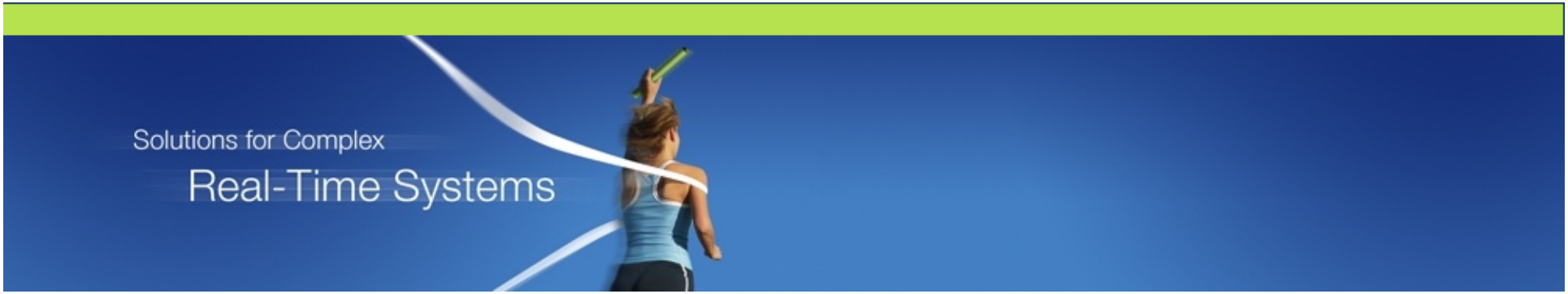
SYMTA VISION

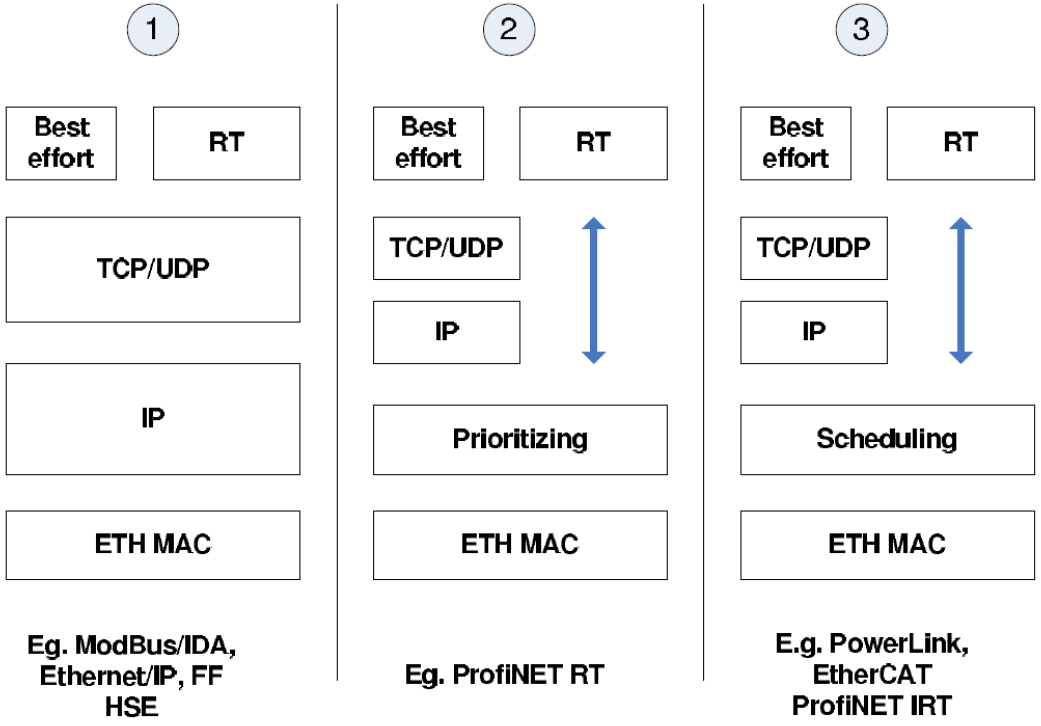
Providing timing guarantees for Ethernet-based networks

Torino
June 09, 2011



Classification of Approaches for Real-Time over Ethernet

- 1) Implementations in software using standard ethernet components
- 2) simple 802.1q VLAN tagging (also COTS), allows latencys ~ 1 to 10ms
- 3) Extensions of frame scheduling in switches (like AVB)



[13] M. Schumacher, J. Jasperneite, and K. Weber. A new Approach for Increasing the Performance of the Industrial Ethernet System PROFINET. In *7th IEEE International Workshop on Factory Communication Systems (WFCS 2008)*, Dresden, Germany, May 2008.

