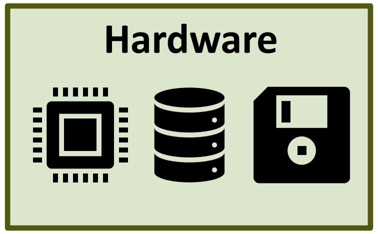
FMI: Fast and Cheap Message Passing for Serverless Functions

Marcin Copik, **Roman Böhringer,** Alexandru Calotoiu, Torsten Hoefler

Cloud and Serverless

Cloud and Serverless



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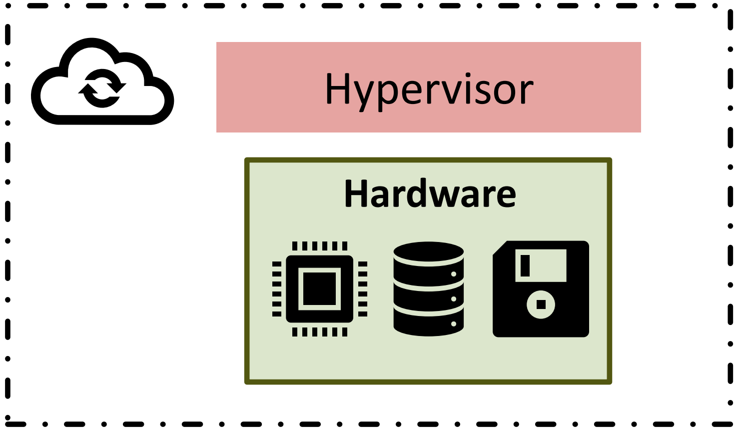

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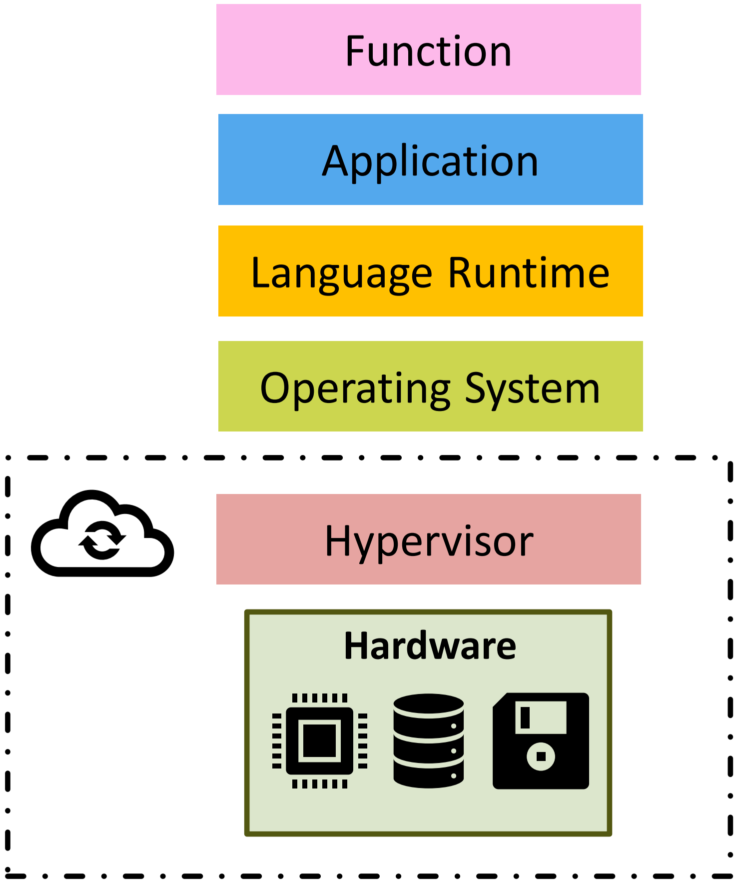
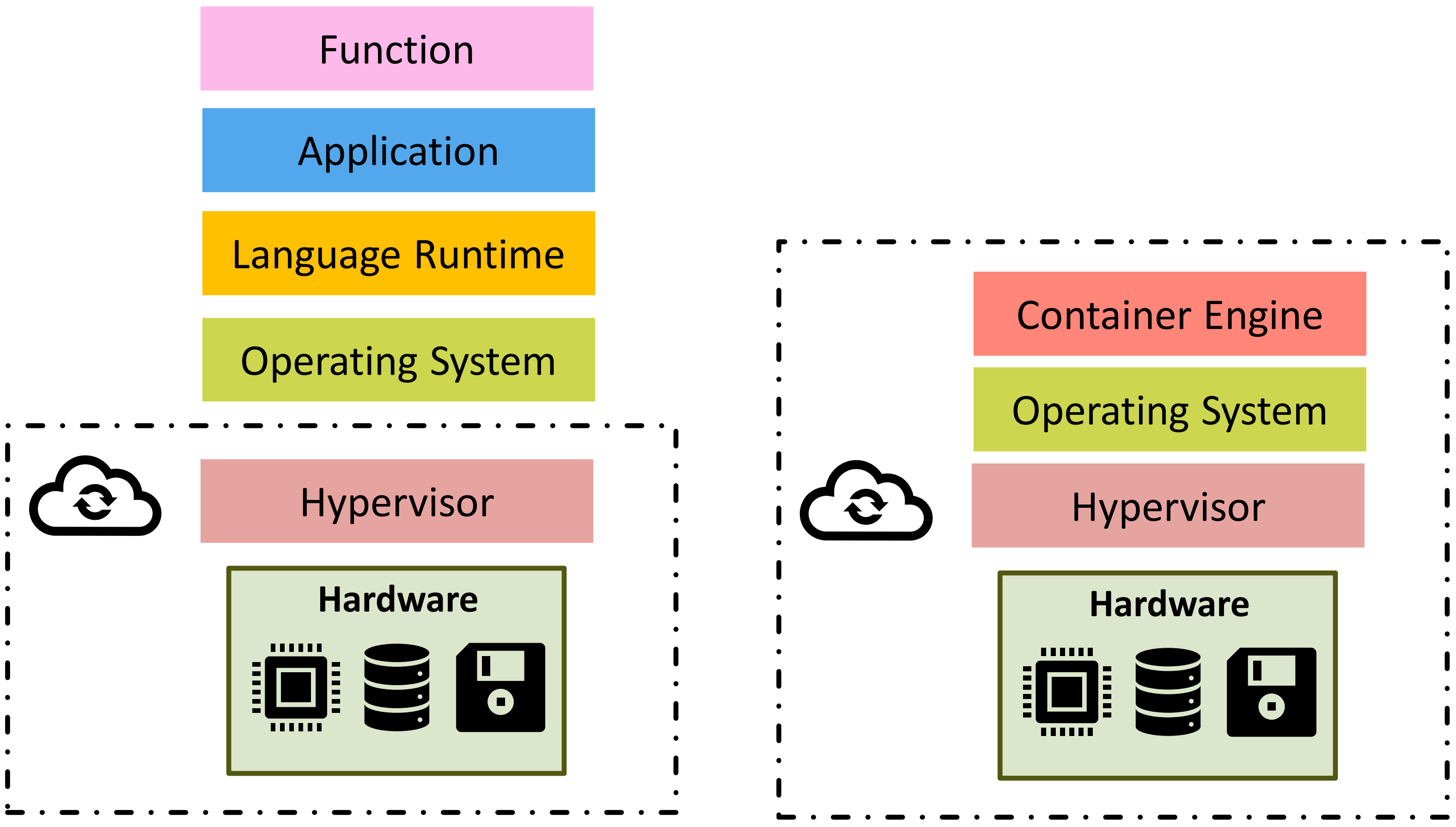


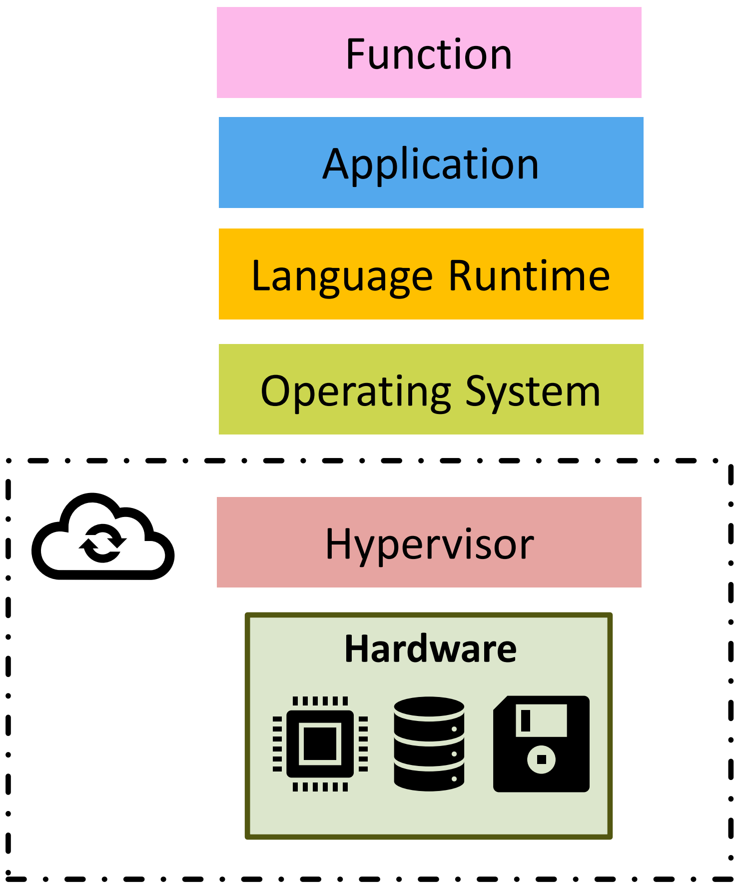
Virtual Machine

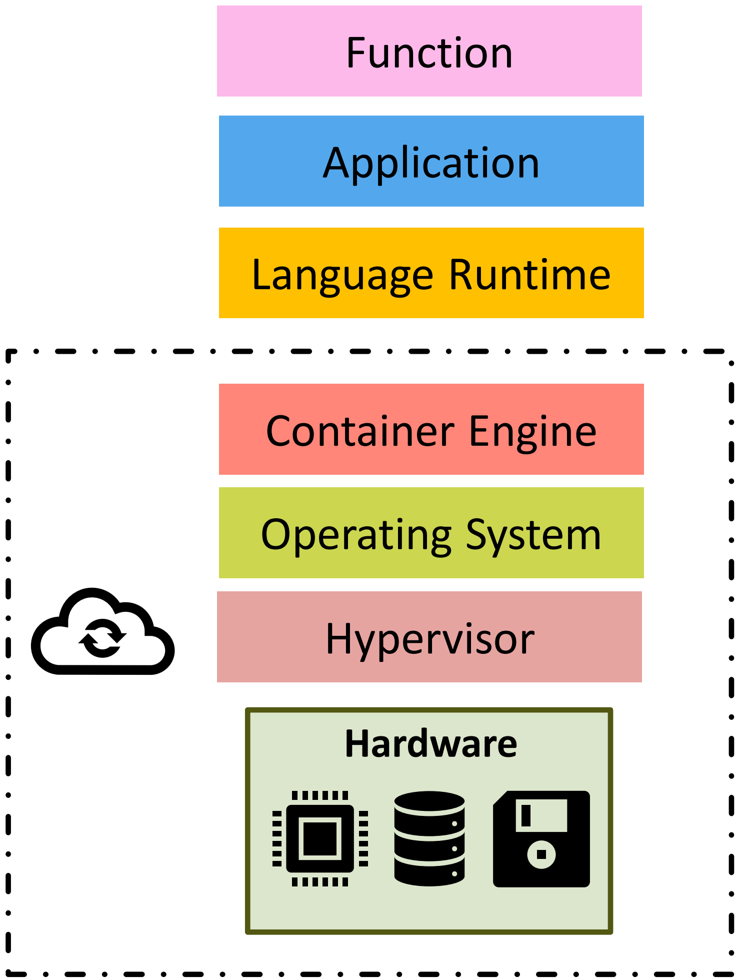
Cloud and Serverless



Virtual Machine **Containers**

Cloud and Serverless





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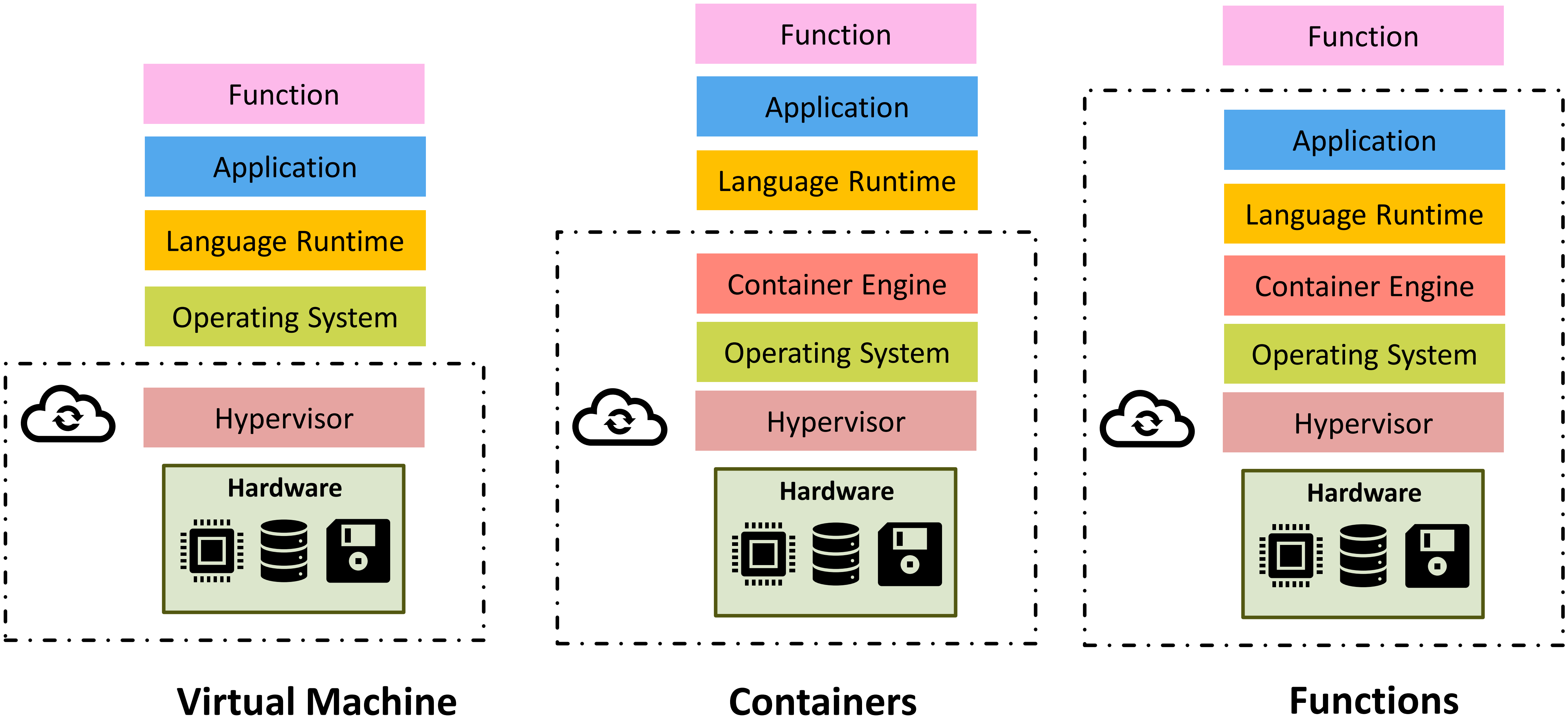

Why is serverless interesting for HPC?

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Job Characteristics on Large-Scale Systems: Long-Term Analysis, Quantification, and Implications*

Tirthak Patel
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Zhengchun Liu, Raj Kettimuthu
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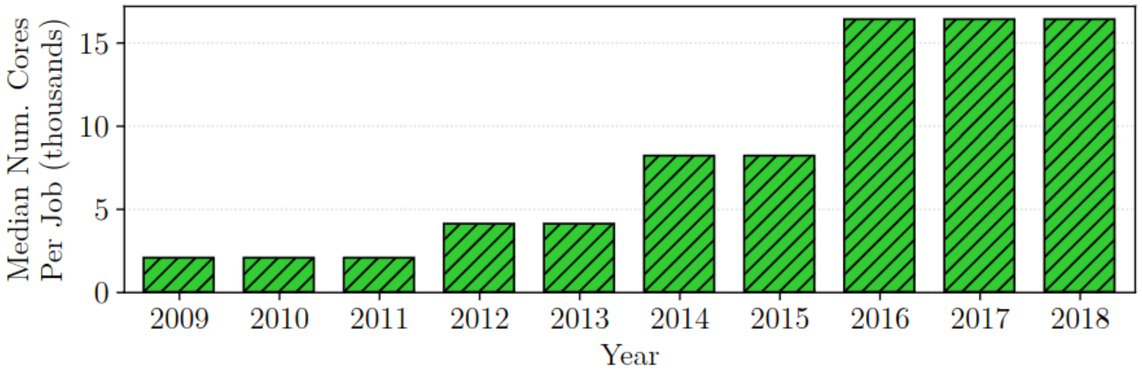
Northeastern University

SC, 2020



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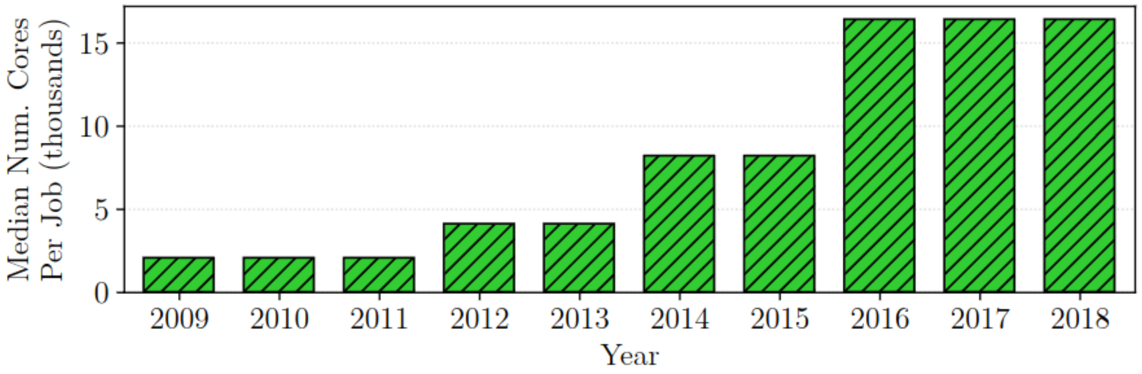
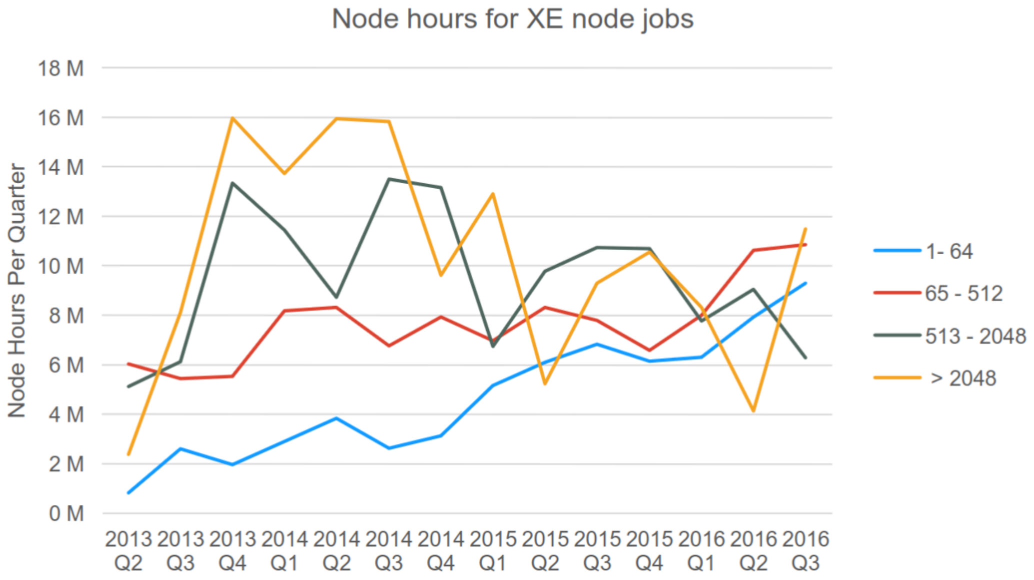
FINAL REPORT
WORKLOAD ANALYSIS OF BLUE WATERS
(ACI 1650758)

Matthew D. Jones, Joseph P. White, Martins Innus, Robert L. DeLeon, Nikolay Simakov, Jeffrey T. Palmer, Steven M. Gallo, and Thomas R. Furlani (furlani@buffalo.edu), Center for Computational Research, University at Buffalo, SUNY

Michael Showerman, Robert Brunner, Andry Kot, Gregory Bauer, Brett Bode, Jeremy Enos, and William Kramer (wtkramer@illinois.edu), National Center for Supercomputing Applications (NCSA), University of Illinois at Urbana Champaign

arXiv, 2017





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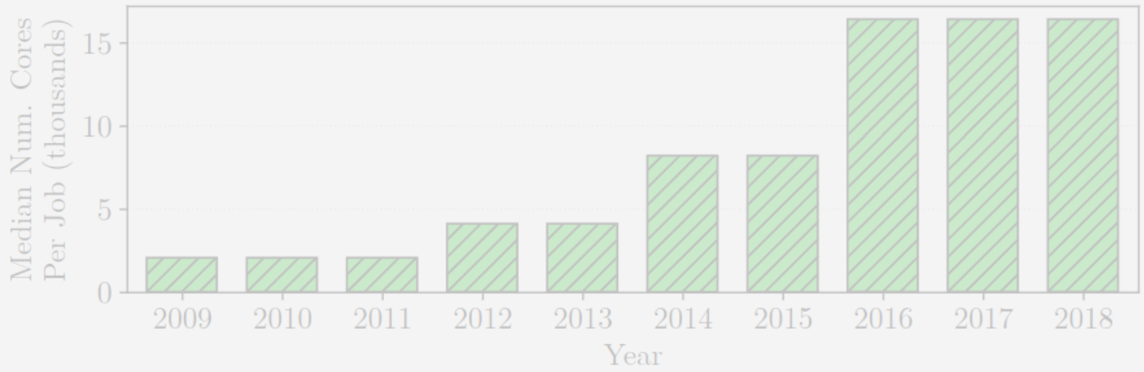
On AWS Lambda, we can run by default up to 1000 concurrent functions, each with up to 6 vCPUs.



