Context-aware Edge Process Management for Mobile Thing-to-Fog Environment

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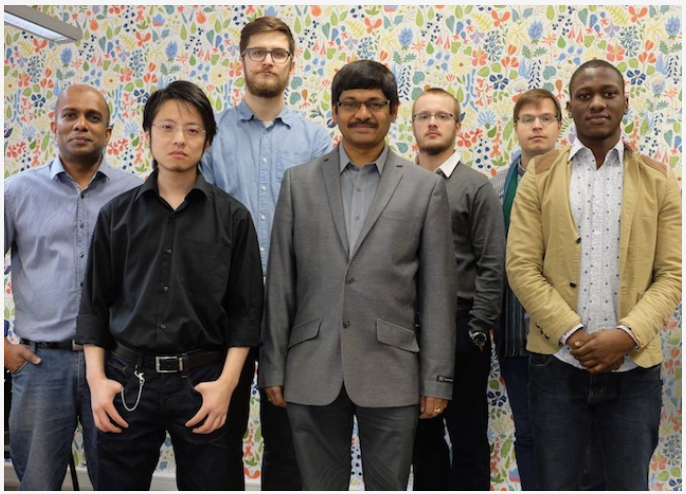
About me

PhD student @



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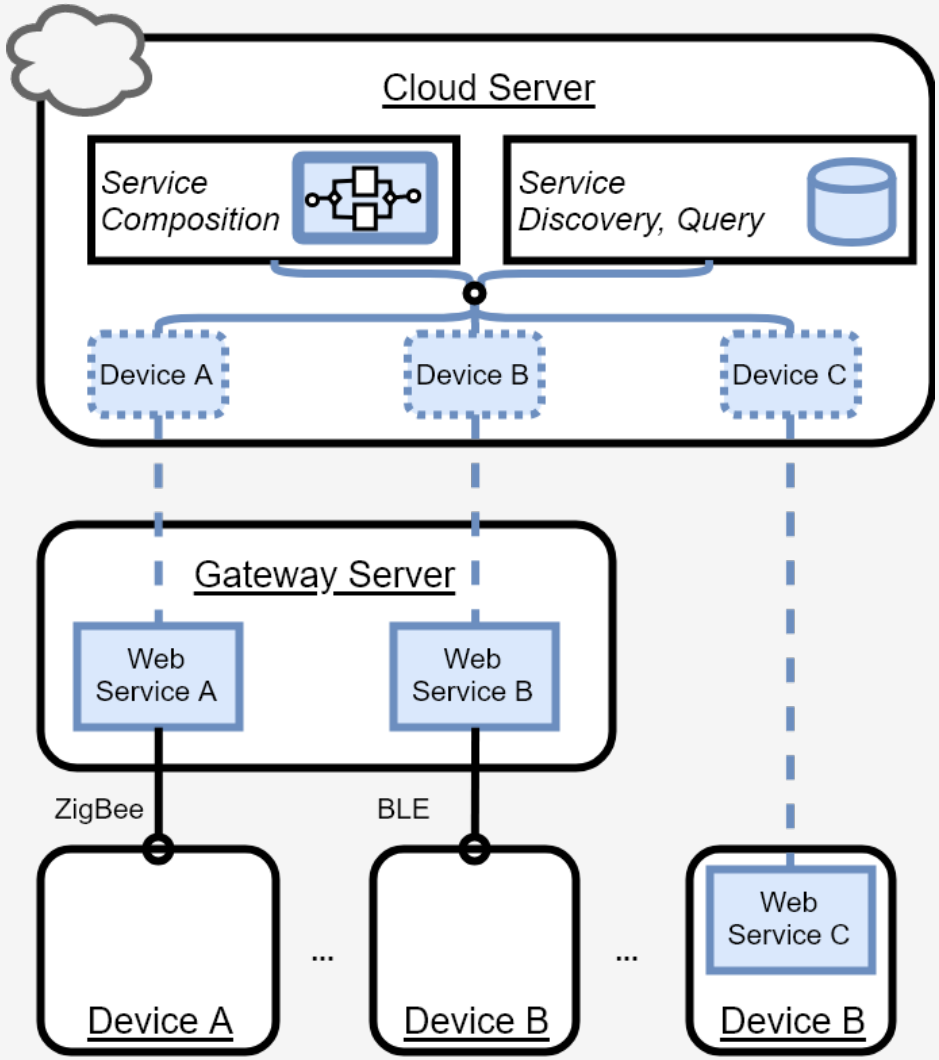
Outline

