CSC9006: Real-Time Systems

Lecture 2: Real-Time Operating Systems

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Background

- The concept of *image*
- Predictability vs. Responsiveness
- Task: an execution of a (sequential) program
- Middleware

- A *design* or an *implementation*?

Task Model

- Simple task (S-task)
- Time-triggered vs. Event-triggered
- Task scheduling
  - Static scheduling (off-line scheduling)
  - Dynamic scheduling (on-line scheduling)

Inter-Task Interactions

- A quick review:
  - Data integrity, Critical section, and Race condition

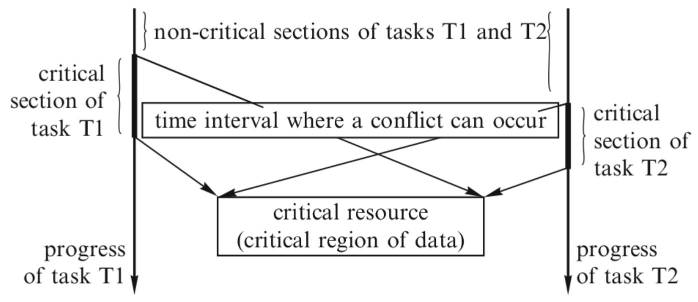

non-critical sections of tasks T1 and T2
critical section of task T1
time interval where a conflict can occur
critical section of task T2
critical resource (critical region of data)
progress of task T1
progress of task T2

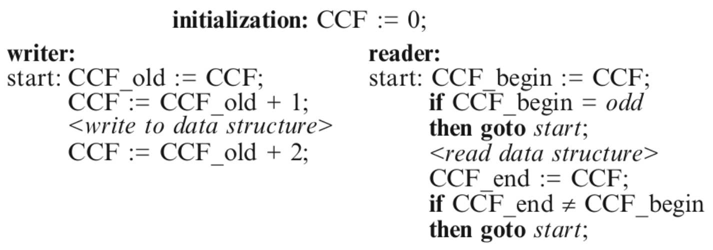
Fig. 9.3 Critical task sections and critical data regions

Static Schedule and Access Control

- Coordinated static schedules
- Access control
  - Semaphore
  - Mutex
  - Spinlock

Non-Blocking Write Protocol

- The single writer is never blocked
- Readers may need to retry
- Atomic access to the CCF (concurrent control field) is guaranteed by hardware



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initialization: CCF := 0;

writer:
start: CCF_old := CCF;
       CCF := CCF_old + 1;
       <write to data structure>
       CCF := CCF_old + 2;

reader:
start: CCF_begin := CCF;
       if CCF_begin = odd
       then goto start;
       <read data structure>
       CCF_end := CCF;
       if CCF_end ≠ CCF_begin
       then goto start;
```

Fig. 9.4 The non-blocking write (NBW) protocol

Process Input/Output

- Analog I/O vs. Digital I/O
- Interrupts

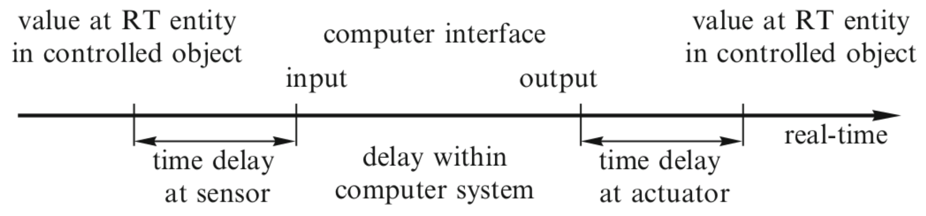

Fig. 9.5 Time delay of a complete I/O transaction

Considerations for fault-tolerant I/O

- Fault model
- Triple modular redundant (TMR)
- Agreement protocols
  - syntactic vs. semantic

Error Detection

- Time-domain error detection vs. value domain error detection
  - Monitoring task execution times and interrupts
  - Double execution of tasks
  - Watchdogs

POSIX, POSIX.4, and Pthreads

- POSIX: Portable Operating System Interface
- POSIX.4: Real-Time Extension for Portable Operating Systems
- Pthreads: POSIX threads

(In-class live demo)