CS330: Operating Systems

Threads

- Threads are (almost!) independent execution entities of a single process

- Threads are (almost!) independent execution entities of a single process
- Threads of a single process can be scheduled different CPUs in a concurrent manner.

- Threads are (almost!) independent execution entities of a single process
- Threads of a single process can be scheduled different CPUs in a concurrent manner. Therefore,
 - Each thread has a different register state and stack
 - At a given point of time, PC of different threads can be different

- Threads are (almost!) independent execution entities of a single process
- Threads of a single process can be scheduled different CPUs in a concurrent manner. Therefore,
 - Each thread has a different register state and stack
 - At a given point of time, PC of different threads can be different
- How threads are different from processes?

- Threads are (almost!) independent execution entities of a single process
- Threads of a single process can be scheduled different CPUs in a concurrent manner. Therefore,
 - Each thread has a different register state and stack
 - At a given point of time, PC of different threads can be different
- How threads are different from processes?
 - Threads of a single process share the address space
 - Context switch between two threads of a process does not require switching the address space

- Threads are (almost!) independent execution entities of a single process
- Why multithreading is useful?
- How does OS maintain thread related information?
- How stacks for multiple threads are managed?
- What is POSIX thread API? How is it used?
- now threads are different from processes:
 - Threads of a single process share the address space
 - Context switch between two threads of a process does not require switching the address space

Leverage multi-core systems

- Threads share the address space
 - Global variables can be accessed from thread functions
 - Dynamically allocated memory can be passed as thread arguments

Leverage multi-core systems

- Threads share the address space
 - Global variables can be accessed from thread functions
 - Dynamically allocated memory can be passed as thread arguments
- Example parallel computation models
 - Data parallel processing: Data is partitioned into disjoint sets and assigned to different threads
 - Task parallel processing: Each thread performs a different computation on the same data

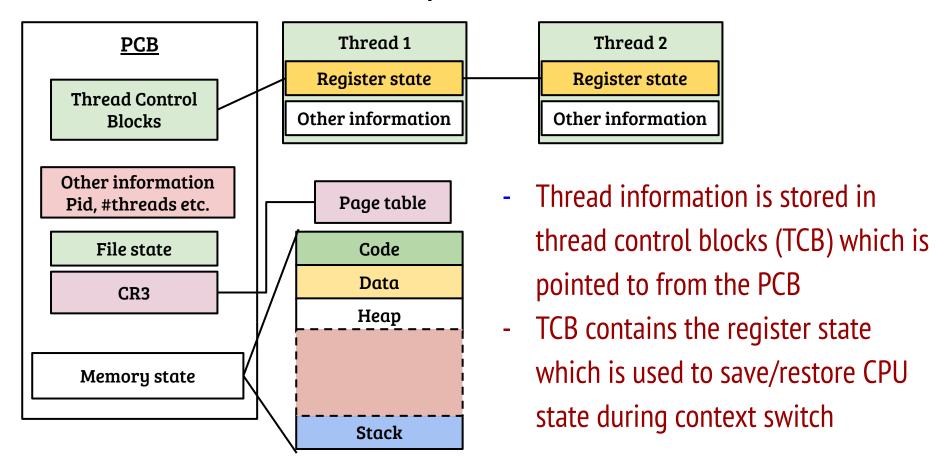
Example: Finding MAX

- Given *N* elements and a function *f*, we are required to find the element *e* such that *f*(*e*) is maximum
- If the computation time for function f is significant, we can employ multithreading with K threads using the following strategy
- Partition N elements into K non-overlapping sets and assign each thread to compute the MAX within its own set
- When all threads complete, we find out the global maximum

