Microsoft Research Faculty Summit 2014

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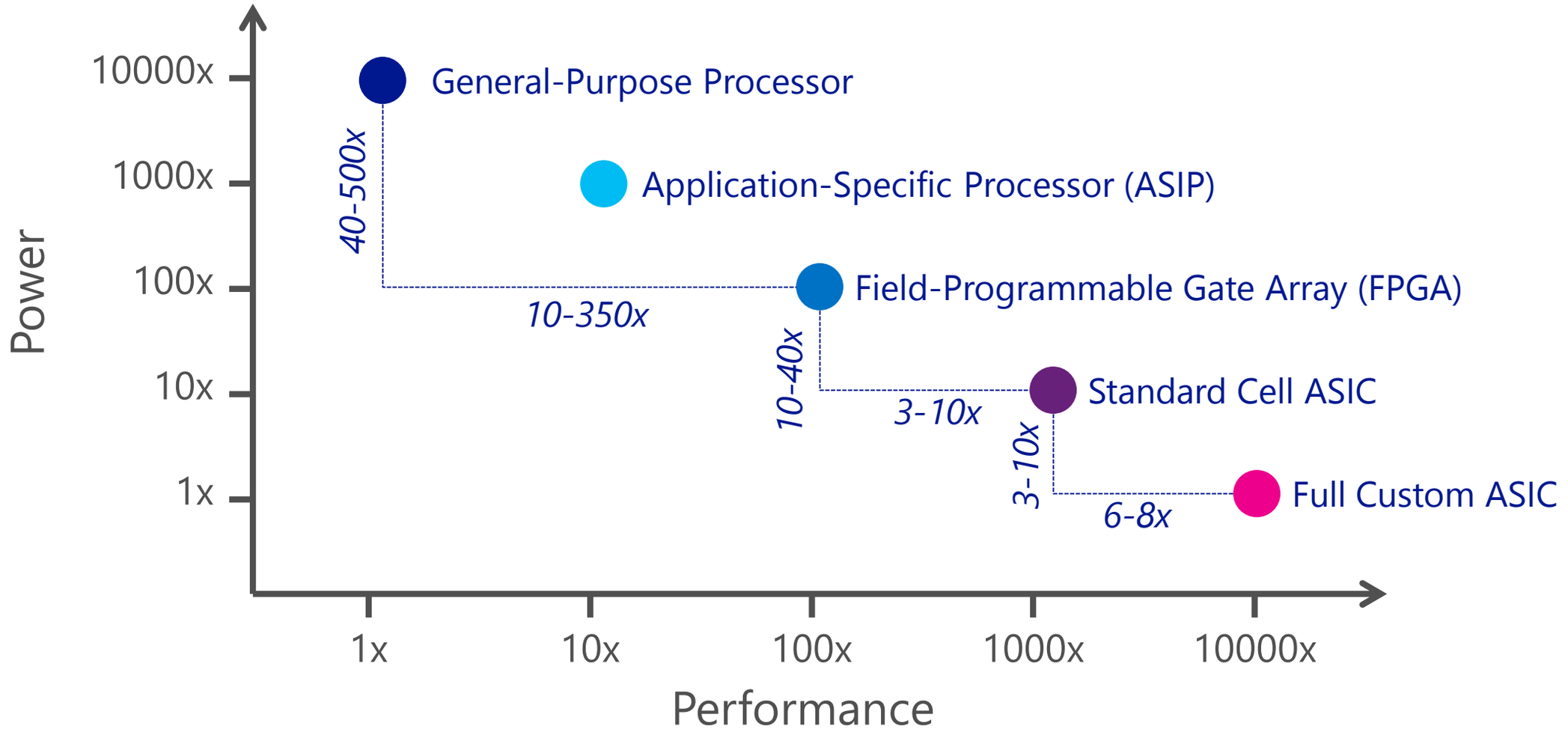
Specialization for Data Analytics

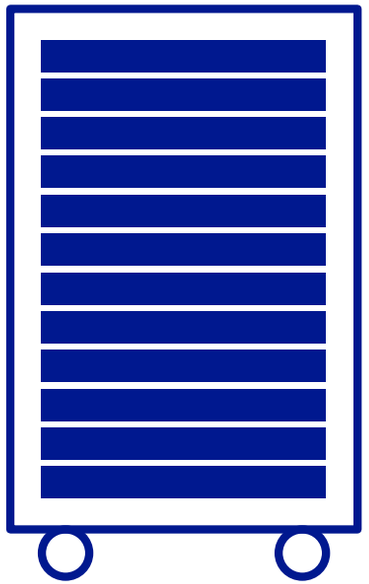
Martha Kim
Columbia University

Microsoft

Why Specialize?



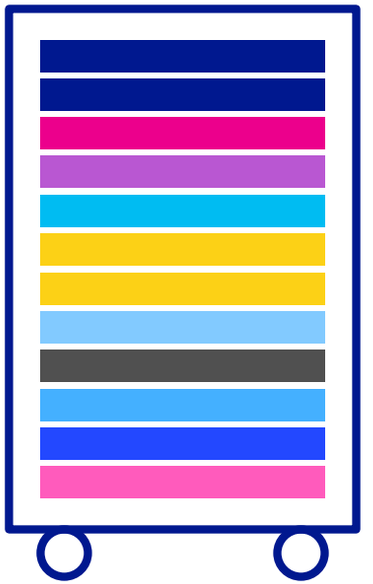
Why Not Specialize?



Homogeneous (design, maintenance)

Uniform software interface

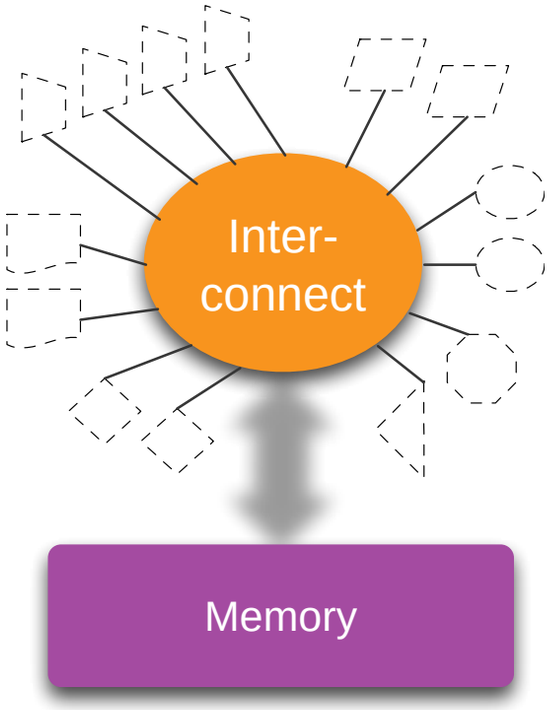
Arbitrary software



Heterogeneous

Complex, arcane

Fixed function(s)

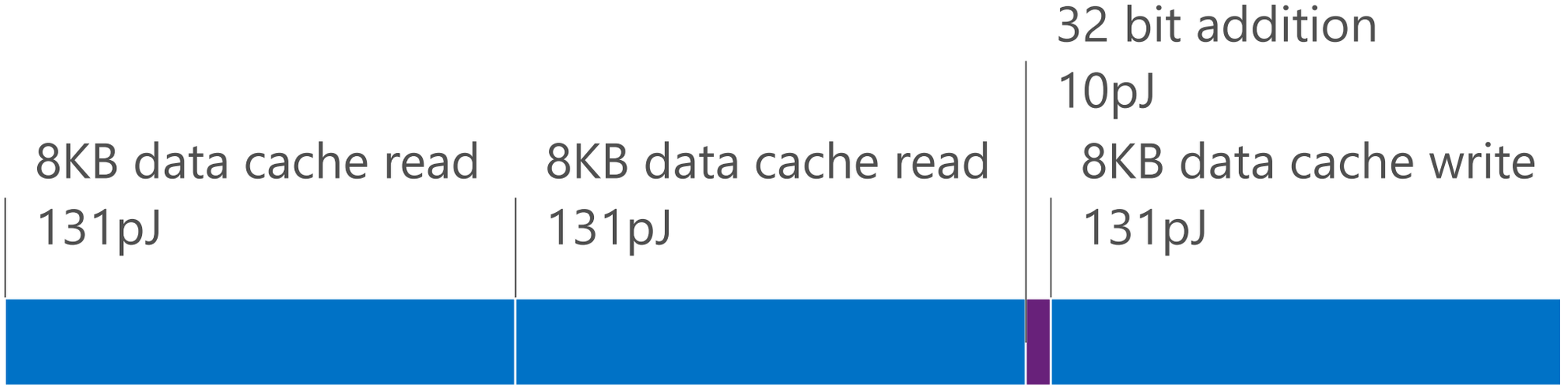


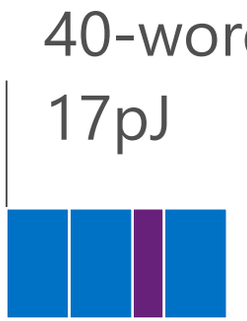
Q100
Data Processing Unit

Data Processing Unit 2.0

System Integration Challenges

Data-Centric Specialization





Data supply accounts for 83%-97% of total energy!

["Efficient Embedded Computing", IEEE Computer, July 2008]

Q100 Database Processing Unit

- Targets analytical queries (not updates or txns)
- Hardware implementations of relational operators
- Processes streams representing columns or tables
- Spatial and temporal ISA

Query

```
SELECT s_season, SUM(s_qty) as sum_qty
FROM sales
WHERE s_shipdate >= ‘2013-01-01’
GROUP BY s_season
ORDER BY s_season
```

