NOKIA Bell Labs

SAND: Towards High-Performance Serverless Computing

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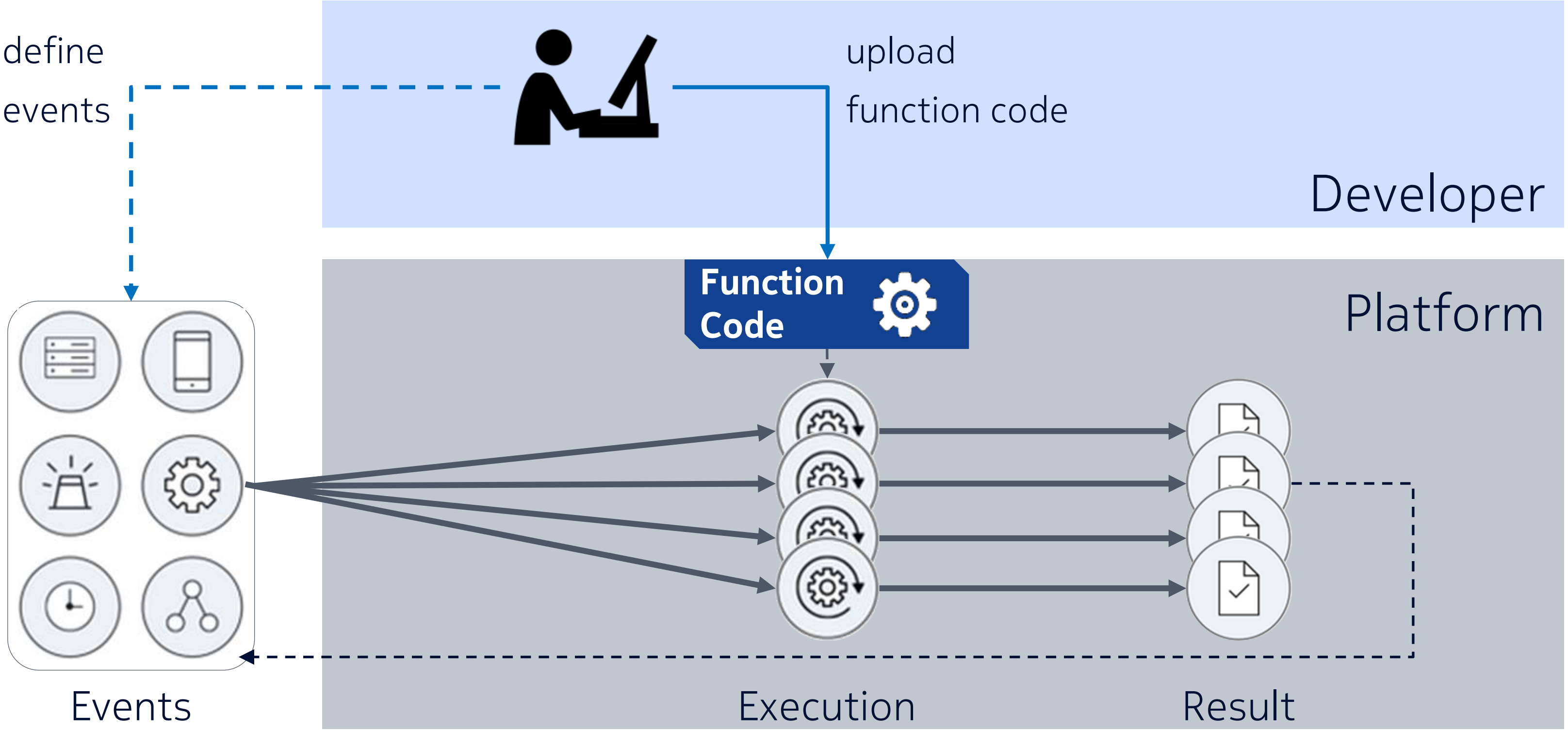
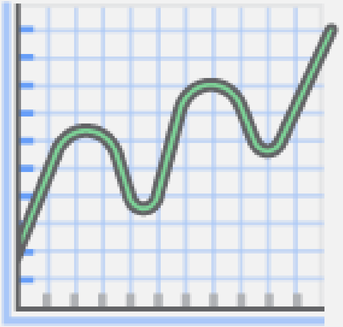
Serverless Computing -- Function-as-a-Service (FaaS)



