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Measuring Activity in Ant Colonies
The Wireless Perspective

http://www.complexperiments.net

- Social Insects
- Motivation
- Counting Ants
- Measurement System
- Some experiments
- Perspectives
- Conclusions

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ICTP-ITU-URSI School on Wireless Networking for Development
February 2006, Trieste, Italy

Measuring Activity in Ant Colonies
Social Insects: Introduction

Over the last fifty years biologists have unravelled some of the mysteries surrounding social insects

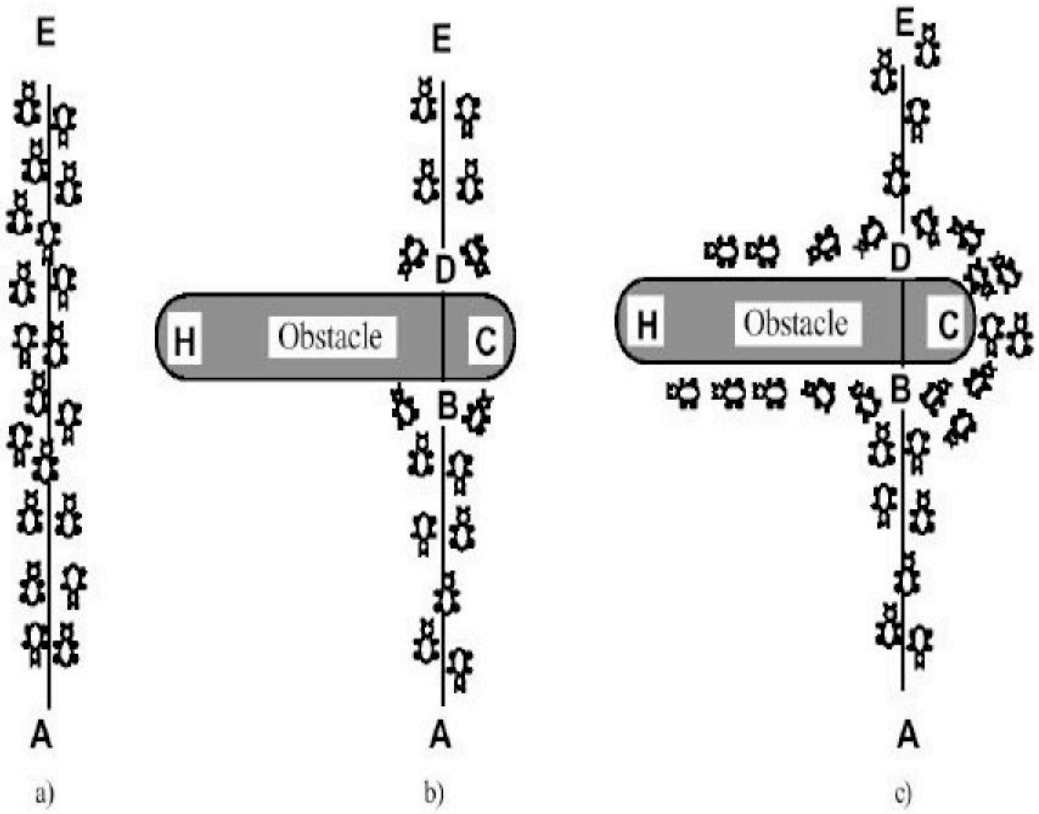
The last decade has seen an explosion of research in fields variously referred to as Collective Intelligence, Swarm Intelligence and emergent behaviour

Even more recently the swarm paradigm has been applied to a broader range of studies, opening up new ways of thinking about theoretical biology, physics, discrete math, economics and philosophy

Ants have become a recurrent example of efficient problem-solvers via self-organization. In spite of the simple behavior of each individual, the colony as a whole displays "swarm intelligence": the organization of ant trails for foraging is a typical output of it

But conventional techniques of observation can hardly record the amount of data needed to get a detailed understanding of self-organization of ant swarms in the wild. Here we present a measurement system that can work unattended in the field performing detailed and high sensitivity measurements.

Measuring Activity in Ant Colonies
Social Insects



Ants go from point A to point E

When an obstacule is interposed ants can choose to go around it on either side with equal probability.

On the shorter path more pheromone is laid down. Therefore this path is prefered.

Adopted from M. Dorigo et. al., "The Ant System: Optimization by a colony of cooperating agents", IEEE Trans on Systems, Man, and Cybernetics, Vol. 26, No. 1, 1996, pp.1-13

Measuring Activity in Ant Colonies
Motivation

The Internet:

An estimated **lower bound** on the size of the indexable web is **320 million** pages.
-Steves Lawrence and C. Lee Giles, Science, 280, **1998**.

Number of web pages indexed by Google in **June 2003:** more than **3 billion**.
-www.google.com.