Plan

Program

Result

Query

Plan

Program

Result

```
SELECT s_season, SUM(s_qty) as sum_qty
FROM sales
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```
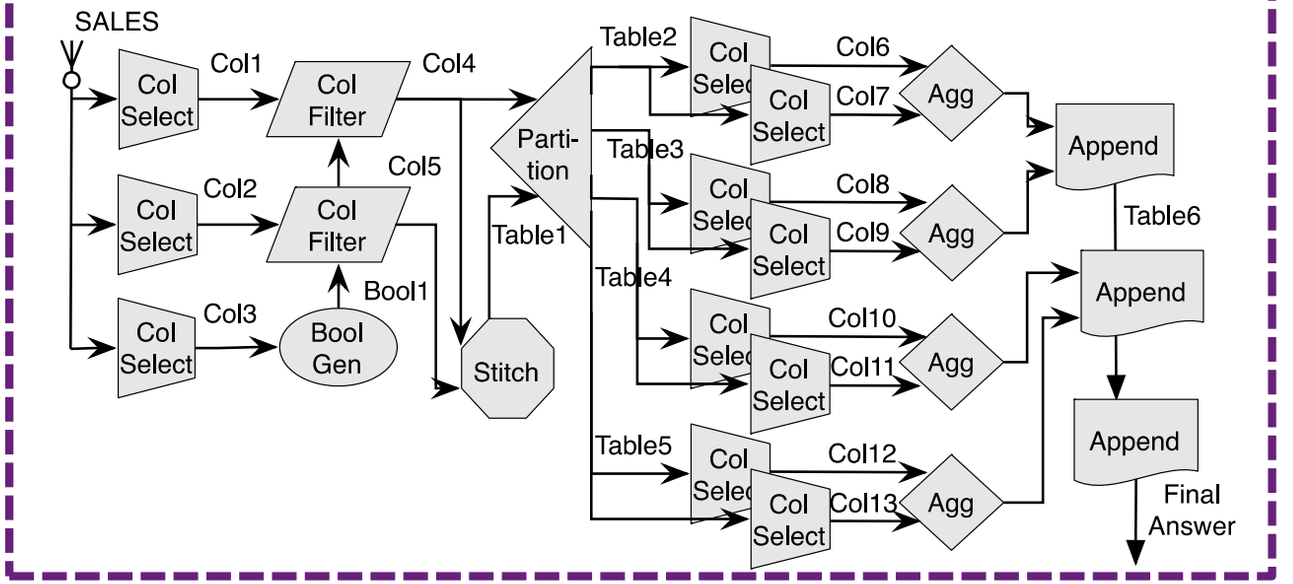
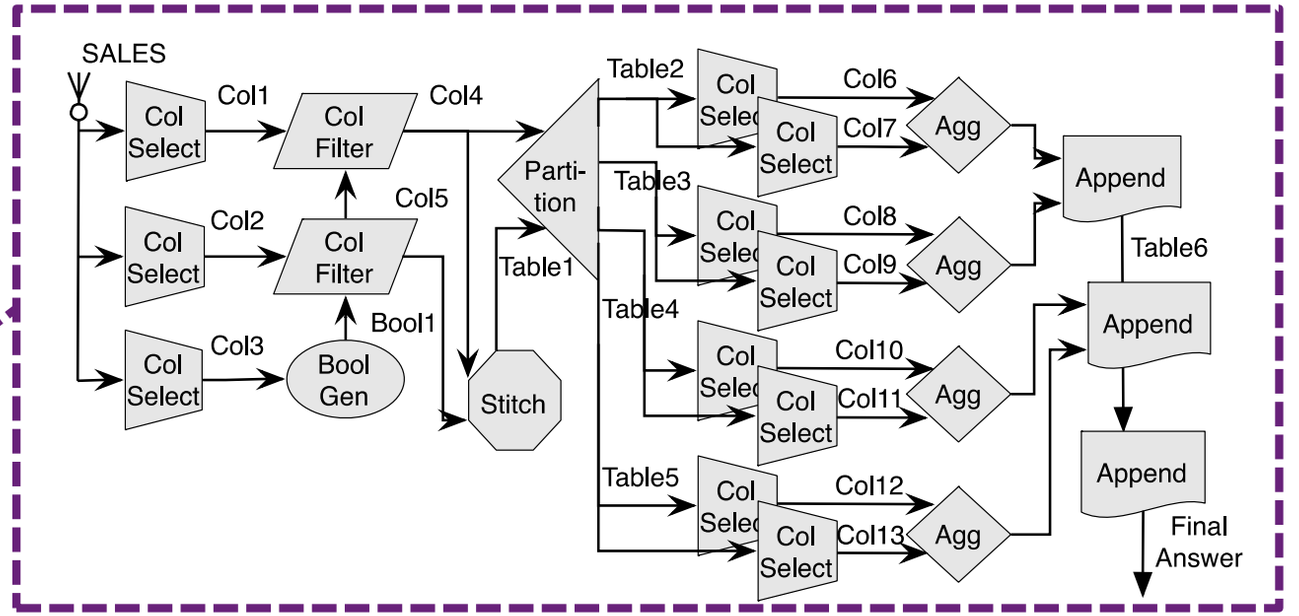



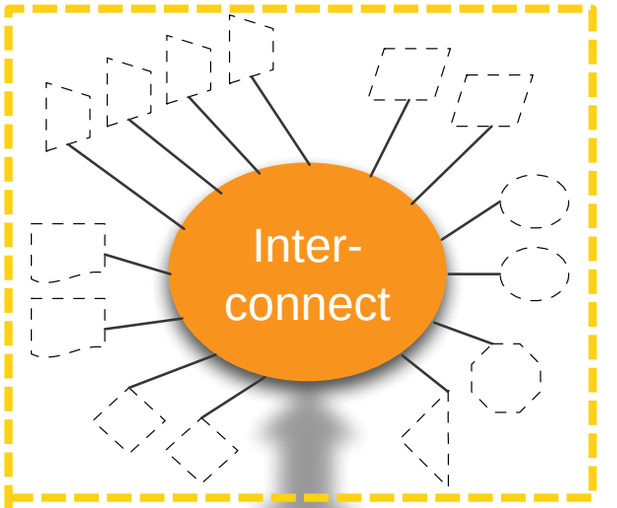
Query

Plan

Program

Result





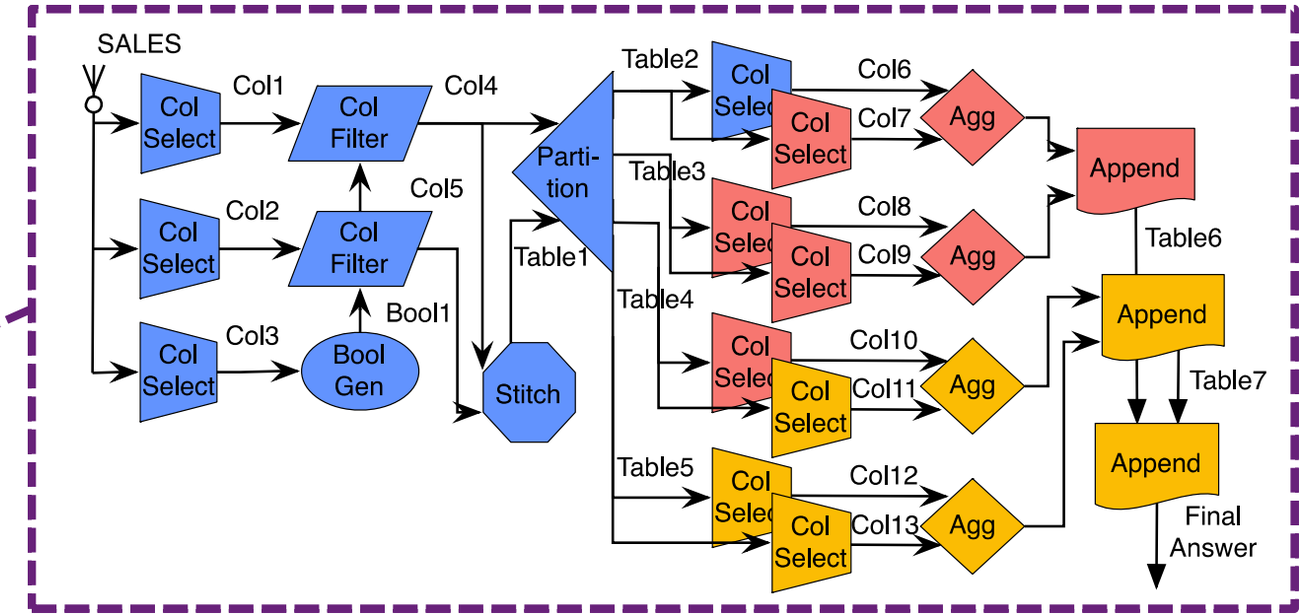
Q100 Device

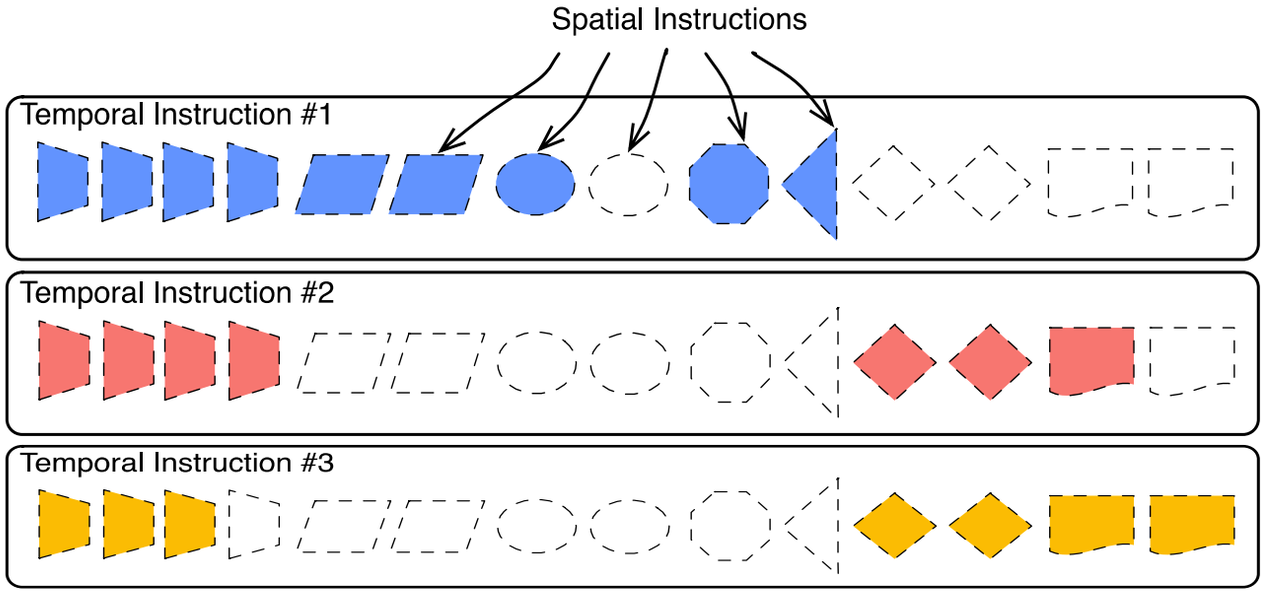
Query

