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UMT Requirements

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GOAL

- **This presentation focuses on Reliability Requirements for the UMT Solution. The presentation describes potential solutions to address these requirements, but does not provide a formal proposal for any specific solution.**
- Although the reliability requirements in this presentation are driven by the need to run openflow on a reliable L2 transport, the same requirements apply in other cases where there is a need to run management/control protocols that require reliable transport on Ethernet network.

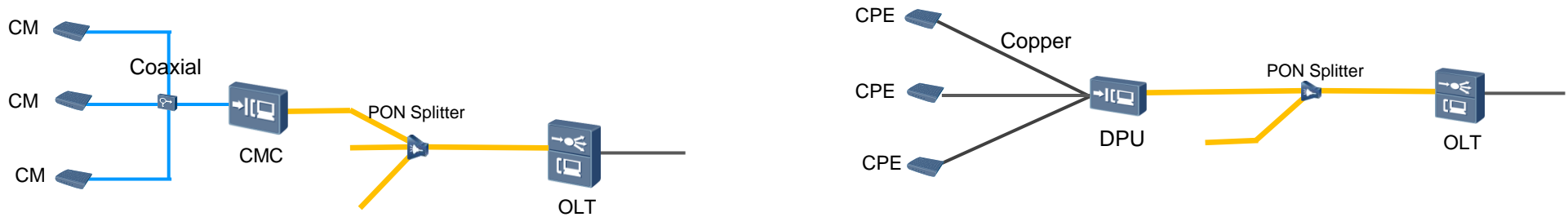
Agenda

- **Solution Requirements**
 - Reliability
- **The need for L2 openflow**
- **Openflow Reliability Requirements**
 - Protection
 - Flow Control (PFC, and Credit Based FC).
 - Using LLC to Provide Reliable Link Layer Communications.
- **Using LLC Encapsulation for UMT**
- **UMT Support of Interlayer Service Interfaces**
 - More discussions are needed.
- **Related 802.1 Standards/Projects.**

Key Solution Requirements

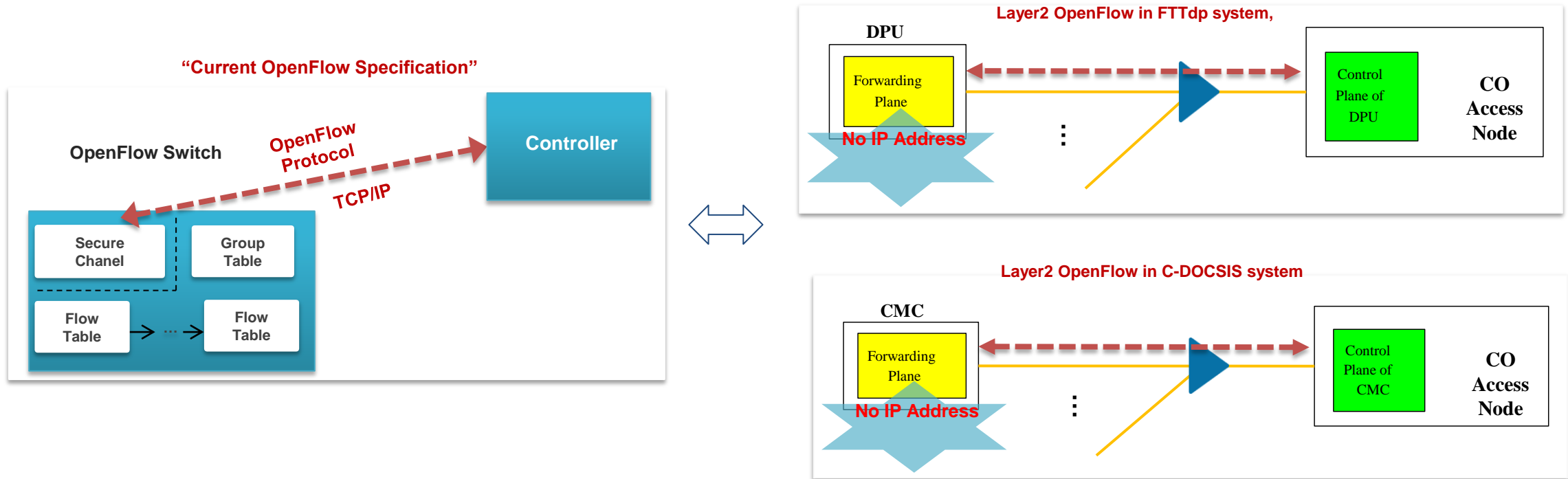
- **The solution shall**
 1. Allow multiple management channels reaching various levels of network hierarchy
 2. Allow L2-only devices to identify and exclude the management traffic from subscriber's SLA quotas
 3. Allow statically-provisioned or dynamically established management channels.
 4. Impose minimal burden on the intermediate nodes
 - ✓ The solution shall allow and support, but not require routing, bridging, or MAC learning in intermediate nodes.
 - ✓ The solution shall not require specialized hardware or software to process management frames in the intermediate nodes
- ✓ **Support Reliable and Secure Communications.**
 - **Support Ethernet Protection**

Current Challenges for Remote Nodes Management



- Distributed solution challenges the management of remote nodes:
 - FTTP/EPoC FCU/Remote CMTS/Remote CCAP brings 10-100 times more nodes
- Remote node supports multiple-services
 - residents, enterprises, mobile backhaul, and wholesale services.
- Remote nodes are expected to **be simple to manage**

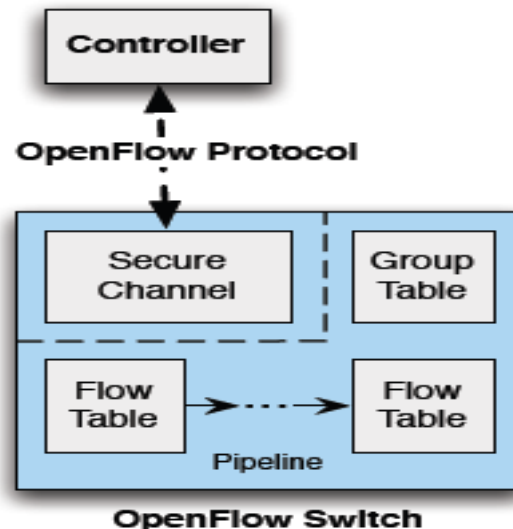
Why Layer 2 OpenFlow is Needed ?



- In the current OpenFlow specification, OpenFlow channel is encrypted using TLS or run directly over TCP, which is not suitable for the access network where DPUs and CMCs work on layer 2 without IP addresses.
- Layer2 OpenFlow allows OpenFlow messages to be exchanged over layer2 network between Controller and DPUs or CMCs, to support programmability of these devices.

Openflow Reliability Requirements (1)

- The openflow controller system should not make the controller the single point of failure
- Ensure the availability of control channels between the OF controller and OF switches and can continue to operate even during failure.
- The main control channel should provide reliable and secure communications with OF switches. The auxiliary connections could use unreliable transport like UDP.

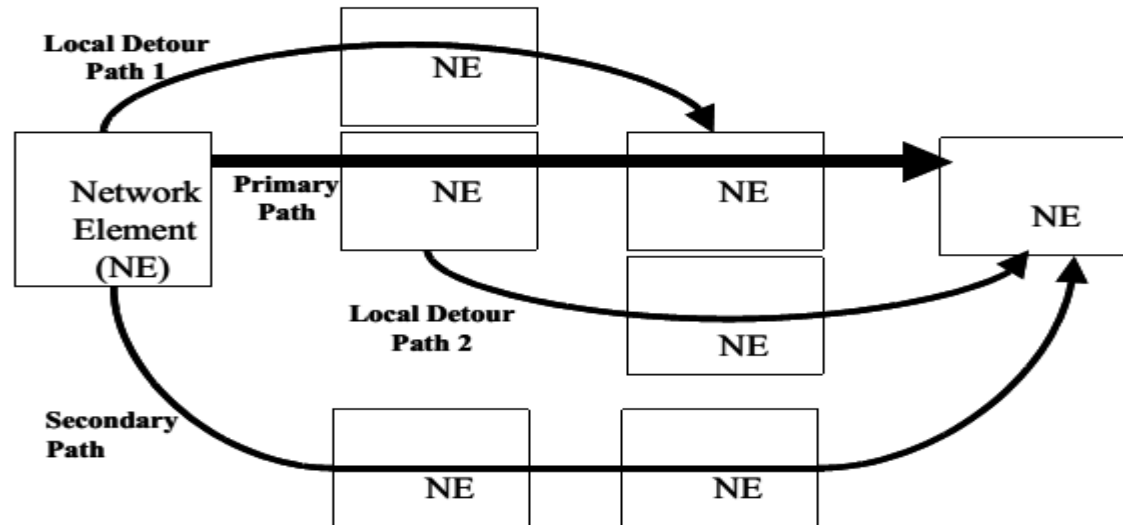


Openflow Reliability Requirements (2)

