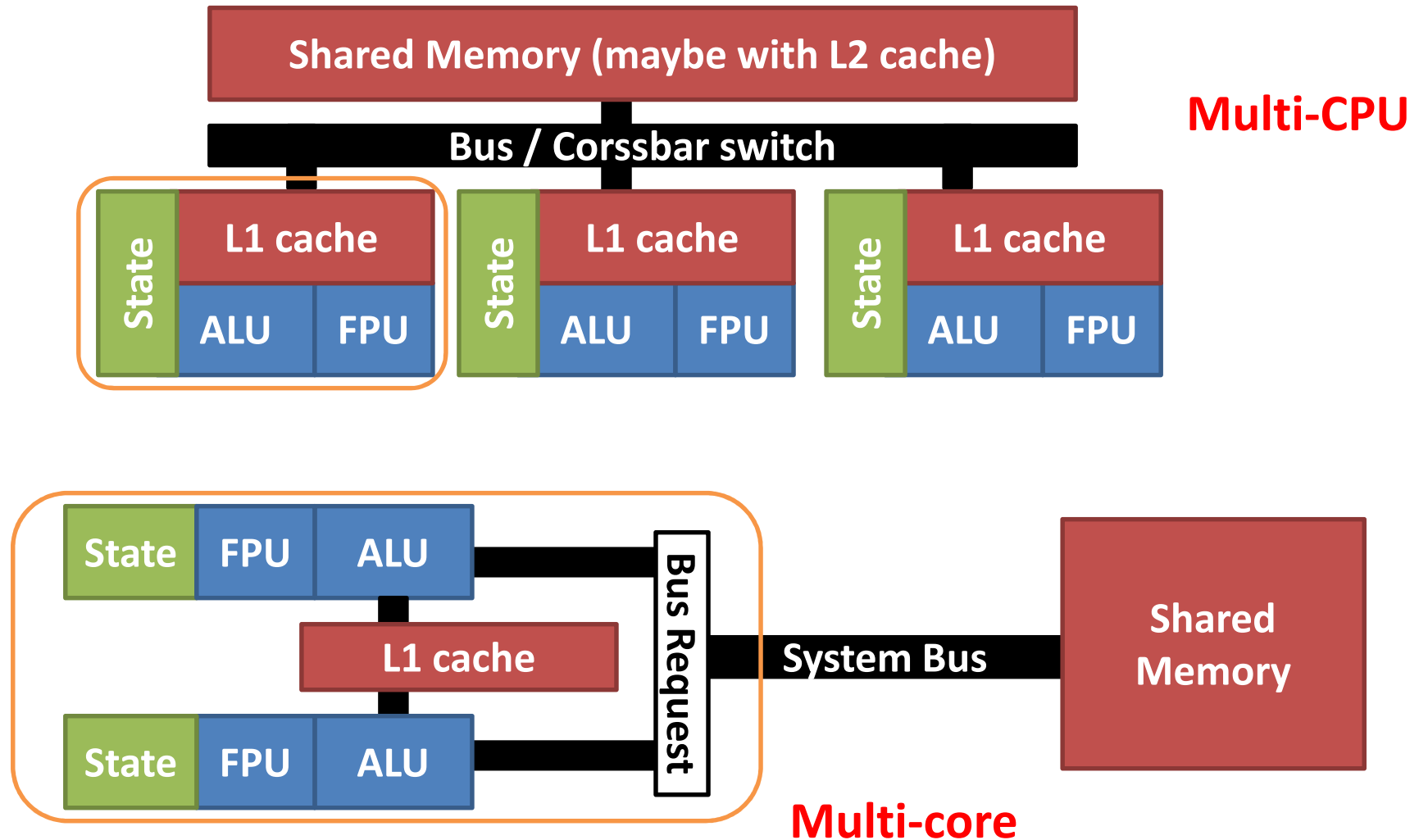


CSL 860: Modern Parallel Computation

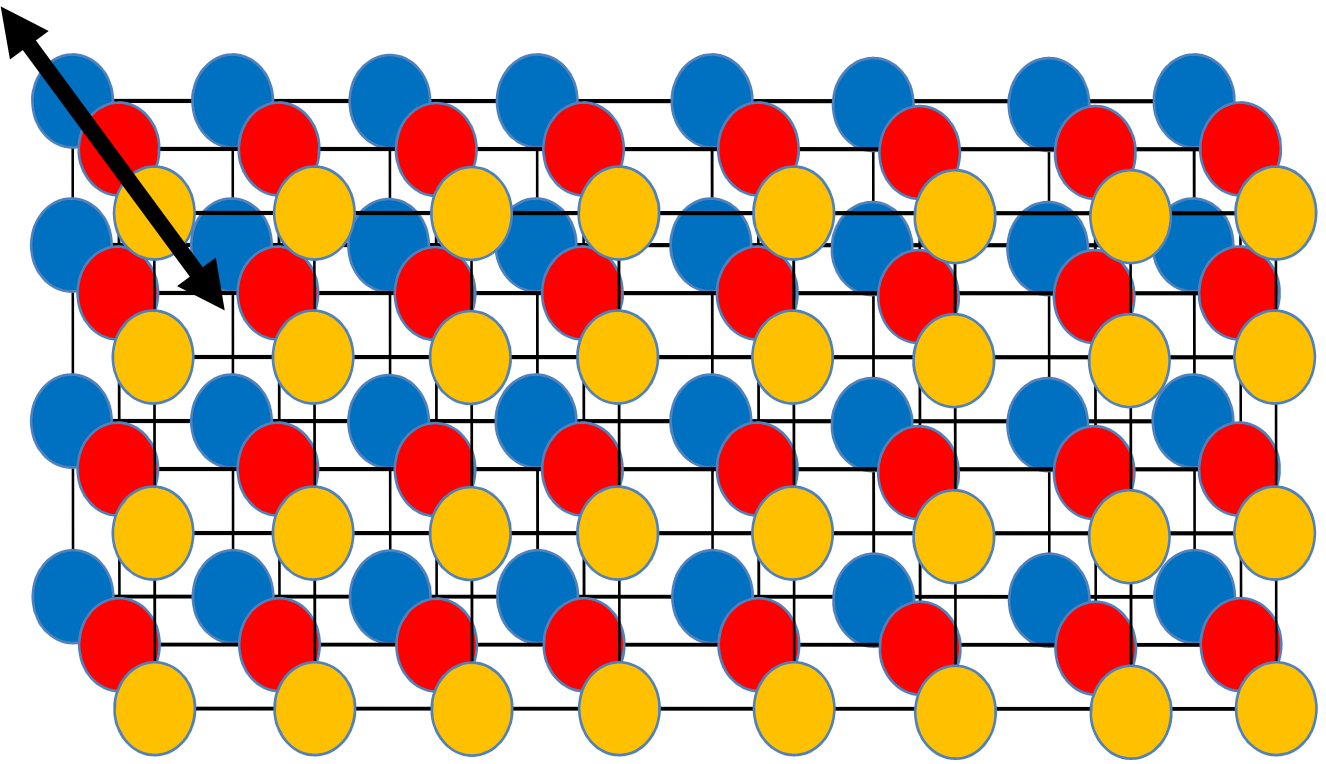
Categories of Processing

- Flynn's classification
- Granularity
 - Coarse grain: Cray C90, Fujitsu
 - small number of very powerful processors
 - Fine grain: CM-2, Quadrics
 - Large number of relatively less powerful processors
 - Medium grain: IBM SP2, CM-5
 - between the two extremes.
 - Communication cost \gg computational cost \rightarrow coarse grain
 - Communication cost \ll computational cost \rightarrow fine grain
- Address Space Organization
 - Single/shared address space
 - Uniform Memory Address: SMP (UMA)
 - Non Uniform Memory Address (NUMA)
 - Distributed memory
 - Message passing

