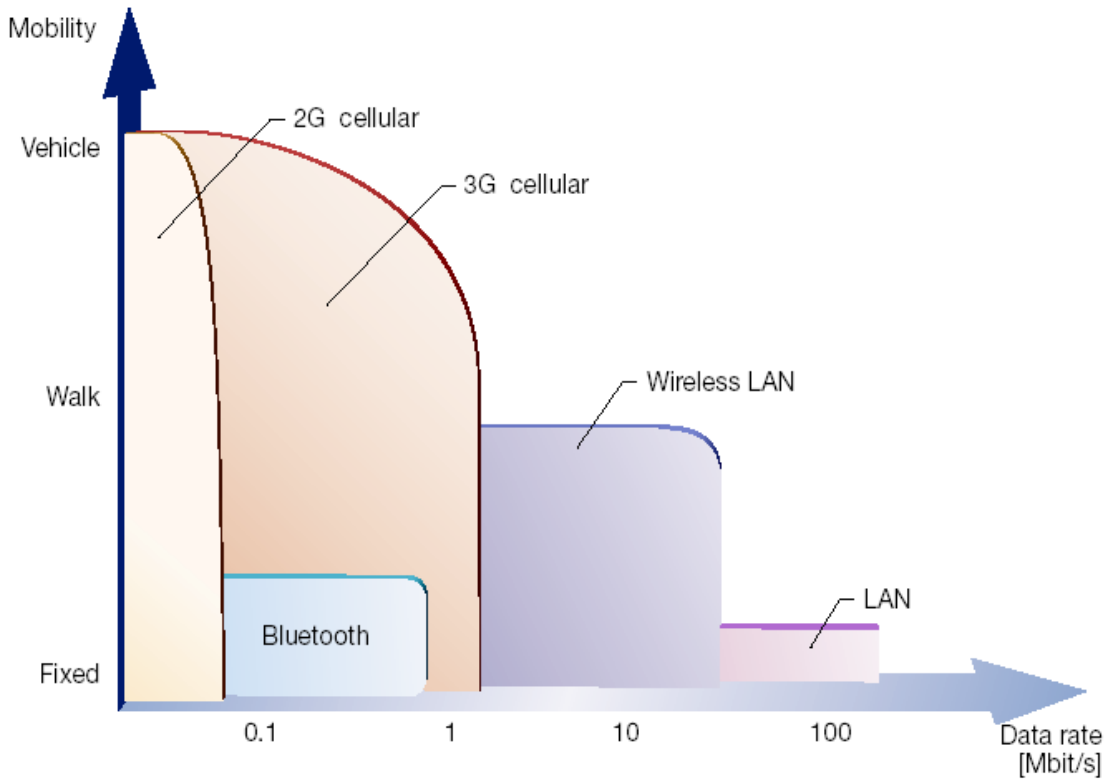
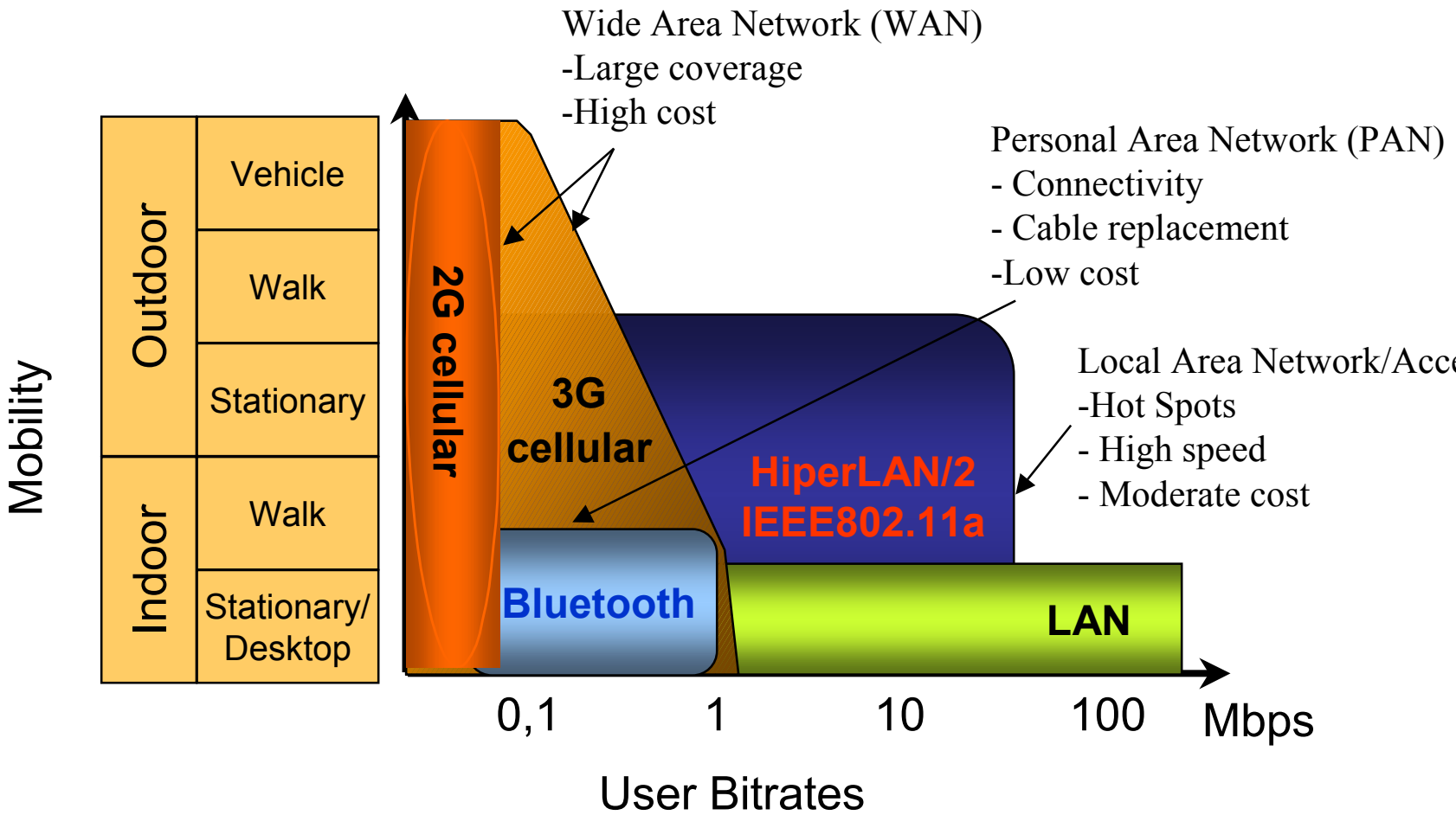
HIPERLAN (High-Performance Local Area Network)

- Part of ETSI(European Telecommunication Standard Institution) BRAN (Broadband Radio Access Network)
- Operational Frequency: 5.2 GHz
- Currently Available data rate : up to 54Mbps: HIPERLAN/2


Mobility
Vehicle
Walk
Fixed
2G cellular
3G cellular
Wireless LAN
Bluetooth
LAN
0.1
1
10
100
Data rate
[Mbit/s]

