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Wireless Sensor Technologies

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Brief Introduction to Wireless Sensor Networks WSNs

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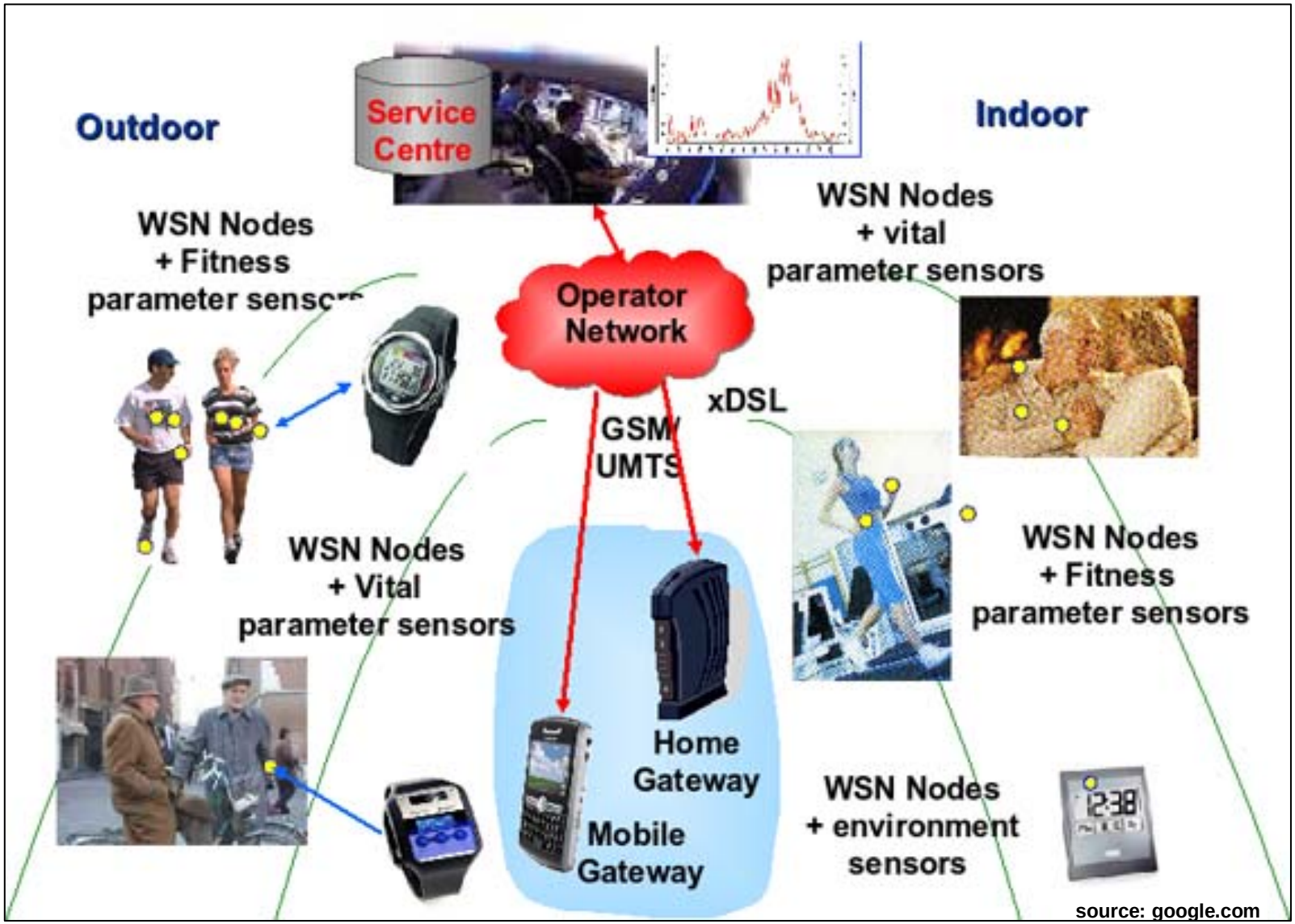
Broad Definition of a WSN

An infrastructure comprised of:

- sensing (measurement)
- computing
- communication

elements to give an administrator the ability to observe and react to events and phenomena in a specified environment.