- **For the main connection, if we do not use TCP/TLS, then the transport to be used must provide:**
 - Proper demultiplexing of multiple controller connections.
 - Retry mechanism. OpenFlow does not have any retry and assume the underlying mechanism is reliable.
 - Segmentation and reassembly. OpenFlow request don't consider the MTU and will routinely exceed the MTU size.
 - **Can we support jumbo frames of at least 9 kB, either natively (through the increase of the size of the MAC frame), or through a fragmentation/assembly mechanism at the sender and the receiver ?**
 - Message ordering. The OpenFlow requires that message order be respected.
 - Flow Control

Protection Mechanisms

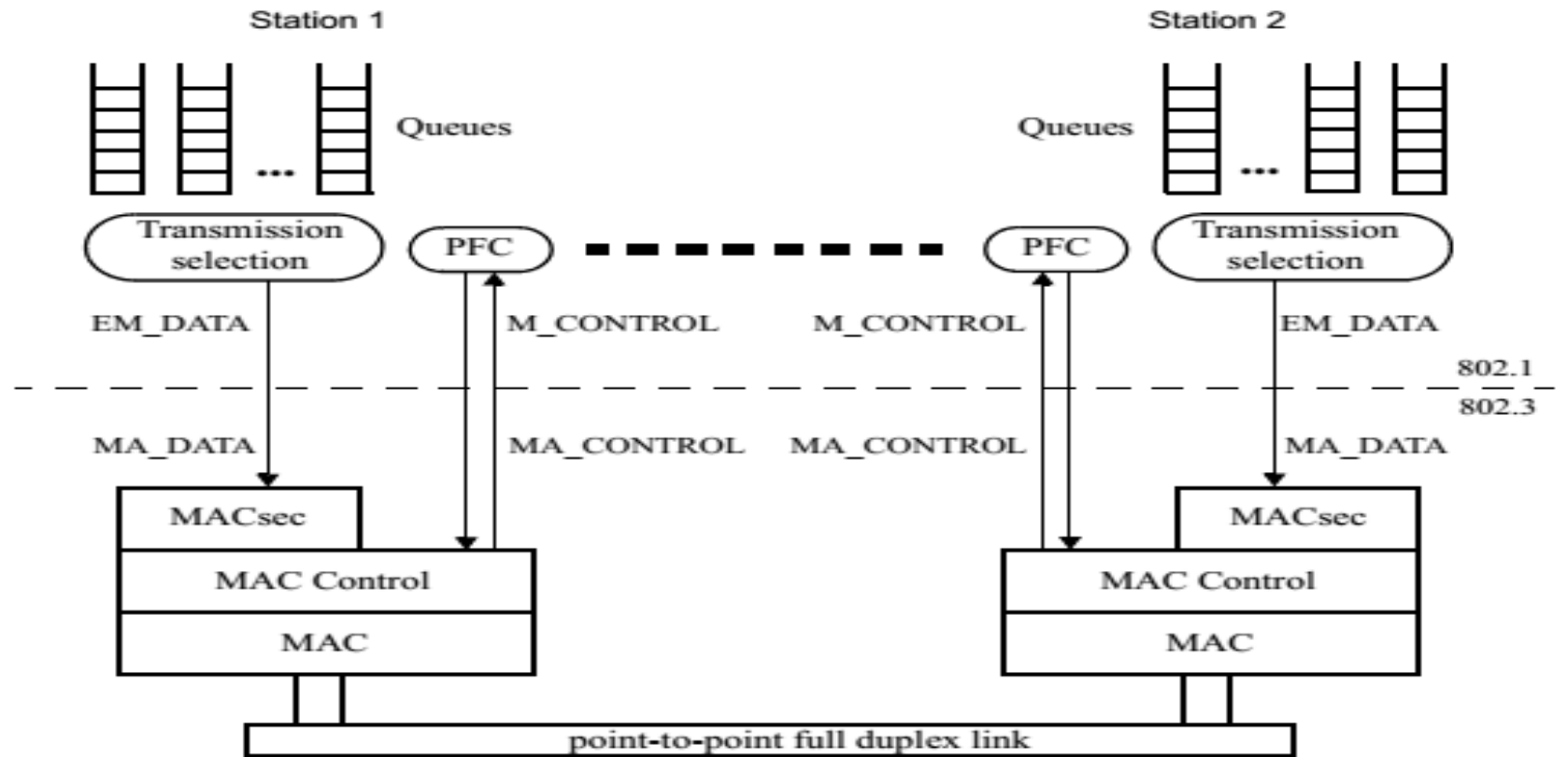
- Link Protection based on Link Aggregation
- PON Protection
- Aggregated Line and Node Protection (ALNP) service
- End-to-End Path Protection using Redundant Paths.
- Ethernet Protection can be achieved using mechanisms defined in G.8031/8032.
- IEEE 802.1ag/Y.1731 can be used for the detection of path failure/problems



Priority-Based Flow Control

- **Traditional IEEE 802.3 Ethernet defines an unreliable communication medium; it does not offer guarantees that a packet injected into the network will arrive at its intended destination.**
- **In a network path that normally consists of multiple hops between source and destination, lack of feedback between transmitters and receivers at each hop is one of the main causes of unreliability.**
- **For applications that cannot build reliability on upper layers, the addition of flow control functions at Layer 2 can offer a solution.**
- **IEEE 802.3x PAUSE suffers a basic disadvantage that limits its field of applicability: after a link is paused, a sender cannot generate any more packet.**
- **IEEE 802.1Qbb PFC extends the basic IEEE 802.3x PAUSE semantics to multiple CoSs, enabling applications that require flow control to coexist on the same wire with applications that perform better without it. PFC uses the IEEE 802.1p CoS values in the IEEE 802.1Q VLAN tag to differentiate up to eight CoS that can be subject to flow control independently**

Priority-Based Flow Control (PFC) Peering



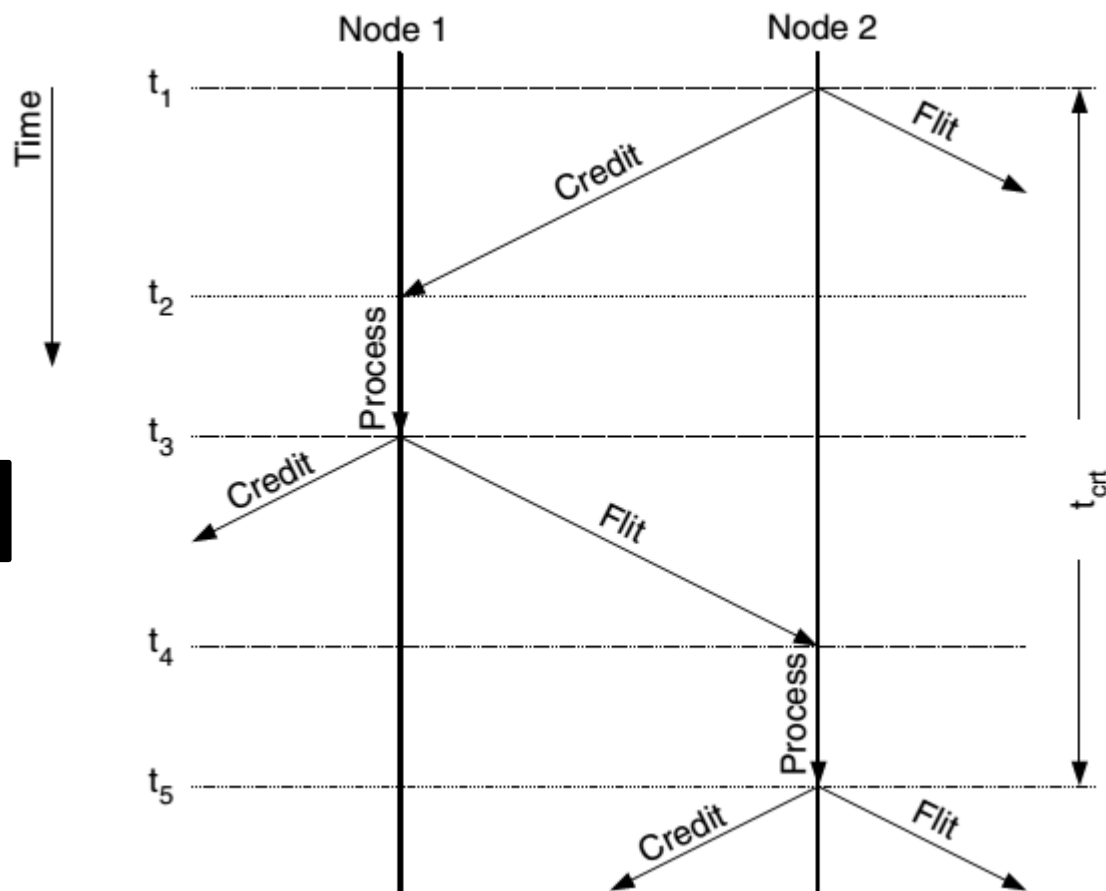
A system client wishing to inhibit transmission of data frames on certain priorities from the remote system on the link generates an M_CONTROL.request primitive specifying:

- a) The globally assigned 48-bit multicast address 01-80-C2-00-00-01;
- b) The PFC opcode (i.e., 01-01); and
- c) A request_operand_list with two operands indicating respectively the set of priorities addressed and the lengths of time for which it wishes to inhibit data frame transmission of the corresponding priorities.