Wireless “Data” Solutions



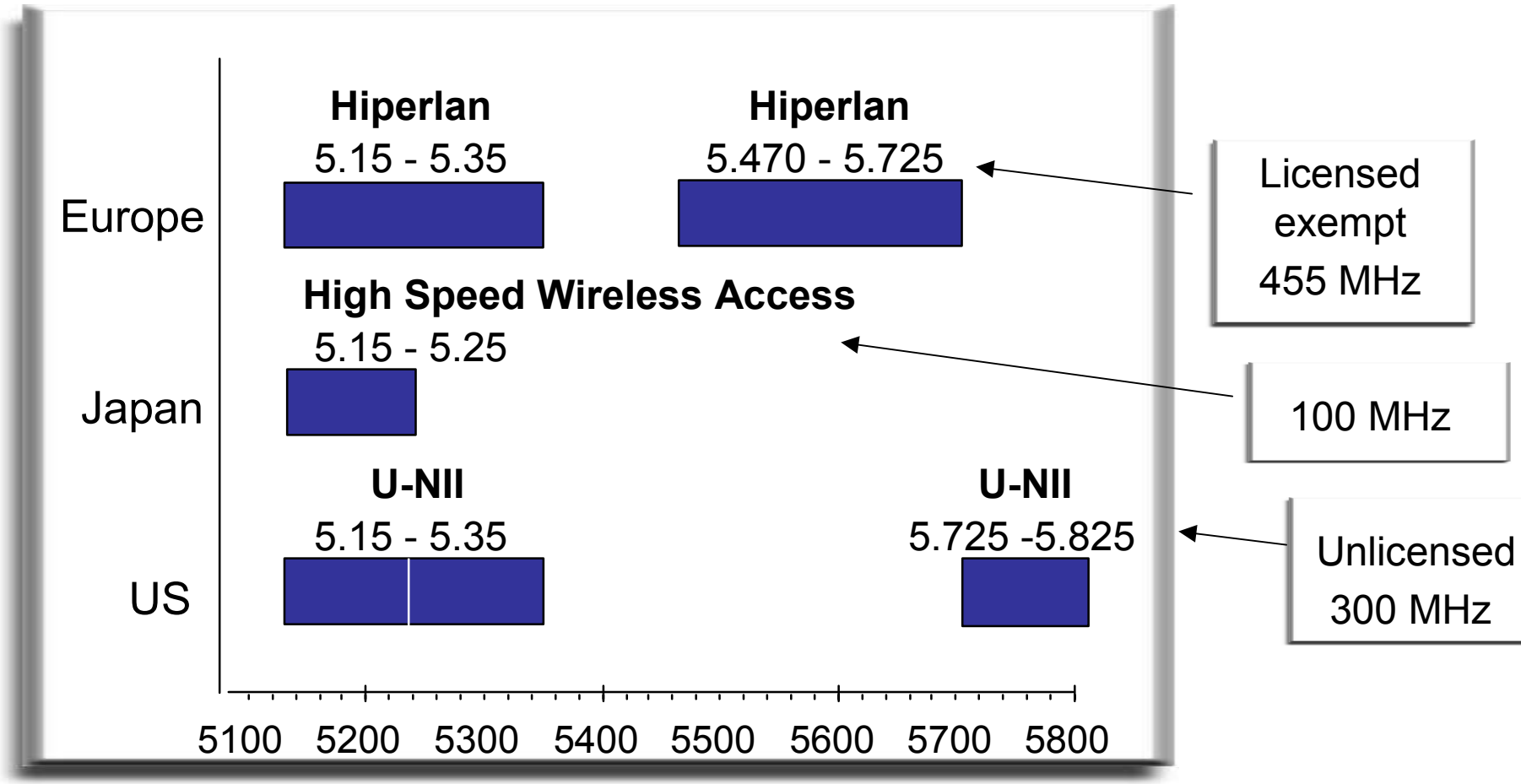
Requirements

- 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…(contd.)

- 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

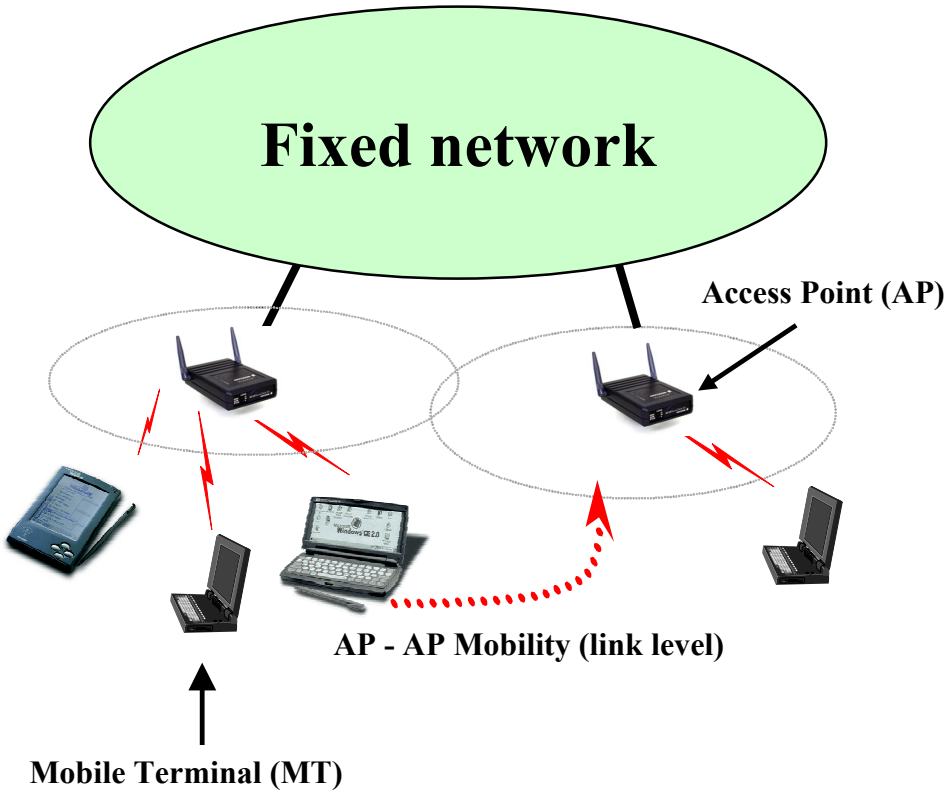
Spectrum Allocation at 5 GHz



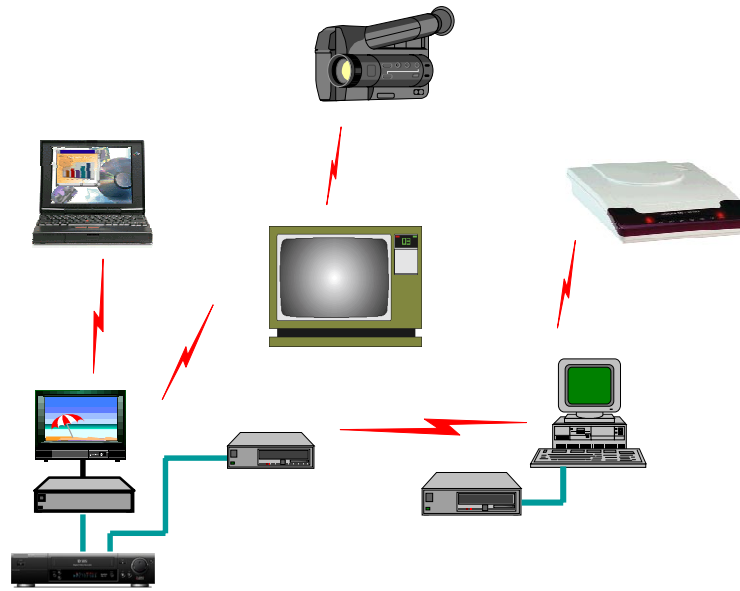
- MAC layer supports both asynchronous and synchronous (time bound) applications
  - Interactive multimedia services
  - High quality video distribution
  - Client-Server applications
- HIPERLAN/1
  - Was a best-effort delivery system
- HIPERLAN/2
  - Provides QoS guarantees and supports mobility up to 10 m/s
  - Uses a variant of CSMA/CA called Elimination Yield - Non Preemptive Priority Multiple Access (EY-NPMA)

Operation Modes

Infrastructure based network:

