PERFORMANCE ANALYSIS OF ARRAY DATABASE SYSTEMS IN NON-UNIFORM MEMORY ARCHITECTURE

EDUARDO C. DE ALMEIDA[1], JORGE A. MEIRA[2], MARCO A. Z. ALVES[1], SIMONE DOMINICO[1]

FEDERAL UNIVERSITY OF PARANÁ, BRAZIL[1], UNIVERSITY OF LUXEMBOURG[2]

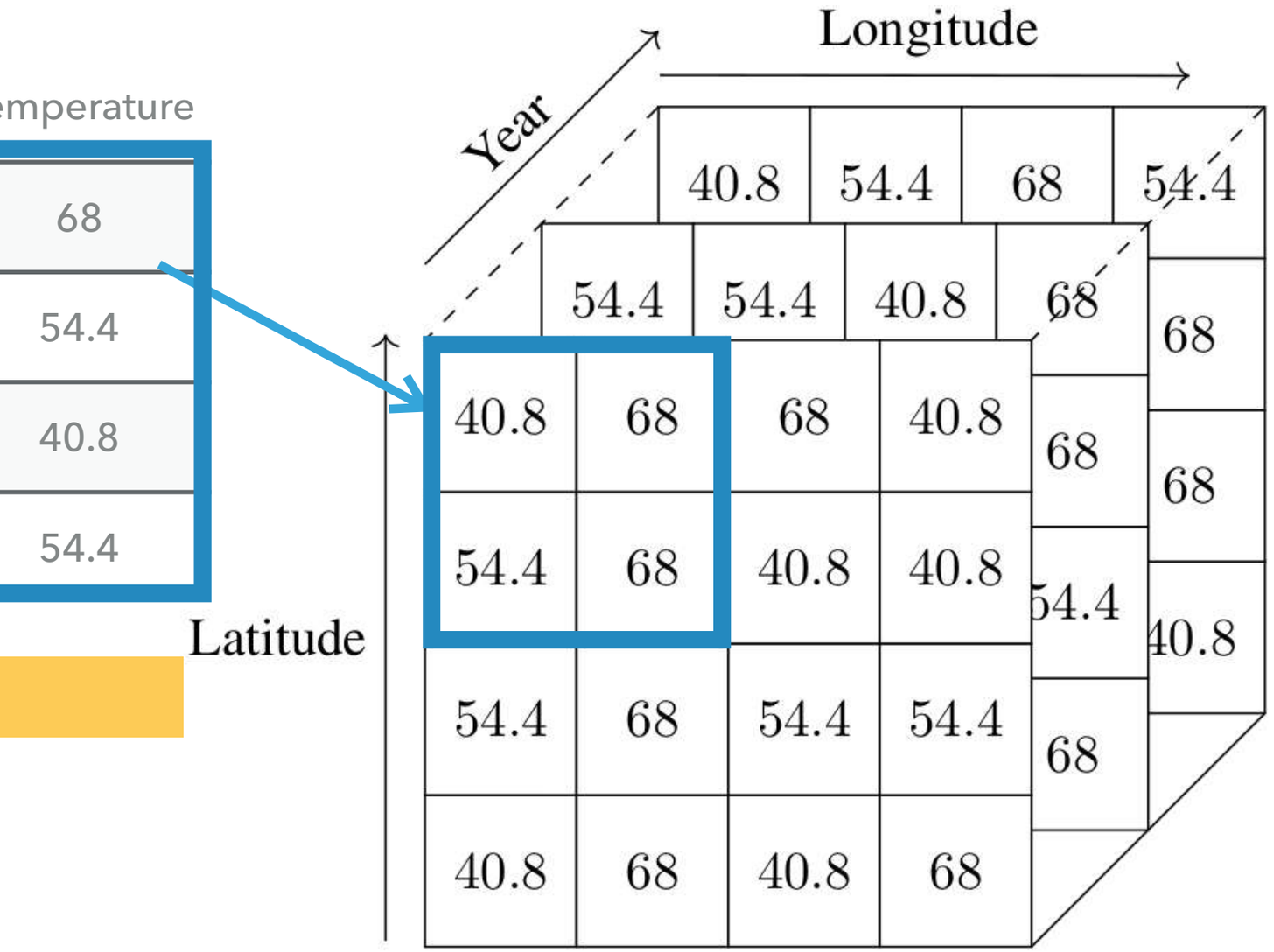
AGENDA

- **Introduction**
  - Array database systems
  - NUMA architecture
    - Array Database Systems in NUMA architecture
- Methodology
  - Thread pinning Strategies
- Experiments
- Conclusion

ARRAY DATABASE AND RELATIONAL MODEL

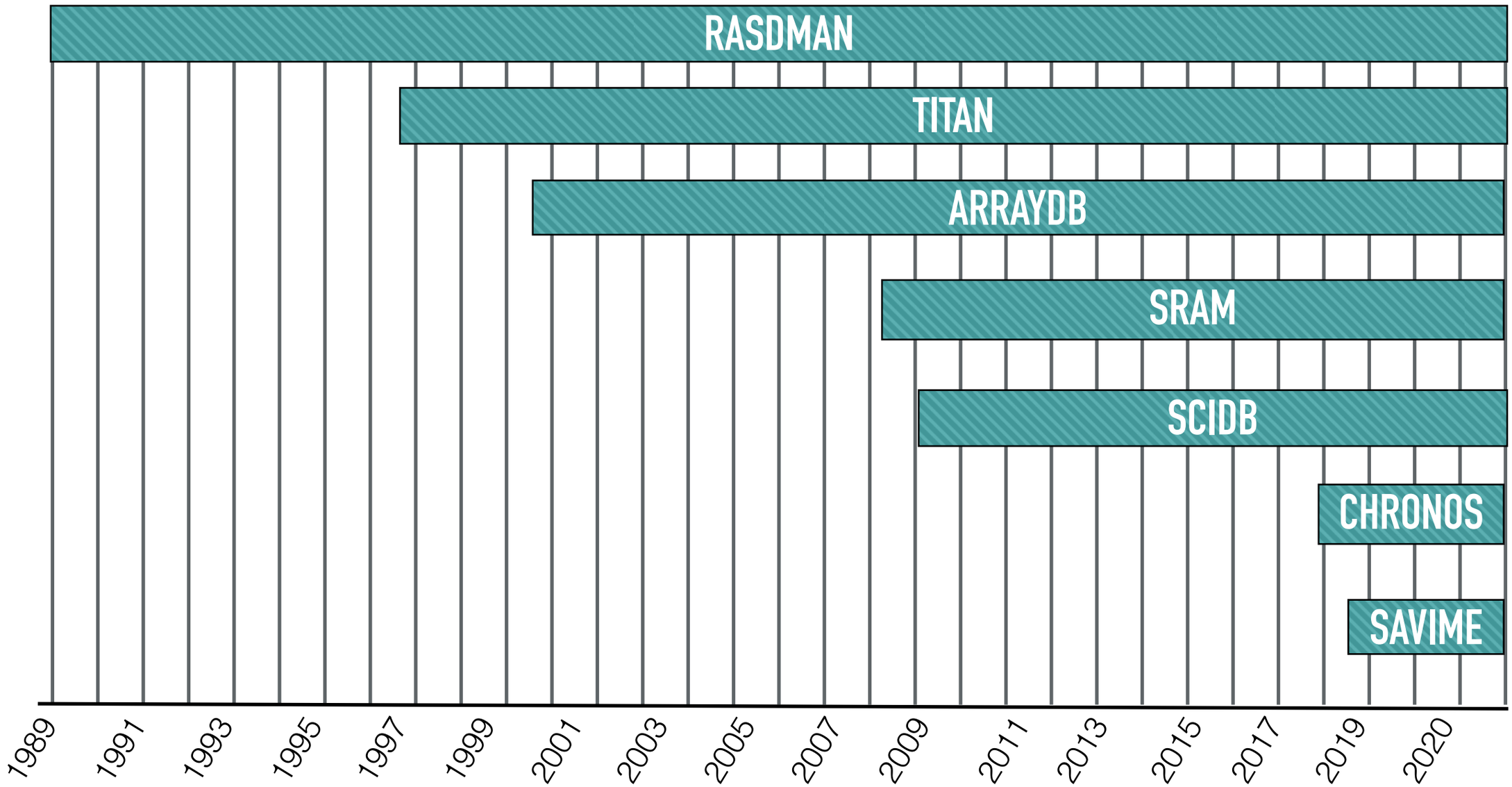
Year	Latitude	Longitude	Temperature
1989	-25° 25' 40''	-49° 16' 23''	68
1989	-30° 01' 59''	-51° 13' 48''	54.4
1989	-05° 05' 21''	-42° 48' 07''	40.8
1989	-02° 31' 47''	-44° 18' 10''	54.4

RELATIONAL MODEL



MULTIDIMENSIONAL ARRAY MODEL

ARRAY DATABASE SYSTEMS



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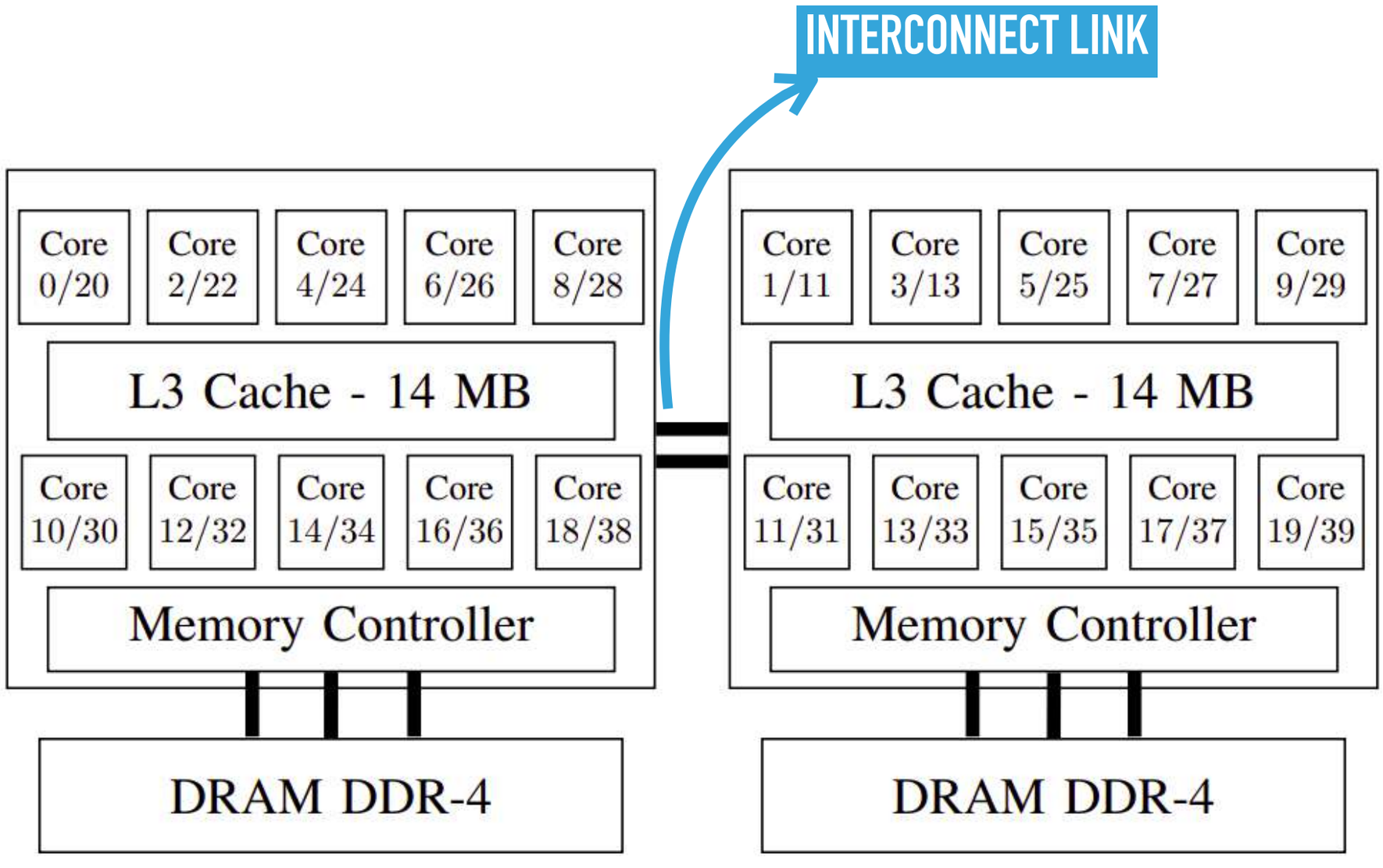
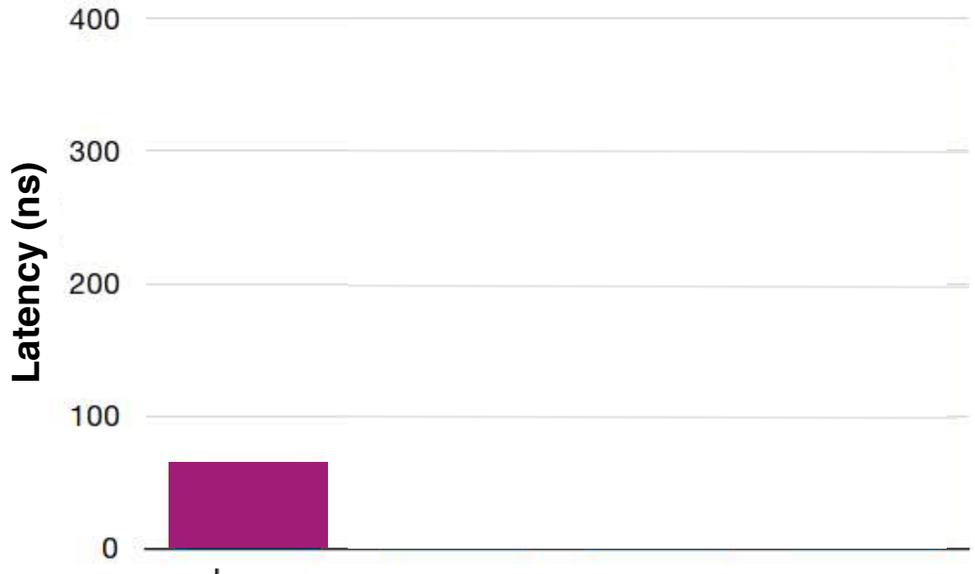
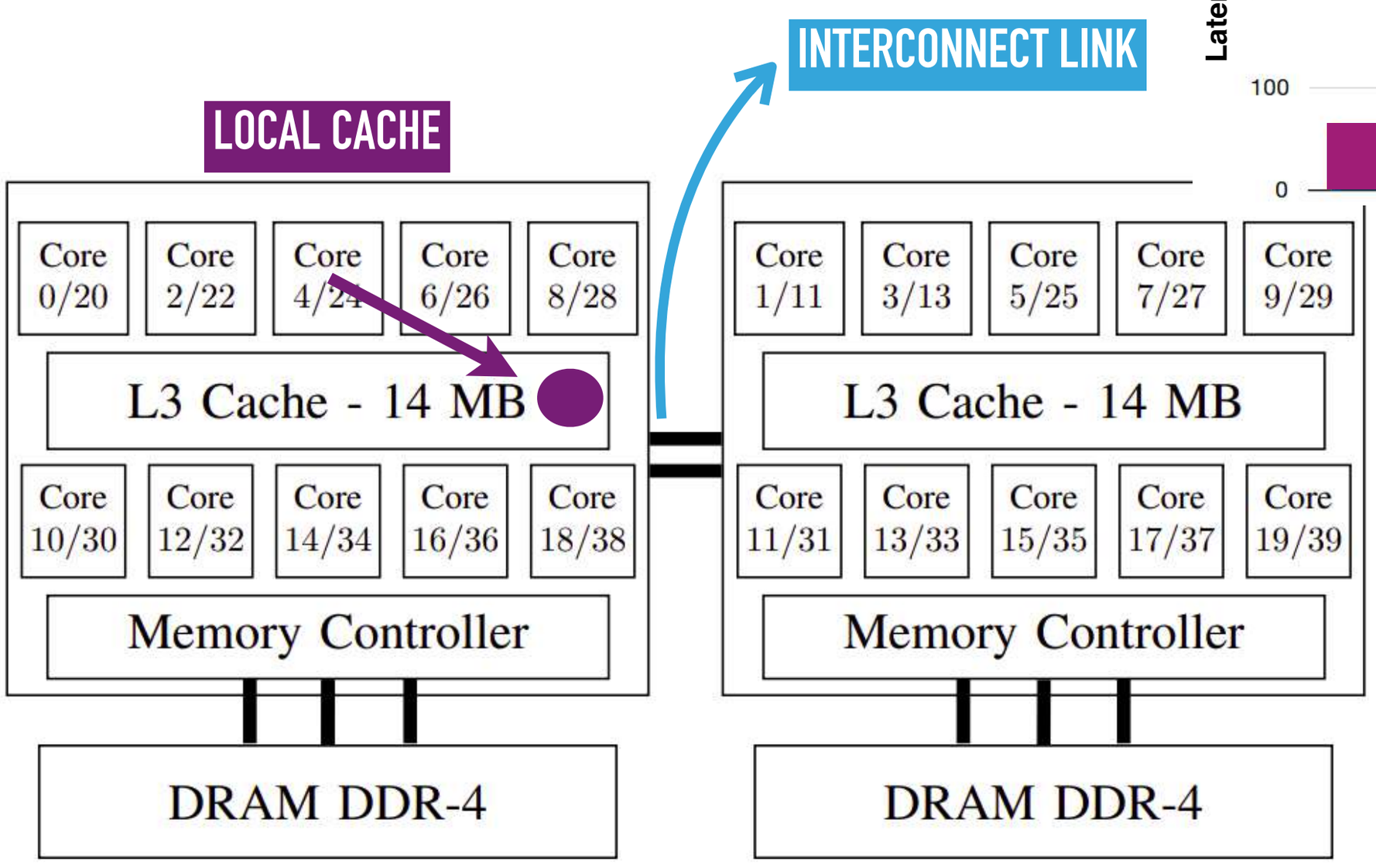
NUMA ARCHITECTURE



