Processes

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KTH

2016

A process

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... a computation

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- a program i.e. a sequence of operations

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Understand how the call stack works and what the heap provides.

the stack

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  return x + y;
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int bar() {
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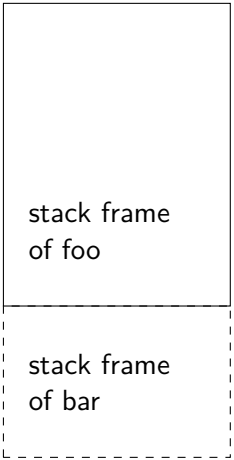


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- magic information to be able to return from a call

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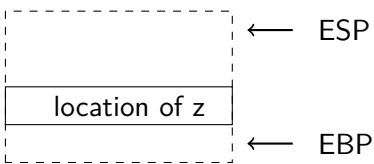


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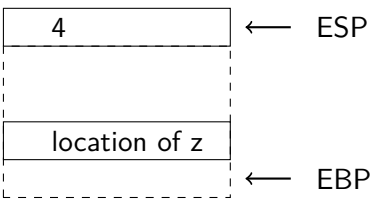


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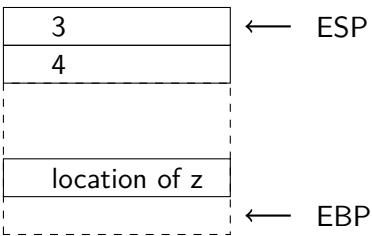


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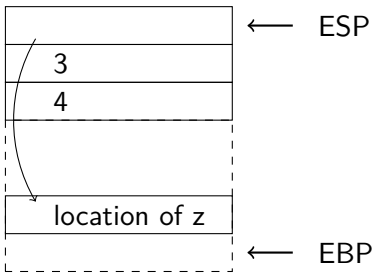


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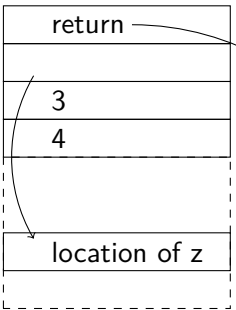


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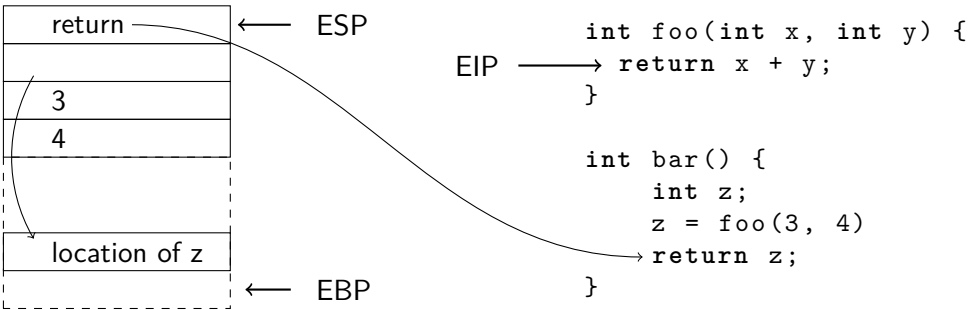

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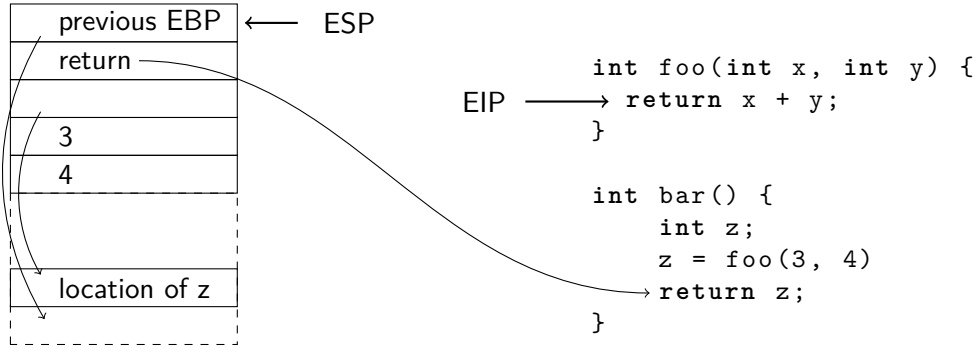

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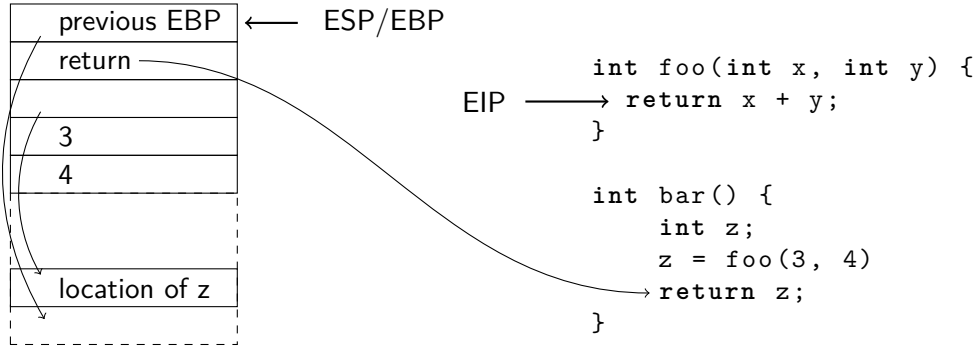

