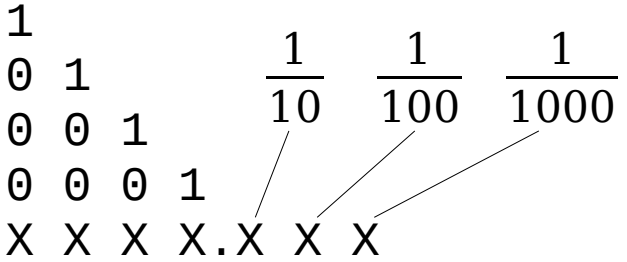
Lecture 8

Numbers & CPUs

Decimal Numbers

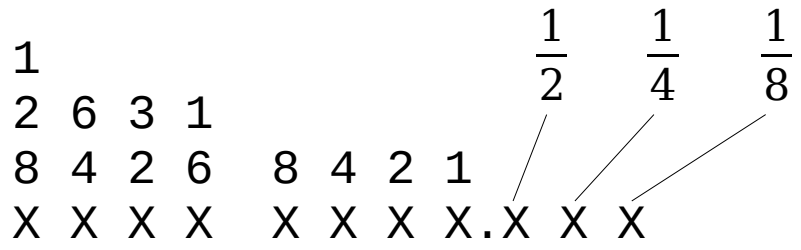


Binary Numbers

```
          1
          2 6 3 1
          8 4 2 6   8 4 2 1
          X X X X   X X X X
```

```
1       0000 0001
2       0000 0010
4       0000 0100
8       0000 1000
15      0000 1111
212     1101 0100
```

Binary Numbers



1	0000 0001
2	0000 0010
4	0000 0100
8	0000 1000
15	0000 1111
212	1101 0100
0.25	0000 0000.010
0.625	0000 0000.101
0.3	0000 0000.0100 1100 1100 ...

IEEE Floating Point

• Single (float)	1/24/8 bits	7 digits	10^{38}
• Double	1/53/11 bits	15 digits	10^{308}
• Long Double	1/64/16 bits	18 digits	10^{9864}

Single:

