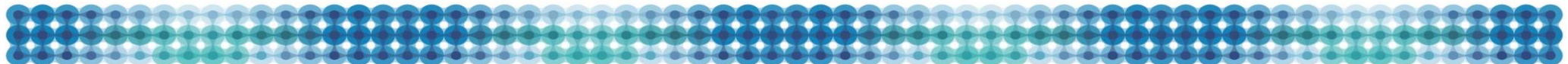# PTPv2 Clock synchronization usage by the financial sector
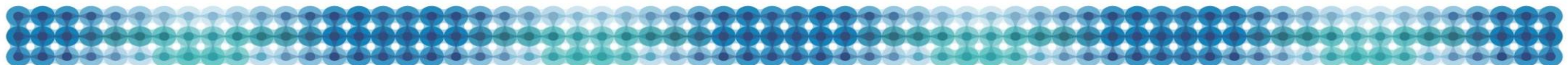
Presented in the Vrije Universiteit Amsterdam (VU)
https://www.vu.nl/en/

Pedro V. Estrela, PhD
Performance Engineer
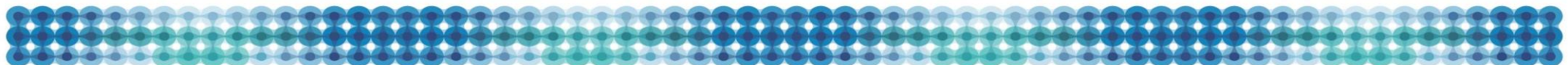14-Jan-2014

Outline

- Part 1: Financial markets overview

  - How electronic markets work
  - Why low-latency a crucial requirement

- Part 2: Industrial research example

  - PTPv2 clock synchronization
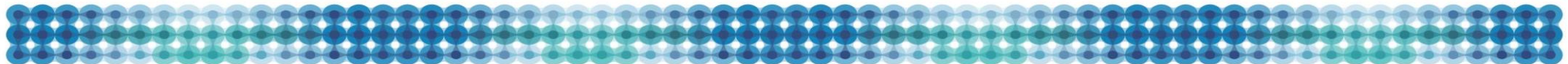 - Issues on the state-of-the-art

About the presenter

- ## Pedro V. Estrela:

  - PhD in Mobile IP networks (2007)

  - Efficiency and Transparency work

  - NS2 network simulations

- ## Performance System Engineer

  - Think of the mechanic that tunes your car

  - Measure all latency steps (accurately)

  - Remove the biggest bottleneck

Financial markets overview

Market participants

- Most market participants have an <u>opinion</u>, to:
  - Invest / raise capital
  - Get / provide Risk insurance

EUR/USD
EURUSD=X

Jan 13, 2014

1.385
1.380
1.375
1.370
1.365
1.360
1.355
1.350
1.345
1.340
1.335
1.330

© Yahoo!

Nov 01   Nov 21   Dec 11   Dec 31

Market making

- ## IMC: Global Liquidity provider

  - Present in all major Equities / Derivatives markets

  - 4 offices worldwide, all time zones

- ## Market-Making business:

  - Like a currency house – **no market opinion**
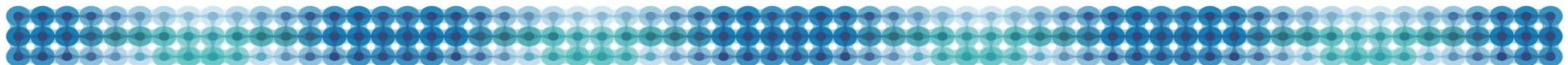
  - We liquidity by providing both **buy and sell** prices
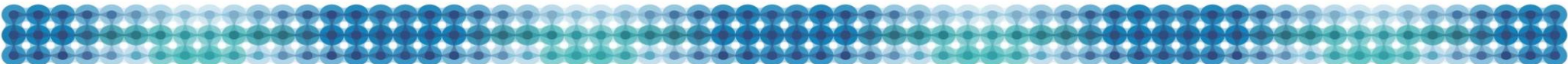
Quoting example

- ## How much is 100 Euros in USD?