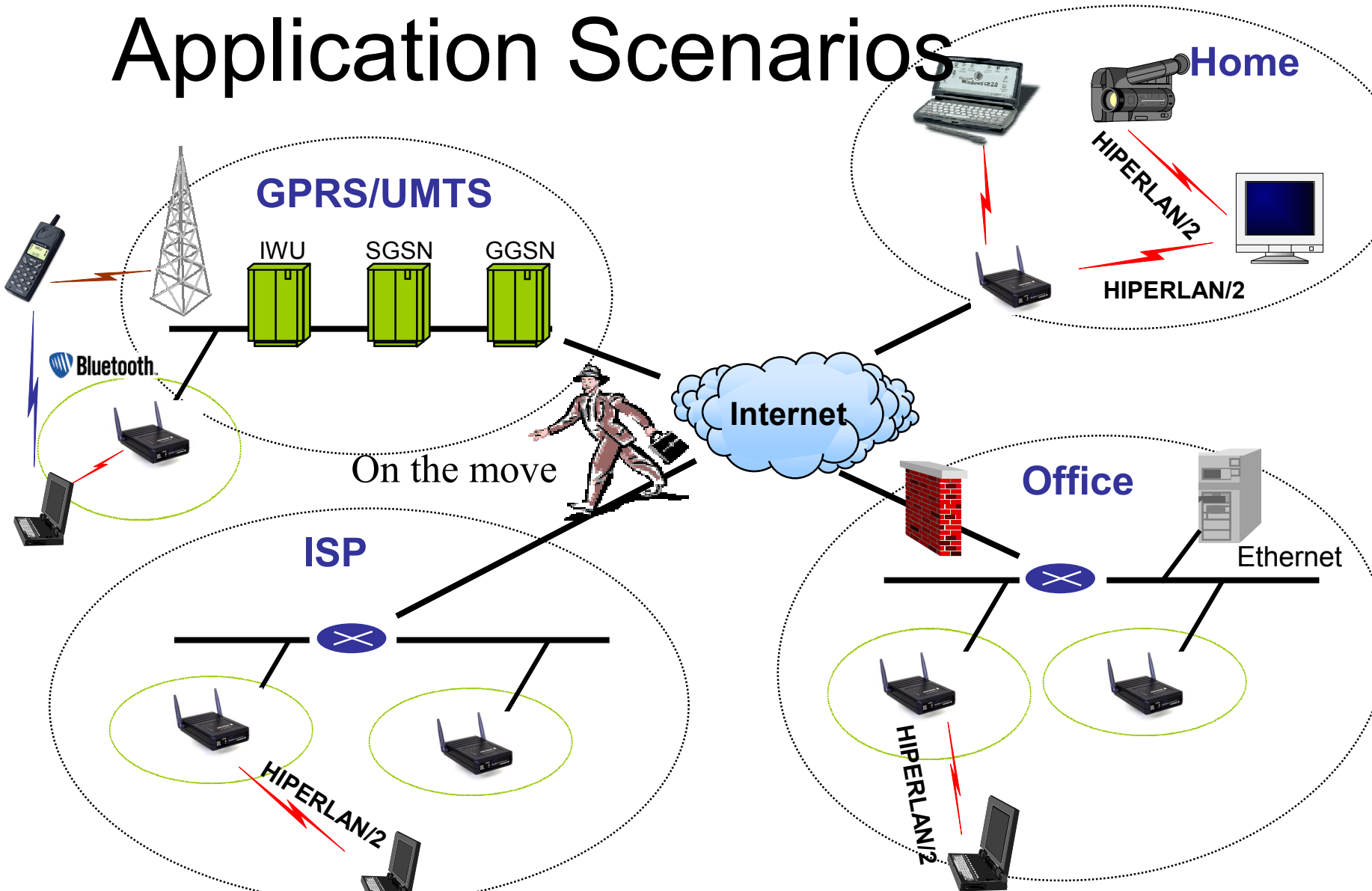


Ad-hoc network:



No compromise on QoS in ad-hoc mode!

Application Scenarios

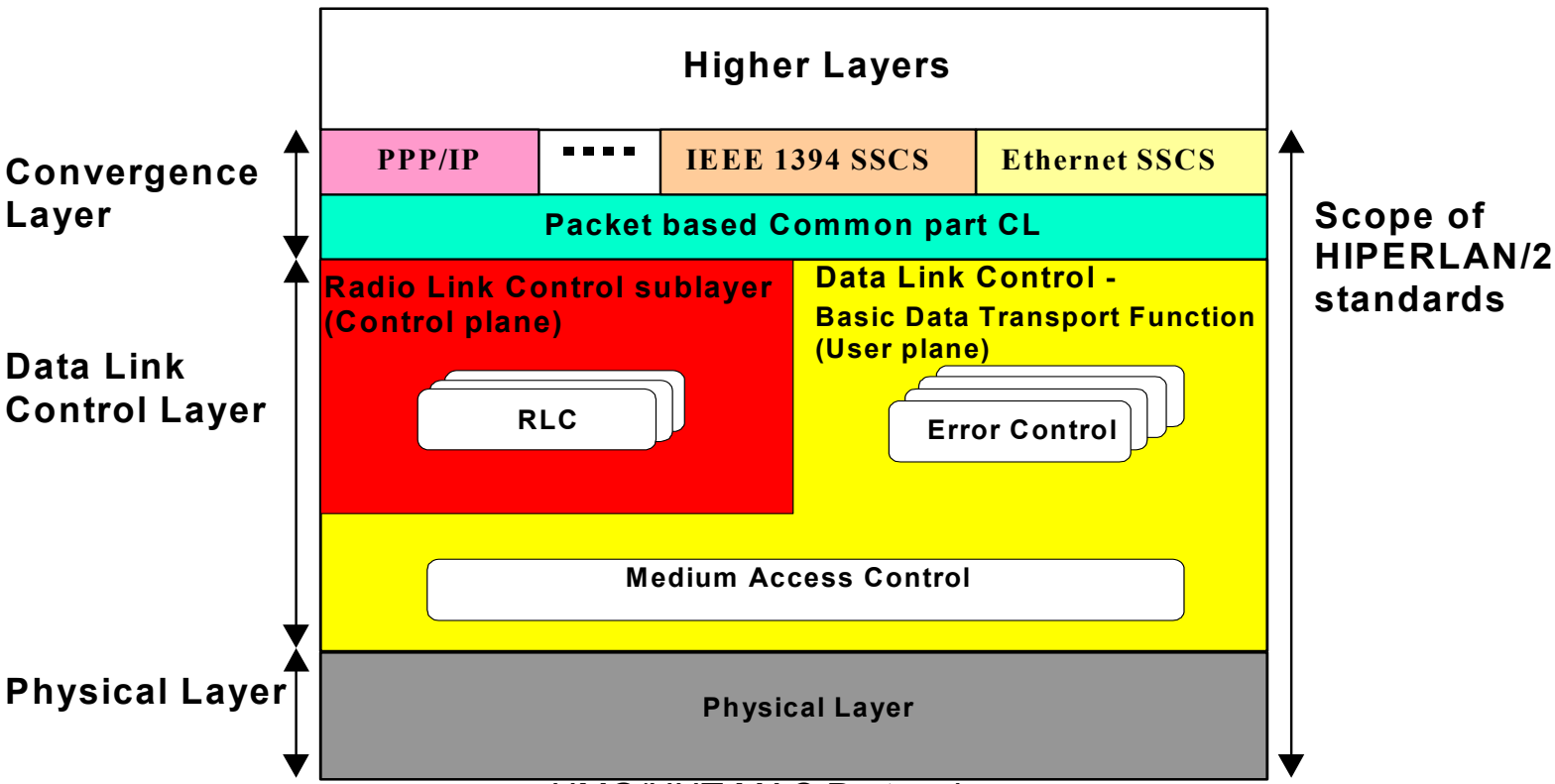


Features of HIPERLAN

- MAC supports centralized mode (CM) (APs) and direct mode (DM) (ad-hoc)
- Ad-hoc mode assumes “single cell” area
- For multihop HIPERLANs (nodes outside radio range), some nodes become forwarder
- Radio Cells need to overlap to implement forwarding mechanism
- Forwarders buffer packets
- Mobility may create fragmented LANs. They need to remerge