PFC is a function defined only for a pair of full duplex MACs (e.g., 802.3 MACs operating in point-to-point full duplex mode) connected by one point-to-point link. Use of PFC on shared media such as EPON is out of the scope of this standard.

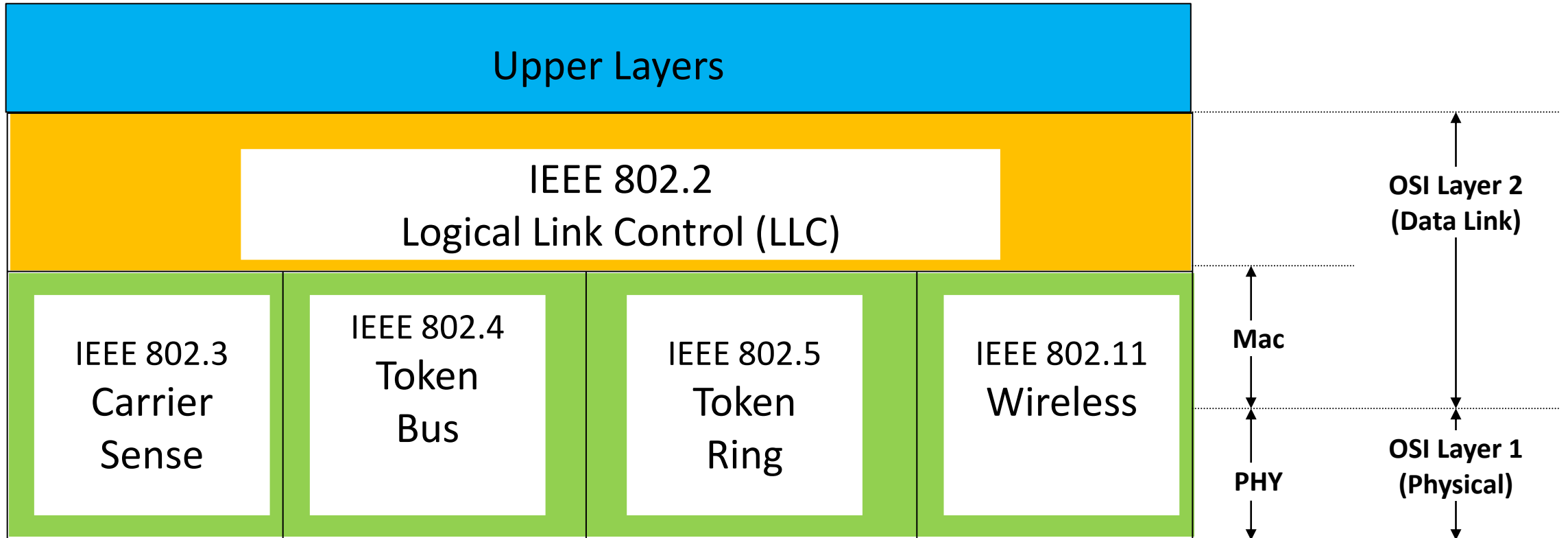
Credit-Based Flow Control

A flit, or flow control digit, is the smallest unit of information recognized by the flow control method

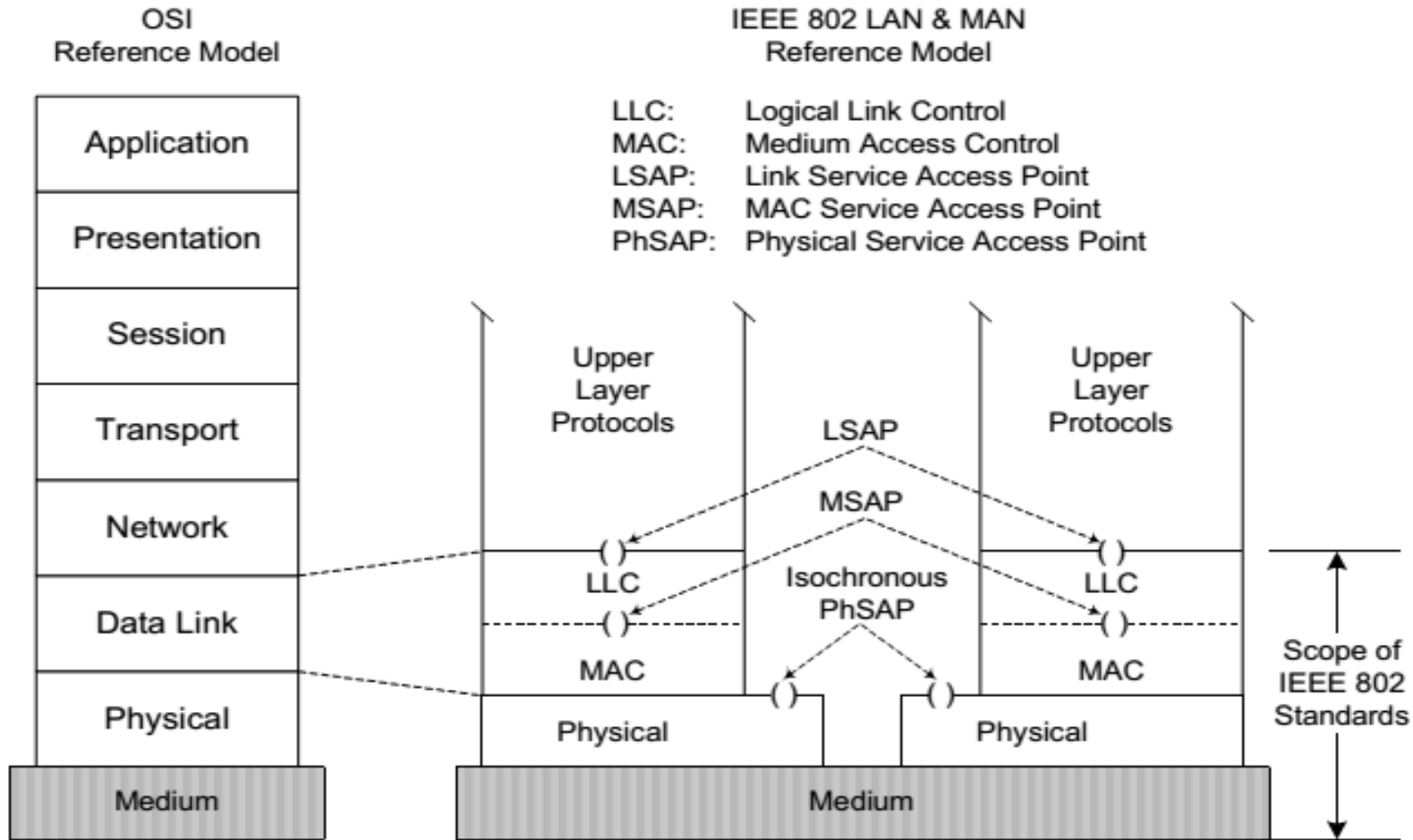


Credit-Based Flow Control is proposed by IBM to 802.1

IEEE 802 LAN Standards Family



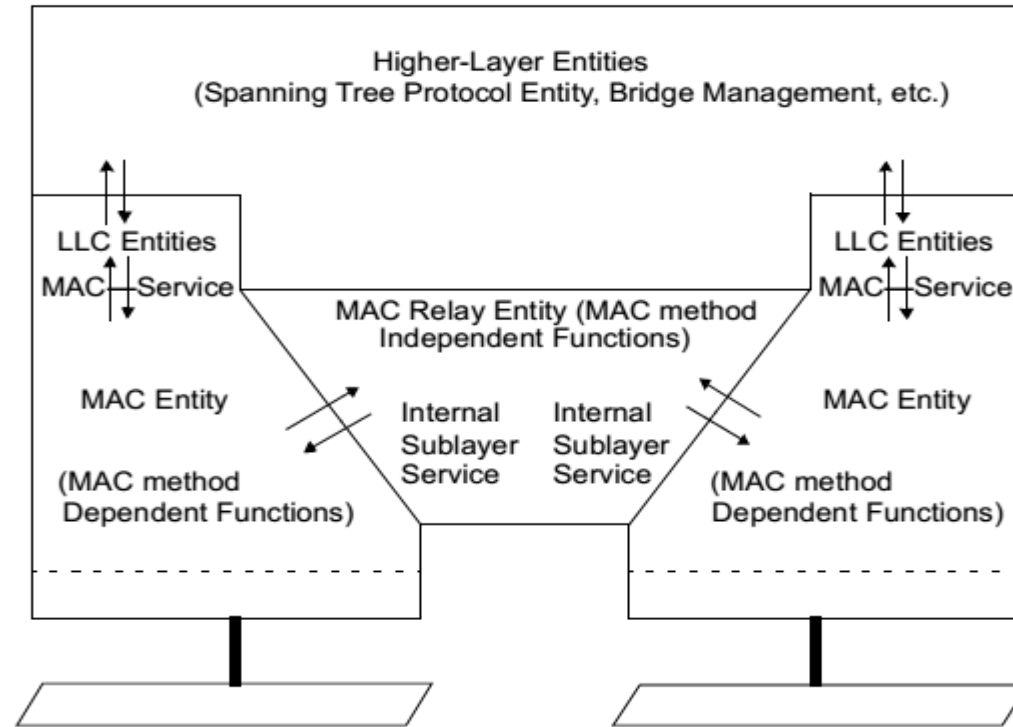
IEEE 802® Reference Model for End Station



