

thursday, may 24, 2007



massachusetts institute of technology

news

- Comparative Media Studies Program and Media Lab top winners in Knight News Challenge
- NMR advance could vastly improve diagnostics
- Coding and computation in microfluidics: forum today
- Gifts from the garden: spring plant sale at Stata

spotlight: **buildings with benefits:
intelligent
infrastructure for energy
efficiency**

education

courses, OpenCourseWare, video

research

labs, centers and programs, libraries

admissions+financial aid

undergraduate, graduate, professional

offices+services

resources, jobs, business, giving

community groups

students, faculty, parents, alumni

events

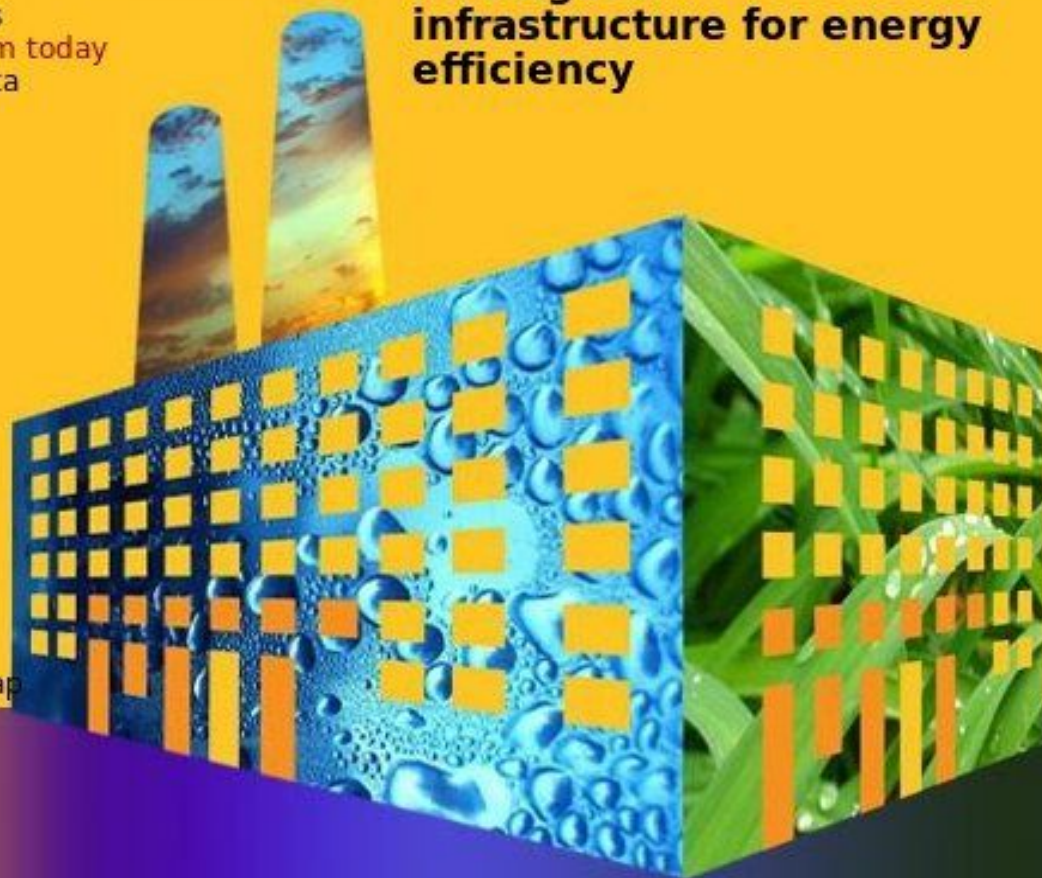
calendar, arts, athletics, Commencement

about mit

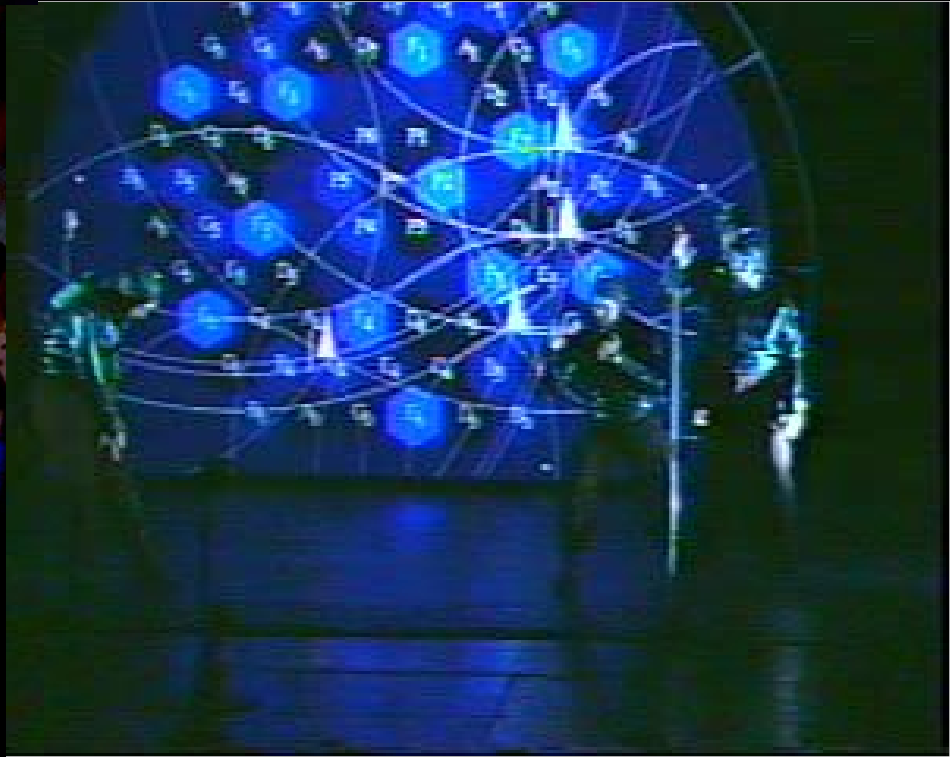
energy, global MIT, presidency, facts, visiting, map

search

MIT Google People Offices



today's page: Tim Blackburn



By Neil Gershenfeld,
Raffi Krikorian and Danny Cohen

In Barcelona about a century ago, Antoni Gaudí pioneered a fluid building style that seamlessly integrated visual and structural design. The expressive curves of his buildings were not just ornamental facades but also integral parts of the load-bearing structure. Unfortunately, a similar unification has yet to happen for the electronic infrastructure in a building. Switches, sockets and thermostats are grafted on as afterthoughts to the architecture, with functions fixed by buried wiring. Appliances and computers arrive as after-the-fact intrusions. Almost nothing talks to anything else, as evidenced by the number of devices in a typical house or office with differing opinions as to the time of day.

These inconveniences have surprisingly broad implications for construction economics, energy efficiency, architectural expression and, ultimately, quality of life. In the U.S., building buildings is a \$1-trillion industry. Of that, billions are spent annually on drawing wiring diagrams, then following, fixing and revising them. Over the years, countless "smart home" projects have sought to find new applications for intelligent building infrastructure—neglecting the enormous existing demand for facilities that can be programmed by their occupants rather than requiring contractors to fix their functionality in advance.

