Connection-Oriented Software-Defined Networking

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Authors:

Name	*Affiliation*	*Phone*	*Email*
Roger Marks	EthAirNet Associates	+1 619 393 1913	roger@EthAir.net

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Abstract

Conventional software-defined networking (SDN) is essentially about managing switches. In order to control the overall network, SDN can be extending to allow management of links as well. Connection-oriented link control, as provided in IEEE 802.16 and other standards, allows a pathway for SDN to manage links. The set of connections within a link can operate on a mixture of mixed access technologies, allowing the Connection-Oriented Software-Defined Networking (COSDN) controller to assign service flows to connections on various media and access technologies.

Connection-Oriented Software-Defined Networking (COSDN)

This contribution based on IEEE 802.16-13-0098 and IEEE 802.16-13-0084 .

Followup to IEEE 802.16-13-0049 (“Integration of IEEE 802.16 and Carrier Ethernet”)

- proposed a switch-centric architecture with a switch in the 802.16 BS
- switch is presumably based on 802.1Q functionality (learning, spanning tree, etc.)

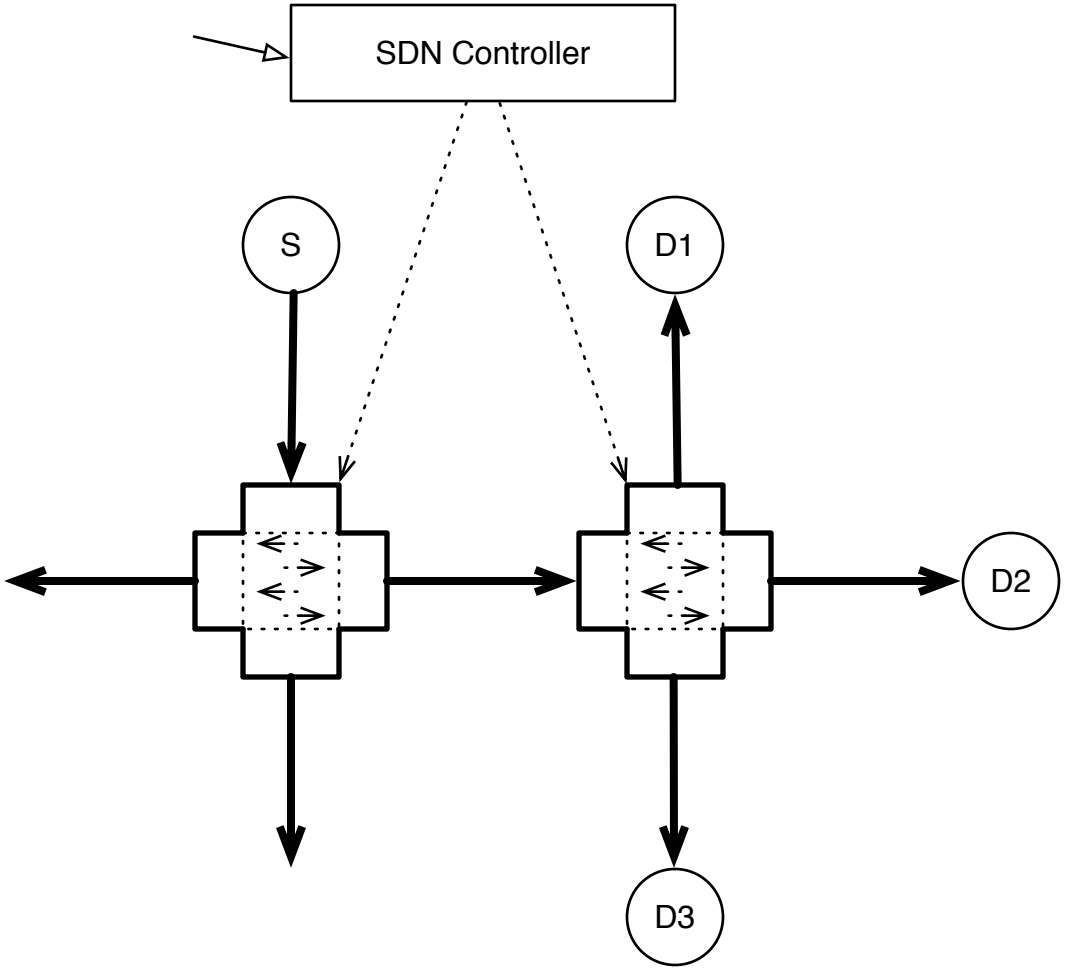
IEEE 802.16-13-0084 (“Integration of IEEE 802.16 with Software-Defined Network Control”)

- followup to IEEE 802.16-13-0049, introducing SDN controller to program the switch and link connections, including QoS control, as an alternative to pure 802.1Q behavior.

SDN

- SDN controller communicates with switches via control path
- SDN controller controls flow forwarding by managing flow tables
- limited QoS enabled by associating a flow with a customized queue
  - Can schedule packets onto a link
  - Can’t control what happens on the link

SDN



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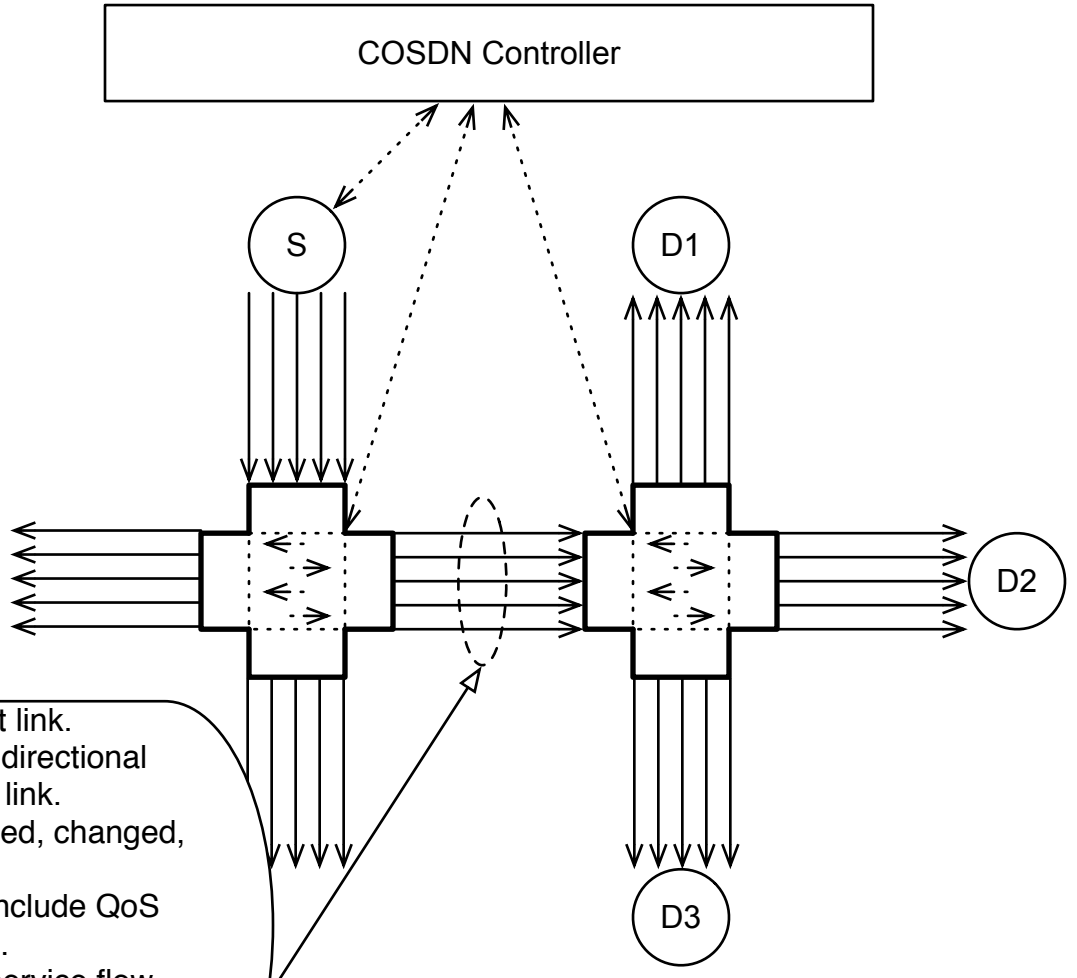
Connection-Oriented SDN (COSDN)

