Introduction: Wireless Sensor Networks Part I

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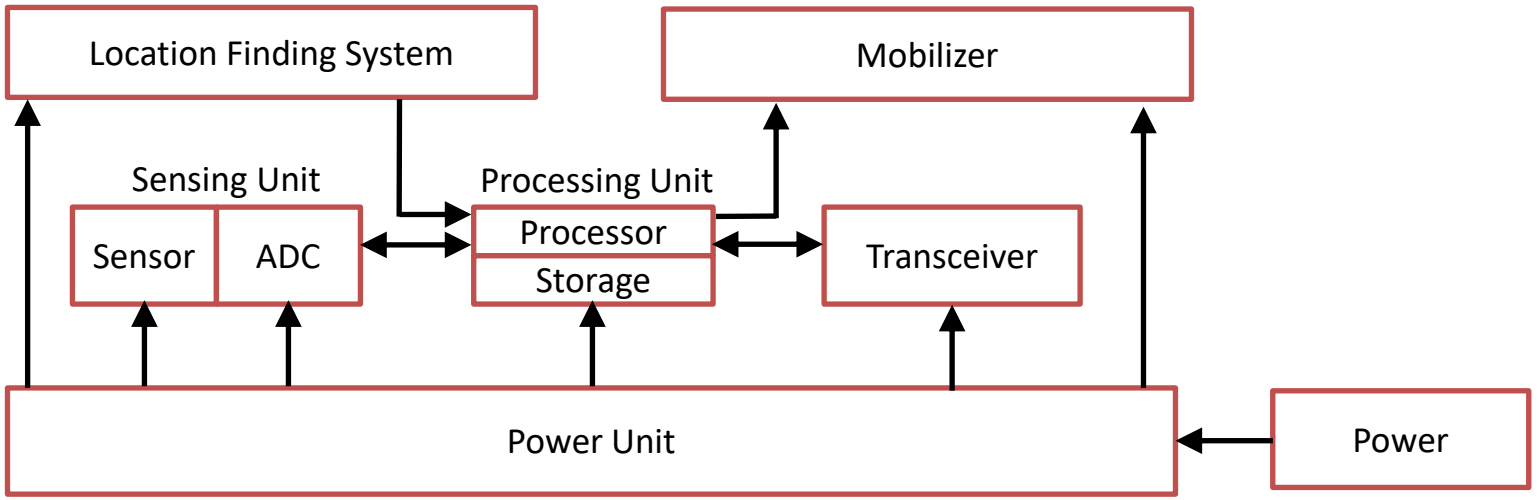
Wireless sensor networks (WSNs)

- Consists of a large number of sensor nodes, densely deployed over an area.
- Sensor nodes are capable of collaborating with one another and measuring the condition of their surrounding environments (i.e. Light, temperature, sound, vibration).
- The sensed measurements are then transformed into digital signals and processed to reveal some properties of the phenomena around sensors.
- Due to the fact that the sensor nodes in wsn have short radio transmission range, intermediate nodes act as relay nodes to transmit data towards the sink node using a multi-hop path.

Basic Components of a Sensor Node



Sensing unit
Processing unit
Transceiver unit

Power unit

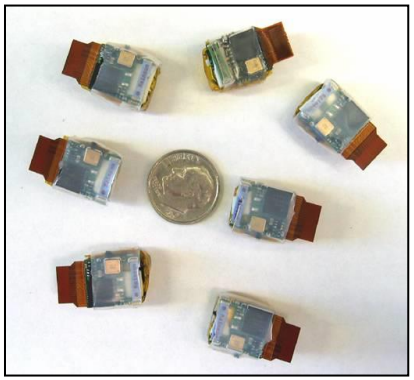
Application-dependent units (e.g., location finding system, mobilizer unit).

Disclaimer: Pictures above adopted from different (copyrighted) sources in the Internet.

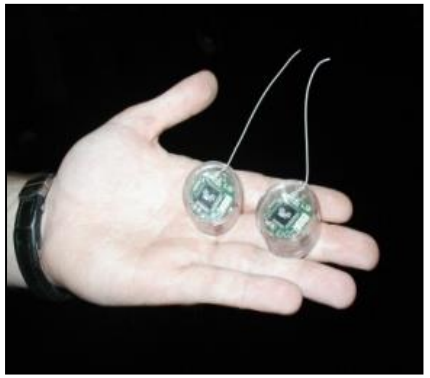
Sensor Nodes (Different Sizes & Shapes)

(a)

(b)



(c)



(d)

(a) Xbow mica mote [ZESS] (b) Eco [CHOU] (c) Eco [MOTE] (d) dots [BERK]

- Multifunctional
  - The number of sensor nodes used depends on the application type.
- Short transmission ranges
- Have OS (e.g., TinyOS).
- Battery Powered – Have limited life.

