UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Integrating Mobile IoT Devices into the Arrowhead Framework Using Web of Things

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Outline

- Integration of legacy IoT devices within the Arrowhead Framework (AHF) through WoT
- Using WoT towards mobility/migration support
- Performance evaluation
- Conclusions and future work

Integration of legacy IoT devices within the AHF through WoT

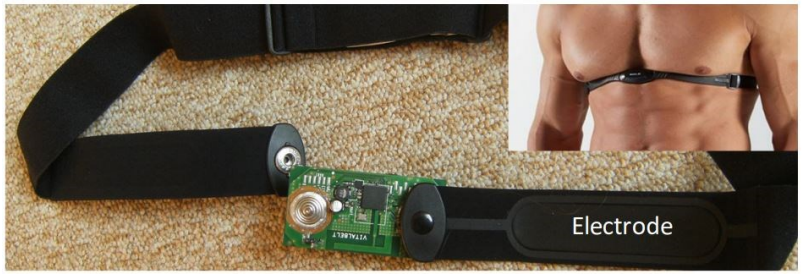
- The **Arrowhead Framework** (AHF) is an open-source platform for IoT interoperability and is currently supported as a project of the Eclipse Foundation[2]

- Developed across several EU projects. We specifically worked in the Arrowhead Tools EU project[3]
  - Main Objective: provide tools, platforms, engineering processes towards industrial automation
  - 80+ Partners from 18 EU Countries
  - 3 Years (May 2019 – July 2022)

- **Legacy devices:** Devices that do not natively talk the same language nor use the same protocols of AHF entities.

[2] https://projects.eclipse.org/projects/iot.arrowhead
[3] https://www.arrowhead.eu/arrowheadtools

Integration of legacy IoT devices within the AHF[3]



ECG device[4]

Size: 6.5 cm x 3.4 cm

BOM cost: <10$

Battery life: five days

Sampling rate: 320 Hz

Transmission rate: 5 kbps

Smart plug[5]

Size: 7.7 cm x 5.7 cm (without external case)

BOM cost: <15$

Monitors: active and reactive power, voltage, and current.

Remotely turn it on or off

[3]Work carried out within the scope of the **Arrowhead Tools** EU project: https://www.arrowhead.eu/arrowheadtools

[4]E. Spanò, S. Di Pascoli, and G. Iannaccone, "Low-power wearable ECG monitoring system for multiple-patient remote monitoring," IEEE Sensors Journal, vol. 16, no. 13, pp. 5452–5462, 2016.

[5]E. Spanò, L. Niccolini, S. D. Pascoli, and G. Iannaccone, "Lastmeter smart grid embedded in an Internet-of-Things platform," IEEE Transactions on Smart Grid, vol. 6, no. 1, pp. 468–476, 2015.

Web of Things (WoT) – Main Components

Web Thing

- Abstracts a physical or virtual entity
- Has a JSON **Thing Description** (TD) associated

