Betriebssysteme

5. Tutorium - Threading, Segmentation, MM

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28. November 2024

ITEC - Operating Systems Group

Threads

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- Thread + Address Space = Process

Spawn a few threads using pthreads!

Write a small program that creates five threads using the pthread library. Each thread should print its number (e.g., `Hello, I am 4`) and the main program should wait for each thread to exit.

Thread models — One To One

One To One

```
new Thread()

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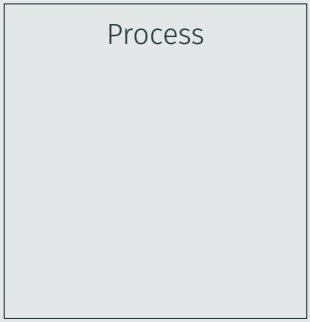

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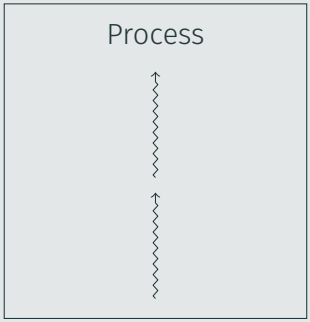

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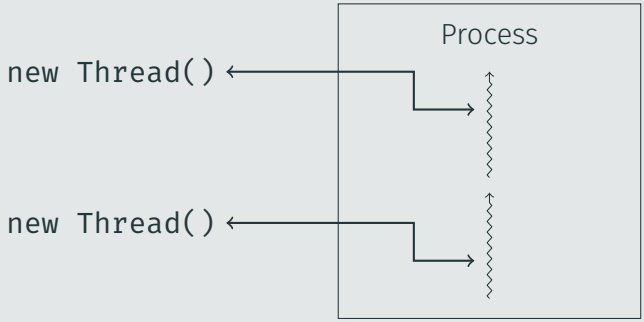

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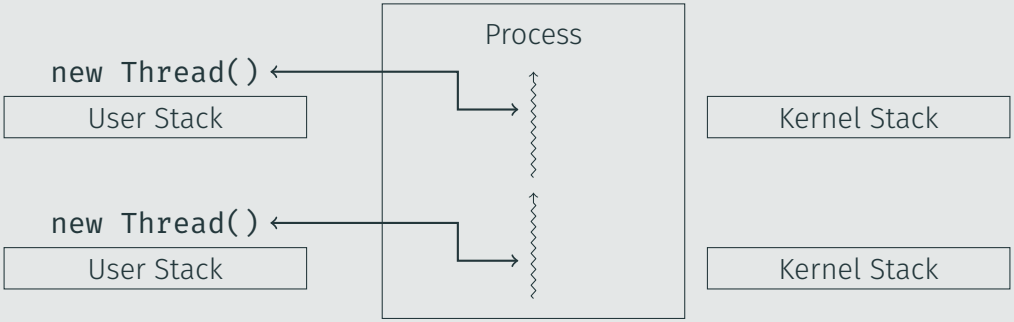

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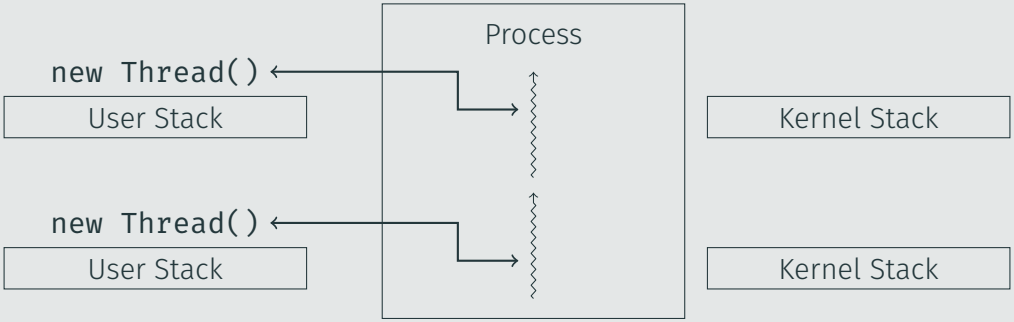

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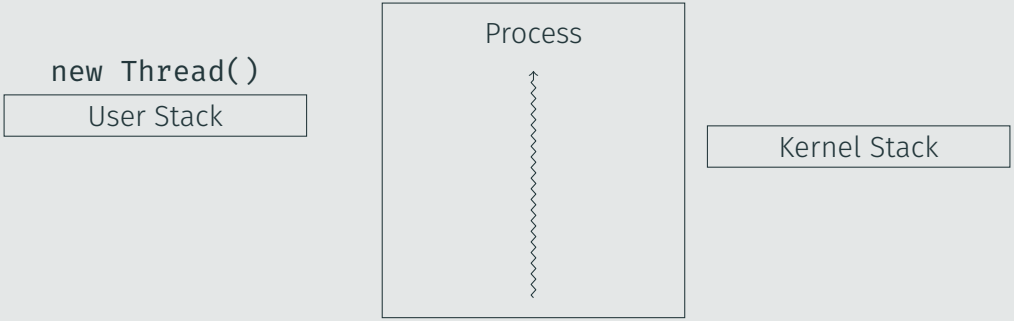

