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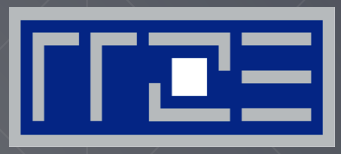

MPI+X Programming Models on Future Systems – the Search for Lowest-Order Effects

Georg Hager
Erlangen Regional Computing Center (RRZE)

Programming Models on the Road to Exascale
ISC High Performance 2015
July 13, 2015, Frankfurt, Germany

Outline

- Resource-aware software engineering
  - Hardware bottlenecks
  - What we need and what we get – resource balance (Kung)
  - Lowest-order thinking (excavator aerodynamics)
- MPI+X programming models
  - X = {}, threading, accelerator
  - Opportunities for addressing the lowest order
  - How to find the lowest order?

Resource-aware software engineering

Resources are means to an end

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Computation

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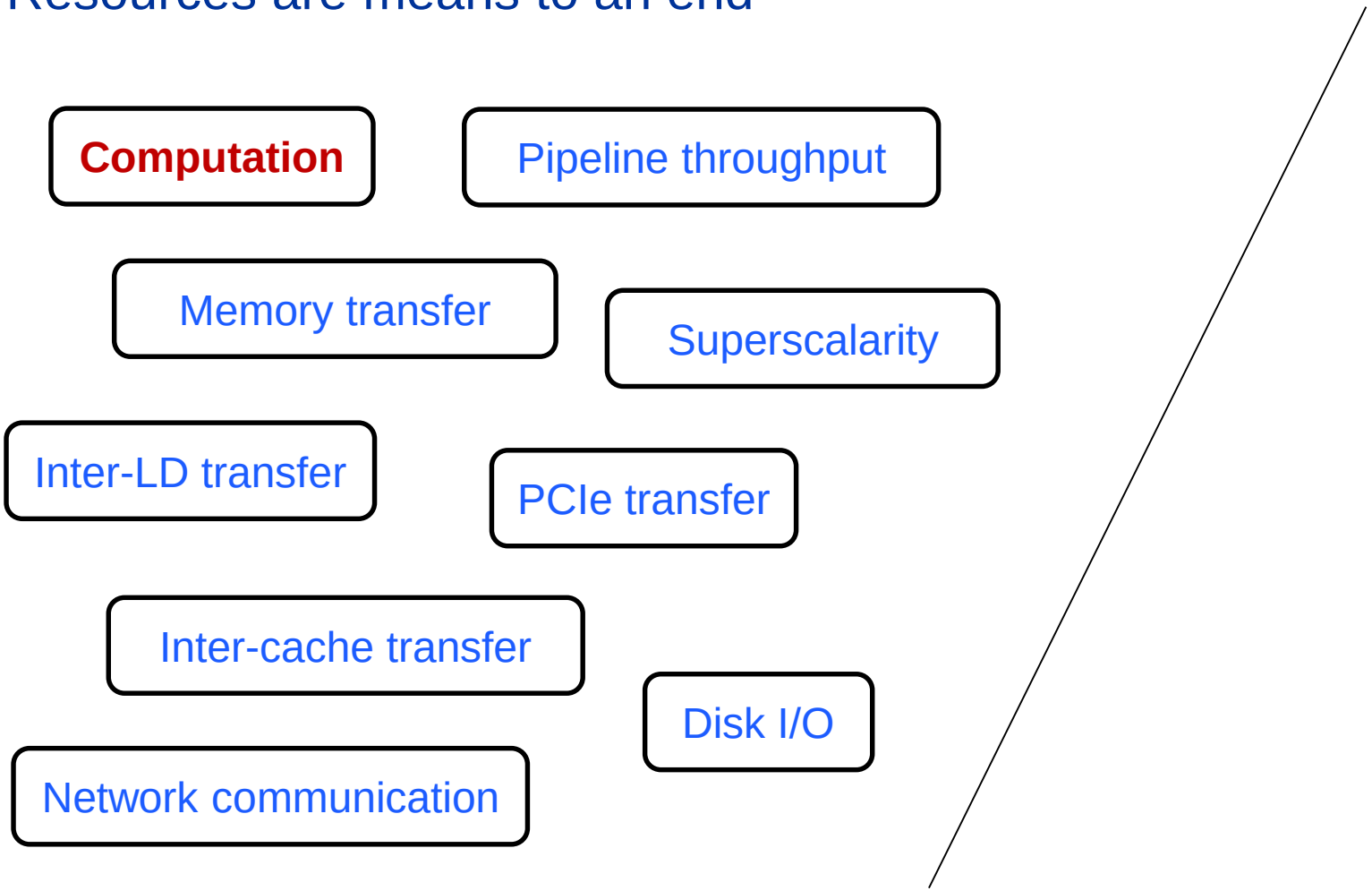

