IoT
Sensor Networks

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CS698T, Lecture 8

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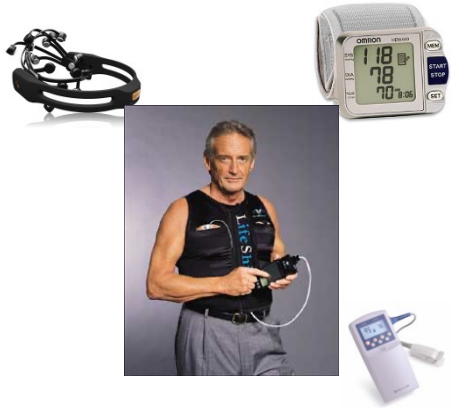
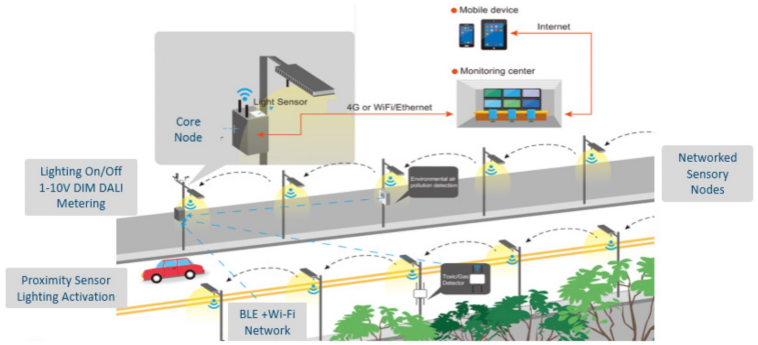
Sensor Network Applications

Smart Home

Precision Agriculture[1]



Remote Health Monitoring

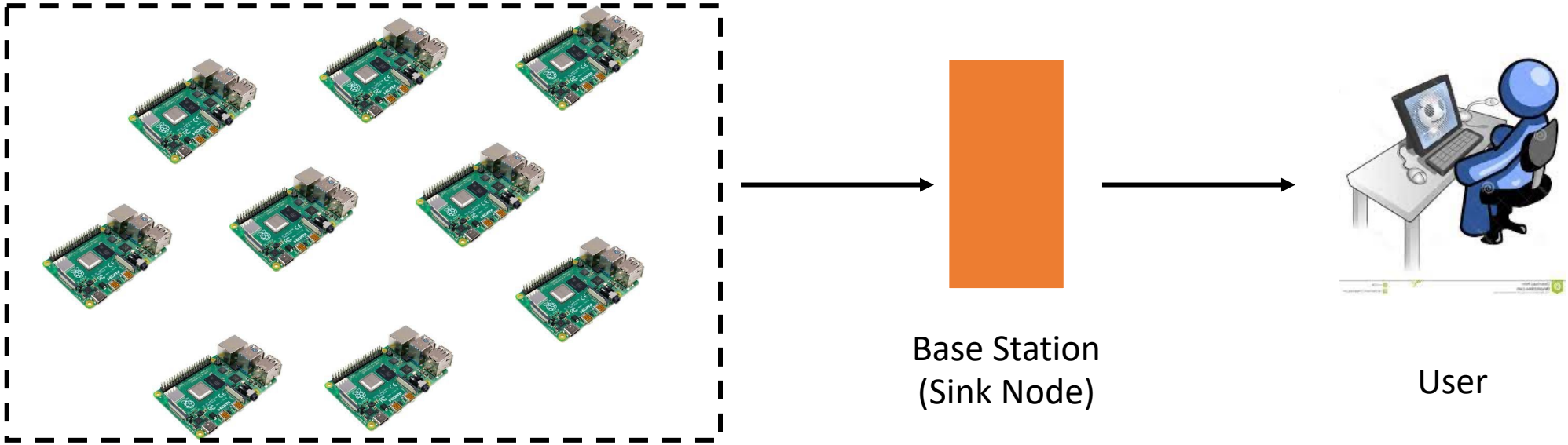


Smart Infrastructure

1. https://www.mccourier.com/explore-how-smart-agriculture-market-is-changing-business-trends-by-2021-by-focuses-on-cisco-systems-inc-semiosbio-technologies-inc-trimble-navigation-ltd-salt-mobile-sa-deere-compan/

