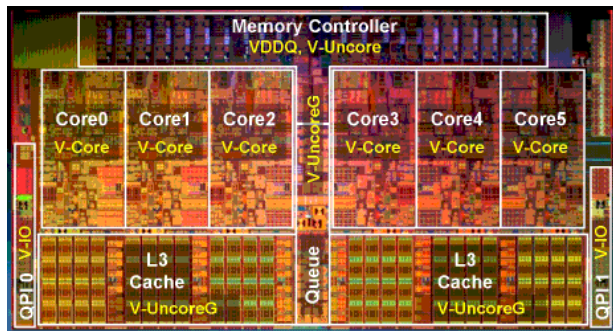


ECE/CS 472/572
Computer Architecture:
Special Topics Part II:
Many-Core Processors and HPCs

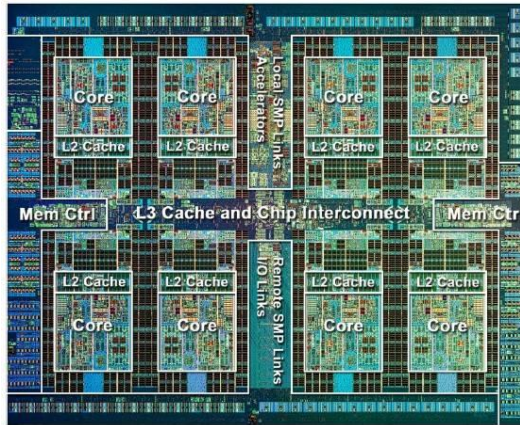
Prof. Lizhong Chen

Spring 2019

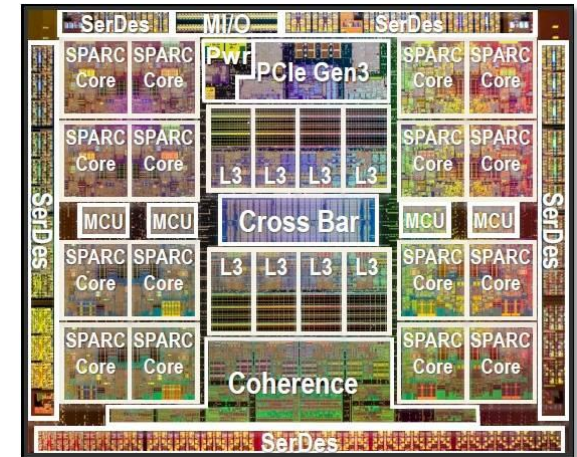
Many-Core Processors



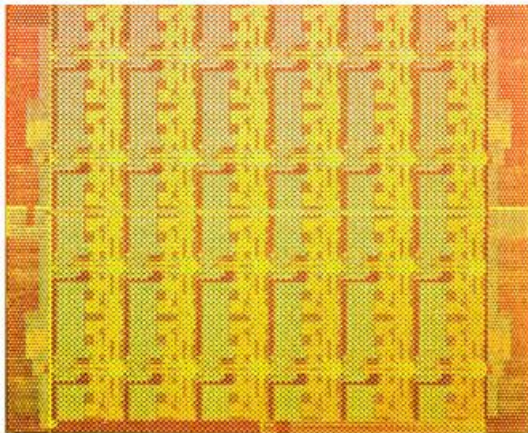
Intel Westmere-EP: 6-core^[1]



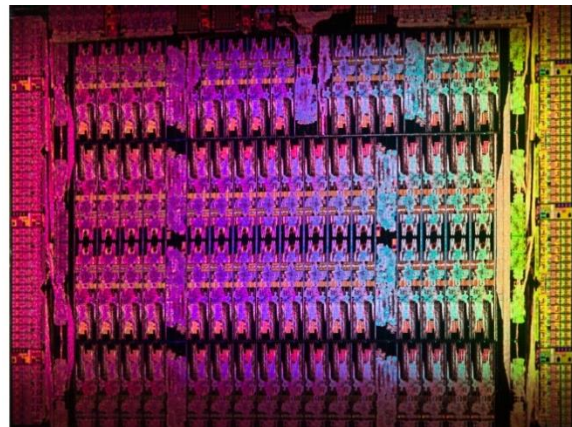
IBM Power7+: 8-core^[2]



Oracle SPARC T5: 16-core^[3]



Intel SCC: 48-core^[4]