- Links are connection-oriented and managed
- COSDN controller manages not only switches but also
  - link connections
    - Connection setup, teardown, maintenance
    - packet classification
  - source ports for connection classification
- Links may be unmanaged
  - e.g. they may not be connection-oriented or may support only a single connection

Connection-Oriented SDN



One point-to-point link.
Arbitrary number of unidirectional connections, per link.
Connections can be created, changed, and deleted.
Connection properties include QoS requirements.
Frames assigned to a service flow based on frame headers. Service flow assigned to a connection.
Scheduler manages the overall QoS.
Header suppression, per connection.

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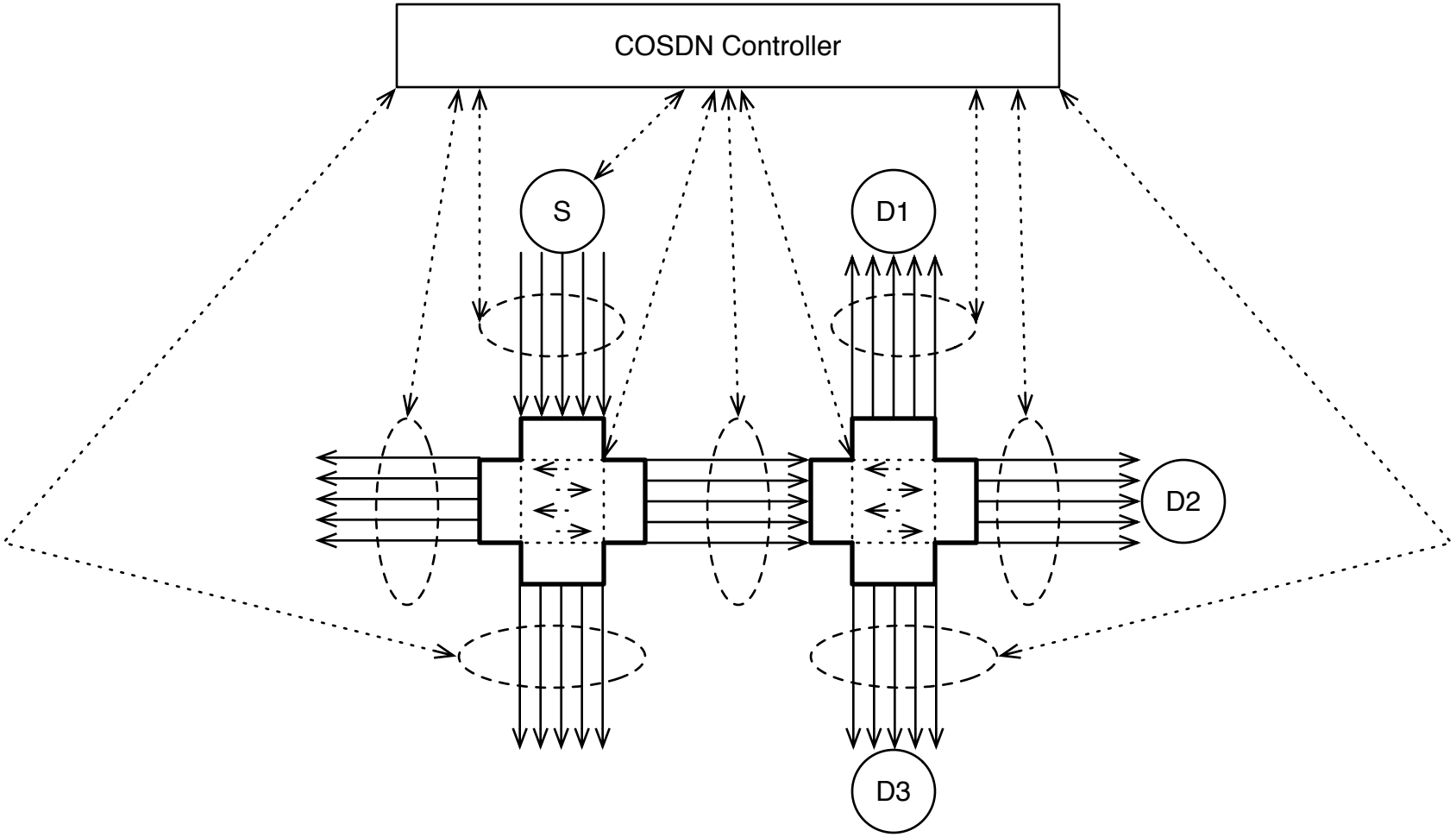
Connection-Oriented SDN
Full Connection Control



