بسم الله الرحمن الرحیم

«سیستم عامل»

1

جلسه ۵: ریسمان

The Process Concept

اصلاح گذشته

Wait & Kill

- ***Wait***
  - *Waits for the children to exit*

- ***Kill***
  - *Kills process*
  - *Children of the killed process remain as children of init*

Threads

Threads

- **Processes have the following components:**
  - an address space
  - a collection of operating system state
  - a CPU context … or thread of control

- **On multiprocessor systems, with several CPUs, it would make sense for a process to have several CPU contexts (threads of control)**
  - Thread fork creates new thread not memory space
  - Multiple threads of control could run in the same memory space on a single CPU system too!

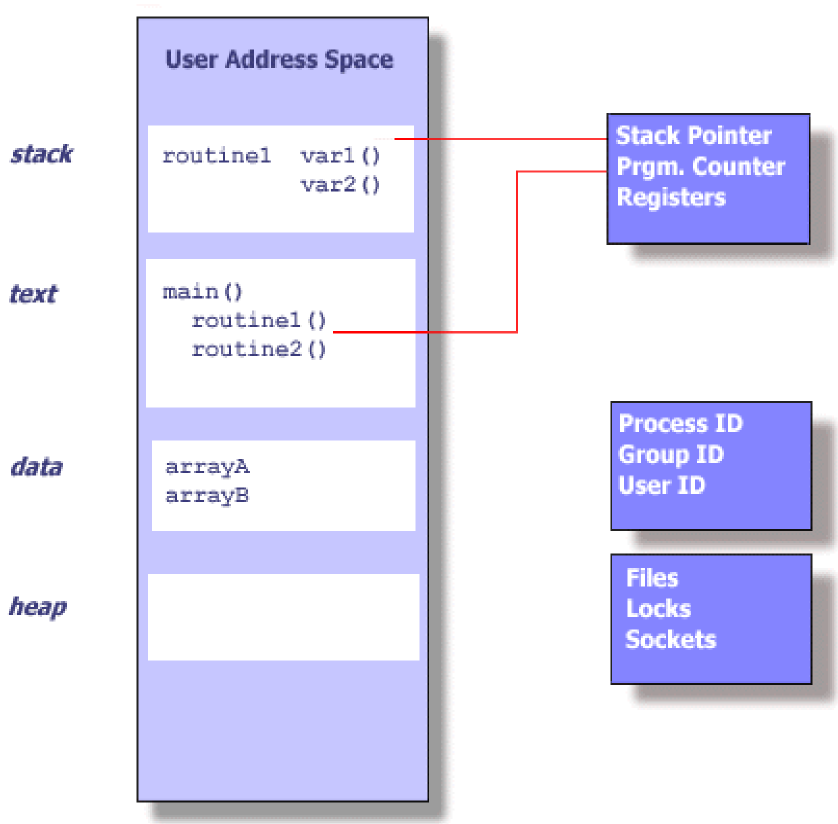
Threads

- Threads share a process address space with zero or more other threads

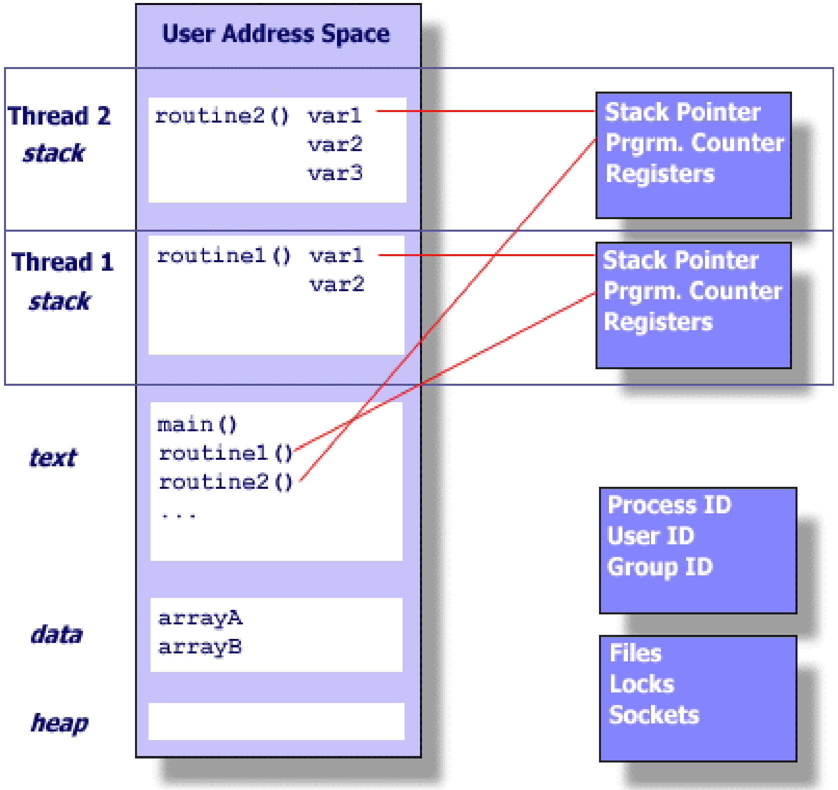
- Threads have their own CPU context
  - PC, SP, register state,
  - stack

- A traditional process can be viewed as a memory address space with a single thread

Single thread state within a process



Multiple threads in an address space



What is a thread?

