Processes

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KTH

2021

A process

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... a computation

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The C process

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

the stack

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int foo(int x, int y) {
  return x + y;
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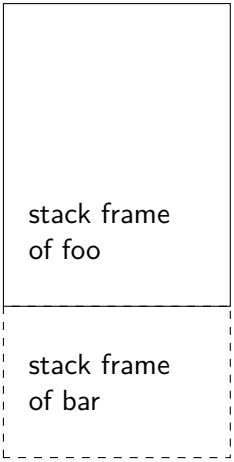


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- the arguments of the procedure
- place to hold local variables
- magic information to be able to return from a call

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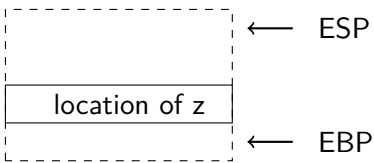


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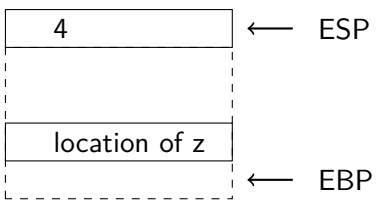


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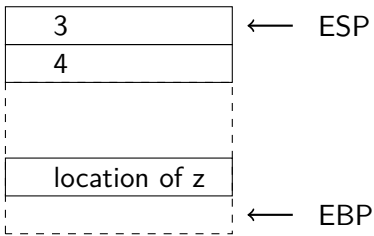


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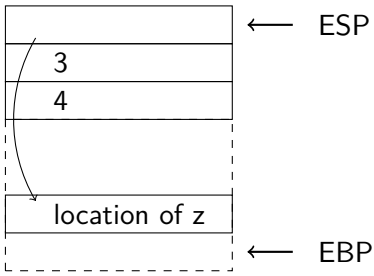


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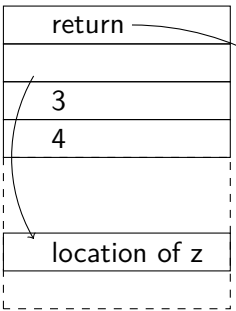


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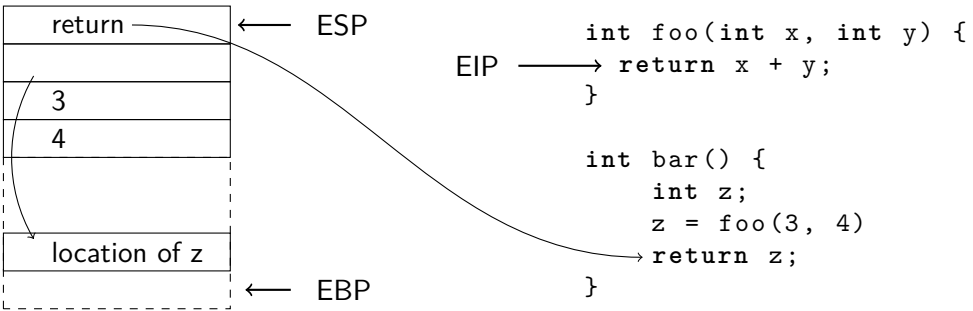

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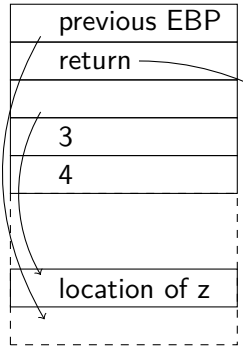

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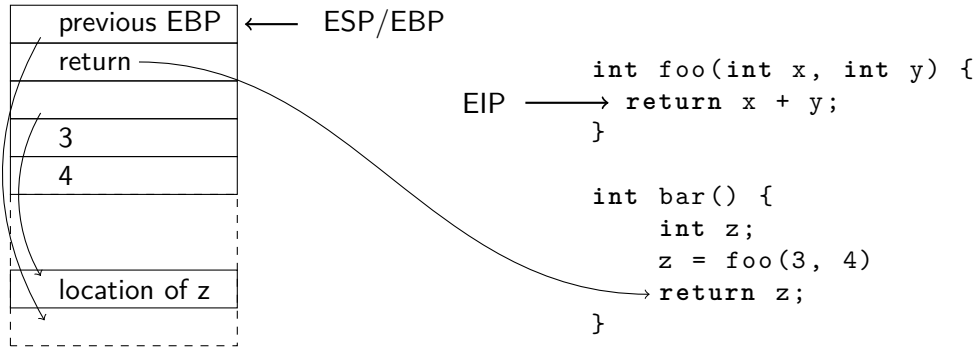

