

Processes

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KTH

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What is 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.


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int foo(int x, int y) {  
    return x + y;  
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int bar() {  
    int z;  
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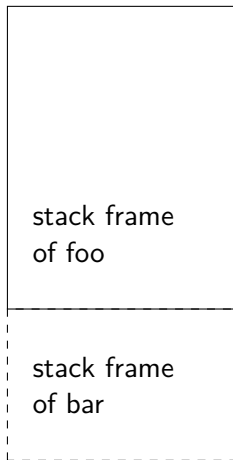
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- magic information to be able to return from a call

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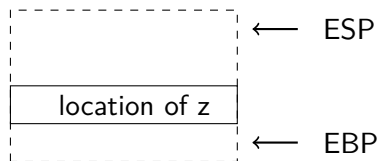
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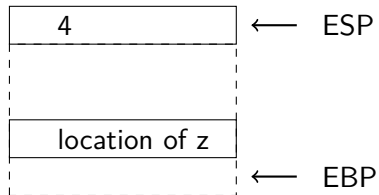
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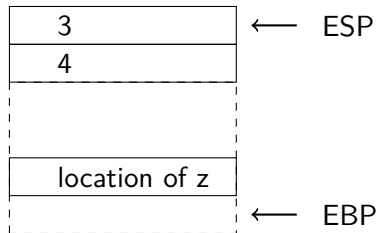
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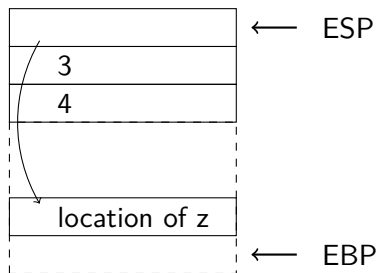

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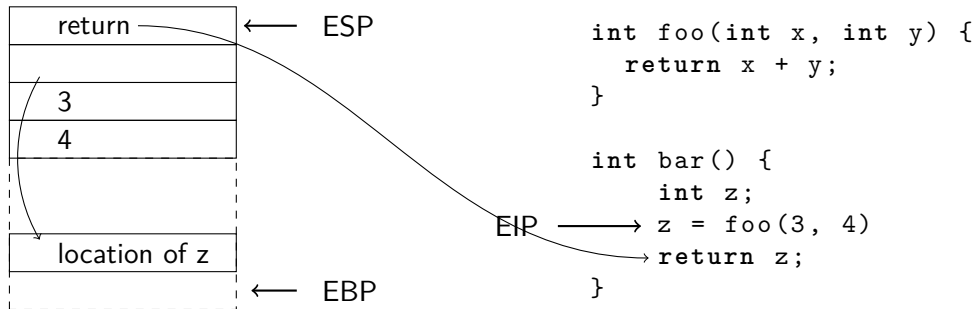
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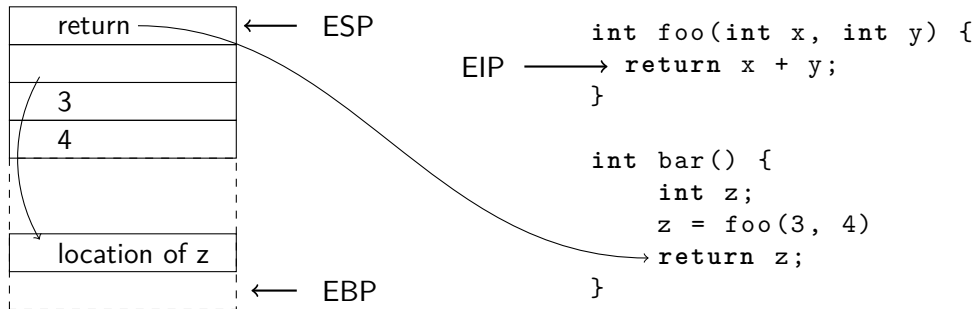


