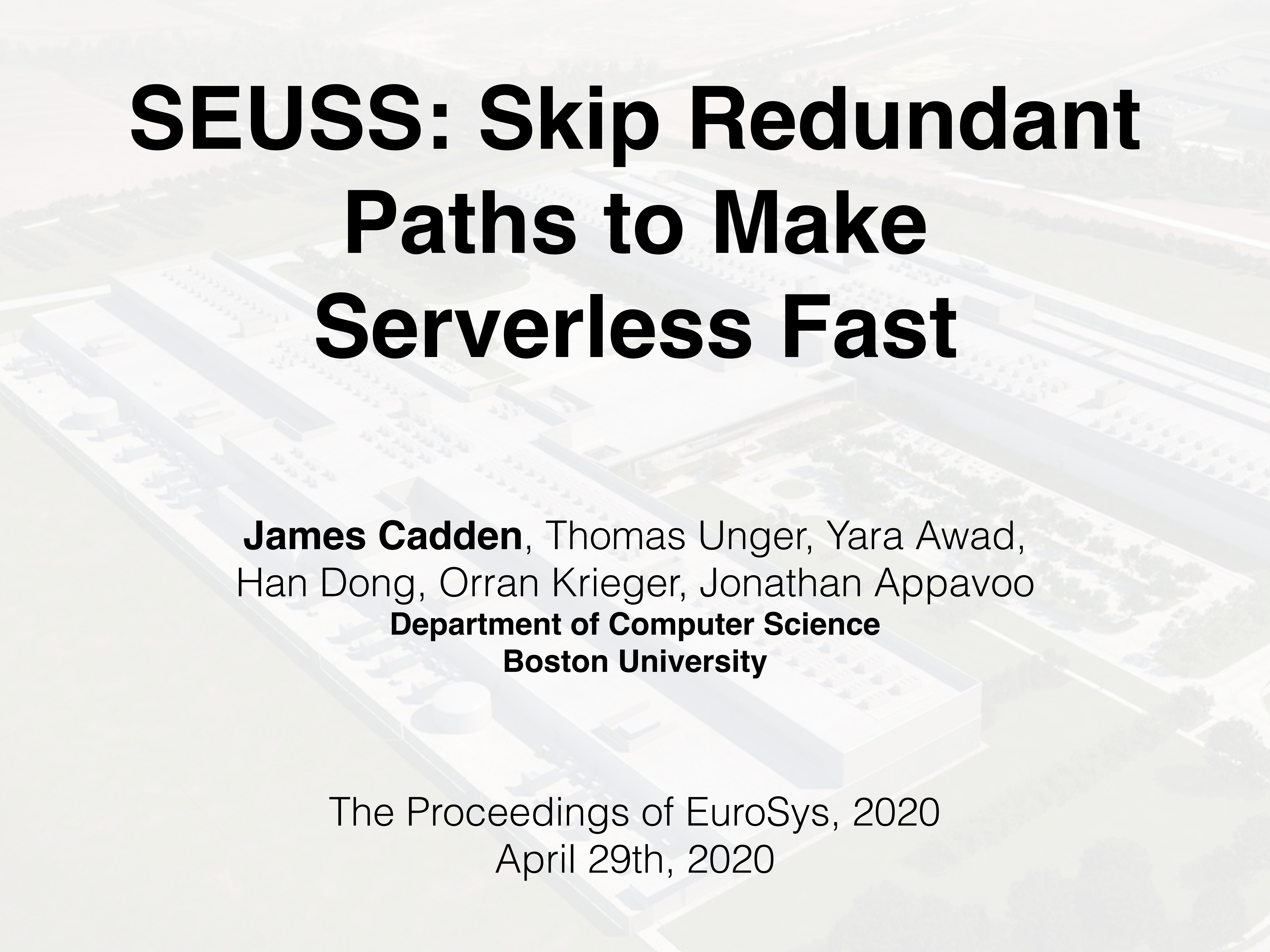

SEUSS: Skip Redundant Paths to Make Serverless Fast

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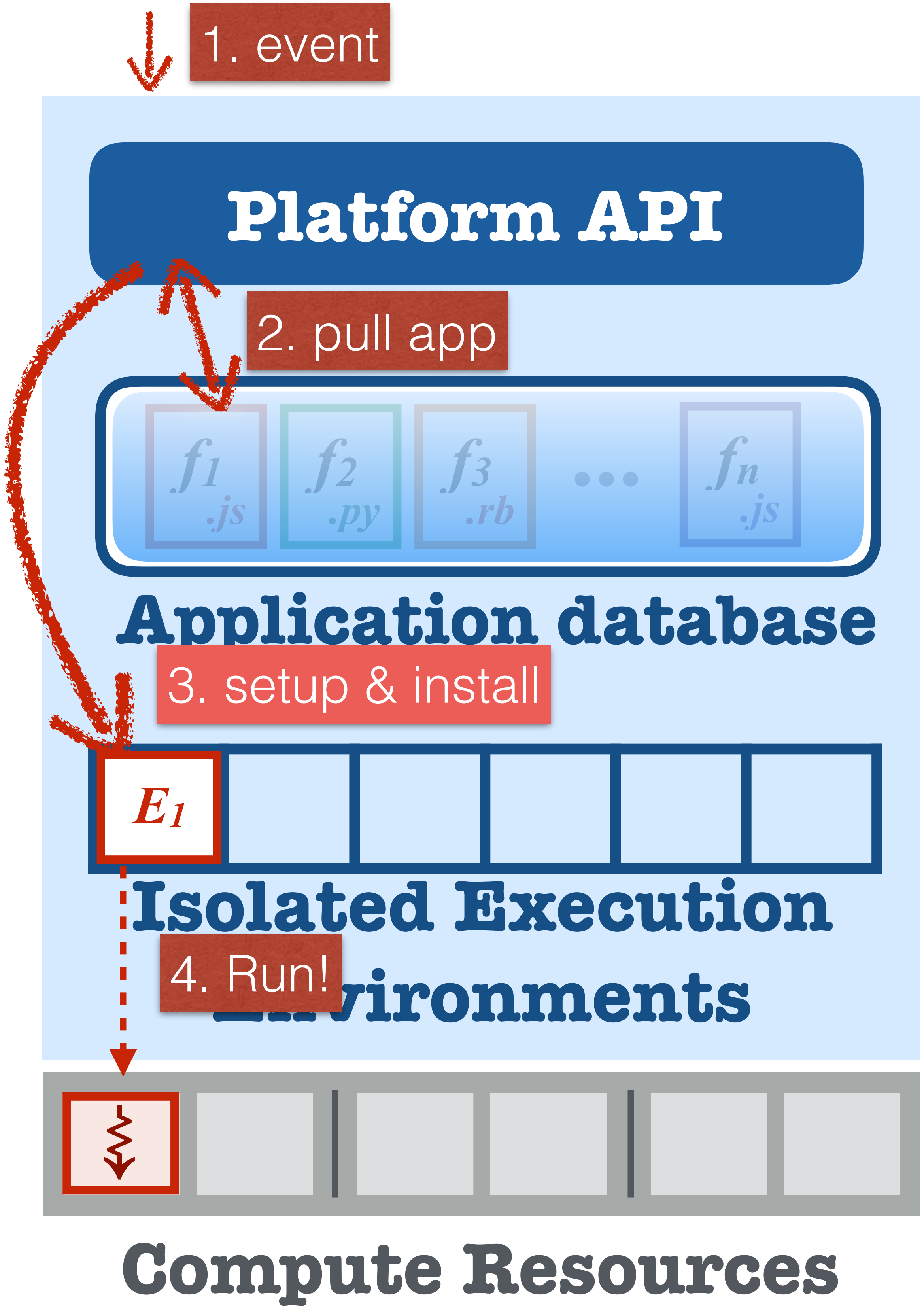
Department of Computer Science
Boston University