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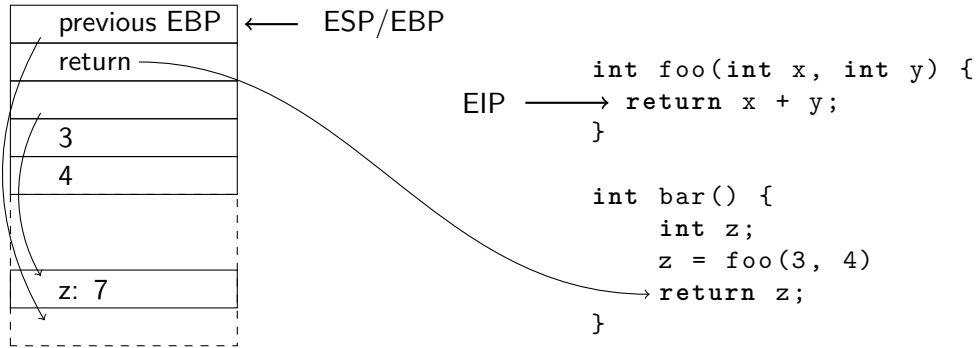

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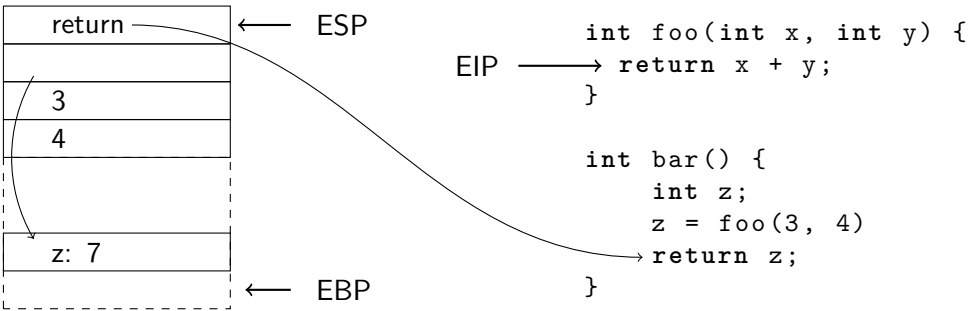

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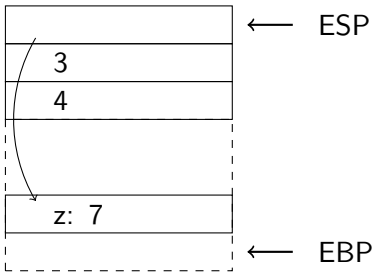


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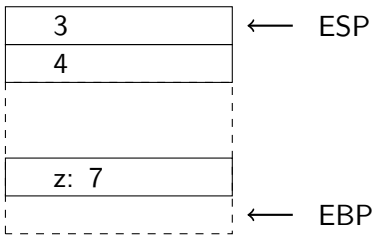


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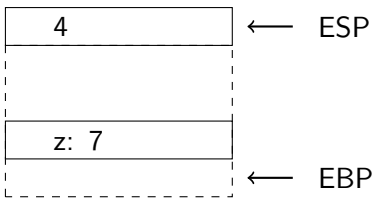


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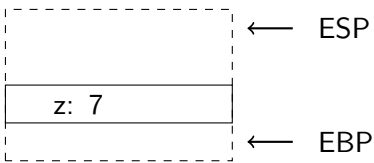


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Separate the *abstraction* of a C procedure call from how the stack is implemented.

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

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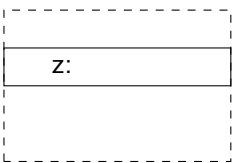

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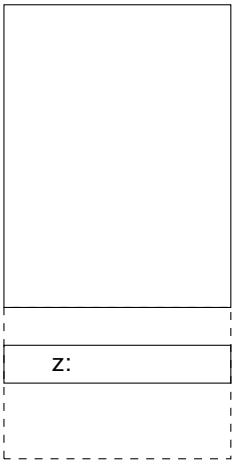


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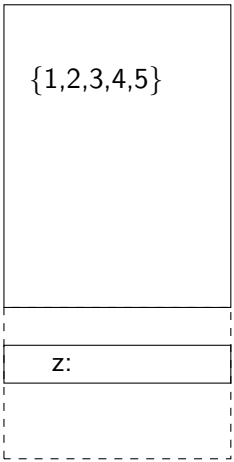


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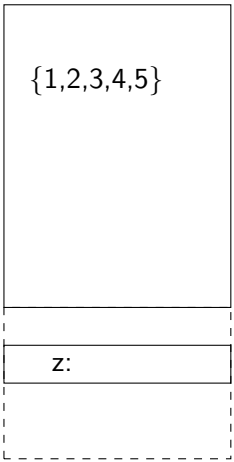


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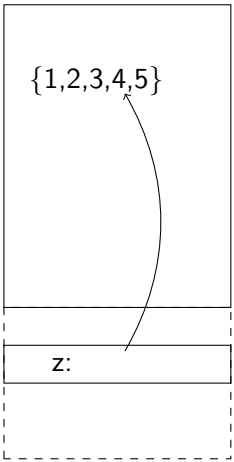


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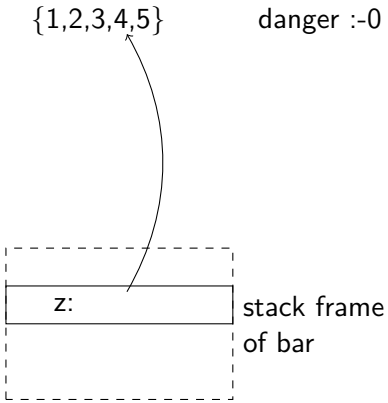