The Promise of Serverless Computing for Developers

No server management

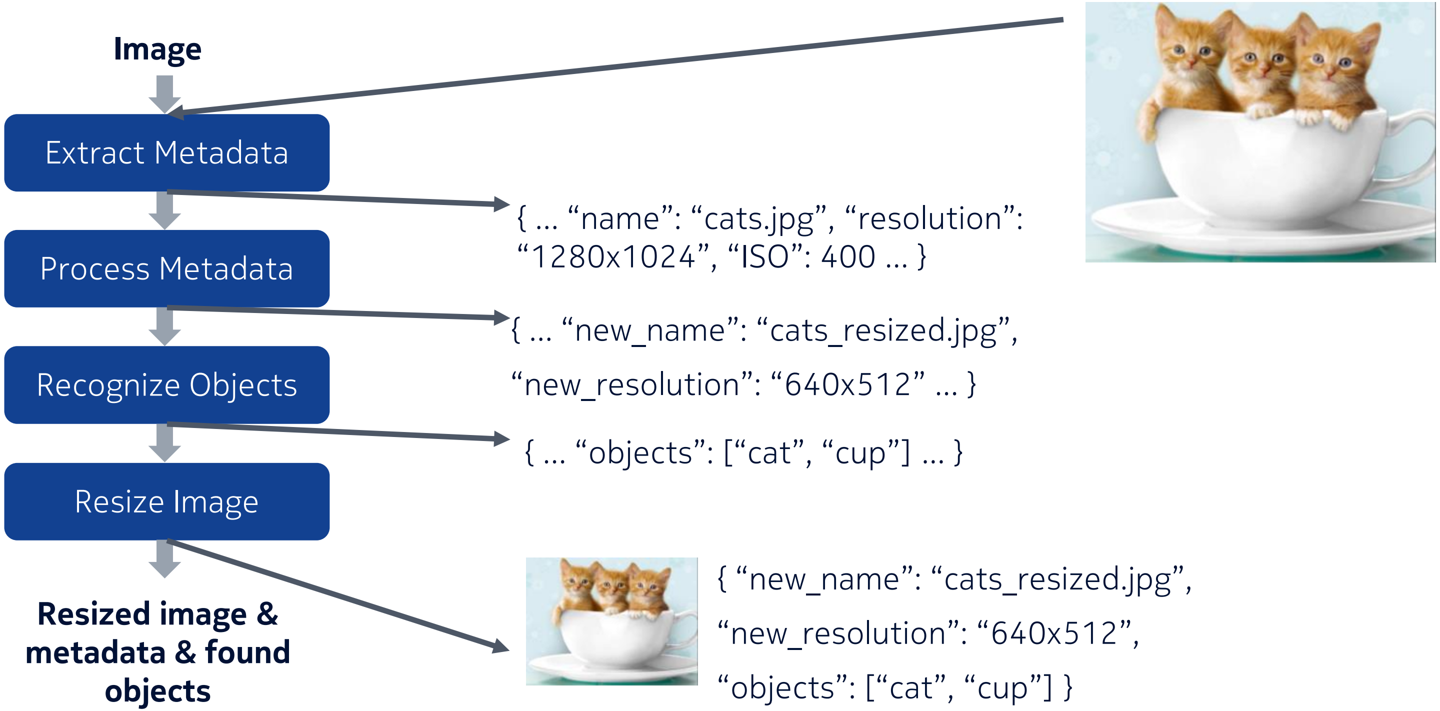


Continuous scaling

Increased productivity

Overheads of Existing Platforms

Running an image processing pipeline on AWS, IBM and OpenWhisk



{ … "name": "cats.jpg", "resolution": "1280x1024", "ISO": 400 … }

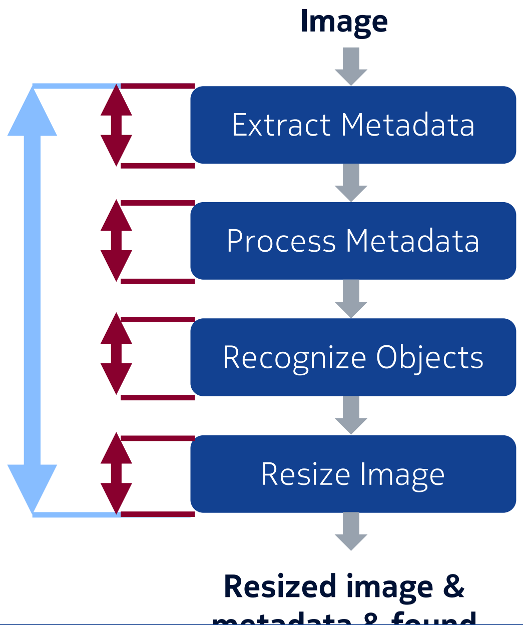
{ … "new_name": "cats_resized.jpg", "new_resolution": "640x512" … }