EXAMPLE OF A NUMA ARCHITECTURE WITH 2-NODES INSPIRED ON INTEL XEON SILVER 4114.

NUMA ARCHITECTURE





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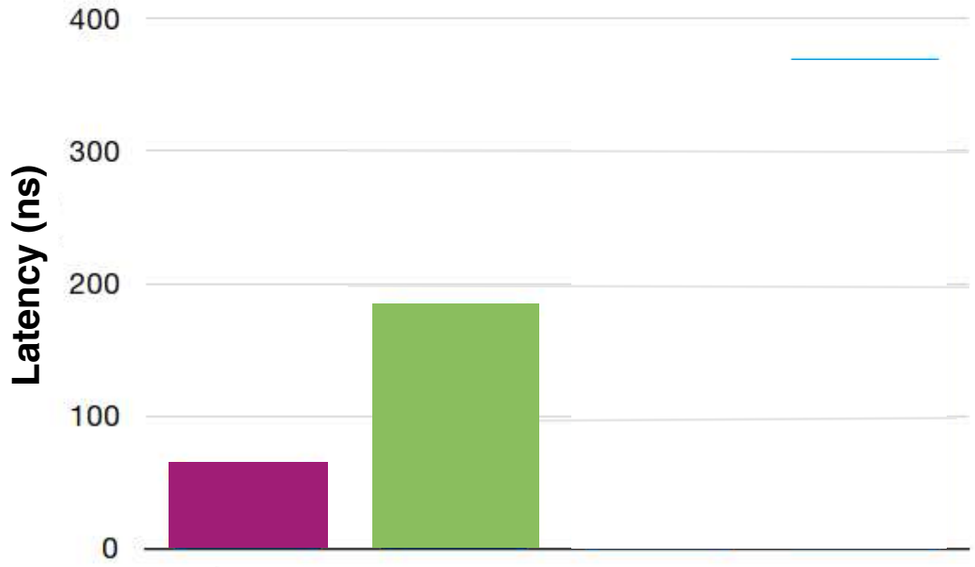

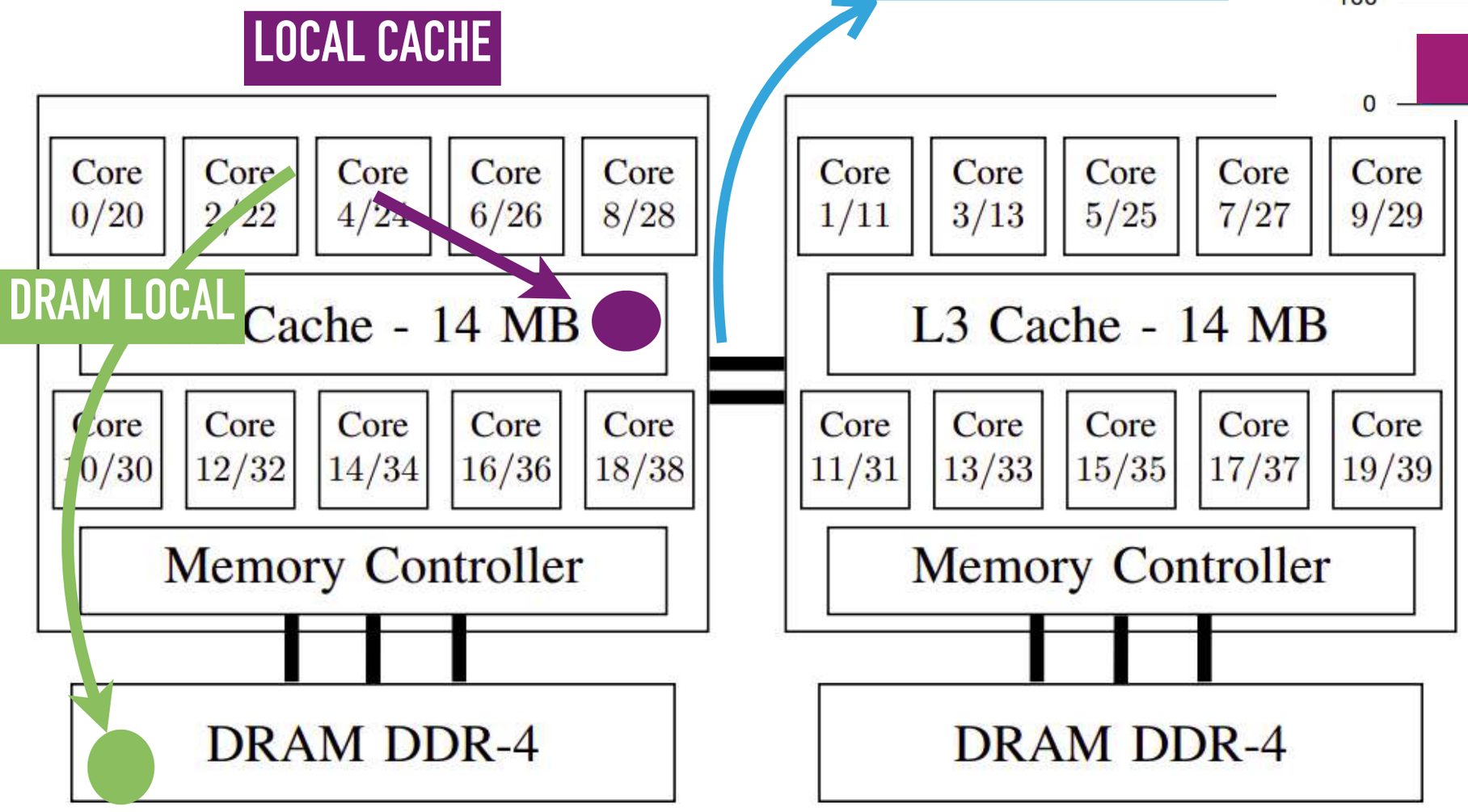

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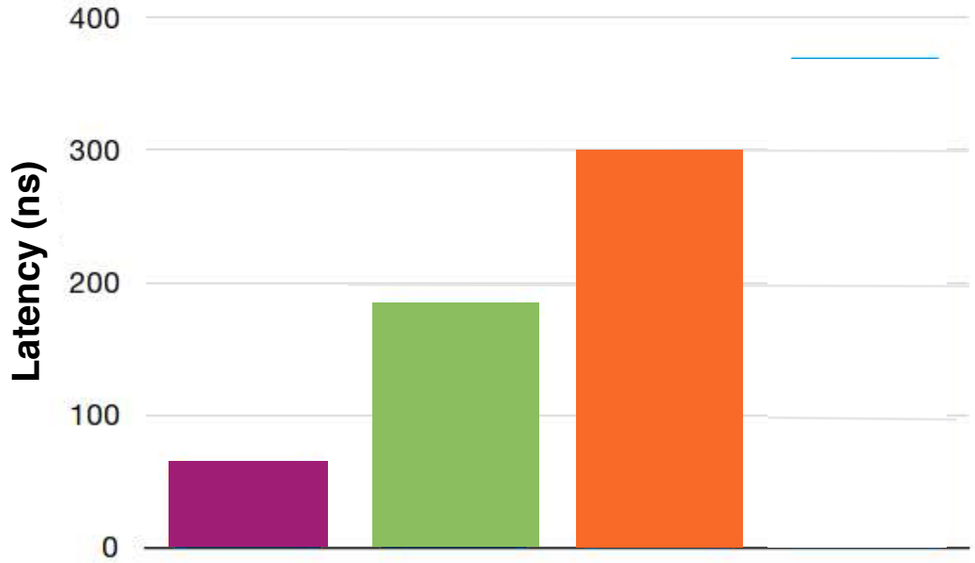

