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# Trends and Opportunities in Networks and Consumer Electronics

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# Electronics Energy Use & Networks

- Networks increase energy use of networked devices
- Solutions are available
  - Require changes to both devices and networks
  - The network ends at the brain
- Whole-house networks, smart appliances, and smart grid complicate the situation

# Networks Change Everything

The behavior of **one device** on the network  
can change the energy use of  
other connected devices

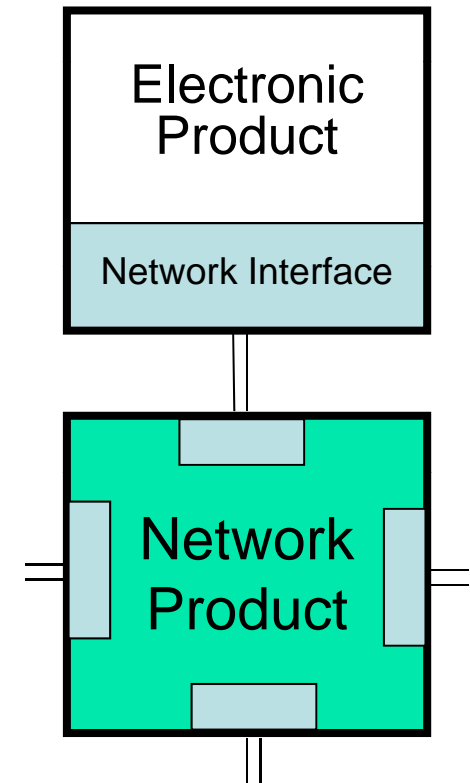
# How Networks Affect Energy Use

## Direct

- Electronic devices (IT, consumer electronics, network equipment)

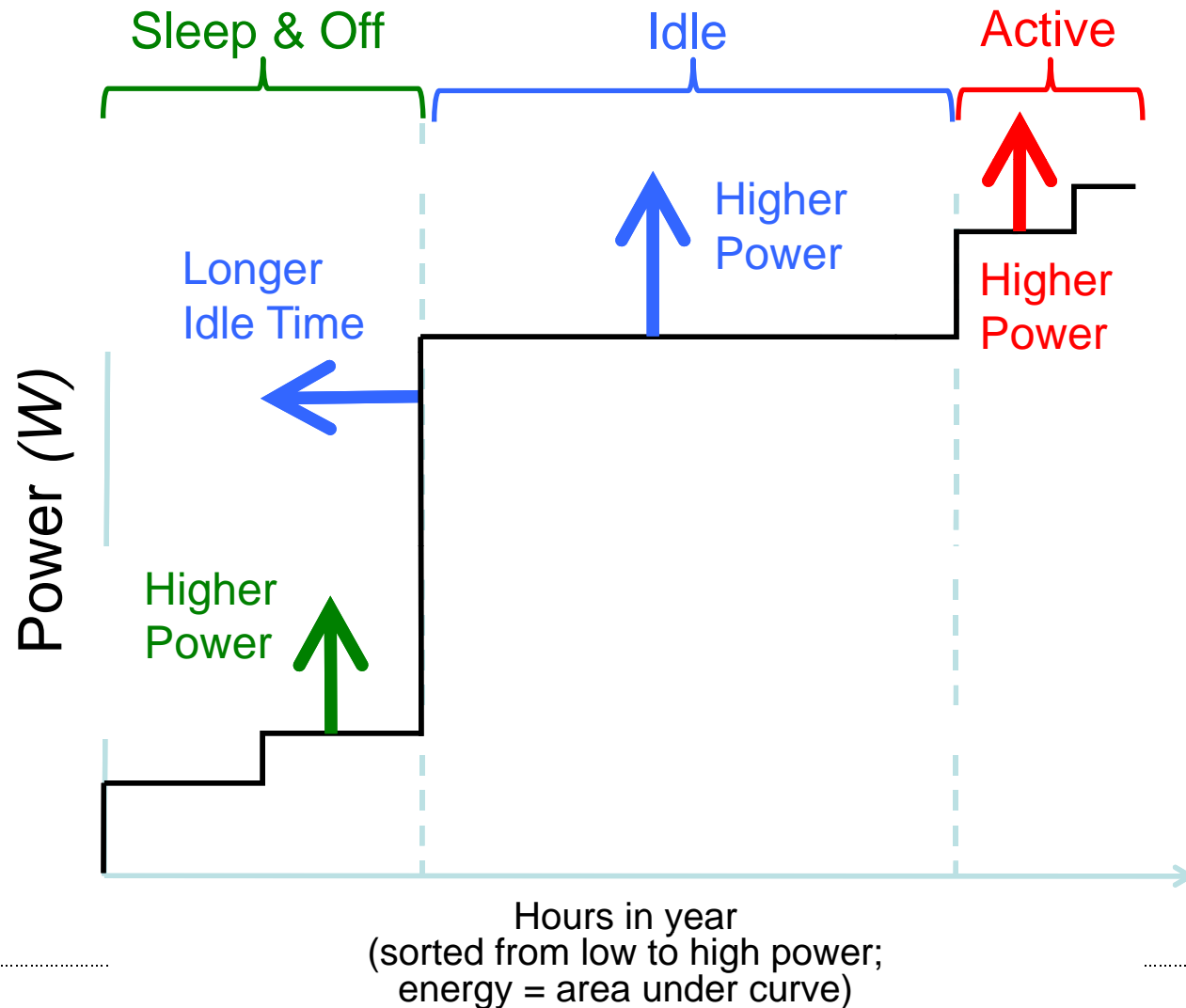
## Indirect (via network)

