Marcin Copik, Alexandru Calotoiu, Torsten Hoefler, Michał Podstawski, Laurin Brandner, Larissa Schmid, Nico Graf, Grzegorz Kwaśniewski, Kacper Janda, Mateusz Knapik, Jakub Czerski, Mahla Sarifi, Paweł Żuk, Sascha Kehrli, Abhishek Kumar, Prajin Khadka, Horia Mercan, and many others!

Demystifying Serverless Performance: A Hands-on Tutorial with Serverless Benchmark Suite SeBS

HiPEAC 2026
Cracow, Poland

Agenda

SeBS Slack

- ✓ Part I
  - ✓ What is Serverless?
  - ✓ Benchmarking Suite SeBS
  - ✓ Working with SeBS
- ✓ Hands-on I: Local Deployment & Storage
- ✓ **Part II**
  - ✓ **Communication and Data**
  - ✓ **Serverless Workflows**
  - ✓ **Experiments in SeBS**
- ✓ Hands-on II: FaaS Platforms & Experiments
- ✓ Part III
  - ✓ Research Directions in Serverless
  - ✓ Development of SeBS

slack **Join SeBS Slack channel: https://serverlessbenchmark.slack.com**

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SeBS Slack

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From Cloud to the Edge

From Cloud to the Edge

Introducing Cloudflare Workers: Run JavaScript Service Workers at the Edge

2017-09-29

From Cloud to the Edge

Introducing Cloudflare Workers:

Ru

th

2017-0

Bringing Python to Workers using Pyodide and WebAssembly

2024-04-02

From Cloud to the Edge

Introducing Cloudflare Workers:
Ru
th
2017-0

Bringing Python to Workers using
Pyo
2024-04-02

Python Workers redux: fast cold starts, packages, and a uv-first workflow
2025-12-08

From Cloud to the Edge

Introducing Cloudflare Workers:

Ru

th

2017-0

Bringing Python to Workers using

Pyo

Python Workers redux: fast cold

-first

Simple, scalable, and global:

Containers are coming to

Cloudflare Workers in June 2025

2025-04-11

From Cloud to the Edge

Cloudflare Workers

From Cloud to the Edge

		Cloudflare Workers
Runtime	Container or microVM.	V8 Isolates.

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Execution Limits	10-15+ minutes	10 ms / 5 minutes CPU time

From Cloud to the Edge: SeBS Compatibility

Sebs Benchmarks Cloudflare Compatibility

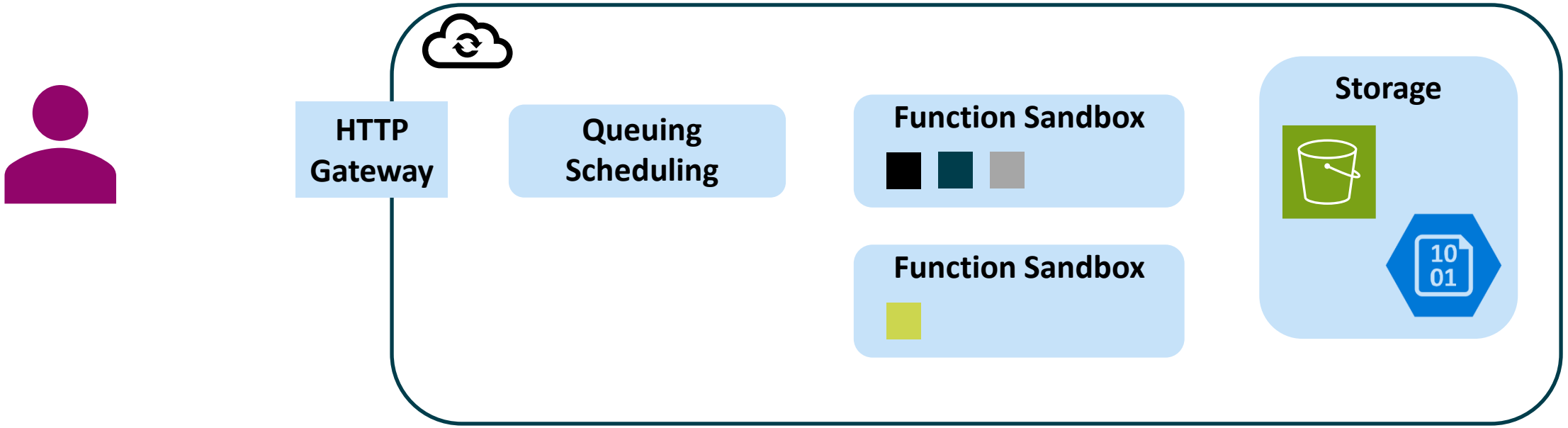
could be polyfilled could be translated not possible

	110	120	130	210	220	311	411	501	502	503	504
Nodejs Worker	✓	✓	✓	sharp n/a	sub-process n/a & too big	✓	pytorch n/a & too big	igraph n/a	igraph n/a	igraph n/a	too big
Python Worker	✓	✓	✓	✓	too big	✓	too big	✓	✓	✓	too big
Nodejs Container	✓	✓	✓	✓	Not Imple-mented	✓	pytorch n/a	igraph n/a	igraph n/a	igraph n/a	igraph n/a
Python Container	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

11

Project from ETH students Livio D'Agostini, Laurin Jahns, and Marouan Mbarek.

LaTeX Microservice in Serverless



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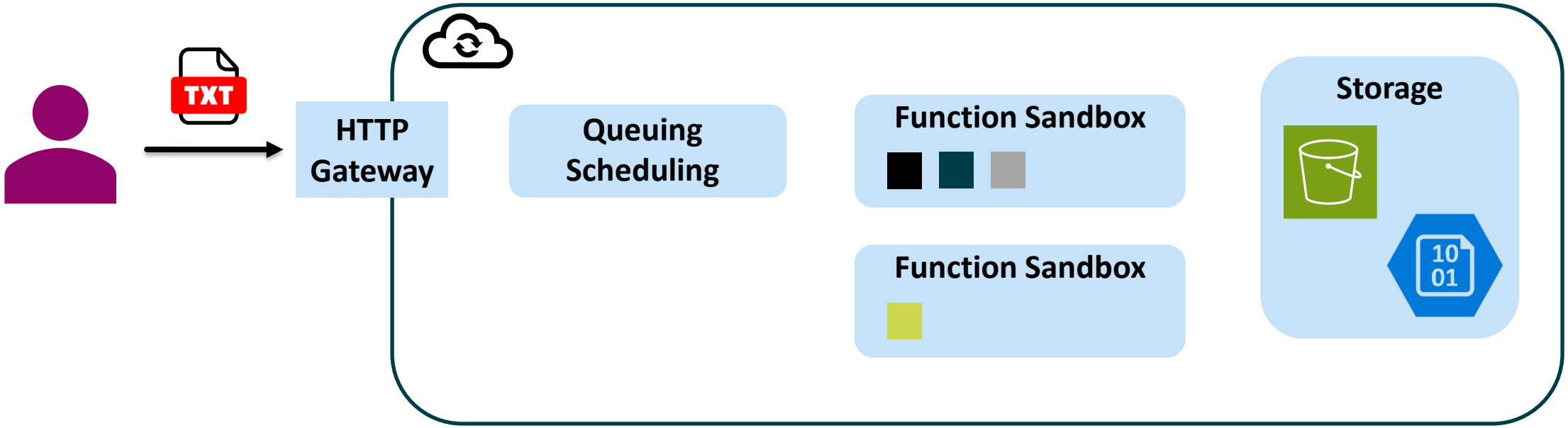

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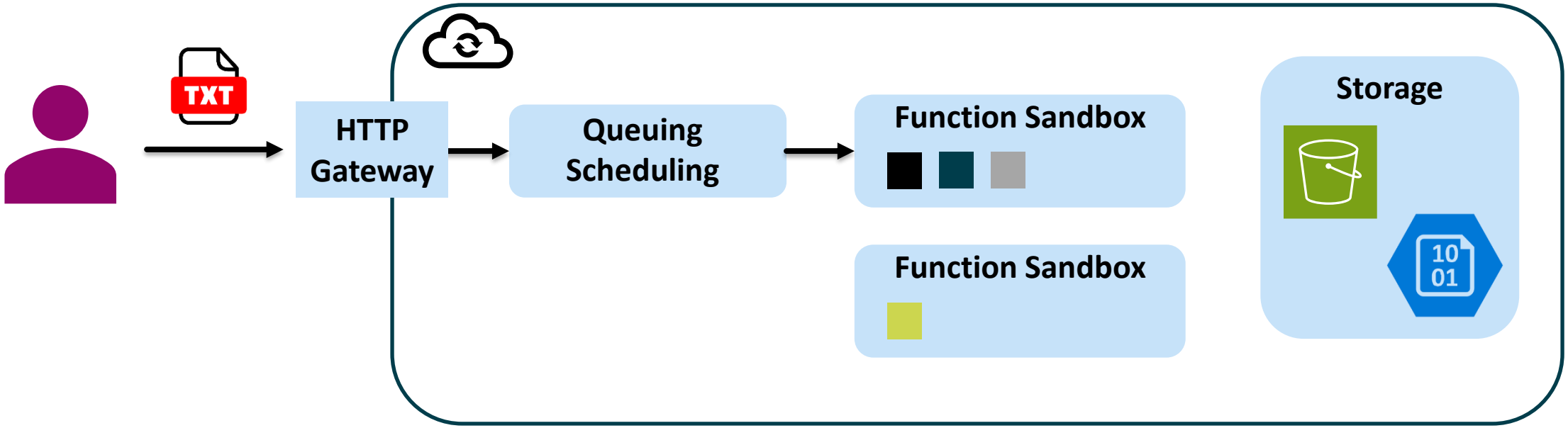
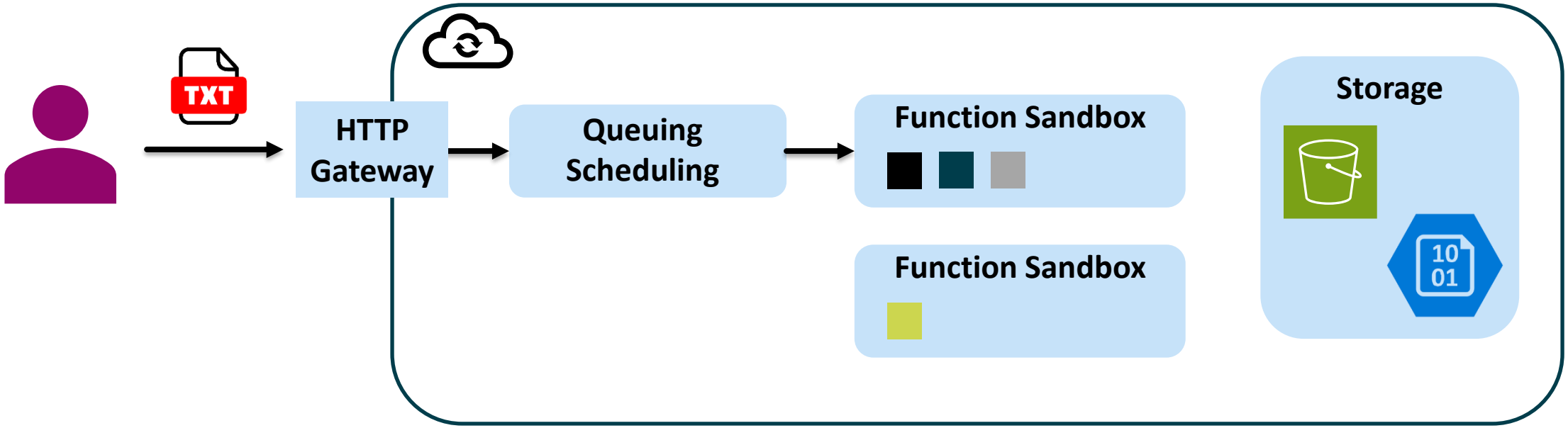


LaTeX Microservice in Serverless

Is cache up to date?
Did other function edit file of this client?



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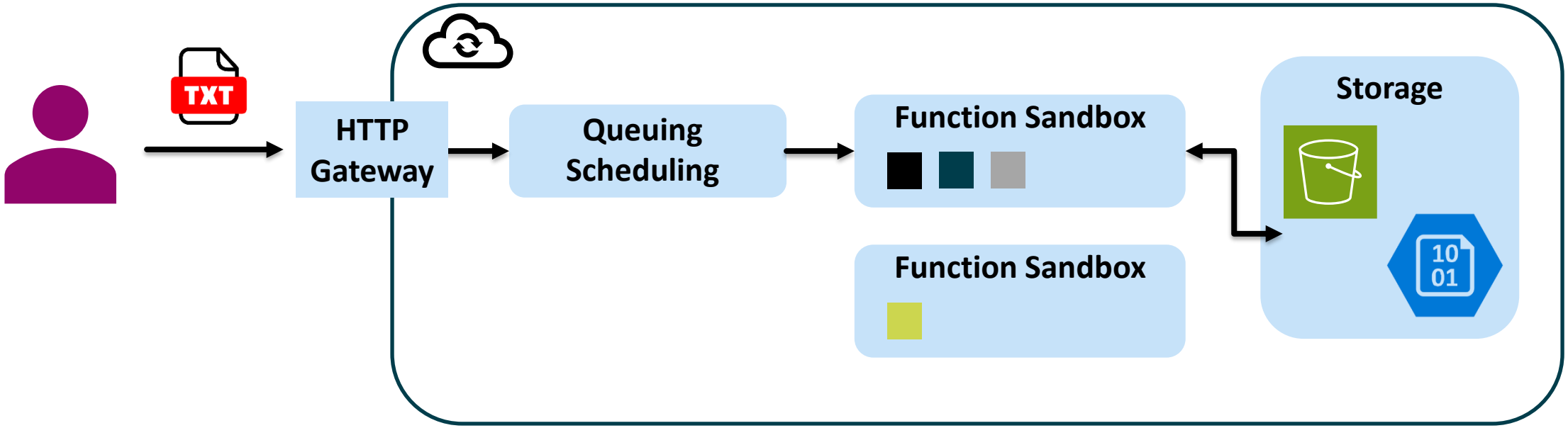

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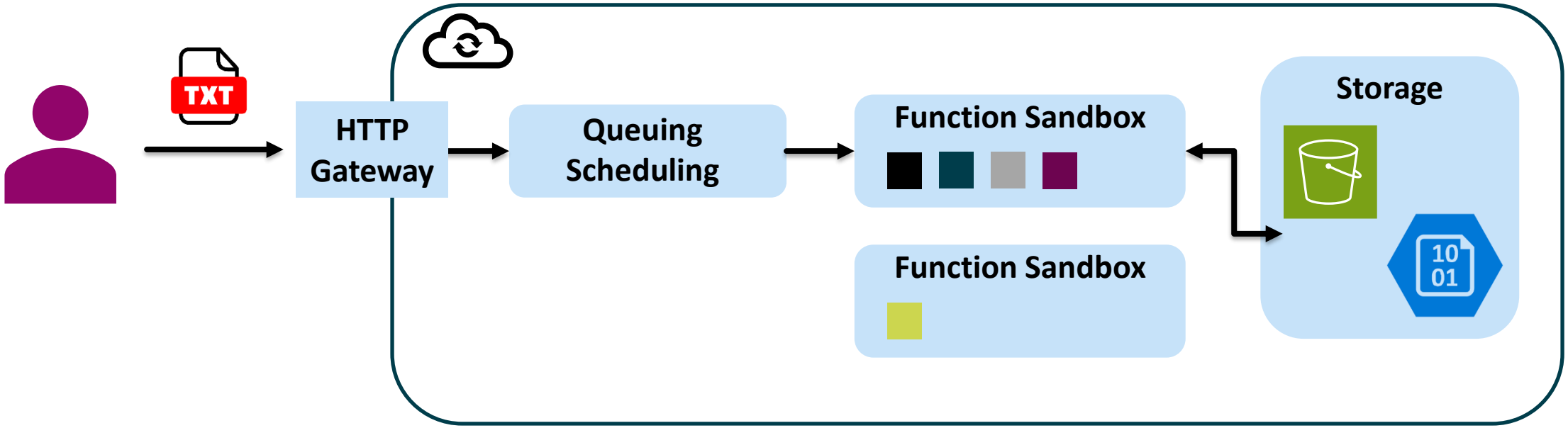
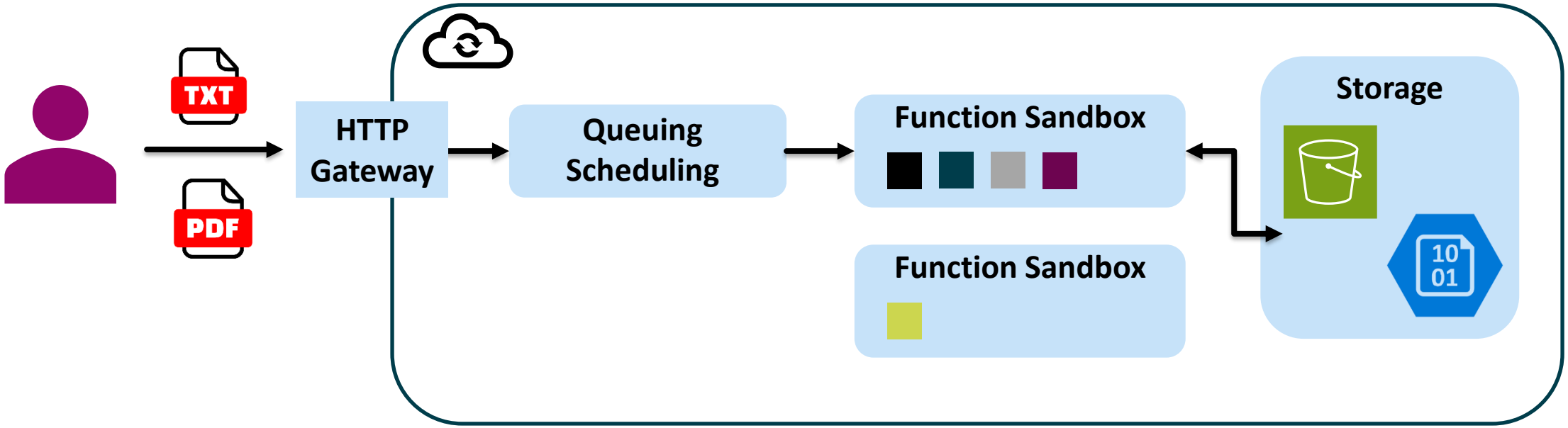


Serverless Service

- Cached function state is not reliable

LaTeX Microservice in Serverless



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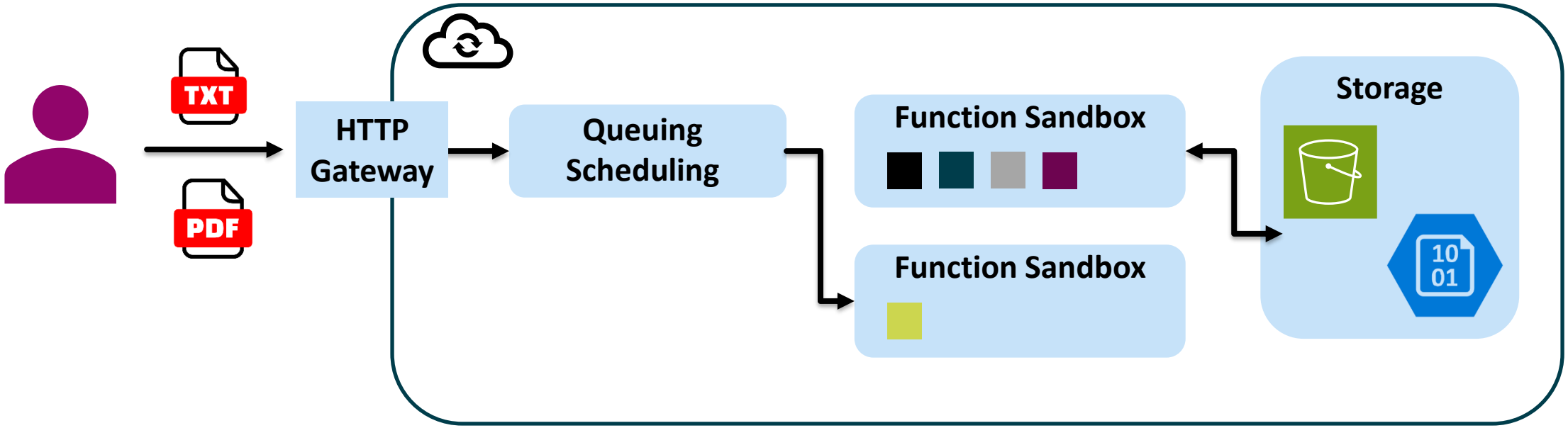

