Thread

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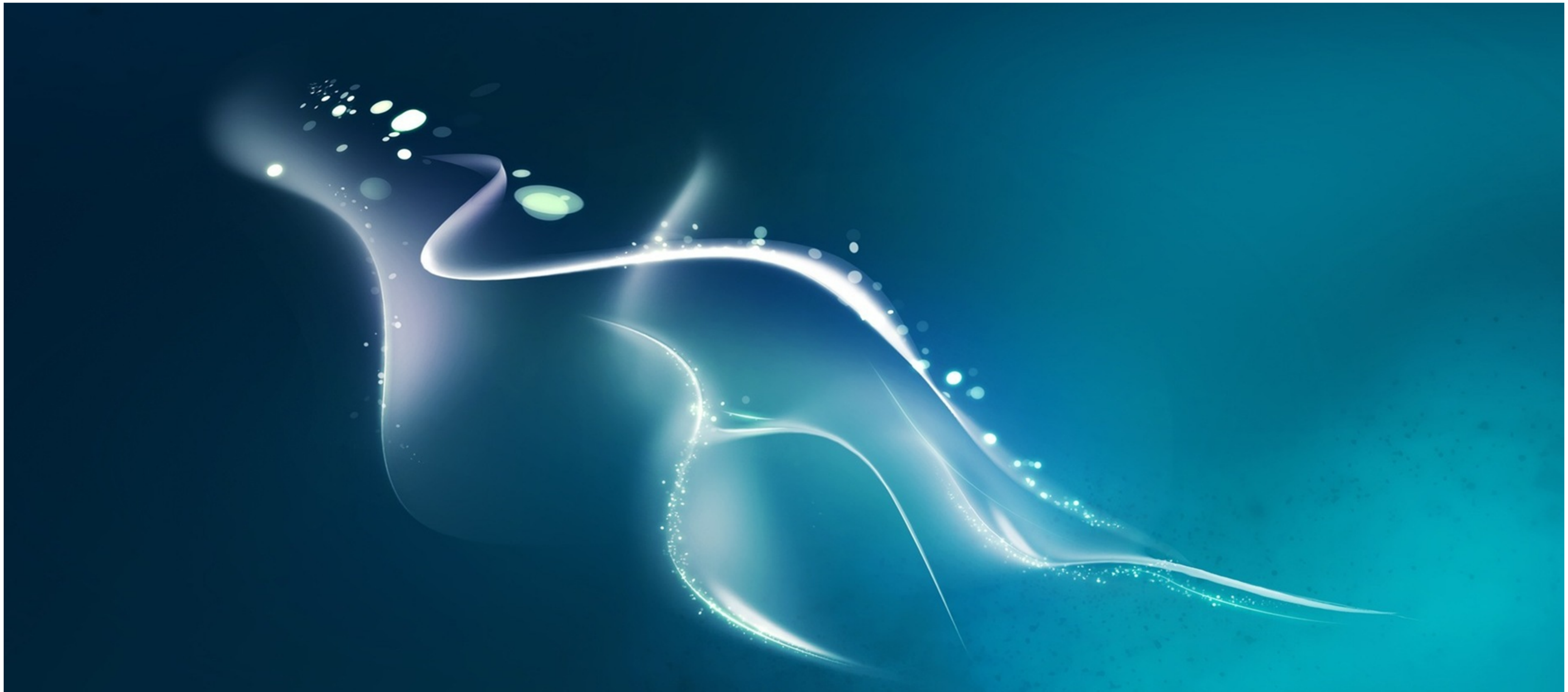
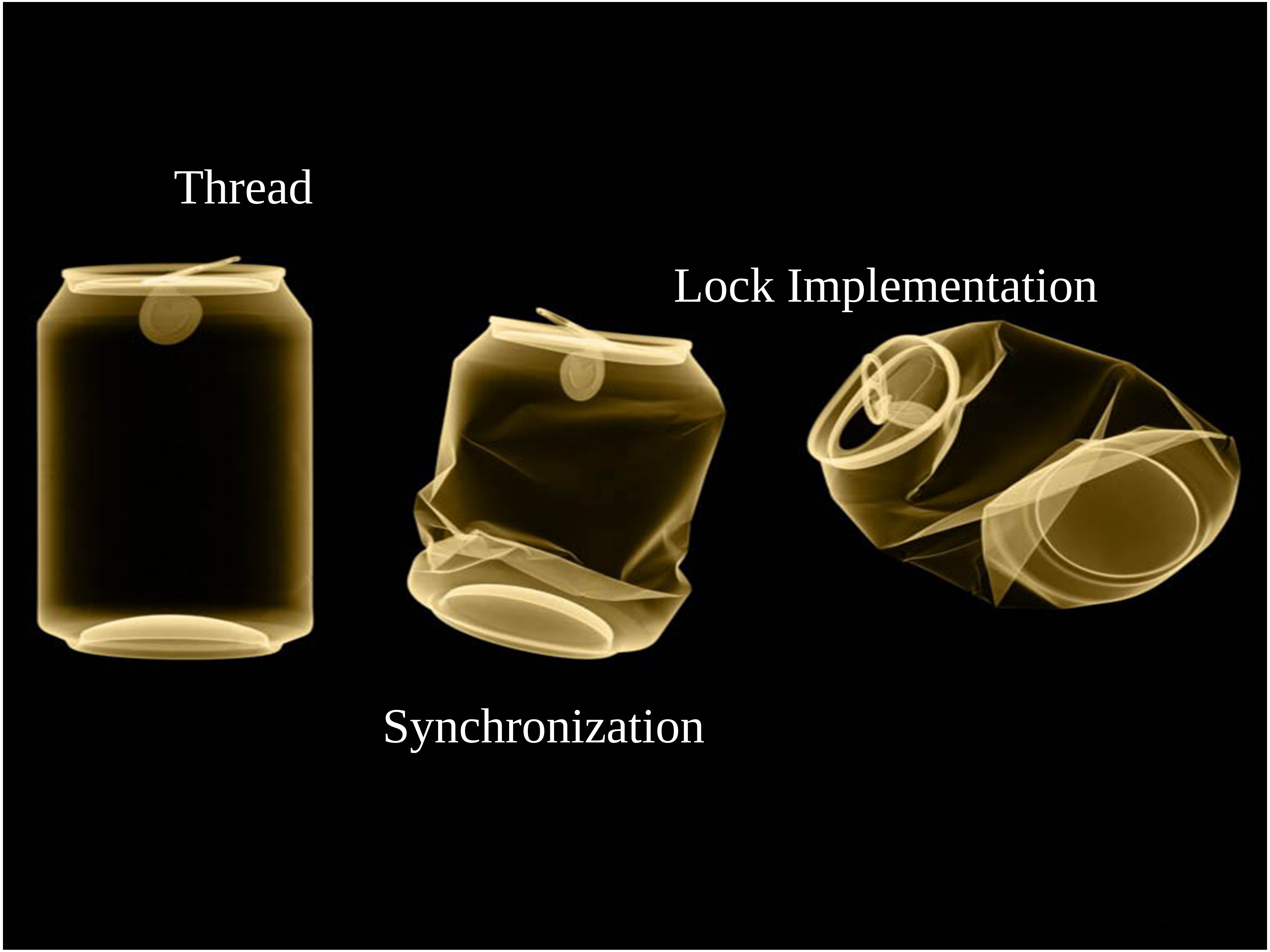


