Timestamp-Based Synchronization Contribution for IEEE

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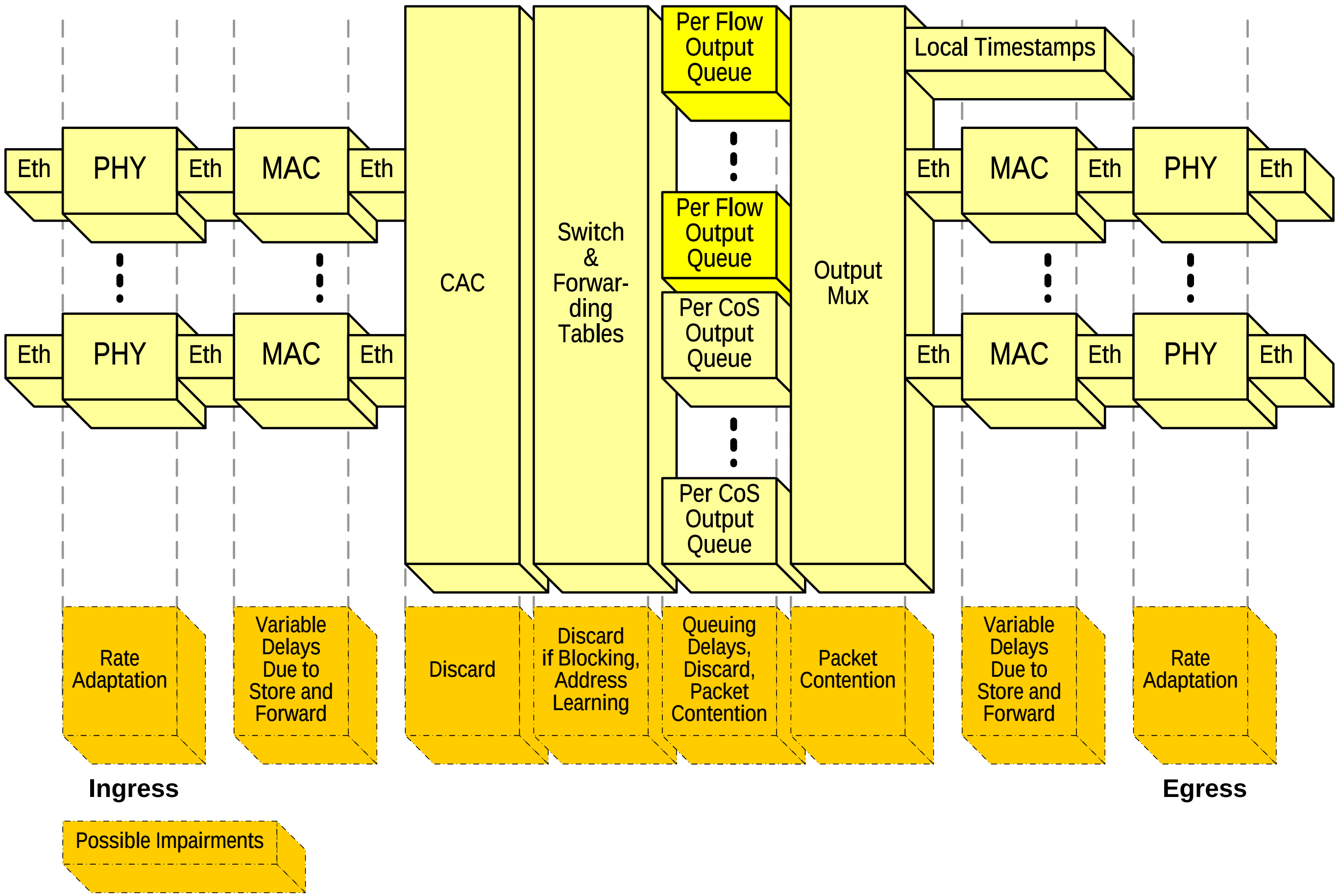
Background for Contribution