Plan

Program

Result



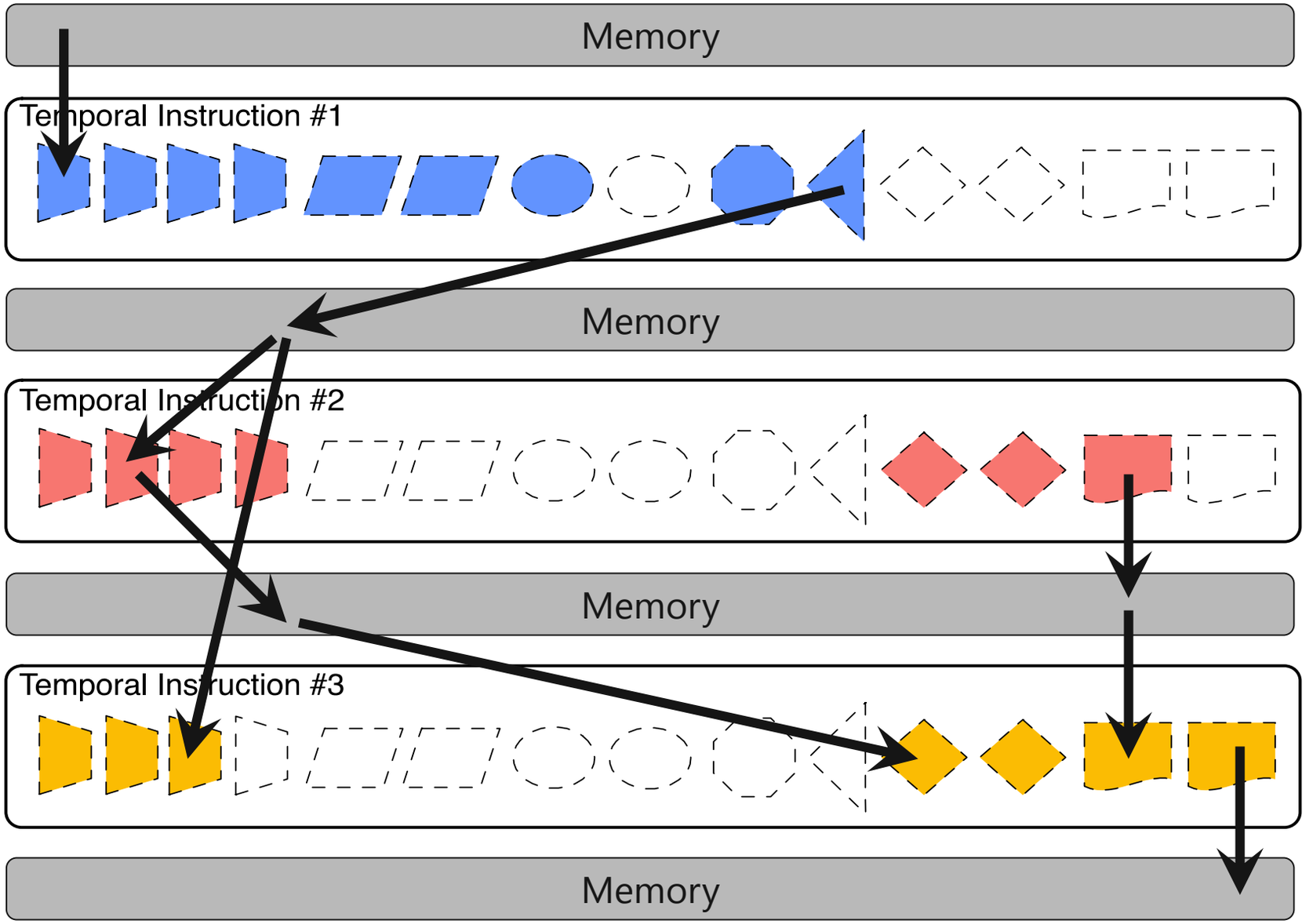


Query

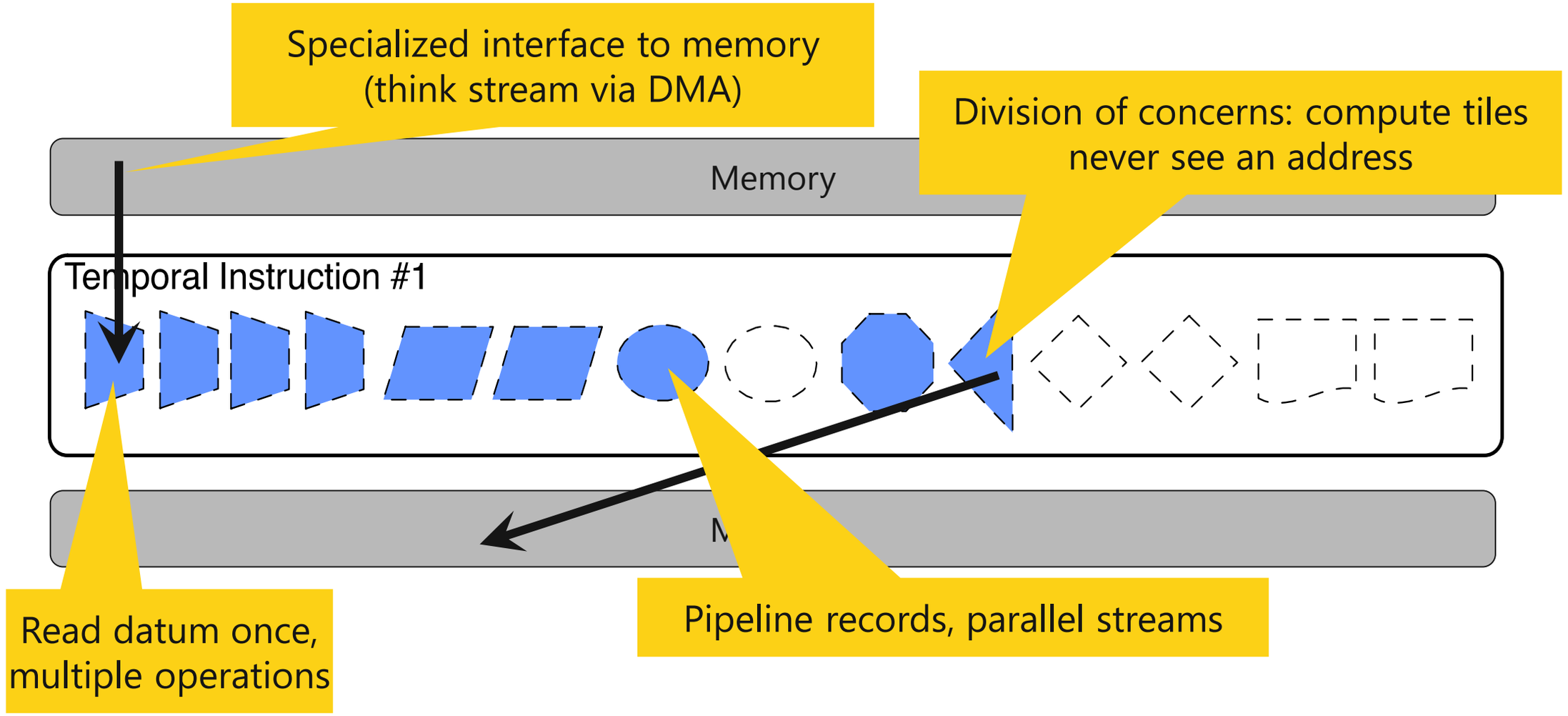
Plan

Program

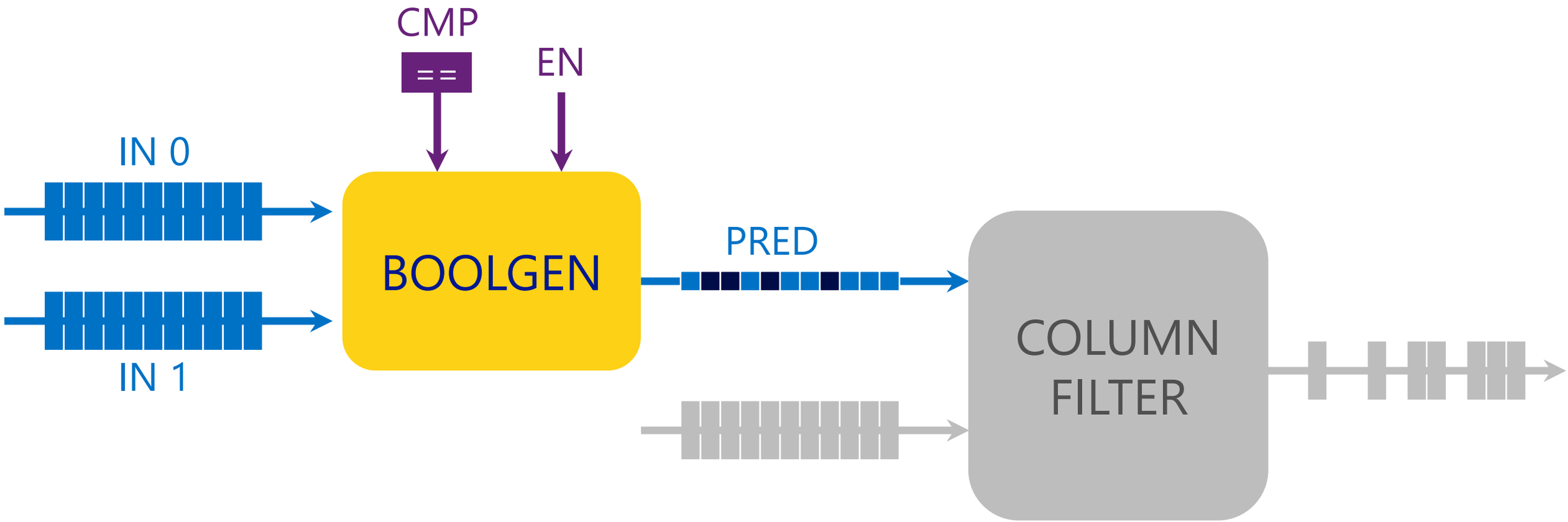
Result



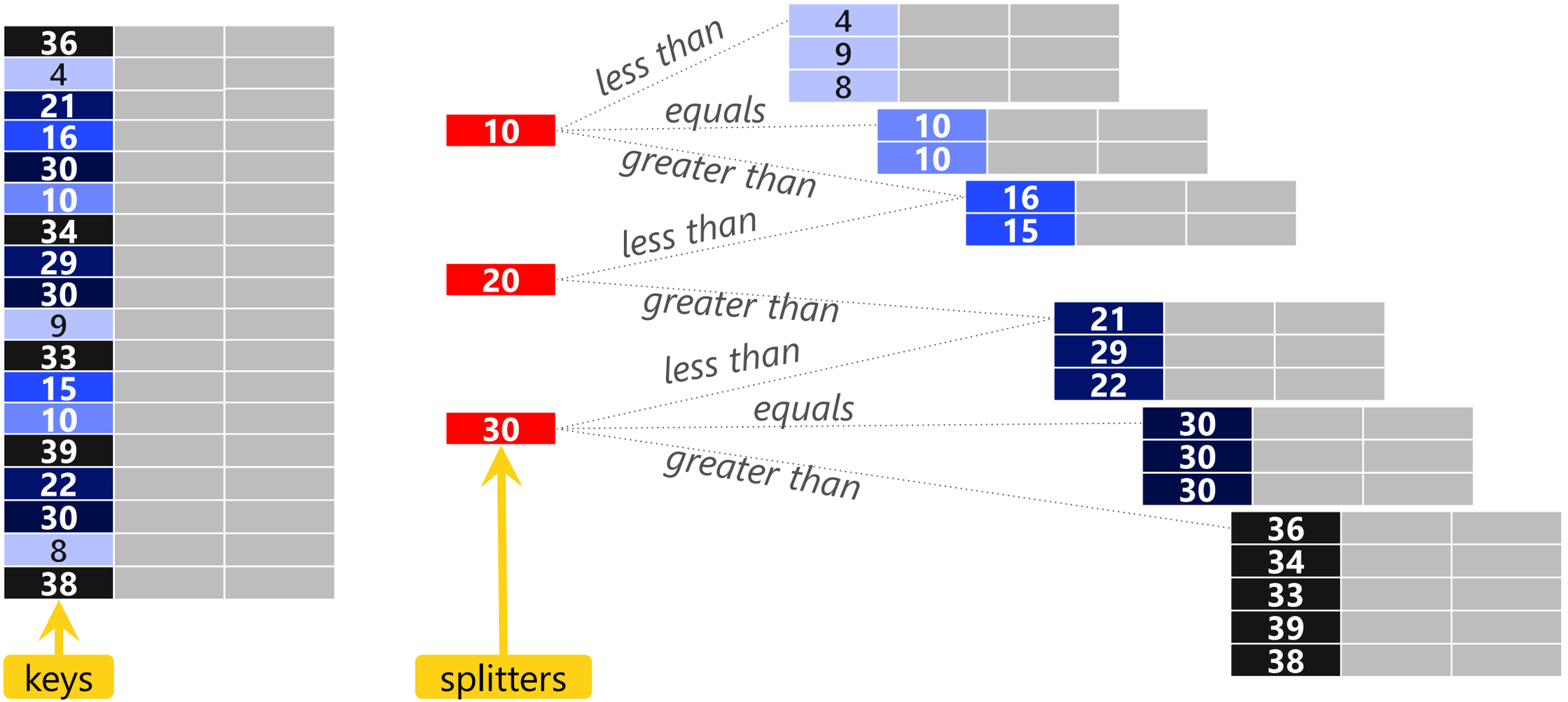
Key Sources of Efficiency



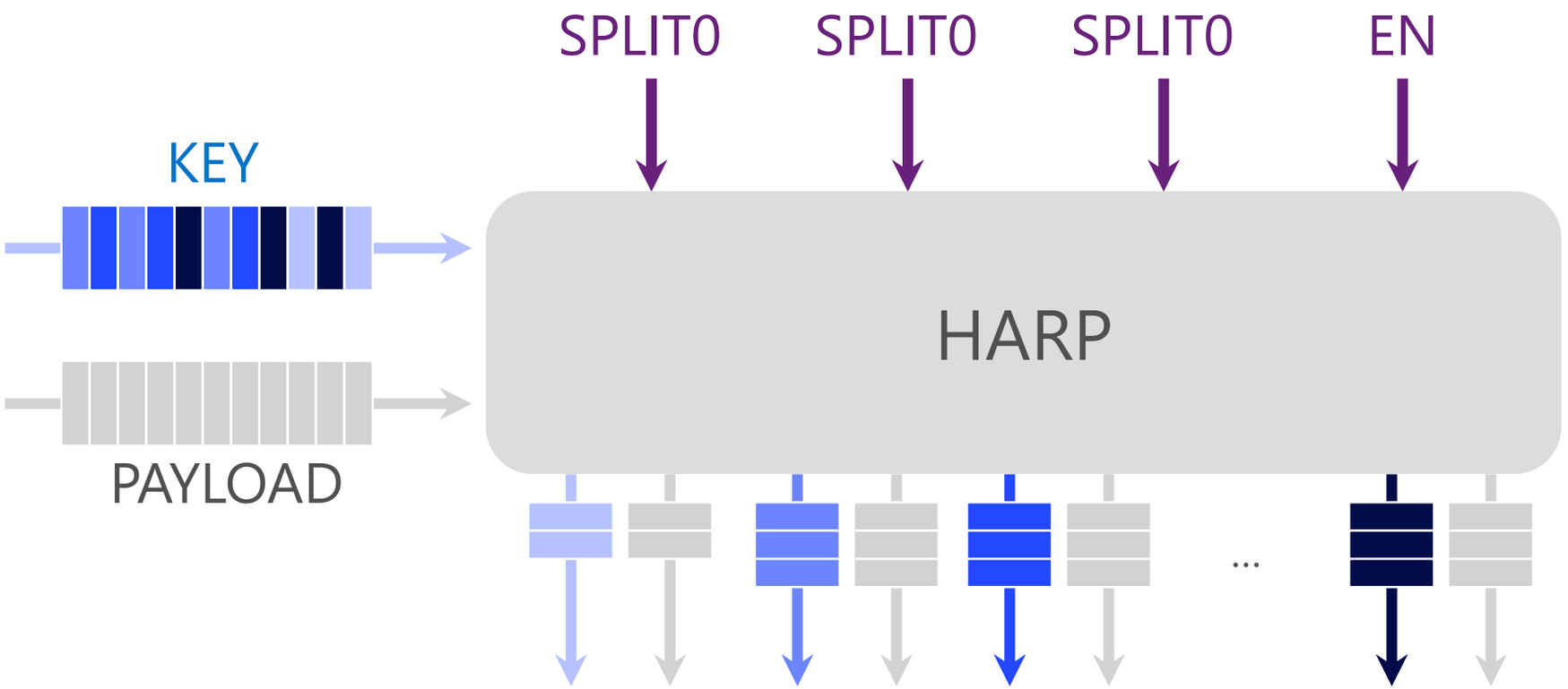
Example Tile: BoolGen



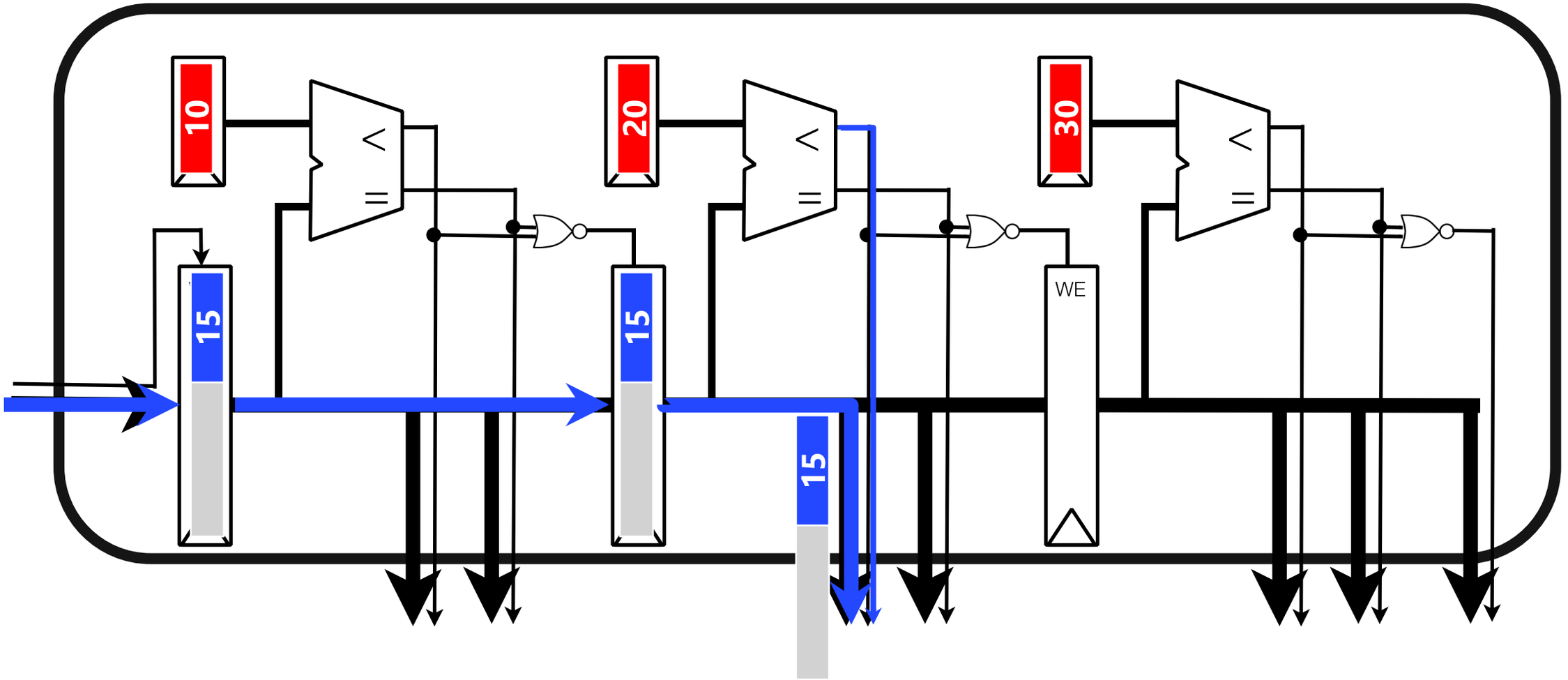
Range Partitioning Operation



Hardware Accelerated Range Partitioner (HARP)

