ExecuTorch on Small Bare-Metal Microcontrollers

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Pietra Ferreira
William Jones
Jeremy Bennett

The Cost of AI

50

The Cost of AI

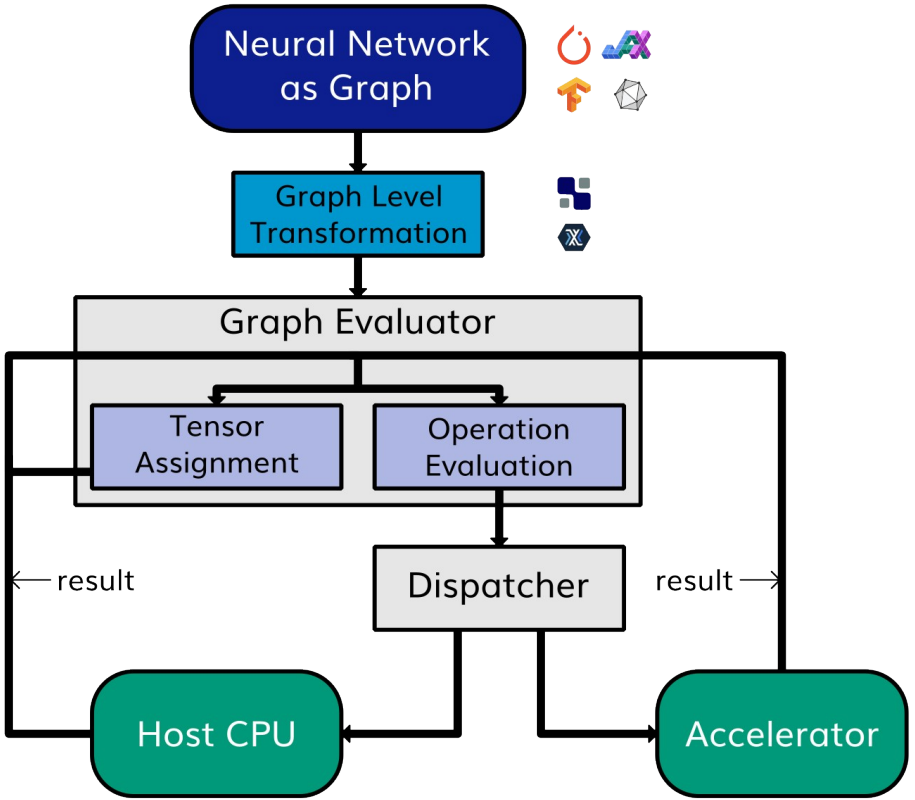
50 0.03

The Cost of AI

50 0.03 10-100+

Building AI at the Edge

What are PyTorch and ExecuTorch?



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PyTorch

- Generic ML framework
- Python based
- Open source

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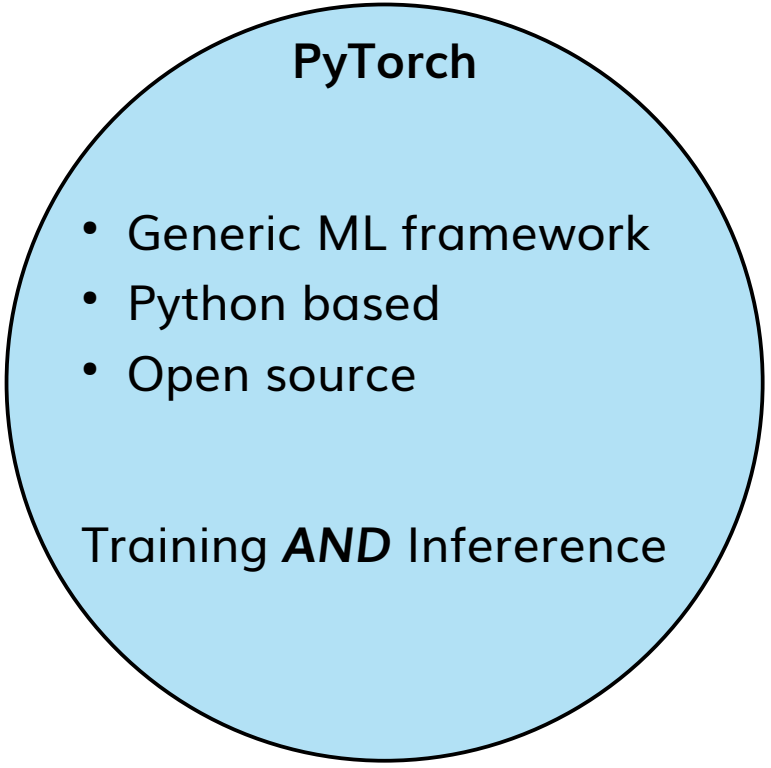

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Training ***AND*** Infererence

ExecuTorch

- PyTorch extension
- Resource limited

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Infererence ***ONLY***

Two Steps to ExecuTorch Development

1. Build ExecuTorch

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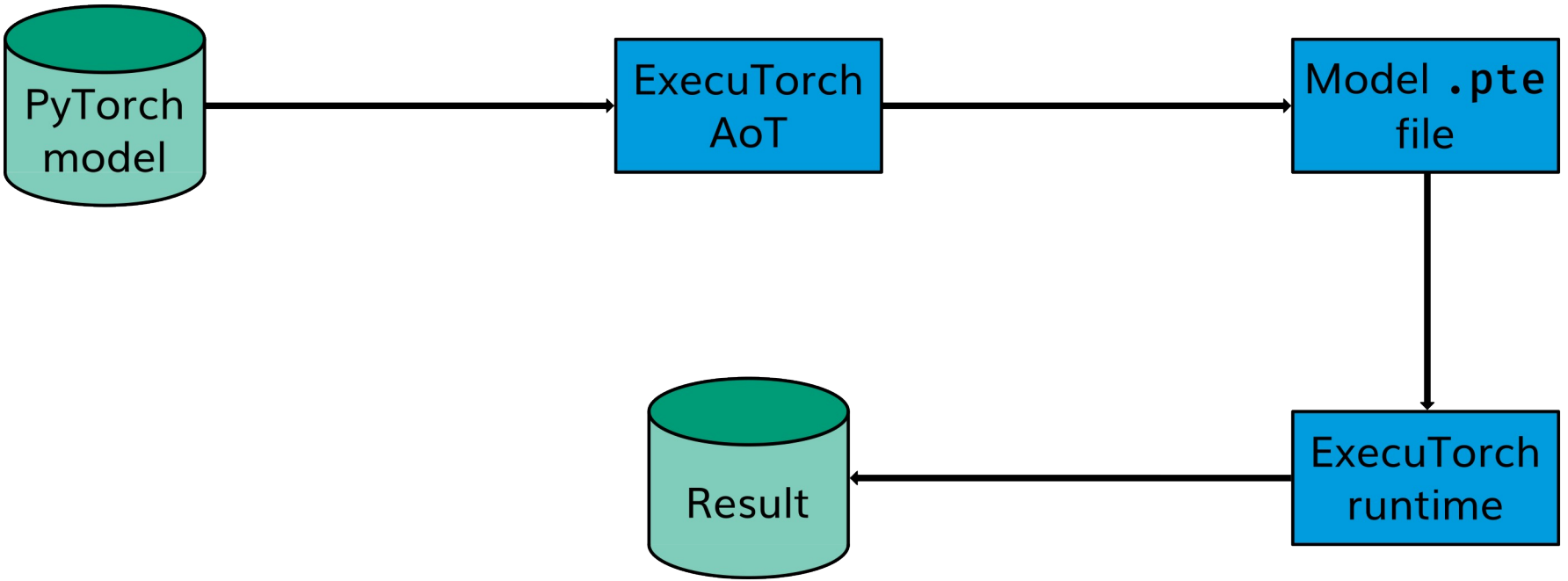
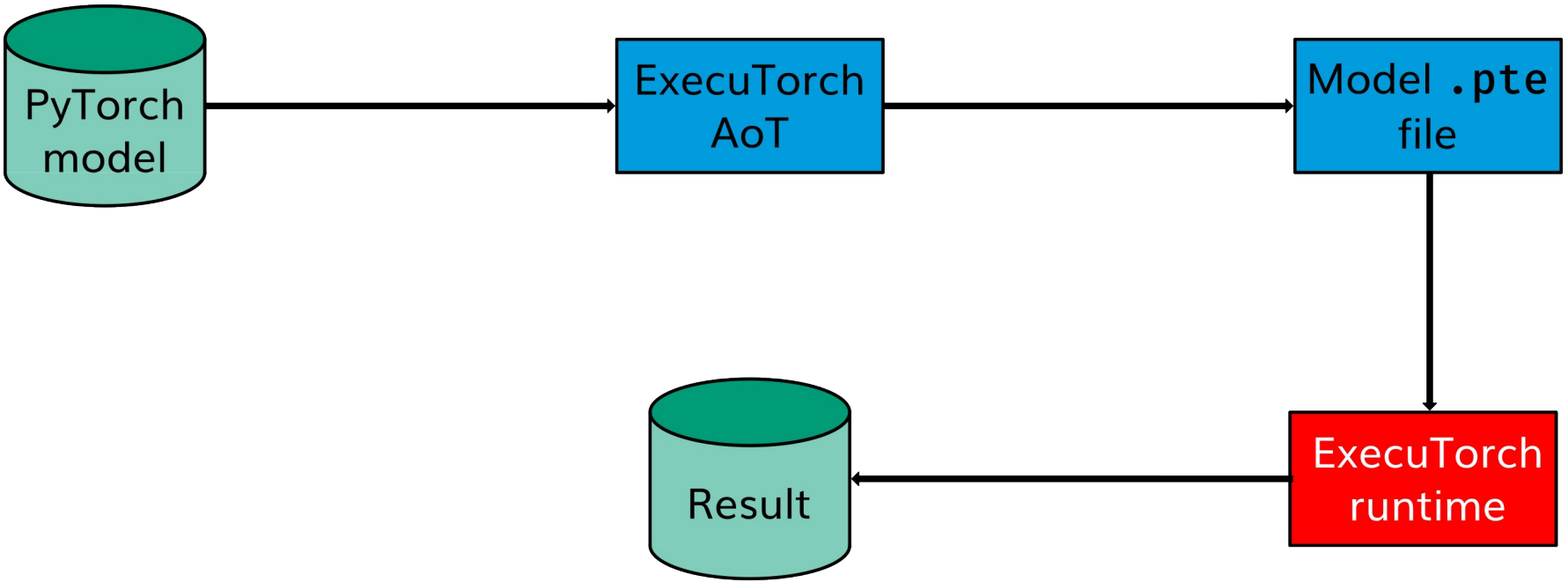
2. Customize Performance