Wireless Sensor Network

- A network of sensors cooperatively sensing together to collect data and control the environment



Sensor nodes

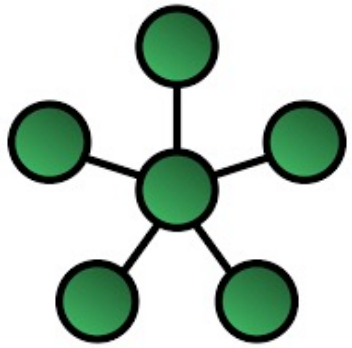
Base Station
(Sink Node)

User

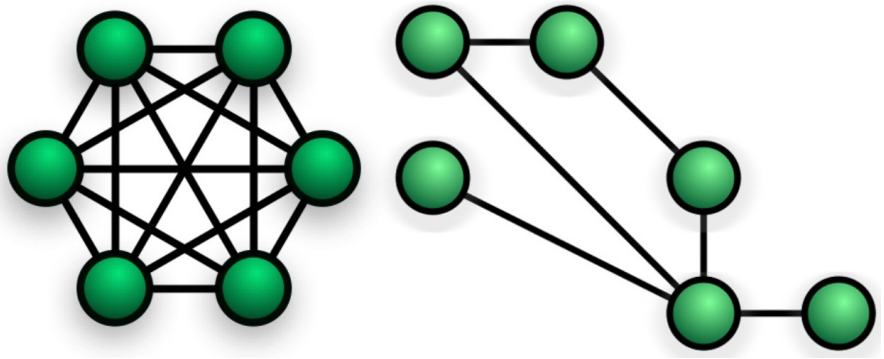
Sensor Node Architecture

- Sensing Unit
- Analog to Digital Convertor
- Processor
- Transceiver
- Power source
- On board Memory

