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.

Automotive  Telecommunications

E-Corner, Siemens  Daimler Chrysler

Military Systems  Instrumentation

Transportation (Air traffic control at SFO)  Courtesy of Kuka Robotics Corp.

Building Systems  Transportation (Air traffic control at SFO)

Factory automation

Power generation and distribution

Courtesy of Doug Schmidt  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

- **Platform time progresses**
  - **增加时间戳**
  - **timestamp \leq platform time**

- **Platform time progresses**
  - **send time stamp and value and over network**

- **Logical time**
  - **timestamp \geq platform time**

- **Response time \leq logical time delay**

- **Time stamp = platform time**
  - **t_{i} + d_{4} + e_{1}**
  - **t_{i} + e_{1}**
  - **t_{2} + e_{2}**
  - **t_{i} + d_{4} + d_{2}**

- **Platform time**

- **Physical interface**
  - **physical interface**

- **Send time stamp and value**

- **Physical plant**

- **Local Event Source**
  - **Computation 4**

- **Merge**
  - **Actuator 1**

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EXPLICIT SPECIFICATION OF TIME

response time = d4 + d2
EXPLICIT SPECIFICATION OF TIME

- Behavior independent of distribution

response time = d4 + d2
PARALLEL EXECUTION
Safe-to-Process Analysis

Event = (timestamp, event)

Can an event at this port arrive with a smaller timestamp later in the execution?
Evaluate other events, Sensor input patterns, delays, dependencies, actor topologies, scheduling strategy, ...
PARALLEL EXECUTION
PARALLEL EXECUTION

Single Core
PARALLEL EXECUTION

Multi Core
PTIDES WORKFLOW

Analysis

Schedulability Analysis

Causality Analysis

Program Analysis

Pts Model

Code Generator

Code

PtidyOS

HW Platform

Software Component Library

Mixed Simulator

Plant Model

Network Model

HW in the Loop Simulator

Reserve Velocity (red), Target Velocity (green) and Tracking Error

Time in seconds

Velocity m/s

Contact (red), Top Dead Center (green), Cut (blue) and Arm (black)

Time in seconds

Events
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**

- e.g. Communication takes time
  - Bus, Switch, Priorities, ...

QM for **Execution**

- e.g. Execution takes time
  - Scheduling strategies: EDF, FP, ...
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

Avionics Full-Duplex Switched Ethernet

Collisions, Multicast, Priorities

Deterministic QoS

cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/CANBus/CANBus.xml
cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/AFDX/AFDX.xml
QM for Communication - Model
cd $PTII; java ptolemy.vergil.VergilApplication ptolemy/actor/lib/qm/demo/CompositeQM/CompositeQM.xml
cd $PTII; java ptolemy.vergil.VergilApplication $PTBook/modelingTime/Models/ResourceScheduler.xml
Co-Simulation

Functional Model

Architecture Model
Co-Simulation

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