

MODELING DISTRIBUTED REAL-TIME SYSTEMS WITH PTOLEMY II

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Edward A. Lee

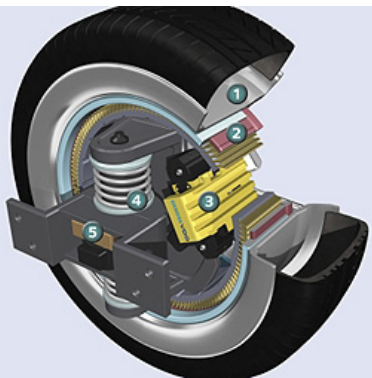
University of California, Berkeley



DISTRIBUTED REAL-TIME SYSTEMS

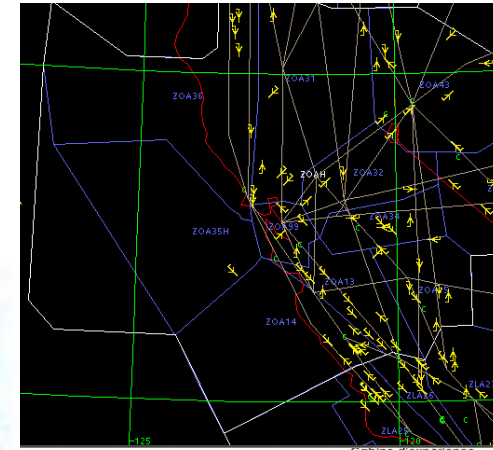
Multiple computers, comprising of sensors and actuators, connected on a network that act and react on events to meet timing constraints.

Automotive

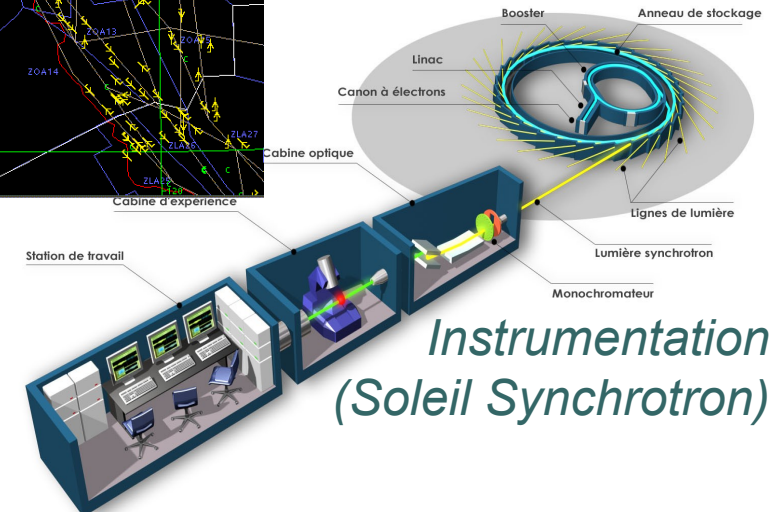


E-Corner, Siemens

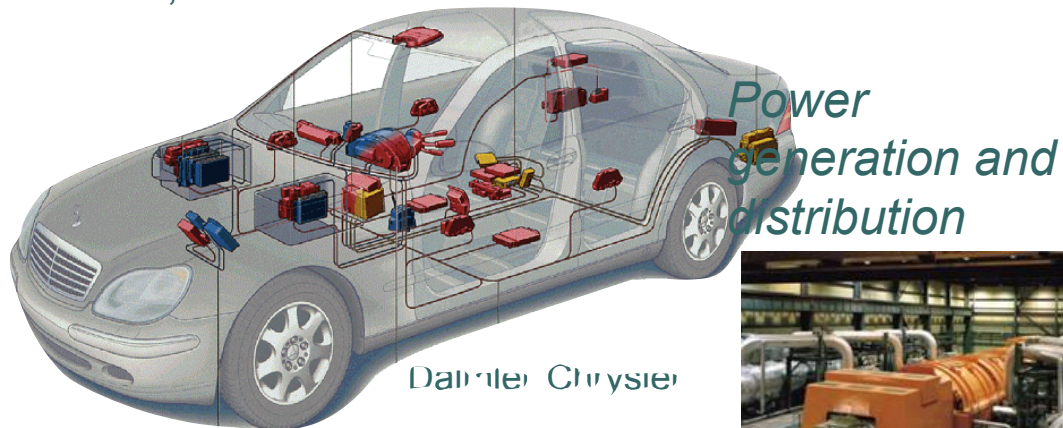
Telecommunications



Transportation
(Air traffic control at SFO)



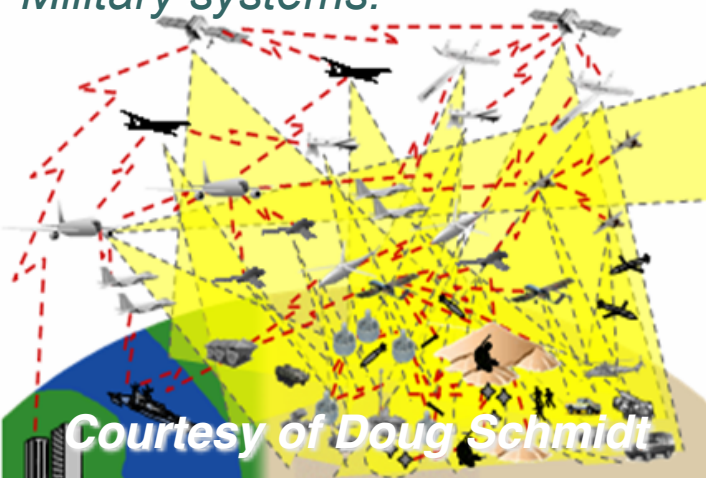
Instrumentation
(Soleil Synchrotron)



Power generation and distribution

Daimler Chrysler

Military systems.



Courtesy of Doug Schmidt

Building Systems



Courtesy of General Electric



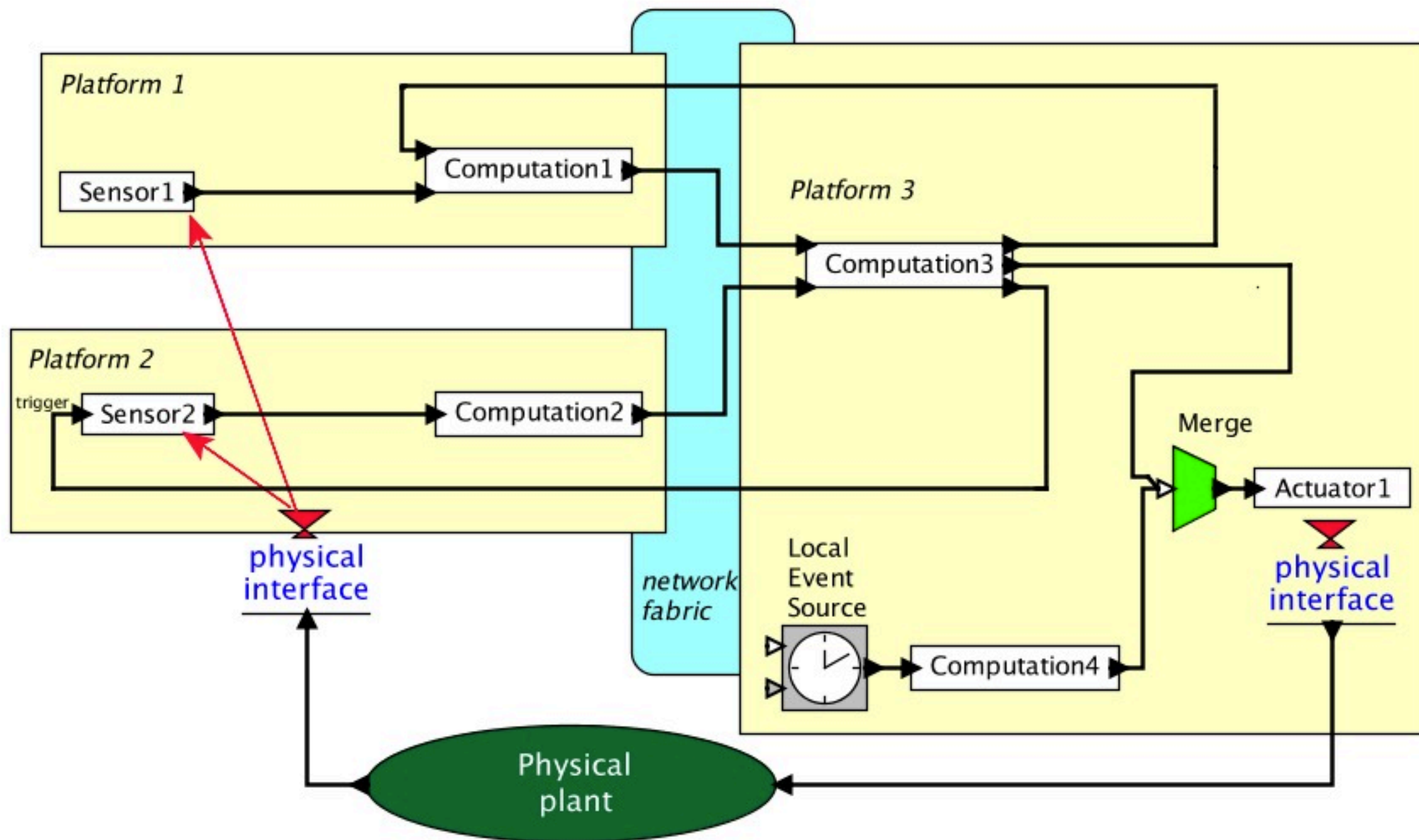
Factory automation



Courtesy of Kuka Robotics Corp.

