Concurrency

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KTH

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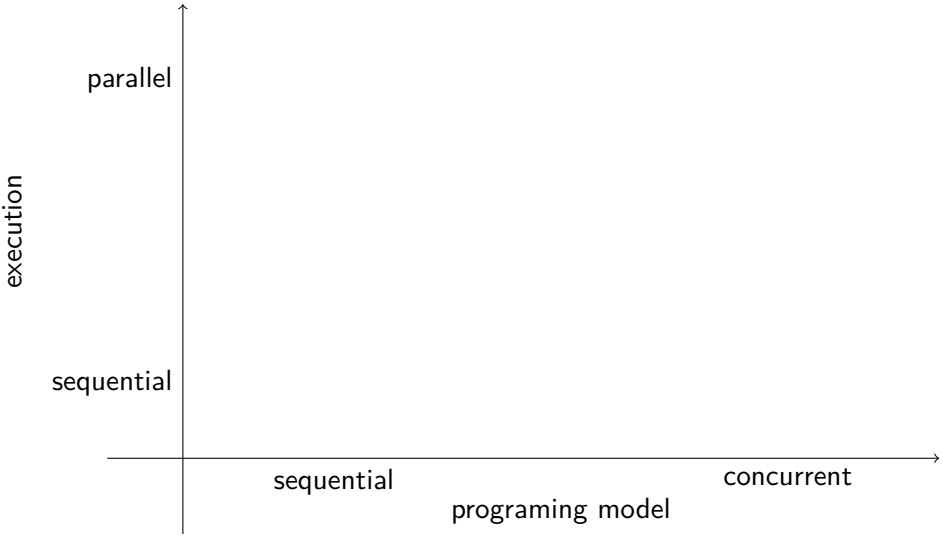
concurrency vs parallelism



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The problem of concurrency was first encountered in the implementation of operating systems. It has since been a central part in any course on operating systems.

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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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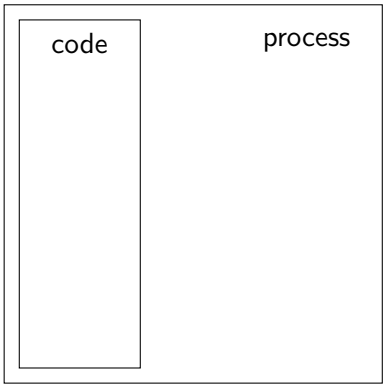

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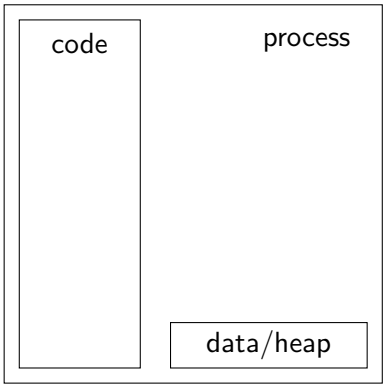

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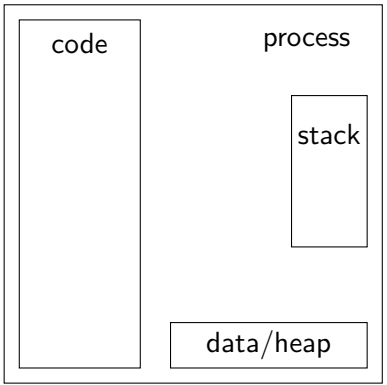

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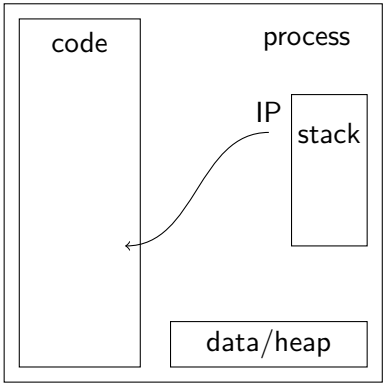

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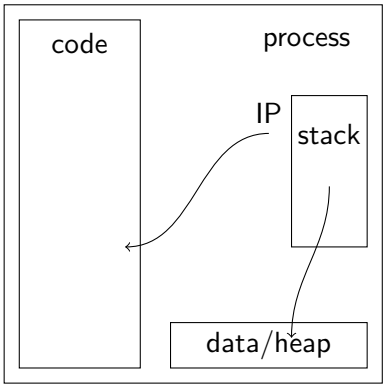

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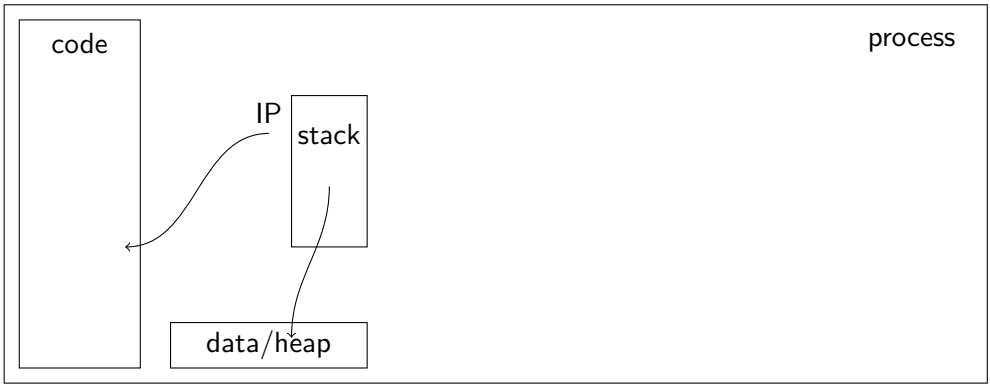

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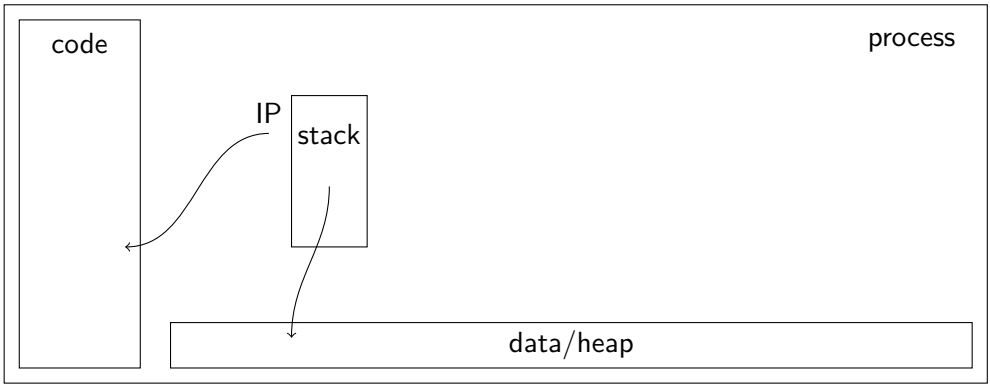

