ASPECT-ORIENTED MODELING

Patricia Derler

MOTIVATION

Functional Model

MOTIVATION

Communication infrastructure

Execution Time

Aspects

Distribution onto different platforms

Power Usage

Functional Model

Cost

Logging

Aspects

...

Exploration of system behavior under faults

Exploration of system behavior under security attacks

A LITTLE BIT OF HISTORY

Conventional programming

global data

objects encapsulate data

sequential — concurrent

Edward A. Lee. 2006. The Problem with Threads. Computer 39, 5 (May 2006), 33-42. DOI=10.1109/MC.2006.180 http://dx.doi.org/10.1109/MC.2006.180

Object-oriented programming

separation of concerns into distinct objects

crosscutting concerns

sequential — concurrent

data — messages

Actor-oriented programming

Aspect-oriented programming

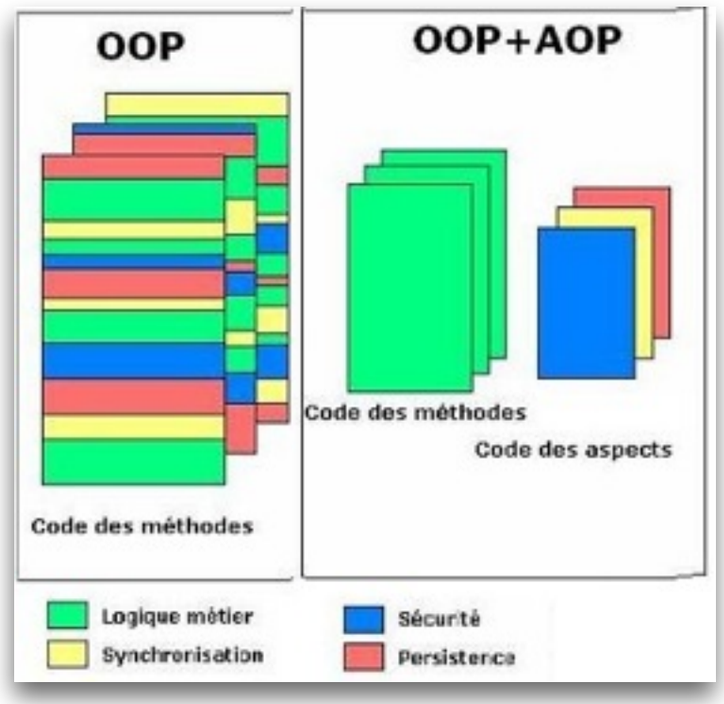
Aspect-oriented programming, G Kiczales, J Lamping, A Mendhekar, C Maeda, C Lopes, JM Loingtier, J Irwin, ECOOP'97—Object-Oriented Programming, 220-242

Aspect-oriented modeling

inspired by Alberto L. Sangiovanni-Vincentelli, Quo Vadis SLD: Reasoning about Trends and Challenges of System-Level Design, Proceedings of the IEEE, 95(3):467-506, March 2007.

ASPECT-ORIENTED PROGRAMMING

- Reduce code duplication/tangling/scattering
- Examples: Logging, security, transaction management
- Various implementations



by Anonymous

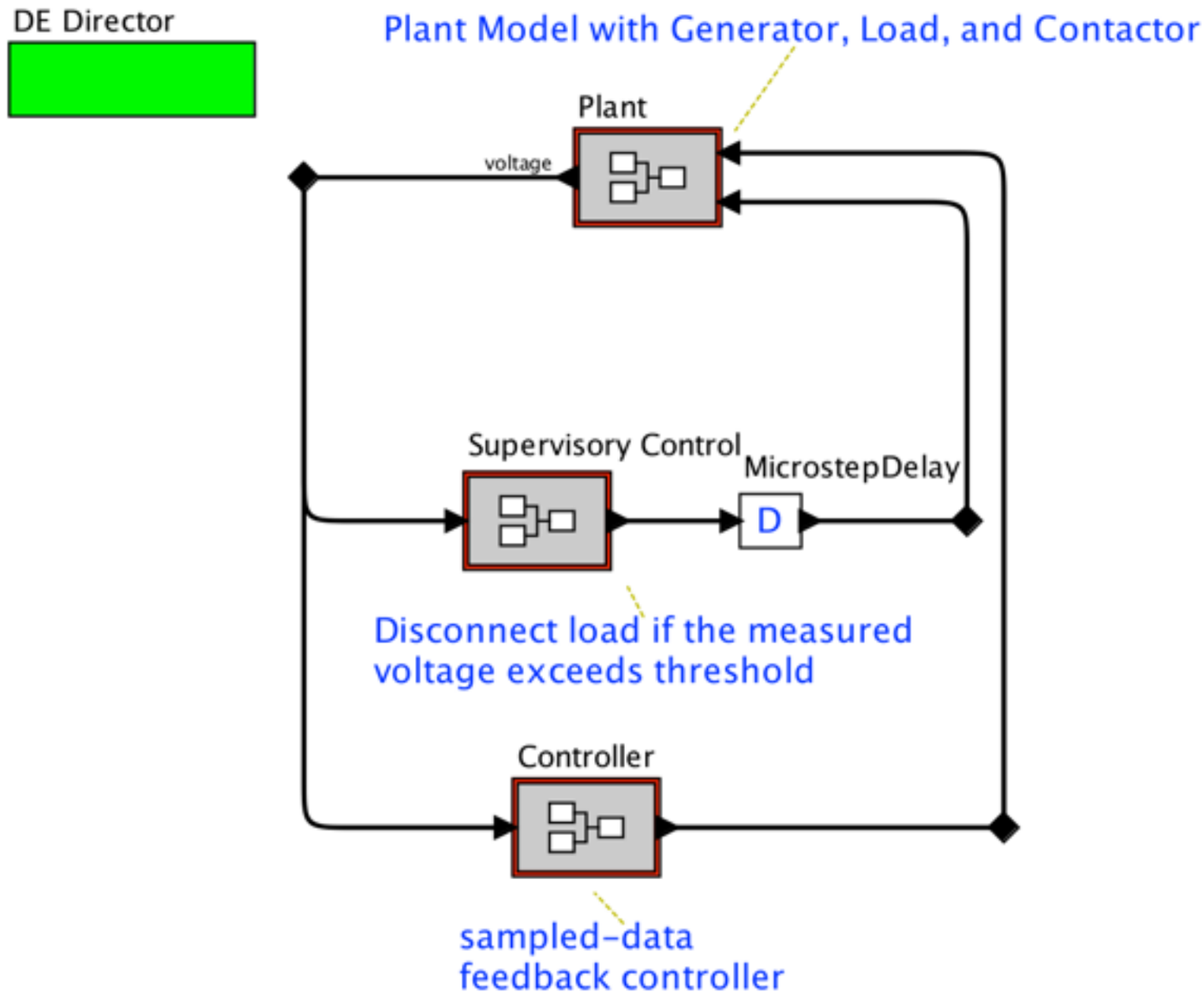
- Slow adoption
- Debugging of AOP is hard
- Studies on fault-proneness in AOP

Haihan Yin, Christoph Bockisch, and Mehmet Aksit. 2012. A fine-grained debugger for aspect-oriented programming. In Proceedings of the 11th annual international conference on Aspect-oriented Software Development (AOSD '12). ACM, New York, NY, USA, 59-70. DOI=10.1145/2162049.2162057 http://doi.acm.org/10.1145/2162049.2162057

Fabiano Ferrari, Rachel Burrows, Otávio Lemos, Alessandro Garcia, Eduardo Figueiredo, Nelio Cacho, Frederico Lopes, Nathalia Temudo, Liana Silva, Sergio Soares, Awais Rashid, Paulo Masiero, Thais Batista, and José Maldonado. 2010. An exploratory study of fault-proneness in evolving aspect-oriented programs. In Proceedings of the 32nd ACM/IEEE International Conference on Software Engineering - Volume 1 (ICSE '10), Vol. 1. ACM, New York, NY, USA, 65-74. DOI=10.1145/1806799.1806813 http://doi.acm.org/10.1145/1806799.1806813

COMMUNICATION

- Cross-cutting concern in actor-oriented models of CPS **Networks and Communication**



