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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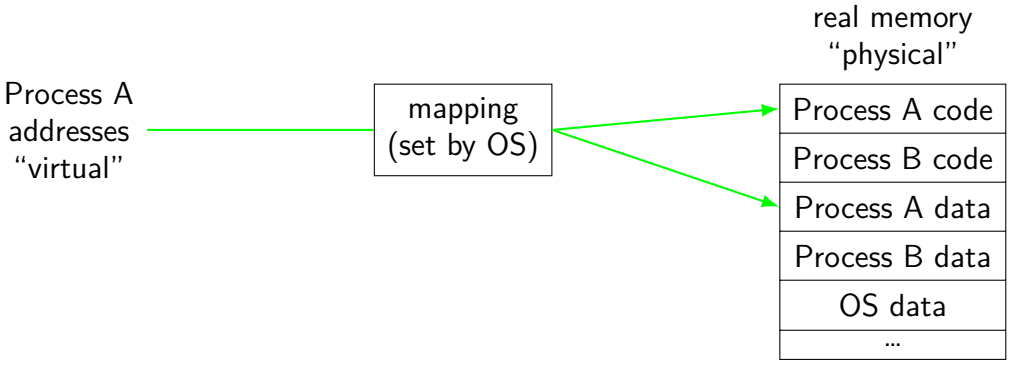
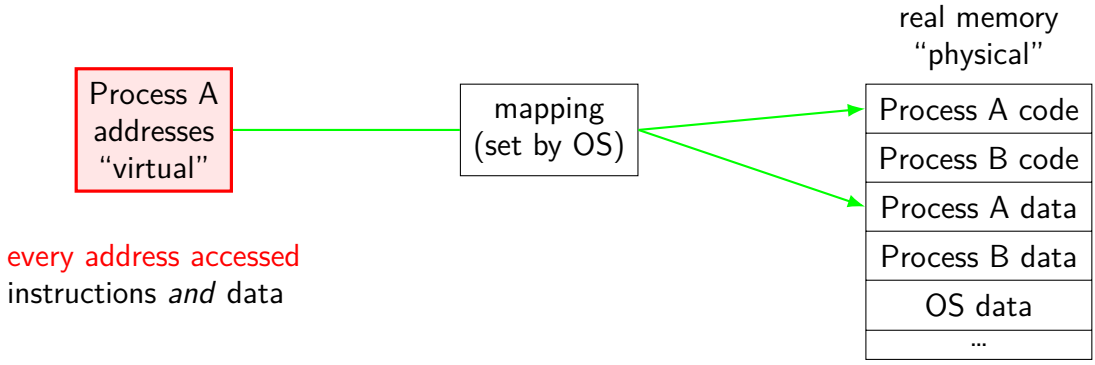
address translation