The Proceedings of EuroSys, 2020
April 29th, 2020

Serverless Computing

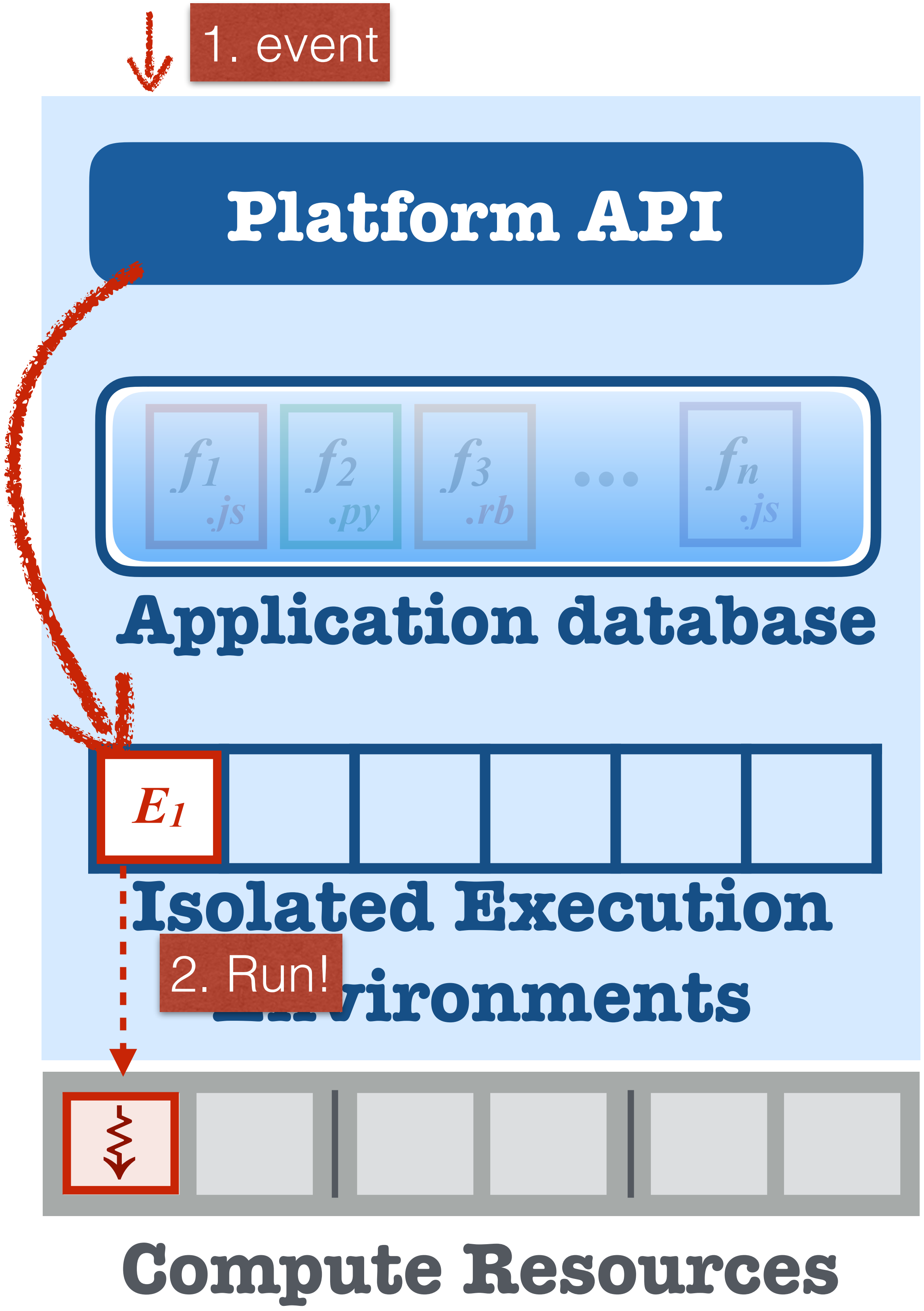


1. ***Function-as-a-Service* (FaaS)**: on-demand execution of a client code snippet (*functions*)

2. Applications are deployed and scaled ***automatically***

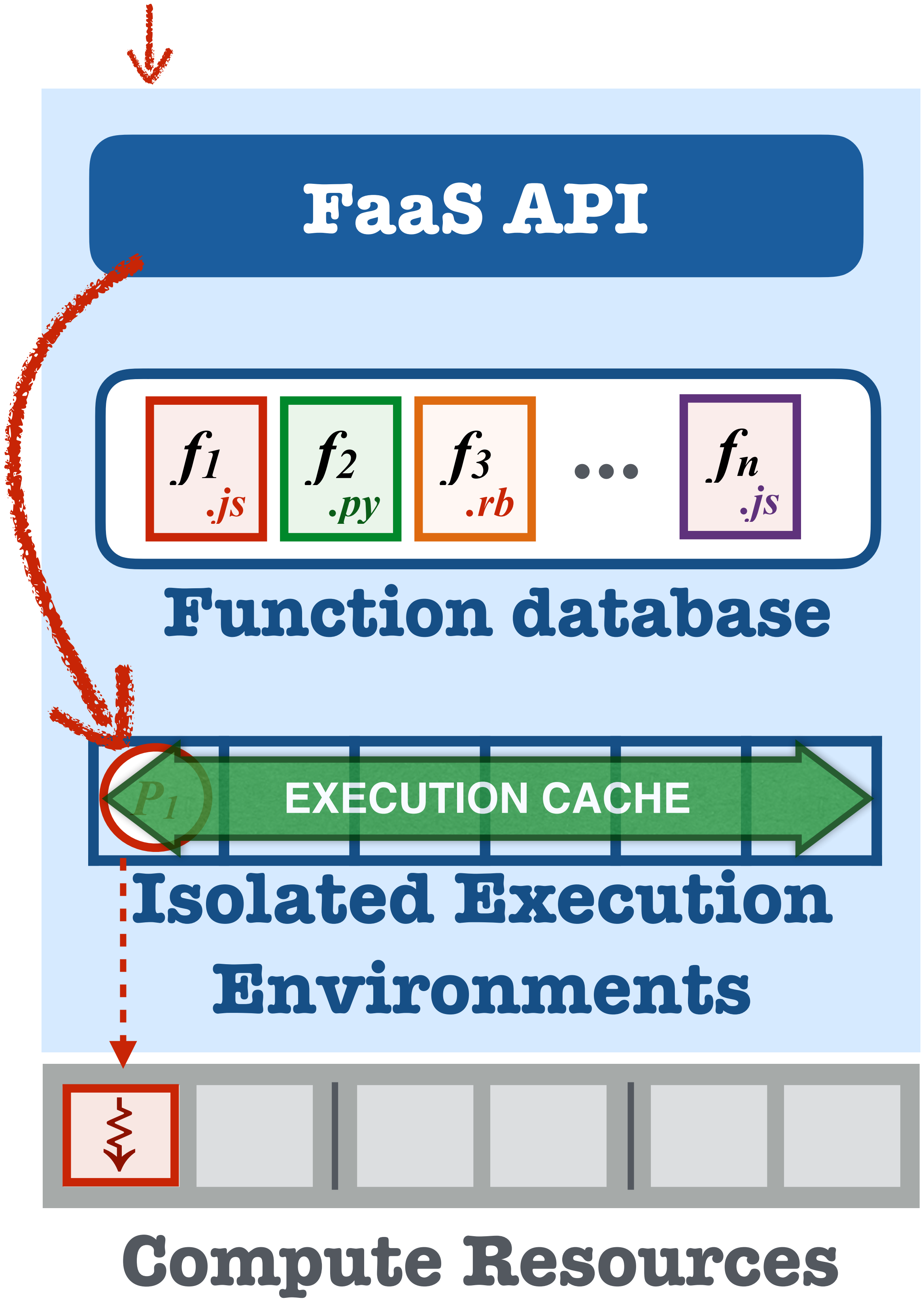
3. Function **start time** is dominated by deterministic **setup & install** paths

Serverless Computing



4. Functions deploy quickly using a **pre-initialized** environment!

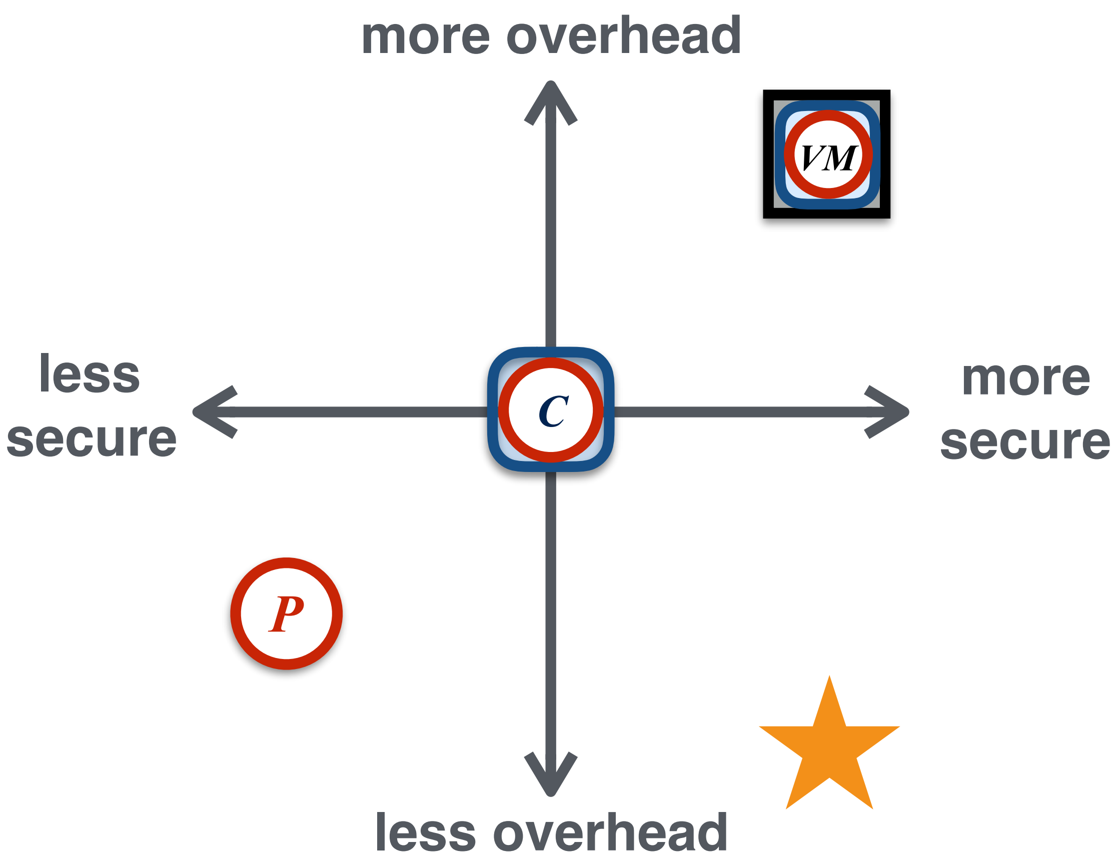
Serverless Computing



5. FaaS platform utility becomes a matter of ***cache efficiency!***

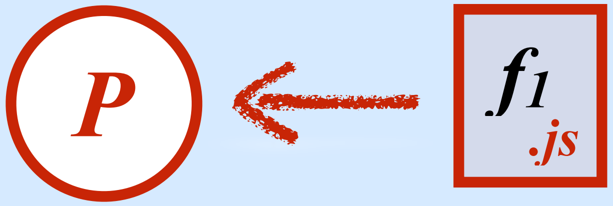
6. Mechanism of the system-level defines the ***security***, ***cache density***, and ***responsiveness***