Protocol Architecture

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

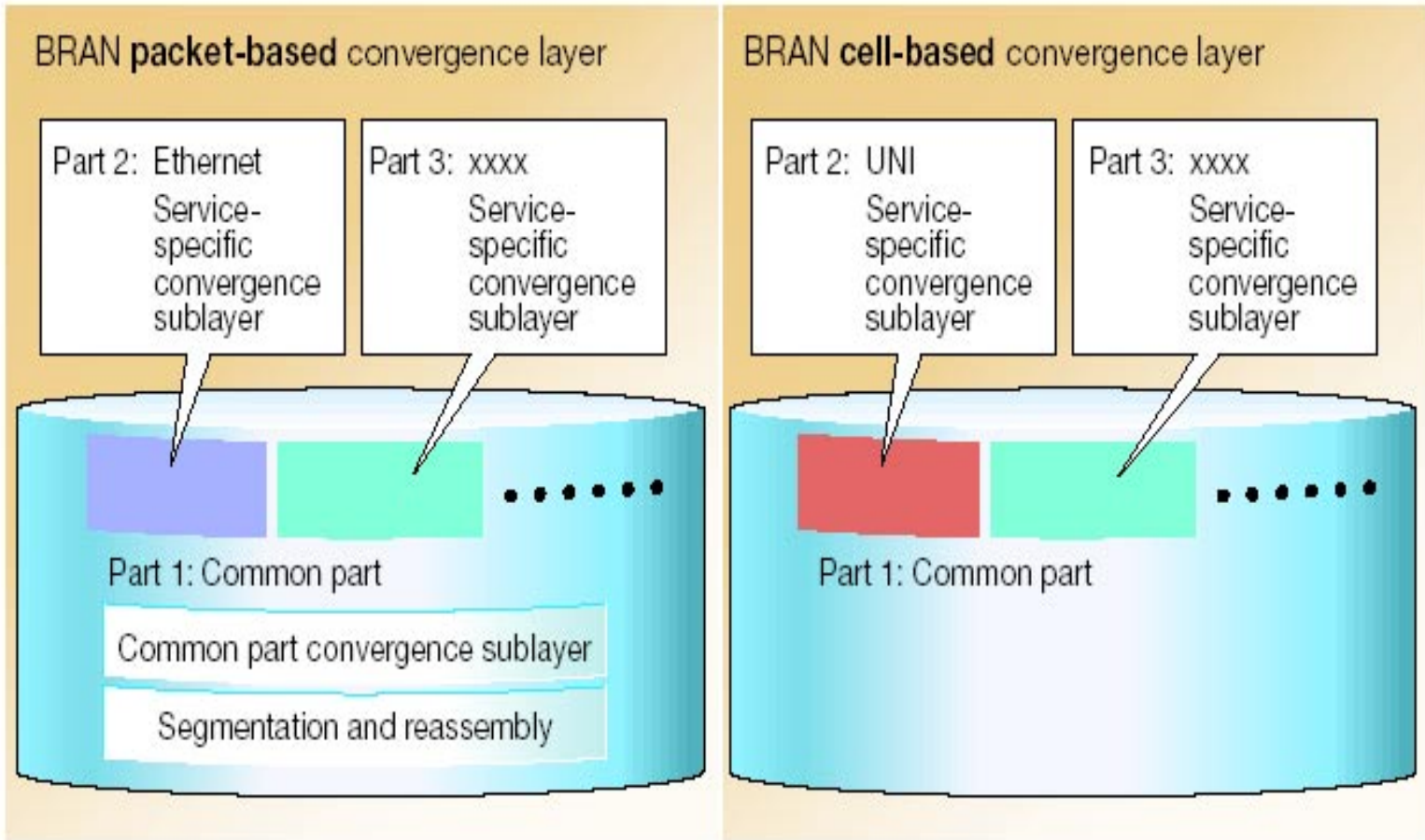


Modulations

Mode	Modulation	Code rate	PHY bit rate	bytes/OFDM
1	BPSK	1/2	6 Mbps	3.0
2	BPSK	3/4	9 Mbps	4.5
3	QPSK	1/2	12 Mbps	6.0
4	QPSK	3/4	18 Mbps	9.0
5	16QAM	9/16	27 Mbps	13.5
6	16QAM	3/4	36 Mbps	18.0
7	64QAM	3/4	54 Mbps	27.0

Functions of Convergence Layer

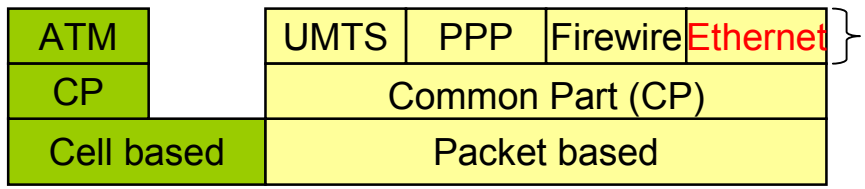
- Adapts services request from higher layers to the service offered by DLC
- Coverts higher layer packets (Fixed or variable lengths) to fixed length SDUs at DLC
- Two types of Convergence Layer
  - Cell based (for ATM type traffic)
  - Packet Based (for Ethernet type traffic)


BRAN packet-based convergence layer
Part 2: Ethernet
Service-specific convergence sublayer
Part 3: xxxx
Service-specific convergence sublayer
Part 1: Common part
Common part convergence sublayer
Segmentation and reassembly
BRAN cell-based convergence layer
Part 2: UNI
Service-specific convergence sublayer
Part 3: xxxx
Service-specific convergence sublayer
Part 1: Common part

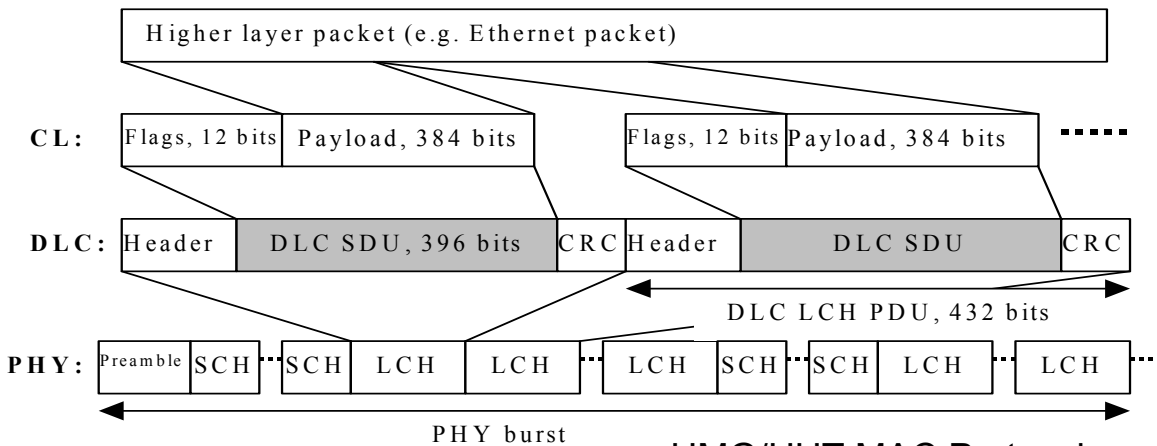
Convergence Layer

- 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

- 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…(contd.)

- 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

Logical and Transport channels are used to construct MAC frame

- Logical Channel:
  - A generic term for any distinct data path which describes a specific da transfer service offered by the MAC entity
  - Defined by the type of information it carries and the interpretation of th 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

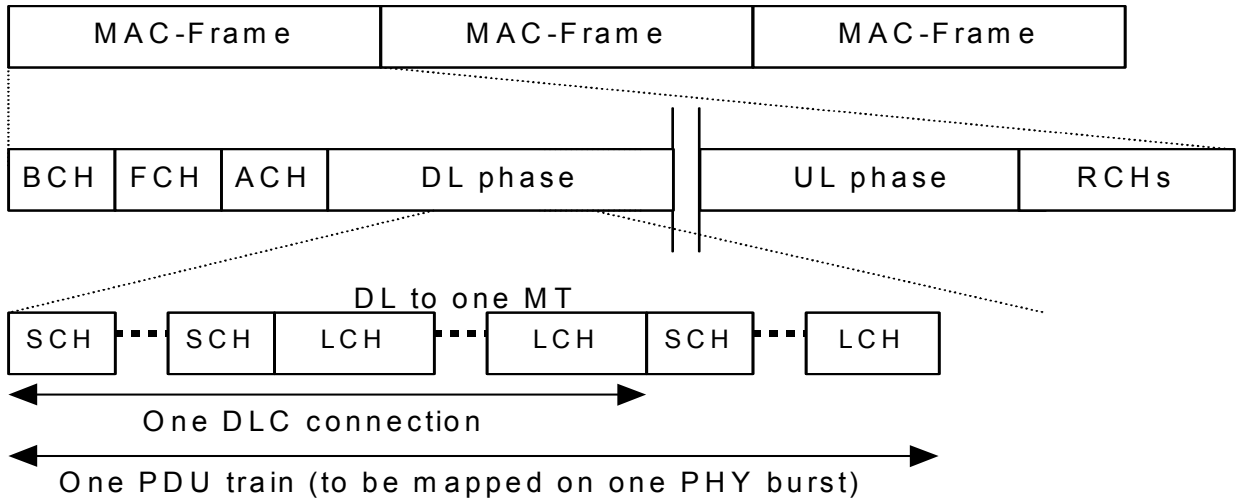
- Some important Logical Channesl: Contd
  - RFCH (Random access Feedback CHannel): used in downlink to inform the MTs that have used the RACH in the previous MAC frame about the result of their access attempts.
  - RBCH (RLC Broadcast CHannel): used in downlink (when necessary) conveying broadcast CONTROL 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