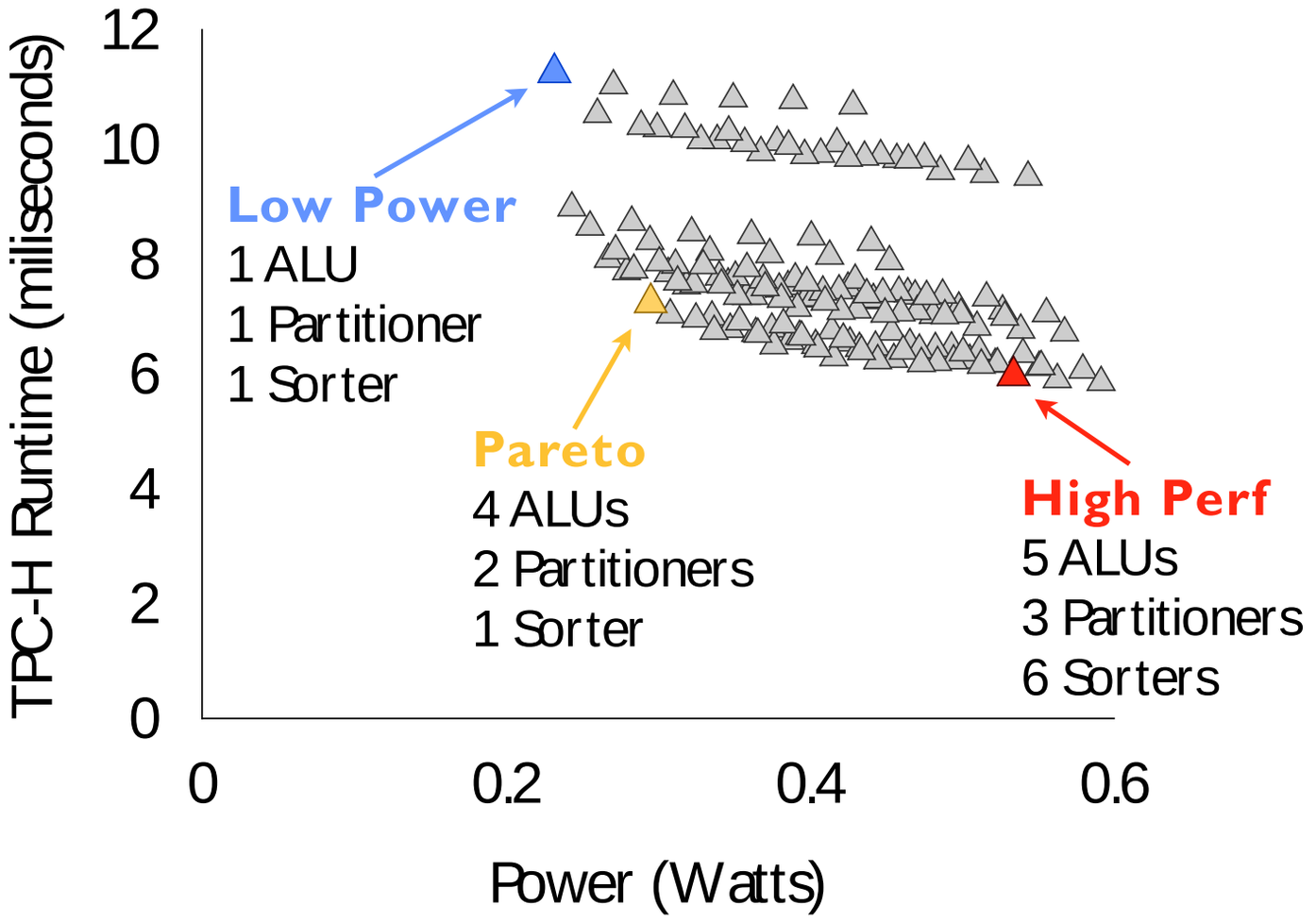


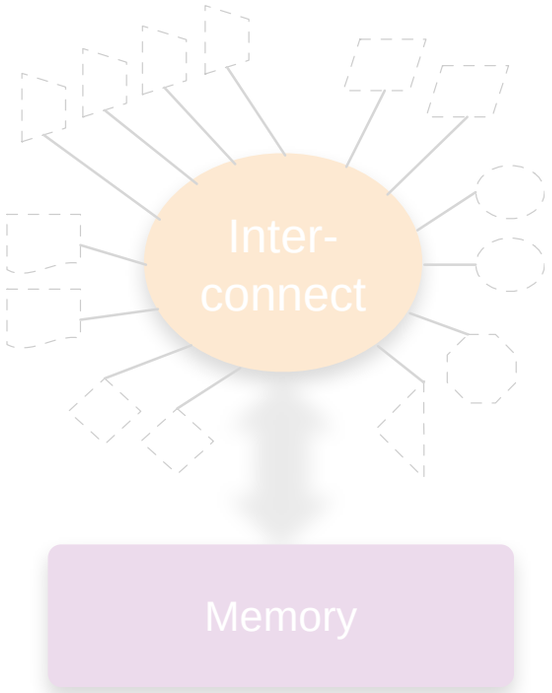
HARP Tile Internals



Tile Characterization

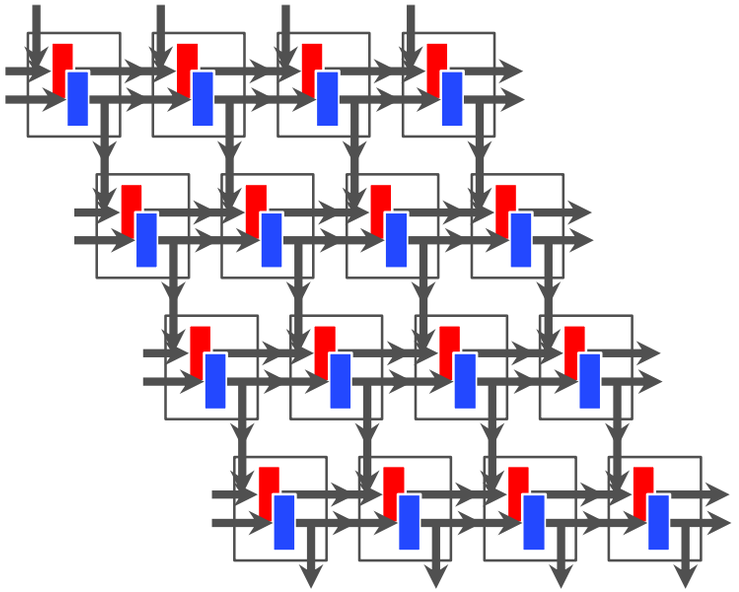
AGG ALU BOOLGEN COLFILTER JOIN PART SORT APPEND COLSELECT CONCAT STITCH


TPC-H Runtime (miliseconds)
12
10
8
6
4
2
0
0
0.2
0.4
0.6
Power (Watts)
Low Power
1 ALU
1 Partitioner
1 Sorter
Pareto
4 ALUs
2 Partitioners
1 Sorter
High Perf
5 ALUs