Intel Xeon Phi: 60-core^[5]

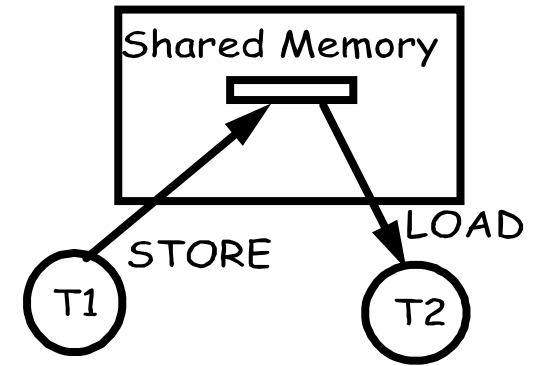
- ❑ Embedded processors
 - ▣ Broadcom XLP-II: 20-core
 - ▣ Cavium Octeon: 48-core
 - ▣ Tileria Tile-Gx8072: 72-core
- ❑ Mobile devices – MPSoCs
 - ▣ CPU, GPU, DSP, etc.
- ❑ (GP)GPUs
 - ▣ Nvidia Kepler: 192x15 cores
 - ▣ AMD Liverpool: 1152 cores

[1] http://www.theregister.co.uk/2010/02/03/intel_westmere_ep_preview/
 [2] http://www.theregister.co.uk/2012/10/03/ibm_power7_plus_server_launch/
 [3] http://www.theregister.co.uk/2012/09/04/oracle_sparc_t5_processor/
 [4] http://www.intel.com/pressroom/archive/releases/2009/20091202comp_sm.htm
 [5] <http://www.scientificcomputing.com/news/2013/02/intel-xeon-phi-coprocessor/>

Inter-Thread Communication

- Shared memory

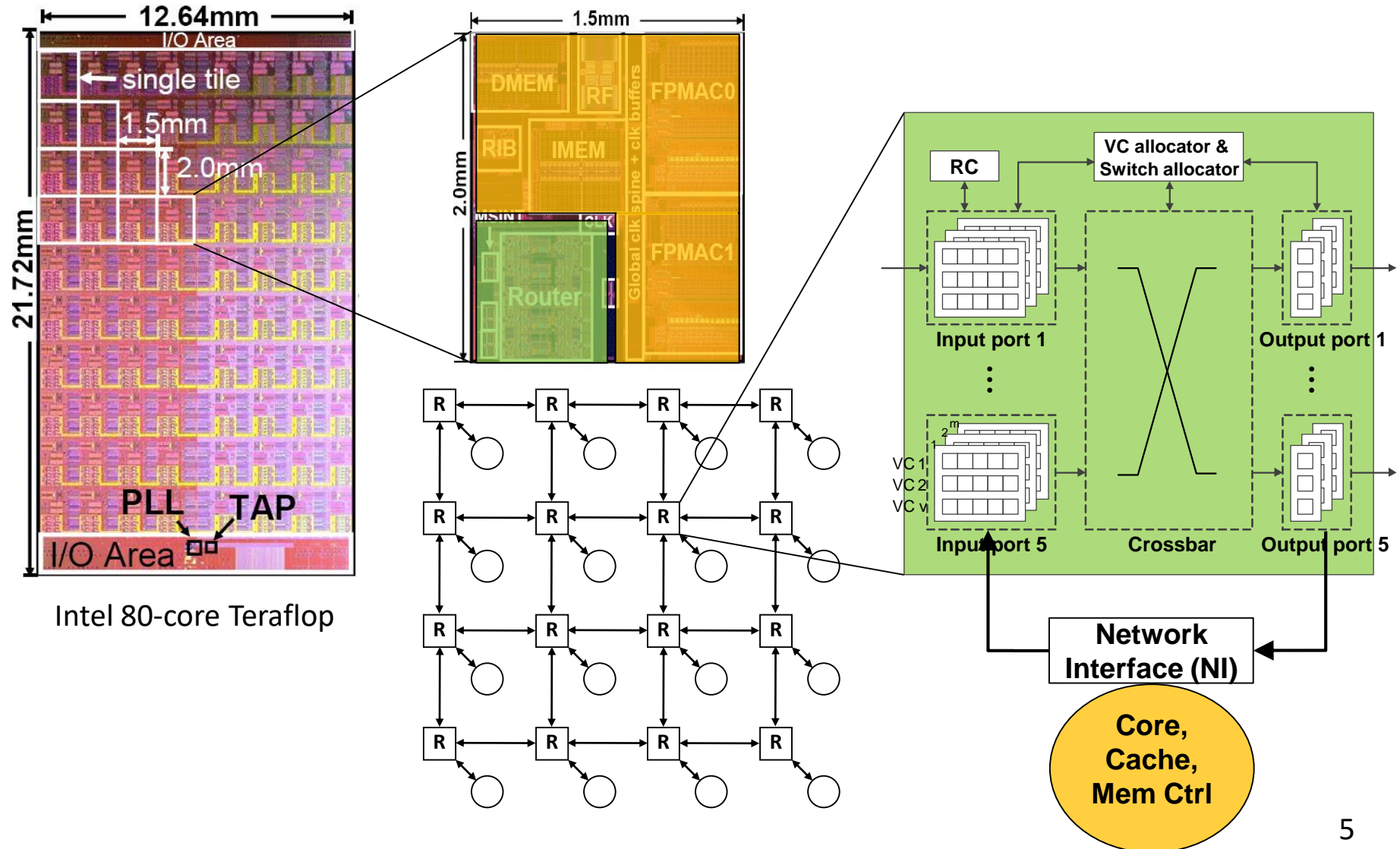
- Processors share some memory
- Communication is implicit through loads and stores



