Reference Design for Residential Energy Gateways

i4Energy Symposium

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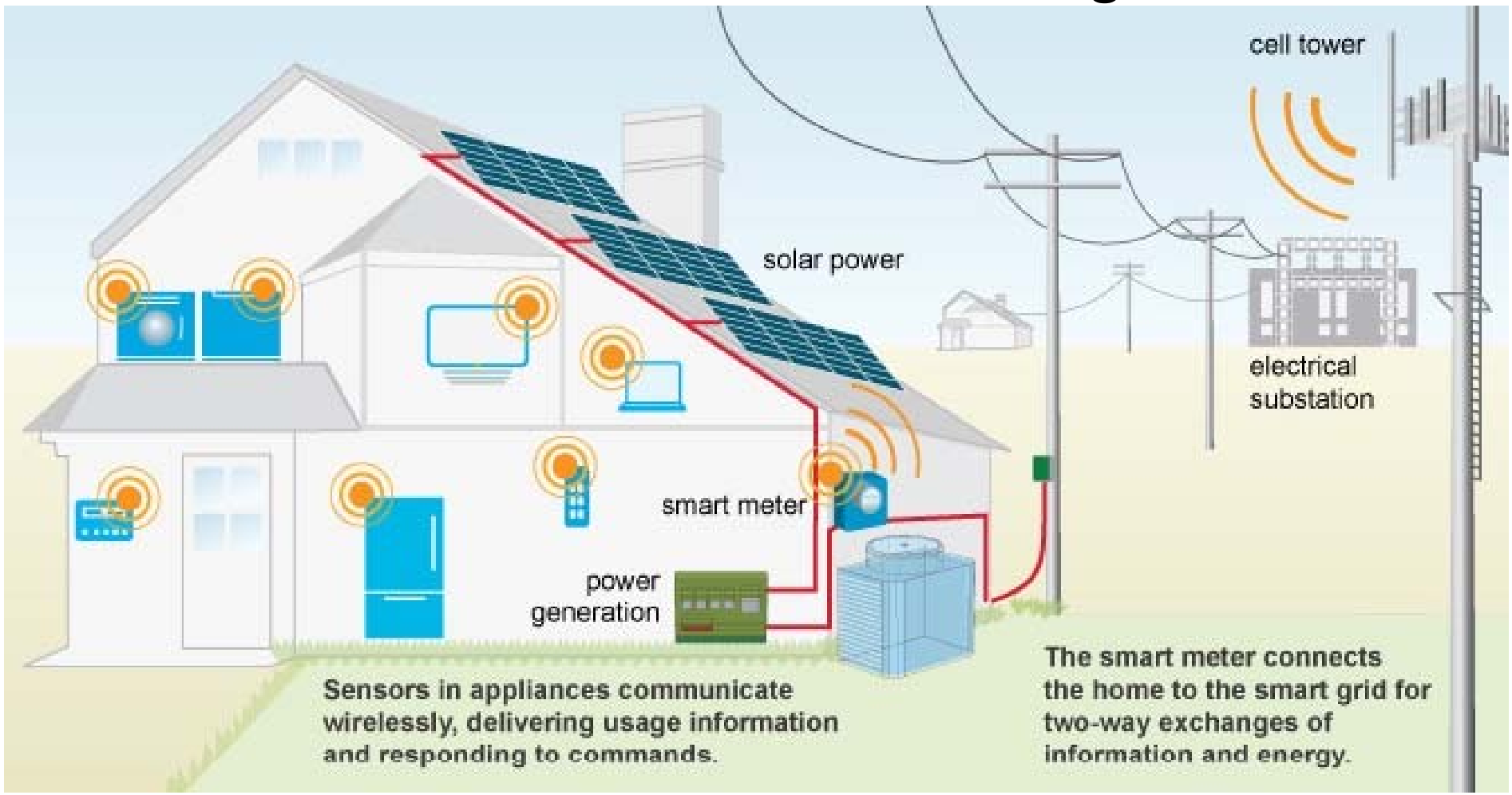
Presentation Outline

- *Background*
- *Motivation*
- *Reference Design Current Progress*
- *Current Plans*
- *Important Issues*

Background

What is the residential “smart grid”?



