

# Wireless Multimedia Sensor Networks: Challenges and Opportunities

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- **Collaborative Multimedia (Multi-modal)  
Sensing is the way to go!**
- **Pervasive Computing and Social  
Informatics is the future!**

# Sensing the Physical World

## Monitoring CReW



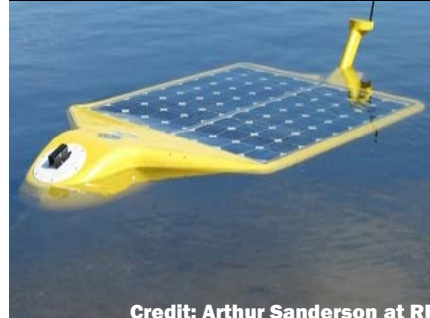
Smart Infrastructures



Credit: MO Dept. of Transportation



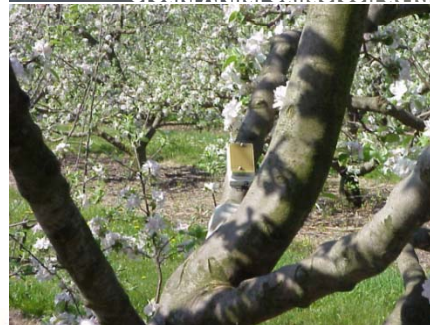
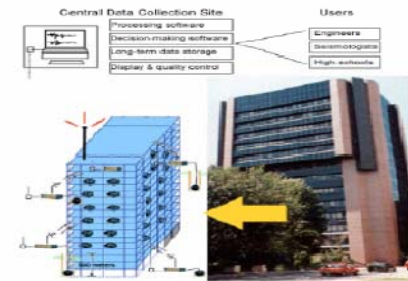
- Environment
- Habitat
- Ecosystem
- Agriculture
- Bldg Structure
- Health
- Border



