ICCE 2011

Electronics, Networks, and Energy

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Overview

- Electronics? Networks? Energy?
- Electronics energy use
- Efficiency opportunities
- A/V device power control
- User Interfaces
- Beyond electronics

Networks a principle theme / example

What are "electronics"

"Devices whose primary function is information"
– Computation, communication, storage, display

Major categories:

Phones

Audio/visual PCs

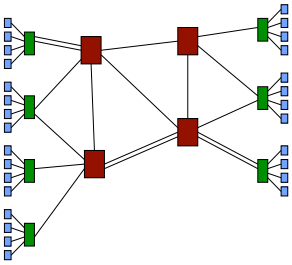
Network equipment

Servers Storage

Printers / copiers

Networks

- Digital
- Mechanism for arbitrary communication among devices
- Helpful to include data links



Why care about electronics, energy?

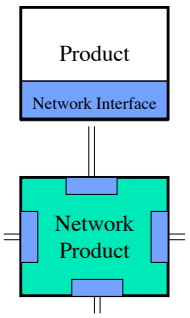
- Core
  - Energy (electricity)
  - Carbon
  - $$€€£¥
- Extreme conditions
  - Power deserts (no mains)
  - Power oceans (datacenters)
  - Power ponds (e.g. notebook)

Most electronics energy use in ordinary conditions

Networks and Energy

Network equipment ….
Routers, switches, modems, wireless APs, …

… vs **networked** equipment
PCs, printers, set-top boxes, …

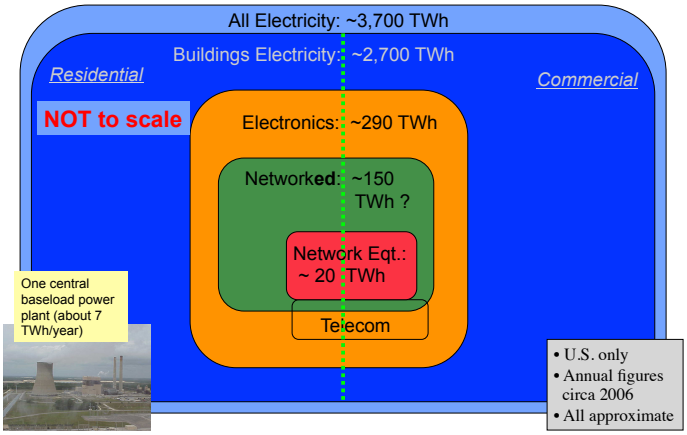


How networks drive energy use

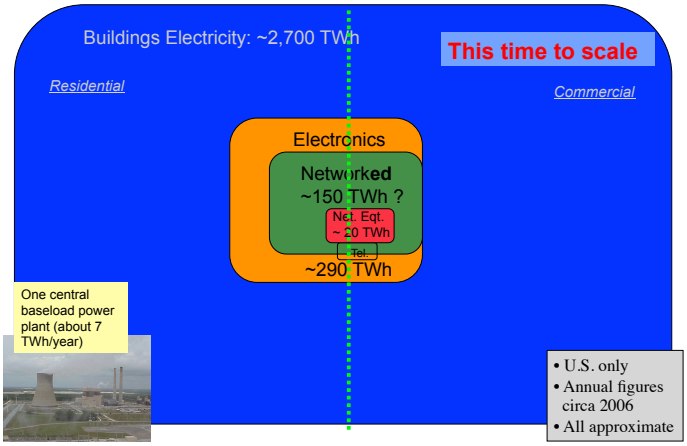
- **Direct**
  - Network interfaces (NICs)
  - Network products
- **Induced** in Networked products
  - Increased power levels
  - Increased time in higher power modes (to maintain network presence)

