

CSO2 (CS3130)

themes

automating building software

libraries, taking advantage of incremental compilation

sharing machines

multiple users/programs on one system

parallelism and concurrency

doing two+ things at once

under the hood of sockets

layered design of networks

implementing secure communication

under the hood of fast processors

caching, (hidden) parallelism, avoiding idle time

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make

```
$ ./foo.exe
```

```
...
```

```
...
```

```
$ edit readline.c
```

```
$ make
```

```
clang -g -O -Wall -c readline.c -o readline.o
```

```
ar rcs terminal.o readline.o libreadline.a
```

```
clang -o foo.exe foo.o foo-utility.o -L. -lreadline
```

```
$
```

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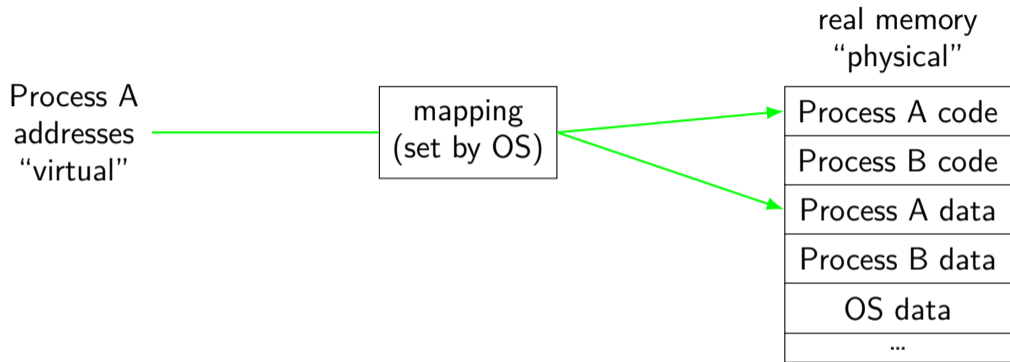
layered design of networks

