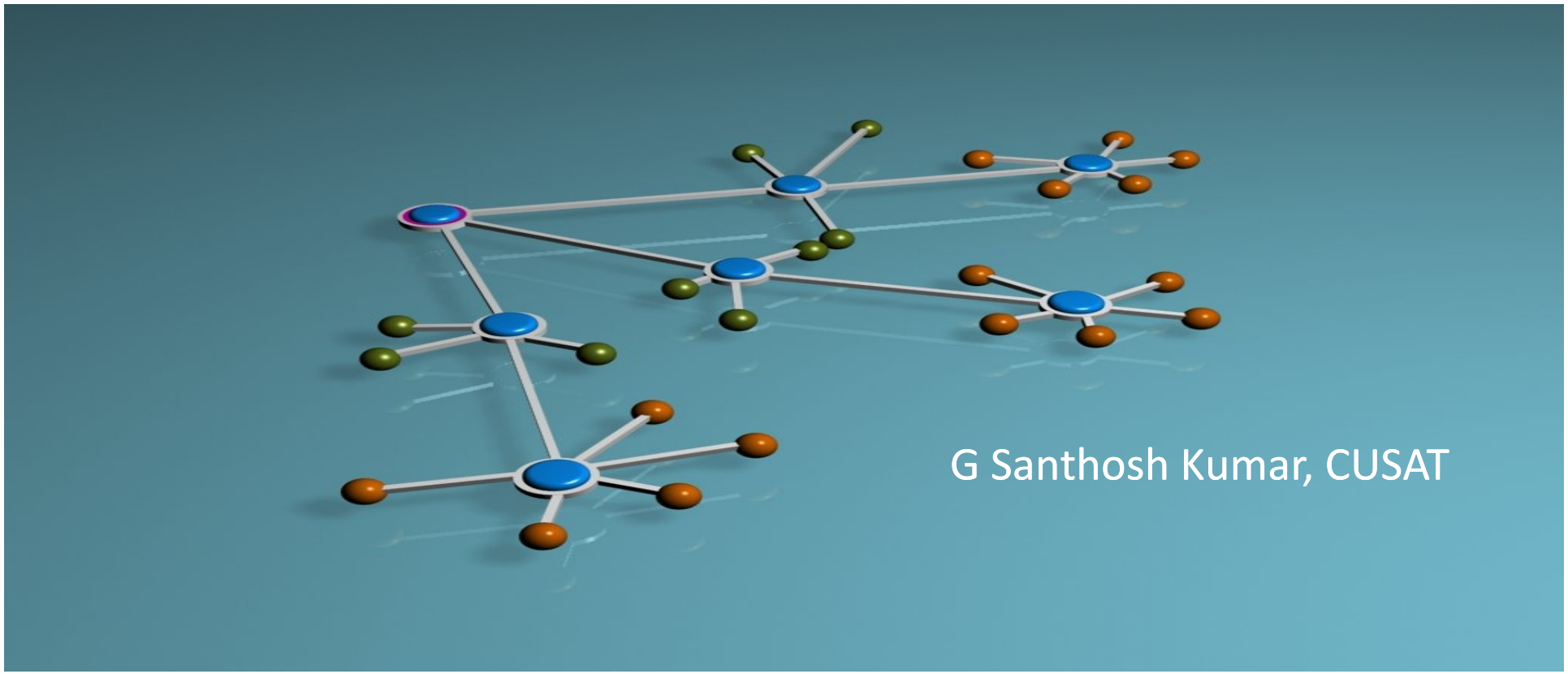
The World of Sensor Networks



G Santhosh Kumar, CUSAT

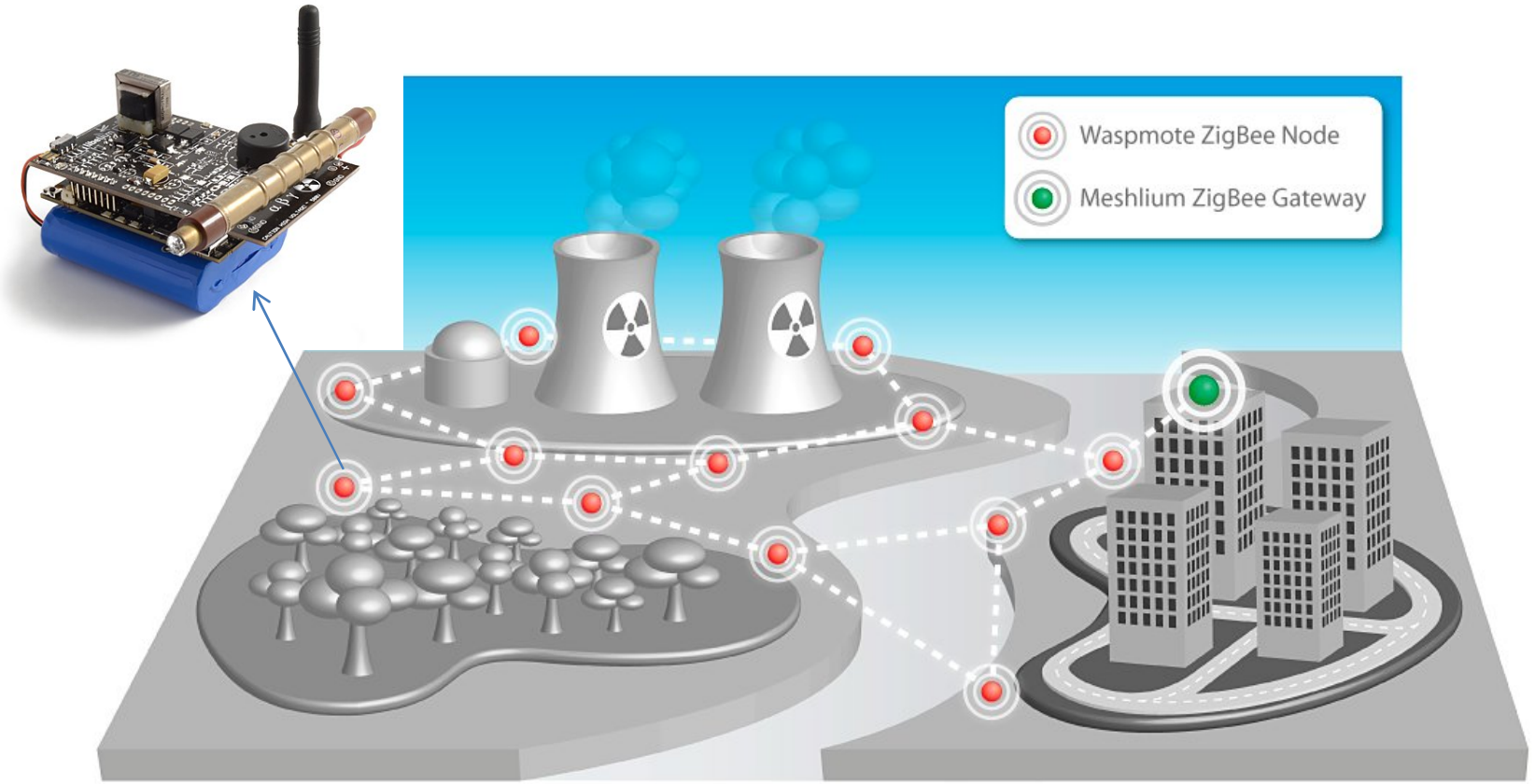
Are you as quick as Messi or Bale?

WSN adidas innovation (source: http://www.wsnblog.com/)

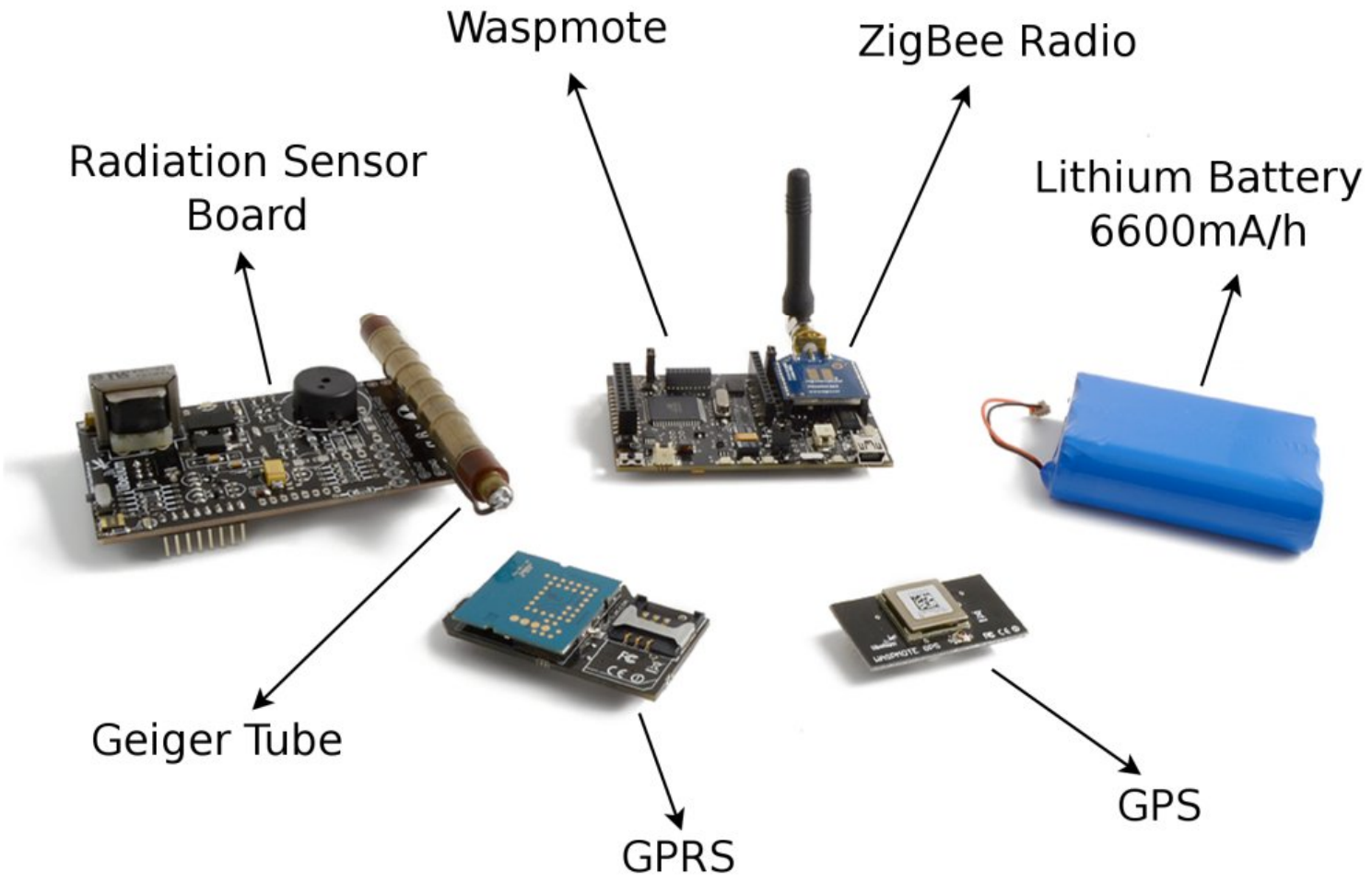
Fukushima nuclear disaster

- **Fukushima Rescue Workers Facing Depression and Death**
- How to measure the levels of radiation of the affected zones without compromising the life of the workers?
- Radiation measurements in real-time