{ … "objects": ["cat", "cup"] … }

{ "new_name": "cats_resized.jpg", "new_resolution": "640x512", "objects": ["cat", "cup"] }

Overheads of Existing Platforms

Running an image processing pipeline on AWS, IBM and OpenWhisk



Image

Extract Metadata

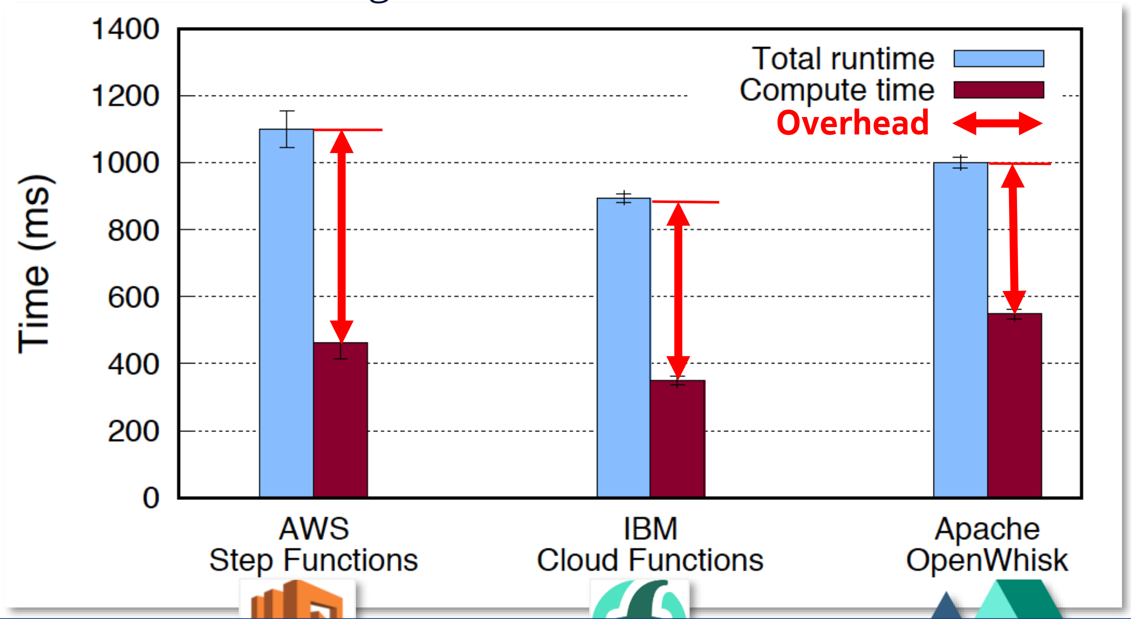
Process Metadata

Recognize Objects

Resize Image

Resized image &
metadata & found

Average of 10 runs with ‘warm’ starts



Overheads in existing solutions can limit the benefits of serverless computing.

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A high-performance serverless computing platform

Goals:

