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Purpose:

This presentation is intended to provide an overview of the submission IEEE 802.16.1mc-00/21r1, “Media Access Control Layer Proposal for the 802.16 Air Interface Specification”.

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Joint Proposal for 802.16.1 MAC

Glen Sater (representing D+)

Ken Stanwood (representing E+)

Outline

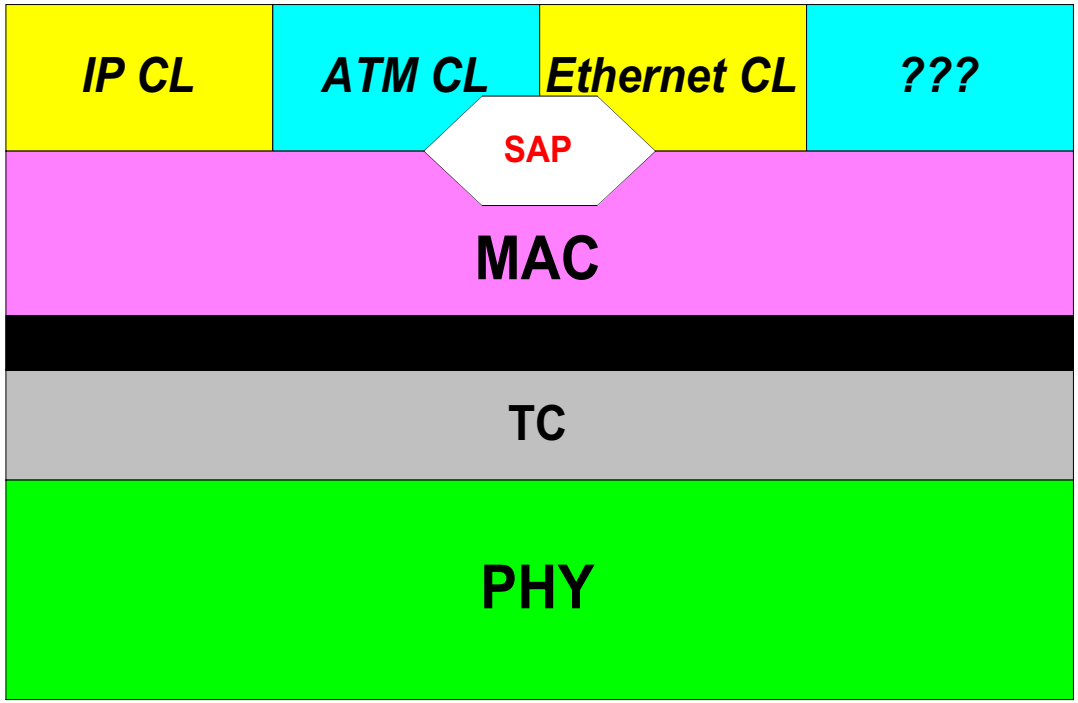
- Working Assumptions from Session 7.5
- Current Proposal
- Issues Requiring Further Investigation

Working Assumptions

Session 7.5, Boulder Meeting

Protocol Stack

- Addressing mechanism
- Parameterized Protocol independent SAP
- TLVs at higher level SAP
- It is useful to have a set of default SAP parameters



Management Messages

- Have 2 categories of Management messages
  - Low level real time: PHY related, Change power level
  - High level non-real time: TFTP, NMS, SW download
  - High level on a different connection and lower priority than low level (which are more “real time”)

SAP Definition

- Data SAP parameters/commands
  - Request (down), Indicate (up)
    - CID, length, PDU, Discarding eligibility
- MAC_Create_Service_Flow
  - Request (down), Response (up)
    - QoS parameters, Traffic descriptors, Sequence number
  - Indicate

SAP Definition – *cont.*

- CID allocation
  - Generated in the base station in response to a request to admit the connection
  - Request can be initiated by either base station or CPE
- Examine D+ MAC management related to provisioning of service flows
- Discard priority information - not over the air, but it is part of the SAP
- SAP would include a master timing parameter
  - Distribution of clock (i.e., 8 KHz) on the CPE side

PDU Header over the Air

- CID (16 bits)
  - Review the case of grants per terminal vs. grants per connection
- Length (11 +/- bits)
  - 2K Ethernet packet max.
- BW Request / PDU
  - Flag to notify type (1 bit)
- Encryption Key
  - Sequence Cycle (4 bits)
  - Encryption On/Off flag (1 bit)
- Header protection (8 bits for short fixed)

PDU Header over the Air – *cont.*

- Fragmentation (6 bits)
  - Begin • Continue • End (2 bits)
  - Sequence numbering (4 bits)
- Grant interval management
  - CBR mode = Poll me bit, Slip buffer indicator bit (2 bits total)
  - UG with activity detection mode = Dynamic grants per interval (7 bits), Slip buffer indicator bit (8 bits total)
  - DAMA = Piggy-back request (8 bits total)

BW Allocation (Grants)

- Base Station
  - Supports both modes
    - BW allocation either to terminal or connection
- Terminal
  - Supports either one of the modes
    - Negotiate at registration

GPT = *Grant per Terminal mode*

GPC = *Grant per Connection mode*

Rules

- Full connection IDs must be supported
- For terminals in GPT mode all grants are to a basic CID

  Remarks:

  – In the terminal, bandwidth would be allocated to individual connections in accordance to its scheduling algorithm

  – The scheduling algorithm must comply with the agreed QoS parameters for the connections
- For terminals in GPC mode all grants are to the connections
- Common structure to both modes
- All requests by connection

Grant Structure

- CID (16 bits)
- Burst type (4 bits)
  - Data, Ranging …
- Offset from previous (12 bits)
  - Determines the location
  - Length by using the next offset
  - Time information
    - A “tick” is multiple of 4 symbols
    - Broadcast
  - Null grant at the end
  - First grant is referenced to frame/map start

Scheduling Services

- UG Service (CG)
- UG with activity detection
- Real-Time Polling(*)
- Non Real-Time Polling
- Best effort (Contention based)

*(*) **Remark**: Basic polling procedures (i.e., algorithm, cycle) need to be defined for the GPC & GPT cases individually*

Poll me bit

- Use depends on granting mode:
  - GPC
    - Currently not used (no “Terminal” concept)
  - GPT
    - Only used for a terminal with a sufficient rate UG connection to request to be polled
    - Standard poll messaging by base station
- Details need to be worked out in both GPC/GPT cases for the exact use of the *Poll me bit*

Downlink

- In the H/FDD case the map is similar to the uplink map as it solves the same TDMA allocation problem
- In TDD (TDM) we need pointers
  - 16 bit modulation change locator

General Issues - I

- 64 bit EUI at Registration
- CID uniquely defines the service flow
- Burst profiling
  - Similar concept to the one in D+
  - Parameters need to be revisited when new FEC chosen
- Frame
  - Definition: “Frame” is PHY related while “Scheduling Interval” MAC related
- “Time stamps”
  - In Mode B PHY the frame concept provides the time base
  - The map is at the “scheduling interval” start and referenced to a PHY related time base

General Issues – II

- Policing
  - Not a MAC issue
- Ranging & Power Control
  - General messaging structure – OK
  - Using either the ranging interval ***or*** a MAC management connection to notify base station for a modulation change (downstream)
  - Missing mechanism to notify the base station when the terminal reaches min/max power level
- Adaptive Modulation
  - Need to overview algorithm for terminal/base station modulation change
  - Threshold modulation change update ?
  - Definition of statistics to be collected by terminals and base stations to assist the adaptive modulation process

General Issues – III

- Registration
  - Initial registration process as defined by the D+ document
    - Reg. Sequence & general format and content of the messages
- Sync. Message
  - Common format for supporting both PHY modes
- Encryption & Authentication
  - D+ Key mgt. Protocol – OK
  - ***Investigate***: Strength of different modes (CBC/Counter), Key sequencing mechanism, version, root certificate authority and validity, counter availability for PHY mode A
- Dynamic service messages
  - D+ concept - OK

General Issues – IV

- Define Convergence Sub-layers for ATM, IP and Ethernet
- Contention resolution
  - Binary exponential Back-off
- Base line for registration
  - Single registration event per “window”
  - Examine the sliding window (multi-reg. Events per window) concept at registration
    - Different message structure to reflect reference timing point
    - Modeling should resolve this issue

Current Proposal

Highlights

- True merge of D+ and E+ proposals
- Supports both PHY mode A and PHY mode B, including variants of mode B