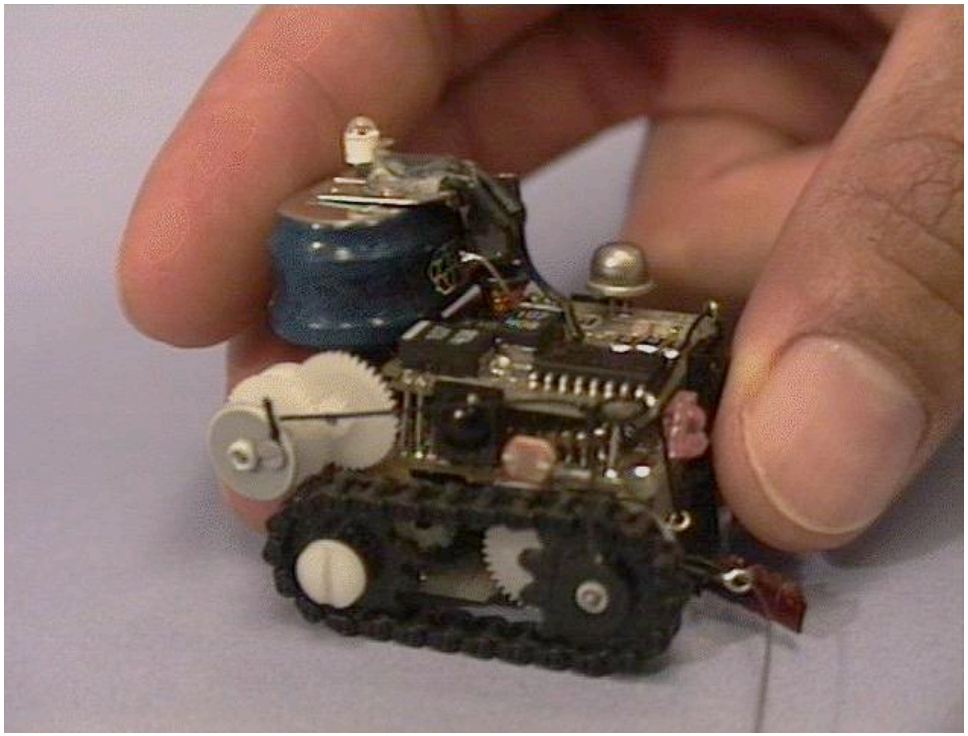
A.Gulli (Università di Pisa) and A. Signorini (University of Iowa)
updated the estimated size of the indexable Web to at least **11.5 billion** pages as of the end of **January 2005**.

Which means that it **grows in** approximately **200% every year**.

This kind of dynamic and highly stochastic problems tend to be untreatable with established tools and models that physics and discrete math has brought so far. **ACO** has also been successfully applied to distributed control problems such as adaptive routing in communications networks

AntNet: Routing protocol for The Internet
Inspired in Social Insects, introduced by M. Dorigo and coworkers (Univ. Libre de Brussels)

Measuring Activity in Ant Colonies
Motivation

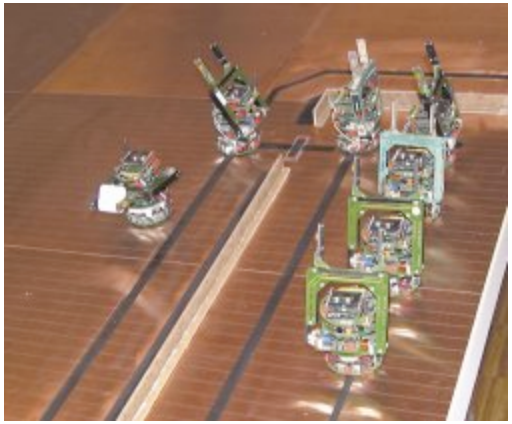


Computer Science and Artifitial Inteligent Laboratory, MIT

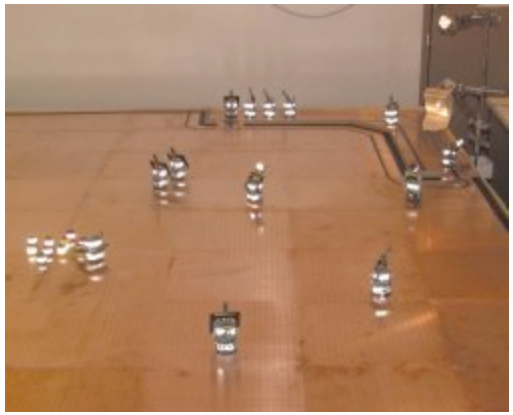
The Ant Farm:
A Community of Microrobots

http://groups.csail.mit.edu/lbr/ants/

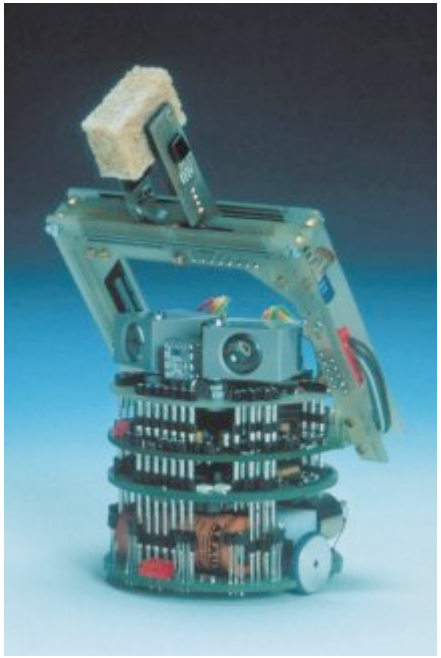
Measuring Activity in Ant Colonies
Motivation



Miniature Khepera robots are programmed to forage like ants.