- Induced energy use in networked devices
- Influence energy-related decisions
- Digital networks for building control



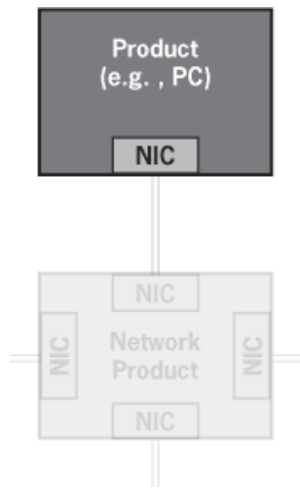


# Networks affect product energy use

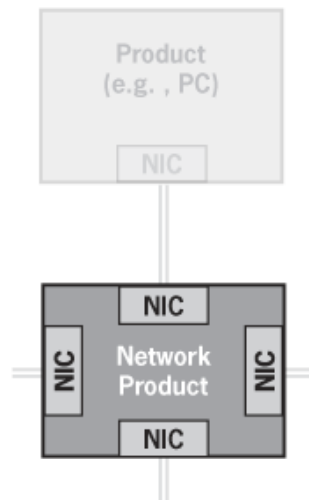


# Efficiency Approaches

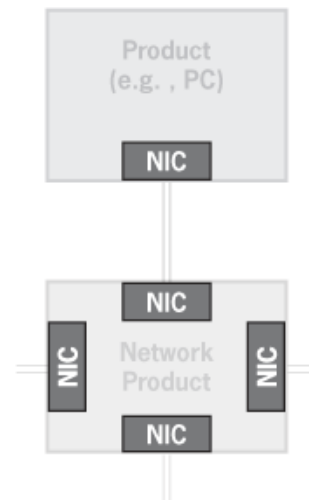
## Product Focus



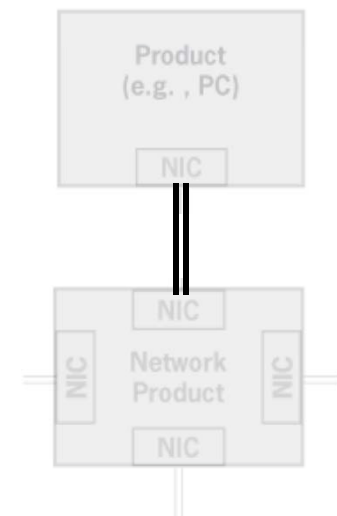
## Network Product Focus



## Interface Focus



## Protocol / Application Focus



Examples:

**Proxying**

**Energy Star**



**CE**

***Need all approaches***

# Typical DVD player / VCR

Both: often left on long after usage times

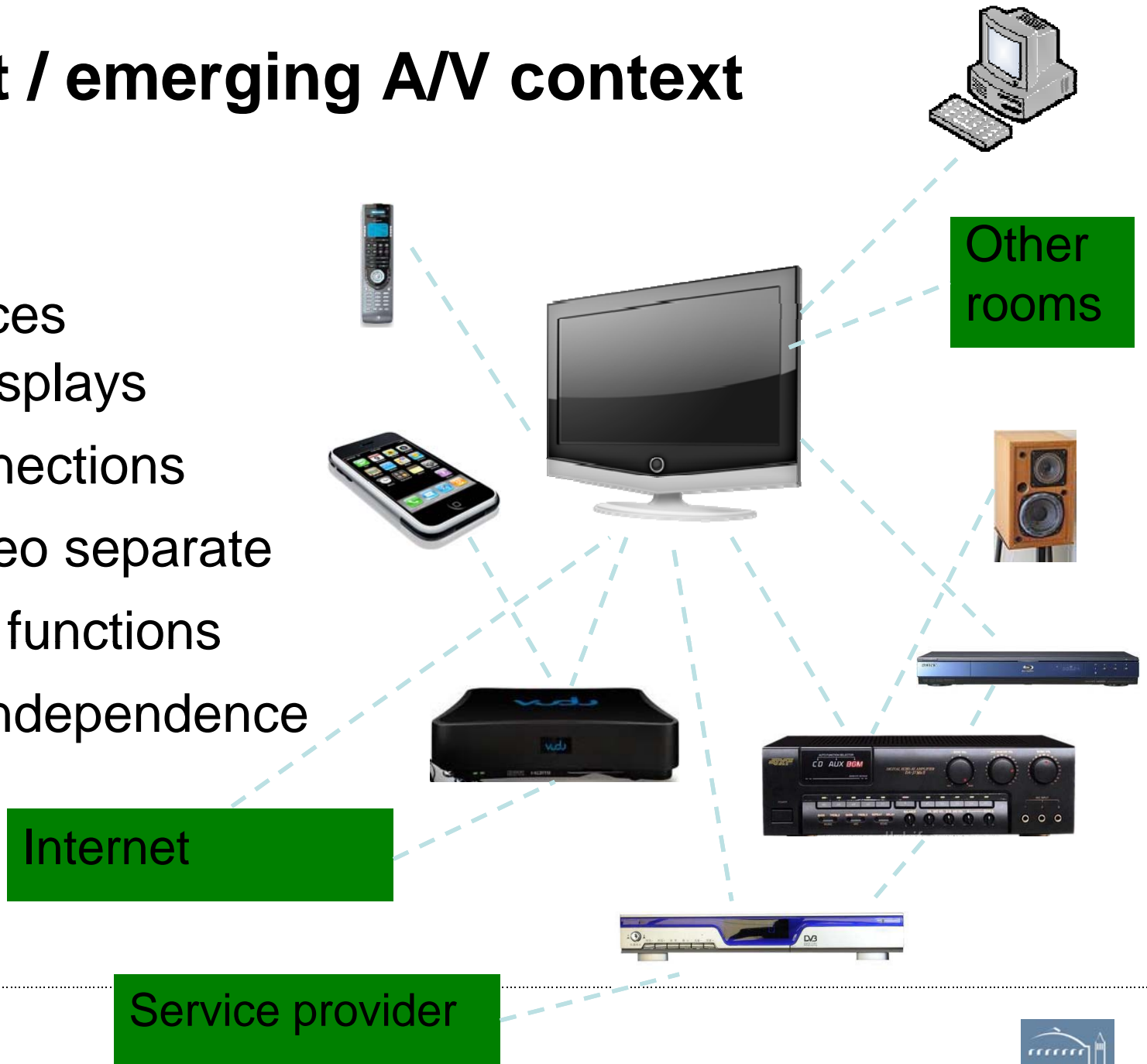
DVD: usually in 'menu' mode, so constantly active