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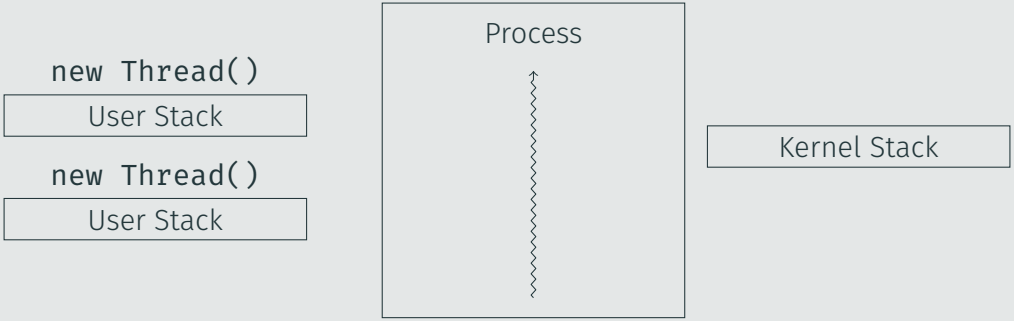

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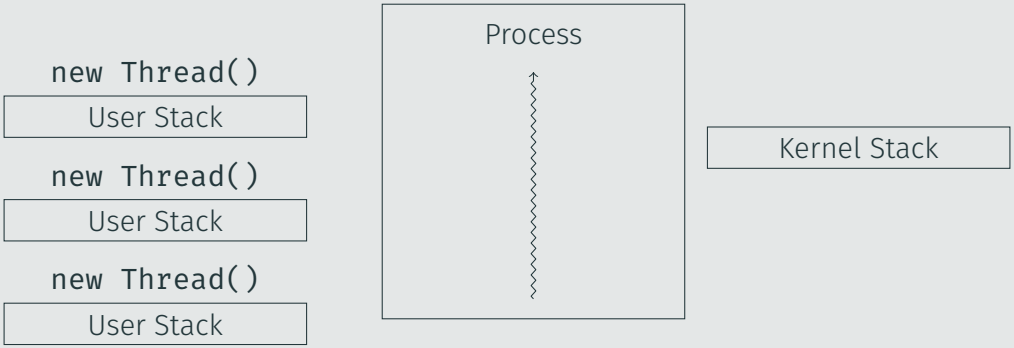

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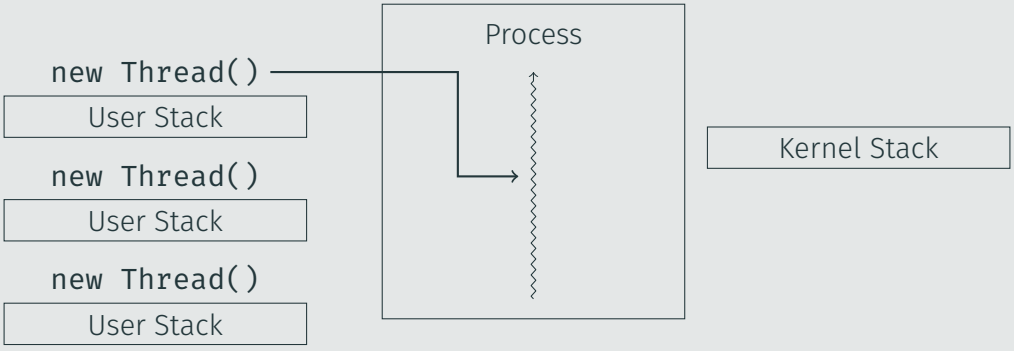

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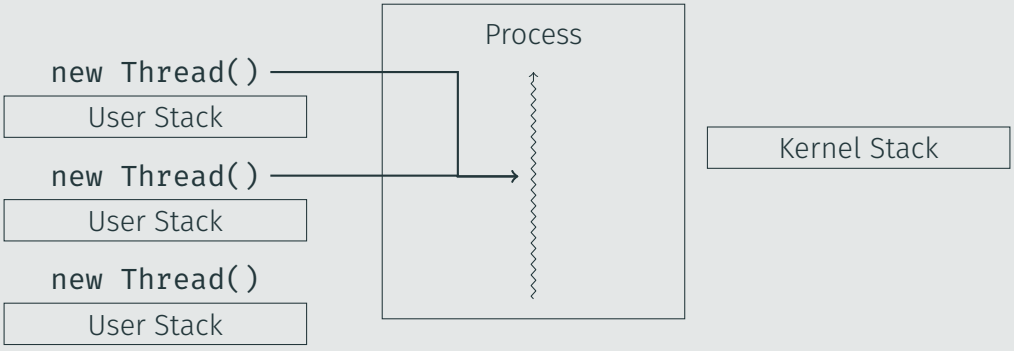

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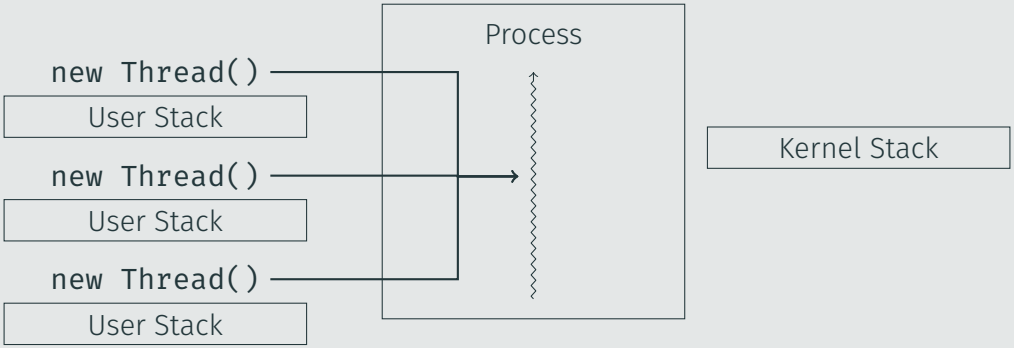

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Famous paper by a proponent of Structured Programming:
„*Go To Statement Considered Harmful*“ by Edsger W. Dijkstra

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So that might sound familiar...

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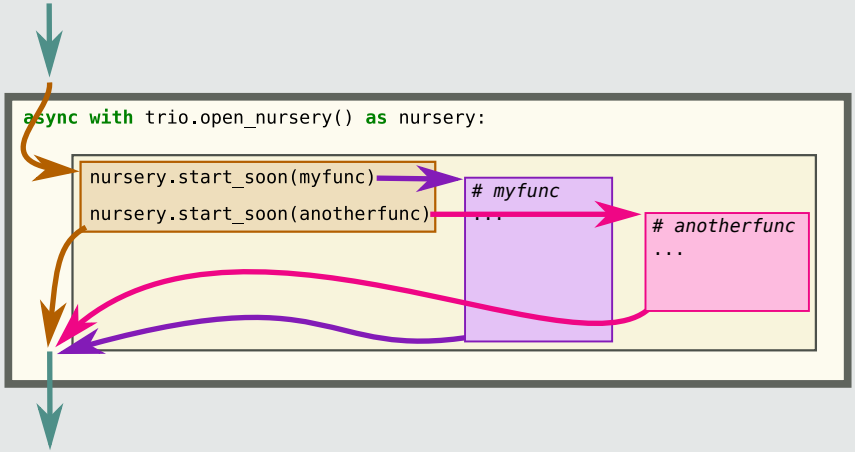
Structured Concurrency



Taken from vorpus.org

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Nice, but what does this have to do with ULTs?

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Nice, but what does this have to do with ULTs?

