Mobile Communications
Chapter 8: Wireless ATM

- ATM
  - Basic principle
  - B-ISDN
  - Protocols
  - Adaptation layer
- Wireless ATM
  - Reference model
- Enhanced functionality
- Architecture
  - Radio Access Layer
  - BRAN
- Handover
- Addressing
- QoS

Why wireless ATM?

- seamless connection to wired ATM, a integrated services high-performance network supporting different types a traffic streams
- ATM networks scale well: private and corporate LANs, WAN
- B-ISDN uses ATM as backbone infrastructure and integrates several different services in one universal system
- mobile phones and mobile communications have an ever increasing importance in everyday life
- current wireless LANs do not offer adequate support for multimedia data streams
- merging mobile communication and ATM leads to wireless ATM from a telecommunication provider point of view
- goal: seamless integration of mobility into B-ISDN

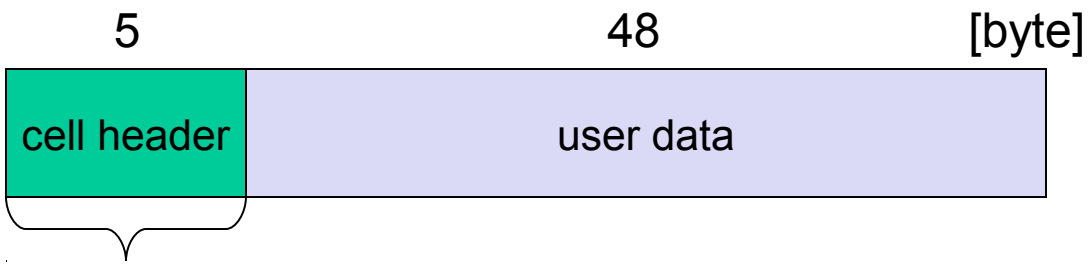
Problem: high complexity of the system

ATM - basic principle

- favored by the telecommunication industry for advanced high-performance networks, e.g., B-ISDN, as transport mechanism
- statistical (asynchronous, on demand) TDM (ATDM, STDM)
- cell header determines the connection the user data belongs to
- mixing of different cell-rates is possible

  different bit-rates, constant or variable, feasible
- interesting for data sources with varying bit-rate:
  - e.g., guaranteed minimum bit-rate
  - additionally bursty traffic if allowed by the network

ATM cell:



Cell-based transmission

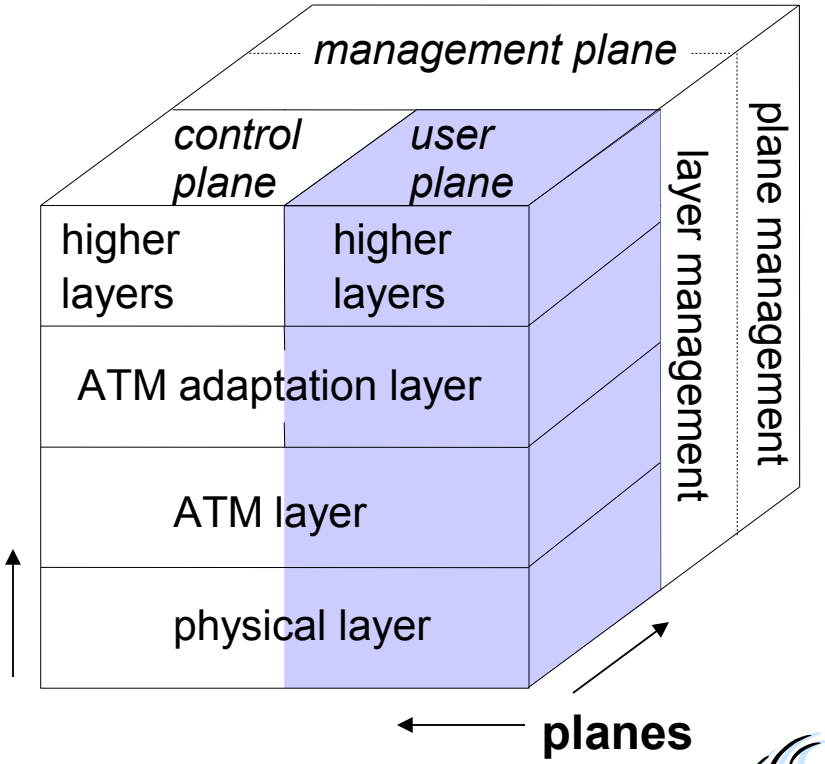
- asynchronous, cell-based transmission as basis for ATM
- continuous cell-stream
- additional cells necessary for operation and maintenance of the network (OAM cells; Operation and Maintenance)
- OAM cells can be inserted after fixed intervals to create a logical frame structure
- if a station has no data to send it automatically inserts idle cells that can be discarded at every intermediate system without further notice
- if no synchronous frame is available for the transport of cells (e.g., SDH or Sonet) cell boundaries have to be detected separately (e.g., via the checksum in the cell header)

B-ISDN protocol reference model

3 dimensional reference model

- three vertical planes (columns)
  - user plane
  - control plane
  - management plane
- three hierarchical layers
  - physical layer
  - ATM layer
  - ATM adaptation layer

Out-of-Band-Signaling: user data is transmitted separately from control information



ATM layers

Physical layer, consisting of two sub-layers

- physical medium dependent sub-layer
  - coding
  - bit timing
  - transmission
- transmission convergence sub-layer
  - HEC (Header Error Correction) sequence generation and verification
  - transmission frame adaptation, generation, and recovery
  - cell delineation, cell rate decoupling

ATM layer

- cell multiplexing/demultiplexing
- VPI/VCI translation
- cell header generation and verification
- GFC (Generic Flow Control)

ATM adaptation layer (AAL)

ATM adaptation layer (AAL)

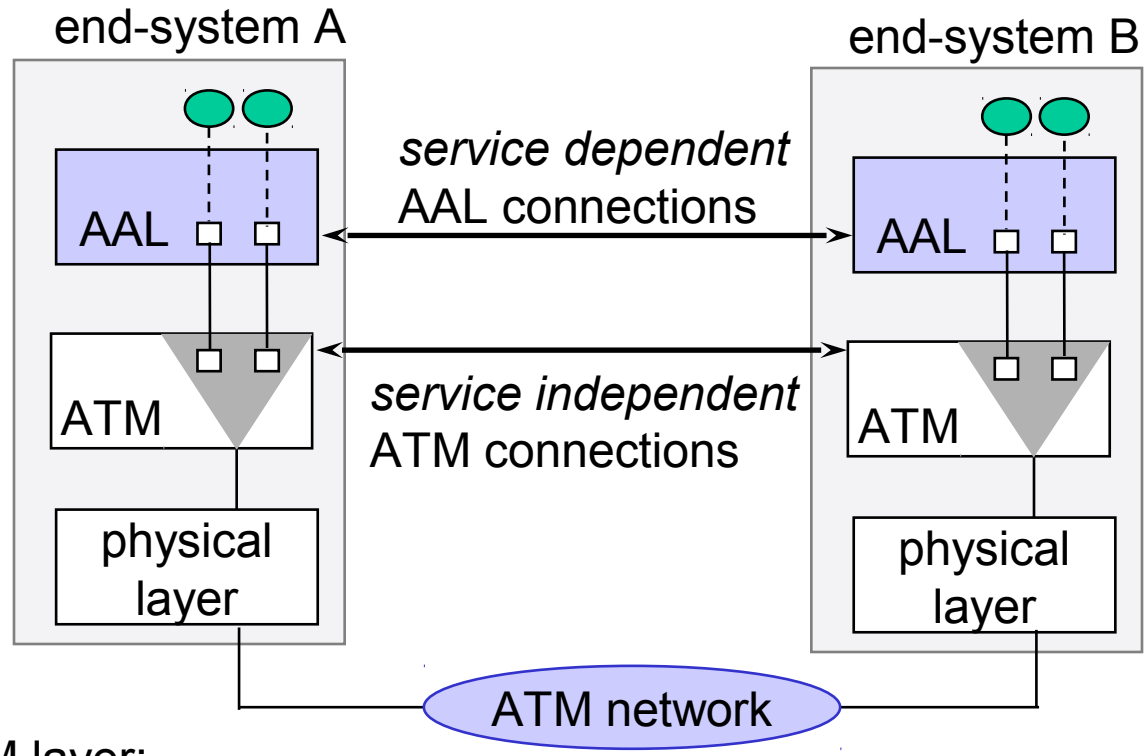
Provides different service classes on top of ATM based on:

- bit rate:
  - constant bit rate: e.g. traditional telephone line
  - variable bit rate: e.g. data communication, compressed video
- time constraints between sender and receiver:
  - with time constraints: e.g. real-time applications, interactive voice and video
  - without time constraints: e.g. mail, file transfer
- mode of connection:
  - connection oriented or connectionless

AAL consists of two sub-layers:

- Convergence Sublayer (CS): service dependent adaptation
  - Common Part Convergence Sublayer (CPCS)
  - Service Specific Convergence Sublayer (SSCS)
- Segmentation and Reassembly Sublayer (SAR)
- sub-layers can be empty

ATM and AAL connections



- ATM layer:
  - service independent transport of ATM cells
  - multiplex and demultiplex functionality
- AAL layer: support of different services

ATM Forum Wireless ATM Working Group

- ATM Forum founded the *Wireless ATM Working Group* June 1996
- Task: development of specifications to enable the use of ATM technology also for wireless networks with a large coverage of current network scenarios (private and public, local and global)
- compatibility to existing ATM Forum standards important
- it should be possible to easily upgrade existing ATM networks with mobility functions and radio access
- two sub-groups of work items

Radio Access Layer (RAL) Protocols

- radio access layer
- wireless media access control
- wireless data link control
- radio resource control
- handover issues

Mobile ATM Protocol Extensions

- handover signaling
- location management
- mobile routing
- traffic and QoS Control
- network management

WATM services

Office environment
- multimedia conferencing, online multimedia database access

Universities, schools, training centers
- distance learning, teaching

Industry
- database connection, surveillance, real-time factory management

Hospitals
- reliable, high-bandwidth network, medical images, remote monitoring

Home
- high-bandwidth interconnect of devices (TV, CD, PC, ...)

