CUDA-OMP – Or: Breaking the Vendor Lock

Performance Portable Programming Through OpenMP as Target Independent Runtime Layer

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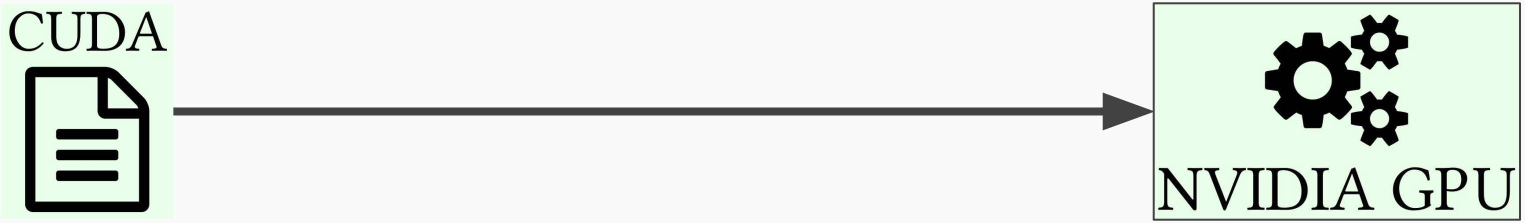
[2] ANL: Argonne National Laboratory (past, email is dead)
[3] ORNL: Oak Ridge National Laboratory (past, email is dead)
[4] AMD
[5] University of Oklahoma (ANL intern)

Motivation



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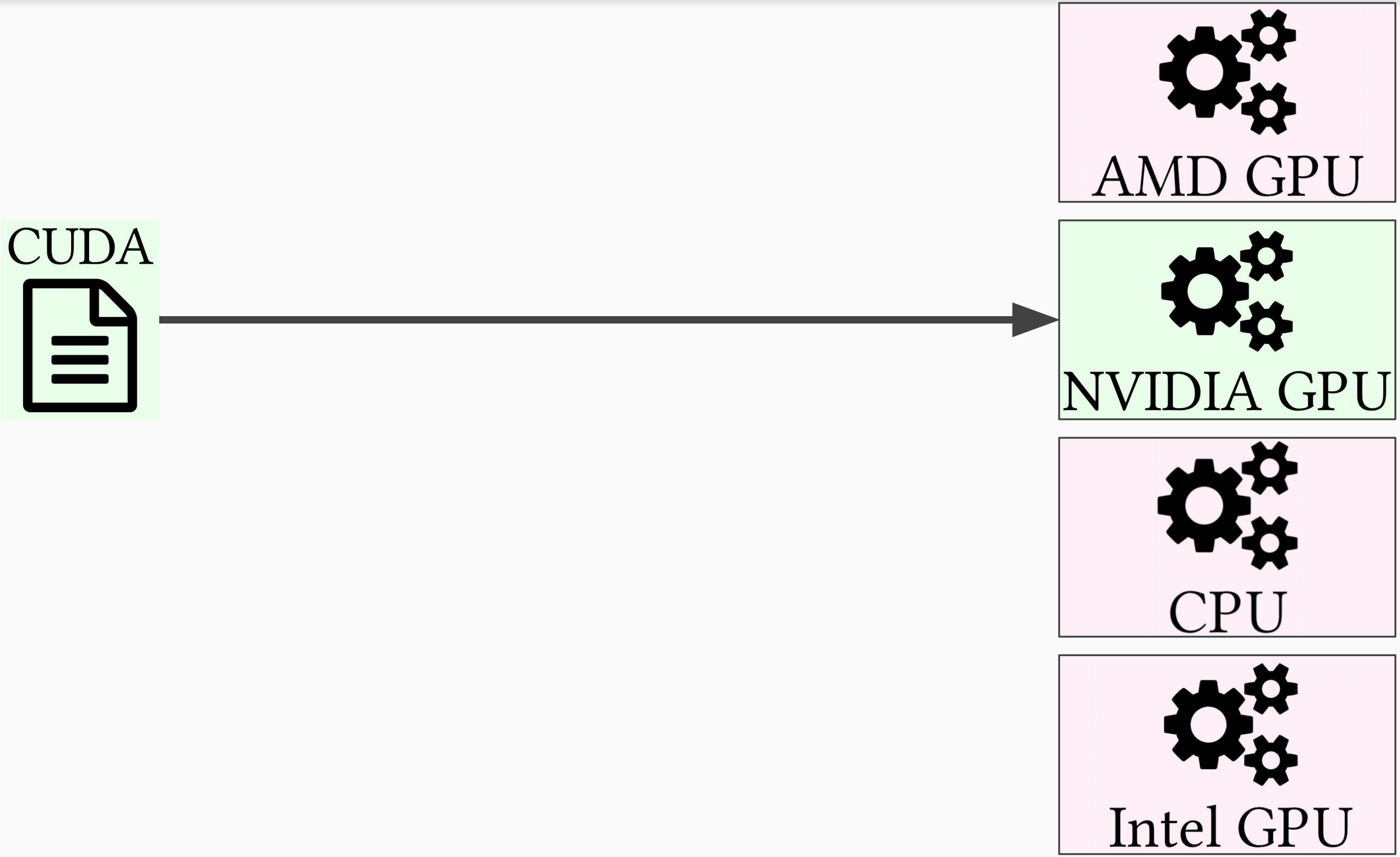

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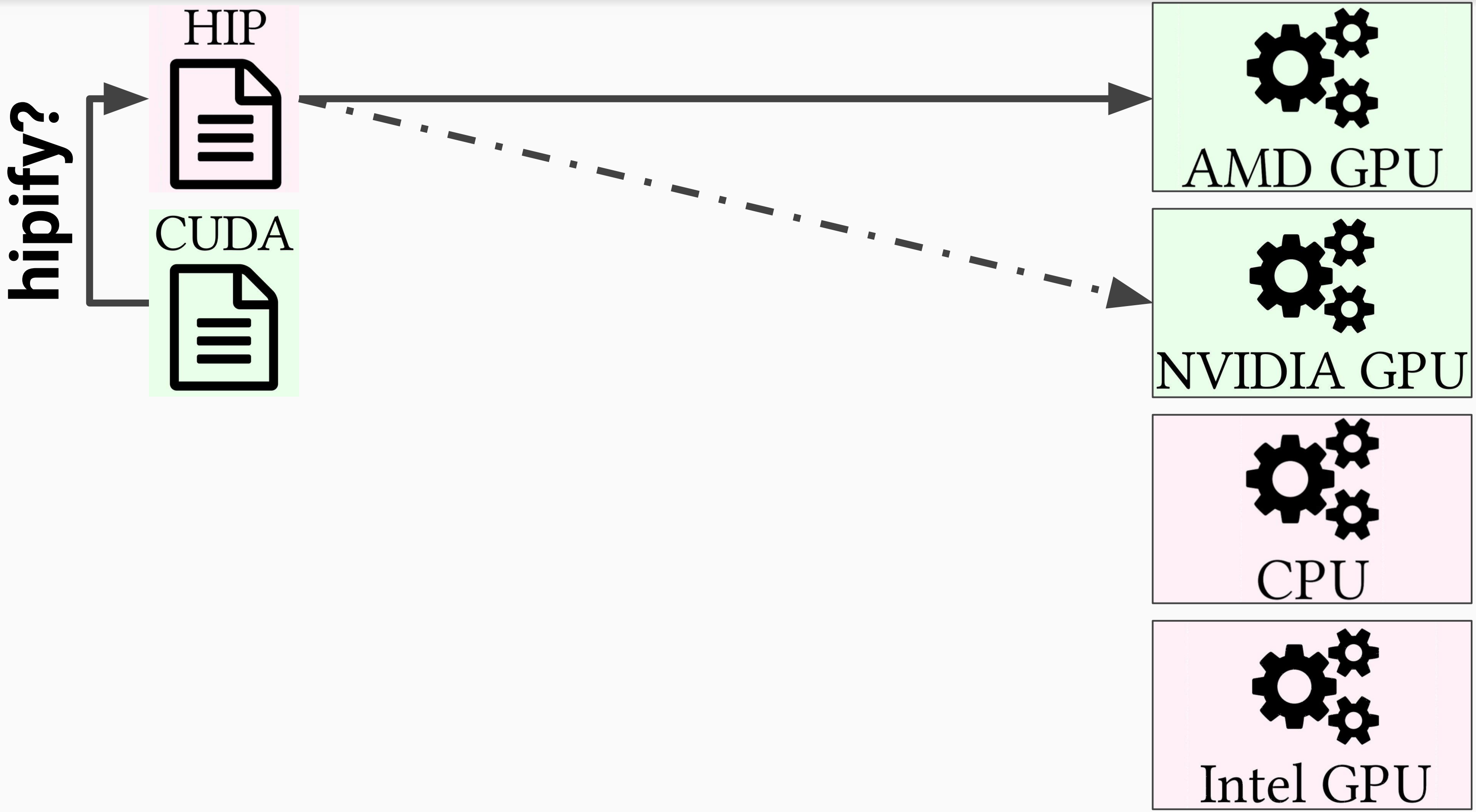

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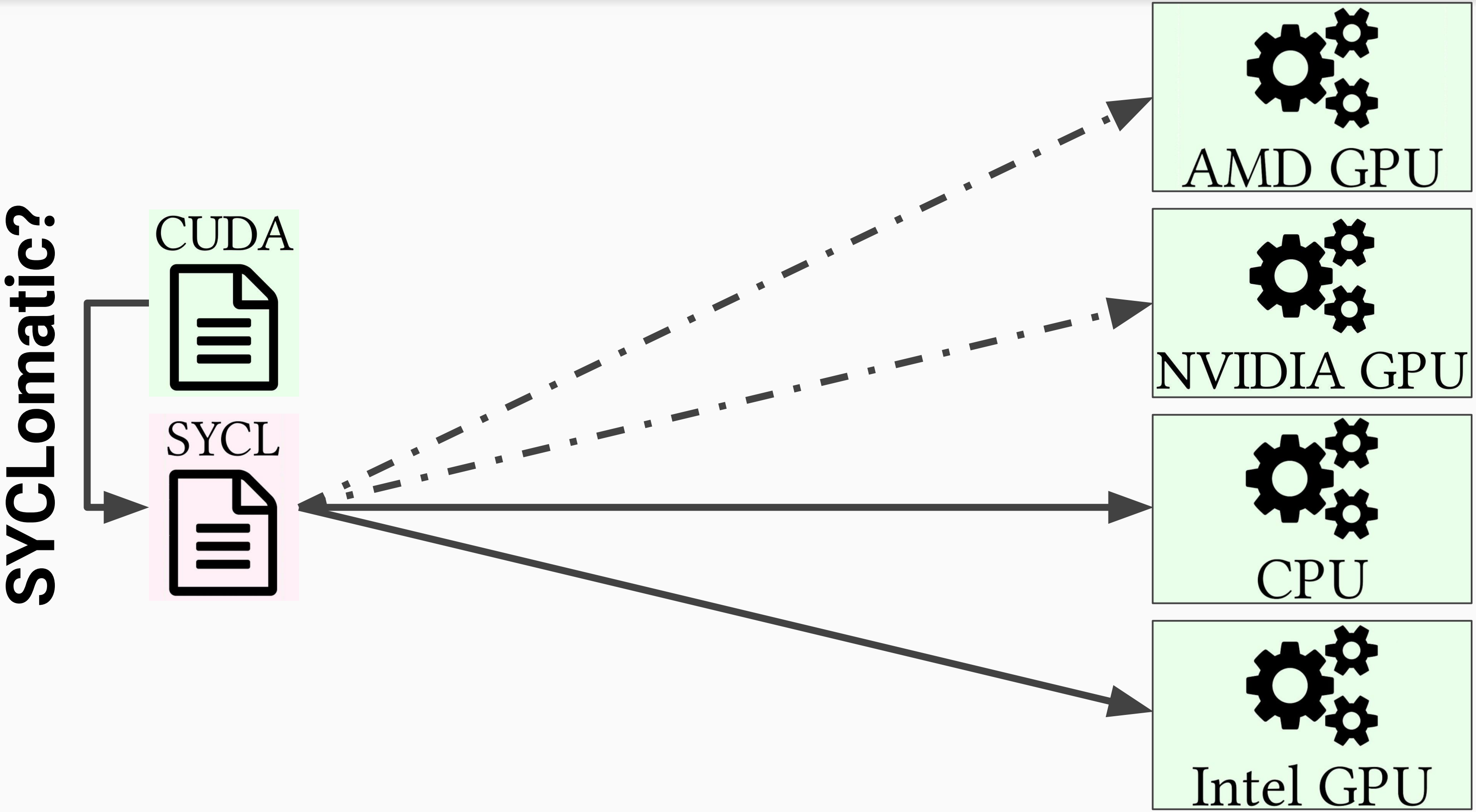

