

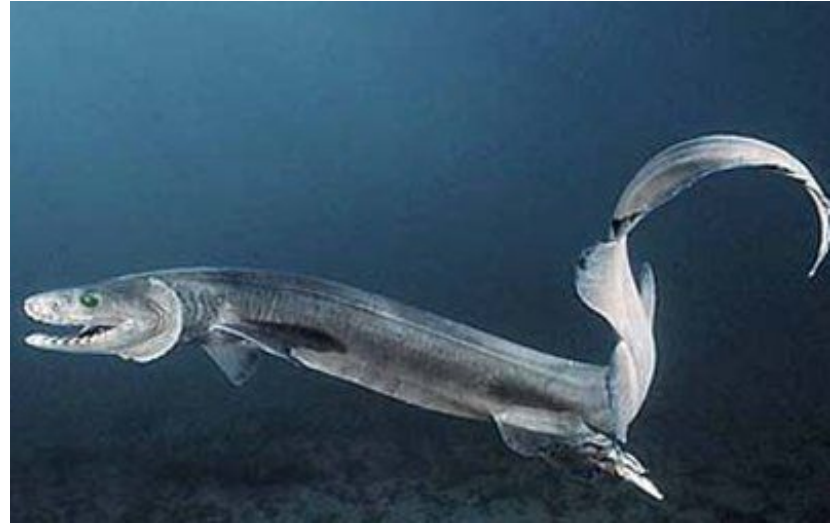
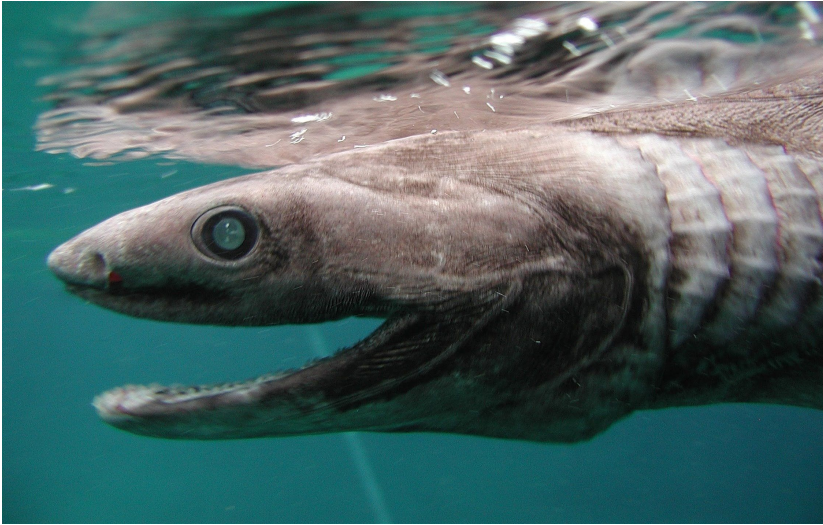


Thread through threads

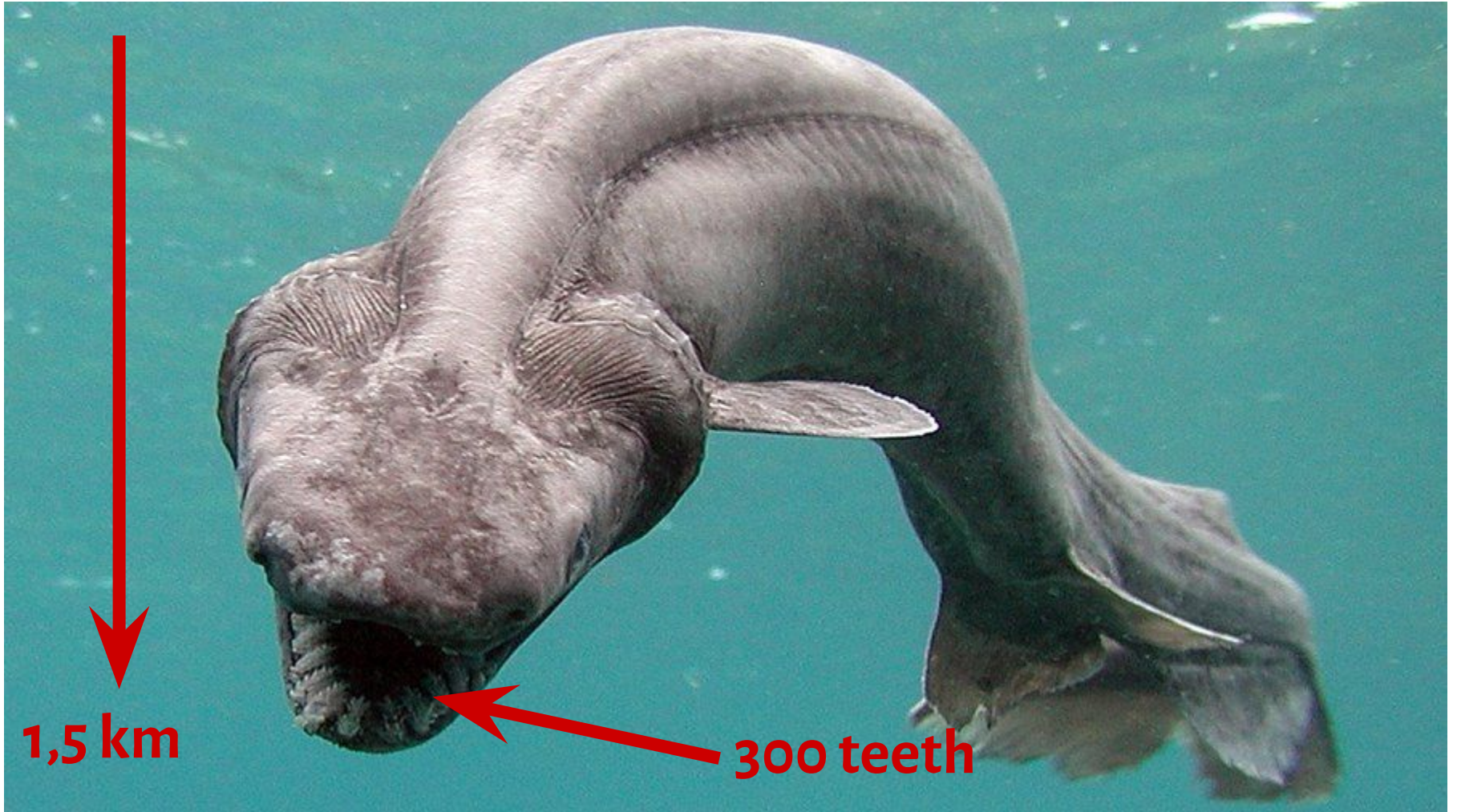
Frilled Shark



Frilled Shark



Frilled Shark



Frilled Shark



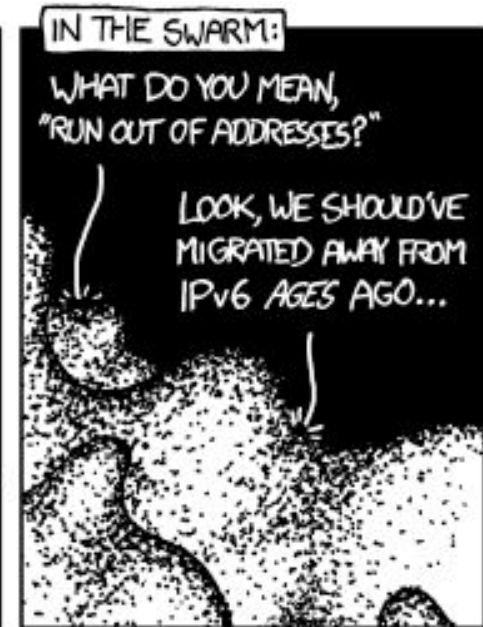
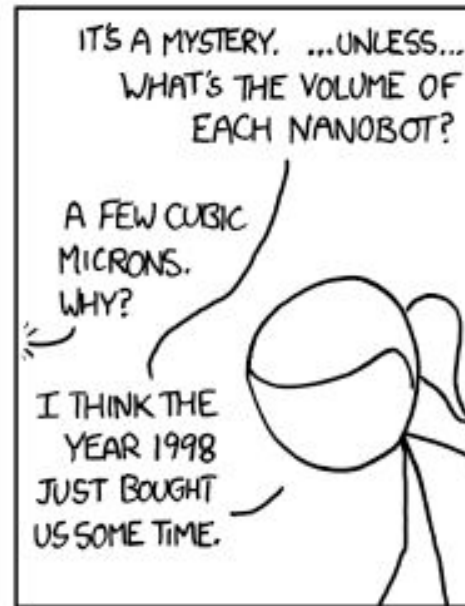
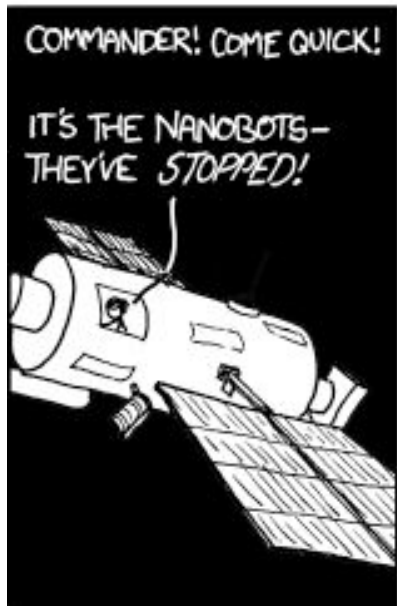
- ★ preys of size of half of their body
- ★ pregnancy of 3,5 years
- ★ no changes for 80 million years

