# CS330: Operating Systems

Threads

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# Multi-threaded processes

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- 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?
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  - 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

# Multi-threaded processes

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- Efficient execution on multicore systems, overlapping I/O and processing
- How does OS maintain thread related information?
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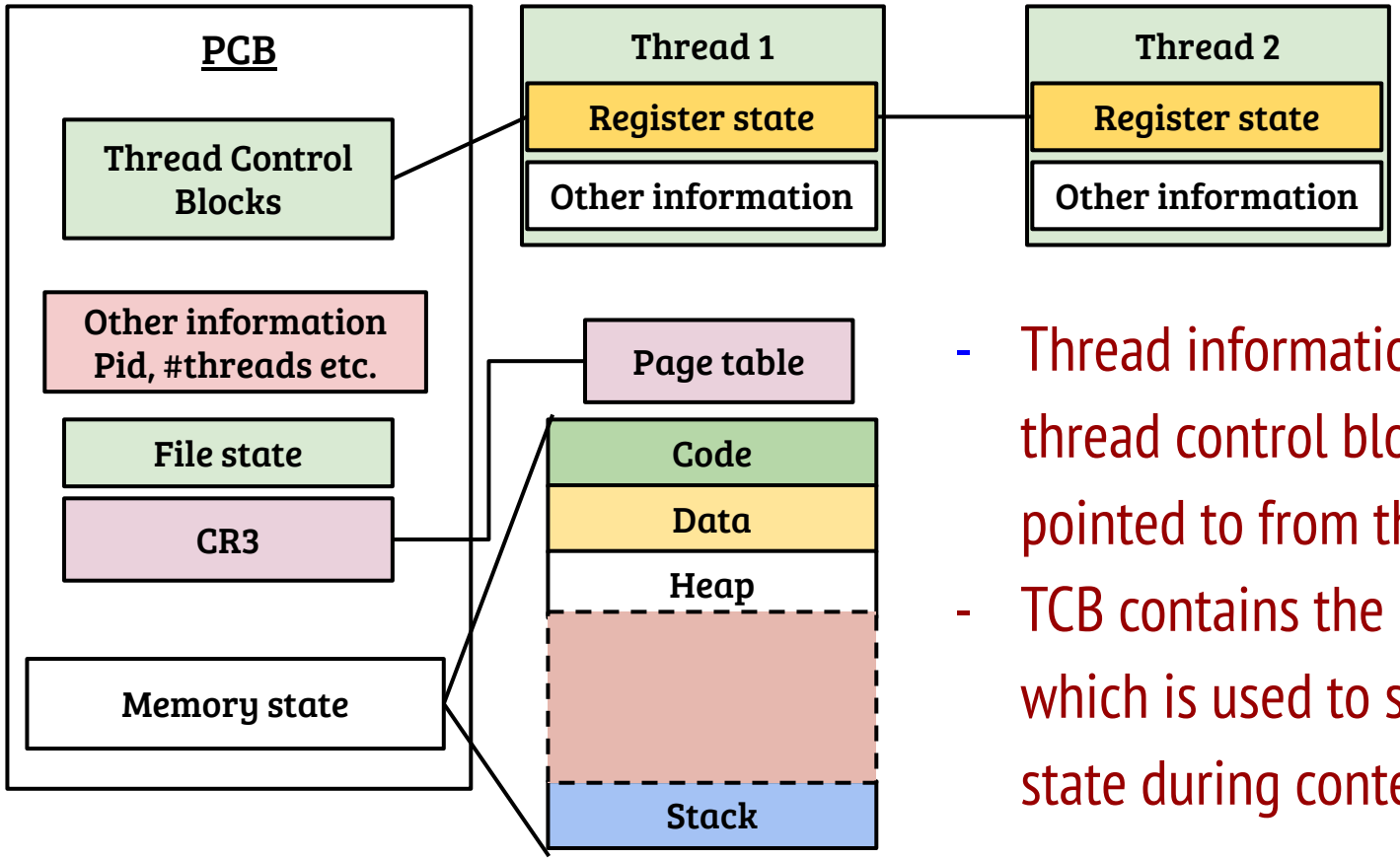
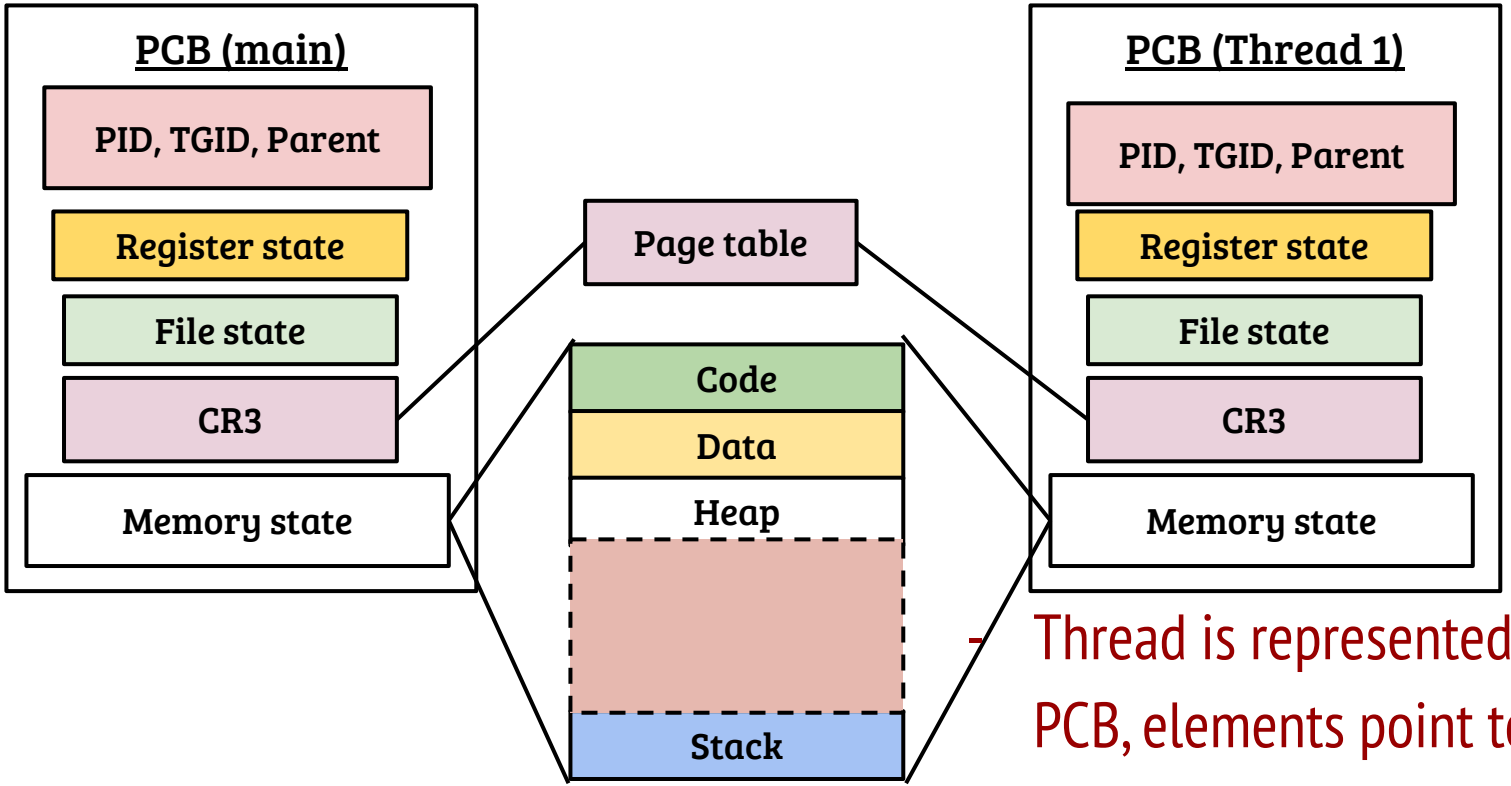
- What is POSIX thread API? How is it used?

