SeBS: a Serverless Benchmark Suite for Function-as-a-Service Computing

Marcin Copik, Grzegorz Kwasniewski, Maciej Besta, Michal Podstawski, Torsten Hoefler

What is serverless?

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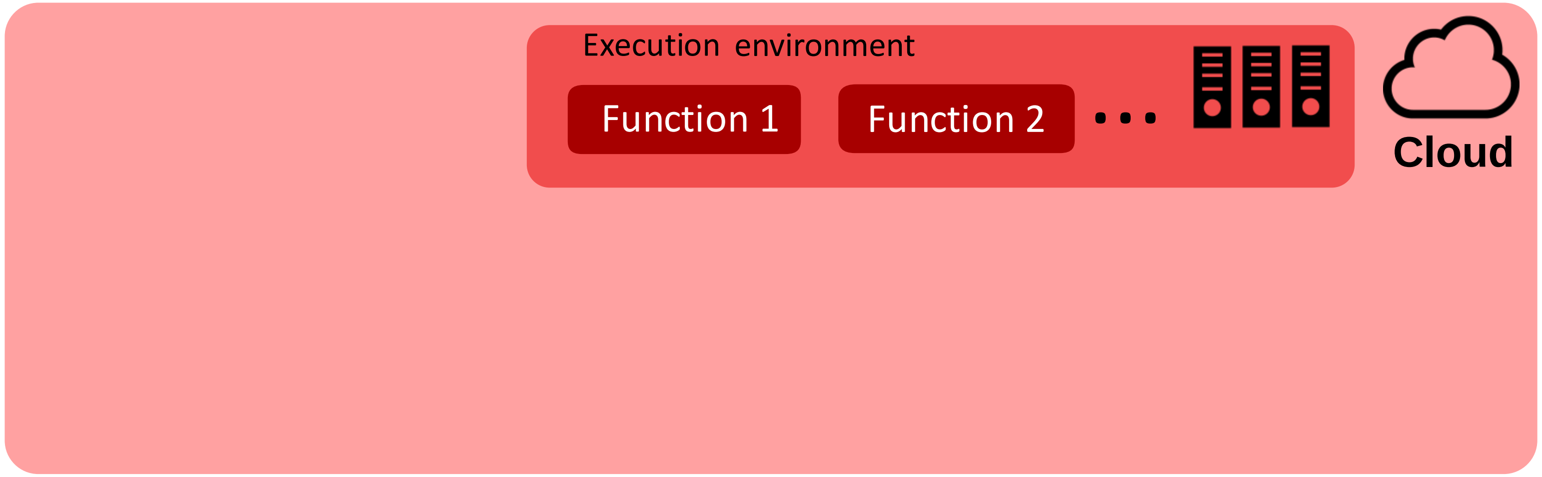

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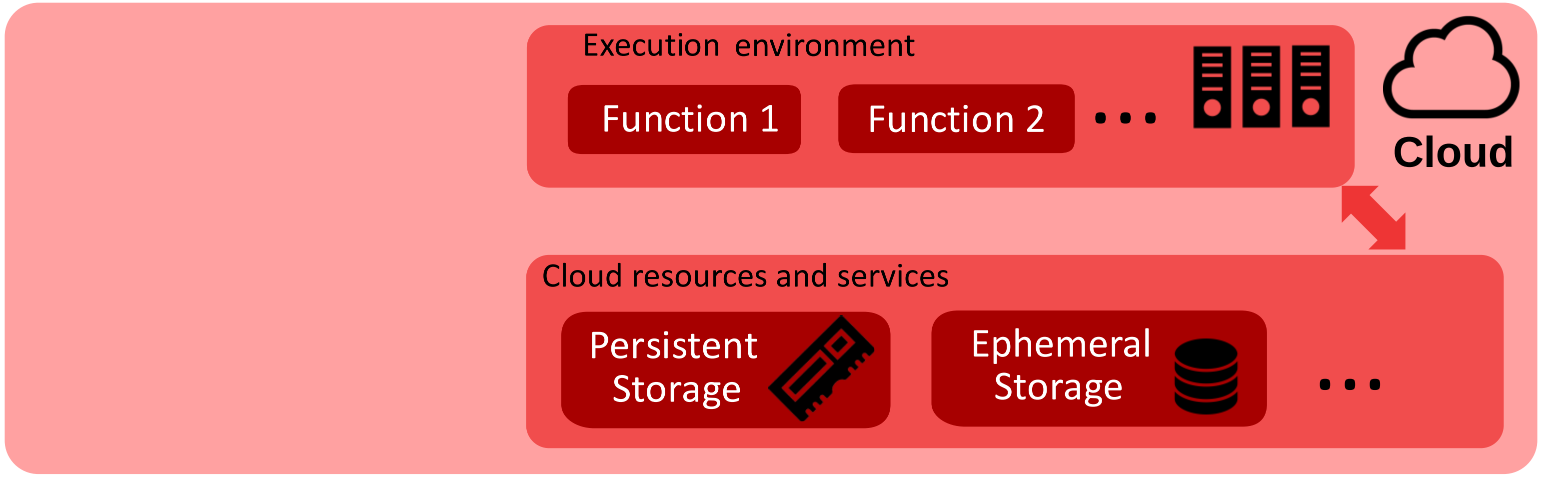

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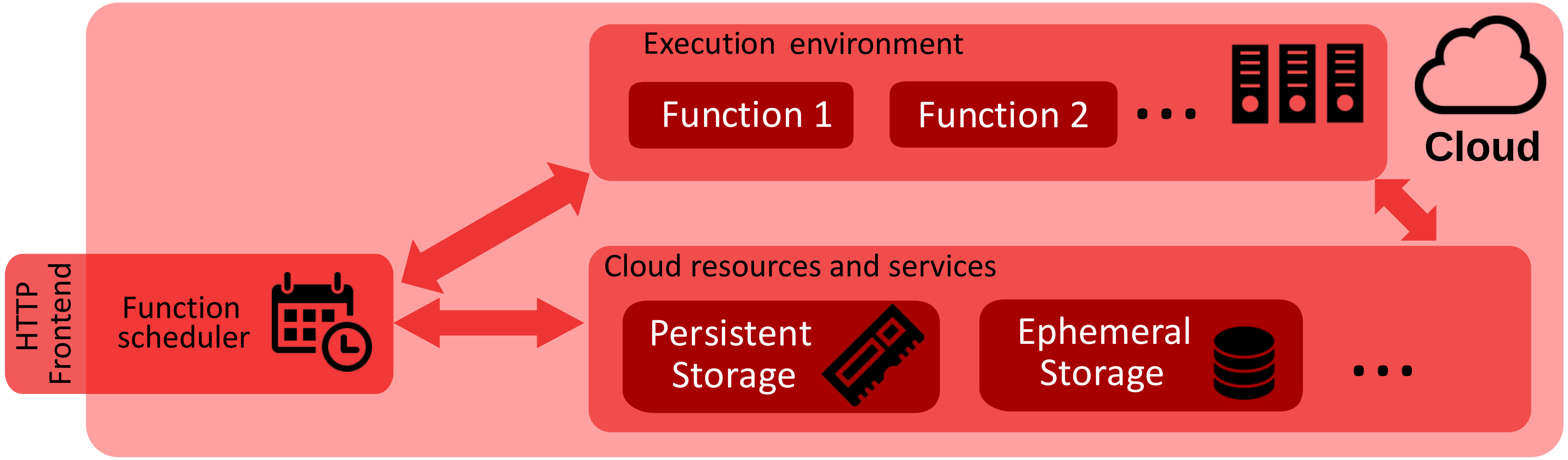

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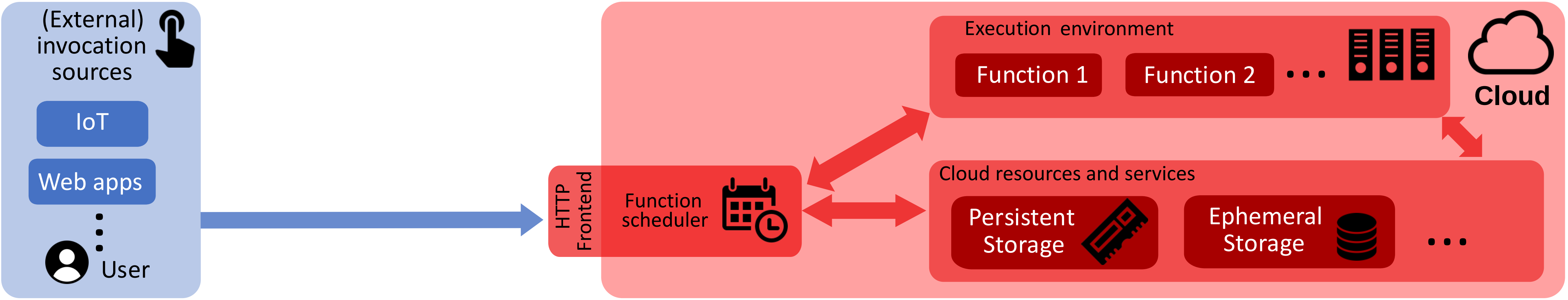

Serverless – why & why not?

User

Cloud Provider

Serverless – why & why not?

User

- Pay-as-you-go billing
- Massive parallelism
- Simplified deployment
- Architecture agnostic

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- Variable performance
- Vendor lock-in
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- Handling heterogeneity
- Micro-architecture effects

Commercial serverless systems

Policy	AWS Lambda	Azure Functions	Google Cloud Functions

Commercial serverless systems

Functions
Workers

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Languages (native)	Python, Node.js, C#, Java, C++, etc.	Python, TypeScript, C#, Java, etc.	Node.js, Python, Java, Go.

Commercial serverless systems

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Memory
configuration

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Function Model

Commercial serverless systems

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Billing	Duration and declared memory.	Average memory use, duration.	Duration, declared CPU and memory.
Deployment	zip package up to 250 MB.	zip package, Docker image.	zip package, up to 100 MB.
Time Limit	15 minutes	10 min / 60 min / unlimited.	9 minutes.

Function Model

CPU Allocation

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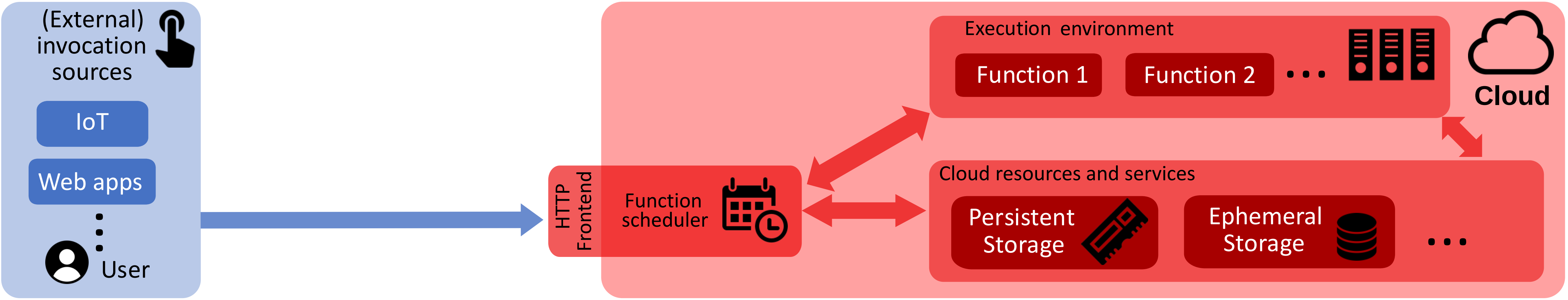

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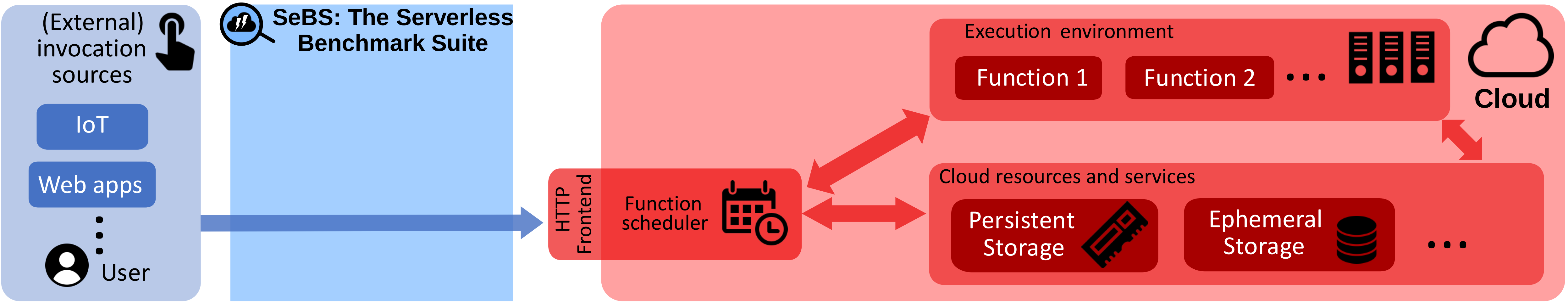

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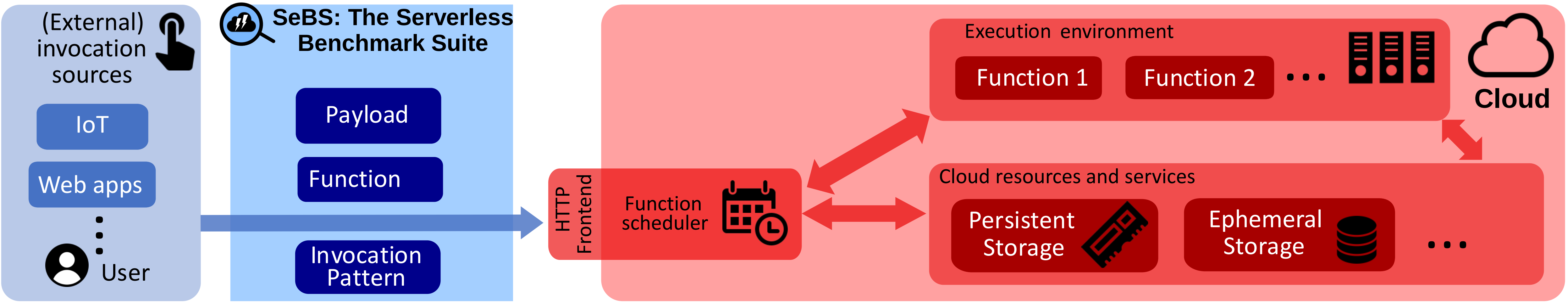

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Results and Insights

	Results, methods, and insights

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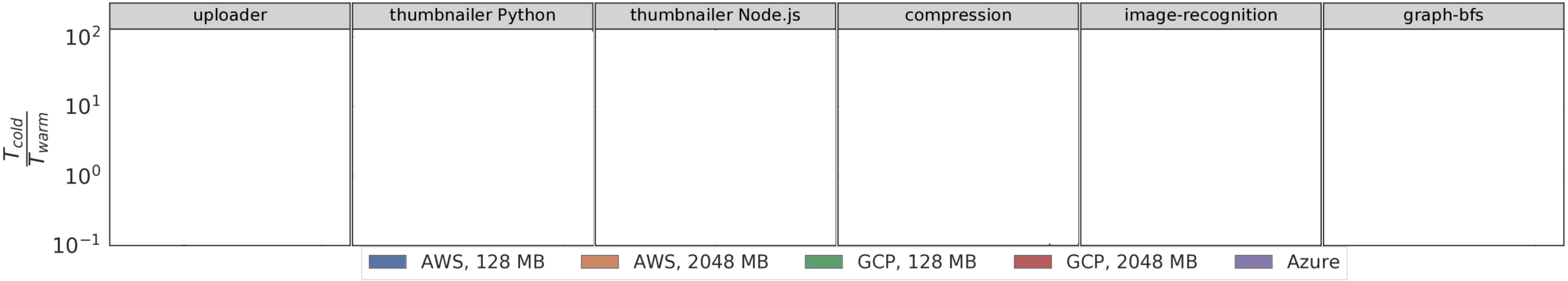
Performance Analysis: Cold Startups



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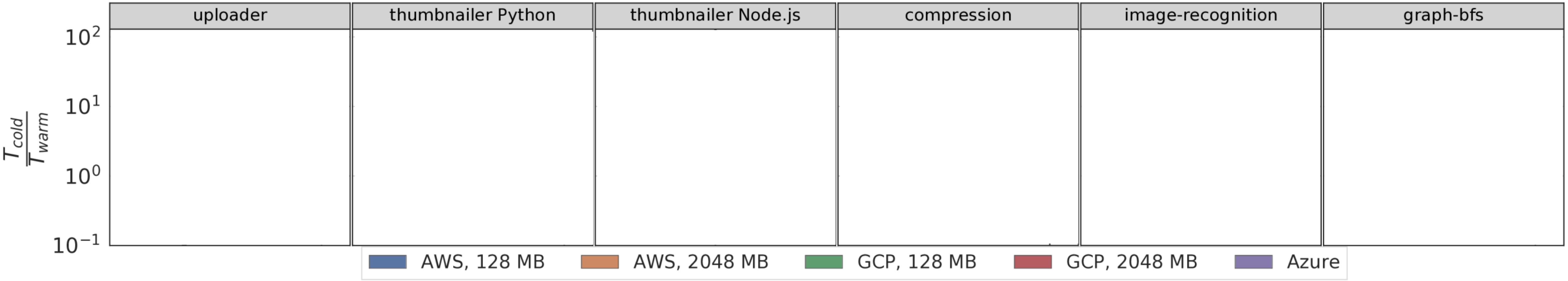

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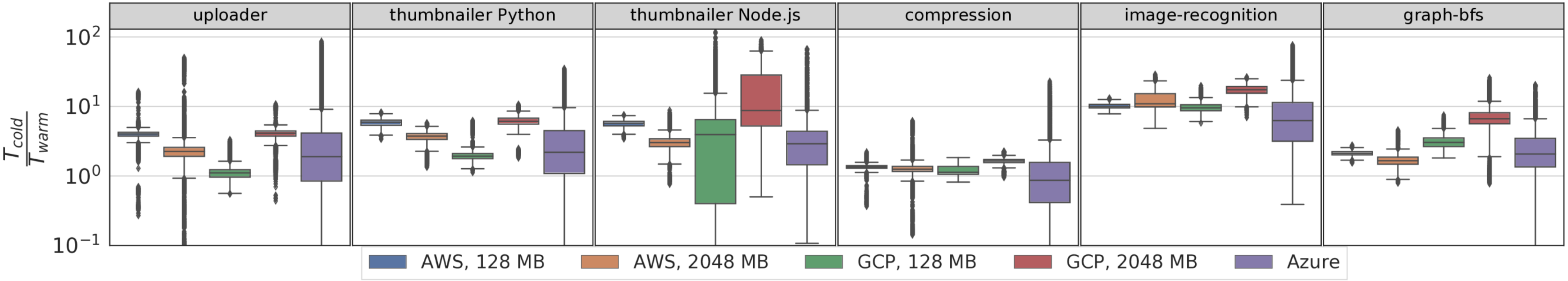