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Background

What is the residential “smart grid”?

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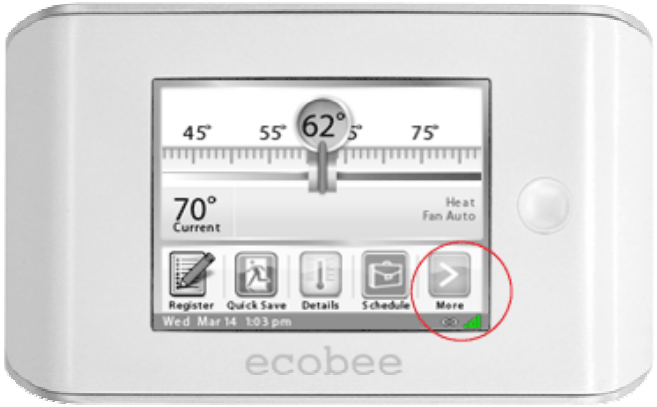
Motivation

So What's the Problem?



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Motivation

In summary:

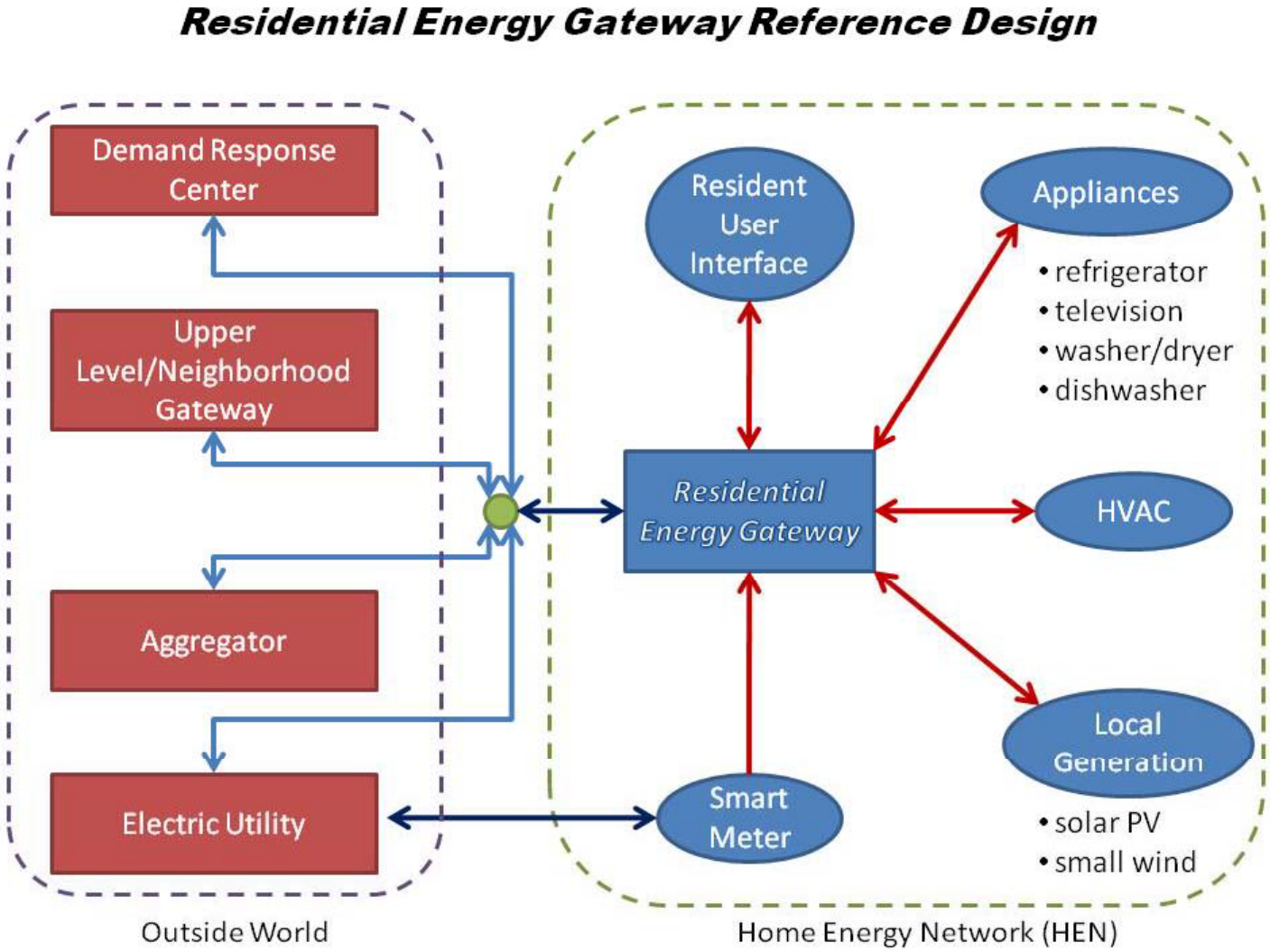
- Multiple communications media exist in the HAN: Wi-Fi, ZigBee Pro, SEP 1.0, SEP 1.x, SEP 2.0, Z-Wave, USNAP
- Different data models are supported: XML, JSON, SEP clusters, proprietary structures
- Lack of interoperability of HAN elements of dissimilar nature

