Ptolemy Project heterogeneous modeling and design

PTIDES AND PLATFORM-BASED DESIGN

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PTIDES

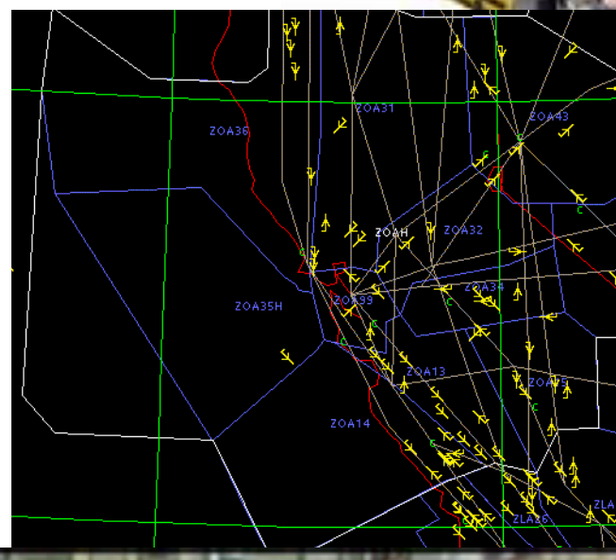
PROGRAMMING TEMPORALLY INTEGRATED DISTRIBUTED EVENT SYSTEMS

CYBER-PHYSICAL SYSTEMS

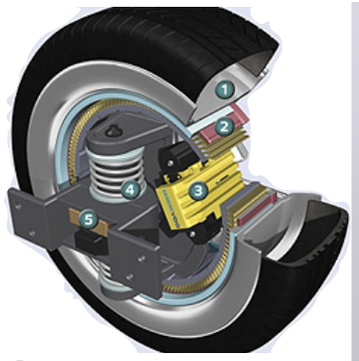
Multiple computers, comprising of sensors and actuators, connected on a network that act and react on events to meet timing constraints.

Avionics

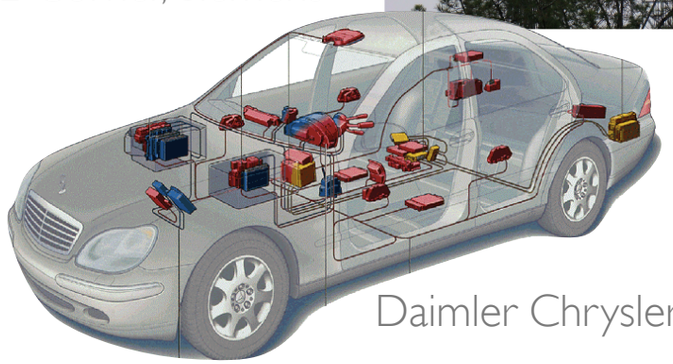
Transportation (Air traffic control at SFO)



Automotive



E-Corner, Siemens

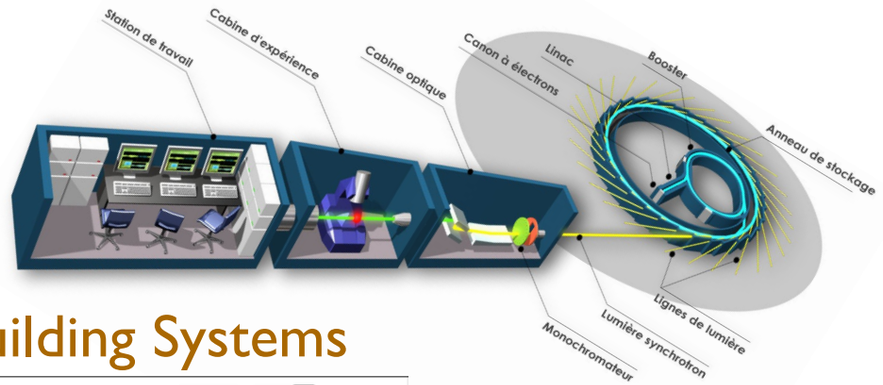


Daimler Chrysler

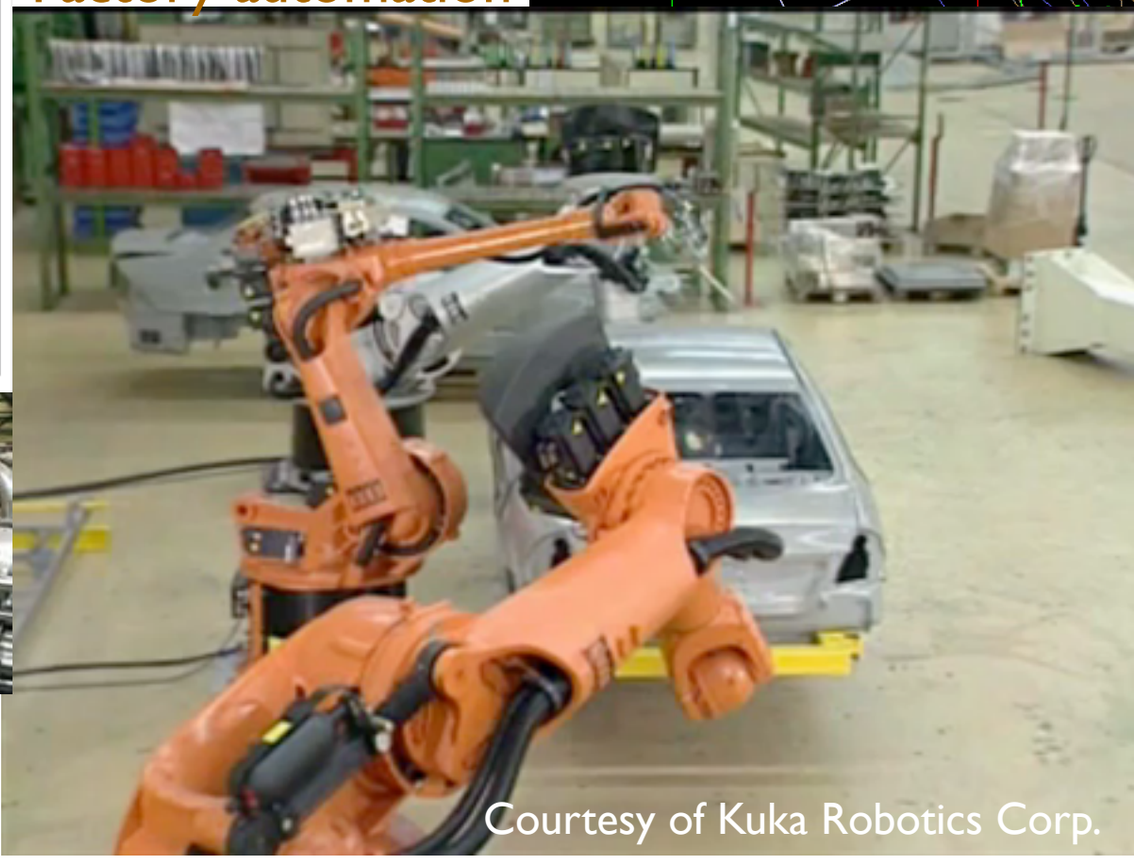
Telecommunications

Building Systems

Instrumentation (Soleil Synchrotron)

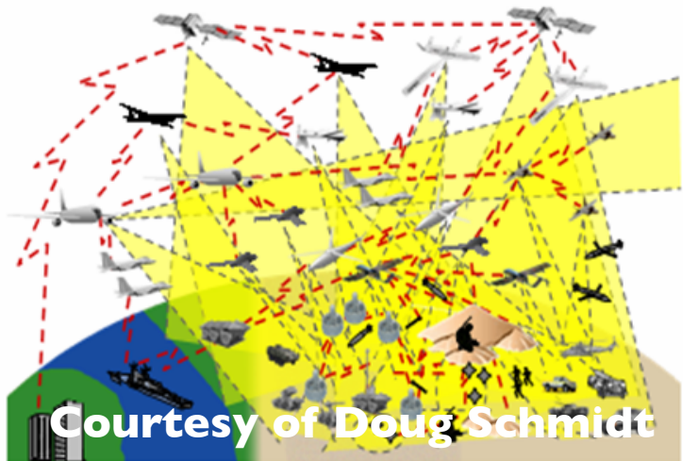


Factory automation



Courtesy of Kuka Robotics Corp.

