ISPCS Brescia '09

White Rabbit: Sub-Nanosecond Timing Distribution over Ethernet

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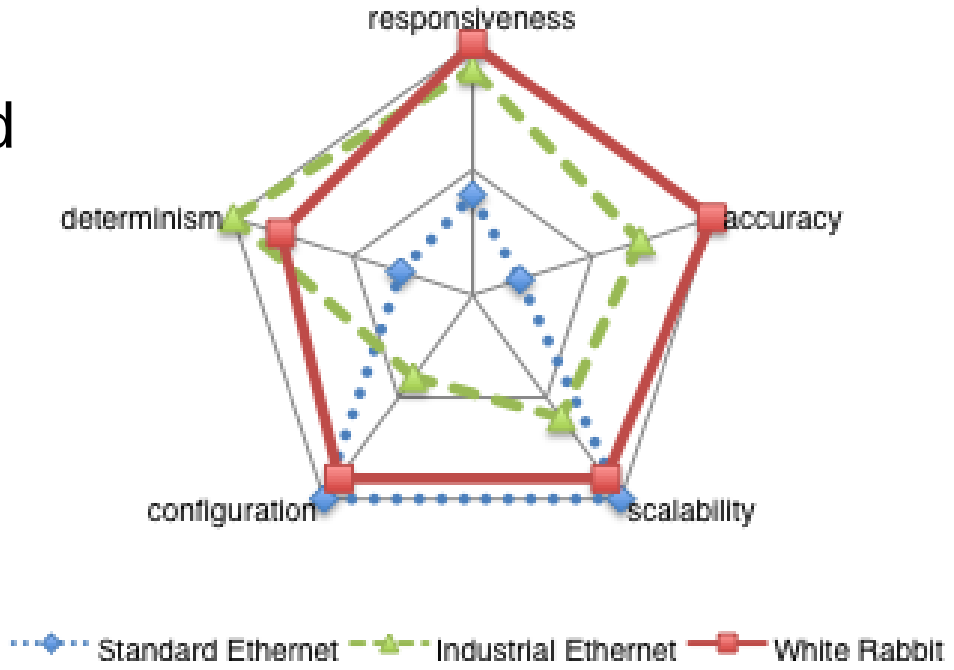
Introduction

- Idea evolved from the need to renovate CERN's accelerator timing system
  - Need for higher bandwidth
  - Combined data and timing network (bidirectional)
  - Large-scale deployment
  - Real-time messaging

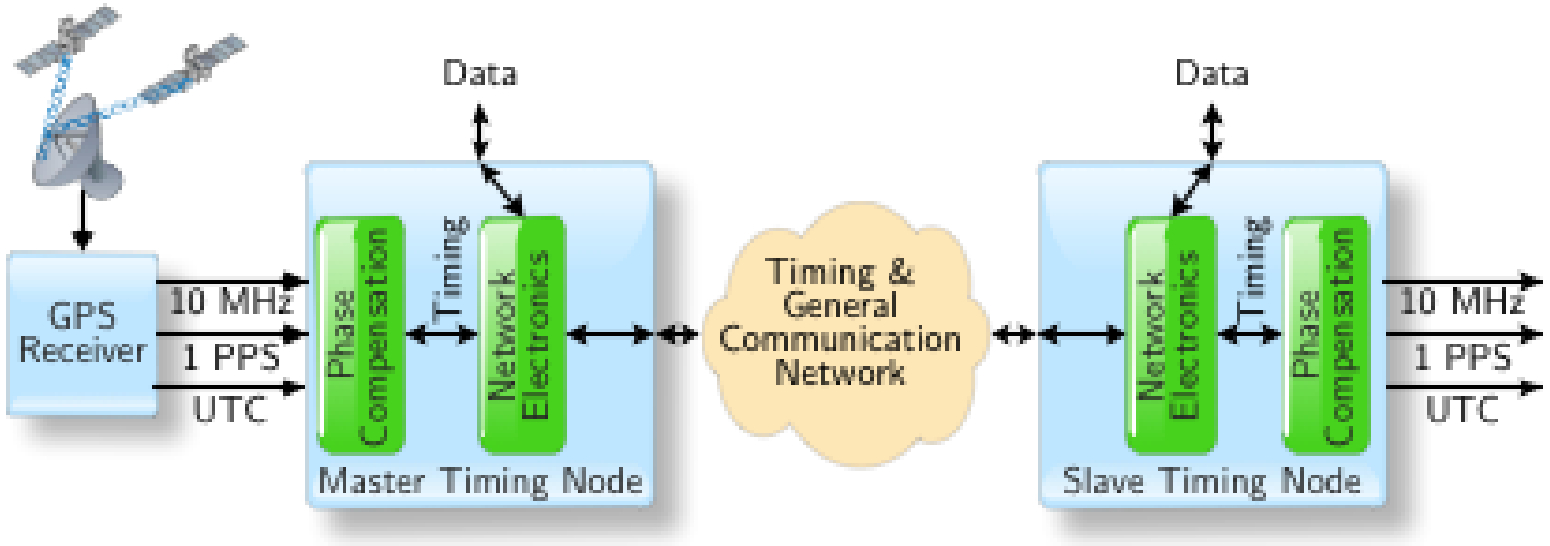
"Oh dear! Oh dear! I shall be too late!"
The White Rabbit in charge of the real time,
Alice in Wonderland