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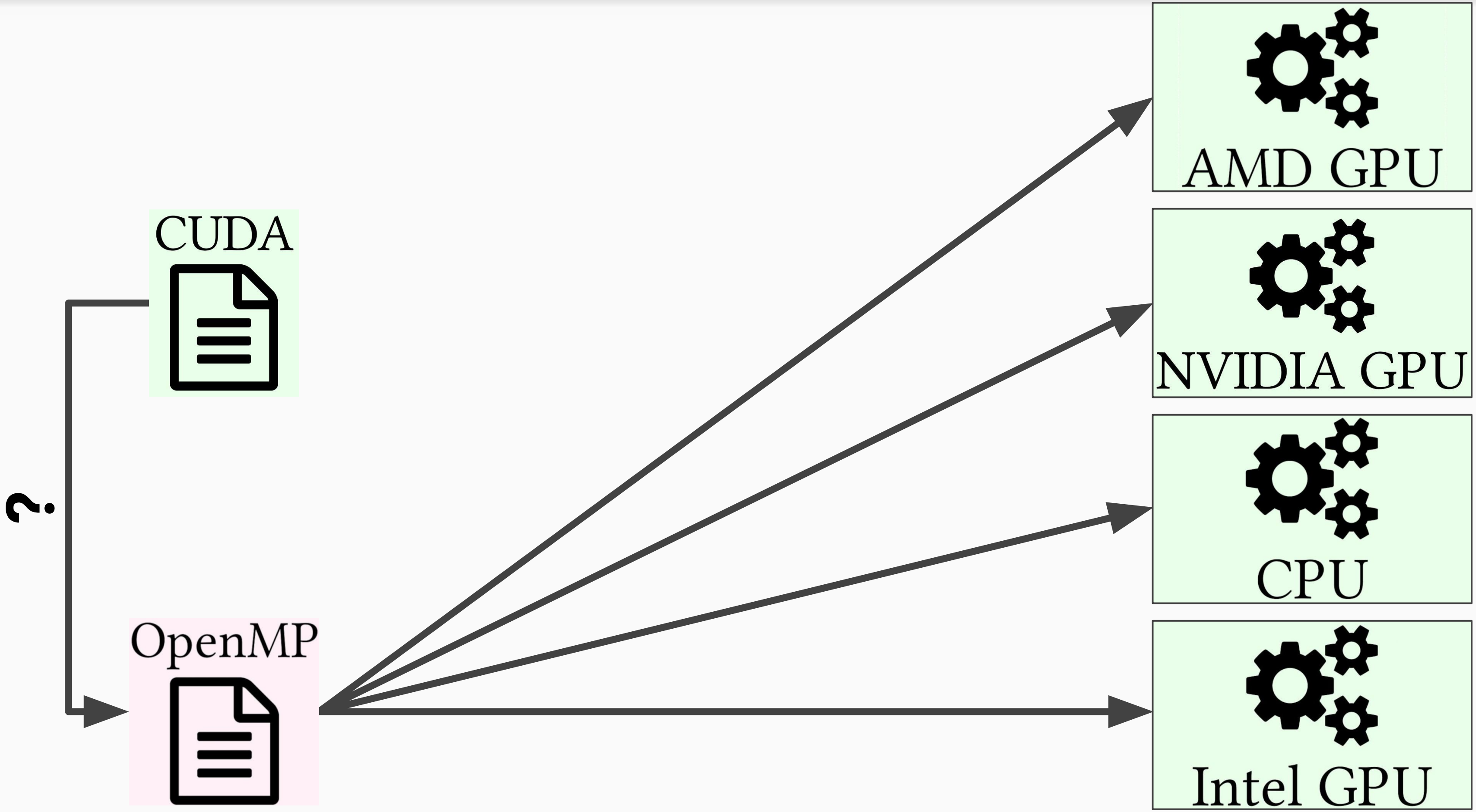

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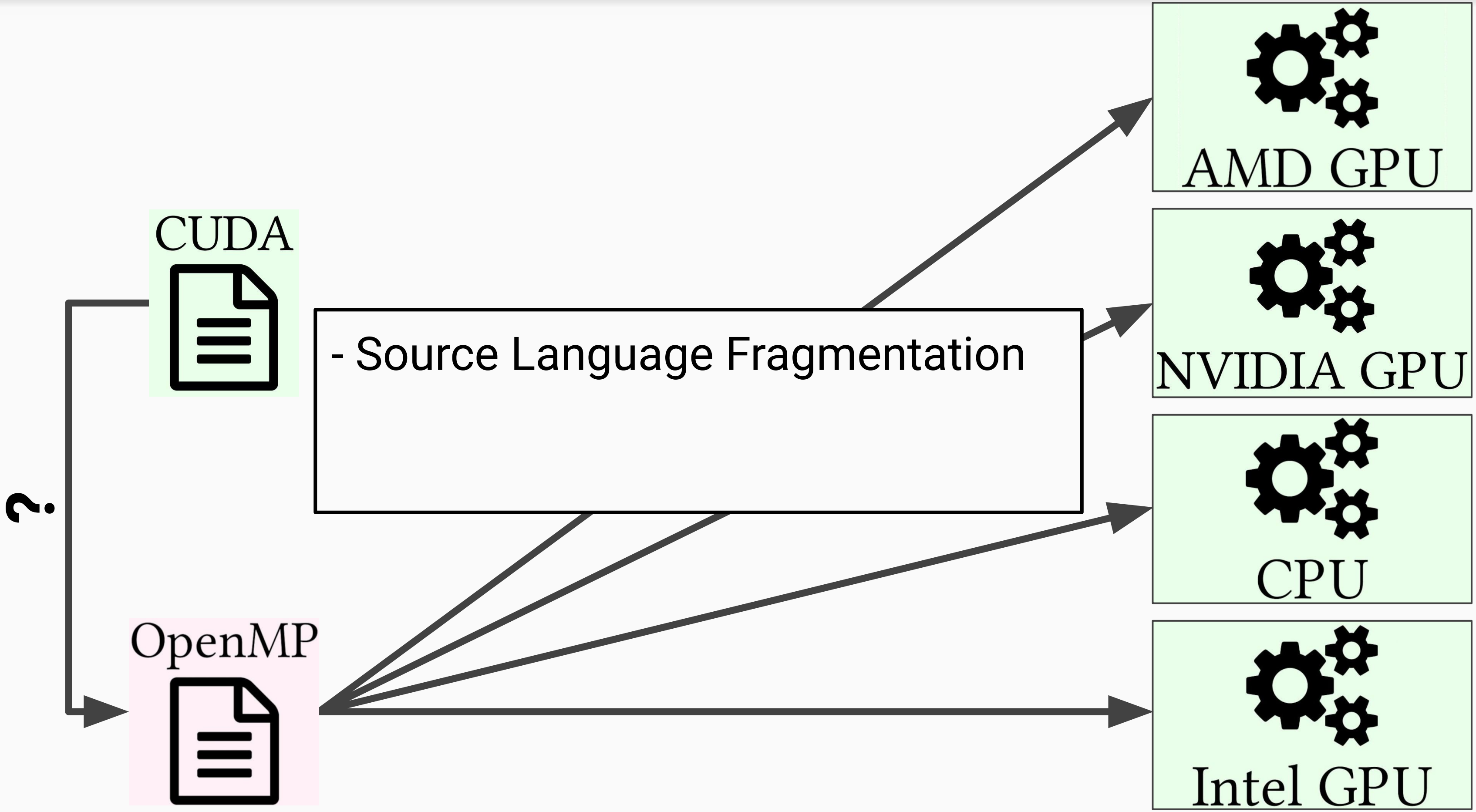

- Source Language Fragmentation

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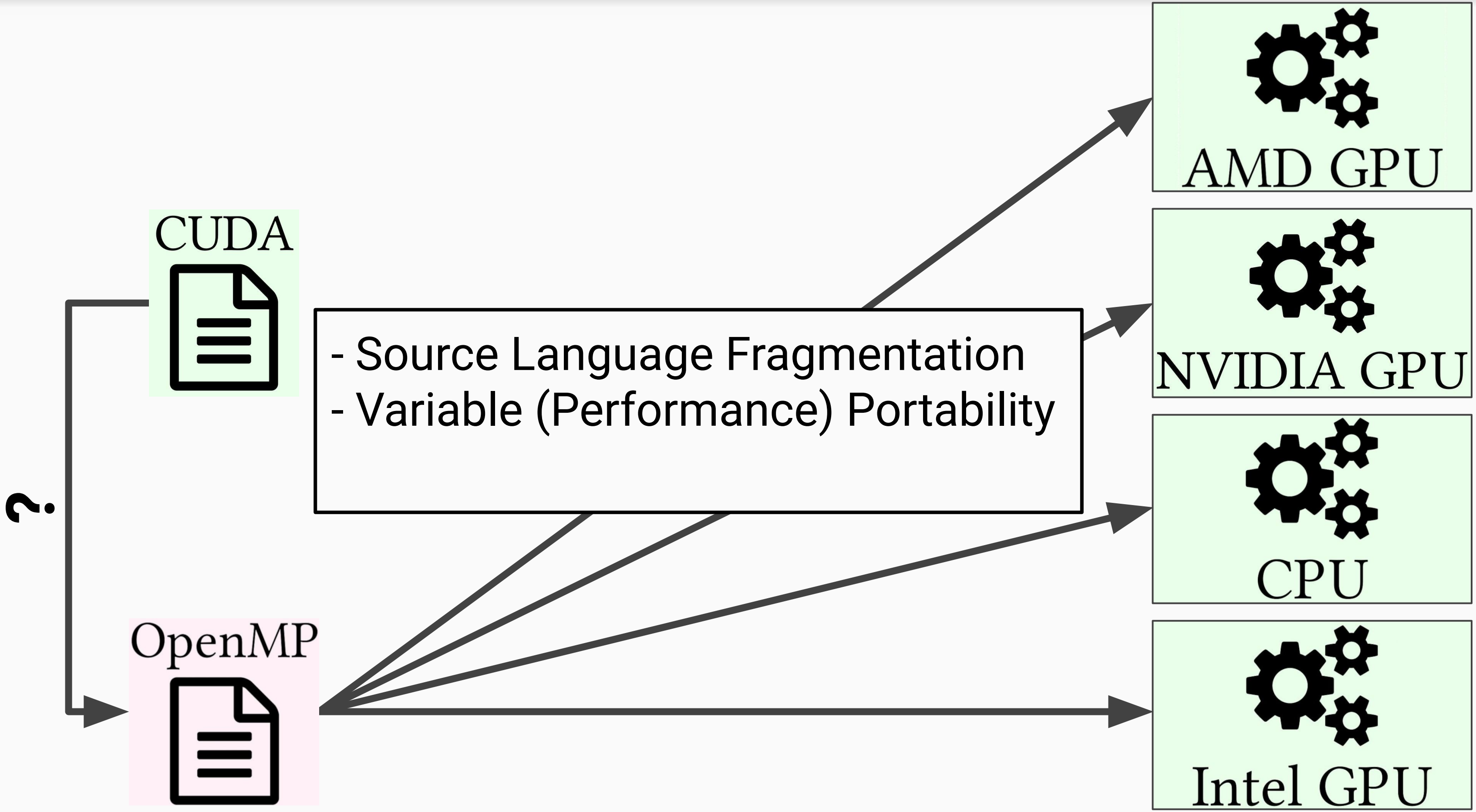