Networked vehicles
- trucks, aircraft etc. interconnect, platooning, intelligent roads

WATM components

WMT (Wireless Mobile ATM Terminal)

RT (Radio Transceiver)

AP (Access Point)

EMAS-E (End-user Mobility-supporting ATM Switch - Edge)

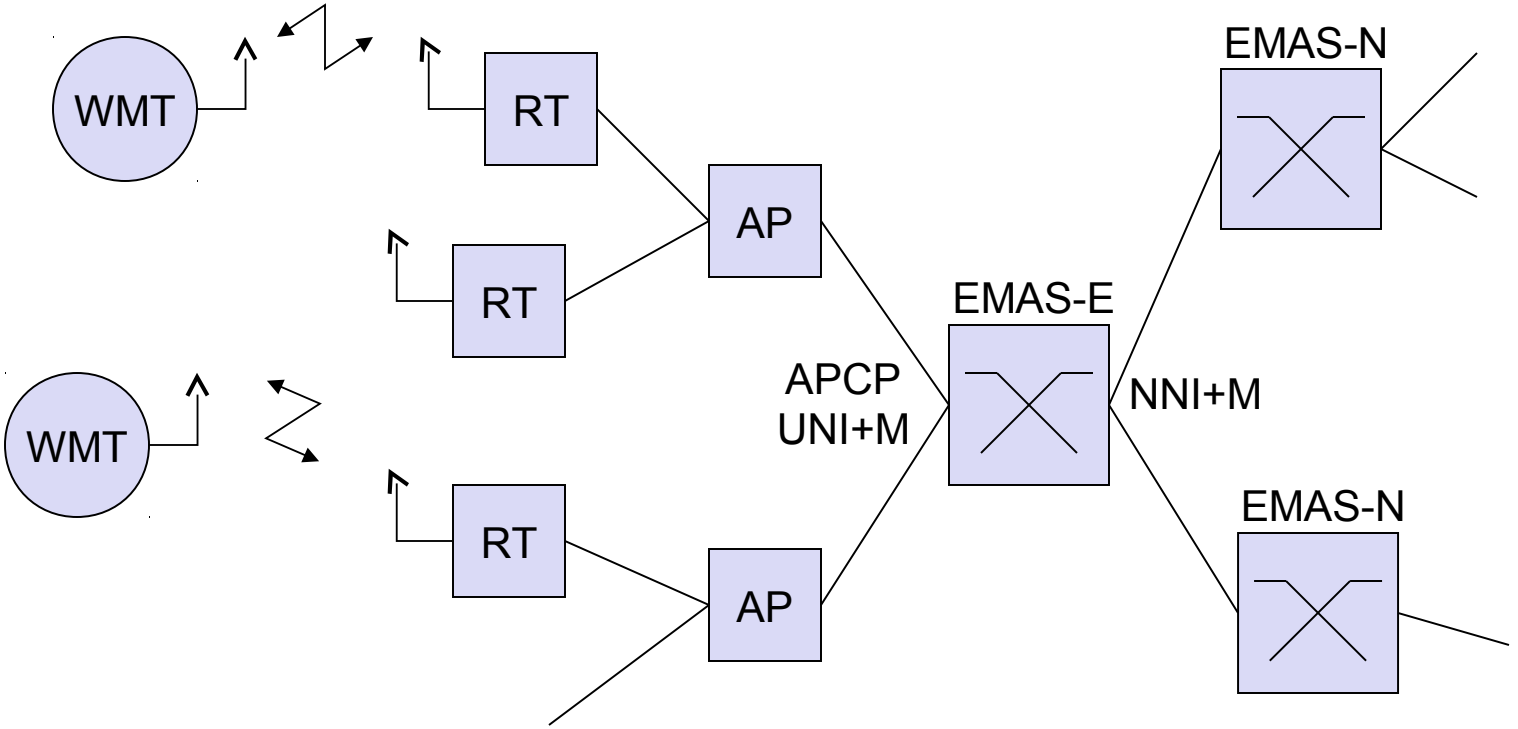
EMAS-N (End-user Mobility-supporting ATM Switch - Network)

APCP (Access Point Control Protocol)

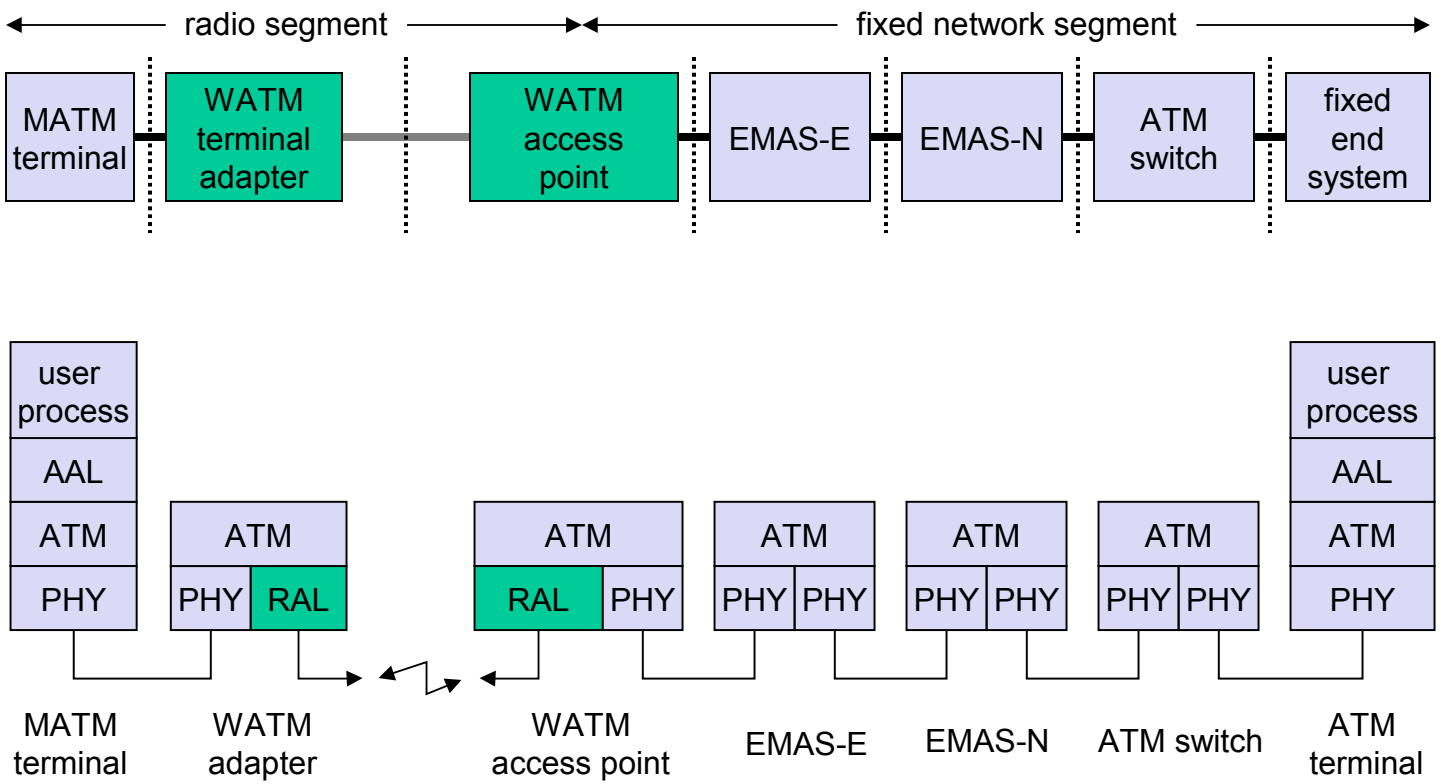
UNI+M (User-to-Network Interface with Mobility support)

NNI+M (Network-to-Network Interface with Mobility support)