Communication in serverless: we need to do better!

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Communication in serverless: we need to do better!

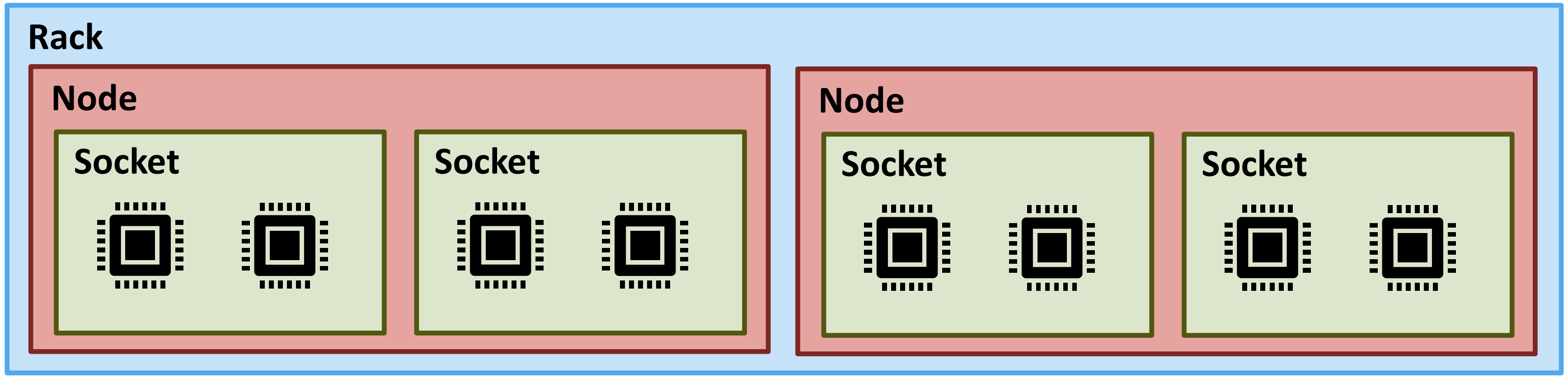
- We need **high performance.**
- We need **division of labor.**

Collectives provide *"division of labor: the programmer thinks in terms of these primitives and the library is responsible for implementing them efficiently".*

Sanders et al., "Two-Tree Algorithms for Full Bandwidth Broadcast, Reduction and Scan", Parallel Computing 2009

Communication in serverless: we need to do better!

- We need **high performance.**
- We need **division of labor.**
- We need **portable performance.**



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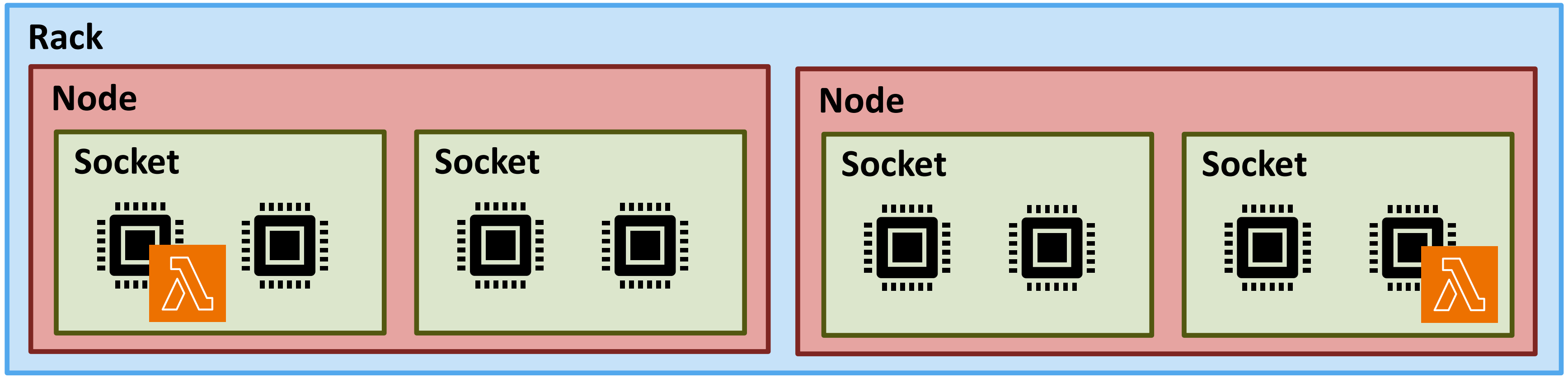

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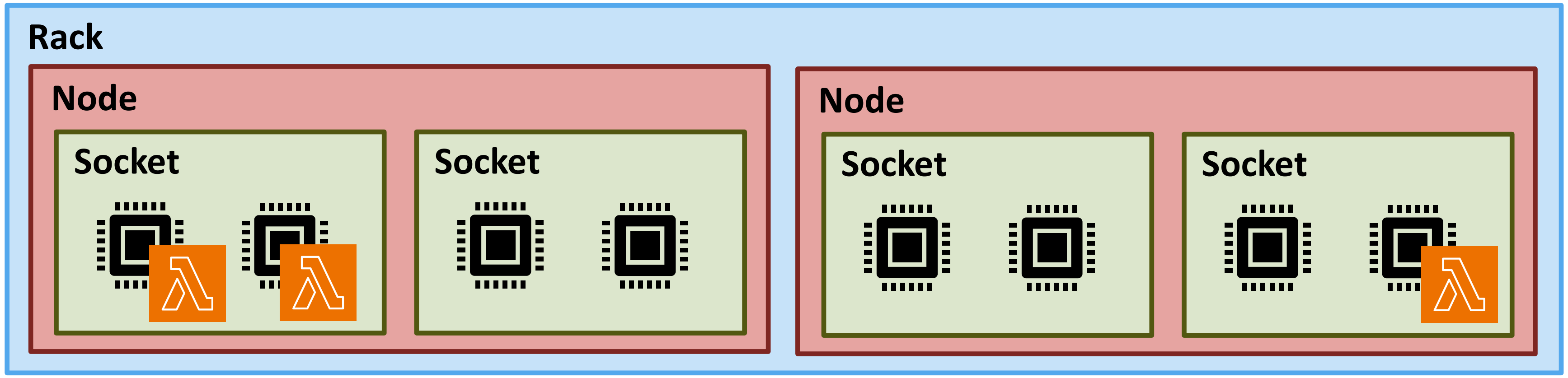

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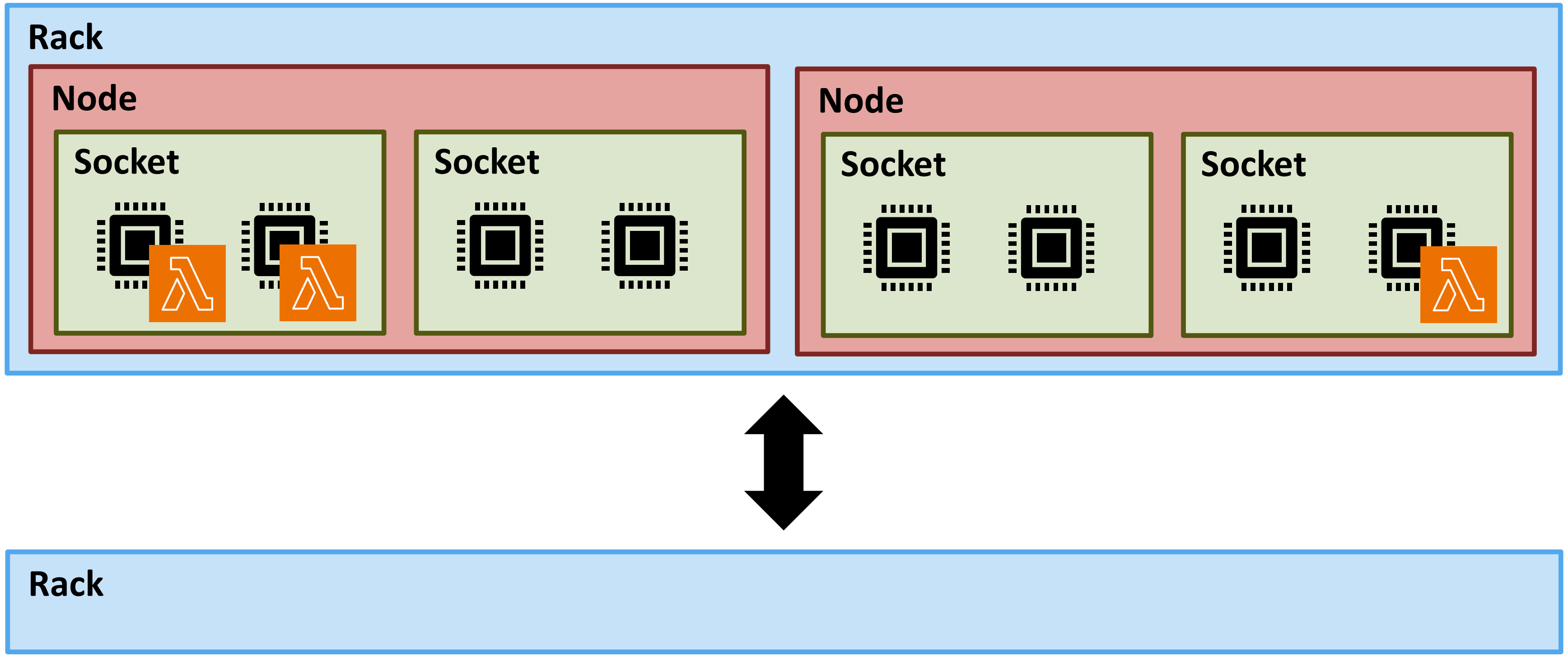

Communication in serverless

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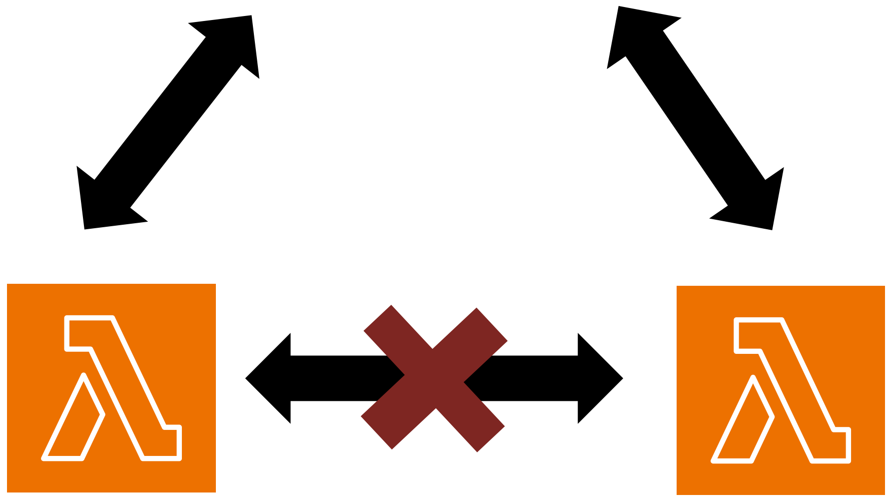

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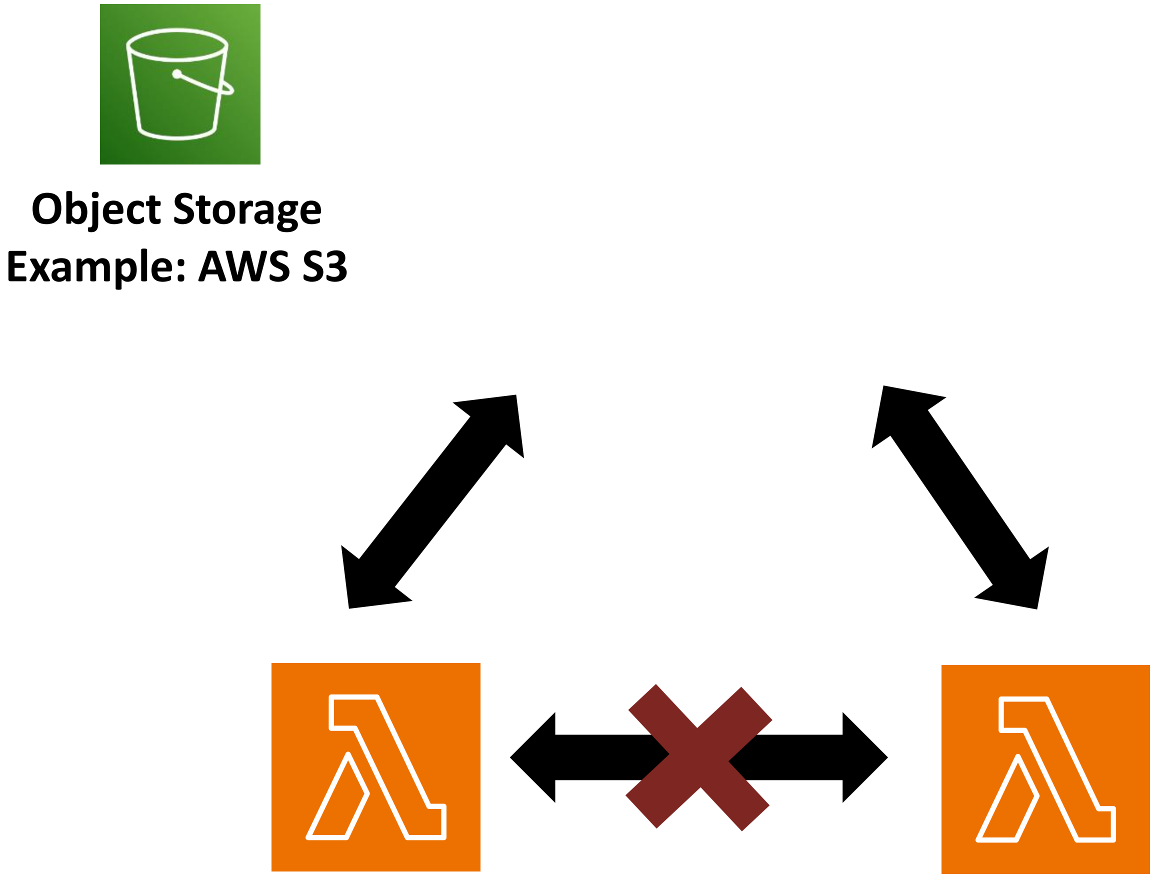

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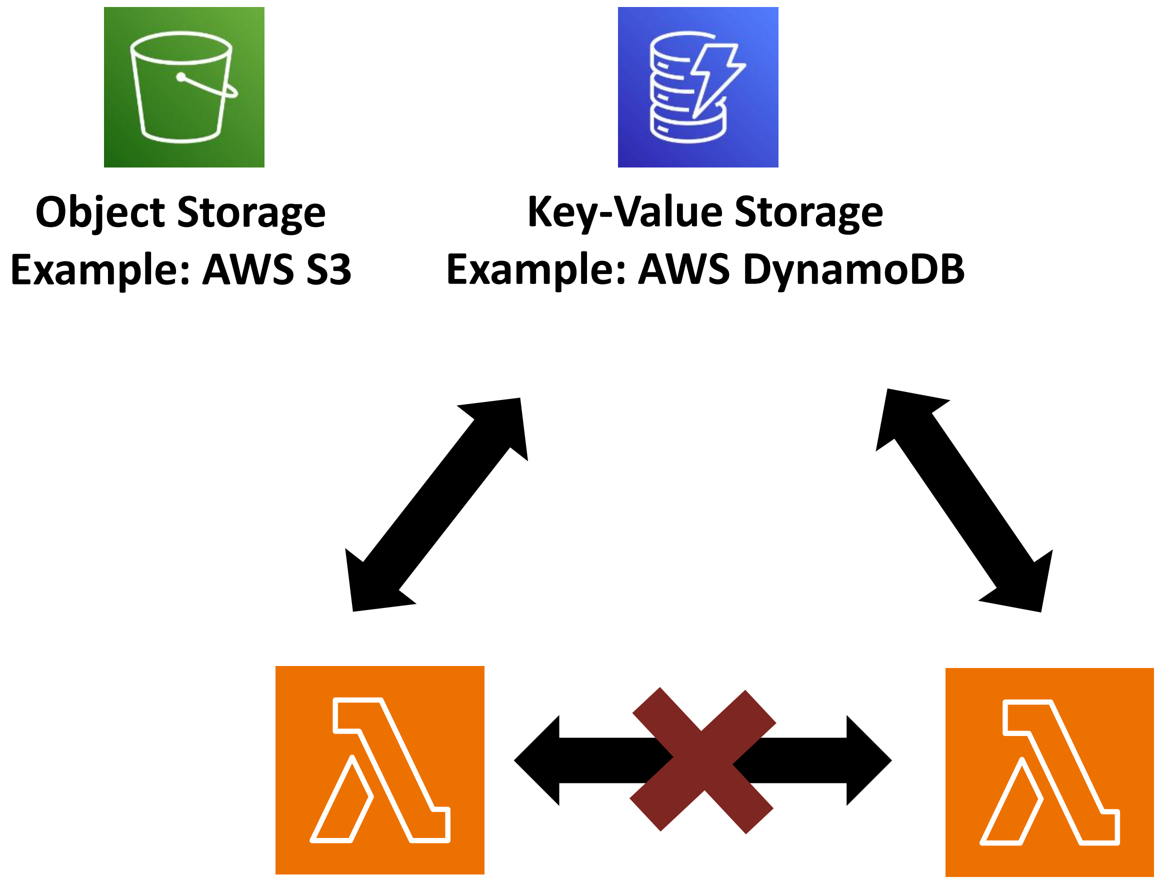

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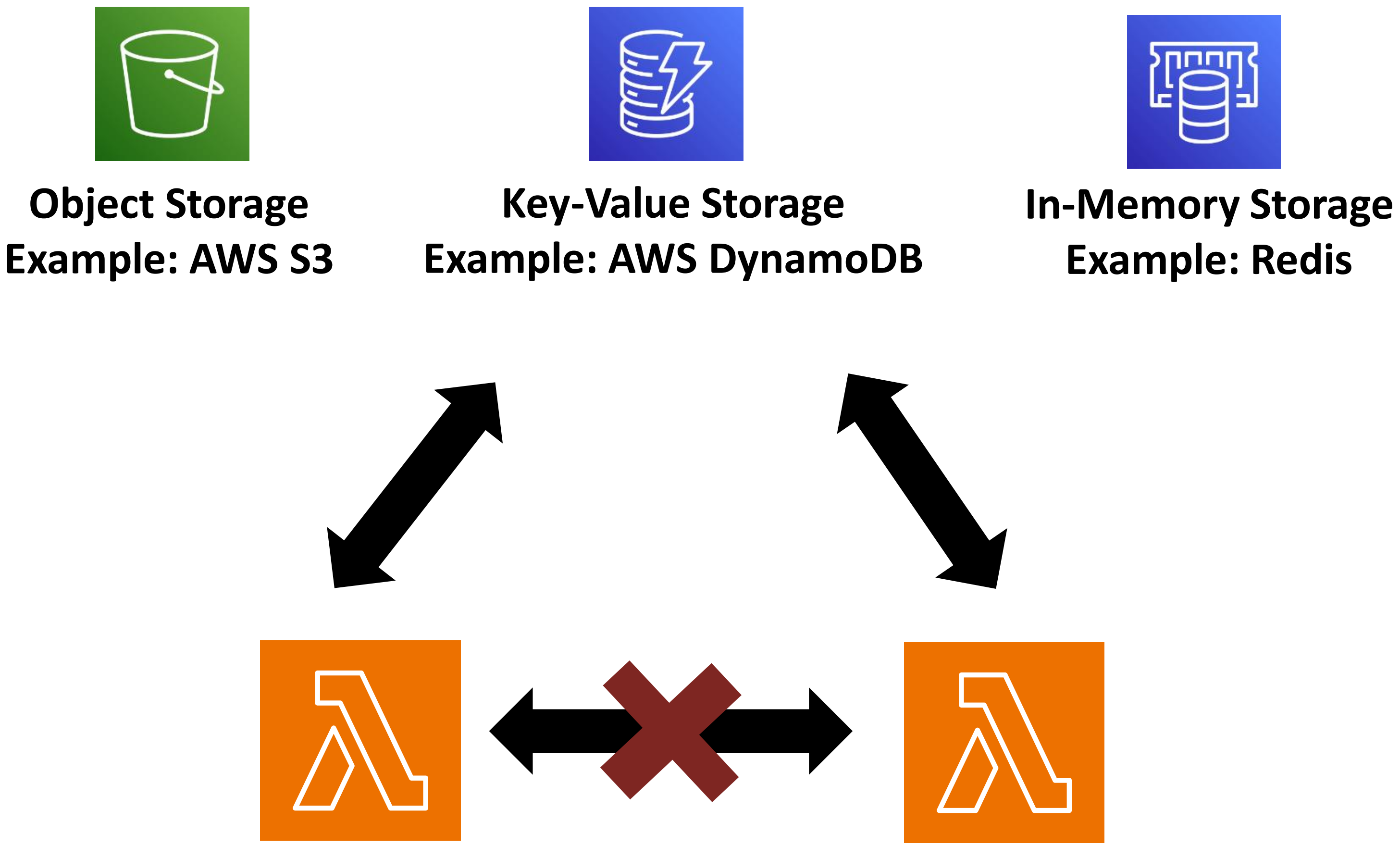
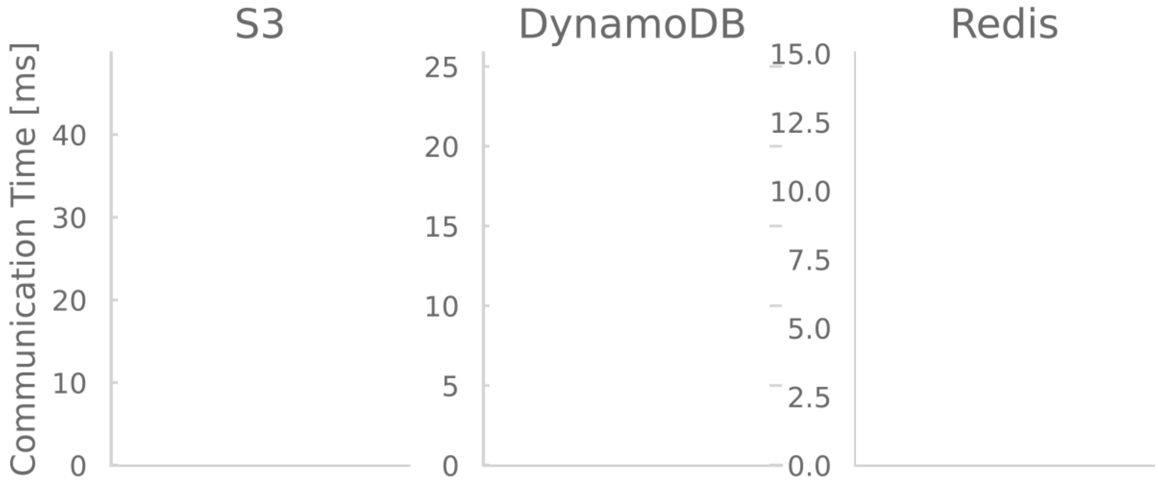