3 Partitioners
6 Sorters



Q100
Data Processing Unit

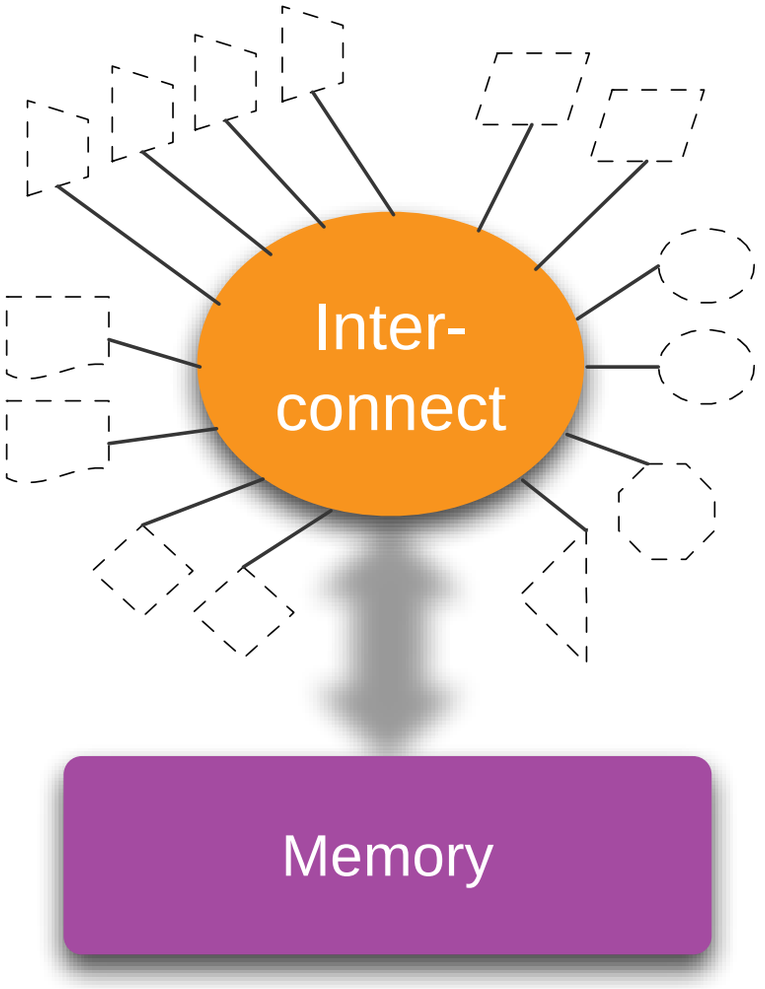
Data Processing Unit 2.0



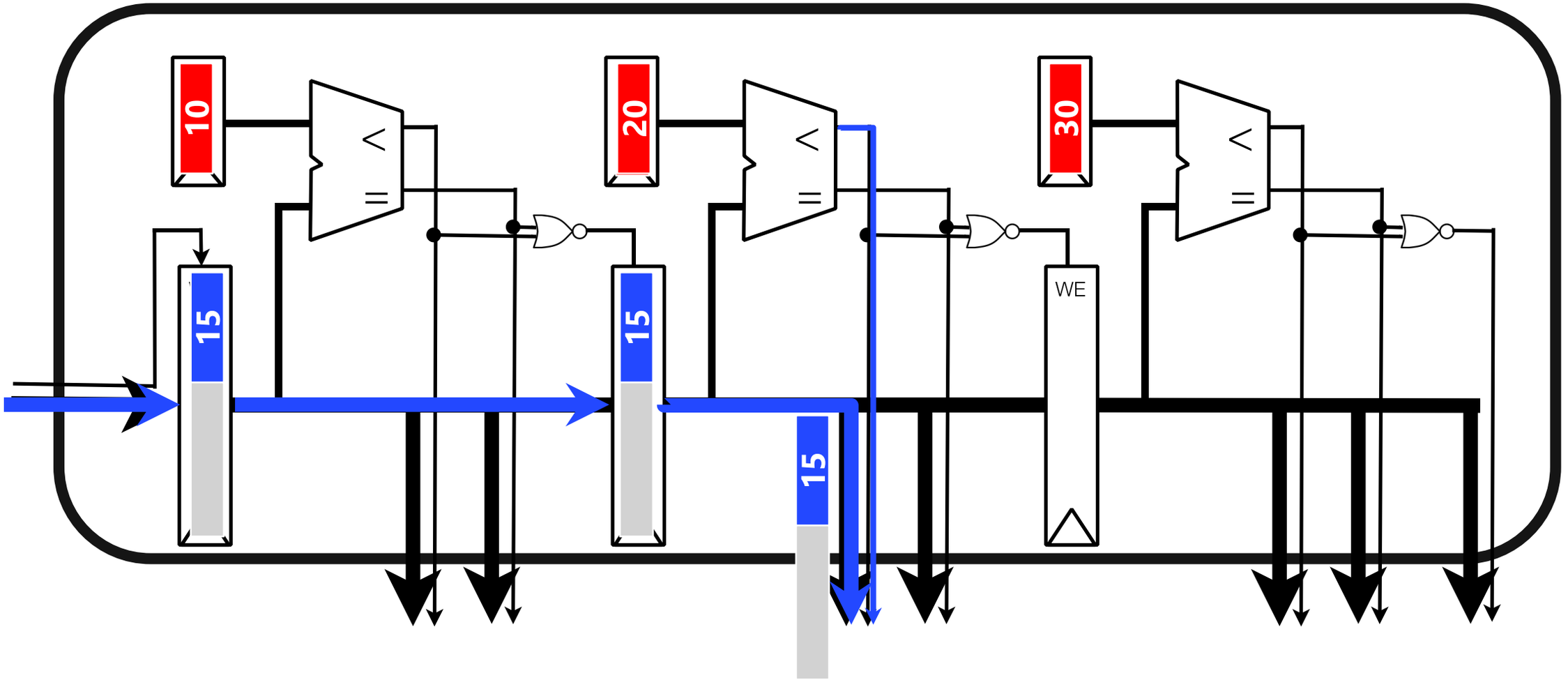
System Integration
Challenges

Is a heterogeneous design best?

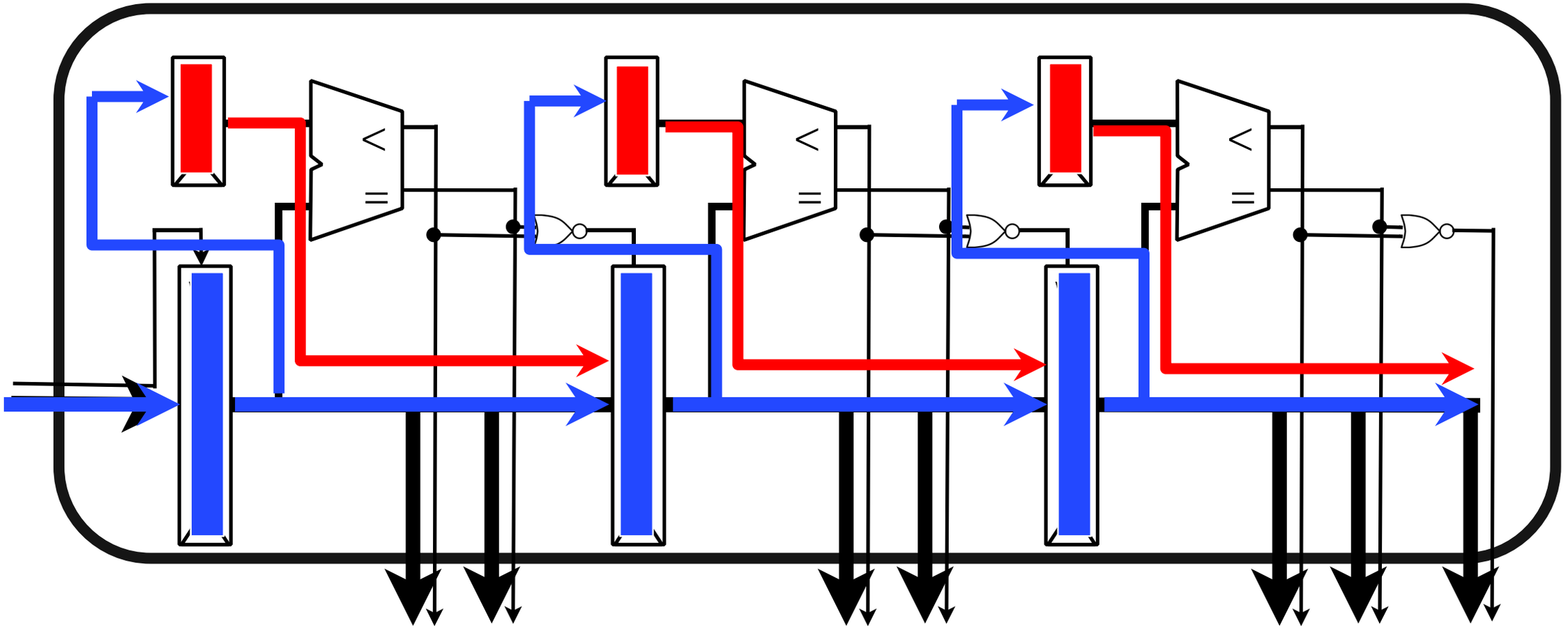
- Tiles are unitaskers
- Yet, they have a lot in common
- Irregular connectivity, tricky NoC
- Ad-hoc support for non-streaming operators