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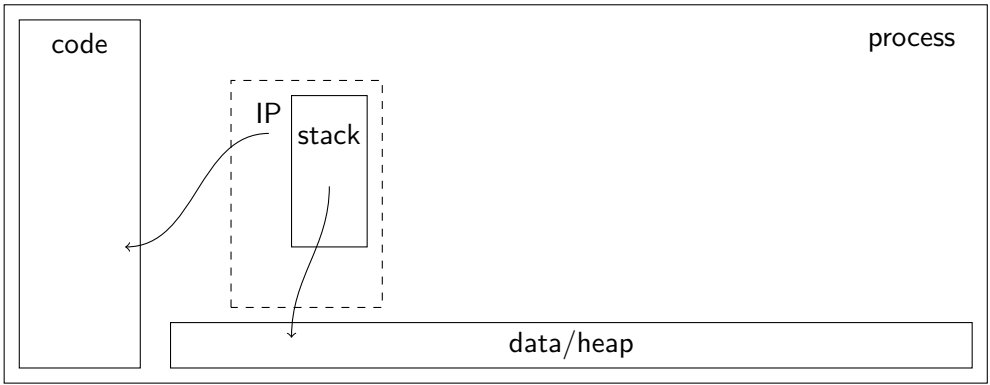

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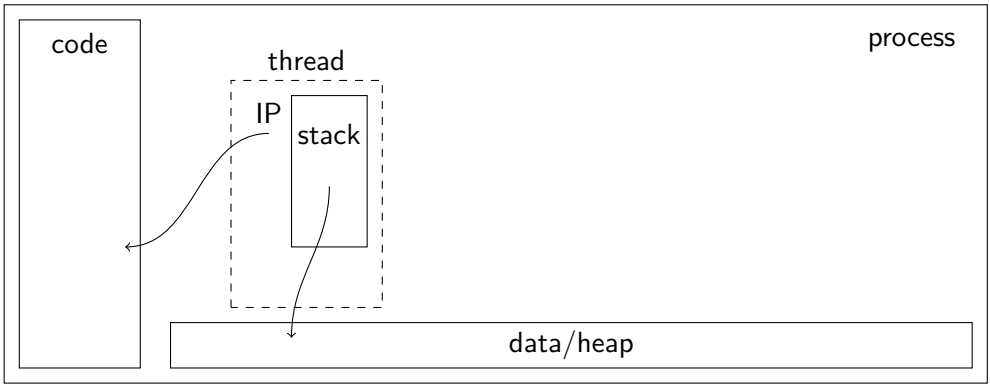

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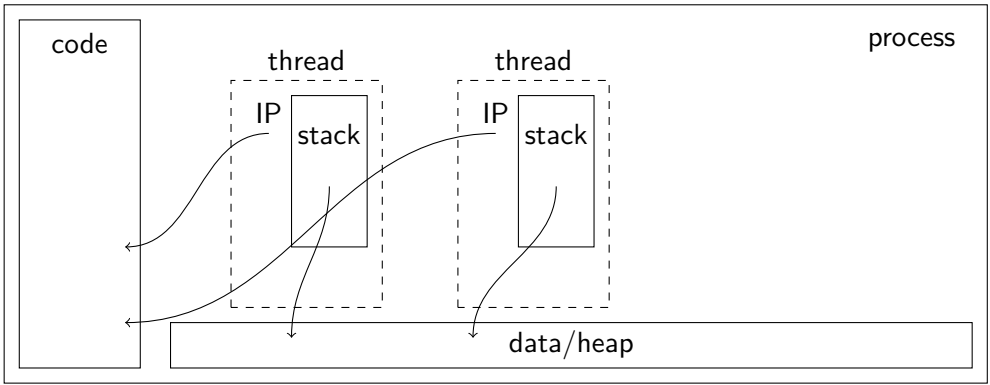

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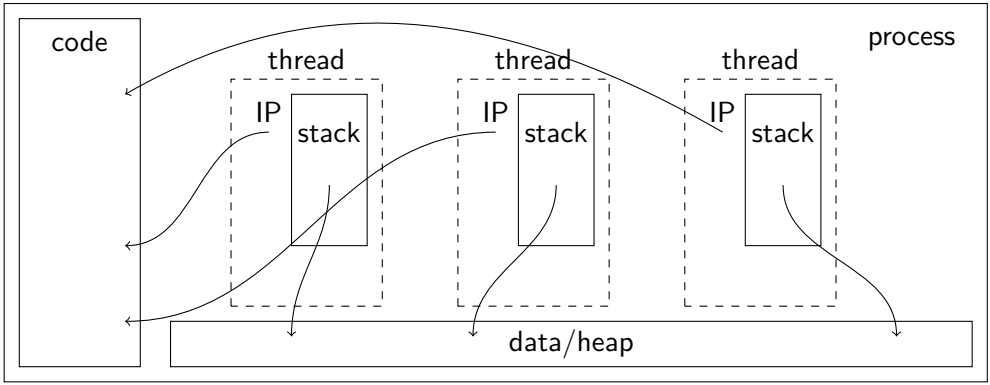
code
process
thread
thread
thread
IP
stack
IP
stack
IP
stack
data/heap

Virtual memory layout

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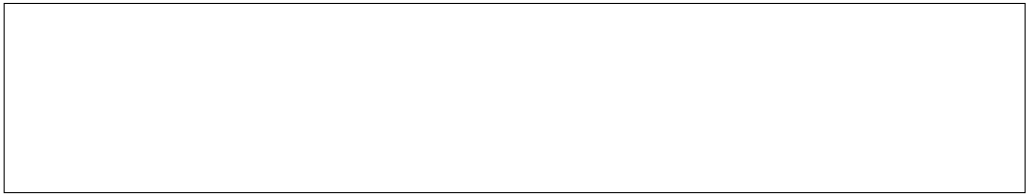

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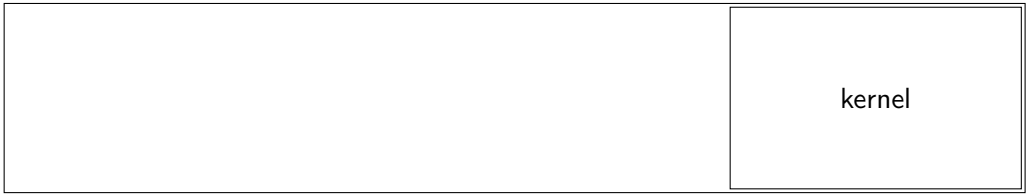

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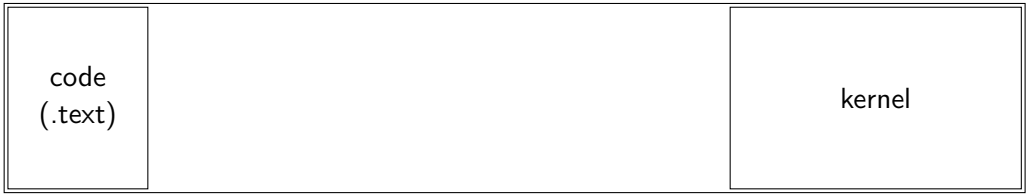

