TDM services on RPR Systems

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Why deal with TDM?

- Virtual Private Lines are a significant source of revenue for service providers and carriers.
  - Emerging paradigm: Ethernet private lines
  - Existing paradigm: TDM private lines
- RPR is a MAN standard
  - Transport function is a basic requirement of MANs

Everything is becoming data !!!

- IP/MPLS is emerging as a common transport network for all service
  - Strong momentum of work on circuit emulation in progress within IETF
  - Various product offerings
- RPR systems may adapt various services as “data” and will require to manage QoS
  - BW, Jitter, Delay, Packet Loss and availability

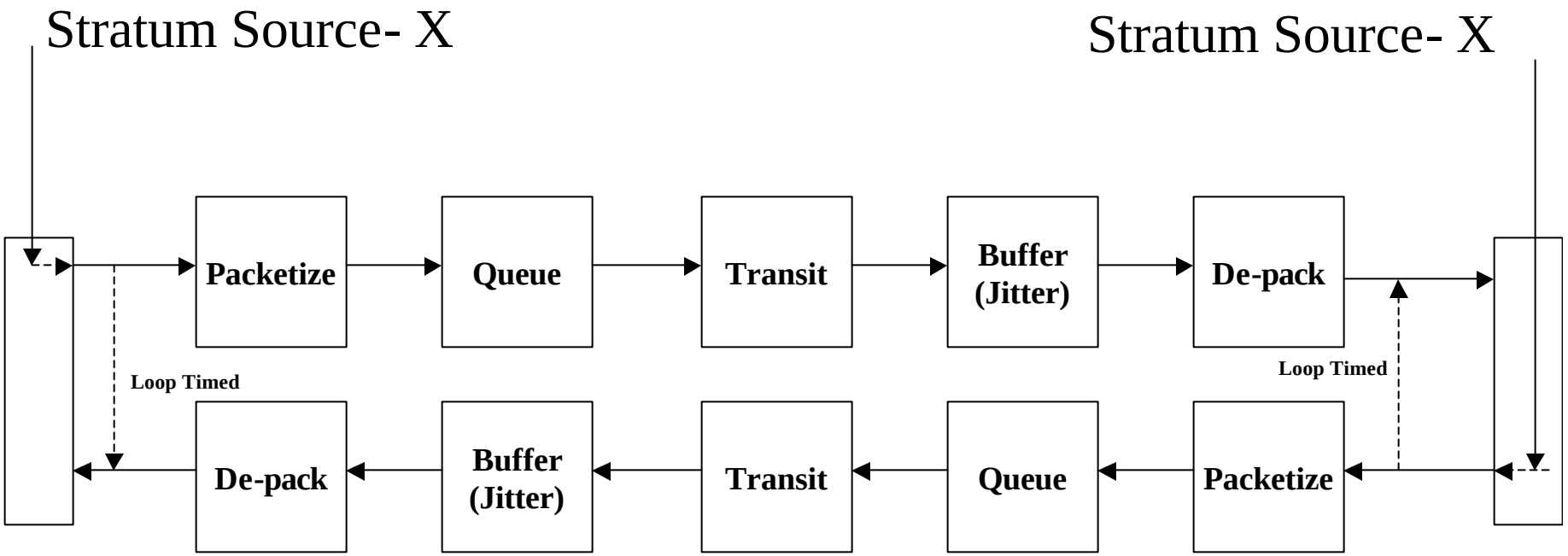
What & Why

- Circuit Emulated Services (CES) over Data networks
  - Extends packet switched data networks to transport of circuit switched connections
- RPR must account for this for wider acceptance as a versatile MAN solution

Issues in TDM CES

- Service interface level issues:
  - Ingress and Egress Clocking arrangement
  - Session establishment and encapsulation
  - Managing QoS specific to each service
- Network dependent issues:
  - Bandwidth assurance through network
  - Delay Bound => Jitter management through packet switched network
  - Managing service availability

CES FLOW



Choice of stratum sources => Slip Rate

Zero slip rate => Synchronized clock

Clock synchronization is a system/PHY issue and not MAC related

Bandwidth Assurance

- Requires isolating impact of one service or customer with another
- Dividing total Add bandwidth between customer is a system issue.
- RPR requires support for traffic differentiation to prioritize between add and pass traffic in RPR
- Two ways to differentiate traffic
  - Per-Flow or Multi Field (MF) differentiation
  - Packet header or Behavior Aggregate (BA) based differentiation

Per-Flow MF differentiation

- Requires explicit definition and signaling of flows to differentiate at transit node
- Requires Service admission control part of signaling
- Transit nodes will require complex packet classification before prioritization between add and pass.
- The number of prioritization levels required is difficult to scale