- ***A thread executes a stream of instructions***
  - *it is an abstraction for control-flow*
- ***Practically, it is a processor context and stack***
  - *Allocated a CPU by a scheduler*
  - *Executes in the context of a memory address space*

Summary of private per-thread state

Things that define the state of a particular flow of control in an executing program:

- *Stack (local variables)*
- *Stack pointer*
- *Registers*
- *Scheduling properties (i.e., priority)*

Shared state among threads

Things that relate to an instance of an executing program (that may have multiple threads)

- *User ID, group ID, process ID*
- *Address space*
  - **Text**
  - **Data (off-stack global variables)**
  - **Heap (dynamic data)**
- *Open files, sockets, locks*

Important: Changes made to shared state by one thread will be visible to the others

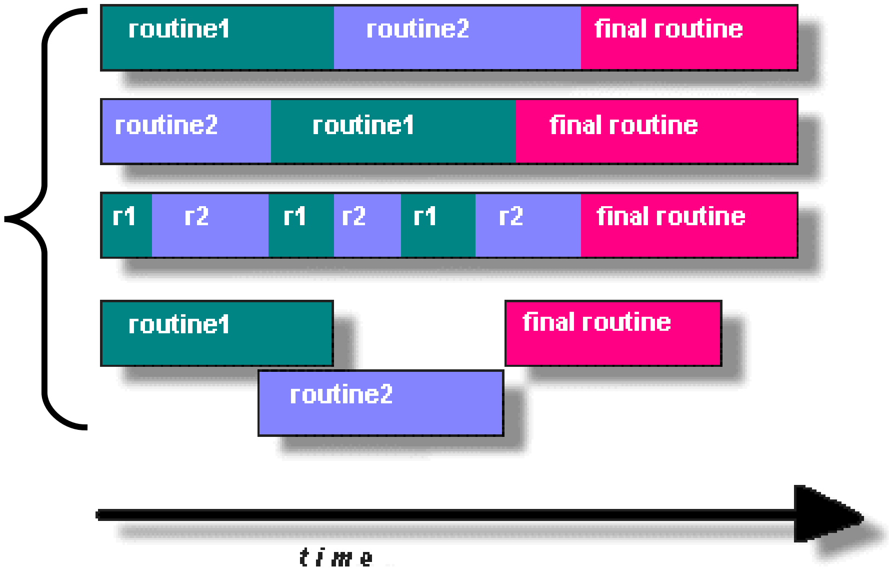
- *Reading and writing memory locations requires synchronization! … a major topic for later …*

How do you program using threads?