# PCB of a multithreaded process




- Thread information is stored in thread control blocks (TCB) which is pointed to from the PCB
- TCB contains the register state which is used to save/restore CPU state during context switch

# PCB of a multithreaded process (Linux)




- Thread is represented by a separate PCB, elements point to the structure containing subsystem level info.

# Multi-threaded processes

- 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
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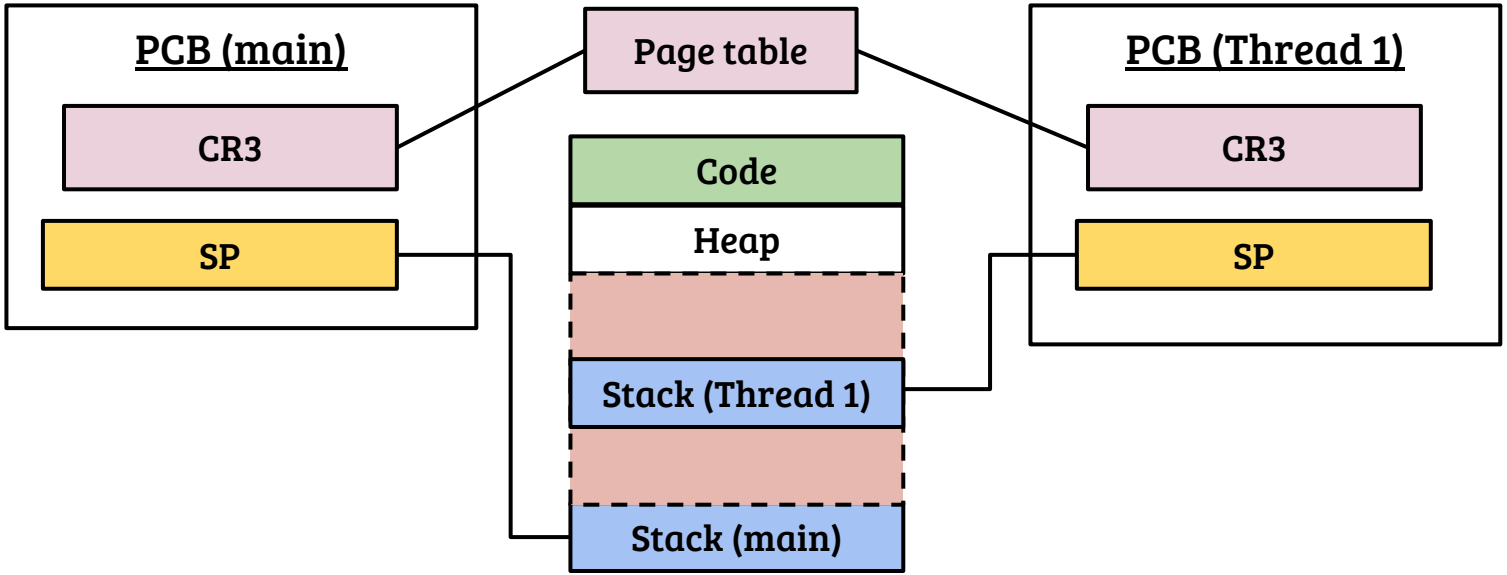
# Stack for multi-threaded processes




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

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switching the address space

# Posix thread API (pthread_create)

```
int pthread_create( pthead_t *tid, pthread_attr_t *attr,
                    void * (*thfunc) (void*), void *arg);
```

- 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

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- 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