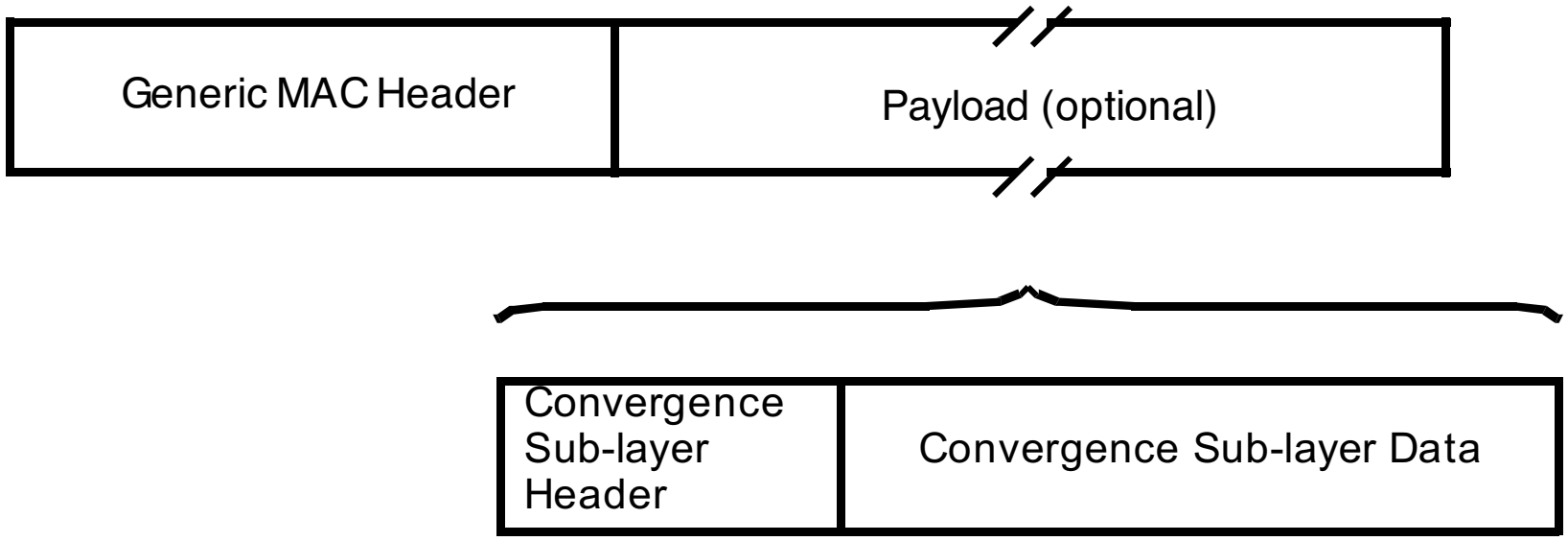
Connections and Service Flows

- Connection oriented - service flows mapped to connections
- Separate UL and DL connections for services
- Basic, higher layer management, and transport connections

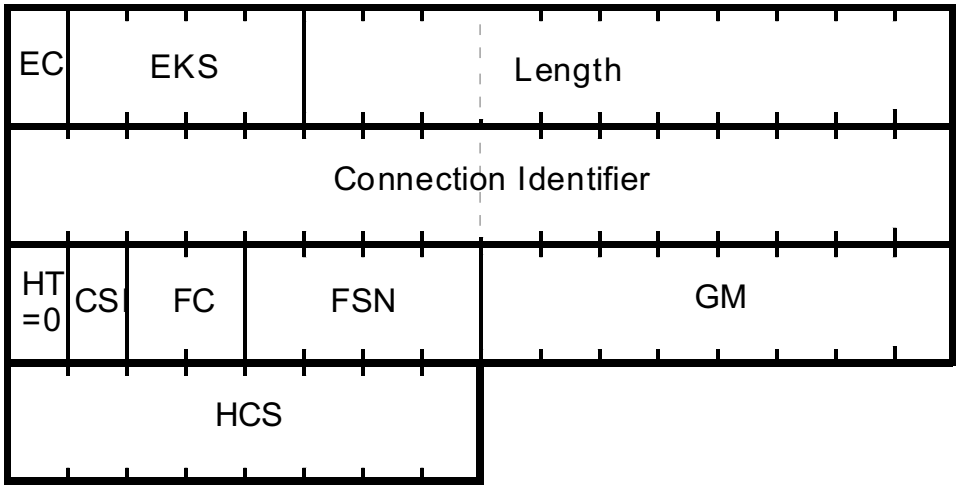
Addressing

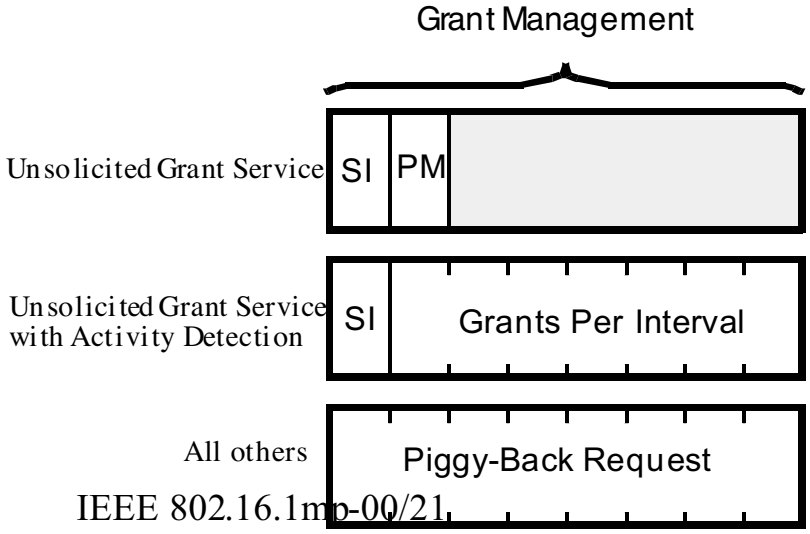
- EUI-64 device Ids
- 16 bit CIDs
  - Initial Ranging
  - Temporary Registration
  - Basic
  - Management
  - Transport
  - Priority Requests
  - Mulitcast Polling
  - Broadcast

