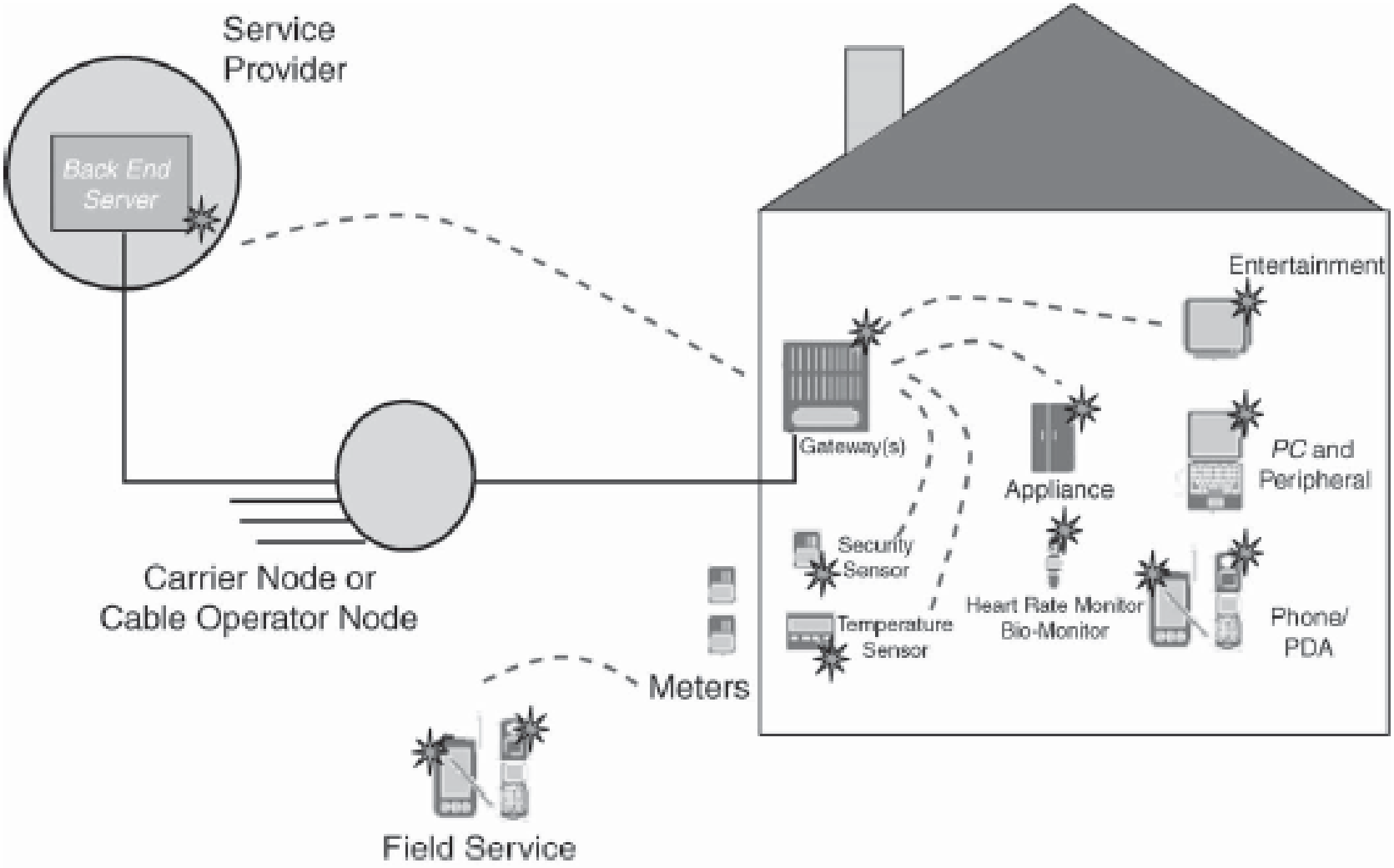
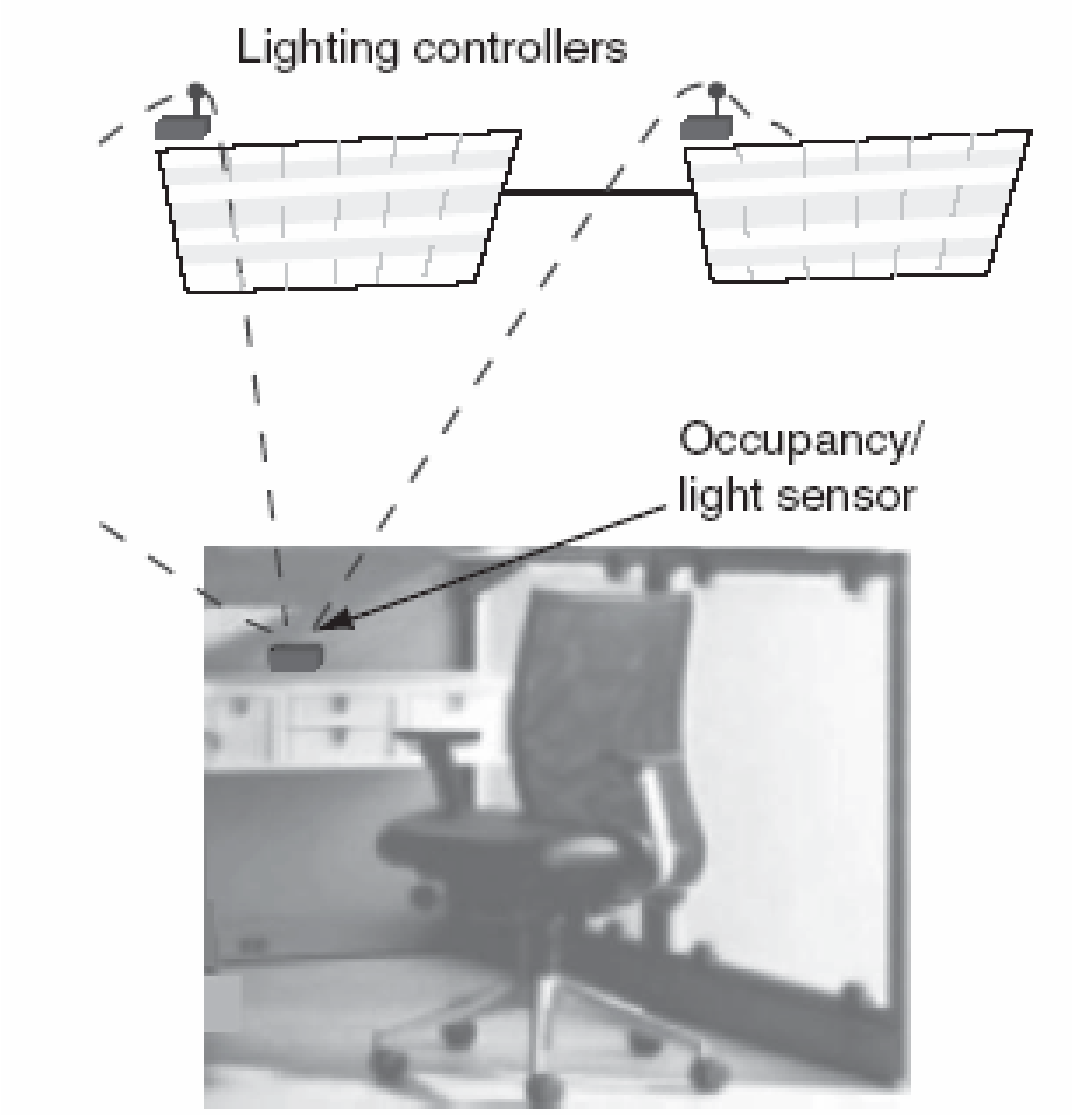
EXAMPLES OF CATEGORY 2 WSN APPLICATIONS