Network induced consumption **>** **all** direct

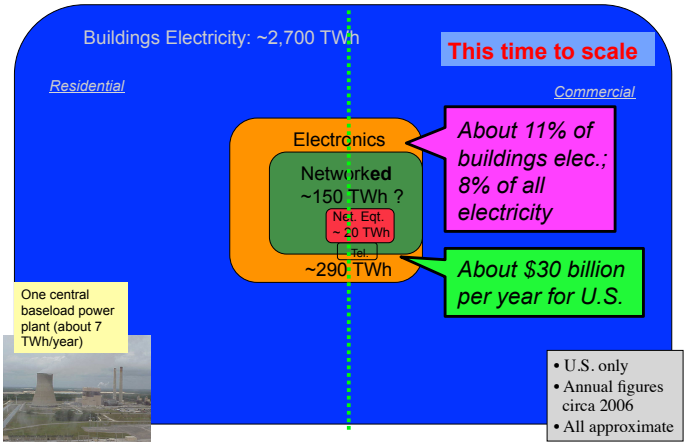
Electronics / network electricity use



Electronics / network electricity use



Electronics / network electricity use



What is in that 290 TWh/year?

Data Centers

22.5	Servers
2.7	Storage
2.7	Network
10	Telecom
37.9	TOTAL

Commercial

47.2	Desktop PCs
11.1	Monitors
9.7	Copiers
8.8	Network
7.3	Notebook PCs
5.7	Printers
89.8	TOTAL

Residential

Information Technology

21	Desktop PCs
7.7	Monitors
7.3	Modem, router, etc.
2.8	Notebook PCs
2.6	Imaging

Consumer Electronics

51	Analog TVs
16	Digital TVs
10	Set top boxes, cable
9	Set top boxes, satellite
6.2	Compact Audio
6.1	Stereos
6	Rechargeable Electronics
5	VCRs
4.4	DVD players
2.3	Clock Radios
2.2	Home Theaters
1.6	Security systems
0.7	Portable Audio
161.9	TOTAL

What is in that 290 TWh/year?

Location		Function (primary)	
Data Centers	13%	Computing	35%
Commercial	30%	Communication	19%
Residential	57%	Storage	4%
		Display	42%

Sources: TIAX, LBNL, Nordman

- These figures rough estimates for 2006
- None of this includes cooling, UPS, or other infrastructure

Is 1% of electricity worth worrying about?

- (network eqt. is ~1% of buildings electricity)
- Consider
  - 1% of a very large number is still a large number
  - Most use of energy can be reduced to categories of a few percent

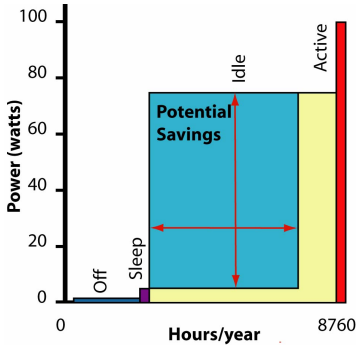
Role of public sector

- Includes
  - government policy and regulation (voluntary and mandatory),
  - public research (universities, etc.),
  - electric utilities,
  - non-profits, …
- Tracking overall topic
- Useful research
- Helping create technology standards
- Provide incentives ($$, other)
- Industry-wide coordination

Electronics challenge traditional notion of energy efficiency

- Traditional end uses are "physics-oriented"
  - convert forms of energy
- Can be reduced to single "efficiency" metrics
  - miles per gallon (cars)
  - lumens per watt (lights)
  - ft^3 per kWh (refrigerators)
- Electronics are different
  - multiple functions
  - application changes efficiency assessment
  - large role of non-active energy use
  - function efficiencies usually quite far from physics limits

Desktop PC energy use



All time for year sorted by power level

Most of time when idle, could be asleep

PC savings potential is **most** of current consumption

Similar patterns apply to set-top boxes, for TVs, printer, …

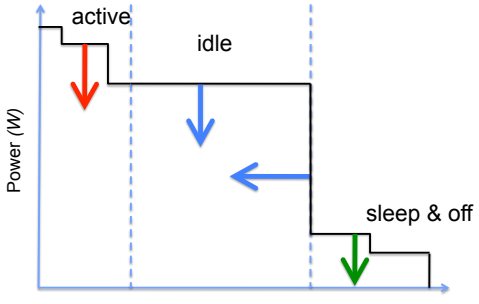
Core Fact: Most PC energy use occurs when no one present

