
# MicroFaaS on OpenFaaS:
# An Embedded Platform for Cloud Functions

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# Efficiency of Cloud Computing

**EFFICIENCY OF CLOUD COMPUTING**

The evolution of **cloud computing** was predominantly driven by **efficiency:**

- Cost efficiency
- Resource efficiency
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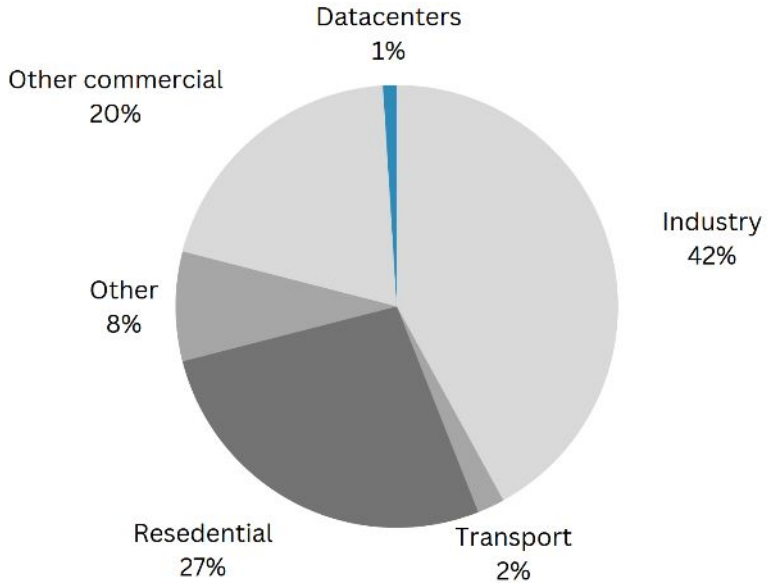
## CURRENT POWER CONSUMPTION

- **~1% of global power** is consumed by datacenters.




*Global Electricity Use by Sector (2020)*

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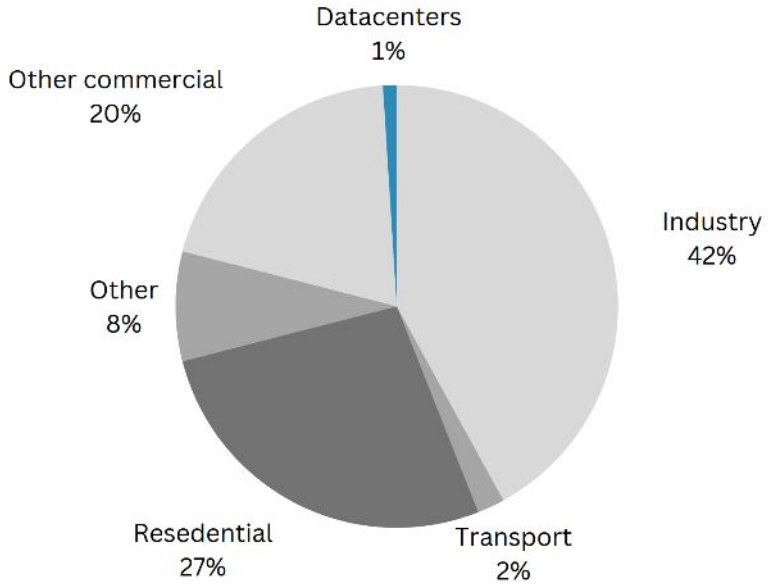


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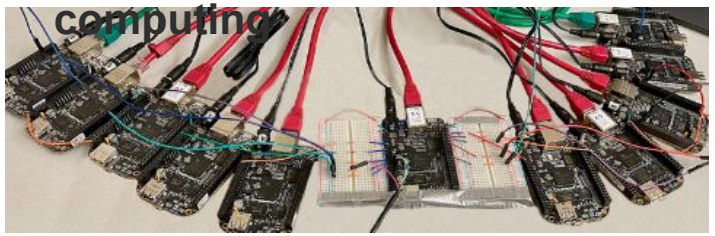
## OUR SOLUTION

- Much of the cloud systems rely on **x86-based servers.**
- By adopting **smaller-scale, energy-efficient hardware,** power consumption can significantly be reduced.
- **MicroFaaS: an embedded platform for serverless computing**



# What is FaaS?

- **FaaS:** Cloud-based software for users to execute short-lived, stateless, loosely-coupled functions.

