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Media Access Control Layer Proposal for the 802.16.1 Air Interface Specification

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Glen Sater	Voice:	480-441-8893
Motorola Inc.	Fax:	480-675-2116
8220 E. Roosevelt Street, M/D R1106	E-mail:	g.sater@motorola.com
Scottsdale, AZ 85257		

Co-Contributors

See following page.

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Purpose:

This presentation is intended to provide an overview of the submission IEEE 802.16.1mc-00/14, “Media Access Control Layer Proposal for the 802.16 Air Interface Specification”.

IEEE 802.16.1 MAC Proposal

May 1-5, 2000
Gaithersburg, NM

Glen Sater and Karl Stambaugh	Motorola
Arun Arunachalam and George Stamatelos	Nortel Networks
Jeff Foerster	Newbridge
Scott Marin and Bill Myers	SpectraPoint
Leland Langston and Wayne Hunter	Crosspan, A Raytheon Company
Phil Guillemette	SpaceBridge Networks Corporation
Chet Shiralli and Menashe Shahar	Vyyo
George Fishel	Communications Consulting Services
Ray Sanders	CircuitPath Networks Systems
Moshe Ran	TelesciCOM
Andrew Sundelin	iSKY
Mark Vogel and Jack Fijolek	3Com
Yonatan Manor	Oren Semiconductors

Presentation Overview

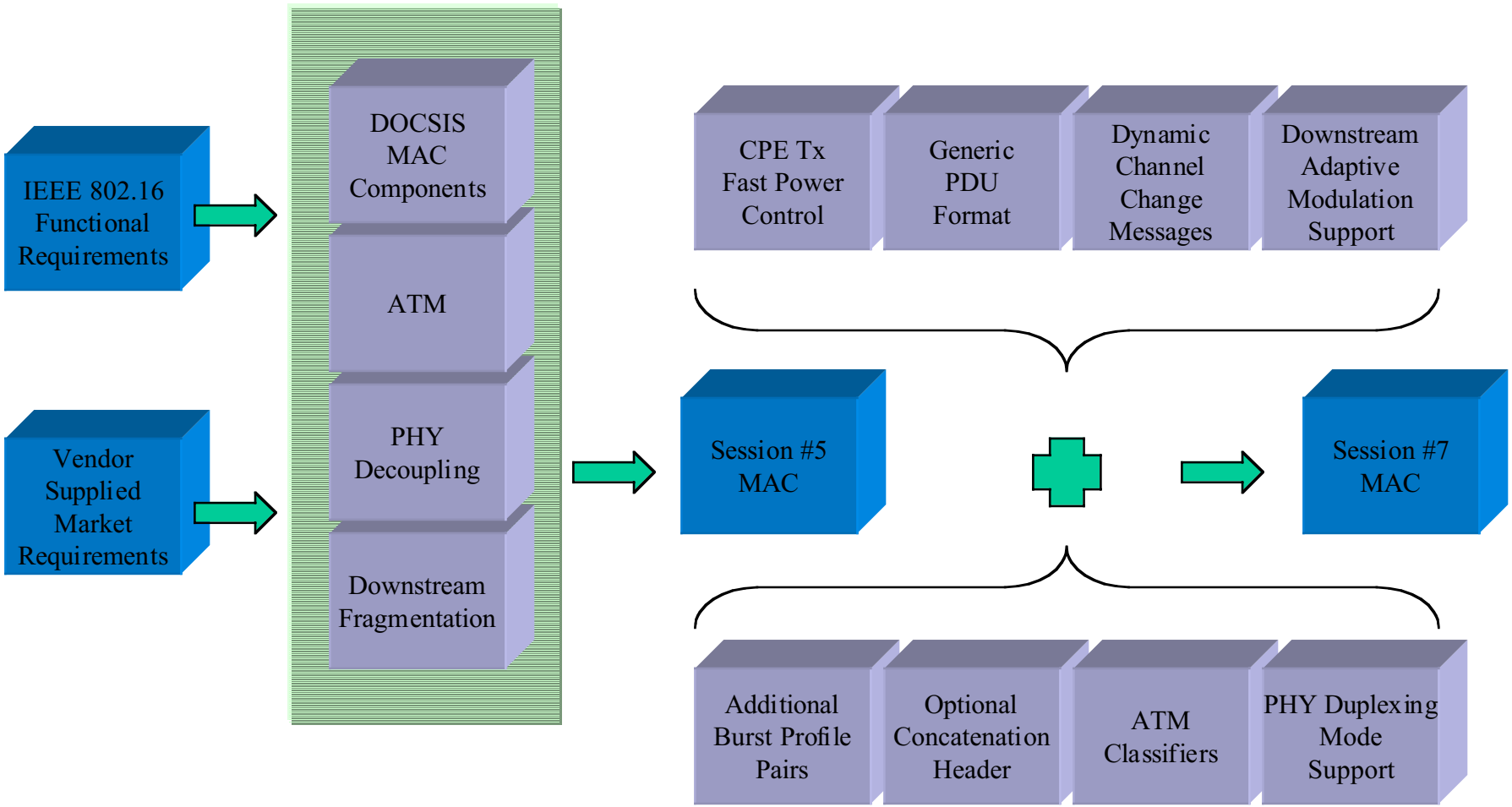
Changes since last Proposal

Overview

PHY Layer Support

Conclusions

MAC Proposal Evolution



Differences Since Session #6

- Defined a SAP Identifier for Generic PDU Formats
  - Allows for coordination of different convergence layers
  - Independent of ATM and 802.3/Ethernet support
- Added Support for Downstream Adaptive Modulation
  - Integrated into the Ranging Process
  - Defines modulation change request and acknowledgement
  - Ensures CPE operates at optimum modulation
- TDD and H-FDD PHY are supported
  - Existing MAP message is used for both TDD and H-FDD
  - Additional IUC defined to support H-FDD
  - Existing MAP message can support framing
    - Works in conjunction with the scheduler

IEEE 802.16.1 MAC Proposal

MAC Protocol Overview

Overview

- Point to multi-point MAC protocol
- Upstream
  - Time divided into continuous stream of mini-slots
  - Contention-based access for latency tolerant applications
  - Reservation-based access for low-latency applications
  - Polling-based access for variable-rate applications
  - Message formats allow efficient scheduling of different message types
- Supports fragmentation, concatenation, and payload header suppression
- MAC User Data Formats
  - Variable-length MAC PDU
  - ATM cell MAC PDU
  - Generic User Data PDU

