# Cloud Language Runtimes on IA - Challenges & Opportunities

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# Agenda

Cloud Runtime Usage & Introduction

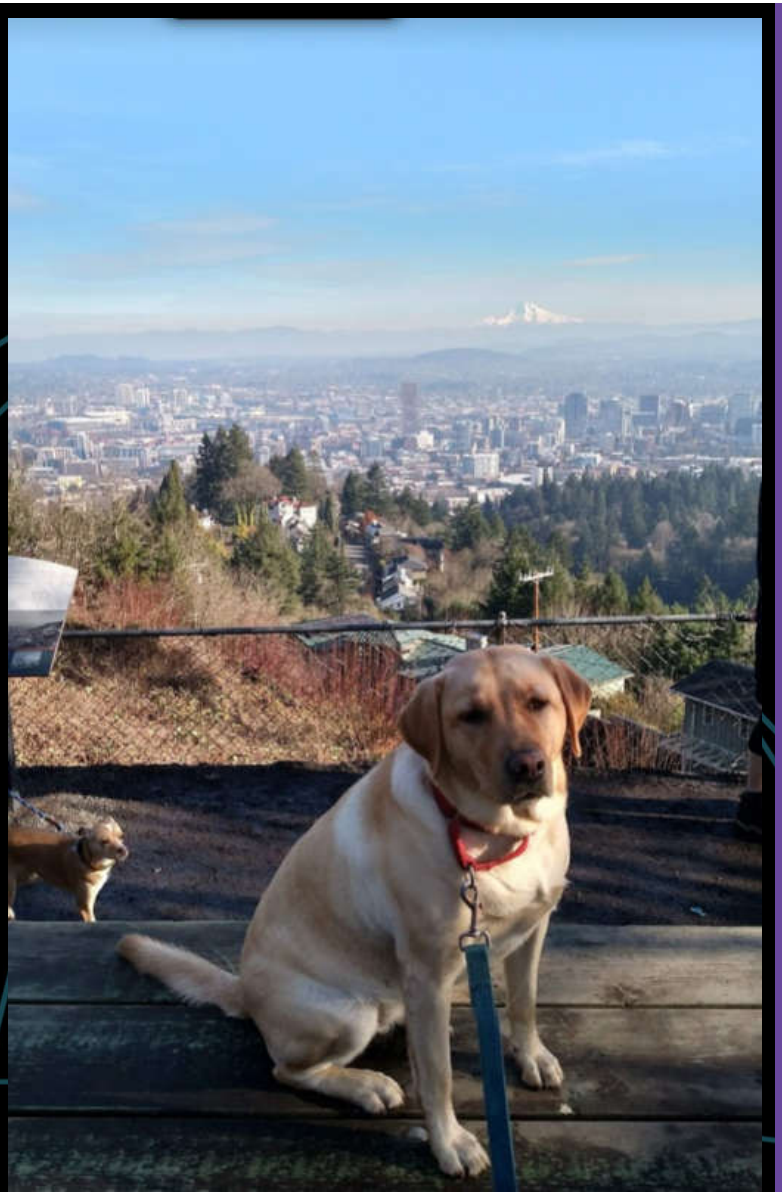
Cloud Runtime Challenges/Problems

Software/Hardware Optimization

Next Steps/Open Problems/Call To Action

# Cloud Runtimes

Usage/Introduction



Title: Luna at Pittock Mansion
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# Cloud Runtime: Usages/Language