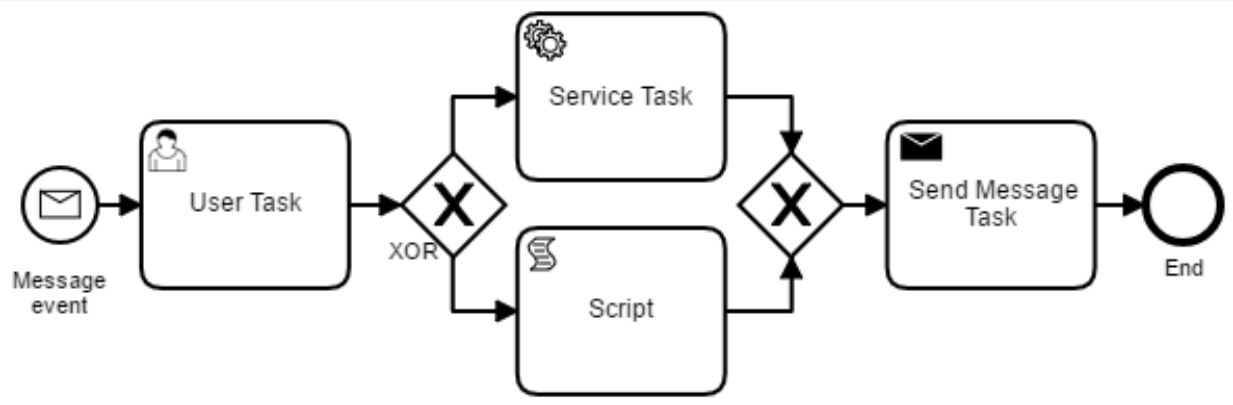
- Background:
  - Service-oriented Internet of Things
  - Edge Process Management
- Research Question - Mobility
- System Architecture Overview
- Experimental Results
- Conclusion

Services-oriented IoT



Workflow Management Systems

- Model group of devices as composite service - a workflow
- WfMS orchestrate, manage and execute these workflows
- Standards such as BPMN 2.0 for defining the workflow (process)
- Traditionally hosted in remote centralised server

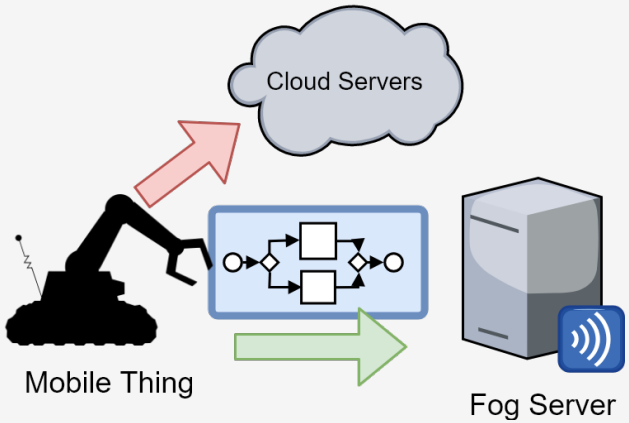


- Decision-making, messaging, event handling

Edge Process Management (EPM)

EPM - Emphasis on decentralised processes

- Distribute tasks to the edge network
- Reduce server-side bandwidth
- Reduce client latency



Use cases & application

- Remote health care, Smart traffic control, Disaster Recovery
- **Fog Computing**: a mobile node distributes computational task to the proximal fog server

Edge Process Management (EPM) Challenges

In case a mobile node needs to execute a task involving nearby wireless fog servers, the result is affected by:

- Fog server hardware configuration
- Fog server workload
- Signal strength
- **Movement trajectory** - Internet of Mobile Things (IoMT)

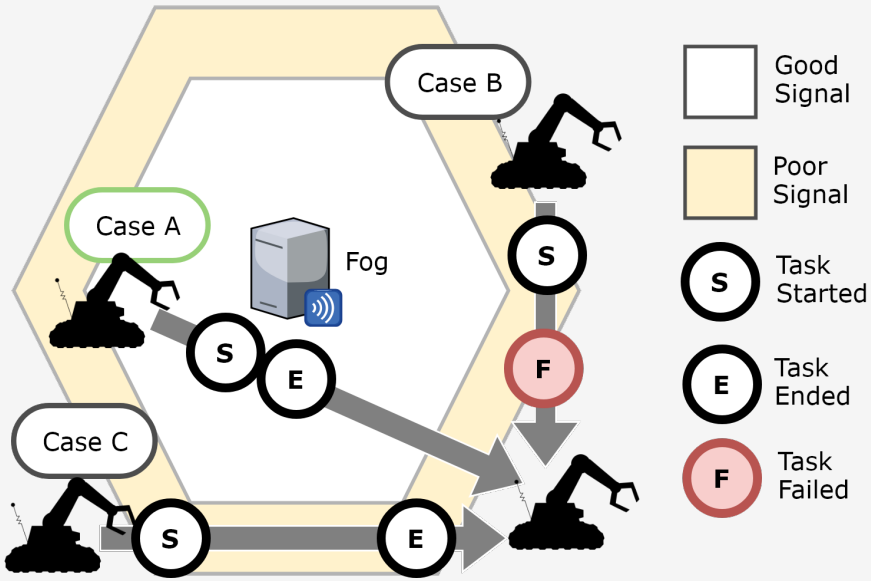
Mobility-related challenges

Executing tasks while signal area is encountered briefly :

- task fails
- task re-executed locally or at next fog server
- resources wasted

Execution with weak signal:

- poor performance
- delays



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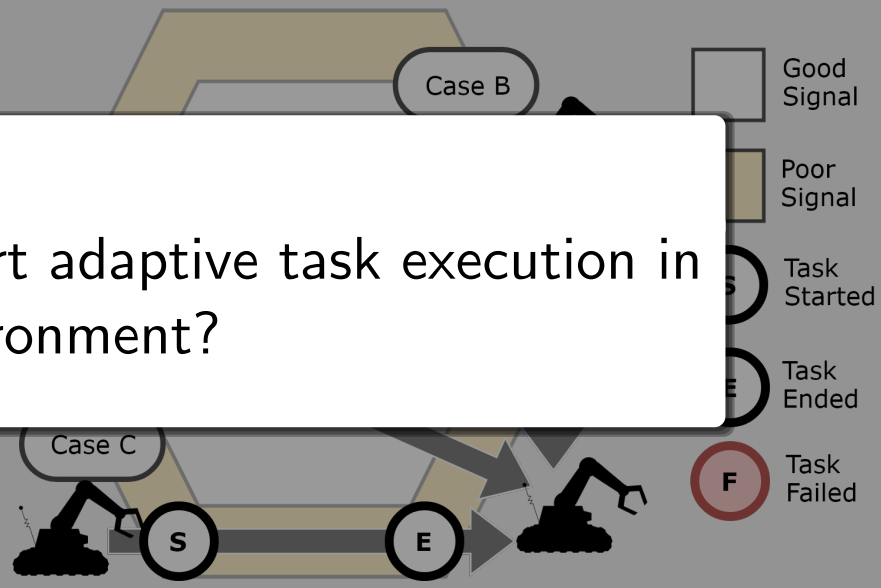


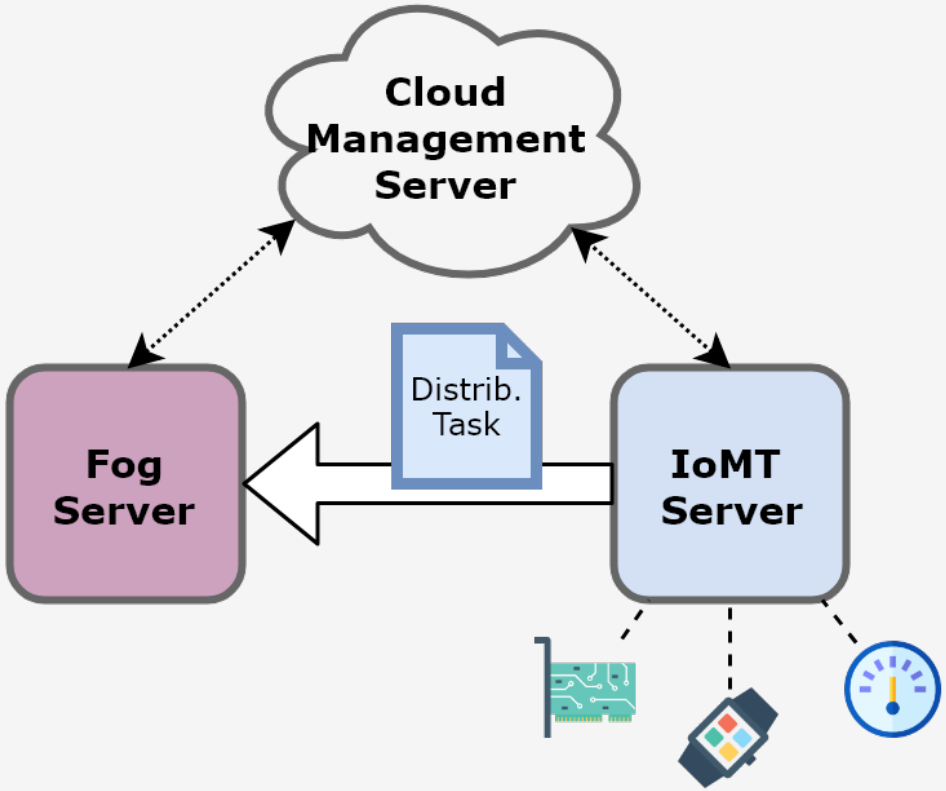
Research Question

How can EPM systems support adaptive task execution in the Mobile Thing-to-Fog environment?

Proposed system

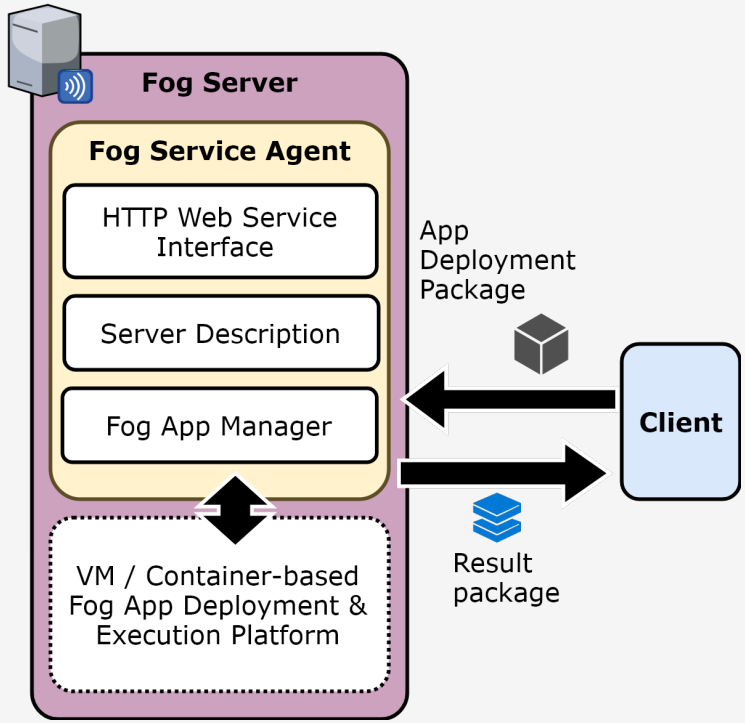
Primary goal - managing workflow task execution schedule based on runtime factors