- IEEE 802.1Qav is considering various Ethernet-based enhancements for the support of time-sensitive applications as part of AVB.
- These enhancements include the use of IEEE 802.1AS Timing and Synchronization.
- IEEE 802.1AS is based on a subset of IEEE 1588 which uses timestamps to provide frequency, phase and time synchronization over Ethernet Layer 2-based networks.
- A proposal was made within IEEE 802.1 requesting that IEEE 802.3 add timestamp support within the lower layers.
- IEEE 802.1 also indicated that the timestamp layer would have applications beyond AVP.
    - In particular, it would be used by service providers in supporting wireless (i.e. cellular) backhaul.
- During the conference call (CFI) of October 16, 2008, IEEE 802.3 recommended that ad hoc meetings be used to firm up the AVB synchronization requirements and familiarize IEEE 802.3 group members with the desired goals.
- Related timestamp-based synchronization technology has been in development at Huawei Technologies (USA) for ~ 2.5 years.
- The presenter was requested to present some of the relevant technology resulting from the Huawei research work for appraisal by the relevant IEEE groups within the context of timestamp-based synchronization.

Hypothetical Ethernet Switching Node

For discussion purposes, a hypothetical Ethernet switching node is depicted below.

- The general-purpose packet traffic, as well as the timestamp packets can be subjected to various impairments within the hypothetical Ethernet switching node
- These impairments are normally of a statistical nature and will affect the performance of L2-based clock synchronization schemes unless compensated for using additional techniques