Motivation

What can be done?

- An intermediary device can facilitate interoperation at the application layer
- A modular architecture makes sense
- Provide single mechanism to incorporate resident feedback (rather than multiple interfaces)
- An open source reference design can help encourage “de facto” standardization

Reference Design Current Progress



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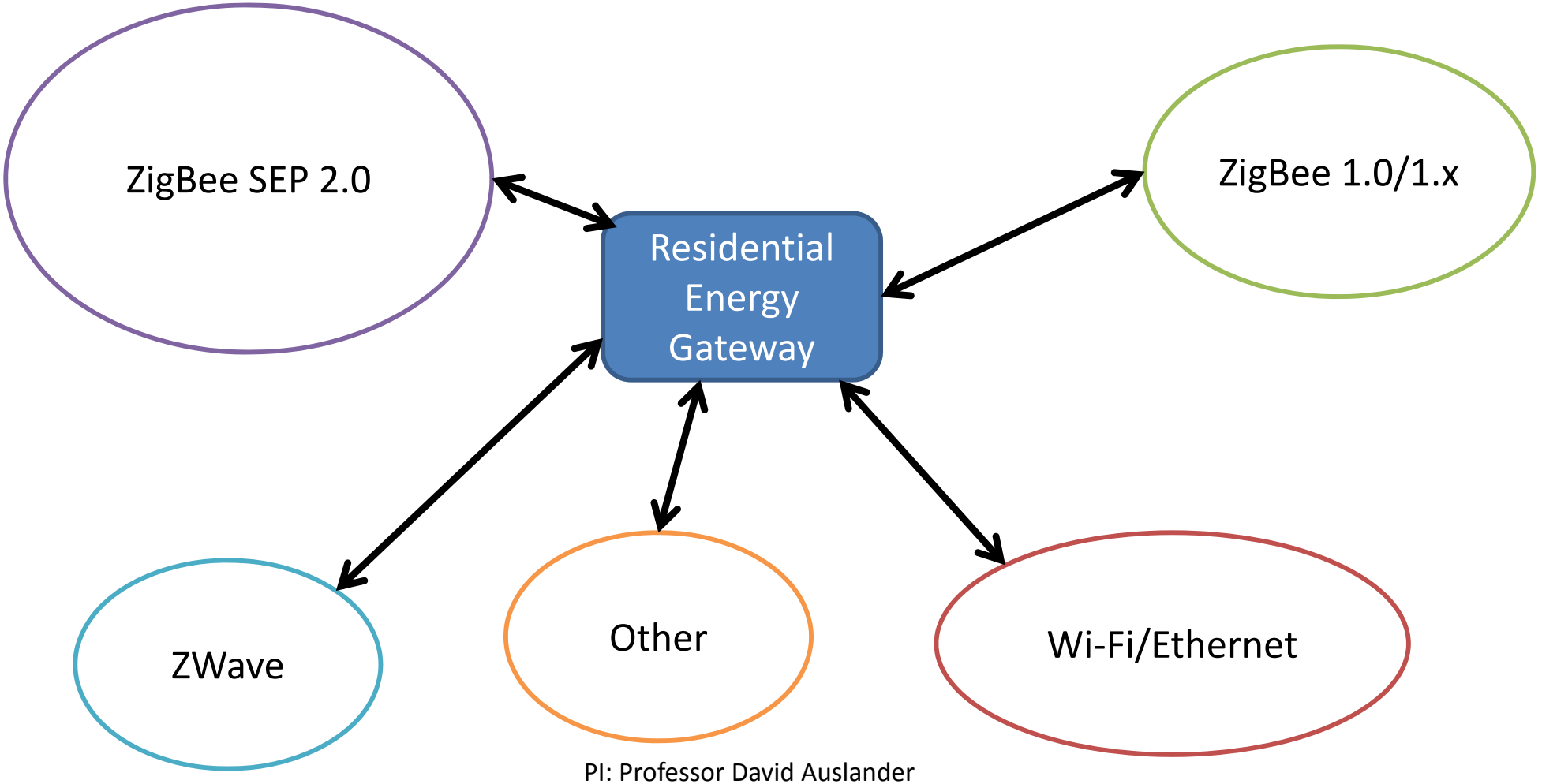
Reference Design Current Progress

With regard to communication networks:



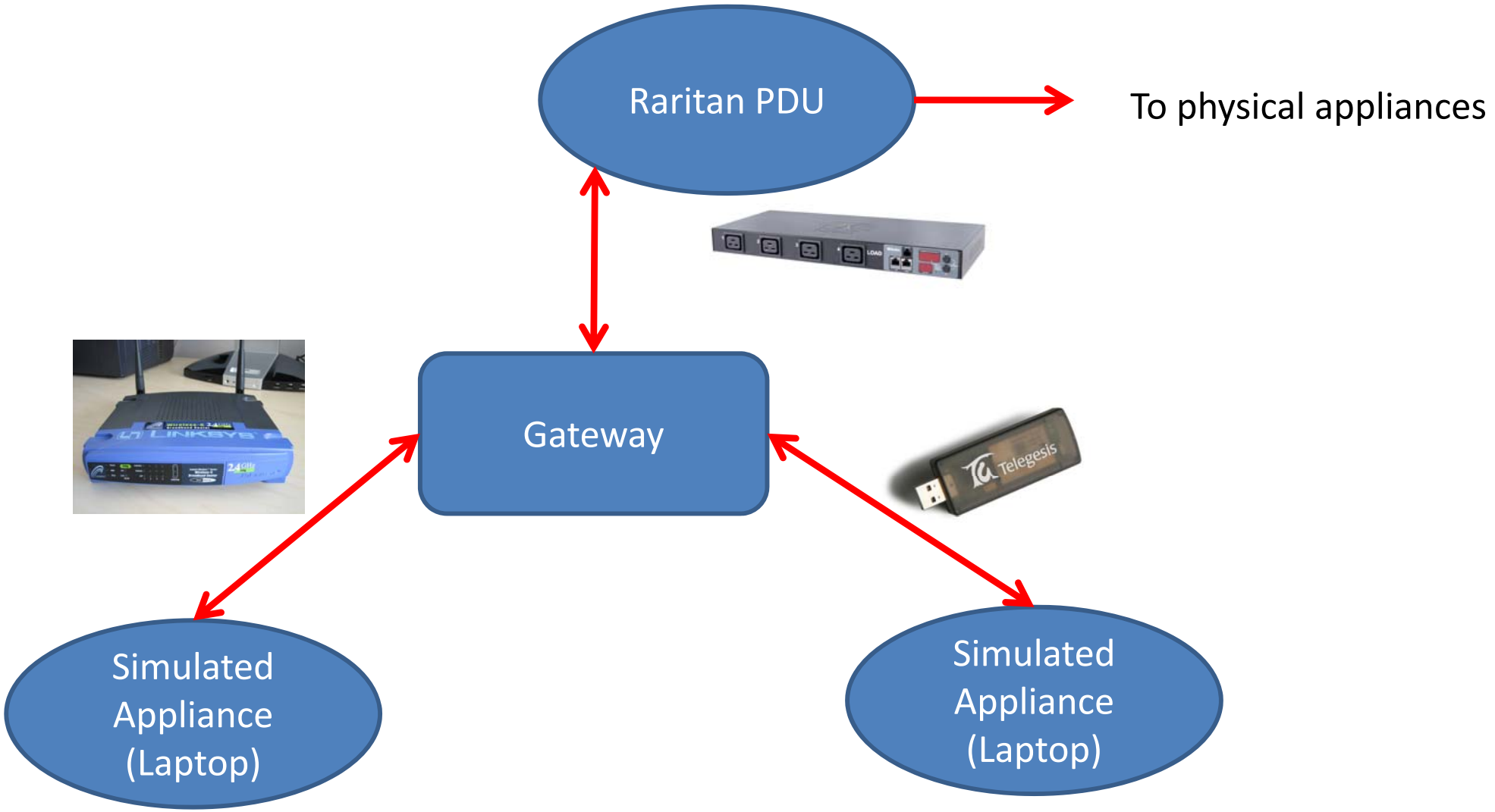
Reference Design Current Progress

- Project timeline: July 2009 – September 2013
- Hardware development environment: Netbook/Laptop
- Communications protocols: Wi-Fi/Ethernet, ZigBee Pro, SSH
- Data models: XML and JSON
- Software programming language: JAVA
- Software architecture: Open Services Gateway Initiative (OSGI)
  - Modular “bundle system” allows for component interoperability
  - Service oriented architecture to support specific functions

Reference Design Current Progress

- Integrated external demand response resource into REG (OpenADR)
- Developed dynamic web based user interface: allows for supervisory control and automation
- Demonstrated REG ability to actuate physical appliances based on demand response signal
- Milestones:
  - REG paper presented at IEEE Power and Energy Society GBM (July 2012)
  - 2011 Dow Sustainability Innovation Student Challenge winner
- Significant industry interest: STMicroelectronics (industry partner)