- IoMT Server
  - IoMT server device
  - co-located sensor devices
- Fog Server
- Cloud Management Server

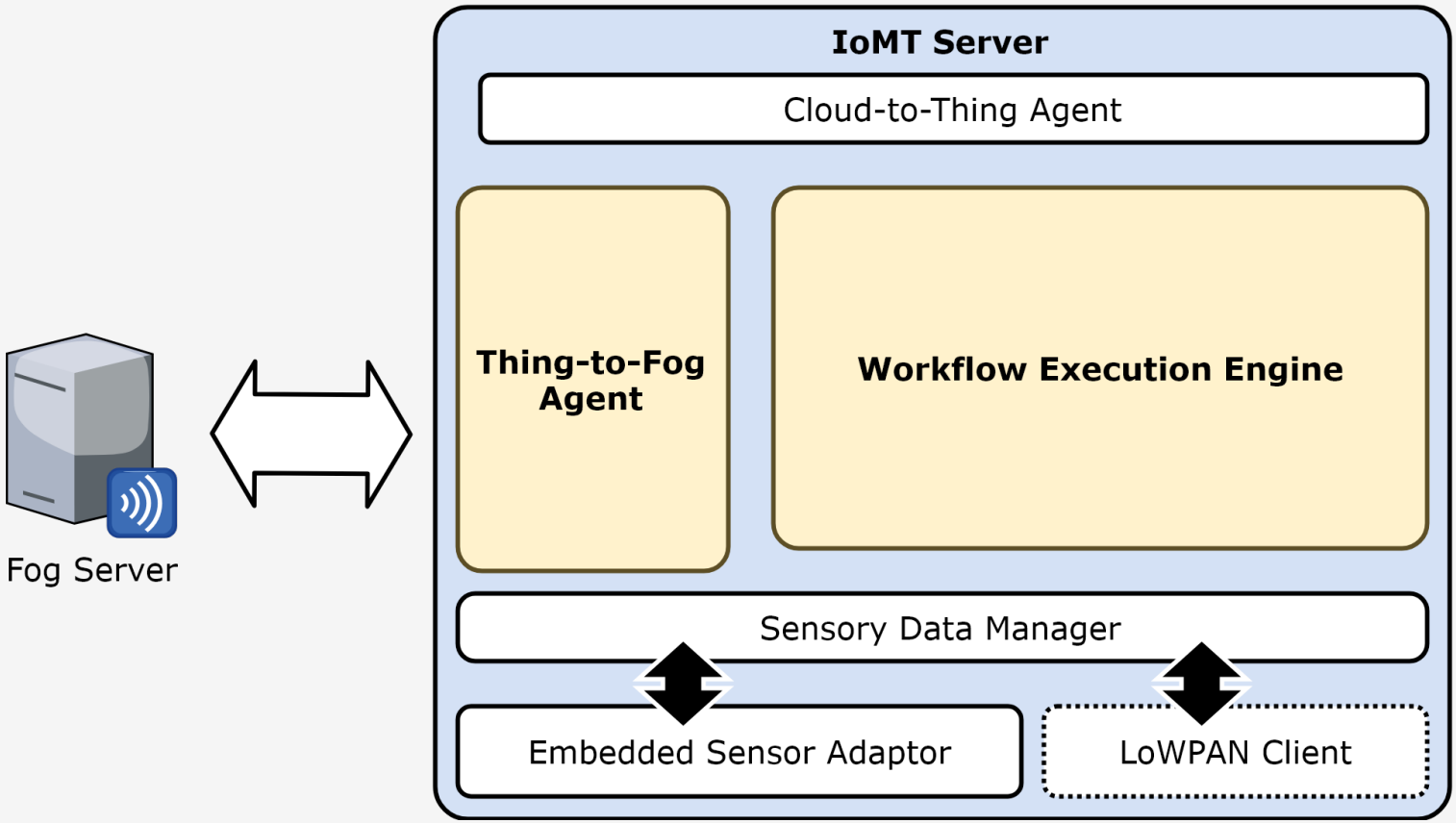


Fog Server

- Advertises system status to nearby clients
- Deployment & Execution Platform
  - Tasks (incl. input data) packaged as *App Deployment Packages (ADM)*
  - Results returned as a *Result package*.