Credit: Arthur Sanderson at RPI



Seismic Structure Response

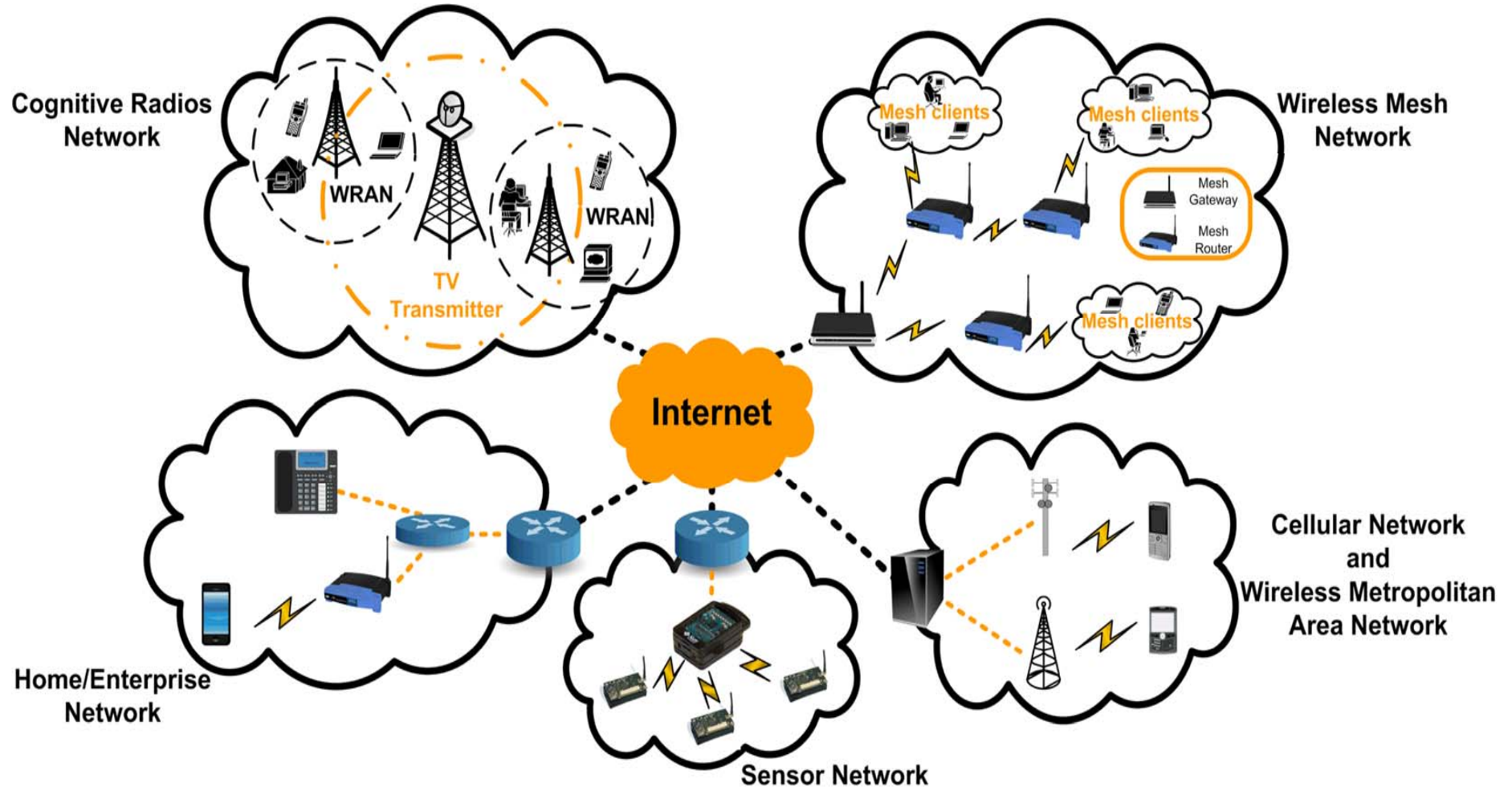


Ecosystems  
Biocomplexity

We live in a physical world, which we need to understand, serve, and control

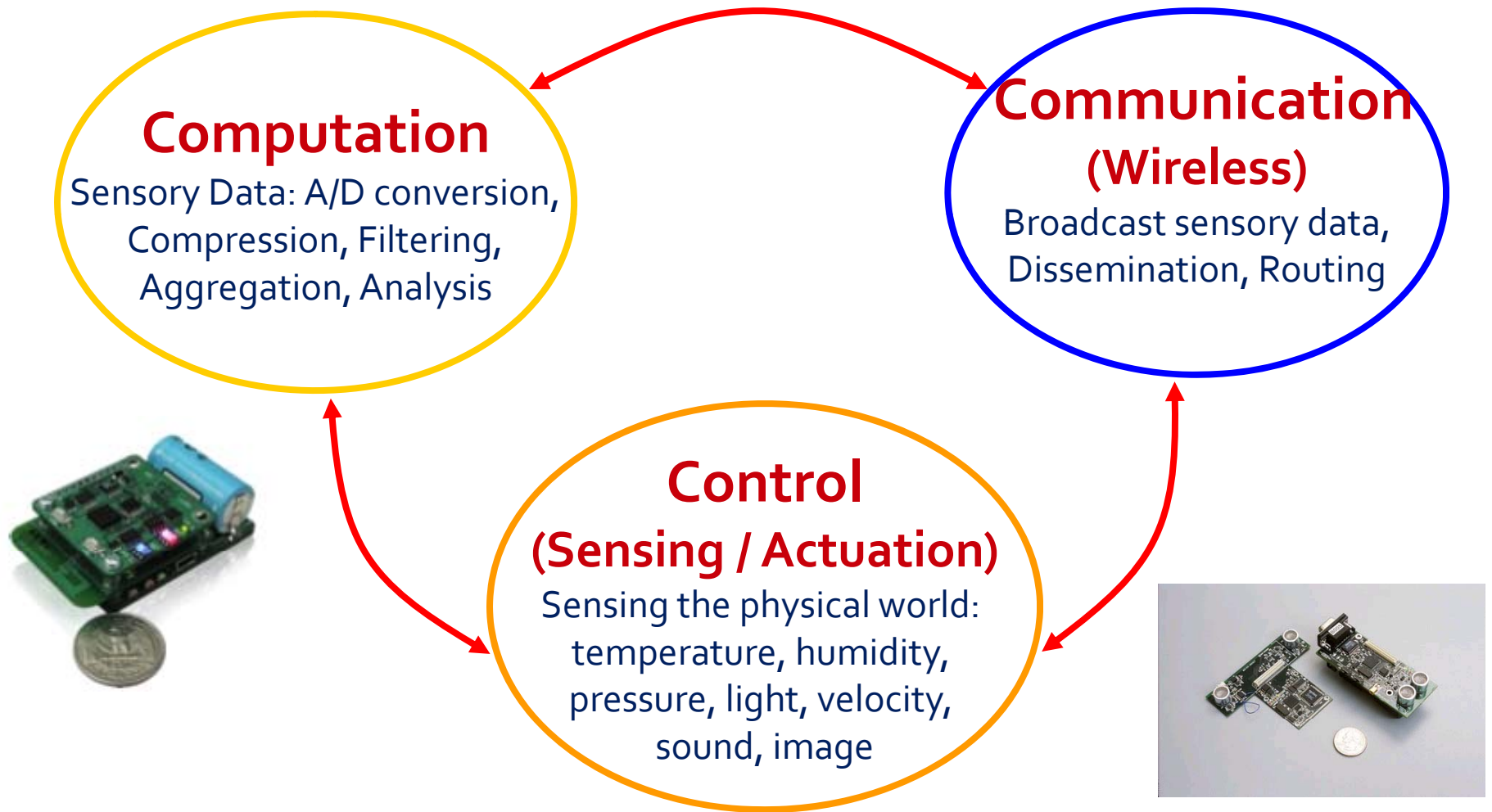
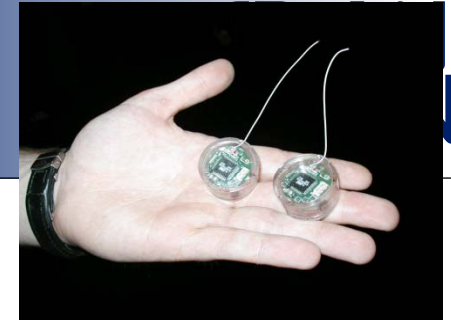