Networks change everything

The behavior on the network
of one device
can change the energy use of devices
it is connected to

Core methods to reduce electronics energy use

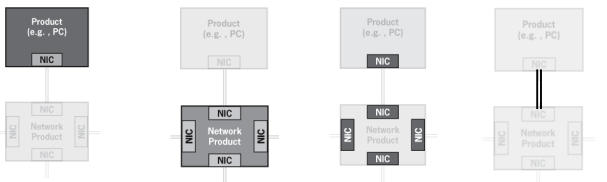
- **active power**
- **low-power mode power**
- **idle time or power**



Annual energy; power sorted high->low

Efficiency approaches for networks

Product Focus	Network Product Focus	Interface Focus	Protocol / Application Focus



Examples:

Proxying

ENERGY STAR

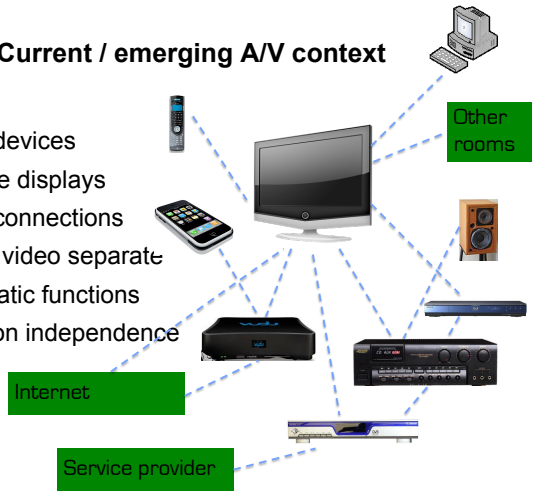
Energy Efficient Ethernet

A/V control

- ***Need all approaches***
- ***Latency is key***

Current / emerging A/V context

- Many devices
- Multiple displays
- Many connections
- Audio, video separate
- Automatic functions
- Location independence



My DVD player / VCR

- Both: often left on long after usage times
- DVD: usually in 'menu' mode, so constantly active

- Great majority of energy use occurs when no content being watched

The Problem

- Many (increasing) devices, multiple locations, out of sight
- May not be obvious (to user) what devices needed at any given time
  - many users did not set up system and are not tech savvy
- Current power state (and how to change) not always obvious
- Some activity not user-initiated (e.g. timed downloads)
- Manually powering up/down (even via remotes) only marginally successful
  - not a good use of people's time/attention

Two (unsatisfactory) approaches

- Do nothing / status quo
  - Waste energy, annoy people
- Command and control, based on:
  - Individual devices – based on their activity
  - Remote controls – based on requested function
  - Brittle, error-prone, not automatic, requires configuration, …

The Solution

Audio/Video Inter-Device Power Control (A/V PC)

- Distributed, self-control
- Automatic – default – no configuration

"wake up when need to; go to sleep when can"

Goal: **deliver more energy savings AND more convenience**

Examples

- Watching DVD, DVD finishes, …
  - DVD powers down after 15 minutes of menu
- Watching DVD, switch TV to broadcast, …
  - DVD pauses and power down if not resume within 5 minutes
- Watching DVD, pause, …
  - DVD powers down if not resume within 15 minutes
- Power up TV, select DVD as source
  - DVD wakes
- Amplifier (or subwoofer) audio input is (near) silent
  - Amp go to sleep after 5 minutes
- Amplifier (or subwoofer) begins to receive audio input
  - Amp wakes
- Doorbell pressed – activates webcam
  - TV wakes to show entry – after 10 seconds webcam stops sending image and TV returns to sleep

- sources
- sinks
- combo

Implementation

- Network-connected sleep states in all devices
- Meta-architecture for protocol capabilities and device behavior, e.g.
  - exposing power state over network
  - standard time-outs to sleep with no (apparent) activity
  - wake events
- Implementation of meta-architecture in individual technology standards
- Codification of standard behavior in product operation
- Increasing device understanding of users
- Assistance of public sector in all of this, including consumer education

Interested? Contact me

Confounding factors

- Legacy interfaces (esp. analog)
- Legacy devices
- Diverse application layers
  - even more physical layers
- Content pass-through

- Makes automatic power control more difficult, but not impossible
- Transition will necessarily require some effort
  - manufacturers, users, public sector

Standard display interaction principles

Situation

5 years from now. You enter a room you are not familiar with. A display is on wall. Room was unoccupied so display is asleep.