Military Systems



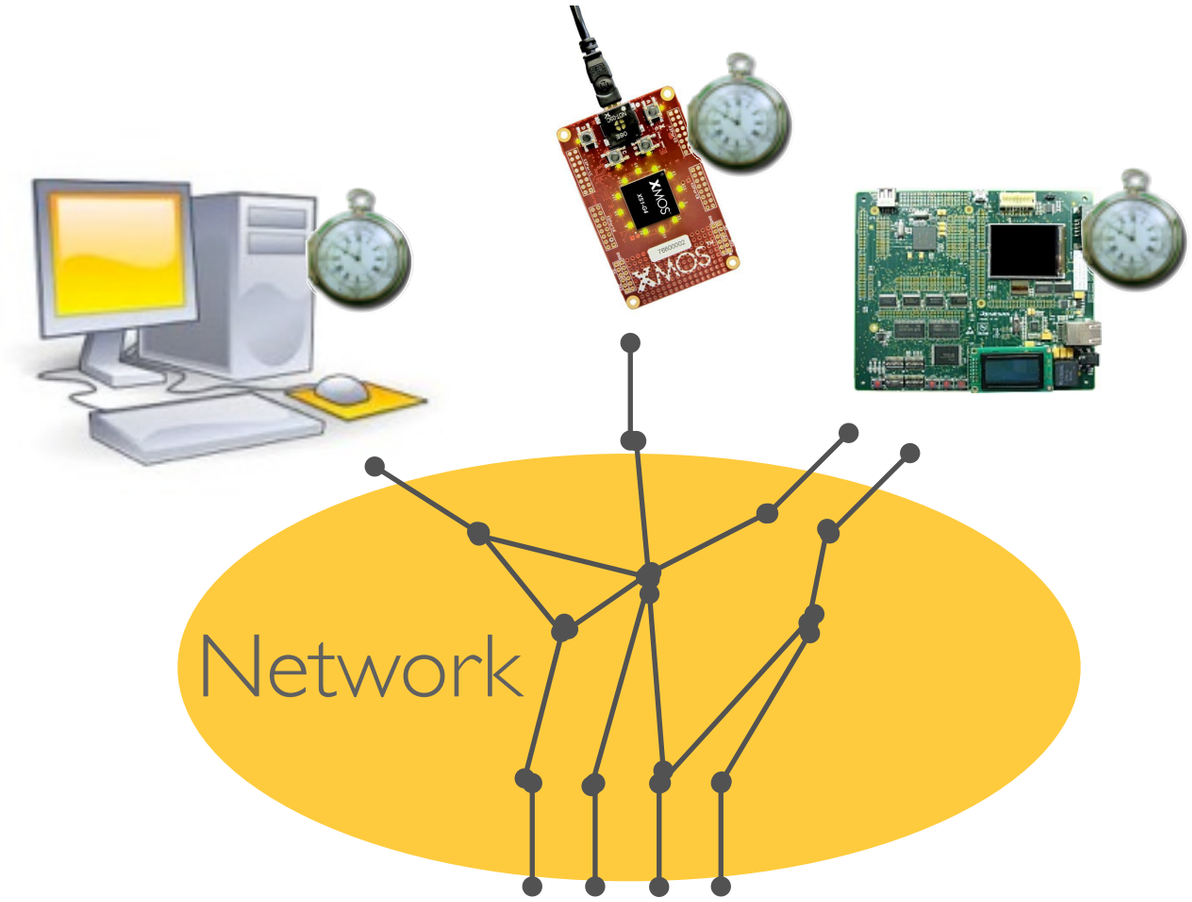
Courtesy of Doug Schmidt

Power generation and distribution

Courtesy of General Electric

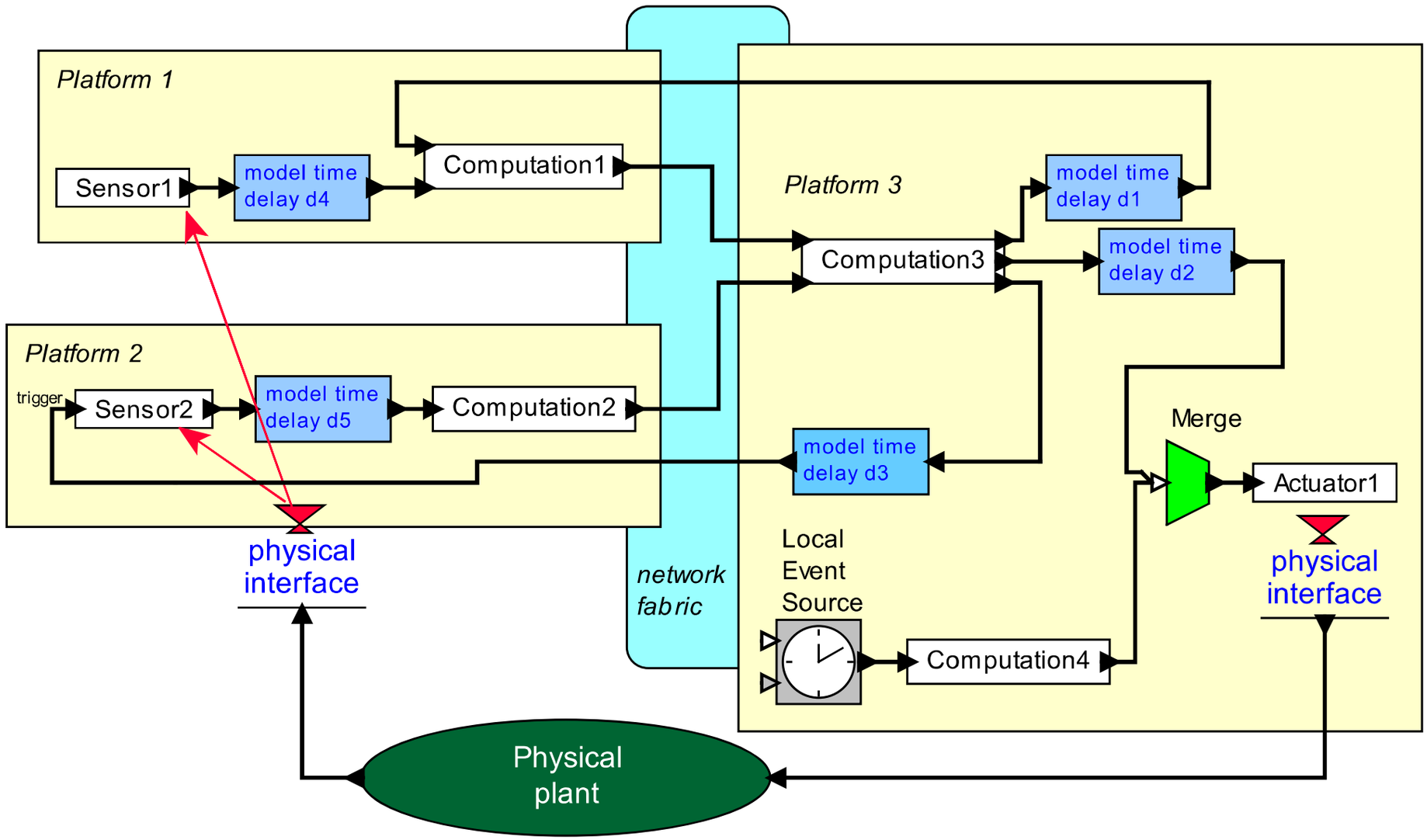
CHALLENGES IN MODELING CPS

- Modeling distributed computations
- Modeling time
  - Execution time
  - Reaction time
  - Timing requirements
  - Time synchronization
  - Time on distributed platforms
- Modeling networks

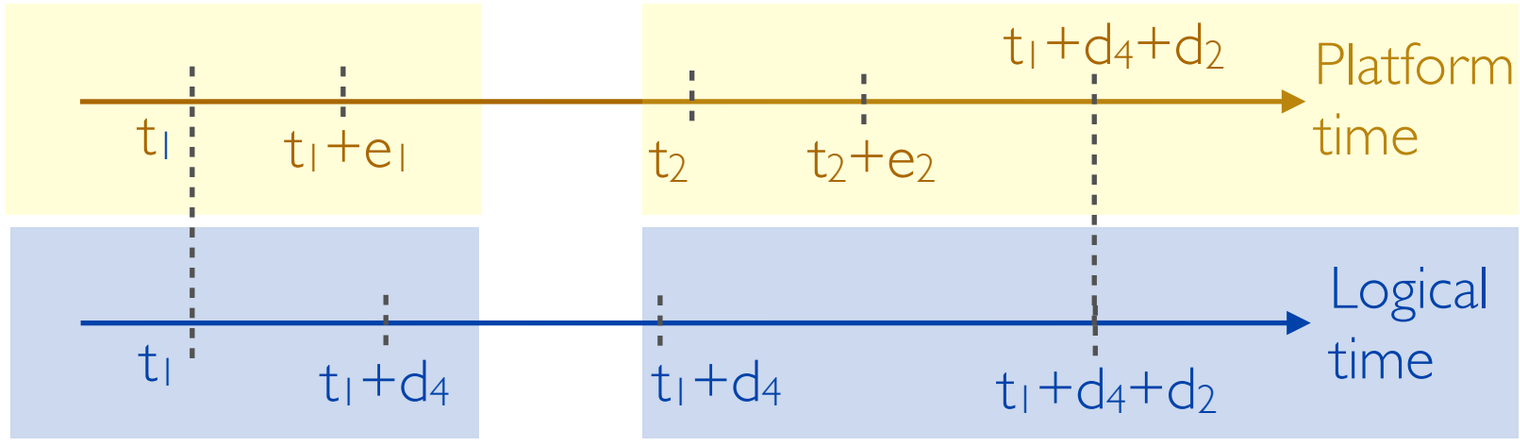


PTIDES

- DE based model of computation
- Model time for model semantics, physical time to explicitly model timing behavior
- Relate physical time to model time at specific points in the model