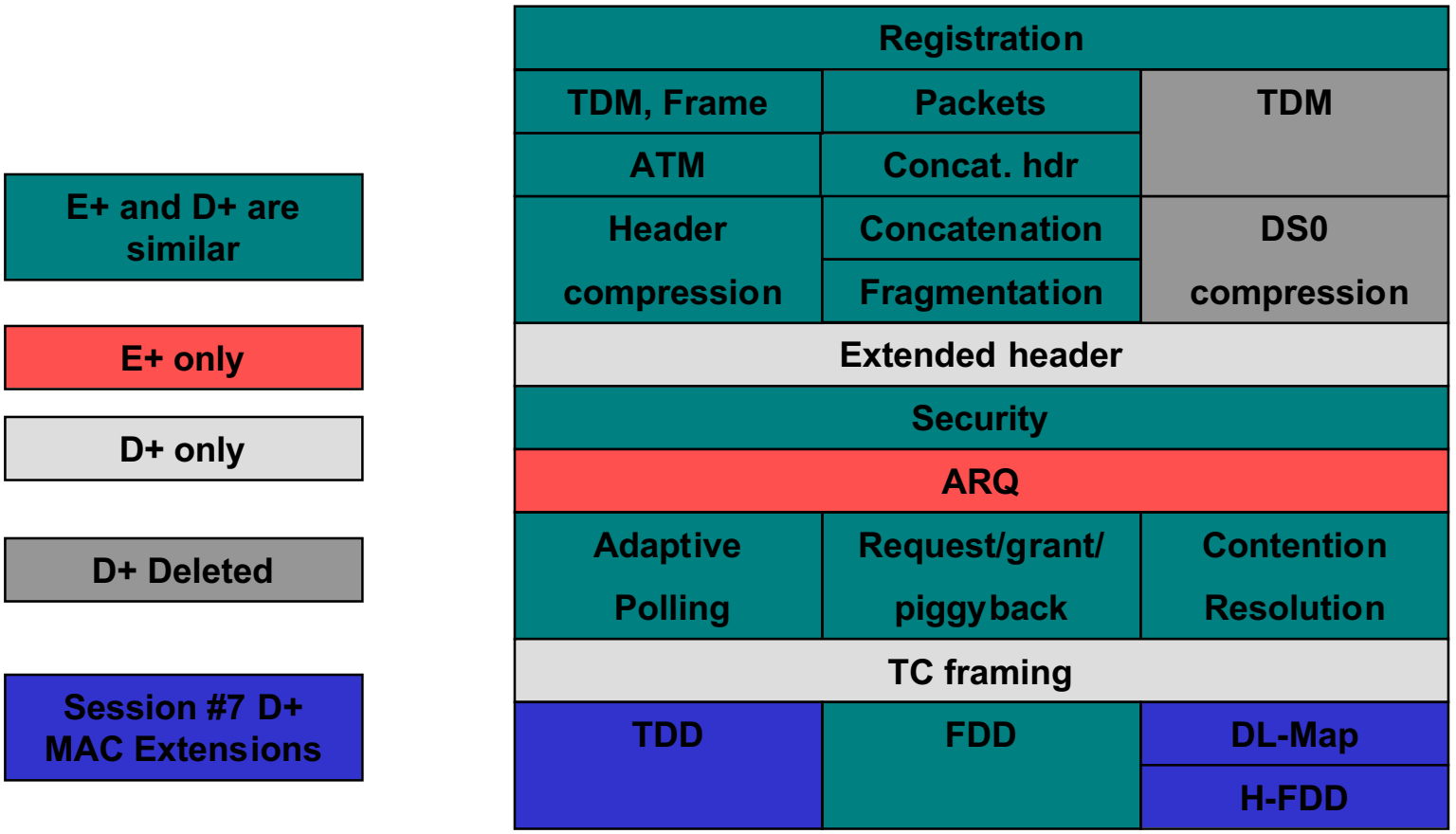
Overview (continued)

- Service Flows
  - Provides mechanism to manage upstream and downstream QoS
  - Integral to bandwidth allocation process (using mini-slots)
  - Multiple service flows per SS
    - each can have a different set of QoS parameters
- Upstream controlled by variety of scheduling services
  - Best Effort
  - Polling
  - Unsolicited Grant
- QoS Parameters used in conjunction with scheduling services
  - Provides ability to bound delay and jitter
  - Specifies bandwidth
- Scheduling algorithms not defined by the MAC

Overview (continued)

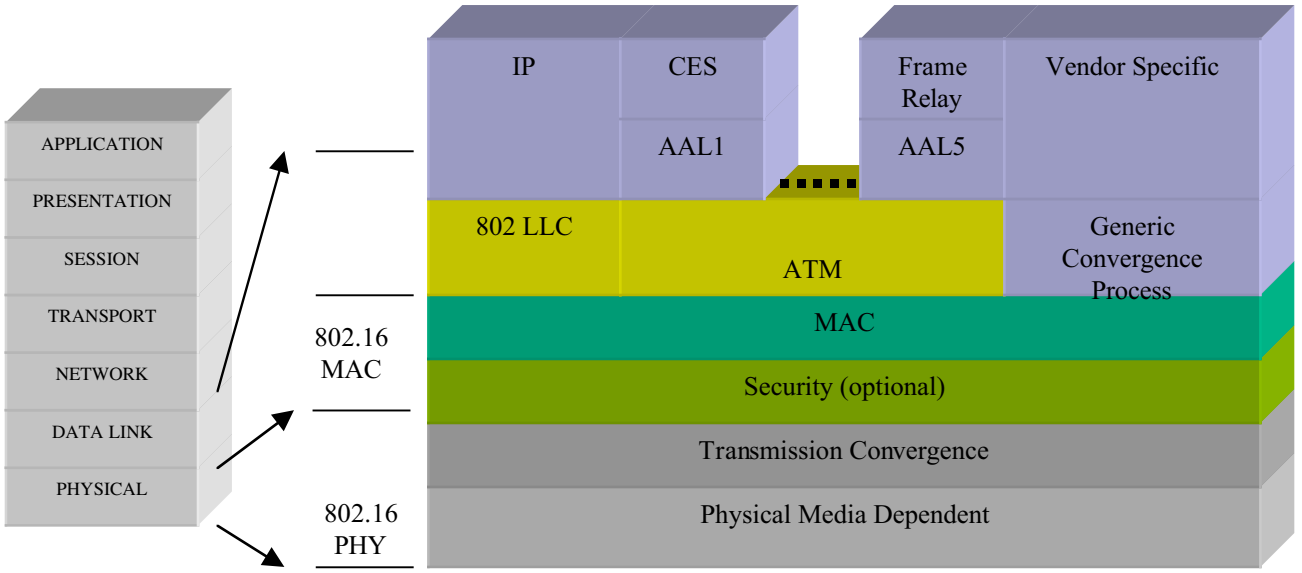
- Full set of MAC management messages
  - Network access, entry, and ranging
  - Upstream bandwidth allocation
  - Dynamic connection creation/modification/deletion
- PHY Support
  - Upstream Adaptive Burst Profiles
  - Downstream Adaptive Modulation
  - FDD carrier-based adaptive modulation
  - FDD, H-FDD, and TDD with CPE-based adaptive modulation
  - Implicit framing
- Security
  - CPE Authentication
  - User data PDU encryption