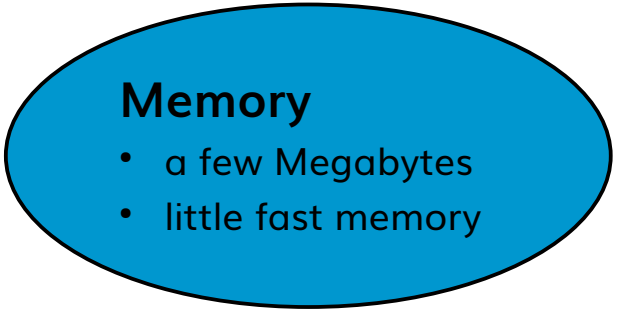
Building With ExecuTorch



Building With ExecuTorch



Our Experience: A RISC-V Platform



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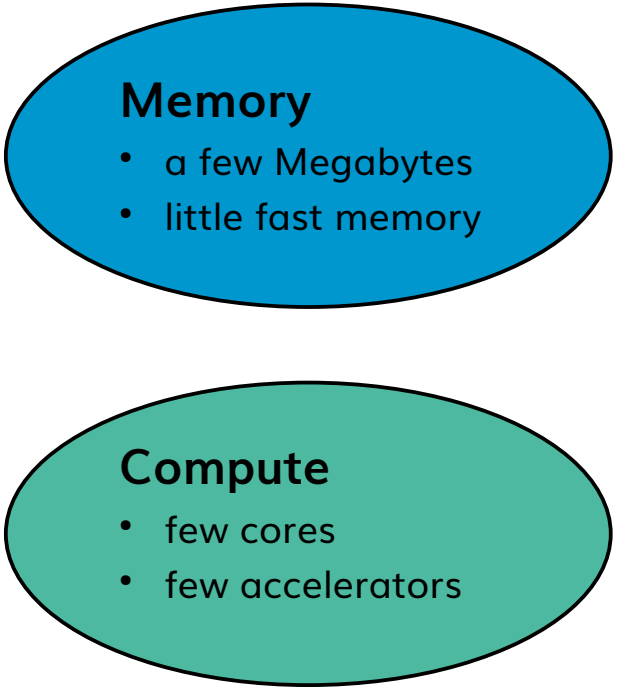

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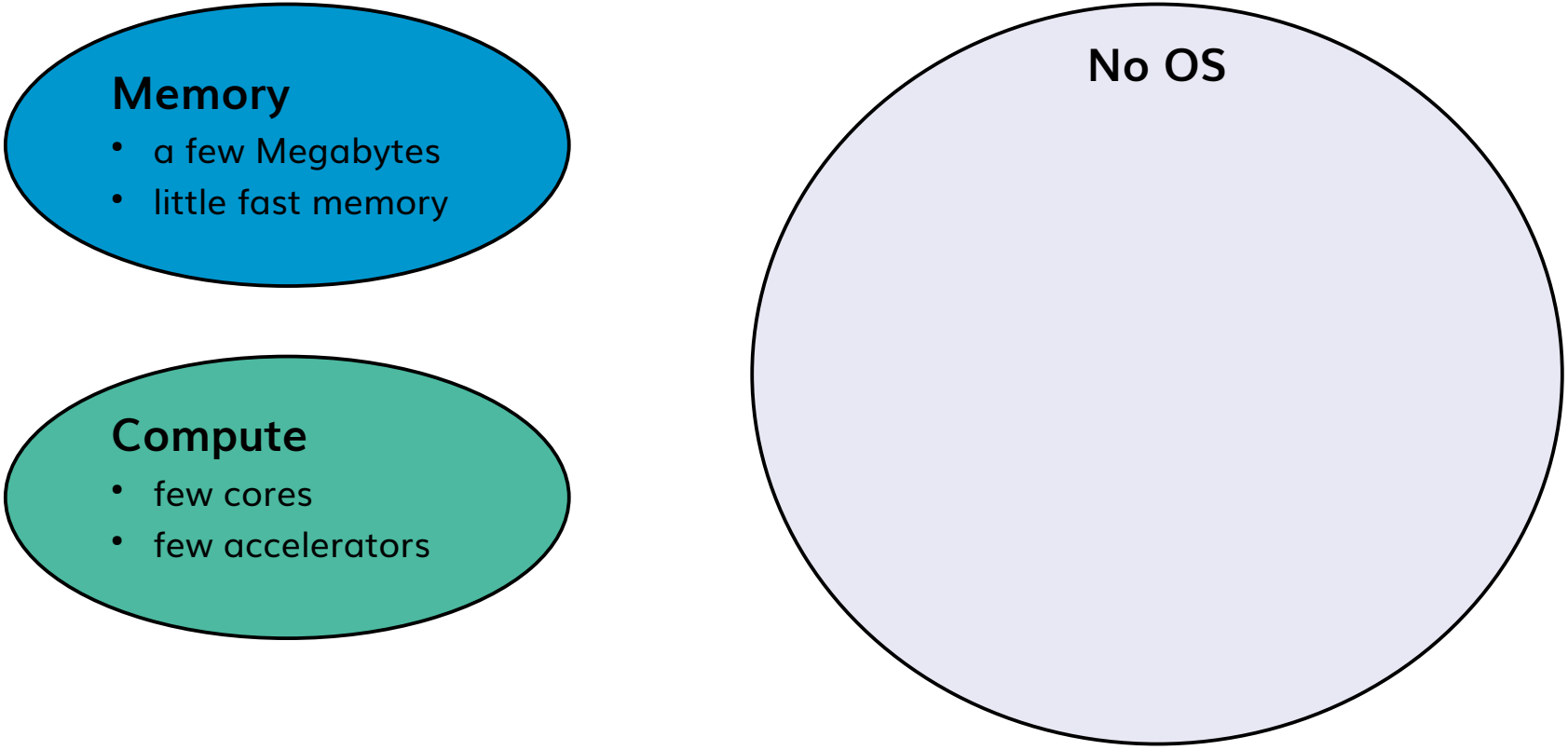

