Counting and Addressing: In-class Practice

ICS332

Operating Systems

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Counting

- How many 8KiB chunks in a 2MiB file?
- How many 32-byte elements in a 128KiB array?
- How many 4MiB images in a 256GiB digital library?
- How many 1GiB memory zones in a 16EiB memory?
  - Remember the sequence: GiB, TiB, PiB, EiB
- How many 4KiB pages in a 2GiB virtual address space?
  - Doesn’t matter that you don’t know what these are yet, since it’s the same for all “thingies”!

Counting

- How many 8KiB chunks in a 2MiB file?

$2 \times 2^{20} / 8 \times 2^{10} = 2^{21} / 2^{13} = \mathbf{2^{8}}$

- How many 32-byte elements in a 128KiB array?

$128 \times 2^{10} / 2^{5} = 2^{17} / 2^{5} = \mathbf{2^{12}}$

- How many 4MiB images in a 256GiB digital library?

$256 \times 2^{30} / 4 \times 2^{20} = 2^{38} / 2^{22} = \mathbf{2^{16}}$

- How many 1GiB memory zones in a 16EiB memory?

$16 \times 2^{60} / 1 \times 2^{30} = 2^{64} / 2^{30} = \mathbf{2^{34}}$

- How many 4KiB pages in a 2GiB virtual address space?

$2 \times 2^{30} / 4 \times 2^{10} = 2^{31} / 2^{12} = \mathbf{2^{19}}$

Addressing (1)

- How many address bits do you need to address 17 distinct bytes?
- With 10-bit addresses can I address each byte in a MiB?
- With 3-bit addresses can I address 6 eggplants?
- With 8-bit addresses I can address at most twice as many firetrucks as with 4-bit addresses? True or False?
- With x-bit addresses I can address 4 times as many files as with y-bit addresses, and with y-bit addresses I can address each byte in a KiB. What's x?

Addressing (1)

- How many address bits do you need to address 17 distinct bytes?

$\lceil \log 17 \rceil = 5$ address bits

- With 10-bit addresses can I address each byte in a MiB?

No, because you'd need 20-bit addresses

- With 3-bit addresses can I address 6 eggplants?

Yes, because $\log_2 6 < 3$ (because $6 < 2^8$)

- With 8-bit addresses I can address at most twice as many firetrucks as with 4-bit addresses? True or False?

FALSE! 2^8 is way more than twice 2^4

- With x-bit addresses I can address 4 times as many files as with y-bit addresses, and with y-bit addresses I can address each byte in a KiB. What's x?

$x = y + 2$ and $y = 10$, so $x = 12$

Addressing (2)

- How many address bits do you need to address each...
  - byte in a 2MiB memory?
  - 4-byte word in a 1MiB memory?
  - 4KiB page in a 16MiB address space?
  - 1MiB file in a 4GiB file system?
- The approach is straightforward:
  - Determine how many thingies you need to address as a power of 2
  - Take the $\log_2$

Addressing (2)

- byte in a 2MiB memory?
  - We have $2 \times 2^{20} = 2^{21}$ bytes
  - We need 21-bit addresses
- 4-byte word in a 1MiB memory?
  - We have $1 \times 2^{20} / 4 = 2^{18}$ words
  - We need 18-bit addresses
- 4KiB page in a 16MiB address space?
  - We have $16 \times 2^{20} / 4 \times 2^{10} = 2^{24} / 2^{12} = 2^{12}$ pages
  - We need 12-bit addresses
- 1MiB file in a 4GiB file system?
  - We have $4 \times 2^{30} / 1 \times 2^{20} = 2^{12}$ files
  - We need 12-bit addresses

Back to the Parking Lot

- Say we have a parking lot with 800 spots, and we structure them in blocks of 10 spots
- What is the index of spot 312 in its block?
- In what block is spot 145?
- What is the global index of spot 8 in block 12?

Back to the Parking Lot

- Say we have a parking lot with 800 spots, and we structure them in blocks of 10 spots

- What is the index of spot 312 in its block?
  - 2
- In what block is spot 145?
  - 14
- What is the global index of spot 8 in block 12?
  - 128

There is No Parking Lot

- Say we have a sequence of N thingies, structured in blocks of n consecutive thingies
- What is the index of thingy x in its block?
- In what block is thingy y?
- What is the global index of thingy a in block b?

There is No Parking Lot

- Say we have a sequence of N thingies, structured in blocks of n consecutive thingies
- What is the index of thingy x its block?
  - x mod n
- In what block is thingy y?
  - x / n
- What is the global index of thingy a in block b?
  - b x n + a

Conclusion

- This should be enough practice
- But if it's not, it's easy to make up more practice examples (by yourselves, or during office hours)