Wide range of uses of WSNs



Introduction to WSNs

- some similarities with common networks
- also some peculiar differences, specially in terms of
  - protocols
  - energy management
  - routing
- makes the treatment somewhat different
- requires special protocols, mechanisms to deal with WSNs

Introduction to WSNs

- some problems are specific to the application domain
- whereas some others are generic
- in this introduction I will highlight some of the problems, difficulties and current solutions
- there is always the possibility of making improvements

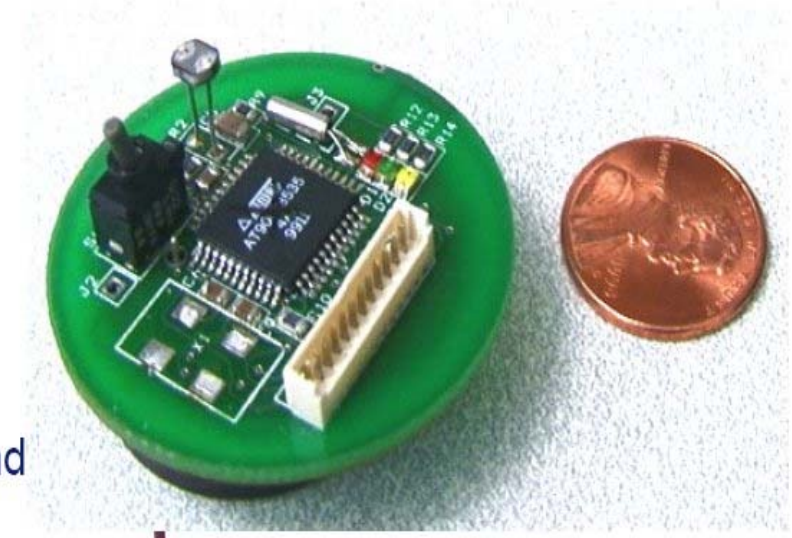
Introduction to WSNs

Wireless sensor networks have become the focus of intense R&D in the past few years due to:

- falling cost of production of small microprocessors with sufficient on board resources
- availability of small cheap sensors
- long life time of batteries
- availability of cheap wireless transceivers for short and medium range
- ability to gather and share information in real-time in unattended, sometimes hostile, environments.

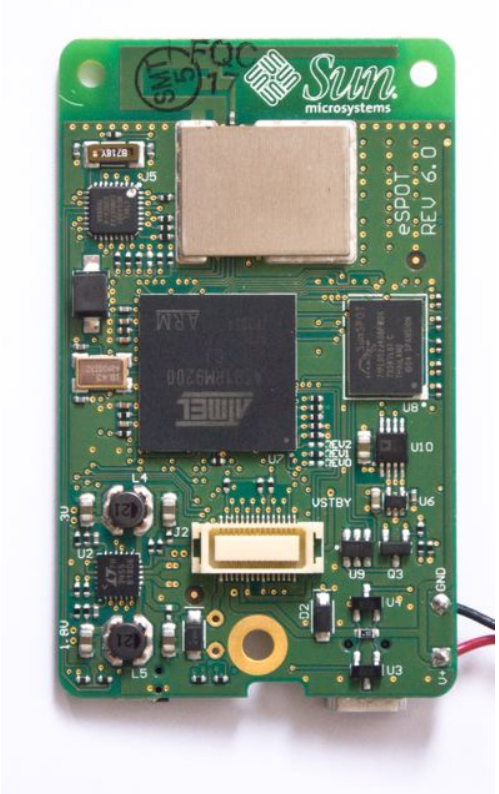
Typical early WSN node

- Tiny devices
- Constrained processor
  - 4Mhz, 8-bit operations
- Little memory
  - 128KB Flash, 4KB EEPROM and 4KB RAM
- Low bit rate communication
  - 40Kbits/second
- Short transmission range
  - ~30 meters (100 feet)
- Low energy
  - Running on batteries