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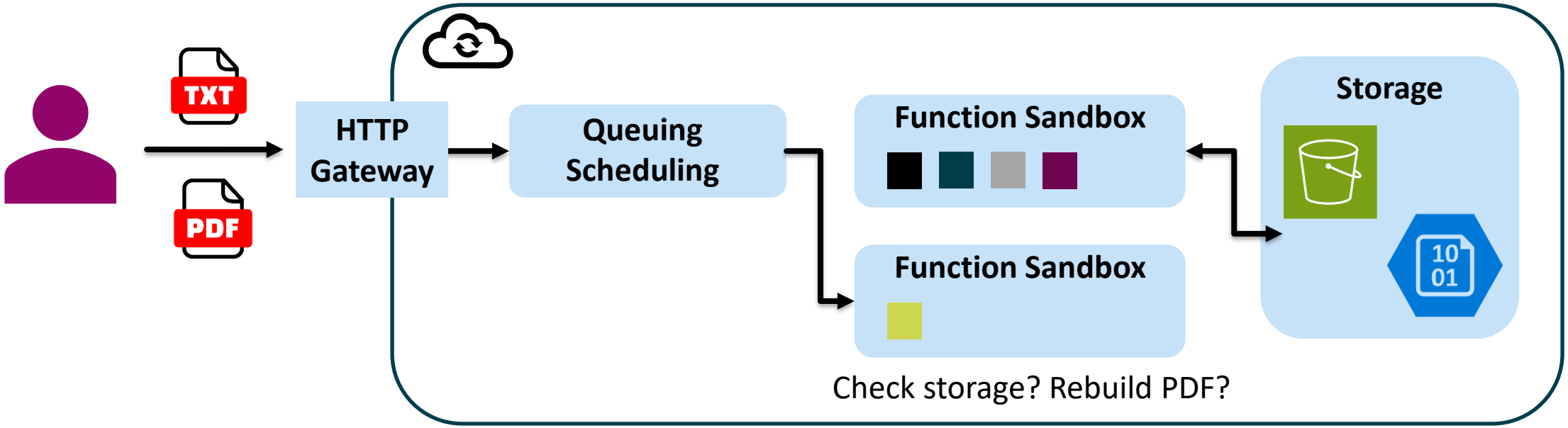

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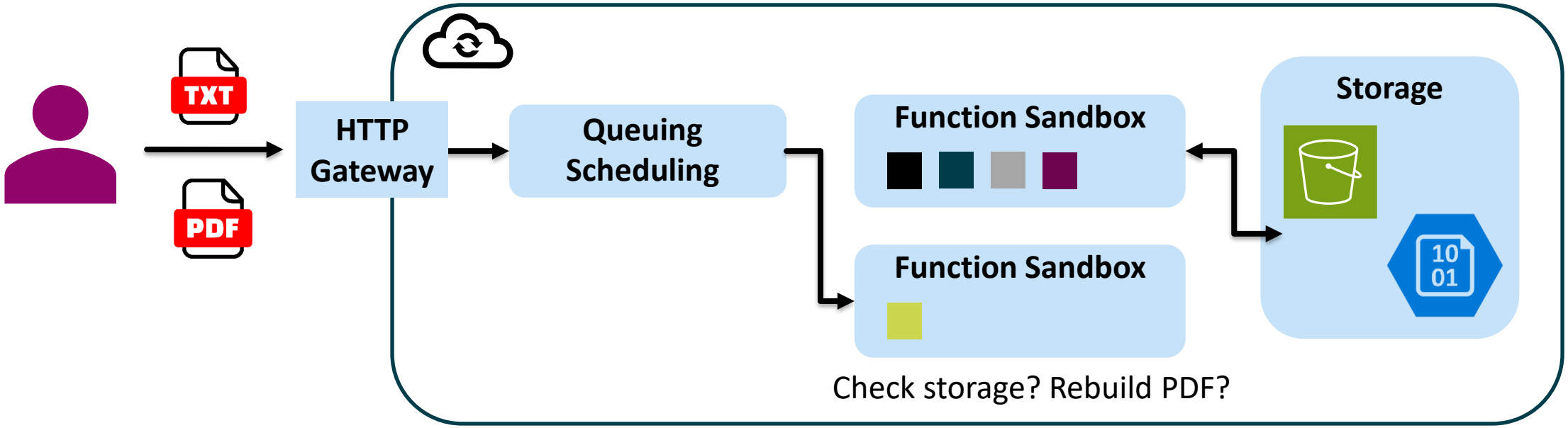
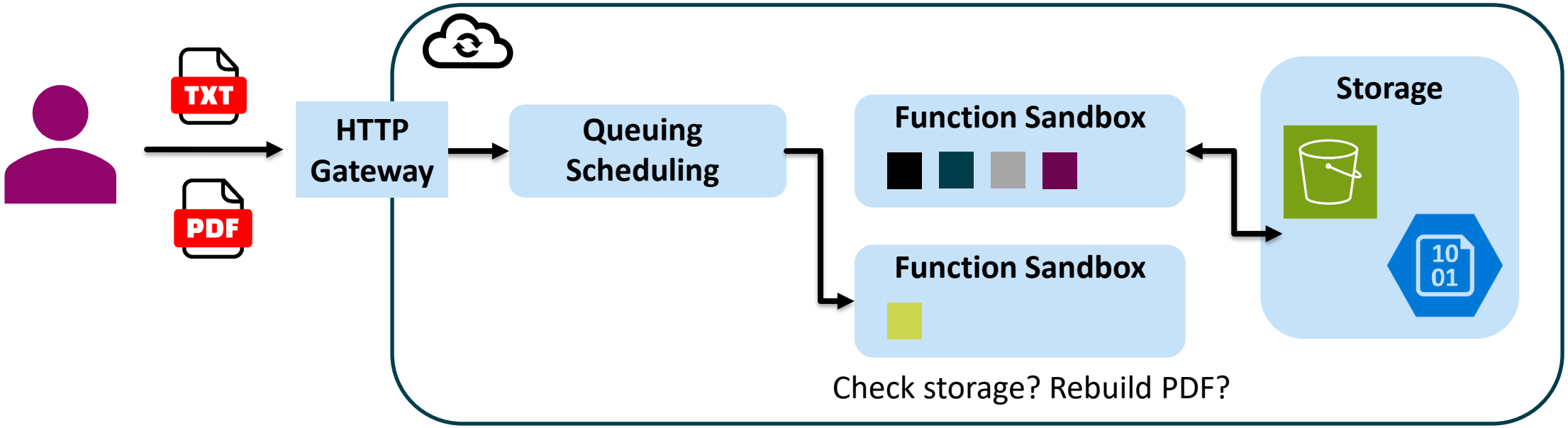


Serverless Service

- ✗ Cached function state is not reliable
- ✗ Request context has no influence on scheduling

LaTeX Microservice in Serverless



Serverless Service

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- Request context has no influence on scheduling

Standard Microservice

- Extensive caching
- Load balancing with sticky sessions

From Serverless Functions to Applications

From Serverless Functions to Applications

Workflows

Offered by the cloud provider.

From Serverless Functions to Applications

Workflows

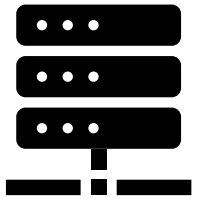
Offered by the cloud provider.

“Applications”

No such product in the cloud.

Combine functions, storage, queues, caches, containers and VMs.

Serverless Applications: Disaggregate



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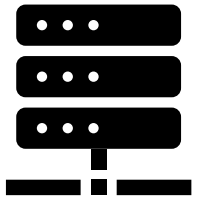
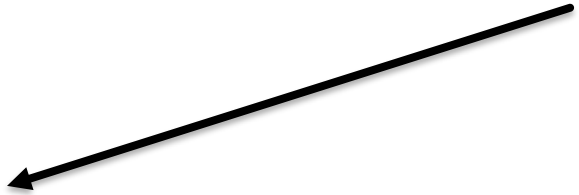
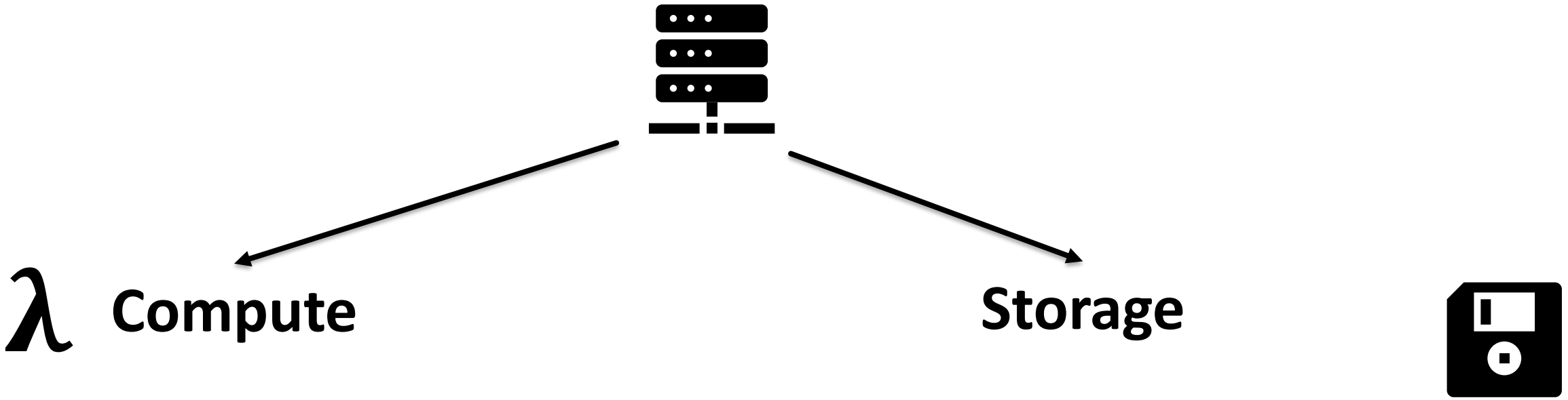




λ Compute

Serverless Applications: Disaggregate



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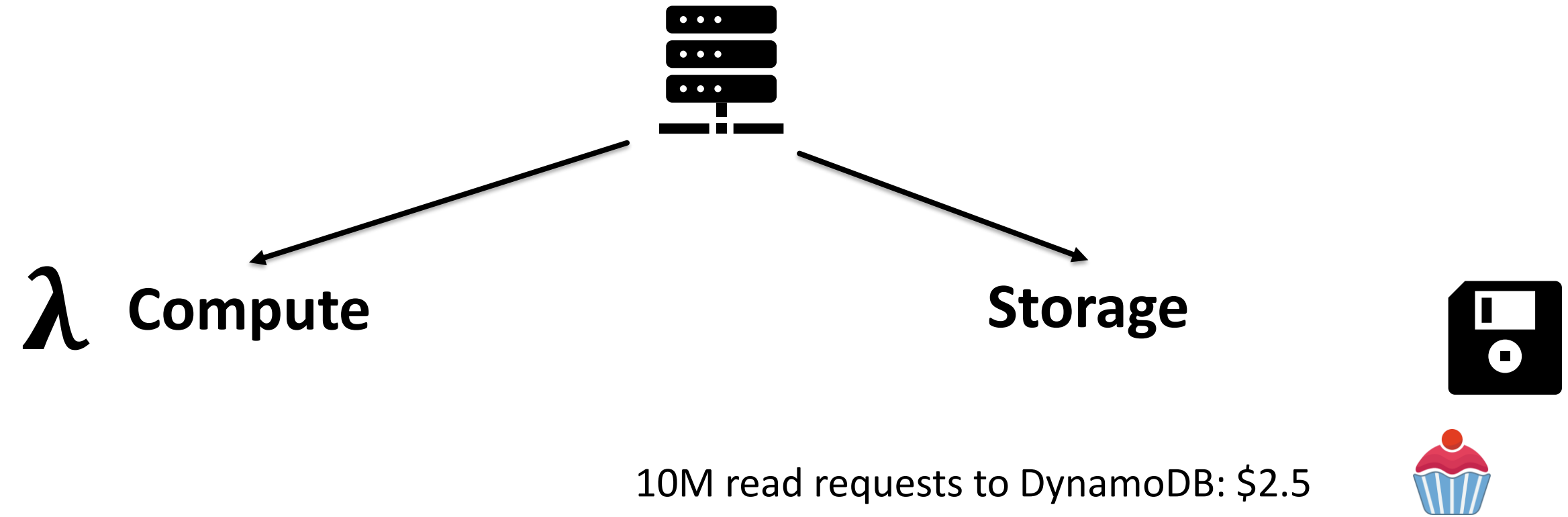
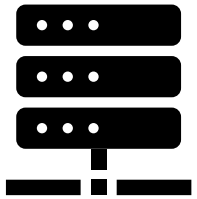


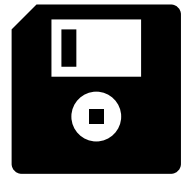
10M read requests to DynamoDB: $2.5

Serverless Applications: Disaggregate



λ Compute

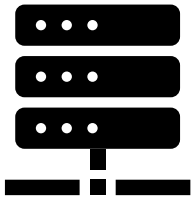
Storage



10M read requests to DynamoDB: $2.5

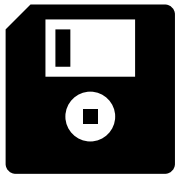
10M read requests to S3: $4

Serverless Applications: Disaggregate



λ Compute

Storage



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10M read requests to S3: $4

10M Lambda invocations for 30 ms: $10

Serverless Applications: From Design to the Cloud

System Concept
Functions
Object Storage
Key-Value Storage
Concurrency Primitives
Queue

“FaaSKeeper: Learning from Building Serverless Services with ZooKeeper as an Example”, HPDC’24

Serverless Applications: From Design to the Cloud

System Concept	AWS
Functions	Lambda
Object Storage	S3
Key-Value Storage	DynamoDB
Concurrency Primitives	Update Expressions
Queue	SQS

“FaaSKeeper: Learning from Building Serverless Services with ZooKeeper as an Example”, HPDC’24

Serverless Applications: From Design to the Cloud

System Concept	AWS	Google Cloud
Functions	Lambda	Cloud Function
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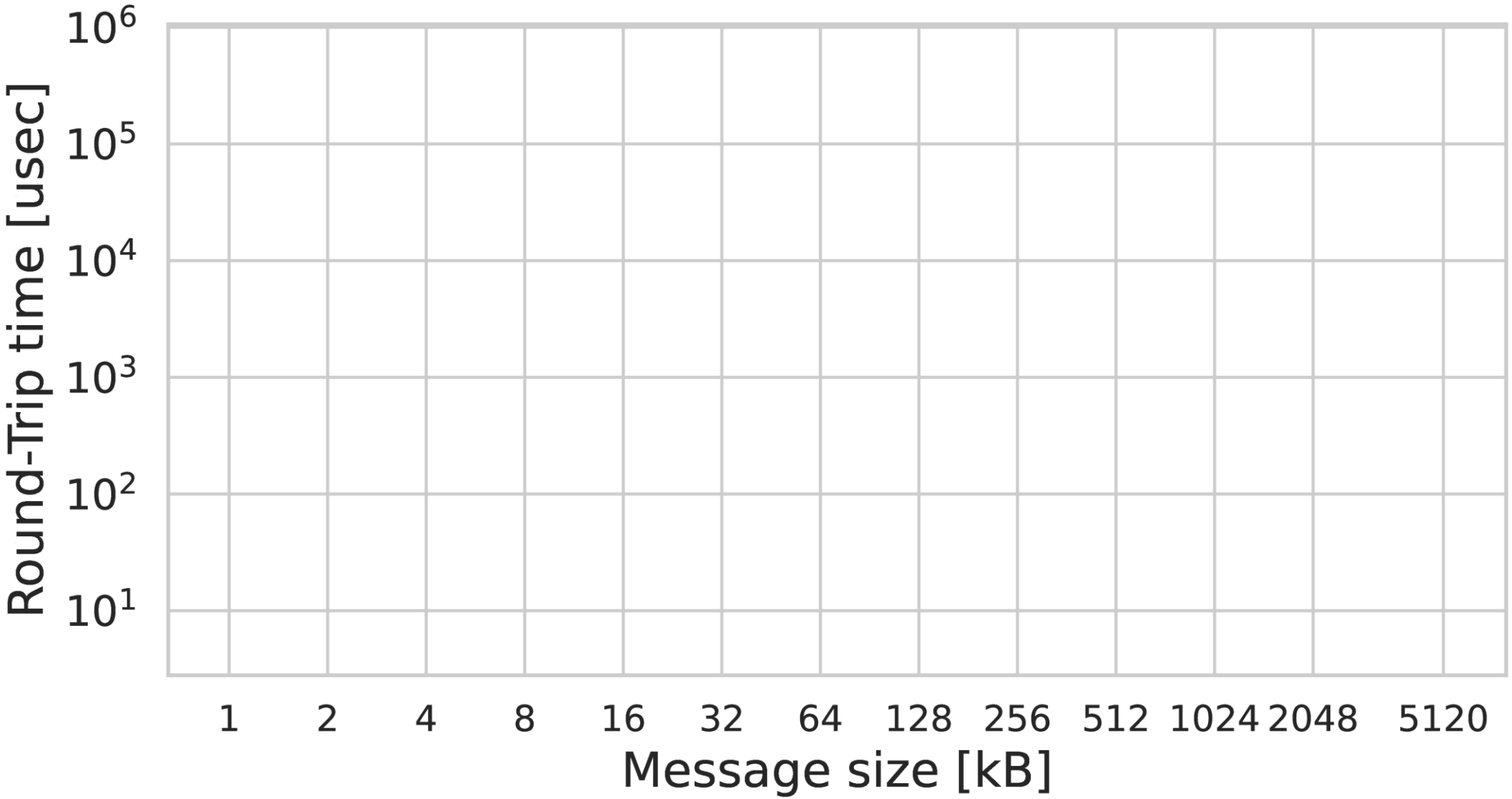
Key-Value Storage	DynamoDB	Datastore
Concurrency Primitives	Update Expressions	Transactions
Queue	SQS	Pub/Sub

