The Abdus Salam
International Centre
for Theoretical Physics

2494-2

Workshop on High Performance Computing (HPC) Architecture and Applications in the ICTP

14 - 25 October 2013

Modern CPU Architectures: Trends and Impacts in HPC

Ivan Girotto
ICTP, Trieste

Modern CPU Architectures: Trends and Impacts in HPC

Ivan Girotto – igirotto@ictp.it

Information & Communication Technology Section (ICTS)

International Centre for Theoretical Physics (ICTP)

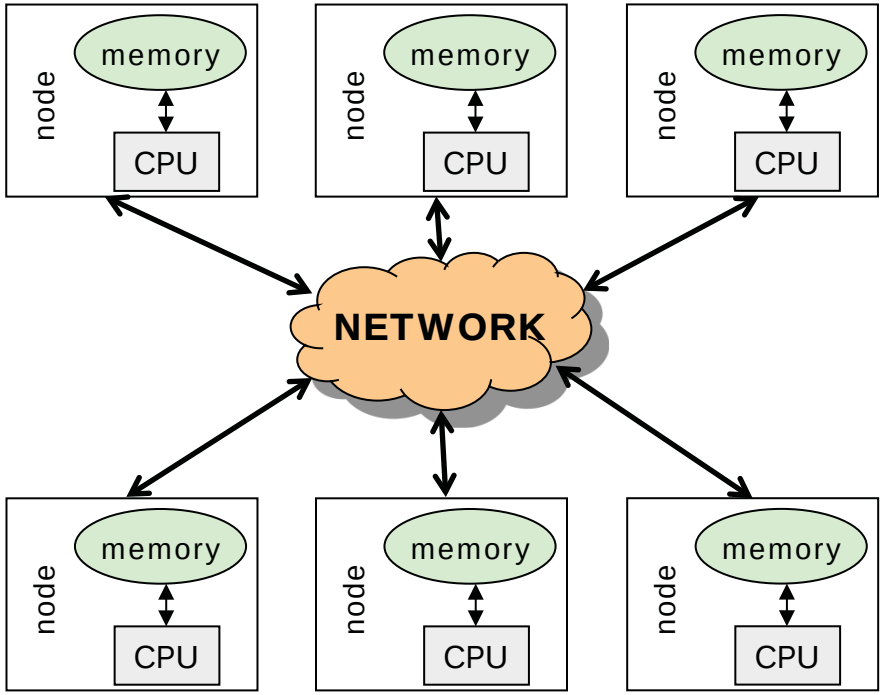
Outline

- Parallel Computer Architectures
- Modern Multicores CPUs
- Memory Hierarchies
- Impact on Software Design
- Conclusions

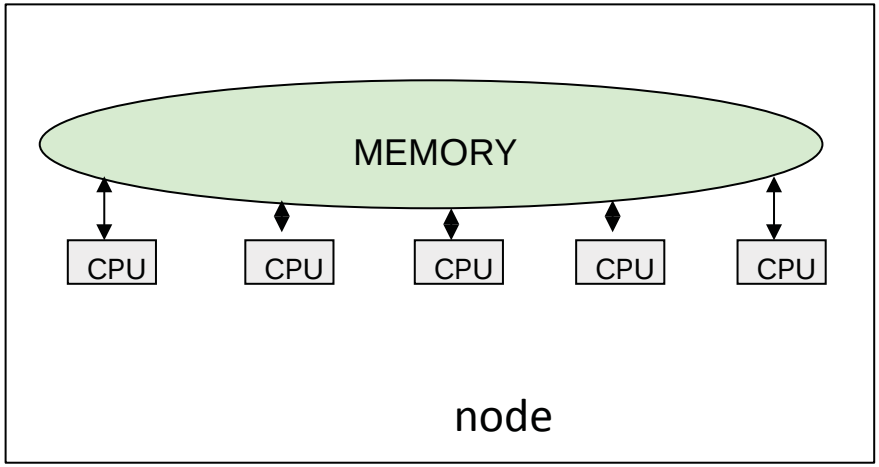
PARALLEL COMPUTER ARCHITECTURE

Parallel Architectures

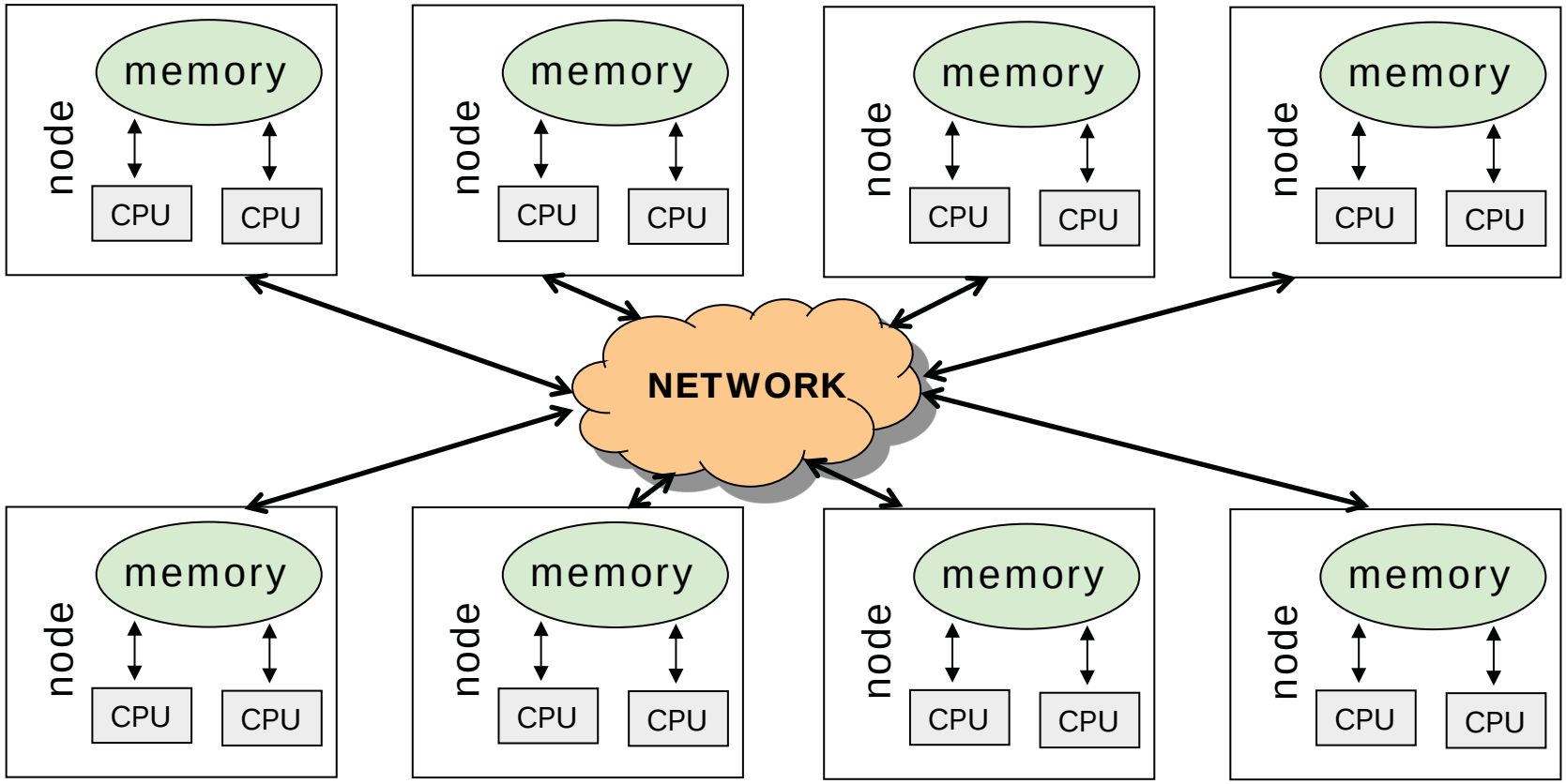
- Distributed Memory



- Shared Memory



Mixed Architectures



MODERN MULTICORES CPU

Causes of the tech-revolution

- Physical (The Dennard Law)

Old VLSI Generation
L' = L / 2
V' = V / 2
F' = ~ F * 2
D' = 1 / L^2 = 4 * D
P' = P

New VLSI Generation
L' = L / 2
V' = ~V
F' = ~ F * 2
D' = 1 / L^2 = 4 * D
P' = 4 * P

The power crisis!