Header based BA differentiation

- Requires explicit field in header but implied differentiation of classes.
- Can have BW allocation to classes and simple admission control
- Simplifies classification to prioritize between add and pass based on traffic classes
- Finite number of priority levels (classes)
- Can extend class based protection

Minimum Classes

- Class EF: Highest Priority, Expedited Forwarded, BW provisioned but not over subscribed class
  - CES and 802.17 control messages can use this class
- Class AF: Next to highest priority, Assured Forwarding rate, BW provisioned and could be over subscribed class (AF1 and AF2)
- Class BE: Lowest priority, Over subscribed residual BW

Class Based Differentiation

- Strict class based separation required
  - Committed BW/Class is a network wide issue
- 802.17 maintains simple Add-Pass prioritization based on EF Class reducing the need for complex Add-Pass packet scheduler in the MAC
  - Add EF includes control traffic (Topology, Protection, Fairness) limited to specific burst size
  - All ring control messages are hop-by-hop (no transit)
  - Pass EF Data has highest priority over any Add traffic
  - All other classes sent to system to enable maintaining class separation and a single Add interface for each direction

Delay & Jitter Management

- Delay = Fixed Delay + Variable Delay

  Fixed Delay = Packetization Delay + Propagation Delay +De-packetization delay

  Variable Delay = Wait to get on the ring + Transit through ring

- Minimum Delay =

  Fixed Delay + Best case transit delay + 0 add delay

- Maximum Delay =

  Fixed Delay + Worst Case transit Delay + Max Add Delay

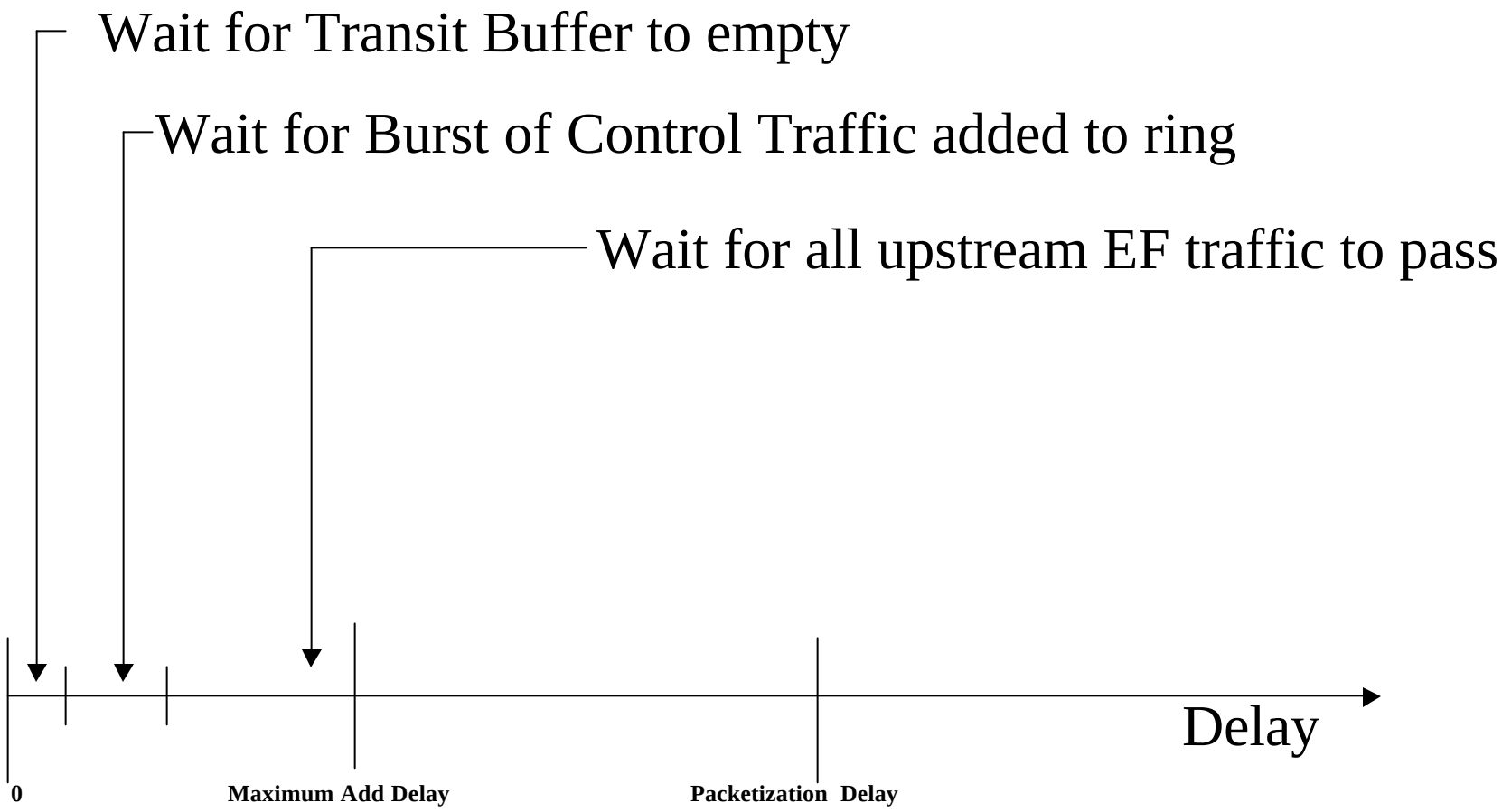
- Jitter = Maximum Delay – Minimum Delay =

