

# A Scalable and Power-Efficient Memory Hierarchy for Multicore Architectures

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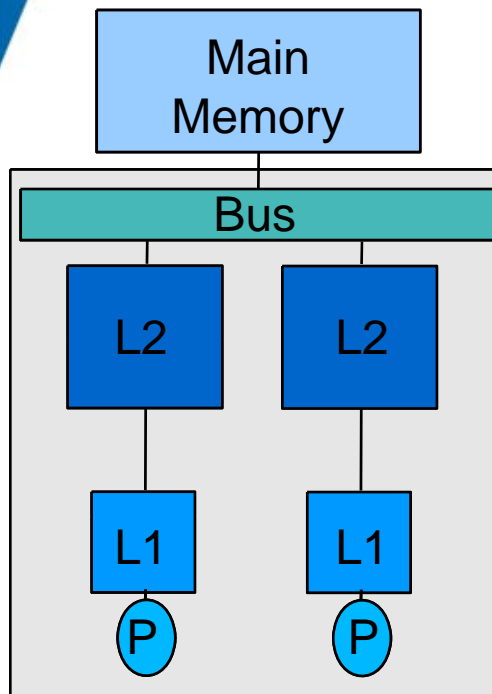
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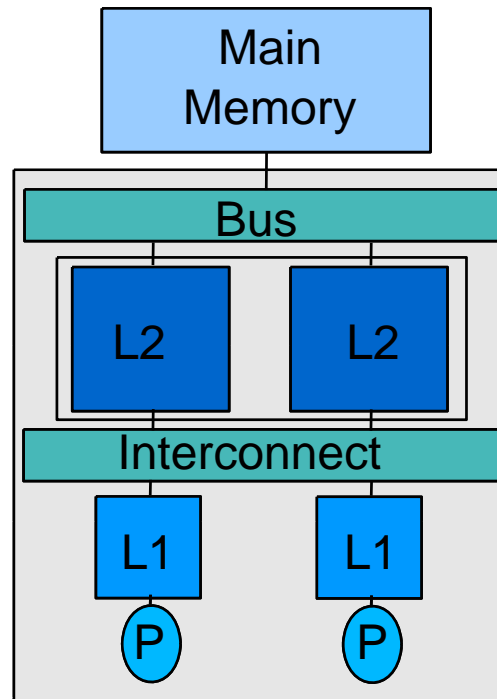
# Multicore Organizations

State of the art  
[Chang and Sohi '06]