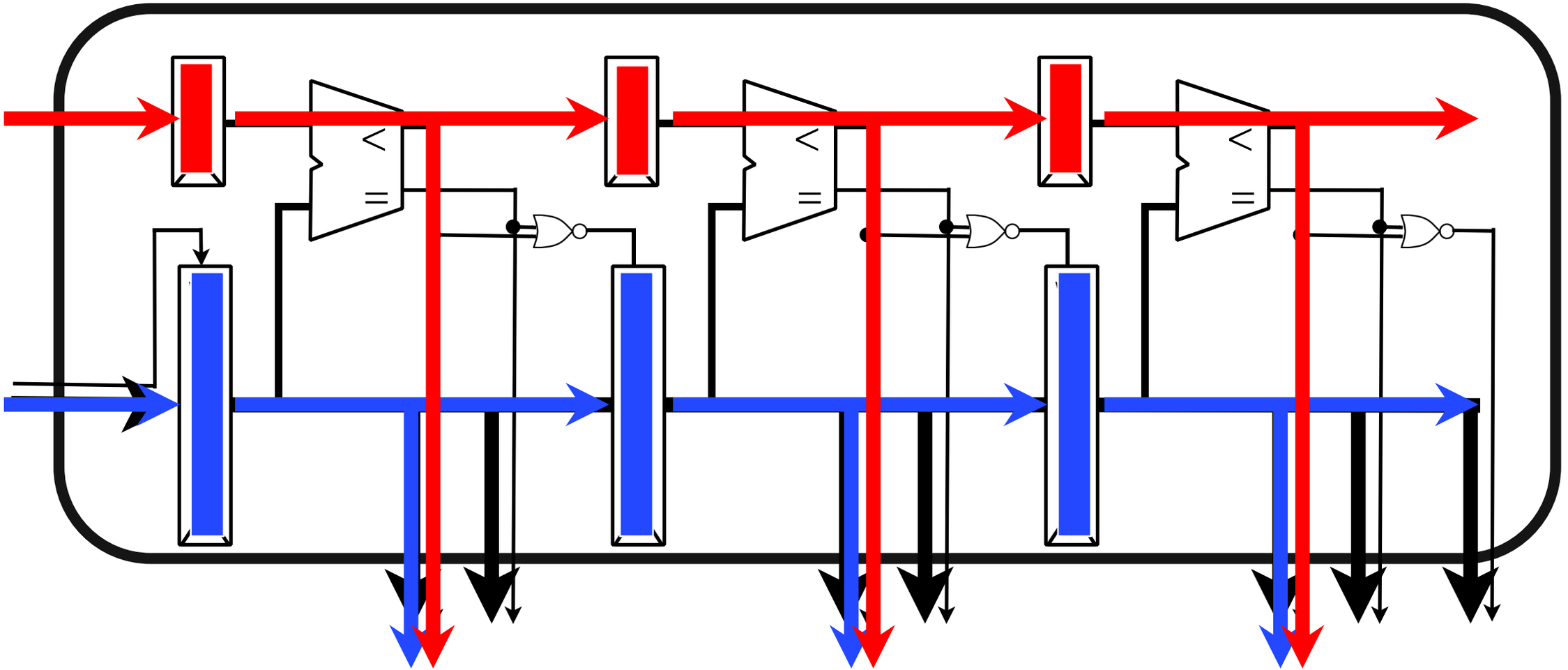
Recall the Partitioner



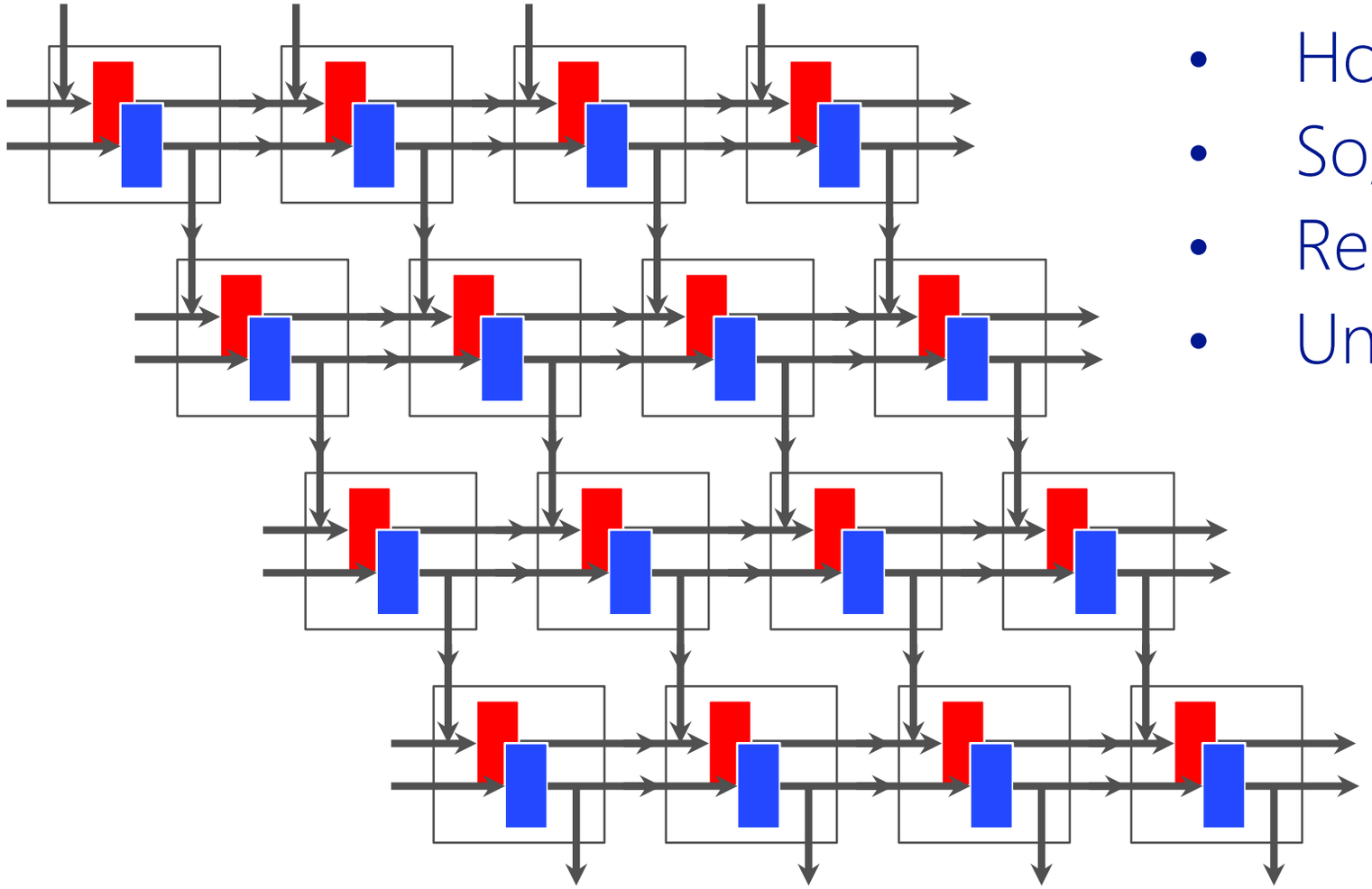
Just a Small Step to Merge…



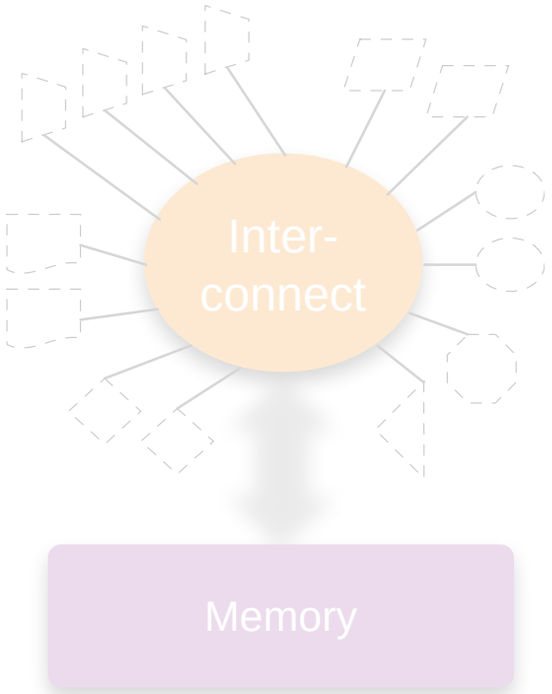
Or to Nested Block Loop Join.



Programmable, Homogeneous DPU

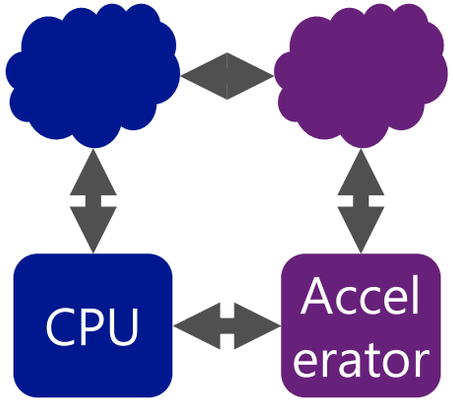


- Homogeneous resources
- So, better usage
- Regular, point-to-point NoC
- Unified buffering and routing



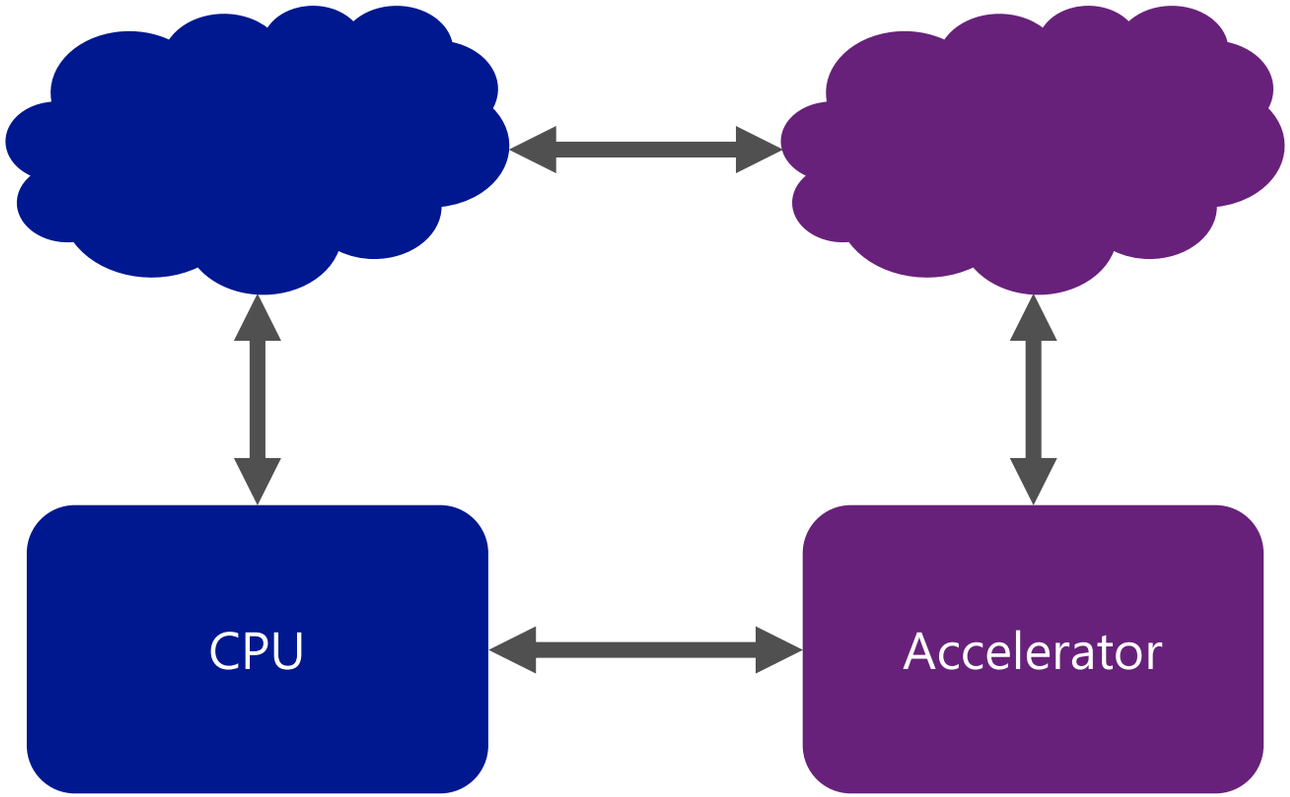