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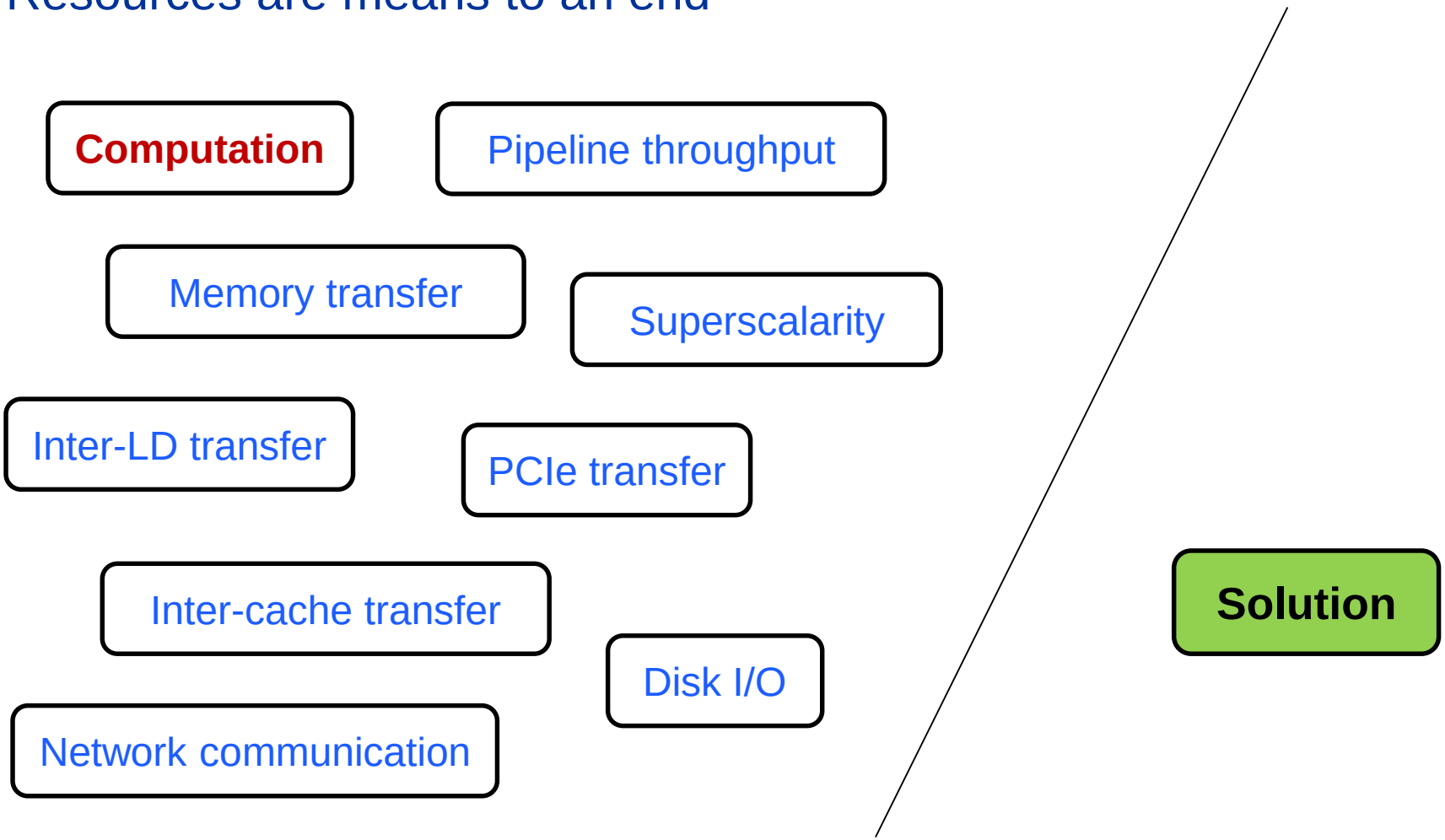
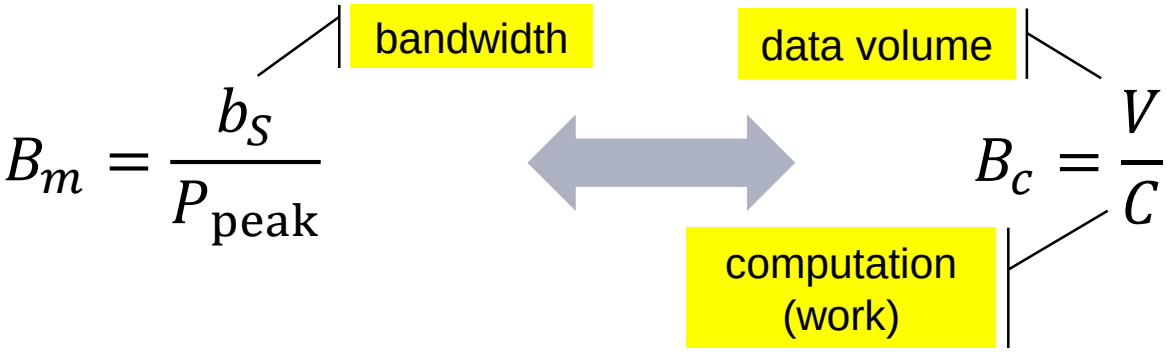