Relevant Domains and Symtavision contribution

- **Avionics**
  - Advanced prototypes available for AFDX and TTP
- **Industrial**
  - Cooperation on research level (inITial project in NRW)
  - “Meta”-analysis project focused on AVB with major integrator
- **Automotive**
  - contributions to SEIS project
  - Maturing roadmap discussions

- **Research Partnerships**
  - Technische Universität Braunschweig
  - University Erlangen-Nürnberg
  - Fraunhofer Institute for Communication Systems (ESK)

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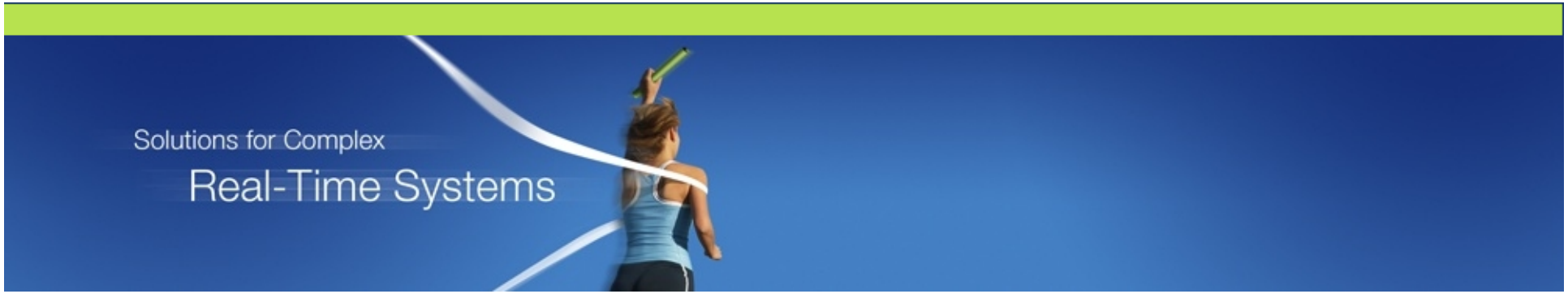
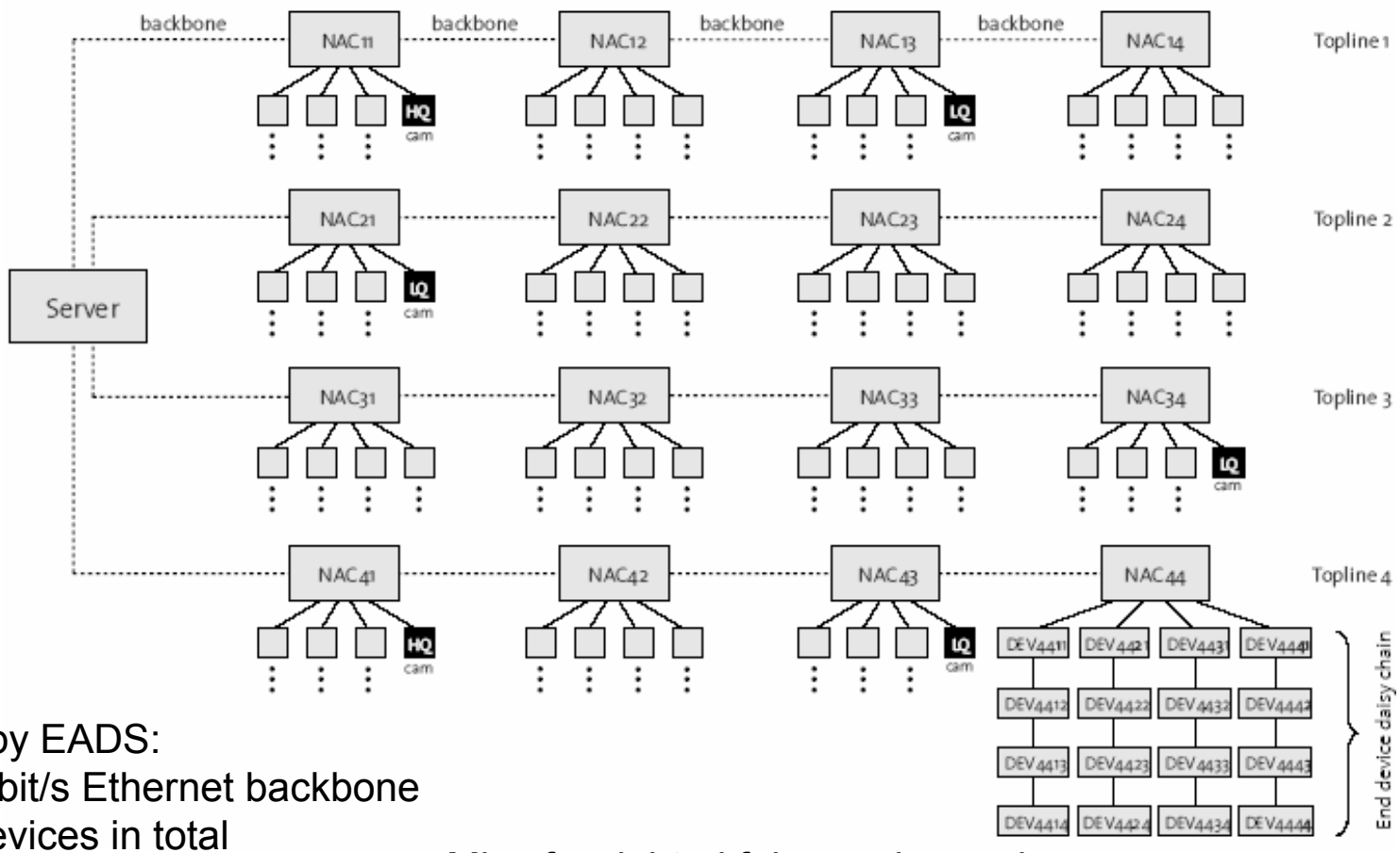
Example I

