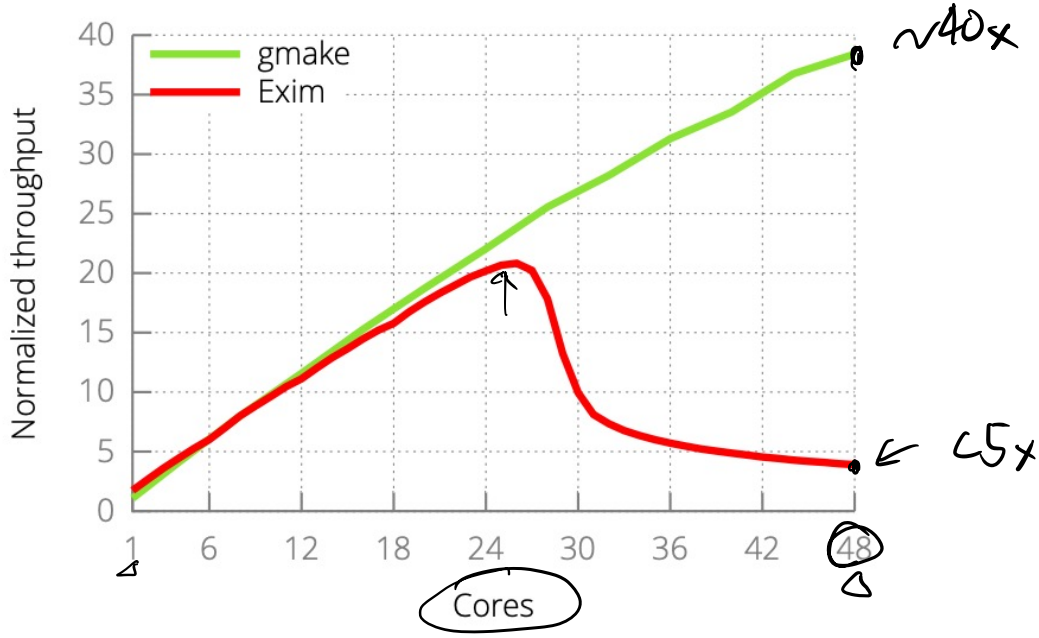
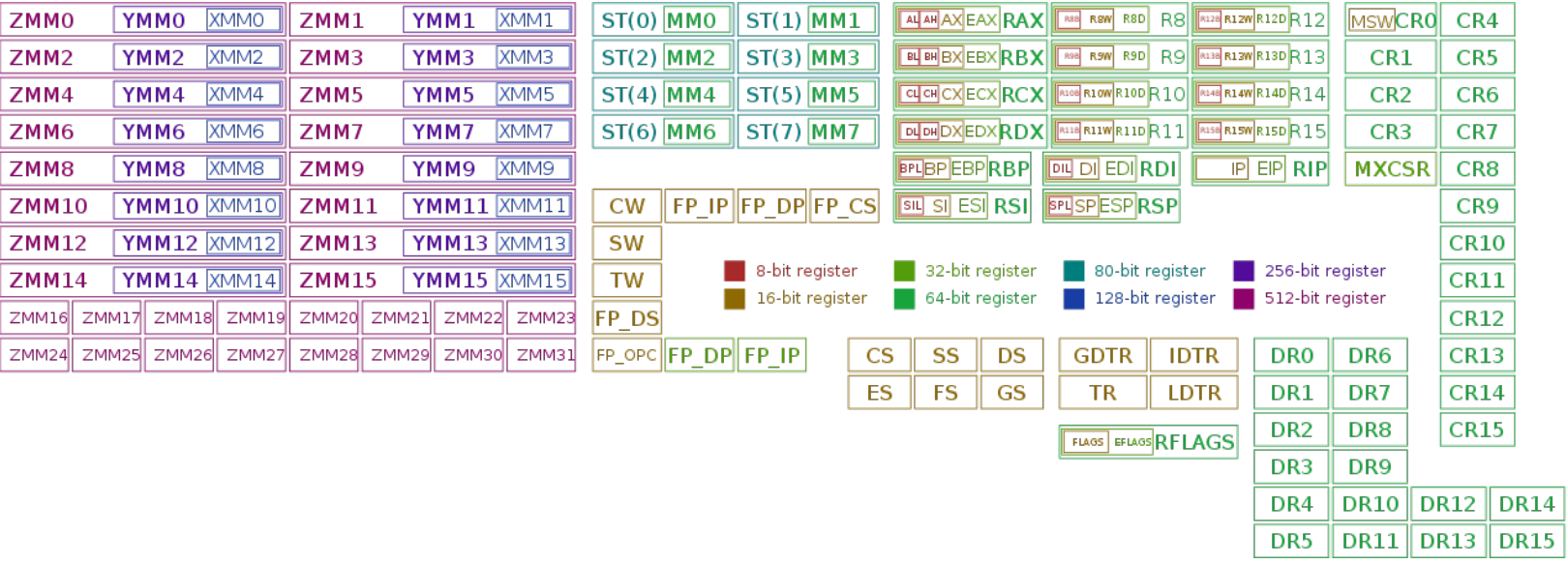
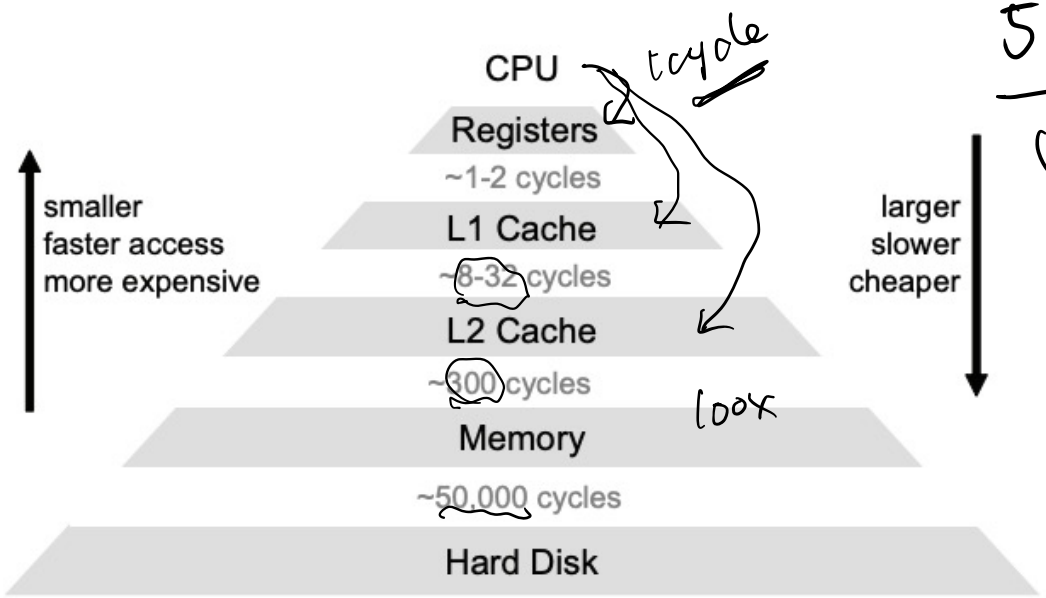