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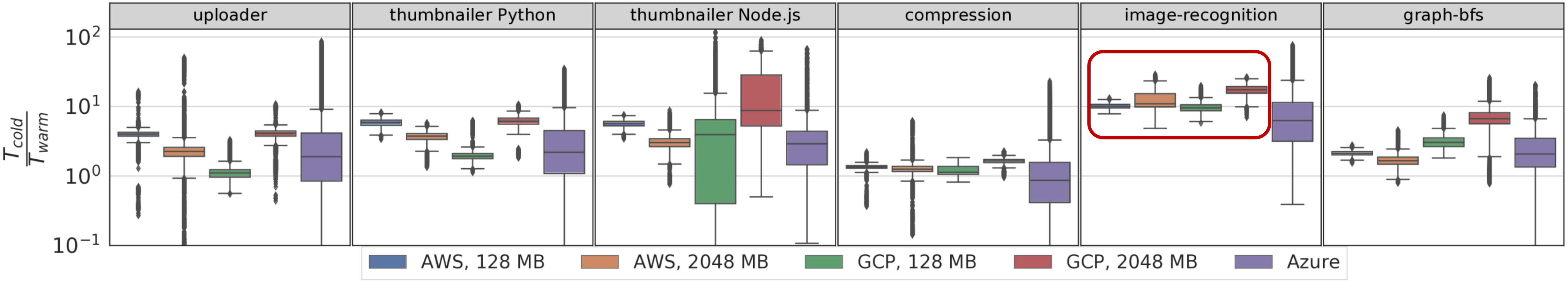

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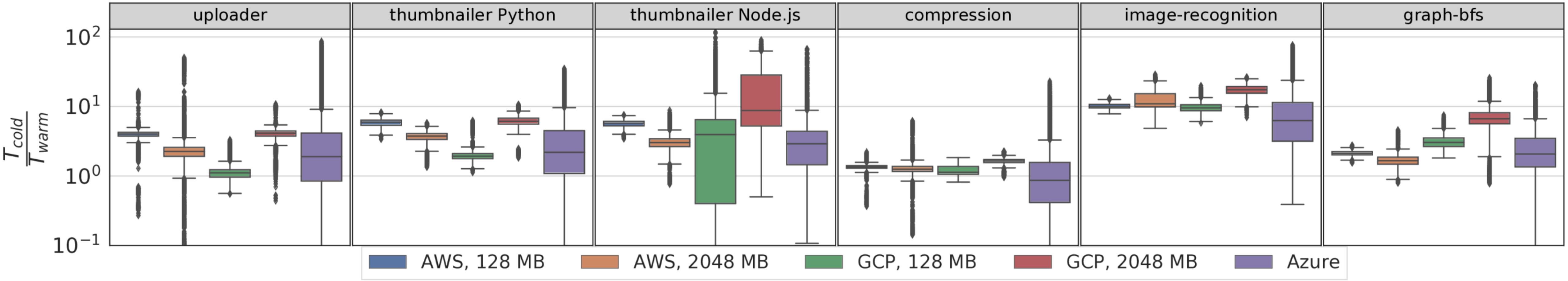

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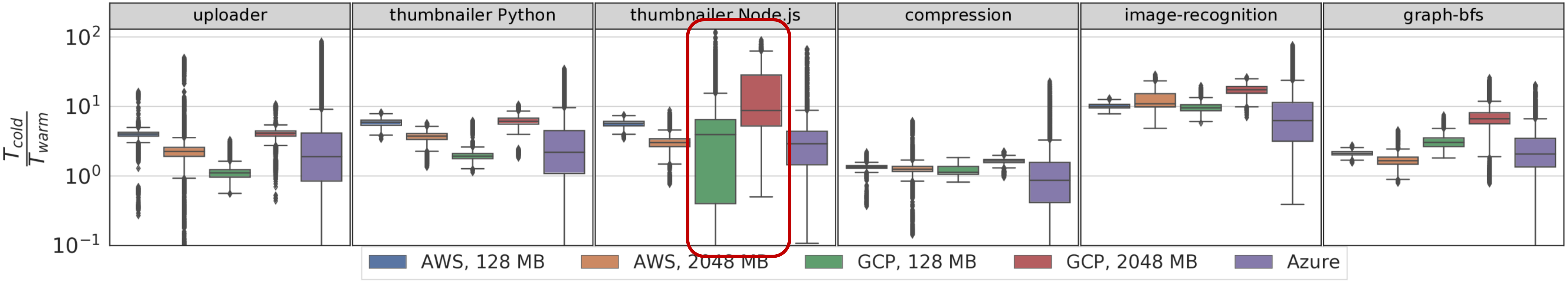

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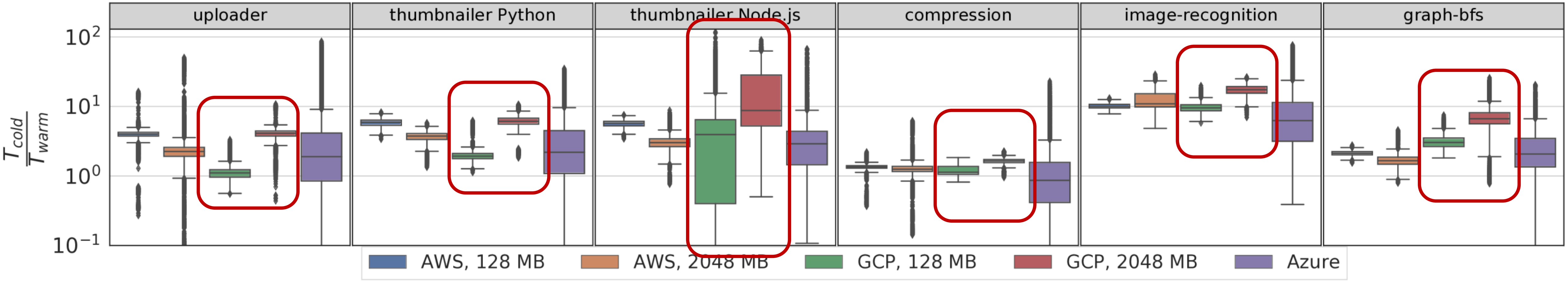

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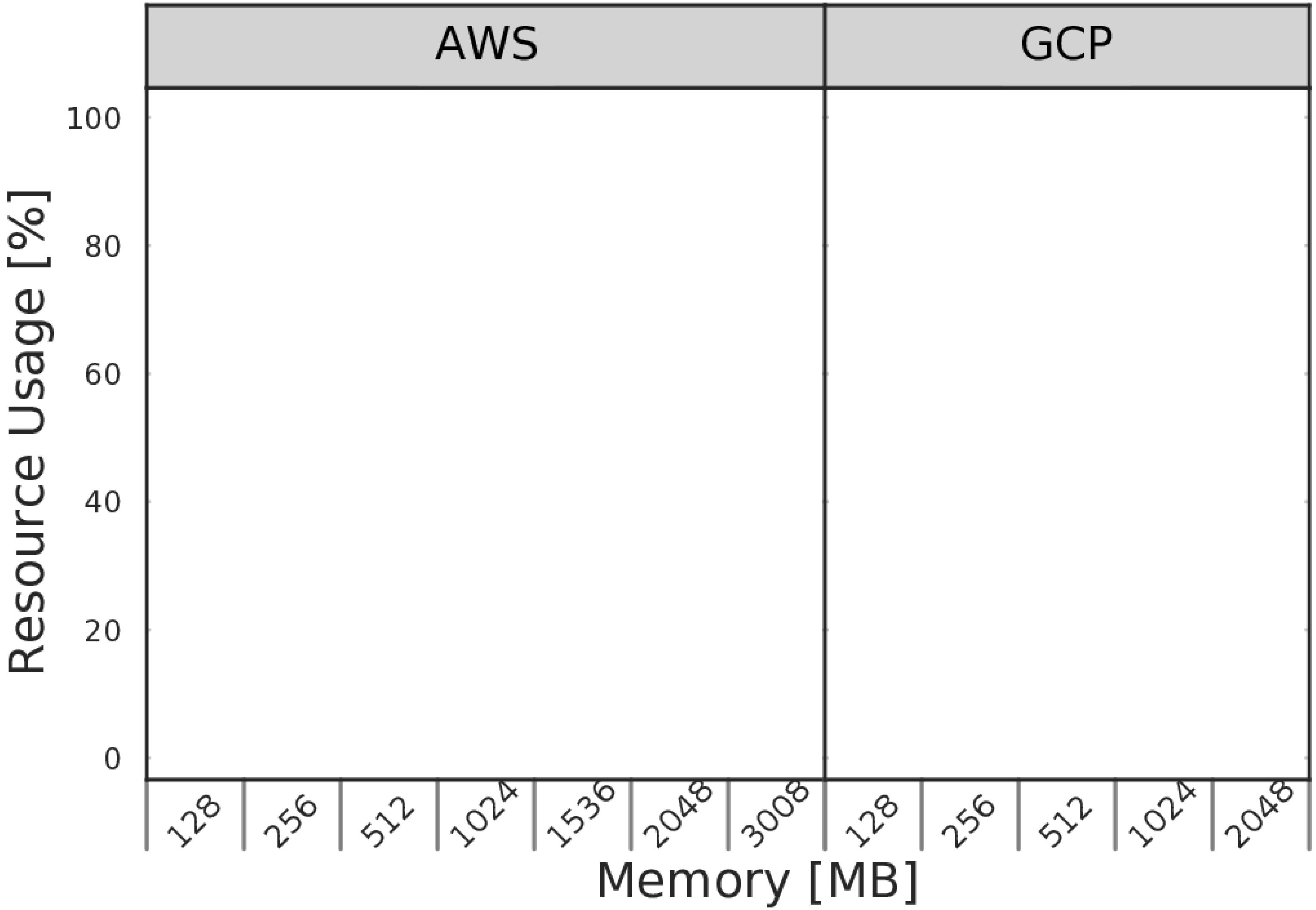

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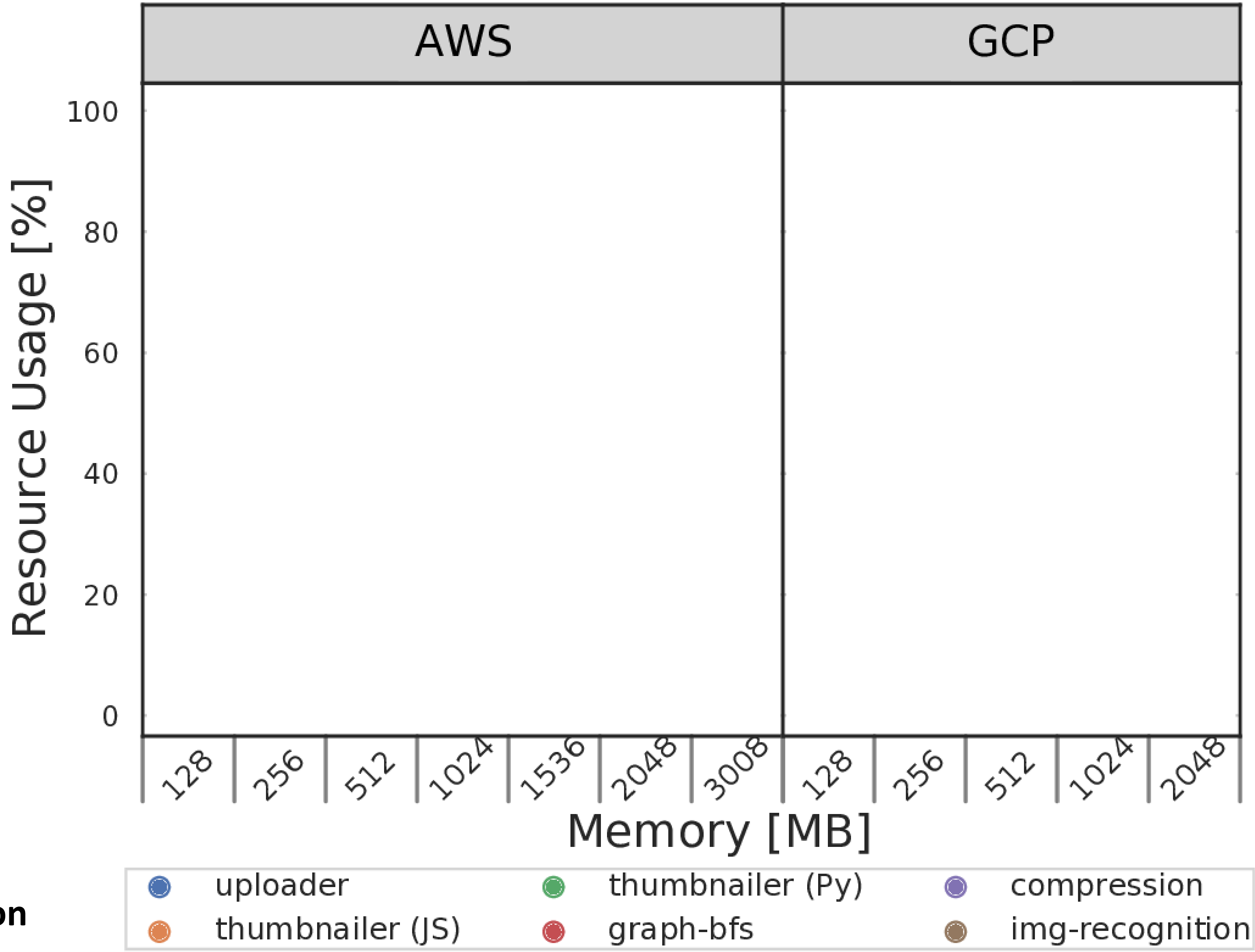

Cold Execution

Warm Execution

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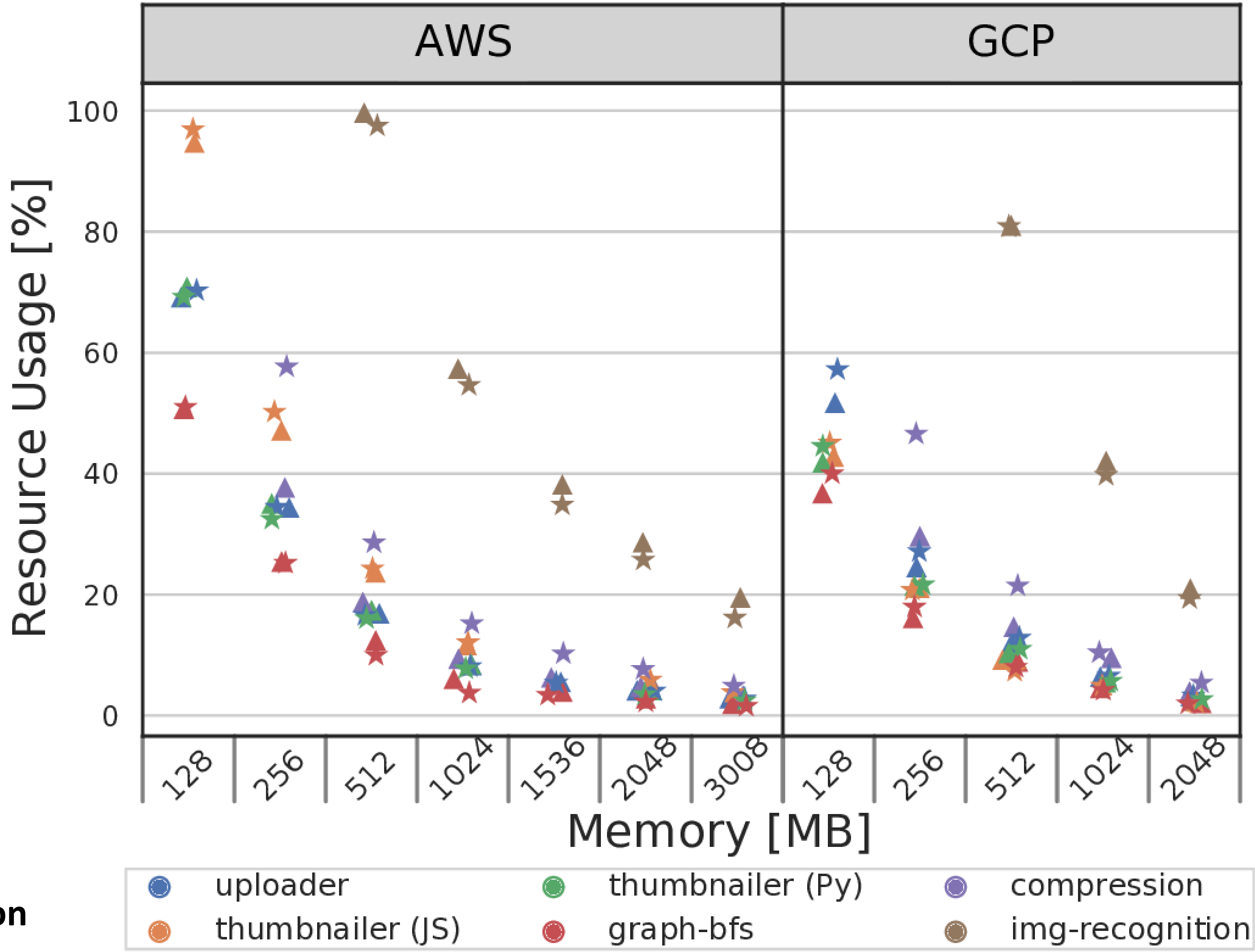

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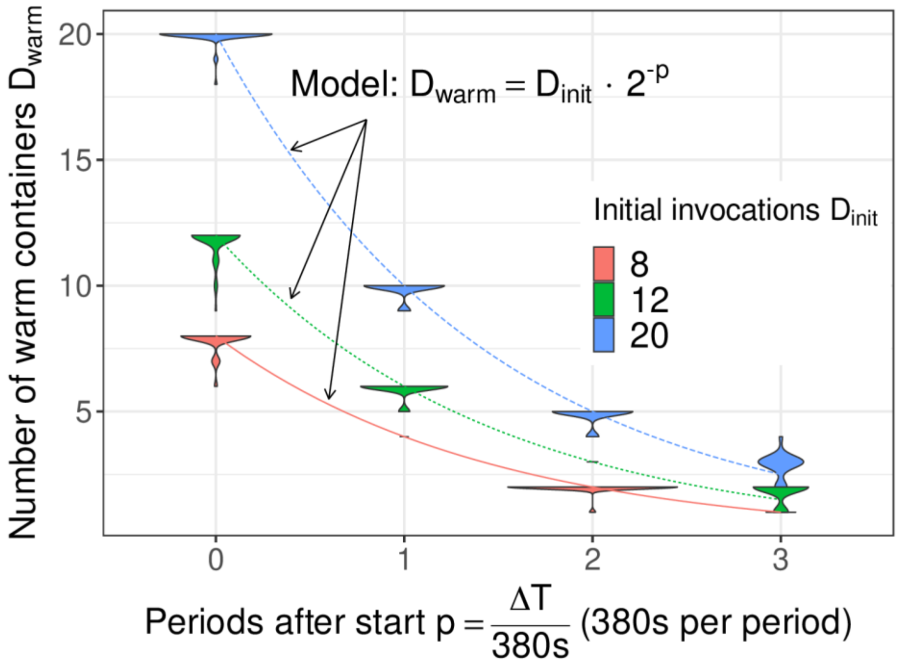

