Center for Information Technology Research in the Interest of Society

Loosely Human Tracking: From Search and Rescue to Energy Conservation

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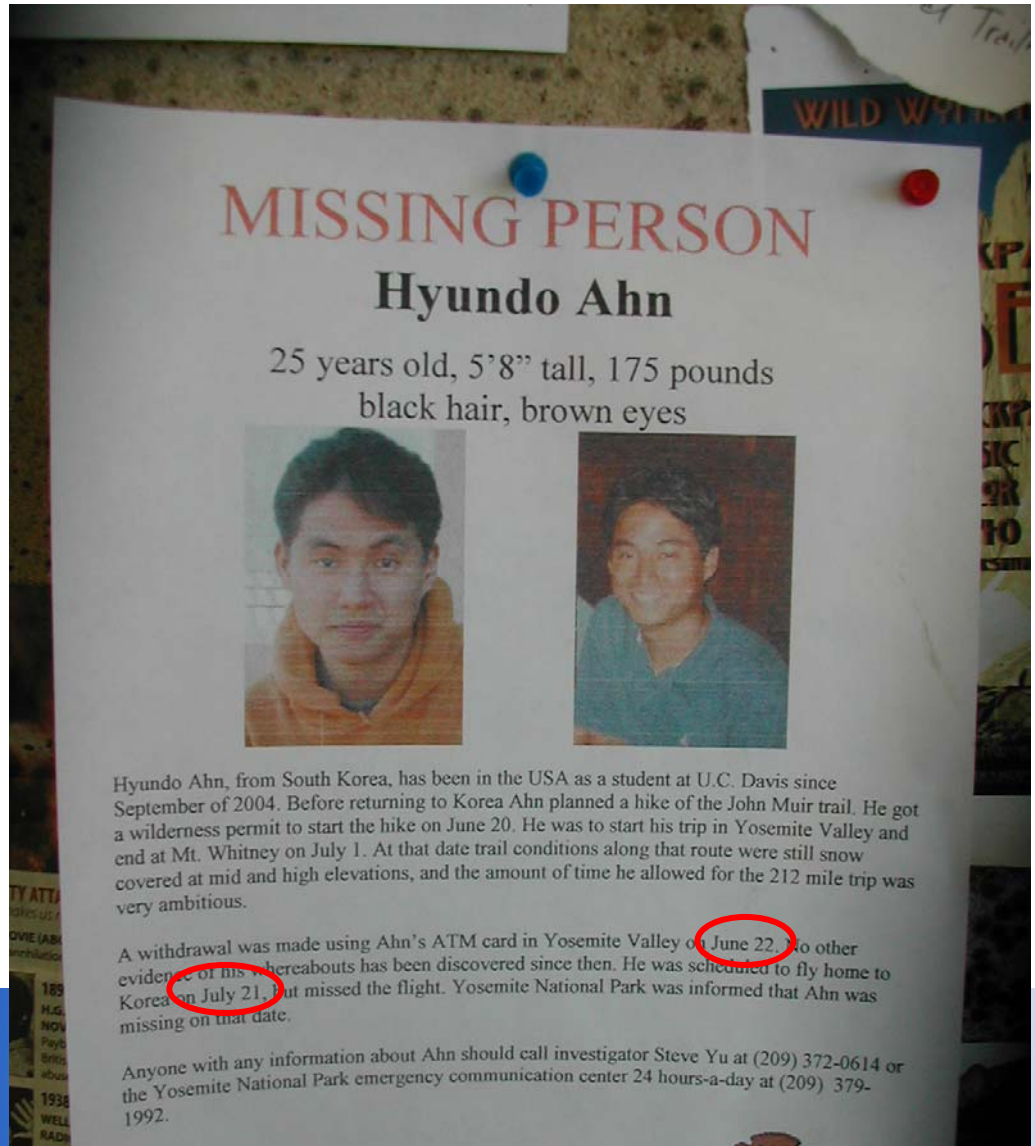
Search and Rescue

- Collaboration with Jyh-How Huang, Shivakant Mishra and Rick Han from University of Colorado at Boulder
- **Goal:** To build a search and rescue system that can pinpoint missing person's last seen point in wilderness areas
  - Lost hikers, stranded climbers, injured skiers, …
  - Difficult because of lack of timely information about the current location
- "Last seen point" is critical for search and rescue actions

Societal "Pull":
A real case of a last seen point



Current Search and Rescue Technologies

- The Old School Way – Ask
- Personal GPS receiver and Satellite transmitter – Power greedy; Must operate manually to send your location
- Localization system and GSM transmitter – Need GSM network coverage
- Avalanche beacon/RFID reflector – Limited usage
- Need a better, cheaper, reliable system

Design Goals

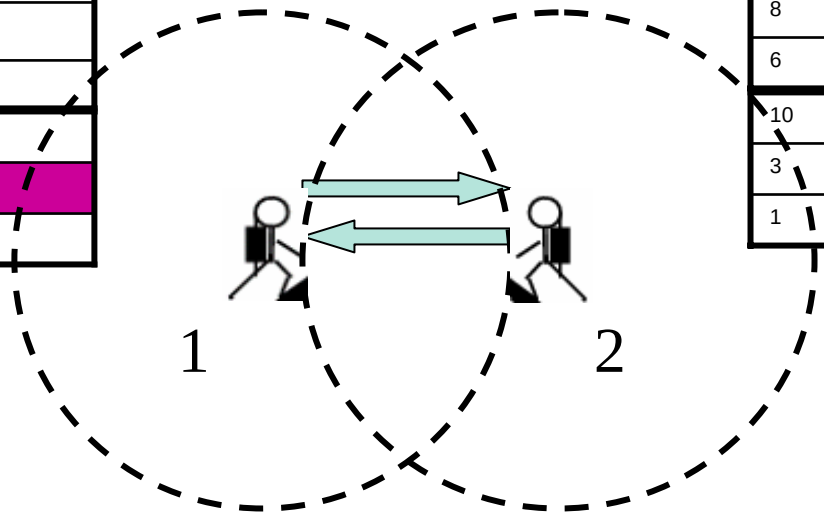
- Self-Operate, long lifetime
- Small and light weight
- Non intrusive; no infrastructure needed
- Power and memory efficient
- Cheap($20~$50)
- Meets security and privacy requirements