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This is why we need the *heap*.

the heap

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  int *h;
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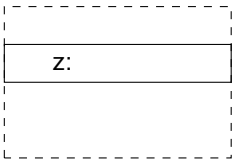


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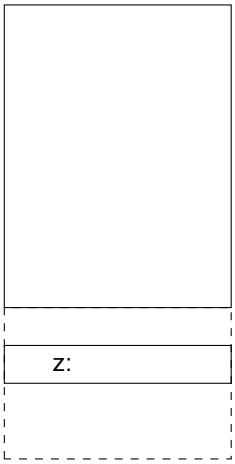


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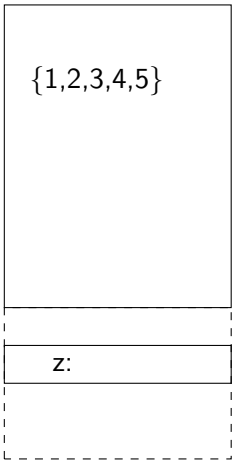


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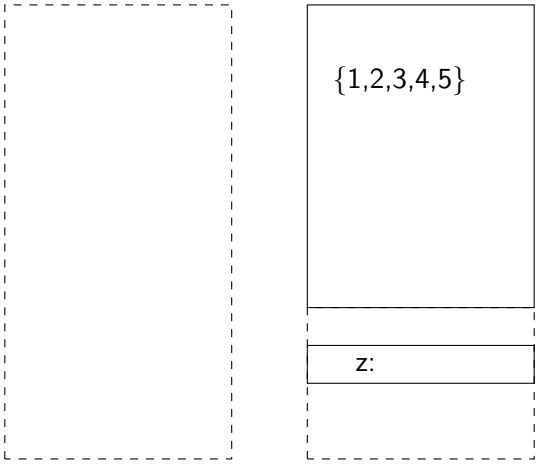


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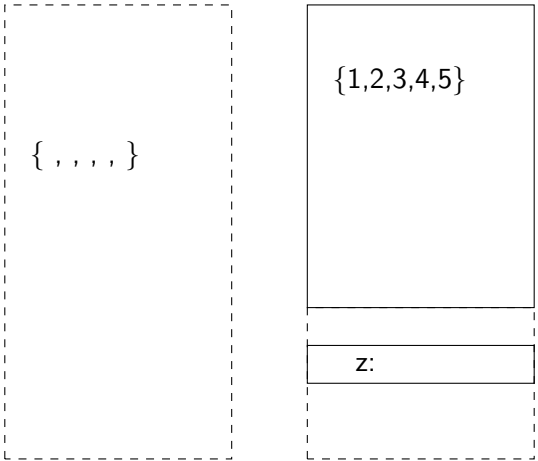


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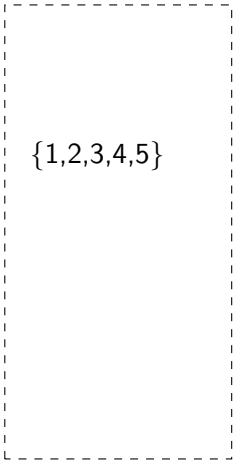

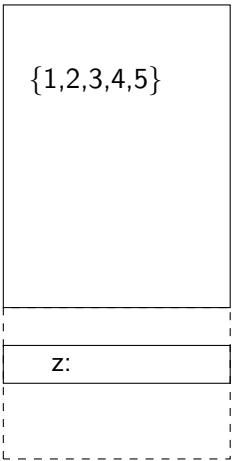


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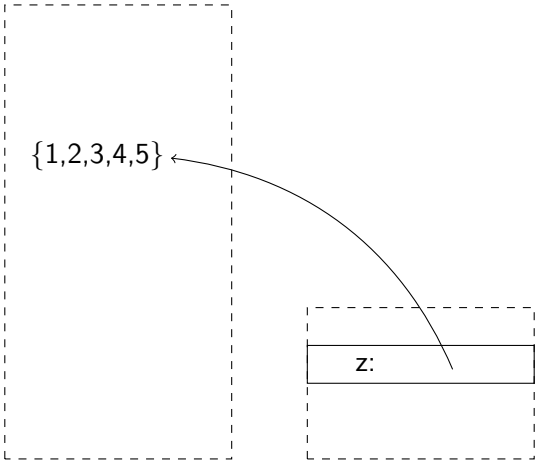


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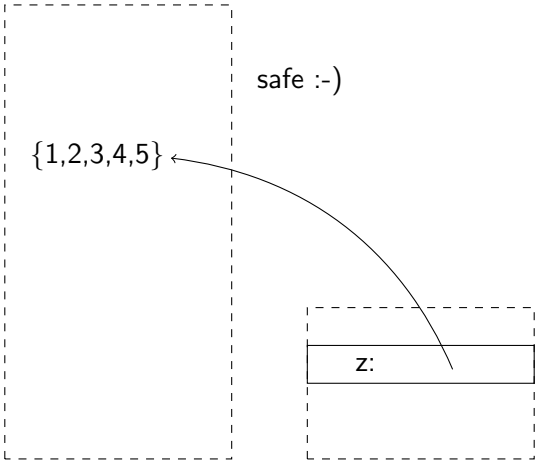


```
int *foo(int x) {
  int a[5] = {1,2,3,4,5};
  int *h;
  int i;

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

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

the heap

- a memory area separated from the stack

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- explicit allocation

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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

how about Java

```
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.