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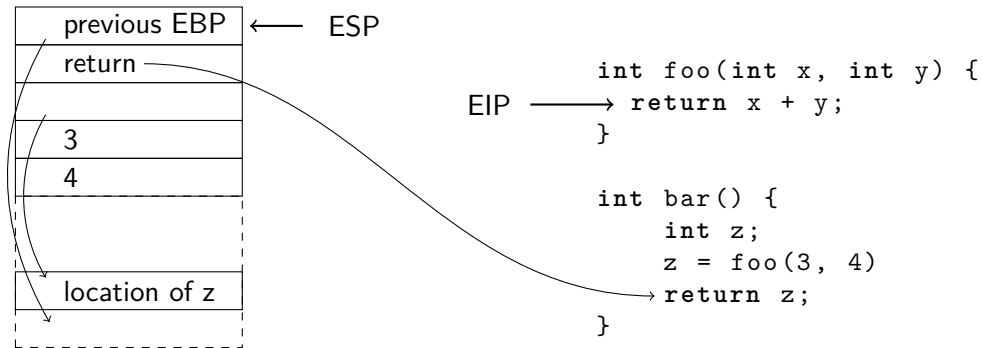
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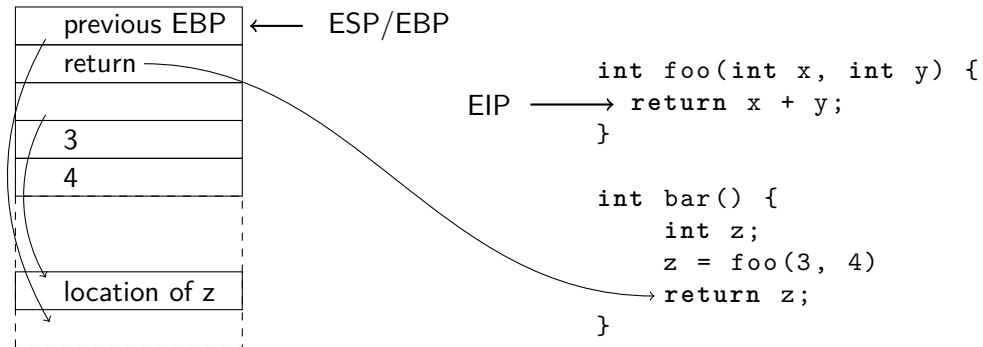
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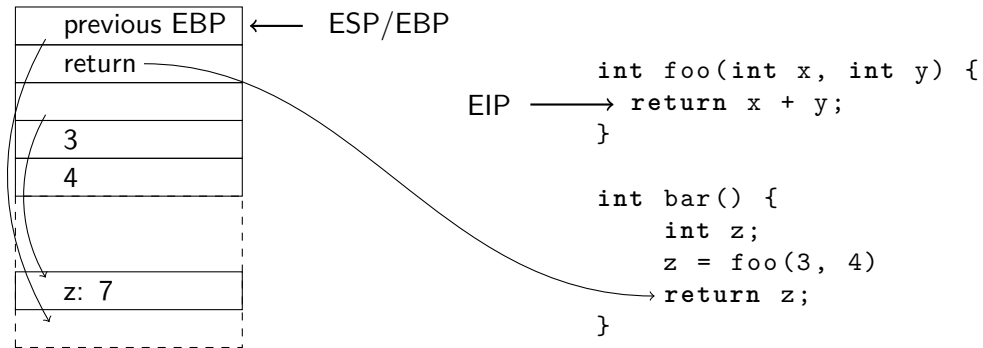
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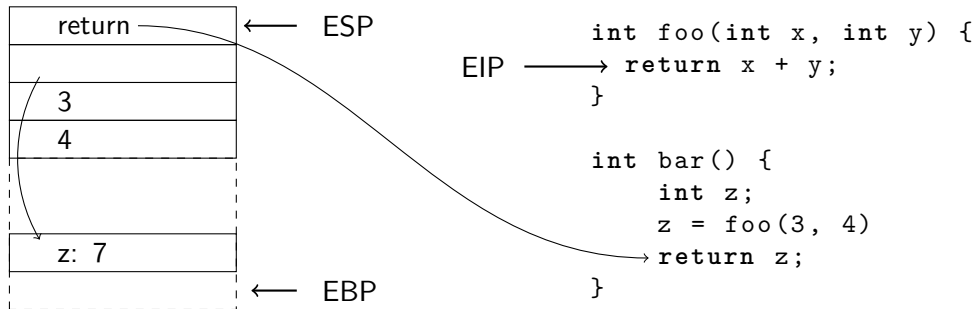
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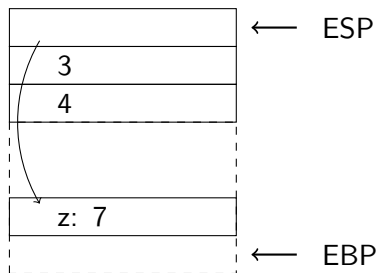
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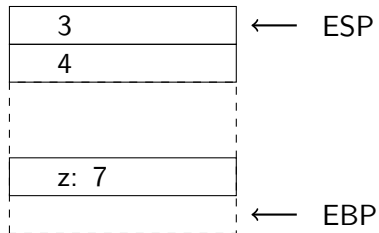


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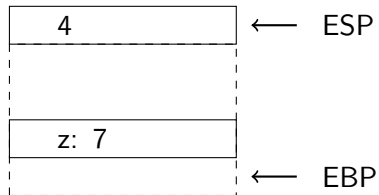
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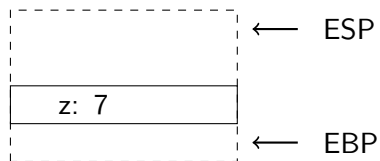
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Separate the *abstraction* of a C procedure call from how the stack is implemented.

How is a data structure returned from a procedure call?