Bank	We buy	Mid Price	We sell		Quote age
ABN Amro	-0.800	136.620	+0.800		6 hours
BPI Portugal	-0.815	136.445	+0.815		1 hour
CapitalSpreads.com	-0.002	136.651	+0.002		3 seconds

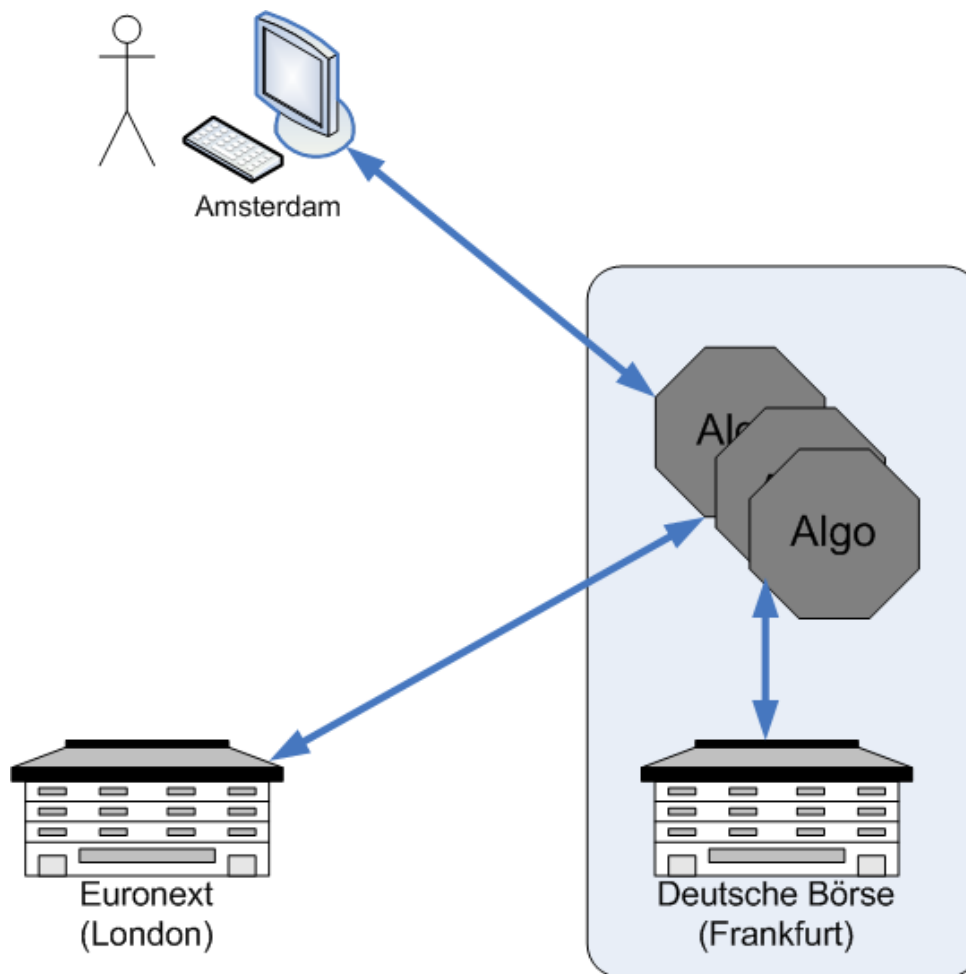- ## How much do you get back in EUR?