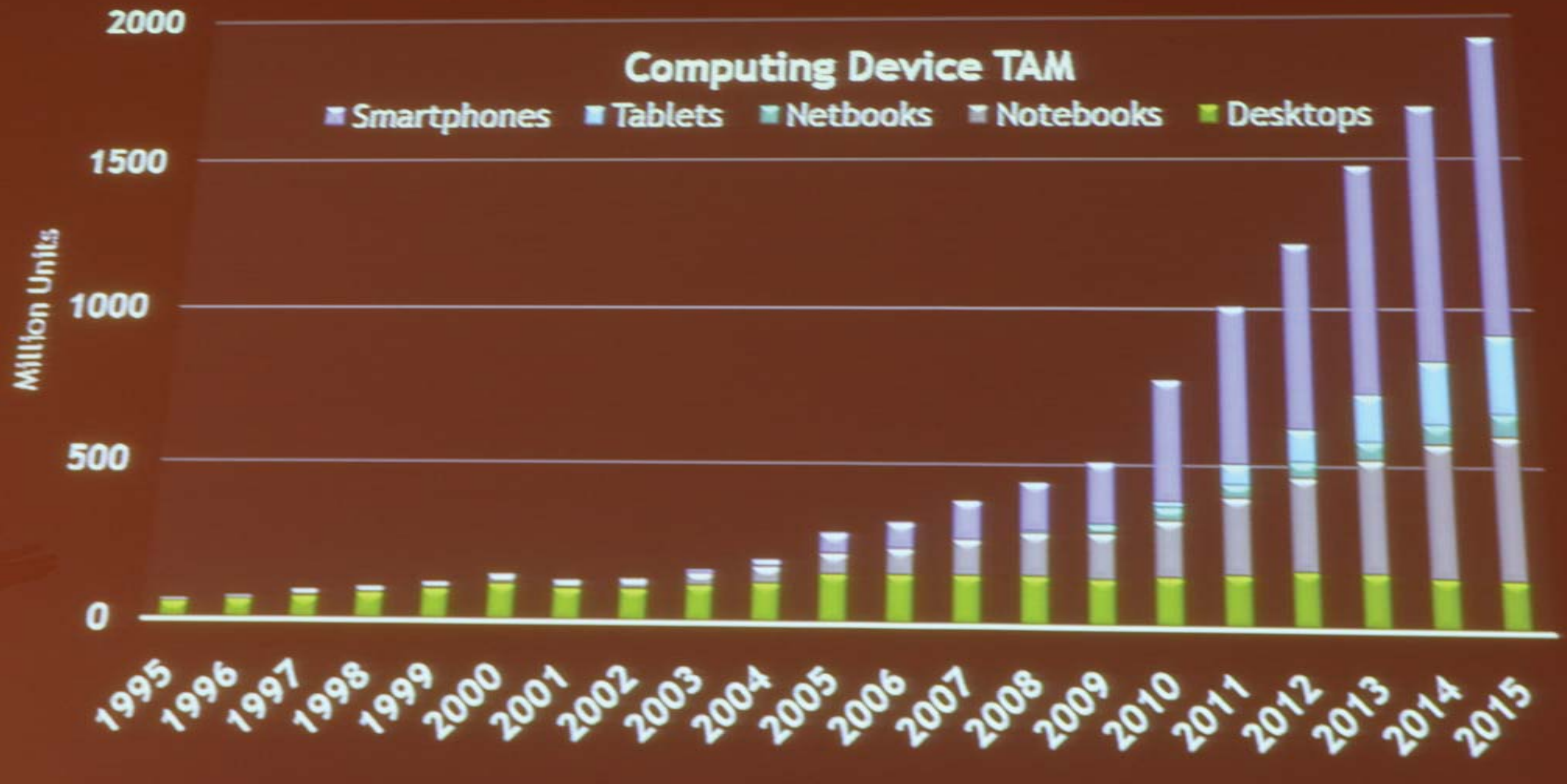
- Business

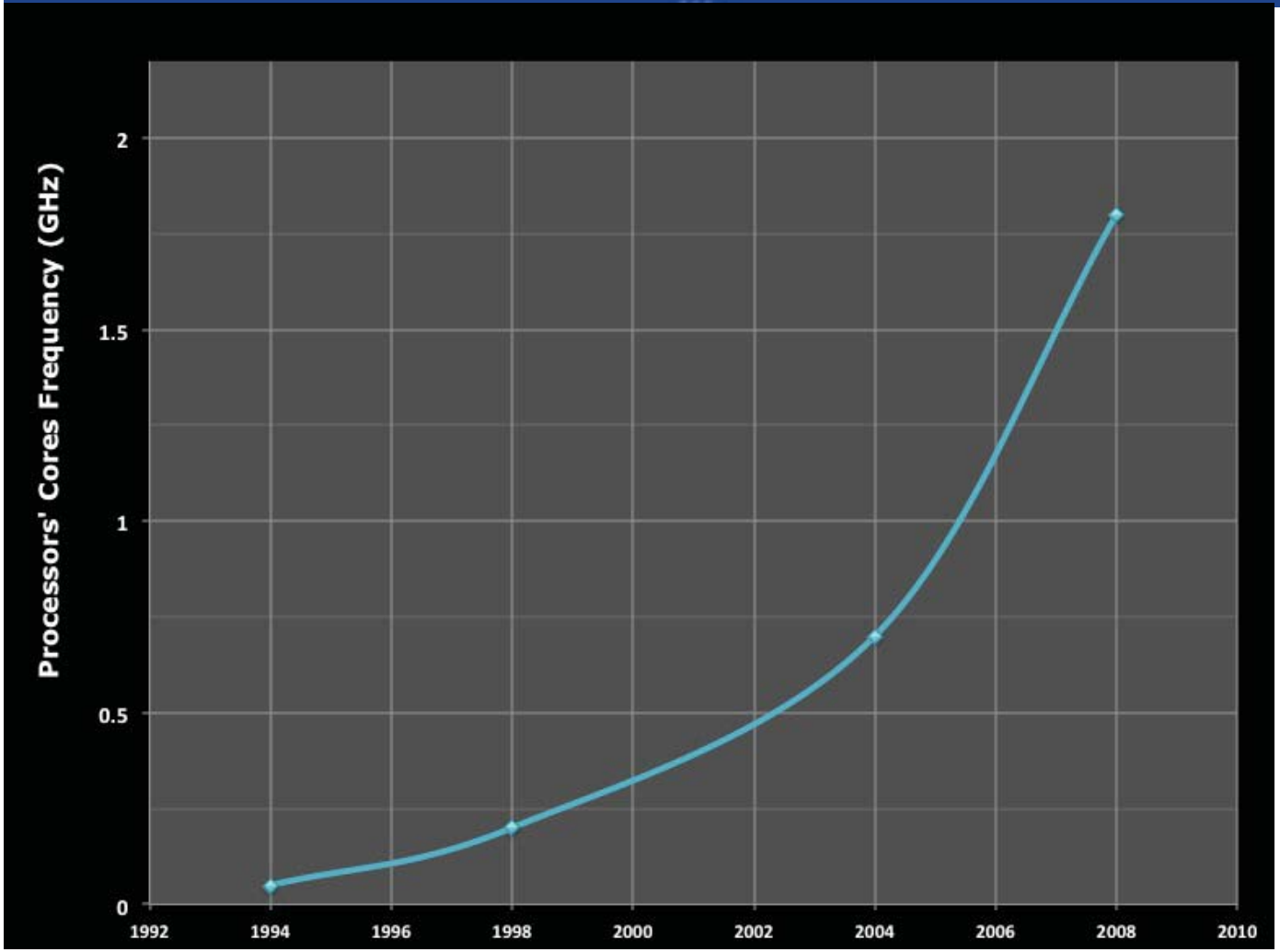
The core frequency and performance do not grow following the Moore's law any longer