Aimed Goals

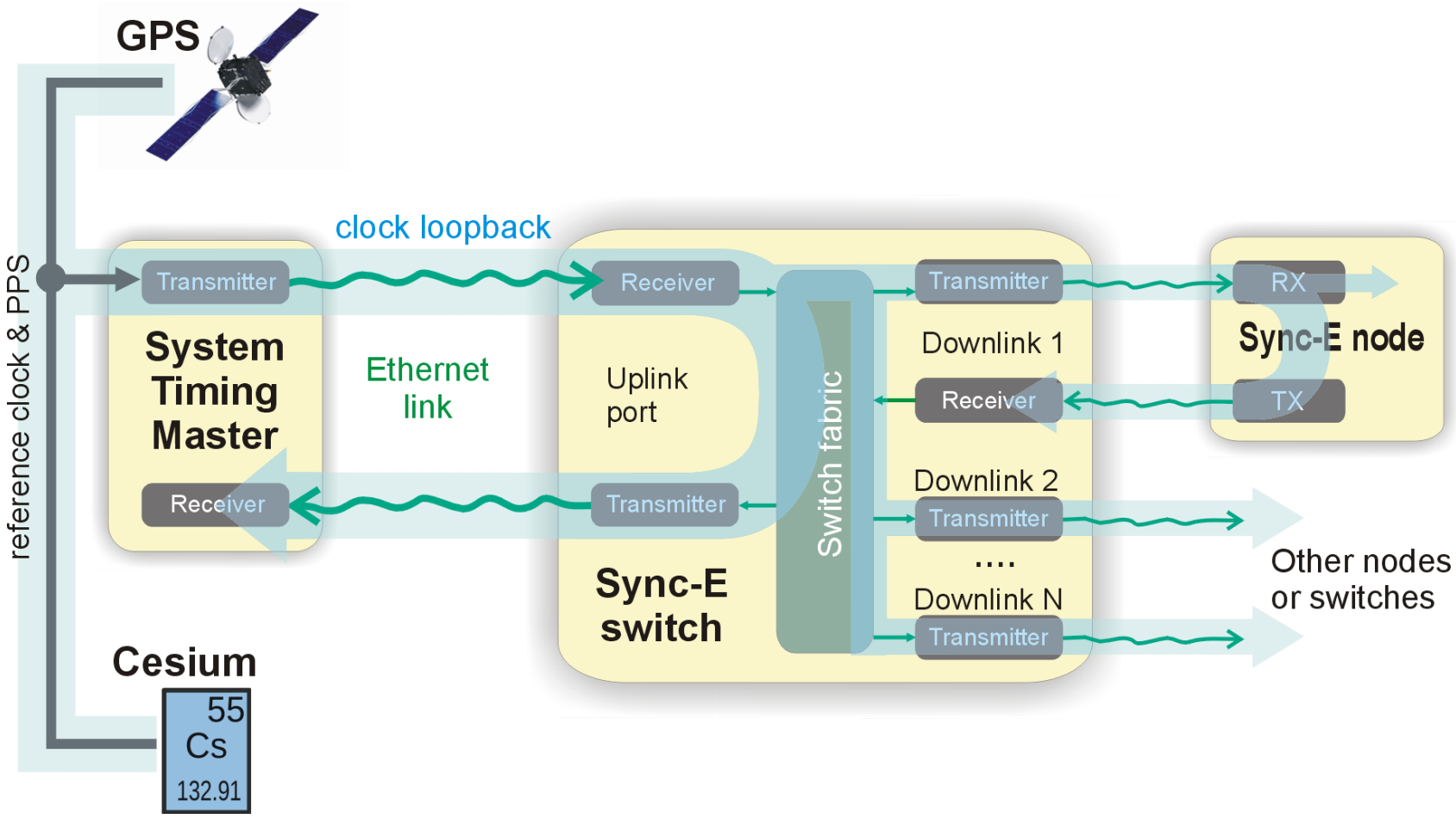
- Bringing together the benefits of Ethernet and timing for large-scale systems
- Low configuration and calibration effort
- Very responsive (low delay)
- Long-term availability