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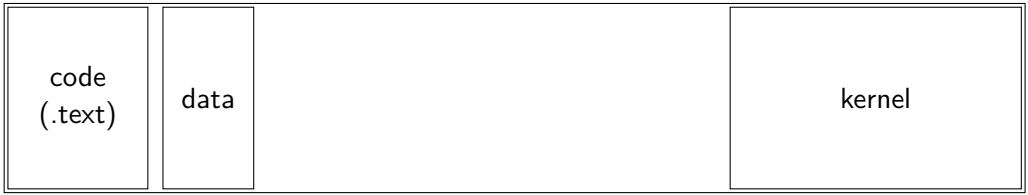

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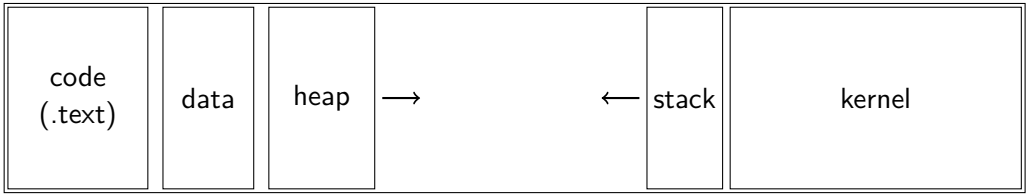

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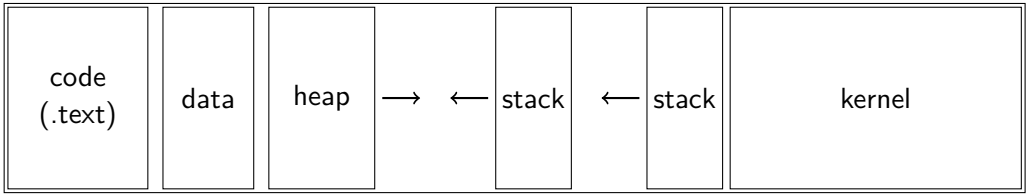