- Spawning lots of threads for small operations *is too slow otherwise*

Further reading:

Notes on Structured Concurrency

ULTs and Structured concurrency in Java - Project Loom

Thread models - Many To Many

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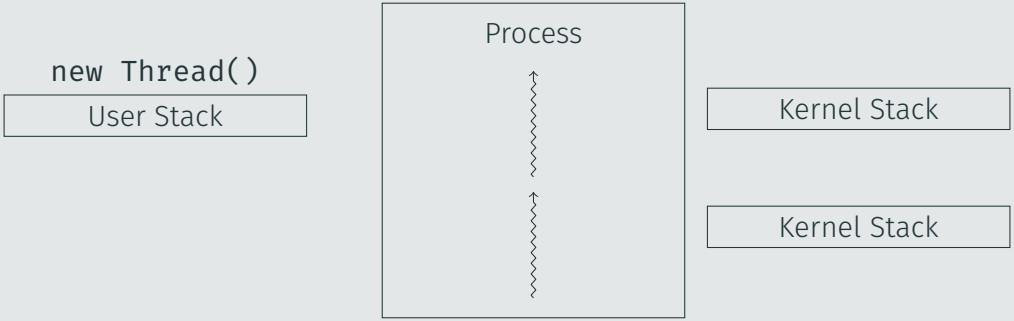

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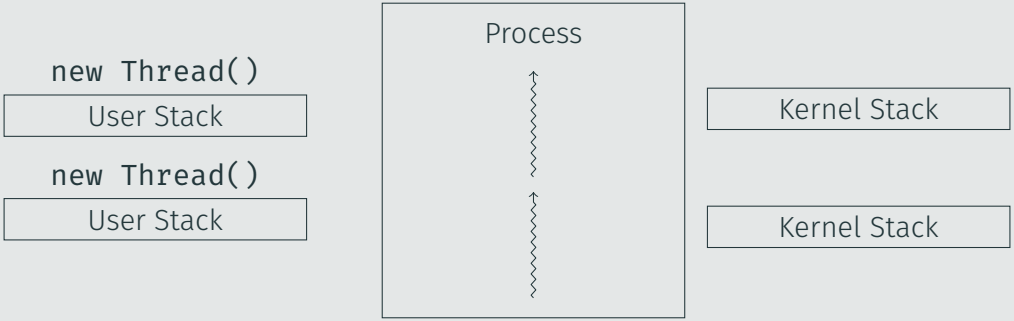

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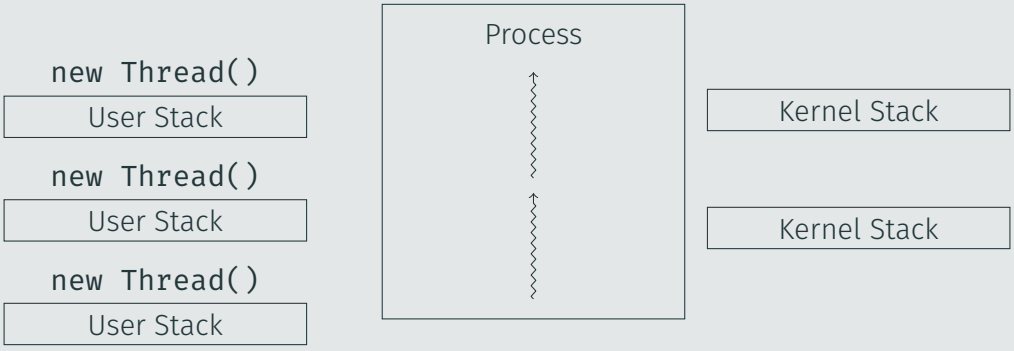

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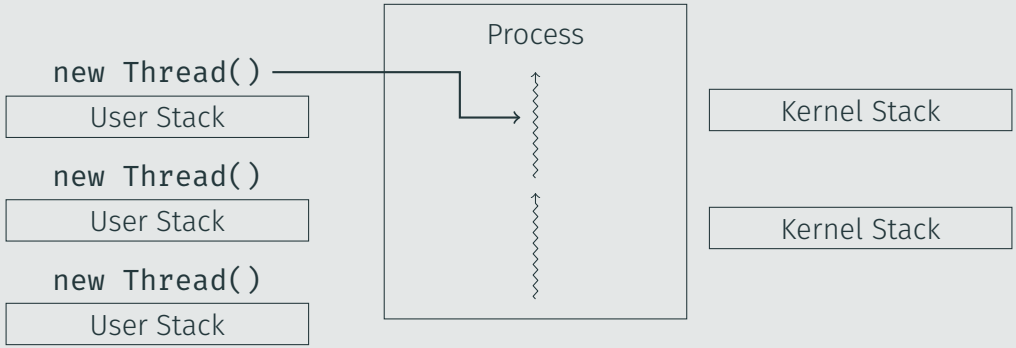

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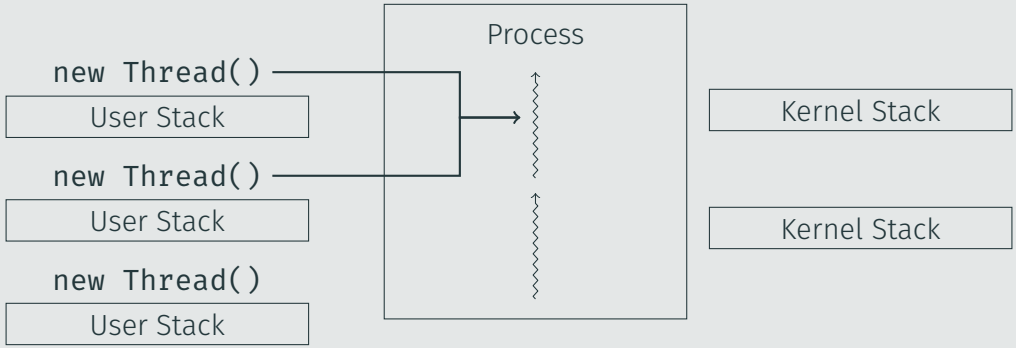

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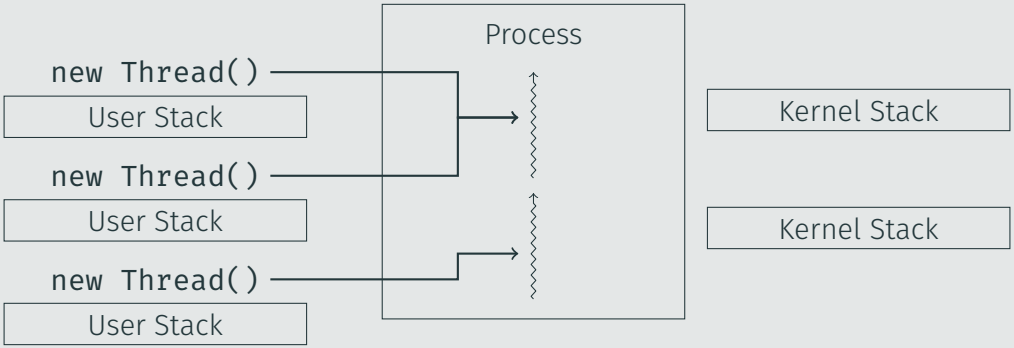

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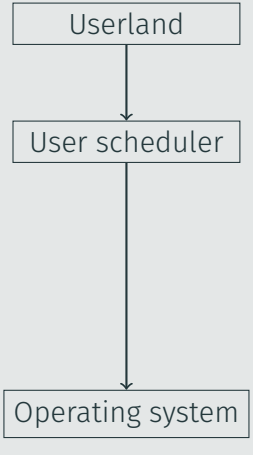

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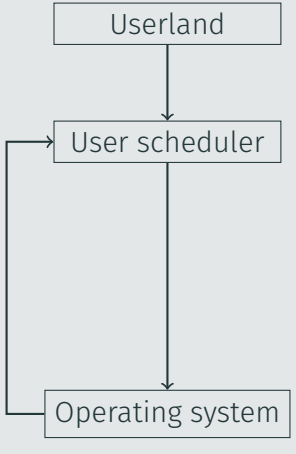

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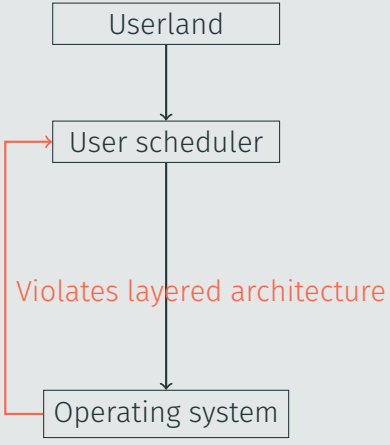

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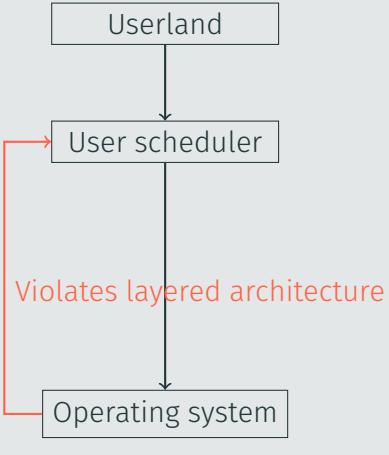

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- Involuntary:
  - interrupts, exceptions, syscalls

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  You can not execute syscalls directly, but need to call library methods!