In Pursuit of Absolute Simplicity 求于至简，归于永恒


Thread
Lock Implementation
Synchronization

Content

- Problem with process
- Thread
  - Thread model
- Thread implementation
  - User level threads
  - Kernel level threads
  - Hybrid
- Thread cooperation
  - Non-determinism

Problems with process

- While supporting multiprogramming on shared hardware
- Itself is single threaded!
  - i.e. a process can do only one thing at a time
  - blocking call renders entire process un-run-able
- Thus, time calls for something else
  - threads

Threads

- Invented to support multiprogramming on process level
- Manage OS complexity
  - Multiple users, programs, I/O devices, etc.
- Each thread dedicated to do one task

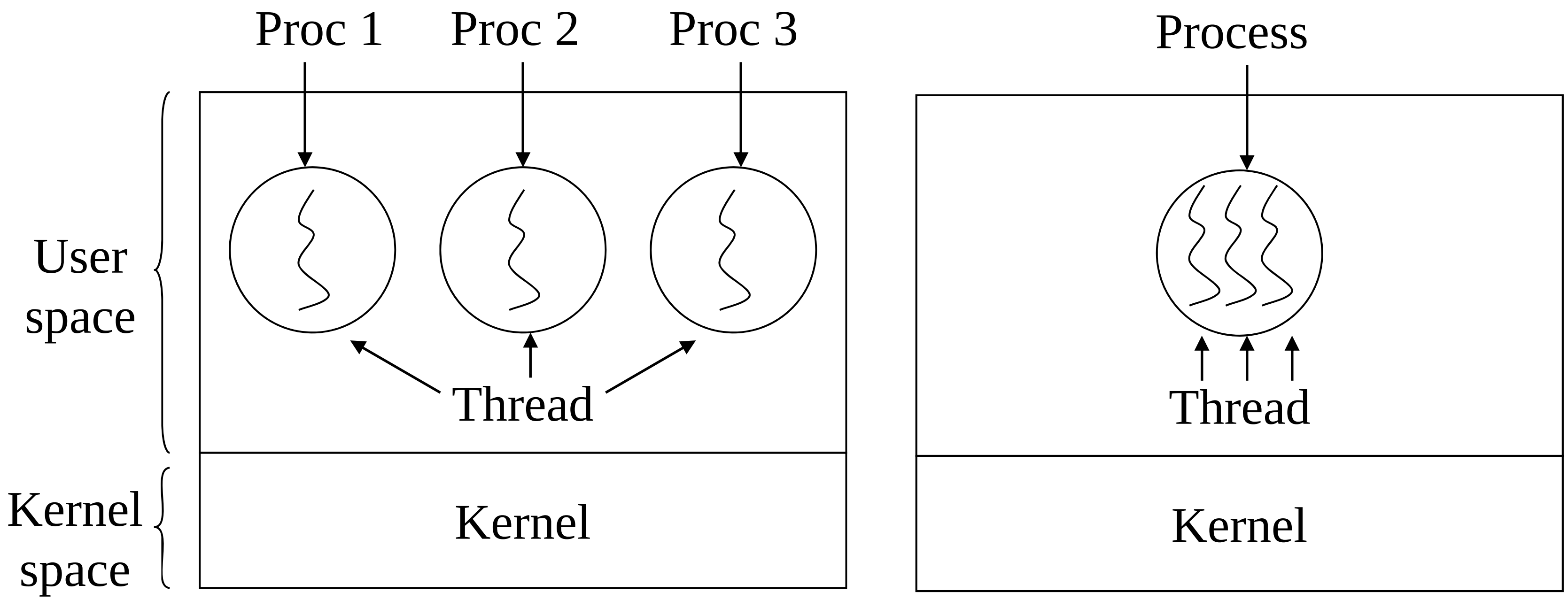
- Sequence of executing instructions from a program
  - i.e. the running computation
- Play analogy: one actor on stage in a play

Threads

- threads decompose mix of activities into several parallel tasks
- Each job can work independently of others

