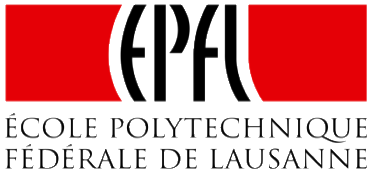
THE LINUX SCHEDULER: A DECADE OF WASTED CORES

Jean-Pierre Lozi
jplozi@unice.fr

Baptiste Lepers
baptiste.lepers@epfl.ch



Fabien Gaud
me@fabiengaud.net

Alexandra Fedorova
sasha@ece.ubc.ca

Justin Funston
jfunston@ece.ubc.ca

Vivien Quéma
vivien.quema@imag.fr

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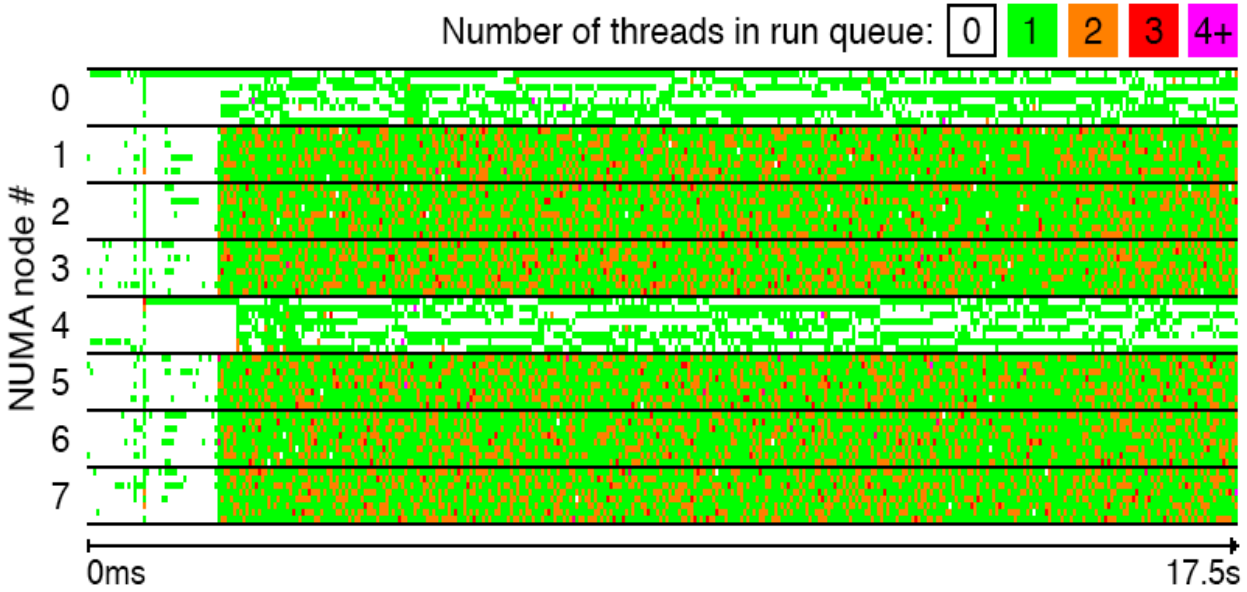

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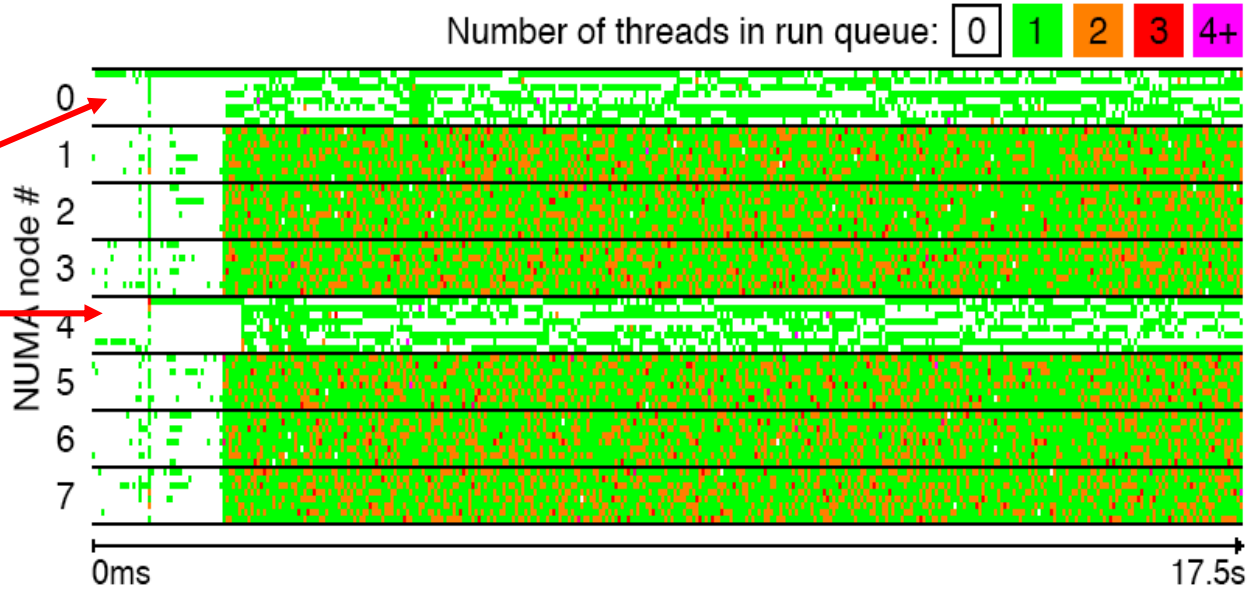

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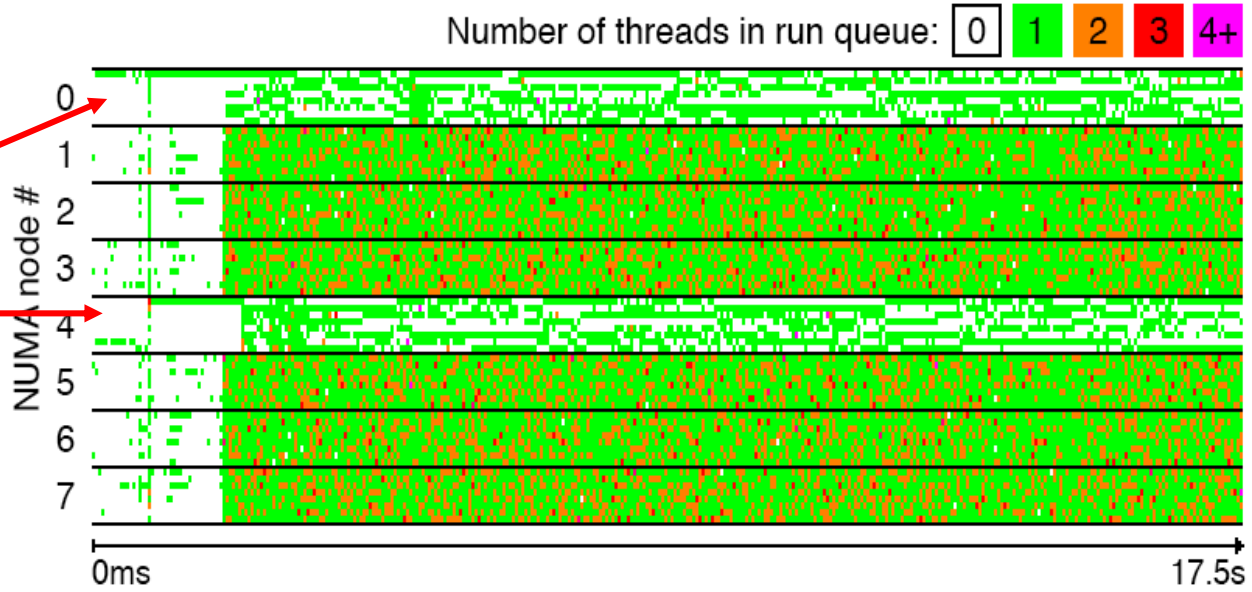

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Performance degradation: 14% for the make process!

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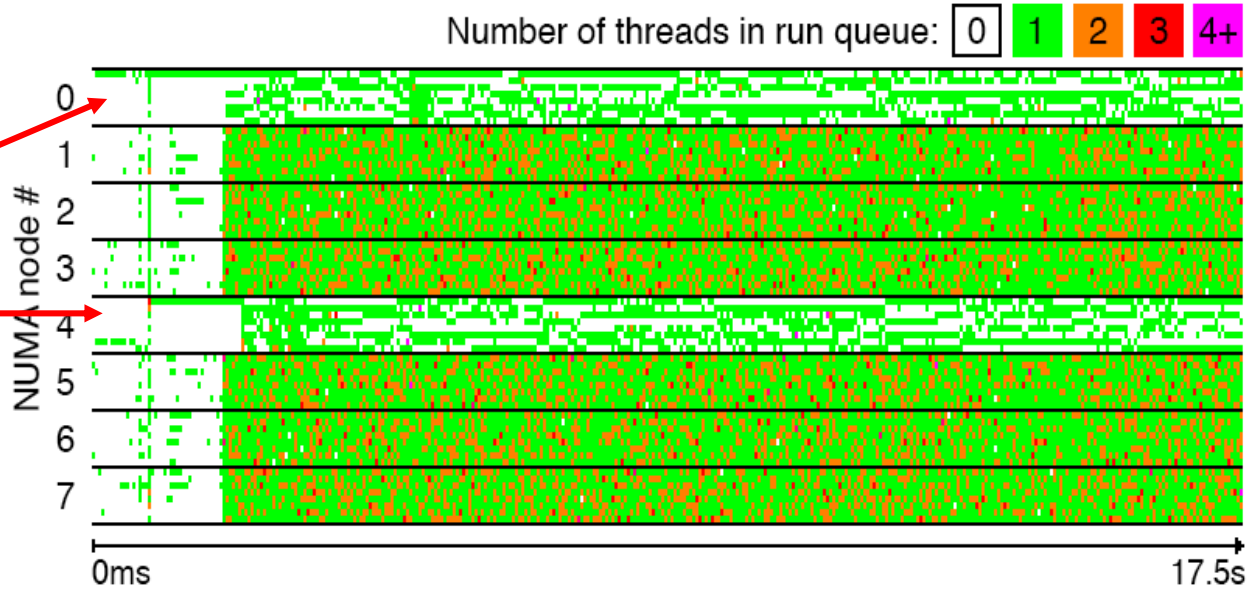

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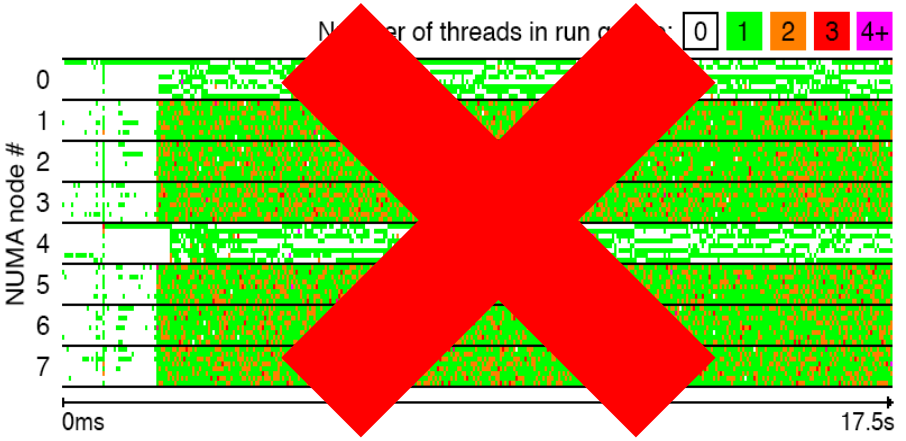

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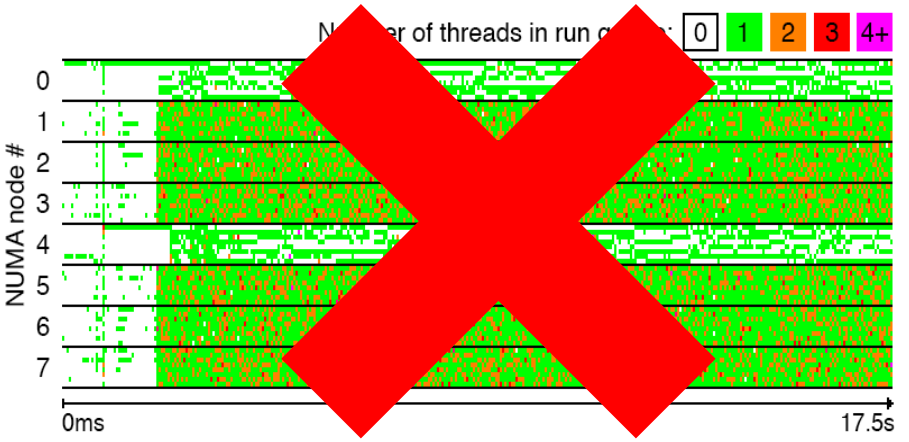

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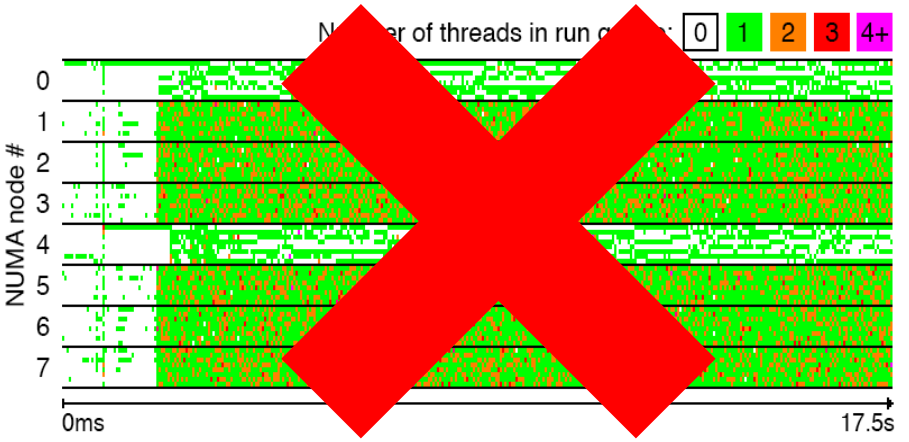

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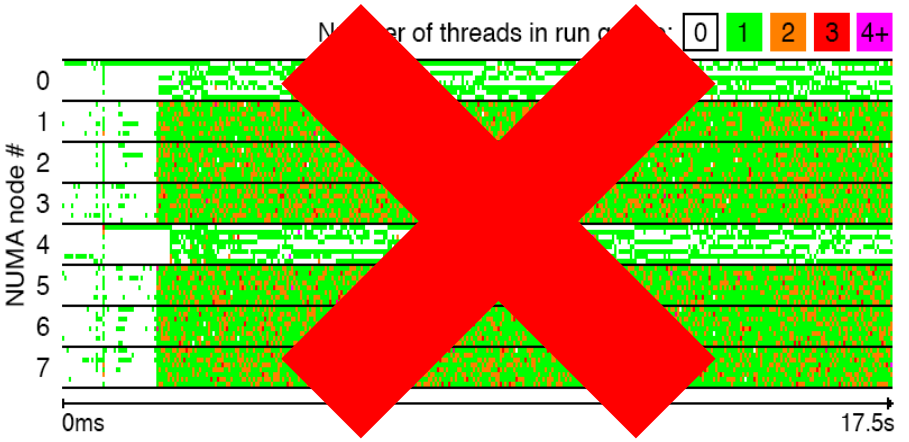

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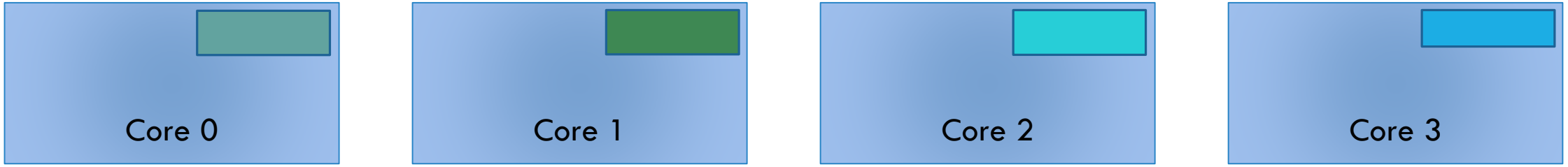
Disclaimer: this is a motivation paper!
Don't expect a solved problem ☺

THE COMPLETELY FAIR SCHEDULER (CFS): CONCEPT



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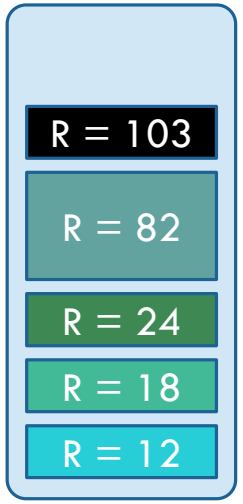

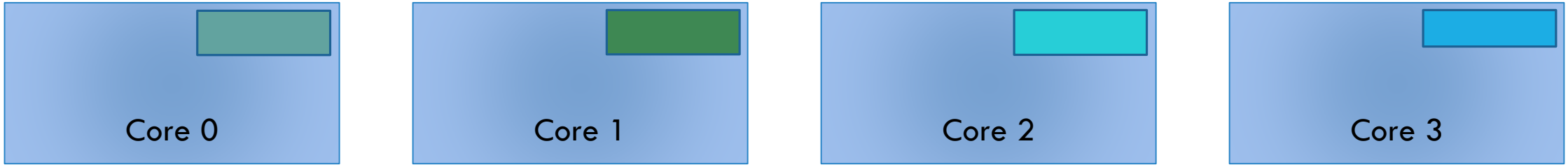

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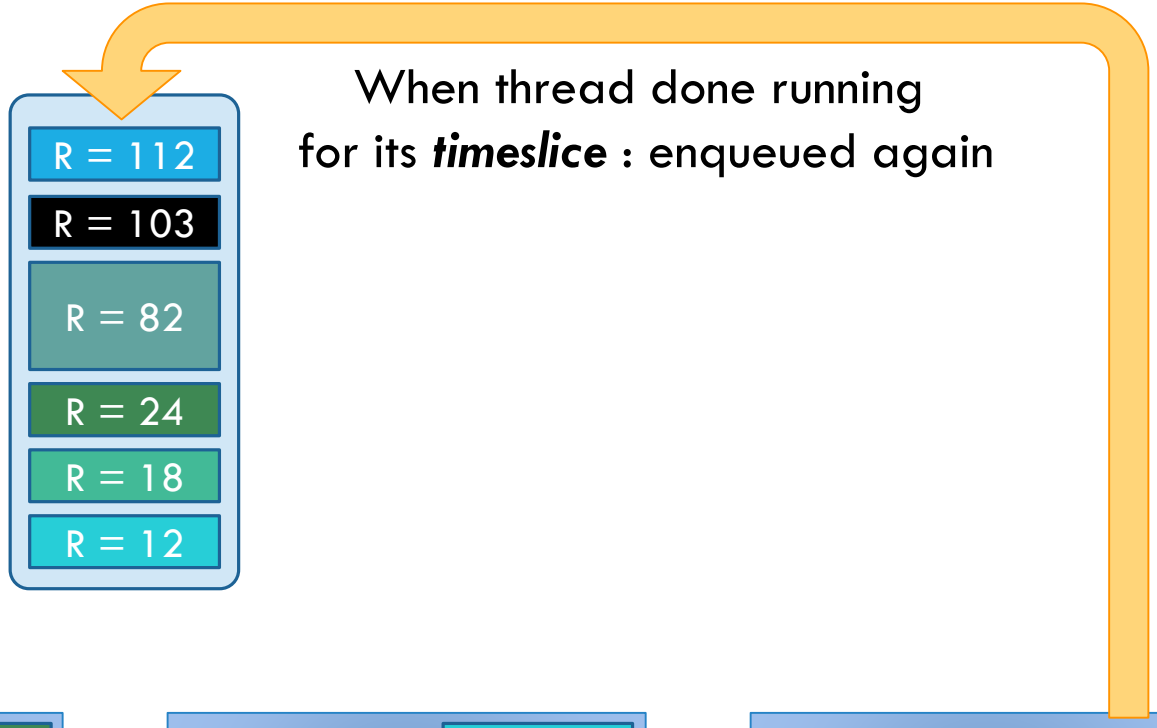