- Benefits include:
  - Greater scalability
  - Reduced development time
  - Easier maintenance



Google Cloud

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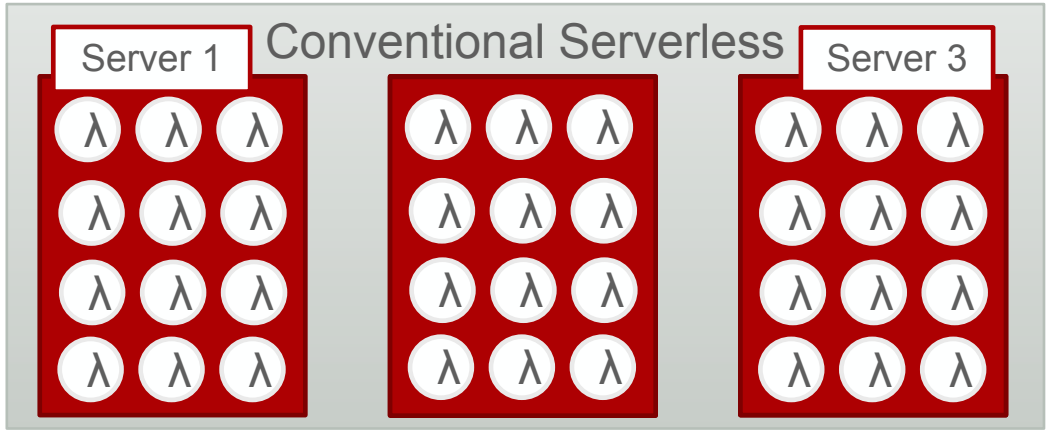
  - Each function, also known as **lambdas,** are executed in VMs or containers that run on a **x86-based servers.**



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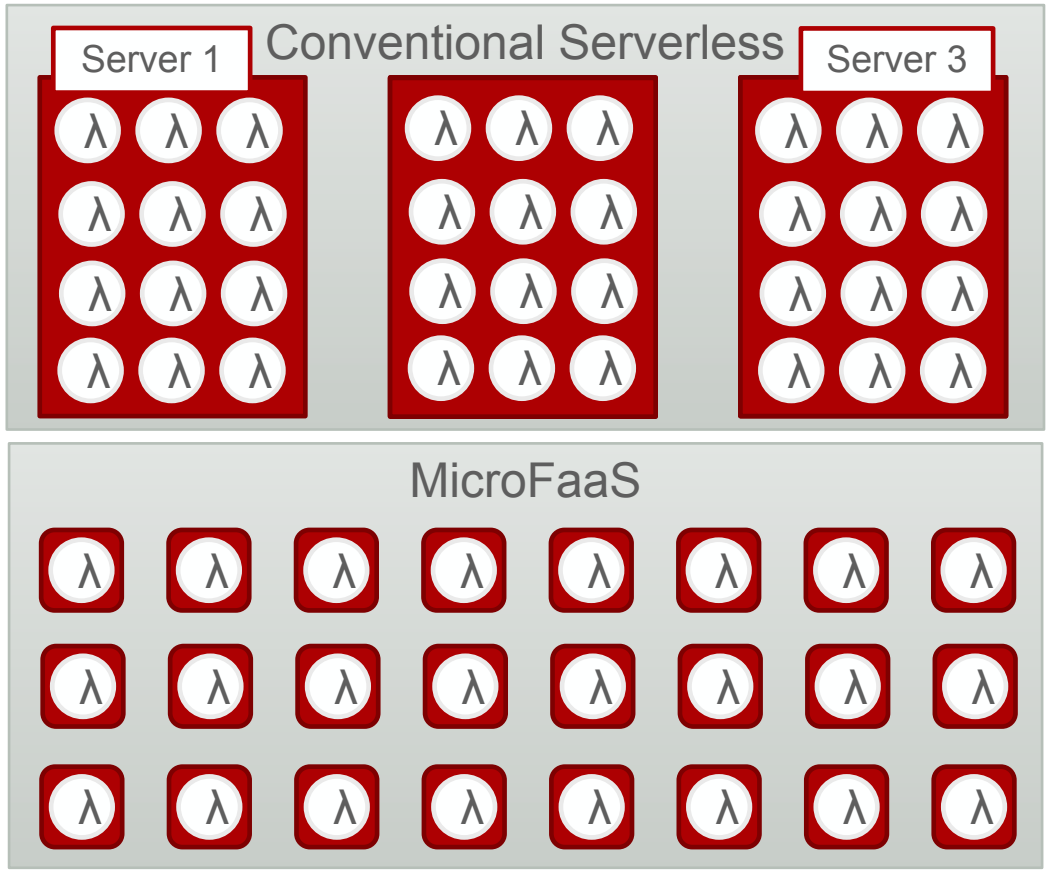
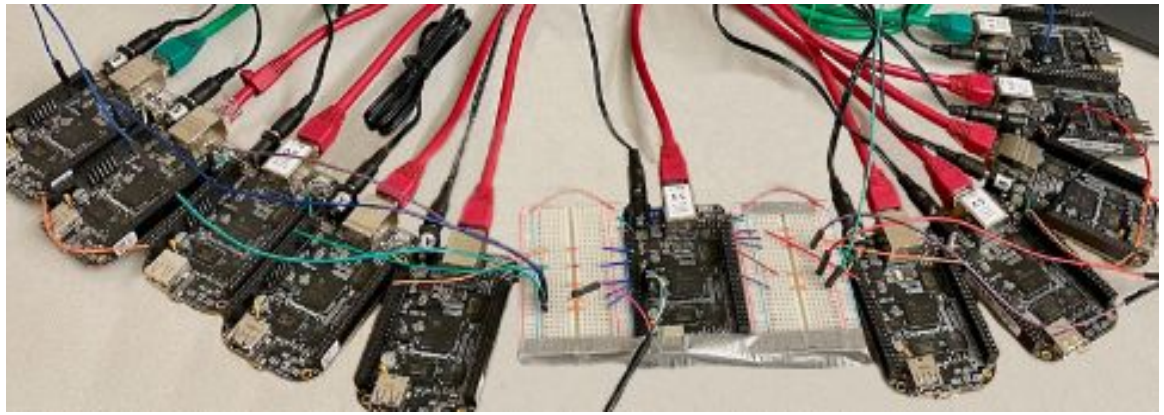
- **MicroFaaS**: Serverless on many small, energy-efficient, hardware-isolated, virtualization-free, ARM-based nodes.