Performance of communication channels

1 B



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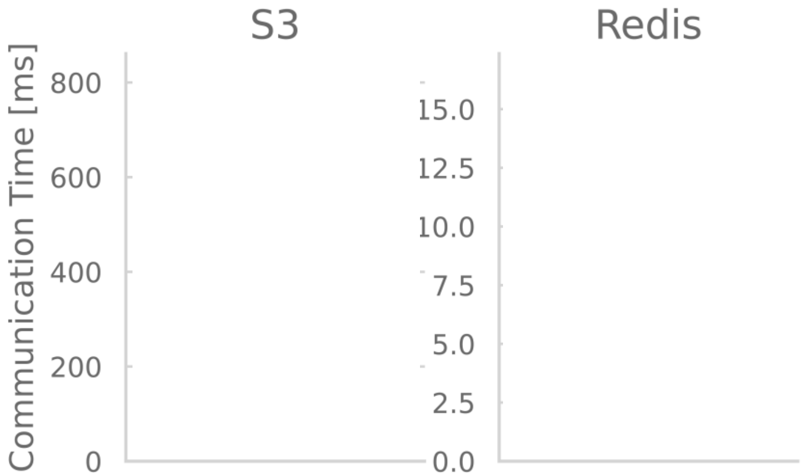

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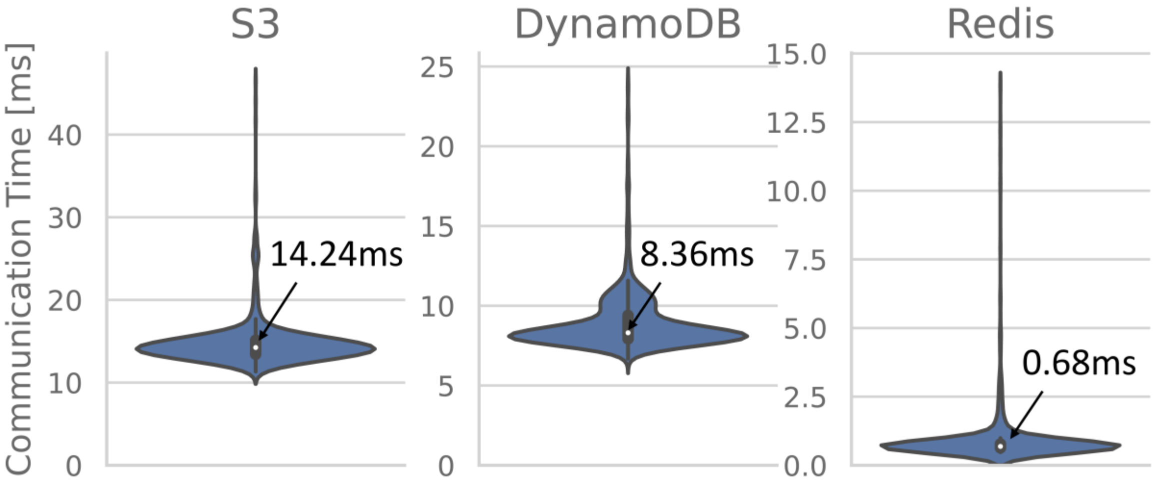

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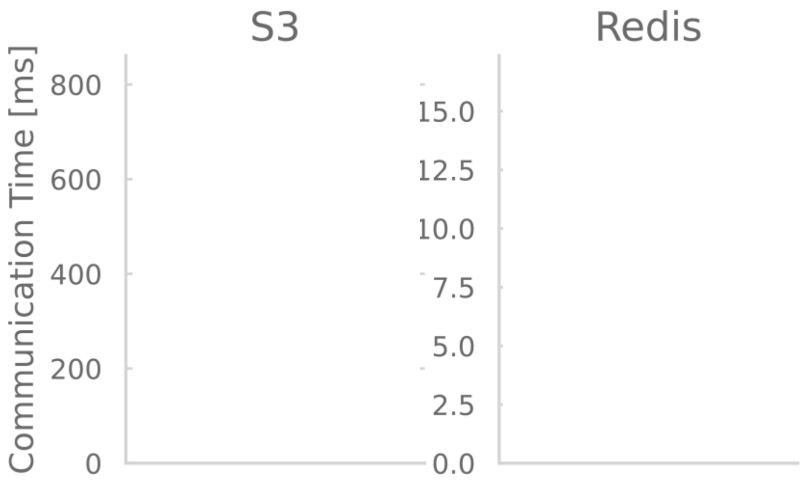

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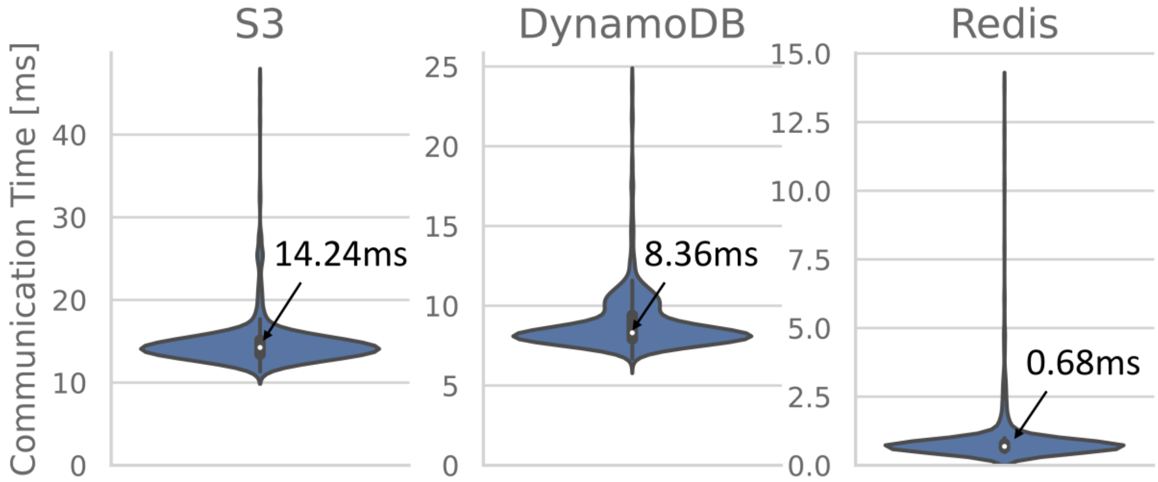

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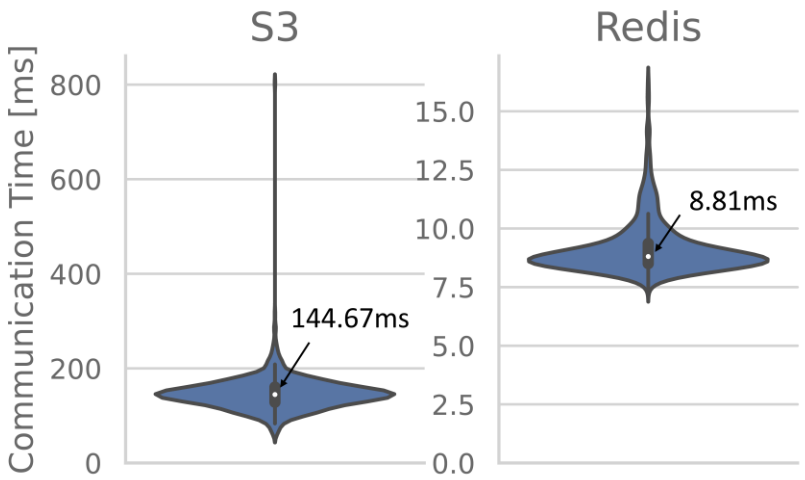


NAT Hole Punching

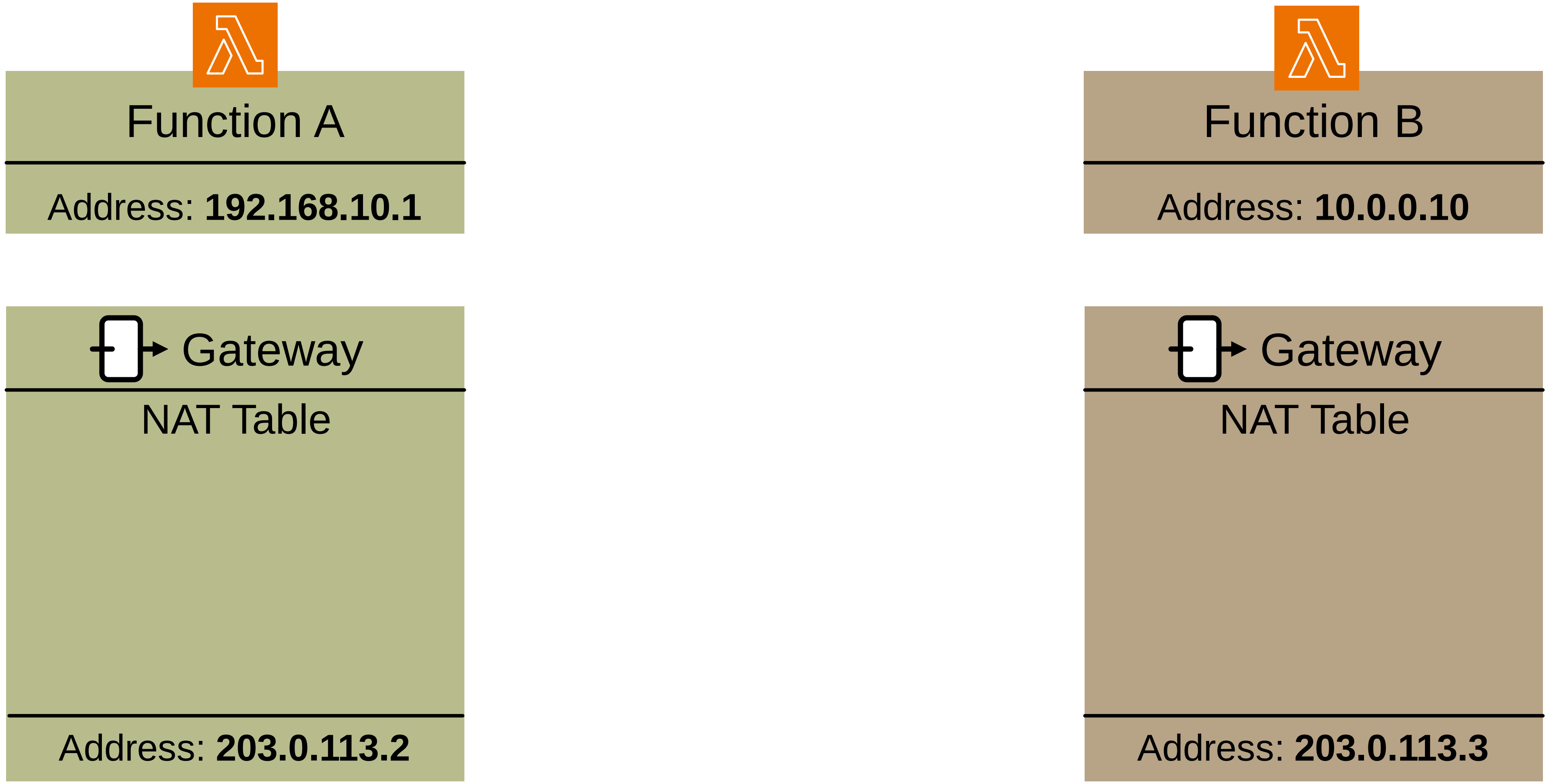
Function A

Address: **192.168.10.1**

Function B

Address: **10.0.0.10**

NAT Hole Punching



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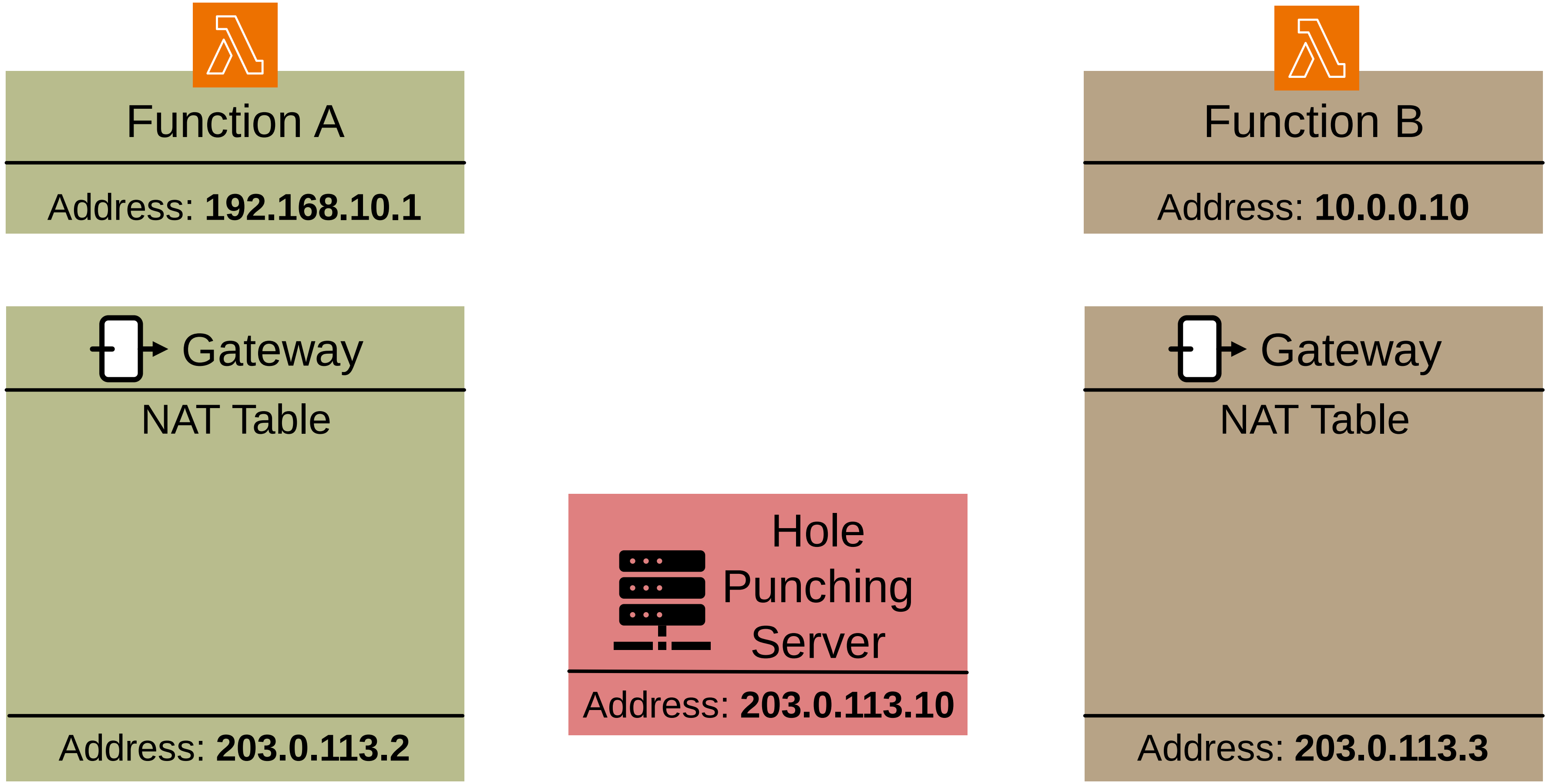

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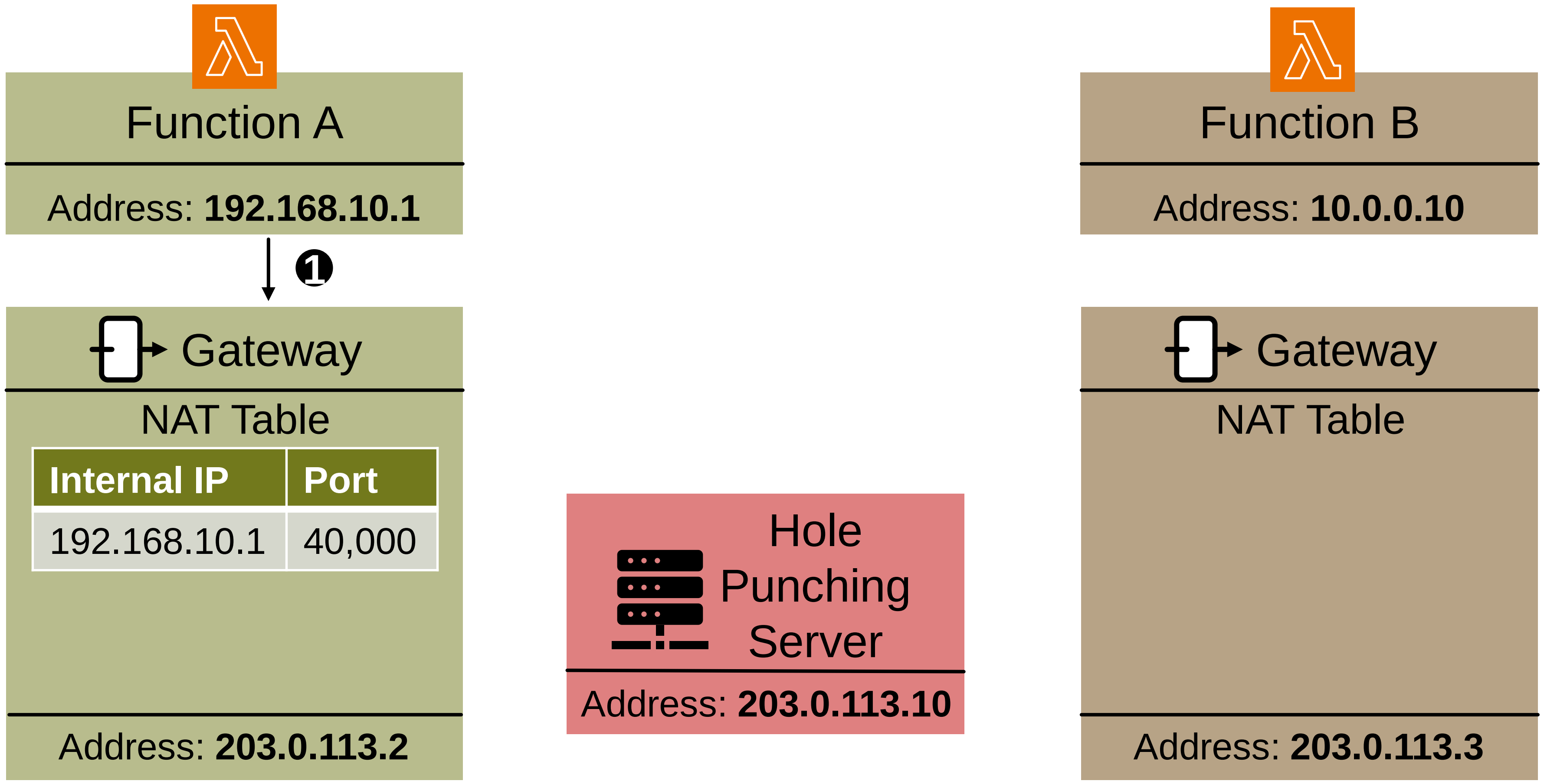
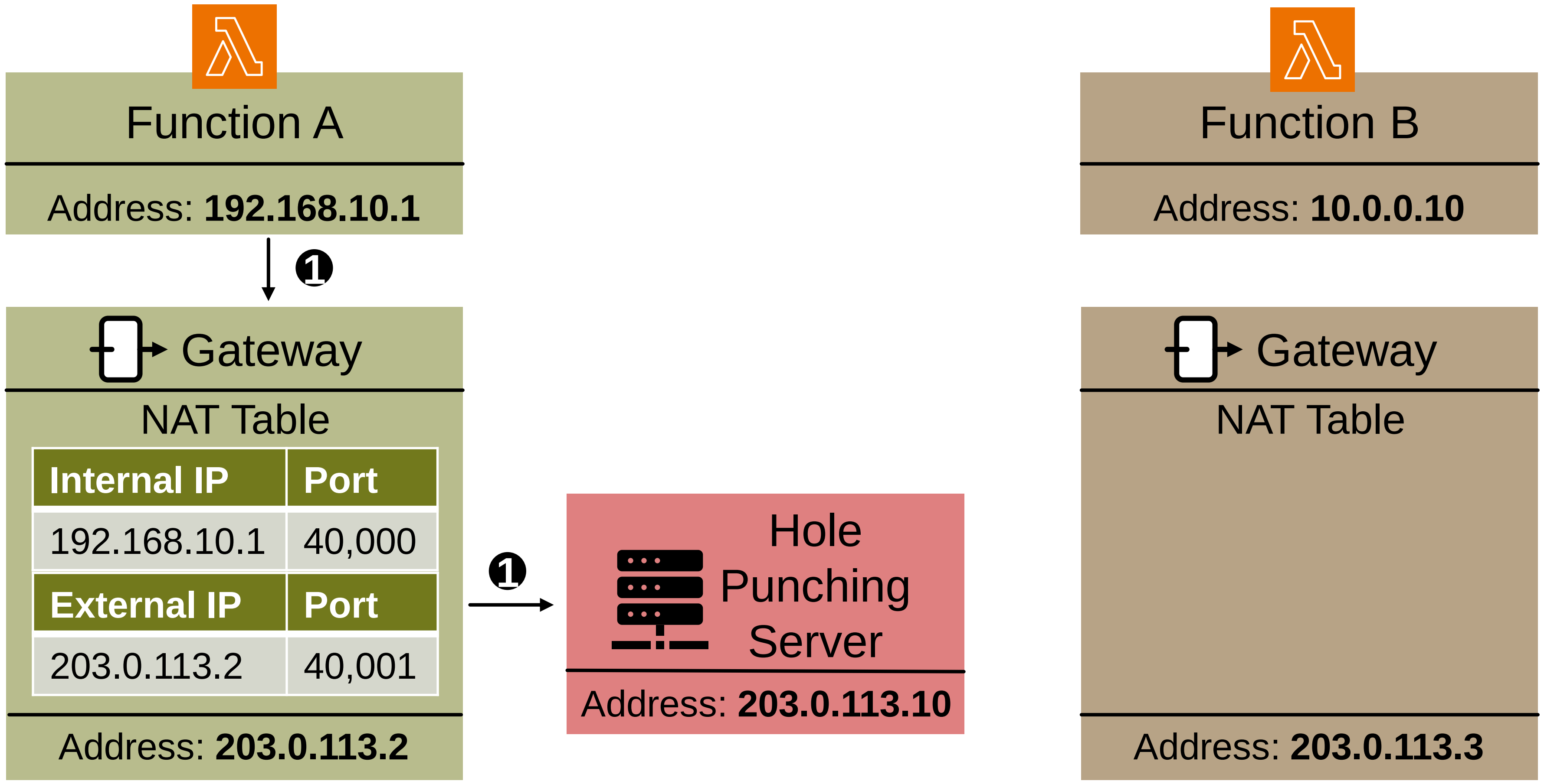


❶ Initial communication to the hole puncher.

