OCC Pinning: Optimizing Concurrent Computations through Thread Pinning

Brahmaiah Gandham **Dr. Praveen Alapati**

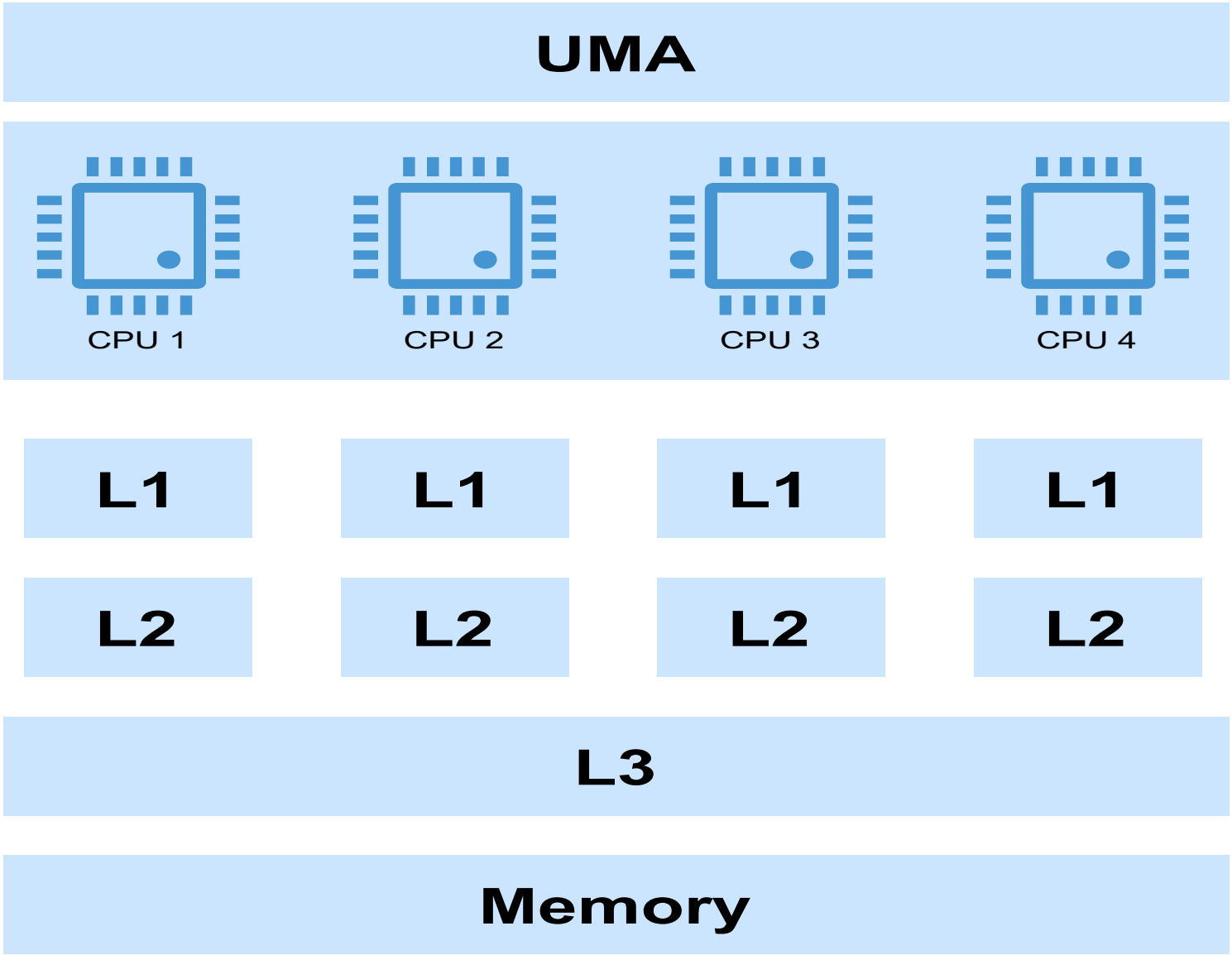
Department of Computer Science and Engineering