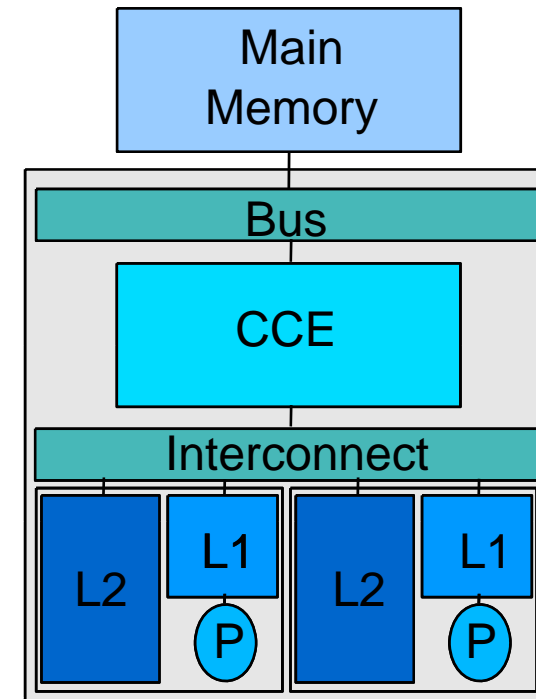
Traditional



Private Memory  
Caching



Shared Memory  
Physically distributed and  
logically unified



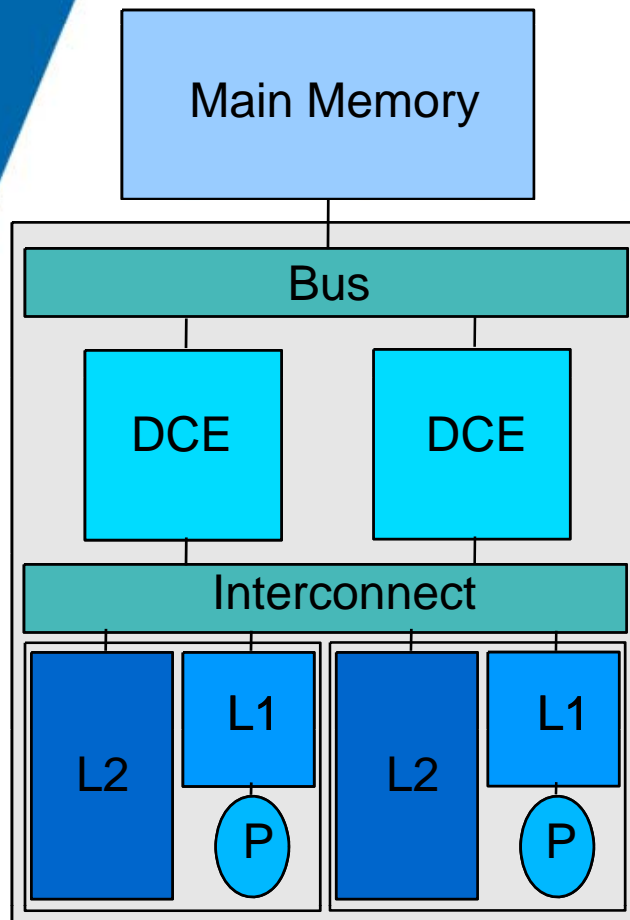
Cooperative



# Our Proposal

## Distributed Cooperative Caching

- Main Idea
- Private L2 to reduce access latency.
  - Distributed Directory (DCEs) to allow intra-chip sharing and reduce off-chip misses.



### Distributed Coherence Engines (Distributed directory)

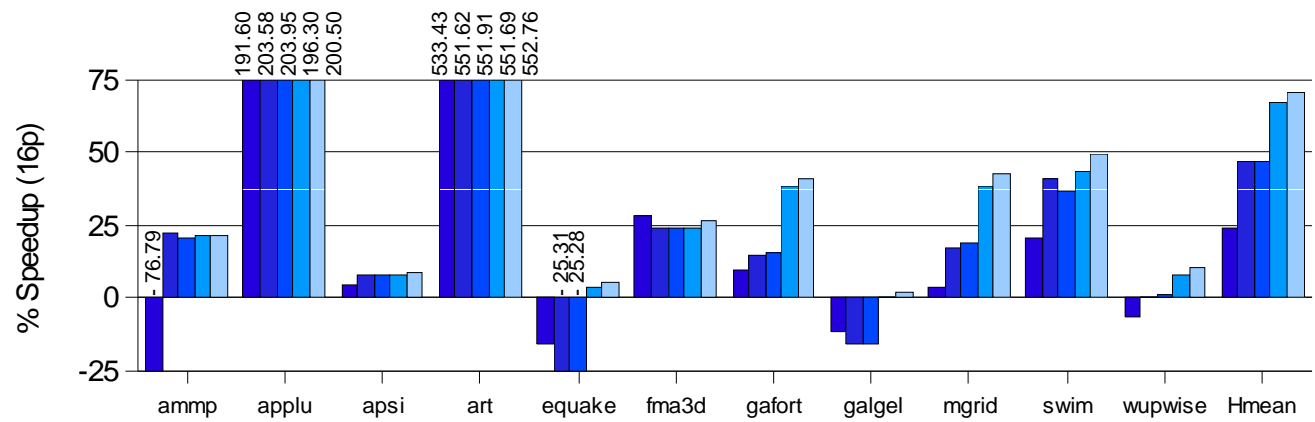
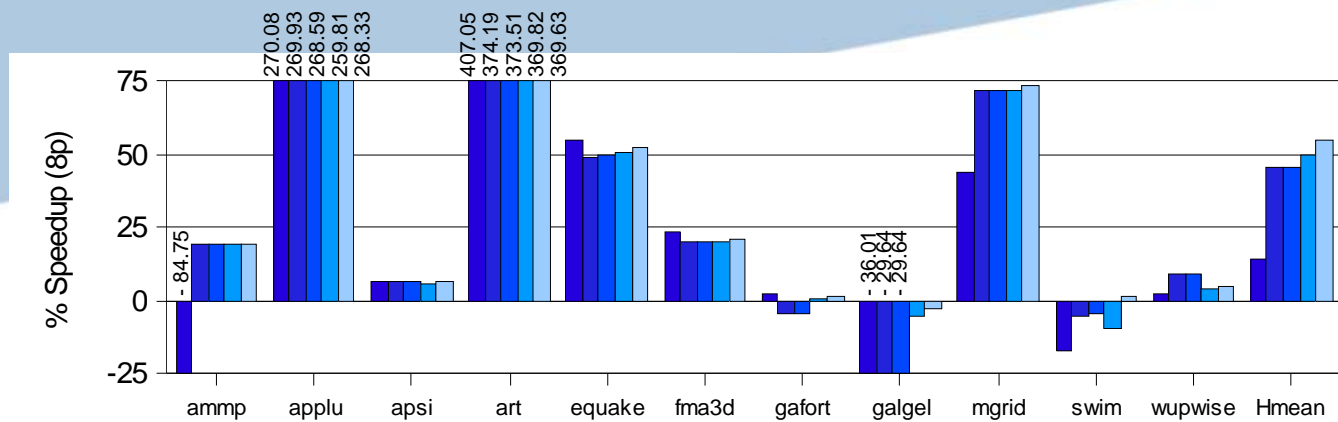
- Tags in the DCEs are not a replica of L1 and L2, every address is mapped to a unique DCE.
- Directory partitioning allows on-chip network traffic distribution and improves scalability
- Power is drastically reduced compared to Coop. Caching (less tags are accessed)
- Extra invalidation mechanism added for handling DCE replacements.