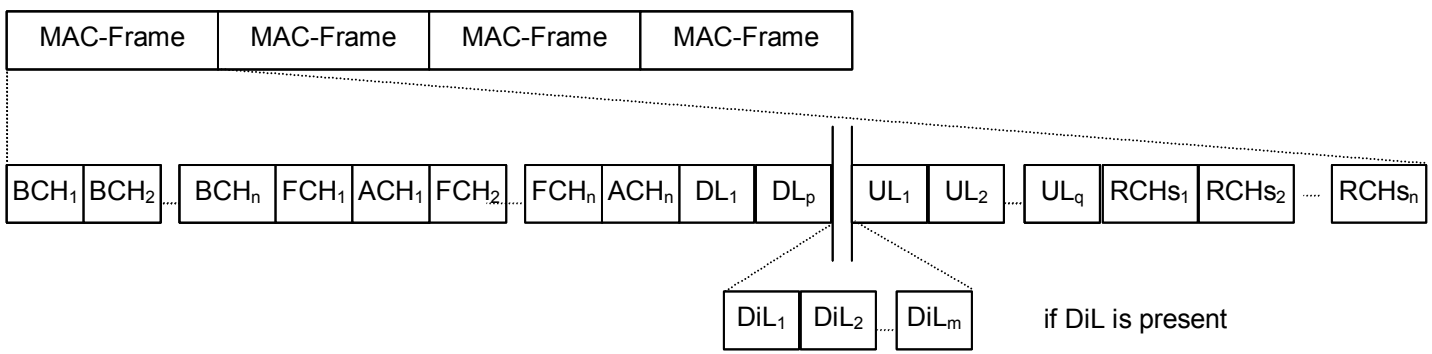
- Logical channels are mapped onto different transport channels which describe the basic message format and are the basic elements for constructing message sequence of each user
  - BCH (Broadcast CHannel): carries BCCH transmitted once per MAC frame per sector antenna
  - FCH (Frame CHannel): used in 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

Basic MAC Frame Structure

- A single sector system



- A multiple sectors system

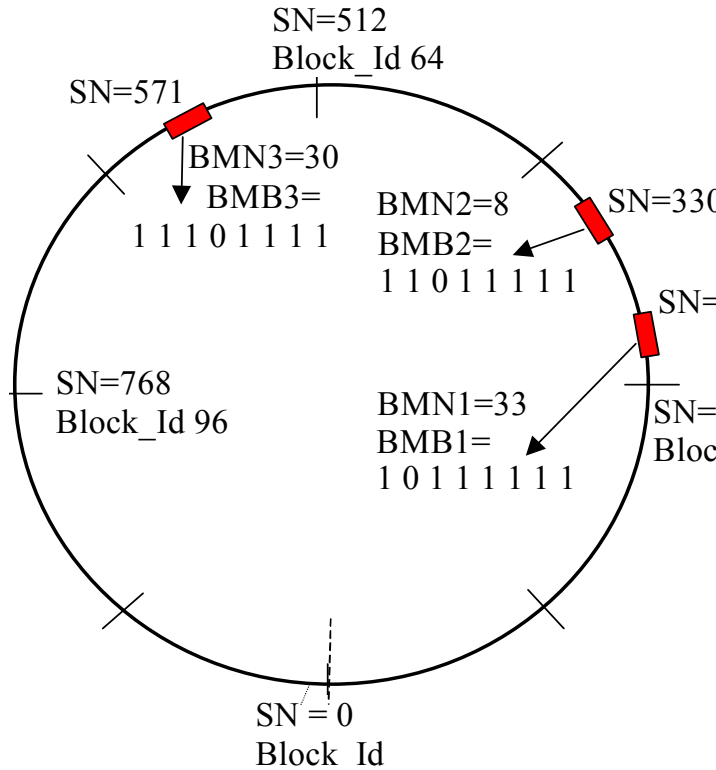


DLC: Error Control

- 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 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

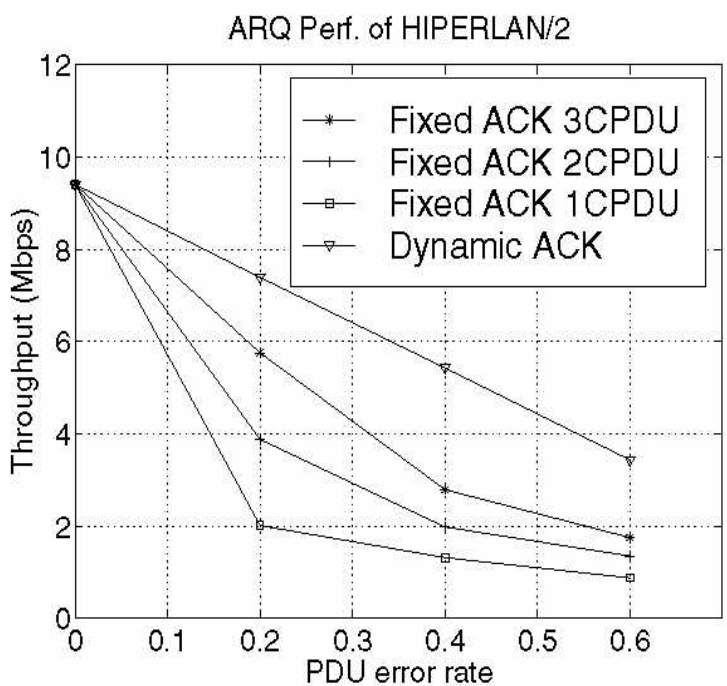
- Numbering of PDU from 0 to 1023 (Sequence Number)
- Grouping 8 PDUs into 1 Block, totally 127 Blocks
- ACK of a PDU: BitMap Block (BMB) & BitMap Number (BMN)
- In the ARQ C-PDU: 3 BMBs & 3 BMNs
- BMN1=Block_Id1, BMN2=Block_Id1 - Block_Id2, BMN3=Block_Id3 - Block_Id2

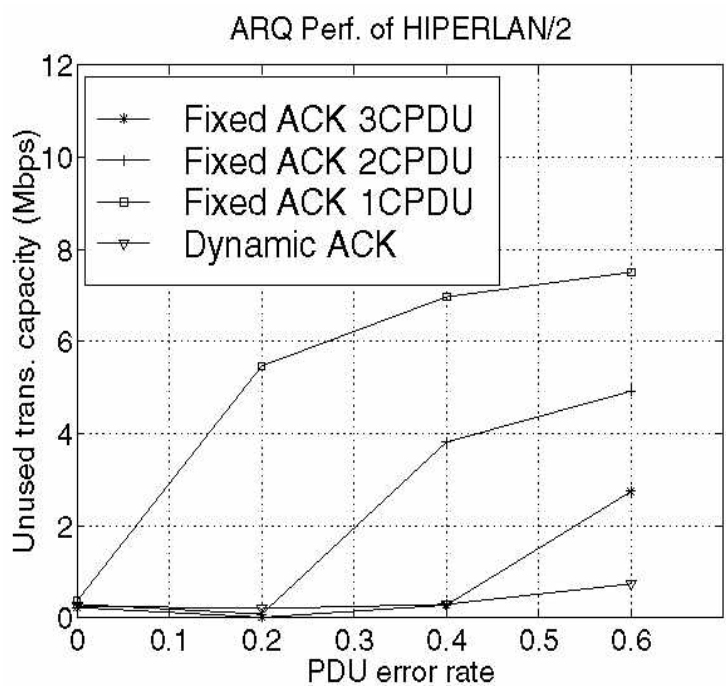


ARQ Message Format (Uplink)								
	8	7	6	5	4	3	2	1
Octet 1	PDU Type				LCH PHY Mode			
Octet 2	CAI	BMN 1						
Octet 3	BMB 1							
Octet 4	SCH PHY Mode			BMN 2				
Octet 5	BMB 2							
Octet 6	FC	ABIR	FU	BMN3				
Octet 7	BMB 3							
Octet 8	CRC-16							
Octet 9								

