Collaborative Processing in Sensor Networ

Lecture 1 - Introduction

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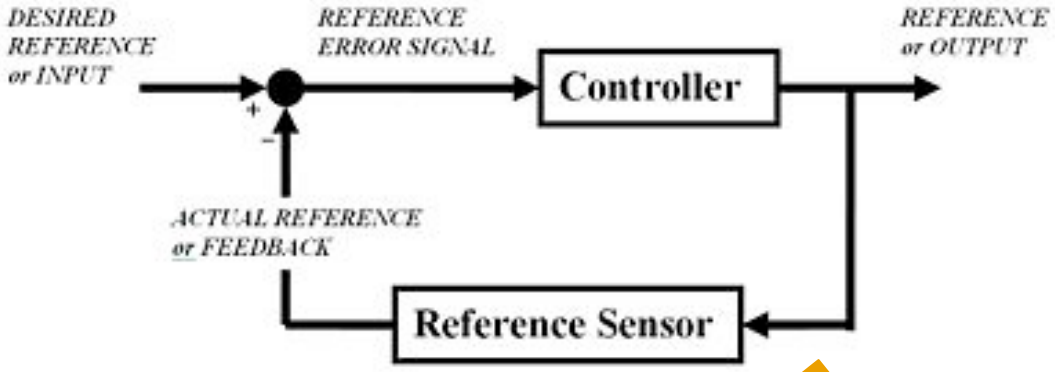
http://www.eecs.utk.edu
http://www.utk.edu

AICIP Research

- Advanced Imaging and Collaborative Information Processing (AICIP)
- Collaborative processing
  - DARPA, NSF, ONR



* Picture from http://en.wikipedia.org/wiki/Control_theory

- Advanced Imaging
  - Automatic target recognition and subpixe recognition using multi-hyper-spectral imaging
  - Medical imaging using infrared
  - US Army, ONR

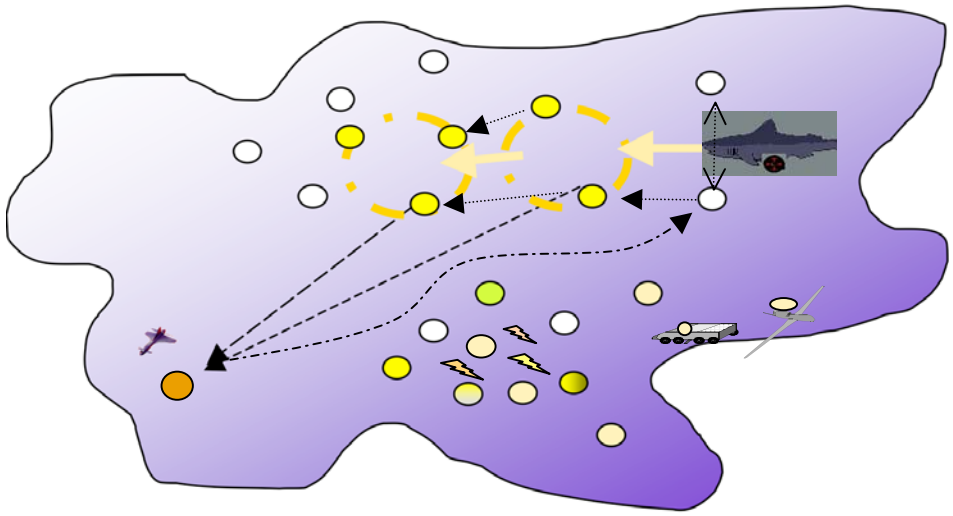
Collaborative Processing in Visual Sensor Networks

AICIP Research (Cont')

AICIP RESEAR

- Graduated 5 Ph.D. students and 16 M.S. students with thesis option
- Currently advising 6 Ph.D. students and 1 M.S. student
- Three sensor network testbeds
  - Motes, sensoria, and MSP
- Webpages
  - http://aicip.ece.utk.edu
  - http://panda.ece.utk.edu/wiki
  - http://panda.ece.utk.edu/wiki/CSIP-ZJU-08