Borrowed from:

The Scalable Commutativity Rule: Designing Scalable Software for Multicore Processors
https://pdos.csail.mit.edu/papers/commutativity:sosp13-slides.pdf



https://en.wikipedia.org/wiki/X86#x86_registers



Chellappa, S., Franchetti, F. and Püschel, M.
How To Write Fast Numerical Code: A Small Introduction
Figure 5, 2007

Borrowed from:
SymbioticLab. https://symbioticlab.org/

0. OS history
1. Processes
2. Process's view of memory (and registers)
3. Crash course of x86-64 assembly
4. Stack frames
5. System calls

Last time

"Iverry" Labs. Slack hour 120

Unix 1969 PDP-7

C Xerox

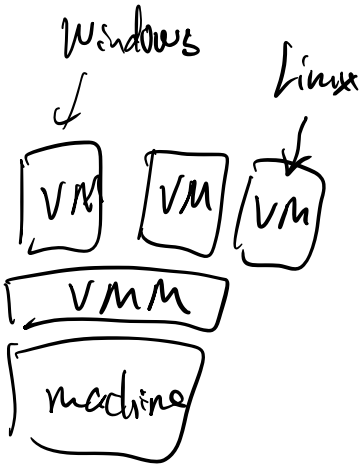
Monolithic kernel (Linux)

