



Reference Design for Residential Energy Gateways



i4Energy Symposium

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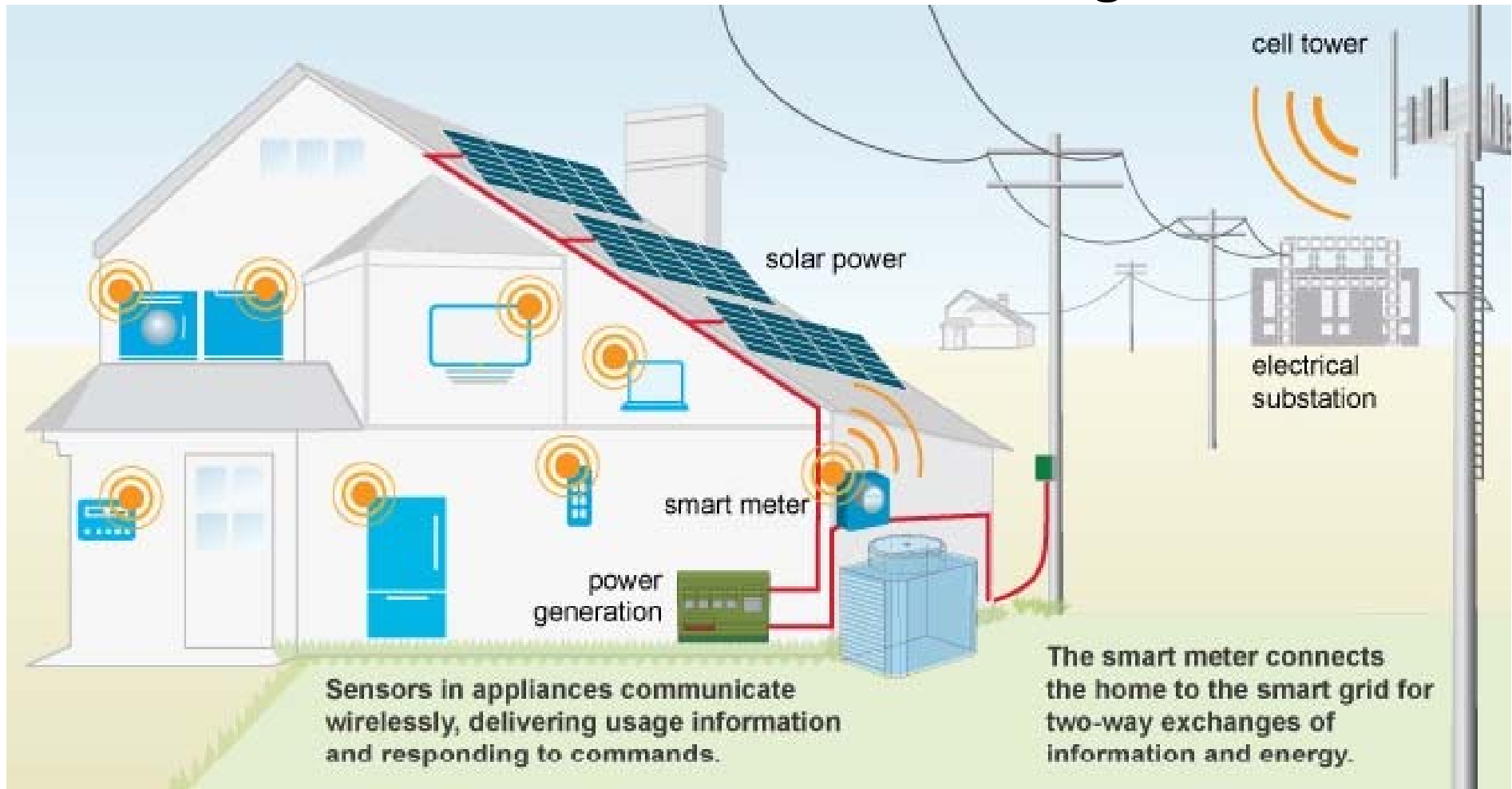


Presentation Outline

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

Background

What is the residential “smart grid”?





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BuLogics, Inc. introduces the world's first Smart Grid compatible Z-Wave® wireless controller, bridging the wireless technology of over 350 Z-Wave Home Area Network (HAN) devices to Advanced Metering Infrastructures that support the Smart Grid.



Available NOW!

