Concurrency

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KTH

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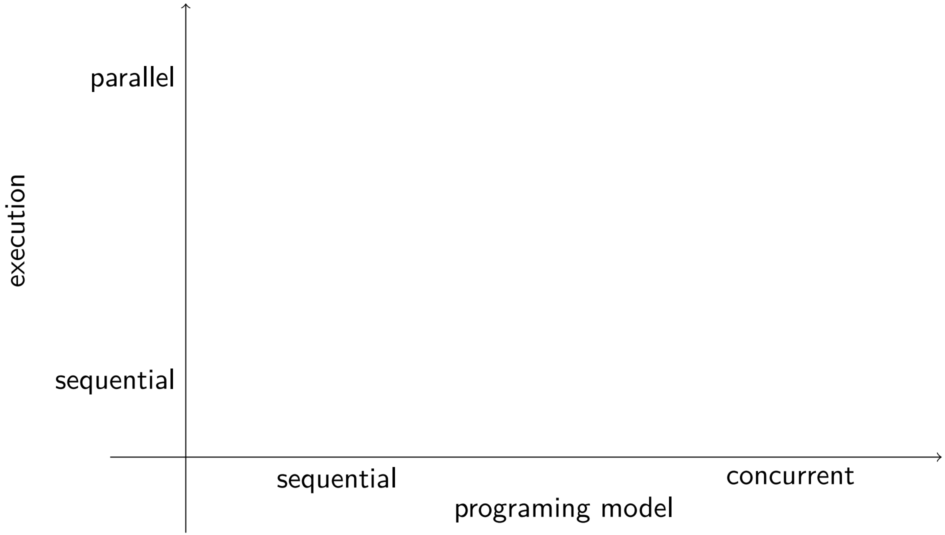
concurrency vs parallelism



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Today - concurrency is such an important topic that it could (and often do) fill up a course of it's own.

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What do two UNIX processes share?

A process

As we have learned - the unit of a computation.

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- a program

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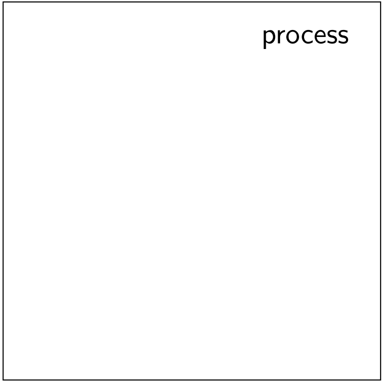

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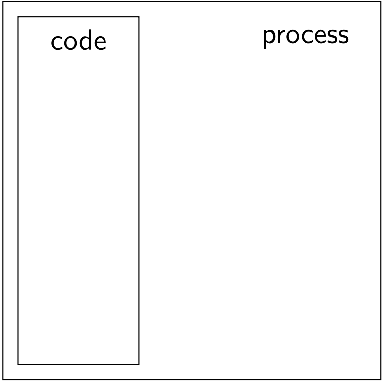

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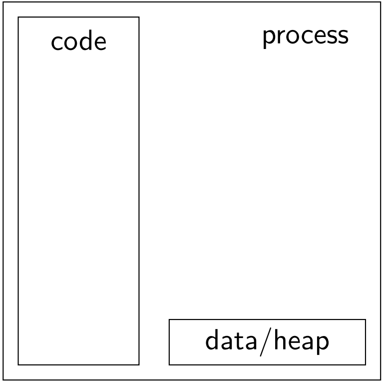

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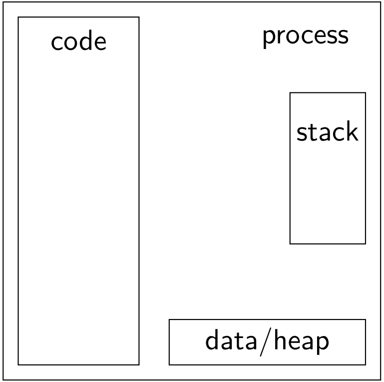

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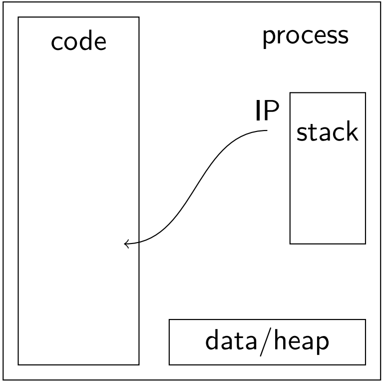

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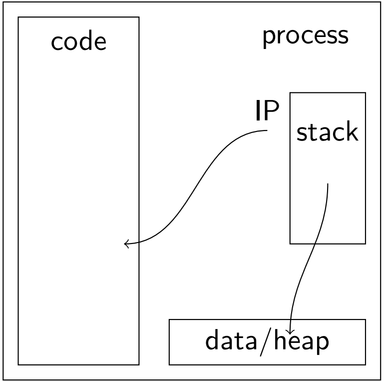

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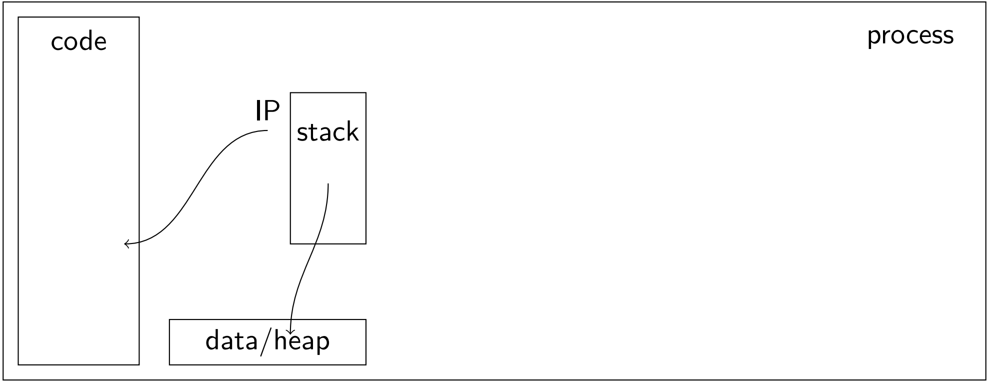

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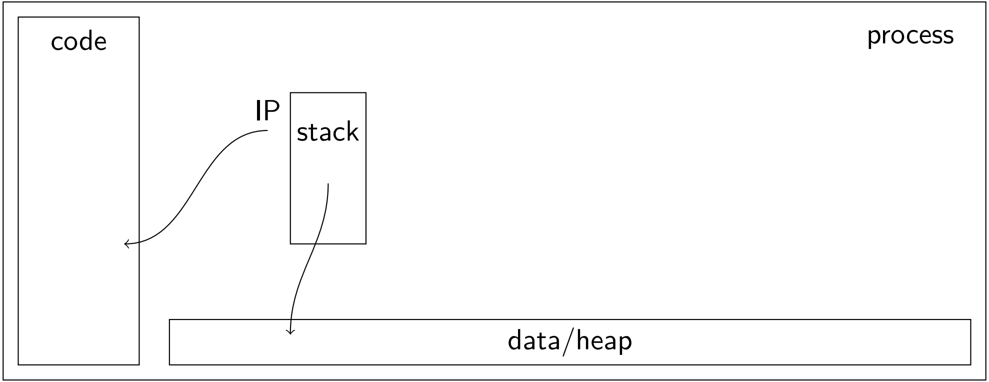

