eSAAM 2023

on Cloud to Edge Continuum

FlexConnect: Mobile Computational Offloading

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Context

- Makerspaces provide AI-based computational support
- Aalborg requires makerspace to
  - Shut-down EVERYTHING when closed
  - Delete data before closing

Problem

*"How can we **provide computational power** to its users at **various locations without loss of progress** using **computational offloading?**"*

Goal

*How to develop an edge-based system that allows computational tasks to be executed and **interrupted/resumed** from edge nodes **without loss of progress**.*

Requirements – User and App

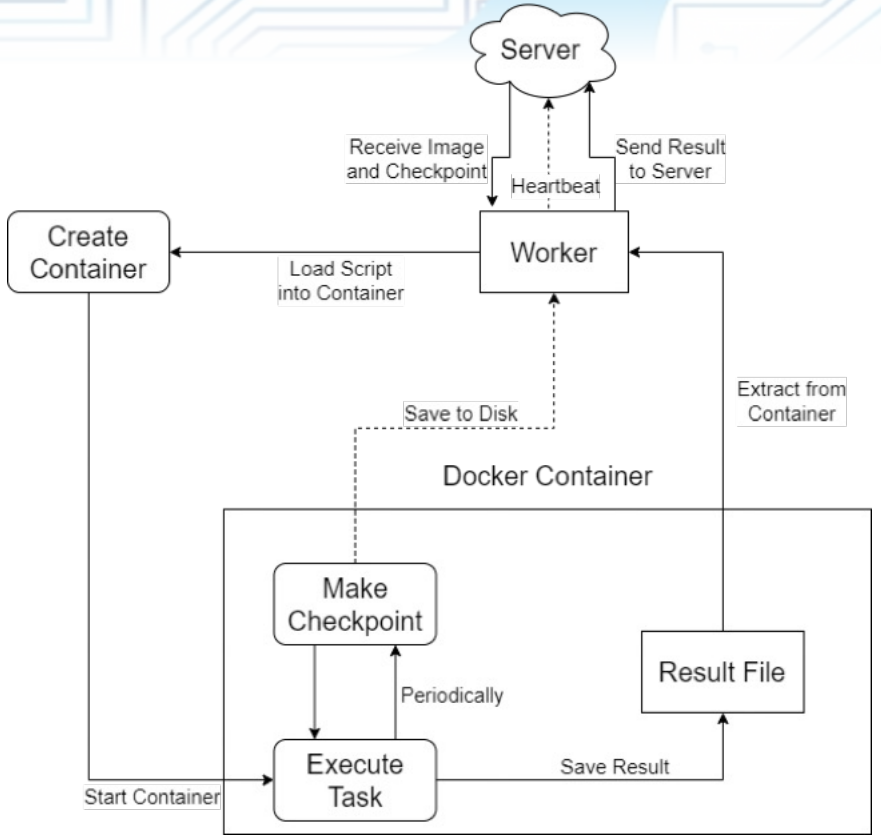
- A user can:
  - Upload a job to the system
  - Download the result from their job
  - Authenticate
  - Can see their job history
  - See the status of their job
  - Can pause and resume a running job
  - See the provider locations,
  - See the distance to provider locations.
- The application implements a user interface.

Requirements - System

- The system and application are connected wirelessly
- The system can:
  - Detect nearby users
  - Has a queuing system for jobs
  - Can handle data-intensive jobs
  - Will notify a user when a job is complete
  - The system must be also secure

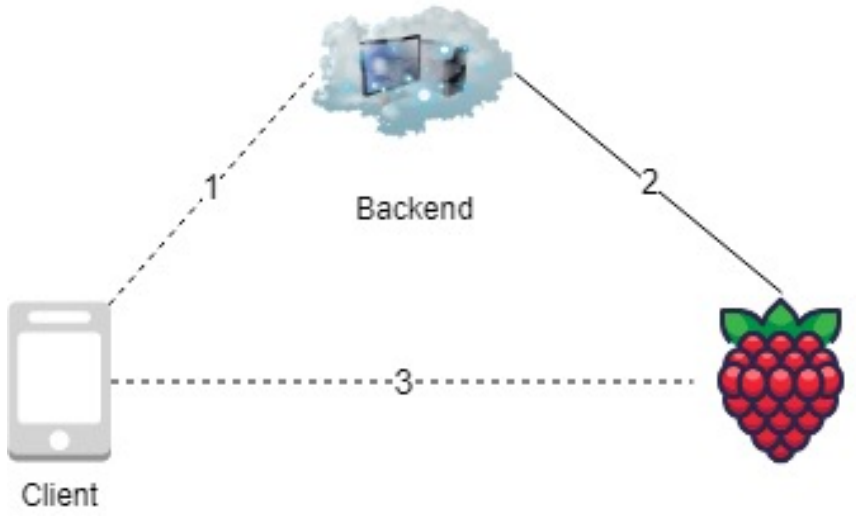
Proposed Solution - Workrs

- **Once the Job is received the worker creates the container**
- **Execute the tasks while:**
  - Creating checkpoints
  - Send heartbeat to the orchestrator
- **Once the process is done send the result to the orchestrator, which sends it to the server.**