NAT Hole Punching



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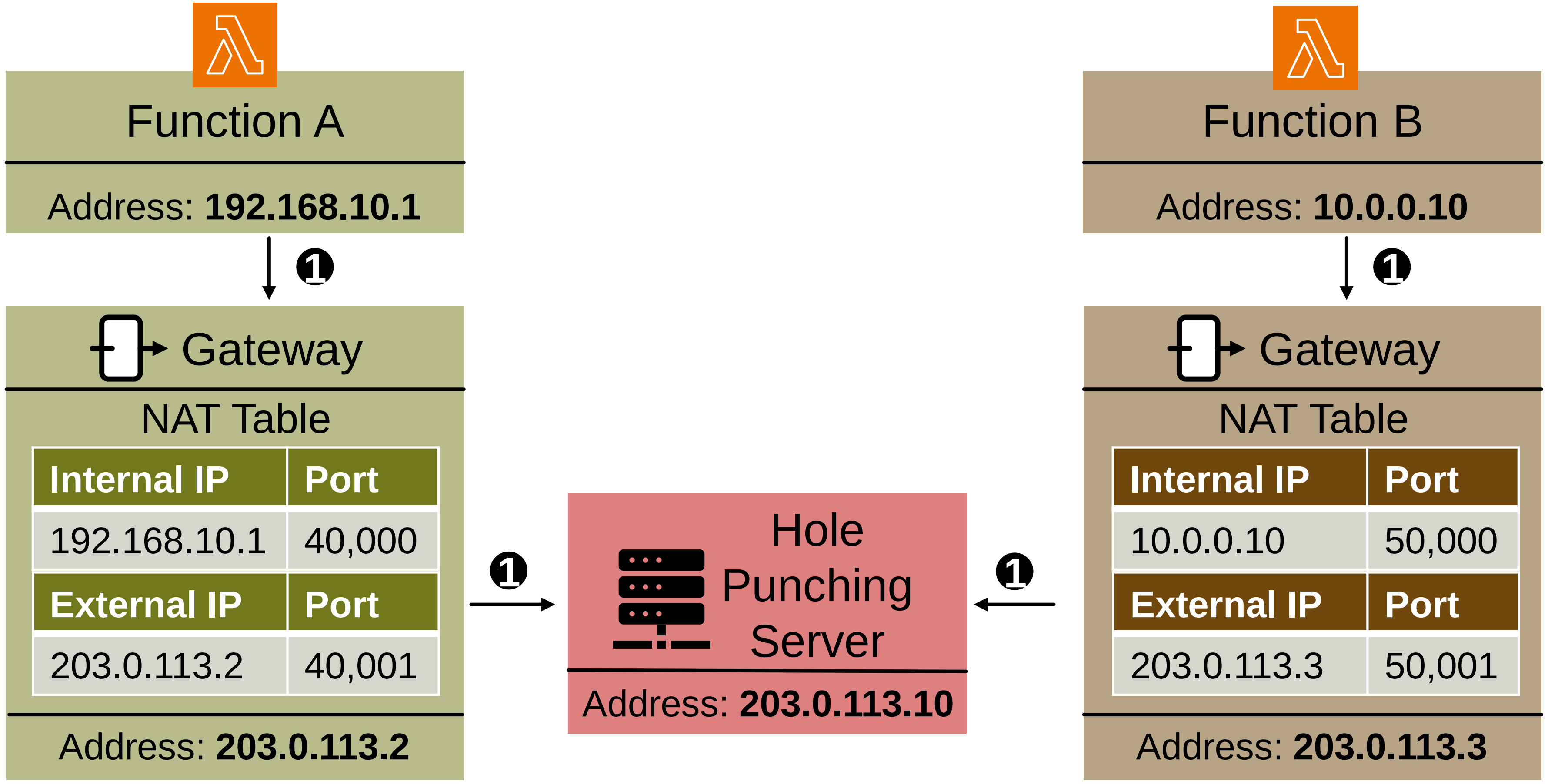

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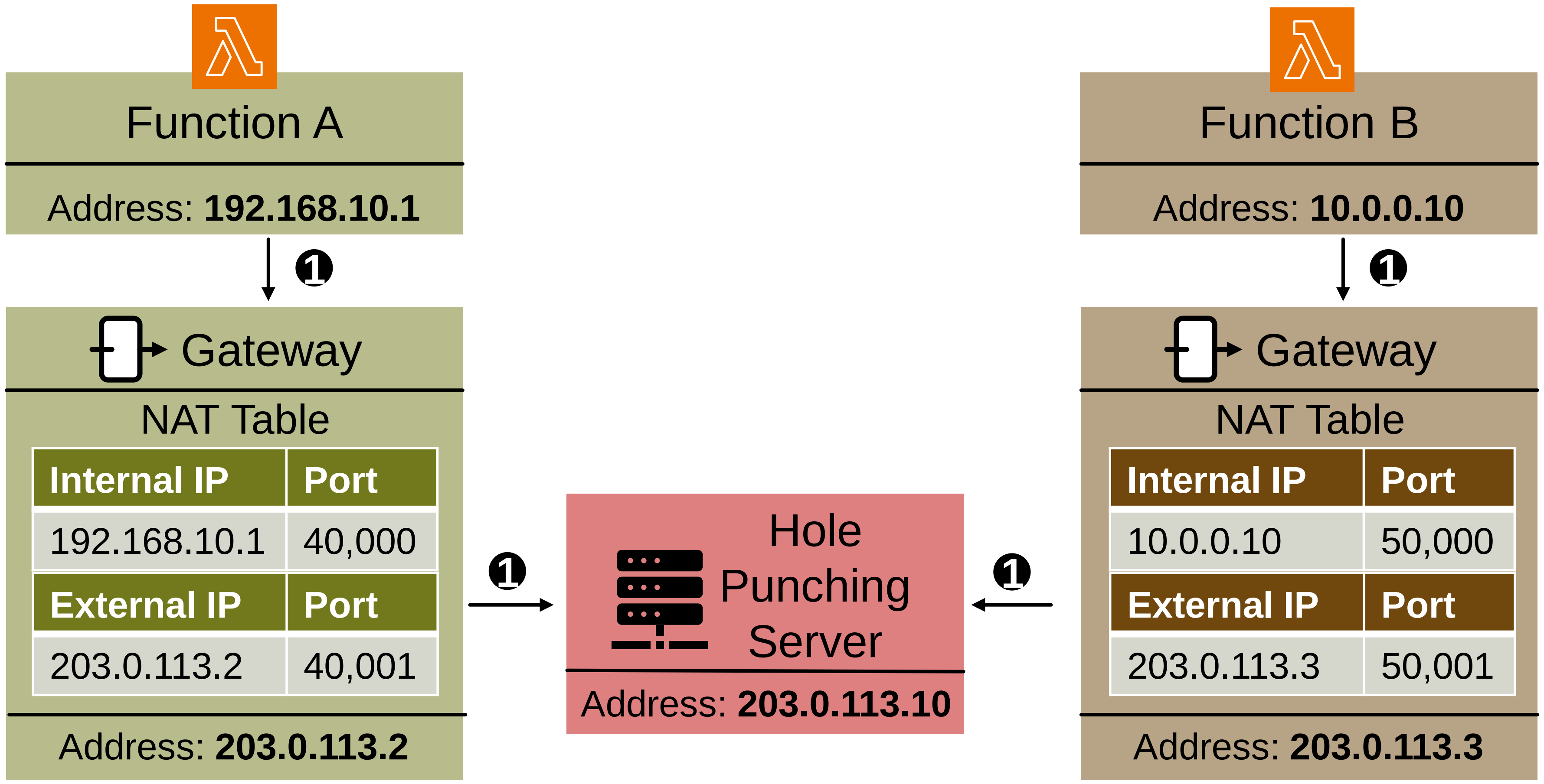

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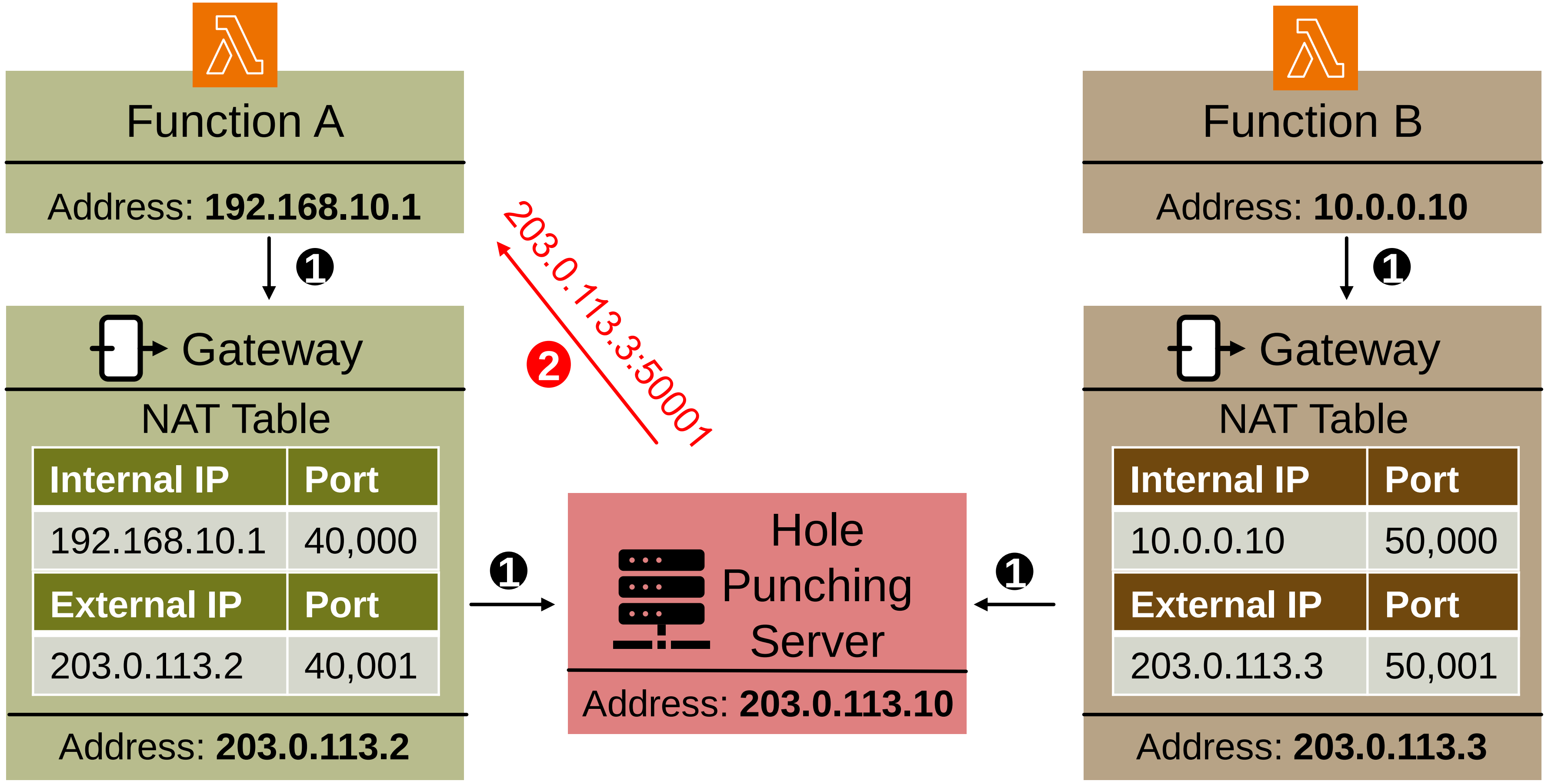
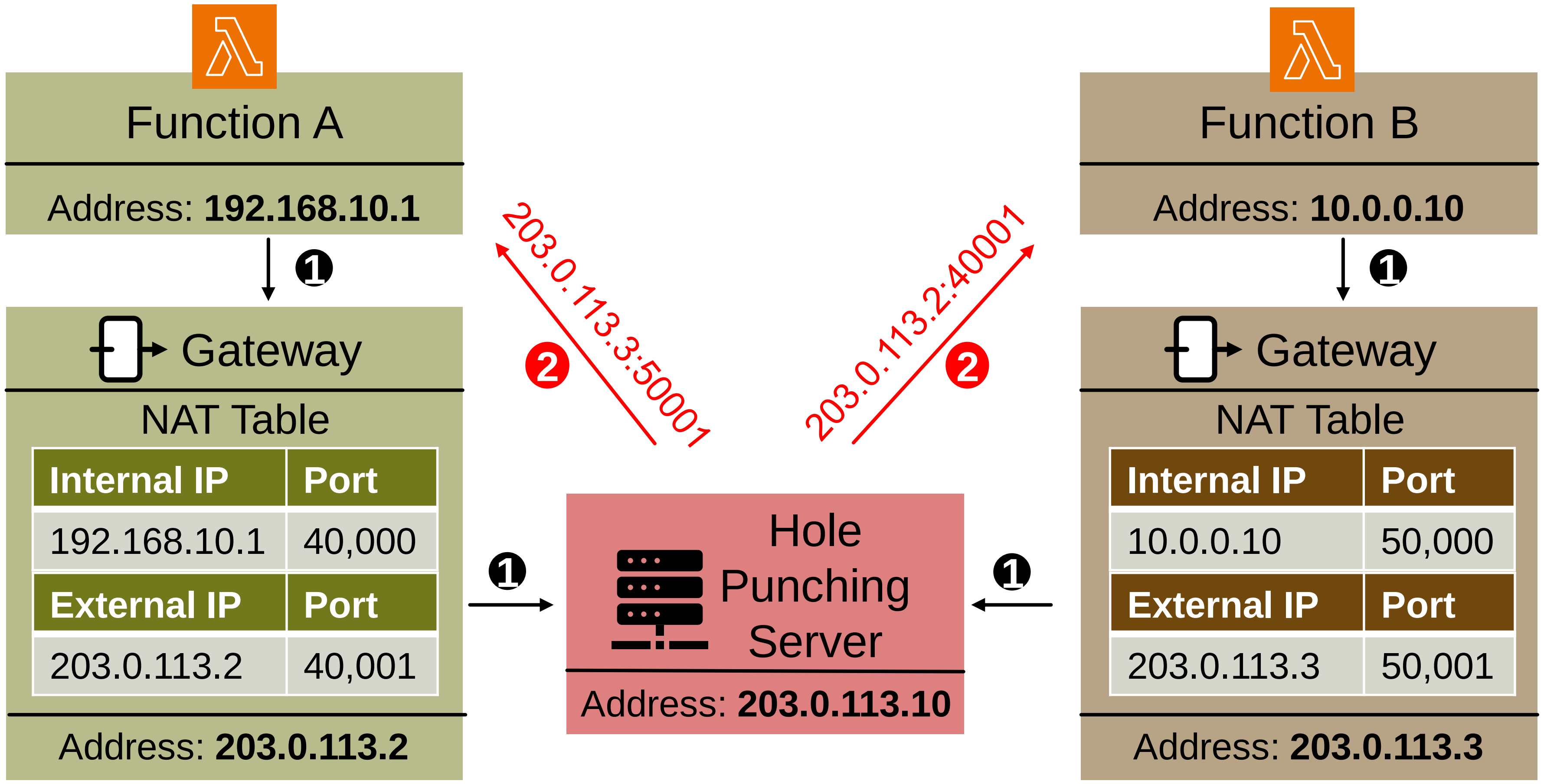


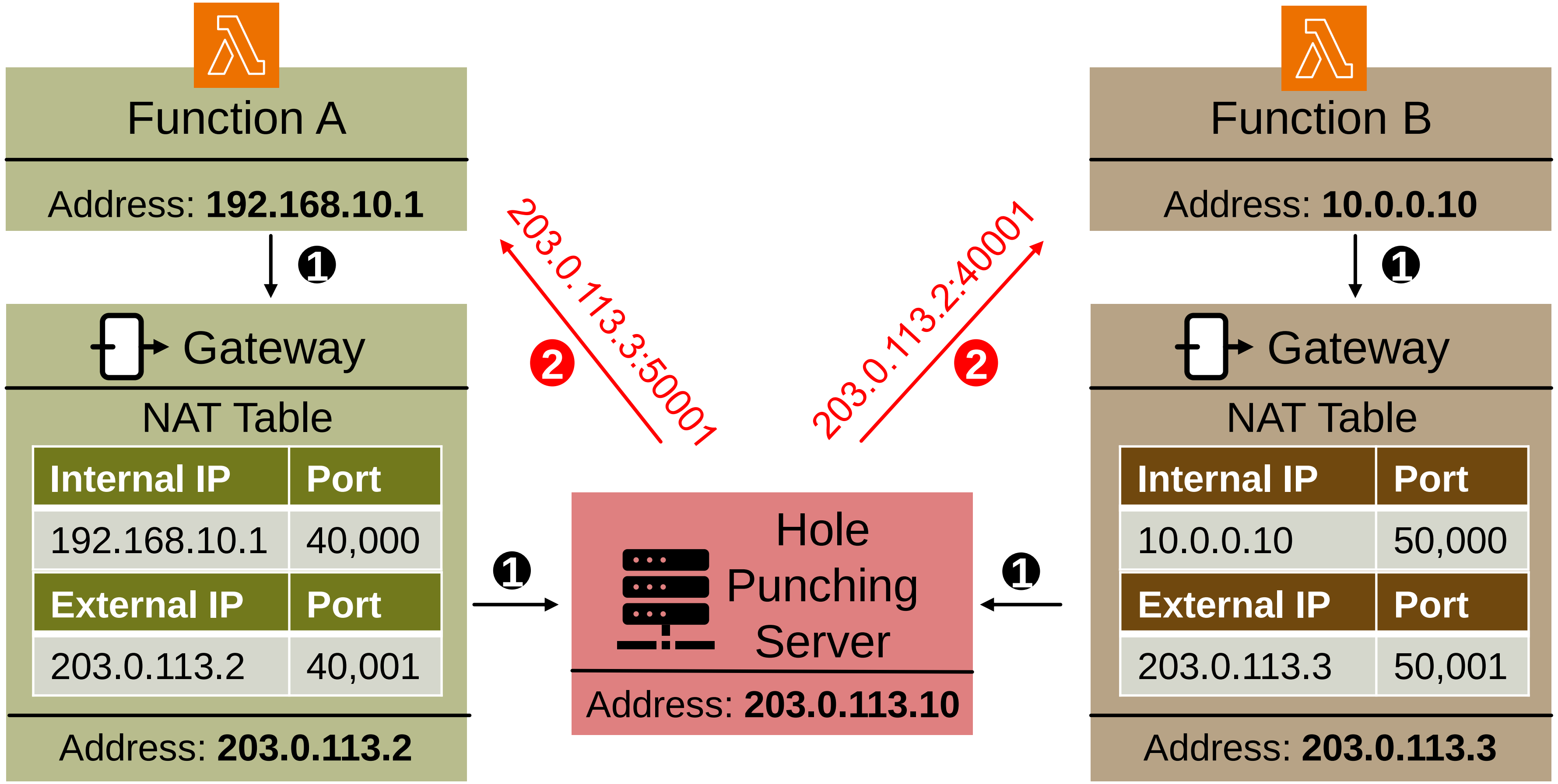
❷ Hole punching server sends connection information of the other function.