Resource balance: what we need and what we get

Initial idea: code balance vs. machine balance



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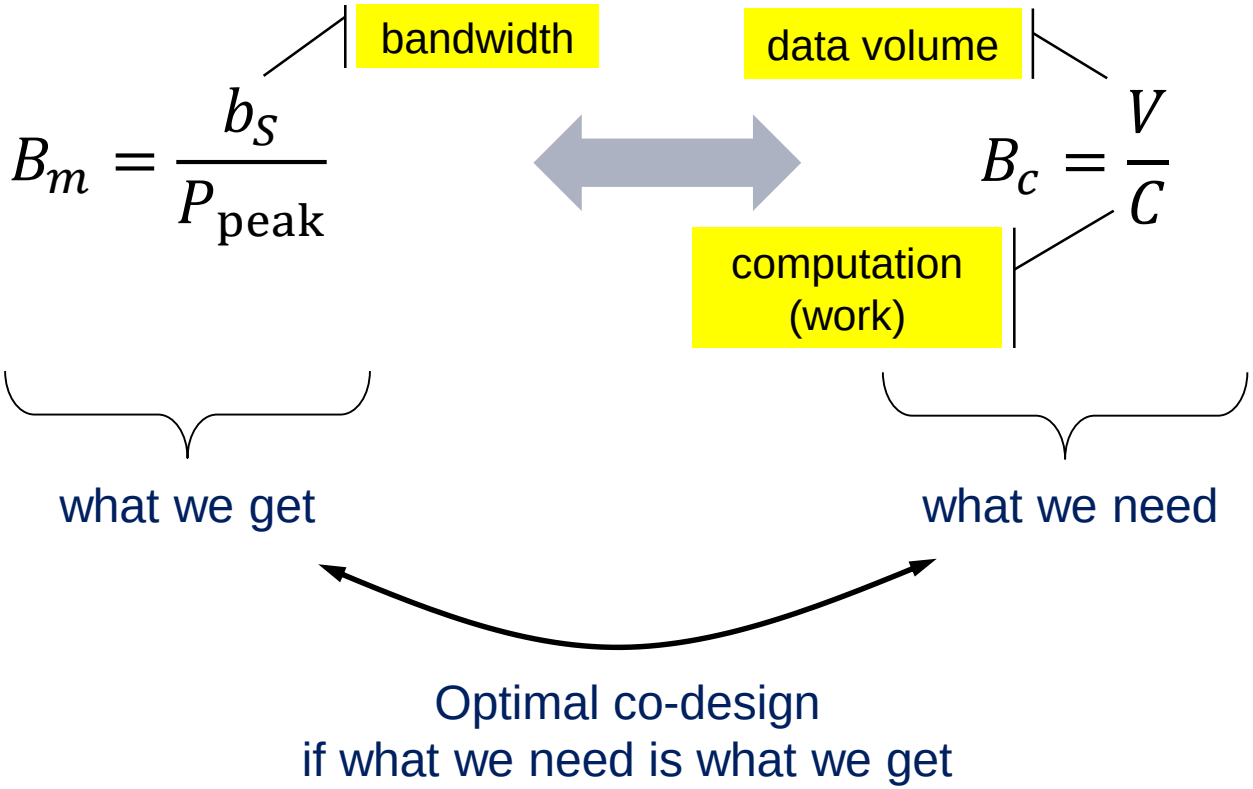
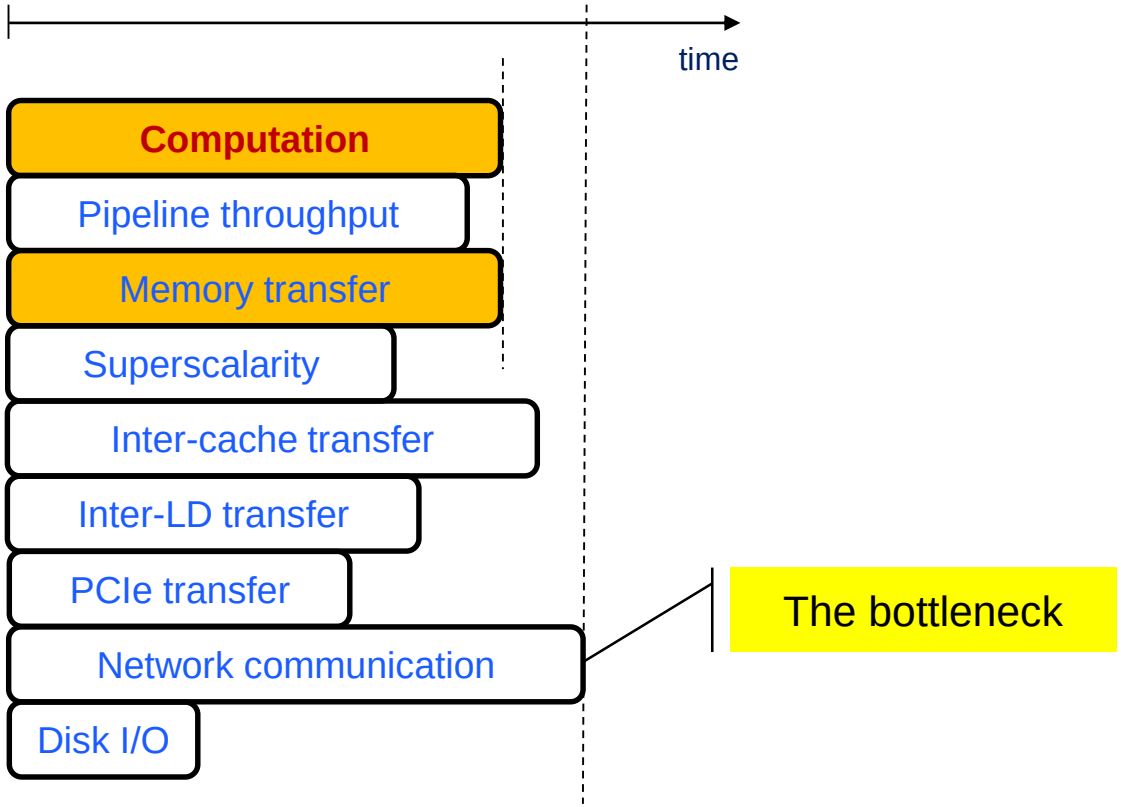


H.T. Kung: Memory requirements for balanced computer architectures. Proc. ISCA'86, DOI: 10.1145/17356.17362