IEEE 802.1D Bridge Architecture

M_UNITDATA.indication (frame_type, destination_address, source_address, mac_service_data_unit, user_priority, frame_check_sequence)

M_UNITDATA.request (frame_type, destination_address, source_address, mac_service_data_unit, user_priority, access_priority, frame_check_sequence)



- ❑ IEEE 802.1D Bridge shall Conform to IEEE Std 802.2 for the implementation of a class of LLC supporting Type 1 operation as required by 7.3 and 7.1.2. Each Bridge Port shall support the operation of LLC Type 1 procedures in order to support the operation of the Spanning Tree Protocol Entity. Bridge Ports may support other types of LLC procedures, which may be used by other protocols.
- ❑ A bridge processes protocols in the MAC sublayer and is functionally transparent to LLC and higher layer protocols. MAC frames are forwarded between access domains, or filtered (i.e., not forwarded to certain access domains), on the basis primarily of MAC addressing information

IEEE 802.1Q Bridge Architecture

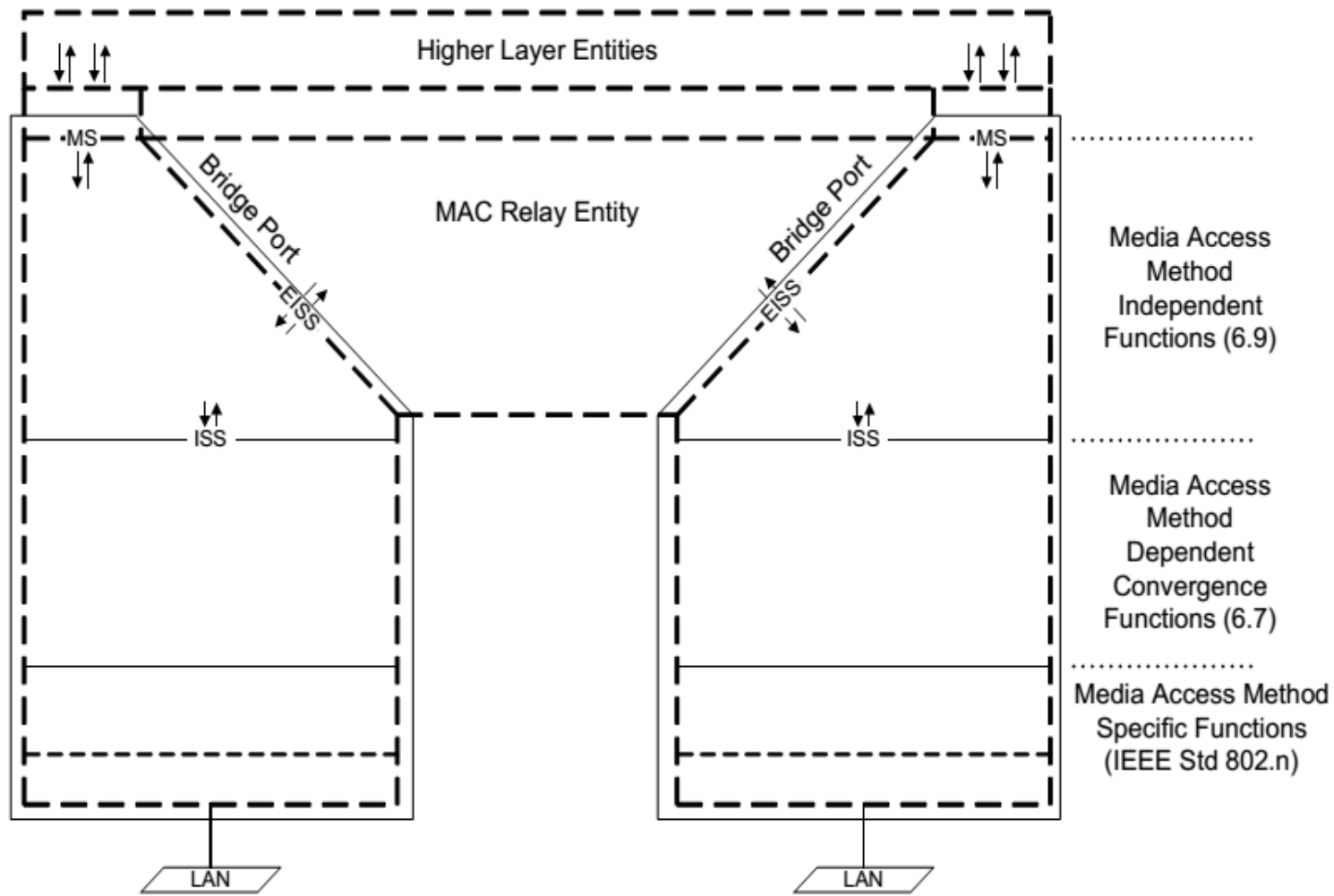
EM_UNITDATA.indication

```
(
  destination_address,
  source_address,
  mac_service_data_unit,
  priority,

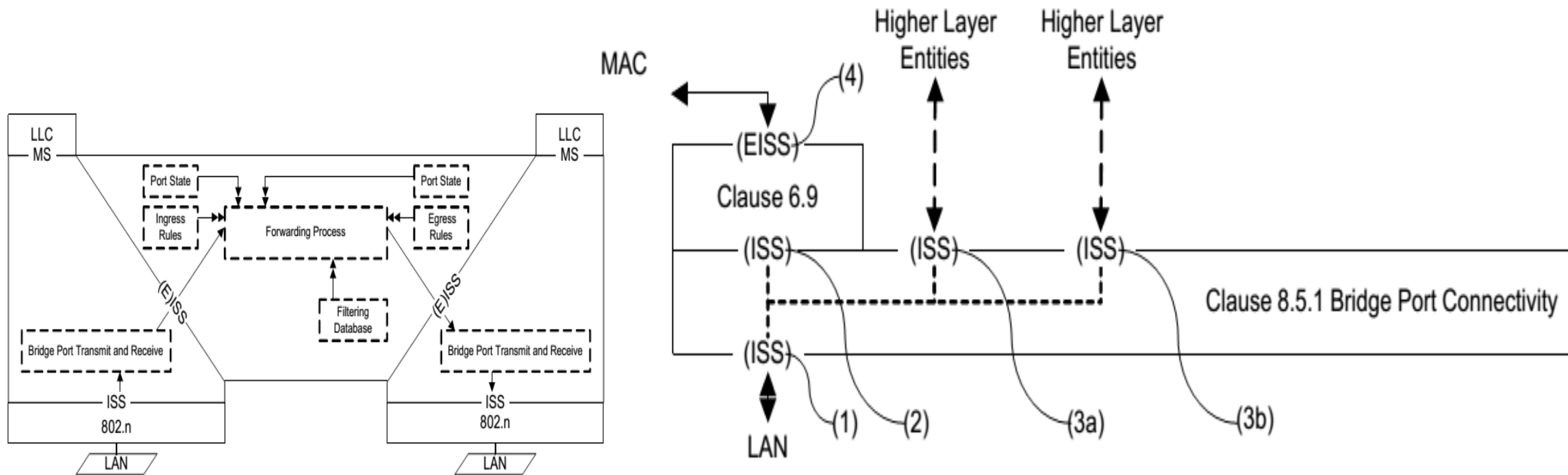
  drop_eligible,
  vlan_identifier,
  frame_check_sequence,
  service_access_point_identifier,
  connection_identifier,
)
```

EM_UNITDATA.request

```
(
  destination_address,
  source_address,
  mac_service_data_unit,
  priority,
  drop_eligible,
  vlan_identifier,
  frame_check_sequence,
  service_access_point_identifier,
  connection_identifier,
)
```



IEEE 802.1Q Bridge Forwarding Process



Forwarding Process is specified in IEEE 802.1Q Clause 8.6

Data Link Layer -- LLC

- **Logical Link Control (LLC)**
 - For IEEE 802, flow control, error control, and part of the framing duties are all brought together in this LLC sub-layer.
 - Framing is also performed in the MAC sub-layer.
 - The LLC provides a single data link control protocol for all IEEE LANs. (Contrast this with the MAC layer where we have different protocol versions for different LANs. See previous slide.)
 - The LLC makes the MAC sub-layer transparent.
 - Framing
 - **LLC provides a PDU similar to HDLC**

LLC Sublayer Connectionless Mode of Operation

- The LLC sublayer standard, ISO/IEC 8802-2, describes two types of connection-less mode of operation for data communication between service access points:
 - **Unacknowledged connectionless-mode (type 1),**
 - Information frames are exchanged between LLC entities without the need for the prior establishment of a logical link between peers. The LLC sublayer does not provide any acknowledgments for these LLC frames, nor does it provide any flow control or error recovery procedures.
 - LLC type 1 also provides a TEST function and an Exchange Identification (XID) function. The capability to act as responder for each of these functions is mandatory: This allows a station to check the functioning of the communication path between itself and any other station, to discover the existence of other stations, and to find out the LLC capabilities of other stations.
 - **Acknowledged connectionless-mode (type 3).**
 - With type 3 operation, information frames are exchanged between LLC entities without the need for the prior establishment of a logical link between peers. However, the frames are acknowledged to allow error recovery and proper ordering. Further, type 3 operation allows one station to poll another for data
 - This type has little or no commercial use.

