Sensor Networks in Pervasive Computing

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Agenda

- Introduction to Sensor Networks (Manie).
- Its current Applications and Management (Meng).
- Its commercial perspective - Case studies, Commercial value and barriers/constraints (Malcolm).
- Its future trends and conclusion (Pluto).
- Q&A.

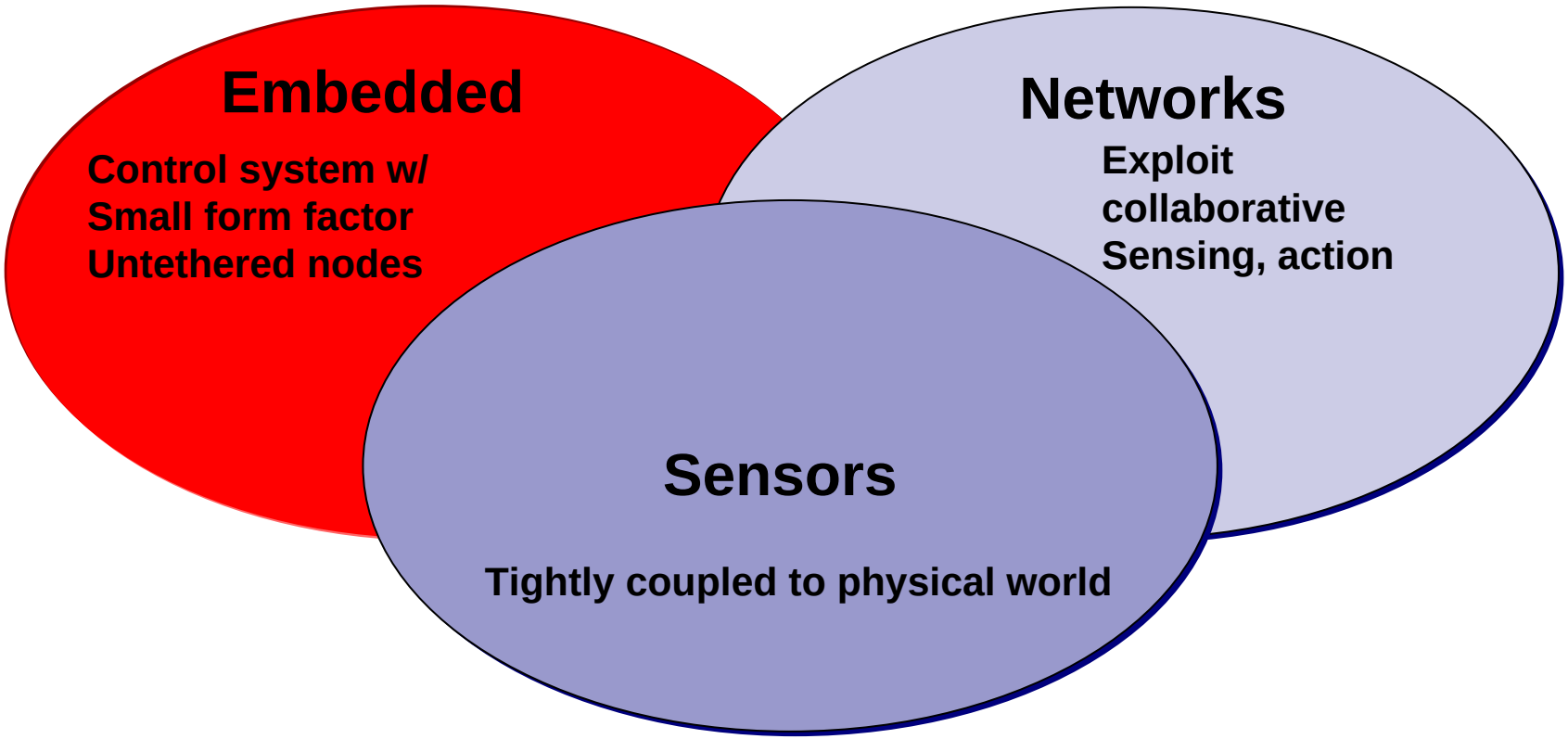
Definition

- “Sensor networks are collections of wirelessly interconnected devices with sensing, computing and communication infrastructure that allow us to instrument, observe, and respond to phenomena in the natural environment and physical infrastructure.” Prof R. Evans Uni of Melbourne.

Enabling Technologies

Embed numerous distributed devices to monitor and interact with physical world

Network devices to coordinate and perform higher-level tasks



Exploit spatially and temporally dense, in situ, sensing and actuation

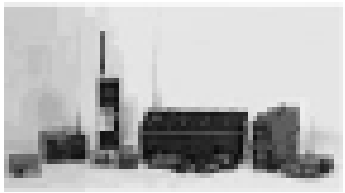
(http://nesl.ee.ucla.edu/tutorials/mobicom02/).

Sensors

- Passive elements.
- Passive Arrays.
- Active sensors.
- Technology trend.

Sensor Generations

	Yesterday (1980's – 1990's)	Today (2000 – 2003)	Tomorrow (2010)
Manufacturer	Custom contractors, e.g., for TRSS	Commercial: Crossbow Technology, Inc. Sensoria Corp., Ember Corp.	Dust, Inc. and others to be formed
Size	Large shoe box and up	Pack of cards to small shoe box	Dust particle
Weight	Kilograms	Grams	Negligible
Node architecture	Separate sensing, processing and communication	Integrated sensing, processing and communication	Integrated sensing, processing and communication
Topology	Point-to-point, star	Client server, peer to peer	Peer to peer
Power supply lifetime	Large batteries; hours, days and longer	AA batteries; days to weeks	Solar; months to years
Deployment	Vehicle-placed or air-drop single sensors	Hand-emplaced	Embedded, "sprinkled" left-behind