Avionics Example: Cabin Communication System
(TU Braunschweig)



Avionics Example: Cabin Communication System

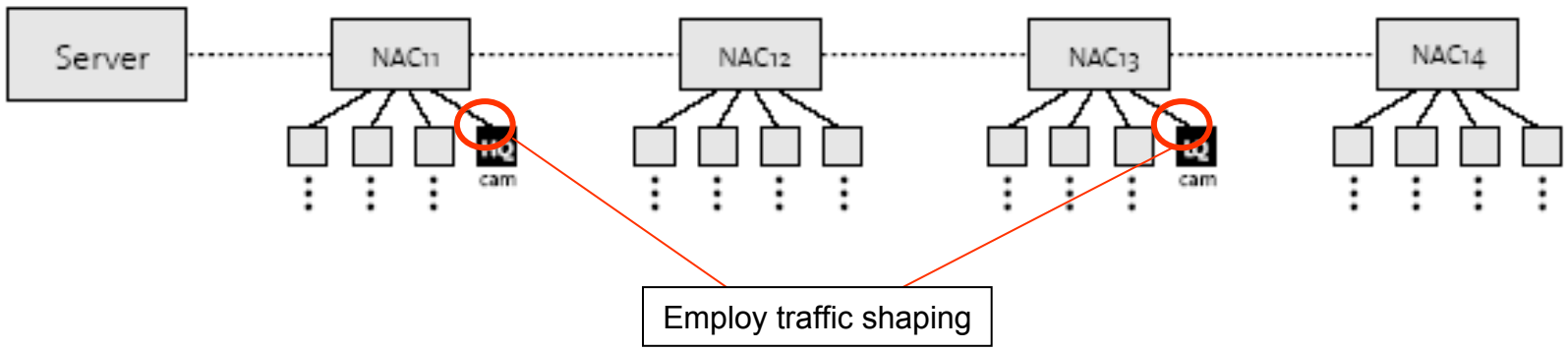


Provided by EADS:

- 100 Mbit/s Ethernet backbone
- 232 devices in total
- 3 HQ and 3 LQ Cameras
- 4 separated top lines