implementing secure communication

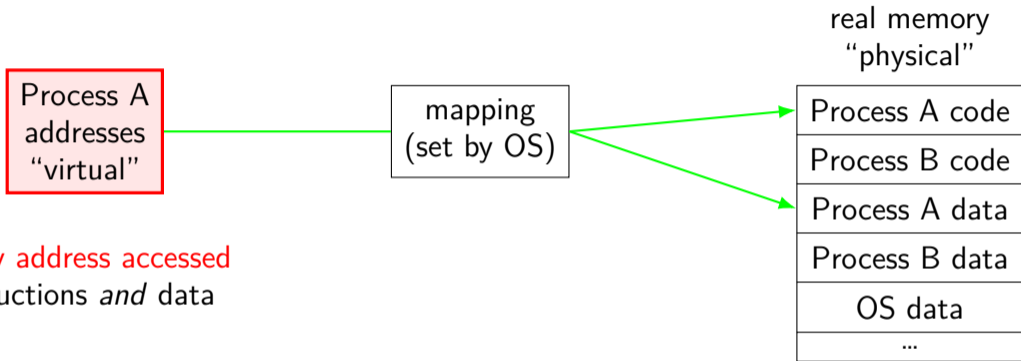
under the hood of fast processors

caching, (hidden) parallelism, avoiding idle time

address translation

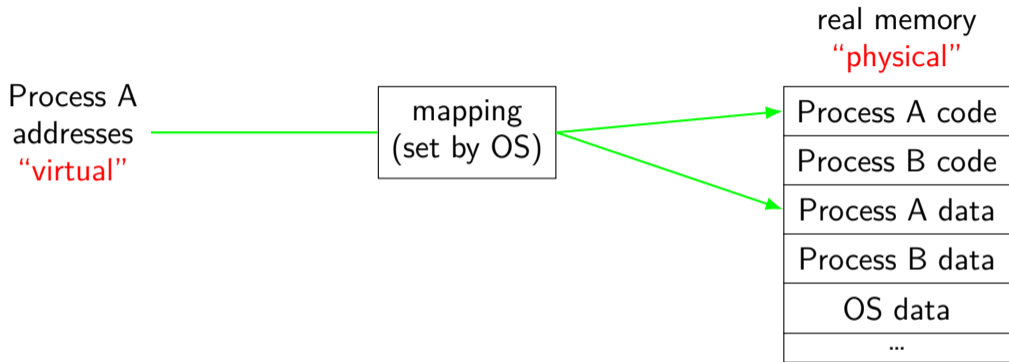


address translation



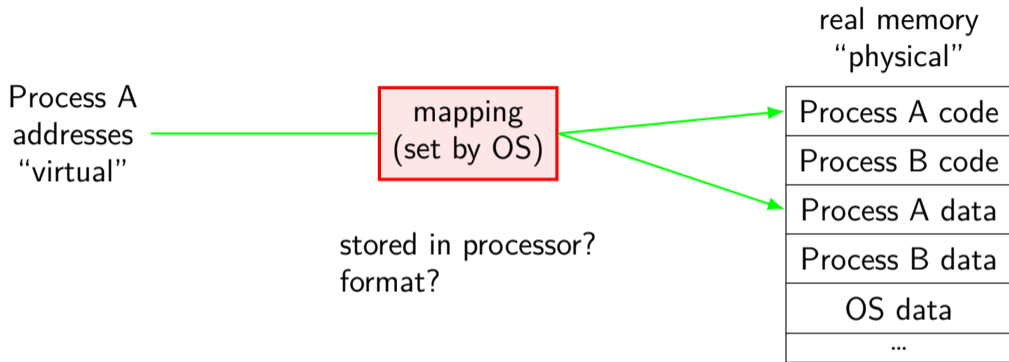
every address accessed
instructions *and* data

address translation



program addresses are 'virtual'
real addresses are 'physical'
can be **different sizes!**

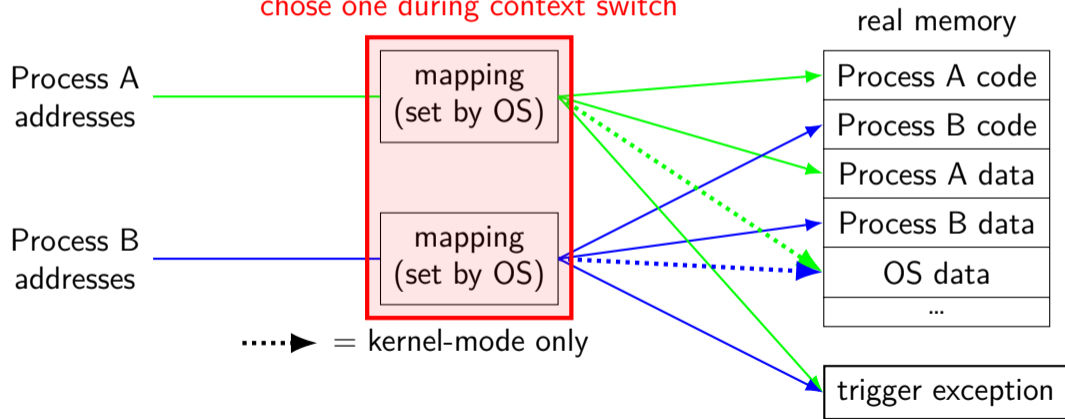
address translation



address spaces

illusion of **dedicated memory**

chose one during context switch



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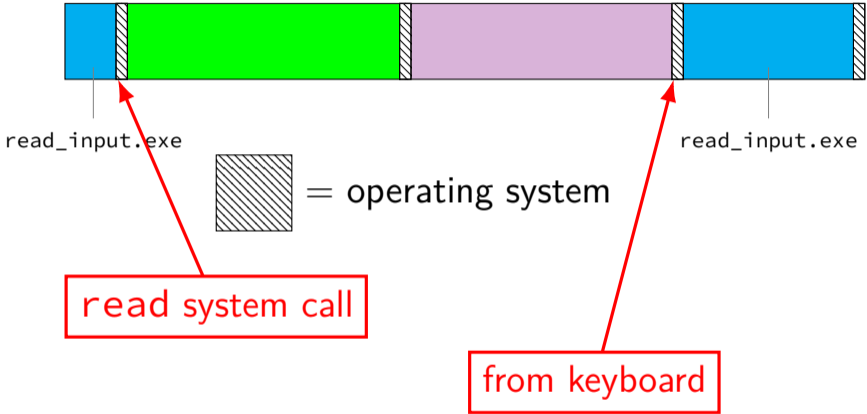
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keyboard input timeline



time multiplexing



time multiplexing



...