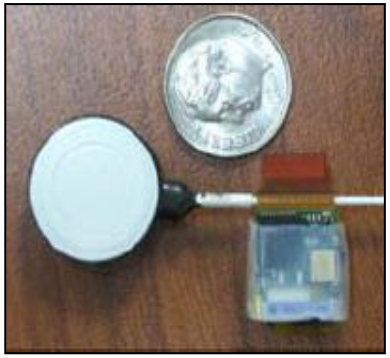
Disclaimer: Pictures above adopted from different (copyrighted) sources in the Internet.

Constraints on the Sensor Nodes

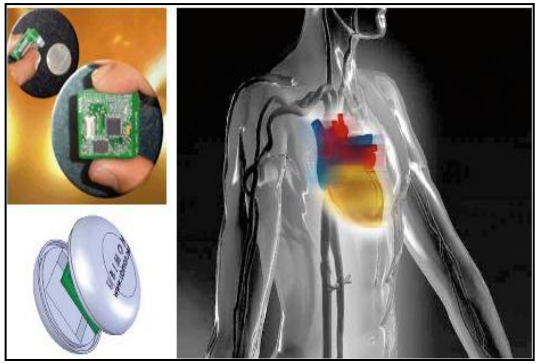
- Small size, typically less than a cubic cm.
- Must consume extremely low power
- Operate in an unattended manner in a highly dense area.
- Should have low production cost and be dispensable
- Be autonomous
- Be adaptive to the environment

Applications on the Sensor Nodes

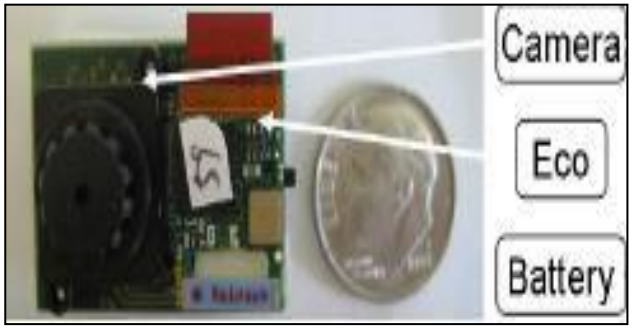
- Temperature measurement
- Humidity level
- Lighting condition
- Air pressure
- Soil makeup
- Noise level
- Vibration



(A) ECG sensor and eco with a dime coin [PCB06]



(B) Cardiac monitoring via implanted sensor node [38]



(C) Ecam with a dime coin [PC06]