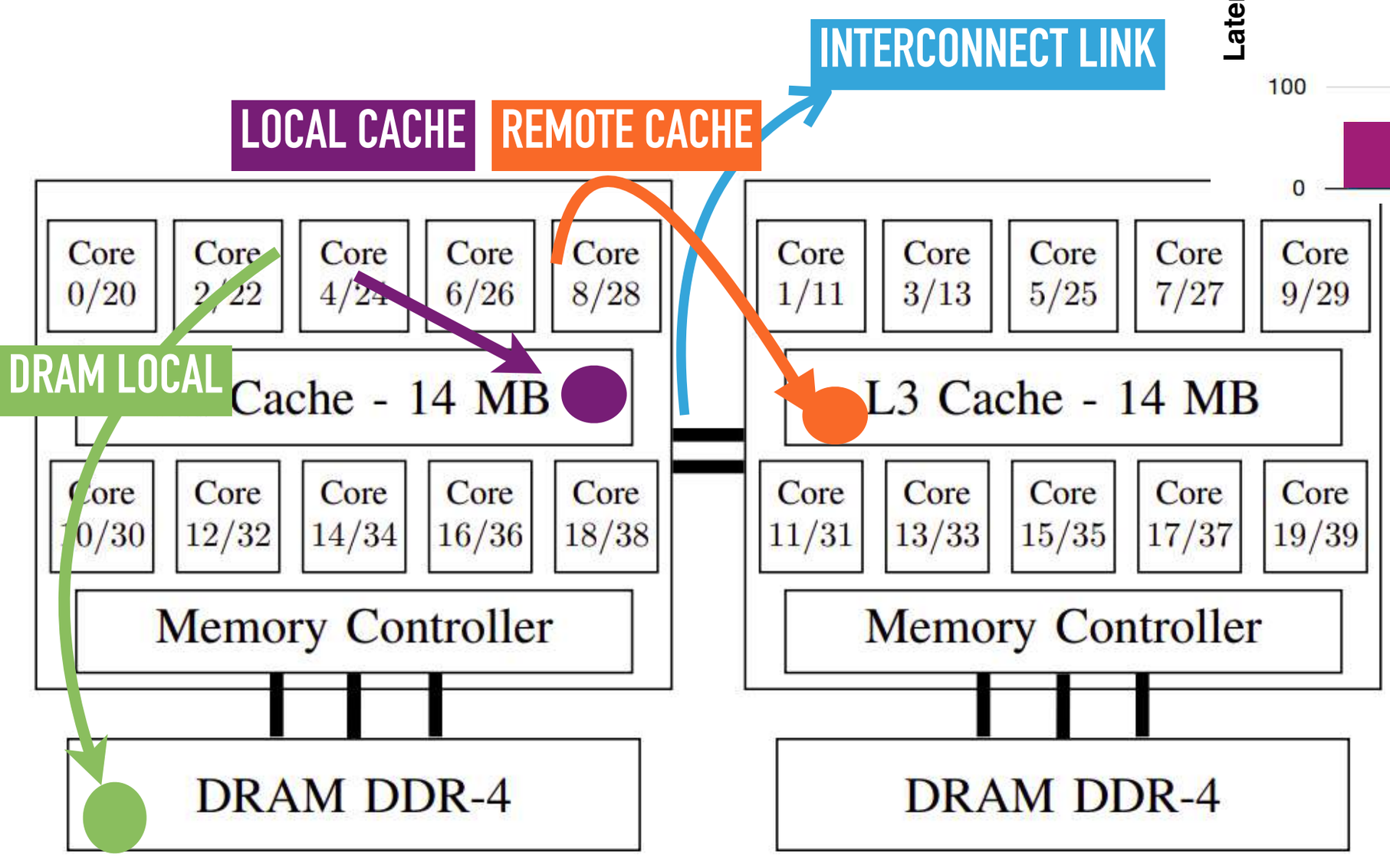

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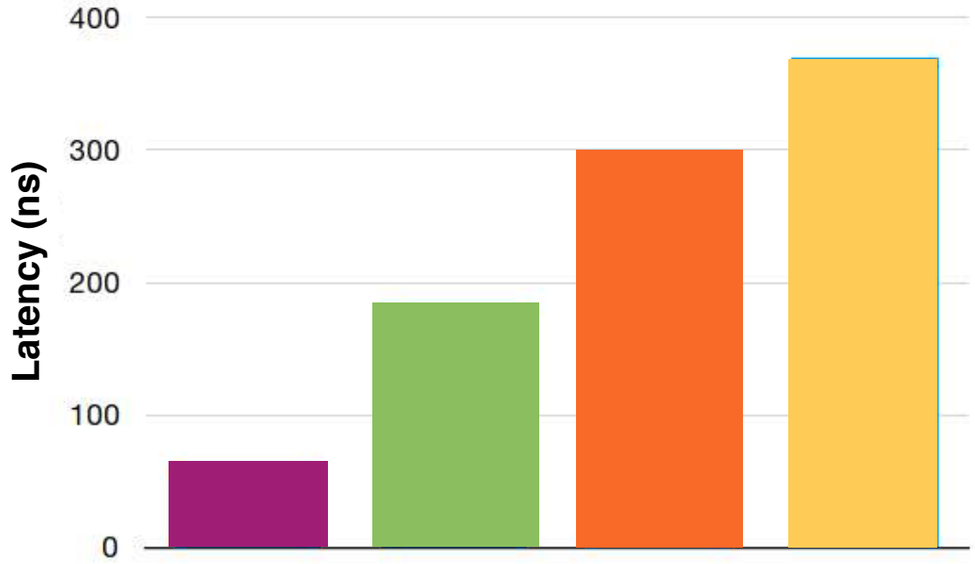
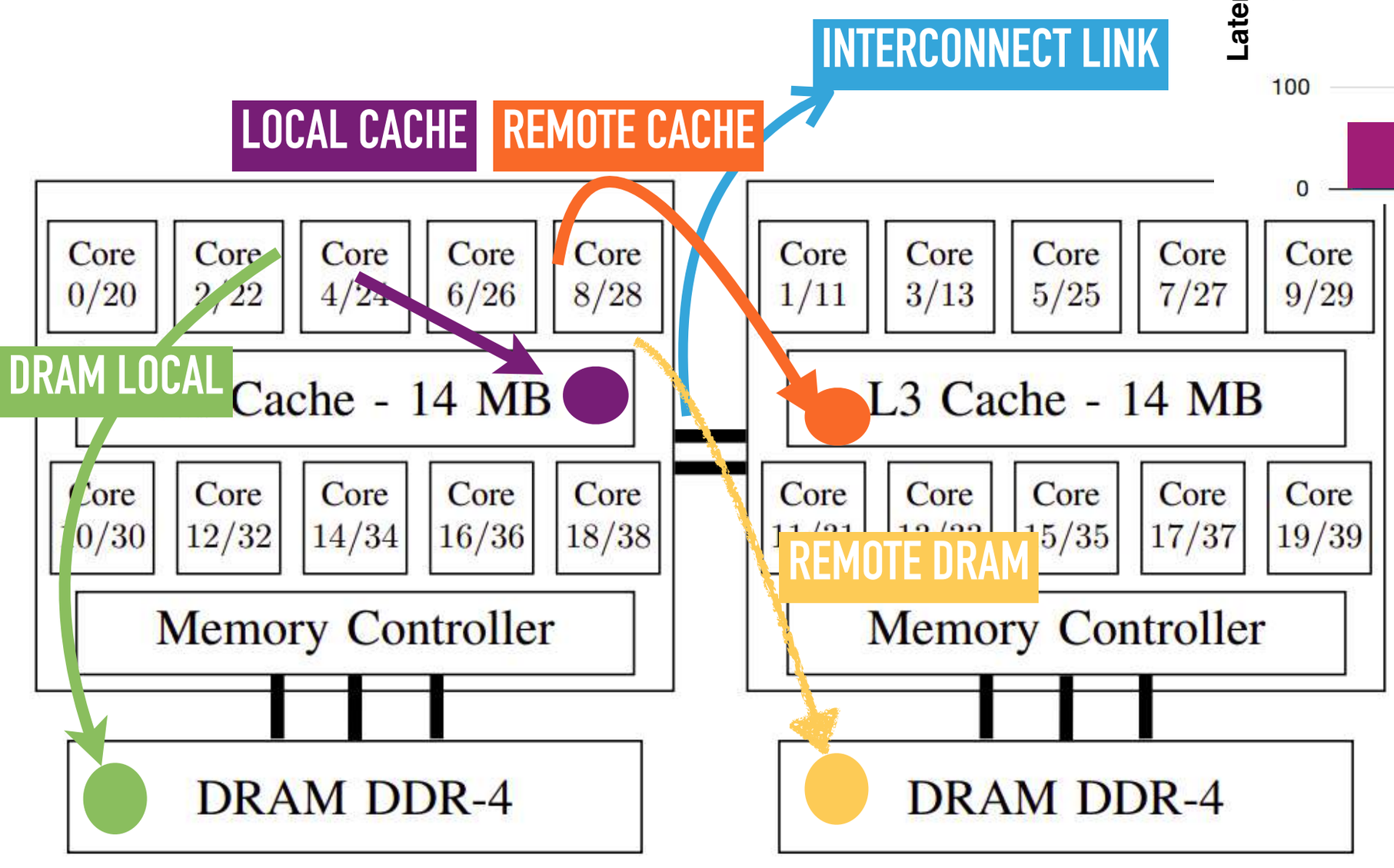
NUMA ARCHITECTURE





EXEMPLO DE ARQUITETURA NUMA COM 2-SOCKETS INSPIRADA NO INTEL XEON SILVER 4114

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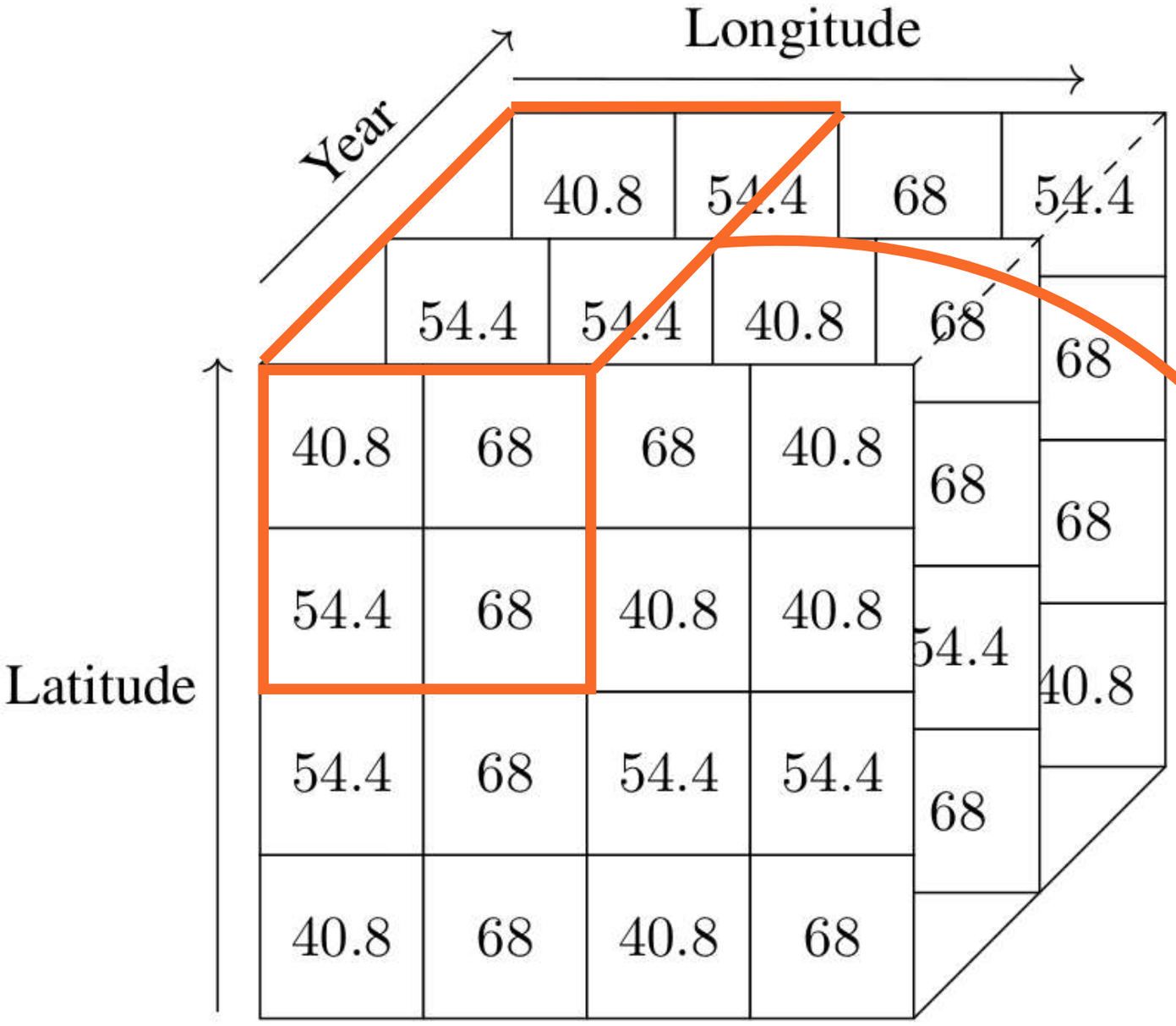
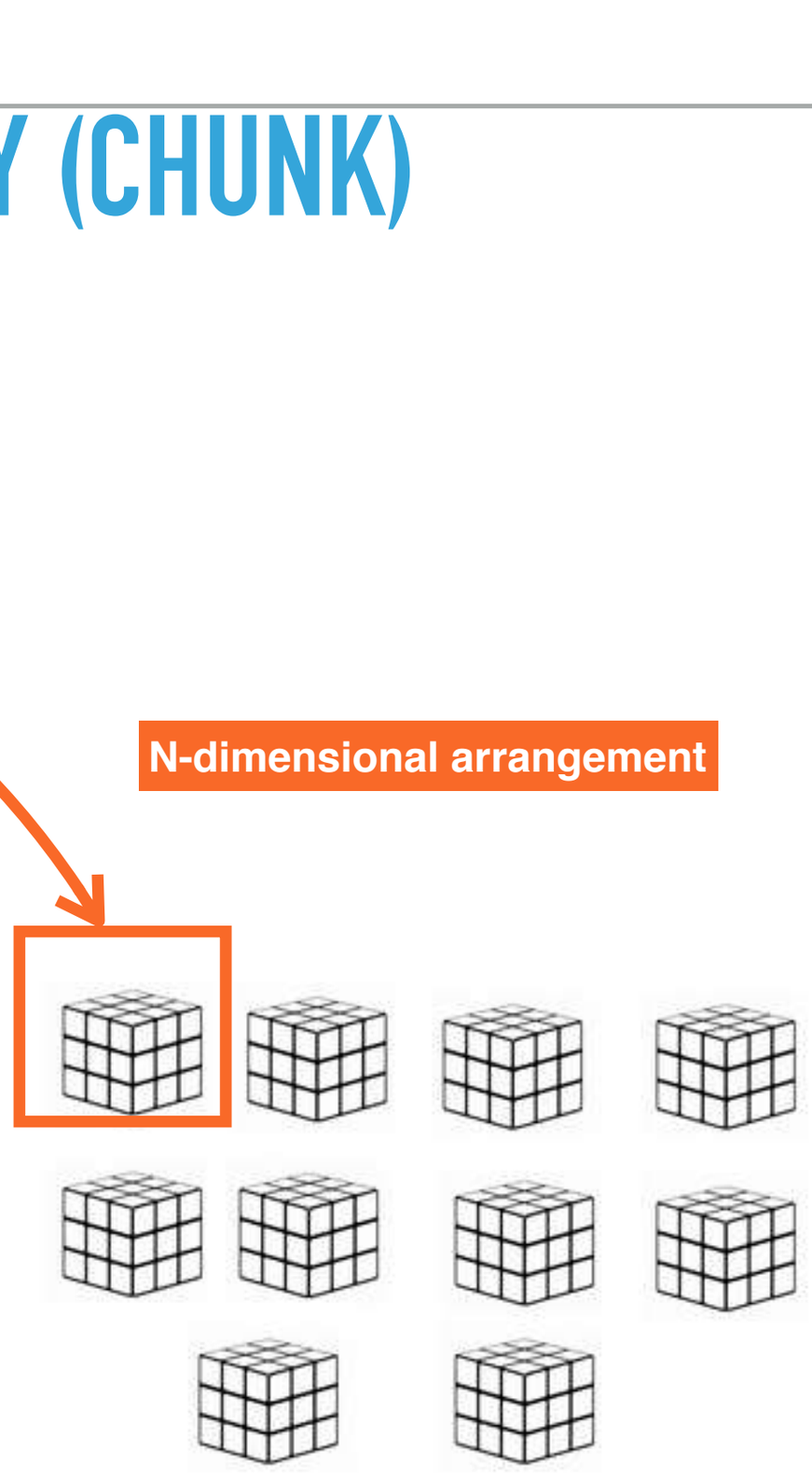
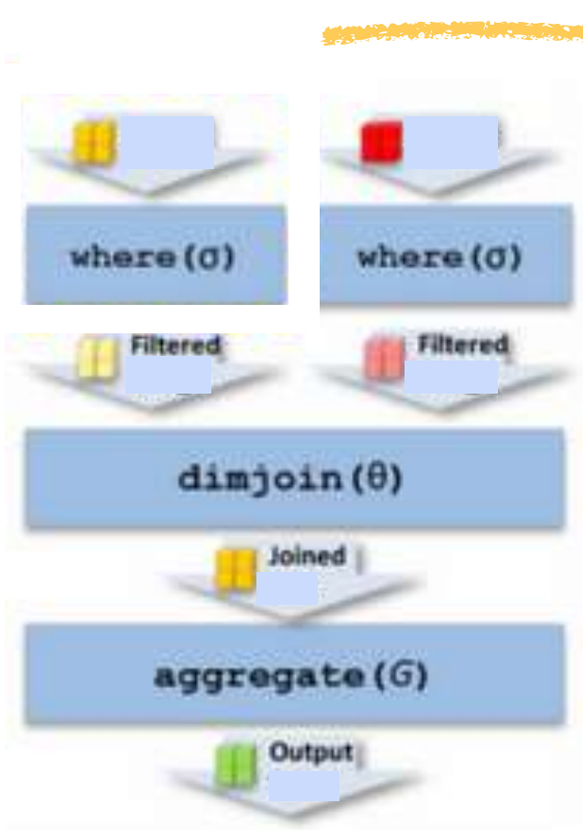
ARRAY STORED AS A SUBARRAY (CHUNK)