- Source Language Fragmentation
- Variable (Performance) Portability

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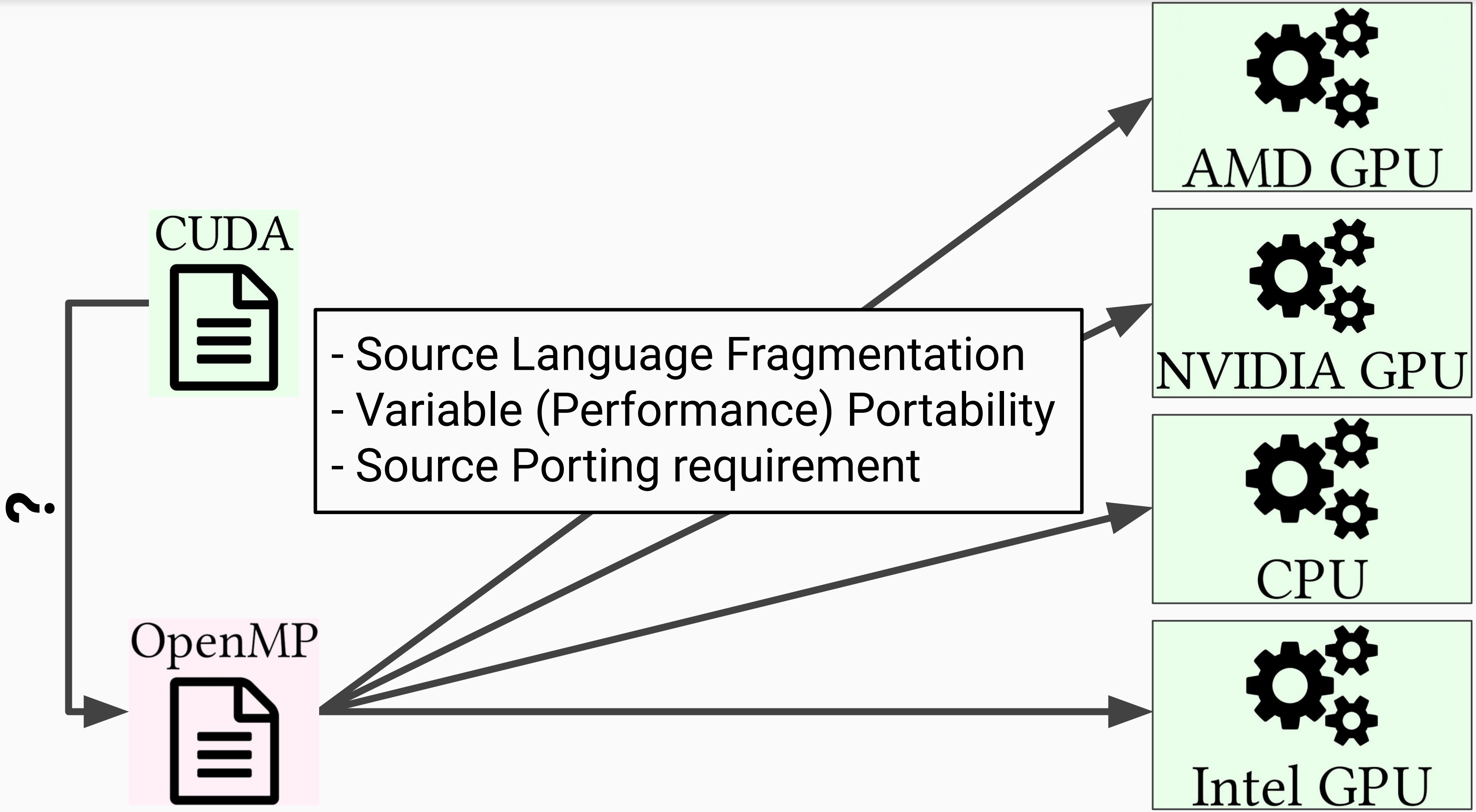


CUDA

?

OpenMP

- Source Language Fragmentation
- Variable (Performance) Portability
- Source Porting requirement

AMD GPU

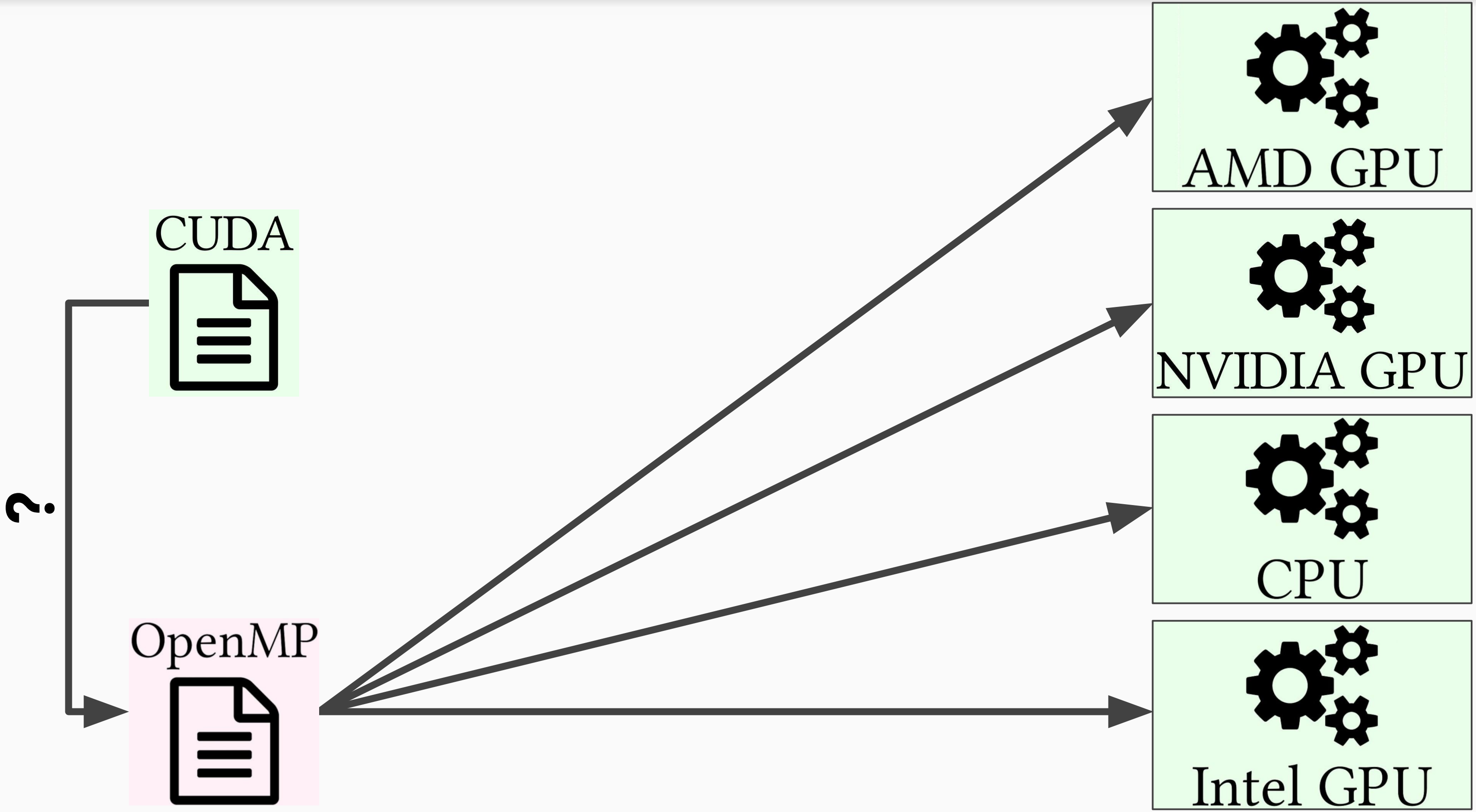
NVIDIA GPU

CPU

Intel GPU

Approach

Approach



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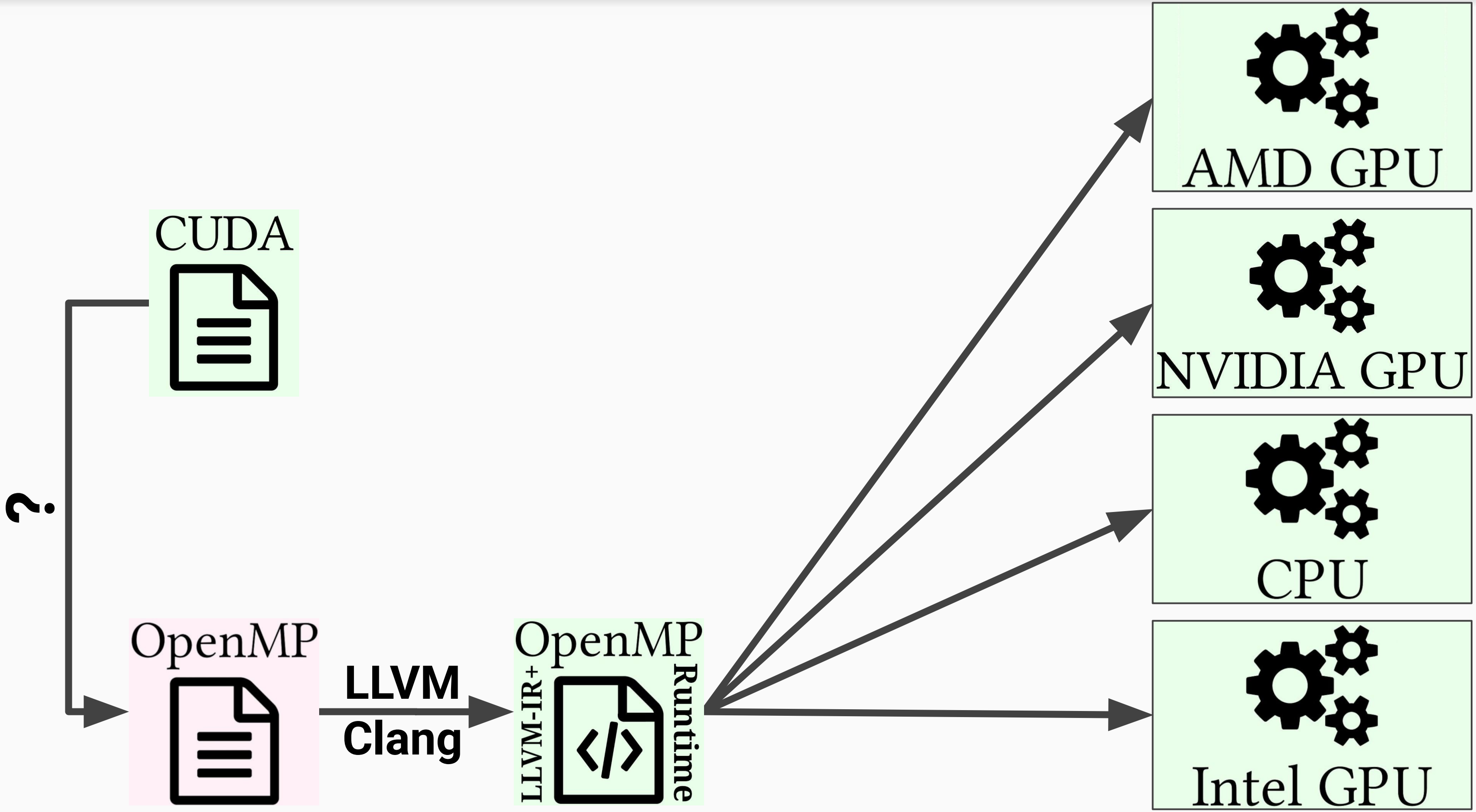
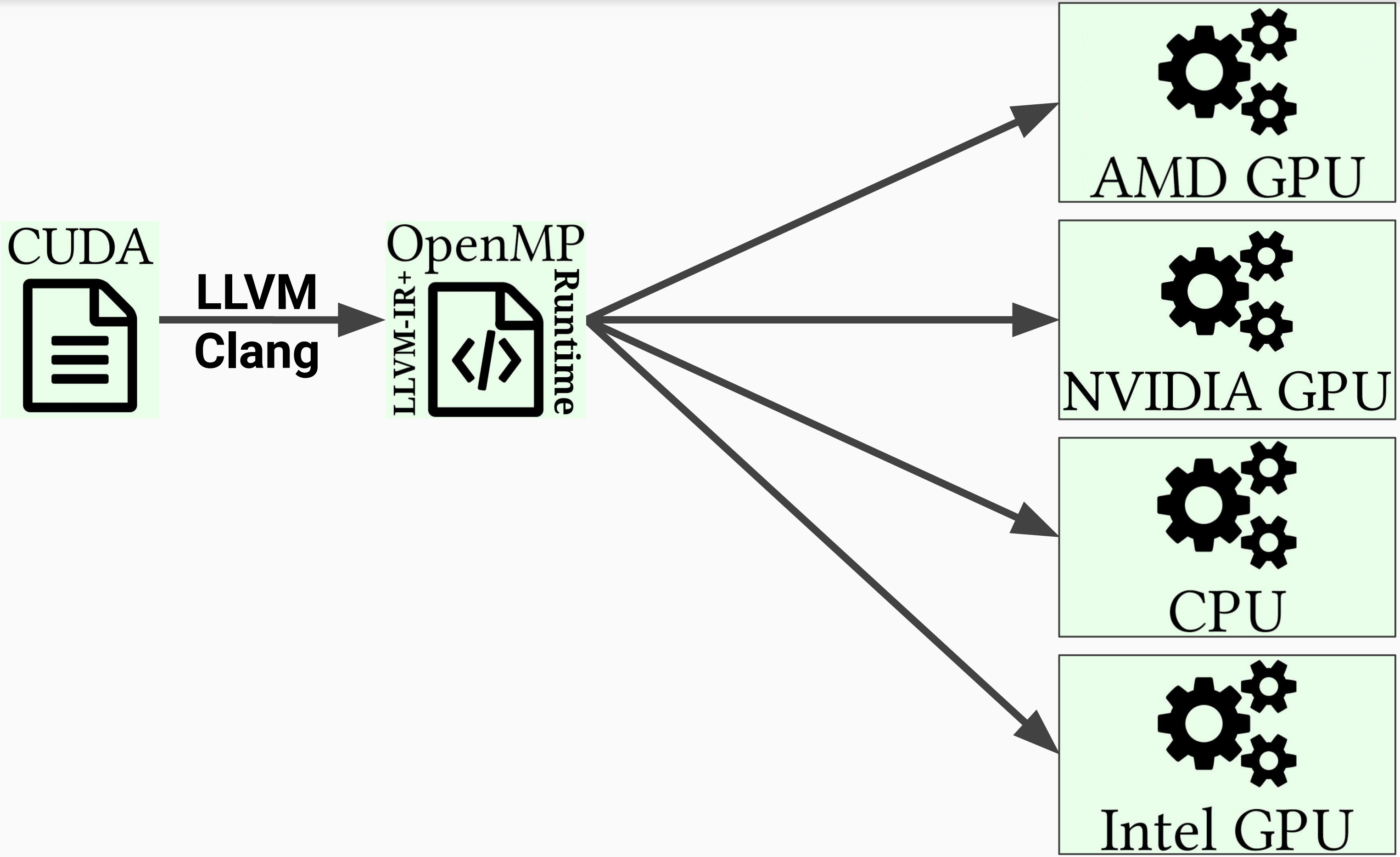