A swarm of miniature robots fans out from a "nest" in search of "food."



A diminutive Khepera robot, developed at EPFL, shows off Its gripping and lifting prowess.

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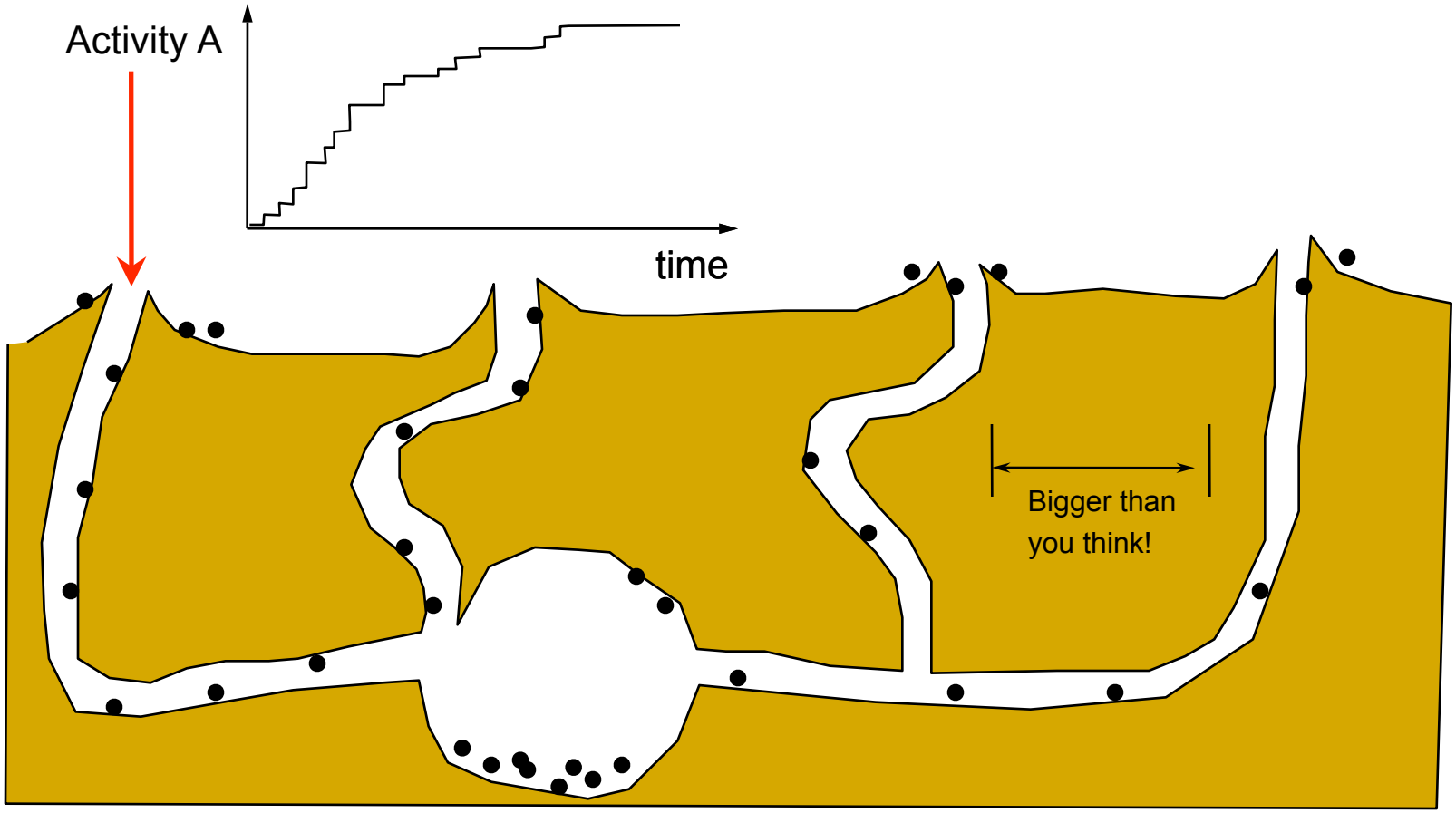
Introducing Atta Insularis

A leaf cutter:
the Atta Insularis, a.k.a. Bibijagua, is endemic of Cuba.

