Binary Number Basics

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Binary Number Basics

- Base 10 (decimal)
  - The most familiar base for most people
    - ones, tens, hundreds, thousands
    - tenths, hundredths, thousandths
  - Base 10 → 10 individual digits
    - Range of individual digit: 0 → 9
  - Each position to the left of the decimal point is 10X the previous position
  - Each position to the right of the decimal point is 1/10th the previous position

1	3	9	4	.	6	2	7
Thousands	Hundreds	Tens	Ones	decimal point	tenths	hundredths	thousandths

1	3	9	4	.	6	2	7
digit x 10^3	digit x 10^2	digit x 10^1	digit x 10^0	decimal point	digit x 10^{-1}	digit x 10^{-2}	digit x 10^{-3}

Binary Number Basics

- Base 2 (binary)
  - The most common base for digital electronics
    - ones, twos, fours, eights
    - halves, quarters, eighths
  - Base 2 → 2 individual digits
    - Range of individual digit: 0 → 1
  - Each position to the left of the binary point is 2X the previous position
  - Each position to the right of the binary point is 1/2 the previous position

1	1	0	1	.	1	0	1
Eights	Fours	Twos	Ones	binary point	Halves	Quarters	Eighths

1	1	0	1	.	1	0	1
digit x 2^3	digit x 2^2	digit x 2^1	digit x 2^0	binary point	digit x 2^{-1}	digit x 2^{-2}	digit x 2^{-3}

Binary Number Basics

- Binary Bit Values

Note: we start counting bits at 0

Right to Left

bit #		Value ($2^{bit\ \#}$)
31	1	2,147,483,648
30	0	1,073,741,824
29	1	536,870,912
28	1	268,435,456
27	1	134,217,728
26	0	67,108,864
25	1	33,554,432
24	1	16,777,216
23	1	8,388,608
22	0	4,194,304
21	0	2,097,152
20	0	1,048,576
19	1	524,288
18	0	262,144
17	0	131,072
16	0	65,536
15	0	32,768
14	1	16,384
13	1	8,192
12	0	4,096
11	0	2,048
10	1	1,024
9	0	512
8	0	256
7	1	128
6	1	64
5	0	32
4	0	16
3	0	8
2	1	4
1	1	2
0	1	1

Binary Point

bit #		Value ($2^{-bit\ \#}$)
1	1	0.5
2	1	0.25
3	0	0.125
4	0	0.0625
5	0	0.03125
6	0	0.015625
7	1	0.0078125
8	0	0.00390625

Left to Right

Binary Number Basics

- Exponential shorthand

- Use of K, M, G, T is situationally dependent
  - In science and math:
    - K = x10^3 — Kilo
    - M = x10^6 — Mega
    - G = x10^9 — Giga
    - T = x10^{12} — Tera
  - In computer and digital systems:
    - K = x2^{10} = x1,024 — Kilo — Kibo
    - M = x2^{20} = x1,048,576 — Mega — Mebi
    - G = x2^{30} = x1,073,741,824 — Giga — Gibi
    - T = x2^{40} = x1,099,511,627,776 — Tera — Tebi

(Kibo, Mebi, Gibi, Tebi: occasionally used)

Binary Number Basics

- Exponential shorthand - examples

$2^{12} \rightarrow 2^{10} * 2^{2} \rightarrow 4K$

$2^{34} \rightarrow 2^{30} * 2^{4} \rightarrow 16G$

$2^{23} \rightarrow 2^{20} * 2^{3} \rightarrow 8M$

$2M \rightarrow 2^{20} * 2^{1} \rightarrow 2^{21}$

$1K \rightarrow 2^{10} * 2^{0} \rightarrow 2^{10}$

$32G \rightarrow 2^{30} * 2^{5} \rightarrow 2^{35}$