Increase the number of cores
to maintain the architectures evolution on the Moore's law

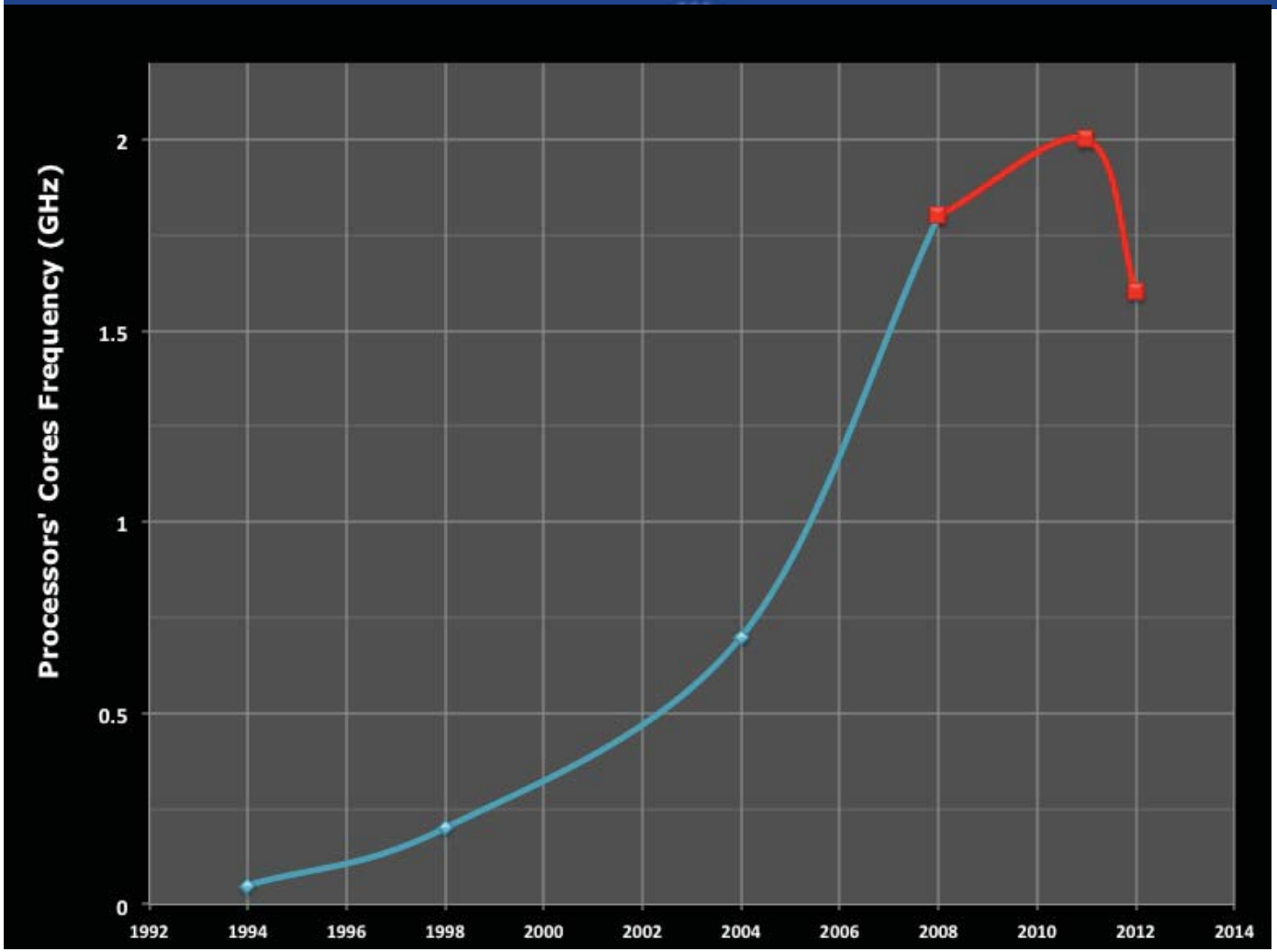
Programming crisis!