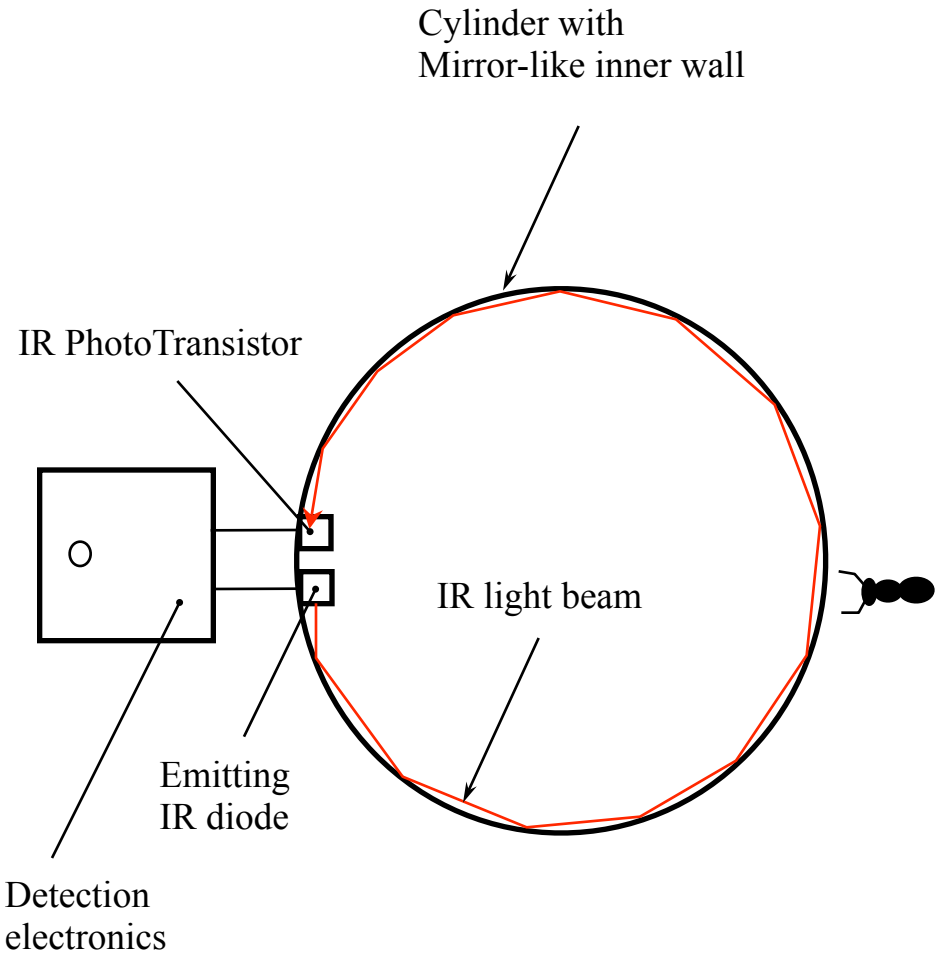
Trieste. Feb, 2006

Measuring Activity in Ant Colonies

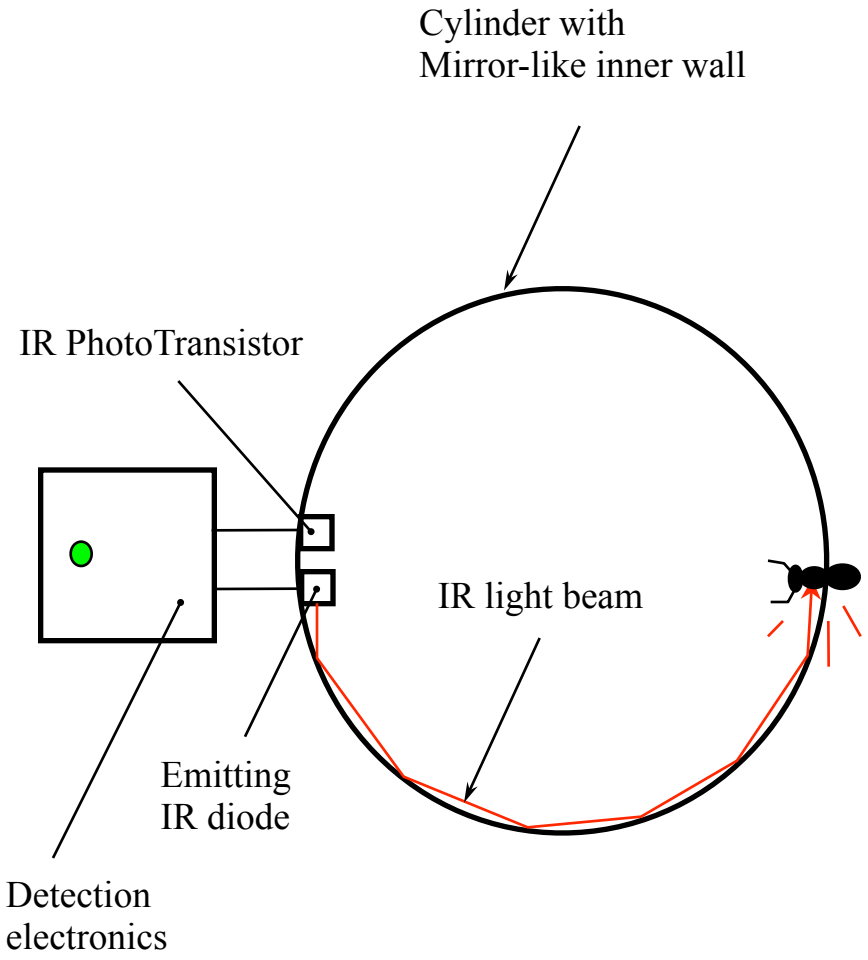
Nest Scenario



Measuring Activity in Ant Colonies
The activity sensor

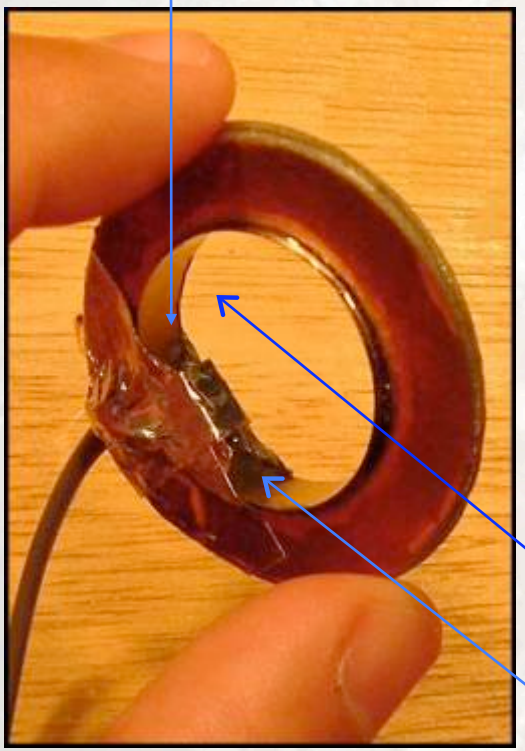


Measuring Activity in Ant Colonies
The activity sensor



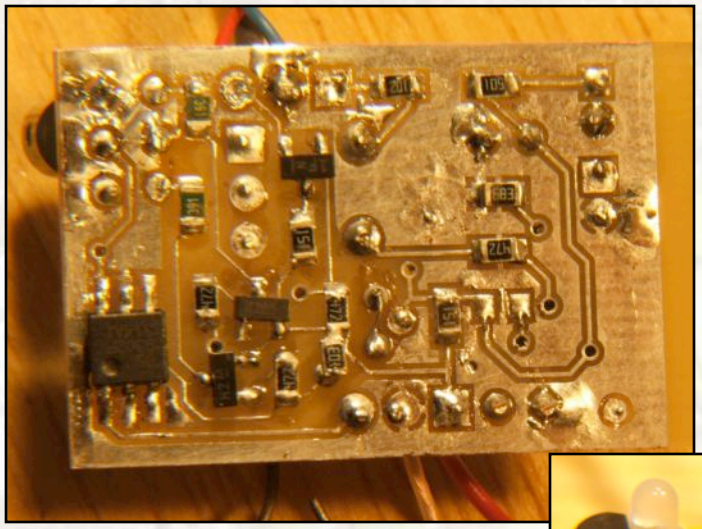
