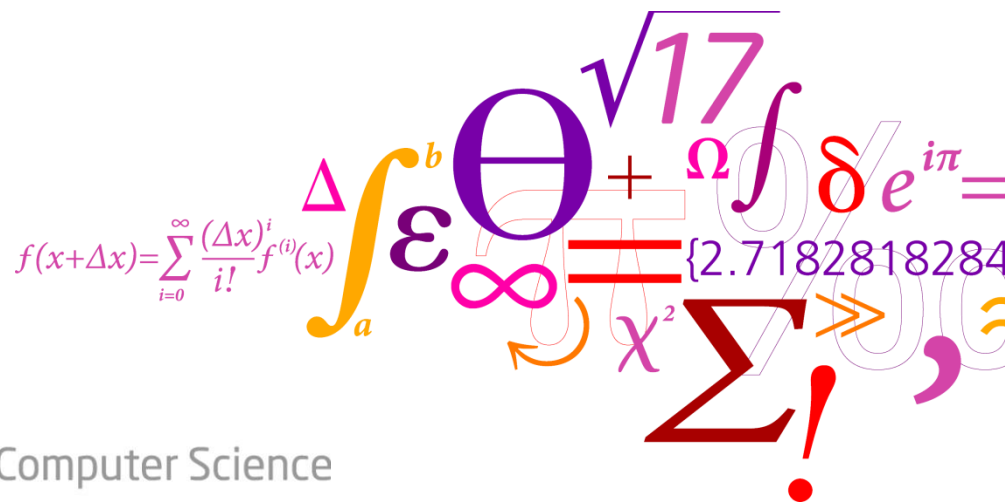


Routing of AVB traffic in 802.1TSN Networks

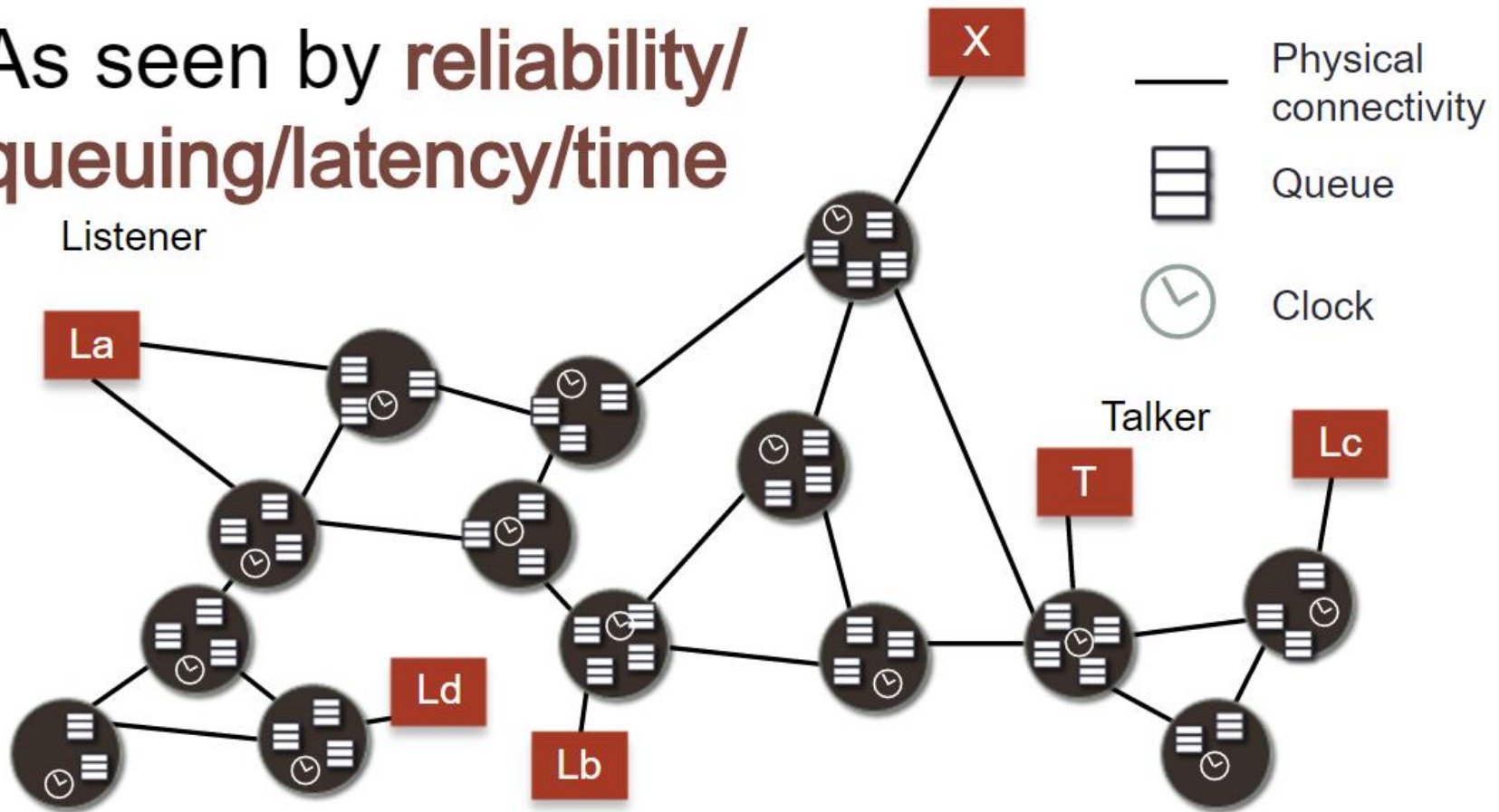
Sune Mølgaard Laursen and Paul Pop
Technical University of Denmark
smla@dtu.dk