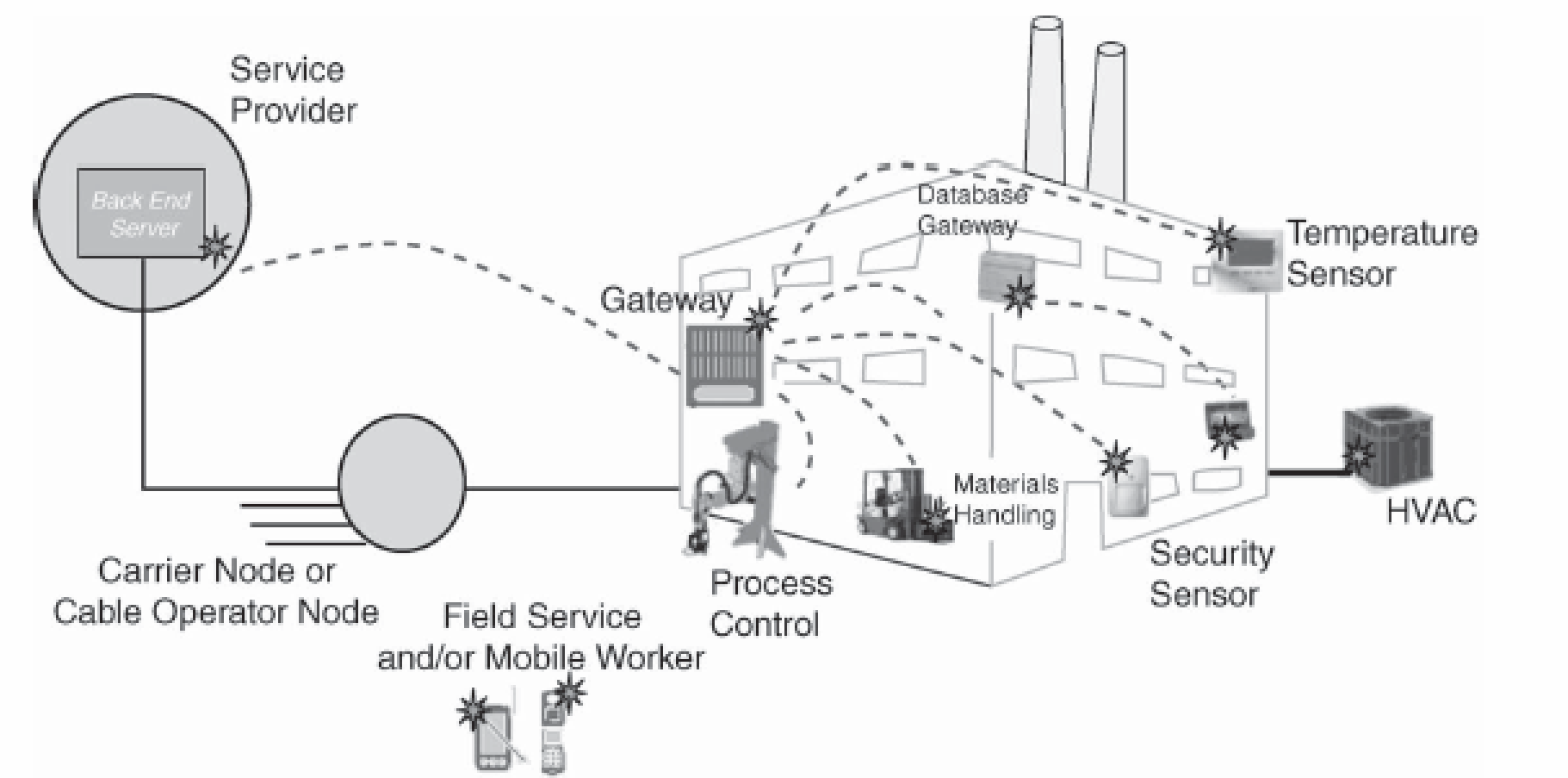
Home Control



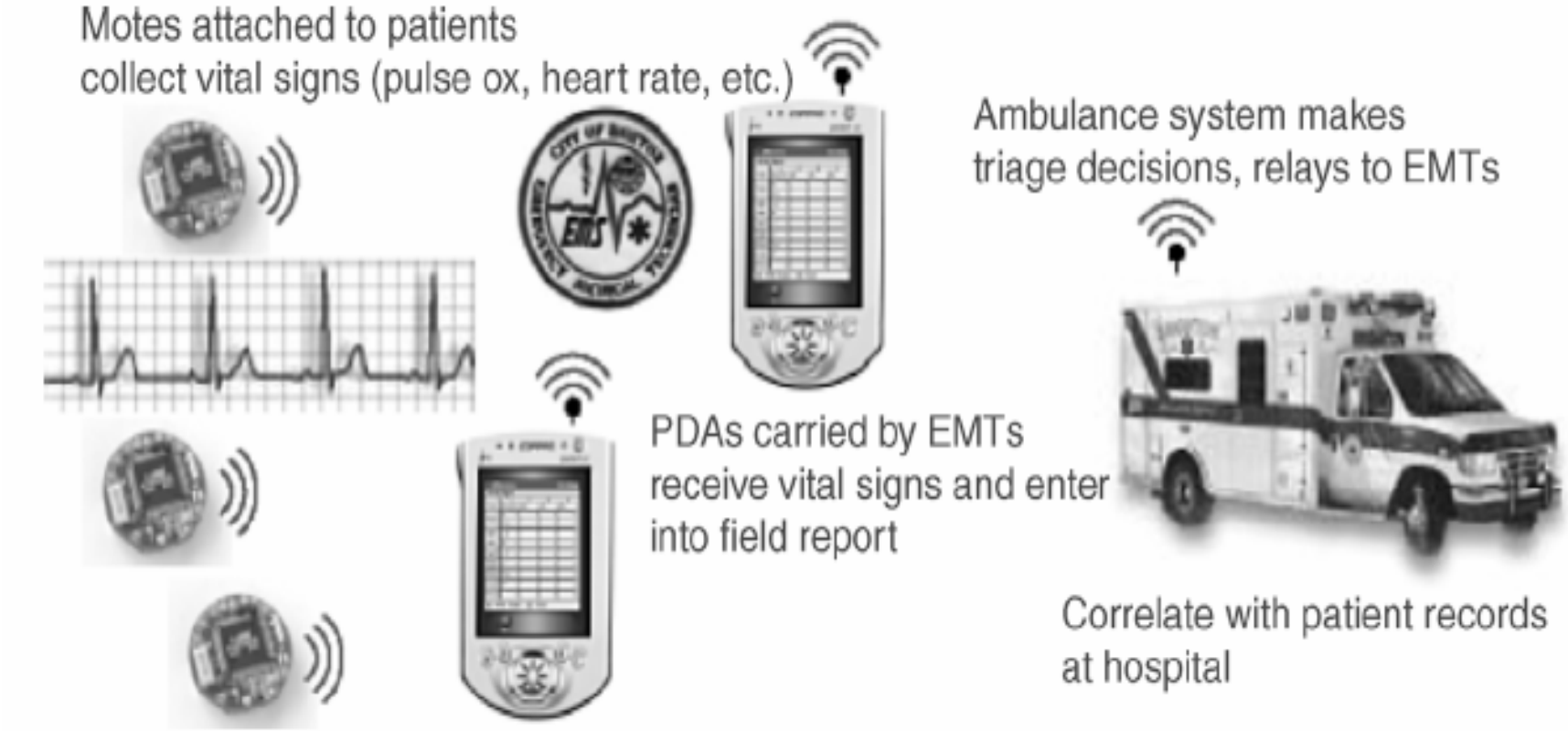
- **Building Automation**



- **Industrial Automation**

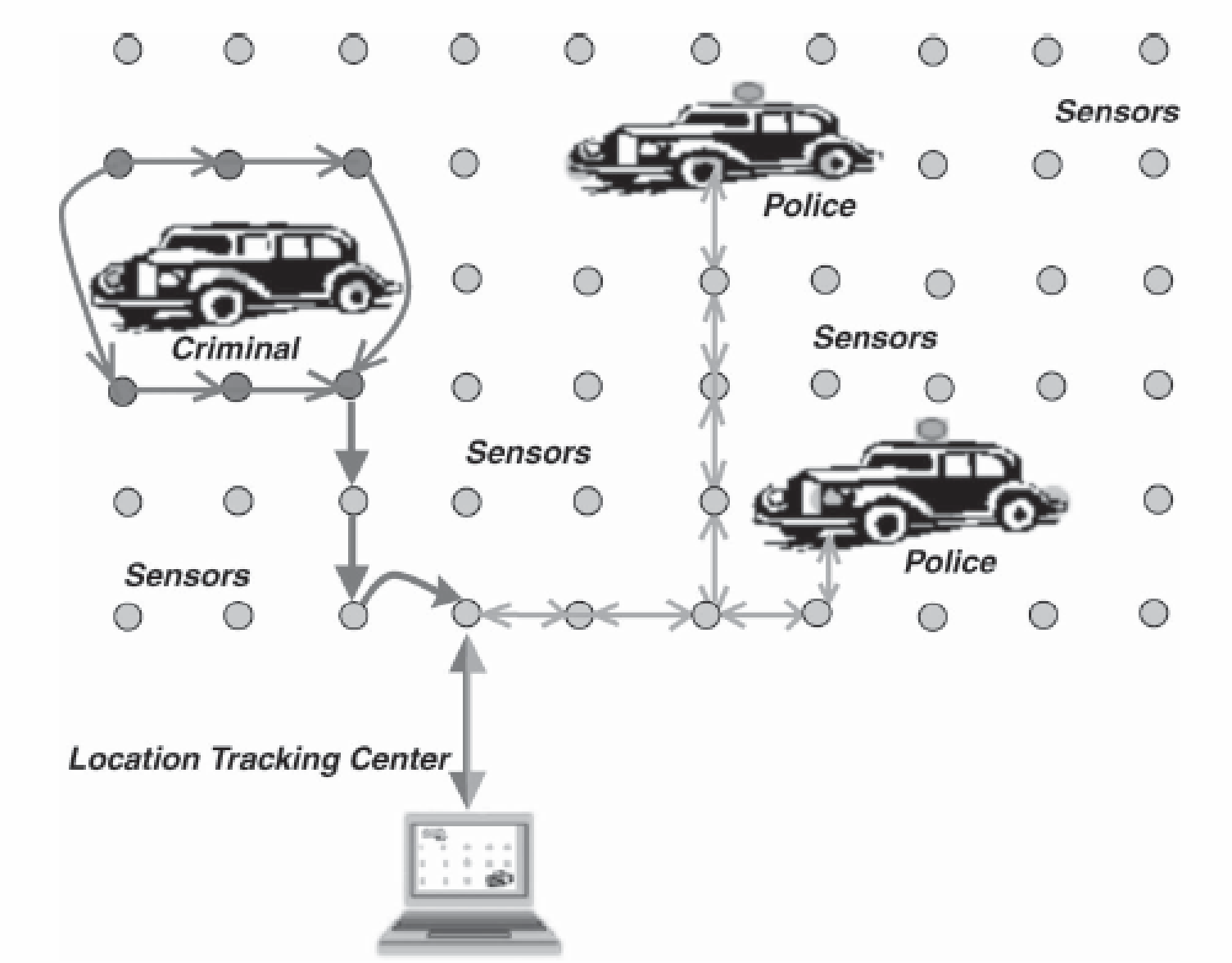


- **Medical Application**

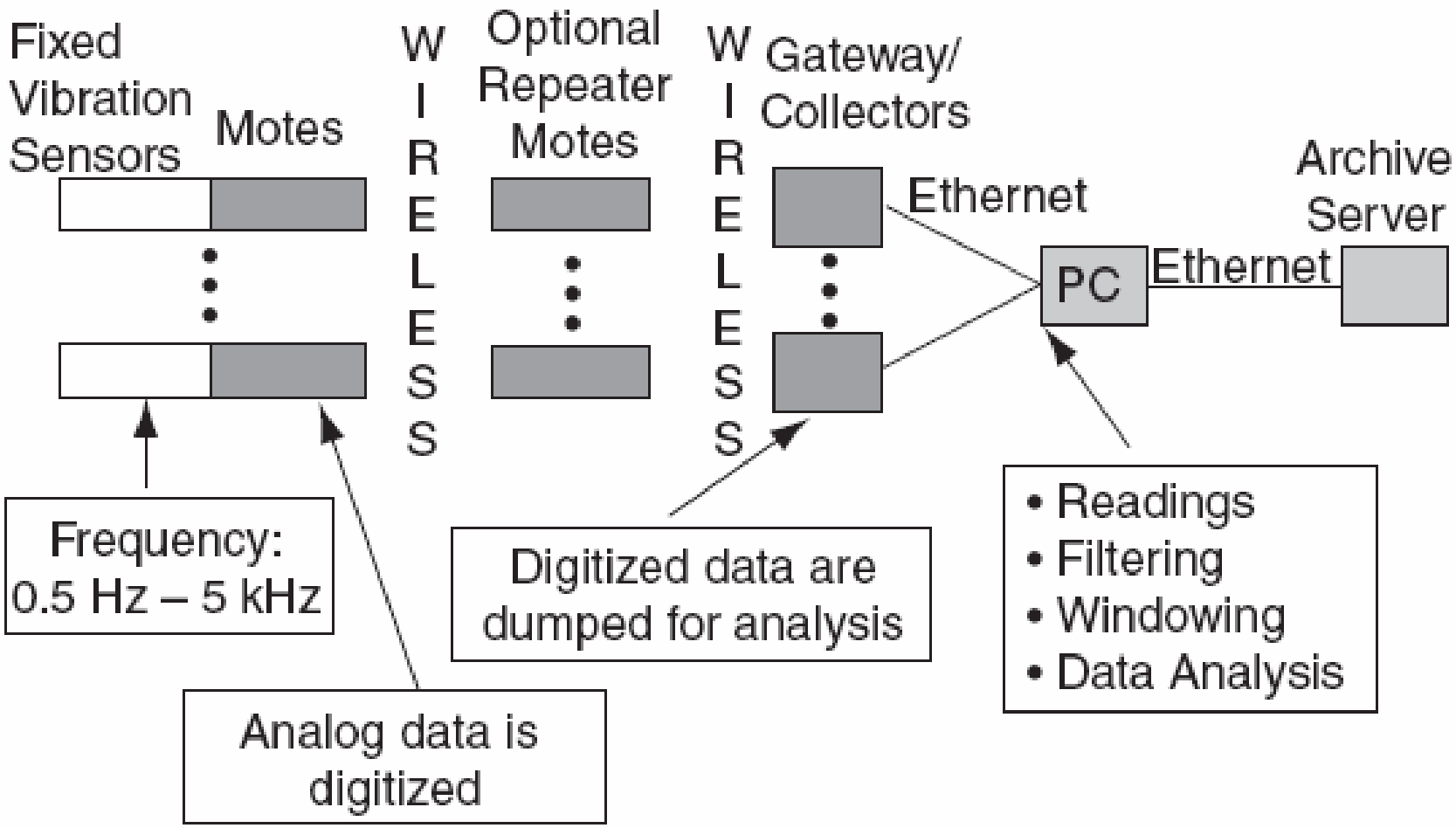


EXAMPLES OF CATEGORY 1 WSN APPLICATIONS

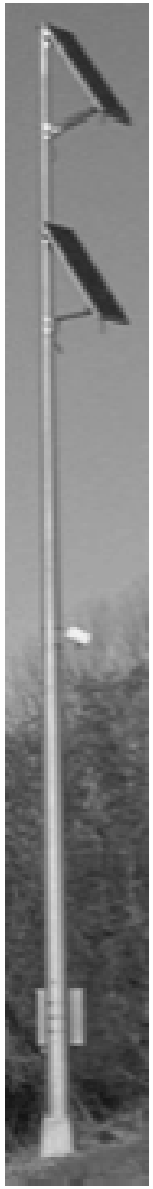
- **National Security System**



Intel fab environment with WSNs.

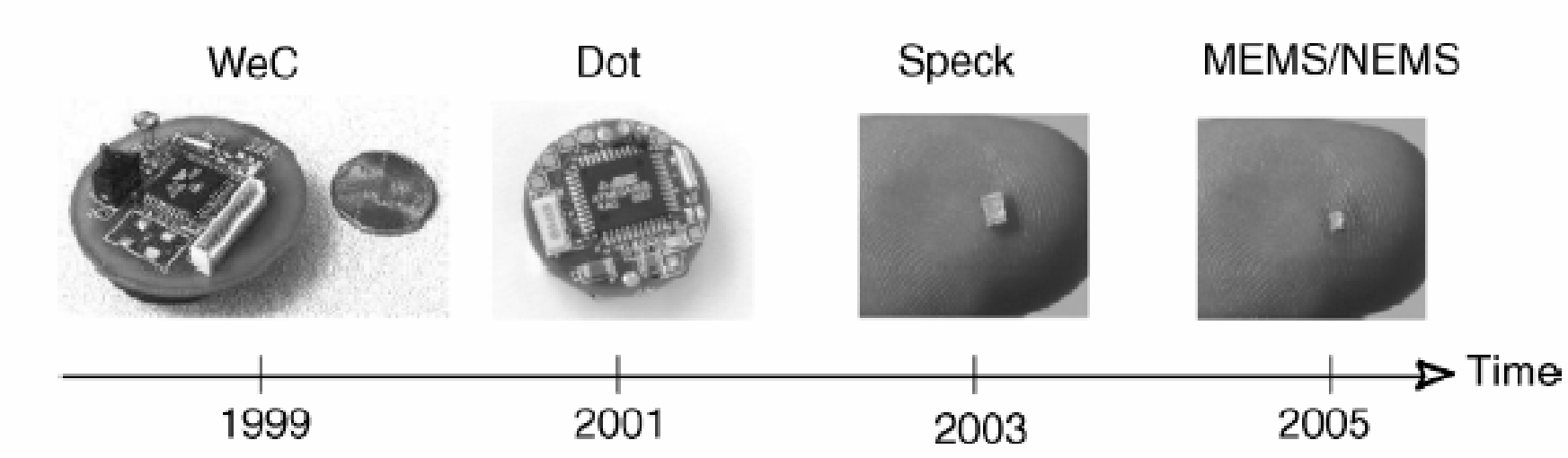


Highway Monitoring



Basic wireless sensor Technology (Chapter-3)

- The terms sensor node, wireless node (WN), Smart Dust, mote, and COTS (commercial off-the-shelf) mote are used somewhat interchangeably in the industry.
- The most general terms used here are sensor node and WN.



Sensor Network Technology

- The basic functionality of a WN generally depends on the application, but the following requirements are typical :

1. Determine the value of a parameter at a given location. For example, in an environment-oriented WSN, one might need to know the temperature, atmospheric pressure, amount of sunlight, and the relative humidity at a number of locations. This example shows that a given WN may be connected to different types of sensors, each with a different sampling rate and range of allowed values.

2. Detect the occurrence of events of interest and estimate the parameters of the events. For example, in a traffic-oriented WSN, one would like to detect a vehicle moving through an intersection and estimate the speed and direction of the vehicle.
3. Classify an object that has been detected. For example, is a vehicle in a traffic sensor network a car, a minivan, a light truck, a bus?
4. Track an object. For example, in a military WSN, track an enemy tank as it moves through the geographic area covered by the network.