Features **expansion modules** for **easy connection to the Smart Grid to ANY wireless standard!**

Bridges meters that utilize the ZigBee® Smart Energy profile!

Empowers Consumers to Save Energy and the Environment

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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

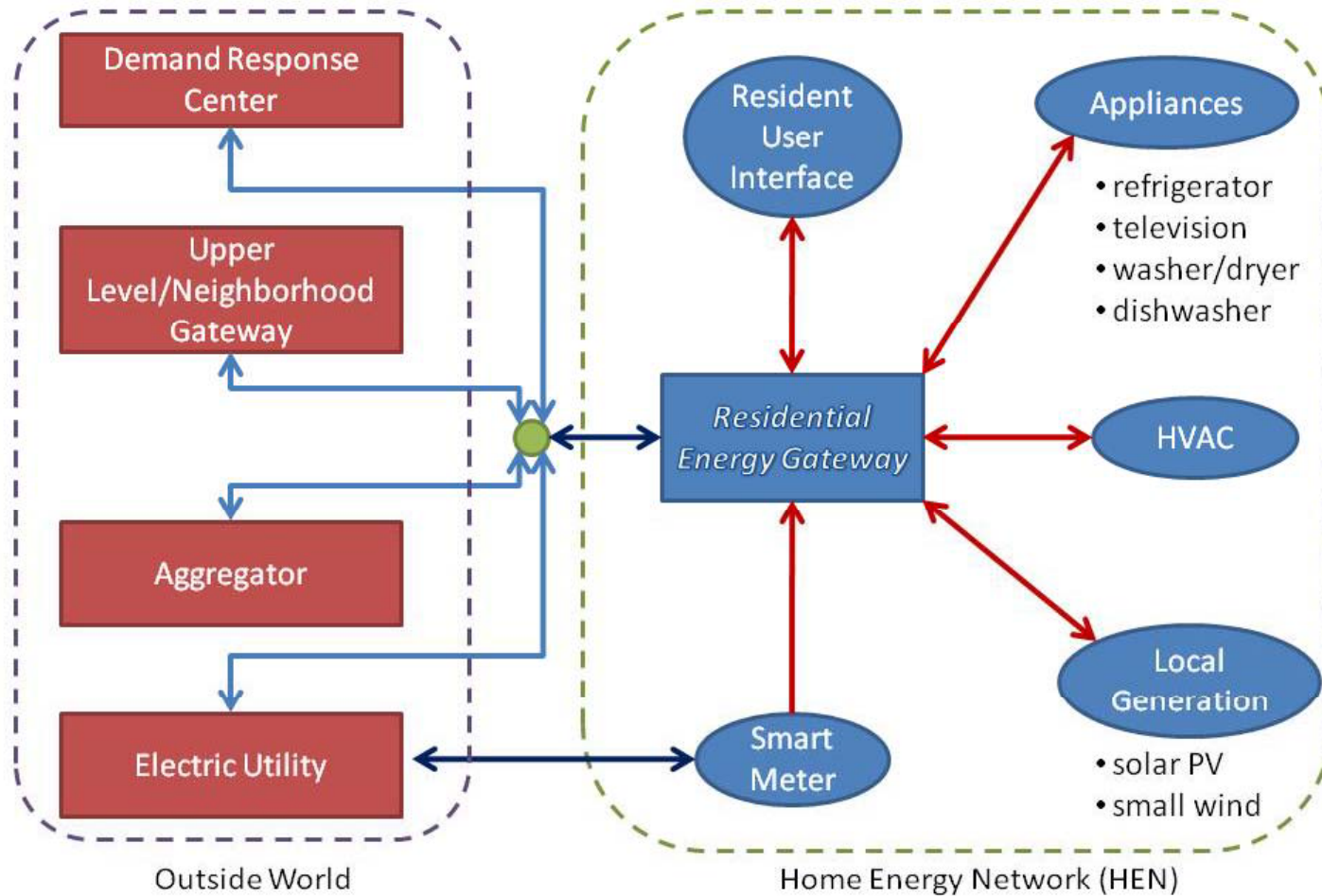
What can be done?

