Energy Harvesting Active Networked Tags (EnHANTs)

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# Energy-Harvesting Active Networked Tags (EnHANTs)

◆ **A new class of ultra-low power devices**

- Small, flexible, energetically self-reliant tags
- Will enable pervasive multihop networks of objects (books, toys, produce, clothing, etc.)
- Will exchange mostly IDs
- Will be used for tracking applications
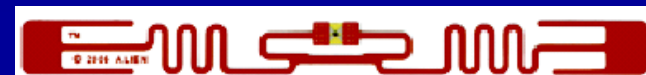
◆ **Energy Harvesting**

- Ambient light
- Organic electronics ➡ Flexible components
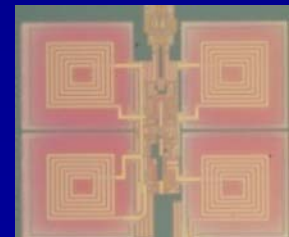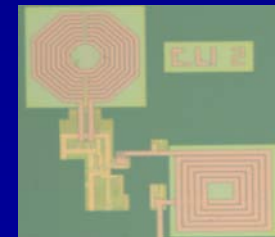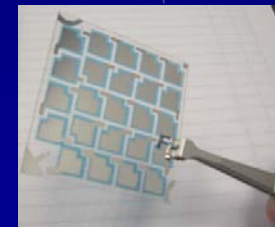
◆ **Ultra-low-power communications**

- Ultra-Wideband (UWB)
- Spend a few nano-Joules per bit

◆ **Fit between sensor networks and RFIDs**

EnHANTs Tracking Application – Example*

Locating a misplaced book in a library

◆ Books will be equipped with EnHANTs on the cover

- Harvest light energy

- Exchange only IDs (Dewey Decimal System)

- Communicate within very short range (ultra-low-power)

◆ A Book whose ID is significantly different from its neighbors will be identified

⬇

◆ The information will be wirelessly forwarded to sink nodes and from there to the librarian
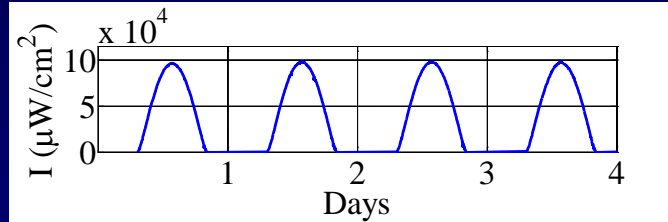
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◆ A Librarian accessing the shelves with a reader will be able to locate a specific book
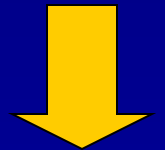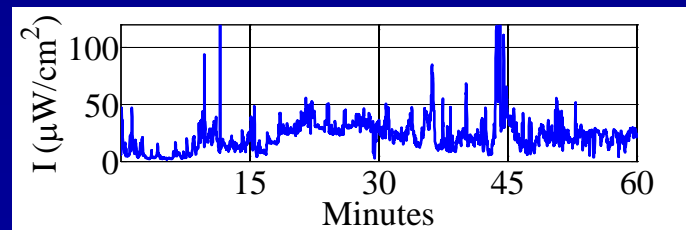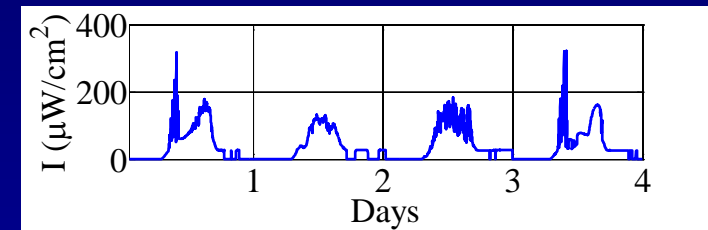
* Sponsored by Google – "organizing the world's **physical objects**"

EnHANTs Energy Budget Characterization

◆ **Determine: data rates, device characteristics, etc.**

◆ Outdoor Solar energy – examined in depth

◆ Indoor light energy – almost no data

◆ Energy measurement campaign

- Long-term (year+) indoor installations
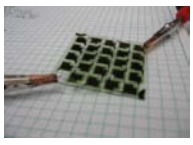- Mobile experiments

~3Kb/s

~10 IDs/sec

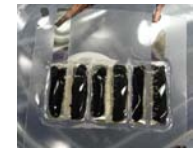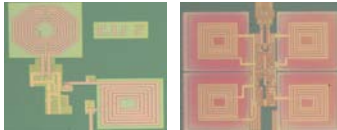◆ Traces available: enhants.ee.columbia.edu