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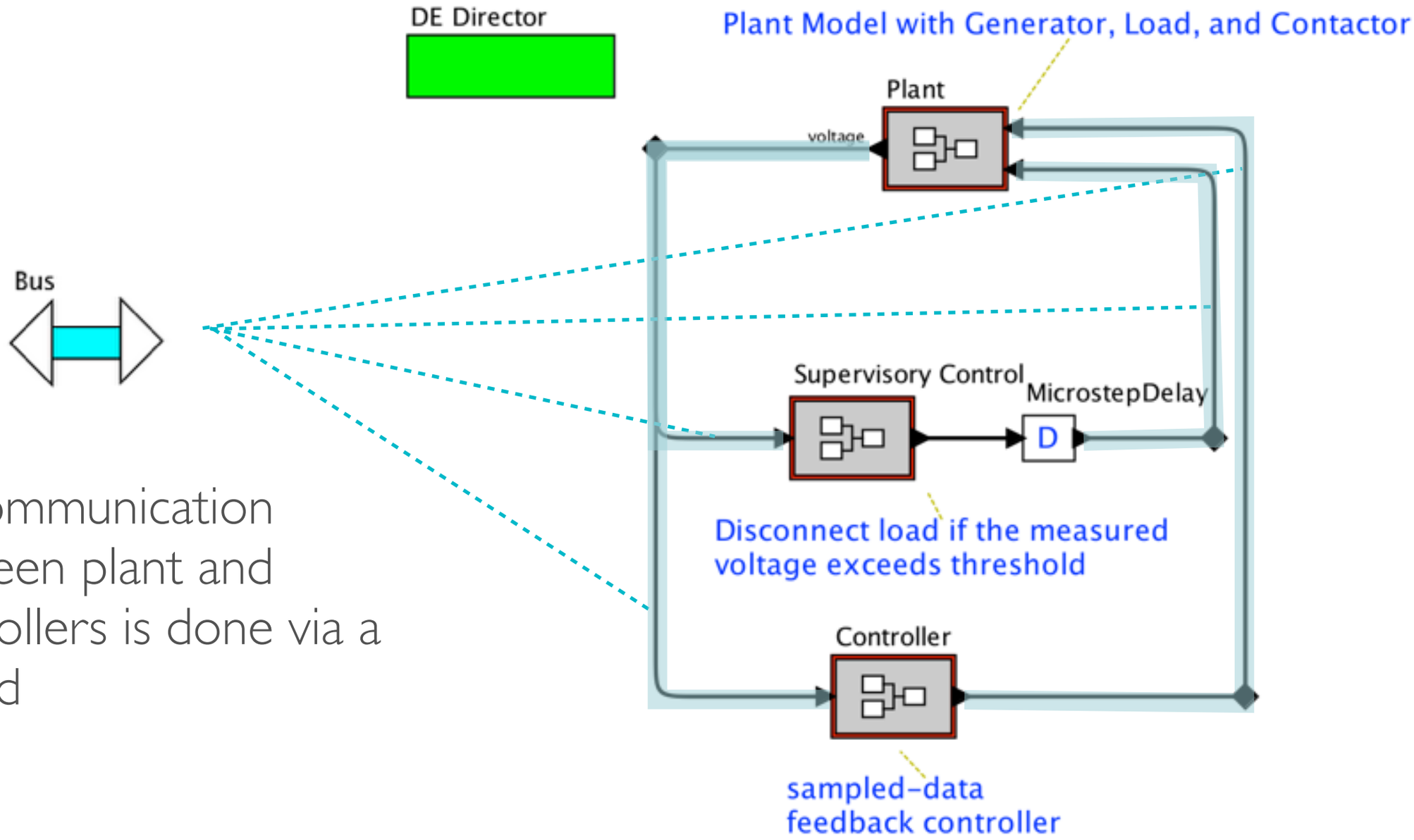
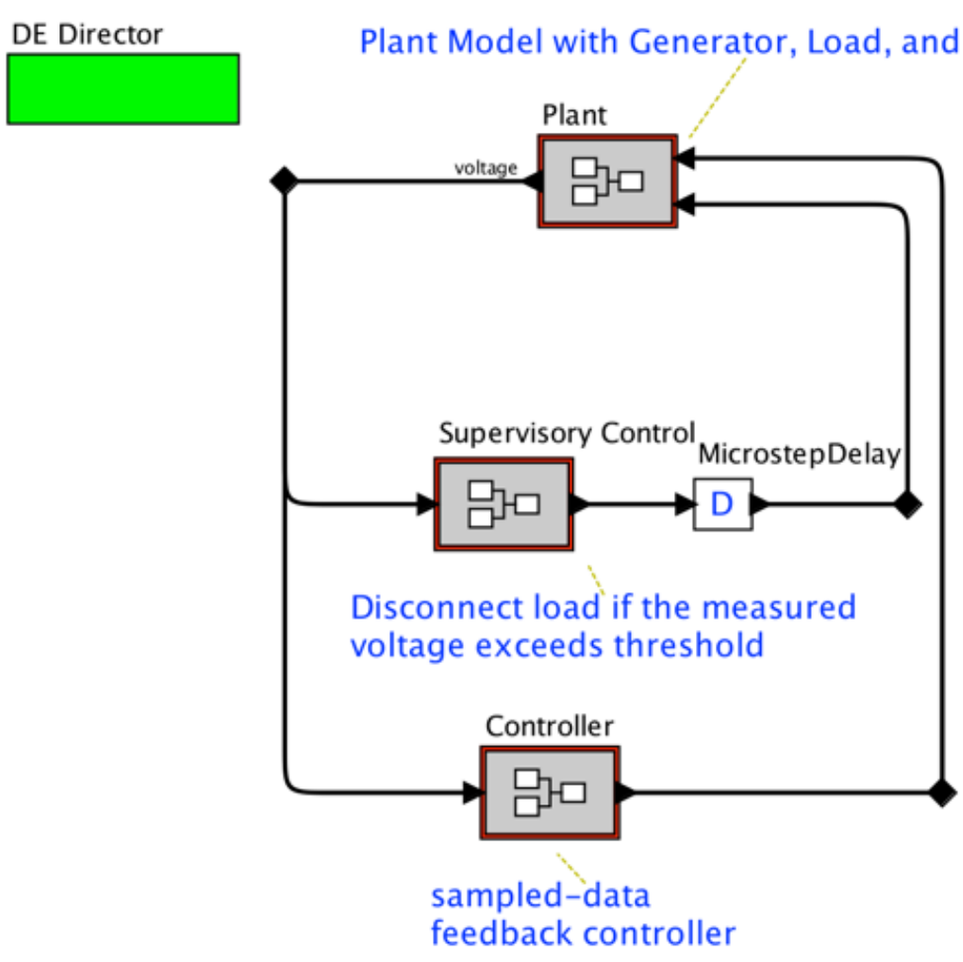


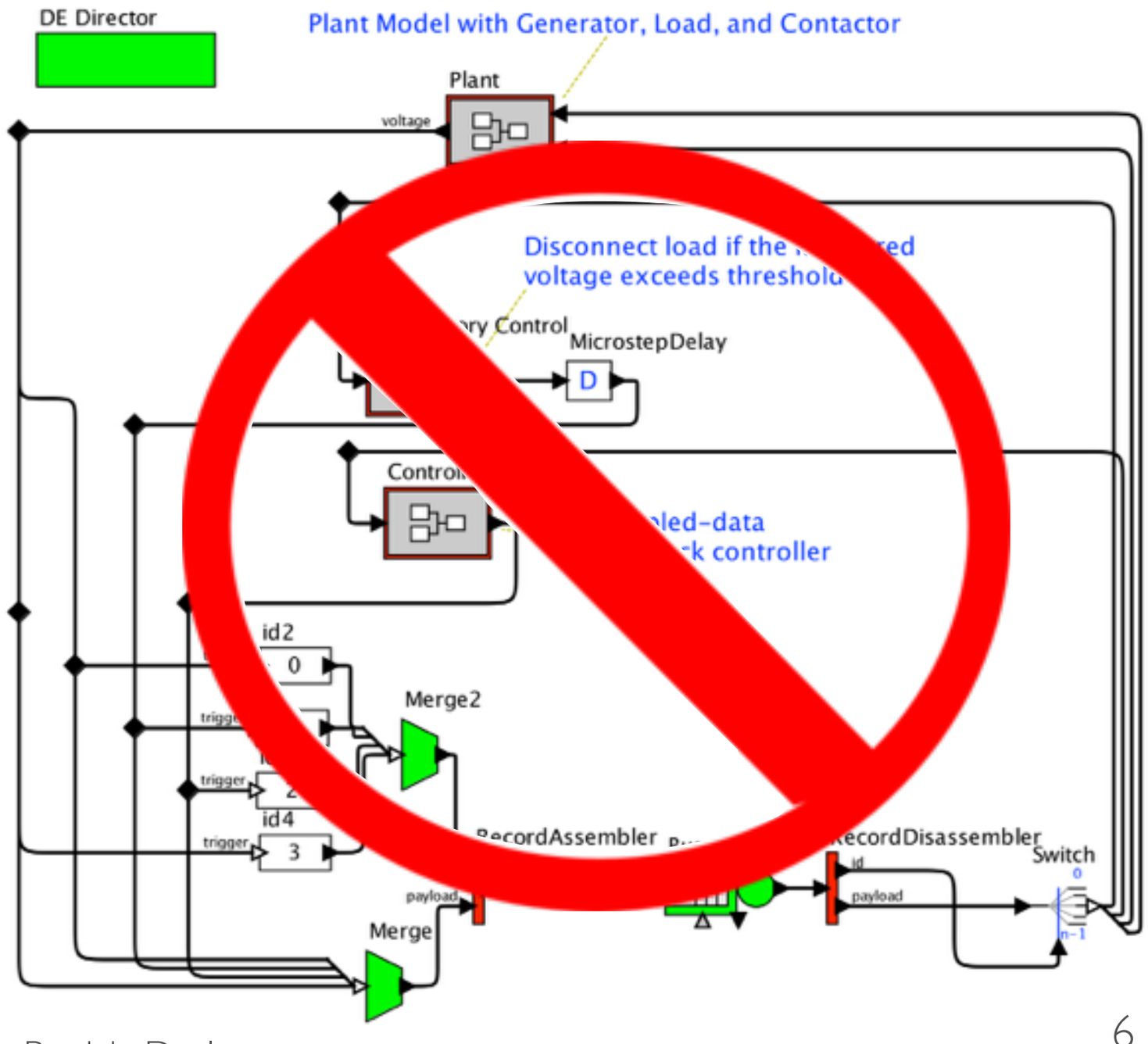
All communication between plant and controllers is done via a shared

COMMUNICATION

- Original Model



- Entangled Model



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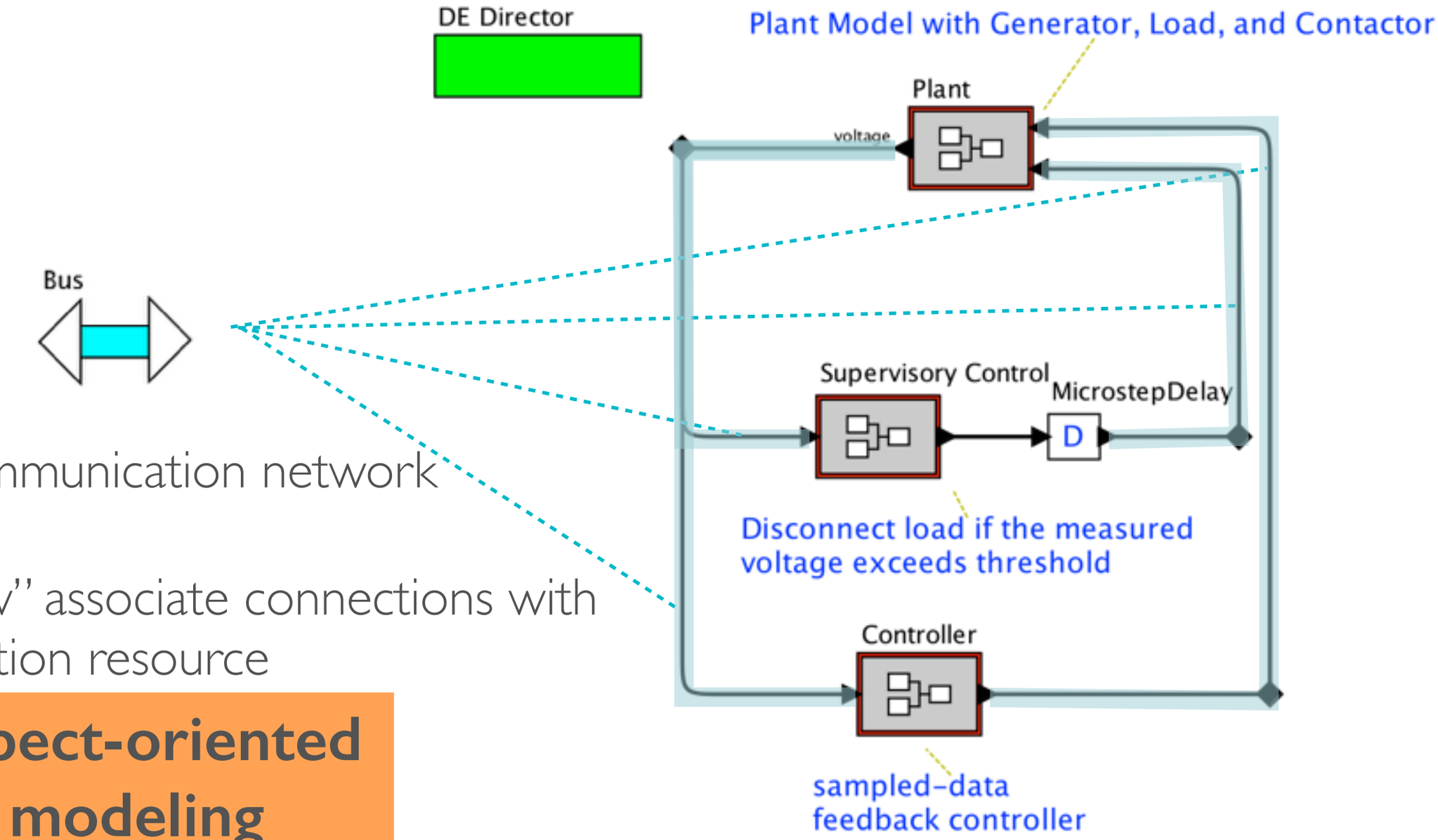
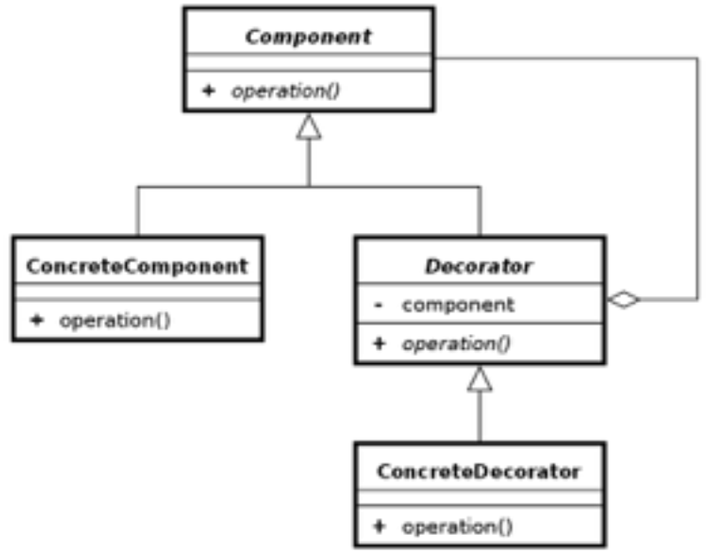