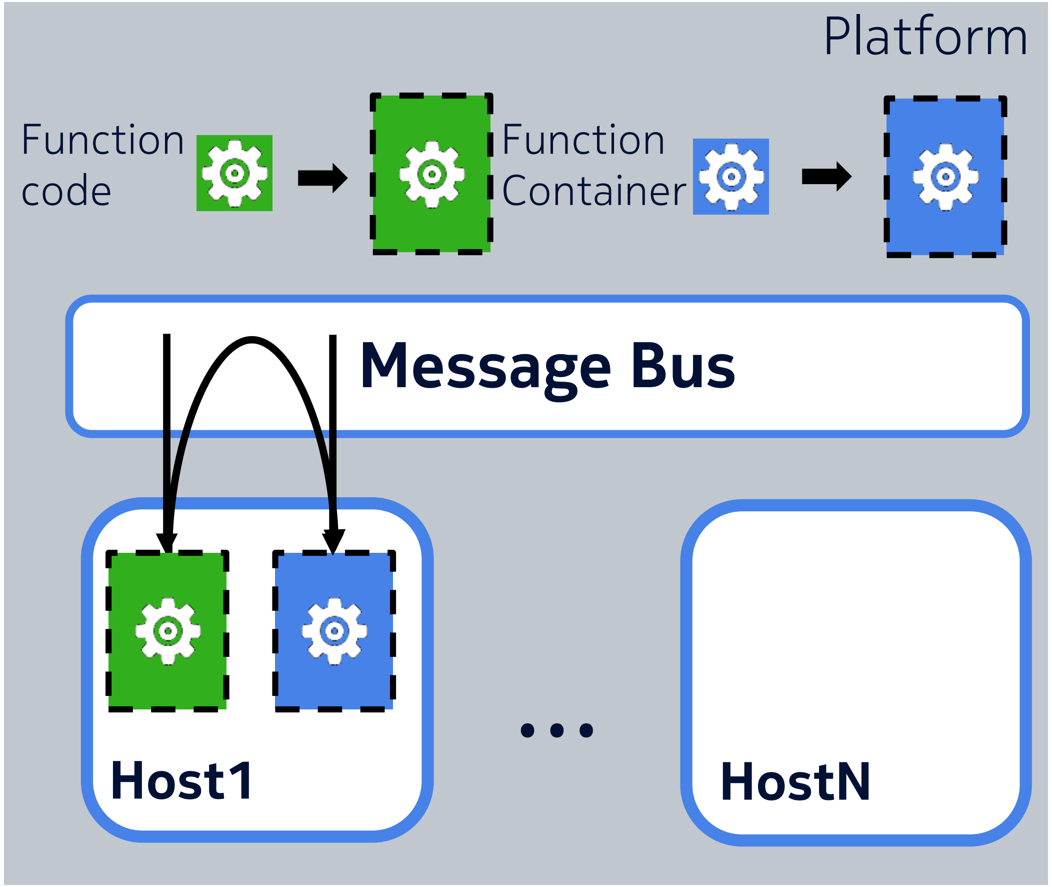
- Reduce latency for applications
- Utilize resources efficiently for platform operators

Outline

- Motivation & Goal
- Background
  - Overview of existing platforms & common practices
- SAND Key Ideas
- Evaluation

Overview of Existing Platforms

- Functions are isolated with containers
- Containers are deployed where resources are available
- Containers handle events and stay deployed until a timeout
- Functions interact via a distributed message bus



Implications of Common Practices

Function Container

Function execution & concurrency:

1. Start a new container for every function execution (i.e., cold start)

→ long invocation latency

2. Keep and reuse idle containers (i.e., warm start)
3. Concurrency: cold starts or queuing

→ resource inefficiency

Function interaction:

- Go through the distributed message bus

→ long function interaction latency

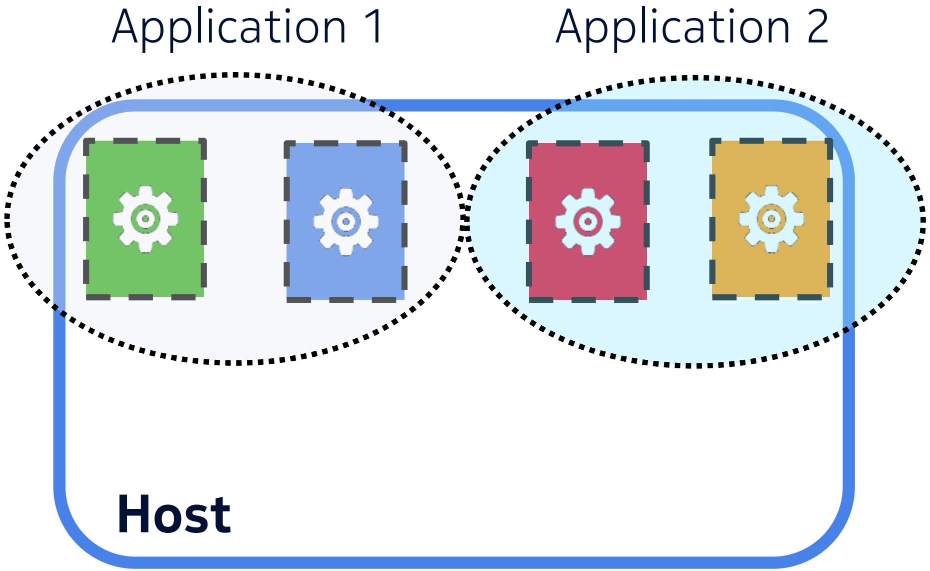
Outline

- Motivation & Goal
- Background
- SAND Key Ideas
  - Application-level sandboxing
  - Hierarchical message queuing
- Evaluation

SAND Application-level Sandboxing

Insight: Different concepts should have different fault isolation

- Stronger isolation between applications
- Weaker isolation between functions of the same application