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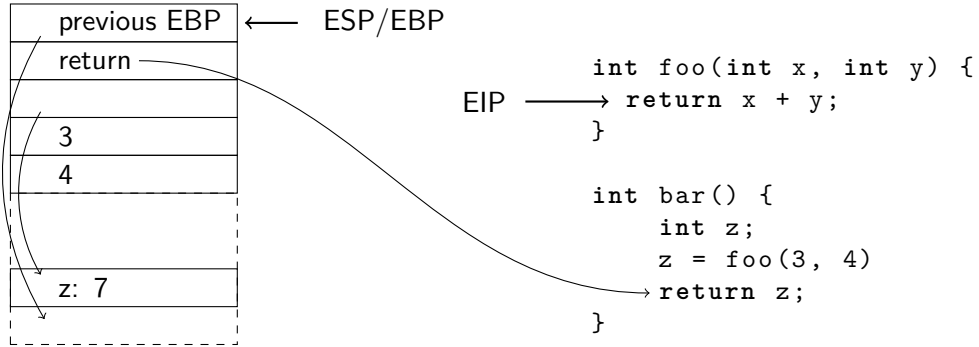

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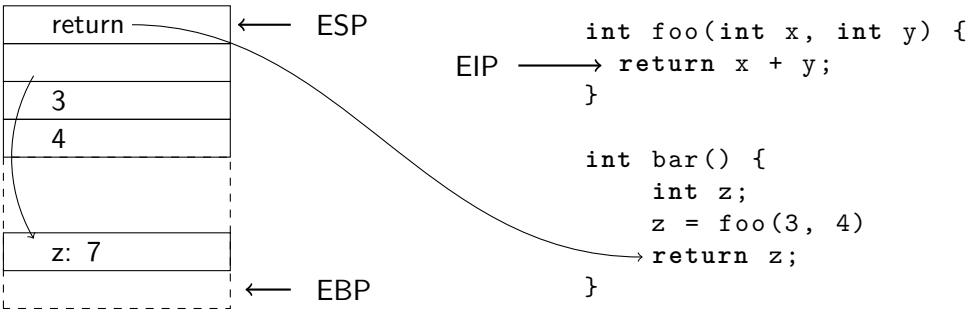

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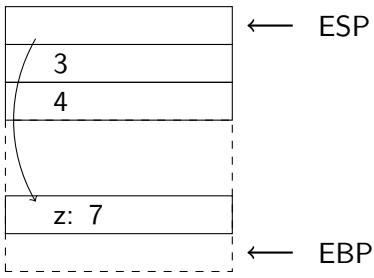


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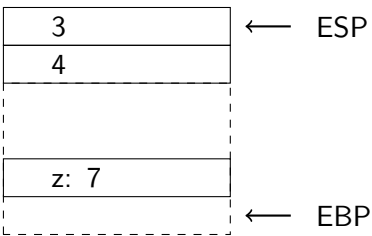


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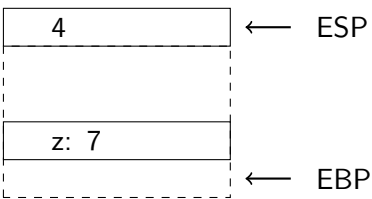


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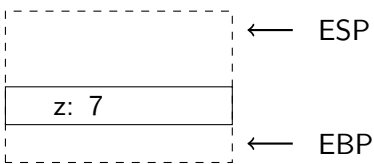


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Separate the *abstraction* of a C procedure call from how the stack is implemented.

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Create a structure and return a pointer to the structure - problem solved.

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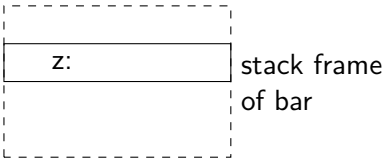

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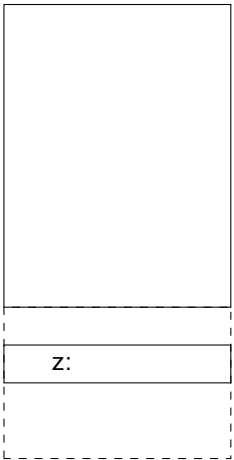


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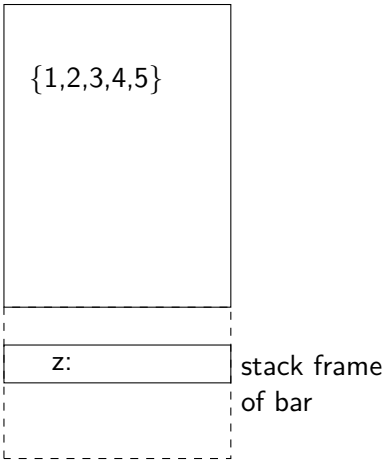


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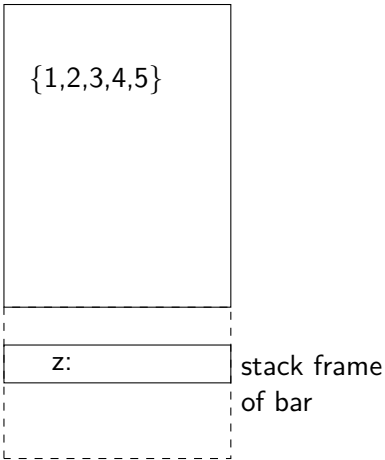


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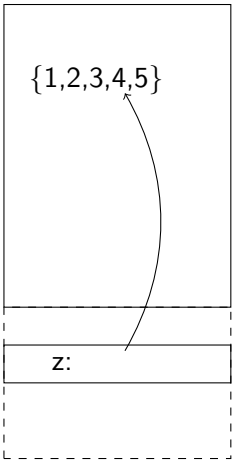


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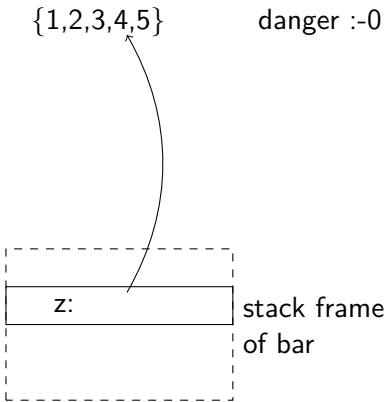


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This is why we need the *heap*.

the heap

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  int *h;
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  h = (int*)malloc(5*sizeof(int));

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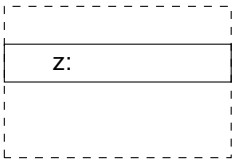