job1	job2	job3
Thread 1	Thread 2	Thread 3

The Thread Model



3 threads each with 1 thread

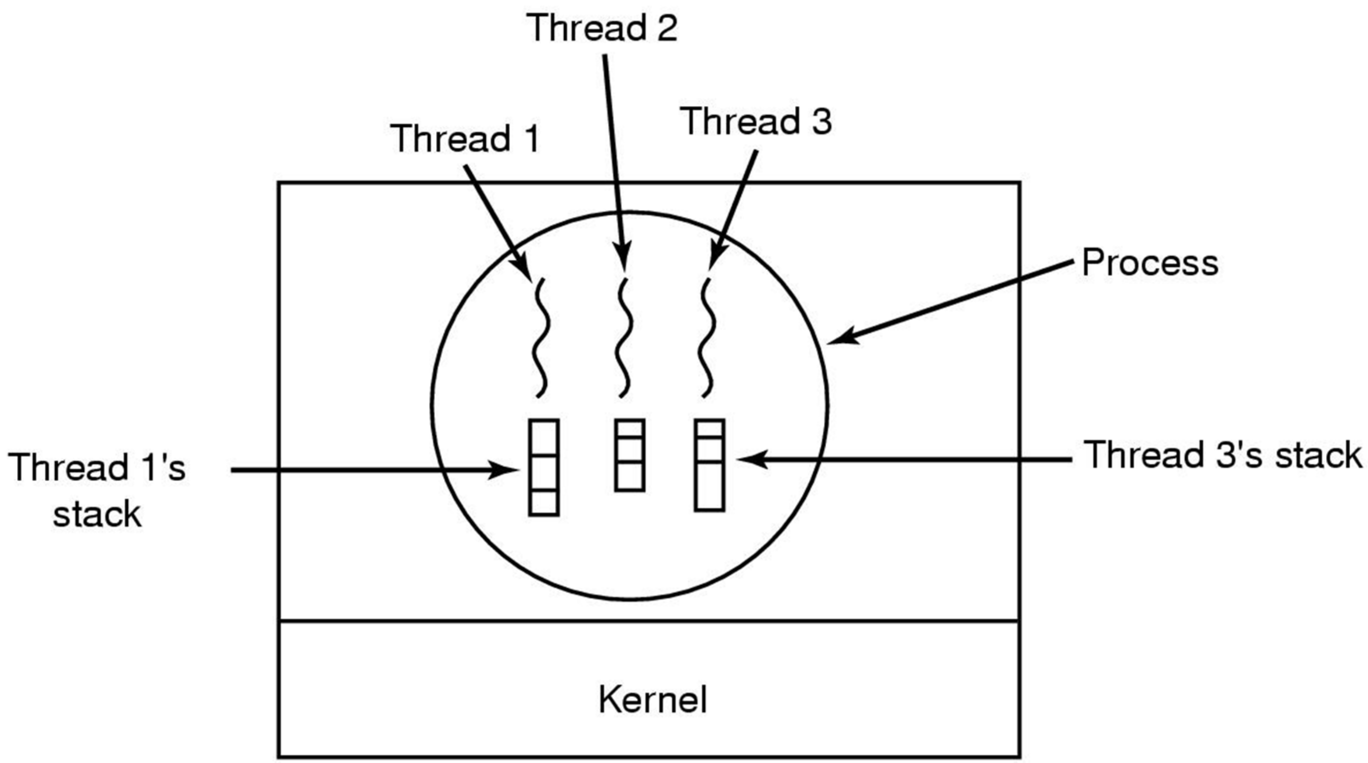
1 thread with 3 threads

Shared and Private Items

- Some items shared by all threads in a thread
- Some items private to each thread