LLC Sublayer Connection-mode of Operation

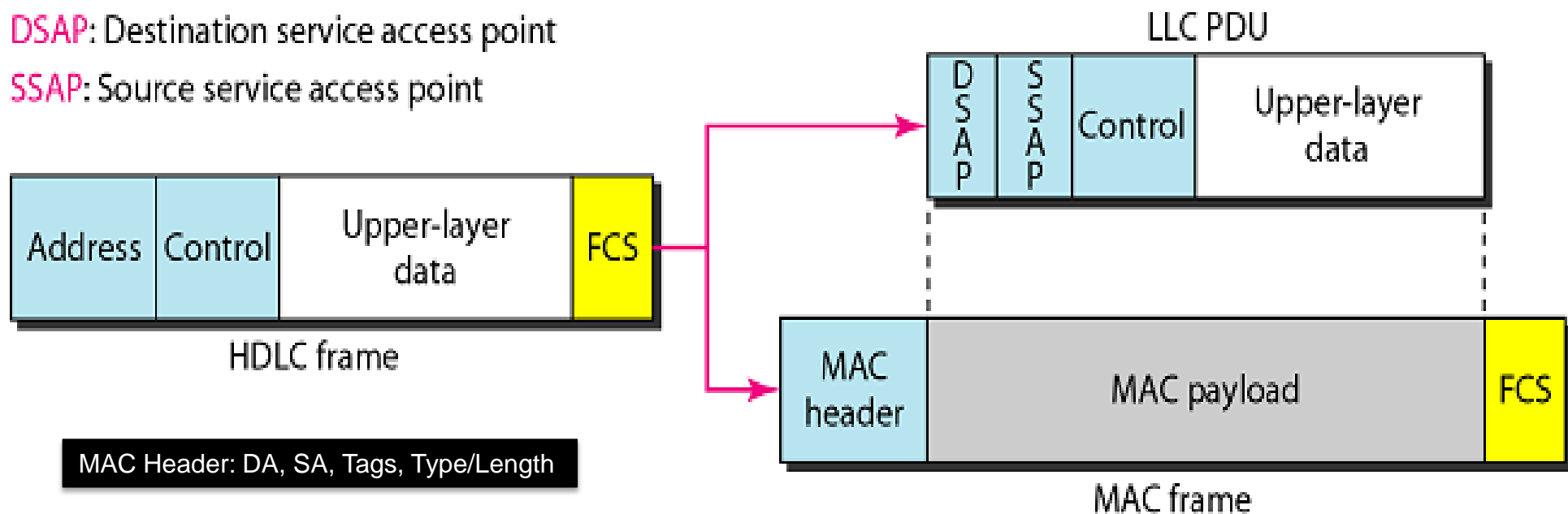
- **Connection-mode (type 2):**
 - A logical link is established between pairs of LLC entities prior to any exchange of information frames.
 - In the data transfer phase of operation, information frames are transmitted and delivered in sequence.
 - Error recovery using positive ACK and retransmission. F
 - low control using fixed-length sliding window of 8 frames are provided within the LLC sublayer.
- **Systems on the same IEEE 802.2 network may use 802.2 Type 2 communications after verifying that it is supported by both ends. This is accomplished using the 802.2 XID mechanism**

LLC Framing

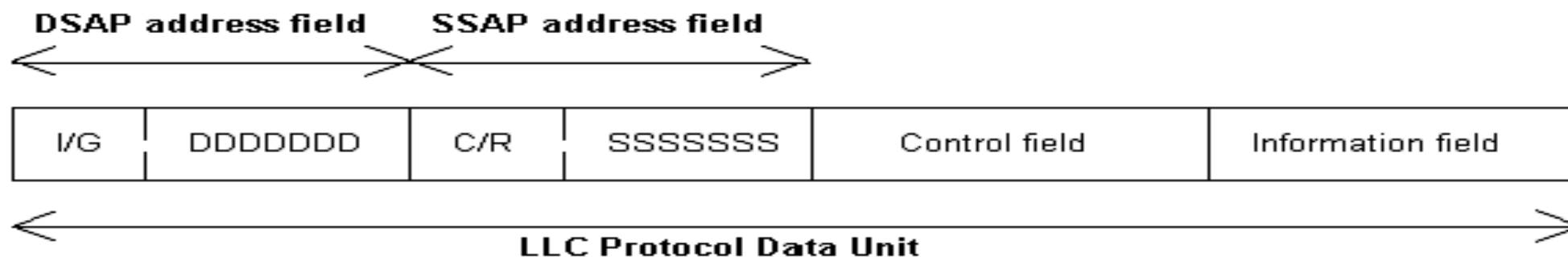
- The LLC header contains a control field like HDLC and is used for flow and error control.
- The two access point fields (DSAP and SSAP) define the upper layer protocol at the source and destination that uses LLC.

DSAP: Destination service access point

SSAP: Source service access point



LLC Address Fields



I/G = *Address type designation bit (indicating individual or group actual addresses)*

0 = Individual DSAP
1 = Group DSAP

C/R = *The command/response identifier bit*

0 = Command } The value of the C/R bit is set by the
1 = Response } operation of the LLC protocol

D D D D D D D = Destination *actual address*

S S S S S S S = Source *actual address*

Note

- A complete LLC PDU is shown so that the address fields can be seen in context.
- The leftmost bit of each field is the least significant bit.
- The Information field is not present in all LLC PDUs

User Data Encapsulation

- **Type Field Encoding**
 - The length/type field (2 bytes) in the Ethernet frame contains a type value in the range of 0x600 to 0xFFFF indicating the higher-layer protocol that is being encapsulated.
 - The most common encapsulation used on Ethernet.
 - Ethertype values are registered with IEEE: <http://standards.ieee.org/develop/regauth/ethertype/>
 - Type field assignments are administered by the Registration Authority, IEEE Standards Department, P.O. Box 1331, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA.
- **LLC Encoding**
 - The SSAP and DSAP identify the higher layer protocol.
 - The control field carries a value indicating the type of frame.
 - **LLC type1 uses unnumbered Information and provides connectionless, best effort service.**
 - **LLC type 2 provides reliable, connection-oriented services.**
 - SSAP/DSAP are allocated by IEEE-RA for a protocol which is a standard published by an internationally recognized standards organization, and has a potentially large field of application.

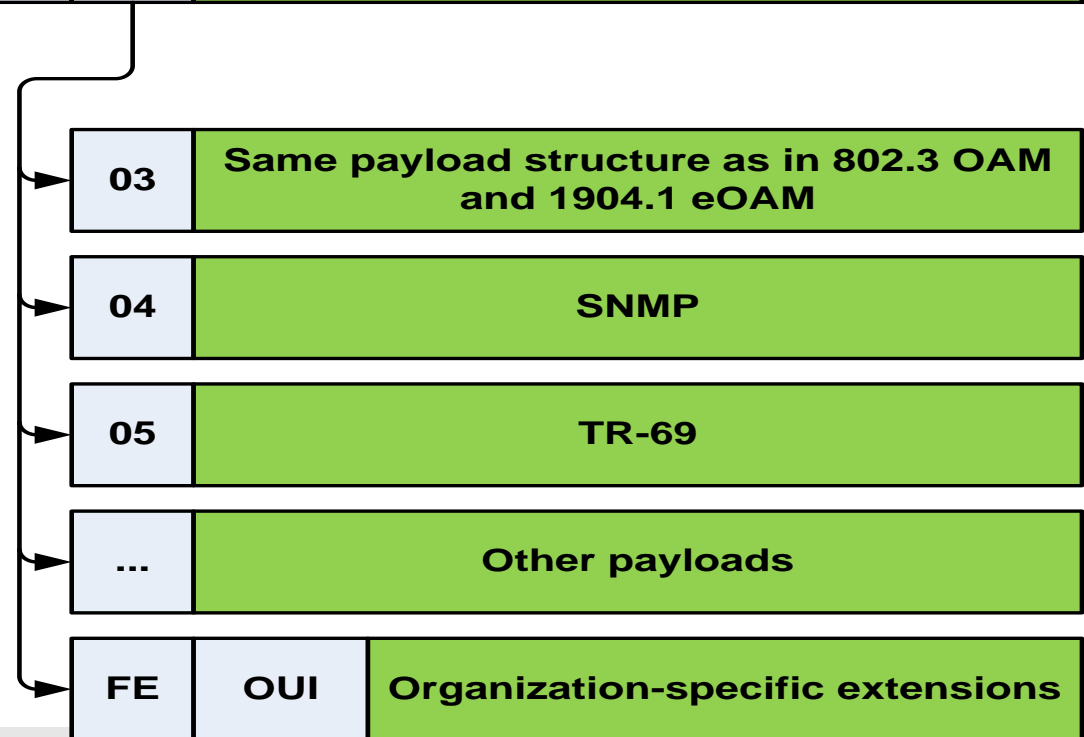
User Data Encapsulation (2)

