Cross-domain IoT Application Development for Smart Home

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Roadmap

- Introduction
- Challenges
- State-of-the-Art
- Cross-domain IoT application development framework
- Conclusion
Introduction

Smart Things Automate the Home

- **Wireless diaper**
  Sleeping baby's diaper tells you it's wet before the wetness wakes your baby.

- **Gardening**
  Sensors that track moisture send messages when it's time to water the plant.

- **Preventing damage**
  Pipes can report leaks.

- **Appliance sensors**
  A washing machine can text you that it's time to put clothes in the dryer.

- **Alarms**
  Wireless smoke and carbon-monoxide sensors sound alarms and also alert you by phone or email.

- **Lights**
  Room lights sense the presence of your phone and turn on when you enter.

- **Child and elder care**
  A door sensor can send a text to say that someone has entered the house or is active in a particular room. (Grandpa is up from his nap).

- **Smart thermostat**
  Homeowners can control heating and cooling remotely.

- **Kitchen help**
  An oven can send a text to say that the cooking time you set has elapsed or that the turkey has reached the temperature you chose.

*Source: market-intel.info*
Data Cycle in Smart Home Applications
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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
But semantics alone 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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Machine-to-Machine Measurement Framework

Semantic Reasoning

Source: Gyrard, A.; Bonnet, C.; Boudaoud, K., "Enrich machine-to-machine data with semantic web technologies for cross-domain applications," in Internet of Things (WF-IoT), 2014 IEEE World Forum on, pp.559-564, 6-8 March 2014
Cross-Domain Framework

1) Discovery phase

2) Provisioning phase

3.a) Convert, Reason and Query phase (Data acquisition + knowledge query + reasoning layer)

3.b) Parsing, naming and storing suggestion results

4) Data dissemination phase (Consumer Mobile Phone)

5) Actuation phase

Sensors, Actuators, Tags

Infrastructure Node

Sensor type + Domain

IoT Application Template Dataset (M3 Framework Cloud)

Middle Node

ASN

GET

Actionable Intelligence

Actuation Command
Discovery Phase

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

- **Storage**
  - POST configuration resources
Provisioning Phase

- User provisioning
- Storage

Smart Device

- Sensor + domain
- List of cross domain IoT application templates

M3 Framework

- searchTemplate
- generateTemplate
- getSparqlQuery

- 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
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

Smart Device          M2M Gateway          M2M Device
Device                  Proxy-out               Proxy-in
Actuator
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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Conclusion

- **In a nutshell,**
  - Challenges towards cross domain IoT application development framework in smart home
  - Limitations found in state-of-the-art
  - A semantic based framework for such development
Sometime Soon …

Fattypants is kidding himself if he thinks he’s eating less than 2000 calories a day!

At least you get used! I never do! All he eats is take-out!

I refuse to pick up this French fry. Lazybones can do it himself!

He spent a fortune on us smartbulbs and he only uses the “white light” setting! *sigh*

Dumwy needs to test me now and then, or at least check my app!

Don’t bother him! The previous smoke detector, he beat to death with a broom handle!!

Hey guys! The house smartmeter is telling everyone that scaredy cat still uses a night light! Ha ha!

Did you see what time he got in last night? Scandalous!

What your Internet of Things is saying about you…
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