A PTIDES MODEL



timestamp ≤ platform time

atform time progresses

timestamp ≥ platform time

response time ≤ logical time delay

send time stamp and value and over network

Platform 1

Sensor1

model time delay d4

Platform 3

model time delay d1

model time delay d2

Platform 2

trigger

Sensor2

model time delay d5

Merge

Actuator1

physical interface

physical interface

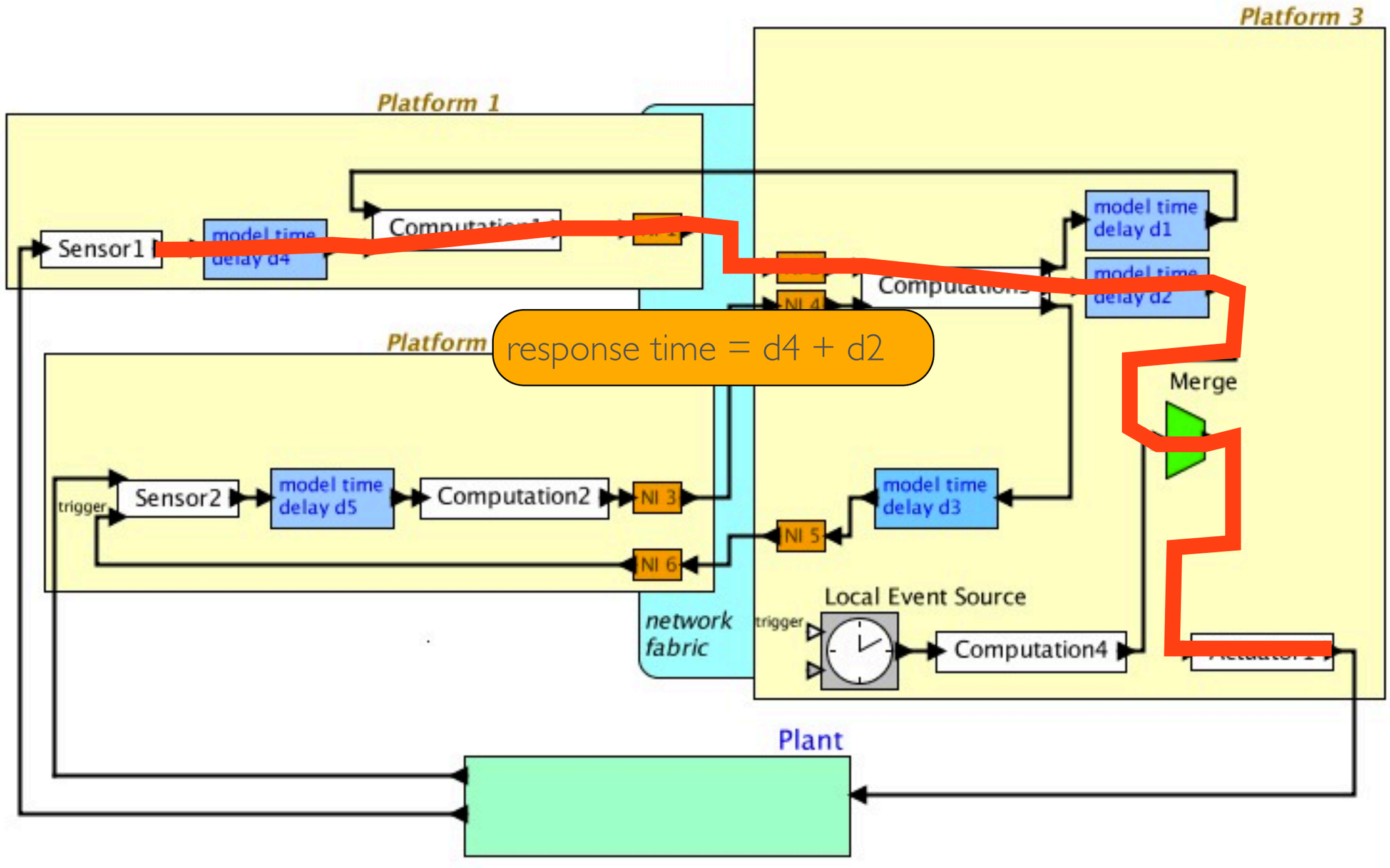
network fabric

Local Event Source

