IoT/PowerMatcher Transactive Energy for Smart Cities

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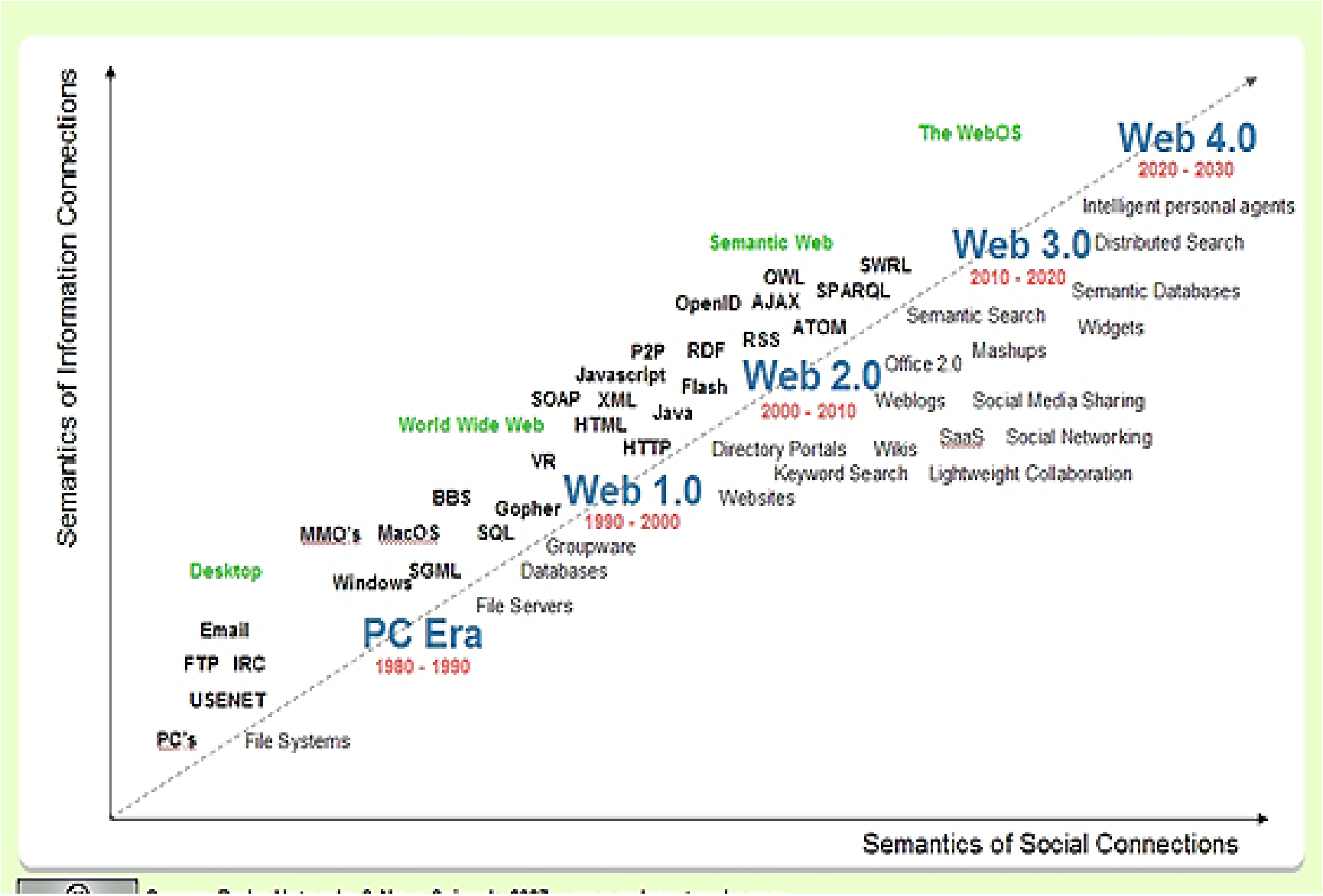
Chairman

THE INTERNET of
THINGS

Social Networking Driving the Evolution of Smart devices

World Wide Web Timeline



DR Today

- Demand Response (DR) has been viewed as requiring all remote consumption and renewable energy generation device data would be sent to an aggregator

Smartness Today

- The Smart Grid is still in transition with continued migration to Smart Meters
- However, this is the beginning of the need to gain greater control which would require access to devices in a owners homes and buildings
- This has been found to be challenging since end devices need to provide greater energy flexibility
- The protocols using the publish-subscribe pattern can expose owners devices to potential man-in-the-middle attack which has now raised privacy concerns