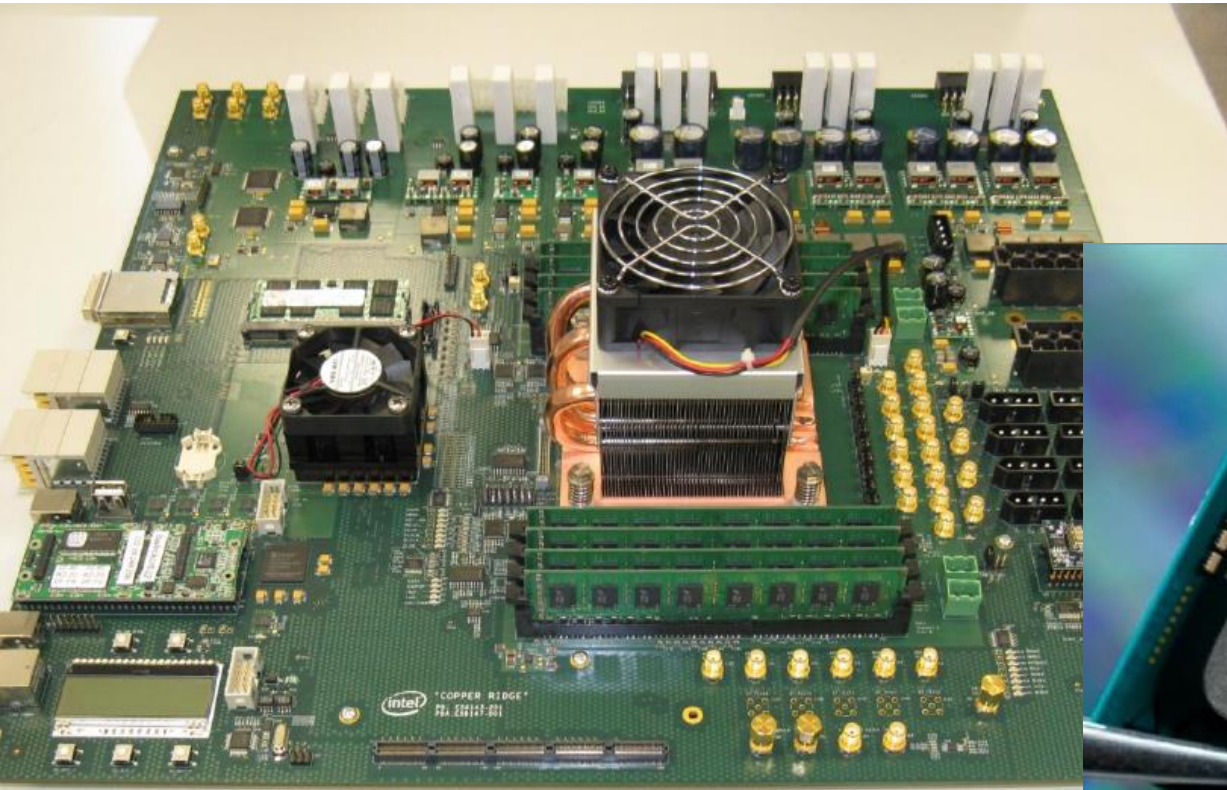
- Message Passing Interface (MPI)