# MicroFaaS Architectural Overview

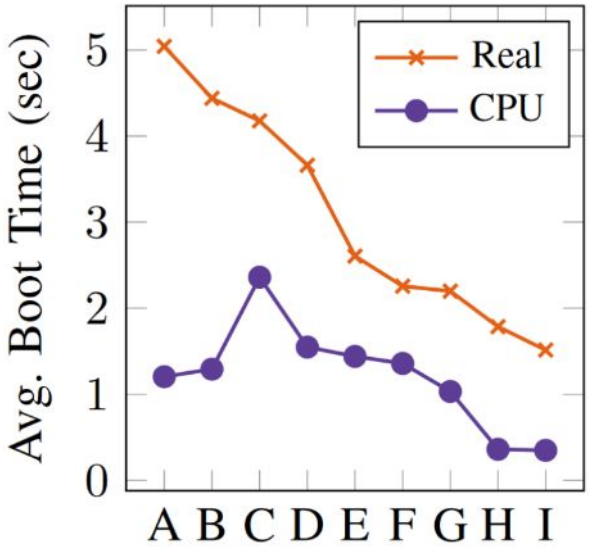
- **Compute nodes:** Inexpensive, low-power single-board computers (SBCs).
- **OS:** Barebone Linux kernel.
- **Execution Model:** Single tenant, run to completion.
- **Security Model**: Hardware isolation, post-execution reboot.
- **Energy Model:** Power down when idle.



# MicroFaaS Prototype

- **MicroFaaS System includes:**
  - 10 BeagleBone Black (BBB) worker nodes.
  - 1 BBB orchestrator node.
- Prepared worker OS with MicroPython.
  - Boots to interpreter in 1.5s on ARM.
- Lowered boot times of the workers by **2.1x**

(Byrne et al., DATE 2022).




| | Optimization |
|---|---|
| **A** | Linux 5.11 default config |
| **B** | Kernel config reduction |
| **C** | Python → MicroPython |
| **D** | rootfs → initramfs |
| **E** | Enab. UBoot falcon mode |
| **F** | Disab. Ethernet auto-neg |
| **G** | Disab. PHY soft reset |
| **H** | DHCP → static IP |
| **I** | Net-config in kernelspace |

# OpenFaaS

- **OpenFaaS:** Framework to execute serverless functions without worrying about cloud infrastructure.