## Multiple Environments

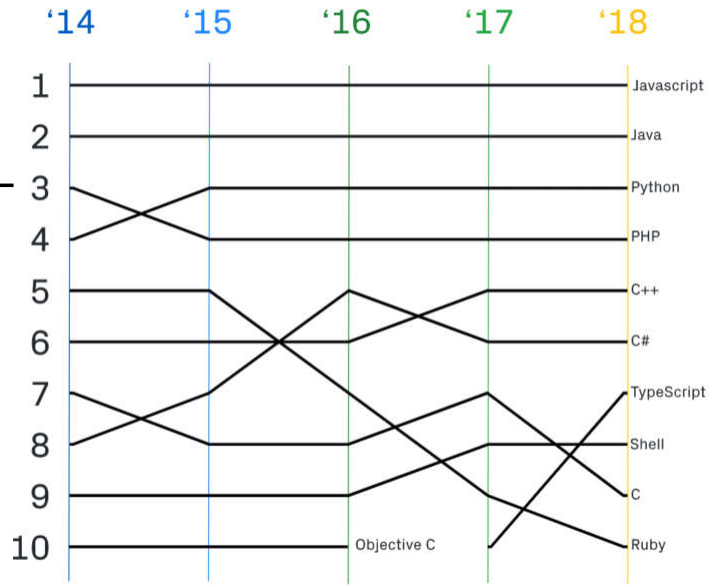
- IaaS->PaaS->FaaS

## Languages

- 4 of top 5 are Runtimes
- 3 are dynamically typed.

## Usages

- Function As Service
- WebTier
- Analytics




https://octoverse.github.com/projects#languages

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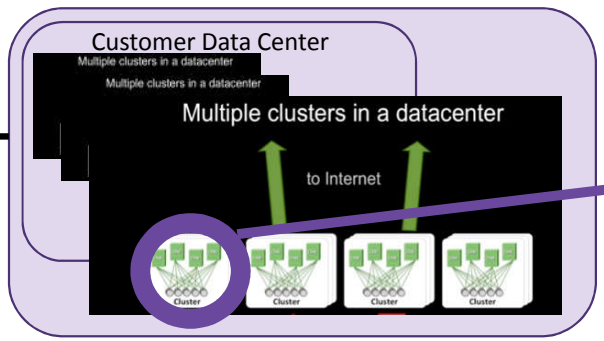
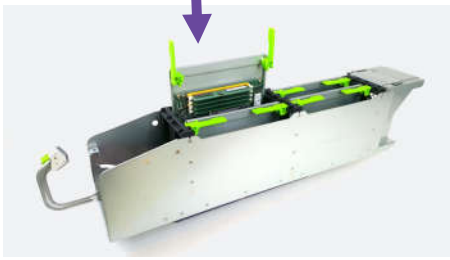
# Cloud Runtime: Web Tier Scale Out Usage

- Each server running a Web Server
- Individual server can run at high utilization (> 90%)
- Each server also running Cloud Runtime
- Scale Out
  - Example: Cluster of Dense Computing Platform with Yosemite v2 (Four 1S servers)
- PHP, Python, Node.js …
- Very different from SPEC benchmarks (Large Scattered Code, JITting, Type Checks, …)







# Cloud Runtimes

Challenges/Problems

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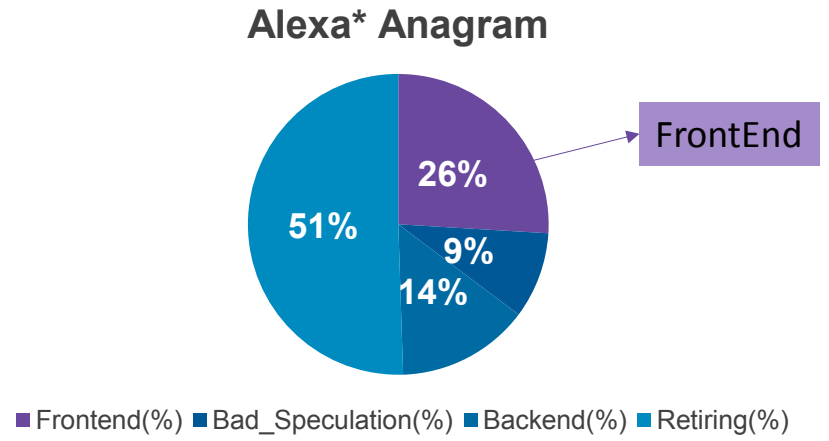
# FaaS JavaScript: Challenges