Great majority of energy use occurs when no content  
being watched

# Current / emerging A/V context

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





# The Control 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

*Result: Many devices fully on when don't need to be*

# Two unsatisfactory approaches

- **Do nothing** (status quo)
  - Waste energy, annoy people
- **Command and control**, from:
  - 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**

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\*except primary display



# Use Cases – examples

- Watching DVD, DVD finishes, ...
  - DVD powers down after 15 minutes of menu
- Watching DVD, switch TV to broadcast, ...
  - DVD pauses and powers down if not resumed within 5 minutes
- Watching DVD, pause, ...
  - DVD powers down if not resumed 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 area – after 20 seconds webcam stops sending image and TV returns to sleep

- sources
- sinks
- combo

Need comprehensive  
use case list

# Key requirements

- 3-state power model – On, Sleep, Off
    - Sleep implies network connectivity & energy savings
  - **Meta-architecture** for protocol capabilities and device behavior
    - exposing power state over network
    - exposing functional state over network
    - standard time-outs to sleep with no (apparent) activity
    - wake events
  - **Standards** that support meta-architecture
  - Clarity in user interface, experience
-



# Confounding factors

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

- Make automatic power control more difficult
- Transition will necessarily require effort
  - manufacturers, users, public sector

## Past Success

# PC / monitor power management

- Initially absent
- Added
  - Power state communication (VESA/DPMS)
  - Sleep state to each device
  - Power management behaviors to each device
    - PC power state not tied to monitor power state
- Created UI language for describing states (IEEE 1621)
- Standard expectations of time-outs (e.g. 15-30 minutes)
- Standard wake mechanisms (keyboard/mouse)
- Quick wake (eventually)

Can be done!

- Few legacy products
- Single interface, type

# Critical role for industry

- Embrace / endorse idea
- Identify key company (standards org.) contacts
- Help design new scheme
- Do standards development
- Put into products
  - Starting NOW

# UI Standard — concept

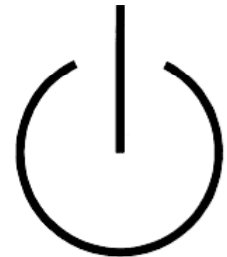
- If User Interface
  - elements — arrangement

are

- clear — consistent

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

- Consistent >> clear
- Should be global



# User Interfaces

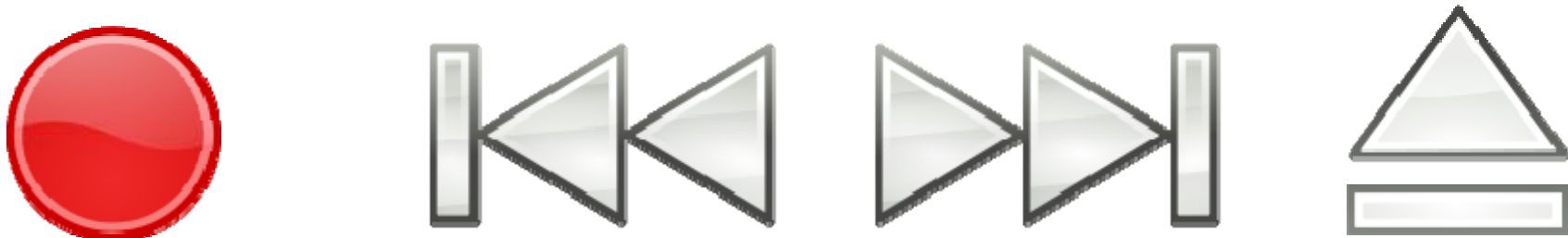
- Standard Interface elements common throughout daily life
- Key to safety, ease of use, efficiency
- Many use graphics, color, location, etc. to improve functionality and reduce language-dependence
- Commonality limited to comprehension needs
- Can deviate from standards when there is a good reason