IoMT server

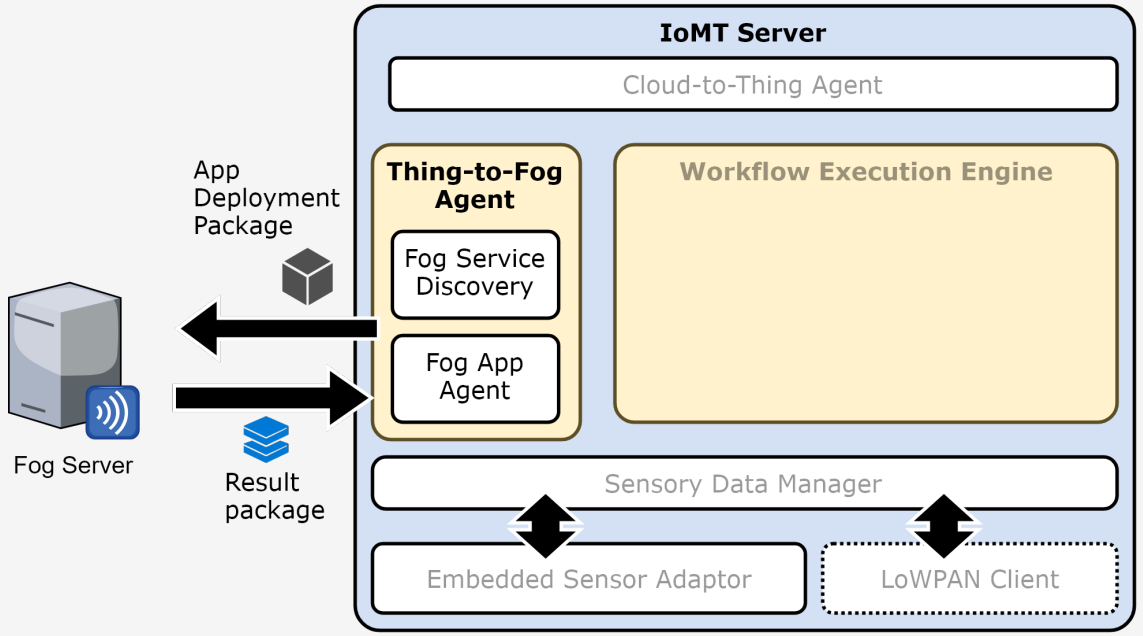

IoMT Server
Cloud-to-Thing Agent
Thing-to-Fog Agent
Workflow Execution Engine
Sensory Data Manager
Embedded Sensor Adaptor
LoWPAN Client
Fog Server

IoMT - Thing-to-Fog Agent

Performs continuous fog server discovery in the background.

Discovery info:

- Hardware specification
- Current system workload
- Available application deployment platform

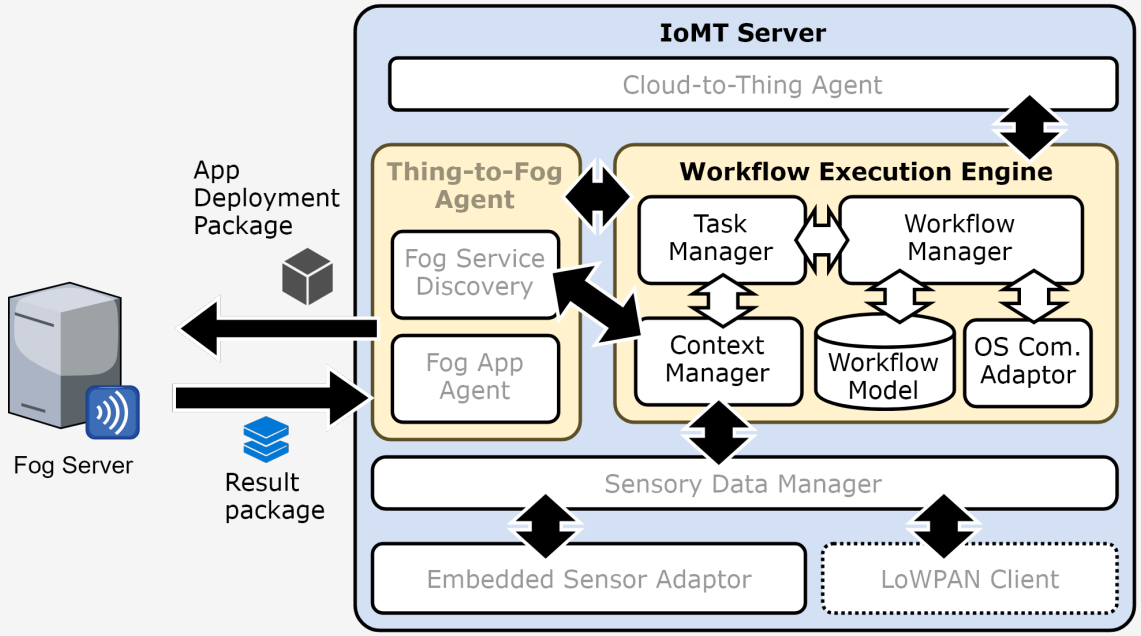


Fog App Agent provides means to distribute tasks to the *App Platform* on the server.

