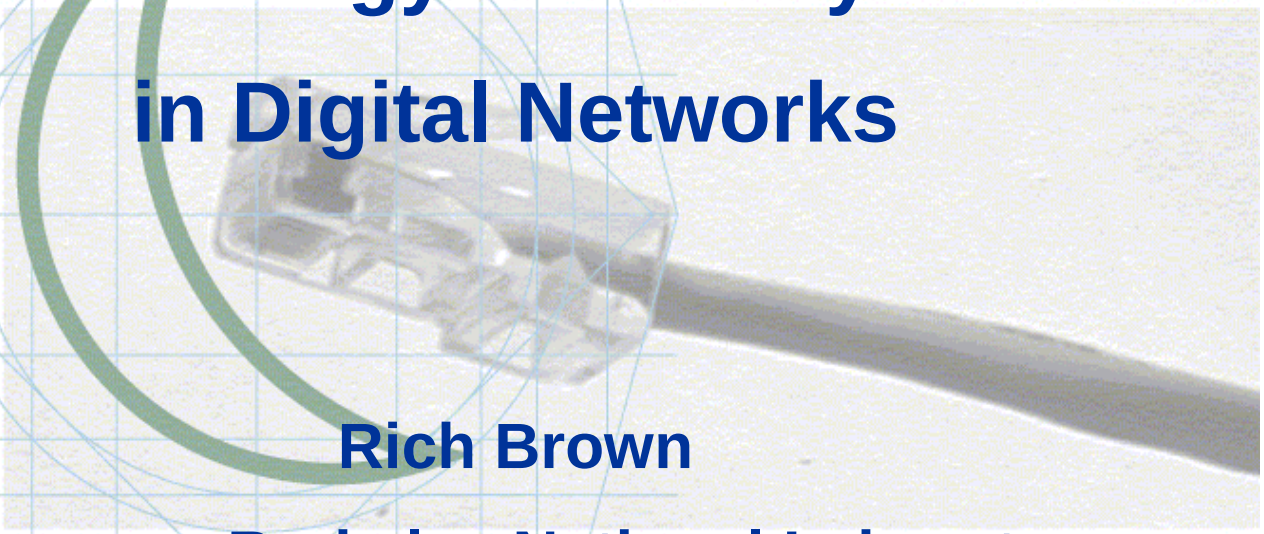
Energy Efficiency in Digital Networks



Rich Brown

Lawrence Berkeley National Laboratory

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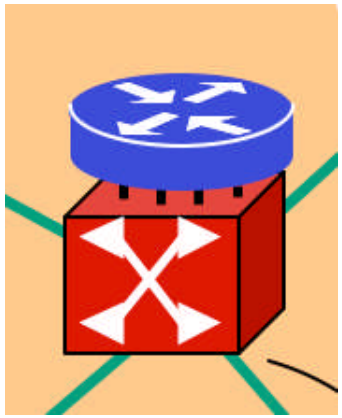
REBrown@LBL.gov — efficientnetworks.LBL.gov

Overview

- **Background: electronics energy consumption**
  - **Times of little or no use play important role**
- **LBNL *Energy Efficient Digital Networks* project**
- **Research and policy agenda for networks and buildings**



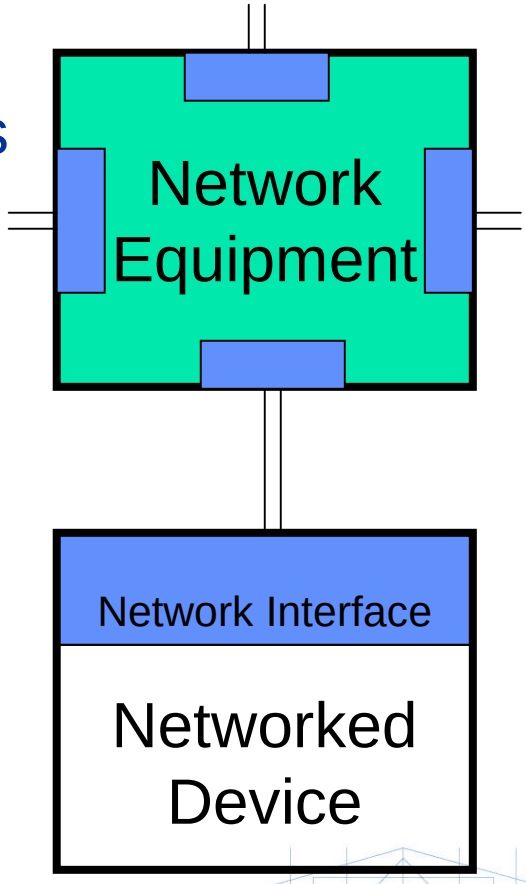
Networks and Energy

Network equipment ….