Technology “Push”: Cenwits

- A Connection-less Sensor-Based Tracking System Using Witnesses
- Comprised of
  - RF sensors
  - GPS receivers
  - Access points
  - Location points
  - Control center

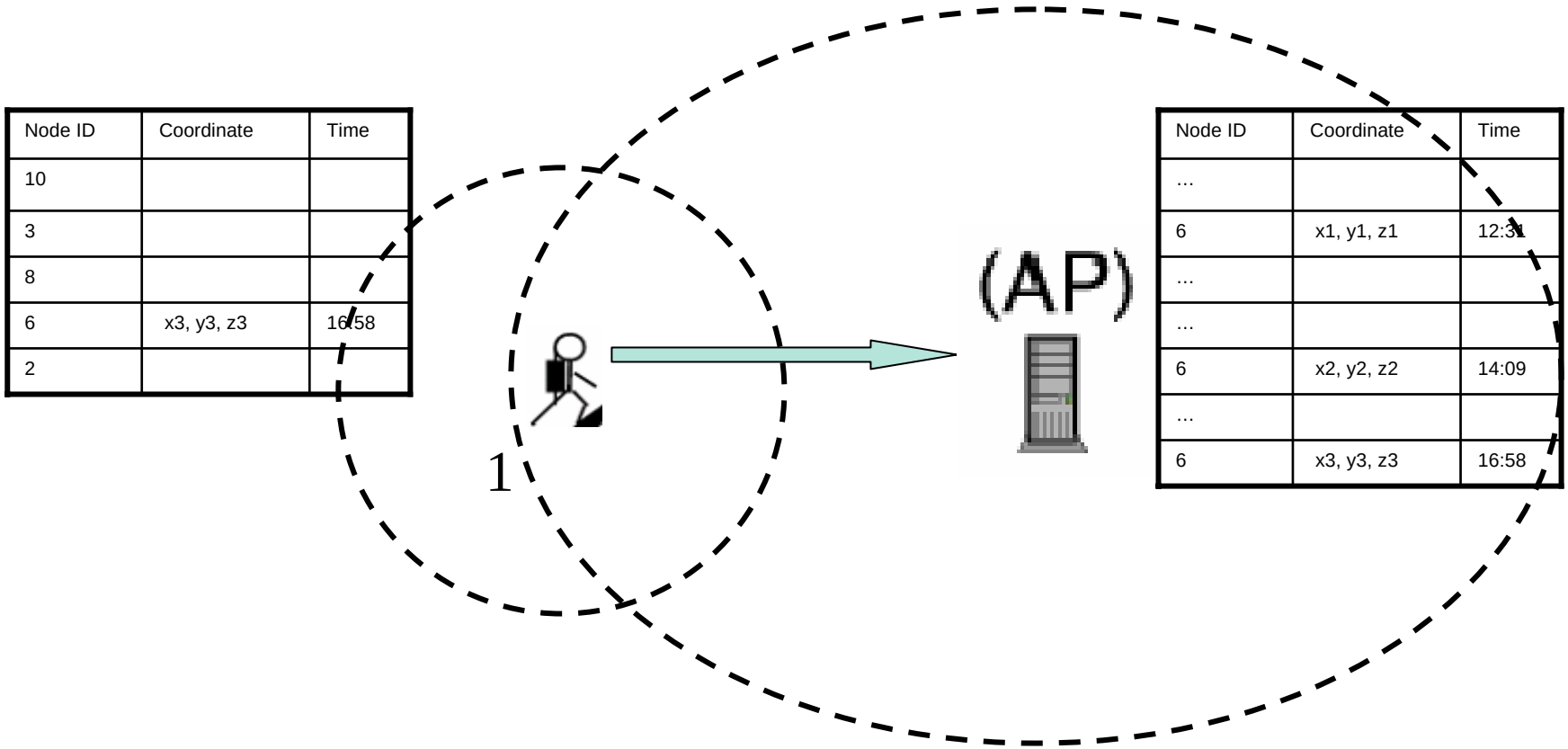
Cenwits – How it Works (I)