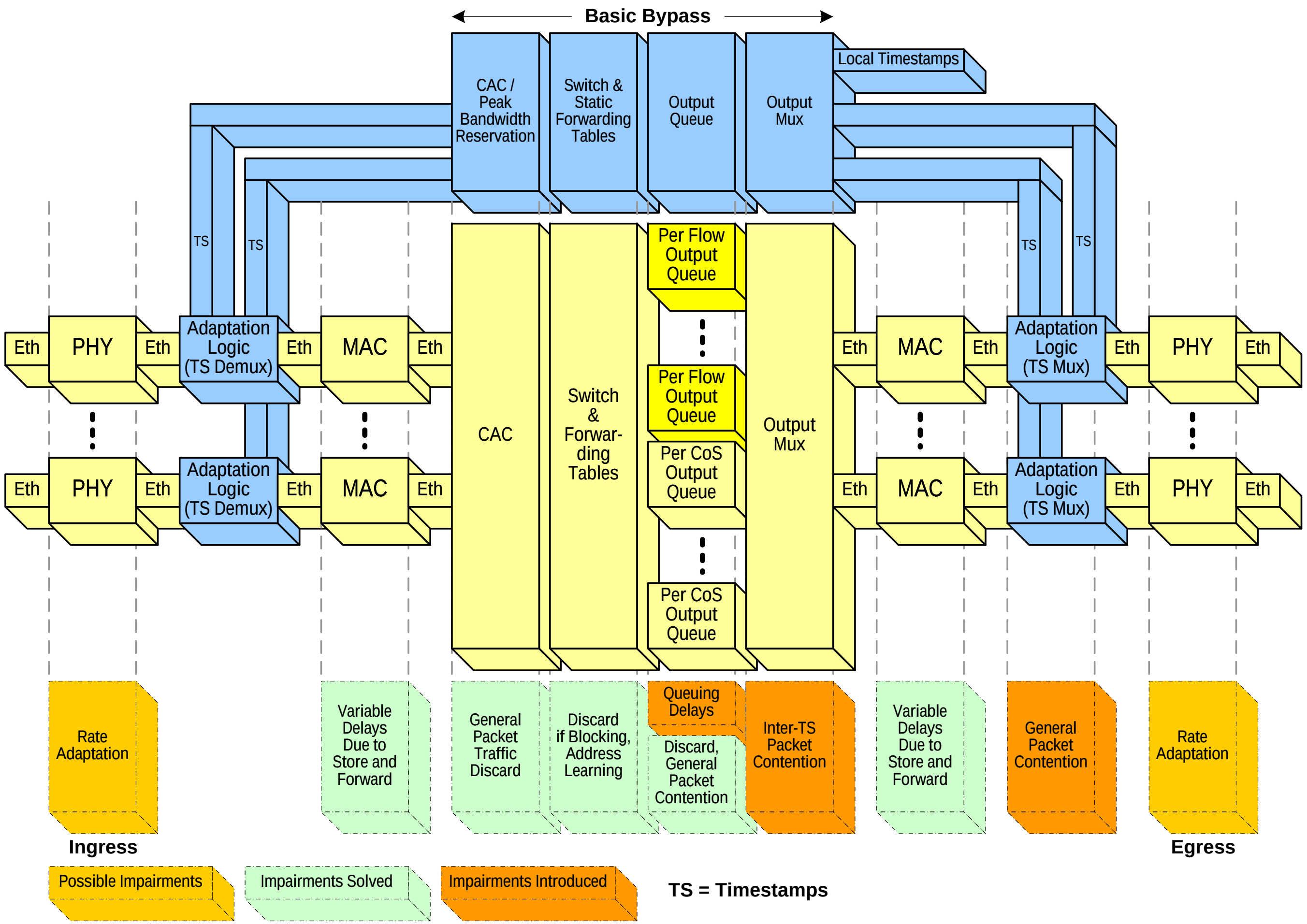


Possible Impairments to Determinism for Hypothetical Ethernet Node

- Possible PHY rate adaptation
  - PHYs may add or remove normally un-used octets to make up for +/-100 ppm clock operation and/or other link delay variations.
- Store-and-forward or cut-through operation selection
  - Store-and-forward mode of operation for general packet traffic contributes to PDV for timestamp packets
  - Differentiated treatment of timestamp packets may be required
- CAC parameters set for general packet traffic may also affect timestamp packets
  - Again, differentiated treatment of timestamp packets may be required
- A non-blocking switching is pretty much required for proper operation of timestamp-based synchronization
- Static forwarding of timestamp packets is also pretty much required for proper operation of timestamp-based synchronization
- Traffic management issues
  - To optimize the performance of timestamps packets, differentiated traffic management rules must be applied
  - Previous priority arrangements may not apply anymore
  - Priority re-arrangement may allow use of Class-of-Service (CoS) queuing
  - Otherwise, per flow queuing may be required
- Some packet contention will occur at the output multiplexer
  - No matter the choice of the priority scheme
  - Variable / inversely proportional to output link bandwidth

Adaptation Logic & Basic Bypass Position and Benefits

- The use of a bypass mechanism as an alternative to measuring the absolute delay contribution of each Ethernet switching node involved in a particular route is investigated.

