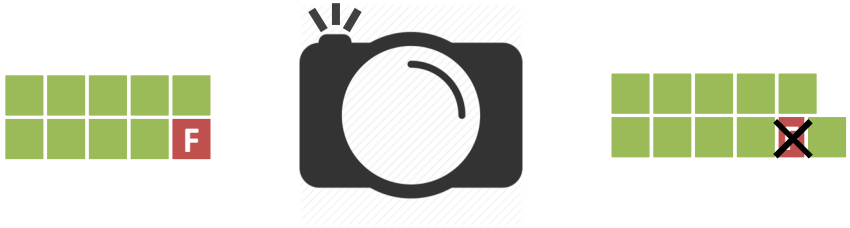



# Virtual Machine Support for Debugging Concurrency Bugs

No Distribution!

## Deterministic Replay, Asynchronous Snapshots, and Bug Detection for Event Loop Systems

**Stefan Marr**
Shonan, May 2019
Ongoing work with Dominik Aumayr, Carmen Torres Lopez,
Elisa Gonzalez Boix, Hanspeter Mössenböck

University of Kent

# Ongoing work

VRIJE UNIVERSITEIT BRUSSEL

involving

JOHANNES KEPLER UNIVERSITY LINZ

Carmen Torres Lopez

Elisa Gonzalez Boix

Dominik Aumayr

Hanspeter Mössenböck

SOM SimpleObjectMachine NS

Based on GraalVM™

# Concurrency Bugs are Common in Event Loop Systems

| | | |
|---|---|---|
| node.js | 53 projects, 57 issues<br>12 projects, 1000 potential issues | 2 studies |
| akka | 12 projects<br>53 concurrency issues | 1 study |
| HTML 5 JS | Websites in top 500<br>≈1-10 concurrency issues | |
| android | 8-27 apps<br>≈2-20 concurrency issues | |
| C | 6 projects<br>35 known event races | |

**Tip of the Iceberg**

# Challenges


## bug reproduction

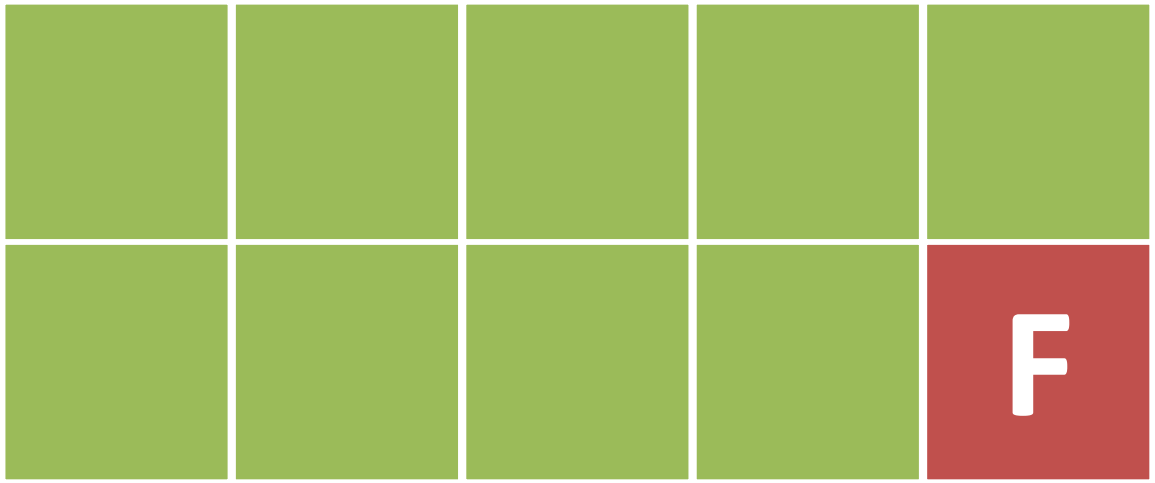
e.g. fails 1 in 10 times

## asynchronous snapshots

saving the world, without stopping it

## bug mitigation

fails 1 in 10 times, can we avert failure?