Routers, switches, modems, wireless APs

… vs **networked** devices

PCs, printers, set-top boxes, …

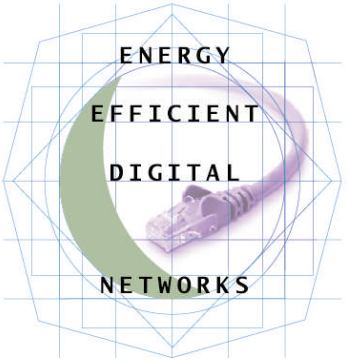


How networks affect energy use

- **Direct**
  - –Network interfaces (NICs)
  - –Network equipment
- **Induced** in Networked devices
  - –Increased power levels
  - –Increased time in higher power modes (to maintain network presence)
  - –Energy info or control signals from network

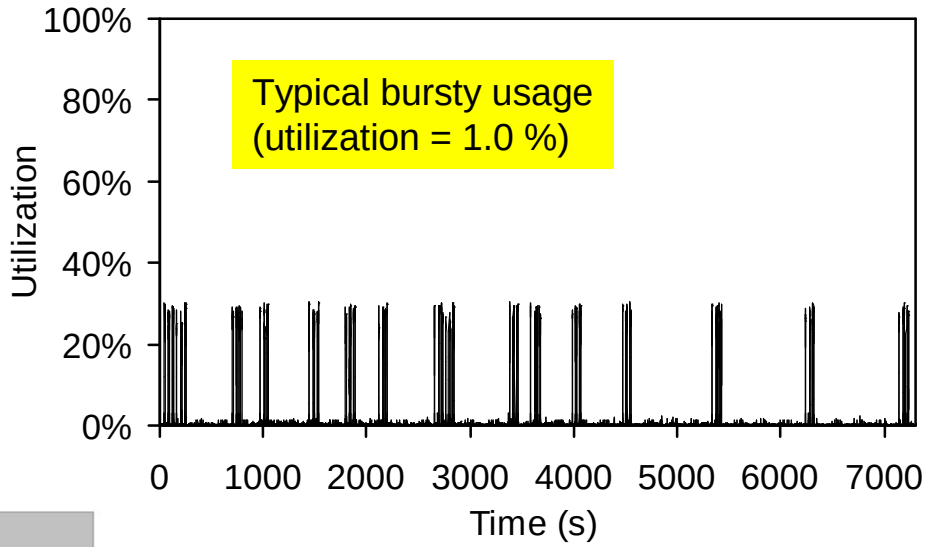
Key Aspects of Electronics Energy Use

- For many devices, times of little or no use dominate annual energy use
  - Corollary: Most savings might occur in these times
- Industry / Technology standards restrict what manufacturers can do
  - Can prohibit energy saving methods
  - Can enforce energy saving methods
- LBNL project: Energy Efficient Digital Networks
  - Better understand and reduce electricity use of electronics, through digital networks
  - Three of seven projects covered here