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

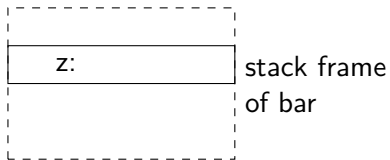


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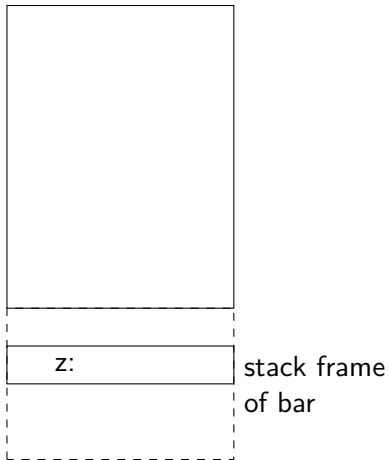
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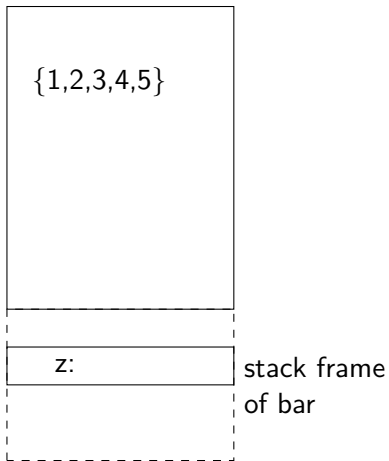
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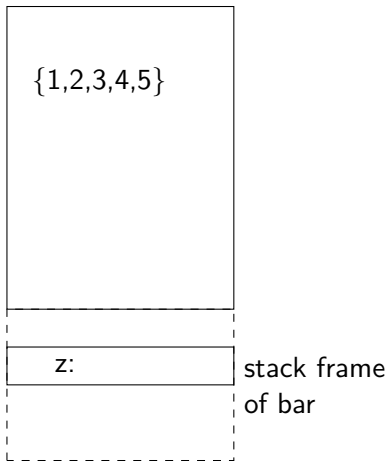
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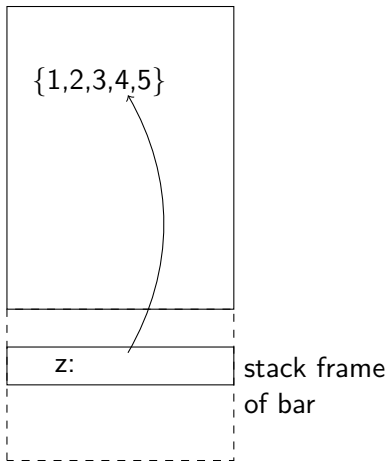
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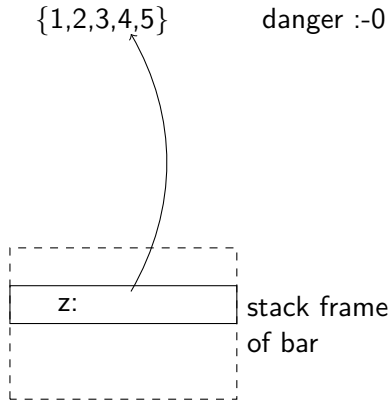
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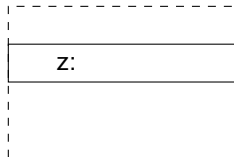
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This is why we need the *heap*.

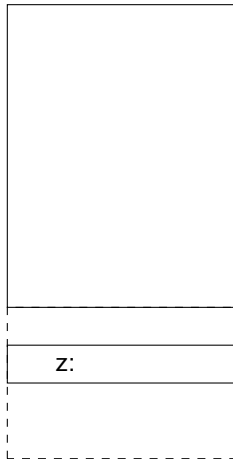


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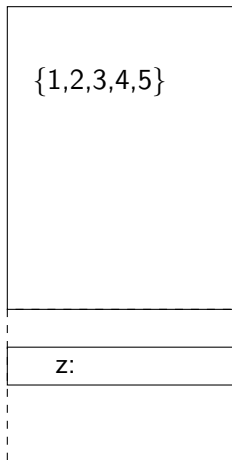
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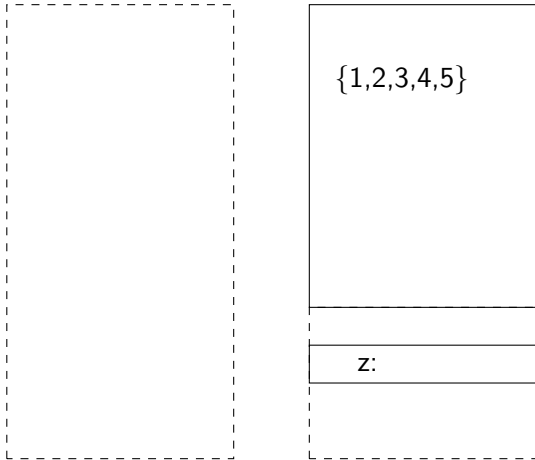
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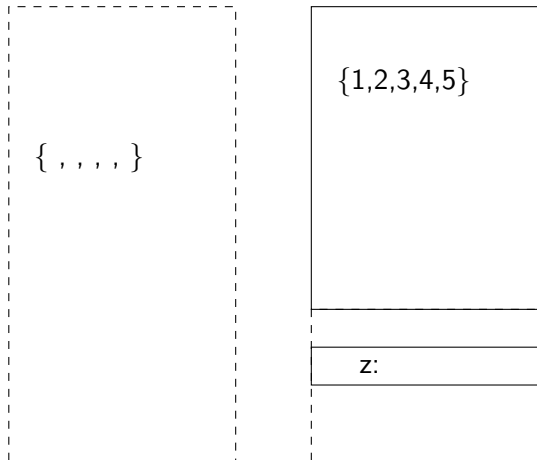
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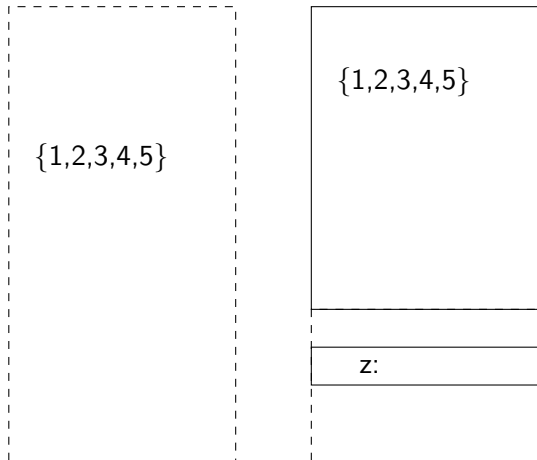
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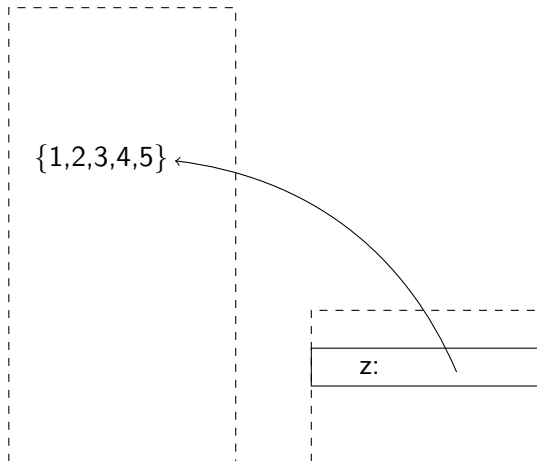
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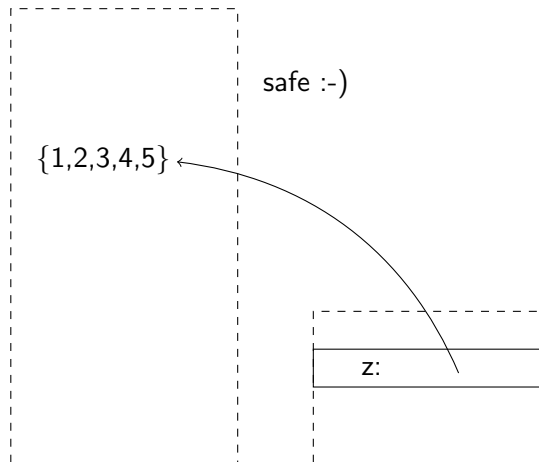
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- the heap is handled using library calls in C