MAC PDU Format

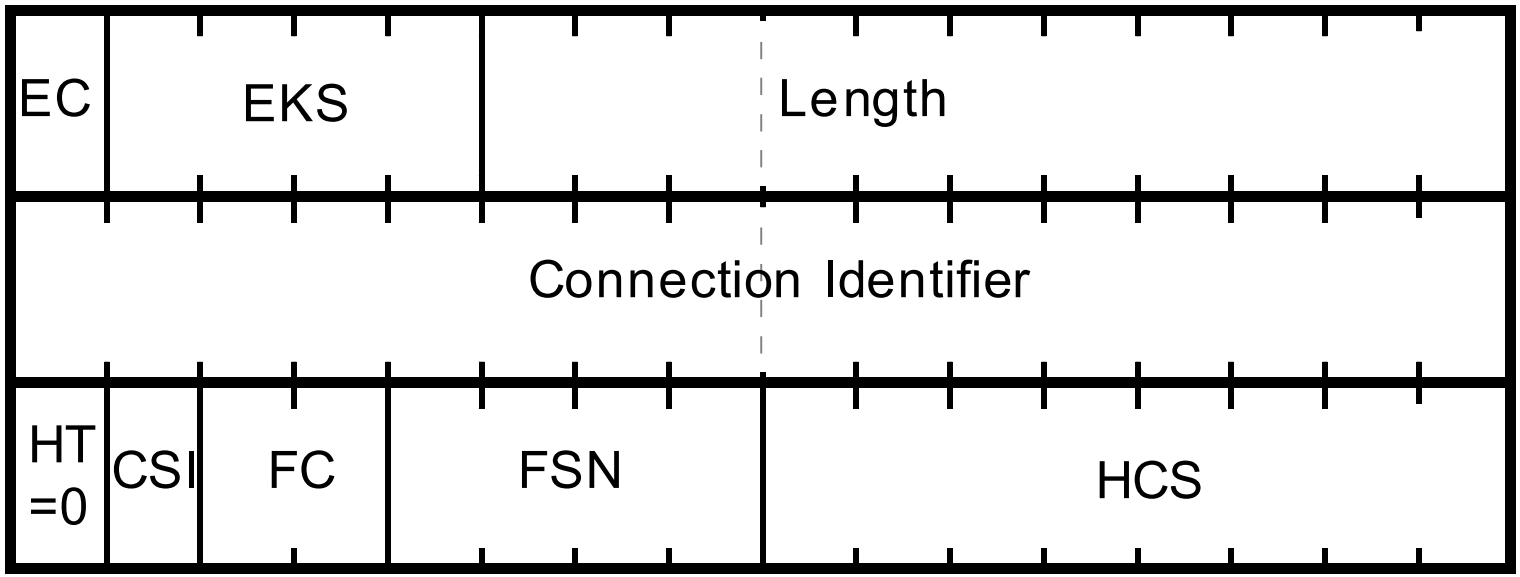


Uplink MAC Header

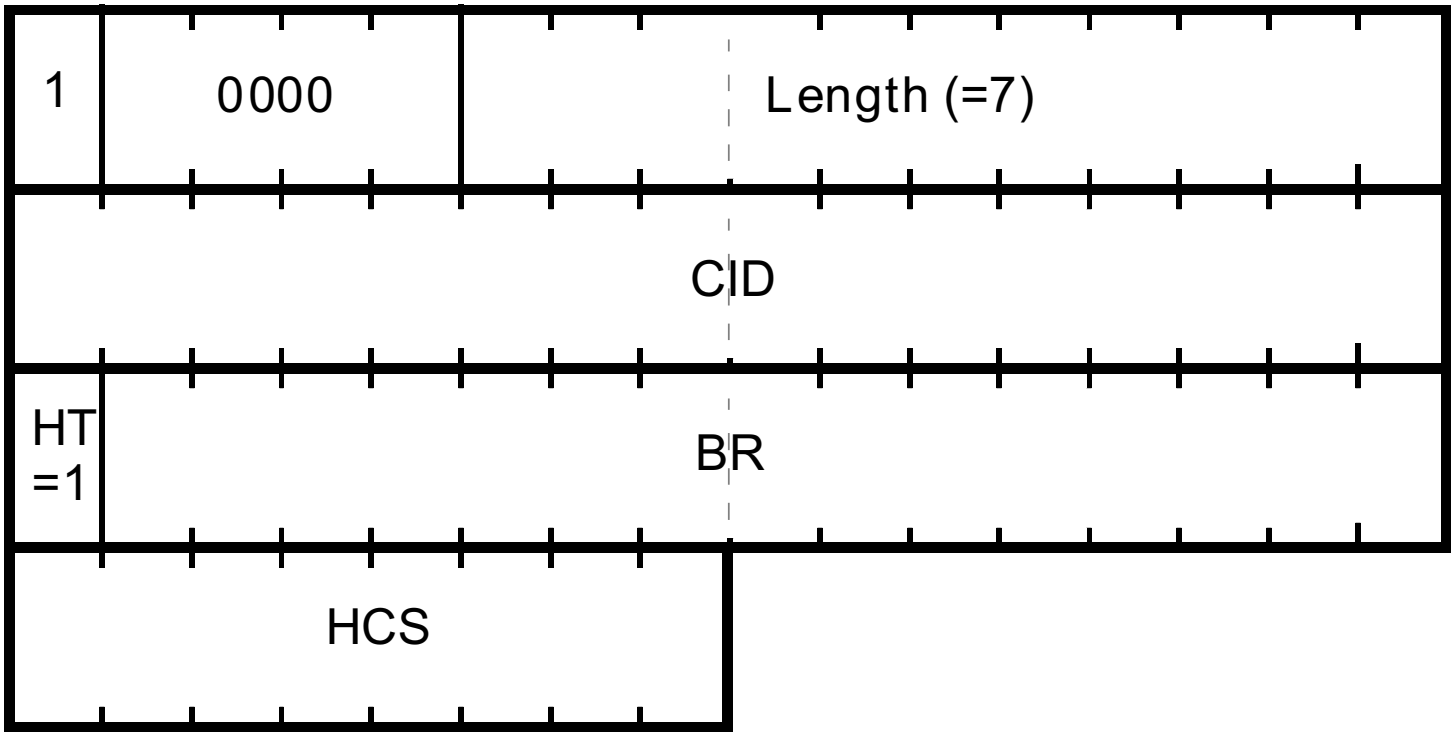




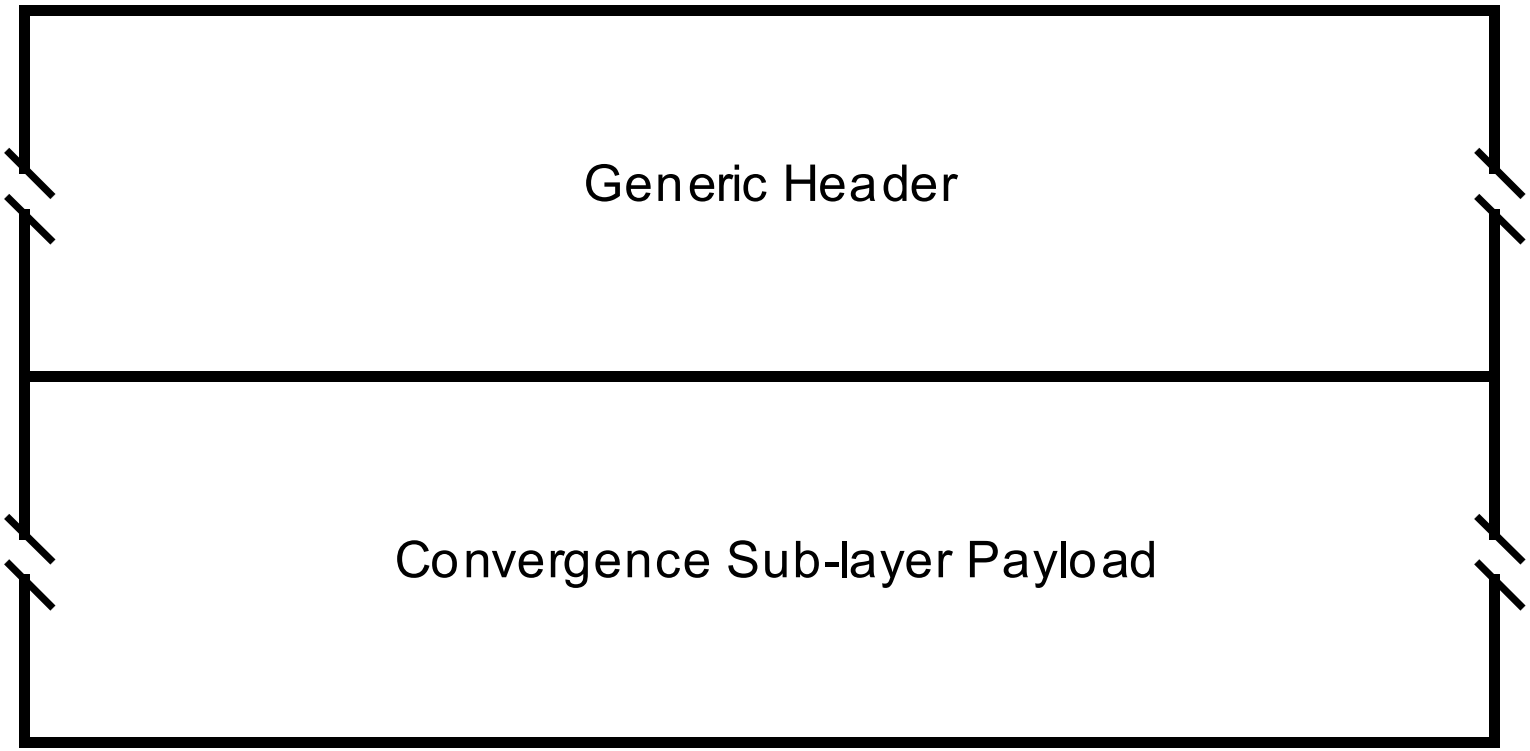
Downlink MAC Header



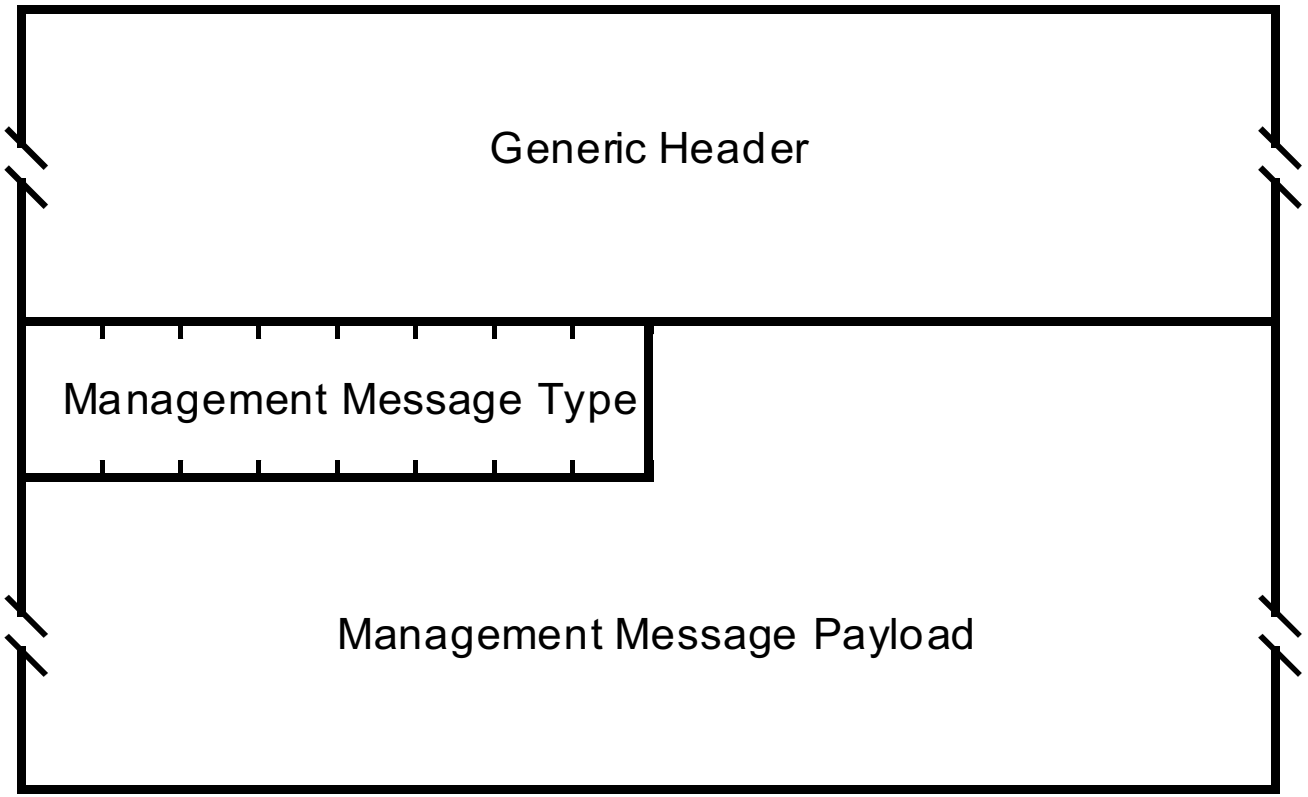
Bandwidth Request Format



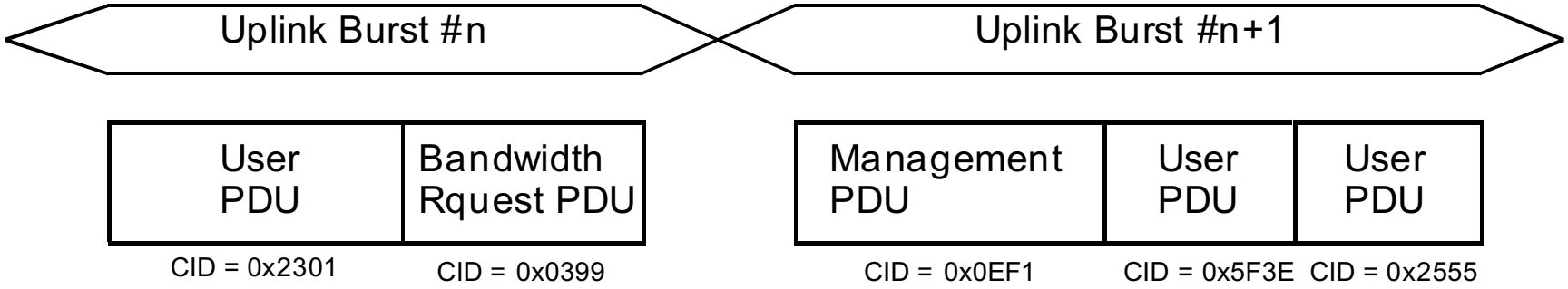
Convergence Sublayer PDU Format



MAC Management Message Format



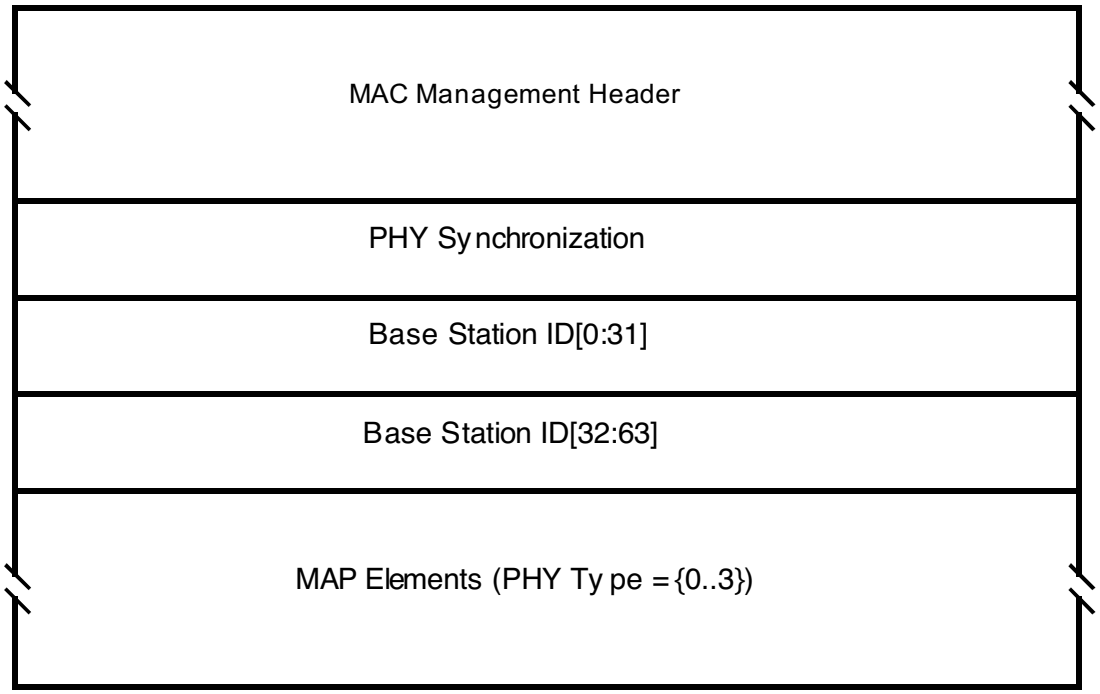