DTU Compute

Department of Applied Mathematics and Computer Science

As seen by **reliability/** **queuing/latency/time**

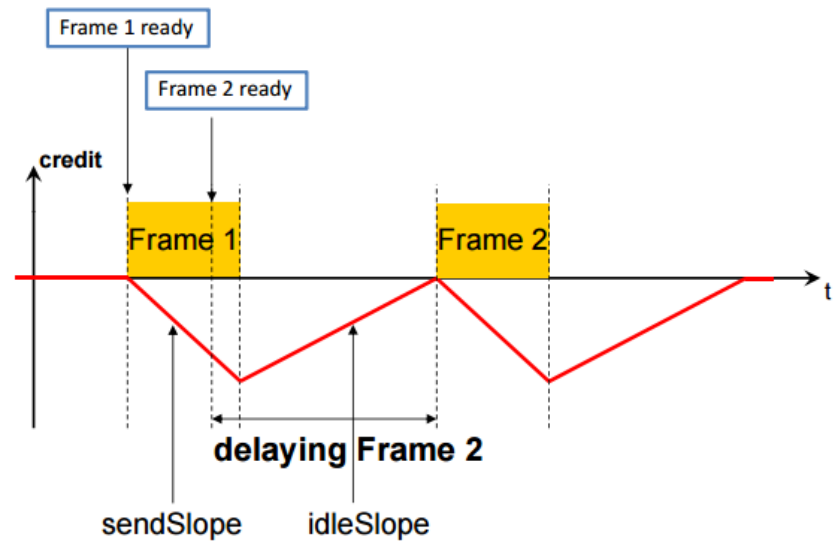


- **Just nodes, queues, clocks, and wires!!**

[DetNet ProblemStatement. Norman Finn, Cisco]

IEEE 802.1AVB

- Allows applications to reserve paths at runtime over AVB-enabled networks for deterministic delivery of frames.
 - Synchronized low-latency multimedia without proprietary equipment
- Introduces the AVB Traffic Class
 - Uses the SRP
 - Avoids bursts
 - Fairness for low priority traffic