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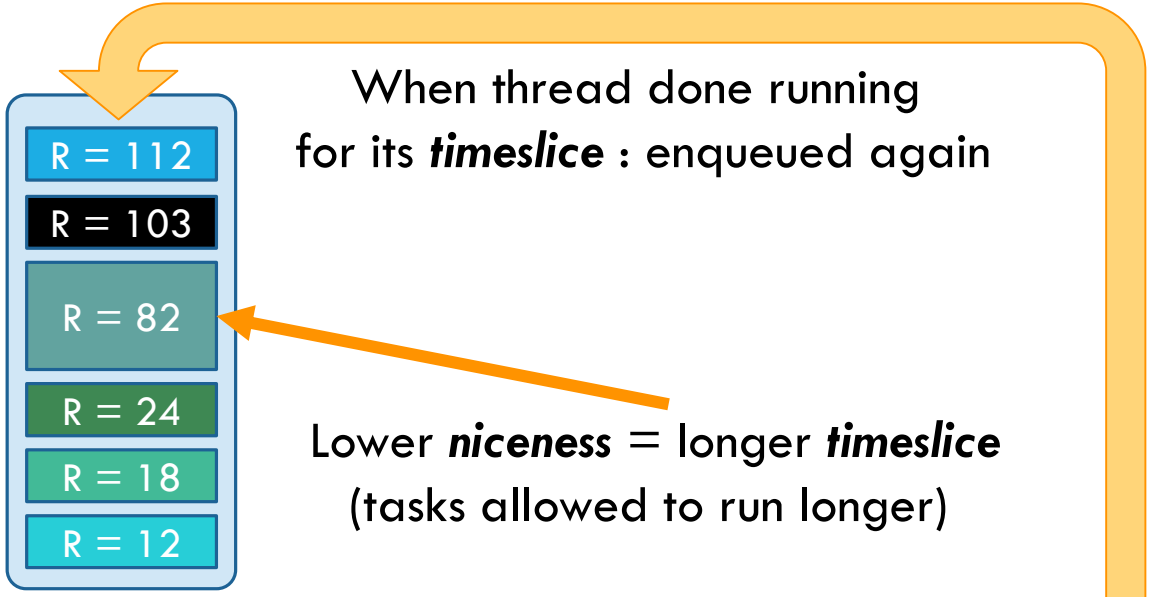

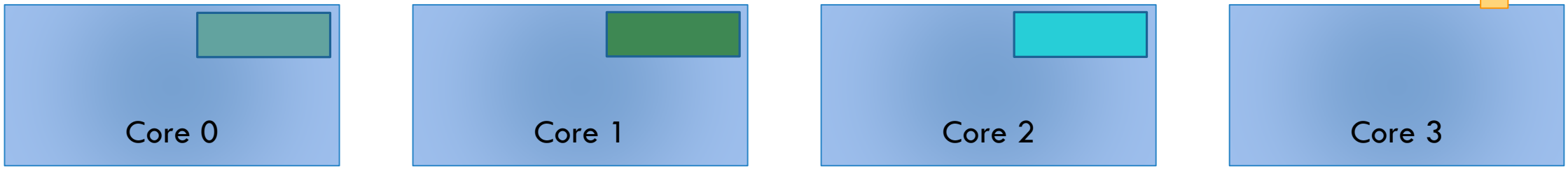

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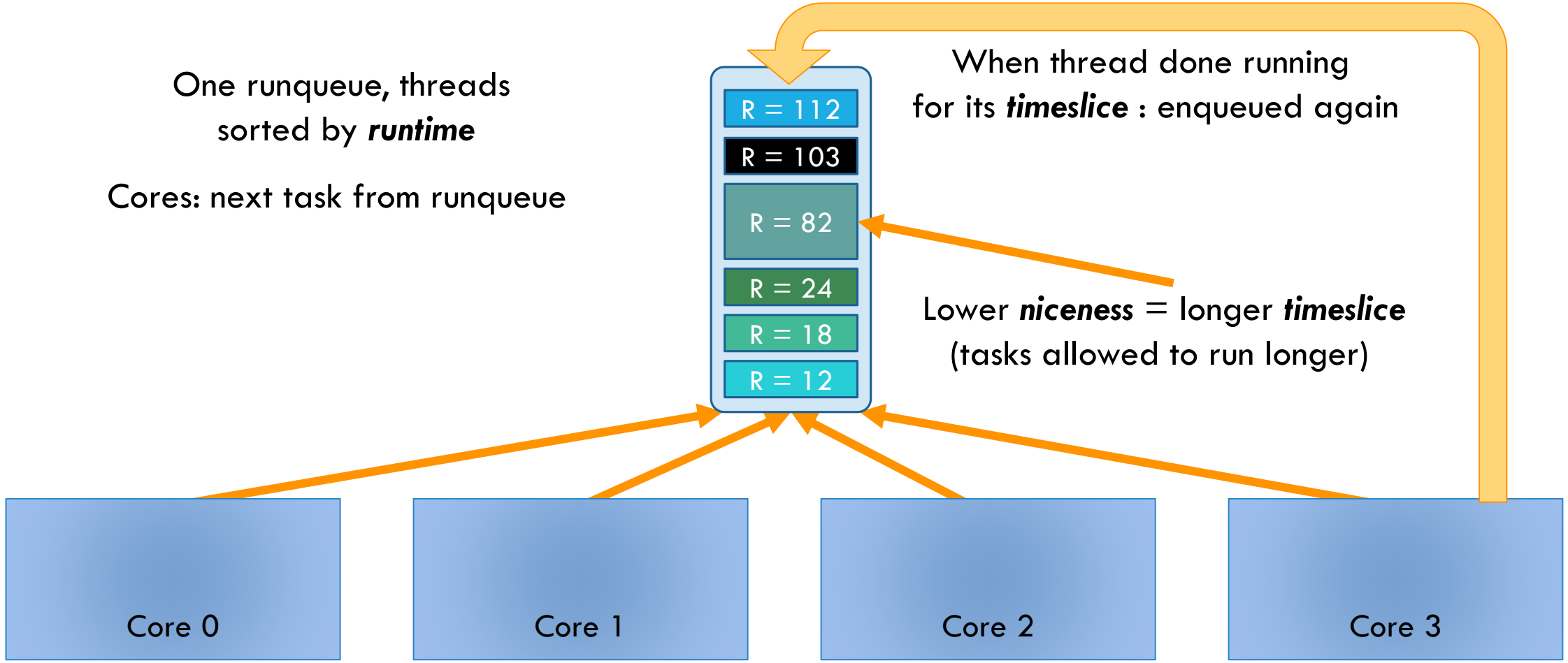

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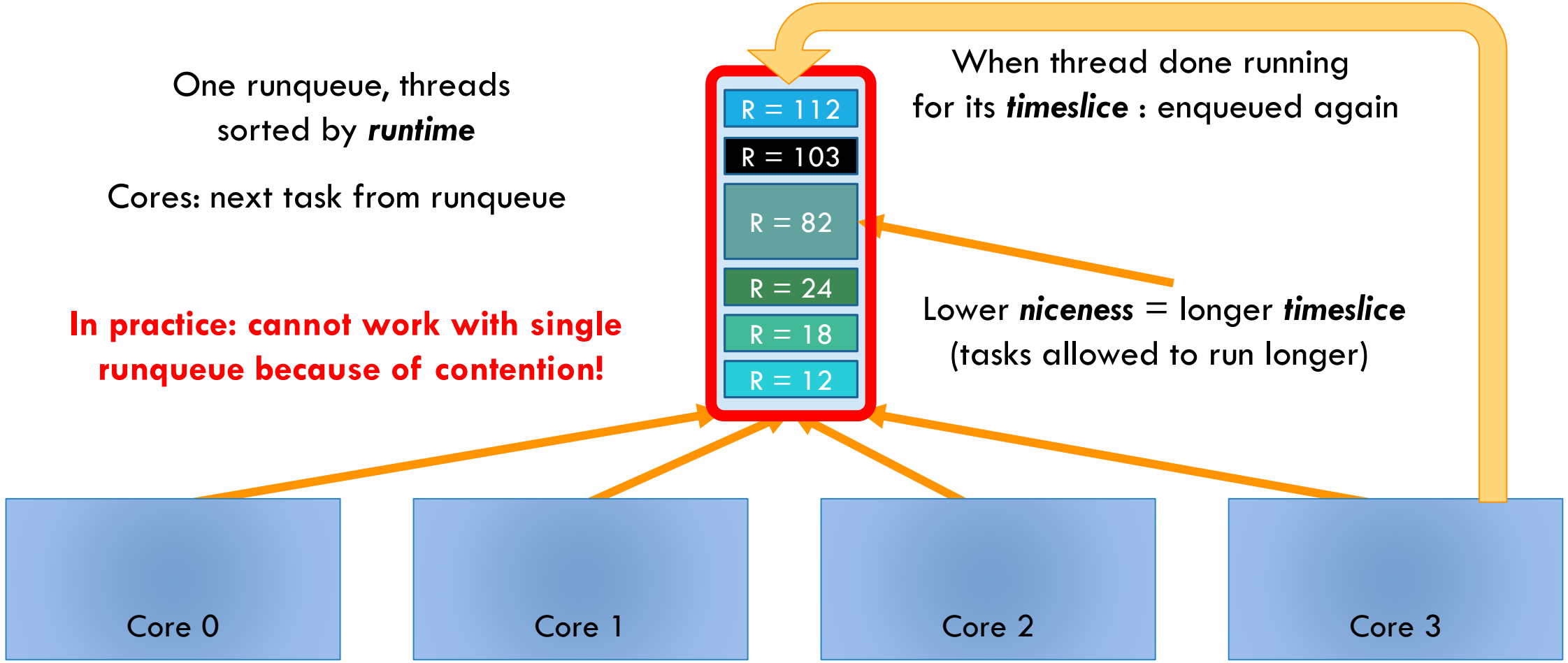
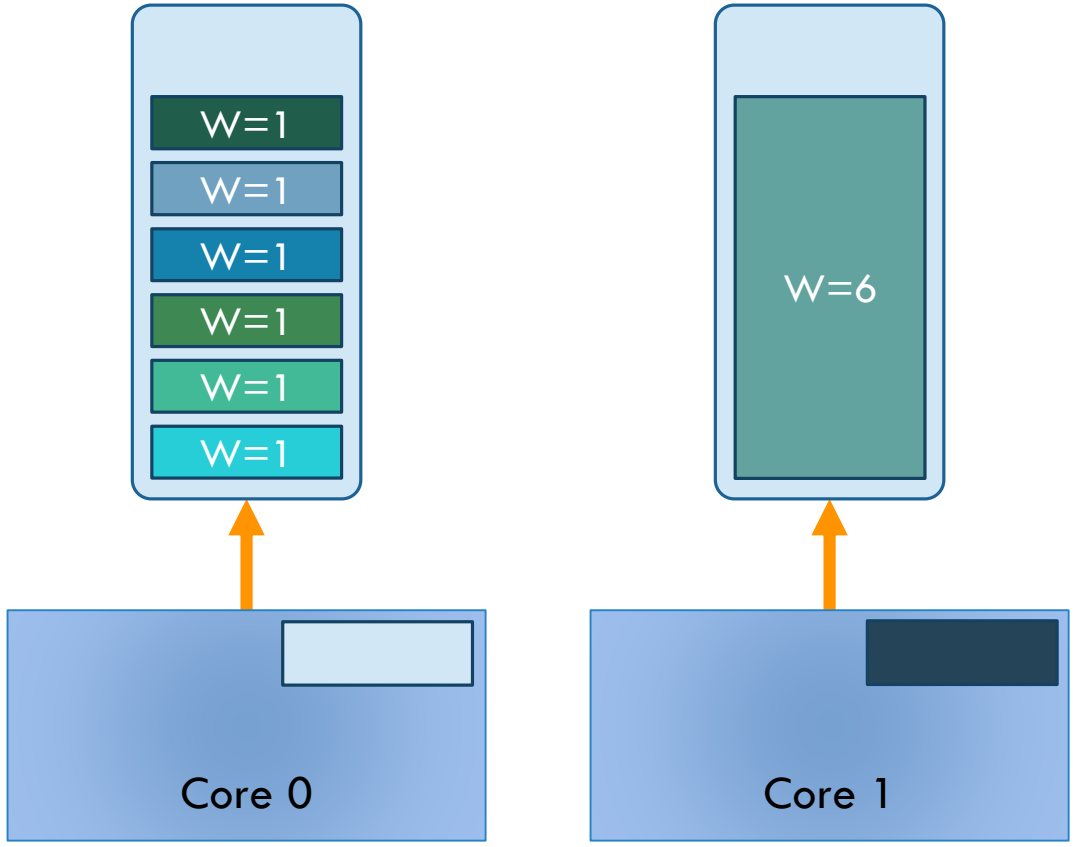
In practice: cannot work with single runqueue because of contention!



CFS: IN PRACTICE

- **One runqueue per core** to avoid contention



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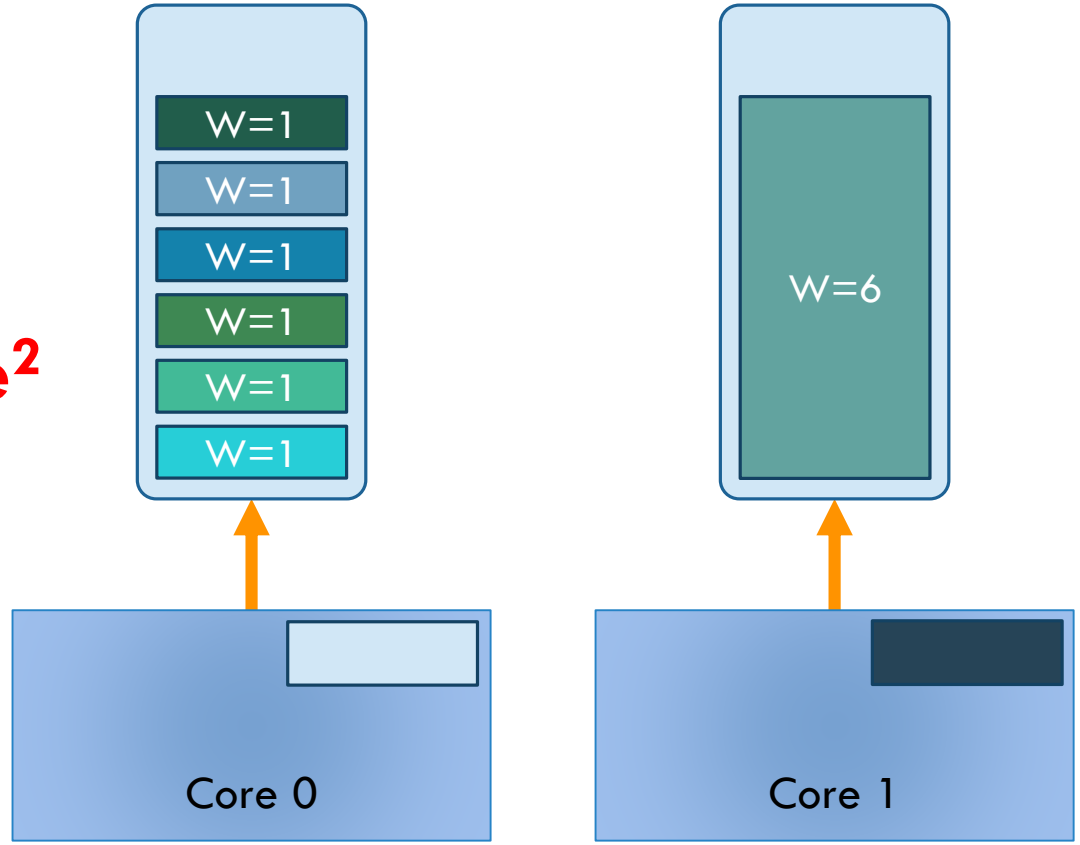

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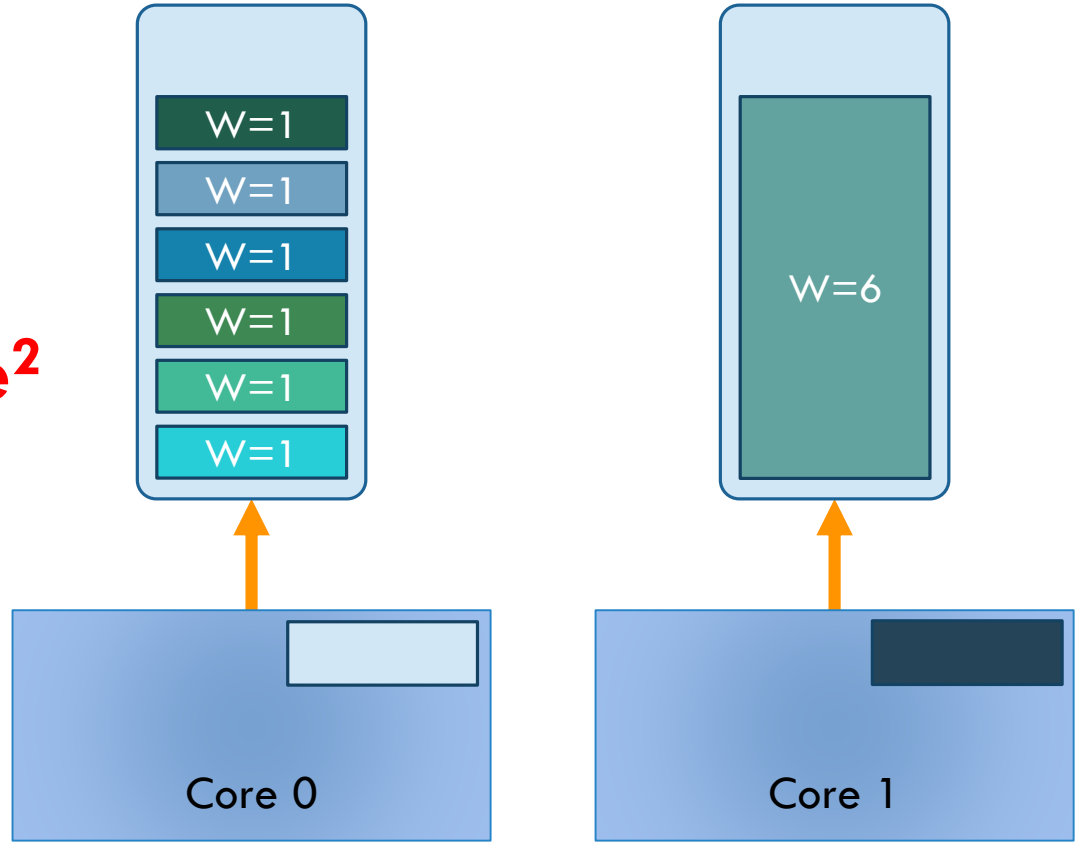

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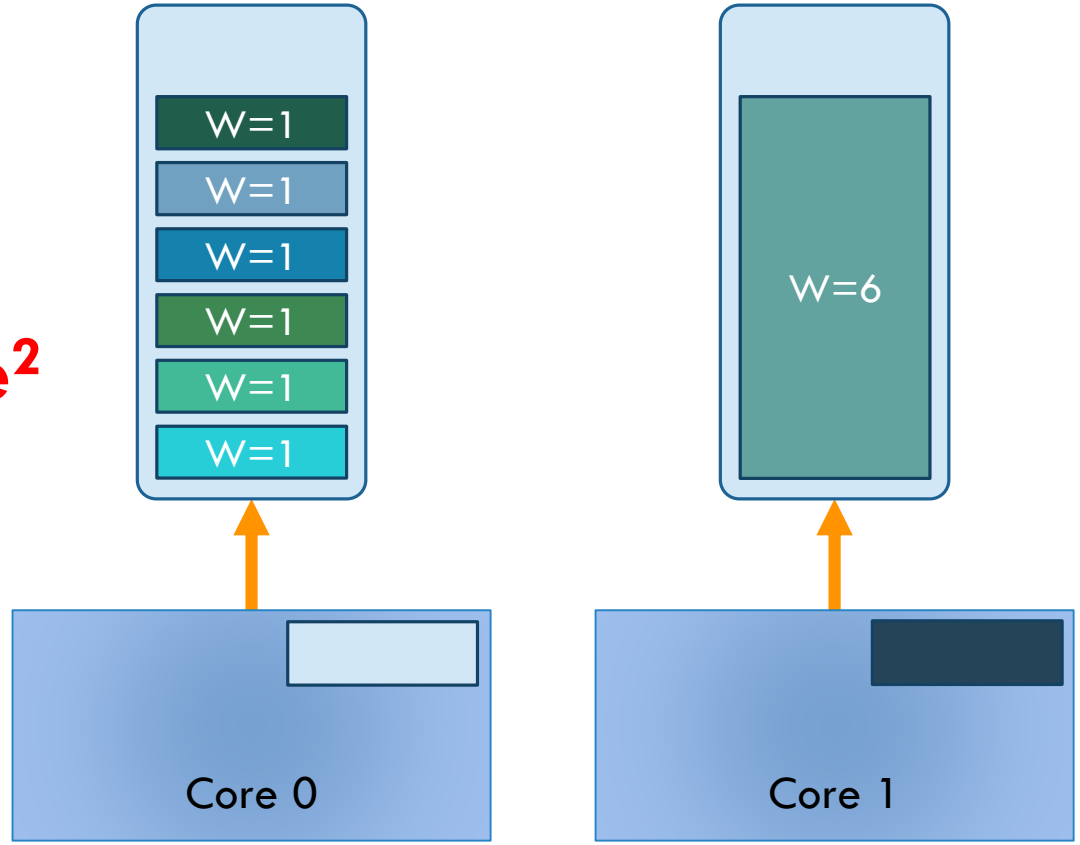