Measuring Activity in Ant Colonies
The activity sensor

Photo Transistor

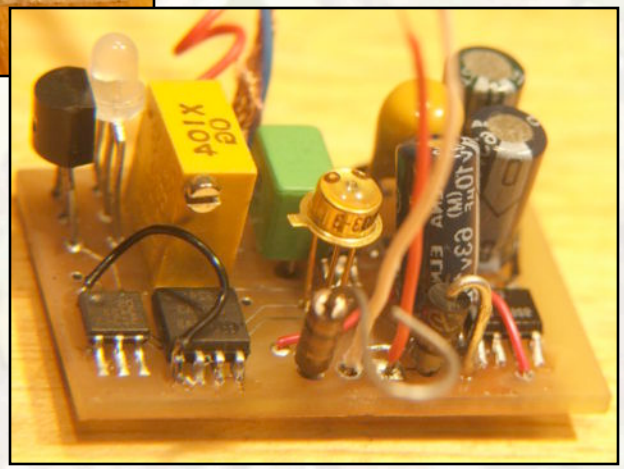


Mirror

IR
LED



Electronics



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The activity sensor

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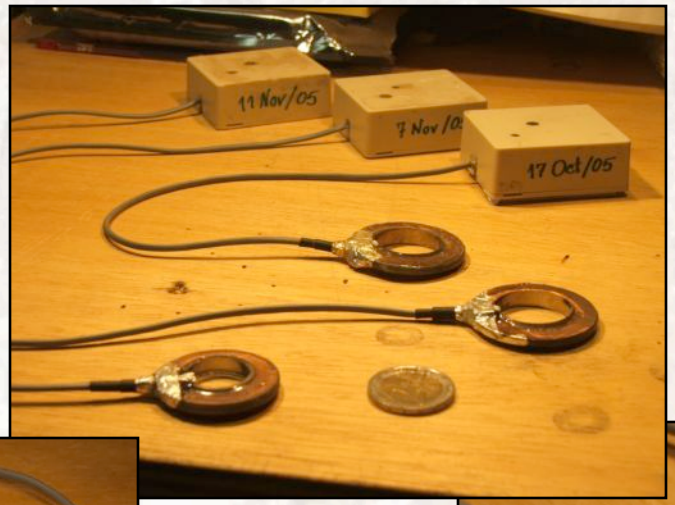