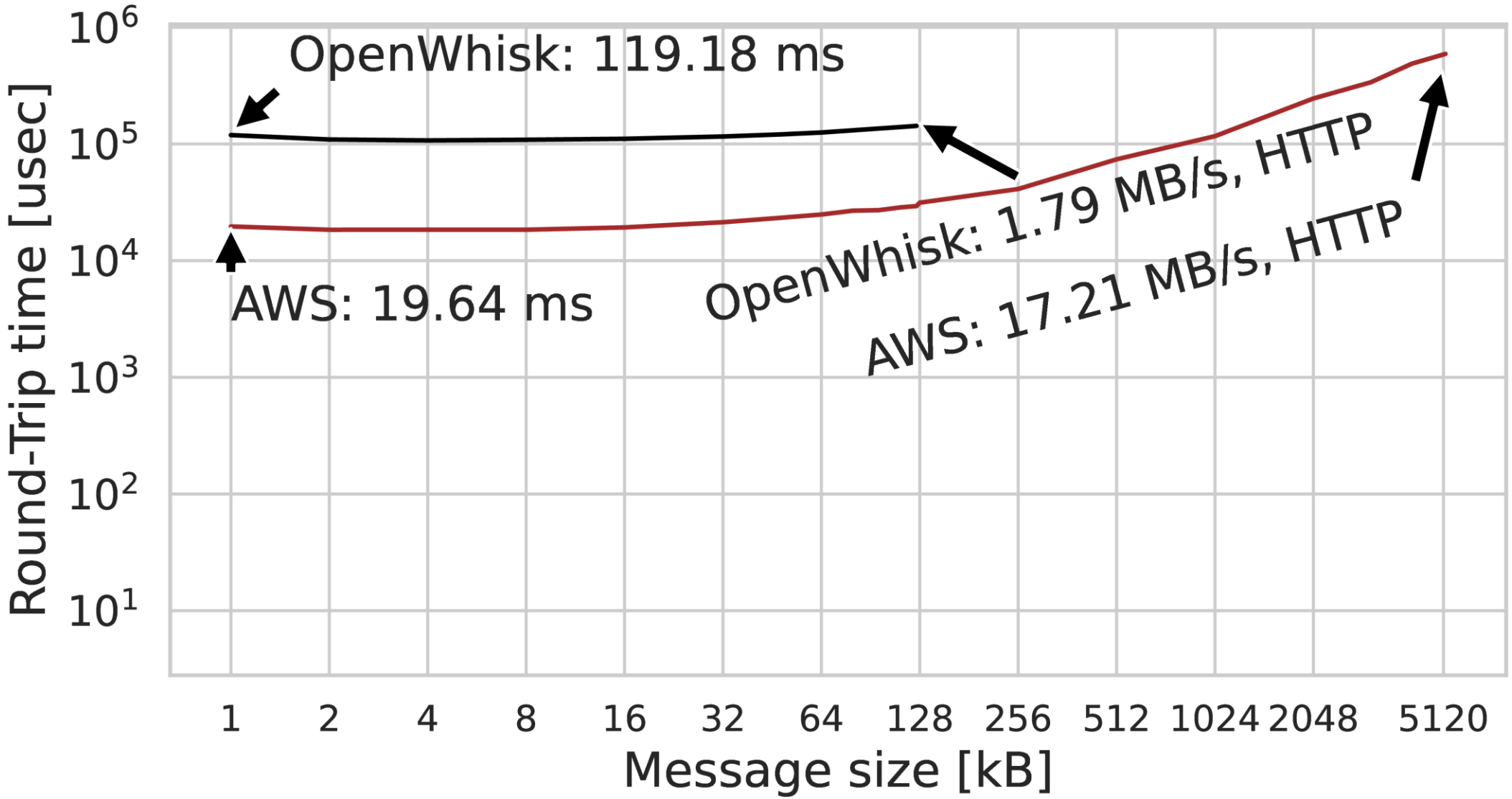
“FaaSKeeper: Learning from Building Serverless Services with ZooKeeper as an Example”, HPDC’24

Serverless Applications: Platform Overheads



“rFaaS: Enabling High Performance Serverless with RDMA and Leases”, IPDPS’23

Serverless Applications: Platform Overheads



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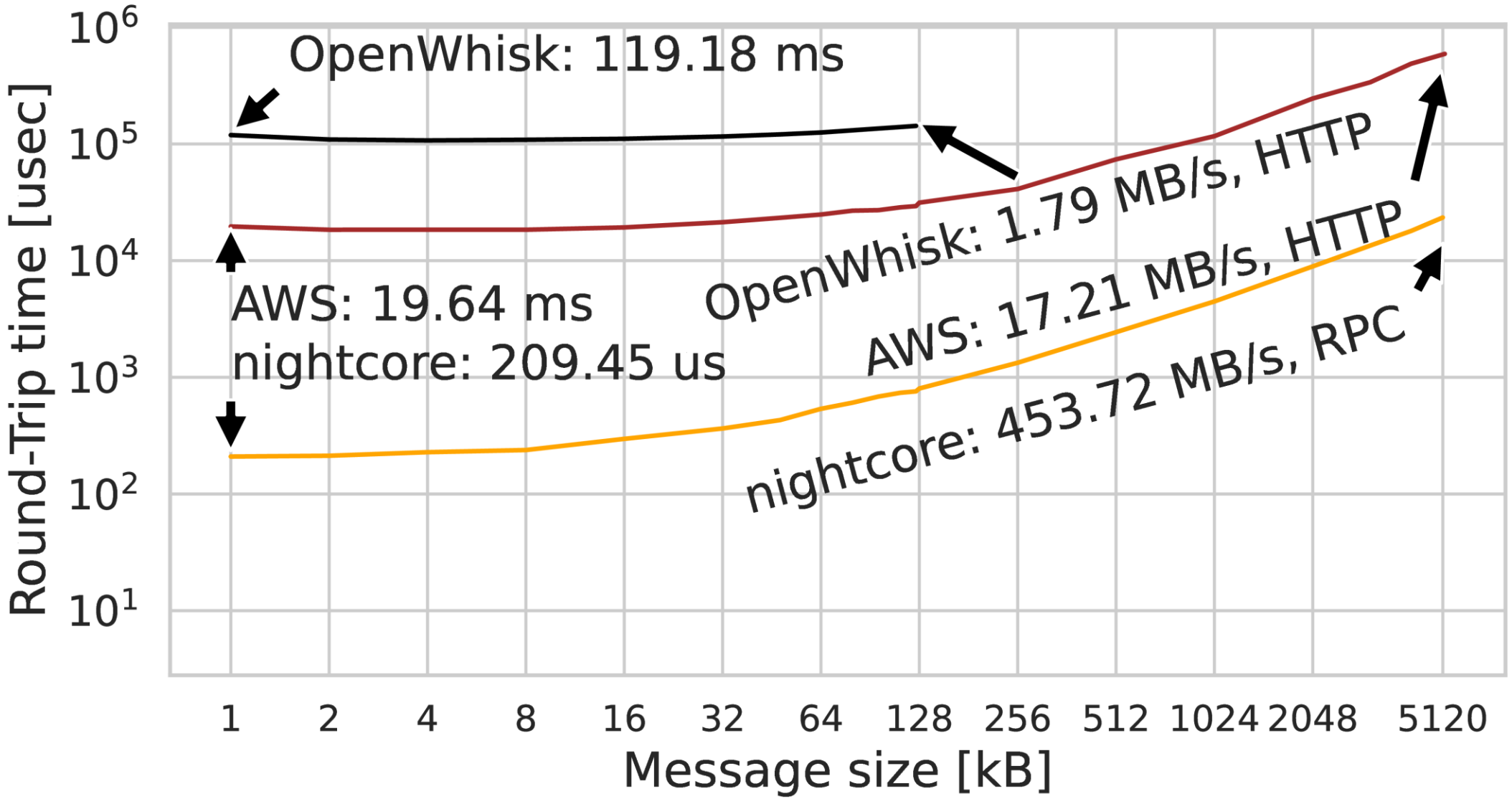

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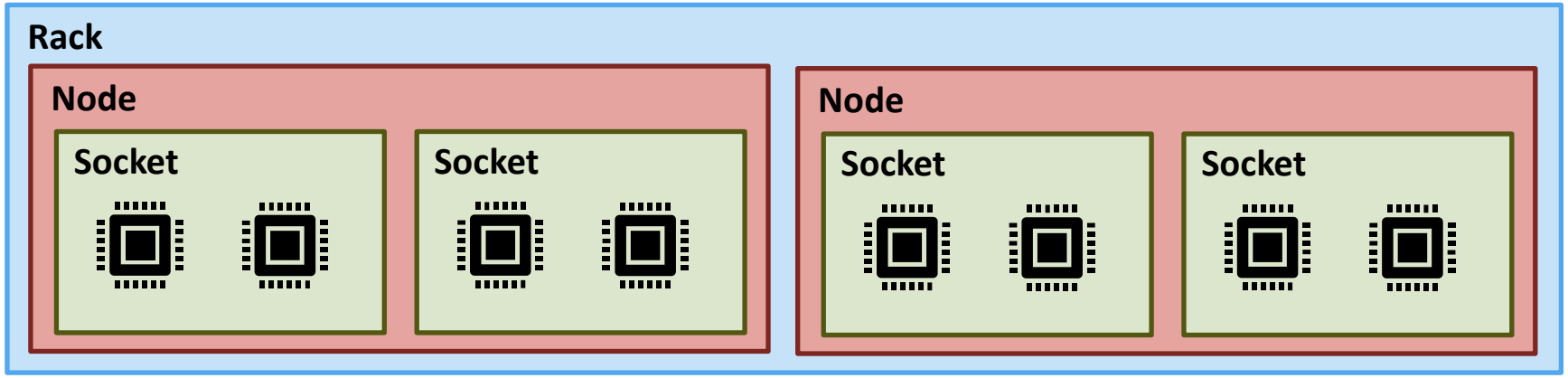
Serverless Applications: Communication

- We need **high performance.**
- We need **portable performance.**



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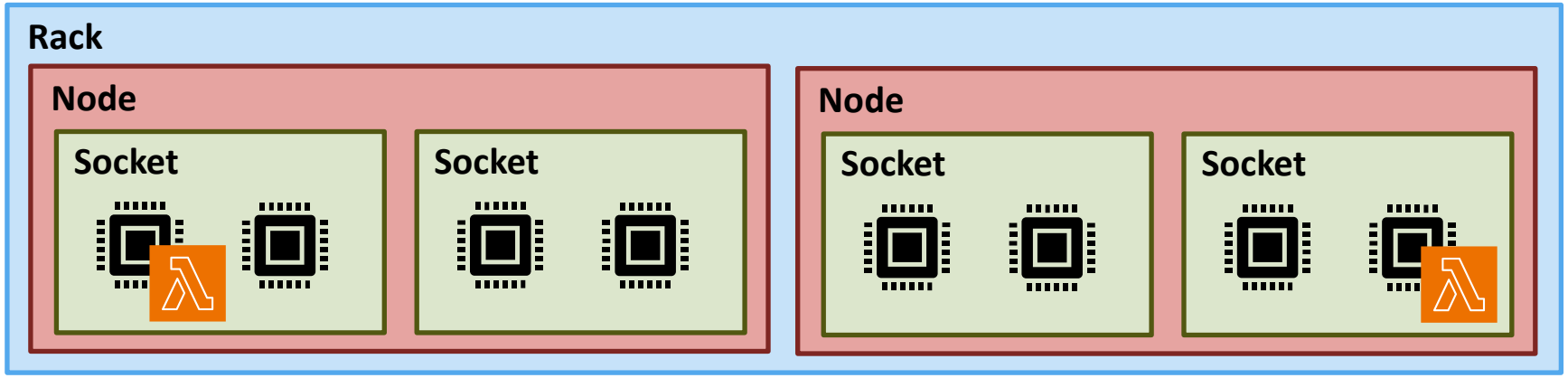

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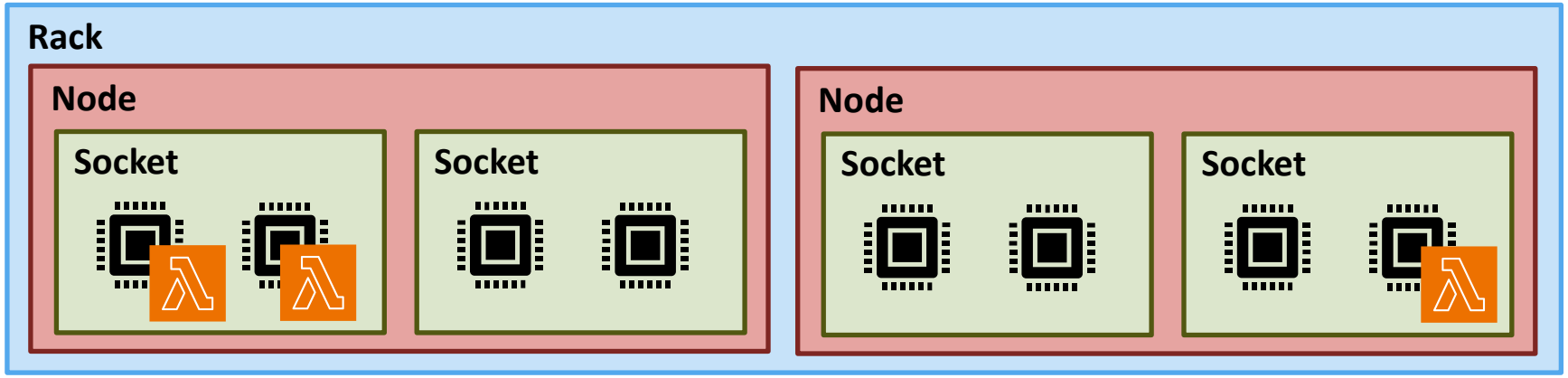

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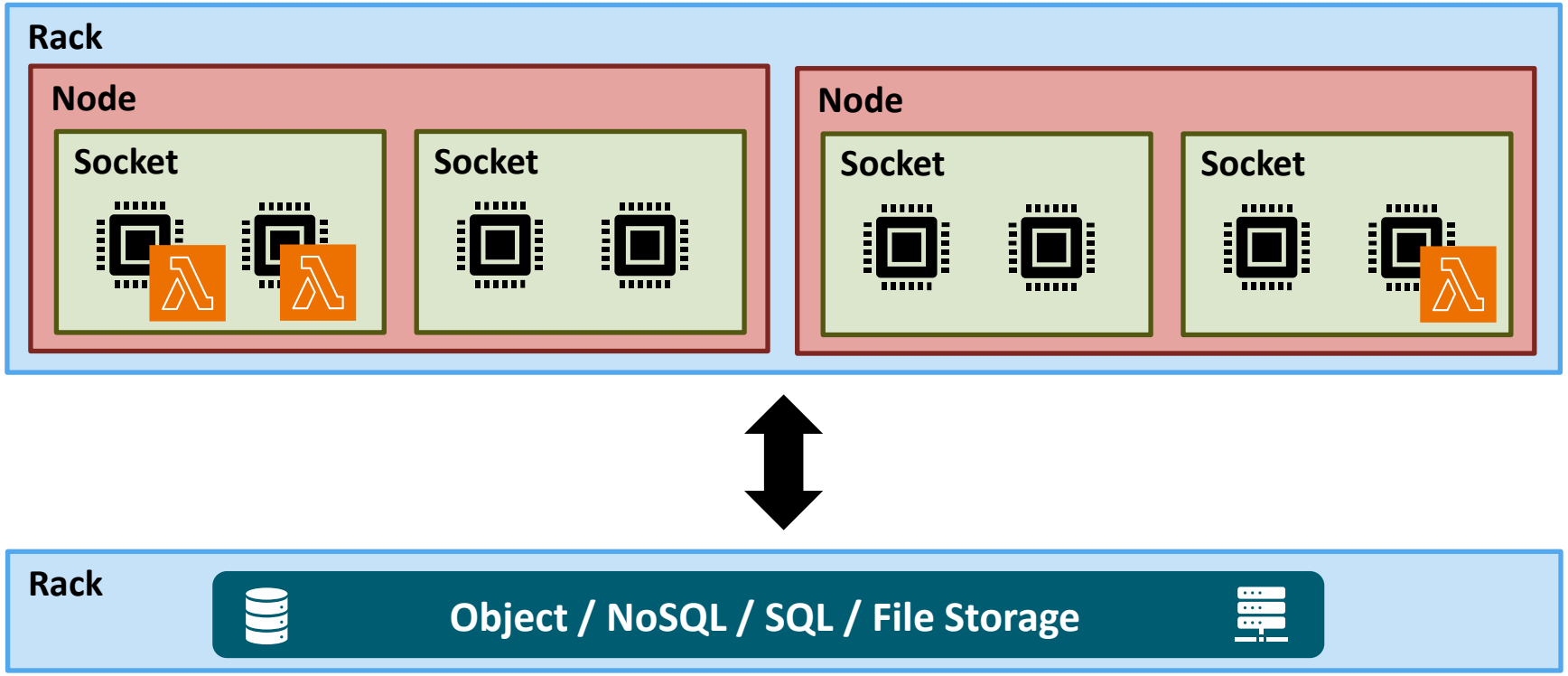


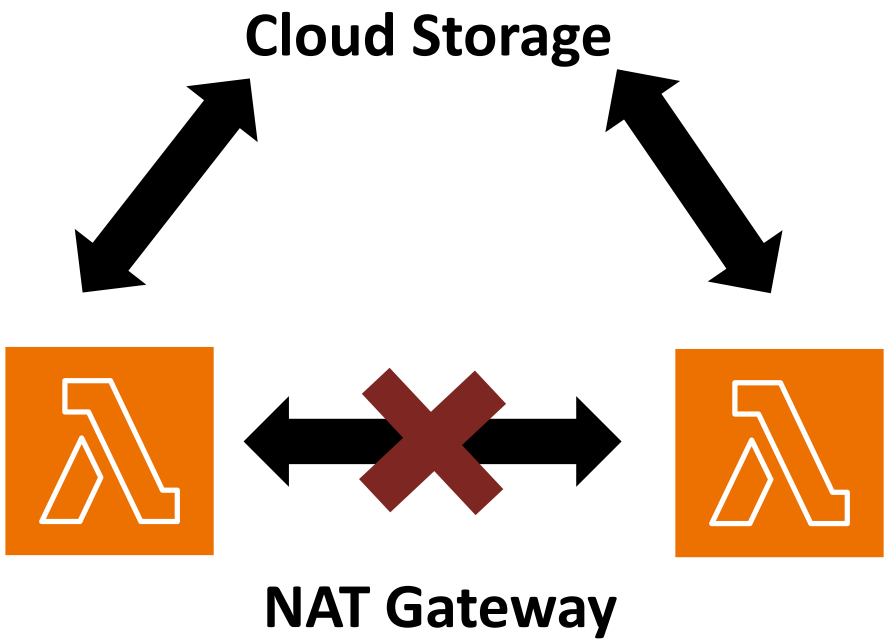
Serverless Applications: Communication

Serverless Applications: Communication

Serverless Applications: Communication

NAT Gateway

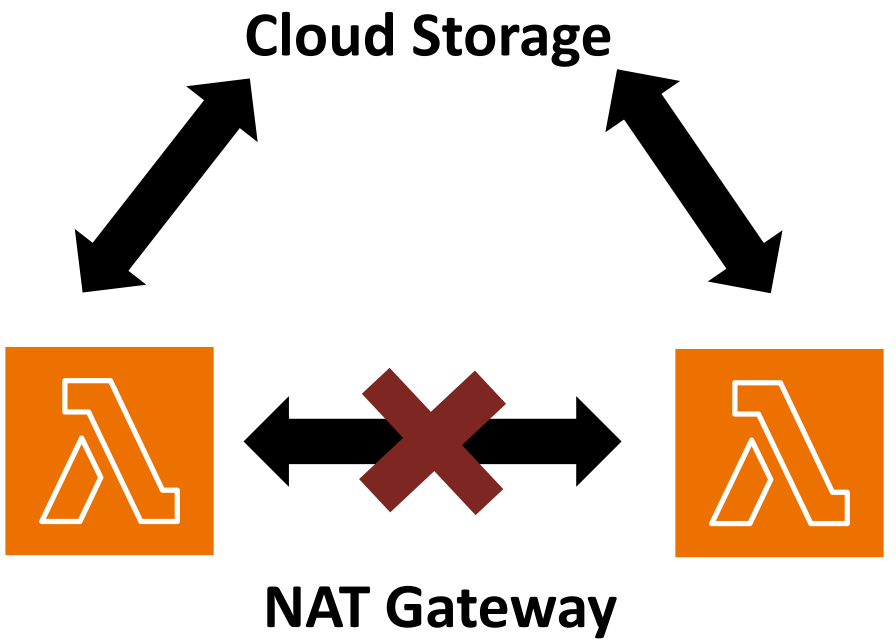
Serverless Applications: Communication



Serverless Applications: Communication

High Latency
For Small Messages

S3



Serverless Applications: Communication

High Latency
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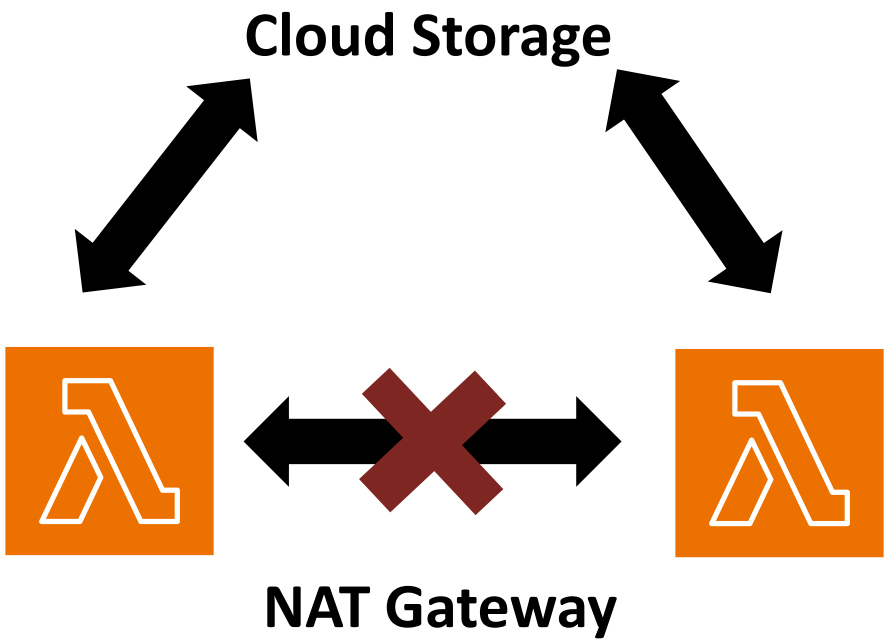
S3