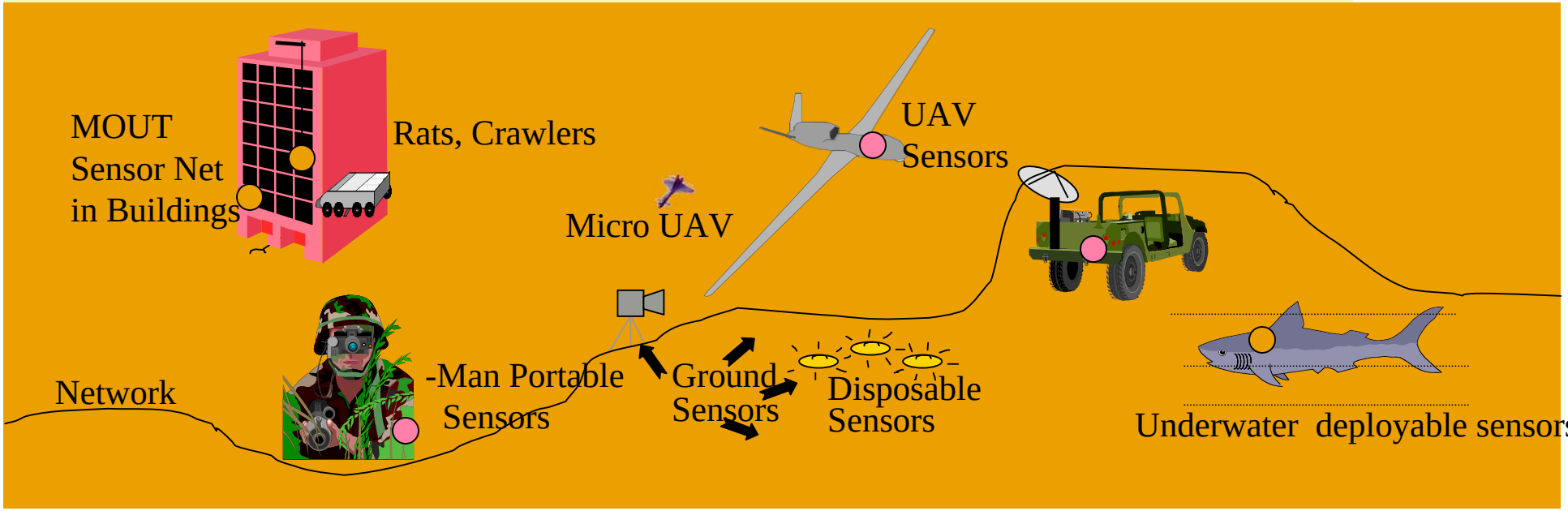
Internet vs. Sensornet



To be able to understand, monitor, and interact with the physical world (real world) in a timely, intelligent, and reliable fashion.

- Low cost
- Small size
- Power constraint
- Computational limited
- Bandwidth limited
- Certain degree of intelligence

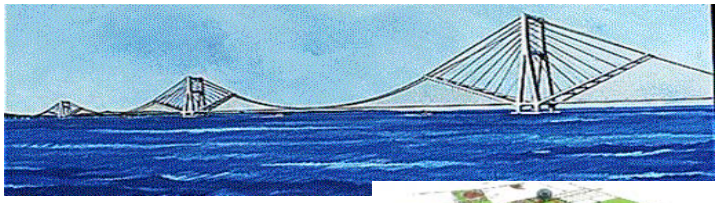
Untethered micro sensors will go anywhere and measure anything - traffic flow, water level, number of people walking by, temperature. This is developing into something like a nervous system for the earth, a skin for the earth. The world will evolve this way.
Horst Stormer
Lucent Technology, Inc.
21 Ideas for the 21st Cent. Business Week. 8/23-30, 1999



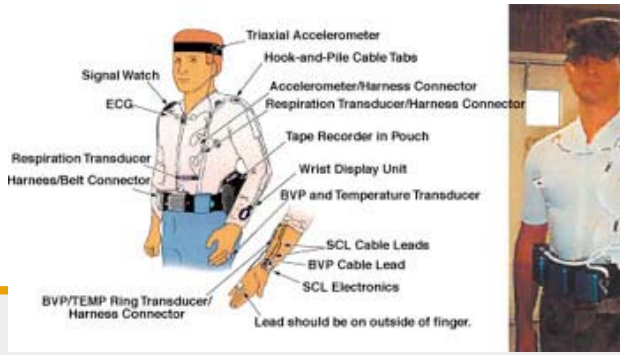
From S. Kumar SensIT 2000 PI Meeting Presentation