Split program into routines to execute in parallel

- True or pseudo (interleaved) parallelism

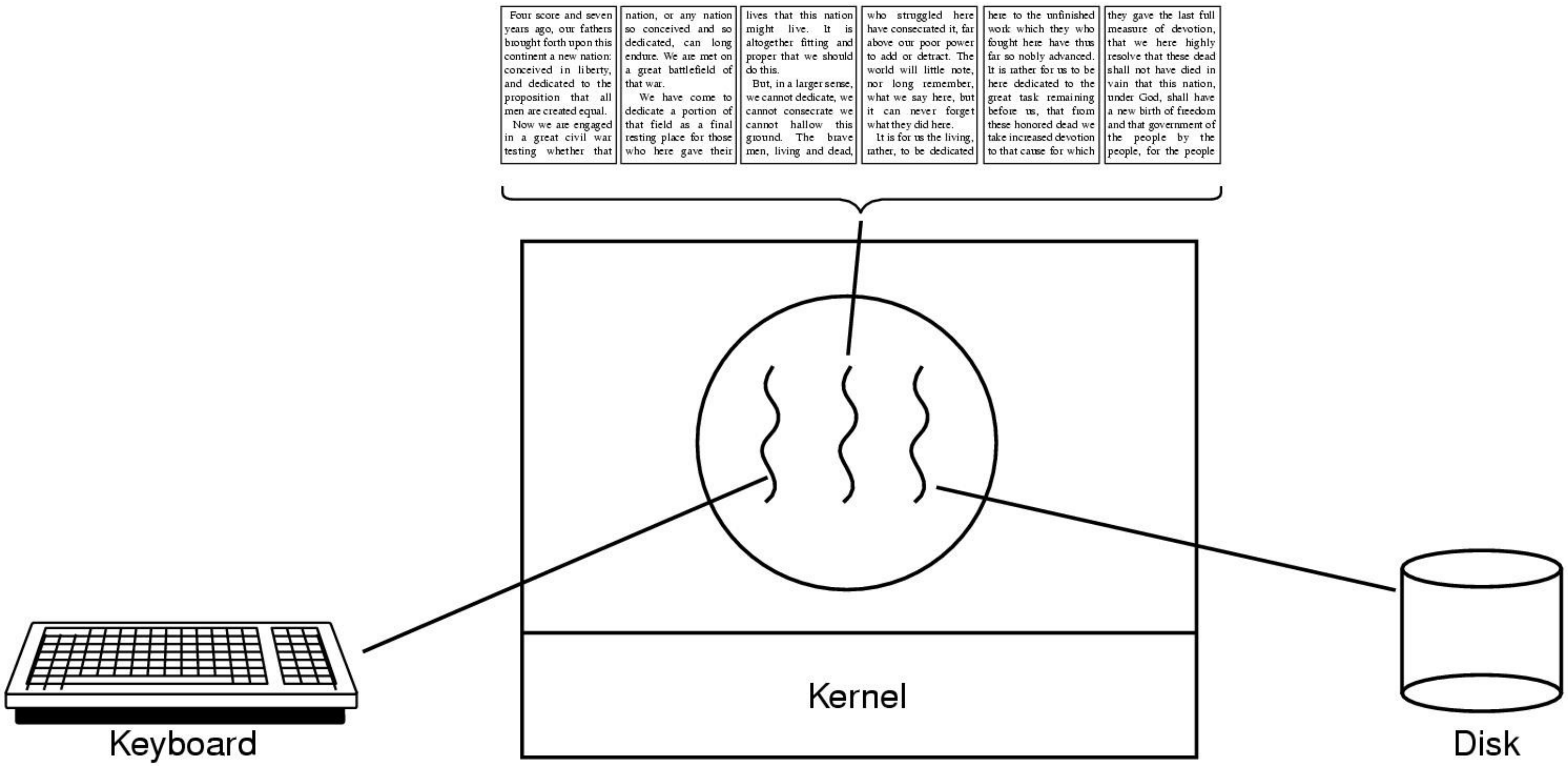
Alternative strategies for executing multiple rountines



Why program using threads?

- **Utilize multiple CPU's concurrently**
- **Low cost communication via shared memory**
- **Overlap computation and blocking on a single CPU**
  - Blocking due to I/O
  - Computation and communication
- **Handle asynchronous events**