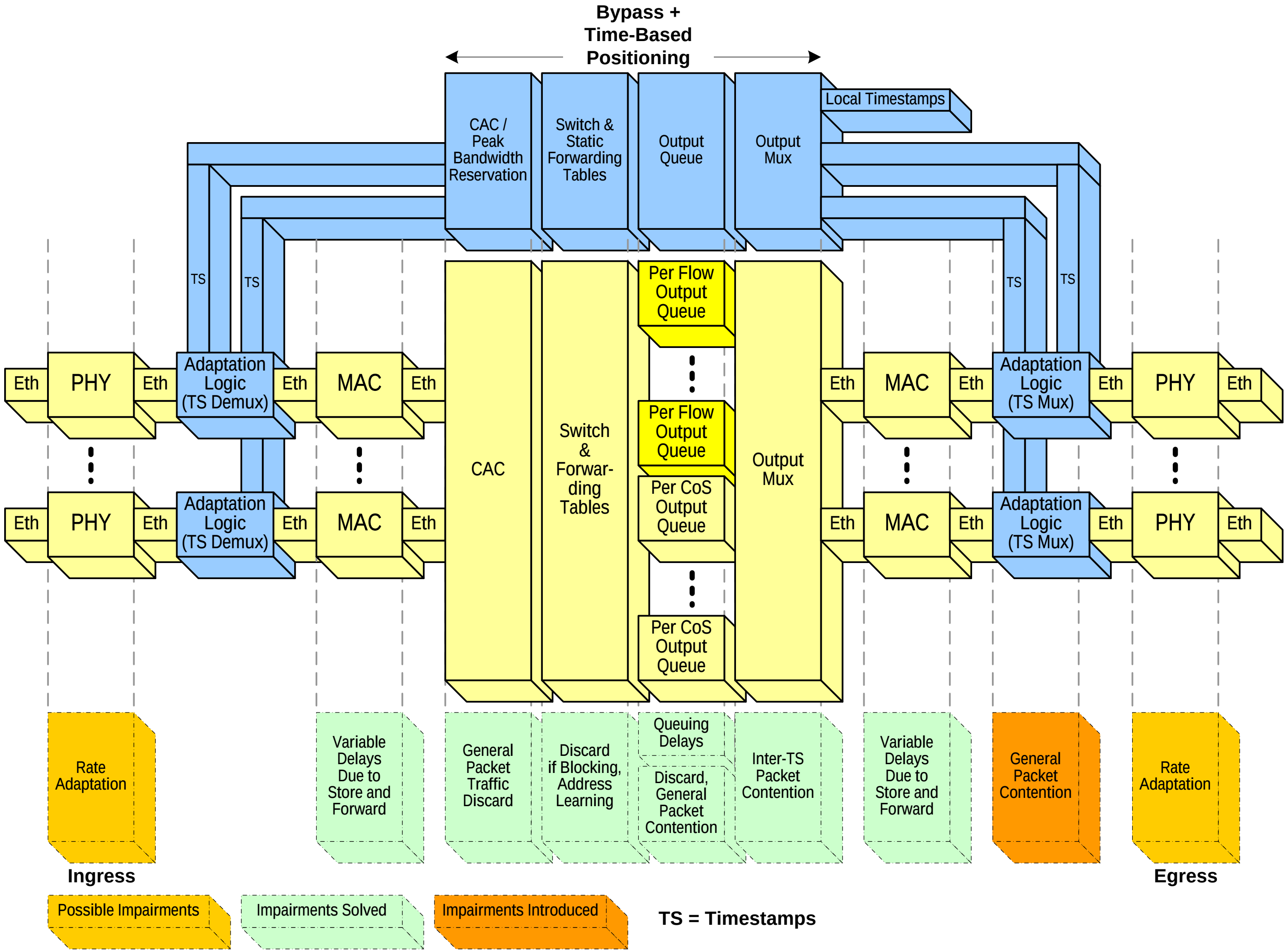


- On ingress, timestamp packets are identified, stripped and routed to a parallel path incorporating an auxiliary switch fabric.
- The auxiliary switch fabric forwards the timestamps using quasi-static tables to minimize timestamp traffic disruption.
- On egress, the un-modified packets are re-inserted in the appropriate ports in the general-purpose packet traffic
- The basic goal is to improve the deterministic characteristics of the bypass to the point where it has a minimal impact on the accuracy of the timestamp-based synchronization mechanism.

- However, when using a conventional packet switching architecture for the bypass, some of the same undesired switching artifacts are re-introduced. These artifacts turn out to be primarily contention-originated.