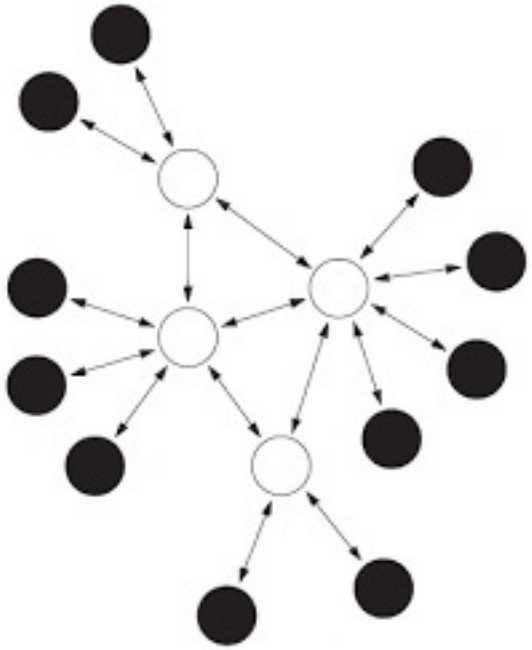
Sensor Network Topology



Star Topology



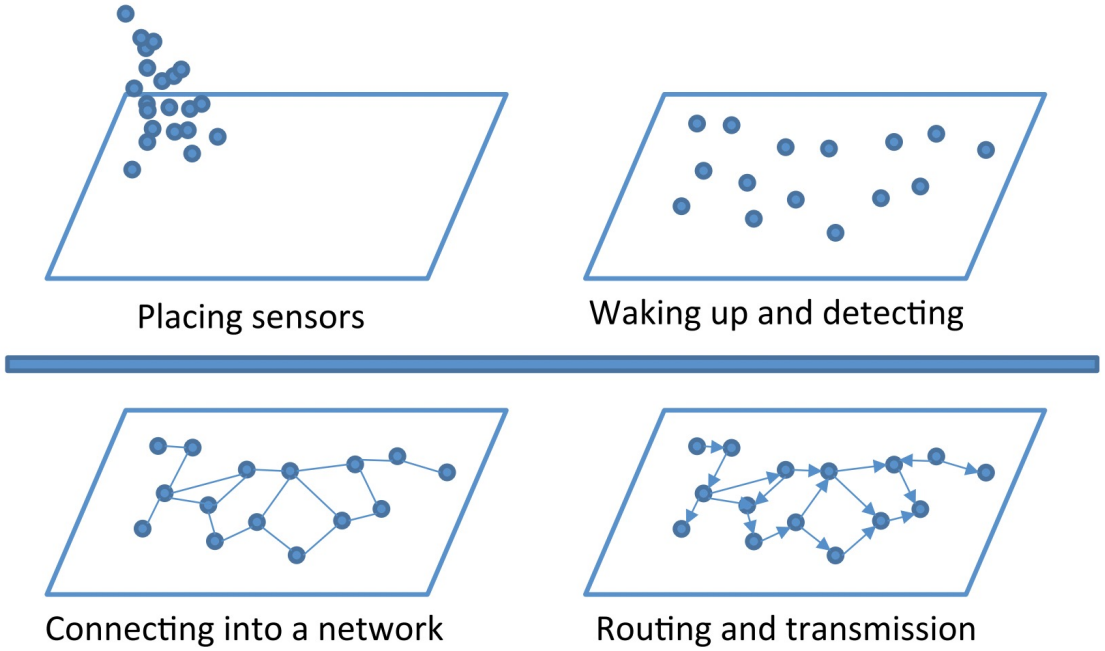
Mesh Topology



Hybrid Star Mesh Topology

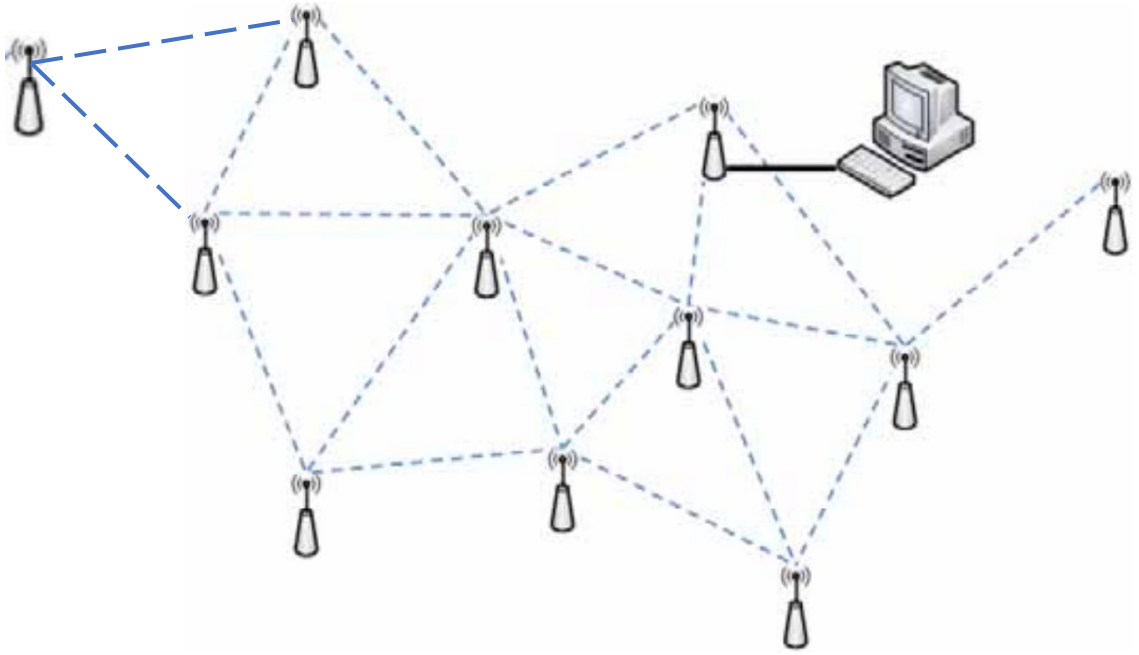
Organizing process of WSNs

- Sensor nodes broadcasts their status and receive status from neighbors
- Use of different topologies to organize the sensor nodes in WSNs
- Find suitable paths to connect nodes for data transmission
- Data forwarding to increase the network coverage
- Features
  - Self organizing networks
  - low cost communication
  - Self-adaptive flow control