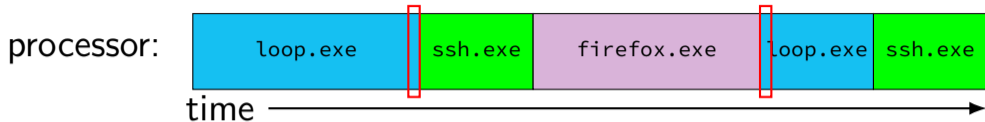
```
call get_time  
    // whatever get_time does  
movq %rax, %rbp
```

———— million cycle delay ————

```
call get_time  
    // whatever get_time does  
subq %rbp, %rax
```

...

time multiplexing



...

```
call get_time
```

```
    // whatever get_time does
```

```
movq %rax, %rbp
```

———— million cycle delay ————

```
call get_time
```

```
    // whatever get_time does
```

```
subq %rbp, %rax
```

...

multiple cores+threads

core 1:

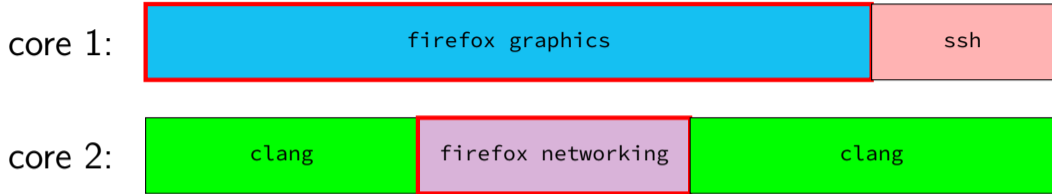


core 2:



multiple cores? each core still divided up

multiple cores+threads



one program with multiple *threads*

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permissions

```
$ ls /u/other/secret  
ls: cannot open directory '/u/other/secret': Permission denied  
$ shutdown  
shutdown: Permission denied
```

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layers

application	HTTP, SSH, SMTP, ...	application-defined meanings
transport	TCP, UDP, ...	reach correct program, reliability/streams
network	IPv4, IPv6, ...	reach correct machine (across networks)
link	Ethernet, Wi-Fi, ...	coordinate shared wire/radio
physical	...	encode bits for wire/radio

layers terminology

application	application-defined meanings	
transport	reach correct program, reliability/streams	segments/datagrams
network	reach correct machine (across networks)	packets
link	coordinate shared wire/radio	frames
physical	encode bits for wire/radio	

names and addresses

name

logical identifier

variable counter

DNS name `www.virginia.edu`

DNS name `mail.google.com`

DNS name `mail.google.com`

DNS name `reiss-t3620.cs.virginia.edu`

DNS name `reiss-t3620.cs.virginia.edu`

service name `https`

service name `ssh`

address

location/how to locate

memory address `0x7FFF9430`

IPv4 address `128.143.22.36`

IPv4 address `216.58.217.69`

IPv6 address `2607:f8b0:4004:80b::2005`

IPv4 address `128.143.67.91`

MAC address `18:66:da:2e:7f:da`

port number `443`

port number `22`

secure communication?

how do you know who your socket is to?

who can read what's on the socket?

what can you do to restrict this?

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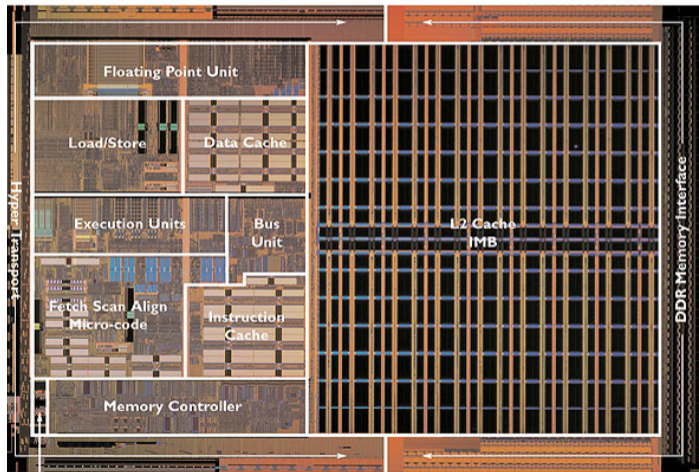
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2004 CPU