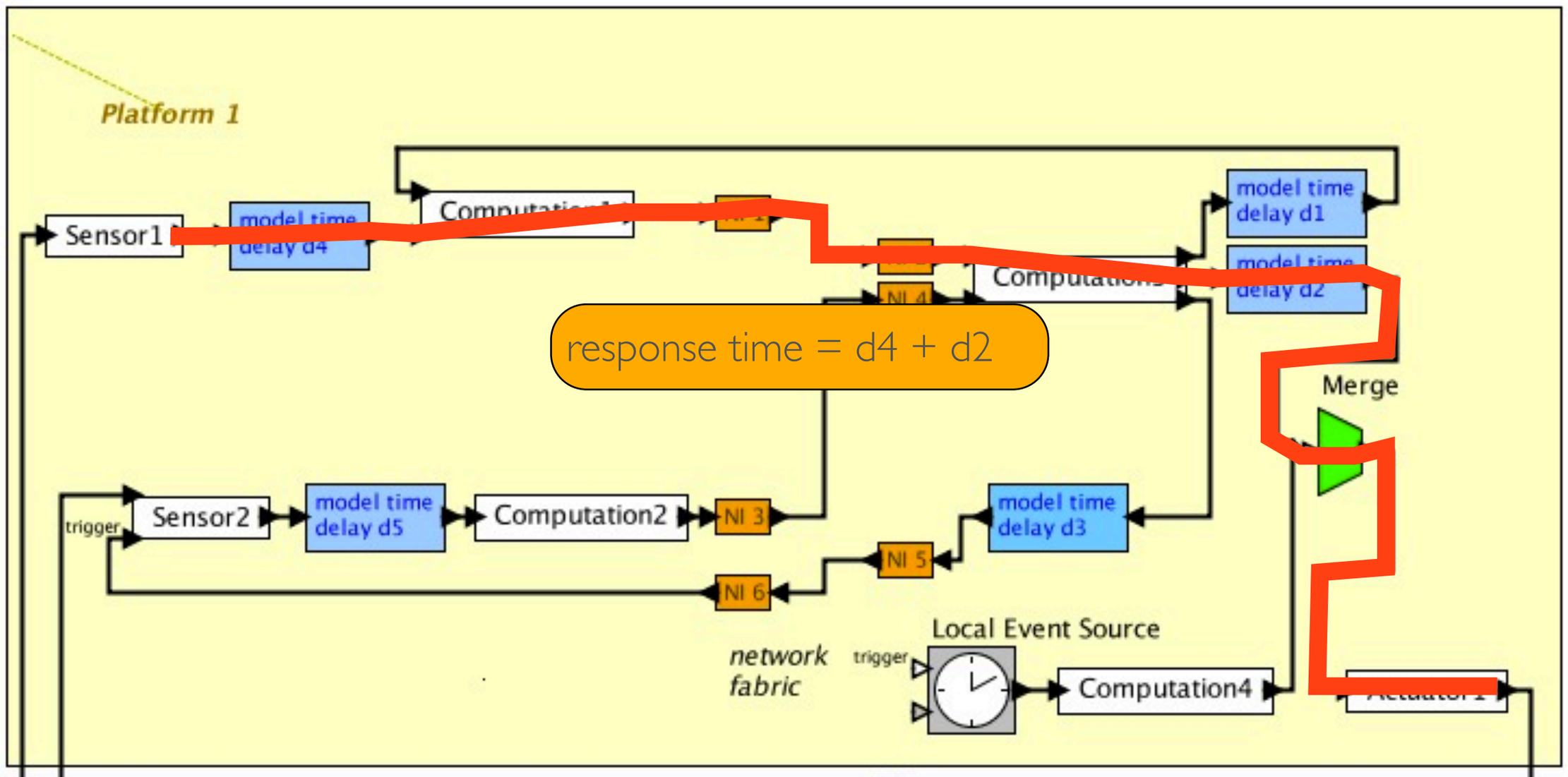
Computation4

Physical plant

EXPLICIT SPECIFICATION OF TIME

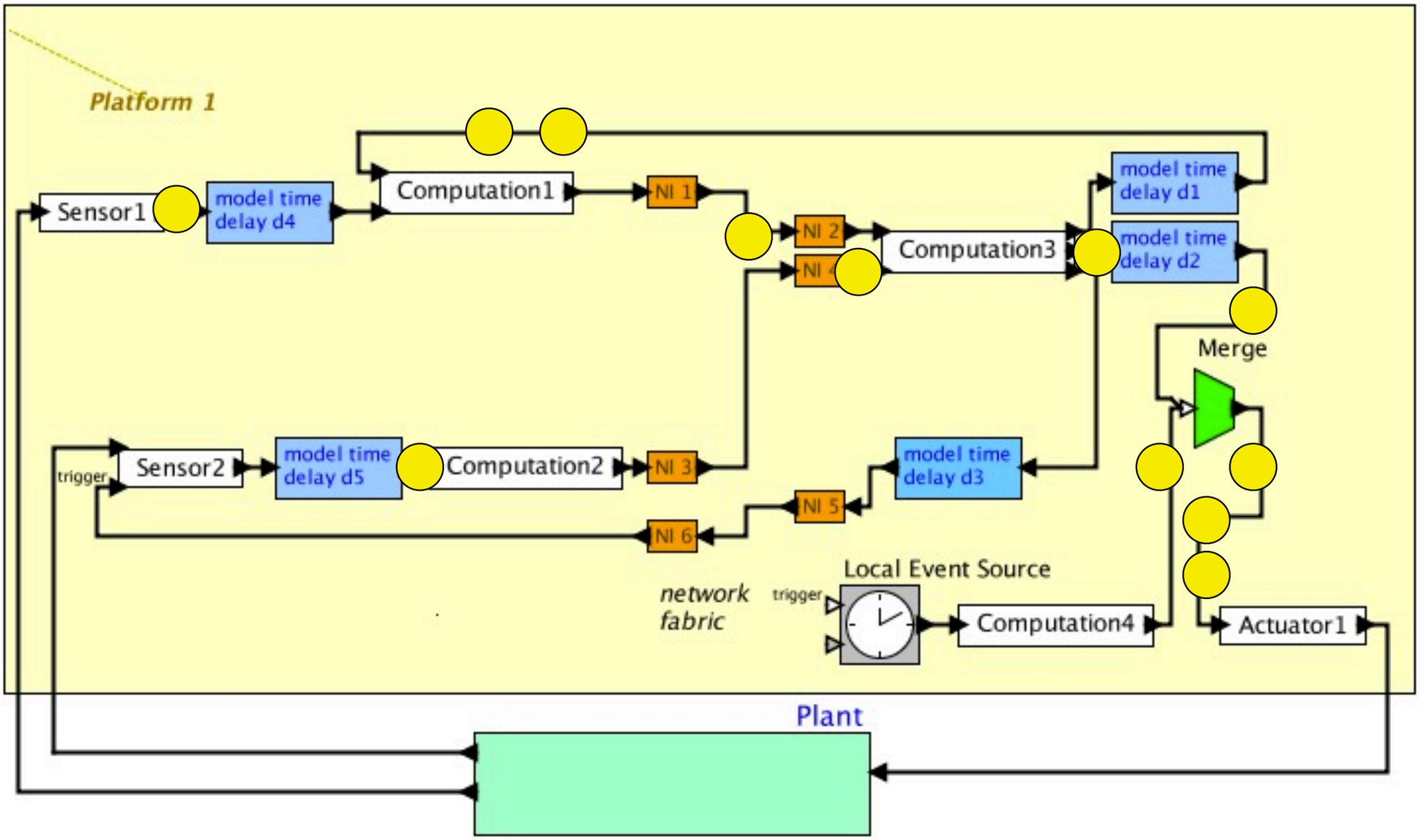


EXPLICIT SPECIFICATION OF TIME

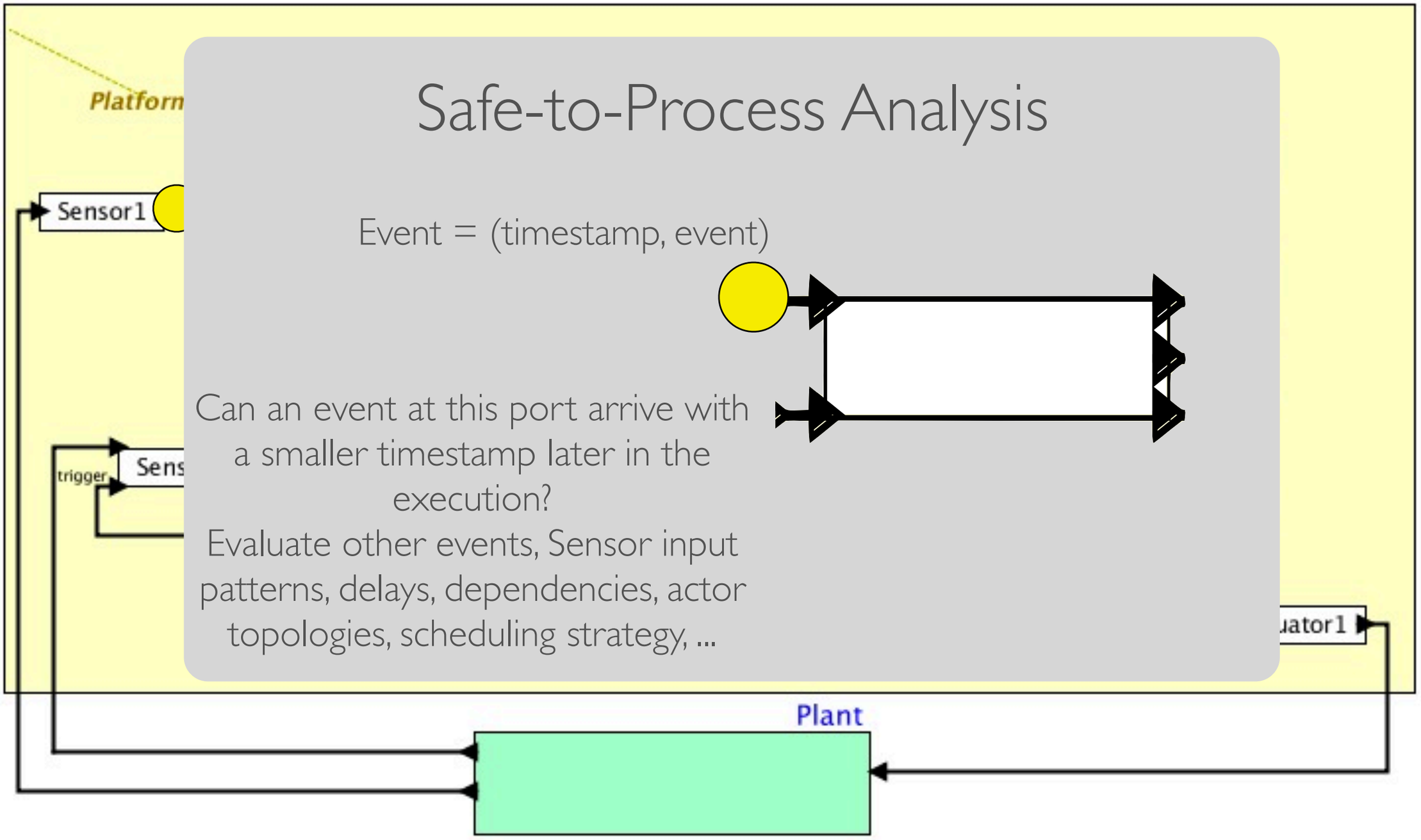


- Behavior independent of distribution

PARALLEL EXECUTION



PARALLEL EXECUTION



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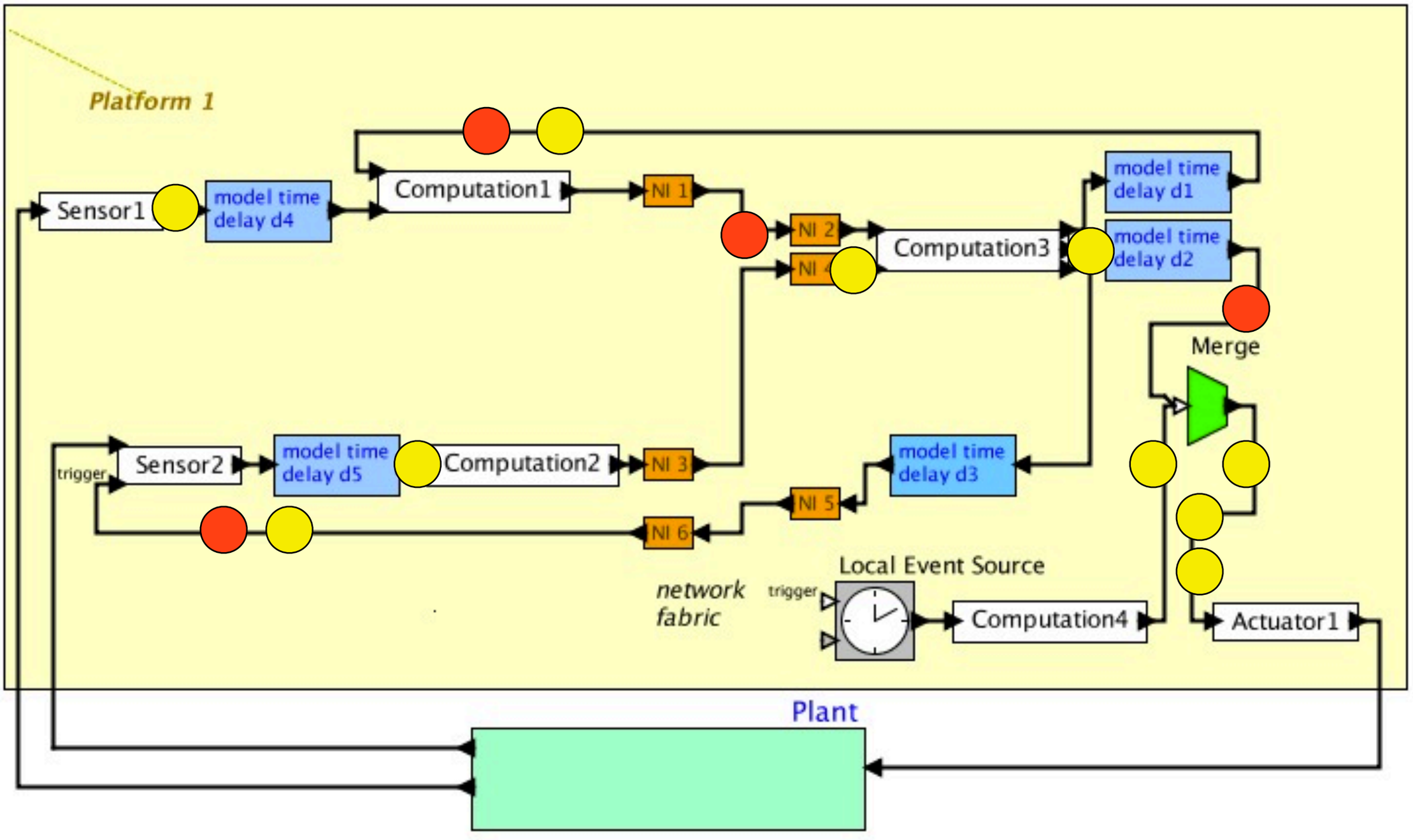
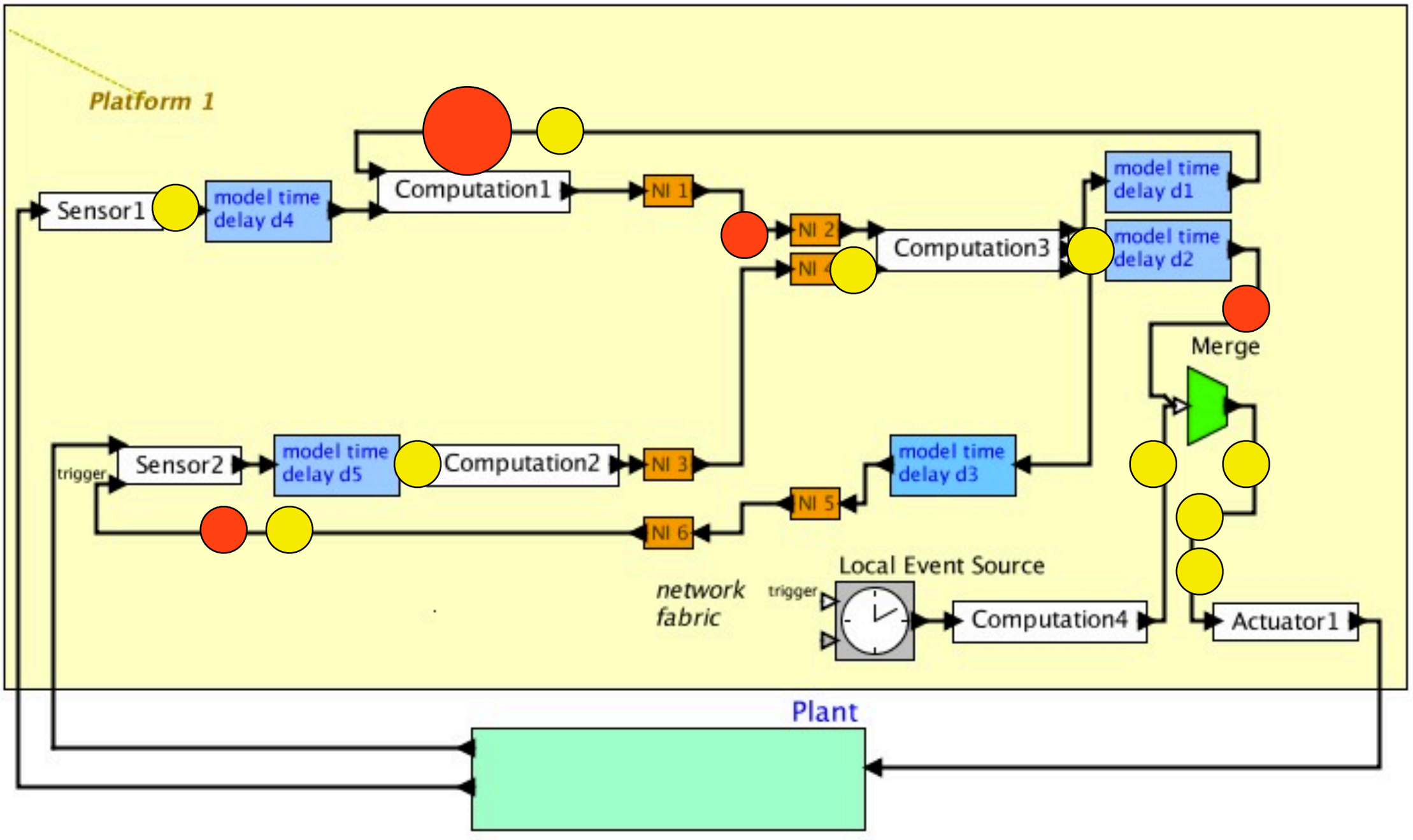