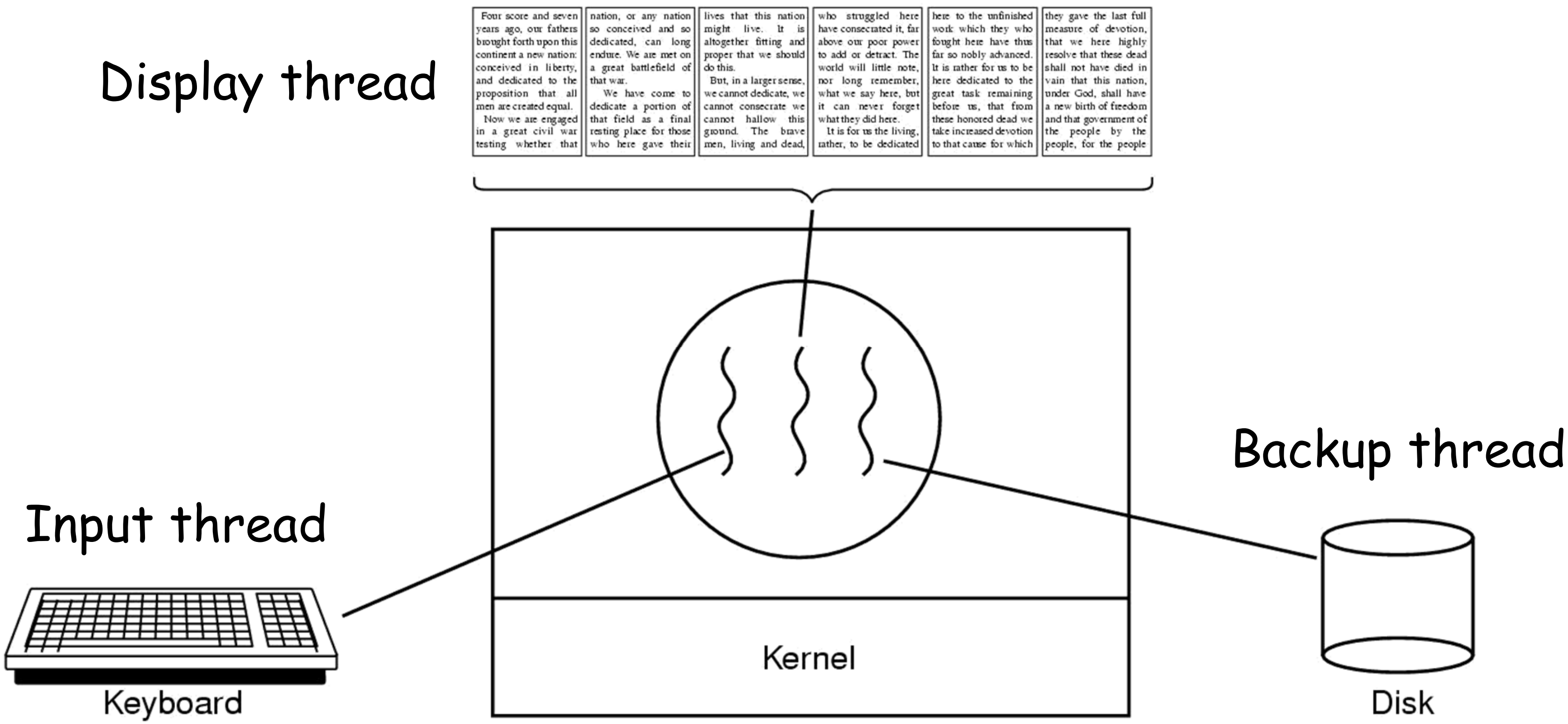
Per process items	Per thread items
Address space	Program counter
Global variables	Registers
Open files	Stack
Child threads	State
Pending alarms	
Signals and signal handlers	
Accounting information	