MAC Proposal Comparison Overview



Protocol Stack

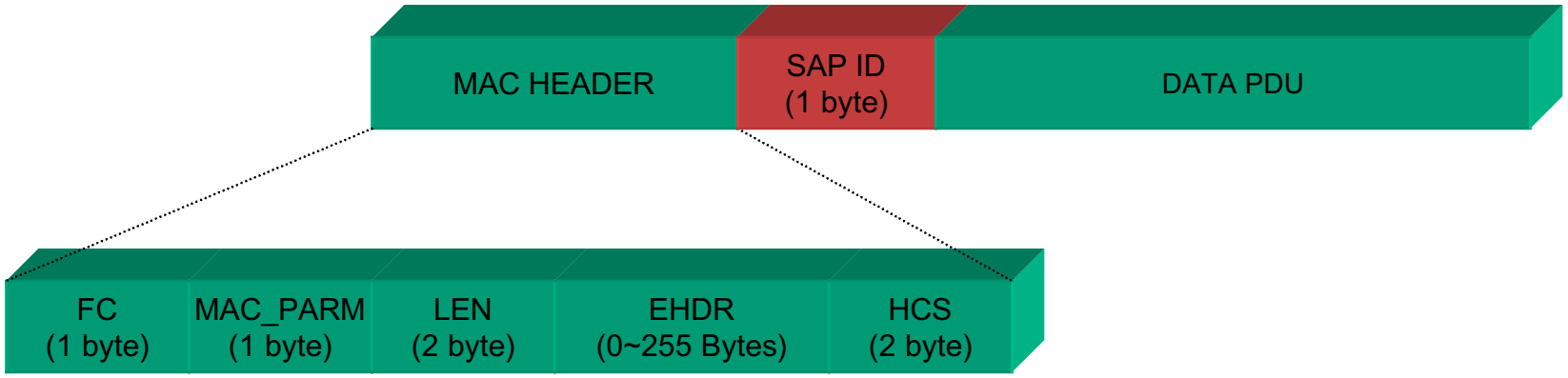
- Flexible Protocol Stack
  - Directly supports IP
  - Supports ATM and Services over ATM
  - Generic Convergence Process for special cases



PDU Formats

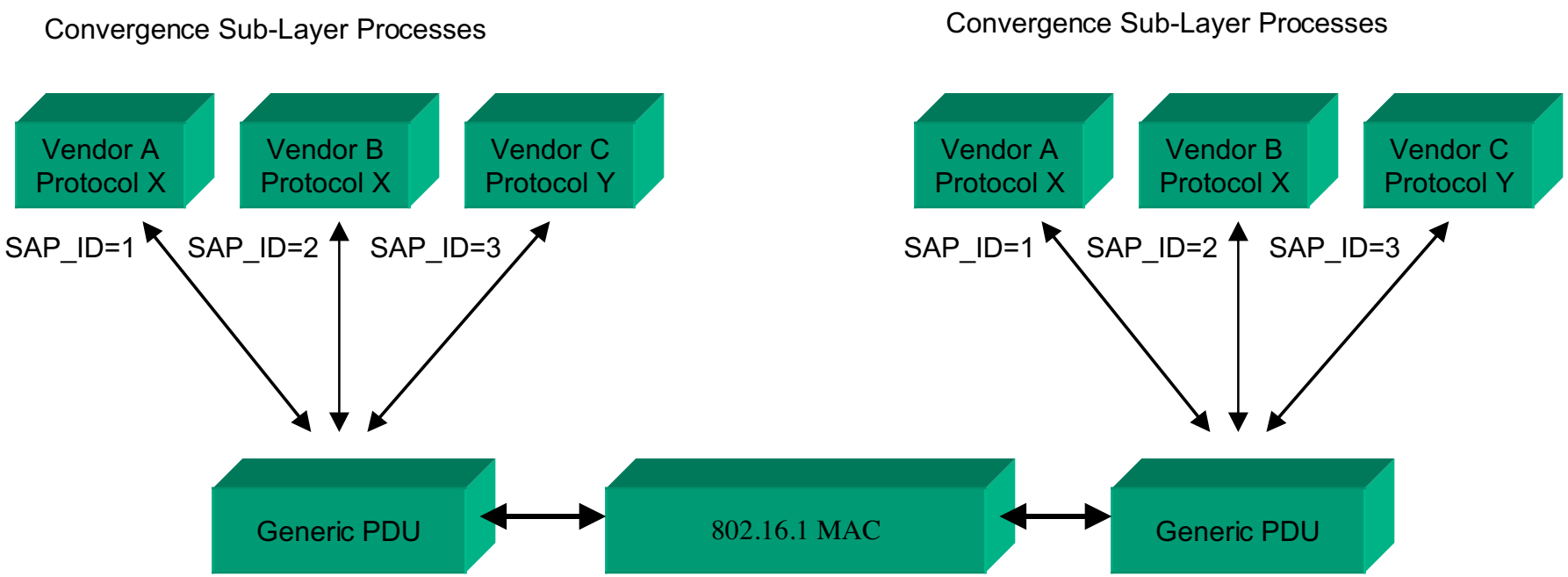
- 802.3/Ethernet
  - Direct, native support for IP-based protocols
  - Fast, efficient
  - No convergence process required
- ATM with Adaptation Layers
  - Chosen to support leased-line services
  - Existing standards by the ITU and ATM Forum
    - DS1, E1, Frame Relay, …
    - No need to develop new convergence process
    - Uses proven technologies