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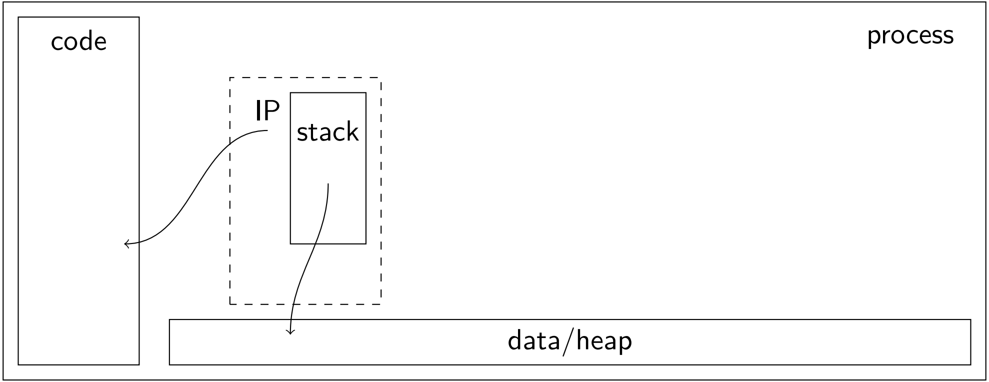

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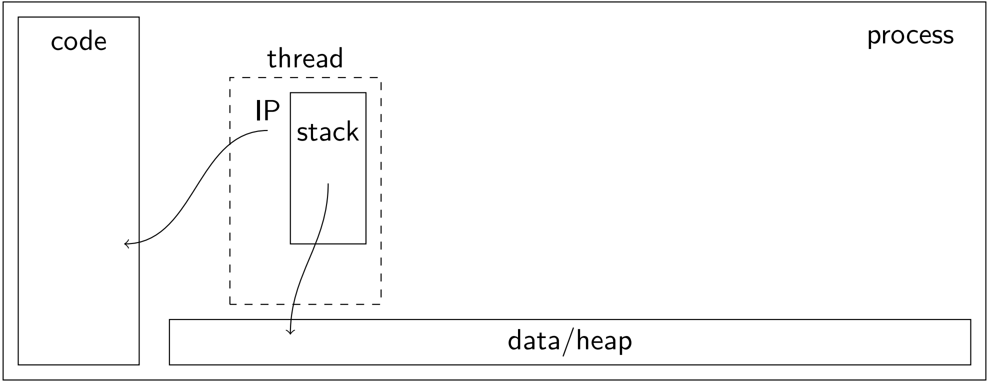

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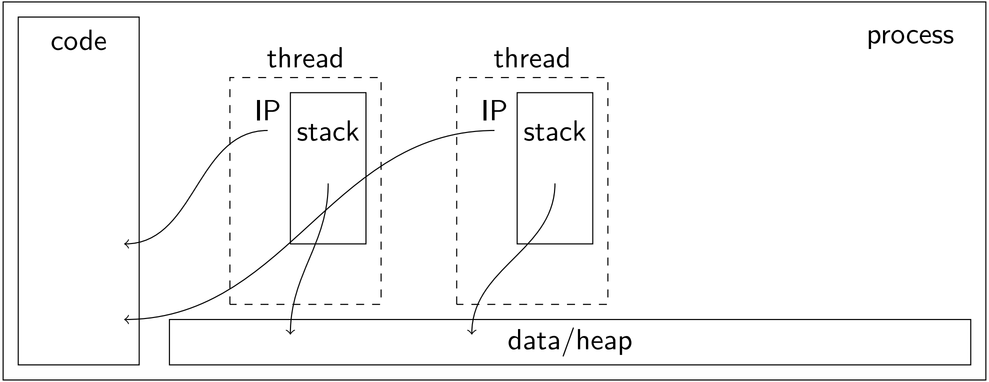

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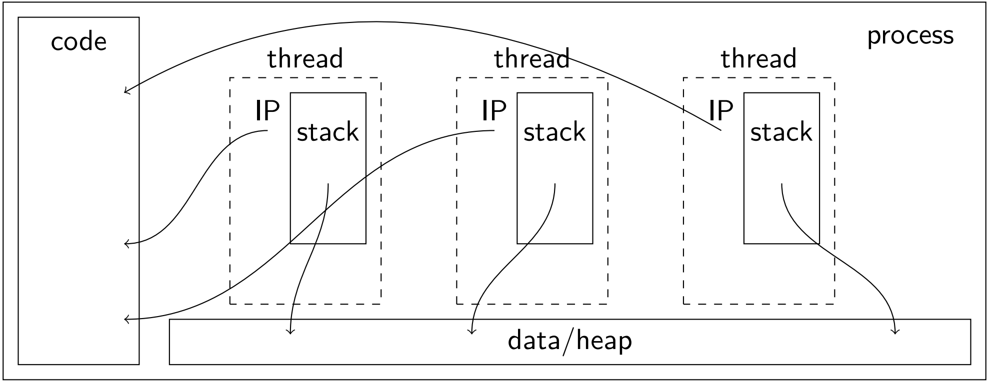

code
process
thread
thread
thread
IP
stack
IP
stack
IP
stack
data/heap

Virtual memory layout

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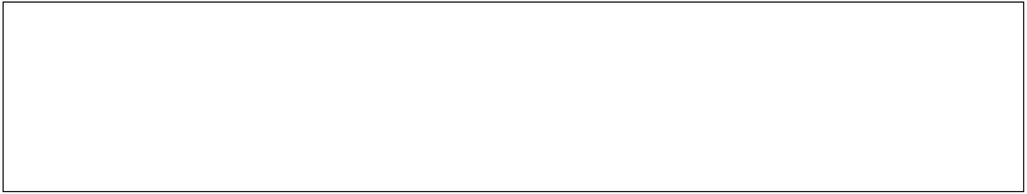

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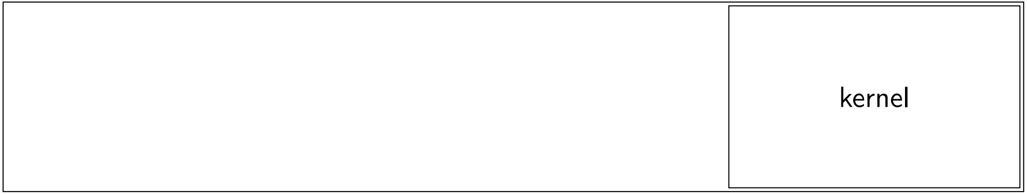

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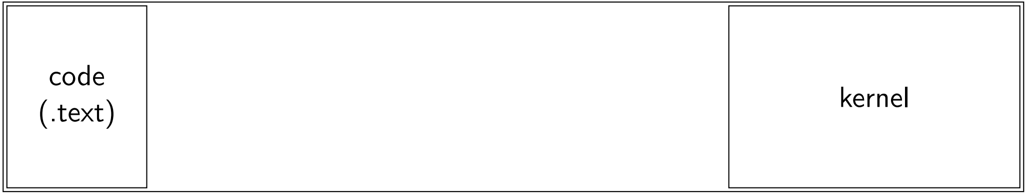

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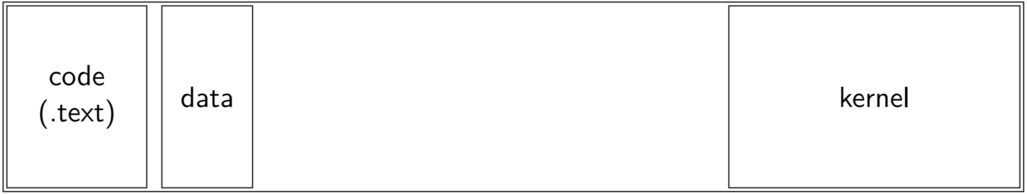

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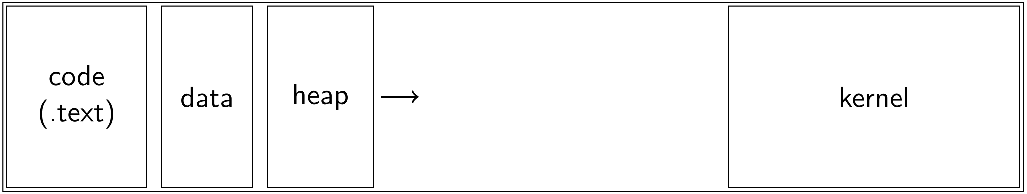