Expensive for
Large Messages

DynamoDB



Serverless Applications: Communication

High Latency
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S3

Expensive for
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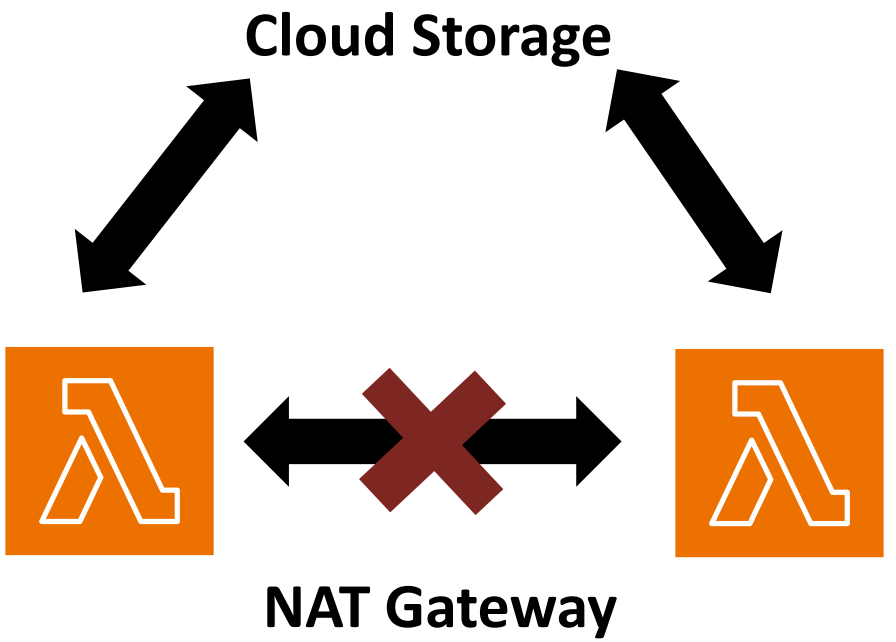
DynamoDB

Not Serverless
Expensive

Redis



Serverless Applications: Communication

High Latency
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Expensive for
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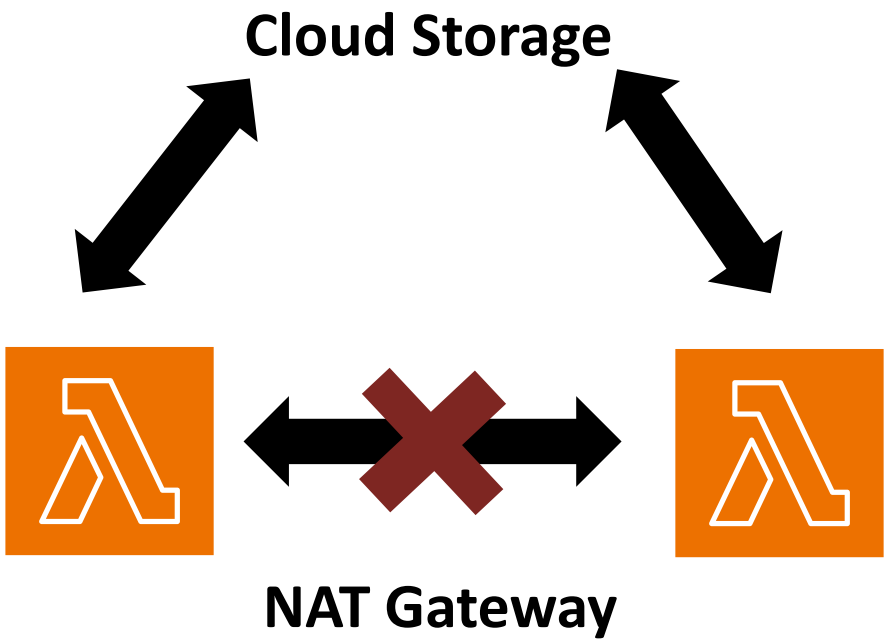
DynamoDB

Not Serverless
Expensive

Redis

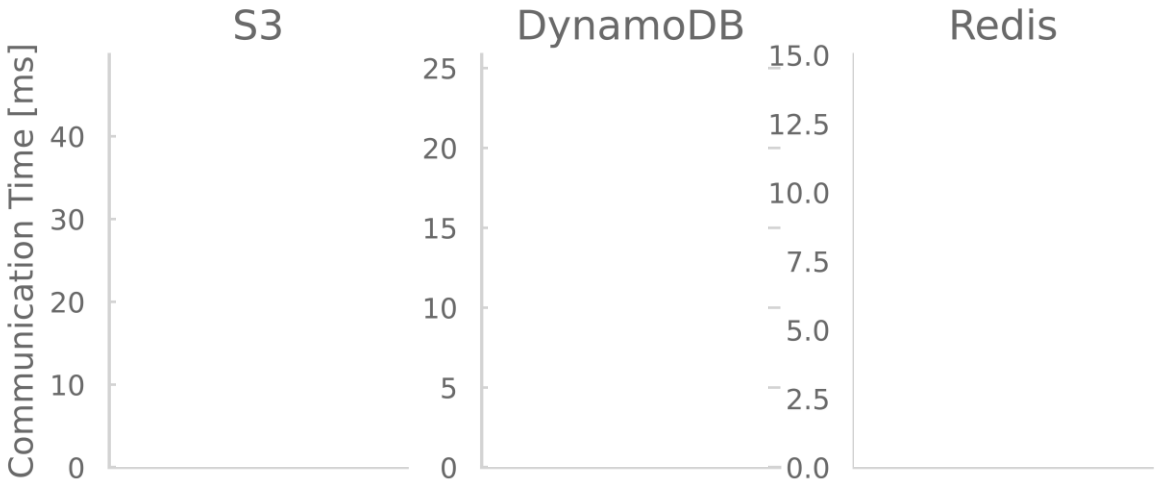
Size Limits
Good Latency

SQS



Serverless Applications: Communication

1 B



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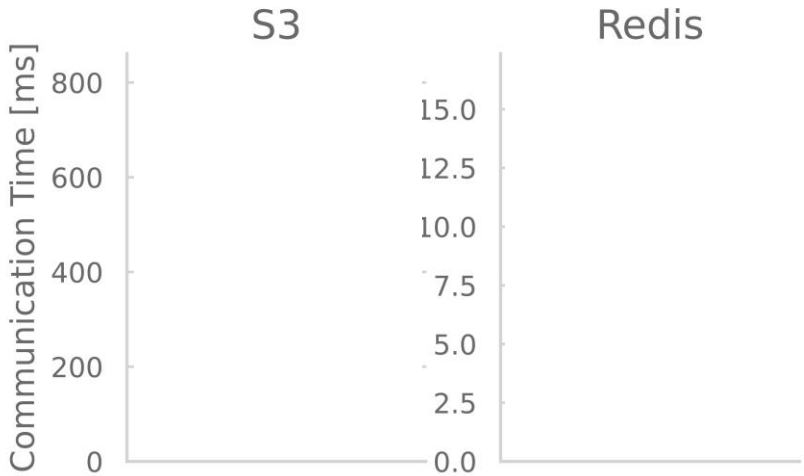
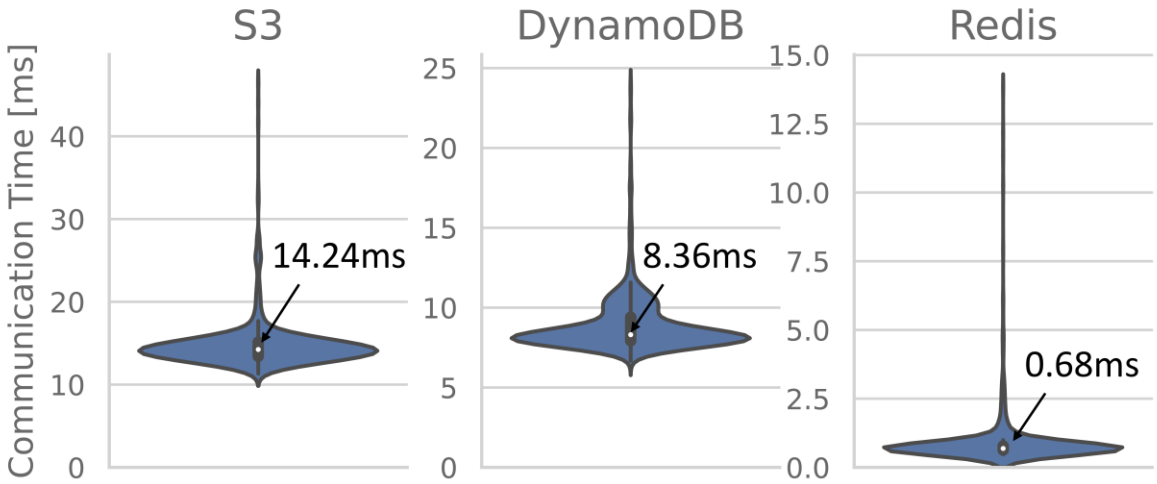


“FMI: Fast and Cheap Message Passing for Serverless Functions”, ICS’23

Serverless Applications: Communication

1 B



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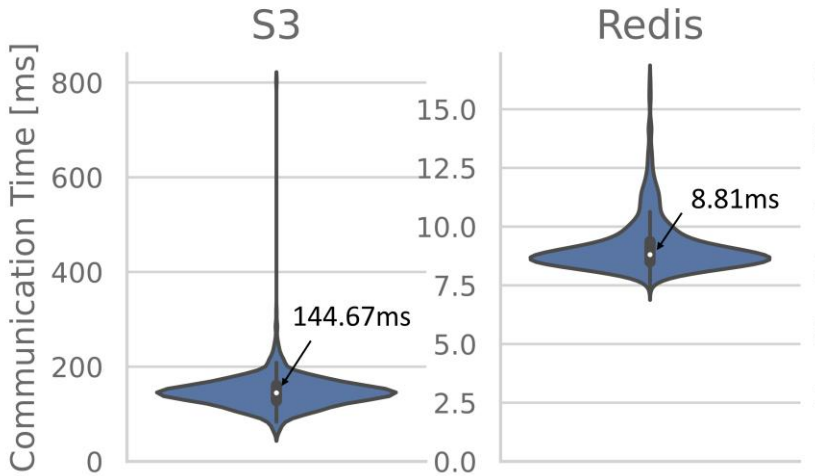

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Serverless Applications: Communication

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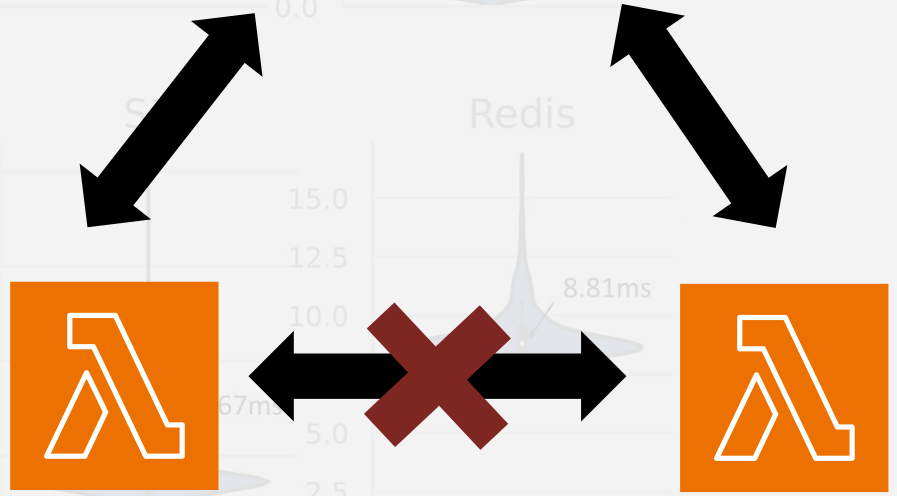
Example: AWS S3

Key-Value Storage
Example: AWS DynamoDB

In-Memory Storage
Example: Redis

Queue
Example: AWS SQS



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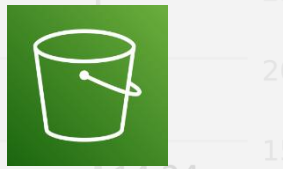

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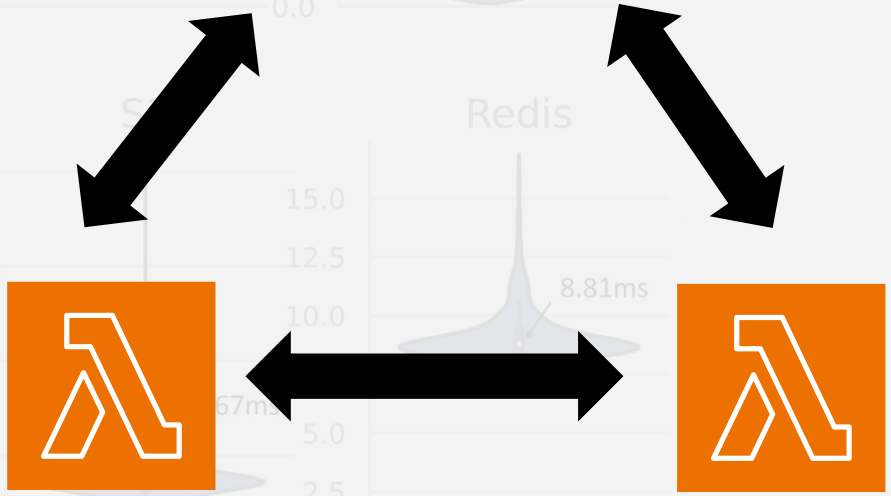

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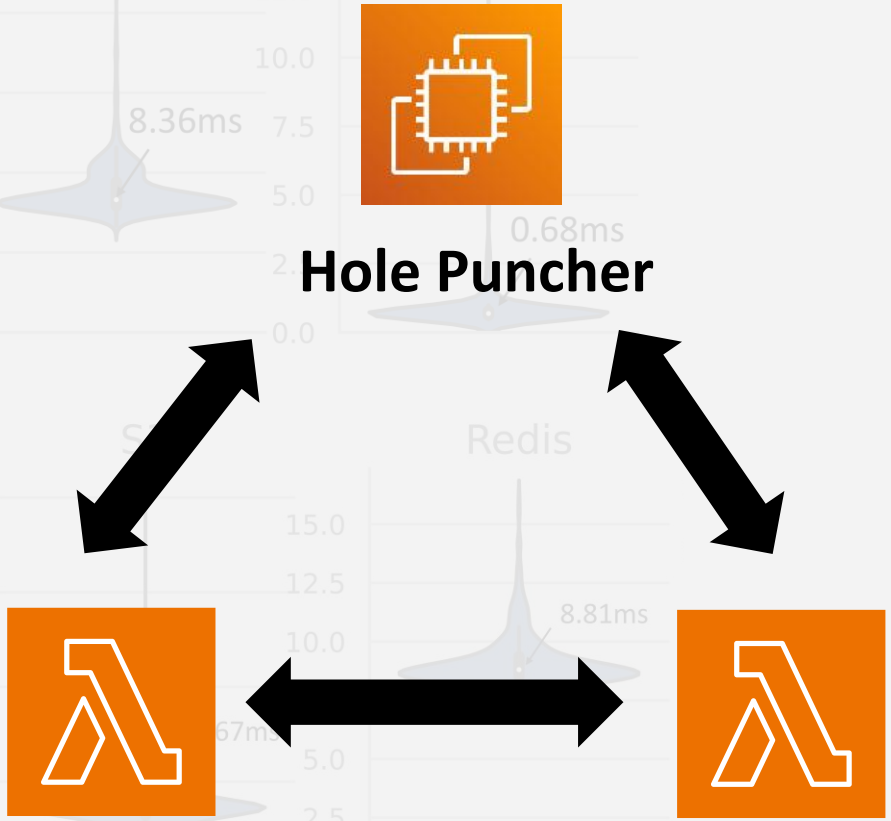

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Serverless Applications: Communication

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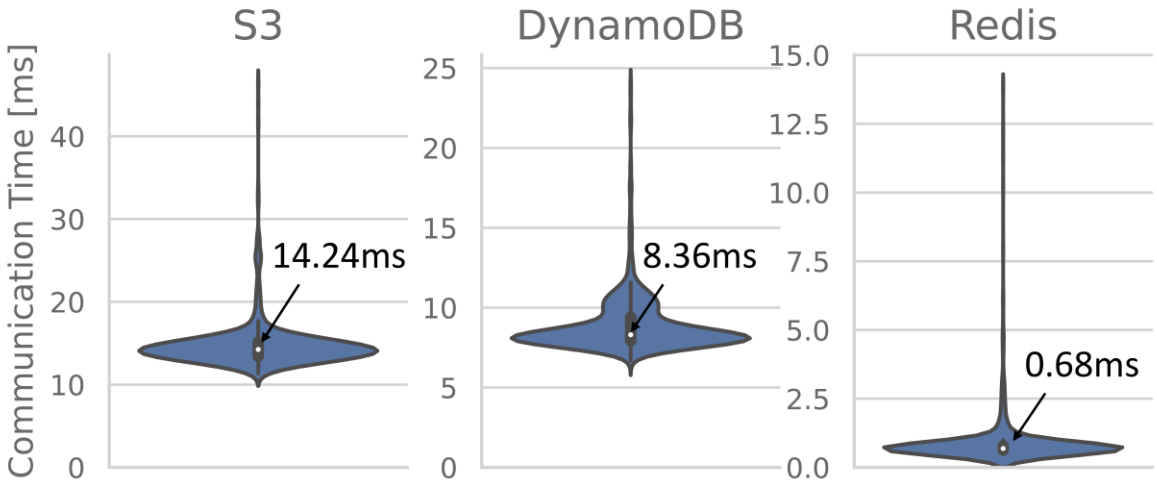