Dynamic Acknowledgement

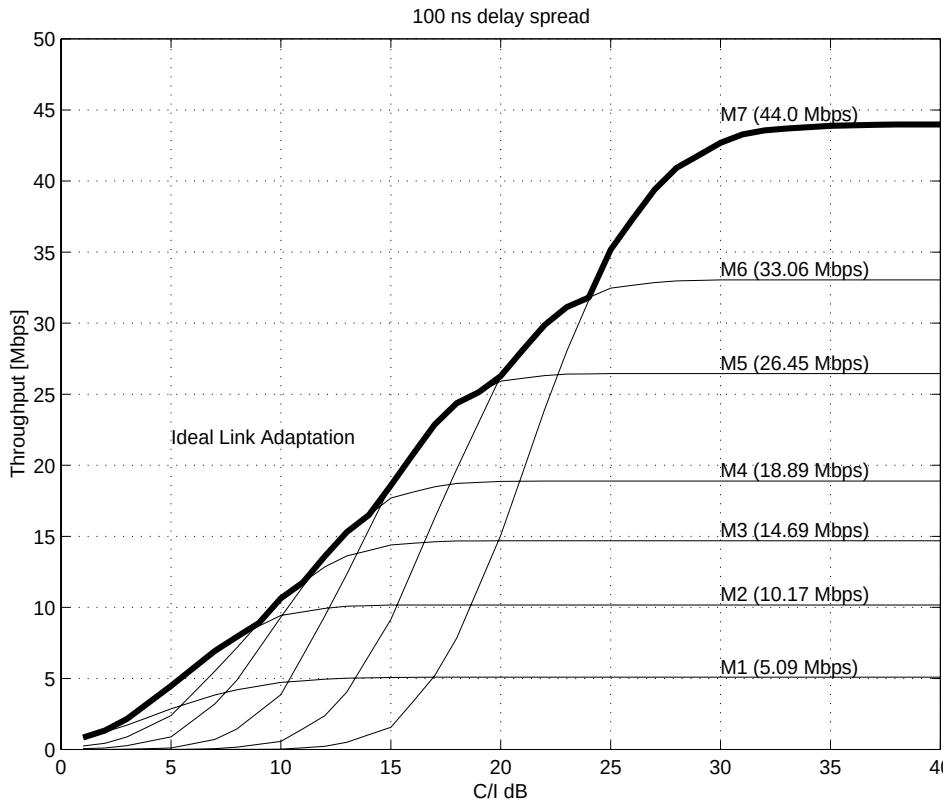
- Problems with fixed ACK
  - low utilisation of channel capacity
  - bottleneck of feedback channel
  - deferring retransmissions
- Dynamic ACK
  - # of ARQ PDUs based on receiver status
  - ABIR-bit used by receiver in MT
  - high utilisation of channel capacity





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



RLC (Radio Link Control) Sub layer

- Used for exchanging data between APs and MTs (Mobile Terminals) for association/re-association
- Signaling uses dedicated control channel
- Error Control
  - Acknowledged Mode: Uses selective repeat ARQs
  - Repetition Mode: Repeats data bearing DLS PDUs
    - No Acks
    - Receiver accepts PDUs with sequence number in window
  - Unacknowledged mode without re-transmission

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

- HIPERLAN/2 uses *Power Control* to decrease interference
- MAC frame size 2ms (fixed)

EY-NPMA

- Three phases in the protocol
  - Priority resolution
  - Elimination
  - Yield
- Four Priority Levels (residual life time dependent)
- PHY operates at two data rates
  - Low Bit rate channel (1.4706 Mb/s)
  - High Bit rate channel (23.5294 Mb/s in HIPERLAN/1)

Priority resolution Phase

- STA listen to channel for specified (priority dependent) interval. If the channel is free, STA announces its operation at high bit rate channel otherwise defers
- Same priority STAs survive

Elimination Phase

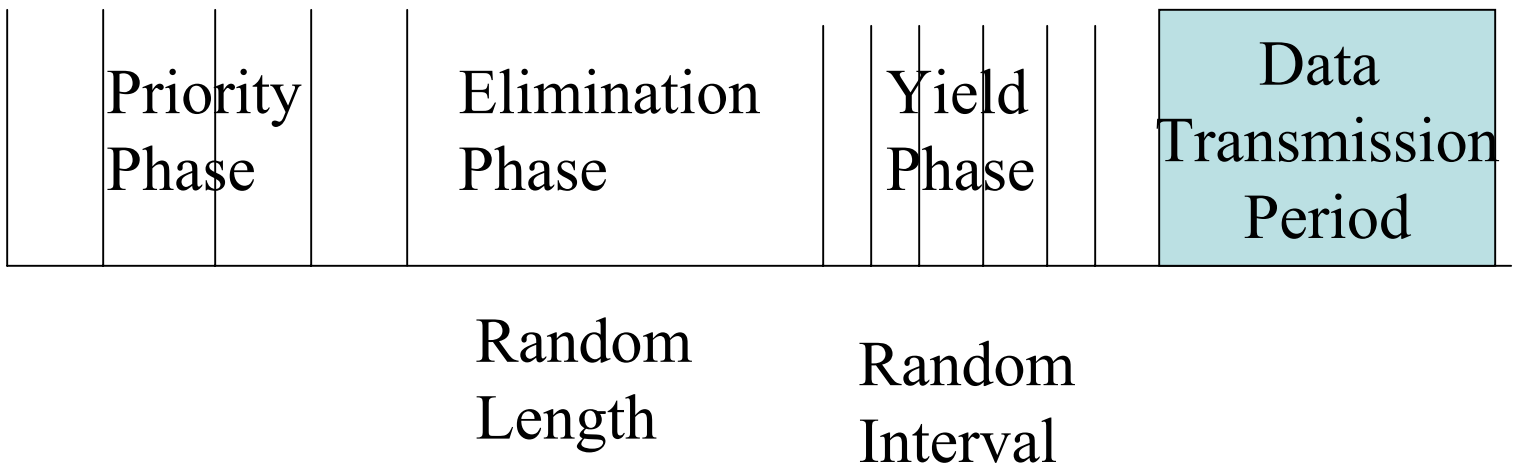
- Surviving STAs send random length burst (from the specified discrete PDF)
  - STAs listen to channel after burst transmission
  - If any other burst detected then STA defers otherwise goes to the next phase (longest burst STAs survive)

Yield Phase

- Surviving STAs listen to the channel again
  - Listen time random (using discrete upper bounded PDF)
  - If a STA listens any transmission in the listen duration it defers, otherwise it survives

Transmission Phase

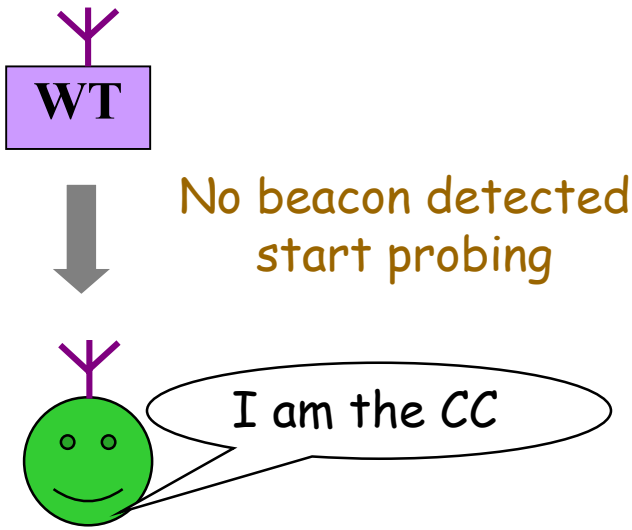
- Surviving STA transmit data



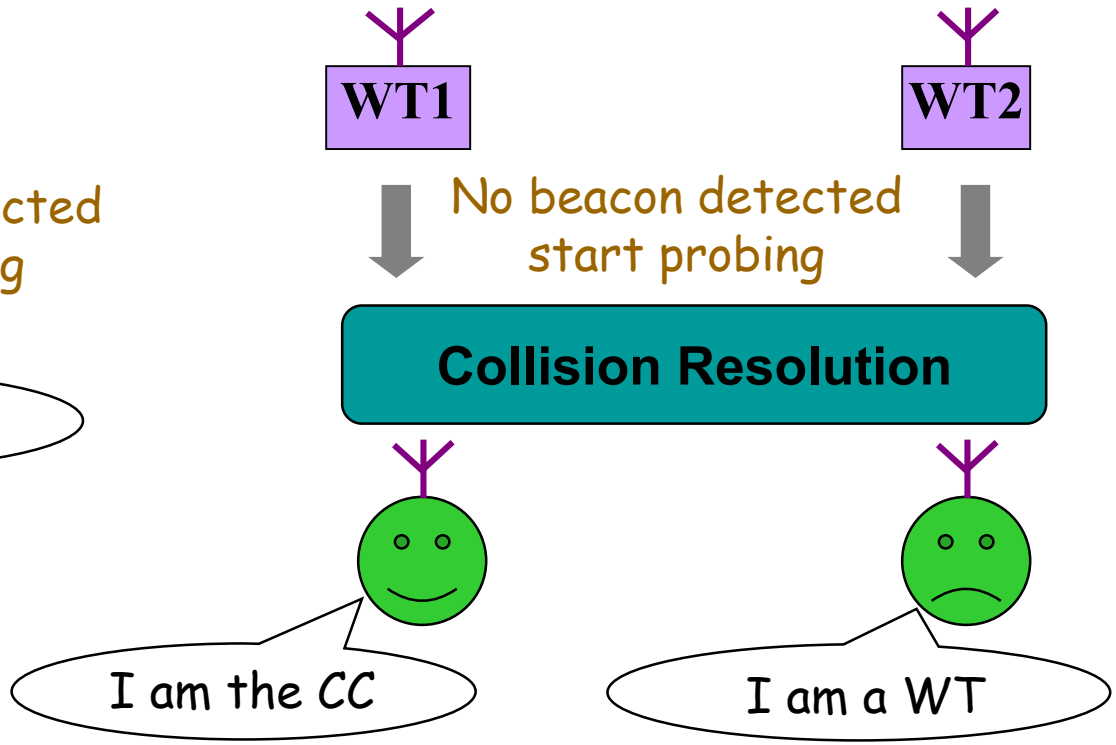
Principals of HiperLAN/2 Ad-hoc Networking