The Opportunity

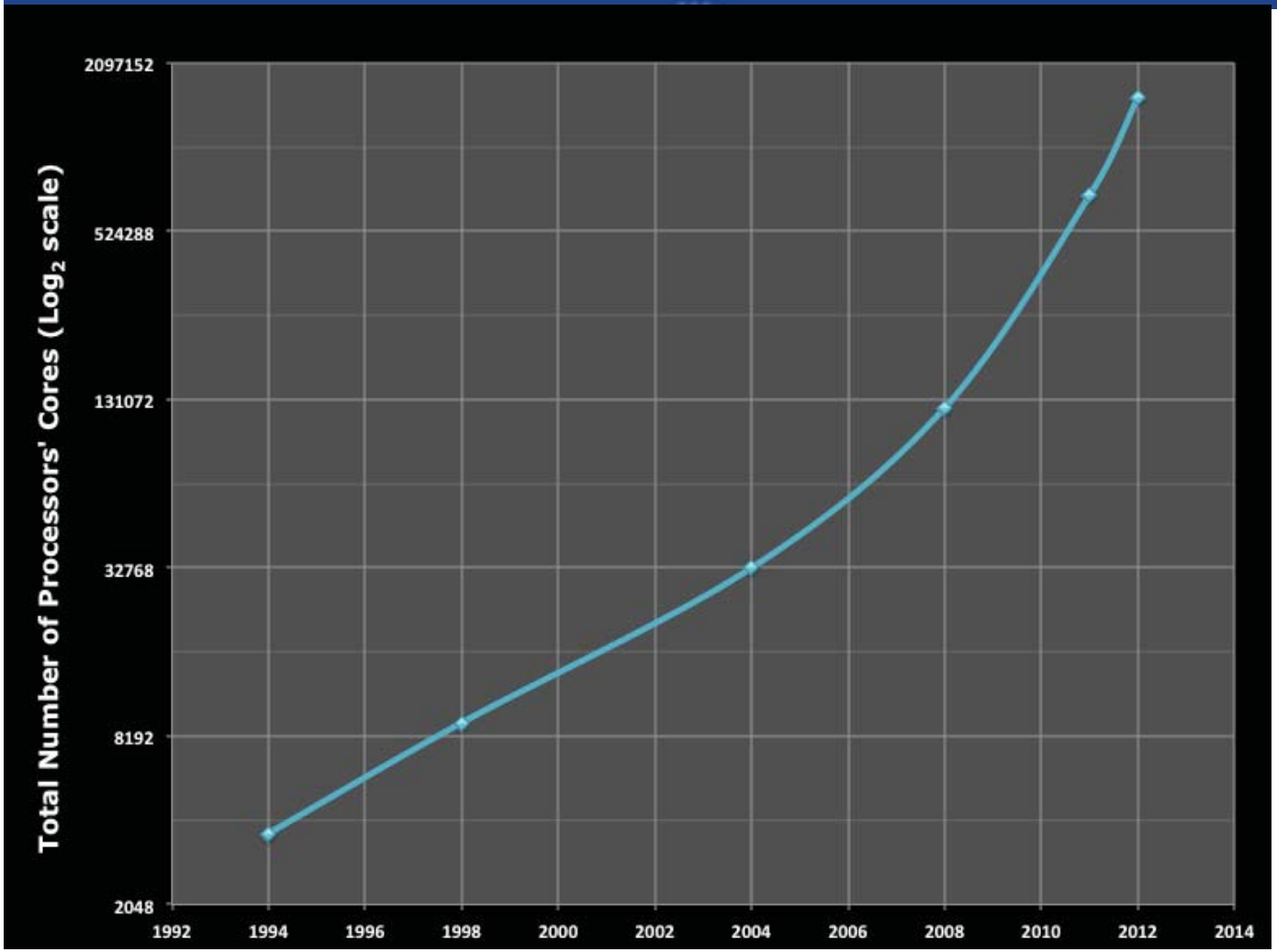




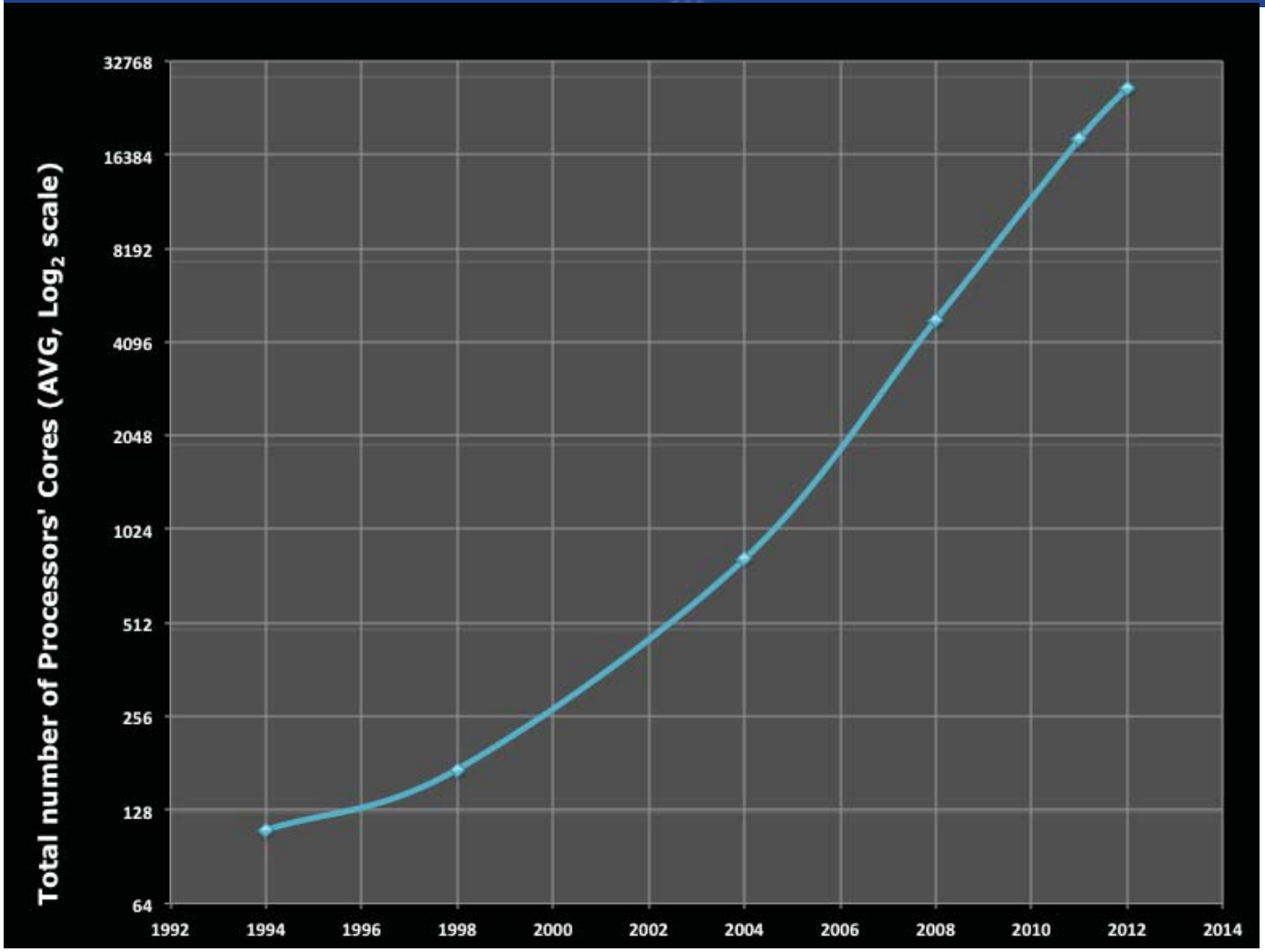
Processors' cores clock frequency to build the most powerful supercomputer in the world from 1994 to 2008. Data from www.top500.org



Processors' cores clock frequency to build the most powerful supercomputer in the world over the last 15 years. Data from www.top500.org

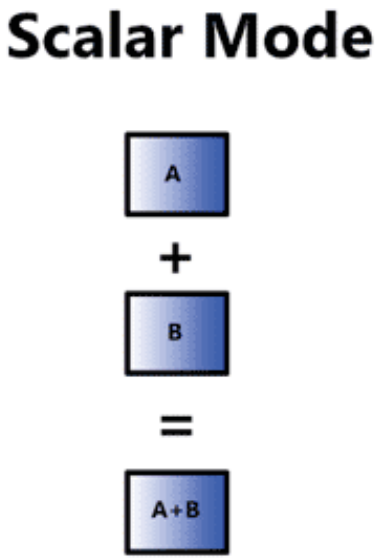


Total number of processors' cores to build the most powerful supercomputer in the world over the last 15 years. Data from www.top500.org