SEEEEEEE EMMMMMMM MMMMMMMM MMMMMMMM

S – Sign bit 0=+

E – Exponent, bias 127

M – Significand (Mantissa), implicit 1 when normalized

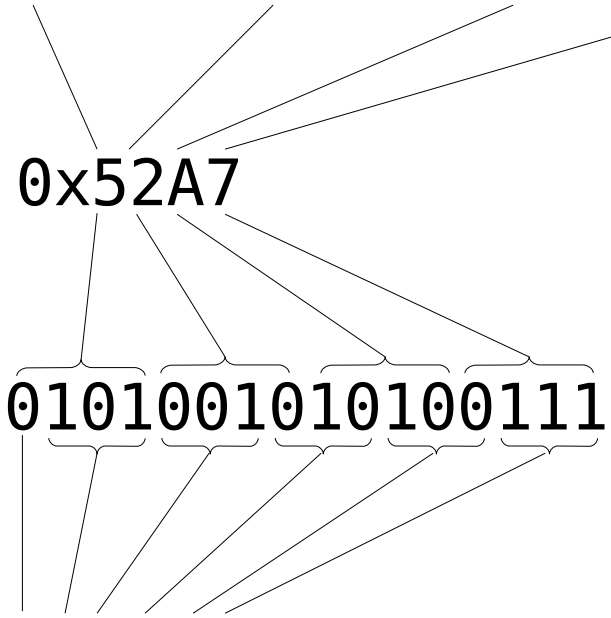
Bases

Decimal `5*4096+2*256+10*16+7 = 21159`

Hexadecimal `0x52A7`

Binary `0101001010100111`

Octal `051247`

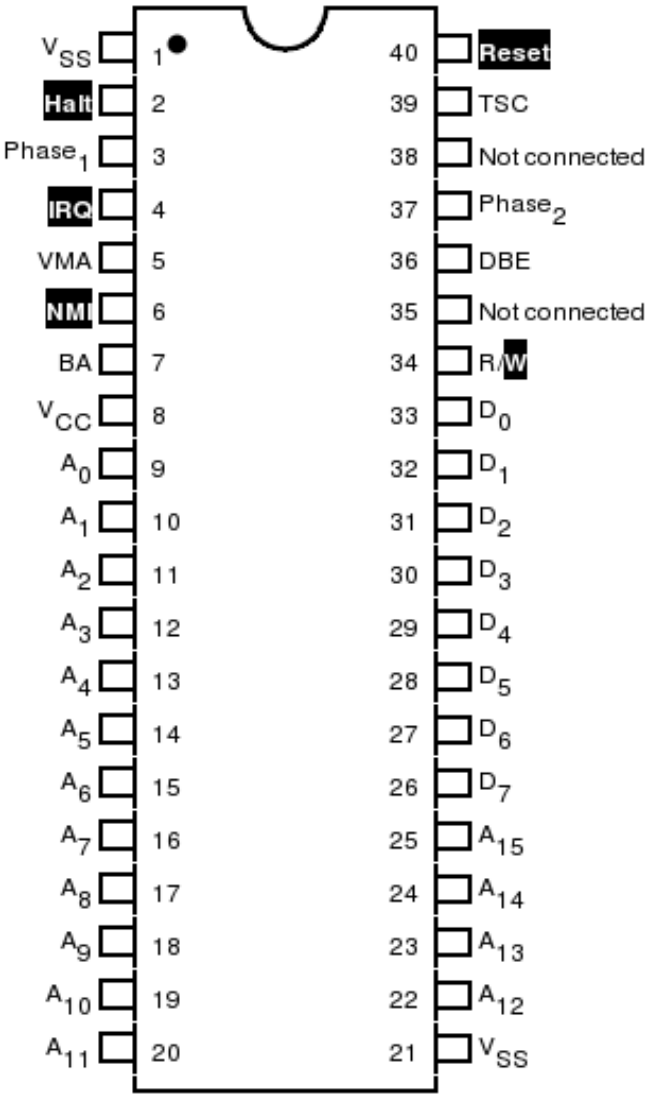


Digital Representation of Numbers

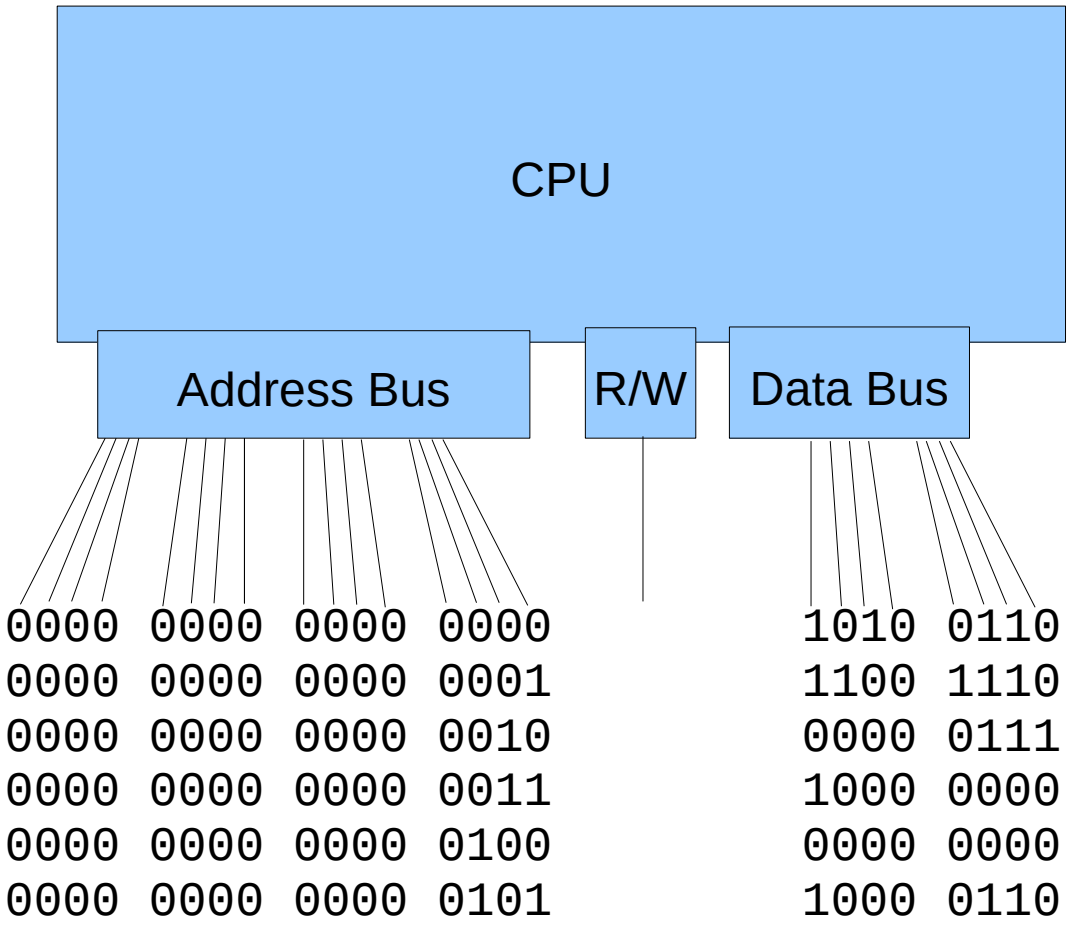
• Bit		0-1
• Nibble	(4 bits)	0-15
• Byte (char)	(8 bits)	0-255
• Word (short)	(16 bits)	0-65,535
• Longword (long)	(32 bits)	0-4,294,967,296
• Long Longword	(64 bits)	$0\text{-}1.844 \times 10^{19}$
• Float	(32 bits)	10^{38}
• Double	(64 bits)	10^{308}