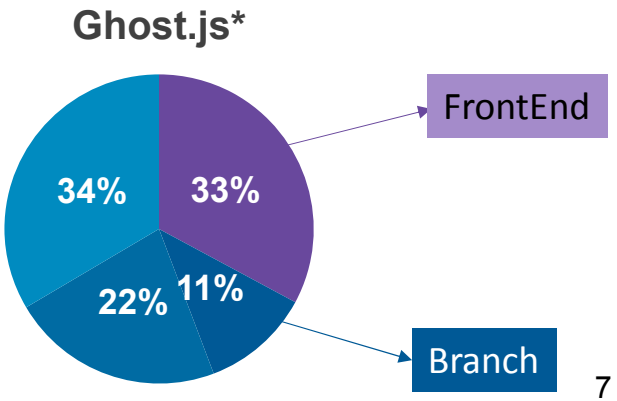
## High CPU bottlenecks ~35-45% stalled

- I-Cache Misses
- I-TLB Misses
- Branch Mispredicts

## Problem gets worse for bigger function

| Anagram | Ghost.js |
|---|---|
| 51% retiring | 34% retiring |
| 1.18% I-TLB misses | 6% I-TLB Misses |
| 1.25% I-$ misses | 10% I-$ Misses |

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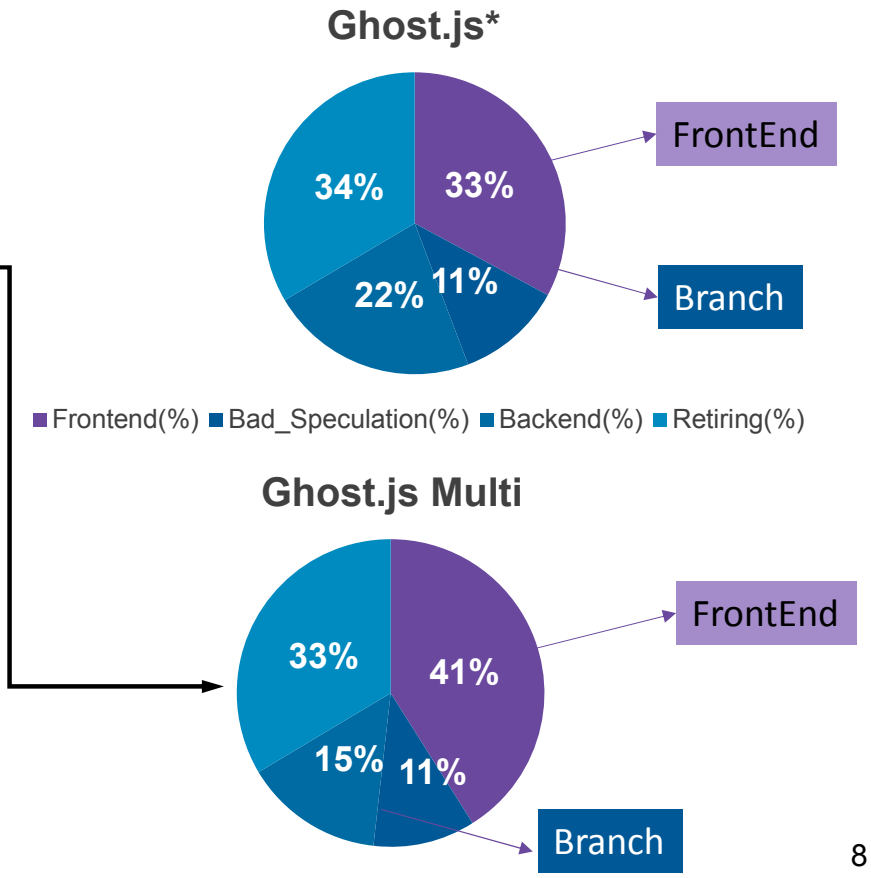
# FaaS JavaScript: Characteristis & Challenges

## Problem gets worse

- Bigger Functions
- When multiple functions executing concurrently
- Frontend Stalls increase from **33% to 41%**
- Cycles/work much higher