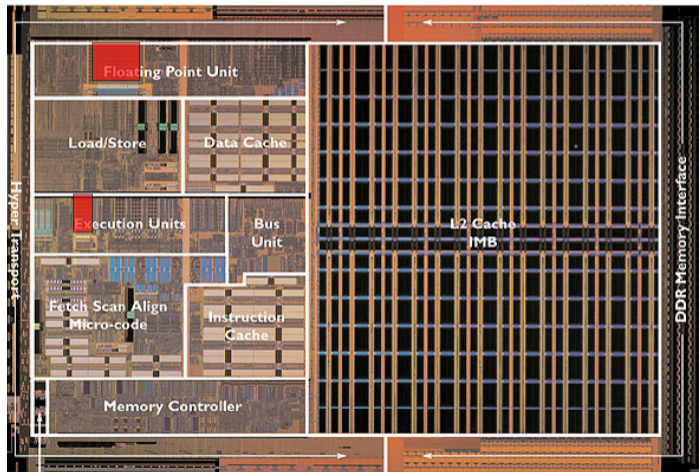
Clock Generator



Image: approx 2004 AMD press image of Opteron die;
approx register location via chip-architect.org (Hans de Vries)

2004 CPU

▲ Registers



Clock Generator



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2004 CPU

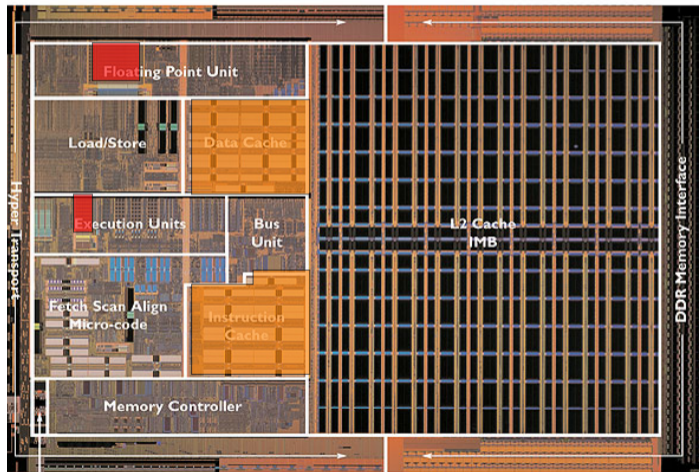
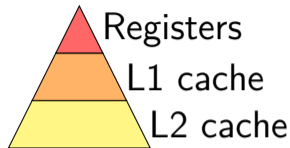
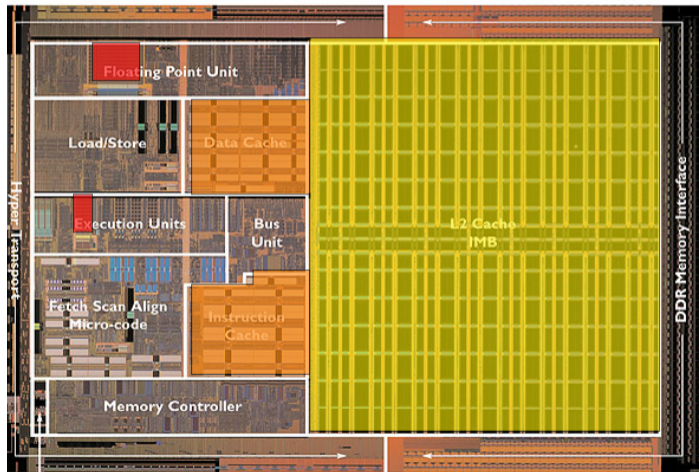
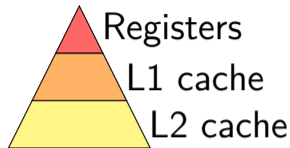
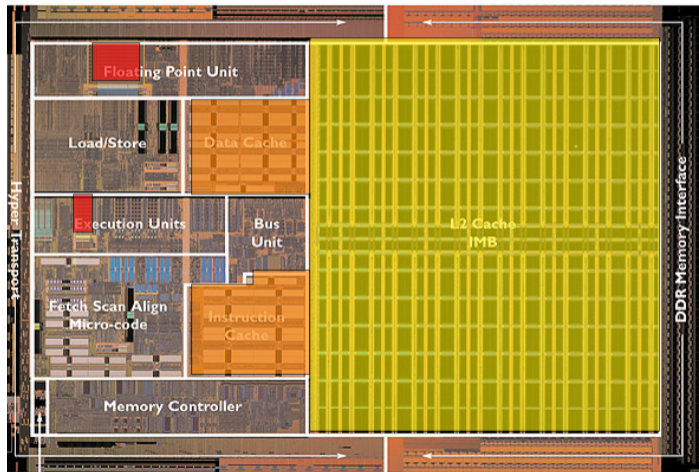