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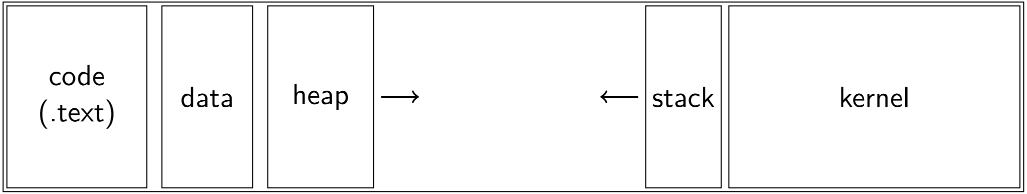

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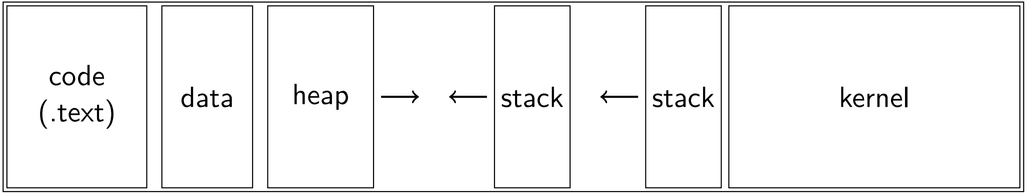

```
#include <pthread.h>
#include <stdio.h>

int loop = 10;
int count = 0;

void *hello(char *name) {
  for(int i = 0; i < loop; i++) {
    count++;
    printf("hello %s %d\n", name, count);
  }
}

int main() {
  pthread_t p1;
  pthread_create(&p1, NULL, hello, "A");
  pthread_join(p1, NULL);
  return 0;
}
```

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There are several alternatives of how coherence is defined, this is one example

More problems

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What is the expected outcome of an execution?

Sequential consistency

The outcome is the same as if all the operations of the program were executed:

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as atomic operations in some sequence,

consistent with the *program order* of each thread.

the code

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int loop = 10;
int count = 0;

void *hello(void *) {
      :
  for(int i = 0; i < loop; i++) {
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```
.L3:
        movl    count(%rip), %eax
        addl    $1, %eax
        movl    %eax, count(%rip)
        addl    $1, -4(%rbp)
        movl    loop(%rip), %eax
        cmpl    %eax, -4(%rbp)
        jl      .L3
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volatile int a = 0;
volatile int b = 0;

void critical( .... ) {
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  while(1) {
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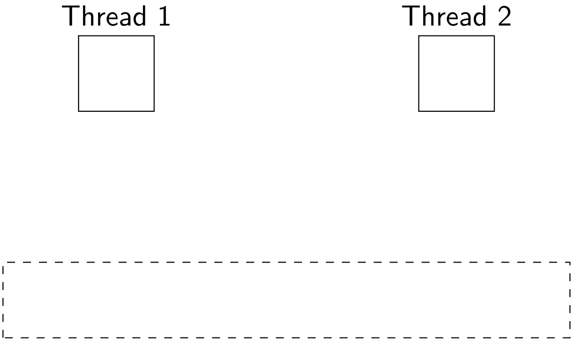

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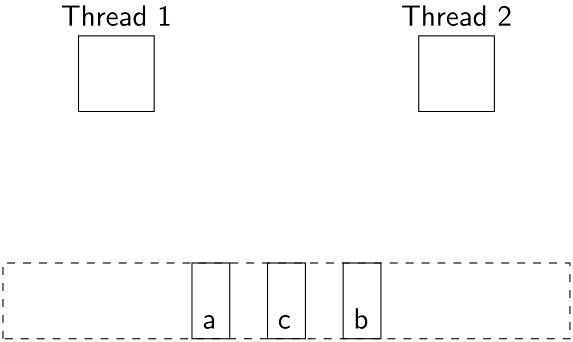

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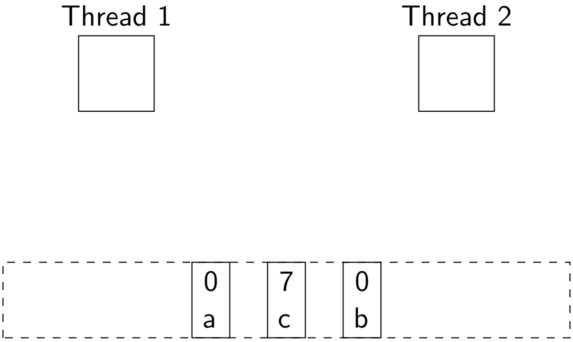

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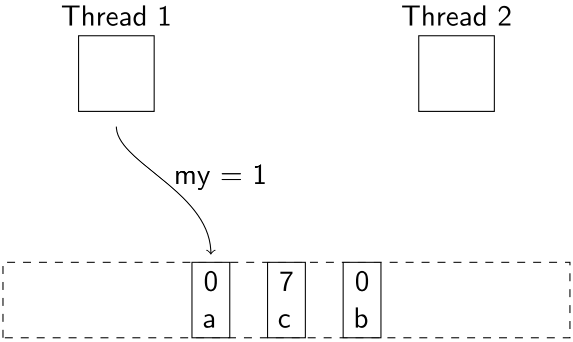

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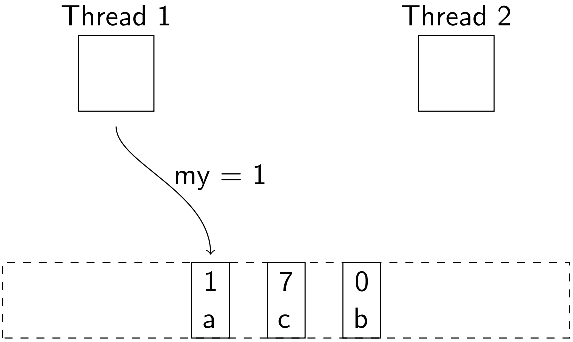

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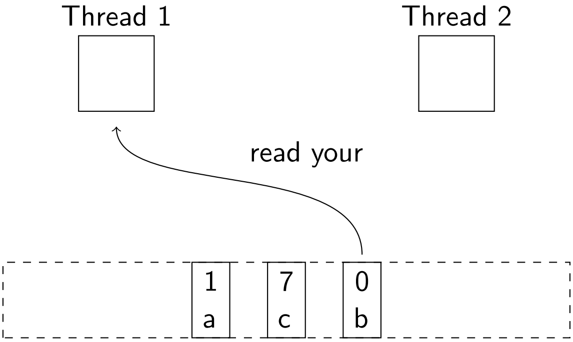

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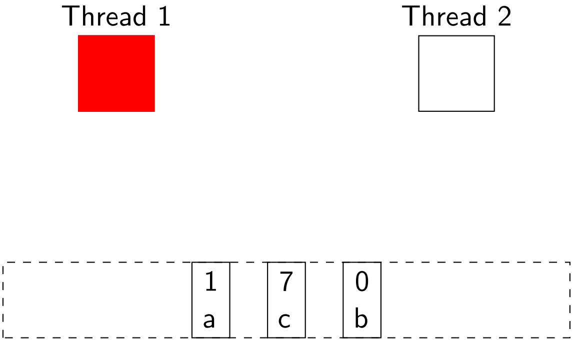