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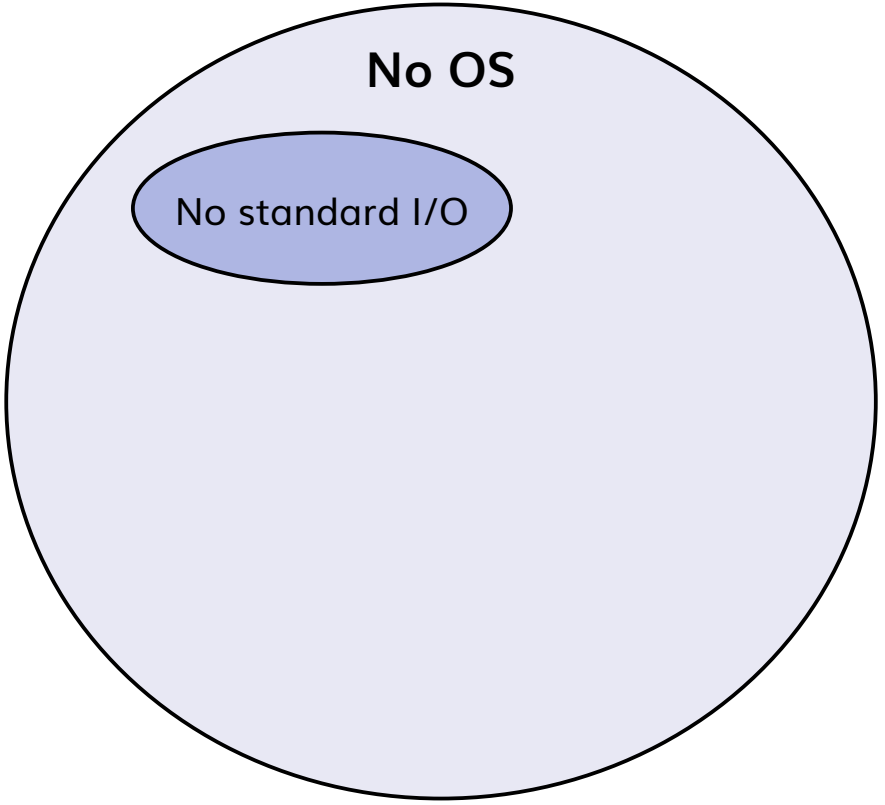
Memory
- a few Megabytes
- little fast memory

Compute
- few cores
- few accelerators



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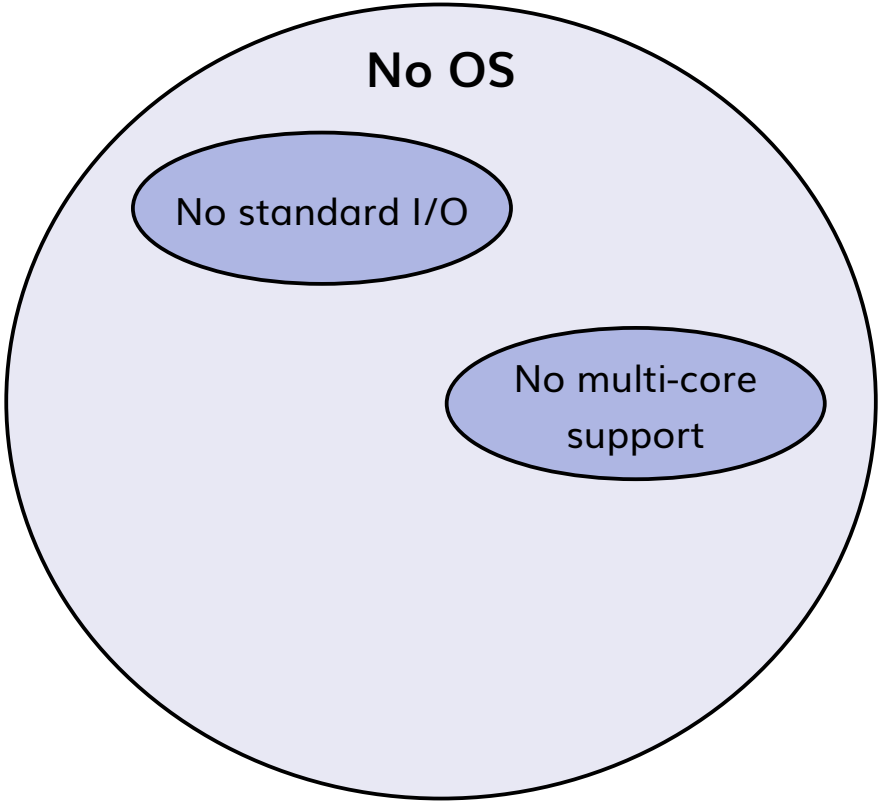

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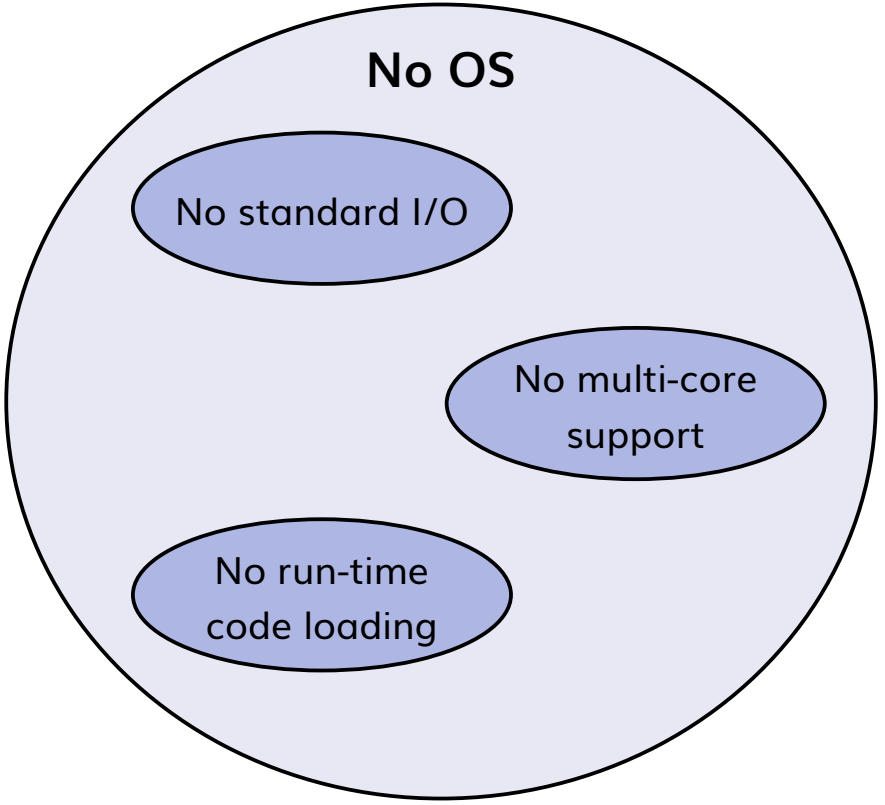