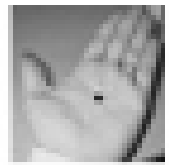


TRSS Node

Crossbow

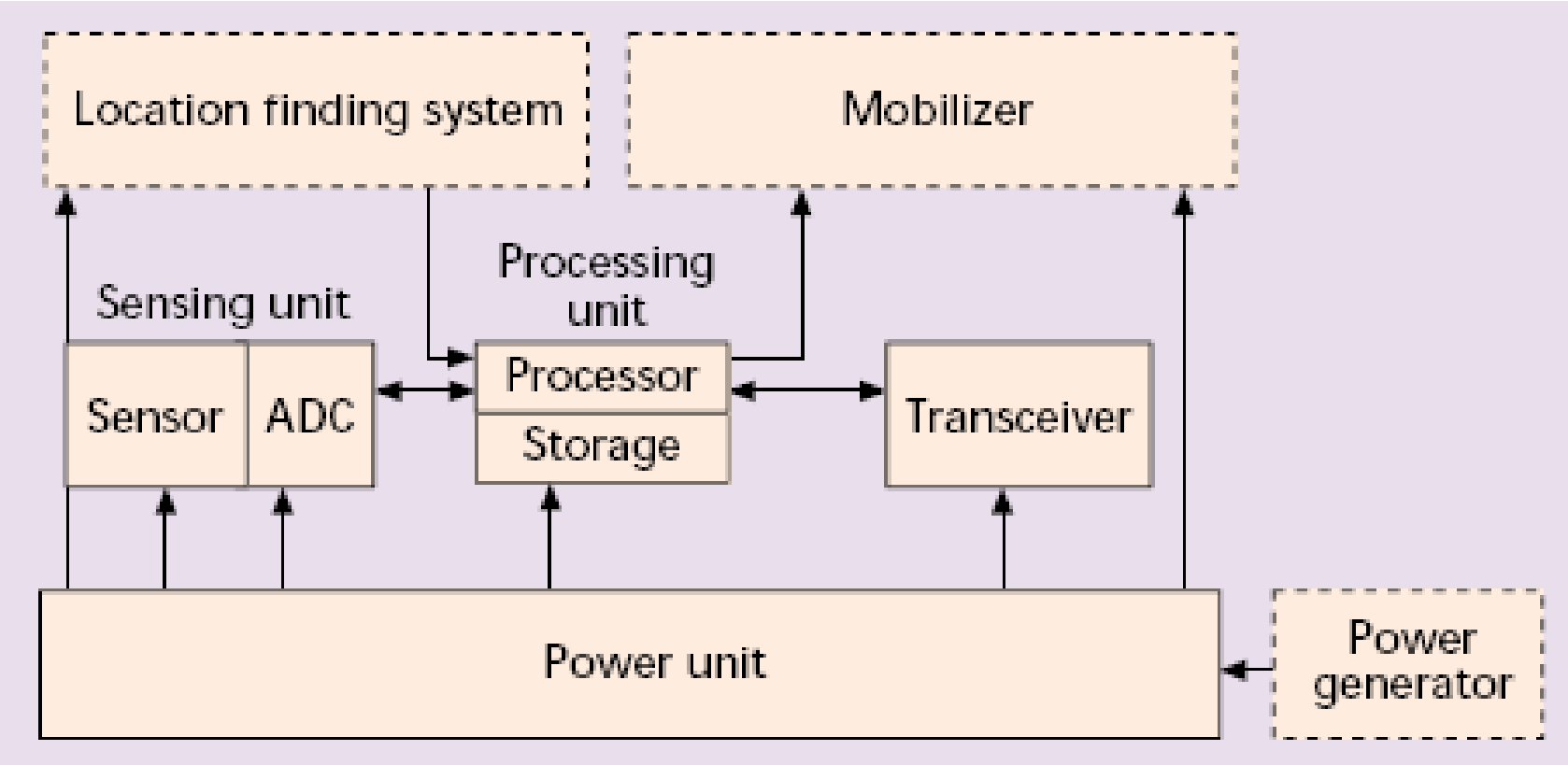
Ember

Sensoria



Dust, Inc.