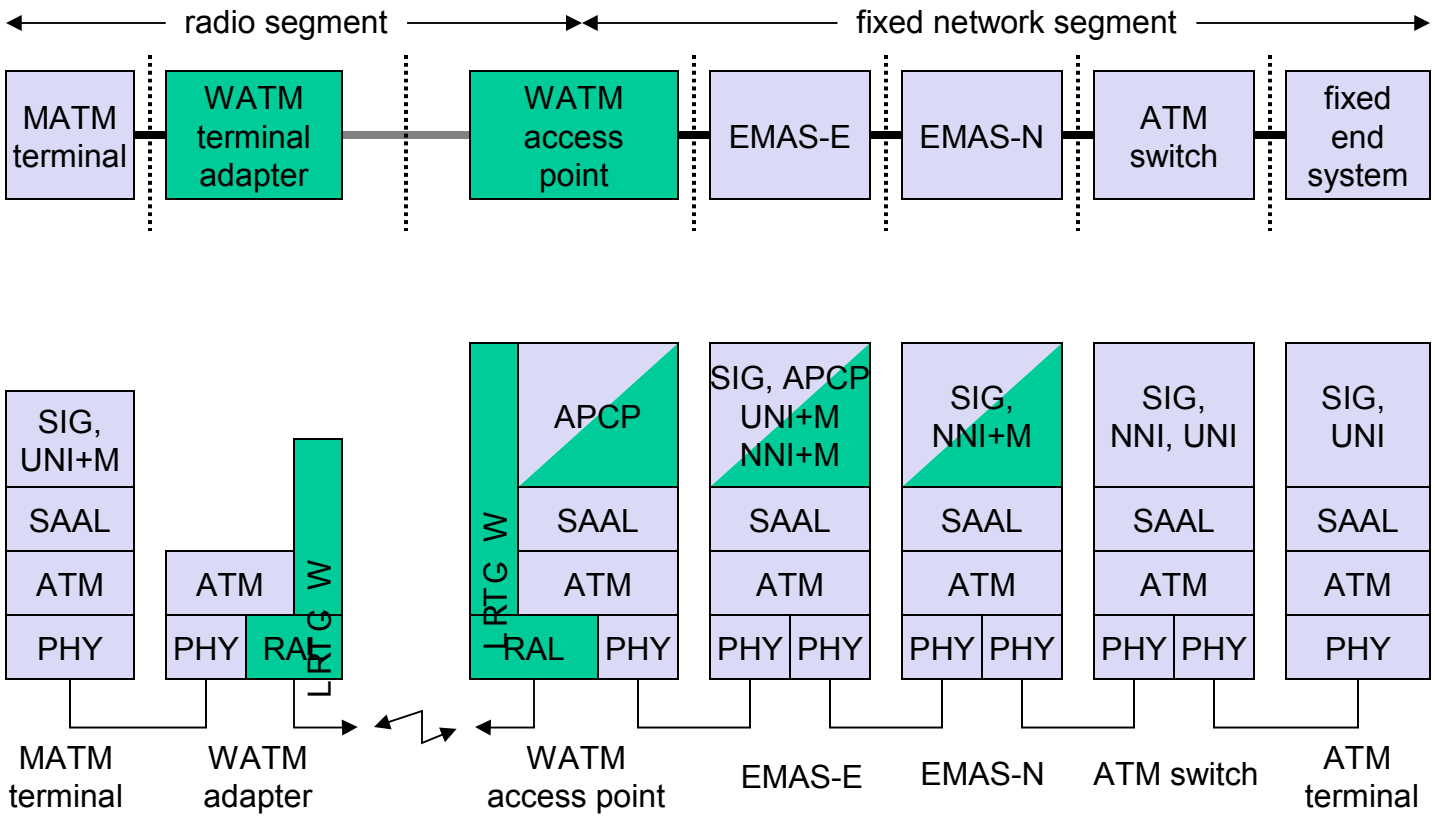
Reference model



User plane protocol layers



Control plane protocol layers



Enhanced functionality I

Additional protocols needed for the support of mobility

- Mobile Connection Management Protocol
  - supports a user for connection setup, specifies, reserves, and controls QoS for a connection
  - controls the assignment of VCIs to connections on the wireless and wired segment
  - supports setup of new or partially new paths during handover
- Mobile Handover Management Protocol
  - support of user mobility
    - find a new base station
    - redirect the data stream during handover
    - return unused VCIs after a handover
    - provide buffers and functions to sort packets out of sequence (ATM guarantees in-sequence delivery of cells!)
- standard functions of user and control plane still needed

Enhanced functionality II

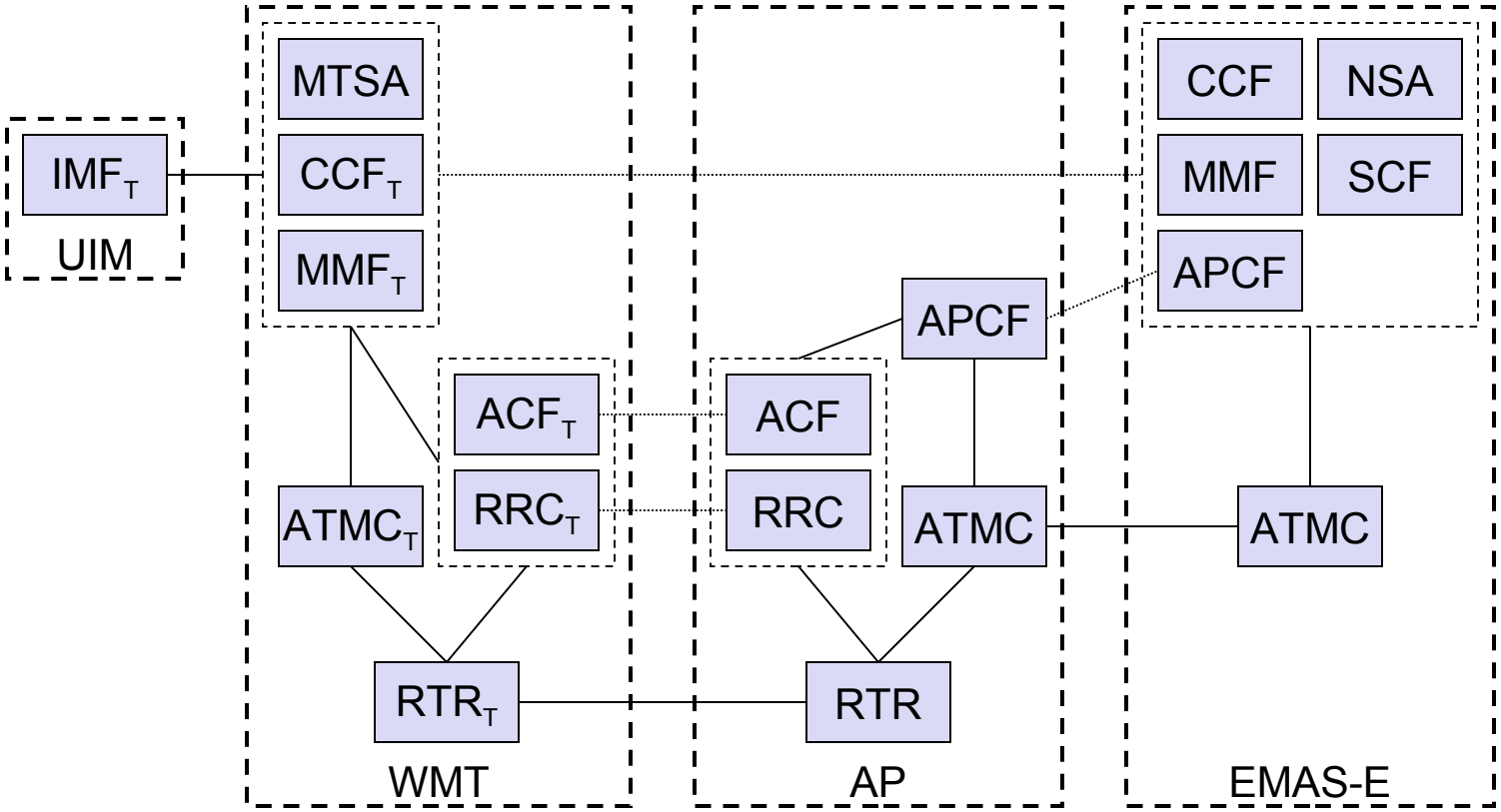
- Mobile Location Management Protocol
  - terminals can change their access points, therefore, several location functions are needed
    - where is a mobile user, what is the current access point, what is the current sub-network of a mobile terminal etc.
- Mobile Routing Protocol
  - access points change over time
    - dynamic topologies influence routing protocols, not supported by traditional routing protocols
    - routing has to support wireless and fixed part of the network
  - example: connection setup between two mobile hosts
    - with the help of the addresses and location registries the current access points can be located
    - routing within fixed network without changes

Enhanced functionality III

- Mobile Media Access Control Protocol
  - a single base station serves as access point for many mobile terminals within radio range
    - coordination of channel access
    - coordination of QoS requirements
    - traditional access schemes do not support different traffic classes with a larger variety of QoS requirements
- Mobile Data-Link Control Protocol
  - transmission and acknowledgement of frames
  - frame synchronization and retransmission
  - flow control

Also fixed networks need many of these functions, however, wireless networks require many adaptations and different mechanisms due to higher error rates and frequent interruptions.

Functional model for the modular access scheme



Wireless mobile terminal side

Mobility Management Function (MMF_T)

- analysis and monitoring of the network, paging response, location update

Call control and Connection control Function (CCF_T)

- call set-up and release, access control, connection control

Identity Management Function (IMF_T)

- security related information, user dependent

Mobile Terminal Security Agent (MTSA)

- additional security information, user independent

Radio Transmission and Reception (RTR_T)

- LLC, MAC, PHY layers for radio transmission

Radio Resource Control function (RRC_T)

- trigger handovers, monitor radio access, control radio resources

Association Control Function (ACF_T)

- set-up and release access to access point

ATM Connection function ($ATMC_T$)

- responsible for ATM connections, standard services (CBR, VBR, ABR, UBR)

Mobility supporting network side

Access Point Control Function (APCF)
- paging, handover, AP management

Call control and Connection control Function (CCF)
- call set-up and release, connection control, requests network and radio resources

Network Security Agent (NSA)
- identity management, authentication, encryption, confidentiality control

Service Control Function (SCF)
- management of service profiles, consistency checks

Mobility Management Function (MMF)
- location management, handover, location data, subscriber identity

Association Control Function (ACF)
- set-up and release access to mobile terminal

Radio Resource Control function (RRC)
- management of radio channels, initiate handover

Radio Transmission and Reception function (RTR)
- LLC, MAC, PHY layers, support of ATM traffic parameters

ATM Connection function (ATMC)
- responsible for ATM connections, standard services (CBR, VBR, ABR, UBR)

