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Precision time synchronization for audio and video signals using Ethernet

Antoine Hermans

Introduction

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Who am I?

- Antoine Hermans, CTO of Adeas B.V.

ALTERA.
XILINX®

Who is Adeas?

- Independent Design House located in Eindhoven.
- Developers of customer specific electronic products, embedded systems and IP.
- Active in professional and industrial markets such as Broadcast, pro AV, printing, semiconductor and high tech machinery

- **Adeas specializes in FPGA and SoC solutions on advanced digital and mixed signal boards**

- Design Partner of both Altera and Xilinx

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Agenda

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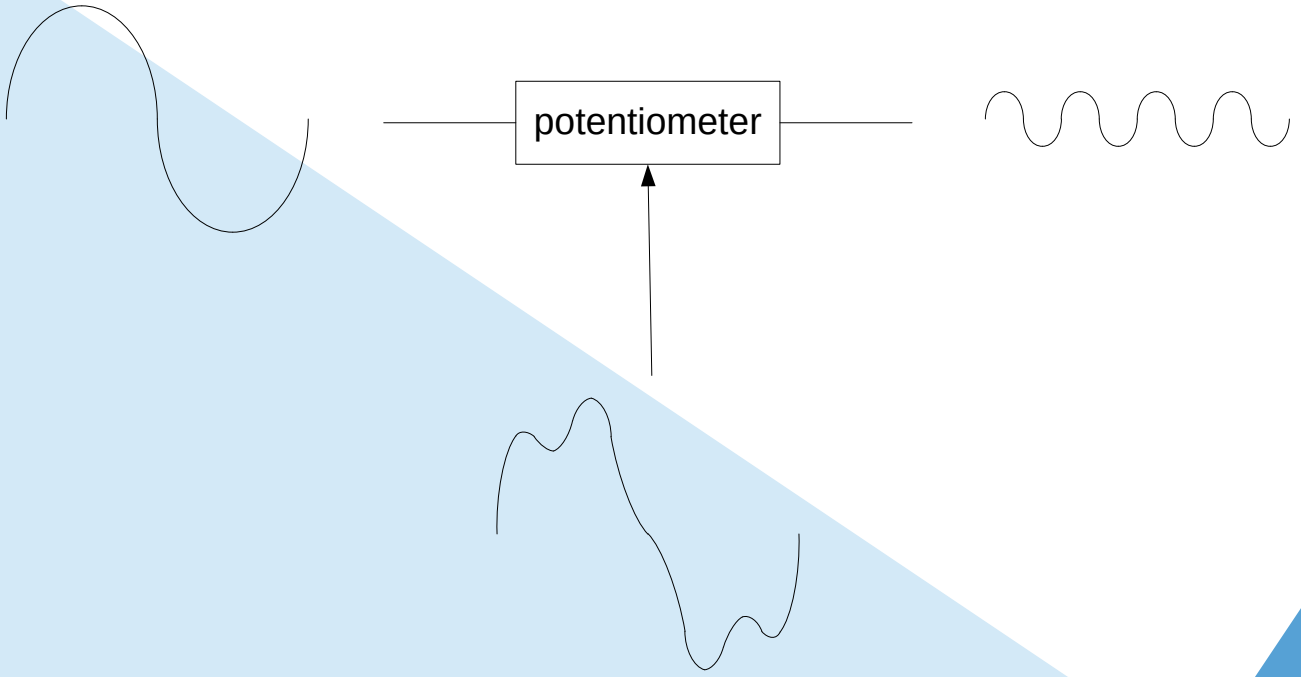
- Background – Why synchronizing?
- Video over IP
- Challenge
- Solution
- Demo setup
- Results / Conclusion

Background

What is synchronizing and why do you want to?