- Explicitly via messages (sends and receives)
- Need to know the destination and what to send
- Explicit message-passing statements in the code

Many-core & On-Chip Networks



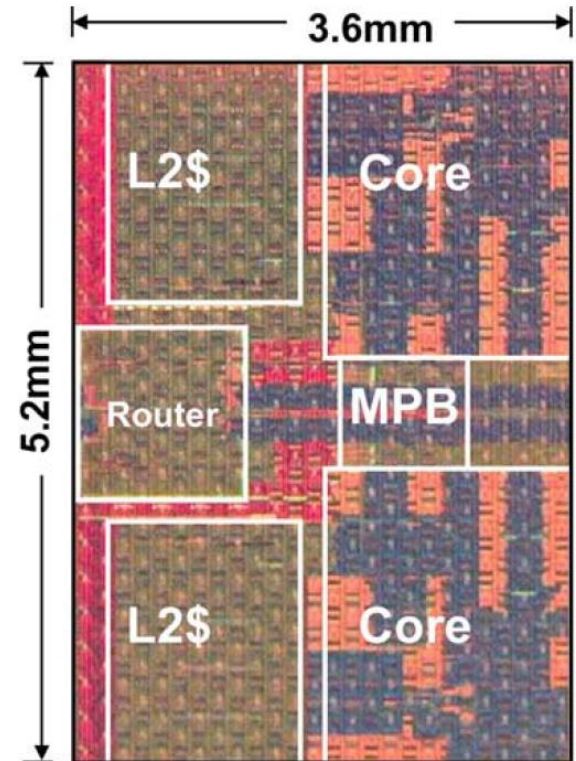
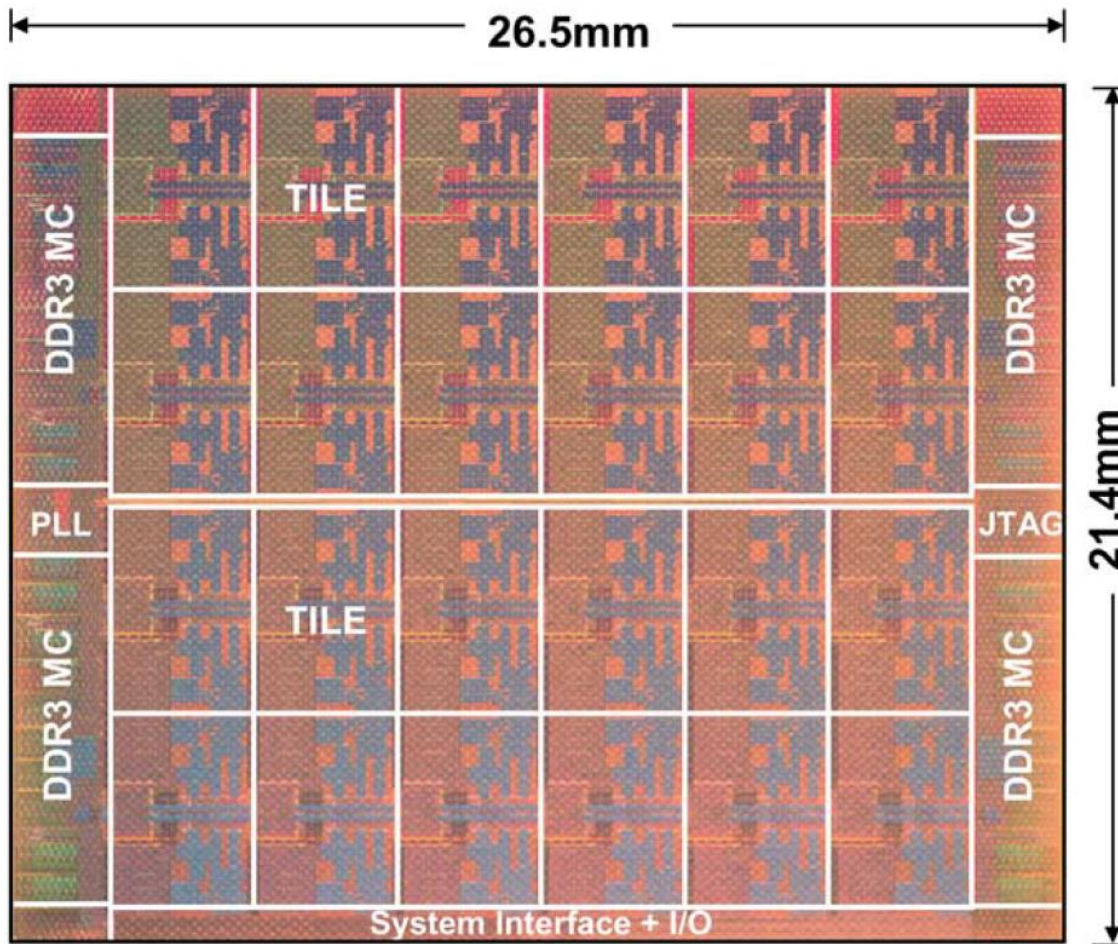
Intel SCC (Single-chip Cloud Computer)



