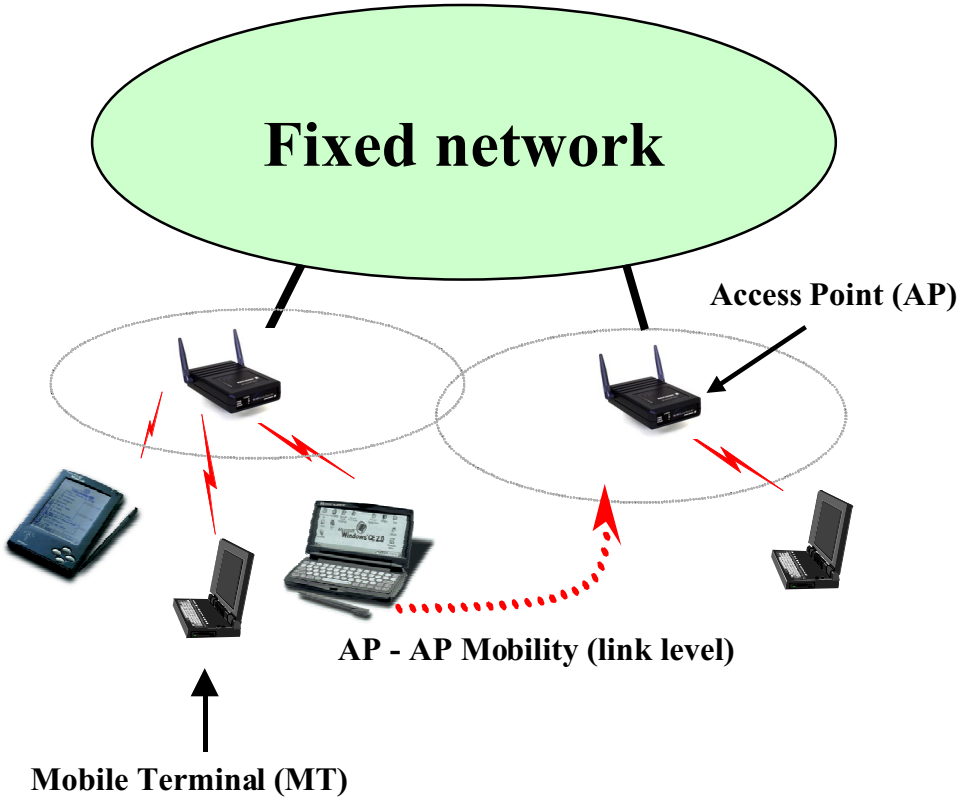
- A cellular multi-cell radio network capable of offering access, switching and management functions within a large coverage area
  - A point-to-multipoint topology with mandatory centralized mode and optional direct mode
  - Mobility management
  - Power management
    - Uplink power control, downlink power setting, sleep mode
- Usage in indoor and outdoor environments
- Multicast and broadcast
- Scalable security
  - Different key encryption: 56 bit and 168 bit
  - Authentication: Optional pre-shared or public key

Spectrum Allocation at 5 GHz

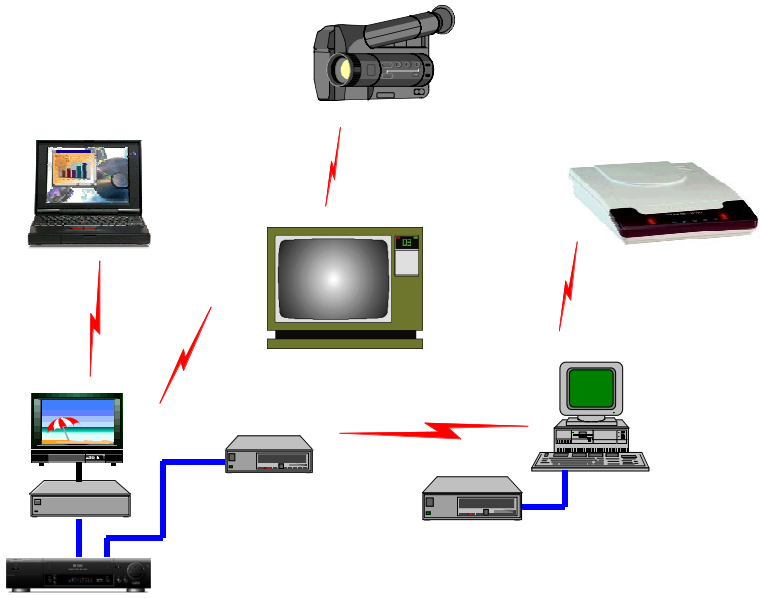


Operation Modes

Infrastructure based network:

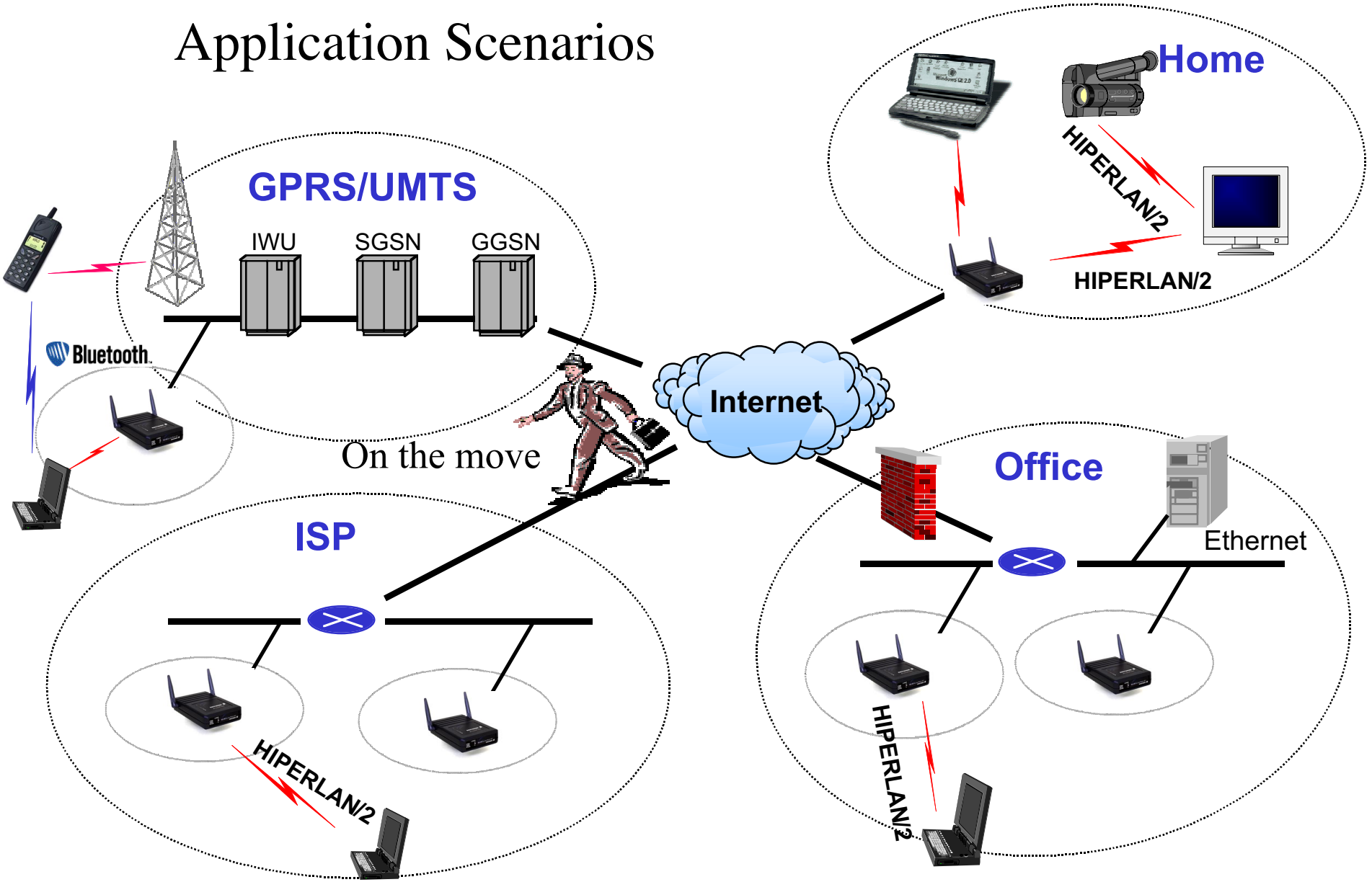


Ad-hoc network:



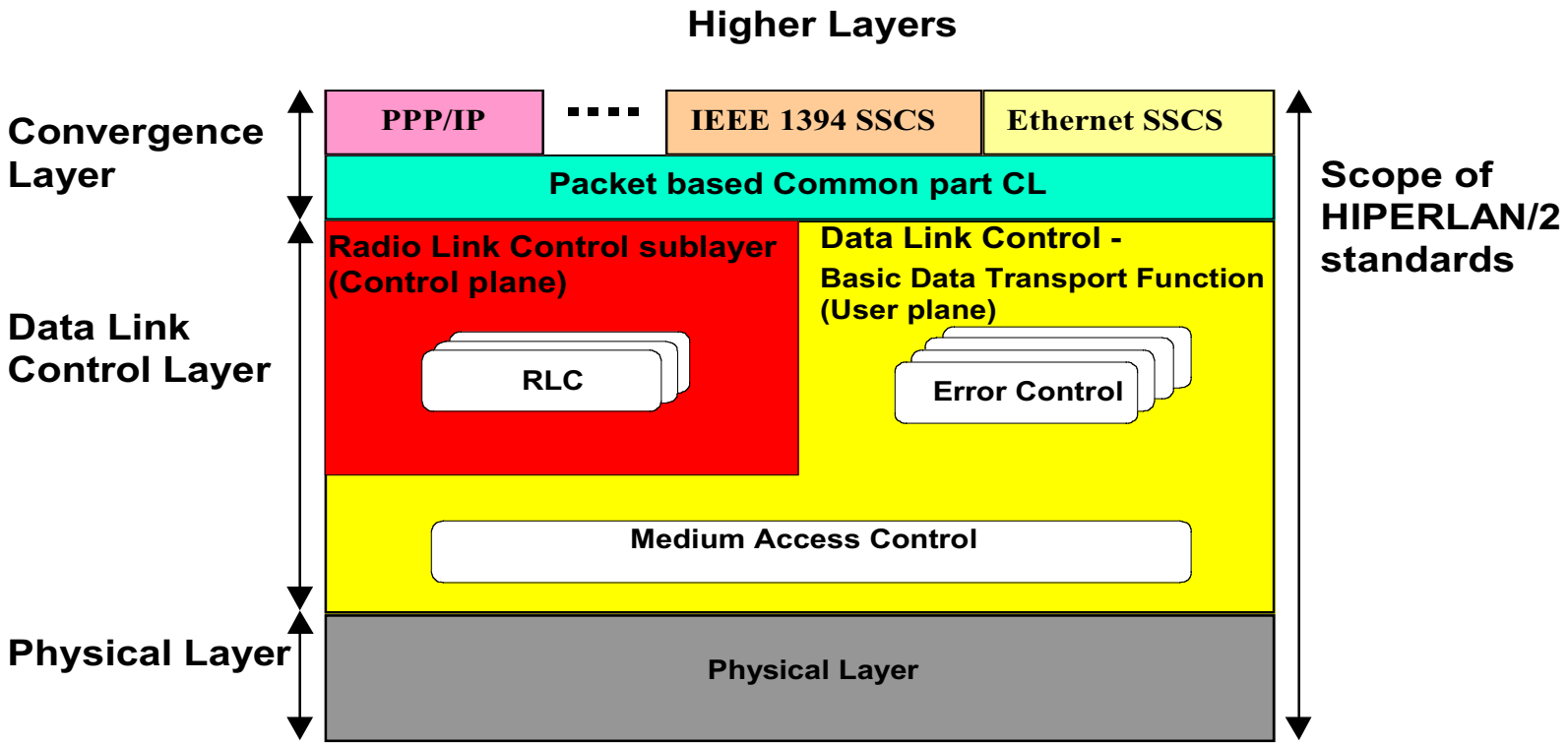
No compromise on QoS in ad-hoc mode!

