

Moving computation to the edges of IoT

..with mobile agents, to provide energy efficiency and interoperability of IoT devices and sub-systems

WHY MOBILE AGENTS?

"A mobile agent is a composition of software and data which is able to control its own execution autonomously on the computer and migrate from one computer to another in networked systems to execute its task"

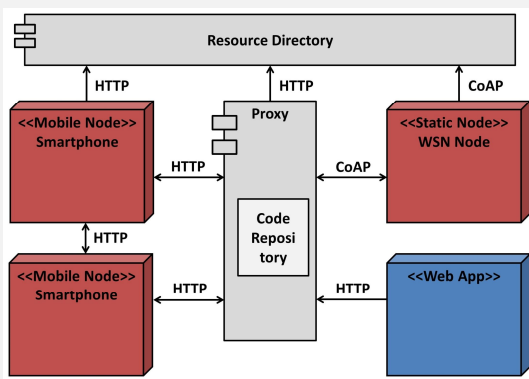
Mobile agents push the computation away from centralized nodes to the source of the data, i.e. IoT edge devices. When data is processed at the source, we enable (local) decisions of which data are discarded and which are retained. Then, only the relevant data is transmitted in the system, reducing network load and energy consumption of resource-constrained devices, such as WSN nodes.

BENEFITS OF MOBILE AGENTS

- **Mobility:** autonomously adapts to the available resources
→ Move away from a device before its resources consumed, e.g. battery drained
- **Social ability:**
→ Abstract heterogeneous resources and sub-systems with standardized communication interfaces
→ Interact with other agents and non-agent components
→ Negotiate about task execution while operating towards common goal
- **Intelligence:** make local decisions about task execution
→ Events detected at the data source
→ Learn from data and interactions
→ Personalization of system services for user's context
- **Scalability:** decentralized and autonomous task execution
→ Operates locally in disconnected systems or systems with intermittent network connectivity

IoT SYSTEM ARCHITECTURE

- Integrates sub-systems over disparate networks, e.g. Wi-Fi and 6LoWPAN. Based on IETF CoRE framework
- Seamlessly integrated into the Web: HTTP and CoAP utilized as universal and standardized communication protocols. Every resource accessed through URL with RESTful interfaces
- (Distributed) resource directory maintains system resource descriptions
- Proxy component enables two-way communications, translates protocol messages (and maintains a repository for mobile agent task codes)



MOBILE AGENT APPLICATIONS

We have implemented a set of mobile agent-based IoT applications that demonstrate interoperability and energy efficiency in resource-constrained heterogeneous IoT devices.

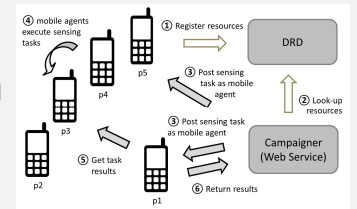
Collaborative sensing

- Sensing tasks are defined as mobile agents that migrate in opportunistic network of both mobile and stationary devices
- Facilitates autonomous co-operation of heterogeneous devices for multiple simultaneous sensing tasks
- Energy is saved as sensing controlled by mobile agents in location
- Extends sensing coverage and removes redundancy in data collection



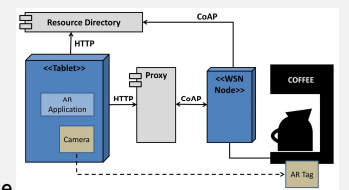
Mobile Crowdsensing

- Campaigns considered as multi-agent systems, where data collection is conducted with mobile agents
- Enables decentralized and autonomous campaigns
- Mobile agents migrate in the opportunistic network of smartphones, negotiate and execute their tasks while taking into account the participants' resource availability
- Mobile agents recruit participants, maintain participants' privacy and monitor their behavior and resource consumption to estimate fair compensations
- Real-world evaluation shows that mobile agents-based campaigns produce the same campaign results with less energy consumption



Augmented Reality

- AR applications inject their own data processing tasks into system as mobile agents and visualize task results in their user interface
- Seamlessly integrated into the Web as AR applications run in Web browsers of users' personal devices
- Mobile agents can continue to live in the system as service providers, "follow" the user, etc.