Generalization of the balance concept: Lowest order

Limited resources impose upper (lower) performance (runtime) limits



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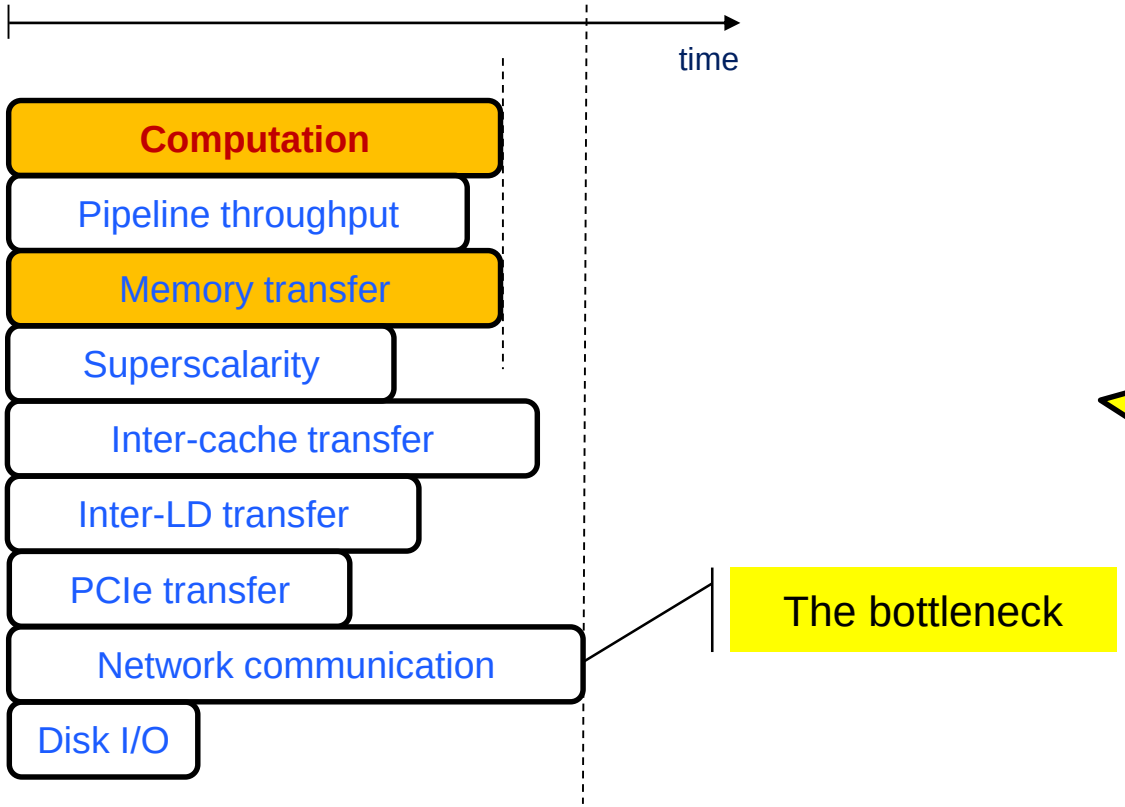
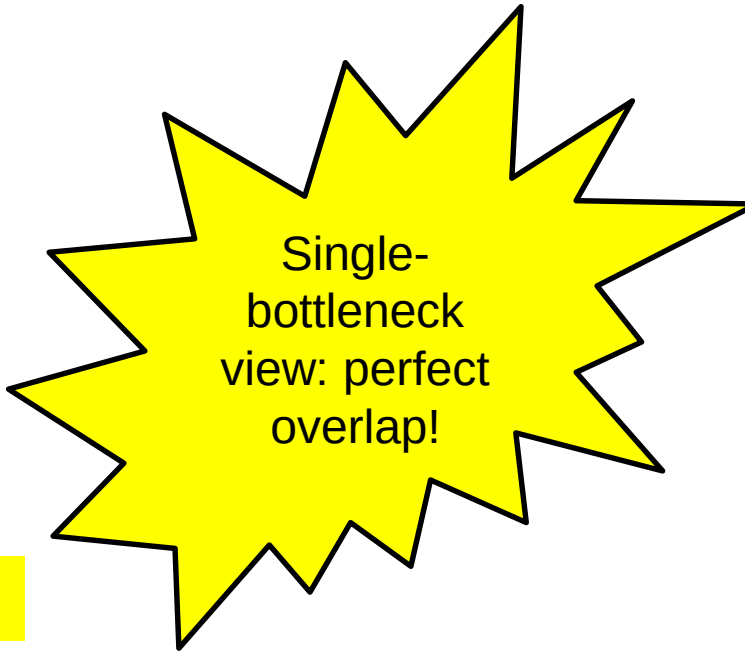