- **Clients using Length Encapsulation and LLC can communicate among themselves, and Clients using Type Encapsulation can communicate among themselves on the same LAN.**
- **When Type Encapsulation is used LLC Protocol is not used and does not need to be present.**
- **If a device supports some clients that use Type Encapsulation and others that use Length Encapsulation, the MAC can demultiplex frames to both sets of clients simultaneously.**

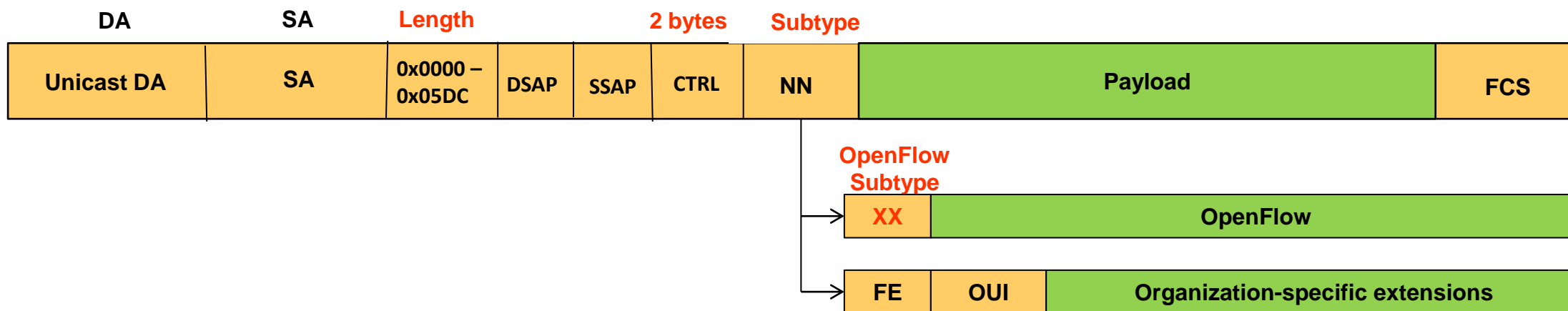
Possible approach for IEEE 1904.2



- 1904.2 may request a new Ethertype
- Devices that don't understand this Ethertype will treat it as a regular data frame
- 1904.2 will administer subtypes to avoid conflicts

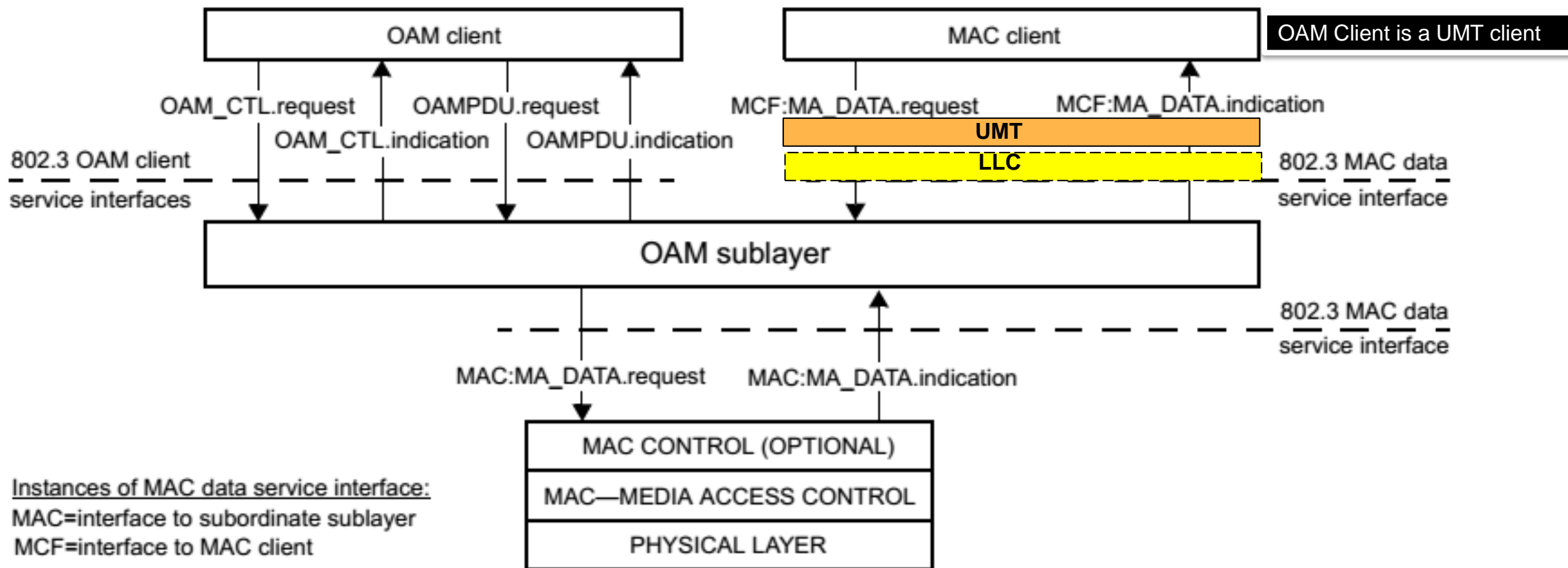


Using LLC Encapsulation for UMT to Support Layer 2 OpenFlow



- Two possible approaches to support OpenFlow:
 - Define a new subtype for openflow protocol
 - Use OUI (Organization-specific extensions)
- **We recommend the 1st approach.**

UMT Support of Interlayer Service Interfaces



Related IEEE 802.1 Standards/Projects (1)

- **802.1aq - Shortest Path Bridging**
 - This amendment will augment the existing, successful, multi-vendor interoperable bridging specifications to allow use of shortest path communication within administratively defined network regions, while retaining concurrent support for all existing capabilities and configurations
- **IEEE 802.1Qbp - Equal Cost Multiple Paths**
 - This standard specifies protocols, procedures and managed objects to support utilizing multiple possible next hop choices for frames within a single service in Shortest Path Bridging MAC Mode (SPBM) networks.
- **802.1Qay - Provider Backbone Bridge Traffic Engineering**
 - This amendment will support provisioning systems that explicitly select traffic engineered paths within Provider Backbone Bridge Networks (P802.1ah) by allowing a network operator to disable unknown destination address forwarding and source address learning for selected VLAN Identifiers, while allowing other network control protocols to dynamically determine active topologies for other services

Related IEEE 802.1 Standards/Projects (2)

- **802.1CB - Frame Replication and Elimination for Reliability**
 - This standard specifies procedures, managed objects and protocols for bridges and end stations that provide:
 - Identification and replication of frames, for redundant transmission.
 - Identification of duplicate frames.
 - Elimination of duplicate frames.
- **IEC 62439-3, Parallel Redundancy Protocol (PRP) and High availability Seamless Redundancy (HSR)**
- **802.1Qca - Path Control and Reservation**
 - This project extends the application of Intermediate System to Intermediate System (IS-IS) to control bridged networks (beyond the capabilities of Shortest Path Bridging) and specifies additional protocols, procedures and managed objects. The new standard will provide explicit path control, bandwidth and stream reservation, redundancy (protection or restoration) for data flows).