- Model communication network

- "Somehow" associate connections with communication resource

Aspect-oriented modeling

DECORATOR MECHANISM



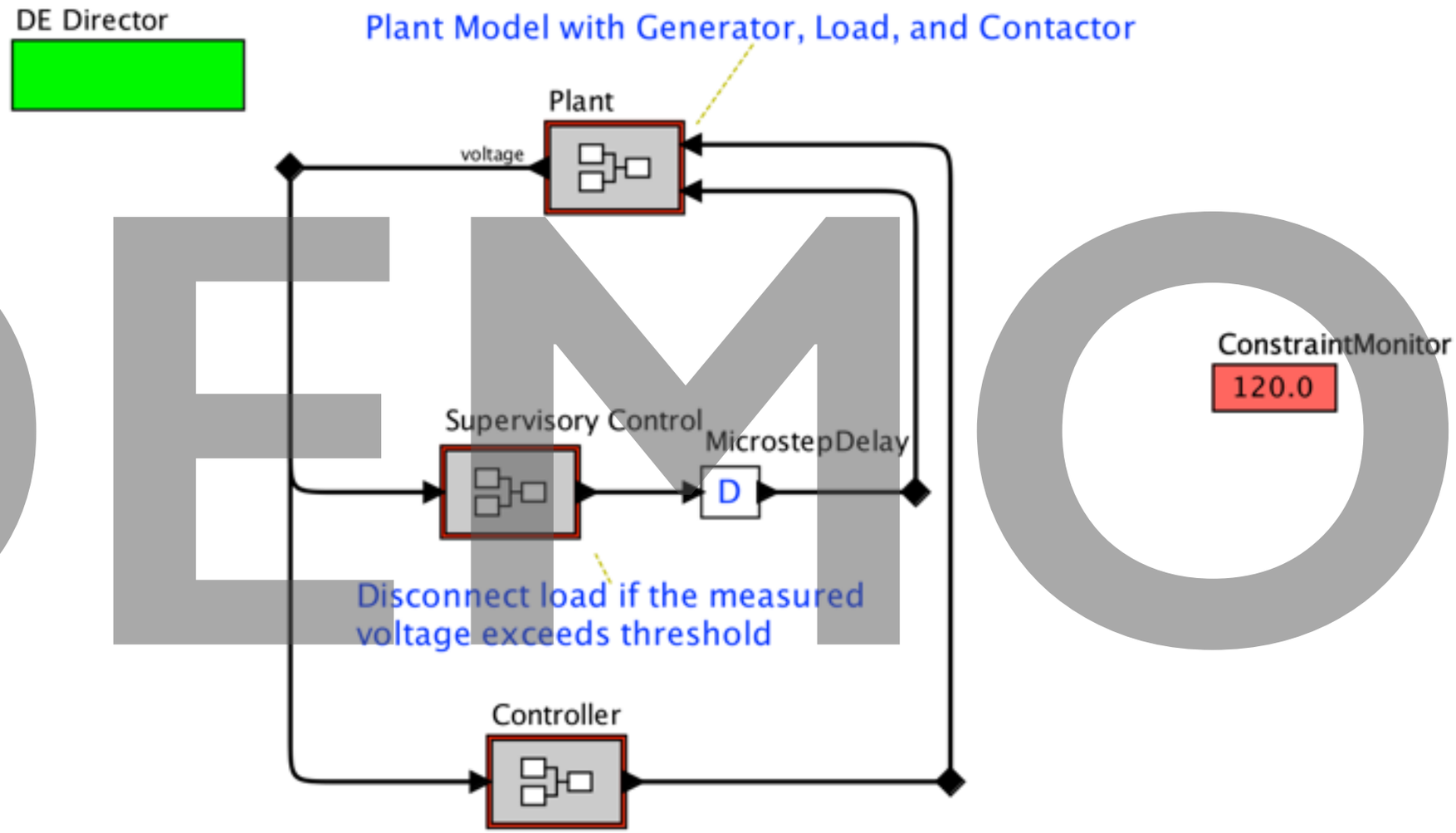
… behavior to be added to an individual object, either statically or dynamically, without affecting the behavior of other objects from the same class …
Wikipedia

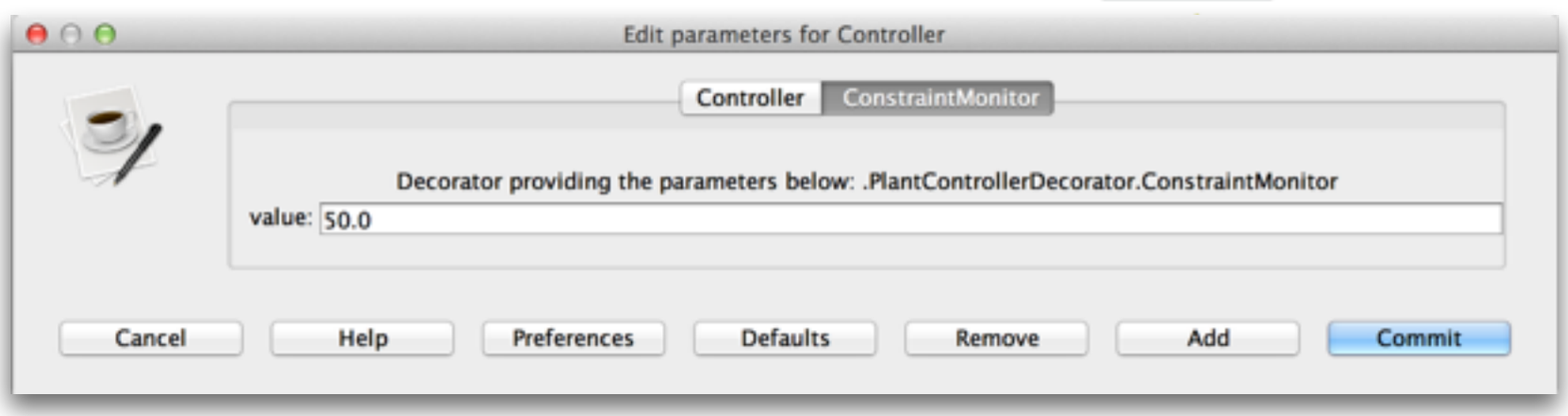
```
/*
@author Bert Rodiers
@author Edward A. Lee
*/

public interface Decorator
```

- Defines objects to decorate (e.g. actors, ports)
- Creates attributes for each decorated object

DECORATOR MECHANISM





java ptolemy.vergil.VergilApplication ptolemy/demo/ElectricPowerSystem/PlantController.xml

java ptolemy.vergil.VergilApplication ptolemy/demo/ElectricPowerSystem/PlantControllerDecorator.xml