threads API

```
#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

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What is the expected outcome of an execution?

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- as atomic operations in some sequence,
- consistent with the *program order* of each thread.

the code

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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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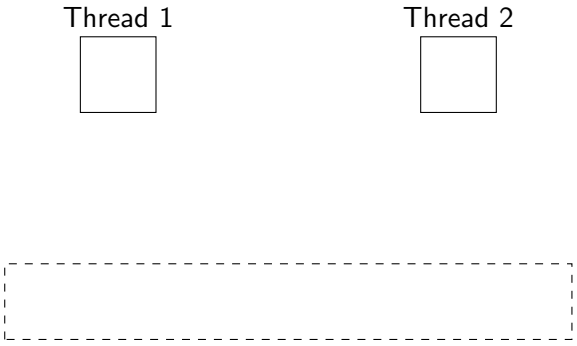

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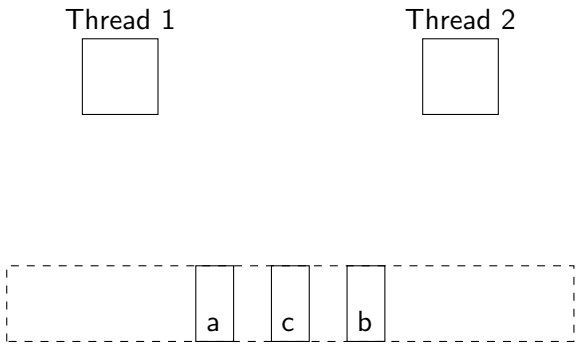

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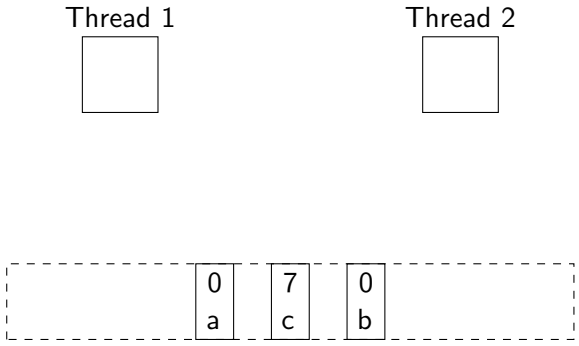

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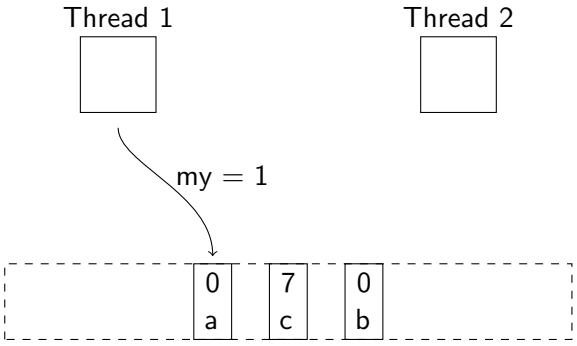

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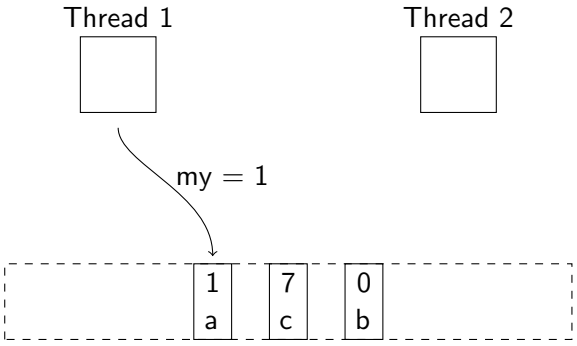

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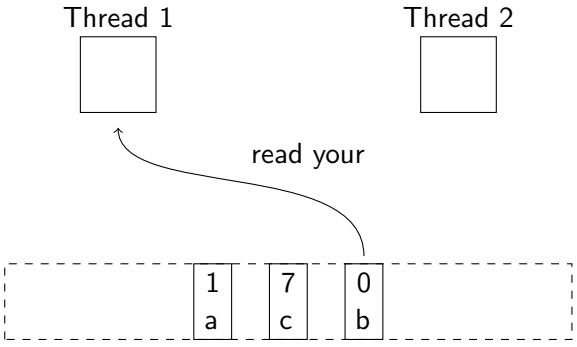

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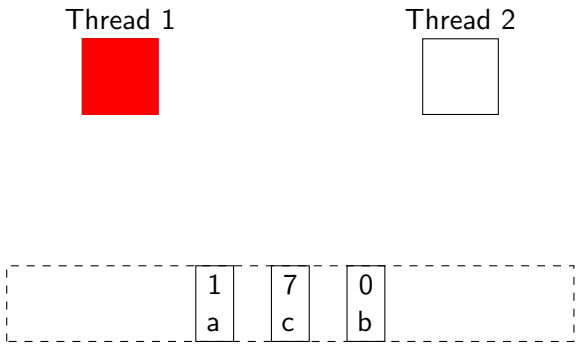

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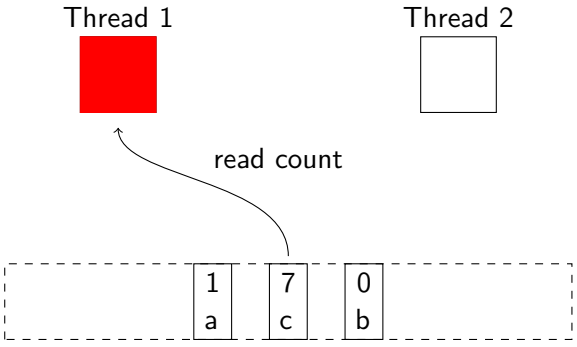

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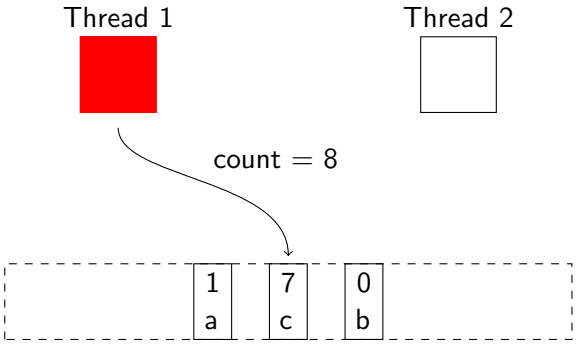

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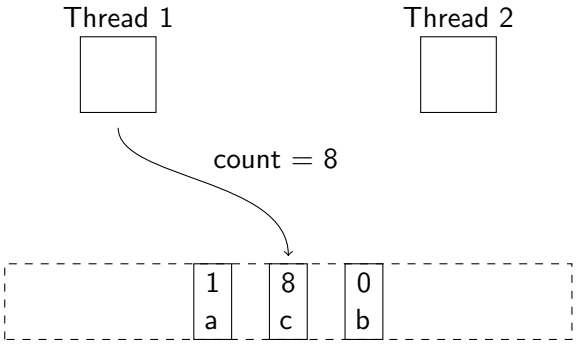

