POSIX Threads

- Why Threads?
  - Latency Hiding / Multiprogramming (covered earlier)
  - Ease of Programming (covered now)
- POSIX Threads (Stevens, Chapter 11)
  - Thread Management
  - Thread Safety
  - Thread Attributes

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- POSIX Threads (R&R, Chapter 12)
  - Thread Management
  - Thread Safety
  - Thread Attributes

Why Threads?

- Many interactive applications run in loops.
- For example, an interactive game.

```
while (1) {
   /* Read Keyboard */
   /* Recompute Player Position */
   /* Update Display */
}
```

- Reference [B.O. Gallmeister, "POSIX.4, Programming for the Real World," O'Reilly&Assoc., Inc.]

Why Threads?

- Many interactive applications run in loops.
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```
while (1) {
   /* Synchronize to Highest
      Frequency */
   /* Read Keyboard */
   /*    AND Read Mouse */
   /* Recompute Player Position */
   /* Update Display */
   /*    AND emit sounds */
}
```

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Why Threads?

- Many interactive applications run in loops.
- For example, an interactive game.

- **It ain't over yet!**
- **What about compute-intensive operations, like AI, video compression?**

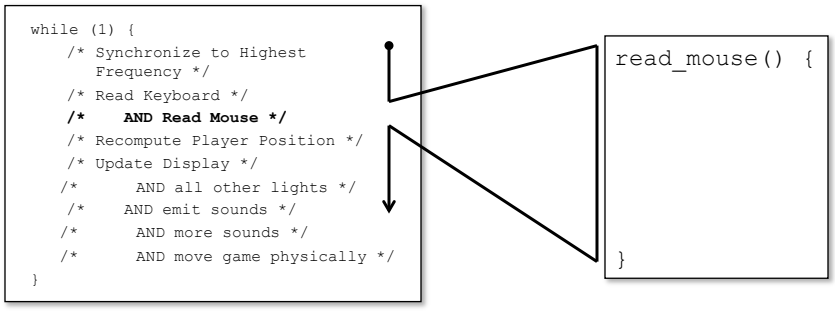
- **How about Signal Handlers?**

```
while (1) {
    /* Synchronize to Highest
       Frequency */
    /* Read Keyboard */
    /*    AND Read Mouse */
    /* Recompute Player Position */
    /* Update Display */
    /*      AND all other lights */
    /*    AND emit sounds */
    /*      AND more sounds */
    /*      AND move game physically */
}
```

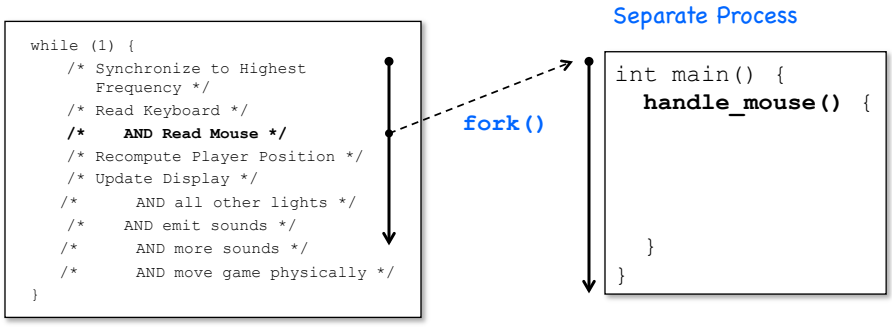
Suddenly, application is getting complex!

- Reference [B.O. Gallmeister, "POSIX.4, Programming for the Real World," O'Reilly&Assoc., Inc.]

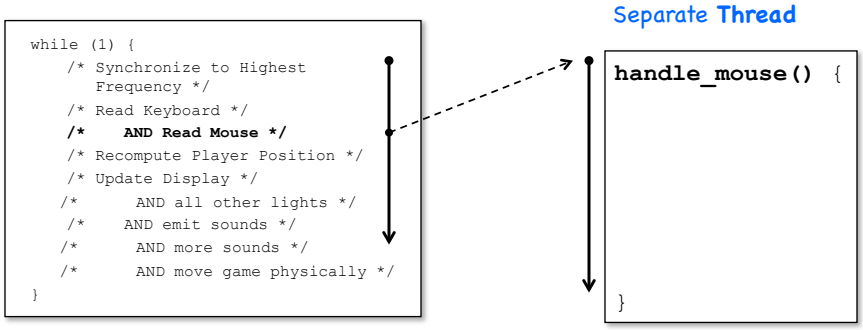
Reading the Mouse



Reading the Mouse (II)



Reading the Mouse (III)



The Thread and its Creation