IoMT - Workflow Execution Engine

Workflow Manager

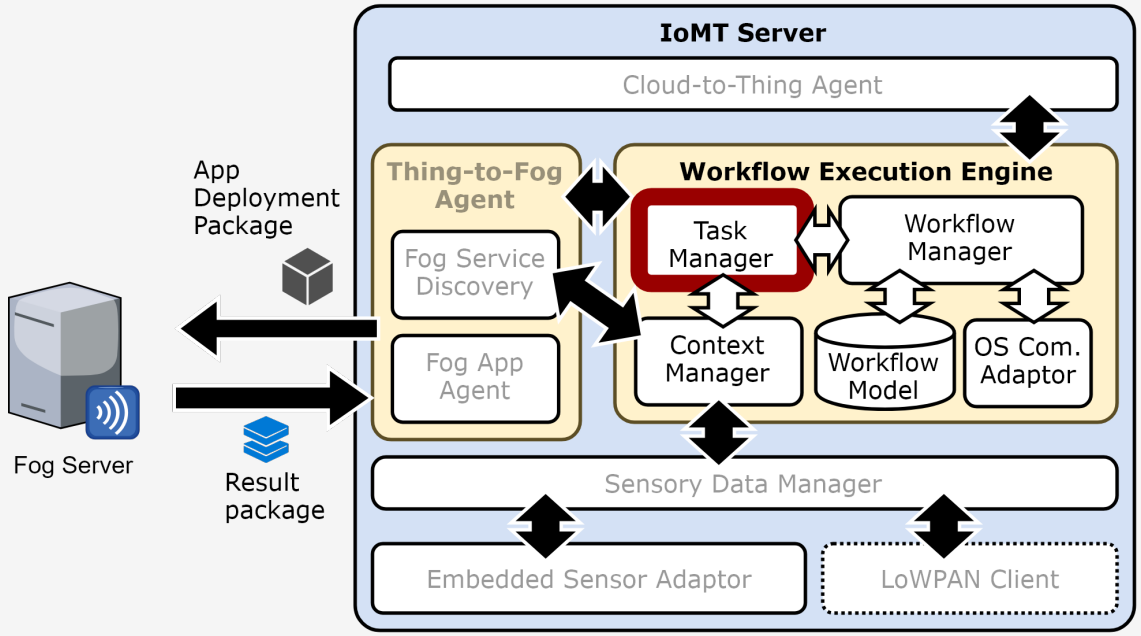
- Maintains WF model DB
- Interfaces with OS components
- Assigns **Task Managers** to workflow tasks



IoMT - Workflow Execution Engine - Task Manager

Task Manager

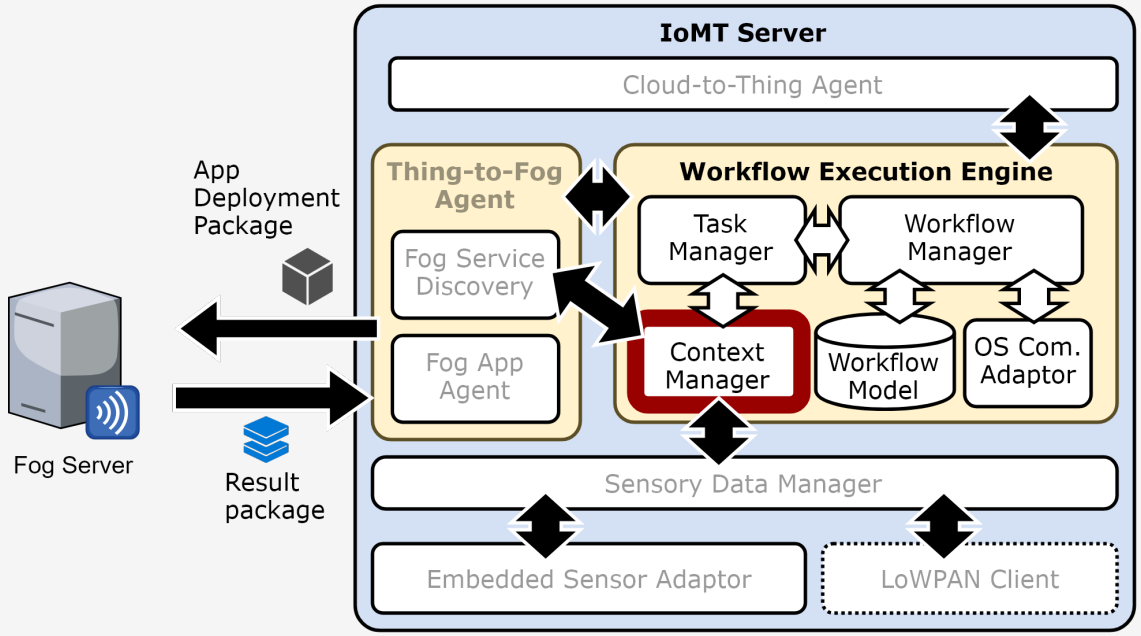
- controls execution of individual WF tasks
- execution schedule based on Context Manager