# Next Generation Wireless Networks



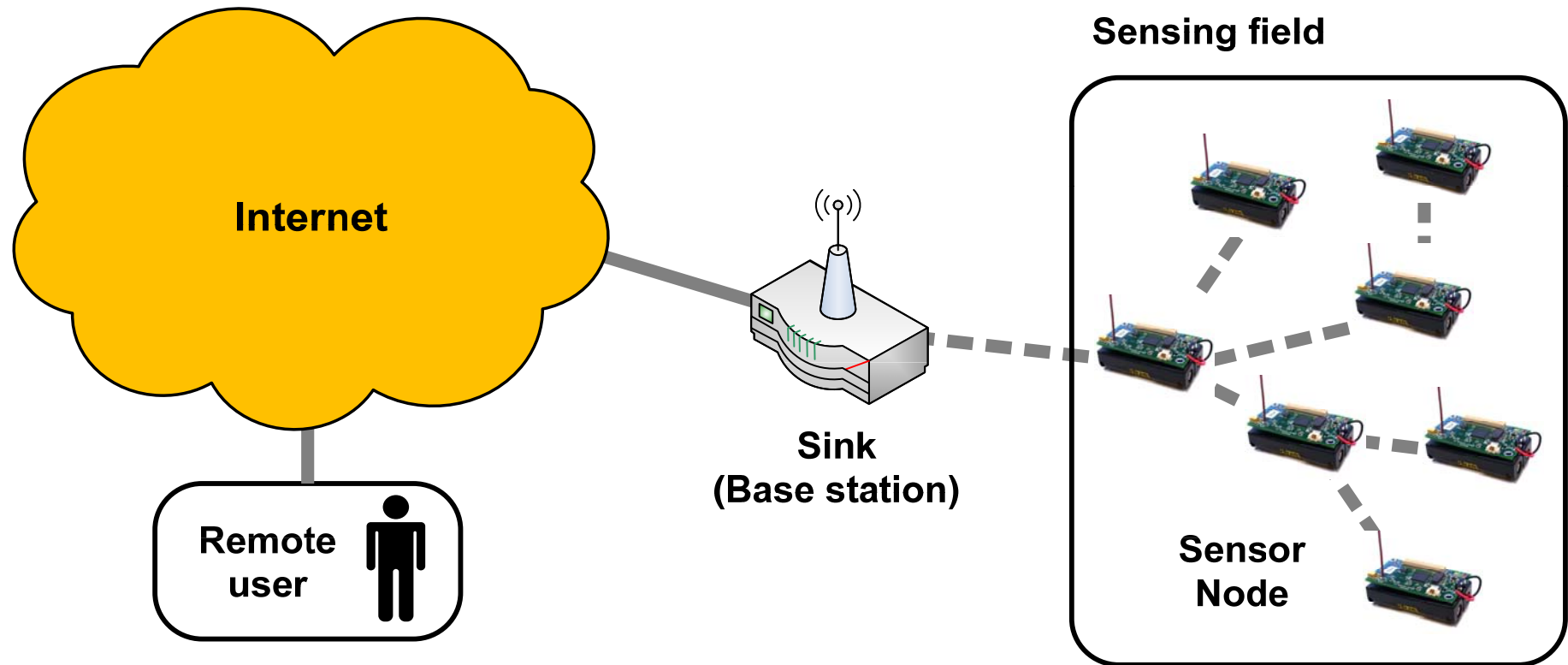
**Opportunistic Clouds of Multi-modal Wireless Access Devices, Heterogeneous Access Networks, Services and Applications**