**Spilling:** Evicted blocks can be redirected to other L2 to make a efficient use of the cache space.

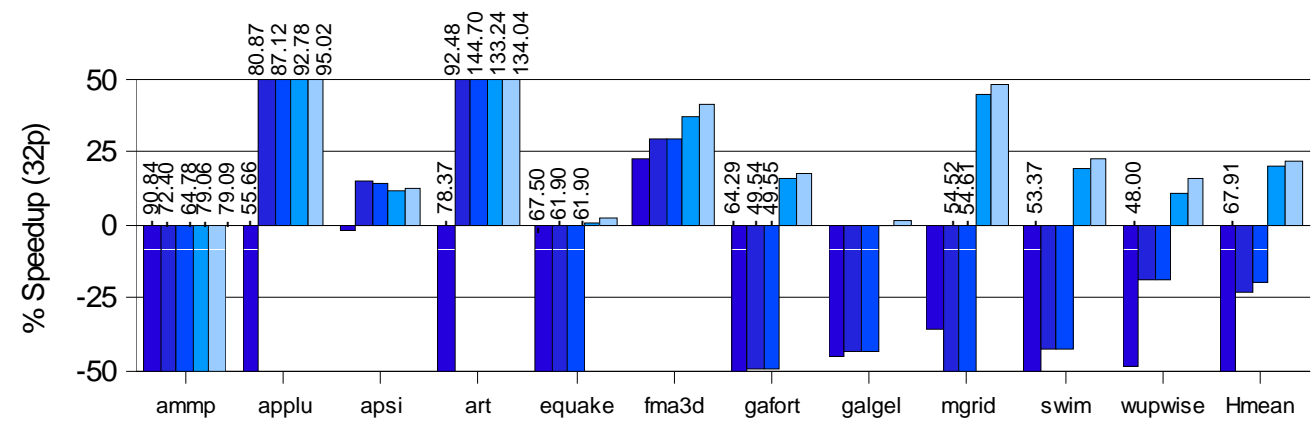
# Simulation Environment

Processors	8, 16, 32	Instruction Set	Sparc V9
Processor_Type	Superscalar OoO	Instruction Window Size	16
Network Structure	Mesh with 2 VNCs	Reorder Buffer Size	48
Virtual Networks	2 (Request, Response)	Max Instr/Cycle	3
Link Bandwidth	16 bytes/cycle	Branch Predictor	YAGS
Technology	70 nm	L1 Cache	16 kb 4-way
Frequency	4 Ghz	L2 Cache	512, 256, 256 kb 4-way
Voltage	1.1 V	Memory Size	4 Gbytes
Benchmark	SPEC OMP 2001	TBE Entries	32
Simulator	Simics full-system execution-driven simulator with the GEMS toolset to provide a detailed memory hierarchy model. Extended with a power model to evaluate the energy savings of each configuration.		





**Better power/performance relation (MIPS<sup>3</sup>/W).**  
 3.66x over Shared memory and 4.30x over Cooperative Caching



**Higher performance**  
 21% performance increase over a Shared memory configuration and 57% over the Cooperative Caching scheme

■ Private Memory 
 ■ CC2T 
 ■ CC4T 
 ■ DCC 
 ■ DCC2x



# Publications

1. E. Herrero, J. González and R. Canal, “Distributed Cooperative Caching”, In the *International Conference on Parallel Architectures and Compilation Techniques (PACT)* (October 2008).
2. E. Herrero, J. González and R. Canal, “Architectural Level Power Simulator of the Memory Hierarchy of Chip Multiprocessors”, *UPC Technical Report UPC-DAC-RR-ARCO-2008-3* (June 2008).

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