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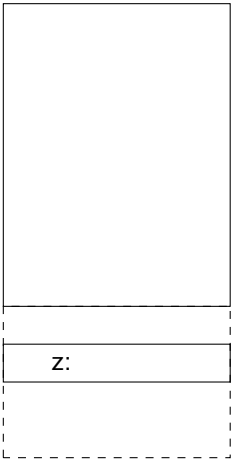


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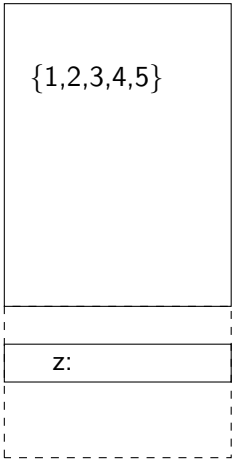


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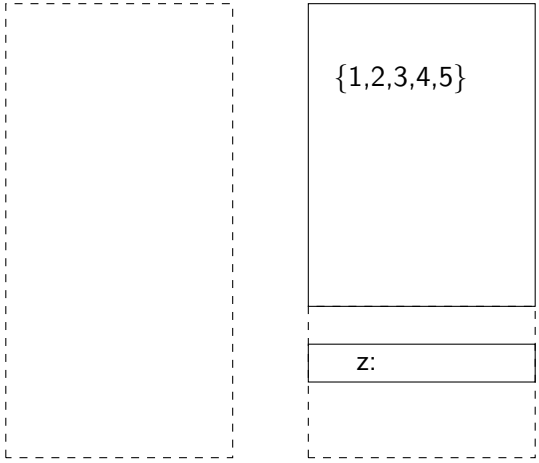


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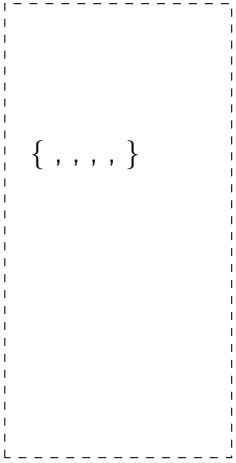

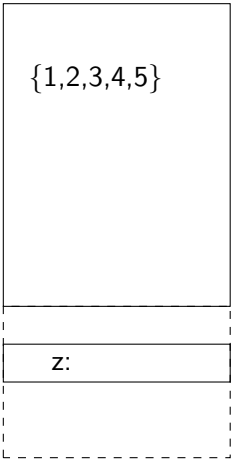


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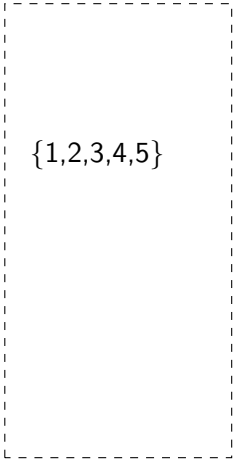

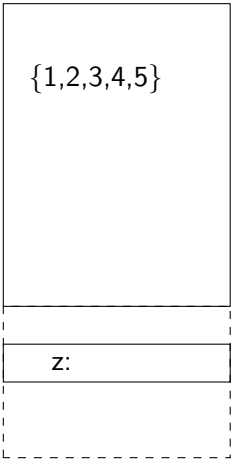


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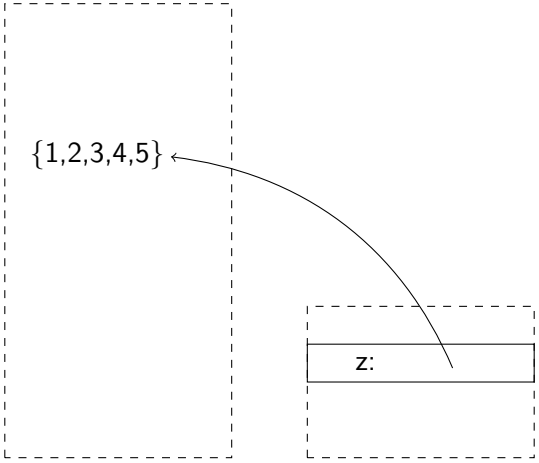


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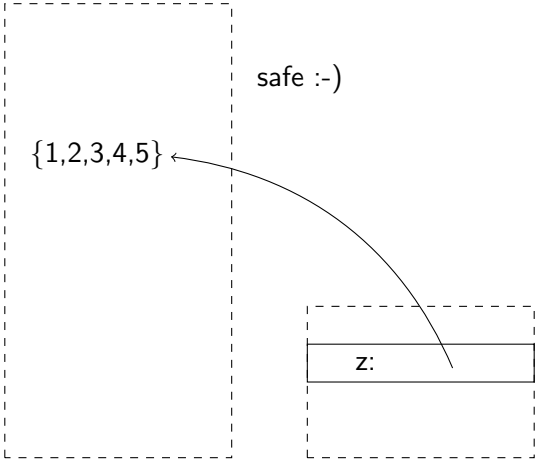
  for(i = 0; i != 5; i++) {
    h[i] = a[i];
  }
  return h;
}
```

the heap




```
int *foo(int x) {
  int a[5] = {1,2,3,4,5};
  int *h;
  int i;

  h = (int*)malloc(5*sizeof(int));

  for(i = 0; i != 5; i++) {
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the heap

- a memory area separated from the stack

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- ... what about deallocation?
- the heap is handled using library calls in C

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how about Java

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```
public class RightTriangle {

    public double a, b, c;

    public RightTriangle(double x, double y) {
        a = x;
        b = y;
        c = Math.sqrt(Math.pow(x,2) + Math.pow(y,2));
    }

    public double area() {
        double ar = (a * b)/2;

        return ar;
    }
}
```

how about Java

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```
public class Test {

    public static void main(String [] args) {

        RightTriangle egypt = new RightTriangle(3,4);

        double hyp = egypt.c;

        double ar = egypt.area();

        System.out.format("hypotenuse is: %.1f%n", hyp);
        System.out.format("    area is is: %.1f%n", ar);
    }
}
```

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.... A Java compiler can (sometimes) detect that an object will not live passed the point of a method return, and then allocate the object on the stack (escape analysis).