AMD GPU
NVIDIA GPU
CPU
Intel GPU
CUDA
?
OpenMP
LLVM
Clang
OpenMP
LLVM-IR+
Runtime

Approach


CUDA
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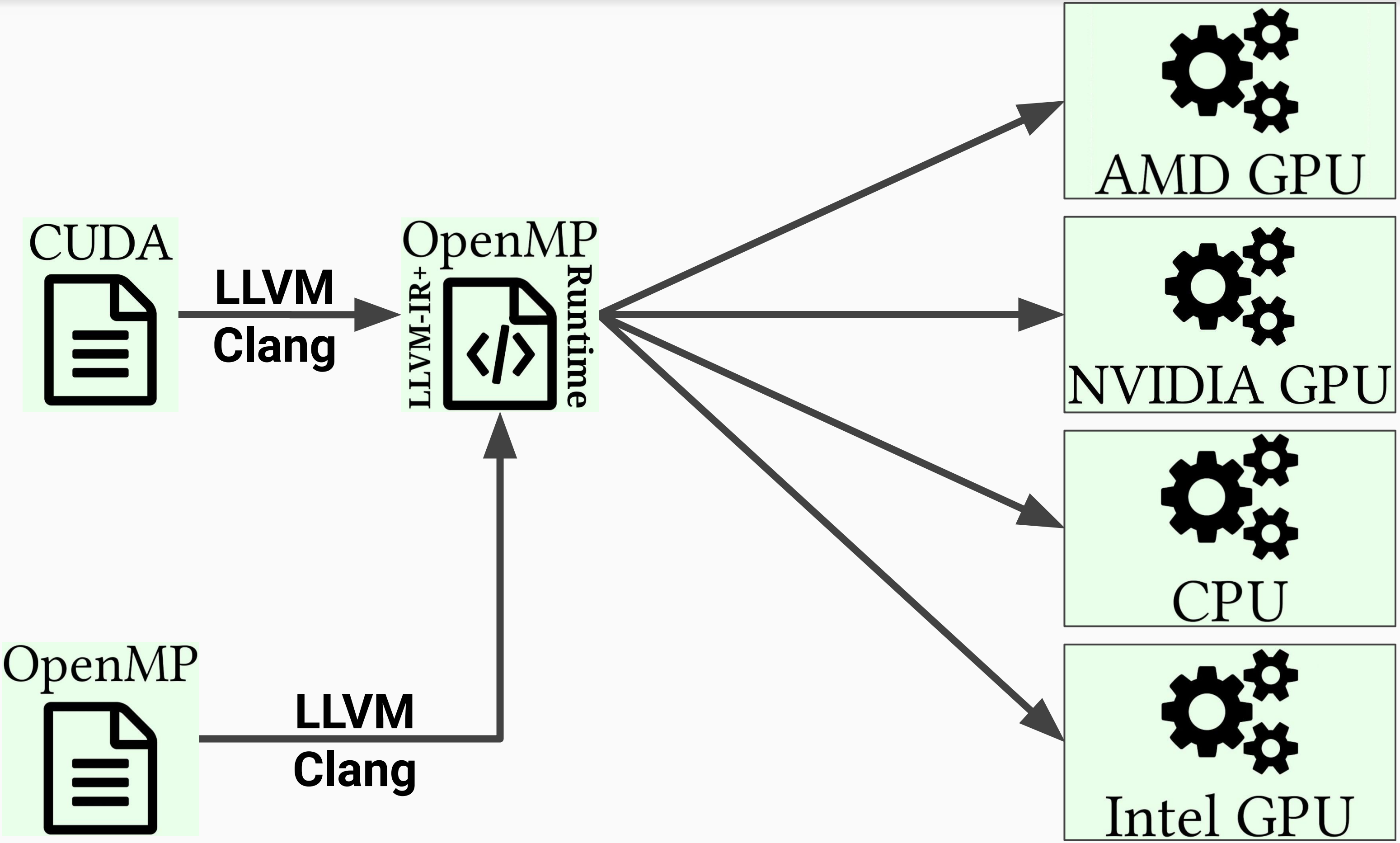
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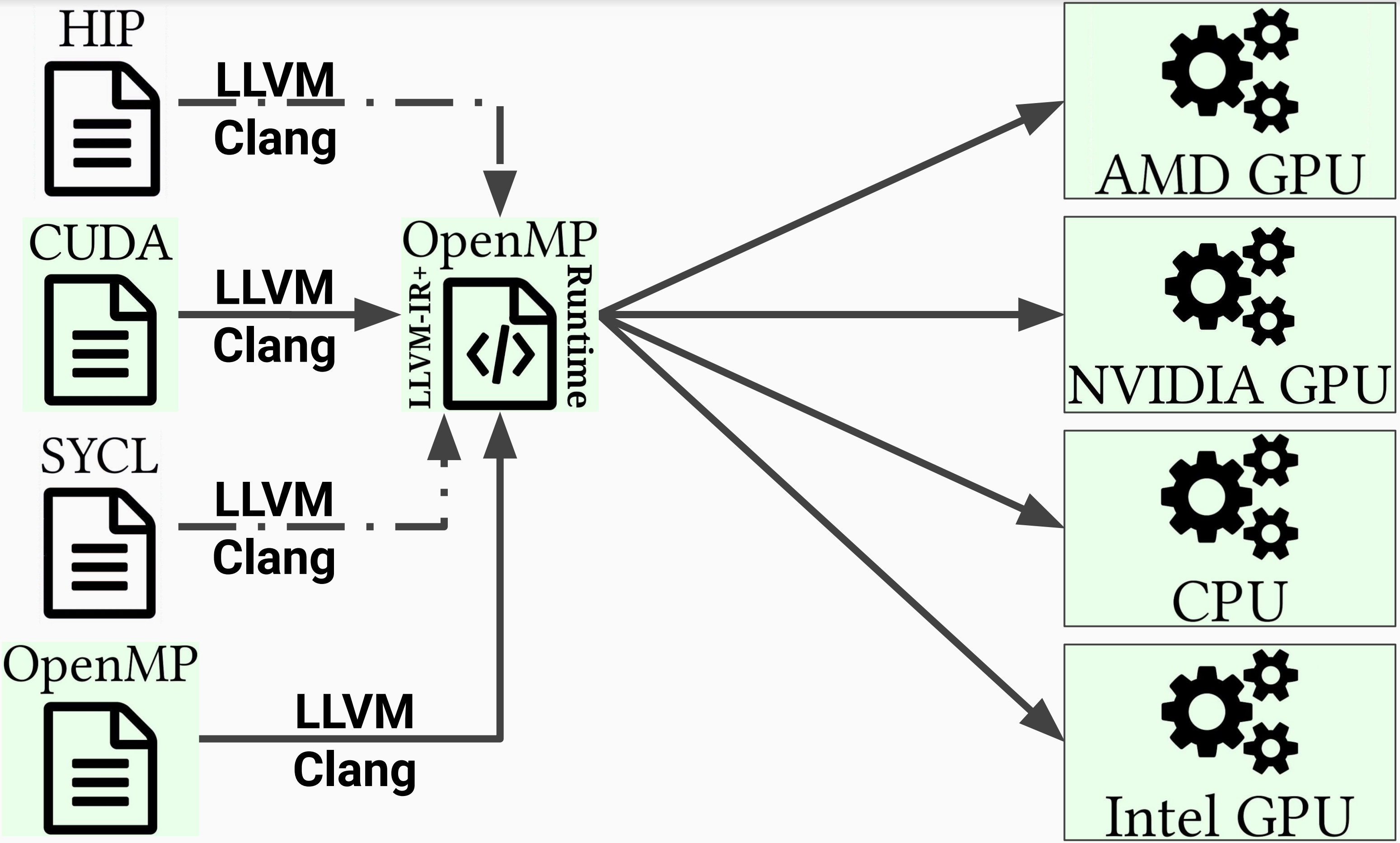
HIP
LLVM
Clang
CUDA
LLVM
Clang
SYCL
LLVM
Clang
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AMD GPU
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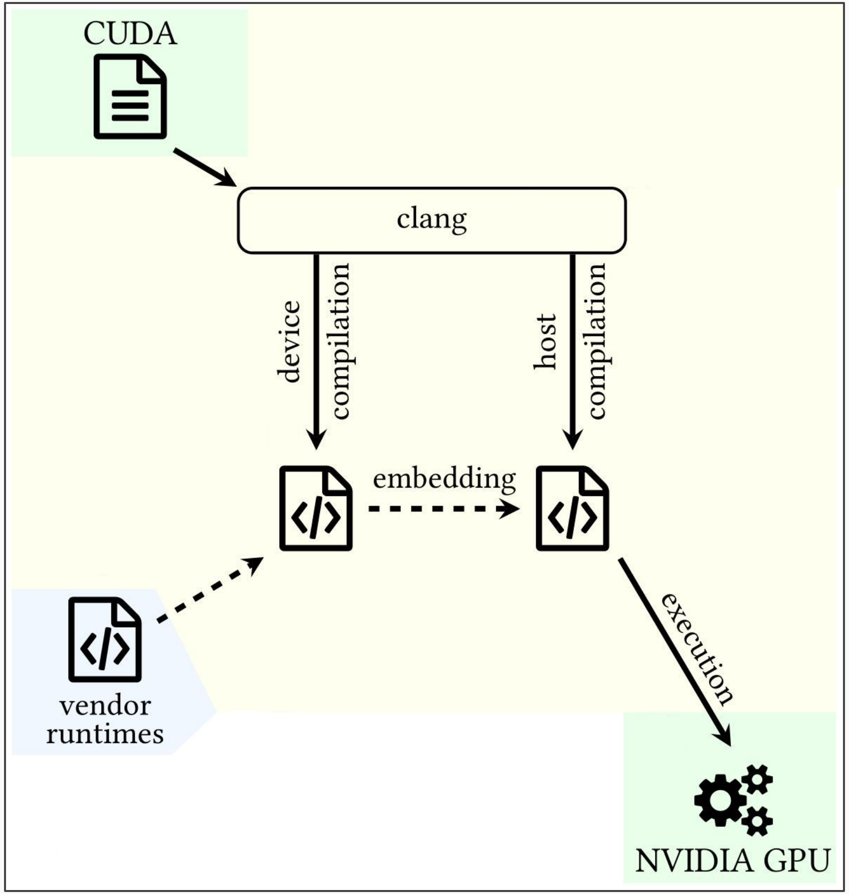
Details