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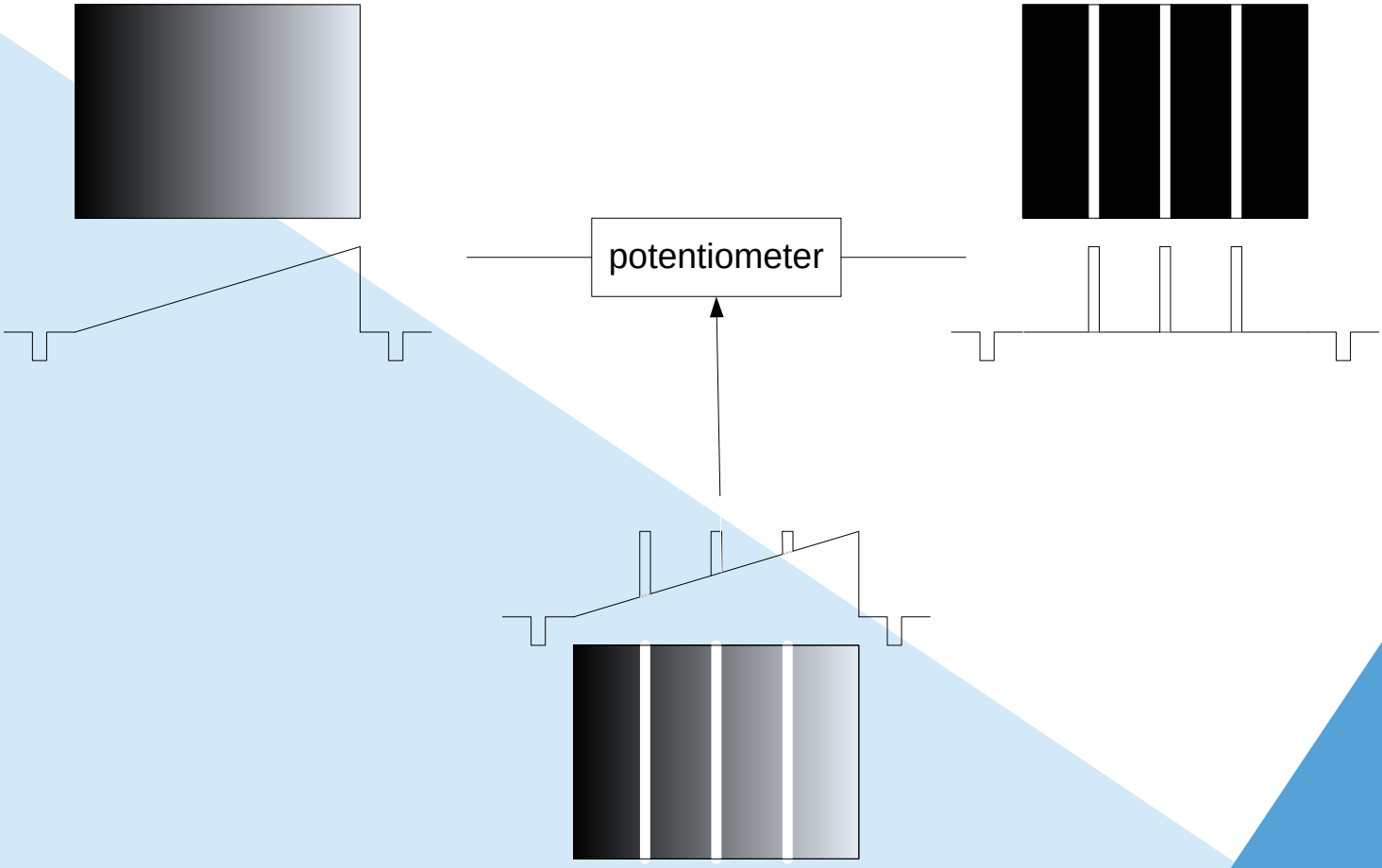
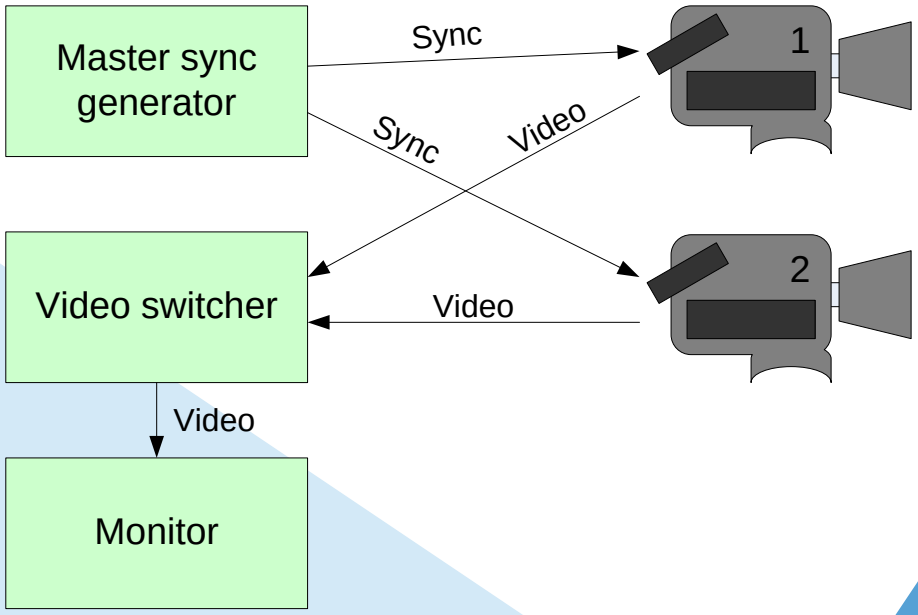