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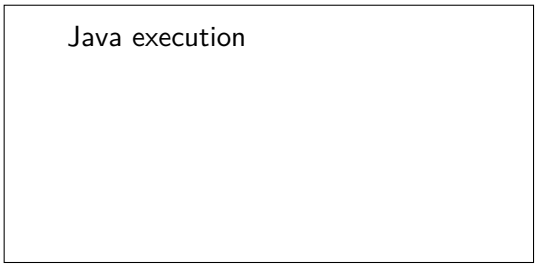

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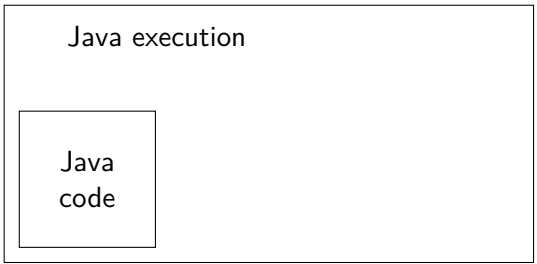

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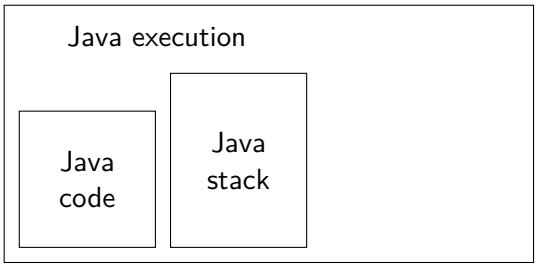

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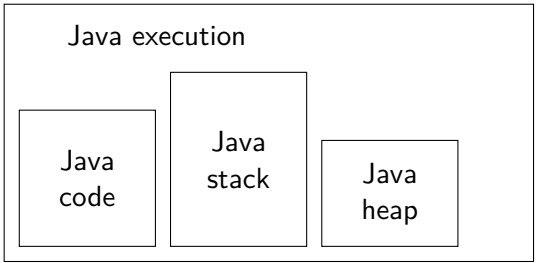

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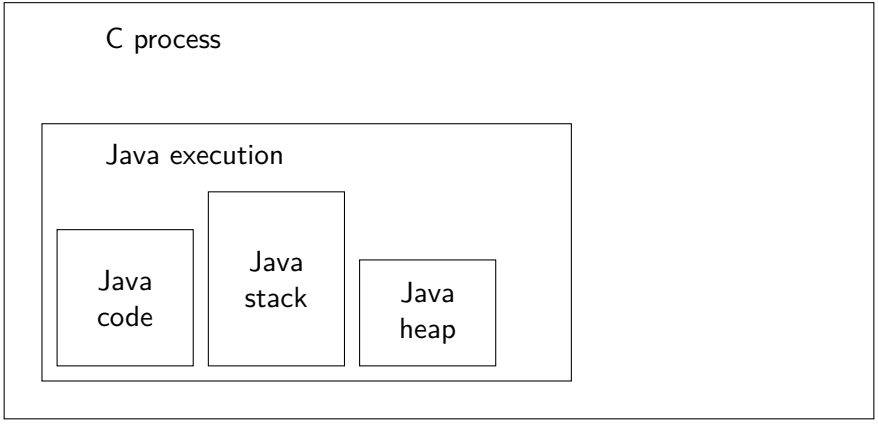

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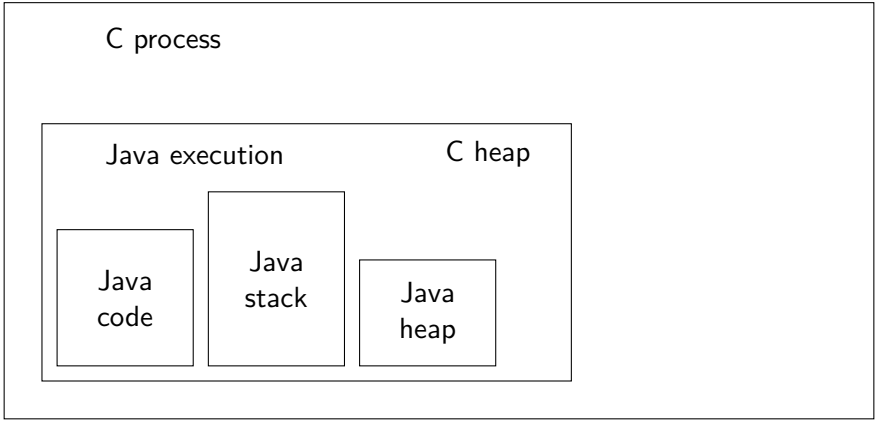