Overview – CUDA via OpenMP Offload Compilation



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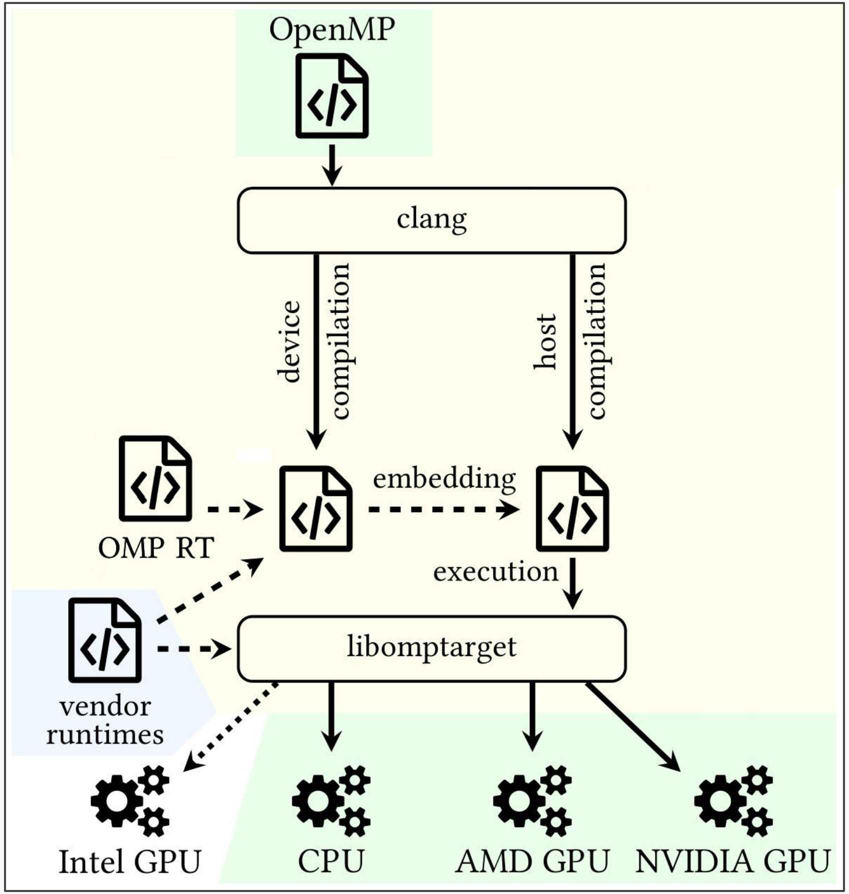

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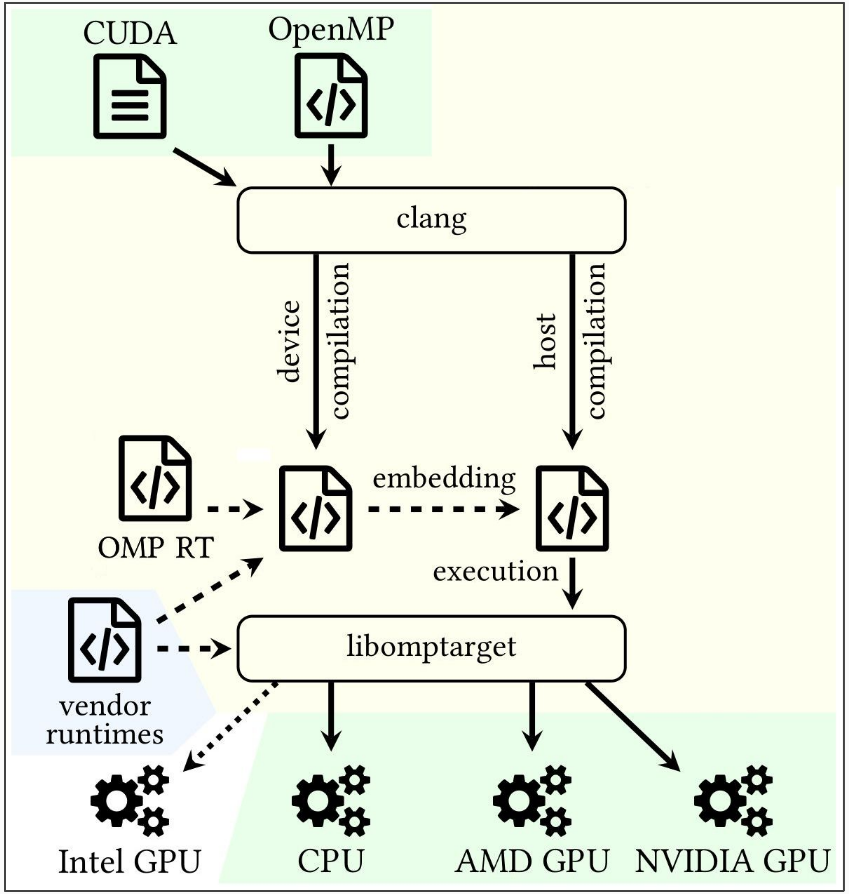
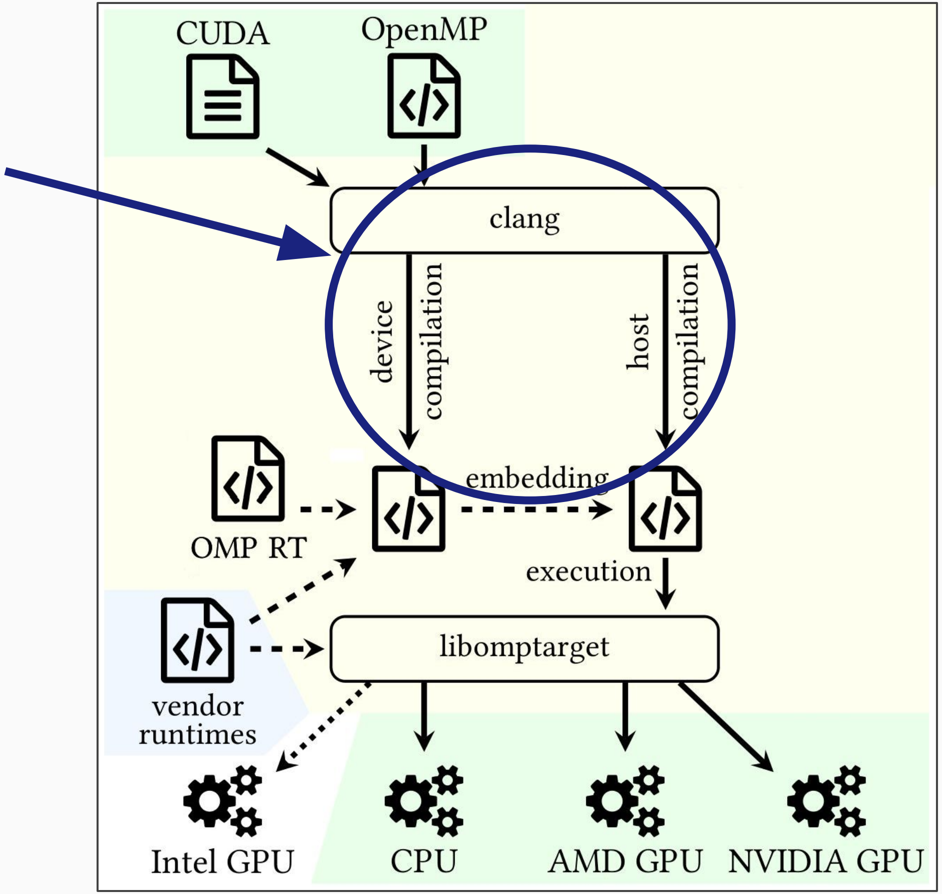


Overview – CUDA via OpenMP Offload Compilation

New Offload Driver
- Language agnostic
- “Classic” design
- Static library support
- LTO-capable



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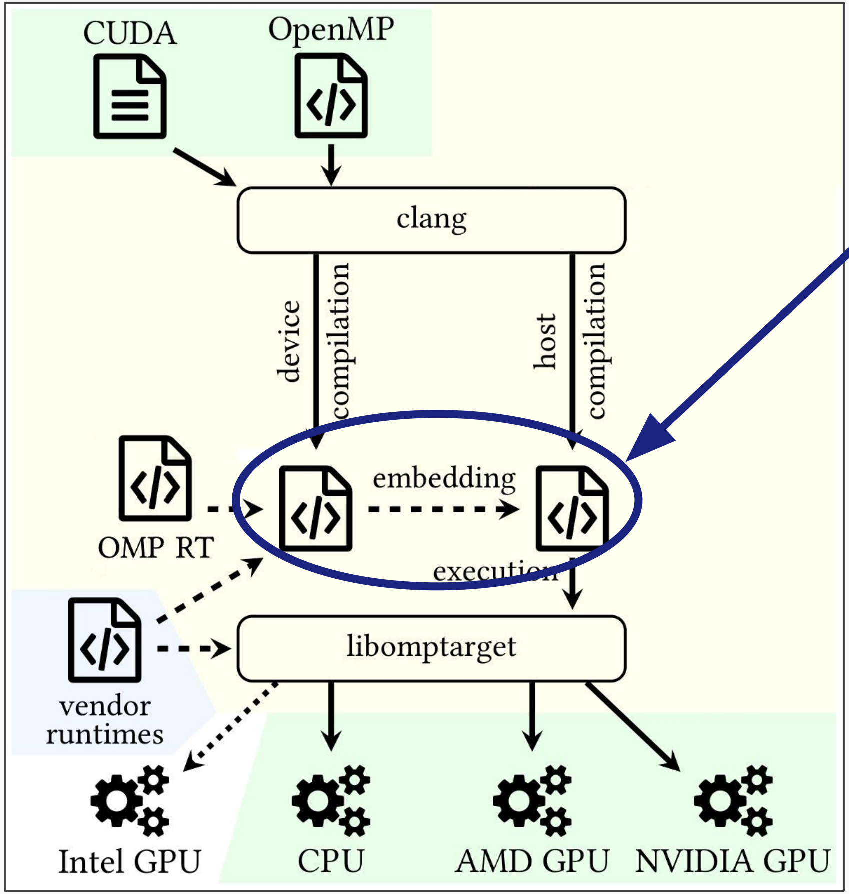

Novel Embedding
- Language agnostic
- Metadata enriched
- Multi-device support
- ELF-tooling available

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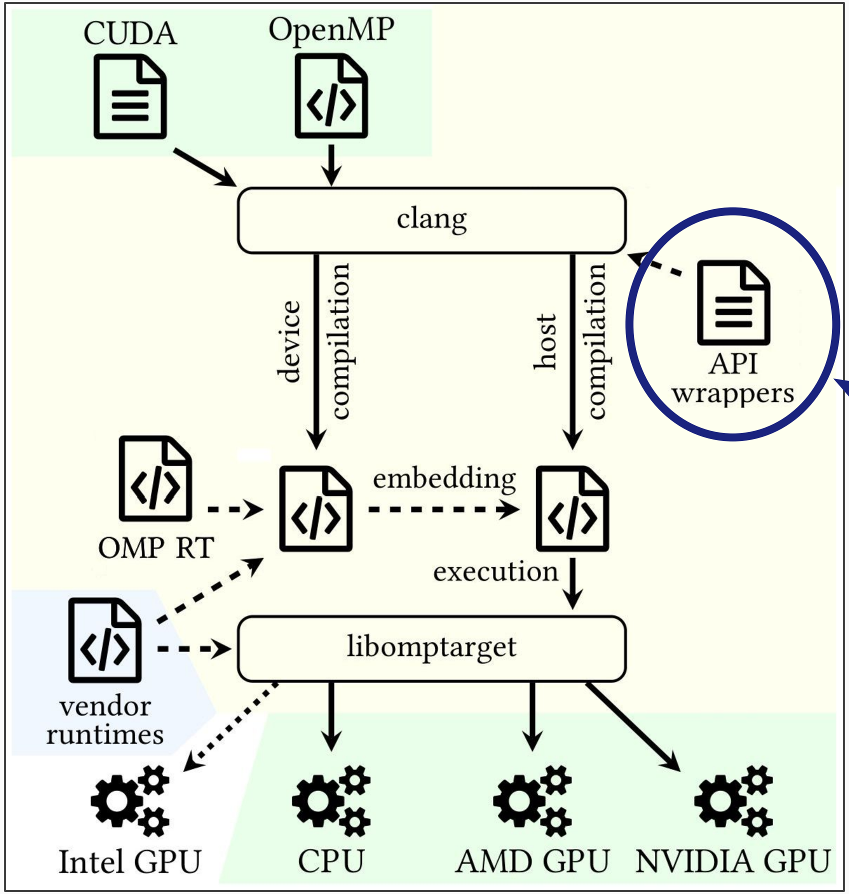