  Suspension points can be inserted there.

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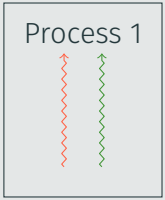
- The same or higher I/O throughput if on an abstracted platform

Should a fork do this?



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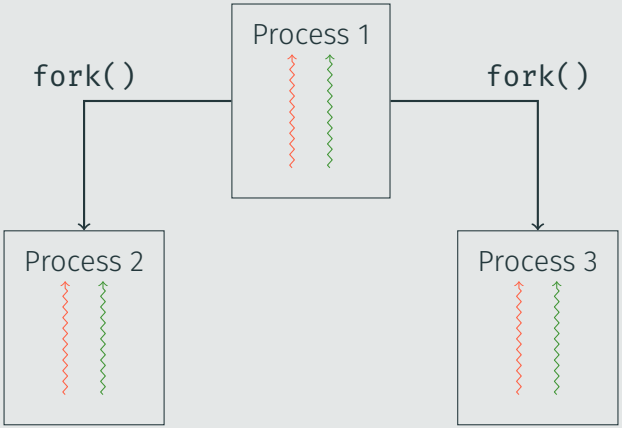

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Summary

`fork` is not as simple as it once was. Is it still a good abstraction?

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- ...

Stackframes

Stackframes

Let's look at some code

```
1 int foo(int a, int b) {
2   int local = a + b;
3   int anotherLocal = 'a';
4   return local + anotherLocal;
5 }
```

Stackframes

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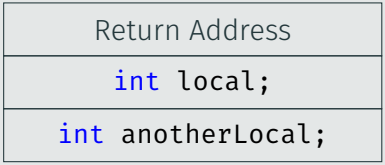

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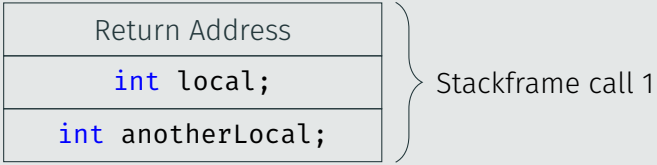

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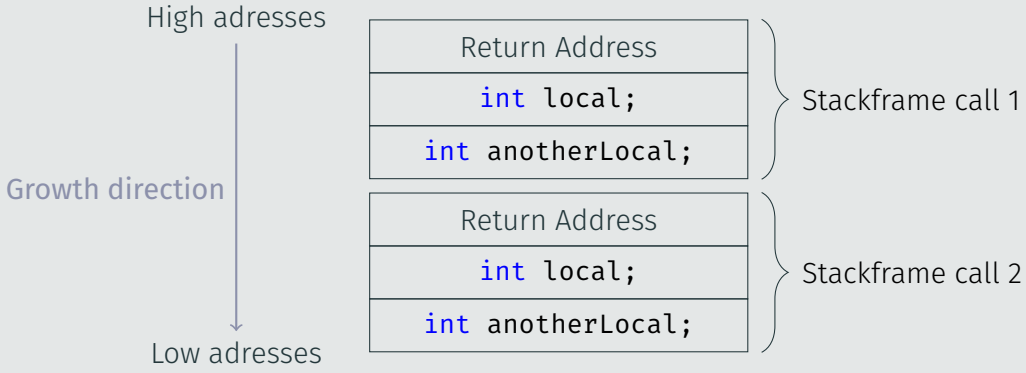

Stackframe

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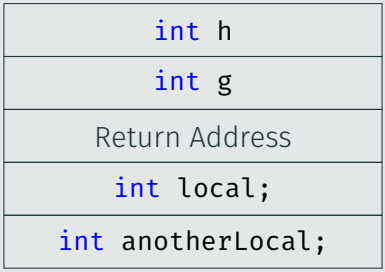

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$\Rightarrow$ Store the address at the start of the frame!

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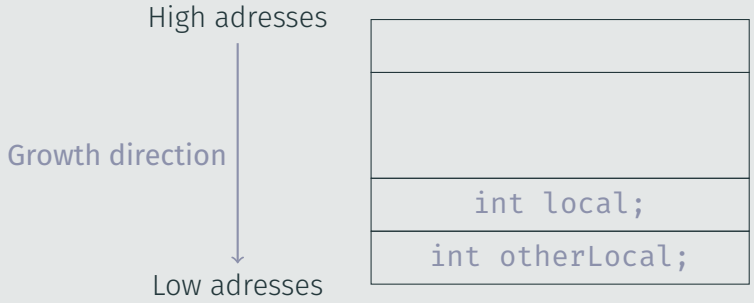
No! C has e.g. *variable-length arrays (VLA)*: `new int[someVariable]`.

⇒ Store the address at the start of the frame! Enter: `rbp`, the base pointer.

