Lecture 5: Monitors and protected objects

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Questions?

- Reminder: course rep meeting after lecture
  - GU students: find a course rep if needed
  - All: give your rep some notes, suggestions, etc. during the break
- Anything you want to say
  - Comments, questions, stray thoughts, etc.
  - Are we too fast/slow?
- More reminders
  - Joined the google group. You must, to mail us and get replies
  - Please don't mail us at our personal addresses
  - Found a lab partner? Ask tutors for help if needed

Plan for today

- Chap 6: recap
- Chap 7
  - Monitors (contd.)
  - protected objects
- Transition to message passing

Chap 3 & 4 (skipped for now)

REMINDER: do the exercises in Chaps. 1, 2, 3, 6

Semaphore recap

- Designed for CS problem or atomic actions
  - (even with n-proc)
  - Avoid busy waiting
- But for the producer-consumer problem
  - The correctness of each proc
    - Depends on the correctness of the other
  - Not modular
- Monitors modularise synchronisation
  - for shared memory

Correctness of semaphore programs

- Look at state diagram (p 112, s 6.4)
  - Mutex, because we don't have a state (p2, q2, ..)
  - No deadlock
    - Of a set of waiting (or blocked) procs, one gets in
    - Simpler definition of deadlock now
      - Both blocked, no hope of release
  - No starvation, with fair scheduler
    - A wait will be executed
    - A blocked process will be released

Recap completed: examples

- We did
  - producer-consumer
    - Finite and infinite buffers
  - Dining philosophers

Different kinds of semaphores

- ”Strong semaphores”
  - use queue insteadof set of blocked procs
    - No starvation
- Busy wait semaphores
  - No blocked processes, simply keep checking
    - See book re problems about starvation
  - Simpler.
    - Useful in multiprocessors where each proc has own CPU
      - The CPU can’t be used for anything else anyway
    - Or if there is very little contention

Monitors = synchronised objects

- A type of monitors looks like a class with sync
- An operation on a monitor
  - Looks atomic
  - All operations are mutex w.r.t. each other
    - i.e., only one operation at a time
- So alg 7.1 can only result in n=2 at the end.

Confusions with O-O programming

- Monitors are static
  - They don’t ”send messages” to each other
- Processes are the running things
  - They can enter the monitor one at a time
  - There is no queue of processes waiting to get in,
    - Only a set

Monitors centralise

- Access to the data
  - Natural generalisation of objects in OO, but
    - With mutex
    - With synchronisation conditions
- Could dump everything in the kernel
  - But this centralises way too much
    - So monitors are a compromise

Condition Variables = named queues

- Mutex?
  - Monitors provide it, by definition (See alg 7.1)
- But often, need explicit synchronisation
  - i.e., processes wait for different events
    - Producer waits till (someone makes) buffer notFull
    - Consumer waits till (someone makes) buffer notEmpty
  - They need to be unblocked
    - when the corresponding event occurs
- In monitors, each such event
  - Has a queue associated with it
    - In fact, for the monitor, the ”event” ***is*** just the queue
    - These queues are called ”condition variables”

Semaphore implemented by monitor

- Alg 7.2
- No explicit release of monitor lock
  - Leave when done
- waitC always blocks
  - This is not the semaphore's wait
  - When unblocked by signal
    - Must wait till signalling proc leaves monitor
- signalC has no effect on empty queue
  - Semaphore signal always has an effect

waitC(cond)

Append p to cond

p.State <- blocked

Monitor release

signalC(cond)

If cond not empty

    q <- head of queue

    ready q

Correctness of semaphore

- See p 151
- Exactly the same as fig 6.1 (s 6.4)
- Note that state diagrams simplify
  - Whole operations are atomic

Producer-consumer

- Alg 7.3
- All interesting code gathered in monitor
- Very simple user code

Immediate resumption

- So signalling proc cannot again falsify cond
  - If signal is the last op, allow proc to leave?
    - How? See protected objects
- Many other choices possible
  - Check what your language implements

Readers and writers

- Alg 7.4
- Not hard to follow, but lots of detail
  - Readers check for no writers
    - But also for no blocked writers
      - Gives blocked writers prioroty
    - Cascaded release of blocked readers
      - But only until next writer shows up
  - No starvation for either reader or writer
- Shows up in long proof (sec 7.7, p 157)
  - Read at home!

Dining philosophers again

- Alg 7.5

Protected objects

- Monitors need waitC and signalC programmed
- Protected objects combine this with queueing
- See alg 7.6 for readers-writers
  - Each operation starts only when its cond is met
    - Called a ”barrier”
  - What happened to signalC?
    - When any op exits, all barriers are checked

Protected objects (contd.)

- See alg 7.6 (p 164, s 7.16)
- Tidies up the mess
  - No separate condition variables
    - Or queues for them
    - Or detailed choices ”immediate release”, etc.
- The simplicity of 7.6 is worth gold!
  - Price: starvation possible
  - Can be fixed, at small price in mess (see exercises)

Ada

- Uses protected objects
  - Since the 1980's
    - though the concept was around earlier
  - Thus has the cleanest shared memory model
- Also has a very good communication model
  - Rendezvous
- Ada was decided carefully through the 1970s
  - Open debates and process of definition
- Has fallen away because of popularity of C, etc.
  - Use now seen as a proprietary secret!

Transition

- Why do we need other models?
- Advent of distributed systems
  - Mostly by packages such as MPI
    - Message passing interface
- But Hoare 1978
  - arrived before distributed systems
  - I see it as the first realisation that
    - Atomic actions, critical regions, semaphores, monitors…
    - Can be replaced by just I/O as primitives!

2010 Valiant, Leslie G ‹**1999** Brooks, Frederick

1998 Gray, Jim

1997 Engelbart, Douglas (Doug)

1996 Pnueli, Amir*

1995 Blum, Manuel

1994 Feigenbaum, Edward A
1994 Reddy, Raj

1993 Hartmanis, Juris
1993 Stearns, Richard E

1992 Lampson, Butler W

1991 Milner, A J (Robin)*

1990 Corbato, Fernando J

2009 Thacker, Charles P

2008 Liskov, Barbara

2007 Clarke, Edmund M
2007 Emerson, E Allen
2007 Sifakis, Joseph

2006 Allen, Frances

2005 Naur, Peter

2004 Cerf, Vinton
2004 Kahn, Robert E

2003 Kay, Alan

2002 Adleman, Leonard M.
2002 Rivest, Ronald L
2002 Shamir, Adi

2001 Dahl, Ole-Johan*
2001 Nygaard, Kristen*

2000 Yao, Andrew C

1989 Kahan, William

1988 Sutherland, Ivan

1987 Cocke, John*