- 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

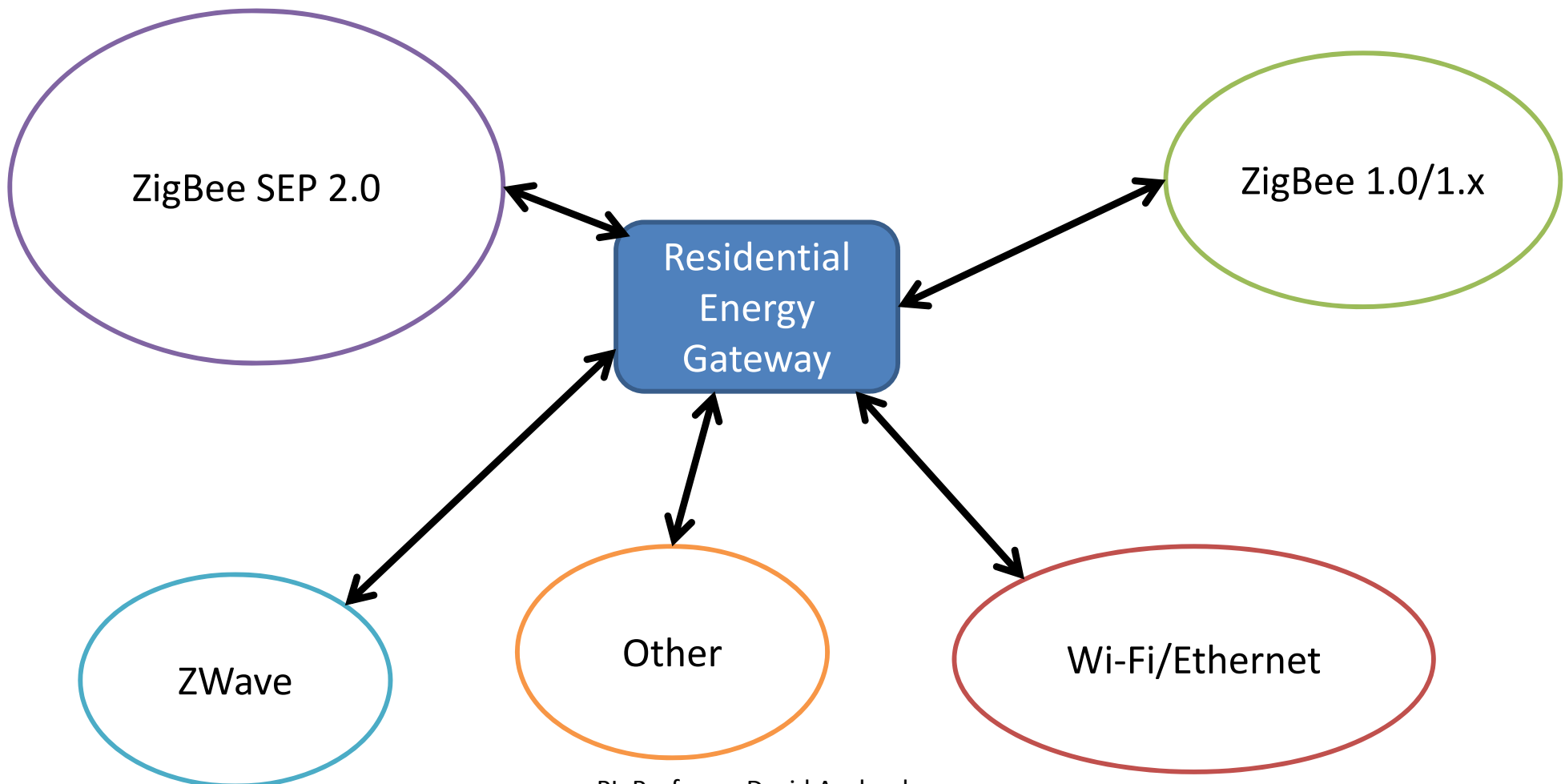
Residential Energy Gateway Reference Design