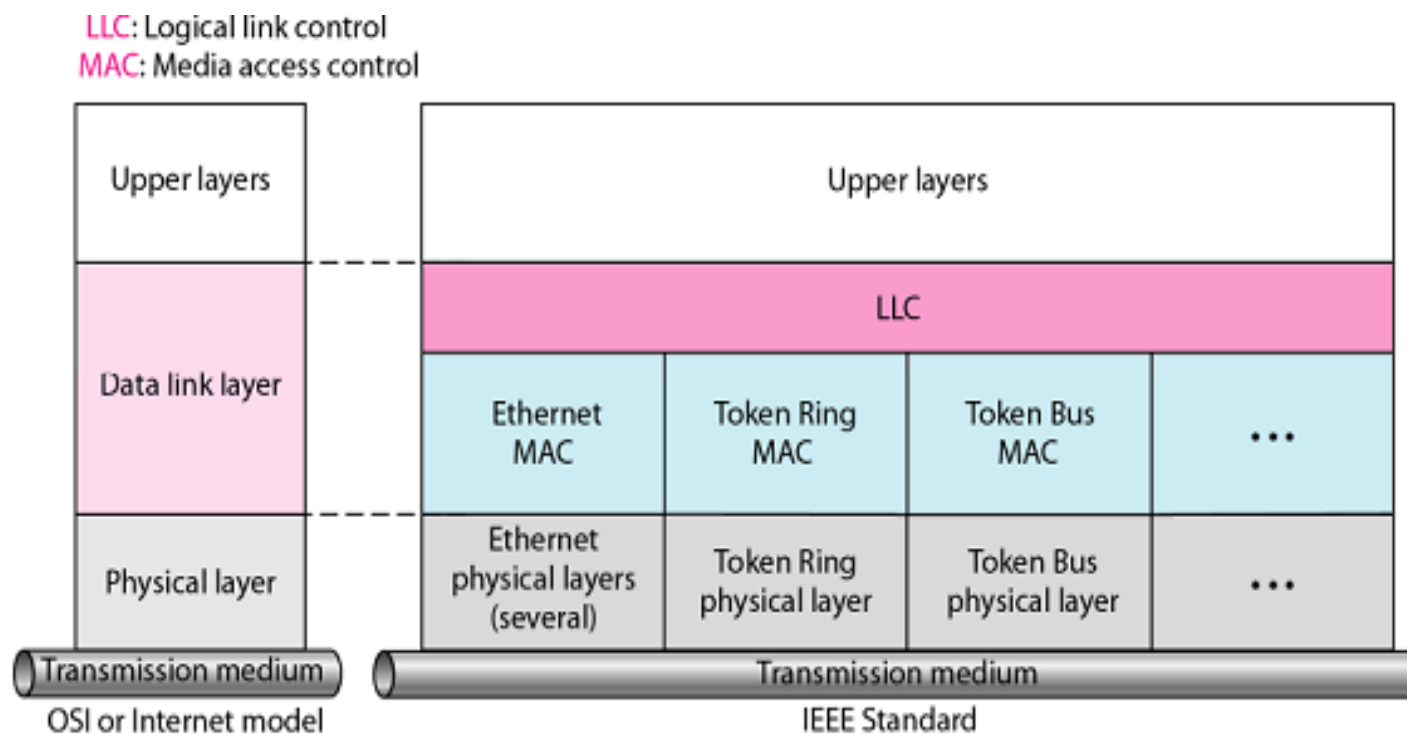
IEEE 802.1CF

- **A new IEEE 802.1 TF has been created to provide *Recommended Practice for Network Reference Model and Functional Description of IEEE 802 Access Network.***
 - Modern heterogeneous networks, for applications such as Smart Grid, Home Automation, and Internet of Things, suffer from limitations in service control, security and provisioning. This project will help to unify the support of different interfaces, enabling shared network control and use of software defined network (SDN) principles, thereby lowering the barriers to new network technologies, to new network operators, and to new service providers. The project will generate a Recommended Practice to deploy IEEE 802 technologies in an access network enabling such heterogeneity.
- **Huawei plans to present SDN/Virtualization layer 2 openflow use cases for access networks.**

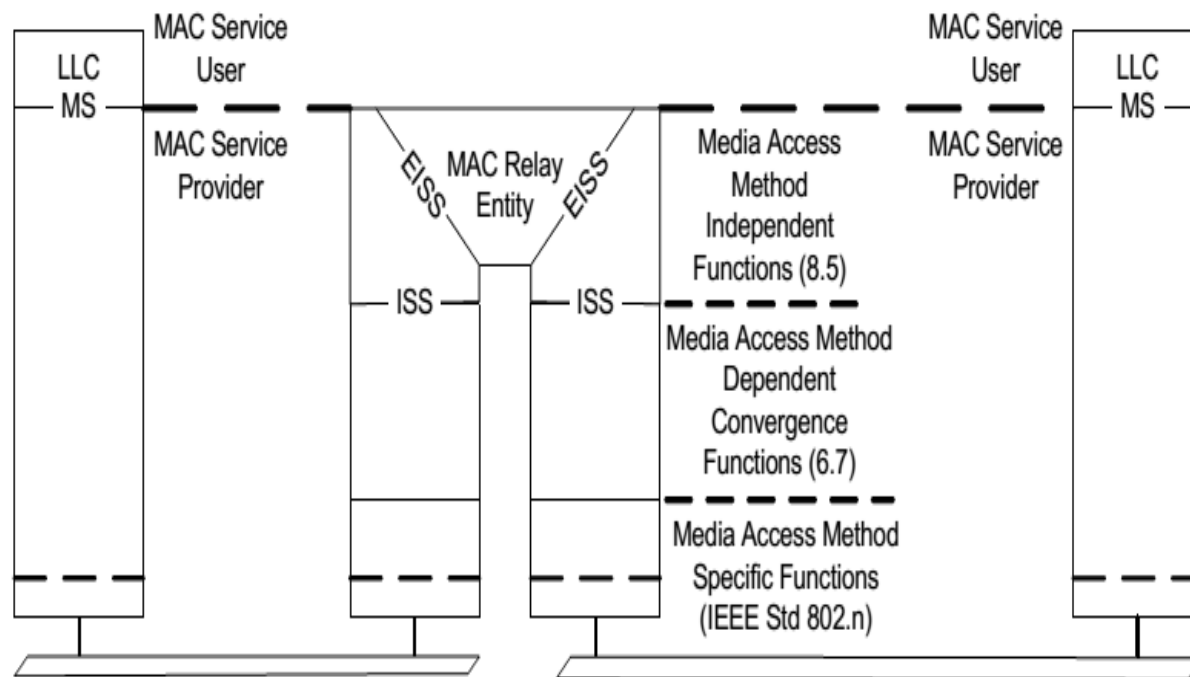
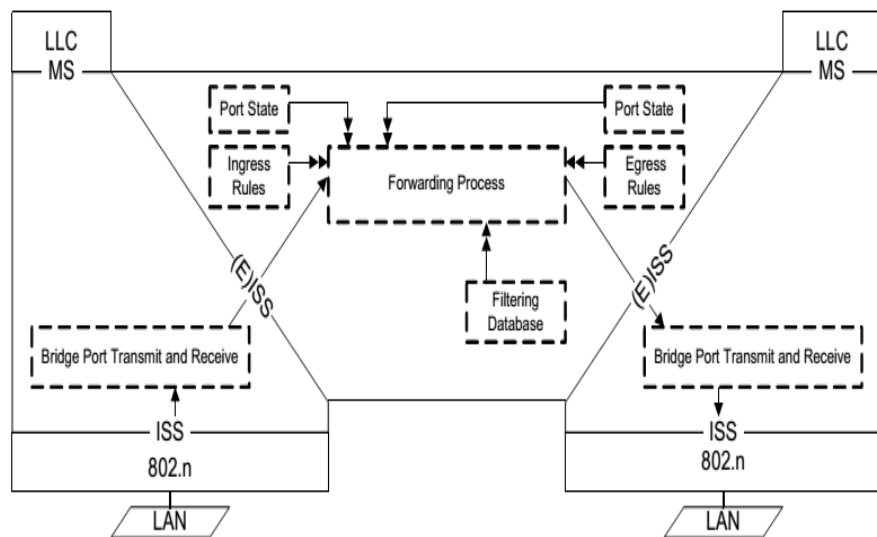
THANK YOU