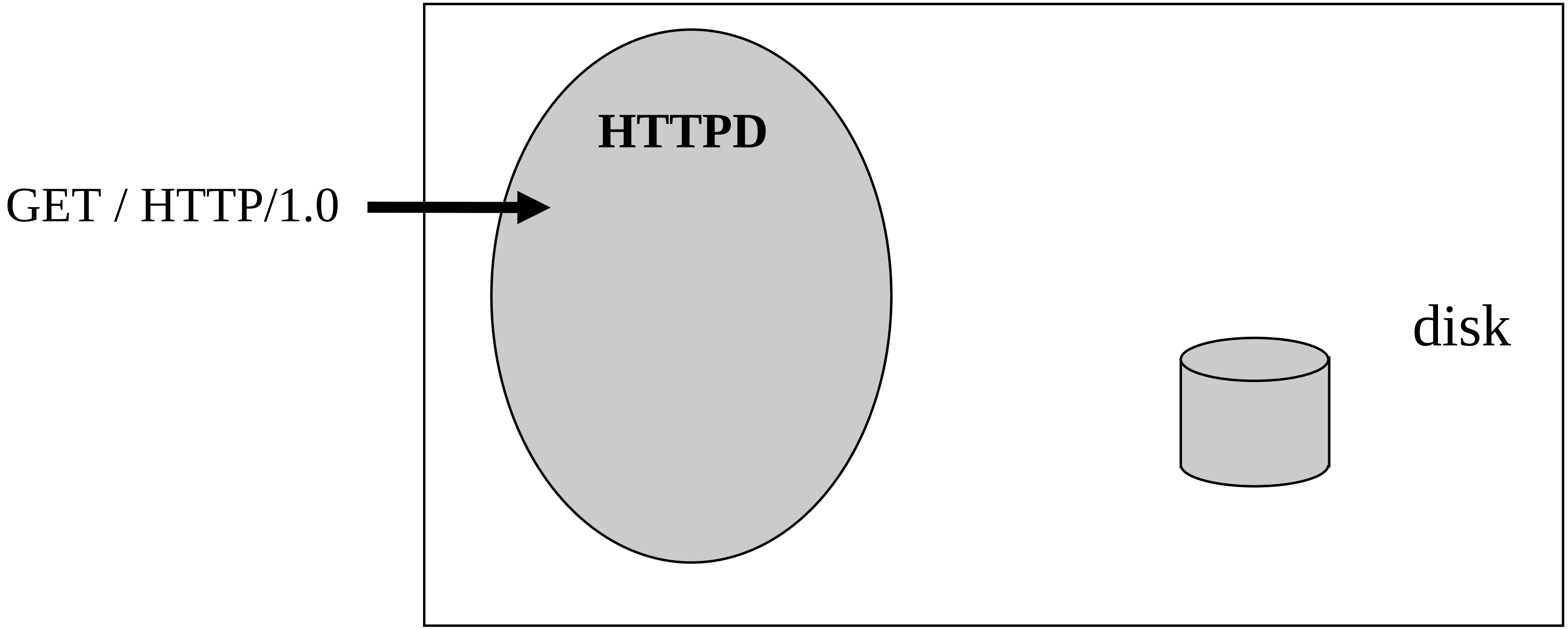
Thread usage



A word processor with three threads

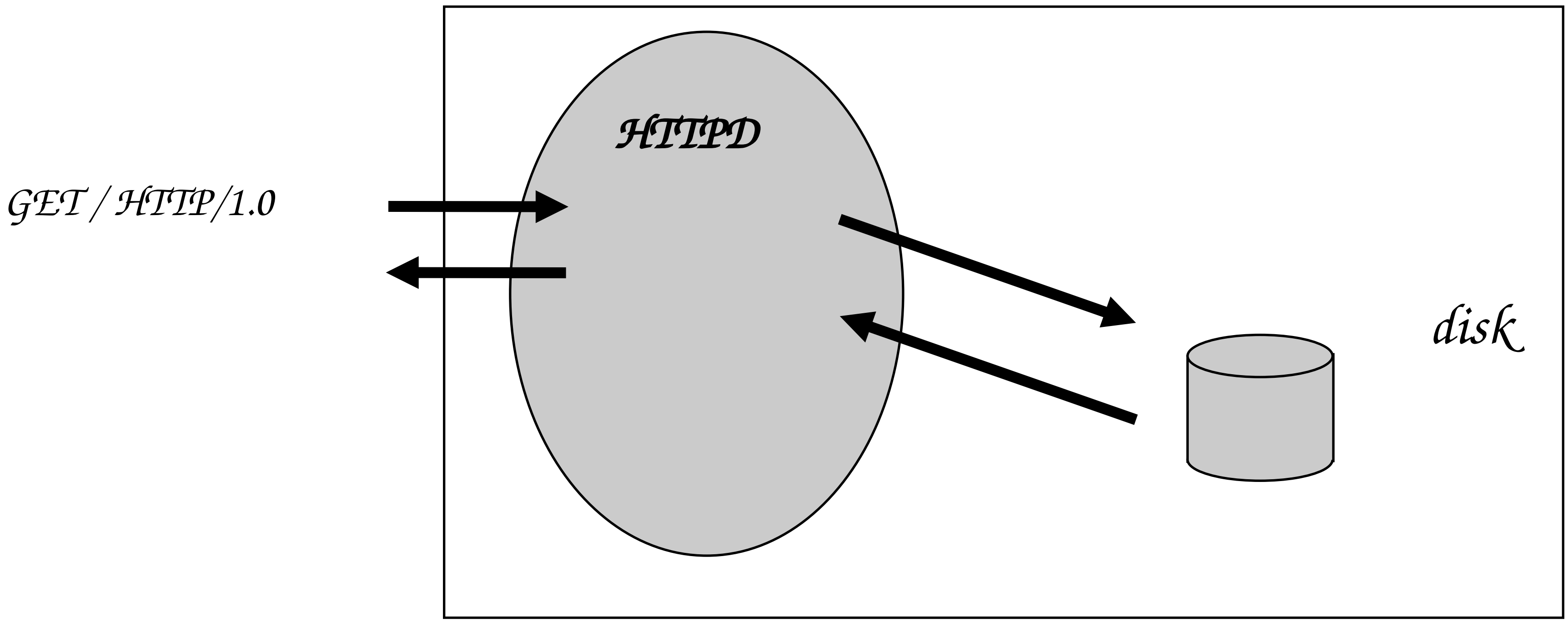
Processes versus threads - example