# Wireless Sensor Networks (WSN)



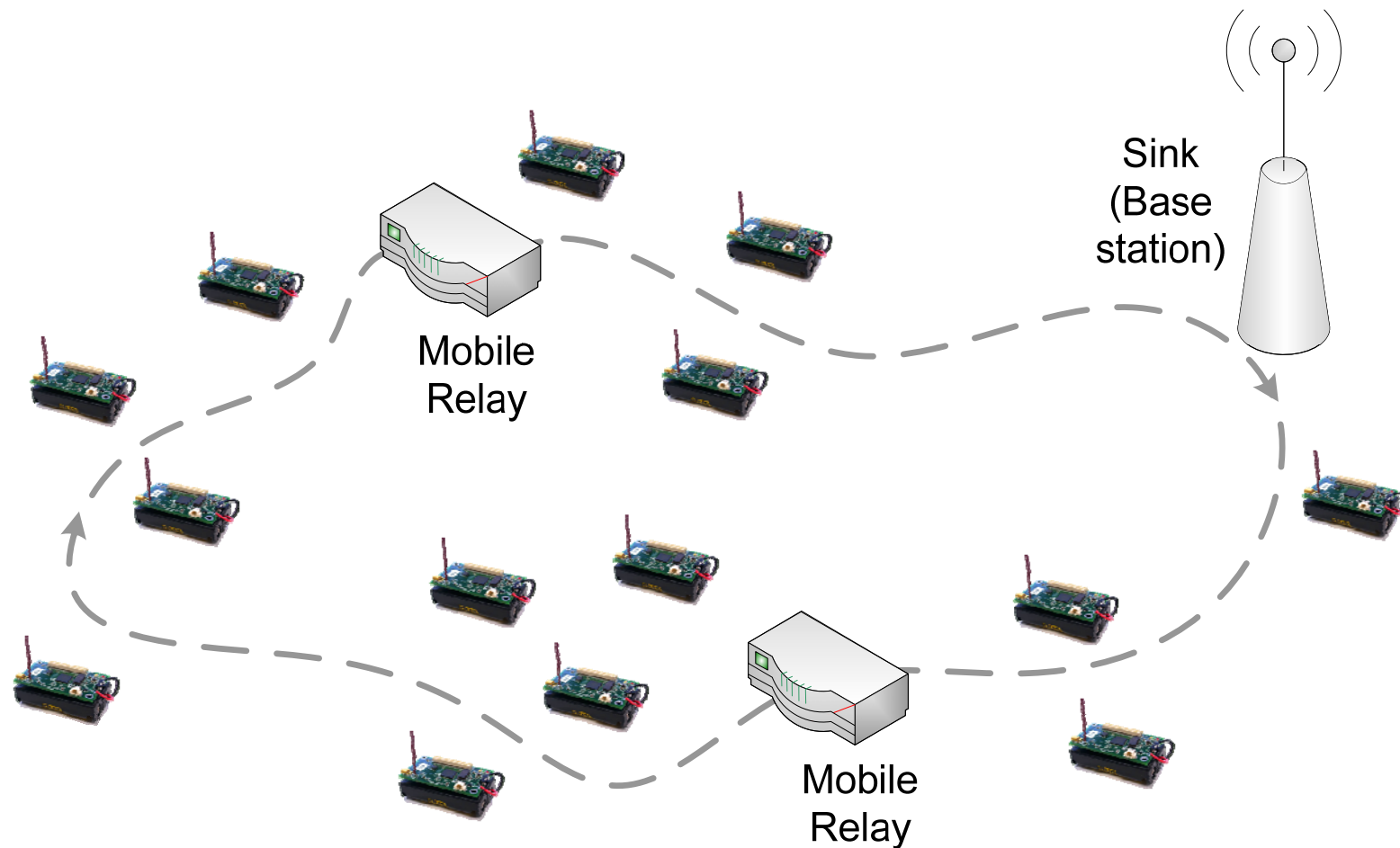
# Static WSNs

Traditional WSN architecture



# Mobile WSNs

## WSNs with mobile relays



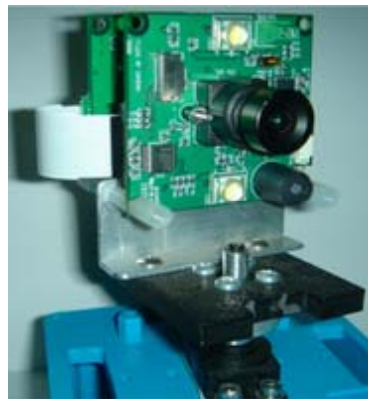
M. Di Francesco, S. K. Das, G. Anastasi, "Wireless Sensor Networks with Mobile Elements: A Survey," *ACM Transactions on Sensor Networks*, Vol. 8, No. 1, Aug. 2011.

# Emerging Trends in Sensors

## Multimedia WSNs



- Multimedia sensors (with image, audio/video streaming)
  - **Application-specific** devices
    - ⇒ Surveillance cameras, stereo-cameras
  - **Multimedia sensing** platforms
    - ⇒ Off-the-shelf products
    - ⇒ Custom platforms



Y. Liu and S. K. Das, "Information Intensive Wireless Sensor Networks: Potential and Challenges," *IEEE Communications*, Vol. 44, No. 11, pp. 142-147, Nov. 2006.



# Emerging Trends in Sensing Applications



## Smartphones and participatory sensing

### ■ Smartphones as sensing platforms

- Abundance of sensors

- ⇒ Acceleration, location, sound, video, orientation

- Rich in processing and storage resources

- ⇒ Enabling computational-intensive applications

- Several wireless technologies

- ⇒ WiFi, Bluetooth, long range cellular radio



### ■ Participatory, persuasive, social sensing applications

- Users involved in sensing campaigns

- ⇒ Traffic/accident monitoring, well being, pollution control

