Chapter 4

Exercises 4, 6, 11, and 15.

Exercise 4 : Memory

1. a) **byte addressable**

$M = 2^{20}$

$2M \times 4\ byte\ word = 2^{20} * 2^2 * 2^1 = 2^{23}$

$\log_2 2^{23} = 23$ bits to address

2. b) **word addressable**

$M = 2^{20}$

$2M \times 32\ bit\ word = 2^{20} * 2^1 = 2^{21}$

$\log_2 2^{21} = 21$ bits to address

Exercise 6 : Memory

1. a) **byte addressable**

$M = 2^{20}$

$1M \times 1\ byte\ word = 2^{20} = 2^{20}$

$\log_2 2^{20} = 20$

21 bits to address

2. b) **word addressable**

$M = 2^{20}$

$1M \times 8\ bit\ word = 2^{20} * 2^0 = 2^{20}$

$\log_2 2^{20} = 20$ bits to address

Exercise 11 : Memory

11. Redo exercise 10 assuming a 16M × 16 memory built using 512K × 8 RAM chips.

- Suppose that a 16M × 16 main memory is built using 512K × 8RAM chips and that memory is word addressable.

1. a) How many RAM chips are necessary?

$16M = 2^{20} * 2^4 = 2^{24}$
$512K = 2^{10} * 2^9 = 2^{19}$
$\text{number of chips} = \frac{2^{24} \times 16}{2^{19} \times 8} = 64$

2. b) If we were accessing one full word, how many chips would be involved?

2 chips would be required because there are two bytes per 16 bit word

3. c) How many address bits are needed for each RAM chip?

$log_2 512 =$ **19 address bits**

4. d) How many banks will this memory have?

$log_2 2^{24} \div 2^{19} = 5\ address\ bits\ required$

5. e) How many address bits are needed for all memory?

$log_2 2^{24} =$ **24 address bits**

6. f) If high-order interleaving is used, where would address 14 (which is E in hex) be located?

High order interleaving results in sequential addressing across all available chips. address 14 is less than 512 so it will exist in the first chip.

7. g) Repeat exercise 9f for low-order interleaving.

low order interleaving results in a chip change for every increment in address, so address 14 will exist as the first word in chip 14

Exercise 12 : Memory

2. L. Suppose we have 1G × 16 RAM chips that make up a 32G × 64 memory that uses high interleaving. (Note: This means that each word is 64 bits in size and there are 32G of these words.)

   M. a) How many RAM chips are necessary?

$G = 2^{30}$
$32G = 2^{30} \times 2^5 = 2^{35}$
$\text{number of chips} = \frac{2^{35} \times 64}{2^{35} \times 16} = 4$

In [22]:
```
from latex2sympy2 import latex2sympy, latex2latex
from sympy import *

tex = r"\frac{2^{35}*64}{2^{35}*16} "
val = latex2sympy(tex)
val.evalf()
```

Out[22]: 4.0

Exercise 15 : Memory

Assume a 2^{20} byte memory.

1. a) What are the lowest and highest addresses if memory is byte addressable?

$2^{20} bytes = 1M \times 8$
$0x00 \rightarrow\ 11111111111111111111 = 0xfffff$

2. b) What are the lowest and highest addresses if memory is word addressable, assuming a 16-bit word?

$L = \frac{2^{20} \times 8}{2^4} = 2^{19}$
$0x00 \rightarrow\ 01111111111111111111 = 0x7ffff$

3. c) What are the lowest and highest addresses if memory is word addressable, assuming a 32-bit word?

$L = \frac{2^{20} \times 8}{2^5} = 2^{18}$
$0x00 \rightarrow\ 00111111111111111111 = 0x3ffff$

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