Base pointer and the function (Pro|Epi)log



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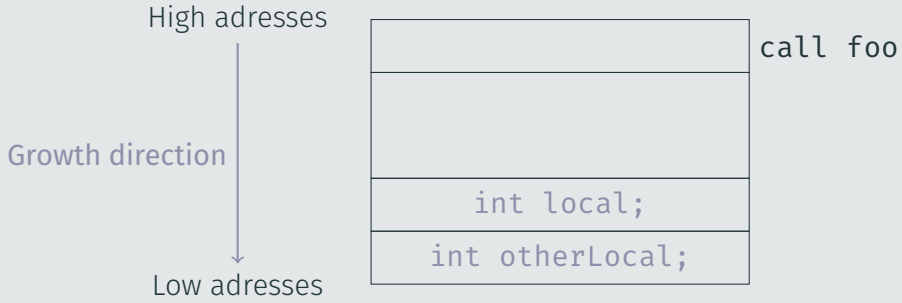

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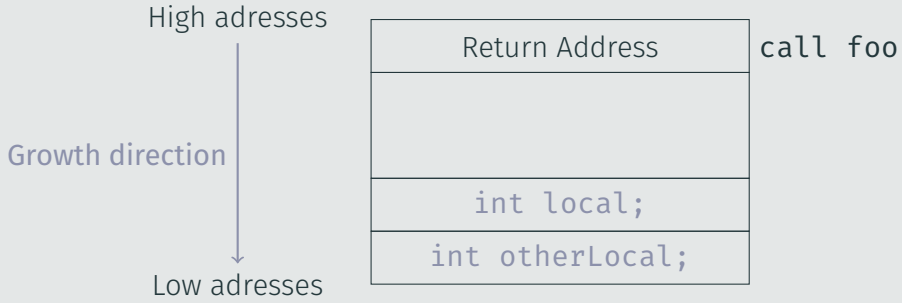

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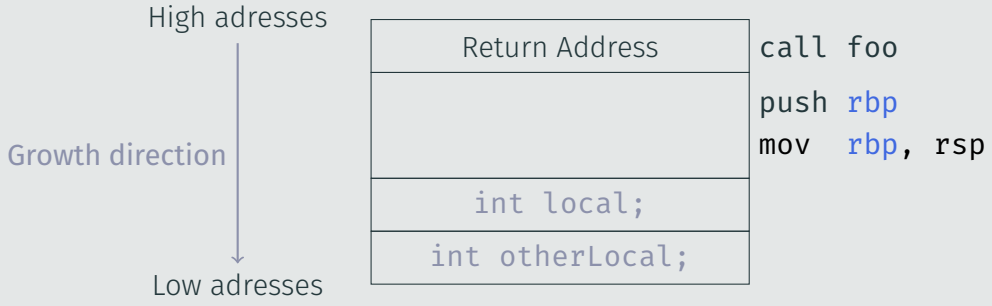

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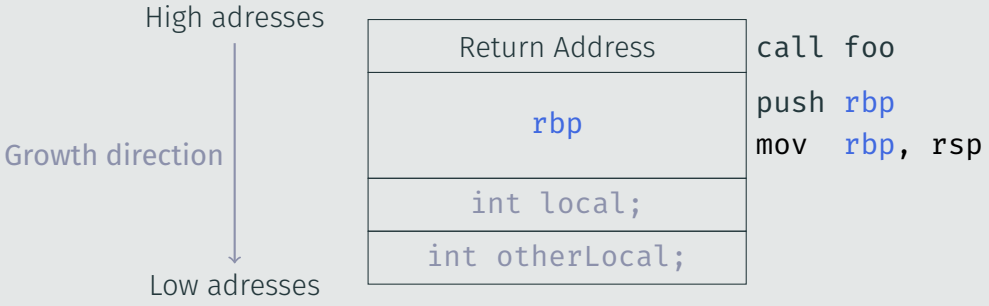

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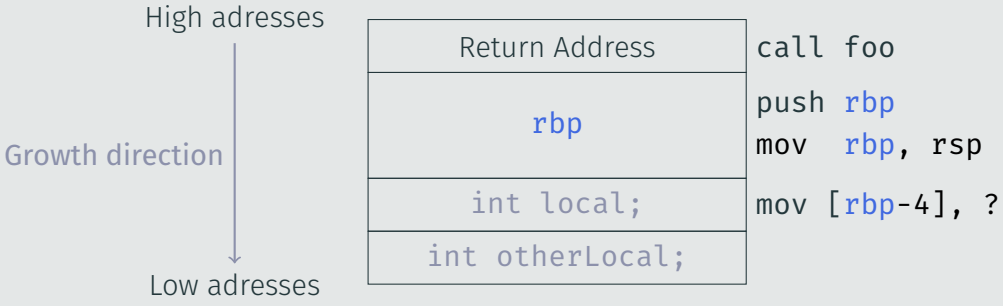

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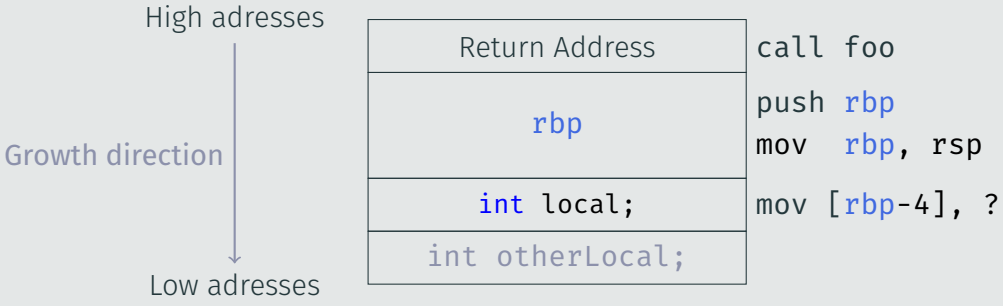

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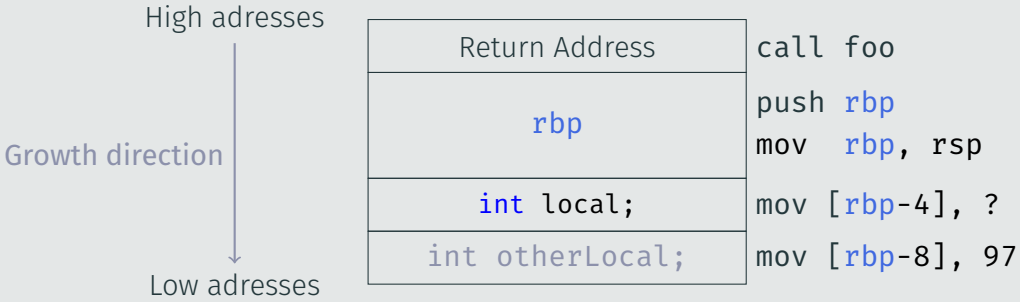

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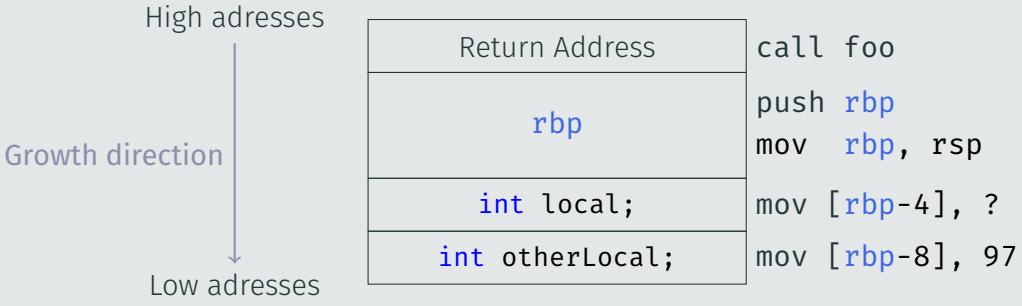

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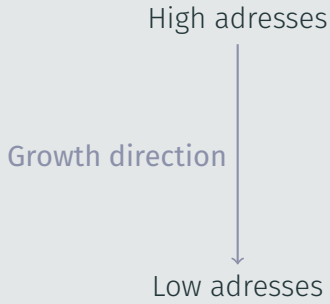

Return Address	`call foo`
`rbp`	`push rbp` `mov rbp, rsp`
`int local;`	`mov [rbp-4], ?`
`int otherLocal;`	`mov [rbp-8], 97`
	`mov rsp, rbp`

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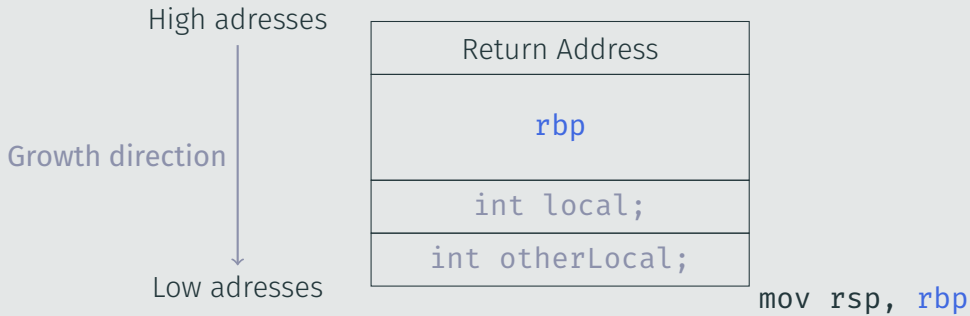

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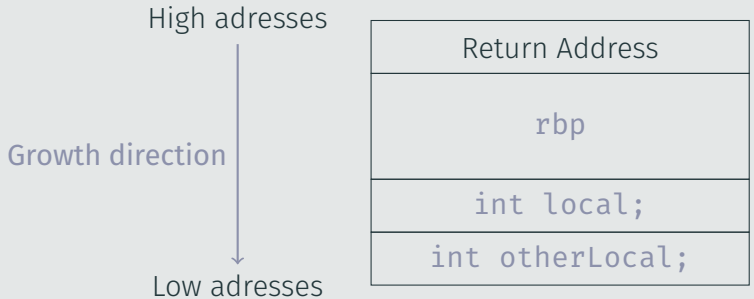