NAT Hole Punching



2 Hole punching server sends connection information of the other function.

NAT Hole Punching



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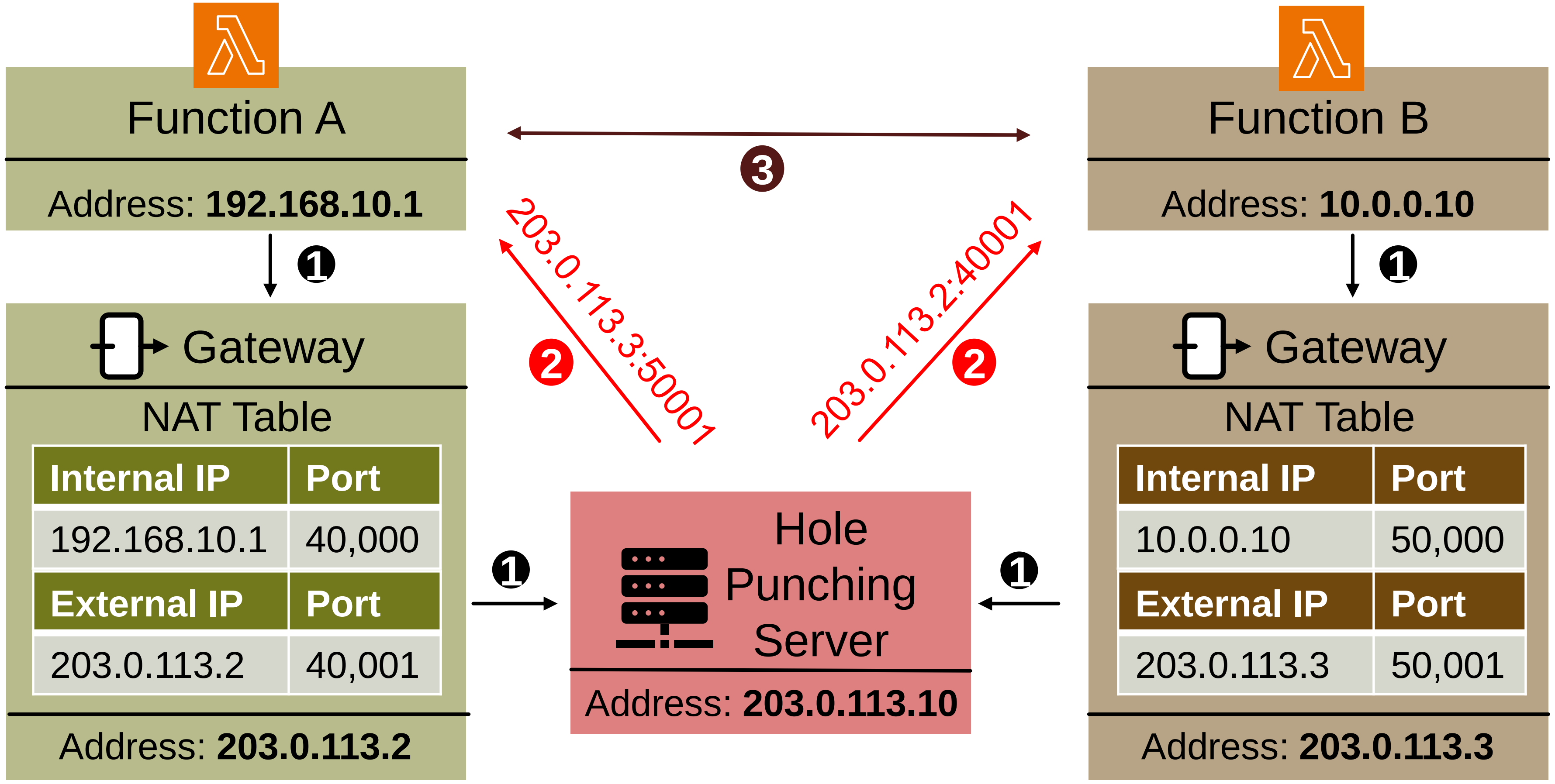
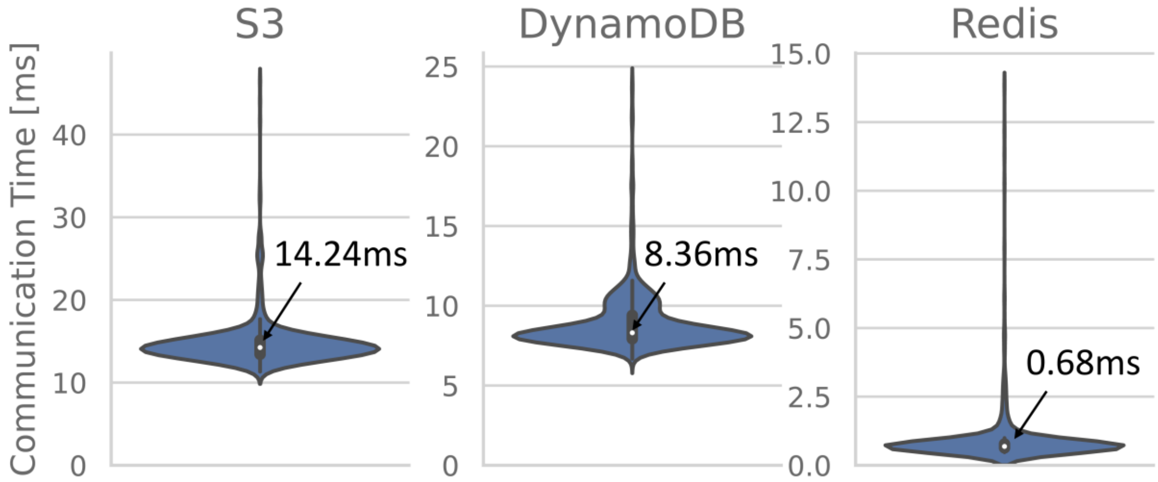


❸ Both functions initiate a connection with the new information.

Communication channels

1 B



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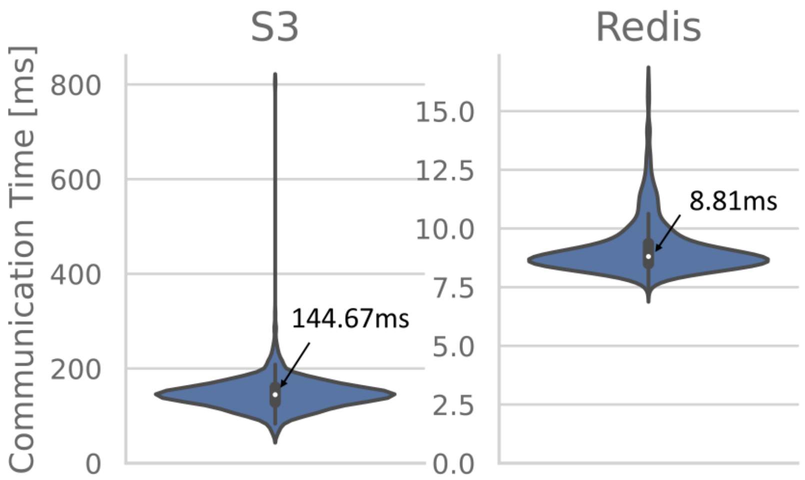

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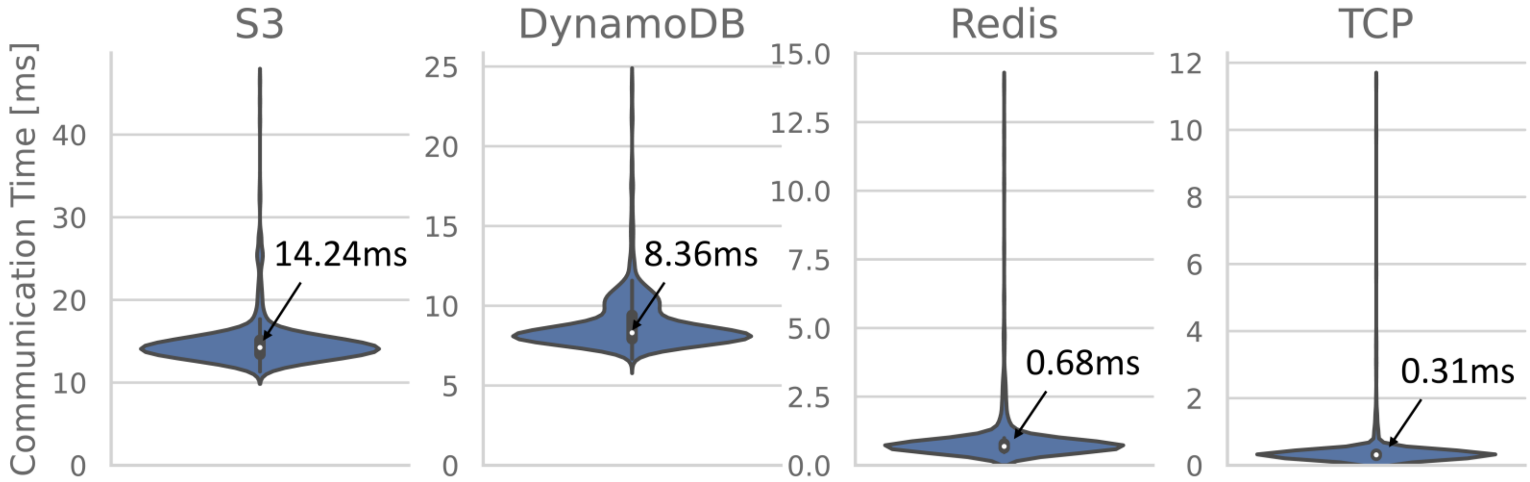

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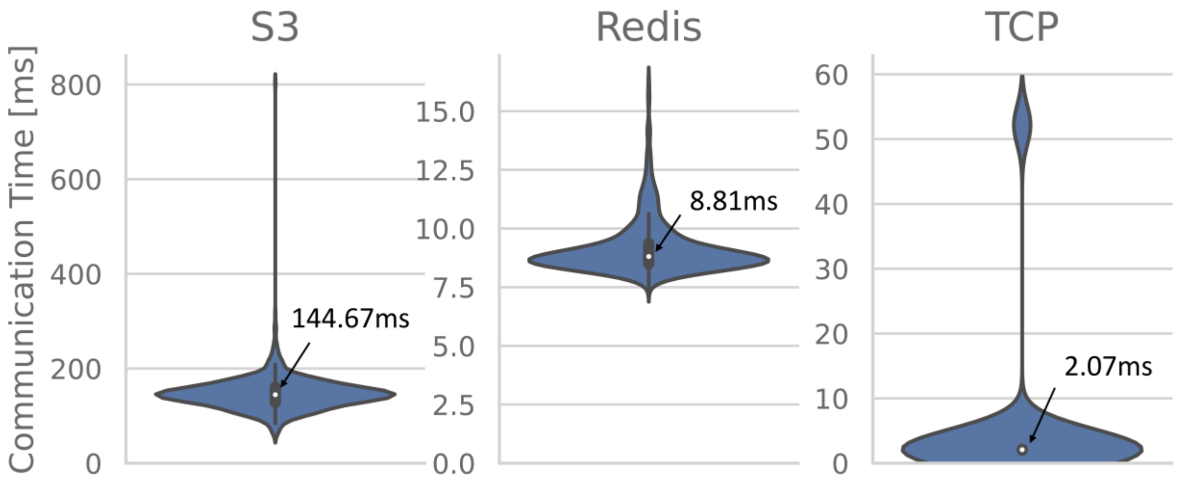

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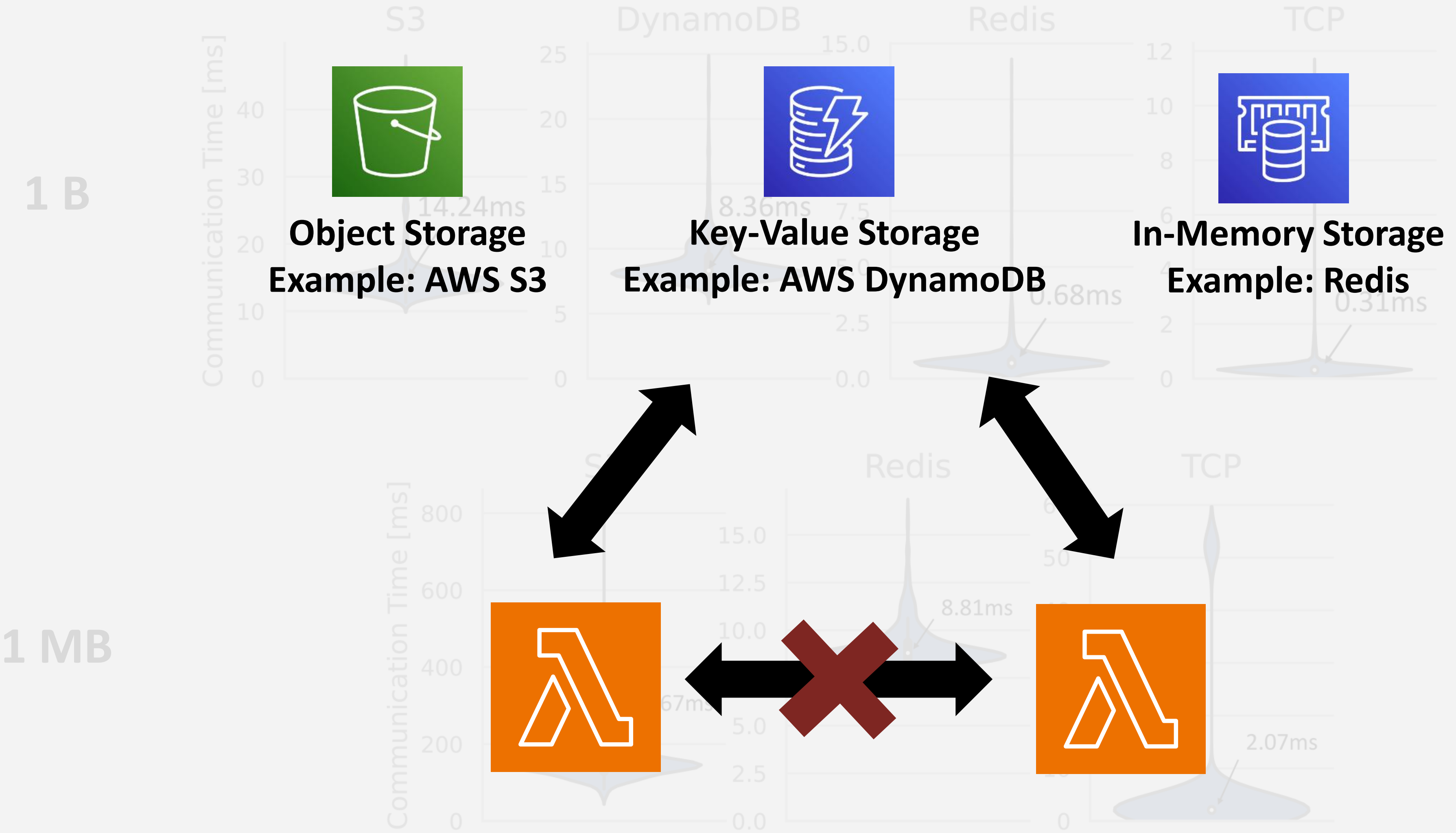

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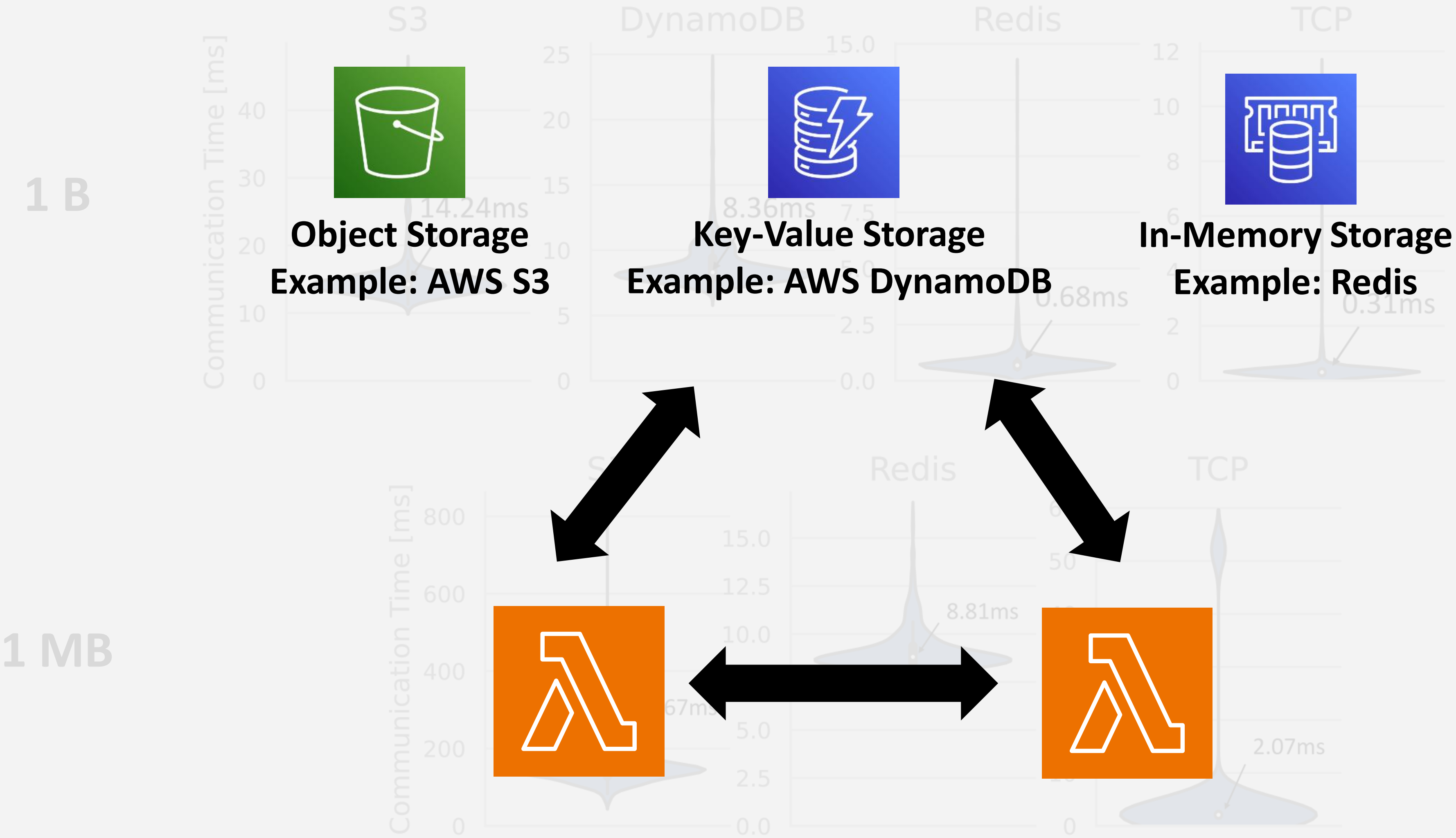

Function Message Interface (FMI): MPI for serverless

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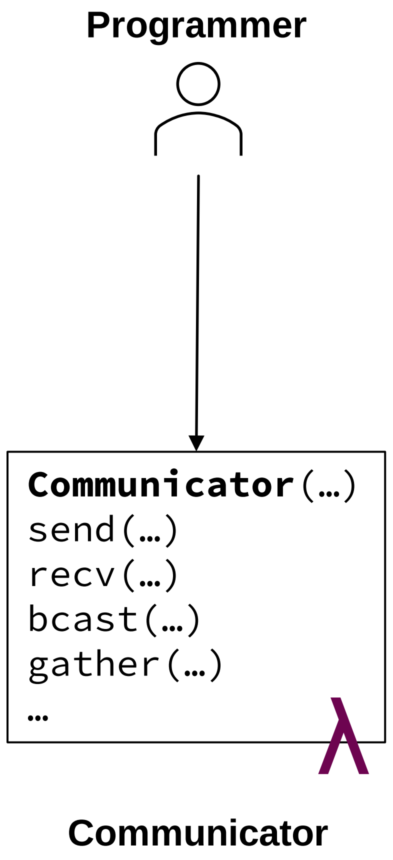

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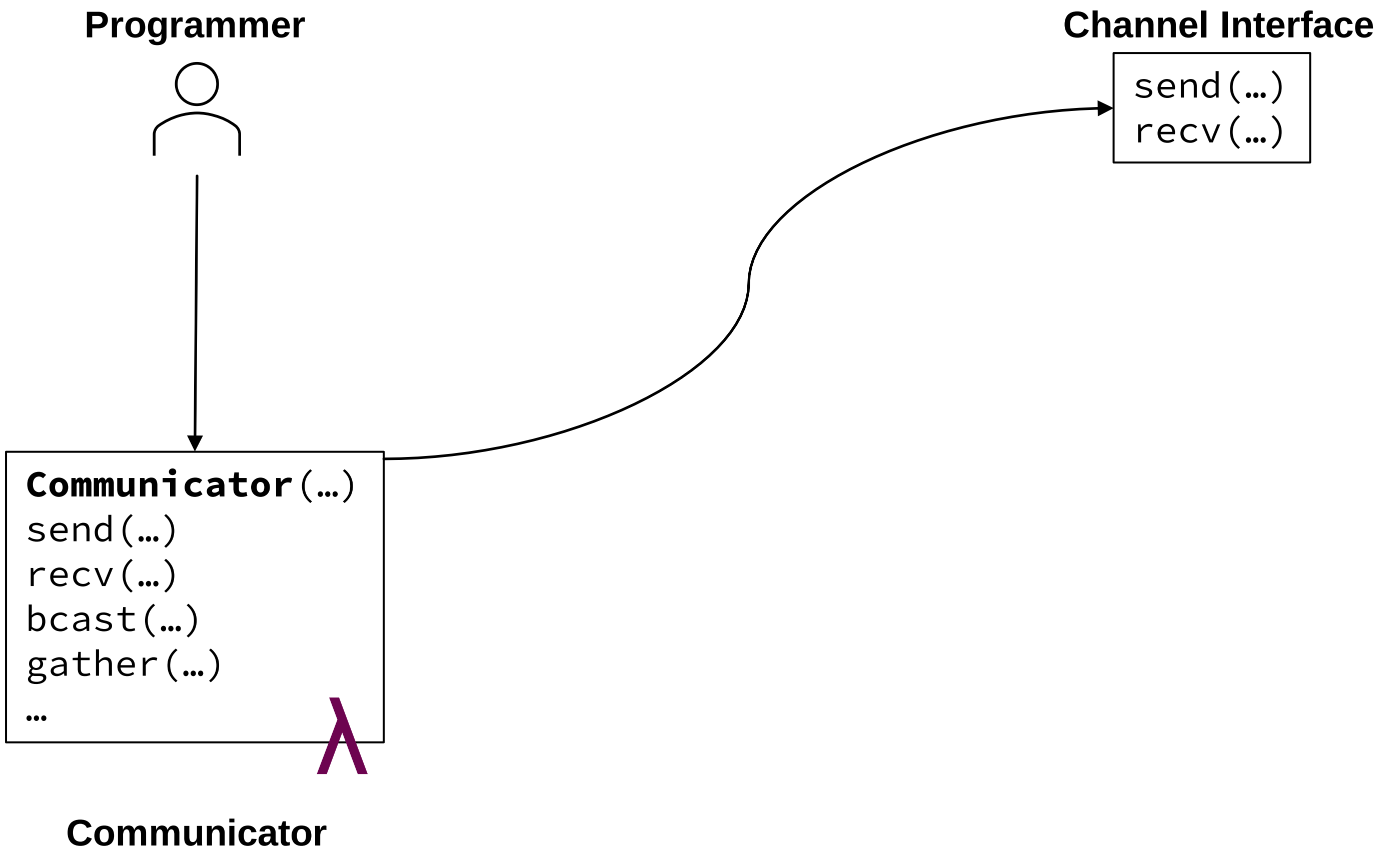