Background

How is frequency and phase lock achieved in e.g. a studio environment?

- Master sync generator
- Sources must genlock to sync from master

- Scalability is poor: System cabling for larger systems, multiple standards, audio, time code, etc.



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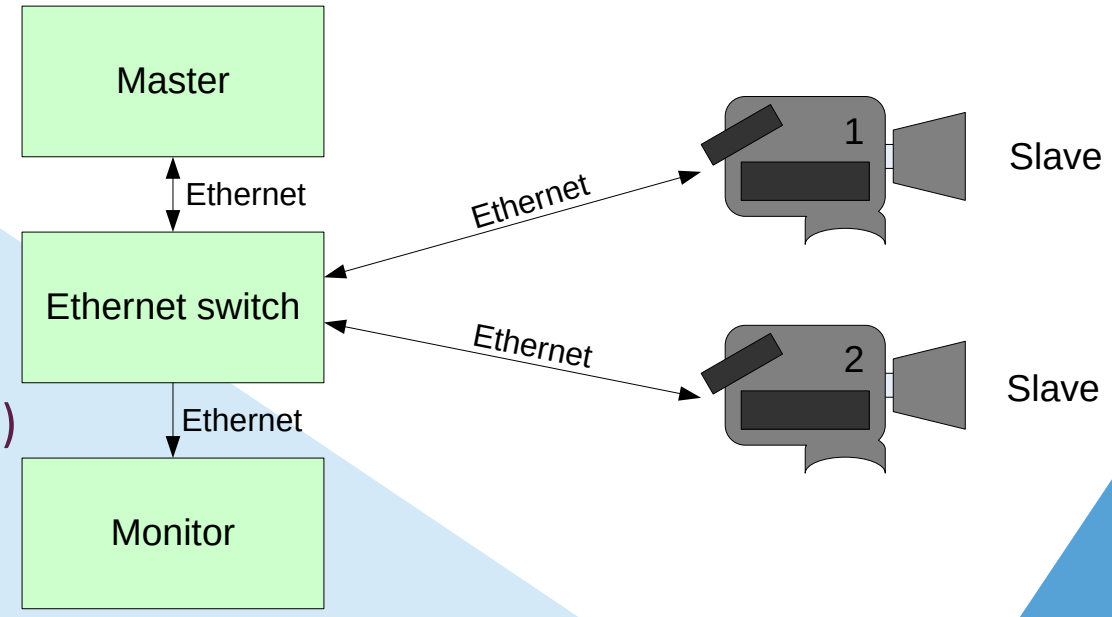
Video over IP

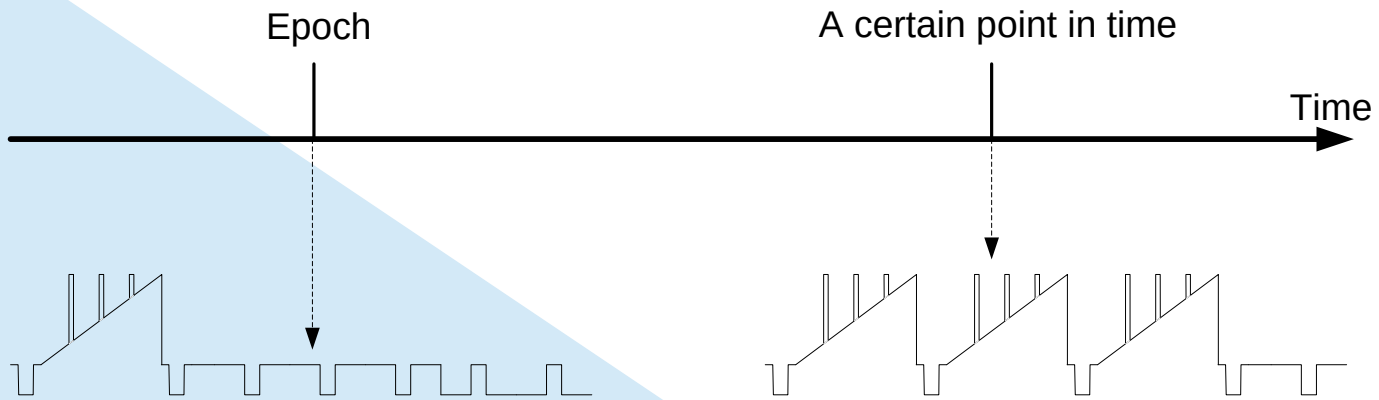
Video over IP architecture, using just one etherent cable.

