From PTIDES to PtidyOS: Programming Distributed Real-Time Embedded Systems

Ptides Design Flow

- Is a library linked against application C code.
- Implements Ptides semantics
- Local execution strategy includes a safe to process analysis and resource scheduling layer.
- Uses a Single Stack
- Steps away from threading model
- To ensure event of highest priority is always processed first, interrupts play an important role:
  - Event processing is done within Interrupt service routines
  - Reentrant interrupts
- No dynamic memory allocation.

Ptides Simulator

Simulate functional and real-time properties.
Function simulation:
- Same denotational semantics as DE simulation, i.e., Same functional outputs whether Prides or DE Director is used.
- Performs safe-to-process analysis instead of DE simulation
- Currently support 2 Ptides execution strategies: Basic, PreemptiveEDF (combines Ptides with Earliest-Deadline-First).

Real-time simulation:
- Users annotate WCET and sensor delays.
- Check for deadline misses at actuators.

PtidyOS

- Code Generation

Ptides Simulator

Sensor Delay $d_s = 0.5$

$\tau \leq t + d_s$ $\Rightarrow$ WCET: 2.0

$\tau \leq t$ $\Rightarrow$ WCET: 1.0

$t$ is the platform physical time an event is delivered from the sensor to the rest of the platform. $\tau$ is the timestamp of the sensor event.

$\tau \leq t$ is the platform physical time an actuation event is delivered to the actuator. $\tau$ is the timestamp of the actuation event.

Event Processing Algorithm Sequence Diagram

Clock Synchronization Simulation

Notions of Time:
- Top level simulate real world (oracle)
- Physical time.
- Each platform contains a clock to keep track its notion of platform physical time.
- Each Ptides director has a notion of model time.

Simulation of platform clock Synchronization:

Slave's platform clock tracks master's platform clock, as shown on the output graph:

Application: The Tunneling Ball Device

- Balls drop above a rapidly spinning disc
- Device must adjust disc to allow ball to pass through a small hole, without stopping disc

WCET:
- 2.0
- 1.0

Sensor Delay:
- $d_s = 0.5$
- $d_s = 0.5$

$\tau$ is the timestamp of the sensor event.

$\tau \leq t$ is the timestamp of the actuation event.