COMMUNICATION

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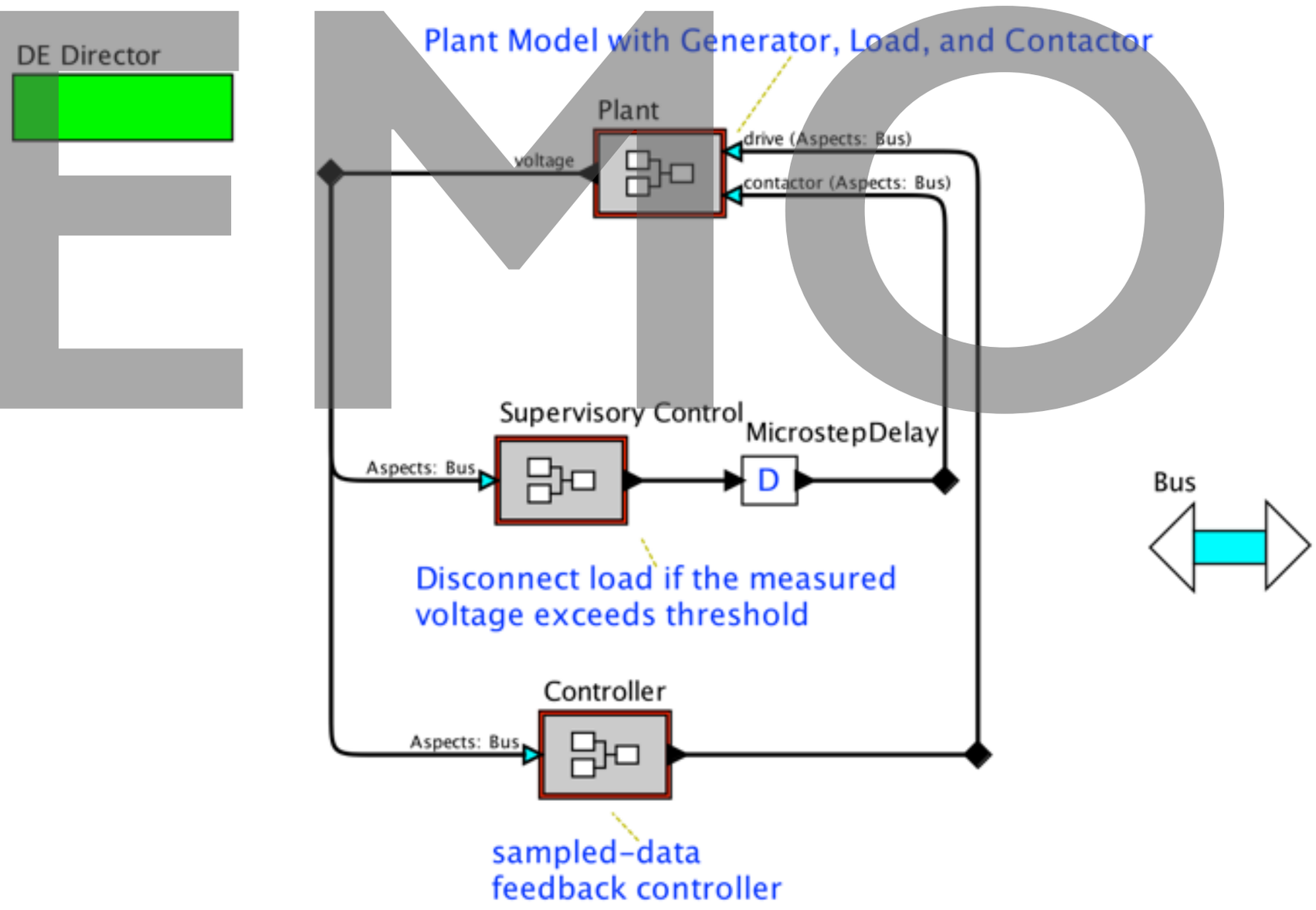
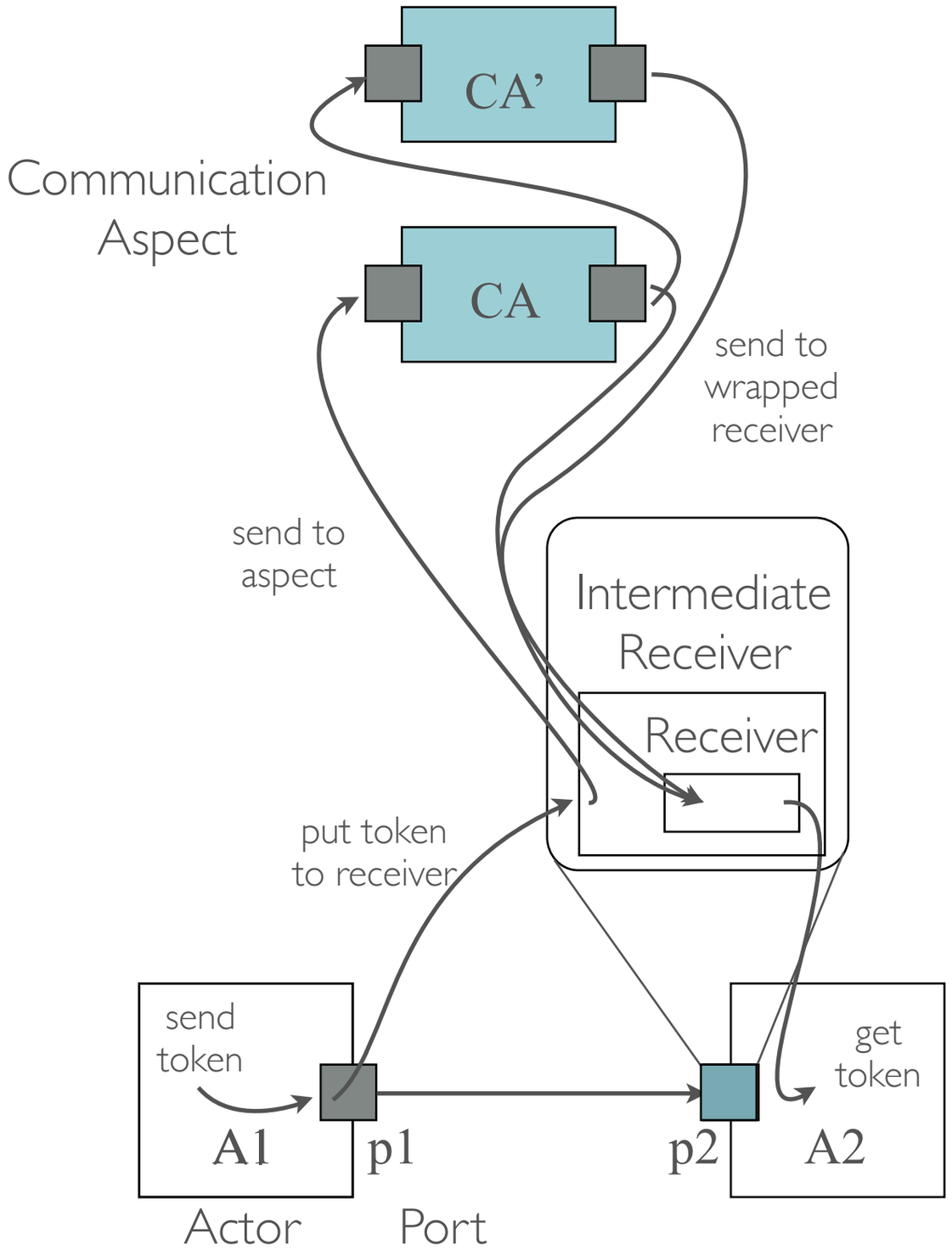


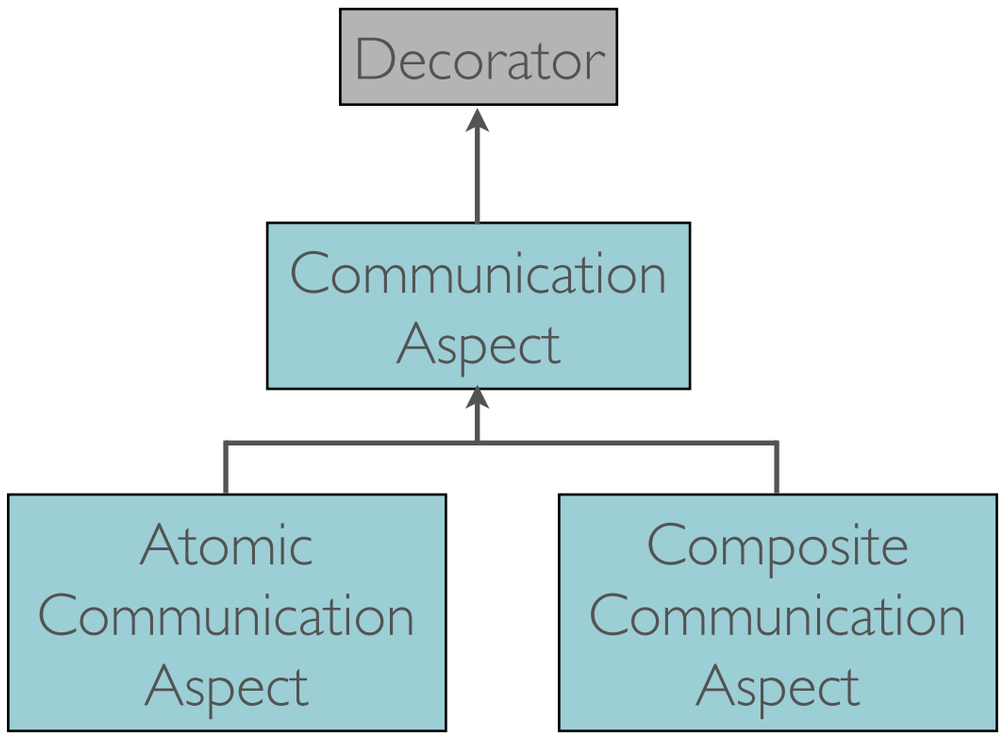
java ptolemy.vergil.VergilApplication ptolemy/demo/ElectricPowerSystem/PlantControllerBus.xml
java ptolemy.vergil.VergilApplication ptolemy/demo/ElectricPowerSystem/PlantControllerBus1.xml

COMMUNICATION ASPECTS

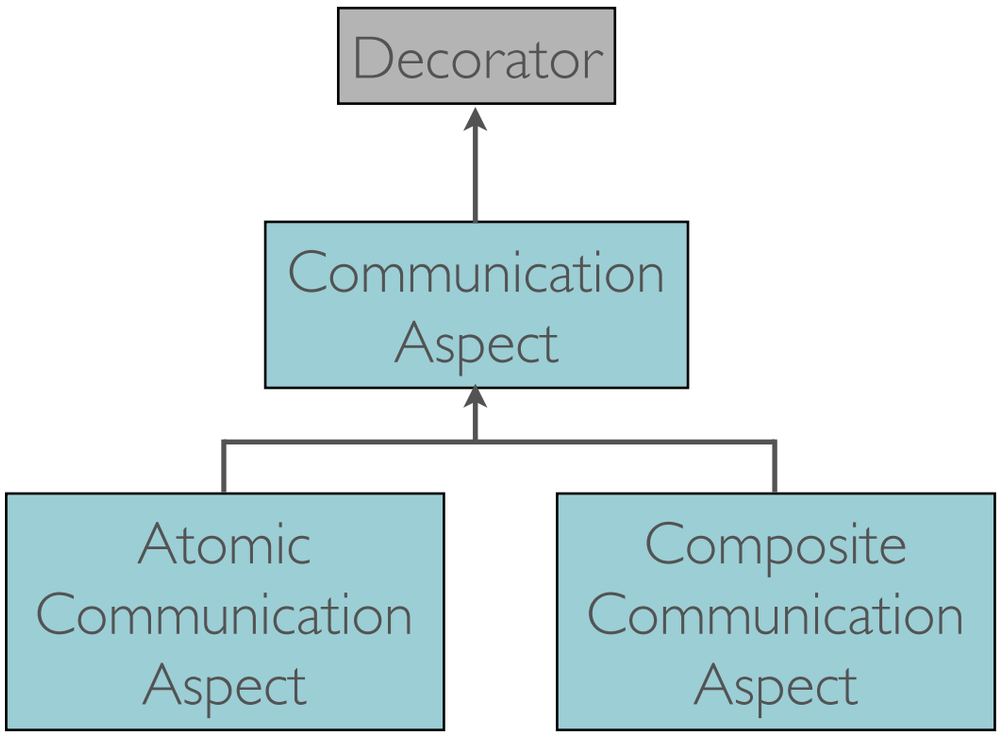


- If a communication between two actors is mediated by a communication aspect
  - An intermediate receiver is created wrapping the original receiver
  - The intermediate receiver receives tokens from the sender
  - The intermediate receiver sends tokens to the aspect
  - The aspect forwards tokens to the original receiver
- Multiple communication aspects possible