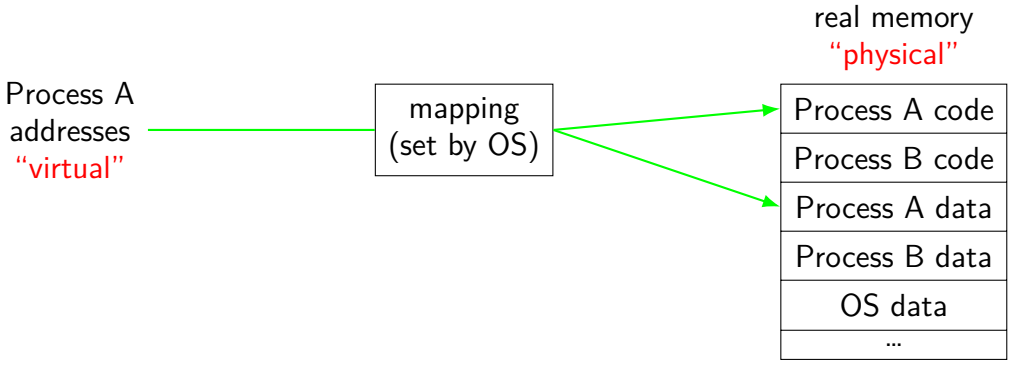


address translation



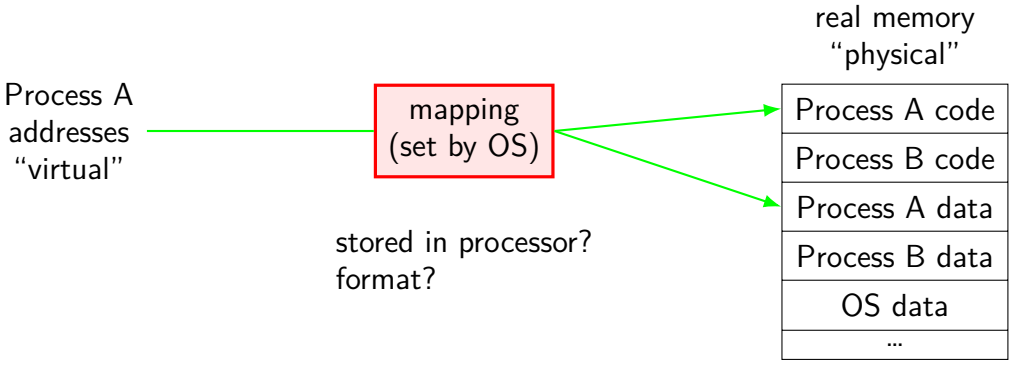
every address accessed
instructions *and* data

address translation



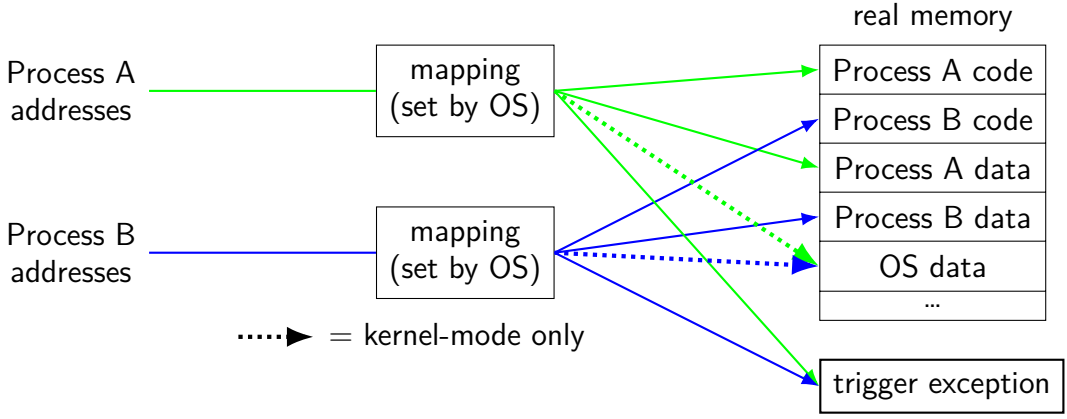
program addresses are 'virtual'
real addresses are 'physical'
can be different sizes!

address translation



address spaces

illuision of dedicated memory



address spaces

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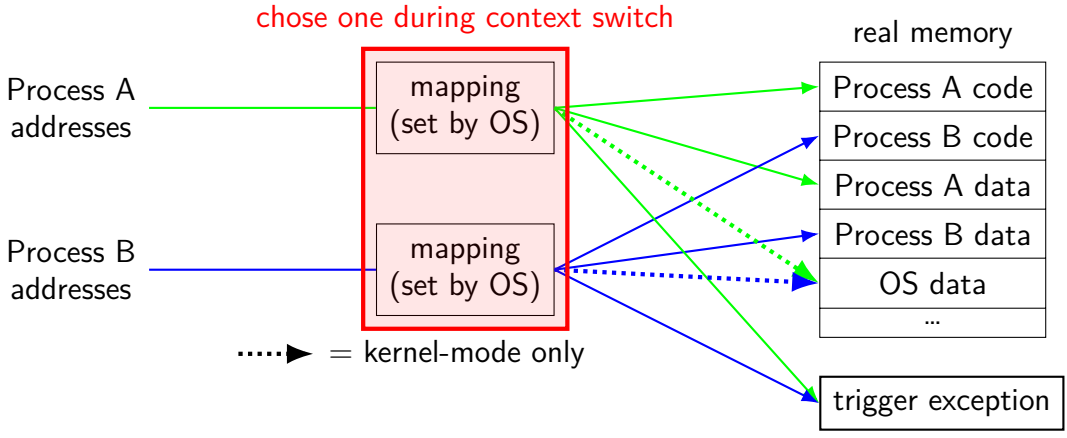