FaaS Environment Caching



Cache Primitive:

Node.js “launcher” provides a REST API to *import and run* an arbitrary JavaScript function



		Machine Density	Start Time
P	Linux Process	4200	0.3 s
C	Docker Container	3000	0.5 to 4 s
VM	Container in a MicroVM	450	1 to 7 s

Linux v4.15; Docker v18.09; [Xeon 2.20 GHz; 88GB]

Serverless Execution via Unikernel SnapShots

Cadden, et al. "*Skip Redundant Paths to Make Serverless Fast*", In The Proceedings of EuroSys '20

Is there...

a method to better enable reuse across the **entire memory footprint** of the function?

We want to...

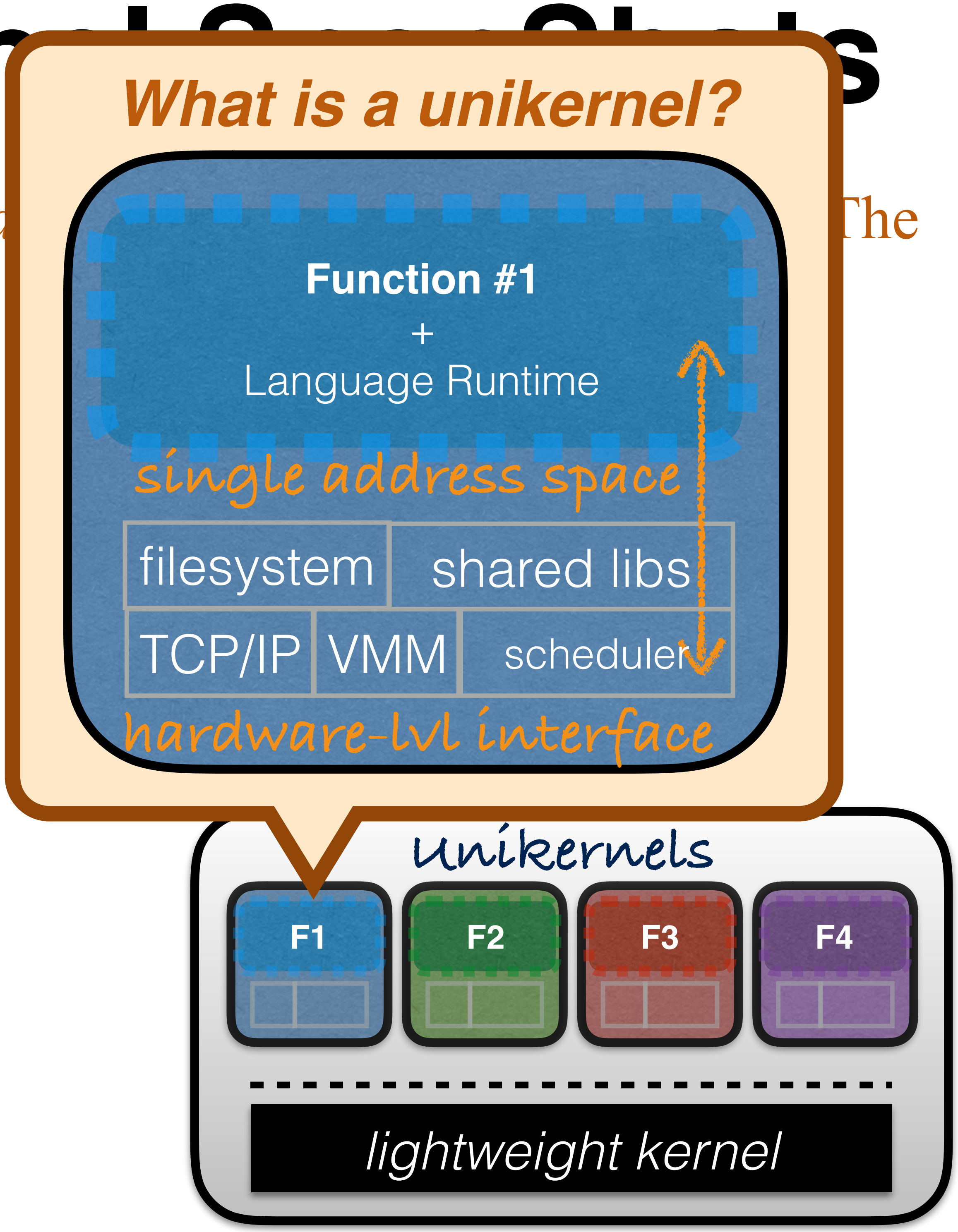
1. Shorten the **setup time** of new function invocations
2. Improve **cache density** for fast repeat invocations

Serverless Execution via Unikern s

Cadden, et al. “*Skip Redundant Pa* The Proceedings

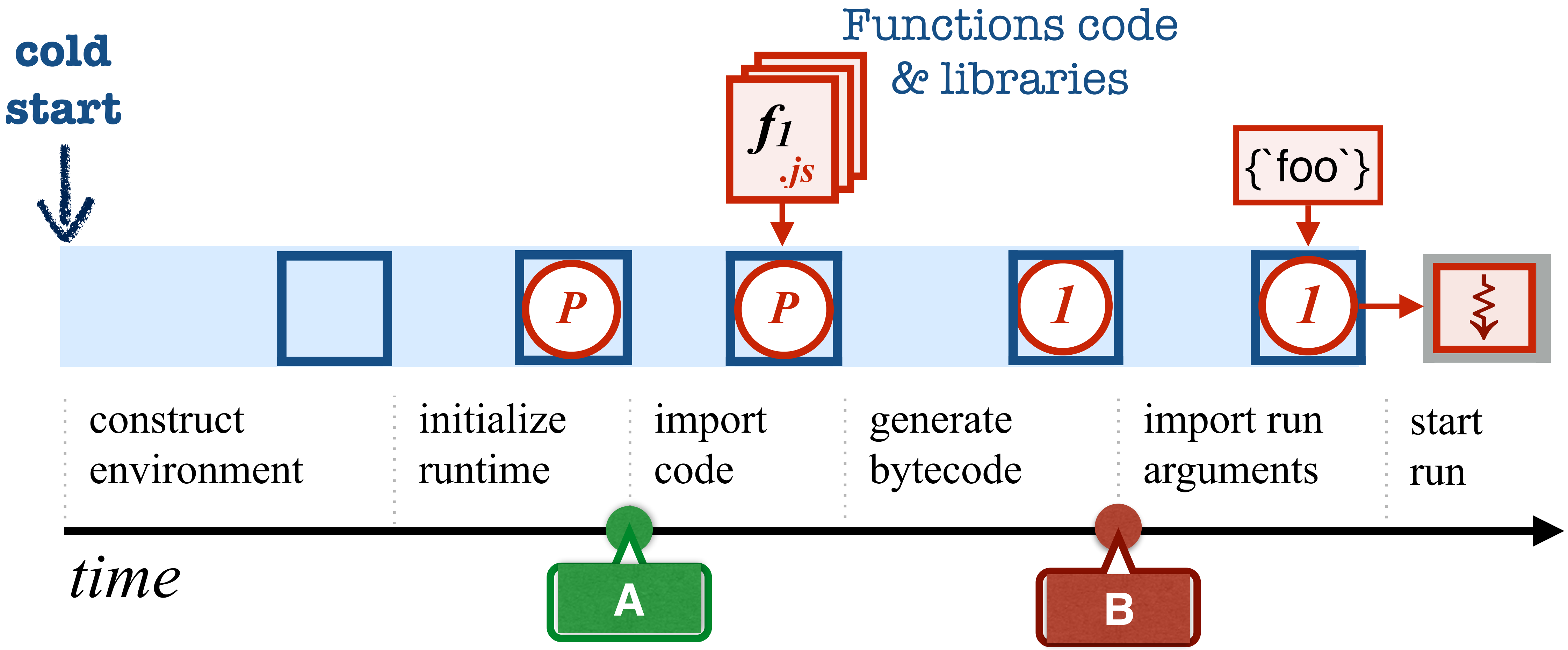
In SEUSS, functions are deployed inside of dedicated ***unikernels***

1. Unikernels support strong isolation semantics
2. Enable “black box” capture of environment’s memory footprint into an ***snapshot*** (object)
3. **Page-level sharing** can be applied ubiquitously across the application and kernel layers