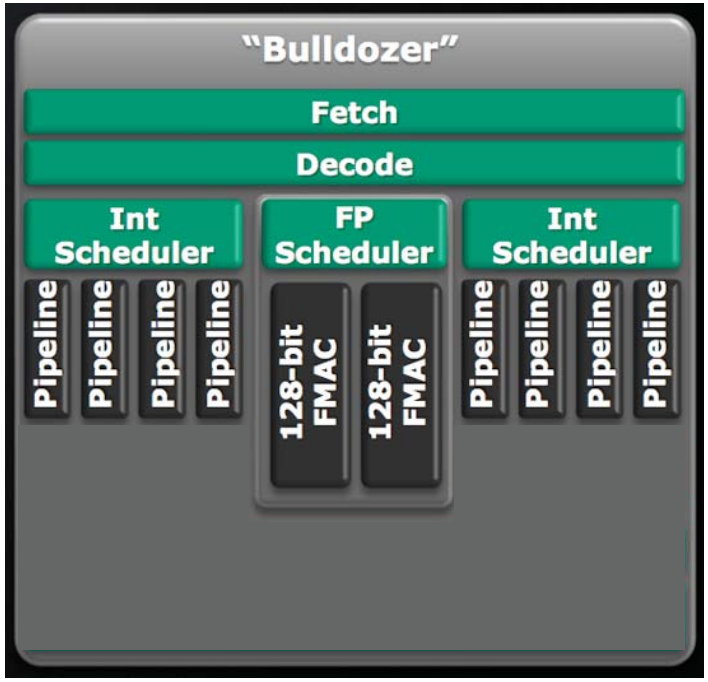
Average of the total number of processors' cores to build the 500 most powerful supercomputers in the world over the last 15 years. Data from www.top500.org