PowerMatcherSuite

Transactive Smart Energy

http://www.flexiblepower.org

PowerMatcher City Video

https://www.youtube.com/watch?v=v-P9eI_A0ak

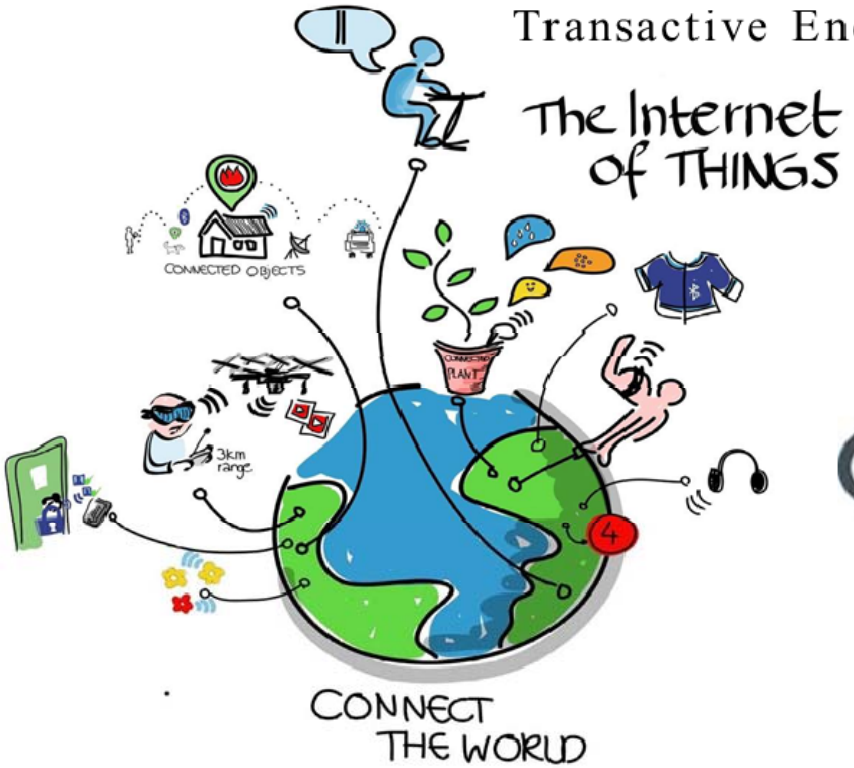
PowerMatcher Value Proposition

- Less cost and greater end-user benefits
- Flexible energy saving appliances
- New job opportunities for energy pioneers including development of energy flexible devices
- Provides community resiliency with greater integration of renewables
- PowerMatcher provides a control point for exchange of energy information without have to obtain sensor data directly from owners devices

NIST Global City Team Challenge
NIST Transactive Energy Challenge

IoT/PowerMatcher TE Test Bed

NIST Transactive Energy Test Bed



Transactive Energy For Smart Cities

GLOBAL CITY TEAMS CHALLENGE

2016

PowerMatcherSuite
Transactive Smart Energy

Sensei/IoT* XMPP

TE Team

- MaCT (DC) – William Miller (Team Leader)
- TNO (Netherlands) – Wilco Wijbrandi
- Alliander (Netherlands) - Alexander Krstulovic
- Clayster (Sweden) – Rikard Strid
- Buffalo State (NY) – Dr. Ilya Grinberg
- Rowan University (NJ) - Dr. John Schmalzel
- UOIT (Canada) – Dr. Hossam Gaber

TE Test Sites

- Erie County, Buffalo, NY
- City of Glassboro, NJ
- City of Oshawa, ON (Canada)

TE Architectural Framework

- The TE Architectural Framework will include a broadband wireless network providing a high speed backhaul between clusters and a local universities (Buffalo State, Rowan University, and UOIT (Canada)
- Provisioning of TE Clusters in each Smart City would connect to homes and/or buildings
- Interface various sensors via EF-PI interfaces
- Federated connections between universities
- Smart City planners and local residents would be able to view the status of community cluster

TE Clusters

- PowerMatcher clusters will consist of multiple homes or buildings to provide sensor data from consuming and renewable generation devices
- PowerMatcher will be authenticate to a XMPP Service Broker/Provisioning Server that has been provisioned and shared by the owner.
- Transactions will be made in near real-time based upon energy supply and demand

TE Actions

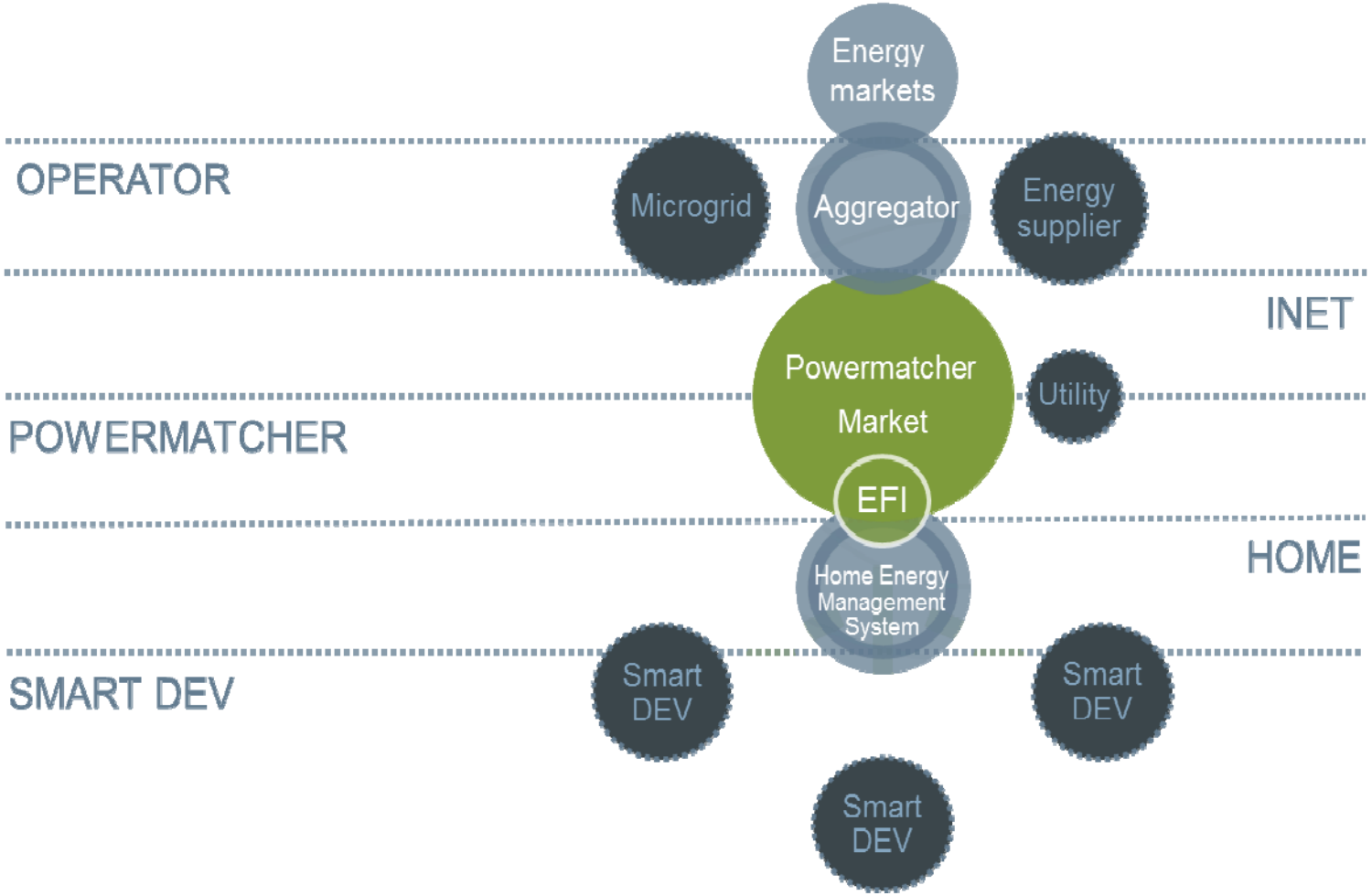
- The bid transactions will be based upon the difference of energy consumption and renewable generation from PowerMatcher
- All price exchanges will be initially simulated to evaluate PowerMatcher transactions under real world conditions
- The difference will be offered to the simulated energy market in exchange for a price at that particular time of day (point pricing)
- The (forward pricing) model will be used to change the schedule based upon projection of weather conditions and expected patterns of energy use by the homes and buildings

