CS 33

Multithreaded Programming IV

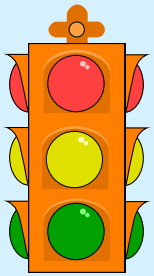
Outline

- Unix signals
- Cancellation

Deviations

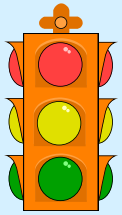
- **Signals**

vs.



- **Cancellation**
  - **tamed lightning**

Signals

- 
  - who gets them?
  - who needs them?
- 
  - how do you respond to them?

Dealing with Signals

- Per-thread signal masks
- Per-process signal vectors
- One delivery per signal

Signals and Threads

```
int pthread_kill(pthread_t thread, int signo);
```

– **thread equivalent of *kill***

```
int pthread_sigmask(int how,
    const sigset_t *newmask,
    sigset_t oldmask);
```

– **thread equivalent of *sigprocmask***

Asynchronous Signals (1)

```
int main( ) {
   void handler(int);
   signal(SIGINT, handler);

   ...

}

void handler(int sig) {
   ...
}
```


Asynchronous Signals (2)

```
int main( ) {
  void handler(int);

  signal(SIGINT, handler);

  ...    // complicated program

  printf("important message: "
     "%s\n", message);

  ...    // more program

}
```

```
void handler(int sig) {

  ...    // deal with signal

  printf("equally important "
     "message: %s\n", message);
}
```


Quiz 1

```
int main( ) {
  void handler(int);

  signal(SIGINT, handler);

  ...    // complicated program

  pthread_mutex_lock(&mut);
  printf("important message: "
     "%s\n", message);
  pthread_mutex_unlock(&mut);

  ...    // more program

}
```

```
void handler(int sig) {

  ...    // deal with signal

  pthread_mutex_lock(&mut);
  printf("equally important "
     "message: %s\n", message);
  pthread_mutex_unlock(&mut);
}
```

Does this work?

a) yes

b) no

Synchronizing Asynchrony

```
computation_state_t   state;
sigset_t set;
int main( ) {
  pthread_t thread;

  sigemptyset(&set);
  sigaddset(&set, SIGINT);
  pthread_sigmask(SIG_BLOCK,
    &set, 0);
  pthread_create(&thread, 0,
    monitor, 0);
  long_running_procedure( );
}
```

```
void *monitor(void *dummy) {
  int sig;
  while (1) {
    sigwait(&set, &sig);
    display(&state);
  }
  return(0);
}
```

Cancellation

Sample Code

```
void *thread_code(void *arg) {
  node_t *head = 0;
  while (1) {
    node_t *nodep;
    nodep = (node_t *)malloc(sizeof(node_t));
    if (read(0, &node->value,
        sizeof(node->value)) == 0) {
      free(nodep);
      break;
    }
    nodep->next = head;
    head = nodep;
  }
  return head;
}
```

```
pthread_cancel(thread);
```


Cancellation Concerns

- Getting cancelled at an inopportune moment
- Cleaning up

Cancellation State

- **Pending cancel**
  - `pthread_cancel(thread)`
- **Cancels enabled or disabled**
  - `int pthread_setcancelstate(`
    `{PTHREAD_CANCEL_DISABLE`
    `PTHREAD_CANCEL_ENABLE},`
    `&oldstate)`
- **Asynchronous vs. deferred cancels**
  - `int pthread_setcanceltype(`
    `{PTHREAD_CANCEL_ASYNCHRONOUS,`
    `PTHREAD_CANCEL_DEFERRED},`
    `&oldtype)`

Cancellation Points

- aio_suspend
- close
- creat
- fcntl (when F_SETLCKW is the command)
- fsync
- mq_receive
- mq_send
- msync
- nanosleep
- open
- pause
- pthread_cond_wait
- pthread_cond_timedwait
- pthread_join
- pthread_testcancel
- read
- sem_wait
- sigwait
- sigwaitinfo
- sigsuspend
- sigtimedwait
- sleep
- system
- tcdrain
- wait
- waitpid
- write