Shared and Private Items



Each thread has its own stack

A Word Process w/3 Threads

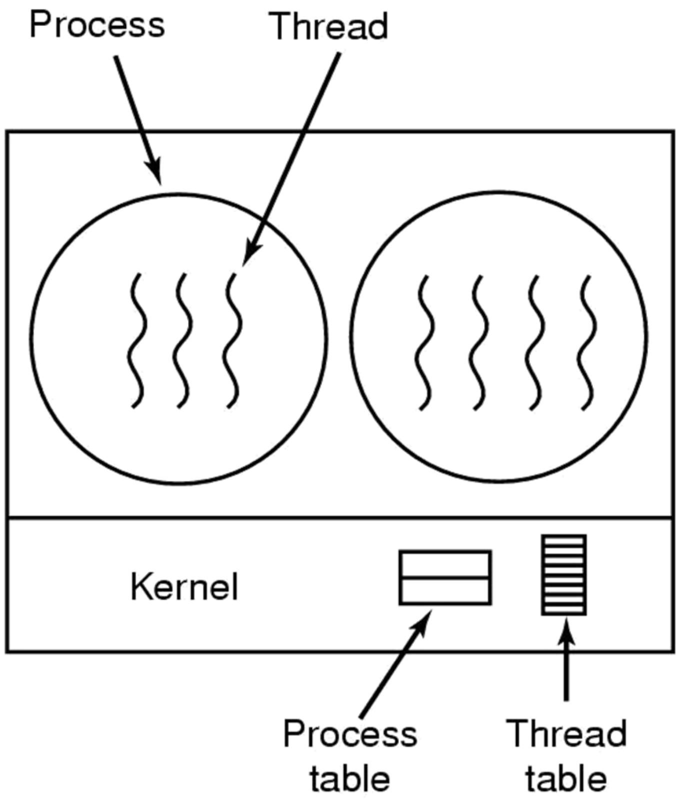


Implementation of Thread

- How many options to implement thread?
- Implement in kernel space
- Implement in user space
- Hybrid implementation

Kernel-Level Implementation

- Completely implemented in kernel space
- OS acts as a scheduler
- OS maintains information about threads
  - In additions to process