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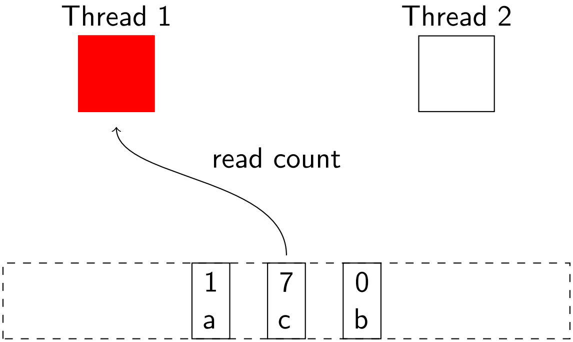

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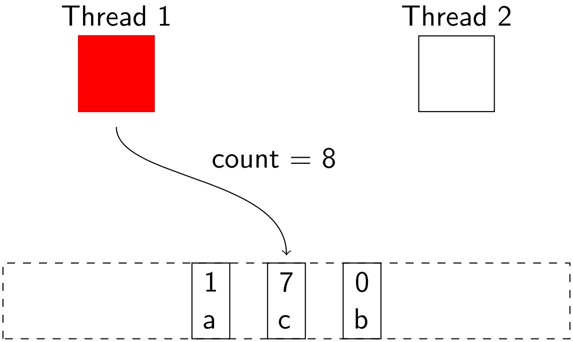

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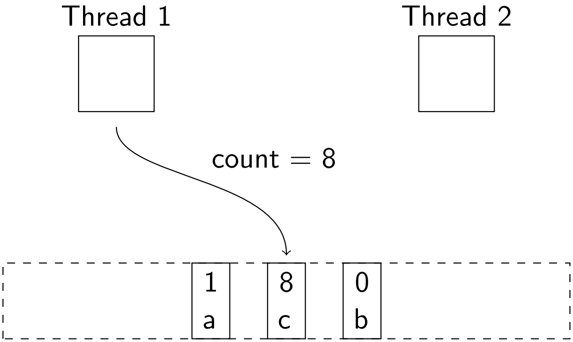

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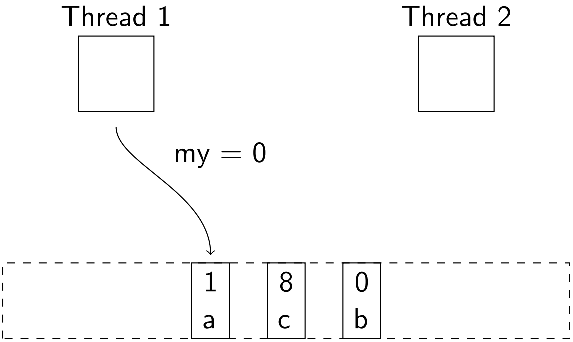

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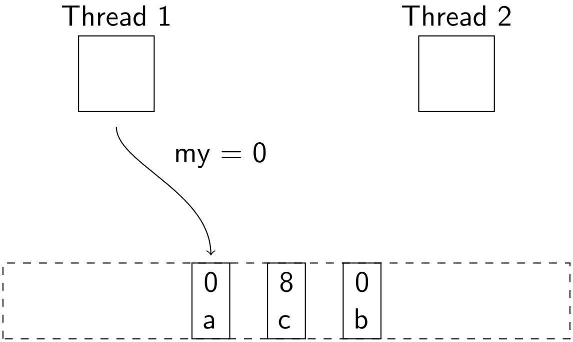

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There are operations provided by the hardware that will give us better guarantees.

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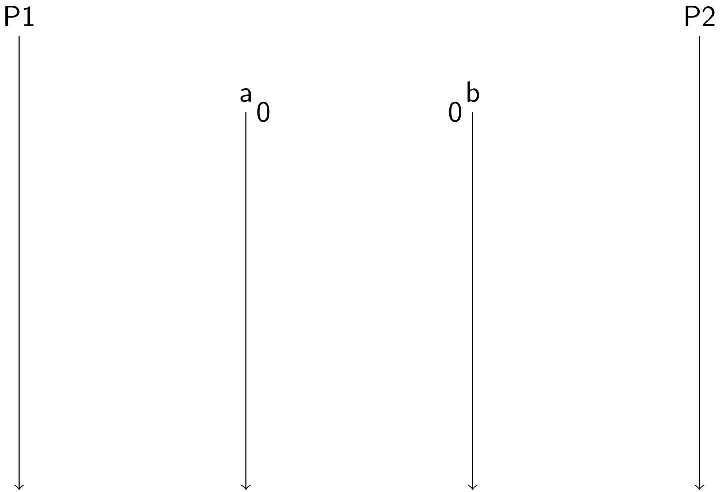

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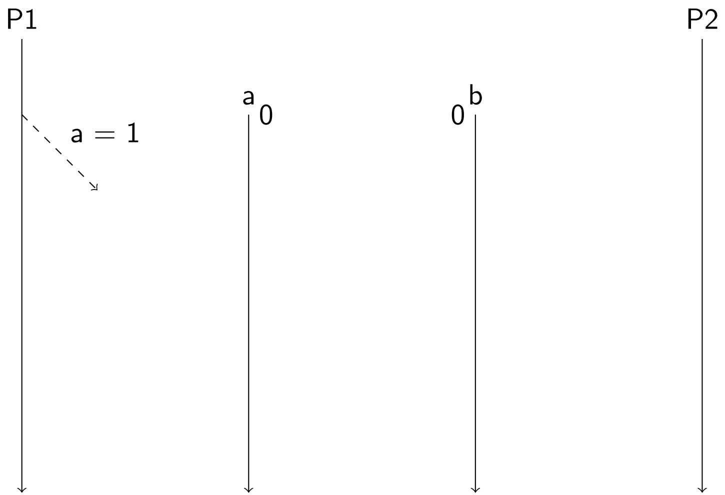

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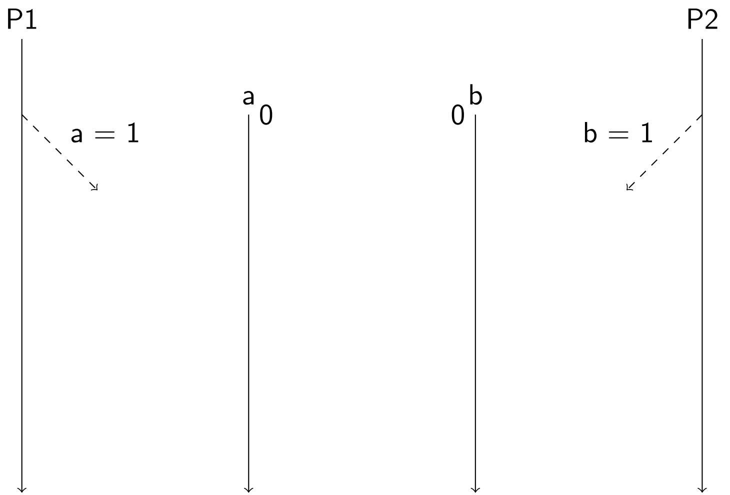

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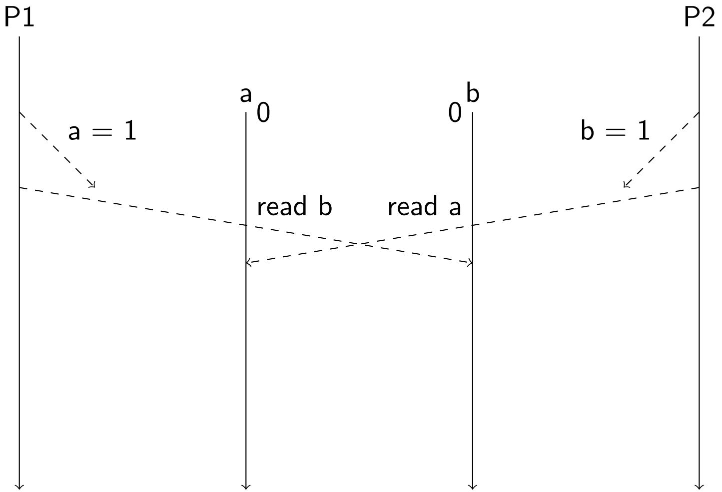