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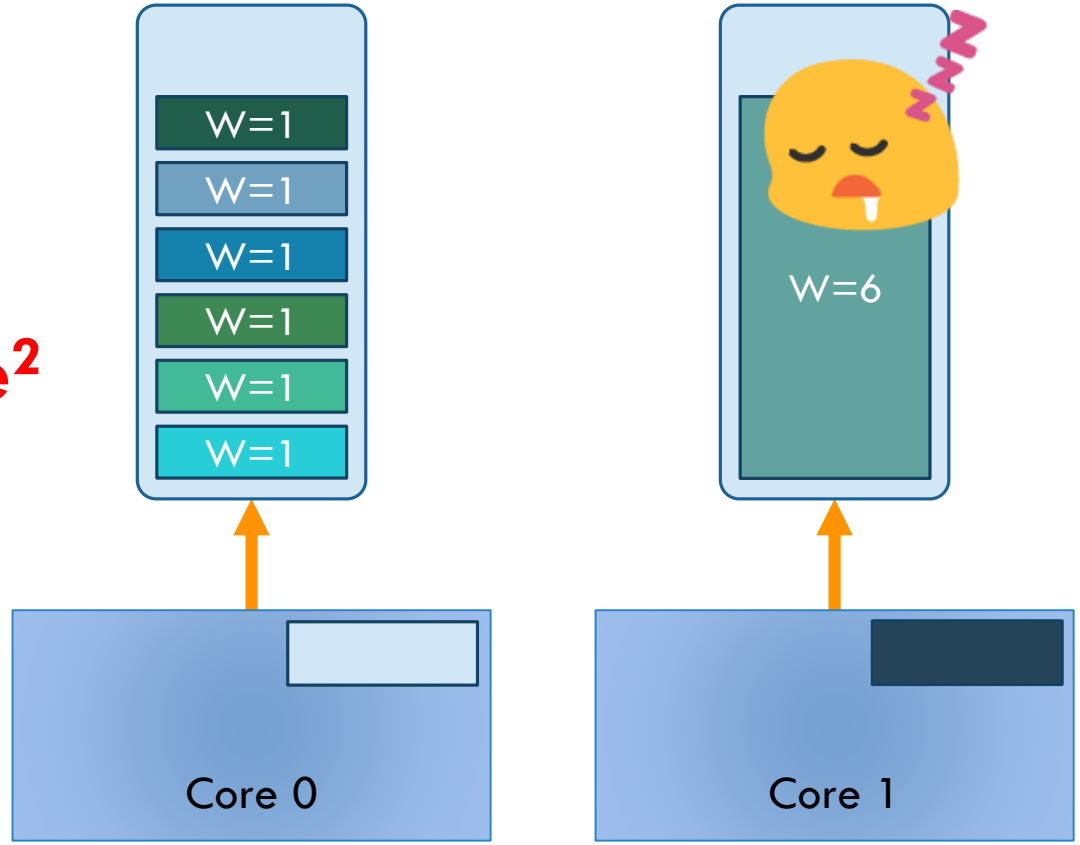

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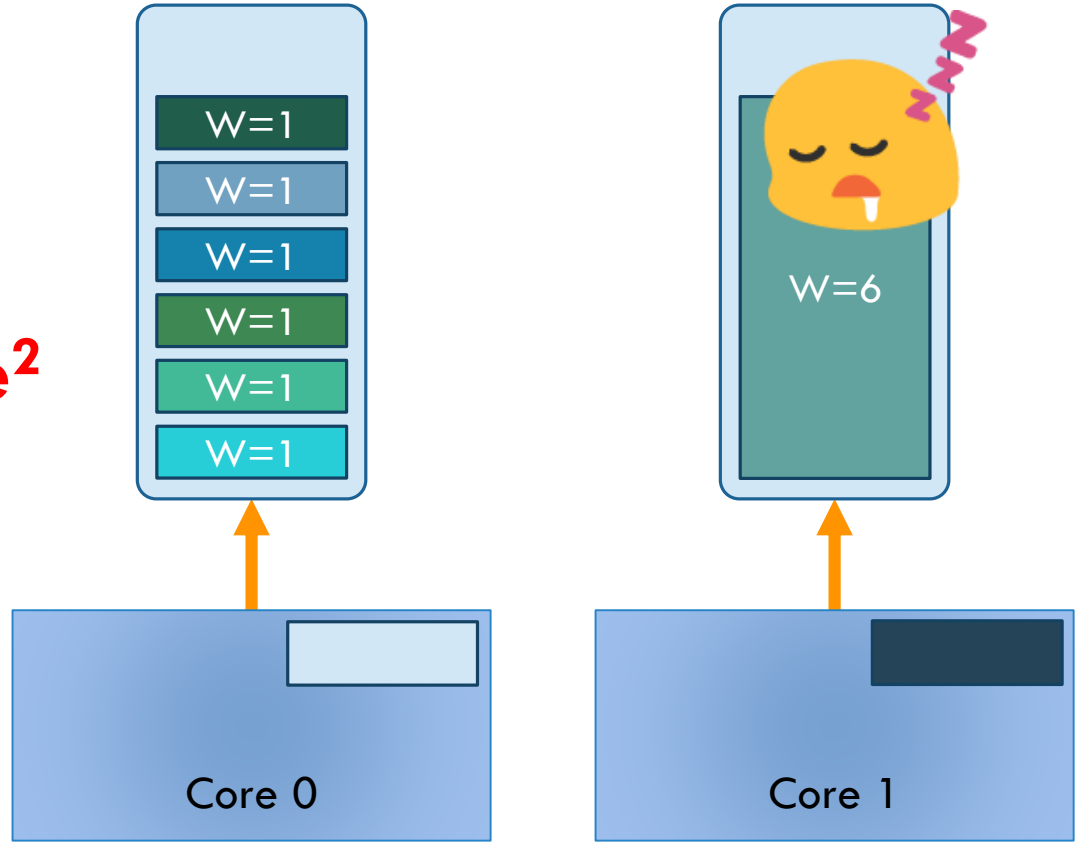
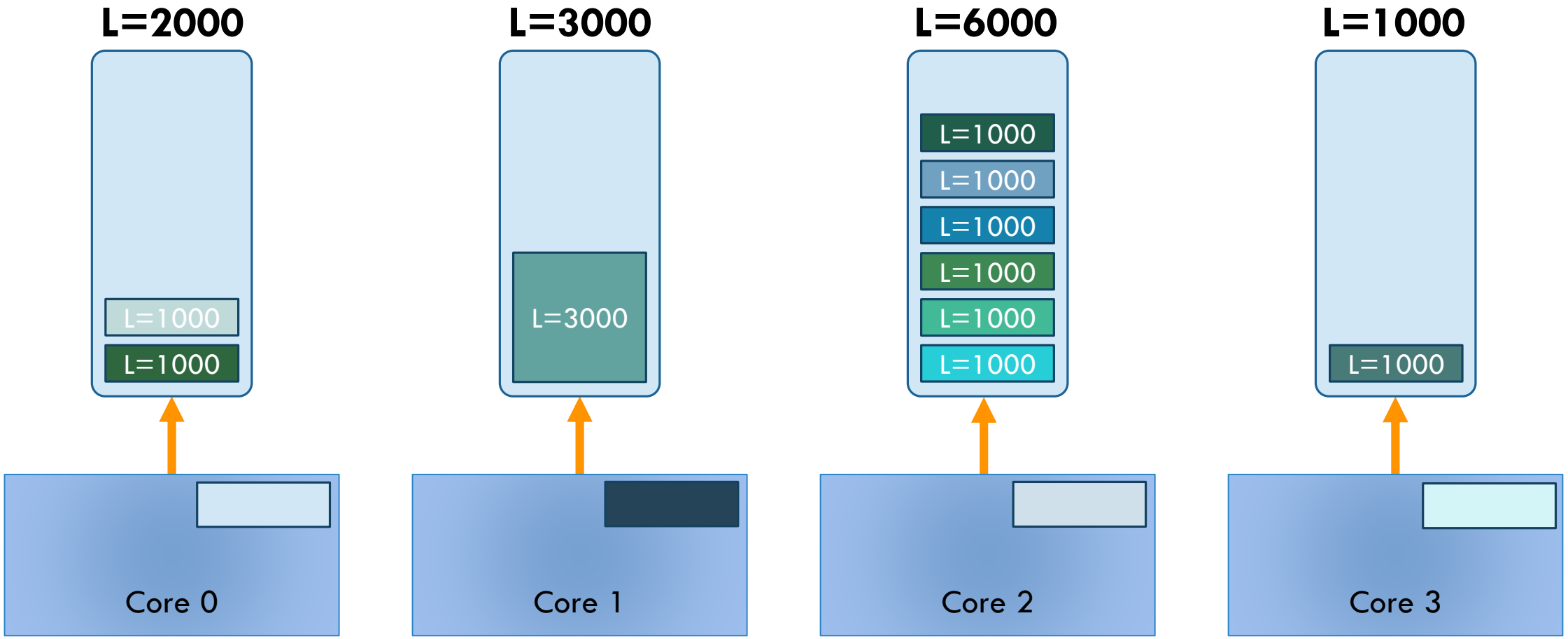


- **Since there can be many cores: hierarchical approach!**

CFS: BALANCING THE LOAD



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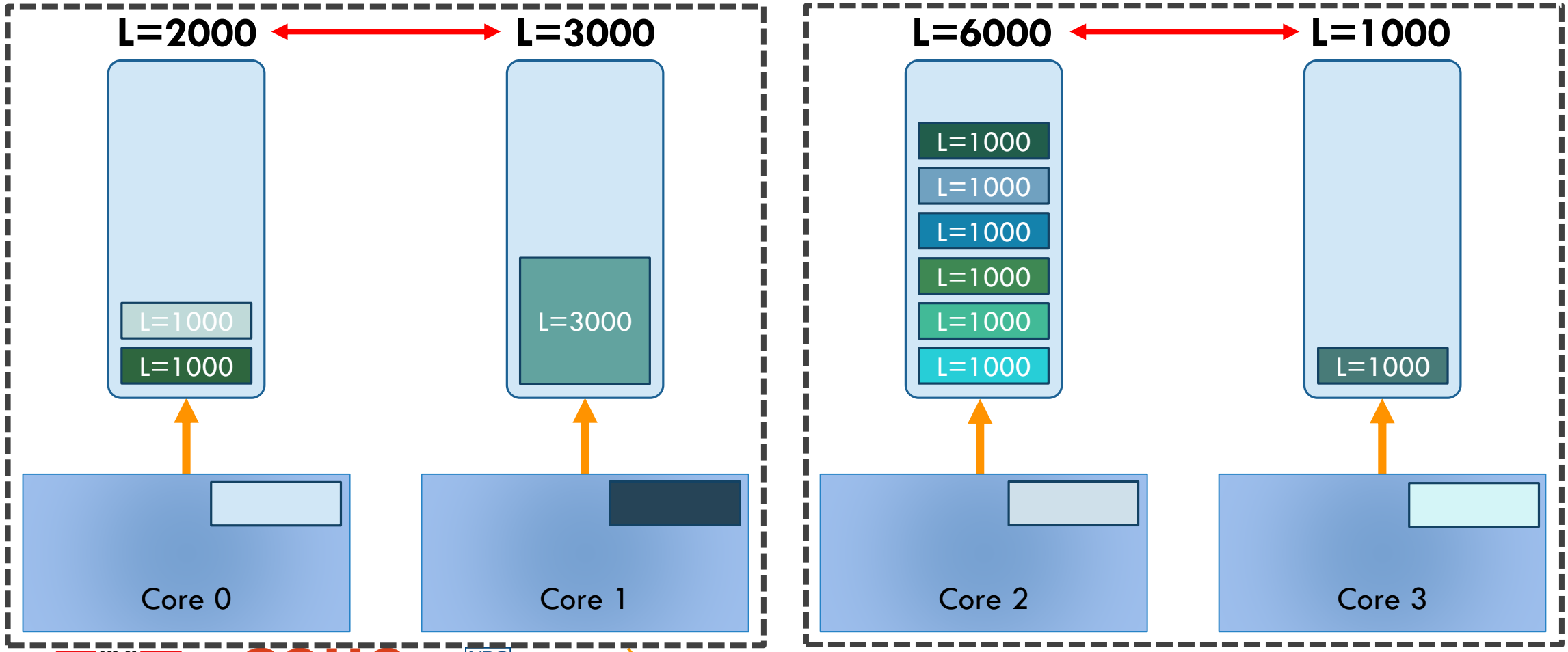

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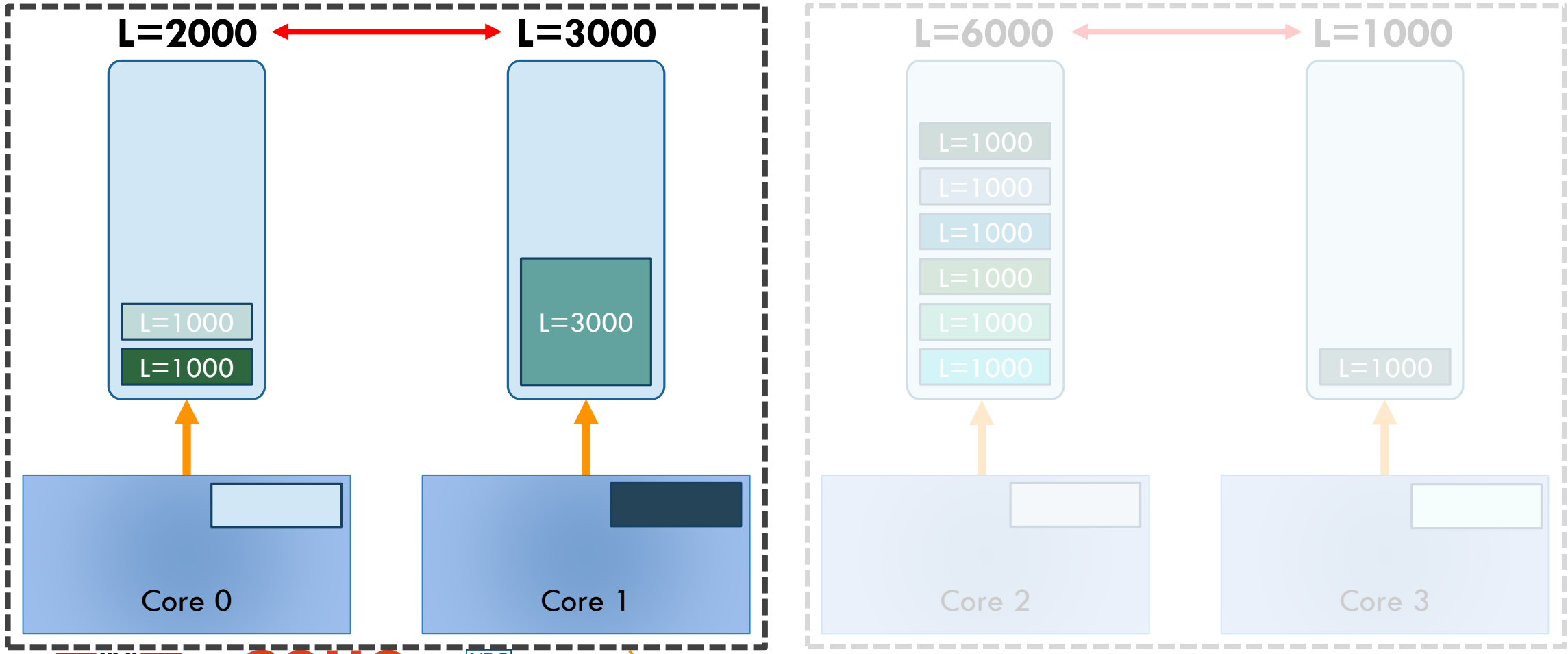

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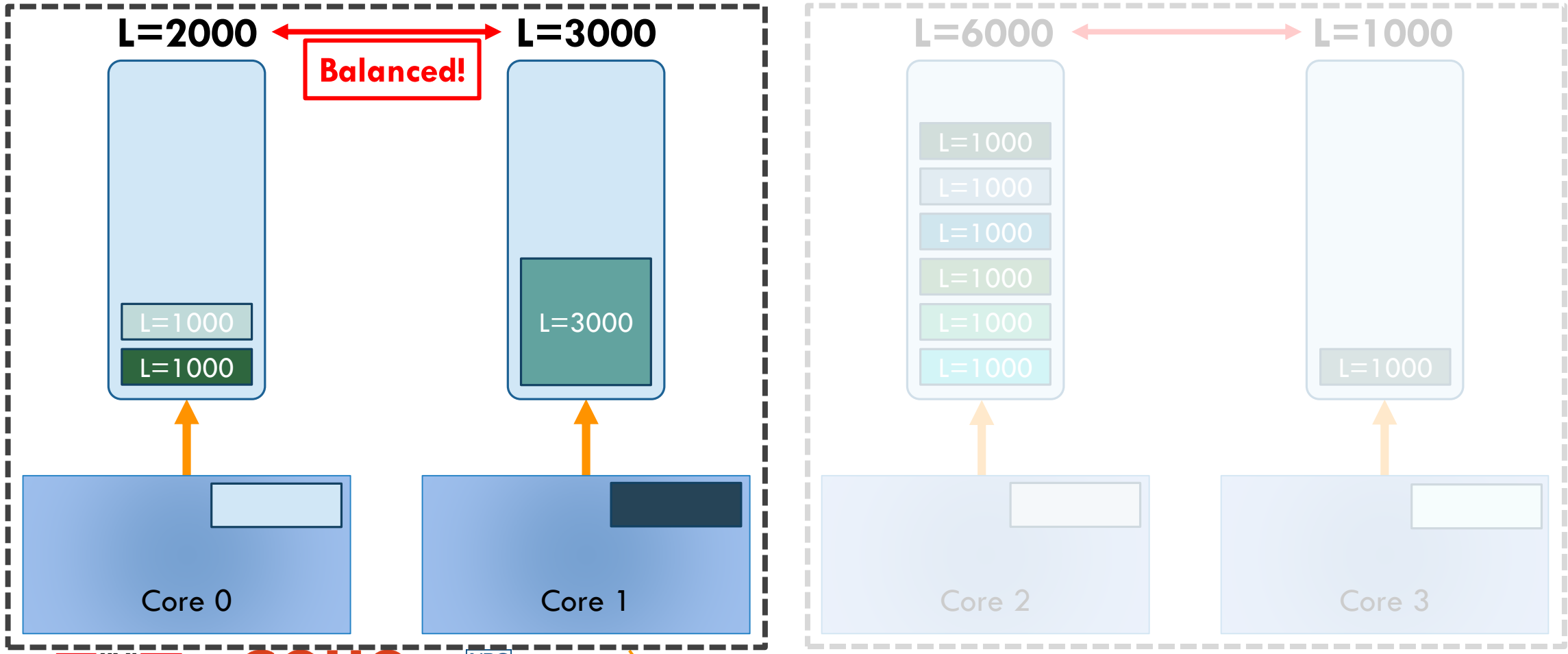

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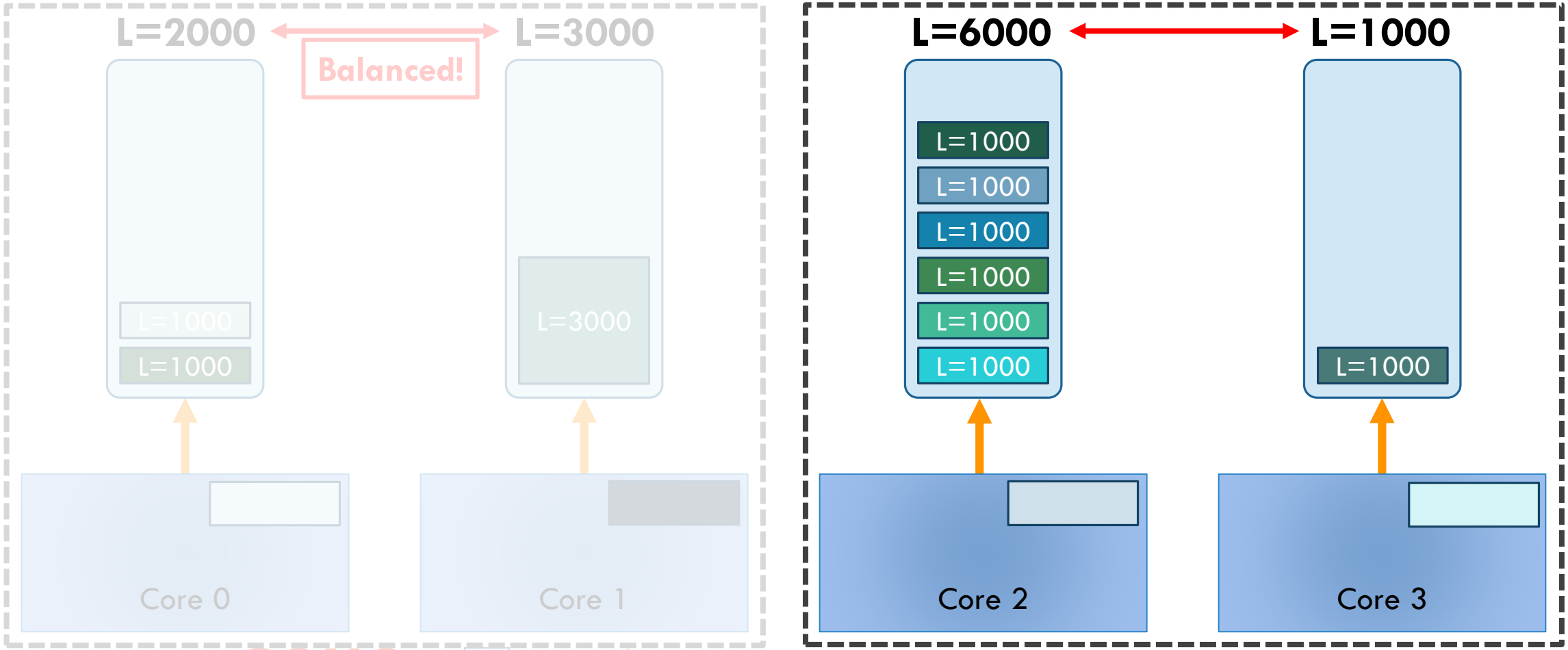