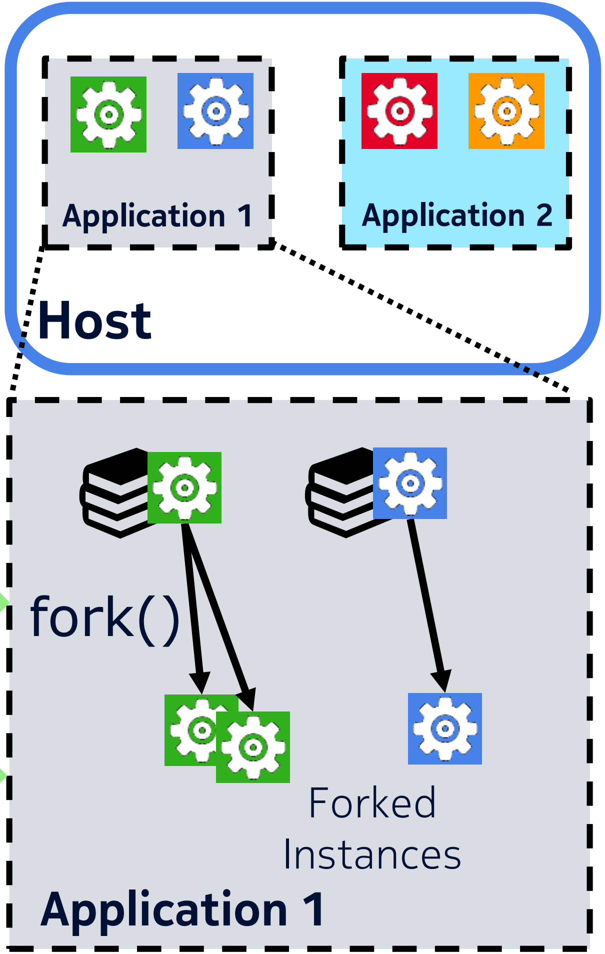


SAND Application-level Sandboxing Operation

1) Put applications in separate containers
2) Run functions as separate processes in the same container
3) Fork new processes to handle new events

Advantages:

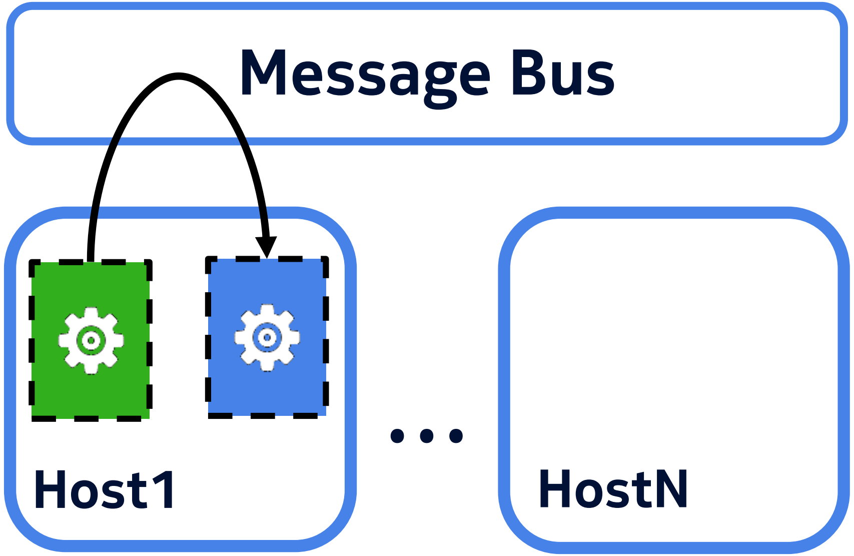
1) Fast creation of function executions
2) Low execution footprint
3) Automatic de-allocation of resources