- *A WWW process*



Processes versus threads - example

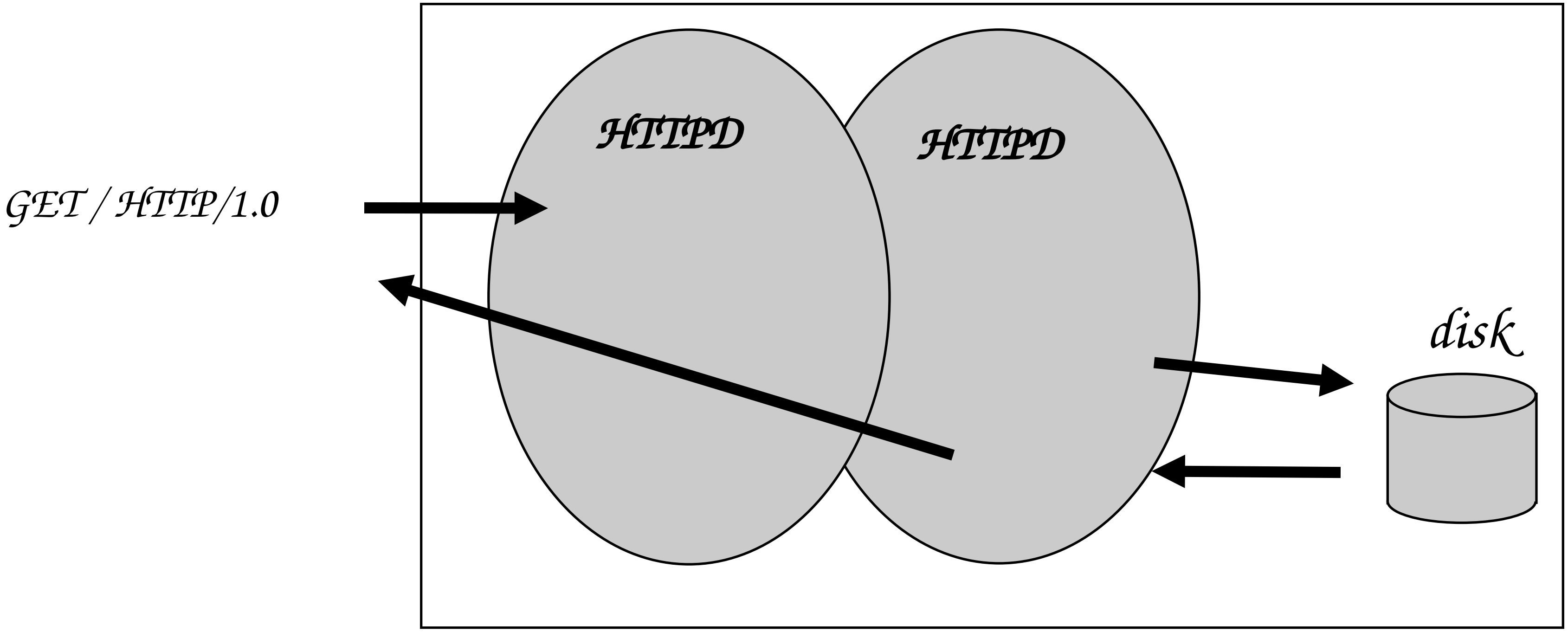
- *A WWW process*



Why is this not a good web server design?