Network creation

Case 1: one CC-capable WT is switched on first

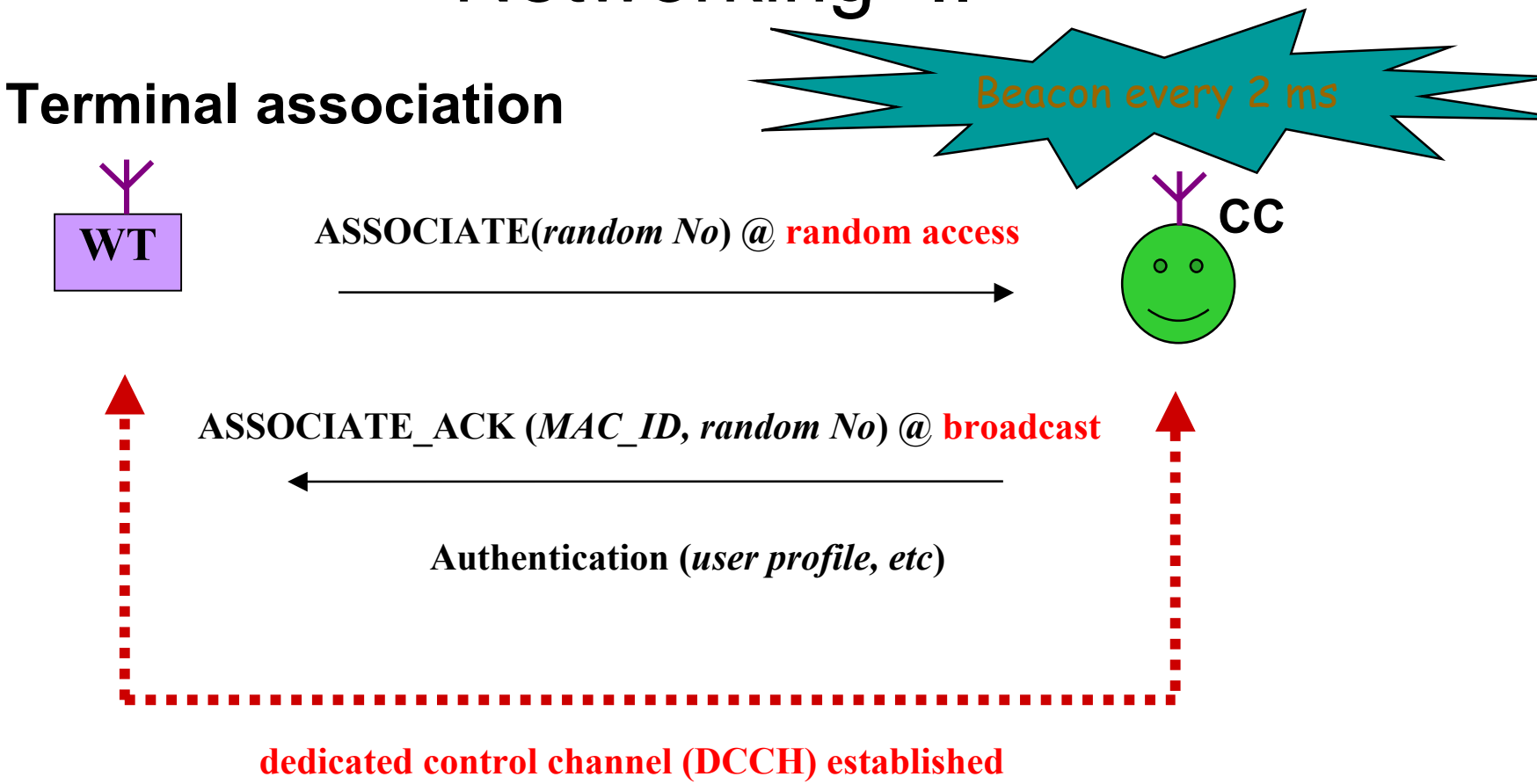


Case 2: two CC-capable WTs are switched on at the same time



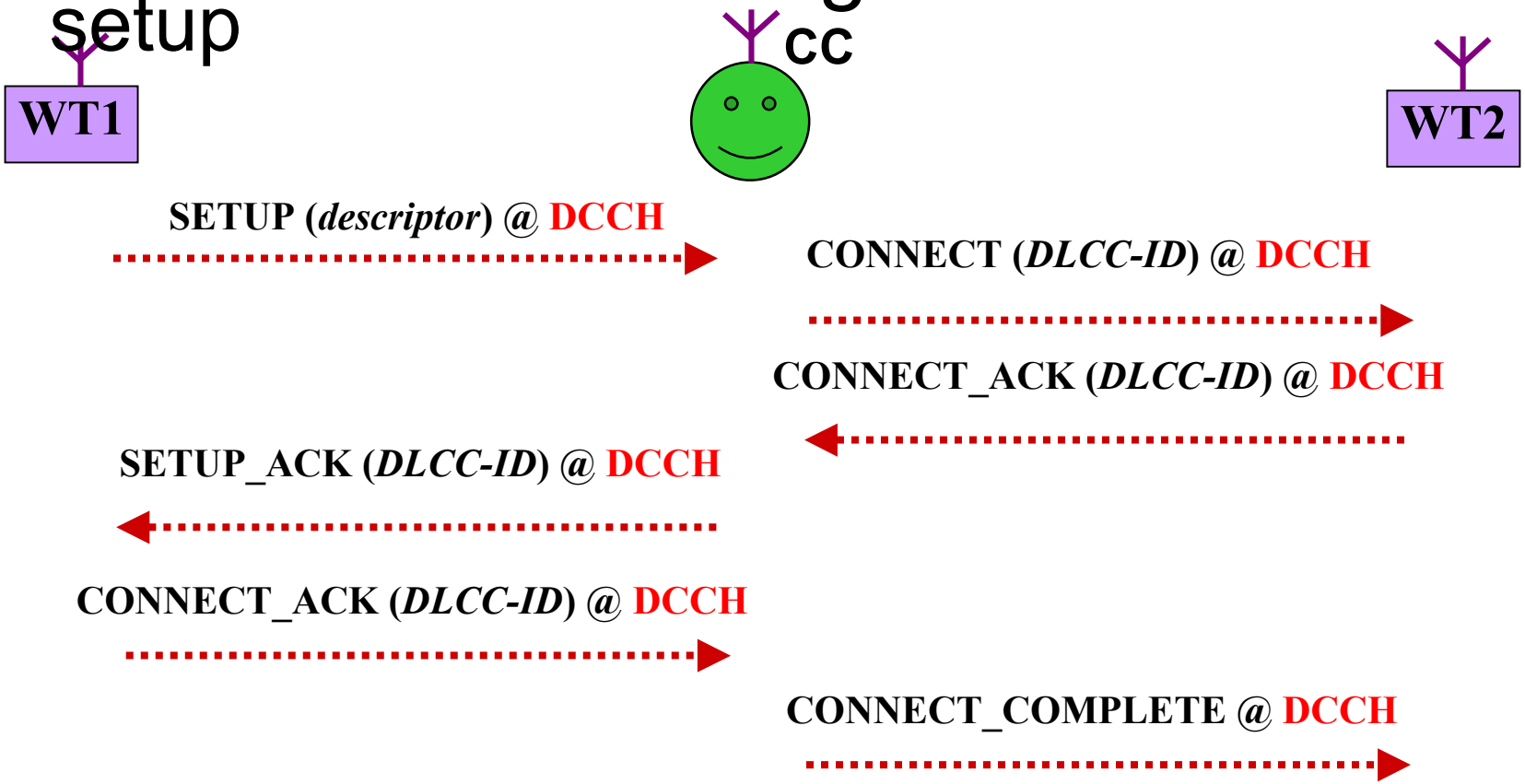
CC: Central Controller

Principals of HiperLAN/2 Ad-hoc Networking -II



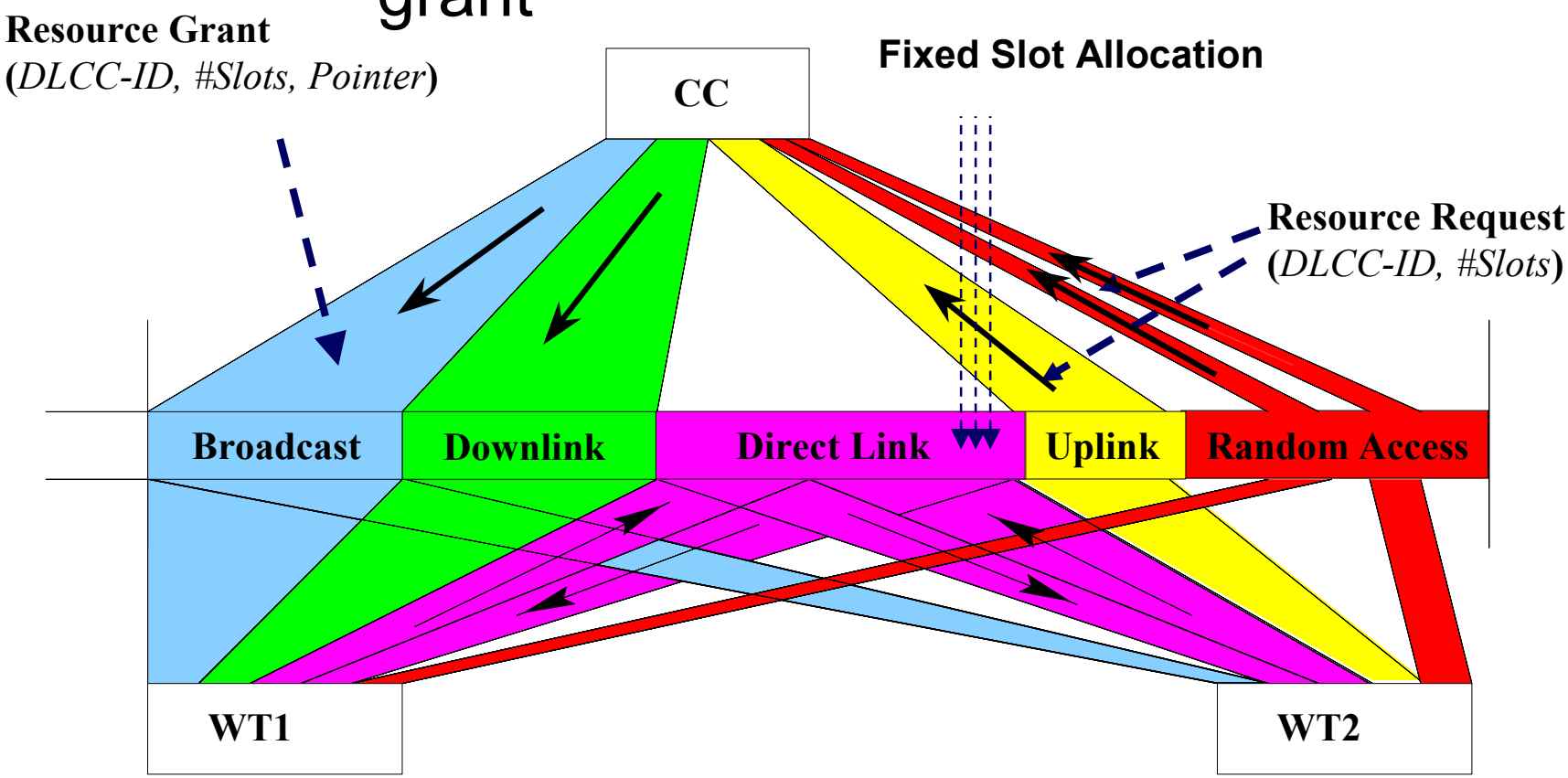
Principals of HiperLAN/2 Ad-hoc Networking - III

Connection setup

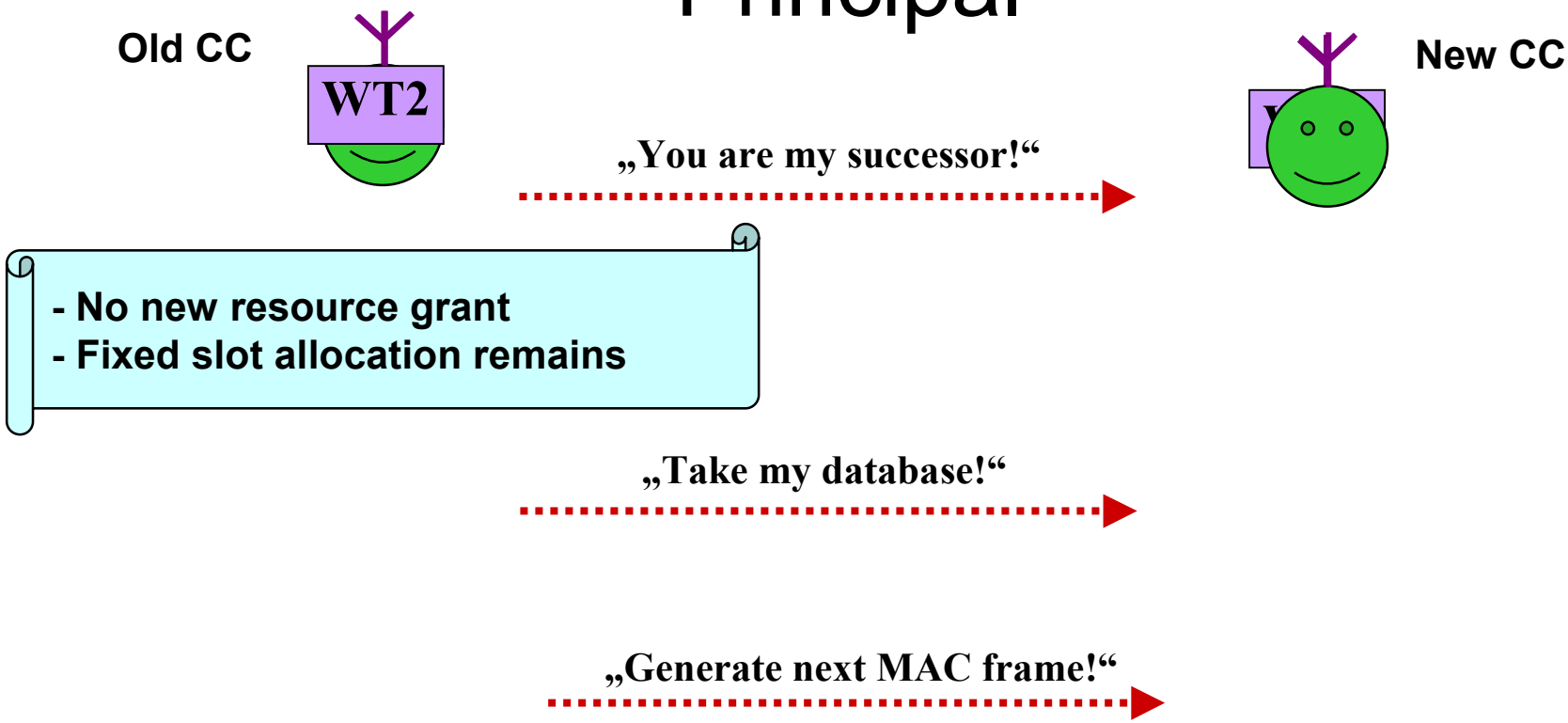


Principals of HiperLAN/2 Ad-hoc Networking - IV

Resource request & resource grant



CC Responsibility Handover Principal



Conclusions

- HiperLAN/2 for Emerging Nomadic Computing
  - Scalable User Security
  - Wireless LAN and Wireless Access
  - Mobile Datacom
    - up to 54 Mbps
    - Mobility
    - Quality of Service
  - Environments
    - Home
    - Office
    - Public
  - Network Topology
    - Infrastructure based networks
    - “Ad-hoc” networks

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
- Contacts:
  - jamshid.khun-jush@eed.ericsson.se (BRAN Chair & HiperLAN2 Coordinator)