SAND Hierarchical Message Queuing

Insight: Exploit locality of the functions

- Shortcuts for interacting functions of an application

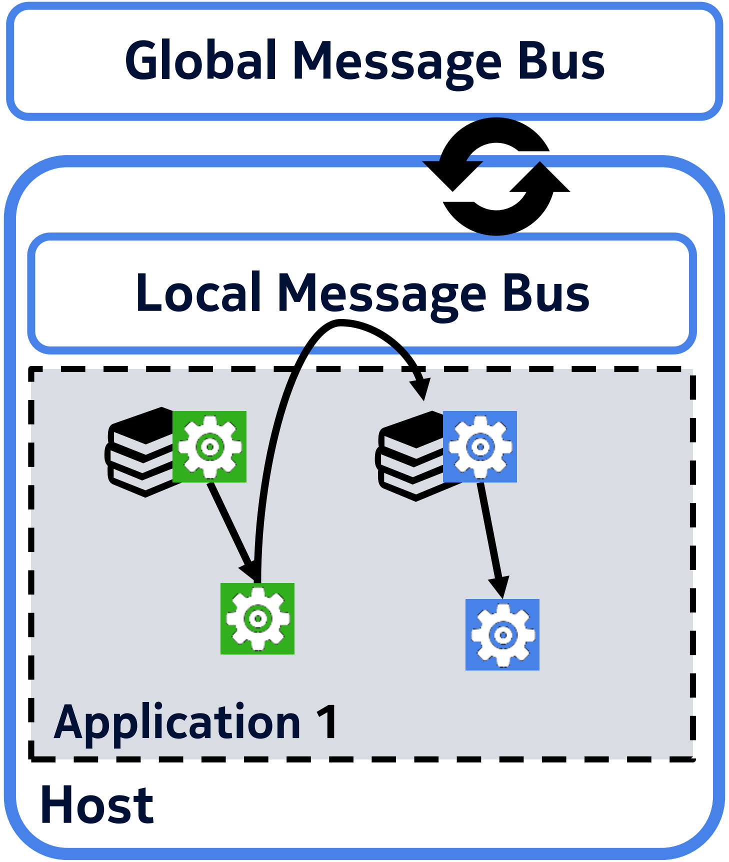


SAND Hierarchical Message Queuing Operation

1) Run a local message bus on each host
2) Functions interact with other functions via the local message bus
3) Coordinate local bus with the global bus

Advantages:

1) Low function interaction latency
2) Fault tolerance & parallelism if needed



Addressing Overheads in SAND

Application-level Sandboxing

- Fast startup
- Low execution footprint
- Automatic de-allocation

Hierarchical Message Queuing

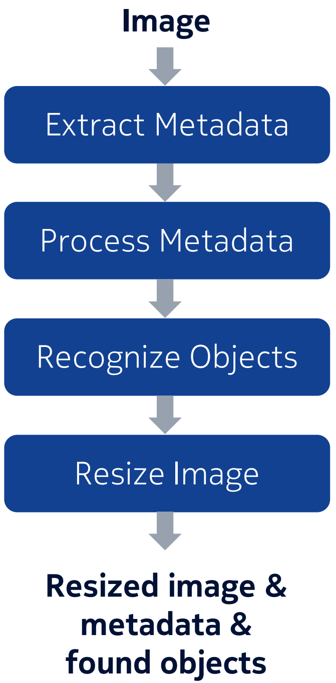
- Shortcuts for interacting functions

Outline

- Motivation & Goal
- Background
- SAND Key Ideas
- Evaluation
  - Revisiting the image processing application
  - Local message bus and function interaction latencies
  - Trade-off between idle memory cost and latency