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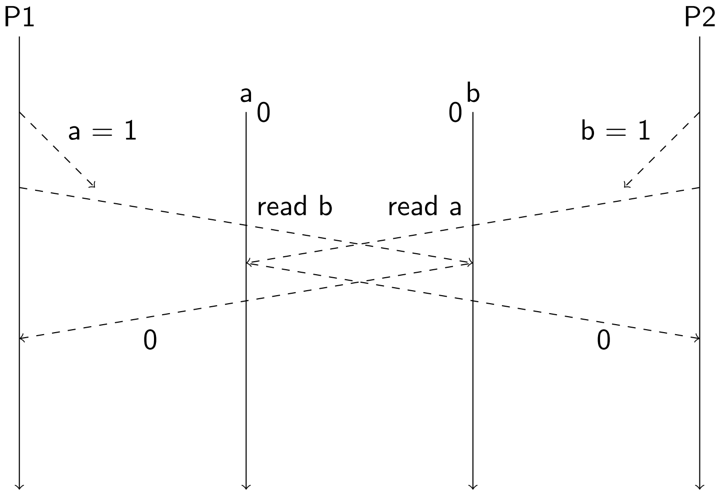

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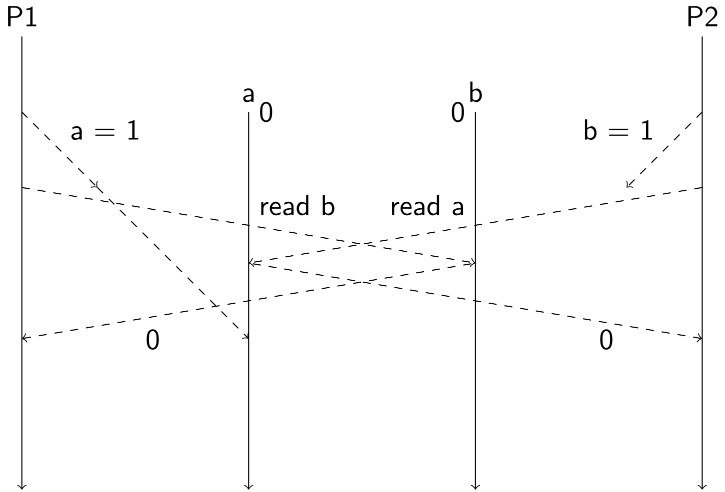

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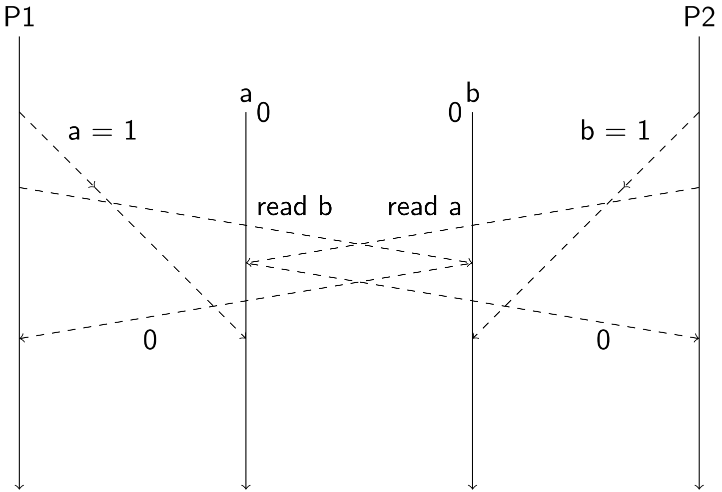

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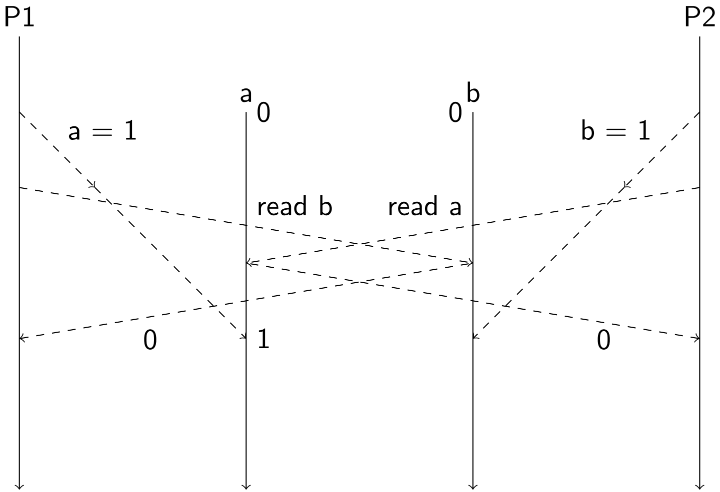

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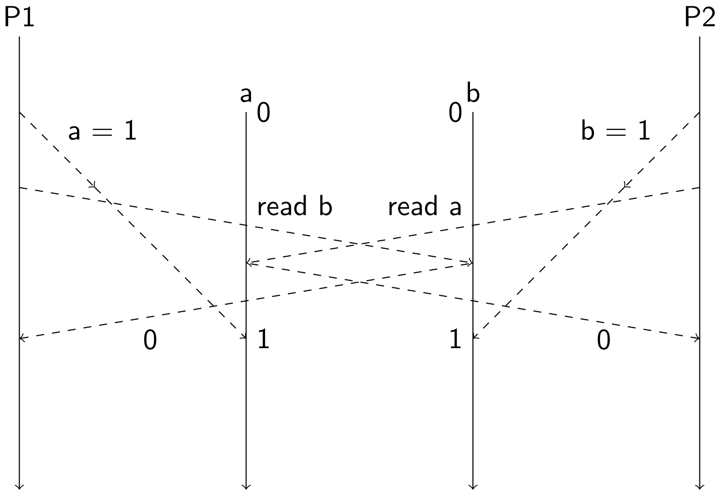

Hardware support - TGH

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Better still - if possible, use a library that handles synchronization.

How to synchronize

How to synchronize

Next week.

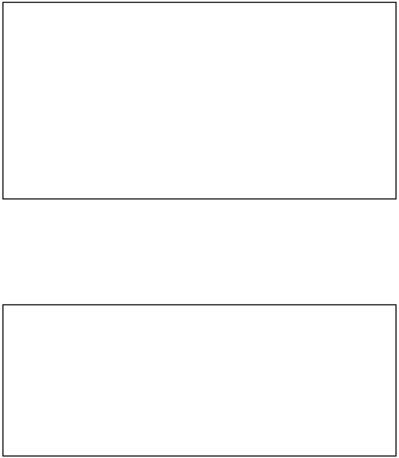
How to implement threads

threads in user space

threads in kernel space

How to implement threads

threads in user space



kernel

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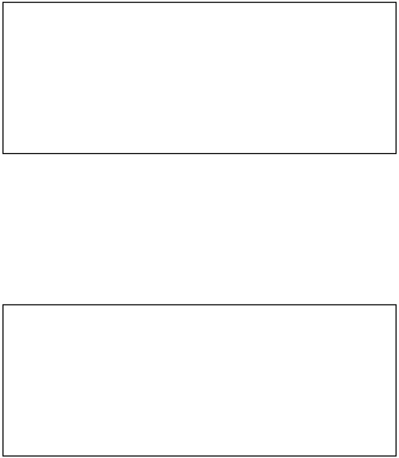