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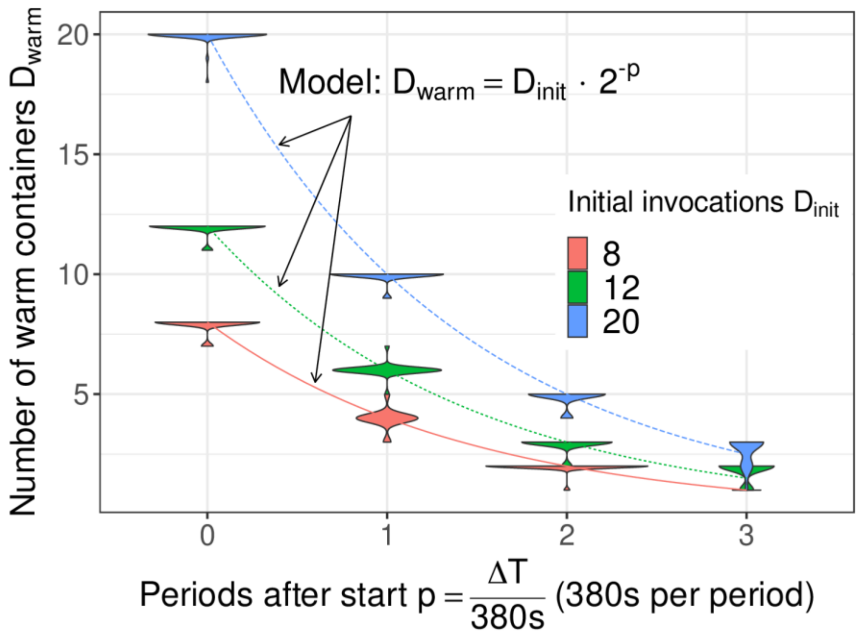

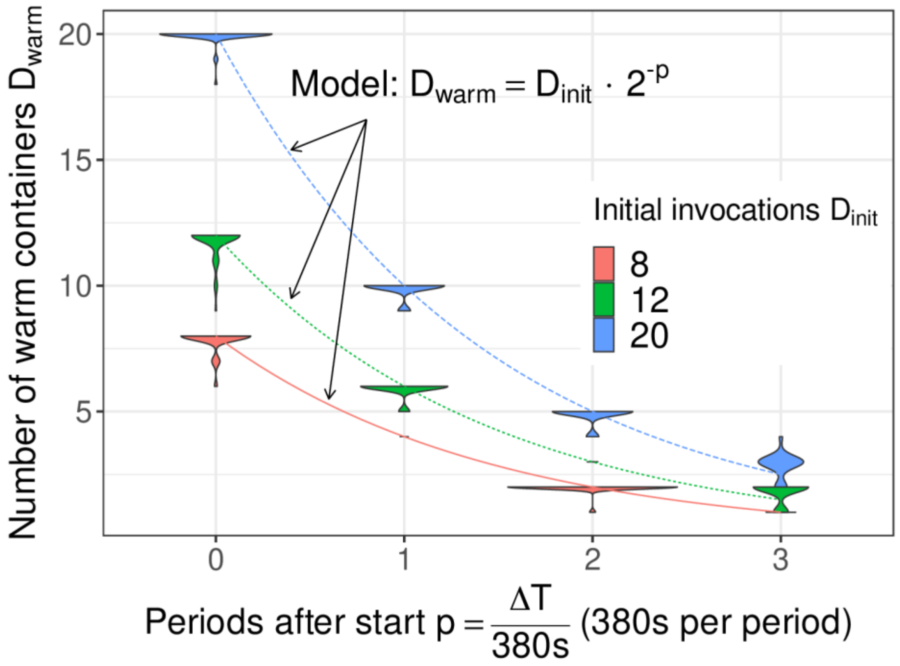

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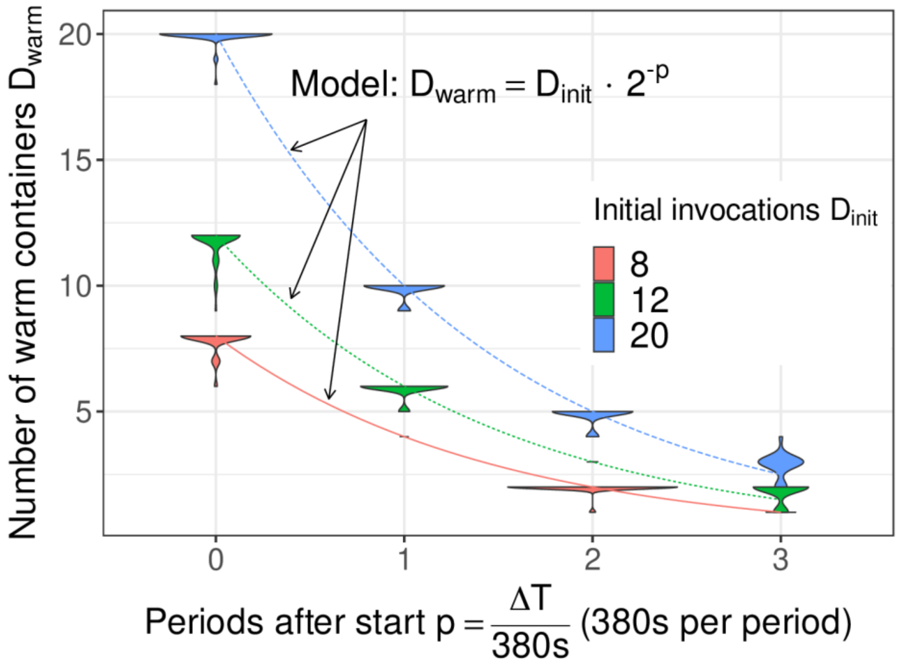

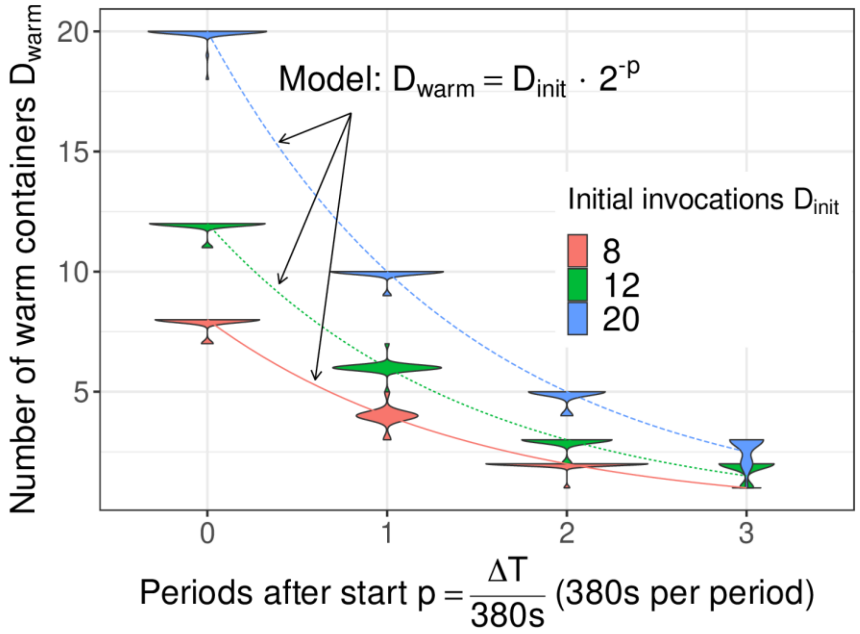

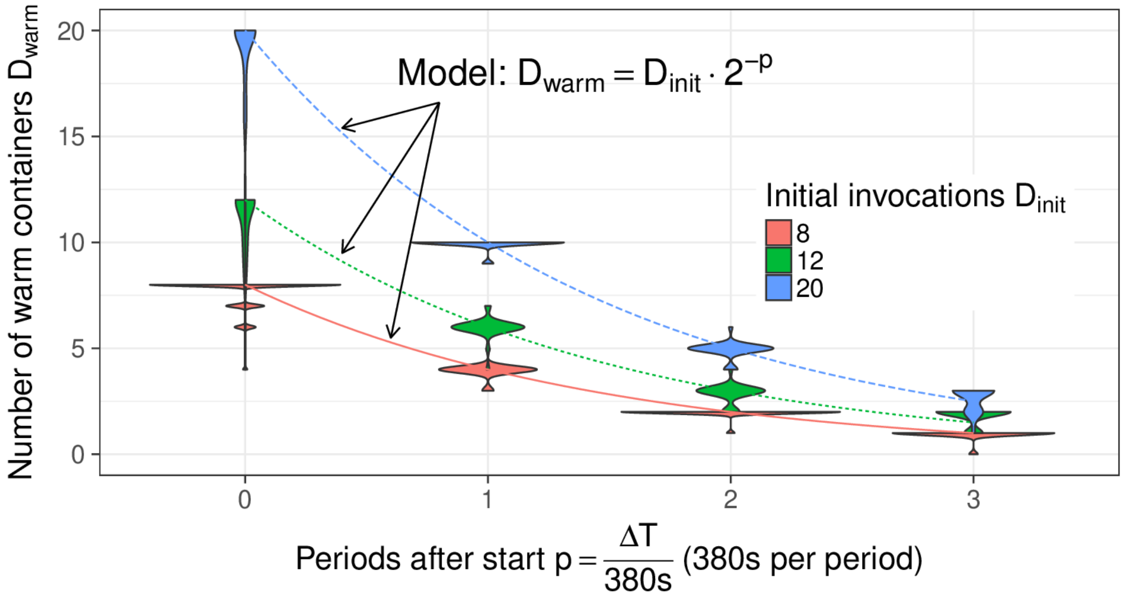

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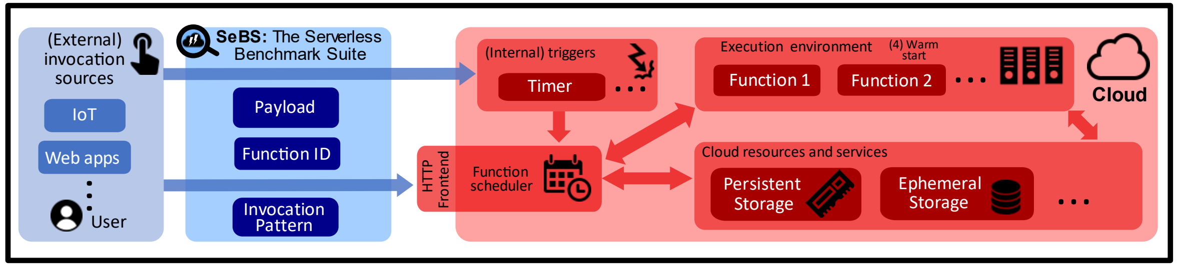
(External) invocation sources
IoT
Web apps
User
SeBS: The Serverless Benchmark Suite
Payload
Function ID
Invocation Pattern
HTTP Frontend
(Internal) triggers
Timer
Function scheduler
Execution environment
(4) Warm start
Function 1
Function 2
Cloud
Cloud resources and services
Persistent Storage
Ephemeral Storage

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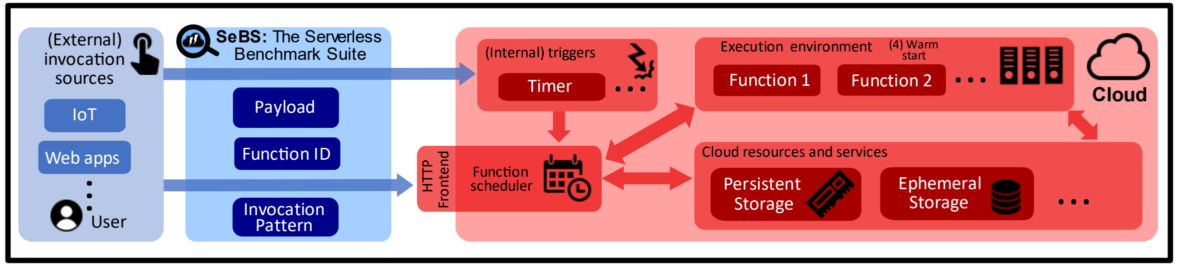

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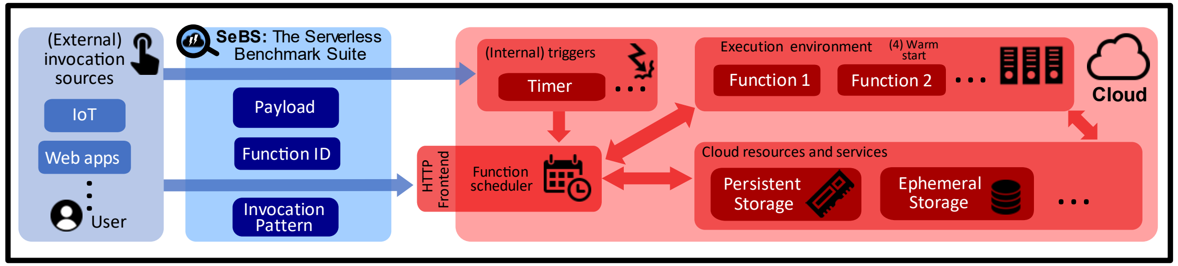

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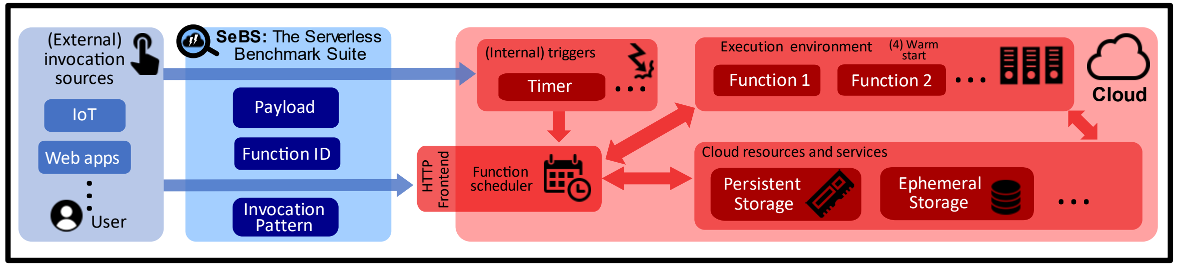

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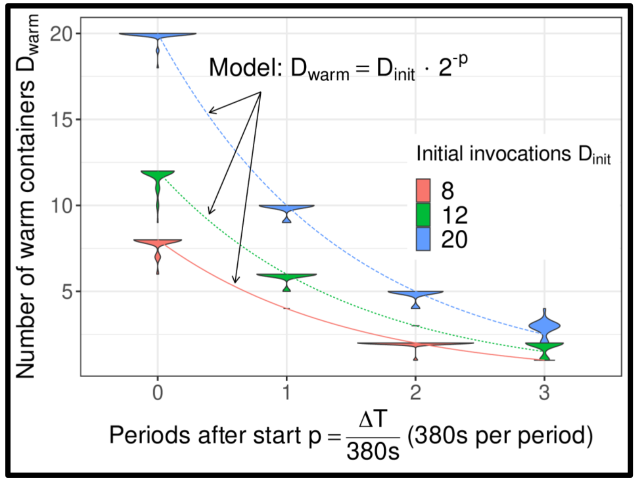

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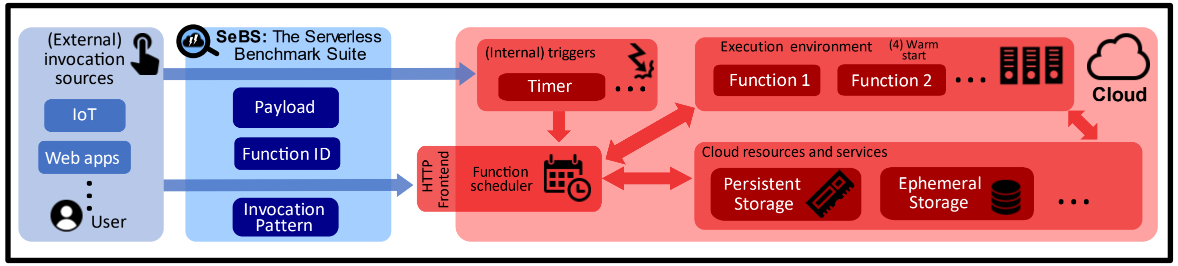

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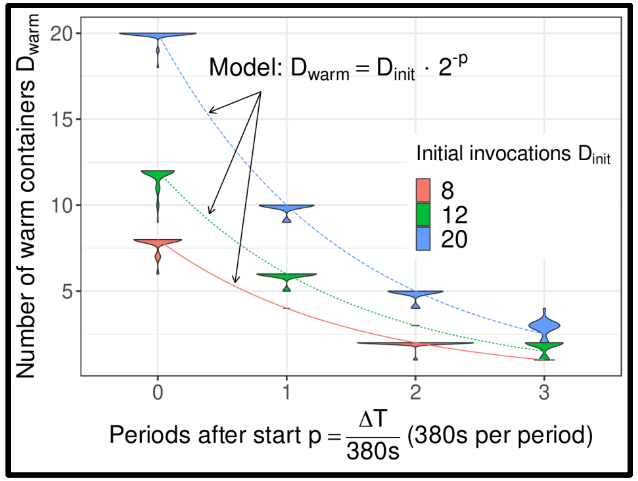
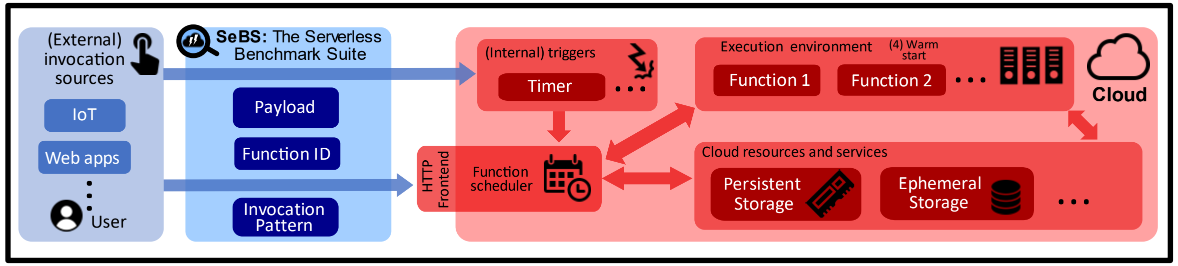


spcl/serverless-benchmarks

Summary



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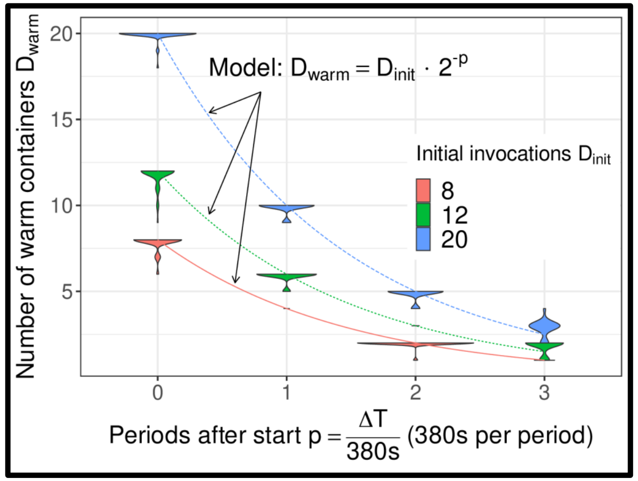

spcl/serverless-benchmarks

- OpenWhisk
- C++ Functions
- Serverless Workflows

Q&A

Future Work

Questions

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Questions

- What are the requirements for a good benchmark suite?
- How can we measure function invocation latency accurately?
- How much performance do we lose when switching from IaaS to FaaS?