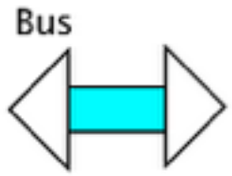
COMMUNICATION ASPECTS

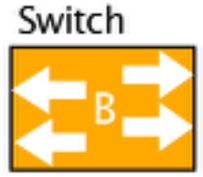


COMMUNICATION ASPECTS



- Communication Modeling





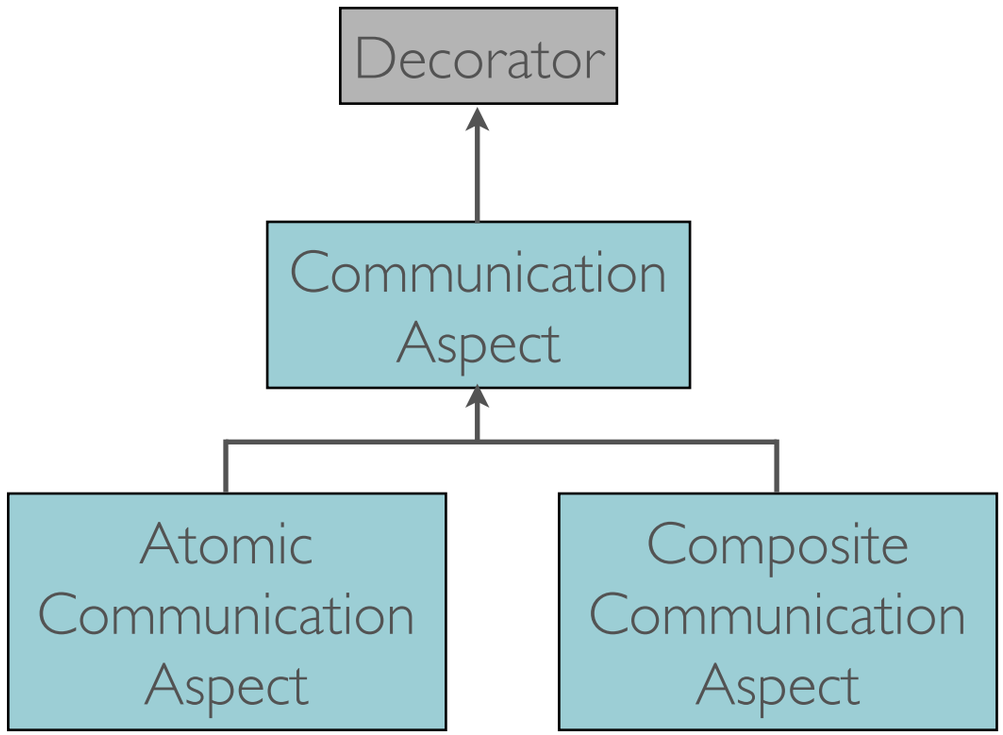
BasicSwitch,
CrossbarSwitch,
TTESwitch

AFDXSwitch

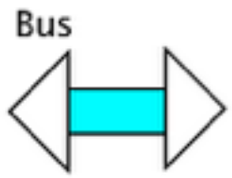
AFDXEndsystem

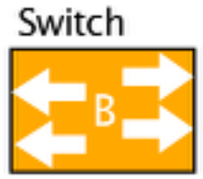
by Janette Cardoso, Gilles Lasnier, David Marciano from ISAE, Toulouse

COMMUNICATION ASPECTS



- Communication Modeling





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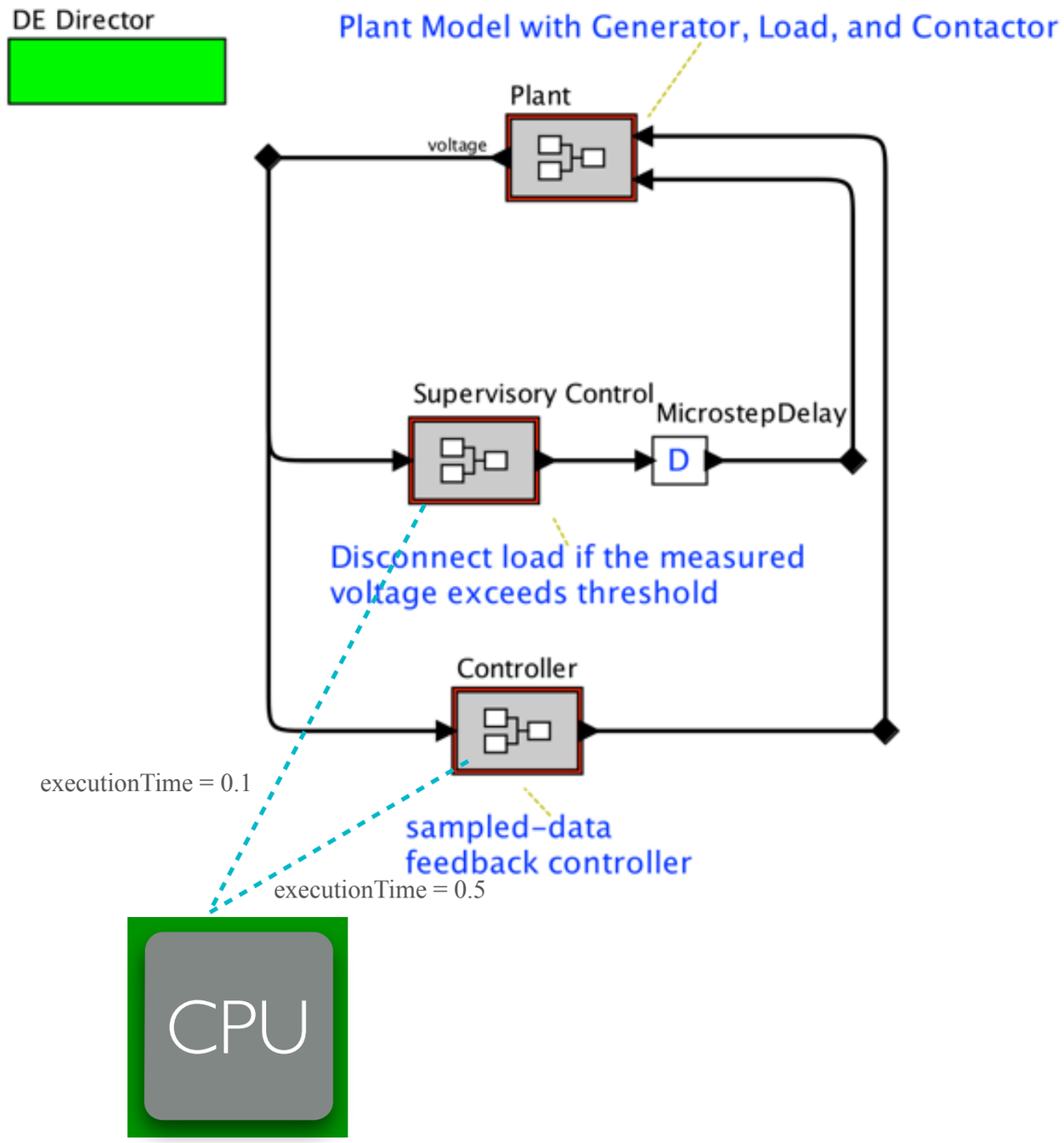
- Other communication aspects:
  - Logging
  - Fault models
  - Security modeling

ASPECT-ORIENTED MODELING & CPS

- Cross-cutting concerns
  - Communication
  - **Execution**
  - Logging and debugging
  - Error modeling - Ilge Akkaya
  - Security - Armin Wasicek



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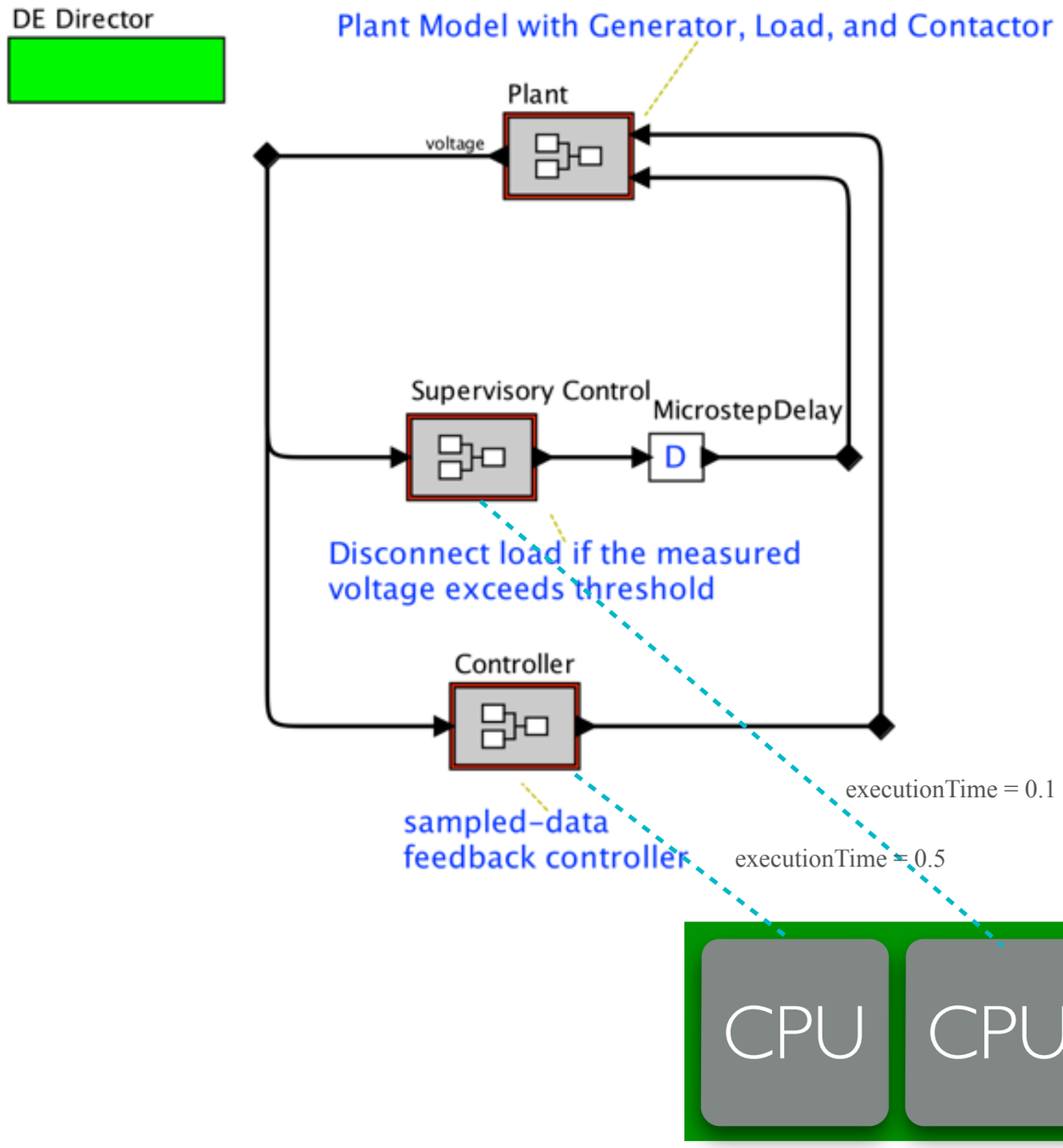