To the Extreme - Parallel Inside

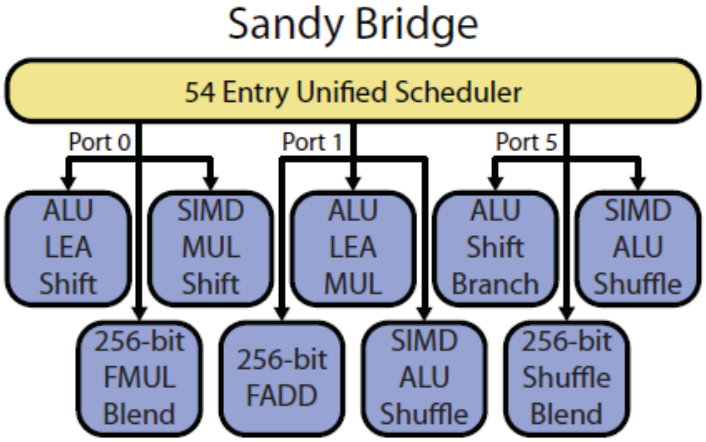


State of the art

- AMD

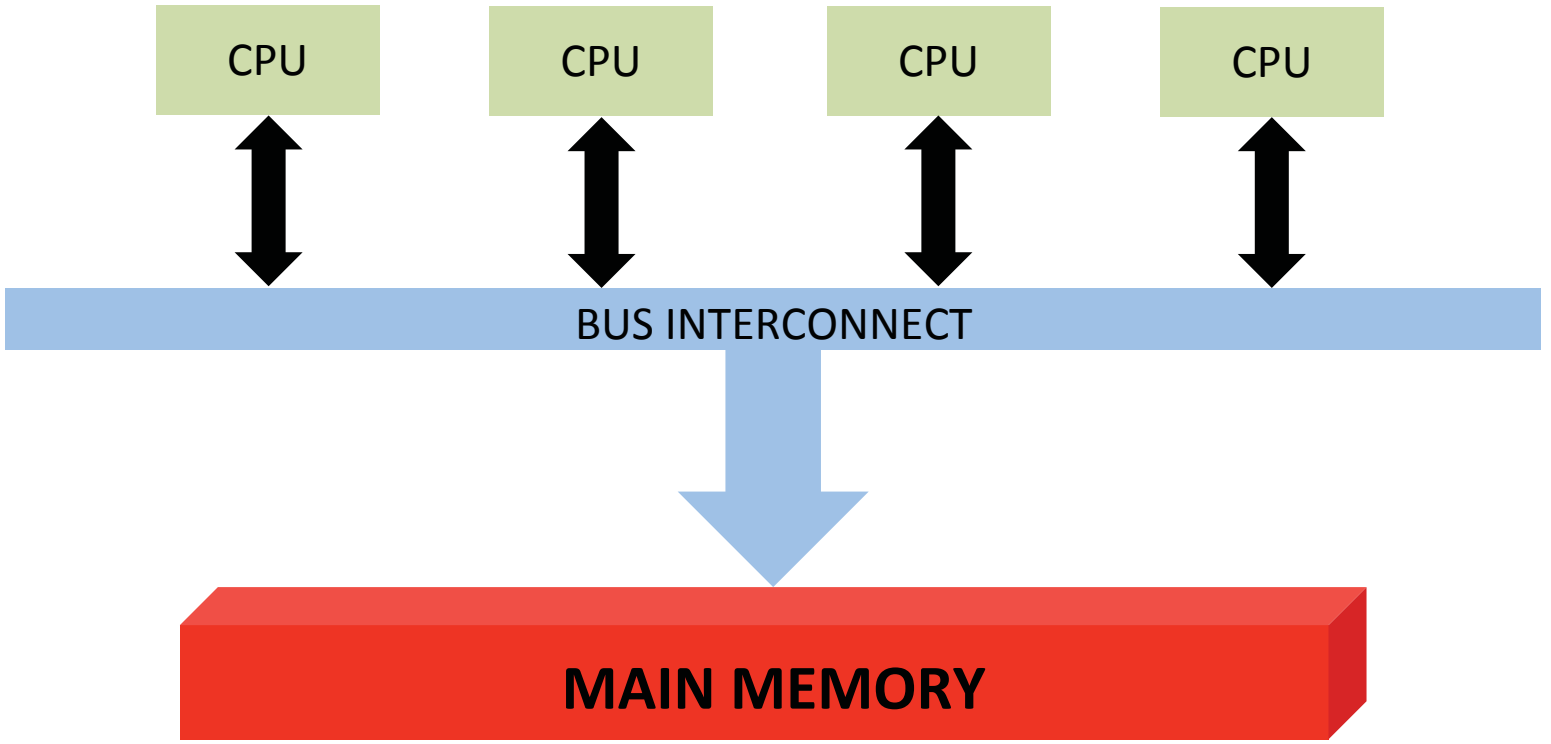


- Intel

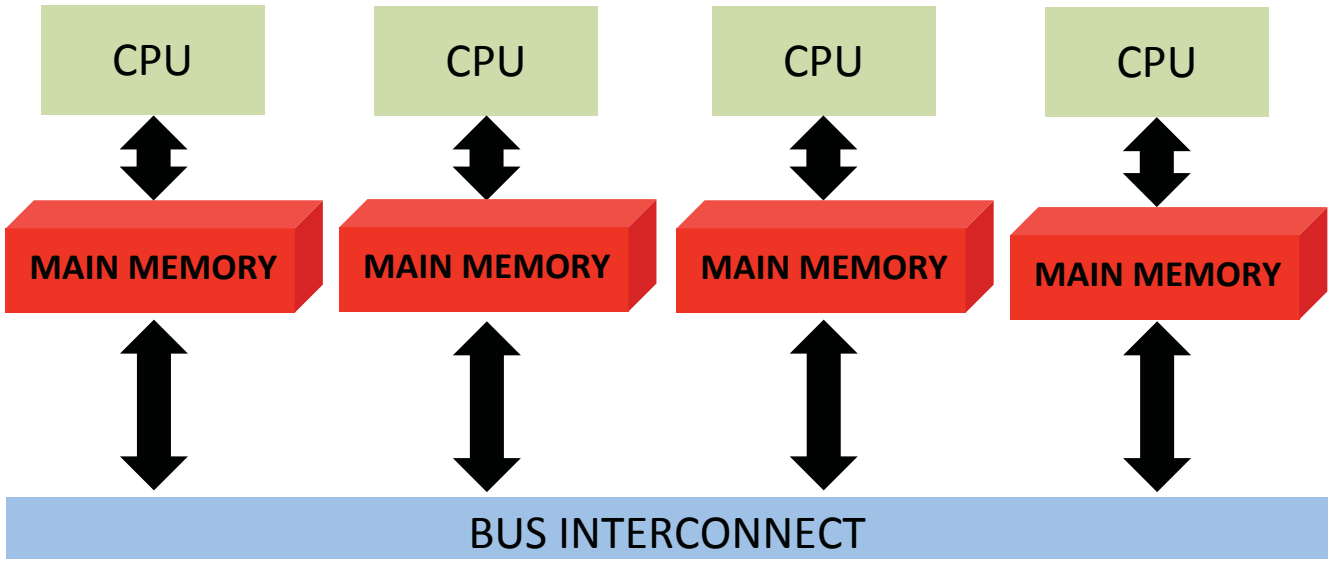


MEMORY HIERARCHIES

Symmetric Multiprocessors (SMP)