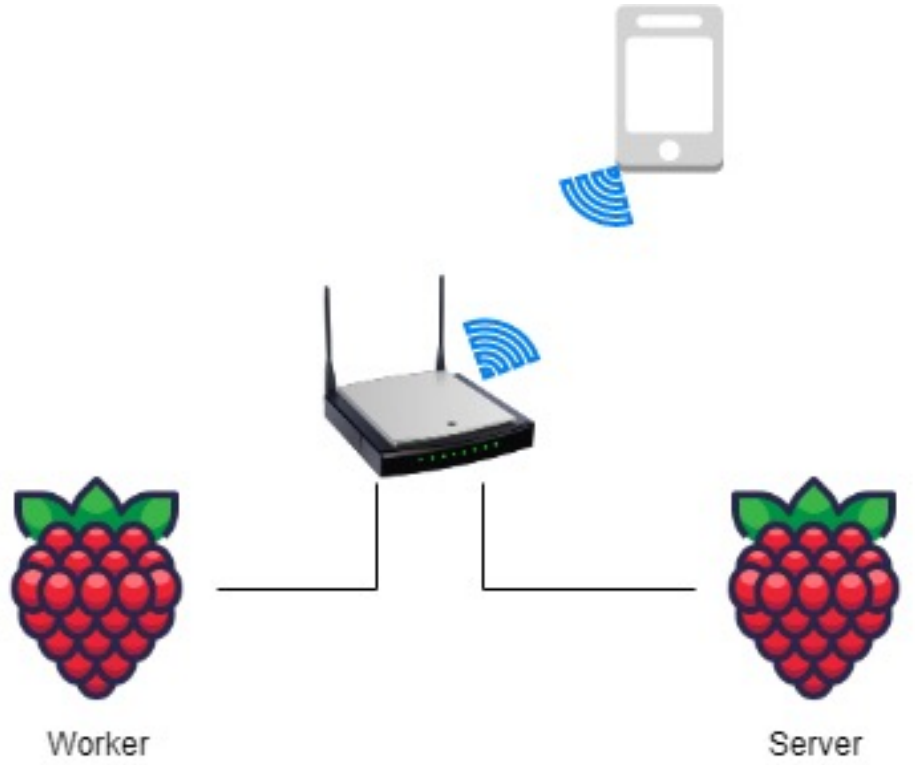
Proposed Solution - Communication

1. Initial connection to the backend: used for business logic such as user information, jobs overview, and starting or stopping jobs
2. Workers' connection to the backend: used for both logic and data flow connection
3. Direct connection from the users' mobile device to the worker: used for data flow, internet to the users' device.