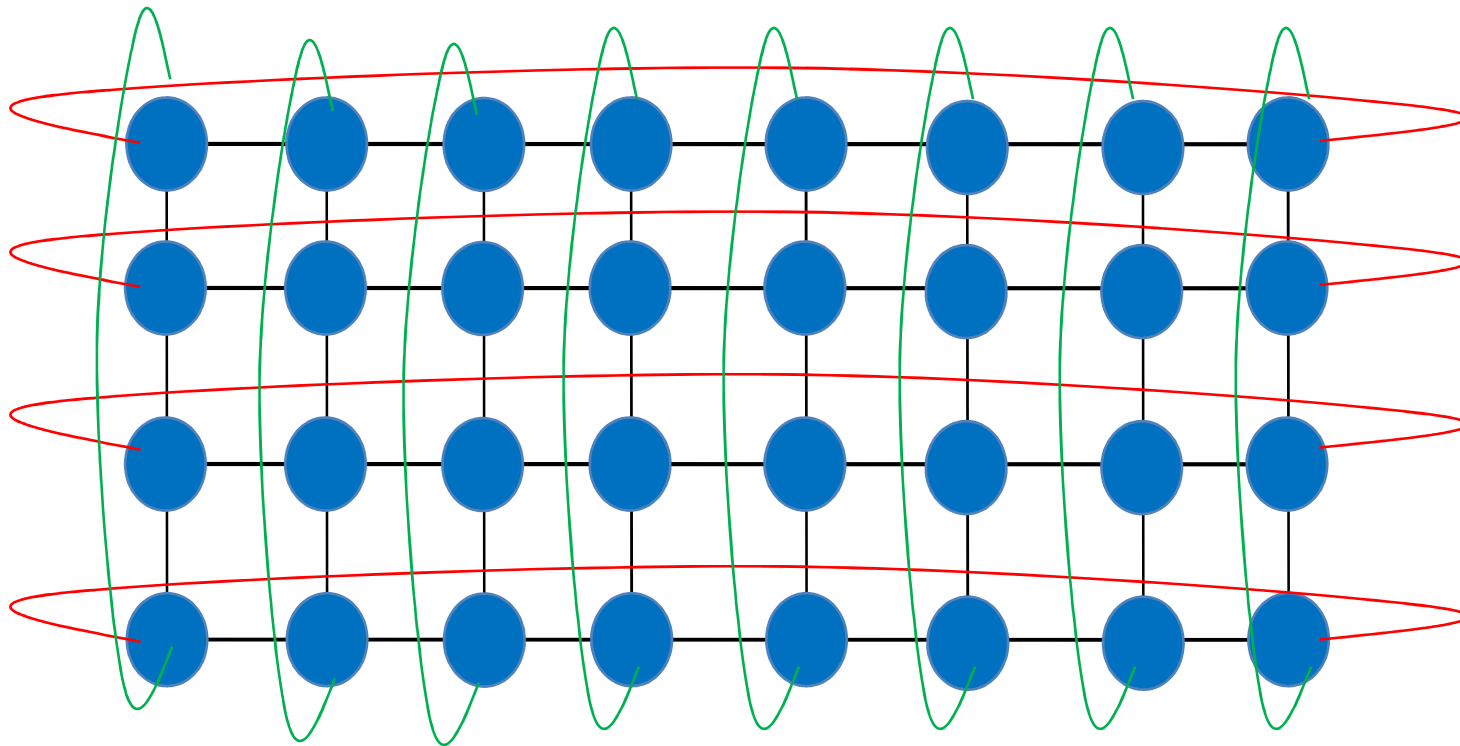
Modern Multi-Processor



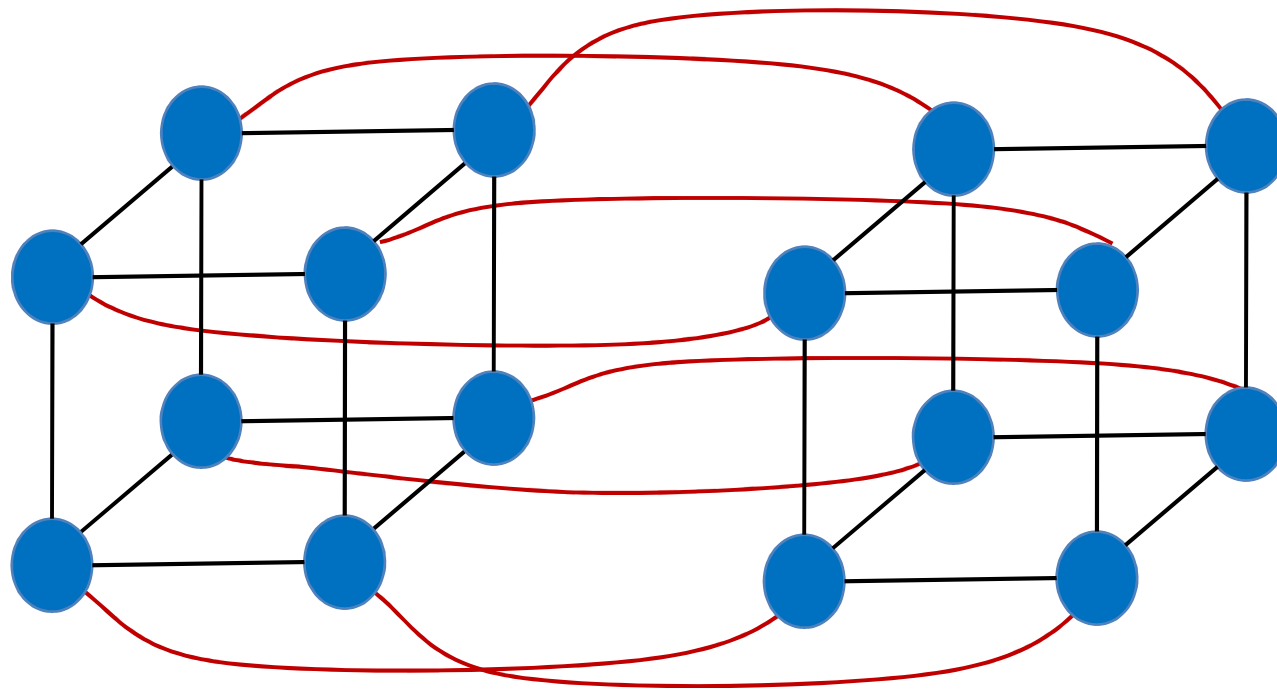
n-dim Grid/Mesh



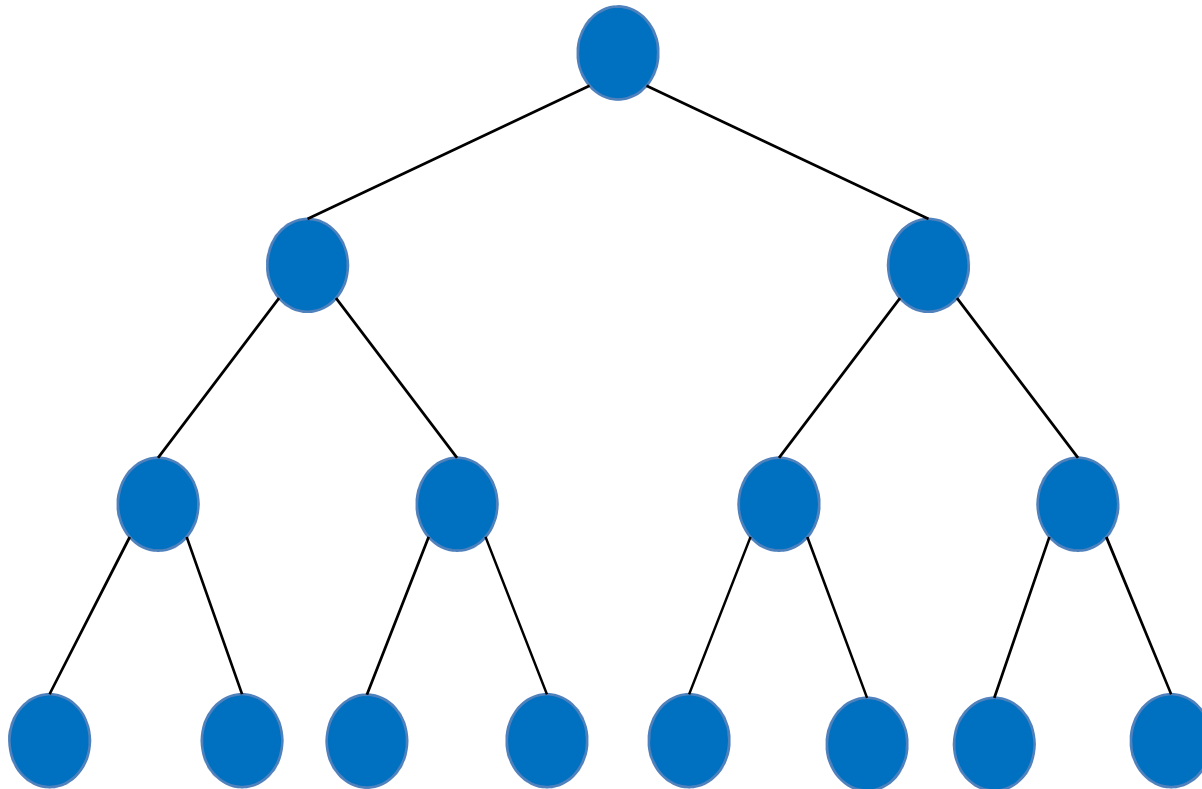
Torus



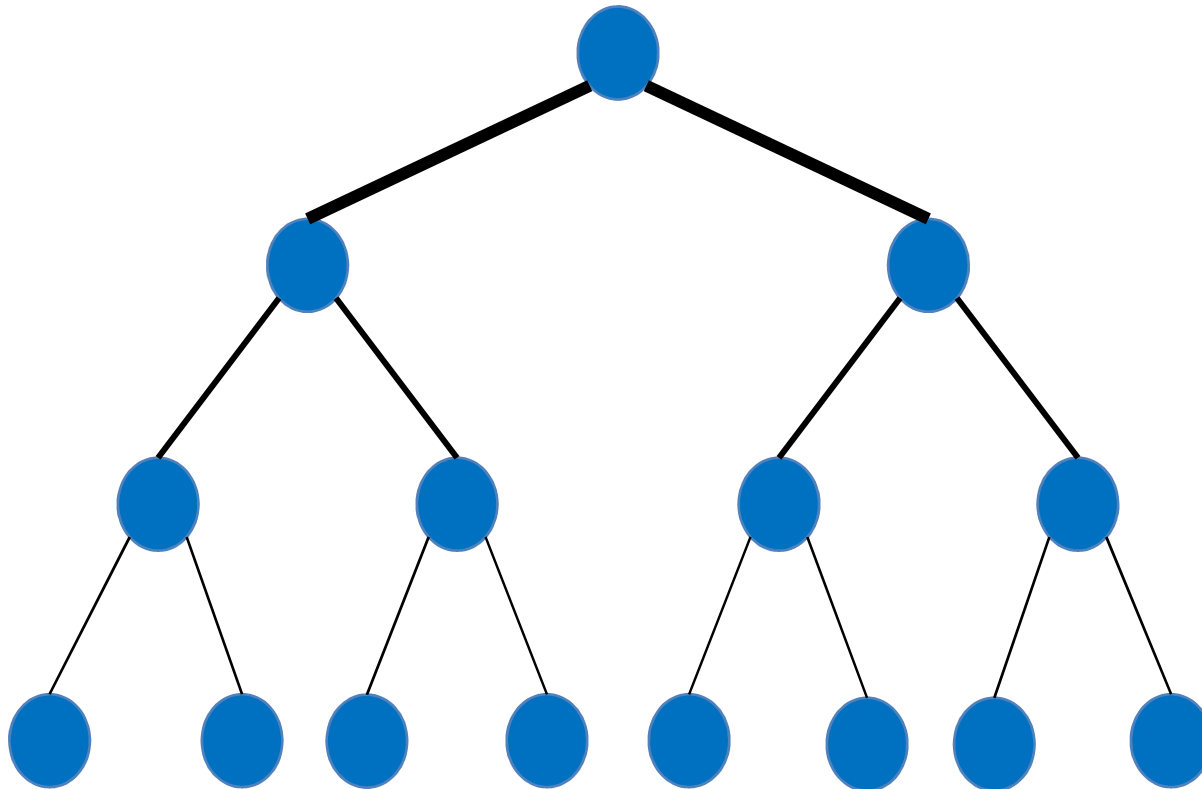
Hypercube