Ecole Centrale School of Engineering

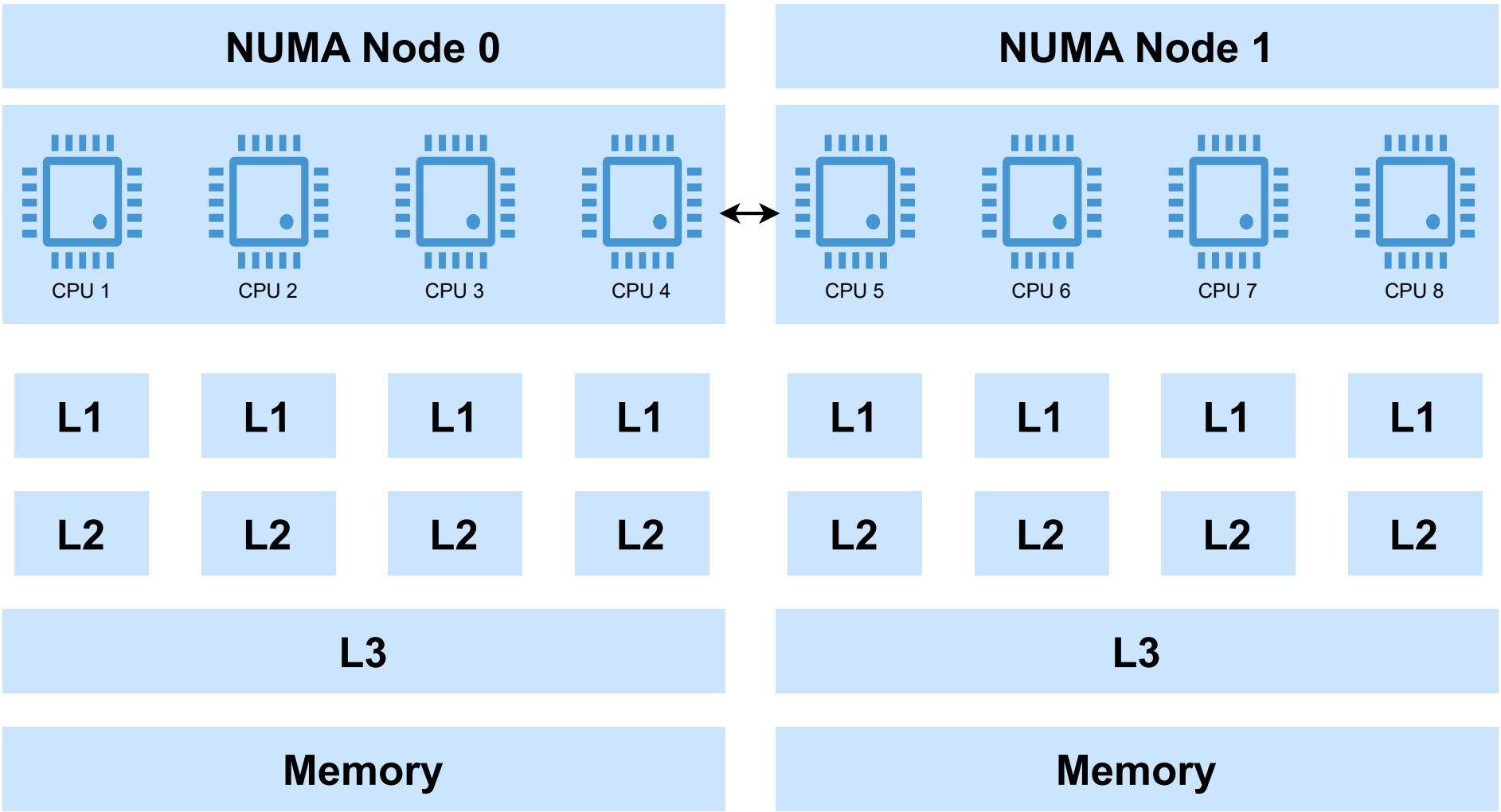
Mahindra University

Outline

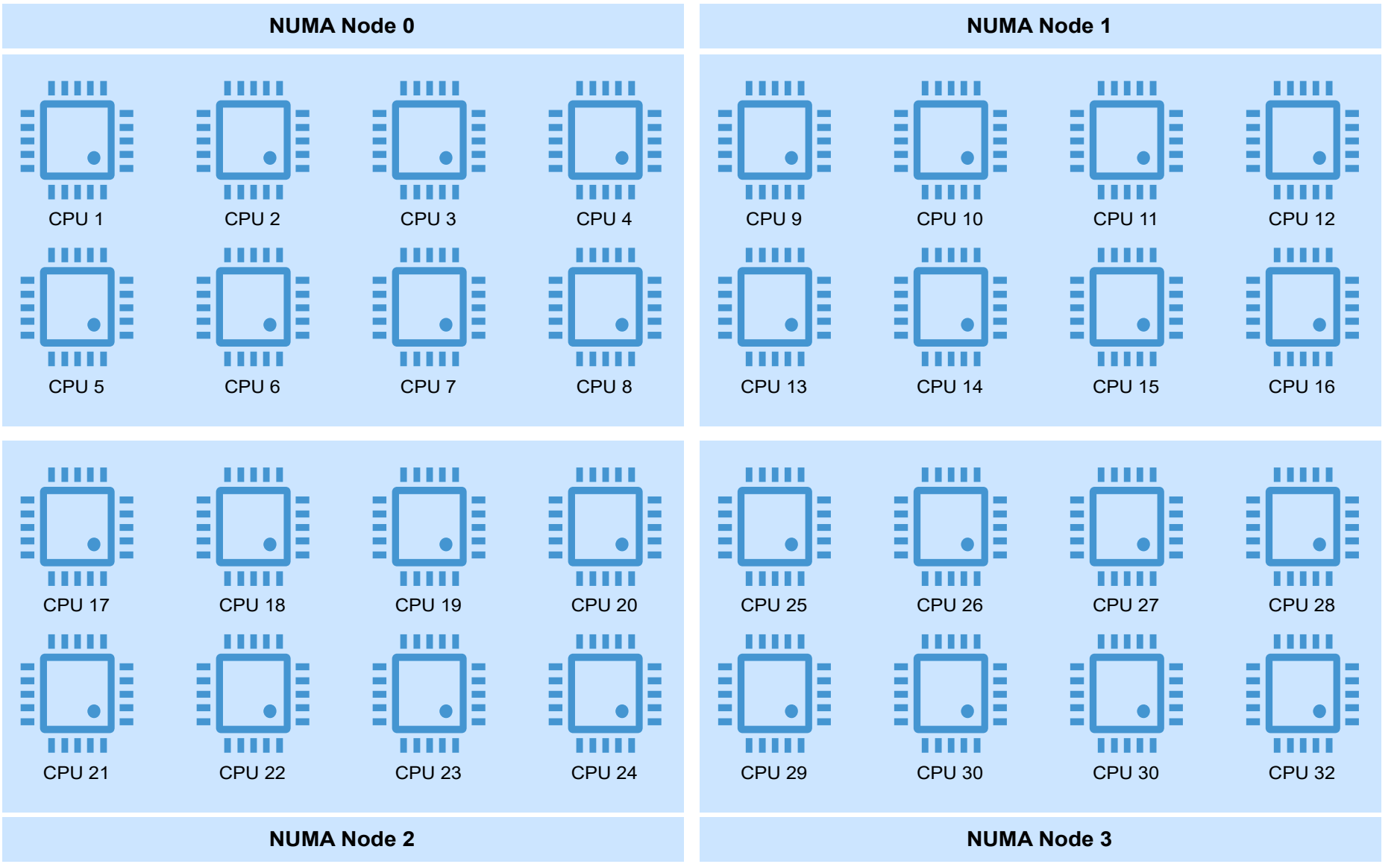
Uniform Memory Access (UMA) Architecture



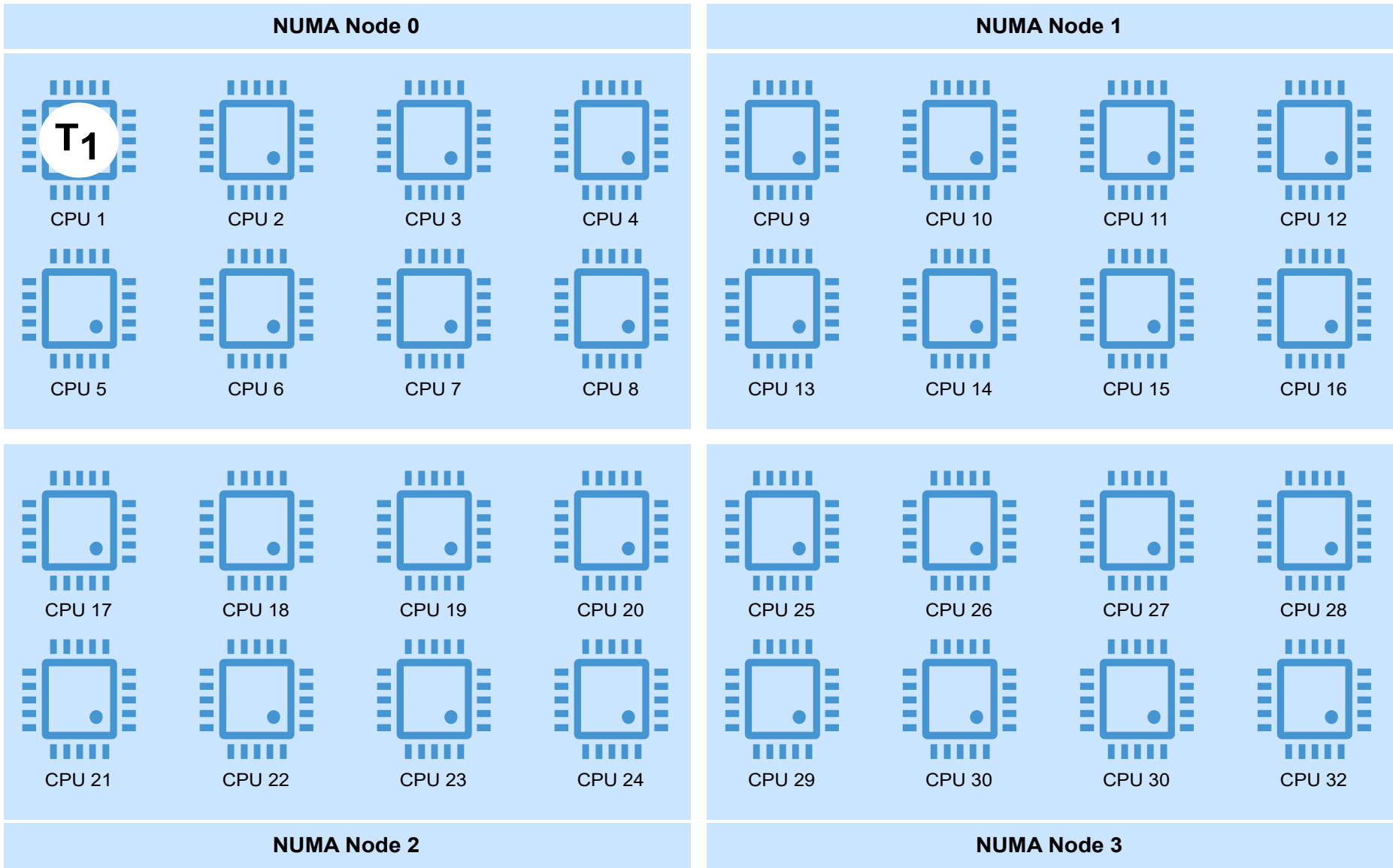
Non-uniform Memory Access (NUMA) Architecture