spcl/serverless-benchmarks

SeBS in details…

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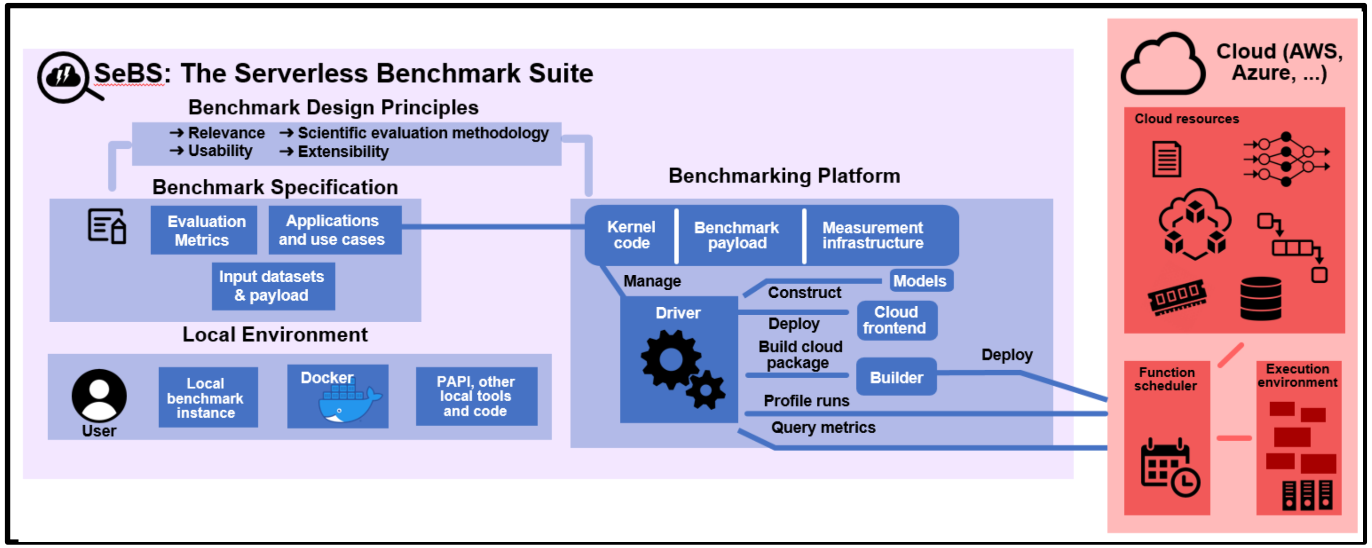
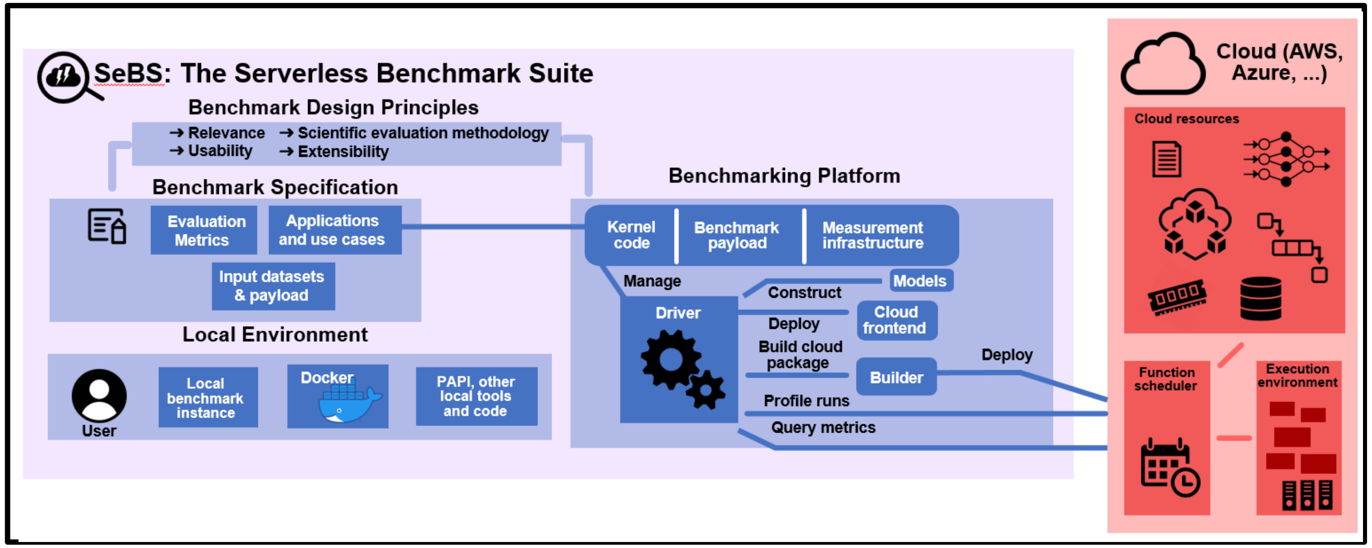
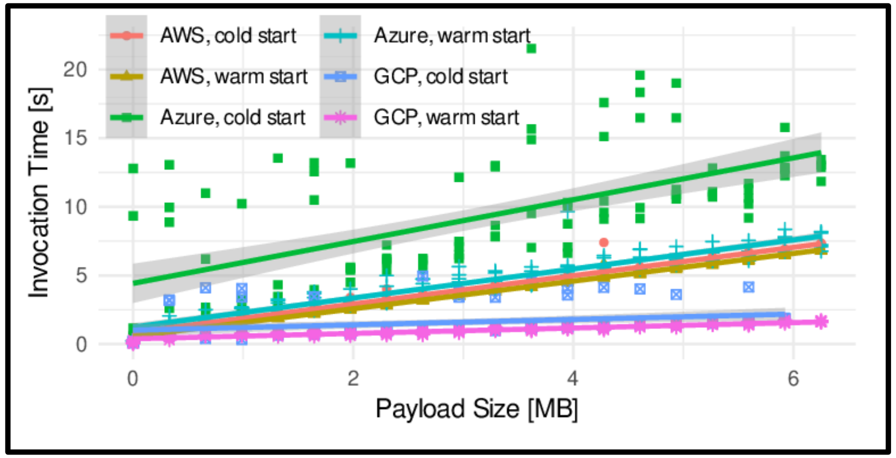


SeBS in details…





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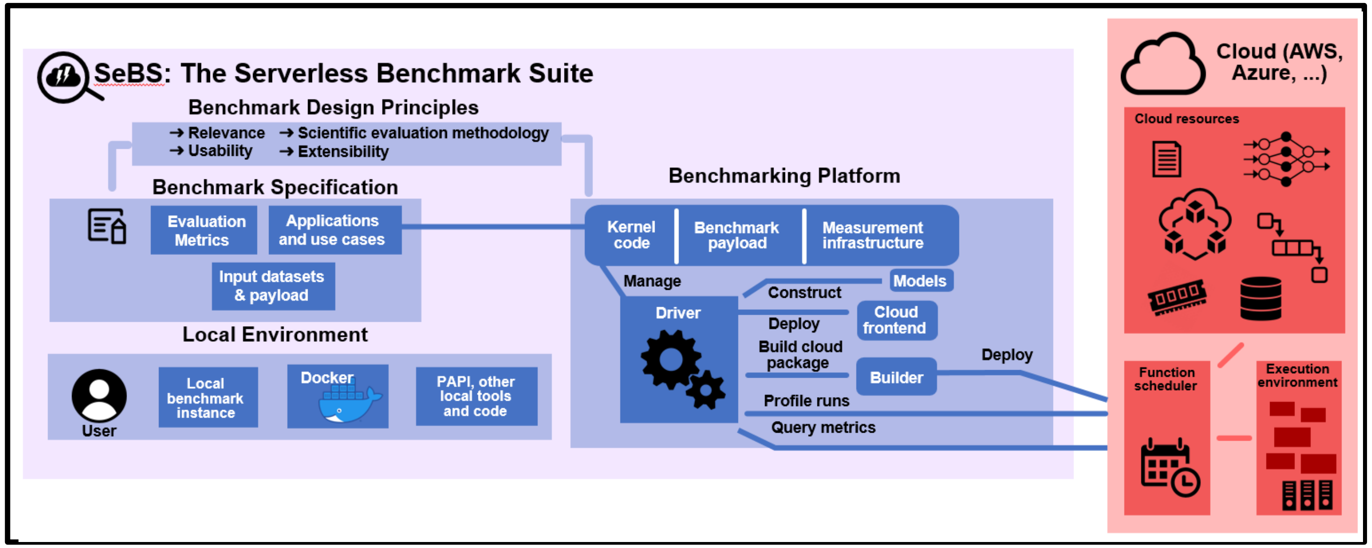

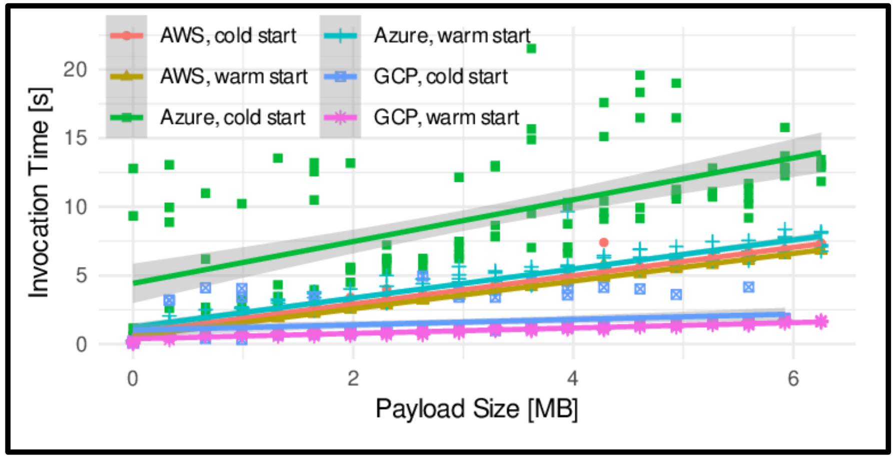

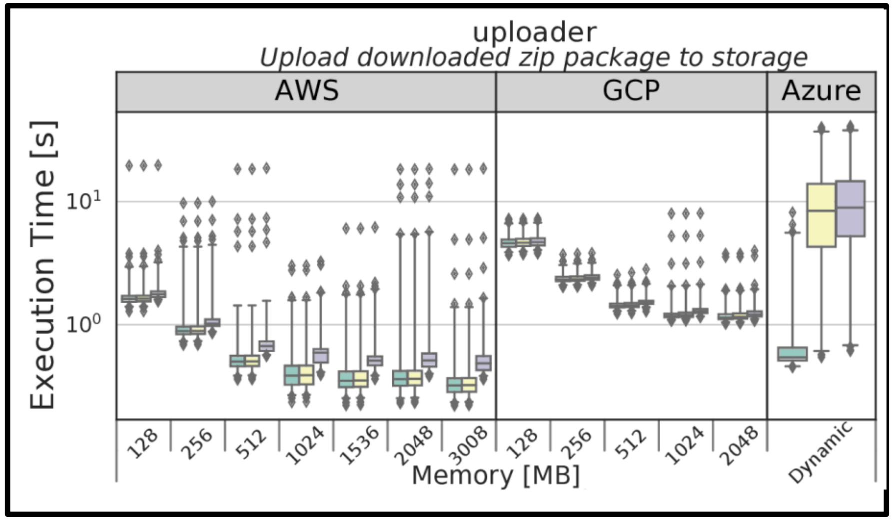

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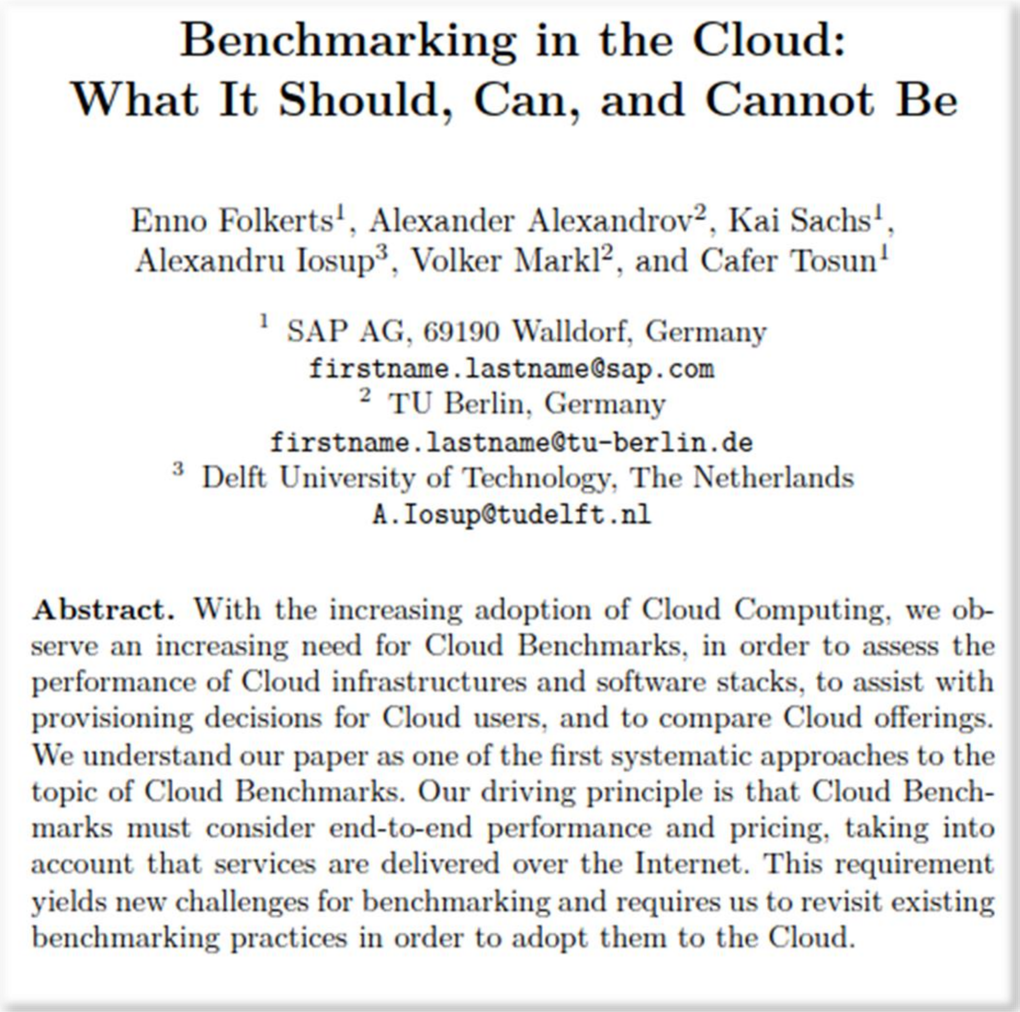

Benchmarking in the Cloud:
What It Should, Can, and Cannot Be

Enno Folkerts[1], Alexander Alexandrov[2], Kai Sachs[1],
Alexandru Iosup[3], Volker Markl[2], and Cafer Tosun[1]

[1] SAP AG, 69190 Walldorf, Germany
firstname.lastname@sap.com
[2] TU Berlin, Germany
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[3] Delft University of Technology, The Netherlands
A.Iosup@tudelft.nl

Abstract. With the increasing adoption of Cloud Computing, we observe an increasing need for Cloud Benchmarks, in order to assess the performance of Cloud infrastructures and software stacks, to assist with provisioning decisions for Cloud users, and to compare Cloud offerings. We understand our paper as one of the first systematic approaches to the topic of Cloud Benchmarks. Our driving principle is that Cloud Benchmarks must consider end-to-end performance and pricing, taking into account that services are delivered over the Internet. This requirement yields new challenges for benchmarking and requires us to revisit existing benchmarking practices in order to adopt them to the Cloud.

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How is the Weather tomorrow? Towards a Benchmark for the Cloud

Carsten Binnig   Donald Kossmann   Tim Kraska   Simon Loesing

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Scientific Benchmarking of Parallel Computing Systems
Twelve ways to tell the masses when reporting performance results

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How to Build a Benchmark

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Benchmarking Goals

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Principles

- ✓ Usability
- ✓ Portability
- ✓ Extensibility
- ✓ Scientific

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- ✓ Single implementation
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Experiments

- ✓ Performance and cost
- ✓ FaaS vs IaaS
- ✓ Invocation overhead
- ✓ Container eviction

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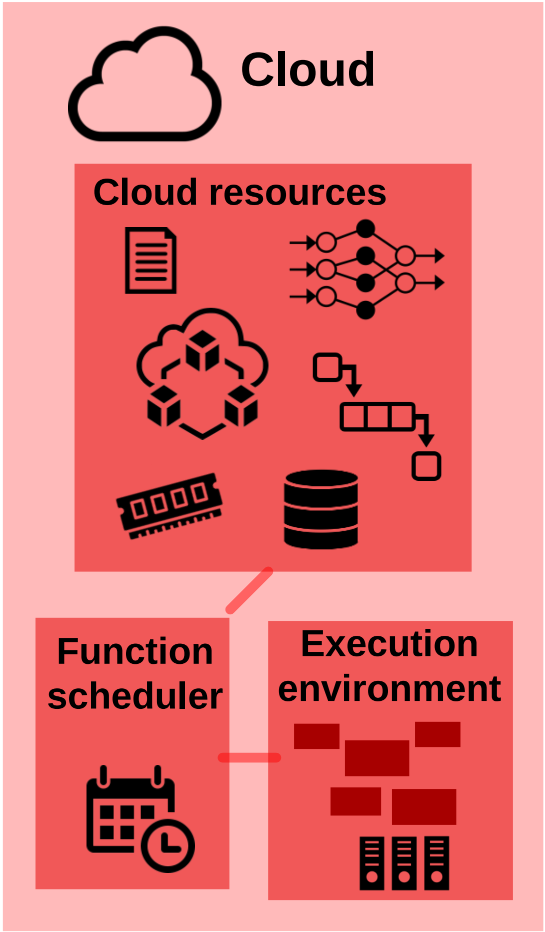
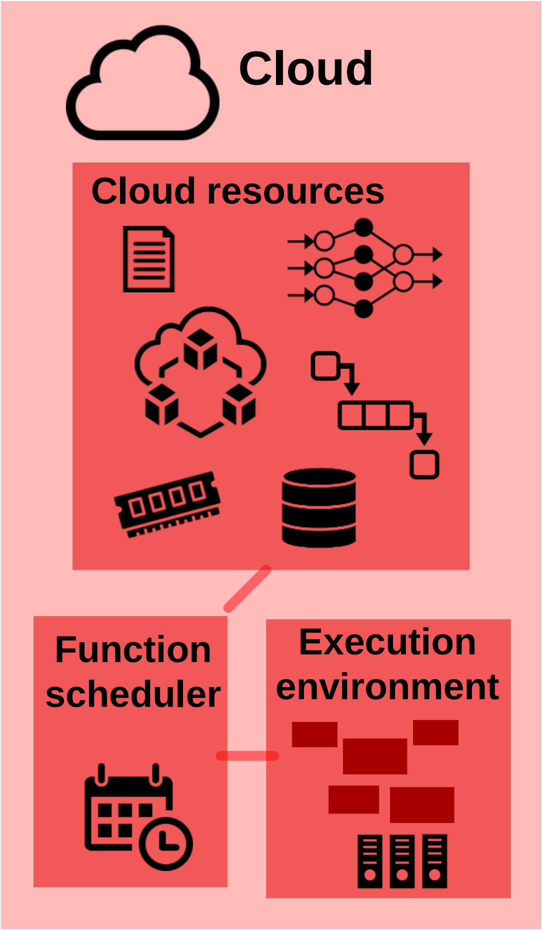


How to build a benchmark?