PowerMatcher

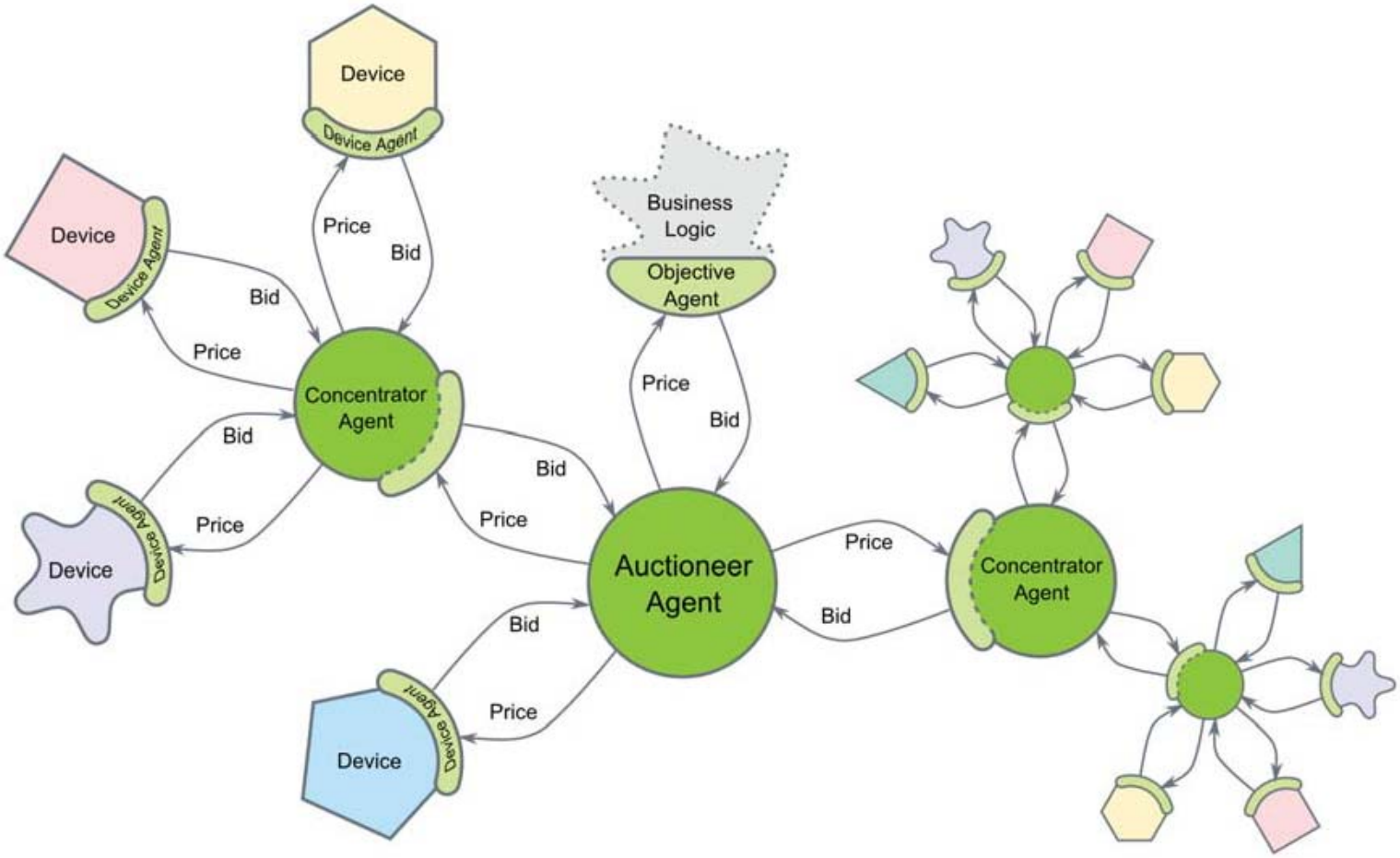
- PowerMatcher is a software developed by the **FlexiblePower Alliance Network (FAN)** with Energy Flexibility – Power Interfaces (EF-PI)
- EF-PI offers APIs to interface to sensors in a home or building as input to PowerMatcher
- PowerMatcher offers decentralized coordination of supply and demand based upon control theory and microeconomics using multi-agents with a standardized bid function.
- The software is open source and written in OSGi Java.