Application Scenarios



Protocol Architecture

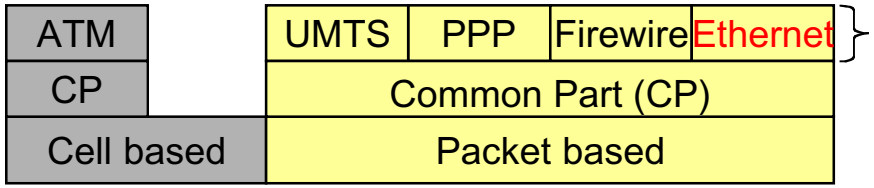
- Standardization scope: air interface, service interfaces of the radio access system and the convergence layer functions



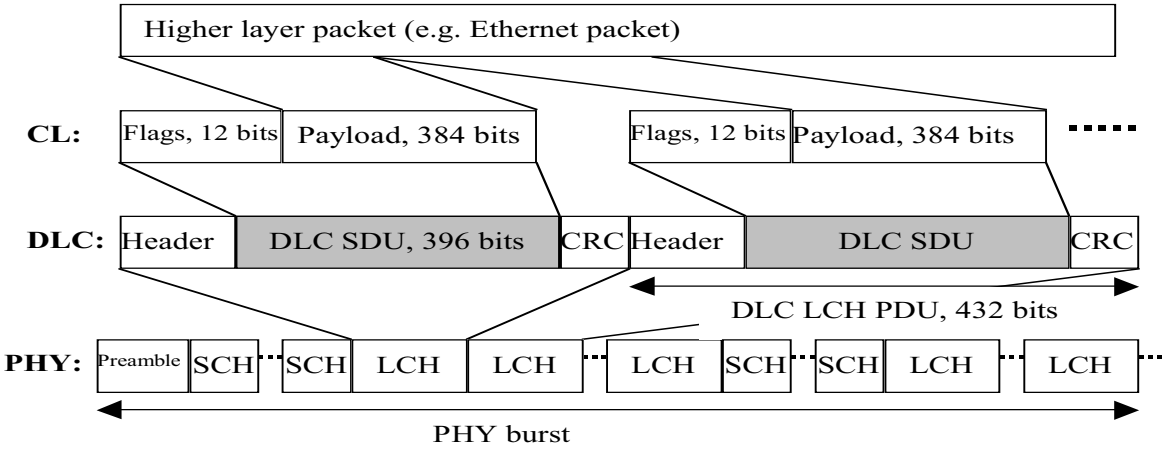
Convergence Layer

- Multiple convergence layers
- One single convergence layer active at a time
- Mapping between higher layer connections/priorities and DLC connections/priorities

- Segmentation and re-assembly to / from 48 bytes packets
- Priority mapping from IEEE 802.1p
- Address mapping from IEEE 802
- Multicast & broadcast handling
- Flexible amount of QoS classes



Service Specific Part



Mapping higher layer packets onto layers of HiperLAN/2

DLC: Medium Access Control - 1

- TDMA/TDD with a fixed frame duration of 2 ms
- 3 transmission possibilities: AP to MT (Downlink), MT to AP (Uplink) and MT to MT (Direct Link)
- Centralized scheduling (not specified)
  - Air interface frame creation in the AP
  - Resource allocation by the AP
  - Resource requests from MTs
  - Dynamic assignment of capacity in uplink and downlink - no fixed slot structure is mandatory, but possible for CBR type services
  - Could consider QoS and link adaptation modes
  - Transmission of Data PDU and ARQ PDU without collisions
- Peer-to-peer and multicast support

DLC: Medium Access Control - 2

- Random access scheme
  - Association and resource request transmissions from MTs
  - Random access in mobile stations: slotted ALOHA with exponential increase of contention window
  - Processing random access in the AP: acknowledgements of random access in the next frame
- Sector antenna support

MAC Frame Channels: Logical Channel - 1

Logical and Transport channels are used to construct MAC frame

- Logical Channel:
  - A generic term for any distinct data path which describes a specific data transfer service offered by the MAC entity
  - Defined by the type of information it carries and the interpretation of the value in the corresponding messages
- Some important Logical Channels
  - BCCH (Broadcast Control CHannel): used in downlink conveying the necessary broadcast information concerning the whole radio cell e.g. scrambler seed, access point ID, network ID, etc.
  - FCCH (Frame Control CHannel): used in downlink conveying information describing the structure of the MAC frame visible at the air interface (resource grant announcement)
  - RACH (Random Access CHannel): used by MTs in uplink to send signalling data (resource request, association request) for DLC or RLC.

MAC Frame Channels: Logical Channel - 2

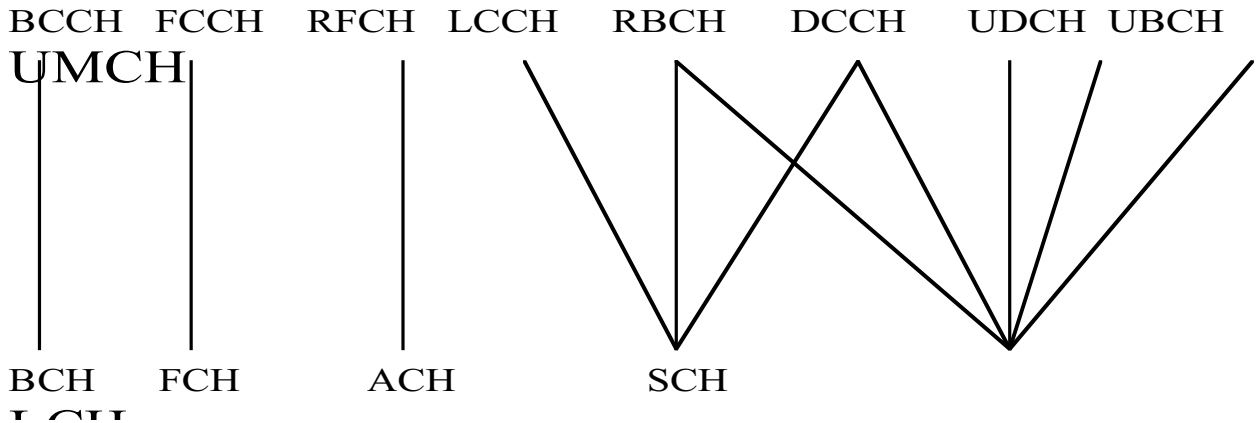
- Some important Logical Channesl: Contd
  - RFCH (Random access Feedback CHannel): used in downlink to inform the MTs that have used the RACH in the previous MAC frame about the result of their access attempts.
  - RBCH (RLC Broadcast CHannel): used in downlink (when necessary) conveying broadcast CONTROL information concerning the whole radio cell, e.g. broadcast RLC message, MAC ID in the association process, encryption seed, etc.
  - DCCH (Dedicated Control Channel): used in downlink, direct link and uplink conveying RLC messages
  - LCCH (Link Control CHannel): used bi-directional to transmit ARQ and discard messages between peer error control functions
  - UDCH (User Data CHannel): used bi-directional to transmit user data