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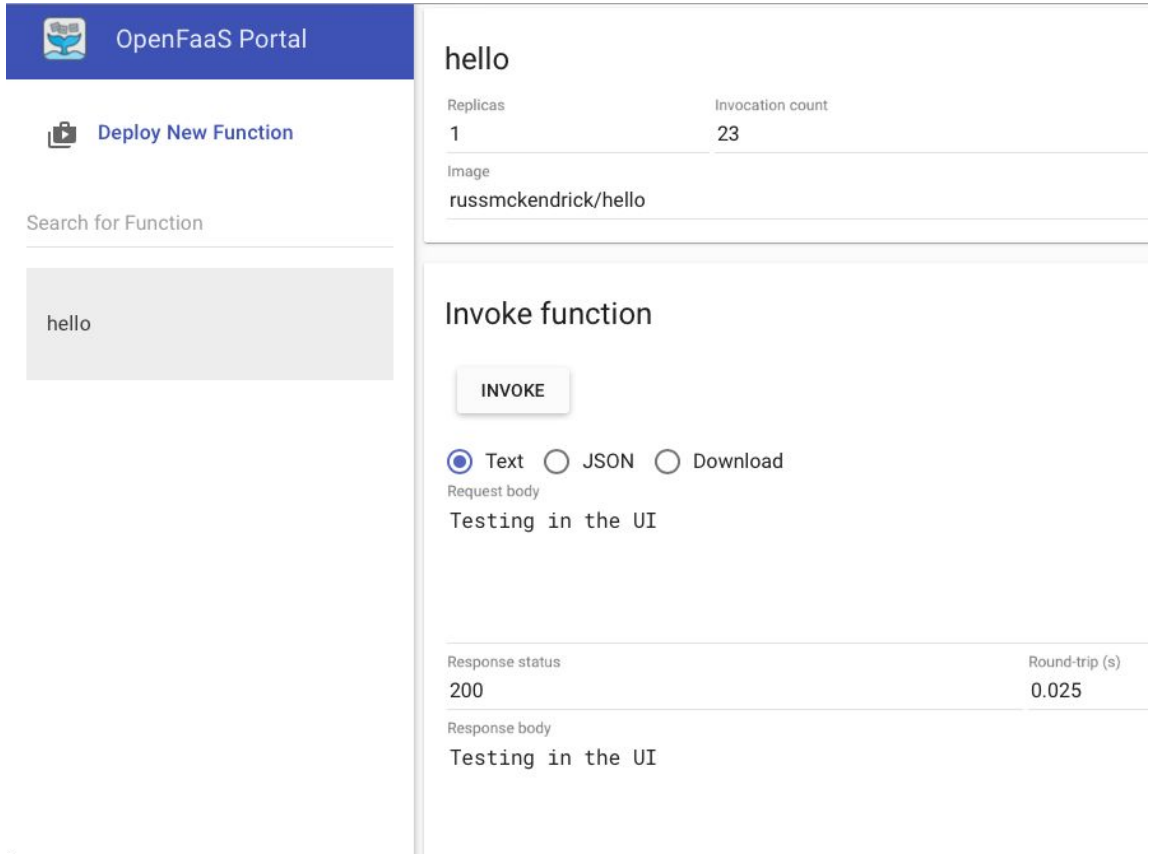
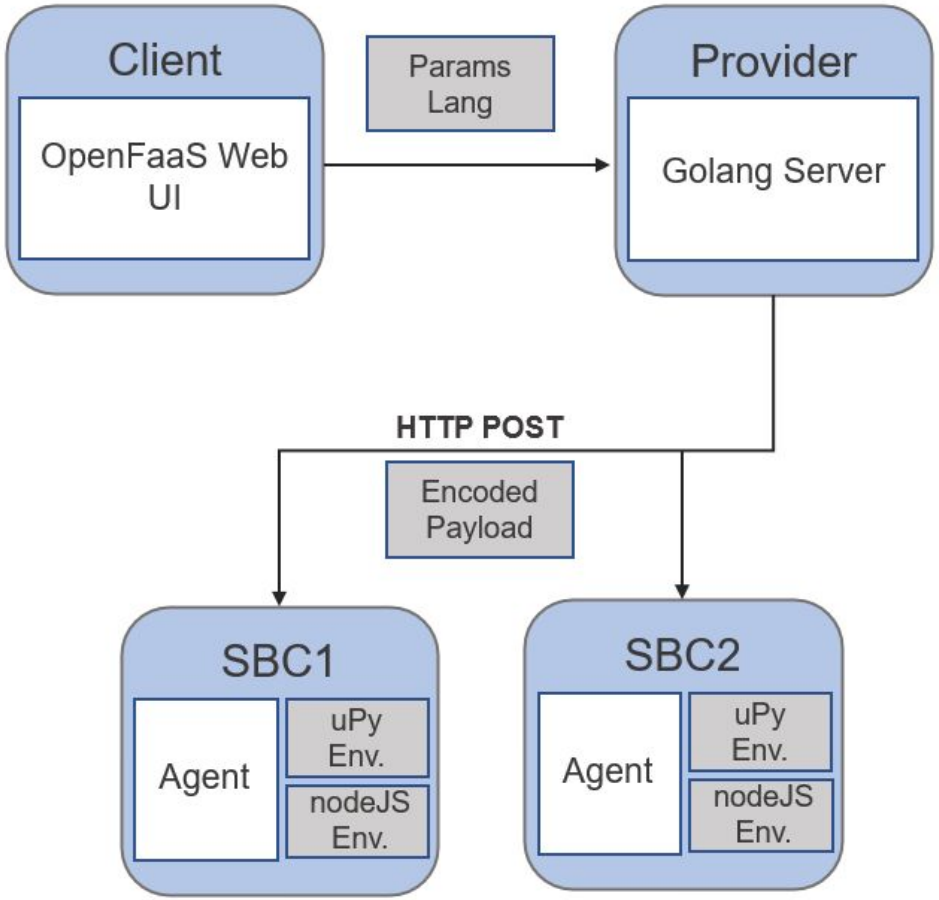