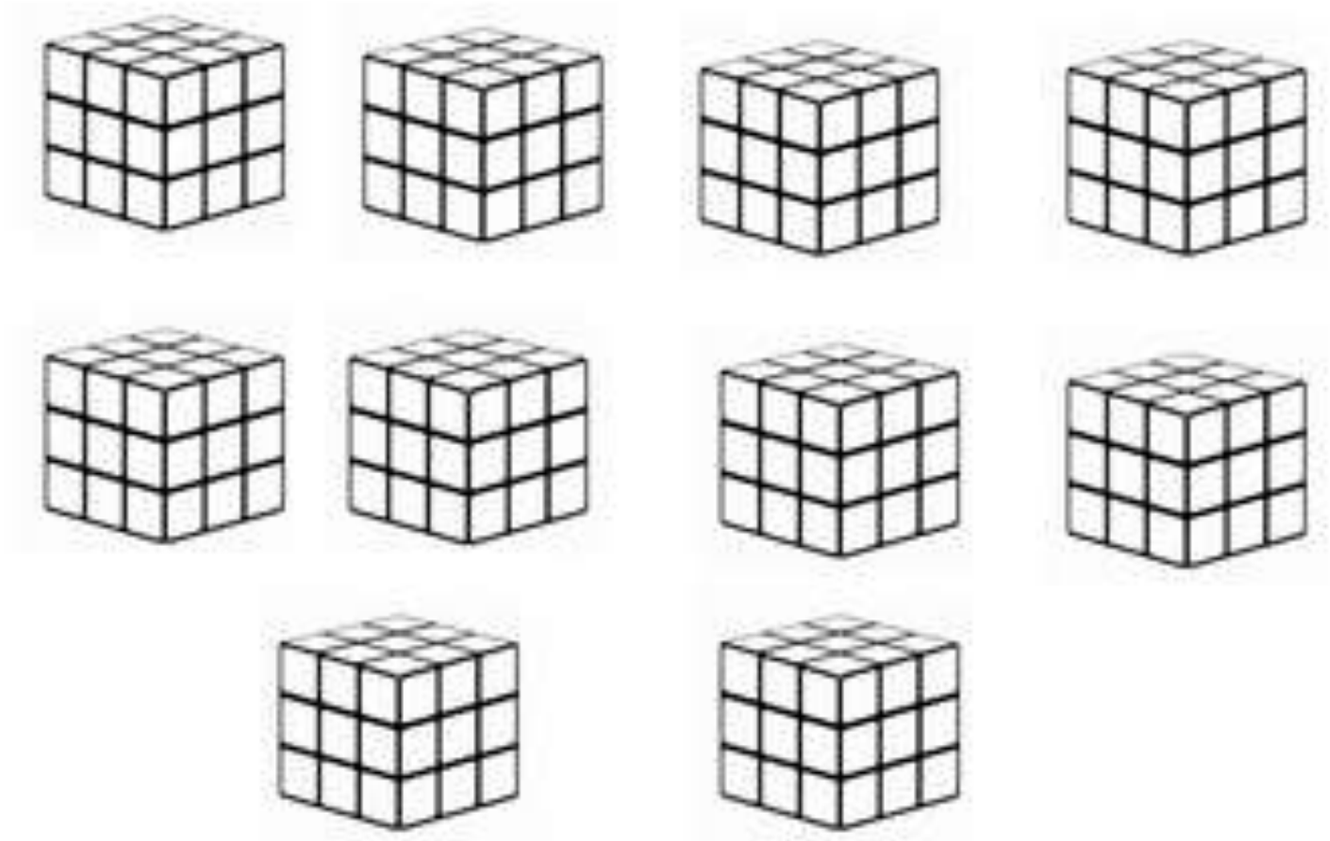


N-dimensional arrangement



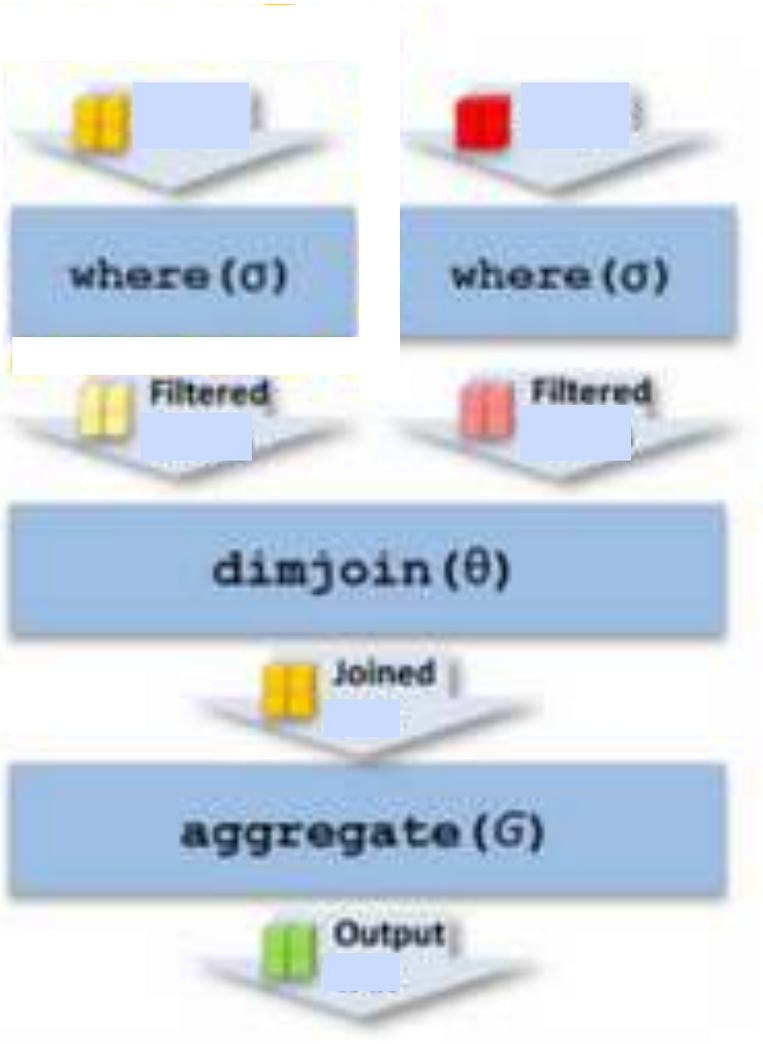
PROCESSING MODEL



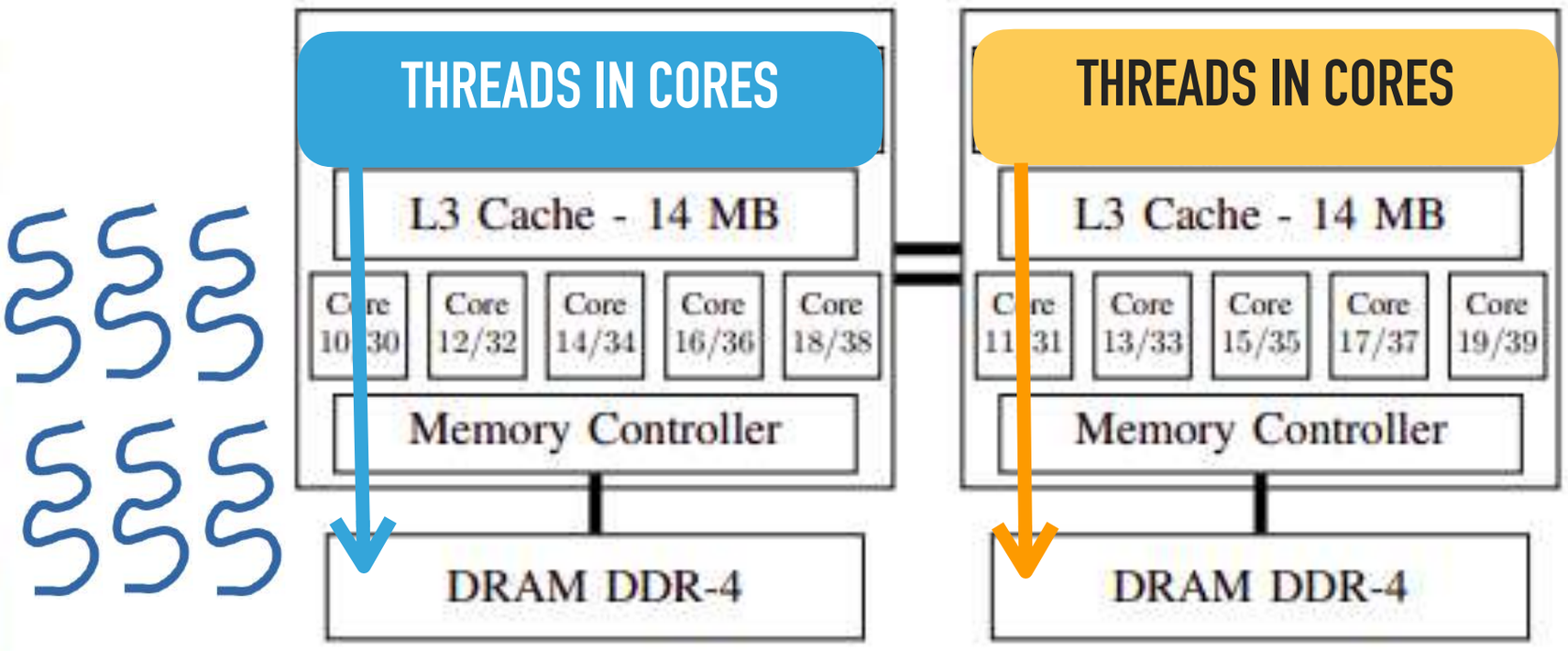


EACH DATABASE OPERATION PROCESSES SUBARRAY WITH MULTIPLE THREADS

THREAD POSITIONING – OPERATION SYSTEM

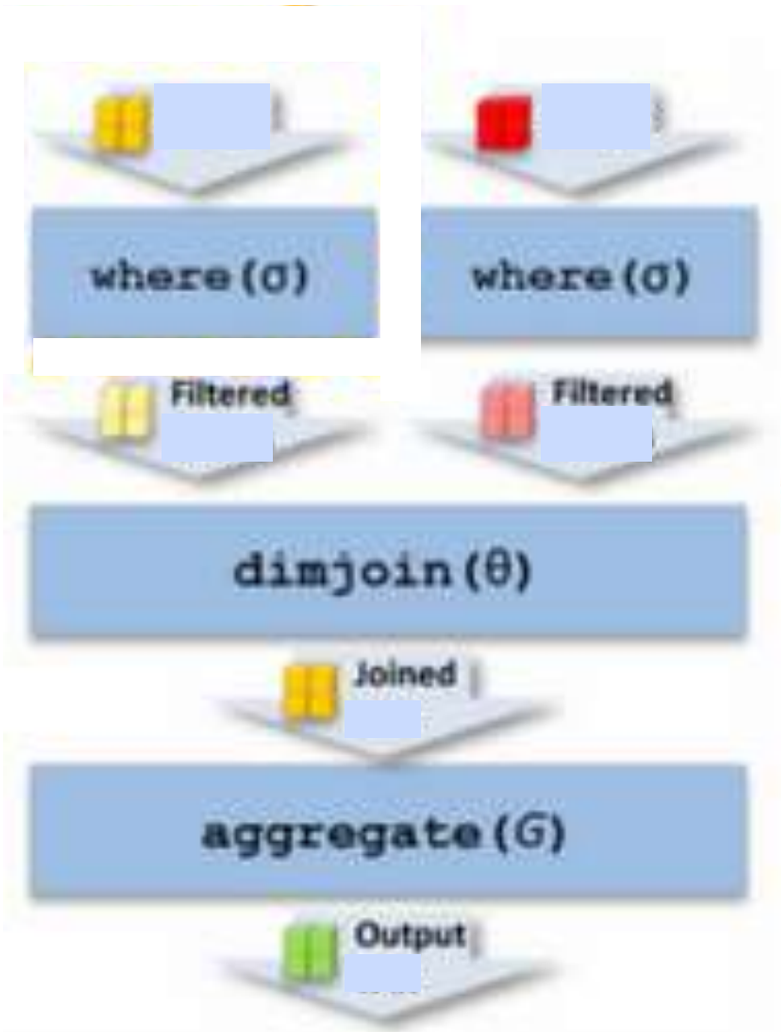


THREADS RUN PARALLEL AND COMPETE FOR SPACE IN THE CORES



MULTIPLE THREADS PROCESS A QUERY OPERATION

THREAD POSITIONING – OPERATION SYSTEM



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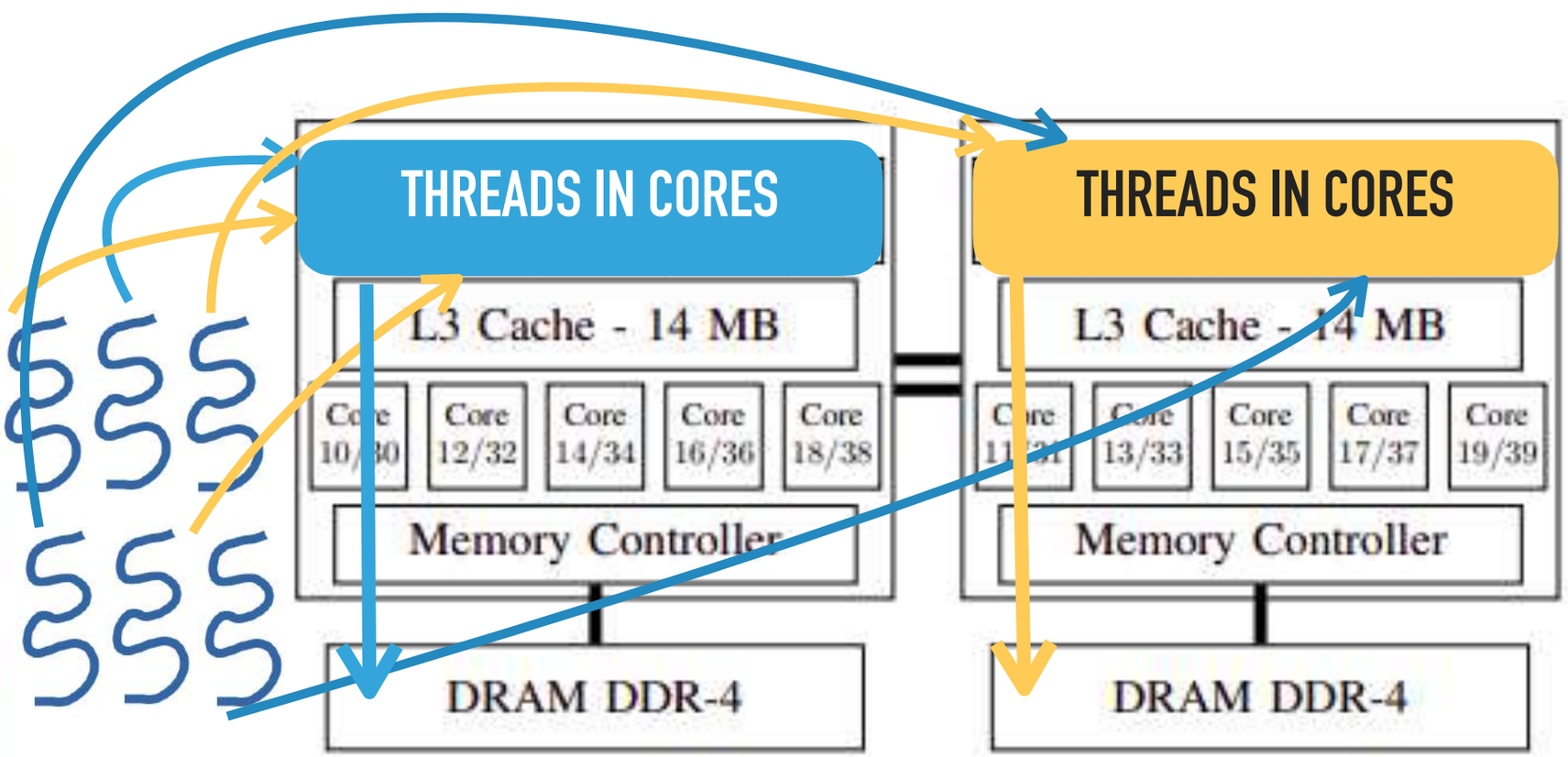