Fukushima nuclear disaster



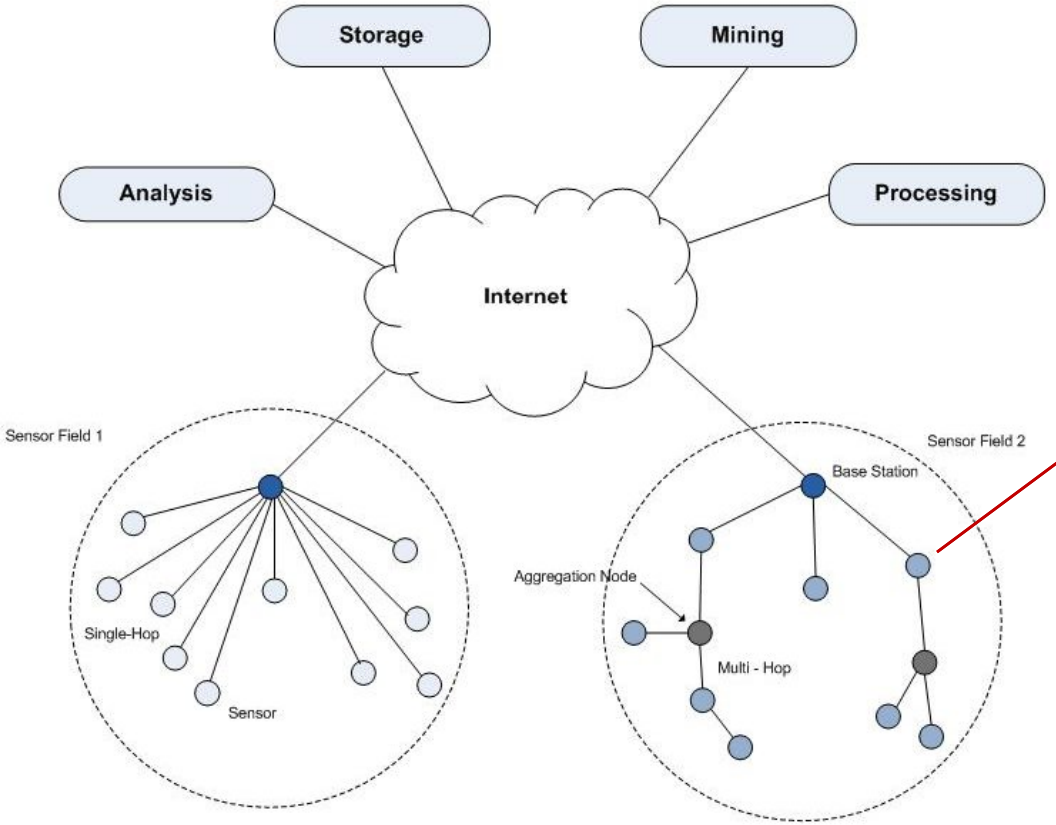
Fukushima nuclear disaster

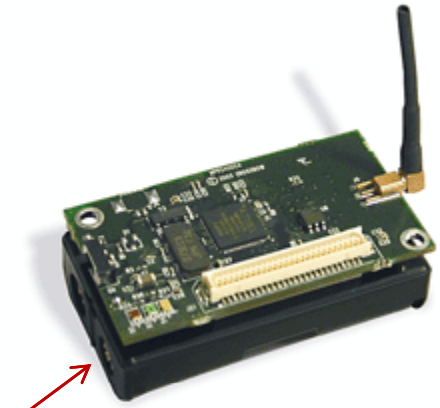


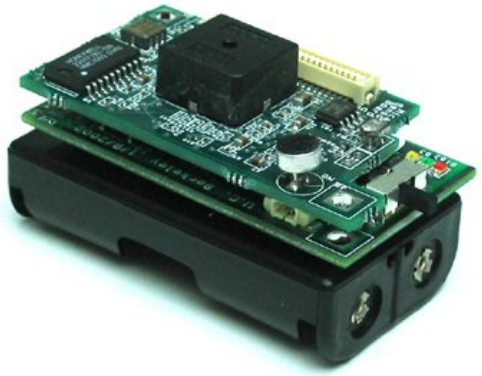
Goals

- Give an understanding of what wireless sensor networks are good for and what their intended application areas are
- Give an idea of what their limitations and current status are
- Glimpse of a sensor classification
- Future developments

What is a Wireless Sensor Network?