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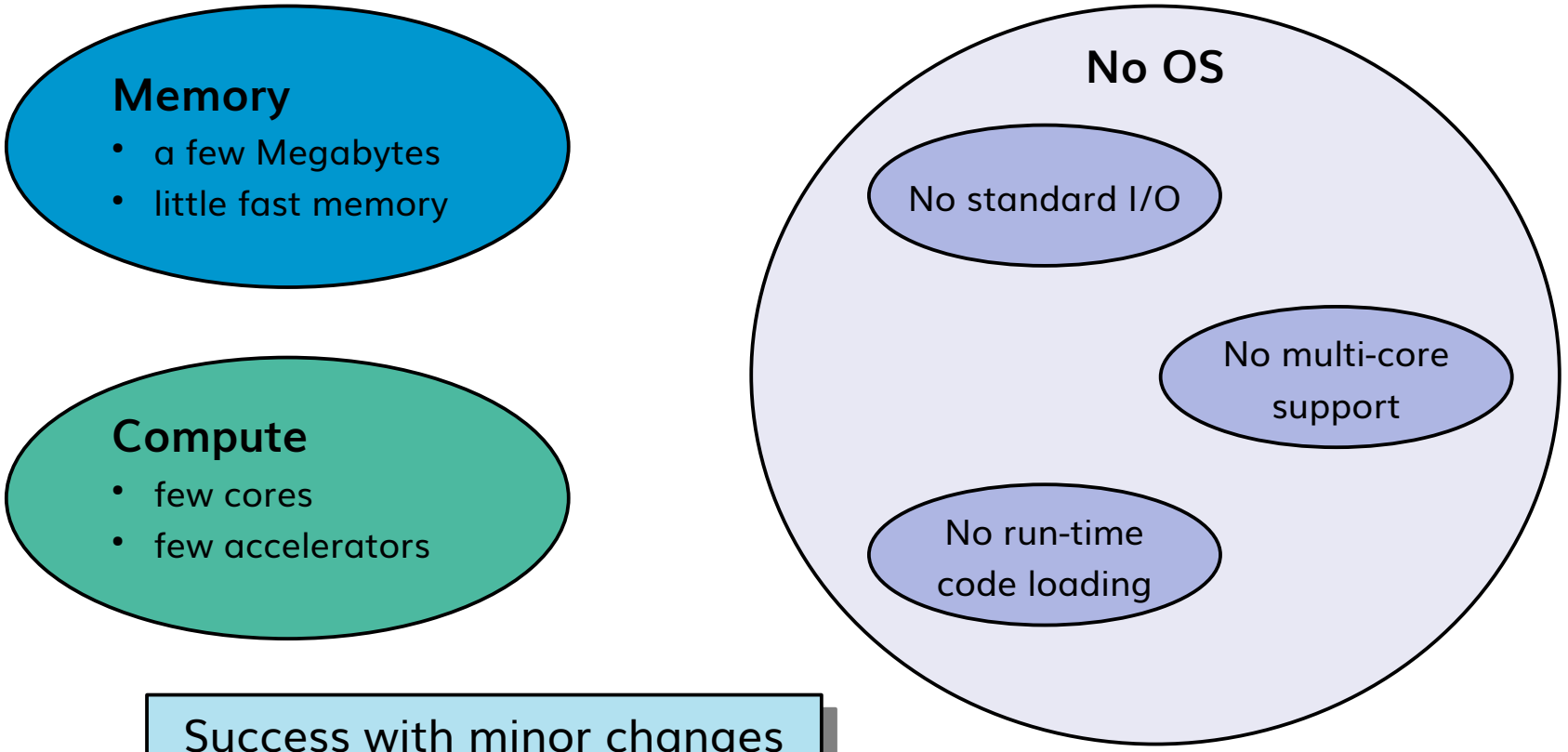
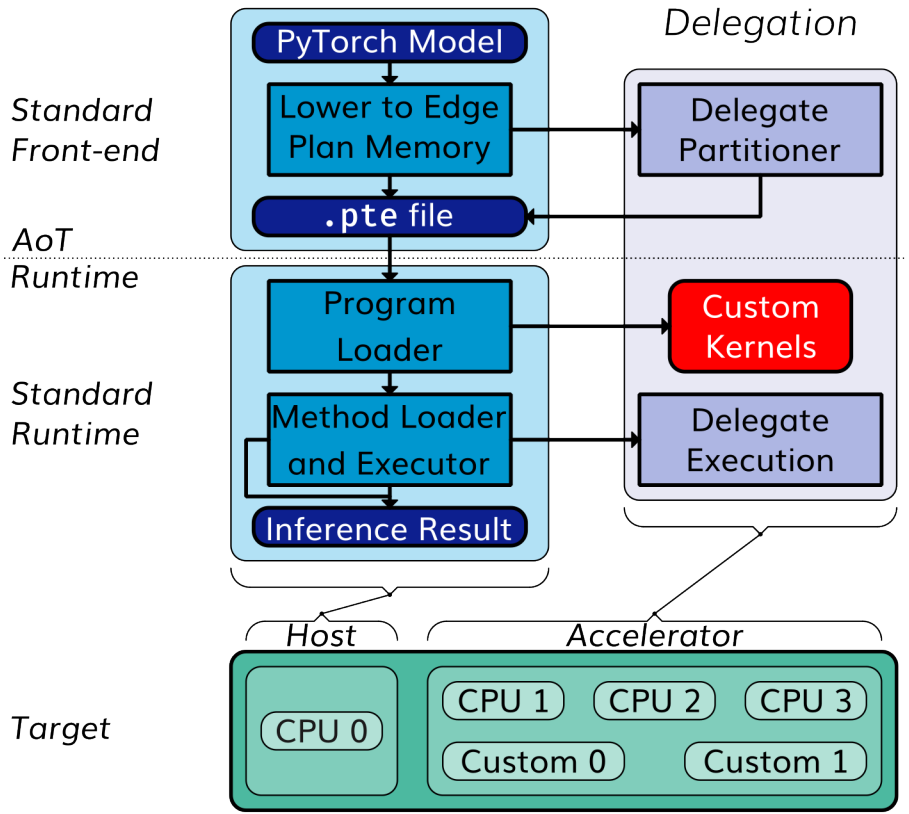