# OpenFaaS

- **OpenFaaS:** Framework to execute serverless functions without worrying about cloud infrastructure.
- **OpenFaaS** allows users to access a simple interface to run serverless functions on **MicroFaaS.**
- **MicroFaaS** uses OpenFaaS gateway to link the provider's HTTP endpoint with the OpenFaaS UI.



# MicroFaaS Evaluation

- **MicroFaaS vs x86 Server (12 core AMD processor)** to run FaaS applications via OpenFaaS.
- Synthesized 15 common FaaS function to evaluate computational and energy performance of **MicroFaaS.**

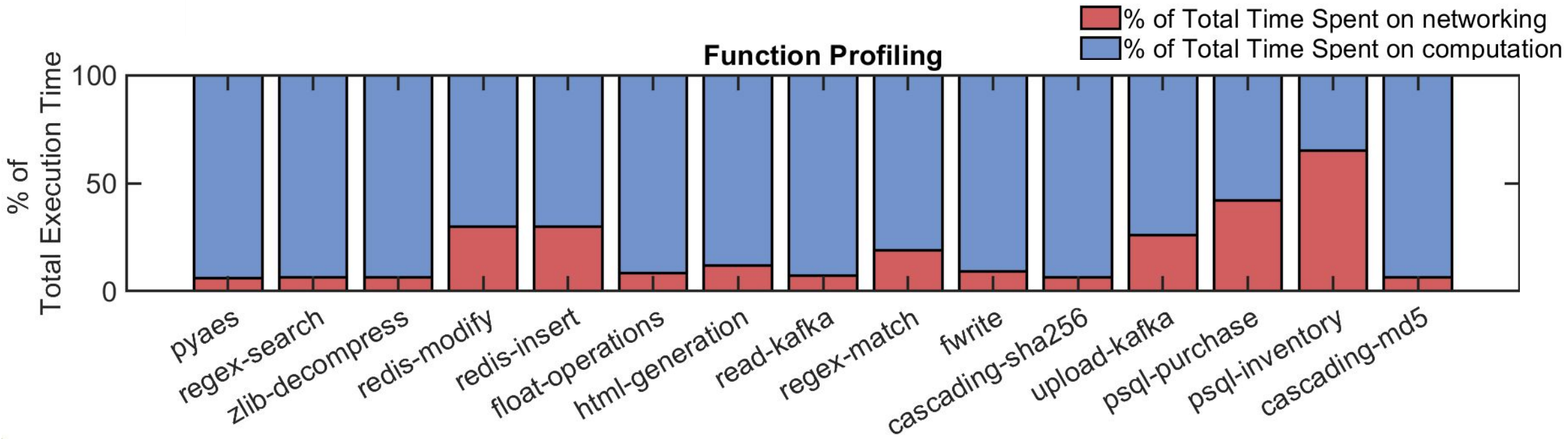
| Name | Description |
|---|---|
| **FloatOps** | Floating-point trigonometric operations. |
| **CasSHA** | SHA256 cascading. |
| **CasMD5** | MD5 cascading. |
| **Fwrite** | Write to a file. |
| **HTMLGen** | Generate HTML. |
| **Decompress** | Extract a compressed string. |
| **AES128** | AES128 Encrytion/decryption. |
| **RegExSearch** | Find string matches in input. |

| Name | Description |
|---|---|
| **RegExMatch** | Determine if string matches input. |
| **RedisInsert** | Insert redis key-value record. |
| **RedisUpdate** | Update redis key-value record. |
| **SQL Select** | Using SELECT to query PSQL server. |
| **SQL Update** | Using UPDATE to query PSQL server. |
| **MQProduce** | Send message to Kafka topic. |
| **MQConsume** | Receive message from Kafka topic. |