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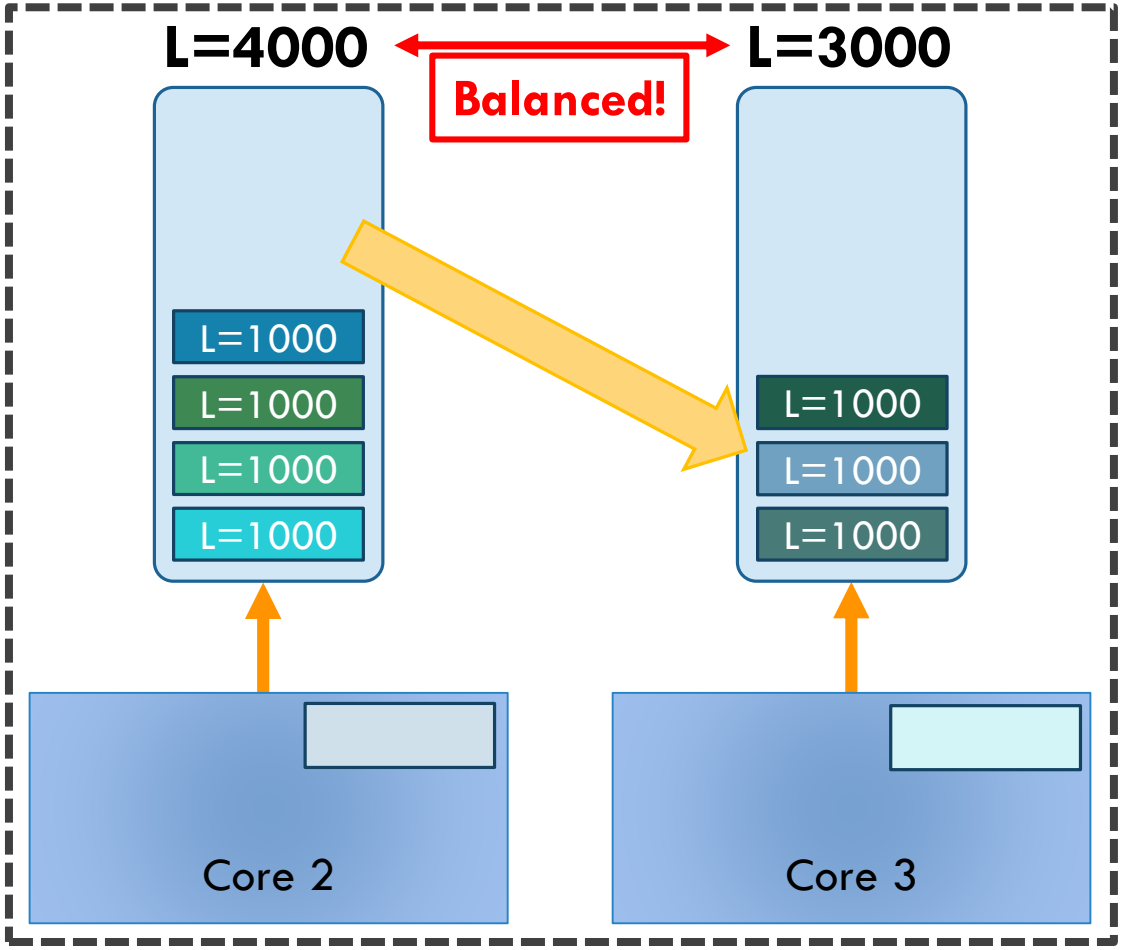

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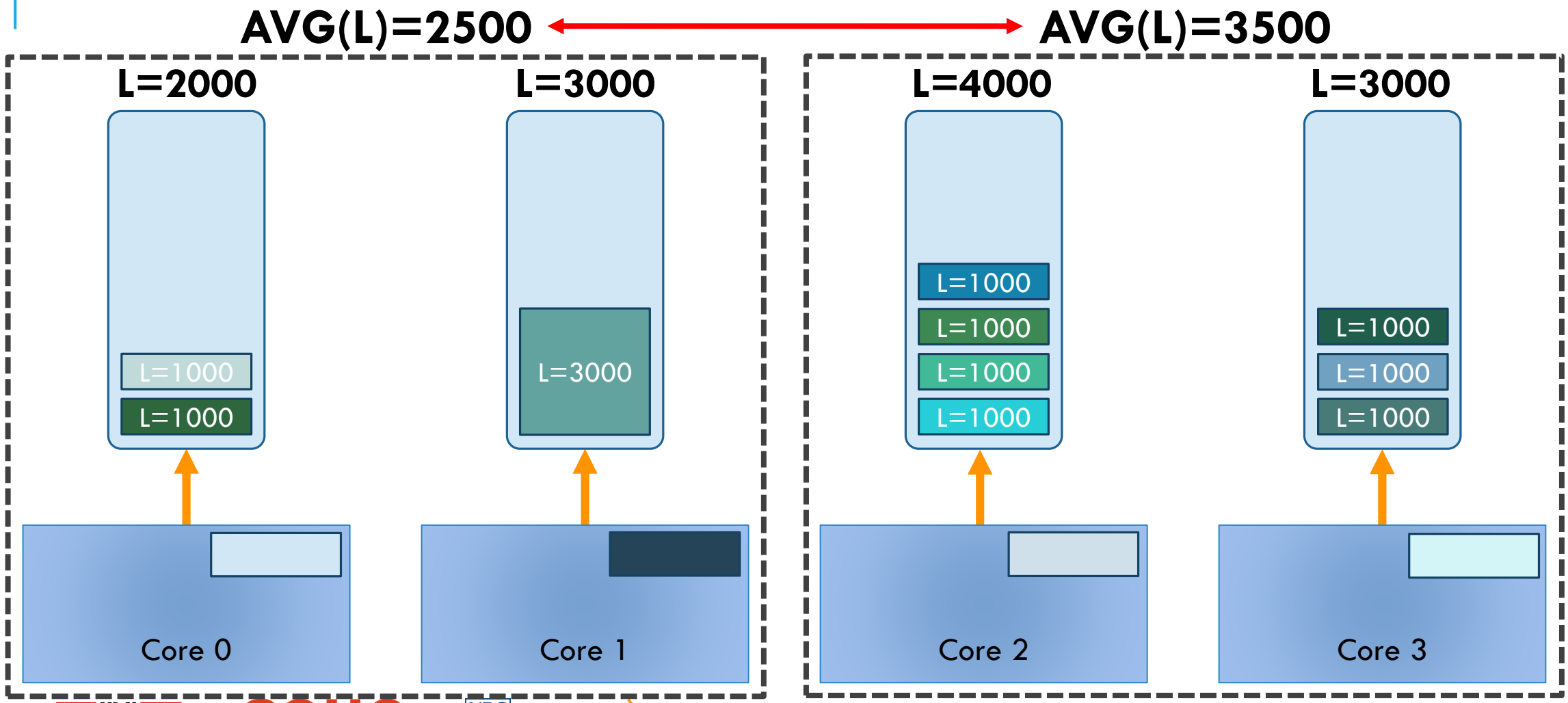

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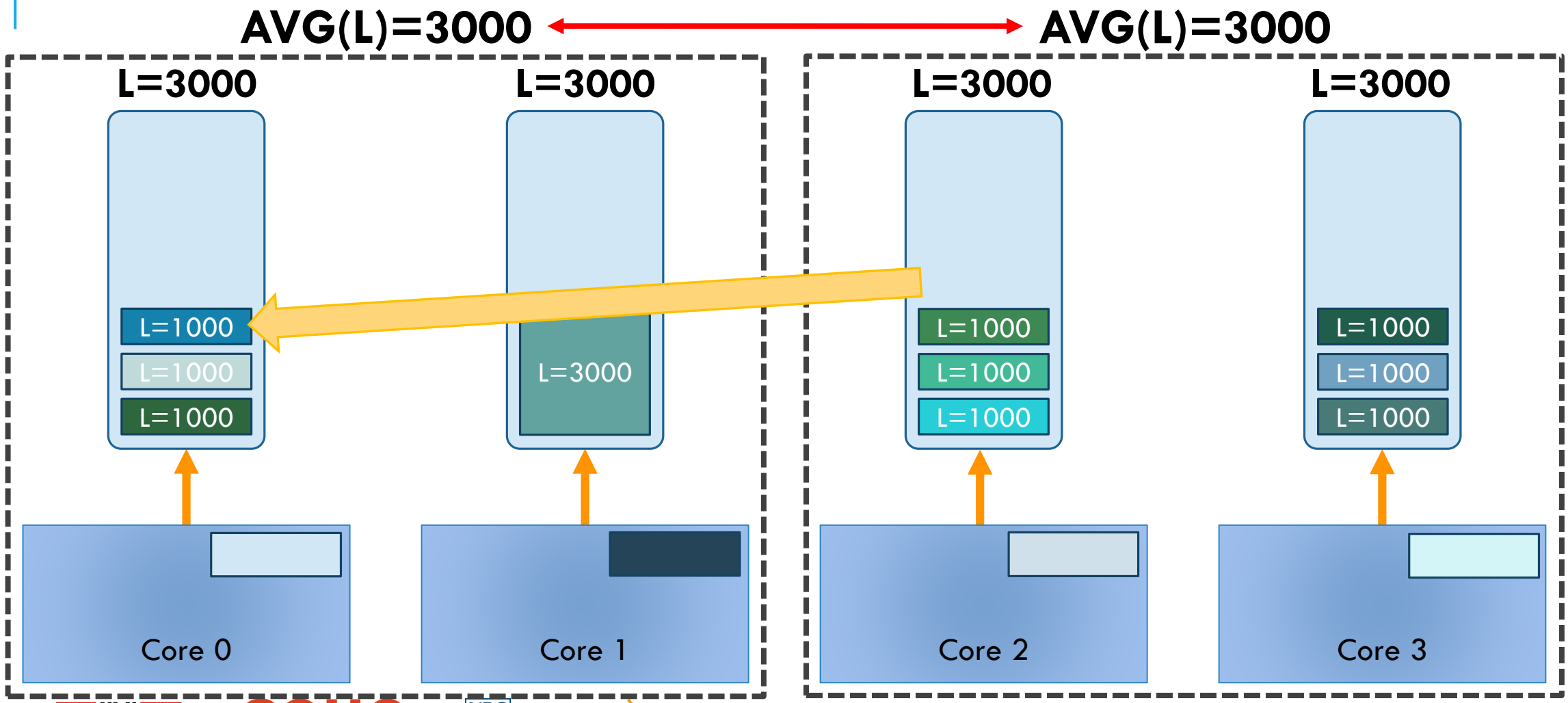

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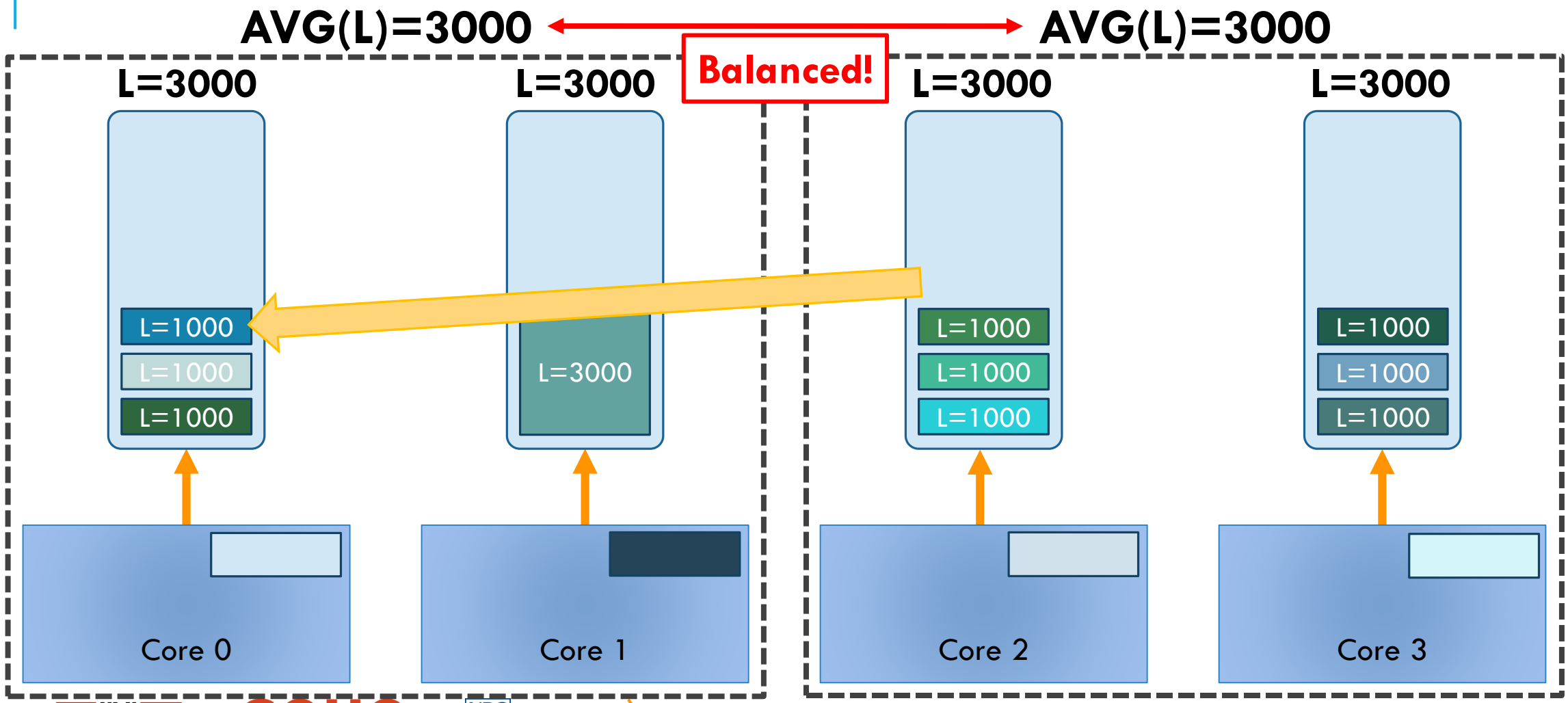

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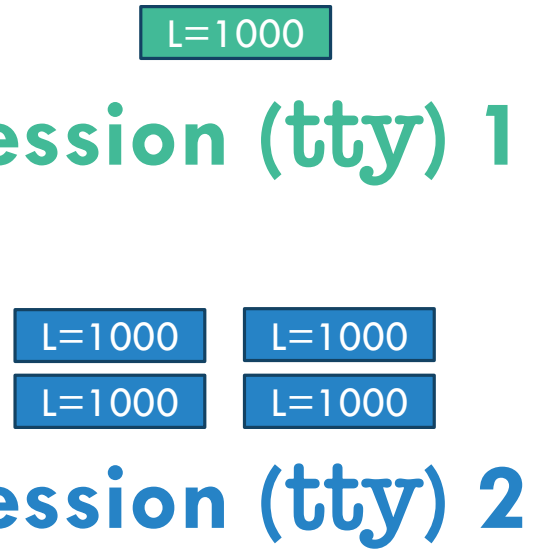

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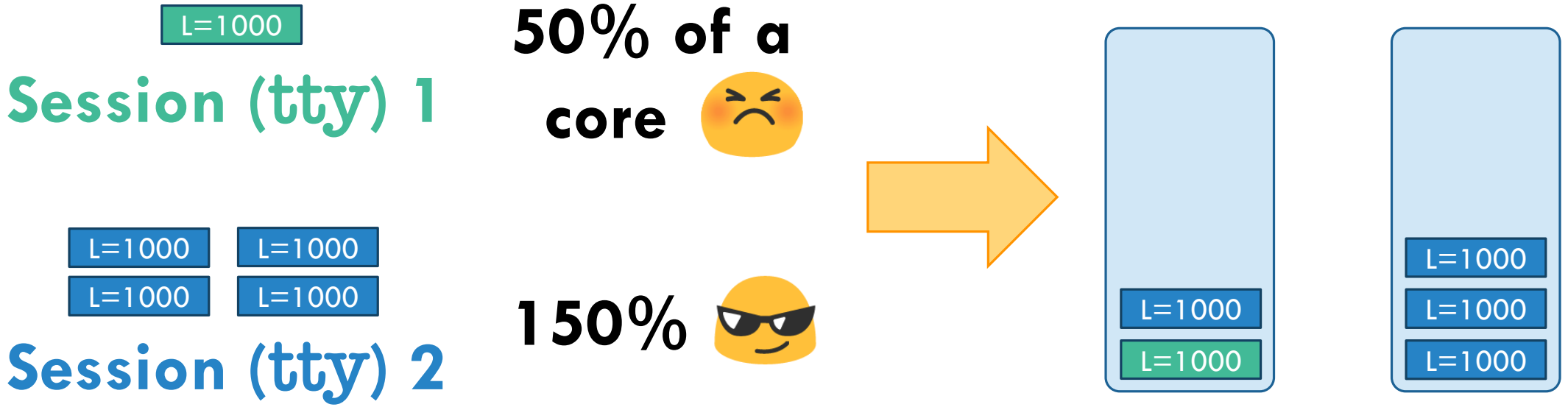

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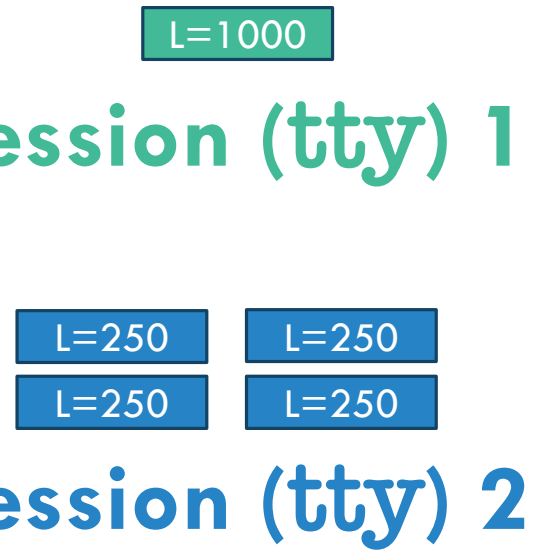

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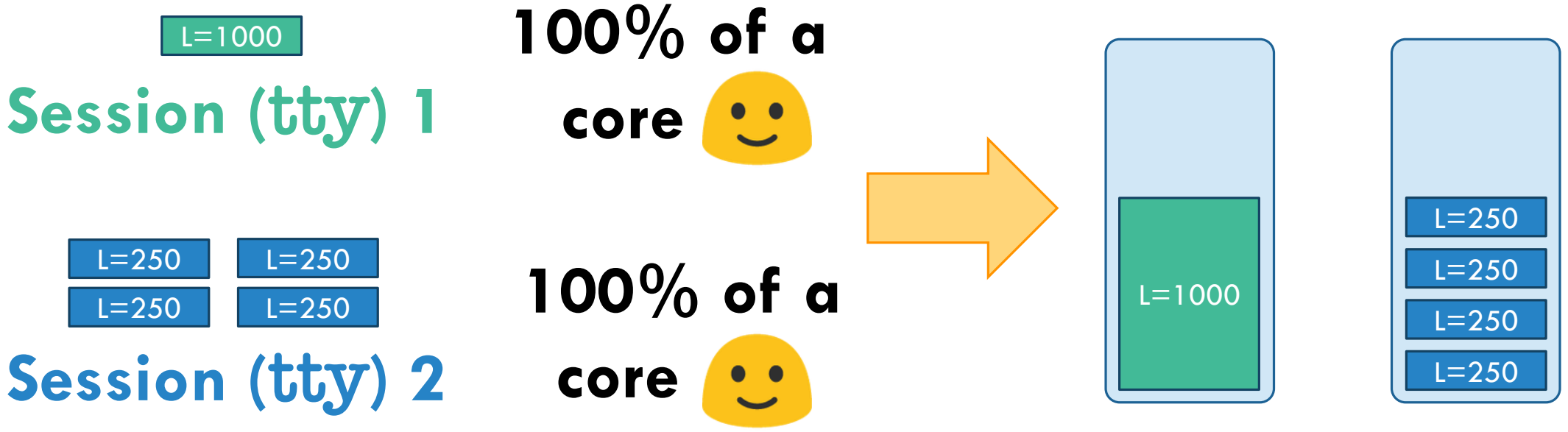