Reference Design Current Progress

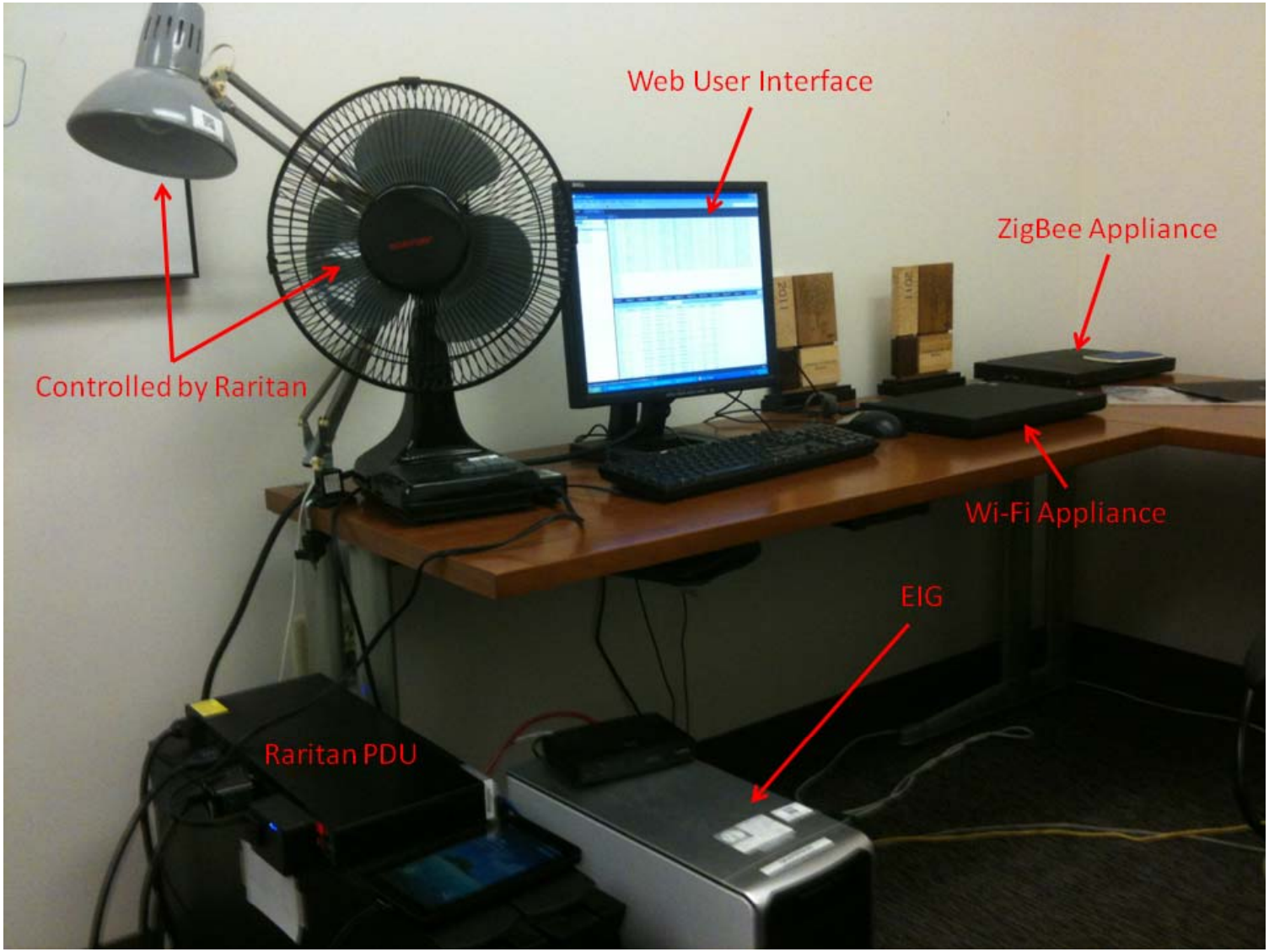


Reference Design Current Progress

Physical Implementations

- REG adapted to manage plug loads in Sutardja Dai office space (DIADR project)
- REG will be implemented to manage plug loads in US Air Force Academy dormitory (Fall 2012)

Reference Design Current Progress



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Current Plans

There's still much to do:

1. *Smart Meter Connection*: Lack of available hardware has prevented us from being able to read meter data over the ZigBee HAN radio
2. *Integrate Dissimilar Products:* In addition to Raritan PDU, other HAN elements with "open" APIs could be integrated
3. *Integrate Products Utilizing Existing Standards:* Zwave, ZigBee SEP 1.0/1.x/2.0

Next revision of the REG software will address these items

Current Plans

How do we integrate multiple communication standards?