Environment Snapshots

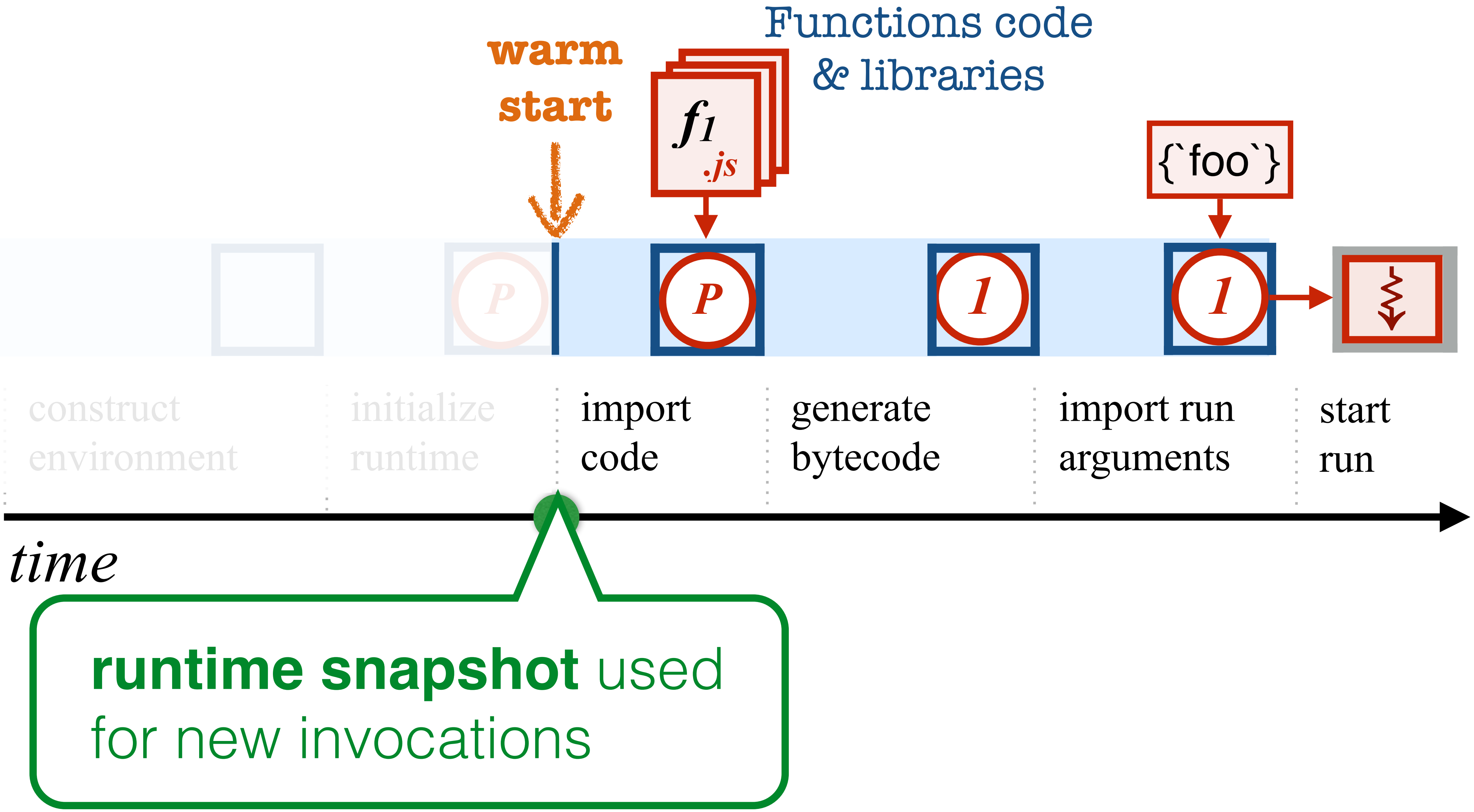
Function invocation times are dominated by deterministic import & initialization procedures



Snapshots captured at strategic **points in time** can be used as **templates** for deploying execution

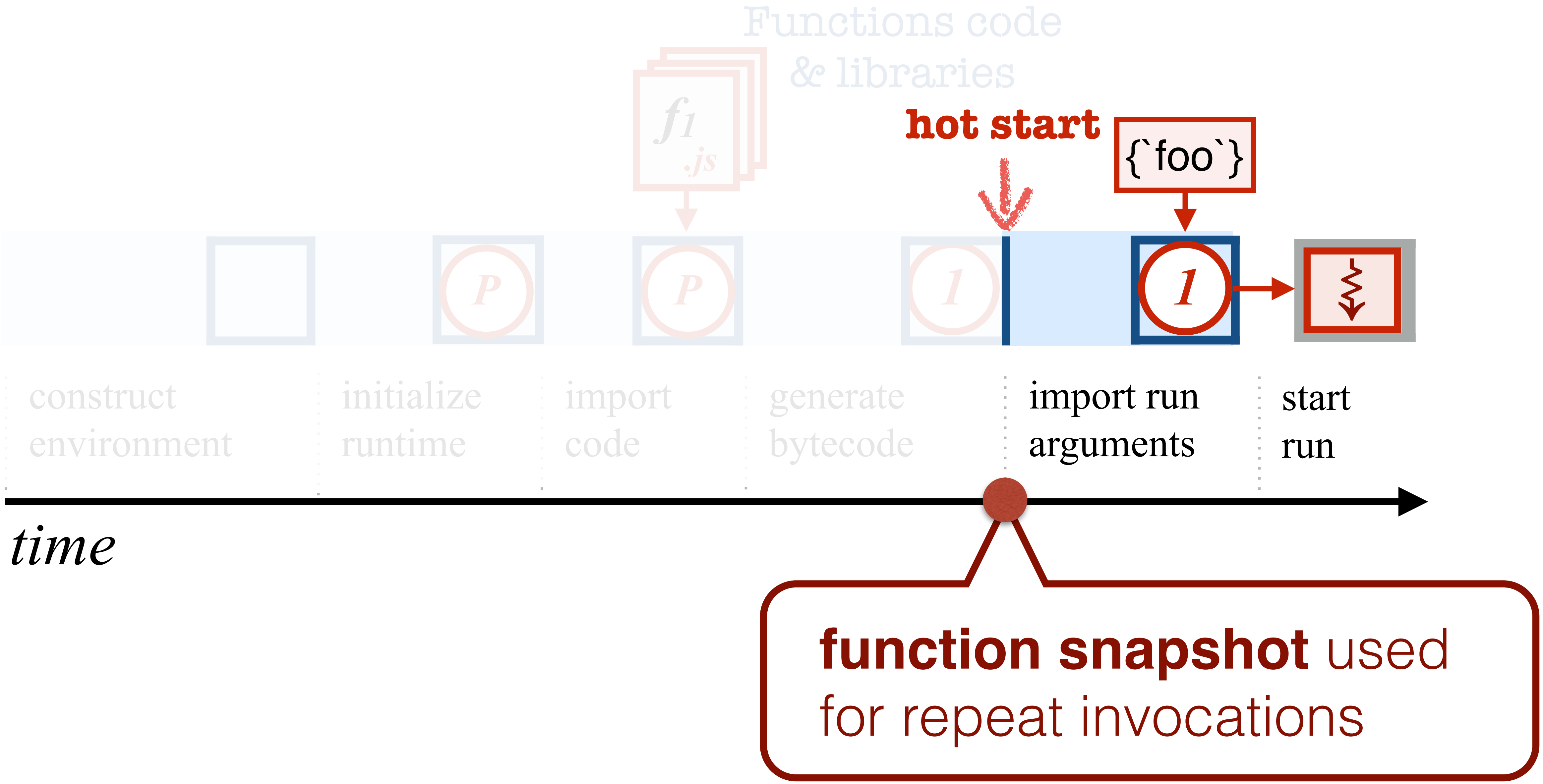
Environment Snapshots

Immutable snapshot images acts as a reusable launch point for new function invocations