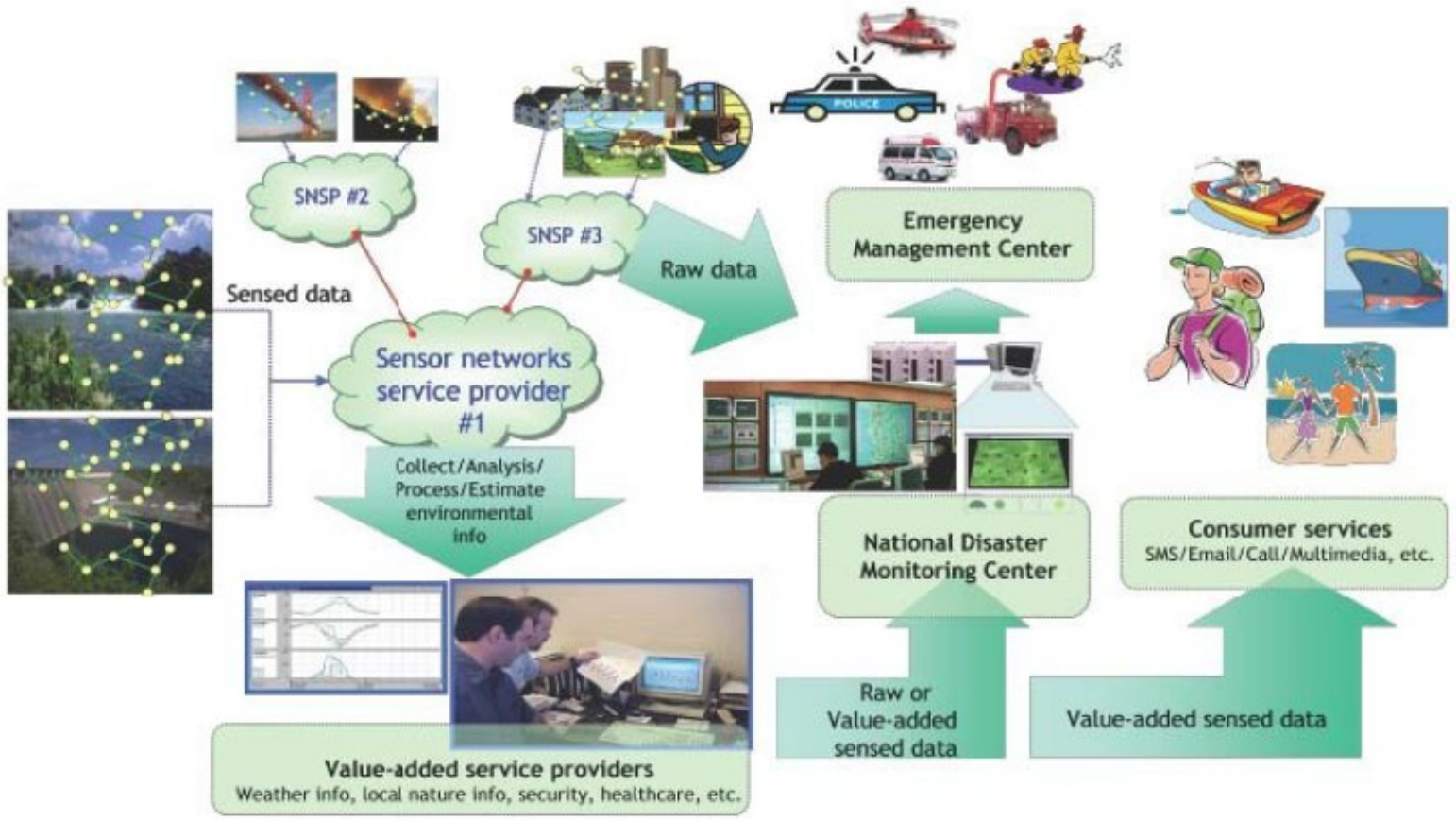




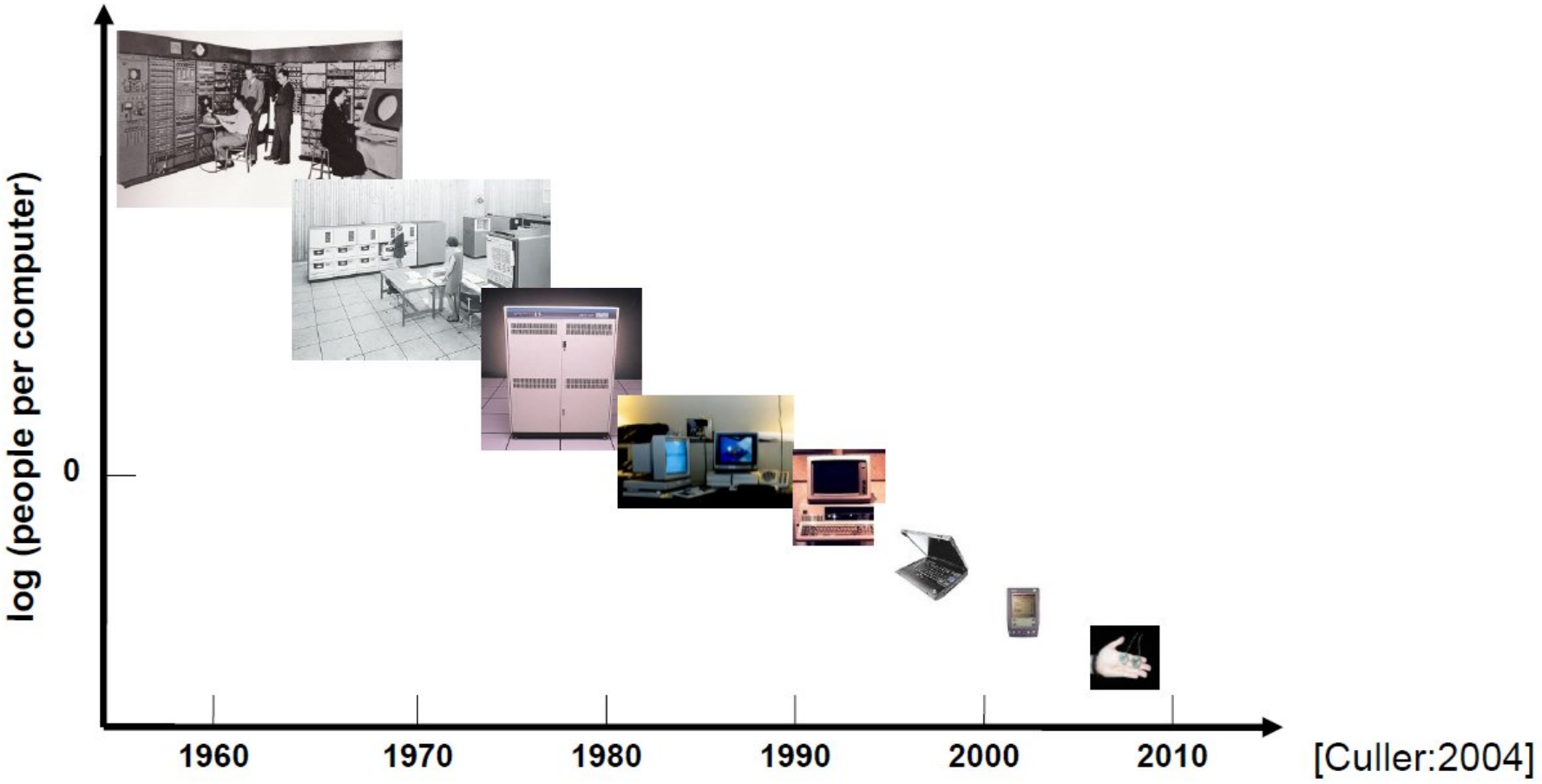


Sensing + Computing + Communicating = Sensor Network (MEMS)

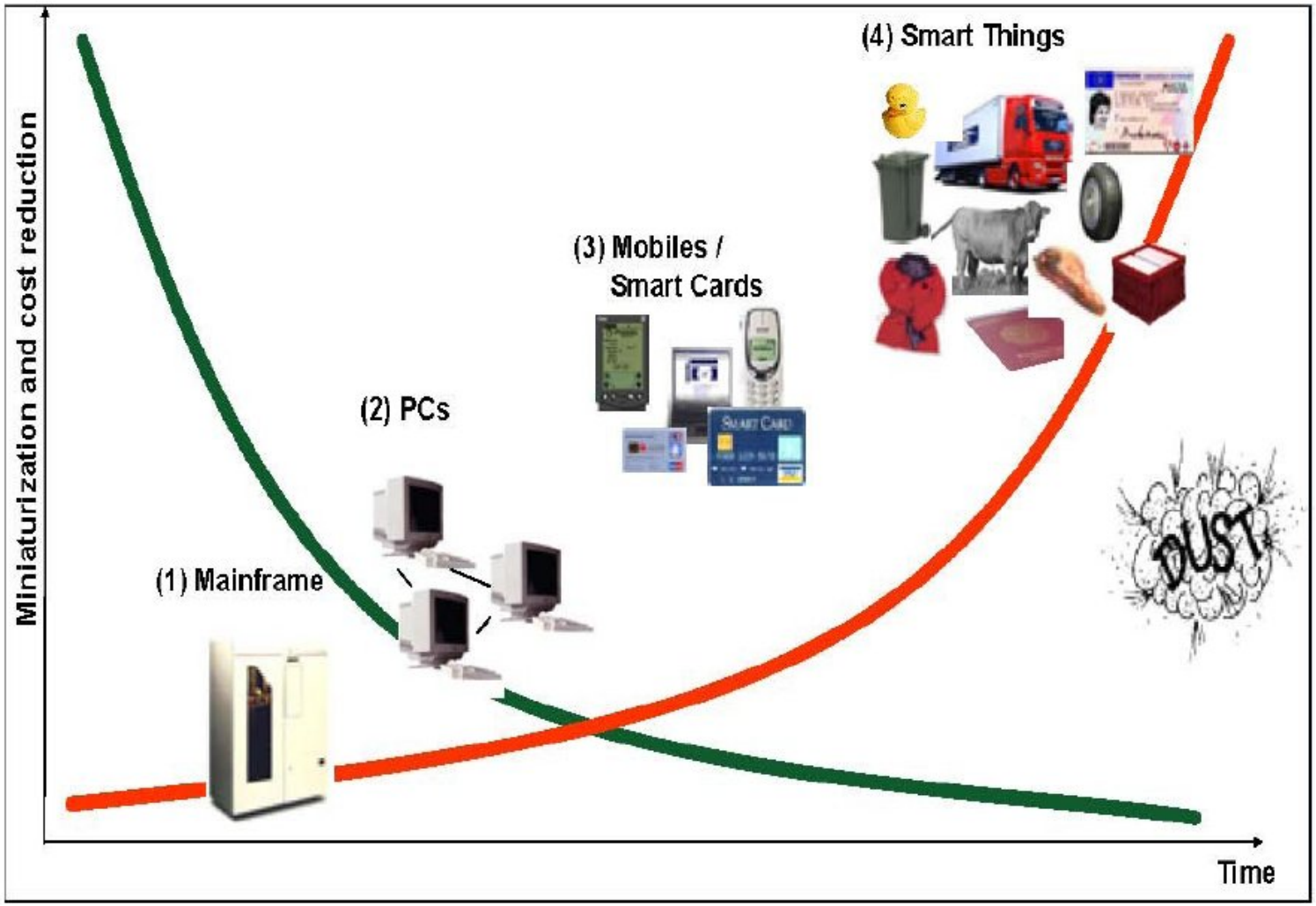
Embed, Network and Serve



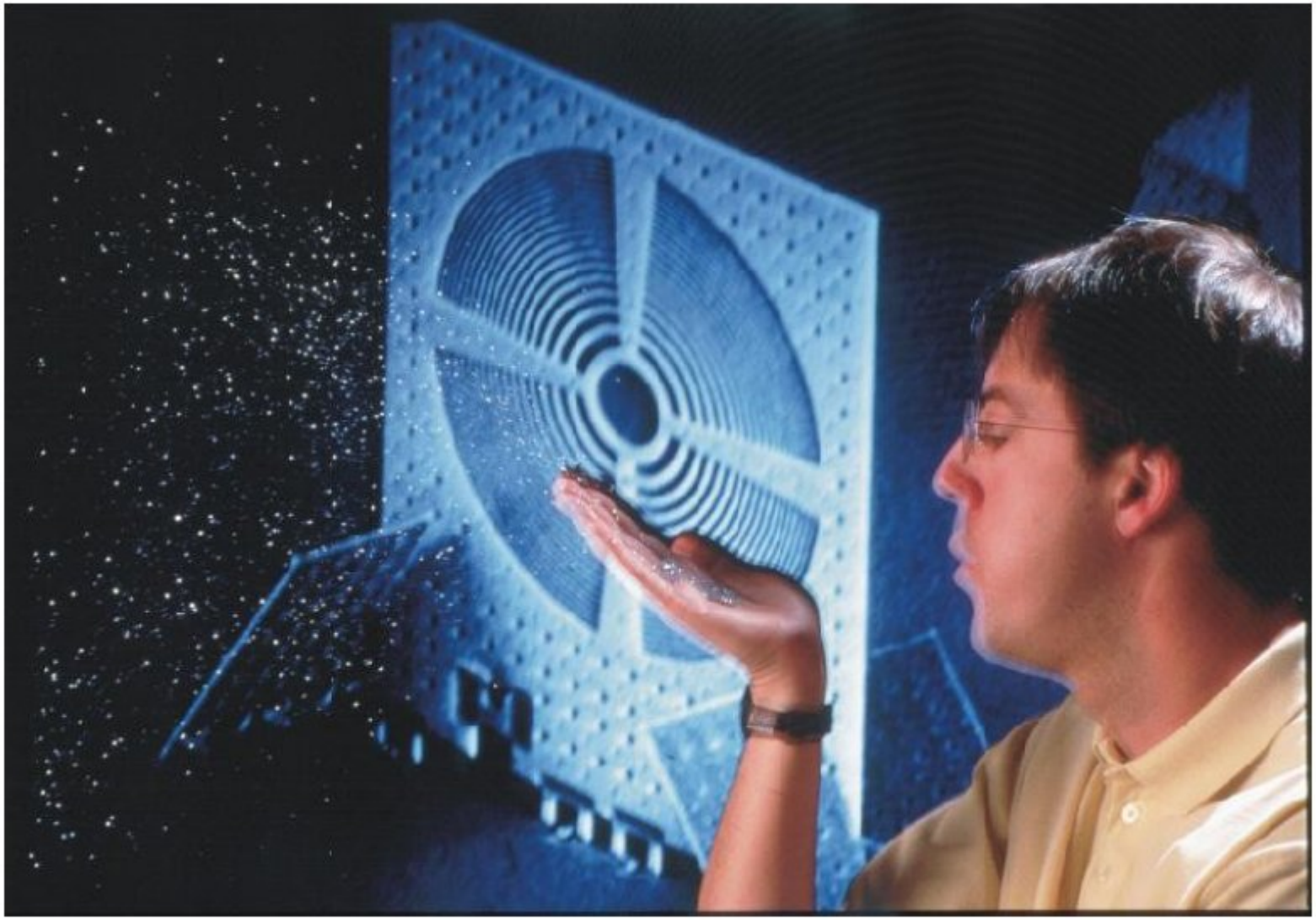
How did we get there?