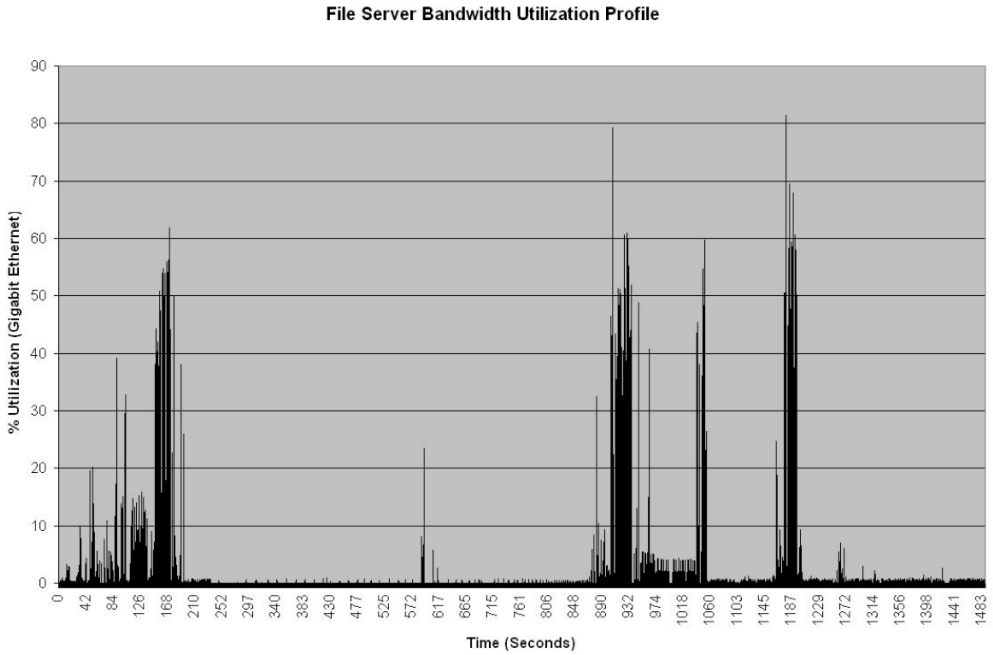


Energy Efficient Ethernet

- Great Majority of network links are relatively idle great majority of time
- Today, power for link is relatively constant
- Challenge: Develop technology to scale power to throughput

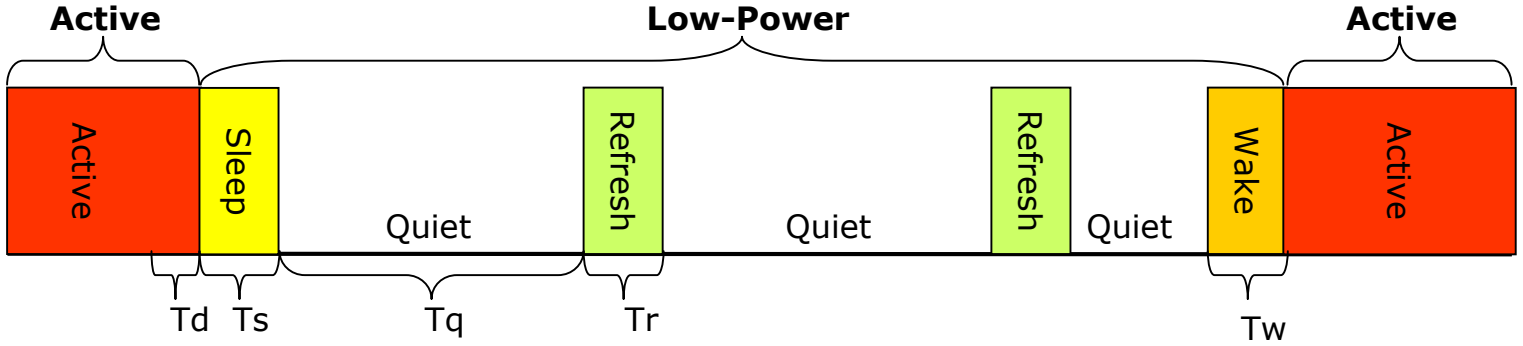


Snapshot of a typical 100 Mb/s Ethernet link *(Singh)*



File server link utilization (daytime) *(Bennett, 2006)*

Energy Efficient Ethernet, cont.