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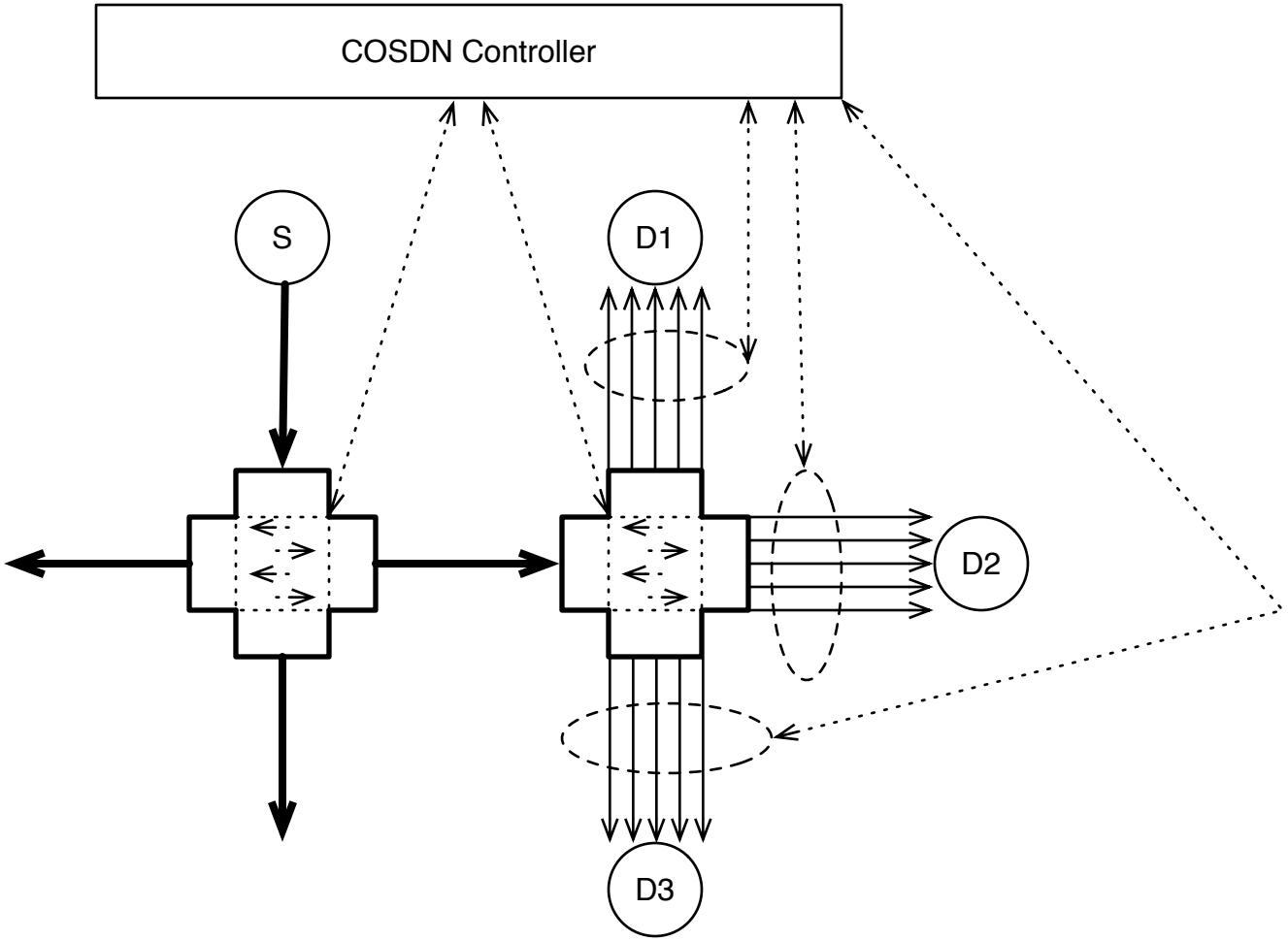
Connection-Oriented SDN
Partial Connection Control



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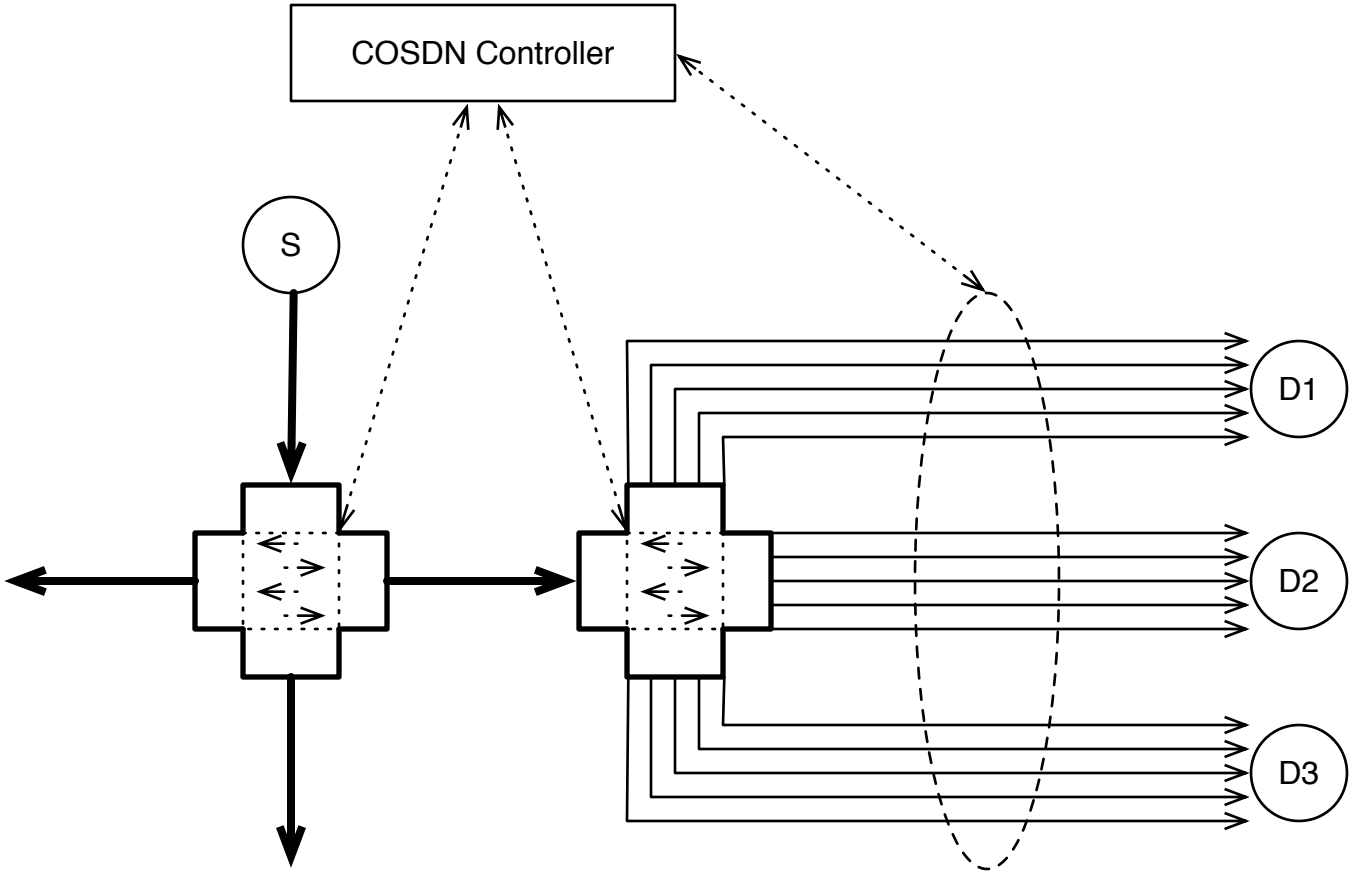
Connection-Oriented SDN with Shared Physical Medium

- Multiple Links may share a physical medium
- This points out a major limitation of queuing only on the link: if the link resource is shared, the entire shared resourced must be managed as a single resource, with scheduling to accommodate connection QoS requirements across all links.
- Example: Point-to-multipoint radio links, as in IEEE 802.16.
- Note: the switch ports are virtual, not physical.