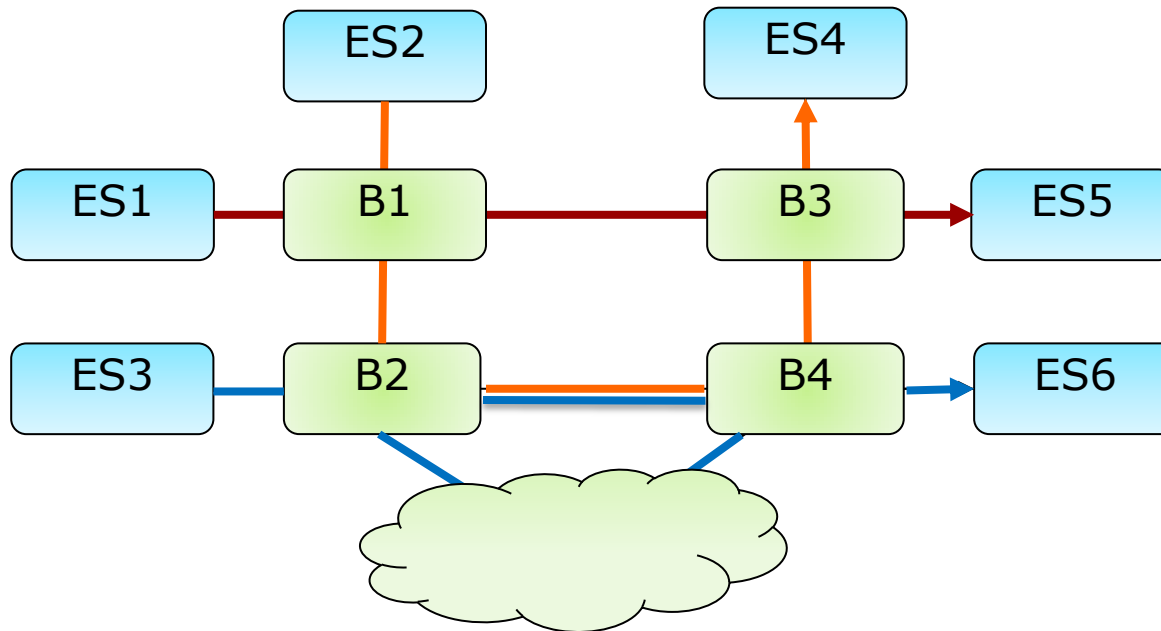


IEEE 802.1TSN

- AVB group renamed to TSN in 2012 to focus on delivering support for deterministic communication in safety-critical systems.
 - Adds a static scheduled traffic class

- Consists of the following ongoing IEEE standards:
 - 802.1Qbu Frame Preemption
 - 802.1Qvb Scheduled Traffic
 - 802.1AS-Rev Timing and Synchronization
 - 802.1Qcc SRP Enhancements and Performance improvements
 - 802.1CB Replication and Elimination for Reliability
 - 802.1Qch Cyclic Queuing and Forwarding
 - 802.1Qci Per-Stream Filtering and Policing

Motivation

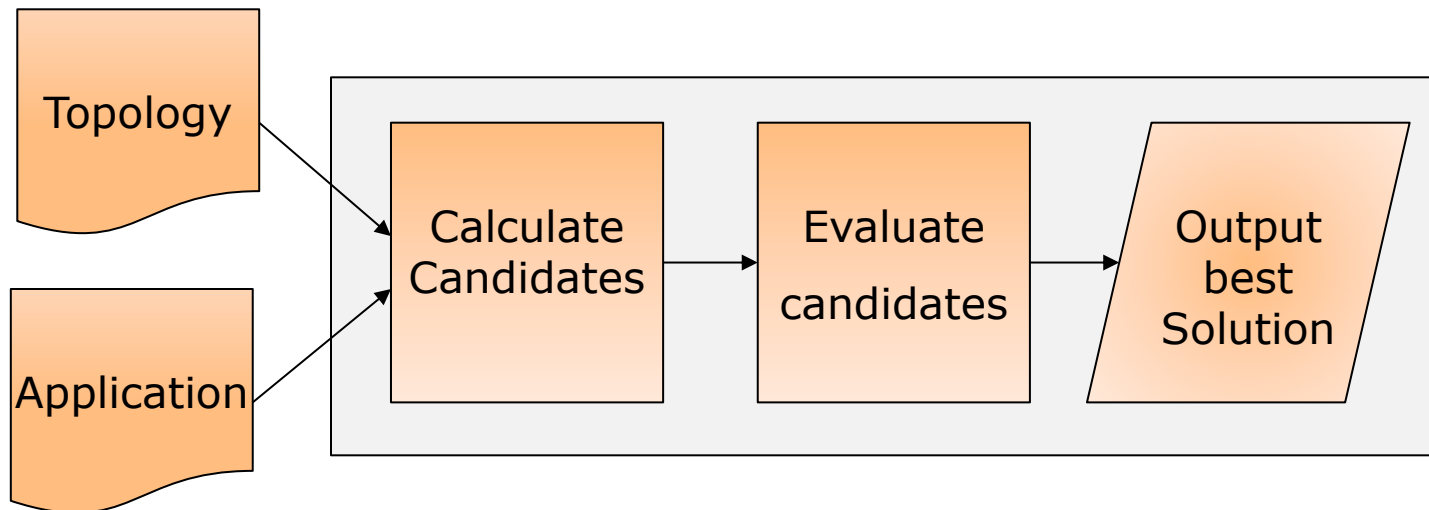


- TT EngineControl
 $ES_1 \rightarrow ES_5$
- AVB Parking
 $ES_2 \rightarrow ES_4$
- AVB Lane
 $ES_3 \rightarrow ES_6$

