Concurrency (Part IV):
Mutual Exclusion, **Synchronization (Finish)**, **Deadlock, and Starvation**

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CSCI 460 Operating Systems
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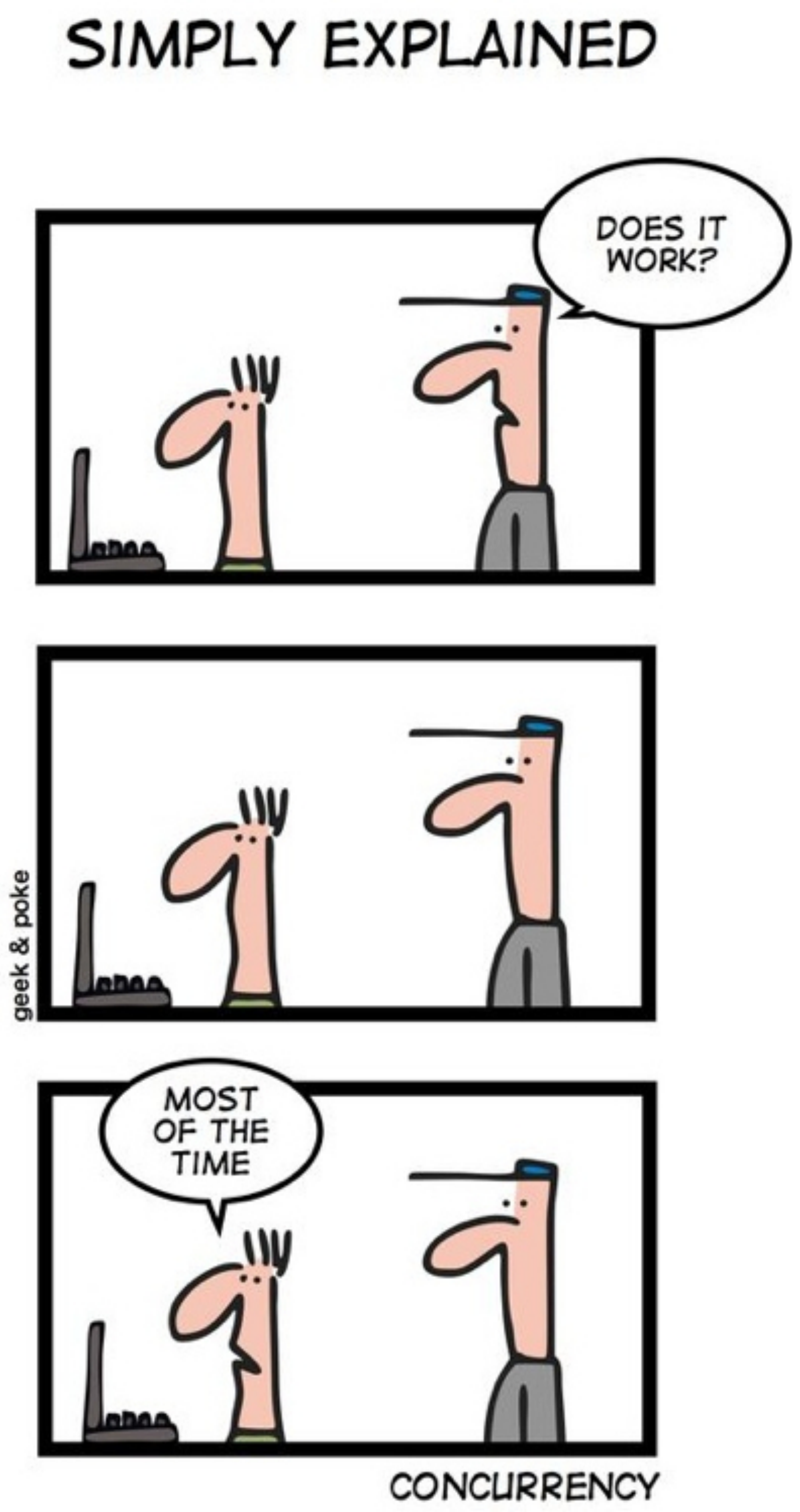