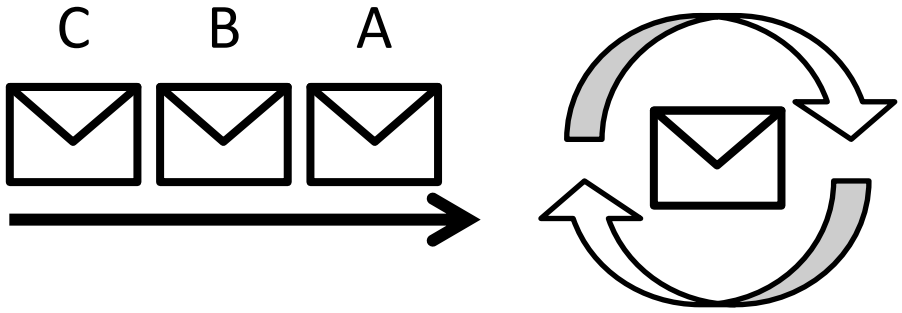



Reproduces only 1 in 10? How can I fix such a bug???

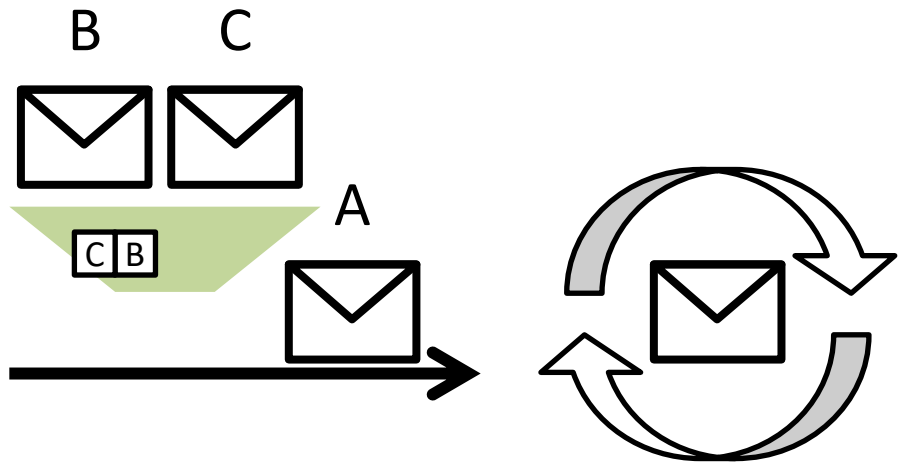
# NON-DETERMINISM MAKES FOR UNHAPPY DEBUGGERS