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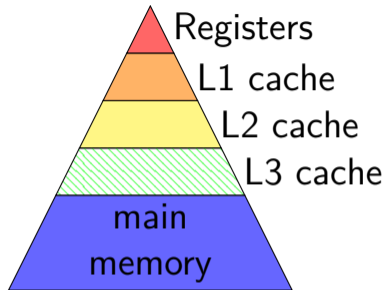
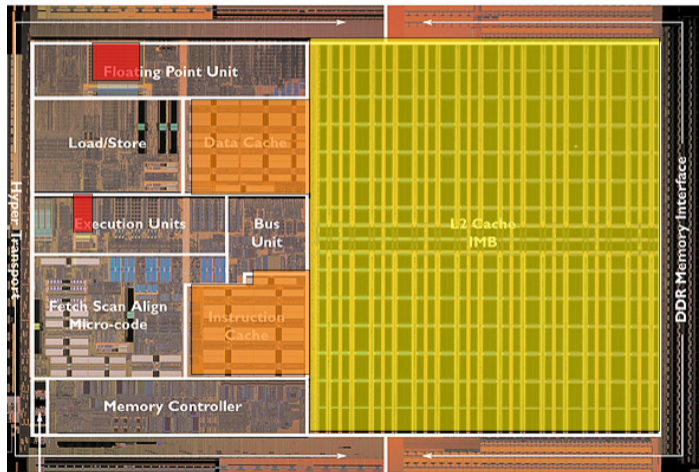
2004 CPU



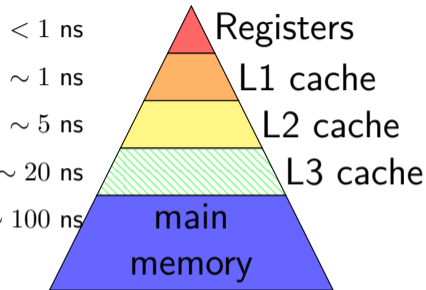
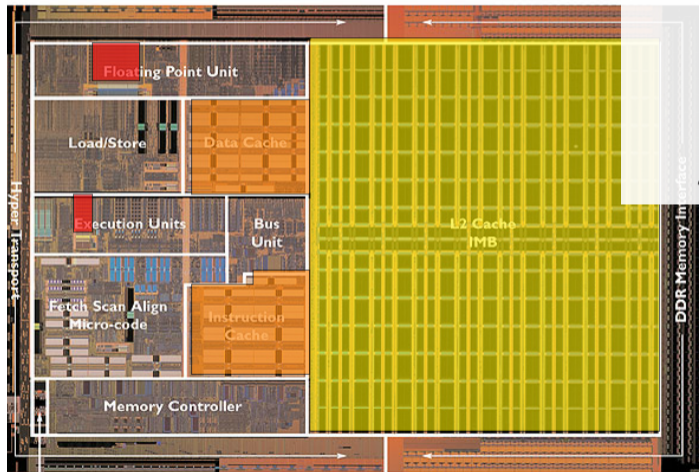
2004 CPU



2004 CPU



2004 CPU



some performance examples

example1:

```
    movq $100000000000, %rax
loop1:
    addq %rbx, %rcx
    decq %rax
    jge loop1
    ret
```

about 30B instructions

my desktop: approx 2.65 sec

example2:

```
    movq $100000000000, %rax
loop2:
    addq %rbx, %rcx
    addq %r8, %r9
    decq %rax
    jge loop2
    ret
```

about 40B instructions

my desktop: approx 2.65 sec

some performance examples

```
example1:  
    movq $100000000000, %rax  
loop1:  
    addq %rbx, %rcx  
    decq %rax  
    jge loop1  
    ret
```

about 30B instructions
my desktop: approx 2.65 sec

```
example2:  
    movq $100000000000, %rax  
loop2:  
    addq %rbx, %rcx  
    addq %r8, %r9  
    decq %rax  
    jge loop2  
    ret
```

about 40B instructions
my desktop: approx 2.65 sec

C exercise

```
int array[4] = {10,20,30,40};  
int *p;  
p = &array[0];  
p += 2;  
p[1] += 1;
```

array =

- A. compile or runtime error
- B. {10,20,30,41}
- C. {10,20,32,41}
- D. {10,21,30,40}
- E. {12,21,30,40}
- F. none of these