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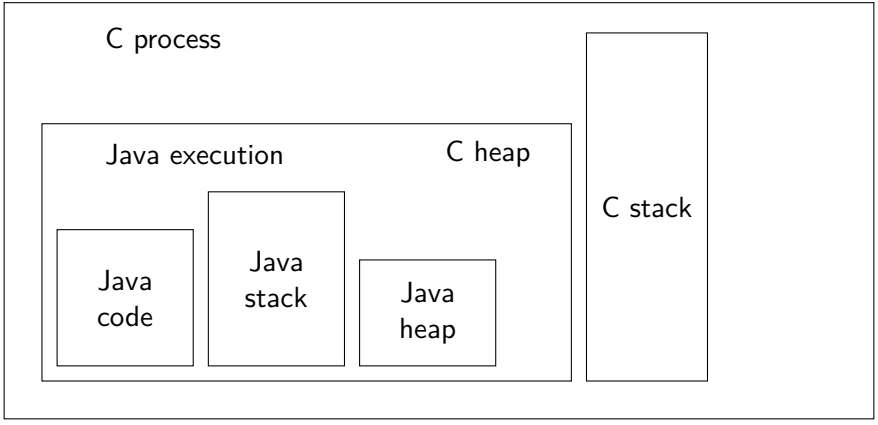

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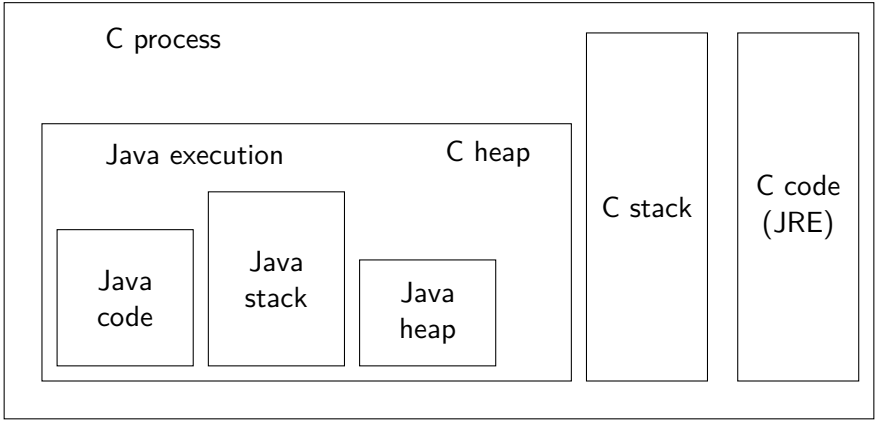

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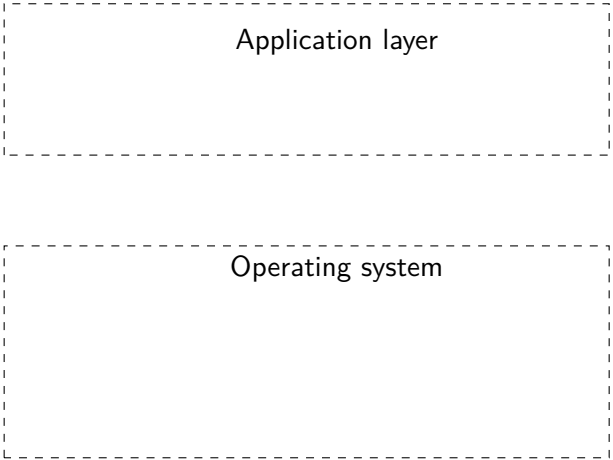
... it is the job of the operating system to provide the functionality.

The operating system



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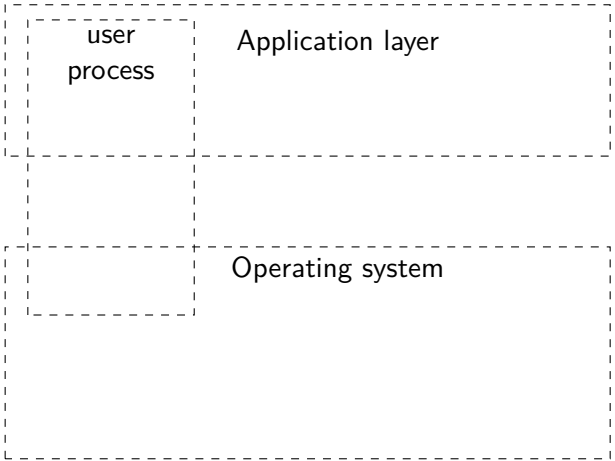

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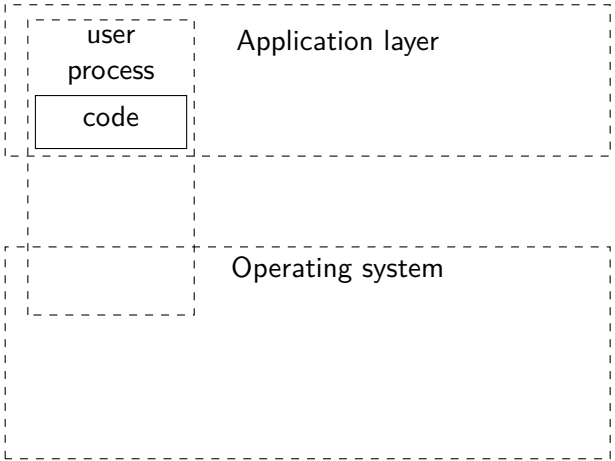