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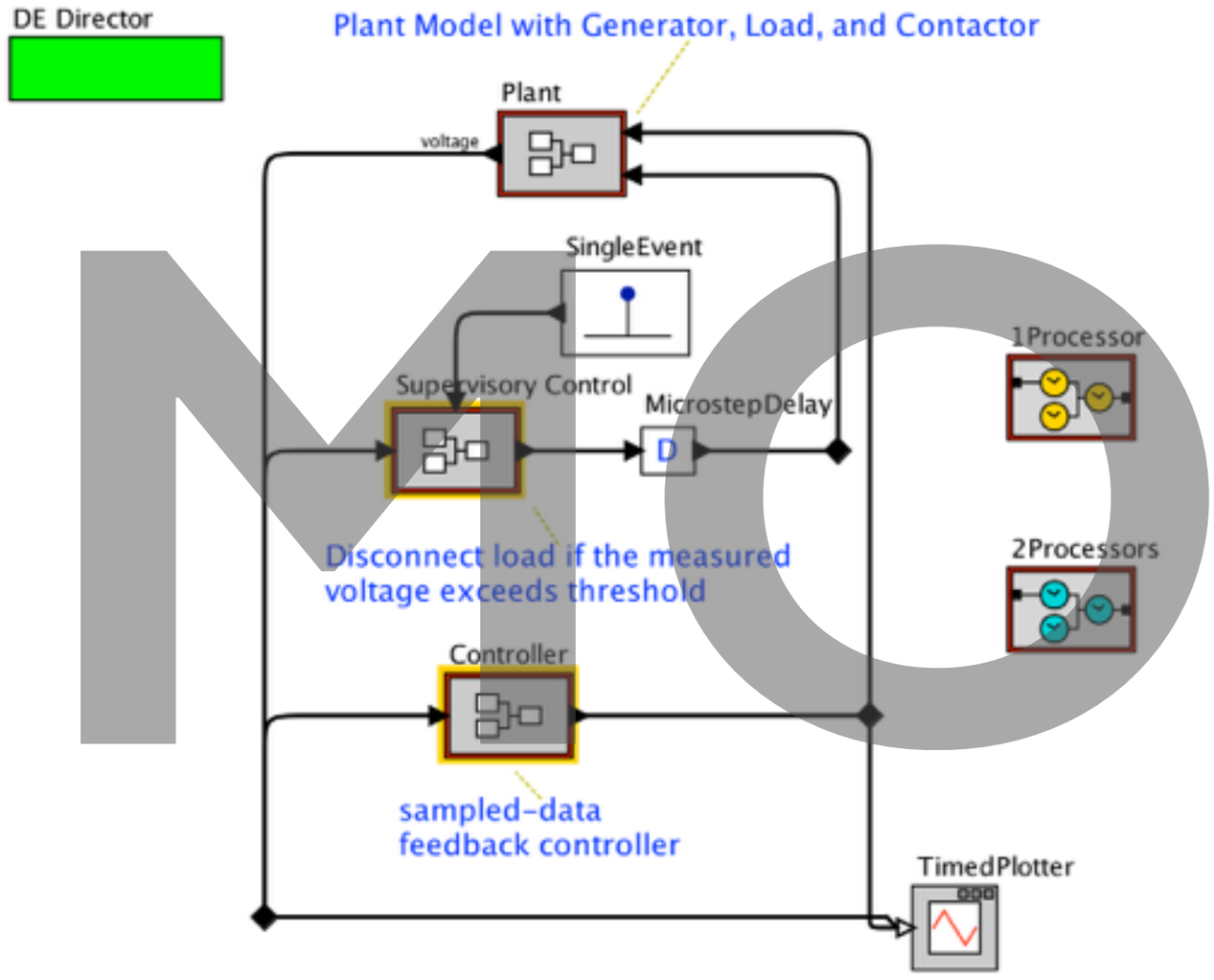

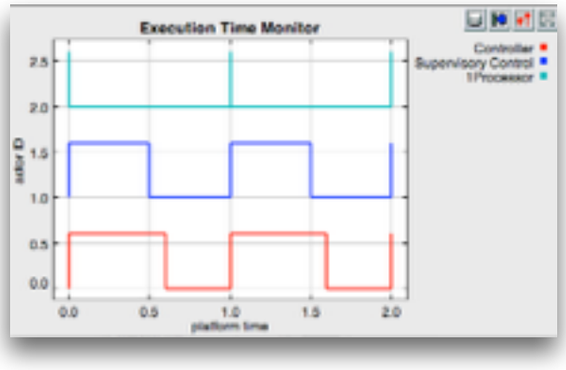

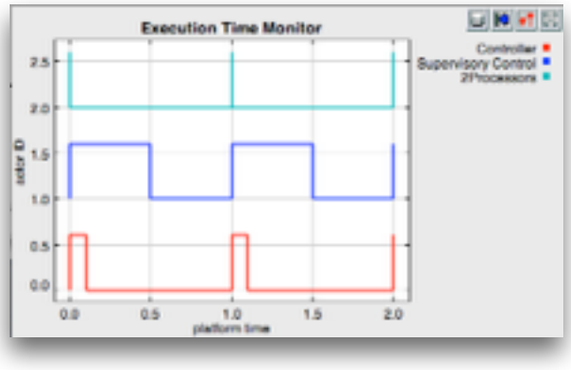

java ptolemy.vergil.VergilApplication ptolemy/demo/ElectricPowerSystem/PlantControllerProcessor.xml

ASPECT-ORIENTED MODELING & CPS

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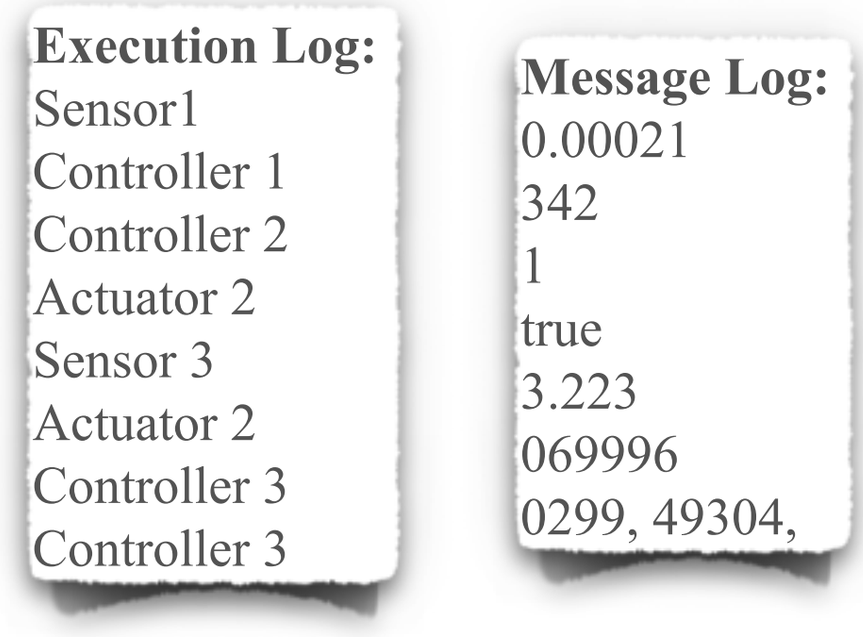

ASPECT-ORIENTED MODELING & CPS

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  - **Error modeling - Ilge Akkaya**
  - Security - Armin Wasicek

Aspect-Oriented Fault Modeling and Anomaly Detection

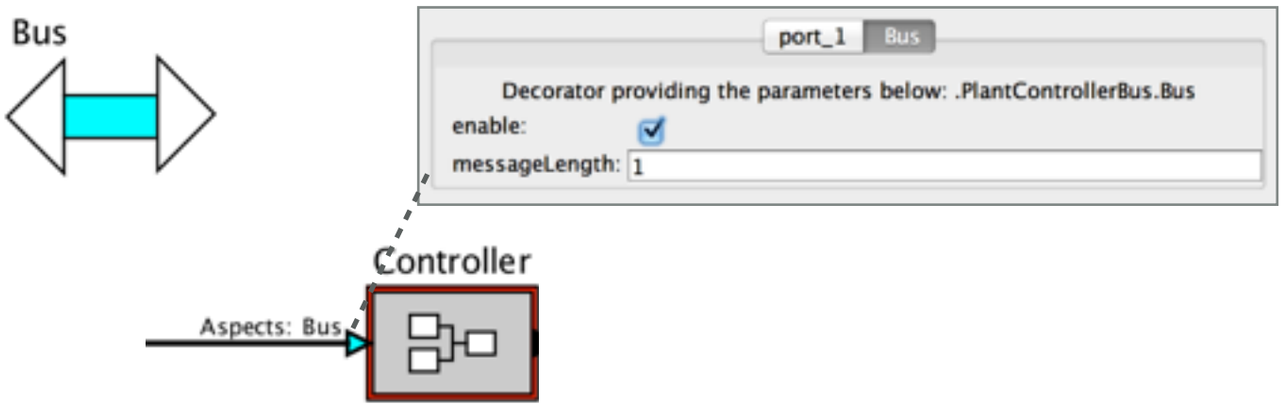
ASPECT-ORIENTED MODELING & CPS

- Cross-cutting concerns
  - Communication
  - Execution
  - Logging and debugging
  - Error modeling - Ilge Akkaya
  - **Security - Armin Wasicek**