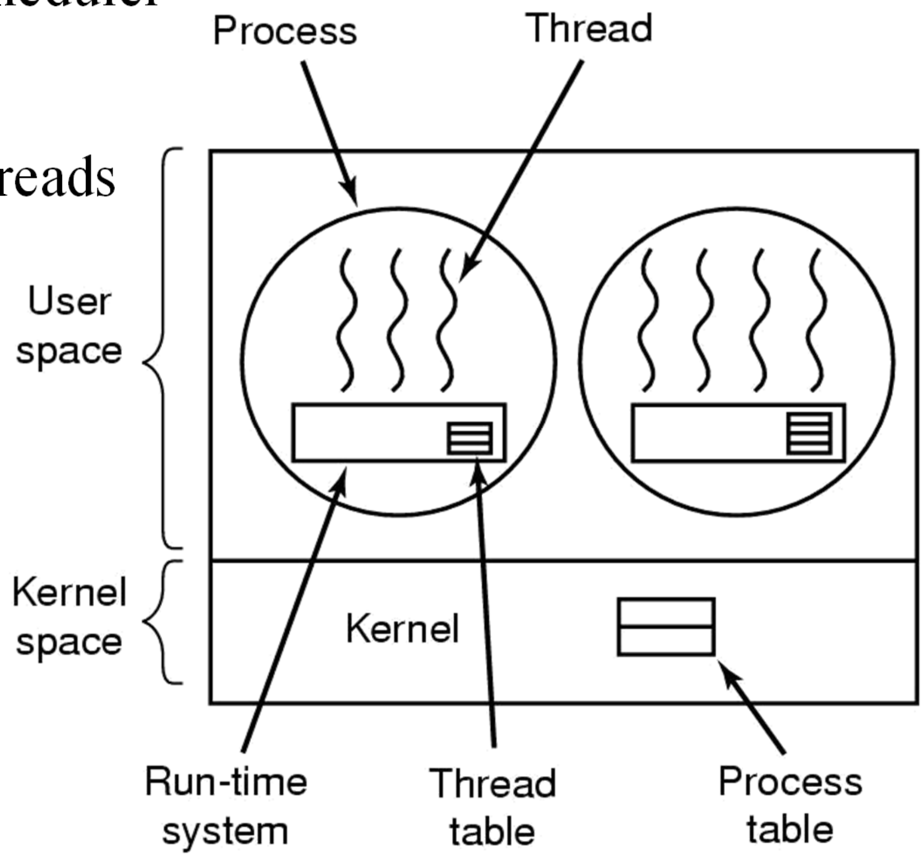
Kernel-level implementation

Kernel-Level Implementation

- Advantage:
  - Easier to programming
  - Blocking threads does not block process
- Problems:
  - Costly: need to trap into OS to switch threads
  - OS space is limited (for maintaining info)
  - Need to modifying OS!

User-Level Implementation

- Implemented in user space
- A run-time system acts as a scheduler
- Threads voluntarily cooperate
  - i.e. yield control to other threads
- OS need not know about it



User-level implementation

User-Level Implementation

- Advantage:
  - Flexible, can be implemented on any OS
  - Faster: no need to trap into OS
- Problems:
  - Programming is tricky
  - blocking threads block process!

- Question:
  - How do we solve the problem of blocking thread blocks the process?