IoMT - Workflow Execution Engine - Context Manager

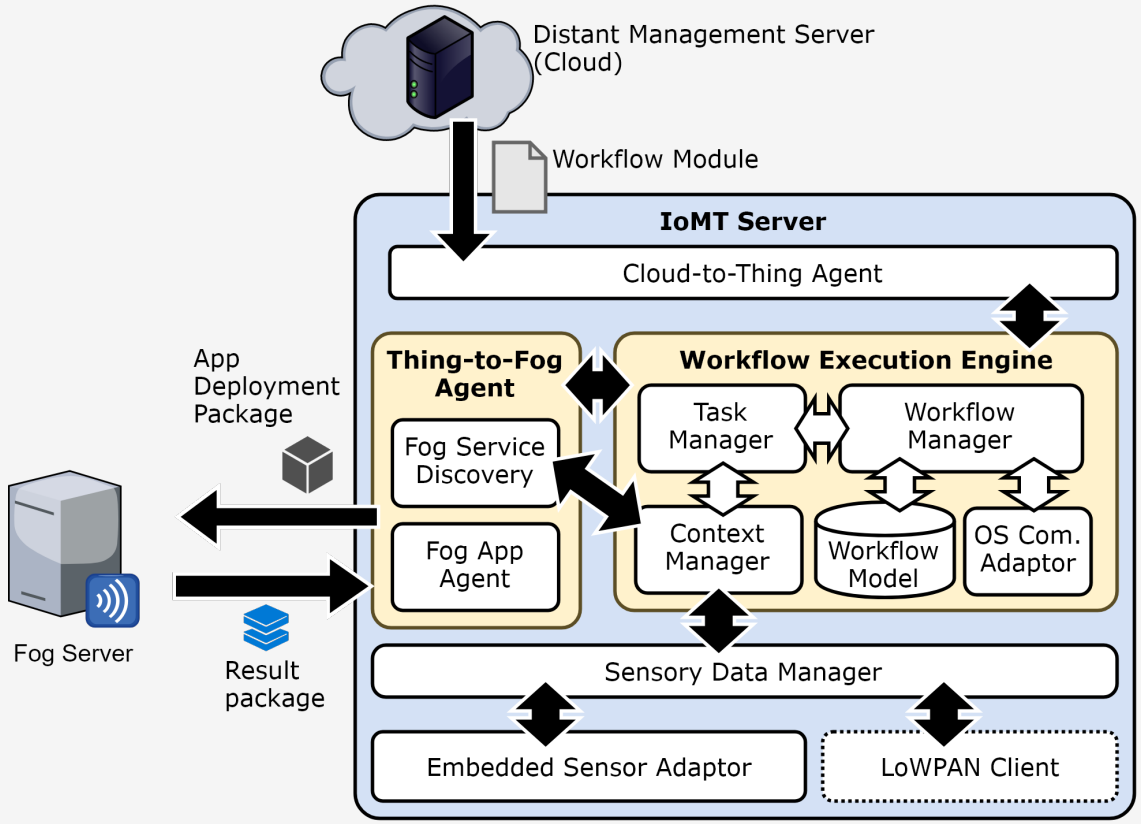
Context Manager

- Interprets sensory data & discovery data
- Includes user movement trajectory
- In this work, we focus on signal strength and mobility



IoMT - Workflow Execution Engine - Other Components

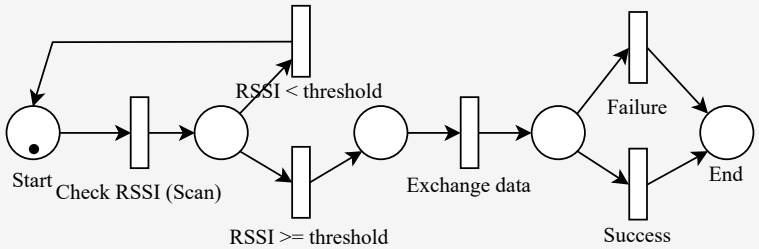
- WF models sent to IoMT server from Cloud
- Sensor Adapters provide interfaces to WF Engine
- LoWPAN Client includes support for auxiliary wireless sensor devices



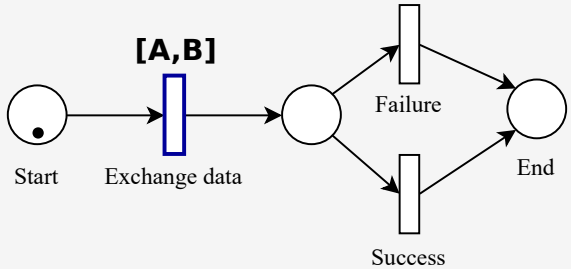
Task Scheduling

As a formal basis for dynamic task execution schedule, we derived a Time Petri Nets based Scheme.

- We define Adaptive Time Petri Nets (ATPN)
- Execution is bound by a contextual earliest firing time and latest firing time, which may change values



(a) Time Petri Net



(b) Adaptive Time Petri Net

Figure: Modelling of the system with different scheduling approaches.

Experiments

Demonstrate the effect of scheduling decisions with real devices

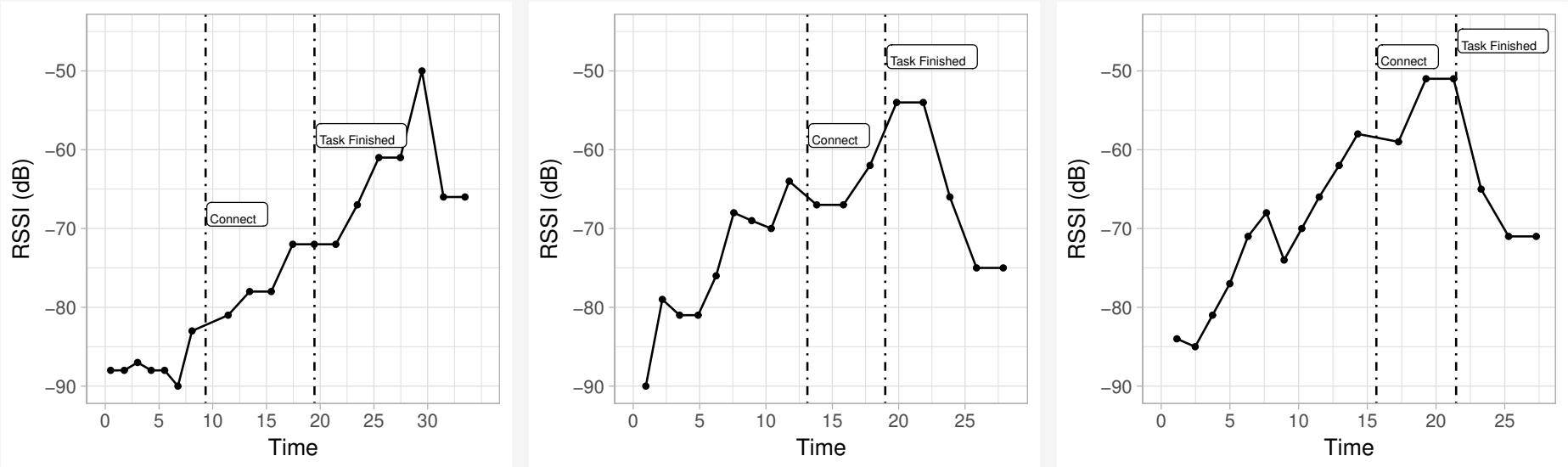
- IoMT server: Android smartphone
- Fog server: PC + WiFi router
- Task: Connect & download payload
- Movement: hallway walking