–http://www.datamation.com/news/tech-comics-quantum-physics-2.html

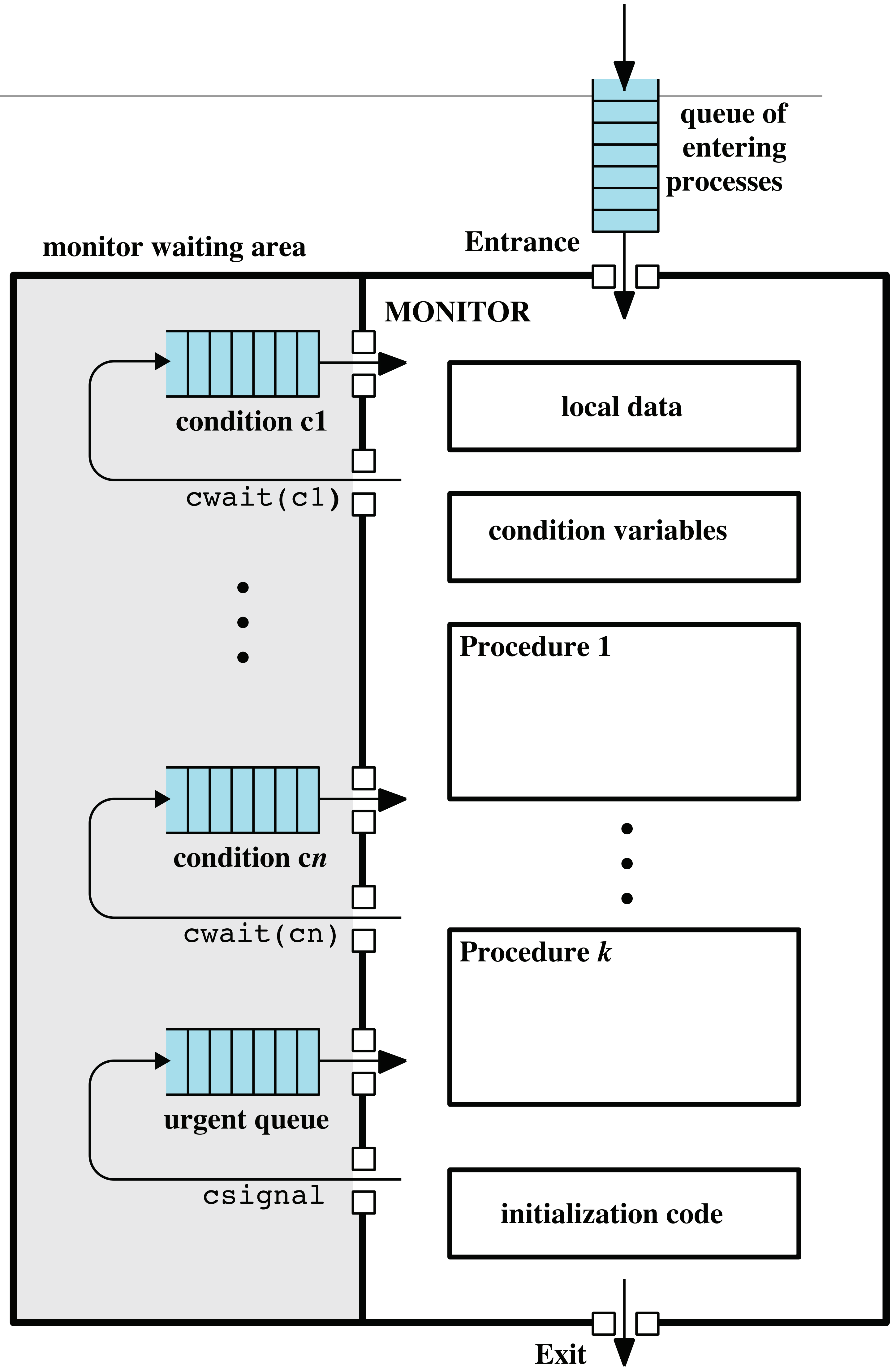
Some slides & figures adapted from Stallings instructor resources.