- 48 cores on a chip

Howard, Jason, et al. "A 48-core IA-32 processor in 45 nm CMOS using on-die message-passing and DVFS for performance and power scaling." *IEEE Journal of Solid-State Circuits* 46.1 (2011): 173-183.

Tile-based Intel SCC



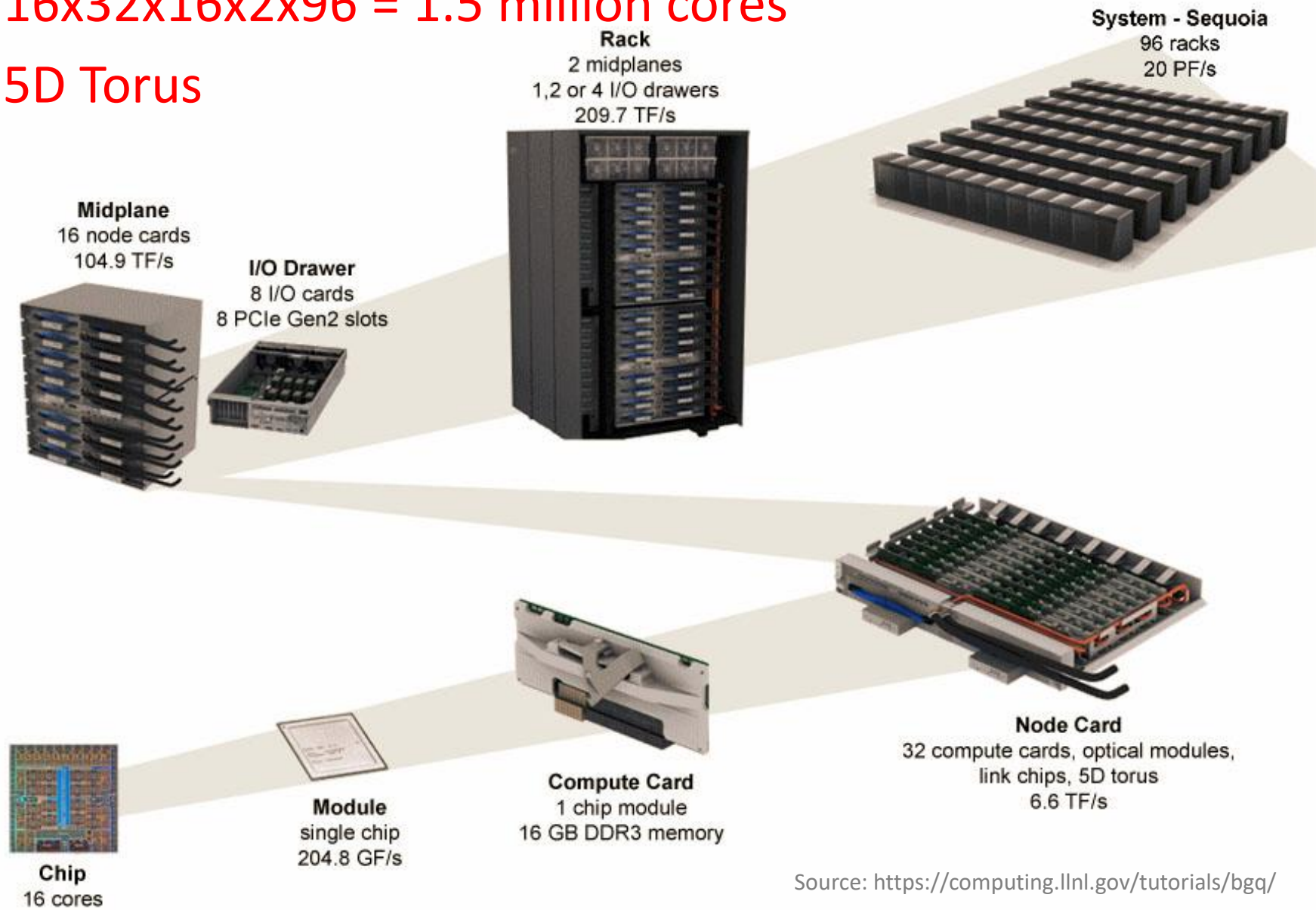
Howard, Jason, et al. "A 48-core IA-32 processor in 45 nm CMOS using on-die message-passing and DVFS for performance and power scaling." *IEEE Journal of Solid-State Circuits* 46.1 (2011): 173-183.