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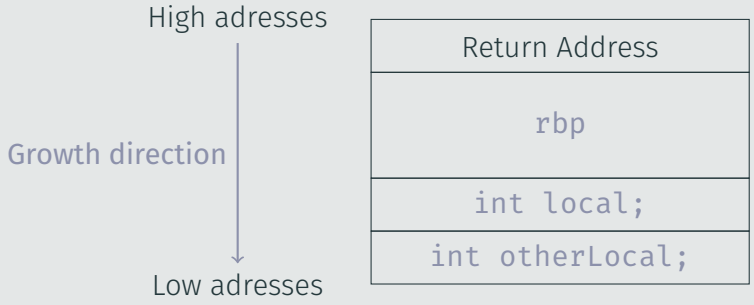


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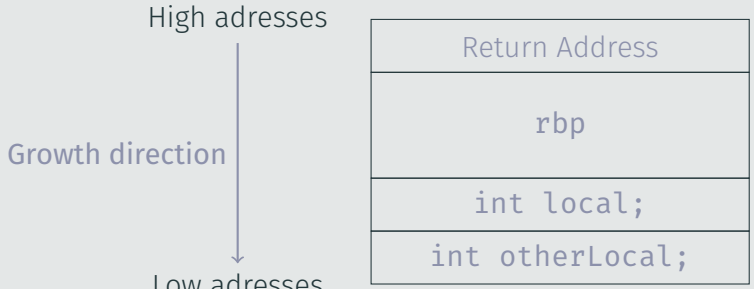


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Segmentation

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Where have you seen that word before while sadly staring at your screen?

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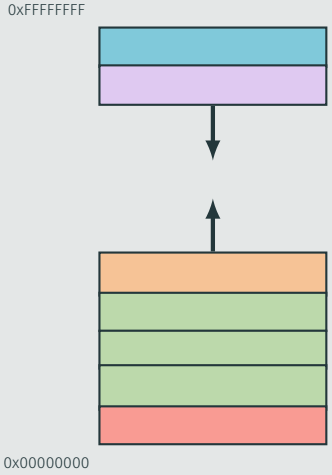
```
> Segmentation fault (core dumped)
```

Segmentation

A few example segments



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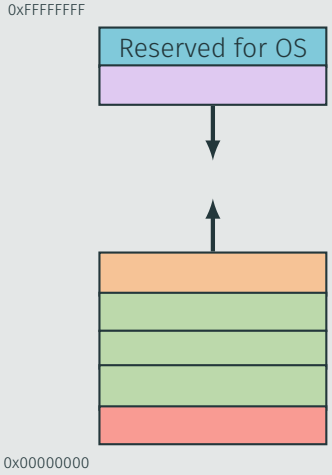

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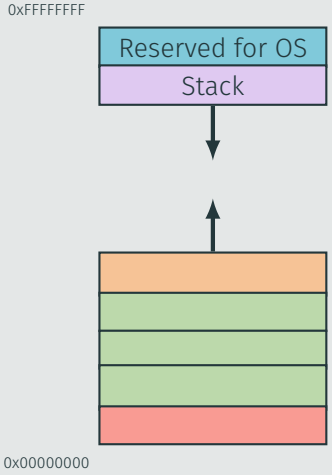

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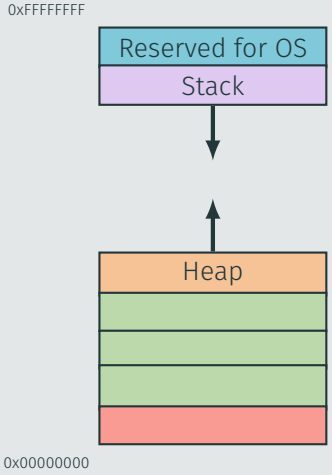

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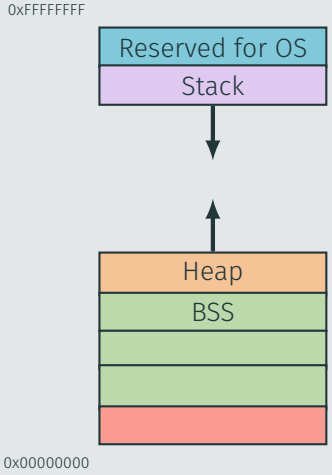

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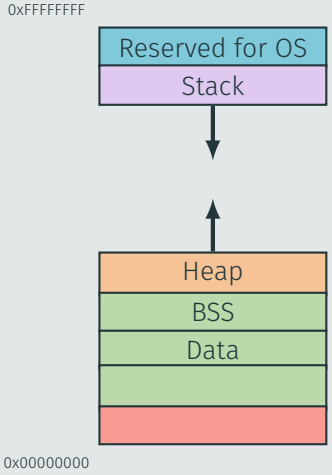

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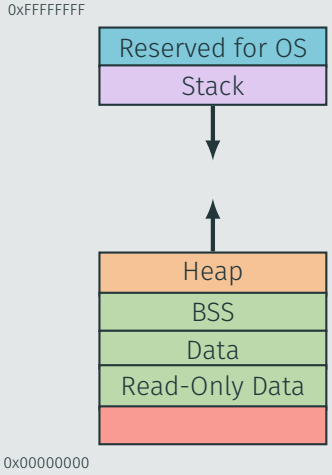

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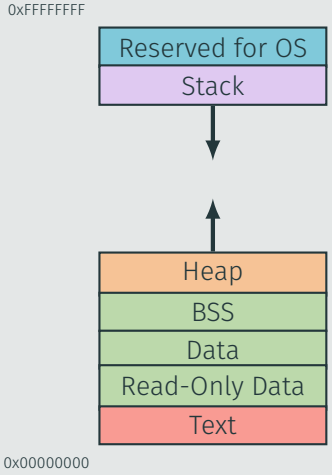

A Virtual Address

What does it look like?