Connection-Oriented SDN
Shared Physical Medium



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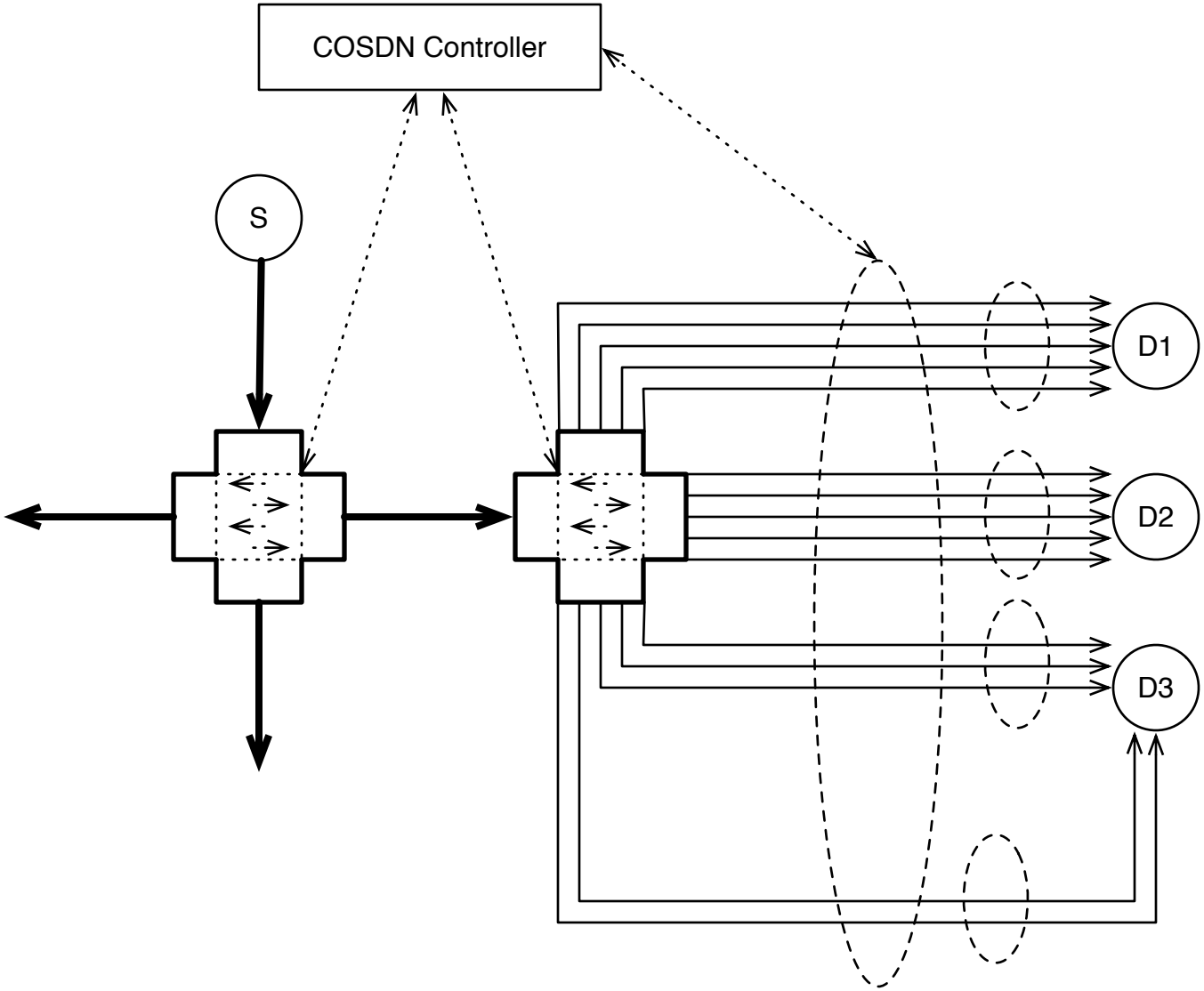
Connection-Oriented SDN with Multiple Physical Media

- Connections need to deliver packets to ports. There are many ways to do so.
- Could separate link connections by physical media.
  - May require a physical switch, not just virtual
- Example: an edge device may support IEEE 802.16 and IEEE 802.11.
  - Provision some connections (e.g., QoS-sensitive ones) over 802.16.
  - Provision other connections (e.g., best-effort) over 802.11.
- Manage all connections in a coordinated fashion using COSDN.
- Enable cross-media handover.
  - Use link aggregation tricks (e.g. IEEE 802.1AX Marker Protocol) to speed transition while maintaining correct packet sequence.

Connection-Oriented SDN
Multiple Physical Media



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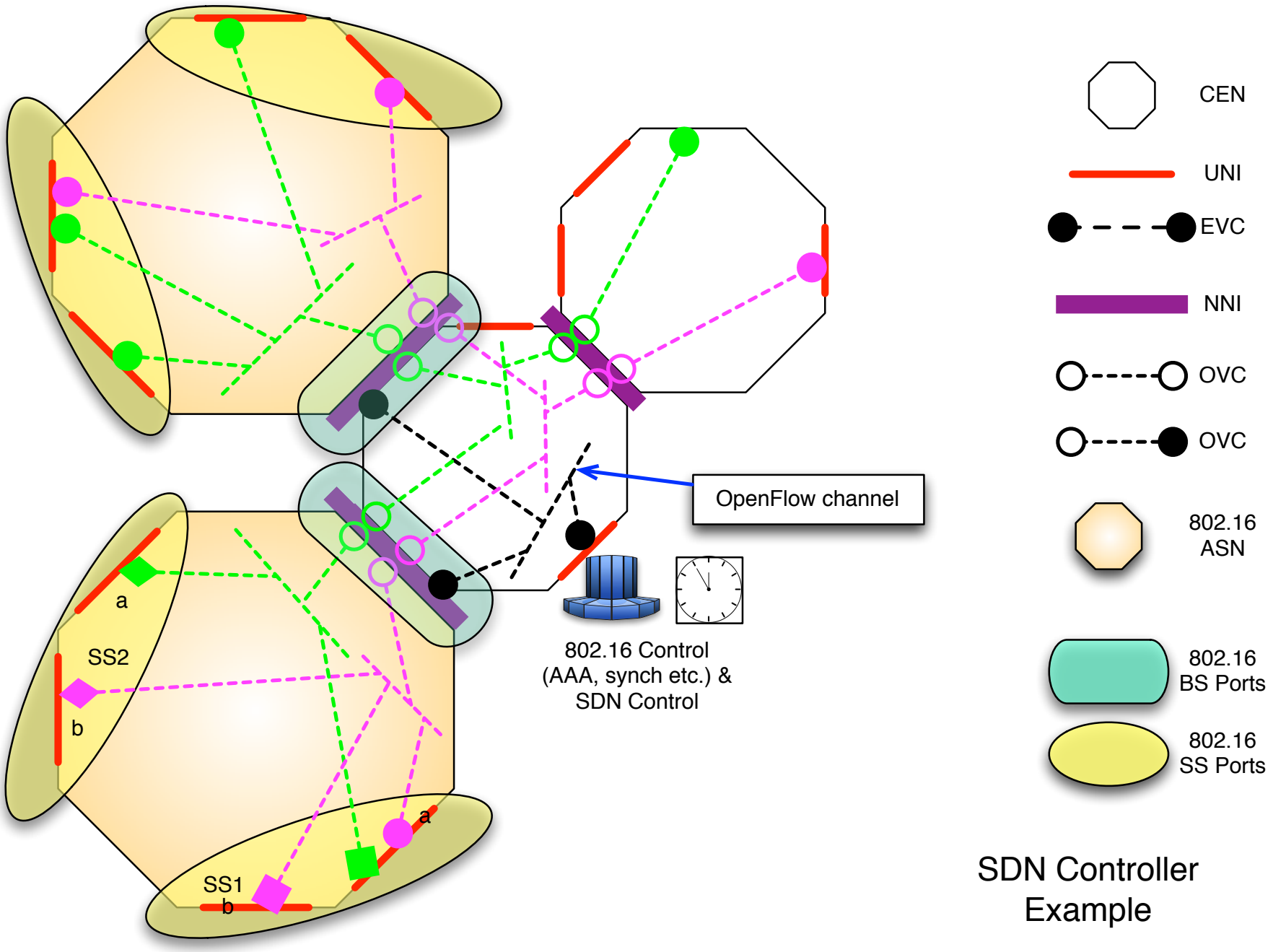
Connection-Oriented SDN with Multiple Physical Media - Uplink

- The previous figures illustrate the “downlink” problem of a point-to-multipoint architecture.
- “Uplink” can be managed in a similar fashion.
- Source packets must be classified and assigned to flows that map to connections appropriate to their QoS requirements.
- COSDN Controller manages connections.
- COSDN Controller configures packet source flow tables
  - Not for switching but for QoS sorting and matching to appropriate connections.