Miniaturization and cost reduction

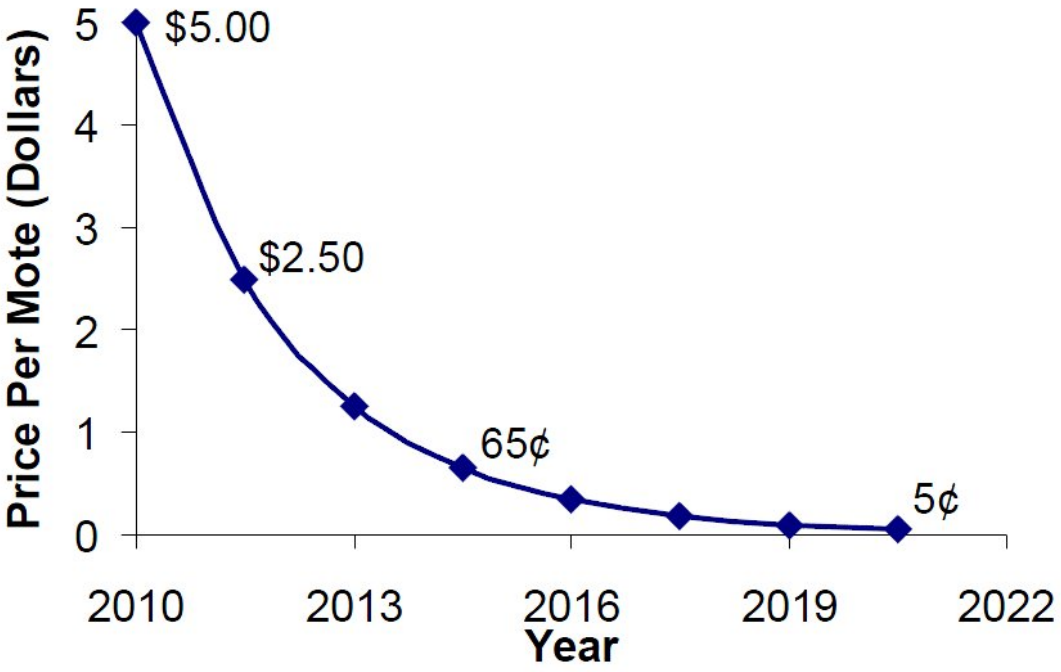


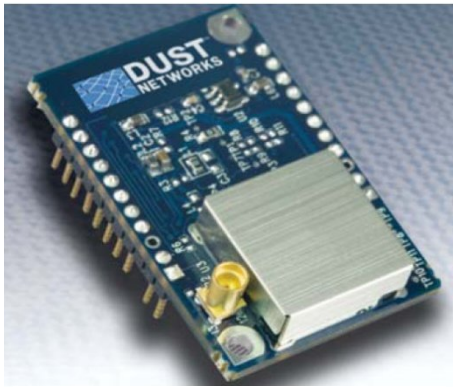
Smart Dust

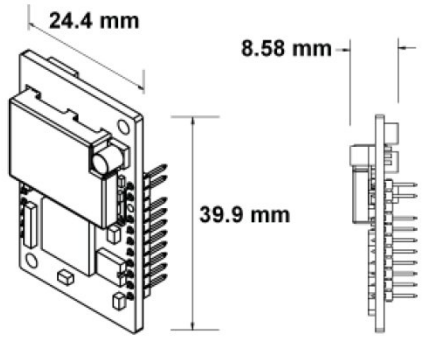


Smart Dust

"Researchers at Intel expect that, with re-engineering, Moore's Law and volume production, motes could drop in price to less than $5 each over the next several years" (Intel 2005).







Source: "Smart Dust": Univ. Houston ISRC Technology Briefing

Wireless Sensor Network

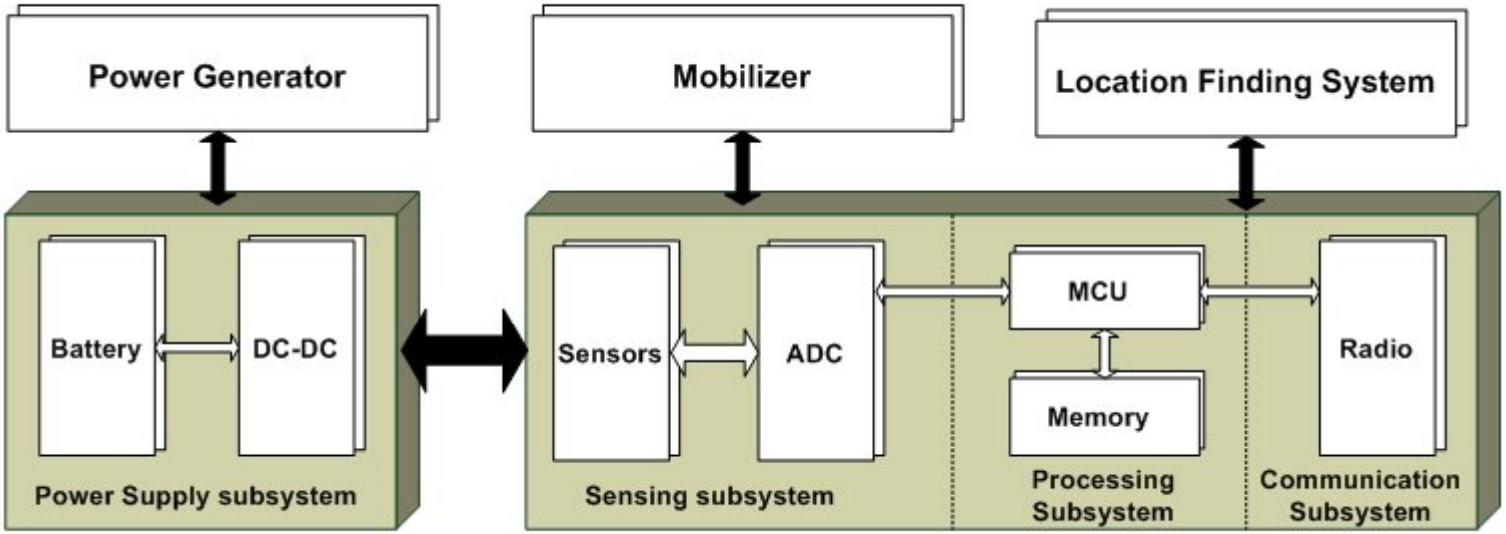
- A **wireless sensor network** (WSN) is a wireless network using sensors to cooperatively monitor physical or environmental conditions.
- The development of wireless sensor networks was originally motivated by military applications.
- Wireless sensor networks are now used in many wide-range application areas.

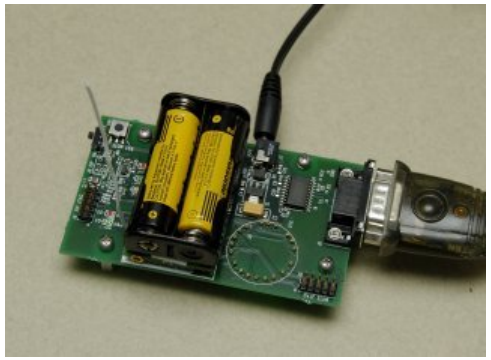
Main Players

The main players into a WSN environment include

- Sensor nodes also referred to as “motes”
- Sink nodes also referred to as “base stations”
- “Actuators” used to control the environment, and
- “Gateways” often connected to sink nodes.

Components of a Mote





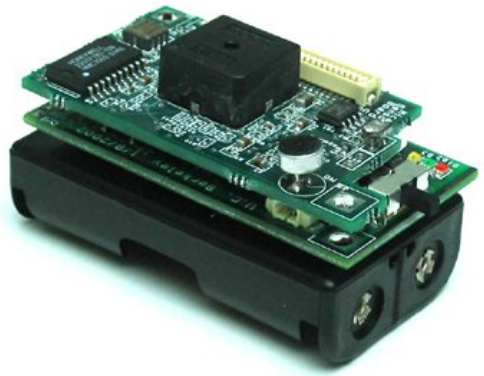
Mica2 dot

MTS420

Mica2 Mote

Characteristics

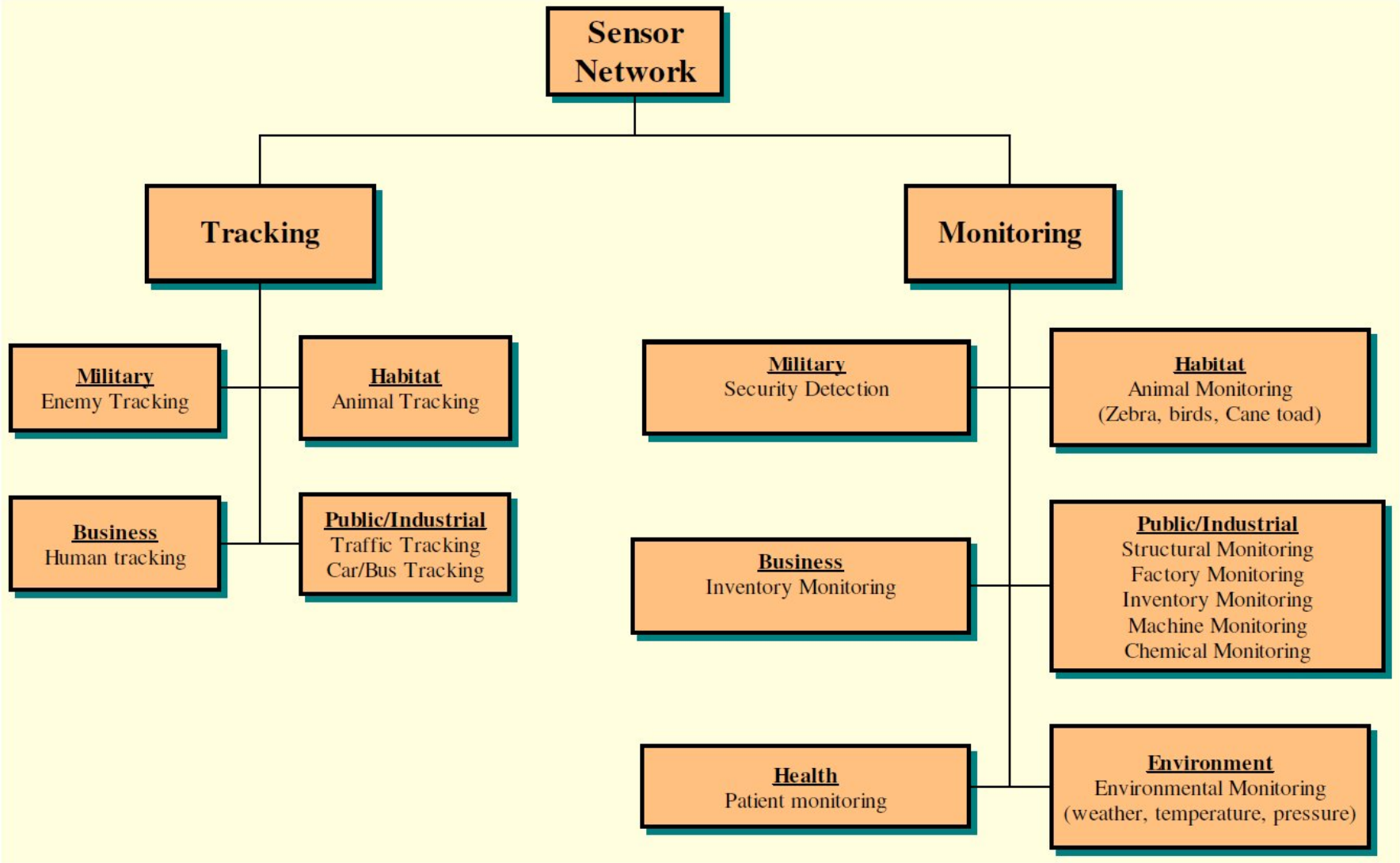
- No infrastructure
- Untethered operation
- Typically deployed large in number (few 10s to 1000)
- limited computation power, memory, range, energy supply
- Self-organizing
- Structured / Unstructured
- Dynamic topology



