Networked Energy Efficiency of Plug Loads -The Internet of Home Entertainment



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Overview





A Brief History of Plug Load Communications

The Evolution

- Individual (Devices and appliances)
- Language (Energy reporting, User interface)
- Networking (Protocols, Standards)
- System (Smart home, Microgrids, Smart Grid)



Creating Connections. Powering Innovation. Boosting Efficiency.



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CalPlug Plug Load Energy Efficiency Roadmap



Individual Device: the set-top boxes





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Intelligent Sleep— CalPlug's 5W5s Solution

A consumer centric solution that adapts to the current STB infrastructure. Consumer input, sensor response and usage pattern are factored in for optimum delivery of service, without "consumer frustration".





5W5s Comparison Test Results





The Impact



From Indidivual Devices to Systems: CalPlug Energy Reporting and Display 2014

- **1.** Device internal energy reporting
 - Develop algorithm
 - Test algorithm for power prediction
 - Self-calibration

2. Energy display for plug loads

- Energy display software(service)
- Cross-platform compatibility
- Interoperability (smart meters, plug load devices)

3. Energy budget estimation

- PC software usage pattern report
- Mapping system resource load to energy consumption
- Test platform

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Collective Systems: Home Entertainment

•Home Entertainment: devices and desired features and services

•Energy efficiency is a negotiation: machine to machine, machine to human, services to energy, etc.

•The uncertain and idiosyncratic nature of the plug load devices prescribes a dynamic, instead of deterministic, architecture.

•Harmonization is required for optimized efficiency, across all layers of systems, (industry supply chain)



T = 5 hrs

E = 9 Twh



Negotiation Among Users, Devices and Contents



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From Indidivual Devices to Systems: Energy Reporting





Savings potential projection

Savings	50-60%	70-80%
30-40%	Tier III: Efficiency Negotiation	Tier III: Efficiency Negotiation
Tier II: Feature/Service	Tier II: Feature/Service	Tier II: Feature/Service
Sharing	Sharing	Sharing
Tier I: Duty Cycle	Tier I: Duty Cycle	Tier I: Duty Cycle
Optimization	Optimization	Optimization





Conclusions

- Future plug load management strategy needs to adress the SYSTEMS as well as INDIVIDUAL DEVICES
 - Technologies: distributed, scalable, efficient, cost-effective
 - Standards
 - Incentive programs
- Users and their demands for services are critical in demand side management
- CalPlug is positioned to enter the age of "Internet of Things"

Intellectual Properties Generated

- *Behavior Adaptive Energy Management for Consumer Electronics*, IEEE International Conference of Consumer Electronics, 2015
- Consumer in-the-Loop: Consumers as Part of Residential Smart Energy Systems, IEEE SmartGridComm 2014 - "Demand, Response and Dynamic Pricing" Symposium
- The 1kWh Challenge: An Experiential Learning Program Designed to Promote Energy Efficient Behavior, ACEEE Summer Study on EE in Buildings, 2014
- *The Wall of Power*, The Information Architecture Summit 2014, San Diego
- Smart Grid and Energy Efficient Consumer Electronics, IEEE ICCE, Shenzhen China 2013
- Patents:
 - Energy Efficiency Application System and Method of its Use for Empowering Consumers to Perform Energy Usage Audit at Home via Energy Data Aggregation of Electronic Appliances and Devices, USPTO 2012
 - A System and Method of Use for Energy Efficiency Applications Driven by Multiple Context Clocks for Personal Energy Footprint Management, USPTO 2013
 - Ubiquitous Anonymous Ultra Low Energy Human Feature Detection Systems and Methods, USPTO 2014



Thank you!



Plug Loads are becoming more intelligent and sociable



Figure 6: Power draw during HD video play (1080p)