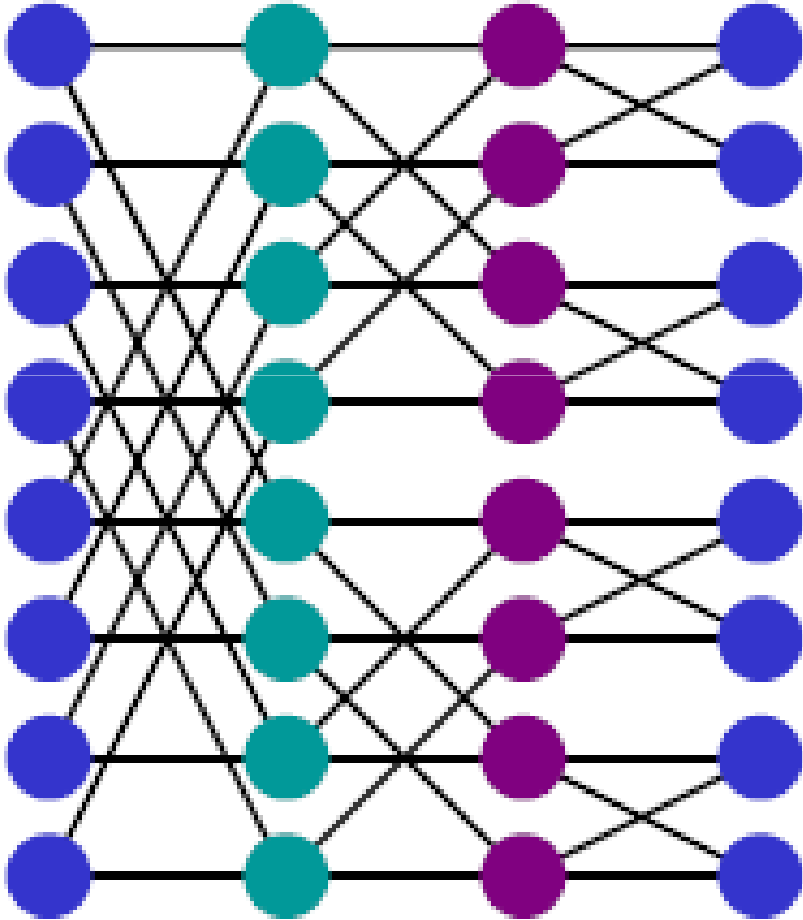
Tree Network



Fat Tree Network



Butterfly



Current Computer Speed

- ~15 Gflop/core
- ~60 Gflop for Quad-core
- ~3GHz clocks
- ~\$1000

Cray

- Late 70s
- Small # vector processors
- \$9 million
- 80 MHz clock
- Later (Early 80s)
 - 105 to 117 MHz clock
 - 800 megaflops for 4-processor machine
 - \$15-20 million

Connection Machine

- CM-2 (SIMD)
 - Host connected
 - ~1989
 - 64k single-bit SIMD processors connected in hypercube, plus 2K Weitek floating point units).
 - 8 MHz clock
 - 6 GFLOPS
 - 400 MFLOPS per million dollars
 - Hypercube architecture
 - \$15 million
- CM-5 (MIMD)
 - ~1991
 - Fat tree network of 896 SPARC RISC processors