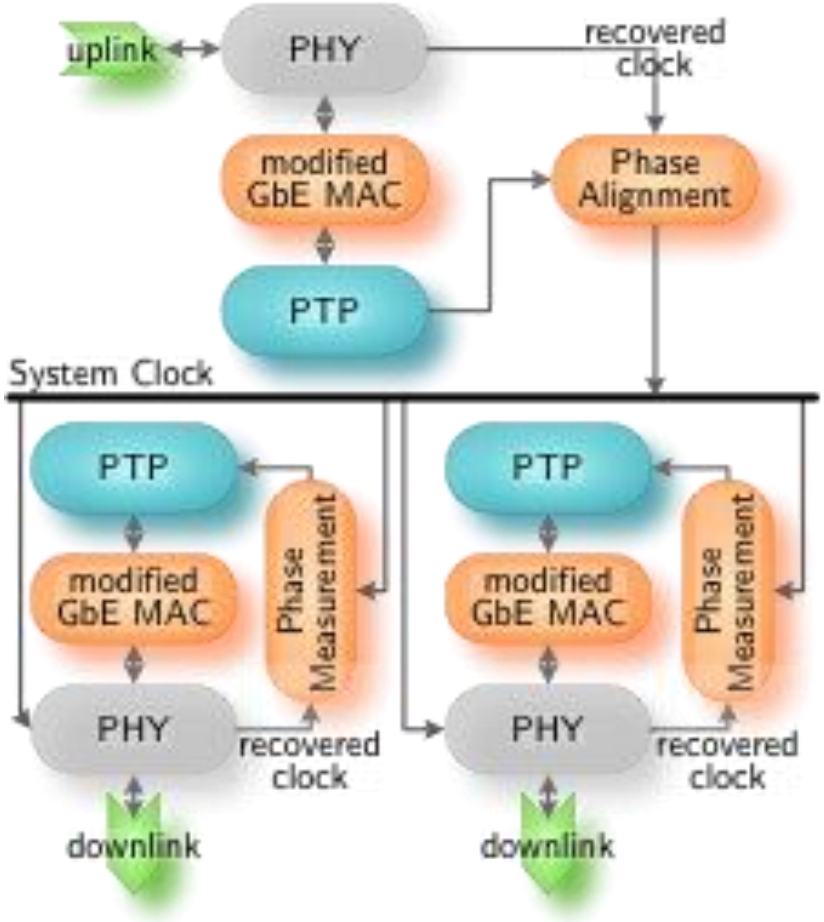
Combined Data/Timing



Timing Hierarchie

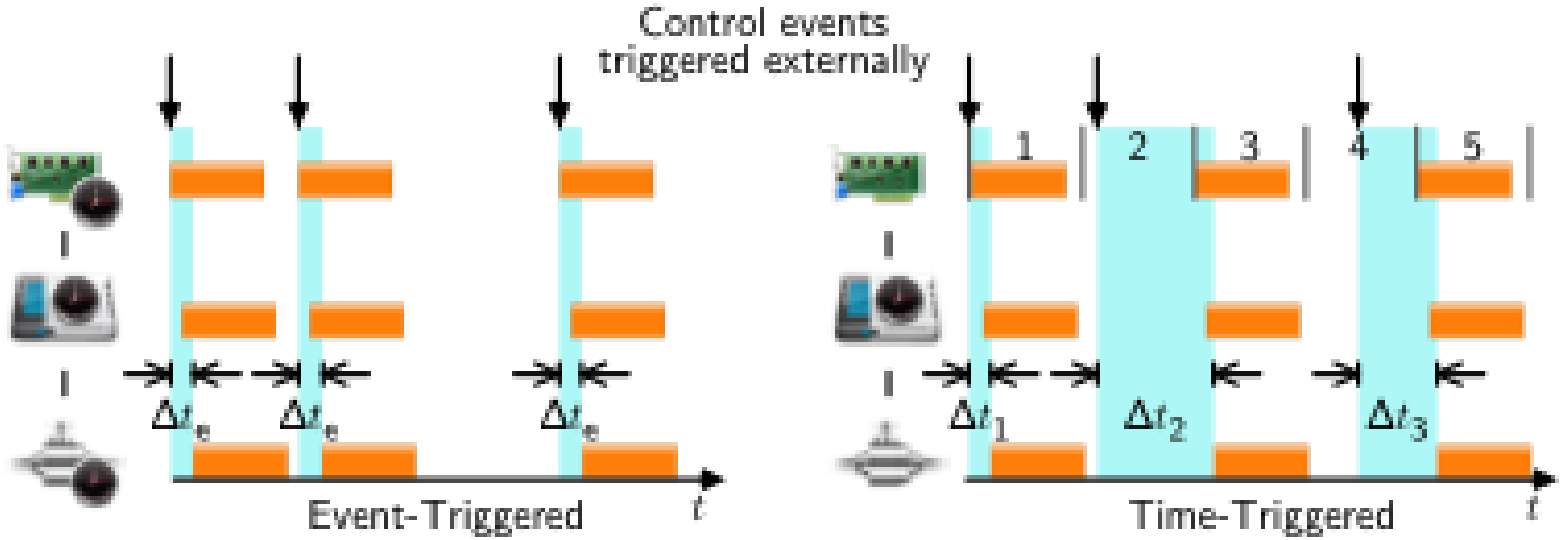


Clock Propagation



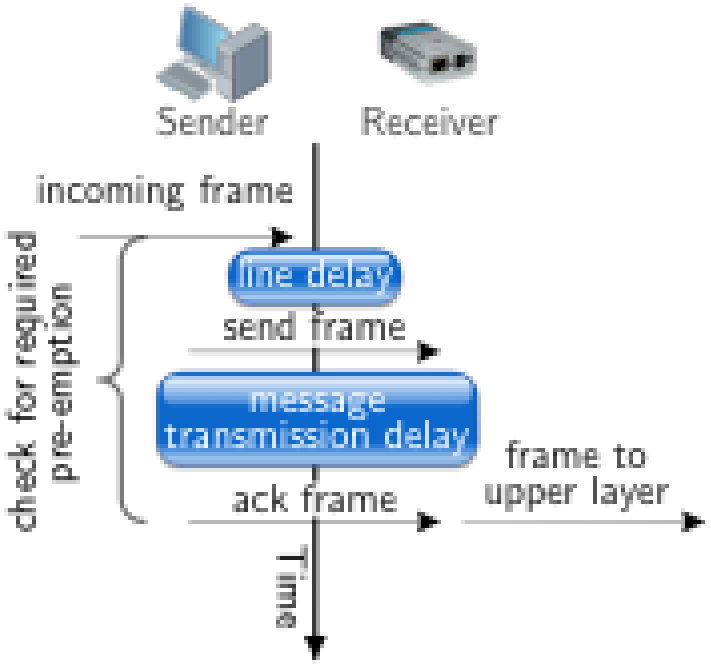
Packet Delivery

- Goal is to establish a deterministic layer 2 implementation allowing for event-triggered packet transmission
- Minimises overall transmission delay on critical messages