  Worst case **-** best case transit delay + Max Add delay

Objective

- Minimize Jitter to get delay bounds
- 1. Make best case transit delay = worst case transit delay
  - Once CES traffic gets on the ring the delay is predictable (pre-computed)
    - Pass EF gets priority over any other Add traffic.
    - This makes transit delay = N * Fixed pass-through delay/node
- 2. Minimize and make Add Delay predictable

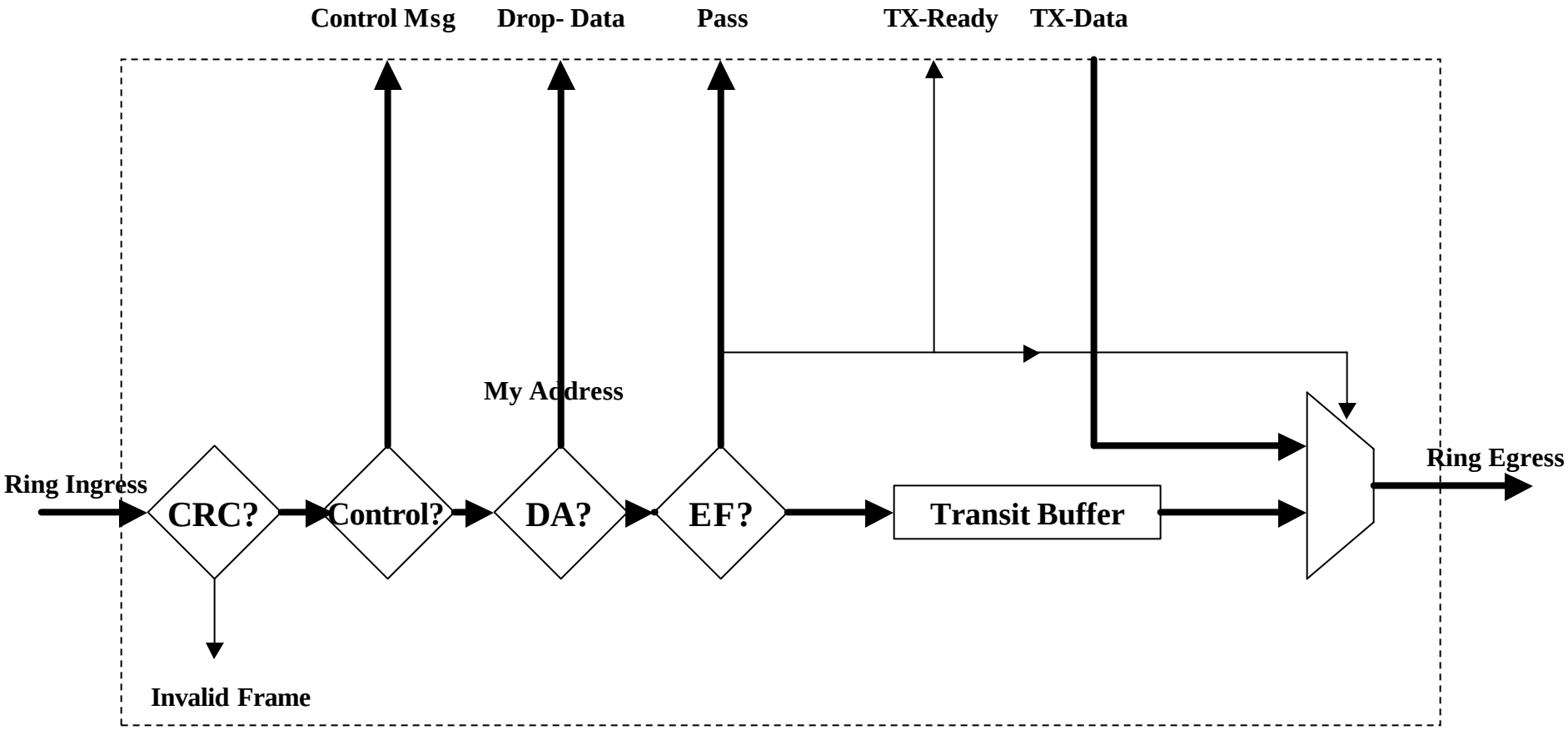
Worst Add Delay