Consumer

- Fetches and processes TD
- Instantiates a Consumed Thing

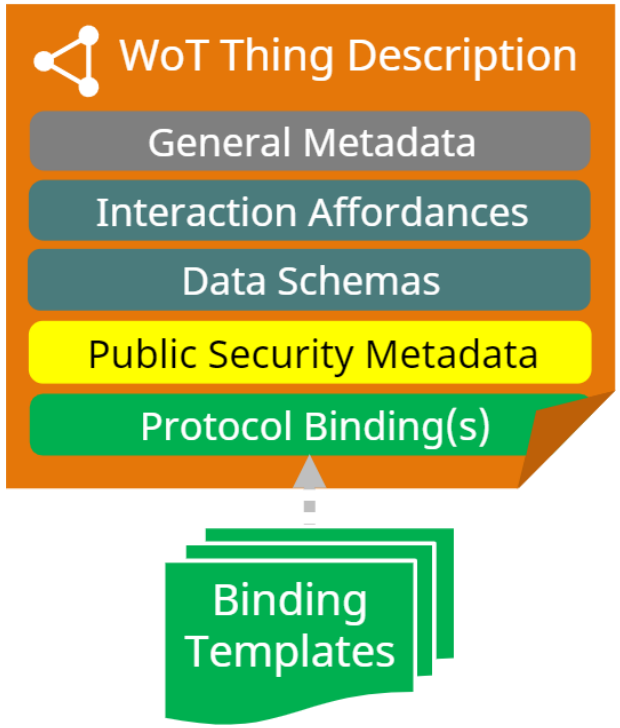
Servient

- A software environment that can expose and/or consume Web Things

Exposer

- Advertises TD
- Instantiates an Exposed Thing

Thing Description



Interaction Affordances

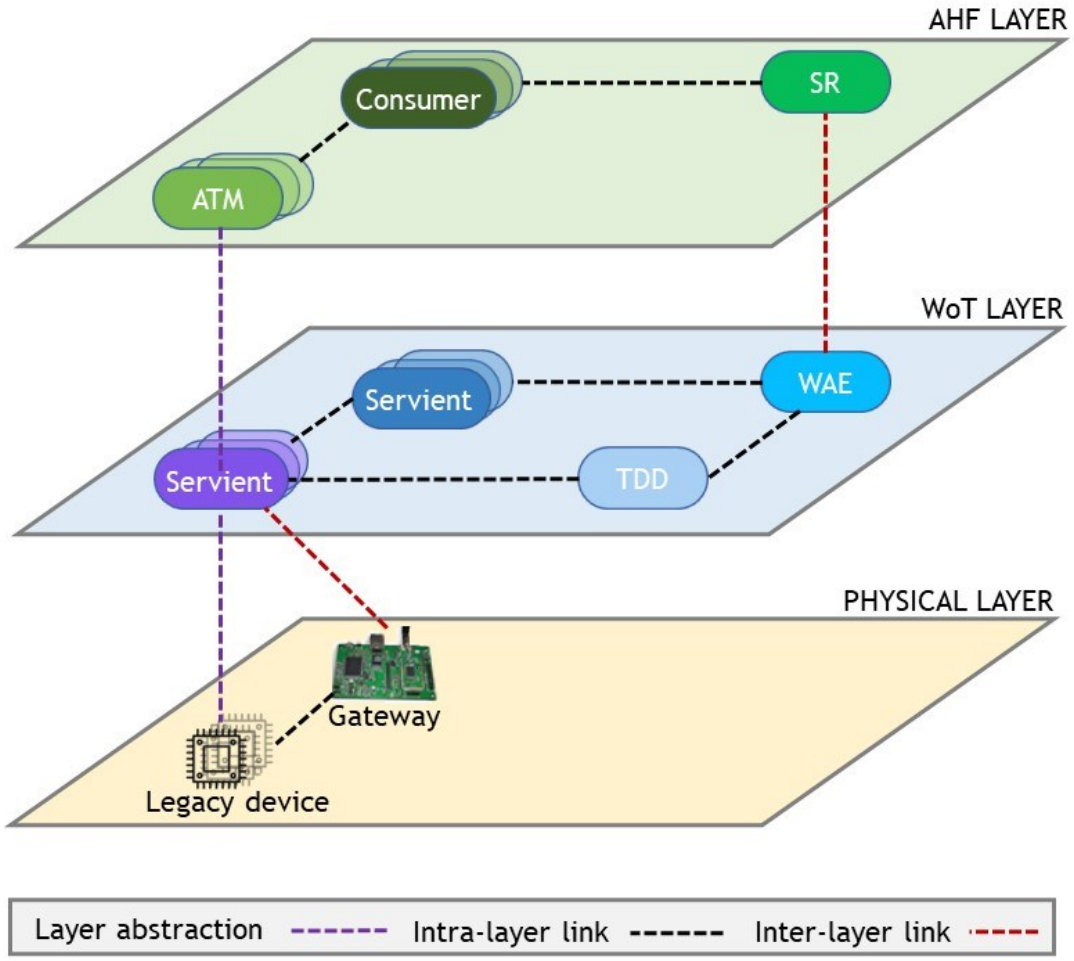
The capabilities offered by the Thing

- Properties: state of the Thing
- Actions: functions provided to manipulate the state
- Events: to asynchronously notify Consumers