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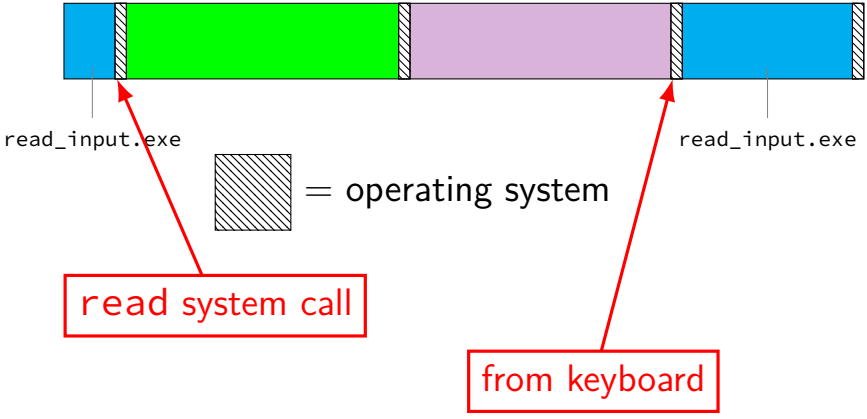
keyboard input timeline



time multiplexing

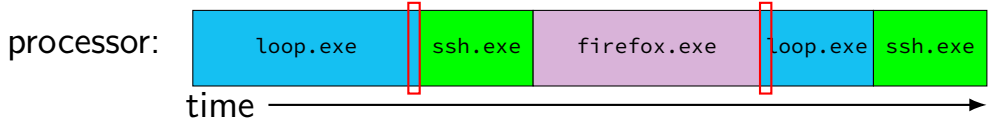
time multiplexing


```
...
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

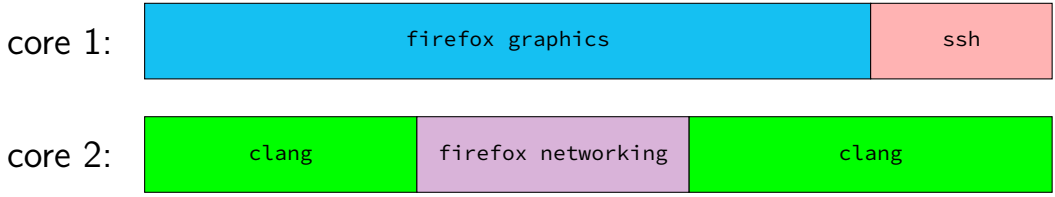