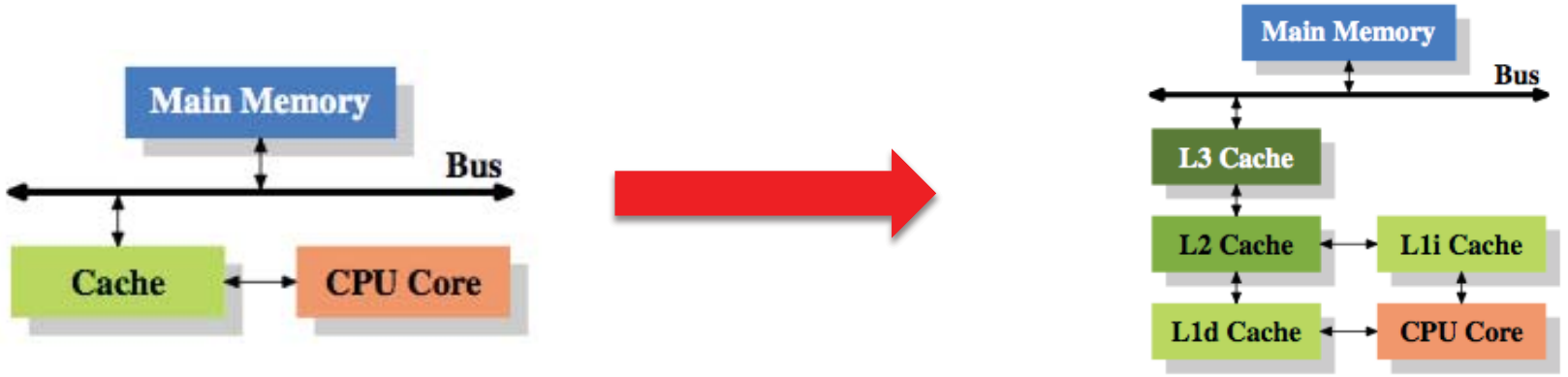


Modern NUMA Multicores

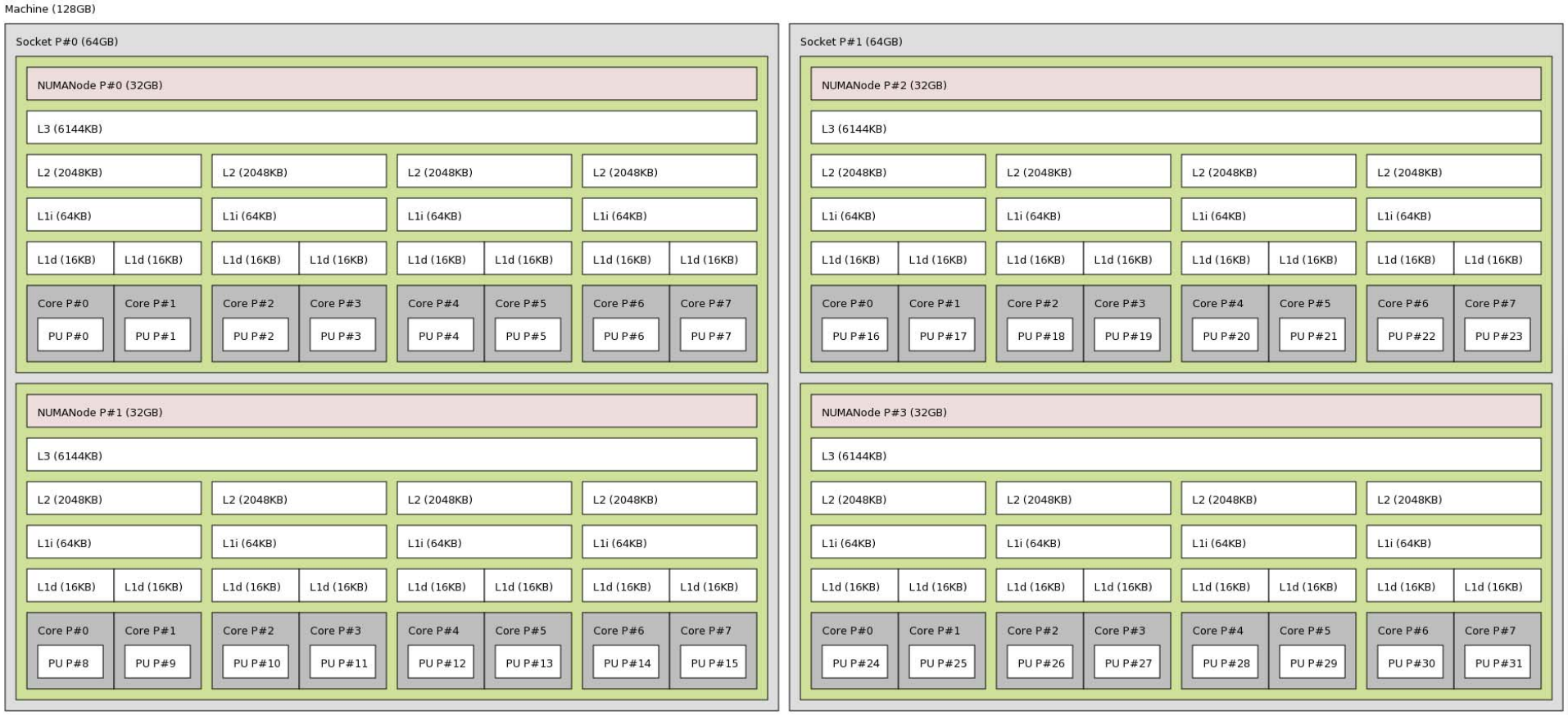


Caches

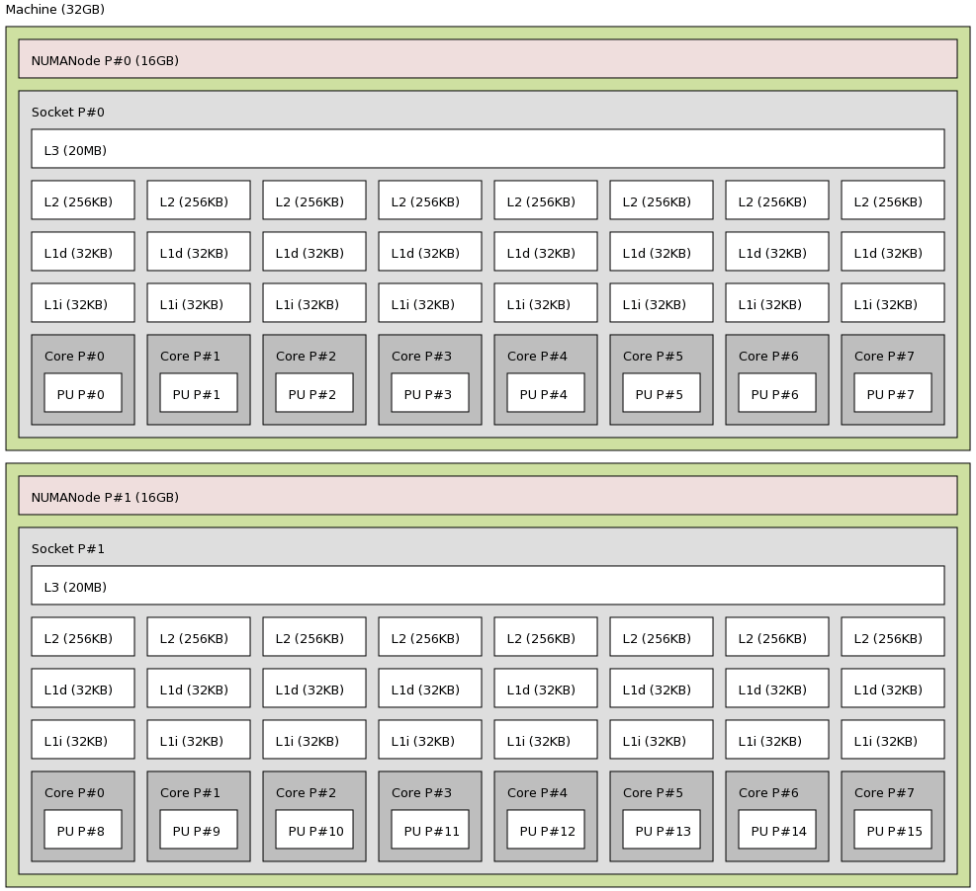
- Fast memory to exploit spatial and temporal locality!