PDU Concatenation



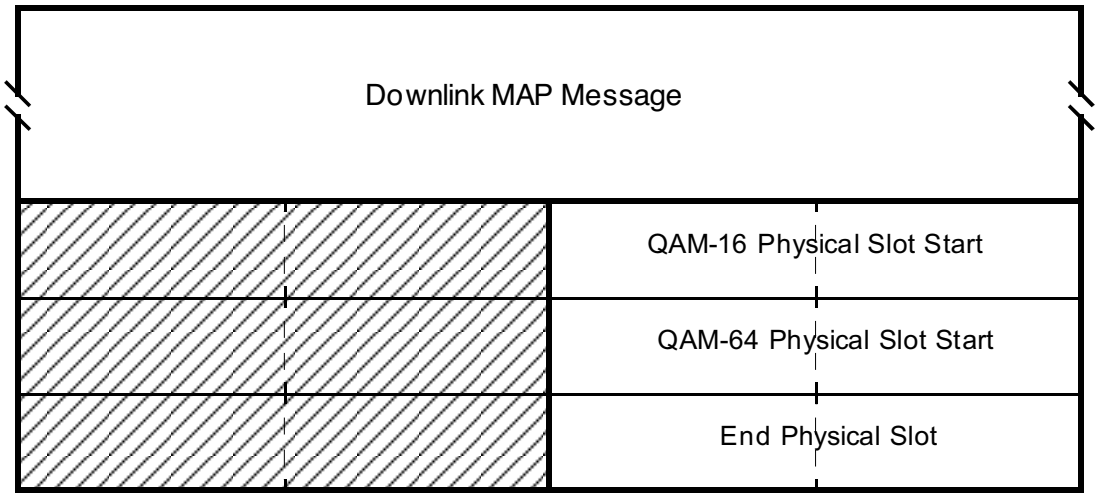
MAC Management Messages

- Physical Channel Desciptor
- Downlink Map
- Uplink Map
- Ranging Req/Resp
- Registration Req/Resp/Ack
- Privacy Key Mgmt Req/Resp
- DL Modulation Change Req
- Dynamic Service Addition Req/Resp/Ack
- Dynamic Service Change Req/Resp/Ack
- Dynamic Service Deletion Req/Resp
- Dynamic Channel Change Req/Resp
- Multicast Assignment Req/Resp