SDN Controller
Example

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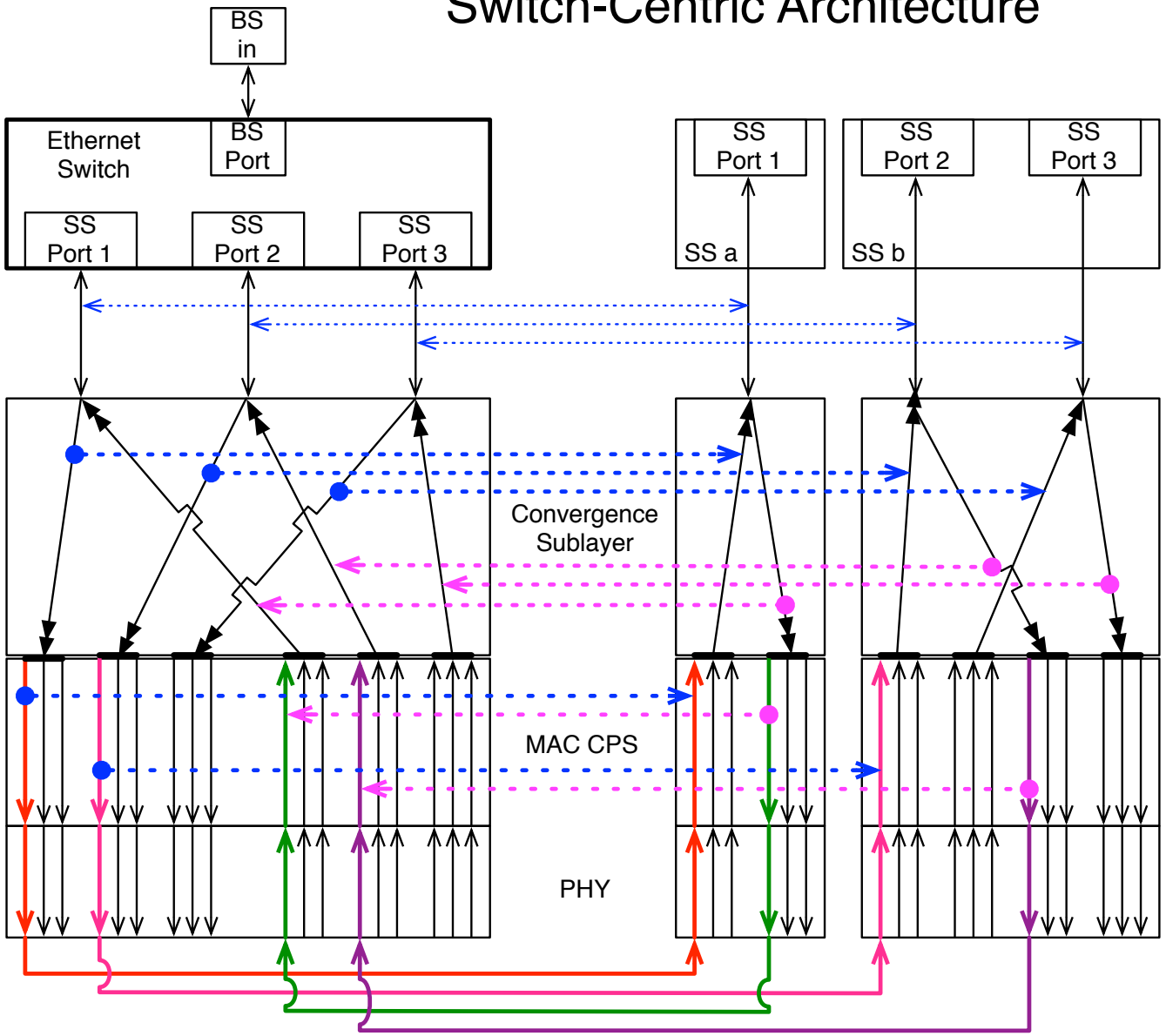
802.16 Packet CS compared to OpenFlow

	802.16-2012 Packet CS	OpenFlow
Destination	CID	Port
Table Pipeline	No; one table, plus PHS	Pipeline sequence
Match on	Headers, with masks	Headers, with masks
Match Priority	Prioritized rules	Prioritized rules
Action without match	Drop	Specified by Table Miss entry; can send to controller for learning, etc.
Match actions & Match instructions	Forward; Drop [PHS]	Forward; Drop; Group; <Set Queue>; <Push/Pop Tag>; <Set Field>; <Change TTL>; <Write Metadata>
Counters & Timers	No	Yes
Meter Tables	No	Yes
Automatic Rule Deletion	No	Timeouts (hard and idle)

Switch-Centric Architecture



multiple SS Ports per SS
one SS per SS Port

One CS instance per SS
Port-aware CS

unidirectional
Connections

multiple Connections per SS Port
one SS Port per Connection
Connections labeled by SS Port

all Connections linked via PHY
[several examples highlighted]