# One Solution

- Record
  event order

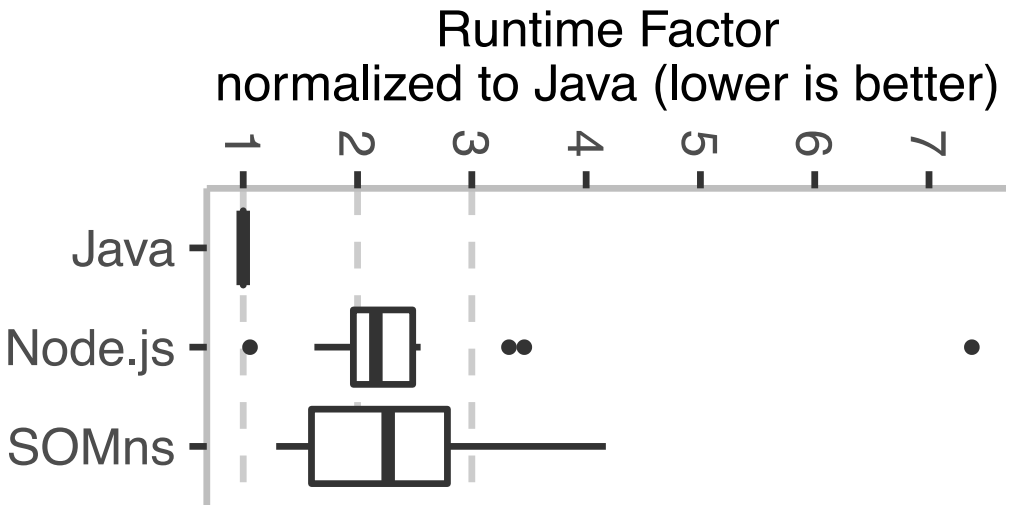


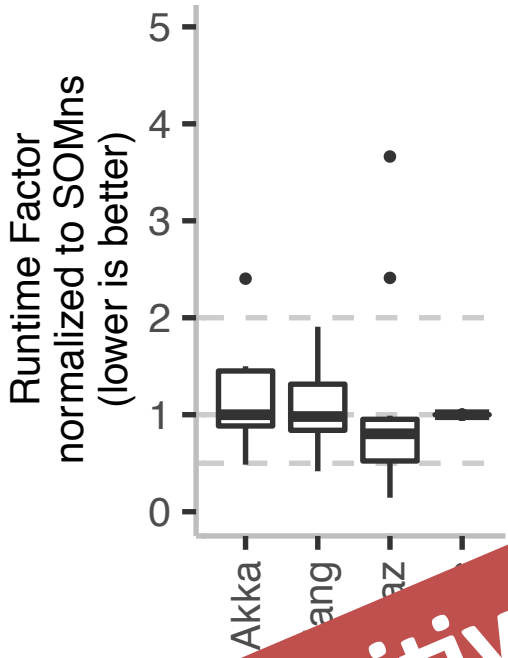

- Replay
  reorder to fit




Efficient and Deterministic Record & Replay for Actor Languages,
D. Aumayr, S. Marr, C. Béra, E. Gonzalez Boix, H. Mössenböck. ManLang'18