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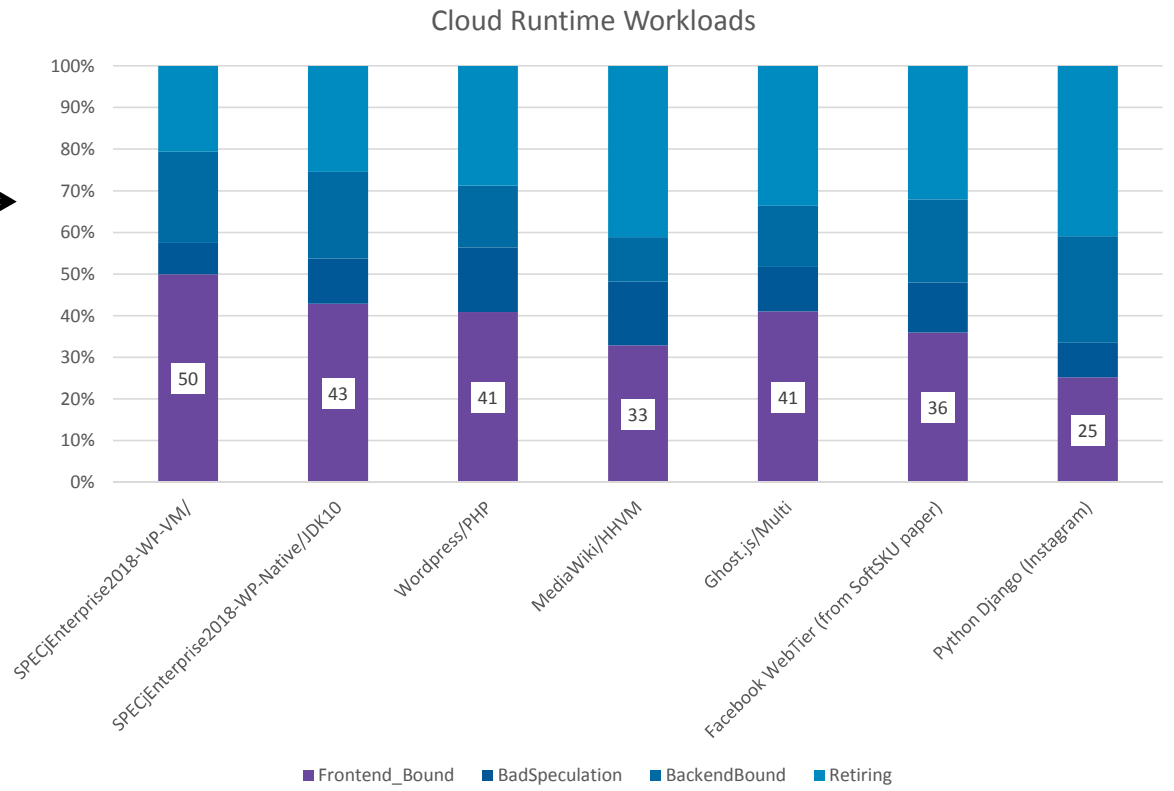
# WebTier: Characteristics & Challenges

## Runtime with High CPU bottlenecks

- Front End Bottlenecks: I-Cache Misses, I-TLB Misses
- Interpreters with high Branch Mispredicts
- Accounting for 50% of Stalls

## Long Pathlength

- 10s of millions of instructions executed per request

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# Cloud Runtimes

## Hardware & Software Optimization

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# Cloud Runtime: Hardware

## Hardware Improvements

- 17% Improvement in Retirement
- 2M Code Pages in shared 2nd level structure
- Larger L2 helps with I$ Misses
  - 40% L2 miss reduction
  - 25% Frontend Improvement

| | MediaWiki BDX-D | MediaWiki SKX-D |
|---|---|---|
| Topdown Frontend bound (%) | 43 | 32 |
| Topdown Retiring (%) | 35 | 41 |
| metric_L2 misses per txn (includes code+data+rfo w/ prefetches) | 1,139,373 | 674,635 |
| RPS | 1.0 | 1.40 |
| Cores | 16 | 18 |
| Package Power | 70W | 85W |