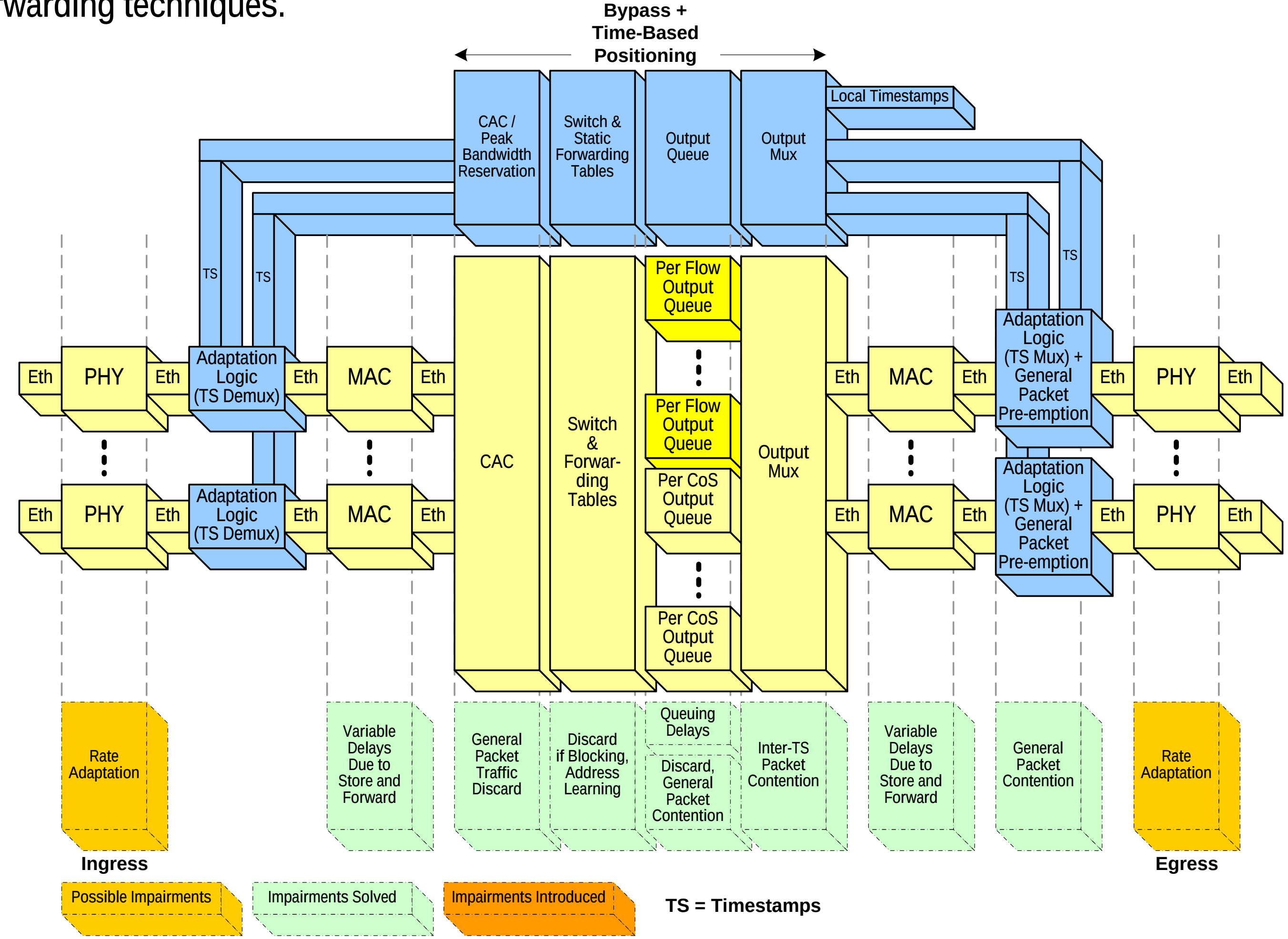
Adding Time-Based Positioning for TS Packets

- To eliminate some of these artifacts, a time-referenced positioning mechanism is used for the timestamp packets.
- While this reduces, or maybe even eliminates, the inter-timestamp packet contention, general-purpose packet contention still occurs when the timestamp packets are re-inserted in the general-purpose packet traffic.