Generic PDU Format



- Service Access Point ID
  - Uniquely identifies different convergence layers using the generic PDU format
  - IDs are assigned by an external authority as vendors/protocols are added

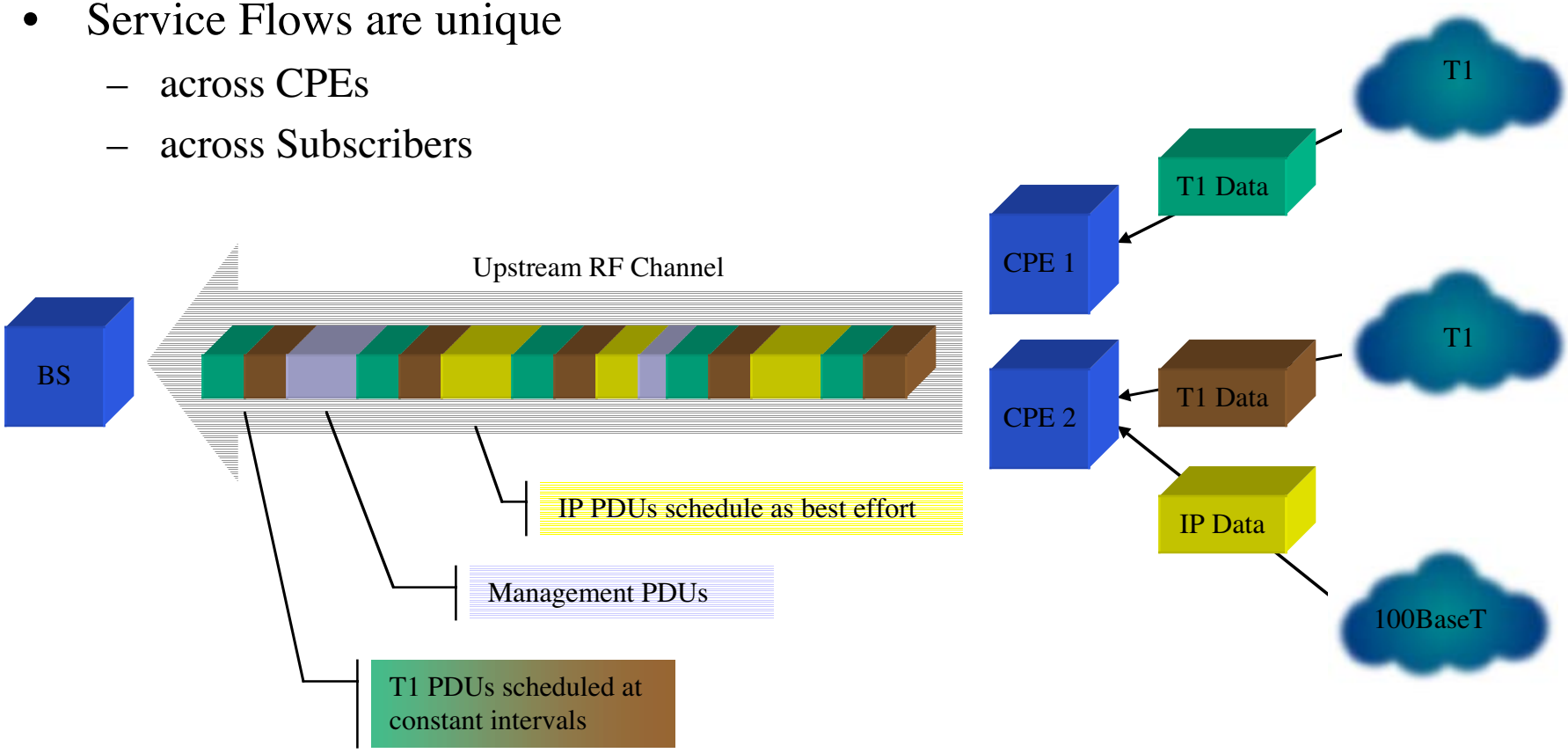
SAP ID Usage



SAP ID is used by the generic SAP to deliver generic PDUs to the appropriate sub-layer process

Bearer Services - Service Flows

- Key to providing different services
- Establish a “virtual circuit” for each service (using a SID)
- Service Flows are unique
  - across CPEs
  - across Subscribers