Sensor Node Components

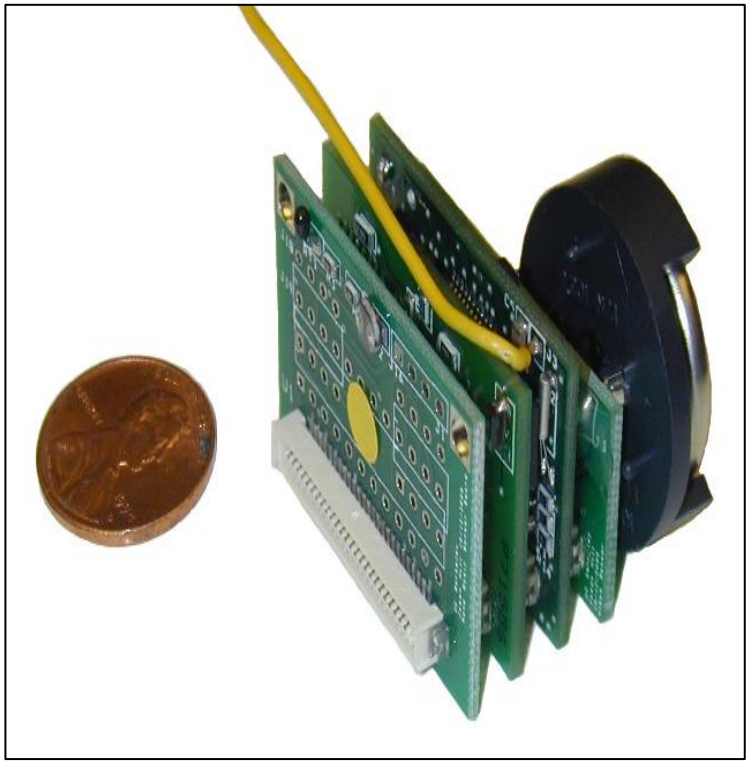


Networked Sensor Nodes

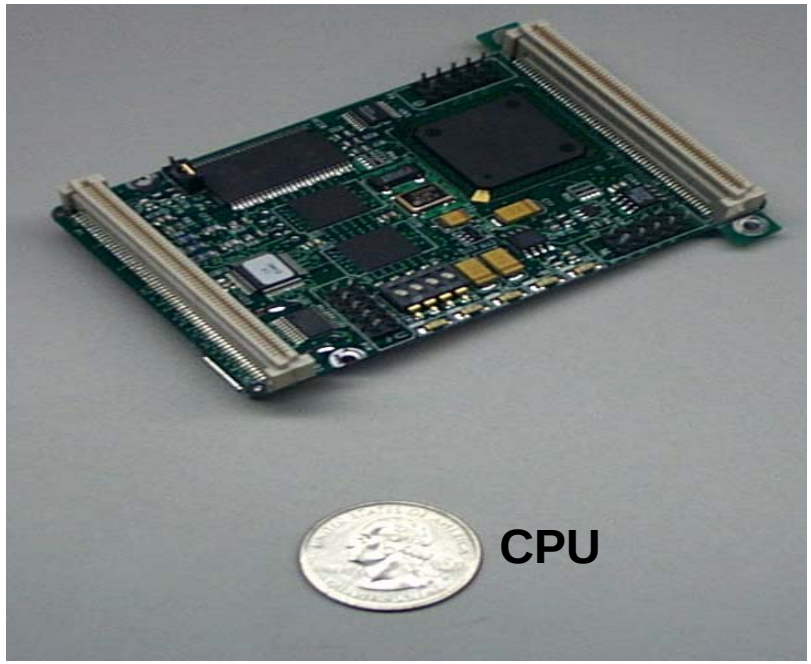
LWIM III, UCLA, 1996, Geophone, RFM radio, PIC, star network

AWAIRS I, UCLA/RSC, 1998, Geophone, DS/SS, Radio, strongARM, Multi-hop networks

Networked Sensor Nodes (cont.)



UCB Mote, 2000, 4 Mhz, 4K Ram 512K EEProm, 128K code, CSMA half-duplex RFM radio

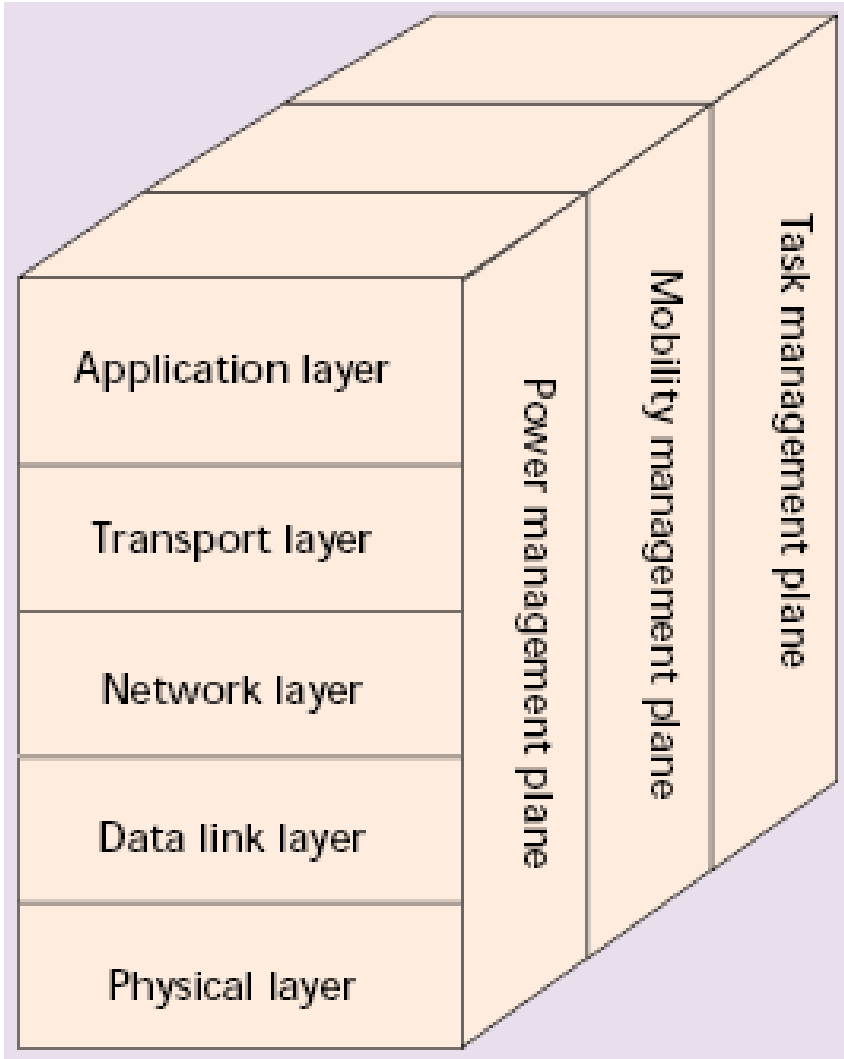


WINS NG 2.0 Sensoria, 2001, Node development platform; multi-sensor, dual radio, Linux on SH4, Preprocessor, GPS

Embedded Design Themes

- Long-lived systems, untethered and unattended.
- Leverage data processing inside network.
- Self configuring systems, deployed ad hoc.
- Global behavior, adaptive localized algorithms

Network Protocol Stack



Current applications and management of sensor networks

Meng YangFan

Introduction

- Now sensor network applications represent a new class of applications, that are:
  - 1. data driven
  - 2. state based
  - Wireless ad hoc sensor network
  - Mainly applied area
  - Sensor Network Management