- Mix of weighted fair queuing and priority based scheduling in the switches

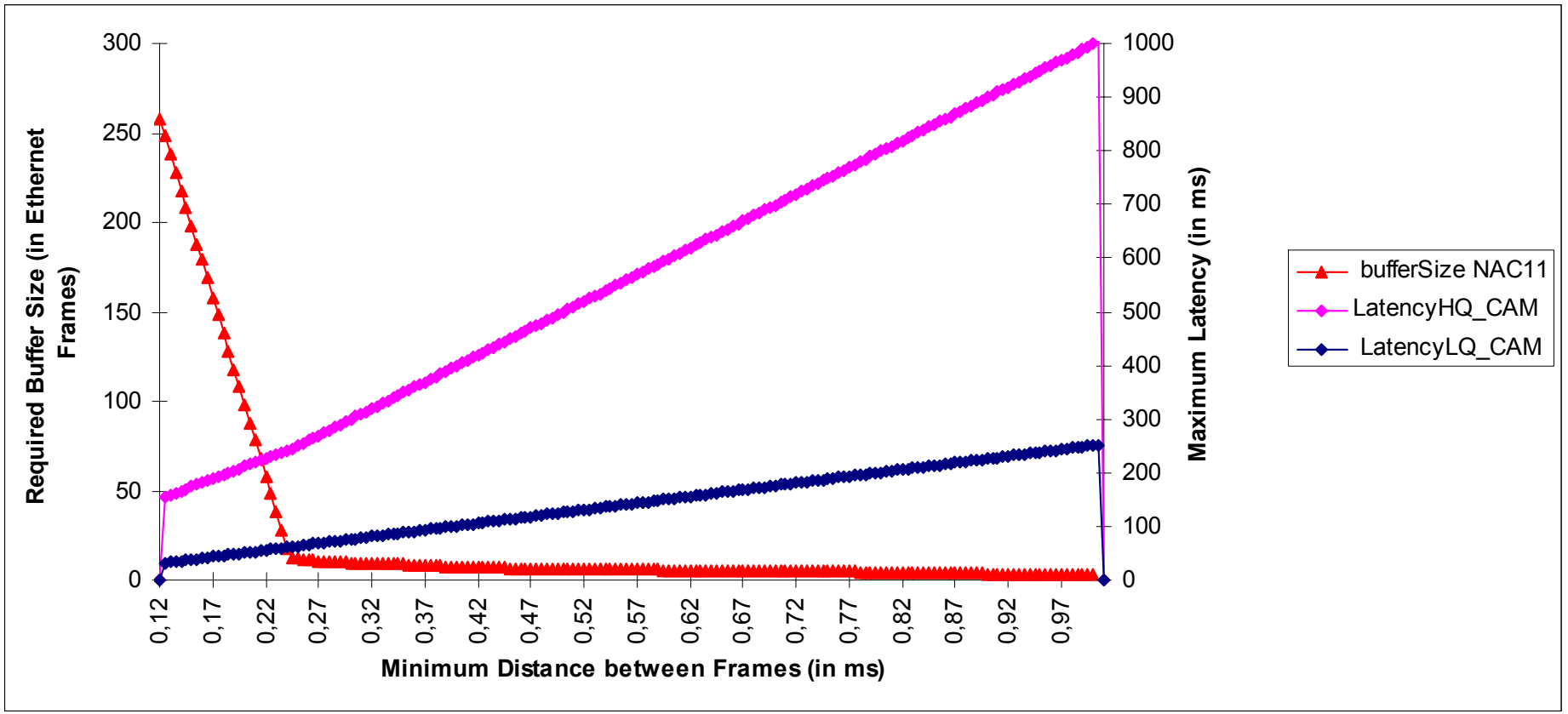
Analysis of Topline 1



- Each topline modeled and analyzed separately with SymTA/S

- **Problem:** Cameras can produce large bursts of data, up to 1000 maximum sized Ethernet frames per second
  ➔ This leads to large buffer requirements in the NACs
- **Idea:** Use traffic shaping on the output streams of the cameras
  ➔ Tradeoff between buffer requirements and latency