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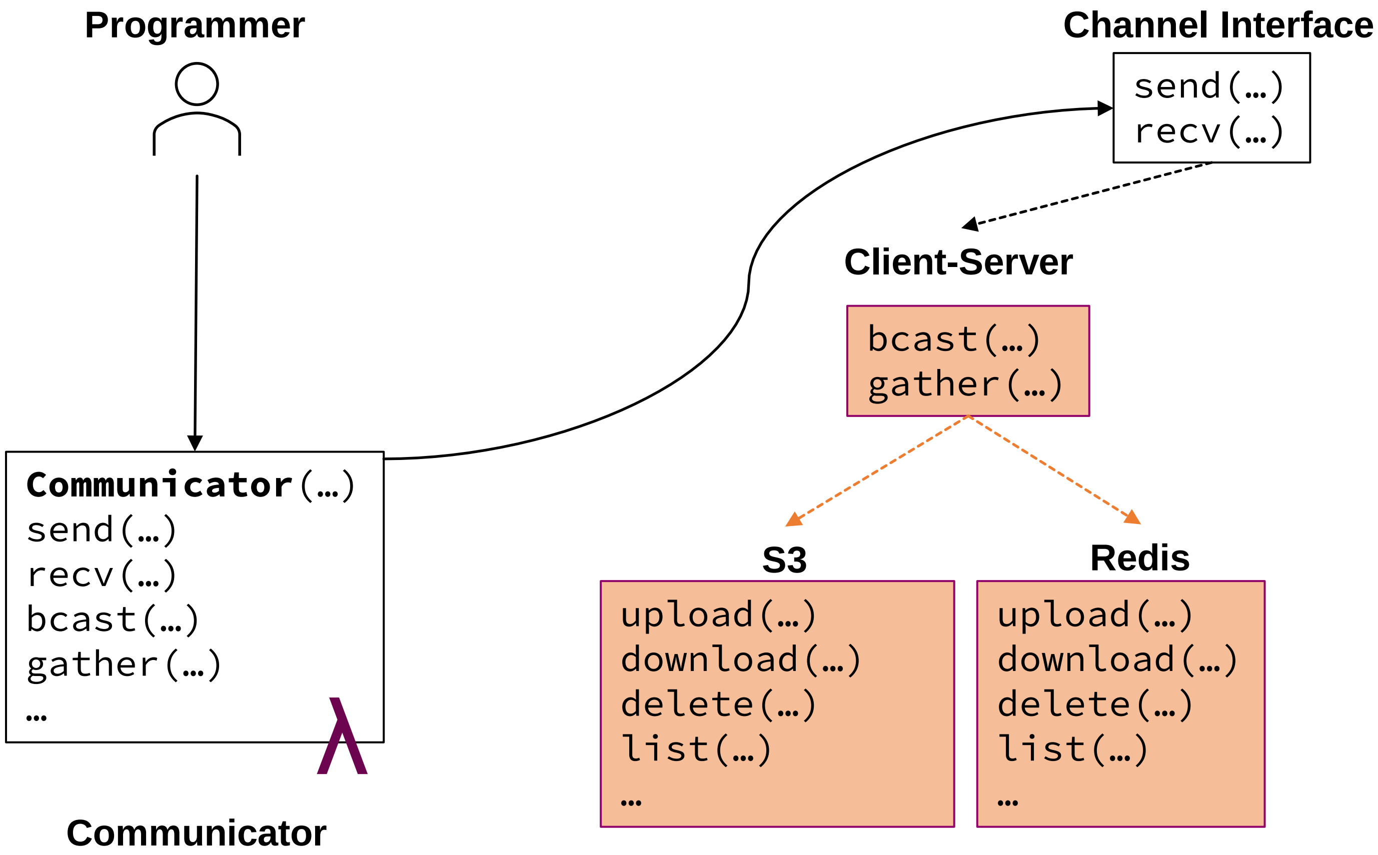

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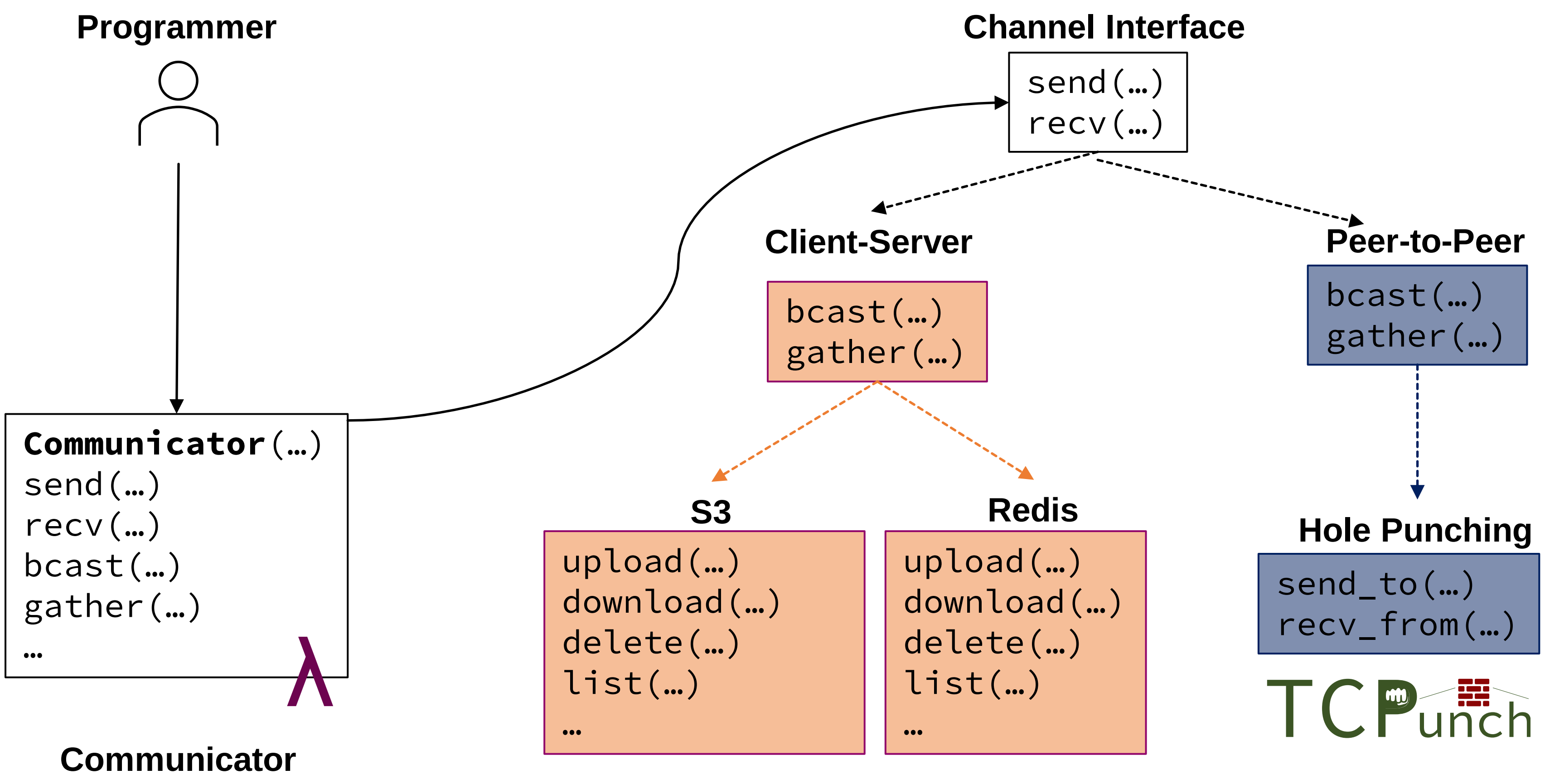

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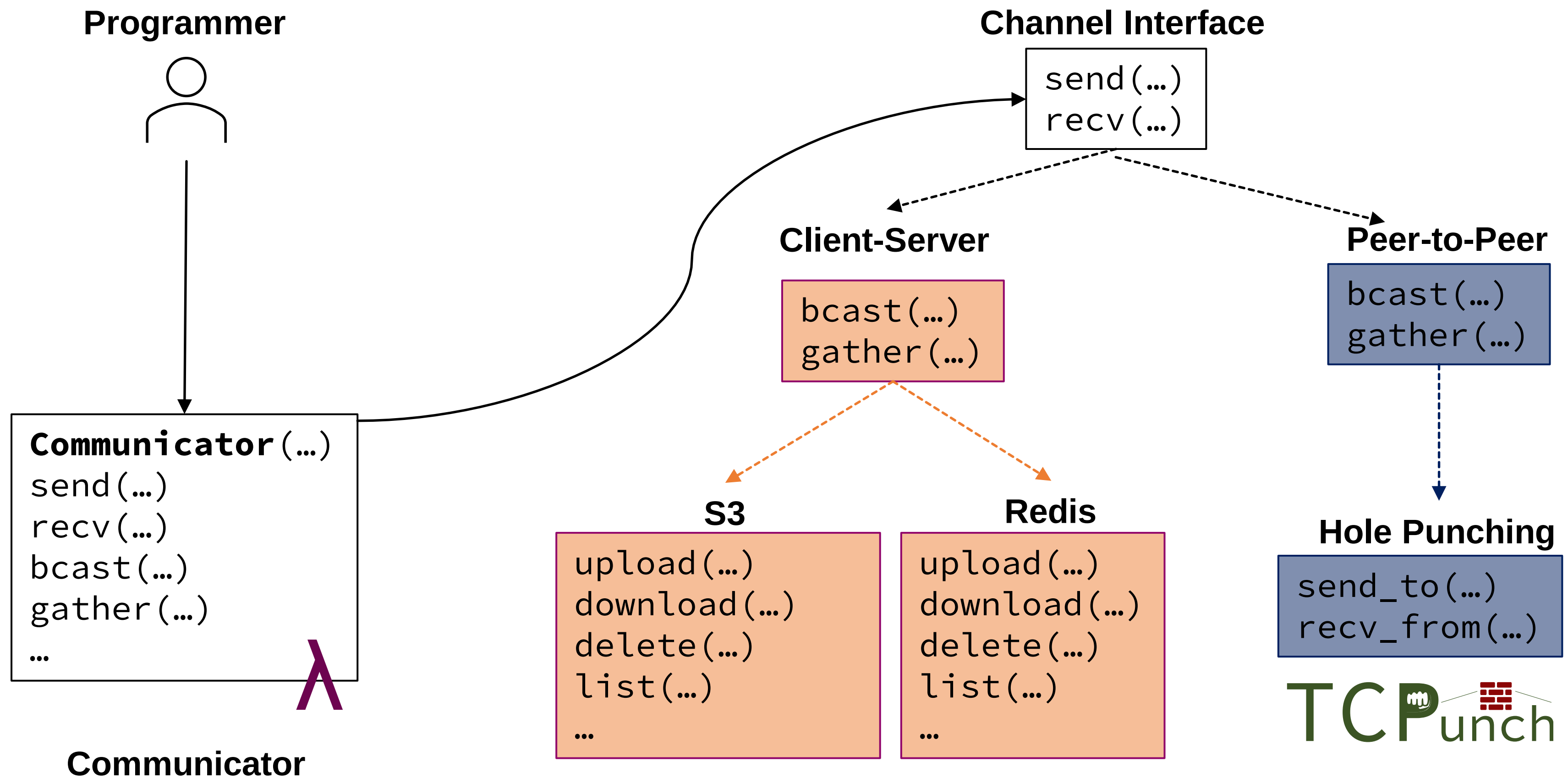


Serverless Cloud: communicate through **mediated** and **direct** channels.

HPC System: map FMI calls to an existing MPI library.

FMI in Python

```python
import fmi

comm = fmi.Communicator(
  peer_id=node_id,
  num_peers=num_nodes,
  config_path="config/fmi.json",
  comm_name="FMI_WORLD",
  faas_memory=function_memory
)
dtype = fmi.types(fmi.datatypes.int)

if my_id == 0:
    comm.bcast(42, 0, dtype)
else:
    assert comm.bcast(None, 0, dtype) == 42
```

FMI on AWS Lambda

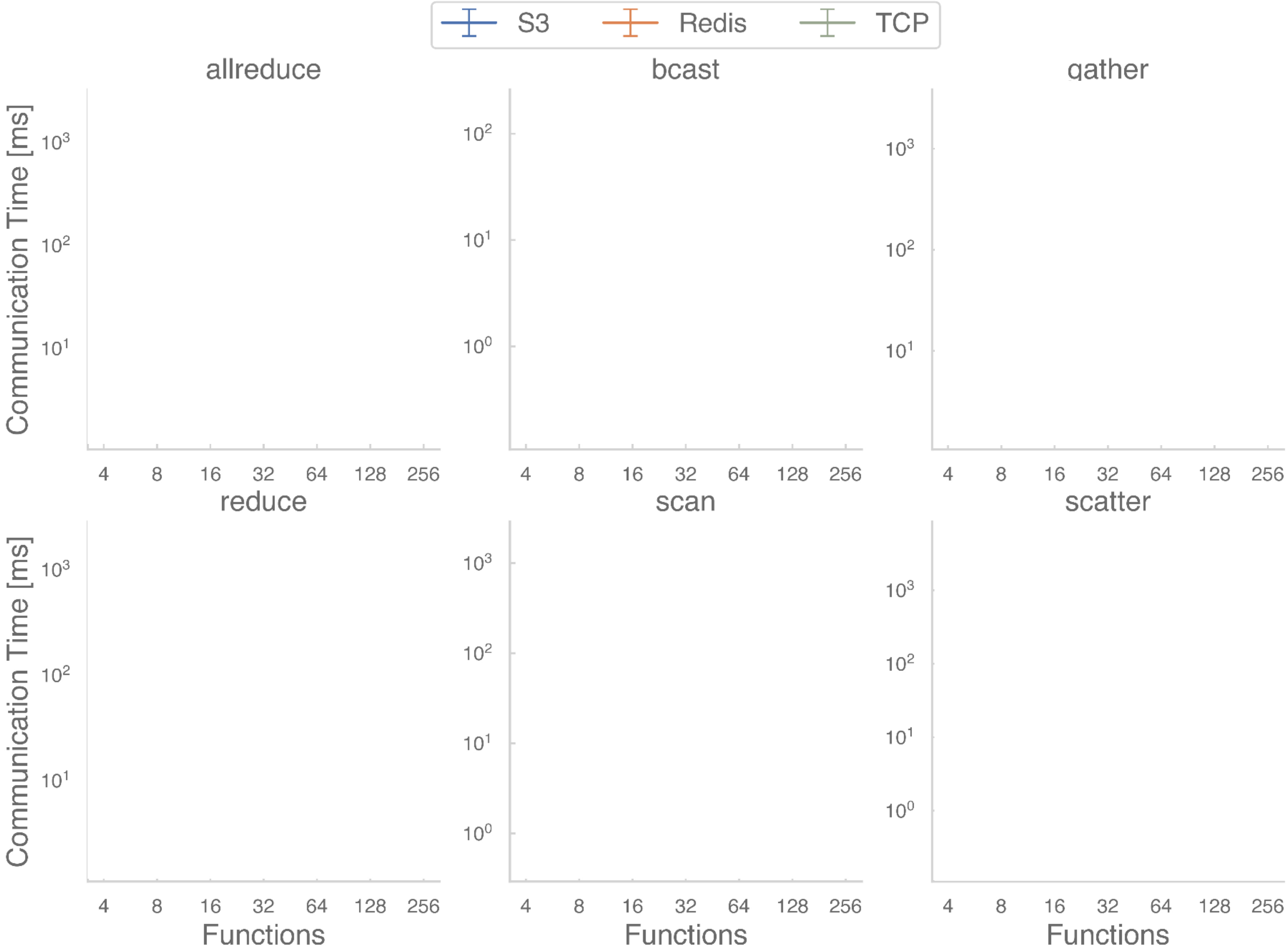
FMI Benchmark

- C++ functions, GCC 9.5
- AWS Lambda Functions with 2048 MB memory
- AWS ElastiCache Redis, cache.t3.small
- S3 with 20 ms polling interval

Collectives

- reduce and allreduce, adding one integer
- broadcast, 4 bytes
- scatter and gather, send 20,000 bytes
- scan, accumulating integers

FMI on AWS Lambda



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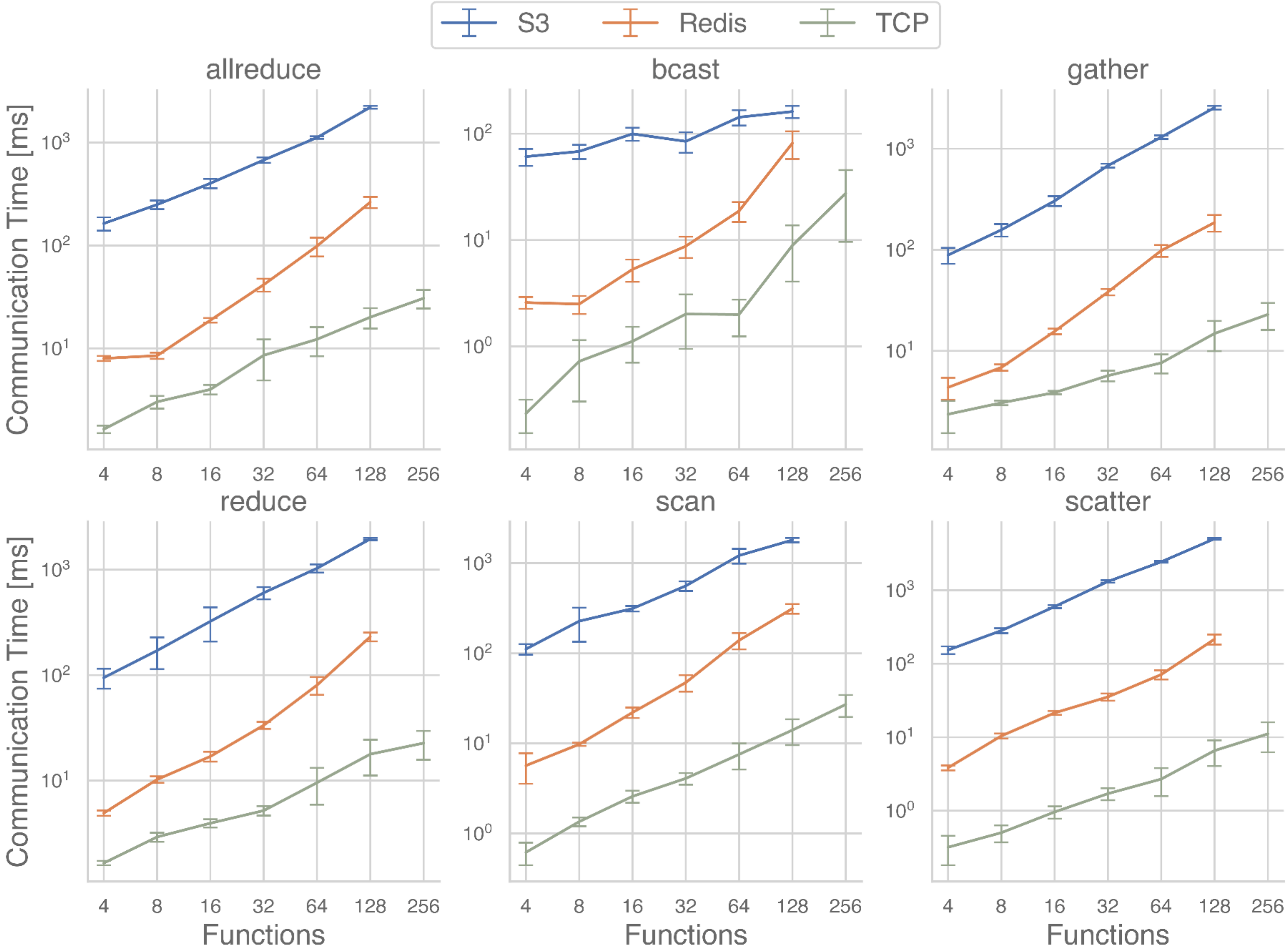

LambdaML

Towards Demystifying Serverless Machine Learning Training

Jiawei Jiang[*,†], Shaoduo Gan[*,†], Yue Liu[†], Fanlin Wang[†]
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SIGMOD, 2021

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SIGMOD, 2021

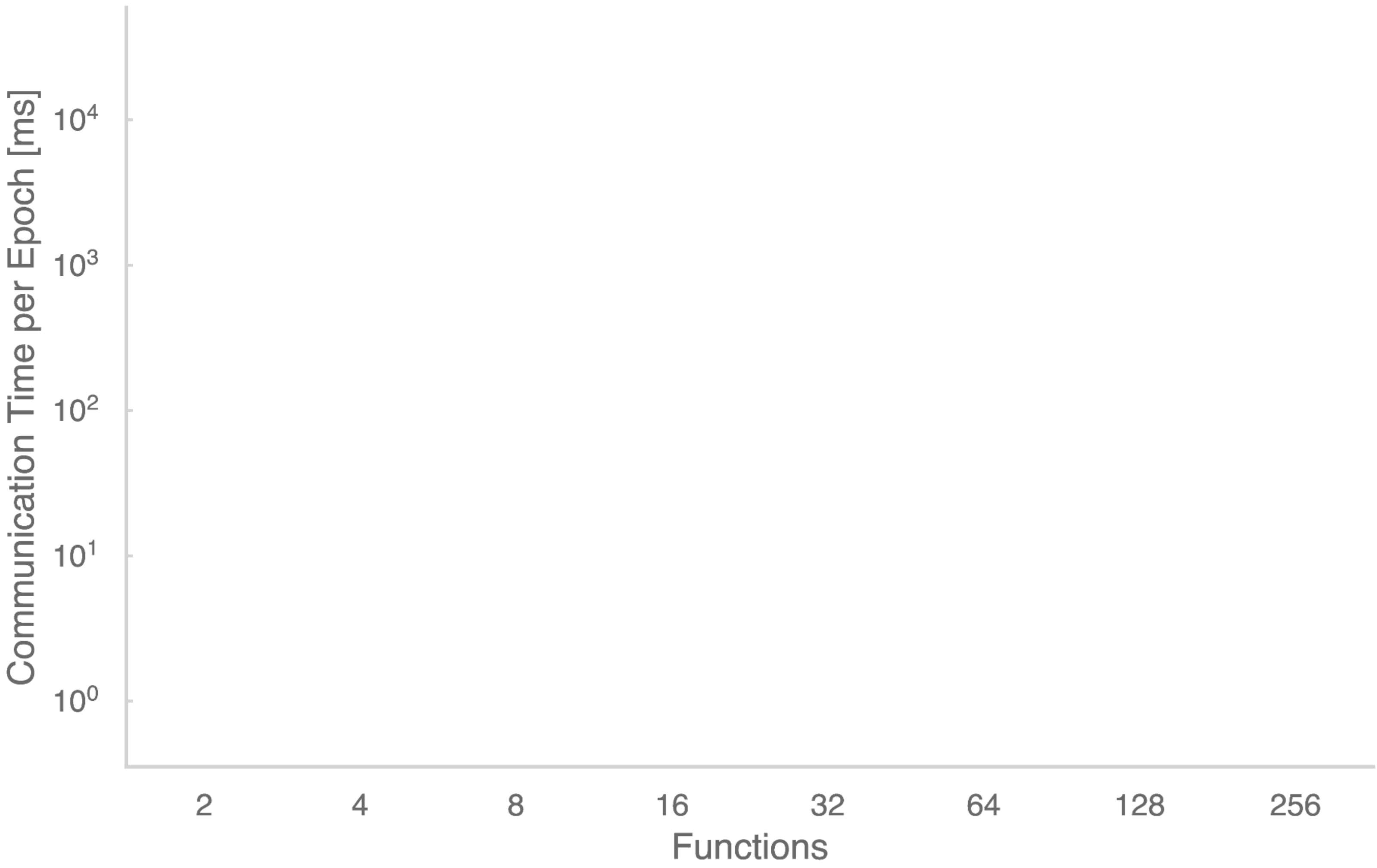
K-Means Benchmark

- HIGGS Dataset, 1 MB per function.
- 10 epochs.
- Lambda functions with 1024 MB memory.
- DynamoDB with autoscaling.