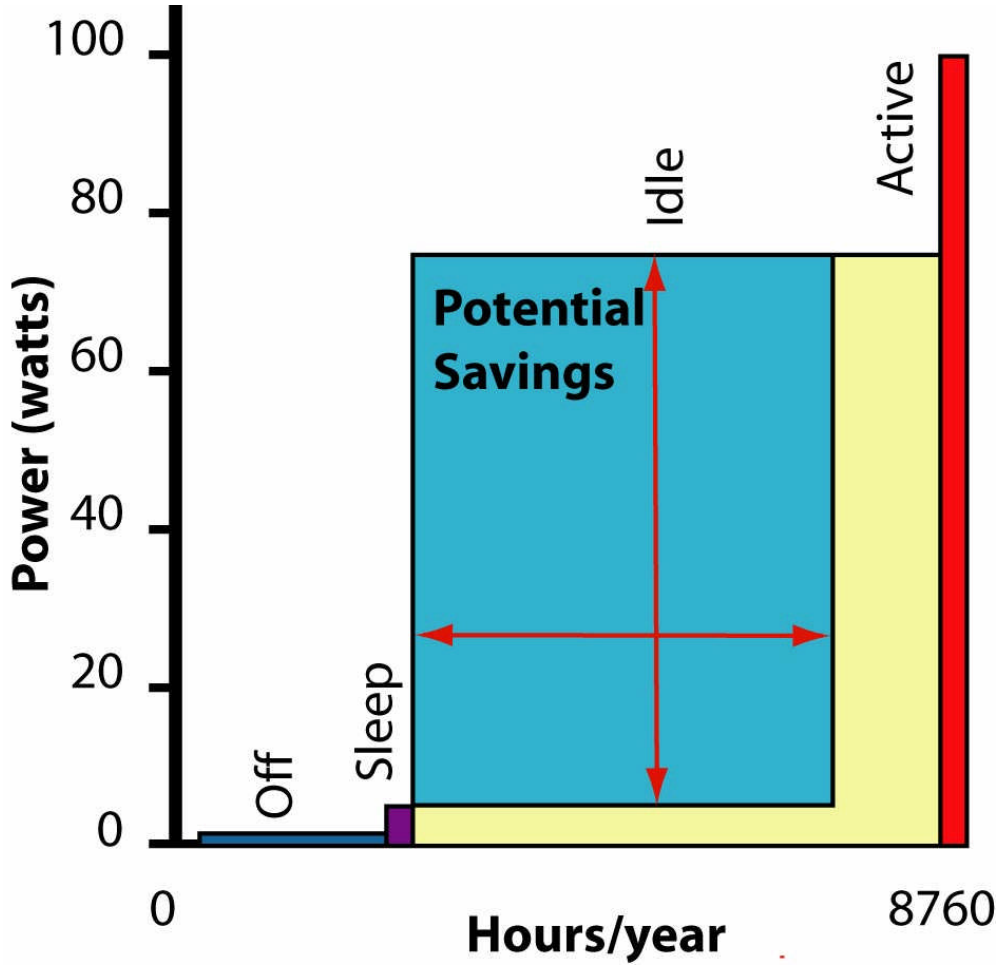
- Original idea: Reduce data rate during times of low throughput but switch rates in *milli*seconds not seconds
- LBNL/USF brought "Adaptive Link Rate" concept to IEEE
- Standards process eventually settled on alternate method "Low Power Idle" to stop transmitting between packets
  - Switch now takes *micro*seconds
- Standards process needs about 1 more year
  - Goal to get EEE technology into ALL Ethernet network hardware globally over next few years

Energy Efficient Ethernet

EFFICIENT DIGITAL NETWORKS

Network Presence "Proxying": The Problem

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



All time for year sorted by power level

Most of time when idle, could be asleep

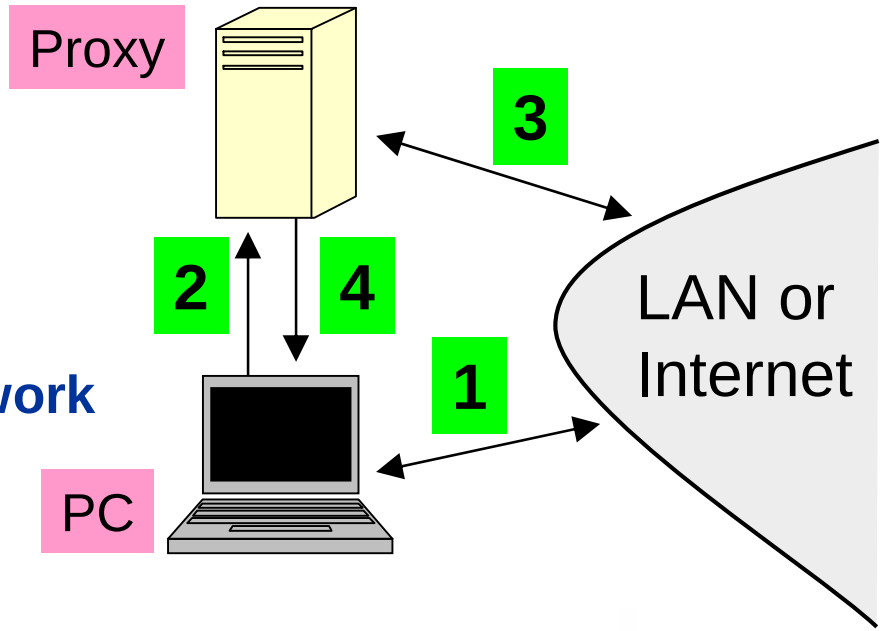
PC savings potential is most of current consumption

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

Proxying — The Solution

Proxy operation

1. PC awake; becomes idle
2. PC transfers network presence to proxy on going to sleep
3. Proxy responds to routine network traffic for sleeping PC
4. Proxy wakes up PC as needed



Proxy can be internal (NIC), immediately adjacent switch, or "third-party" device elsewhere on network

Proxy does: ARP, DHCP, TCP, ICMP, SNMP, SIP, ….