SeBS: The Serverless Benchmark Suite



How to build a benchmark?

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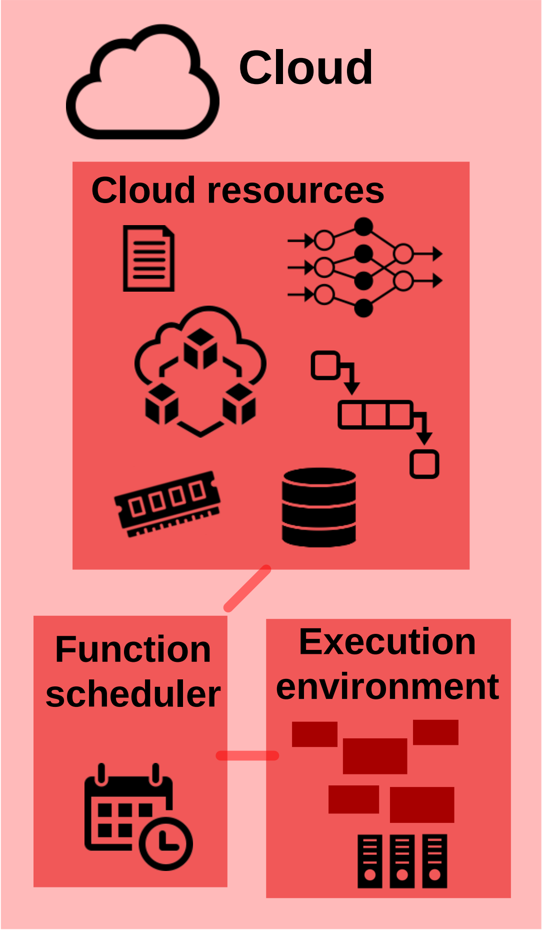
Benchmark Design Principles

- ➜ Relevance
- ➜ Usability
- ➜ Scientific evaluation methodology
- ➜ Extensibility



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Benchmark Design Principles

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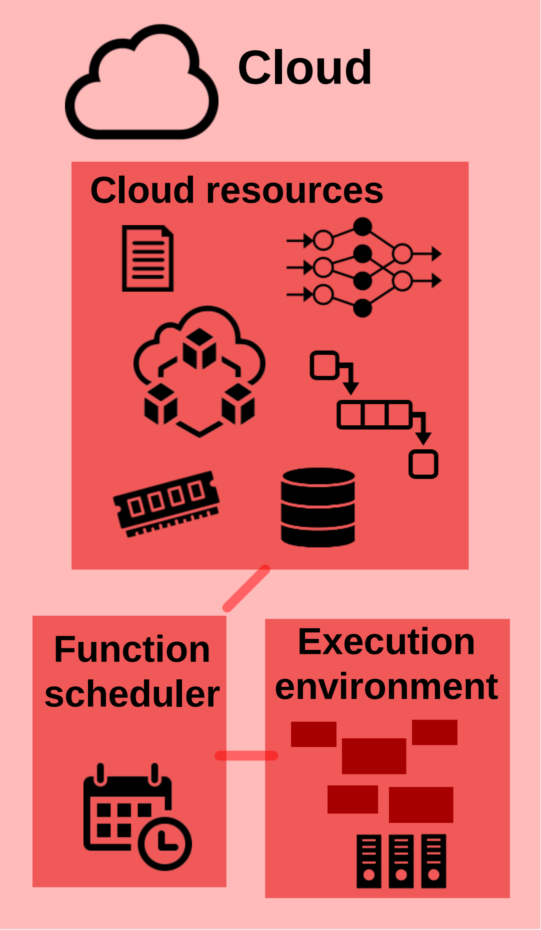
- ➜ Extensibility

Benchmark Specification

- Metrics
- Applications
- Input datasets



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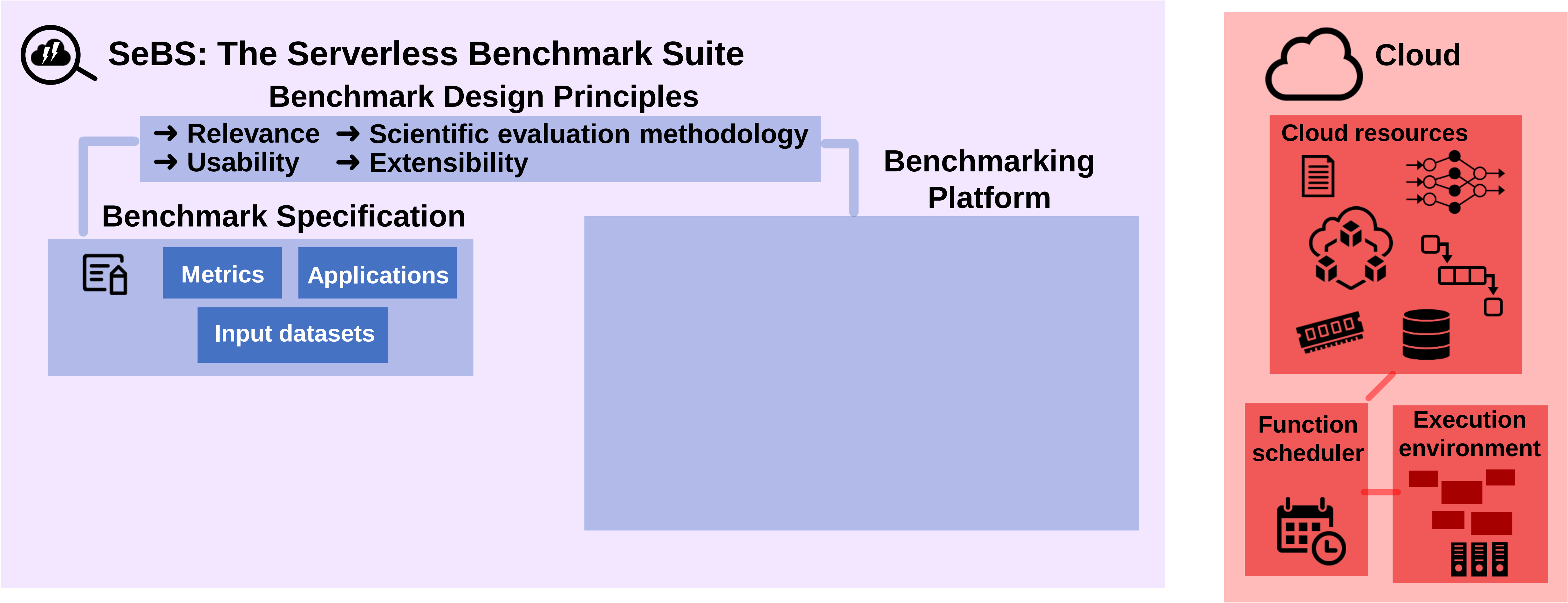

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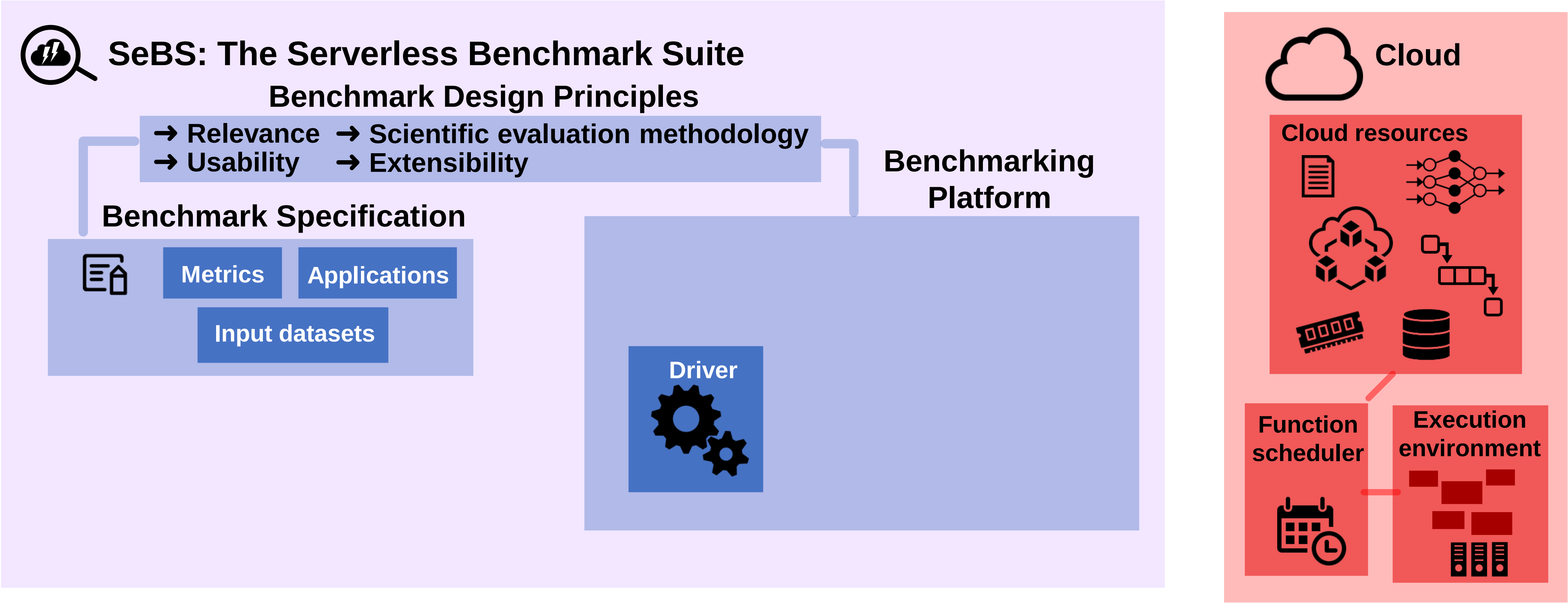

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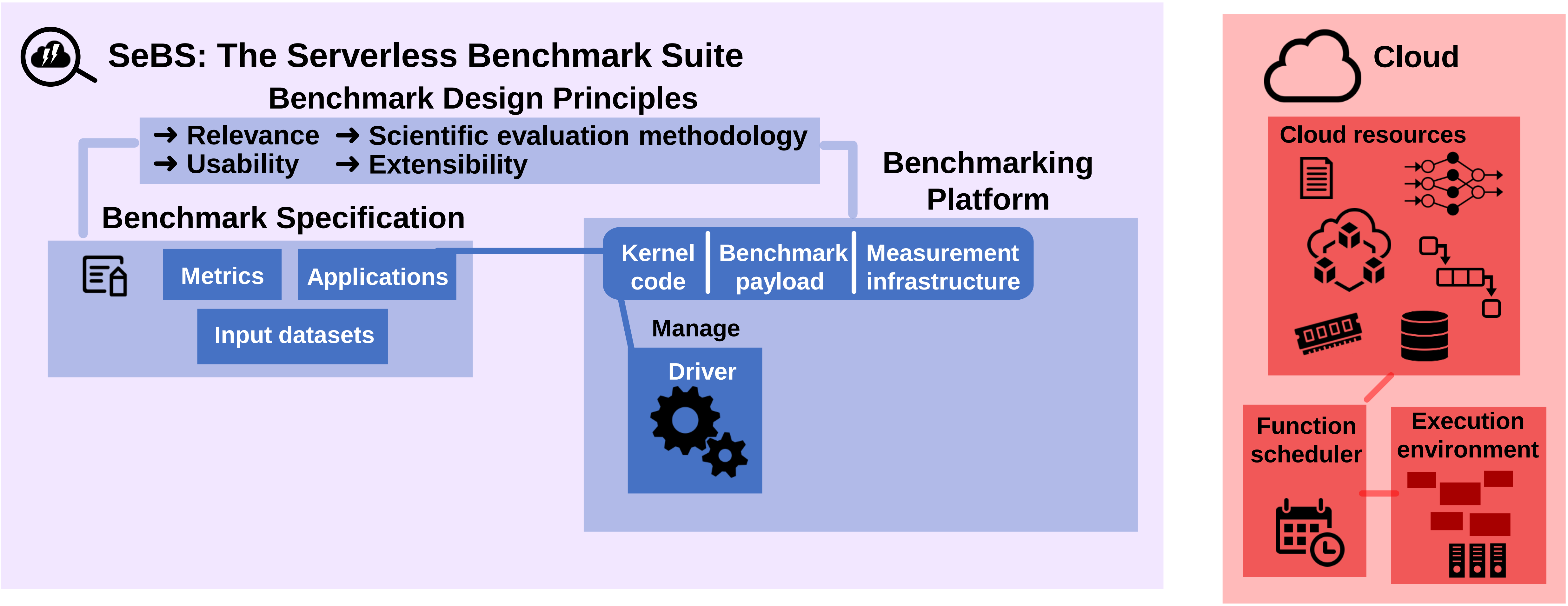

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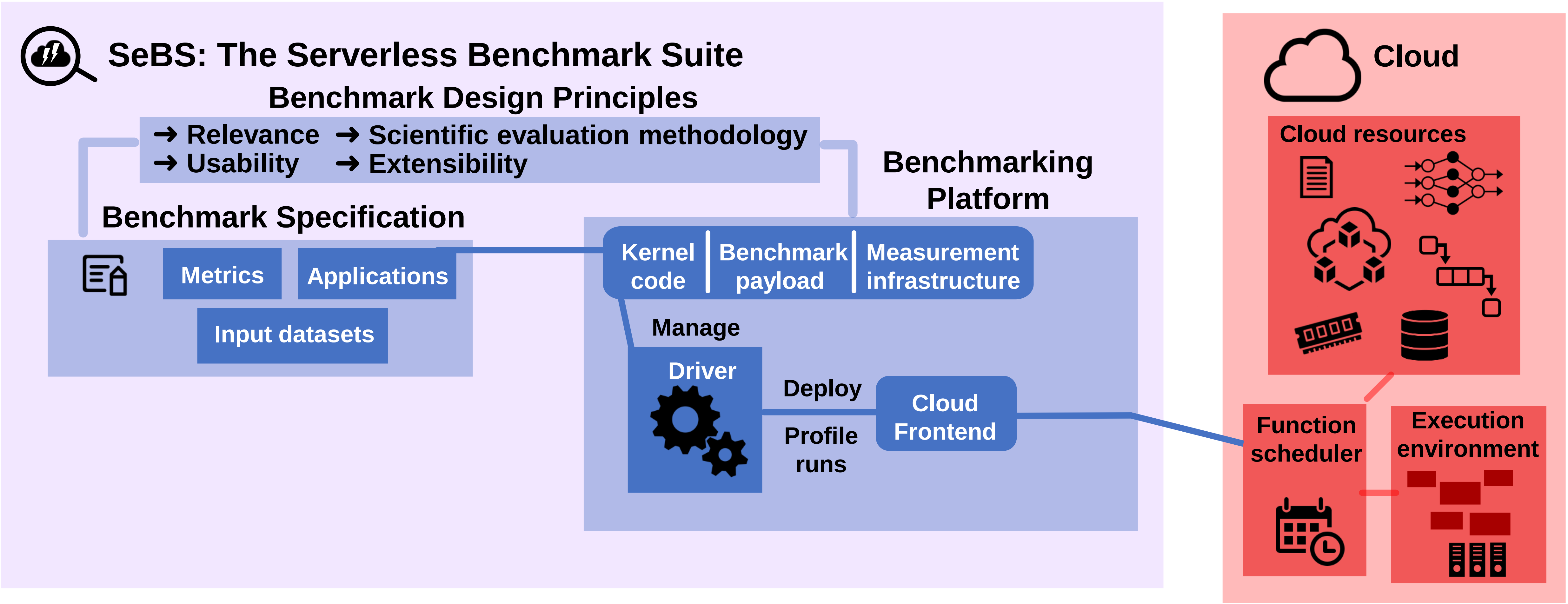

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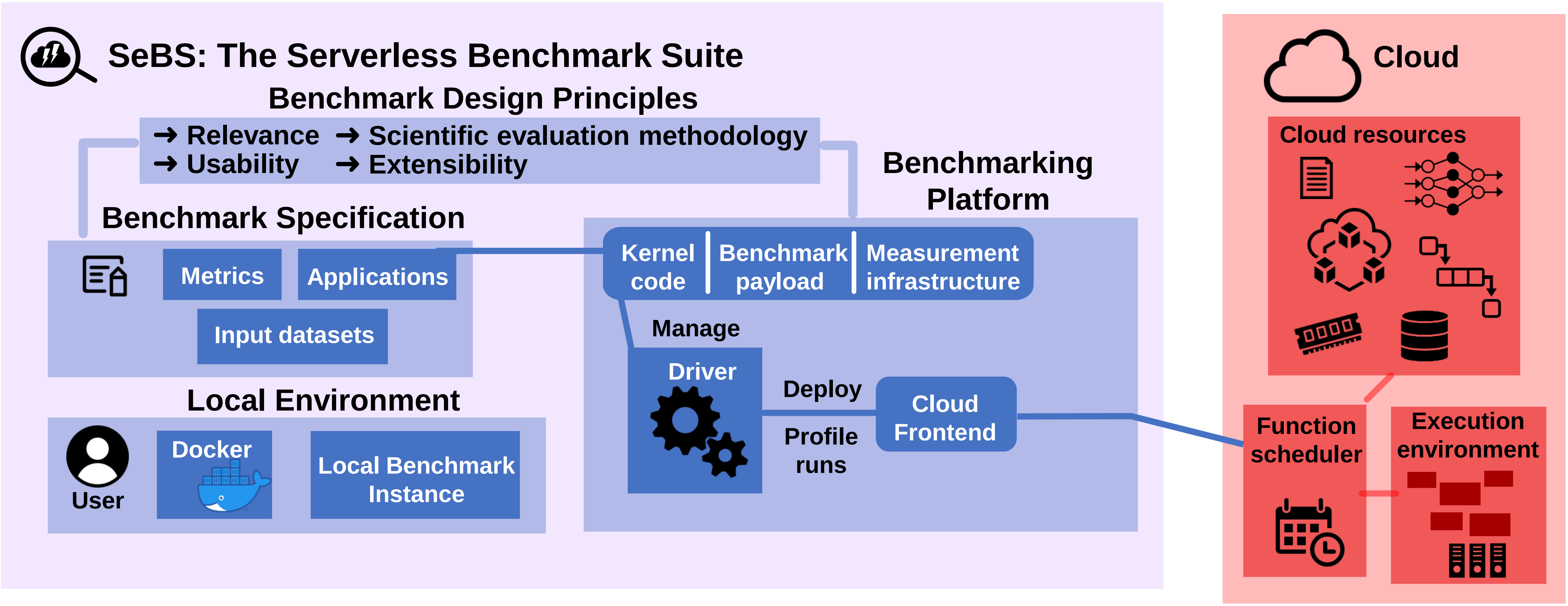