source: google.com

Current WSN Hardware
SunSpot



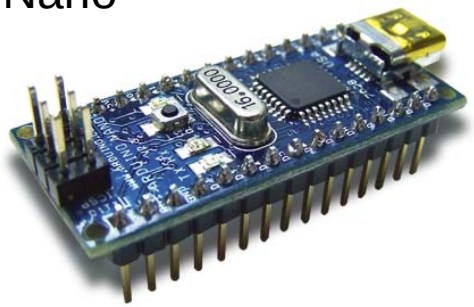
eSPOT Main Board Features

ARM920T 180MHz Processor (Atmel AT91RM9200)
4Mbyte Flash PROM
512Kbyte Psuedo static RAM
2.4GHz 802.15.4 DSSS Radio Transceiver (TI CC2420)
Real Time Clock and Power Management Processor (Atmega88)
USB Battery Charger/Switching Regulator (Linear LTC3455)
30 pin high density interboard connector

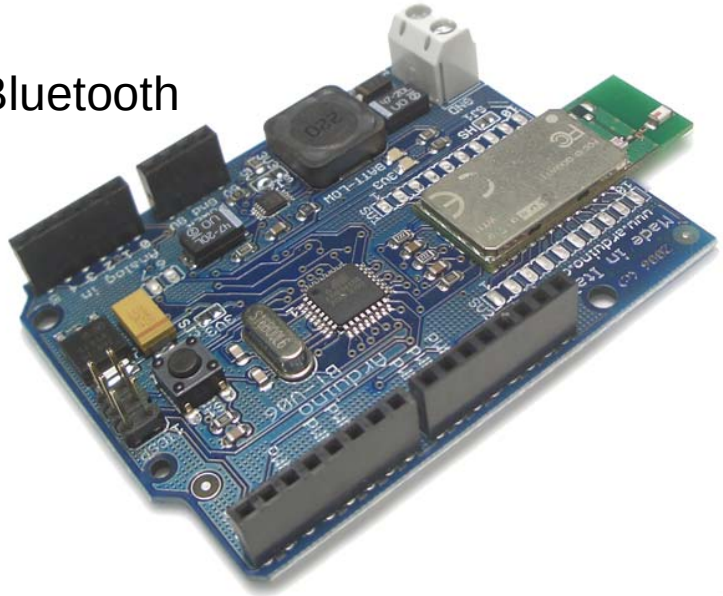
source: https://spots.dev.java.net/

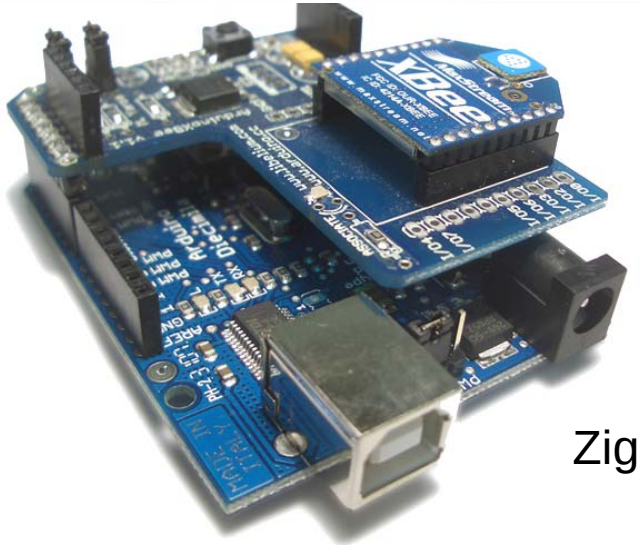
Current WSN Hardware
Arduino Family

Nano

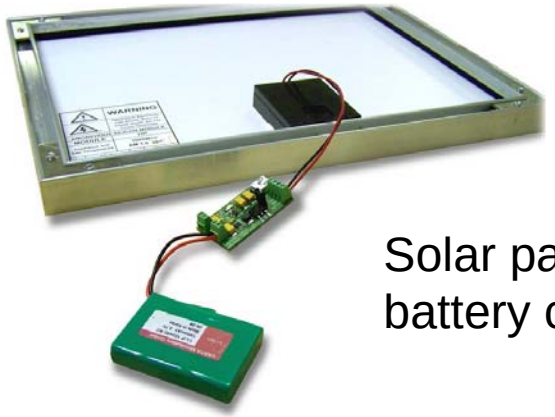


Bluetooth





ZigBee



Solar panel
battery charger

source: http://www.libelium.com/tienda/catalog/index.php

Some Measurement Sensors for Environmental Monitoring

pH and Redox (ORP) Sensor

DO Sensor

Sodium Sensor

Methane Gas Sensor

- A wide collection of sensors is available from many suppliers for most measurements.
- Most common sensors give an output of few hundred mV.