Some slides adapted from Adam Bates's F'18 CS423 course @ UIUC
https://courses.engr.illinois.edu/cs423/sp2018/schedule.html

Monitors

- A SW module consisting of…
  - an initialization sequence
  - 1+ procedures *—the only way for a process to enter the monitor*
  - local data *—accessible only by monitor’s procedures; similar to objects in OOP*

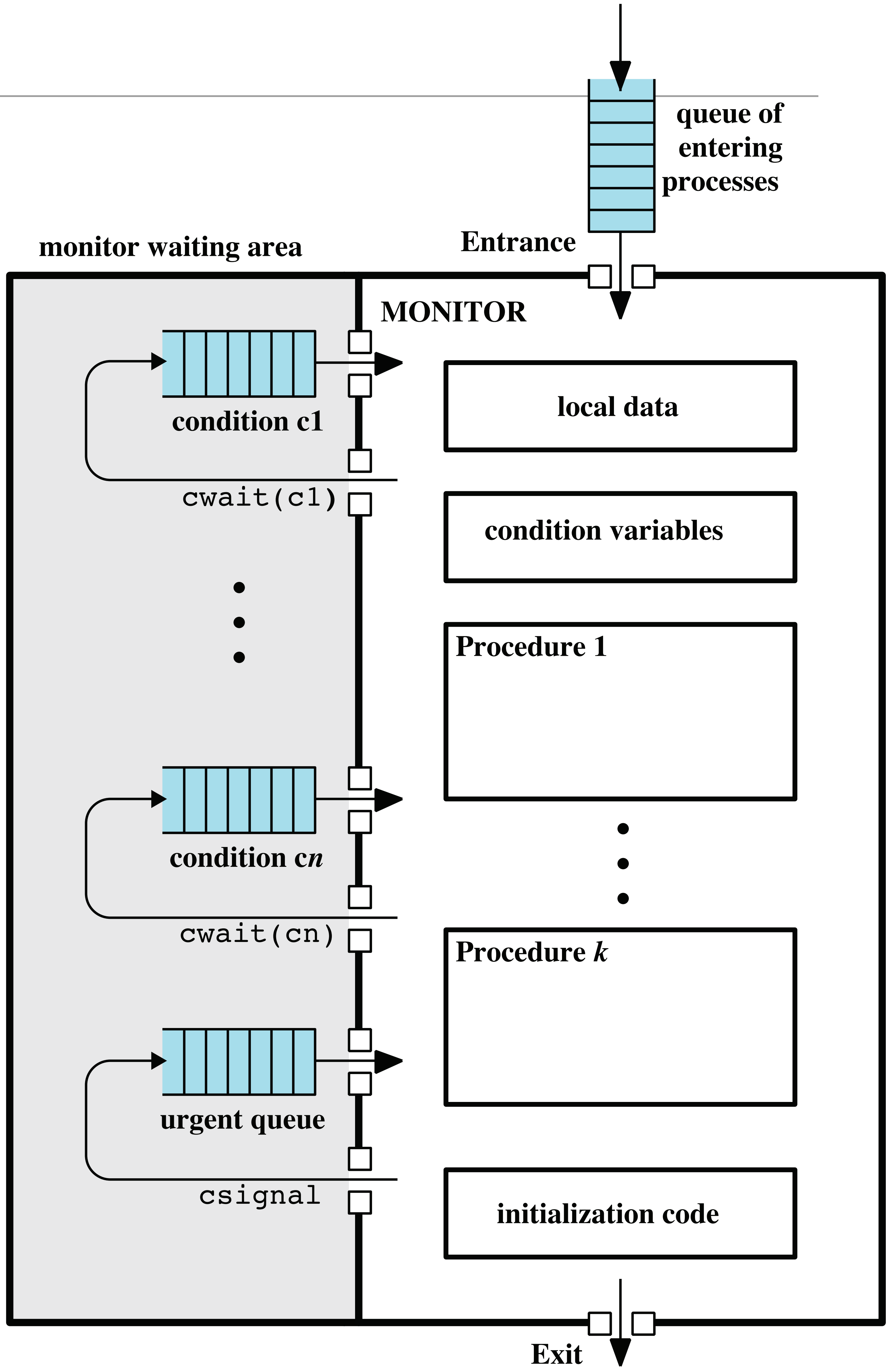
- Eqivalent to semaphores, but easier!
  - Only one process may execute within the monitor at a time;
    all other processes are blocked until it becomes available again
    => Mutual Exclusion by design!
  - Synchronization achieved via **condition variables**.
    - Used to represent a condition that needs to be waited on until the condition is True
    - No “value”
    - Think of it as a waiting queue (initial “non-value” = Empty)