Patricia Derler - Ptolemy Miniconference 2011

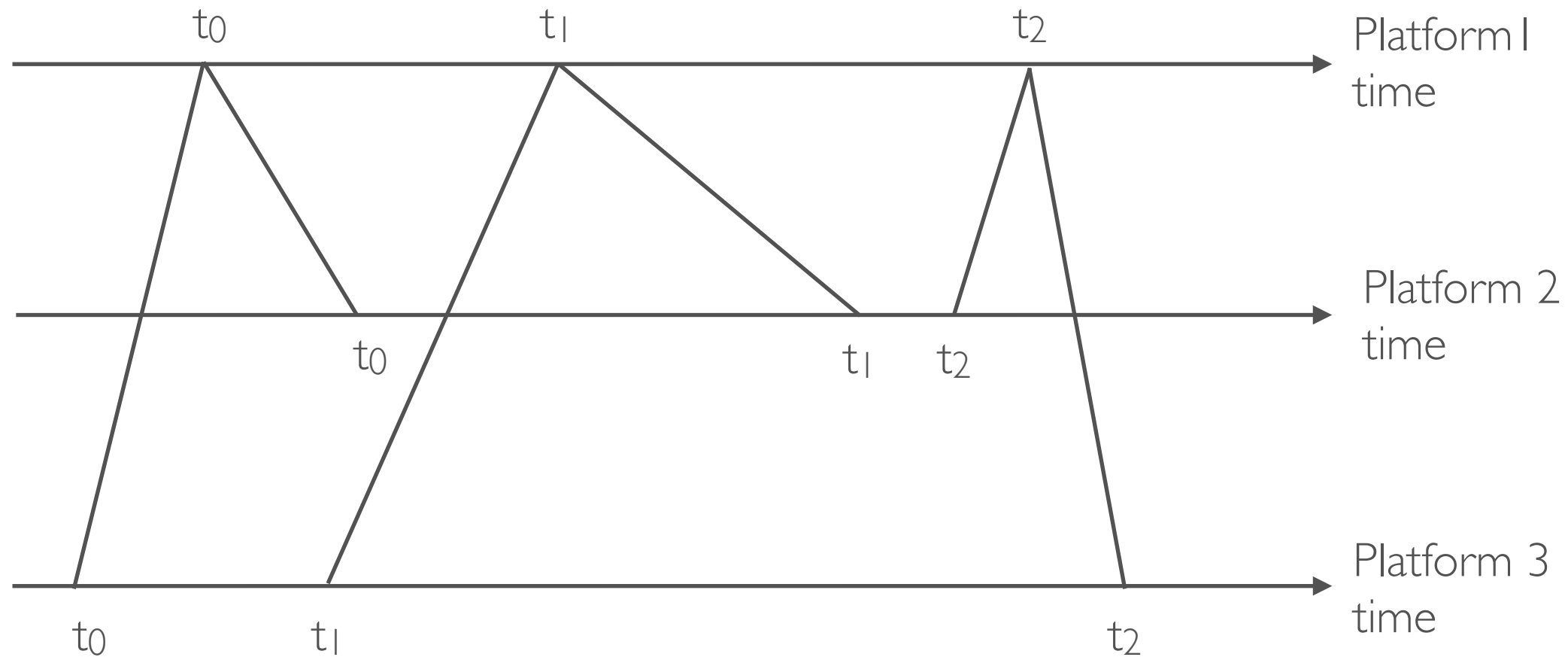
MODELING DISTRIBUTED REAL-TIME SYSTEMS



OVERVIEW

- Challenges: How to model
 - Time
 - Network
 - Execution time
 - Execution semantics
- Address modeling challenges in PTIDES

THE TIME CHALLENGE



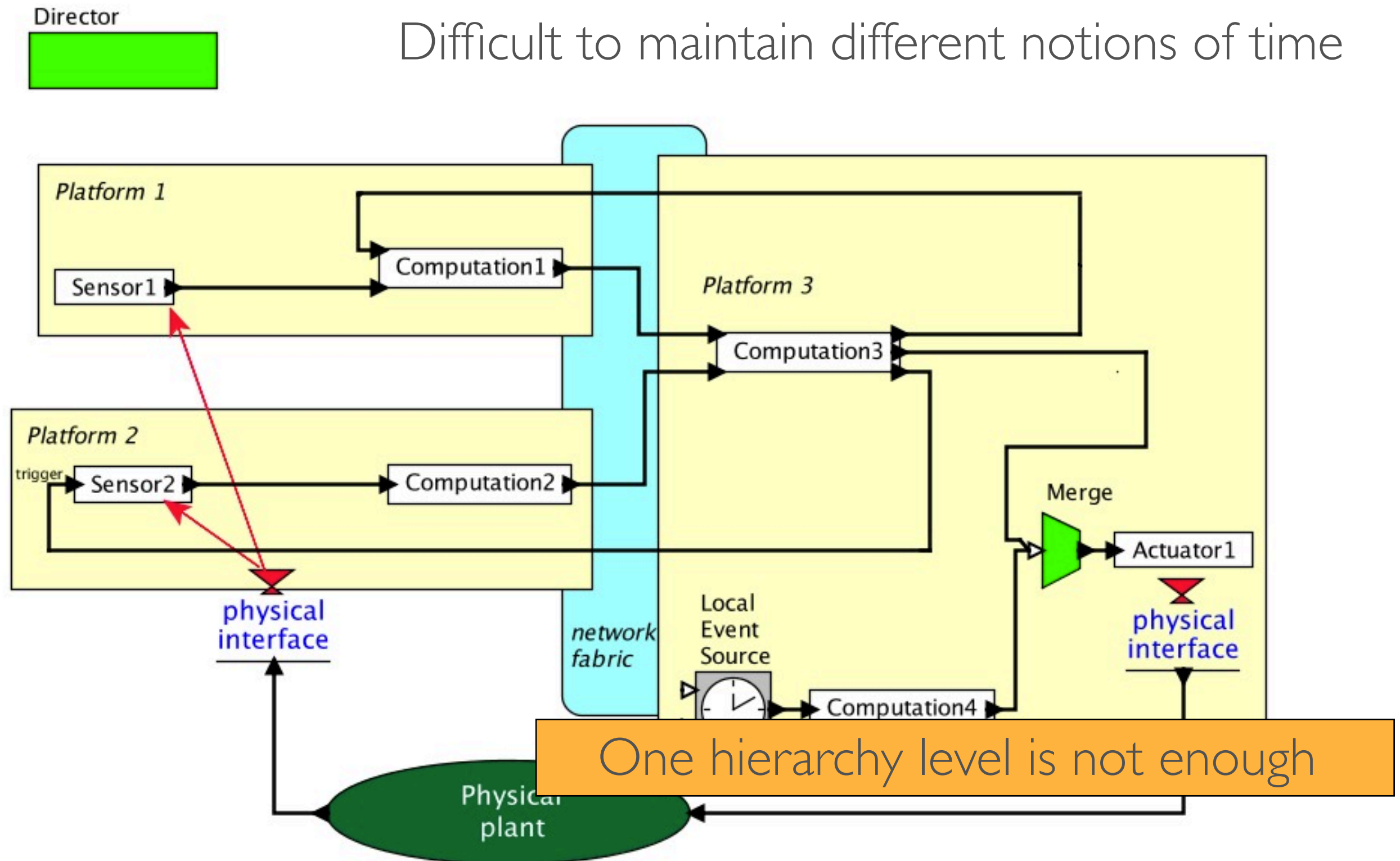
Distributed platforms have different notions of time