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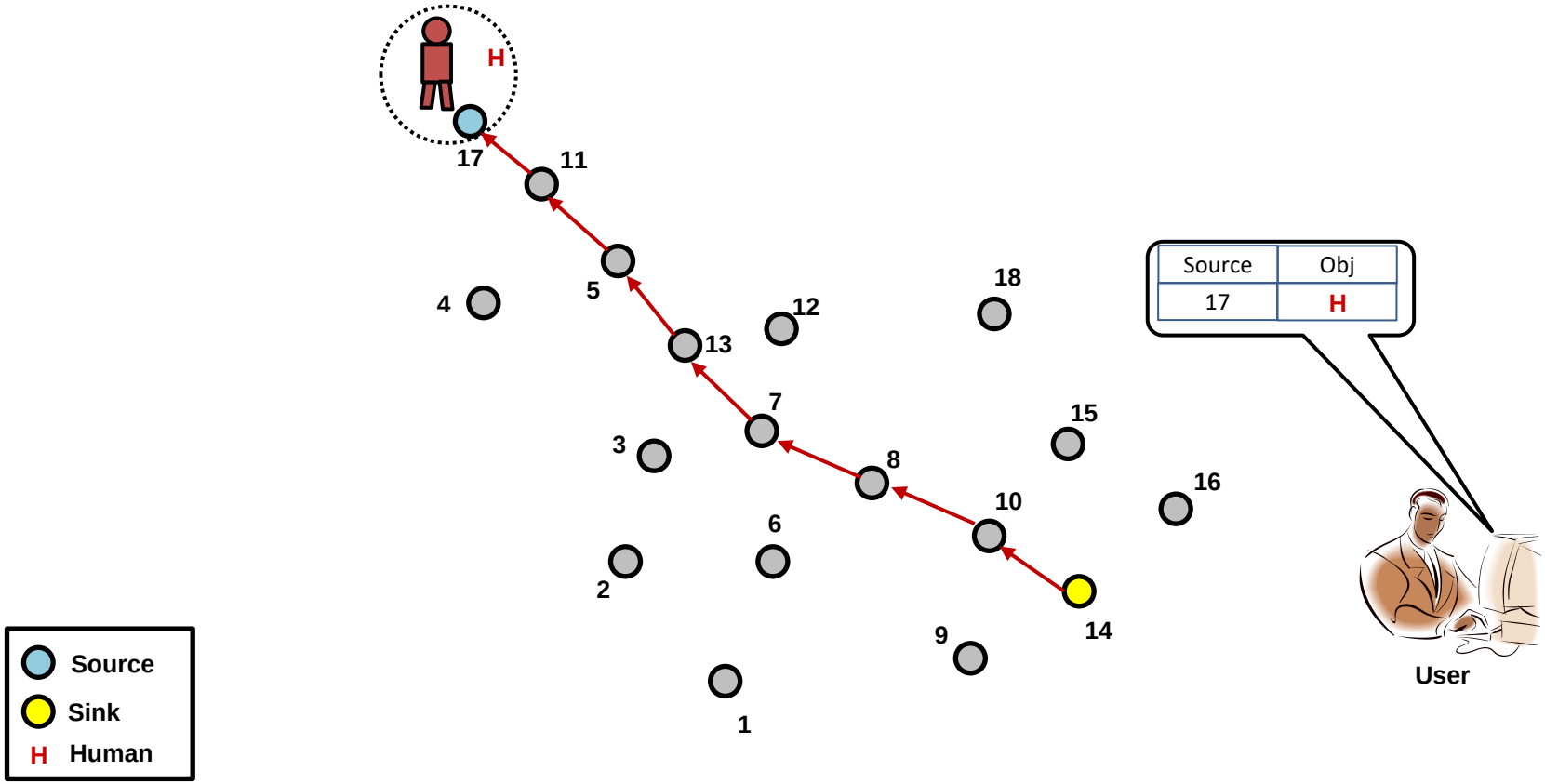