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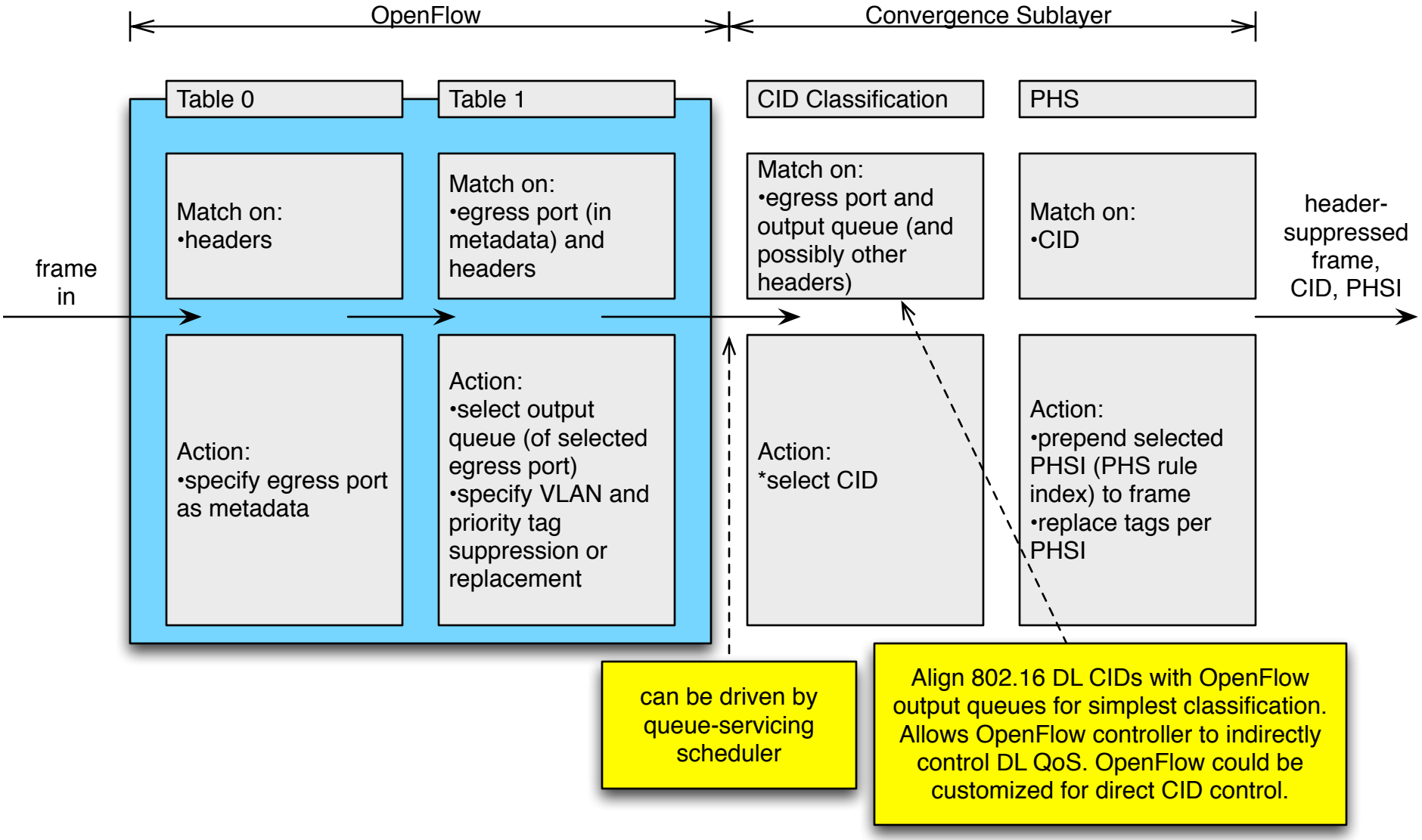
Downlink Pipeline



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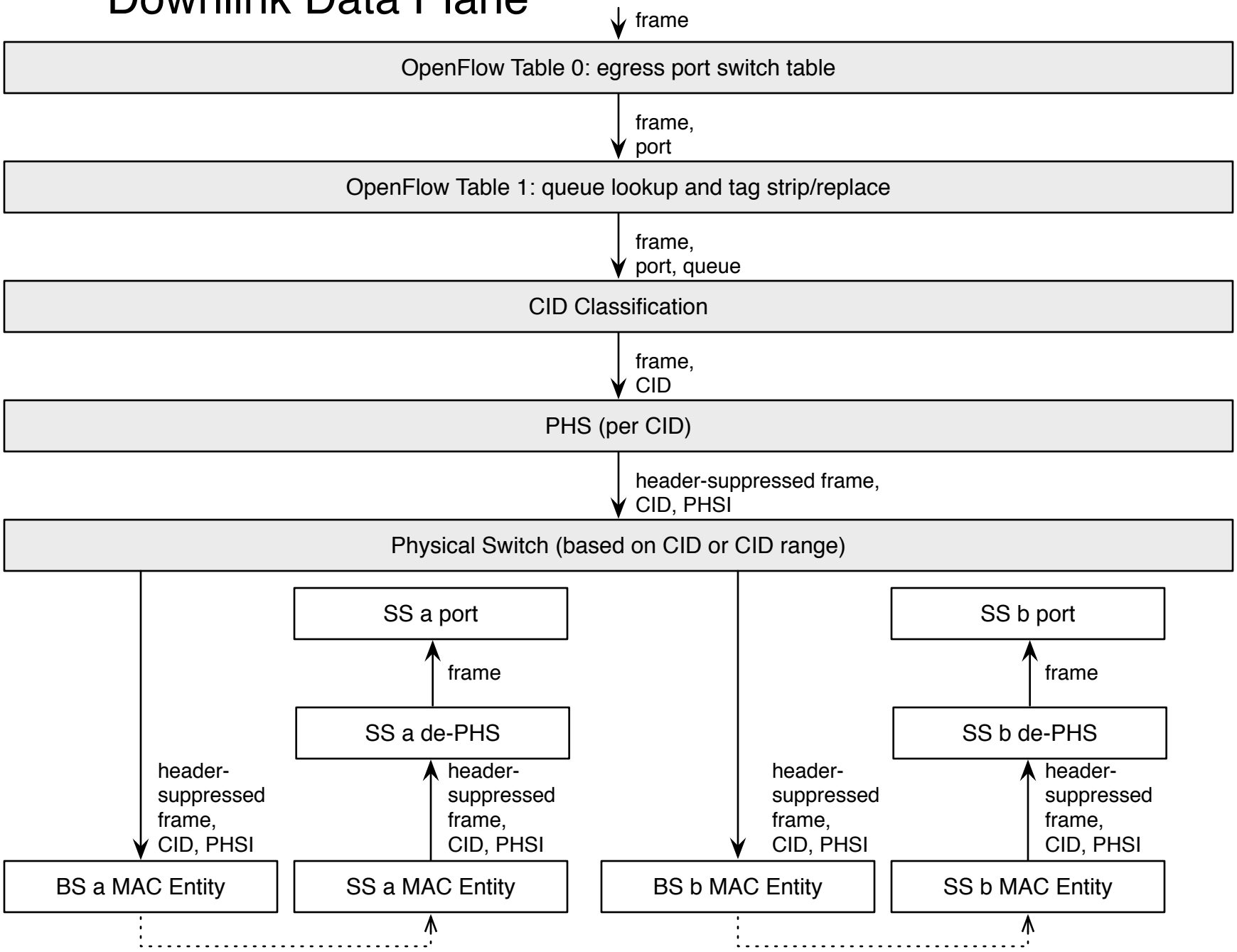
Downlink Data Plane