Radio Access Layer (RAL) requirements: PHY layer

- Definition of cell characteristics
  - frequencies, efficient re-use of frequencies, antennas, power, range
- Carrier frequency, symbol rate, modulation, coding, training sequences etc.
- Data and control interfaces to the radio unit

- Requirements
  - Bit Error Rate (BER) <= 10^{-4}, availability 99.5 %
  - data rate: 25 Mbit/s
  - range: indoor 30-50 m, outdoor 200-300 m
  - power: 100 mW

Radio Access Layer (RAL) requirements: MAC layer

- Supports
  - simultaneous access of several mobile terminals to the medium
  - several ATM service classes (CBR, VBR, ABR, UBR) including QoS control
- MAC protocol and syntax definition, MAC control algorithms
- Interfaces to PHY and LLC layer
- Support of user mobility

- Requirements
  - MAC efficiency: 60-75 % (over 90% is possible)
  - data rates
    - peak 25 Mbit/s
    - sustained 6 Mbit/s
    - still efficient for low rates (e.g., 32 kbit/s CBR)

Radio Access Layer (RAL) requirements: LLC layer

- Layer between ATM and MAC/PHY layers to solve specific problems of the wireless transmission
- Definition of LLC protocol and syntax
  - wireless header, control messages
- Special functions for ATM service classes
  - error control
    - error detection and correction
    - selective retransmission
  - forward error correction

- Requirements
  - mandatory: ARQ (Automatic Repeat Request)
  - optional: FEC for real-time services
  - optional: meta-signaling to support handover

ETSI Broadband Radio Access Network (BRAN)

Motivation

- deregulation, privatization, new companies, new services
- How to reach the customer?
  - alternatives: xDSL, cable, satellite, radio

Radio access

- flexible (supports traffic mix, multiplexing for higher efficiency, can be asymmetrical)
- quick installation
- economic (incremental growth possible)

Market

- private customers (Internet access, tele-xy...)
- small and medium sized business (Internet, MM conferencing, VPN)

Scope of standardization

- access networks, indoor/campus mobility, 25-155 Mbit/s, 50 m-5 km
- coordination with ATM Forum, IETF, ETSI, IEEE, ...

Broadband network types

Common characteristics

- ATM QoS (CBR, VBR, UBR, ABR)

HIPERLAN 2

- short range (< 200 m), indoor/campus, 25 Mbit/s
- extension of HIPERLAN 1, access to telecommunication systems, multimedia applications, mobility (<10 m/s)

HIPERACCESS

- wider range (< 5 km), outdoor, 25 Mbit/s
- fixed radio links to customers (“last mile”), alternative to xDSL or cable modem, quick installation

HIPERLINK

- intermediate link, 155 Mbit/s
- connection of HIPERLAN access points or connection between HIPERACCESS nodes

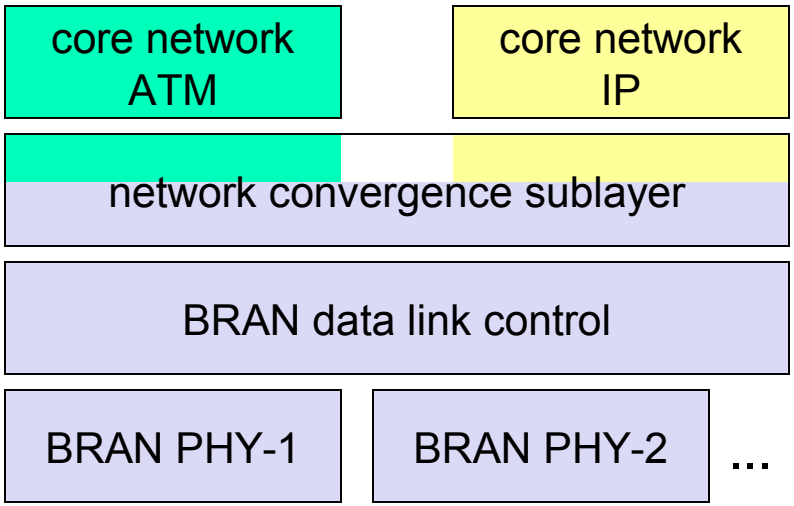
BRAN and legacy networks

Independence

- BRAN as access network independent from the fixed network
- interworking of TCP/IP and ATM under study

Layered model

- Network Convergence Sub-layer as superset of all requirements for IP and ATM

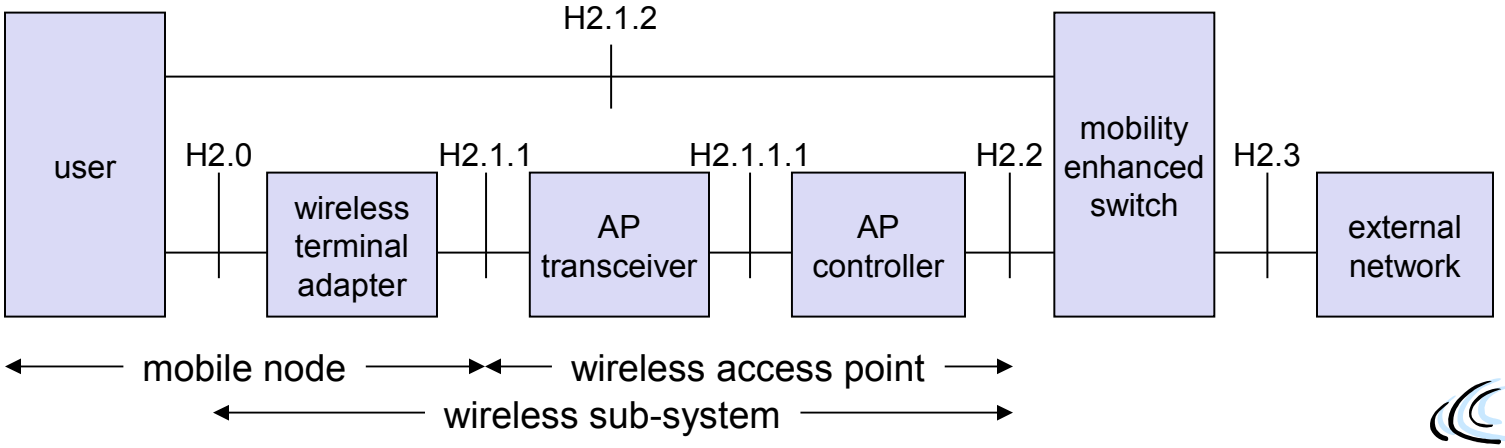


Coordination

- IETF (TCP/IP)
- ATM forum (ATM)
- ETSI (UMTS)
- CEPT, ITU-R, ... (radio frequencies)

ETSI Broadband Radio Access Network (BRAN)

- wireless access with bit rates ≥ 25 Mbit/s
- connection to private and public networks
- scope of specifications
  - physical layer
  - data link control layer
  - interworking, especially to fixed ATM networks and TCP/IP protocols
- coordination with ATM Forum, IEEE 802.11, IETF, ITU-R, ...
- reference points



Handover

Procedure to hand over connection(s) from a mobile ATM terminal from one access point to another access point

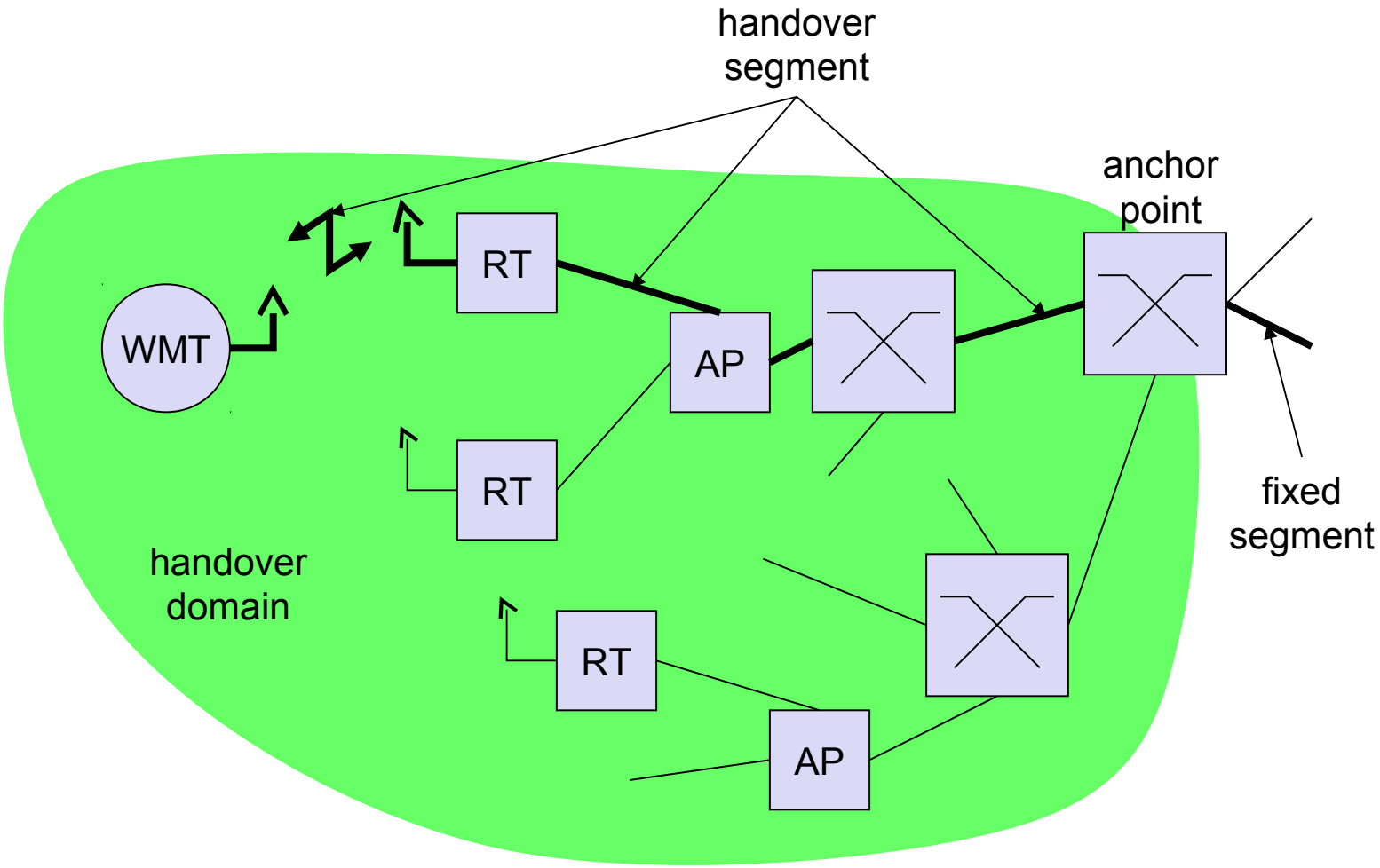
Support of an handover domain

- several access points cover a certain area
- common handover protocol and strategy
- all access points and switches belong to one administrative domain