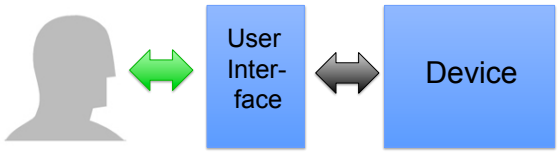
- How do you wake the display to use it?
- Can you touch it? multi-touch?
- Does it do Bluetooth? Wi-Fi? Voice? Gestures?
  - How are these activated? (not always for energy, functionality)
- How to power down display?

Need

Standard indications, controls, actions for basic display interaction — separate from functional interaction

User Interfaces and Energy

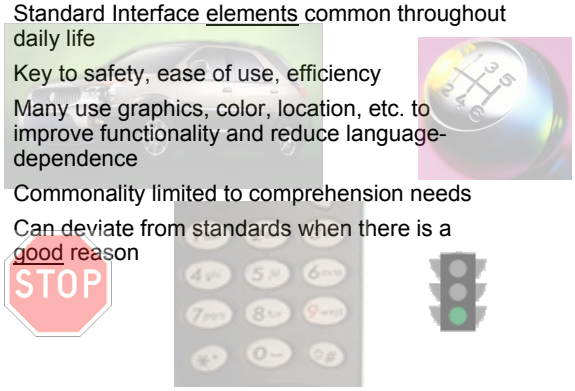
- Energy-UI examples: Lighting, climate control, power control of electronics, cars, windows, …



- UI is conceptually separate from device
  - increasingly exported
- Senses: Visual, audio, tactile

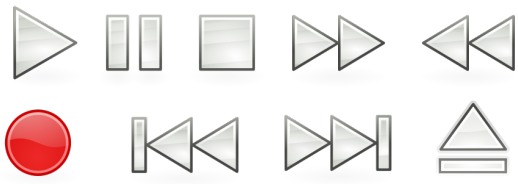
Standard User Interface elements

- Standard Interface elements common throughout daily life
- Key to safety, ease of use, efficiency
- Many use graphics, color, location, etc. to improve functionality and reduce language-dependence
- Commonality limited to comprehension needs
- Can deviate from standards when there is a good reason

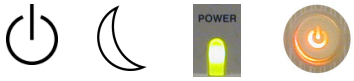


CE devices rely on UI standards

- Tape transport symbols
  - since generalized to any medium



- Power Control



Power control elements

When communication fails

User unable to

- understand capabilities
- understand status
- know how to take action

Device unable to

- deliver all services people want

➔ **operational failure**

- NOT deliver services not wanted

➔ **wasted energy**

UI Standard — concept

- If User Interface
  - elements – arrangement

  are
  - clear – consistent

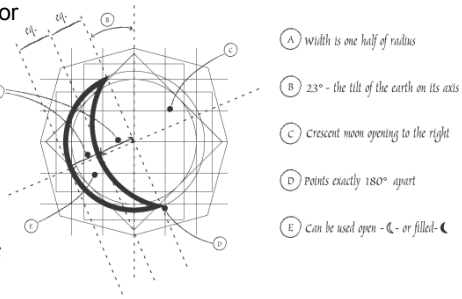
  then maximize chances of optimal matching of user desires with service delivered