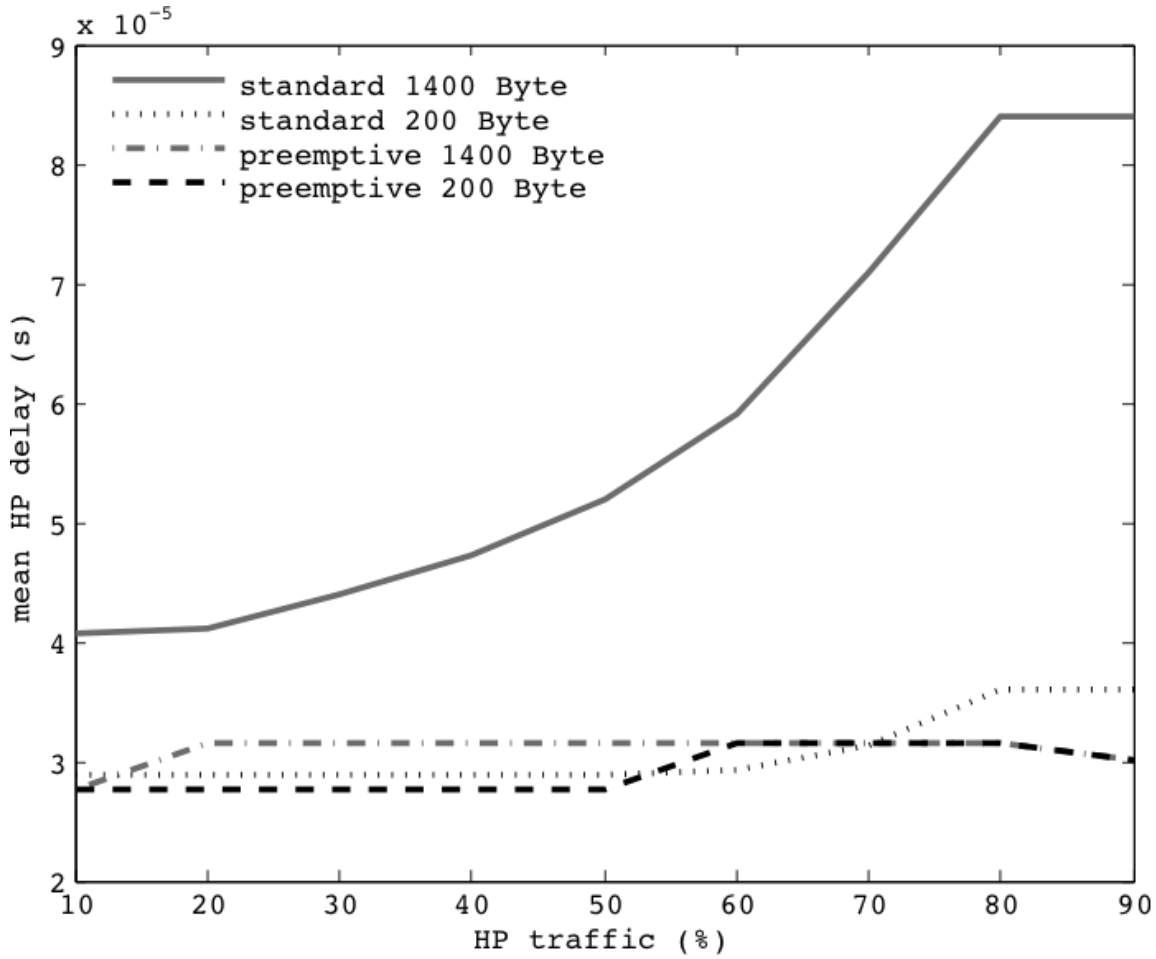


Discrete Event Simulation

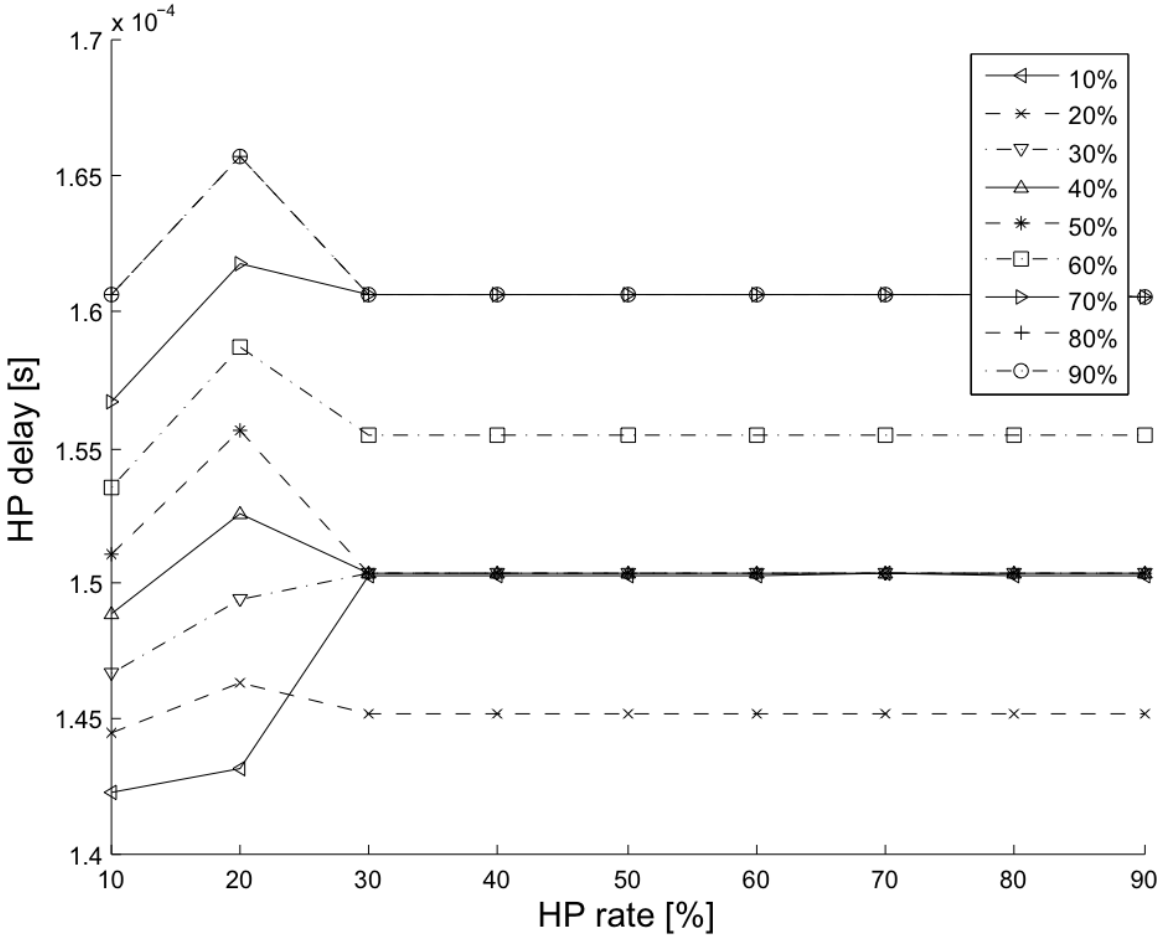
- Simulation is based on scheduled messages
- Processing takes no simulation time
- Transmission delays are modelled using re-scheduling of messages
- Pre-emption is modelled in the sender