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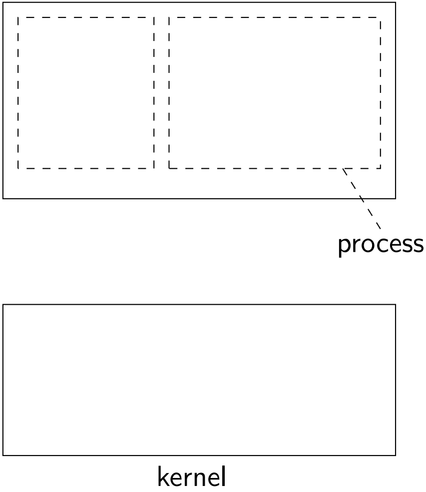

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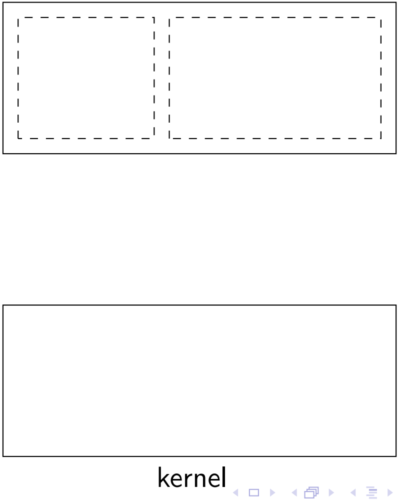

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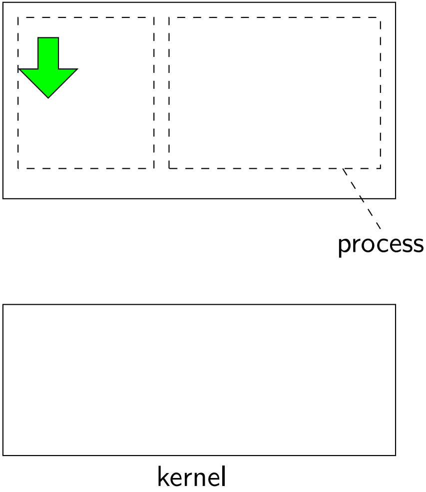

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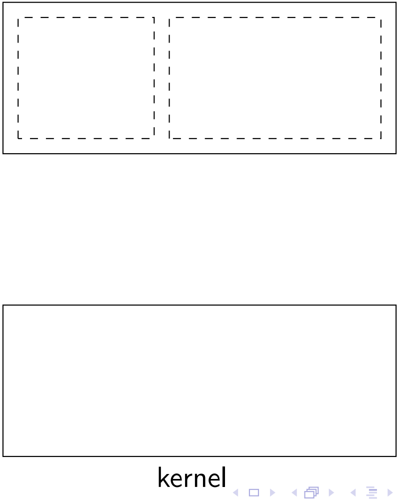

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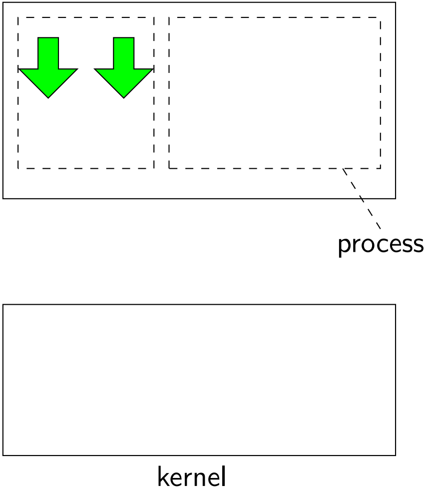

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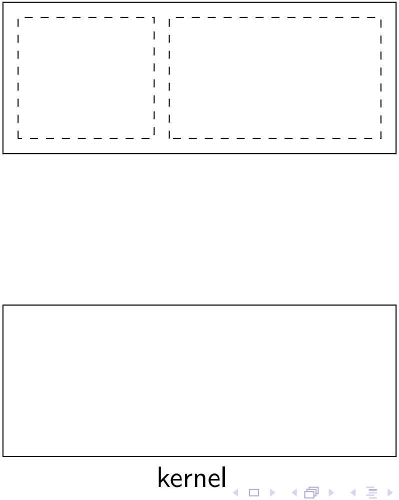

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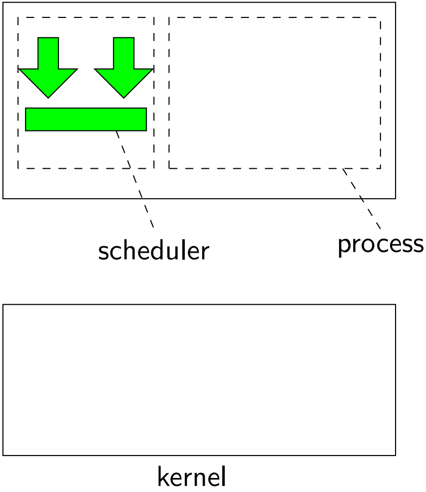

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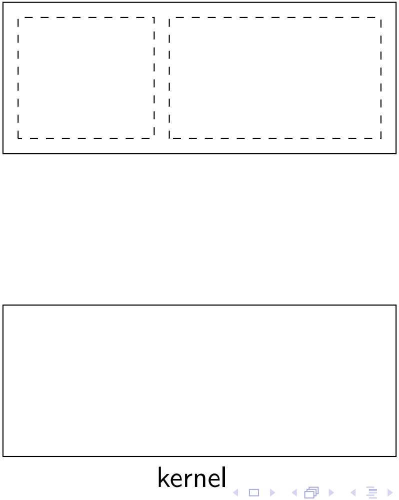

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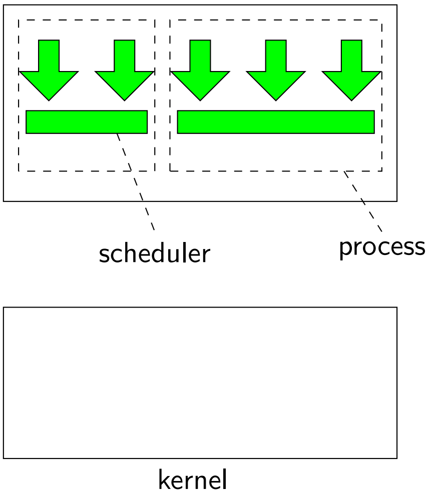

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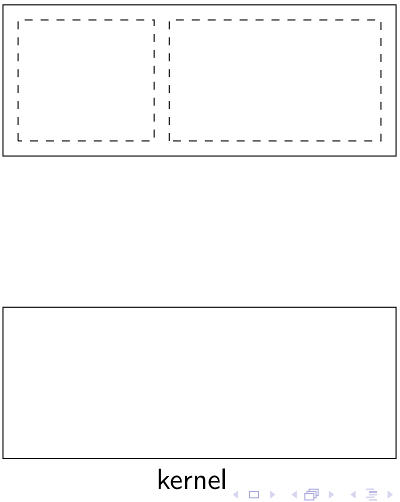

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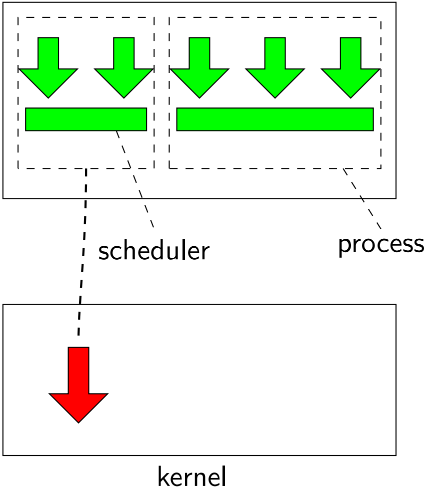