Any effort to meet that demand, though, will be doomed if a lightbulb requires a skilled network engineer to install it and the services of a corporate IT department to manage it. The challenge of improving connectivity requires neither gigabit speeds nor gigabyte storage but rather the opposite: dramatic reductions in the cost and complexity of network installation and configuration.

Over the years, a bewildering variety of standards have been developed to interconnect household devices, including X10,

LonWorks, CEBus, BACnet, ZigBee, Bluetooth, IrDA and HomePlug. The situation is analogous to that in the 1960s when the Arpanet, the Internet's predecessor, was developed. There were multiple types of computers and networks then, requiring special-purpose hardware to bridge these islands of incompatibility.

The solution to building a global network out of heterogeneous local networks, called internetworking, was found in two big ideas. The first was packet switching: data are chopped up into packets that can be routed independently as needed and then recombined. This technique marked a break from the traditional approach, used in telephone networks, of dedicating a static circuit to each connection. The second idea was the "end-to-end" principle: the behavior of the network should be determined by what is connected to it rather than by its internal construction, a concept embodied in the Internet Protocol (IP). Gradually the Internet expanded to handle applications ranging from remote computer access to e-commerce to interactive video. Each of these services introduced new types of data for packets to carry, but engineers did not need to change the network's hardware or software to implement them.

These principles have carried the Internet through three decades of growth spanning seven orders of magnitude in both performance and size—from the Arpanet's 64 sites to today's 200 million registered hosts. They represent timeless insights into good system design, and, crucially, they contain no specific performance requirements. With great effort and discipline, technology-dependent parameters were kept out of the specifications so that hardware could evolve without requiring a revision of the Internet's basic architecture.