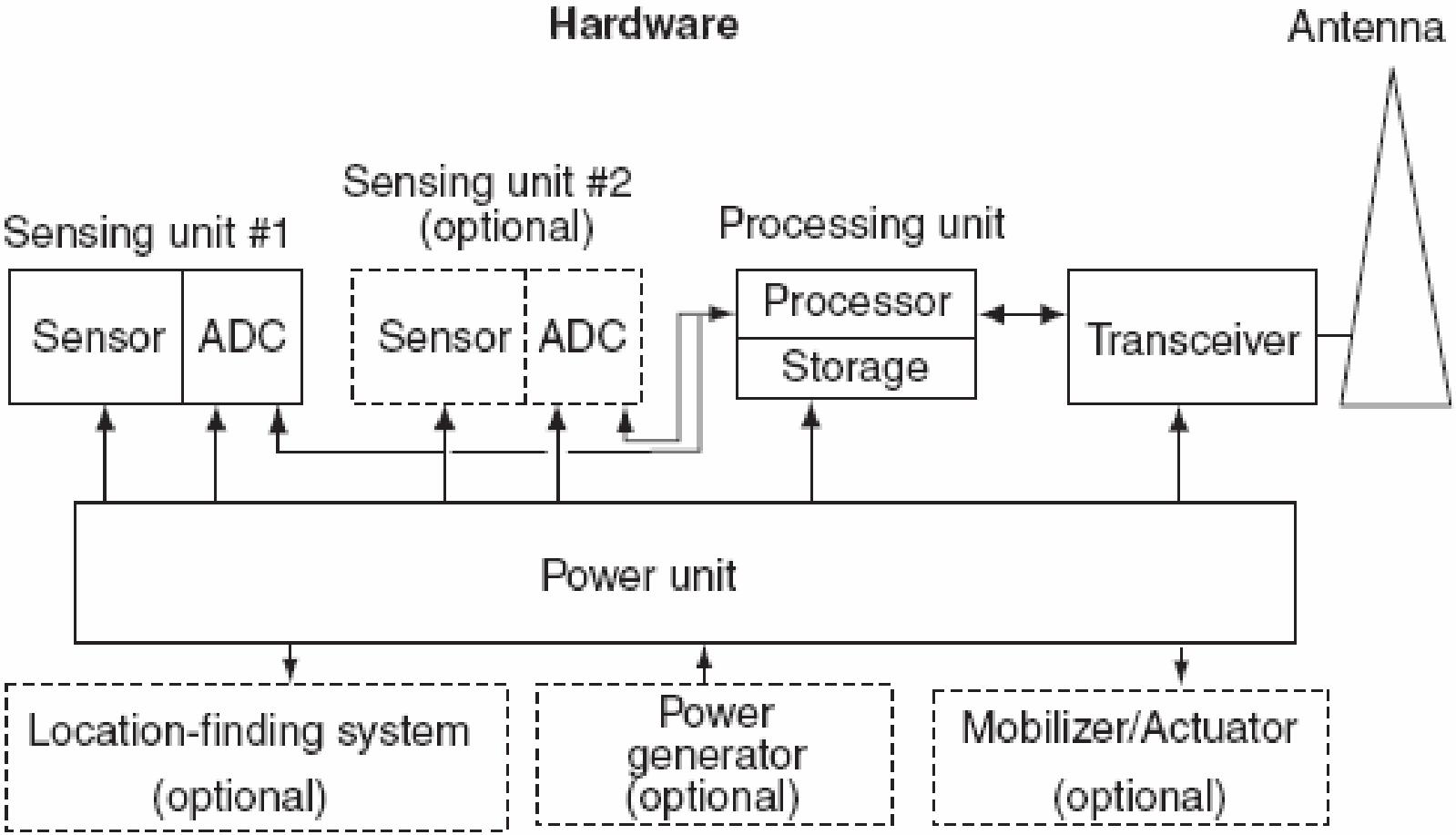
Typical sensor parameters (measurands) include:

- **Physical measurement**. Examples include two-axis magnetometers; light and ultraviolet intensity (photo resistor); radiation levels, radio, and microwave; humidity, temperature (thermistor), atmospheric pressure, fog, and dust; sound and acoustics; two-axis accelerometers, shock wave, seismic, physical pressure, and motion; video and image (visible or infrared); and location (GPS) and locomotion measurements.
- **Chemical and biological measurements**. Examples include the presence or concentration of a substance or agent at specified concentration levels (there are no less than 50 biological agents of interest.
- **Event measurement**. Examples include determination of the occurrence of human-made or natural events, including cyber-level events; tracking of internal and external events.

Hardware and Software

Related to WN design, the following functionality typically needs to be supported:

- intrinsic node functionality; signal processing, including digital signal processing (e.g., FFT/DCT), compression, forward error correction, and encryption; control and actuation; clustering and in-network computation; self-assembly; communication; routing and forwarding; and connectivity management.
- To support this functionality, the hardware components of a WN include the sensing and actuation unit (single element or array), the processing unit, the communication unit, the power unit, and other application-dependent units.