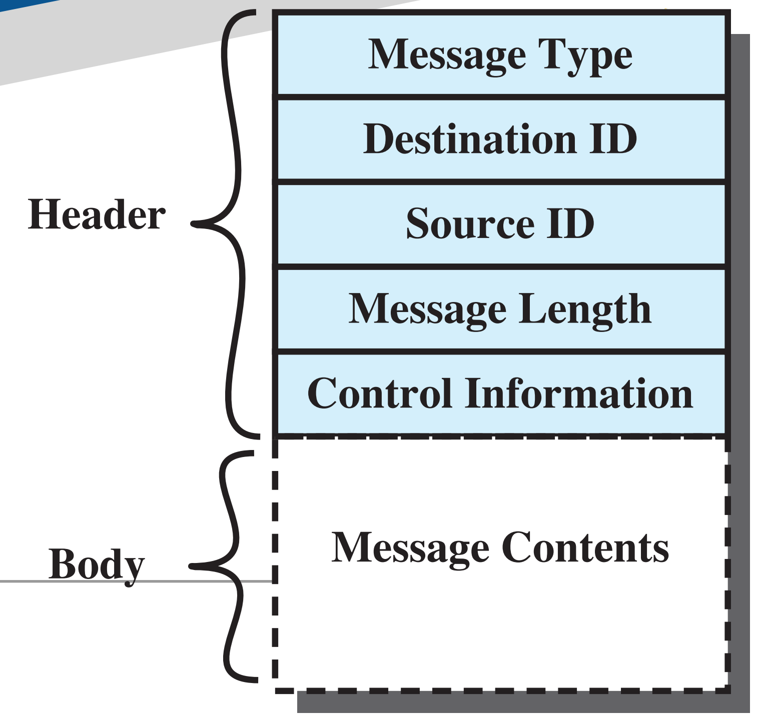


Monitors *(cont.)*

- <u>Hoare-Style</u>
  - Block caller (signaller) *immediately* and run the next waiting proc
  - Operations for condition variables (cvar):
    - `cwait( cvar )` *//suspend caller on condition `cvar`*
    - `csignal ( cvar )` *//resume some process waiting on condition `cvar`*
  - **Questions:** Advantages? Limitations? Drawbacks? Potential improvements?

- <u>Mesa-Style</u>
  - Called (signaller) keeps running and retains access to the monitor
  - Waiter placed on ready queue
  - *On resume, need to re-check conition!*
  - Operations for condition variables (cvar):
    - `notify( cvar )` *//resume the next waiting process at some convenient time (later)*
    - `broadcast ( cvar )` *//all procs waiting on cvar get moved to a ready state/queue*
  - **Questions:** Advantages? Limitations? Drawbacks? Potential improvements?