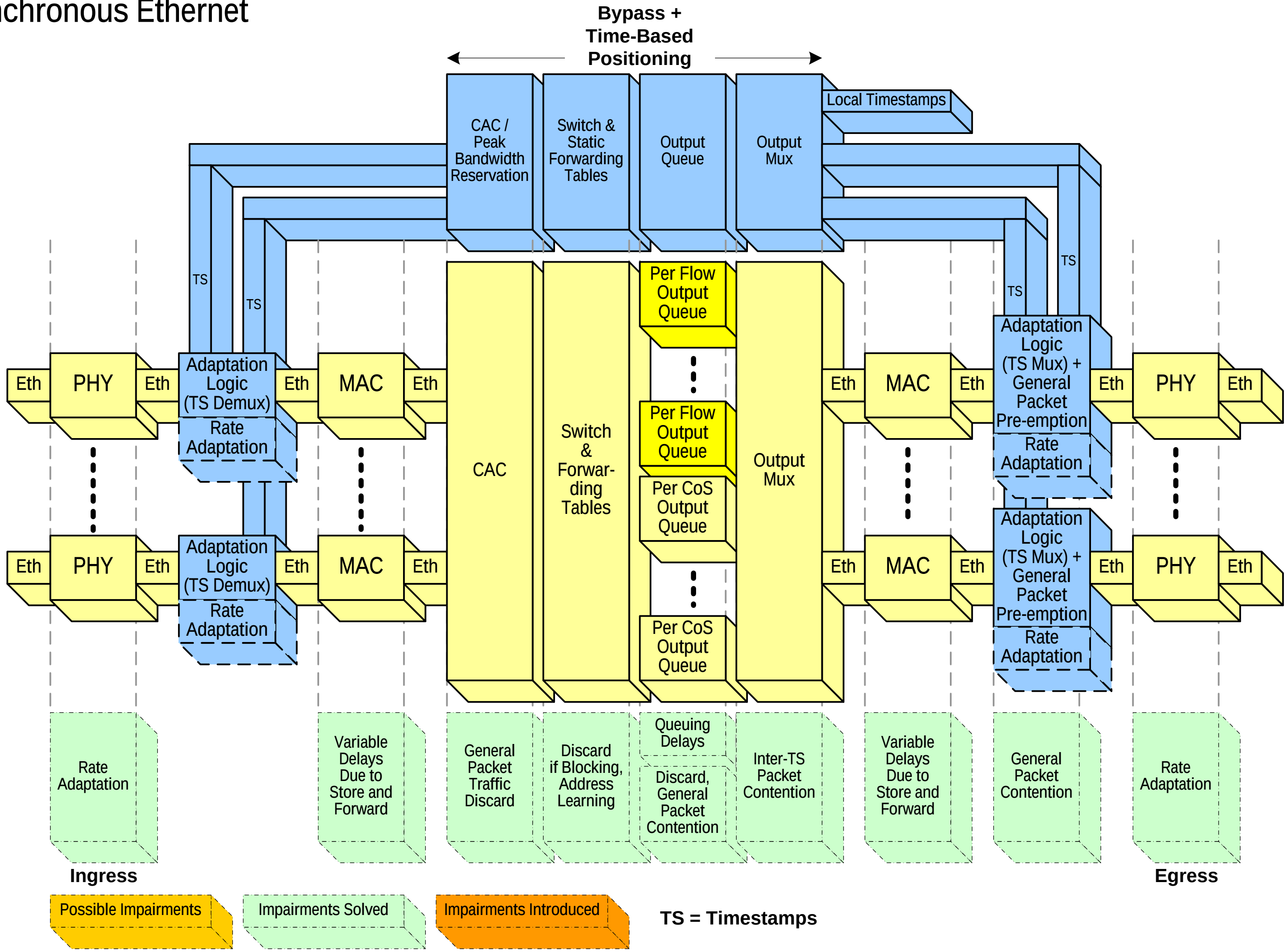
Adding Packet Pre-Emption Capabilities to Egress Adaptation Logic

- This last remaining source of packet contention can be minimized / eliminated by using a strict pre-emption mechanism on egress to re-insert the timestamps in the general-purpose packet traffic.
- Pre-emption mechanisms down to the octet-level have been found to be practical.
- A certain amount of packet buffering must then be put in place at both the ingress and egress to accommodate possible general-purpose packet fragmentation.
- This has also a possible impact on general-purpose packet traffic delay characteristics, including the implementation of cut-through forwarding techniques.



Eliminating the PHY’s Rate Adaptation Requirement

- Finally, un-signaled rate adaptation mechanisms within the PHY can be eliminated by either
  - Moving the rate adaptation function to the newly added Adaptation Logic where it can be signaled and compensated for within the bypass
  - Using other mechanisms that eliminate altogether the need for rate adaptation during normal operation, such as Synchronous Ethernet



Recap and Concluding Remarks

- An alternative to measuring the internal delay of each switching element within a network and adjusting the corresponding timestamps to support a Layer 2-based synchronization scheme was described.
- Various independent mechanisms can be applied in a piece-meal fashion depending on the options selected.
- The basic underlying technique relies on providing a deterministic path for the timestamp packets.
- Integration within traditional packet switch fabrics is possible.
- As an evolutionary measure, if needed, this path can be seen as co-existing in parallel with existing packet switch fabrics.
- In a more encompassing approach, bypass technique may be extended to include other traffic types, such as hard-QoS, connection-oriented packet traffic.
- The implementation of the bypass technique can alleviate L2 traffic dependencies of existing timestamp-based synchronization schemes and support high-quality adaptive clock recovery mechanisms with a minimum of algorithmic complexity even in the context of traditional asynchronous Ethernet.
- In particular, strict pre-emption techniques applied to the multiplexing the timestamp packet with the general-purpose packet traffic eliminate the need to implement complex and expensive traffic engineering techniques to improve the determinism of the data path to support the timestamp function.
- When coupled with other technologies such a Synchronous Ethernet to support the synchronization of the frequency component, the bypass technique can provide highly-accurate phase alignment synchronization support and time distribution support for both network-oriented synchronization schemes and service clock-based synchronization schemes.

Thank You