# Performance: Baselines




**On level of Dynamic Languages!**

**Competitive with JVM frameworks!**

ross-Language C

m/smarr/are-we-fa

chmark Suite

om/shamsimam/savina

# Tracing Performance: Savina

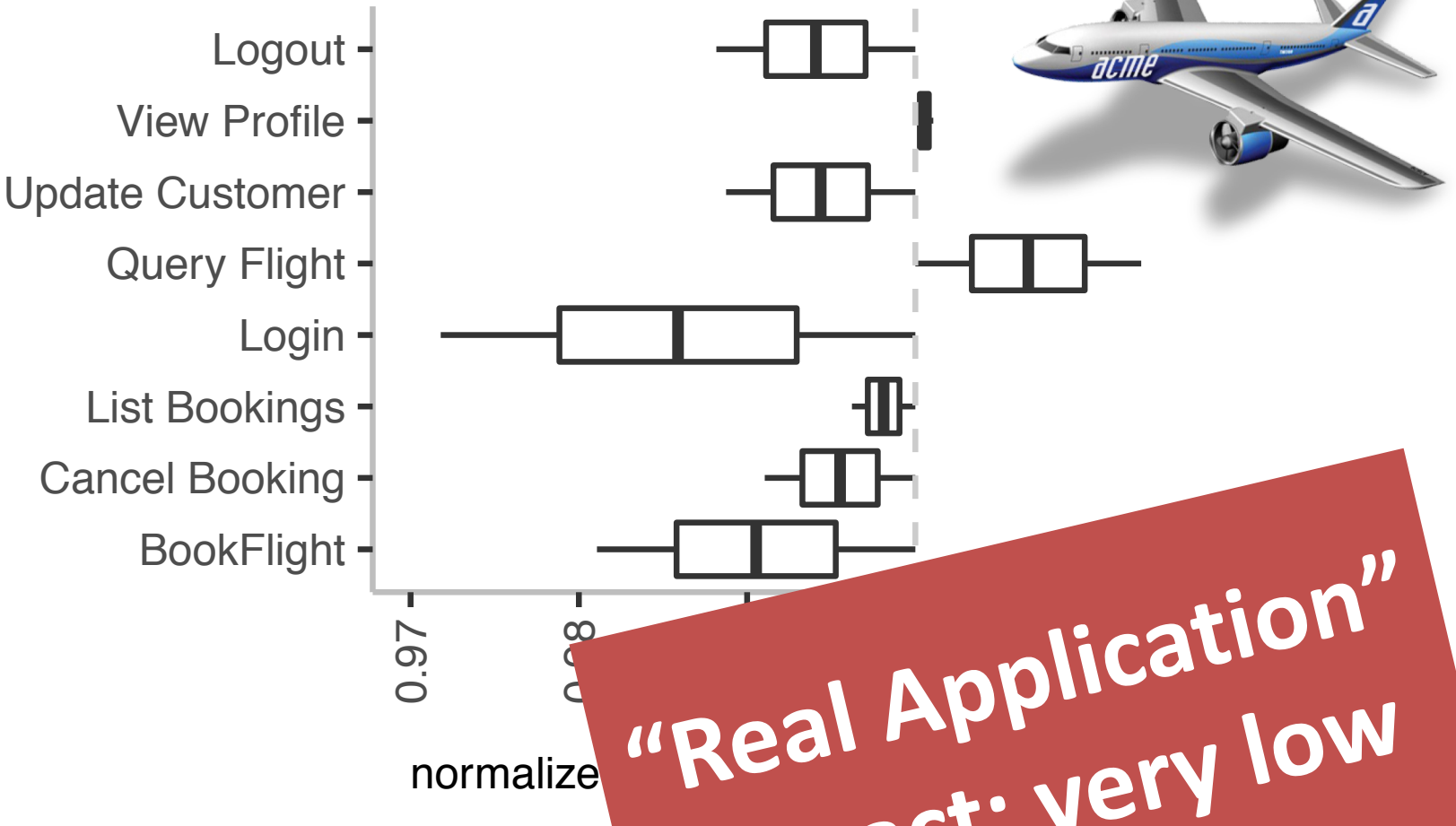

**Worst case:**
**20% overhead**

# AcmeAir: Microservices Evaluator

- Airline booking system
- Designed as benchmark


https://github.com/acmeair

# Tracing Performance: Acme Air



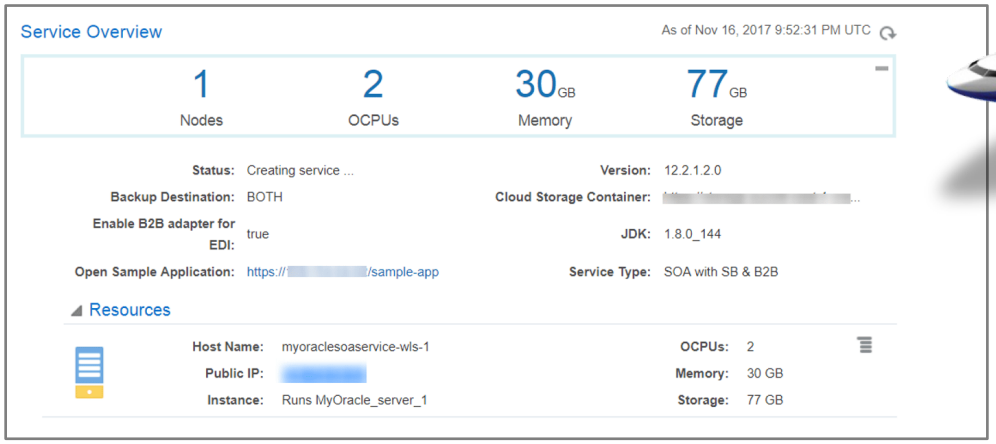

**"Real Application" impact: very low**

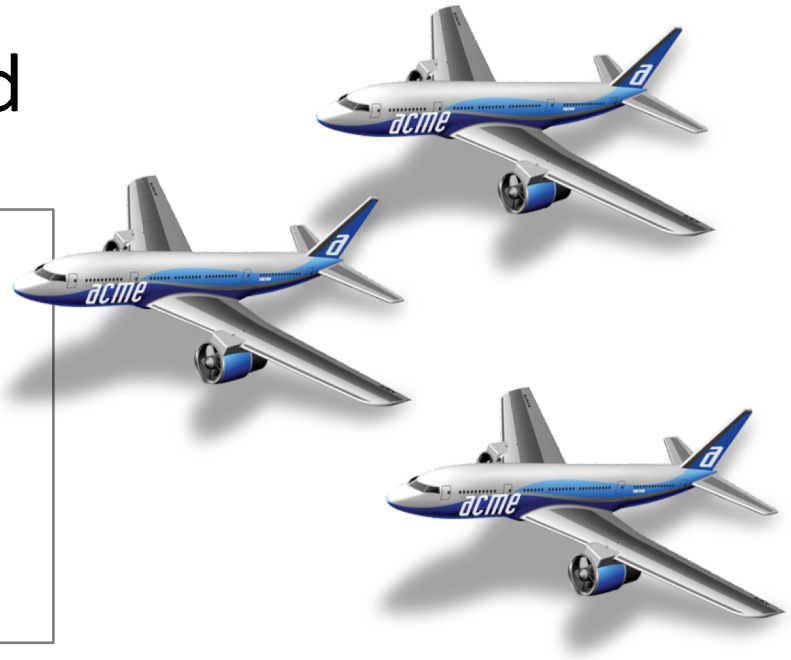

Snapshotting Actor Systems without Stopping Them