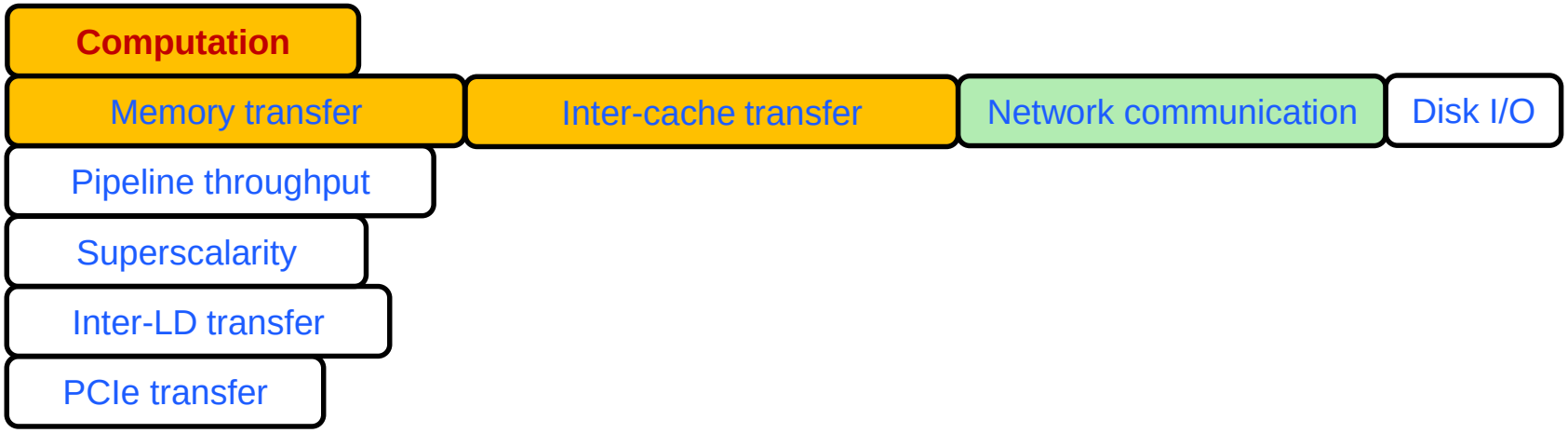


Callahan, Cocke, Kennedy (1988), DOI: 10.1016/0743-7315(88)90002-0

Williams, Waterman, Patterson (2009), DOI: 10.1145/1498765.1498785

Reality: Next to lowest order

Simple balance picture does not hold due to non-overlap



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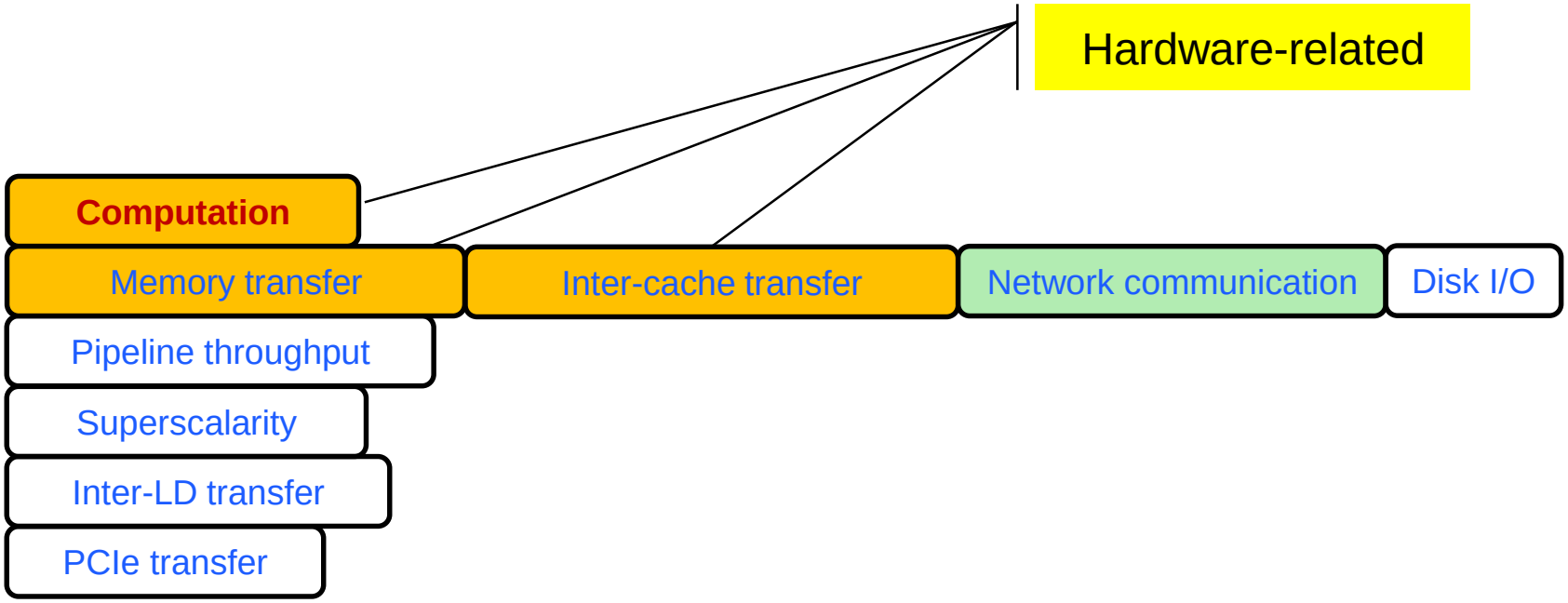