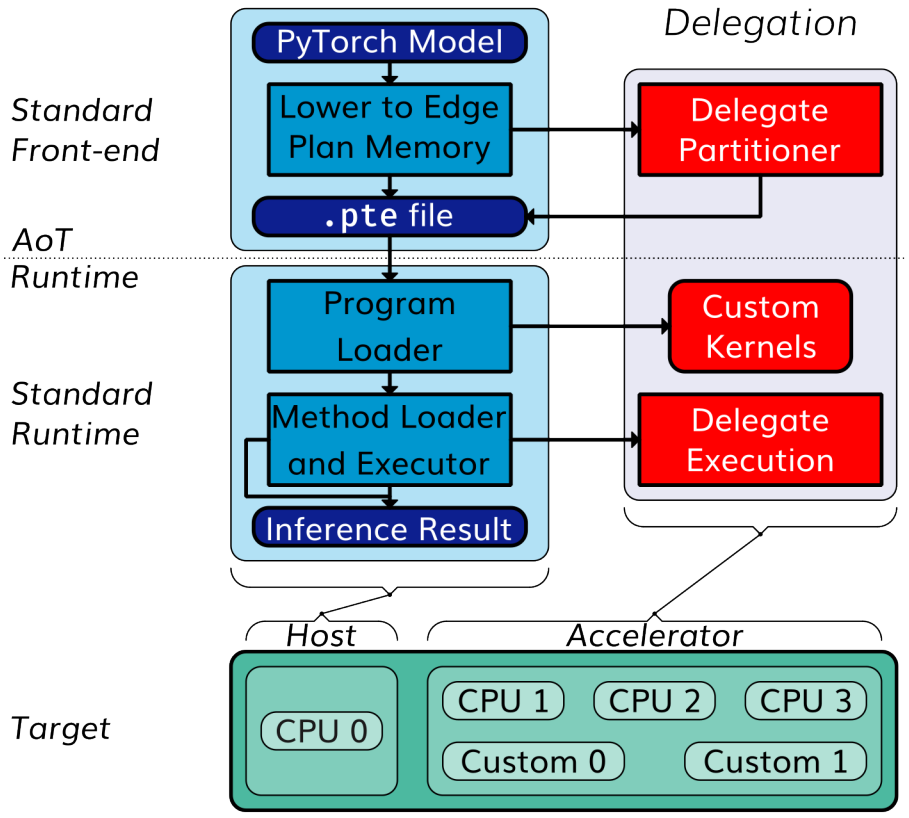
Success with minor changes

Customize Performance



Existing functions

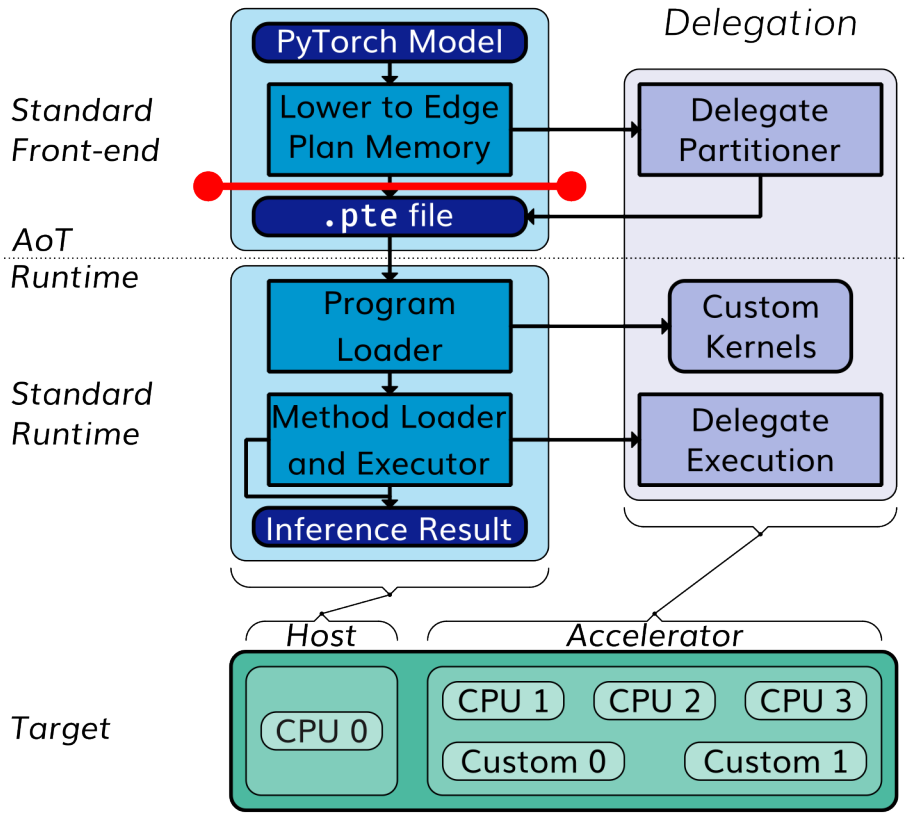
Customize Performance



Existing functions

New capabilities

Customize Performance



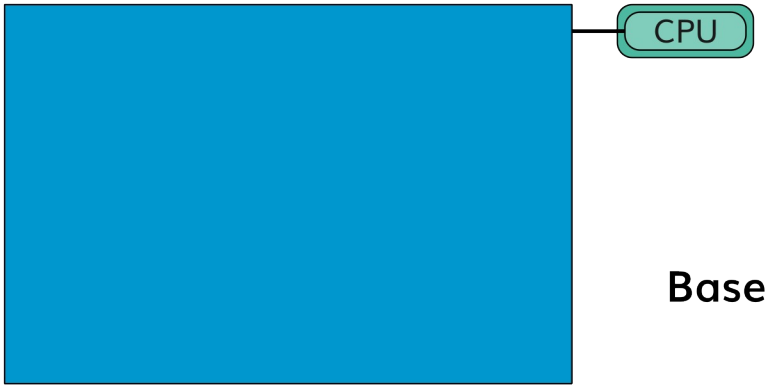
Existing functions

New capabilities

Graph level optimization

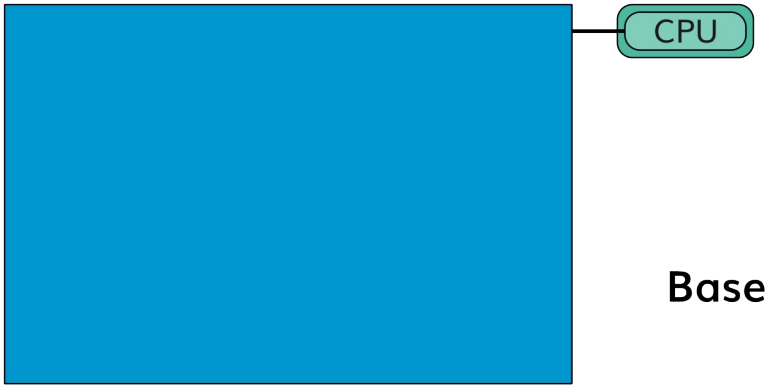
Case Study: A RISC-V Processor with Custom NPU

Optimization Strategies



Baseline

Optimization Strategies



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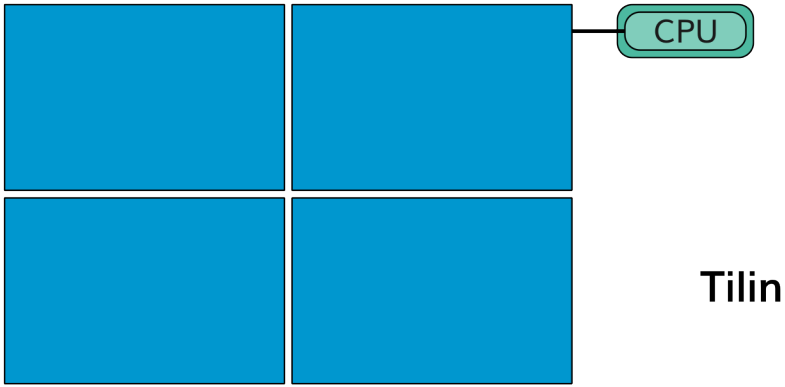
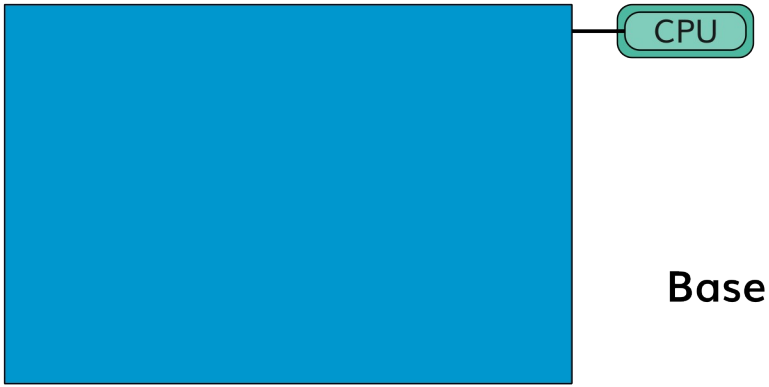


Tiling

Optimization Strategies



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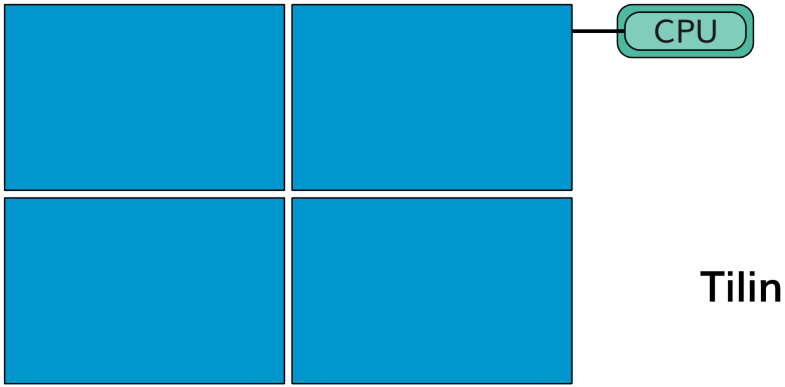