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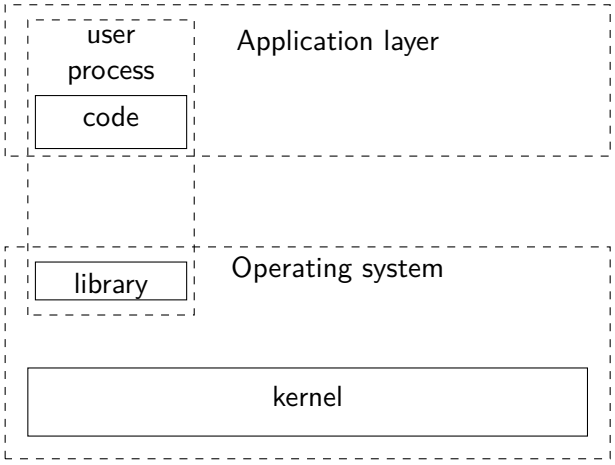

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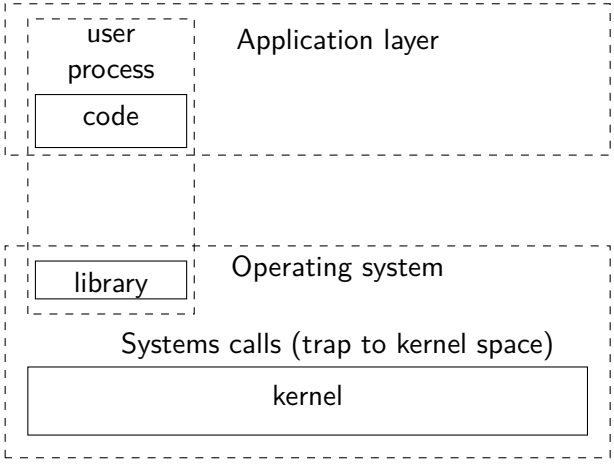

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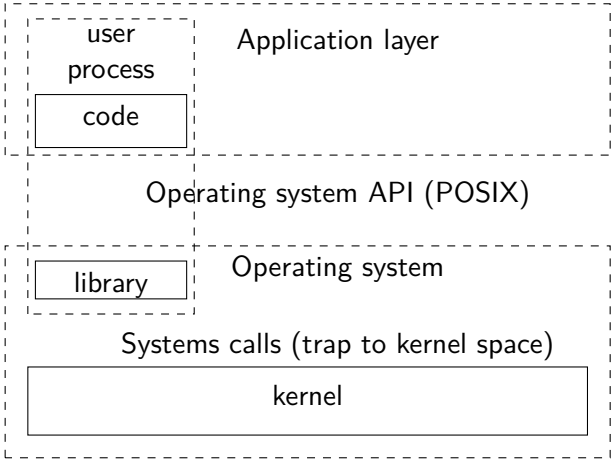

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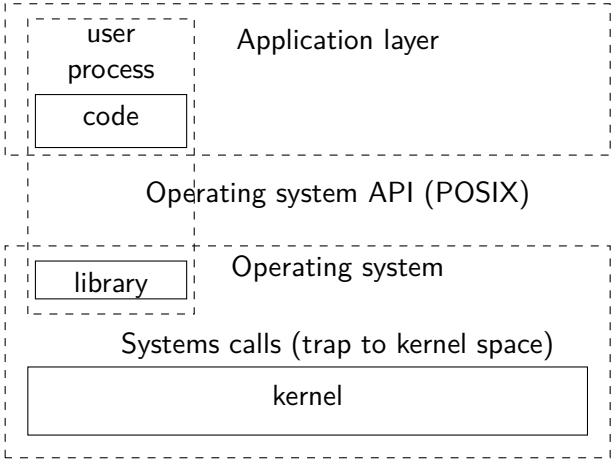

Library is often just a wrapper for the system call - sometimes more complex.

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We're now presenting how the operating system **might** implement the *process abstraction*. One should never take for granted that things are actually implemented one way or another.

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Examples are from Linux on a x86 architecture.

from program to process

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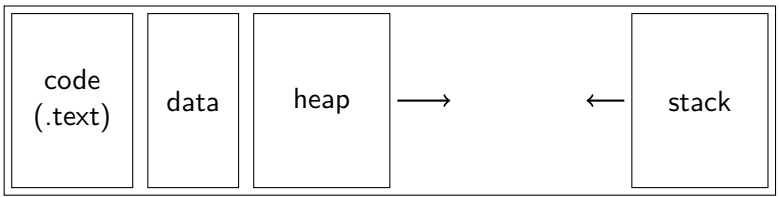