Motorola 6800 CPU

- 72 instructions (197 opcodes)
- 8 bit data bus (0-255)
- 16 bit address bus (64k max RAM)
- 6 registers:
  - 8 bit ACCA
  - 8 bit ACCB
  - 16 bit IX
  - 16 bit PC
  - 16 bit SP
  - 6 bit CC



CPU Communications



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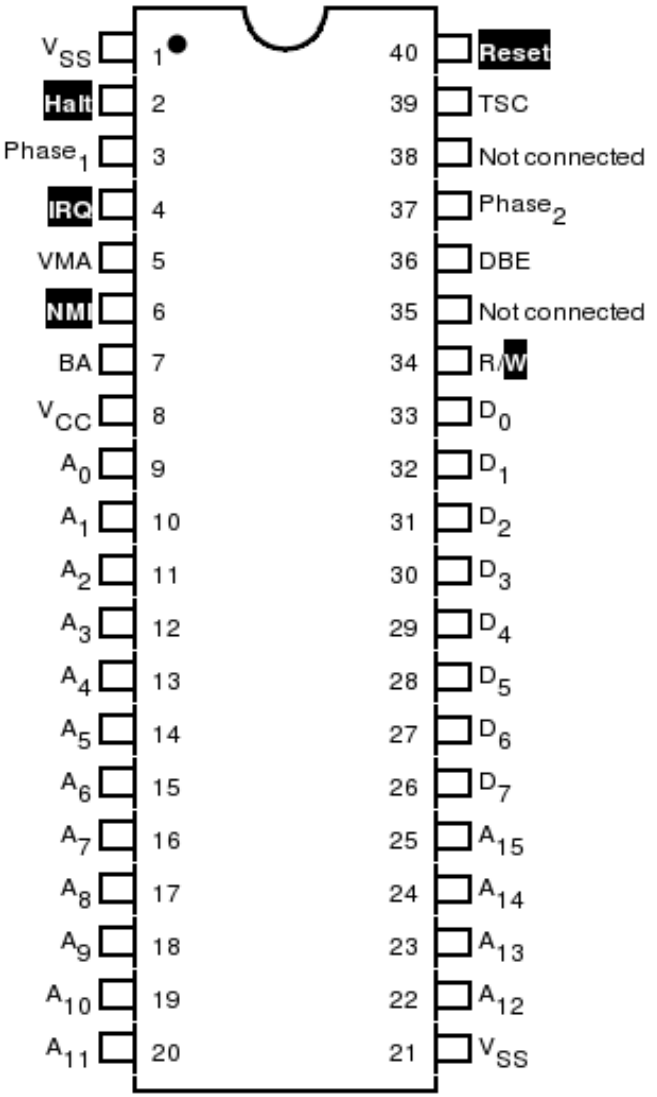