SAND Overhead Comparison

Image processing pipeline



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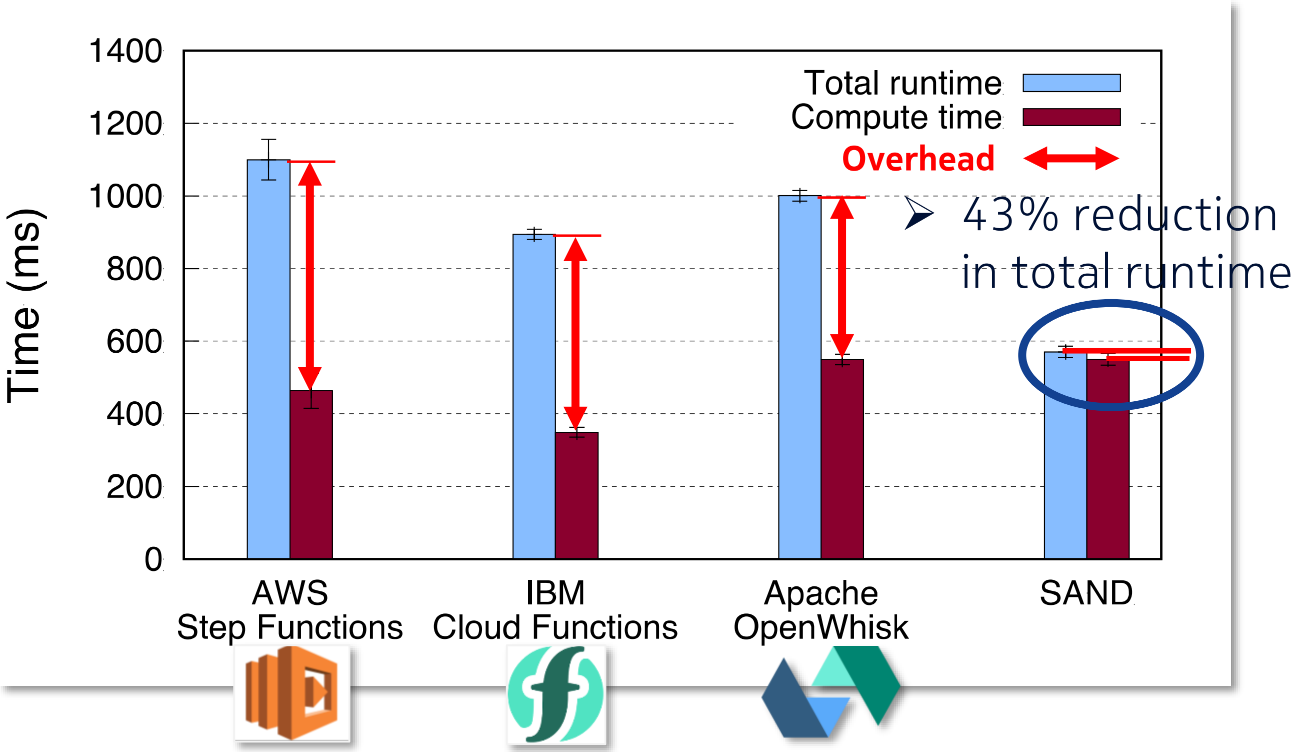
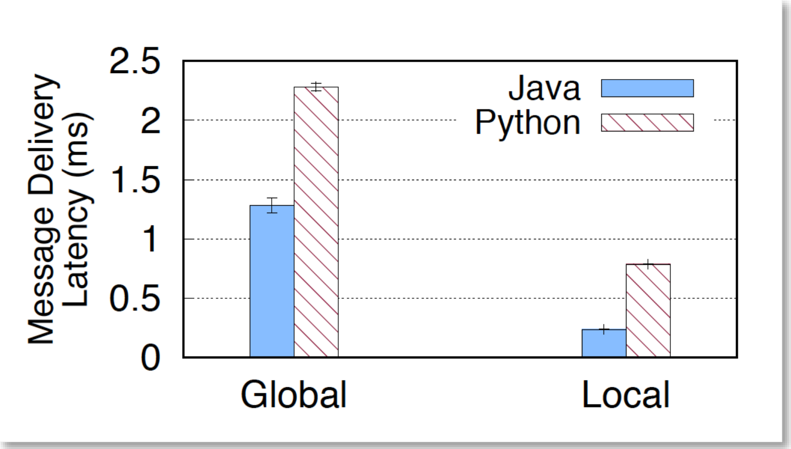
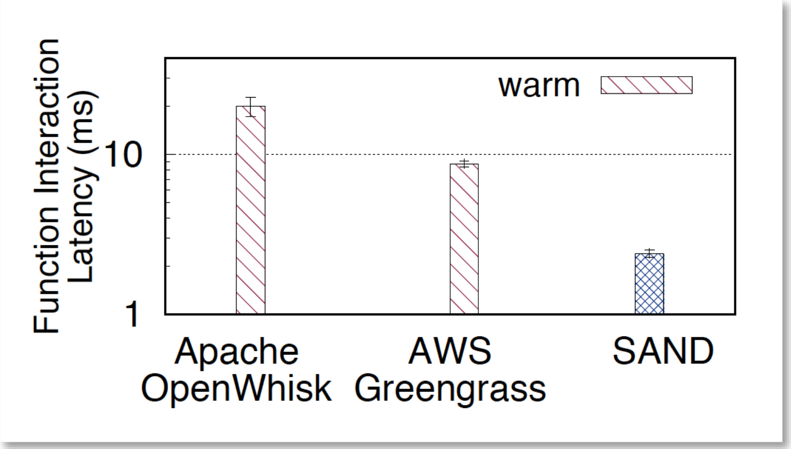


- 43% reduction in total runtime

SAND Microbenchmarks

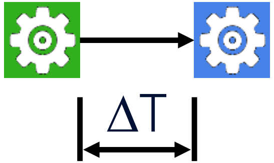
Message Bus Access & Function Interaction Latencies