Wireless ad hoc sensor network

- What is it ? → Definition
- The basic goals of a wireless ad hoc sensor network

1. Determine the value of some parameter at a given location.
2. Detect the occurrence of events of interest and estimate parameters of the detected event or events
3. Classify a detected object
4. Track an object

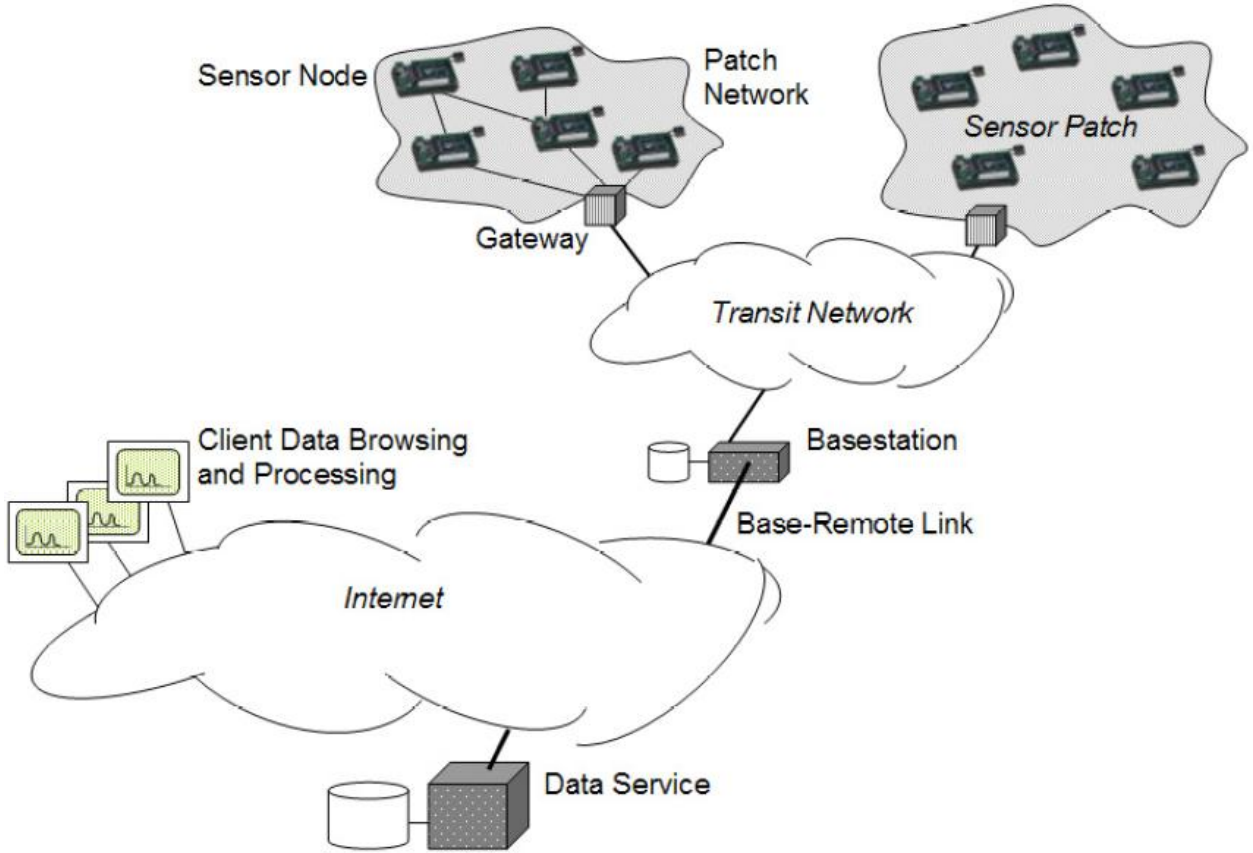
Wireless ad hoc sensor network

- Some examples of wireless ad hoc sensor networks :
  - Military sensor networks
  - detect and characterize attacks and material.
  - detect and monitor environmental changes
  - monitor vehicle traffic on highways or in congested parts of a city.
  - providing security
  - determine which spots are occupied and which are free.

Mainly Applied Area

- Environmental Surveillance
- Home/Office Security
- Medical Monitoring

Habitat Monitoring



- Tiered Network
- Motes positioned in pairs, one in burrow, one above ground outside (transmit bucket-brigade style to Gateway)
- Commercial WLAN [Pol03] between Gateway and Base station where stored in database.

Habitat Monitoring

Sensor Analysis

sensors used in the system:

- Light
- Temp
- Humidity
- Pressure
- Passive IR

Wearable and Implantable Body Sensor Networks

several promising prototypes are starting to emerge for managing patients with acute diabetes, for treatment of epilepsy and other debilitating neurological disorders, and for the monitoring of patients with chronic cardiac diseases.

Wearable and Implantable Body Sensor Networks

- Hardware considerations for body sensor networks, including:

1. Low power RF transceivers,
2. Context awareness and multi-sensor data fusion for body sensor networks
3. Quality of service and security issues for body sensor networks
4. Standards and light-weight communication protocols for body sensor networks
5. Links from the body to environment sensing, smart dwellings, and home monitoring
6. Wearable and implantable sensor integration and development platforms
7. Wearable biomotion sensors
8. Applications of body-sensor networks

Sensor Network Management

- Application performance:
- Sensor lifetime:
- Network protocol:.