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# Cloud Runtime: Software

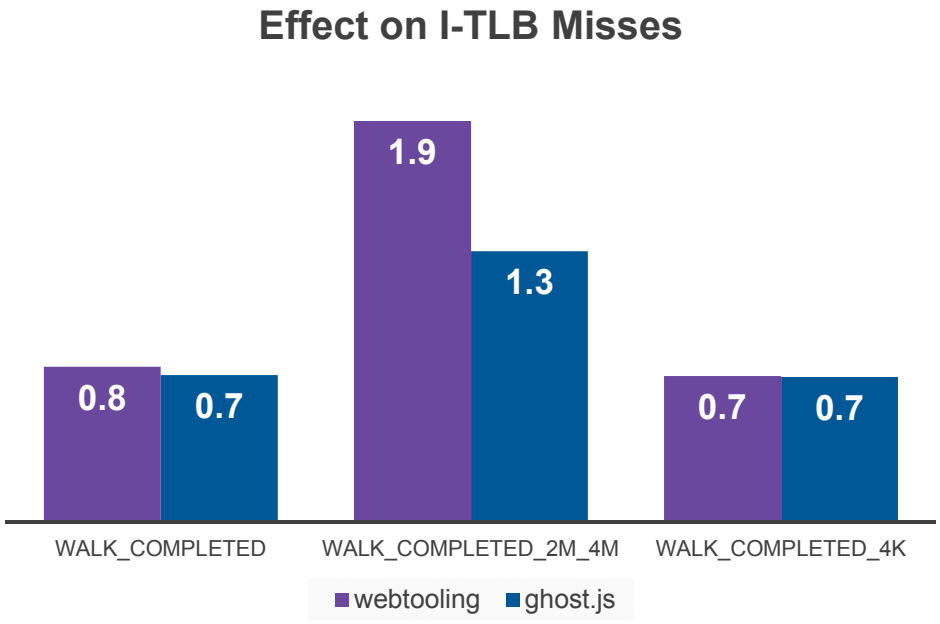
## Reduce I-TLB misses and cycles by using large pages for code

- Remap a subset of .text segment to 2M pages
- Relies on THP through `madvise`
- Reduce 4K walks and Reduce cycles
  - 30% Reduction in 4K Walks

## Benefits longer running workloads

- Ghost.js*: 5%, WebTooling: 3%

**Using 2M Pages reduces I-TLB misses 20-30% & improves perf 3-5%**

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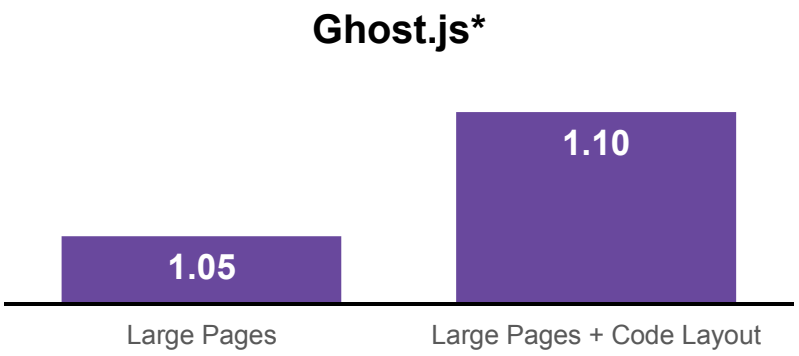
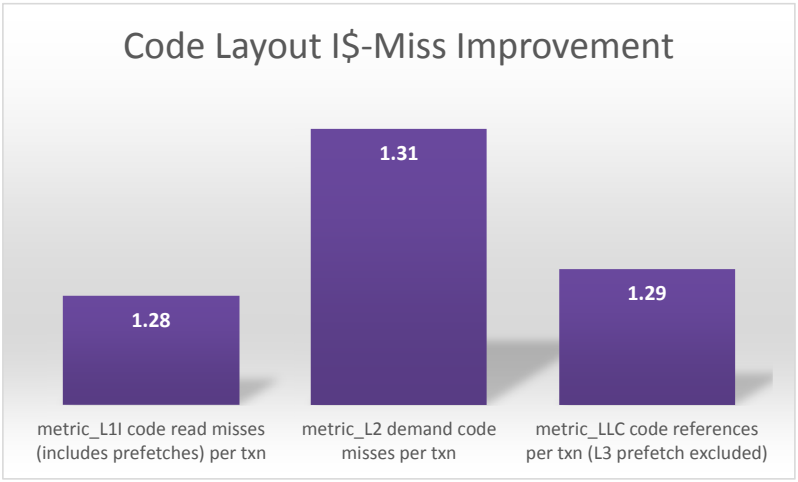
# Cloud Runtime: Software

## Reduce I-Cache Misses through Code Layout Optimization

- Intel CPUs have a feature called last branch records (LBR) where the CPU can continuously log branches to a set of model-specific registers (MSRs).
- Profile guided reordering of the static code in .text reduces L1-I, L2, LLC Code Misses.
- 5-7% Performance improvement