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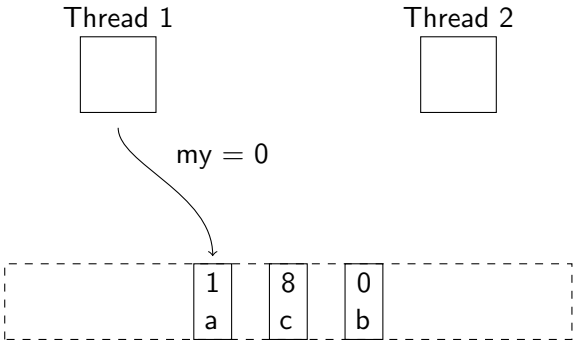

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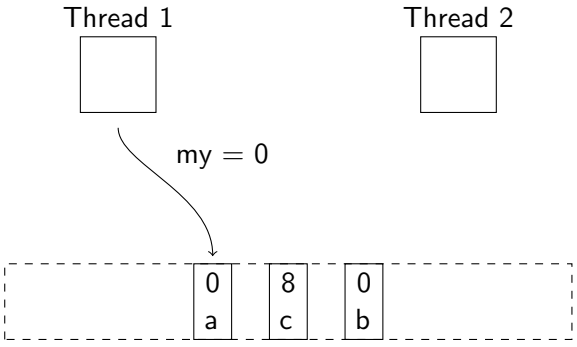

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There are operations provided by the hardware that will give us better guarantees.

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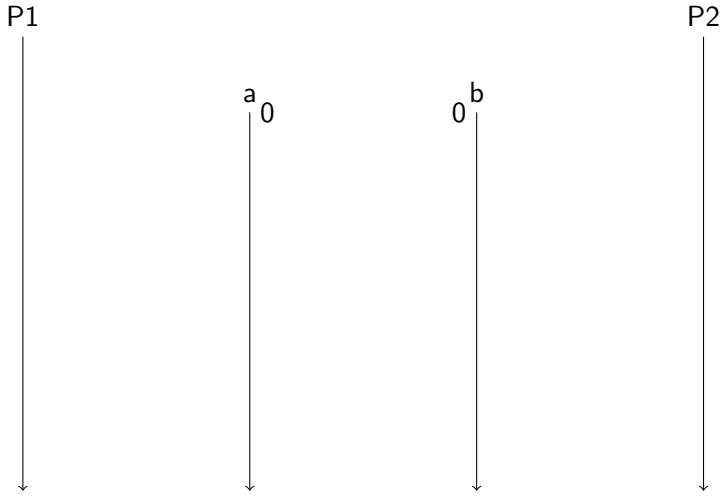

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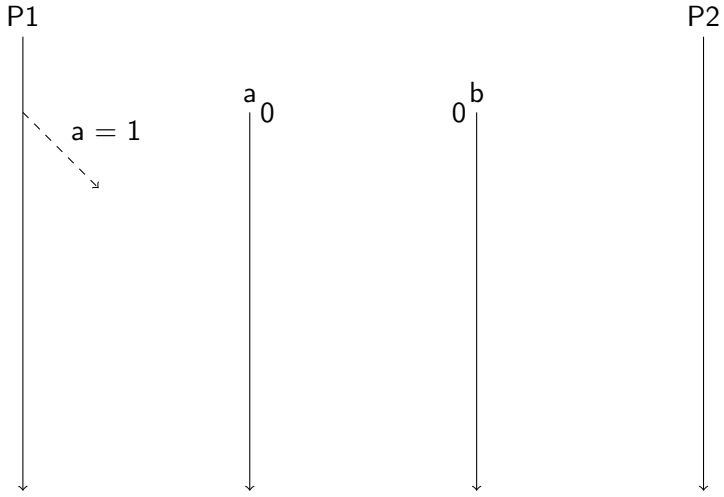

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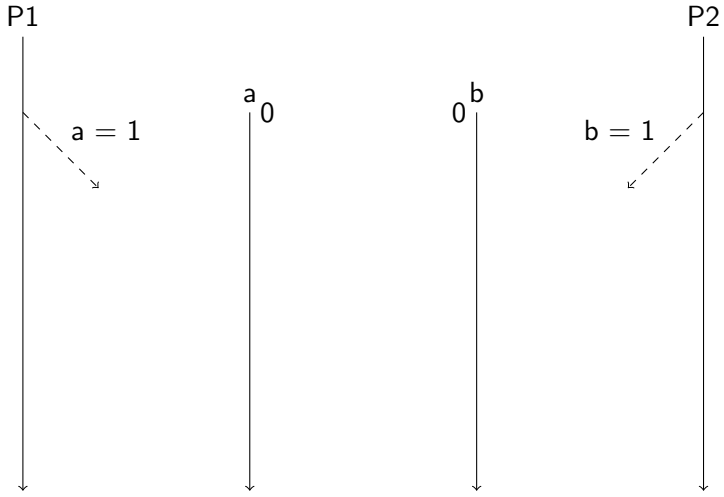

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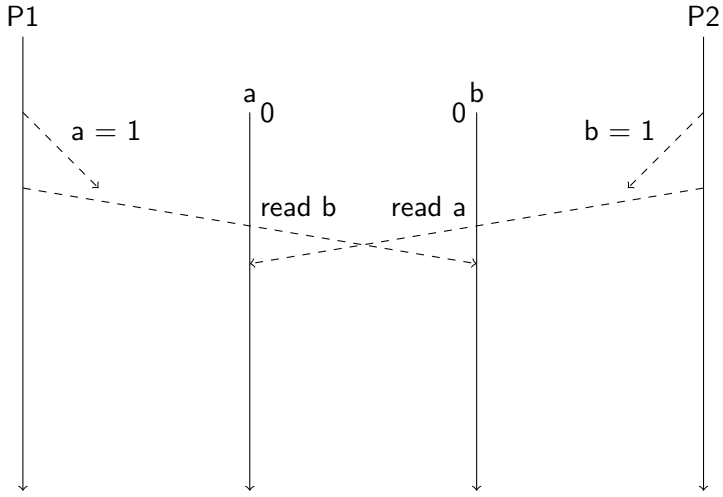

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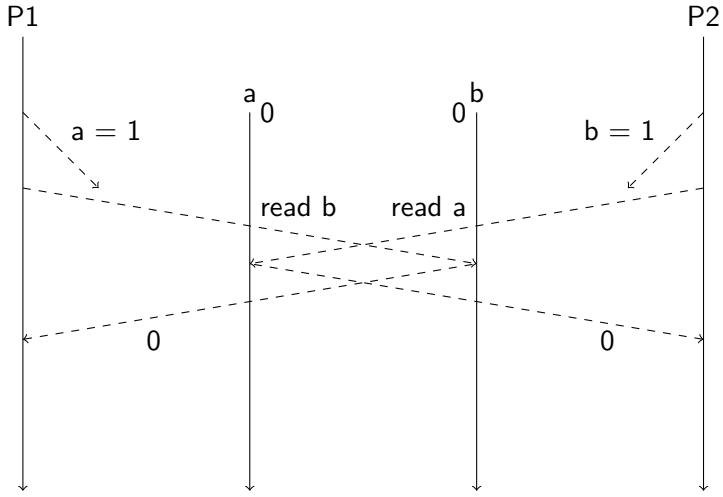

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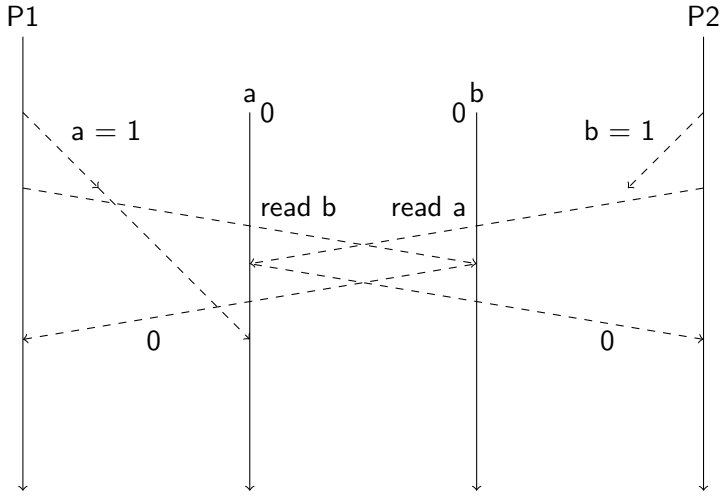

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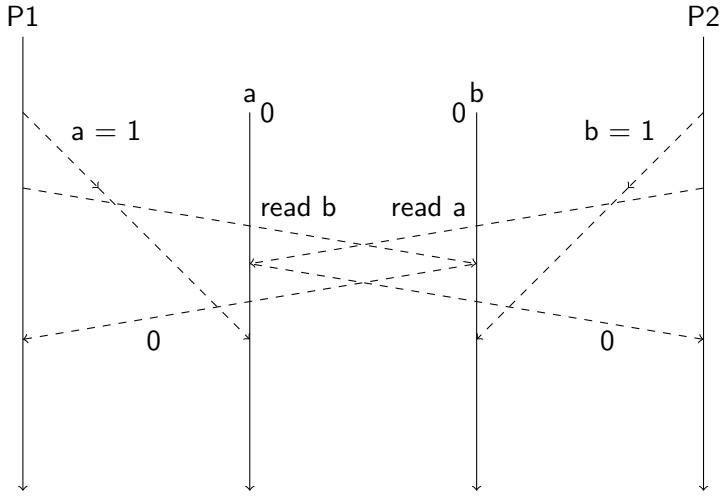

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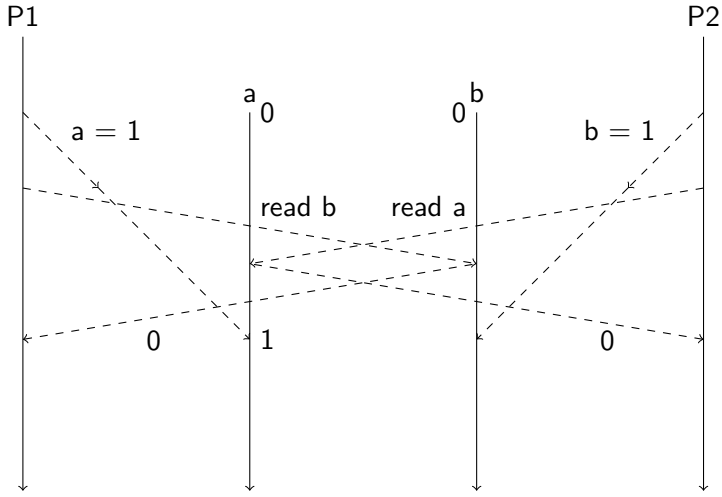

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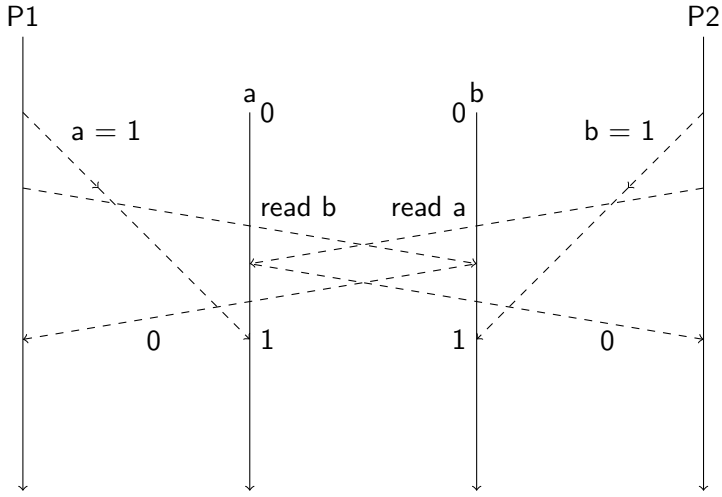

Hardware support - TGH

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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

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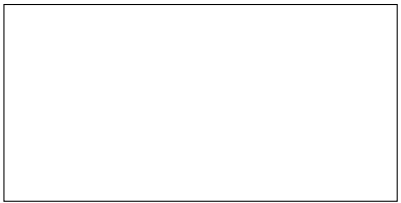

kernel