Protocol Bindings

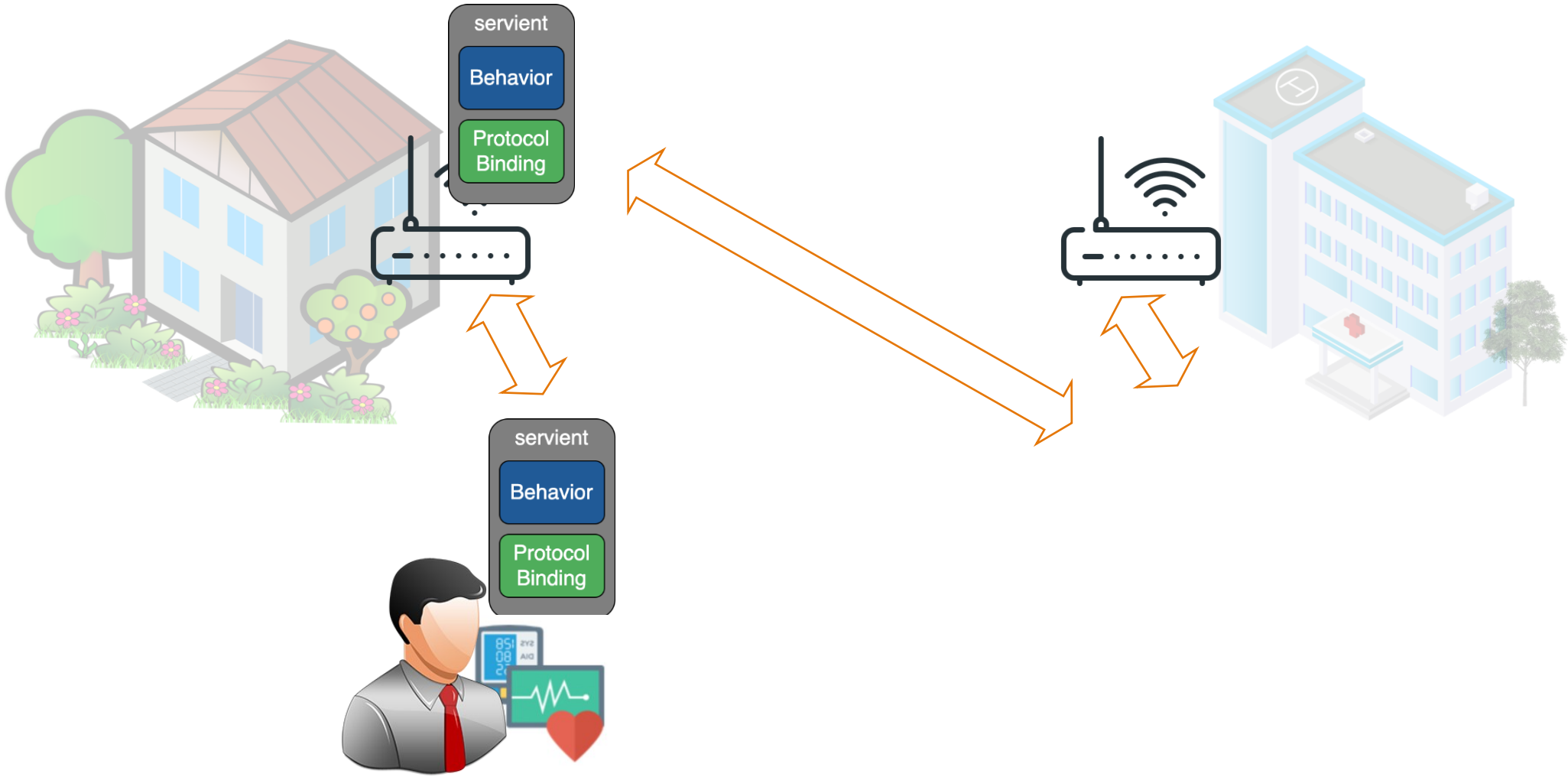
- Mapping from Interaction Affordances to concrete messages of protocols (HTTP, CoAP, MQTT, …)

Integration architecture



- AHF consumers in a local cloud can **access legacy devices**
- This architecture opens up opportunities towards **edge computing**