MAC Frame Channels: Transport Channel

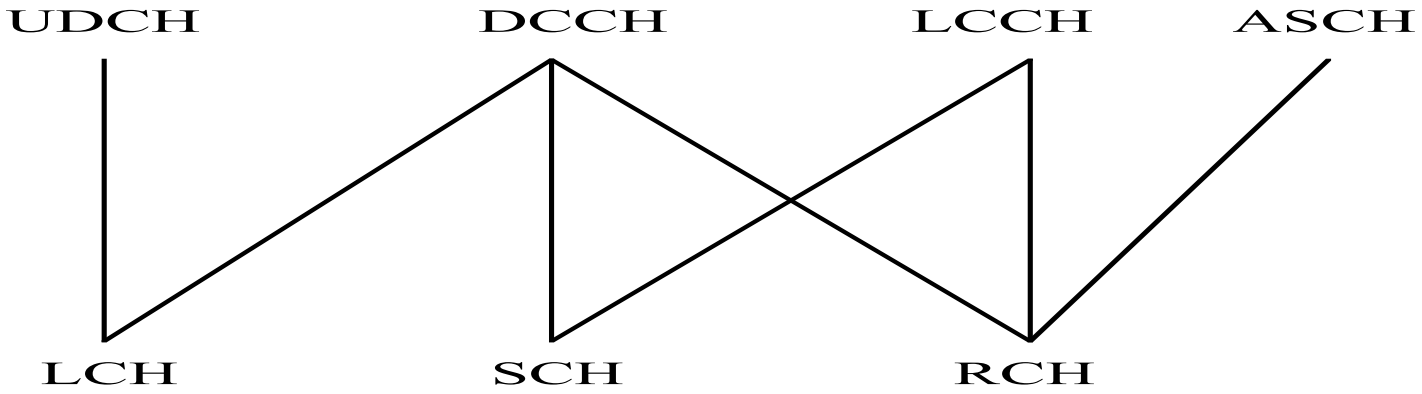
- Logical channels are mapped onto different transport channels which describe the basic message format and are the basic elements for constructing message sequence of each user
  - BCH (Broadcast CHannel): carries BCCH transmitted once per MAC frame per sector antenna
  - FCH (Frame CHannel): used in downlink for carring FCCH with variable amount of data
  - ACH (Access feedback CHannel): used in downlink for transporting RFCH
  - LCH (Long Transport CHannel): used for transporting user data and control information
  - SCH (Short CHannel): used for transporting short control information
  - RCH (Random CHannel): used in uplink for transmitting resource request or association request