Orders matching

- ## Buyers and Sellers

  - Meet at a regulated exchange

  - Express their <u>intention</u> to buy / sell

  - Orders continuously matched by price-time priority
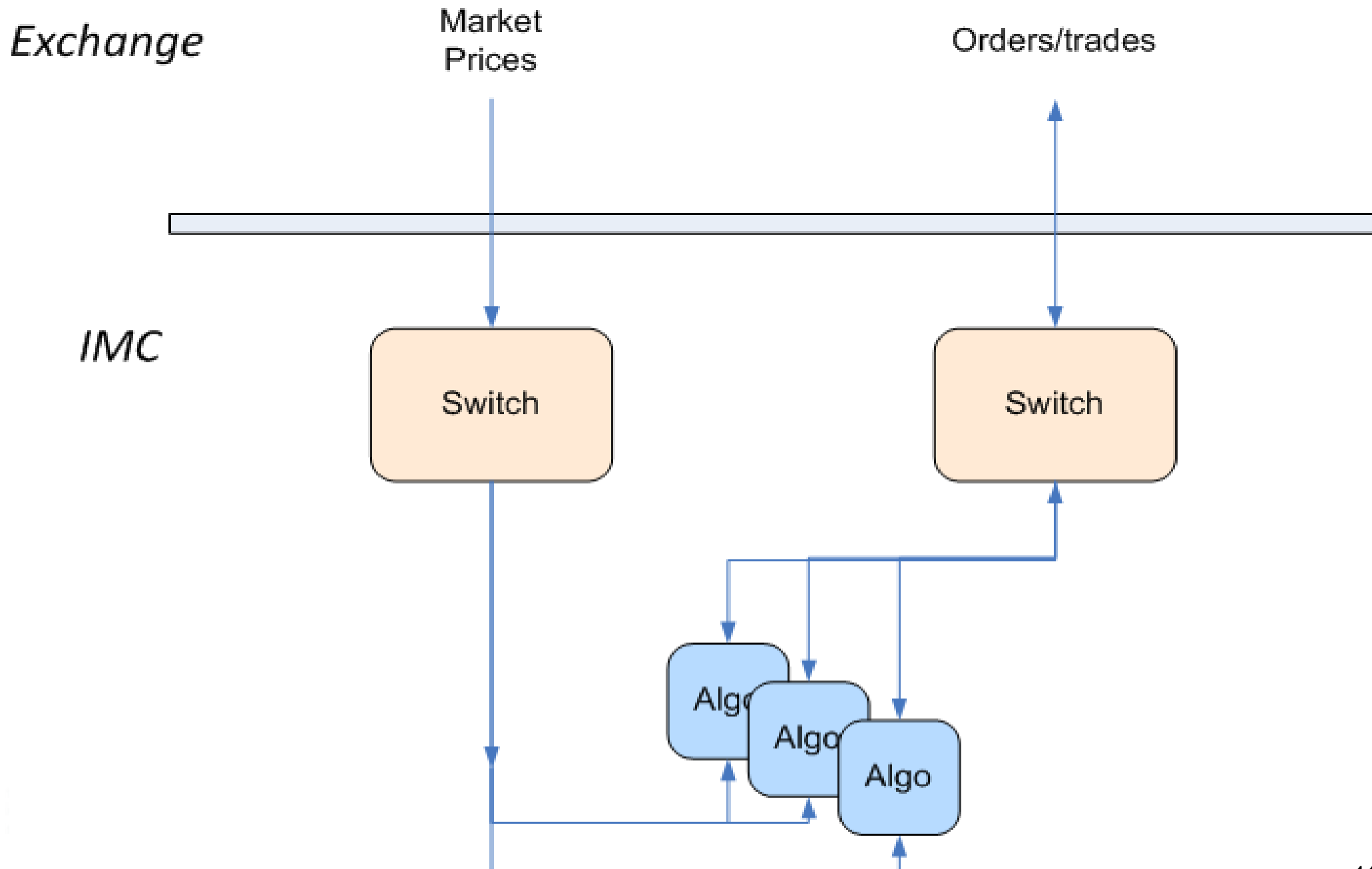
BUYERS				**SELLERS**			
Worse			Best	Best			Worse
7 eur	8 eur	9 eur	10 eur	11 eur	12 eur	13 eur	14 eur

Trading 101

- Imagine this just happened…

	BUYERS			SELLERS		
London	8 eur	9 eur	10 eur	11 eur	12 eur	13 eur
Frankfurt	6 eur	7 eur	8 eur	9 eur	10 eur	11 eur

- Questions

  - Q1: what would <u>you</u> do here?
 - Q2: what should the <u>market maker</u> do here?