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- .... messages need to be copied from one heap to the other.

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The language prevents you from doing things that are possible in C.

let's complicate things

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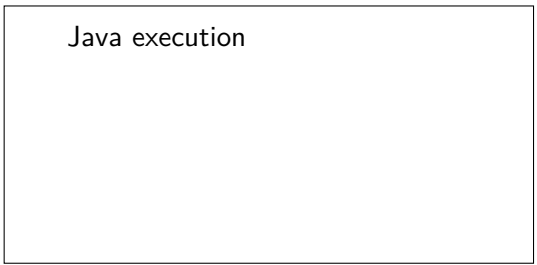

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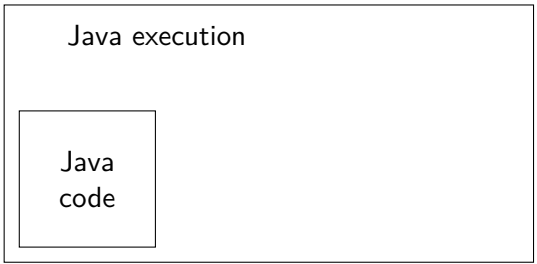

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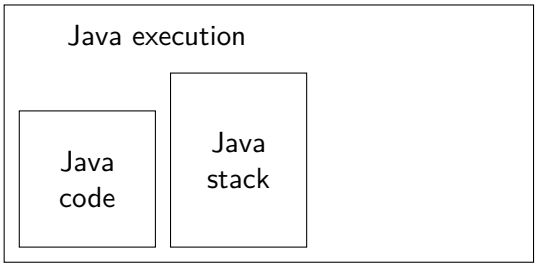

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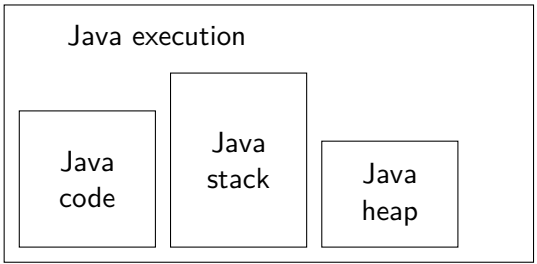

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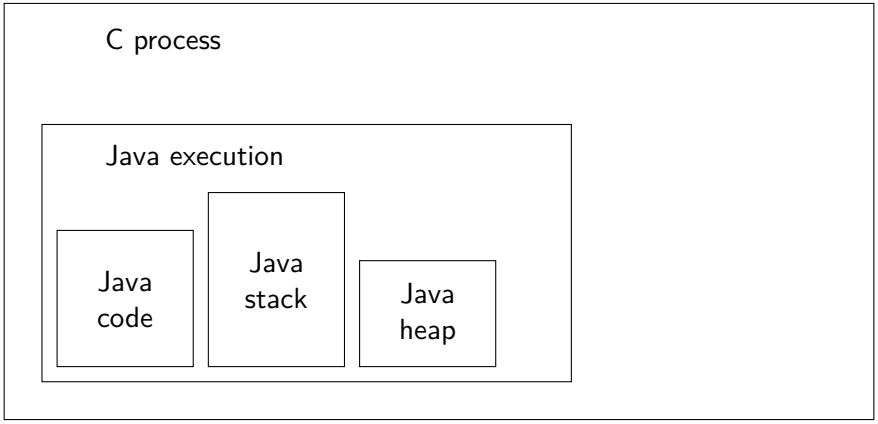

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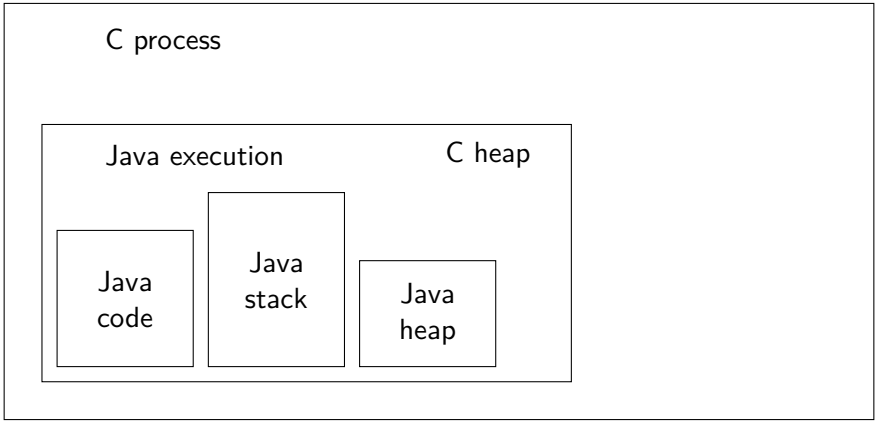

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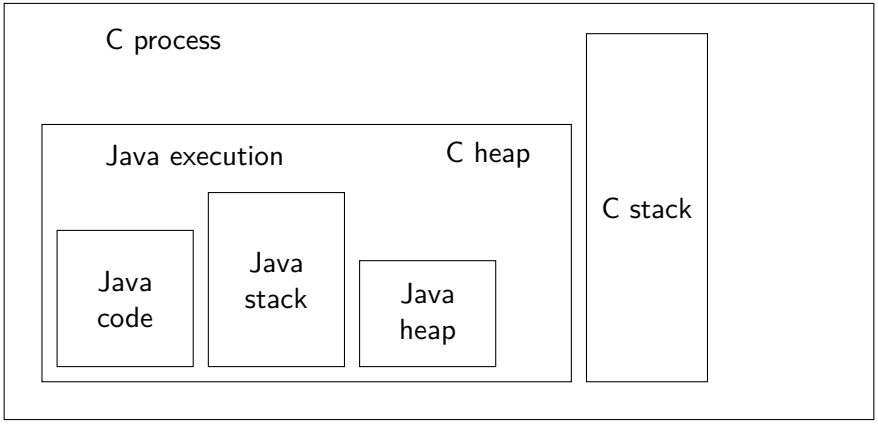