Proxying: Goals, Process

- Enable large majority of PC users to use sleep without breaking their own or IT admin applications
  - At least 80%. > 90% better. > 95% or > 98% even better.
- Enable both current and emerging common applications
- Enable standard to directly (or easily adapted) for use in printers, set-top boxes, game consoles, etc.
- Now, International Standards Committee on this, Ecma TC32-TG21
- Products: late '09 or '10 ?

Efficiency Specs for Network Equipment

Today:

- Network equipment a growing electricity use in all sectors
- Companies increasingly claiming energy efficiency as a feature
- No current test procedures
- No efficiency specifications
- Little knowledge of networks in energy community

ENERGY EFFICIENT DIGITAL NETWORKS

Efficiency Specs for Network Equipment, cont.

LBNL project:

- Estimate total energy use of network equipment in U.S.
  - Approximately 1% of total
- Identify product types with largest consumption, largest potential savings, and ease of rating for efficiency
- Work with industry to develop standard test procedures
- Create community of interest on topic
- Hand off to Energy Star for spec process

The Other Networks: Buildings Generally

"Networking the Real World" —

*The other **90%** of Buildings Energy*

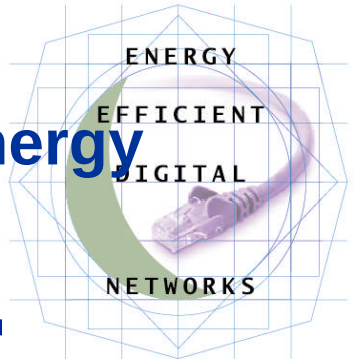
Automated (device-to-device) control of:

Climate (heating, cooling, ventilation), lighting, appliances, security*

- Need Building Network architecture designed with same sophistication and care that went into Internet design
- Infrastructure designs will last for decades to come

Future Scenarios of Building Networks

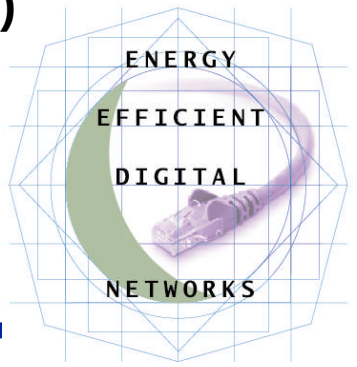
- Business as usual
  - Lack of interoperability
  - Lack of standardized user interfaces
  - Little coordination across domains
  - Increased energy use
- Design for energy efficiency
  - Networks use open international standards
  - Controls coordinated across domains (e.g., climate control and lighting)
  - Building controls are highly dynamic, to optimize service delivered and minimize energy



A Building Networks Agenda

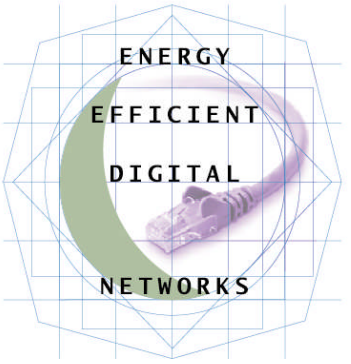
- For ICT to do for buildings what the Internet and web did for information sharing, we need:
  - Global interoperability
  - Well-conceived network architecture (requires specialists in network architectures, not just energy, building, or climate specialists)
  - Institutions to develop and maintain the required standards

(more details: eetd.lbl.gov/EA/nordman/bldgsasnetworks.html)



Conclusions

- Networks are key driver of indirect energy use:
  - –Induced energy use when low power modes not used
  - – Building Networks: large potential increases or decreases in building energy use due to networks (but no assurance that networking will improve energy efficiency)
- LBNL digital networks project is developing solutions to reduce this energy use
- Success with building networks requires universal interoperability through a high-level policy commitment to global network architecture, protocols, and UI standards



Thank You

Rich Brown

Environmental Energy Technologies Division

Lawrence Berkeley National Laboratory

Berkeley, CA 94720

REBrown@lbl.gov