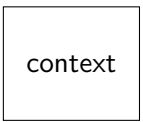

process execution

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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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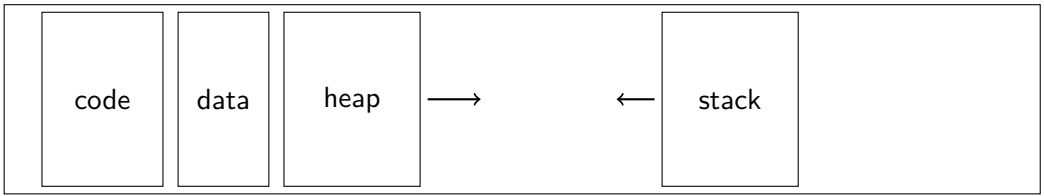

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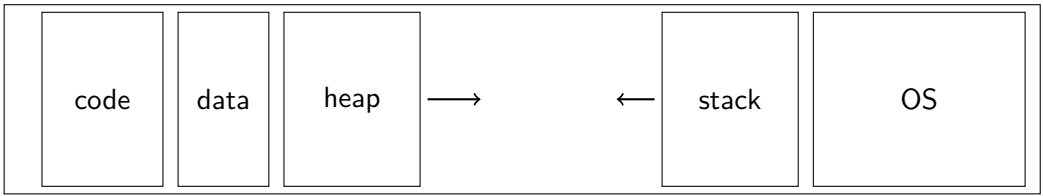

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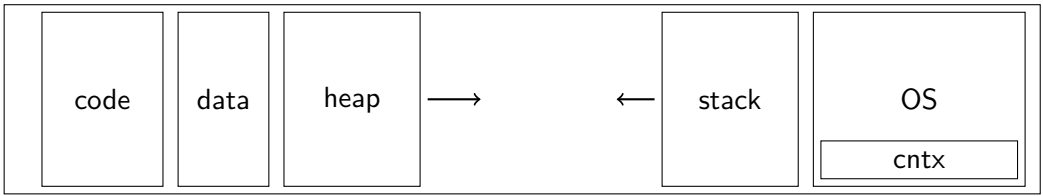

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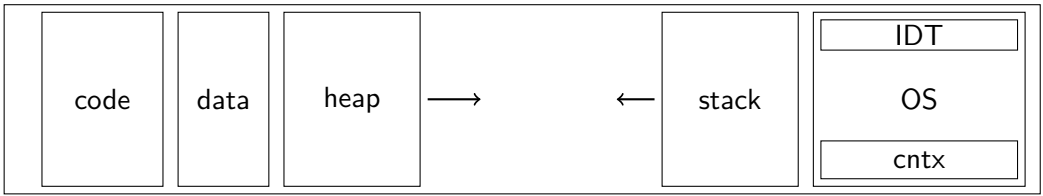

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The `Interrupt Descriptor Table` can only be set using the *privileged instruction* LIDT (*Load Interrupt Descriptor Table*).

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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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The kernel sets a *timer interrupt* before it allows the user process to execute.

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

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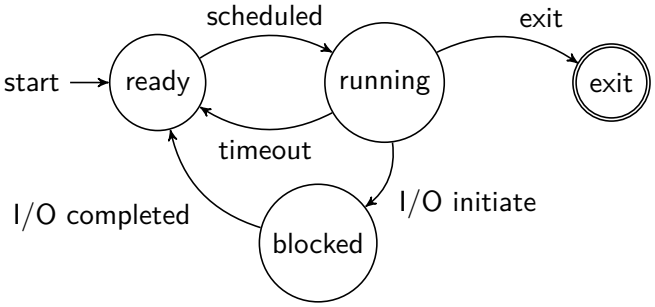
This is the Intel terminology.

process state



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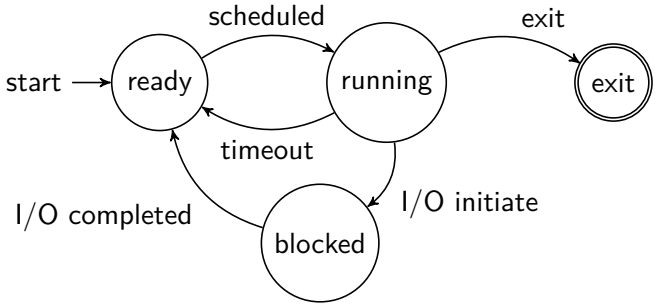

Where are interrupts used?

creating a process

How do we create a new 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>

int 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?

```
int 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);
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    printf("  Mother: address of x is  %p\n", &x);
  }
  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;
}
```

process creation

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- Newly open files are not shared.