Mobility/migration of WoT servients in edge computing



Using WoT towards mobility/migration support

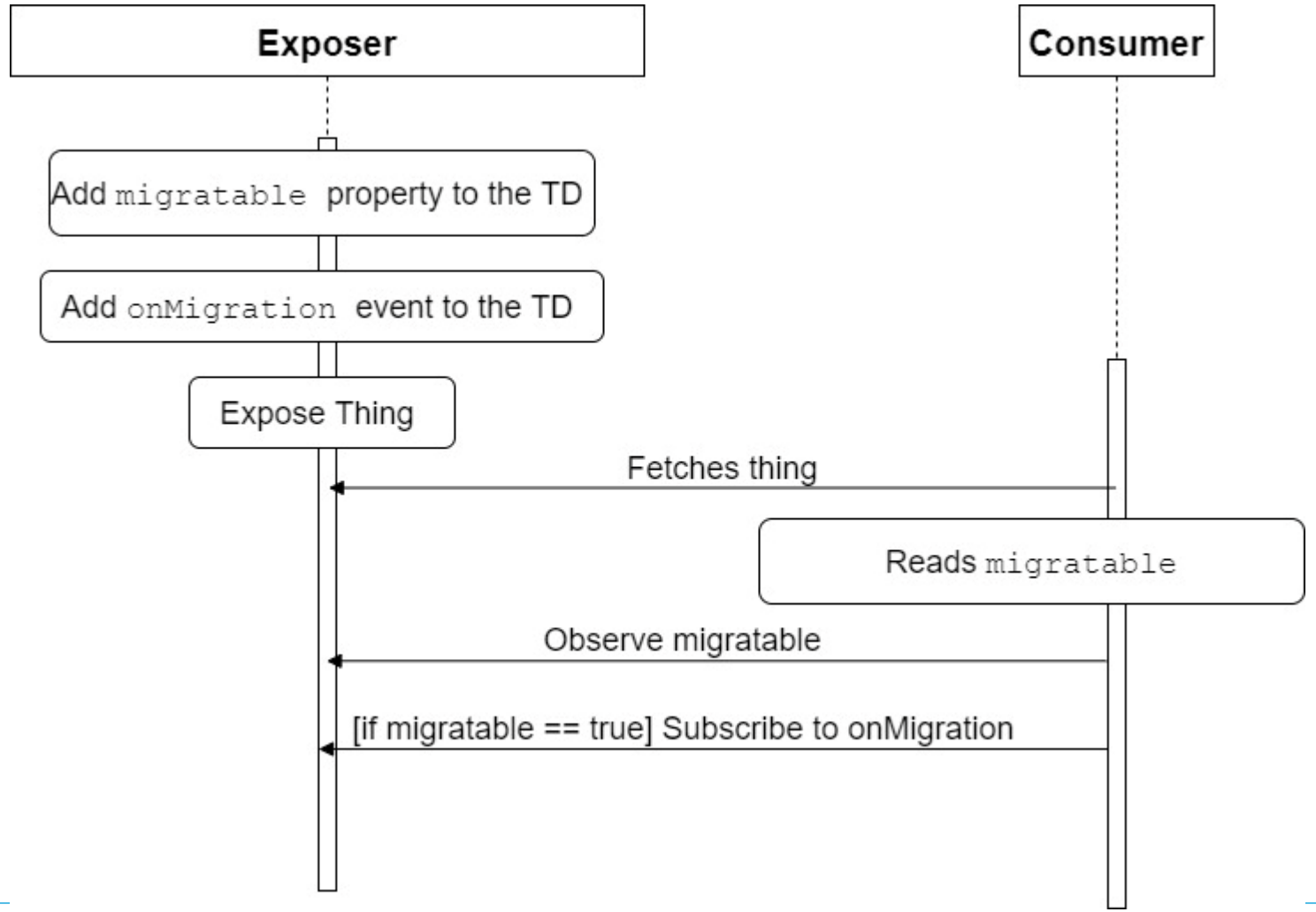
State management

- We consider **stateful** servients at the edge. How to handle the state?
- Managing (i.e., save, transfer, and restore) the state at the application-level is not transparent to the application itself
- We choose to host a servient inside a **container** and migrate it using container migration techniques, transparently to the application

Addressing

- Mobility/migration typically causes **IP addresses to change**
- It is possible to use auxiliary elements (e.g., DNS), which however introduce complexity and potential delays
- Our mechanisms to recover connectivity:
  - Are designed as **part of WoT** itself
  - Involve only the **two endpoints**
  - Are **transparent** to the application logic