Mapping between Logical and Transport Channels

- Downlink

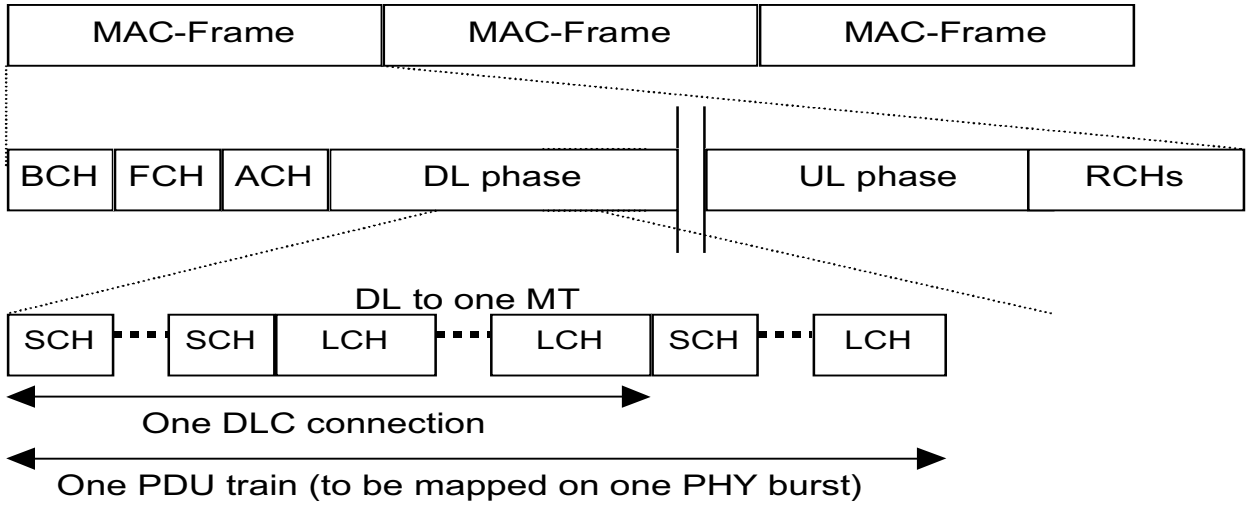


- Uplink

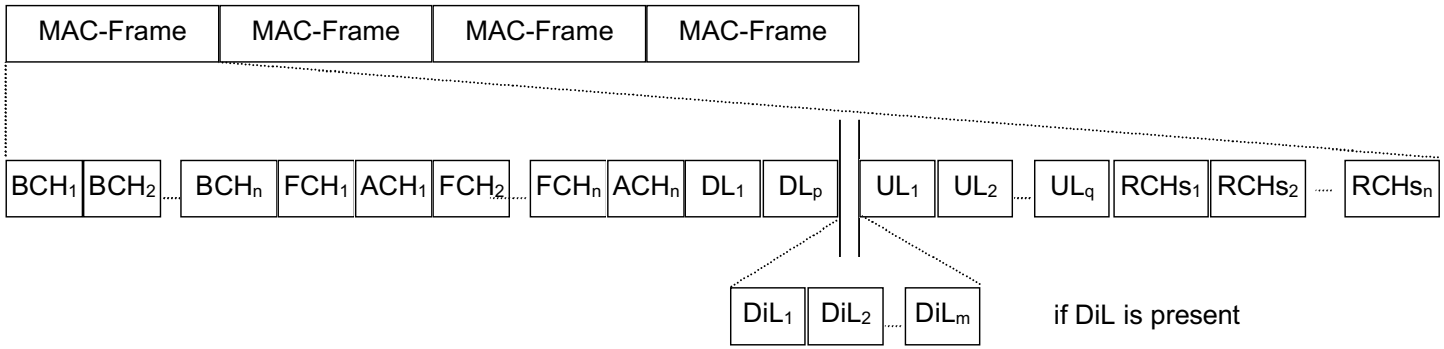


Basic MAC Frame Structure

- A single sector system



- A multiple sectors system

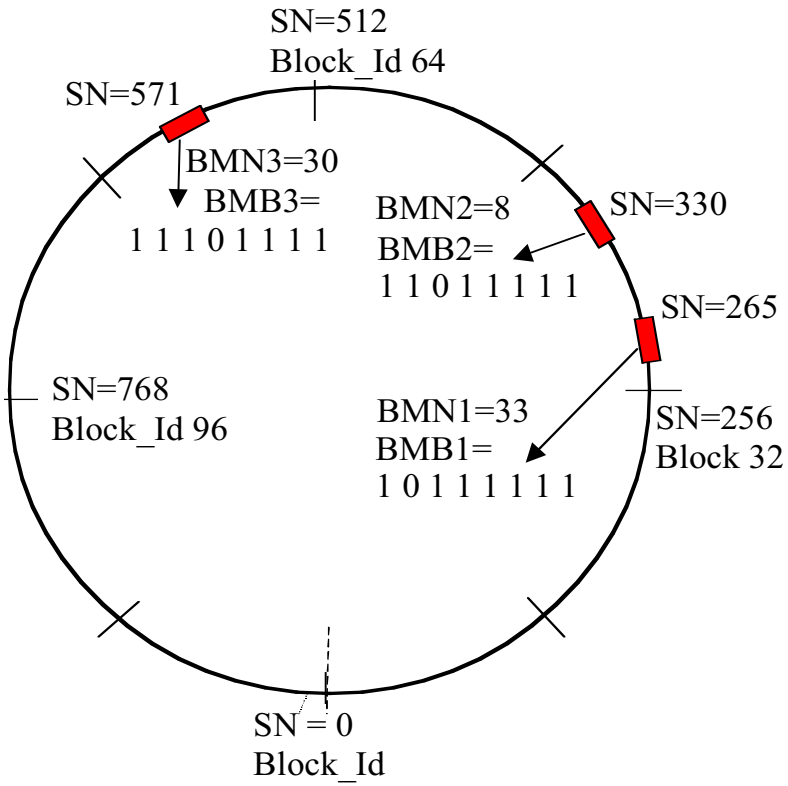


DLC: Error Control

- Scaleable Error Control: three EC modes
  - Acknowledged mode for reliable transmission by using ARQ
  - Repetition mode for reliable transmission by repeating LCHs
  - Unacknowledged mode for transmissions with low latency
- SR-ARQ with partial bitmap
  - retransmission efficiency as conventional SR
  - Optimized overhead and delay for acknowledgements
    - acknowledgements are sent not for every erroneous packet but a bitmap for several ones
    - Dynamical management of bitmap packets
    - Cumulative Acknowledgement and Flow Control possible
  - Discarding capability
    - efficient for real time applications
- Short MAC frame (2 ms) allows re-transmission even for voice

Partial Bitmap Basics

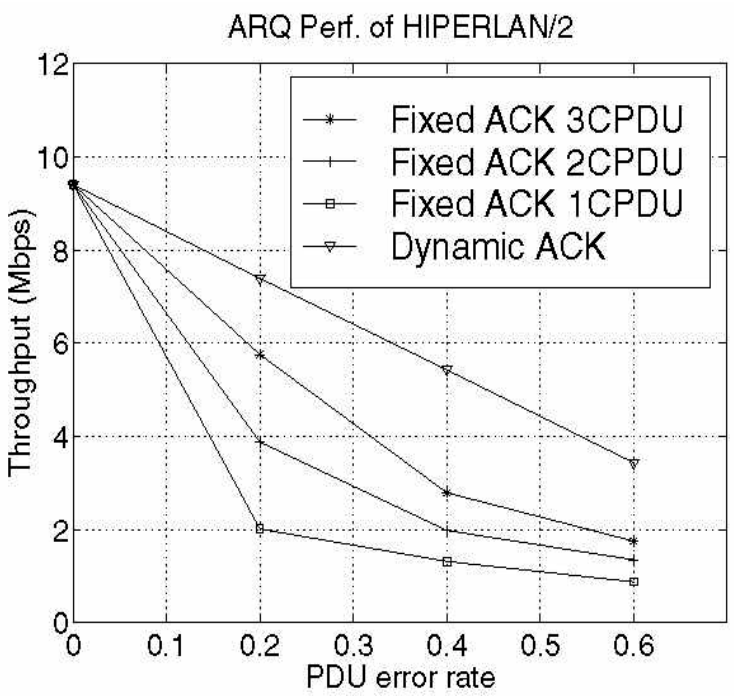
- Numbering of PDU from 0 to 1023 (Sequence Number)
- Grouping 8 PDUs into 1 Block, totally 127 Blocks
- ACK of a PDU: BitMap Block (BMB) & BitMap Number (BMN)
- In the ARQ C-PDU: 3 BMBs & 3 BMNs
- BMN1=Block_Id1, BMN2=Block_Id1 - Block_Id2, BMN3=Block_Id3 - Block_Id2