User-Level Implementation

- Modifying system calls to be unblocking
- Write a wrap around blocking calls
  - i.e. call only when it is safe to do so

- Example: Scheduler Activations
  - A technique solves the problem of blocking calls in user-level threads
- Method:
  - use up-call
- Goal – mimic functionality of kernel threads
  - gain performance of user space threads

Scheduler Activations

- Kernel assigns virtual processors to thread
- Runtime sys. allocate threads to processors
- Blocking threads are handled by OS up-call
  - i.e. OS notify runtime system about blocking calls

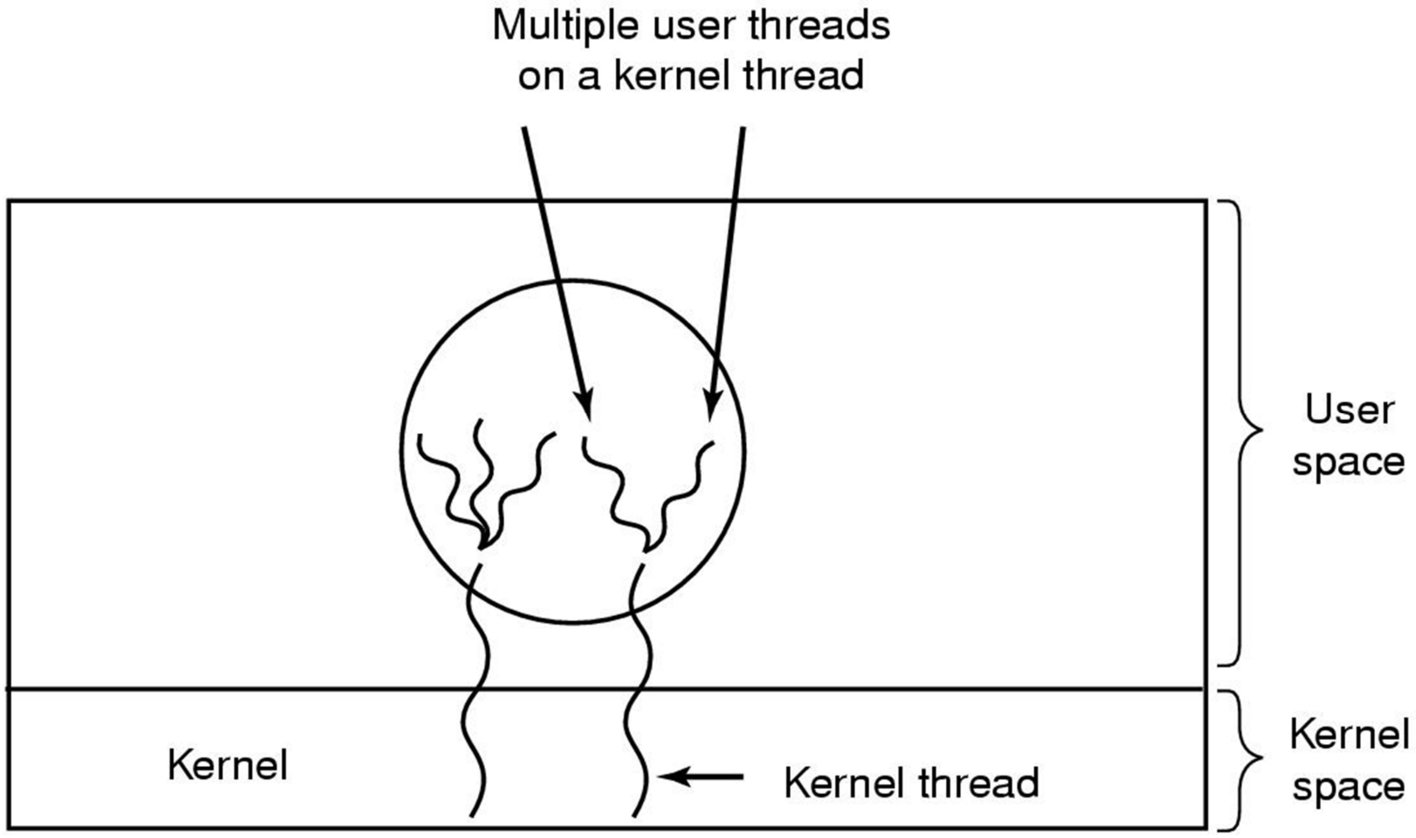
- Problems?:
  - Reliance on kernel (lower layer) calling
    - →procedures in user space (higher layer)
  - Violates layered structure of OS design
  - OS correctness depends on run-time system