Type of Sensor Networks

- terrestrial WSN (deployed on land)
- underground WSN (caves, mines, underground)
- underwater WSN (ocean environment)
- multi-media WSN (video, audio, and images)
- mobile WSN (ability to move)

WSN applications



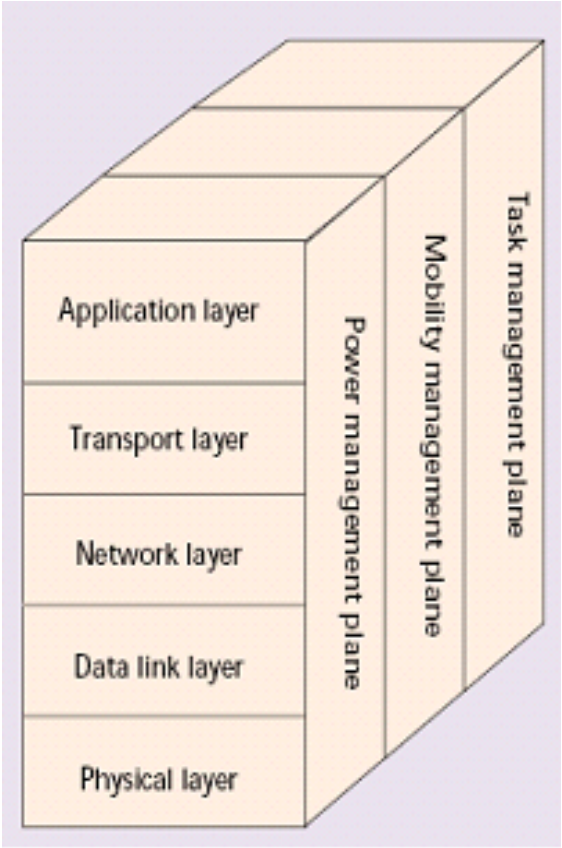
Source: WSN Survey, Computer Networks 52 (2008) 2292–2330

Protocol Stack

OpenWSN
Implementing the Internet of Things

application	openADR, HTTP, Sensor.network
transport	TCP, UDP
IP/routing	IETF RPL
adaptation	IETF 6LoWPAN
medium access	IEEE 802.15.4e
phy	IEEE 802.15.4-2006

openADR – open Automation of Demand Response
Sensor.network - sensor data storing service (SUN)
many databases, RESTful API,
Google Visualization API
RPL – Multi-hop Routing protocol
6LoWPAN – a mechanism for an IPv6 packet to travel over networks of devices communicating using IEEE802.15.4 radios



IEEE 802.15.4 – Low Power, Low Rate WPAN standard
10m communication @ 250kbps

No Spectrum Scam!

- 433.05–434.79 MHz (433.92 MHz)
- 902-928 MHz (915 MHz)
- 2400-2483.5 MHz (2.450 GHz)

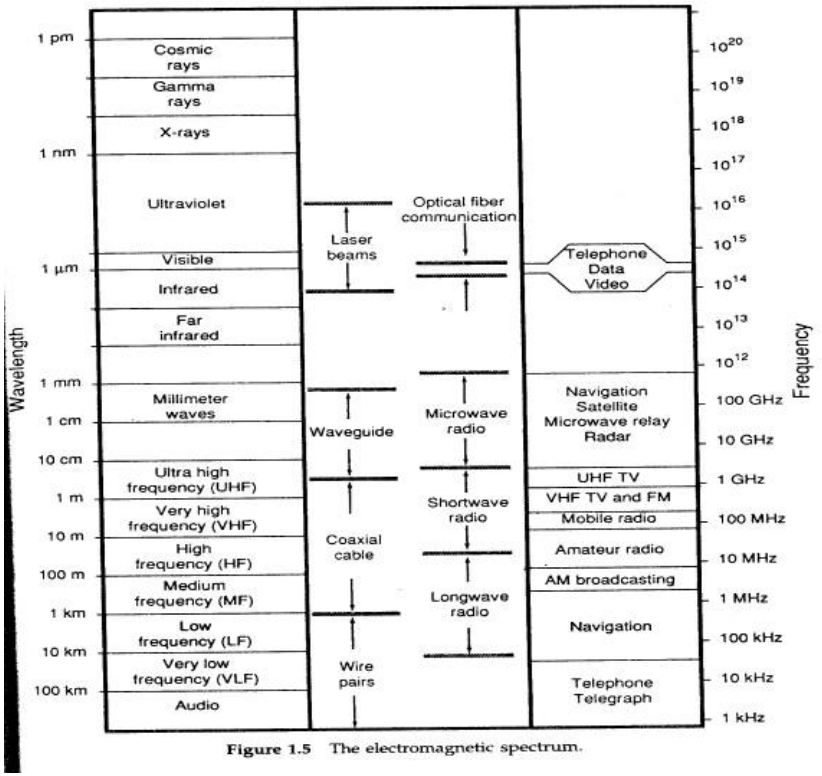


Figure 1.5 The electromagnetic spectrum.

Wireless Sensor Network Technologies

DASH 7 technology highlights

- **Range:** Dynamically adjustable from 10 meters to 10 kilometers
- **Power:** <1 milliwatt power draw
- **Data Rate:** dynamically adjustable from 28kbps to 200kbps.
- **Frequency:** 433.92 MHz (available worldwide)
- **Signal Propagation:** Penetrates Walls, Concrete, Water
- **Real-Time Locating Precision:** within 4 meters
- **Latency:** Configurable, but worst case is less than two seconds
- **P2P Messaging:** Yes
- **IPv6 Support:** Yes
- **Security:** 128-bit AES, public key
- **Application Profiles:** None
- **Standard:** ISO/IEC 18000-7

IEEE 802.15

DASH7 ALLIANCE

ZigBee Alliance

enocean alliance
No Wires. No Batteries. No Limits.

Bluetooth
Low energy

Z-WAVE

Low power

Wi Fi

wavenis
more than wireless

WirelessHART

wibree

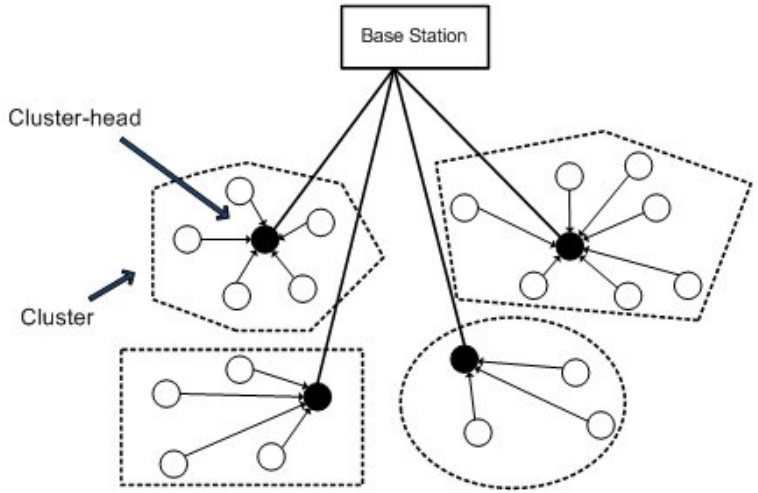
ISA100Wireless

MAC layer

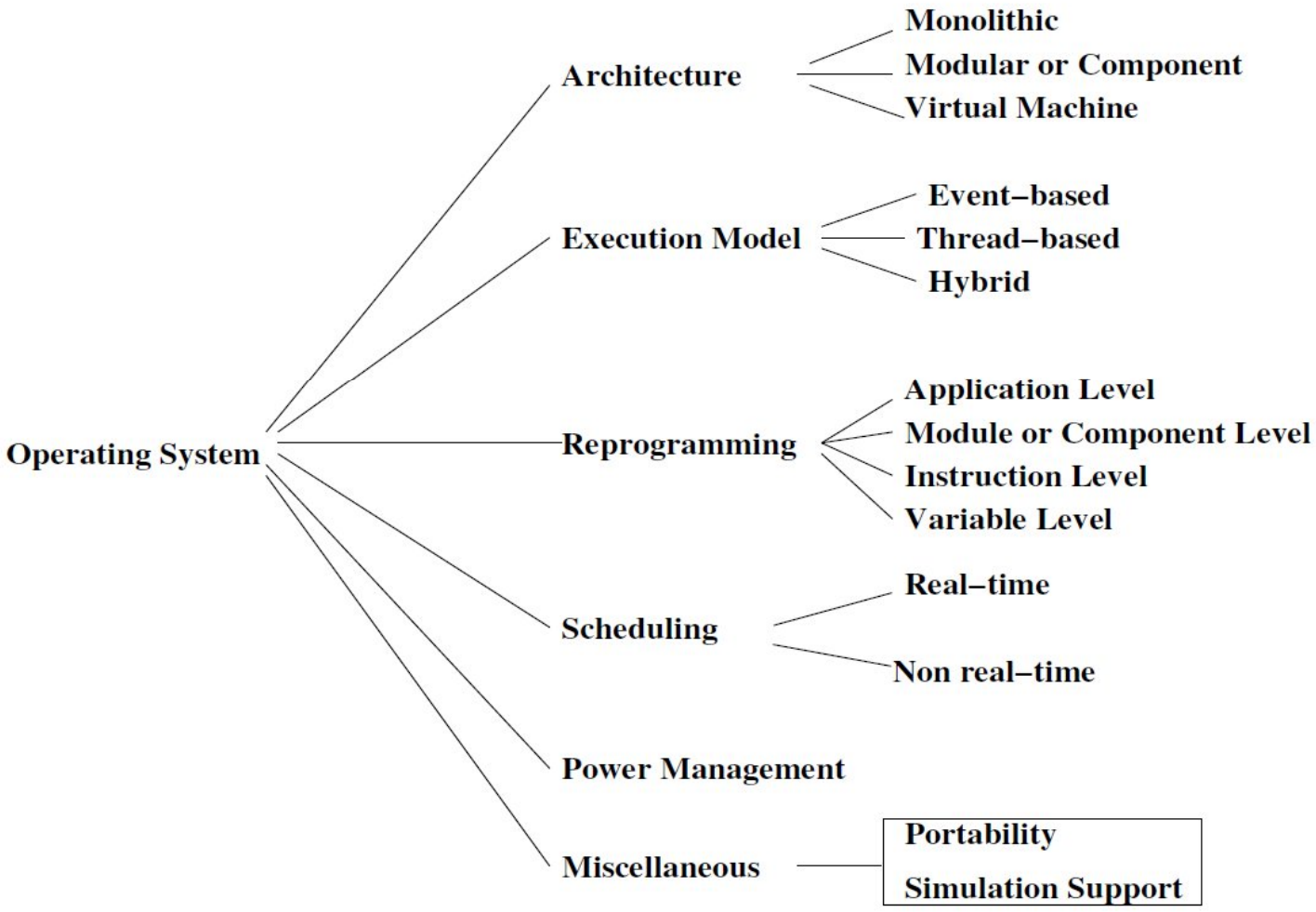
- DSSS & FHSS (Physical Access)
- Channel Access Method
- CSMA/CA using RTS/CTS/ACK
- Many Protocols S-MAC, T-MAC etc.
- Energy Saving is important
- Sleep/Listen/Wakeup model