## Combining Optimization:

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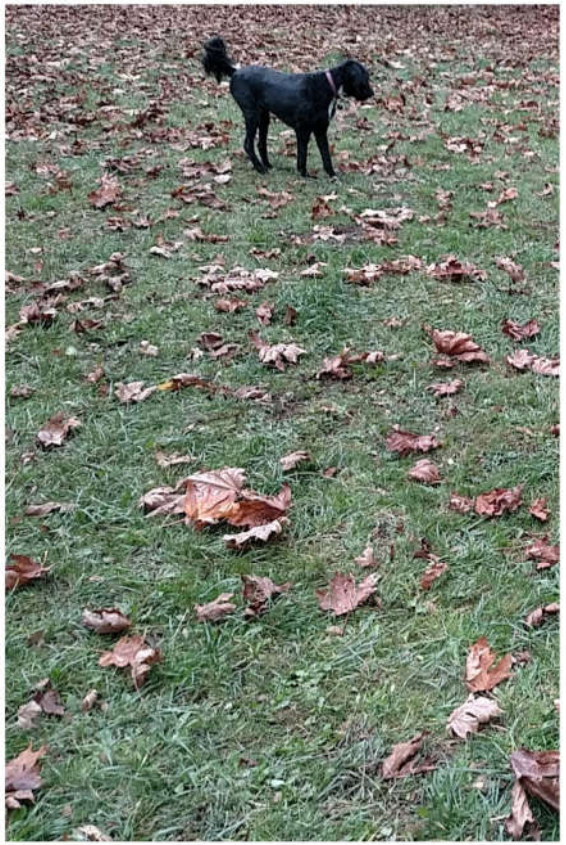
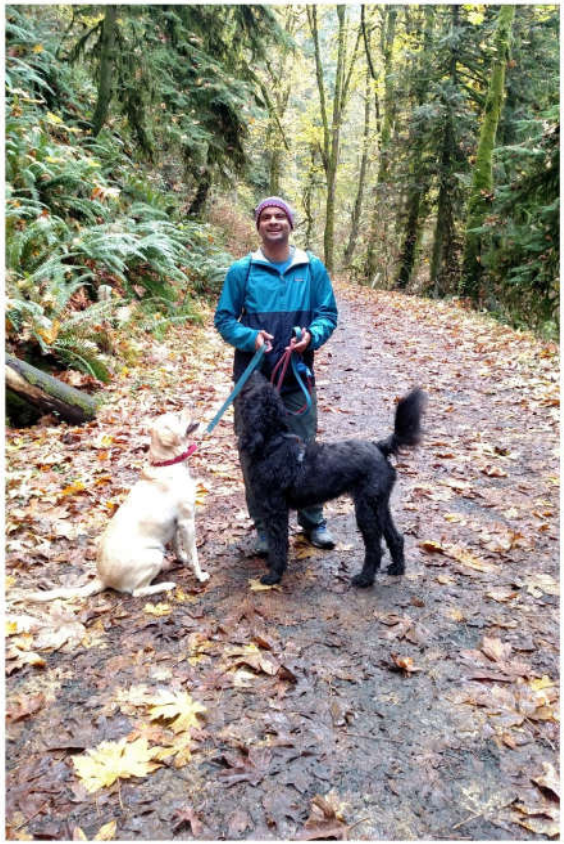
# Cloud Runtimes