Node ID	Coordinate	Time
10		
3		
8		
6		
2		



Node ID	Coordinate	Time
8		
6		
10		
3		
1		

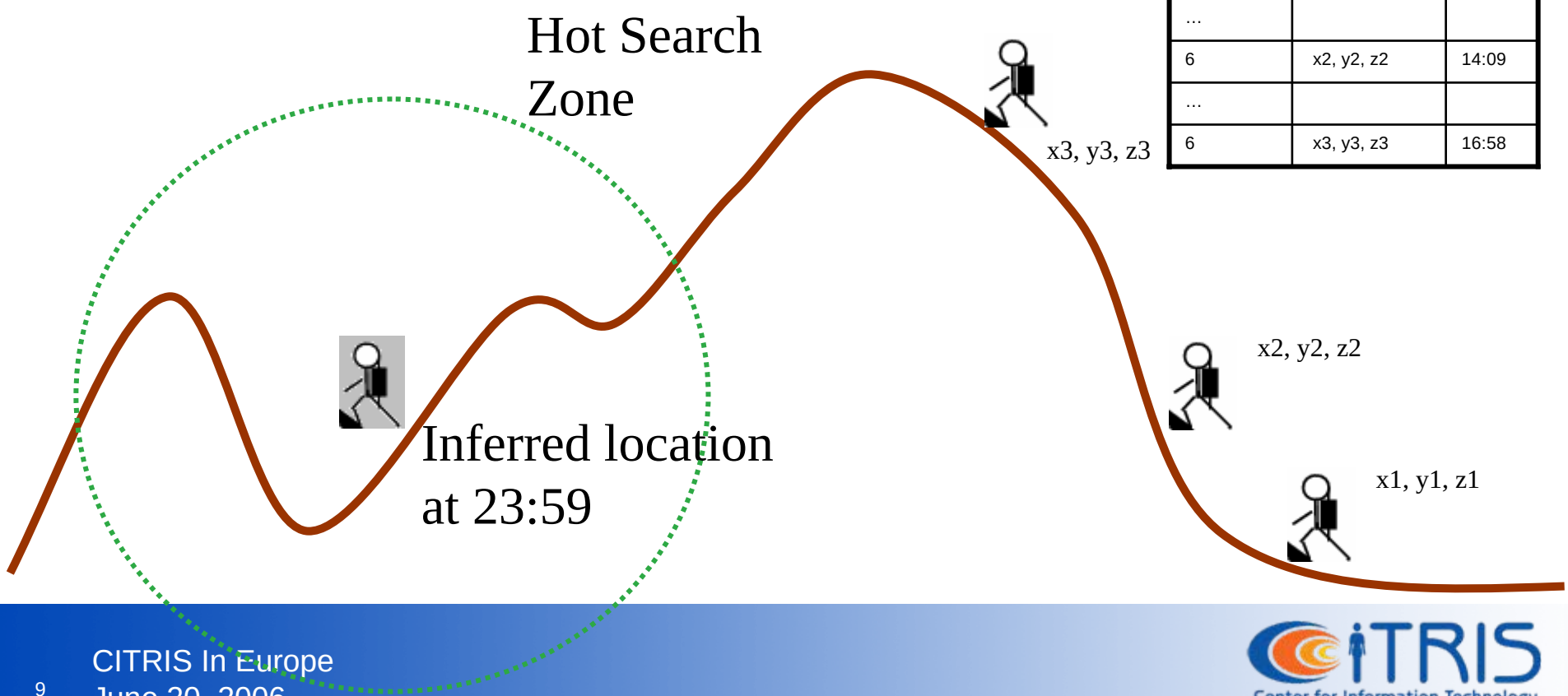
Cenwits – How it Works (II)



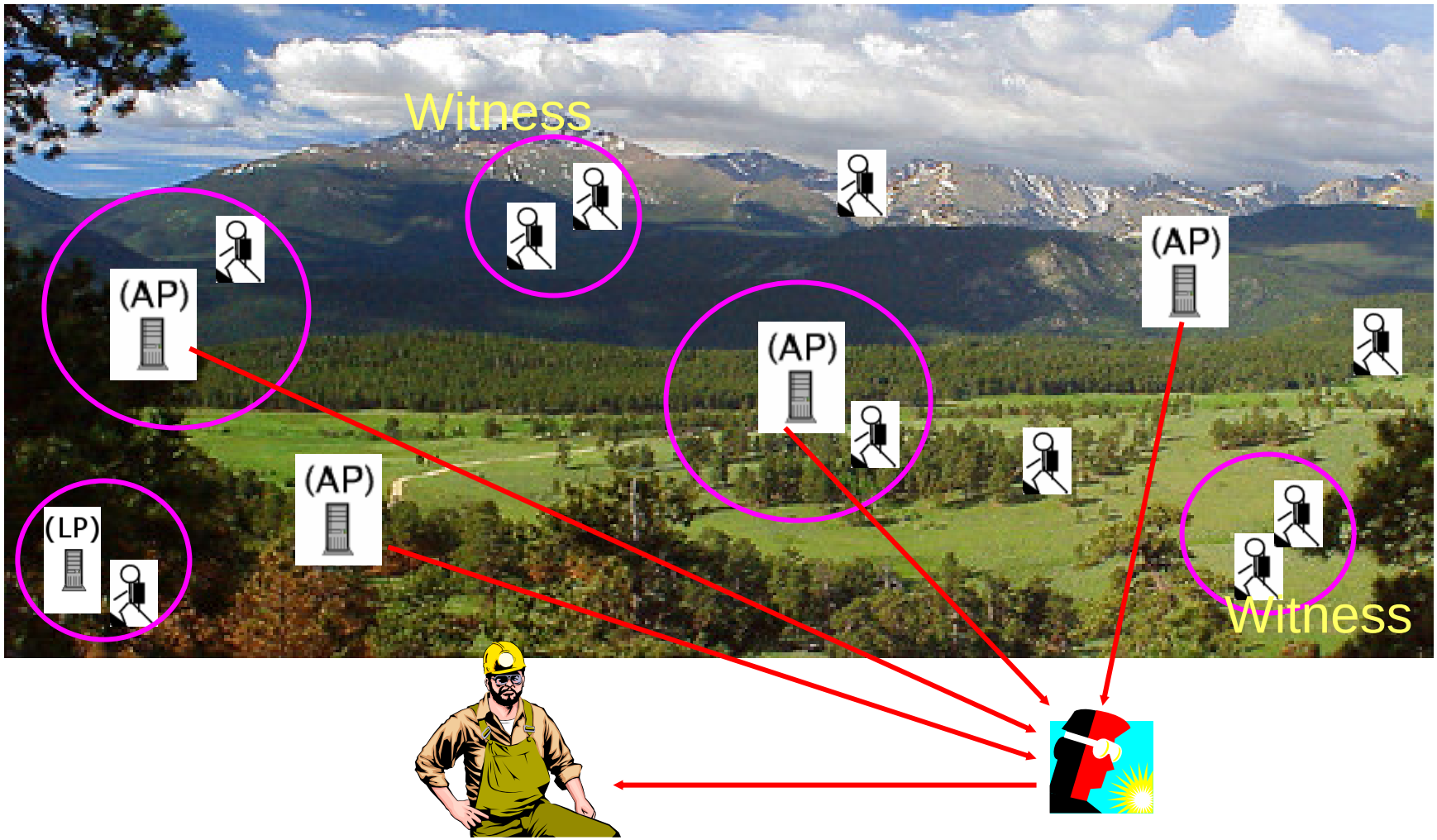
Cenwits – How it Works (III)