Introduction to WSNs

Wireless sensor networks in terms of

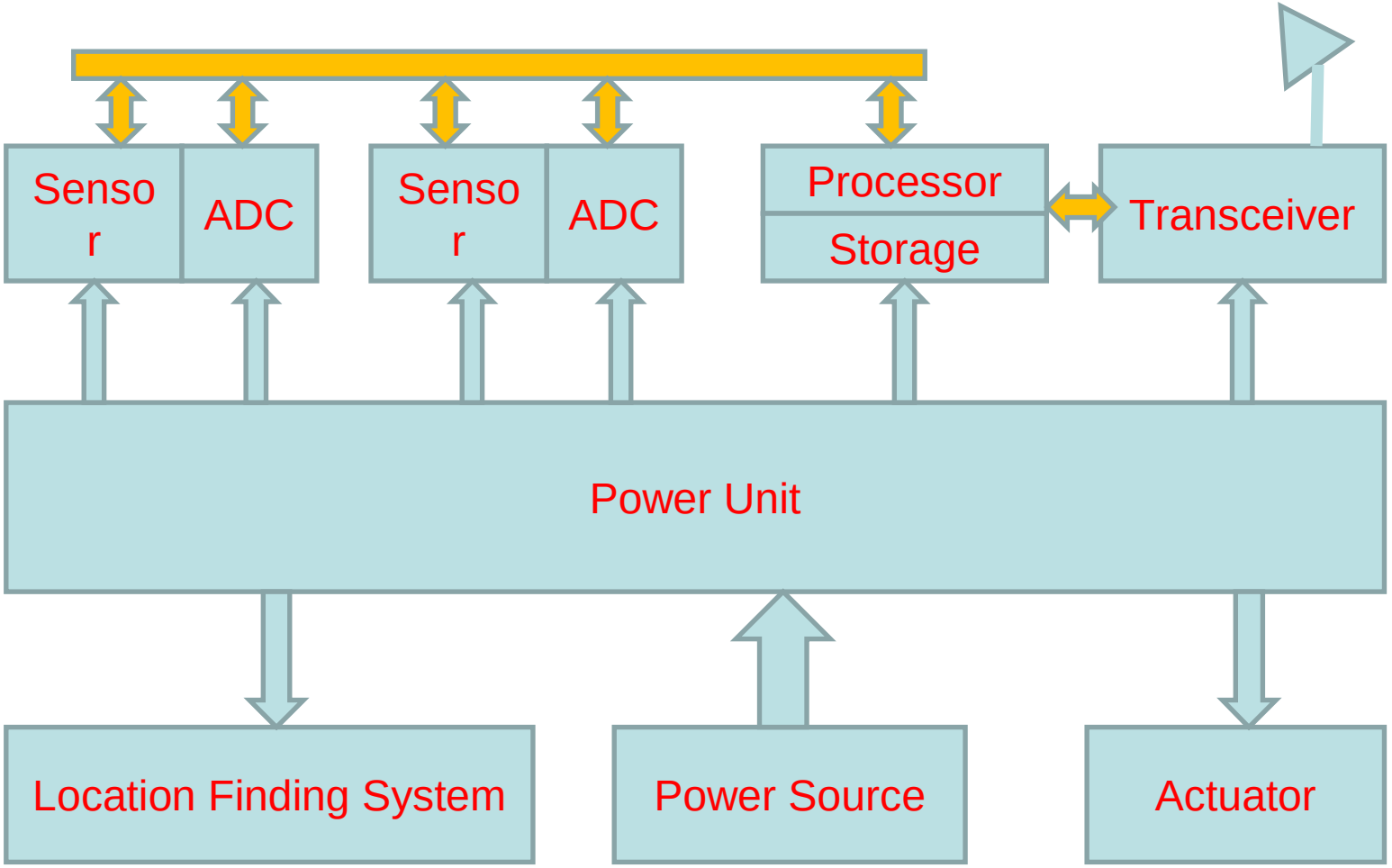
- Applications
- Architecture
- Wireless Protocols
- Wireless Technologies