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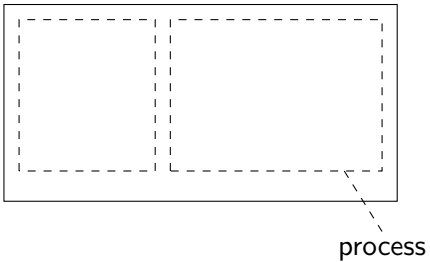

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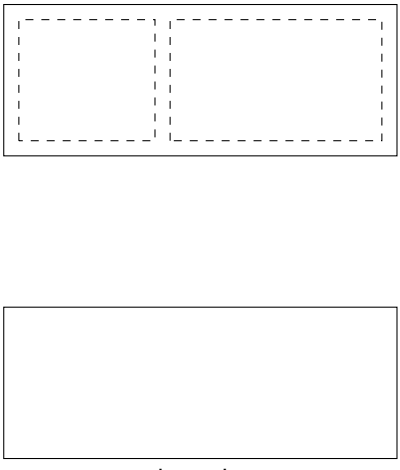

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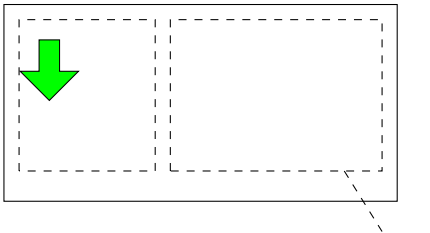

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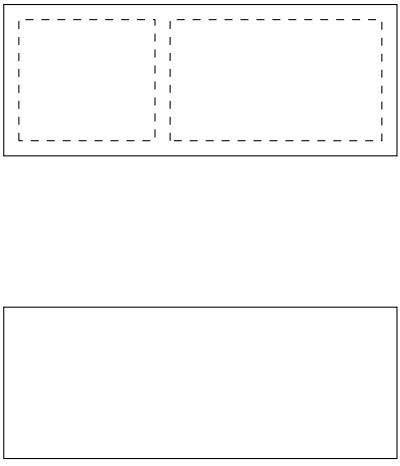

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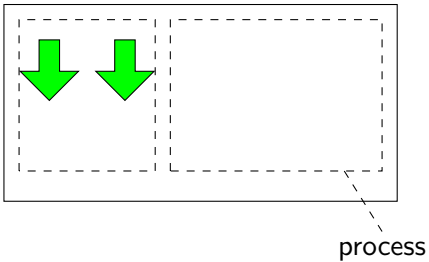

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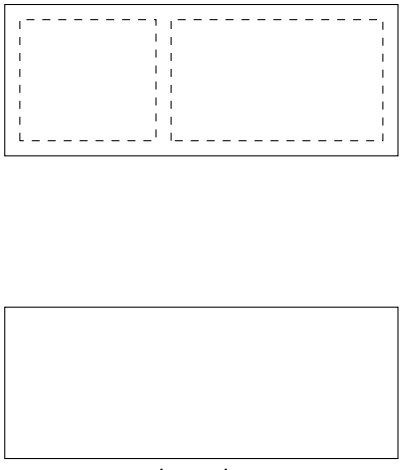

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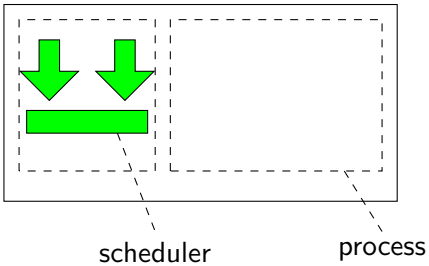

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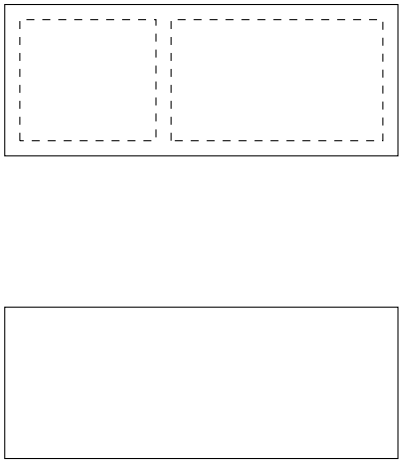

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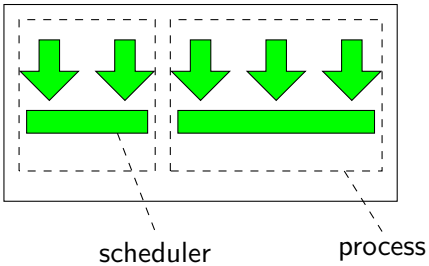

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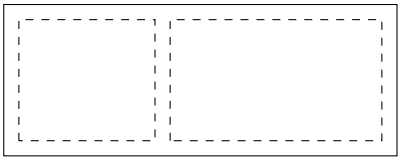

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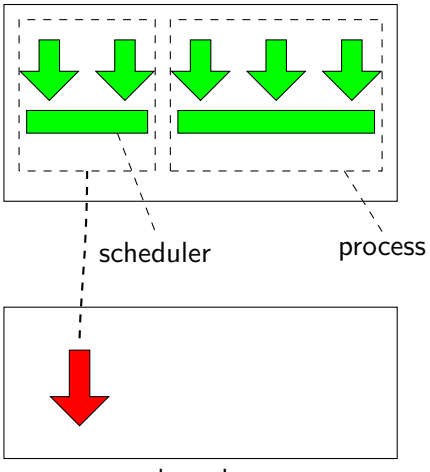

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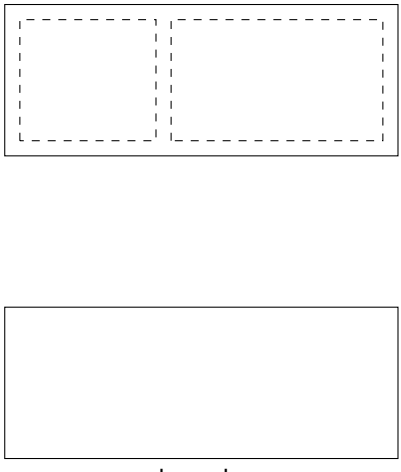

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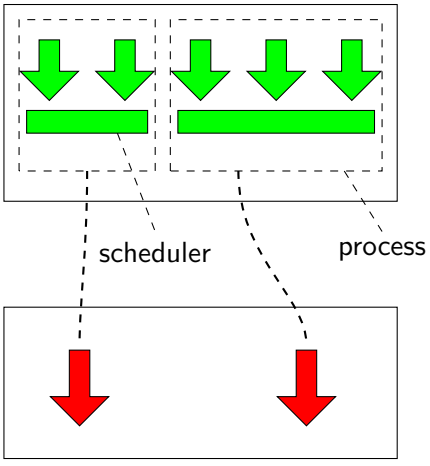

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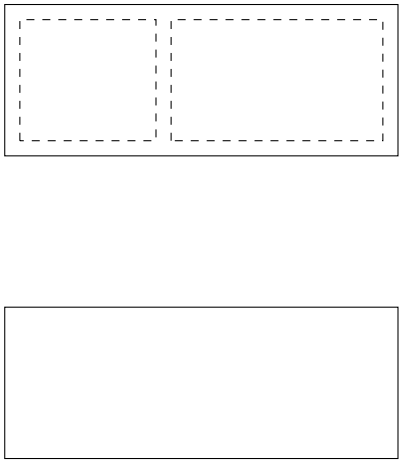

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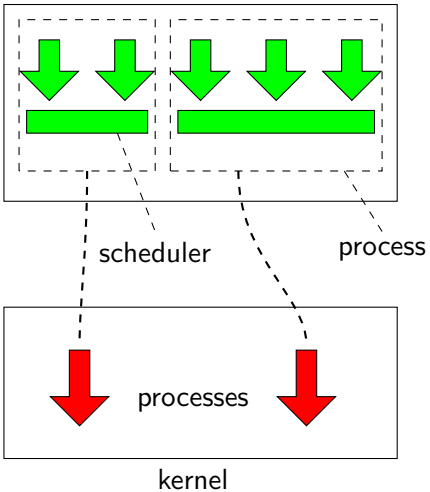