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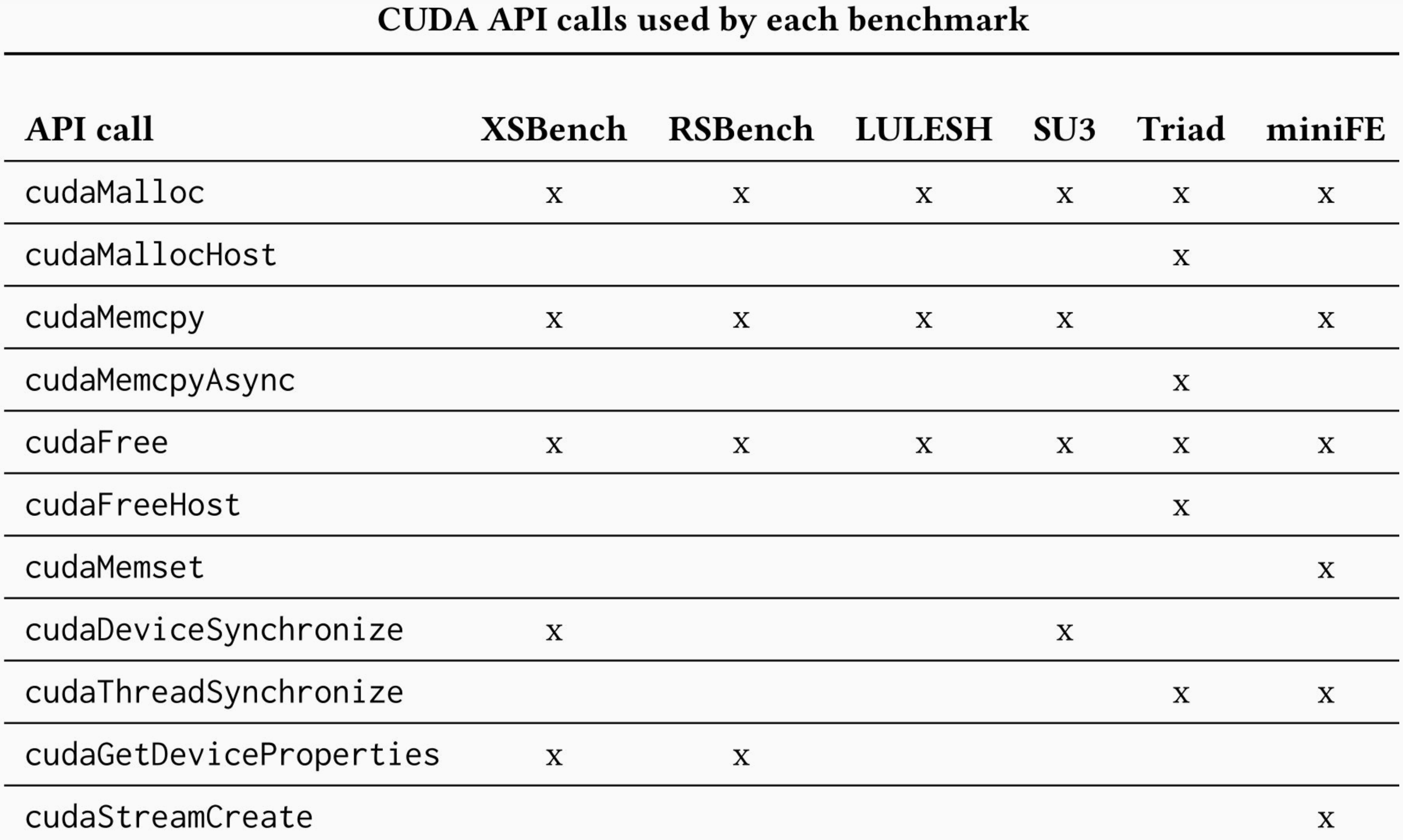
CUDA API Wrappers
- Map to OpenMP RT
- Use existing & new APIs
- Incl. compiler used APIs

Wrapped (User) CUDA APIs



CUDA API calls used by each benchmark

API call	XSBench	RSBench	LULESH	SU3	Triad	miniFE
`cudaMalloc`	x	x	x	x	x	x
`cudaMallocHost`					x	
`cudaMemcpy`	x	x	x	x		x
`cudaMemcpyAsync`					x	
`cudaFree`	x	x	x	x	x	x
`cudaFreeHost`					x	
`cudaMemset`						x
`cudaDeviceSynchronize`	x			x		
`cudaThreadSynchronize`					x	x
`cudaGetDeviceProperties`	x	x				
`cudaStreamCreate`						x

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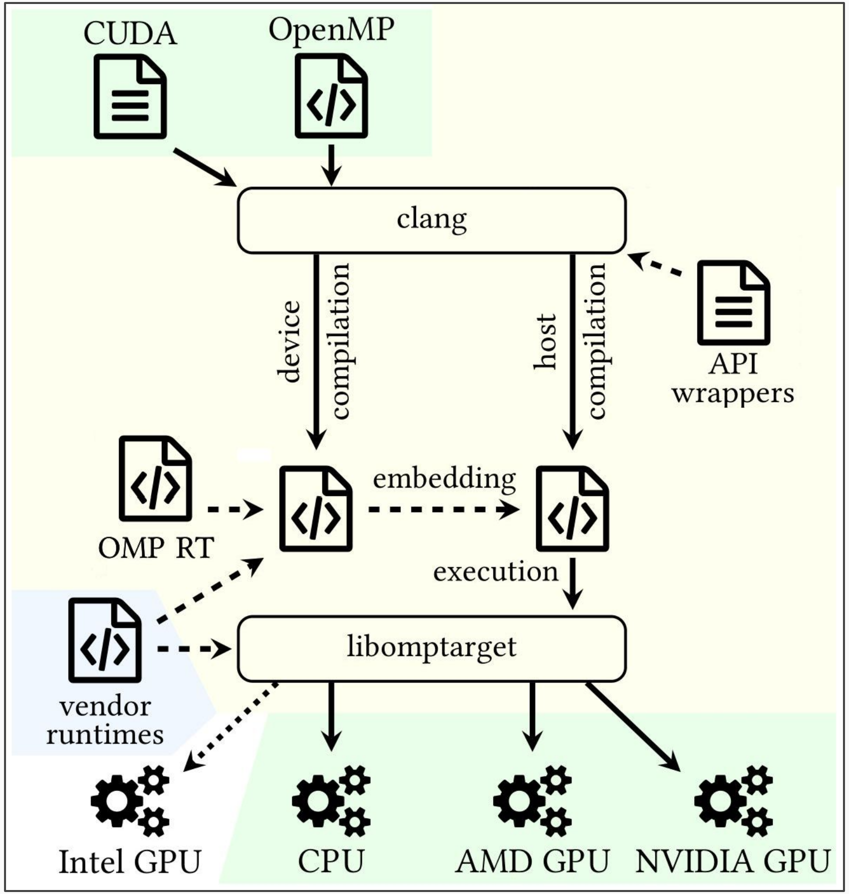

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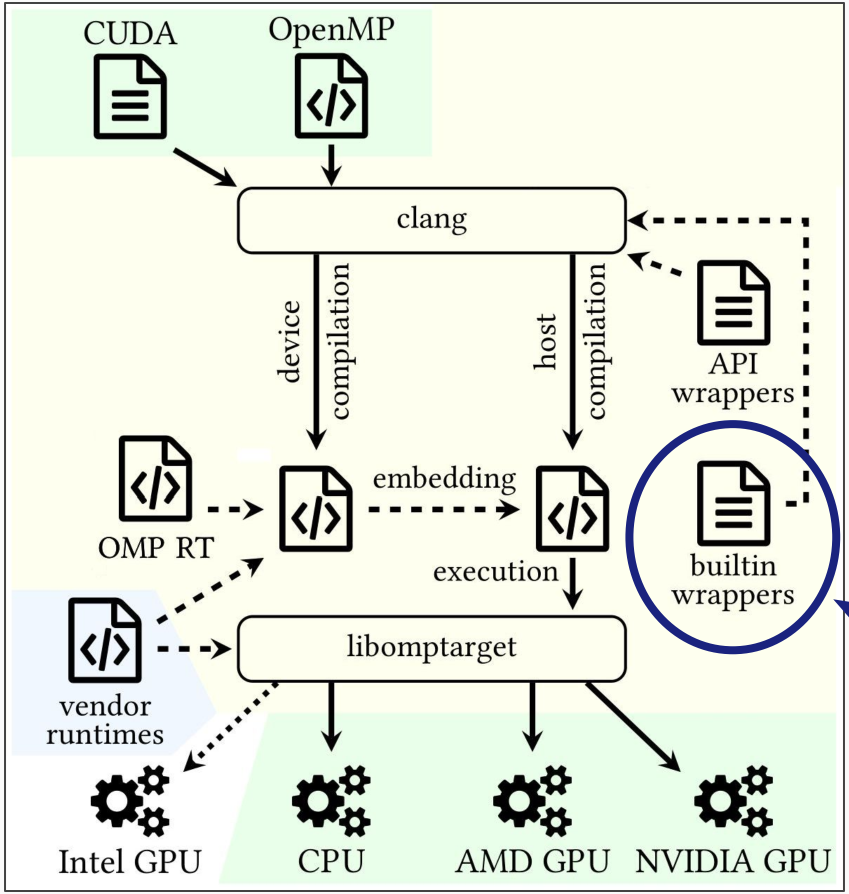

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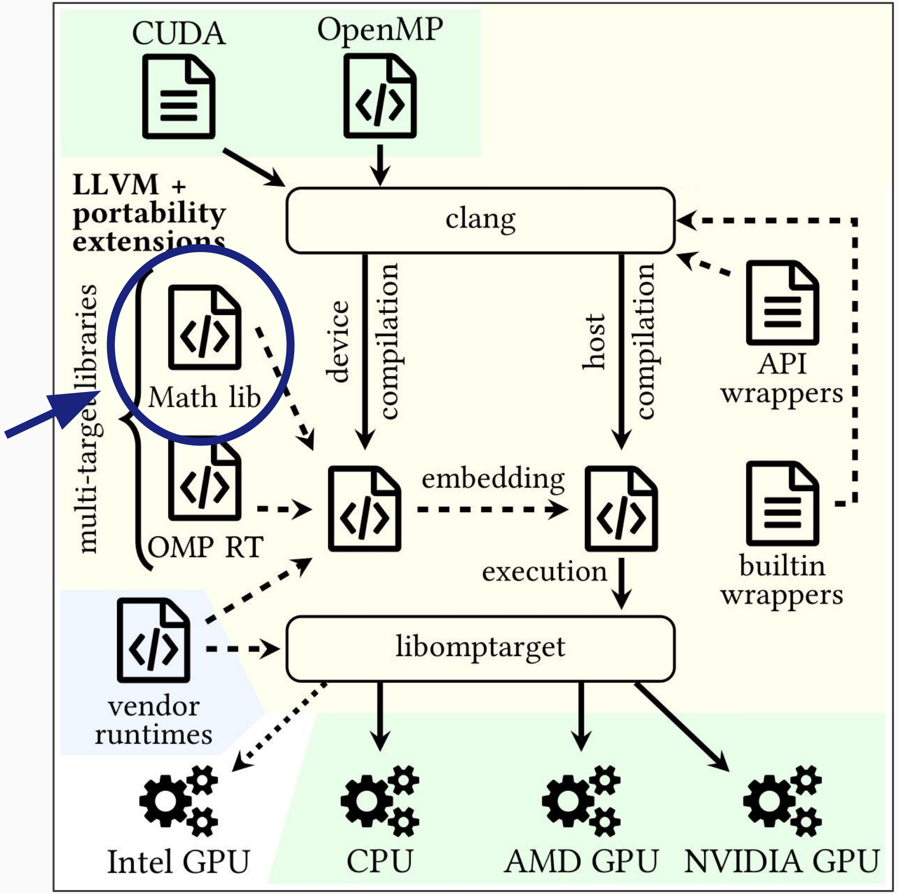
- Map to target math impl.
- Multi-(sub-)target support
- Enable math optimization