K-Means Benchmark with FMI

- Direct TCP communication.
- Replace reduce algorithm.

LambdaML Performance



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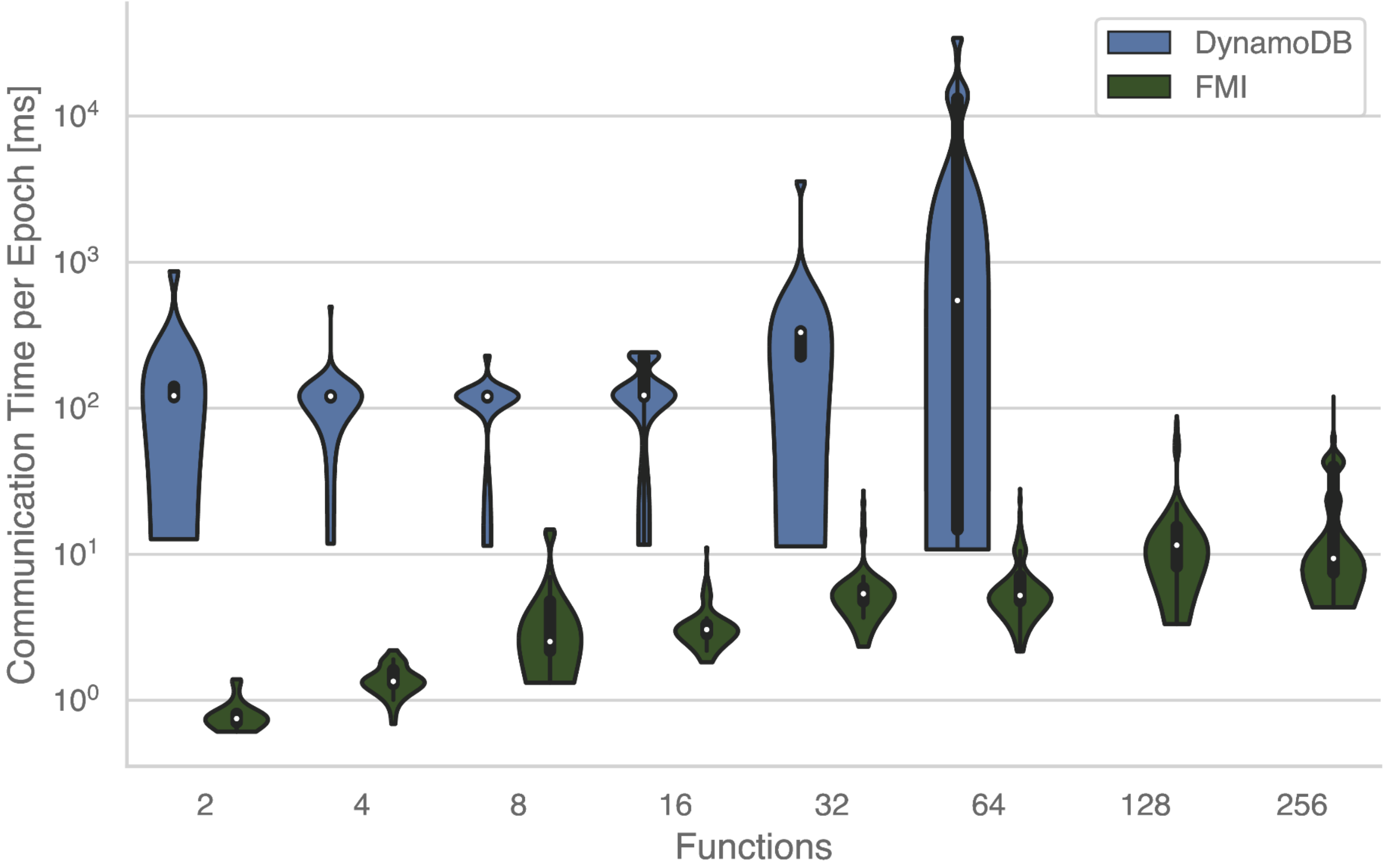

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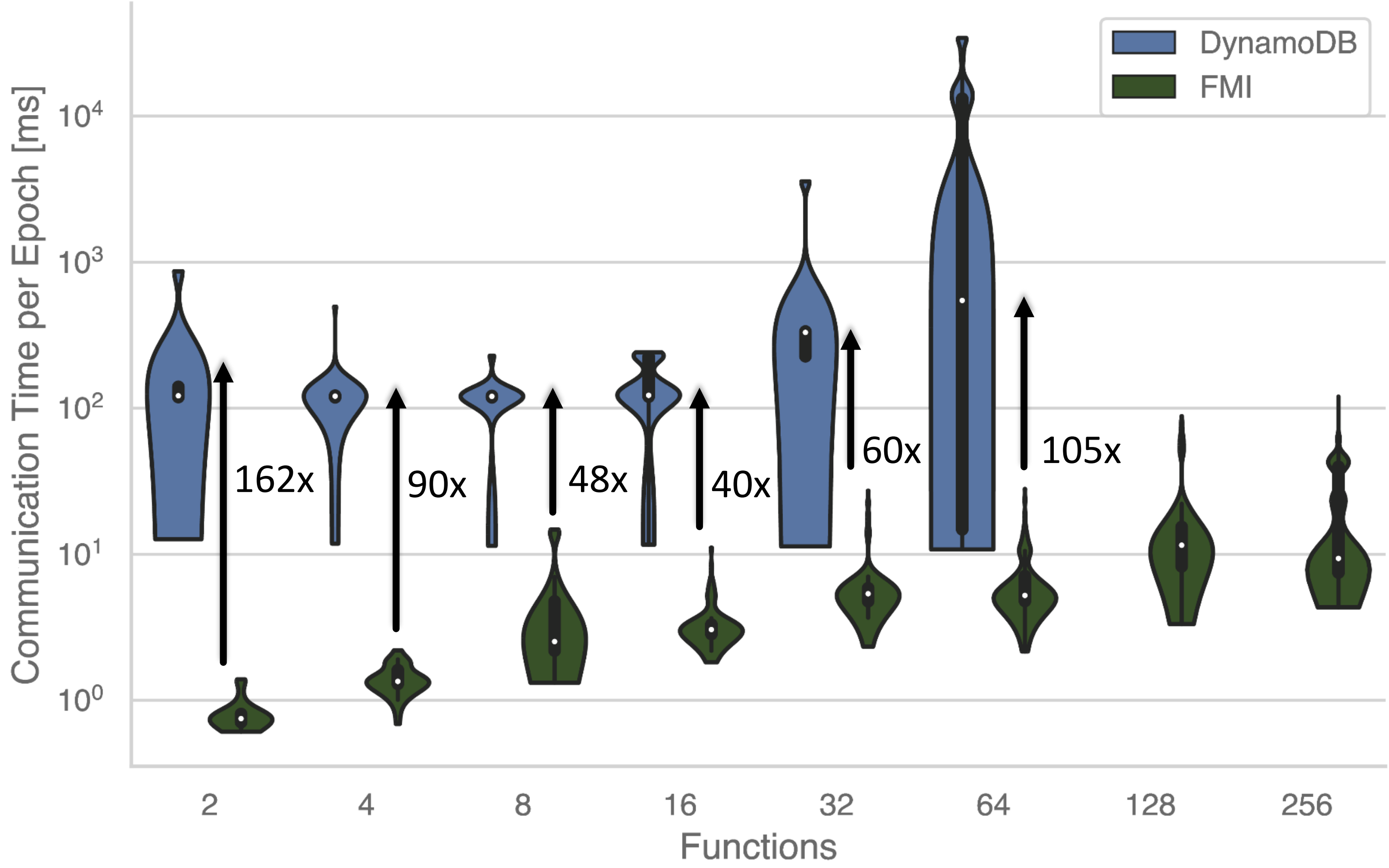

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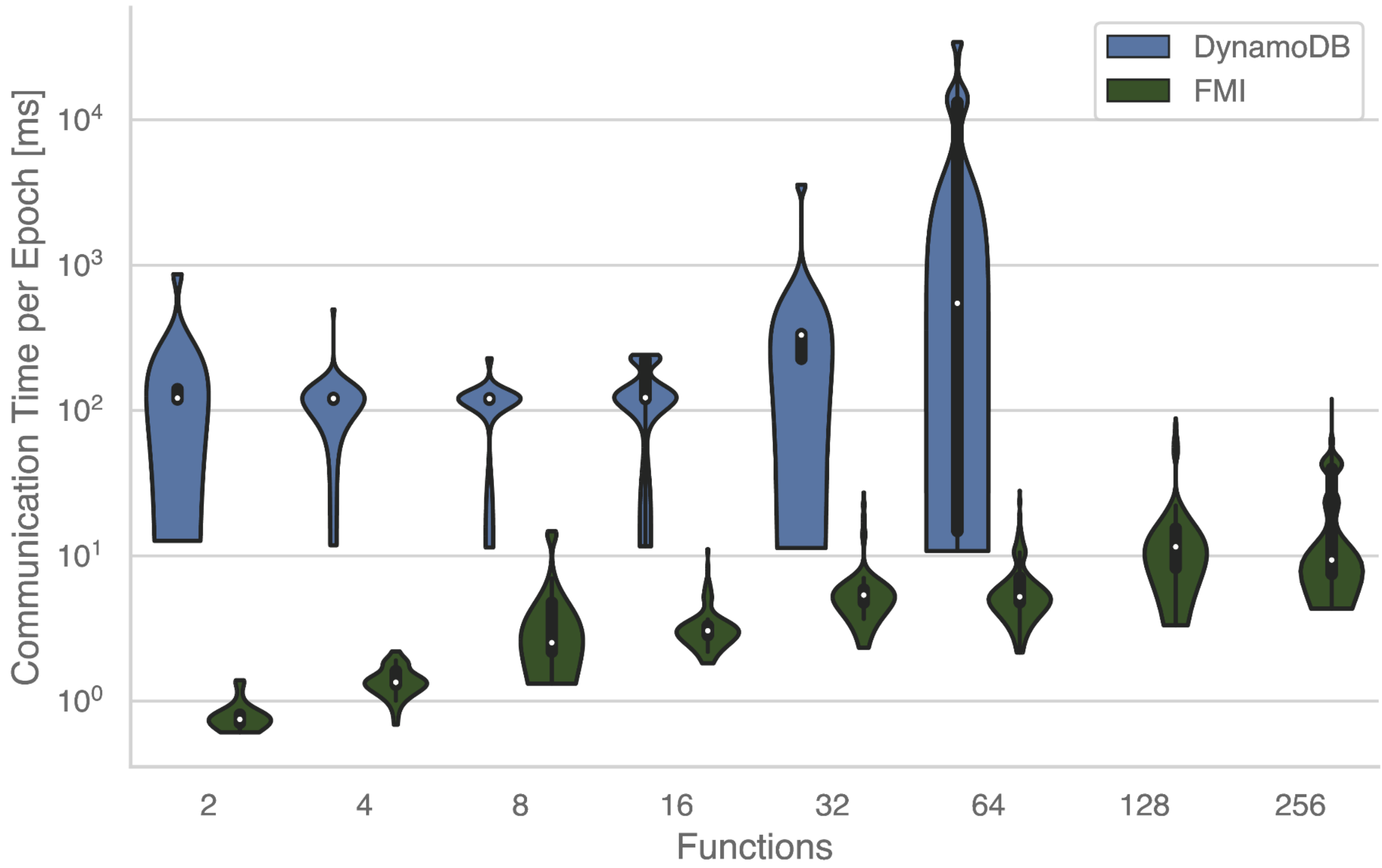

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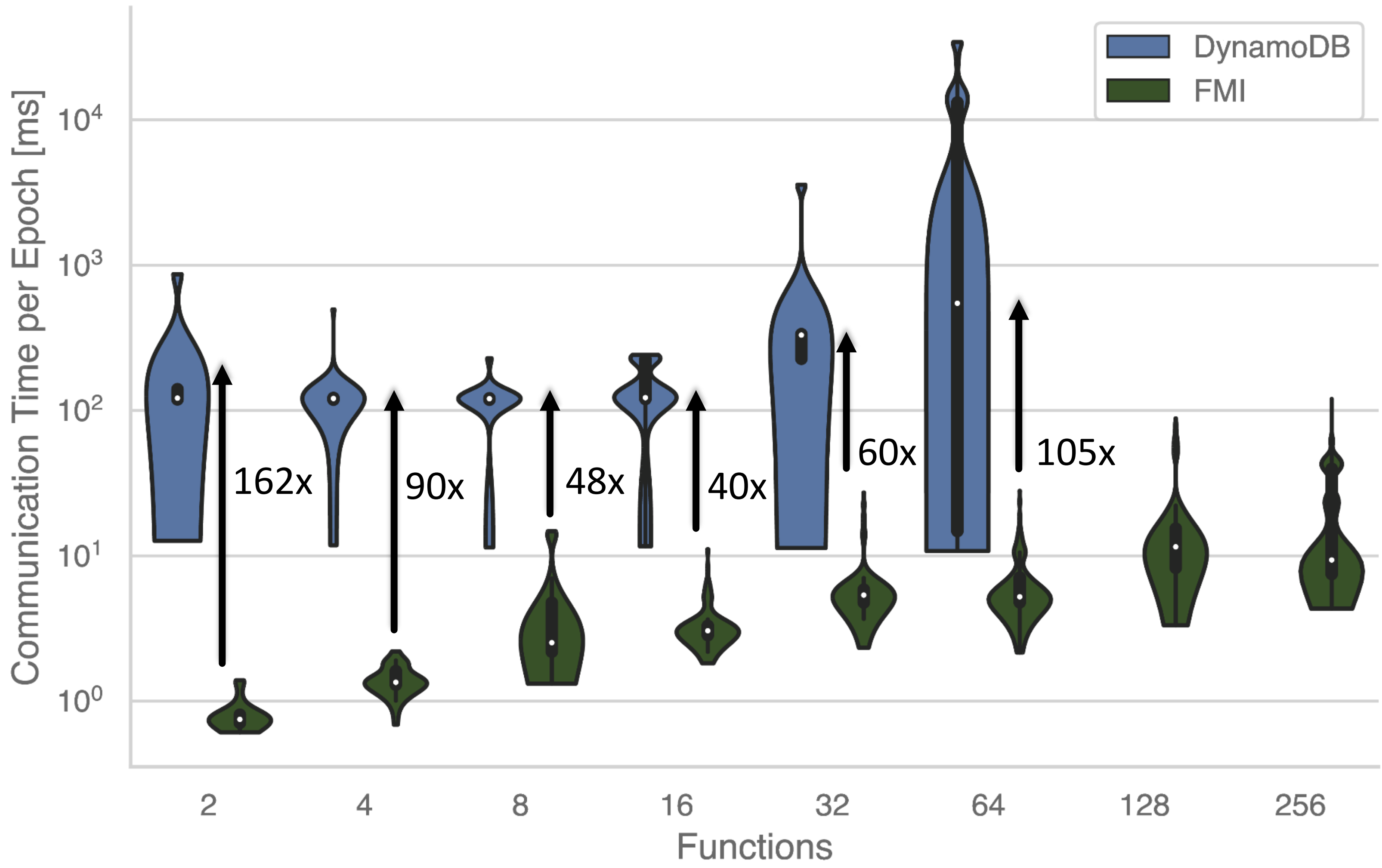
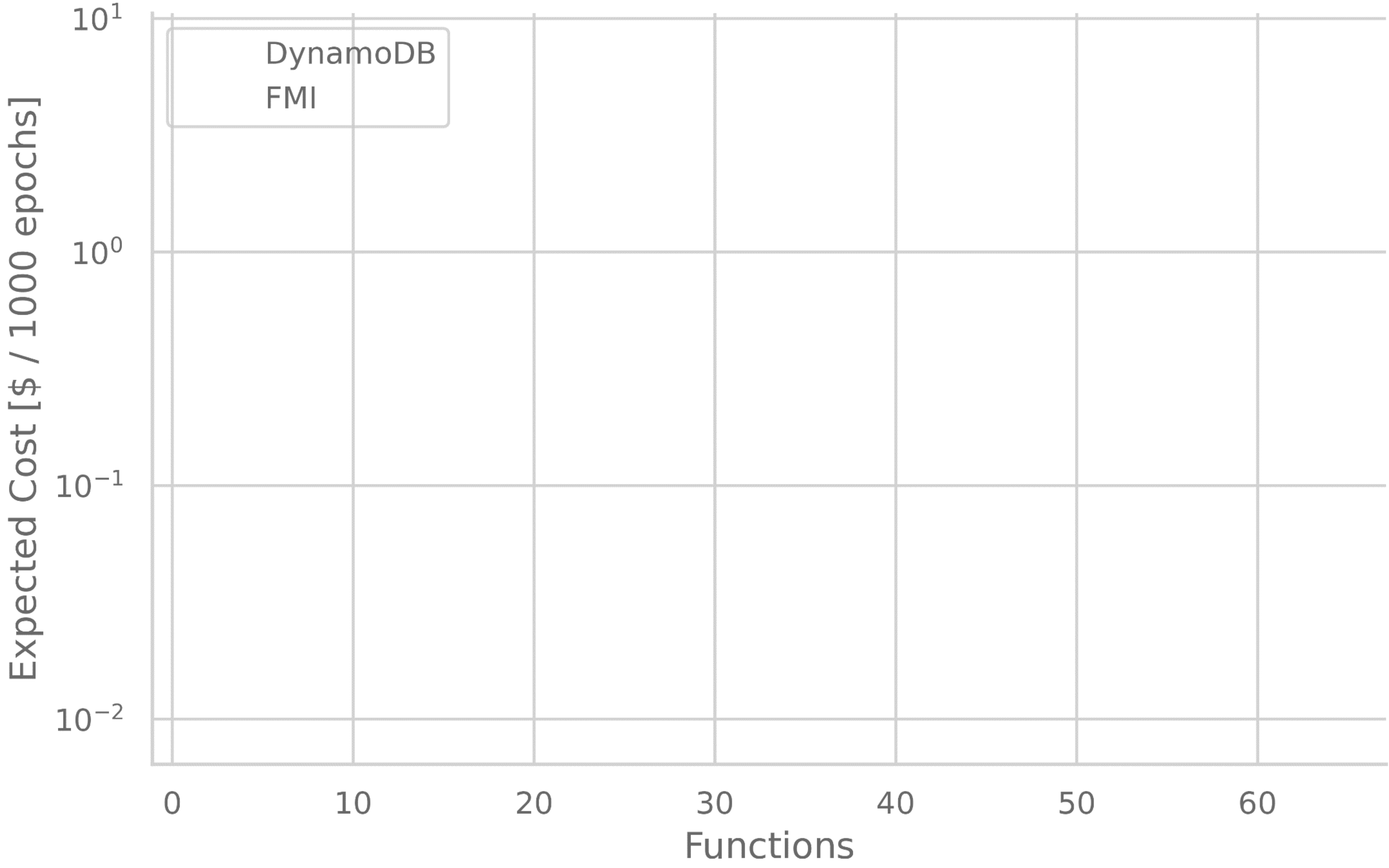


LambdaML Cost

DynamoDB Cost = (Compute Cost + Storage Cost) * Time
FMI TCP Cost = (Compute Cost + Hole Puncher Cost) * Time

LambdaML Cost



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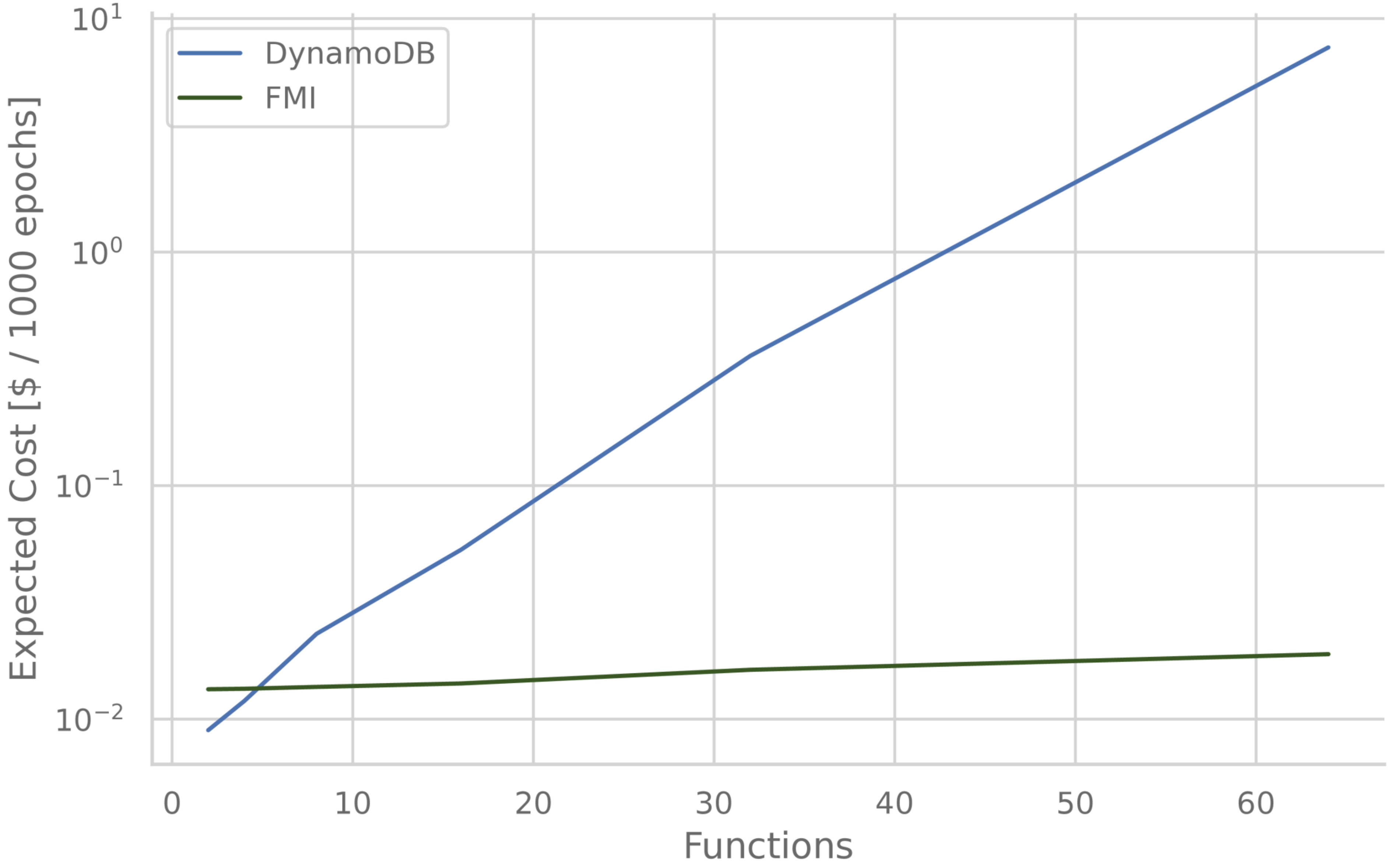