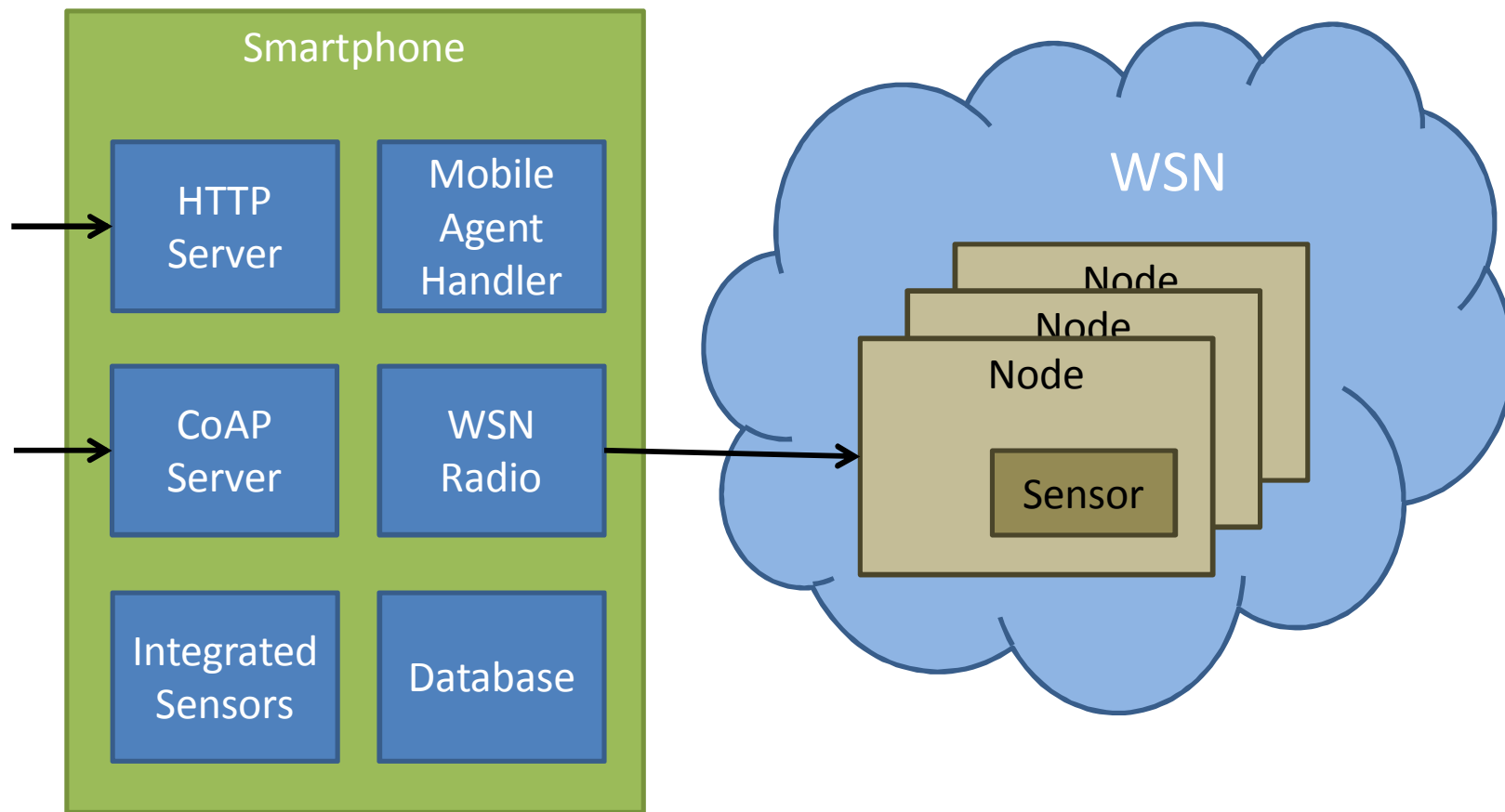
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SMARTPHONE-BASED MOBILE GATEWAY FOR IoT

- Exposes smartphone and WSN resources to the Internet
- Enables mobile agent-based task execution in both smartphone and WSN cooperatively



Kataja J., "Smartphone-based Mobile Gateway for the Internet of Things", Master's thesis, University of Oulu, 2015.