Assignment #1

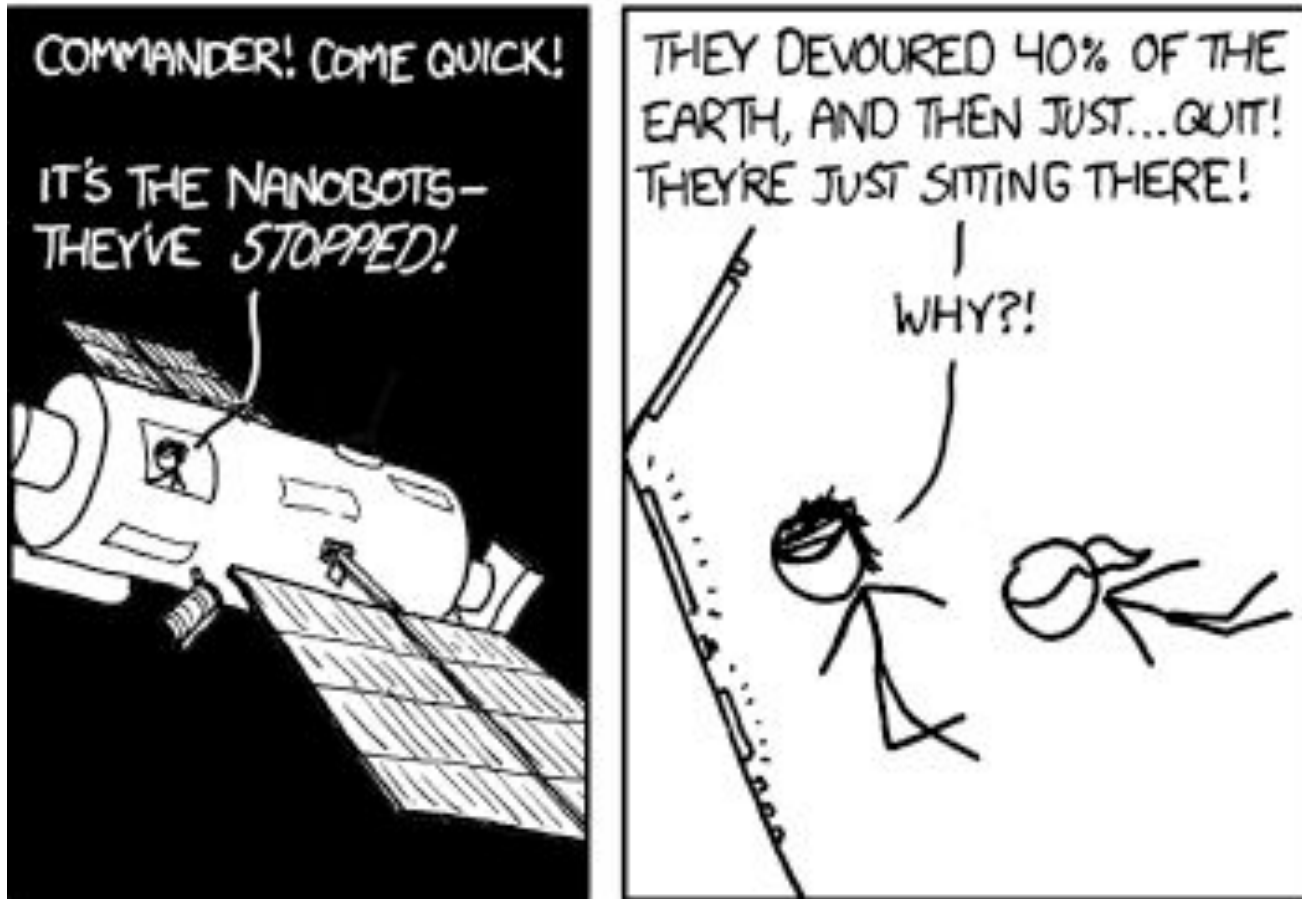
Make sure that:

- ★ uninitialized data are kept in .bss section
 - ★ input bytes are buffered
- ★ correctness of permutations is verified immediately

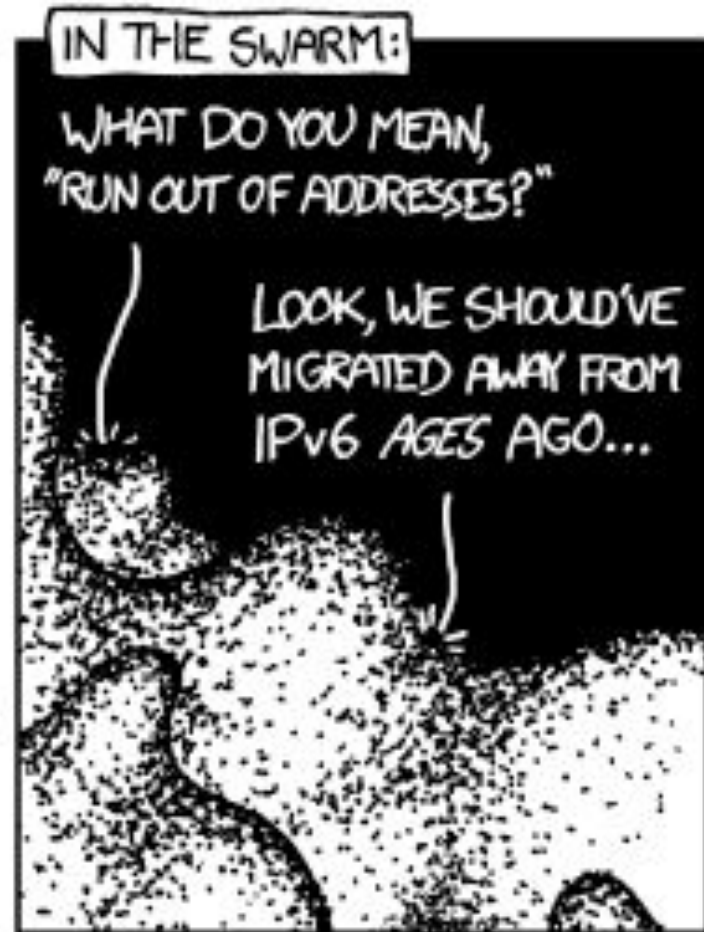
Is 2^{64} enough?



Is 2^{64} enough?



Is 2^{64} enough?





★ **Concepts**

★ Assembly instructions

★ Assignment #2

A concept of a *process*

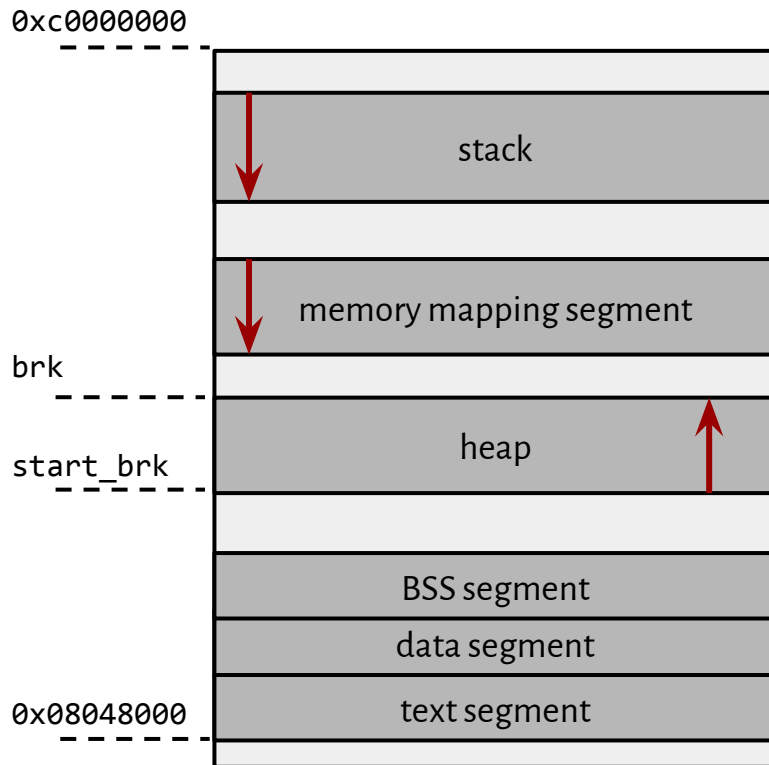
*A **computer program** is a passive collection of instructions, while a **process** is the actual execution of those instructions.*