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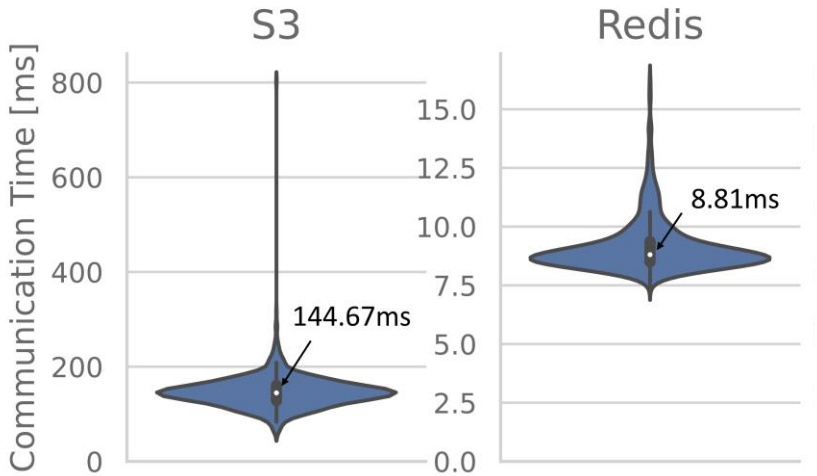

"FMI: Fast and Cheap Message Passing for Serverless Functions", ICS'23

Serverless Applications: Communication

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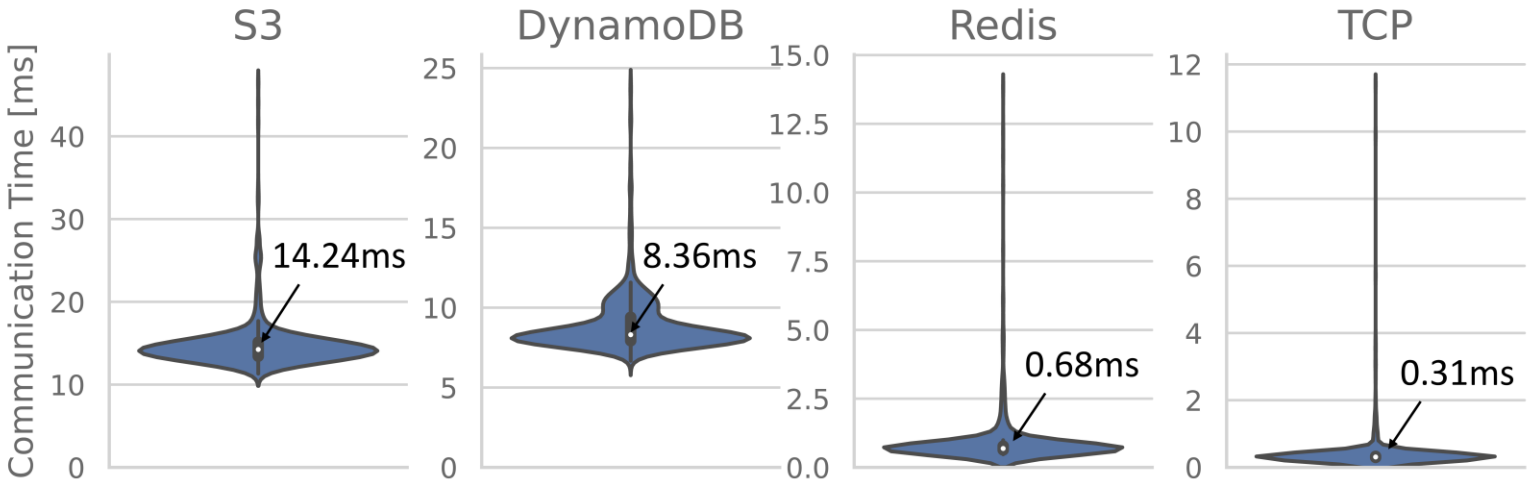

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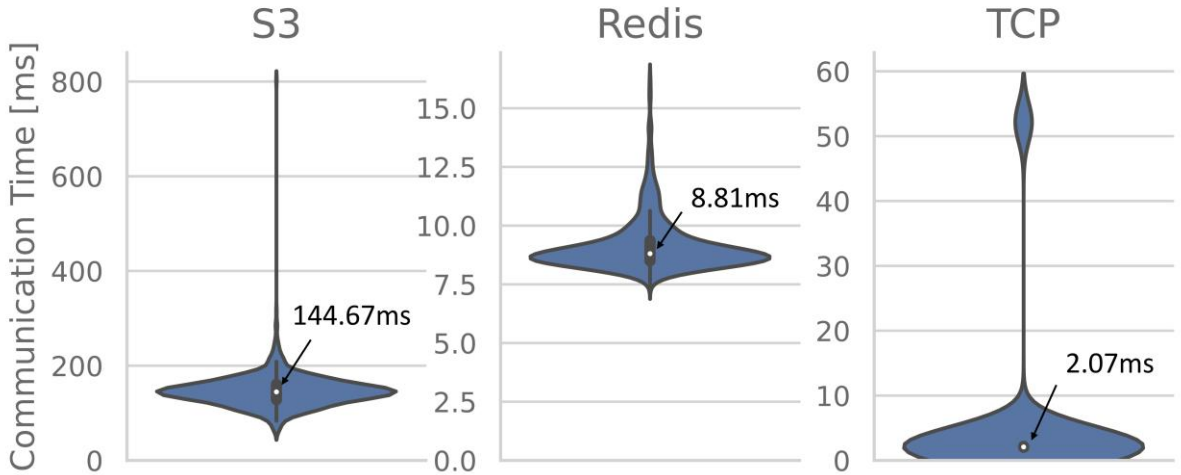


"FMI: Fast and Cheap Message Passing for Serverless Functions", ICS'23

Serverless Applications: Communication

An Empirical Evaluation of Serverless Cloud Infrastructure for Large-Scale Data Processing

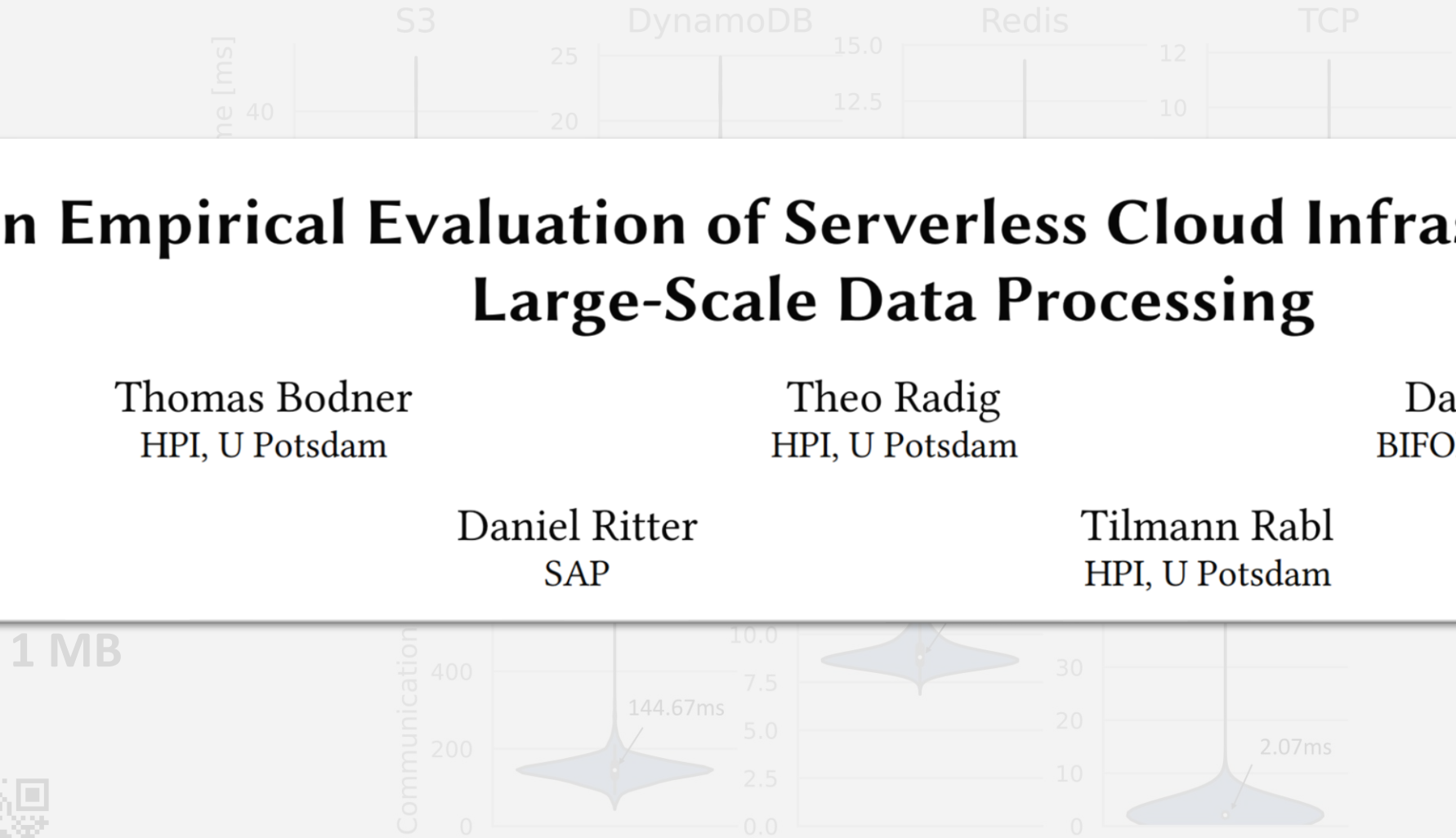
Thomas Bodner
HPI, U Potsdam

Theo Radig
HPI, U Potsdam

David Justen
BIFOLD, TU Berlin

Daniel Ritter
SAP

Tilmann Rabl
HPI, U Potsdam



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SeBS Slack

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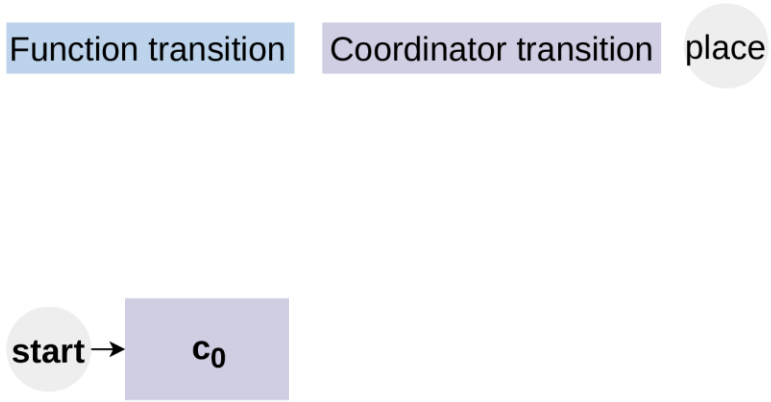
SeBS-Flow: Let the Work Flow in the Cloud



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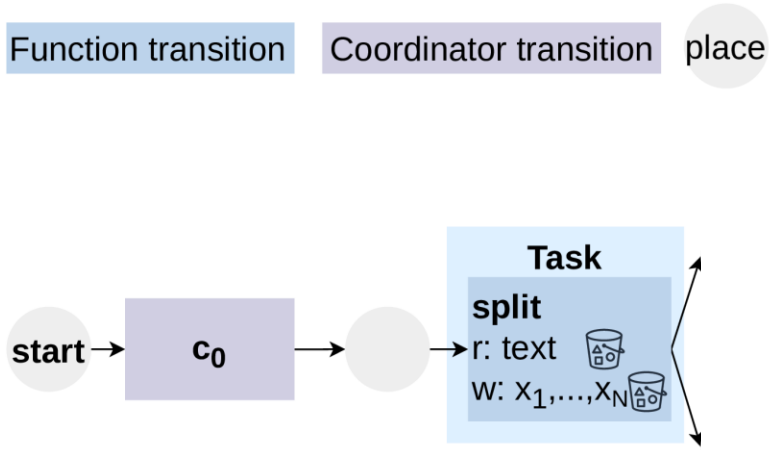

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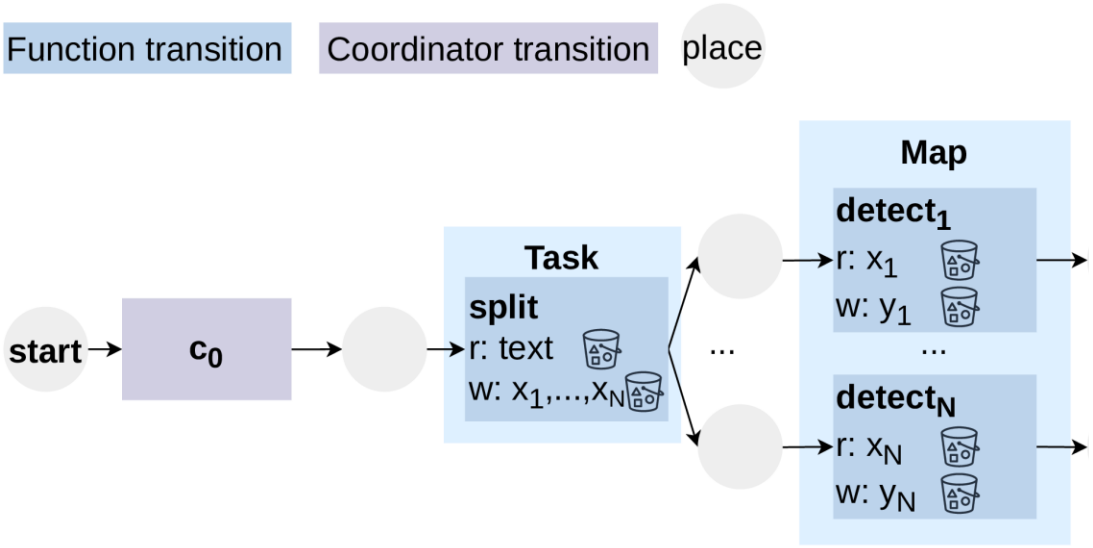

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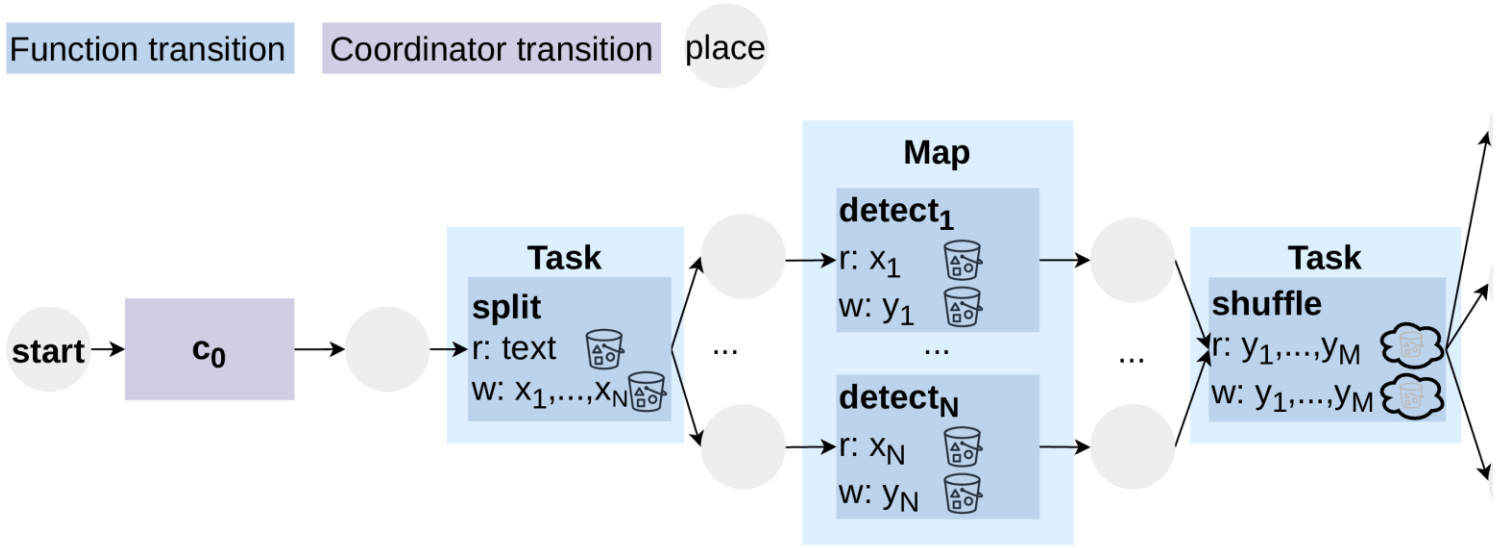

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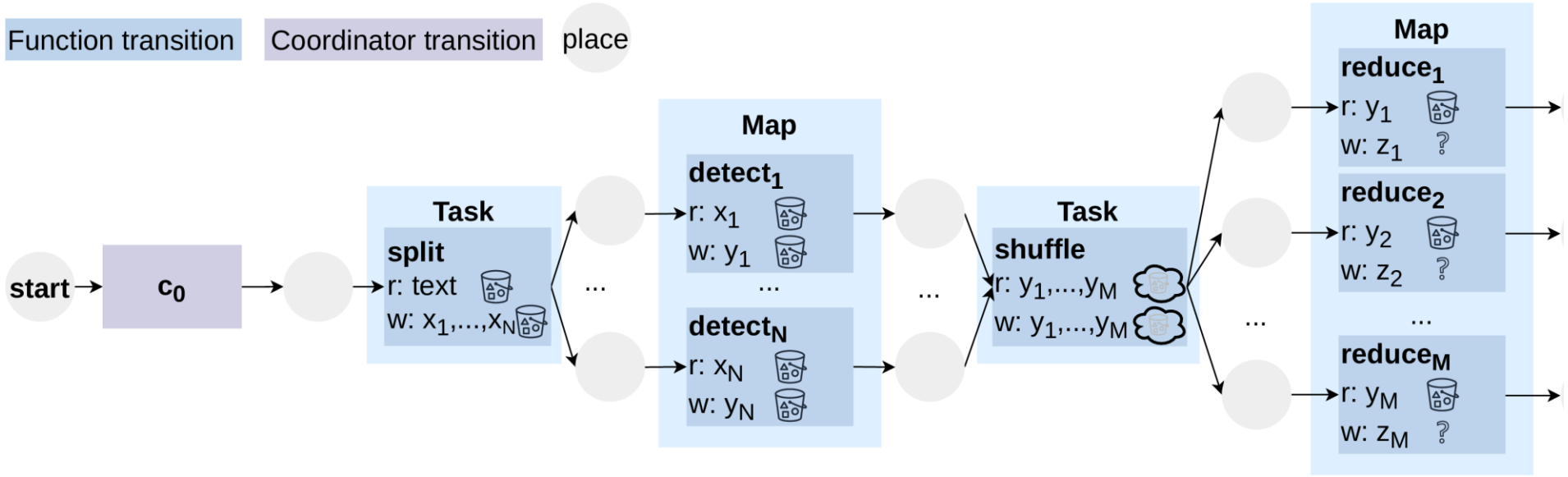