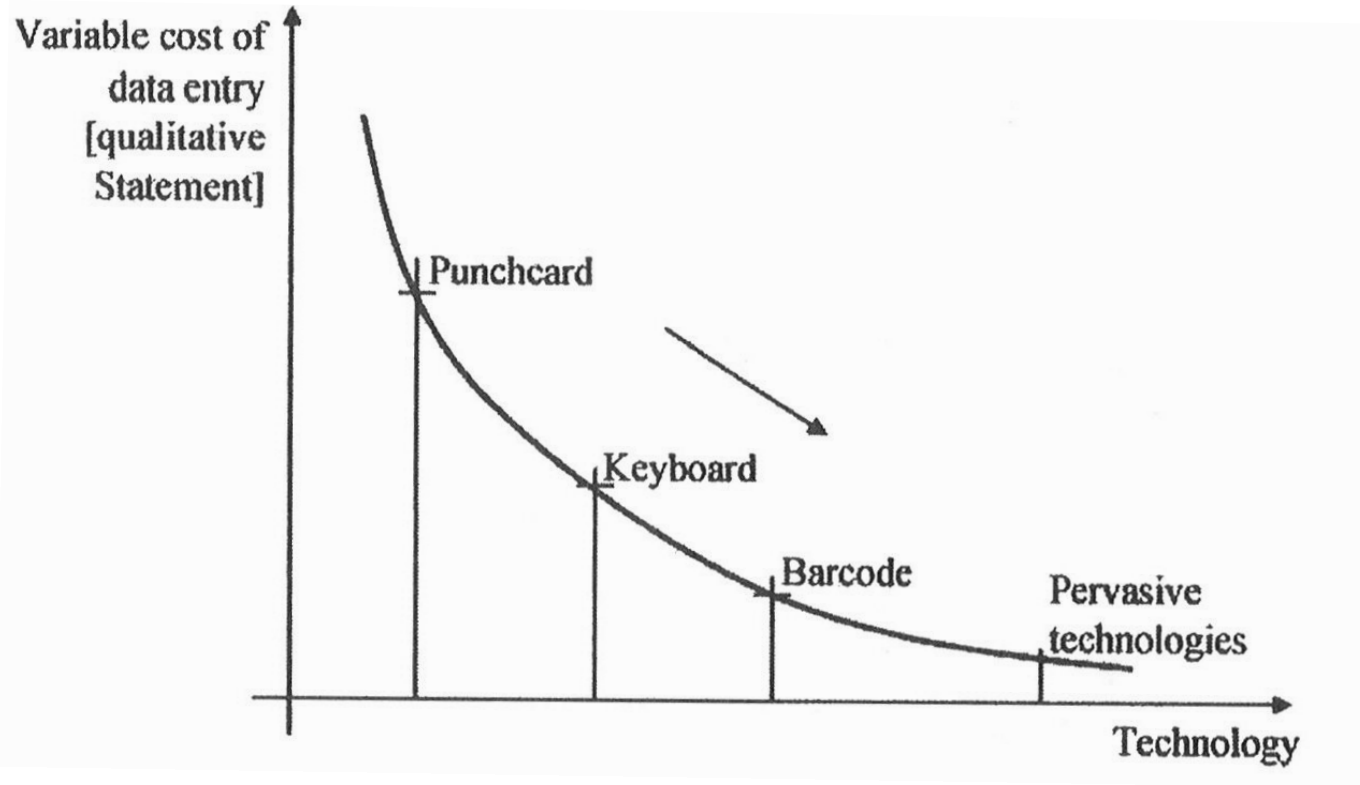
Sensor Networks – A Commercial perspective

Malcolm Drego

Topics covered

- Commercial value
- Industrial Automation - Case Study 1
- Asset Security - Case Study 2
- Barriers/constraints