Results and Insights

	Results, methods, and insights
$	

Results and Insights

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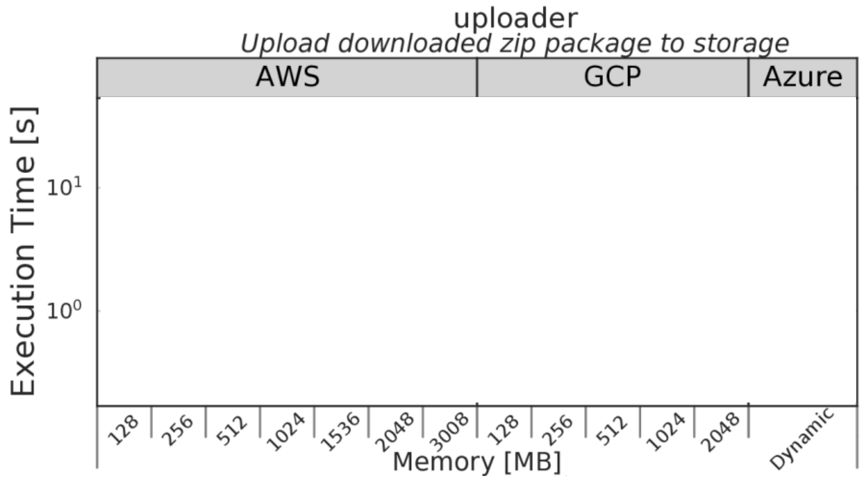
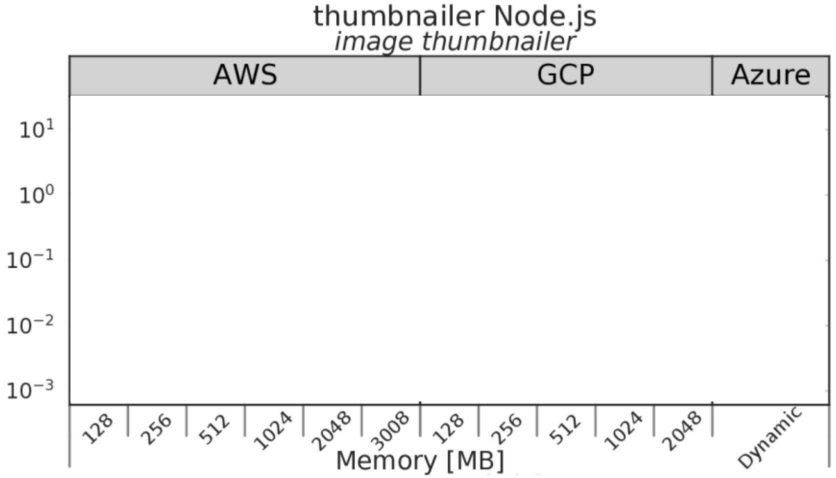
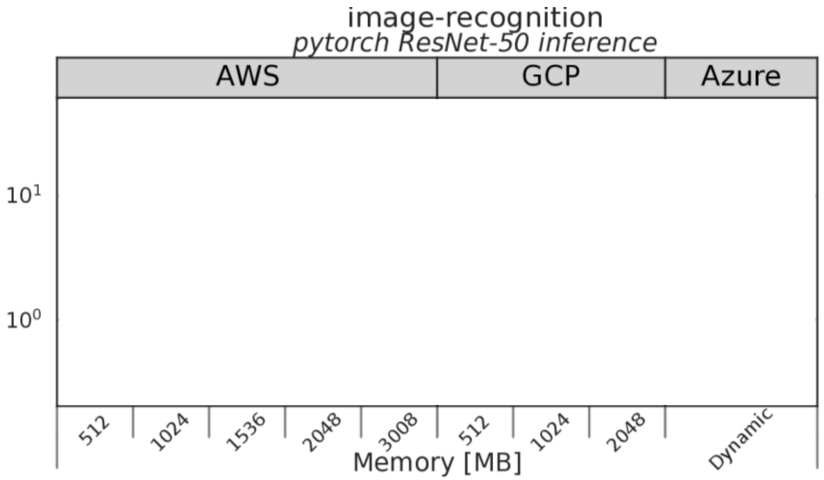
Performance Analysis: Warm Startups







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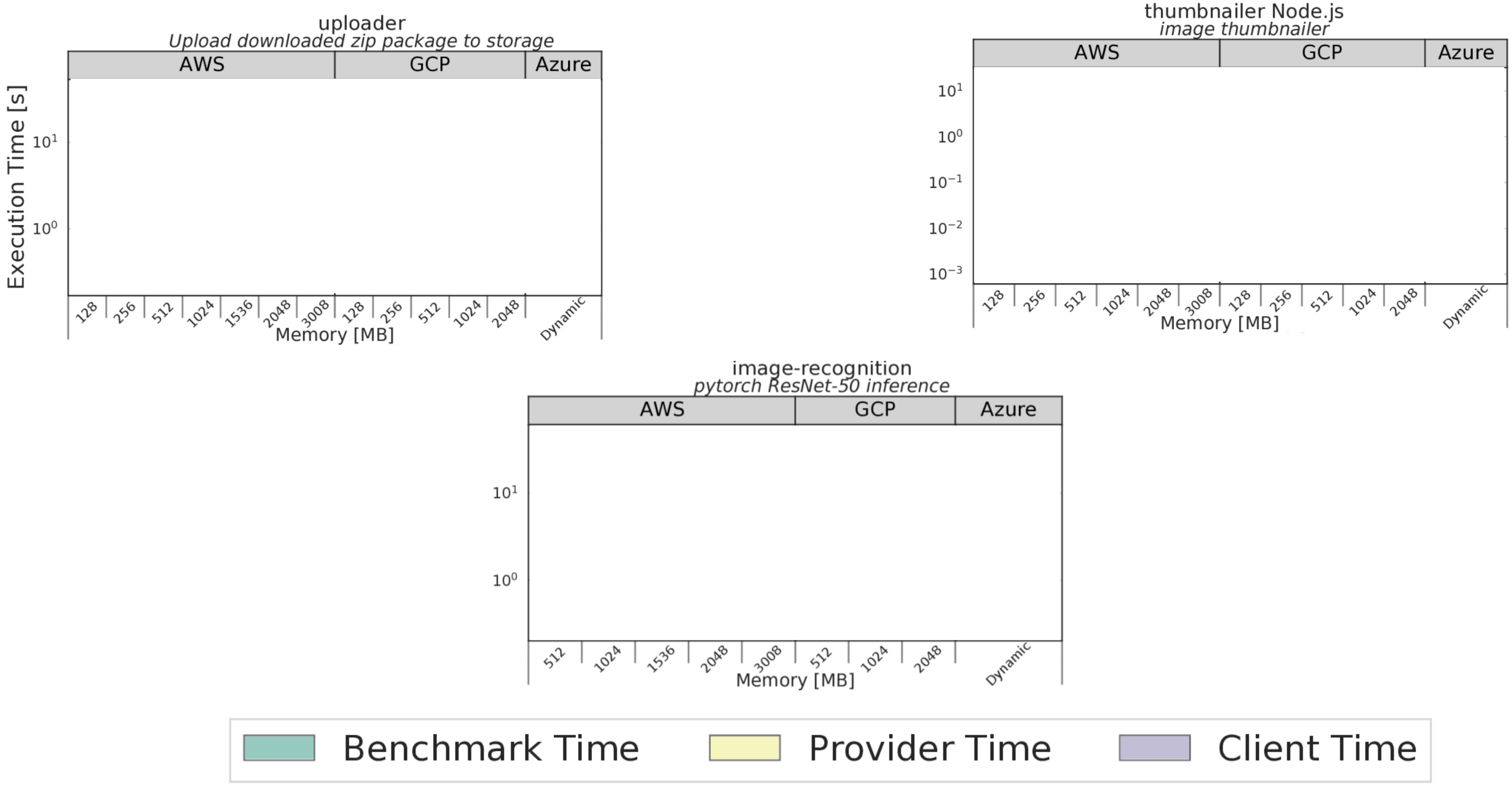

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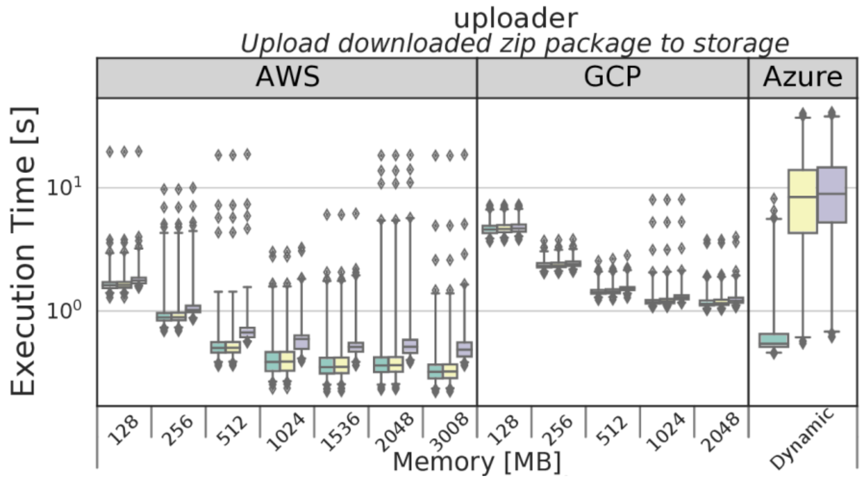

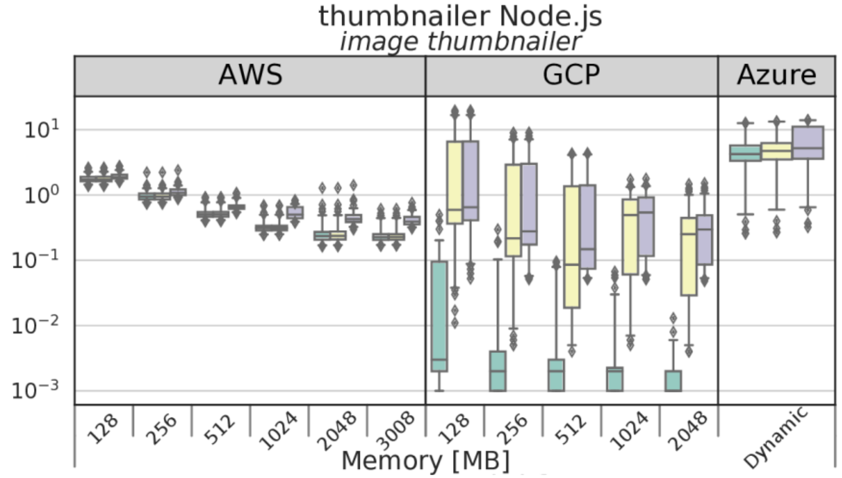

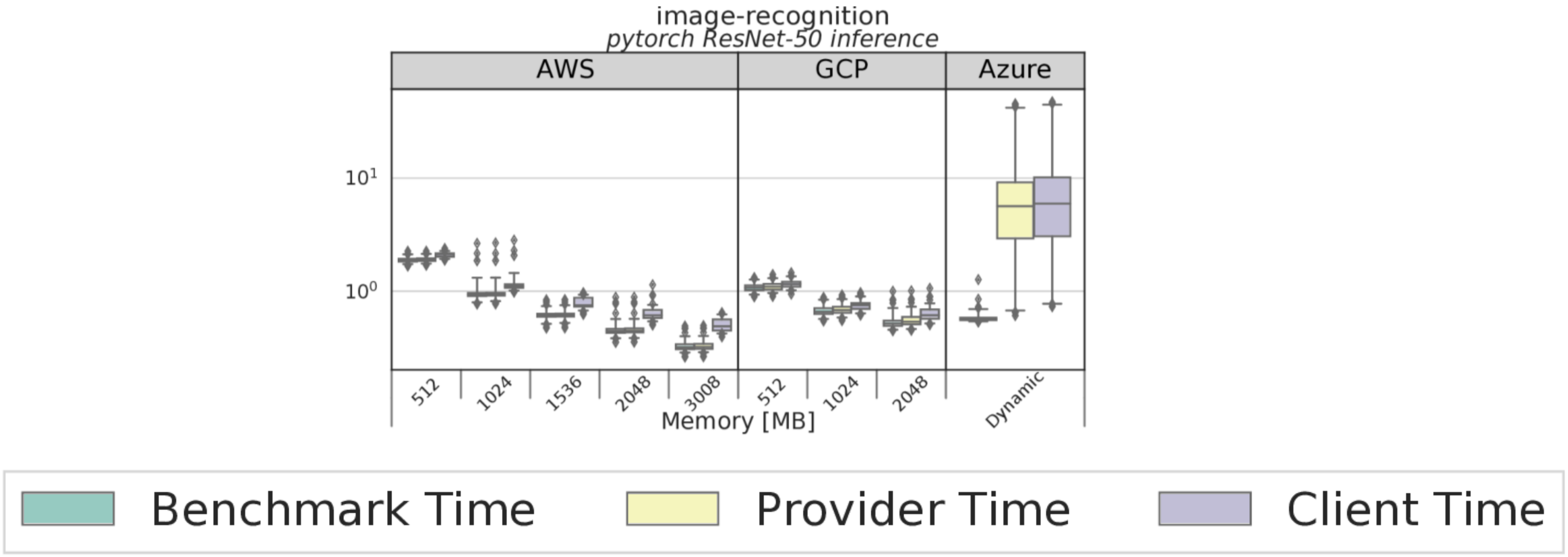

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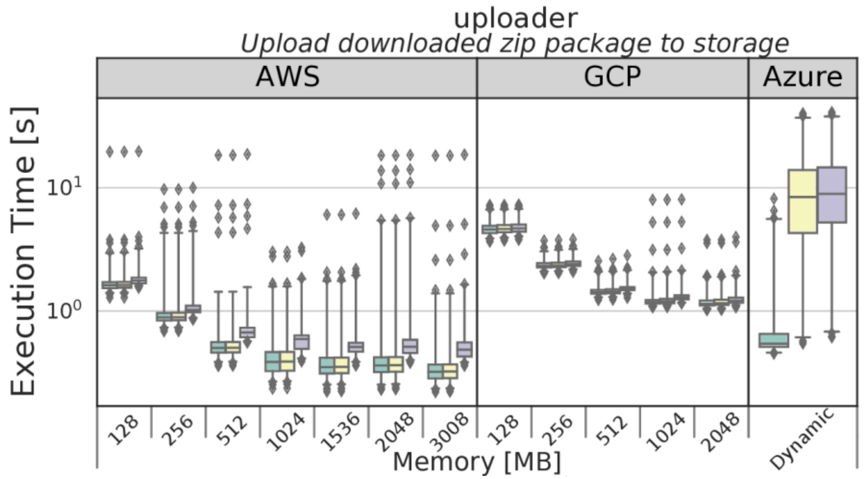
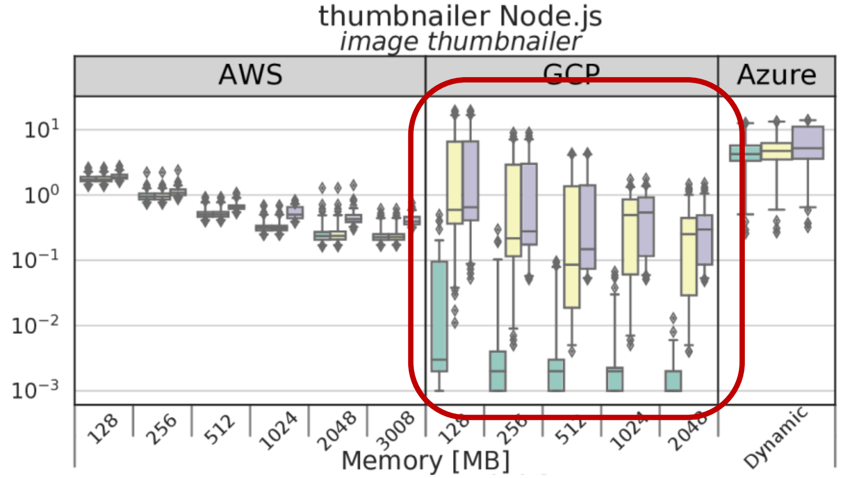
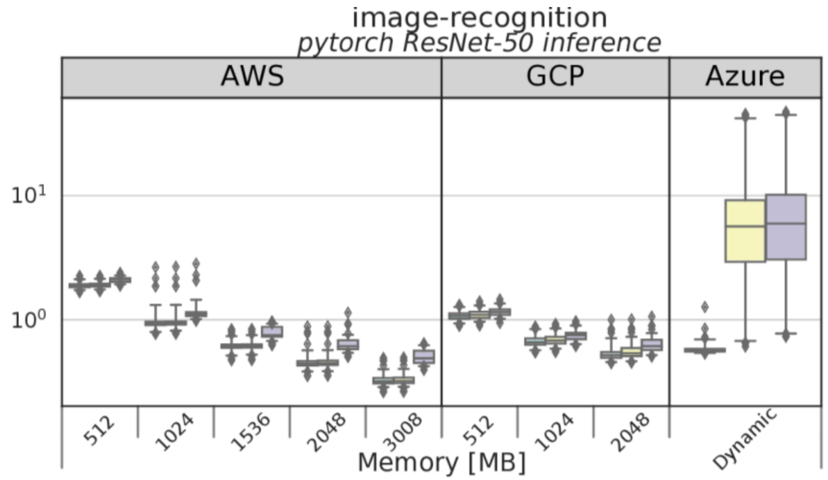
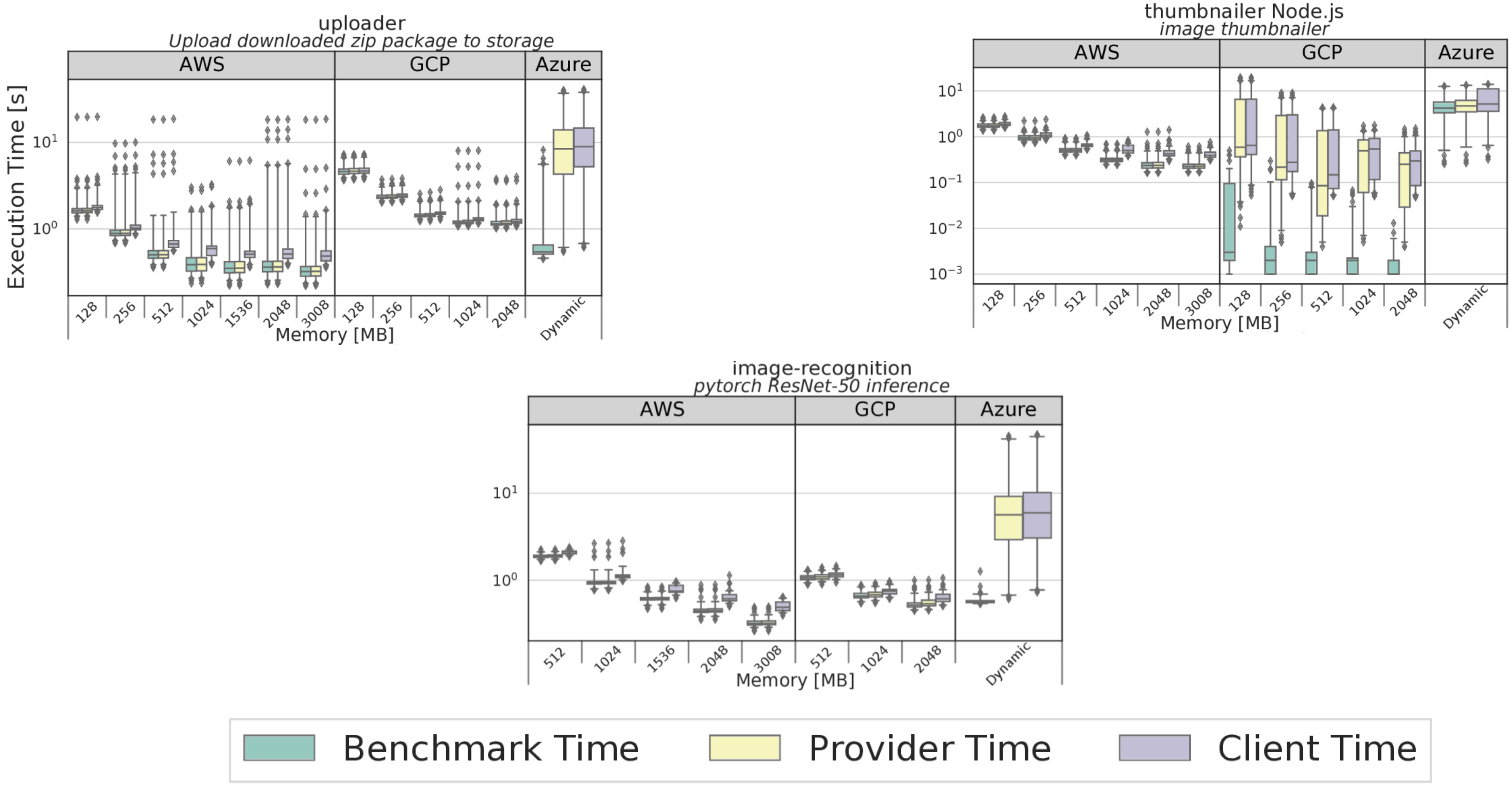