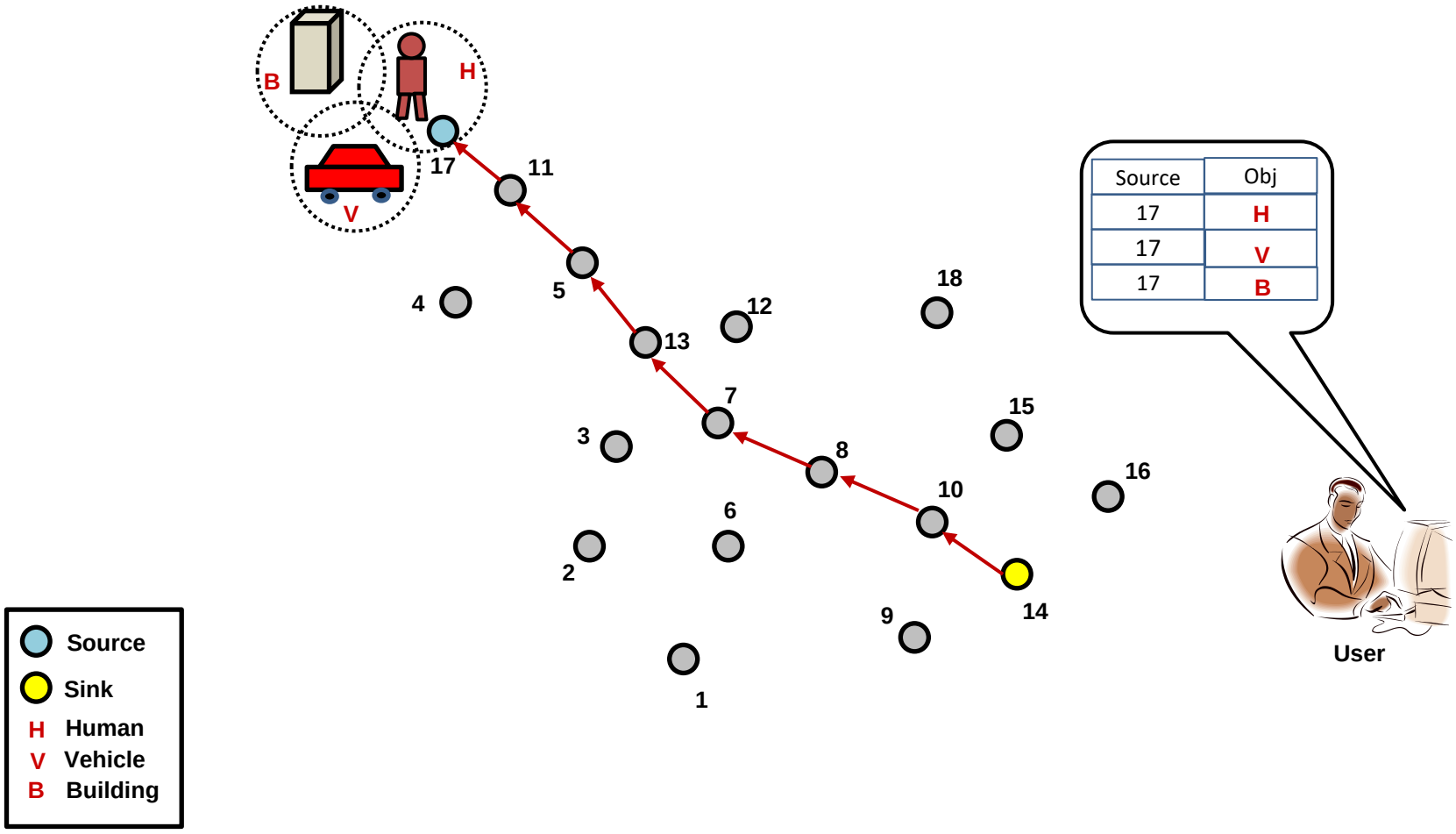
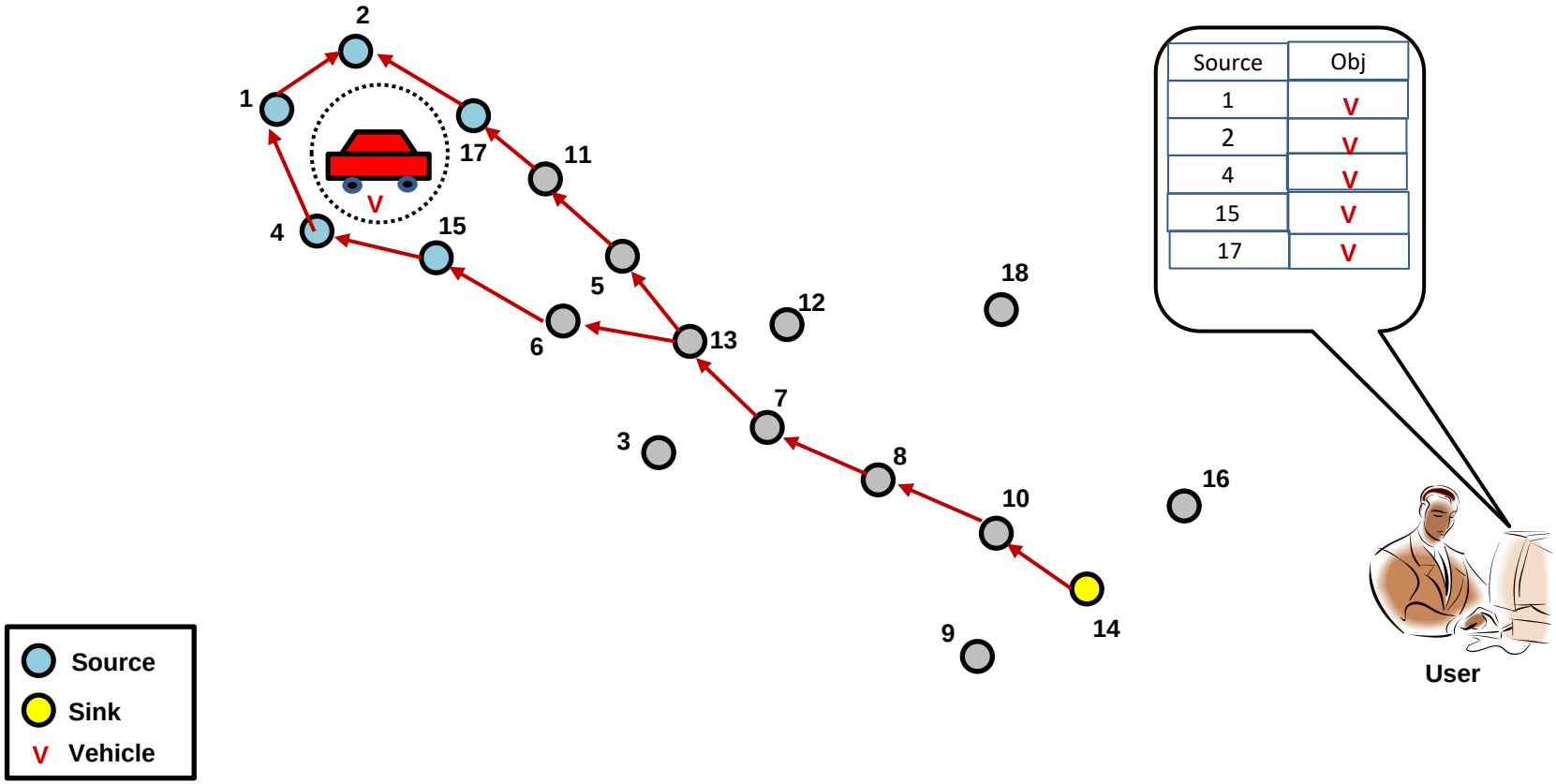
Single Source detects Single Object