42	0xCAFE

Segment Number	Base	Limit
...	...	...
42	0xB105	0xF00D
...	...	...

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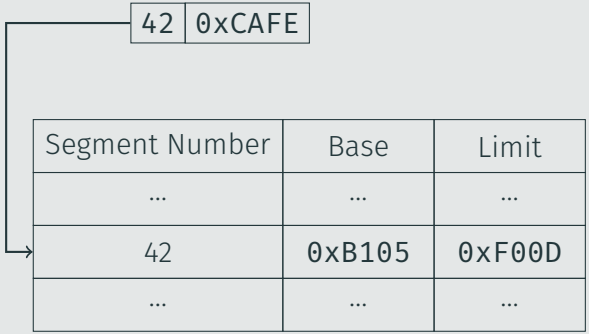

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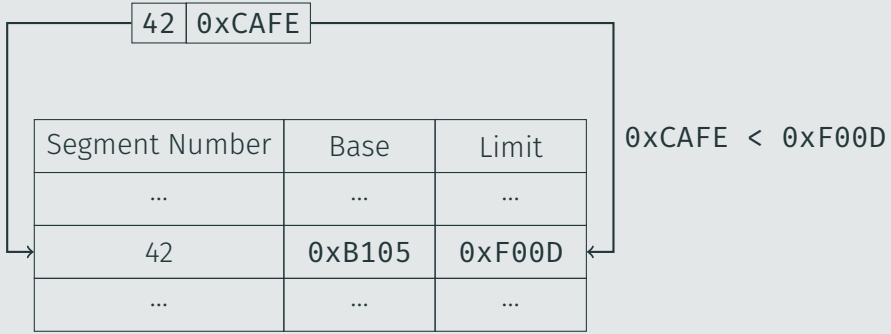

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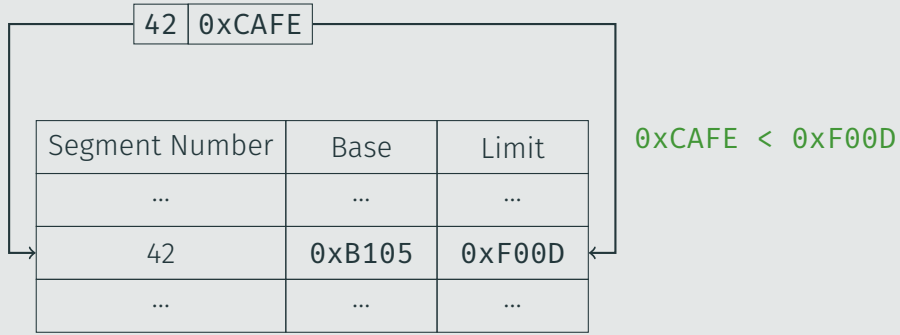

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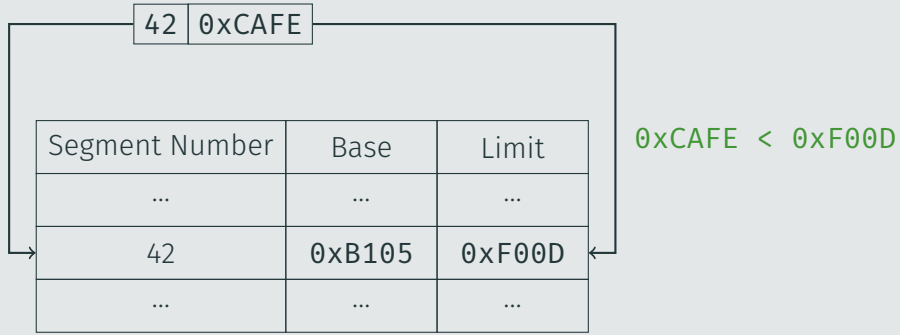


```
0xB105 + 0xCAFE = 0x17C03
```

And let's try it

Segments

Segment Number	Base	Limit
0	0xdead	0x00ef
1	0xf154	0x013a
2	0x0000	0x0000
3	0x0000	0x3fff

Your task

Virtual Address	Segment Number	Offset	Valid?	Physical Address
	3	0x3999		
0x2020				
		0x0204	yes	
			yes	0xf15f

And let's try it

Solution

Virtual Address	Segment Number	Offset	Valid?	Physical Address
`0xf999`	3	`0x3999`	yes	`0x3999`
`0x2020`	0	`0x2020`	no	Offset outside limit
`0xc204`	3	`0x0204`	yes	`0x0204`
`0x400b`	1	`0x000b`	yes	`0xf15f`

Memory Management Basics

Physical And Virtual Addresses

And once again: What is the difference?

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- *All program addresses are virtual*
- Mapped to *physical* addresses as needed by the memory management unit

Fragmentation

What is *internal* fragmentation?