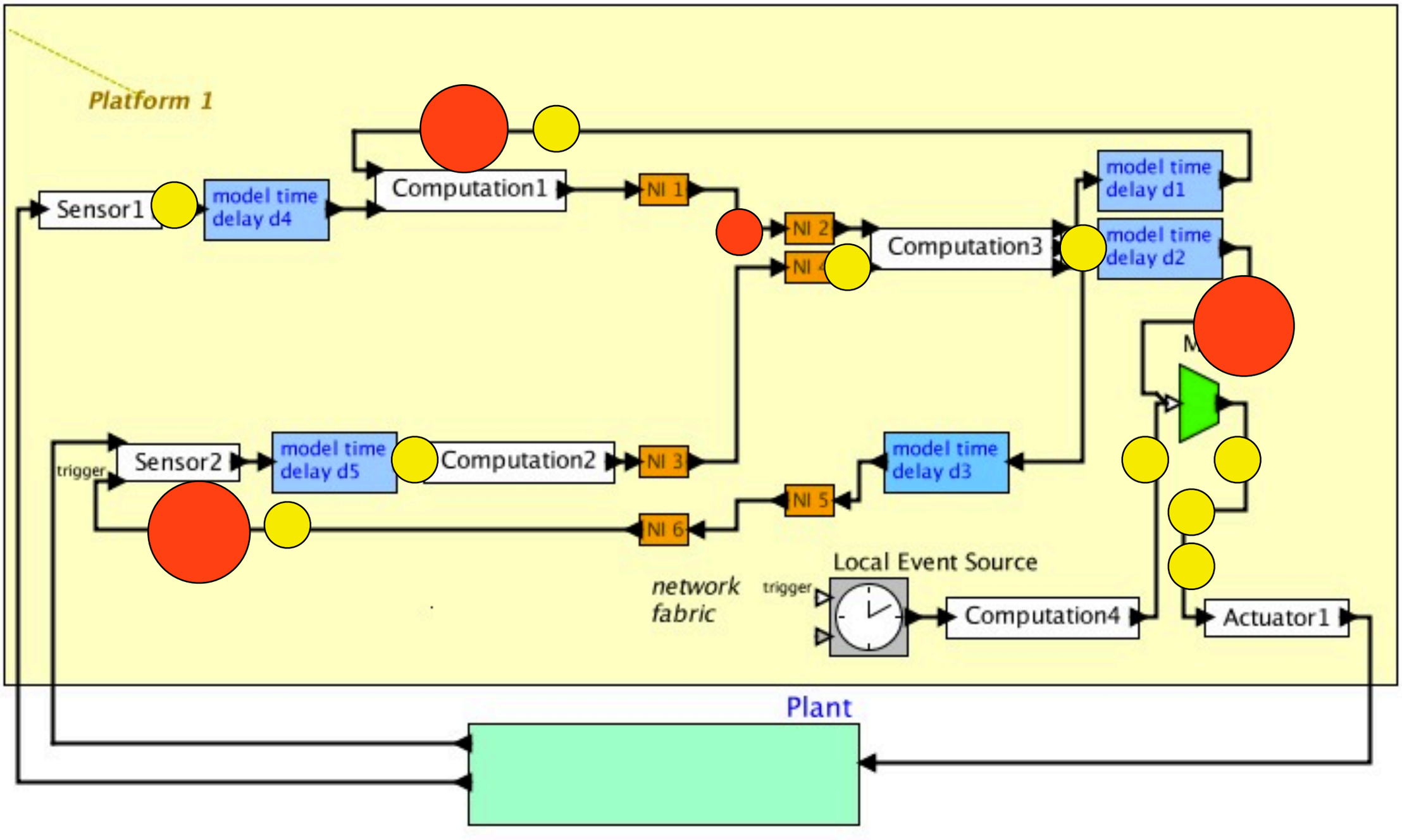
PARALLEL EXECUTION

Single Core

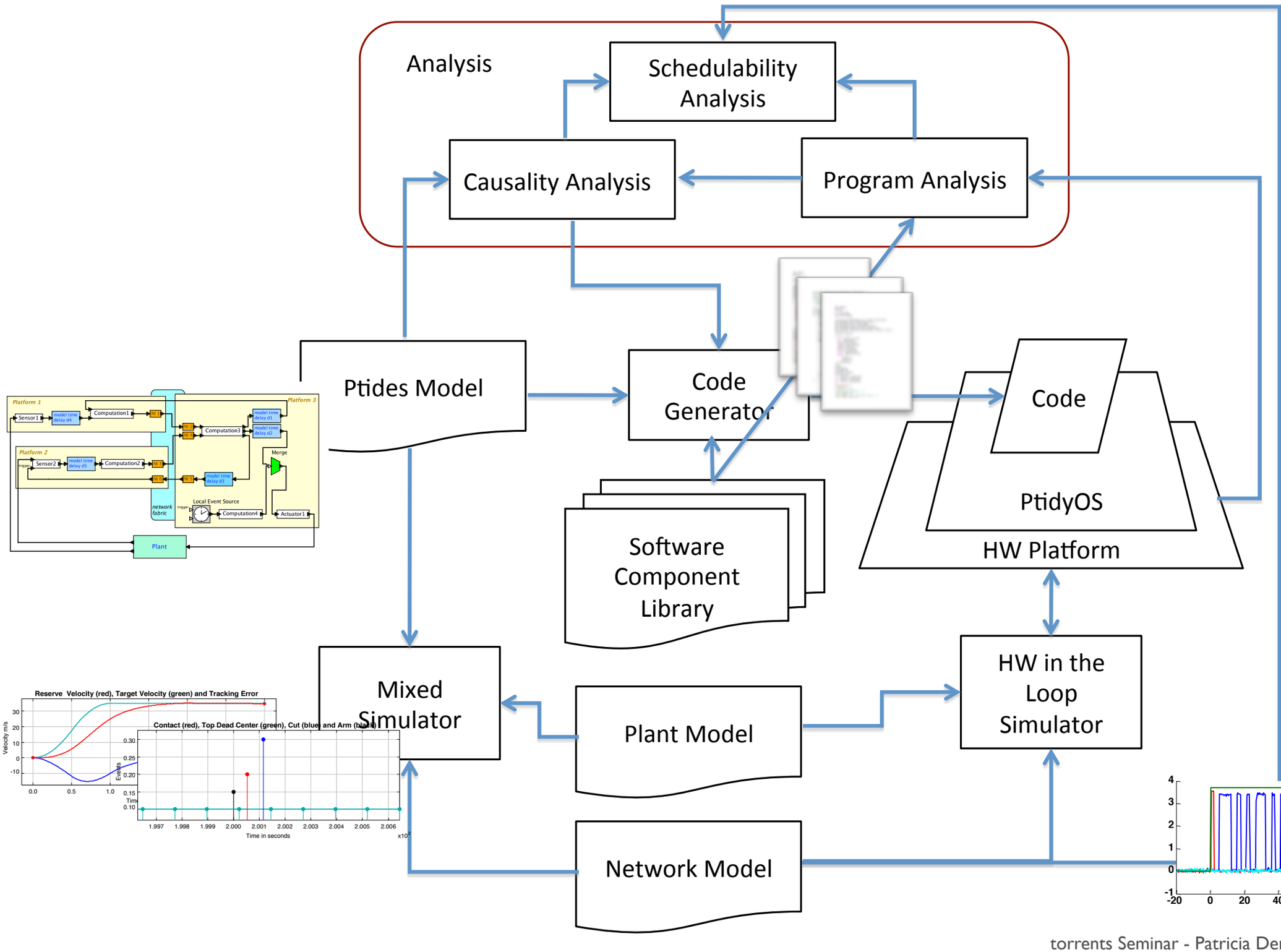


PARALLEL EXECUTION

Multi Core



PTIDES WORKFLOW

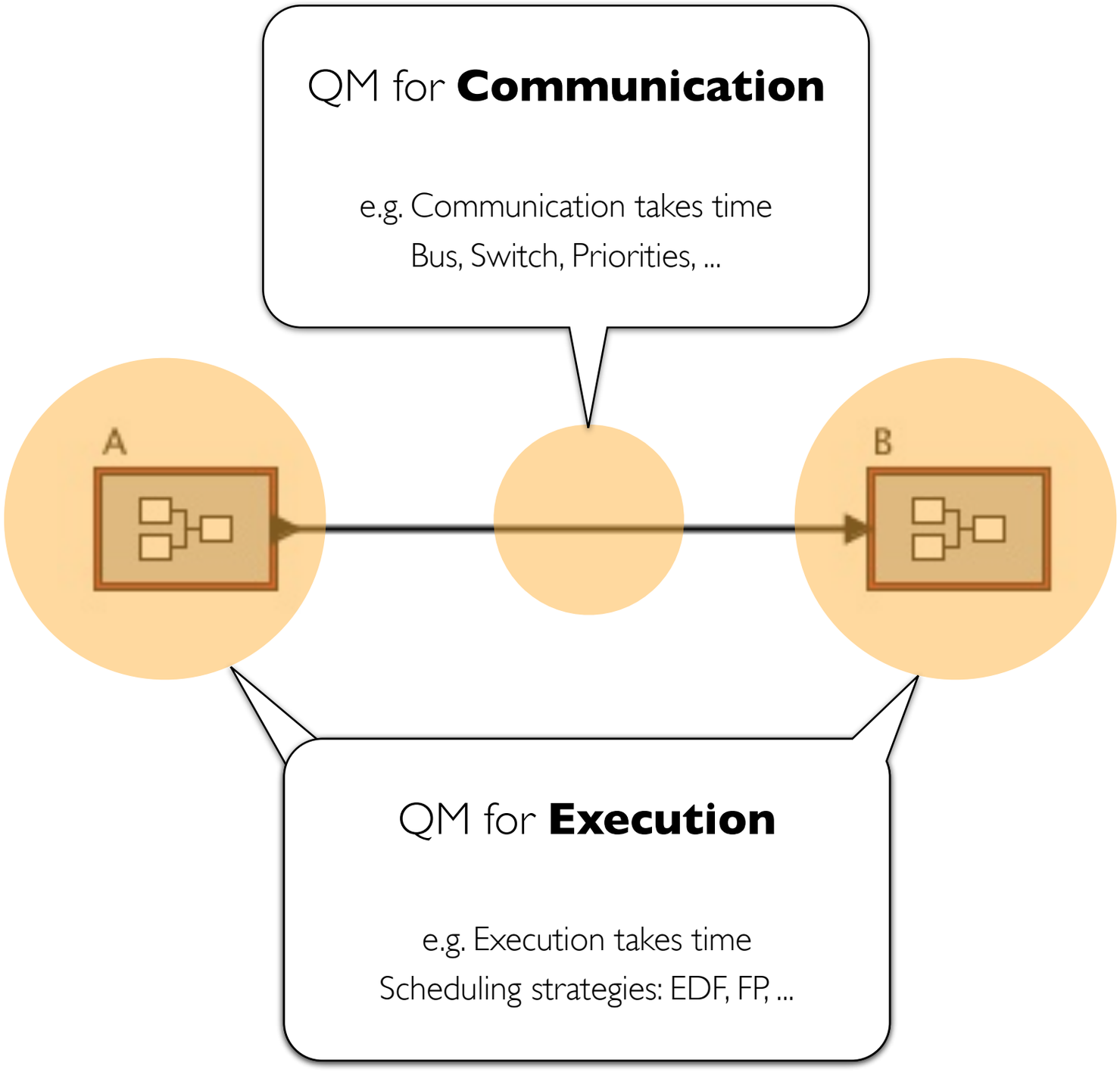


PLATFORM-BASED DESIGN
ARCHITECTURE DRIVEN-DEVELOPMENT
CO-SIMULATION
ASPECT-ORIENTED MODELING

Overview

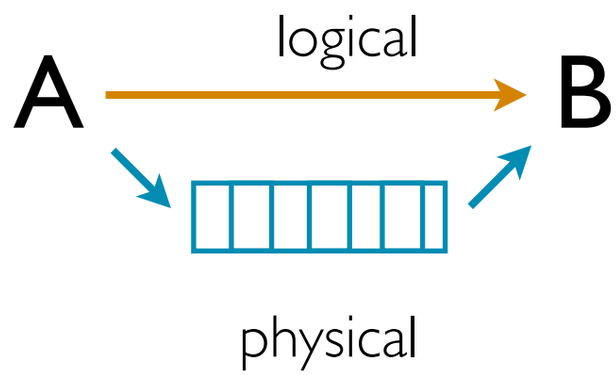
Annotate functional models with aspects

by using quantity managers (QM)