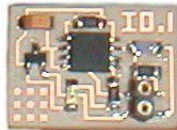
These same ideas can now solve the problem of connecting

The Internet of Things

The principles that gave rise to the Internet are now leading to a new kind of network of everyday devices, an "Internet-0"

EVEN SOMETHING AS SIMPLE as a lightbulb could be connected directly to the Internet, if suitably equipped with cheap circuitry that sends signals along the electrical wiring.

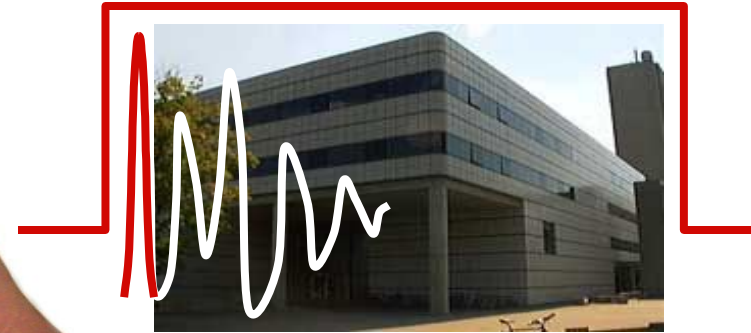




Internet 0: Past, Present, and Future

October 1, 2004

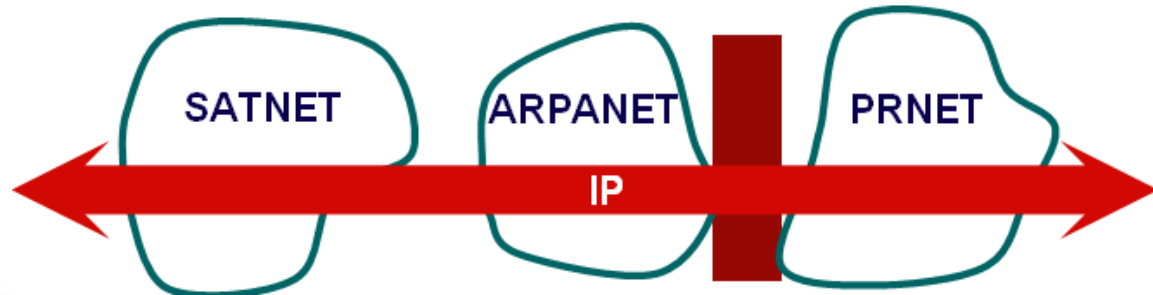
The Bartos Theater
Building E15
MIT



- 8:00-9:00 **Breakfast**
- 9:00-10:00 **Internet 0 (video)**
Neil Gershenfeld: *The Past*
Raffi Krikorian: *The Present*
Danny Cohen: *The Future*

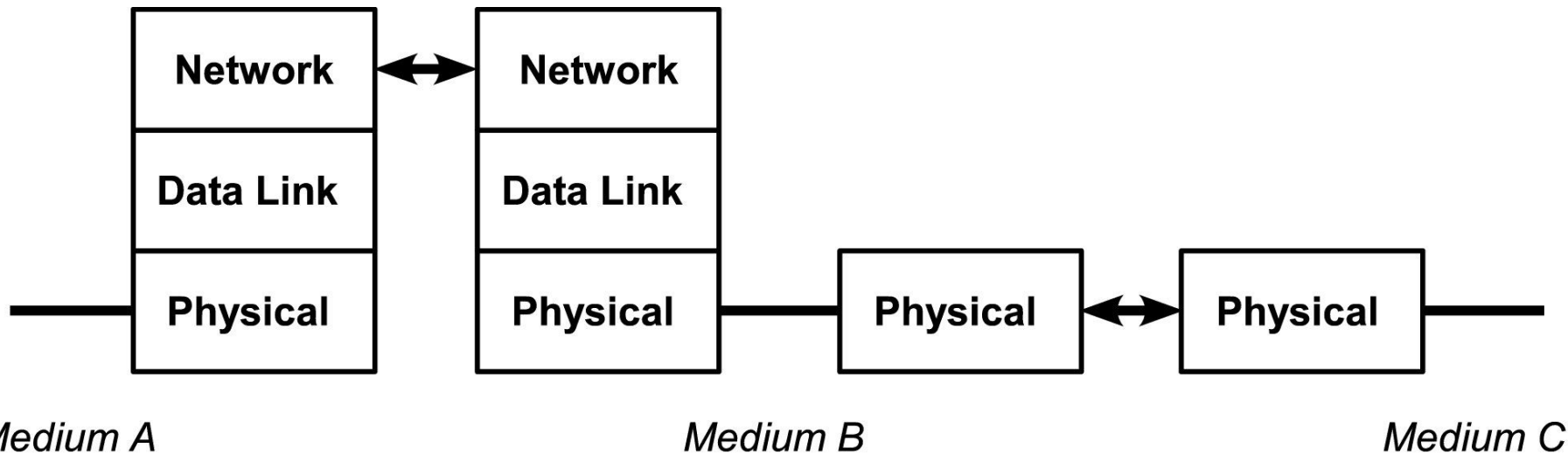
- 10:00-10:30 **Break**
- 10:30-12:00 **Foundations (video)**
Len Kleinrock: *Principles from the Past*
Barry Wessler: *Addressing Risk Management*
Bob Kahn: *Myths, Critical Decisions, and Lessons Learned*
Dave Reed: *Layering, End-to-End, and Security*