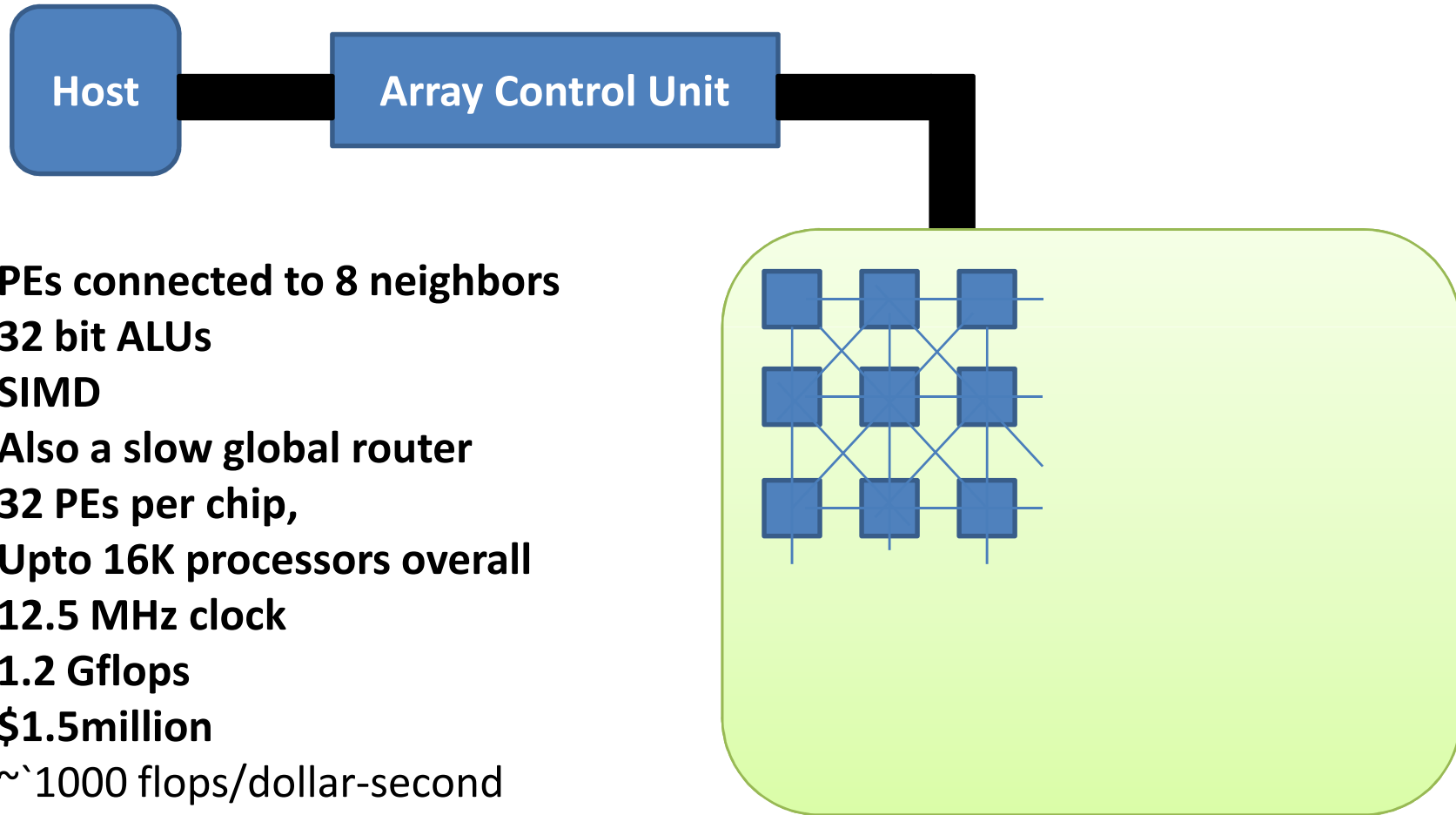
nCube

- nCube 2 costs between \$500,000 and \$2m
 - \$2m for 27 GFLOPS machine

nCube3 (1994):

- 50 MHz
- Processor Module: 512 nodes and 32 GB memory
 - Up to 20 Modules for 1.0 TFLOP system of 10,240 nodes
 - \$40 million
 - \$40,000/Gflop