Hiker 6 is reported missing at 23:59

Node ID	Coordinate	Time
…		
6	x1, y1, z1	12:31
…		
…		
6	x2, y2, z2	14:09
…		
6	x3, y3, z3	16:58



CenWits – System Architecture



Energy Management

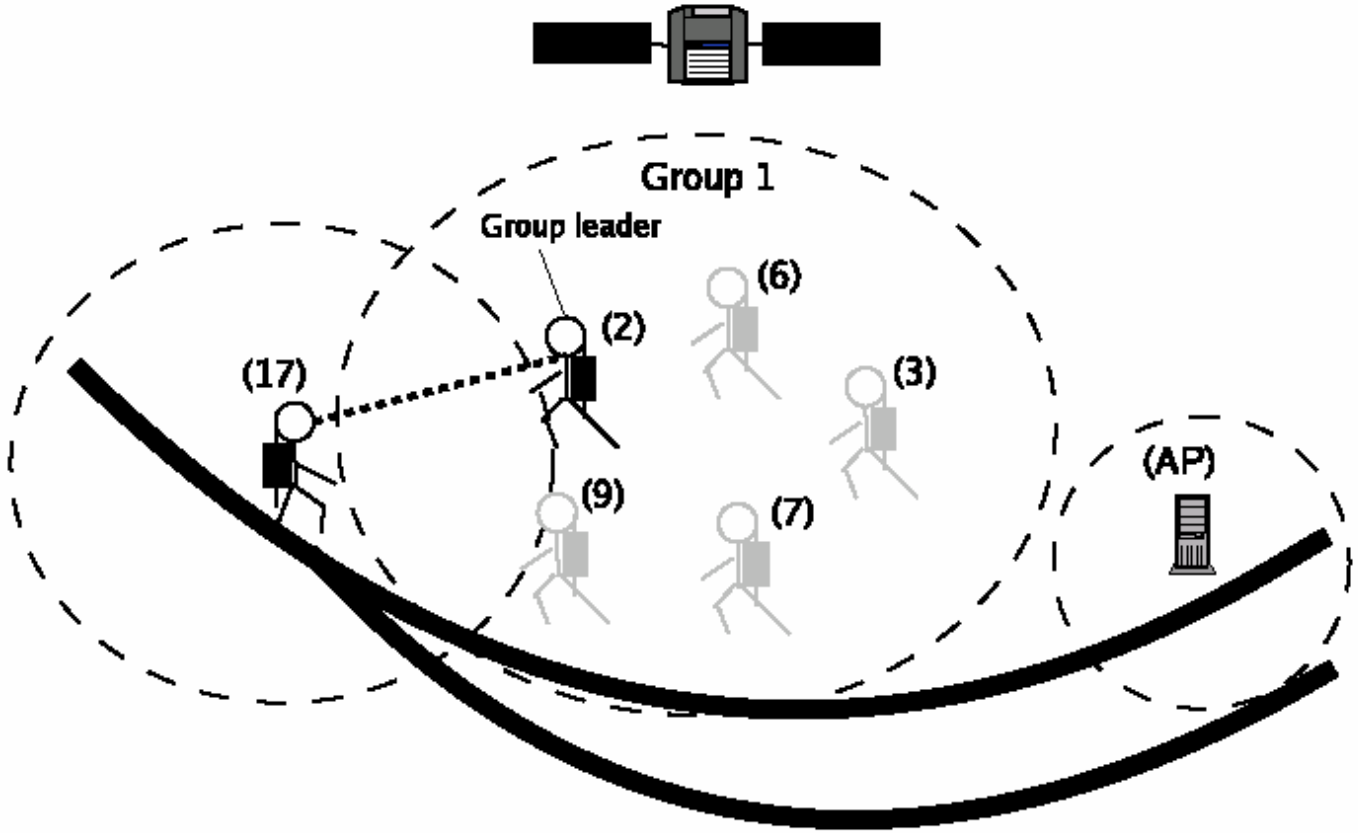


Fig. 10. A group of five people. Node 2 is the group leader and it is communicating on behalf of the group with an external node 17. All other (shown in a lighter shade) are in sleep mode.