http://www.flexiblepower.org

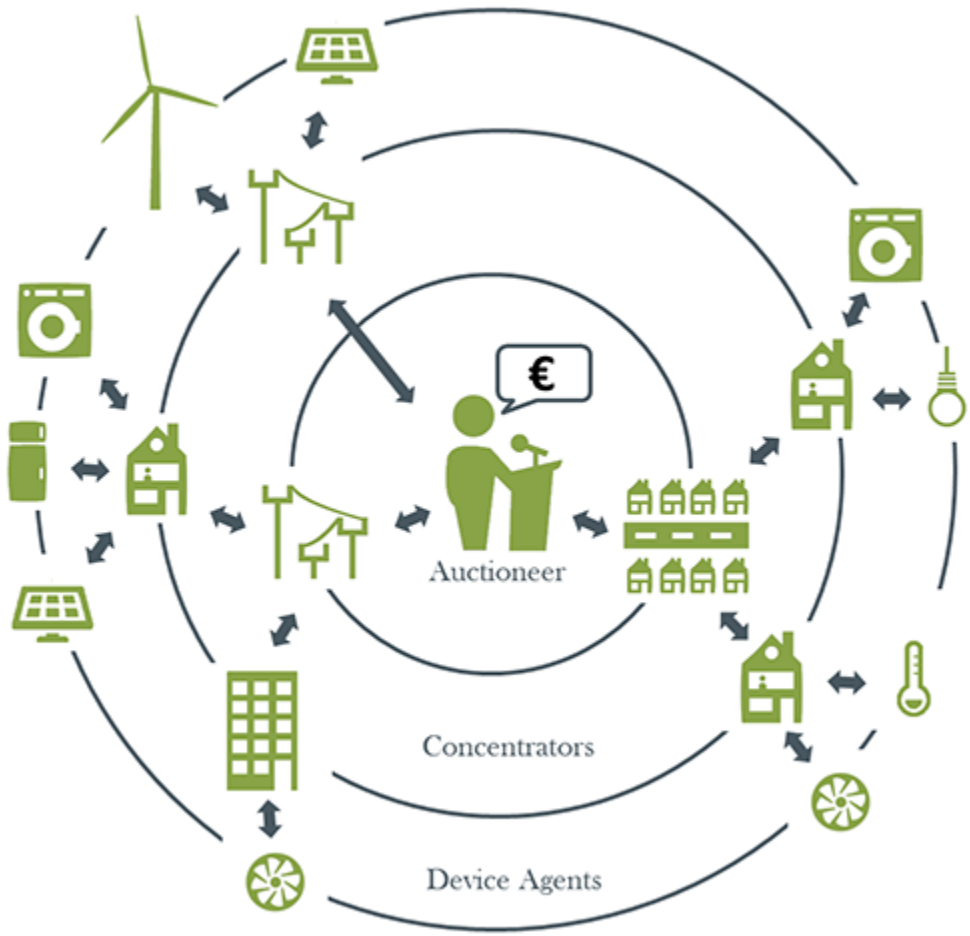
PowerMatcher Framework



Schematic overview of the entities in a PowerMatcher network



The Auctioneer is at the center



Background

- A PowerMatcher network contains a single ***Auctioneer***, which is the electronic market place in the system where the electricity is traded.
- Devices that can and wish to trade on this market are represented by ***Device agents***.
- Such agents attempt to operate the associated processes in an economically optimal way, whereby no central optimization algorithm is necessary and communication with the auctioneer is limited.

Background

- The only information that is exchanged between the agents and the auctioneer are bids.
- These bids express to what degree an agent is willing to pay or be paid for a certain amount of electricity.
- Bids can thus be seen as the priority of a device to turn on or off. As a response to these bids, the market clearing price is returned to the agent.
- The device agents react appropriately by either start producing (or consuming), or wait until the market price or priority of the device changes.