Microkernel

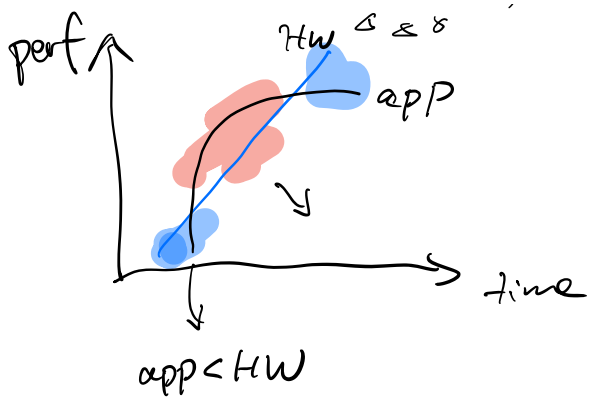
Exokernel (1995)

Virtualization (Cloud)

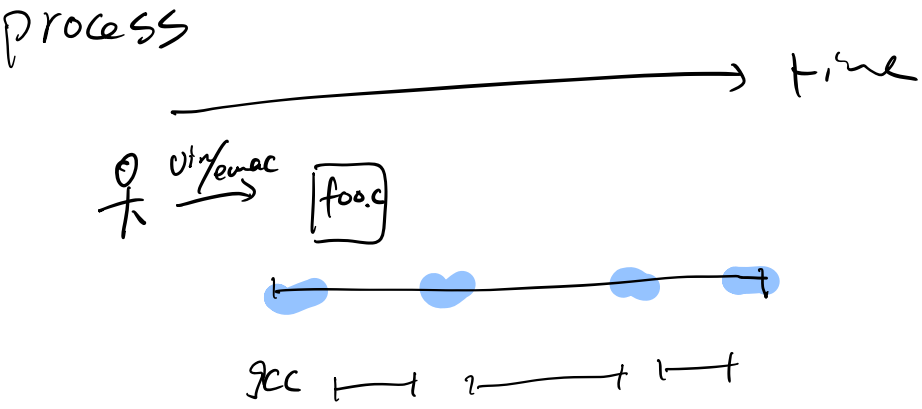
- DISCO. 1997
- VEE
- hardware, IPU, FPGA, GPU..