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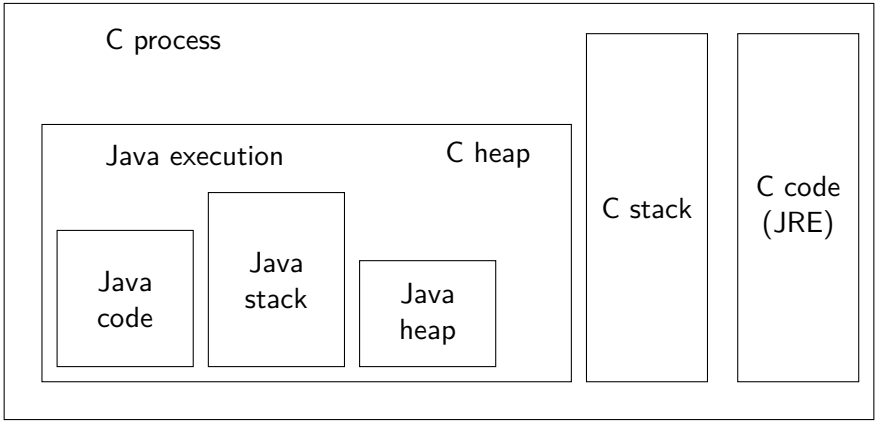

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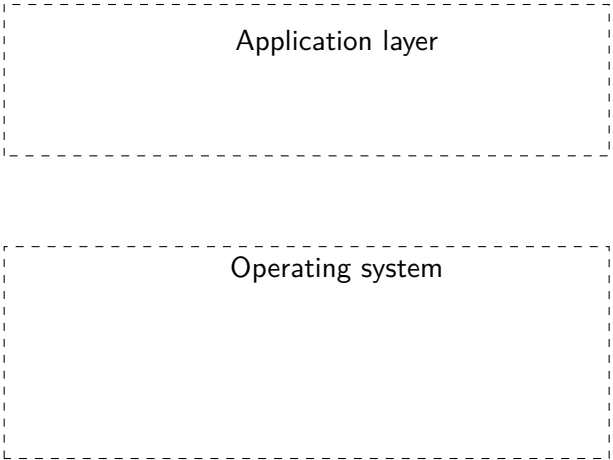
... it is the job of the operating system to provide the functionality.

The operating system



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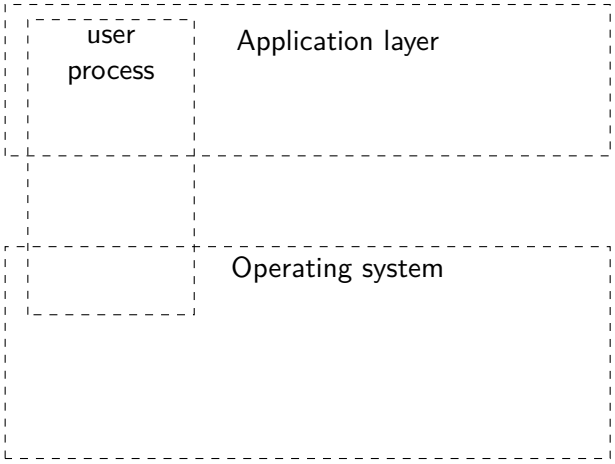

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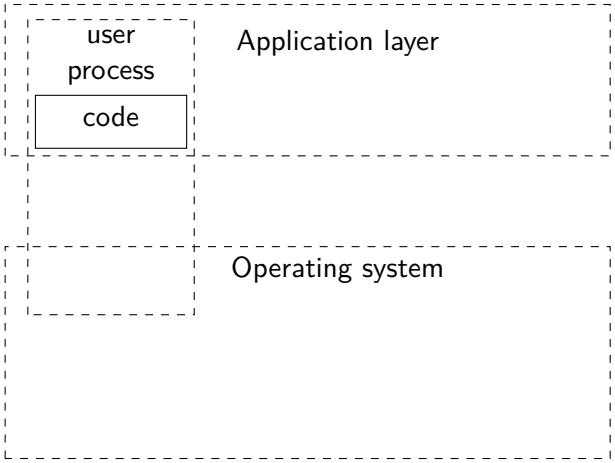

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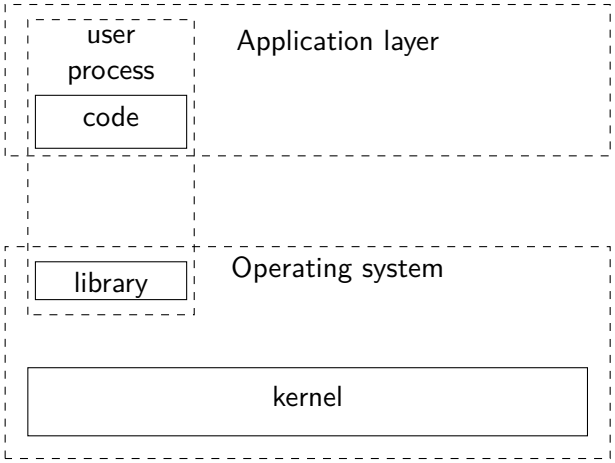

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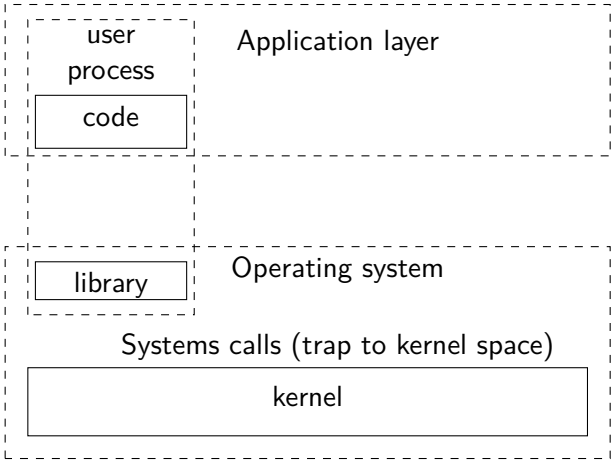