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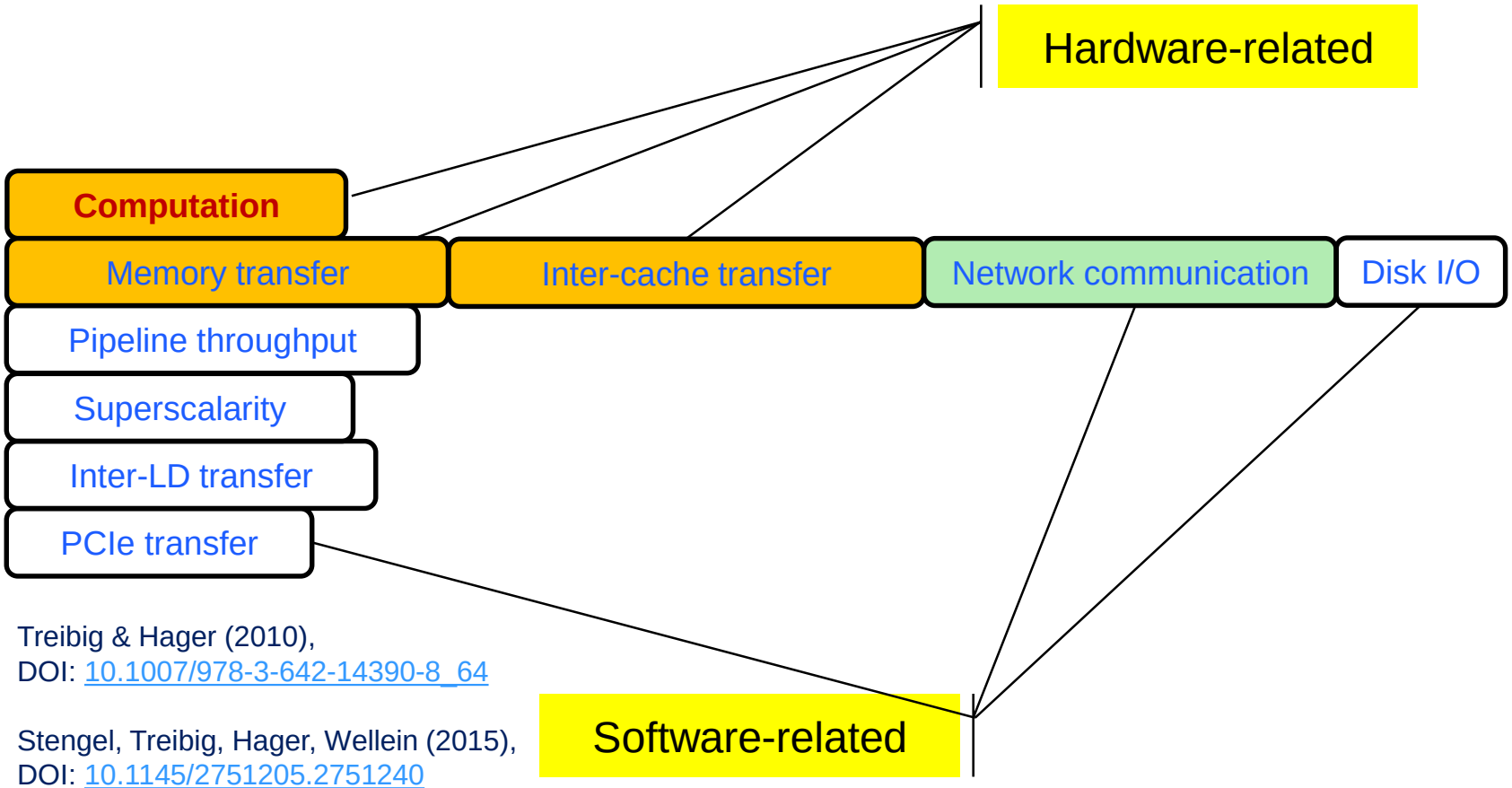

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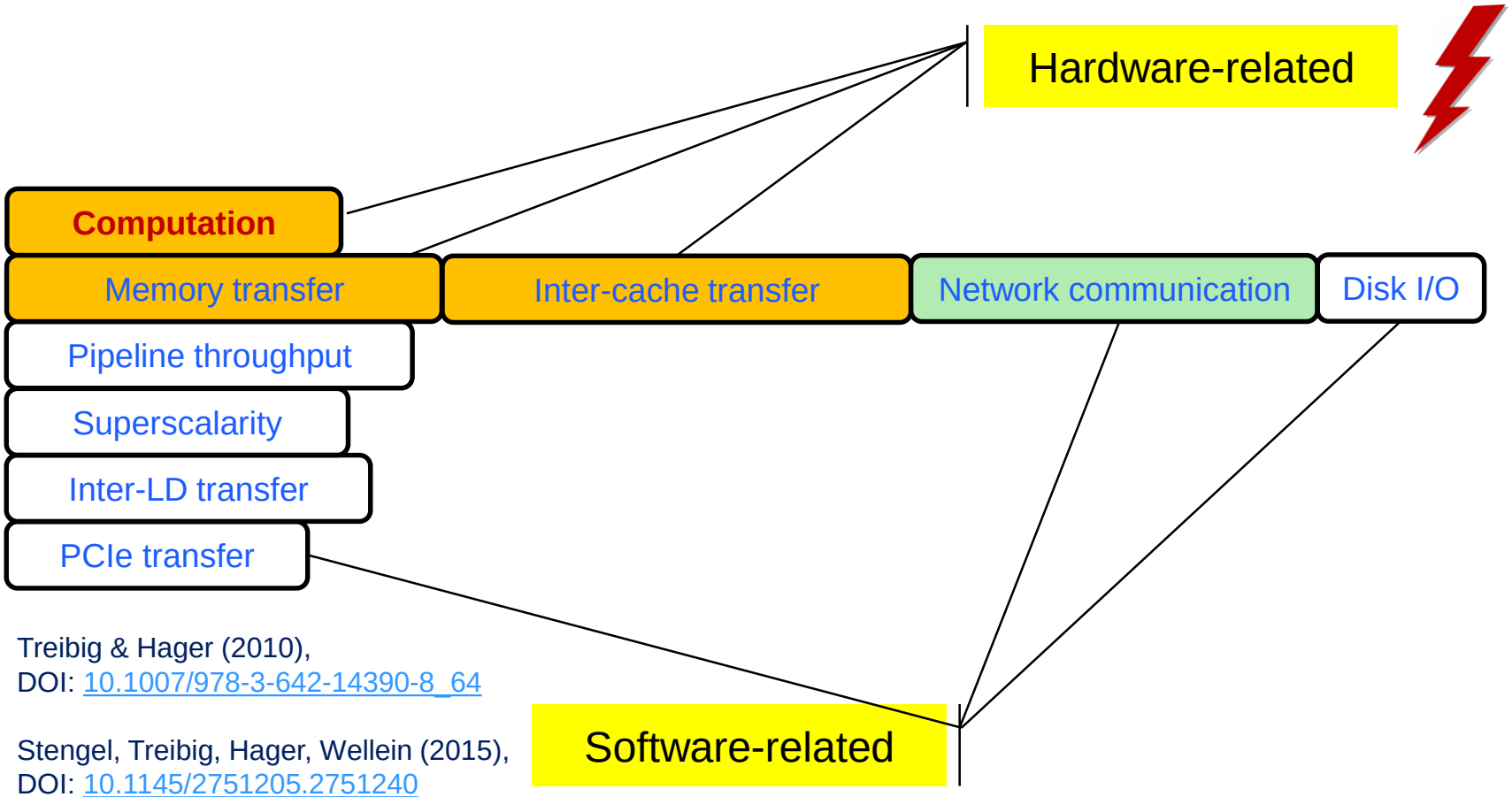