MULTIPLE THREADS PROCESS A QUERY OPERATION

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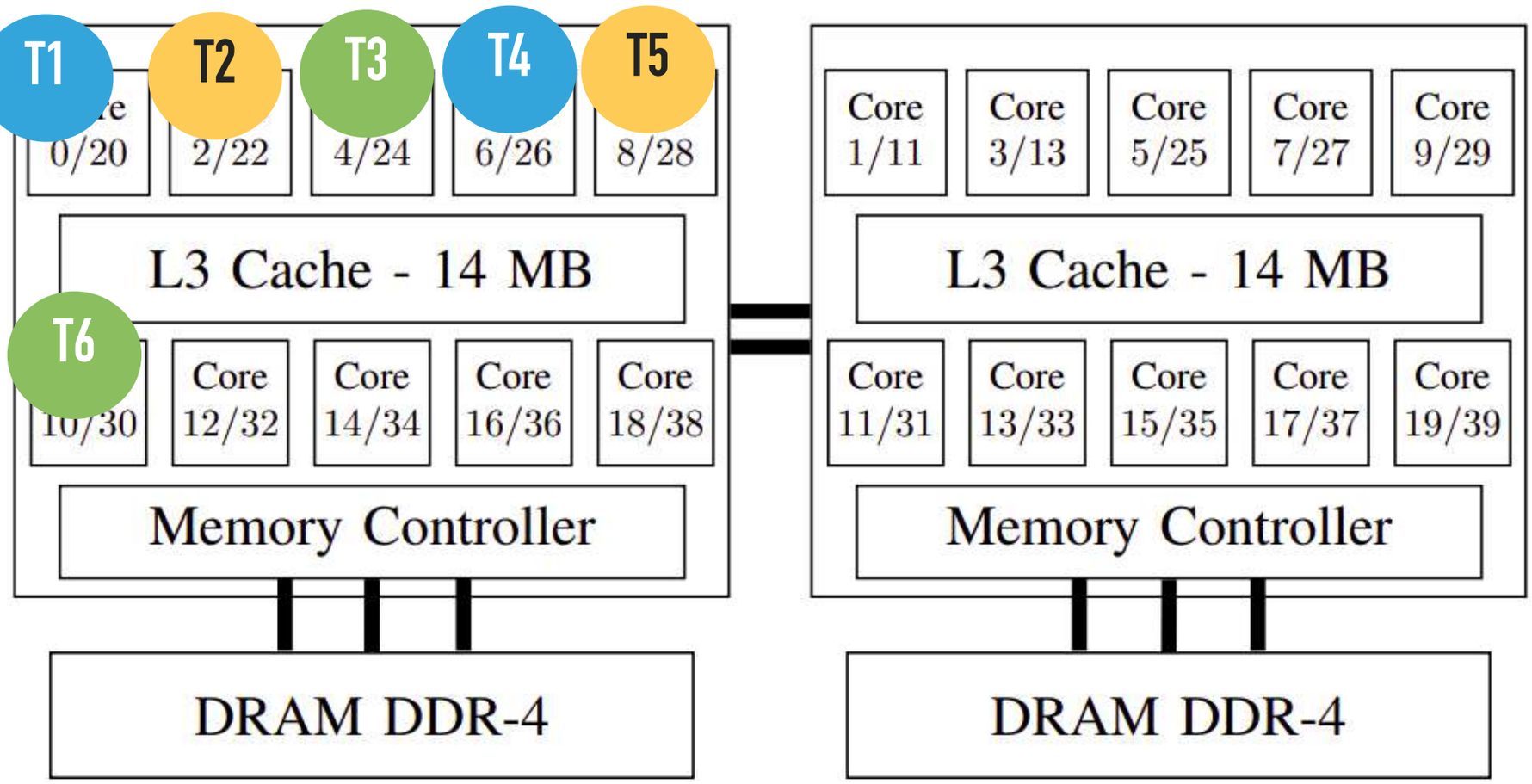
THREAD PINNING STRATEGIES

- state-of-the-art strategies
- Petri net
- Random allocation

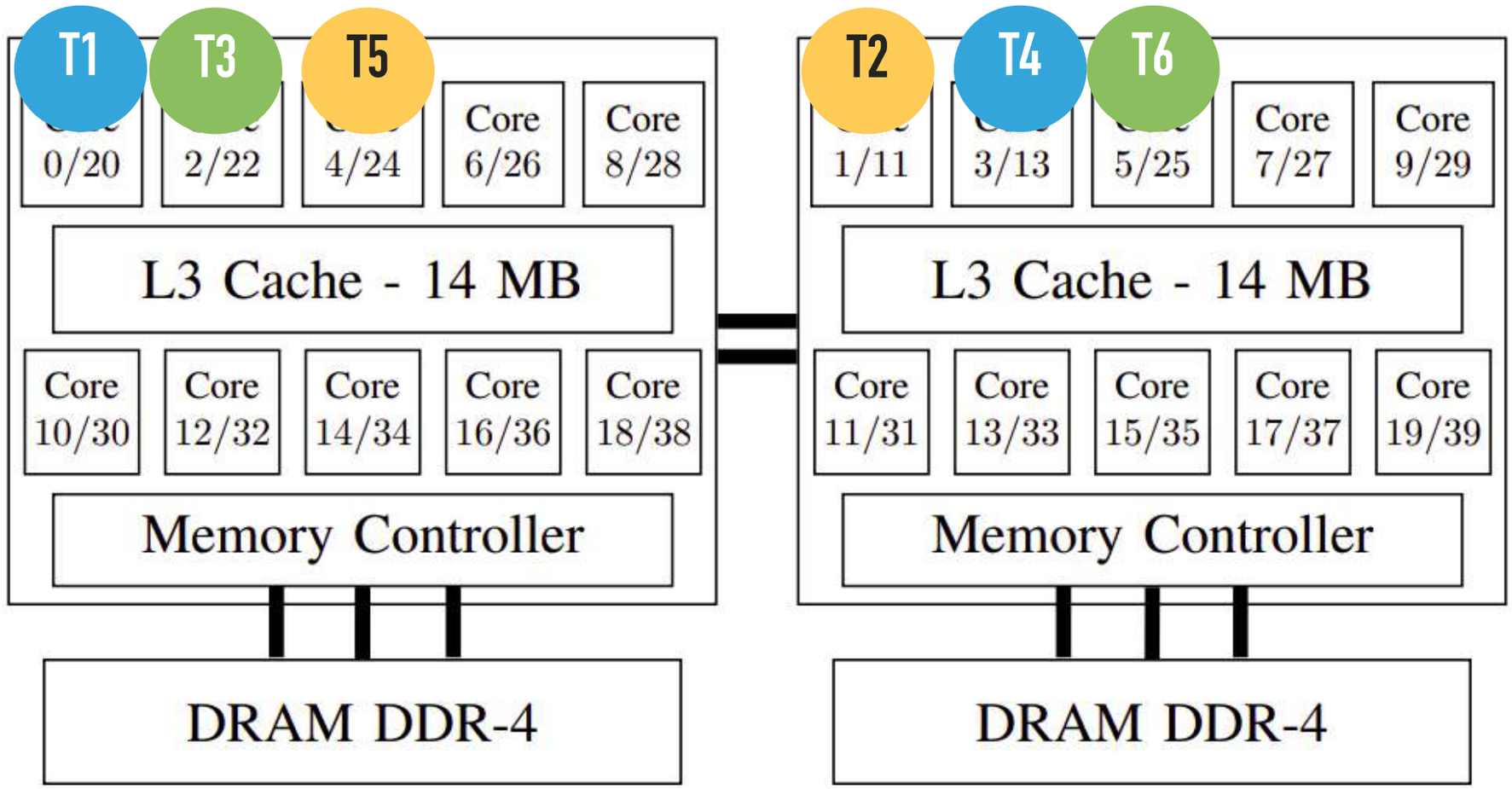
THREAD PINNING STRATEGIES

- COMPACT
  - Same Socket



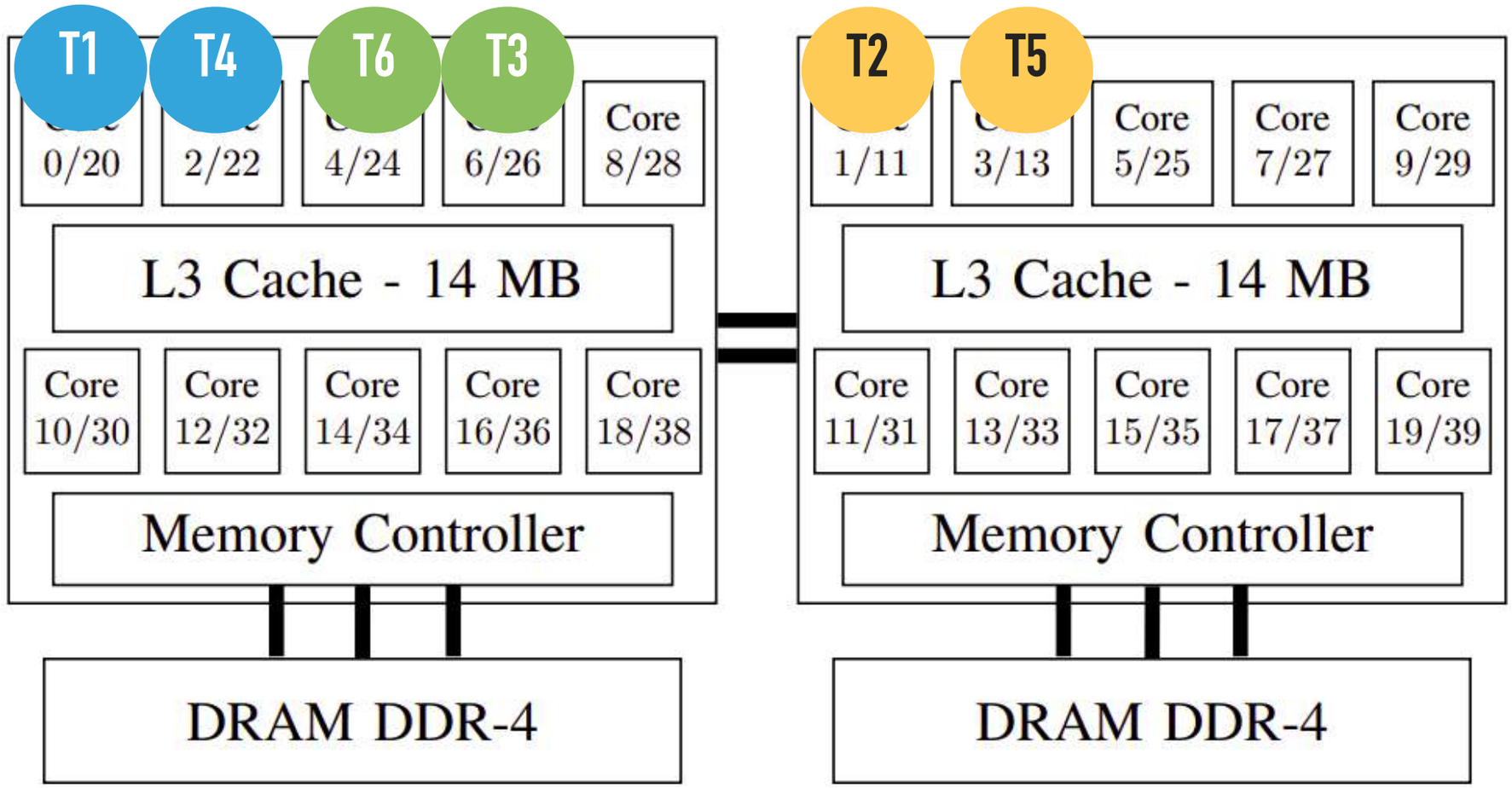
THREAD PINNING STRATEGIES

- SPARSE
  - One thread each socket



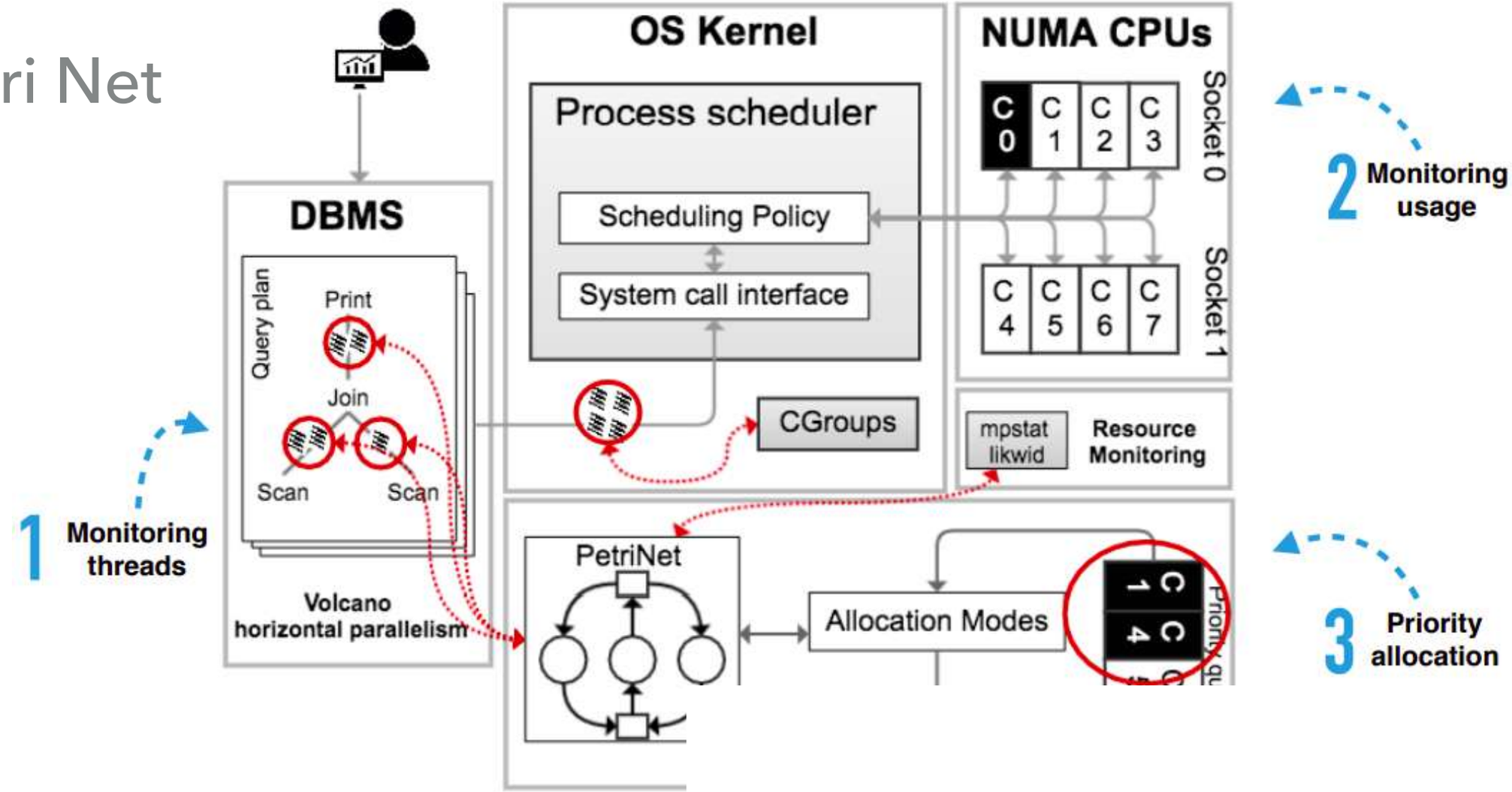
THREAD PINNING STRATEGIES

- SHARED
  - Threads that share data on the same node.