Requirements

- multiple connection handover
- point-to-point and point-to-multipoint
- QoS support
- data integrity and security
- signaling and routing support
- high performance and low complexity

Simple handover reference model



Types of handover

Hard handover
- only one connection to one access point possible

Terminal initiated
- WTM initiates HO based on, e.g., signal quality

Network initiated
- Network initiates HO based on, e.g., network load

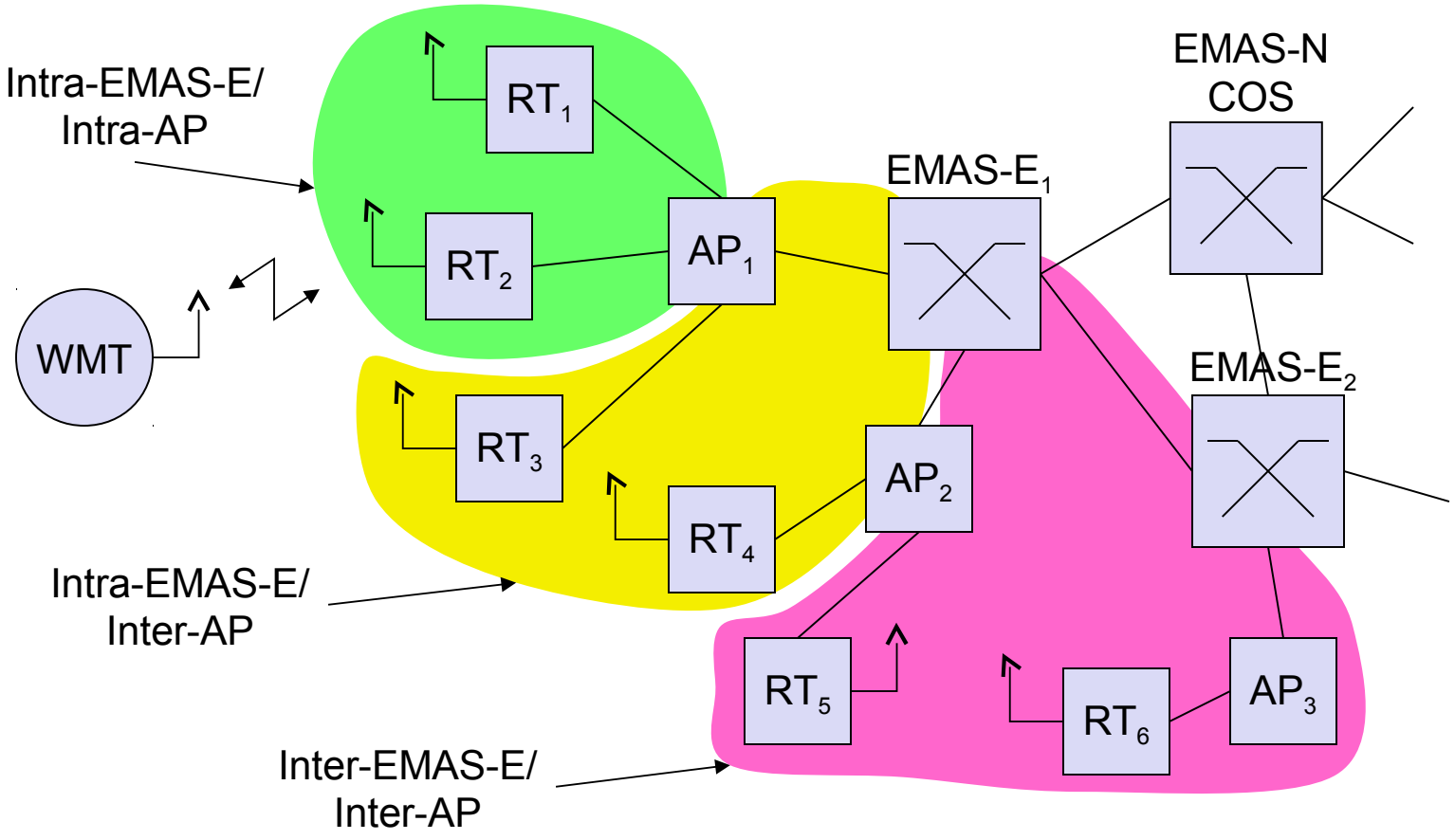
Network initiated, terminal assisted
- WTM provides information about radio conditions

Network controlled
- HO decision always at network

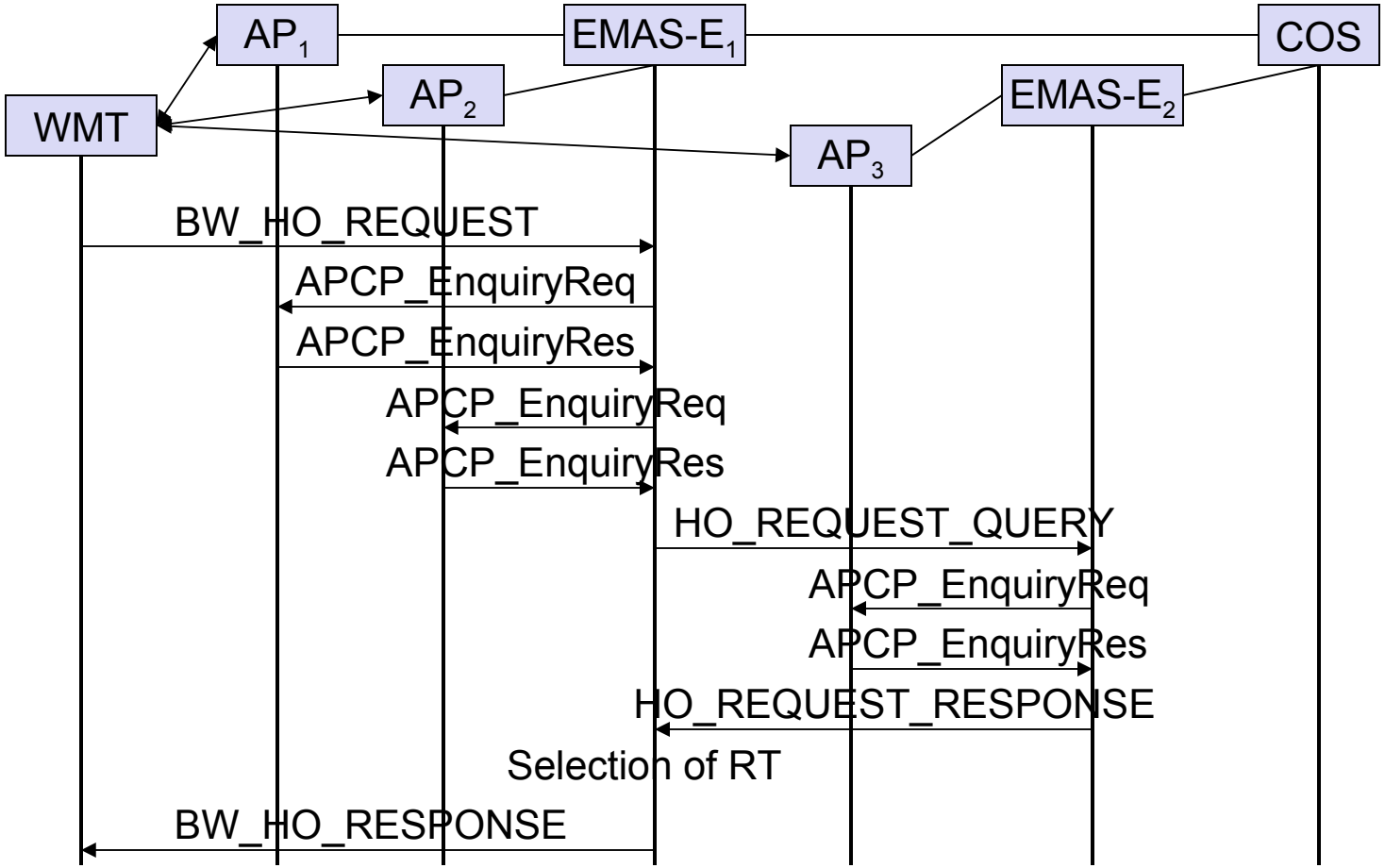
Backward handover
- standard type, WMT initiates HO, everything is prepared for HO *before* HO takes place