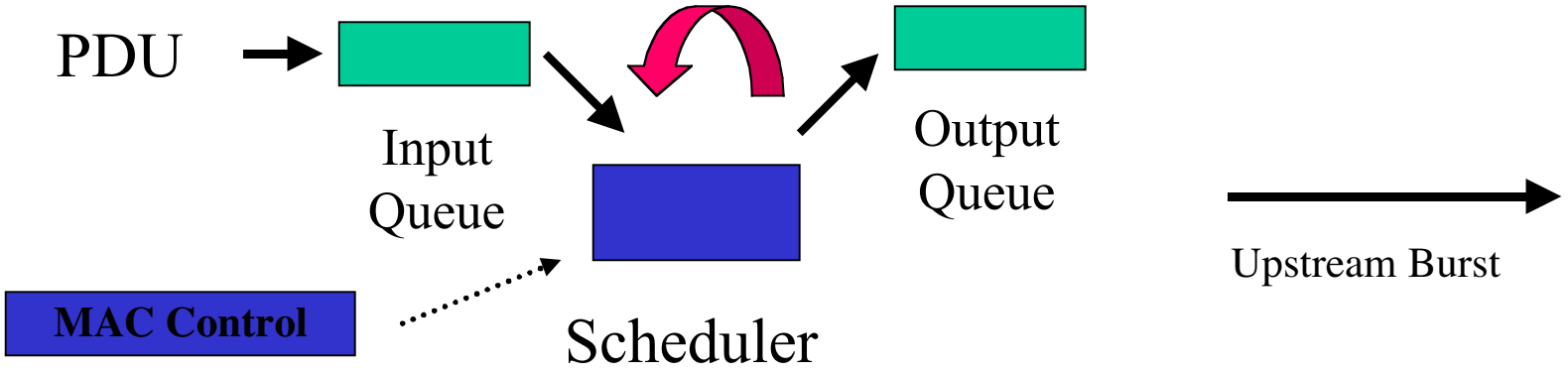


Bearer Services - Scheduling and QoS

Supports different types of services using the scheduling and QoS parameters

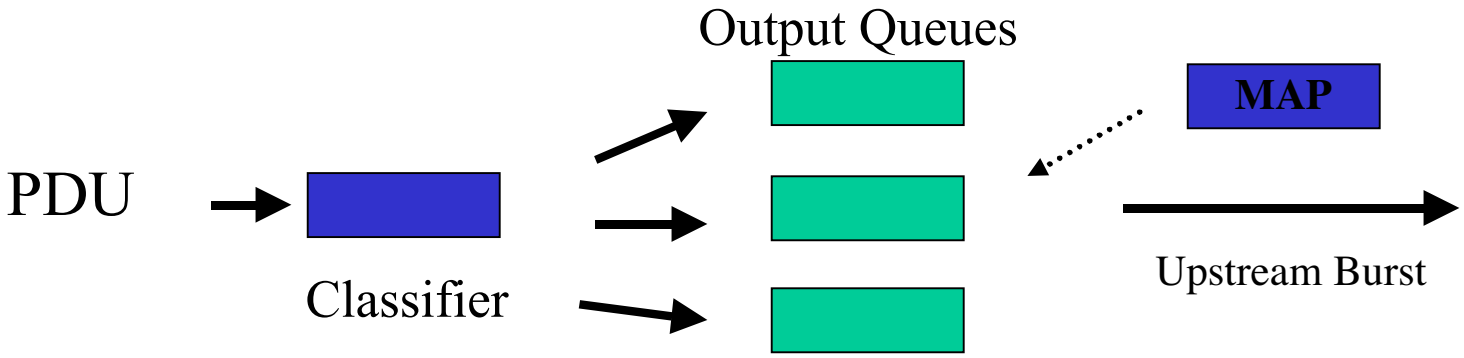
Application	Service Class	MAC PDU Type	MAC Scheduling
Circuit Emulation	CBR	ATM/AAL1	Unsolicited Grant Service
Web Browsing	UBR	802.3/Ethernet	Best Effort
VoIP	CBR	802.3/Ethernet	UGS with Activity Detection
Frame Relay	CBR	ATM/AAL5	Unsolicited Grant Service
	VBR	ATM/AAL5	Real Time Polling
Streaming Video	VBR	802.3/Ethernet	Real Time Polling

Distributed Scheduling (E+ Approach)



- CPE active participant in scheduling
  - CPE knows QoS requirements and reorders input queue PDUs for output queue
  - BS and CPE must coordinate to guarantee QoS
  - QoS will fail if either CPE or BS makes mistake
- Complex CPE implementation

Centralized Scheduling (D+ Approach)



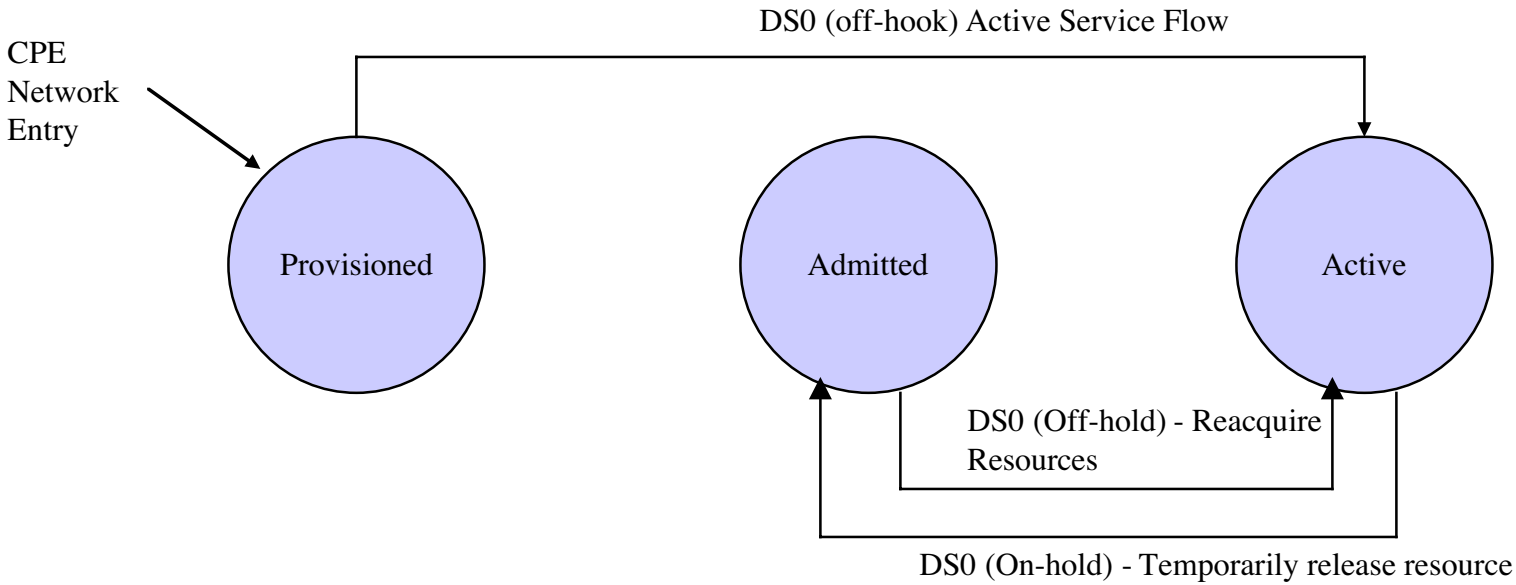
- CPE passive participant in scheduling
  - CPE does not even need to know QoS req'ts
  - CPE simply puts packet in proper FIFO queue
  - BS alone guarantees QoS
  - Easier to have interoperable implementations
- Simple & inexpensive CPE implementation

Bearer Services - Service Flows

- 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)

Bearer Services - Service Flows (cont.)