Historical Commercial value



- Reduced cost of physical to IT integration
- Increasing data granularity

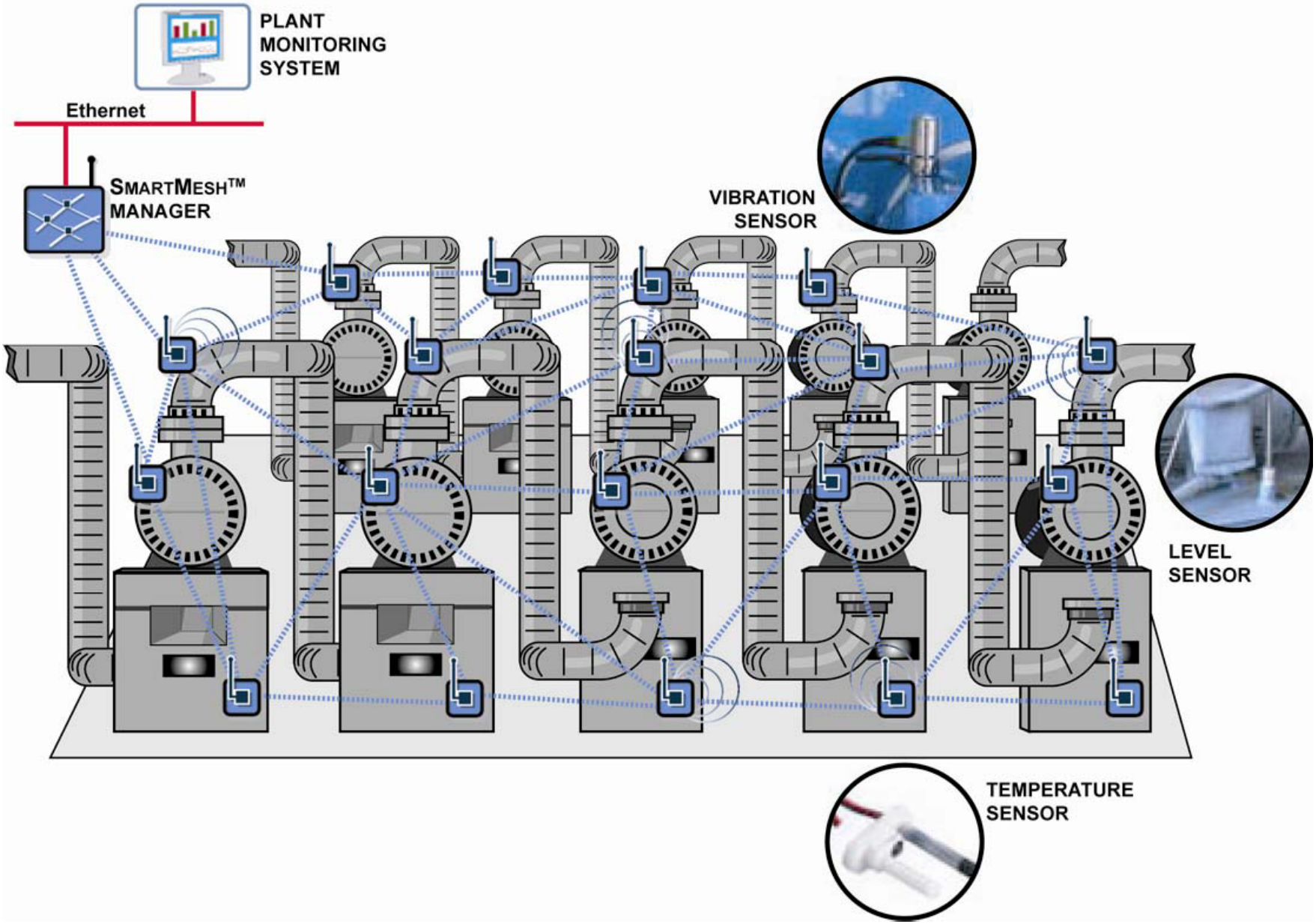
Emerging commercial value

- eHealth
- Military
- Security
- Industry

Industrial Automation

A Case Study in Predictive Maintenance

- Reducing machinery downtime
- Highly reliable sensor solution
- Simple and quick installation



Ref: Dust Networks: http://www.dustnetworks.com/solutions/main.shtml

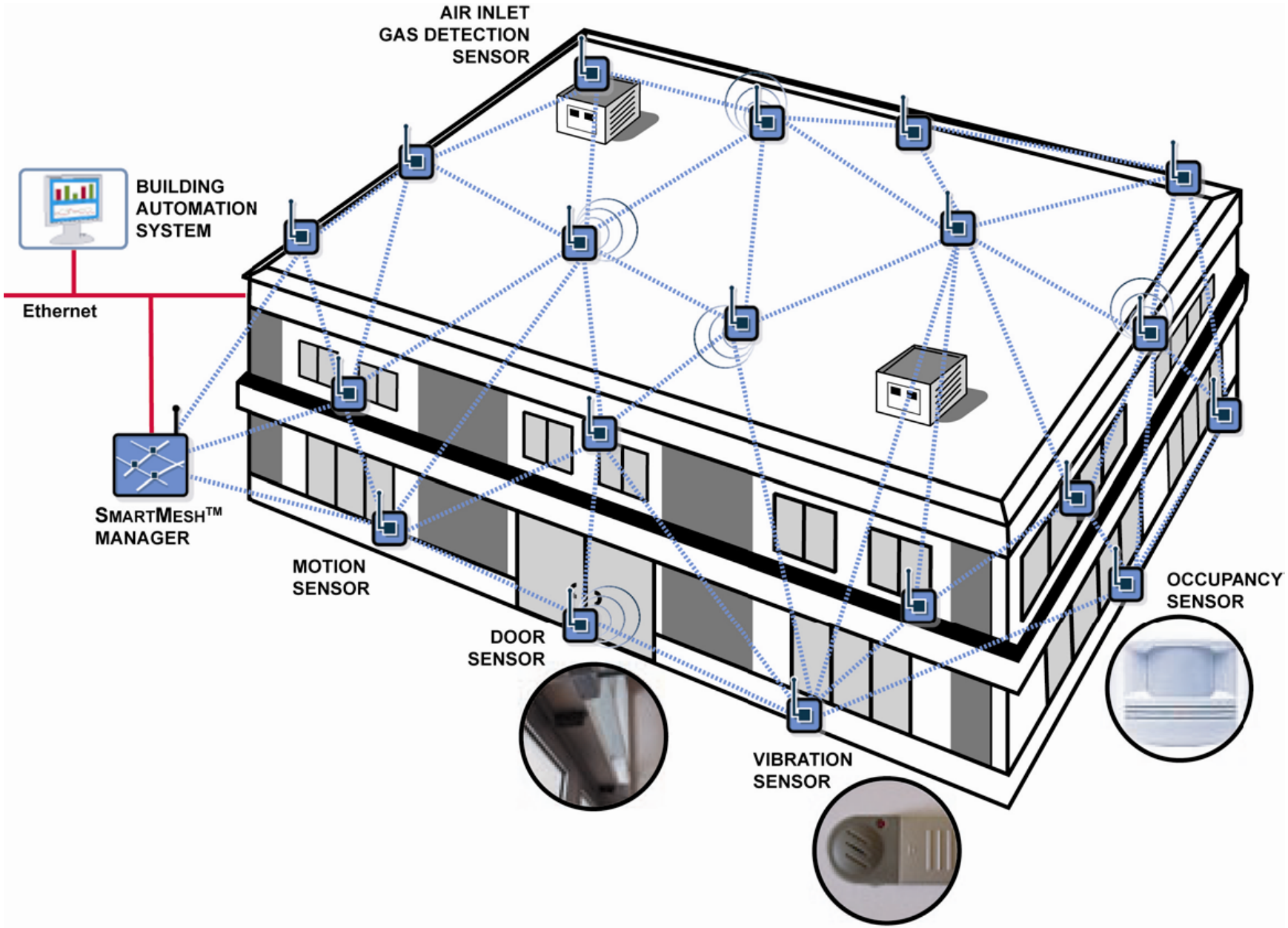
Business Impact

- More frequent data from more monitoring points reduces unexpected down-time
- Reduction of maintenance labour costs
- Only maintenance cost is new batteries every 3-5 years

