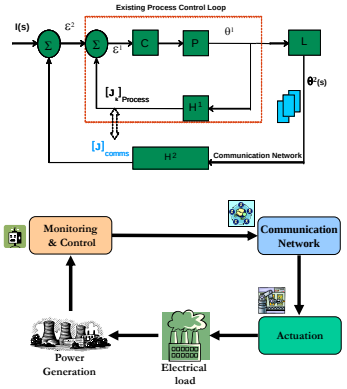
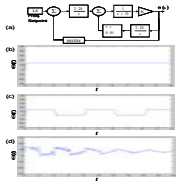
Toolkit for Hybrid Systems Modeling and Evaluation

THYME: Simulating Large-Scale Networked Physical Systems

Control Over Communication Systems

- A new generation of large scale, geographical distributed systems are beginning to emerge in which actuation, sensing, and control processes are separated by data communication networks
- Working examples of these systems are found in electric power grids, automotive controls, and manufacturing processes
- Modeling and simulation is essential for successfully designing next generation systems of these communications dependent systems

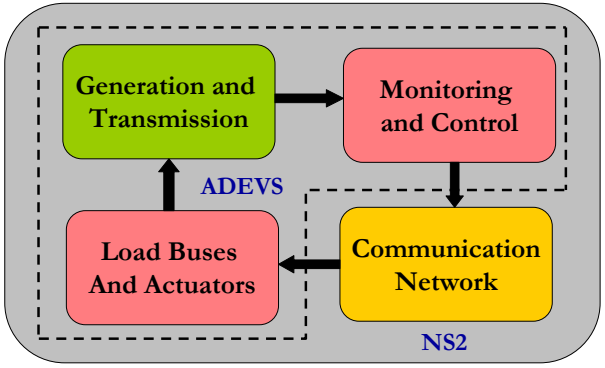




The Goal

To build simulation software for complex hybrid systems that incorporates

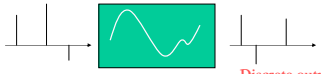
- Non-trivial continuous models with state events
- Includes large discrete event sub-components packet-level network models
- Numerically robust
- Computationally efficient



Technology Pathway

Thyme is an extensible framework for integrating continuous and hybrid system models into NS2 simulations. It includes a small set of numerical integration schemes for solving ordinary differential equations and can be easily extended by end users who require specialized or especially robustness continuous system simulation algorithms.

Solution: Continuous sub-systems with Discrete event I/O



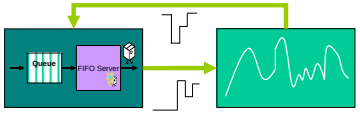
Discrete input arrives from discrete event sub-systems

Discrete output specified by state and time events
Event condition: g(x,t) = 0

Internal dynamics described by DAE or ODE with zero crossing function for state event detection

Integrating discrete/continuous models

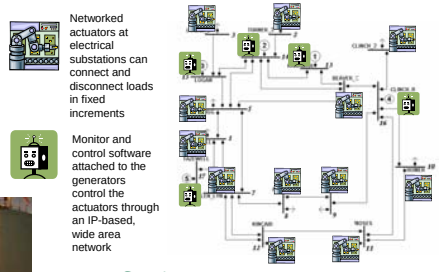
- Overarching simulation is discrete event
- Continuous sub-systems are simulated with embedded numerical algorithms



"Complex" discrete events dynamics

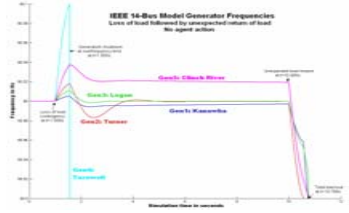
Continuous models with state events and other "simple" discrete event dynamics

Demonstration

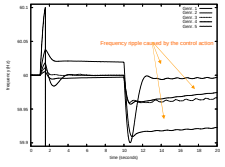


Networked actuators at electrical substations can connect and disconnect loads in fixed increments

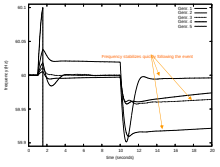
Monitor and control software attached to the generators control the actuators through an IP-based, wide area network



Case 1:
130 ms, 1 Mbps



Case 2:
20 ms, 256Kbps



THYME is :

- for simulating network-centric systems with continuous and discrete event sub-components
- for building comprehensive, integrated modeling of networked controllers and plants
- designed for easy extension by end users who require specific continuous system simulation algorithms
- based on the NS2 and ADEVS open source simulation packages