A concept of a **process**

a group of related resources

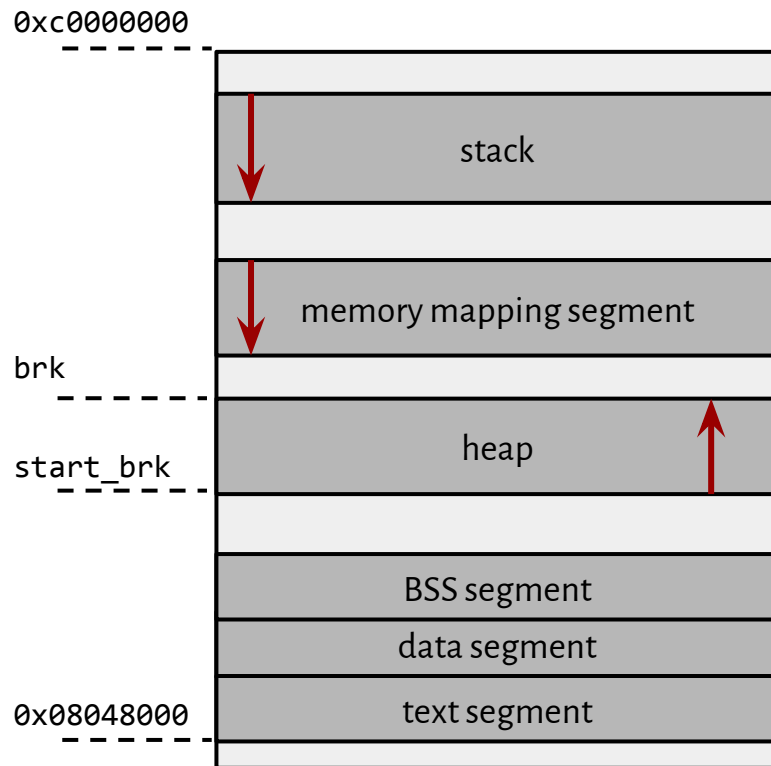
A concept of a **process**

a group of related resources



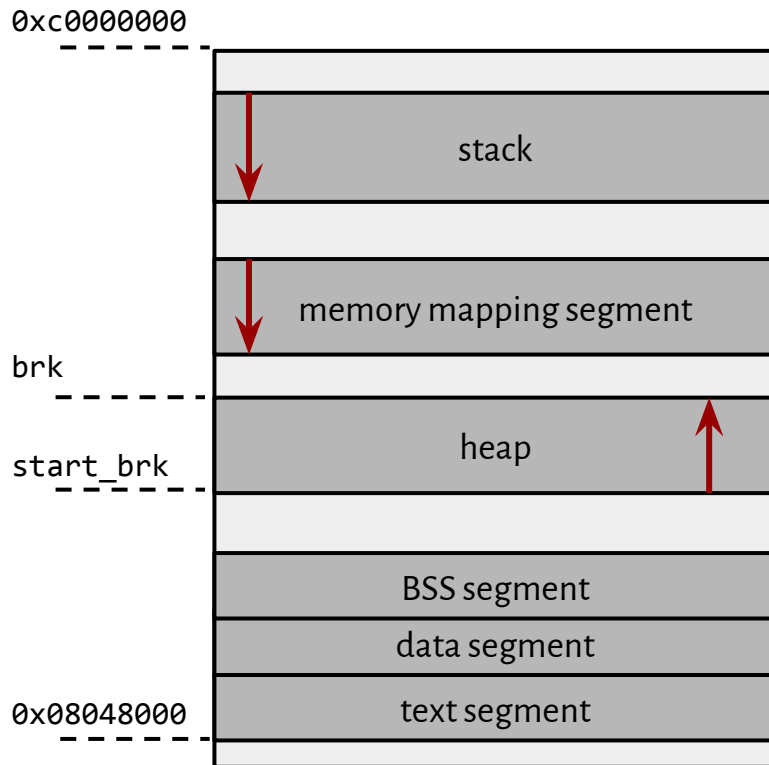
A concept of a **process**

a group of related resources



A concept of a **process**

a group of related resources

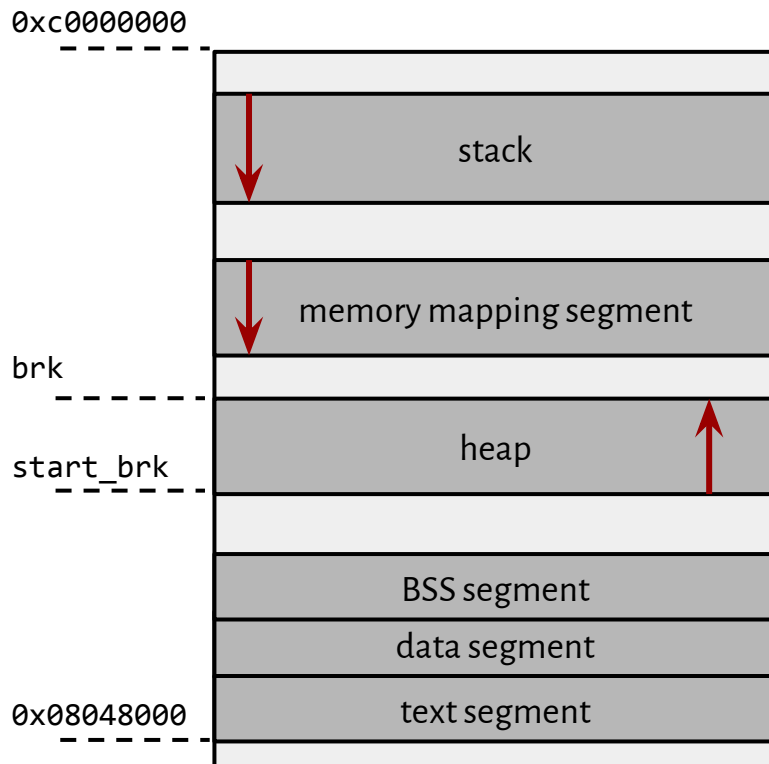


A concept of a **thread**

execution of instructions within a process

A concept of a **thread**

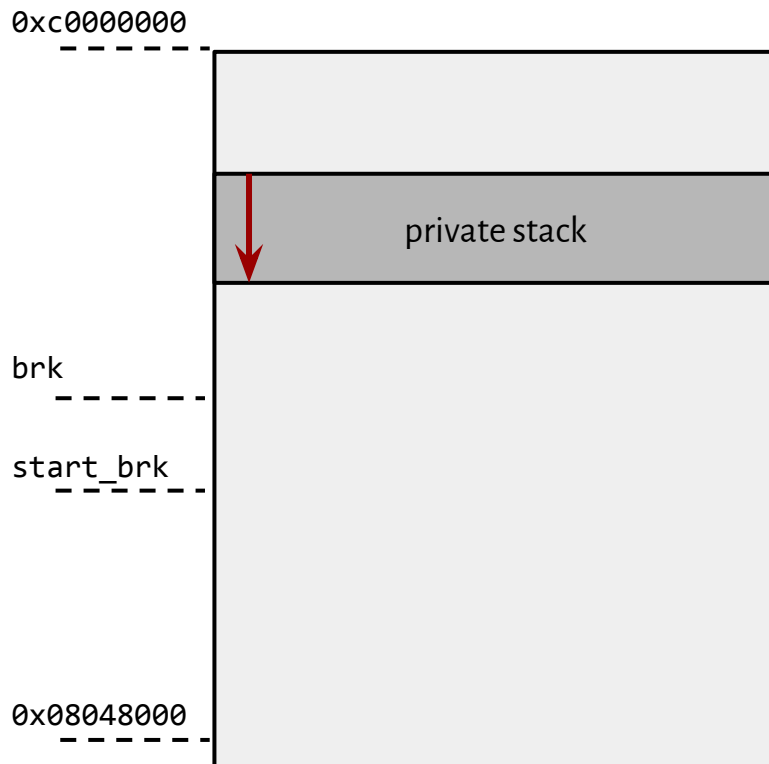
execution of instructions within a process



shared resources

A concept of a **thread**

execution of instructions within a process



private resources

Let's see!

[simple.c](#)

```
$ gcc -pthread simple.c -o simple; ./simple
```

```
$ cat /proc/29298/maps
```

Let's see!