```
...
call get_time
    // whatever get_time does
movq %rax, %rbp
```

million cycle delay

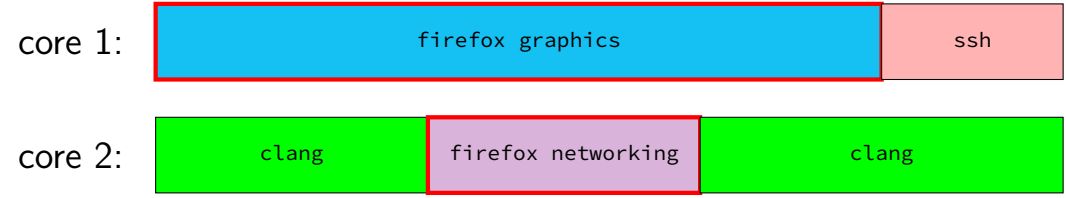
```
call get_time
    // whatever get_time does
subq %rbp, %rax
...
```

multiple cores+threads



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, reliablity/streams
network	IPv4, IPv6, ...	reach correct machine (across networks)
link	Ethernet, Wi-Fi, ...	coordinate shared wire/radio
physical	...	encode bits for wire/radio

names and addresses

name	address
logical identifier	location/how to locate
variable `counter`	memory address `0x7FFF9430`
DNS name `www.virginia.edu`	IPv4 address `128.143.22.36`
DNS name `mail.google.com`	IPv4 address `216.58.217.69`
DNS name `mail.google.com`	IPv6 address `2607:f8b0:4004:80b::2005`
DNS name `reiss-t3620.cs.virginia.edu`	IPv4 address `128.143.67.91`
DNS name `reiss-t3620.cs.virginia.edu`	MAC address `18:66:da:2e:7f:da`
service name `https`	port number 443
service name `ssh`	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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2004 CPU