- One interface for everything.
- Better scalable using ethernet switches
- Slaves copy (absolute) time
- Refer all audio and video signals to that time



Video over IP

How to determine phase of e.g. a video signal if (absolute) time is known?



- Define the Epoch
- Define the phase of A/V signals at the Epoch
- The phase of A/V signal is determined deterministically at the arbitrary time

Video over IP

Summery. What is needed to synchronize using the Ethernet interface?

1. Each slave must copy the grand masters' time as exact as possible
2. The slave must output or generate the phase and frequency of its (audio / video) signals according that time

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Challenge

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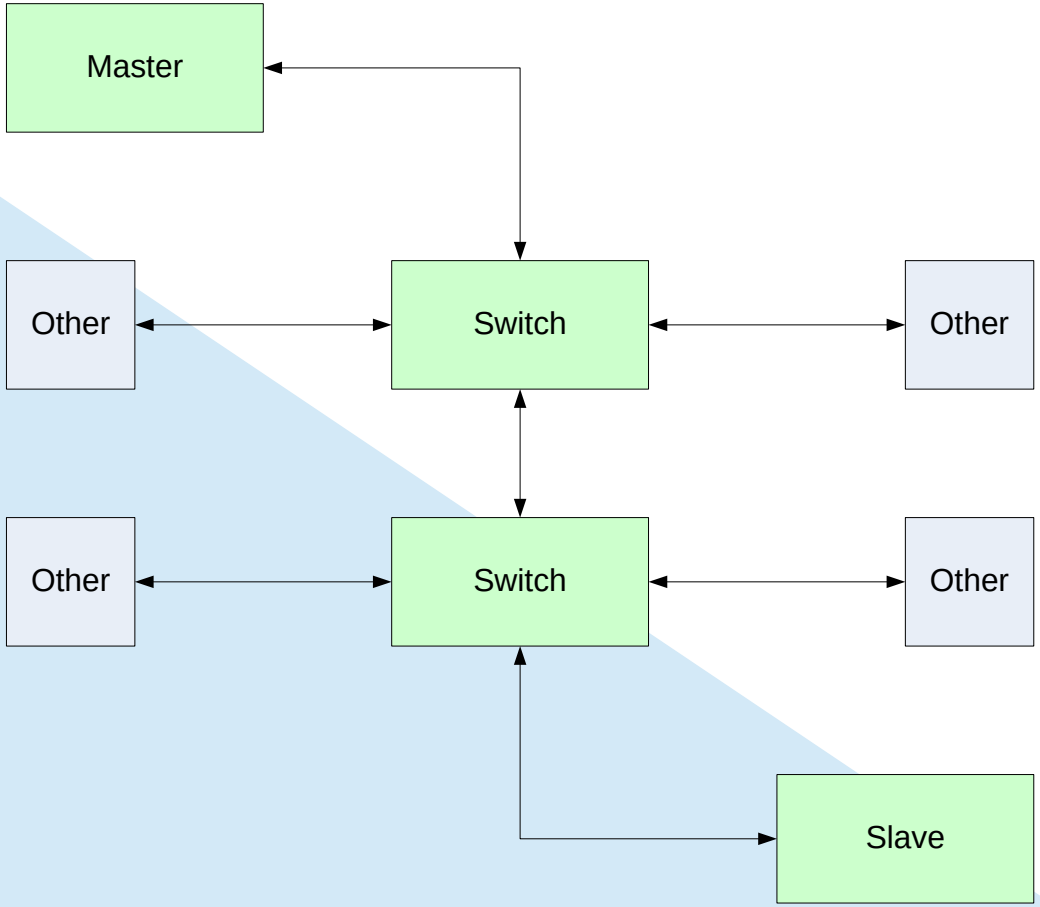
Why is time synchronization over ethernet a challenge?



