Models for representing broadcast and multicast communication

August 17, 2011

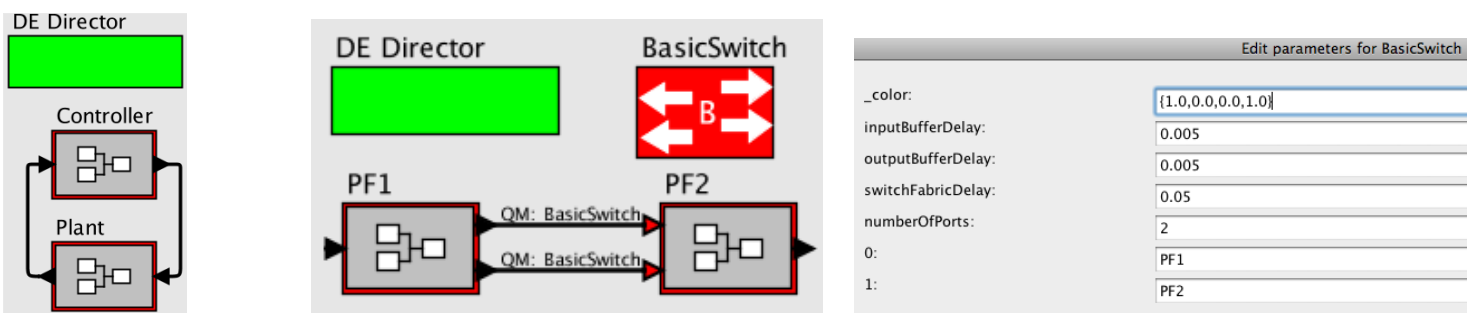
1 Goal

The goal of this project is to implement broadcast and multicast communication in models of networked cyber-physical systems (CPS). The modeling environment used in this project is Ptolemy II [Lee03]. These communication mechanisms will allow for analysis of network latencies through simulation.

In a first step, existing networks should be modeled. In a second step, smarter networks should be investigated that allow for deterministic communication in CPS.

2 A networked CPS

Ptolemy [Lee03] is an open source modeling and simulation tool for heterogeneous models of computation. Ptolemy models are actor-oriented. A simplified Ptolemy model of a networked CPS is shown in Figure 1.a. It contains a plant model and a controller model implemented over a network. In this example, two messages are sent from platform PF1 to platform PF2.



a) b) c)

Figure 1: a) A model of a CPS, b) A controller over a network, c) Switch parameters

3 Quantity Manager

One mechanism to model networks in Ptolemy as of now is by using quantity managers. Four quantity managers representing network elements are implemented [Der11, Der11a]: Bus, TTESwitch, BasicSwitch, CrossbarSwitch. Quantity managers were introduced in Metropolis [Bal03]. They allow modeling of physical properties on top of a functional model in an aspect-oriented way. Consider the model in Figure 1.b: i) the *functional* connections between actors PF1 and PF2 are represented by the lines between the actors, ii) the

physical connections are described in the parameters of the quantity manager as well as in parameters of the functional connection.

In Figure 1.b, a switch is used as a network element. The parameters to configure the switch are the number of ports and the delays introduced by the switch (inputBufferDelay, outputBufferDelay and switchBufferDelay) as depicted in Figure 1.c. The designer needs: i) to specify which actor is connected on which port, ii) and declare which network elements are used on functional connections. The latter is done by specifying the network elements at input ports of actors receiving data from these devices. In Figure 1.b this is specified on input ports of PF2.

4 Designing and Testing

The multicast and broadcast communication mechanisms should take into account the different delays (input and output queueing, switch fabric delay, processing time for packets). The multicast model should provide an user-friendly interface for specifying information such as: the group of destination computers, the network topology, and scheduling of messages on the network. Scheduling can be done based on arrival time, deadline, priority or other information specified by the sender. Constraints on network components such as buffer sizes have to be taken into consideration.

Using the simulation framework, different scenarios (periodic messages, sporadic messages, message bursts) should be tested to evaluate how the delay variation modifies the control behavior. A *plus* in this project would be to compare these results with the worst case analytical delays using, for example, the Network Calculus [Cru91, Wop10].

References

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