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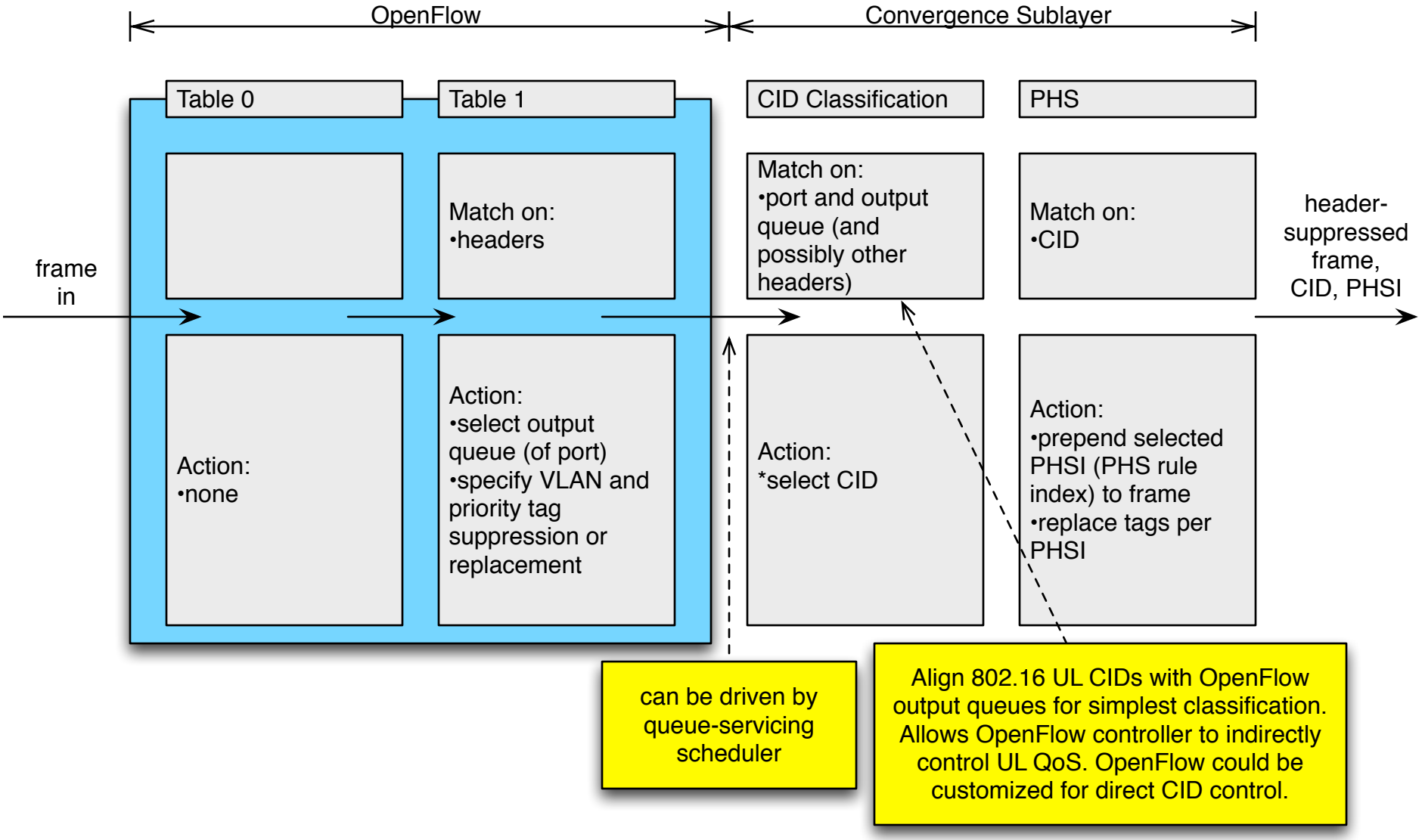
Uplink Pipeline



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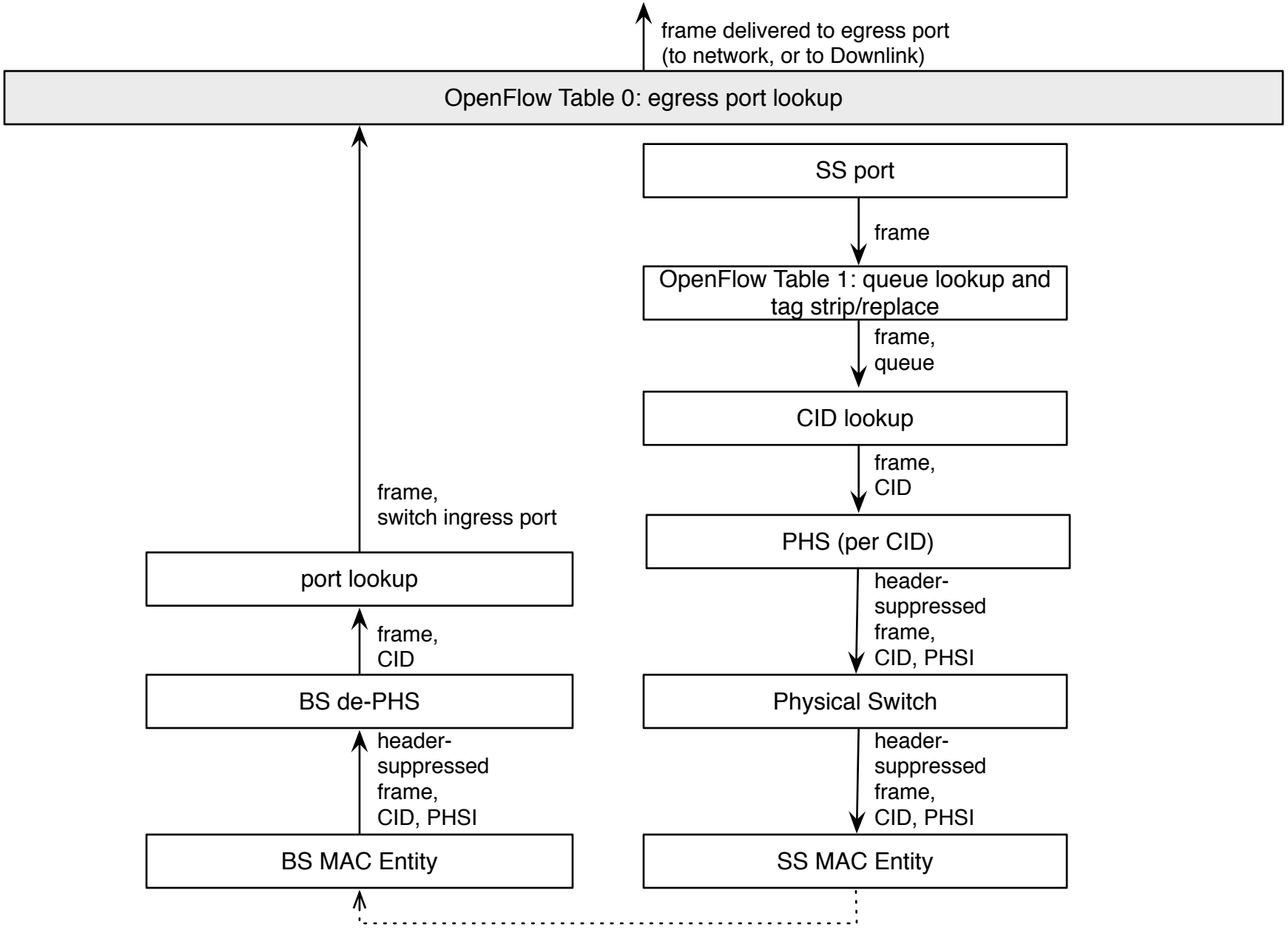
Uplink Data Plane