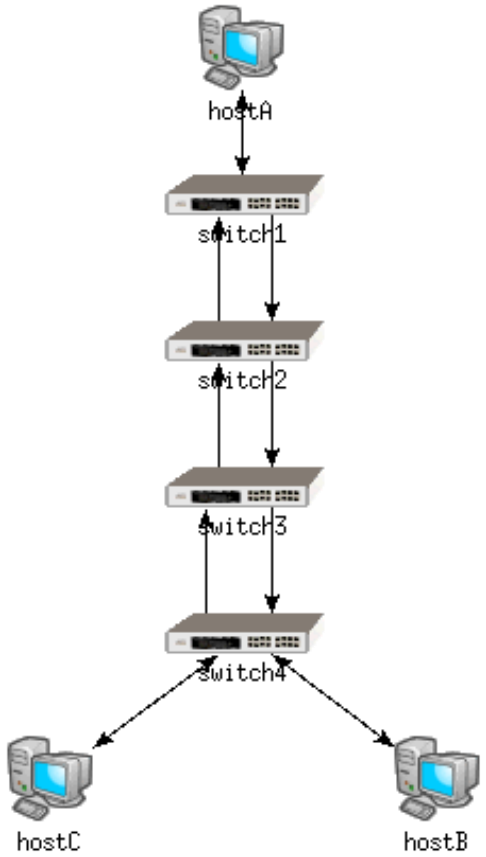


Effect of preemption



Simulation Results



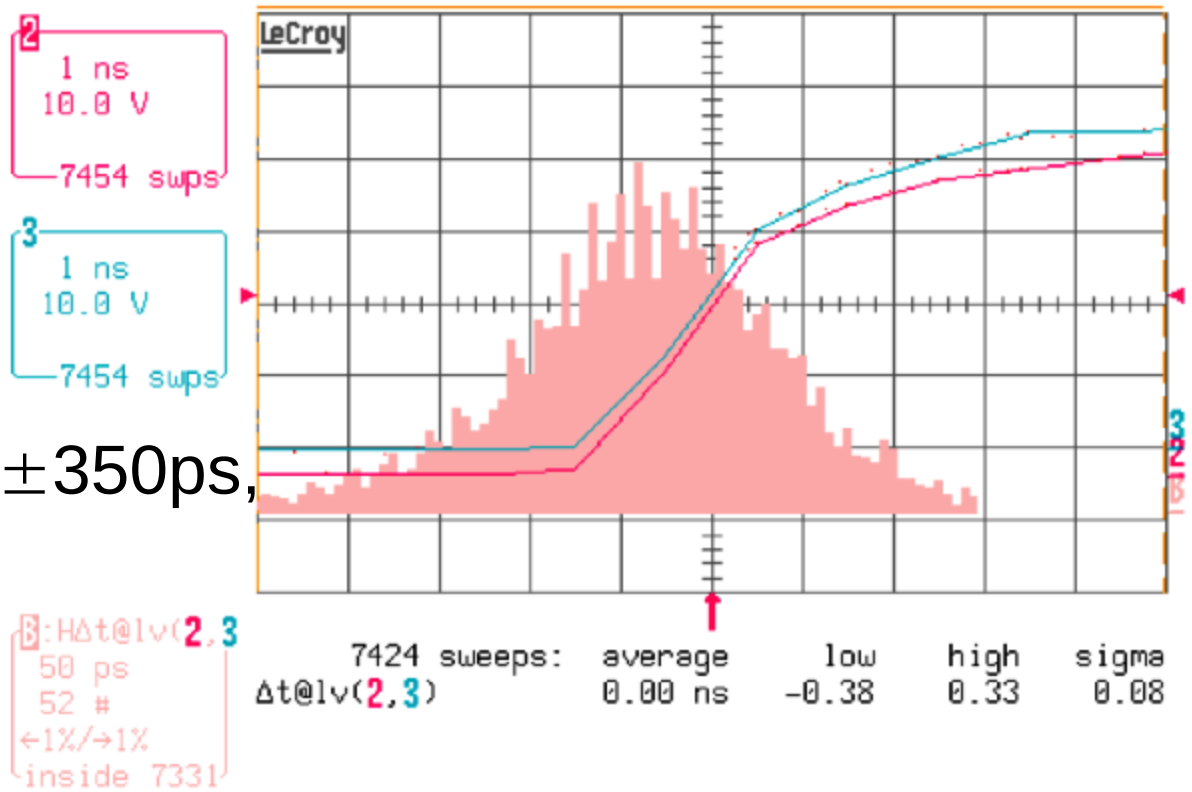


Prototype

- µTCA crate based switch
- Master port (MCH)
  - Switching fabric
  - Clock recovery and cleaning
  - Management functionality
- Slave cards (AMC)
  - Downlink ports (4 each card)
- Open hardware design (www.ohwr.org)

Measurements

- Measurements taken using prototype @ CERN
- Point-to-point 5 km fibre link, delay compensation
- 1 sec



- Accuracy: ±350ps, σ=80ps

Deployment in FP7 Project

ISPCS Brescia '09

- Control of large-scale complex systems
- Build control system featuring
  - Large scale
  - Real-time
  - High throughput, Quality of Service
  - Clock propagation
- Benefit from
  - Synchronous Ethernet
  - IEEE 1588
  - Existing higher layer protocols

Partners

- CERN (BE-CO-HT)
- Austrian Academy of Sciences (IISS)
- GSI Helmholtzzentrum für Schwerionenforschung
- University of Brescia
- Zürcher Hochschule für Angewandte WissenschaftenNational Instruments (InES)
- Cosylab
- Oregano Systems
- Hirschmann Automation and Control

Questions?

Thank you for your attention!

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