32 - Core Server



Execution of a Sequential Program



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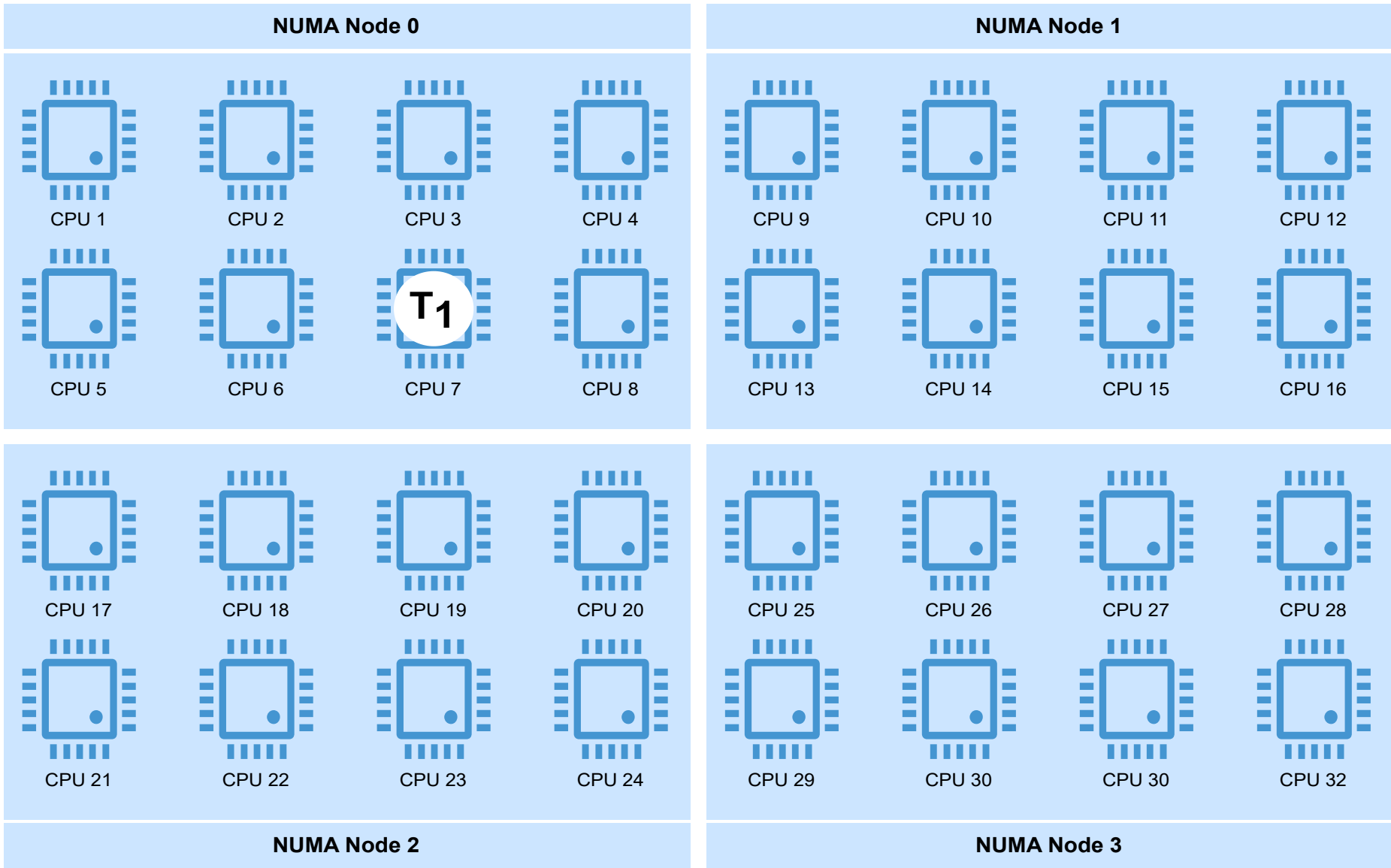