- Access to local bus is 3-5x faster than global bus

- 8.3x as fast as OpenWhisk
- 3.6x as fast as Greengrass



Idle Memory Cost vs. Latency

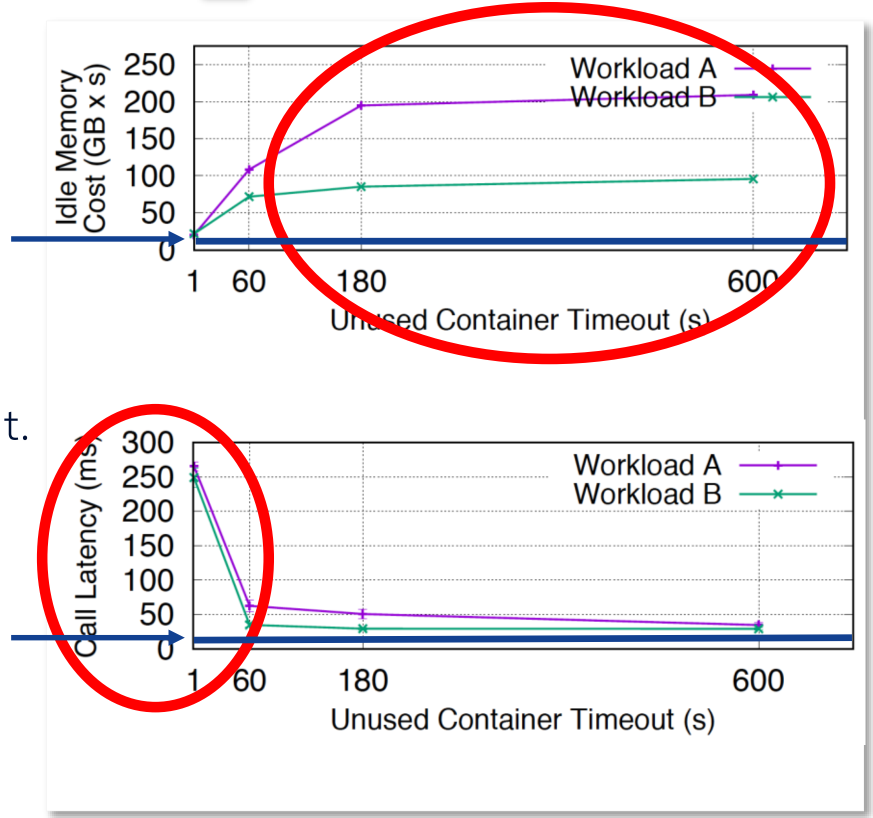
Exploring container timeout with OpenWhisk

Longer timeouts lead to high idle memory cost

Setup:

- 5 synthetic workloads
- Different burst parameters
- Call a single function

Idle memory cost: product of assigned but unused memory and the duration of assignment.



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With 1 sec timeout, 18 - 33% of calls have cold starts

3.3x to 2 orders of magnitude reduced idle memory cost with no sacrifice in latency

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High-performance serverless computing platform

✓ Fast function invocation

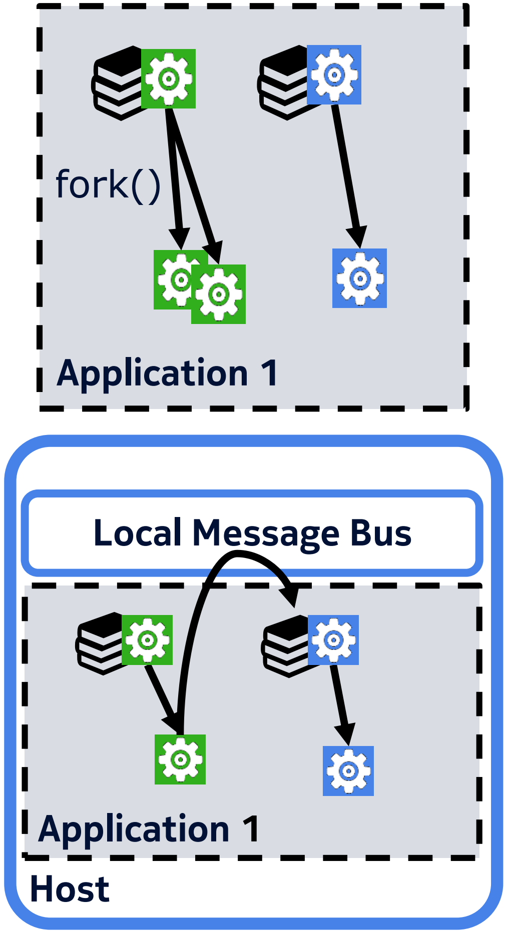
✓ Increased resource efficiency

✓ Short function interaction latencies

➢ Application-level sandboxing

➢ Hierarchical message queuing

Invite-only beta coming soon!



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