Adapted from or inspired by *FunctionBench*

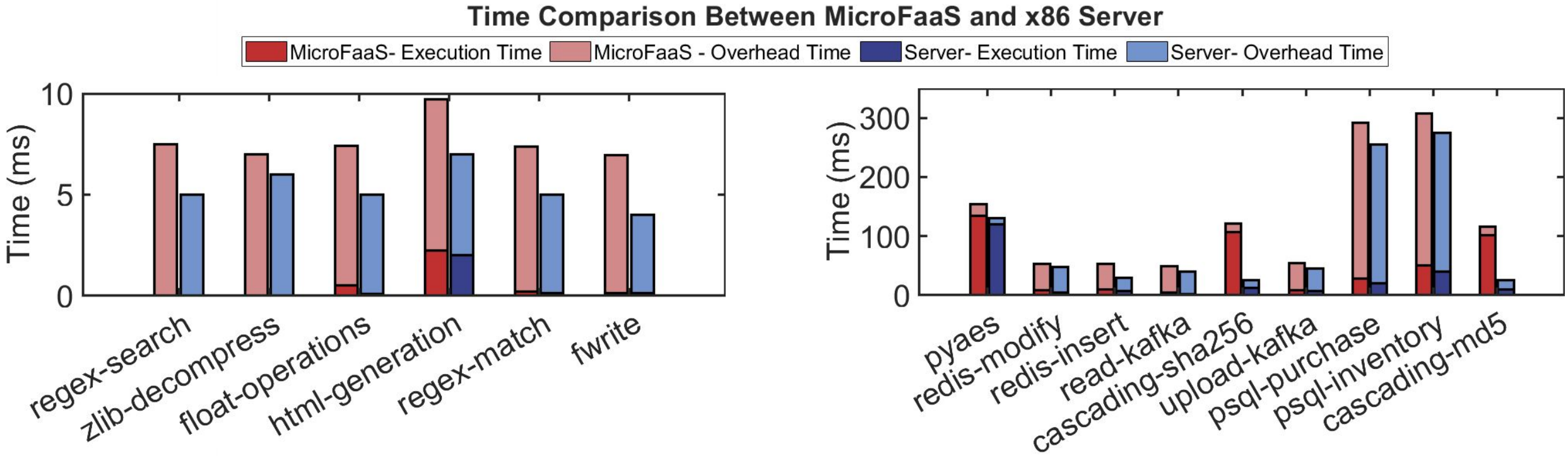
# Workload Function Profiling

- The workload functions were **profiled** to determine the behavior of these functions.
  - **perf: CPU related** performance.
  - **nload: network related** parameters.



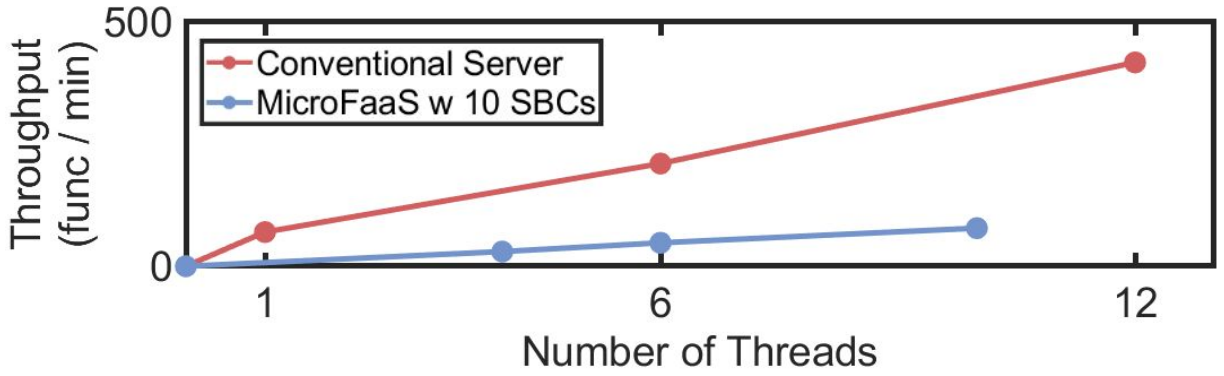
# MicroFaaS Time Evaluation

- **Execution Time:** Time taken to execute a function.
- **Overhead Time:** Time spent on worker nodes receiving function input(s) and returning the output.