Where do we need speed?

What speed do we need?

How long is a....

- ## millisecond (ms)
  - A camera flash illuminates for 1 millisecond
  - Distance between countries

- ## microsecond (μs)
  - 3 microseconds – Light to travel one Kilometer (1 billion km/h)
  - In and Out a machine, including all processing

- ## nanosecond (ns)
  - 3 nanoseconds – Light to travel one meter cable
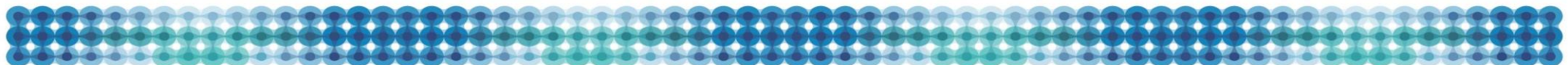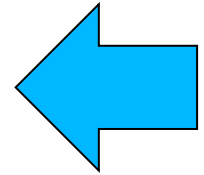 - 350ns packet forward in a switch
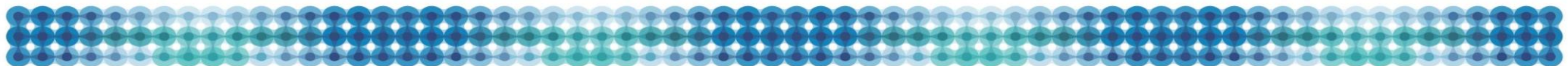
Industrial research example:

Clock Sync distribution
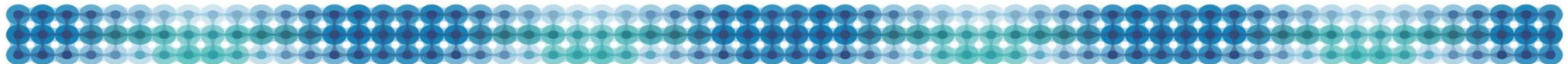
Clock sync Distribution

