Cyclic Executive for Safety-Critical Java on Chip-Multiprocessors

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OUTLINE

- Cyclic executive
  - Advantages and disadvantages
- Cyclic executive on a CMP
- Schedule generation
- Implementation for SCJ
- Summary

CYCLIC EXECUTIVE

- Static schedule of tasks
- No preemption
- Organized in minor and major cycles
- Used in safety-critical applications

ADVANTAGES

- Deterministic schedule
- Easy communication & precedents constraints
- Simple implementation
- Simple context switch
- Fewer context switches
- WCET friendly

DISADVANTAGES

- Constraints on task periods
  - Long running tasks need to be split
- Deadline miss influences all tasks

WCET ANALYSIS

- Considers individual tasks
- Scheduling effects are usually ignored
  - Cost of preemption and dispatch
  - Cost of scheduling
  - Cache trashing due to a task switch
- Analysis works well for CE

SAFETY-CRITICAL JAVA

- Three levels:
  - L0 cyclic executive
  - L1 preemptive, static schedule, single mission
  - L2 nested missions
- CMP considered only for L1 and L2

CYCLIC EX. ON CMP

- Keep the CE advantages and relax constraints
  - Long running tasks can have their own CPU
  - Schedules are synchronous on the cores
- Tasks are allowed to migrate
  - Cheap on chip-multiprocessors

Migration example

- Two processors
- Three tasks
- Schedulable only with migration of task A

	T	C
Task A	2	1
Task B	4	3
Task C	4	3

Core 1	A	B	B	B
Core 2	C	C	C	A

Shared resources

- Easy on uniprocessor CE
- Options for CMP CE
  - Locks with blocking (spin lock)
  - Precedence constraints in the schedule
  - Non-blocking queues between tasks

PRECEDENCE CONSTR.

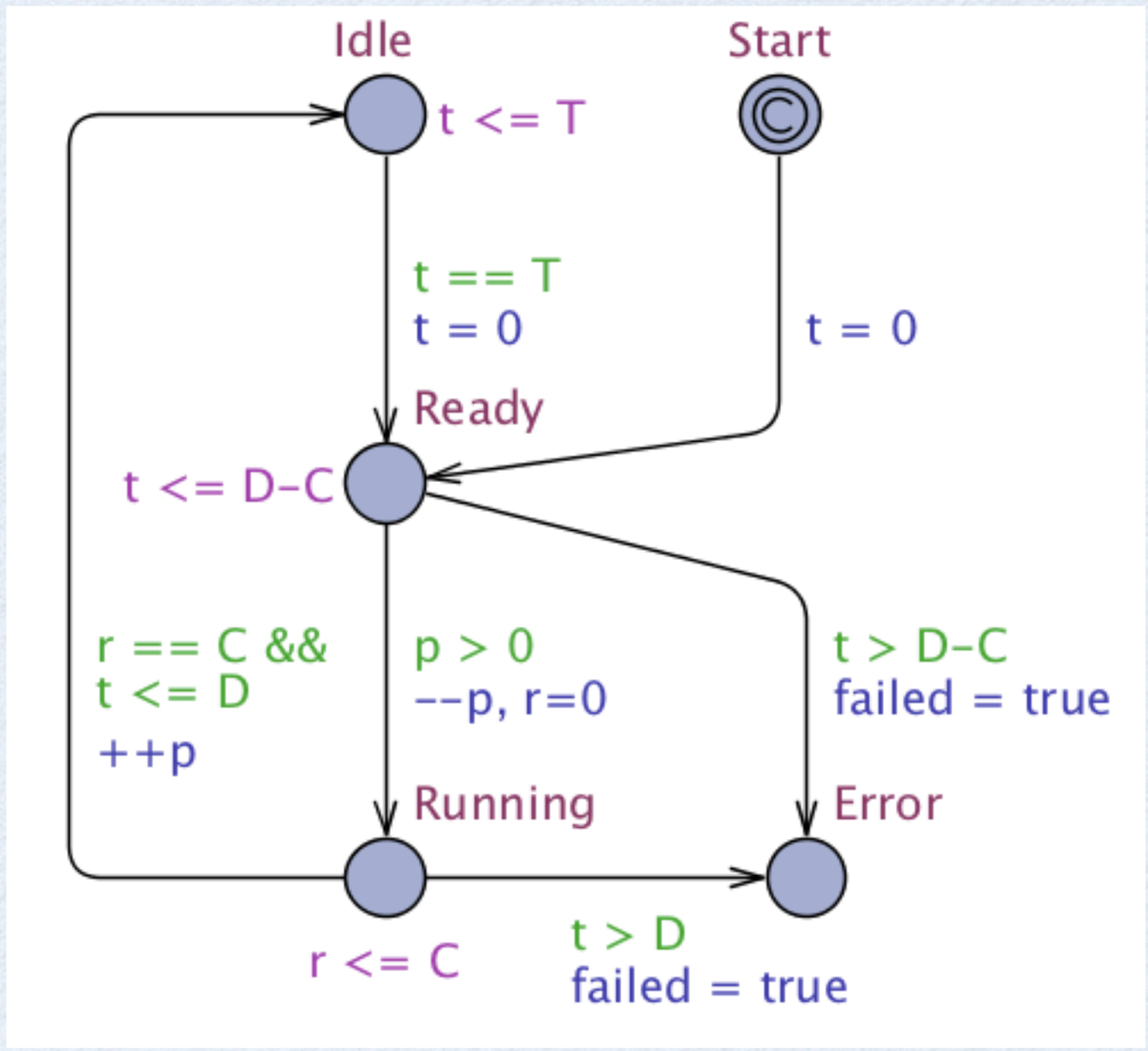
- Tasks that share a resource
  - One writes, another reads or writes
    - Not allowed to run in parallel
- Part of the schedule generation
- More schedule flexibility with simple task model: read - execute - write

SCHEDULE GENERATION

- Schedule generation is NP-complete
  - We use model checking (UppAal)
- No restrictions on minor frames
- Each task represented by one automaton
- Check the tasks until global $t > SCM(T_i)$
  - Results in one possible schedule or failure

UPPAAL MODEL

- One automaton per task
- Parameterized with
  - T, C, and D
- Number of processors: p
- Local time: t
- Local execution time: r



IMPLEMENTATION

- Prerequisites
  - Common passive fine grain clock
    - No interrupts needed
- Schedules are synchronous
- Schedule is a simple table of slot times and Runnables

Implementation

- Use a Java CMP (JOP)
- Each core has its own clock
- Scheduler in Java - just a few lines of code
- Deadline overrun can be querried

DEPARTURE FROM SCJ

- CMP at Level 0 ;-)
- Runnable instead of BAEH
- Task migration is allowed
- One Runnable per Frame
- Overrun detection (late)
- getCurrentProcessor()

SUMMARY

- Cyclic executive on a CMP combines
  - deterministic schedule with
    - more processing power
- Model checking used for schedule generation
- Runtime implementation is very simple