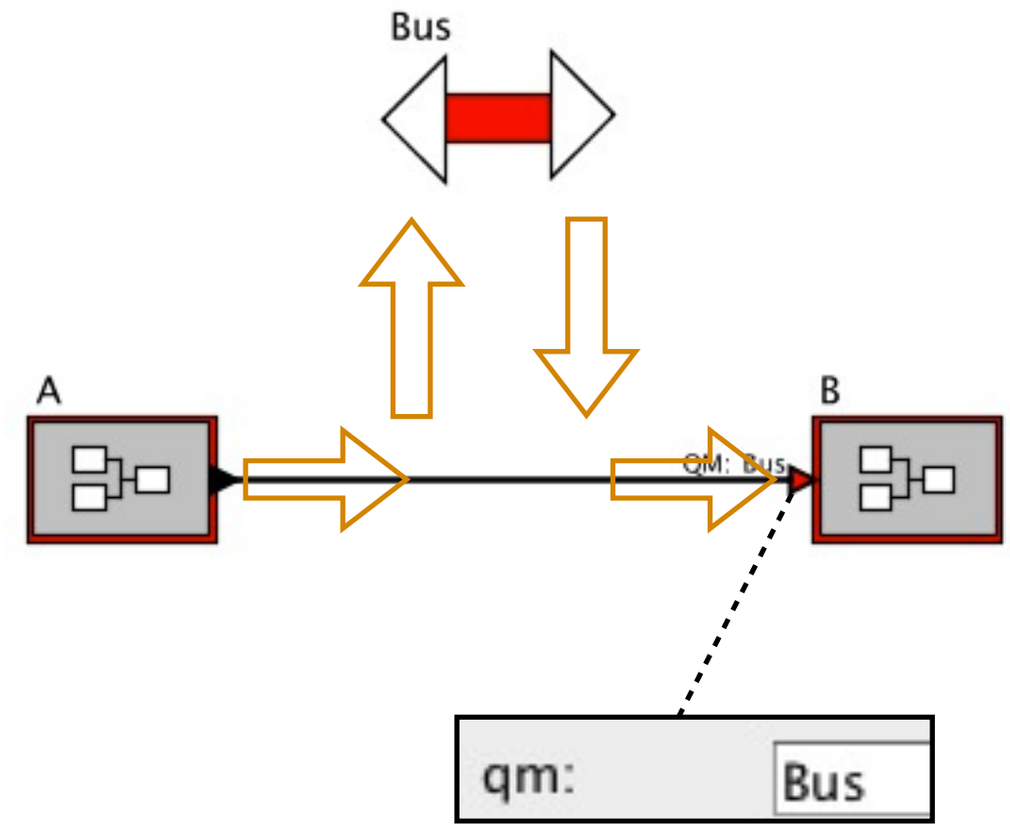


QM for Communication

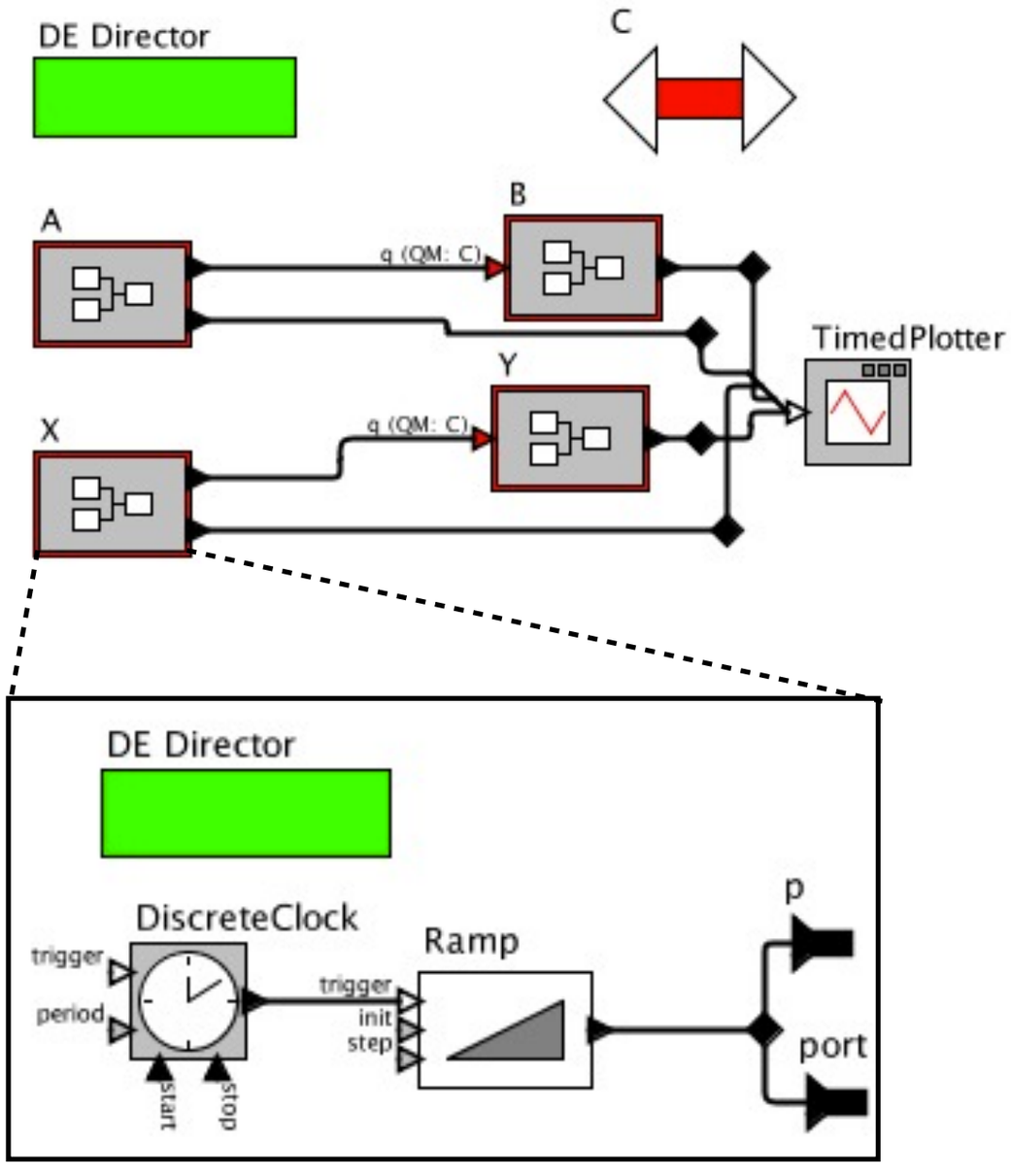
- Since 2010 in Ptolemy II

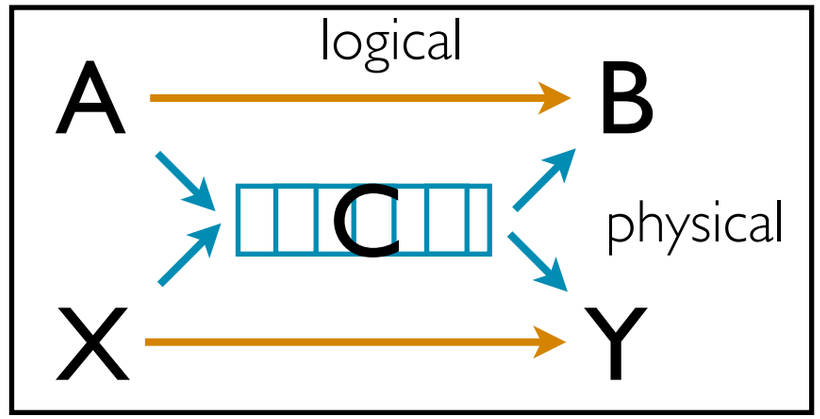


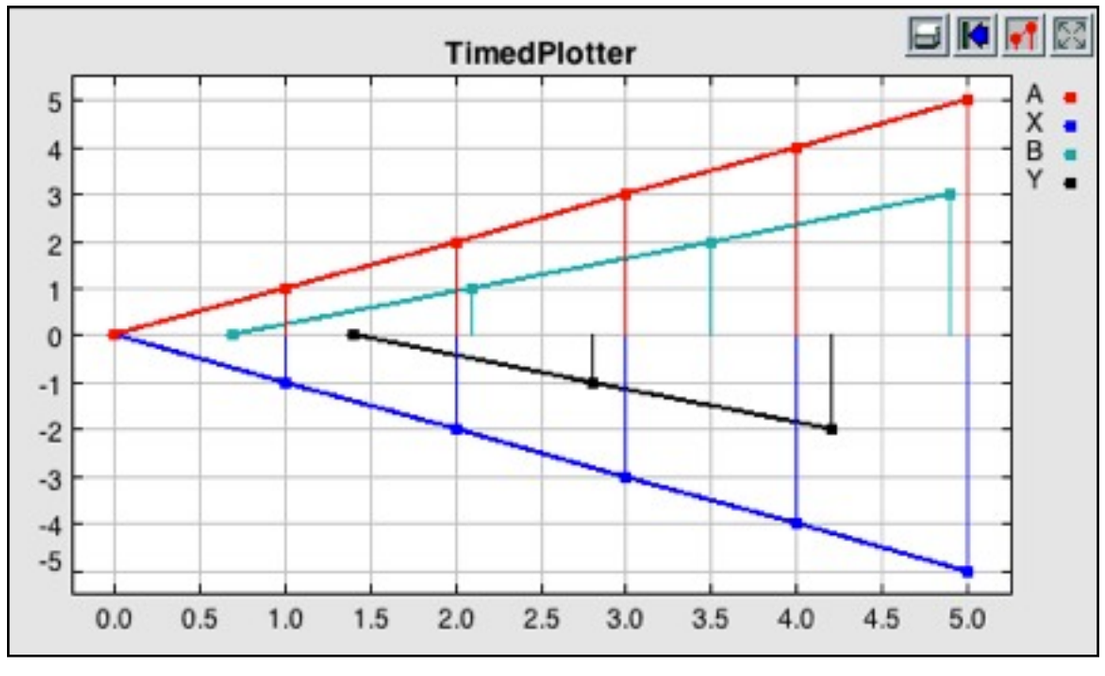
Schedules incoming tokens



QM for Communication - Java Code







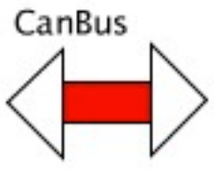
cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/CompositeQM/CompositeQM1.xml

CAN and AFDX

by Janette Cardoso, Gilles Lasnier and David Marciano, ISAE, Toulouse

Control Area Network

_color:	{1.0,0.0,0.0,1.0}
canFormatOfFrame:	"Standard frame"
bitRate (kbit/s):	125
canFramePolicy:	"Send all frames"
bitRate (kbit/s):	0.098181818
Frame policy:	"Send all frames"