IEEE 802 Standards for LANs

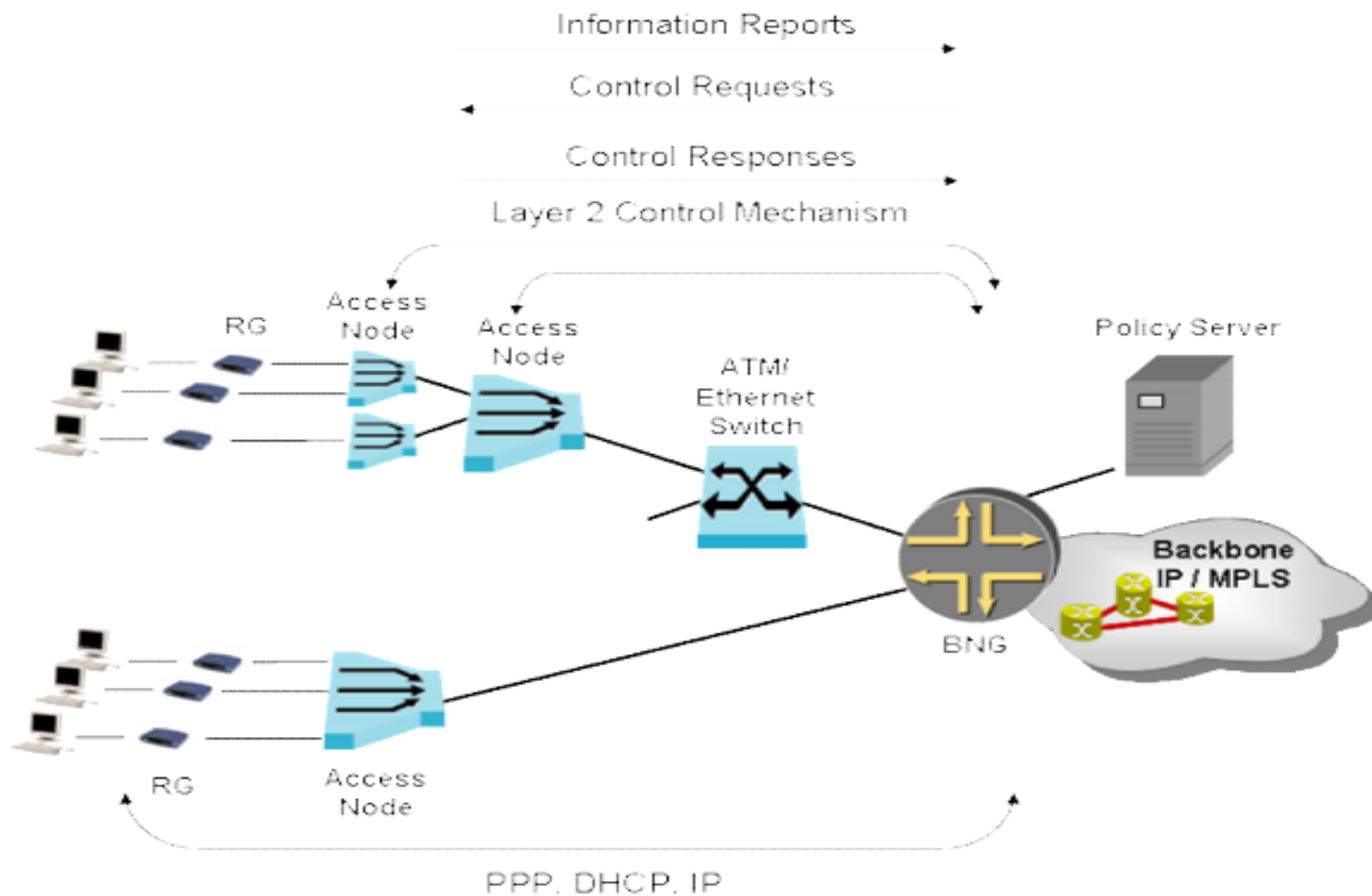
- The 802 standard has sub-divided the Data Link Layer into two parts:
 - LLC Link Layer Control
 - MAC (Media Access Control) Layer



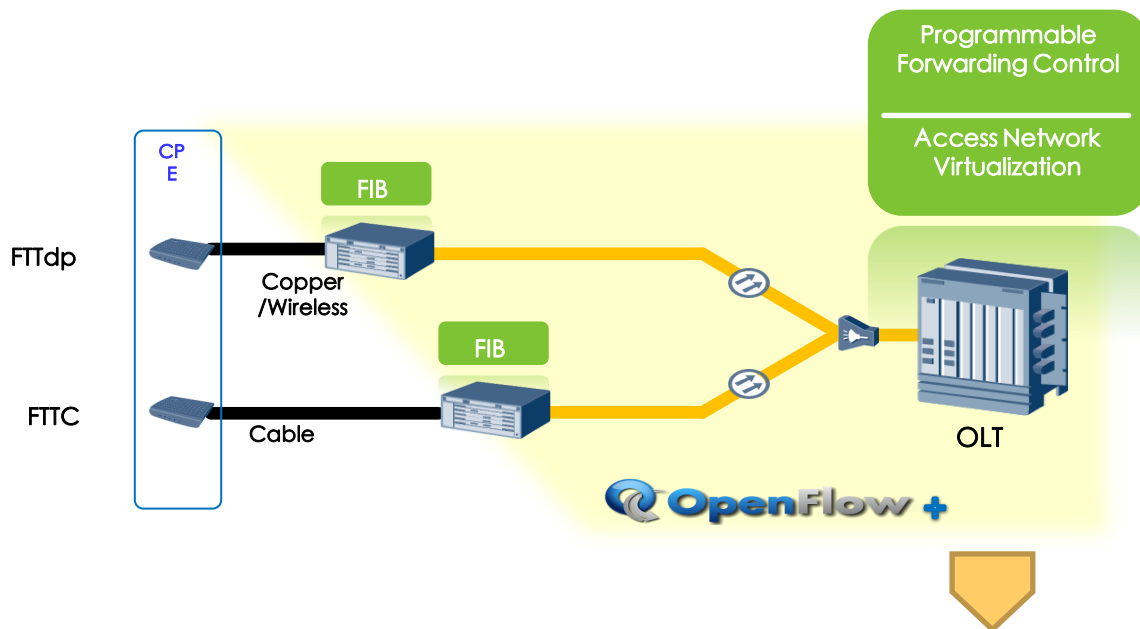
IEEE 802.1Q Internal organization of the MAC sublayer



BBF TR-147: Layer 2 Control Mechanism For Broadband Multi-Service Architectures



Software Defined Access Network & AN Virtualization

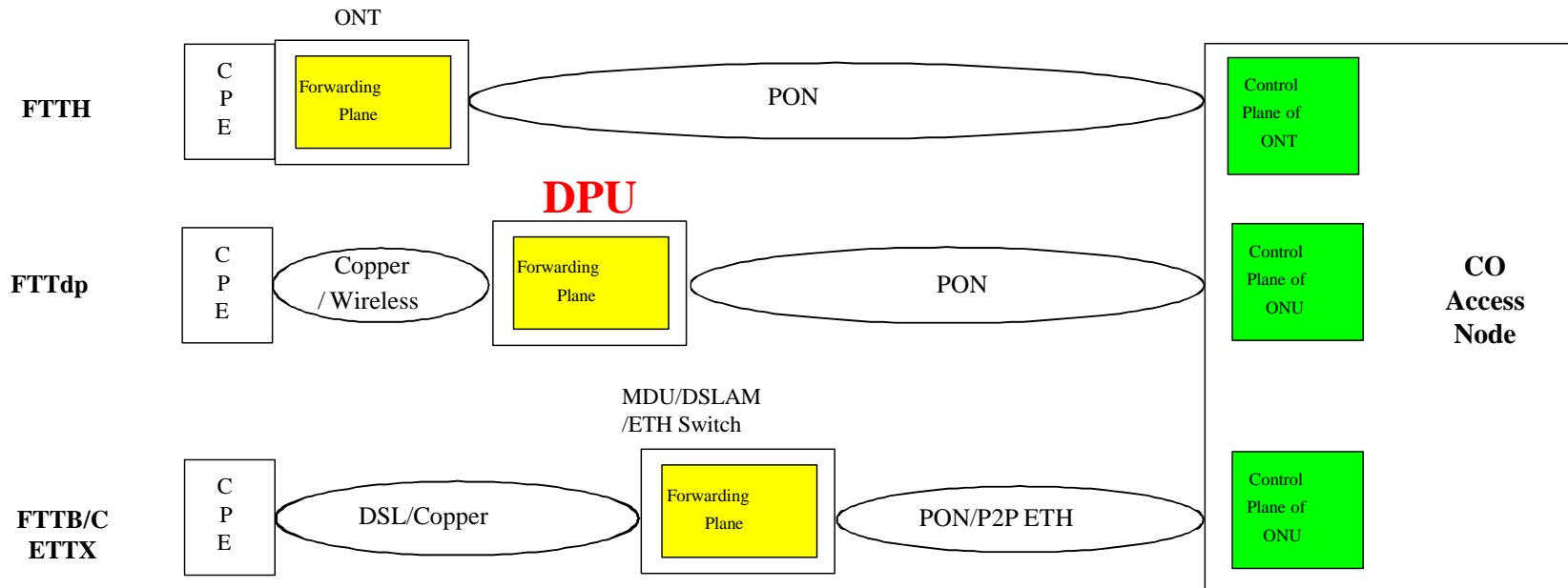


- Based on the separation of the forwarding and control planes , the control plane for remote nodes are relocated and centralized to OLT.
- OLT and its remote nodes are virtualized as one access node with one management IP address.

• Benefits

- Remote nodes are simplified to programmable devices.
- Decouple access devices from services.
- Simplified O&M
- No IP address is needed to configure remote nodes.

Use Case Defined by BBF SD-313: Remote Nodes Plug & Play in Access Networks



- Control planes of remote nodes are moved to the aggregation OLT, while remote nodes implements forwarding plane.

Use Case Defined by ETSI NFV: Access Network Virtualization