Environment Snapshots

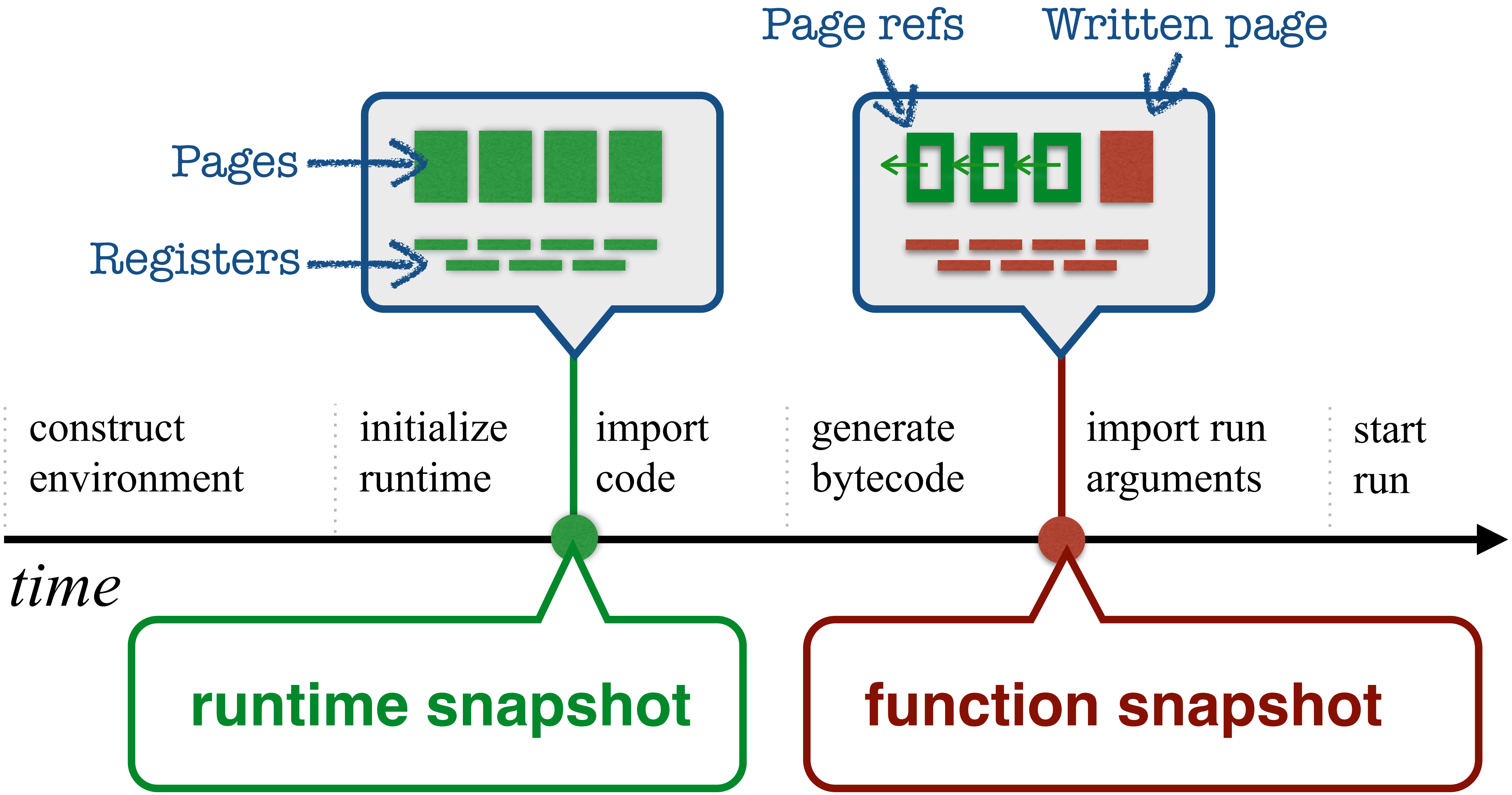
Function-specific snapshots provide the near-immediate execution of function bytecode



function snapshot used for repeat invocations

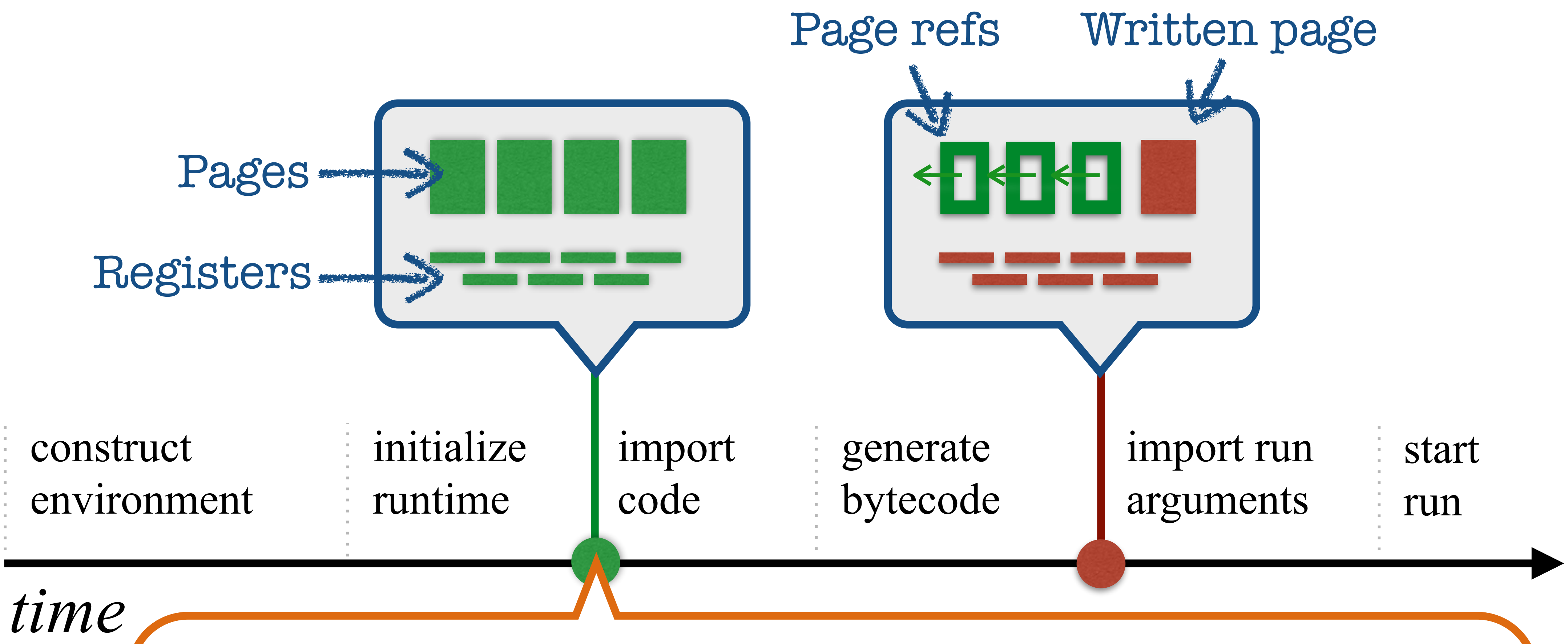
Snapshot Lineages

Page-level sharing & copy-on-write (COW) can be applied to drastically reduce replicated state



Snapshot Lineages

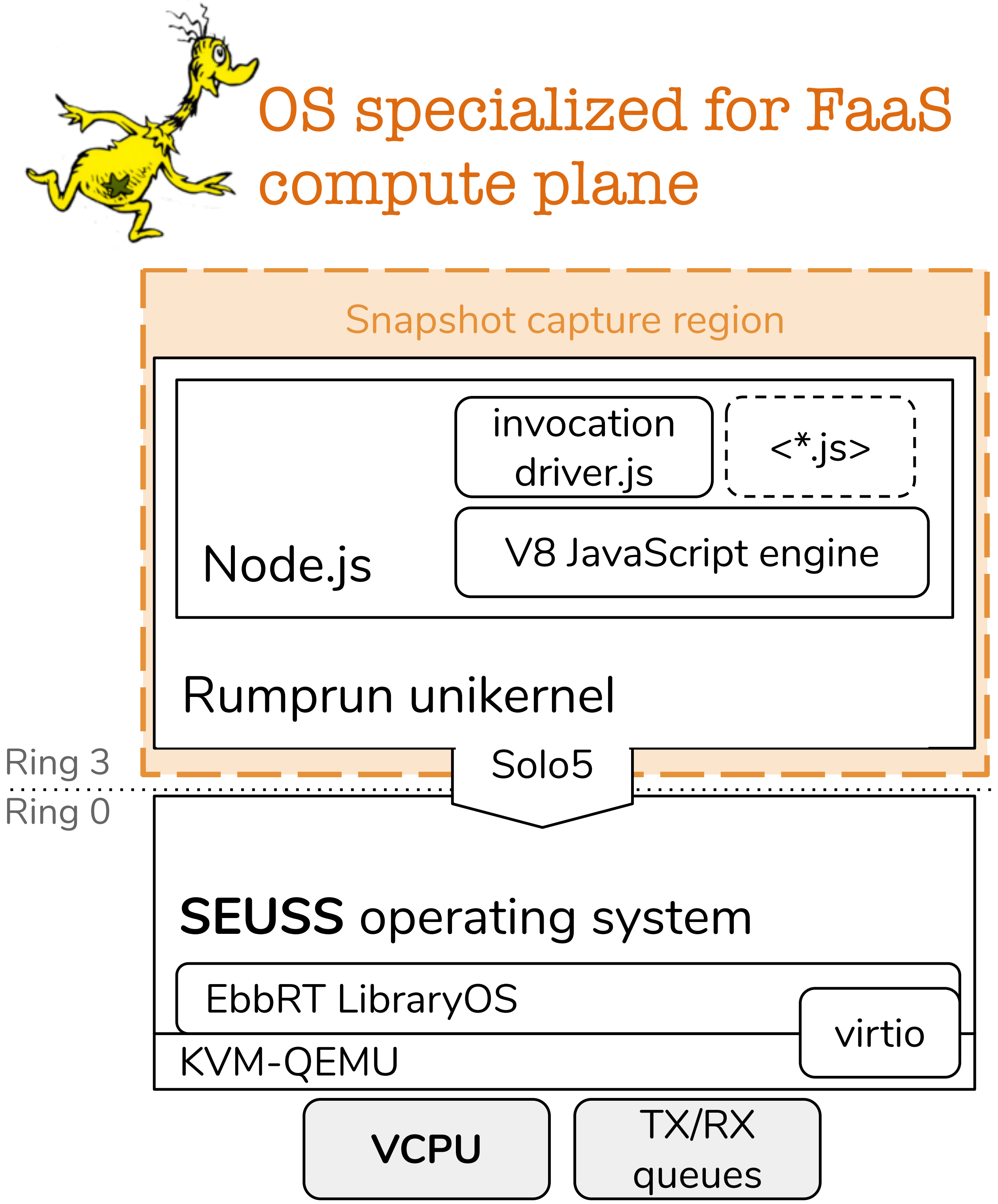
Child snapshots contain only a memory ‘*diff*’ of written pages