Platform clocks drift

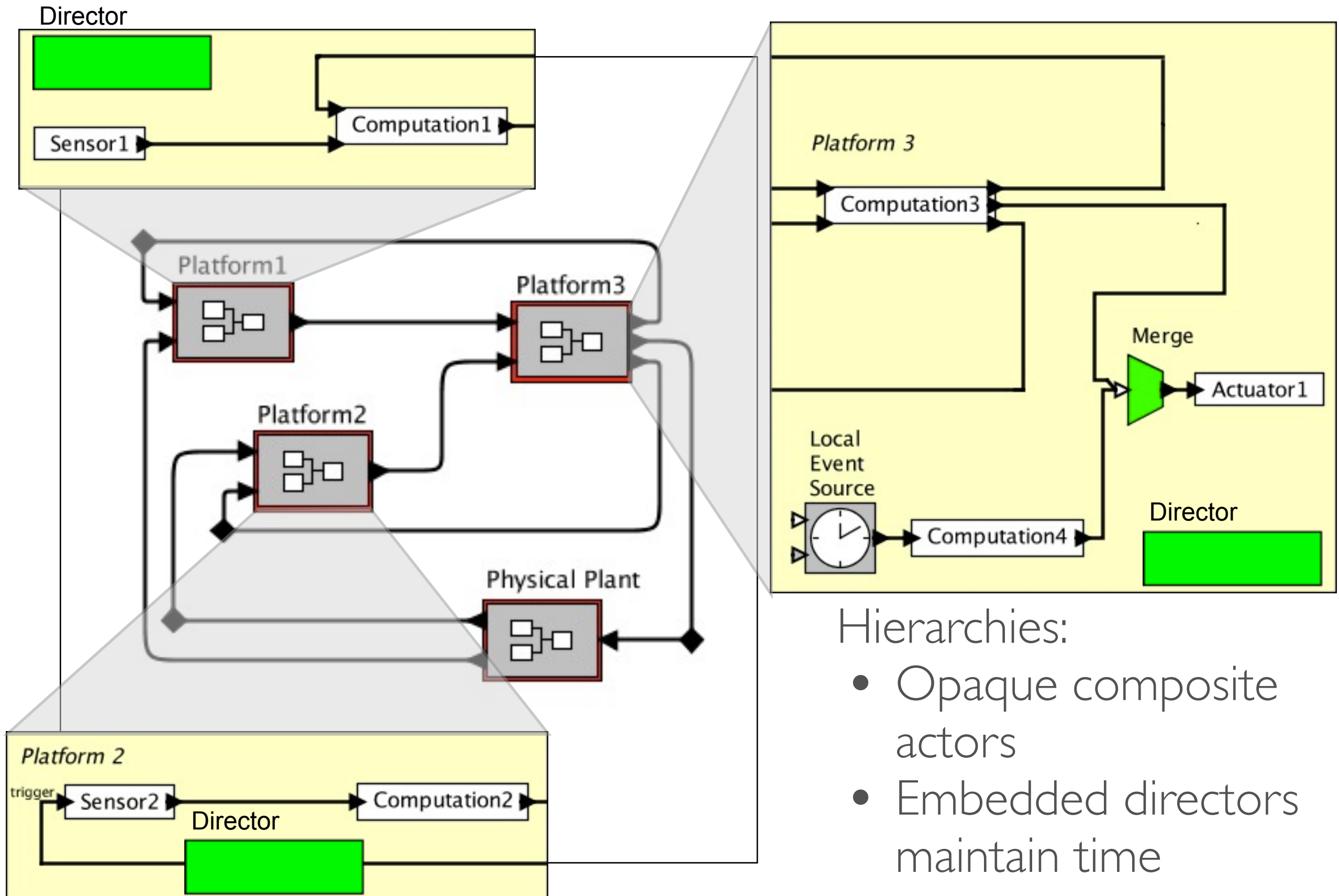
Platform clocks drift at varying rates

MODELING DISTRIBUTED SYSTEMS

Director mediates between actors
Difficult to maintain different notions of time



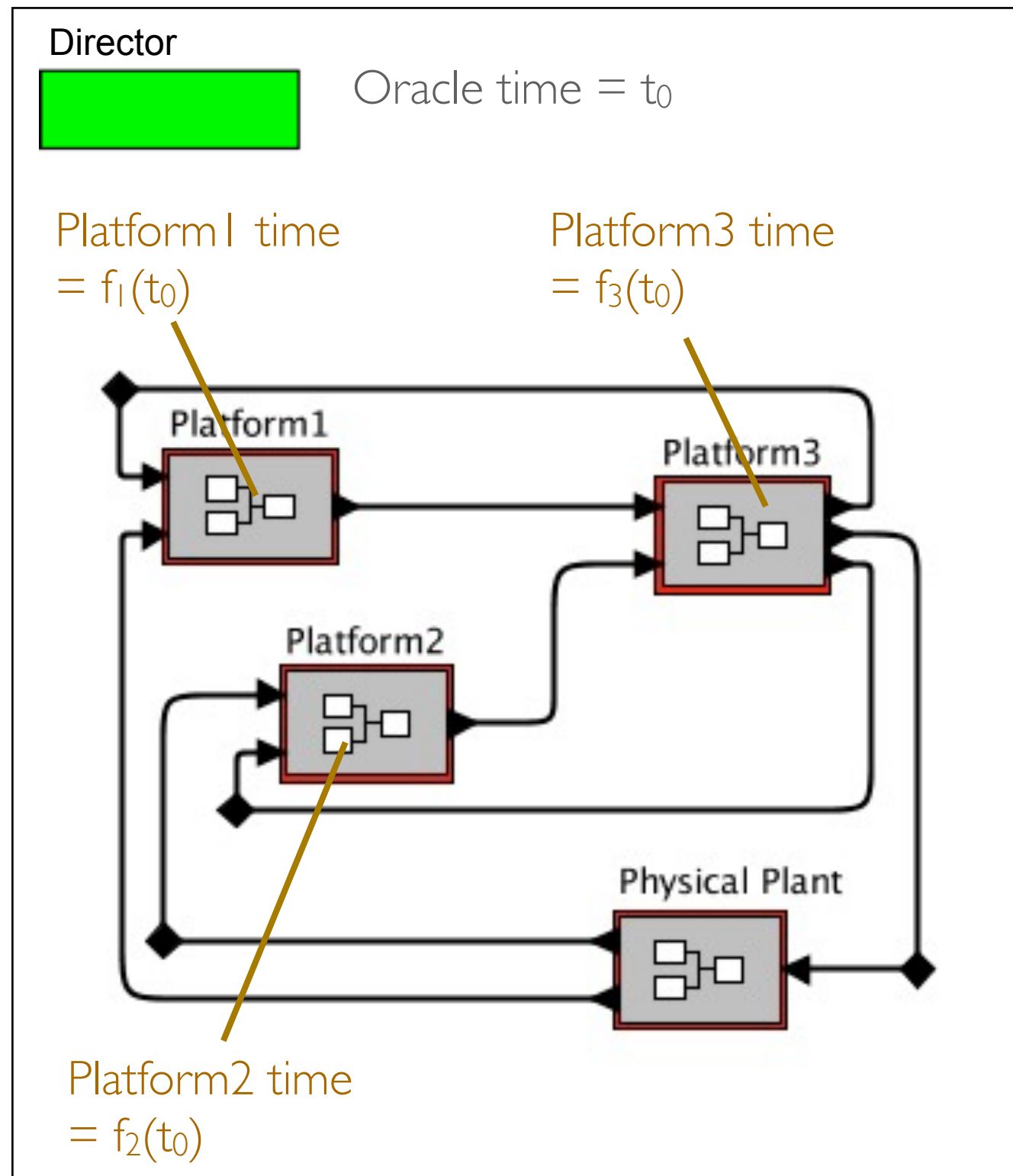
MODELING DISTRIBUTED SYSTEMS



Hierarchies:

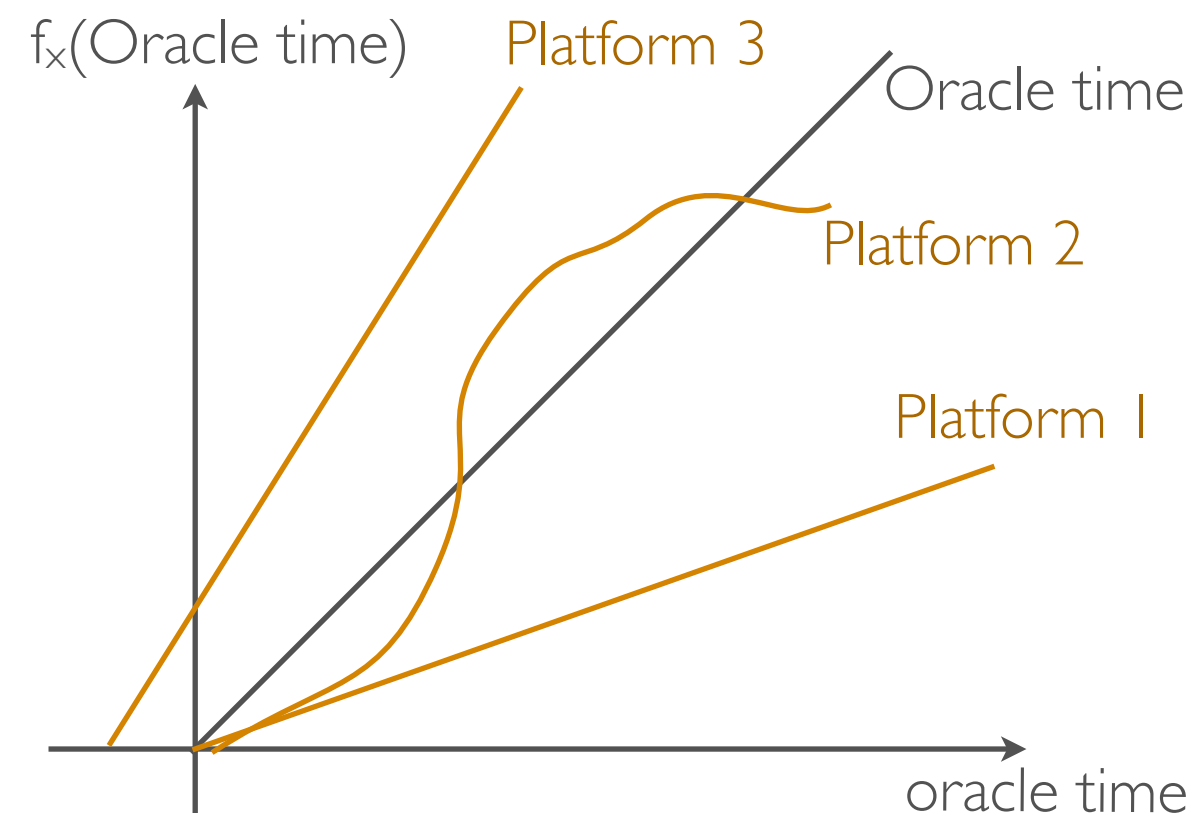
- Opaque composite actors
- Embedded directors maintain time

