A Consumer-Centric Architecture for Energy Data Analytics

Rayman Preet Singh, S. Keshav, and Tim Brecht
Home Energy Data
Smart Meter Deployments

Energy Retail Association
Energy Data Use

E-mail
“Your decade-old furnace is in-efficient and is costing you an additional $400 a year. **Click here** to see replacement options.”

Text Message
“It is unusual for your oven to be on at this time of day. Would you like to turn it off? **Click Yes/No**”
Energy Data Privacy

Time of Day

Power (W)

0 1 2 3 4 5 6 7 8 9 10
11 12
Current Situation

- Utility websites
- Google Powermeter
- Microsoft Hohm
- Green Button

"Our constitution allows us not to have that kind of intrusion on our personal privacy"

"They’ll be able to tell if you are running your computer, air conditioner, whatever it is"
Problems

Data privacy loss

Frozen innovation in analytics

No data ownership or control
Goals

Data ownership

Consolidation
Durability
Portability
Integrity

Data access

Data privacy
Universal access

Data analytics

Flexibility
Scalability
Extensibility
Performance
Approach 1

Privacy, portability, ...

Scalability*
Extensibility*

Consolidation
Durability
Approach 2

- Scalability, ...
- Privacy*
- Consolidation
- Durability
Approach 3

Universal Access, ...

Privacy
Extensibility
Flexibility
Proposed Architecture

Data sources

Cloud Based App

Native App

VHome

App Store

Data

Control

Smart meter
Weather
Grid
Implementation

Gateway: Microsoft HomeOS

Implementation

Gateway: Microsoft HomeOS

- Driver modules
- Communication module
- Coordinator module

<setStatus classID=1 objectID=2>
<power>0.0</power>
</setStatus>
VHome

Suite of web applications using JAX-RS

Access Control Mechanisms  Privacy Protection Mechanisms  APIs  Web Services  Native App

Apache Tomcat (Web App Container)

Java ➔ Portability across clouds (Amazon EC2, Root BSD, Windows Azure)
VHome Implementation Details

Vhome DB using cloud datastores

*Datastream:* (Class ID, Object ID) specific time series
  e.g., class – heating, object – space heaters

RESTful APIs to access datastreams

Token-based *fine-grained access control* mechanism
  - OAuth 2.0
VHome Implementation Details

Access scope

\( r/w + \text{datastream(s)} + \text{value-based and/or timestamp-based} \)

API access for a CBA
Example Applications

Data scraper

Energy data analytics

<table>
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<th>Date</th>
<th>ON-Peak (kWh)</th>
<th>MID-Peak (kWh)</th>
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Example Applications

Interactive monitoring and control

- Current Power: 55.97 W
- Temperature: 22.5°C
- Illuminance: 5.2 lx
- Today’s Usage: 7.71 kWh
- Week’s Usage: 113.77 kWh

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Current Power Consumption (Watts)
## Comparison with Existing Solutions

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<th>Microsoft Hohm, Google Powermeter</th>
<th>Utility Web Portals</th>
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<th>Green Button (Third Party)</th>
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Related Work

• **Sandboxing** native applications
  – *Language* based, e.g. *Transmute* (Griffins et al.)
  – *System* based, e.g. *xBook* (Singh et al.), OSN (Sariou et al.)

• **Dataware manifesto** (McAuley et al.)

• **Privacy Analytics** (Haddadi et al.)
Conclusions

• *Data privacy v/s data analytics*
  – Existing solutions provide just one

• Application *ecosystem* for home energy
  – Apple App Store, Google Play

• Leveraging modern clouds preserves *privacy*, fosters *application development*