Prototyping and Testbed Development

Envisioned EnHANT Components

Organic Semiconductor-Based Solar Cell

UWB Transceiver

Flexible Battery

- ◆ Mica2 mote–based wireless devices
- ◆ Hardware integration
- ◆ Algorithm testing and demonstration
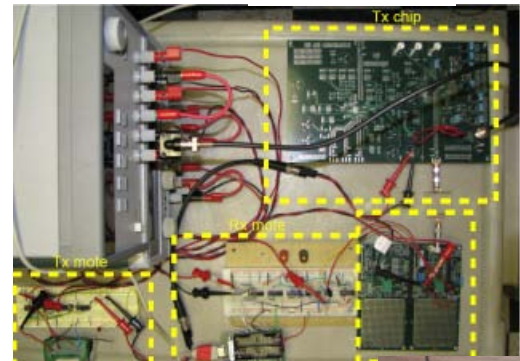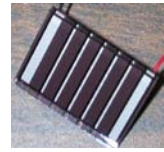
Current State

Mica2 Mote

Custom Sensor Board

Energy Harvesting Module

Arduino board

Thin film /organic semiconductor-based solar cells

Small battery

Photometric light sensor

Mica2 Mote

Integrating a custom UWB Transceiver
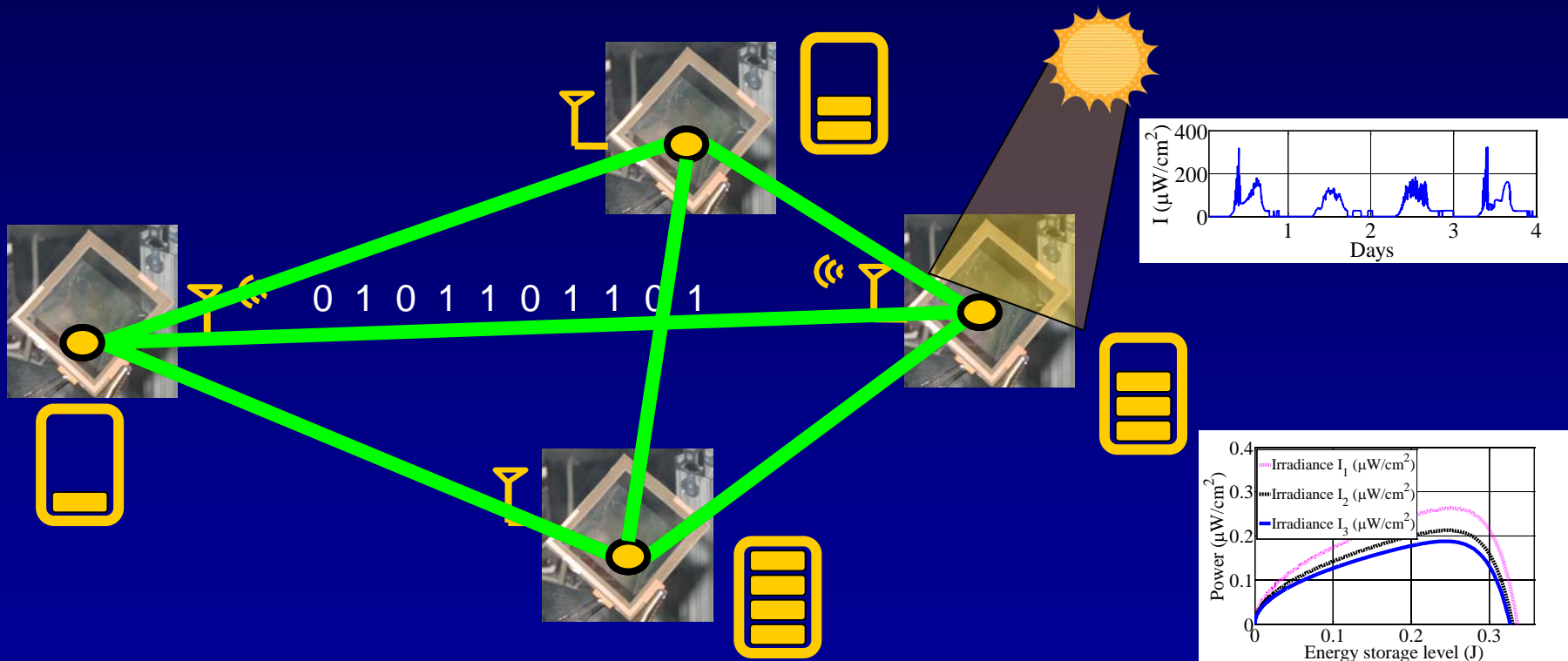
Information Exchange

◆ Each EnHANT has a unique ID

◆ Main Application - form a network of EnHANTs and collect IDs

0 1 0 1 1 0 1 1 0 1

◆ Algorithms for joint decisions regarding states and rates

• Limited exchange of control information

• Limited computation

Summary

◆ EnHANTs will be one of the enabler for the **Internet of Things**

- **Mostly for tracking applications** (healthcare, supply chain management, disaster recovery, public safety)

◆ Developing the enabling technologies

◆ Characterizing energy availability

◆ Designing energy harvesting adaptive algorithms

- Various tradeoffs between computation and communications
- Most of the previous work dealt with a few nodes, sunlight, etc.
- Scalability is the next big challenge

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Questions?

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