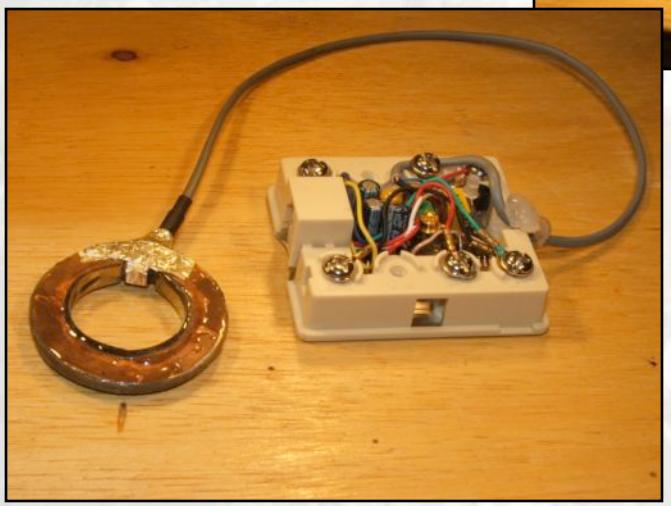

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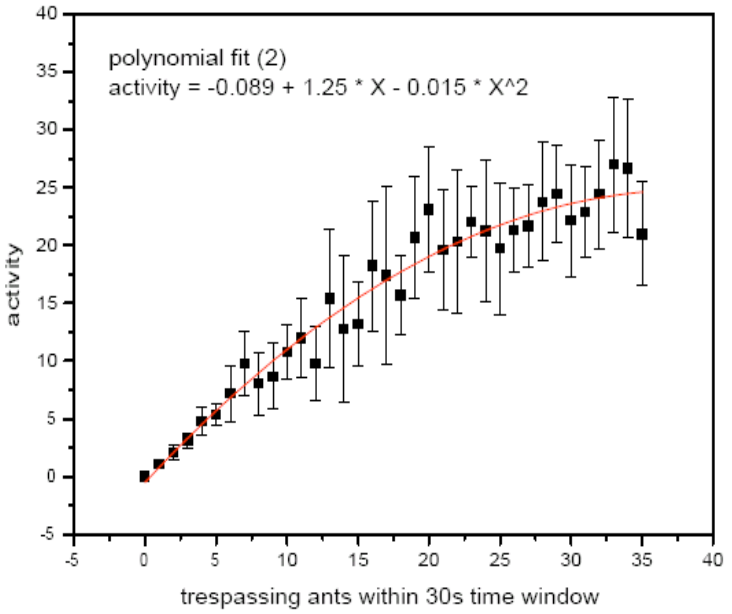
The Activity Sensor Calibration

http://www.complexperiments.net



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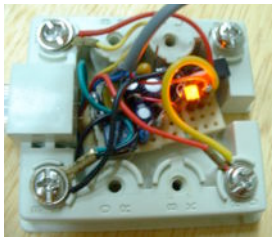
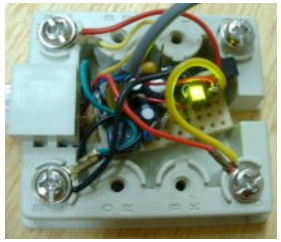
Measuring Activity in Ant Colonies Measurement System

Up to 100 m

..in the field.



n2



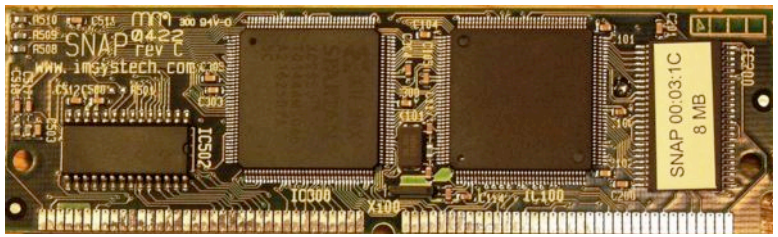
n1

Each node measures:

- **Activity**
- **Temperature**
- **Daylight Intensity**

...in the Lab.