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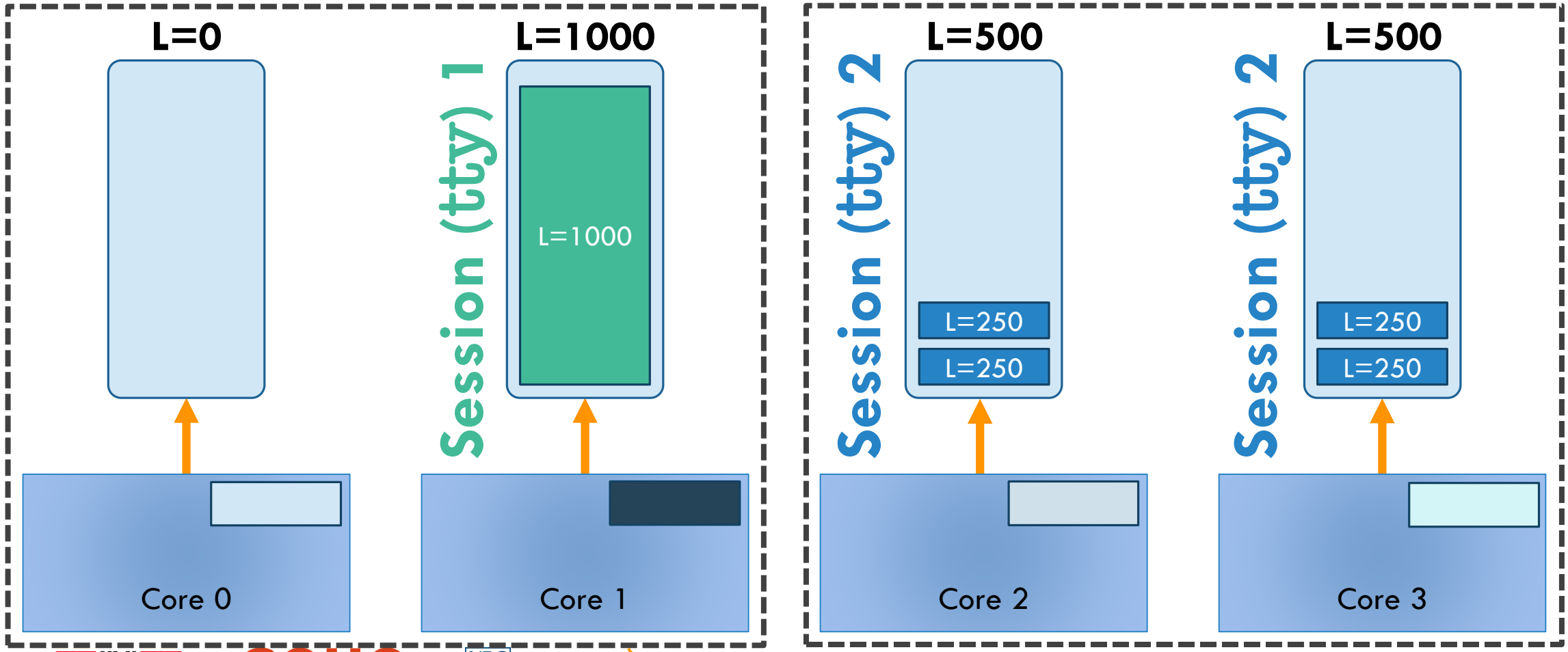

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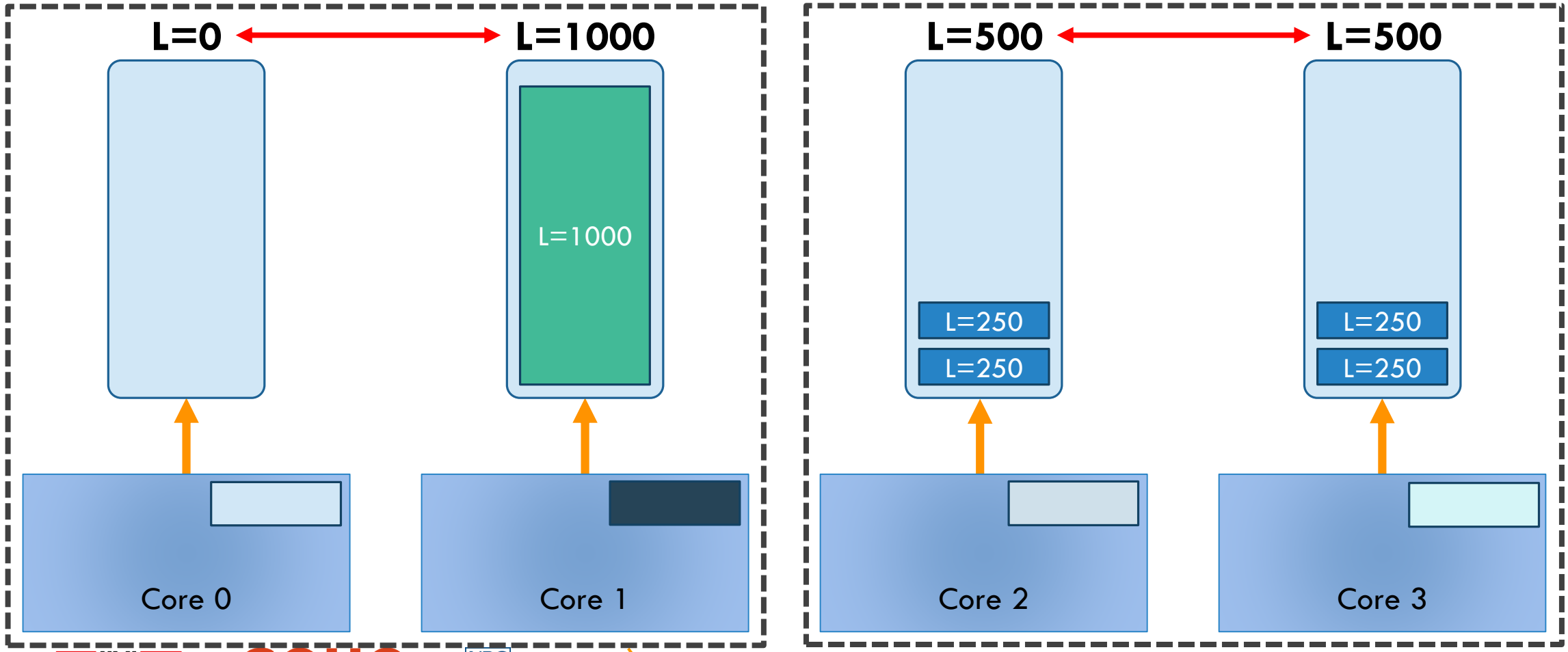

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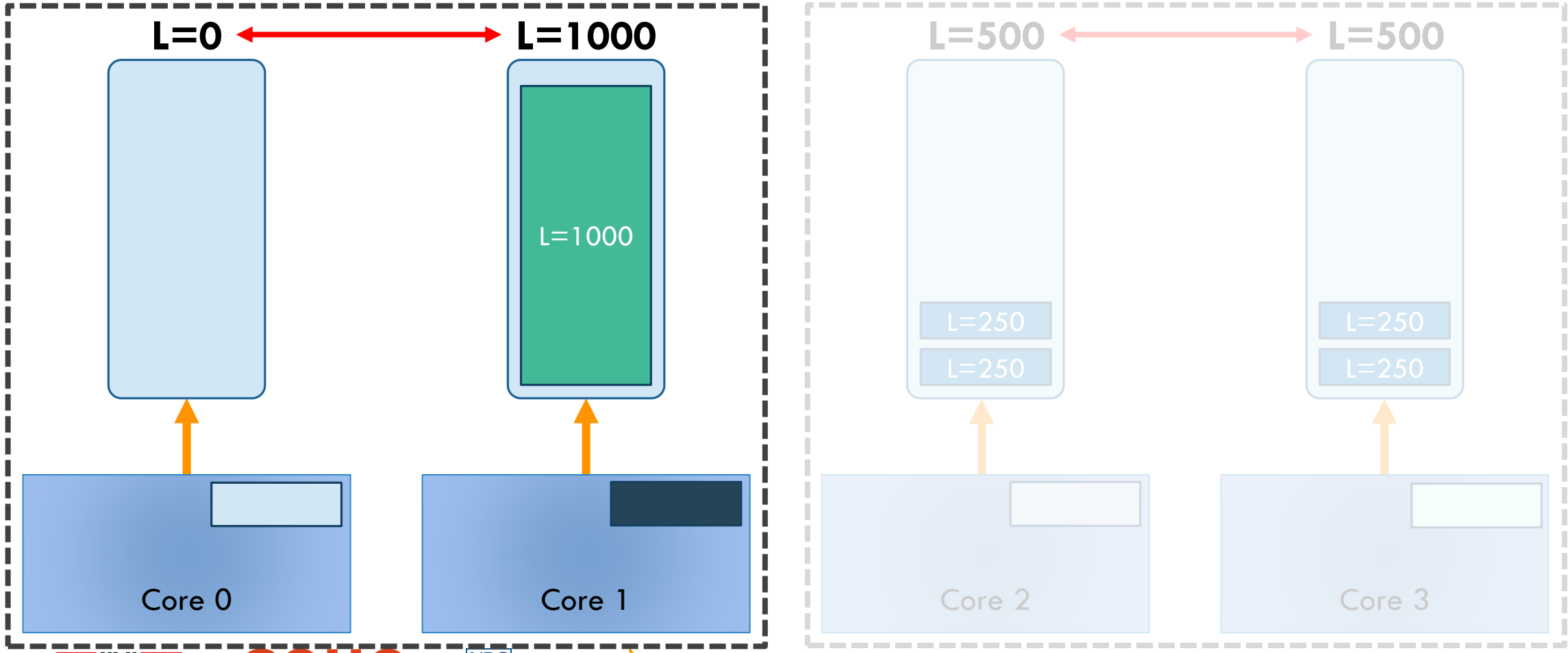

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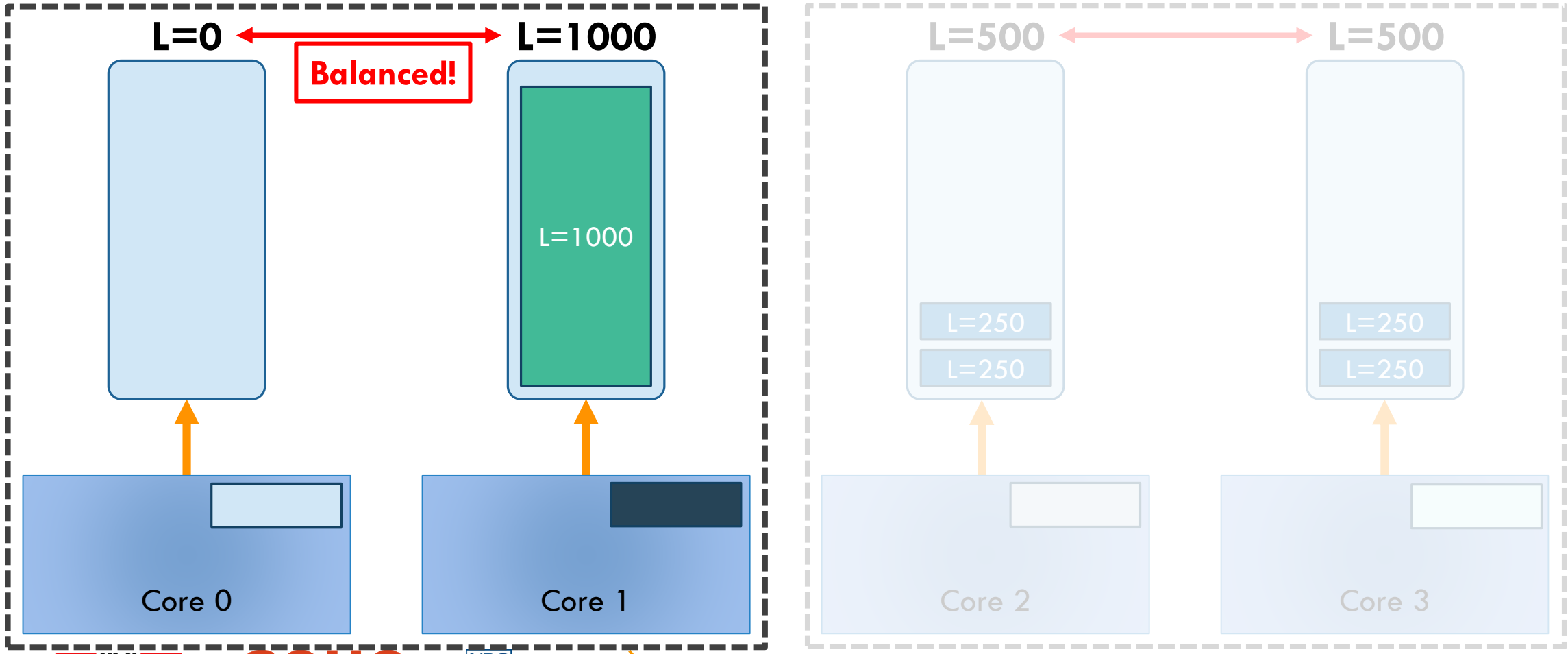

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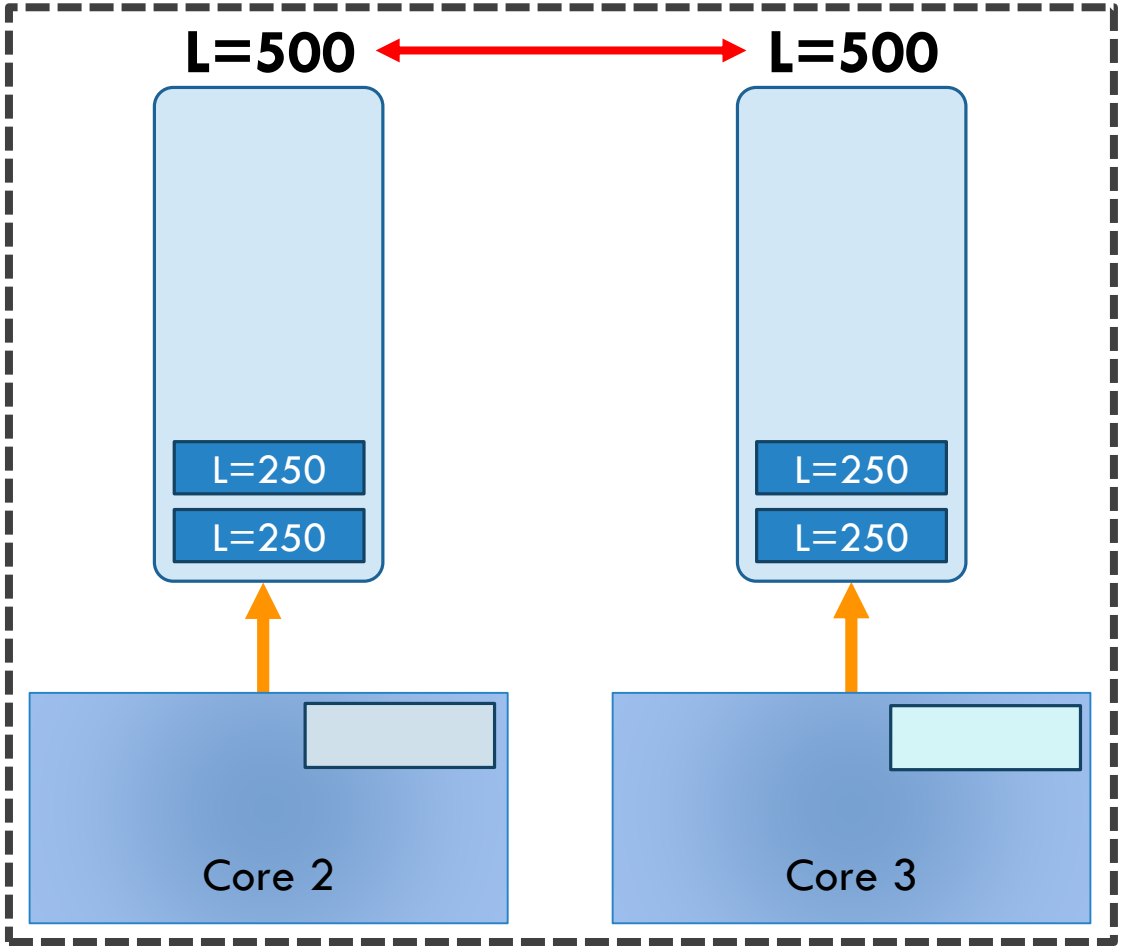

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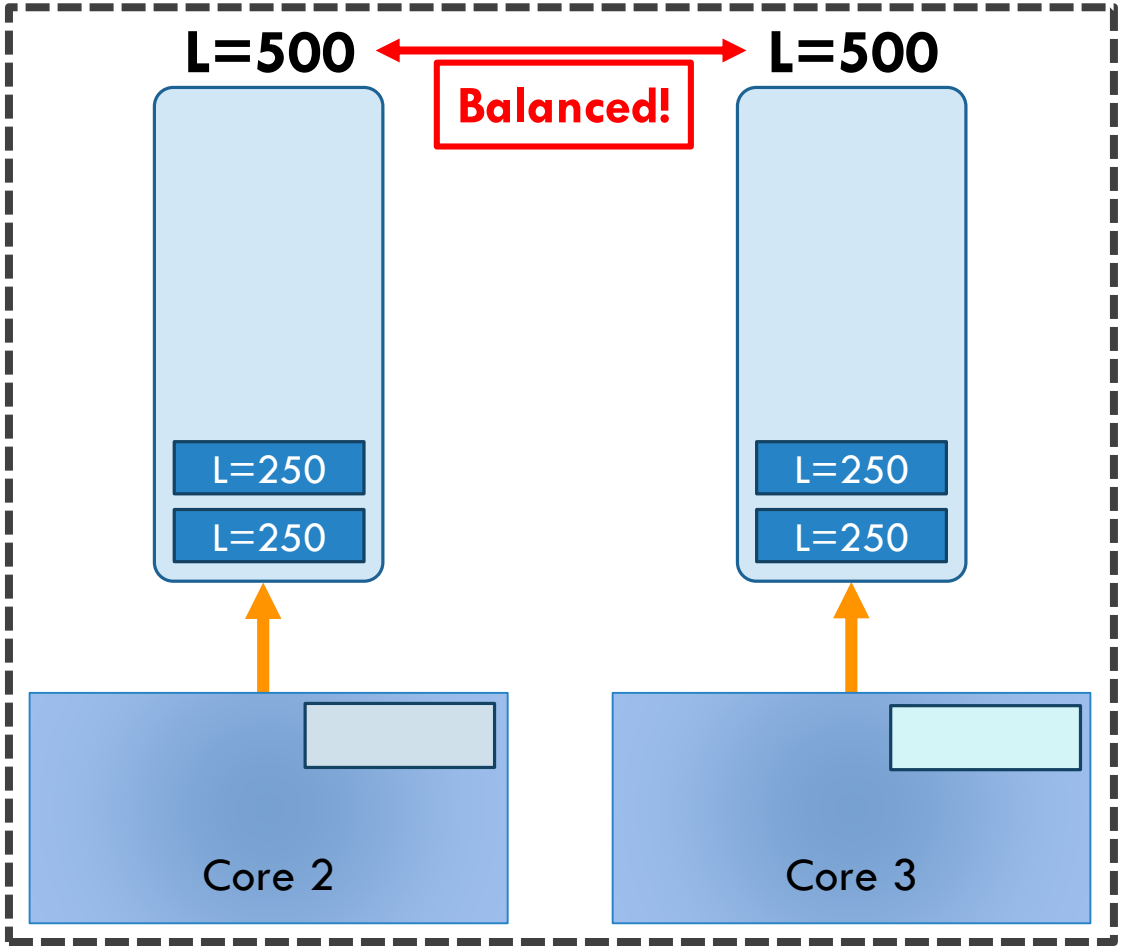

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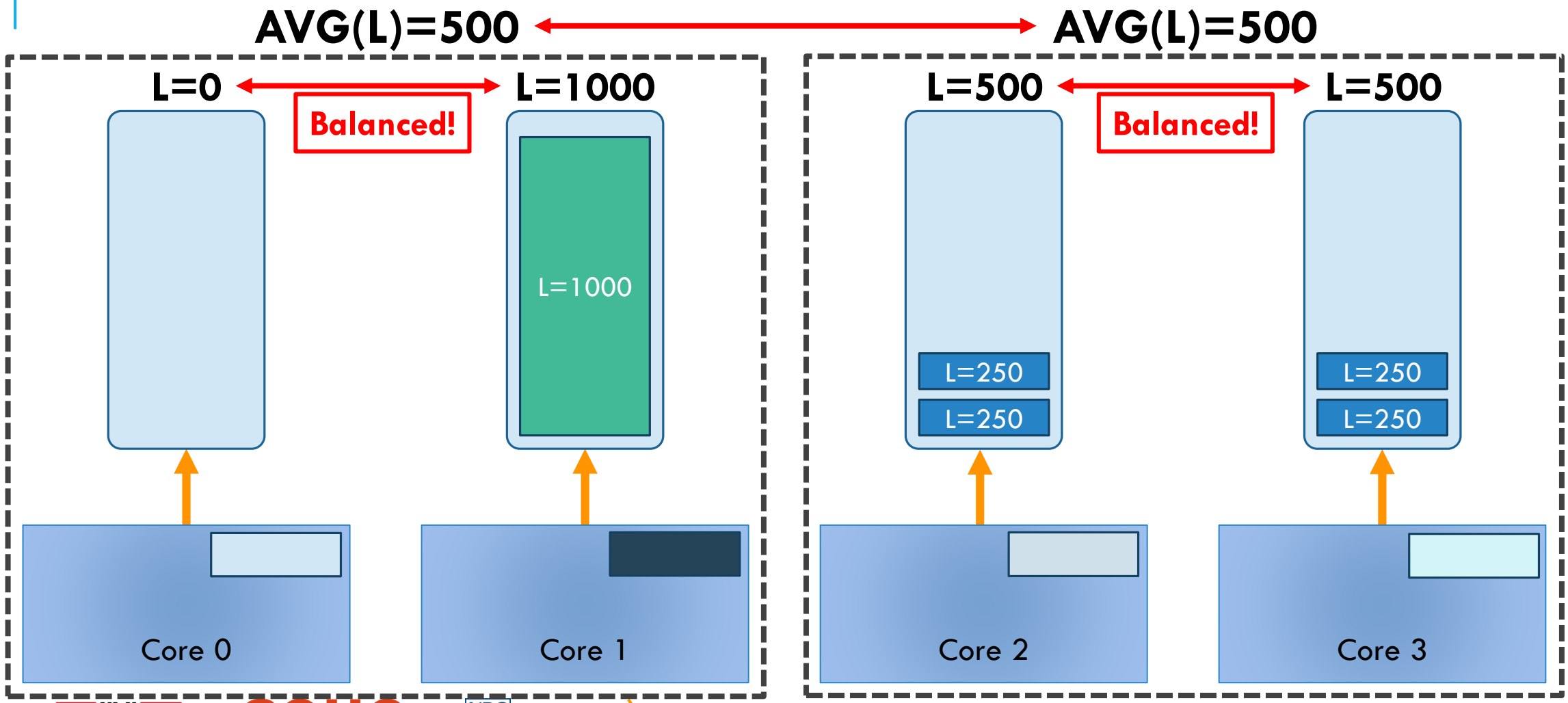