C exercise (2)

```
int *array2[4]; int array1[4] = {10,20,30,40};
void mystery(int **p) {
    *p = &array1[2];
}
int main() {
    int **q;
    q = array2;
    mystery(q);
    array1[1] = *q;
    ...
}
```

array1 =

- A. compile or runtime error
- B. {10,10,30,40}
- C. {10,30,30,40}
- D. {10,10,20,30}
- E. {10,20,10,20}
- F. none of these

C exercise (2)

```
int *array2[4]; int array1[4] = {10,20,30,40};
void mystery(int **p) {
    *p = &array1[2];
}
int main() {
    int **q;
    q = array2;
    mystery(q);
    array1[1] = *q;
    ...
}
```

array1 =

- A. compile or runtime error
- B. {10,10,30,40}
- C. {10,30,30,40}
- D. {10,10,20,30}
- E. {10,20,10,20}
- F. none of these

some avenues for review

review CSO1 stuff

labs 9–12 (of last Fall)

<https://researcher111.github.io/uva-cso1-F23-DG/>

exercises we've used in the past:

implement strsep library function

implement conversion from dynamic array to linked list

some pointer stuff

0x040

0x038

0x030

0x028

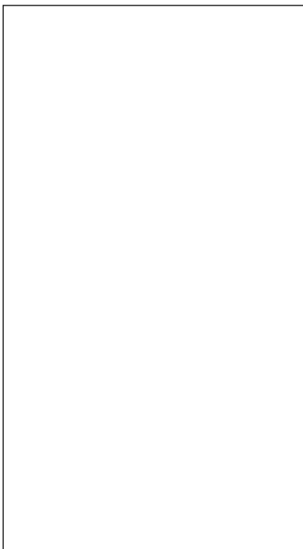
0x020

0x018

0x010

0x008

0x000



```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```


some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr = ???
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```

some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr = ???
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```

~~*ptr = 0xAB;~~ runtime error

some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr: 0x28
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```

```
ptr = &single;  
ptr = (int*) 0x28; addr. of single
```

some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr: 0x28
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```

```
ptr = &single;  
ptr = (int*) 0x28;  addr. of single
```

~~ptr = 0x28; compile error~~

~~ptr = (int*) single;~~

pointer to unknown place

some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
0x028	single: 0xFF
	ptr: 0x28
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;  
ptr = &single;
```

```
*ptr = 0xFF;
```

some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr: 0x2C
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};
int single = 0x78;
int *ptr;

ptr = array;
ptr = &array[0];
ptr = (int*) 0x2C;
```

some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr: 0x2C
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```

```
ptr = array;  
ptr = &array[0];  
ptr = (int*) 0x2C;
```

~~ptr = array[0]; compile error~~

~~ptr = (int*) array[0];~~

pointer to unknown place

some pointer stuff

0x040	
0x038	array[2]: 0xFF
	array[1]: 0x45
0x030	array[0]: 0x12
	single: 0x78
0x028	ptr: 0x2C
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};
int single = 0x78;
int *ptr;
ptr = &array[0];
```

```
ptr[2] = 0xFF;
*(ptr + 2) = 0xFF;
```

```
int *temp1; temp1 = ptr + 2;
*temp1 = 0xFF;
```

```
int *temp2; temp2 = &ptr[2];
*temp2 = 0xFF;
```


some pointer stuff

0x040	
0x038	array[2]: 0x67
	array[1]: 0x45
0x030	array[0]: 0x12
0x028	single: ...
	ptr: 0x2C
0x020	
0x018	
0x010	
0x008	
0x000	

```
int array[3]={0x12,0x45,0x67};  
int single = 0x78;  
int *ptr;
```

```
void change_arg(int *x) {  
    *x = compute_some_value();  
}  
...  
change_arg(&single);
```

backup slides