Threads
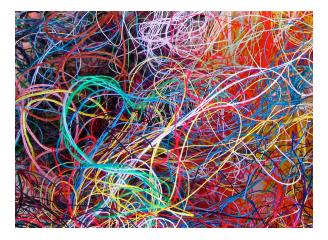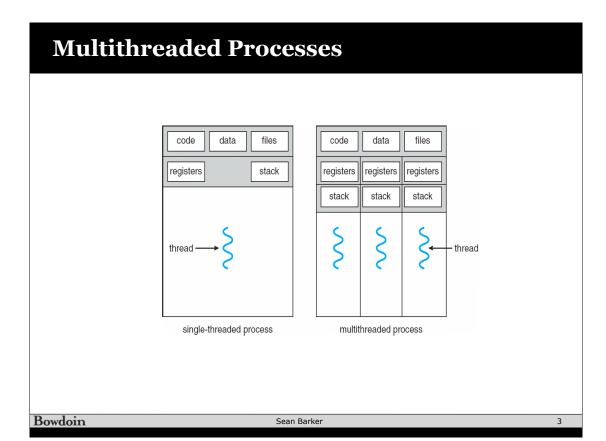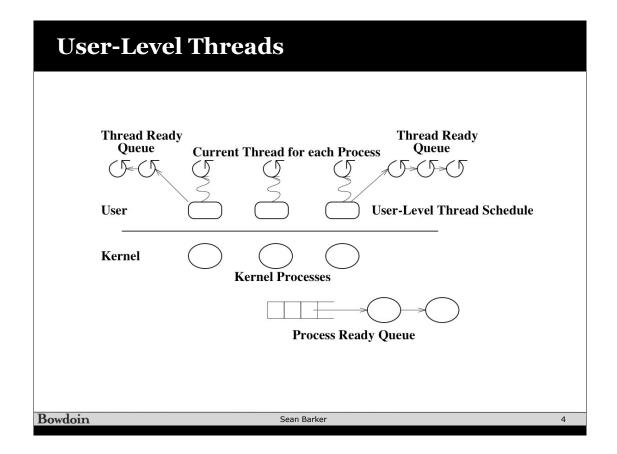

Thread Examples

```
Pthreads:
    pthread_attr_init(&attr);
    pthread_create(&tid, &attr, sum, &param); // thread runs sum


Win32 Threads:
ThreadHandle  = CreateThread(NULL, 0, Sum, &Param, 0, &ThreadID);


Java Threads:
Thread t = new Thread(new Summation(param));
t.start();  // start the thread running Summation.run()
```