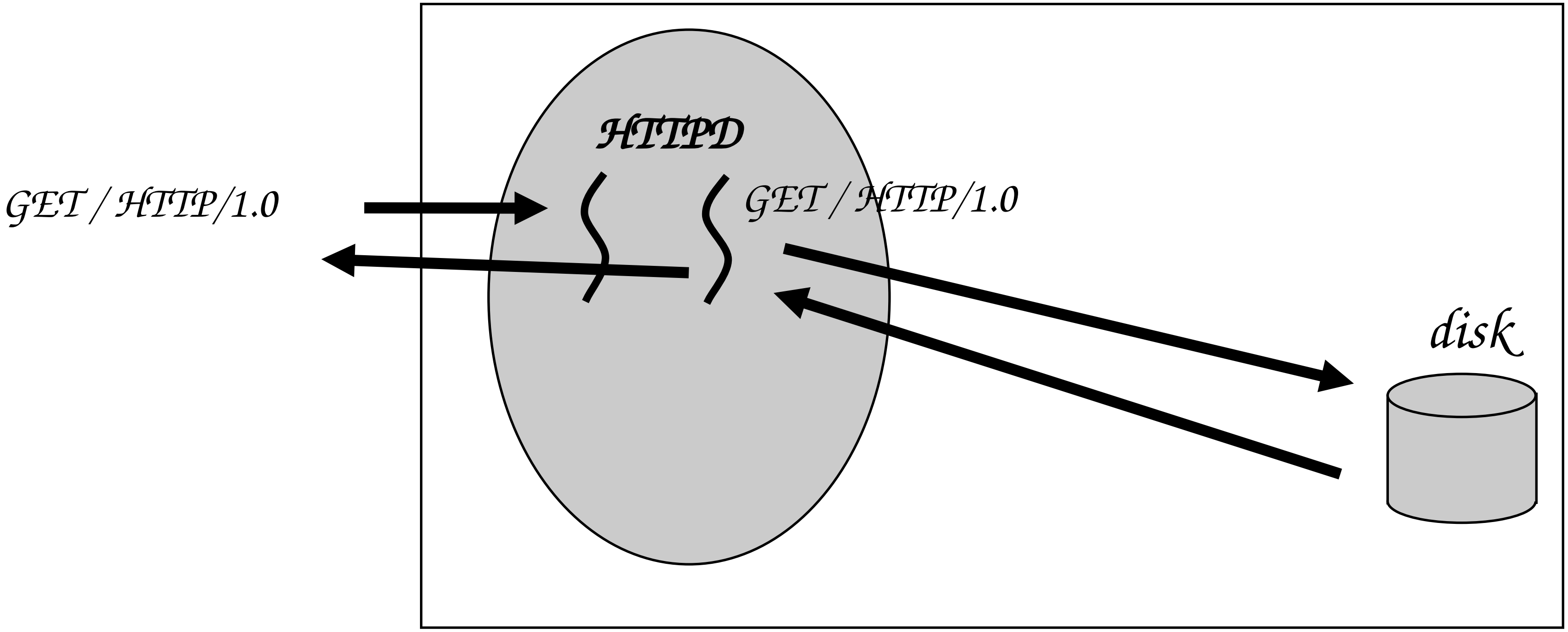
Processes versus threads - example

- A WWW process



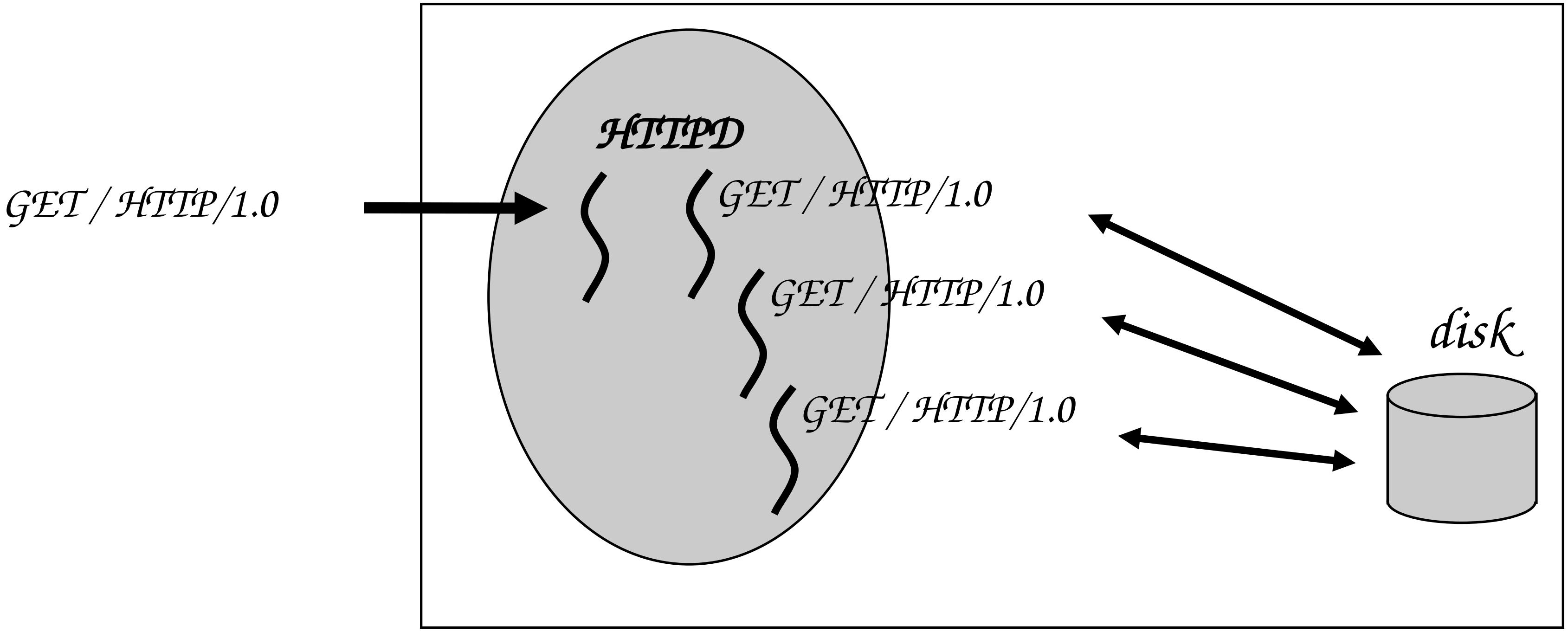
Processes versus threads - example

- A WWW process



Processes versus threads - example

- A WWW process



System structuring options

Model	Characteristics
Threads	Parallelism, blocking system calls
Single-threaded process	No parallelism, blocking system calls
Finite-state machine	Parallelism, nonblocking system calls, interrupts

Three ways to construct a server

Common thread programming models

- ***Manager/worker***
  - *Manager thread handles I/O and assigns work to worker threads*
  - *Worker threads may be created dynamically, or allocated from a thread-pool*

- ***Pipeline***
  - *Each thread handles a different stage of an assembly line*
  - *Threads hand work off to each other in a producer-consumer relationship*