Application Examples

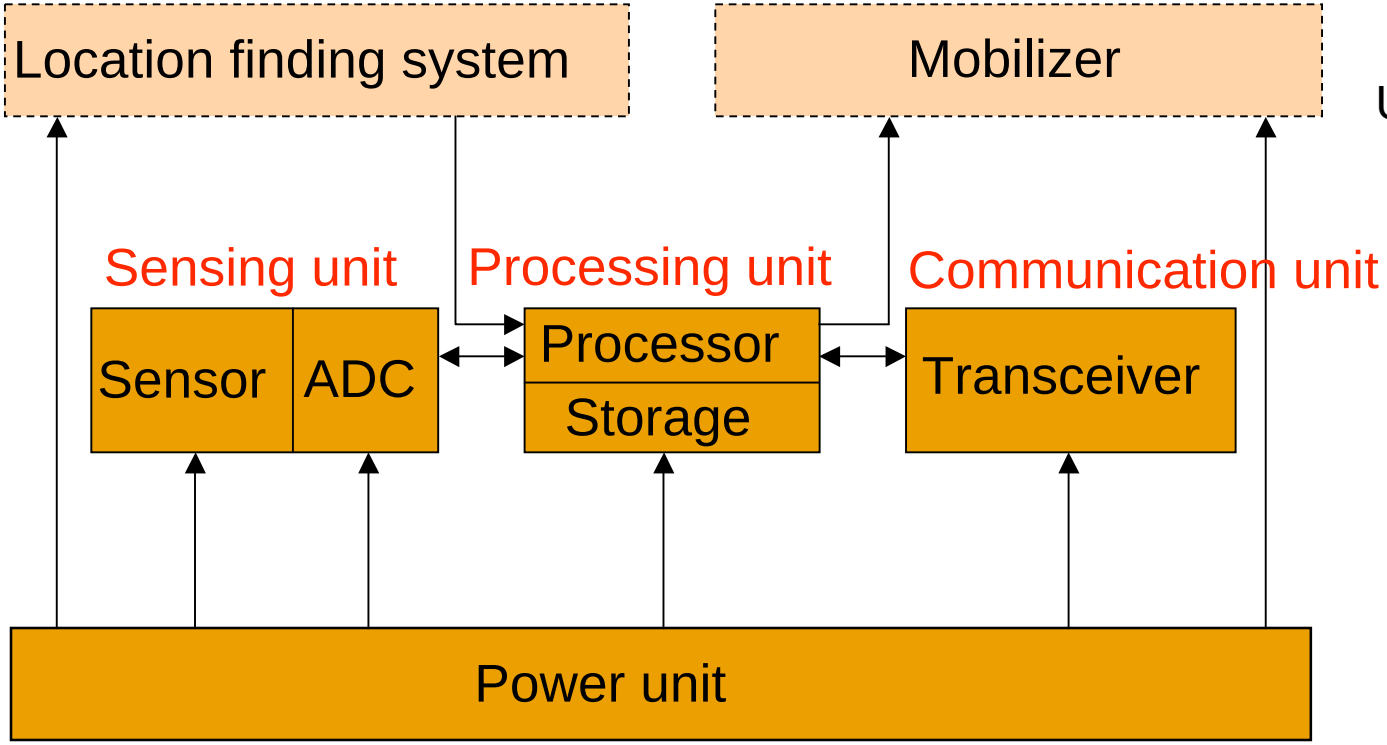
- Hubble telescope (every 5 to 10 ft)
- Structuring health monitoring (SHM)
  - Bridge
  - Space shuttle
- Environmental monitoring
  - Bio/chemical agent detection
- Biosensors for human health monitoring
- Remote surveillance
  - Battlefield
  - Hazardous area



NASA Tech Briefs, January 2



Sensor Node Architecture

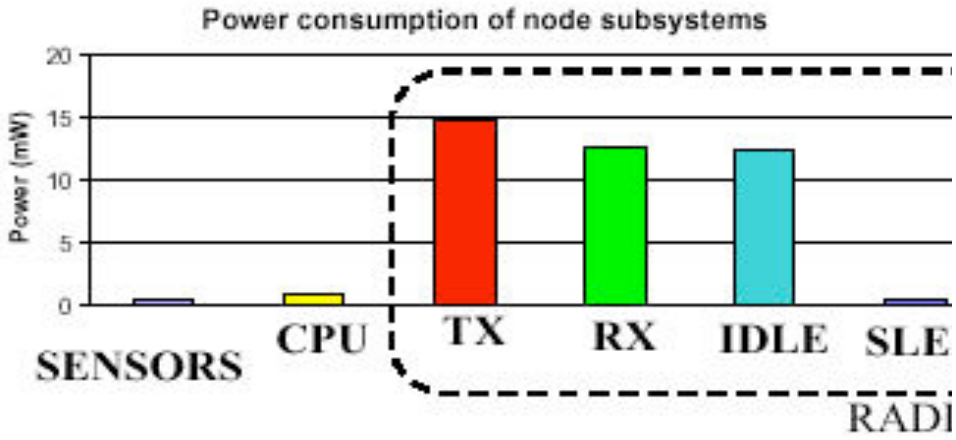


UCB mote (Crossbow

sGate sensor node (Sensoria)