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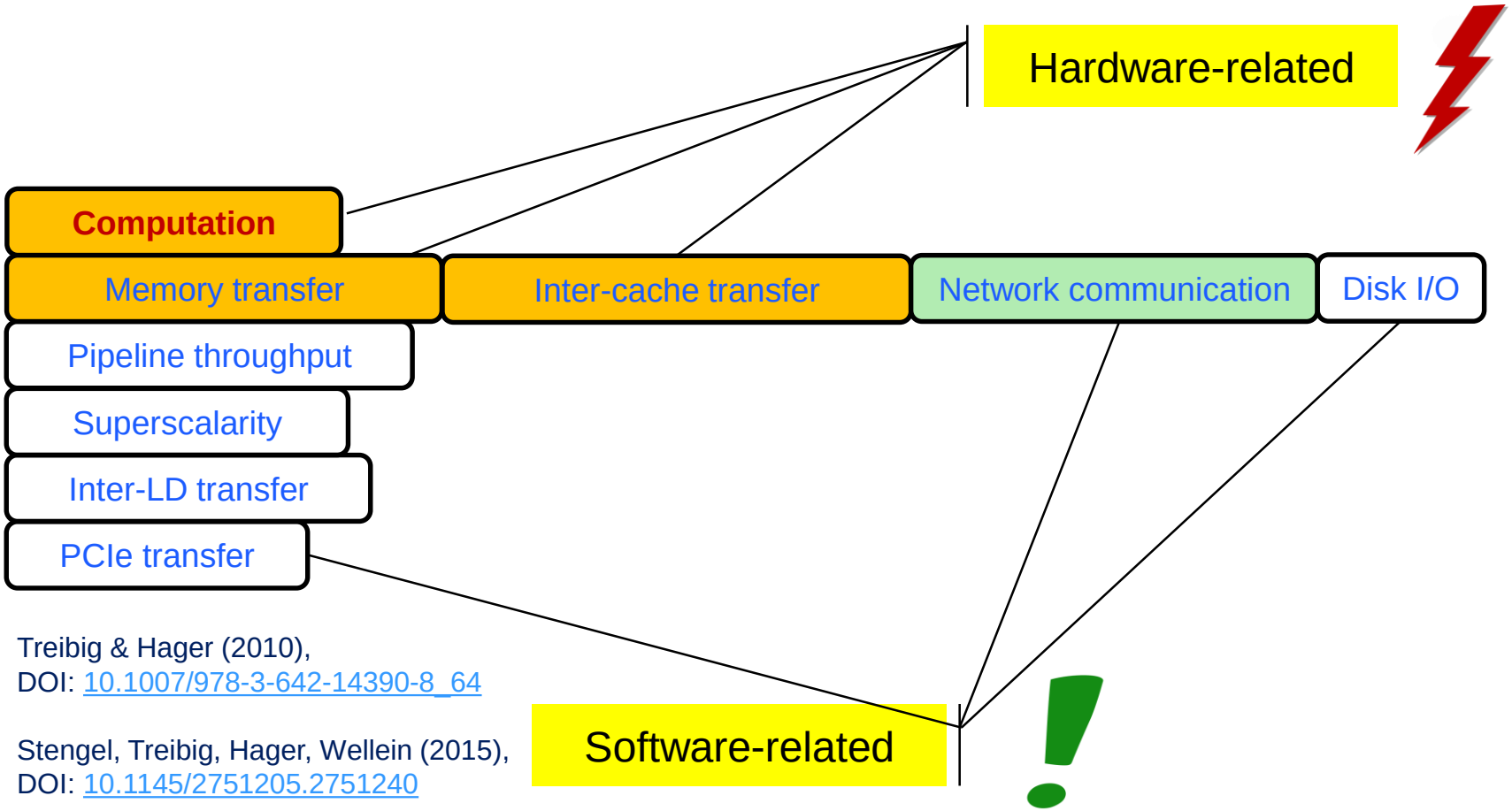

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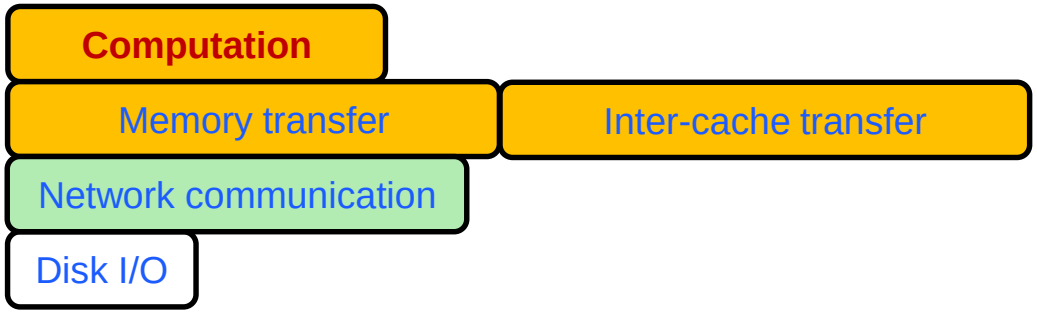