Technology	45nm Process
Interconnect	1 Poly, 9 Metal (Cu)
Transistors	Die: 1.3B, Tile: 48M
Tile Area	18.7mm ²
Die Area	567.1mm ²
Signals	970
Package	1567 pin LGA package

HPC Systems (Supercomputers)

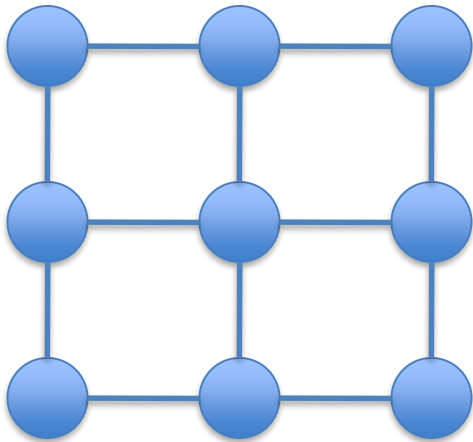
IBM Blue Gene/Q Supercomputer

- $16 \times 32 \times 16 \times 2 \times 96 = 1.5$ million cores
- 5D Torus

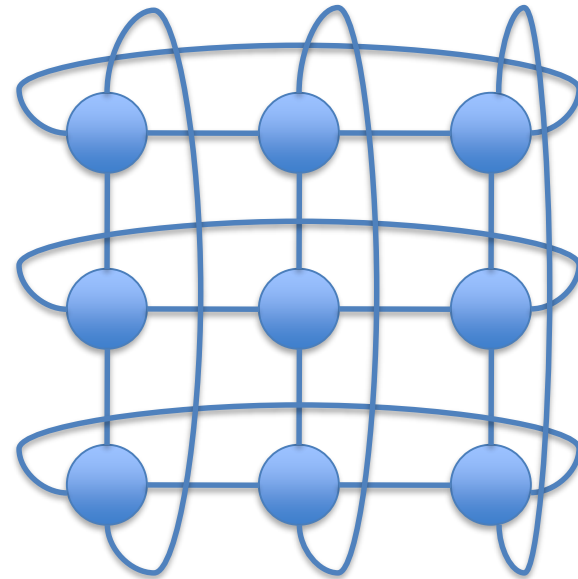


Mesh vs. Torus

- n-Dimensional grid with k nodes in each dim



2D Mesh



2D Torus

Top Supercomputers

- Top 500 list (<https://www.top500.org/>)

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
2	Tianhe-2 (MilkyWay-2) - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P , NUDT National Super Computer Center in Guangzhou China	3,120,000	33,862.7	54,902.4	17,808
3	Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100 , Cray Inc. Swiss National Supercomputing Centre (CSCS) Switzerland	361,760	19,590.0	25,326.3	2,272
4	Gyokou - ZettaScaler-2.2 HPC system, Xeon D-1571 16C 1.3GHz, Infiniband EDR, PEZY-SC2 700Mhz , ExaScaler Japan Agency for Marine-Earth Science and Technology Japan	19,860,000	19,135.8	28,192.0	1,350
5	Titan - Cray XK7, Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x , Cray Inc. DOE/SC/Oak Ridge National Laboratory United States	560,640	17,590.0	27,112.5	8,209

No. 1: Sunway TaihuLight



HPC simulations for Science and Industry ([link](#))