- Where does civil time comes from?
  - "Mean" of the world's stablest atomic clocks
  - Pushed every month to GPS Satellites
  - Continuously broadcasted to GPS receivers
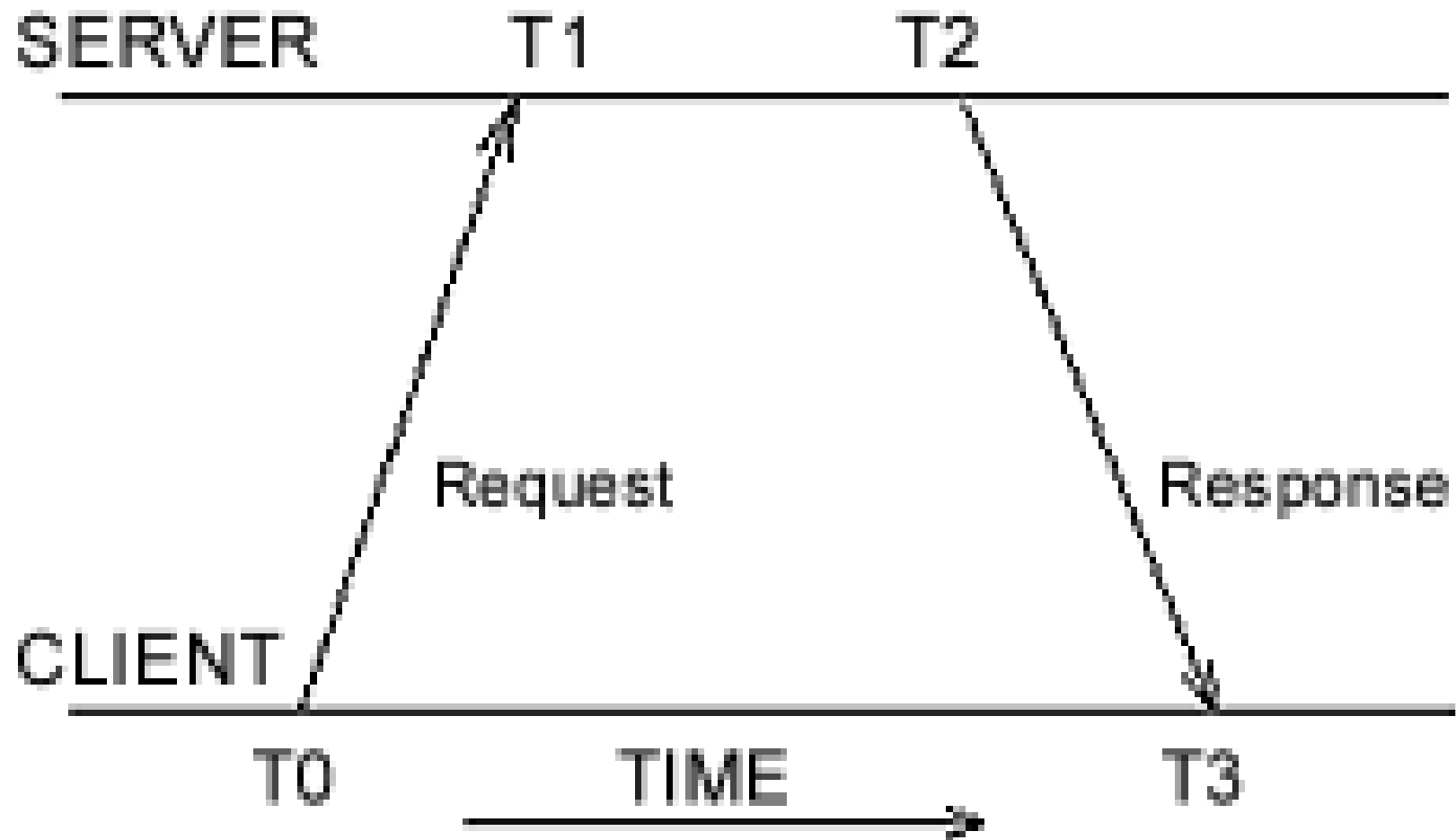 - <u>Distributed</u> to every machine at IMC

NTP summary

- ## Network Time Protocol (NTP)