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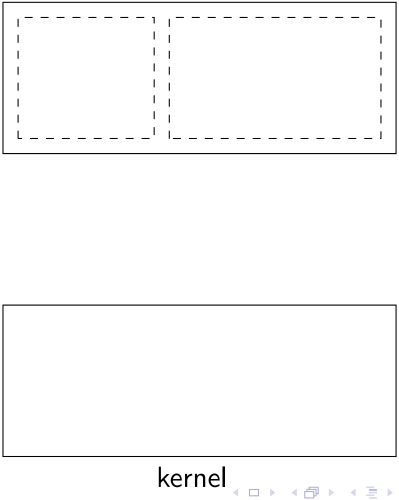

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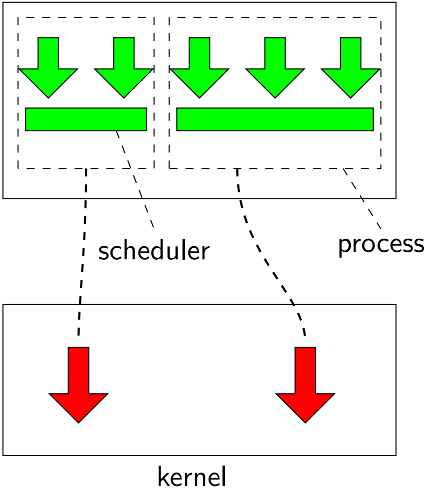

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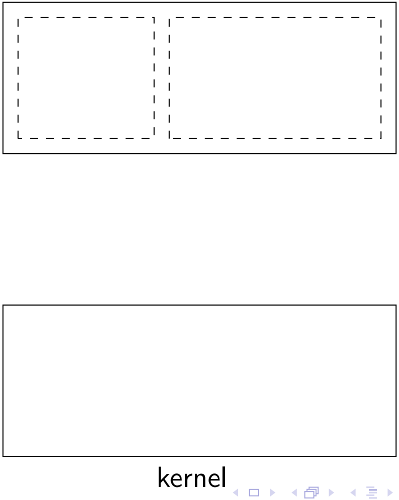

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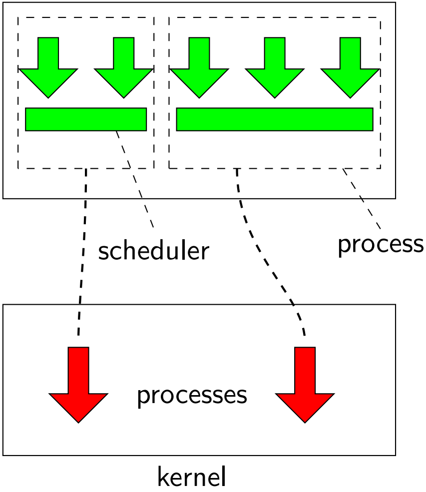

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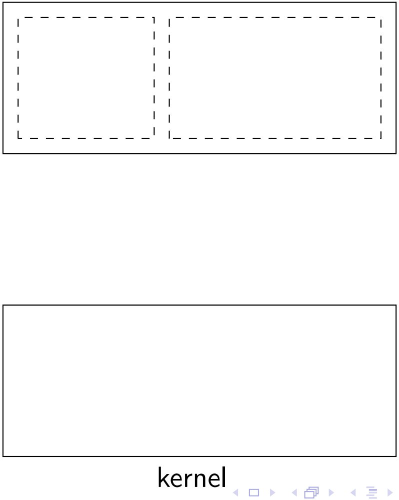

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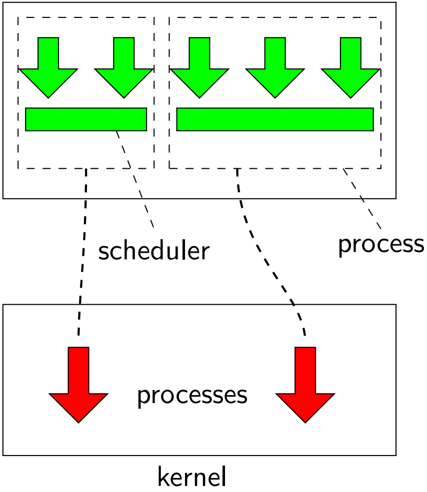

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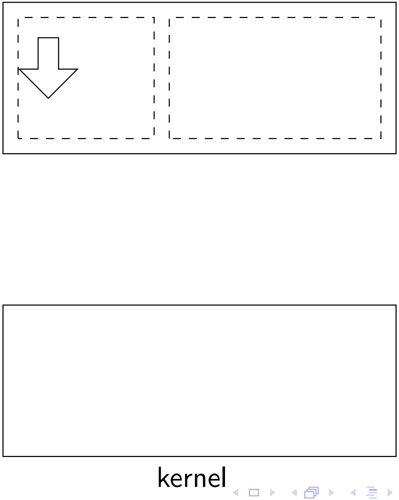

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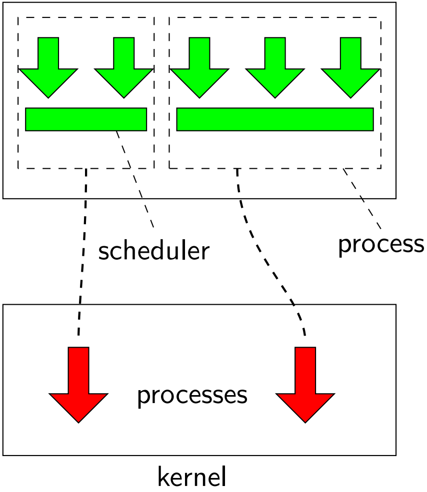

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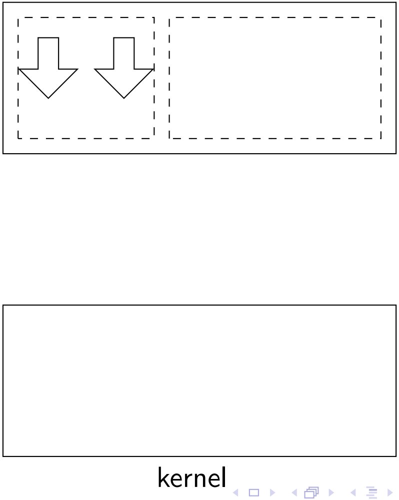

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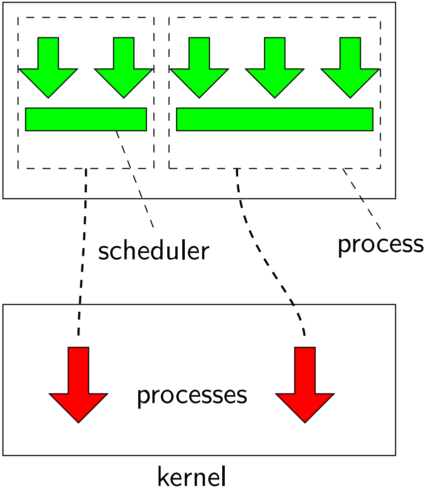

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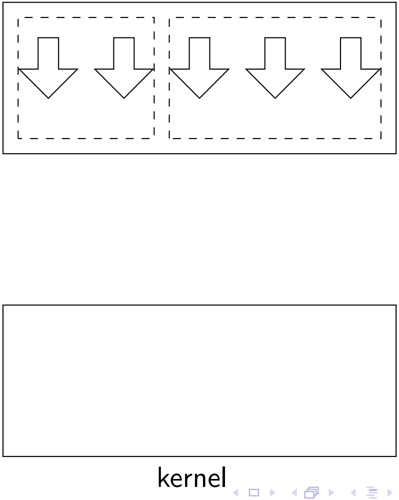