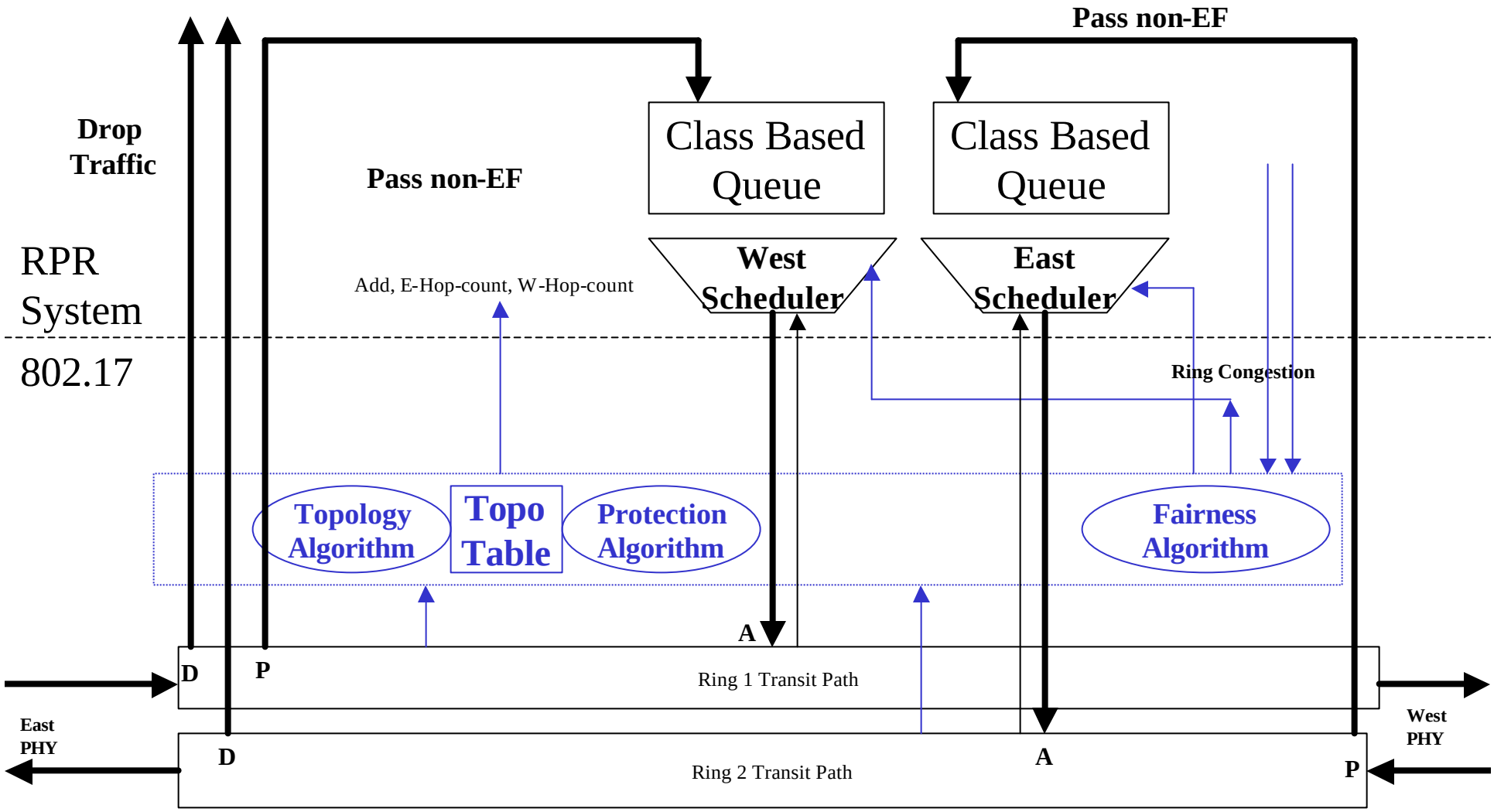
Add Delay

- RPR system will schedule EF has highest priority over other classes – on RPR it will only contend with Pass EF from upstream – this is network wide provisioned (BW/Class)
- Add Delay for EF waiting for the current packet in transit is bounded by MTU size
- Control packet is always to neighboring node, length and maximum burst is fixed, hence only accounted as part of Add EF.
- Cut-through vs. Store-forward has no impact