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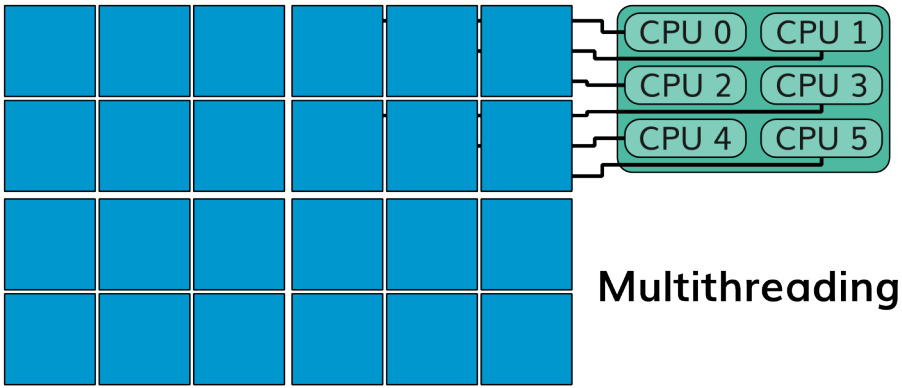
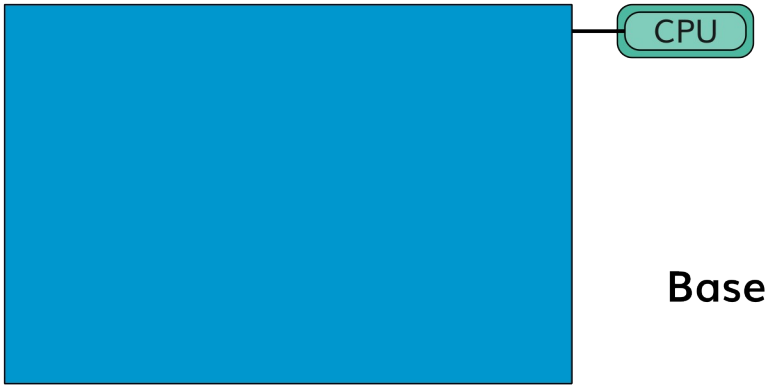


Multithreading

Optimization Strategies



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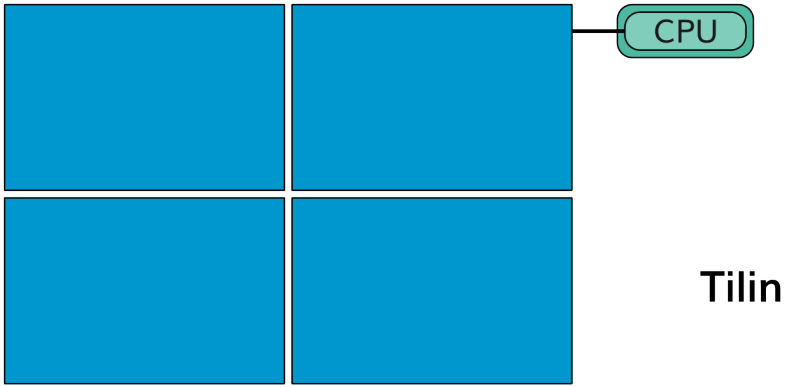

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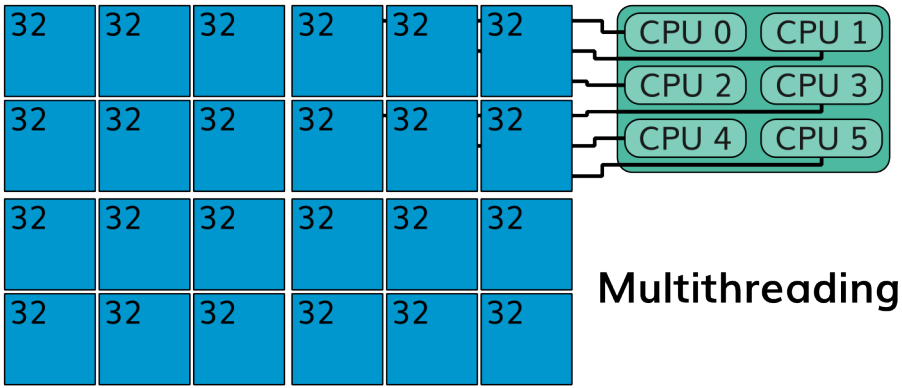

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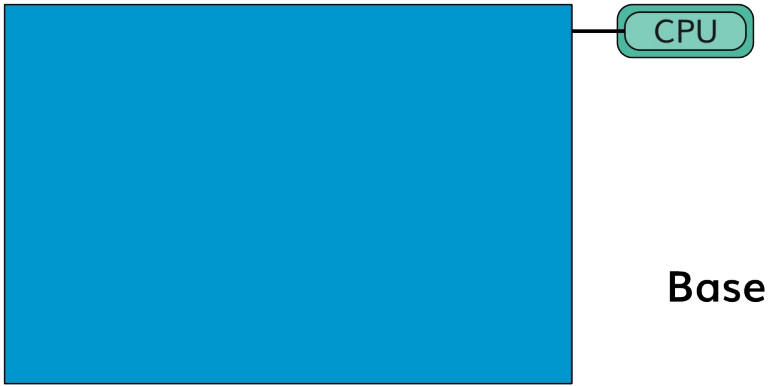

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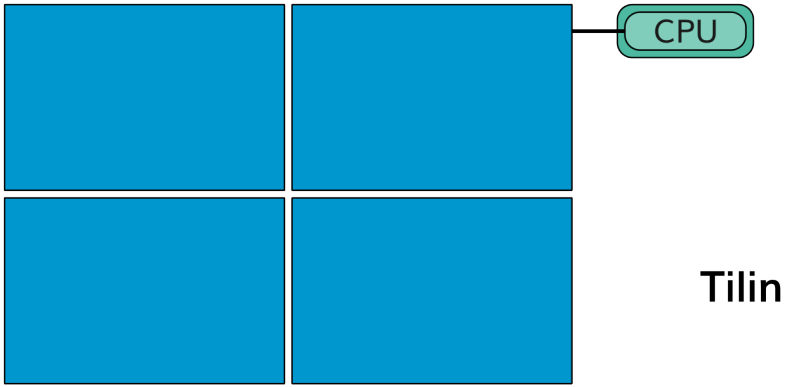

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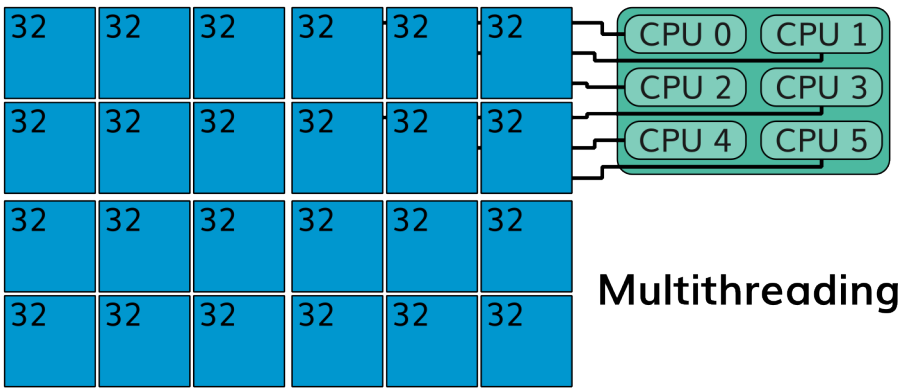