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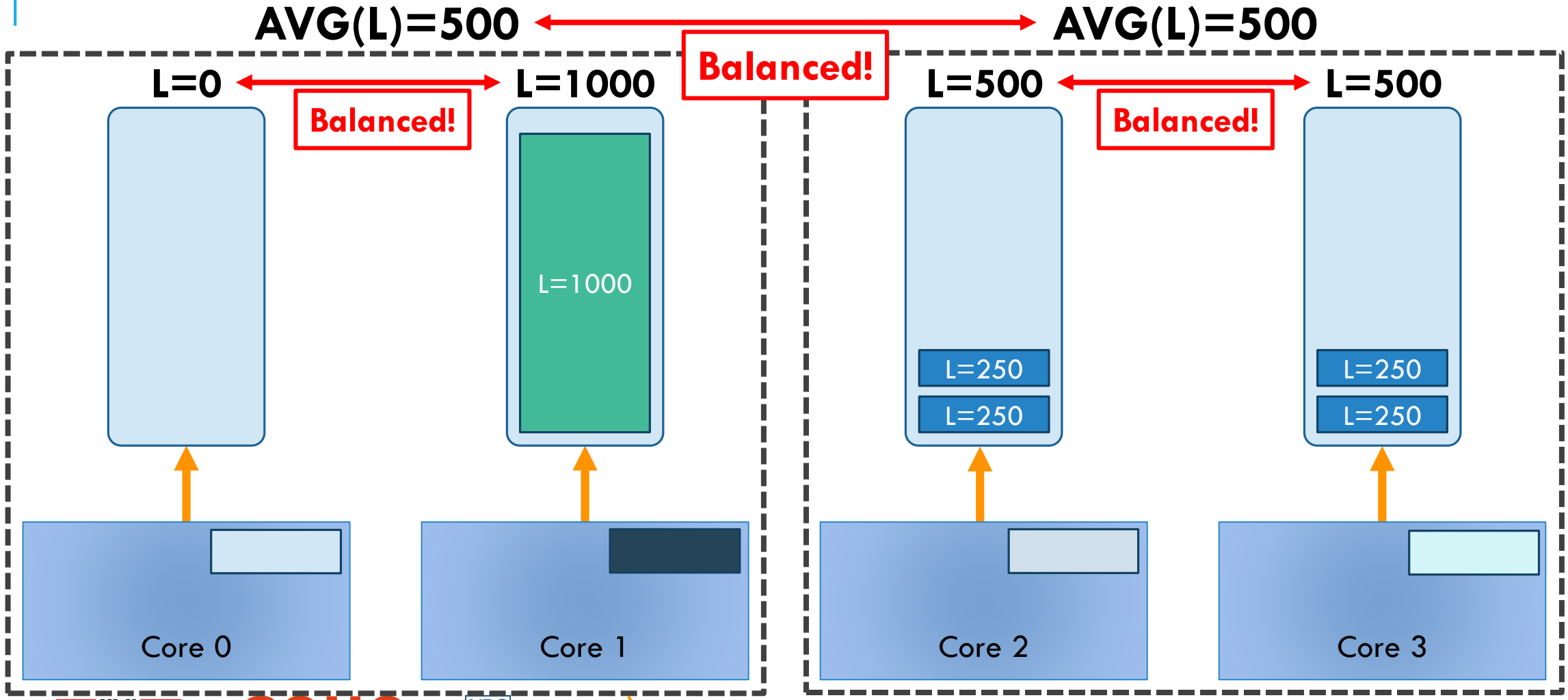

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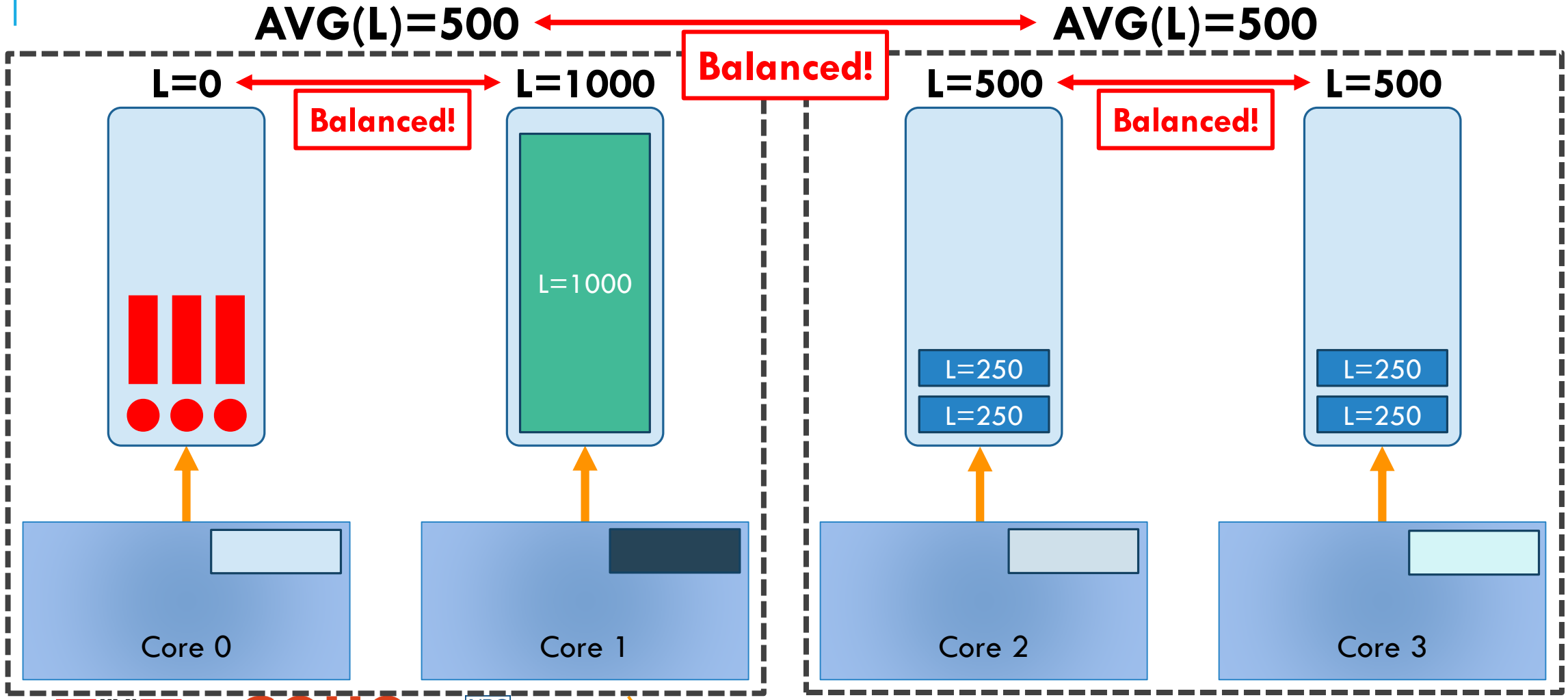

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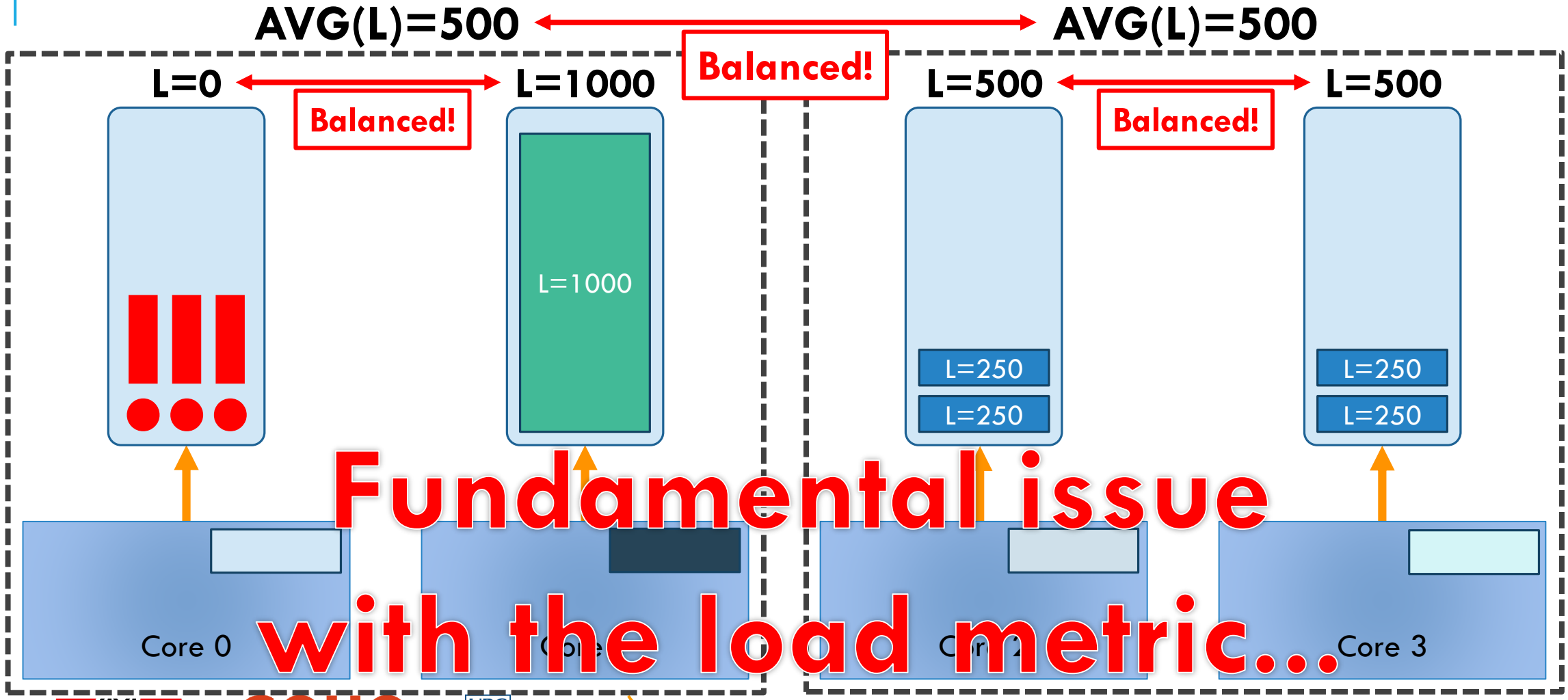

Fundamental issue with the load metric...

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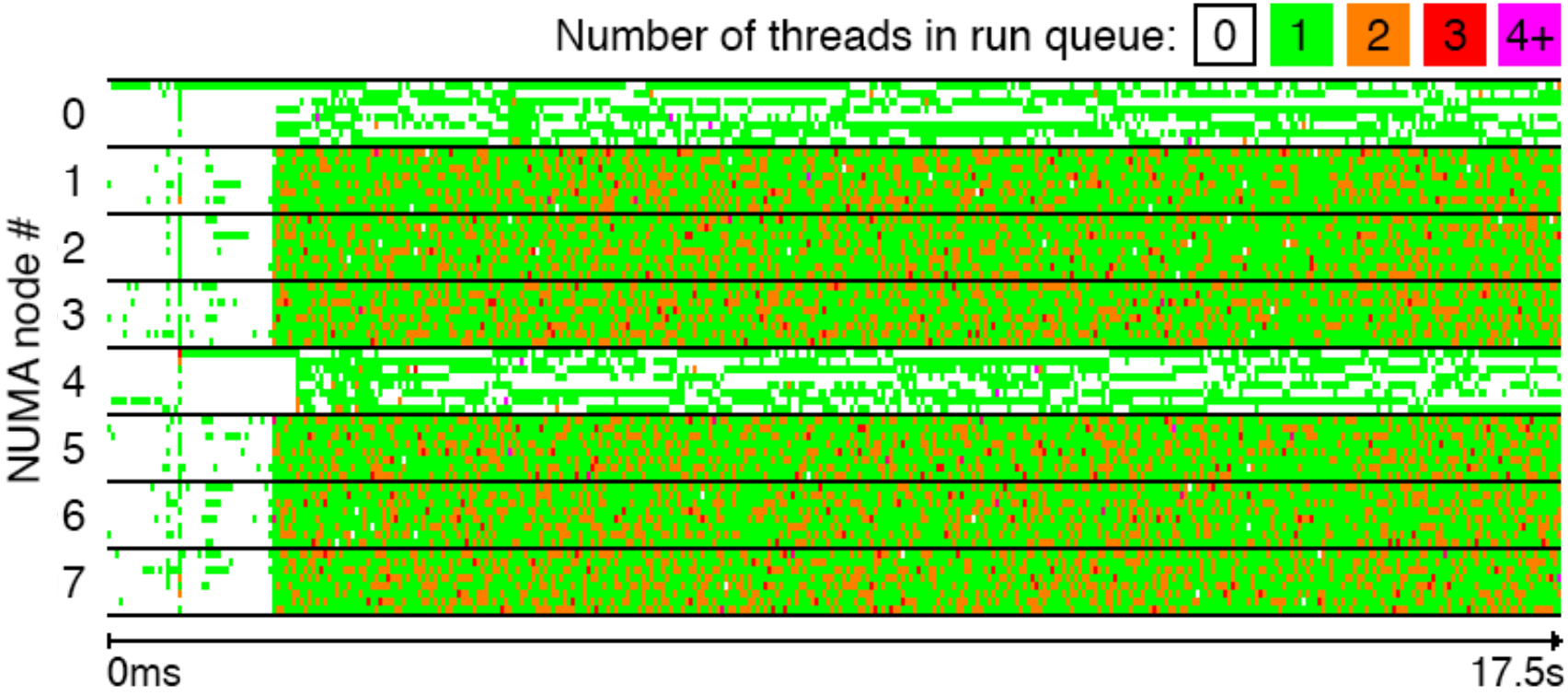

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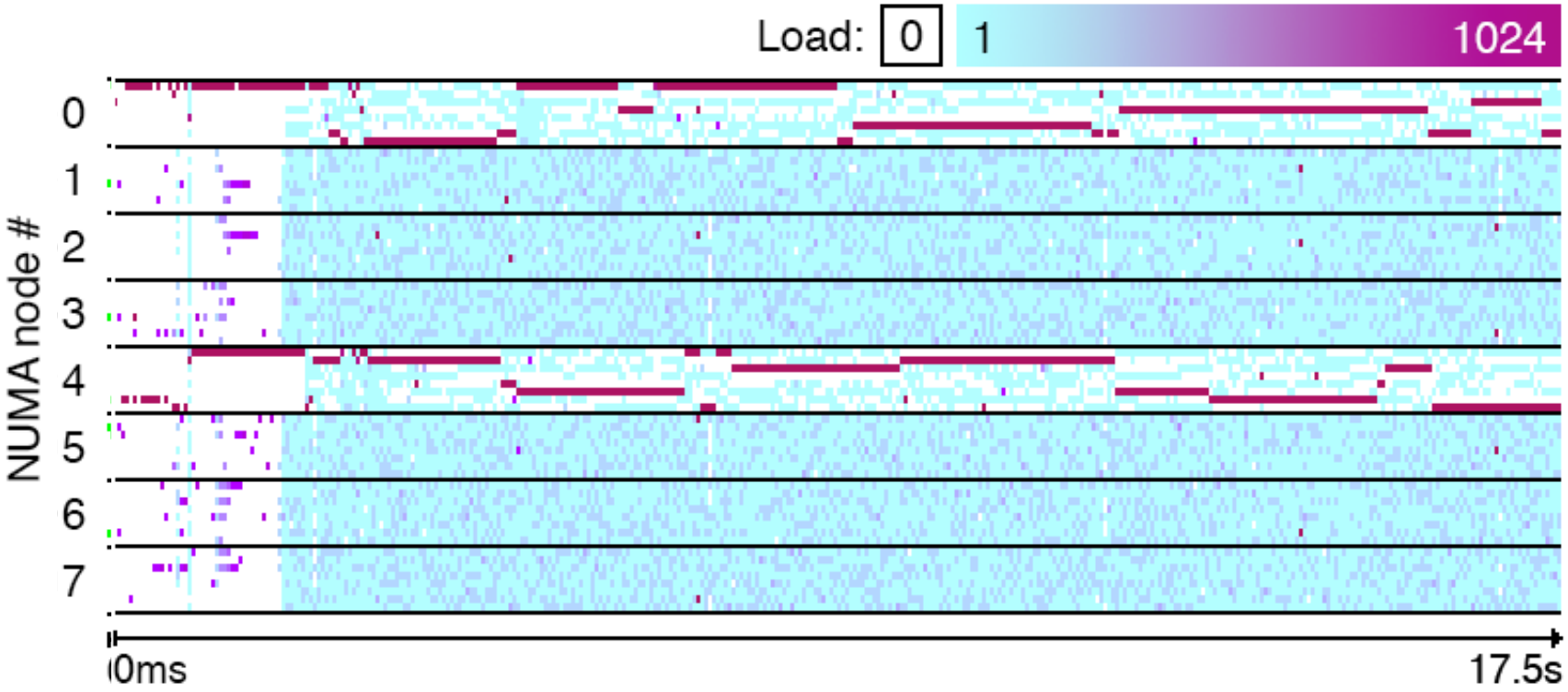

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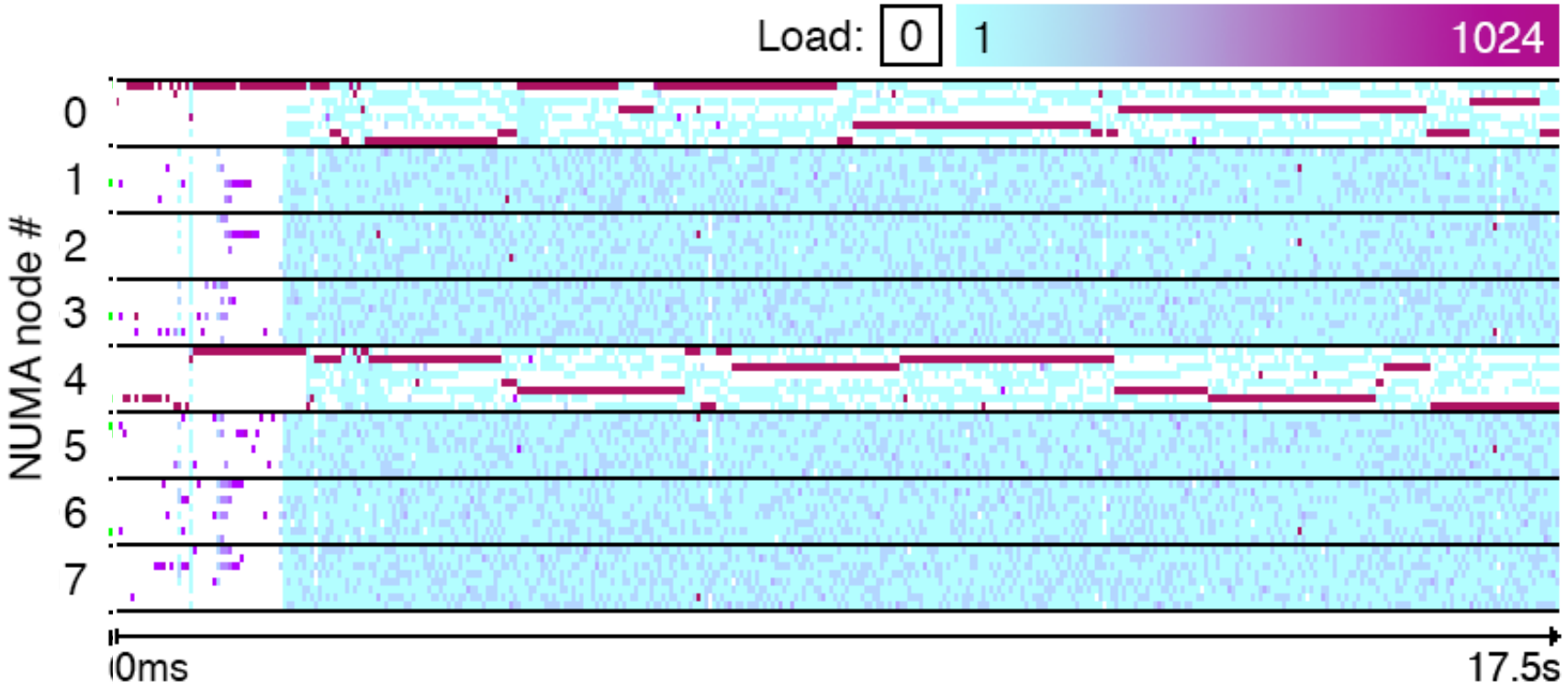