Memory Management

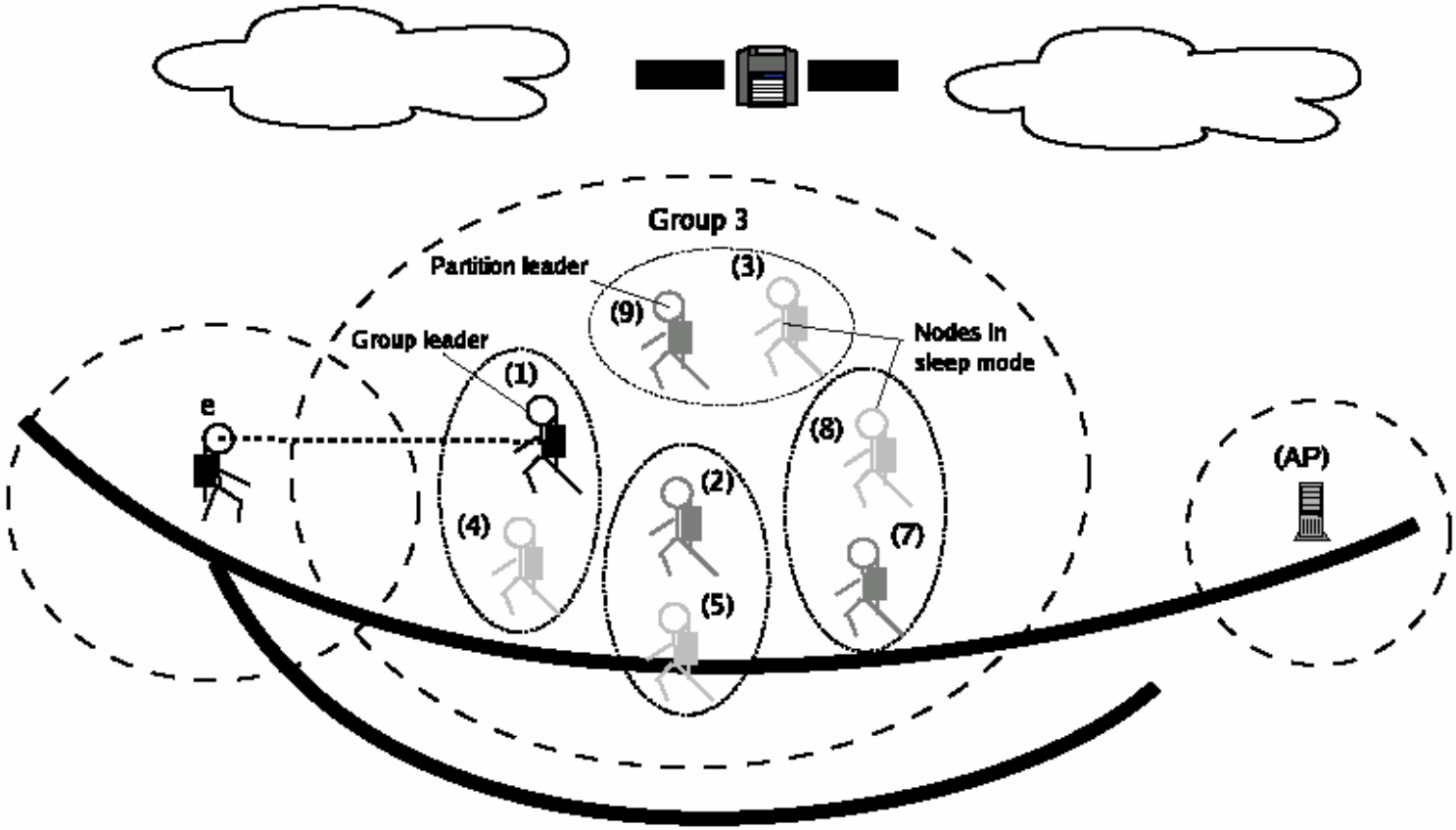


Fig. 11. The figure shows a group of eight nodes divided into four partitions of 2 nodes each. Node 1 is the group leader whereas nodes 2, 9, and 7 are partition leaders. All other nodes are in the sleep mode.