Asset Security

Small to Medium Commercial Property Case Study

- Employee Safety and Asset Protection a Necessity
- A Highly Reliable Wireless Solution
- Quick Installation Virtually Anywhere



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Carriers/constraints

- Aversion to change from decision makers
- Business case not yet convincing
- Lack of standardisation
- Cost

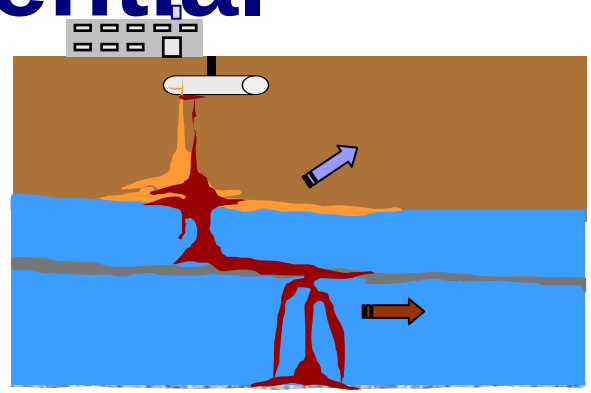
Future Development of Sensor Networks

Pluto WANG

Networked Sensing Potential

Seismic Structure response

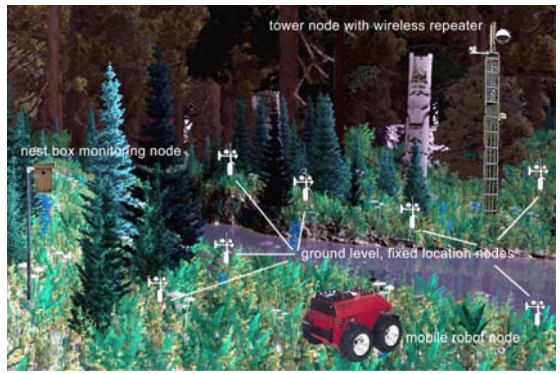
- Micro-sensors, on-board processing, and wireless interfaces all feasible at very small scale
- Will enable spatially and temporally dense environmental monitoring
- Embedded Networked Sensing will reveal previously unobservable phenomena