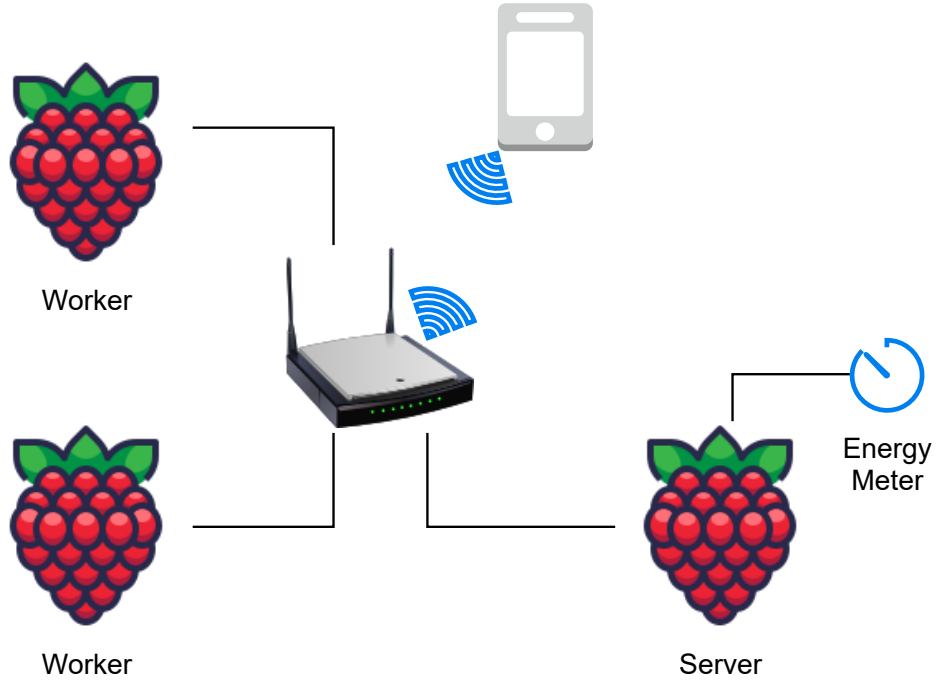
Implementation

- Physical Setup
  - 2x Raspberry Pi 4b (4GB Ram)
  - 1x Internet Router/Network Switch
  - 1x Mobile Android Device
- Raspberry Pi worker unit and FTP server
- Raspberry Pi backend and message broker
- Mobile device client unit
- In the prototype implemented instead of using a WebDAV connection, an FTP solution has been implemented.

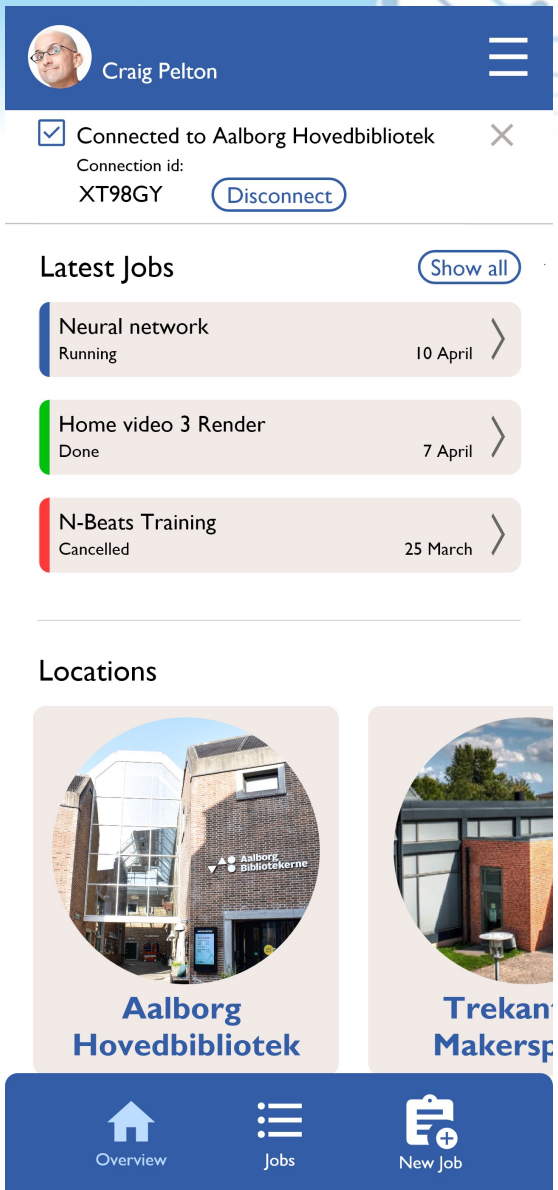


Testing Prototype

- Physical Setup
  - 2x Raspberry Pi 4b as workers
  - 1x Raspberry Pi 4b as Backend and Coordinator
  - 1x Internet Router/Network Switch
  - 1x Mobile Android Device
  - 1x Energy meter to measure energy consumption of checkpointing on the system.



The application Prototype



Testing

- **Test script** which multiplied matrices, simulating tasks performed by the worker unit.
- A **calculated failure time** was sent to the worker after which the worker would emulate a hardware failure.
  - Calculated through a semi-random calculation based on a given failure rate μ.

	Failure rate μ	Number of checkpoints
1.	0.0001	0
2.	0.0001	15
3.	0.0005	0
4.	0.0005	1
5.	0.0005	15
6.	0.003	0
7.	0.003	5
8.	0.003	15
9.	0.0131	0
10.	0.0131	11
11.	0.0131	15

Table 1: Test cases for the automatic testing system.

Conclusion

- Design and implementation of a mobile computational offloading system
- Ability to checkpoint user computations and resume progress at a later point.
- Users can divide their computational work into smaller chunks.
- MVP prototype created.

Future Work

- Implementation of missing features:
  - Queuing system
  - Increased security (Encryption)
  - Docker validation
  - Systematic testing process (ex. Stress test)
- GPU support
- Support for more workload types
- Support for Federated Learning

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