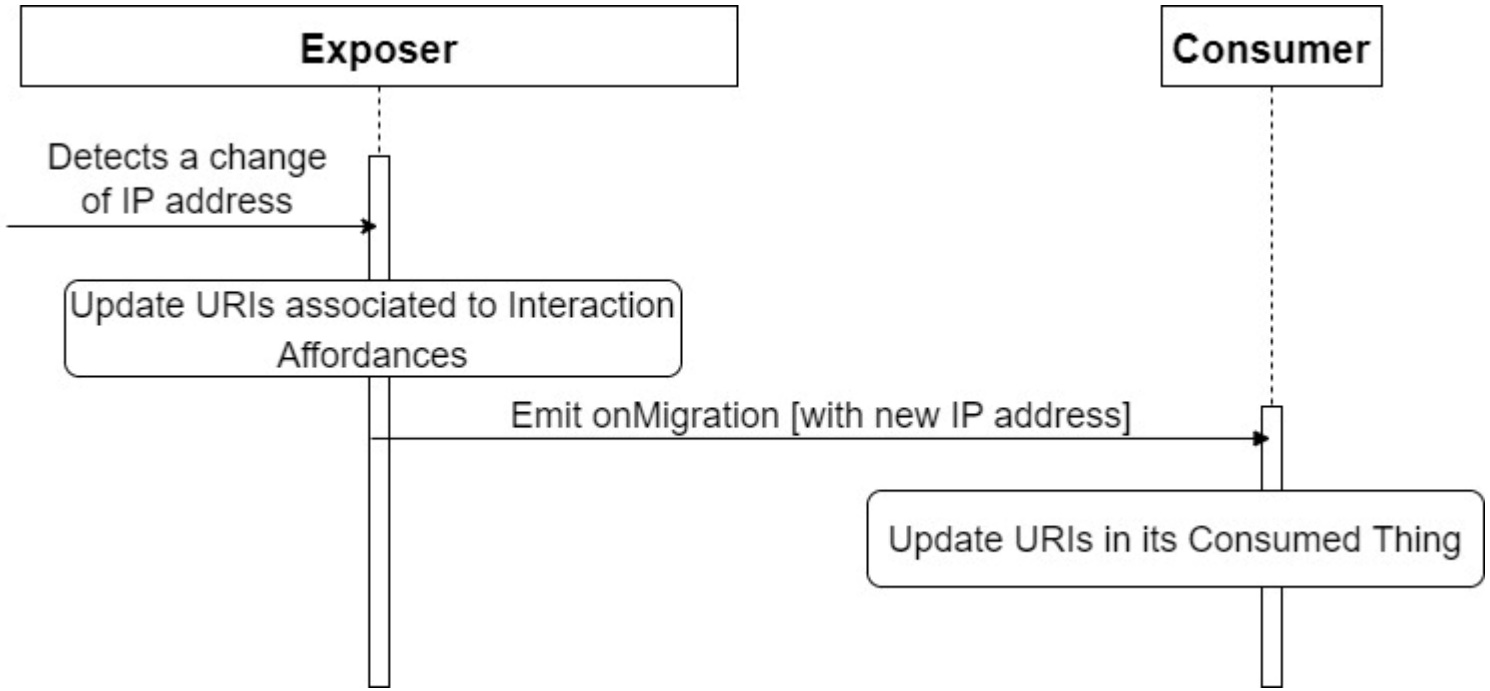
Mobility/Migration Support – Servient Migratability Configuration



Mobility/Migration Support - Exposer Migration

After migration:

- URIs of Interaction Affordances unreachable
- notifications still received by Consumer