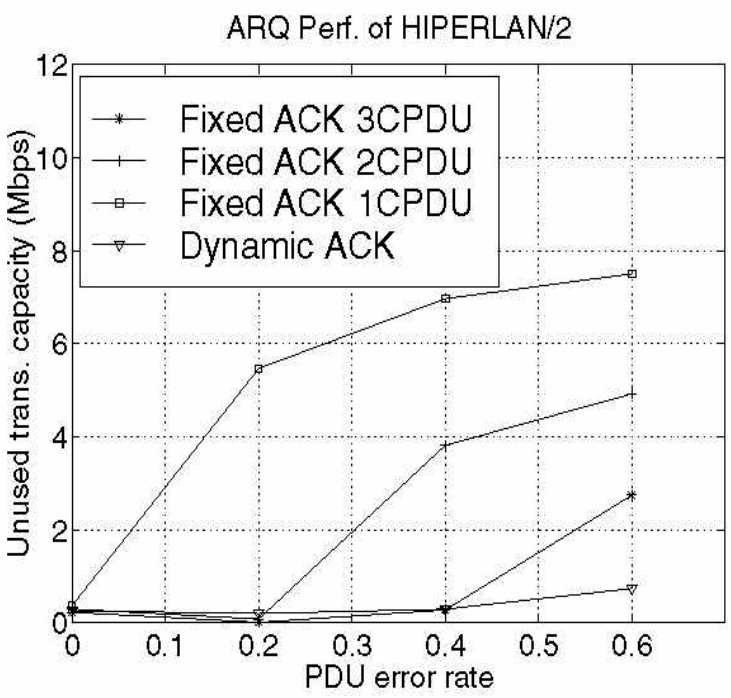


ARQ Message Format (Uplink)								
	8	7	6	5	4	3	2	1
Octet 1	PDU Type				LCH PHY Mode			
Octet 2	CAI	BMN 1						
Octet 3	BMB 1							
Octet 4	SCH PHY Mode			BMN 2				
Octet 5	BMB 2							
Octet 6	FC	ABIR	FU	BMN3				
Octet 7	BMB 3							
Octet 8	CRC-16							
Octet 9								

Dynamic Acknowledgement

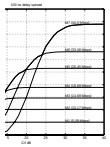
- Problems with fixed ACK
  - low utilisation of channel capacity
  - bottleneck of feedback channel
  - deferring retransmissions
- Dynamic ACK
  - # of ARQ PDUs based on receiver status
  - ABIR-bit used by receiver in MT
  - high utilisation of channel capacity





Link Adaptation

- Link Adaptation
  - Code rate and modulation alphabet (7 modes) adaptive to current propagation and interference environments



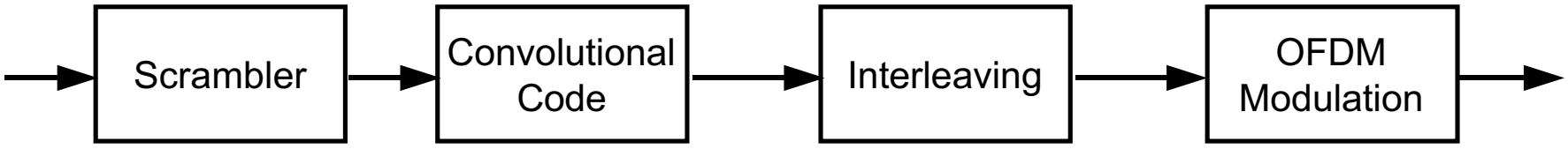
- Link throughput versus C/I
  - Link quality measurements (C/I) in access point and mobile terminal
  - rms delay spread 100 ns
  - Selective-repeat ARQ,
  - ideal link adaptation

DLC: Radio Link Control

- Connection handling
  - Setup / release of DLC connections
  - Peer-to-peer (ad-hoc)
  - Multicast
- Security
  - Authentication
  - Encryption key distribution
  - Alternative security negotiation
- Management functions
  - Mobility
    - Association / de-association
    - Handover
    - Location update
  - Radio resource management
    - Dynamic frequency selection
  - Power management
    - Sleep mode
    - uplink and downlink power control

HIPERLAN2 & 802.11a PHY - Key Parameters

- Multi-carrier modulation by *OFDM*



A length-127 scrambler with generator polynomial $S(x)=x^7+x^4+1$

Punctured convolutional code, based on rate-1/2 code, constraint length 7

- Intra-symbol bit interleaving
- Block size depends on the sub-carrier modulation

- 48 (data) + 4 (pilot) sub-carriers
- PSK/QAM (coherent)