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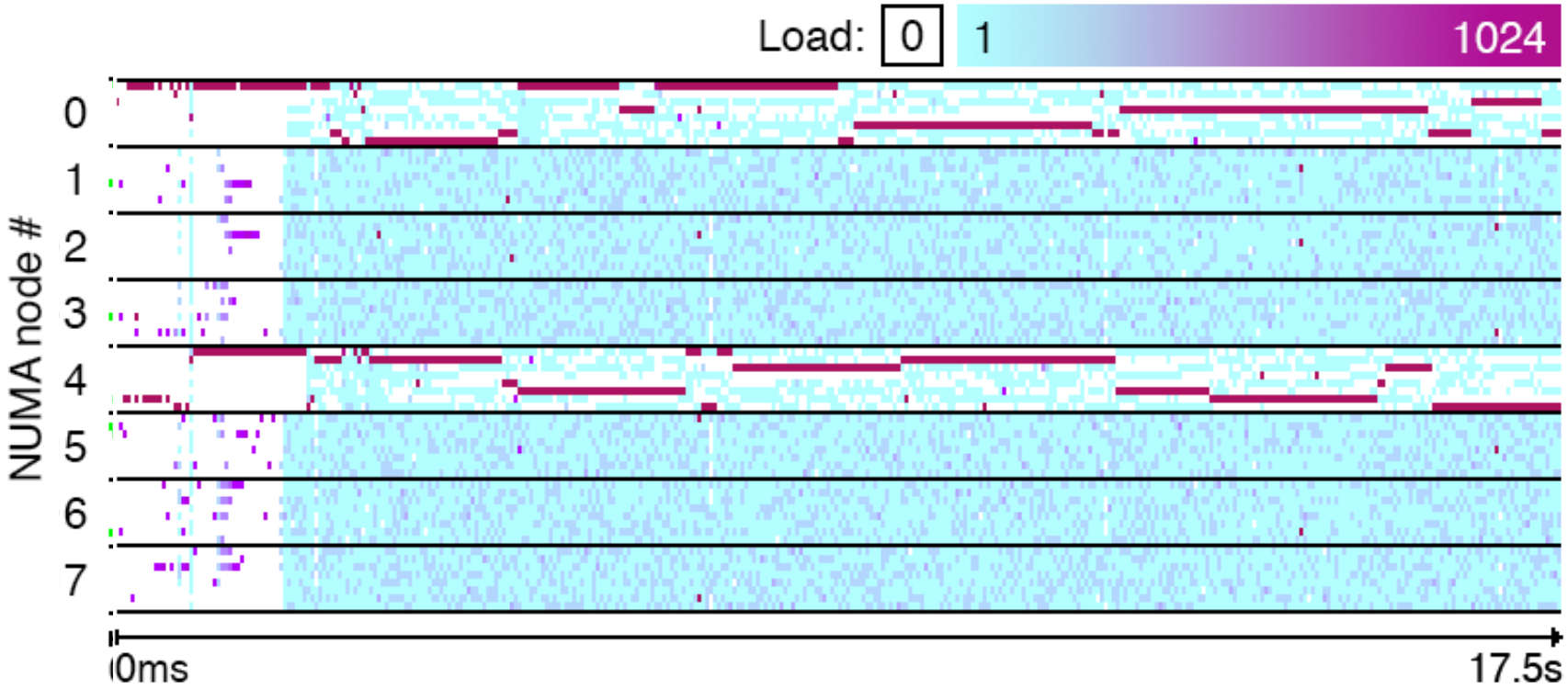

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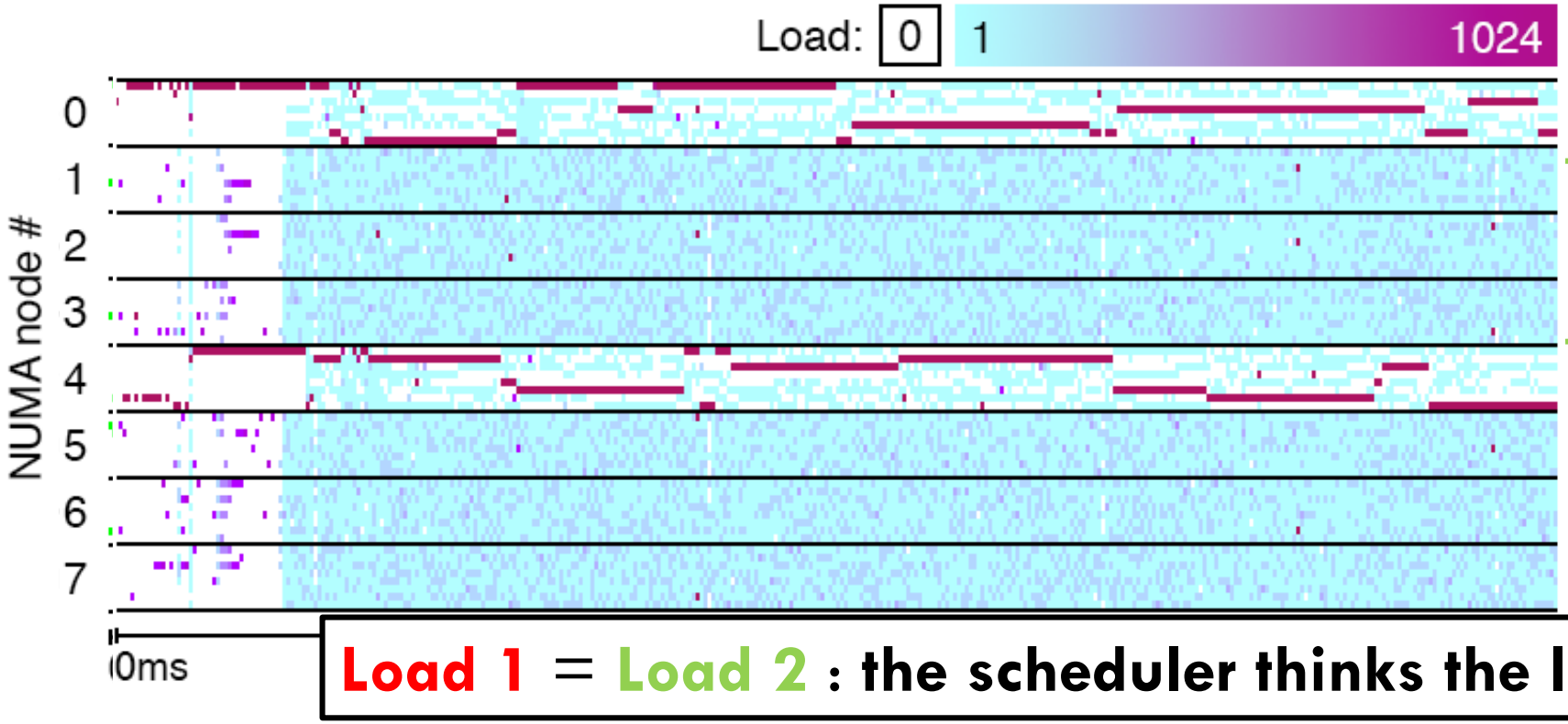

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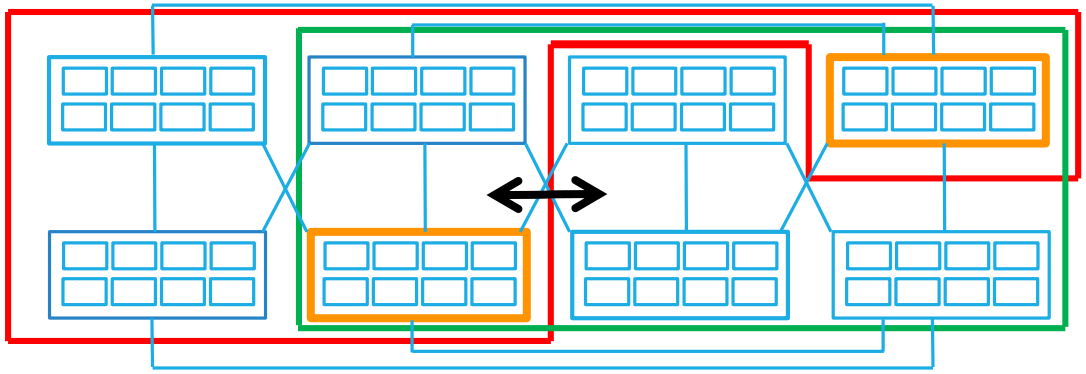

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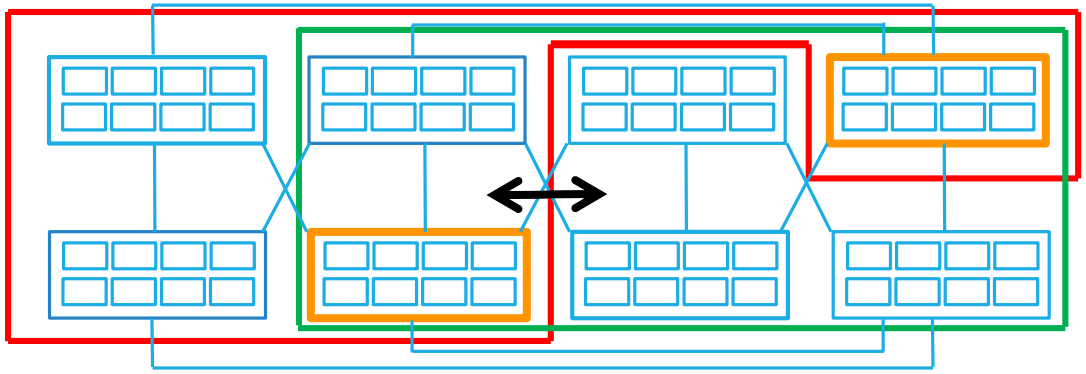

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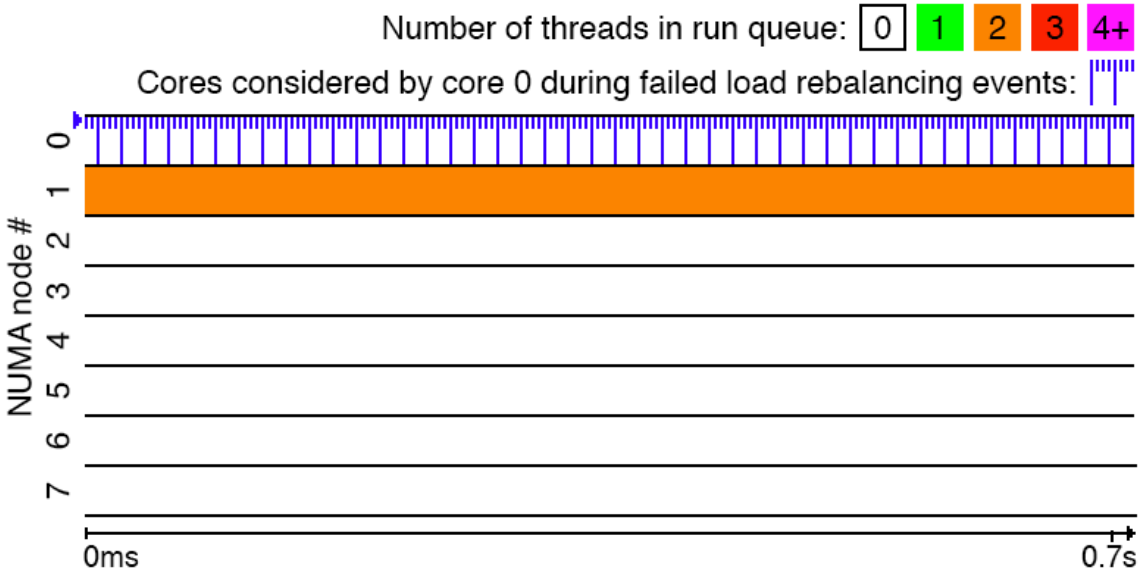

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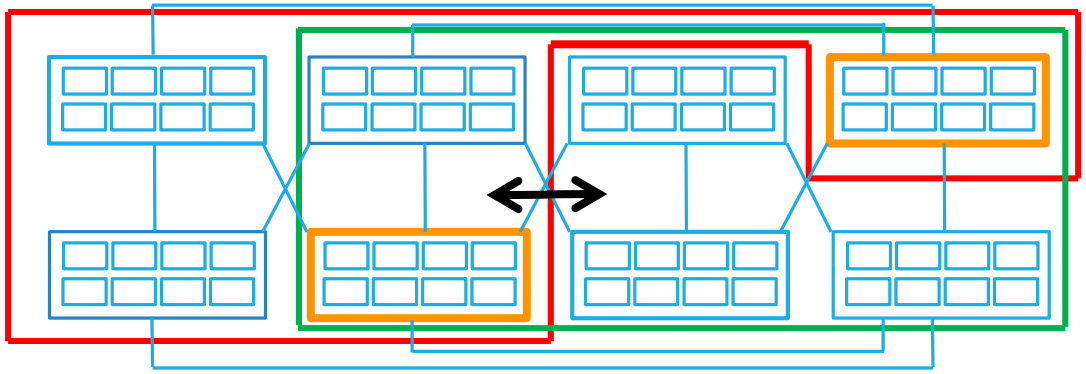

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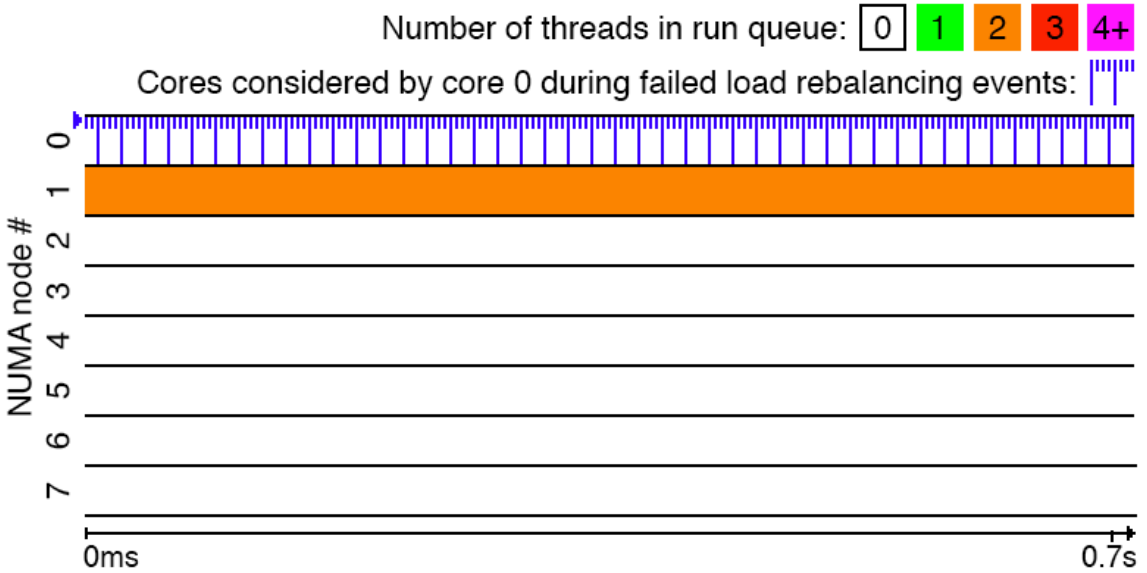

- **Bug #3: disabling/reenabling a core breaks the hierarchy completely**

MORE BUGS: WAKEUPS

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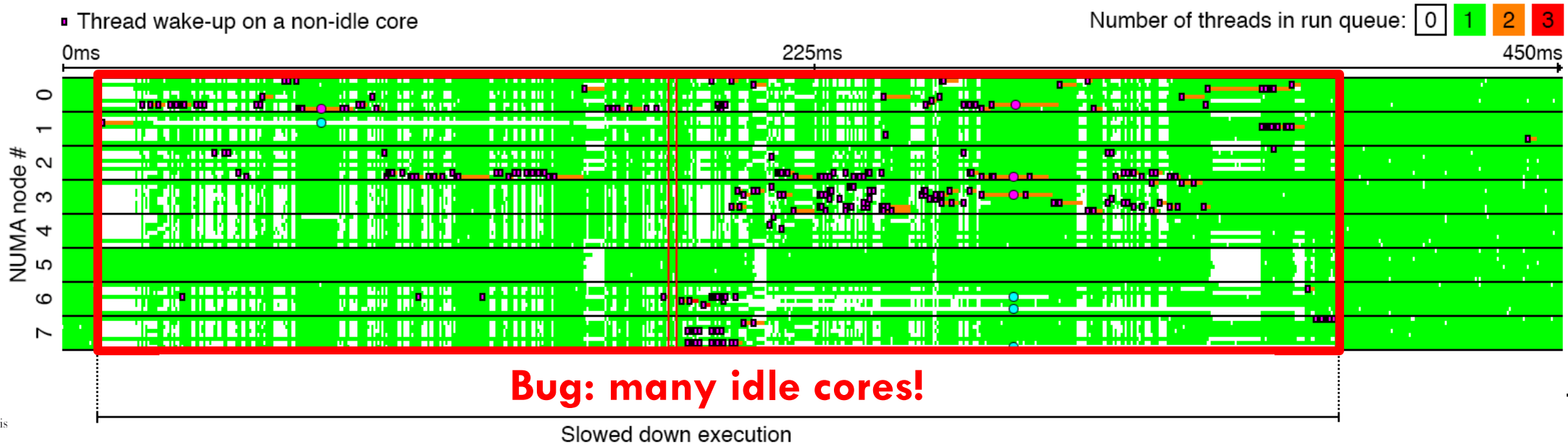

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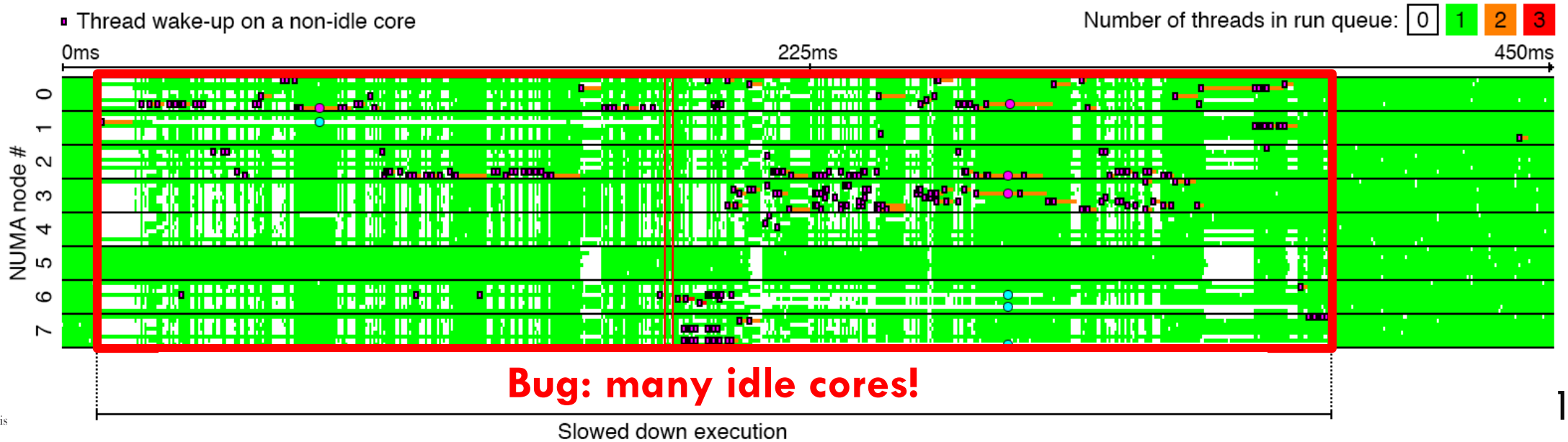