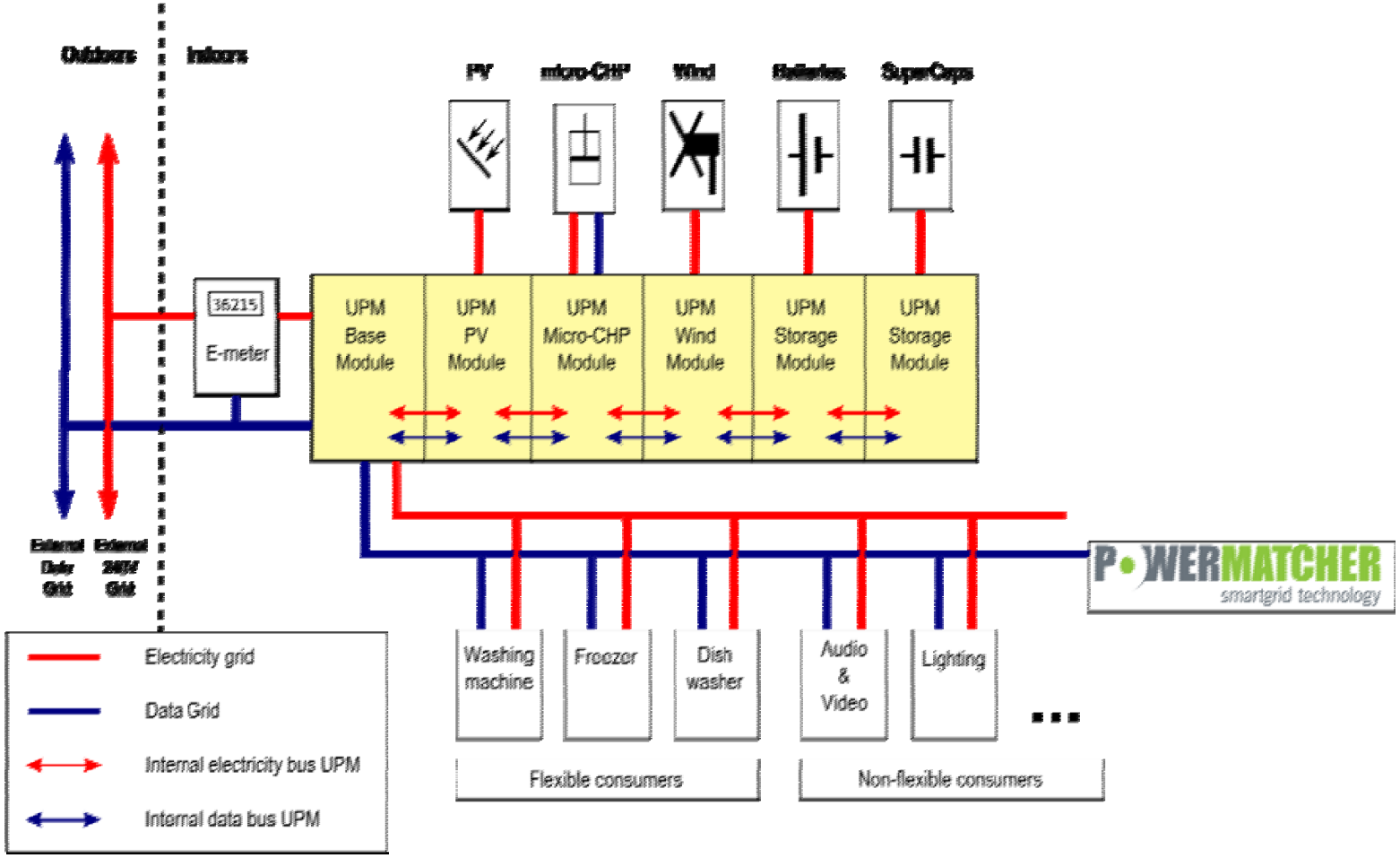
Bid Propagation

- At the intermediate levels between device agents and the auctioneer, one or more *concentrators* may be located. Concentrators aggregate the bids sent by lower level agents.
- an auctioneer or higher level concentrator is unable to distinguish between bids received from device agents or lower level concentrators.
- This property ensures a standardized interface for all types of devices.
- The use of concentrators at multiple levels allows economical optimizations for multiple stakeholders

Impact

- While an energy trader, for example, can minimize imbalance at the auctioneer level,
- a grid operator can use a concentrator to handle high peak loads in its substation, to ensure only those that are directly involved with the high peaks are affected.
- Likewise, a concentrator at household level can optimize for the devices solely inside the house.

Schematic overview of the Universal Power Manager



PowerMatcher Security and Privacy Protection

Sensei/IoT* XMPP

What is IoT XMPP?

- **XMPP (eXtensible Messaging and Presence Protocol)** that is based on eXtensiuble Markup language (XML) standardized by the W3C and used for instant messaging (IM) and online presence detection by the XMPP Standards Foundation (XSF) http://www.sensei-iot.org

- **ISO/IEC/IEEE P21451-1-4** is the DRAFT standard based on new IoT XEPs (eXtensions) for Instant Sensor Messaging and a common metadata transport for the Internet of Things (IoT) http://www.sensei-iot.org