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the heap API

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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

```
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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- using the primitive `new` the object is allocated on the heap (as in Java).

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

let's complicate things

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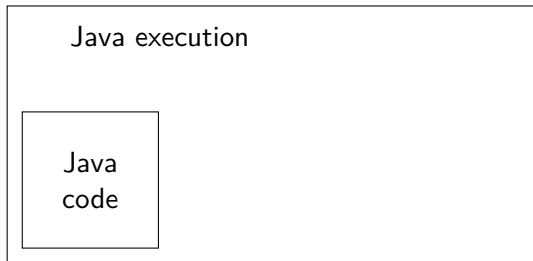
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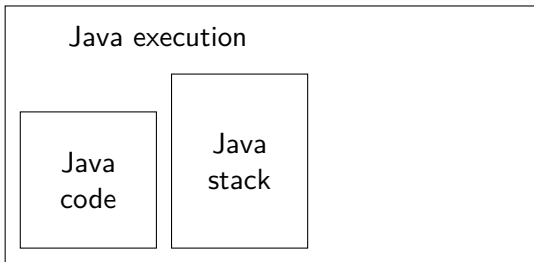
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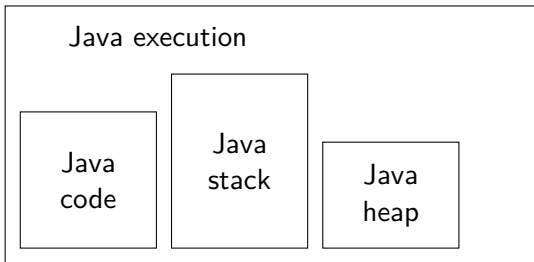
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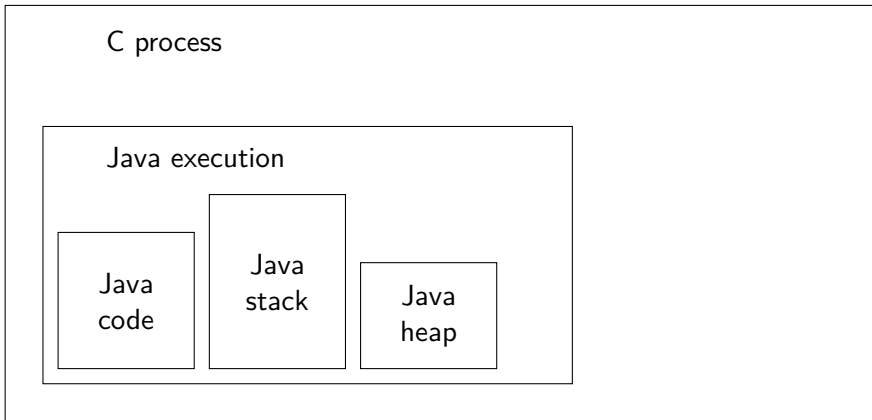
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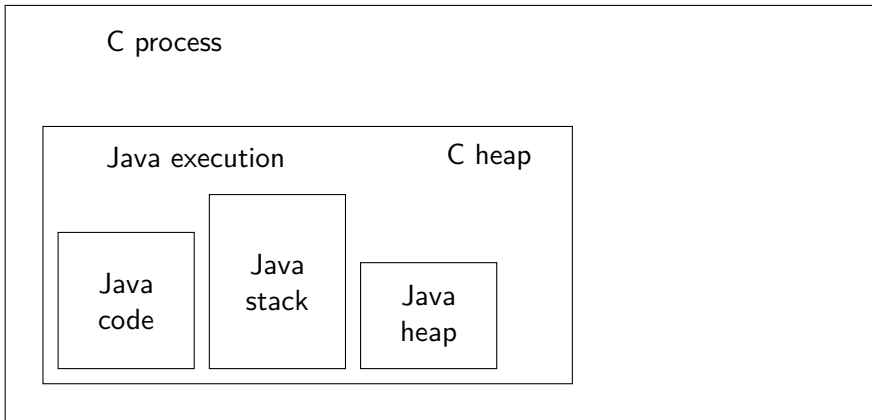
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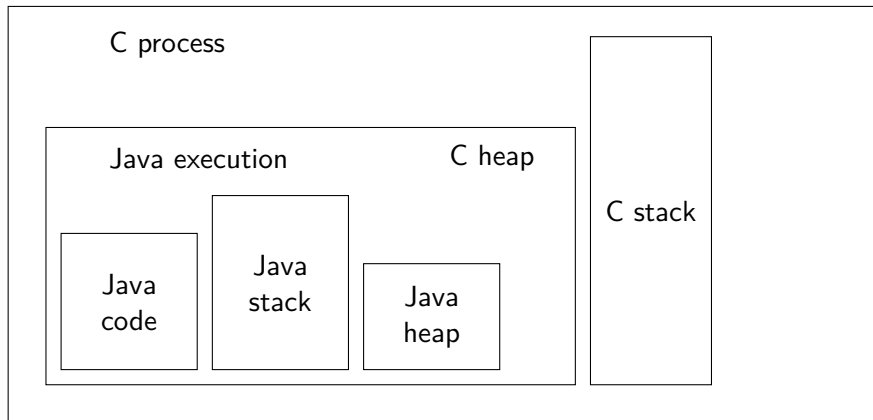
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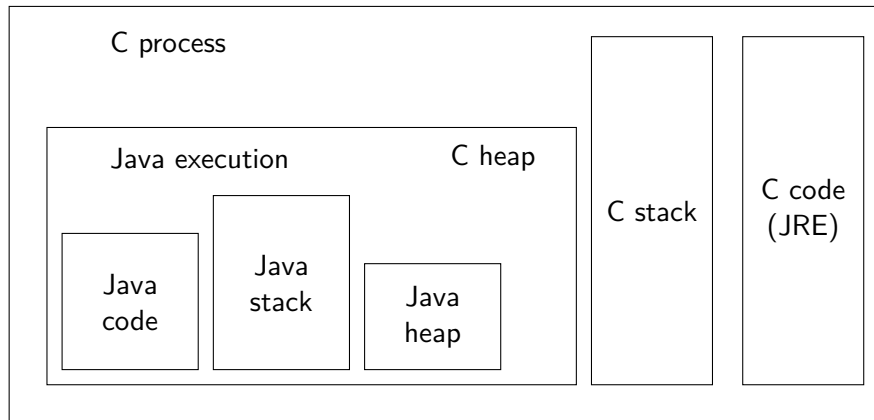