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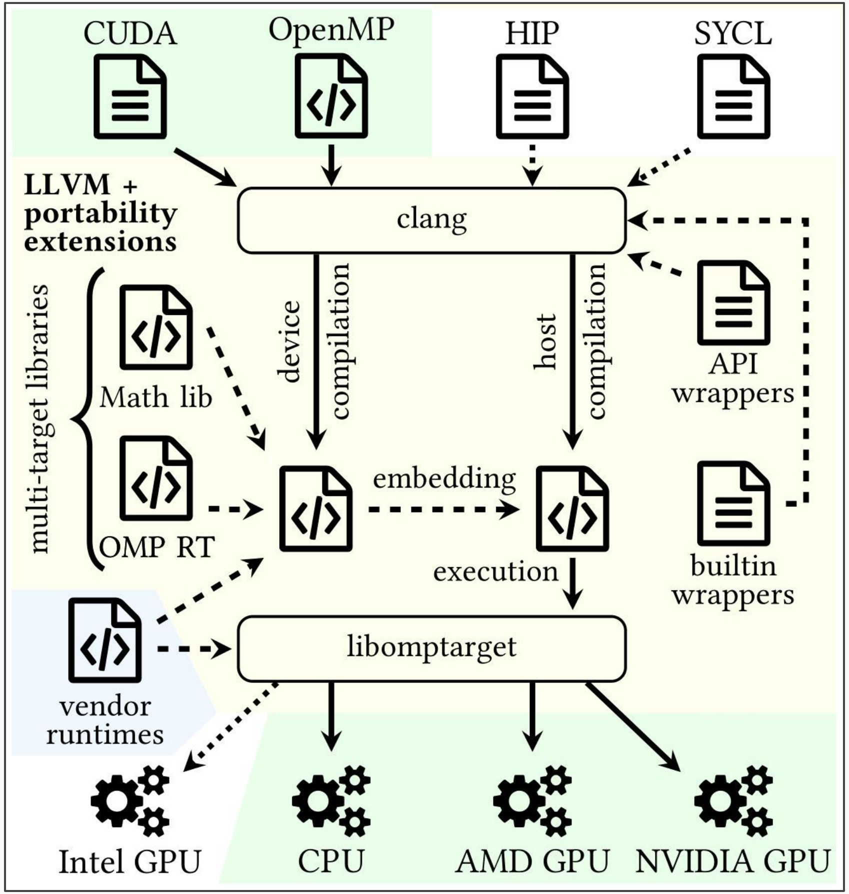

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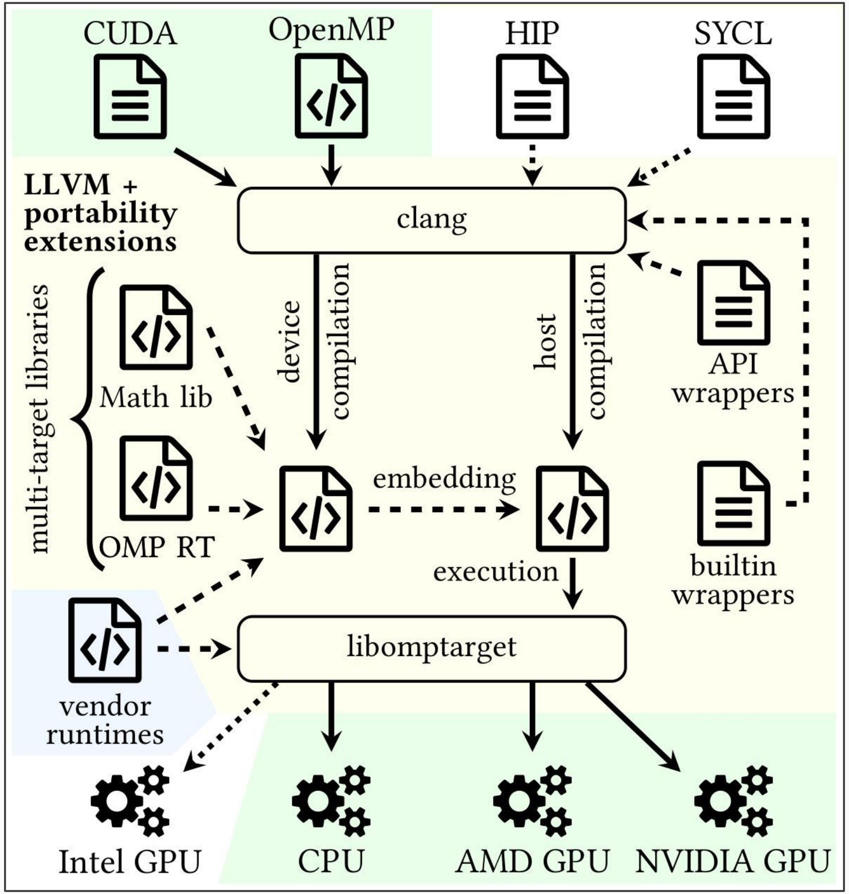
Results:
- Portable CUDA
- Interoperable
  CUDA (+ HIP) + OpenMP
- Access to OpenMP features



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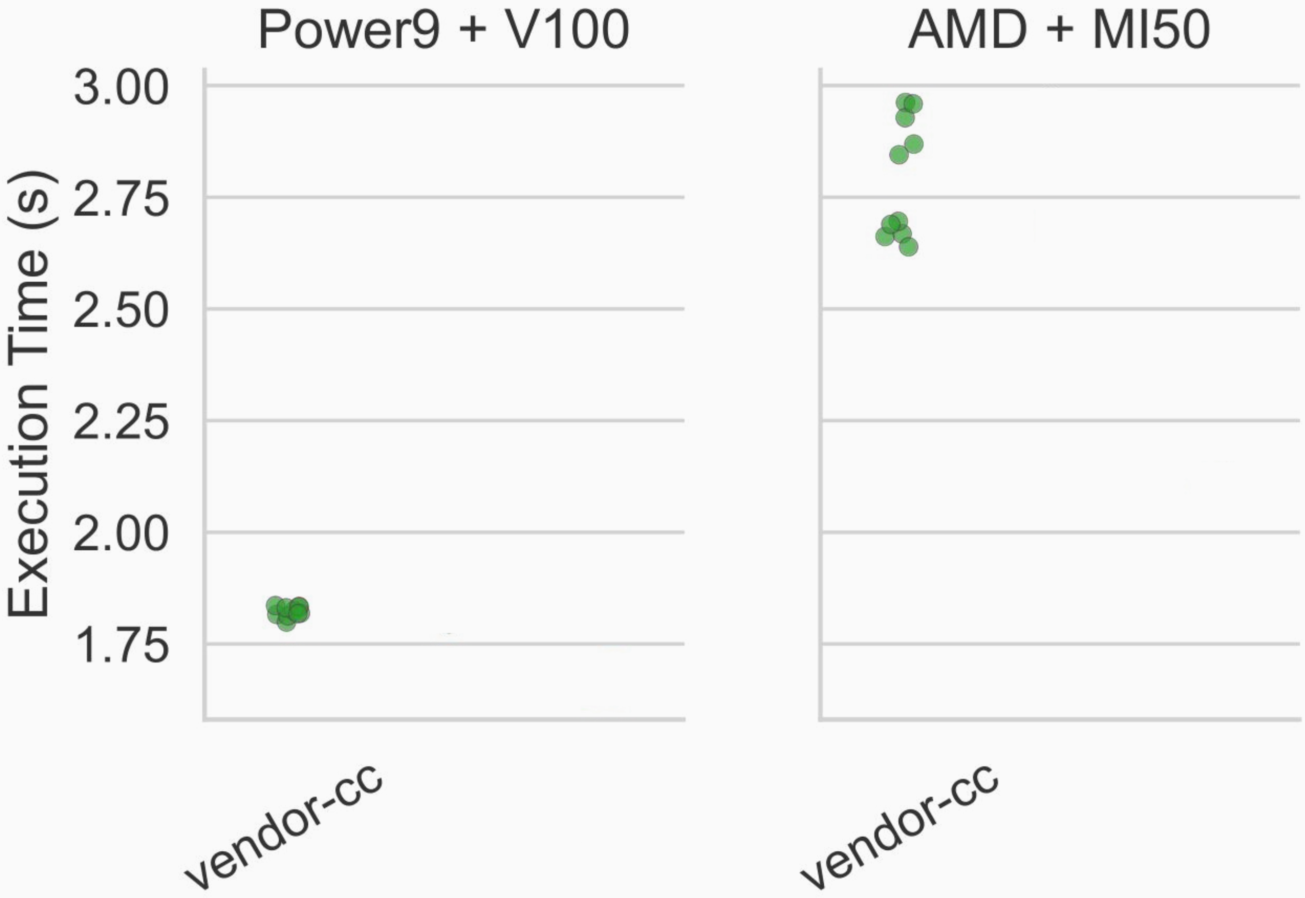
Evaluation

Performance Evaluation – XSBench



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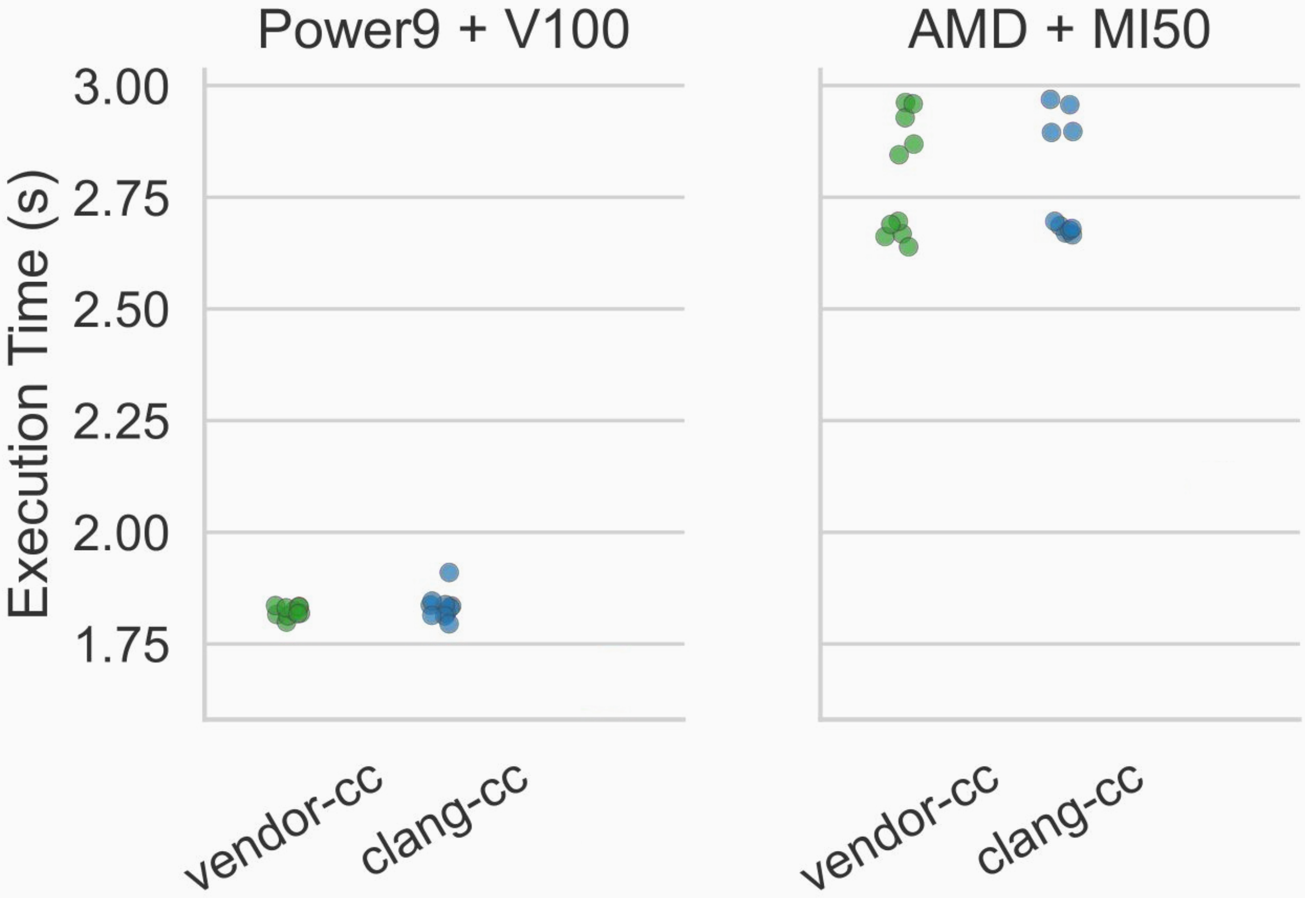