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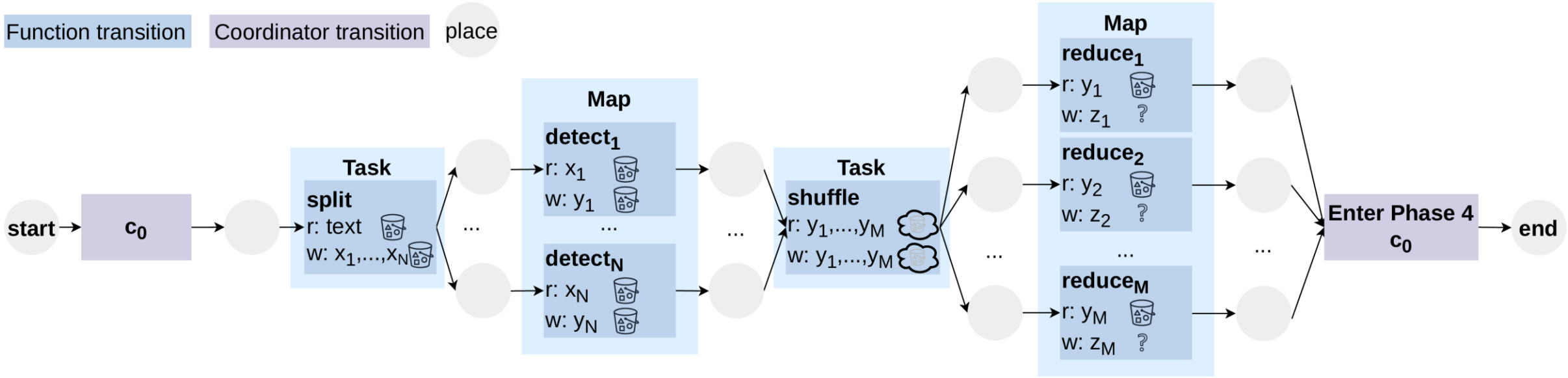

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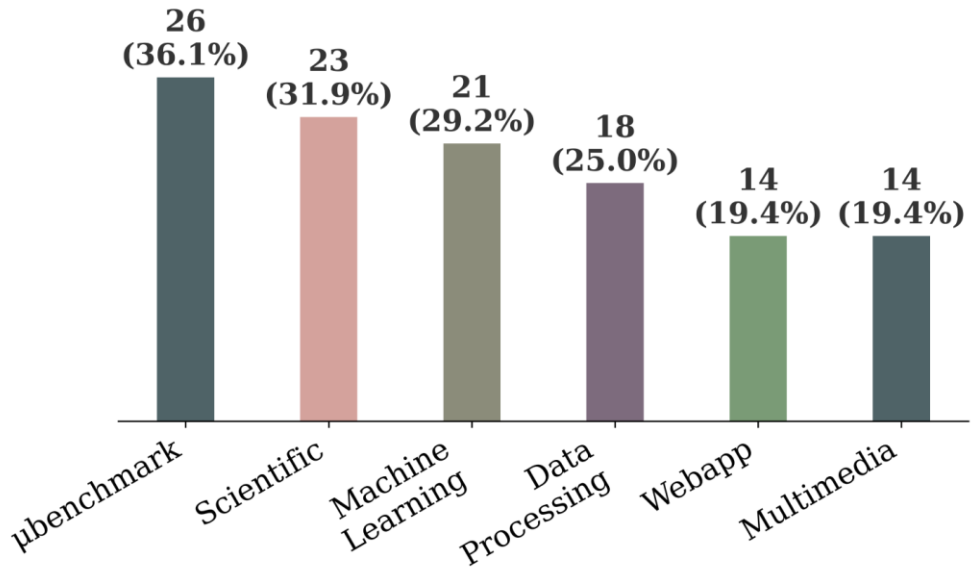

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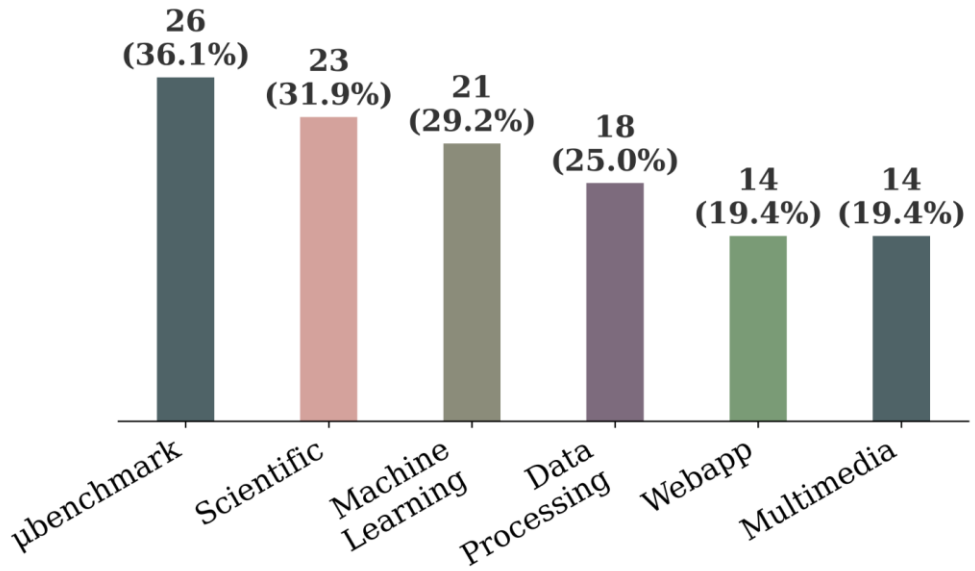

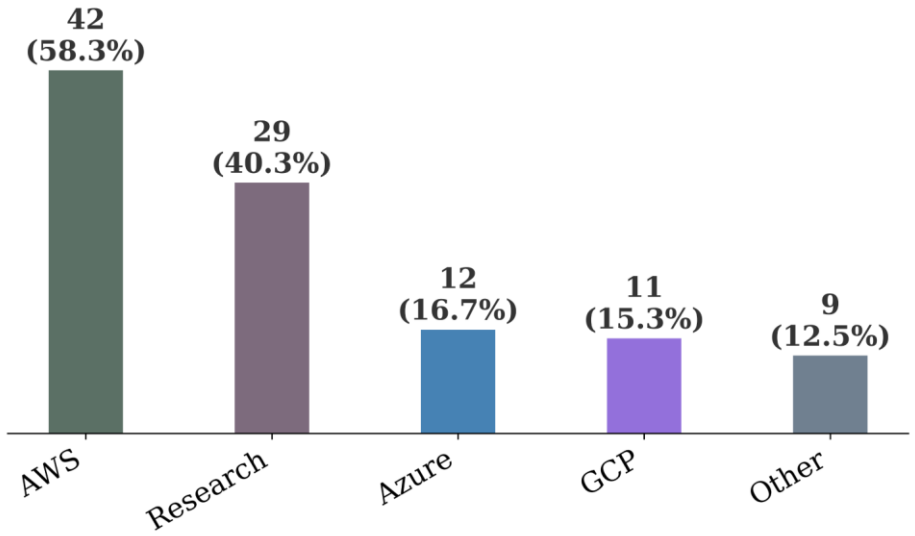

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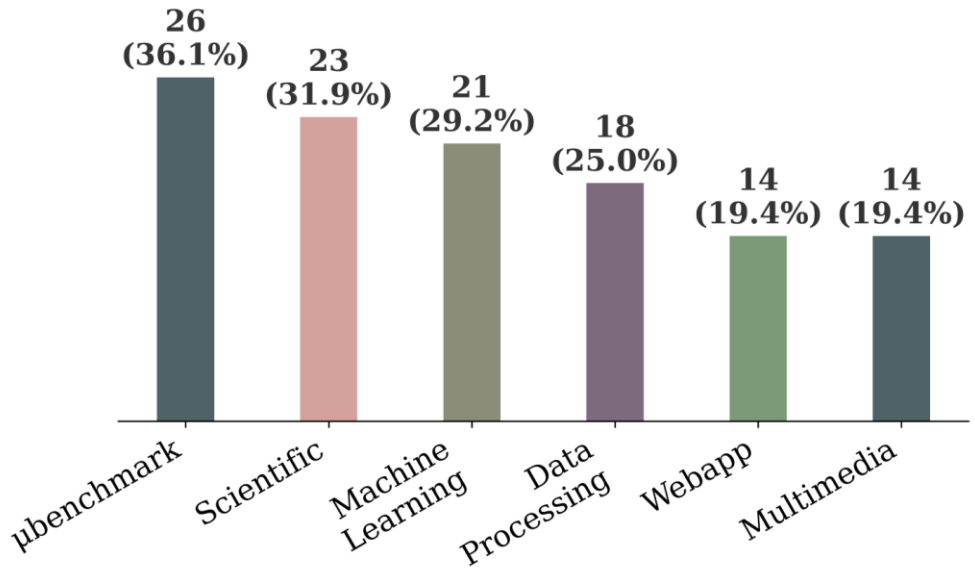

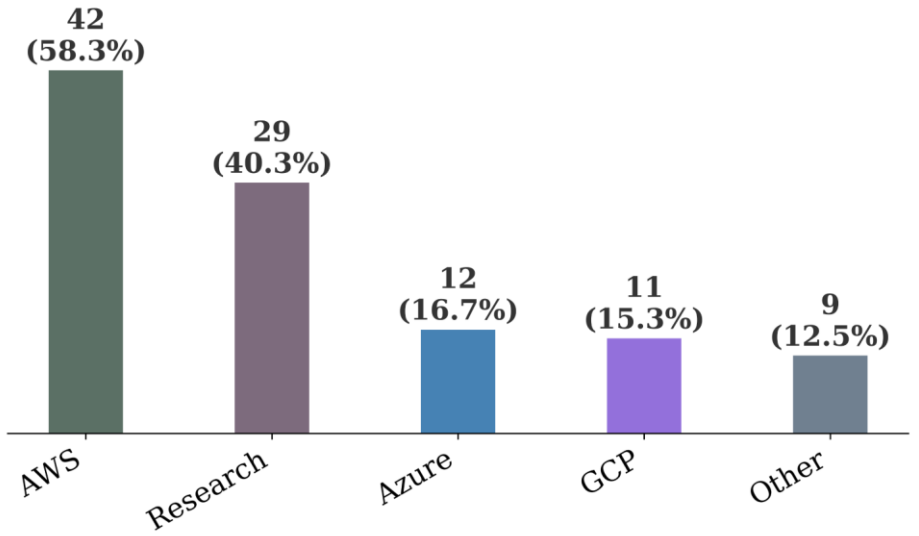

AWS Step Functions

Azure Durable Functions

Google Cloud Workflows

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SeBS-Flow: Let the Work Flow in the Cloud

Azure Durable

```
tasks = []
for i in range(4):
  tasks.append(context.call_activity("process", i)
res = yield context.task_all(parallel_tasks)
```

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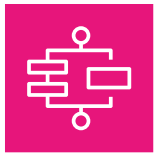

AWS Step Functions

```
"init": {
  "Type": "Pass",
  "Result": "States.Array(0,
             1, 2, 3)",
  "ResultPath": "$.array",
  "Next": "map"
},
"map": {
  "Type": "Map",
  "ItemsPath": "$.array",
  "Parameters": {
    "payload.$":
      "$$.Map.Item.Value"
  },
  "Iterator": {
    "StartAt": "process",
    "States": {
      "process": {
        "Type": "Task",
        "Resource": "arn:proc",
        "Parameters": {
          "payload.$":
            "$.payload"
        },
        "End": true
      }
    }
  },
  "ResultPath": "$.res",
  "End": true
}
```

Azure Durable

```
tasks = []
for i in range(4):
  tasks.append(context.call_activity("process", i)
res = yield context.task_all(parallel_tasks)
```

“SeBS-Flow: Benchmarking Serverless Cloud Function Workflows”, Schmid et al., EuroSys 2025

SeBS-Flow: Let the Work Flow in the Cloud

AWS Step Functions

```
"init": {
  "Type": "Pass",
  "Result": "States.Array(0,
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  "ResultPath": "$.array",
  "Next": "map"
},
"map": {
  "Type": "Map",
  "ItemsPath": "$.array",
  "Parameters": {
    "payload.$":
      "$$.Map.Item.Value"
  },
  "Iterator": {
    "StartAt": "process",
    "States": {
      "process": {
        "Type": "Task",
        "Resource": "arn:proc",
        "Parameters": {
          "payload.$":
            "$.payload"
        },
        "End": true
      }
    }
  },
  "ResultPath": "$.res",
  "End": true
}
```

Azure Durable

```
tasks = []
for i in range(4):
  tasks.append(context.call_activity("process", i)
res = yield context.task_all(parallel_tasks)
```

Google Cloud Workflows

```
"assign_array": {
    "assign": [
      {"array": [0, 1, 2, 3]}]
},
"process": {
    "call":"exp.exec.map",
    "args":{
      "workflow_id":"map",
      "arguments":"${array}"
    },
    "result":"res"
}
"separate map-workflow:"
"main": {
"params":[ "elem" ],
"steps":[
  {
  "map":{
    "call":"http.post",
    "args":{
      "url":"google.process",
      "body":{
        "payload":"${elem}"
      }
    },
    "result":"elem" }
  },
  { "ret": {
      "return":
      "${elem.body}" } }
] }
```

"SeBS-Flow: Benchmarking Serverless Cloud Function Workflows", Schmid et al., EuroSys 2025

SeBS-Flow: Let the Work Flow in the Cloud

Google Cloud Workflows

AWS Step Functions

```
"init": {
  "Type": "Pass",
  "Result": "States.Array(0,
            1, 2, 3)",
  "ResultPath": "$.array",
  "Next": "map"
},
"map": {
  "Type": "Map",
```

```
"assign_array": {
    "assign": [
      {"array": [0, 1, 2, 3]}]
},
"process": {
    "call":"exp.exec.map",
    "args":{
      "workflow_id":"map",
```

#1 Different Workflow Semantics

#2 Different Workflow Definitions

```
          "Parameters": {
            "payload.$":
              "$.payload"
          },
          "End": true
        }
      }
    },
    "ResultPath": "$.res",
    "End": true
  }
```

```
      "url":"google.process",
      "body":{
        "payload":"${elem}"
      }
    },
    "result":"elem" }
  },
  { "ret": {
      "return":
      "${elem.body}" } }
] }
```

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SeBS-Flow: Let the Work Flow in the Cloud

Workflow in Unified State Model

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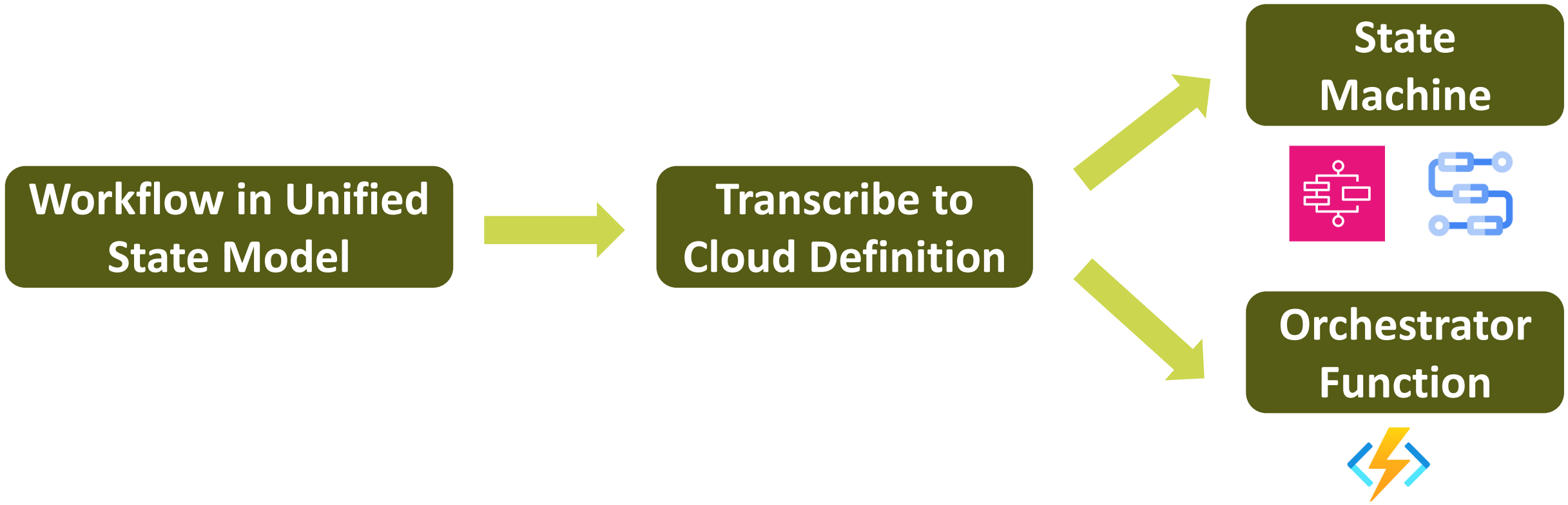

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ExCamera

Trip Booking

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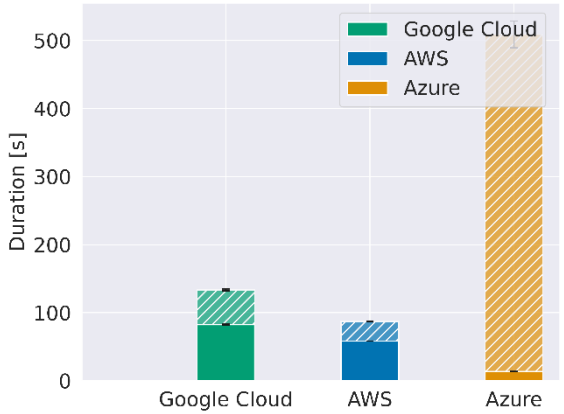

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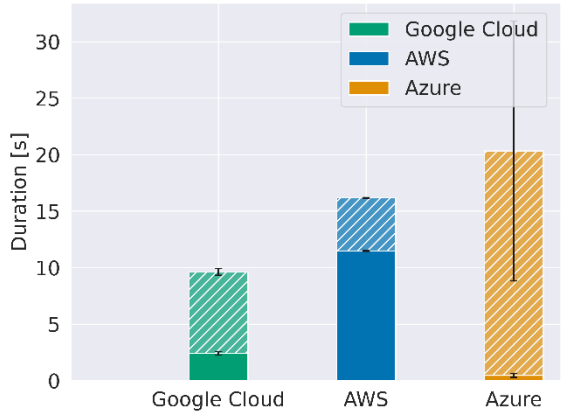

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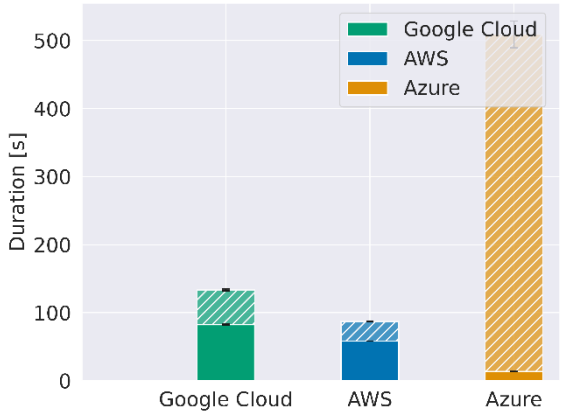

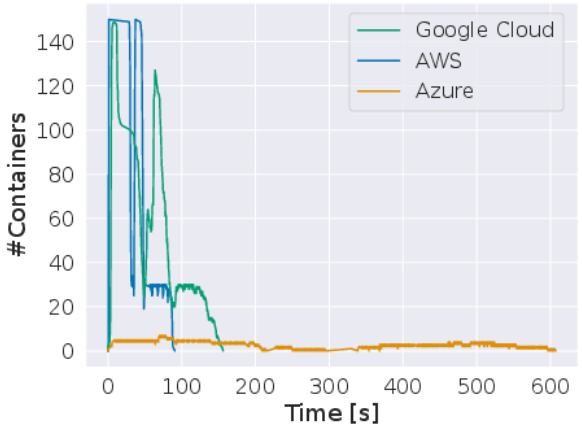

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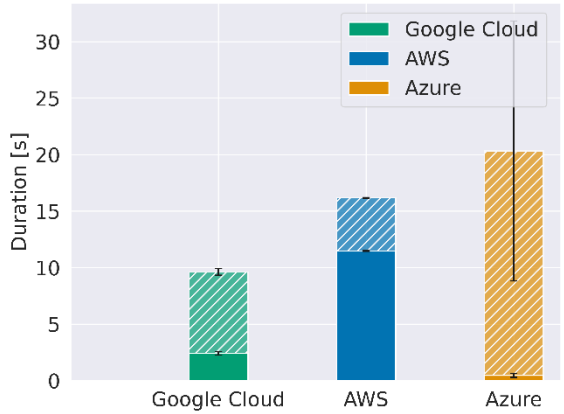

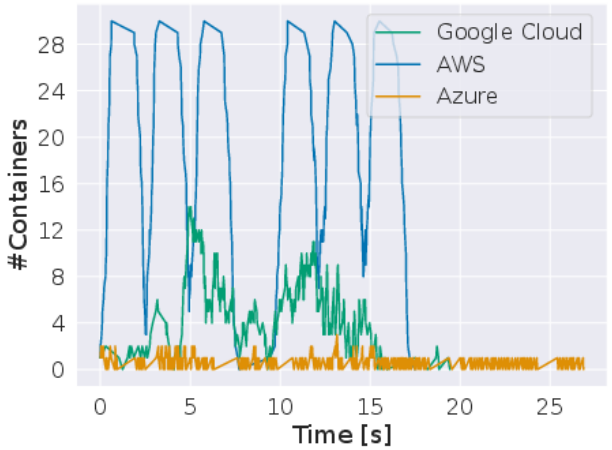

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spcl/serverless-benchmarks

Branch: feature/workflows

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Requires Redis for performance metrics.