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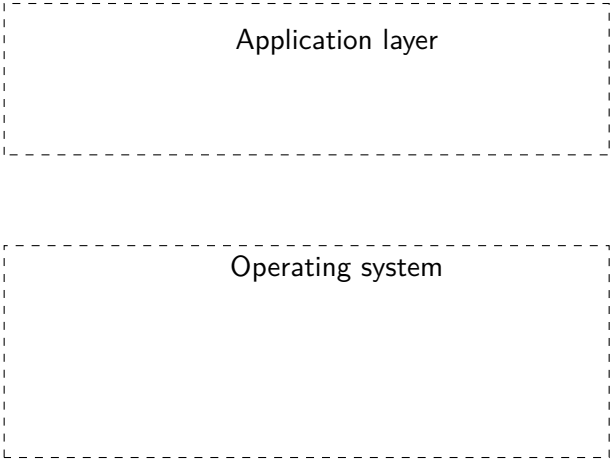
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... it is the job of the operating system to provide the functionality.

The operating system

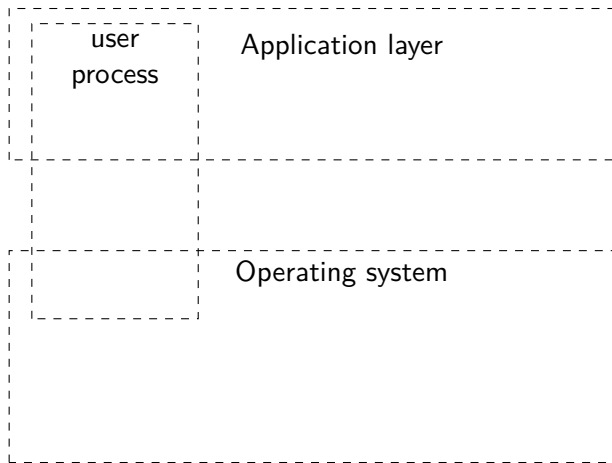


Application layer

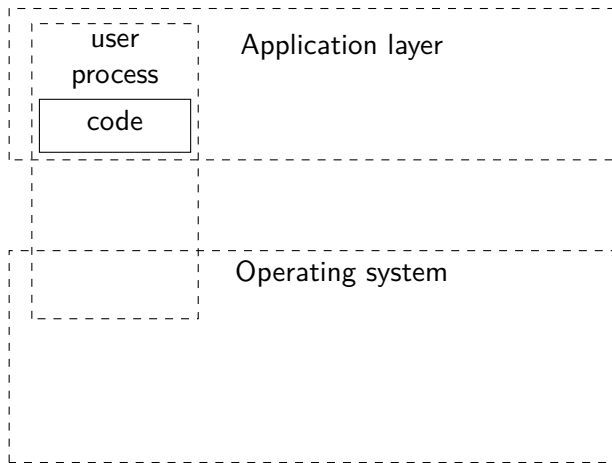
The diagram consists of two vertically stacked rectangular boxes with dashed borders. The top box is labeled 'Application layer' and the bottom box is labeled 'Operating system'. Both boxes are empty except for their respective labels.

Operating system

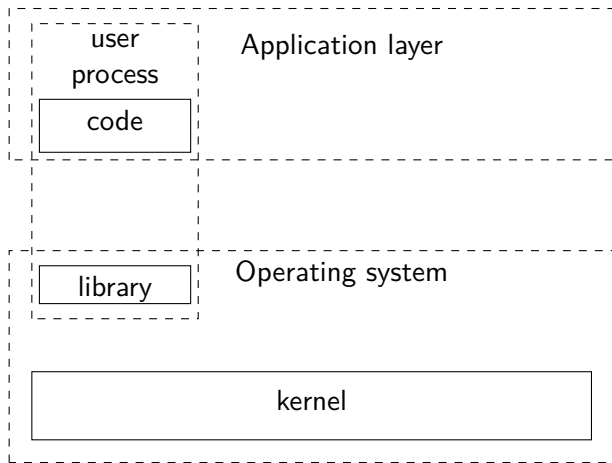
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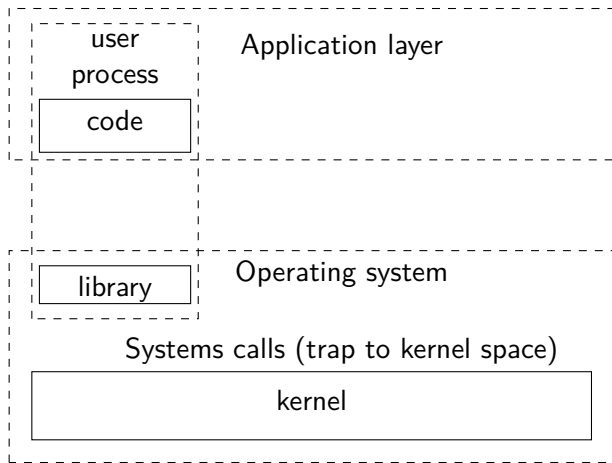
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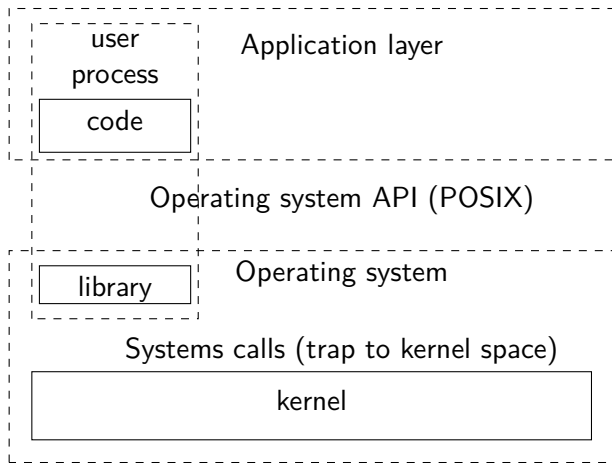
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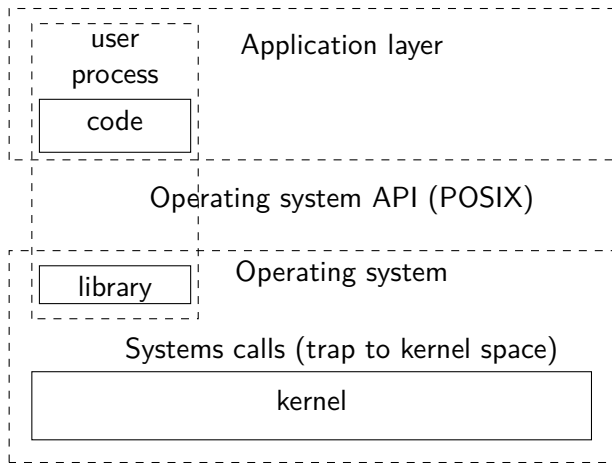
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Library is often just a wrapper for the system call - sometimes more complex.

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Examples are from Linux on a x86 architecture.