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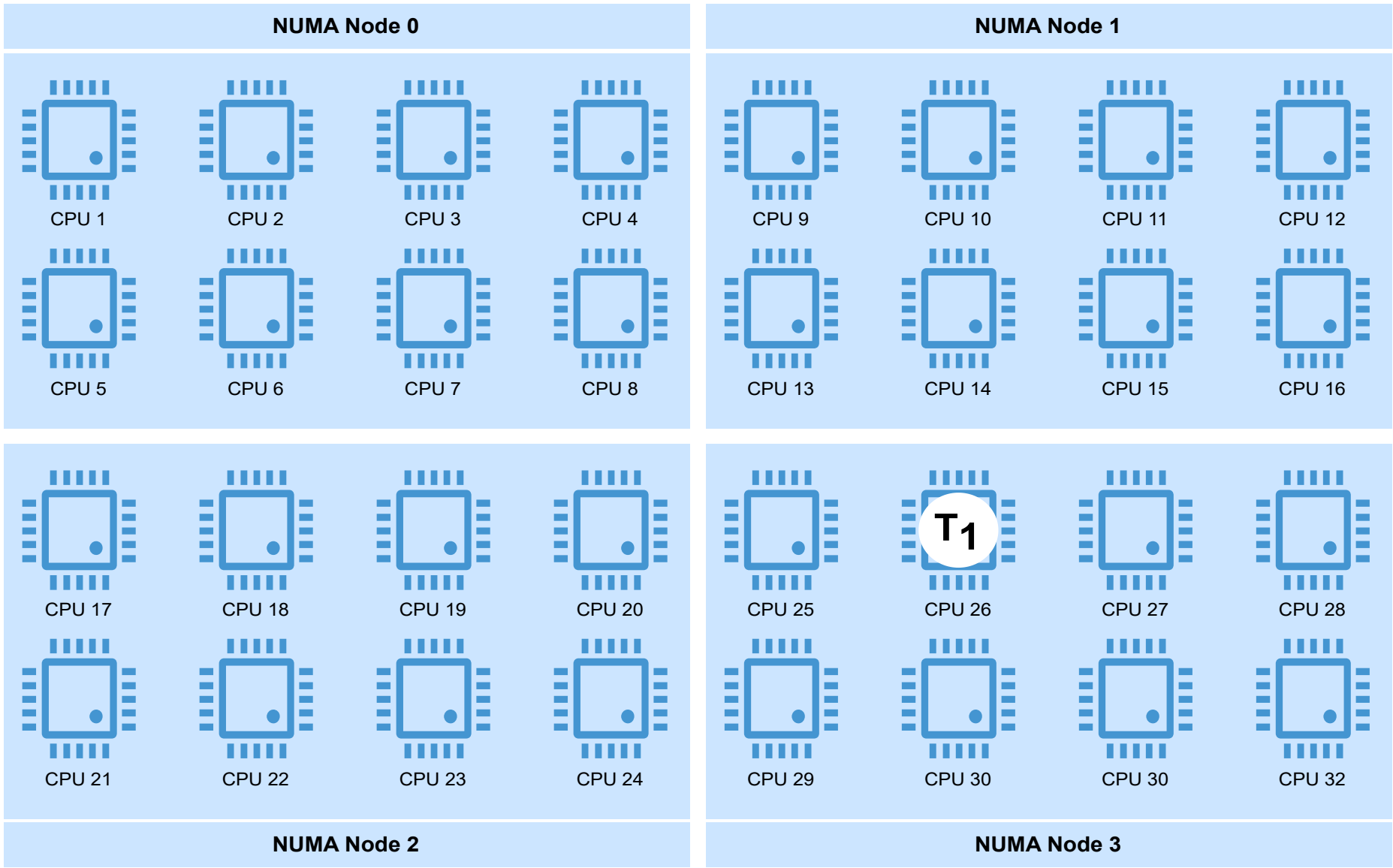

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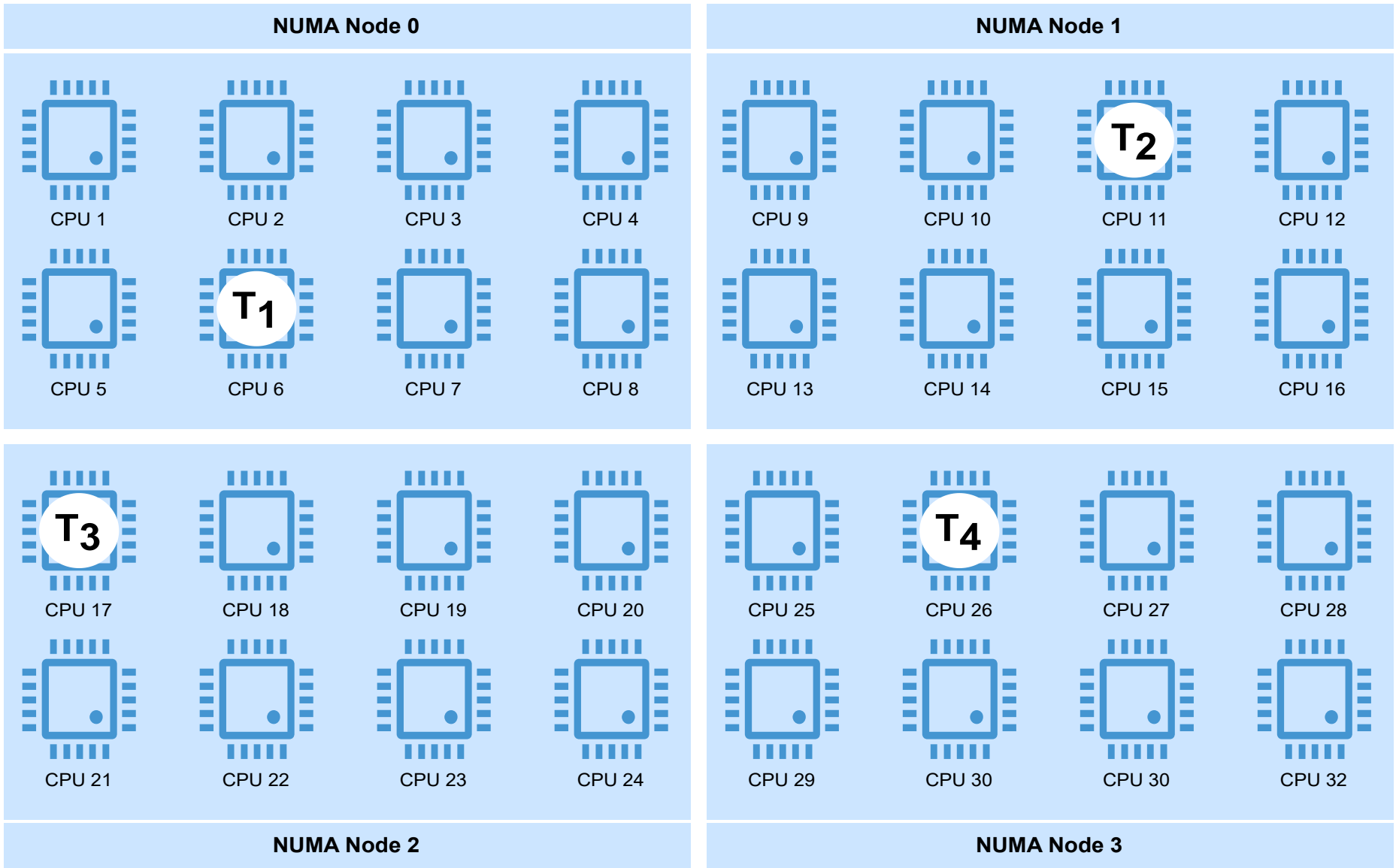