Prototype Implementation

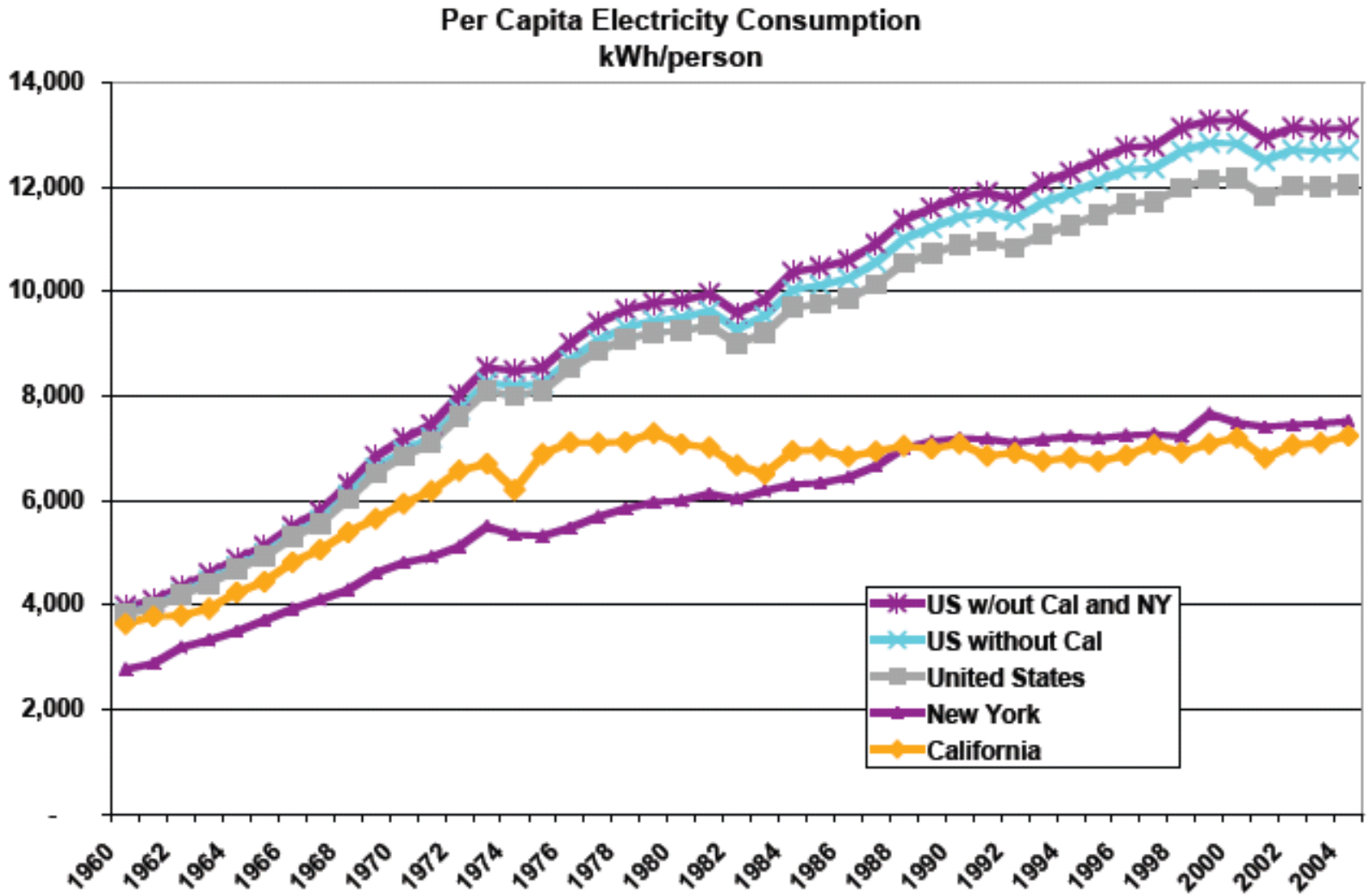
- MICA2 sensors
  - 900 MHz; 4 KB SDRAM; 128 KB flash; and 4-512 KB EEPROM
  - Mantis OS 0.9.1b
  - MTS420CA GPS module

- Successfully conducted a number of experiments in an indoor environment
- More realistic and larger scale experiments to be conducted during the Summer at the Virginia Smith Trust wilderness area (5000 acres) co-located to UC Merced

Indoor Tracking

- In collaboration with Roland Winston and Alexander Ritschel from the Energy Research Institute at UC Merced, and with Agilent Technologies
- **Goal:** build a distributed vision based tracking system for human density estimation inside buildings
  - Automatic distributed control of HVAC systems
  - Efficient lighting use and control
  - Building usage and design
  - Social networking
- Having accurate models and real time data permits further innovation in other areas

Societal “Pull”: Energy Efficiency



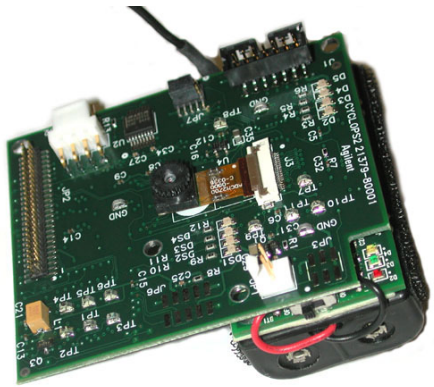
Source: California Energy Commission

Design Goals

- Self-configuration, long lifetime
- Small and light weight, easy to integrate into buildings' ceilings
- Non intrusive; no special infrastructure needed
- Power and memory efficient
- Economical
- Meets security and privacy requirements

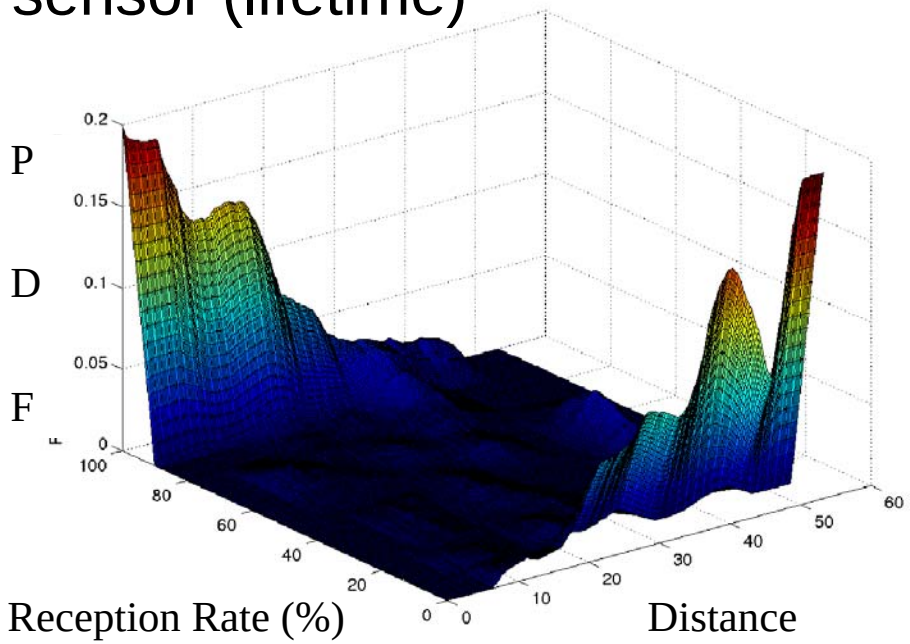
Technology “Pull”: Vision Sensor Networks