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

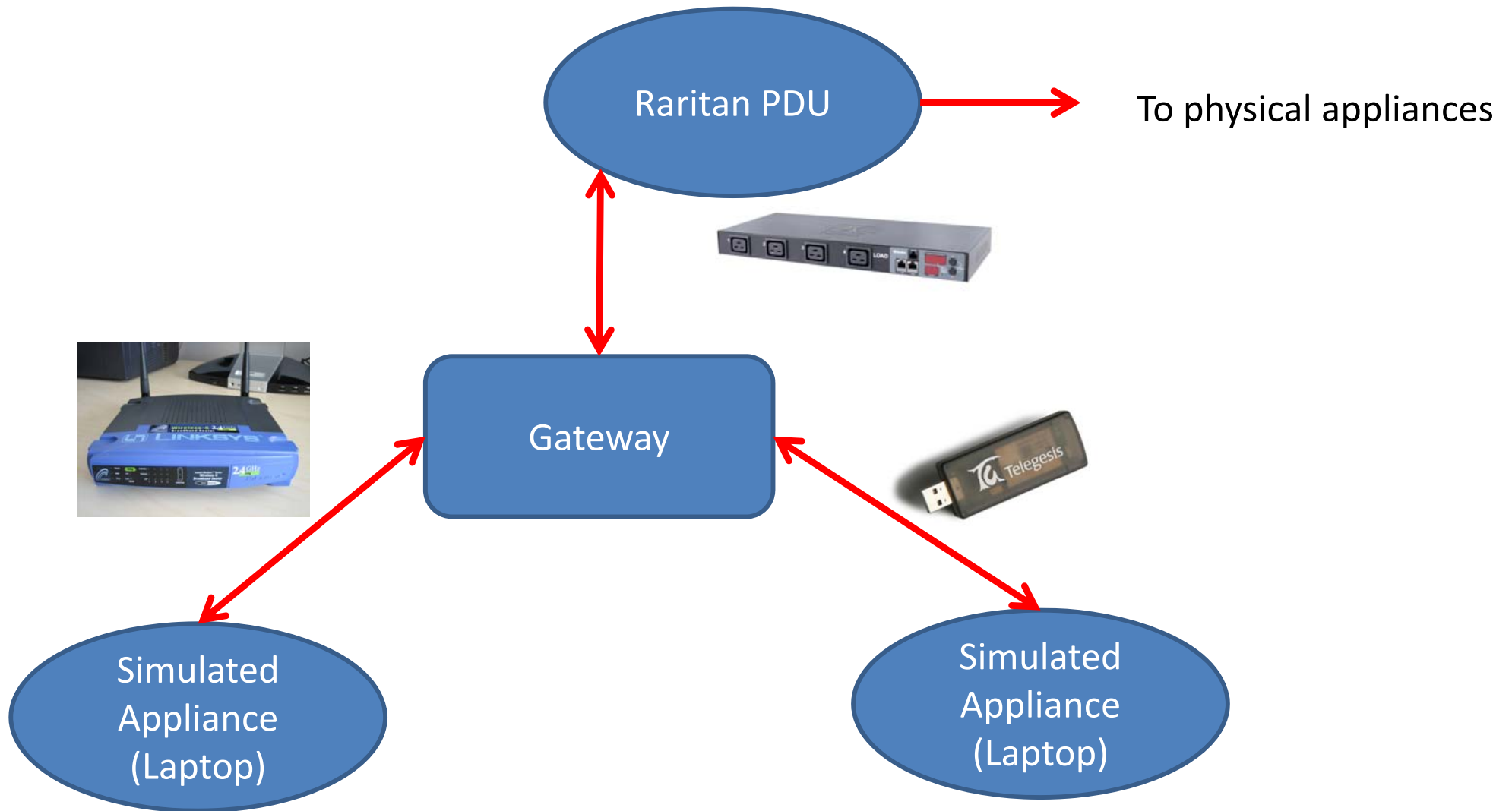


Reference Design Current Progress

- 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



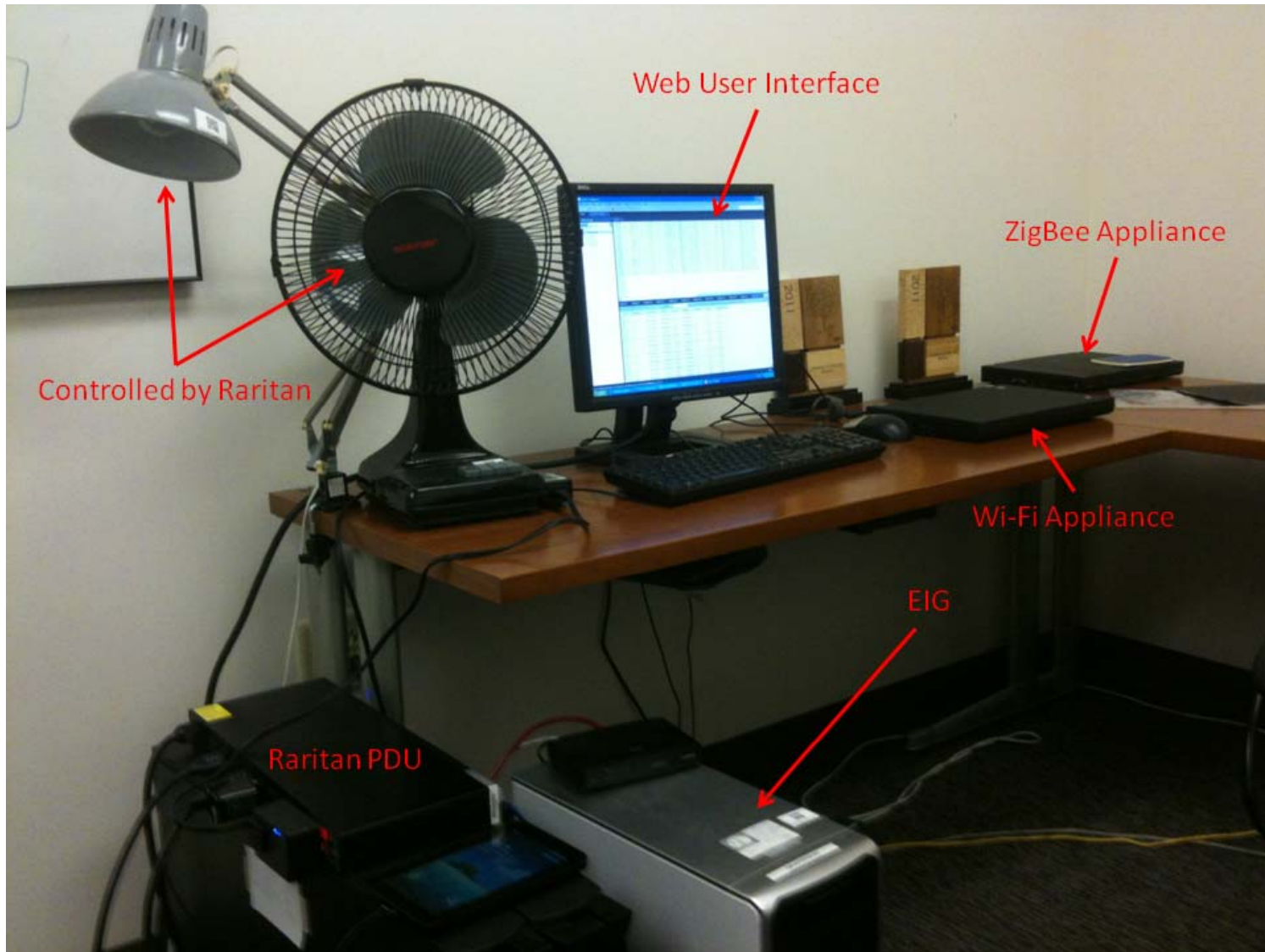


Physical Implementations