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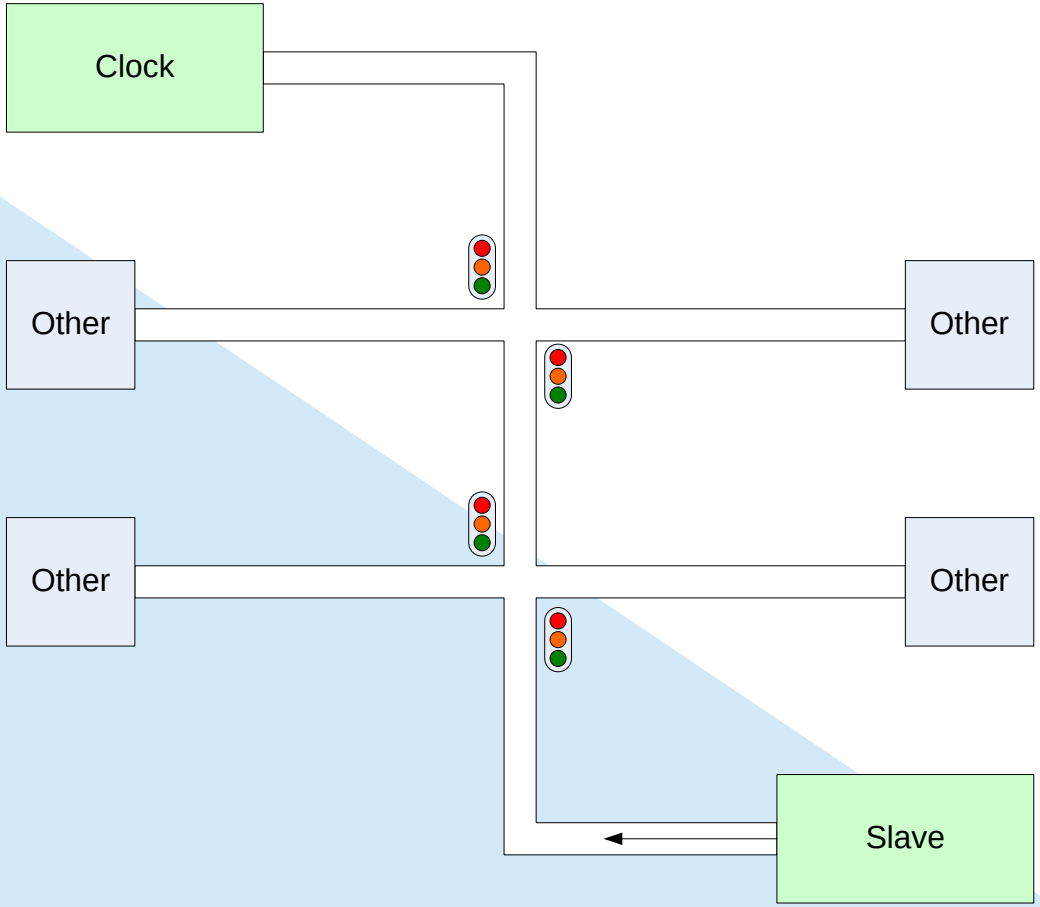
Why is time synchronization over ethernet a challenge?