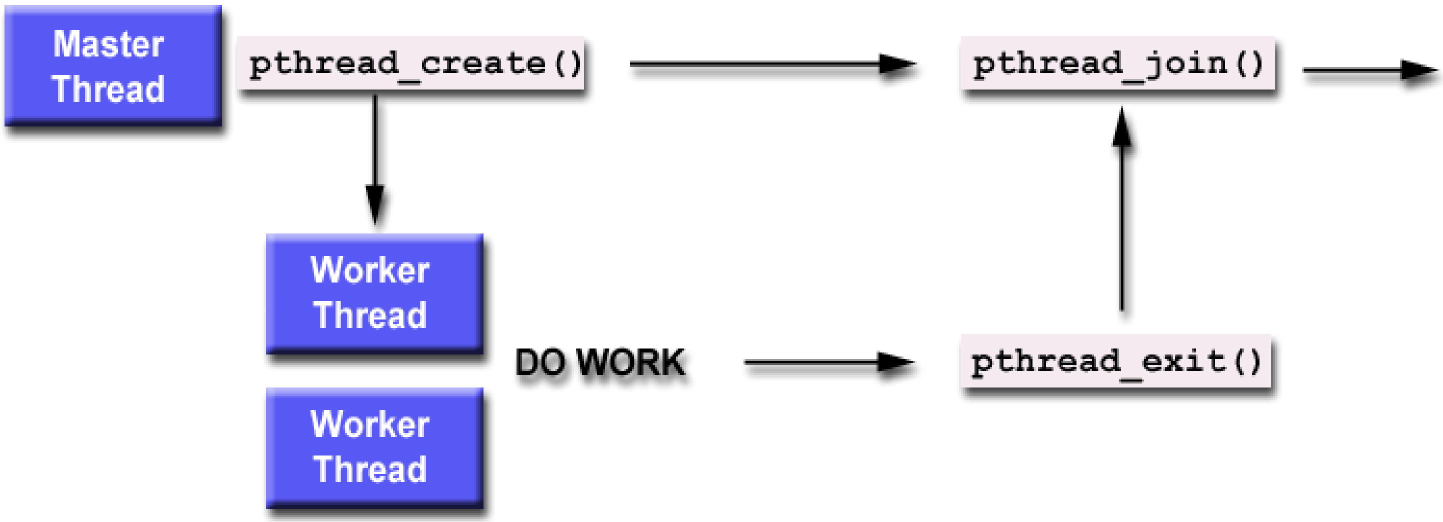
What does a typical thread API look like?

- POSIX standard threads (Pthreads)
- First thread exists in main(), typically creates the others
- pthread_create (thread,attr,start_routine,arg)
  - Returns new thread ID in "thread"
  - Executes routine specified by "start_routine" with argument specified by "arg"
  - Exits on return from routine or when told explicitly

Thread API (continued)

- pthread_exit (status)
  - Terminates the thread and returns "status" to any joining thread
- pthread_join (threadid,status)
  - Blocks the calling thread until thread specified by "threadid" terminates
  - Return status from pthread_exit is passed in "status"
  - One way of synchronizing between threads
- pthread_yield ()
  - Thread gives up the CPU and enters the run queue

Using create, join and exit primitives



An example Pthreads program

```
#include <pthread.h>
#include <stdio.h>
#define NUM_THREADS 5

void *PrintHello(void *threadid)
{
  printf("\n%d: Hello World!\n", threadid);
  pthread_exit(NULL);
}

int main (int argc, char *argv[])
{
  pthread_t threads[NUM_THREADS];
  int rc, t;
  for(t=0; t<NUM_THREADS; t++)
  {
    printf("Creating thread %d\n", t);
    rc = pthread_create(&threads[t], NULL, PrintHello, (void *)t);
    if (rc)
    {
      printf("ERROR; return code from pthread_create() is %d\n", rc);
      exit(-1);
    }
  }
  pthread_exit(NULL);
}
```

Program Output

```
Creating thread 0
Creating thread 1
0: Hello World!
1: Hello World!
Creating thread 2
Creating thread 3
2: Hello World!
3: Hello World!
Creating thread 4
4: Hello World!
```

For more examples see: http://www.llnl.gov/computing/tutorials/pthreads

Pros & cons of threads

- **Pros**
  - Overlap I/O with computation!
  - Cheaper context switches
  - Better mapping to shared memory multiprocessors
- **Cons**
  - Potential thread interactions
  - Complexity of debugging
  - Complexity of multi-threaded programming
  - Backwards compatibility with existing code