Collisions, Multicast, Priorities

cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/CANBus/CANBus.xml

Avionics Full-Duplex Switched Ethernet

AFDX End System

_color:	{1.0,0.0,0.0,1.0}
bitRate (Mbit/s):	100

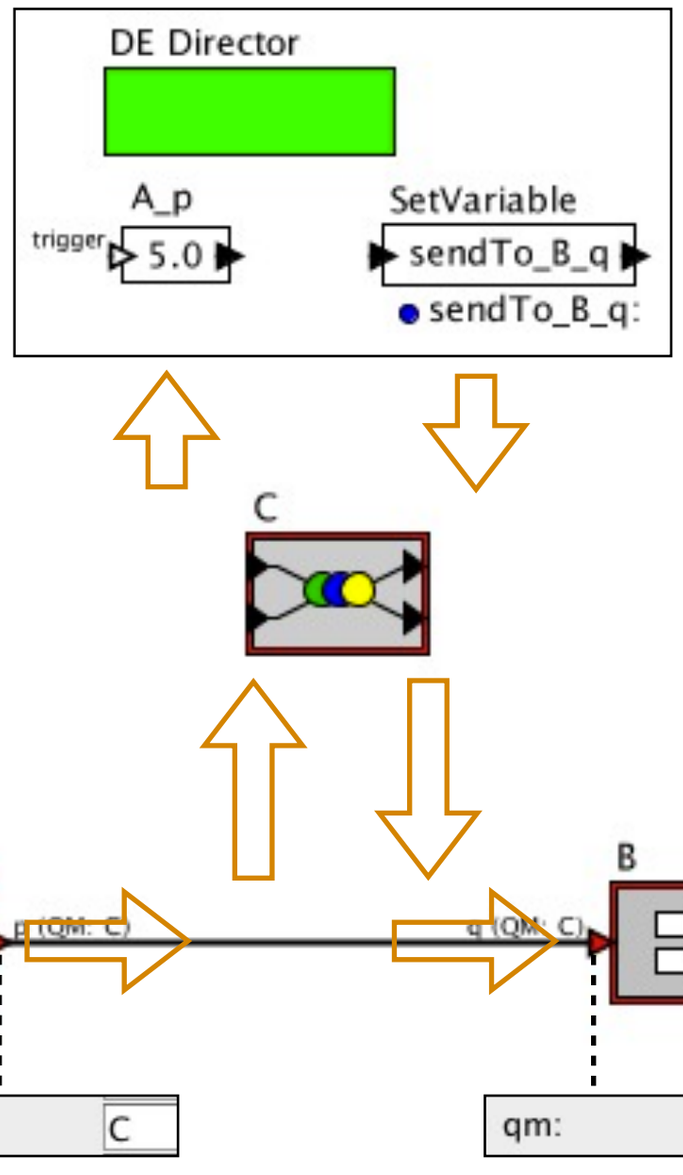
AFDX Switch

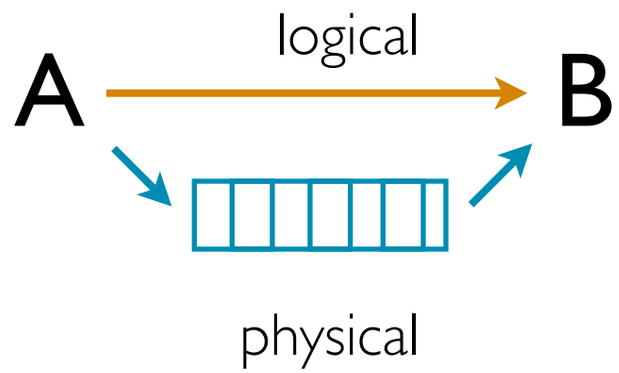
_color:	{1.0,0.0,0.0,1.0}
bitRate (Mbit/s):	100
technologicalDelay (us):	140
inputBufferDelay (ms):	0.0
outputBufferDelay (ms):	0.0
Number of ports:	3
0:	AFDX_ESs
1:	N2
2:	N3

Deterministic QoS

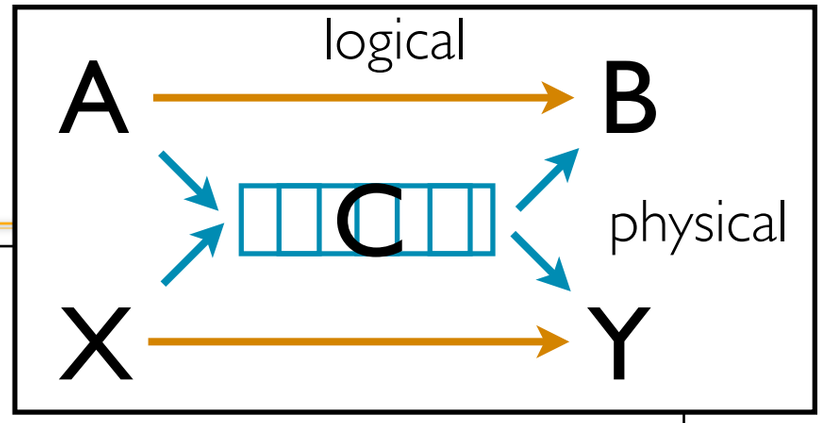
cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/AFDX/AFDX.xml

