ECE3140 / CS3420
Embedded Systems

Condition Variables and Semaphores

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Recap: Readers and Writers

```
enter_r:
  lock(m);
  while (nw) {
    unlock(m);
    while (nw);
    lock(m);
  }
  nr=nr+1;
  unlock(m);
```

```
enter_w:
  lock(m);
  while (nw>0 || nr>0) {
    unlock(m);
    while (nw>0 || nr>0);
    lock(m);
  }
  nw=1;
  unlock(m);
```

Outline

- Condition variables
  - Definition
  - Usage patterns and examples
- Semaphores
  - Definition
  - Producer-consumer example

Condition Variables

- A condition variable `c` has two basic operations:
  - `wait(l,c)`: wait on a condition `c` using lock `l`
  - `signal(l,c)`: signal condition

- `wait(l,c)` is a *blocking* operation

Condition Variables

- `wait(l,c)`
  - Waits for a condition to be signaled
  - While it is waiting, the lock is released
  - When we continue after the wait, the lock has been re-acquired

- `signal(l,c)`
  - Signal the condition
  - In this version, also release the lock; the next use of the released lock is a process that was previously blocked on the wait.
    - In some implementations, signals do no release the lock

Basic Usage Pattern

```
// acquire a lock
lock(l);
...
if (test) {
  // wait for
  // a condition
  wait(l,c);
}
...
// release a lock
unlock(l)
```

```
// acquire a lock
lock(l);
...
if (other test) {
  // signal condition
  signal(l,c);
}
else {
  // release a lock
  unlock(l);
}
```

Locks + Condition Variables

- Condition variable is used with a lock
  - `wait(l,c)` assumes that it has the lock when called

- In this version, a program never signals a condition unless some process is waiting
  - `waiting(l,c)`: returns true or false depending on whether or not there is a process blocked on the condition—you must hold the lock when this is executed.
  - More common implementations may simply ignore a signal when there is no thread/process waiting

Example: Readers and Writers

```
enter_r:
  lock(m);
  while (nw) {
    unlock(m);
    while (nw);
    lock(m);
  }
  nr=nr+1;
  unlock(m);
```

Example: Readers and Writers

```
enter_r:
  lock(m);
  while (nw) {
    unlock(m);
    while (nw);
    lock(m);
  }
  nr=nr+1;
  unlock(m);
```

```
enter_r:
  lock(m);
  if (nw) {
    wait(m,cr);
  }
  nr=nr+1;
  if (waiting(m,cr)) {
    signal(m,cr);
  } else {
    unlock(m);
  }
```

Example: Readers and Writers

```
exit_w:
  nw=0;
```

```
exit_w:
  lock(m);
  nw=0;
  if (waiting(m,cr)) {
    signal(m,cr);
  }
  else {
    unlock(m);
  }
```

Semaphores

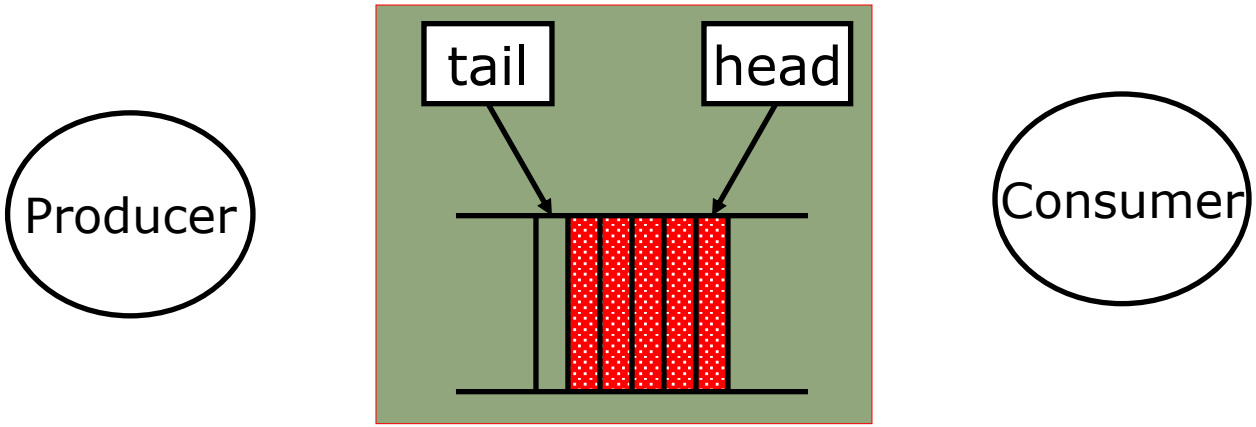
- A semaphore is a non-negative integer, with the following operations
  - P(s): if s>0, decremented by 1, otherwise wait
  - V(s): increment s by 1 and wake up one of the waiting processes (if any)
  - P(s) and V(s) must be executed atomically

- A semaphore can be used to control access to a critical section

```
P(s)
<critical section>
V(s)
```

Initial value of s determines the maximum no. of processes in the critical section

Producer-Consumer Example




```
producer:
while (1) {
   item=produce();
   fifo_put(item);
}
```

```
consumer:
while (1) {
   item=fifo_get();
   consume(item);
}
```

Read when FIFO is not empty

```
producer:
while (1) {
  item=produce();

  fifo_put(item);

}
```

```
consumer:
while (1) {

  item=fifo_get();

  consume(item);
}
```

Write when FIFO is not full

```
producer:
while (1) {
  item=produce();

  fifo_put(item);

}
```

```
consumer:
while (1) {

  item=fifo_get();

  consume(item);
}
```