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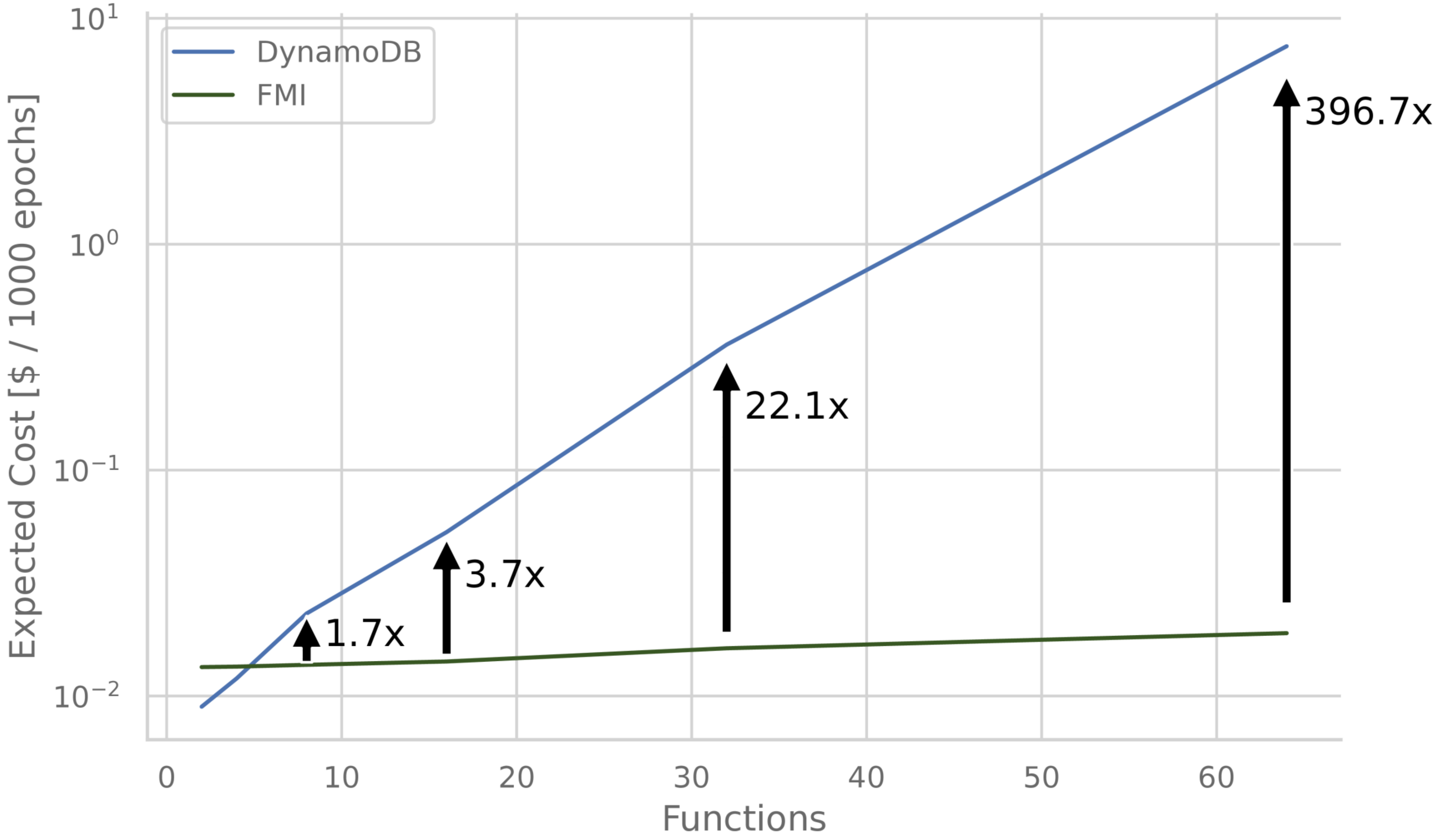


Serverless Solutions for HPC

Serverless Solutions for HPC

spcl/fmi

spcl/ TCPunch

Serverless Solutions for HPC

spcl/fmi

spcl/ TCPunch

spcl/serverless-benchmarks

spcl/rFaaS

spcl/PraaS

Conclusions

More of SPCL's research:

youtube.com/@spcl — 150+ Talks

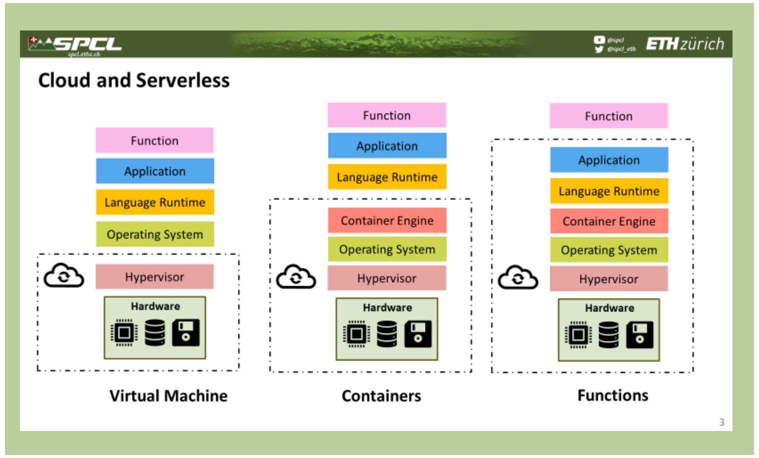
twitter.com/spcl_eth — 1.2K+ Followers

github.com/spcl — 2K+ Stars

… or spcl.ethz.ch

This work has received funding from the European Research Council (ERC) and from Amazon Web Services through the AWS Cloud Credits for Research program.

Conclusions



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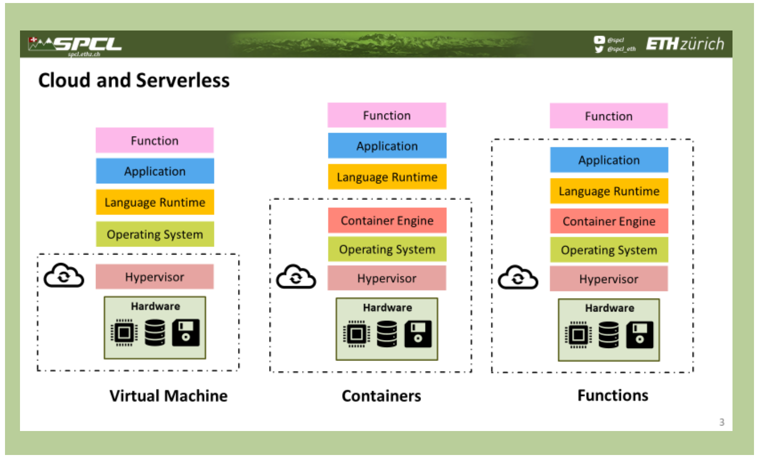

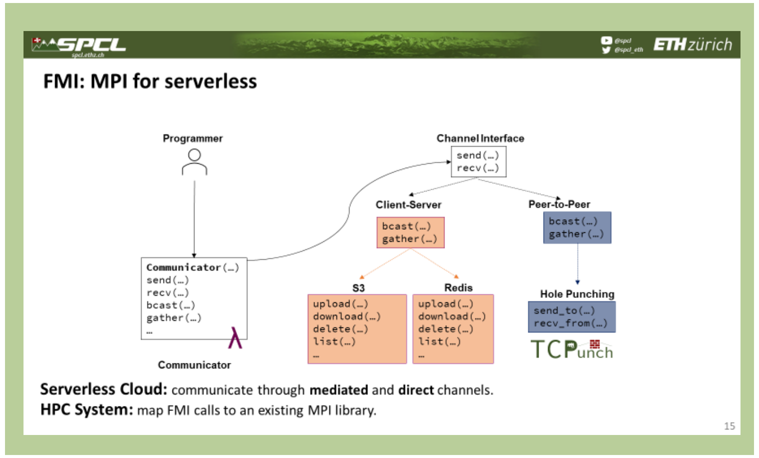

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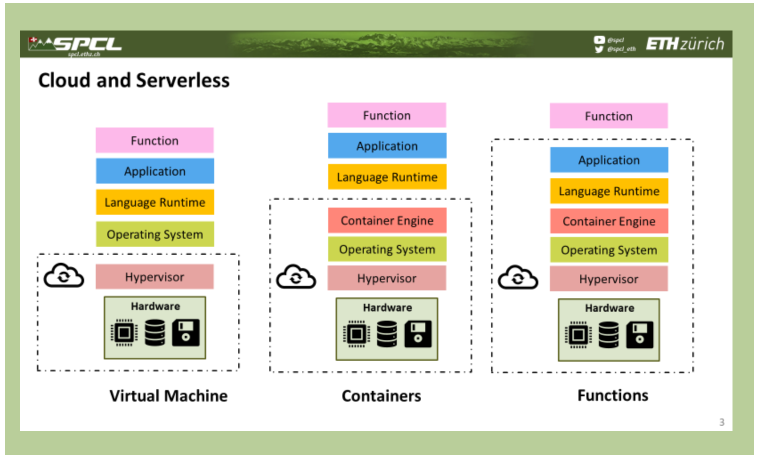

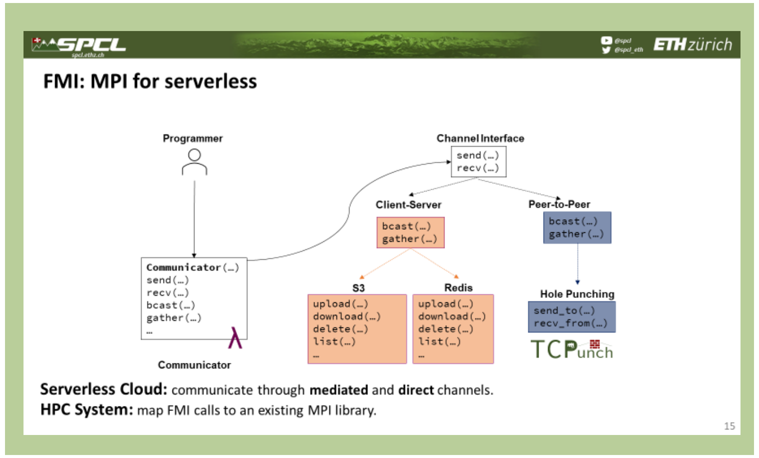

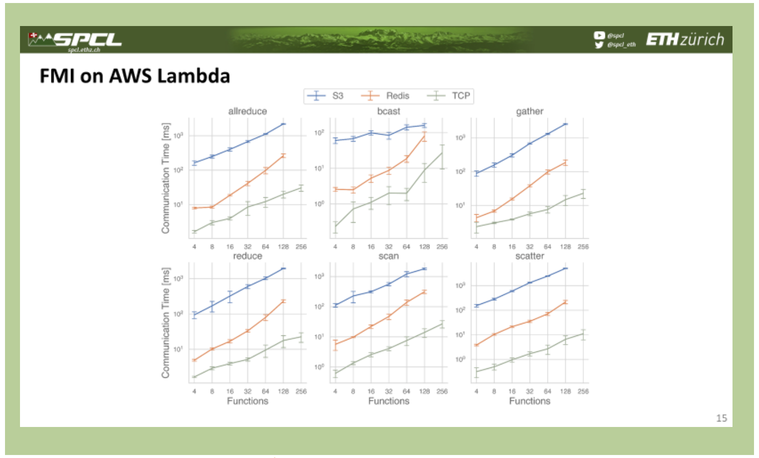

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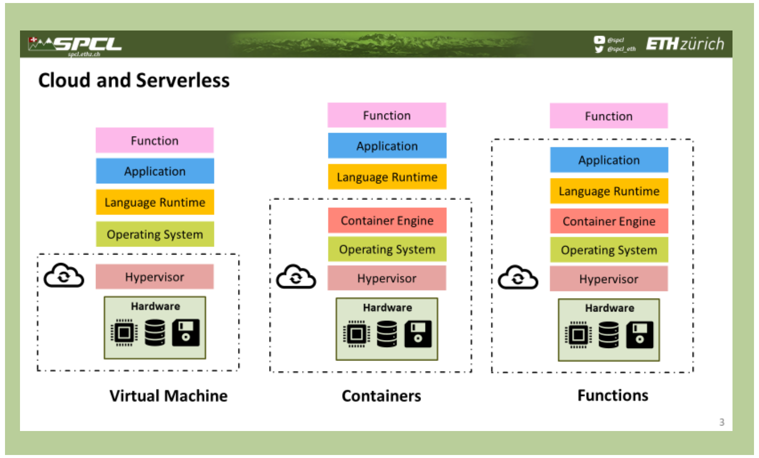

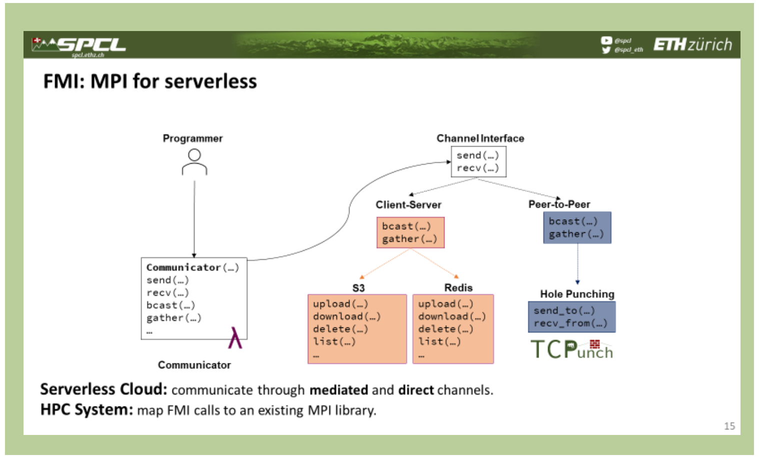

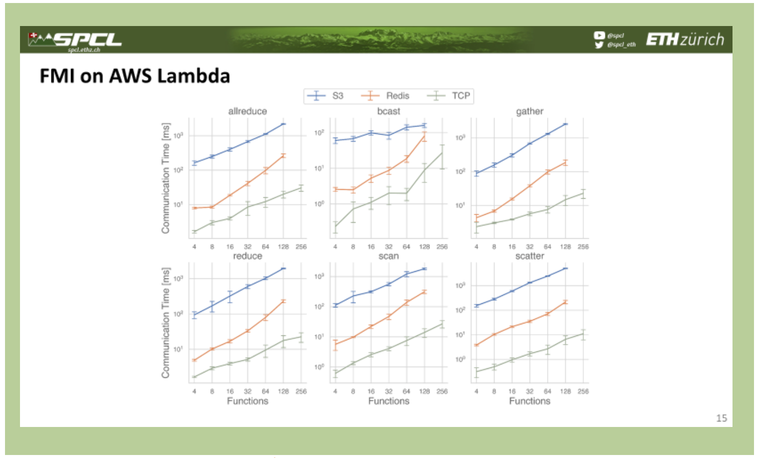

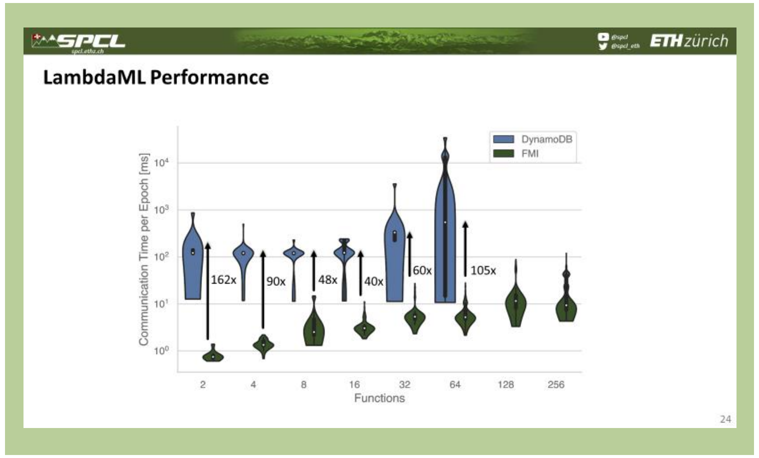

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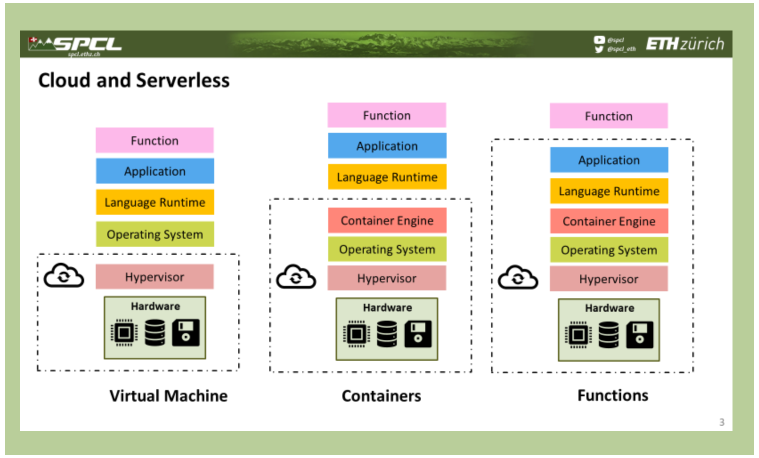

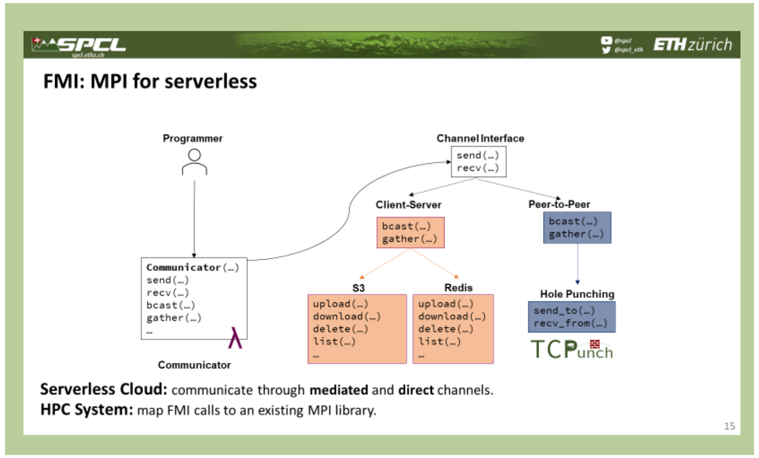

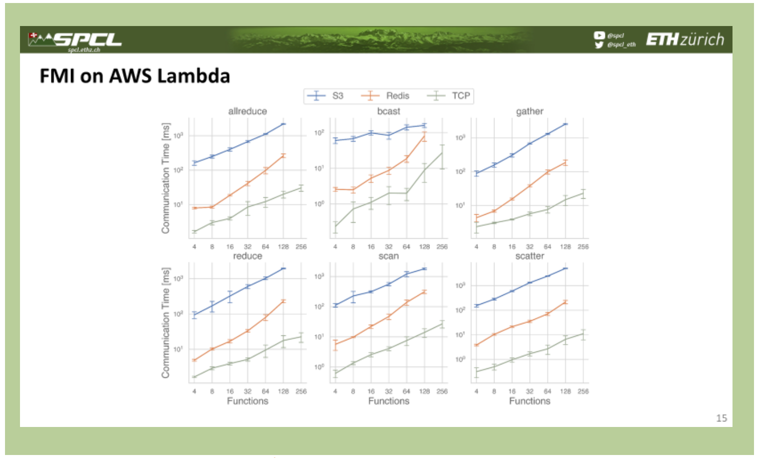

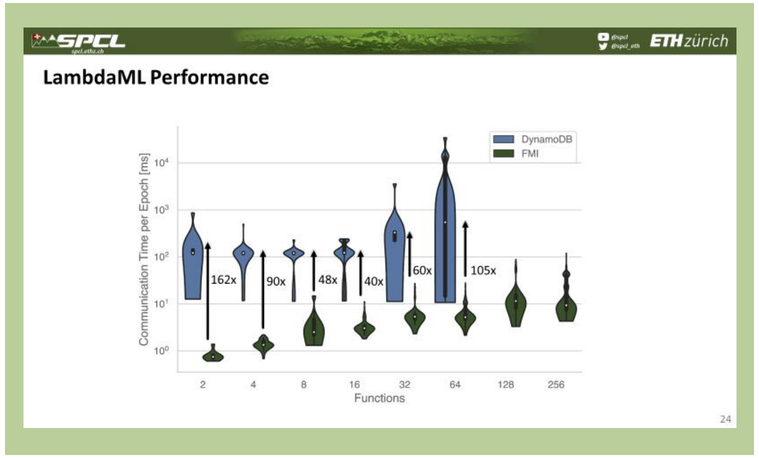

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Paper **Paper artifact**

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