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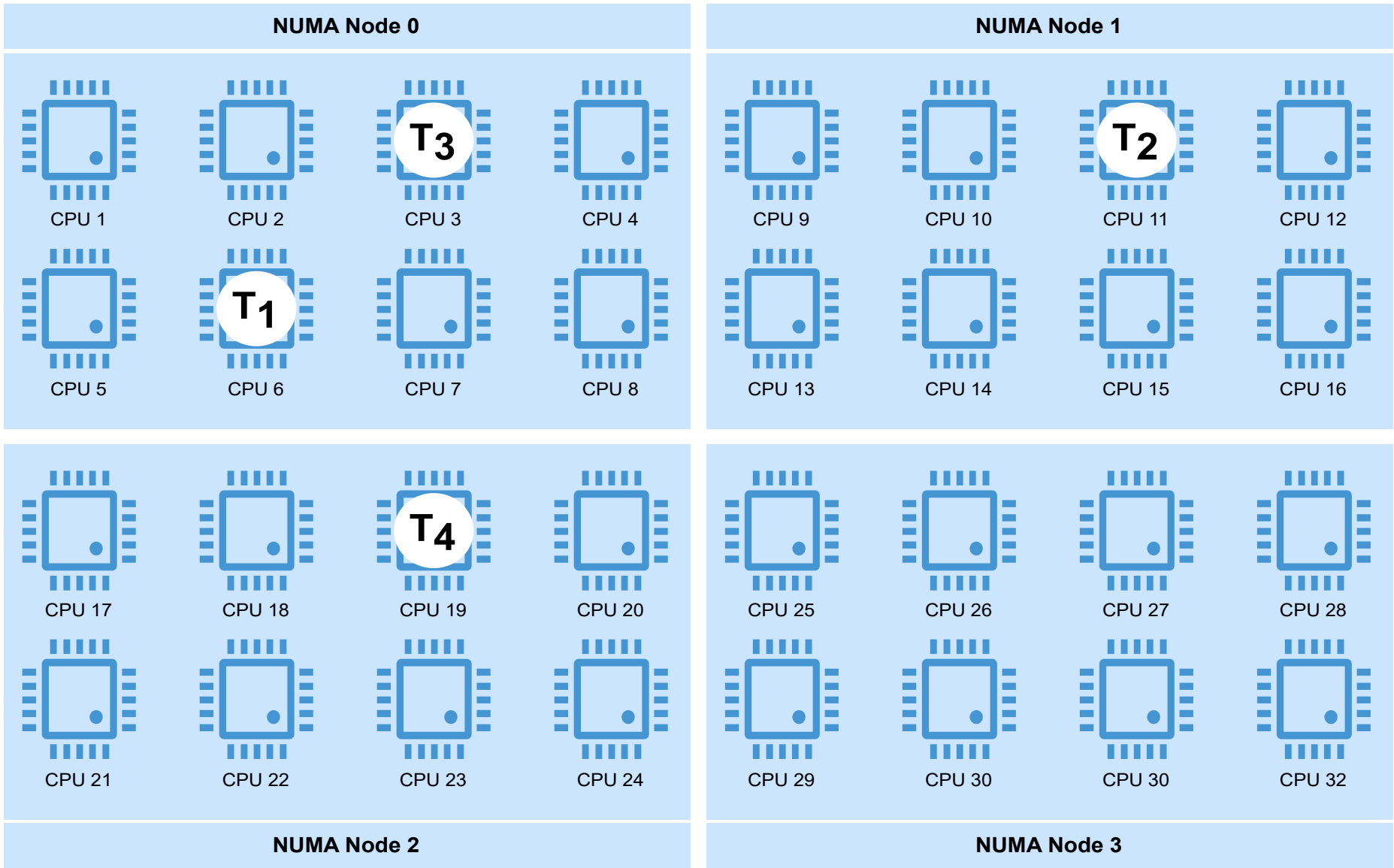
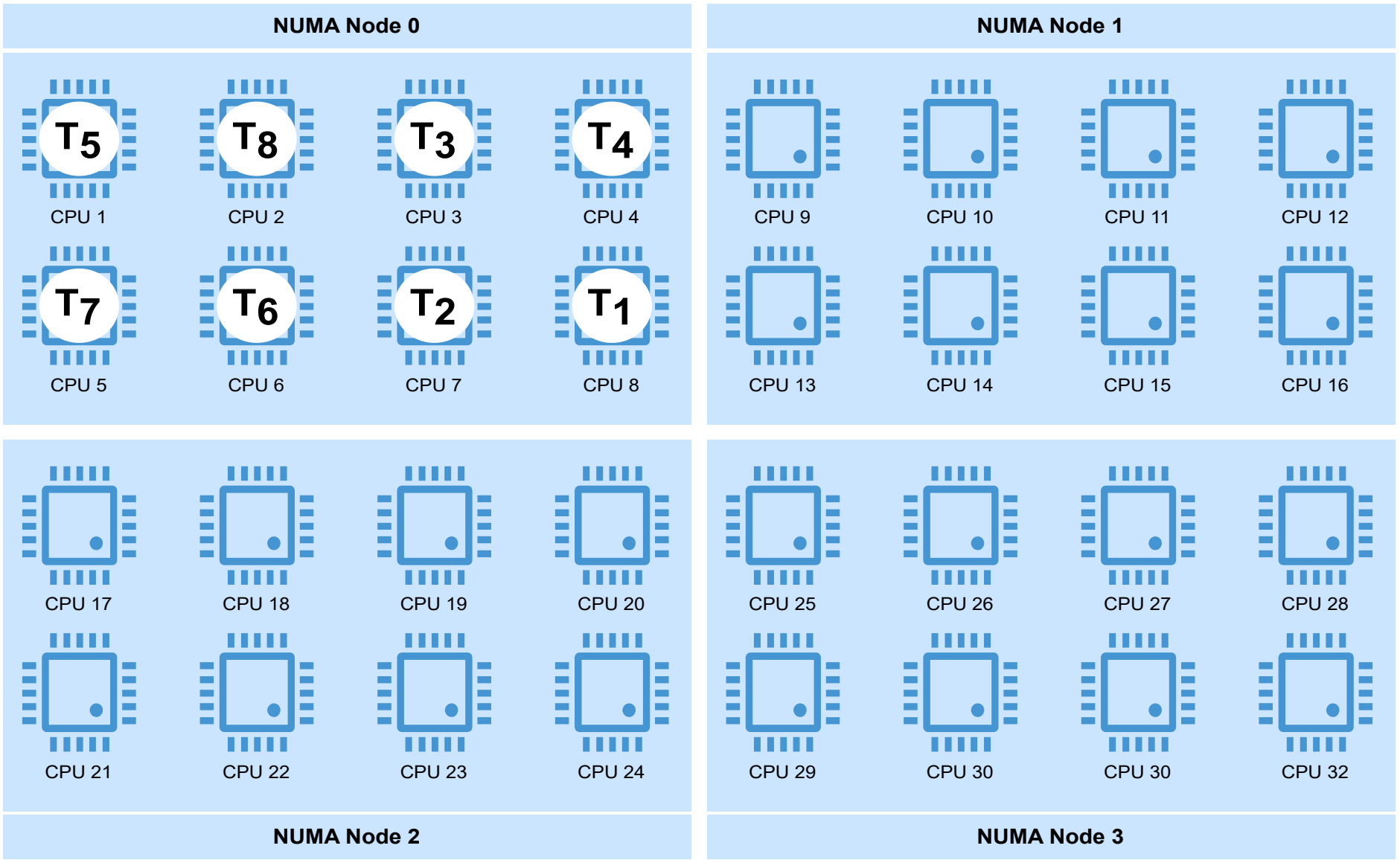