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



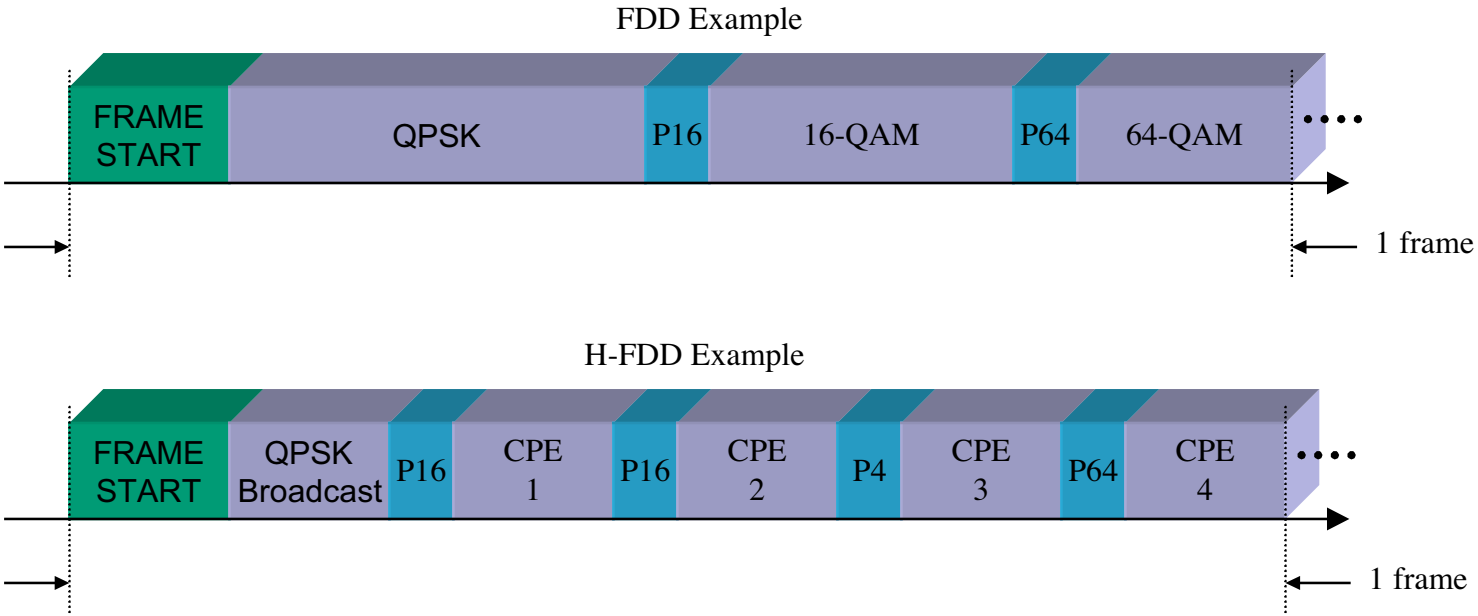
Additional PHY Layer Support

Upstream Burst Profiles

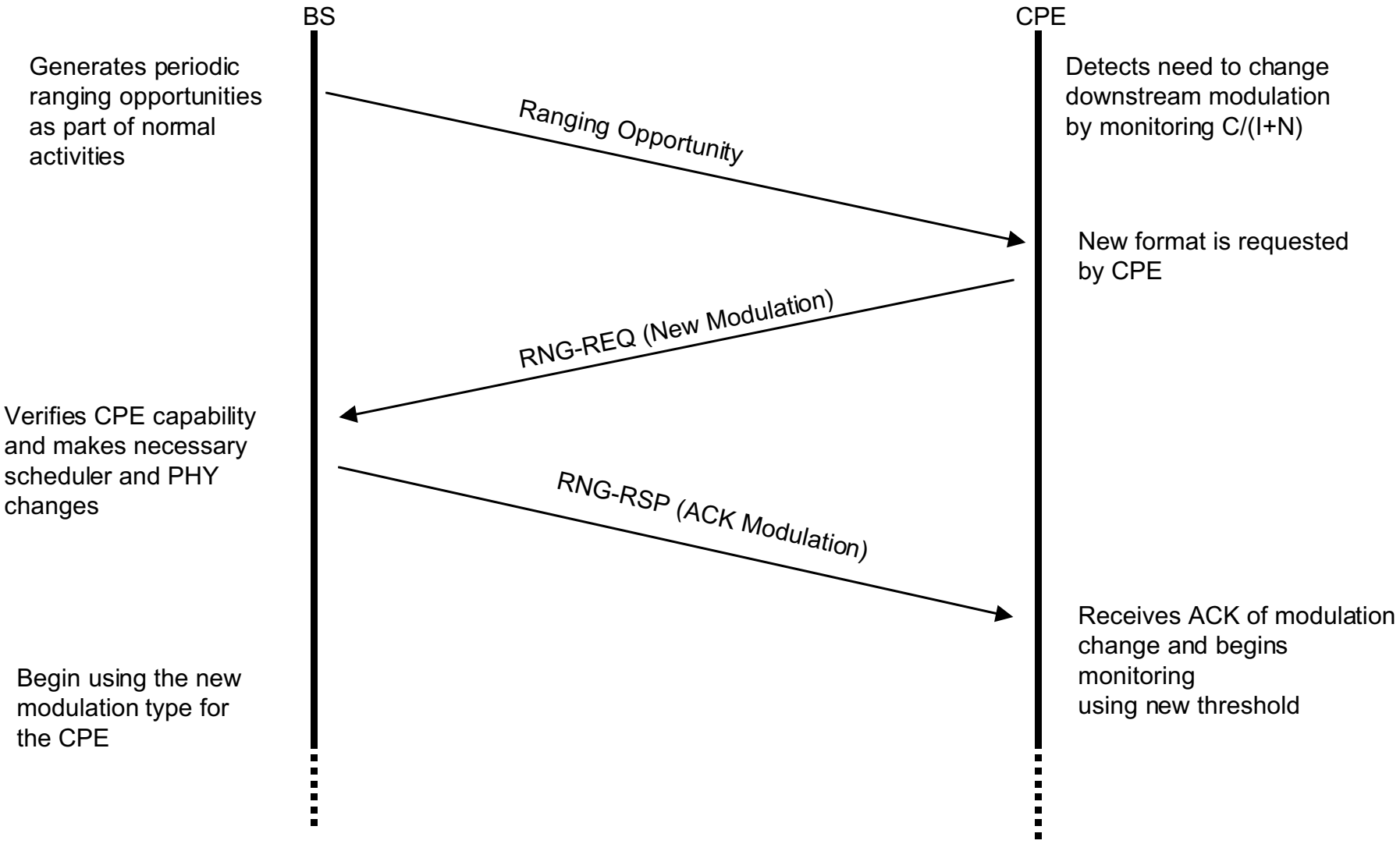
- Different Services require different FEC
  - Examples:
    - UDP packets get lower FEC
    - ATM carrying CES get higher FEC
  - Implemented with 3 pairs of data grants
    - Scheduler can apply as needed
- Feature can not be leveraged if different services are carried in the same burst
- Also supports different modulation types