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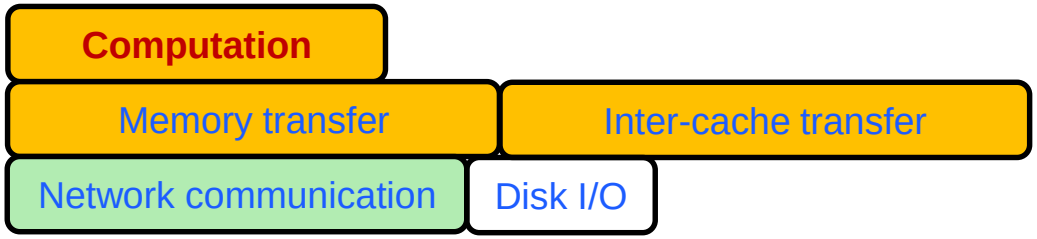

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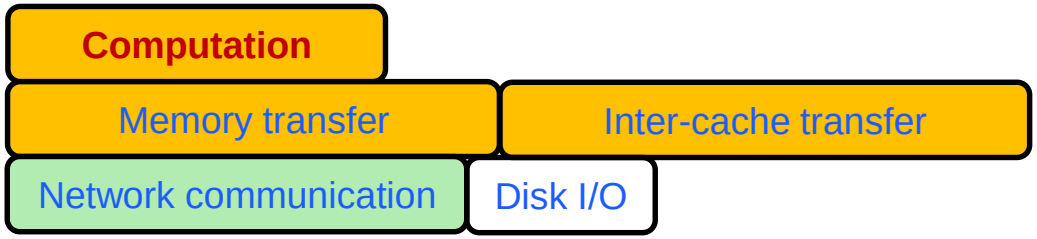

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Resource optimization ==

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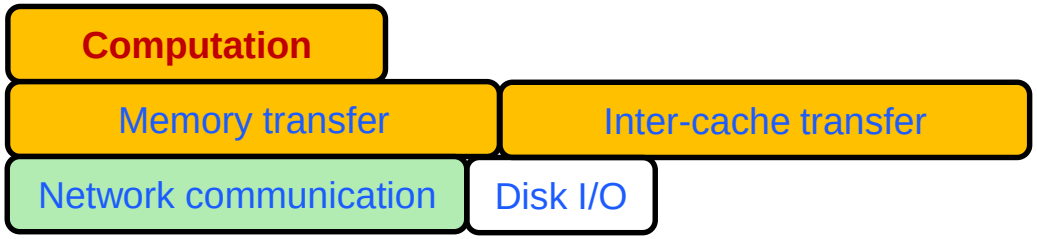

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Resource optimization == **exposing the lowest-order bottleneck**

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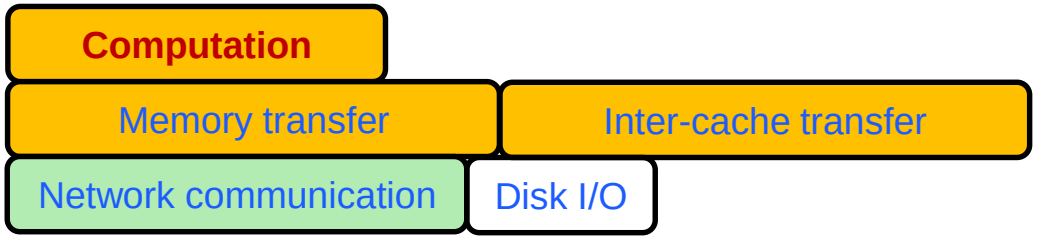

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Resource optimization ==
- **exposing the lowest-order bottleneck**
- **reducing the impact of the bottleneck**

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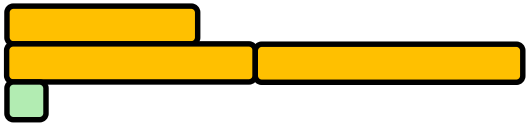

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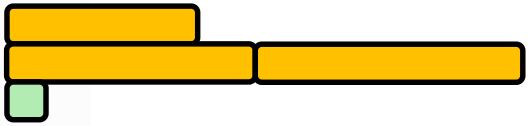

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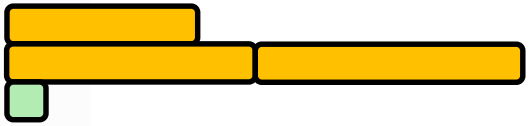

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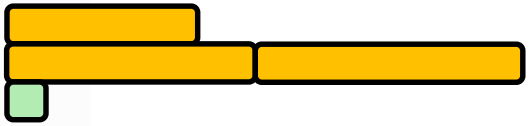

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?

… even if your programming model allows it!

Now what about the X?

X =

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X = { }

OpenMP, TBB, OmpSs, pthreads, Cilk(+)

CUDA, OpenCL

OpenACC, OpenMP4

tiny.cc/GHOST

some-library-that-does-the-trick

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GHOST for expressing asynchronicity and enforcing resource affínity

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How do you know what the lowest order is?

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  - Roofline model, ECM model, LogP model, …

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  - Roofline model, ECM model, LogP model, …
  - Performance patterns (Treibig Hager, Wellein (2012), DOI: 10.1007/978-3-642-36949-0_50)

    Visit our ISC15 workshop
    Performance Modeling: Methods & Applications
    (Marriott, Room Gold 1+2)

Take-home messages

- If it does the trick, it is a candidate
  - The trick being the full utilization of a bottleneck
- If it does the trick better than anything else, it may be worth serious consideration
- If it is sustainable, take it.
- What is the trick?

  → A performance model will probably guide you!

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Thank You.