Towards Federated Learning Using FaaS Fabric

Mohak Chadha, Anshul Jindal, Michael Gerndt
mohak.chadha@tum.de, jindal@in.tum.de, gerndt@in.tum.de
Chair of Computer Architecture and Parallel Systems,
Technical University of Munich (TUM)
Garching (near Munich), Germany

https://www.serverlesscomputing.org/wosc6/#p9
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
Motivation

Top Growing Cloud Services

<table>
<thead>
<tr>
<th>PLACE</th>
<th>SERVICE</th>
<th>2019</th>
<th>2020</th>
<th>GROWTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IoT</td>
<td>29%</td>
<td>35%</td>
<td>21%</td>
</tr>
<tr>
<td>2</td>
<td>Container-as-a-service</td>
<td>48%</td>
<td>56%</td>
<td>17%</td>
</tr>
<tr>
<td>3</td>
<td>Machine learning/Al</td>
<td>35%</td>
<td>41%</td>
<td>17%</td>
</tr>
<tr>
<td>4</td>
<td>Data warehouse</td>
<td>50%</td>
<td>56%</td>
<td>12%</td>
</tr>
<tr>
<td>5</td>
<td>Serverless</td>
<td>43%</td>
<td>48%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Trend for Search Term: Federated Learning

Source: https://blogs.nvidia.com/blog/2019/10/13/what-is-federated-learning/

tff.federated_computation(lambda: 'Hello, World!')()
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
Federated Learning
FaaS Fabric
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
Goals

1. Extension of FaaS to multiple heterogeneous FaaS platforms.
3. Ease of use.
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
System Design

FedKeeper

MongoDB Object Store

Client Register
Weights Updater
Client Invoker

FL Server {⋯}

Server Manager

OpenWhisk local

invoker-function {⋯}

Client Function

 invoker-function {⋯}

Client Weights

 invoker-function {⋯}

Updated Weights

 invoker-function {⋯}

 invoker-function {⋯}

 invoker-function {⋯}

 invoker-function {⋯}

Edge 1
Client {⋯}

Edge 2
Client {⋯}

Edge 3
Client {⋯}

OpenFaaS

OpenWhisk local

Google Cloud Platform
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
OpenWhisk (OW)
- Deployed over a single node Kubernetes Cluster (On-premise)
- Two sockets, Intel Cascade Lake-SP, 22 cores each

OpenFaaS (OF)
- Edge Cluster with 3 Nvidia Jetson Nano Devices (On-premise)
- K3s as the container-orchestration system

Google Cloud Functions (GCF)
- Each platform runs Tensorflow
- Evaluation on a Image Classification Task
- Two architectures:
  - 2-layer Fully connected NN
  - CNN

<table>
<thead>
<tr>
<th>Configuration</th>
<th>OW</th>
<th>OF</th>
<th>GCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>2 GiB</td>
<td>2 GiB</td>
<td>2 GiB</td>
</tr>
<tr>
<td>FL-Clients</td>
<td>7</td>
<td>3</td>
<td>93</td>
</tr>
</tbody>
</table>
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
Increasing Parallelism and local computation

**NN, 5 local epochs**

**CNN, 5 local epochs**

**NN, 10 local epochs**

**CNN, 10 local epochs**
Accuracy Across Communication Rounds

NN

CNN

Test Set Accuracy

Communication Rounds

local-epochs=5
local-epochs=10

Test Set Accuracy

Communication Rounds

local-epochs=5
local-epochs=10

Mohak Chadha | Towards Federated Learning Using FaaS Fabric | WoSC6
Performance Across Communication Rounds

- **NN**
  - local-epochs=5
  - local-epochs=10

- **CNN**
  - local-epochs=5
  - local-epochs=10
Time Distribution

- CNN (cold start)
- CNN
- NN (cold start)
- NN

Legend:
- Aggregation time
- Aggregator start time
- Training time
- Clients start + training time
- Invokers start time
- Invocation time
Outline

- Motivation
- Background
- Goals
- System Design
- Experimental Setup
- Results
- Conclusion and Future Work
Conclusion and Future Work

- Manageability
- Simplicity
- Scalability

Future Work

- Optimizing FedKeeper’s Performance
- Compute-aware scheduling of Clients on heterogeneous devices
- Dynamic addition/removal of clients
- Integration of privacy solutions
We are..

**Edge-Cloud, IoT, HPC RG @ Chair of Computer Architecture and Parallel Systems**

**Technical University of Munich**

- **P.hD. Student**
  - Mohak Chadha
- **P.hD. Student**
  - Anshul Jindal
- **Prof. Dr. Michael Gerndt**

**Research Areas:**
- Dynamic Resource Management HPC/Cloud
- Function scheduling in heterogeneous FaaS platforms
- Modelling of microservices/FaaS applications
- AI for smart Cloud operations (anomaly detection and failure predictions) and many more..

Visit Us!

Mohak Chadha | Towards Federated Learning Using FaaS Fabric | WoSC6
Contact

Thank you for your attention!

Questions?

mohak.chadha@tum.de