THREAD PINNING STRATEGIES

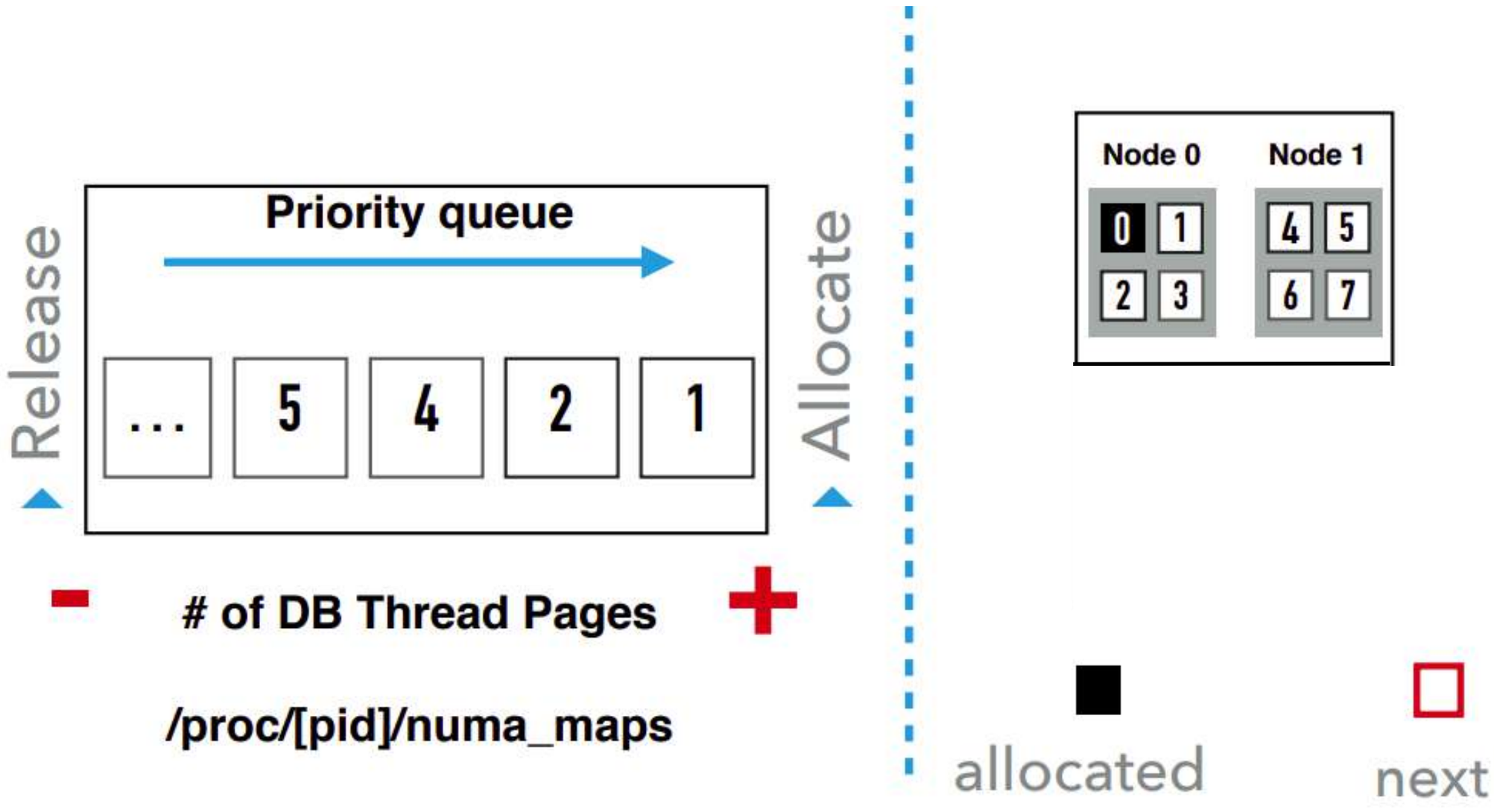
- Petri Net



S. Dominico, E. C. de Almeida, J. A. Meira, and M. A. Z. Alves, “An elastic multi-core allocation mechanism for database systems,” in IEEE 34th Int. Conf. on Data Eng. (ICDE), 2018, pp. 473–484.

THREAD PINNING STRATEGIES

- Petri Net



THREAD PINNING STRATEGIES

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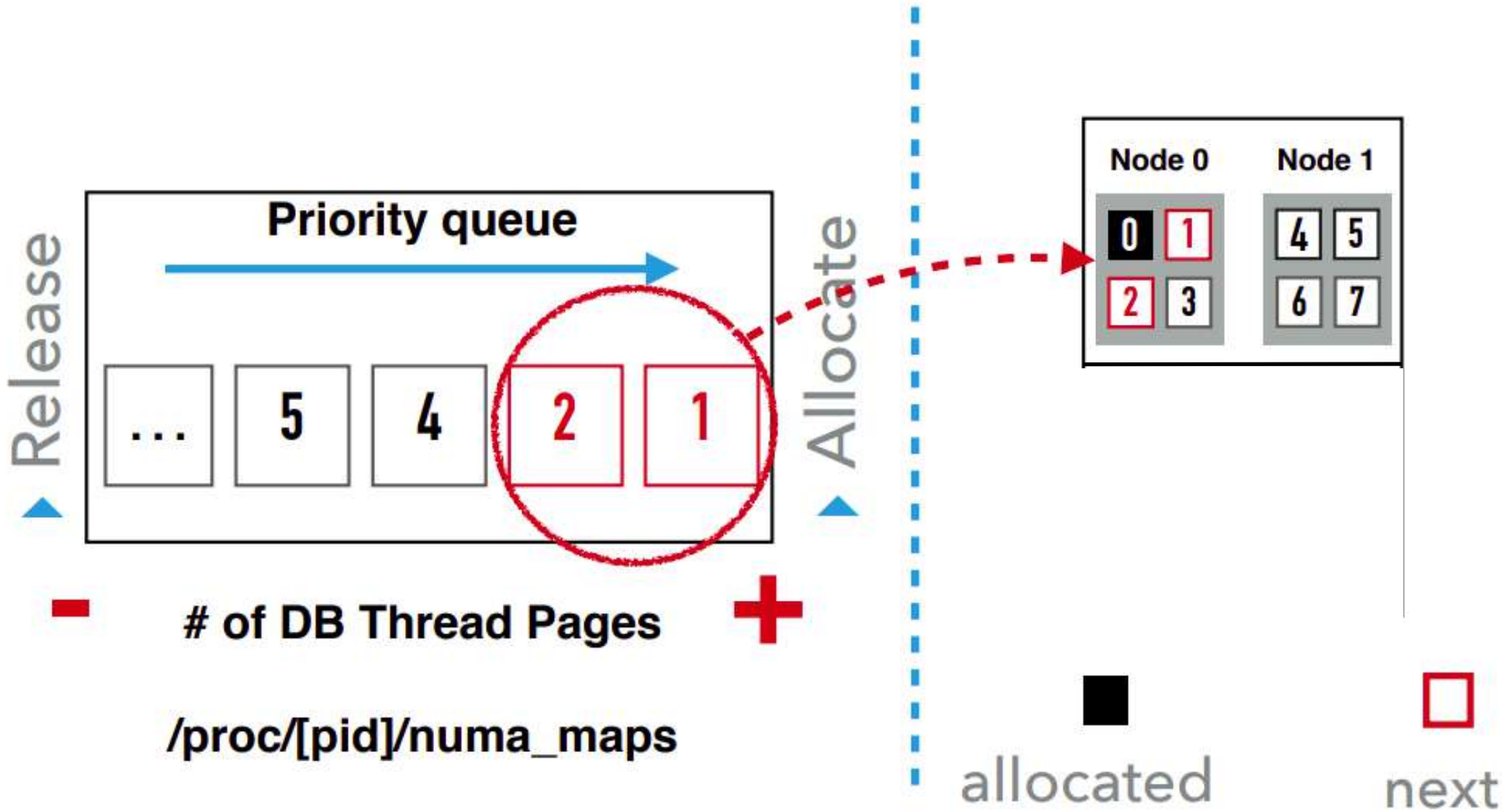
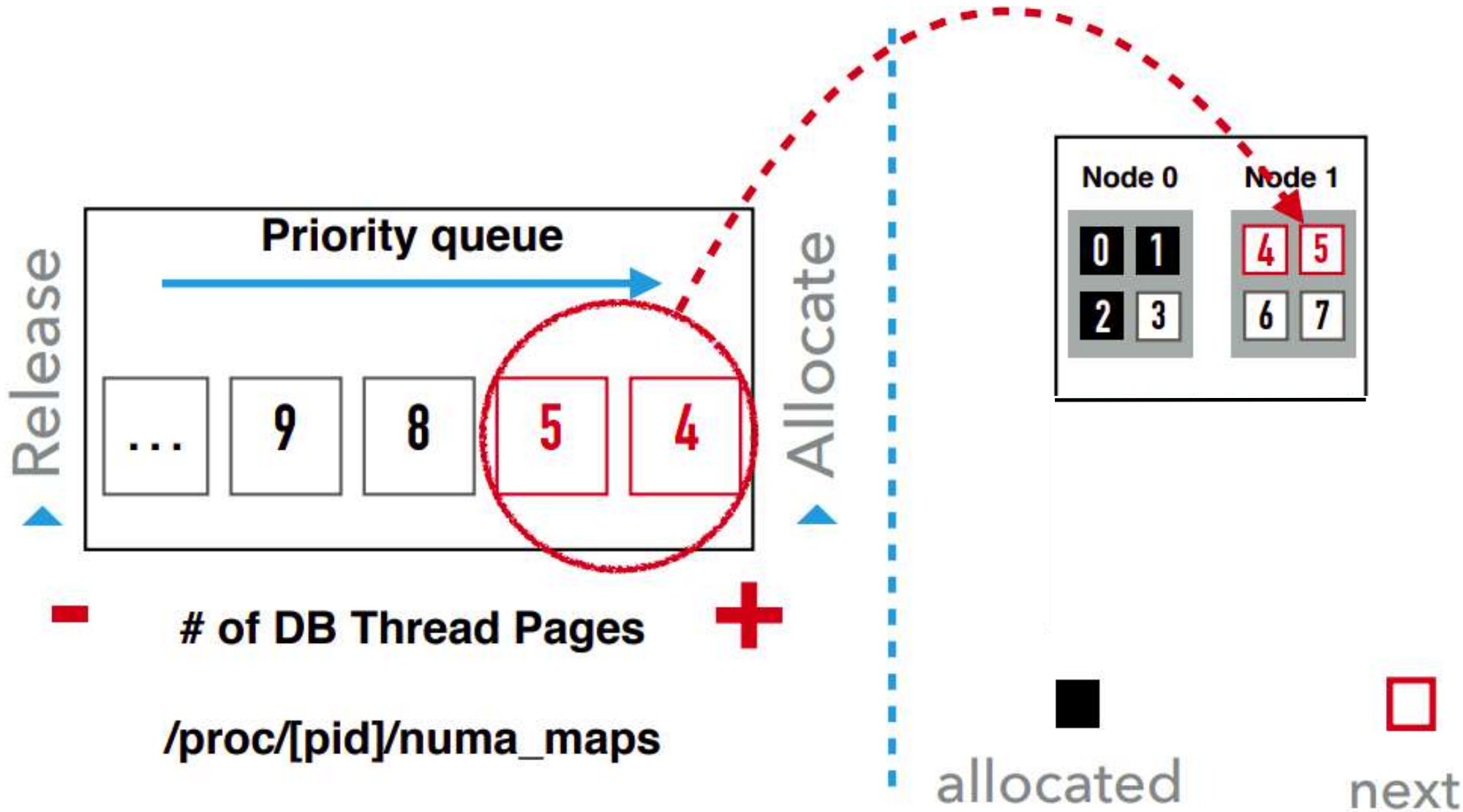