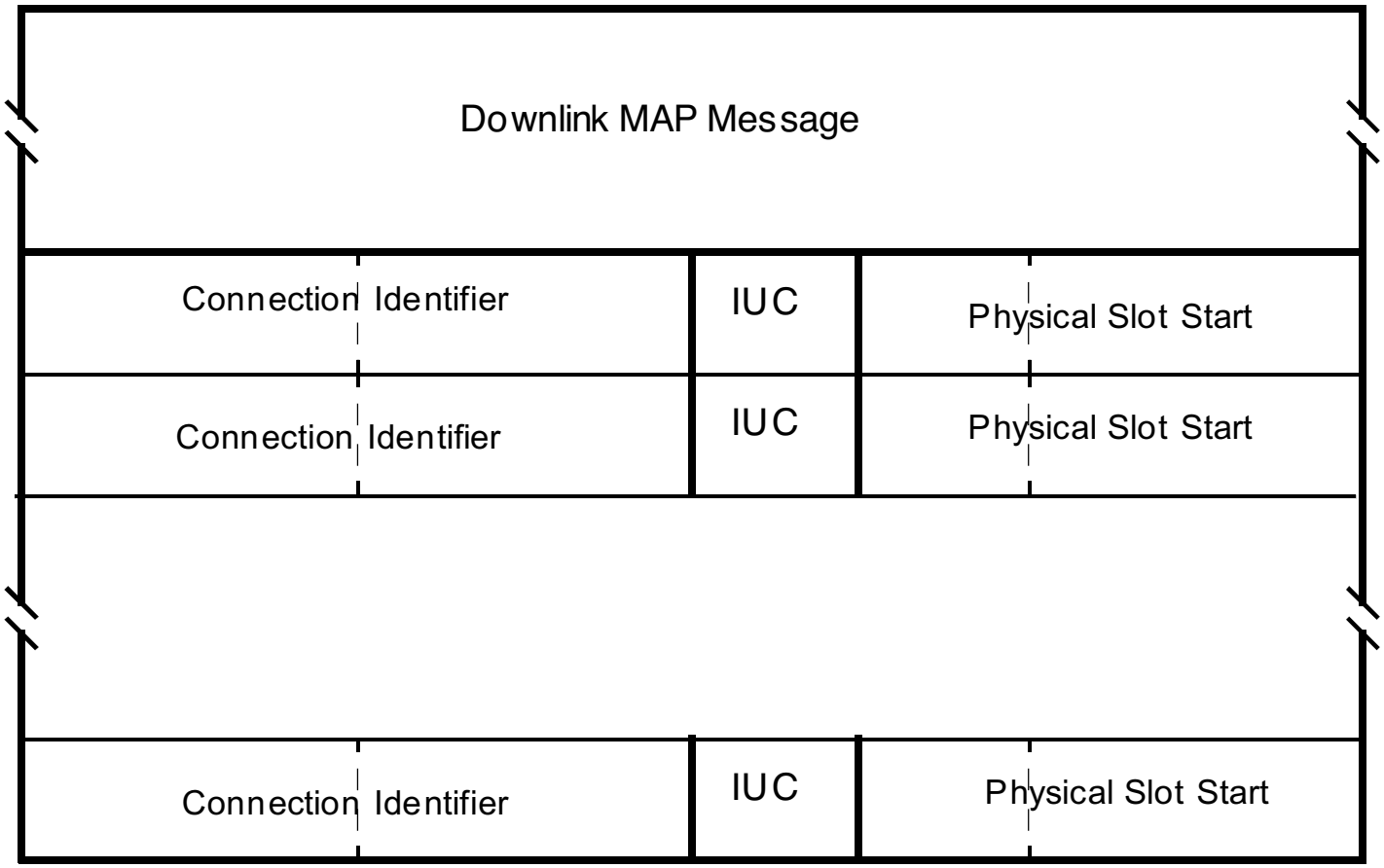
Downlink Map (Common Part)



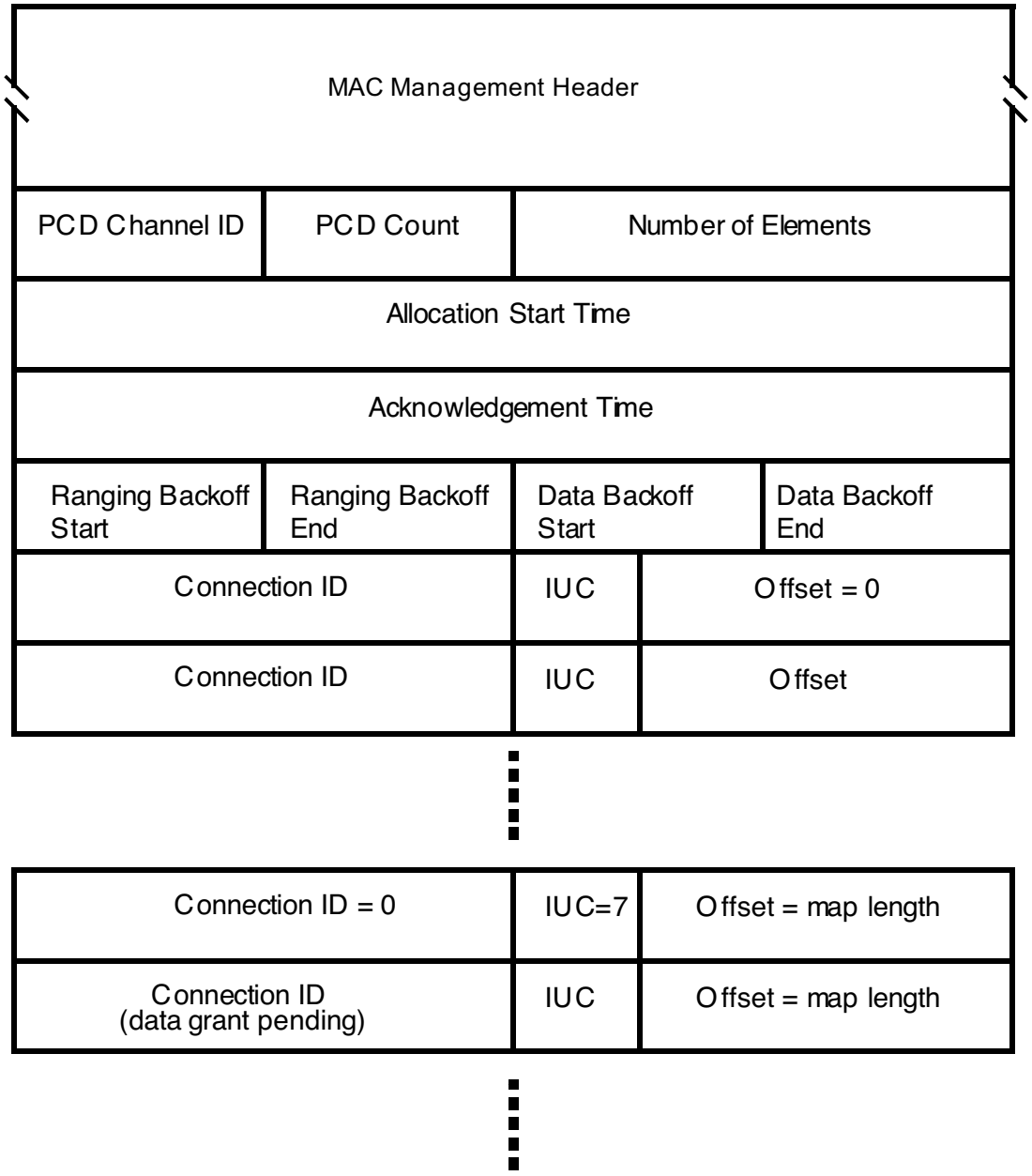
Downlink Map (Burst TDM)



Downlink Map (Burst TDMA)