Network layer

- No IP!
- Topology Management
- Routing (flat, Clustered, Hierarchical)



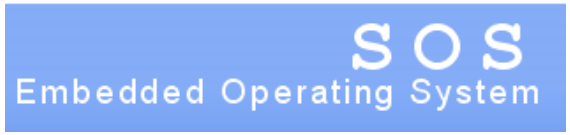
Operating Systems



Source: AM Reddy, Operating Systems for WSN: Technical Report, 2007

Operating Systems

Monolithic	Modular	VM
TinyOS	SOS	VMSTAR
MagnetOS	Contiki	Matè
	MantisOS	MagnetOS
	CORMOS	ContkiVM
	Bertha	
	kOS	



Event-based	Thread-based	Hybrid	Others
TinyOS	MantisOS	Contiki (Event+Thread)	SenOS
SOS		kOS (Event+Object)	Nano-RK
CORMOS			
EYES			
PEEROS			

WSN Programming

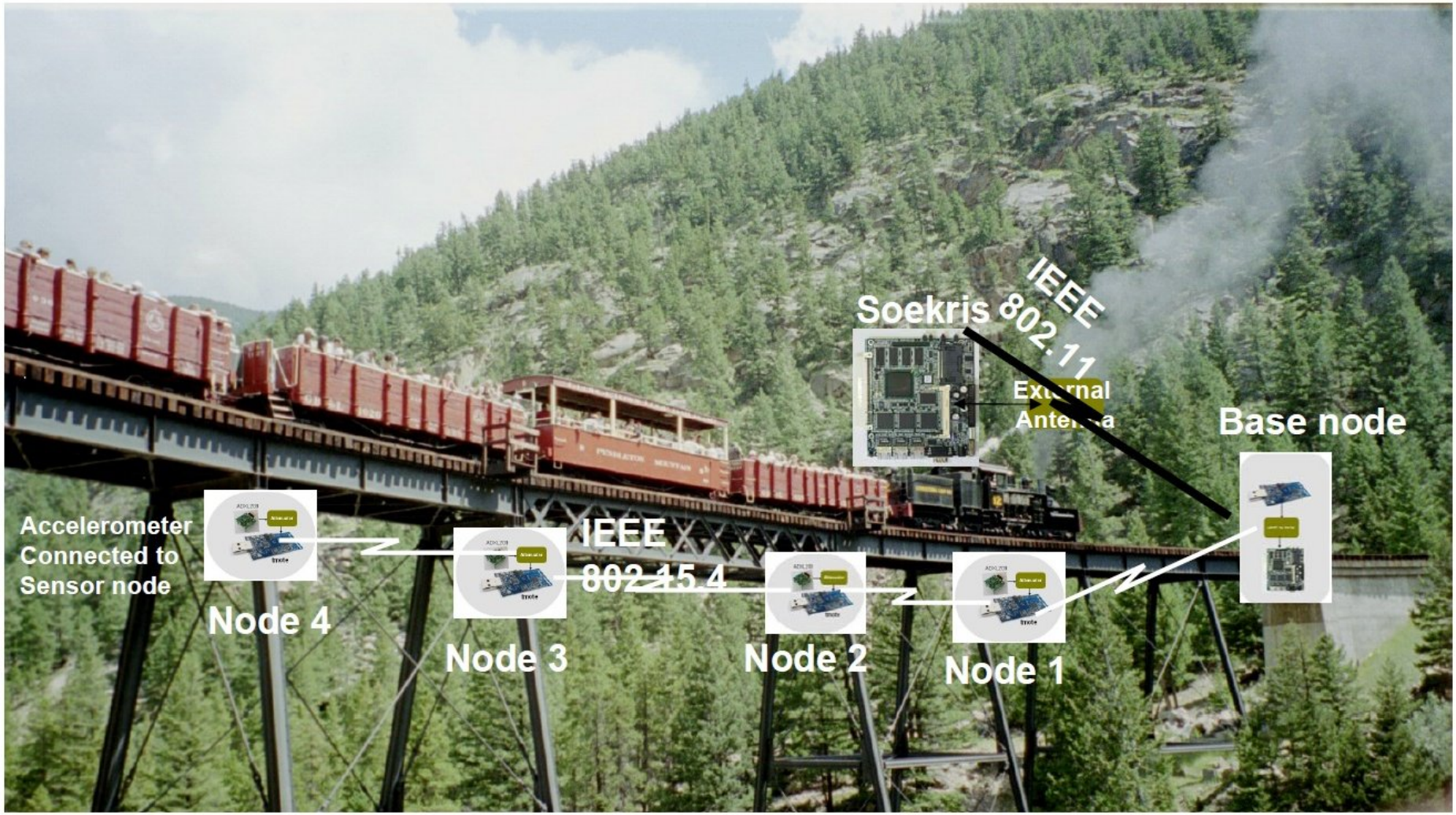
- TinyOS supports event driven programming (nesC language) footprint of 400 bytes!
- Contiki supports multi threading (C language)
- LiteOS (Unix like & C language)

Simulation

- TOSSIM
- PowerTOSSIM
- SENSE
- NS2 , Glomosim, Qualnet, Matlab

Applications

BriMon: Railway Bridge Monitoring Application



Kameswari Chebrolu et al.; **BriMon: A Sensor Network System for Railway Bridge Monitoring** *MobiSys'08* (IIT Mumbai)

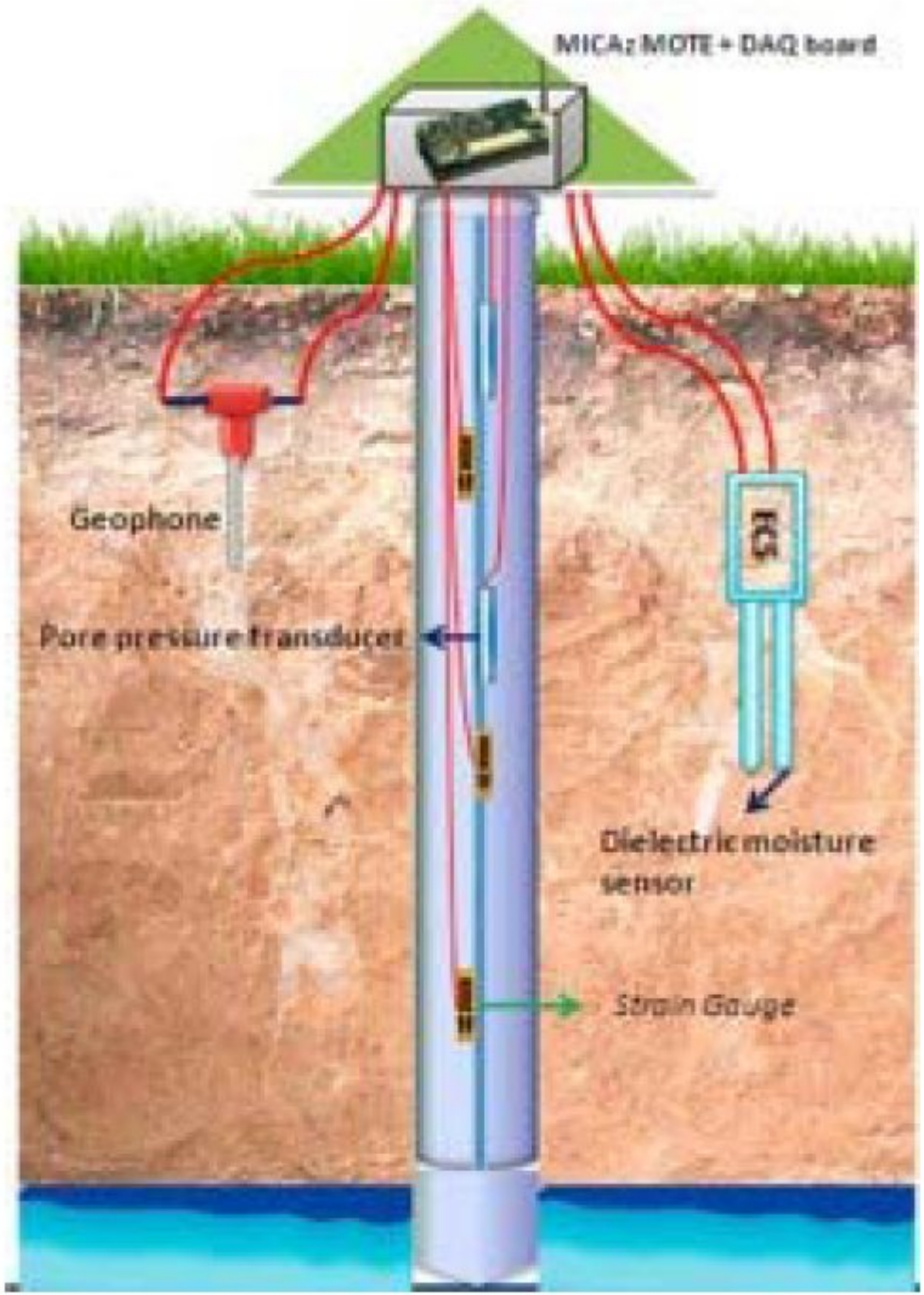
Wireless Sensor Network for Landslide Detection