# MicroFaaS Energy Evaluation

- X86-based server has a **higher throughput** than MicroFaaS.



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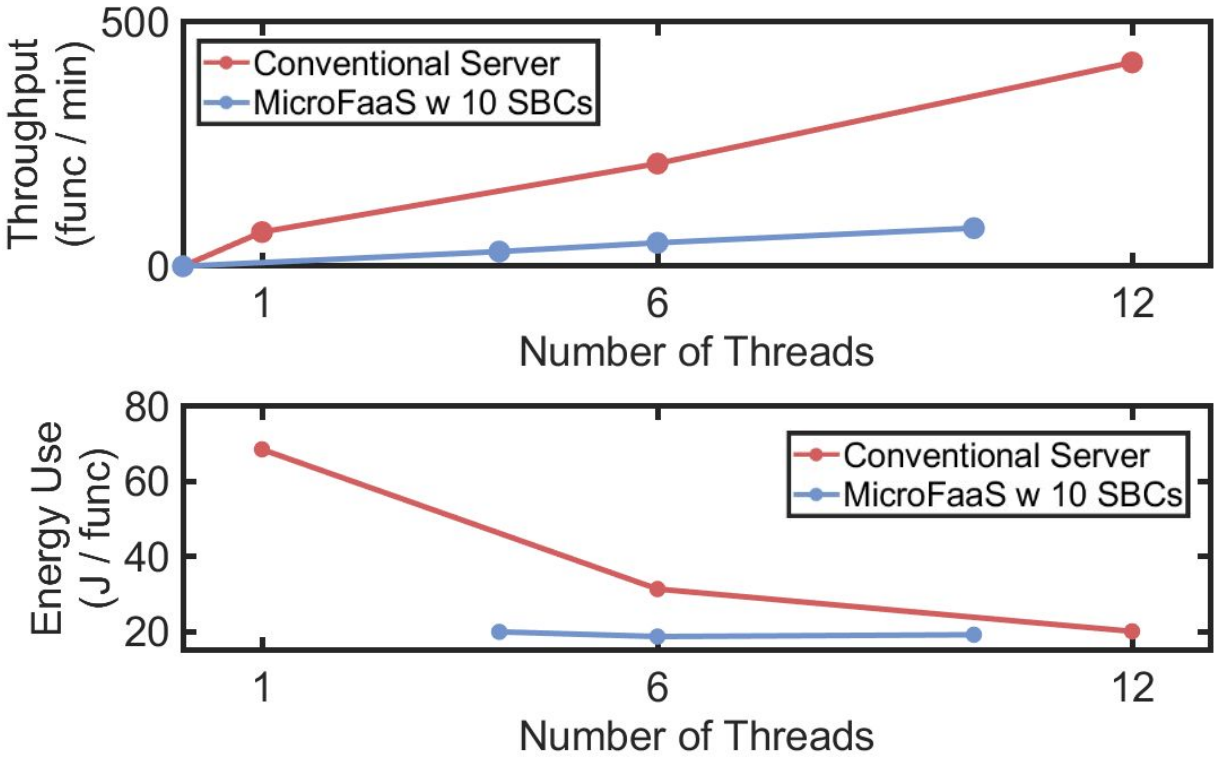
- On average, MicroFaaS consumes **~20J** to execute a function, while the x86 server consumes **~40J**.