Effect of shaping the camera traffic



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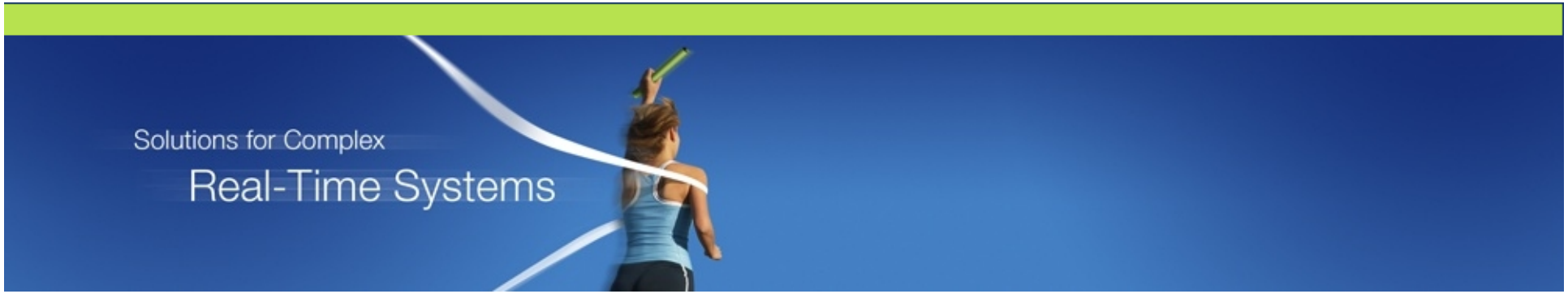
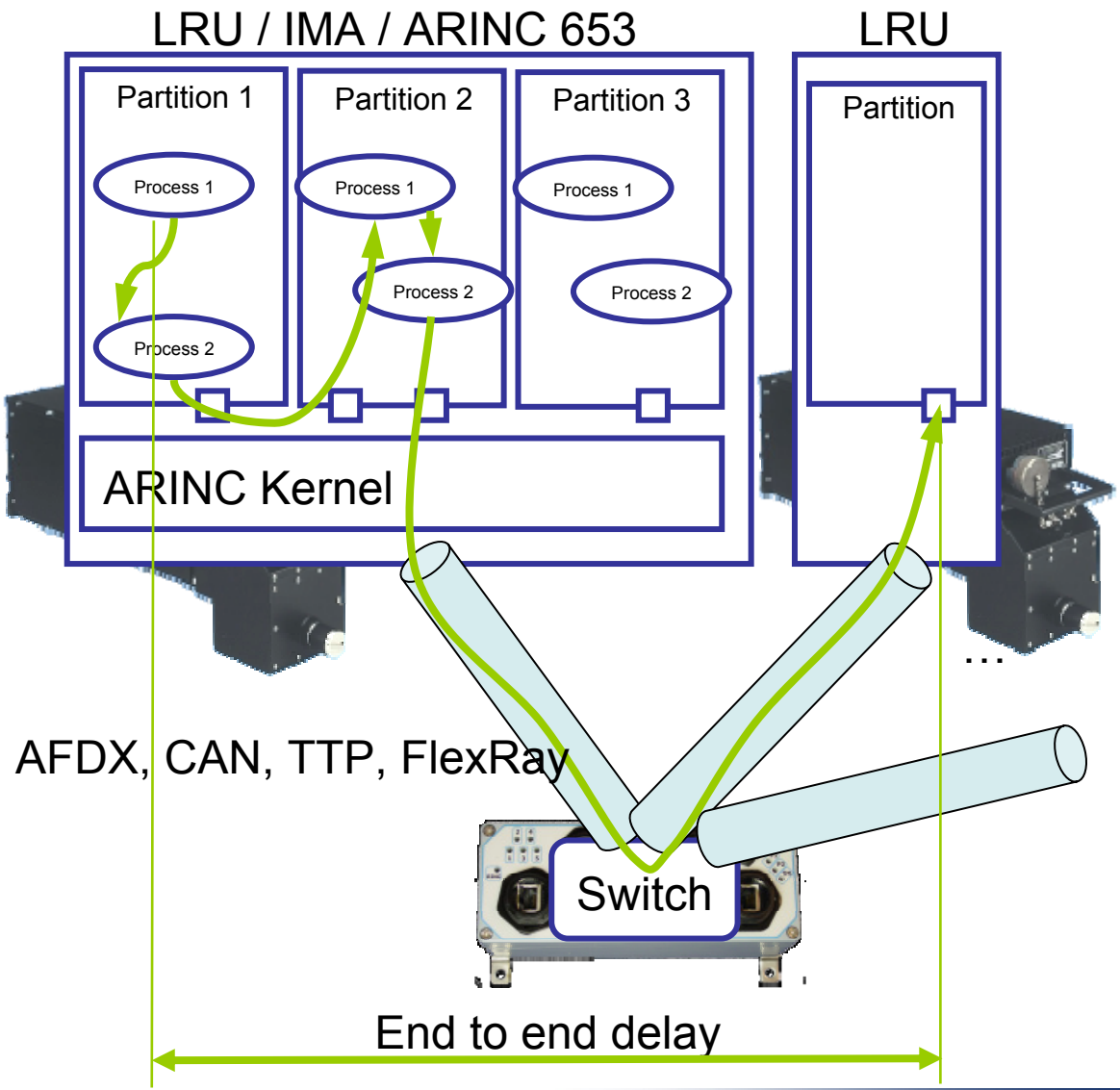
Example II

Avionics Example: Switched AFDX System
(Symtavision)



System Timing Issues in Avionics Systems



Scope:

- single partition
- one LRU / IMA
- network end system
- switched network

Measure:

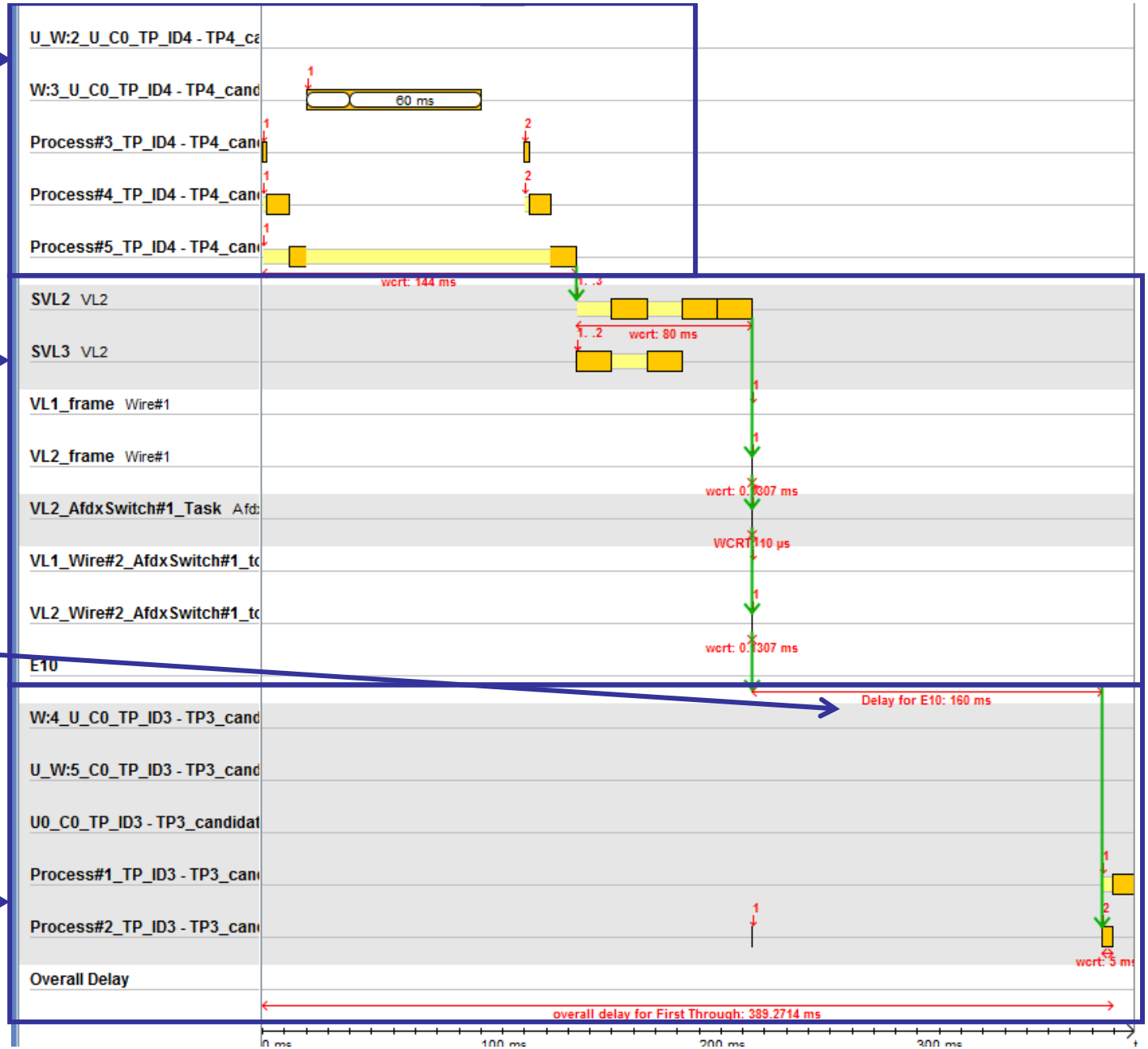
- load / utilization
- delays / deadlines
- communication / end-to-end

Use Case:

- design
- integration
- optimization
- verification

+ Design process integration

- Sending IMA/Partition
- AFDX
- Sampling delay
- → Asynchronous execution
- Receiving IMA/Partition



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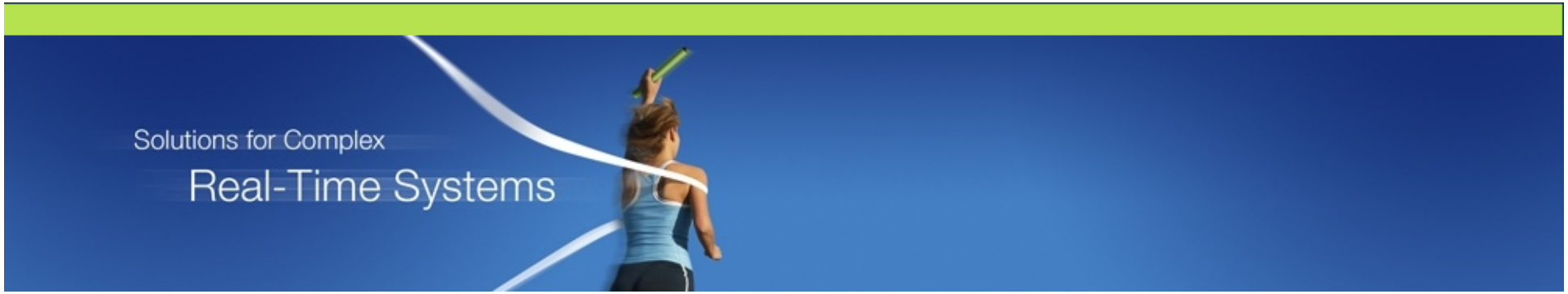
Example III

AVB

(Symtavision, TU Braunschweig)