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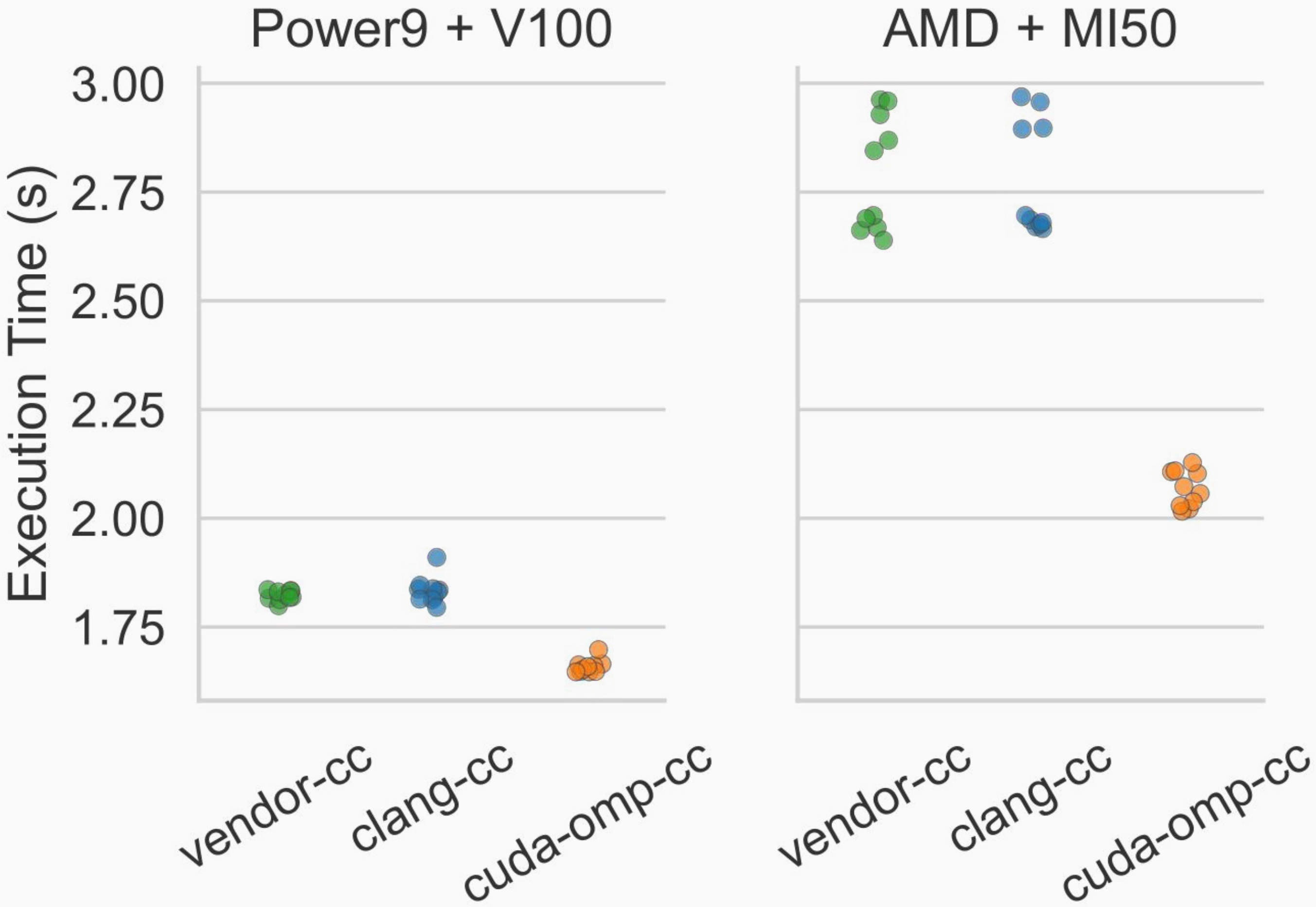

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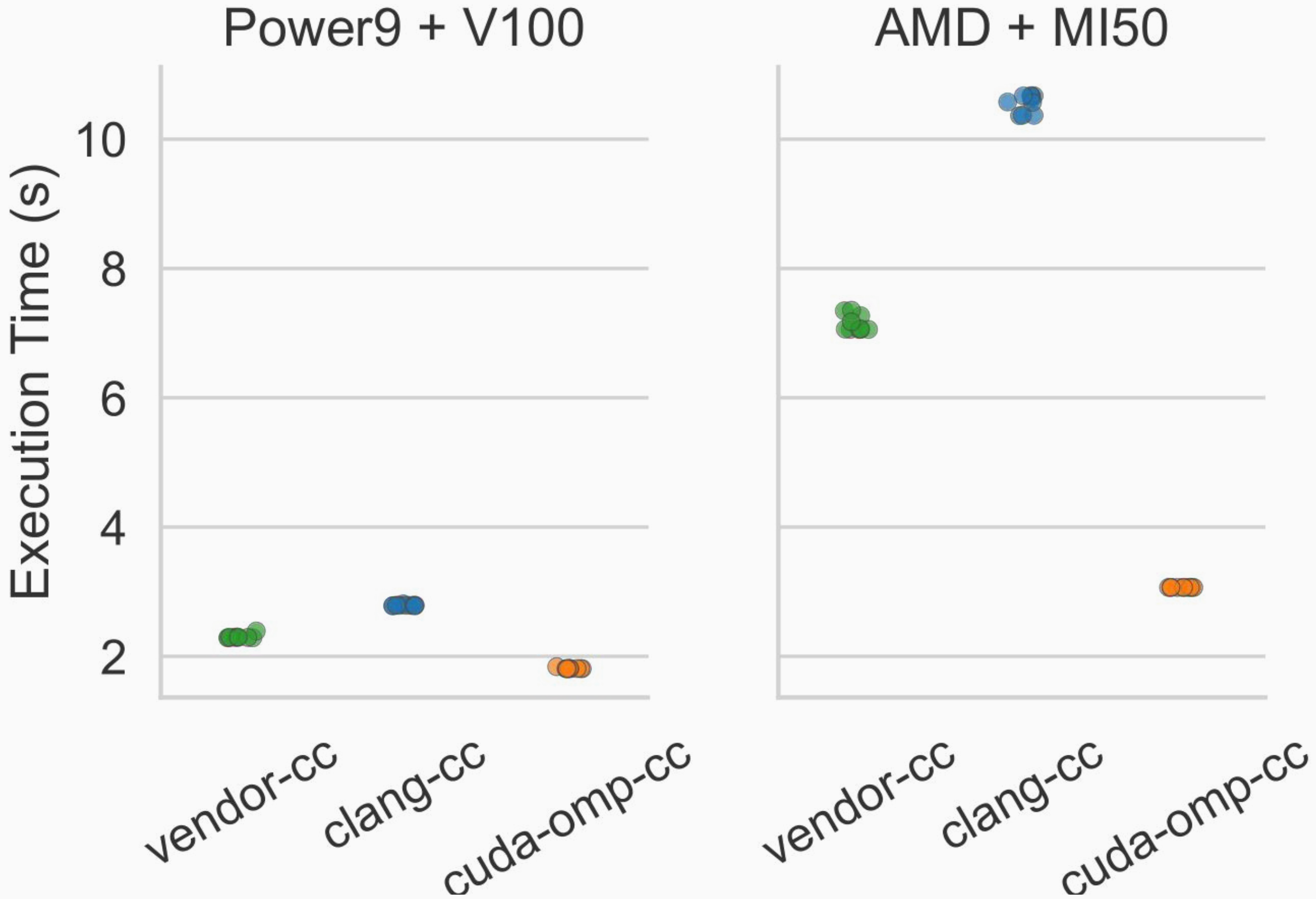
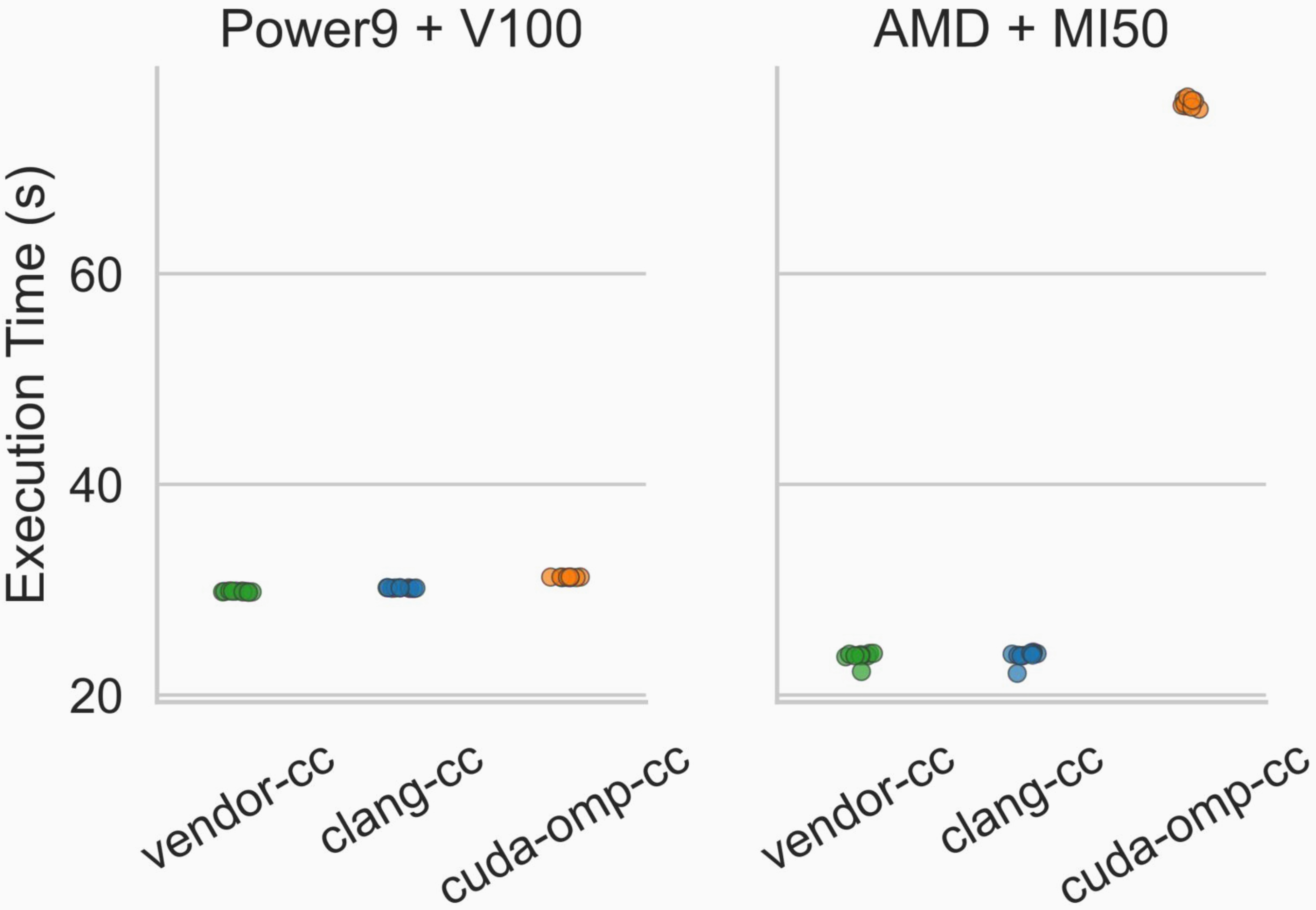


Performance Evaluation – RSBench



Performance Evaluation – Triad (Stream)