MODELING DISTRIBUTED SYSTEMS

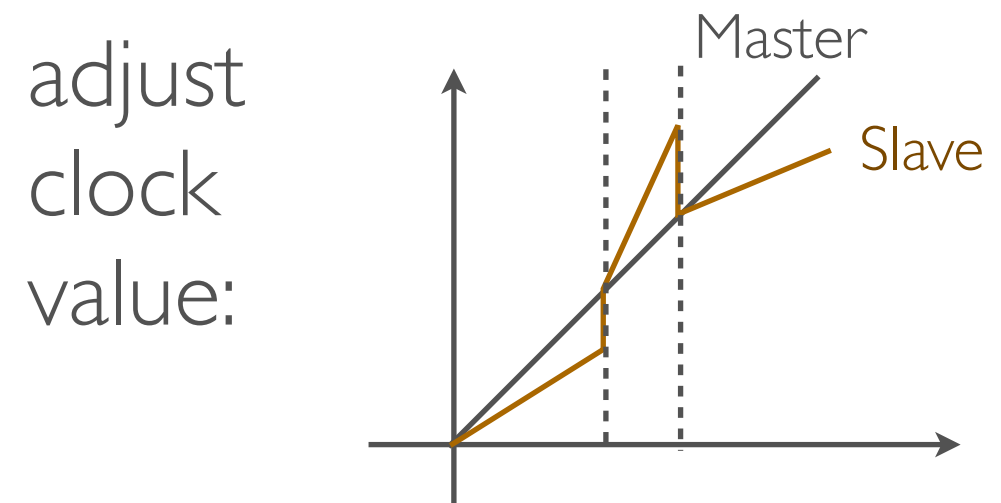
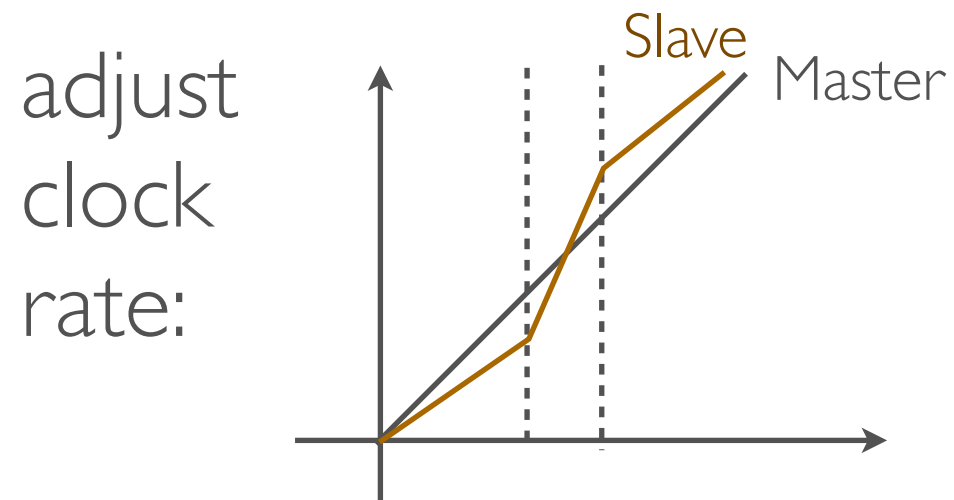
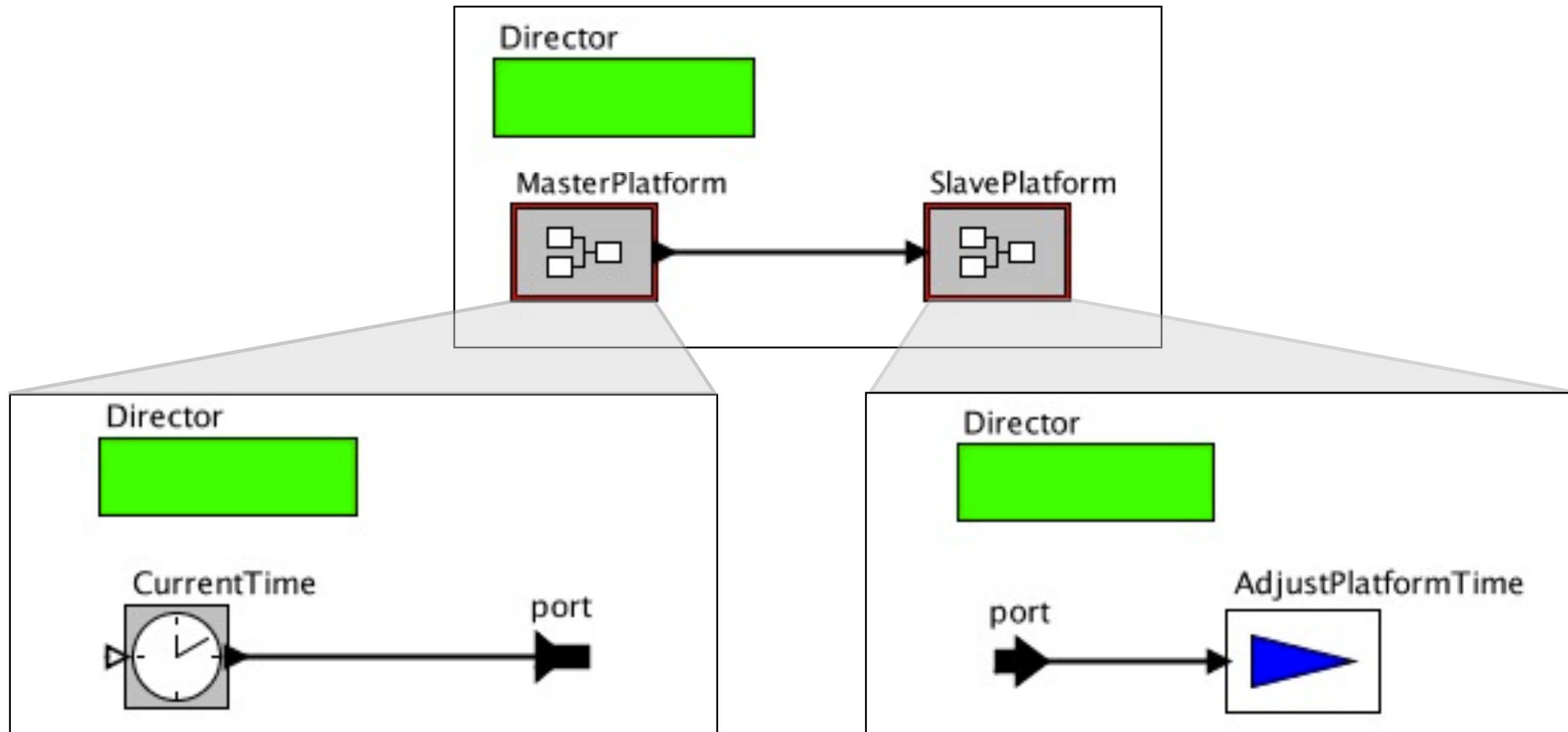