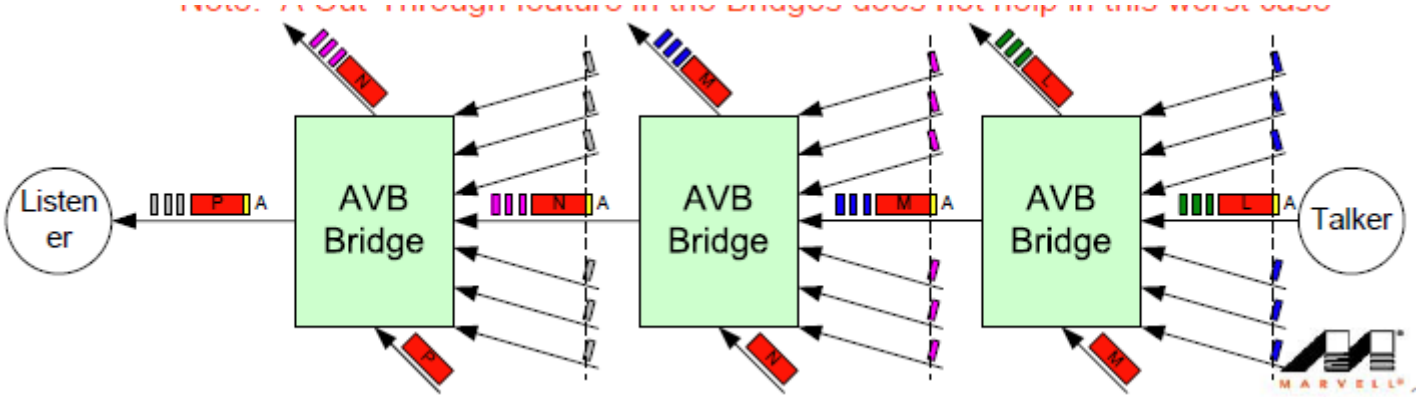
Introduction AVB

- AVB adds predictability quality of service through stream reservation protocols (802.1Qat) → guaranteed bandwidth
- provides low-latency (guarantees < 2ms over 7 hops) through 802.1Qav
- enables precise global synchronization (802.1AS Precision Time Protocol)
- In addition to Ethernet benefits:
  - High bandwidth, simplified cabling
  - allows mixing different link speeds (→backwards compatibility)
  - Multi-supplier through standard technology (e.g. as opposed to MOST)

- AVB is not without alternative: AFDX, Standard Ethernet with SW extensions (+ VLAN tagging prioritization), … MOST, …

AVB Study

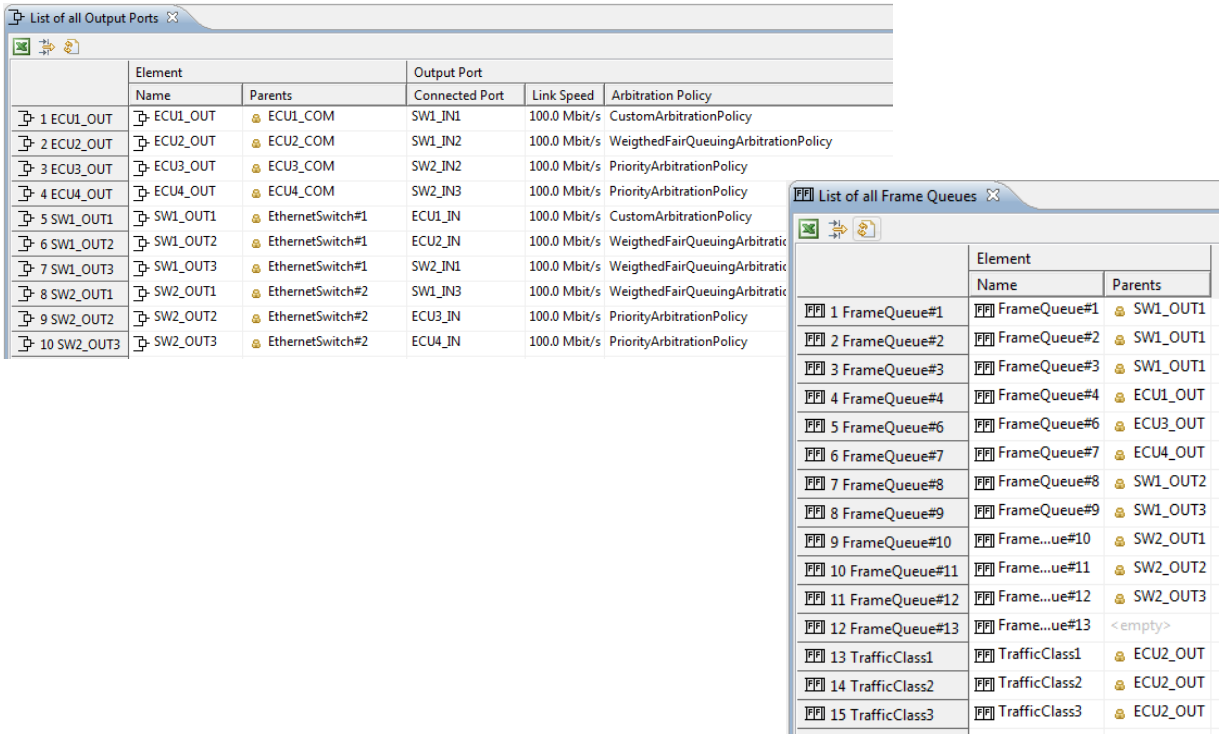
- AVB promises 2ms maximum latency over 7 hops for Class A traffic
- This can not be kept when legacy traffic is involved