Downstream Adaptive Modulation

- CPE Modulation change identified by PHY preamble
- BS must schedule downstream appropriately
  - QPSK broadcast data first, followed by 16-QAM and 64-QAM
  - No MAC-specific messaging required to identify transitions



Adaptive Modulation and Ranging

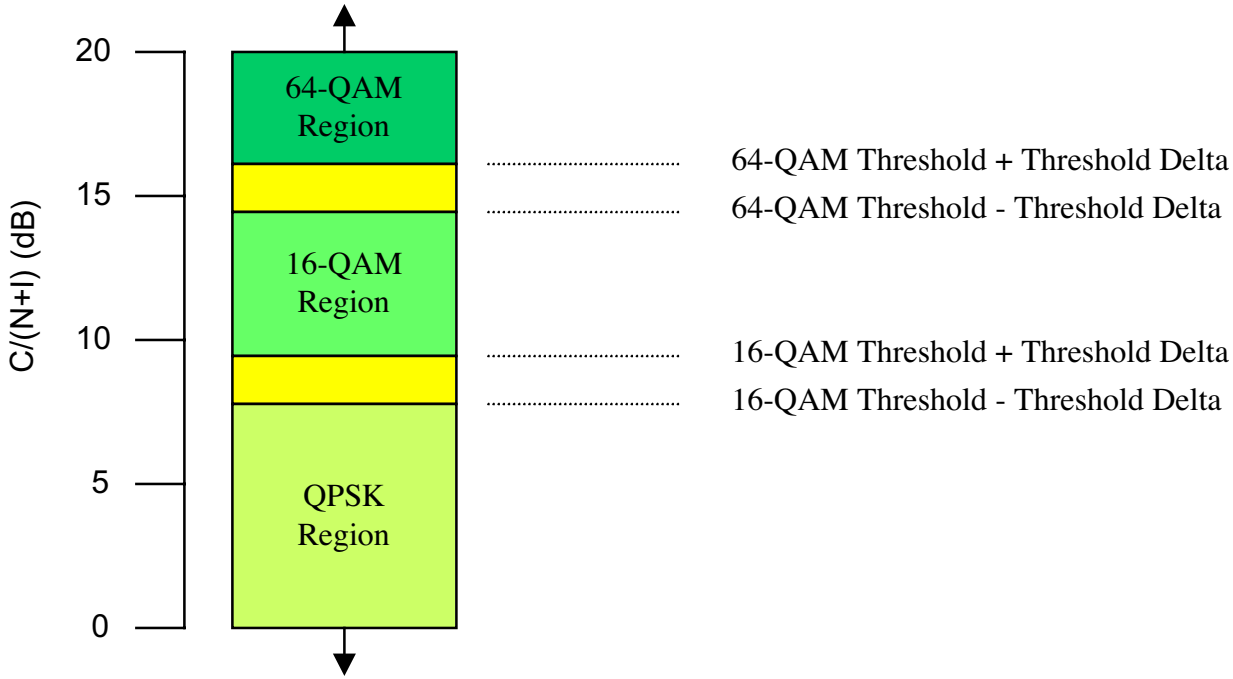


Ranging Message Extensions

- RNG-REQ
  - Added one TLV to indicate modulation type
    - Optional (sent when needed)
    - 1 = QPSK, 2 = 16-QAM, 4 = 64-QAM
- RNG-RSP
  - Added four TLVs (optional, sent when needed)
    - Acknowledged modulation type (as above)
    - 16-QAM Threshold in C/(N+I)
    - 64-QAM Threshold in C/(N+I)
    - Threshold Delta in C/(N+I)

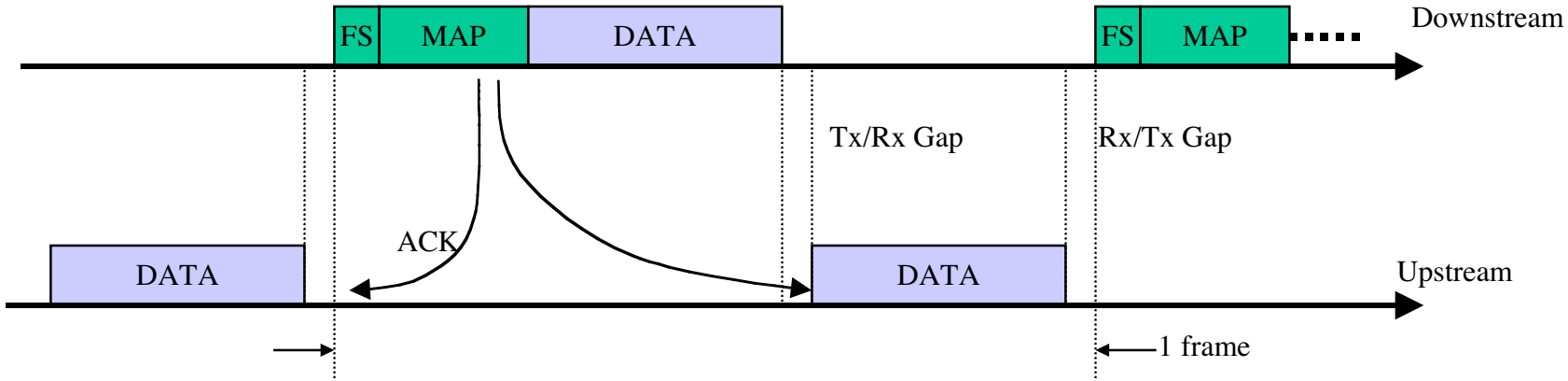
Threshold Usage

- CPE utilizes thresholds to determine when to request change to minimize overhead



TDD Support

- MAP message defines
  - Starting mini-slot for this frame's upstream burst
  - ACK time for previous frames upstream burst
    - contention resolution
  - All mini-slot offsets (upstream burst allocations) for CPE
  - Receive time (implicitly by lack of upstream mapping)
    - CPE must listen to downstream when not mapped to upstream