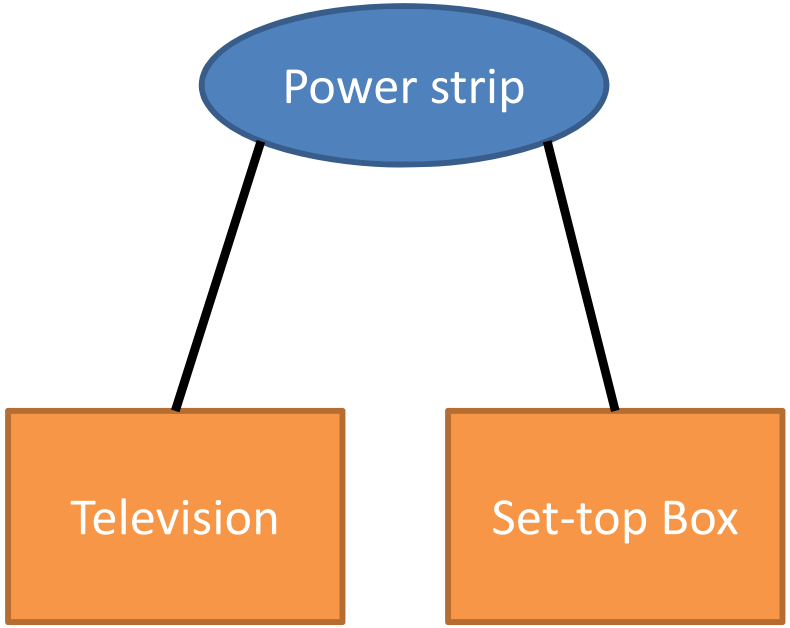
- Each standard has it's own data structure
- Need to account for the possibility of multiple networks in the HAN
- It is desired to have a single interface to interact with the occupant
- In addition, it is possible that these networks can intermingle (a Zwave power strip in series with a ZigBee smart appliance)

What issues need to be resolved in order for the REG to meet these objectives?

Important Issues

1. Hierarchy of devices is important:

- Controlling the parent device affects all children
- How do we communicate this relationship with the occupant?
- How do we define these associations within the REG?



Important Issues

2. Data schemas continue to evolve:

- How does the REG handle new elements?
- How are new schemas integrated into the system?
- What happens to data that was validated against an older schema?

```
<?xml version="1.0"?>
<xs:schema
xmlns:xs="http://www.w3.org/2001/XMLSchema">

<xs:element name="note">
 <xs:complexType>
  <xs:sequence>
   <xs:element name="to" type="xs:string"/>
   <xs:element name="from" type="xs:string"/>
   <xs:element name="heading" type="xs:string"/>
   <xs:element name="body" type="xs:string"/>
  </xs:sequence>
 </xs:complexType>
</xs:element>

</xs:schema>
```

Important Issues

3: An internal REG data structure is necessary

- Z: ZigBee, W: Zwave, G:Gateway
- Gateway data schema must be a superset of Z and W
- Define mappings into/out of the Gateway data structure
- This allows elements from one network (w) to be translated into an element of another network (z)