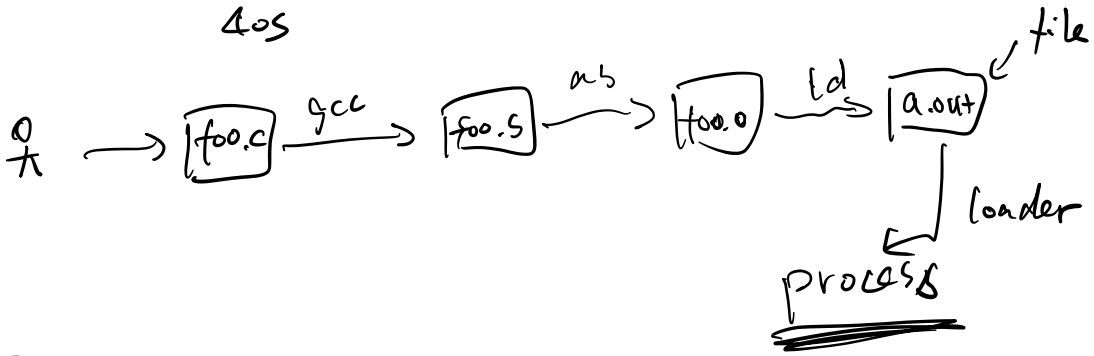


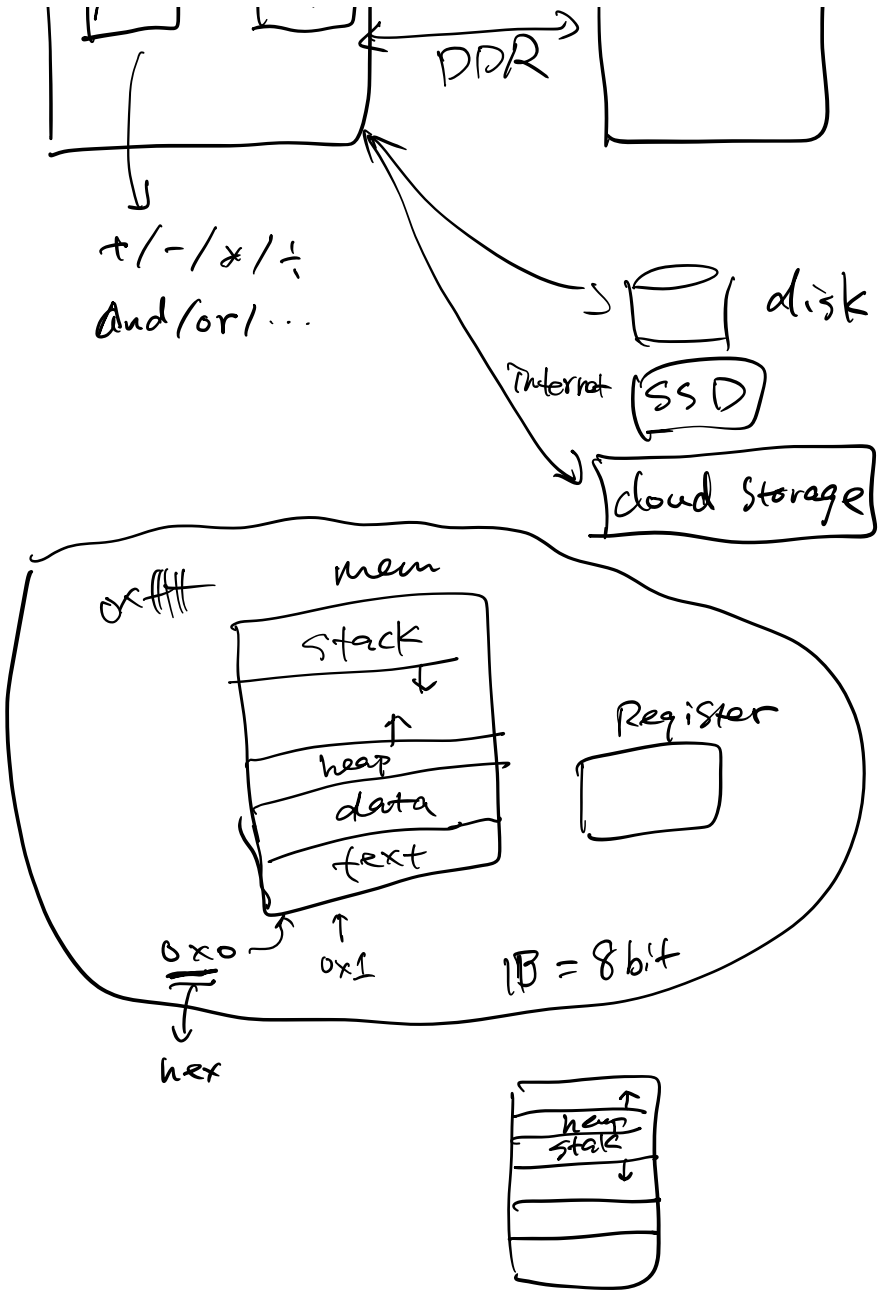
SmartNIC



process

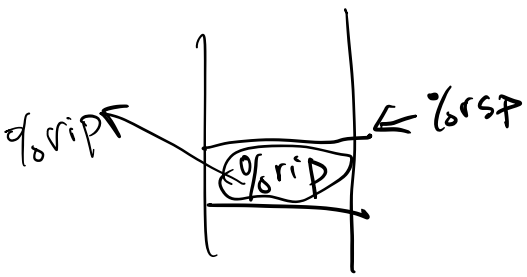





DDR
+/-/*/÷
and/or/...
disk
Internal
SSD
cloud storage
mem
0xffff
stack
heap
data
text
Register
0x0
0x1
1B = 8bit
hex
heap
stack

Crash course in x86-64 assembly + stack:

- `movq PLACE1, PLACE2`
- `pushq %rax` equivalent to :
  `[ subq $8, %rsp`
  `movq %rax, (%rsp) ]`
- `popq %rax` `[ movq (%rsp), %rax`
  `addq $8, %rsp ]`
- `call 0x12345` `[ pushq %rip`
  `movq $0x12345, %rip]`
  call foo
- `ret` `[ popq %rip ]`