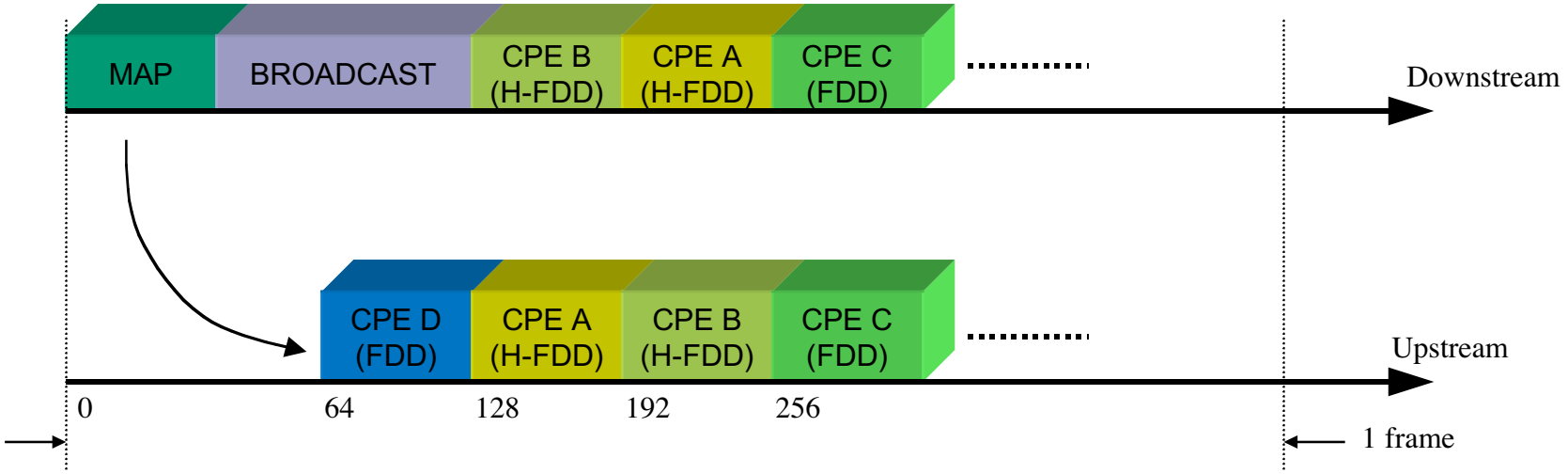


H-FDD Support

- Same method as for TDD
- Downstream access scheduled by BS
- Upstream access handled by MAP
- Both H-FDD and FDD supported

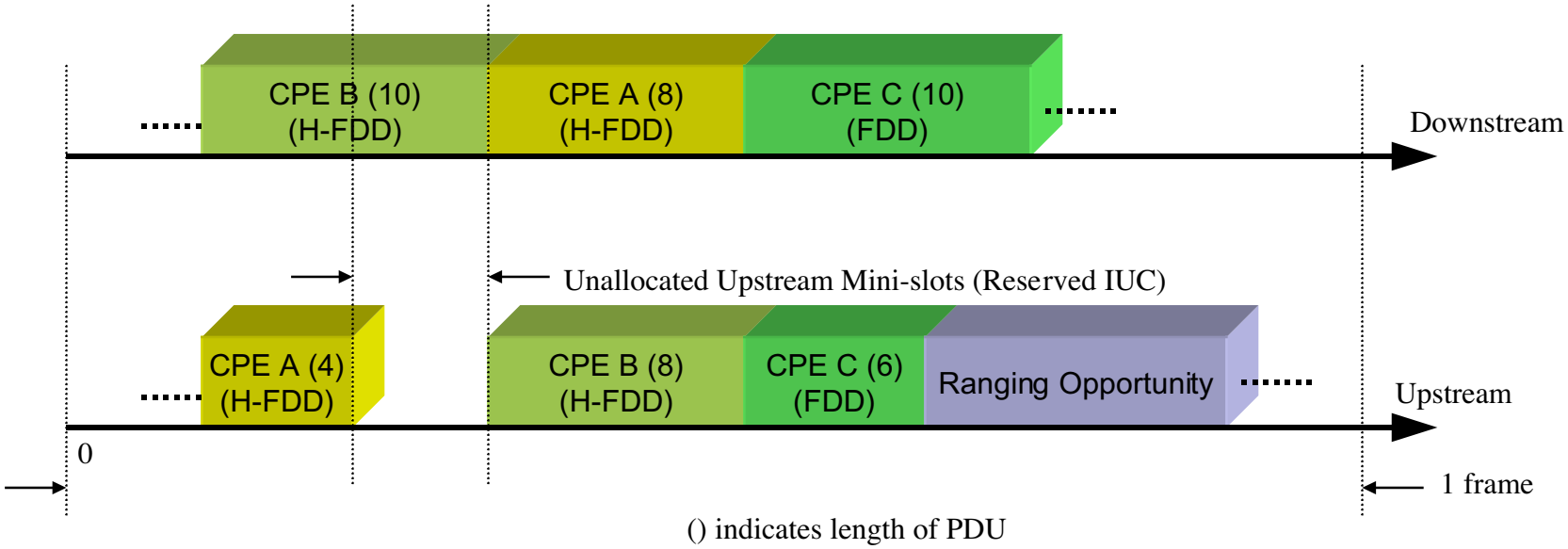
Example MAP

SID	Mini-Slot Offset
CPE D	64
CPE A	128
CPE B	192
CPE C	256



HD-FDD Scheduling

- PDU lengths don't always allow "perfect" scheduling
  - Scheduler may use a Reserved IUC in the MAP for this time
  - Forces all CPEs to listen to downstream



() indicates length of PDU

Framing

- Framing implicitly defined by MAP at MAC layer
  - Frame Start (FS) marks start of PHY frame
  - TDD
    - BS can be synchronized for coordination of multiple TDD channels
    - External timing trigger at BS can mark start of “frame”
    - Up/Down bandwidth split is implicitly defined via MAP
- Management messages broadcast at regular intervals
  - SYNC, UCD and Ranging (Initial and Maintenance)
- Broadcast user data typically sent first
  - Required for TDD

Conclusions and Summary

Conclusions

- Supports the functional requirements
  - Multiple classes of services
  - Multiple services per subscriber
  - Multiplexing allows statistical gains
- Uses proven technologies
  - Extensive implementation experience
  - Extensive research
    - academic/commercial
  - History of on-going change process to strengthen the MAC technologies

Conclusions (cont.)

- Robust *and* efficient solution
- Well defined
  - A complete solution
  - SDL used to describe dynamic behavior
  - No undefined convergence layers/processes
- Tailored for hardware implementation
  - Faster operation, simpler CPEs
- Complete PHY support
  - FDD with continuous or adaptive modulation
  - H-FDD and TDD with adaptive modulation