- Based on new generation Telos mote
- Ultra-low power-consumption Cyclops camera
- Integration with concentrated photovoltaic cells for solar lighting and thermal energy
- Close the loop: actuate by controlling HVAC systems in real time

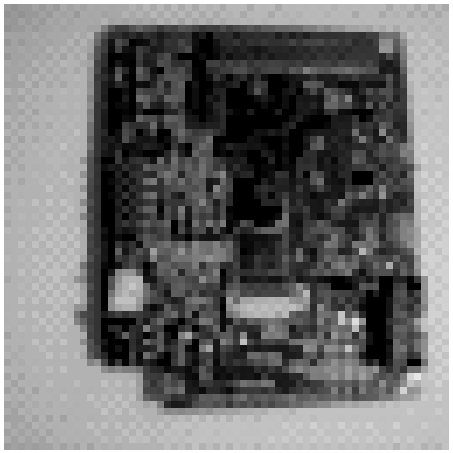


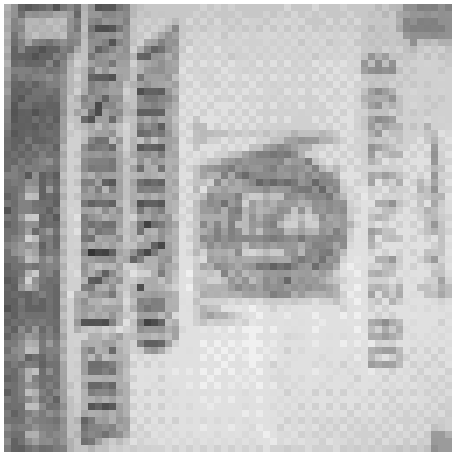
Technical Challenges

- RF propagation quite unpredictable in indoors
- Camera is a power hungry sensor (lifetime)
- No precise enough models of the phenomena
- New distributed algorithms for optimal routing and adaptive data sampling