# LONG AND HUGE TRACES MAKE REPLAY IMPRACTICAL

# Deterministic Replay and Snapshots

## Microservices in the Cloud




Service runs for days or weeks
Can't have replay from start

➡ Need Snapshots

# Deterministic Replay and Snapshots

## Microservices in the Cloud


Service Overview

As of Nov 16, 2017 9:52:31 PM UTC

| 1 | 2 | 30 GB | 77 GB |
|---|---|---|---|
| Nodes | OCPUs | Memory | Storage |

**Status:** Creating service ...
**Backup Destination:** BOTH
**Enable B2B adapter for EDI:** true
**Open Sample Application:** https://[redacted]/sample-a

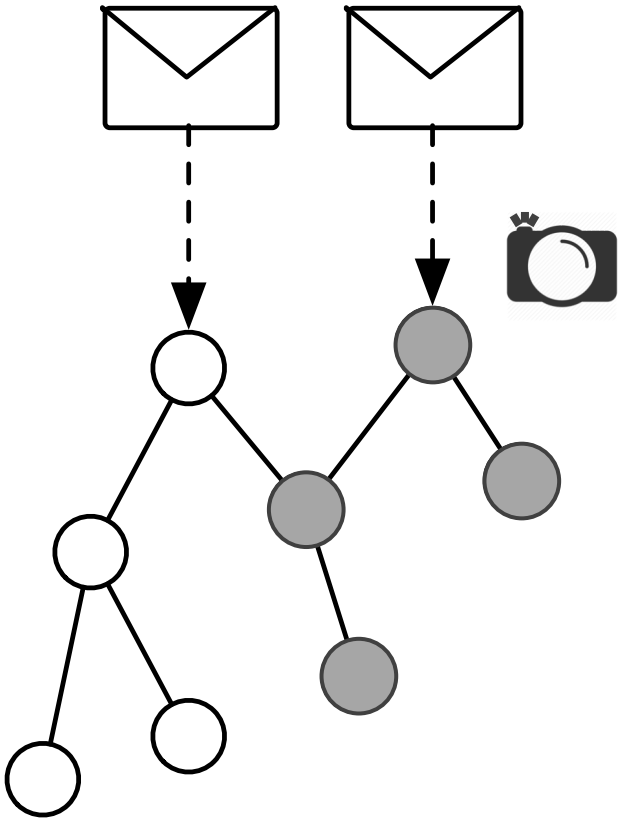
**Version:** 12.2.1.2.0
**Cloud Storage Container:** [redacted]
**JDK:** 1.8.0_144