SNAP



1-Wire Bus

Etherne
t

Wi-Fi adapter

Programming for the SNAP

Our Java code

OS and API from Imsys

SNAP Hardware

Application: Data Collection | Logs Cntrl | ACPI, Batt, WiFi | FTP

JRTE: 1-Wire API (com.dalsemi) | java.net / java.comm

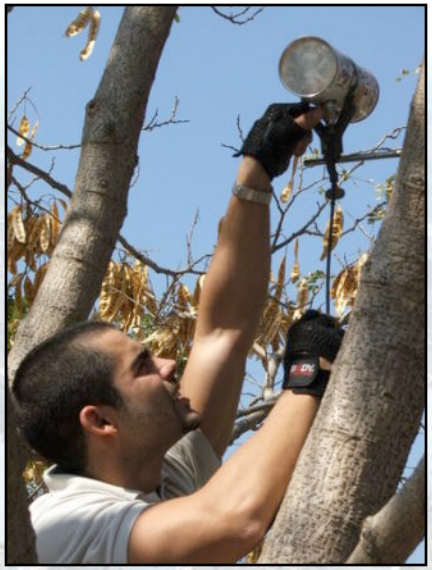
SNAP Run Time Environment

SNAP: 1-Wire | Cjip, 66Mhz | RAM, 8MB | Flash, 2MB | Ethernet

Deploying The Measuring System

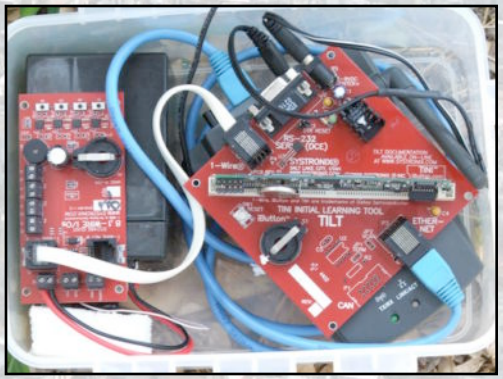
Embedded system in the field

Deploying The Measuring System



In field measurement system...

In campus network link end...



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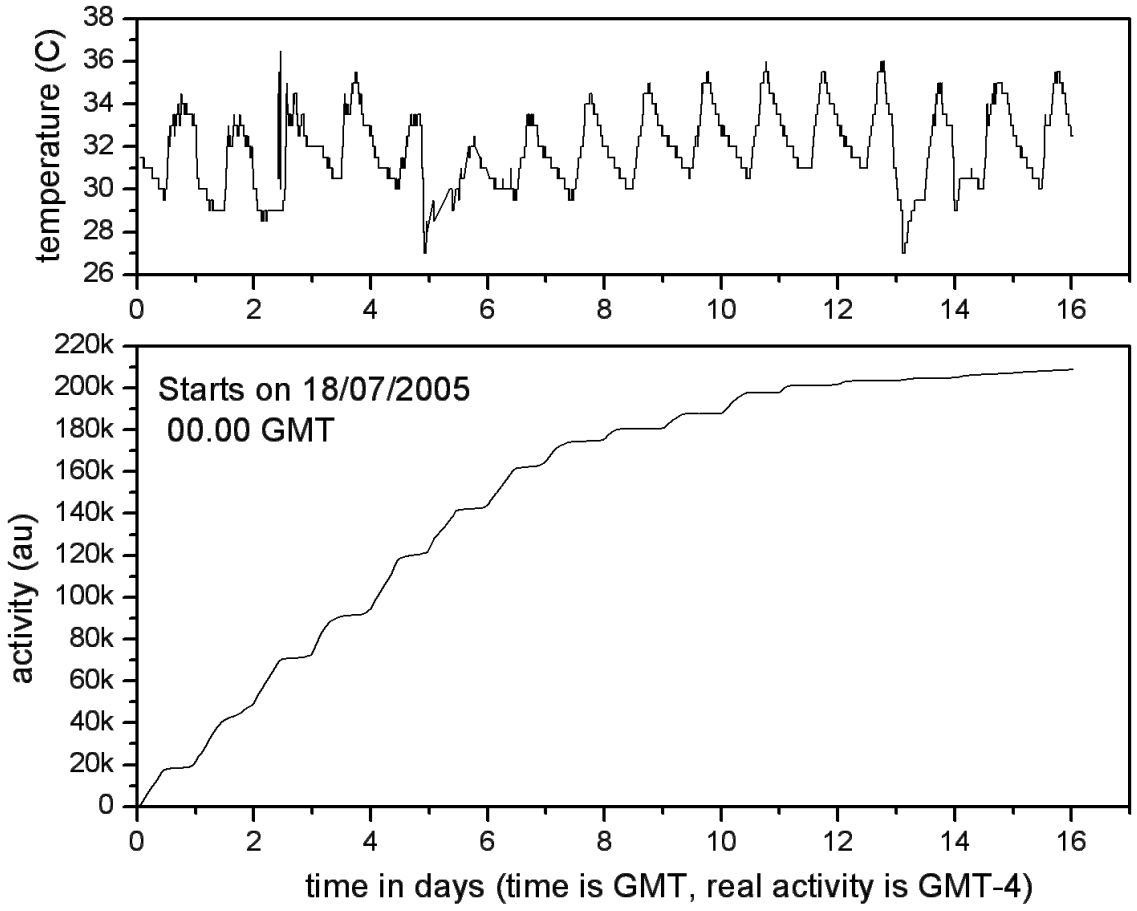
Sample Data from the Wired Field Sensors



Scaling up: The Wired Field Sensors

Wired field sensors soon become a handicap to scale up the system

In order to coupe with the dynamics of the ant society data from neighboring nests has to be measured.