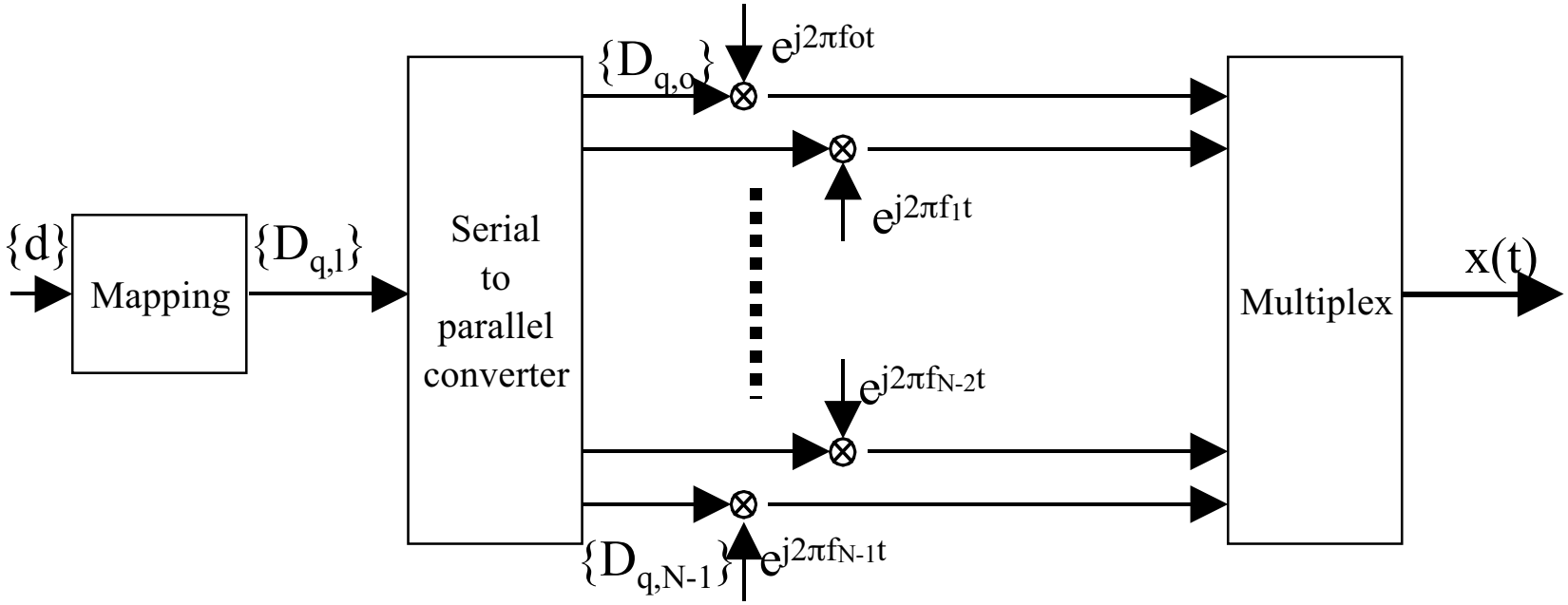
- Channel spacing 20 MHz
- Cyclic prefix 800 ns (optional 400 ns only in HIPERLAN/2)
- Possible delay spread (at least) 250 ns

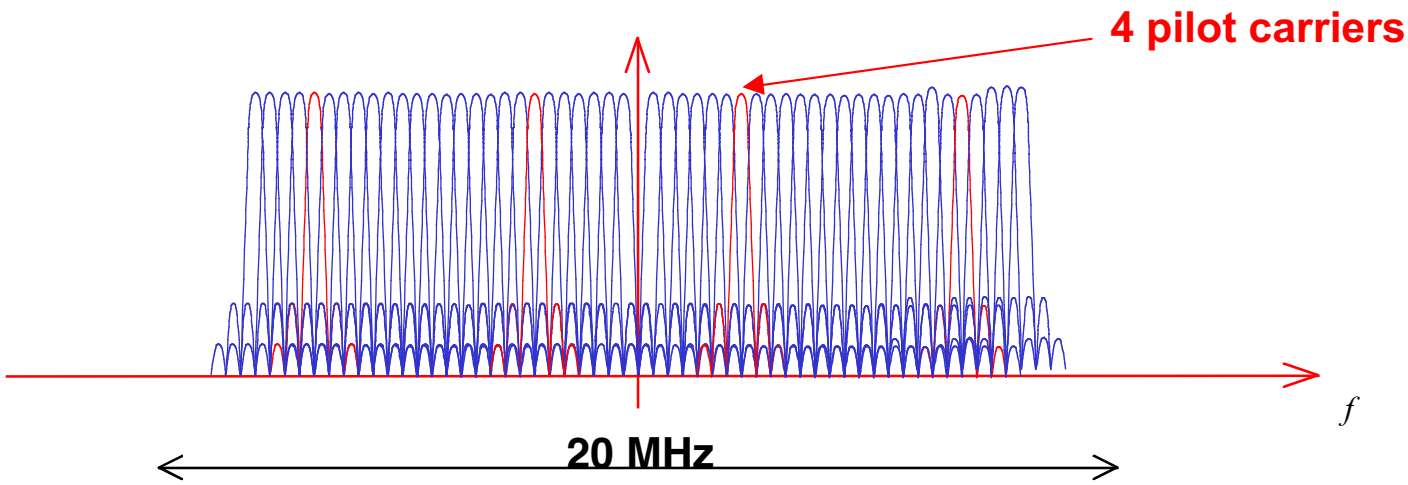
Physical Layer Modes

- Main difference between 802.11a and HIPERLAN/2: Preamble due to different multiple access scheme
- Several physical layer modes are provided
  - **Link adaptation** selects the "most appropriate" mode.
- Physical layer modes of HIPERLAN/2 & IEEE 802.11a:

Modulation	Code rate	Net bit rate	System
BPSK	1/2	6 Mbps	H/2 and IEEE
BPSK	3/4	9 Mbps	H/2 and IEEE
QPSK	1/2	12 Mbps	H/2 and IEEE
QPSK	3/4	18 Mbps	H/2 and IEEE
16QAM	1/2	24 Mbps	IEEE
16QAM	9/16	27 Mbps	H/2
16QAM	3/4	36 Mbps	H/2 and IEEE
64QAM	2/3	48 Mbps	IEEE
64QAM	3/4	54 Mbps	H/2 and IEEE

OFDM Modulation

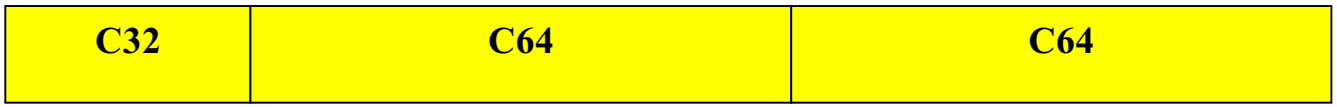




Preamble: HIPERLAN2 Downlink

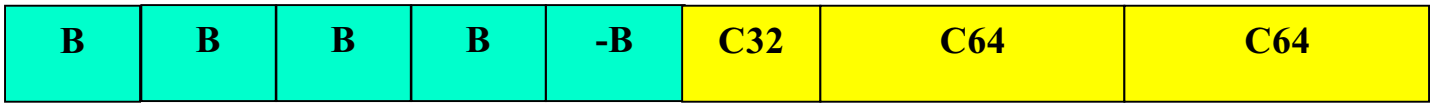
- Preamble for Broadcast Control Channel
  - A and B part could be used e.g. for AGC setting, coarse frequency/time synchronization as well as fine frequency/time synchronization
  - C part could be used e.g. for channel estimation