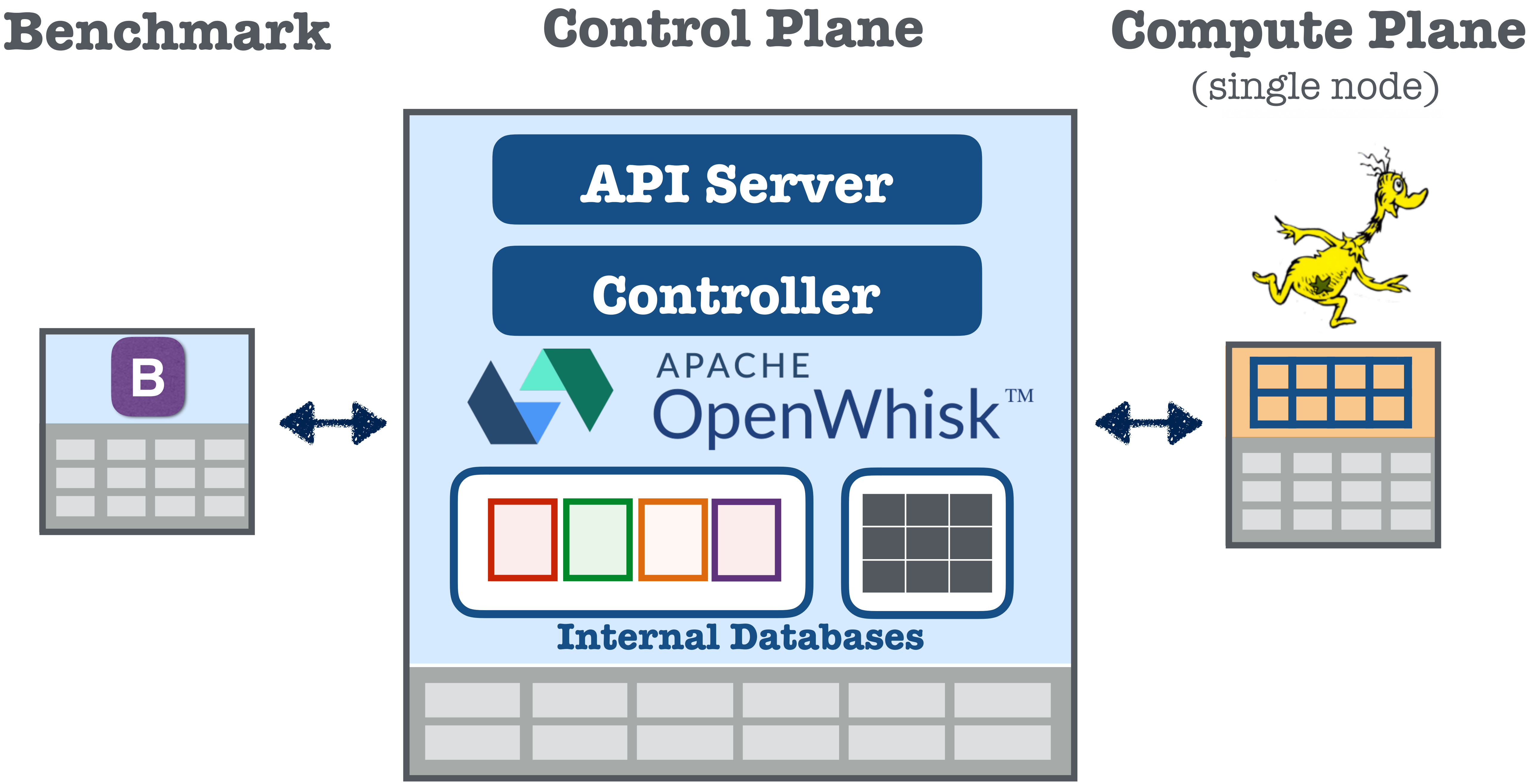
Anticipatory optimization enabled by accumulating state within the origin snapshot

SEUSS OS

- Foundation event-driven multi-core kernel (x86_64 native)
- Per-core job scheduler & network (NAT) layer
- In-memory snapshot cache
- Unprivileged unikernel guest:
  - POSIX0*ish* unikernel (Rumprun)
  - Minimal domain interface (Solo5)



FaaS Performance



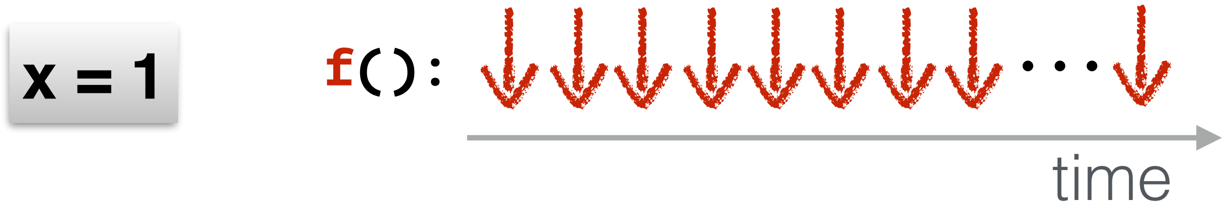
- 3-node OpenWhisk cluster
- custom benchmark tool
- 12-core, 88GB nodes