from program to process

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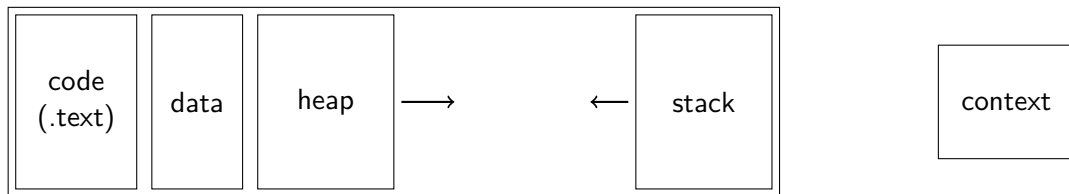
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Direct execution:

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

the process memory layout

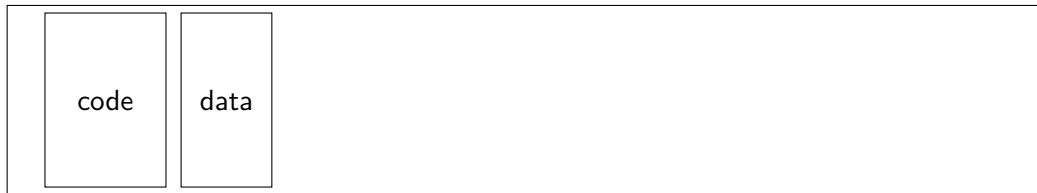


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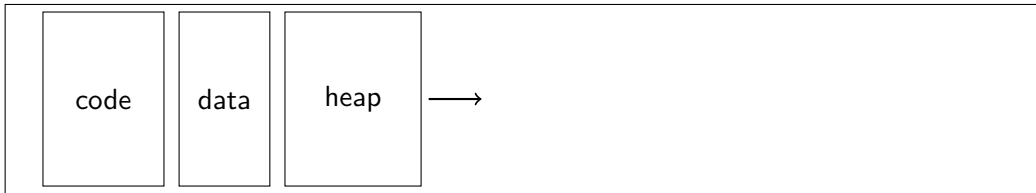
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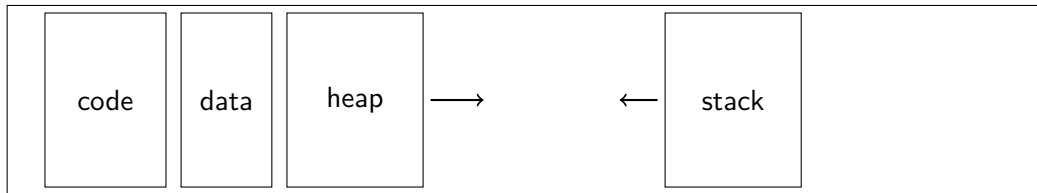
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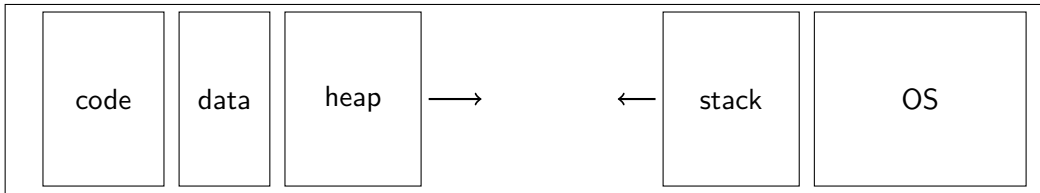
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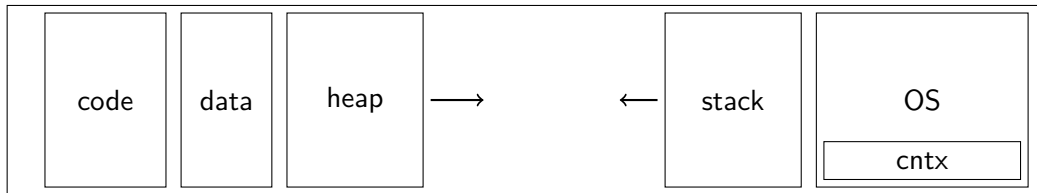
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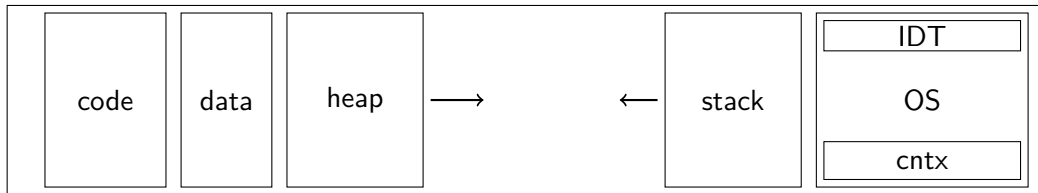
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The Interrupt Descriptor Table can only be set using the *privileged instruction* LIDT (*Load Interrupt Descriptor Table*).

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

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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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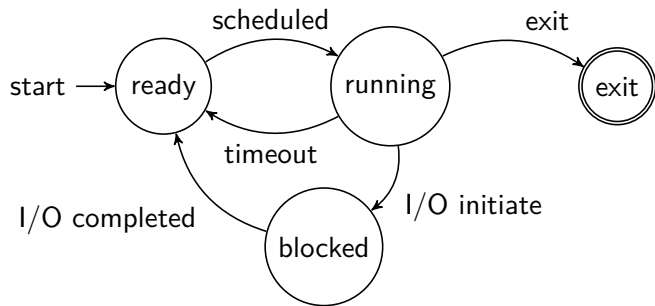