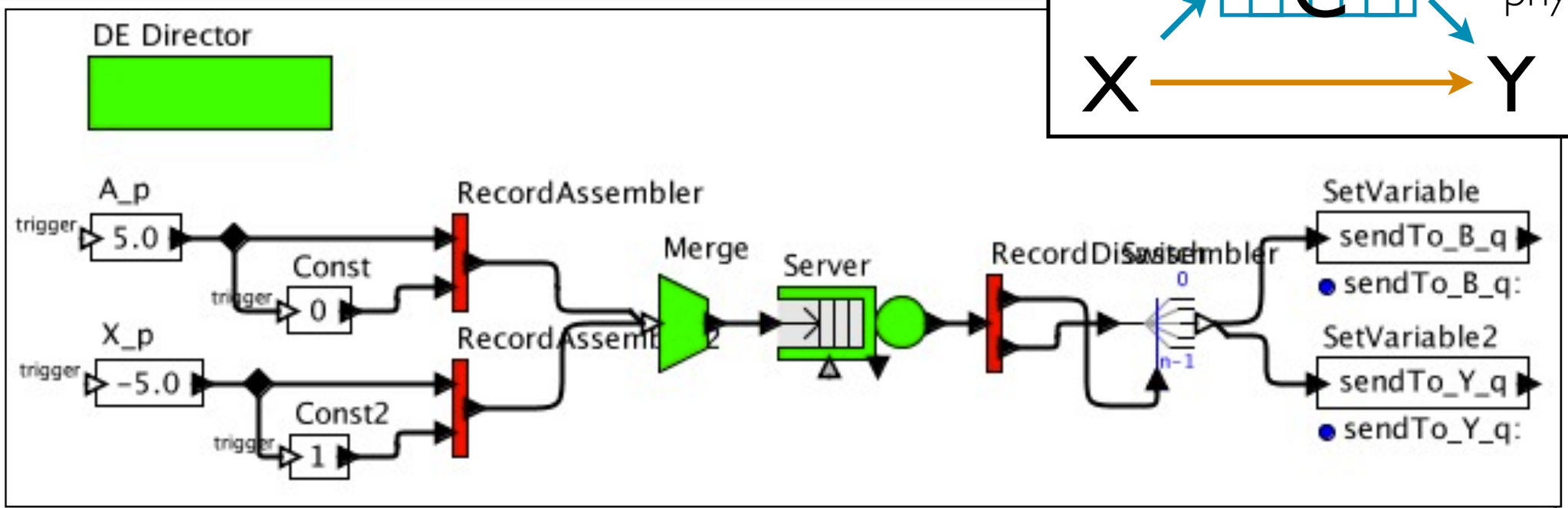
QM for Communication - Model

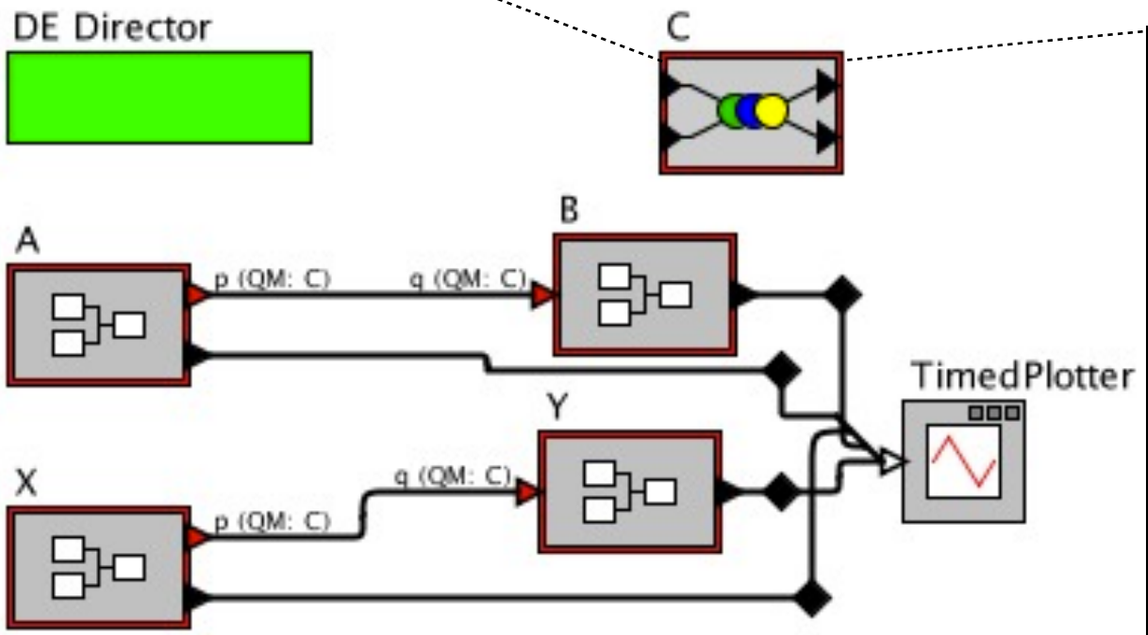


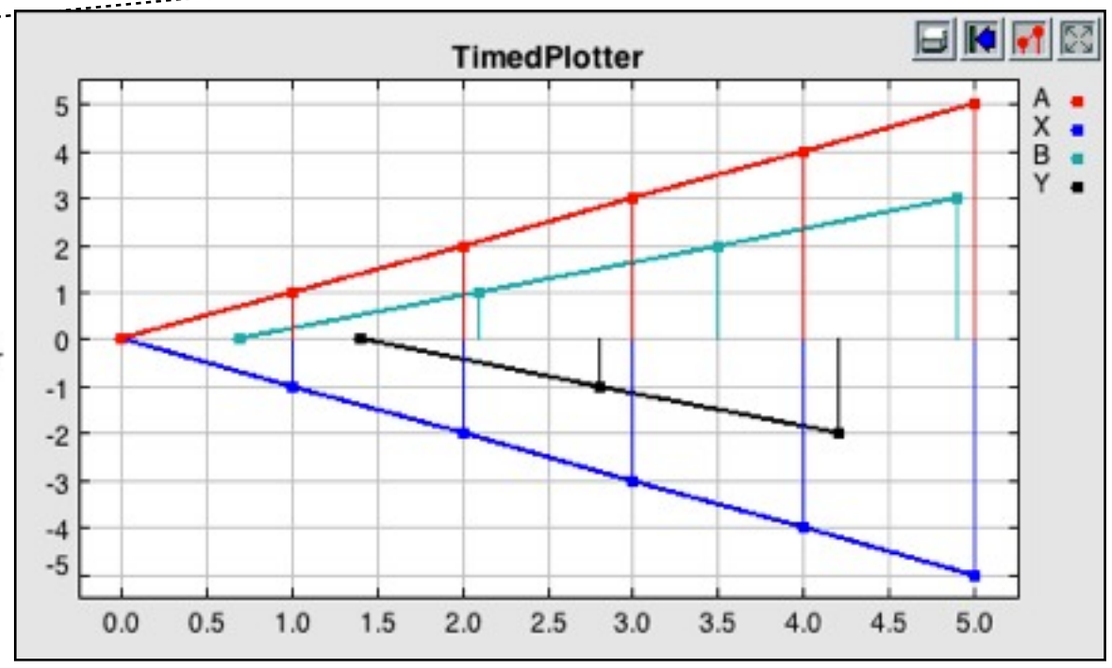


QM for Communication - Model



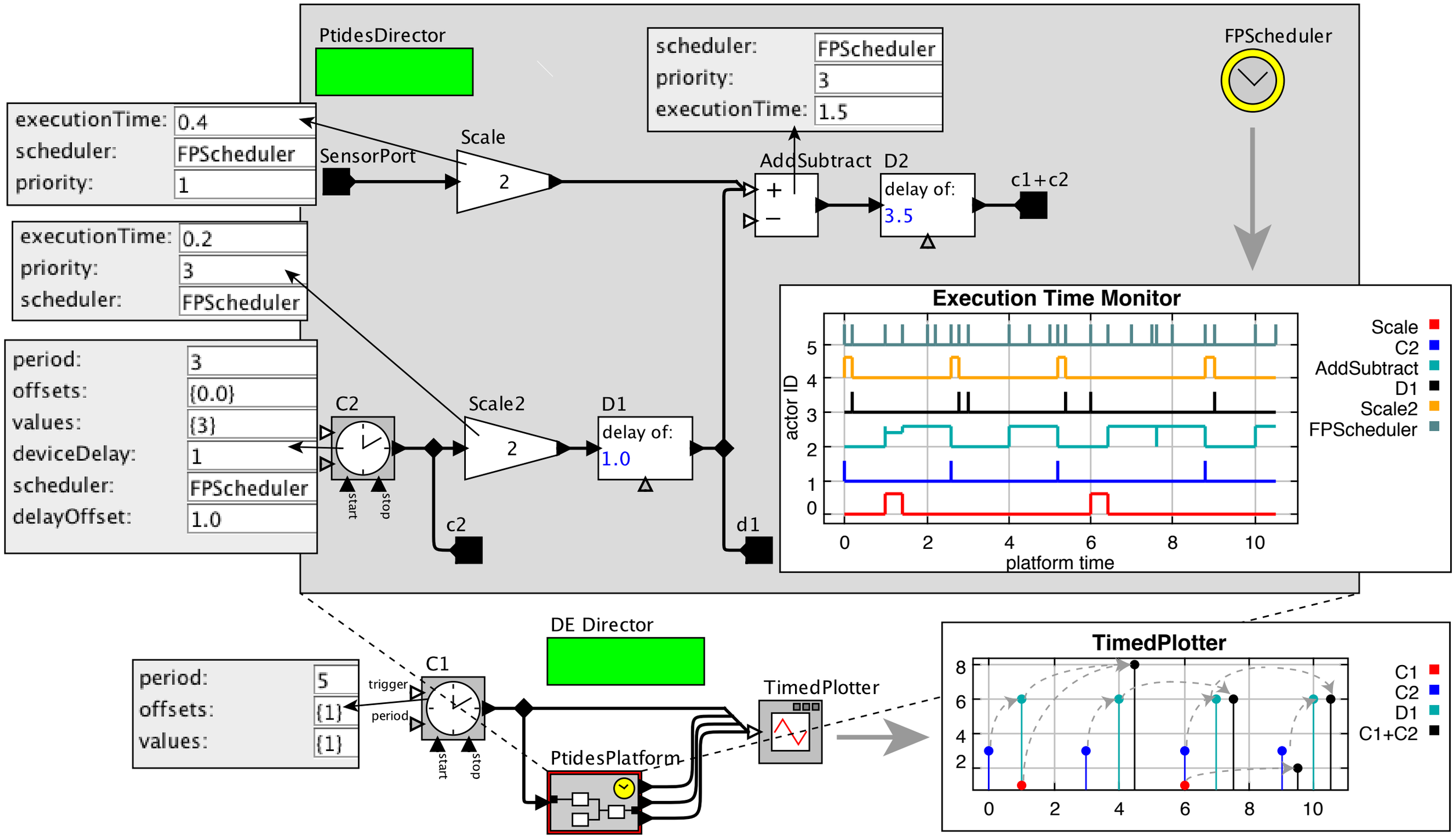






cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/CompositeQM/CompositeQM.xml

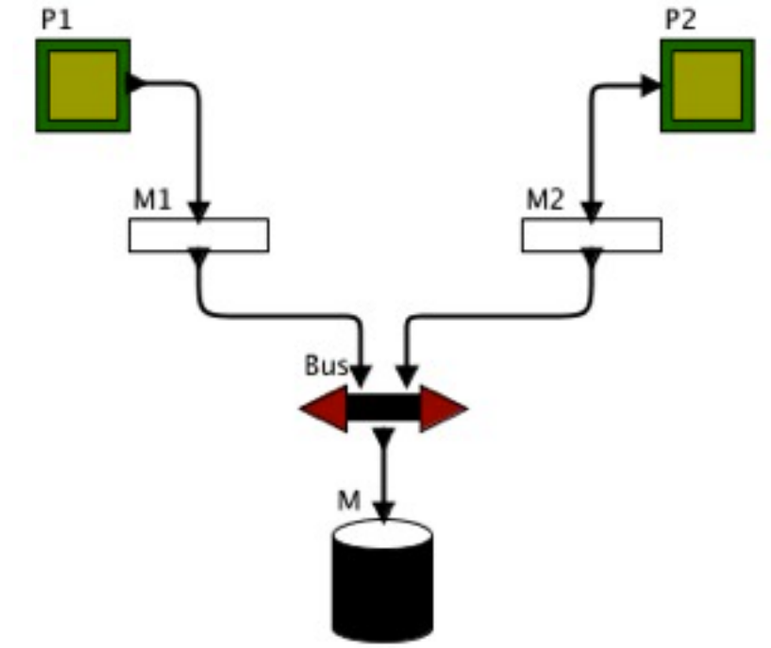
QM for Execution



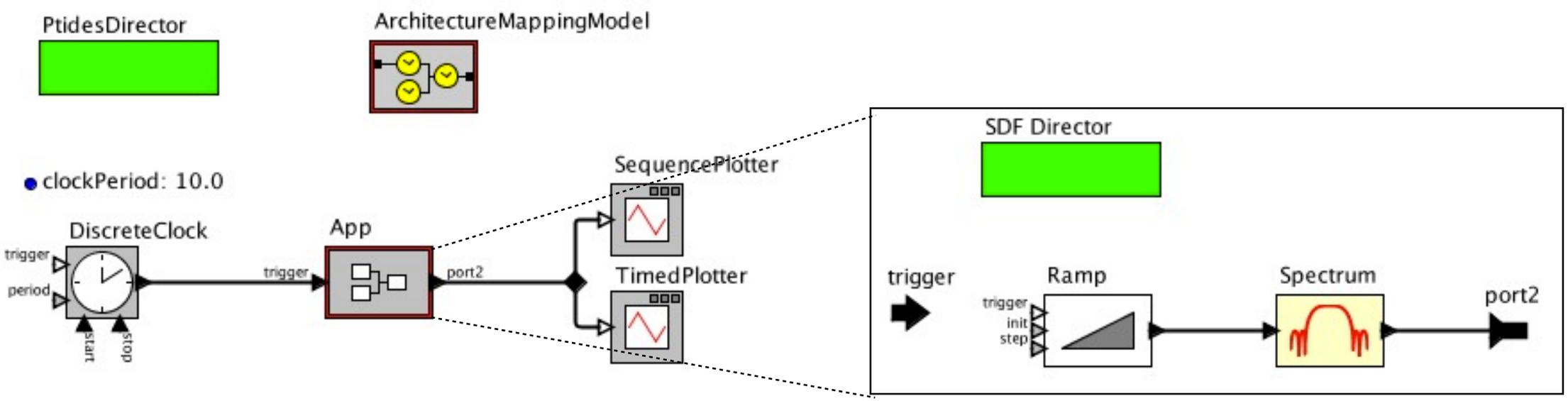
cd $PTII; java ptolemy.vergil.VergilApplication $PTBook/modelingTime/Models/ResourceScheduler.xml

Co-Simulation

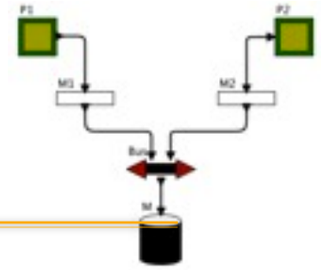
Architecture Model



Functional Model



Co-Simulation



cd $PTII; java ptolemy.vergil.VergilApplication $PTII/ptolemy/domains/ptides/demo/CoSimulation/CoSimulation.xml

SchedulerDirector

- etClock: 0.1
- etSpectrum: 0.1
- etRamp: 0.3
- delayM: 0.1
- m1Capacity: 4
- m2Capacity: 9
- tokenConsumptionRateSpectrum: 8
- delayBetweenRequests: 2.0

Init

DiscreteClock P1 trigger Ramp trigger

- resumeDiscreteClock: false
- resumeRamp: false

P2 SinternalTrigger trigger

- resumeSpectrum: false

Ramp out sendToM delay of: 2.0 in request D out FFT in out do done

PtidesDirector

ArchitectureMappingModel

- clockPeriod: 10.0

DiscreteClock trigger period start stop trigger App port2 SequencePlotter TimedPlotter

SDF Director trigger Ramp trigger init step Spectrum port2