Q100
Data Processing Unit

Data Processing Unit
2.0



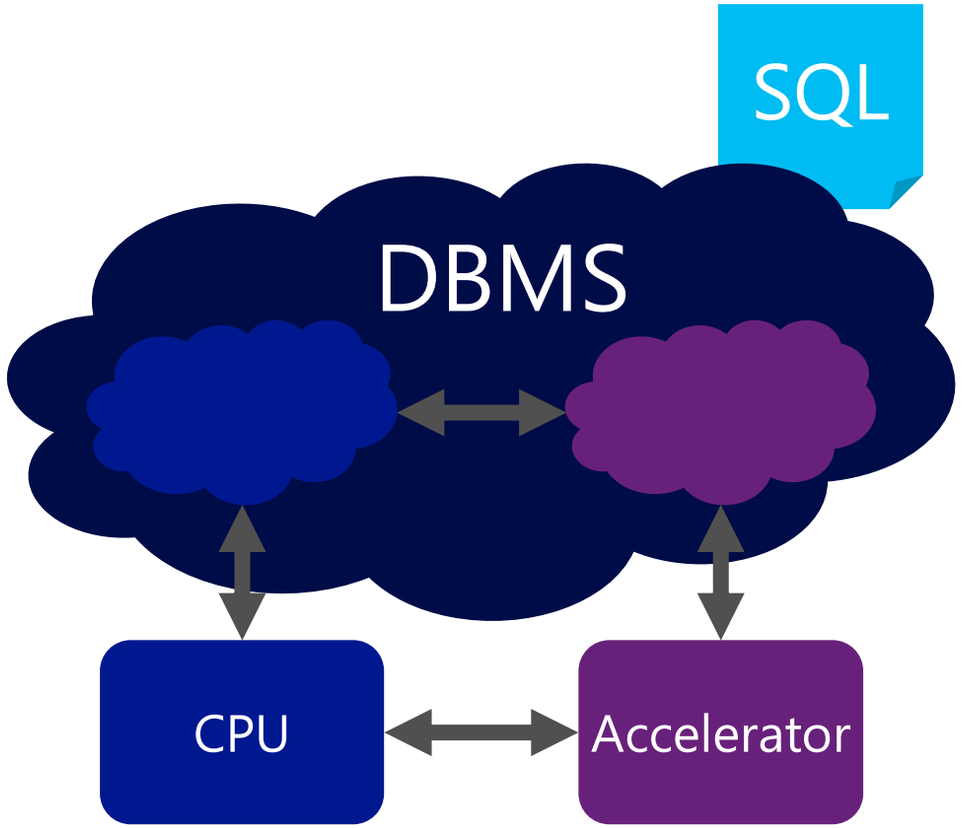
System Integration
Challenges

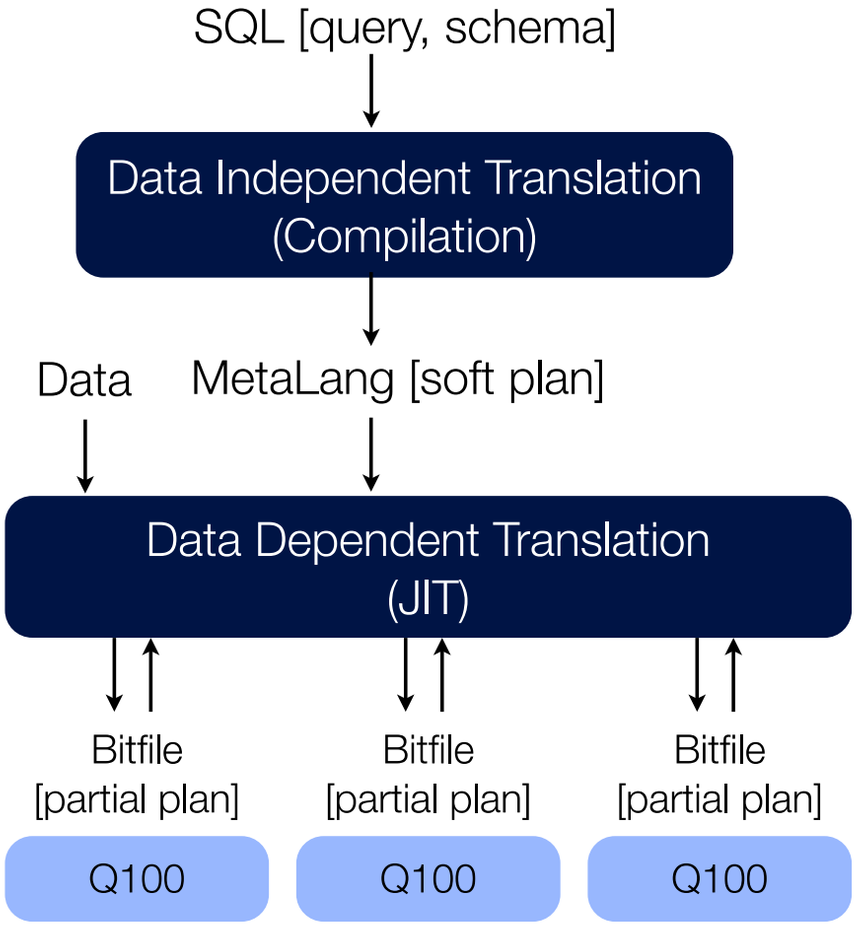
Hardware and Software Integration



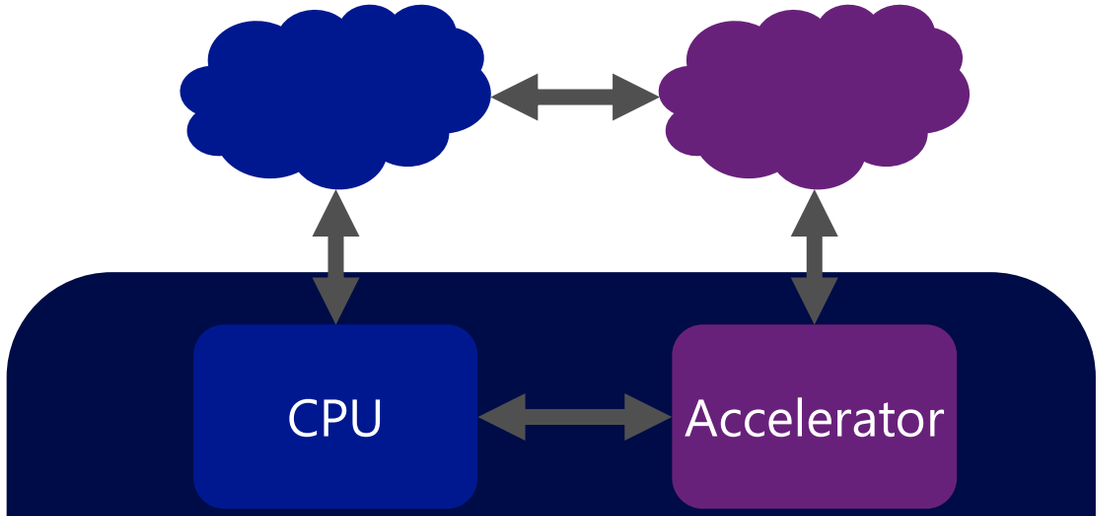
It is all one problem!

Exploit established software interfaces

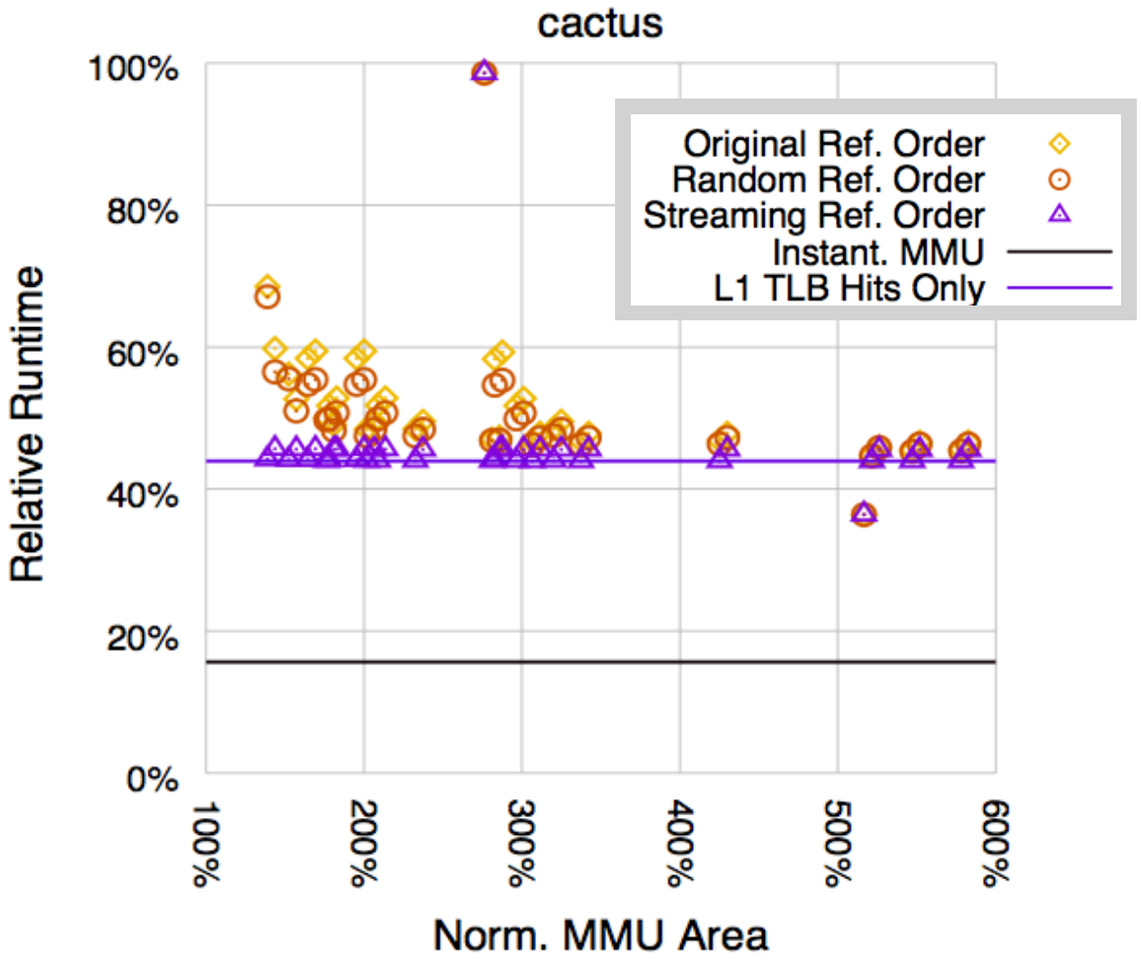




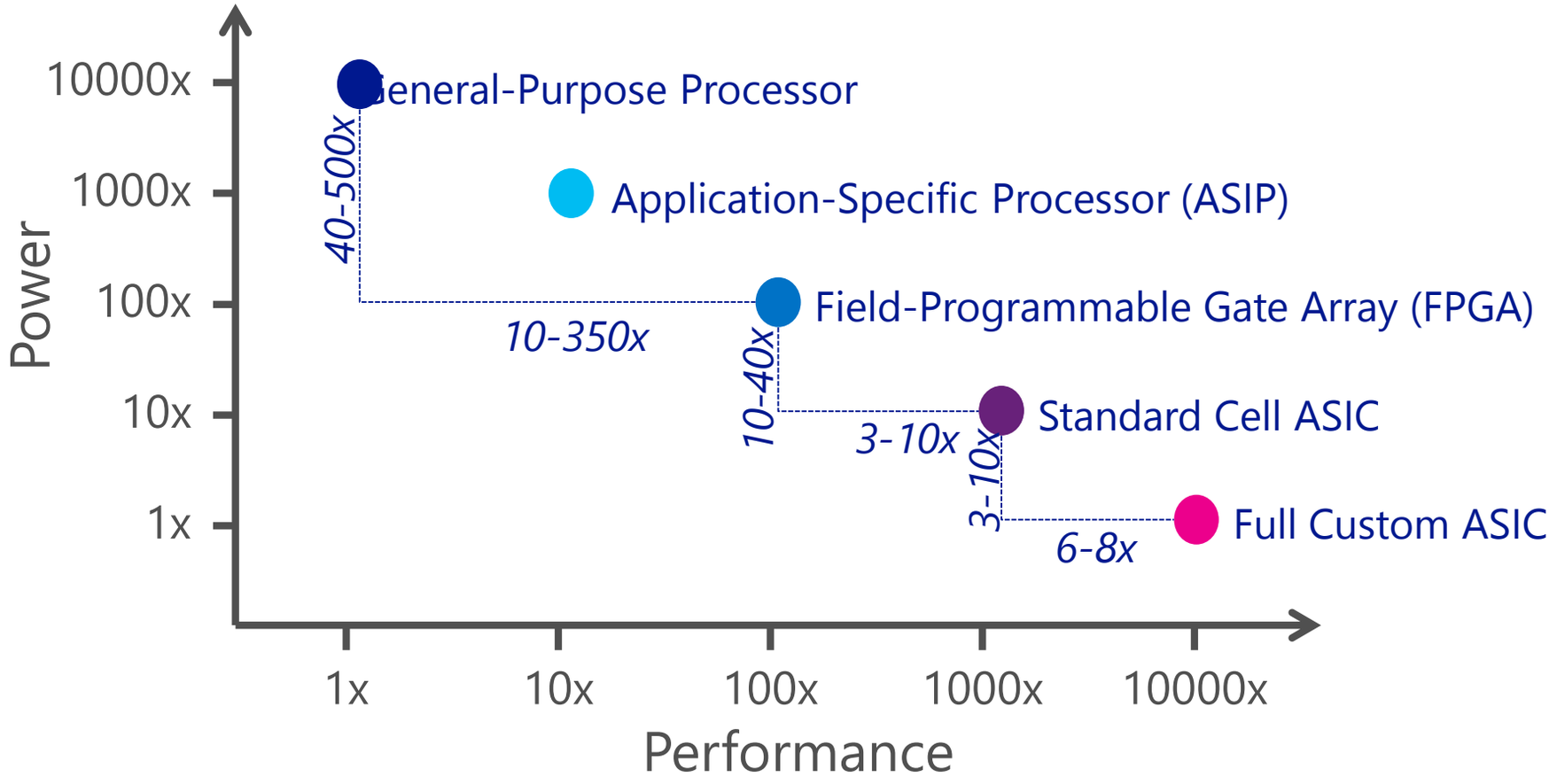
Develop software-friendly microarchitectures