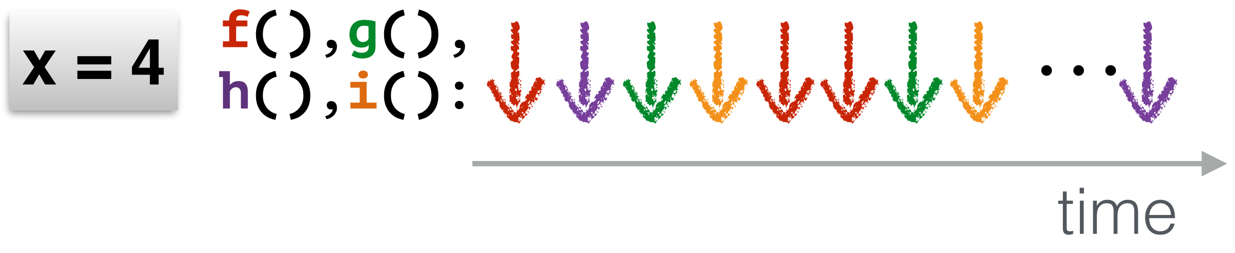
FaaS Platform Cache

using Docker containers

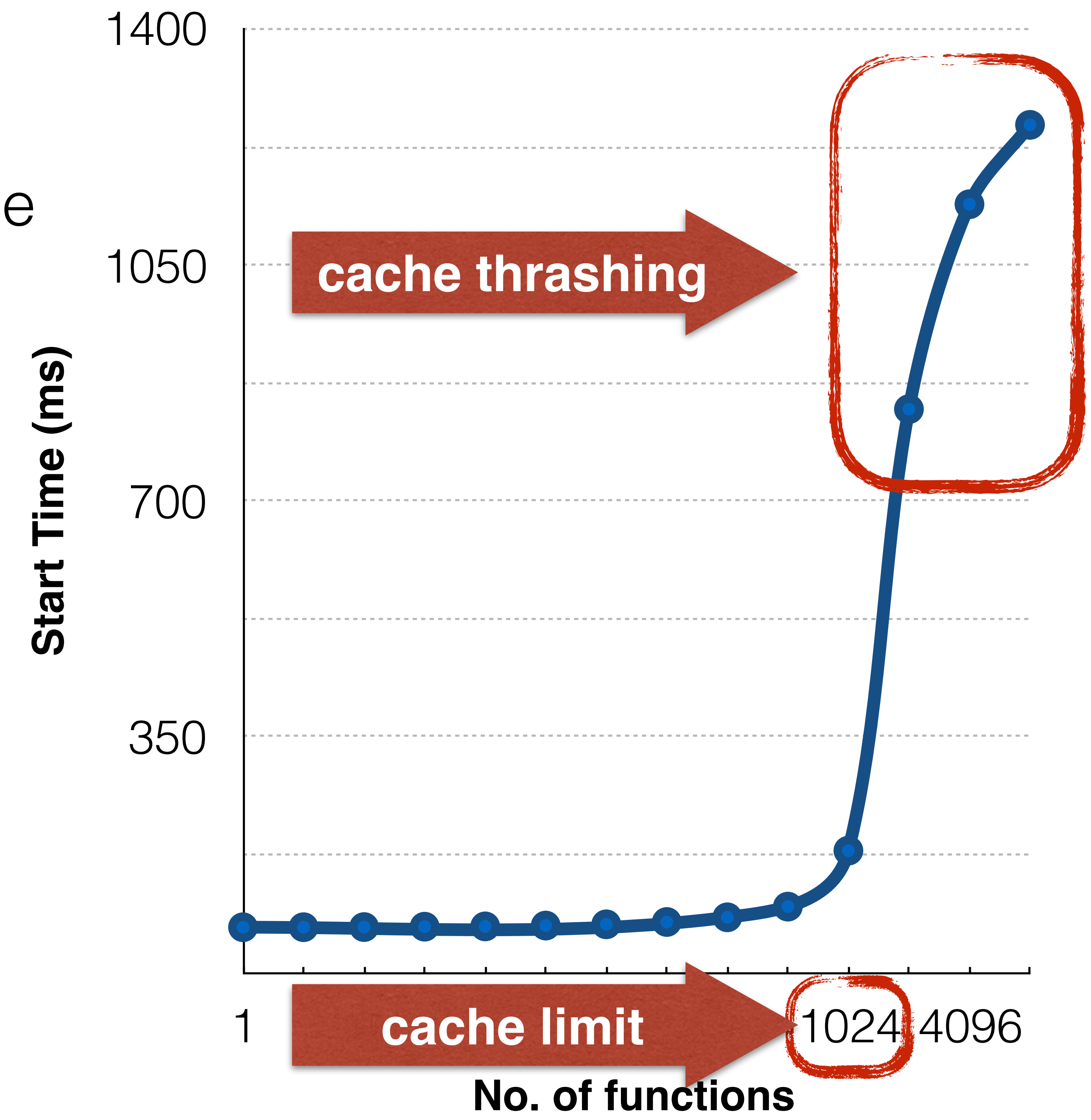
Apache OpenWhisk

Sequential invocation requests to an Apache OpenWhisk compute node





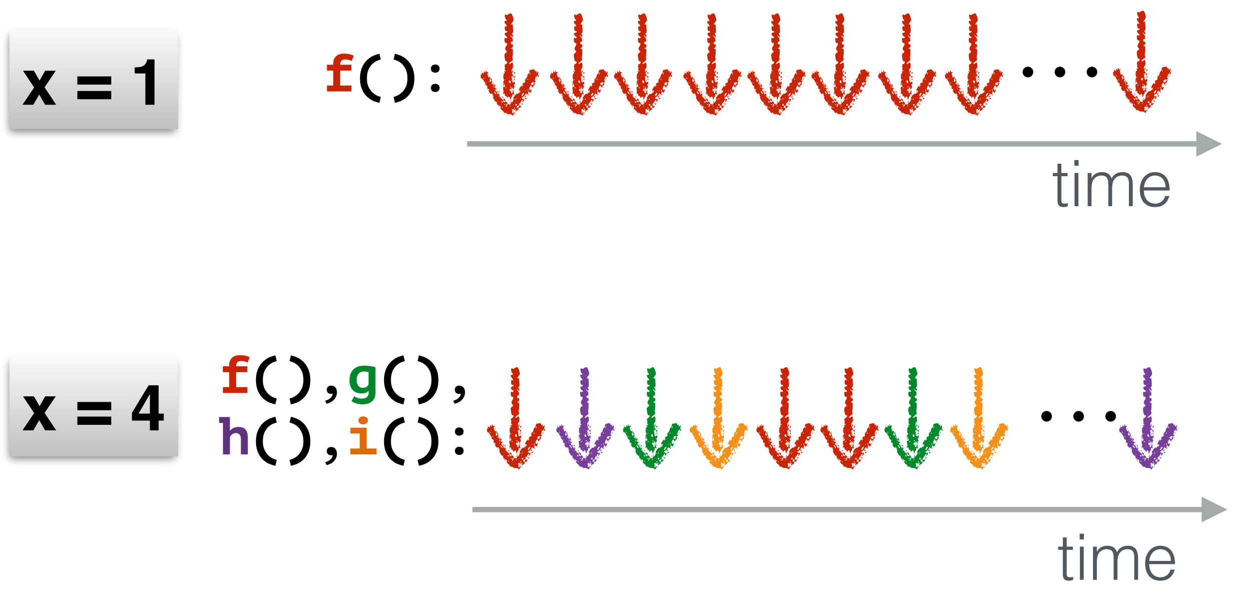
Report the average start time



(Linux v4.15; Xeon 2.20 GHz; 88GB)

FaaS Platform Cache

Sequential invocation requests to an Apache OpenWhisk compute node



x = 1

f():

time

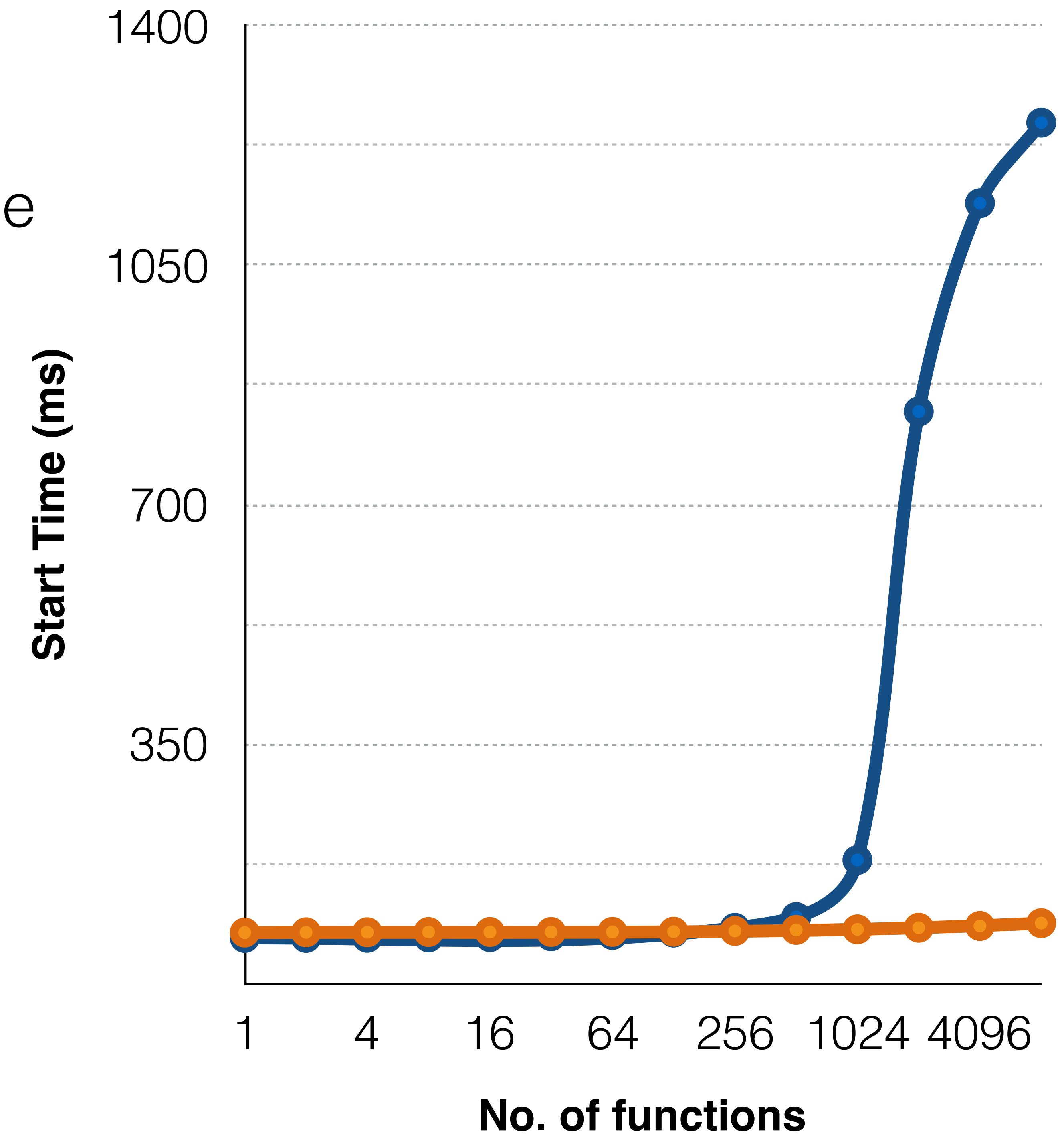
x = 4

f(),g(),
h(),i():