Mobility/Migration Support - Consumer Migration

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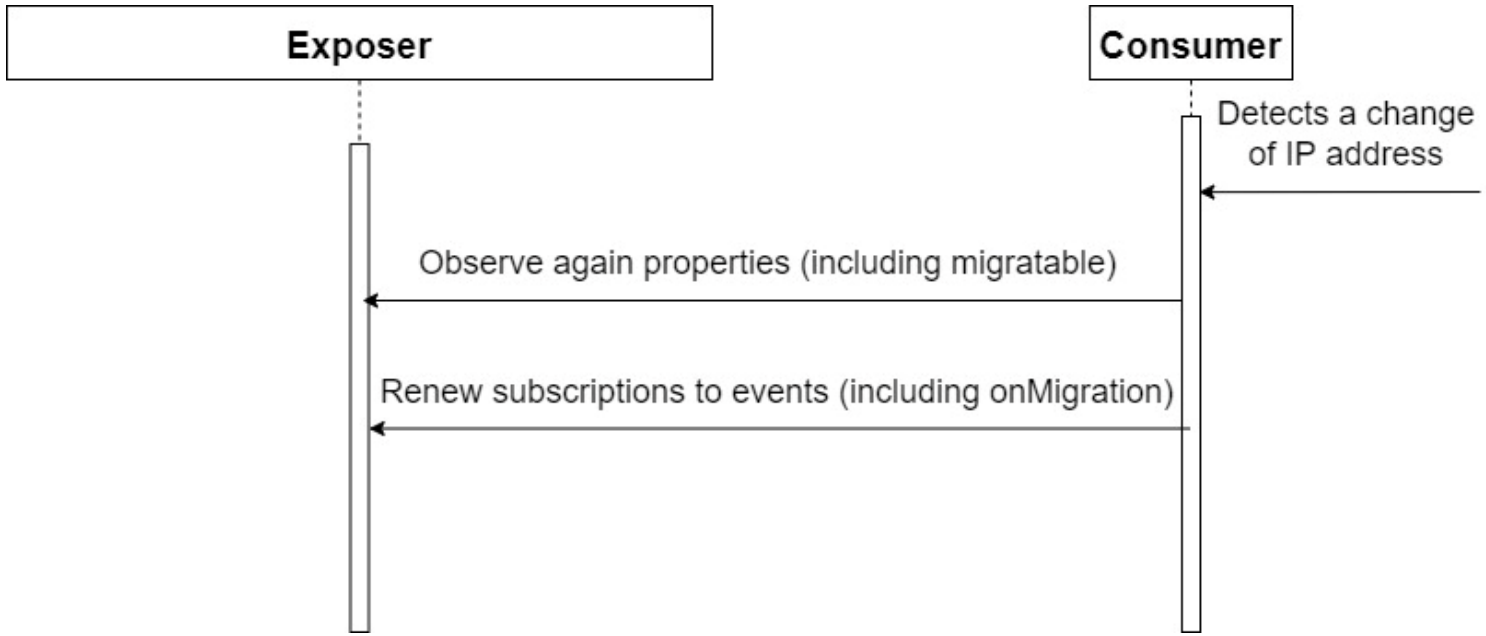
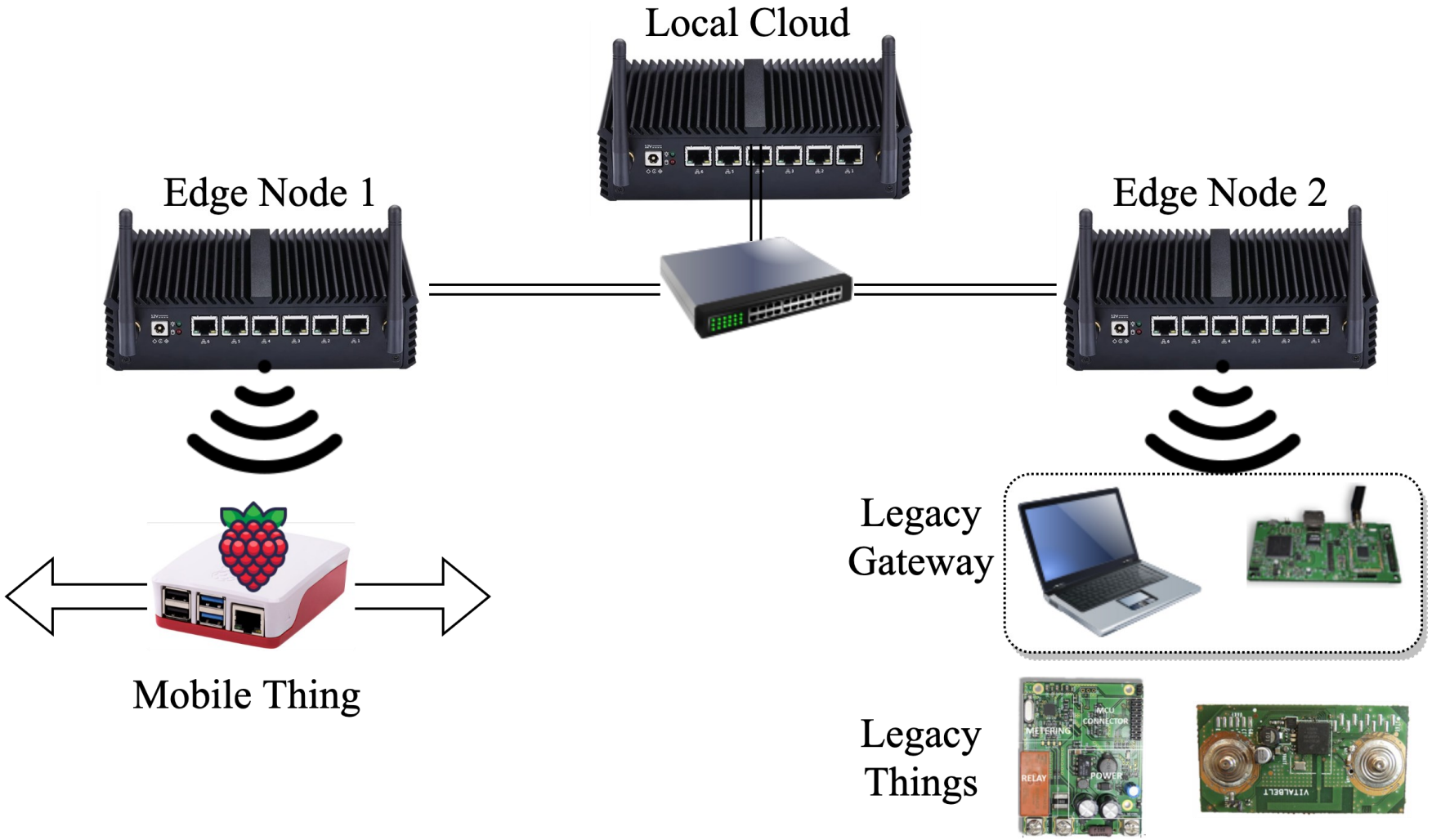
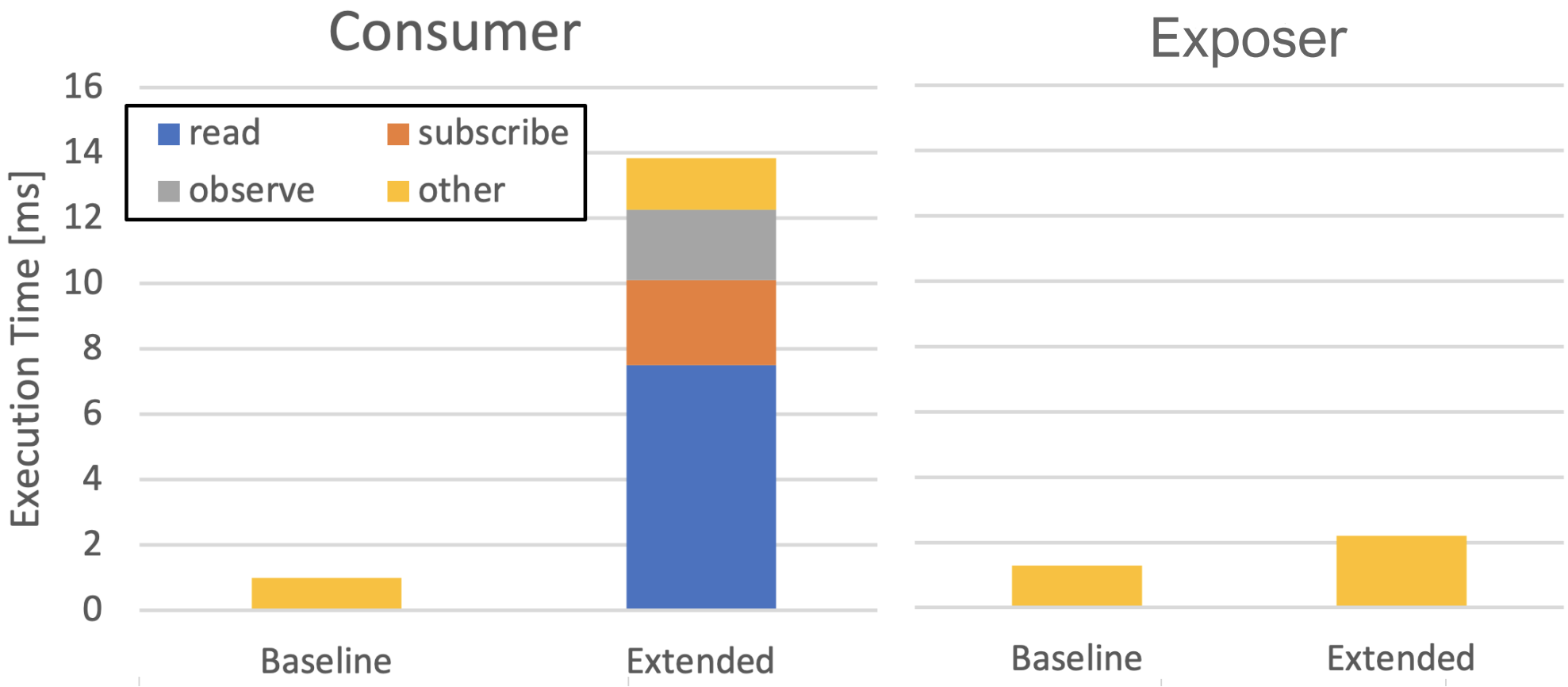