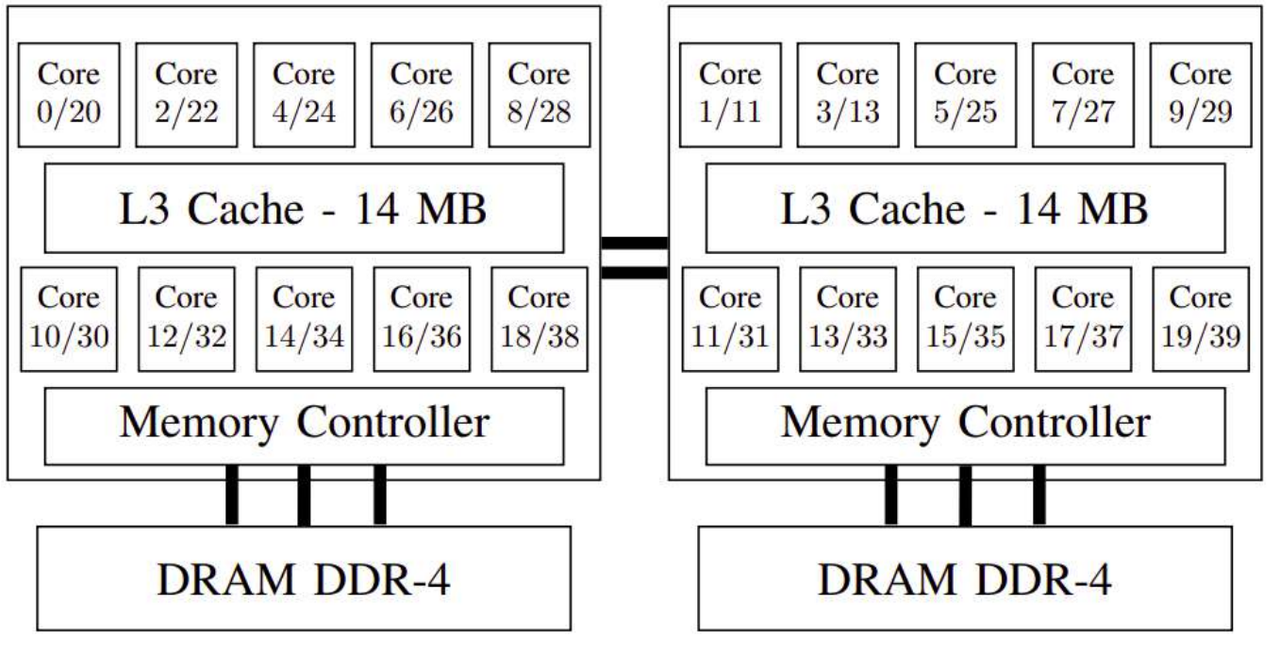
THREAD PINNING STRATEGIES

- Rede de Petri



THREAD PINNING STRATEGIES

- RANDOM



THREAD PINNING STRATEGIES

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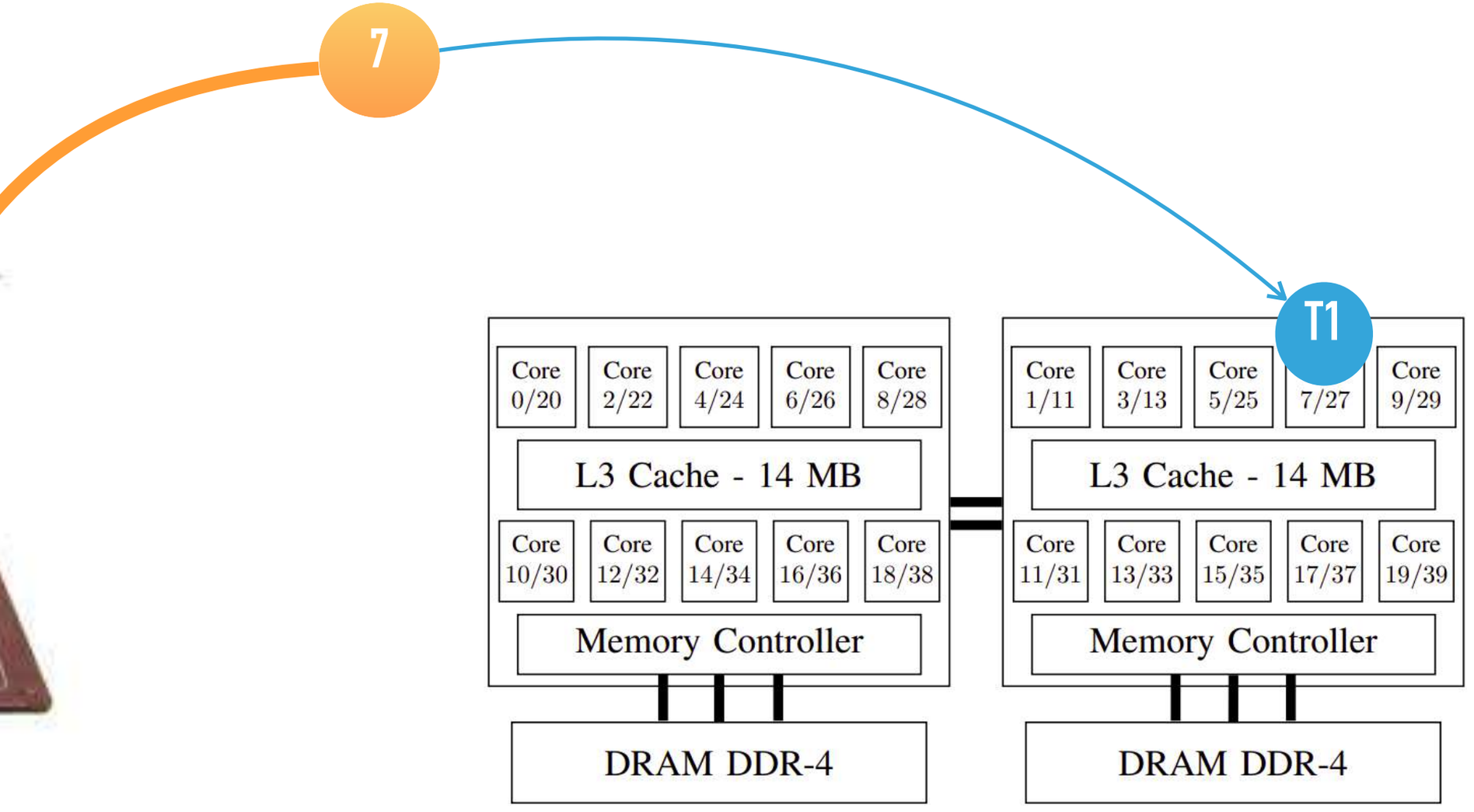

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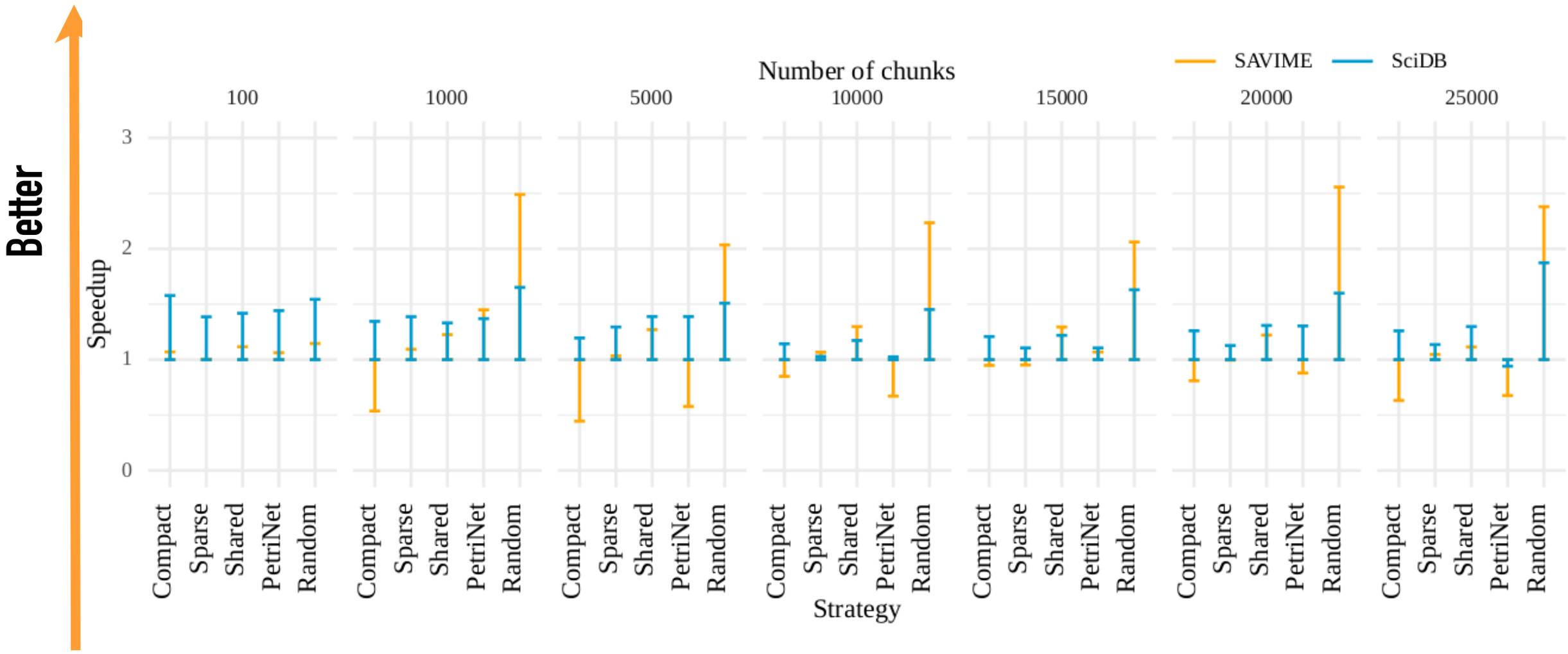
SETUP

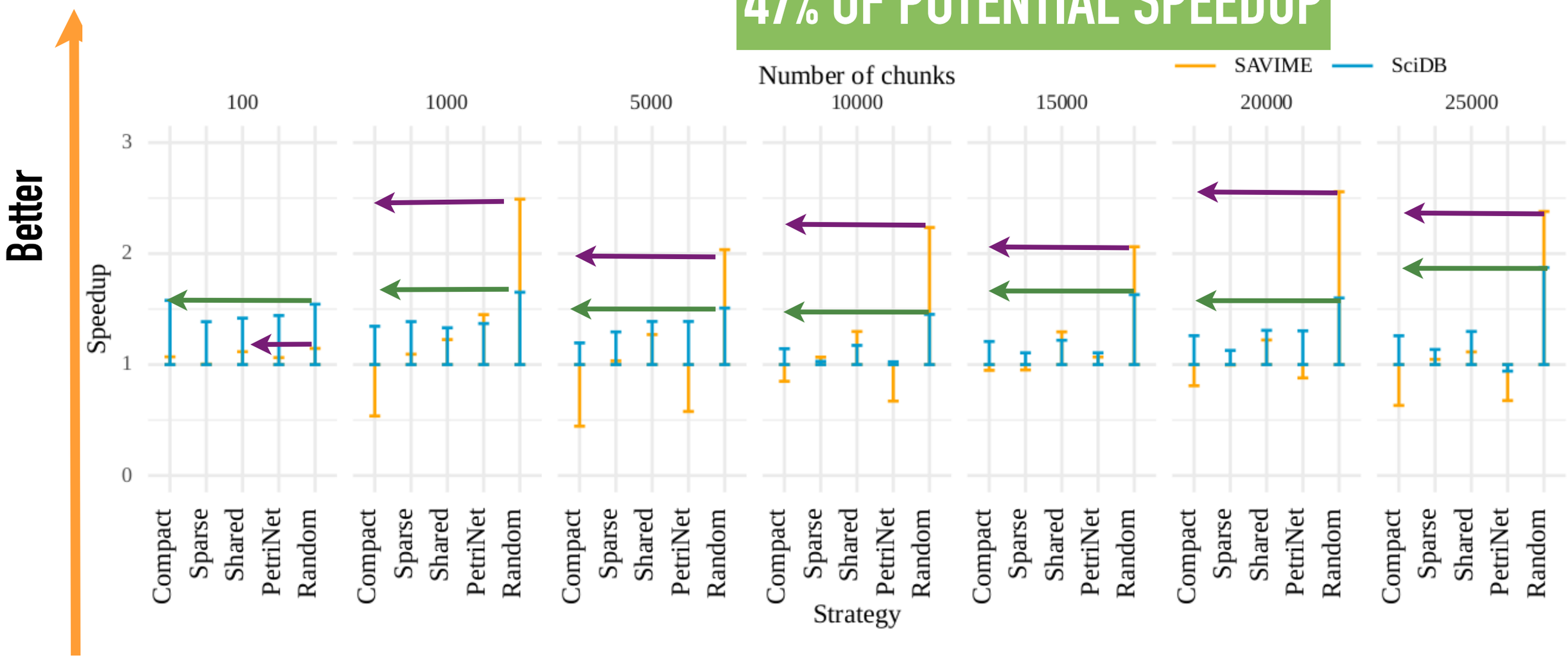
- Subarray: Savime and SciDB
- Server with 2-Sockets Intel Xeon Silver 4114 (20 cores)
- Ubuntu 18.04.01 LTS “Bionic Beaver” (Savime) and Ubuntu 14.04.6 LTS “Trusty Tahr”;
- Threads: 20
- 1 GB: different numbers of chunks
- 50 GB: Selectivity

PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN 1 GB DATABASE – SPEEDUP



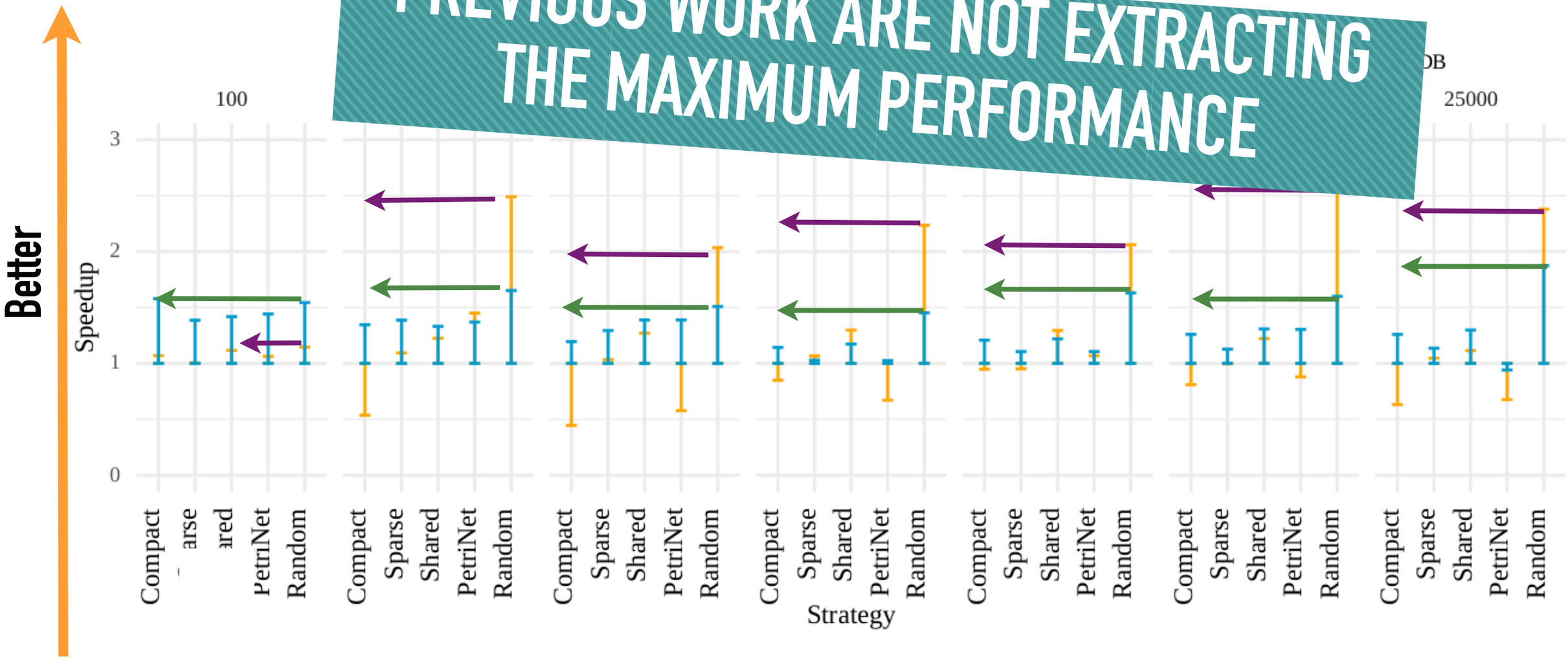
PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN 1 GB DATABASE – SPEEDUP