Next Steps,
Open Problems
Call to Action

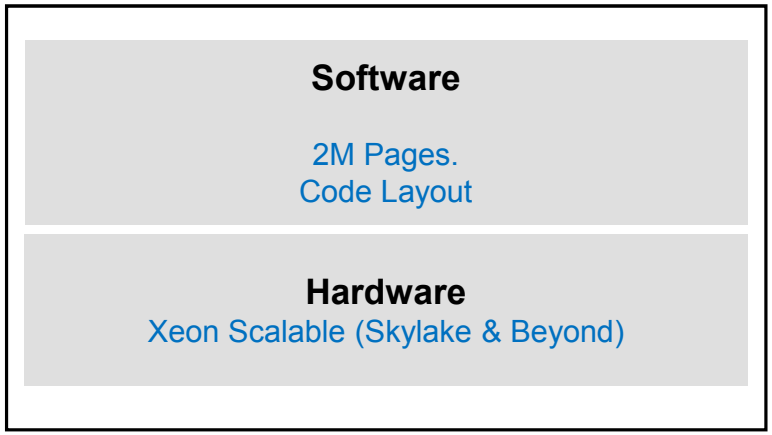




# Next Steps

## Intel Focus:

- Continue to optimize Cloud Runtimes
- Collaborate to address Runtime Bottlenecks
- Enhance our Products
- Develop runtime performance optimization blue print(s)



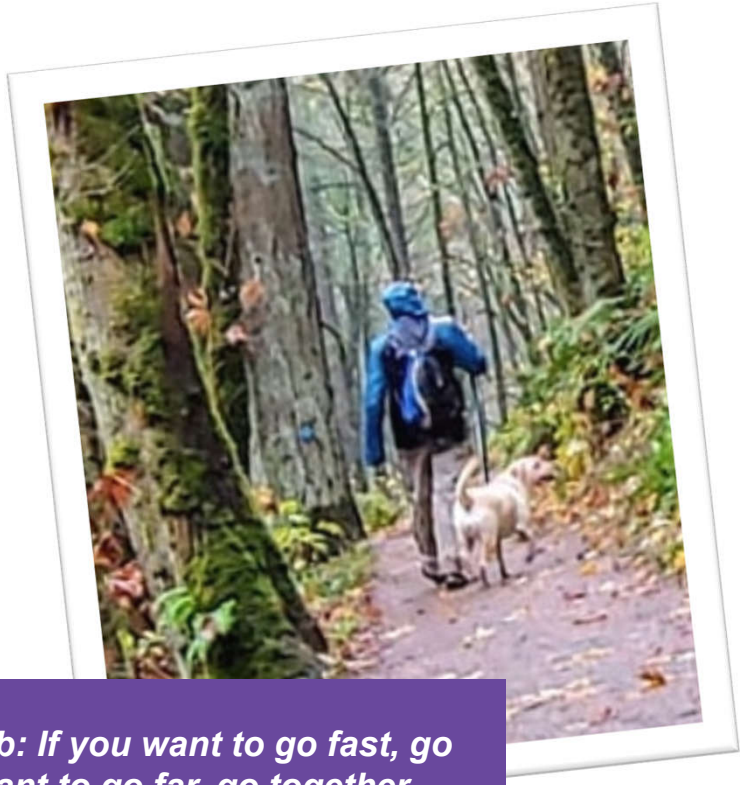
# Open Problems

- Address Frontend problems (I$, I-TLB) in JITs
- Better locality of Native & JIT code
- Better use of SIMD & u-architecture
- Sharing dynamic code across JIT instances
- HW/SW Communication
  - SW Controlled Instruction Fetch
  - SW Control for Indirect Branches

# Call to Action

- Diagnose uarch bottlenecks
- Apply known solutions
- Collaborate on Open Problems

- Contact me suresh.srinivas@intel.com



*African Proverb: If you want to go fast, go alone. If you want to go far, go together.*

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## Collaborate to Solve these Cloud Runtime problems on Intel Architecture