NUMA Pinning



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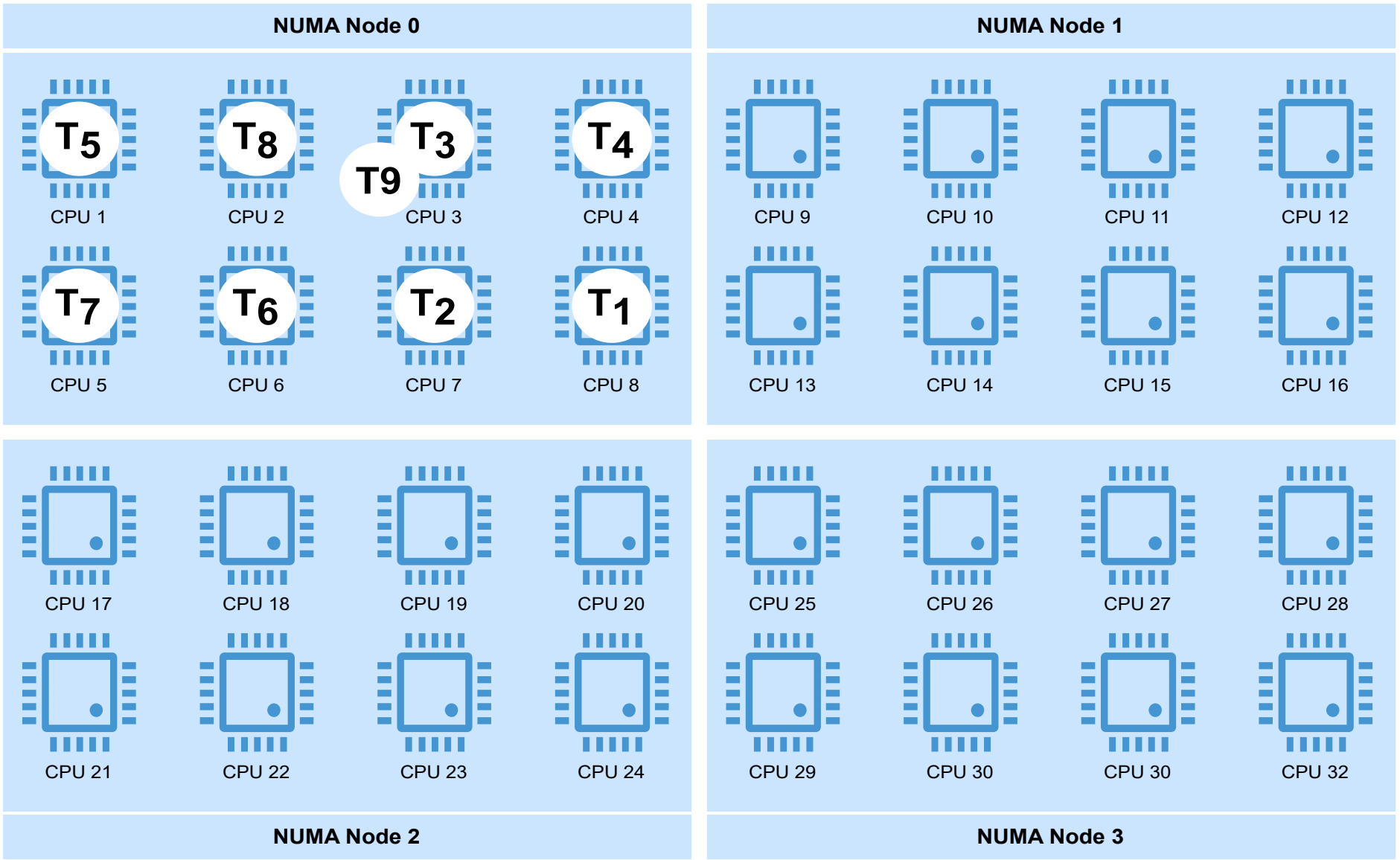