47% OF POTENTIAL SPEEDUP



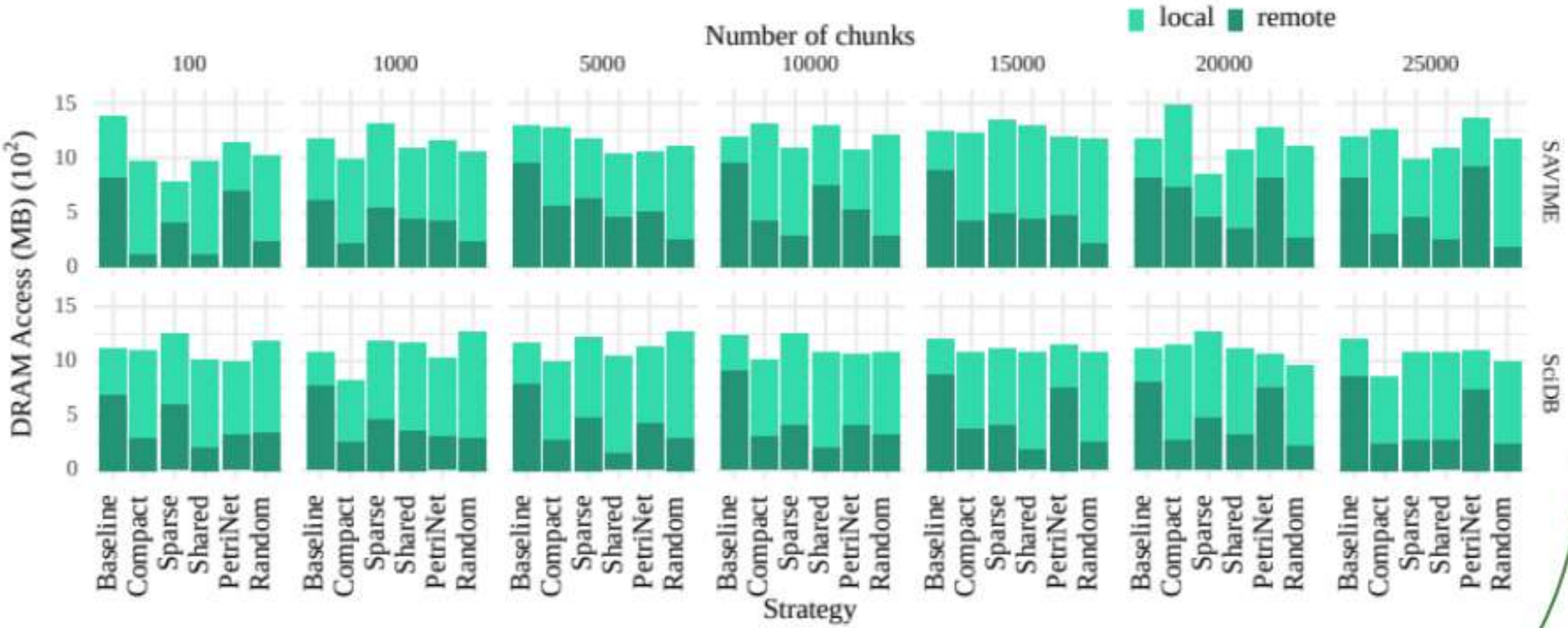
PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN 1 GB DATABASE – SPEEDUP

PREVIOUS WORK ARE NOT EXTRACTING THE MAXIMUM PERFORMANCE



PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN 1 GB DATABASE – MEMORY ACCESS

REMOTE ACCESS – 4.9X

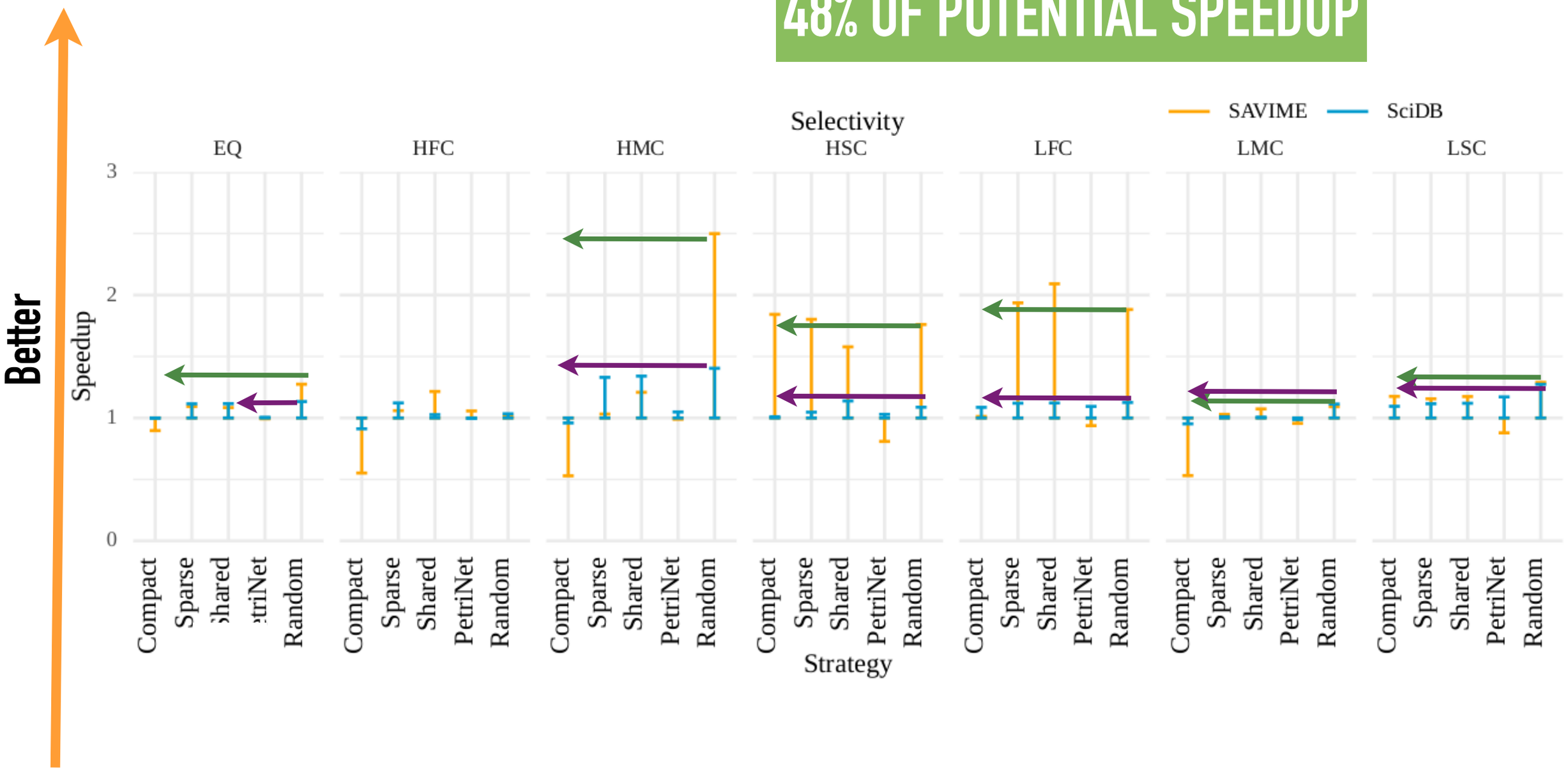


Evaluation of remote and local memory access in *subarray* operation in a 1 GB varying the amount of array chunks in the Array database.

REMOTE ACCESS – 3.5X

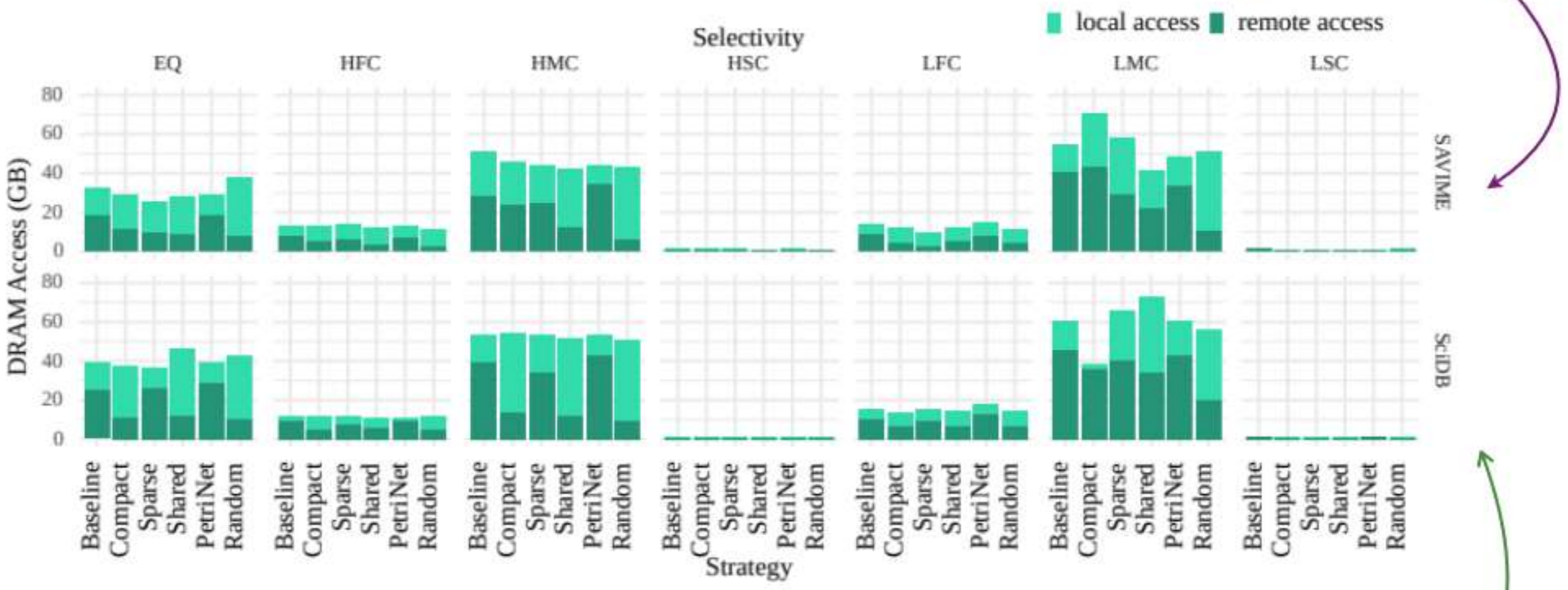
PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN A 50 GB DATABASE – SPEEDUP

48% OF POTENTIAL SPEEDUP



PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN A 50 GB DATABASE- MEMORY ACCESS

REMOTE ACCESS- 5X



Evaluation of remote and local memory access in *subarray* operation in a 50 GB varying the operator selectivity in the Array database.

REMOTE ACCESS - 4.1X

PERFORMANCE COMPARISON OF SUBARRAY OPERATOR IN A 50 GB DATABASE- ENERGY COMSUPTION

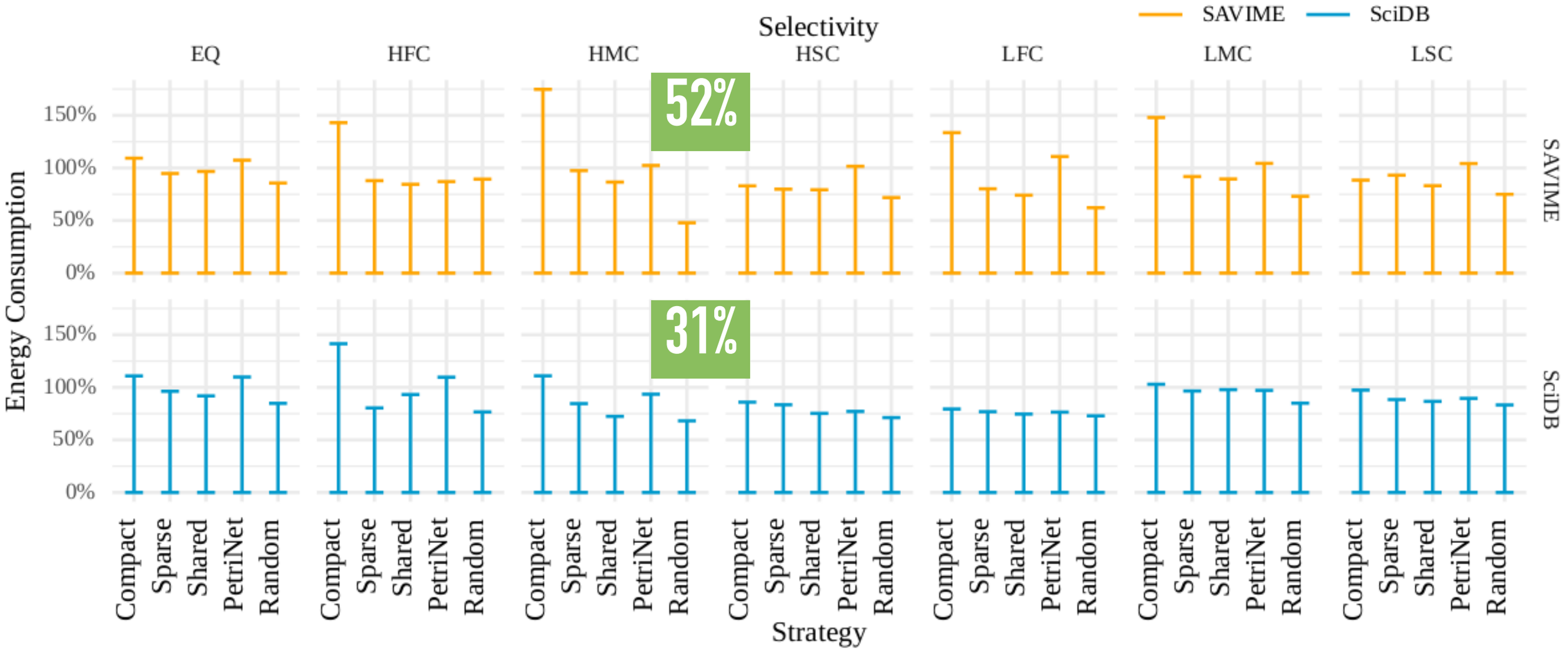


Fig. 8: Energy consumption in DRAM with 50 GB database using different operator selectivity in the Array database.

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CONCLUSION AND FUTURE WORK

- NUMA architecture affects in performance of subarray operations in array database systems.
- Traditional techniques are still far from the maximum possible gains.
- Static strategies only yield 48% from the potential speedup (and 26% of the energy reduction)
- Opening a new research topic
- Understanding the NUMA effects in other array database operators and designing an array database scheduler that finds the best thread pinning.

THANKS!

SDOMINICO@INF.UFPR.BR

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