$$Z \subseteq G$$

$$W \subseteq G$$

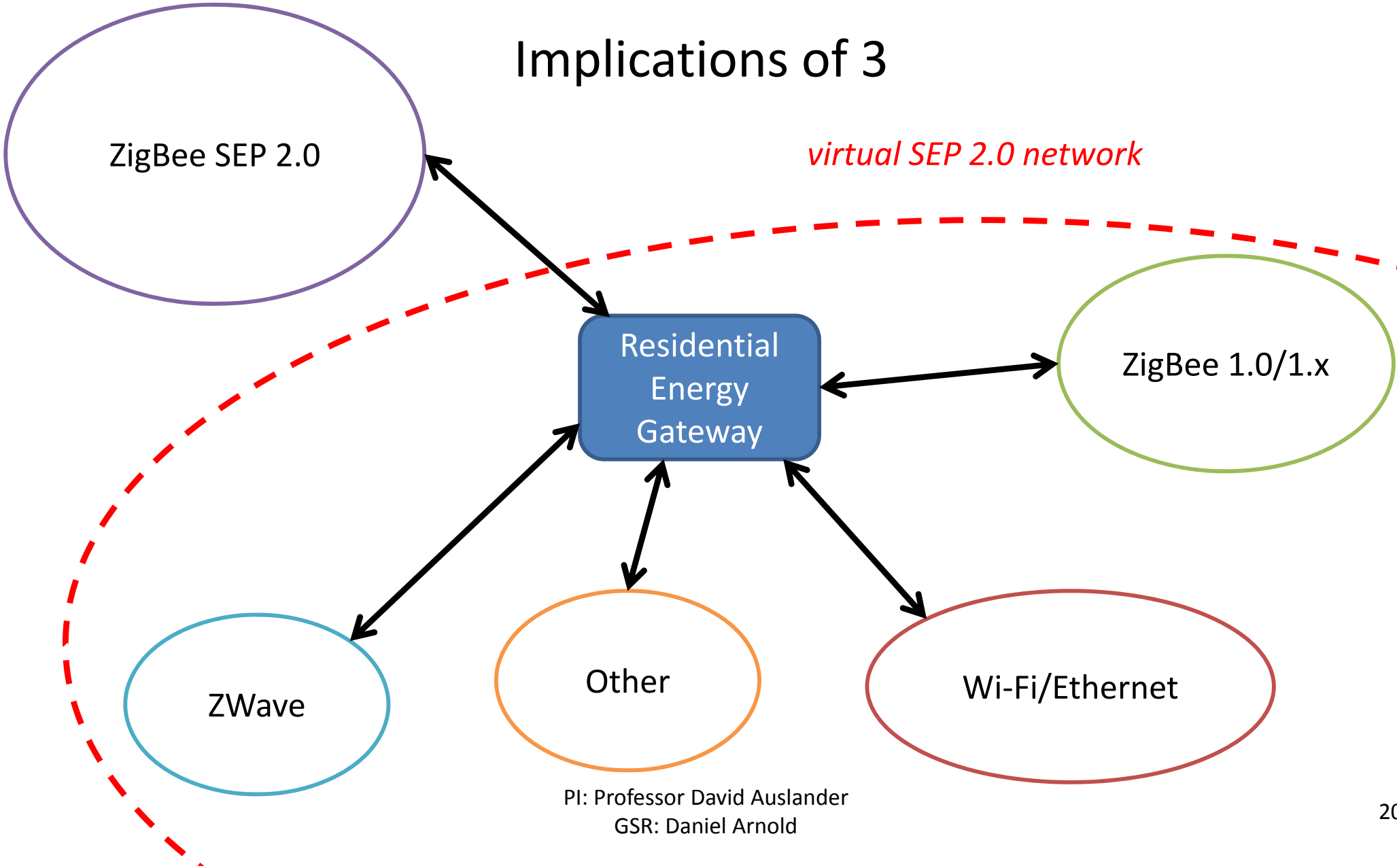
$$f_{Z,G} : Z \to G$$

$$f_{W,G} : W \to G$$

$$\Rightarrow z = f_{Z,G}^{-1}\left(f_{W,G}(w)\right)$$

Important Issues

Implications of 3



Important Issues

How do we incorporate these improvements into our design?

1. *Device Hierarchy:* Utilize Java Naming and Directory Interface (JNDI) to establish parent/child relationships between devices
2. *Data Schema Evolution:* Do not “hard code” schemas into code. Utilize dynamic schema binding (map XML into JAVA at runtime)
3. *Internal REG Data Structure:* Clearly define mappings via XML. JAVA uses XML file for object to object mappings

Summary

Thank You

For more information, please visit
http://mechatronics.berkeley.edu/gateway.htm

Special Thanks To:
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