- 12:00-1:00 **Lunch**
- 1:00-2:30 **Frontiers (video)**
Bob Briscoe: *Event Notification*
Jean-Jacques Quisqater: *Security: Frontiers*
Steven Low: *Optimizing Internet Protocols*
Mung Chiang: *Layering*
- 2:30-4:00 **Working Groups**
IO Implementation
Security
Applications
Protocols and Standards
Community Process



**end-to-end modulation
interdevice internetworking**





internetworking

interdevice internetworking

The Internet may be the most complex system ever engineered; from the first host in 1969, it's grown to comprise more than 1 billion routable host addresses [1]. Its future expansion may be more dramatic still due to the demand to extend the Internet from people to things [2], but the frontiers of high-speed networking have receded further and further from the requirements of small, cheap, slow devices. These things need the Internet's original insights, rather than their current implementation; this is being done in the IØ initiative.

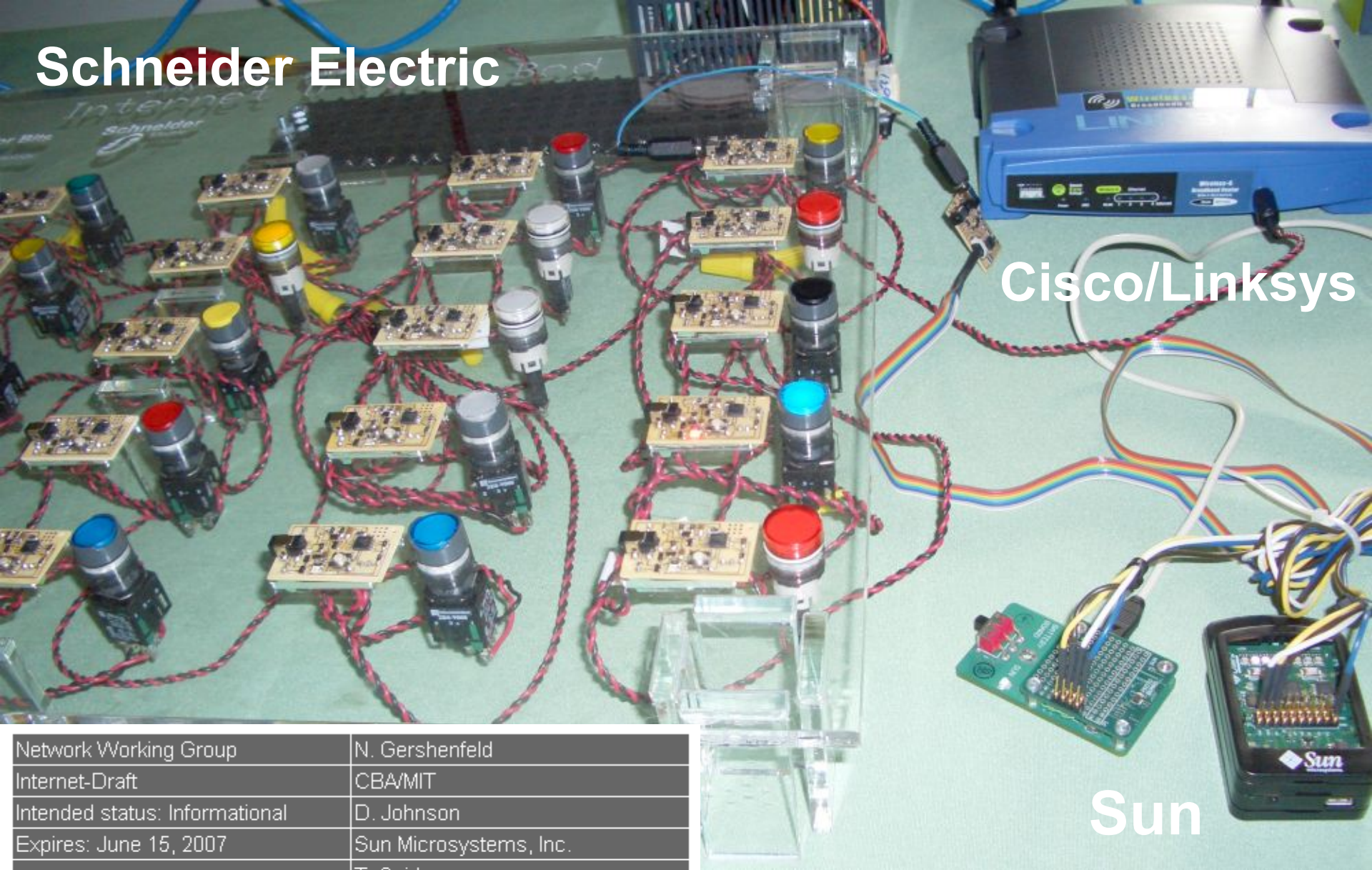
The demand for networking embedded devices has led to a proliferation of stan-