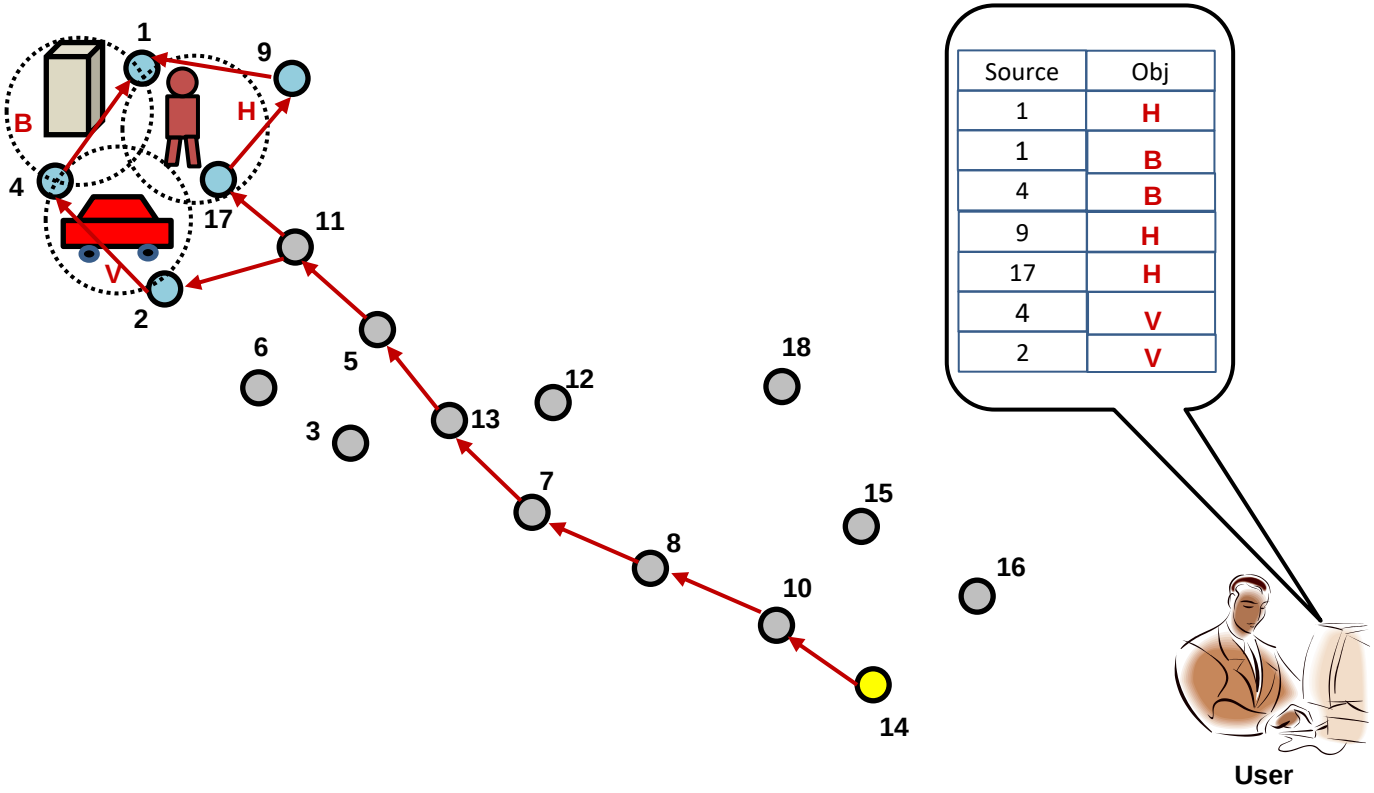
Single Source detects Multiple Objects



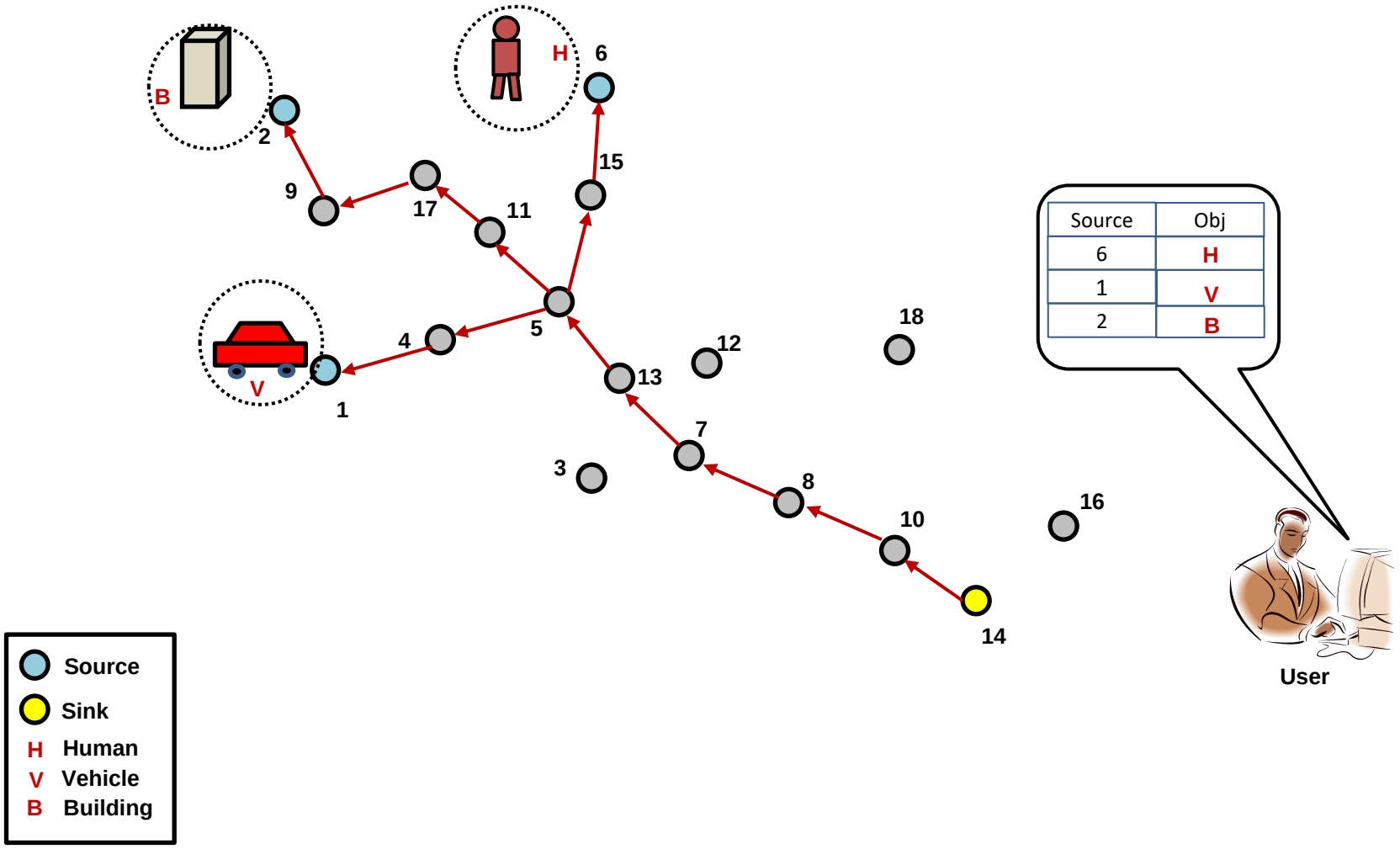
Multiple Sources detect Single Object



Multiple Sources detect Multiple Objects



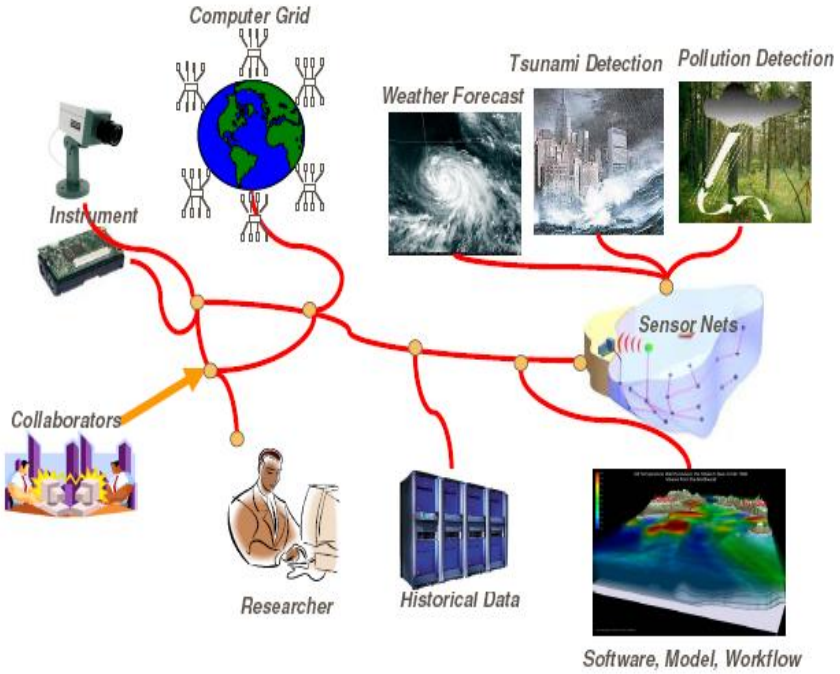
Single Source detects Multiple Objects



Common challenges

- Scalability
  - Providing acceptable levels of service in the presence of large number of nodes.
  - Typically, throughput decreases at a rate of $1/\sqrt{N}$, N = number of nodes.