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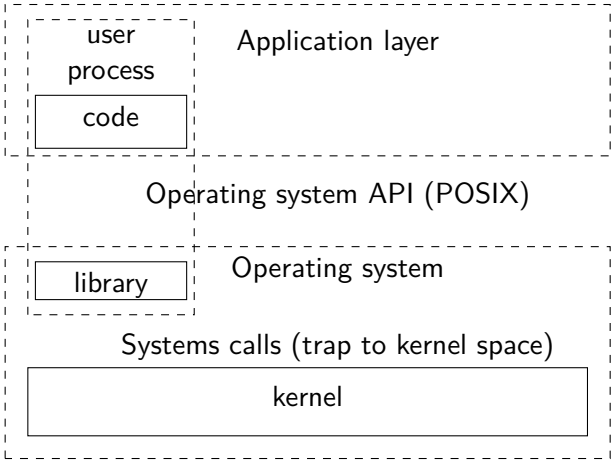

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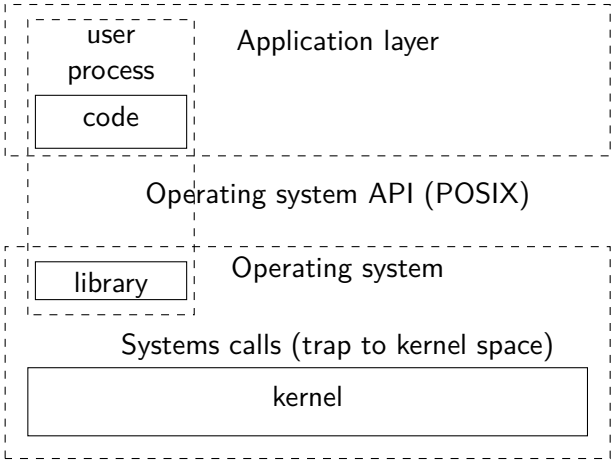

Library is often just a wrapper for the system call - sometimes more complex.

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Examples are from Linux on a x86 architecture.

from program to process

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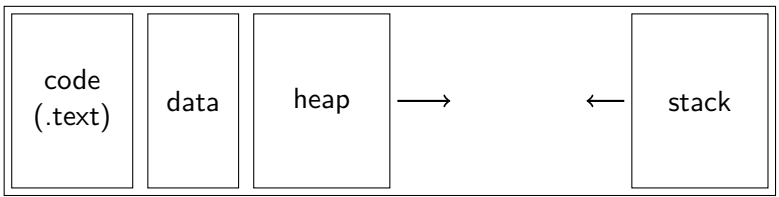

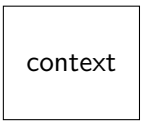

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Direct execution:

> The operating system loads the code of the user process, sets the stack and heap pointers and jumps to the first instruction of the process.

who is in control?

The operating system loads the code to memory, sets the register values for stack and heap pointers and ...

.... sets the instruction pointer (EIP).

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Is this a good thing?

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The hardware allows an execution to be in either “user mode” or “kernel mode”.

life of an execution

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Kernel mode: handle system call - prepare result - return from trap

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Important - the interrupt descriptor table must be protected, not modified in user mode

the process memory layout

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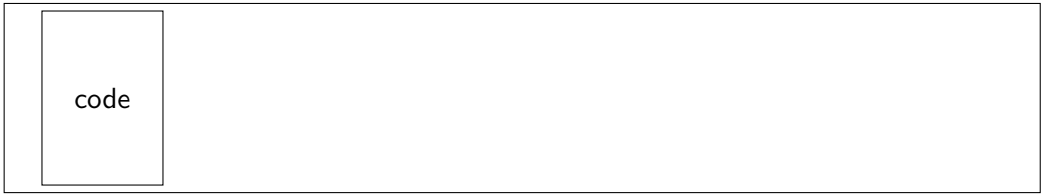

The operating system and user program is part of the same memory layout.

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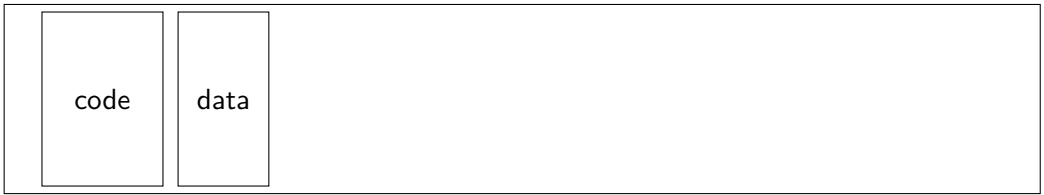

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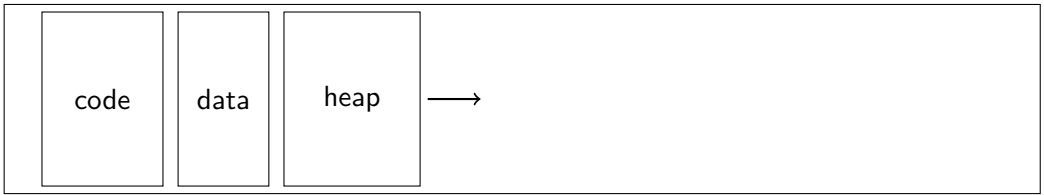

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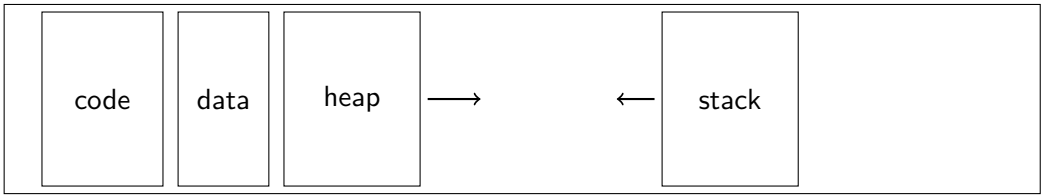