- Consistent **>>** clear
- Should be global

- Inexpensive source of savings – *plus other benefits*

Key elements of IEEE 1621 – Power Control

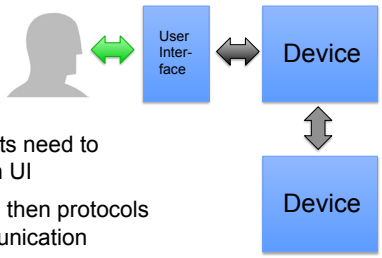
- 3 Basic Power States: On, Sleep, Off …
- … with standard colors: Green, Amber, Off
- Key symbols: Power; Sleep
- Sleep Metaphor ("wake up")
- "Hibernate" a form of Off



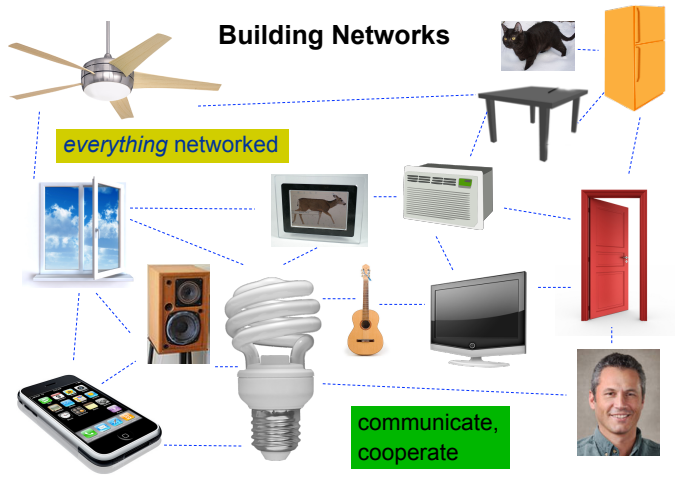
- *Need contact on IEC SC 3C*

UI standards and network standards

- Network standards cover device ➔➔ device communication
- Concepts and elements need to correspond to those in UI
- Should *first* design UI, then protocols for inter-device communication
  - Make devices conform to humans
  - **not** humans conform to devices



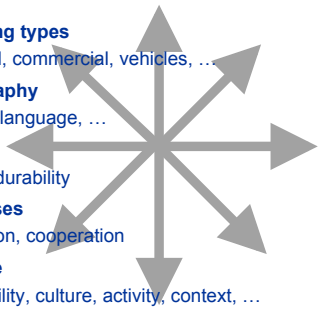
Building Networks



Universal Interoperability

Any device should work with all other objects in any space

- Across **building types**
  - Residential, commercial, vehicles, …
- Across **geography**
  - Countries, language, …
- Across **time**
  - Worthy of durability
- Across **end uses**
  - Coordination, cooperation
- Across **people**
  - Age, disability, culture, activity, context, …

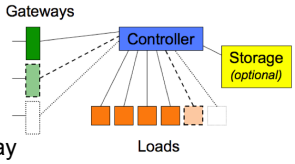


Building Networks — development

- "Smart Grid" concept un-suited for use within buildings — wrong metaphor, functionality
  - Need to plan for **all** energy-using devices to be networked
- Building networks will grow organically from IT/CE networks, not as separate entitites
- Need to design around functional properties and needs of people — not energy
  - Start with user interface
- Assume all will use Internet Protocol

Nanogrids

- Outgrowth of "alternative power distribution" tech. (alt. to AC)
- Nanogrids: (very) small power distribution systems
  - Single domain for voltage, reliability, administration
  - Gateways may be to AC grid or elsewhere
  - May enable functionalities not otherwise available
  - Existing examples: USB, PoE, 12V vehicle power, …
- Useful for (native DC) electronics
- Easier integration of local generation and storage
- Useful in off-grid contexts
  - incl. developing countries
- Networking the grid from the bottom up — "Intergrid"
- Need standard architecture to enable highly functional gateway



Summary

- Energy use of electronics is large enough to be concerned with
- Networks pose new challenges and opportunities
- Audio / video power control a near-term priority
- Networks of electronic devices should highly inform how we network everything else
- Need to embrace innovative power supply options
- More research needed on all these topics
- Need more attention to energy issues by CE community

Thank you