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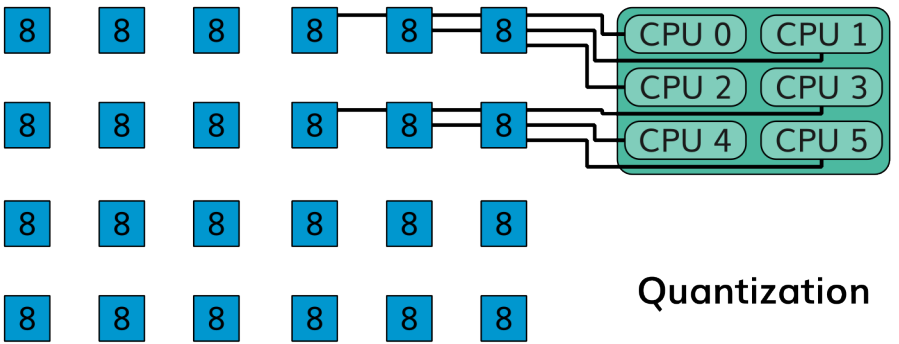
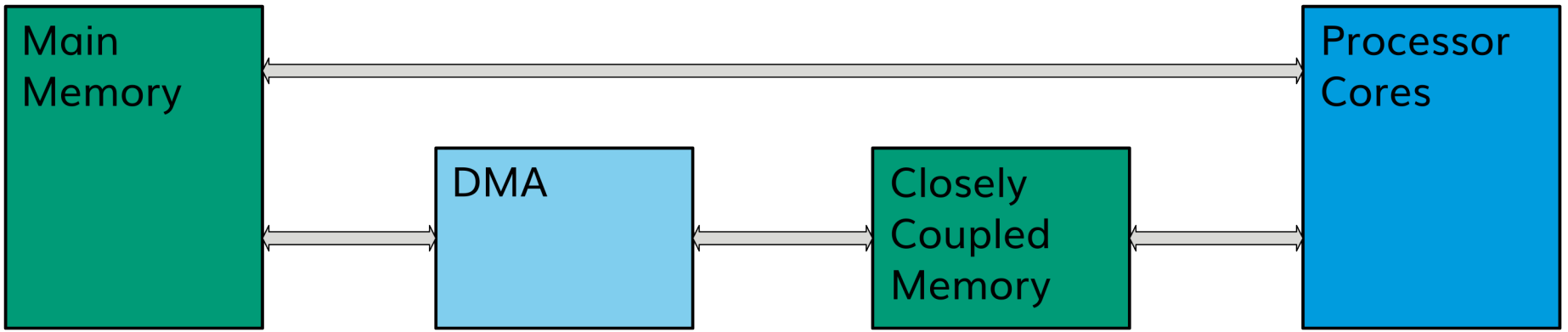


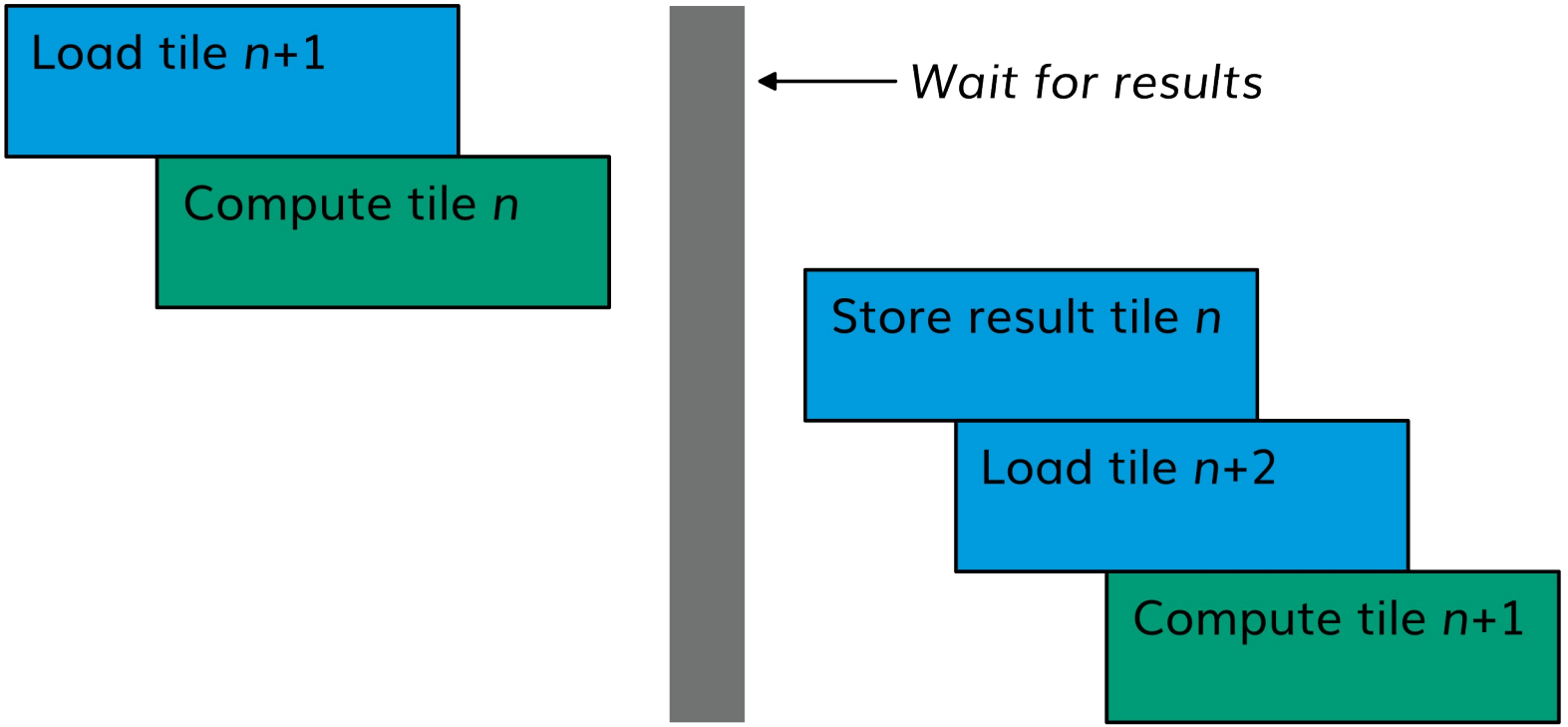
Quantization

Optimization in Depth: Memory



- Cache frequently used data
  - e.g. initial layers
- Break data into “tiles”
  - e.g. sub-areas of images
- Algorithms are predictable
  - regular loops
  - pre-fetch data
  - e.g. image convolution

Optimization in Depth: DMA



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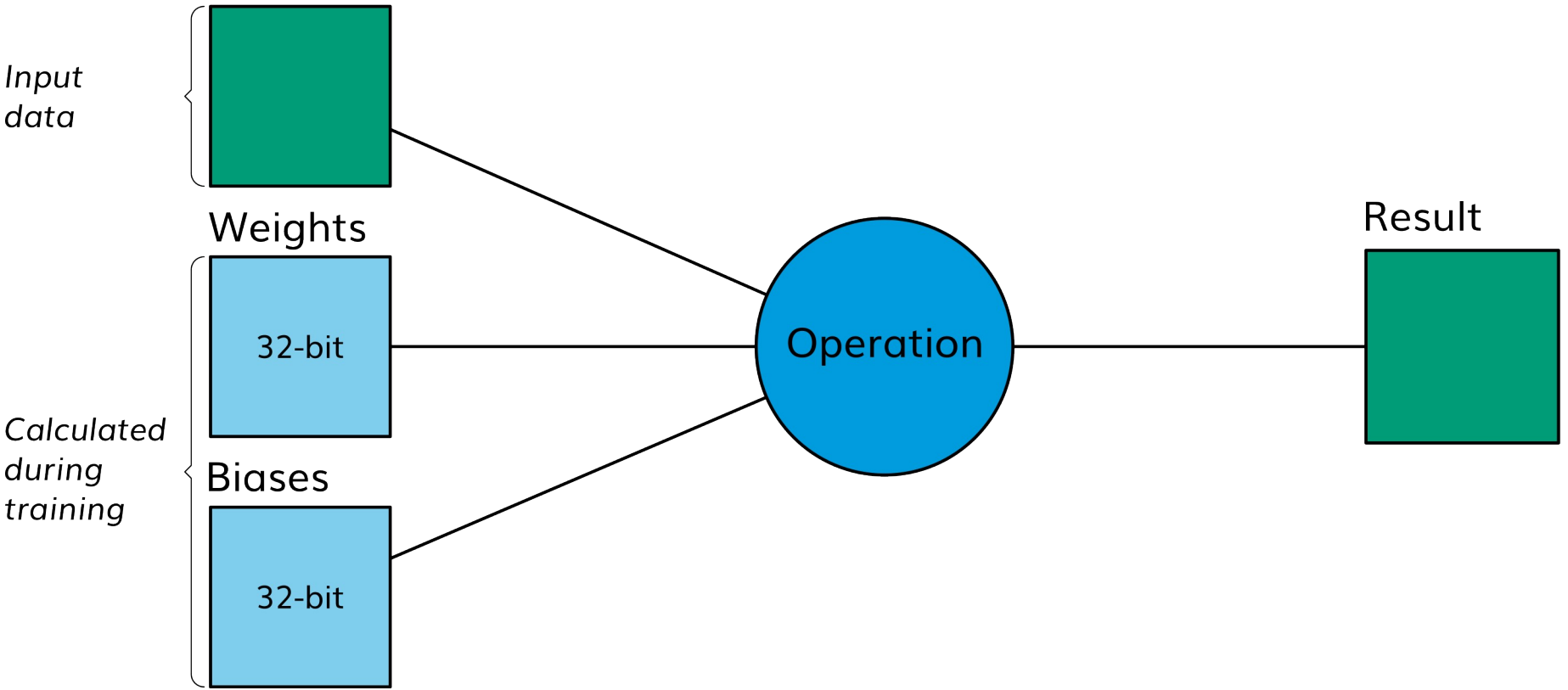