[simple.c](#)

```
$ gcc -pthread simple.c -o simple; ./simple
```

```
$ cat /proc/29298/maps
```

```
00400000-00401000 r-xp 00000000 08:02 43010148 /home/inga/SO/3/simple
00600000-00601000 r--p 00000000 08:02 43010148 /home/inga/SO/3/simple
00601000-00602000 rw-p 00001000 08:02 43010148 /home/inga/SO/3/simple
019d0000-019f1000 rw-p 00000000 00:00 0 [heap]
7ff49b60f000-7ff49b610000 ---p 00000000 00:00 0
7ff49b610000-7ff49be10000 rw-p 00000000 00:00 0
[...]
7ff49c61d000-7ff49c61e000 rw-p 00000000 00:00 0
7ffffb6c9000-7ffffb6ea000 rw-p 00000000 00:00 0 [stack]
7ffffb779000-7ffffb77b000 r--p 00000000 00:00 0 [vvar]
7ffffb77b000-7ffffb77d000 r-xp 00000000 00:00 0 [vdso]
ffffffffffff600000-ffffffffffff601000 r-xp 00000000 00:00 0 [vsyscall]
```


My adventure with htop

```
1 [|||
2 [||
3 [|||
4 [|||||
Mem[|||||] 2.56G/3.75G
Swp[|||] 68.4M/3.89G

1.3%] Tasks: 120, 380 thr; 1 running
0.7%] Load average: 1.36 0.63 0.39
1.3%] Uptime: 08:11:41
4.6%]

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
29337 inga 20 0 27920 4404 3128 R 2.0 0.1 0:23.89 htop
29298 inga 20 0 14716 756 672 T 0.0 0.0 0:03.51 ./simple
29299 inga 20 0 14716 756 672 T 0.0 0.0 0:01.75 ./simple
3319 inga 20 0 14872 1756 1600 S 0.0 0.0 0:00.00 gnome-pty-helper
3310 inga 20 0 770M 66444 36444 S 0.0 1.7 0:00.00 /usr/bin/python /usr/bin/terminator
3309 inga 20 0 770M 66444 36444 S 0.0 1.7 0:02.88 /usr/bin/python /usr/bin/terminator
3308 inga 20 0 770M 66444 36444 S 0.0 1.7 0:00.00 /usr/bin/python /usr/bin/terminator
2543 inga 20 0 62392 5500 5048 S 0.0 0.1 0:00.03 /usr/lib/x86_64-linux-gnu/gconf/gconfd-2
2488 inga 20 0 2692M 476M 129M S 3.3 12.4 21:01.13 /usr/lib/firefox/firefox
29963 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29925 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.42 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29930 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29929 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29928 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29927 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29918 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29915 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29466 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.02 /usr/lib/firefox/firefox
29062 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.05 /usr/lib/firefox/firefox
27775 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
25668 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
24943 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
23104 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.26 /usr/lib/firefox/firefox
18465 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
18338 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
16848 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
11881 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
8890 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
4281 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2868 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2651 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2650 inga 20 0 3069M 1176M 111M S 1.3 30.6 41:20.78 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /usr/l
4321 inga 21 1 3069M 1176M 111M S 0.0 30.6 0:16.10 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2688 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2685 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.64 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2675 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2674 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2673 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us

F1 Help F2 Setup F3 Search F4 Filter F5 Sorted F6 Collap F7 Nice F8 Nice F9 Kill F10 Quit
```

My adventure with htop

```
1 [|||
2 [||
3 [|||
4 [|||||
Mem[|||||||||||||||||||||||||||||||||||||] 2.56G/3.75G
Swp[|||] 68.4M/3.89G

1.3%] Tasks: 120, 380 thr; 1 running
0.7%] Load average: 1.36 0.63 0.39
1.3%] Uptime: 08:11:41
4.6%]

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
29298 inga 20 0 14716 756 672 T 0.0 0.0 0:03.51 htop
29299 inga 20 0 14716 756 672 T 0.0 0.0 0:01.75 ./simple
3319 inga 20 0 14872 1756 1600 S 0.0 0.0 0:00.00 ./simple
3310 inga 20 0 770M 66444 36444 S 0.0 1.7 0:00.00 gnome-pty-helper
3309 inga 20 0 770M 66444 36444 S 0.0 1.7 0:02.88 /usr/bin/python /usr/bin/terminator
3308 inga 20 0 770M 66444 36444 S 0.0 1.7 0:00.00 /usr/bin/python /usr/bin/terminator
2543 inga 20 0 62392 5500 5048 S 0.0 0.1 0:00.03 /usr/bin/python /usr/bin/terminator
2488 inga 20 0 2692M 476M 129M S 3.3 12.4 21:01.13 /usr/lib/x86_64-linux-gnu/gconf/gconfd-2
29963 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29925 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.42 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29930 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29929 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29928 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29927 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29918 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29915 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29466 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.02 /usr/lib/firefox/firefox
29062 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.05 /usr/lib/firefox/firefox
27775 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
25668 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
24943 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
23104 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.26 /usr/lib/firefox/firefox
18465 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
18338 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
16848 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
11881 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
8890 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
4281 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2868 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2651 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2650 inga 20 0 3069M 1176M 111M S 1.3 30.6 41:20.78 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /usr/l
4321 inga 21 1 3069M 1176M 111M S 0.0 30.6 0:16.10 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2688 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2685 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.64 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2675 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2674 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2673 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us

F1 Help F2 Setup F3 Search F4 Filter F5 Sorted F6 Collap F7 Nice F8 Nice F9 Kill F10 Quit
```


My adventure with htop

```
1  [|||] 1.3%] Tasks: 120, 380 thr; 1 running
2  [||] 0.7%] Load average: 1.36 0.63 0.39
3  [|||] 1.3%] Uptime: 08:11:41
4  [||||] 4.6%]
Mem[|||||] 2.56G/3.75G]
Swp[||] 68.4M/3.89G]
```

PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
20337	inga	20	0	27928	4484	3128	R	2.0	0.1	0:23.89	htop
29298	inga	20	0	14716	756	672	T	0.0	0.0	0:03.51	./simple
29299	inga	20	0	14716	756	672	T	0.0	0.0	0:01.75	./simple
3319	inga	20	0	14872	1756	1600	S	0.0	0.0	0:00.00	gnome-pty-helper
3310	inga	20	0	770M	66444	36444	S	0.0	1.7	0:00.00	/usr/bin/python /usr/bin/terminator
3309	inga	20	0	770M	66444	36444	S	0.0	1.7	0:02.88	/usr/bin/python /usr/bin/terminator
3308	inga	20	0	770M	66444	36444	S	0.0	1.7	0:00.00	/usr/bin/python /usr/bin/terminator
2543	inga	20	0	62392	5500	5048	S	0.0	0.1	0:00.03	/usr/lib/x86_64-linux-gnu/gconf/gconfd-2
2488	inga	20	0	2692M	476M	129M	S	3.3	12.4	1:01.13	/usr/lib/firefox/firefox

29298	inga	20	0	14716	756	672	T	0.0	0.0	0:03.51	./simple
29299	inga	20	0	14716	756	672	T	0.0	0.0	0:01.75	./simple

Why PIDs are different?

What are threads in Linux?

processes that share certain resources

What are threads in Linux?

***tasks** that share certain resources*

What are threads in Linux?

tasks that share certain resources

```
$ strace ./simple
```

```
clone(child_stack=0x7f18a5423ff0,  
flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETT  
LS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID, parent_tidptr=0x7f18a54249d0,  
tls=0x7f18a5424700, child_tidptr=0x7f18a54249d0) = 29299  
child thread pid is 29299
```

What are threads in Linux?

tasks that share certain resources

```
$ strace ./simple
```

```
clone(child_stack=0x7f18a5423ff0,  
flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETT  
LS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARTID, parent_tidptr=0x7f18a54249d0,  
tls=0x7f18a5424700, child_tidptr=0x7f18a54249d0) = 29299  
child thread pid is 29299
```

```
$ cat /proc/29298/maps
```

```
$ cat /proc/29299/maps
```

What are threads in Linux?

processes that share certain resources

```
$ strace ./simple
```

```
clone(child_stack=0x7f18a5423ff0,  
flags=CLONE_VM|CLONE_FS|CLONE_FILES|CLONE_SIGHAND|CLONE_THREAD|CLONE_SYSVSEM|CLONE_SETT  
LS|CLONE_PARENT_SETTID|CLONE_CHILD_CLEARPID, parent_tidptr=0x7f18a54249d0,  
tls=0x7f18a5424700, child_tidptr=0x7f18a54249d0) = 29299  
child thread pid is 29299
```

```
$ cat /proc/29298/maps
```

```
$ cat /proc/29299/maps
```

```
$ ls -s /proc/29299
```