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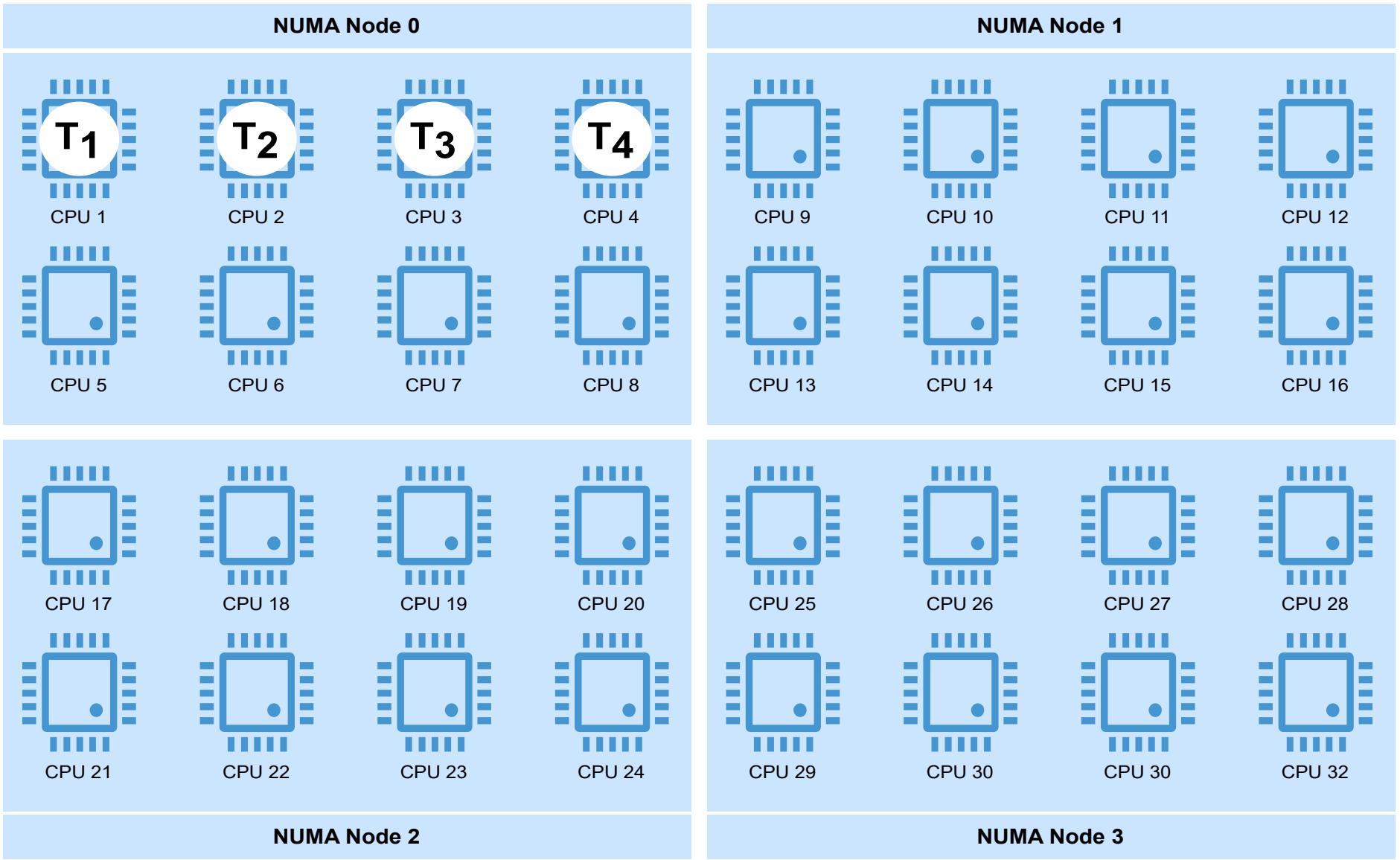
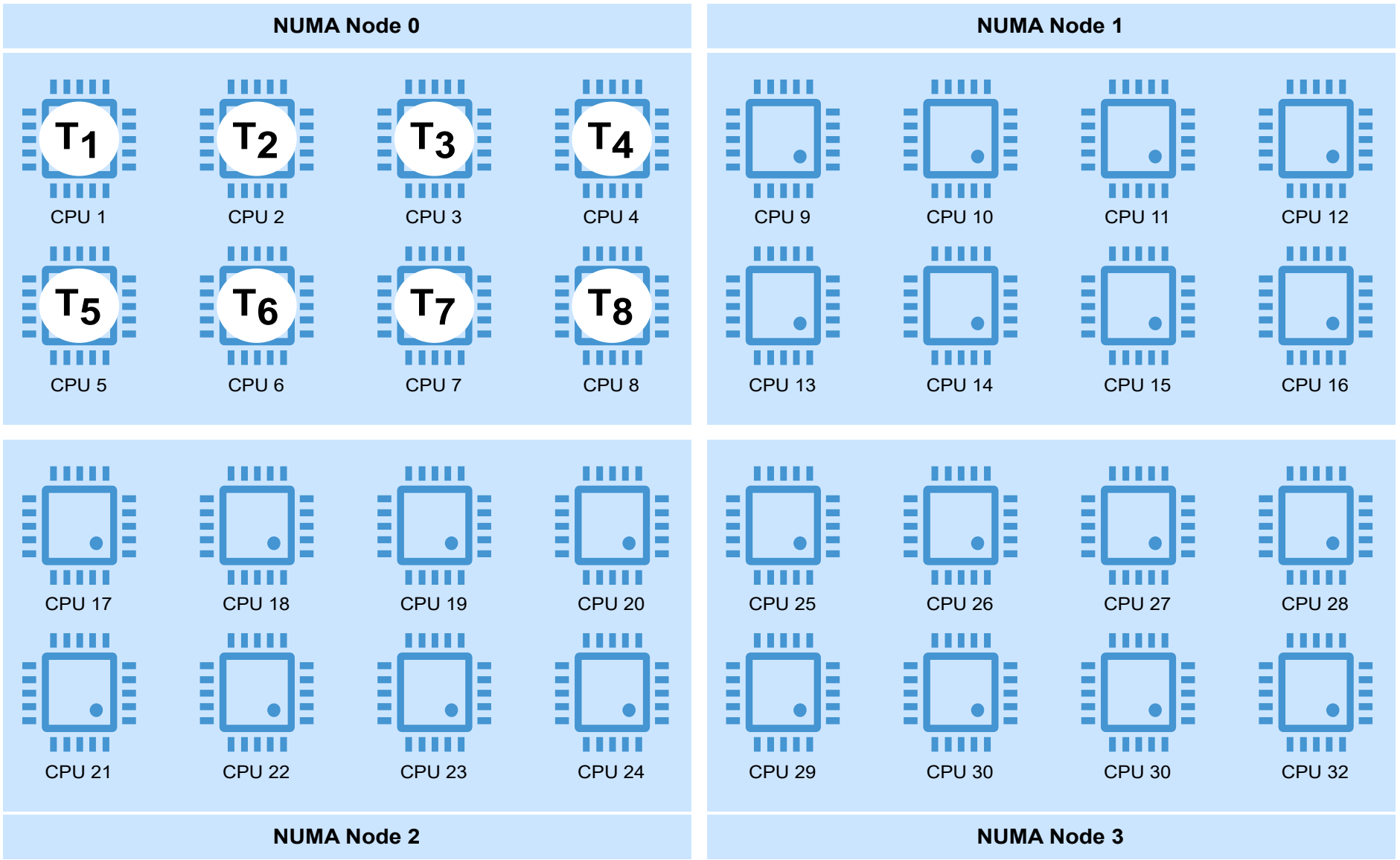
- Load imbalance.

OCC Pinning


NUMA Node 0
T1
T2
T3
T4
CPU 1
CPU 2
CPU 3
CPU 4
CPU 5
CPU 6
CPU 7
CPU 8
NUMA Node 1
CPU 9
CPU 10
CPU 11
CPU 12
CPU 13
CPU 14
CPU 15
CPU 16
CPU 17
CPU 18
CPU 19
CPU 20
CPU 21
CPU 22
CPU 23
CPU 24
NUMA Node 2
CPU 25
CPU 26
CPU 27
CPU 28
CPU 29
CPU 30
CPU 30
CPU 32
NUMA Node 3

OCC Pinning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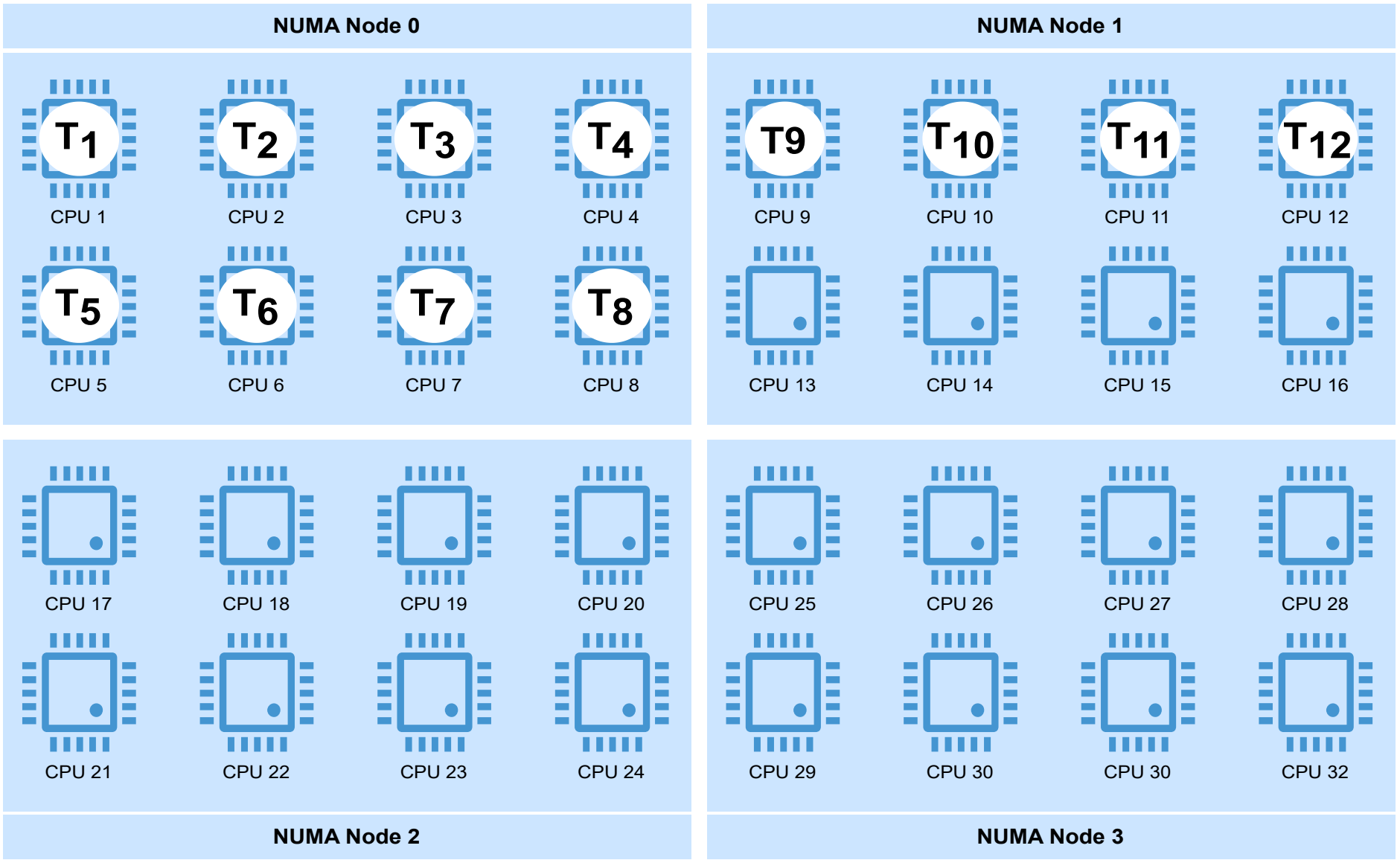
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Algorithm of OCC Pinning