To deal with this problem we have designed a very low power version of the activity sensor to deal with the stringen demands of a Wireless Sensor Network (WSN)

The new sensor (just been prototyped) operates by projecting an electric sense field in the ants path. The associated electronics is based in some fresh "of-the-shelf" chips from Quantum Research, Inc. Based in Leeds, UK.

The sensor performace will inherit those features of the infrared version but will be able to operate over small litium ion battery for several months.

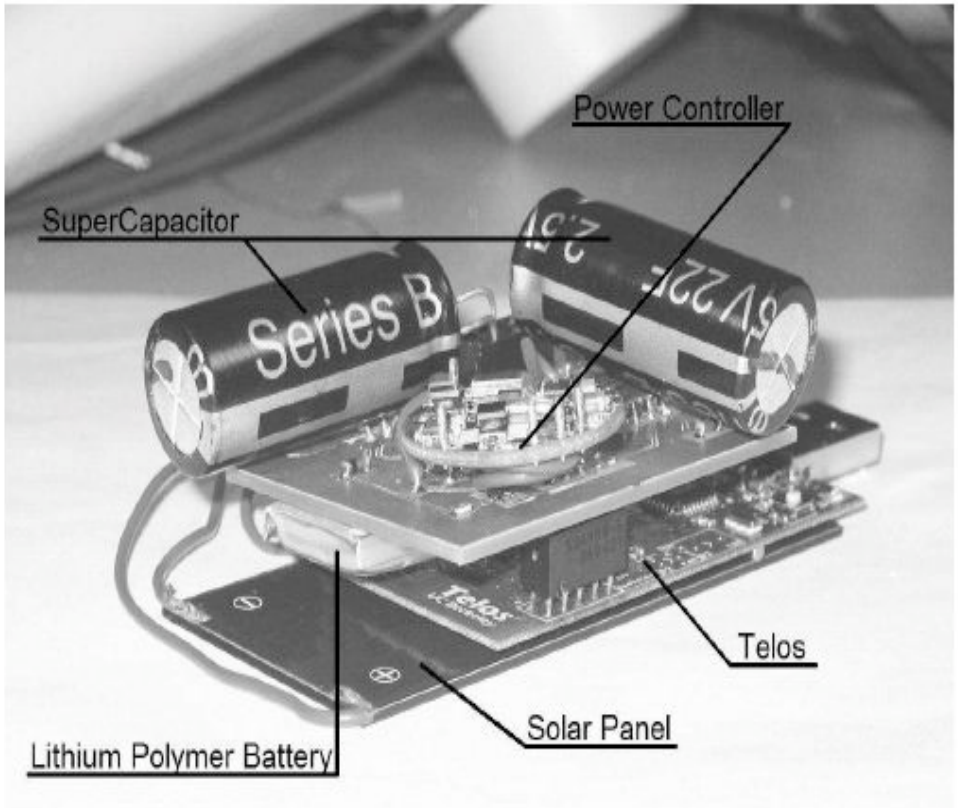
Scaling up: The Wireless Sensor Network

TELOS PLATFORM

IEEE 802.15.4 Radio
Chipcon CC2420 radio 2.4GHz
O-QPSK modulation with DSSS

over 12 months of research
and development by two full-time graduate students, and numerous collaborator, at the University of California, Berkeley.

Scaling up: The Wireless Sensor Network



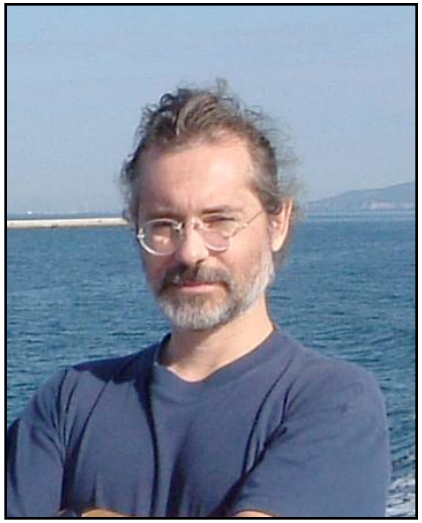
Prometheus: Perpetual Self Sustaining Telos Mote
CS Dept. University of California, Berkeley

Conclusions

We have developed a system to obtain high resolution activity measurements, which comprises an average of twenty thousand experimental points every 15 days. The system is capable of working relatively unattended in the field and collocate the data in the our campus servers for further analysis
Some global features of ants' activity immediately become apparent in the data
One is the correlation between temperature and activity cycles. With a period of approximately 24 hours: as the temperature starts to decrease each day, the activity starts to increase. A second observation is the net decrease in the use of the door under study as days pass by, due to some self-organized process beyond daily temperature cycles.
To the authors' knowledge, this constitutes an original observation that suggests a critical self-organized process that will continue to be study as more data become available.
It would be very interesting to deploy activity sensor at different nests, for which a wireless sensor network would be very convenient, permitting to scale up measurements to collect sufficient data to study correlation functions among them, in order to penetrate further in the details of the self organization mechanisms of the ant society.

Our work team

back at home



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Javier Fernández

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