Source of Power Consumption

- Processor
  - Three modes: Active, Idle, and Sleep
  - Active > Idle > Sleep
  - Transition between modes involves a power and latency overhead
- Transceiver
  - Four modes: Transmit, Receive, Idle, and Sleep
  - Transmit power can be controlled
  - Receive > Idle >> Sleep
  - Avoid unnecessary change of modes
- Sensing Unit
  - Signal sampling
  - A/D and D/A

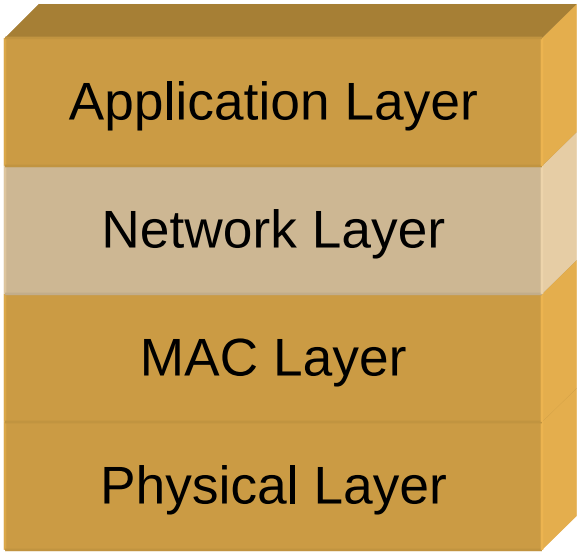


D. Estrin, A. Sayeed, M. Srivastava. Mobicom 2002 tutorial: Wireless sensor networks.

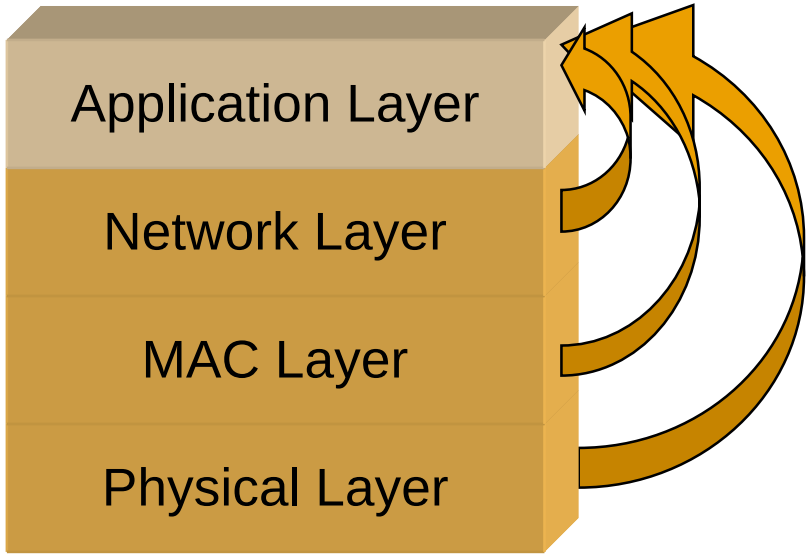
Uniqueness of Sensor Networks - Challenges

- Scale
- Dynamic environment
- Infrastructureless
- Limited individual capability
- Limited resource (energy, computation, communication bandwidth, etc.)
- Scalability
- Adaptivity
- Self-organization
- Reliability issue and Collaborative processing
- Energy efficiency, bandwidth efficiency, computation efficiency