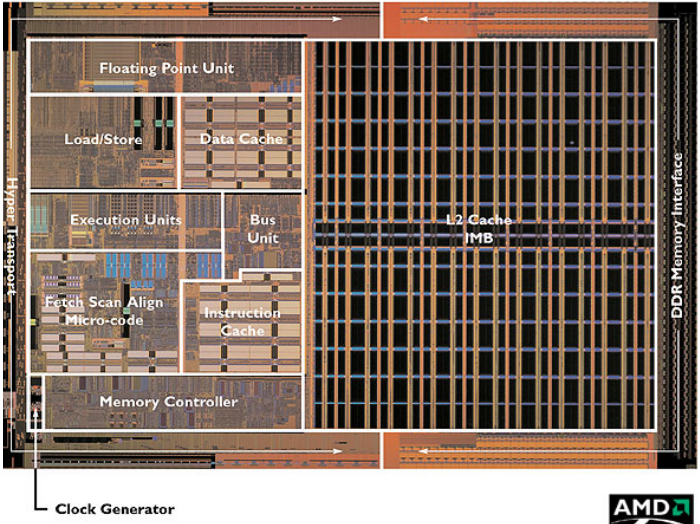
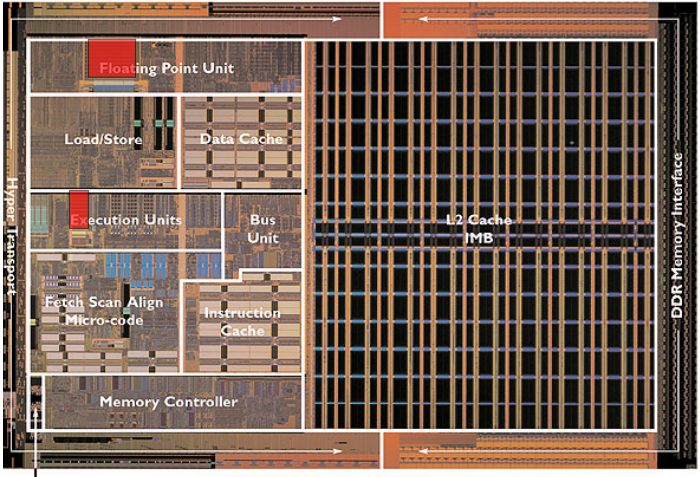


Image: approx 2004 AMD press image of Opteron die;
approx register location via chip-architect.org (Hans de Vries)

2004 CPU



Registers

AMD 64 Opteron

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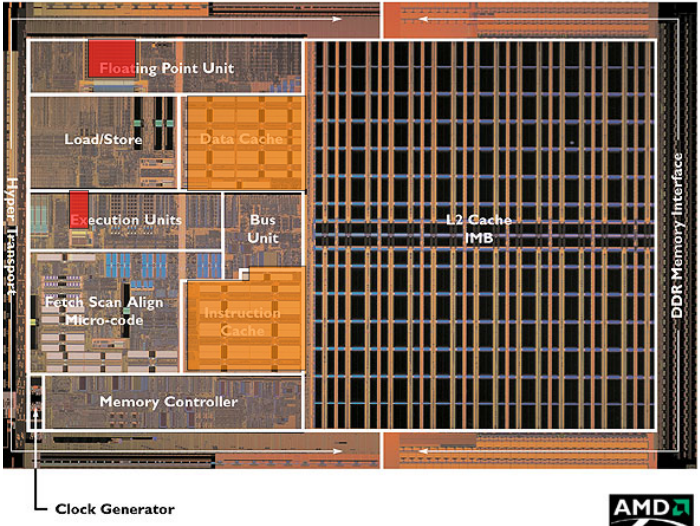
2004 CPU



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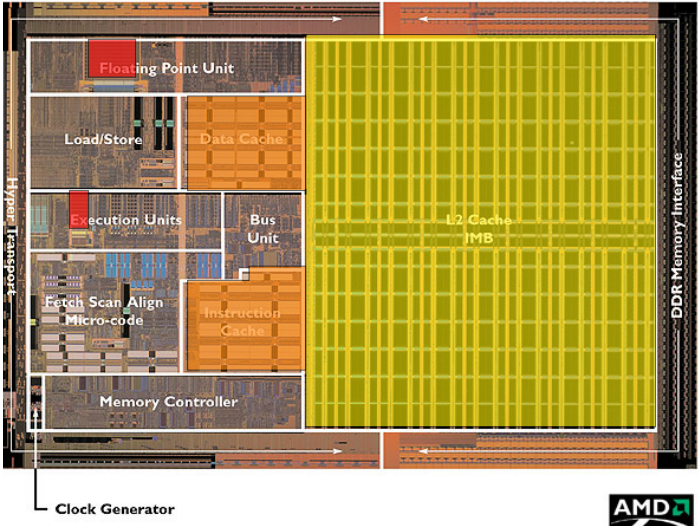

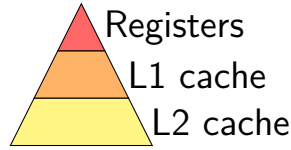

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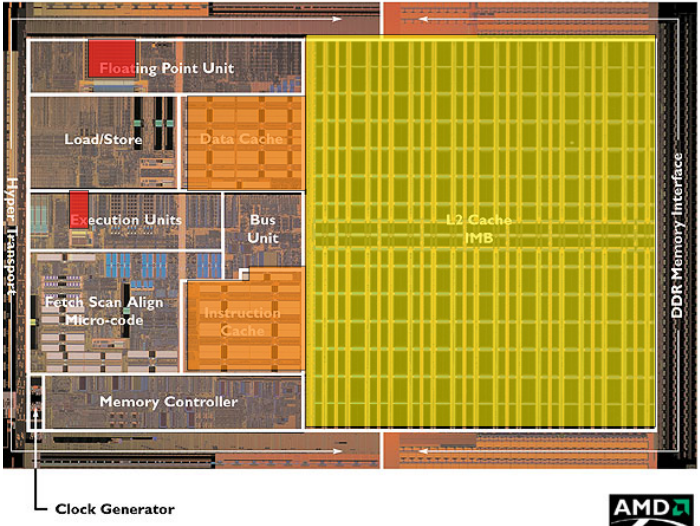

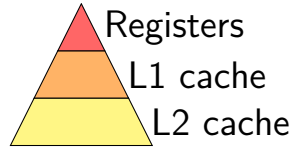

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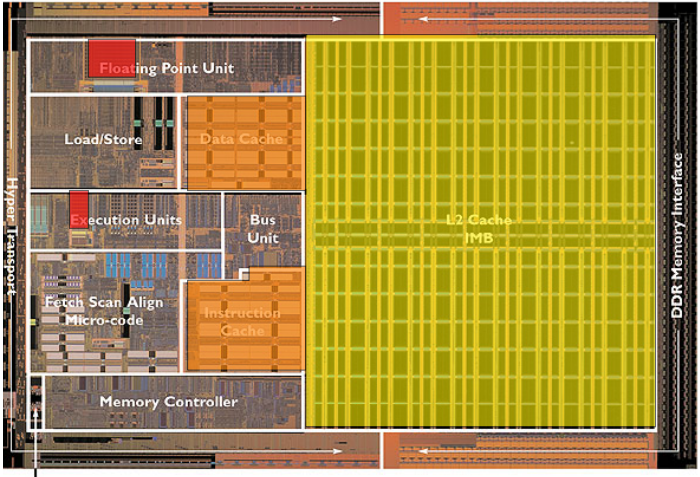

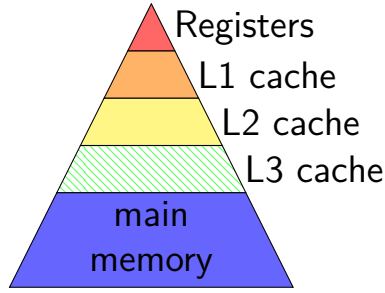

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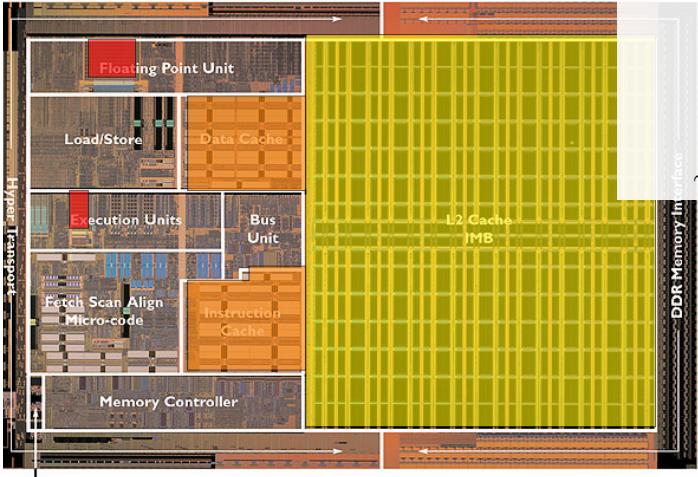

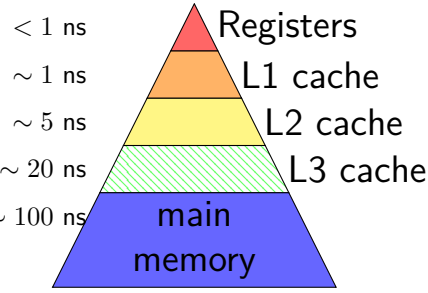

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some performance examples