- 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 its 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)

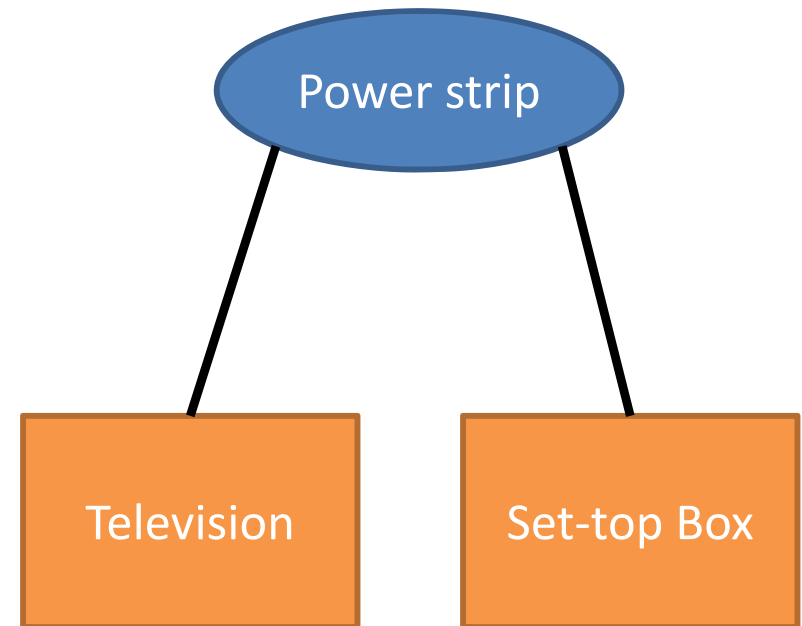
What issues need to be resolved in order for the REG to meet these objectives?