  - Very mature IETF standard

  - All messages unicast

  - Multiple time sources

  - <u>Only accurate to milliseconds worldwide</u>
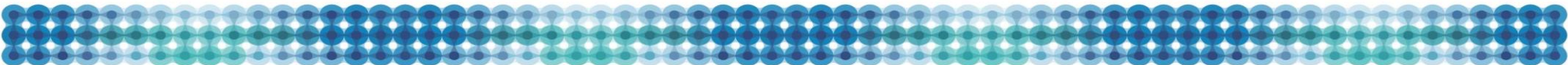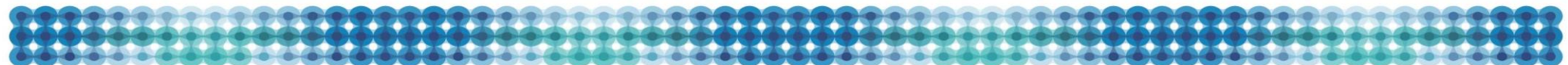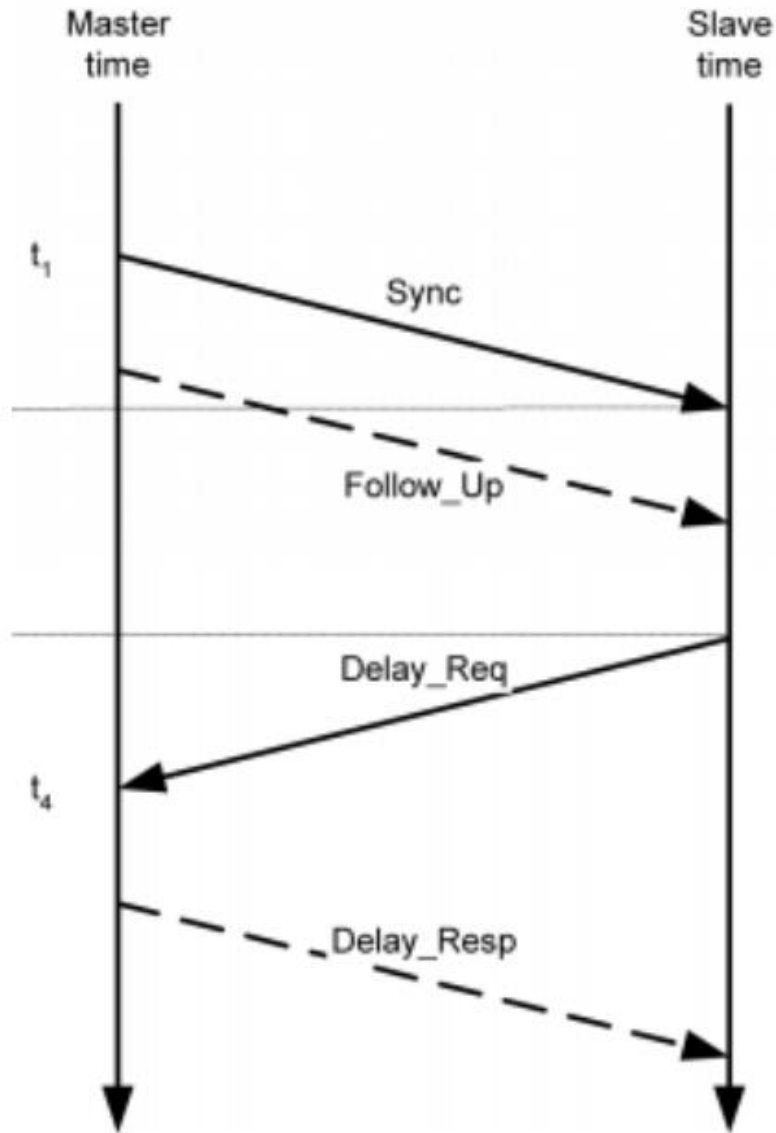
NTP operation

PTPv2 summary

- Precision Time Protocol (PTPv2)

  - Recent IEEE 1588 standard

  - Multicast messages

  - Single time source

  - Accurate to microseconds worldwide

    - Supports HW timestamping

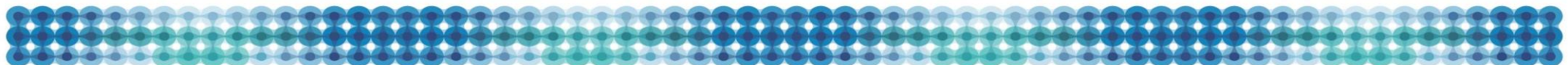   - PTP support on the switches

PTPv2 operation

Master multicasts its time to all clients

Clients separately measure the return path

Single master problem

- ## GM "traitor" scenario:

  - GM sent bad time (<u>leap seconds</u> = 0)
  - Backup GMs stay passive (same BMC)
  - Clients trust their single GM = jumps / slews

- ## Byzantine robustness

  - <u>Always</u> corner cases with single GM
  - Clients <u>must</u> listen to 2*T+1 sources (1997 proof)