```
example1:
    movq $10000000000, %rax
loop1:
    addq %rbx, %rcx
    decq %rax
    jge loop1
    ret
```

about 30B instructions

my desktop: approx 2.65 sec

```
example2:
    movq $10000000000, %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 $10000000000, %rax
loop1:
    addq %rbx, %rcx
    decq %rax
    jge loop1
    ret
```

about 30B instructions

my desktop: approx 2.65 sec

```
example2:
    movq $10000000000, %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

some avenues for review

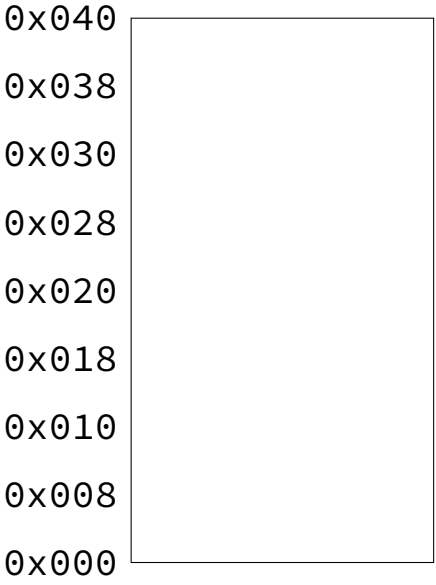
review CSO1 stuff

- labs 9–12 (of last Spring)
  `https://www.cs.virginia.edu/~jh2jf/courses/cs2130/spring2023/`

exercises we've used in the past:

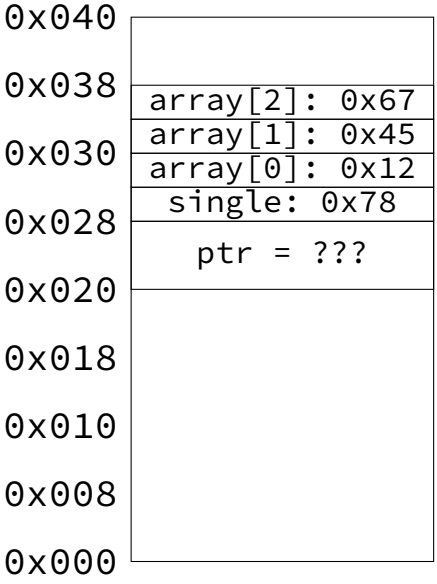
- implement strsep library function
- implement conversion from dynamic array to linked list

some pointer stuff




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

some pointer stuff

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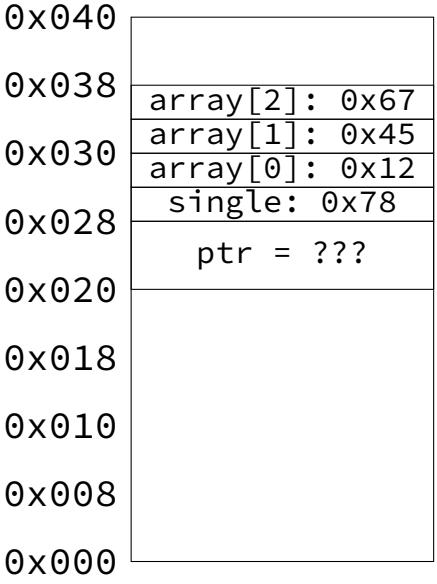
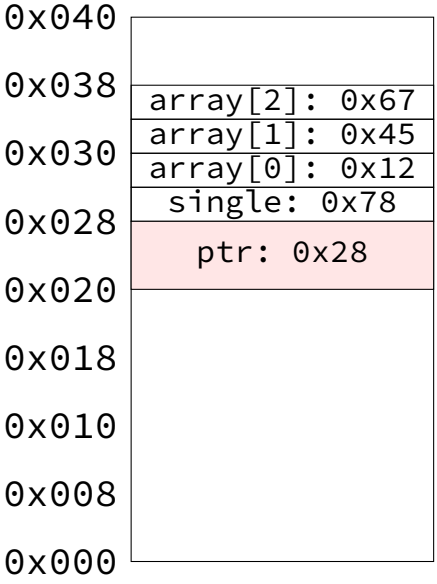



```
int array[3]={0x12,0x45,0x67};
int single = 0x78;
int *ptr;
```