Top level: Oracle time

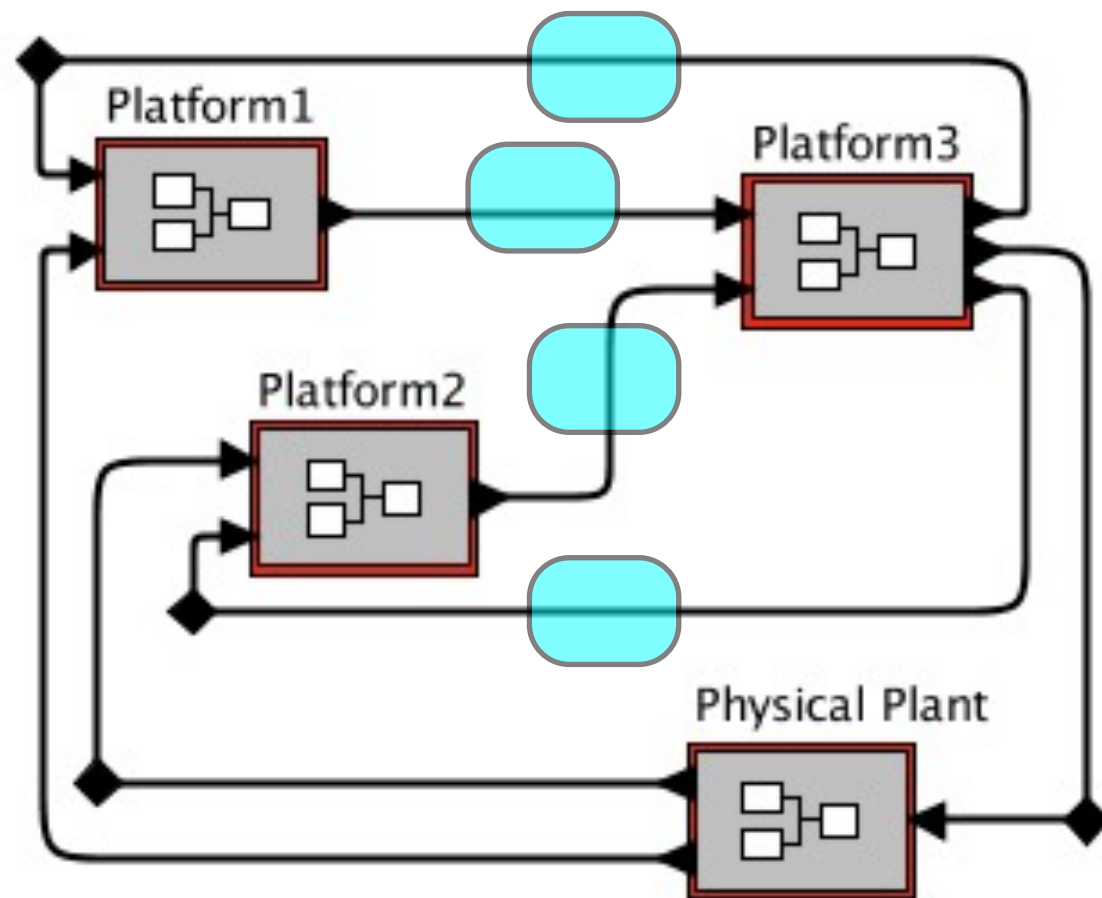
Every platform time is defined with respect to oracle time