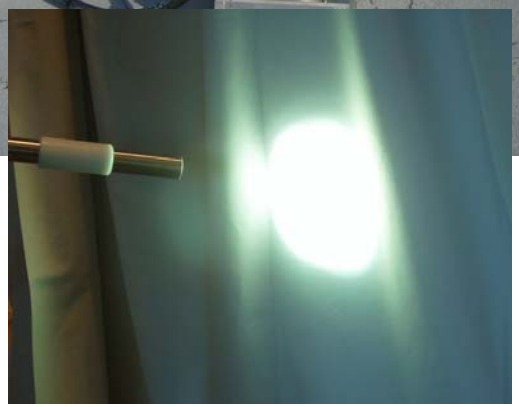


Ceiling Array



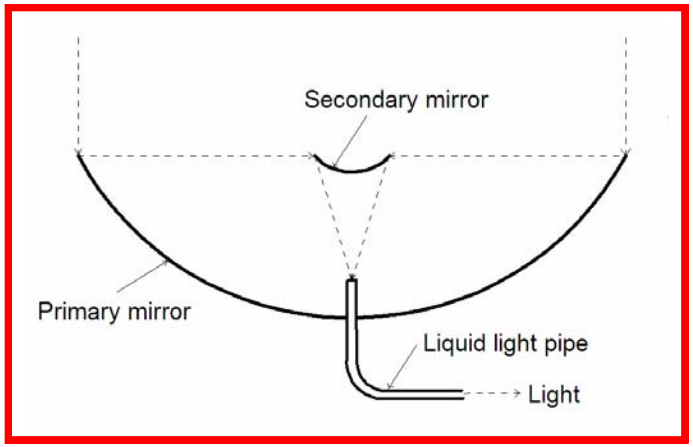


PVC System Demonstration



- California Lighting Technology Center at UC Davis

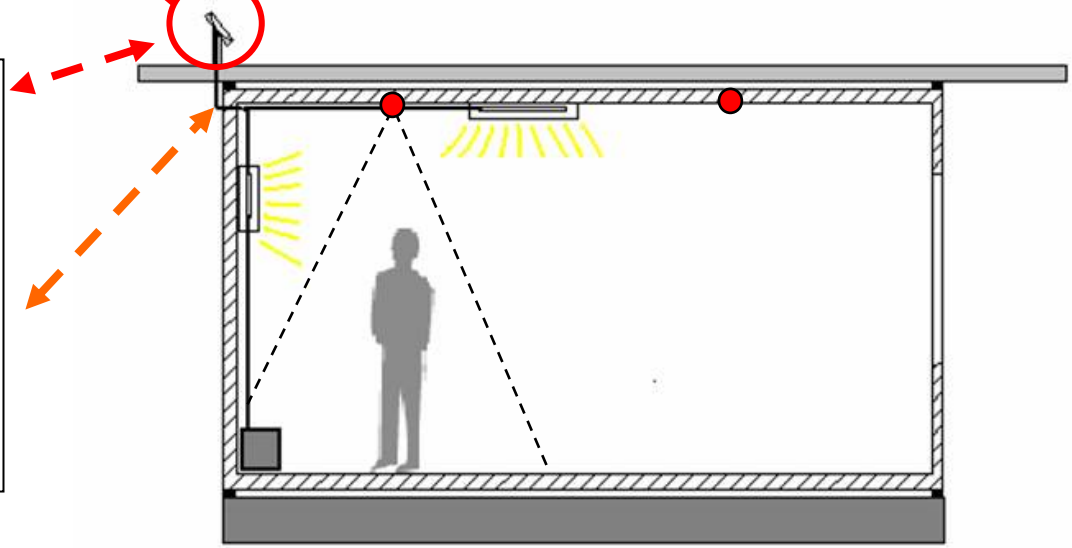
Integration: provide natural lighting



Concentrated and filtered natural daylight

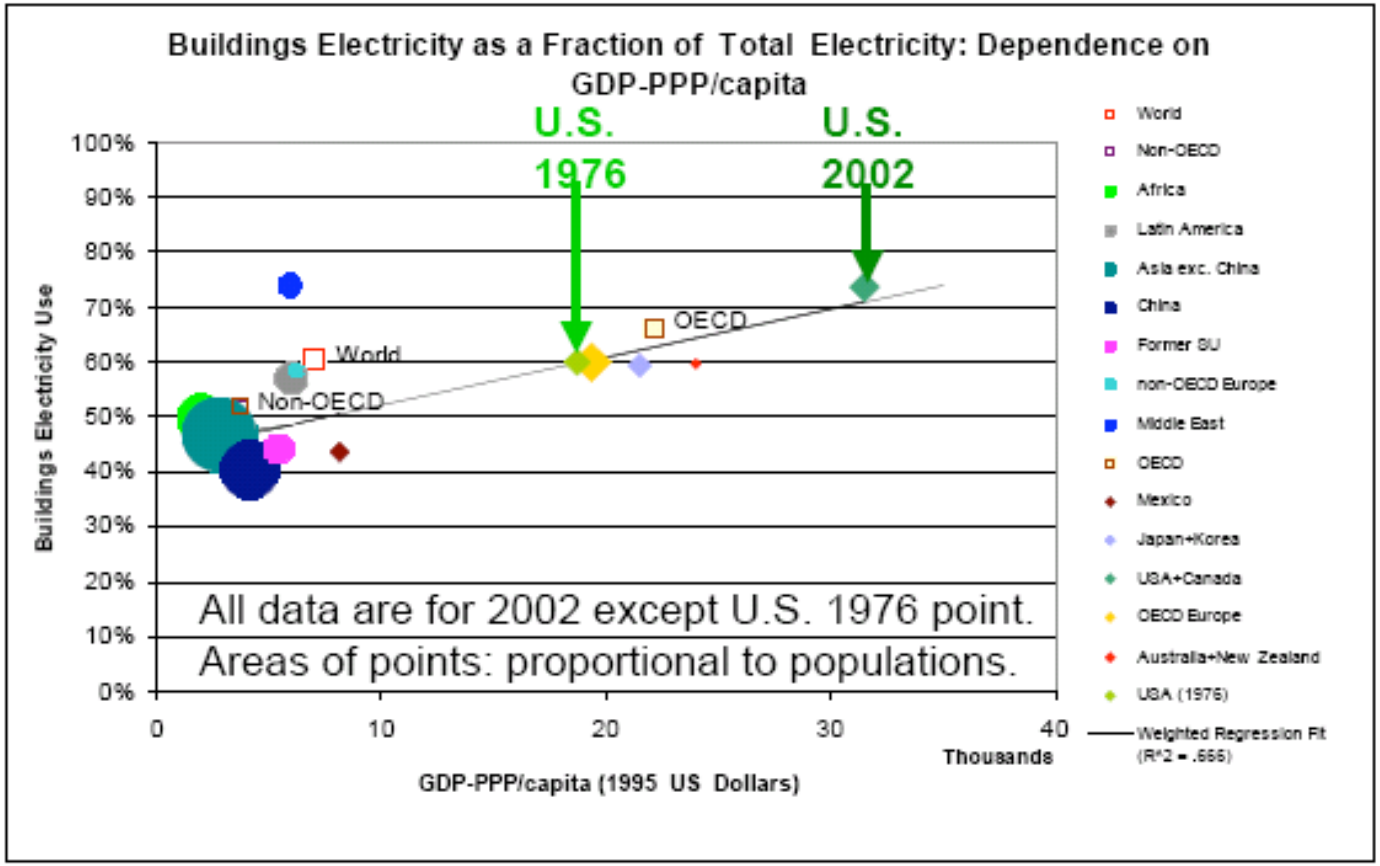
is conveyed to the interior

through a liquid light pipe with minimal roof penetration



Economic Impact

A larger fraction of electricity goes to buildings in rich countries!



"Buildings Electricity" = 100% Commercial and Residential + 15% Industrial + 10% Agricultural.

Data provided by Paul Waide, graphics by Shoibal Chakravarty, from Robert Scollow

Conclusions

- Energy Conservation is key for the future: maximize energy efficiency and minimize energy use, while insuring economic prosperity
- Sensor network technology will play a big role in achieving that goal
- It is critical that privacy and security issues are addressed if the technology is to be massively accepted
- It is equally critical the establishment of efficiency standards. The *expectation* of efficiency standards also stimulated industry innovation