Forward handover
- WMT suddenly arrives at a new AP, connection loss possible

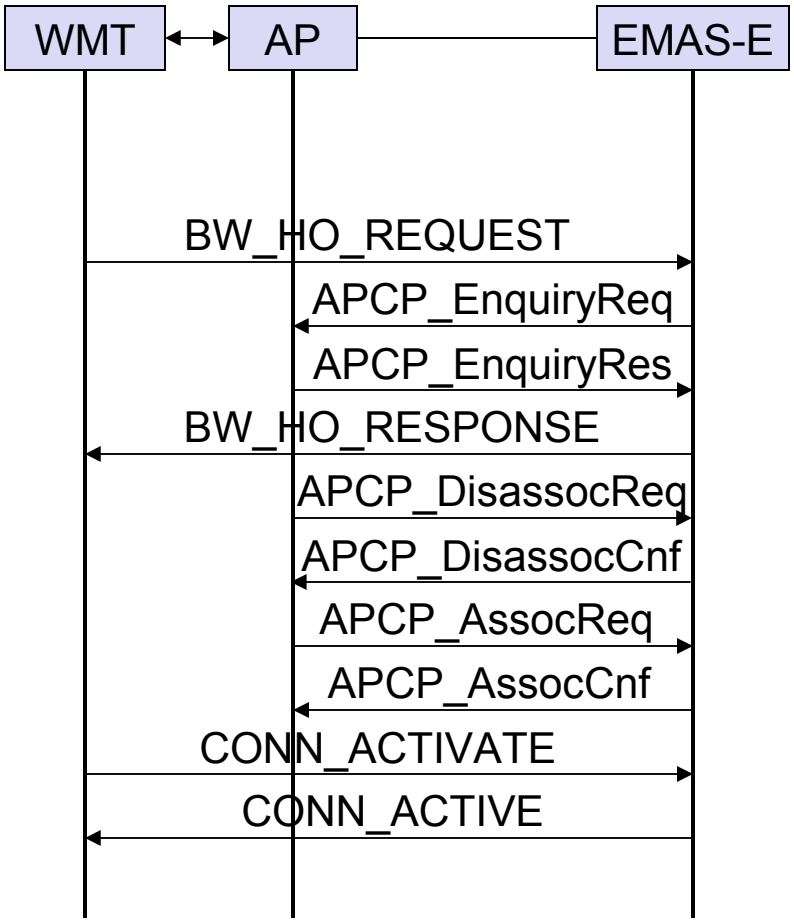
Handover scenarios



Backward handover with multiple possible APs



BW handover - Intra-EMAS-E/Intra-AP



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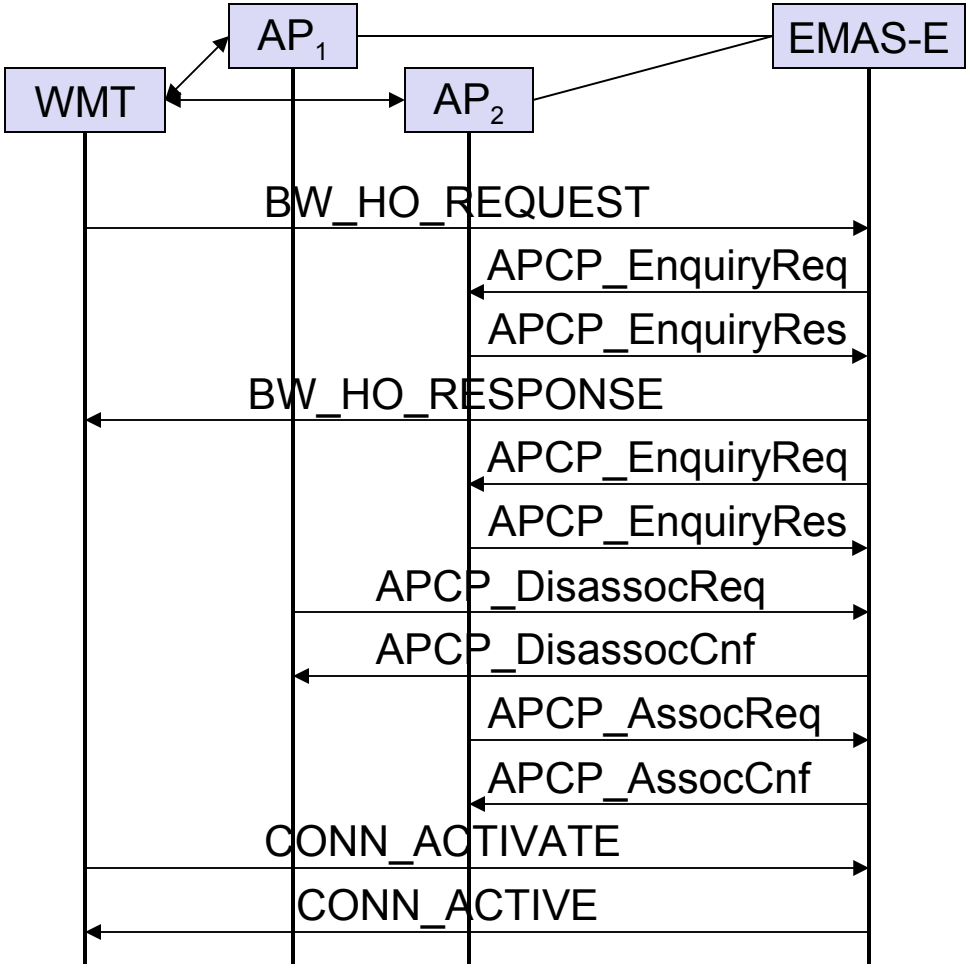

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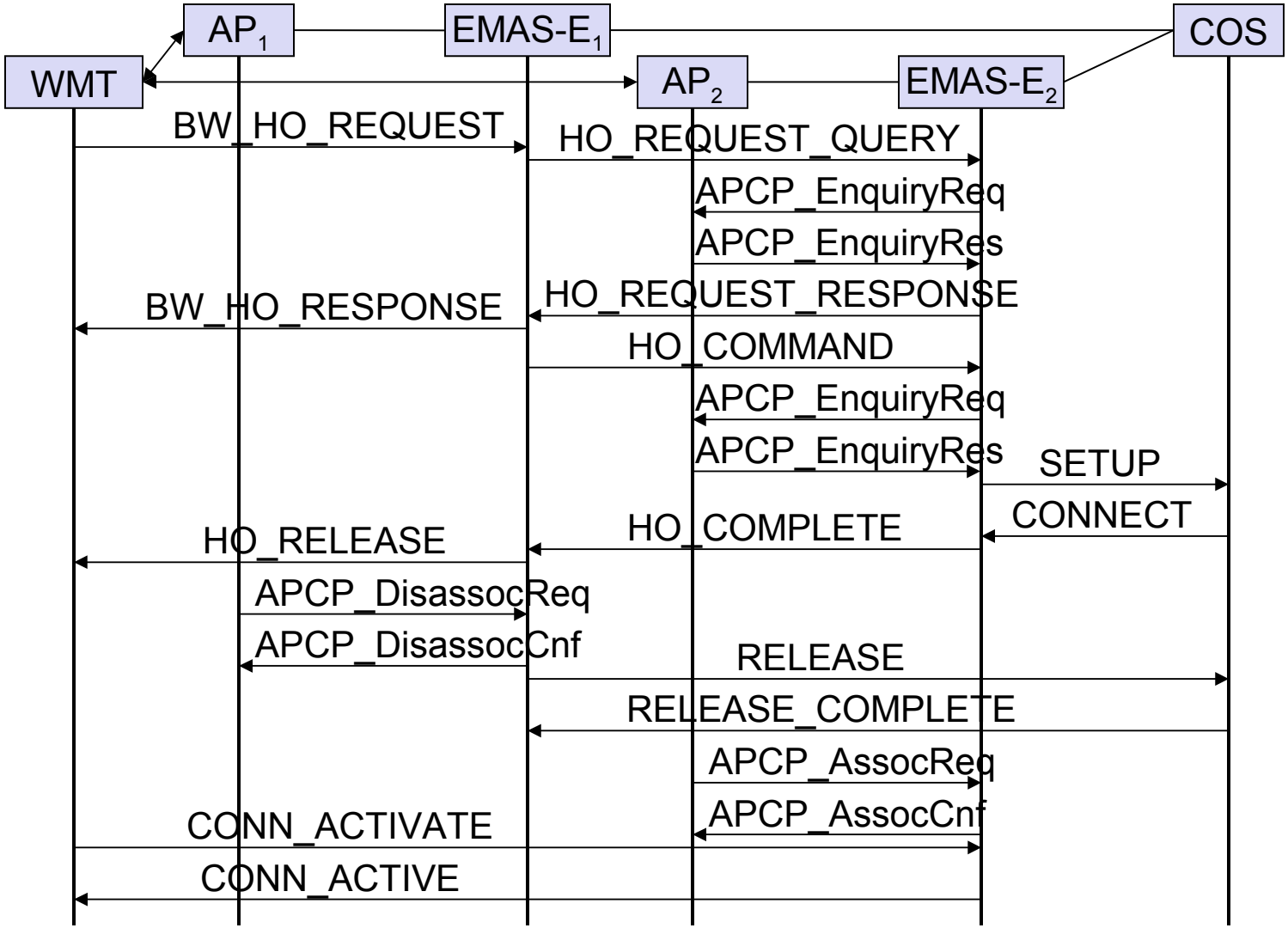
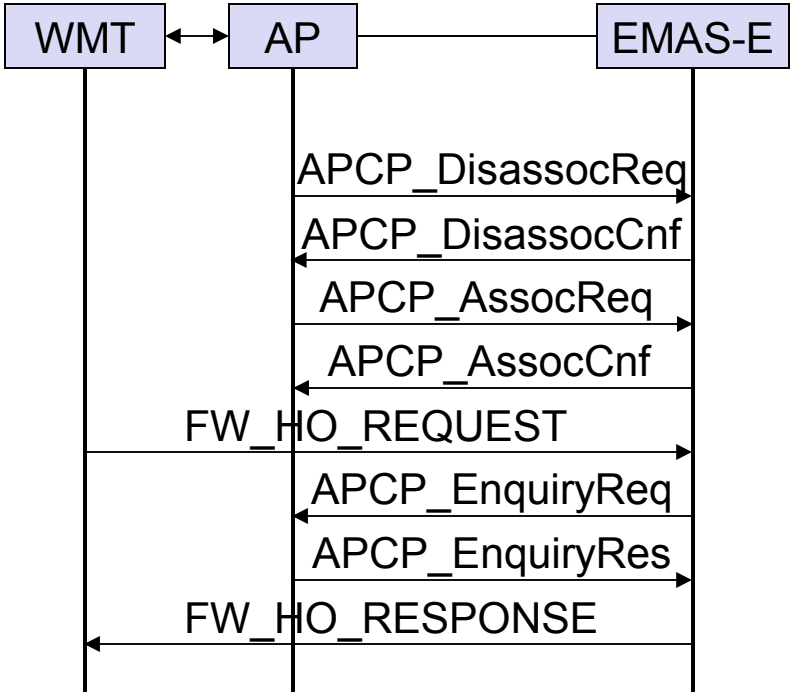


