Horizontal IoT Application Development using Semantics

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Roadmap

- Introduction
- Challenges
- State-of-the-Art
- Horizontal IoT application development framework
- Conclusion
Introduction - Ingredients

- Low-cost sensors, actuators, tags
- Networking chips
- Lightweight software development frameworks
- Low power communication protocols
- Growing trend of making everything “connected”
- Availability of cloud platform and smart devices
- New business opportunities
Data Cycle in IoT Applications
Roadmap

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Challenges

- Connecting heterogeneous things
- Combine data from different sensors and domains
- Uniform representation, treatment and interpretation of sensor data for cross domain applications
- Uniform application development framework for any smart home scenario
- Deploy across multiple platforms (cloud, home gateway)
- Derive actionable intelligence allowing humans or things to react
- Support resource discovery, automatic management, provisioning while maintaining interoperability
- Preserve privacy through secure mechanisms
Solution: Semantic Web Technologies

- Physical Things
- Data Collection
- Data Processing
- Data Dissemination
- Actuation
- Notification

- Heterogeneity
- Semantic Web Technologies

- But semantics along is not sufficient
- Still need components for
  - Resource discovery, provisioning, automatic management of things
  - Deployment platform, support for actuators
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State-of-the-Art

- The reasoning engines and semantic algorithms in a mobile app are largely based on internal sensors.
  - No consideration towards external sensors (deployed in smart home).
  - No dynamic discovery of sensors.

- Current initiatives are largely focused on domain specific scenarios.
  - What about cross-domain (horizontal scenarios)

- Interoperability issue
  - No common catalogue exists for sensors, measurements, units, and domain names.

- Not oriented to a standard

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Horizontal IoT Application Development Framework

1) Discovery phase
- Sensor type + Domain
- Infrastructure Node

2) Provisioning phase
- Middle Node

3) Convert, Reason and Query phase
- (Data acquisition + knowledge query + reasoning layer)
- 3.a) Parsing, naming and storing suggestion results
- IoT Application Template Dataset (M3 Framework Cloud)

4) Data dissemination phase
- (Consumer Mobile Phone)
- Actionable Intelligence
- GET
- Actuation Command

5) Actuation phase
- Sensors, Actuators, Tags
Machine-to-Machine Measurement (M3) Framework

Semantic Reasoning

Discovery Phase

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Smart Device → M2M Gateway → M2M Devices and Endpoints

**Discovery**
- GET request: Discovery
- Internal query at local storage
- Retrieve list of M2M Devices, Endpoints and Domain names

**Configuration**
- Configuration storage
- POST configuration resources

**Storage**

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Provisioning Phase

Smart Device
- User provisioning
- Storage

M3 Framework
- searchTemplate
- generateTemplate
- getSparqlQuery

Sensor + domain

List of cross domain IoT application templates

User chooses an IoT application template

Generate template:
- M3 ontologies
- M3 datasets
- M3 domain rules
- M3 rules converter

Query for M3 generic sparql query

M3 generic sparql query
Convert, Reason and Query Phase

Smart device (e.g., phone, tablet)

User interface → M3 Execute SPARQL Query → M3 Reasoner → M3 Converter → Storage

Get sensor metadata

M2M device (e.g., sensor)

Gateway

Get sensor metadata

sensor data

- RDF SenML data
- M3 converter rules
- M3 RDF SenML data
- M3 domain rules
- M3 RDF SenML inferred

get M3 SPARQL query

Load M3 ontologies and datasets & M3 RDF SenML inferred

Execute M3 SPARQL query

M3 SPARQL result to parse and display
### Data Dissemination Phase

- **Based on HTTP GET**
  - Consumer mobile phone request for actionable intelligence from Middle Node.

- **Based on Push notification**
  - Middle node uses Google Cloud Messaging platform to push actionable intelligence into Android powered devices.
  - Apple Push Notification platform is used for iOS powered devices.
Actuation Phase

User selects an actuator
GET: proxy-out URI and destination URI of actuator
Return the proxy-out URI and destination URI
POST new value of actuator
Response: 204, No Content
Push notification with updated value

Request actuator to change value
Response: 204, No Content

Push updated value
Deployment and Prototype

- **M3 Framework – Cloud**
  - Developed using Jena Framework
  - Available at - http://sensormeasurement.appspot.com/

- **Cross domain IoT application development framework – Android powered device acting as a home gateway**
  - Developed using Android SDK and AndroJena

- **Initial testing performed with**
  - Combining weather and vehicular sensors data
  - Combining eHealth and home automation sensors data
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- **In a nutshell,**
  - Challenges towards horizontal IoT application development framework in smart home
  - Limitations found in state-of-the-art
  - A semantic based framework for such development and its deployment

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Sometime Soon …
Thank You

Grazie

Danke

Ευχαριστίες

Thank You

Köszönöm

Obrigado

Merci

Gracias

See

Natick

Dalu

Tack

Grazie

Merci

Thank You

See
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