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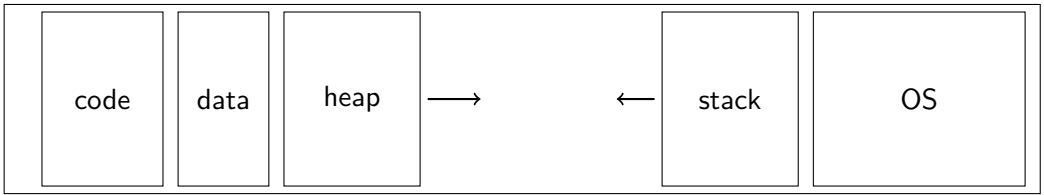

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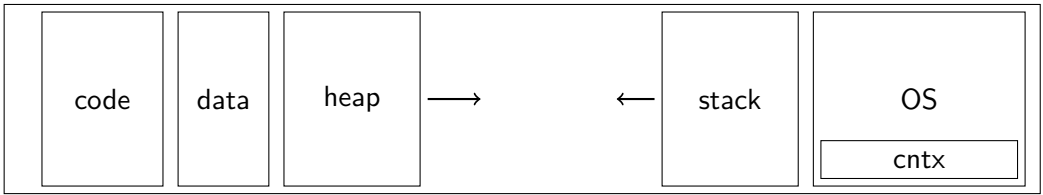

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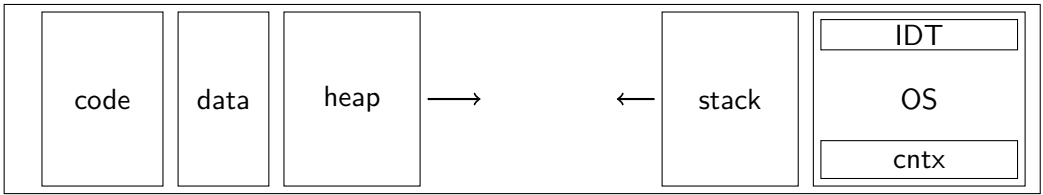

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The `Interrupt Descriptor Table` can only be set using the *privileged instruction* LIDT (*Load Interrupt Descriptor Table*).

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Check `vsyscall` *and* `vdso` *to learn more.*

user and kernel space

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The kernel should not take for granted that it can trust memory references from user space - security and portability. It should use special procedures when reading or writing to user space.

Take over control

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When the interrupt is generate by the hardware, the kernel can make a decision to *schedule* another process.

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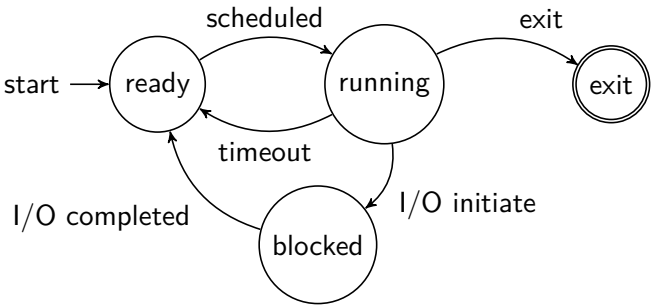
This is the Intel terminology.

process state



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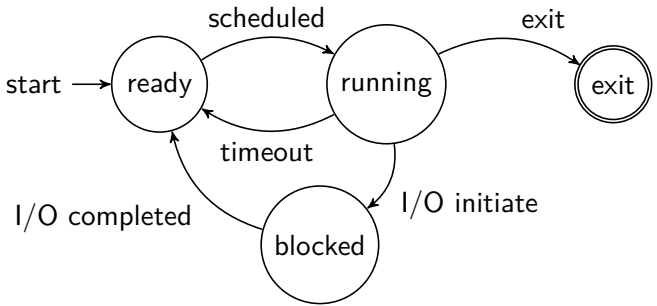

Where are interrupts used?

creating a process

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- In Unix the procedure is . . . strange, but very efficient.
- The POSIX API is not exactly what the Linux kernel provides - wrapper functions are used.

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The `fork()` system call will create a new process - that is a copy of the current process.

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```
#include <stdlib.h>
#include <unistd.h>
#include <stdio.h>

main(int argc, char *argv[]) {

  printf("Let's go \n");

  int pid = fork();

  printf("  Hello, the pid is  %d\n", pid)

  sleep(10);
  return 0;
}
```

is the memory shared?

```
main(int argc, char *argv[]) {
  int x = 42;

  int pid = fork();

  if(pid == 0) {
    sleep(10);
    printf("  Hello, I'm the child and x is  %d\n", x);
  } else {
    sleep(10);
    printf("  Hello, I'm the mother and x is  %d\n", x);
  }
  return 0;
}
```

magic

```
main(int argc, char *argv[]) {
  int x = 42;
  int pid = fork();

  if(pid == 0) {
    x = 12;
    sleep(10);
    printf("  Child:  address of x is %p\n", &x);
  } else {
    x = 13;
    sleep(10);
    printf("  Mother: address of x is  %p\n", &x);
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  }
  return 0;
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```

This will be explained when we look at memory virtualisation.

what about open files

```
int main(int argc, char *argv[]) {
  FILE *foo = fopen("foo.txt", "w+");

  int pid = fork();
  if(pid == 0) {
    fprintf(foo, "  this is the child \n");
  } else {
    fprintf(foo, "  this is the mother \n");
  }
  return 0;
}
```

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- Newly open files are not shared.