CLOCK SYNCHRONIZATION



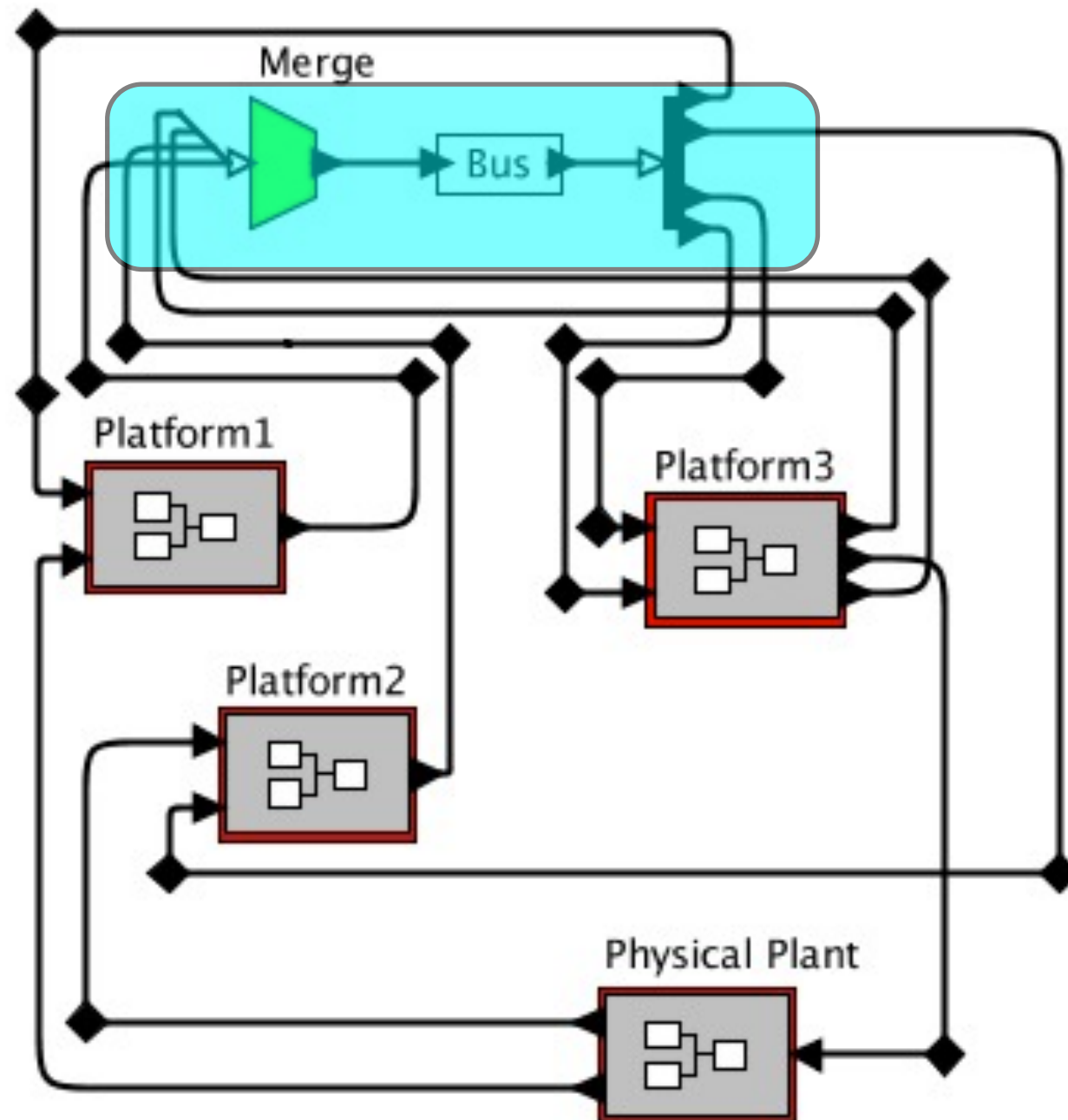
MODELING NETWORKS



Distributed platforms
communicate via
networks

Networks have latencies
e.g. CAN Bus, TTEthernet

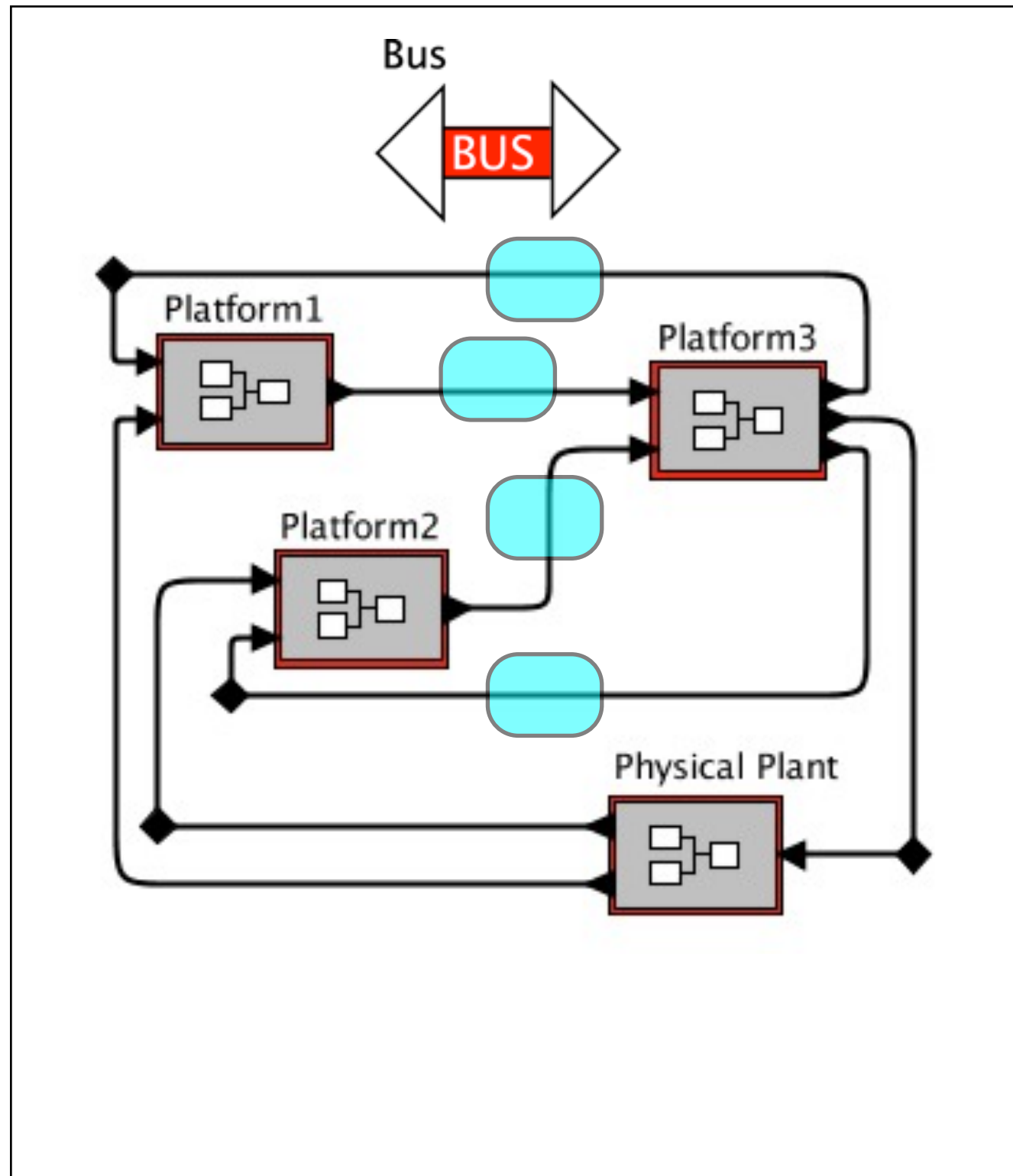
MODELING NETWORKS



Physical connections vs.
Logical connections

Logical connections are lost

MODELING NETWORKS

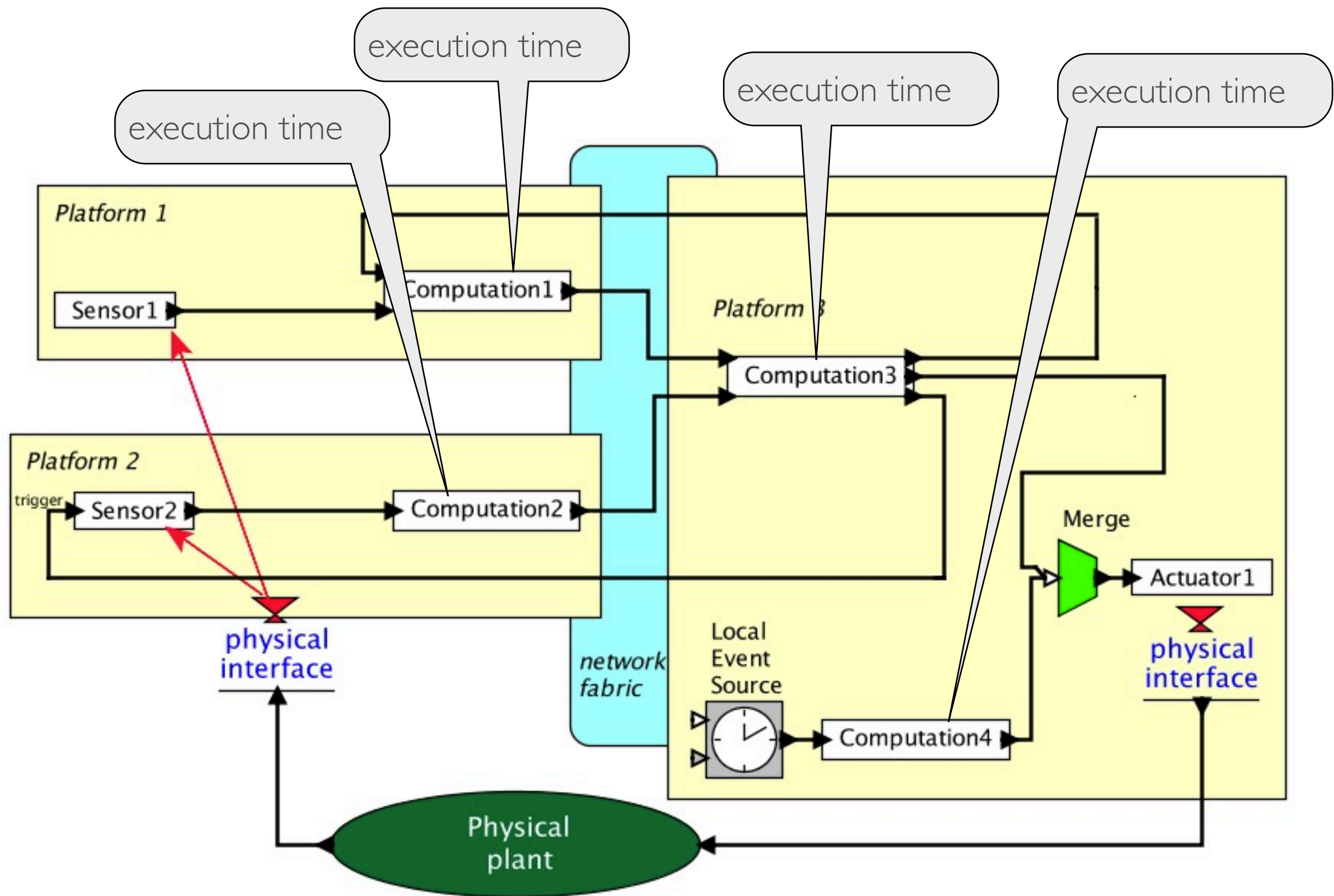


Aspect-oriented modeling

Quantity managers [Balarin03] and schedulers to simulate network latency

[Balarin03] F. Balarin, H. Hsieh, L. Lavagno, C. Passerone, A. L. Sangiovanni-Vincentelli, and Y. Watanabe. Metropolis: an integrated electronic system design environment. *Computer*, 36(4), 2003.

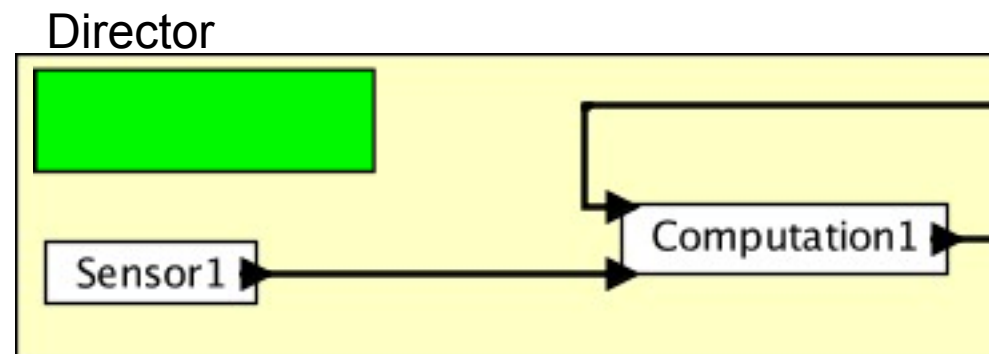
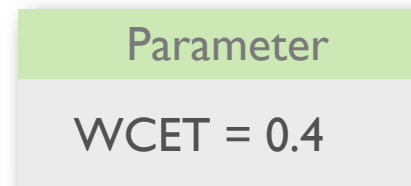
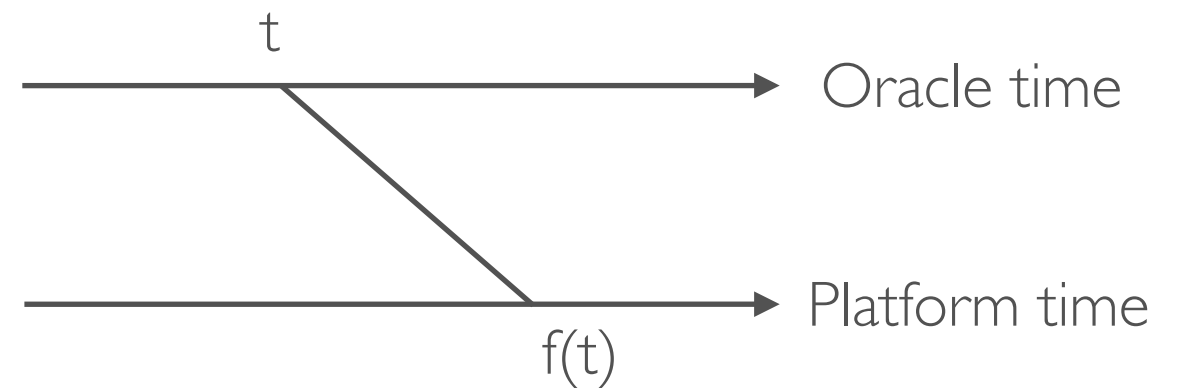
MODELING EXECUTION TIME