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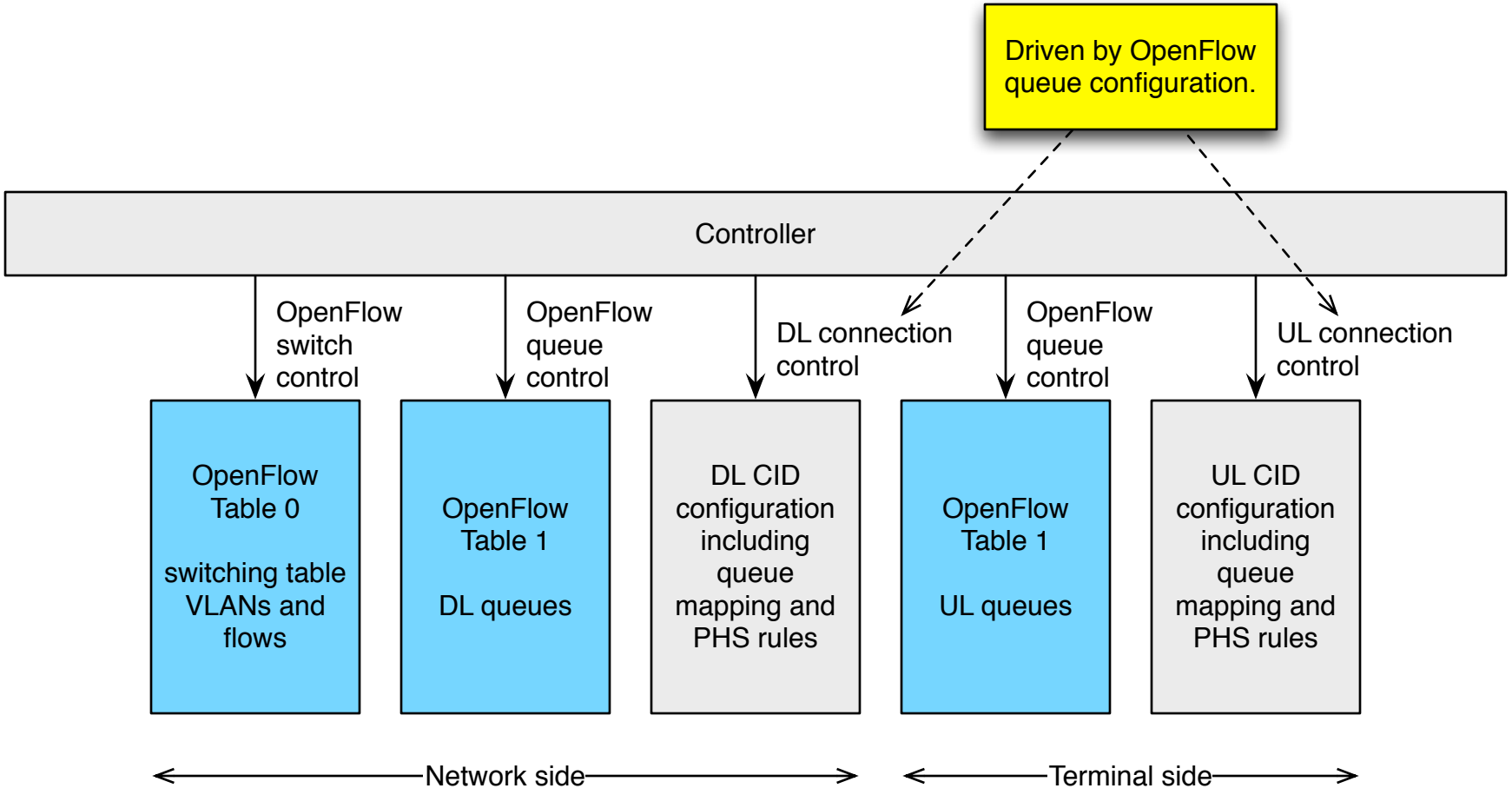
Control Plane



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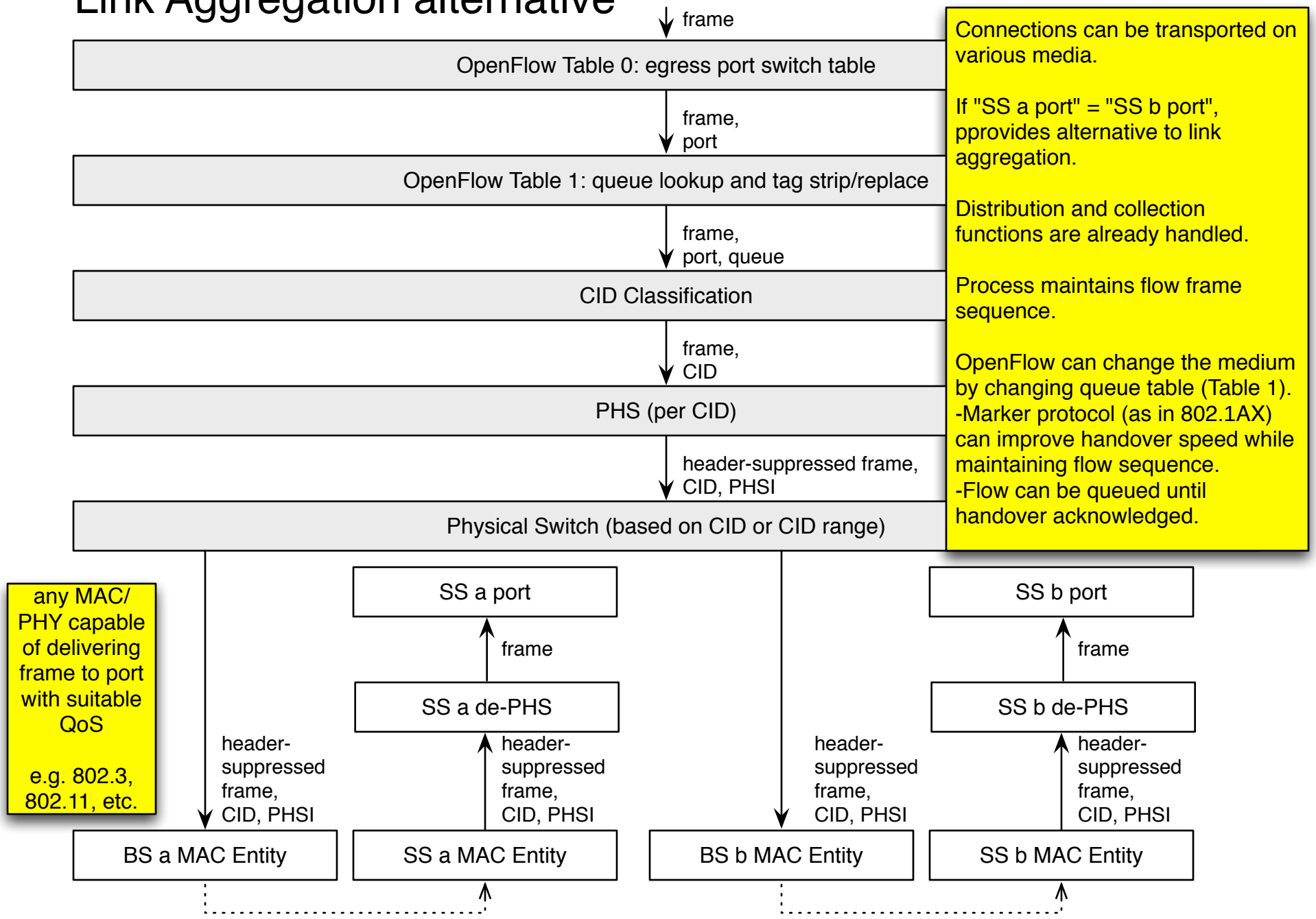
Link Aggregation alternative



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Conclusions

- SDN manages switches but not links
- Connection-oriented transport networks, like IEEE 802.16 and others, provide QoS control by managing connections in a manner that is parallel to SDN switch management
- SDN can be extended to COSDN to allow control of the entire port-to-port network flow, including, switches and links.