Attack Modeling in Ptolemy: Towards a Secure Design for Cyber-Physical Systems

CURRENT STATE AND FUTURE WORK

- Communication aspects



CURRENT STATE AND FUTURE WORK

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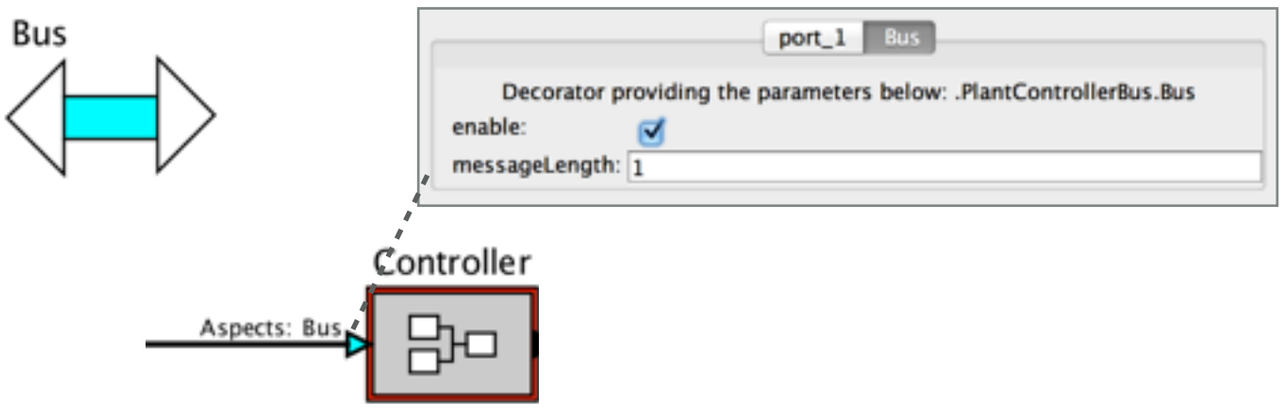

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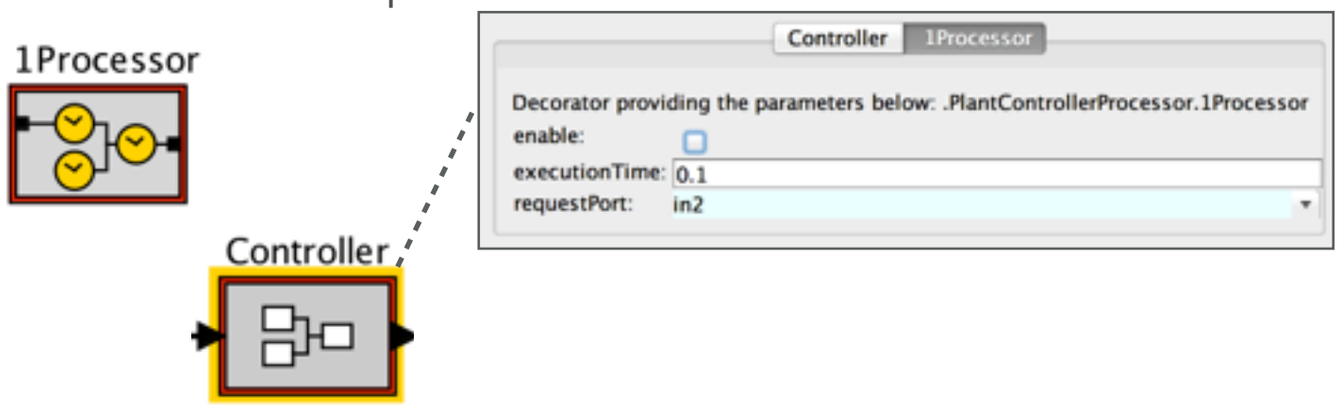

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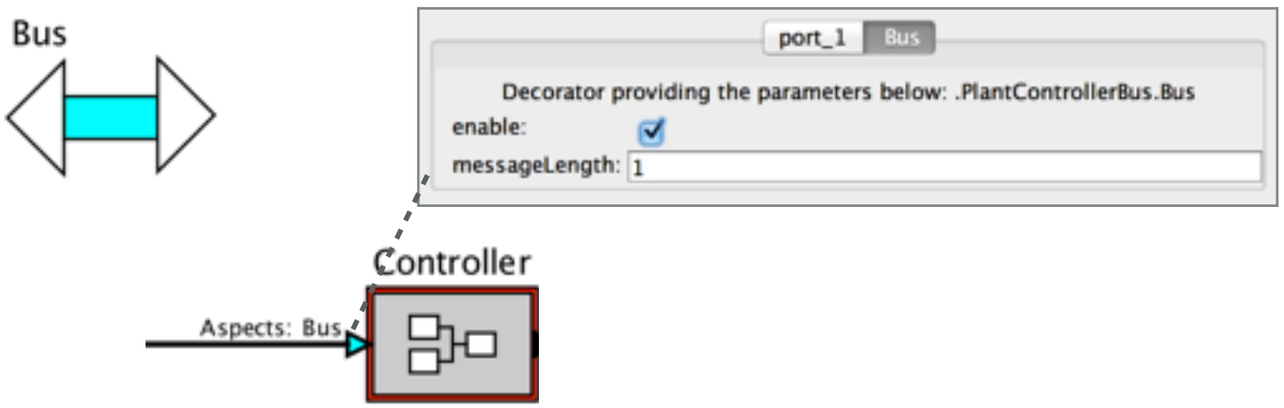

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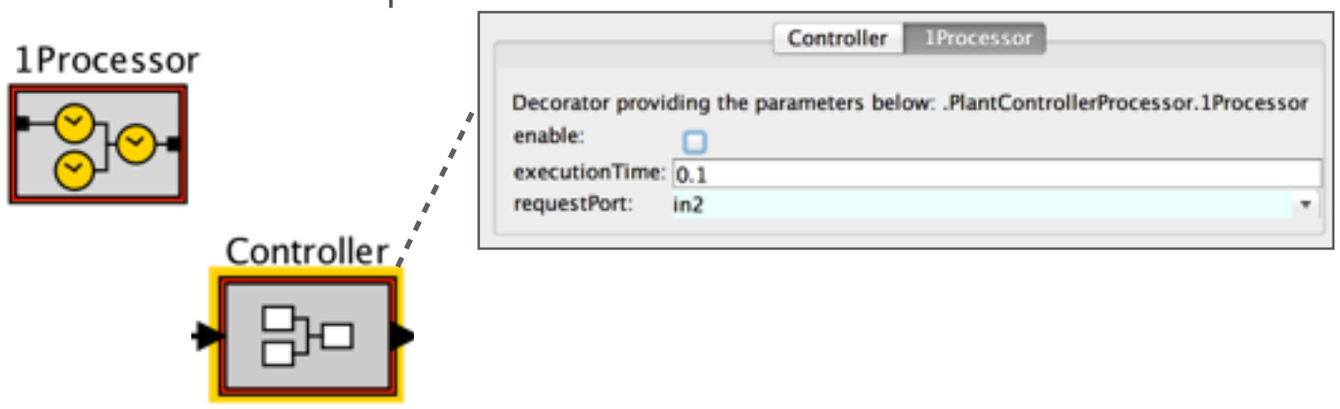
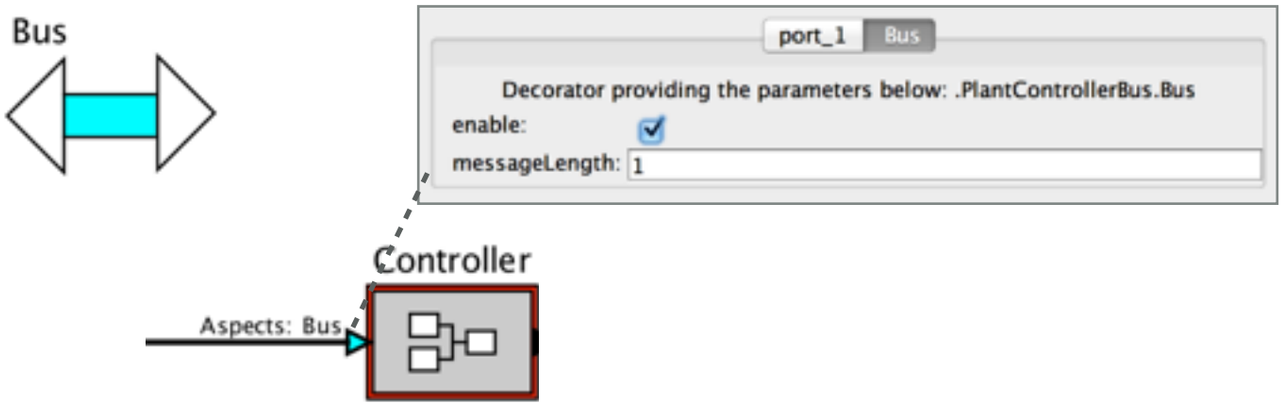
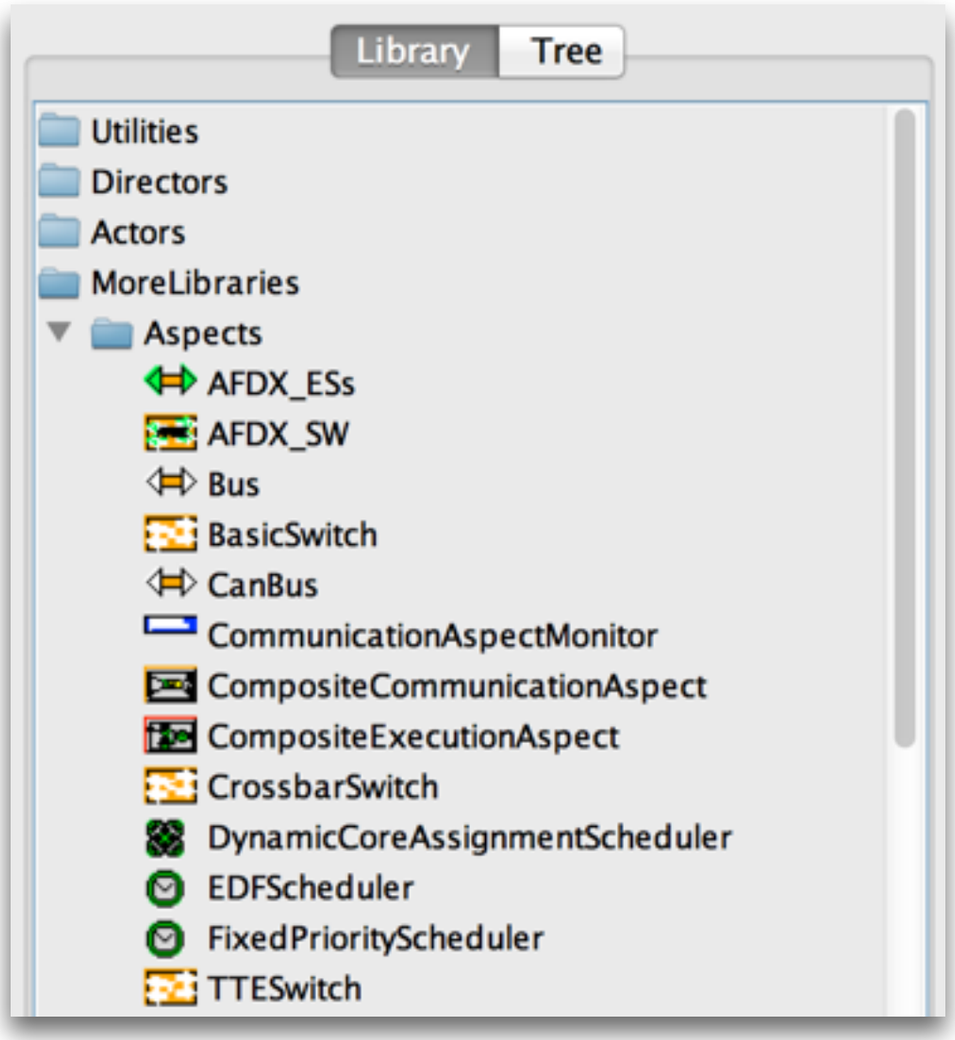