MODELING EXECUTION TIME

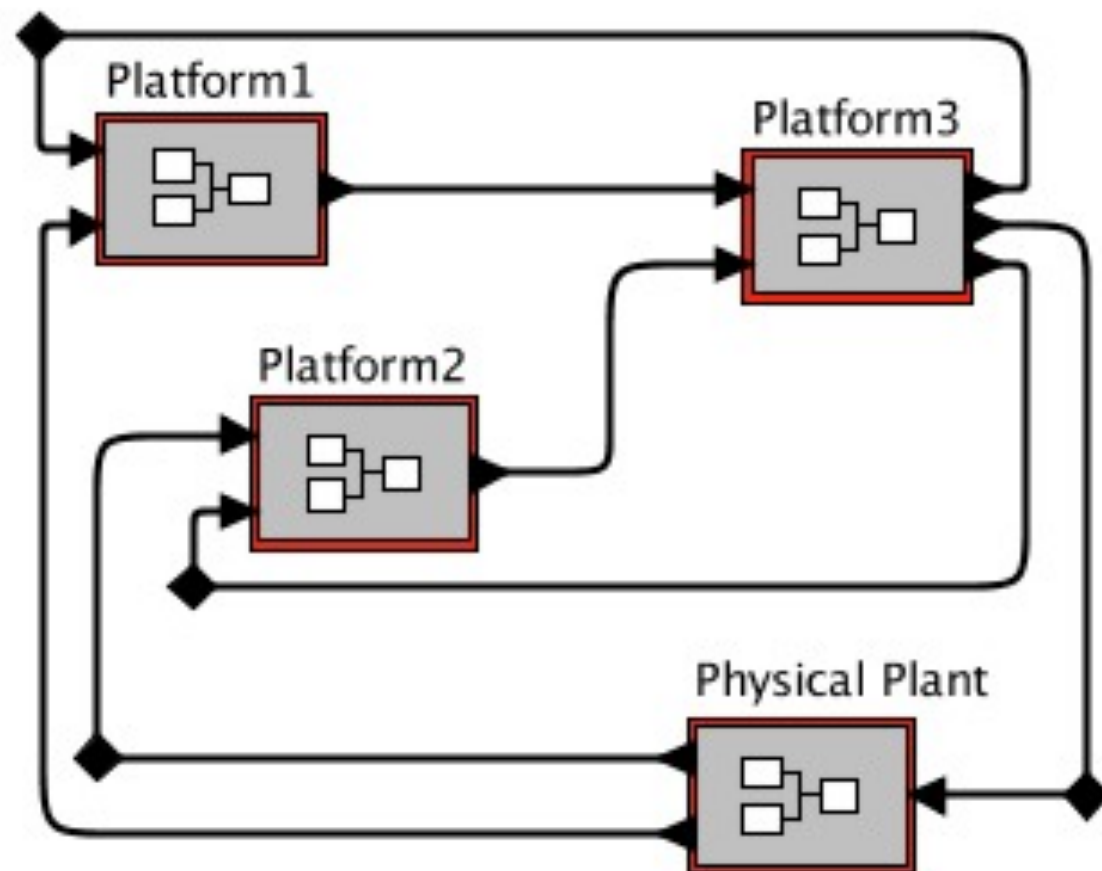
How is execution time computed?

Which time line to use for specifying execution time?



Aspect-oriented
programming

DISTRIBUTED DISCRETE-EVENT MODELS

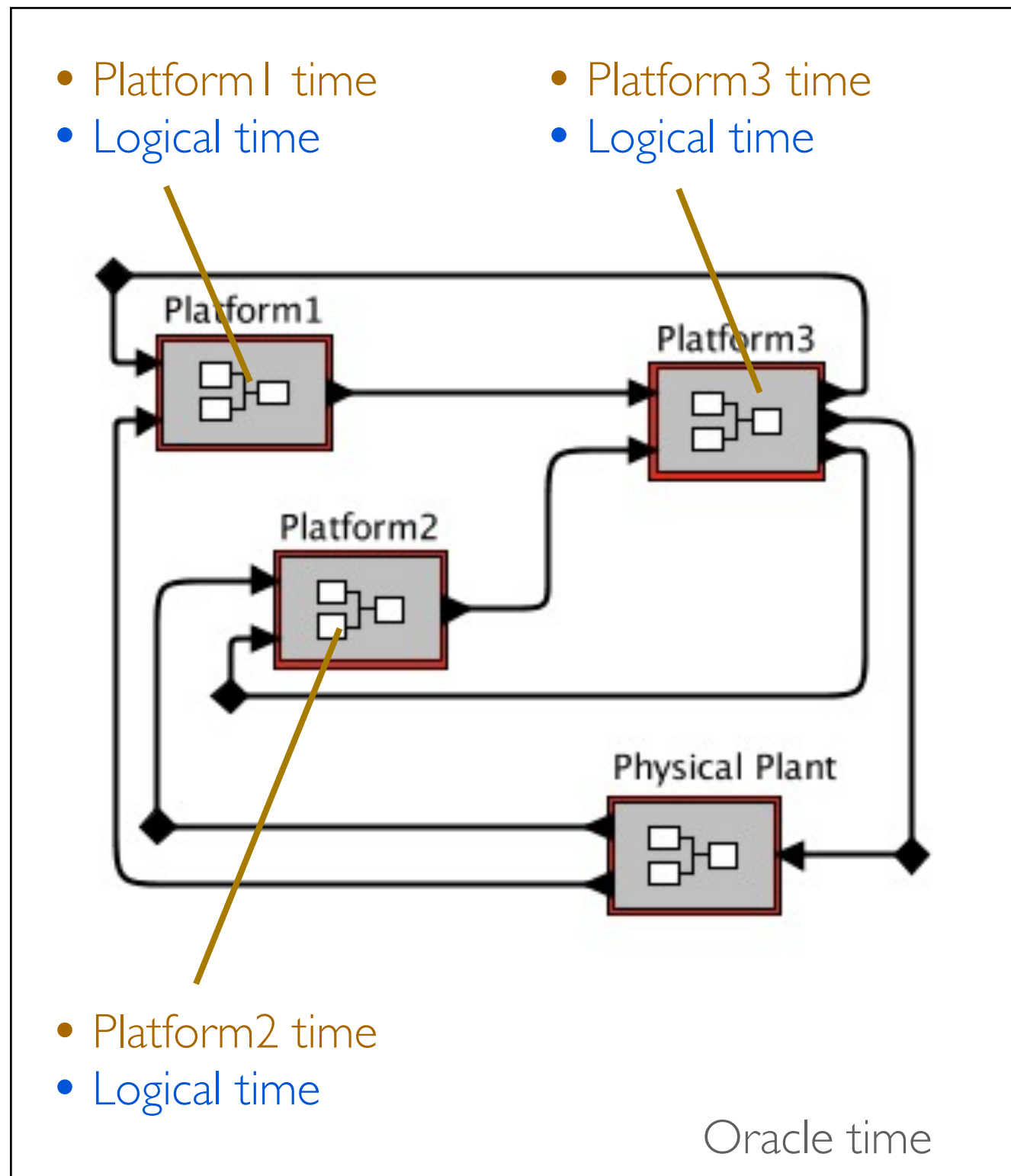


Discrete-Event (DE) for simulation

DE as a application specification language which serves as a semantic basis for obtaining determinism in distributed real-time systems.