Fragmentation

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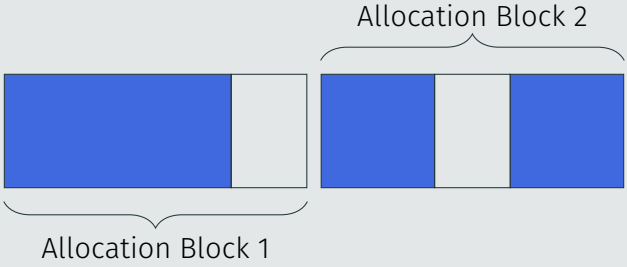
Internal, i.e. *within* a block

Fragmentation

What is *internal* fragmentation?



Internal, i.e. *within* a block

Fragmentation

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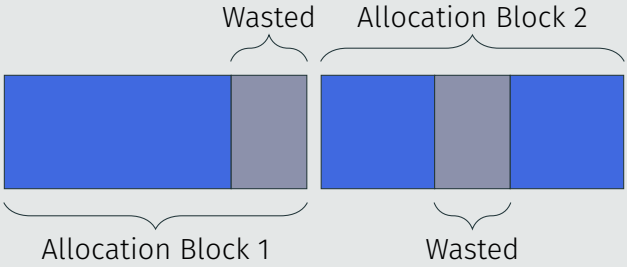

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Fragmentation

What is *external* fragmentation?

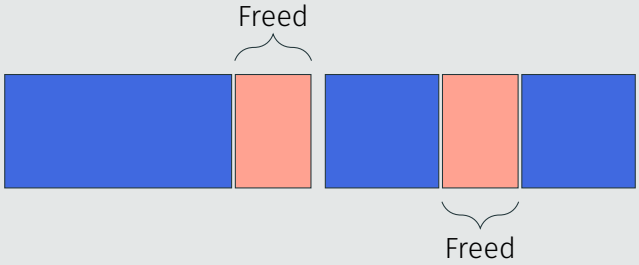
Fragmentation

What is *external* fragmentation?

External, i.e. due to *external factors* (different time-to-free)

Fragmentation

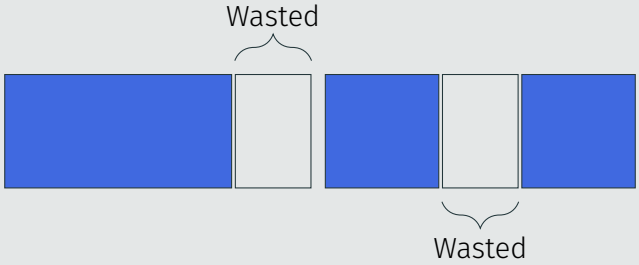
What is *external* fragmentation?



External, i.e. due to *external factors* (different time-to-free)

Fragmentation

What is *external* fragmentation?



External, i.e. due to *external factors* (different time-to-free)

Fragmentation

Can you have *both* types at the same time?

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- Allocate in *chunks* by e.g. rounding up to 2^x

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Fragmentation

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Yes!

- Allocate in *chunks* by e.g. rounding up to 2^x
- Have different lifetimes

$\Rightarrow$ Wasteful allocations scattered throughout RAM

Fragmentation

What do we do now? This sounds bad!

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- Works just fine in languages with indirections (e.g. garbage collection)
- Also works for segments in physical memory! How? Update base addresses in MMU

Memory allocation policies

Some common strategies

Which strategies for finding free blocks do you know?

First Fit,

Some common strategies

Which strategies for finding free blocks do you know?

First Fit, Best Fit,

Some common strategies

Which strategies for finding free blocks do you know?

First Fit, Best Fit, Worst Fit

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First Fit, Best Fit, Worst Fit

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Worst Fit

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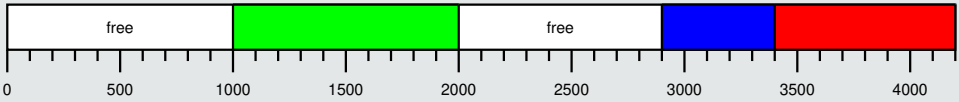
Let's try them

Best fit

Allocate 500, 1200, and 200, fail if not possible.



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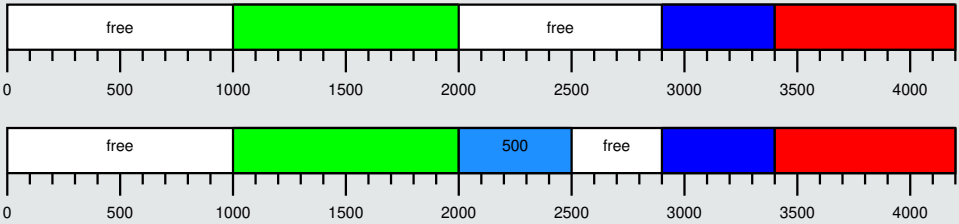
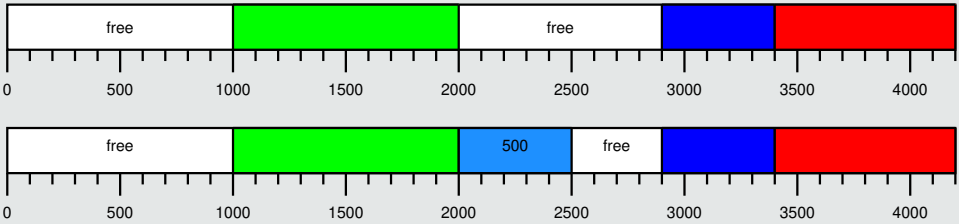


And compact it to fit the next one!

Let's try them

Best fit

Allocate 500, 1200, and 200, fail if not possible.



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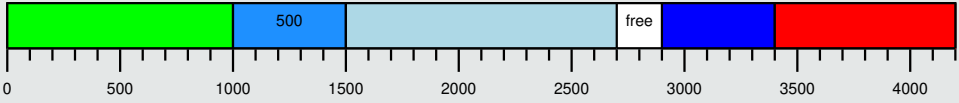
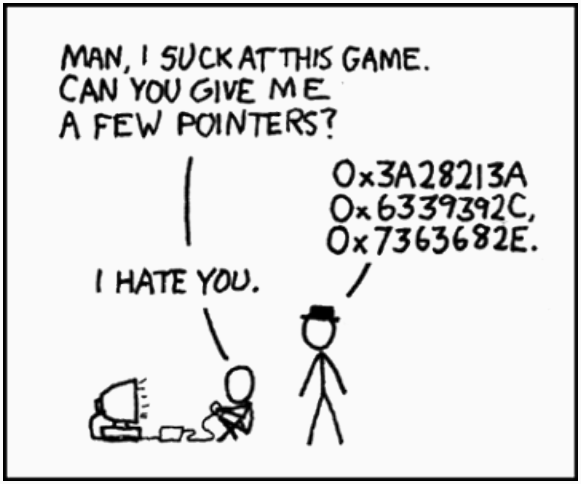


Ende



XKCD 138 - Pointers

F R A G E N?

Bis nächste Woche :)