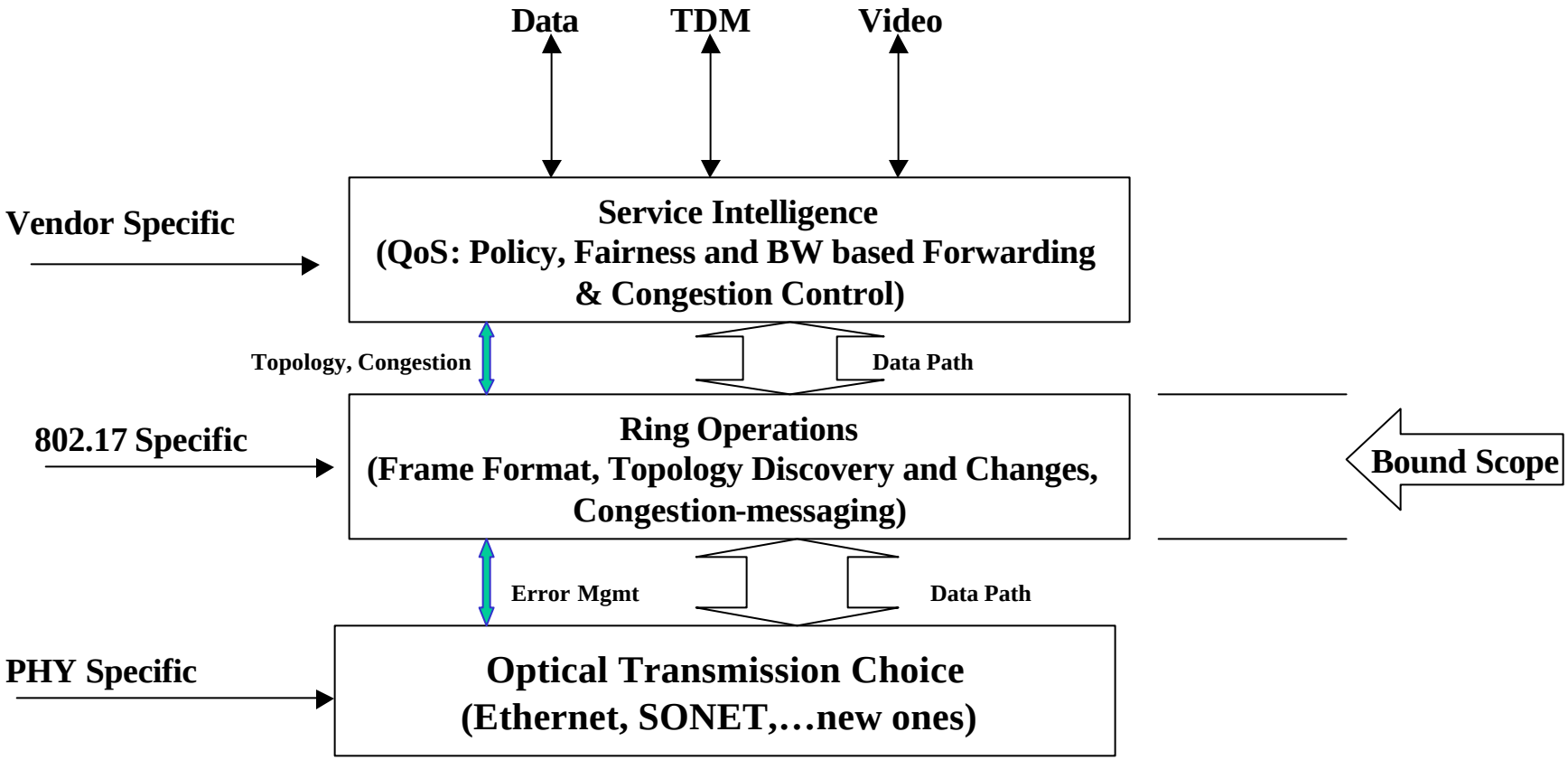
MAC Receive path



RPR System Architecture



Simplify MAC



Summary

- 802.17 header needs class indication
- Single Class based Add-Pass arbitration in transit path
- Ring congestion/fairness scheme is only for Over Subscribed Class – system will decide which class is over subscribed
- All nodes cognizant of all control activities
- QoS is a System level issue and uses CoS bits in header to communicate between nodes