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Requires Redis for performance metrics.

Works well with the Perf-Cost experiment.

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From Functions to Applications

Workflows

“Applications”

From Functions to Applications

Workflows

“Applications”

- ❖ Native support.
- ❖ Easy transition from functions.
- ❖ “Serverless” deployment.

- ❖ Static design.
- ❖ Can be slow.
- ❖ Can be expensive.

From Functions to Applications

Workflows

- Native support.
- Easy transition from functions.
- “Serverless” deployment.

- Static design.
- Can be slow.
- Can be expensive.

“Applications”

- Dynamic behavior.
- Can be cheaper than workflows.
- Can be faster.

- Performance trade-offs unclear.
- Manual implementation.
- Different cloud semantics.

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Eviction Modeling

“SeBS: a Serverless Benchmark Suite for Function-as-a-Service Computing”, Middleware 2021

Eviction Modeling

Configuration:

- **Time between invocations:** 1 – 1600s.
- **# of function instances:** 1 -20
- **Memory:** 128 – 1536 MB
- **Package size:** 8 kB, 250 MB
- **Duration:** 1 – 10s
- **Language:** Python, Node.js

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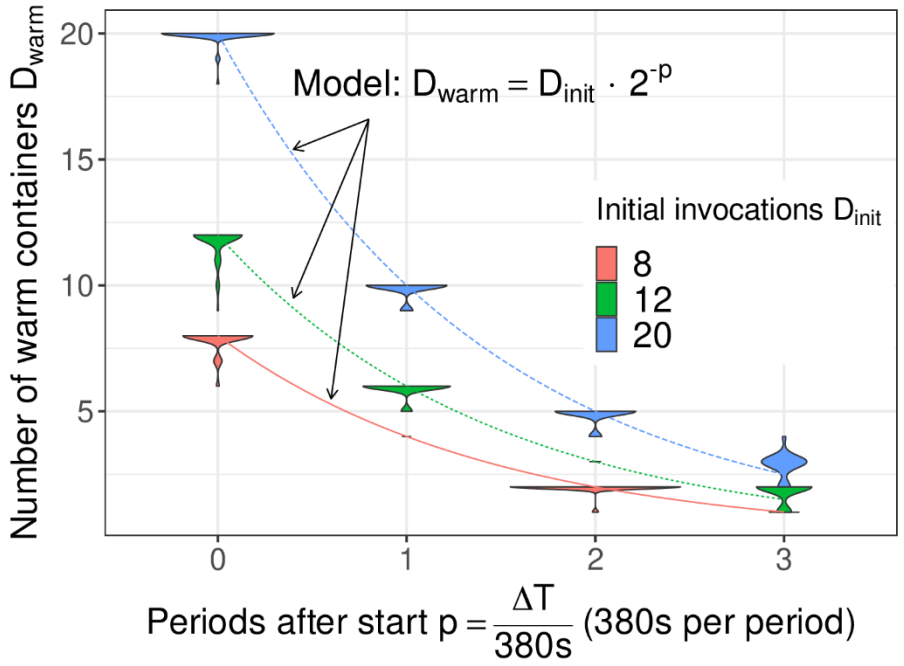

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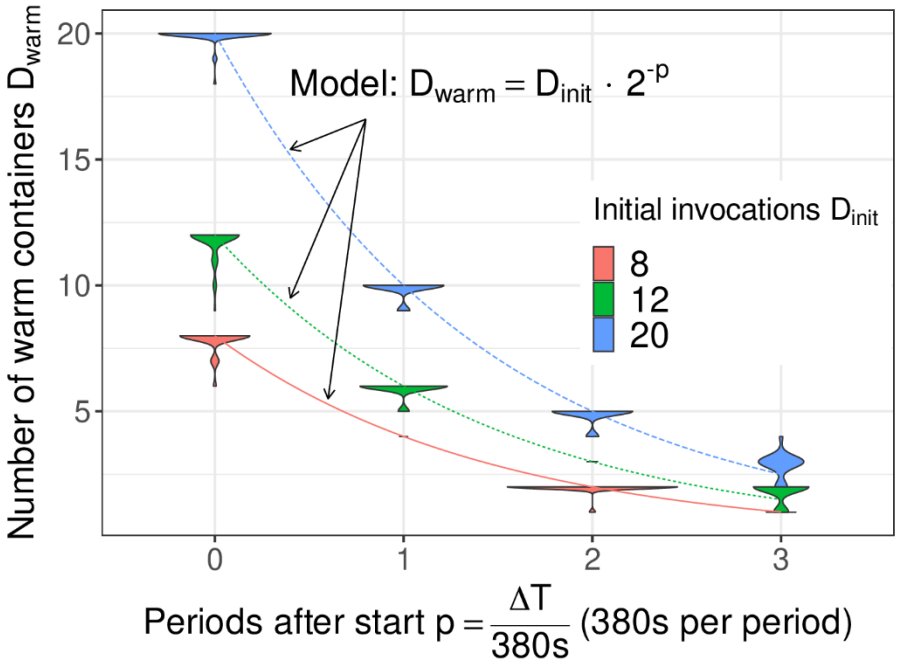

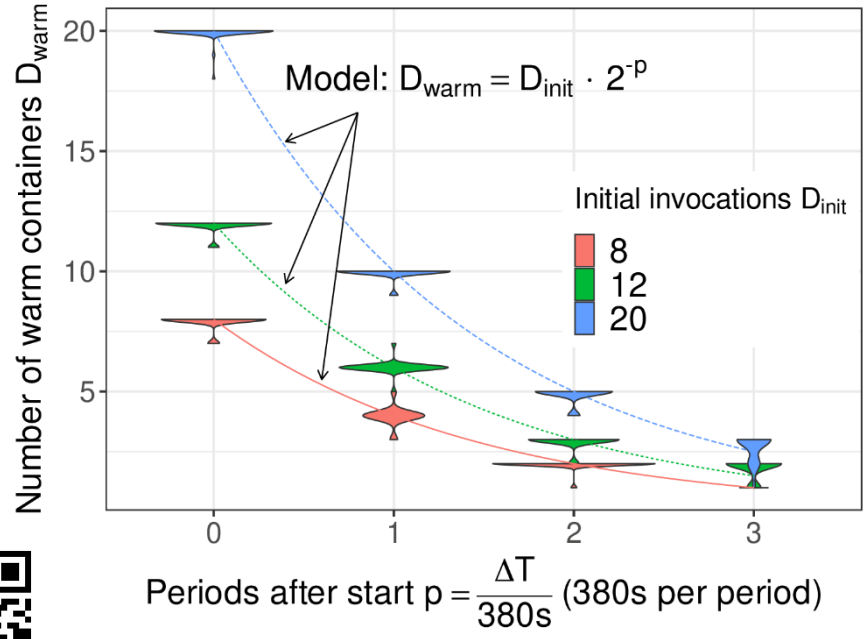

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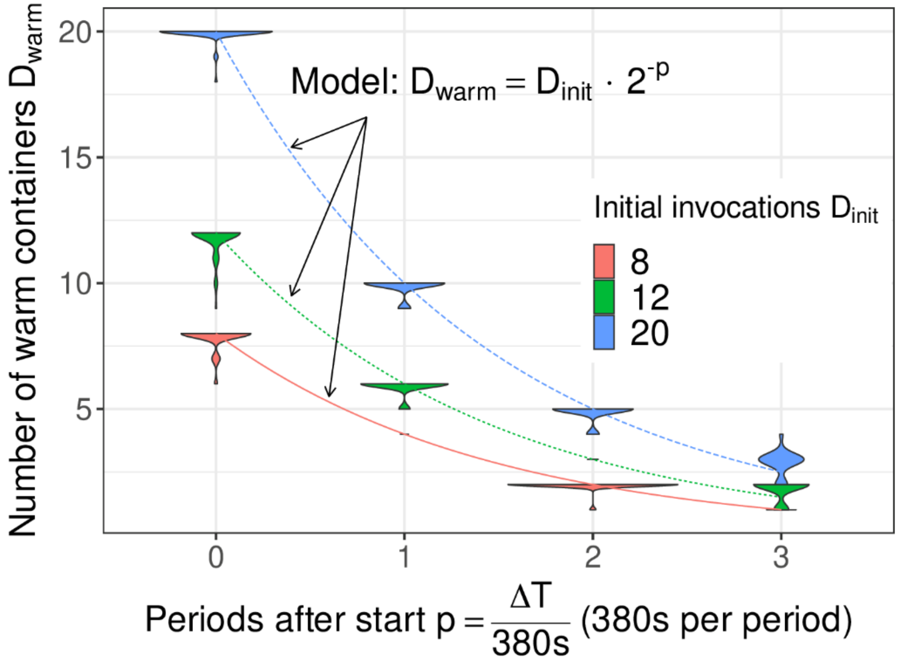

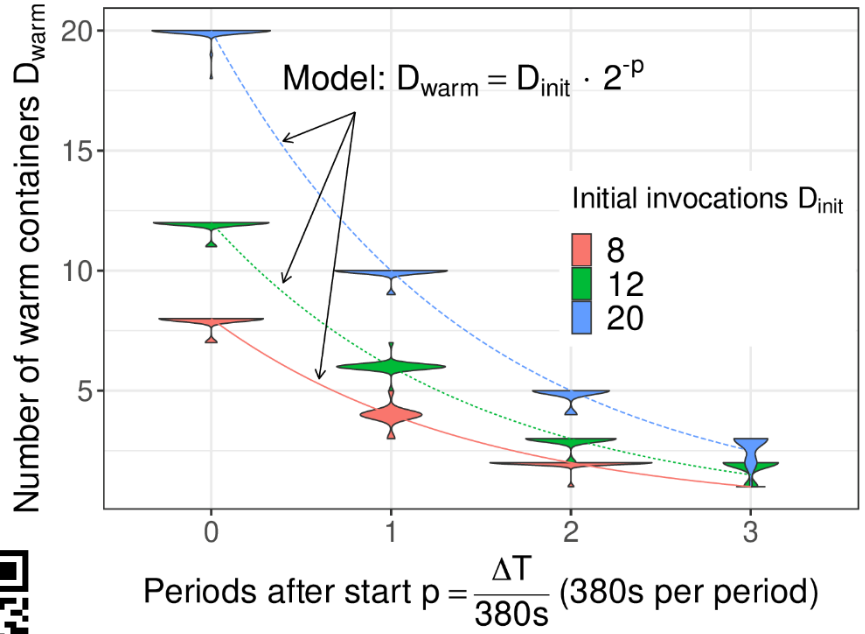

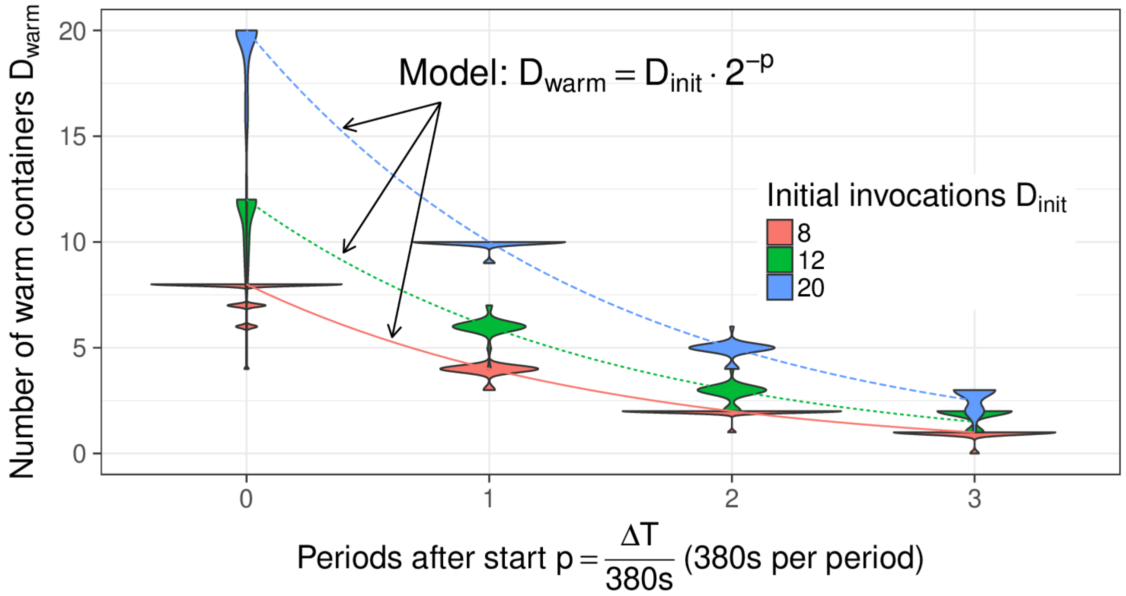

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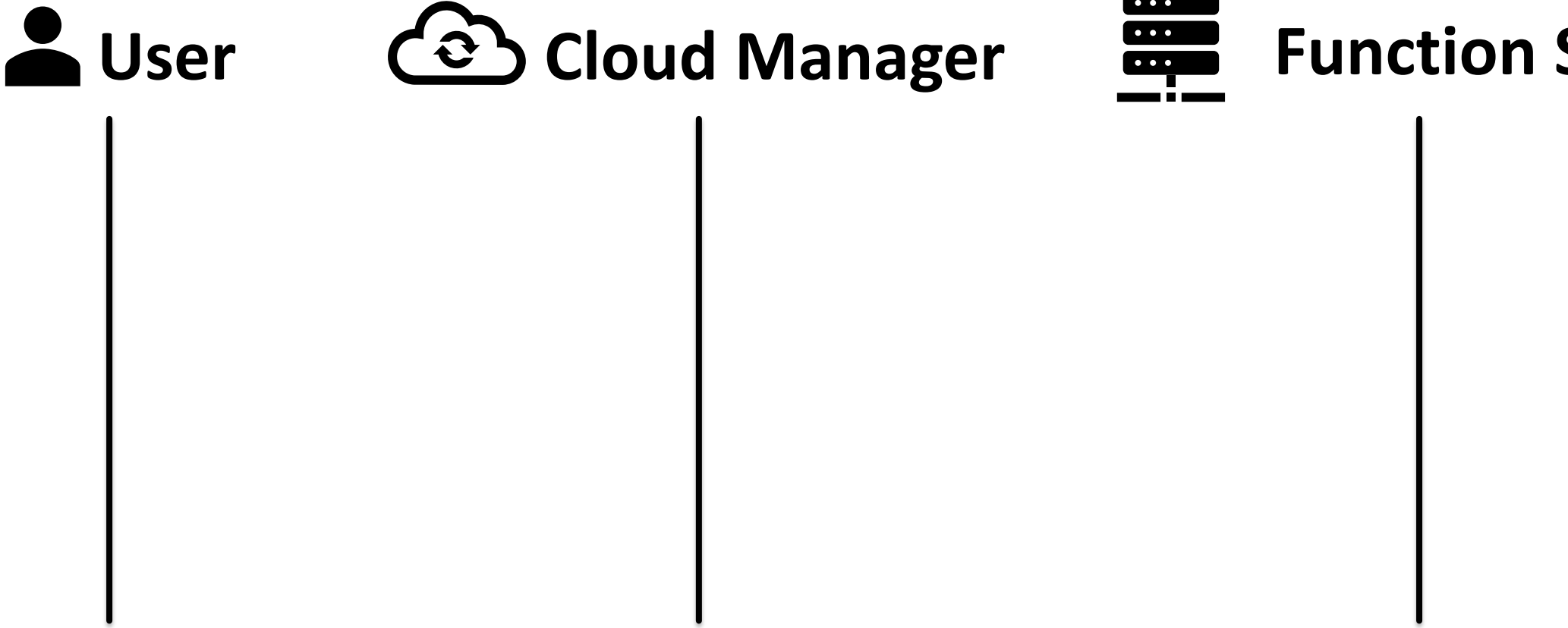
FaaS Analysis: Invocation Overhead



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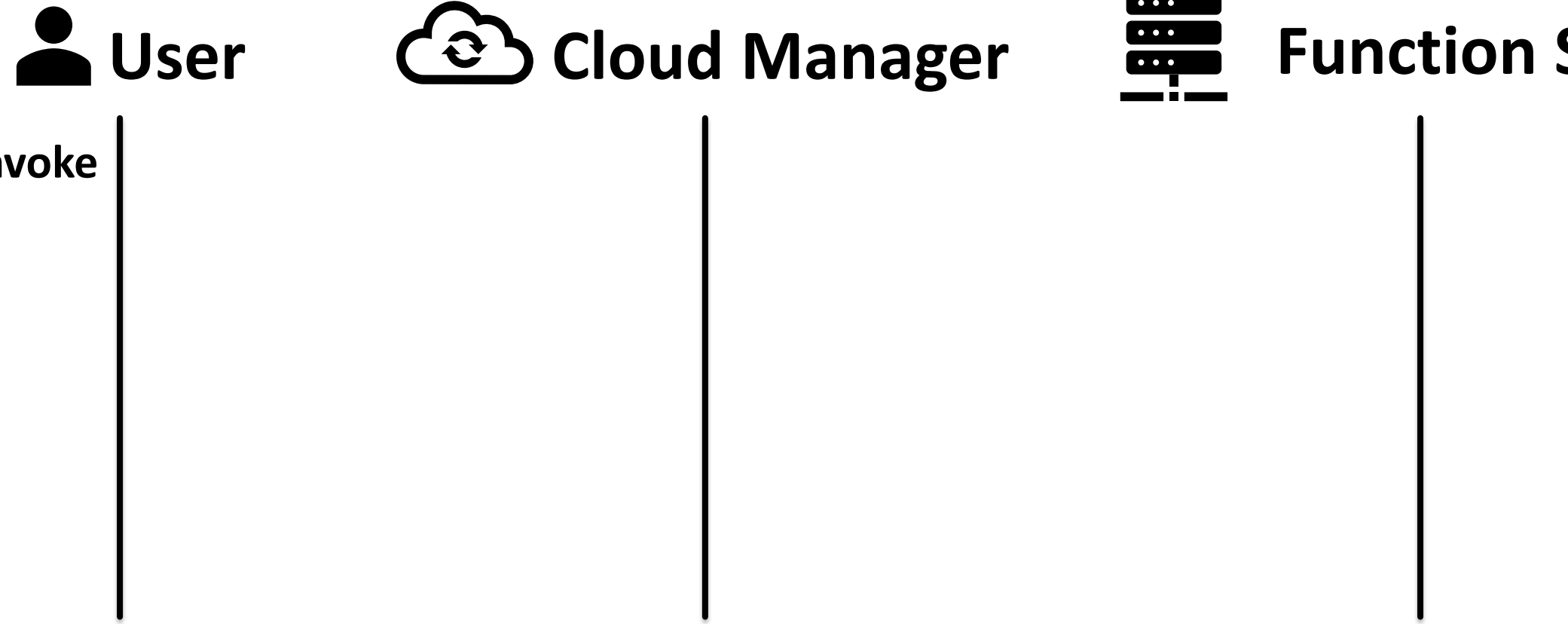