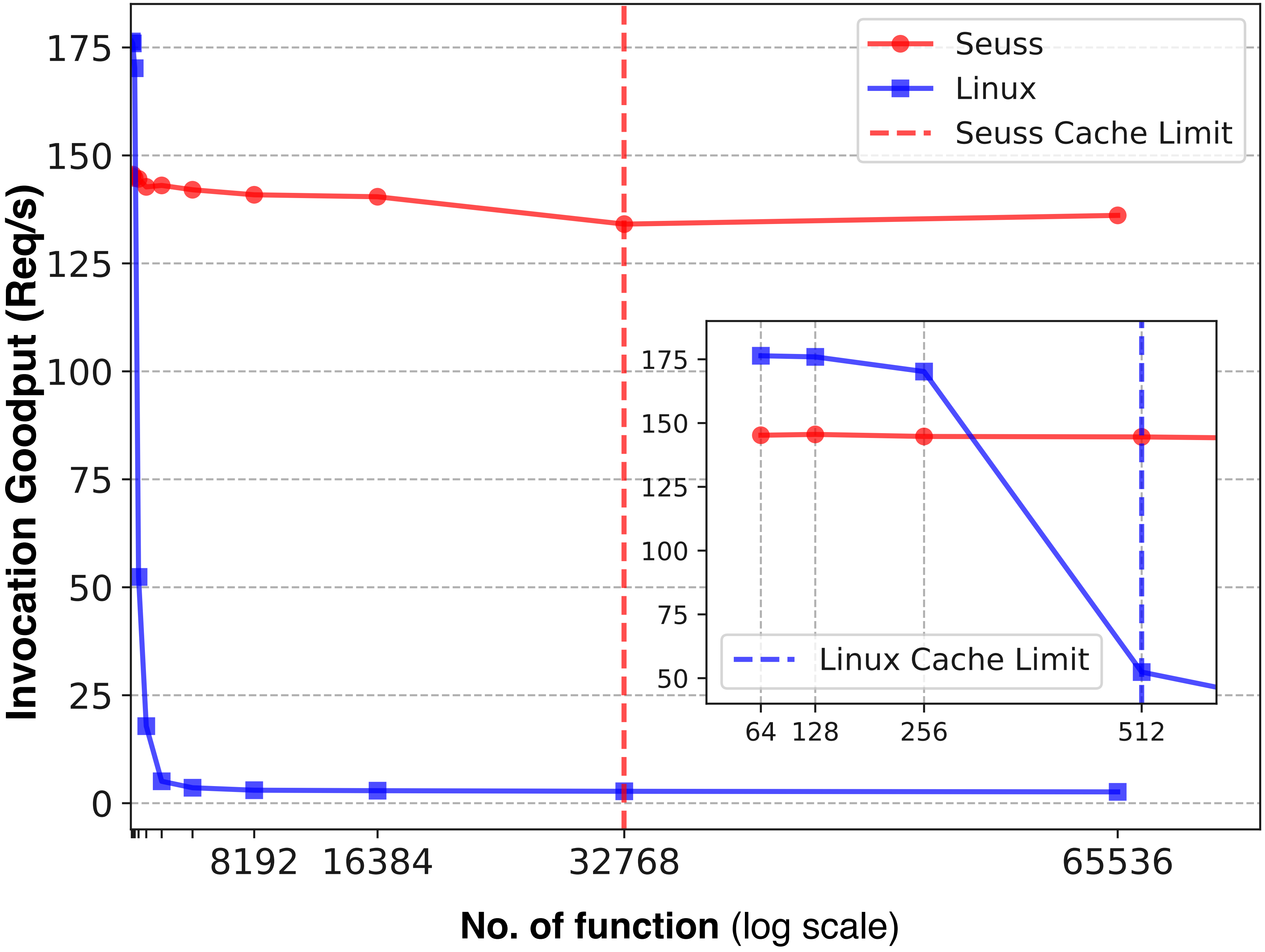
time

Report the average start time

using Docker containers
vs. unikernel snapshots

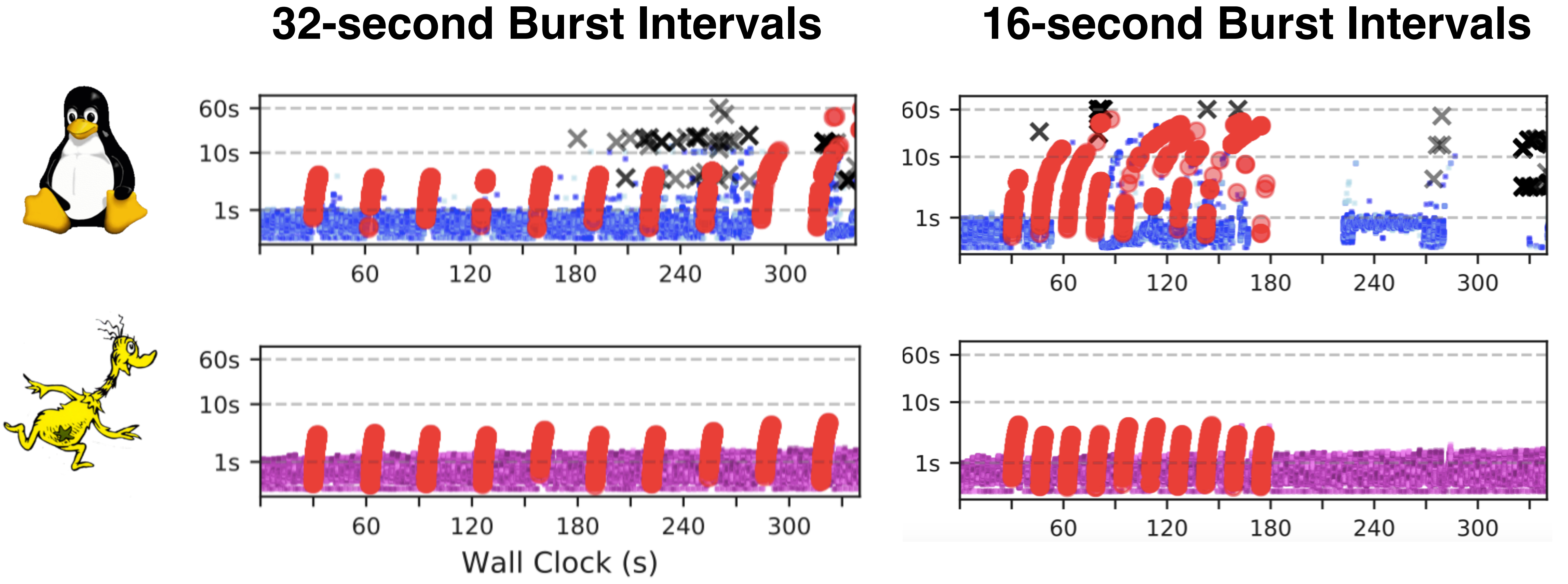


FaaS Platform Throughput



- 64 concurrent requests
- NOP (‘hello world) invocations

Resiliency to Traffic *Bursts*



32-second Burst Intervals

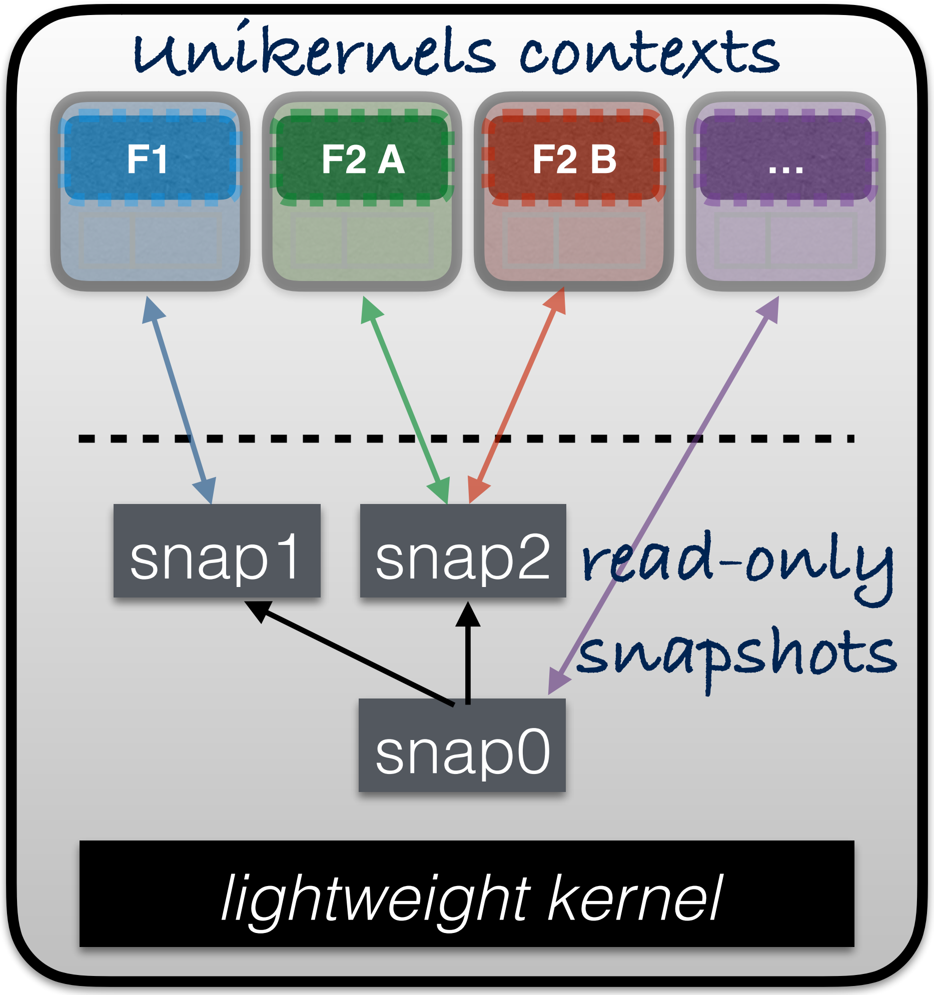
16-second Burst Intervals

blue/purple: Blocking IO requests to an external HTTP host (~250ms)

red: 128 concurrent CPU-bound functions (~150 ms)

Final Thoughts

- Unikernel snapshots promote reuse in a safe, simple, and effective way
- Prototype demonstrates a major advantage for serverless applications models
- In the end, high-performance cloud computing will continue to challenged our infrastructure software in new
- It will be the **operating system** (design, mechanisms & techniques) that will address challenge and enable new workloads



SEUSS OS