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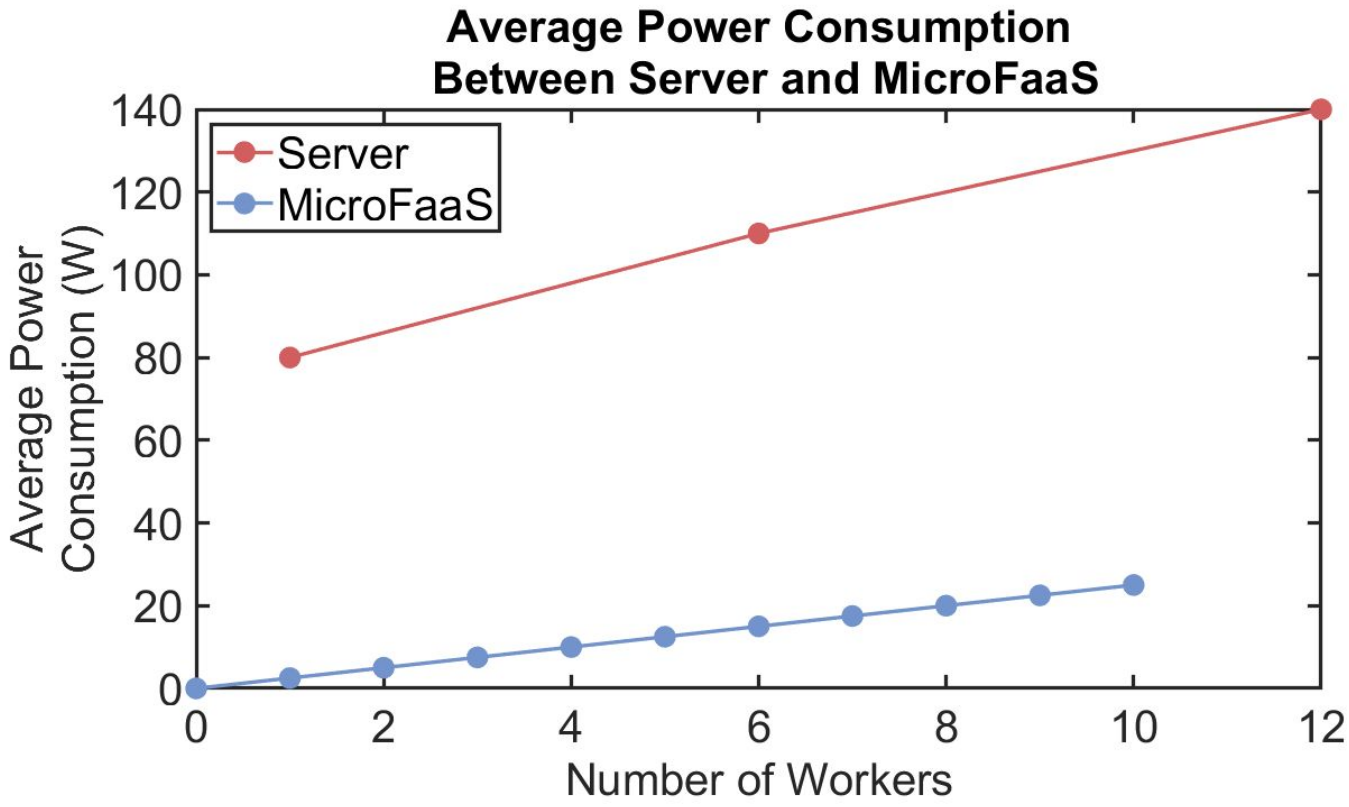
- On average, MicroFaaS consumes **~20J** to execute a function, while the x86 server consumes **~40J**.
- MicroFaaS uses, at most, **25% of the power consumed per function** compared to the x86 server.



# MicroFaaS Cost Analysis

- Compare cost of running on **conventional serverless platforms** versus **MicroFaaS** over 5 years.
  - Conventional: 41 servers + 1 ToR switch.
  - MicroFaaS: 989 SBCs + 21 ToR switches.

**Ideal:** fully utilized & nothing breaks.

| | **Ideal** *(100% Util, 100% OR)* | |
|---|---|---|
| **Expense** | Conventional | MicroFaaS |
| **Compute** | $82,451 | $51,923 |
| **Network** | $574 | $12,280 |
| **Energy** | $41,303 | $17,884 |
| **Total** | $124,328 | $82,087 |

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**Realistic:** 50% utilized & 5% of nodes break.

| | **Ideal** *(100% Util, 100% OR)* | | **Realistic** *(50% Util, 95% OR)* | |
|---|---|---|---|---|
| **Expense** | Conventional | MicroFaaS | Conventional | MicroFaaS |
| **Compute** | $82,451 | $51,923 | $86,791 | $54,655 |
| **Network** | $574 | $12,280 | $574 | $12,280 |
| **Energy** | $41,303 | $17,884 | $29,056 | $11,778 |
| **Total** | $124,328 | $82,087 | $116,421 | $78,713 |

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- **MicroFaaS ~33% cheaper than conventional platforms.**

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# Conclusion

- MicroFaaS is **~2x more power-efficient** than conventional rack servers.
- MicroFaaS is **~33% cheaper** than the x86-based rack server due to
  - Inexpensive SBCs.
  - Energy proportionality design of SBCs.
- **MicroFaaS on OpenFaaS** provides an energy- and cost-efficient alternative to standard FaaS platforms.