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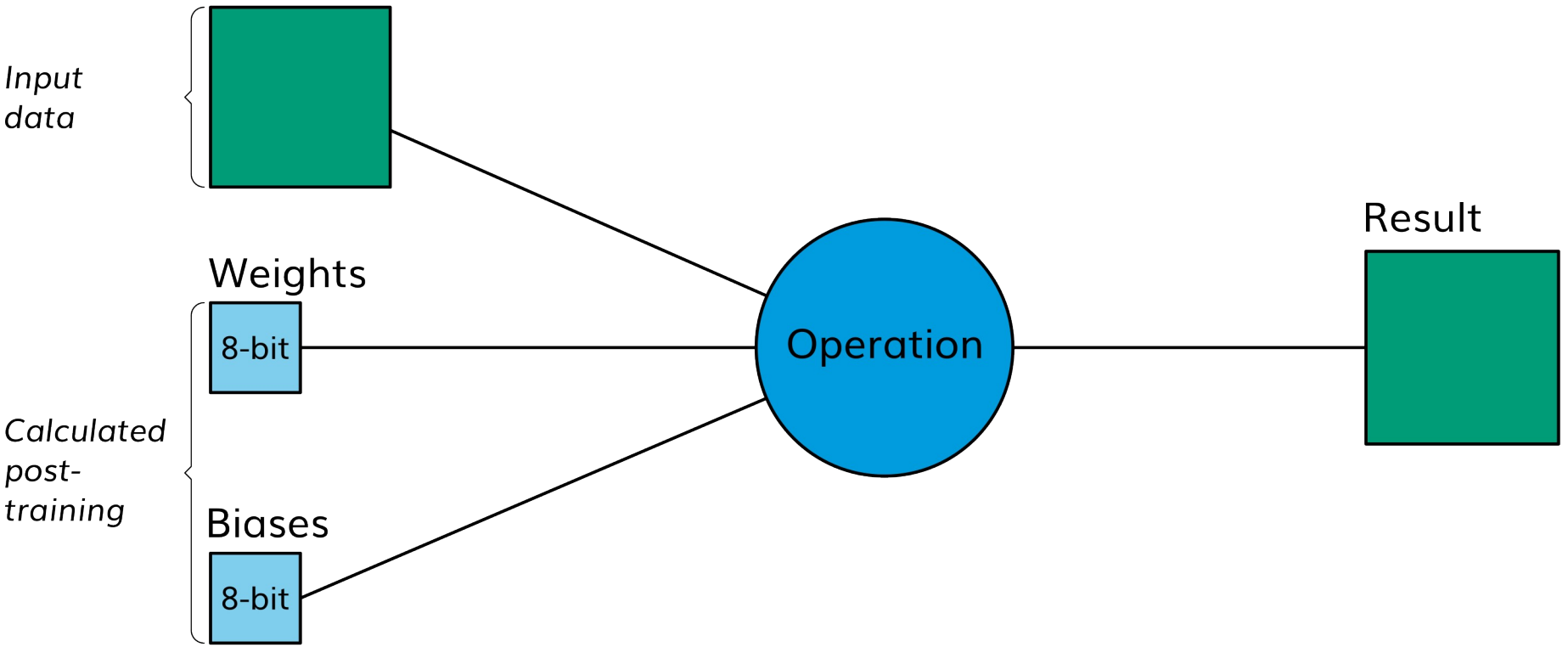
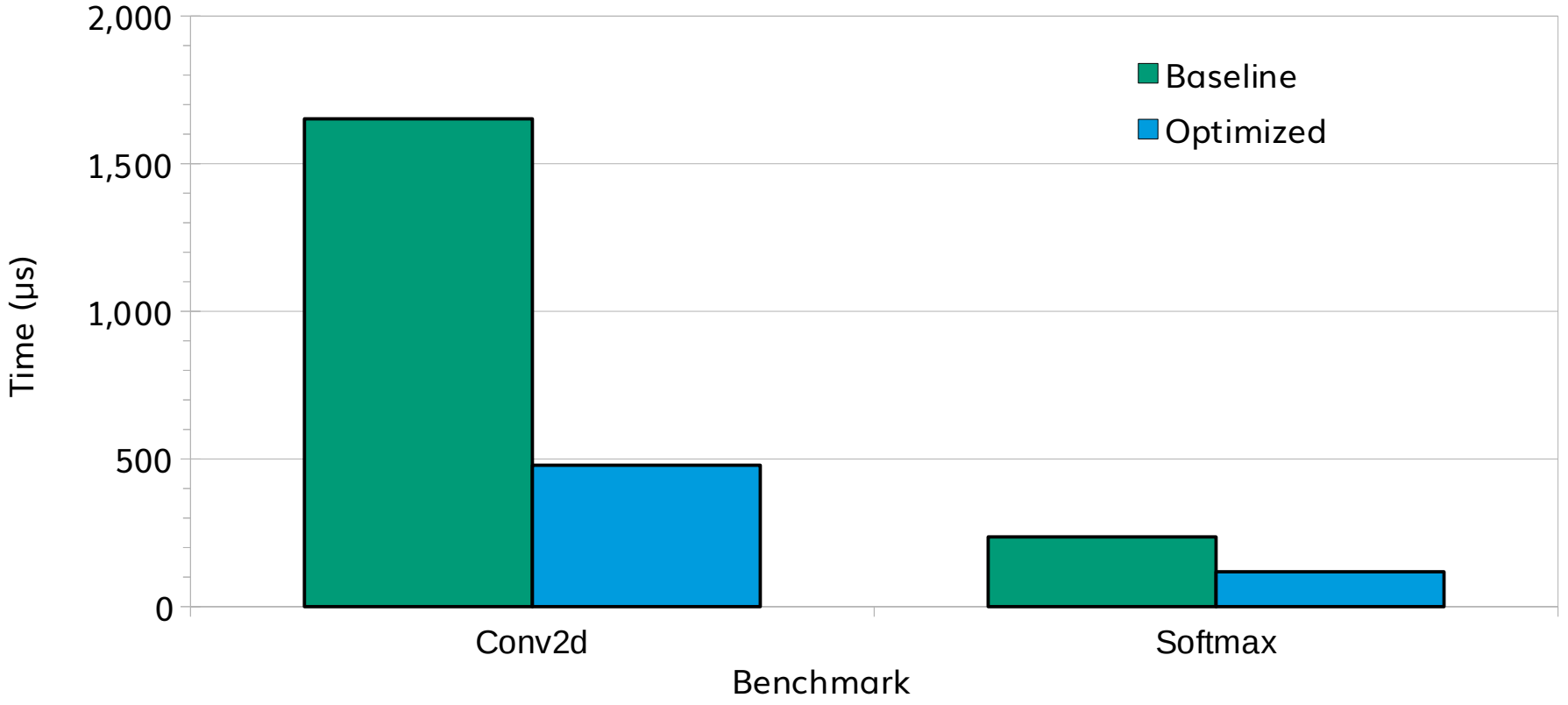


The Performance Benefit



Acknowlegement

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Thank You

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