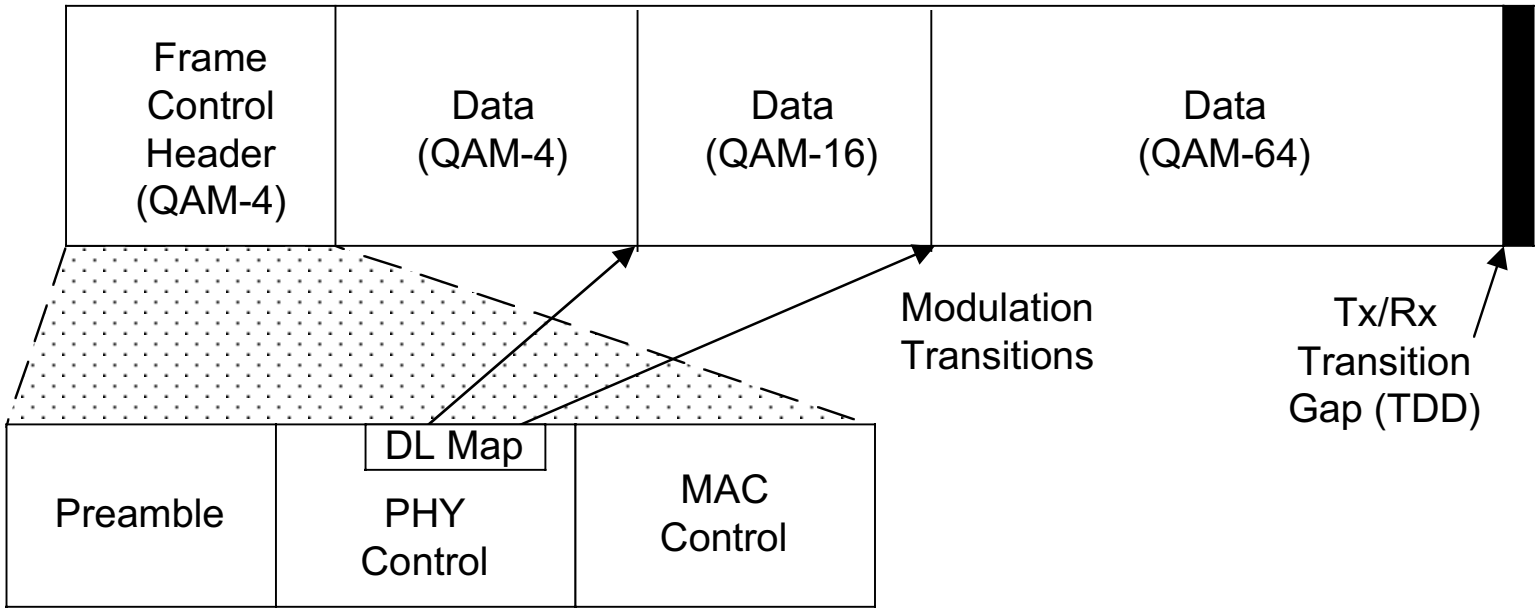
Uplink Map


MAC Management Header
PCD Channel ID
PCD Count
Number of Elements
Allocation Start Time
Acknowledgement Time
Ranging Backoff Start
Ranging Backoff End
Data Backoff Start
Data Backoff End
Connection ID
IUC
Offset = 0
Connection ID
IUC
Offset
Connection ID = 0
IUC=7
Offset = map length
Connection ID (data grant pending)
IUC
Offset = map length

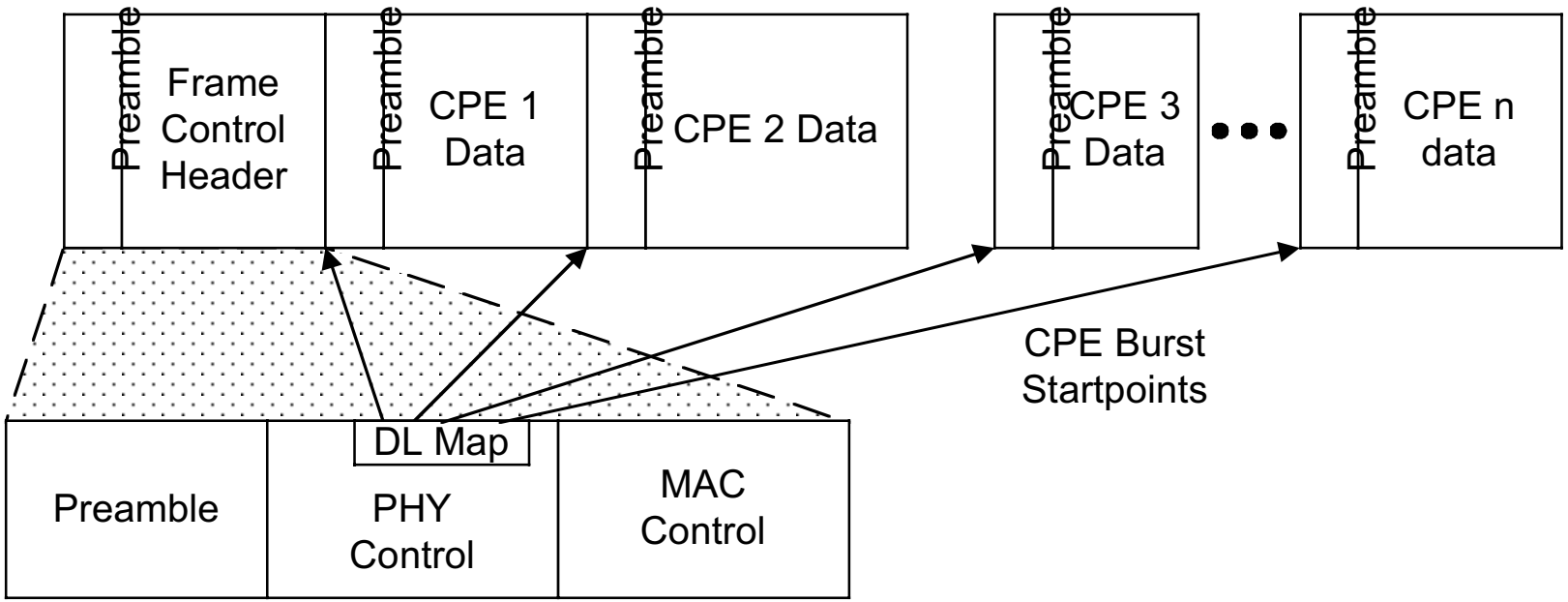
UL Interval Usage Codes

- Initial Ranging (registration)
- Maintenance Ranging (GPC)
- Bandwidth Contention Request
- Bandwidth Grant
  - 3 Pairs (PHY mode support)
  - Short/Long Grant Pairs
  - 0 Length Grant for Acks
- Null (for terminating MAP)