Hybrid Implementation

- Can we have the best of both worlds
  - i.e. kernel-level and user-level implementations
- While avoiding the problems of either?

- Hybrid implementation
  - User-level threads are managed by runtime systems
  - Kernel-level threads are managed by OS
  - Multiplexing user-level threads onto kernel- level threads

Hybrid Implementation



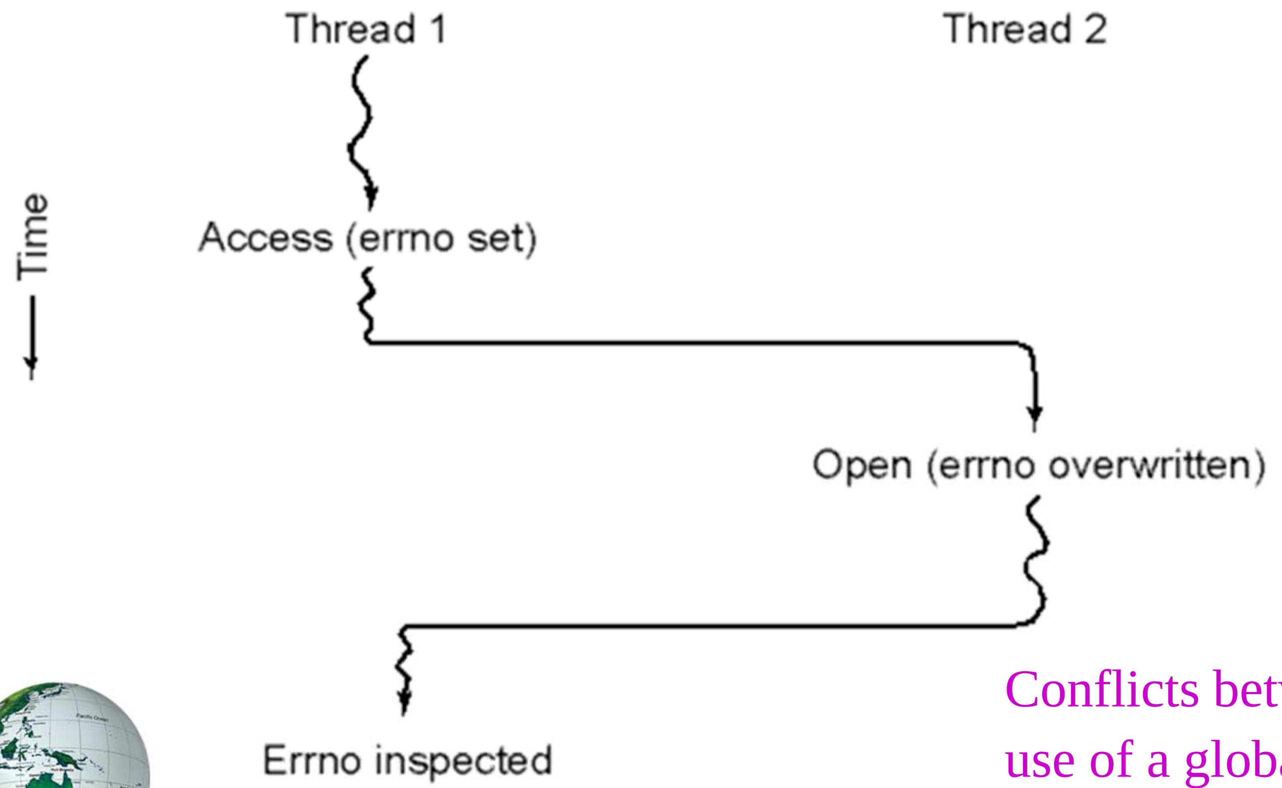
Multiple Threads

- Can have several threads in a single address space
  - That is what thread is invented for
- Play analogy: several actors on a single set
  - Sometimes interact (e.g. dance together)
  - Sometimes do independent tasks

- Private state for a thread vs. global state shared between threads
  - What private state must a thread have?
  - Other state is shared between all threads in a thread

Multiple Threads

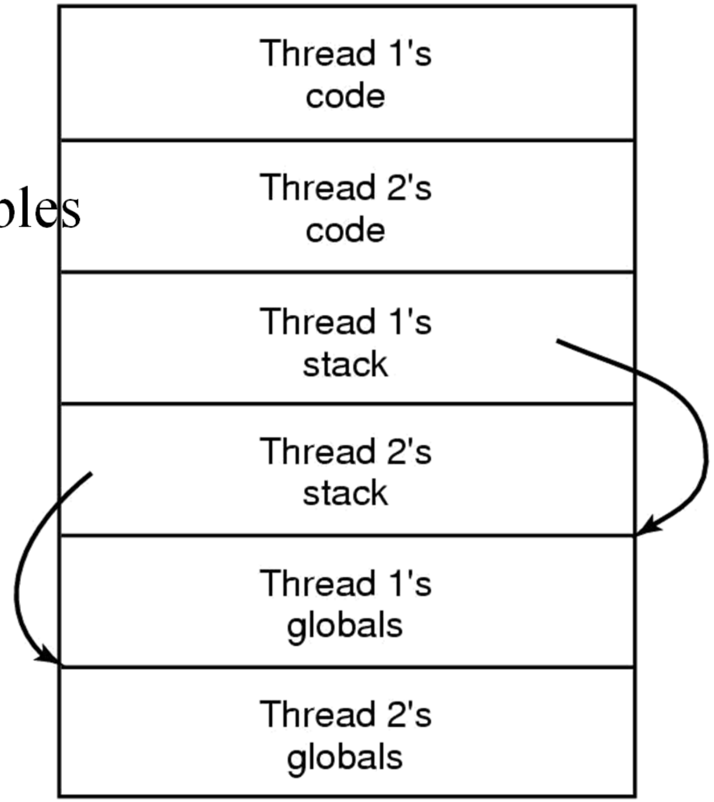
- Many programs are written in single-threaded threads
  - Make them multithreaded is very tricky



Conflicts between threads over use of a global variable

Multiple Threads

- So what can we do about it?
- Many solutions:
  - Prohibit global variables
  - Assign each thread private global variables



Threads can have

private global variables

Cooperating Threads

- Often we create threads to cooperate:
  - Each thread handles one request
  - Each thread can issue a blocking disk I/O,
    - →wait for I/O to finish
    - →then continue with next part of its request
- Even though thread blocks, other threads can make progress
  - and new threads can start to handle new requests

Cooperating Threads

- Issues with cooperating threads?
- Where is the state of each request stored?
  - In thread space shared by all threads?
  - In private space of the thread?
- How to communicate with each other?
- How to synchronize with each other

Cooperating Threads

- Ordering of events from different threads is non-deterministic
  - different threads may have differing amounts of work done in 10s
- thread A --------------------------------->
- thread B - - - - >
- thread C - - - - - - - - - - ->

Cooperating Threads

- Consequence:
  - Results of multi-threaded programming can be non-deterministic
- Example
  - thread A: x=1
  - thread B: x=2
- Possible results?
- Is 3 a possible output?
  - yes

Atomic Operations

- Another example:

– thread A	thread B
– i=0	i=0
– while (i < 10) {	while (i > -10) {
– i++	i--
– }	}
– print “A finished”	print “B finished”

- Who will win?


Thoughts Change Reality
意念改变现实