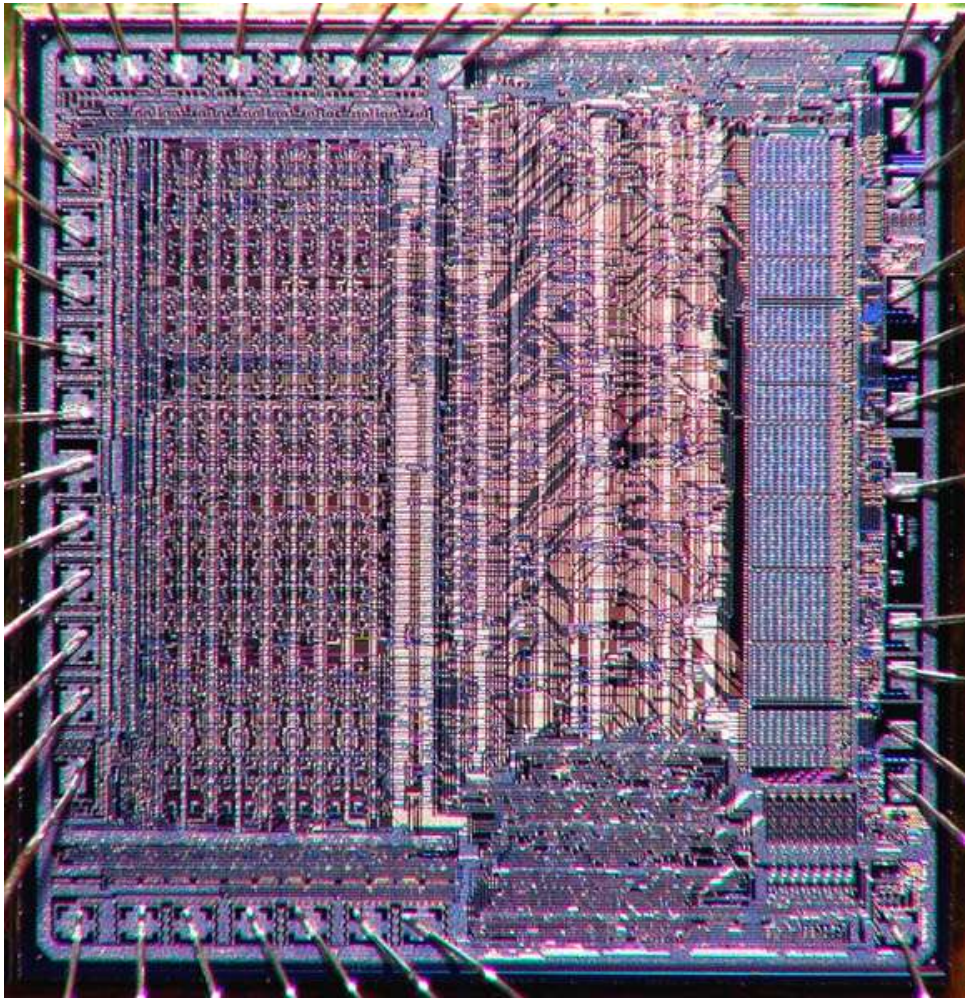
6800 Assembly Language

```
33+10/2

Memory:
0000: 1000 0110     LDA
0001: 0010 0001     33          33 -> ACCA
0002: 1000 1011     ADDA
0003: 0000 1010     10          43 -> ACCA
0004: 0100 0110     RORA        21 -> ACCA
0005: 1001 0111     STAA
0006: 0000 1010     10          ACCA -> mem(10)
...
000A: 0001 0101
```