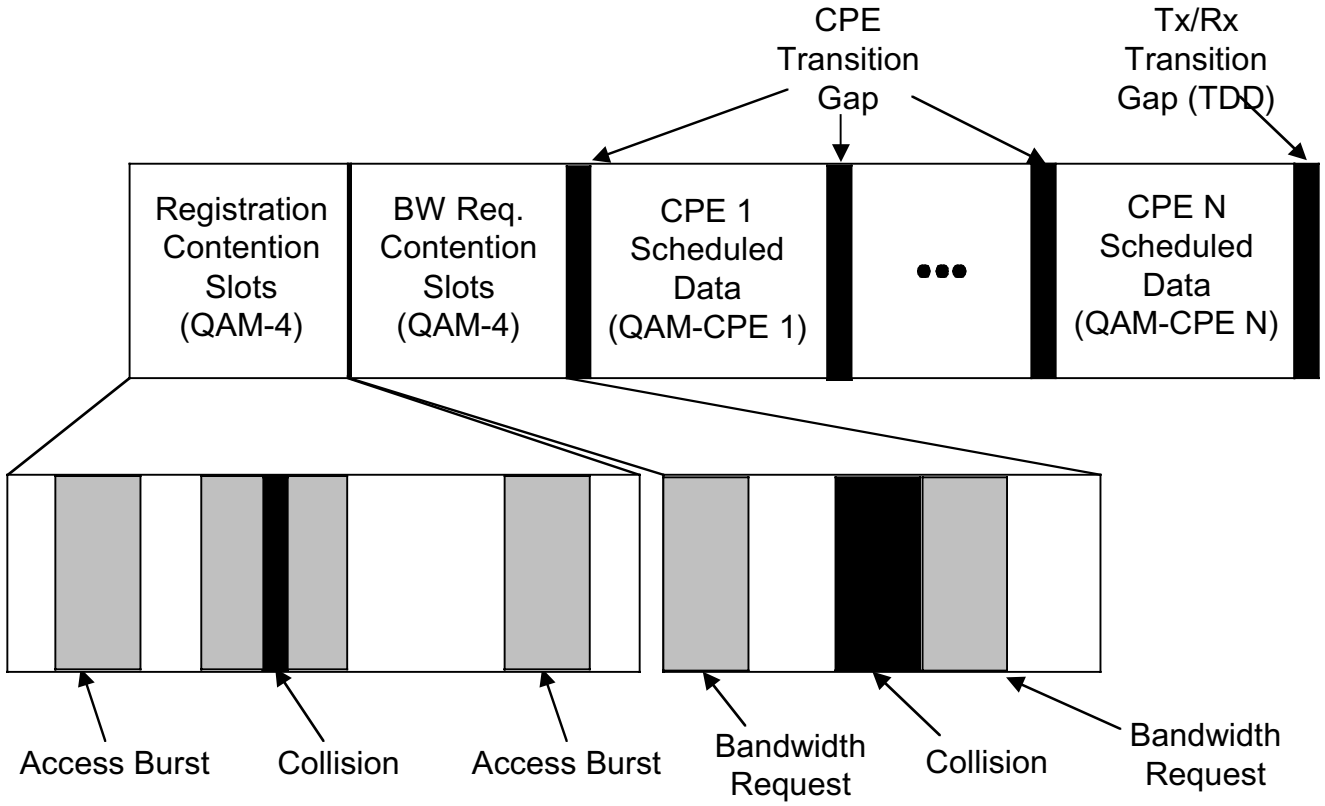
PHY Mode B TDD, FDD/TDM DS Mapping



PHY Mode B FDD/TDMA DS Mapping

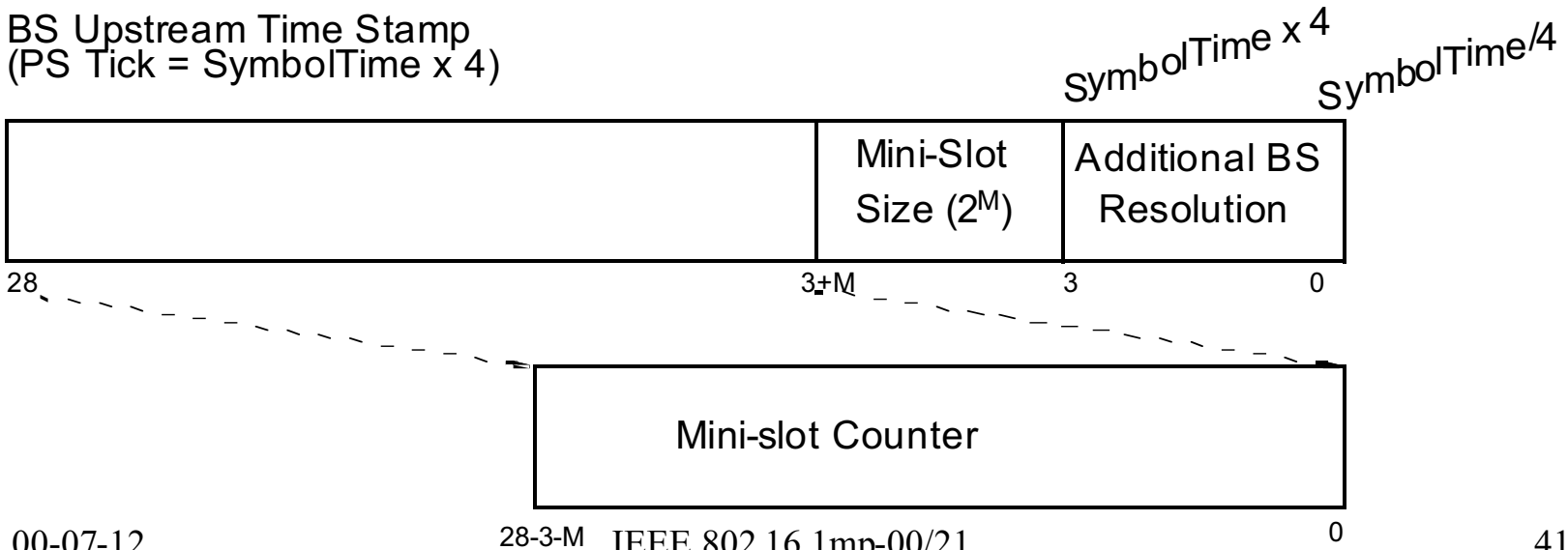


Uplink Subframe

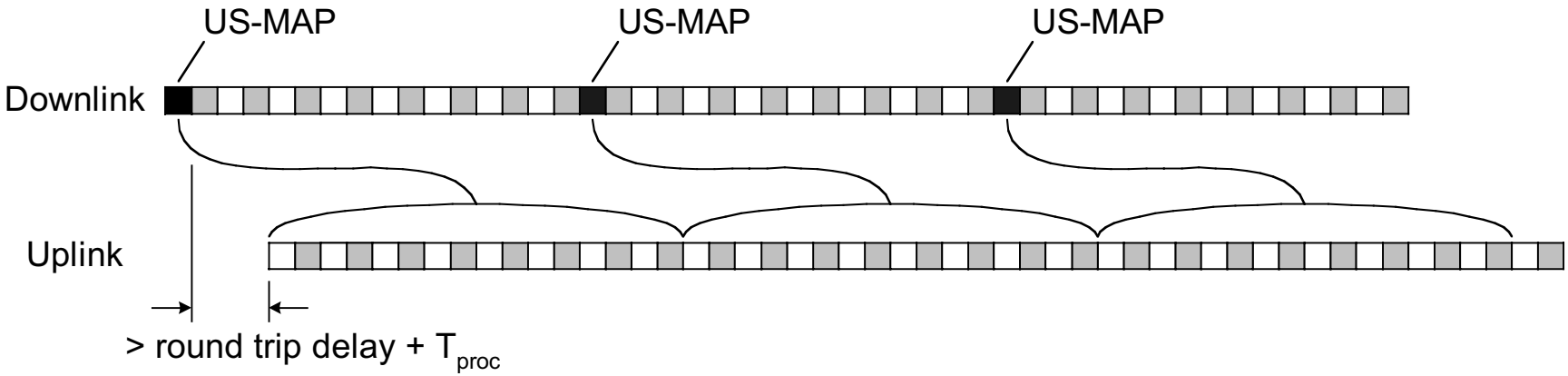


Minislot Definition

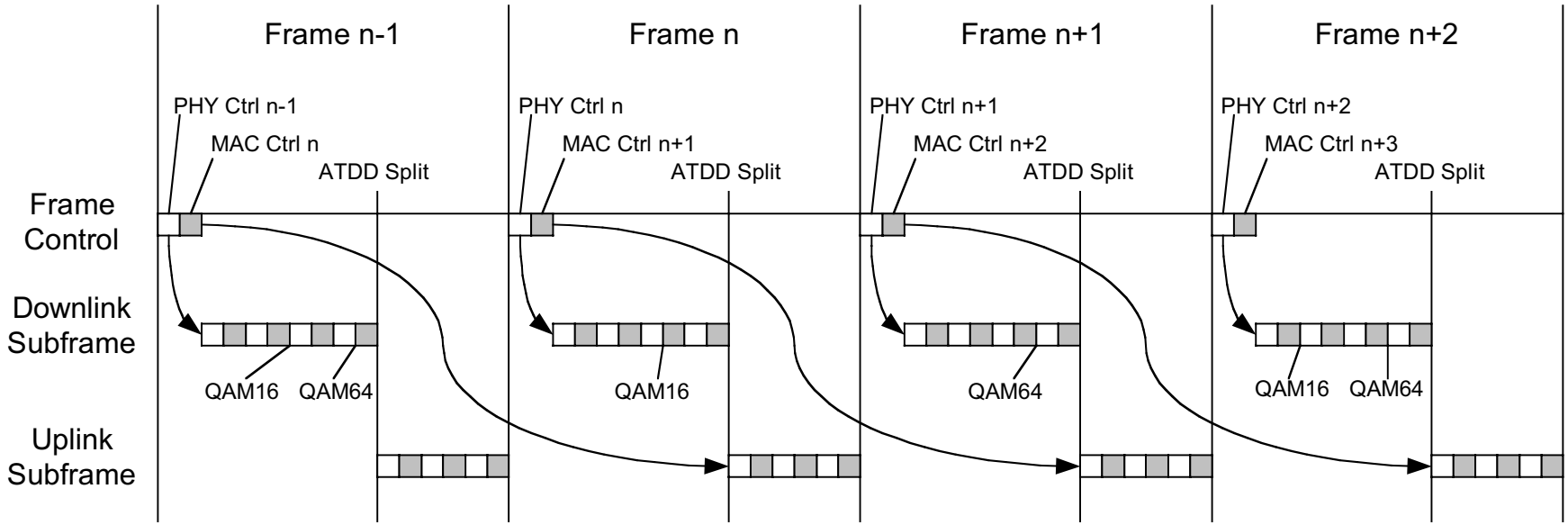
- Power of 2 muliple of PHY Slot
- Allows flexible definition of uplink bandwidth granularity