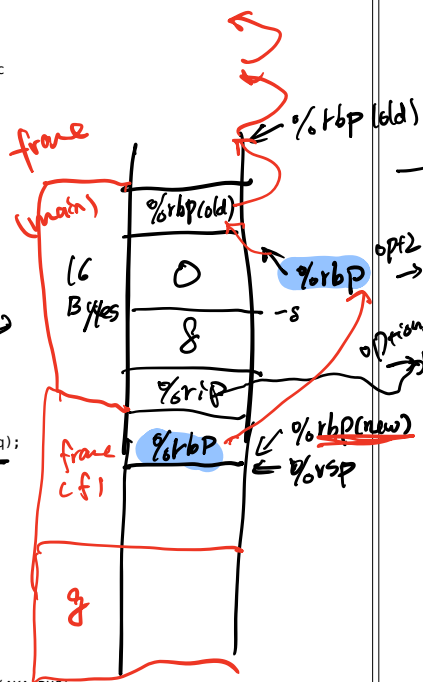
%rax = 0x12345

(%rax) = content of addr 0x12345

main
inst 1
%rip → inst 2

----------[example.c]----------

```
1   /* CS5600 -- handout w01a
2    * compile and run this code with:
3    * $ gcc -g -Wall -o example example.c
4    * $ ./example
5    *
6    * examine its assembly with:
7    * $ gcc -O0 -S example.c
8    * $ [editor] example.s
9    */
10
11  #include <stdio.h>
12  #include <stdint.h>
13
14  uint64_t f(uint64_t* ptr);
15  uint64_t g(uint64_t a);
16  uint64_t* q;
17
18  int main(void)
19  {
20      uint64_t x = 0;
21      uint64_t arg = 8;
22
23      x = f(&arg);
24
25      printf("x: %lu\n", x);
26      printf("dereference q: %lu\n", *q);
27
28      return 0;
29  }
30
31  uint64_t f(uint64_t* ptr)
32  {
33      uint64_t x = 0;
34      x = g(*ptr);
35      return x + 1;
36  }
37
38  uint64_t g(uint64_t a)
39  {
40      uint64_t x = 2*a;
41      q = &x; // <-- THIS IS AN ERROR (AKA BUG)
42      return x;
43  }
```



----------[as.txt]----------

```
1   2. A look at the assembly...
2
3   To see the assembly code that the C compiler (gcc) produces:
4   $ gcc -O0 -S example.c
5   (then look at example.s.)
6   NOTE: what we show below is not exactly what gcc produces. We have
7   simplified, omitted, and modified certain things.
8
9   main:
10      pushq %rbp              # prologue: store caller's frame pointer
11      movq %rsp, %rbp         # prologue: set frame pointer for new frame
12
13      subq $16, %rsp          # make stack space
14
15      movq $0, -8(%rbp)       # x = 0 (x lives at address rbp - 8)
16      movq $8, -16(%rbp)      # arg = 8 (arg lives at address rbp - 16)
17
18      leaq -16(%rbp), %rdi    # load the address of (rbp-16) into %rdi
19                              # this implements "get ready to pass (&arg)
20                              # to f"
21
22      call f                  # invoke f
23
24      movq %rax, -8(%rbp)     # x = (return value of f)
25
26      # eliding the rest of main()
27
28  f:
29      pushq %rbp              # prologue: store caller's frame pointer
30      movq %rsp, %rbp         # prologue: set frame pointer for new frame
31
32      subq $32, %rsp          # make stack space
33      movq %rdi, -24(%rbp)    # Move ptr to the stack
34                              # (ptr now lives at rbp - 24)
35      movq $0, -8(%rbp)       # x = 0 (x's address is rbp - 8)
36
37      movq -24(%rbp), %r8     # move 'ptr' to %r8
38      movq (%r8), %r9         # dereference 'ptr' and save value to %r9
39      movq %r9, %rdi          # Move the value of *ptr to rdi,
40                              # so we can call g
41
42      call g                  # invoke g
43
44      movq %rax, -8(%rbp)     # x = (return value of g)
45      movq -8(%rbp), %r10     # compute x + 1, part I
46      addq $1, %r10           # compute x + 1, part II
47      movq %r10, %rax         # Get ready to return x + 1
48
49      movq %rpb, %rsp         # epilogue: undo stack frame
50      popq %rbp               # epilogue: restore frame pointer from caller
51      ret                     # return
52
53  g:
54      pushq %rbp              # prologue: store caller's frame pointer
55      movq %rsp, %rbp         # prologue: set frame pointer for new frame
56
57      ....
58
59      movq %rbp, %rsp         # epilogue: undo stack frame
60      popq %rbp               # epilogue: restore frame pointer from caller
61      ret                     # return
```