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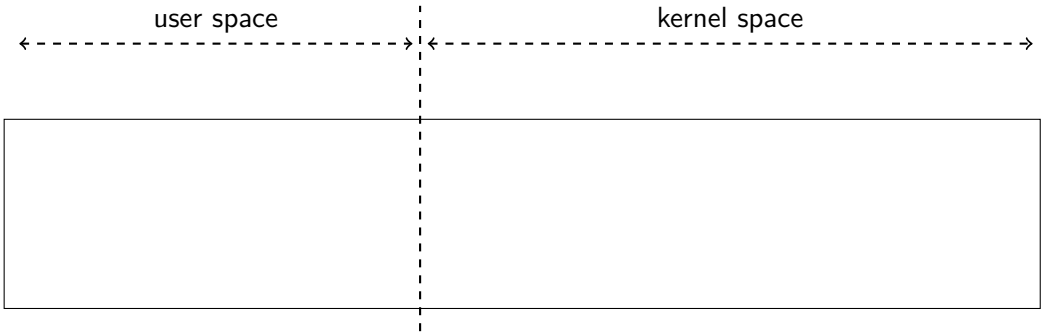

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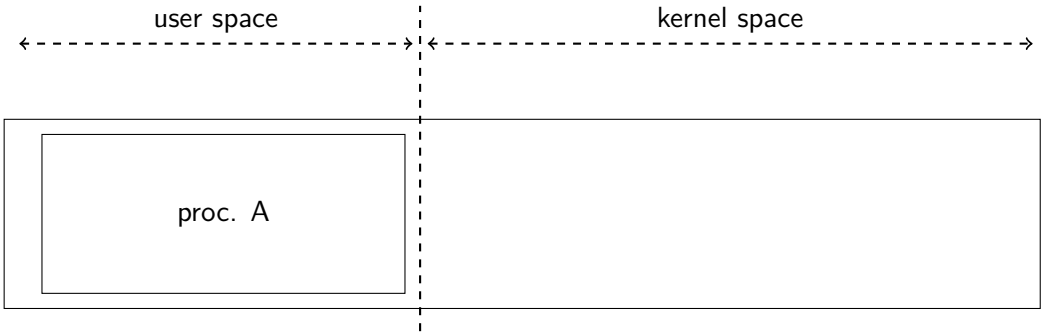
process scheduling



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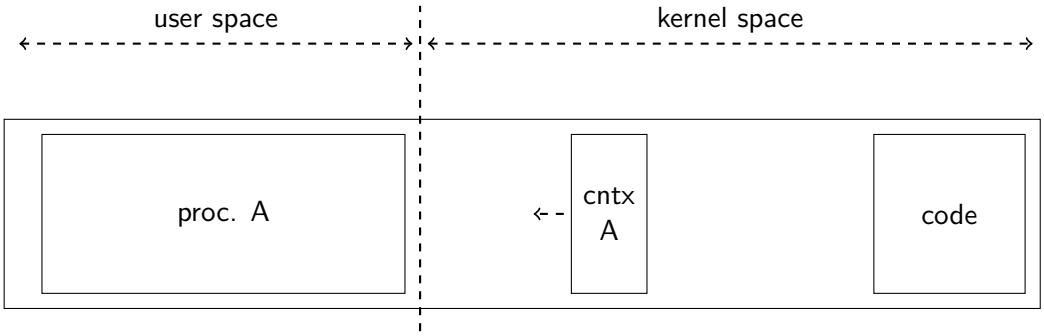

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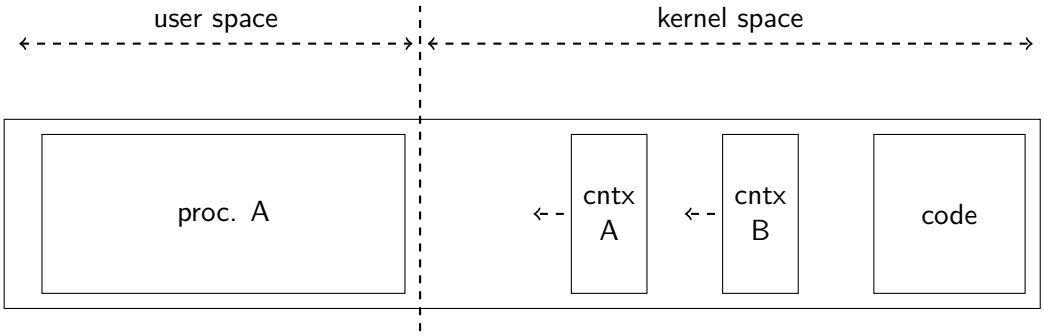

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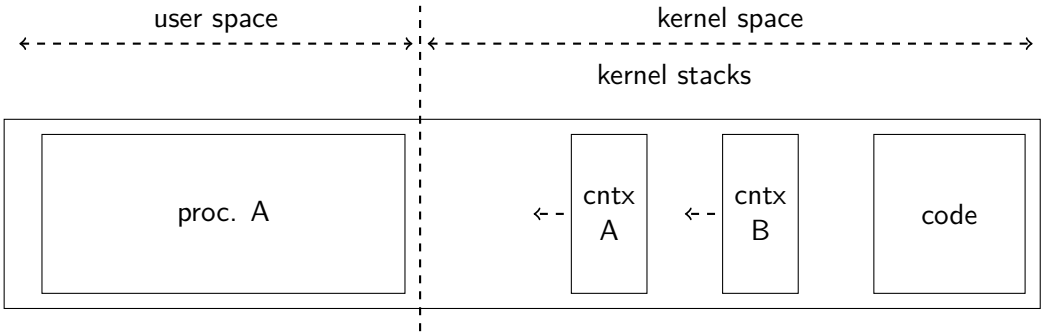

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The kernel also needs a stack and uses a per-process kernel stack.

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