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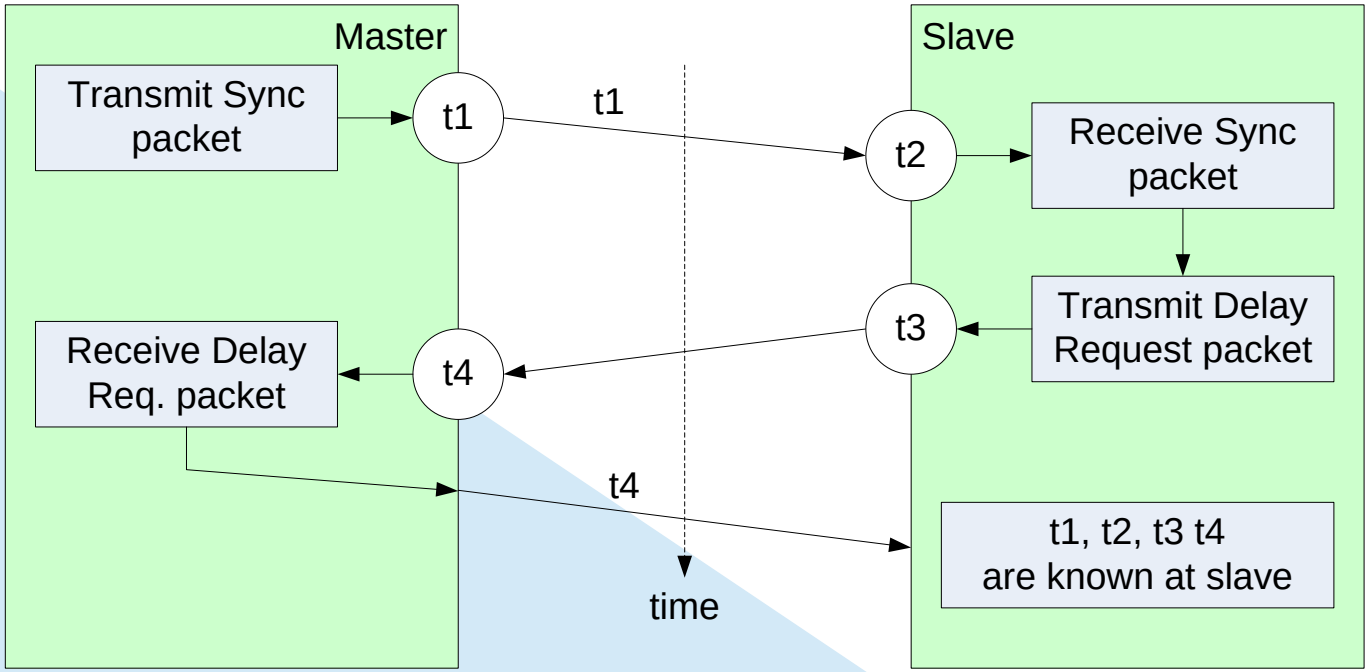
Solution

How can we realize precision time at the slave?



network delay = t2 - t1 - (offset between master and slave)

network delay = t4 - t3 + (offset between master and slave)

Offset between master and slave = (t2 - t1 - t4 + t3) / 2

Solution

What is influencing the precision of the offset measurement?

External influences:

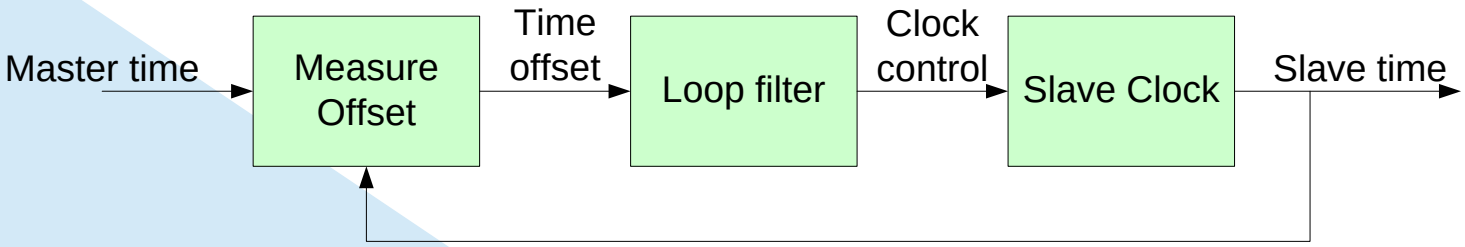
- Asymetry in network delay
- Non-constant delay of the ethernet packets
  - Physical interfaces (Ethernet Phy)
  - Other network traffic
  - Switches -> Use special switch
  - Can be as high as milliseconds!

Internal influences:

- Periodic time of internal clock frequencies (e.g. 125MHz -> 8 ns)
- Clock domain crossings
- Calculation precision (80 bit + 32 bit = 112 bit)

Solution

The offset between master and slave is measured multiple times a second.