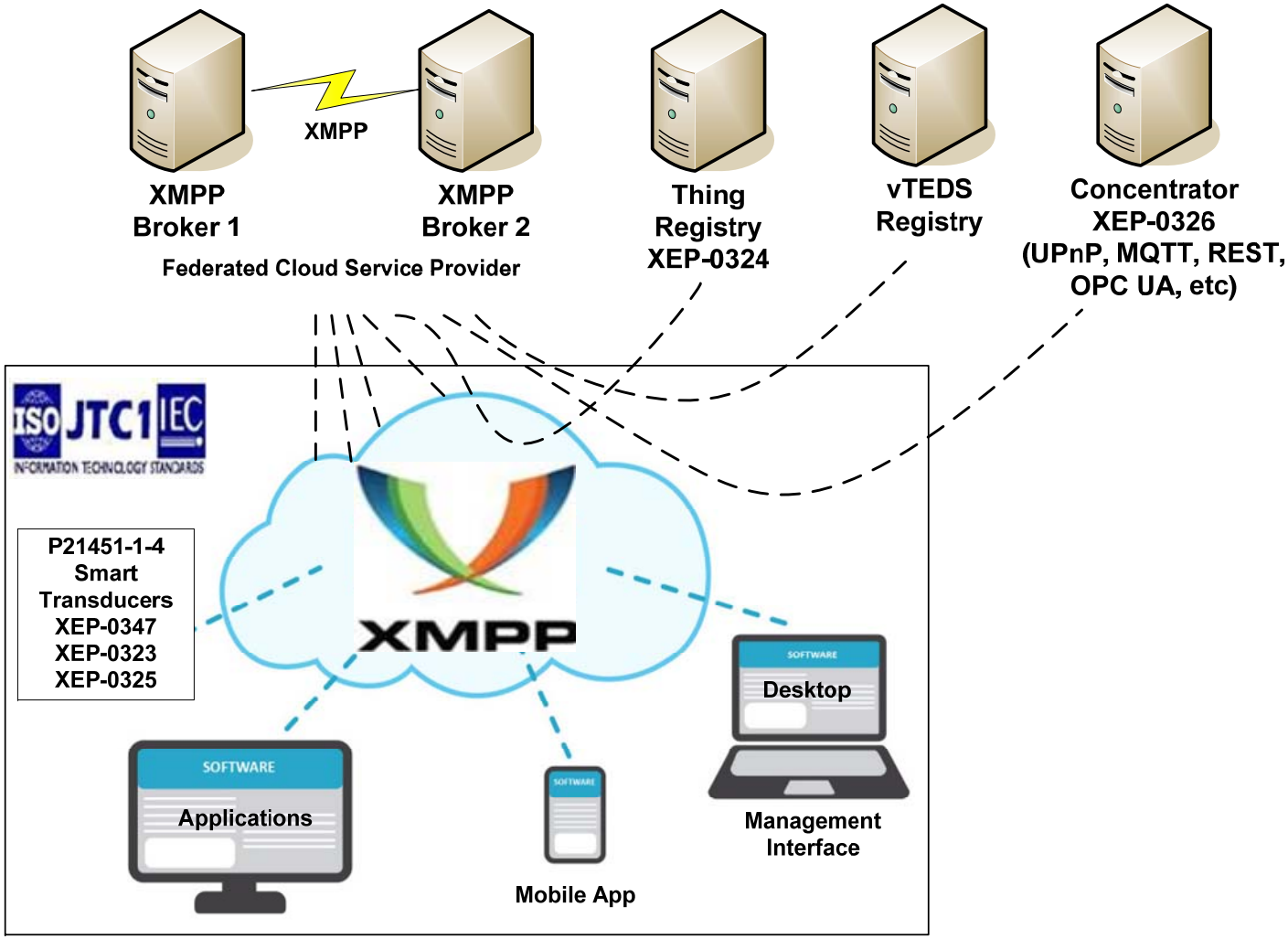
PowerMatcher
Cyber Considerations

- Unique Identification of Things
- Registration of Things
- Transfer of a Thing
- Delegating Trust to a Provisioning Server known as a “Thing Registry”
- Transfer from a Thing owner

Trust and Security

- Provide an IoT approach that can be trusted to protect data the may infringe on the privacy of users and used without the Owner's consent
- Privacy is viewed differently around the world. Ex In the EU and in the USA, it has been viewed as an infringement of privacy to install "Smart Meters"
- Integrity of IoT is at risk if there is a lack of Trust, so we MUST assure that actions cannot be compromised or data used inappropriately thru actions not authorized by the device owner

P21451-1-4 Reference Architecture



IoT Universal Unique Identification

- **ISO/IEC/IEEE P21451-1-4** uses a JID (Jabber IDentifier), Universal Unique IDentifier (UUID), defined in the DRAFT ISO/IEC 29161 Automatic Identification for the Internet of Things developed by ISO/IEC/JTC1/SG31/WG6 Automatic Identification & Data Capture and ISO/IEC/TC122 Packaging.
- **jid = [node "@"] domain ["/" resource {device}]**
  - The full JID is more secure and offers greater flexibility
- **Example:**

EPCglobal

31

IoT XEP-0347 Discovery Resource Identification

```
<iq type=’get’
  from=’requester@example.org’
  to=’responder@example.org’
  id=’info1>
  <query xmlns=’https://jabber.org/protocol/disco#info>
  <identity category’gateway’ type=’ncap
name=’ncapid’/>
   <feature var=’urn:xmpp:iot:provisioning'/> REQ’D
   <feature var=’urn:xmpp:iot:interoperability'/> REQ’D
   <feature var=’http://jabber.org/protocol/disco#info’/>
   <feature var=’http://jabber.org/protocol/disco#items’/>
  <identity>
 </guery>
 </iq>
```

Registering a Thing
IoT XEP-0347 Discovery

```
• <iq type='set‘
•     from='thing@example.org/imc'
      to='discovery.example.org'
      id='1'>
•    <register xmlns='urn:xmpp:iot:discovery'>
        <str name='SN' value='39487234873294872 3'/>
        <str name='MAN' value='www.ktc.se'/>
        <str name='MODEL' value='IMC'/>
        <num name='V' value='1.2'/>
        <str name='KEY' value='4857402340298342'/>
     </register>
• </iq>
```