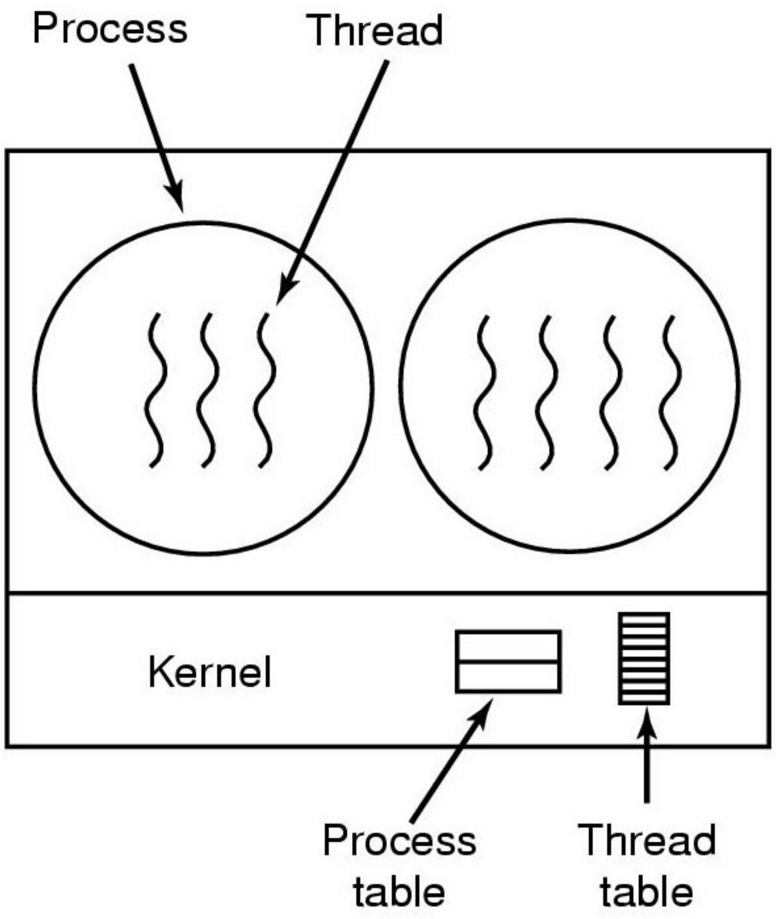
User-level threads

- **The idea of managing multiple abstract program counters above a single real one can be implemented using privileged or non-privileged code.**
  - Threads can be implemented in the OS or at user level

- **User level thread implementations**
  - thread scheduler runs as user code (thread library)
  - manages thread contexts in user space
  - The underlying OS sees only a traditional process above

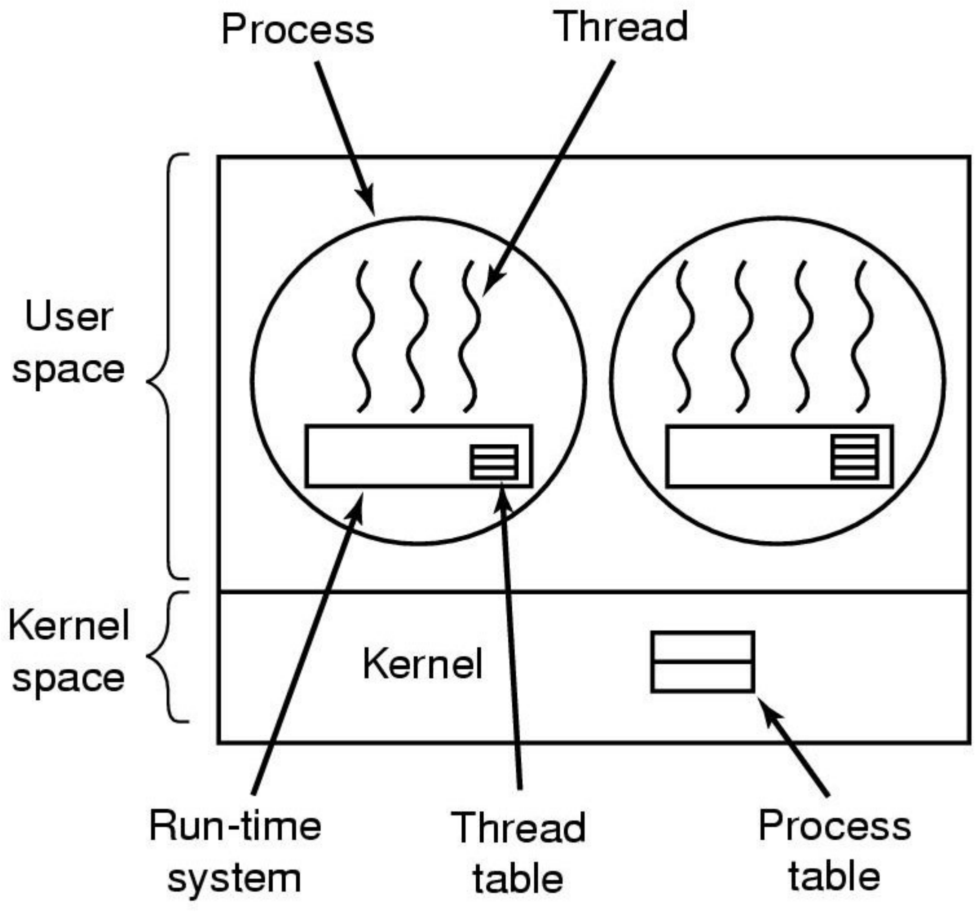
Kernel-level threads

The thread-switching code is in the kernel



User-level threads package

The thread-switching code is in user space



User-level threads

- ***Advantages***
  - *cheap context switch costs among threads in the same process!*
    - ***A procedure call not a system call!***
  - *User-programmable scheduling policy*

- ***Disadvantages***
  - *How to deal with blocking system calls!*
  - *How to overlap I/O and computation!*