Possible solution

Byzantine faults: effect of accelerating time in PTP Master
Timesources: PTP + 5 NTP servers
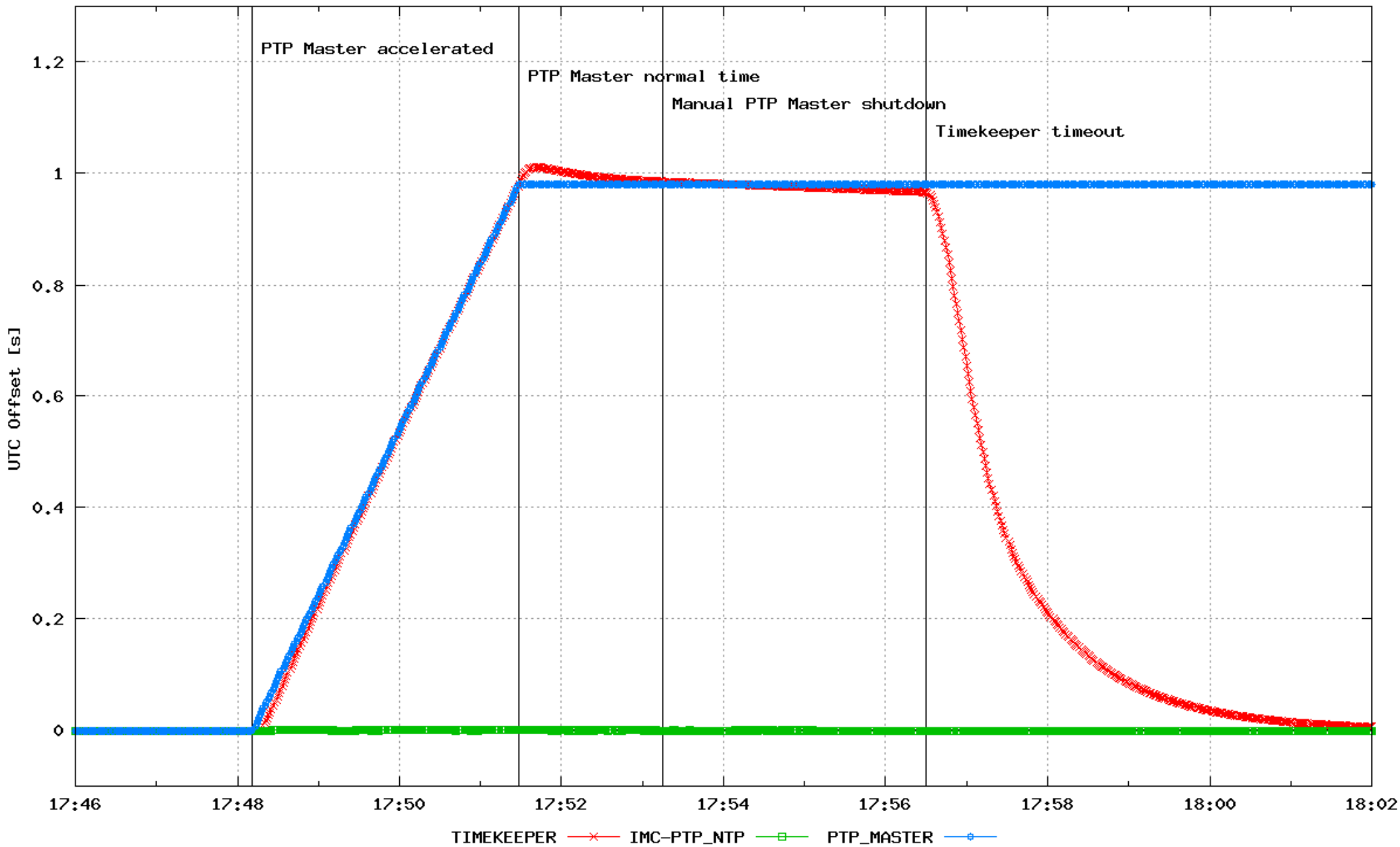
Conclusion

- IMC

  - IT Internships

  - Trainee Traders

  - Research collaborations

- More questions?

  - Contact pedro.estrela@imc.nl

  - Paper: http://tagus.inesc-id.pt/~pestrela/timip/Challenges_deploying_PTPv2_in_a_Global_Financial_company.pdf