ADC = Analog-to-Digital Converter

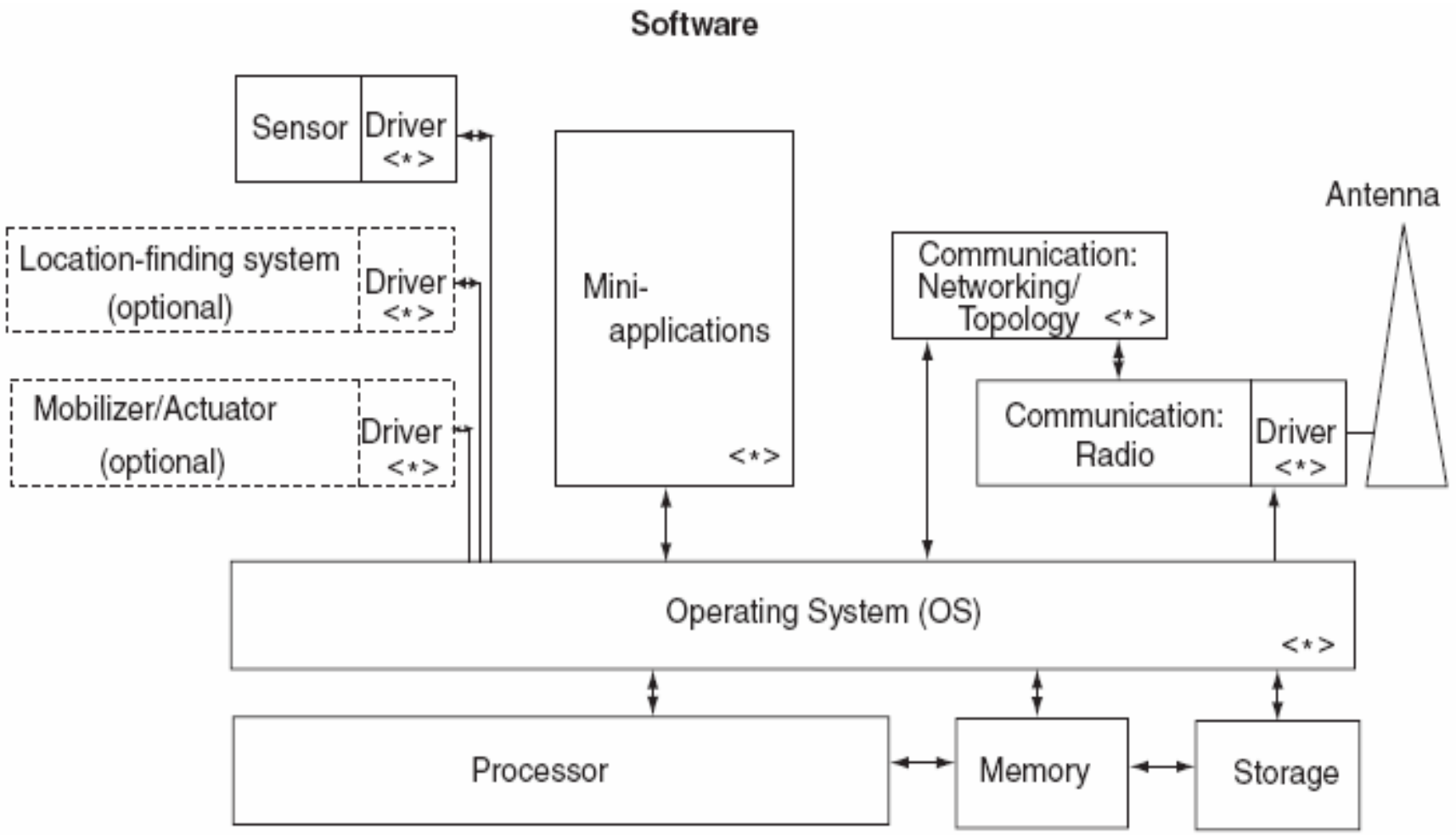
- Sensors, particularly Smart Dust and COTS motes, have four basic hardware subsystems:

1. **Power.** An appropriate energy infrastructure or supply is necessary to support operation from a few hours to months or years (depending on the application).
2. **Computational logic and storage**. These are used to handle onboard data processing and manipulation, transient and short-term storage, encryption, forward error correction (FEC), digital modulation, and digital transmission. WNs have computational requirements typically ranging from an 8-bit microcontroller to a 64-bit microprocessor. Storage requirements typically range from 0.01 to 100 gigabytes (GB).

3. **Sensor transducer(s)**. The interface between the environment and the WN is the sensor. Basic environmental sensors include, but are not limited to, acceleration, humidity, light, magnetic flux, temperature, pressure, and sound.

4. **Communication.** WNs must have the ability to communicate either in C1WSN arrangements (mesh-based systems with multihop radio connectivity among or between WNs, utilizing dynamic routing in both the wireless and wireline portions

Software


Software
Sensor
Driver
<*>
Location-finding system
(optional)
Driver
<*>
Mobilizer/Actuator
(optional)
Driver
<*>
Mini-
applications
<*>
Communication:
Networking/
Topology
<*>
Antenna
Communication:
Radio
Driver
<*>
Operating System (OS)
<*>
Processor
Memory
Storage

- Sensors typically have five basic software subsystems:

1. **Operating system (OS) microcode (also called middleware).** This is the board common microcode that is used by all high-level node-resident software modules to support various functions. As is generally the case, the purpose of an operating system is to shield the software from the machine-level functionality of the microprocessor. It is desirable to have open-source operating systems designed specifically for WSNs; these OSs typically utilize an architecture that enables rapid implementation while minimizing code size. TinyOS is one suc example of a commonly used OS.
2. **Sensor drivers**. These are the software modules that manage basic functions of the sensor transceivers; sensors may possibly be of the modular/plug-in type, and depending on the type and sophistication, the appropriate configuration and settings must be uploaded into the sensor (drivers shield the application software from the machine-level functionality of the sensor or other peripheral).