Application-Oriented Design

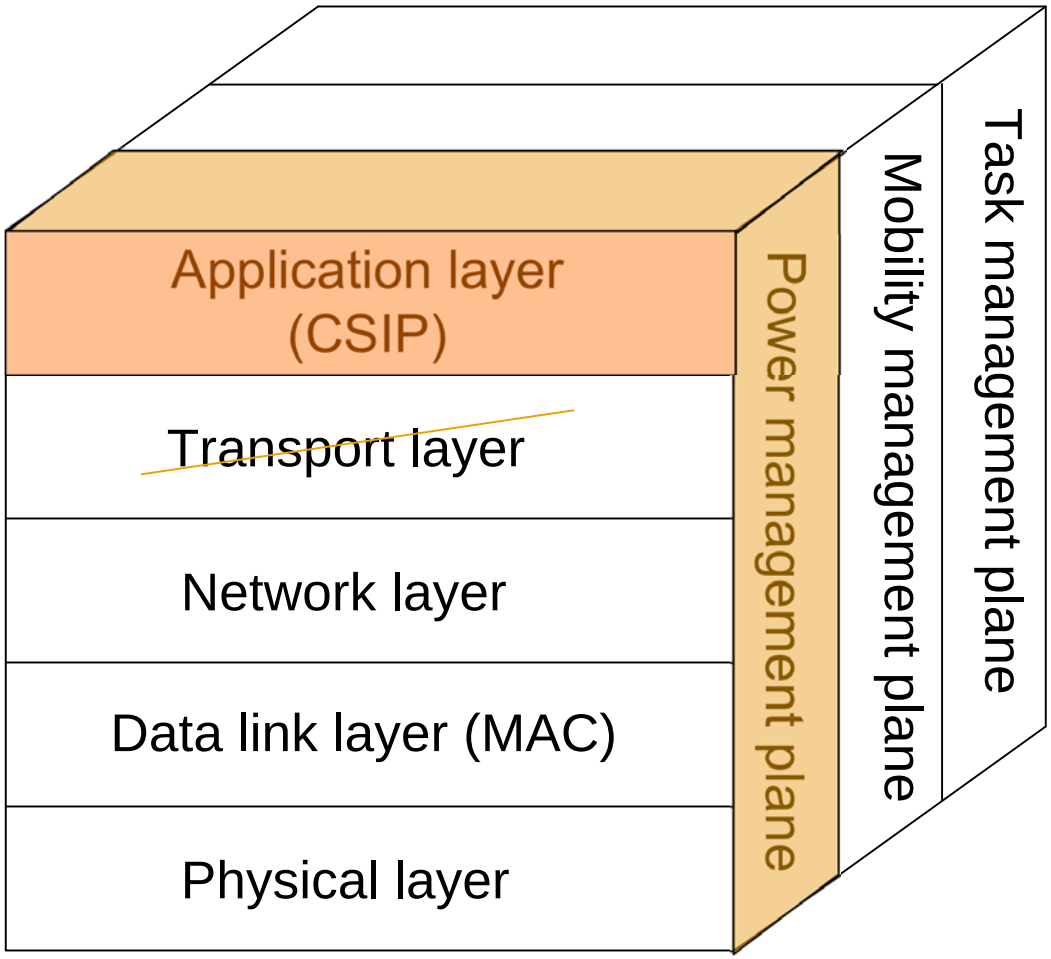


Traditional TCP/IP
Protocol Stack



Sensor Network
Protocol Stack

Sensor Network Protocol Stack

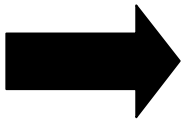


- Application-oriented
  - Task-adaptive
  - Mission-oriented
- Energy-efficient

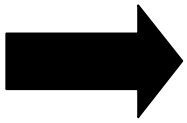
I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci. A survey on sensor networks. IEEE Communications Magazine, 40(8):102-114, August 2002.

Two Contradictory Requirements

- Energy-efficiency
  - Operating system
  - Communication
  - Routing
  - Computing
  - etc.
- Fault-tolerance
  - Robust response
  - compensation



Eliminate redundancy



Need redundancy

Collaborative Processing conce

- Lower-power communication ar computation
- Space-time processing
- Distributed and fault-tolerant algorithms
- Adaptive systen
- Sensor fusion
- Decision theory

Research Focus

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- Develop energy-efficient collaborative processing algorithms with fault tolerance in sensor networks
  - Where to perform collaboration?
    - Computing paradigms
  - Who should participate in the collaboration?
    - Reactive clustering protocols
    - Sensor selection protocols
  - How to conduct collaboration?
    - In-network processing
    - Self deployment

Syllabus

AICIP RESEAR

- Lecture 1: Introduction
- Lecture 2: Mobile-agent-based computing
- Lecture 3: Clustering protocols
- Lecture 4: In-network processing
- Lecture 5: Sensor deployment
- Lecture 6: Coverage problem
- Lecture 7: Sensor network security
- Lecture 8: Simulation and testbed