- ⇒ Incentives for participation

# Multimedia and Heterogeneous WSNs

## Putting everything together



- A wide variety of sensing devices
- Each device best suited for a specific task
- Exploit **heterogeneity** for **collaborative sensing**



# Advantages of Collaborative Sensing



## Energy conservation and sensing accuracy

- **Multi-scale** and **triggered** sensing
  - Low-power low-accuracy sensor can be used
  - Higher accuracy (power-hungry) sensors can be exploited only when necessary
    - ⇒ Tradeoff between accuracy and energy consumption
- Different **sensing modalities**
  - Better characterization of the environment
    - ⇒ Data fusion
  - Higher efficiency
    - ⇒ Less bandwidth and energy usage

J. Wang, Y. Liu, and S. K. Das, "Energy Efficient Data Gathering in Wireless Sensor Networks with Asynchronous Sampling," *ACM Transactions on Sensor Networks*, Vol. 6, No. 3, May 2010.

# Premise: Sensors Everywhere

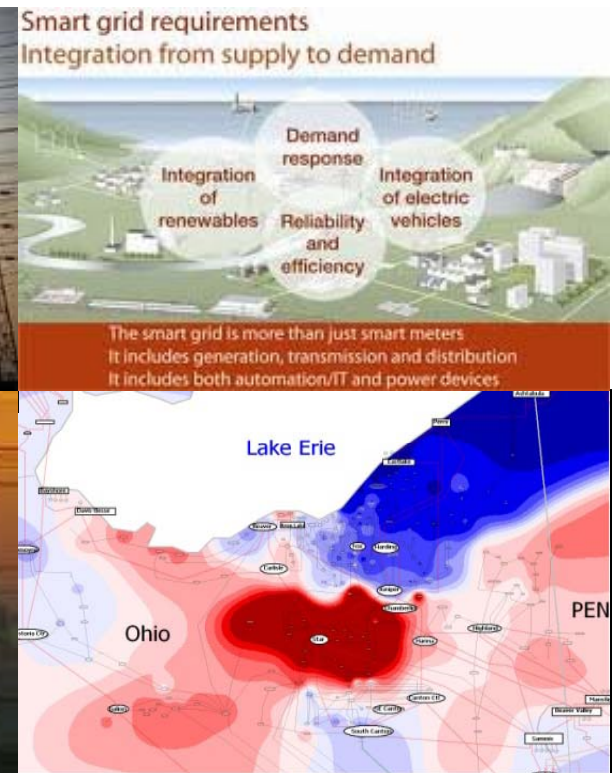
- Ultra light, ultra power, embeddable wireless devices networked everywhere (*Internet of things*)
- Sensors will be all pervasive, from clothing to coffee mugs to building structures
- Wireless and ubiquitous connectivity taken for granted
- Cognitive networks based overlay architectures
- Content rich (multi-modal) sensor applications
- Information deluge (e.g., recording every event in life)