# CE devices already rely on standard UI elements

Tape transport symbols

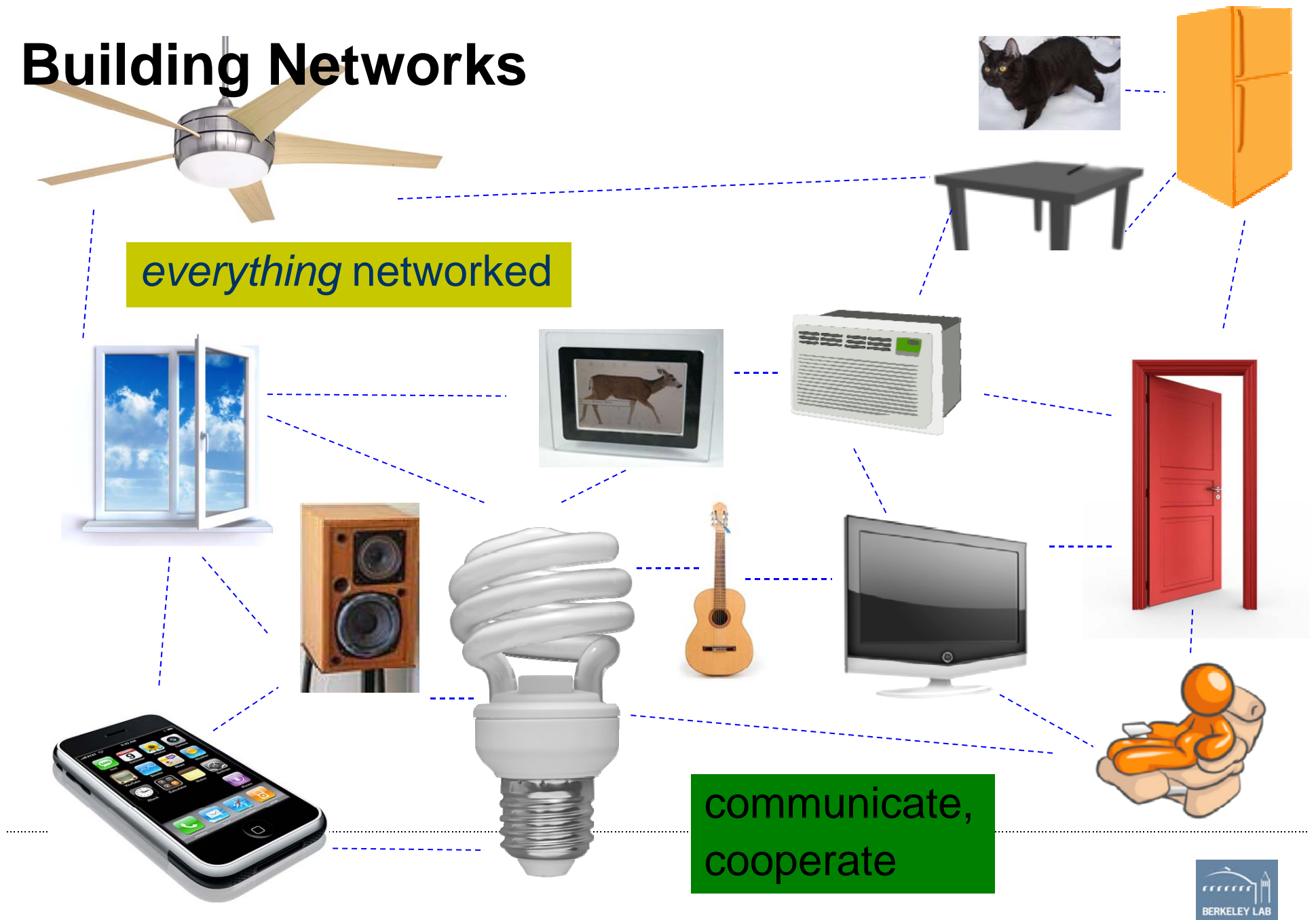
- since generalized to any medium



- Power Control (IEEE 1621)



# Building Networks



# Thank You

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[eetd.lbl.gov/ea/nordman/avcontrol.html](http://eetd.lbl.gov/ea/nordman/avcontrol.html)

(and also my colleagues: Bruce Nordman, Steven  
Lanzisera, Alan Meier)