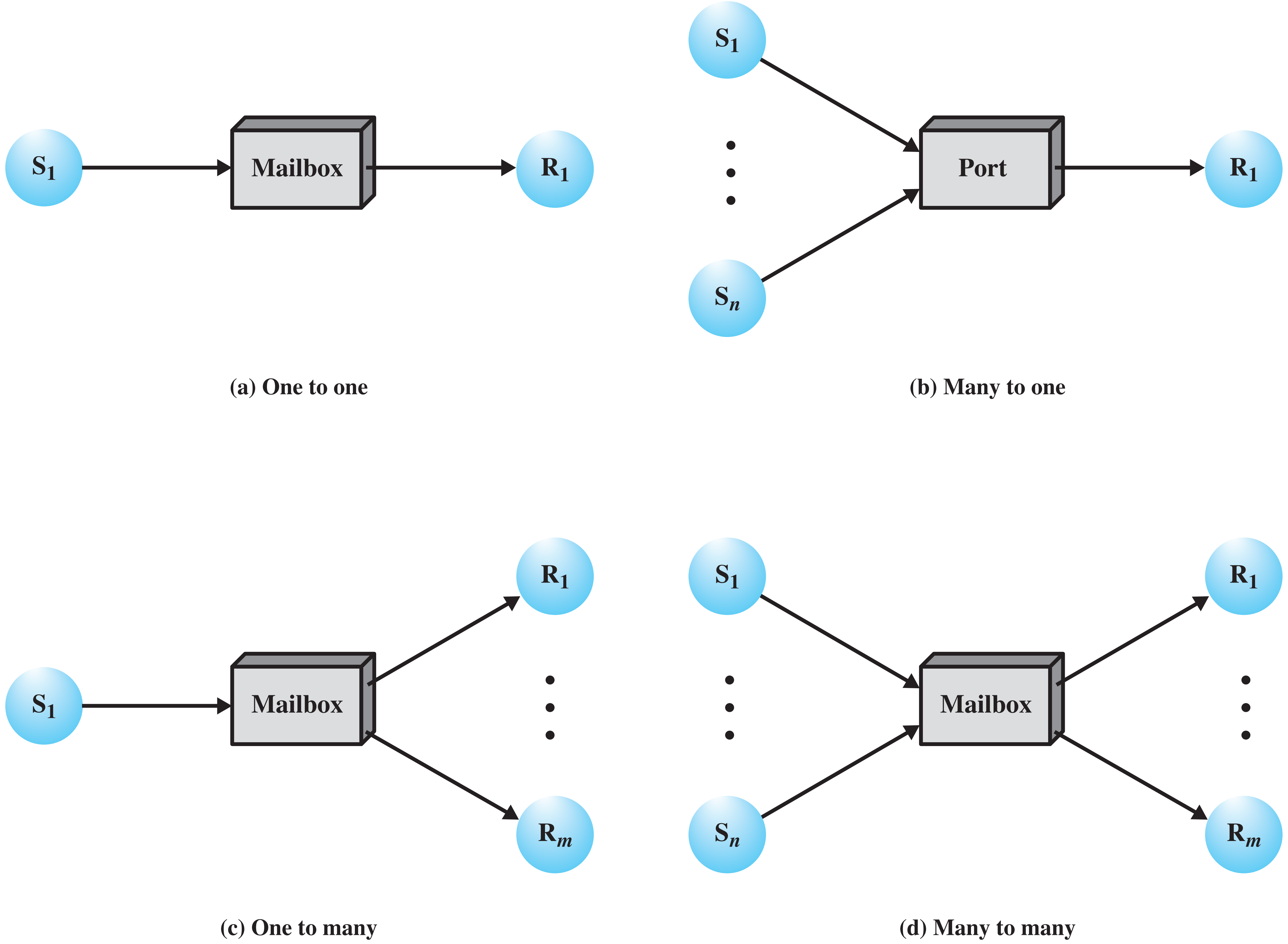


Message Passing

- Operations
  - `send( dest, msg )`
  - `receive ( src, msg )`
- Operations come in diffferent flavors…
  - blocking send, blocking receive *(a.k.a. "rendezvous")*
  - nonblocking send, blocking receive *(most common)*
  - nonblocking send, nonblocking receive
- Addressing
  - direct addressing (e.g., specific process ID known)

    vs.

    indirect addresses (msgs sent to shared mailbox)