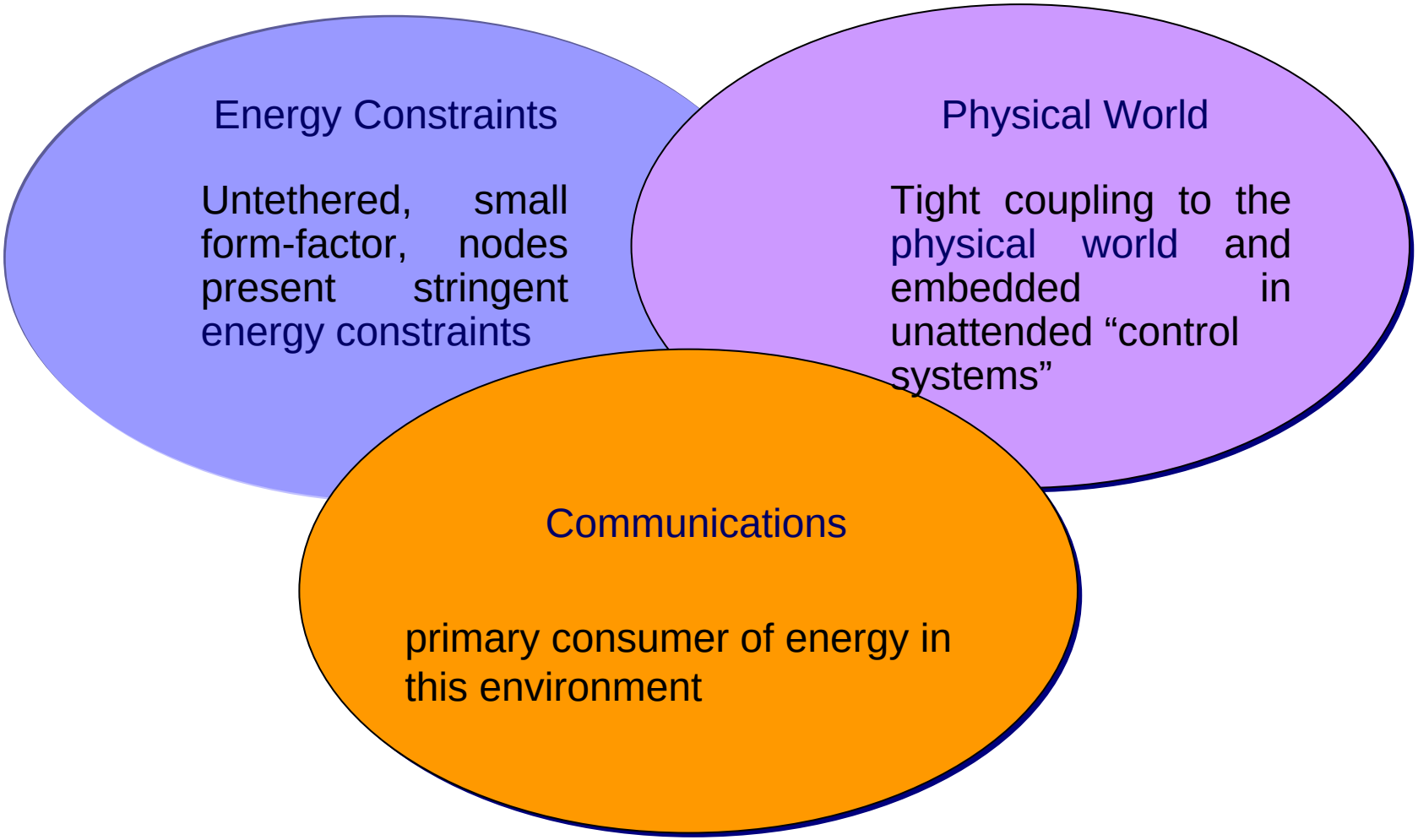
Contaminant Transport

Marine Microorganisms

Ecosystems, Biocomplexity



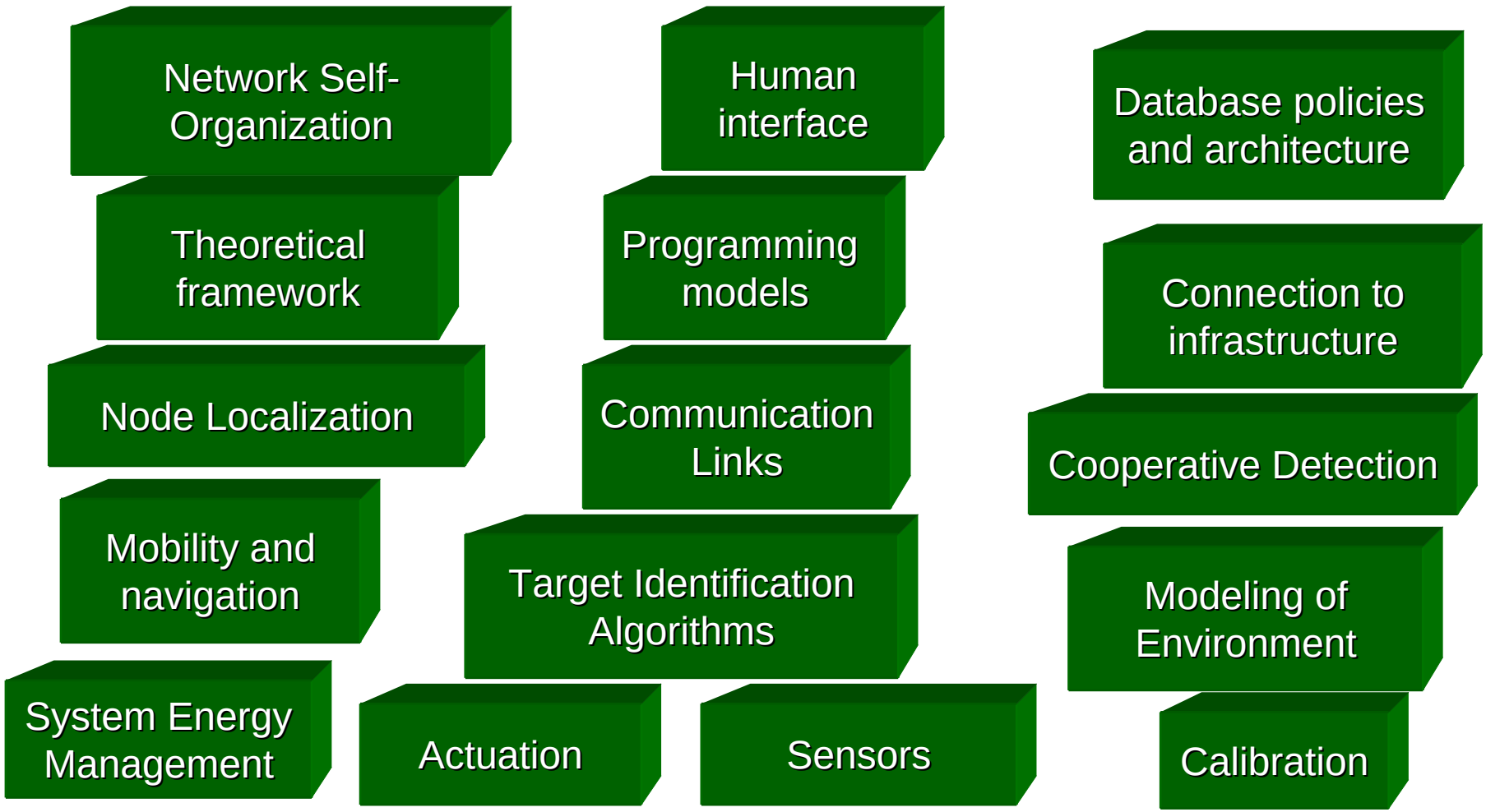
Challenging



Technical Challenges

- **Energy constraints**
- Level of **dynamics**
- **Scaling** challenges

Future Development Areas



New Design Themes

Massively distributed, untethered, and unattended systems to cover spatially distributed phenomena in natural, obstructed, environments

- **In-network processing**
- **Self configuring** systems that can be deployed **ad hoc**
- **Adaptive localized algorithms** to achieve desired global behavior
- Integrated, small form factor, devices
- Time and location synchronization

Adaptive Self-Organization

-- with Localized Algorithms

- Goal: achieve reliable, long-lived, operation in dynamic, resource-limited, harsh environment.
- Adapt
  - Topology to achieve efficient communication, sensing, processing, or dissemination coverage (may be application and data driven)
- How well can we do with localized algorithms that do not rely on centralized control or global knowledge ?
  - Metrics: system lifetime, quality of “detection”
- Investigating applicability, convergence, role of selective global information

Collaborative, multi-modal, processing

- Common time coordinate for in situ processing, correlation of events
- Common spatial coordinate for 3-space related tasks and network operation (e.g., geo-routing)

Sensor coordinated actuation

- Actuation needed for fully self-configuring and reconfiguring systems
  - Allow for adaptation in physical space
- Services provided
  - Energy delivery
  - Calibration
  - Localization
  - Sample collection
  - Node placement
- Static sensors can assist mobile elements with navigation, search, coordination

Other Future Directions

- Tremendous opportunities for expanding research on horizon
- Critical Concerns: Security, Privacy, and Safety

Space exploration Demo

- Dr James Garvin – NASA Chief Scientist
- Leo-head
- Leo-hand

Conclusion

- What are sensor networks? – an overview
- Application and management of sensor networks
- Commercial perspective – with case studies and discussion
- Future trends

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Thank You!!!

Any questions?