Virginia Tech
ECE 5484: Fundamentals of Computer Systems

Memory Organization Examples

Consider each of the memory units specified below. For each, indicate: (a) the total number of bytes in the memory; (b) the number of address lines needed if the memory is byte addressable; (c) the total number of words in the memory; and (d) the number of address lines if the memory is word addressable.

Note that, 1K = 2^{10} = 1024, 1M = 2^{20} = 1,048,576, and 1G = 2^{30} = 1,073,741,824.[1]

1. 2K × 16 (word size is 16 bits or 2 bytes)
   a) Number of bytes: $2 \times 2^{10} \times 2 = 4K = 4{,}096$ bytes
   b) Number of address lines (byte addressable): $4096 = 2^{12} \Rightarrow$ 12 address lines
   c) Number of words: $2 \times 2^{10} = 2K = 2{,}048$ words
   d) Number of address lines (word addressable): $2048 = 2^{11} \Rightarrow$ 11 address lines

2. 64K × 8 (word size is 8 bits or 1 byte)
   a) Number of bytes (and words): $64 \times 2^{10} = 64K = 65{,}536$ bytes
   b) Number of address lines (byte or word addressable): $64 \times 2^{10} = 2^6 \times 2^{10} = 2^{16} \Rightarrow$ 16 address lines
   c) See (a) above
   d) See (b) above

3. 16M × 32 (word size is 32 bits or 4 bytes)
   a) Number of bytes: $16 \times 2^{20} \times 4 = 64M = 67{,}108{,}864$ bytes
   b) Number of address lines (byte addressable): $16 \times 2^{20} \times 4 = 2^4 \times 2^{20} \times 2^2 = 2^{26} \Rightarrow$ 26 address lines
   c) Number of words: $16 \times 2^{20} = 16M = 16{,}777{,}216$ words
   d) Number of address lines (word addressable): $16 \times 2^{20} = 2^4 \times 2^{20} = 2^{24} \Rightarrow$ 24 address lines

3. 4G × 64 (word size is 64 bits or 8 bytes)
   a) Number of bytes: $4 \times 2^{30} \times 8 = 32G = 34{,}359{,}738{,}368$ bytes
   b) Number of address lines (byte addressable): $4 \times 2^{30} \times 8 = 2^2 \times 2^{30} \times 2^3 = 2^{35} \Rightarrow$ 35 address lines
   c) Number of words: $4 \times 2^{30} = 4G = 4{,}294{,}967{,}296$ words
   d) Number of address lines (word addressable): $4 \times 2^{30} = 2^2 \times 2^{30} = 2^{32} \Rightarrow$ 32 address lines

[1] This is the standard convention for specifying memory sizes. Note that communication systems typically use 1K = 10^3, 1M = 10^6, and 1G = 10^9. For example, a 10 megabit, or 10 Mb, memory would hold 10×2^{20} or 10,485,760 bits, but a 10 megabit per second, or 10 Mbps, link can carry 10,000,000 bits per second.