```
/* The Mouse Input Function */

void * handle_mouse() {
  char buf[BUFSIZE]; ssize_t nbytes;
  for (;;) {
    if ((nbytes = read_from_mouse(buf,BUFSIZE)) <= 0)
      break;
    dosomething_with(buf, nbytes);
  }
  return NULL;
}
```

```
while (1) {
    /* Synchronize
       Frequency */
    /* Read Keyboar
    /*    AND Read
    /* Recompute Pl
    /* Update Displ
    /*      AND all
    /*    AND emit
    /*      AND more
    /*      AND move game physically */
}
```

The Thread and its Creation

```
#include <pthread.h>

int error;
pthread_t tid;

if (error = pthread_create(&tid, NULL, handle_mouse, NULL))
    perror("Failed to create read_mouse thread");

for(;;) {
   /* Synchronize to Highest
      Frequency */
   /* Read Keyboard */
   /*    AND Read Mouse */ <- Handled by separate thread!
   /* Recompute Player Position */
   /* Update Display */
   /*      AND all other lights */
   /*    AND emit sounds */
   /*      AND more sounds */
   /*      AND move game physically */
}
```

```
FSIZE)) <= 0)
```

Thread Management

- **pthread_cancel** (terminate another thread)
- **pthread_create** (create a thread)
- **pthread_detach** (have thread release res's)
- **pthread_equal** (two thread id's equal?)
- **pthread_exit** (exit a thread)
- **pthread_kill** (send a signal to a thread)
- **pthread_join** (wait for a thread)
- **pthread_self** (what is my id?)

Thread Management

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- **pthread_equal** (two thread id's equal?)
- **pthread_**
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```
int pthread_create(pthread_t * thread,
                   const pthread_attr_t * attr,
                   void *(*start_routine)(void *),
                   void * arg)
```

```
fd = open("my.dat", O_RDONLY);

if (error = pthread_create(&t_id, NULL, processfd, &fd))
   fprintf(stderr, "Failed create thread: %s\n", strerror(error));
```

Thread Attributes

atribute objects	`pthread_attr_destroy` `pthread_attr_init`
state	`pthread_attr_getdetachstate` `pthread_attr_setdetachstate`

stack	`pthread_attr_getguardsize`
	`pthread_attr_setguardsize`
	`pthread_attr_getstack`
	`pthread_attr_setstack`

scheduling	`pthread_attr_getinheritedsched`
	`pthread_attr_setinheritedsched`
	`pthread_attr_getschedparam`
	`pthread_attr_setschedparam`
	`pthread_attr_getschedpolicy`
	`pthread_attr_setschedpolicy`
	`pthread_attr_getscope`
	`pthread_attr_setscope`

Thread Attributes: State

atribute objects	`pthread_attr_destroy` `pthread_attr_init`
state	`pthread_attr_getdetachstate` `pthread_attr_setdetachstate`

stack	`pthread_attr_getguardsize`
	`pthread_attr_setg`
	`pthread_attr_gets`
	`pthread_attr_sets`

scheduling	`pthread_attr_geti`
	`pthread_attr_seti`
	`pthread_attr_gets`
	`pthread_attr_setschedparam`
	`pthread_attr_getschedpolicy`
	`pthread_attr_setschedpolicy`
	`pthread_attr_getscope`
	`pthread_attr_setscope`

- **Detached** threads release resources when terminate.
- **Attached** states hold on to resources until parent thread calls `pthread_join`.

Thread Attributes: Stack

atribute objects	`pthread_attr_destroy` `pthread_attr_init`
state	`pthread_attr_getdetachstate` `pthread_attr_setdetachstate`

stack	`pthread_attr_getguardsize`
	`pthread_attr_setguardsize`
	`pthread_attr_getstack`
	`pthread_attr_setstack`

scheduling	`pthread_attr_getinheritedsched`
	`pthread_a`
	`pthread_a`
	`pthread_a`
	`pthread_a`
	`pthread_a`
	`pthread_a`
	`pthread_attr_setscope`

- **setstack** defines location and size of stack.
- **setguardsize** allocates additional memory. If the thread overflows into this extra memory, an error is generated.

Thread Attributes: Scheduling

atribute objects	
state	
stack	`pthread_attr_setstack`

scheduling	`pthread_attr_getinheritedsched`
	`pthread_attr_setinheritedsched`
	`pthread_attr_getschedparam`
	`pthread_attr_setschedparam`
	`pthread_attr_getschedpolicy`
	`pthread_attr_setschedpolicy`
	`pthread_attr_getscope`
	`pthread_attr_setscope`

- **PTHREAD_INHERIT_SCHED** defines that scheduling parameters are inherited from parent thread. (as opposed to **PTHREAD_EXPLICIT_SCHED**).
- Scheduling policies: SCHED_FIFO, SCHED_RR, SCHED_SPORADIC, SCHED_OTHER, ...
- **contention scope** defines whether process competes at process level or at system level for resources.