Additional data structure is required

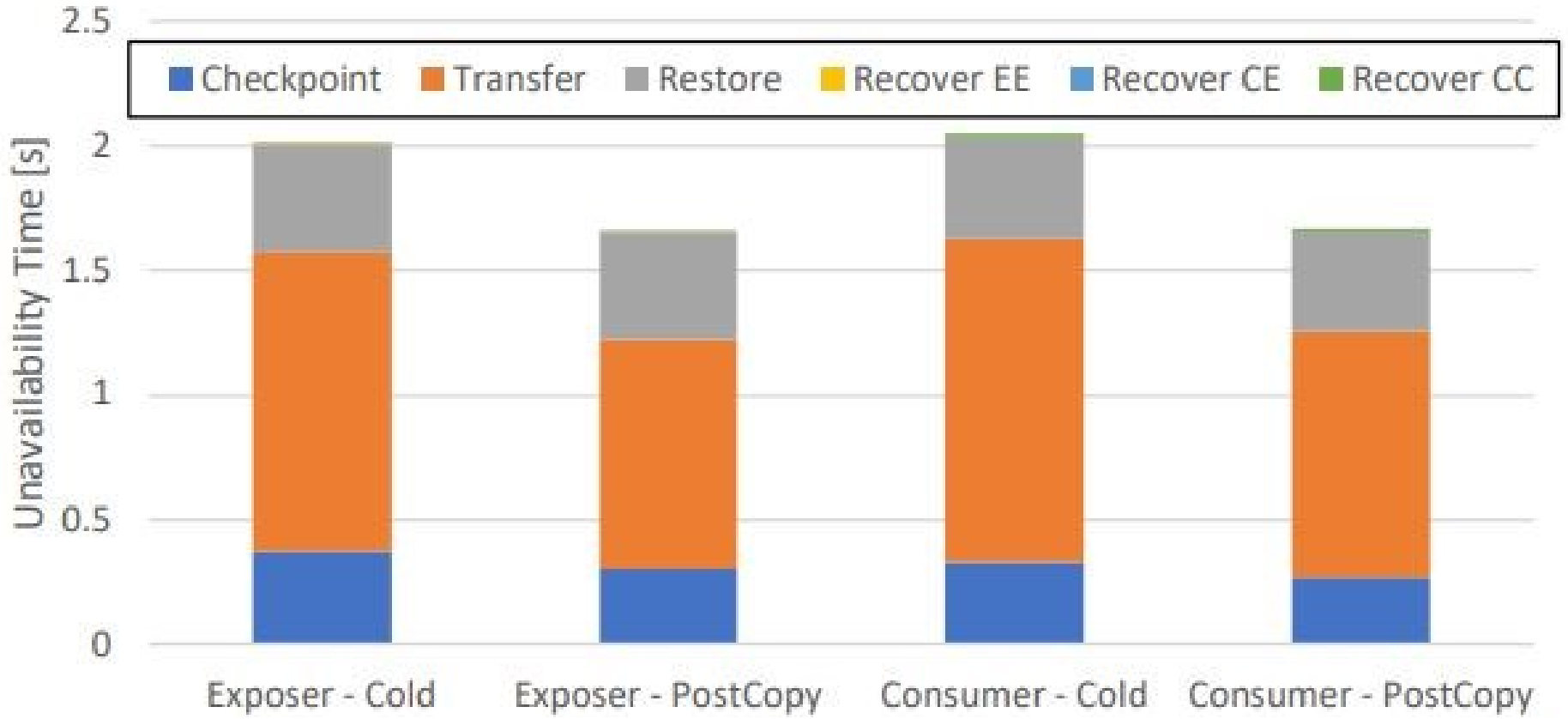
Performance evaluation - Testbed configuration



Execution time of the `consume()` and `produce()` methods



Unavailability time due to Exposer and Consumer migration



Conclusions

- Integration of legacy devices (ECG and smart plug) into the AHF through WoT
- Using WoT to support mobility/migration of servients in edge computing scenarios
- Performance evaluation has shown a negligible overhead of our solution to baseline WoT and to the unavailability time perceived by endpoints

Future Work

- Investigate the orchestration of the migration of multiple WoT servients

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Thank you!

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