My adventure with htop

```
 1 [|||] 1.3%] Tasks: 120, 380 thr; 1 running
 2 [||] 0.7%] Load average: 1.36 0.63 0.39
 3 [|||] 1.3%] Uptime: 08:11:41
 4 [||||] 4.6%]
Mem[|||||] 2.56G/3.75G]
Swp[||] 68.4M/3.89G]

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
29337 inga 20 0 27920 4404 3128 R 2.0 0.1 0:23.89 htop
29298 inga 20 0 14716 756 672 T 0.0 0.0 0:03.51 ./simple
29299 inga 20 0 14716 756 672 T 0.0 0.0 0:01.75 ./simple
3319 inga 20 0 14872 1756 1600 S 0.0 0.0 0:00.00 gnome-pty-helper
3310 inga 20 0 770M 66444 36444 S 0.0 1.7 0:00.00 /usr/bin/python /usr/bin/terminator
3309 inga 20 0 770M 66444 36444 S 0.0 1.7 0:02.88 /usr/bin/python /usr/bin/terminator
3308 inga 20 0 770M 66444 36444 S 0.0 1.7 0:00.00 /usr/bin/python /usr/bin/terminator
2543 inga 20 0 62392 5500 5048 S 0.0 0.1 0:00.03 /usr/lib/x86_64-linux-gnu/gconf/gconfd-2
2488 inga 20 0 2692M 476M 129M S 3.3 12.4 21:01.13 /usr/lib/firefox/firefox
29963 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29925 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.42 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29930 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29929 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29928 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29927 inga 20 0 655M 63748 50672 S 0.0 1.6 0:00.00 /usr/lib/firefox/plugin-container /usr/lib/flashplugin-installer/libflashplayer.so
29918 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29915 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
29466 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.02 /usr/lib/firefox/firefox
29062 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.05 /usr/lib/firefox/firefox
27775 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
25668 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
24943 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
23104 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.26 /usr/lib/firefox/firefox
18465 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
18338 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
16848 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
11881 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
8890 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
4281 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2868 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2651 inga 20 0 2692M 476M 129M S 0.0 12.4 0:00.00 /usr/lib/firefox/firefox
2650 inga 20 0 3069M 1176M 111M S 1.3 30.6 41:20.78 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /usr/l
4321 inga 21 1 3069M 1176M 111M S 0.0 30.6 0:16.10 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2688 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2685 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.64 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2675 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2674 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us
2673 inga 20 0 3069M 1176M 111M S 0.0 30.6 0:00.00 /usr/lib/firefox/plugin-container -greomni /usr/lib/firefox/omni.ja -appomni /us

F1 Help F2 Setup F3 Search F4 Filter F5 Sorted F6 Collap F7 Nice F8 Nice F9 Kill F10 Quit
```



★ Concepts

★ **Assembly instructions**

★ Assignment #2

Assembly - atomic instructions

**lock **

<instr>

Assembly - atomic instructions

**lock **

<instr>

xchg **dst**, **src**

dst' = **src**

src' = **dst**

Assembly - atomic instructions

**lock **
<instr>

xchg **dst**, **src**

dst' = **src**
src' = **dst**

cmpxchg **dst**, **src**

if **rax** == **dst**:
 dst' = **src**
else:
 rax' = **dst**

Scenario

```
void *inc_thread(void *);
```

```
typedef struct {  
    int *value;  
    int count;  
} thread_data_t;
```

```
$ cd /home/students/inf/PUBLIC/S0/scenariusze/3
```

```
$ make
```

```
$ ./inc_thread_test_naive 3 1000000
```

Scenario

```
global inc_thread
```

lock

```
section .text
```

```
align 8
```

```
inc_thread:
```

```
    mov     rsi, [rdi]      ; value  
    mov     ecx, [rdi + 8] ; count  
    jmp     end
```

```
count_loop:
```

```
    inc     dword [rsi]    ; ++*value
```

```
count_test:
```

```
    sub     ecx, 1         ; --count  
    jge    loop           ; skok, gdy count >= 0  
    xor     eax, eax      ; return NULL  
    ret
```

Scenario

```
global inc_thread
```

```
section .text
```

```
align 8
```

```
inc_thread:
```

```
    mov     rsi, [rdi]      ; value  
    mov     ecx, [rdi + 8] ; count  
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    inc     dword [rsi]    ; ++*value
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```
count_test:
```

```
    sub     ecx, 1         ; --count  
    jge    loop           ; skok, gdy count >= 0  
    xor     eax, eax      ; return NULL  
    ret
```

lock

xchg

Spinlock

wait:

```
    if (spinlock == 0) {  
        spinlock = 1  
        go to critical_section  
        spinlock = 0  
    } else {  
        go to wait  
    }
```

critical_section:

...

Spinlock

```
wait:  
    if (spinlock == 0) {  
        spinlock = 1  
        go to critical_section  
        spinlock = 0  
    } else {  
        go to wait  
    }  
  
critical_section:  
...
```


Spinlock

```
wait:  
    if (spinlock == 0) {  
        spinlock = 1  
        go to critical_section  
        spinlock = 0  
    } else {  
        go to wait  
    }  
  
critical_section:  
...
```

Spinlock

```
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    if (spinlock == 0) {  
        spinlock = 1  
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        spinlock = 0  
    } else {  
        go to wait  
    }
```

```
critical_section:  
...
```

Spinlock

wait:

```
if (spinlock == 0) {  
    spinlock = 1  
    go to critical_section  
    spinlock = 0  
} else {  
    go to wait  
}
```

critical_section:

...

What does need to be atomic?

Spinlock

wait:

```
    if (spinlock == 0) {  
        spinlock = 1  
        go to critical_section  
        spinlock = 0  
    } else {  
        go to wait  
    }
```

} atomic

critical_section:

...

Scenario

```
global inc_thread
```

```
section .text
```

```
align 8
```

```
inc_thread:
```

```
    mov     rsi, [rdi]      ; value  
    mov     ecx, [rdi + 8] ; count  
    jmp     end
```

```
count_loop:
```

```
    inc     dword [rsi]    ; ++*value
```

```
count_test:
```

```
    sub     ecx, 1         ; --count  
    jge     loop          ; skok, gdy count >= 0  
    xor     eax, eax      ; return NULL  
    ret
```

lock

xchg

cmpxchg

Scenario

```
global inc_thread
```

```
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```

```
align 8
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    mov     rsi, [rdi]      ; value  
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count_test:
```

```
    sub     ecx, 1         ; --count  
    jge    loop          ; skok, gdy count >= 0  
    xor     eax, eax      ; return NULL  
    ret
```

lock

xchg

cmpxchg

bts, btr



- ★ Concepts
- ★ Assembly instructions
- ★ **Assignment #2**

Assignment #2

Solutions expected by **26 March** 2018, 8 p.m.

Put your solutions here:

<https://svn.mimuw.edu.pl/repos/SO/studenci/login/zadanie2>

If you want to consult your solution let me know before:

23 March 2018, 8 p.m.

Assignment #2

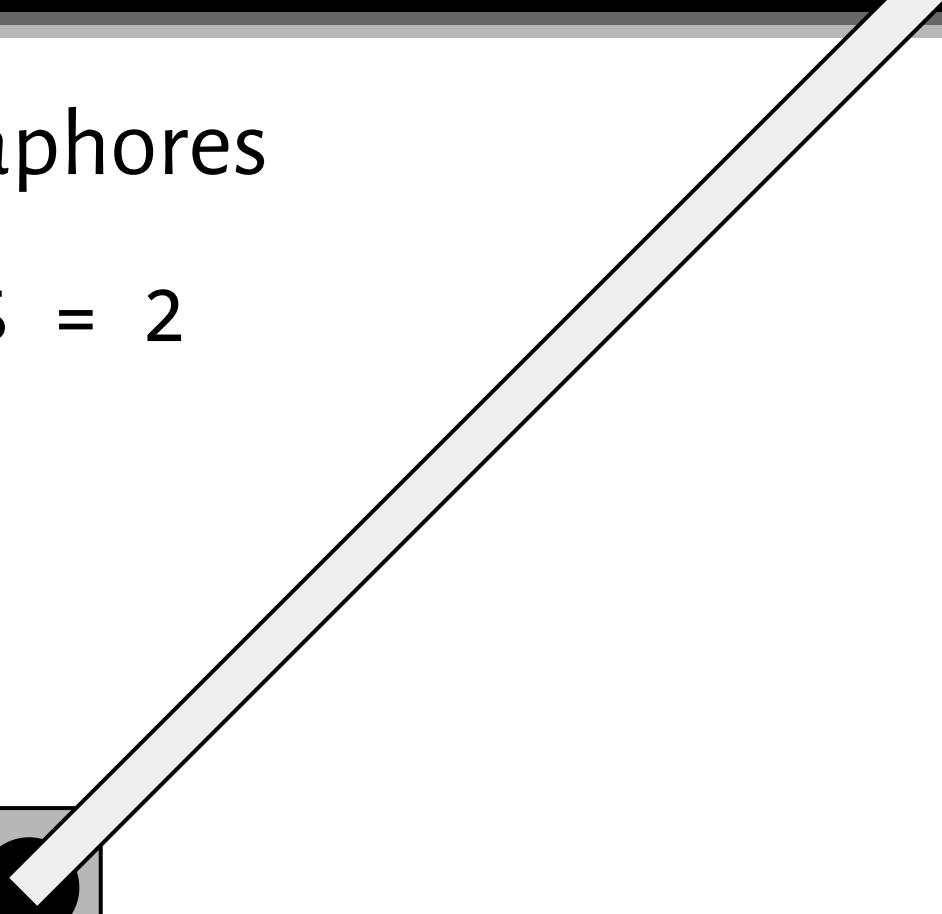
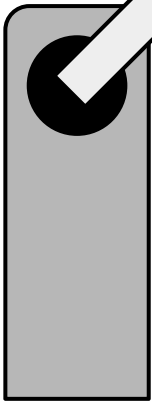
Zaimplementuj w asemblerze x86_64 **uogólniony semafor**, który może być używany w programach napisanych w języku C. Implementacja semafora ma się składać z trzech funkcji, które w C będą widziane jako:

```
void proberen(int32_t *semaphore, int32_t value);  
void verhogen(int32_t *semaphore, int32_t value);  
uint64_t proberen_time(int32_t *semaphore, int32_t value);
```

Parametr **semaphore** jest adresem zmiennej przechowującej wartość semafora.
Parametr **value** jest liczbą całkowitą z przedziału od 1 do $2^{31} - 1$.

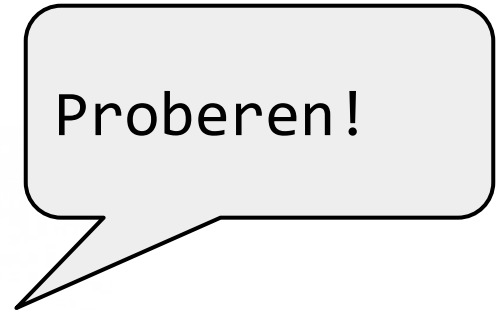
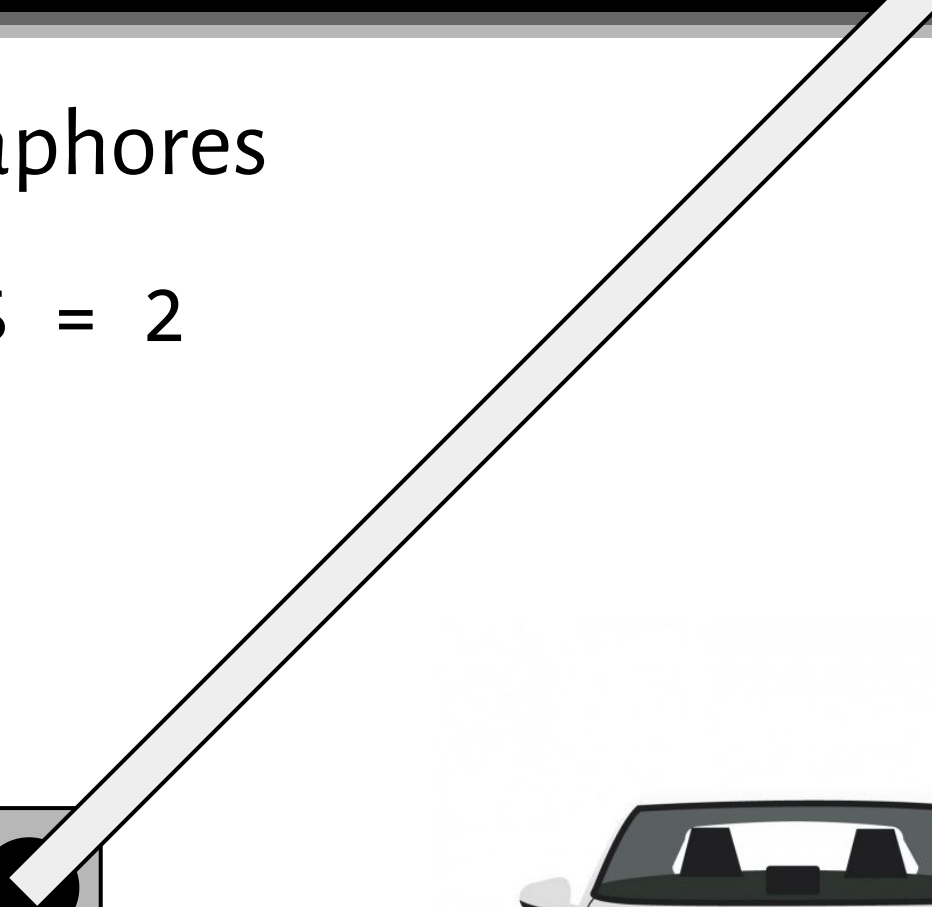
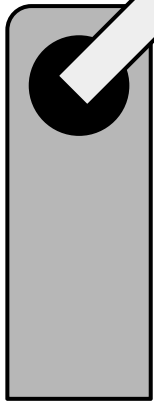
Semaphores

$$S = 2$$



Semaphores

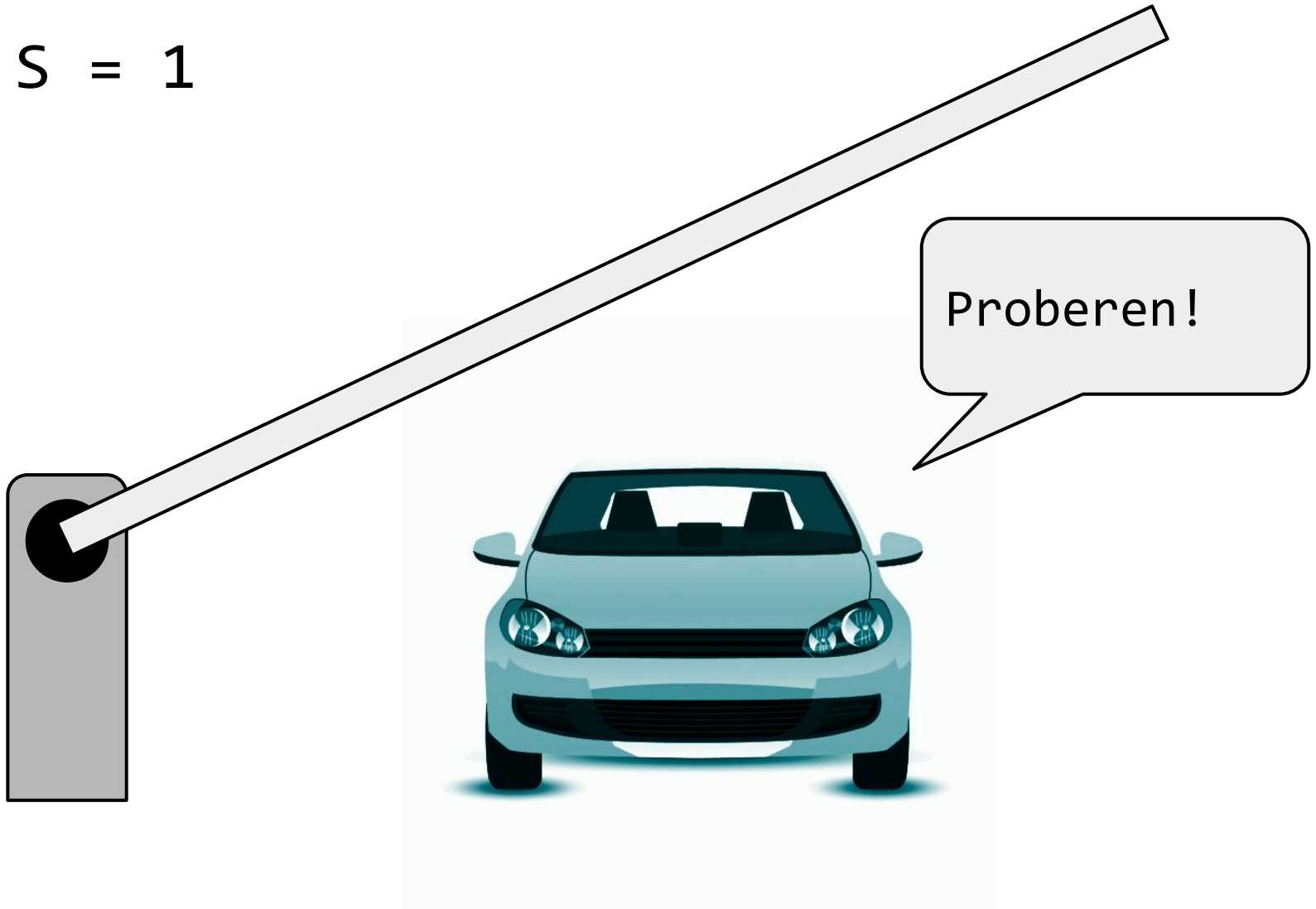
$$S = 2$$



Proberen!

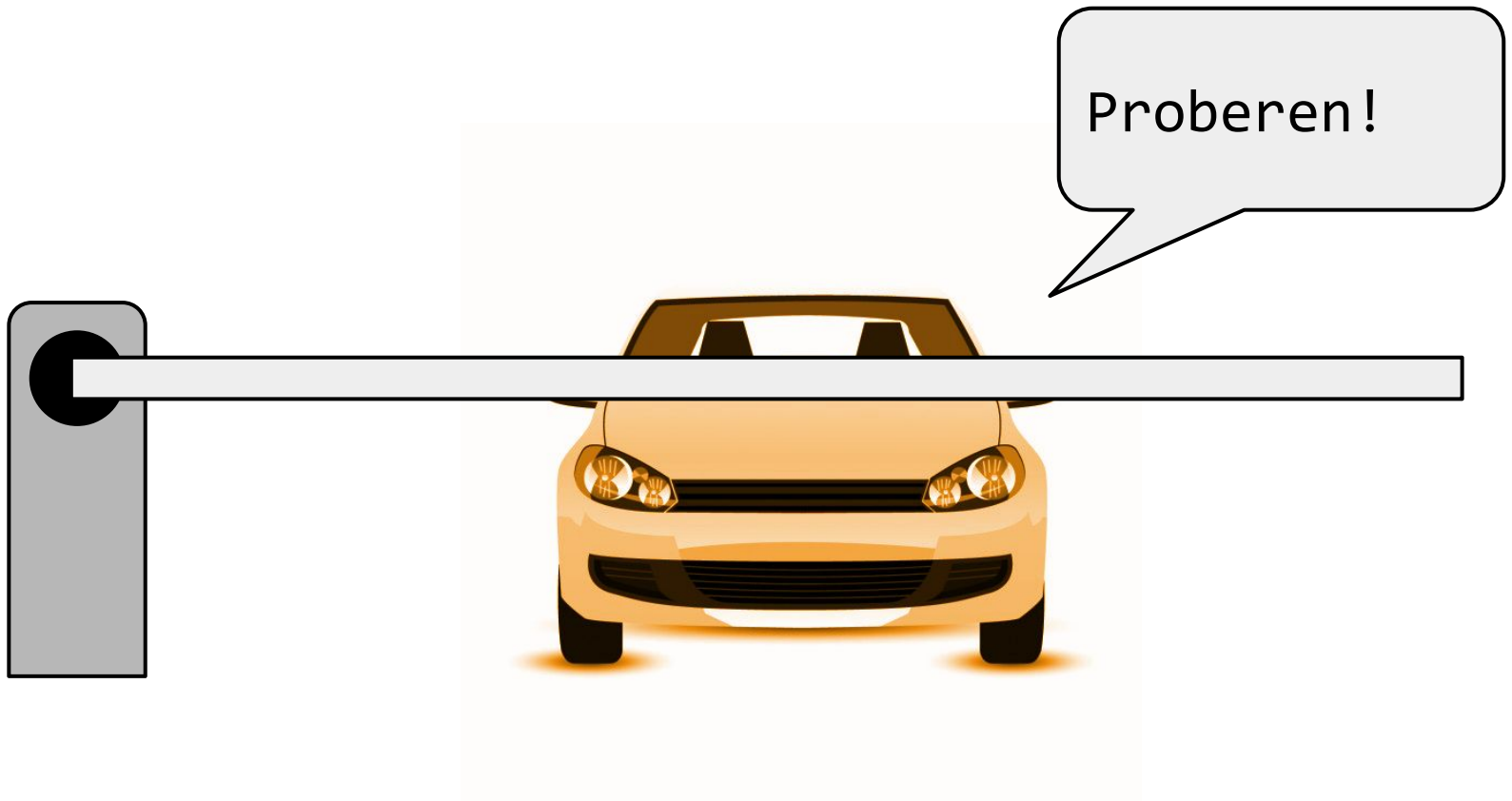
Semaphores

$S = 1$



Semaphores

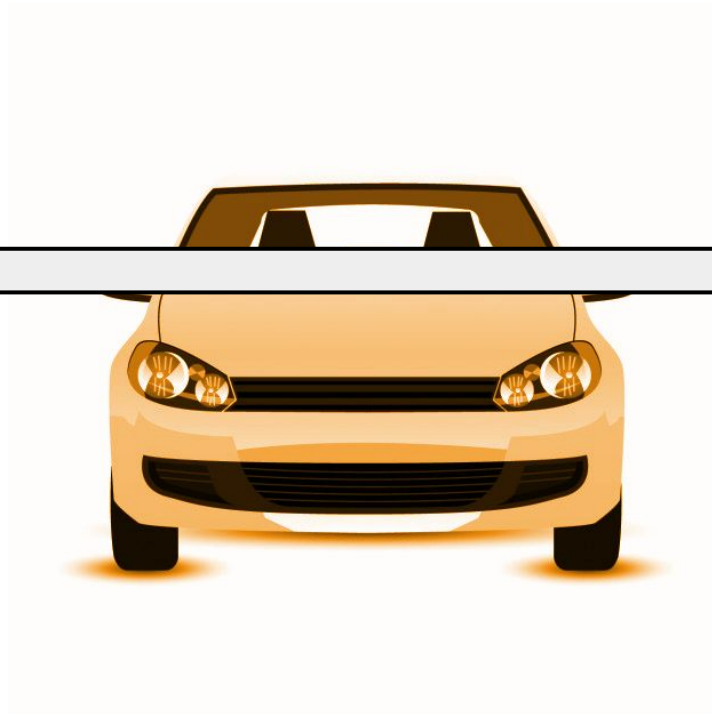