WSN Applications

WSNs find their applications in many number of real life situations

- Environmental Monitoring
  - Forest Fire Detection
  - Flood Detection
  - Structural Integrity Detection
  - Volcanic Activity Monitoring
- Health care
- Positioning and animal tracking
- Logistics
- Transportation
- Industrial Applications
- Agricultural Applications

Typical Architecture of a Sensing Node



Protocols for WSNs

- Classic MAC routing protocols suitable for wireless data networks are not suitable for WSNs

Protocols for WSNs

- Challenges:
  - nodes are based on battery supplied power
  - typical application environments do not allow simple battery change
  - often nodes are deployed in an ad-hoc manner; there is little or no pre-planning
  - node density is generally high but this can vary in different places
  - some areas can be sparse while the others may have many neighbours; meaning more communication
  - traffic is generated by sensing events; can be extremely bursty

Protocols for WSNs

- MAC and routing protocols have to tackle each of these issues
- MAC and routing protocols should be extremely energy efficient
- they should address the major sources of energy waste

MAC Protocols for WSNs

- Causes for energy wastage at the MAC layer:
  1. retransmission of data after a collision
  2. *overhearing* – receiving data destined to other nodes
  3. overheads due to control data
  4. idle active listening to receive possible data traffic

Design of MAC Protocols for WSNs

To reduce energy consumption

- put nodes into a sleep state as much as possible

Needs to address issues due to aggressive sleep policy, for example:

1. connectivity of the whole network
2. time synchronisation
3. routing

Design of MAC Protocols for WSNs

Two types of MAC protocols are possible:

1. Scheduled protocols
   - TDMA – Time Division Multiple Access
   - nodes can turn off the radio during the slots of other nodes – reduces overhearing
   - not easily scalable – when new nodes join or existing ones leave, the base station must adjust the slot allocation

Design of MAC Protocols for WSNs

Two types of MAC protocols are possible:

2. Contention-based protocols

more flexible with respect to changes in

- traffic/load
- network topology
- node density

because resource allocation is done in an "on-demand" fashion.

Some form of CSMA extension is used.

Routing Protocols for WSNs

- Routing in WSNs faces a different set of challenges compared to other wireless networks, such as cellular or mobile
- WSNs have large number of sensor nodes
- getting the data is often more important than knowing the identity of the source
- Since data collected by sensors in a WSN are typically based on a common phenomena, hence highly correlated with a lot of redundancy
- This redundancy must be exploited by the routing protocol
- One reference lists 17 routing protocols

Communication Technologies for WSNs

- ZigBee technology
- Bluetooth technology
- Infrared IrDA technology
- RFID technology

Communication Technologies for WSNs

ZigBee technology

- low complexity
- low cost
- low power consumption
- low data rate transmission
- standardised by the IEEE 802.15.4

Communication Technologies for WSNs

Bluetooth technology

operates in the ISM 2.4 GHz band

- robust
- low cost
- low power consumption
- low data rate transmission
- short range operation
- standardised by the IEEE 802.15.1

Communication Technologies for WSNs

Infrared (IrDA)

point-to-point

- low – high data rate transmission (9600 bps to several Mbps)
- very short range operation (up to 1 m)

Communication Technologies for WSNs

Radio Frequency Identification (RFID)

operates at LF (> 100 MHz), HF (< 100 MHz) or UHF (868 – 954 MHz)

- two types of tags
- active or self powered tags can be read at a greater distance
- passive or unpowered – can be powered at a distance by a reader which is kept within a few feet
- operates at low frequency

Wireless Sensor Networks

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Wireless Sensor Networks

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