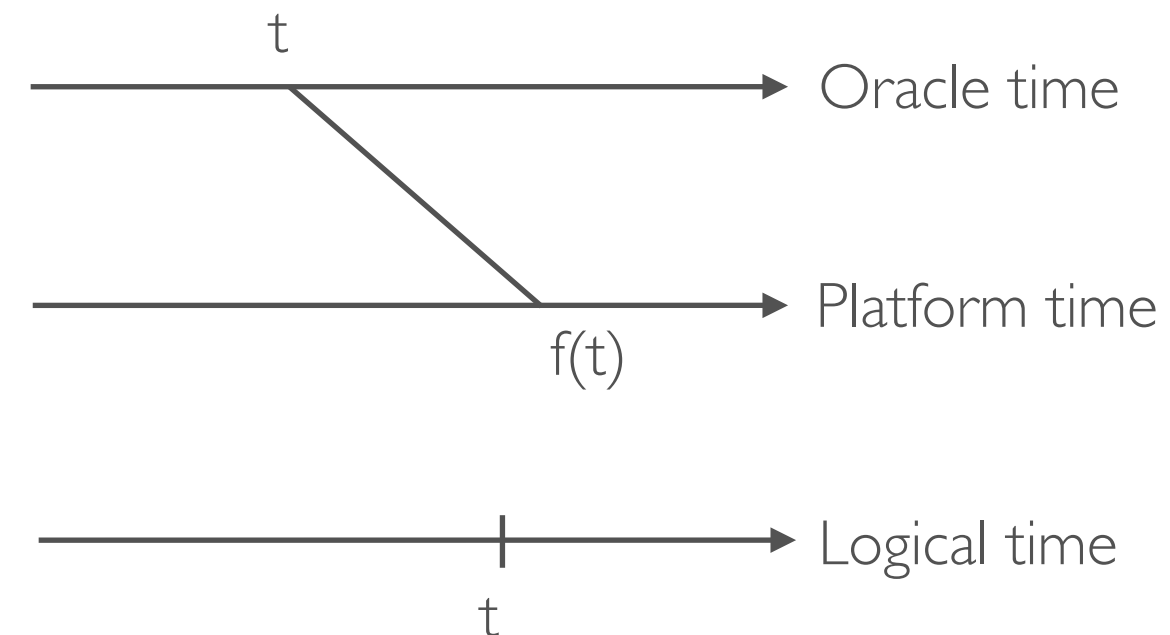
We need another time line

DISTRIBUTED DISCRETE-EVENT MODELS



Logical time describe the execution semantics

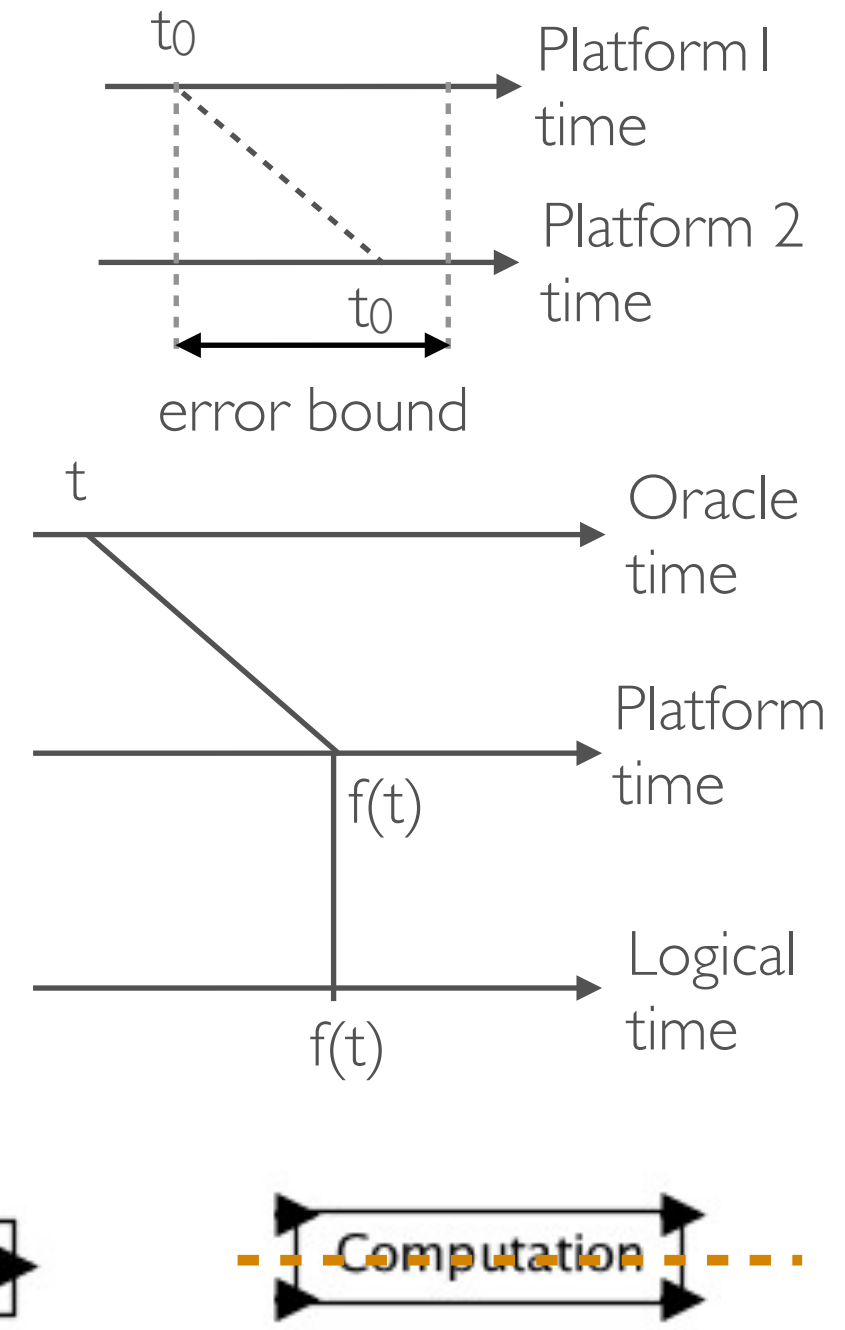
New time line: logical time



PTIDES: AN APPLICATION

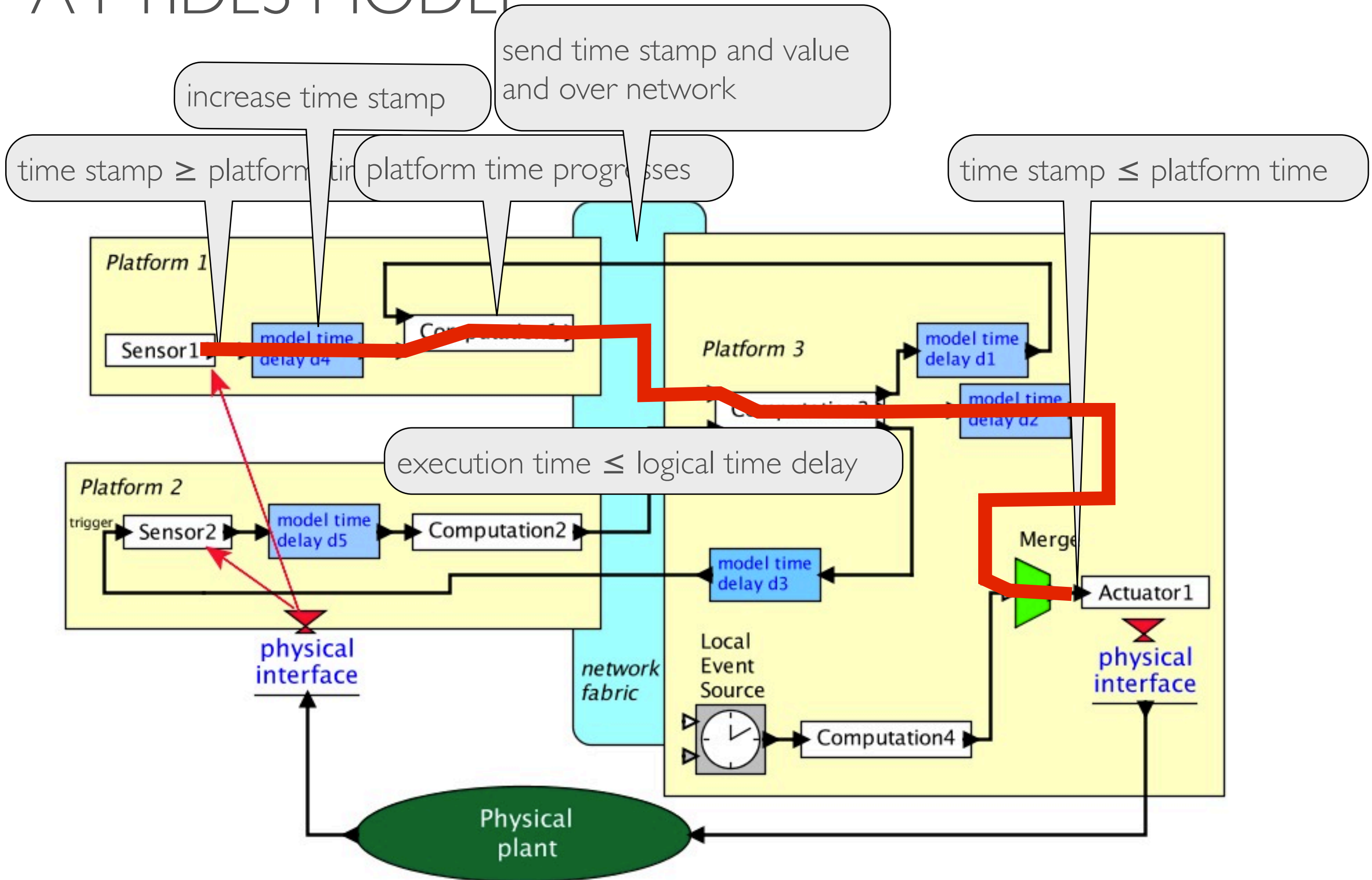
Programming temporally integrated distributed event systems
[Zhao07]

- Discrete event model for execution
- Relates logical time to platform time whenever necessary
- Requires bounded error between platform clocks: Relies on clock synchronization
- Events are processed in time-stamped order



[Zhao07] Y. Zhao, J. Liu, and E. A. Lee. A programming model for time-synchronized distributed real-time systems. In Proceedings of the 13th IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS 07), pages 259–268, Bellevue, WA, USA, Apr 2007.

A PTIDES MODEL



SUMMARY

- Distributed embedded systems
- Each distributed platform has its own notion of time
- Modeling distributed systems with different notions of time and clock drifts
- Clock synchronization
- Modeling networks
- Modeling distributed discrete event systems
- PTIDES