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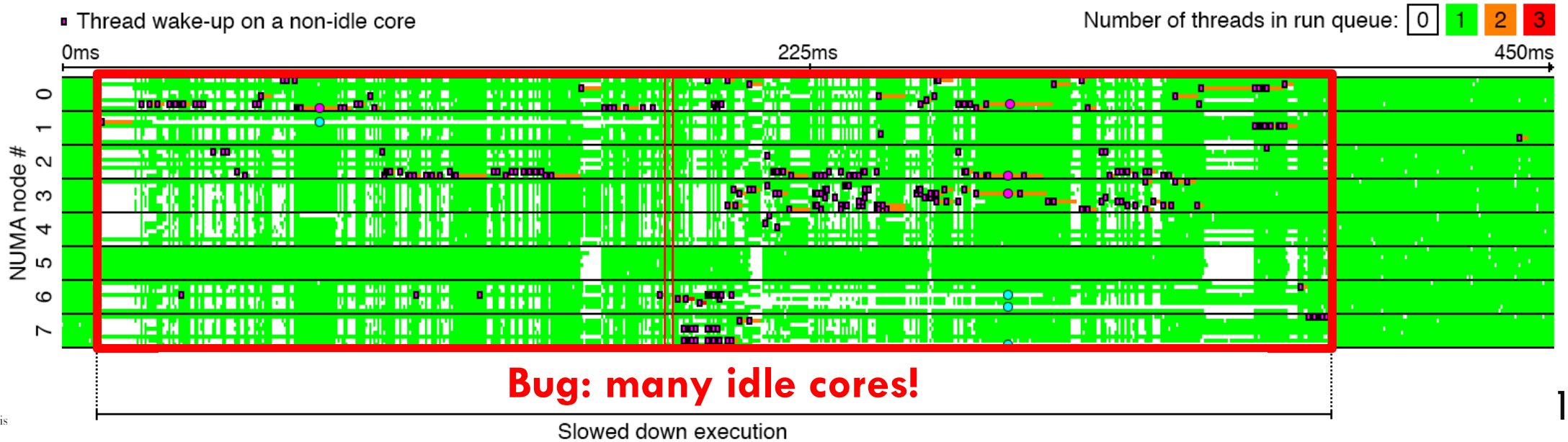

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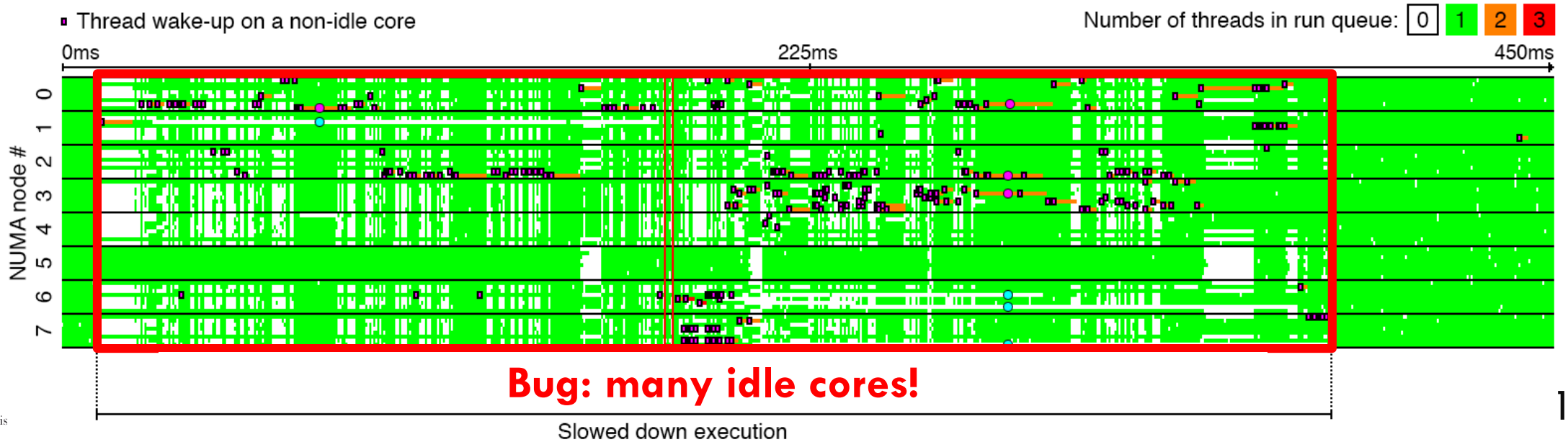

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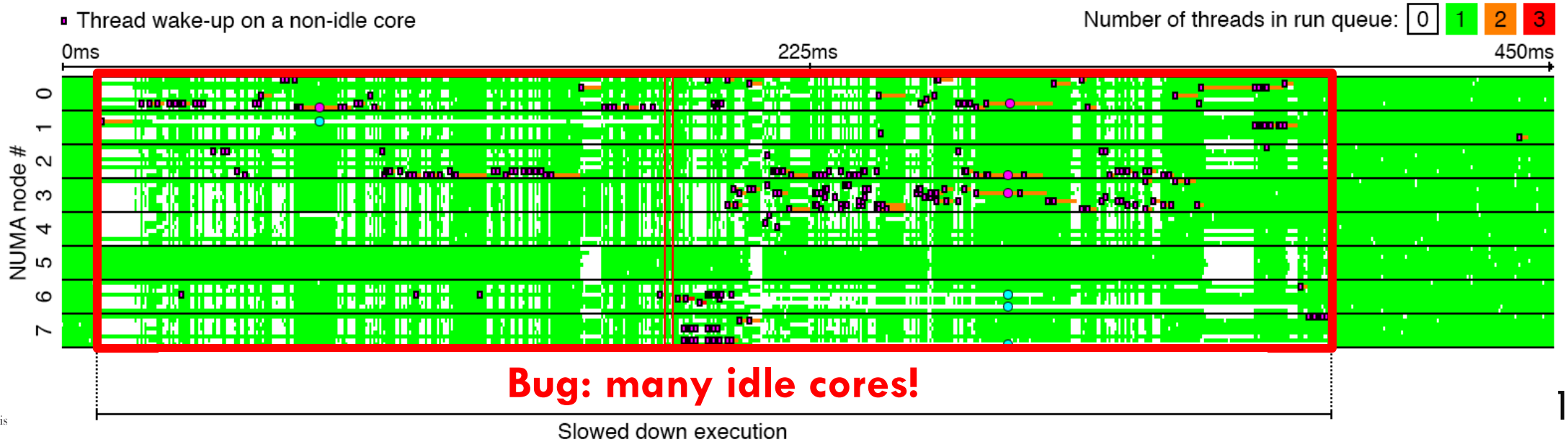

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Performance degradation: 13-24%!

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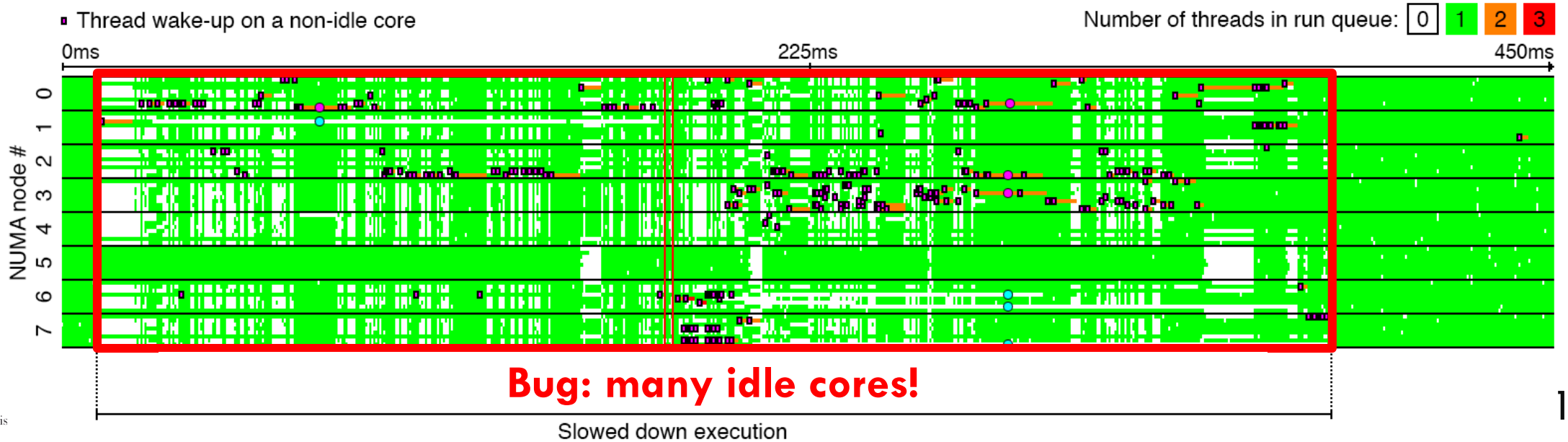

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CFS was simple...

then became complex/broken when needed to support new hardware/uses!

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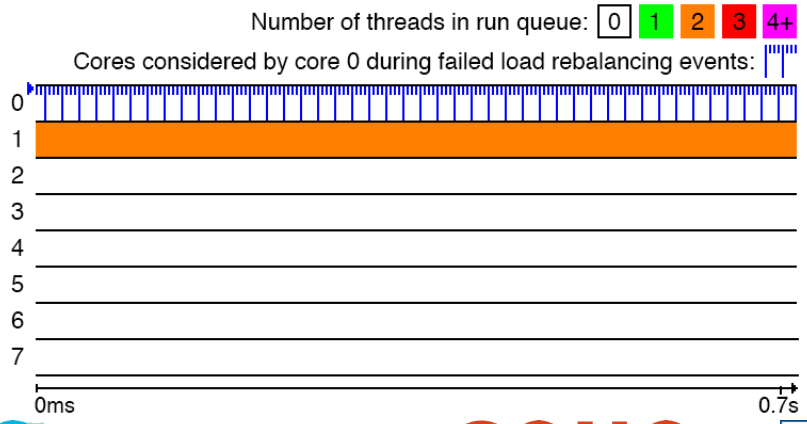

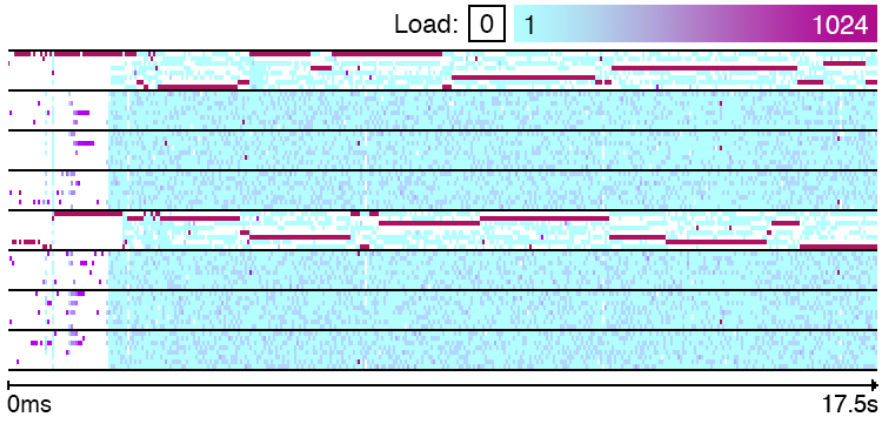

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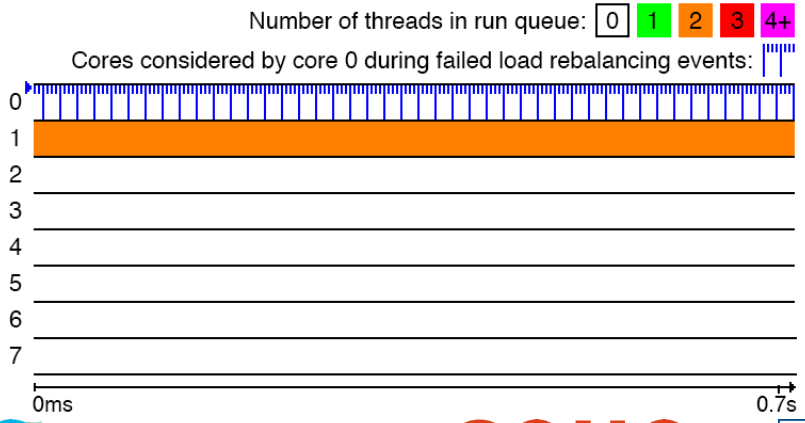

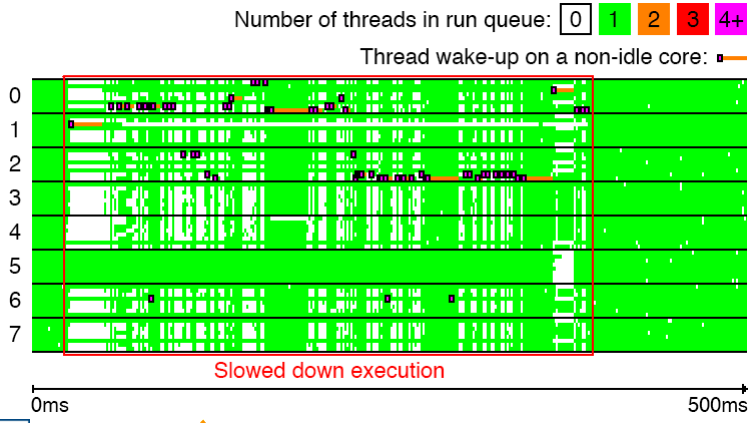

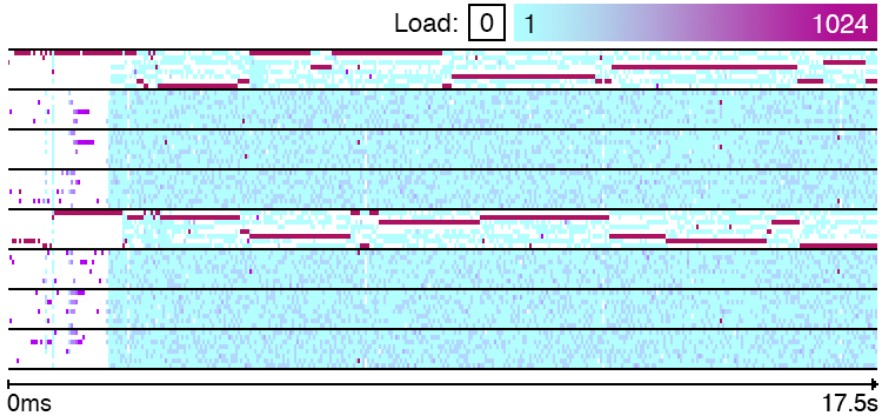

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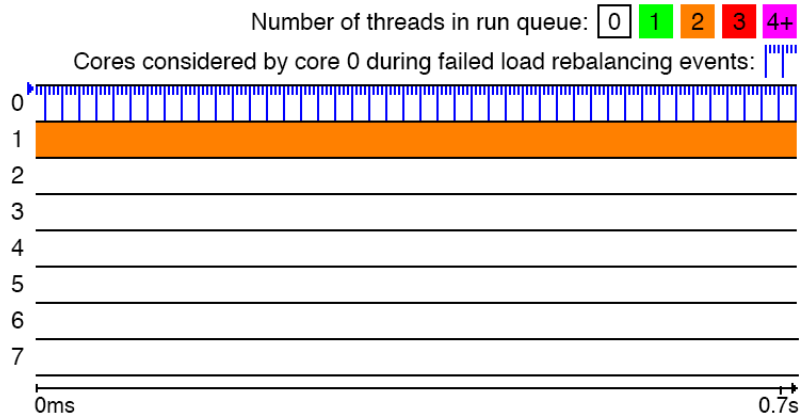

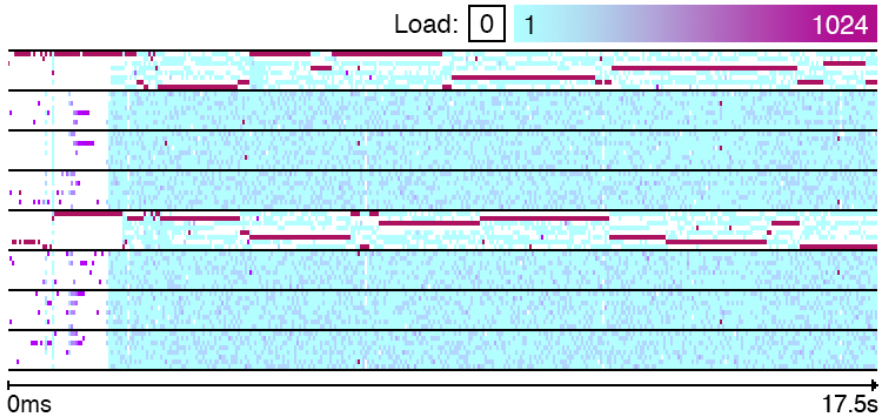

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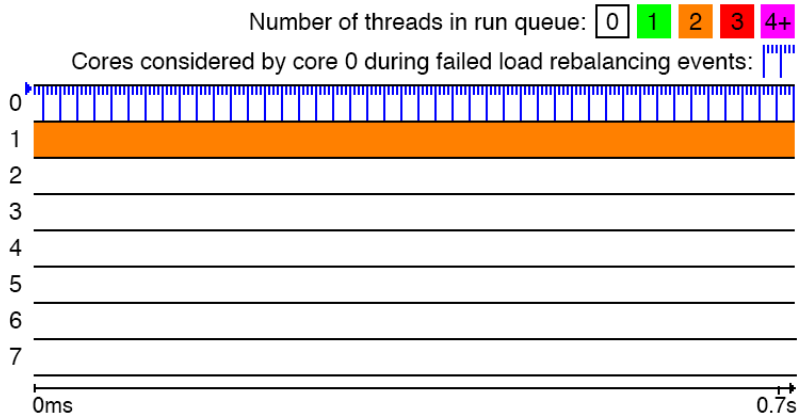

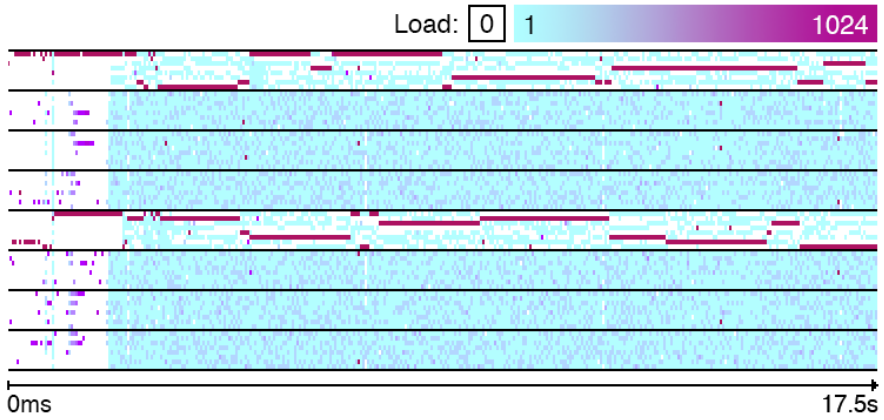

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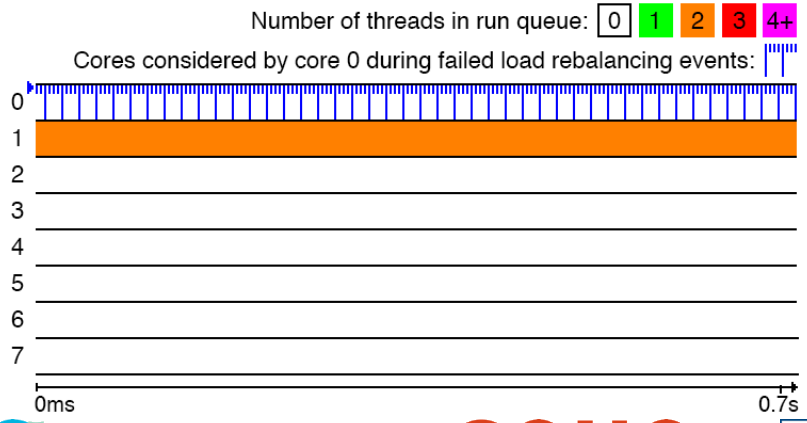

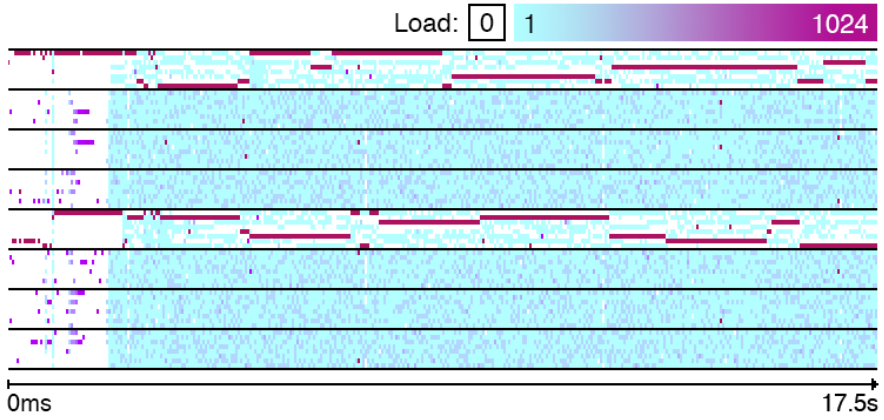

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Open problem: how do we ensure the scheduler works/evolves correctly ?

New design? New techniques involving testing/performance regression/proofs/...?

CONCLUSION

- Scheduling (as in dividing CPU cycles among theads) often thought to be a solved problem
- **Analysis:** fundamental issues (added incrementally), even basic invariant violated!
- **Proposed pragmatic detection approach (*sanity checker* + traces):** helpful
- **Proposed fixes:** not always satisfactory

Open problem: how do we ensure the scheduler works/evolves correctly ?

New design? New techniques involving testing/performance regression/proofs/...?

Your next paper ☺