- Quality of service
  - Offering guarantees in terms of bandwidth, delay, jitter, packet loss probability.
  - Limited bandwidth, unpredictable changes in RF channel characteristics.
- Energy efficiency
  - Nodes have limited battery power
  - Nodes need to cooperate with other nodes for relaying their information.
- Security
  - Open medium.
  - Nodes prone to malicious attacks, infiltration, eavesdropping, interference.

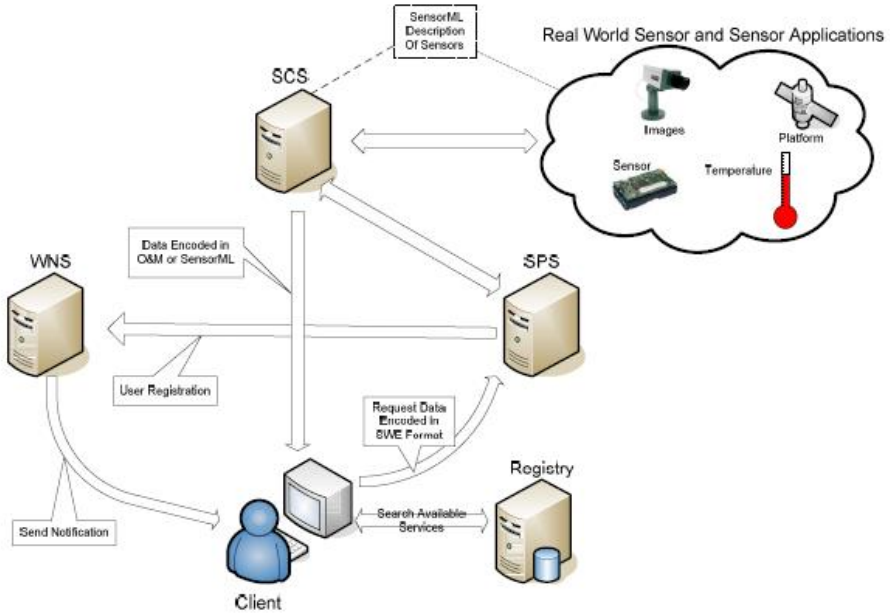
Sensor Web



Data acquisition (RT, nRT)

+

Data Dissemination / Sharing



X. Chu and R. Buyya, "Service Oriented Sensor Web", Sensor Networks and Configuration, Springer, 2007, pp. 51-74.

Sensor Web Enablement

- Observations & measurements (O&M)
- Sensor model language (sensorml)
- Transducer model language (transducerml or TML)
- Sensor observations service (SOS)
- Sensor planning service (SPS)
- Sensor alert service (SAS)
- Web notification services (WNS)