Algorithm 1 OCC Pinning

```
1: pid ← getCurrentProcessID();
2: threadsInfo ← getThreadsInfoForPID(pid);
3: spids ← extractSPIDs(threadsInfo);
4: for spid in spids do
5:     cpuIndex ← getAndIncrement() % totalCPUs;
6:     setThreadAffinity(spid, cpuIndex);
7: end for
```

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- Leverage operating system mechanisms to identify processes and threads.
- Leverage the taskset command to enforce desired thread-to-core mappings.
- This effectively overrides the dynamic behavior of the operating system scheduler.

Experimental System

Hardware:

- Intel(R) Xeon(R) Platinum 8260 CPU @ 2.40GHz
- RAM: 512GB RAM
- CPU(s): 96
- Thread(s) per core: 2
- Core(s) per socket: 24
- Socket(s): 2
- L1d cache: 32K, L1i cache: 32K, L2 cache: 1MB, L3 cache: 36MB

Software:

- Ubuntu 22.04 LTS
- JDK Runtime version 19.02

Experimental Evaluation

Pinning configurations:

- OCC Pinning
- NUMA Pinning
- No Pinning

Concurrent Data structures:

- Contention Adapting Binary Search Tree [1]
- Striped Hash Set [2]
- Lazy List [3]

Workload representation:

- xC-yI-zD

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- Update dominant workload (30C-35I-35D).
- Update only workload (0C-50I-50D).

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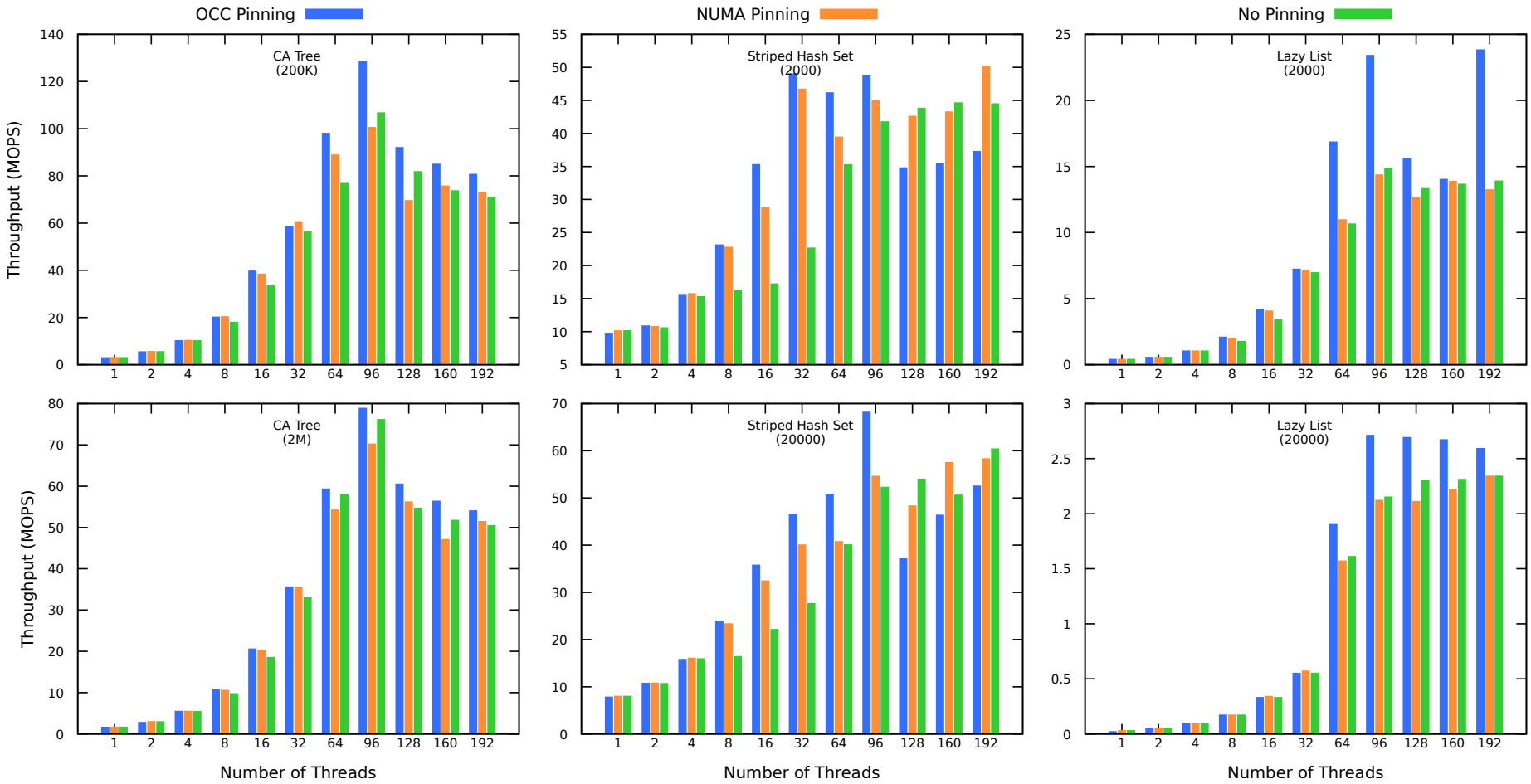

Figure 1: Average throughput of a CA tree, striped hash set, and lazy list implementations.

Experimental Evaluation

CA Tree

- OCC pinning achieved an average speedup of **1.10**× compared to both NUMA pinning and No pinning.

Striped Hash Set

- OCC pinning achieved an average speedup of **1.25**× compared to both NUMA pinning and No pinning.

Lazy List

- OCC pinning achieved an average speedup of **1.26**× compared to both NUMA pinning and No pinning.

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- It paves the way for realizing the full potential of concurrent applications.
- Future work includes the potential extension of this strategy to GPUs.

References


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Thank You ☺