3. **Communication processors**. This code manages the communication functions, including routing, packet buffering and forwarding, topology maintenance, medium access control (e.g., contention mechanisms, direct-sequence spread-spectrum mechanisms), encryption, and FEC, to list a few (e.g., see Figure 3.3).
4. **Communication drivers** (encoding and the physical layer). These software modules manage the minutia of the radio channel transmission link, including clocking and synchronization, signal encoding, bit recovery, bit counting, signal levels, and modulation.
5. **Data processing mini-apps**. These are numerical, data-processing, signal value storage and manipulations, or other basic applications that are supported at the node level for in-network processing.

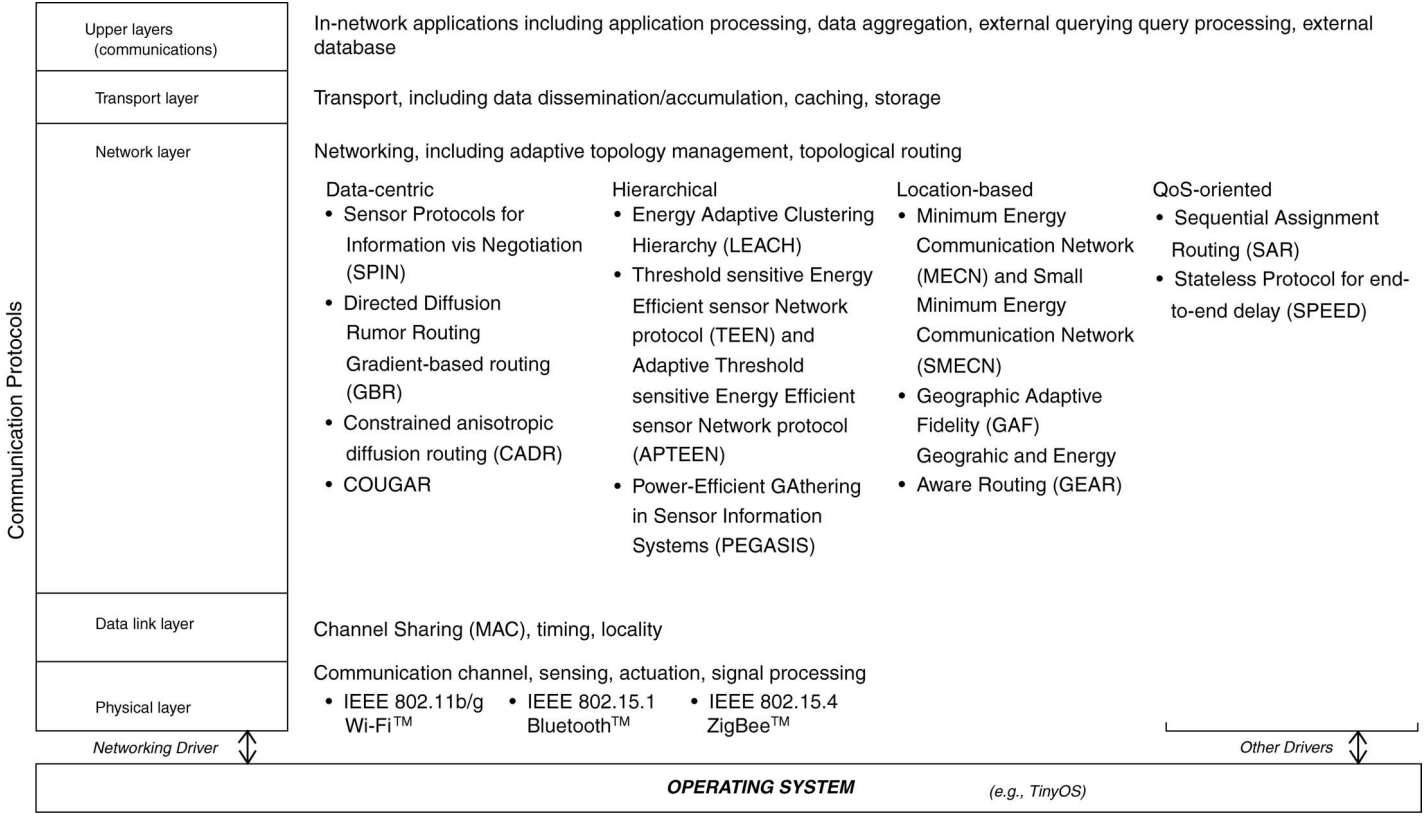


Figure 3.3 Some of the networking protocols supported by WNs.

Taxonomy of Sensor Nodes

Size of Sensor, s	Mobility of Sensor, m	Power of Sensor, p	Computation Logic and Storage Capability of Sensor, cp	Sensor Mode, md	Communication Apparatus or Protocols of Sensor, cm
1 Large	1 Mobile	1 Self-replenishable	1 High-end processor and storage	1 Multimodal, physics	1 Multihop/mesh with dynamic routing
2 Small	2 Static	2 Battery, hours–days	2 Midrange processor and storage	2 Multimodal, chemistry/biology	2 Single hop with static routing
3 Microscopic		3 Battery, weeks–months	3 Low-end processor and storage	3 Single function, physics	
4 Nanoscopic		4 Battery, years		4 Single function, chemistry–biology	

Taxonomy of WSN

1. Nonpropagating WSN systems
2. Deterministic routing WSN systems
   a. Aggregating
   b. Nonaggregating systems
3. Self-configurable and self-organizing WSN systems
   a. Aggregating
   b. Nonaggregating systems