Maspar



PEs connected to 8 neighbors

32 bit ALUs

SIMD

Also a slow global router

32 PEs per chip,

Upto 16K processors overall

12.5 MHz clock

1.2 Gflops

\$1.5million

~1000 flops/dollar-second

Early 90s

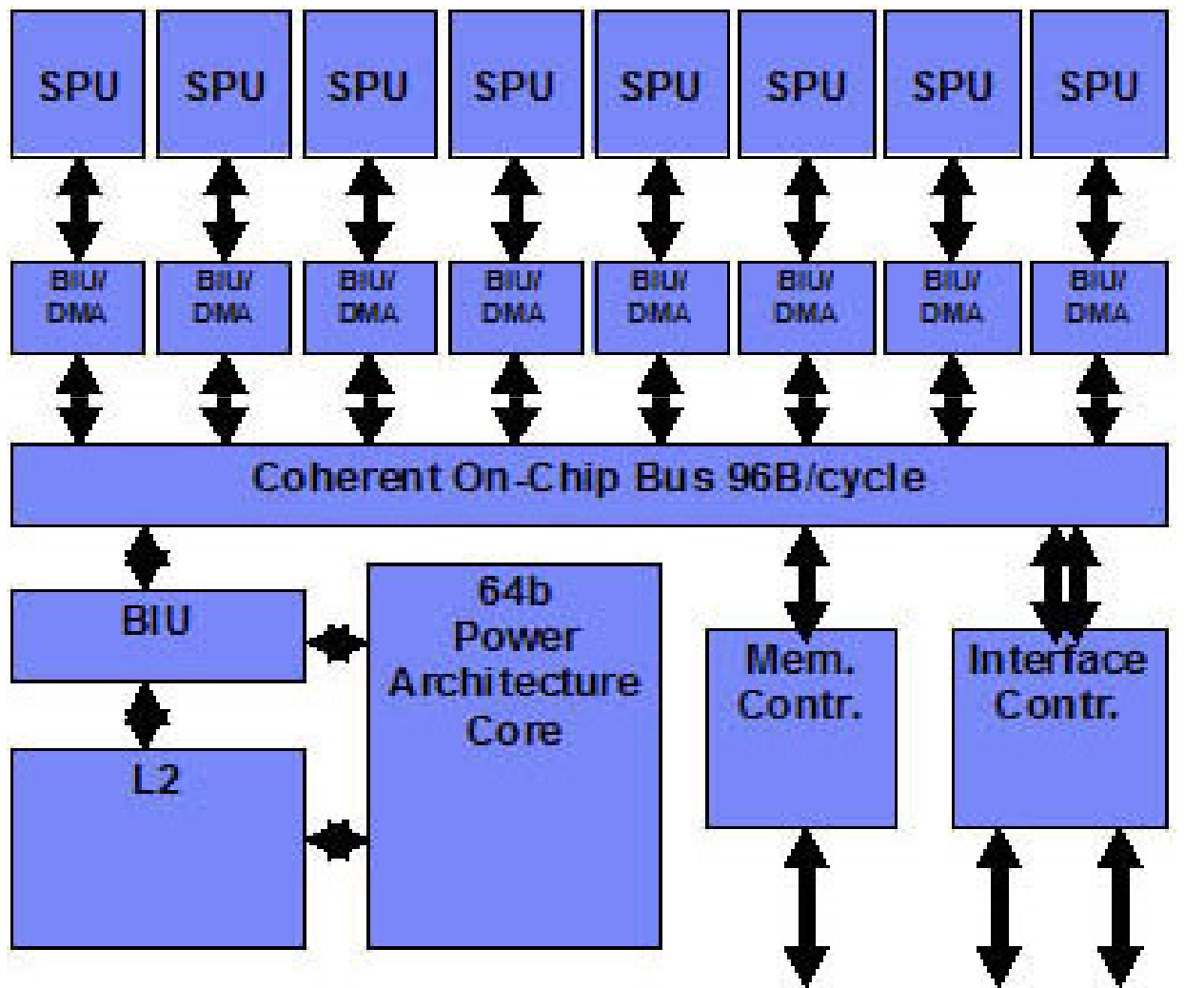
Cray T90

- 1995
- 450 MHz
- 4-32 vector processors
 - Peak 1.8 Gflops per processor
 - 57.6 Gflops
- Shared (upto) 8G memory
- Multiple ports
 - 3 64-bit words per cycle per CPU x32 > 300 GB/s per second
- 32-processor version cost \$39 million.

Roadrunner

- \$133 million
- Multi-stage InfiniBand interconnect
 - Infiniband: 2-level fat-tree, each leaf switch has 180 down links and 96 up links (18 such CUs), 12 up links from each CU connected each of the 2nd level switches
- cluster
- 122400 cores
 - 6912 dual-core Opterons
 - 12960 power XCell eDP: 116640 cores
- peak **1.45 PetaFlops**

IBM Cell Processor



NVIDIA GF8800