dards and protocols, including X10, HomePlug, LonWorks, BACnet, CEBus, Fieldbus, ModBus, CAN, Lin, I²C, SPI, SSI, ASI, USB, EPC, IrDA, Bluetooth, 802.15.4, and ZigBee. While each of these has been optimized for a particular domain, all are encountering many of the same issues that the Internet faced as it grew, including inadequate address space, the need for naming and routing across networks, and mutual incompatibility. This situation is in fact analogous to the early days of the Internet itself.

Early packet-switched networks, including ARPANET, PRNET, and SATNET either relied on complex protocol converters at their

*Neil Gershenfeld
and Danny Cohen*

Schneider Electric



Cisco/Linksys

Sun

Internet 0: A Proposal for End-to-End Modulation

Trivial Hypertext Transfer Protocol (THTP)

...

Network Working Group	N. Gershenfeld
Internet-Draft	CBA/MIT
Intended status: Informational	D. Johnson
Expires: June 15, 2007	Sun Microsystems, Inc.
	T. Snide
	Schneider Electric
	K. Lynn
	Cisco
	December 12, 2006

Building Energy

- **demand**
 - ~40% energy
 - ~70% electricity
- **opportunity**
 - ~1/3 recovery
- **intelligent infrastructure**
 - windows ↔ air handlers
 - natural ↔ artificial light
 - occupied ↔ unoccupied spaces



"On the Internet, nobody knows you're a dog."



"On the Internet, nobody knows you're a light bulb."



Intelligent Infrastructure for Energy Efficiency

May 25, 2007

The Bartos Theater
[Building E15](#)
MIT

9:00-10:30 **Background Presentations**

Introduction

Neil Gershenfeld (MIT Center for Bits and Atoms)

The Long Green Tail

Danny Cohen (Sun Microsystems)

Building Energy Use

Les Norford (MIT Architecture)

Campus Energy Use

Peter Cooper (MIT Facilities)

Intelligent Infrastructure and Energy Efficiency

Claude Ricaud (Schneider Electric)

Dave Berardi (Tour Andover Controls)

Internet 0

Kerry Lynn (Cisco Systems)

David Kopp (Schneider Electric)

Passive vs Active Building Energy Systems

John Fernandez (MIT Architecture)

Building Information Interfaces

Manu Gupta (MIT House_n Research Consortium)

Security, Optimization, and NW35

David Dalrymple (MIT Center for Bits and Atoms)

Sharing Tower, Sharing Energy

Vicente Gualart (Barcelona)

Printing Building Infrastructure

Berok Khoshnevis (USC (video))

10:30-11:00 **Break**

11:00-12:00 **Project Planning**

MIT Energy Initiative

Leon Glicksman (MIT Mechanical Engineering)