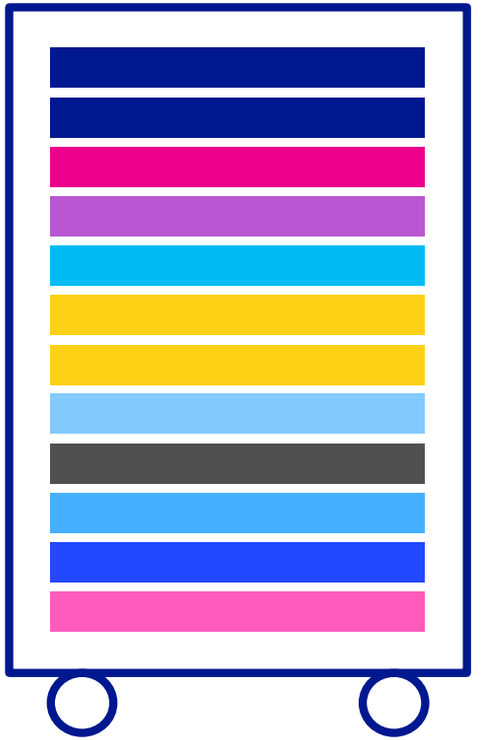


- Globally visible pointers, so no data marshaling
- No pinning pages for accelerator
- Efficient virtual to physical address translation



How To ~~Why~~ Specialize?





Thank You

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Save the planet and return
your name badge before you
leave (on Tuesday)

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