- Aspects work in a small set of Models of Computations (DE, Continuous, Ptides, SDF)

CURRENT STATE AND FUTURE WORK

- Communication aspects





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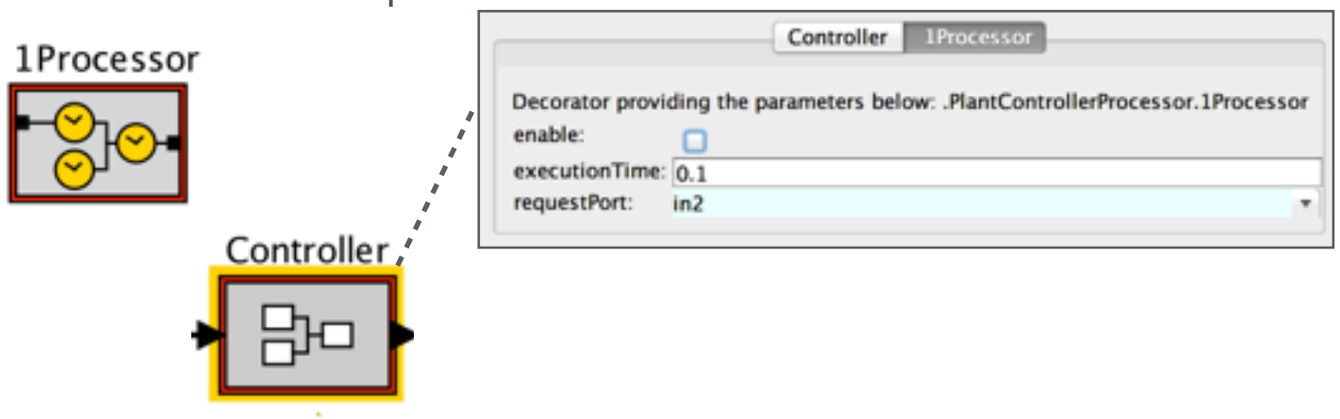
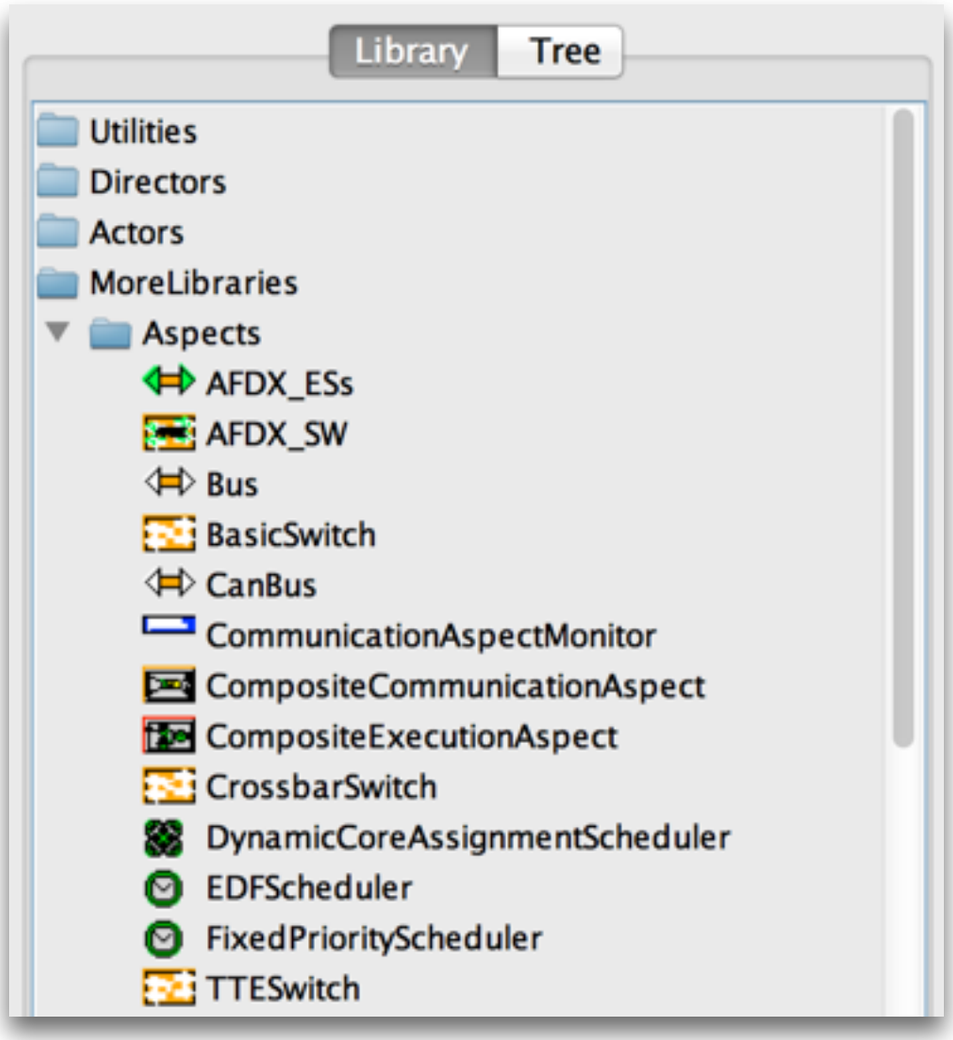


- Aspects work in a small set of Models of Computations (DE, Continuous, Ptides, SDF)

CURRENT STATE AND FUTURE WORK

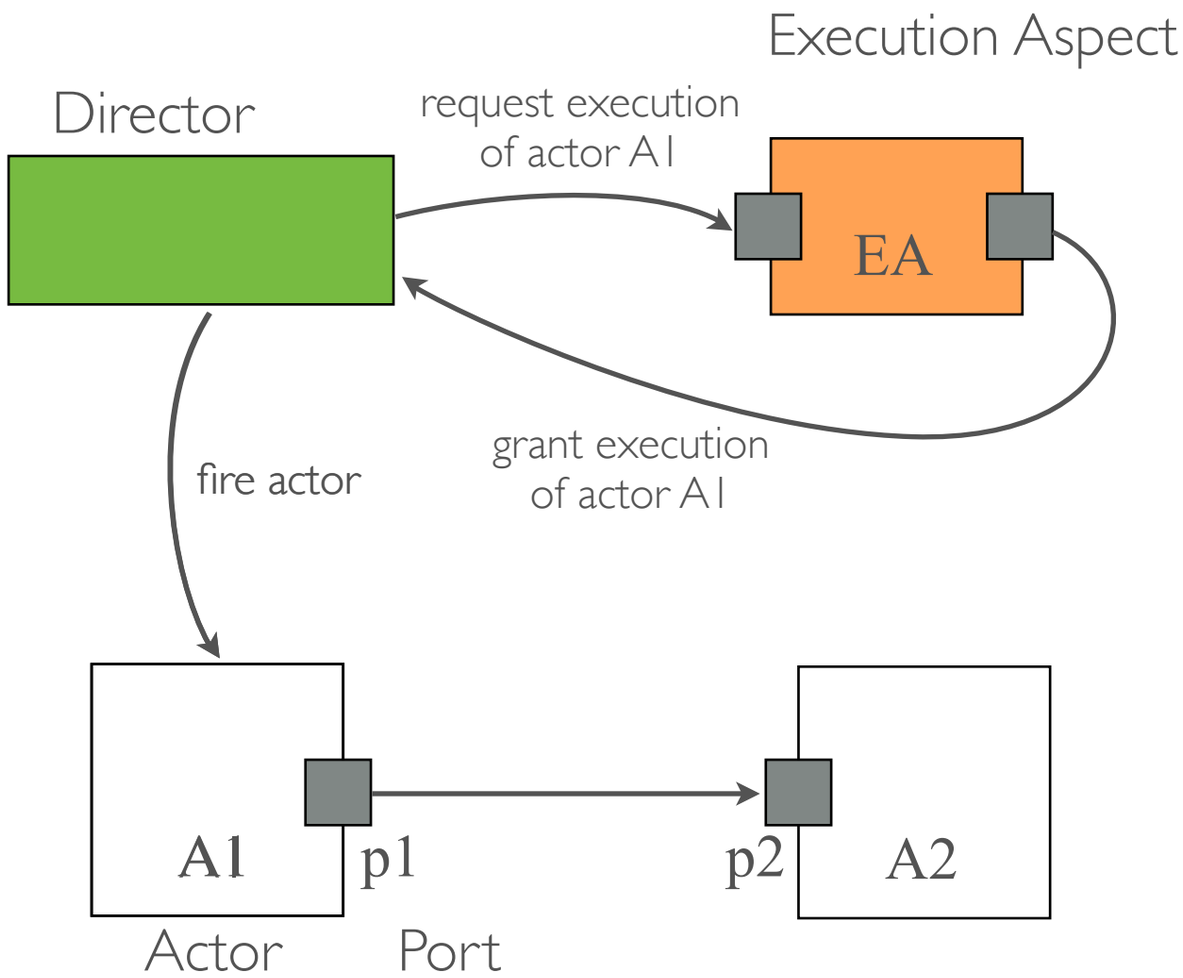
- Support for other MoCs

- Additional aspects:
  - Initialization aspect
  - After-actor-execution aspect



THANKS

EXECUTION ASPECTS



- DE Director
  - get event with smallest timestamp

    contact EA
  - fire actor corresponding to event
- SDF Director
  - compute static schedule

    contact EA
  - execute next actor in schedule