~~`*ptr = 0xAB;`~~ compile error

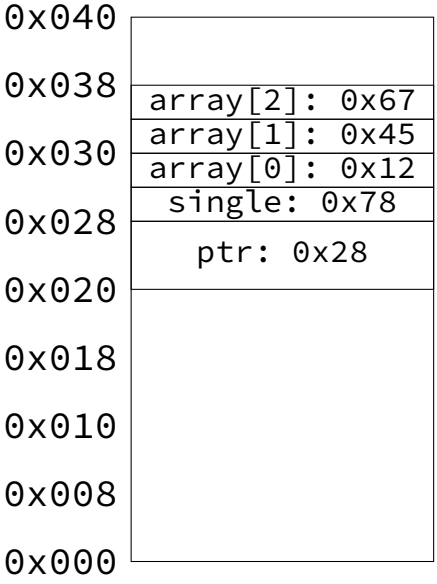
some pointer stuff




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

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

addr. of single

some pointer stuff



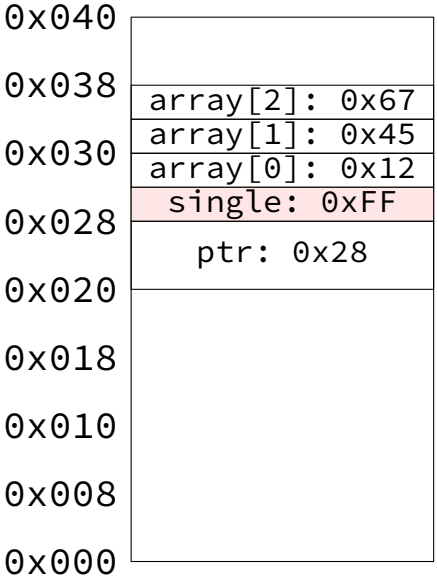

```
int array[3]={0x12,0x45,0x67};
int single = 0x78;
int *ptr;

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

~~`ptr = 0x28;`~~ compile error

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

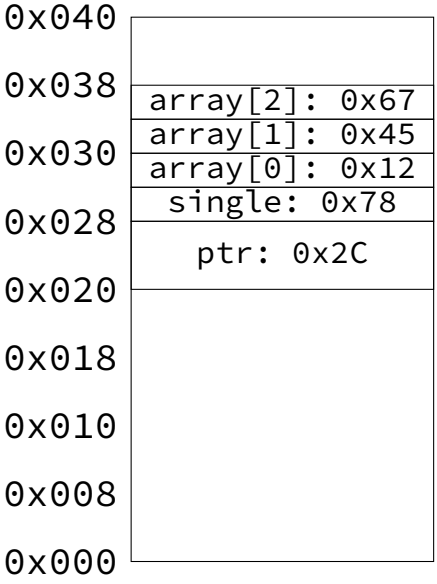
pointer to unknown place

some pointer stuff



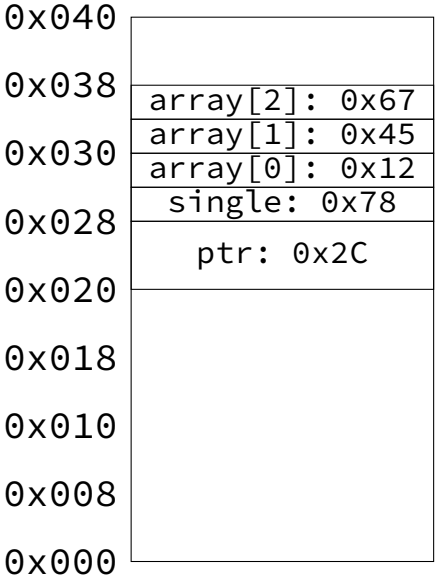

```
int array[3]={0x12,0x45,0x67};
int single = 0x78;
int *ptr;
ptr = &single;

*ptr = 0xFF;
```

some pointer stuff




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

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

some pointer stuff



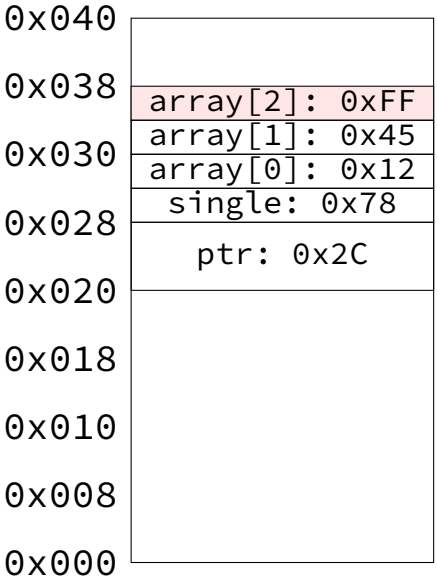

```
int array[3]={0x12,0x45,0x67};
int single = 0x78;
int *ptr;

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

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

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

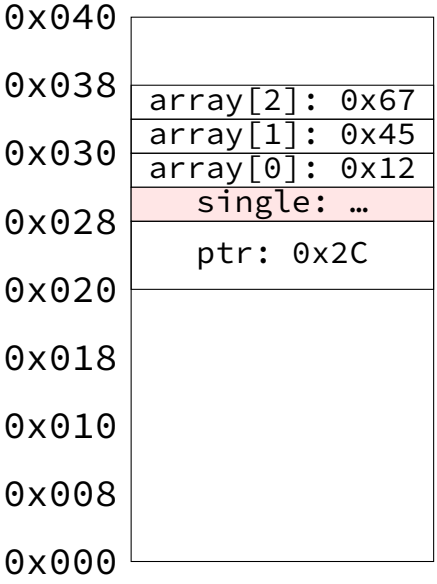
pointer to unknown place

some pointer stuff




```
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




```
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