6800 CPU

- Introduced 1974
- 4000 transistors
- 1.0-2.5 MHz
- 3, 8 bit registers
- 3, 16 bit registers



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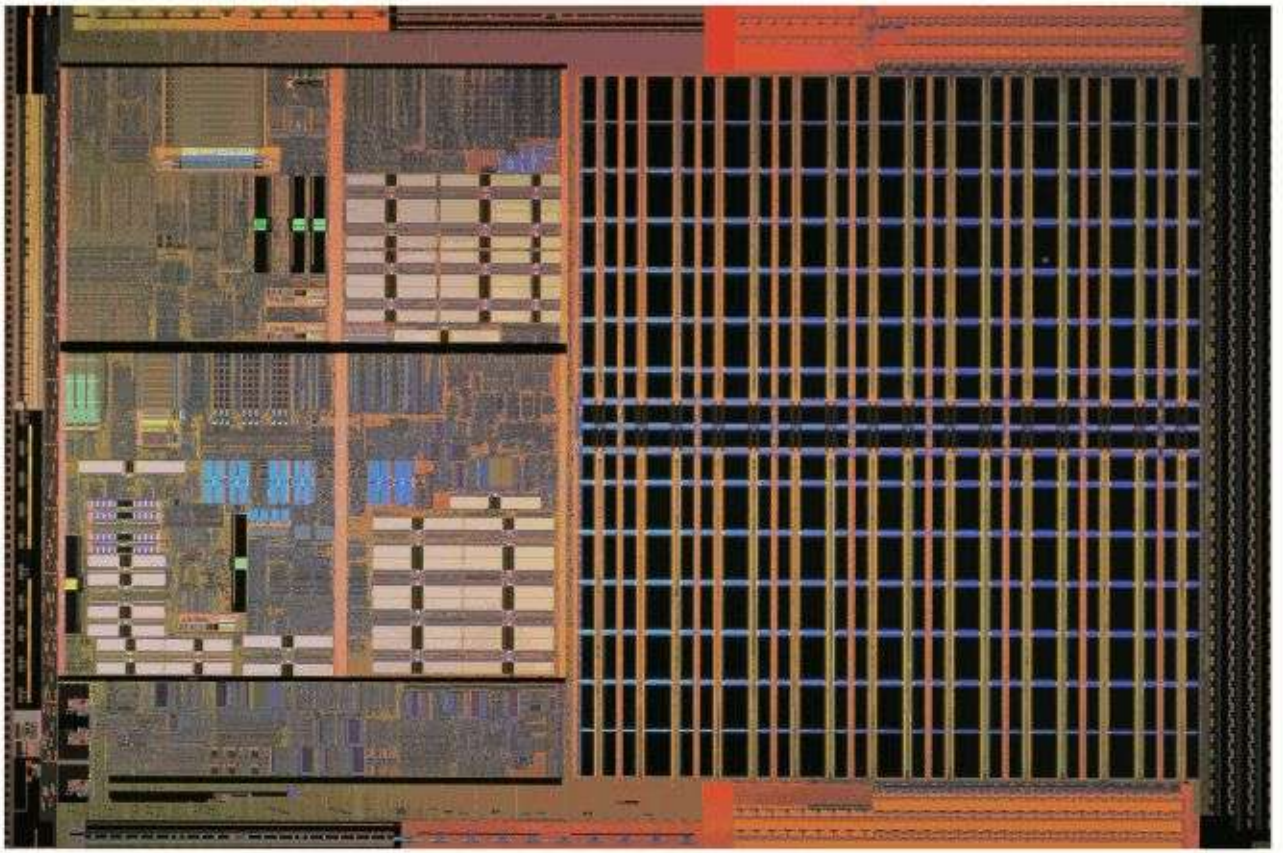
Athlon-64

- ~106 million transistors (~10 m^3 if individually packaged)
- Socket-939 (939 pins)
- 40 bit addressing (1 TB)
- 64 bit data bus
- ~2 GHz
- registers:
- 16, 64 bit integer
- 16, 128 bit 'media'
- 8, 64 bit float



Opteron Execution Units