Resources

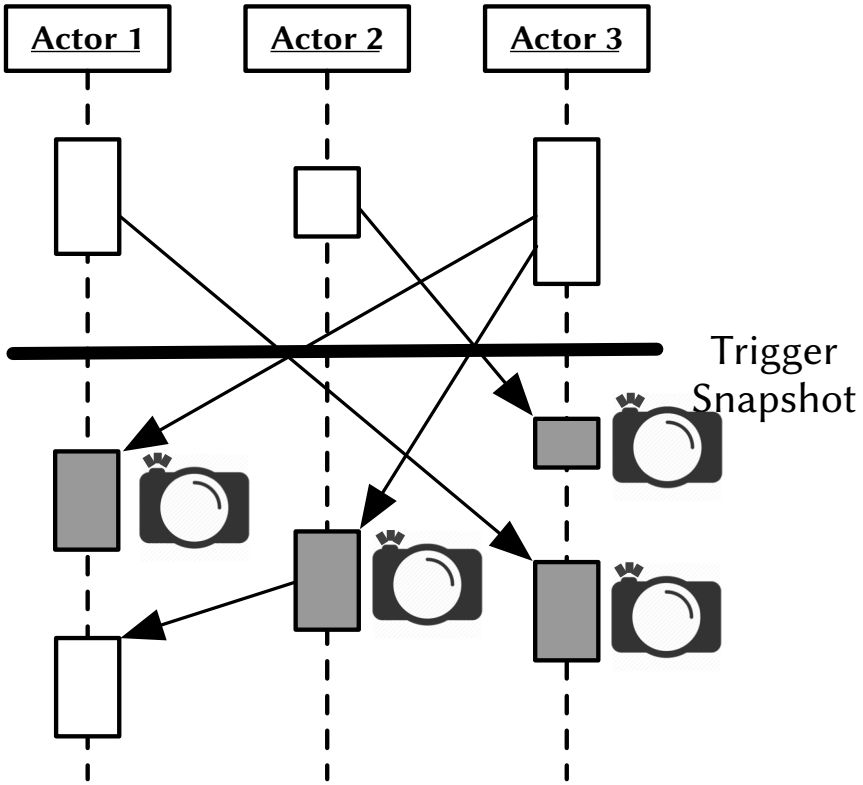
**Host Name:** myoraclesoaservice-wls-
**Public IP:** [redacted]
**Instance:** Runs MyOracle_server_1

**Download Snapshot.**
**Debug Locally!**


# Asynchronous and Partial Heap Snapshots



snapshot only objects reachable from a message



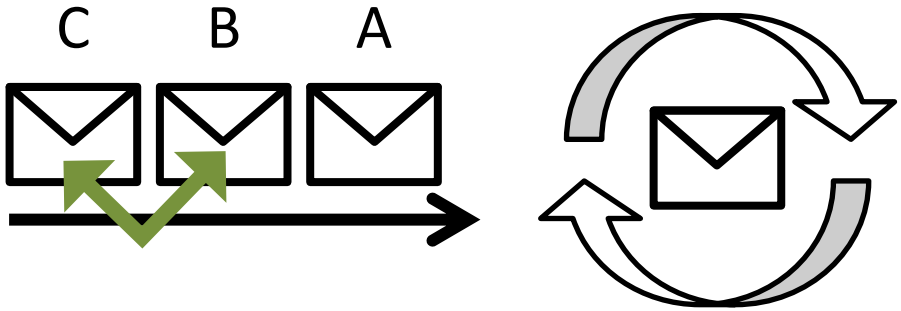

serialize partial heap before message execution

Where to go from here?