- Loop filter is critical:
  - Must be non-oscillating
  - Must be fast because of fast locking and to allow tracking of changes
  - Must be slow because of averaging offset measurement error

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Demo setup

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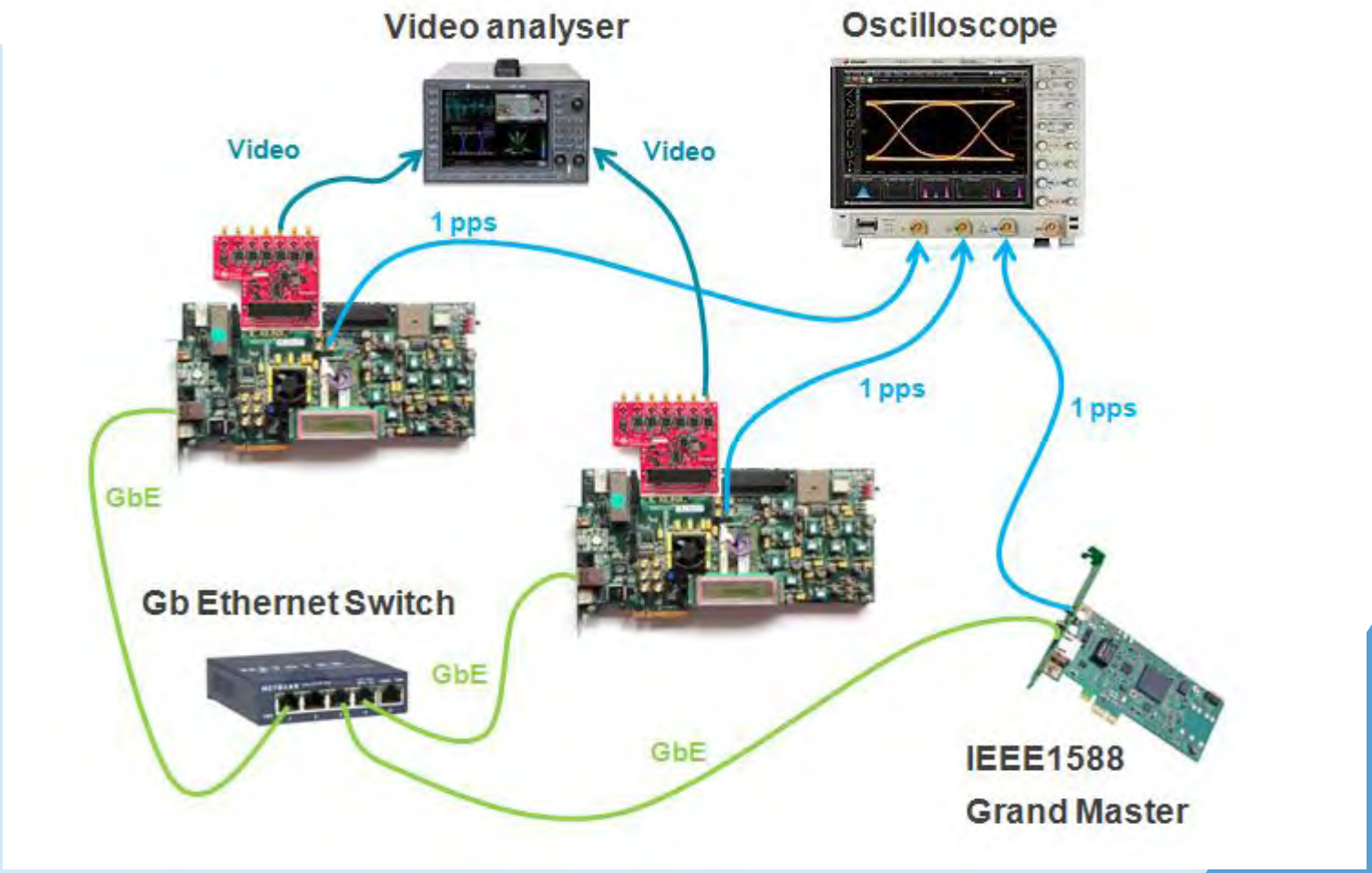
Demo can be seen at the Adeas booth



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Results / Conclusion

- Precision time synchronisation using ethernet is possible
- Theory looks quite simple, actual implementation is not straight forward
- Performance depending on HW precision, must be balanced

Achieved performance for audio and video purpose on a standard Xilinx development kit:

- Precision up to nanoseconds
- Fast locking time: better than 5 seconds
- Low frequency jitter (wander) in range of 20 ns

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Questions?

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Thank you for your attention!