

Focus Area – User End Systems

- **Most ICT energy use and waste is in user end systems**

- PCs, NAT routers, game consoles, set-top boxes, etc.
- Not data centers
- Not Internet core

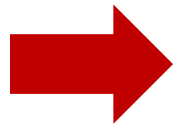
EPA estimates 2% of total US electricity is from PCs, and a Congressional Report estimates 1.5% is from data centers.

“Most PC energy use in the US occurs when no one is there, and this is greater than the total energy use of all network equipment.” (Bruce Nordman, LBNL)

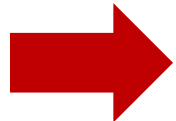
- **ICT energy use can be categorized as *direct* or *induced***

- **Induced energy use is the additional increment required for maintaining network presence in end hosts**

- In short, keeping your PC fully powered on to be “connected”



Need specific focus on induced energy use of end systems



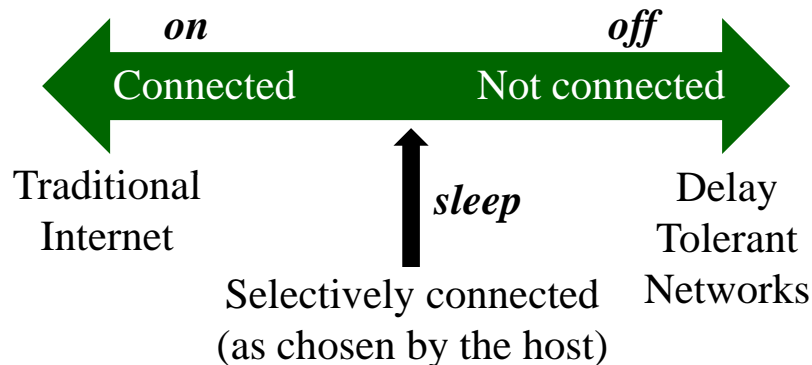
Need new view of “network presence”

Addressing Network Presence

- Industry offers point solutions to enable sleep – e.g., Verdiem
- Research projects are underway – e.g., Somniloquy
- Standards addressing idea of a *network connectivity proxy*
 - Ecma TC32-TG21 – Proxying support for sleep modes
 - Resulting from work from a previously funded NSF grant and with Bruce Nordman at LBNL. Adopted in EPA Energy Star specification.



- **New view of network connectivity is needed**



To support selective connectivity need to explore [1]:

- Assistants
- Exposing selective connectivity
- Evolving soft state
- Host-based control
- Application primitives
- Security

[1] M. Allman, K. Christensen, B. Nordman, and V. Paxson, "Enabling an Energy-Efficient Future Internet through Selectively Connected End Systems," *Sixth Workshop on Hot Topics in Networks (HotNets-VI)*, November 2007.

Considering the Science

- Science evolves as *Describe – Explain – Predict*
- To *describe* we need to...
 - Expose power state (especially of sleeping hosts)
 - Also useful for energy use audits, redirection of requests, etc.
 - Categorize energy use (by user profile, activity, time-of-day, etc.)
- To *explain* we need to...
 - Understand why hosts are powered-on for network presence
 - Protocols, applications, etc. that drive this
 - Understand how protocols and applications can be designed for sleep
- To *predict* we need to...
 - Develop new tools to predict performance versus energy use trade-offs



Goal must be energy-proportional computing at all levels
– Not just in the data center