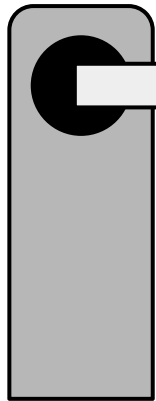
$$S = 0$$



Semaphores

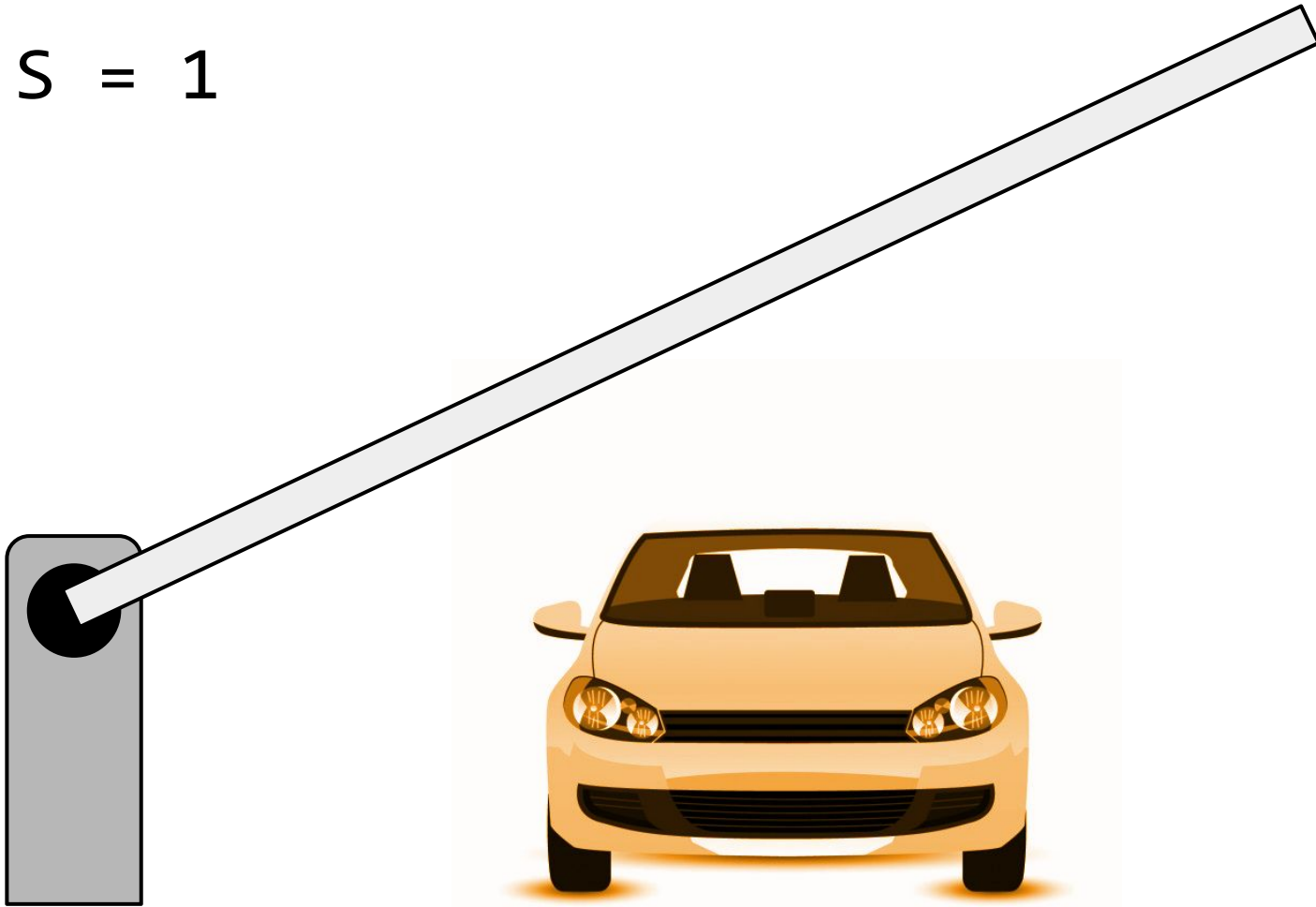
$$S = 0$$

Verhogen!



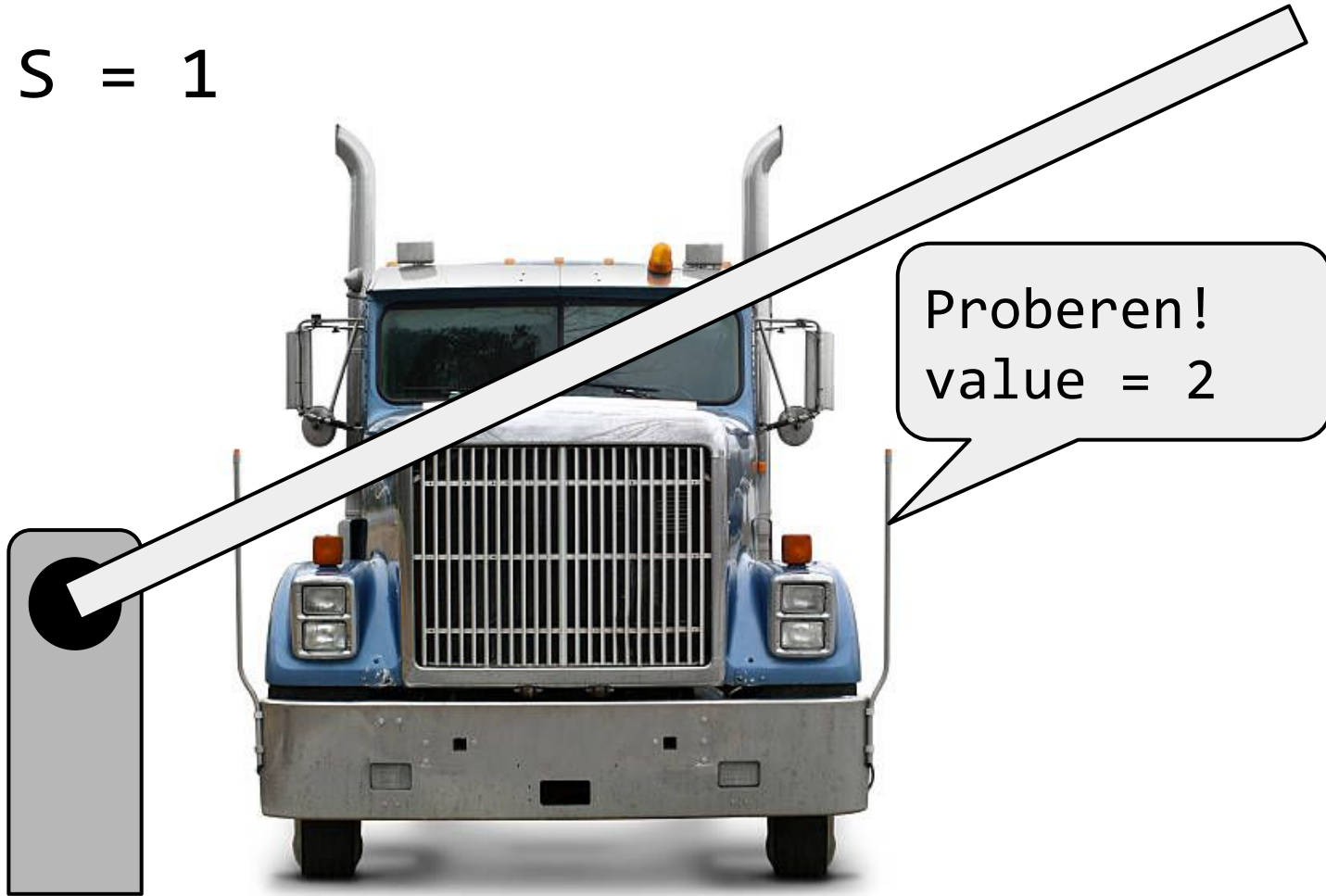
Semaphores

$$S = 1$$



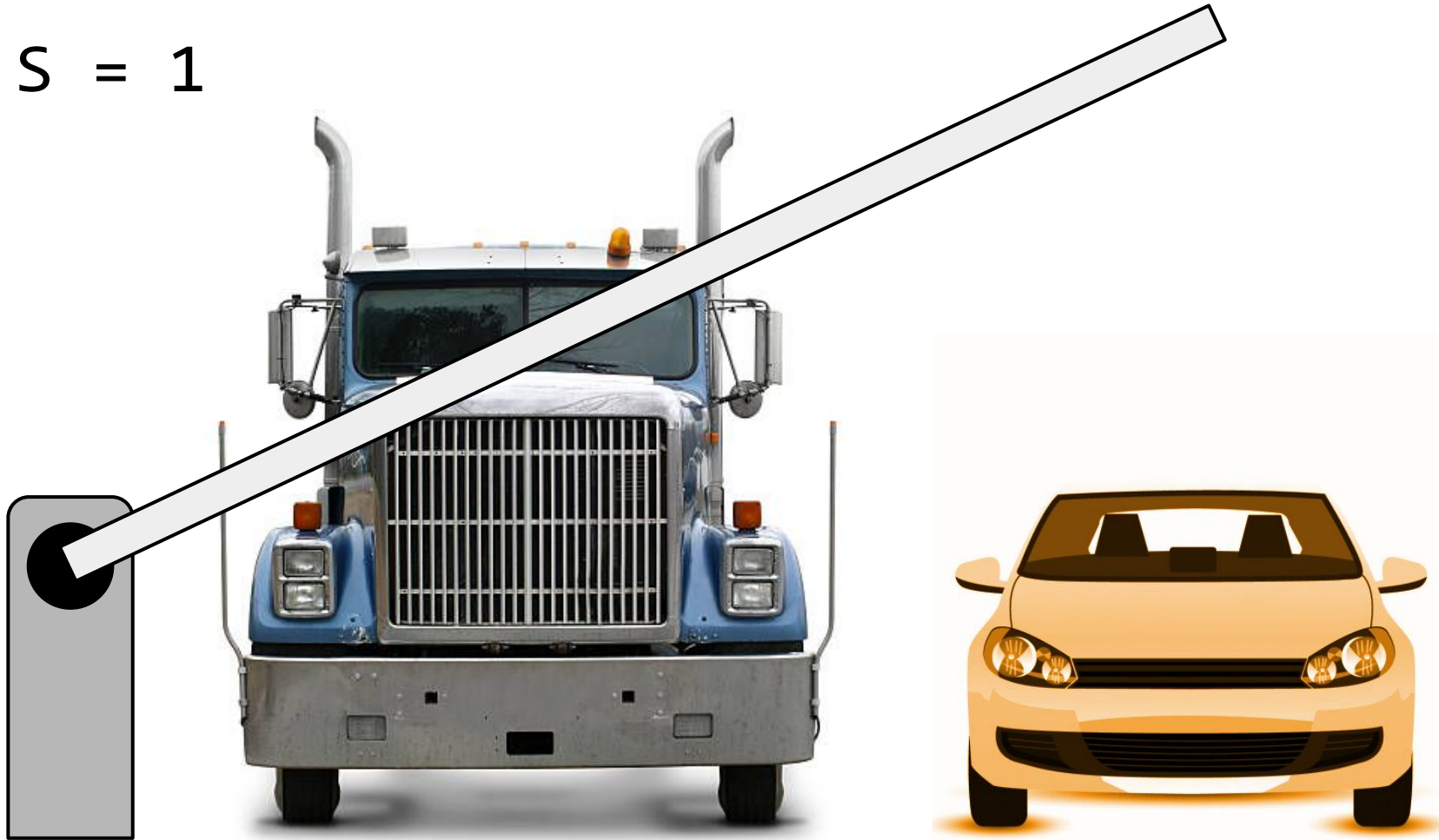
Semaphores

$S = 1$



Semaphores

$$S = 1$$



Assignment #2

Zaimplementuj w asemblerze x86_64 **uogólniony semafor**, który może być używany w programach napisanych w języku C. Implementacja semafora ma się składać z trzech funkcji, które w C będą widziane jako:

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Assignment #2

Zaimplementuj w asemblerze x86_64 **uogólniony semafor**, który może być używany w programach napisanych w języku C. Implementacja semafora ma się składać z trzech funkcji, które w C będą widziane jako:

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Parametr **value** jest liczbą całkowitą z przedziału od 1 do $2^{31} - 1$.

Funkcja **proberen_time** woła funkcję proberen z tymi samymi argumentami, które dostała, i mierzy (zwraca) czas przebywania sterowania w proberen. W tym celu woła dwukrotnie funkcję:

```
uint64_t get_os_time(void);
```

Assignment #2

How to implement `get_os_time`?

<https://stackoverflow.com/questions/8594277/clock-precision-in-time-h>

Makefile

```
life: lifemain.c life.o
    gcc -o life lifemain.c life.o

%.o: %.asm
    nasm -f elf64 -F dwarf -g $<
```