Self Organizing Networking Technique

- Random positions of sensor nodes in WSN
- Mesh topology allows flexibility and robustness
- Ad hoc mesh network
  - Sensor node monitors the neighbors
  - Based on the signal strength, it sends the join network request to the neighboring node.
  - Gateway node assigns the networking resource to the new node – enable time synchronization
  - Sensor nodes send data to 2 or more nodes to improve network reliability



Low-cost IP interconnection technology

- Early WSNs used internal addresses (MAC address) to establish communication between nodes
- Not compatible with IP method to connect to the internet and traditional IP nodes
- Solution: 6LoWPAN
  - Implemented a simplified IPv6 protocol above the link layer of the IEEE 802.15.4 protocol.
  - Supports large addressing space
  - Requires less power compared to traditional IP protocol
    - Optimizations: header compression, packet fragmentation

Self-adaptive flow control technology

- Instability in wireless networks leads to loss of data packets
- Adjust the data flow rate based on the packet loss
  - If more packets are getting lost, reduce the transmission rate
  - Check for the reason of packet loss and adjust the transmission rate while considering following conditions
    - transmission distance
    - Throughput
    - Quality of the network
    - Number of packets lost

Challenges in designing WSN

- Wireless communication over lossy channel
- Limited power supply – battery operated
  - Need to finalize the design for energy efficiency before actual deployment
  - Use of simulators for designing WSN
- Scalability
  - Collecting high resolution data leads to thousands of sensors nodes transmitting data
  - Sensor network protocol should be scalable to achieve the desired performance
  - Throughput decreases at the rate of $1/\sqrt{N}$, N = number of sensors
    - Due to packet collision and high network traffic
  - Interoperability

Challenges in designing WSN (1)

- Fault Tolerance
  - Deployment in remote/vulnerable environment
  - Hardware failure or physical damage
  - Running out of power source (battery)
  - WSN should be designed to detect these failures and have a backup plan to handle them
    - Maintain overall functionality of the system
    - Reroute data packets
- Hardware constraints
  - Additional sensor node components for location aware routing leads to more power consumption and hardware cost
- Communication Protocols
  - Most of the nodes communicate using radio communication over the popular ISM bands
  - Use of optical or infrared communication - robust and virtually interference free

Challenges in designing WSN (2)

- Power Consumption
  - Limited battery power – small size device
  - Data compression
    - reduce the size of the data packet
    - Send data only if it is different from the previous instance
  - Harvesting energy sources
    - Solar, body heat, light
    - Scarce and unpredictable
    - Design the sensor parameters to reduce power consumption
- Data aggregation and processing
  - IoT Sensing data is 30 times more than human data
  - multi-dimensional heterogeneous characteristics of the sensor data

Challenges in designing WSN (3)

- Intelligent control and services to dynamic changes
  - respond to dynamic changes
  - ensure the security and reliability of intelligent control
  - transform from the single and predefined into the dynamic and personalized
- Support concurrent access to the system

Reading Material

- https://www.intechopen.com/chapters/38793
- https://storage-iecwebsite-prd-iec-ch.s3.eu-west-1.amazonaws.com/2019-09/content/media/files/iec_wp_internet_of_things_en.pdf

Discussions

- Quiz 1 results
  - Highest: 21
  - Lowest: 5
  - Median: 12

- Project presentations
  - Present the project idea in 10 mins – single slide
  - Clarify doubts/questions/brainstorm ideas

Questions?