- **Societal Grand Challenges (National & Global)**
  - Security and Safety (before, during and after events)
  - Healthcare (health risks, wellbeing and care)
  - Energy & Sustainability (monitoring and mitigation)
  - Extreme Events Management (disasters, forest-fires, ...)
  
- **Citizen Science**
  - Smart phones w/ burgeoning capabilities and sensors
  - Deep penetration of mobile devices and networking
  
- **How to handle pervasive computing at scale?**



# Energy and Sustainability

- Smart appliances, buildings, power grid
  - Net-zero energy buildings
  - Minimize peak system usage
  - No cascading failures
  - Climate control



# Smart Health Care

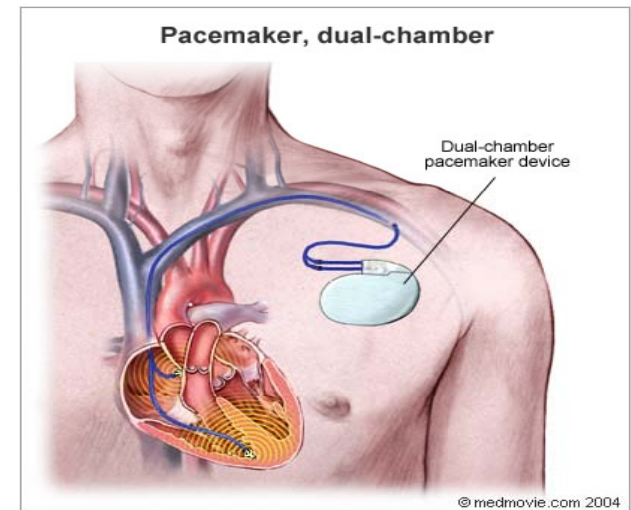


Infusion pump

- ⇒ Patient records at every point of care
- ⇒ 24/7 monitoring and treatment
- ⇒ Assisted Technology for everyone
- ⇒ Smart prosthetics



Operating room  
of future



Embedded medical  
devices

## ElderCare



*Handbook on*  
**Securing Cyber-Physical Critical Infrastructure**



**Foundations and Challenges**

**Sajal Das, Krishna Kant, Nan Zhang**



# Wireless Multimedia Sensor Networks: New Challenges



- How to handle higher data rates (video/audio streaming)?
  - Innovative energy-saving architectures, algorithms, and protocols
- How to exploit higher spatio-temporal data correlation?
  - In-network: Fusion, estimation, detection, filtering, gathering, ...
- How to provide higher information assurance?
  - Accuracy, reliability, fault-tolerance, resiliency, security, robustness, ...
- How to deal with emerging security and privacy threats?
  - Virus spreading, e.g., *Cabir* for wireless cell phone networks

- **How to deal with (or tame) inherent Uncertainty?**
  - ⇒ sensing, wireless communications, mobility, topology control, coverage, routing, bandwidth and battery power, ...
  - ⇒ distributed collaboration and coordination, aggregation (fusion), processing, decision making, duty cycling, ...
- **Context Resolution and Situation-Awareness**
  - ⇒ How to unambiguously capture contexts from multi-modal sources despite noisy and incomplete information?
- **Supporting QoS and QoI (quality of information)**
  - ⇒ How to improve information accuracy, reliability, latency?  
How to measure sensing quality in presence of uncertainty?



# Socio-Pervasive World

## Environment Sensing / Smart Environments

Agent Reasoning

Percepts (sensors)

Actions (controllers)

**Pervasive Computing**

## Disaster / Emergency Response

Situation Awareness: Humans as sensors feed multi-modal data streams

**Social Informatics**

## People-Centric Sensing

Personal Sensing

Public Sensing

Social Sensing

**Social Informatics**

## Smart Health Care

Temperature, light, microphone

ECG

Blood pressure

SpO<sub>2</sub>, GSR

Accelerometer

Evaluate, Sense, Intervene, Identify, Assess

**Smart Health Care**

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