Delegating Trust
IoT XEP-0324 Provisioning

- The Provisioning Server is a
  - 1) “Thing Registry” and a trusted 3rd party
  - 2) provides access control and identity management
  - 3) uses Simple Authentication and Security Layer (SASL)
  - 4) provides delegation of a Things as either public or private
  - 5) allows Thing Owner’s to “friend” there Things.
  - 6) have full control to establish, alter, or remove access
  - 7) restricts access to Thing attributes via rules and policies
  - 8) Tokens and X.509 certificates are used to limit access during read or write operations to prevent contention
  - 9) provides reactive learning of responses leading to zero configuration

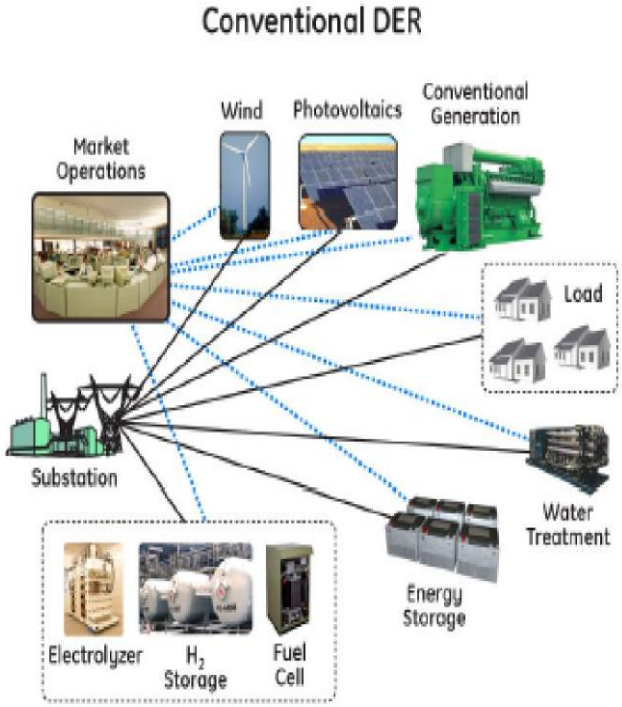
Transfer of a Thing To an Owner

- The steps to register a Thing:
  - 1) provide unique identification of the Thing that is difficult (in practice impossible) to guess,
  - 2) simple to implement and simple to transfer the Thing to the Owner with use of QR-Codes,
  - 3) Owner claims the Thing and then authorizes access to share data with other devices, users, or applications as either public or private

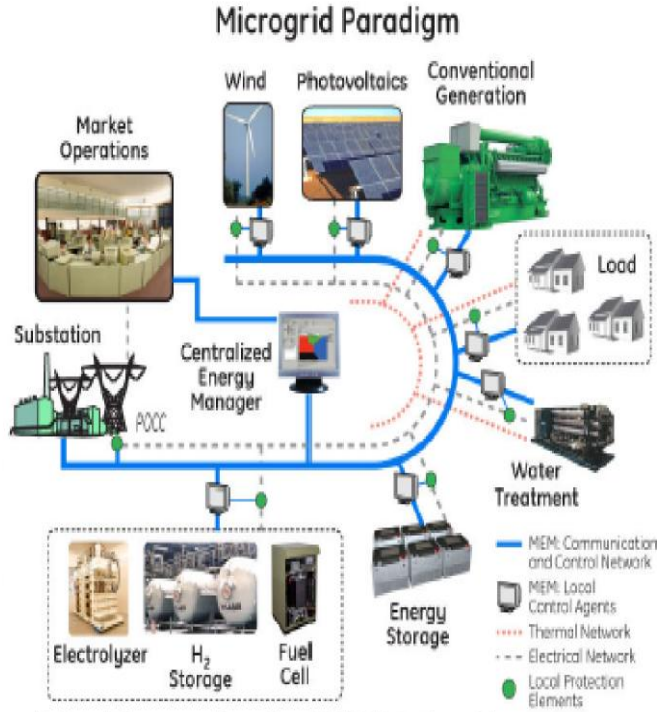
Transactive Energy for Smart Cities

“The Big Picture”

Integration of Renewable Generation Conventional vs. Microgrid Paradigm

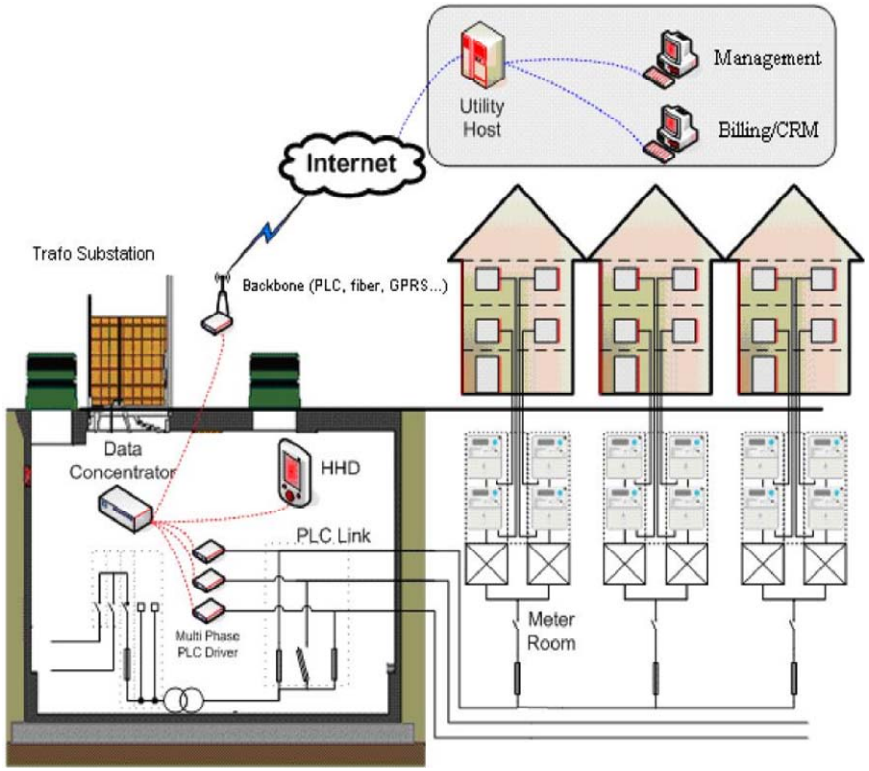


- Many points of coupling
- Lack of system coordination to take full advantage of DER assets
- Complexity in grid interconnection
- Utility concerns