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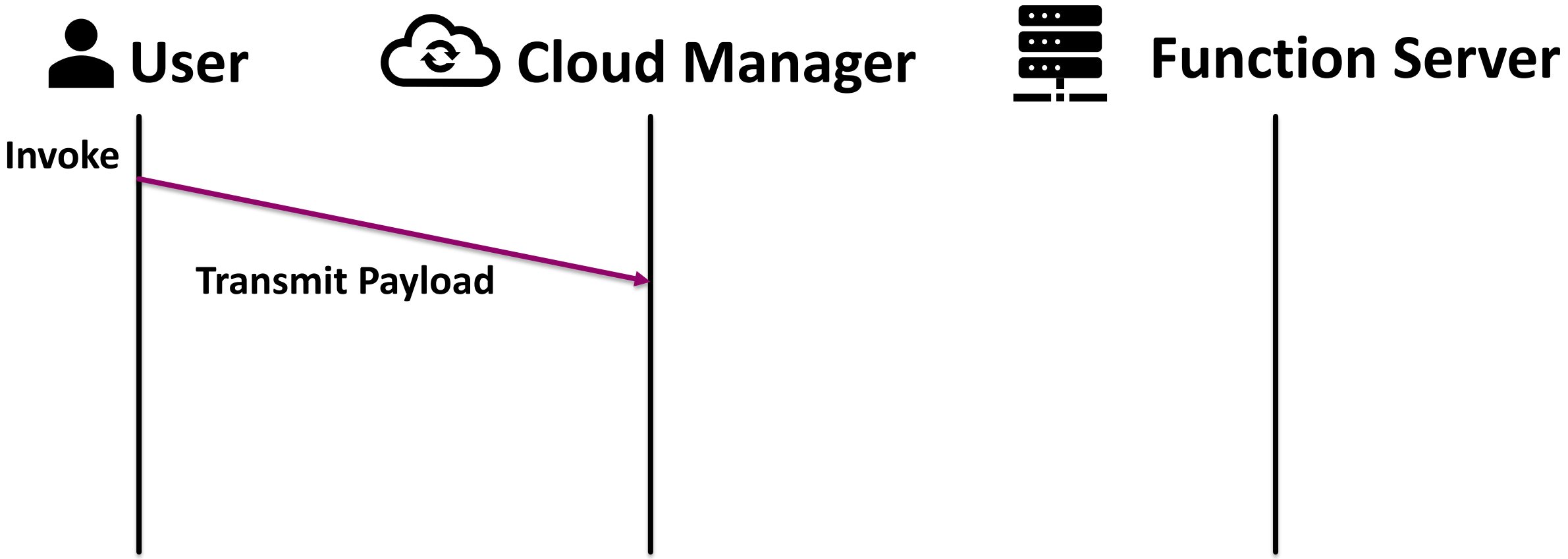

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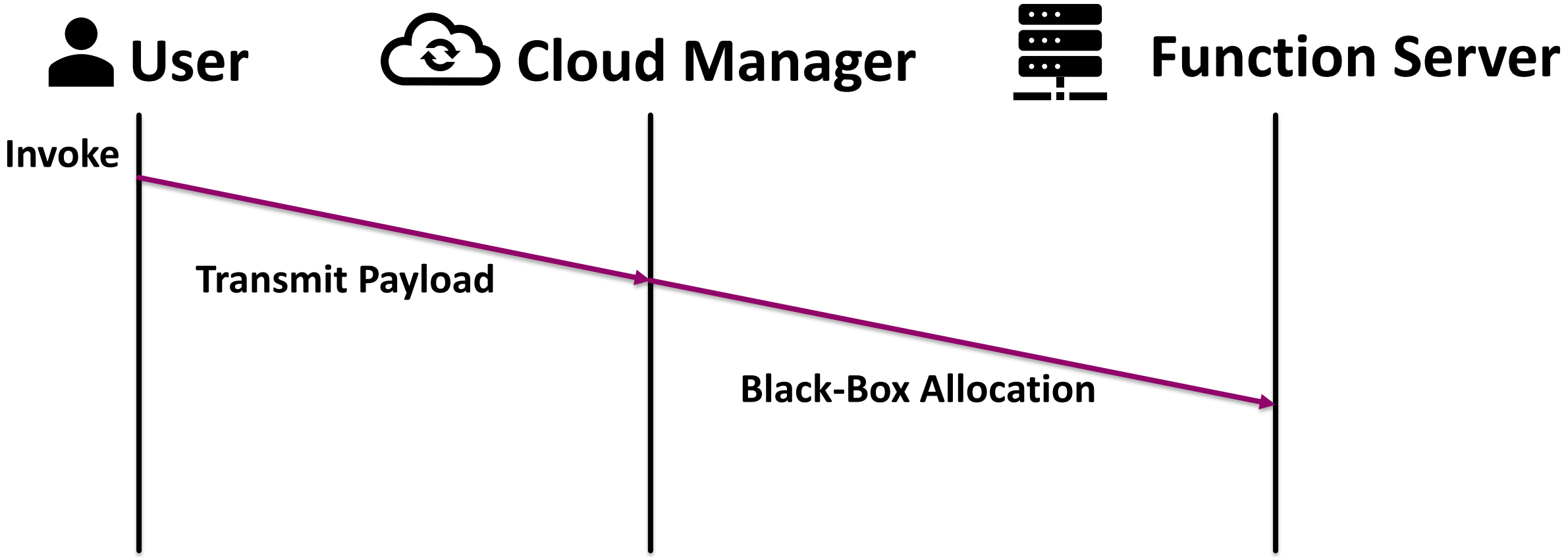
FaaS Analysis: Invocation Overhead



“SeBS: a Serverless Benchmark Suite for Function-as-a-Service Computing”, Middleware 2021

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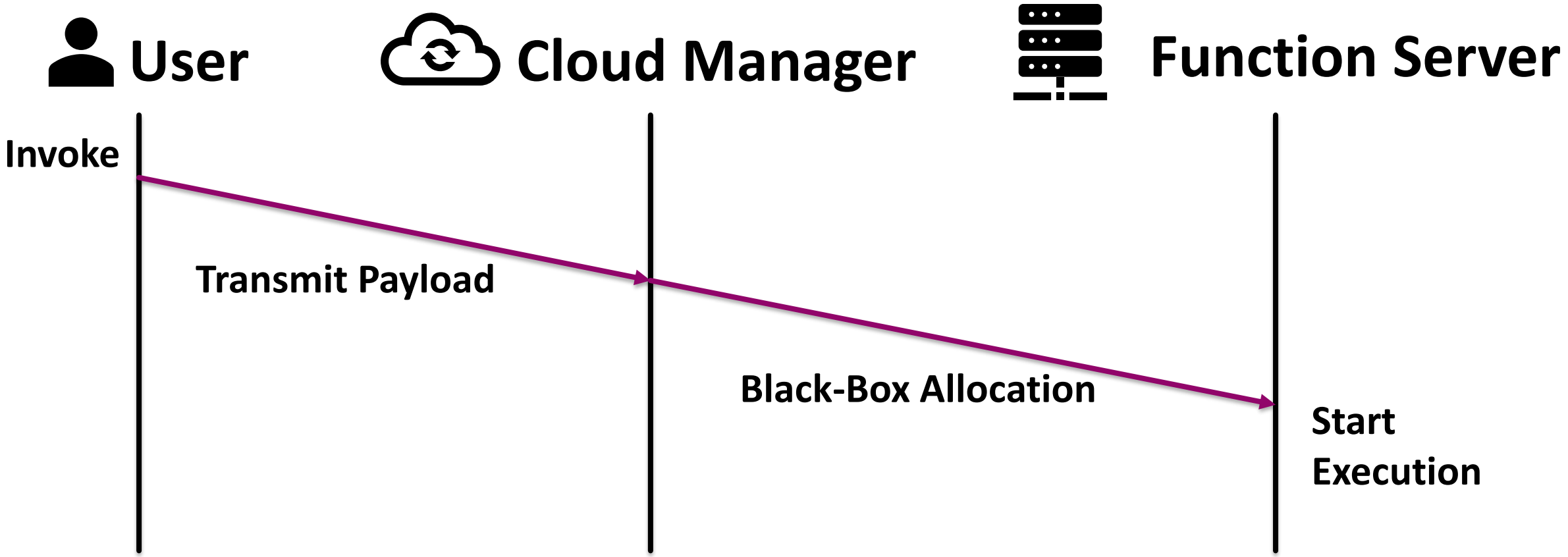

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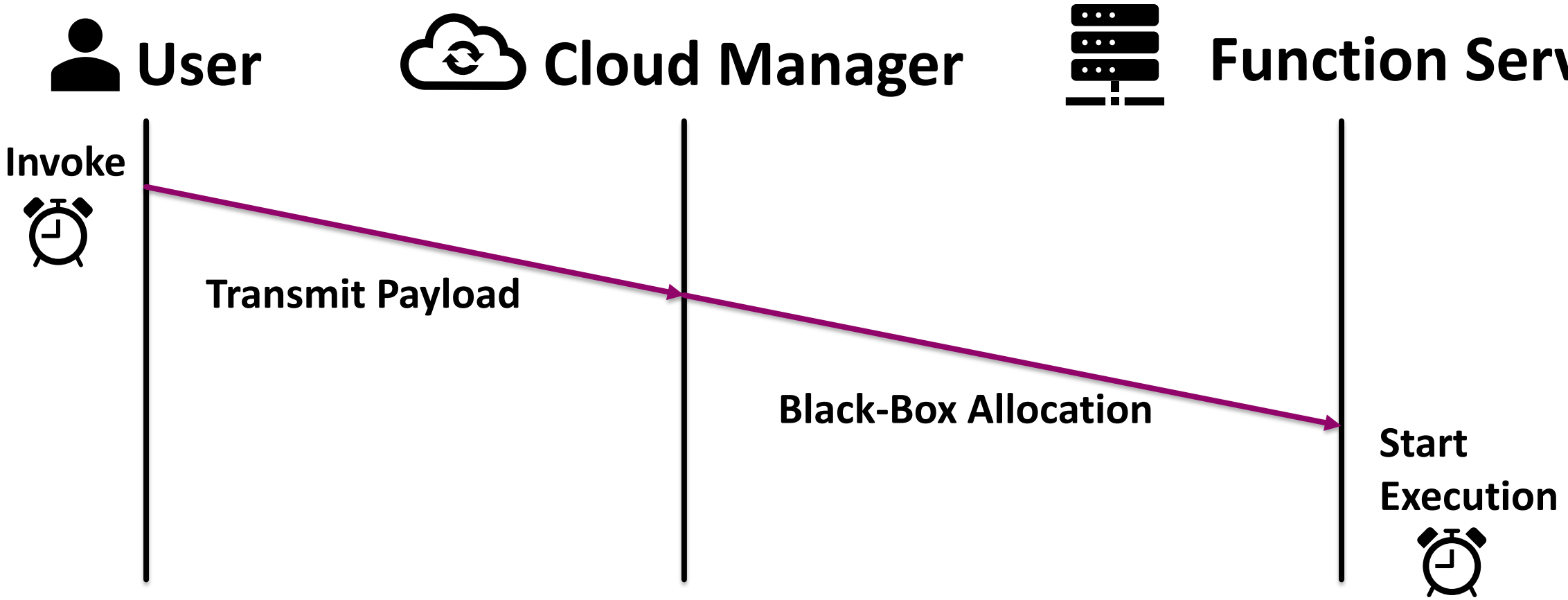

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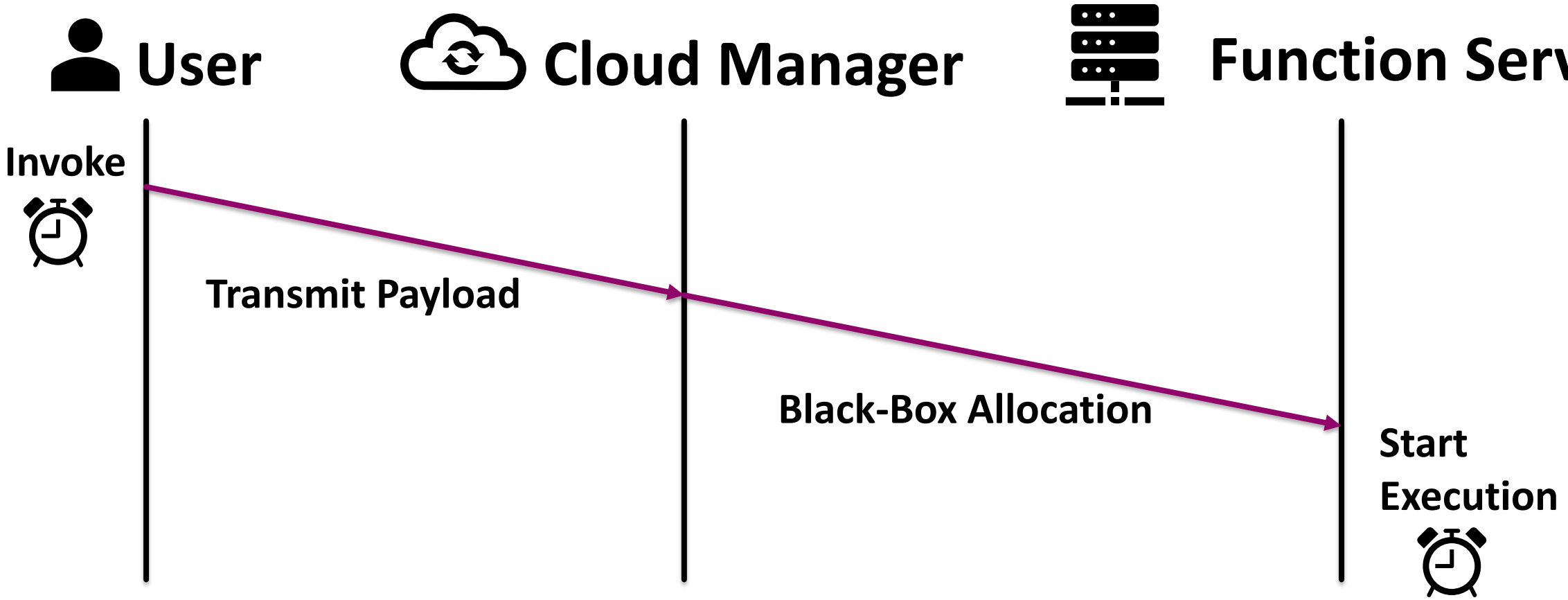

Solution: apply clock-drift estimation protocols!

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FaaS Analysis: Invocation Overhead

Configuration:

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

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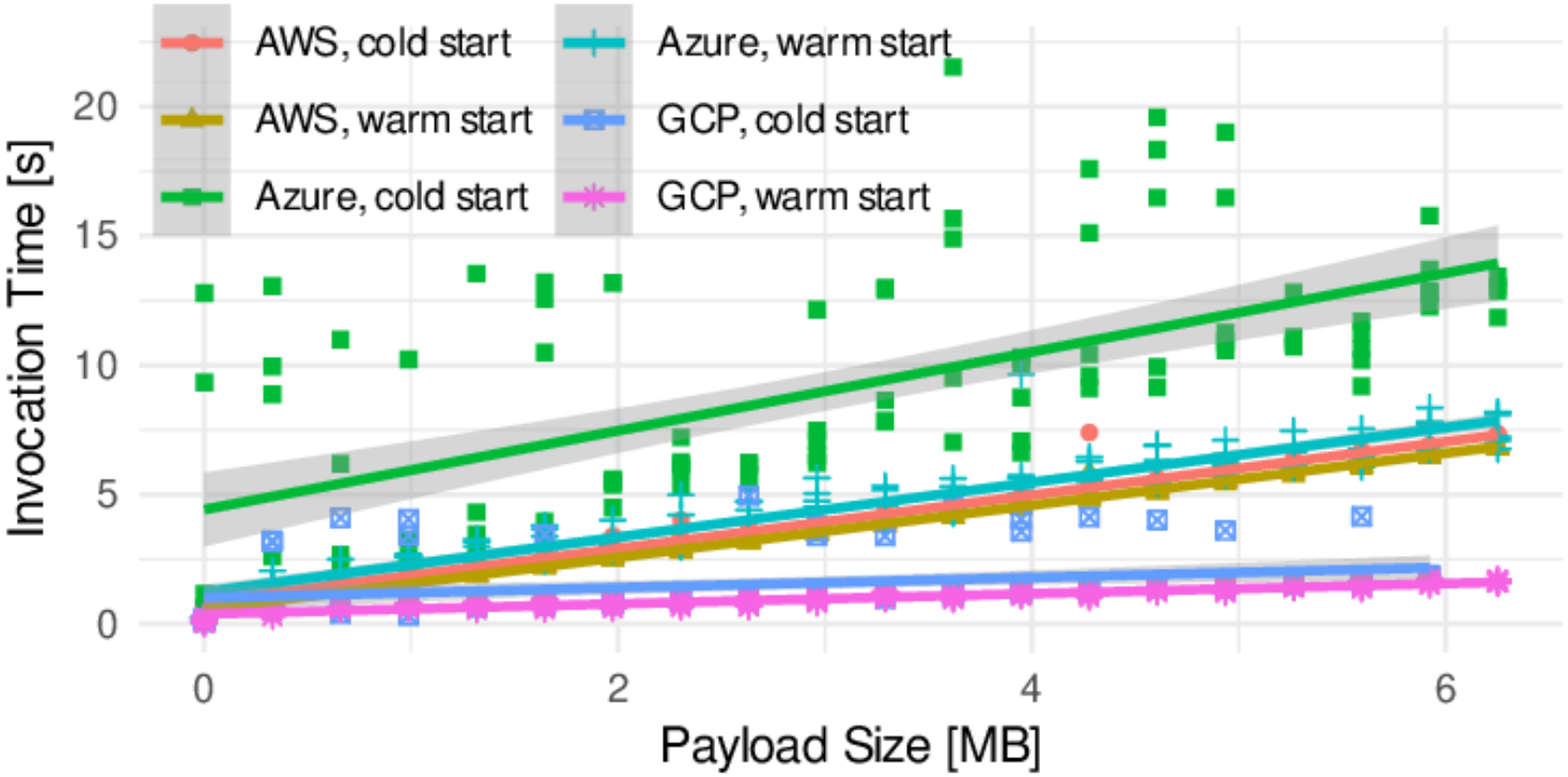

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Agenda

SeBS Slack

- ✓ Part I
  - ✓ What is Serverless?
  - ✓ Benchmarking Suite SeBS
  - ✓ Working with SeBS
- ✓ Hands-on I: Local Deployment & Storage
- ✓ Part II
  - ✓ Communication and Data
  - ✓ Serverless Workflows
  - ✓ Experiments in SeBS
- ✓ **Hands-on II: FaaS Platforms & Experiments**
- ✓ Part III
  - ✓ Research Directions in Serverless
  - ✓ Development of SeBS

slack **Join SeBS Slack channel: https://serverlessbenchmark.slack.com**

SeBS Modularity

spcl/serverless-benchmarks

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spcl/serverless-benchmarks

Add new function?

- ❖ Define dependencies (pip, npm, C++ binaries, etc.).
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spcl/serverless-benchmarks

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SeBS in Practice: Part II

SeBS Slack

spcl/sebs-tutorial

git clone https://github.com/spcl/sebs-tutorial.git

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