FW handover - Intra-EMAS-E/Intra-AP



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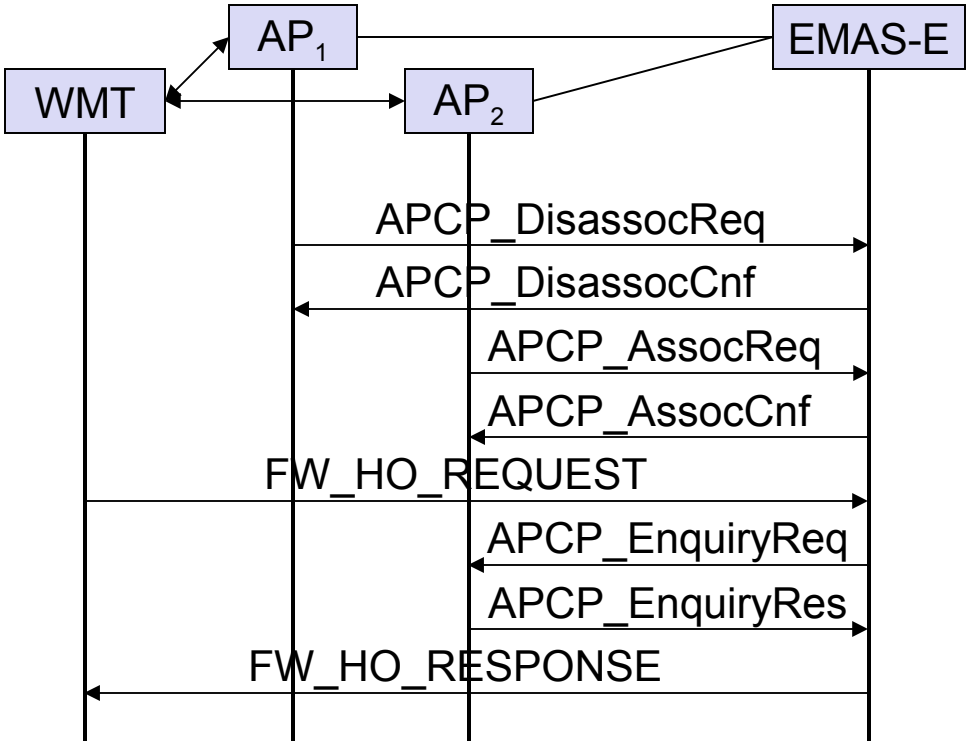

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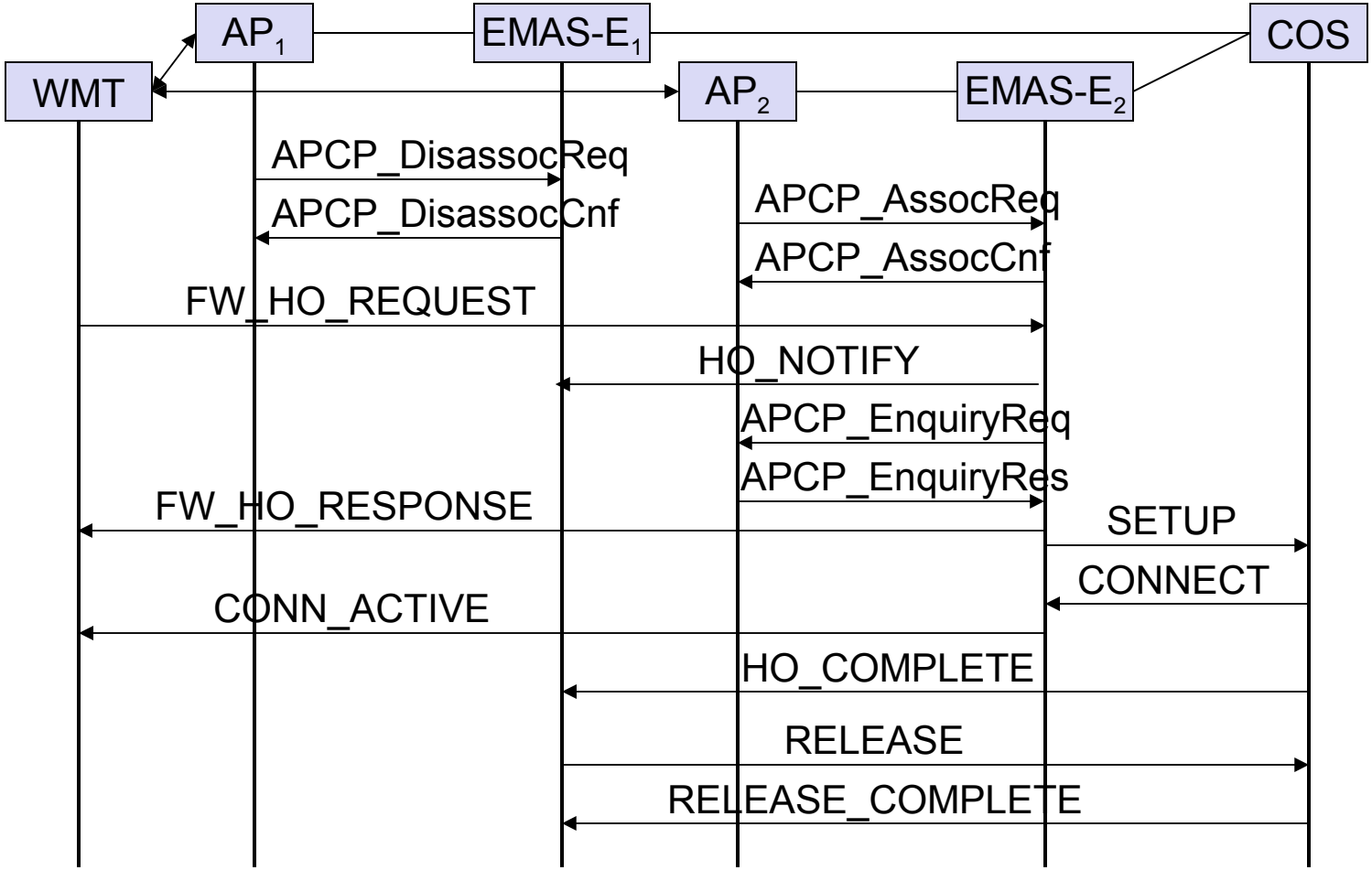