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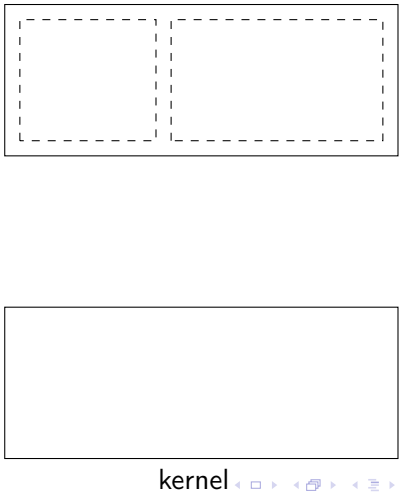

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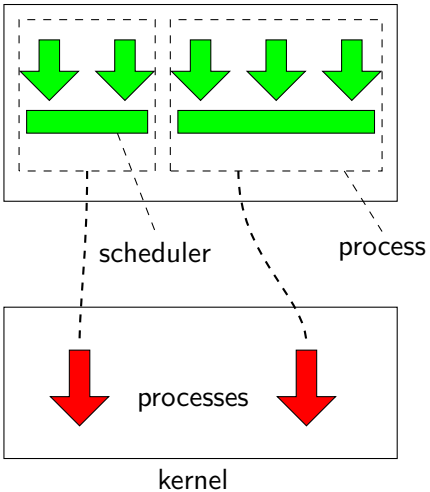

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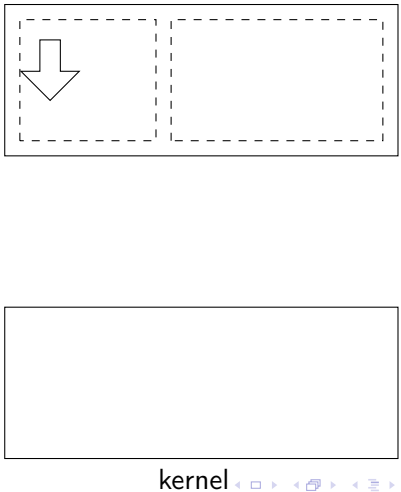

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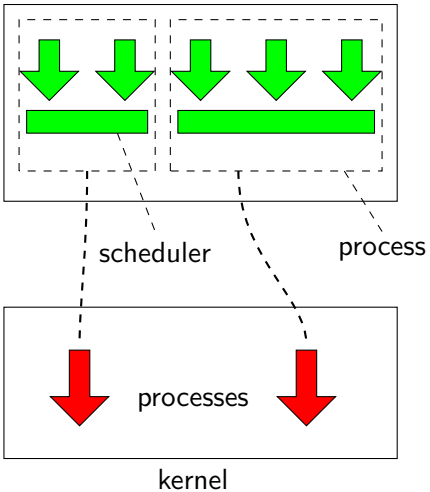

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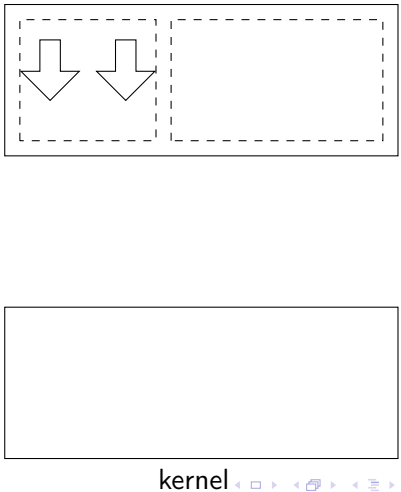

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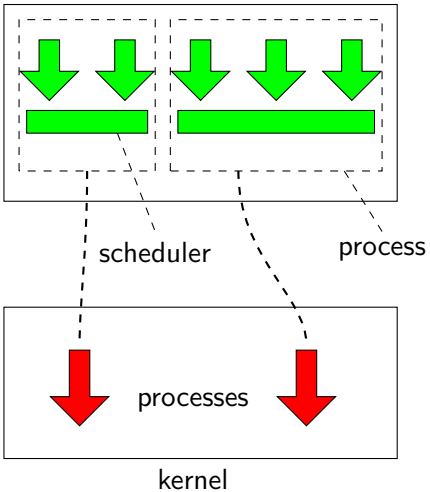

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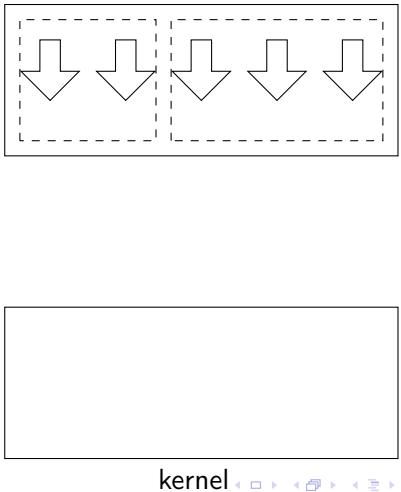

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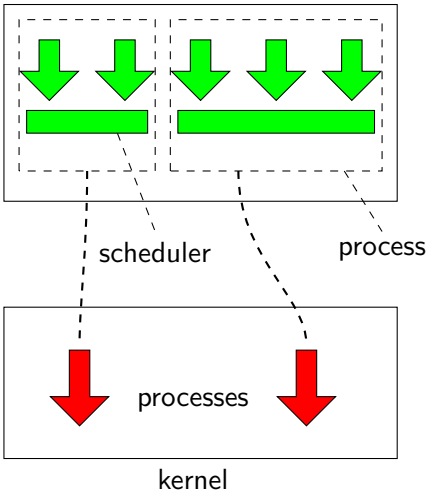

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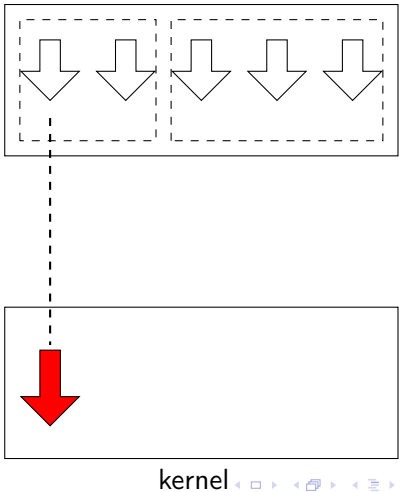

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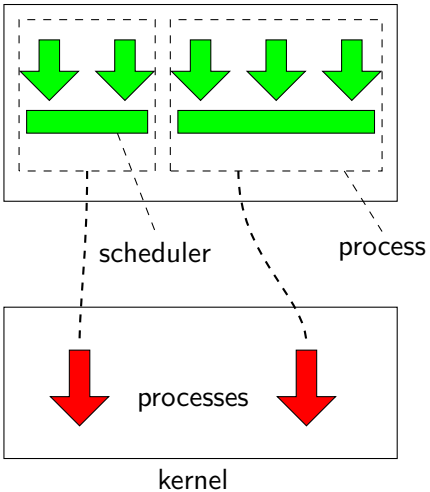

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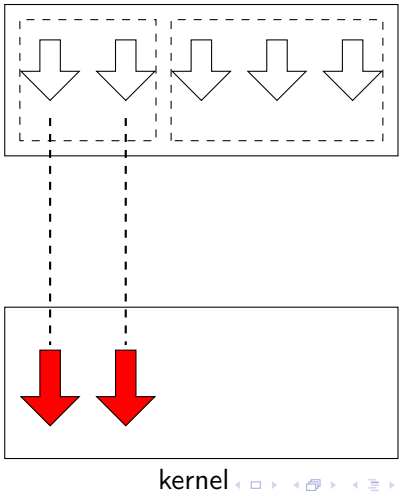

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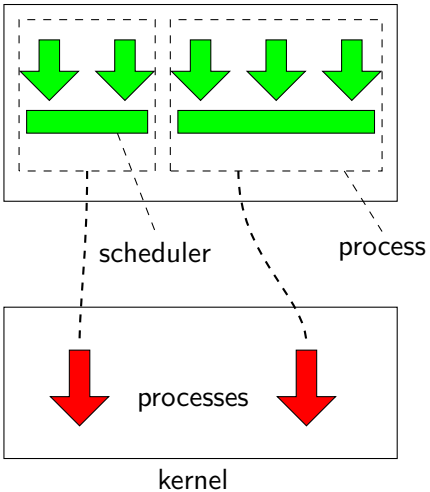

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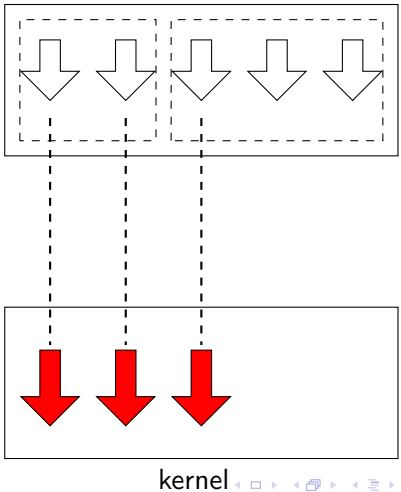

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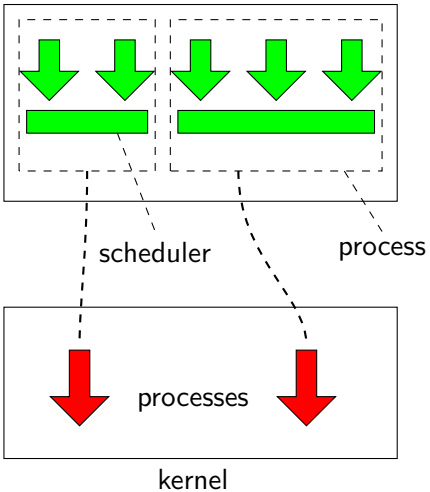

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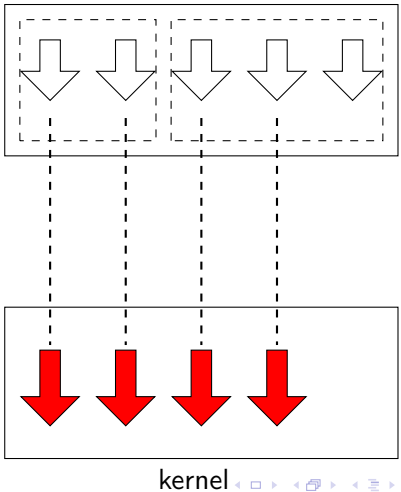