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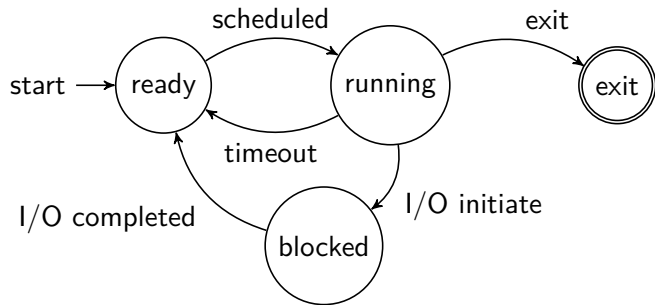
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- Asynchronous interrupts: raised by the hardware: keyboard, IO, etc, can be *masked* by the kernel.
- Synchronous interrupts - exceptions: raised by the CPU
 - faults: something strange happens, will be handled by the kernel and instruction is re-executed (if the kernel can fix it).
 - traps: something special happens, used mainly by debugging.
 - abort: severe errors that will not be fixed by the kernel.
 - programmed exceptions (software exceptions): raised by for example the INT instruction, used by system calls and debuggers.

This is the Intel terminology.

process state





Where are interrupts used?

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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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```
#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;  
}
```



```
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);  
    }  
    return 0;  
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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;  
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```


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- The memory of the two processes are separated from each other (but use the same addresses).
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- Newly open files are not shared.

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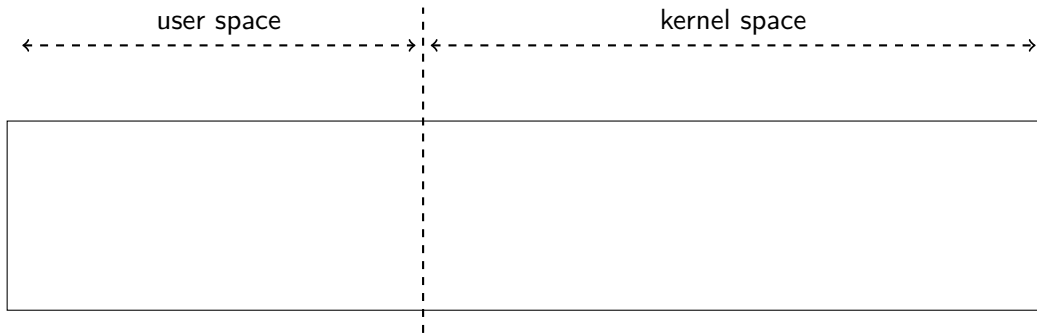
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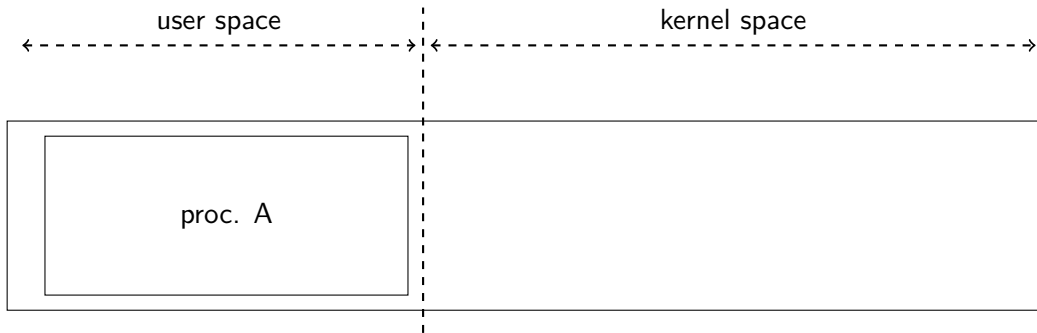
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process scheduling

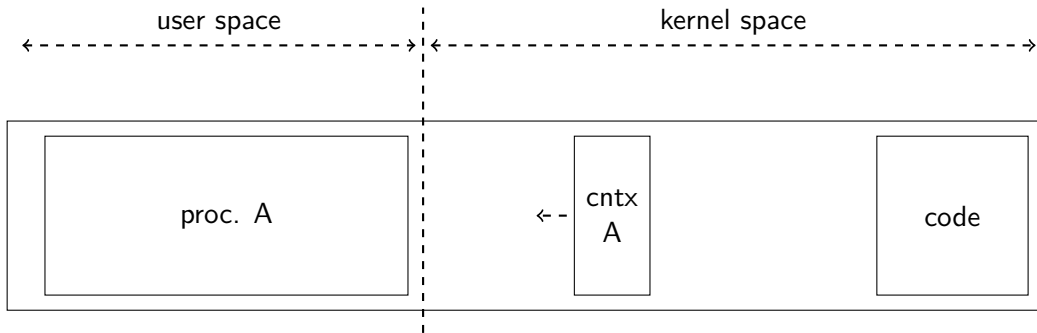


what happens when a timer interrupt is received?.



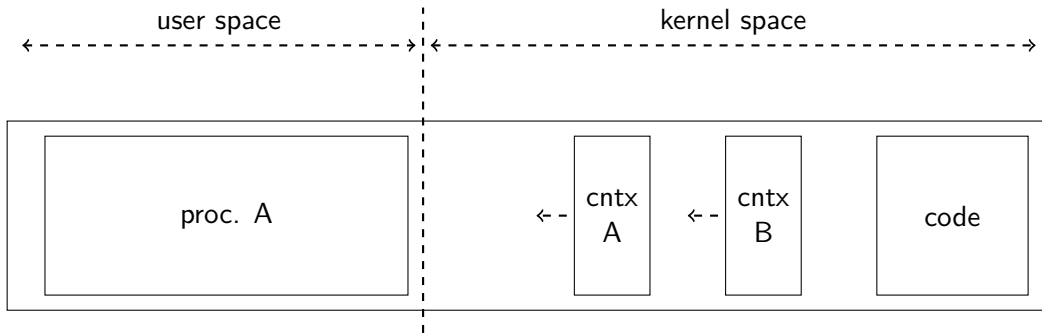
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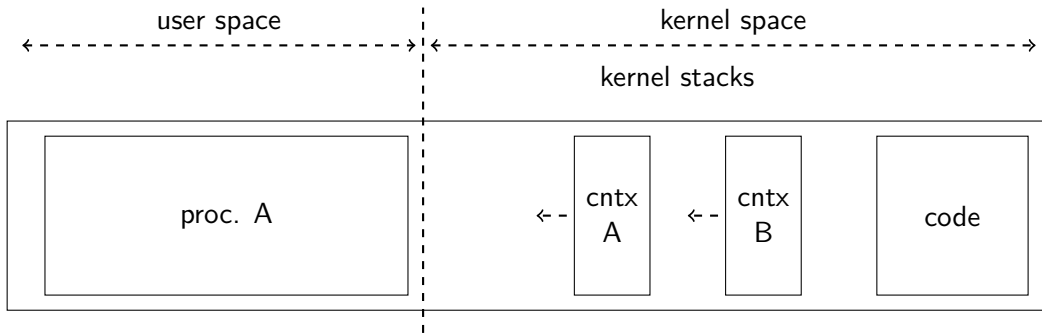


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The kernel also needs a stack and uses a per-process kernel stack.

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