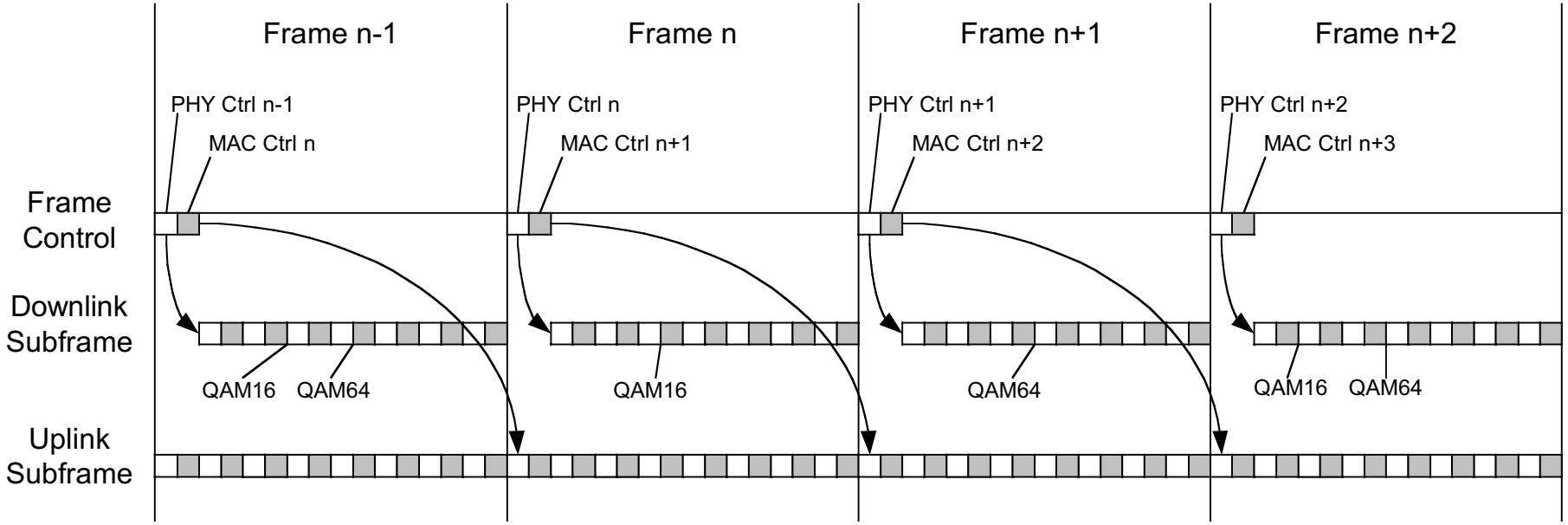
Time Relevance of Maps - PHY Mode A



Time Relevance of Maps - PHY Mode B TDD



Time Relevance of Maps - PHY Mode B FDD



Fragmentation

- Fragmentation at MAC layer of CS PDU
- Begin, Continue, End, Unfragmented
- Fragmentation sequence number for detection of missing continuation packets
- Only 1 fragmentation state per connection
- Low Level MAC Management msgs not fragmented
- No other restrictions

Upstream Service Definitions

- Unsolicited Grant Services
- Unsolicited Grant with Activity Detection
- Real-Time Polling Services
- Non-Real-Time Polling Services
- Best Effort Services

Scheduling Service Rules

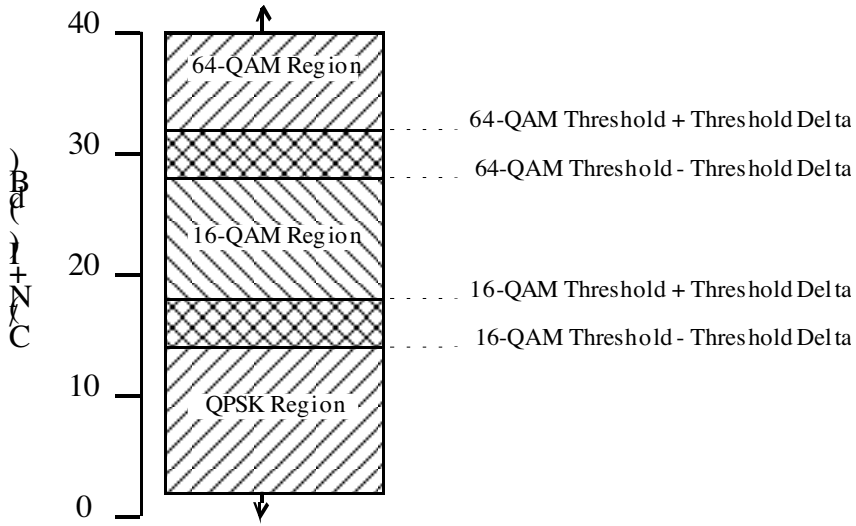
Scheduling Type	**Piggy-Back Request**	**Bandwidth Stealing**	**Pollng**
UGS	Not Allowed	Not Allowed	PM bit is used to request a unicast poll for bandwidth needs of non-UGS connections
UGS-AD	Not Allowed	Not Allowed	Not Allowed
rtPS	Allowed	Allowed for GPT	Scheduling only allows unicast polling
nrtPS	Allowed	Allowed for GPT	Scheduling may restrict a service flow to unicast polling via the transmission/request policy; otherwise all forms of polling are allowed
BE	Allowed	Allowed for GPT	All forms of polling allowed

CPE Initialization

- Scanning & Synchronization
- Obtain Channel Parameters
- Ranging and Power Leveling
- Registration and Authentication
- Initial Connection Establishment

Modulation Change

- Uplink expressed via UL-MAP
- Downlink expressed via DL-MAP



Service (Flow) Establishment

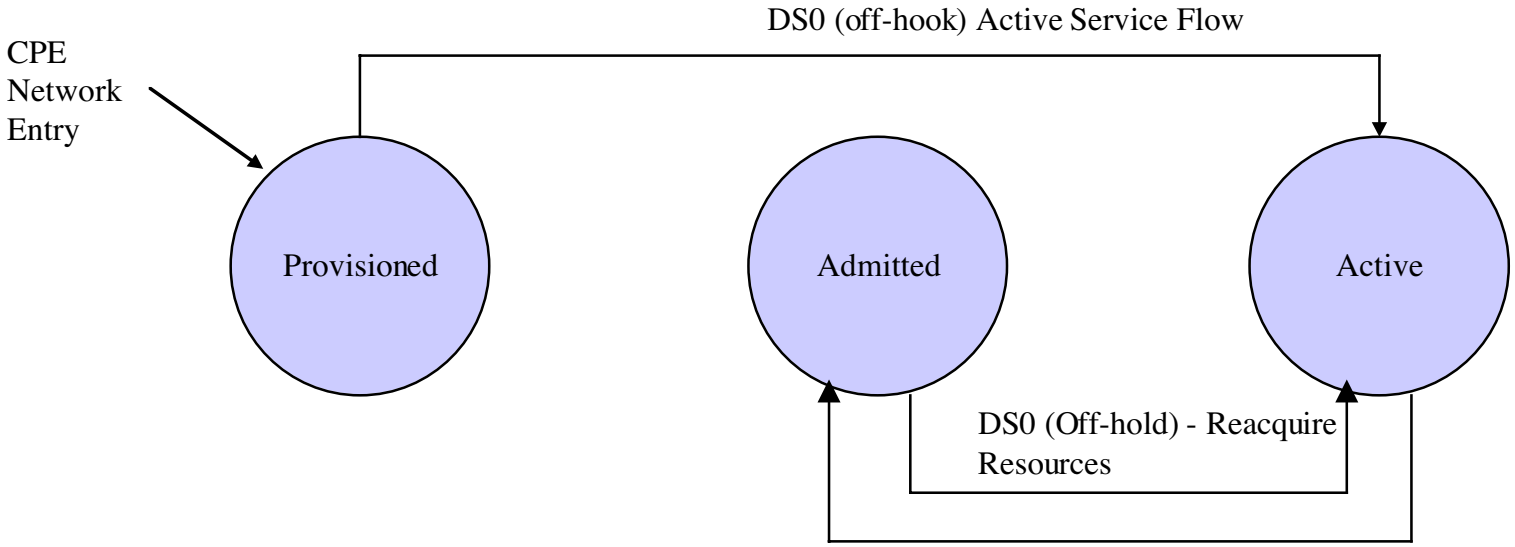
- Static Provisioning
  - Configuration file defines QoS at registration
  - Separate definition for each Connection
- Dynamic Services
  - Add, delete, and change QoS characteristics
    - Utilizes Dynamic Service Messages
  - External entity authorizes dynamic services

QoS Support

- Three-tiered Service Flow approach
  - Provisioned - known to both BS and CPE
  - Admitted - Resources reserved but not used
  - Active - Resources committed
- Why provision without use?
  - To allow quick establishment of service flows
- Why have an admitted state?
  - To allow resources to be temporarily allocated to other services (but resumption is guaranteed)

Two-Phase Activation Model

- Conserve network resources until end-to-end connection has been established
- Fast policy checks and admission control



Authentication and Privacy

- Authentication of CPE
  - X.509 Certificates and Public/Private (RSA)Keys
- Encryption of MAC payloads (user privacy)
  - DES (CBC or Counter Mode)
- Key Management Protocol
  - Public Keys
    - Used to create shared Authorization Keys (Fast)
  - Authorization Key
    - used to distribute Traffic Encryption Keys

Additional Issues

Further investigation required

ARQ

- Convergence Sub-layer
  - support from TC
  - support of fragmentation and sequencing

Bandwidth Request Acks

- Deterministic (GPC) v. Non-deterministic approach (GPT)
- Explicit ACK (GPC)
  - Part of MAP message
- Self-correcting protocol (GPT)
  - CPE resets the BS perception of BW needs on every request
- Can have a CID bandwidth replacement request - update needs complete definition

Second Connection ID

- Management CID
  - Non-MAC management transport
- Currently defined in the REG-RSP
- May be returned in RNG-RSP (investigation)

Ranging

- Definition of Periodic Maintenance is optionally offered by the BS
  - Other means are available
- GPC would need some periodic ranging to handle fades
- GPT would handle fades (Ranging messages) using bandwidth stealing

Security

- How are multicast (downstream) SA mappings generated at the MAC layer
- Use of CBC v. Counter Mode
- Simplification of Shared Secret Key instead of RSA