(a) One to one

(b) Many to one

(c) One to many

(d) Many to many

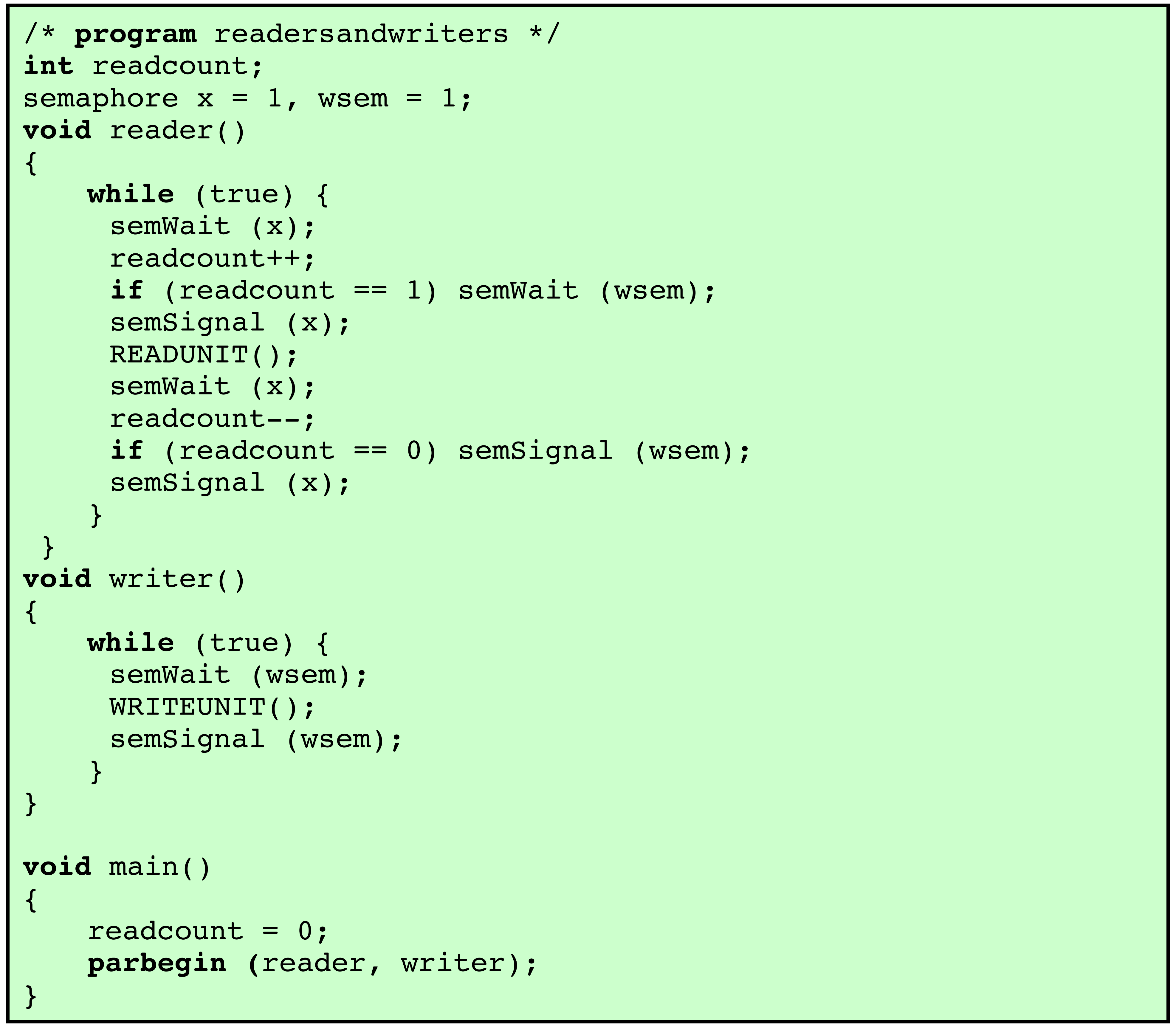
Examples?

Be sure to review solutions for, e.g., Produce/Consmer with different styles of monitors, message passing schemes, etc.

Readers/Writers Problem

- Each process is either a ***reader*** or a ***writer***
- Both readers and writers share access to a data object
  (e.g., file, database)
- Multiple readers can access the data object simultaneously
- Each writer must have exclusive access
  (i.e., cannot share w/ readers OR any other writer)