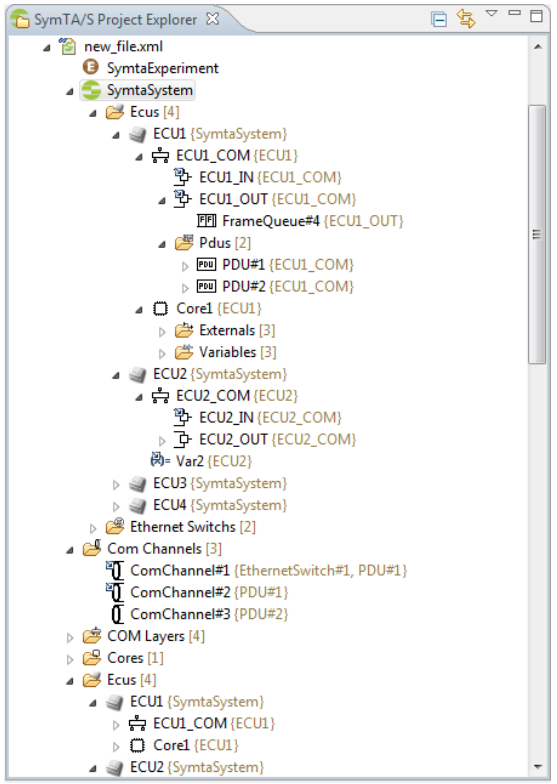


- Then, what is the worst-case?
- What can be done to ameliorate the situation?

Phase 1: Modeling

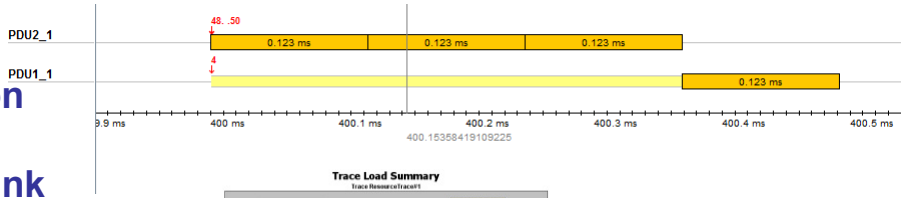
- Modeling of network architecture
- Modeling of individual system structure
- Modeling of data streams

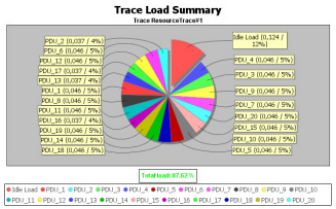




Example Results (Phase 1)

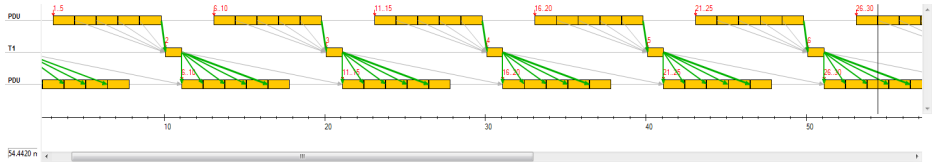
Visualization of Traffic per Link

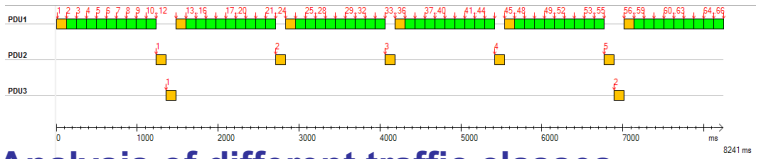




Load per Link

Analysis of Data Paths

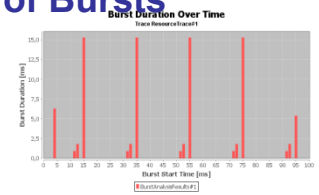




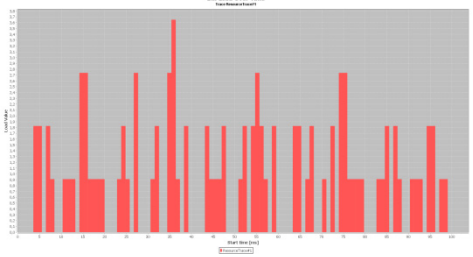
Analysis of different traffic classes

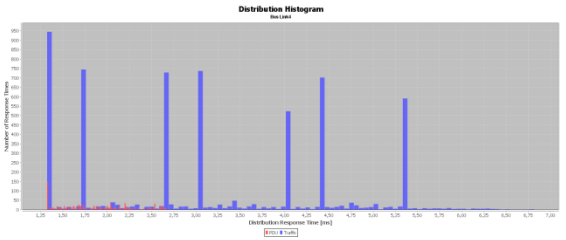
Topology Visualization

Visualization of Bursts



Buffer Load over Time





Statistical Results of Packet Transmission Times

Thank You!

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