Cleaning Up

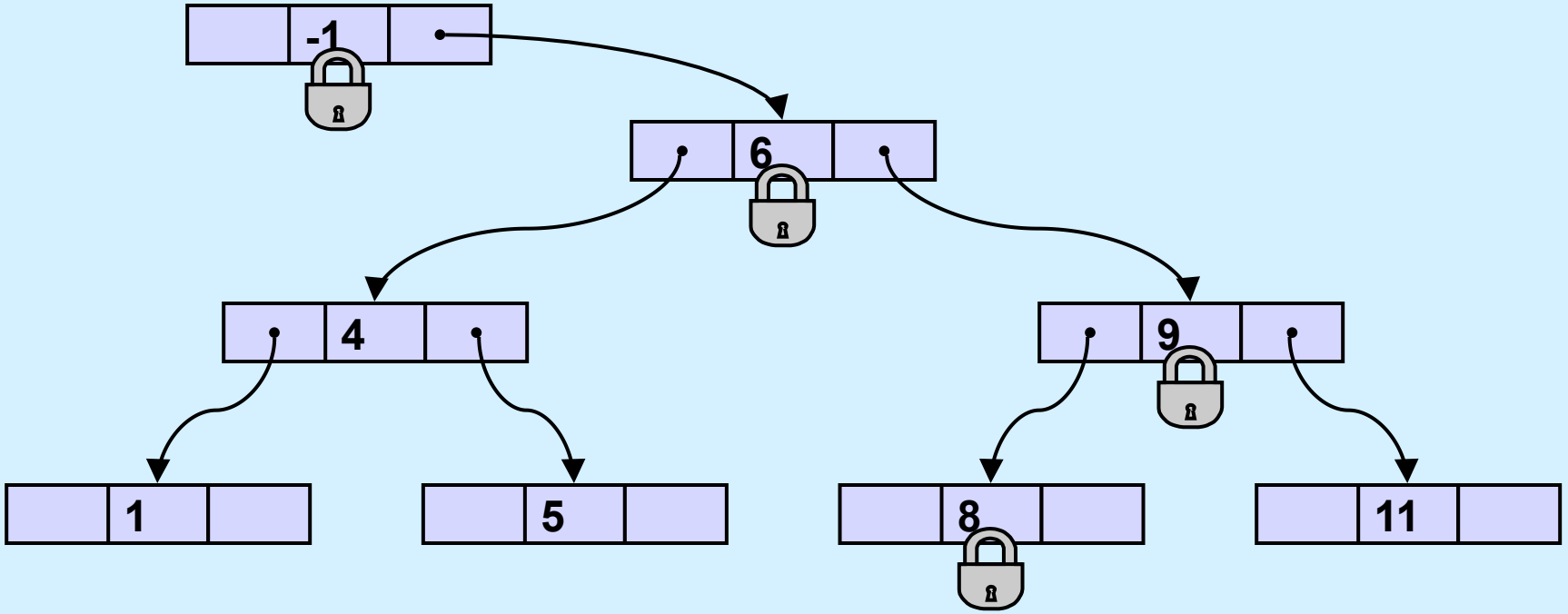
- `void pthread_cleanup_push((void)(*routine)(void *), void *arg)`
- `void pthread_cleanup_pop(int execute)`

Sample Code, Revisited

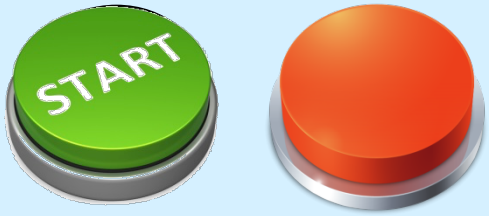
```
void *thread_code(void *arg) {
  node_t *head = 0;
  pthread_cleanup_push(
      cleanup, &head);
    while (1) {
      node_t *nodep;
      nodep = (node_t *)
      malloc(sizeof(node_t));
      if (read(0, &node->value,
          sizeof(node->value)) == 0) {
        free(nodep);
        break;
      }
      nodep->next = head;
      head = nodep;
    }
  pthread_cleanup_pop(0);
  return head;
}
```

```
void cleanup(void *arg) {
  node_t **headp = arg;
  while(*headp) {
    node_t *nodep = head->next;
    free(*headp);
    *headp = nodep;
  }
}
```

A More Complicated Situation …



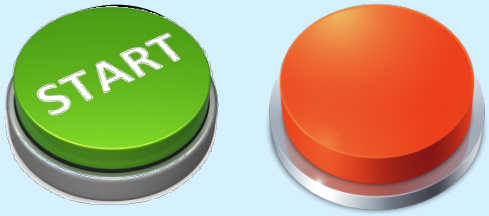
Start/Stop



- **Start/Stop interface**

```
void wait_for_start(state_t *s){
  pthread_mutex_lock(&s->mutex);
  while(s->state == stopped)
    pthread_cond_wait(&s->queue, &s->mutex);
  pthread_mutex_unlock(&s->mutex);
}
void start(state_t *s) {
  pthread_mutex_lock(&s->mutex);
  s->state = started;
  pthread_cond_broadcast(&s->queue);
  pthread_mutex_unlock(&s->mutex);
}
```


Start/Stop



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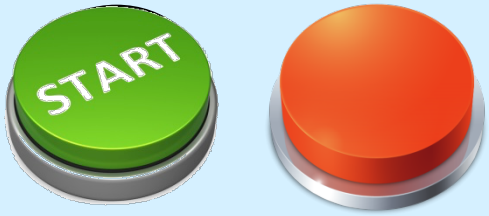
}
void start(state_t *s) {
  pthread_mutex_lock(&s->mutex);
  s->state = started;
  pthread_cond_broadcast(&s->queue);
  pthread_mutex_unlock(&s->mutex);
}
```

Quiz 2

You're in charge of designing POSIX threads. Should *pthread_cond_wait* be a cancellation point?

a) no
b) yes; cancelled threads must acquire mutex before invoking cleanup handler
c) yes; but they don't acquire mutex

Start/Stop



- **Start/Stop interface**

```
void wait_for_start(state_t *s){
  pthread_mutex_lock(&s->mutex);
  pthread_cleanup_push(
    pthread_mutex_unlock, &m);
  while(s->state == stopped)
    pthread_cond_wait(&s->queue, &s->mutex);
  pthread_cleanup_pop(1);
}
void start(state_t *s) {
  pthread_mutex_lock(&s->mutex);
  s->state = started;
  pthread_cond_broadcast(&s->queue);
  pthread_mutex_unlock(&s->mutex);
}
```


Cancellation and Conditions

```
pthread_mutex_lock(&m);
pthread_cleanup_push(pthread_mutex_unlock, &m);
while(should_wait)
  pthread_cond_wait(&cv, &m);

// … (code perhaps containing other cancellation points)

pthread_cleanup_pop(1);
```