Multithreaded Processes

single-threaded process   multithreaded process

User-Level Threads

Lightweight Processes

User Thread

Kernel Threads

Kernel

Address Space

Lightweight process

Thread

Threading Models

User Threads

user thread

kernel thread

Kernel Threads

user thread

kernel thread

Hybrid

user thread

kernel thread

Two-Level Hybrid

user thread

kernel thread
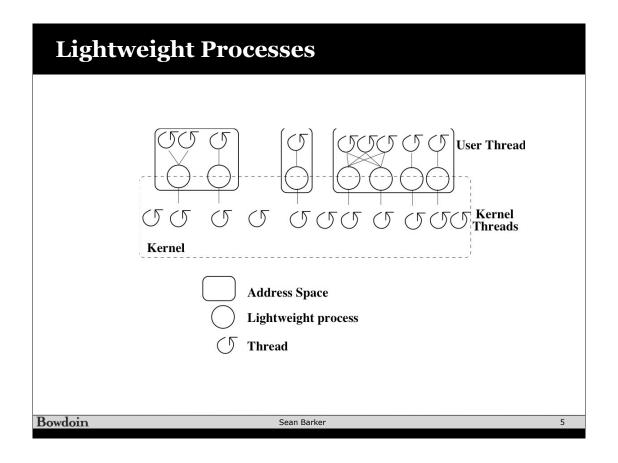
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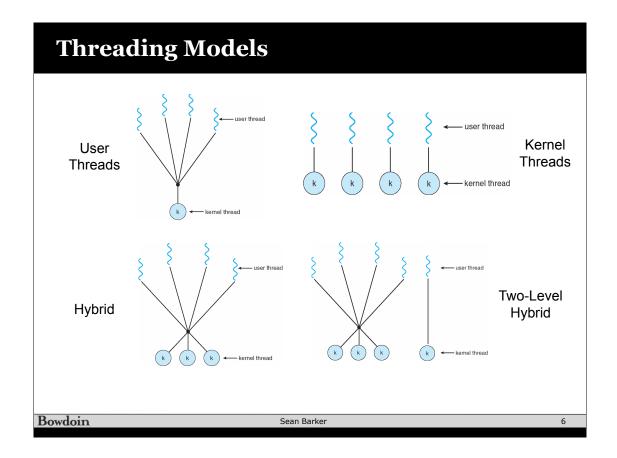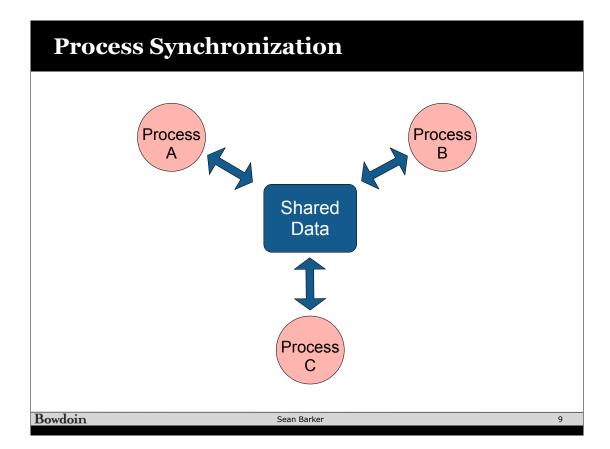
Threads Summary

- Threads vs processes

- User-level and kernel-level threads

- Thread interfaces vs implementations

Process Synchronization

ATM Example

```
// get funds in account
int total = get_account_total();

// get amount to withdraw
int withdraw = get_withdraw_amount();

if (total >= withdraw) {

    // withdraw funds from account
    total -= withdraw;
    update_account_total(total);
    dispense_money(withdraw);

}
```

Too Much Milk

Time	You	Your Roommate
3:00	Arrive home	
3:05	Look in fridge, no milk	
3:10	Leave for grocery store	
3:15		Arrive home
3:20	Arrive at grocery store	Look in fridge, no milk
3:25	Buy milk	Leave for grocery store
3:35	Arrive home, put milk in fridge	
3:45		Buy milk
3:50		Arrive home with milk
3:50		Too much milk!

```
if (noMilk) {            if (noMilk) {
   buy milk;               buy milk;
}                        }
```

Too Much Milk: Solution 1?

Thread A   **Thread B**

```
if (noMilk & NoNote) {      if (noMilk & NoNote) {
    leave note;                 leave note;
    buy milk;                   buy milk;
    remove note;                remove note;
}                           }
```

Too Much Milk: Solution 2?

Thread A

```
leave note A;
if (noNote B) {
    if (noMilk) {
        buy milk;
    }
}
remove note A;
```

Thread B

```
leave note B;
if (noNote A) {
    if (noMilk) {
        buy milk;
    }
}
remove note B;
```

Too Much Milk: Solution 3?

Thread A

```
leave note A;
while (note B) {
    do nothing;
}
if (noMilk) {
    buy milk;
}
remove note A;
```

Thread B

```
leave note B;
if (noNote A) {
    if (noMilk) {
        buy milk;
    }
}
remove note B;
```

Critical Sections

```
                ...
         arriveHome();

         if (noMilk) {
            buy milk;
         }

         makeCoffee();
                ...
```

Critical Section

Requirement of **mutual exclusion**