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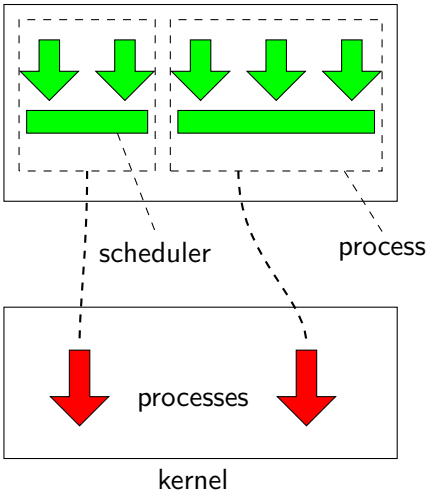

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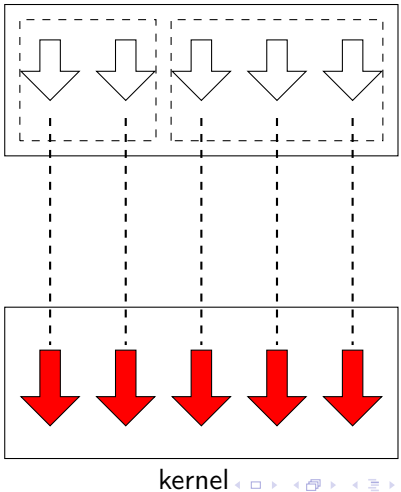

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Which approach is taken by GNU/Linux?

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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.

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 -pthread.`

Pthreads in Linux

How do we implement threads in Linux?

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In Linux, both `fork()` and `pthread_create()` are implemented using the system call `clone()`.

Pthreads in Linux

How do we implement threads in Linux?

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What is clone()?

clone() - from man pages

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- fork(): copy table of file descriptors, copy memory space and signal handlers i.e a perfect copy
- pthread_create(): share table of file descriptors and memory, copy signal handlers

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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;
```

TLS implementation

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__thread int local = 0;

int global = 1;

void *hello(void *name) {

  int stk = 2;
  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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