Benchmark Time Provider Time Client Time

Performance Analysis: Warm Startups



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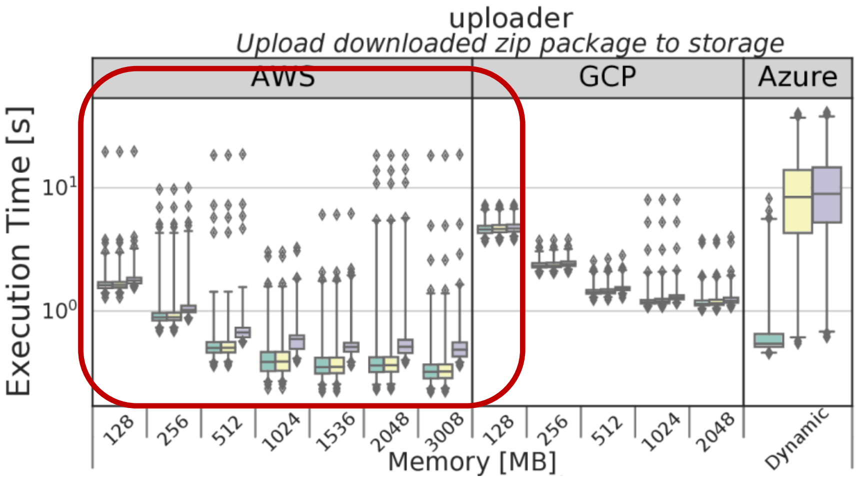

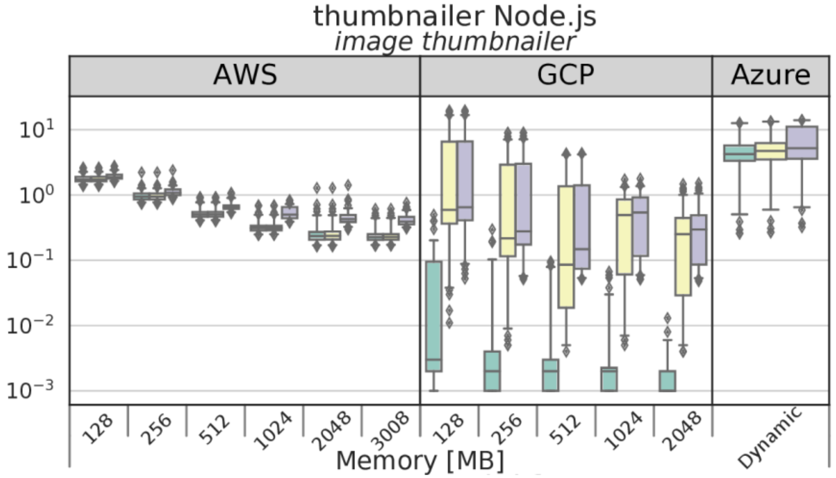

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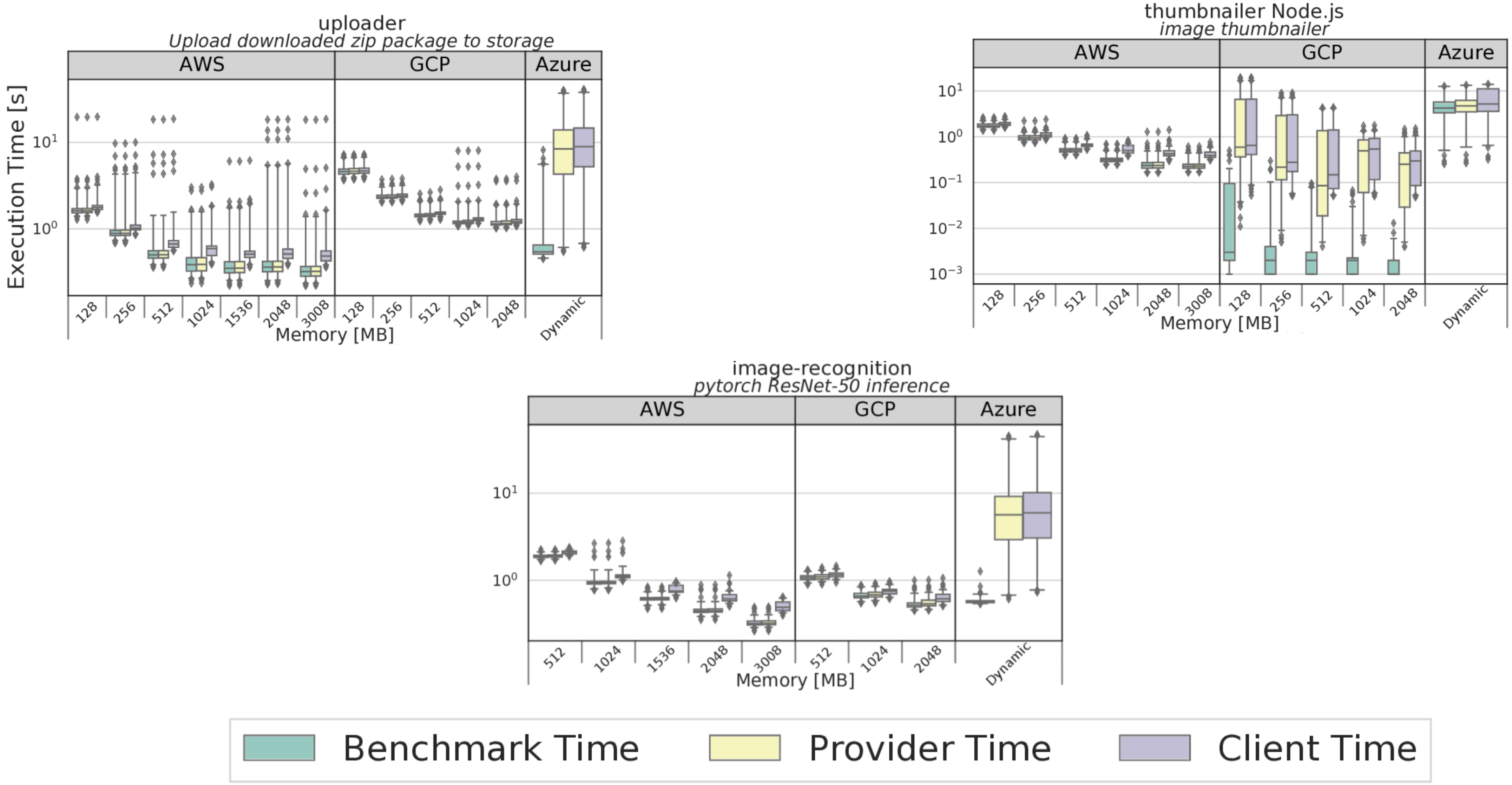

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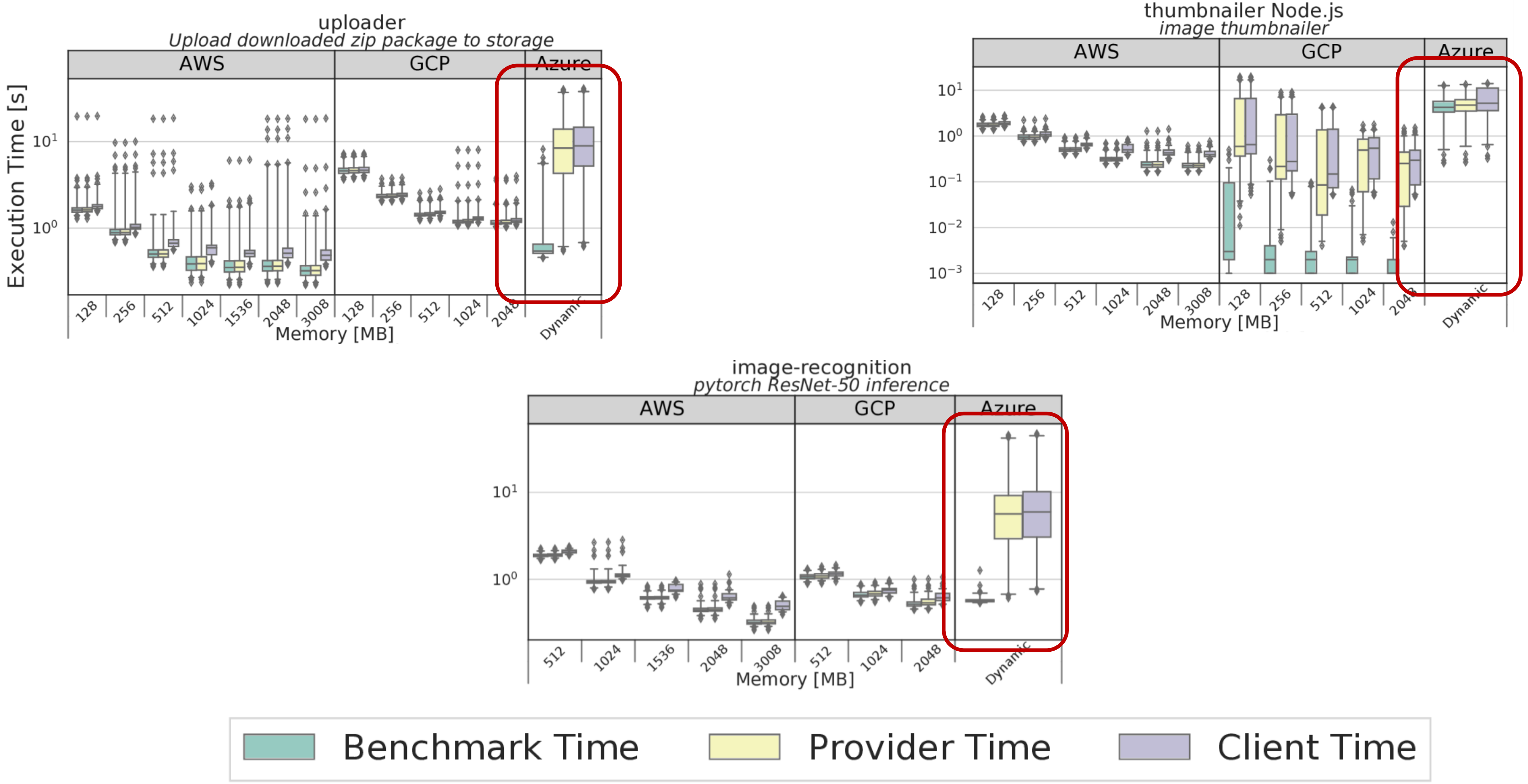

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Performance Analysis: IaaS vs FaaS

	Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search

Performance Analysis: IaaS vs FaaS

	Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS [s]						
FaaS [s]						
Overhead						
Memory [MB]						

Configuration:
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- **FaaS**: AWS Lambda.
- **Local storage**: Minio as Docker container.
- **Measurements:** 200 warm executions.

Performance Analysis: IaaS vs FaaS

	Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS [s]	0.316	0.13	0.191	2.803	0.235	0.03
FaaS [s]	0.389	0.188	0.253	2.949	0.321	0.075
Overhead	1.23x	1.43x	1.24x	1.05x	1.37x	2.4x
Memory [MB]	1024	1024	2048	1024	3008	1536

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$	Break-even analysis for IaaS and FaaS deployment.

Cost Analysis: FaaS vs IaaS

		Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS							
FaaS							

Cost Analysis: FaaS vs IaaS

		Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS							
FaaS							

Configuration:

- **IaaS:** AWS t2.micro instance with 1 vCPU and 1 GB RAM, 100% utilization, $0.0116/h.
- **FaaS**: AWS Lambda.
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Cost Analysis: FaaS vs IaaS

		Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS	Cloud Storage [req/h]						
FaaS							

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Cost Analysis: FaaS vs IaaS

		Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS	Cloud Storage [req/h]	11371	27503	18819	1284	15312	117153
FaaS							

Configuration:
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Cost Analysis: FaaS vs IaaS

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IaaS	Cloud Storage [req/h]	11371	27503	18819	1284	15312	117153
FaaS	Eco 1M [$]						
	Eco Break-Even						
	Perf 1M [$]						
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Cost Analysis: FaaS vs IaaS

		Uploader	Thumbnailer Python	Thumbnailer Node.js	Compression	Image Recognition	Breadth-First Search
IaaS	Cloud Storage [req/h]	11371	27503	18819	1284	15312	117153
FaaS	Eco 1M [$]	3.54	2.29	3.75	32.1	15.8	2.08
	Eco Break-Even	3275	5062	3093	362	733	5568
	Perf 1M [$]	6.67	3.34	10	50	19.58	2.5
	Perf Break-Even	1740	3480	1160	232	592	4640

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FaaS	Eco 1M [$]	3.54	2.29	3.75	32.1	15.8	2.08
	Eco Break-Even	3275	5062	3093	362	733	5568
	Perf 1M [$]	6.67	3.34	10	50	19.58	2.5
	Perf Break-Even	1740	3480	1160	232	592	4640

Configuration:
- **IaaS:** AWS t2.micro instance with 1 vCPU and 1 GB RAM, 100% utilization, $0.0116/h.
- **FaaS**: AWS Lambda.
- **Local storage**: Minio as Docker container.

Results and Insights

	Results, methods, and insights
	AWS Lambda achieves the best performance on all workloads.
	Irregular performance of concurrent Azure Function executions.
	I/O-bound functions experience very high latency variations.
	AWS Lambda performance is not competitive against VMs assuming comparable resources.
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	Break-even analysis for IaaS and FaaS deployment.

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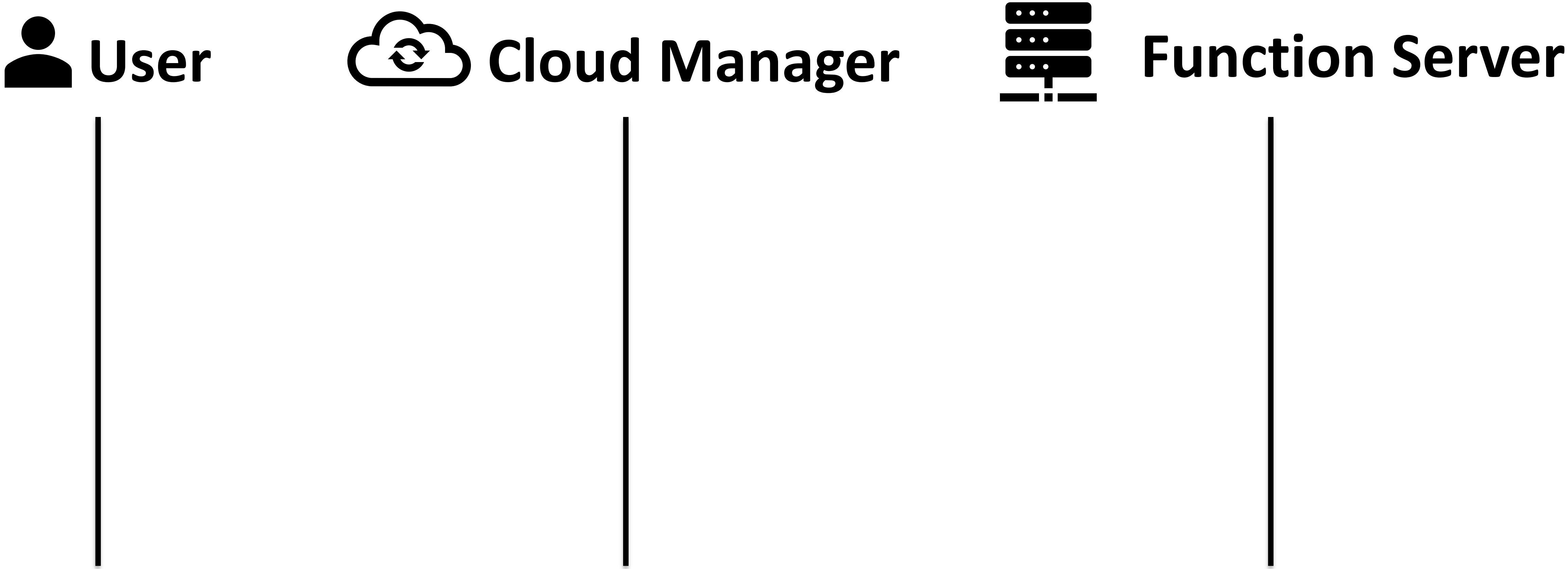
	Break-even analysis for IaaS and FaaS deployment.
	Accurate methodology for estimation of invocation latency.
	Warm latencies are consistent and depend linearly on payload size.
	Highly variable and unpredictable cold latencies on Azure and GCP.