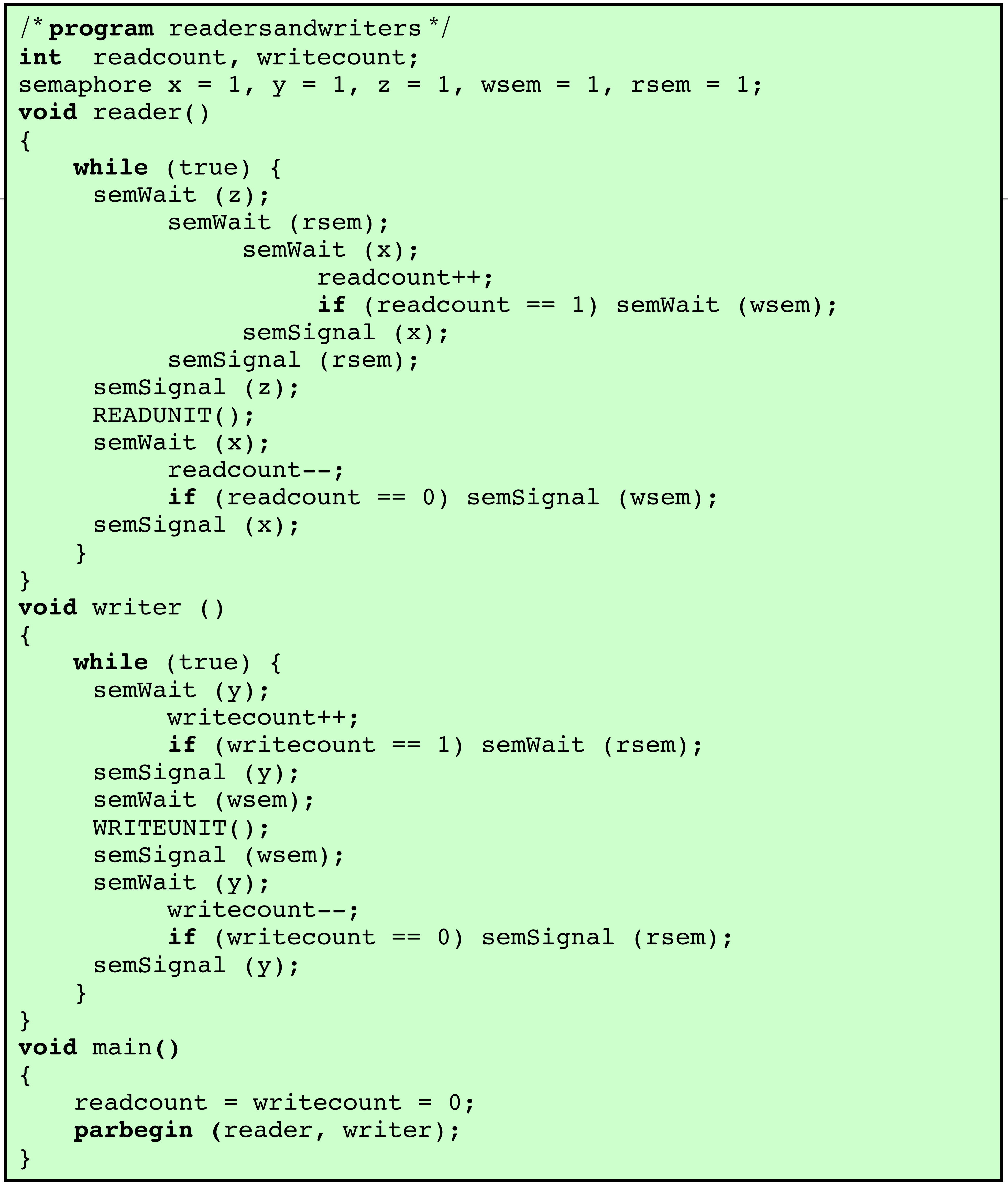
Readers/Writers Problem



```
/* program readersandwriters */
int readcount;
semaphore x = 1, wsem = 1;
void reader()
{
    while (true) {
     semWait (x);
     readcount++;
     if (readcount == 1) semWait (wsem);
     semSignal (x);
     READUNIT();
     semWait (x);
     readcount--;
     if (readcount == 0) semSignal (wsem);
     semSignal (x);
    }
 }
void writer()
{
    while (true) {
     semWait (wsem);
     WRITEUNIT();
     semSignal (wsem);
    }
}

void main()
{
    readcount = 0;
    parbegin (reader, writer);
}
```

Priority goes to readers…



```
/* program readersandwriters */
int  readcount, writecount;
semaphore x = 1, y = 1, z = 1, wsem = 1, rsem = 1;
void reader()
{
   while (true) {
    semWait (z);
        semWait (rsem);
            semWait (x);
                readcount++;
                if (readcount == 1) semWait (wsem);
            semSignal (x);
        semSignal (rsem);
    semSignal (z);
    READUNIT();
    semWait (x);
        readcount--;
        if (readcount == 0) semSignal (wsem);
    semSignal (x);
   }
}
void writer ()
{
   while (true) {
    semWait (y);
        writecount++;
        if (writecount == 1) semWait (rsem);
    semSignal (y);
    semWait (wsem);
    WRITEUNIT();
    semSignal (wsem);
    semWait (y);
        writecount--;
        if (writecount == 0) semSignal (rsem);
    semSignal (y);
   }
}
void main()
{
   readcount = writecount = 0;
   parbegin (reader, writer);
}
```

Priority goes to writers…