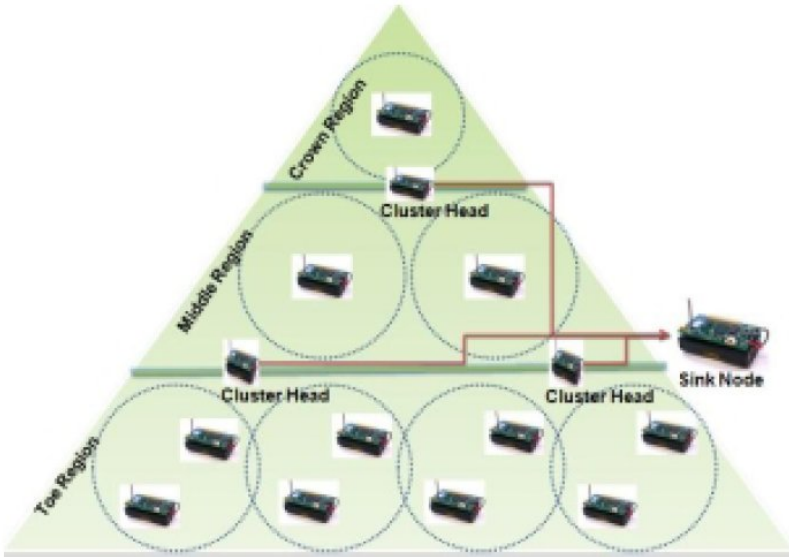
Anthoniar Colony,Munnar, Idukki (Dist), Kerala (State), India

Maneesha V. Ramesh et al.; SENSORCOMM.2009,

Wireless Sensor Network for Landslide Detection

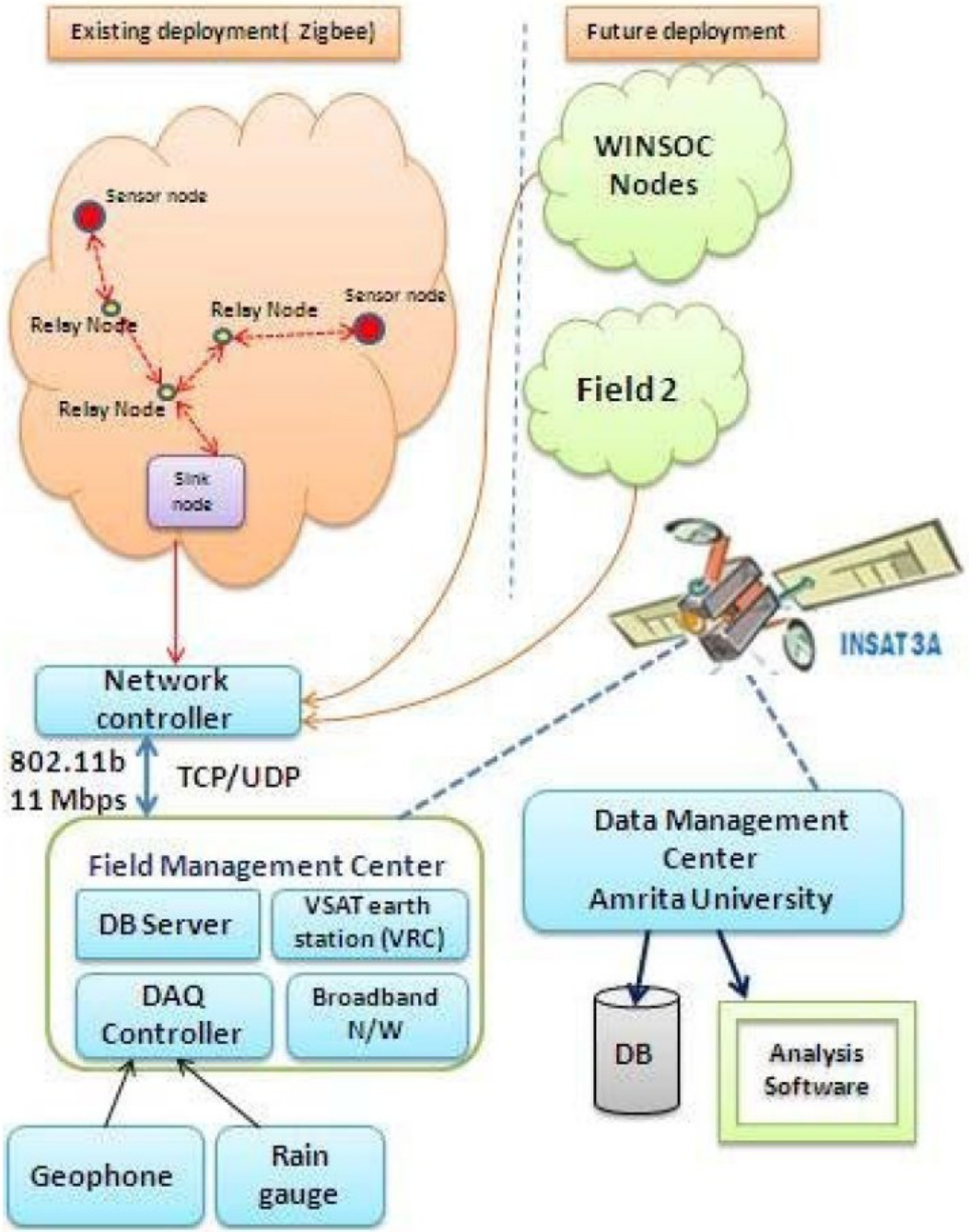
Anthoniar Colony,Munnar, Idukki (Dist), Kerala (State), India



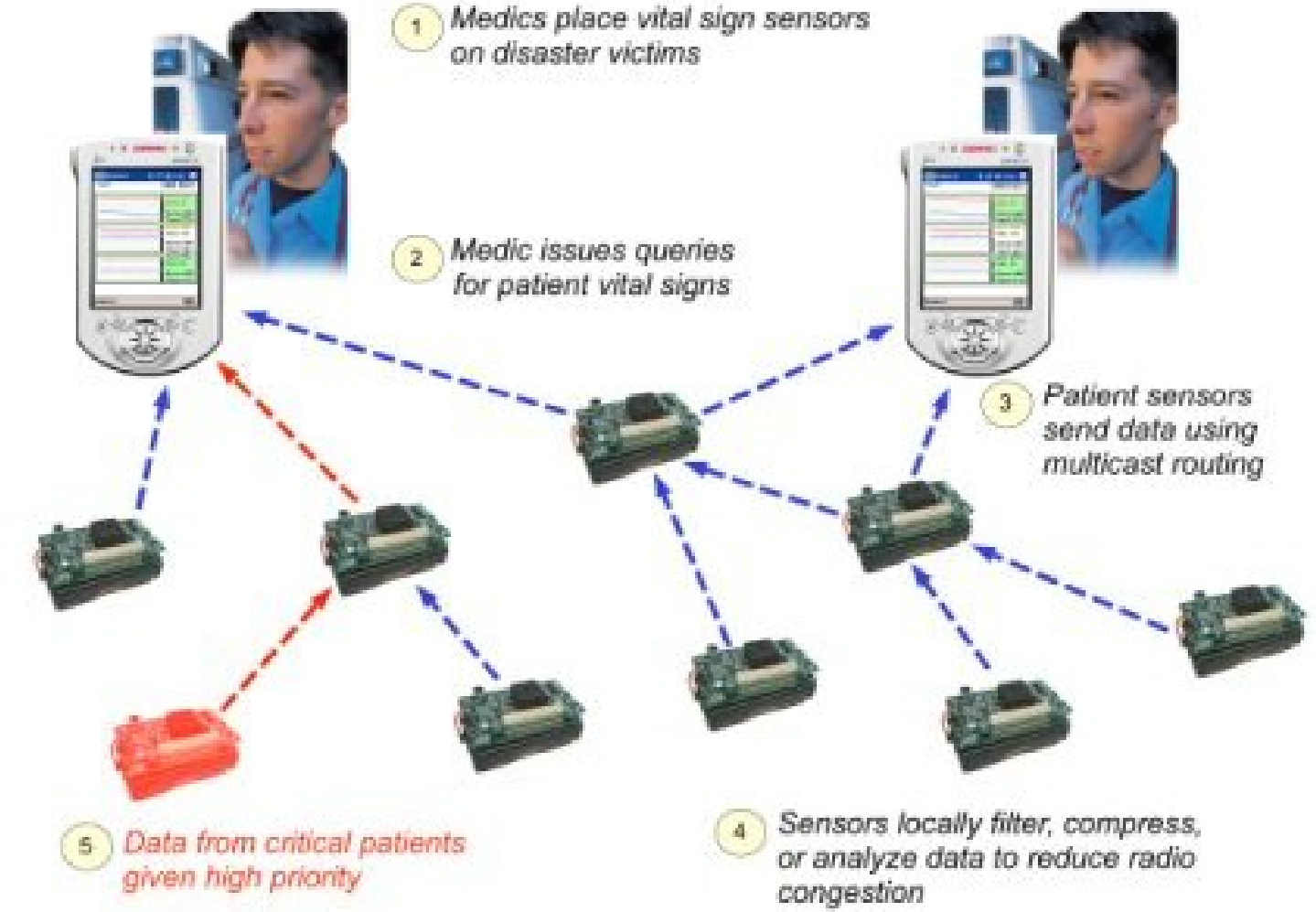


Architecture

Sensors used

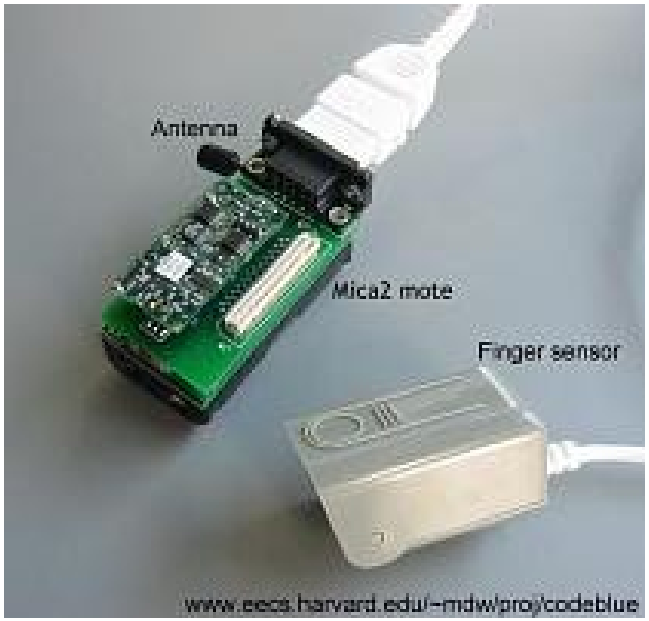

Existing deployment(Zigbee)
Future deployment
WINSOC Nodes
Field 2
Sensor node
Relay Node
Relay Node
Sensor node
Relay Node
Sink node
INSAT 3A
Network controller
802.11b
11 Mbps
TCP/UDP
Field Management Center
DB Server
VSAT earth station (VRC)
DAQ Controller
Broadband N/W
Data Management Center Amrita University
DB
Analysis Software
Geophone
Rain gauge