FaaS Analysis: Invocation Overhead



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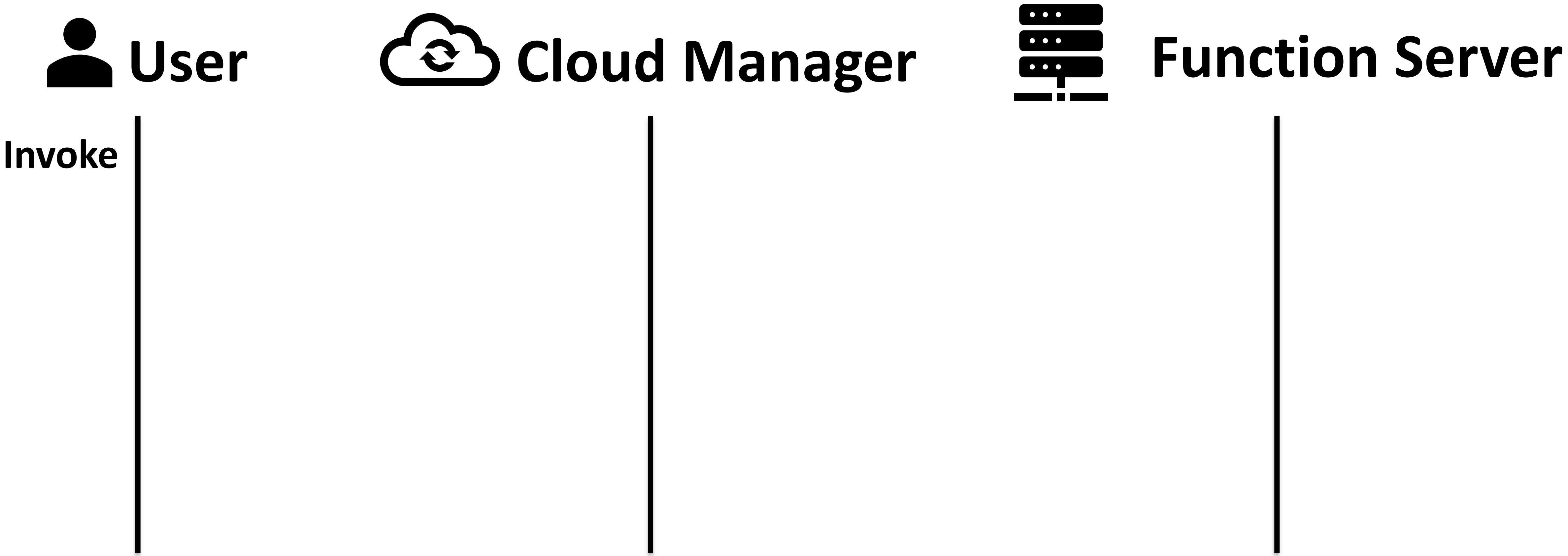

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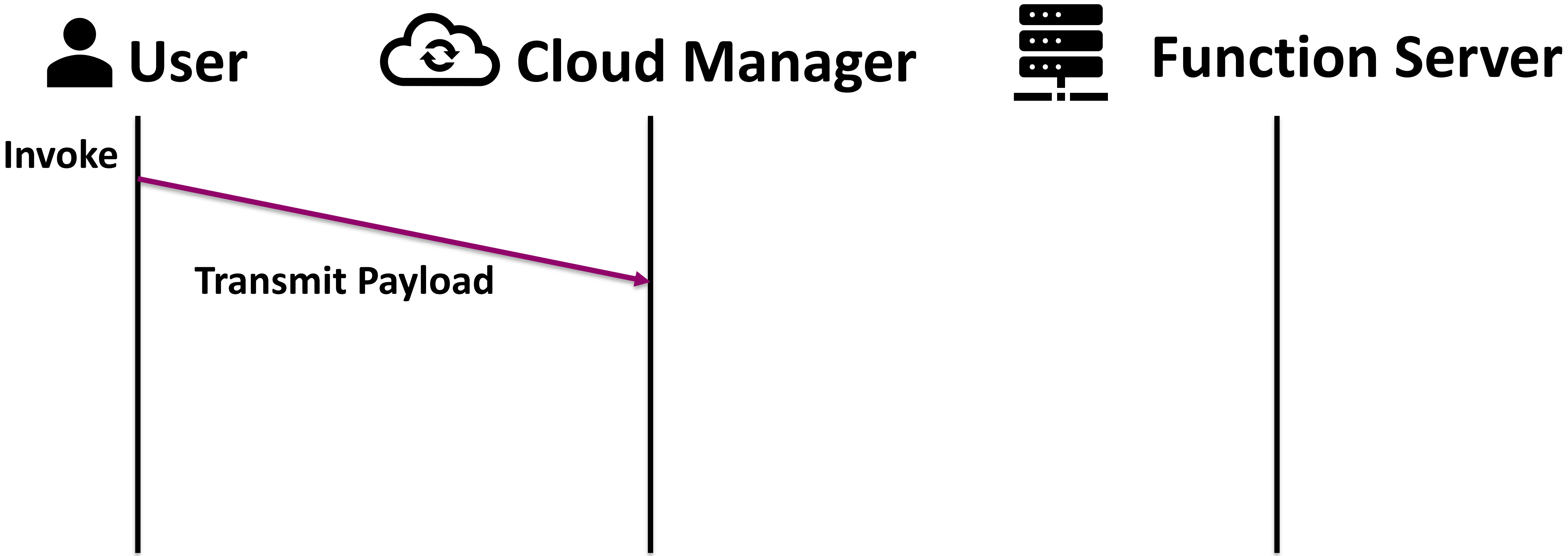

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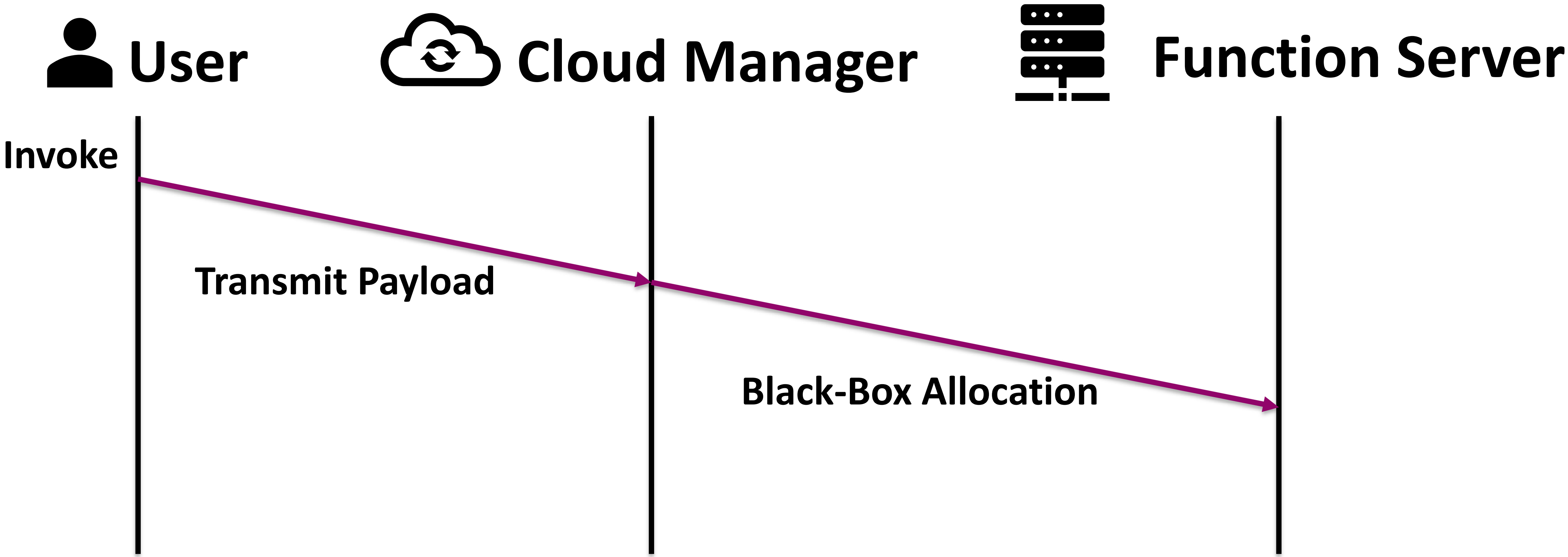
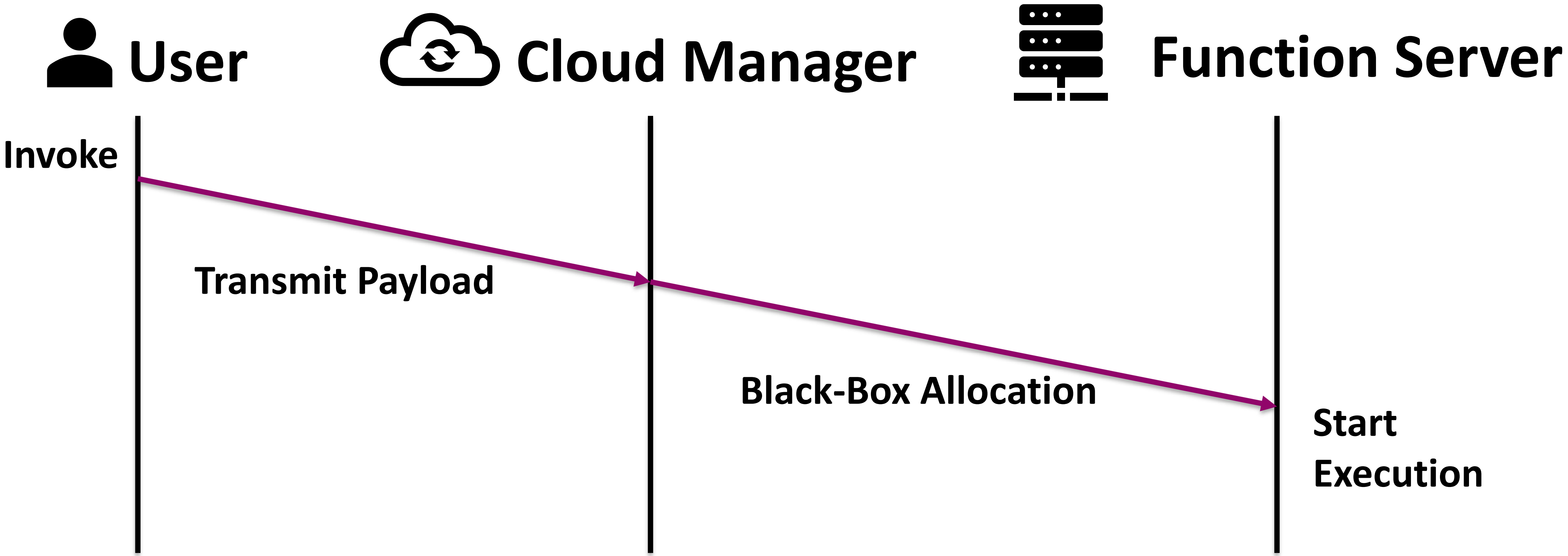
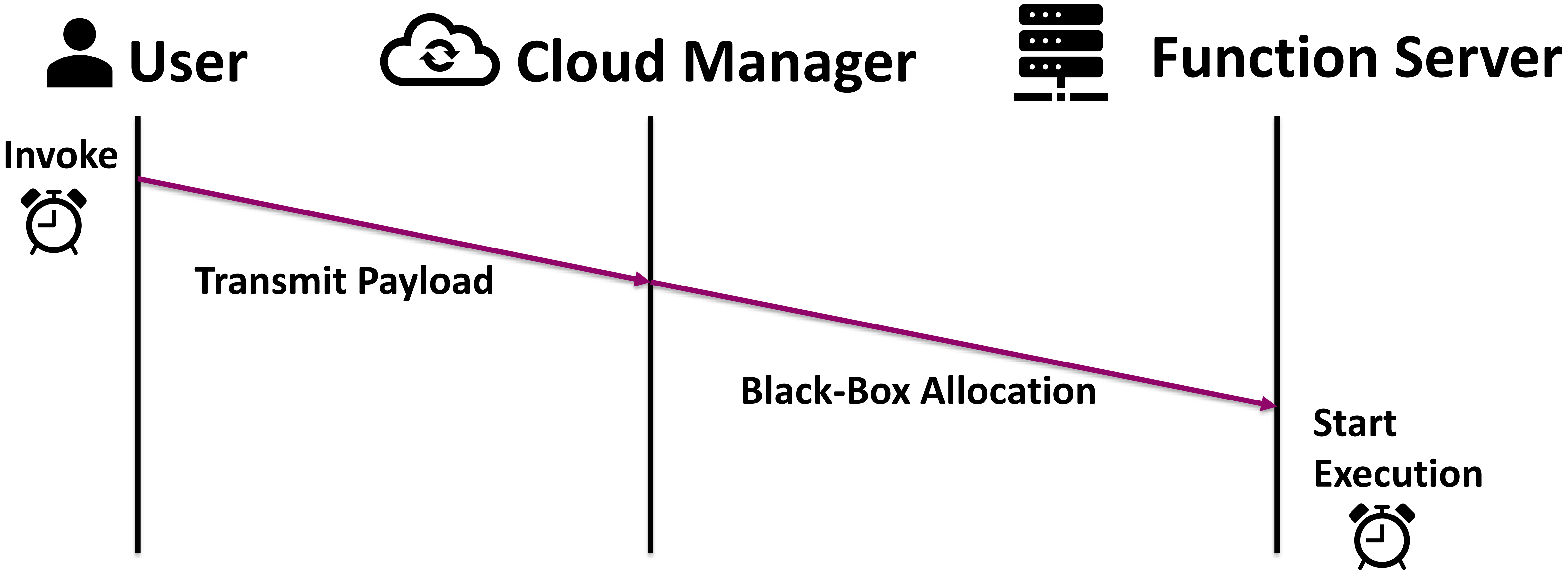


FaaS Analysis: Invocation Overhead



FaaS Analysis: Invocation Overhead



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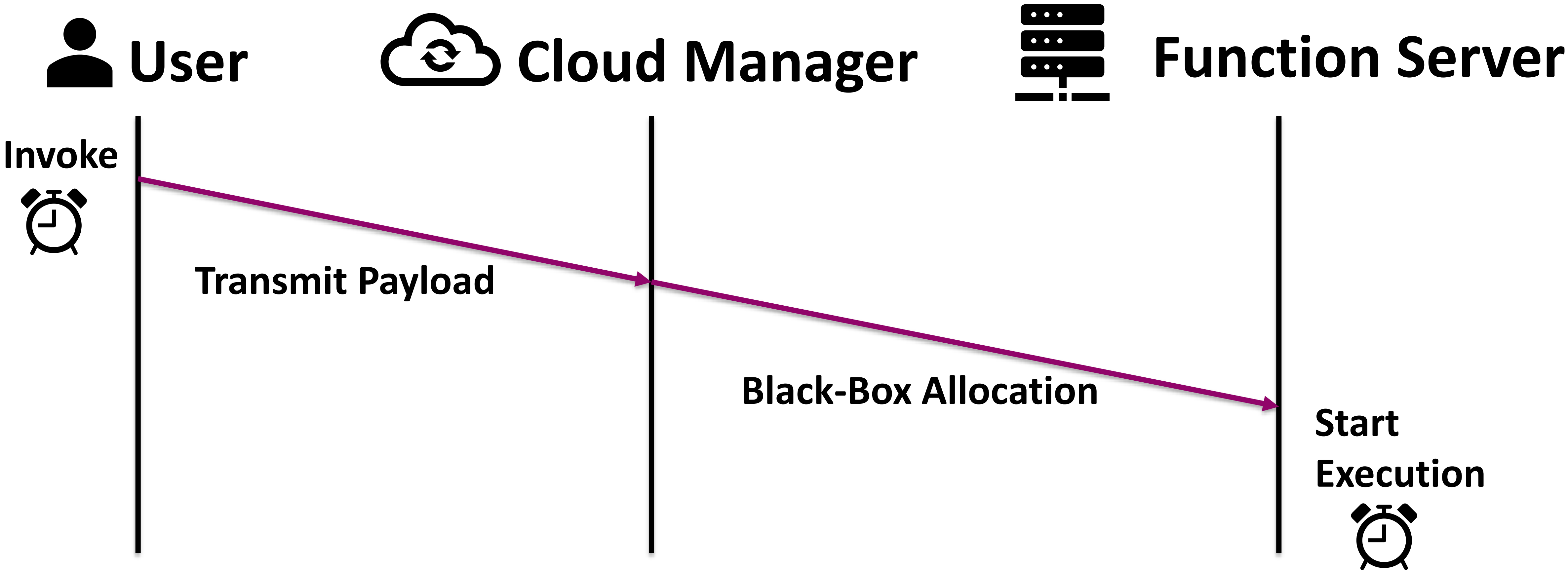

Solution: apply clock-drift estimation protocols!

FaaS Analysis: Invocation Overhead

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Configuration:

- Compare timestamps on client and function side.
- Clock drift estimation protocol.
- Payload: 1 kB – 5.9 MB

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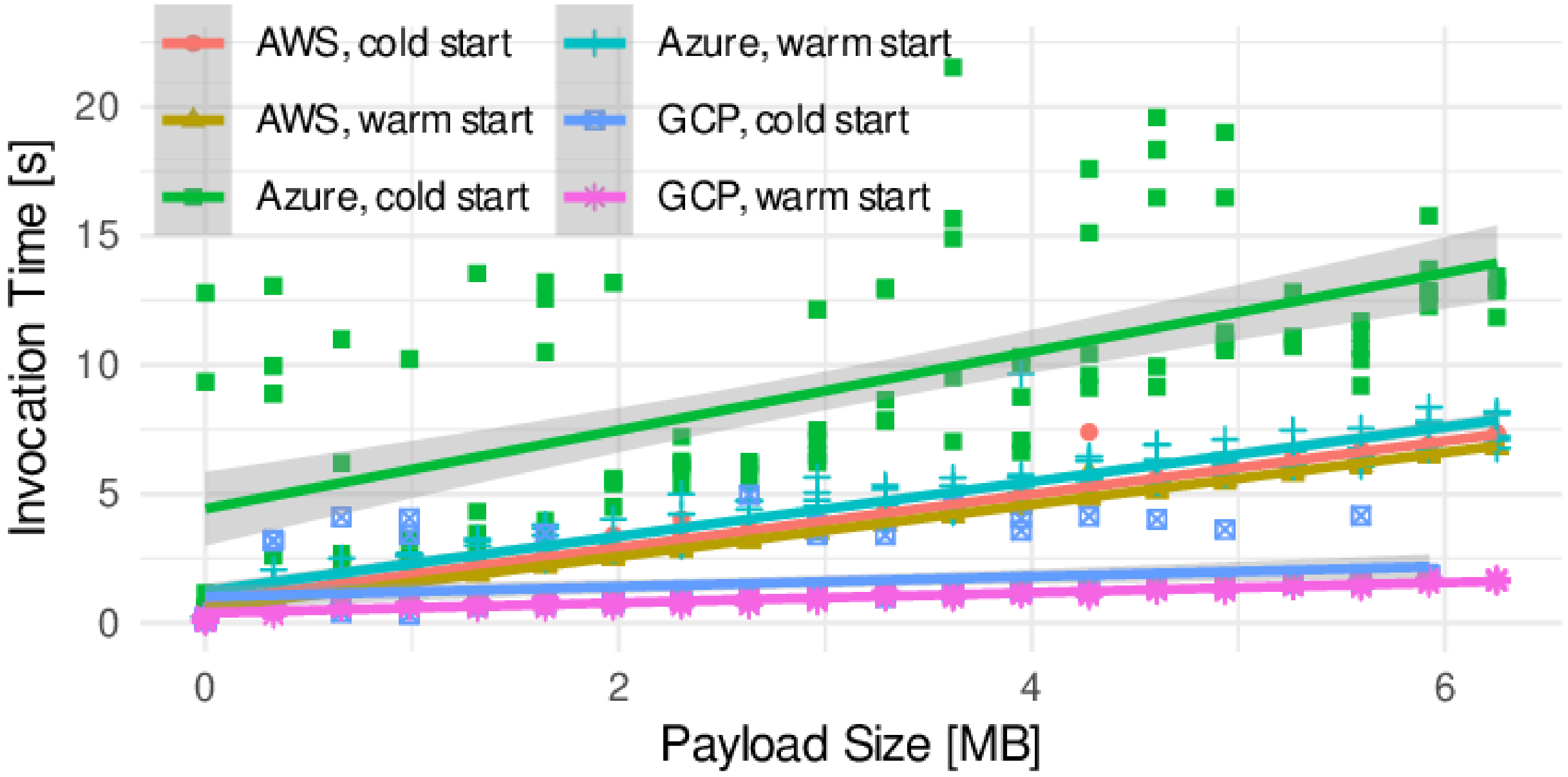

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Summary

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spcl/serverless-benchmarks