# THE FUTURE?

# Bug Mitigation?

# Detect Event Races At Run Time

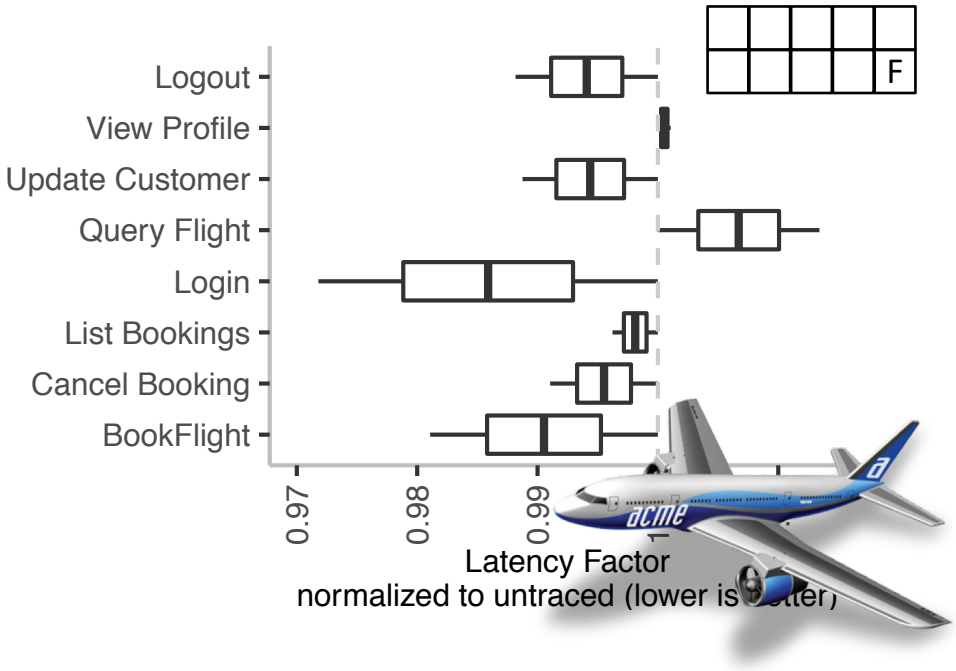



Order A -> B -> C problematic?

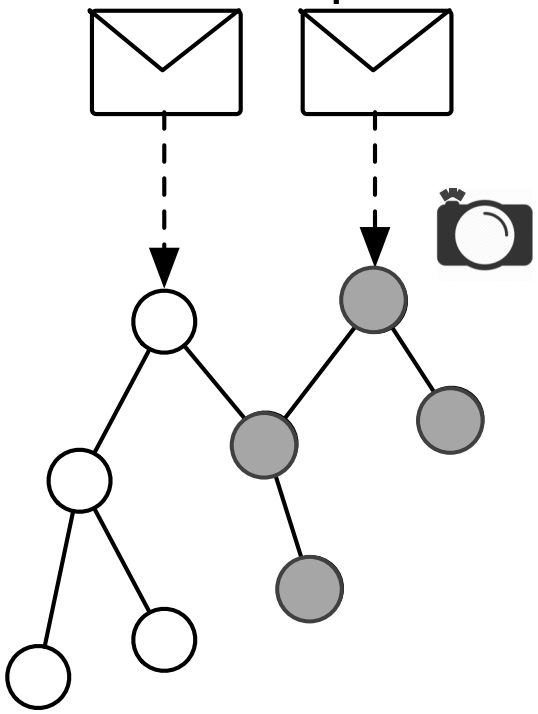
Let’s swap them!

# Summary


## Deterministic Replay with low overhead




## Asynchronous Partial Snapshots



## Future: Race Detection and Bug Mitigation