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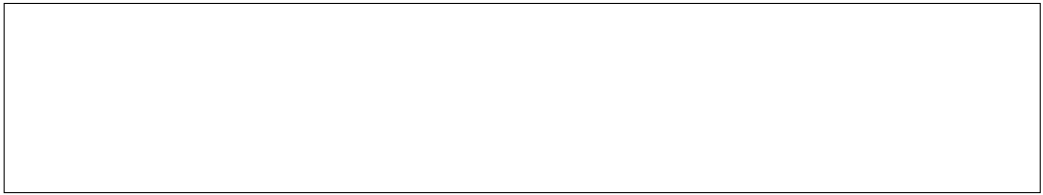

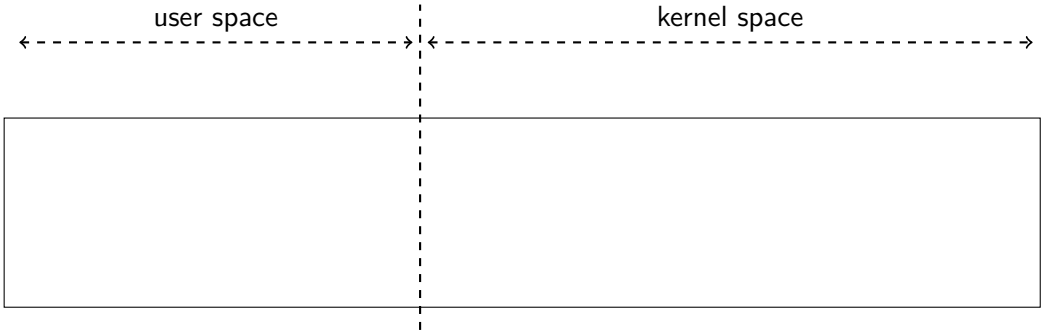

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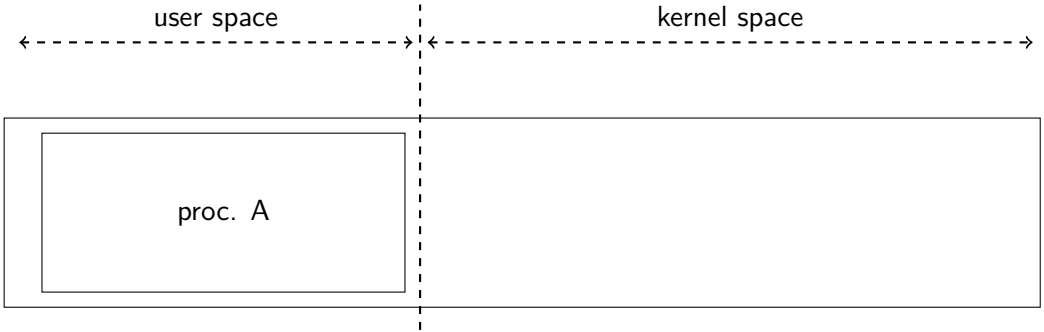

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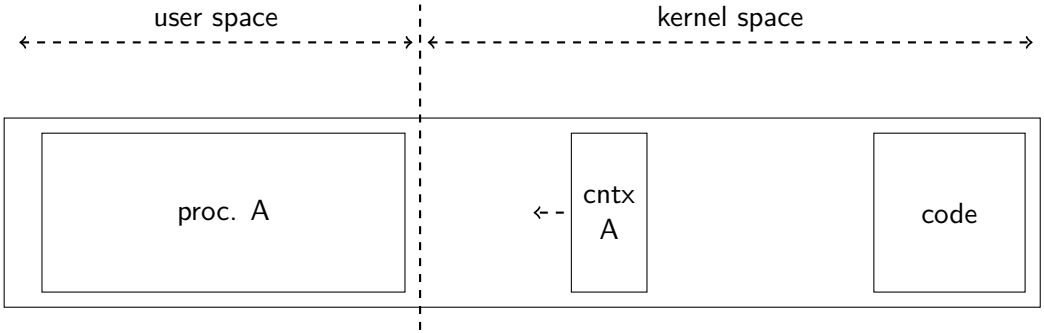

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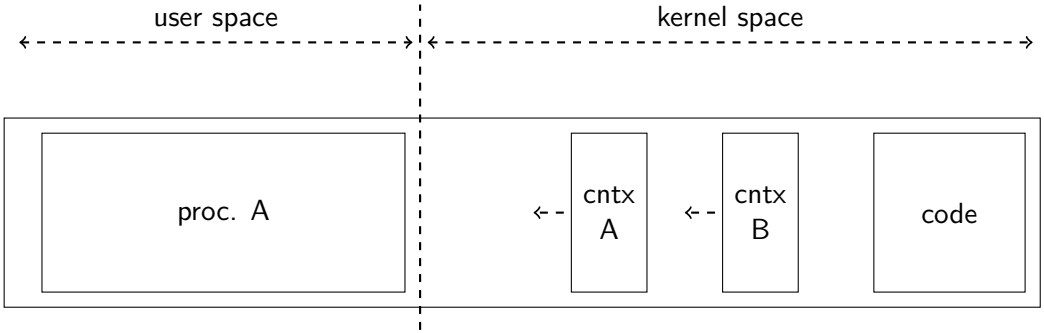

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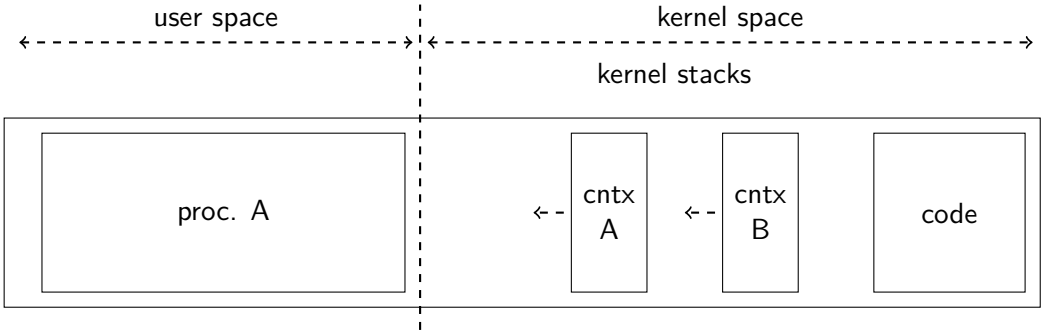

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The kernel also needs a stack and uses a per-process kernel stack.

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