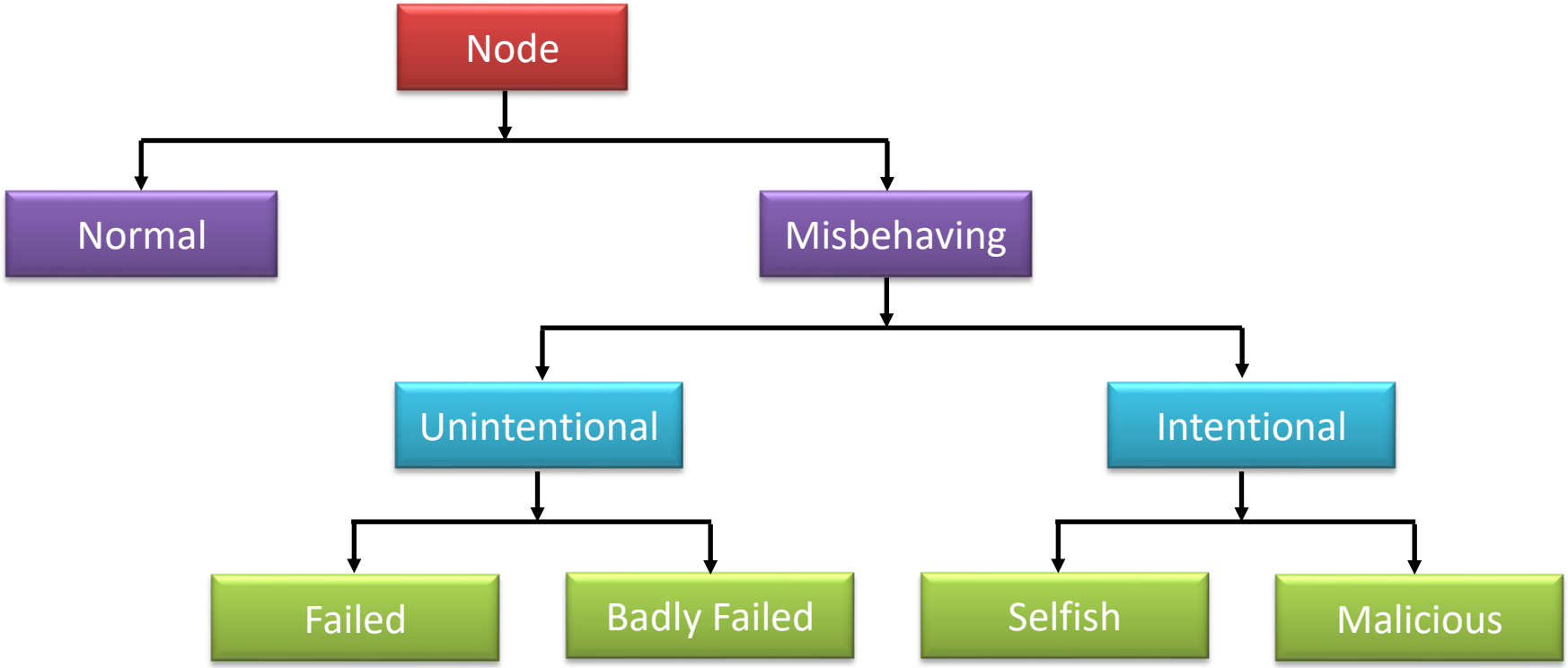
Cooperation in Wireless Ad Hoc and Sensor Networks

- Nodes communicate with other nodes with the help of intermediate nodes.
- The intermediate nodes act as relays.
- Wireless nodes are energy-constrained.
- Nodes may or may not cooperate.
- Two extremities:
  - Total cooperation: if all relay requests are accepted, nodes will quickly exhaust limited energy.
  - Total non-cooperation: if no relay requests are accepted, the network throughput will go down rapidly.
- Issues:
  - Selfishness, self-interests, etc.
  - Symbiotic dependence
  - Tradeoff: individual node's lifetime vs. Throughput.

Security Challenges in Cooperation

- Open, shared radio medium by the nodes, which dynamically change positions.
- No centralized network management or certification authority.
- Existence of malicious nodes.
- Nodes prone to attacks, infiltration, eavesdropping, interference.
- Nodes can be captured, compromised, false routing information can be sent – paralyzing the whole network.
- The cooperating node or the node being cooperated might be victimized.

Types of Node Behavior



Types of Node Behavior (Contd…)

- Normal nodes work perfectly in ideal environmental conditions
- Failed nodes are simply those unable to perform an operation; this could be because power failure and environmental events.
- Badly failed nodes exhibit features of failed nodes but they can also send false routing messages which are a threat to the integrity of the network.
- Selfish nodes are typified by their unwillingness to cooperate, as the protocol requires whenever there is a personal cost involved. Packet dropping is the main attack by selfish nodes.
- Malicious nodes aim to deliberately disrupt the correct operation of the routing protocol, denying network service if possible.

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End of Module I

Thank You!