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# Q&A

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# Cloud Runtime: FaaS

## Evolution

- IaaS->PaaS->FaaS
- FaaS business model vs. IaaS business model

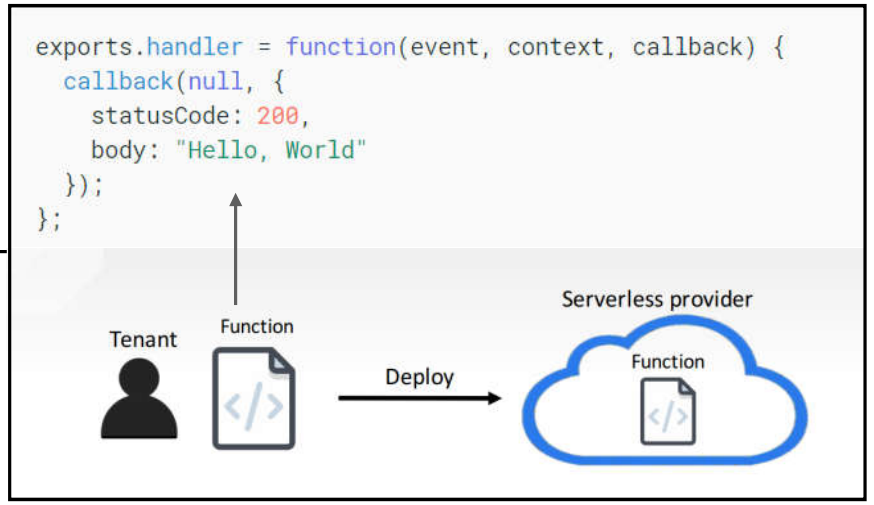
## Pay for Useful Work (Duration of Execution)

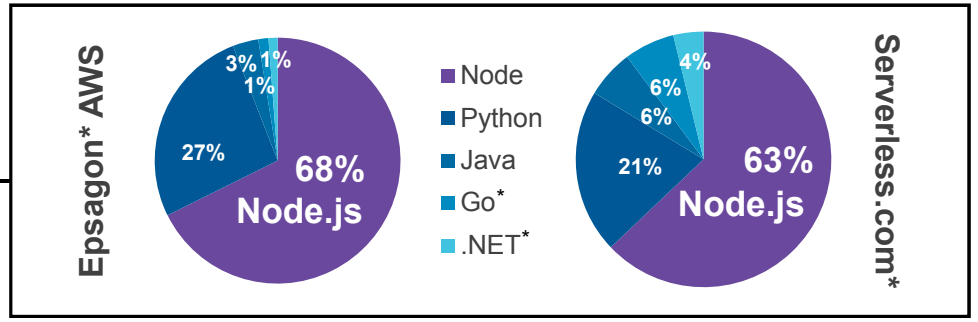
- No effort for server management
- Autoscaling & CSP determines platform for execution

## Function

- From 5 lines to multiple megabytes
- Triggered from an event source

## JavaScript* (with Node.js*) and Python* are leading FaaS languages

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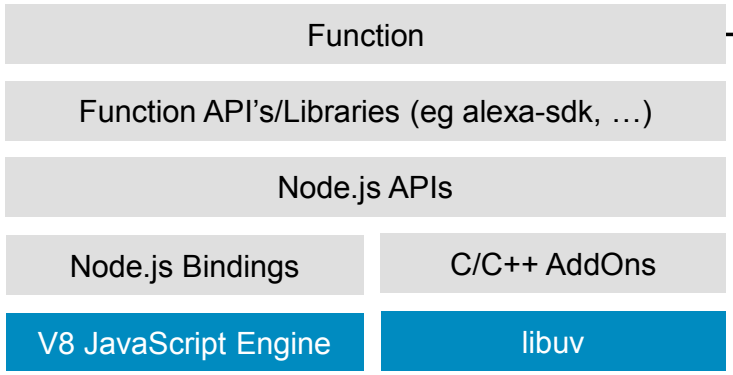
# JavaScript* on Server

- Node.js* is a JavaScript Server runtime built on top of the Chrome* v8 JavaScript engine
- FaaS Function built with Function APIs/Libraries (eg. Alexa-sdk, others)




**Node.js* Stack**

```
const Alexa = require('alexa-sdk');
const anagrams = require('./anagrams');
var handlers = {
     getAnagrams: function() {… }, …
};

export.handler = function (event, c, l) {
 var alexa = Alexa.handler(event, c, l);
 alexa.registerHandlers(handlers);
 alexa.execute();
}
```

**FaaS Alexa* Anagram Skill**
**https://github.com/evanchiu/alexa-anagram**

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# Common Runtime Challenges

- **Runtimes need high performance primitives**
  - Memory & String Operations (memcpy, memchr, …)
  - Compression
  - IA Encoder/Decoder
  - Several rely on system (glibc: In 2019 people are still using glibc 2.17 from 2014)
- **Runtimes need tooling and common infrastructure**
  - LBR Samples decorated to IR
  - Processor-Trace -> JIT
- **Runtimes Libraries don’t expose optimized native**
  - JavaScript/PHP dont expose IA optimized libs