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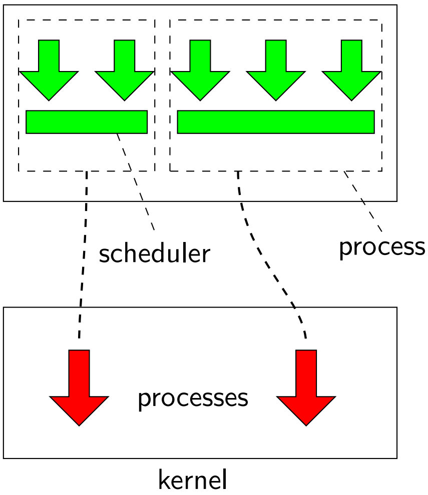

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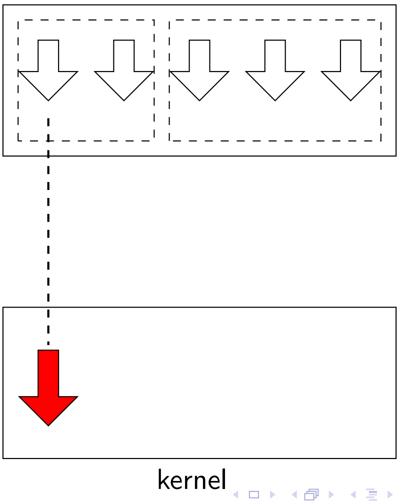

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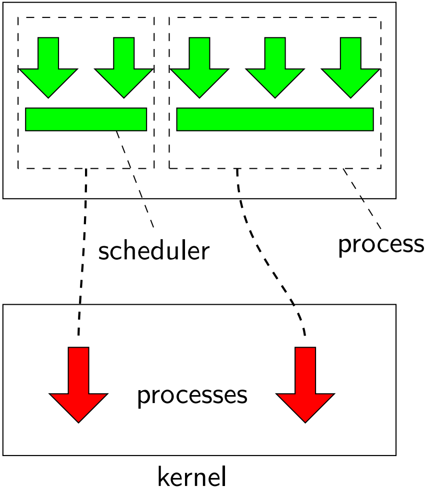

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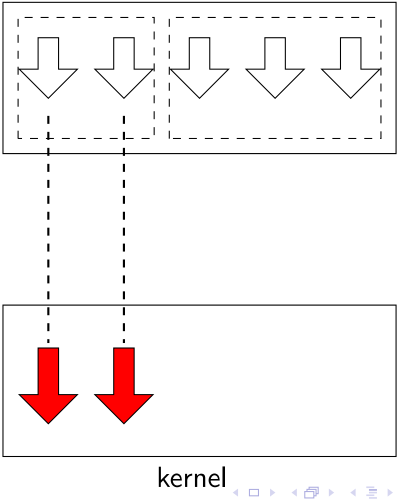

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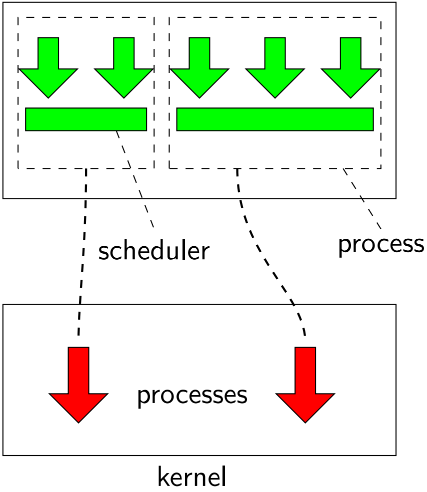

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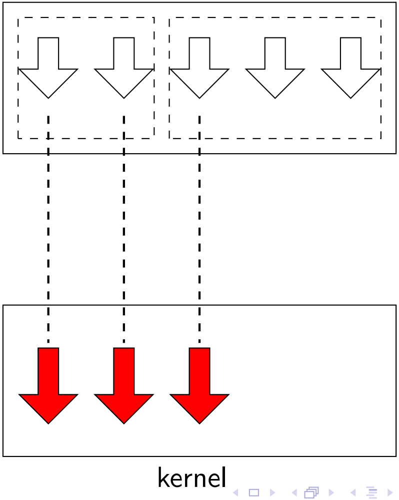

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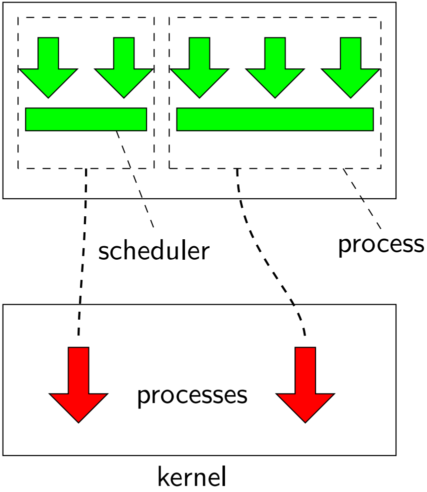

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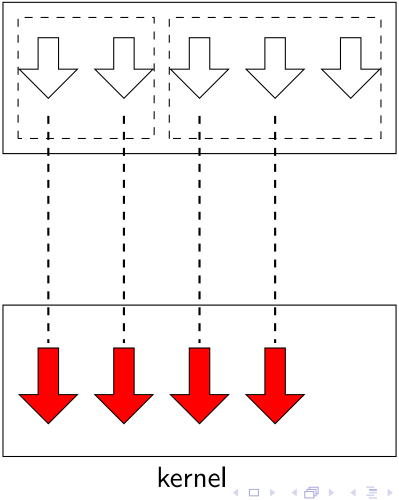

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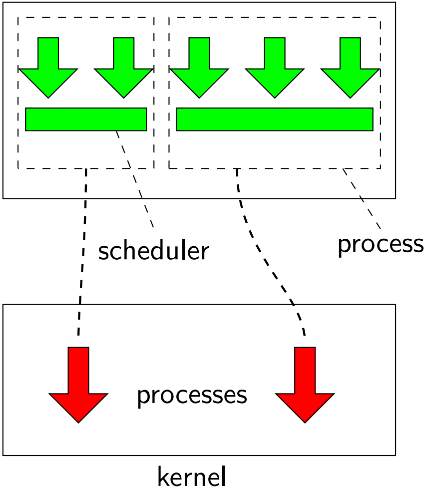

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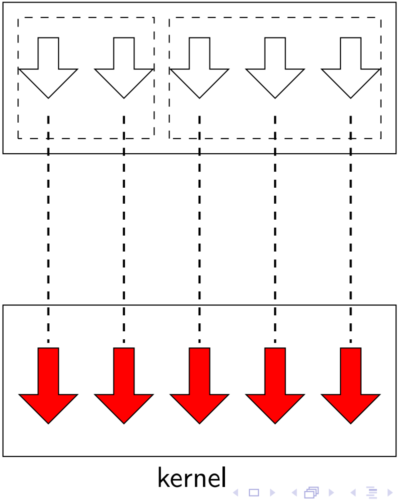

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Java originally had user space threads, and introduced the name, "green threads". This was later replaced by "native threads" i.e. each Java thread attached to a kernel operating system thread.

an experiment

How long time does it take to send a message around a ring of a hundred threads?

pthread_create() - from man pages

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Compile and link with `-lpthread`.

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What is clone()?

clone() - from man pages

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Using clone() directly you can pick and choose of more than twenty parameters what the clone should share.

Thread Local Storage (TLS)

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__thread int local = 42;
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TLS implementation

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__thread int local = 0;

int global = 1;

void *hello(void *name) {

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  int sum = local + global + stk;
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```
pushq   %rbp
movq    %rsp, %rbp
movq    %rdi, -24(%rbp)
movl    $2, -8(%rbp)
movl    %fs:local@tpoff, %edx
movl    global(%rip), %eax
addl    %eax, %edx
movl    -8(%rbp), %eax
addl    %edx, %eax
movl    %eax, -4(%rbp)
nop
popq    %rbp
ret
$
```

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