- Preamble for other downlink channels
  - C part could be used e.g. for update of channel estimation or a new one

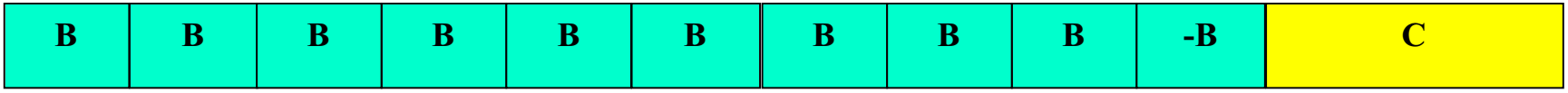


Preamble: IEEE / HIPERLAN2 Uplink and Direct Mode

- HIPERLAN2 Short Preamble (only uplink)



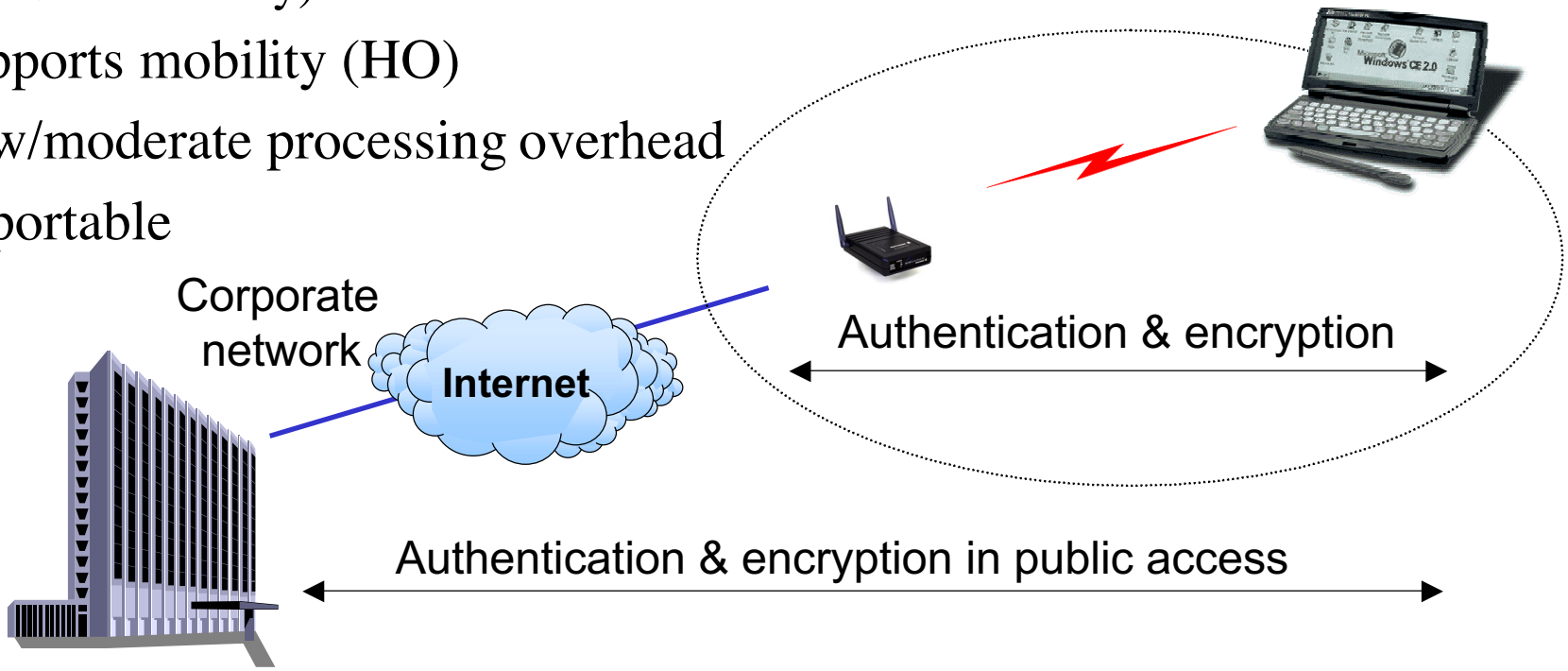
- HIPERLAN2 Long Preamble (very similar to 802.11a PLCP preamble)



- IEEE802.11 Preamble

Security Overview

- Wired equivalency
- Sufficient in business, residential and public access environments
- Supports negotiation of different security levels including:
  - encryption (data confidentiality) and authentication (user confidentiality)
- Supports mobility (HO)
- Low/moderate processing overhead
- Exportable



Security Features

- Mobile identity protection
- Restricted to the radio access system
  - High level security not provided, e.g. user authentication through the Internet to corporate network Link level encryption
  - unicast, multicast, broadcast
  - for both user data and signaling
  - 56 bit and 168 bit key encryption based on DES
- Mutual authentication based on challenge/response
  - Optional pre-shared key or public key
- Token based handover authentication
- Key generation based on Diffie-Hellman exchange
- Regular key refresh

Conclusions: Adoption of HiperLAN2 to FWA 802.16.3

- DLC/MAC layer
  - TDD vs. FDD?
  - Deletion of management functions regarding mobility and radio resource (DFS)?
  - Is peer-to-peer communications between wireless terminals needed?
  - Security aspects?
  - ...?
- Physical layer
  - The same channel spacing (20 MHz)?
  - The same delay spread and as a result the same OFDM guard time?
  - Higher distances of terminals to access points (central stations) result in larger guard times for “PHY burst”?
  - …?

BRAN Information

- HiperLAN/2 Technical Specifications
  - Free of charge @ http://www.etsi.org/bran (Click on Work Items)
    - PHY: ts_101475v010101
    - DLC (basic functions): ts_10176101v010101
    - RLC: ts_10176102v010101
    - Packet based CL Common Part: ts_10149301v010101
    - Packet based CL Ethernet part: ts_10149302v010101
    - Cell based CL Common Part: ts_10176301v010101
    - Cell based CL UNI Part: ts_10176302v010101
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    - leif.jansson@era.ericsson.se (Chair of Work Item on FWA below 11 GHz)