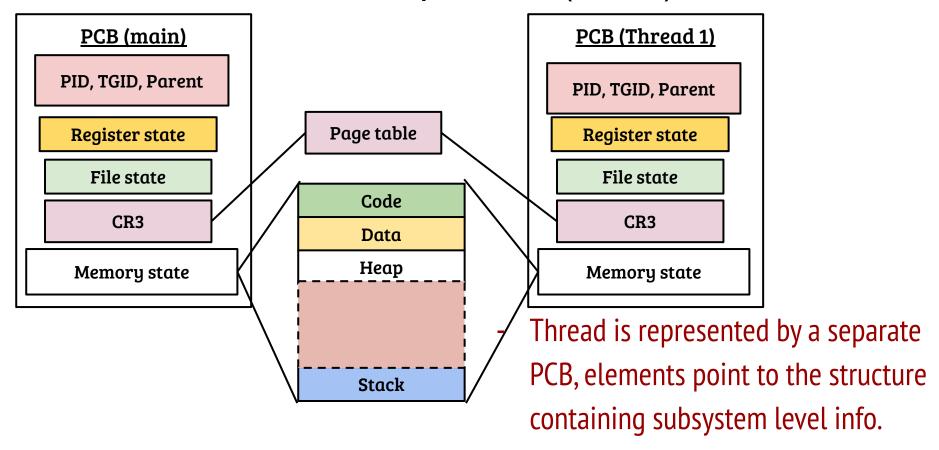
Threads are (almost) independent execution entities of a single process

- Why multithreading is useful?
- Efficient execution on multicore systems, overlapping I/O and processing
- How does OS maintain thread related information?
- How stacks for multiple threads are managed?
- What is POSIX thread API? How is it used?
 - Threads of a single process share the address space
 - Context switch between two threads of a process does not require switching the address space

PCB of a multithreaded process



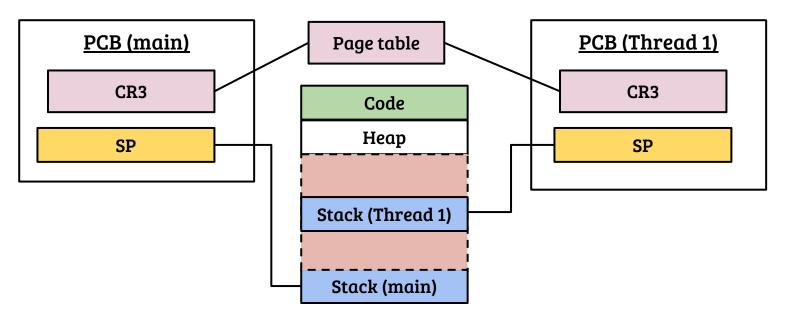
PCB of a multithreaded process (Linux)



Threads are (almost) independent execution entities of a single process

- Why multithreading is useful?
- Efficient execution on multicore systems, overlapping I/O and processing
- How does OS maintain thread related information?
- Maintain thread information using separate PCB or using TCB
- How stacks for multiple threads are managed?
- What is POSIX thread API? How is it used?
 - Context switch between two threads of a process does not require switching the address space

Stack for multi-threaded processes



Stack for threads dynamically allocated from the address space using mmap(
) system call and passed to the OS during thread creation

Threads are (almost) independent execution entities of a single process

- Why multithreading is useful?
- Efficient execution on multicore systems, overlapping I/O and processing
- How does OS maintain thread related information?
- Maintain thread information using separate PCB or using TCB
- How stacks for multiple threads are managed?
- Stacks for threads are allocated using memory allocation APIs
- What is POSIX thread API? How is it used?

Posix thread API (pthread_create)

- Creates a thread with "tid" as its handle and the thread starts executing the function pointed to by the "thfunc" argument
- A single argument (of type void *) can be passed to the thread
- Thread attribute can be used to control the thread behavior e.g., stack size, stack address etc. Passing NULL sets the defaults
- Returns 0 on success.
- Thread termination: return from thfunc, pthread_exit() or pthread_cancel()
- In Linux, pthread_create and fork implemented using clone() system call

Posix thread API (pthread_join)

int pthread_join(pthead_t tid, void **retval)

- This call waits for the thread with handle "tid" to finish
- The return value of the thread is captured using the "retval" argument
 - The thread must allocate the return value which is freed after the process joins
- Invoking pthread_join for an already finished thread returns immediately

- Why multithreading is useful?
- Efficient execution on multicore systems, overlapping I/O and processing
- How does OS maintain thread related information?
- Maintain thread information using separate PCB or using TCB
- How stacks for multiple threads are managed?
- Stacks for threads are allocated using memory allocation APIs
- What is POSIX thread API? How is it used?
- Easy to use thread library with OS support. Important APIs: pthread_create, pthread_join