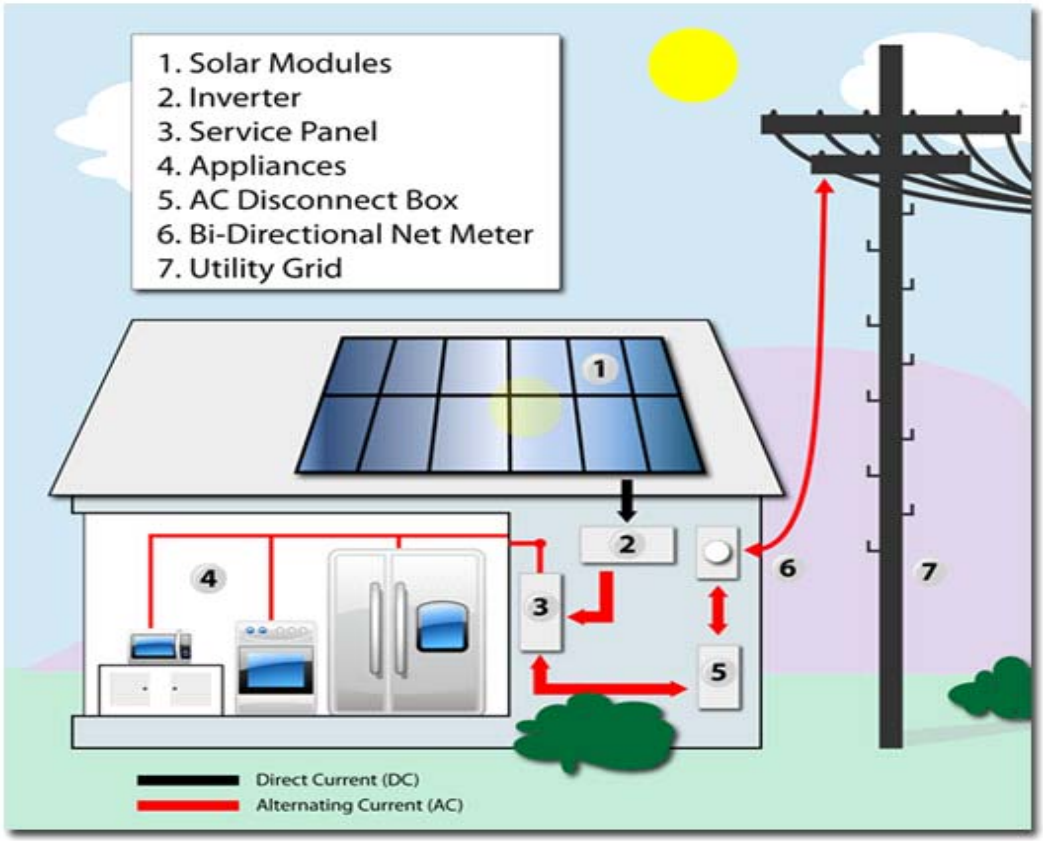


- Point of Common Coupling (POCC) to the grid
- System coordination and optimization for asset utilization (electrical and thermal)
- Grid-connected and/or island operation to increase availability
- Achieve benefits to utility and end-user

Microgrids


Utility
Host
Management
Billing/CRM
Internet
Trafo Substation
Backbone (PLC, fiber, GPRS...)
Data
Concentrator
HHD
PLC Link
Multi Phase
PLC Driver
Meter
Room

Prosumers


1. Solar Modules
2. Inverter
3. Service Panel
4. Appliances
5. AC Disconnect Box
6. Bi-Directional Net Meter
7. Utility Grid
1
2
3
4
5
6
7
Direct Current (DC)
Alternating Current (AC)

Microgrids vs. Prosumers

- **Microgrids** are generally utility or a 3rd party provider owned assets
- **Prosumers** are those who are consumers, but also have renewable generation capability such as solar, wind, etc.
- ***"The ownership of the devices should determine authorization to the information"***
- The is also the concern that when using a telecom or 3rd party provider, who may feel they have data rights. This will remain a challenge for law and policy makers.

Conclusions

- **ISO/IEC/IEEE P21451-1-4 (Sensei-IoT*)** offers Semantic Web 3.0 capabilities that includes unique identification, access control, device sharing, built-in Transport Layer Security (TLS), a common reference architecture for data exchange that is technology agnostic and protocol independent. Privacy is protected with use of “Thing Registries” limiting access to other devices authorized by the Thing owner.

Conclusions

- The registration of PowerMatcher units provides the owner with a means to authorize access to their devices that is not done today
- The sensor data is behind a PowerMatcher unit and not accessible outside of the premises
- Smart energy transactions are protected

Internet of Things (IoT)

http://www.sensei-iot.org

Sensei/IoT*

NREL SGES

April 12, 2016

Thank You!