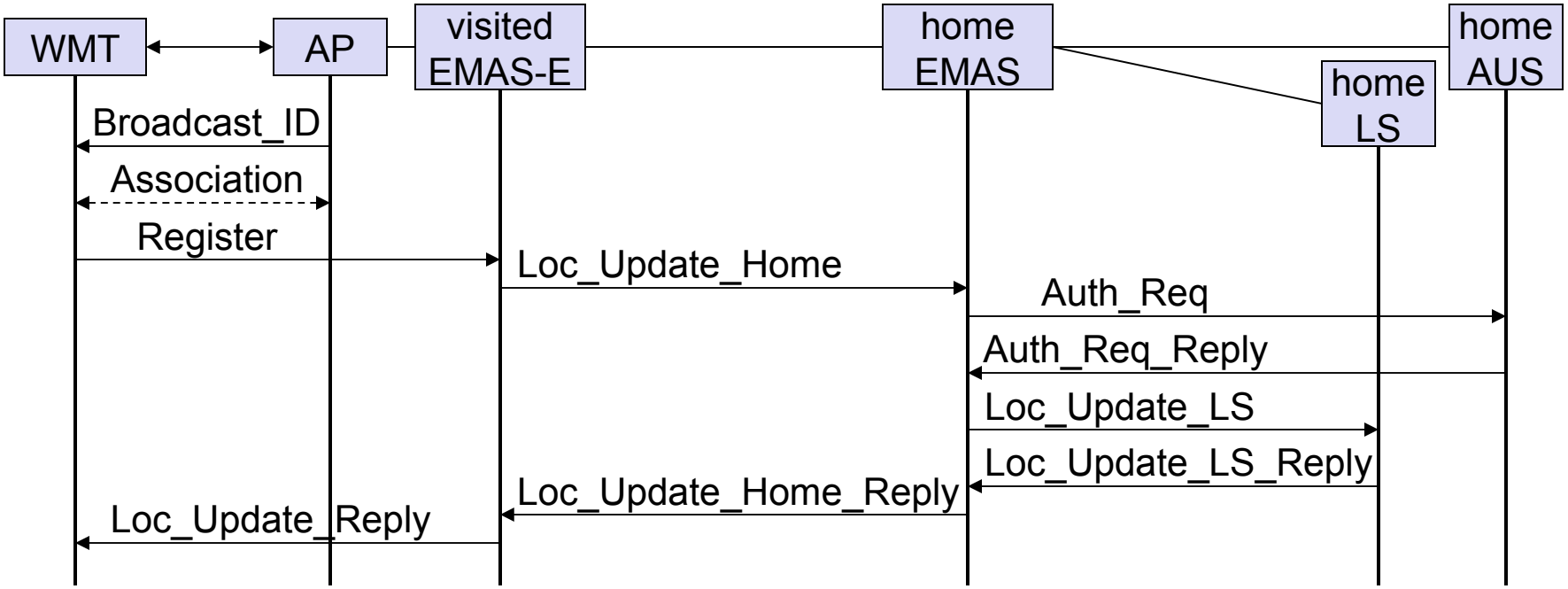
Location management

Requirements

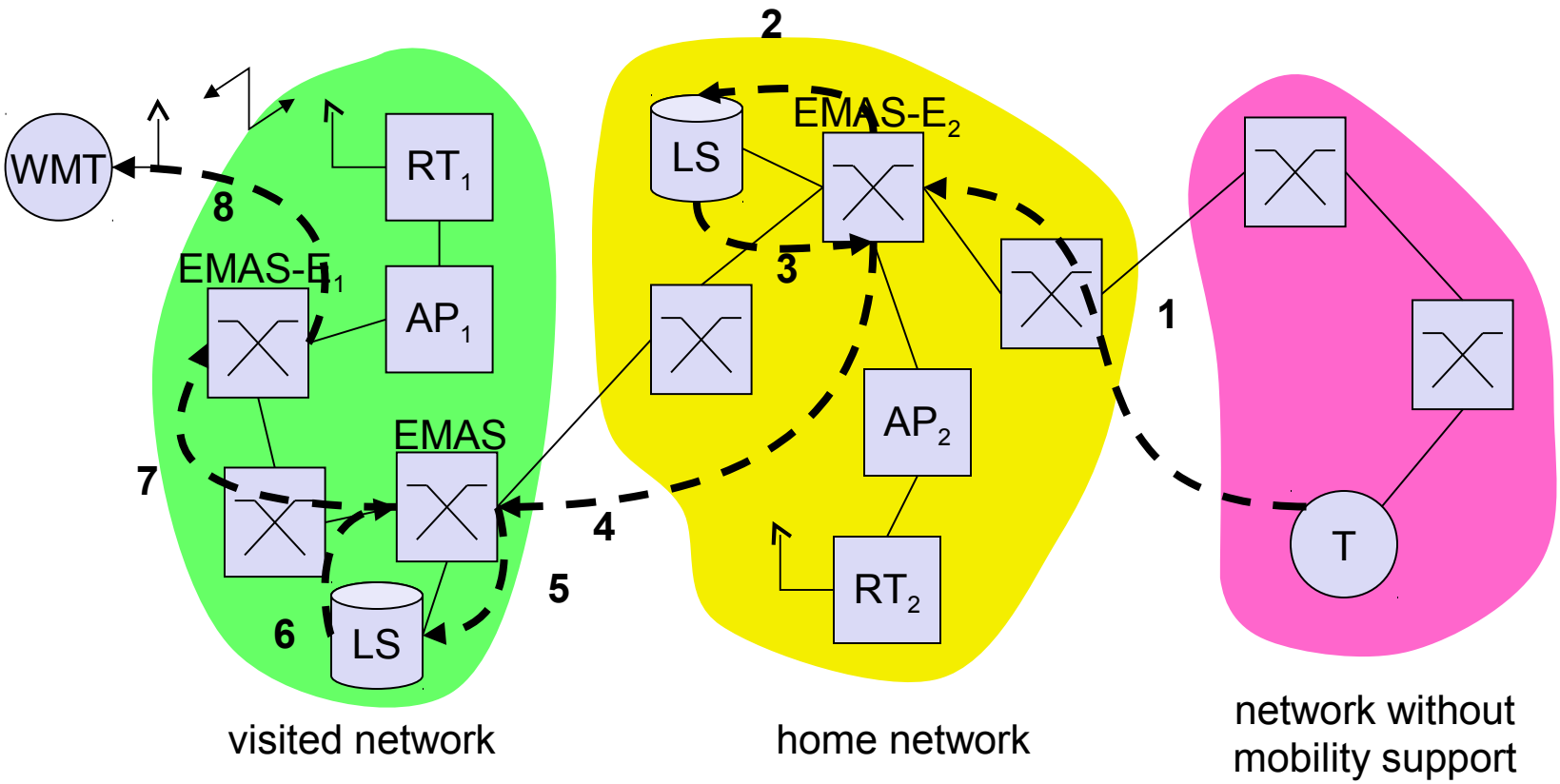
- transparent for users
- privacy of location and user information
- cell and network identification
- minimum of additional signaling required
- access control, accounting
- roaming
- scalability

- standardized method for registration (i.e, a new user joins the network)
- mobile terminals get temporary, routable addresses
- common protocol for database/registry updates
- location management must cooperate with unchanged ATM routing

Registration and location update



Incoming connection setup, WMT in foreign network



LS: Location Server

Addressing

- should support all formats of ATM end-system addresses (AESA)
- uses a permanent, location independent address which has to correspond with a routable address from the “home network”
- supports the assignment of temporary, routable addresses during registration of the mobile terminal in a foreign domain

Mobile Quality of Service (M-QoS)

Main difference to, e.g., Mobile IP

M-QoS main reason for high complexity

M-QoS parts

- Wired QoS
  - same as in wired ATM networks
- Wireless QoS
  - delay and error rates higher, multiplexing and reservation important
- Handover QoS
  - blocking, cell loss during handover, duration of handover

Hard handover QoS

- no QoS guarantee after handover
- disconnect if not enough resources in new cell

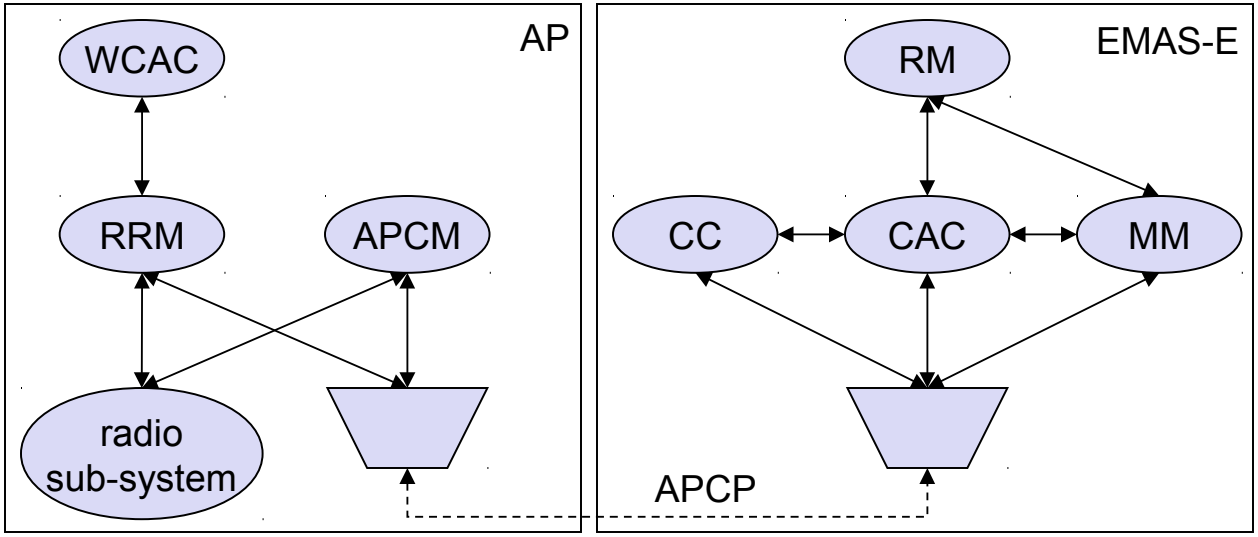
Soft handover QoS

- only statistical guarantees
- applications have to adapt

Access Point Control Protocol

Interface between a wireless aware segment and an unchanged segment of the ATM network

- Switch protocol to control wireless access points
  - reservation and release of resources
  - preparation of access points for new connections
  - handover support
  - announcement of new mobile terminals



RM: switch resource management
CC: call control
CAC: connection admission control
MM: mobility management
RRM: radio resource management
WCAC: wireless CAC
APCM: AP connection management
APCP: AP control protocol

Reference model with further access scenarios I

1: wireless ad-hoc ATM network

2: wireless mobile ATM terminals

3: mobile ATM terminals

4: mobile ATM switches

5: fixed ATM terminals

6: fixed wireless ATM terminals

WMT: wireless mobile terminal

WT: wireless terminal

MT: mobile terminal

T: terminal

AP: access point

EMAS: end-user mobility supporting ATM switch (-E: edge, -N: network)

NMAS: network mobility supporting ATM switch

MS: mobile ATM switch

Reference model with further access scenarios II