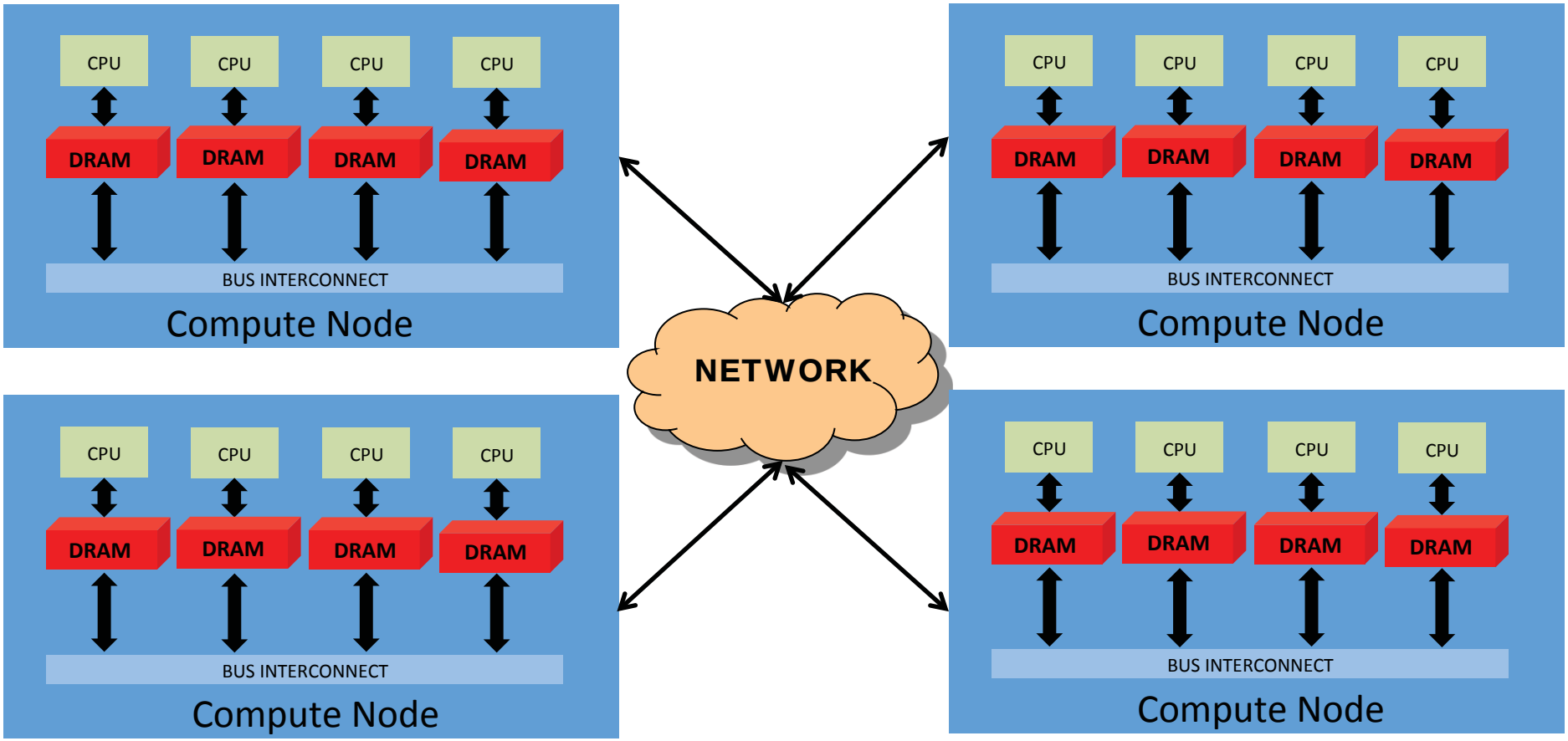
The AMD Opteron 6380 Abu Dhabi 2.5GHz



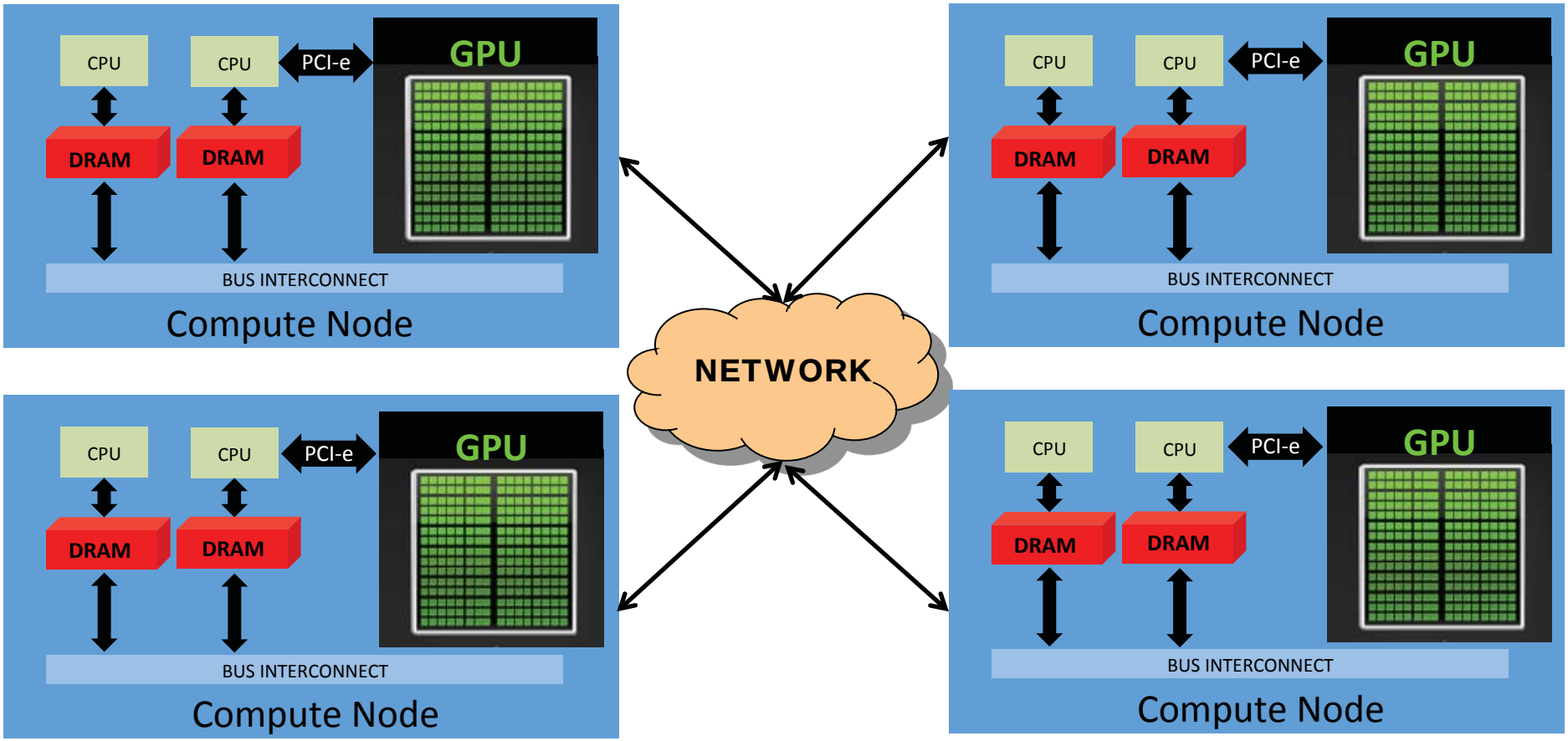
The Intel Xeon E5-2665 Sandy Bridge-EP 2.4GHz



Modern Hybrid Architectures



Modern Hybrid Architectures

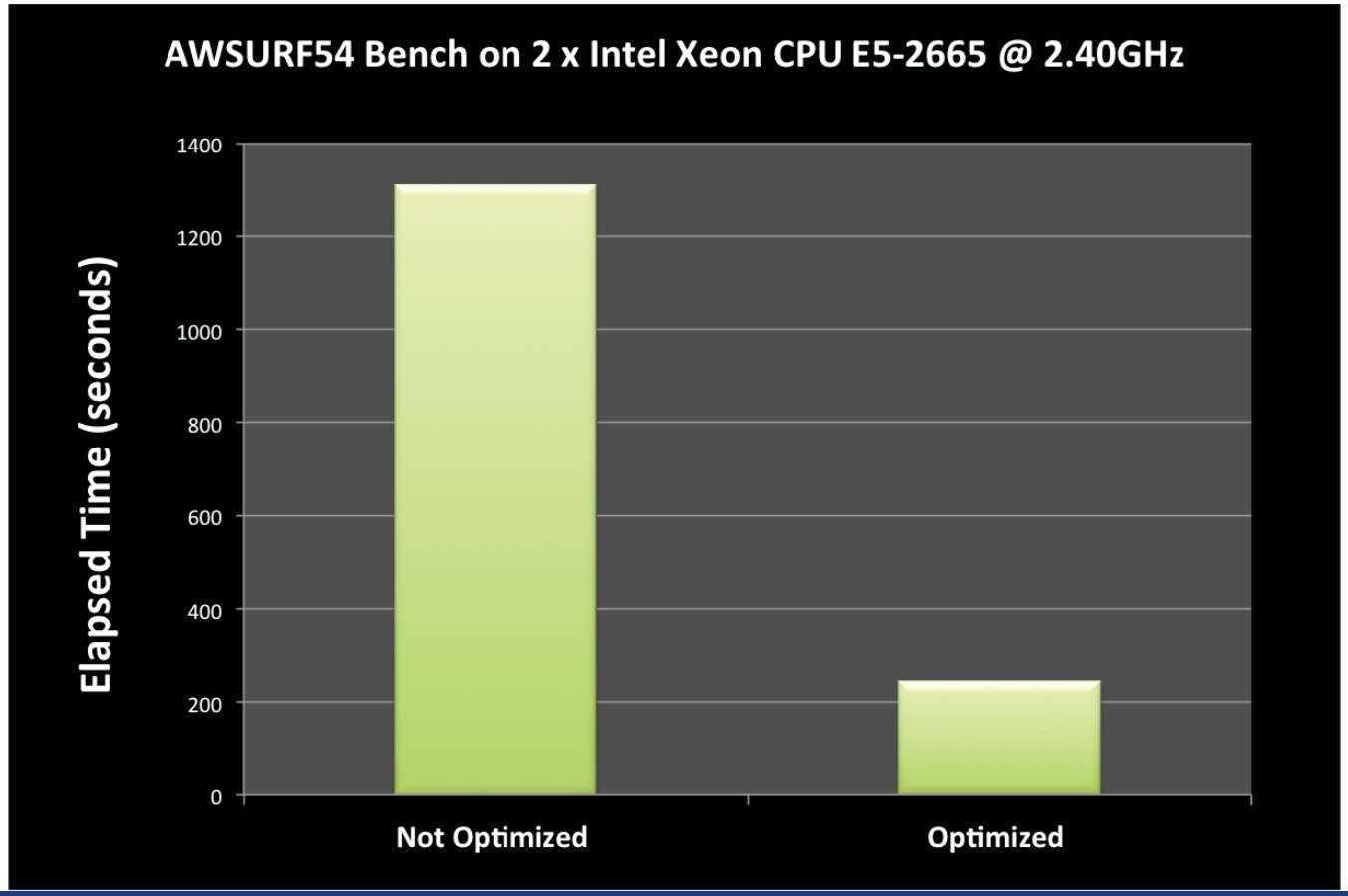


IMPACT ON SOFTWARE DESIGN

Impact on Software Design

- Modern architectures are a real nightmare for developers of scientific software
  - Massive parallelism
  - Rapidly increasing complexity
  - Fast development
  - Less efficiency for legacy software
  - Hard to make long term investments and plans

Performance Examples



Conclusions

- Exclusive access to compute nodes
- Intensive monitoring of users applications
- Full control of the operational software environment
- Full control on the application software environment
- Efficient software enhance efficient production
- Production or Research and Development?
- Efficiency or Peak Performances?