CodeBlue: Wireless Sensors for Medical Care

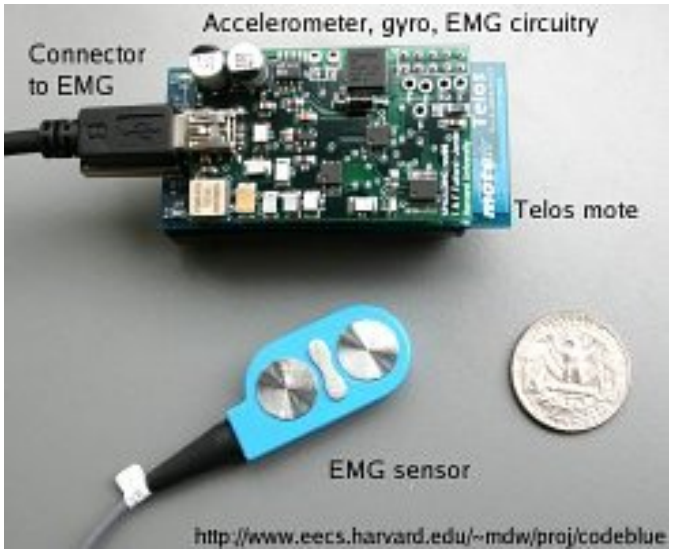


Harvard University, http://www.eecs.harvard.edu

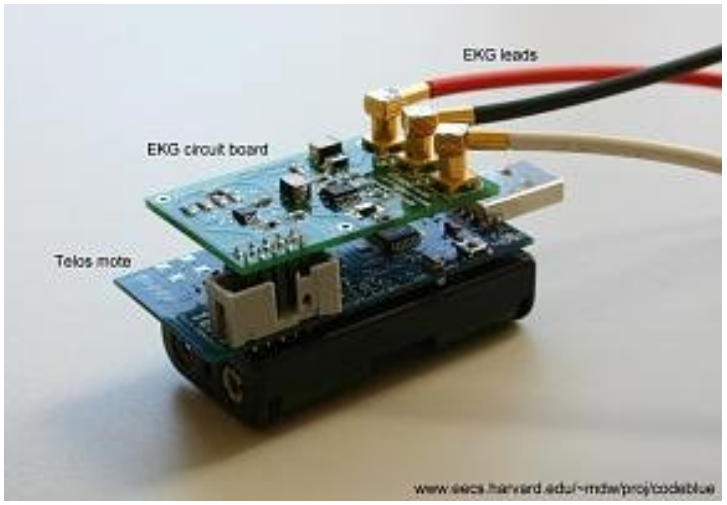
Sensors developed



Wireless pulse oximeter sensor to collect heart rate and Oxygen saturation (SpO2)

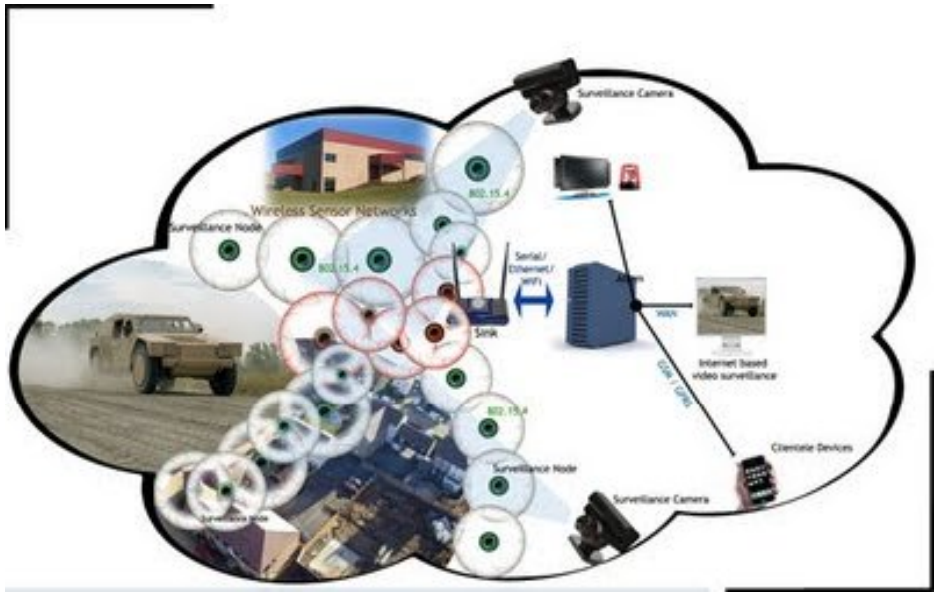


Accelerometer, gyroscope, and electromyogram (EMG) sensor for stroke patient monitoring.



Wireless two-lead EKG (electrocardiogram).

Intelligent Intrusion Detection System (In2DS)



TelosB Sensor nodes

Features of In2DS system:

Event based video surveillance and recording
Fault tolerant
Object tracking
Reduced false alarm rate
Rapid deployment capability
Battery operated low power devices
Easy to transport and operate
User notification through SMS, voice and displays
Internet and mobile based alert monitoring capability
Ability to integrate with existing camera / CCTV units

Developed by Centre for Development of Advanced Computing (C-DAC)

Precision Agriculture in India using Wireless Sensor Networks

- **COMMON-Sense Net (*Panchard et al., 2007)***

  An integrated WSN system for improved water management for resource-poor farmers (deployed in Karnataka)

- **U-Agri *(Santosh et al., 2008)***

  To automate weather data acquisition from fields thereby facilitating decision support system for irrigation and pest management (CDAC-Hyderabad)

- **AGRO-SENSE: (*Roy et al., 2008)***

  real time monitoring of the climatological (soil pH, soil salinity, soil temperature and the soil moisture)conditions of agricultural field using wireless sensor network (IIM, Calcutta)

- **mKRISHI, *(Pande et al., 2009)***

  An agro-advisory system through mobile telephony which integrates the sensor network and speech recognition technologies (TCS, Innovation Lab, Mumbai)

Precision Agriculture in India using Wireless Sensor Networks

Sensor network within the test bed facility at IIT Bombay, for testing the ruggedness of WSN

Precision Agriculture in India using Wireless Sensor Networks

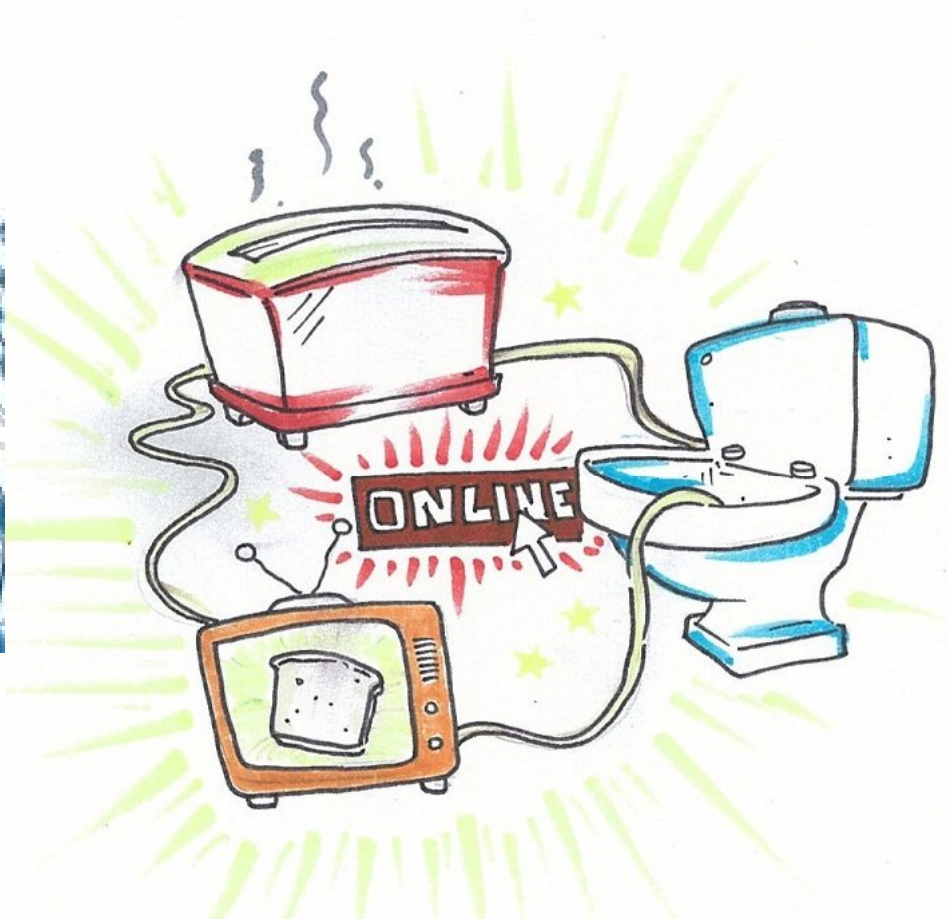
WSN deployment in Vineyard, Nashik, MH, India
Temperature, Humidity, soil parameters are periodically send via GPRS to Agri-information server

Wireless sensor network monitors microclimate in the forest

Smart Cities: Cities of the XXI century

Monitor pollution levels
Noise Maps
Public light management
Parking spaces

Internet of Things




Thank you!