Compare:

- baseline - Signal Strength Threshold (SST) approach
- mobility-based scheduling approach (MOBI)

Experiments - single instance comparison

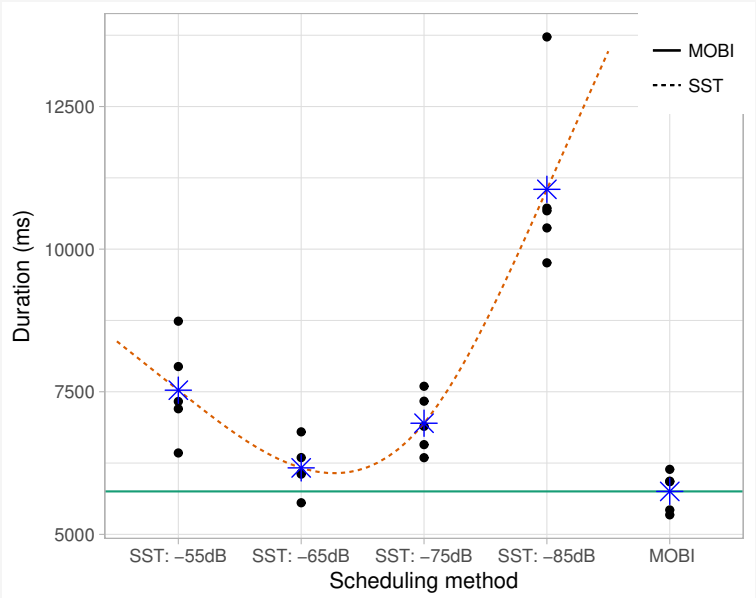
Mobility-based scheduling scheduling (MOBI) against Signal Strength Threshold (SST) scheduling.



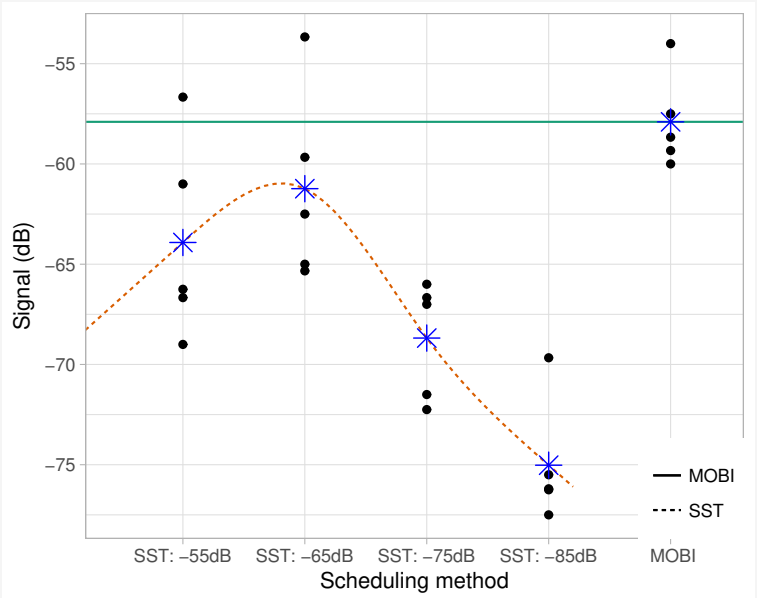
(a) SST: -85dB. (b) SST: -65dB. (c) MOBI.

Figure: Timeseries comparison.

Experiments



(a) Total time of task.



(b) Average RSSI during download.

Figure: Performance with different scheduling configurations.

Discussion

- SST approach needs manual tuning. Tighter constraints generally improve performance, but the danger of over-constrainting exists.
- MOBI approach both improves performance while having more stable signal throughout task.
- On the other hand, MOBI is dependent on quality of mobility modelling and prediction.

Conclusion

- Presented Architecture for Edge Process Management
  - Process-based Fog Task distribution
  - ATPN modelling for task schedules
- Experimented task scheduling with devices
  - Simple threshold-based approach can be outperformed
  - However, influenced by mobility prediction accuracy
- Future work
  - Mobility prediction algorithms
  - Consider other context like system load
  - Integrate with existing BPMN tools (e.g. Camunda)

Thank you for listening!