Collaborative vs. Distributive

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- Collaboration among neighbors
- Distributed processing

A Bit History

- 70s: Distributed sensor network program
- 1999: DARPA SensIT Program
- Two papers on MobiCom'99
  - D. Estrin, R. Govindan, J. Heidemann, S. Kumar, "Next century challenges: Scalable coordination in sensor networks," MobiCom'99. (USC/ISI)
  - J. Kahn, R. H. Katz, K. S. J. Pister, "Next century challenges: Mobile networking for "smart dust"," MobiCom'99. (Berkeley)

Programs

- SensIT (1999 - 2003) - Sensor Information Technology
  - DARPA
  - http://www.darpa.mil/ipto/programs/sensit/ (broken)
- NEST (2001 - 2005) - Networked Embedded Software Technology
  - DARPA
  - http://dtsn.darpa.mil/ixo/programdetail.asp?progid=65 (broken)
- Sensors (2003 - 2005) - Sensor and Sensor Networks
  - NSF
  - http://www.nsf.gov/pubs/2005/nsf05526/nsf05526.htm
- NeTS NOSS (2004 - 2007) - Networking Technology and Systems, Networking of Sensor Systems
  - NSF NeTS (2002 - present)
  - http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=12765&org=CNS
- SensorWeb
  - NASA/JPL
  - http://sensorweb.jpl.nasa.gov/
- SensorNet
  - DOE
  - http://www.sensornet.gov/
- ONR Surveillance
  - Sensing and Systems Division – Underwater Sensor Network
  - EO/IR Division – Swarm Mini-UAVs
- Sensor Fusion Testbed
  - NVL
  - Visual sensor network

Conferences

- Directly related to CSIP
  - IPSN
    - Debut: 2001
    - Due: Nov, Conf: Apr
    - http://ipsn.acm.org
  - DCOSS
    - Debut: 2005
    - Due: Feb, Conf: Jun
    - http://www.dcoss.org/
- Directly related to SN
  - SenSys
    - Debut: 2003
    - Due: Apr, Conf: Nov
    - http://sensys.acm.org
  - SECON
    - Debut: 2004
    - Due: Dec, Conf: Jun
    - http://www.ieee-secon.org/
  - MobiHoc
    - Debut: 2000
    - Due: Nov, Conf: May
    - http://www.sigmobile.org/mobihoc
  - MASS
    - Debut: 2003 (???)
    - http://www.cse.psu.edu/IEEEMASS

Journals

- ACM Transactions on Sensor Networks
  - http://tosn.acm.org/
  - Debut: August 2005
  - Publisher: ACM
- International Journal of Distributed Sensor Networks
  - http://www.informaworld.com/smpp/title~content=t714578688~link=cover
  - Debut: 2005
  - Publisher: Taylor & Francis
- International Journal of Sensor Networks
  - http://www.inderscience.com/browse/index.php?journalCODE=ijsnet
  - Debut: 2006
  - Publisher: Inderscience

Special Issues

AICIP RESEAR

- Proceedings of the IEEE, vol. 91, no. 8, August 2003
- IEEE Computer, August 2004
- IEEE Trans. on Mobile Computing, 3Q 2004
- Journal of Computer Communications, Fall 2004
- Journal of Distributed and Parallel Computing,
- JSAC
- IEEE Wireless Communications Magazine, August 2004
- International Journal of Computers and Applications, Jan 2005

Books

- S. Phoha, T. F. LaPorta, *Sensor Network Operations*, Wiley-IEEE Press, 2005
- R. Brooks, S. S. Iyengar, *Frontiers in Distributed Sensor Networks*, CRC Press, 2004
- F. Zhao, L. Guibas, *Wireless Sensor Network*, Morgan Kaufmann, 2004.

Research Groups

AICIP RESEAR

- CENS
  - http://research.cens.ucla.edu/
- Berkeley WEBS
  - http://local.cs.berkeley.edu/webs/

Industry Players

- Wireless Industry Network Alliance
  - http://www.wina.org/
- Microsoft Research
  - http://research.microsoft.com/nec/
- Intel Research
  - http://www.intel.com/research/exploratory/wireless_sensors.htm
- Ember
  - http://www.ember.com
- Dust Networks
  - http://www.dustnetworks.com/index.shtml
- Crossbow and TinyOS
  - http://www.crossbow.com
  - http://www.tinyos.net

AICIP
RESEAR

What is the future of sensor networks?