AVB Parking and AVB Lane mutual exclusive

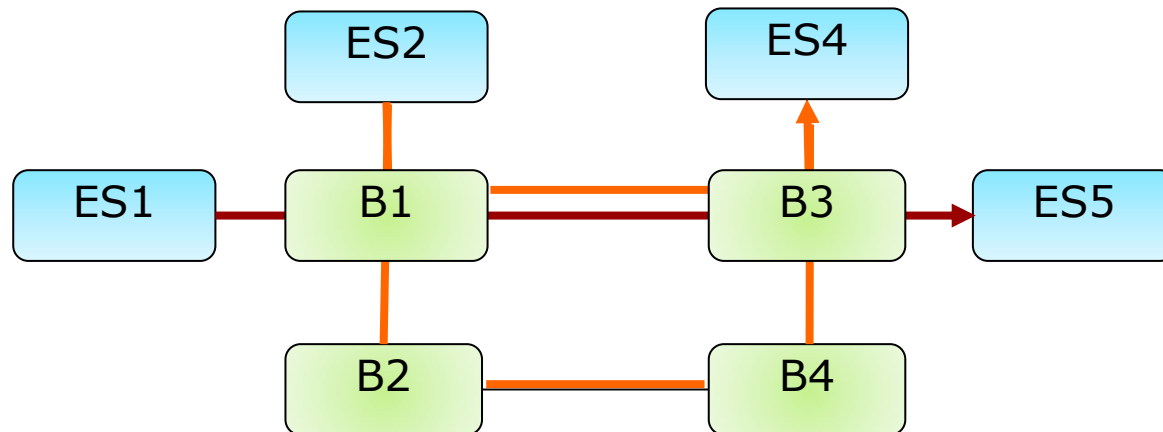
- Dynamic systems with pure TDMA leads to overprovisioning = bad SWaP characteristics

Framework Overview

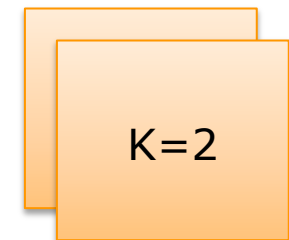


Calculating the Candidates

- *K-Shortest path based heuristic*
 - *Good chance of finding the best solution early*



AVB Parking
 $ES_2 \rightarrow ES_4$



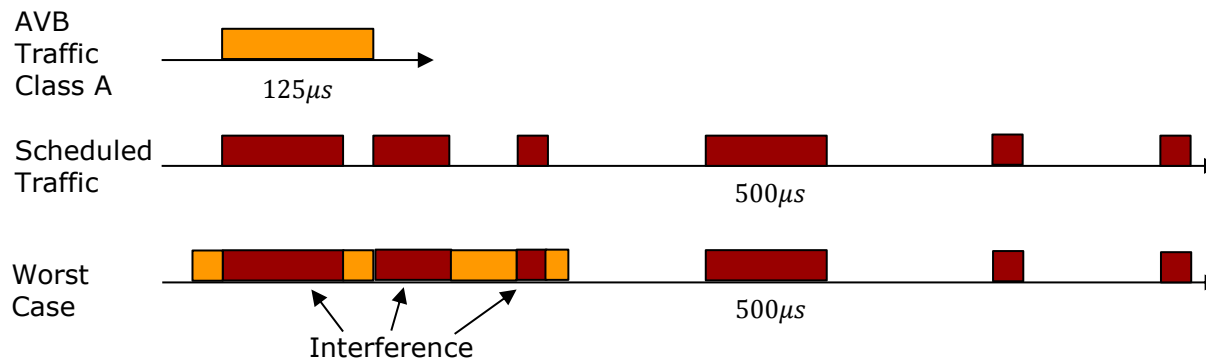
- **Bounded** with a complexity of $O(A' * K * n * (m^2))$ analysis needed
 - $O(K * n * (m^2))$ for *K-ShortestPaths*
 - *A applications. A' for multicasts split into X-unicasts*

Response Time Analysis

- Formula used for admission control in the AVB switches :

$$WCRT = t_{Device} + t_{MaxPacketSize+IFG} + (t_{AllStreams} - t_{StreamPacket+IFG}) * rate/MaxAllocBand + t_{StreamPacket}$$

- *Adding interference from scheduled traffic with preemption*



$$MaxAllocBand \text{ --} = MaxScheduledTraffic$$

$$t_{StreamPacket} \text{ += } t_{WCInterference}$$

$$t_{MaxPacketSize} \text{ += } t_{WCInterference}$$

Evaluating the Candidates

- We assign a cost **C** calculated as follows
 - For each hop **C += 1.0** (penalizes disjoint multicasts)
 - For each % of WCRT within 80% of deadline **C += 0.1**
 - Abort If any WCRT > deadline
- Future work includes looking at both *simulation* and *analysis techniques* for calculating WCRT, which can be quite difficult due to the many possible sources of interference :
 - *Synchronization*
 - *Traffic-Shaping*
 - *Lower priority Task*
 - *Same priority Tasks*
 - *Higher priority Tasks*

Questions ?

IEEE 802.1TSN



Credit-Based Shaper