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

$$Z \subseteq G$$

- Gateway data schema must be a superset of Z and W

$$W \subseteq G$$

- Define mappings into/out of the Gateway data structure

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

- This allows elements from one network (w) to be translated into an element of another network (z)

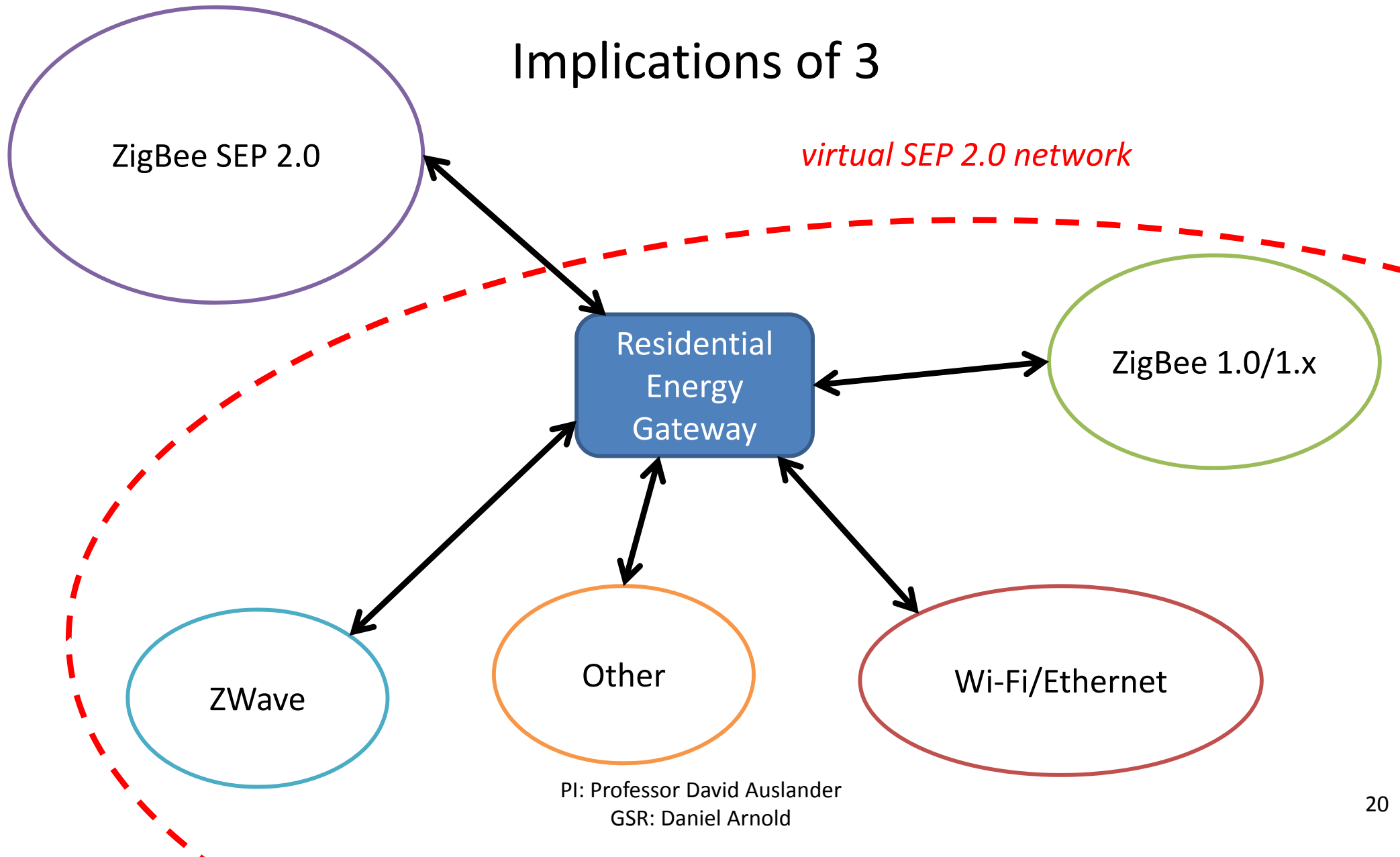
$$f_{W,G} : W \rightarrow G$$

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



Important Issues

Implications of 3



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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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CIEE

LBL

DIADR (Siemens, UC Berkeley, DOE, LBNL)

Akuakom

STMicroelectronics