IoT
Sensor Networks – Routing Protocols

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CS698T, Lecture 10

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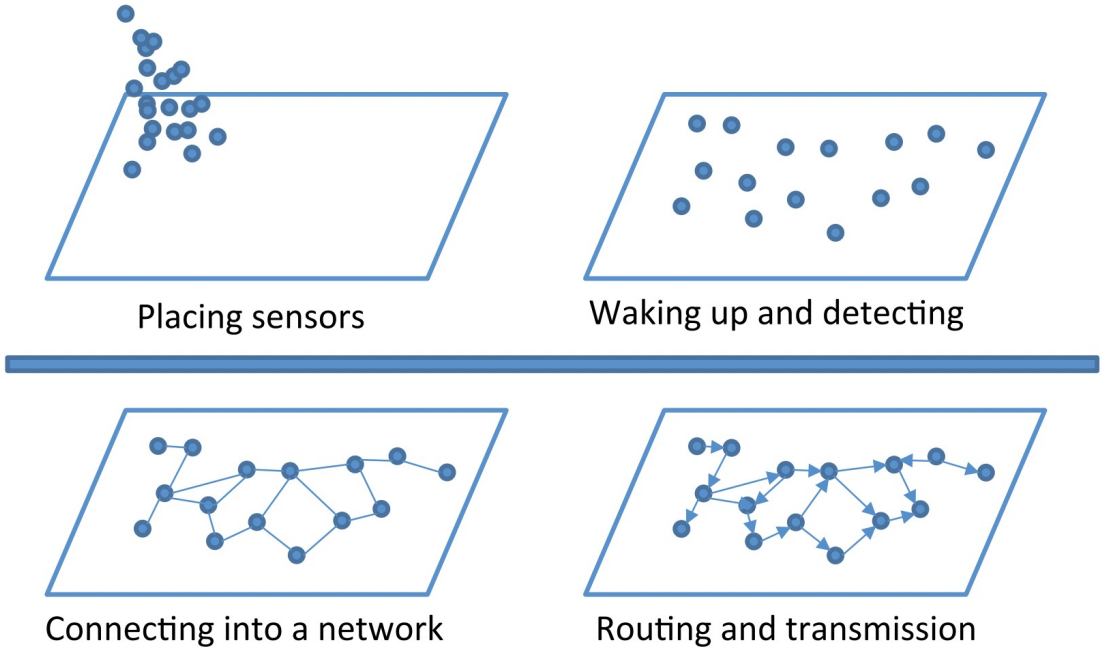
Organizing process of WSNs

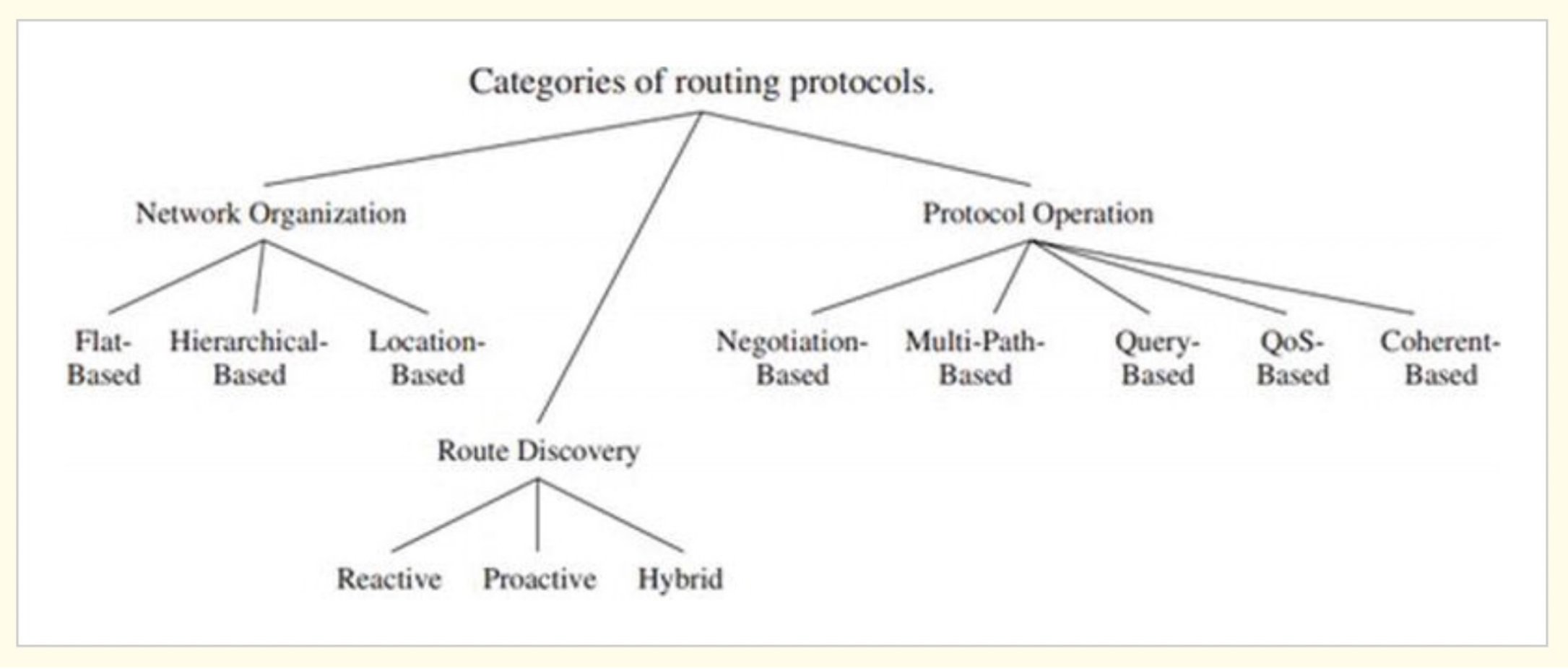
- Sensor nodes broadcasts their status and receive status from neighbors
- Use of different topologies to organize the sensor nodes in WSNs
- Find suitable paths to connect nodes for data transmission
- Data forwarding to increase the network coverage
- Features
  - Self organizing networks
  - low cost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



WSN Routing Protocols

- Focused on sending data from a sensor node to a base station or sink node
- Design requirements of WSN routing protocols
  - Energy efficiency - power and resource limitations of the network nodes
  - Scalability
  - Minimize delay
  - Robustness-
    - time-varying quality of the wireless channel for moving sensor nodes
    - possibility for packet loss and delay
  - Sensor Location
    - With GPS
    - GPS-free

Classification of WSN routing protocols



Network Structure – Flat Network Architecture

- all sensor nodes are peers
  - treats all node equally
  - All participating nodes are homogeneous – same characteristics and functionality
  - Does not maintain global id for all sensors
  - Data centric routing
    - base station queries certain region to collect sensor data
    - uses attribute-based naming
    - queries to relative to specific attributes
    - Different strategies can be used to query sensor nodes, including broadcasting, attribute-based multicasting, geo-casting, and any casting.

- Advantages:
    - minimal overhead to maintain the infrastructure
    - the potential for the discovery of multiple routes between communicating nodes for fault tolerance.

Hierarchical based routing

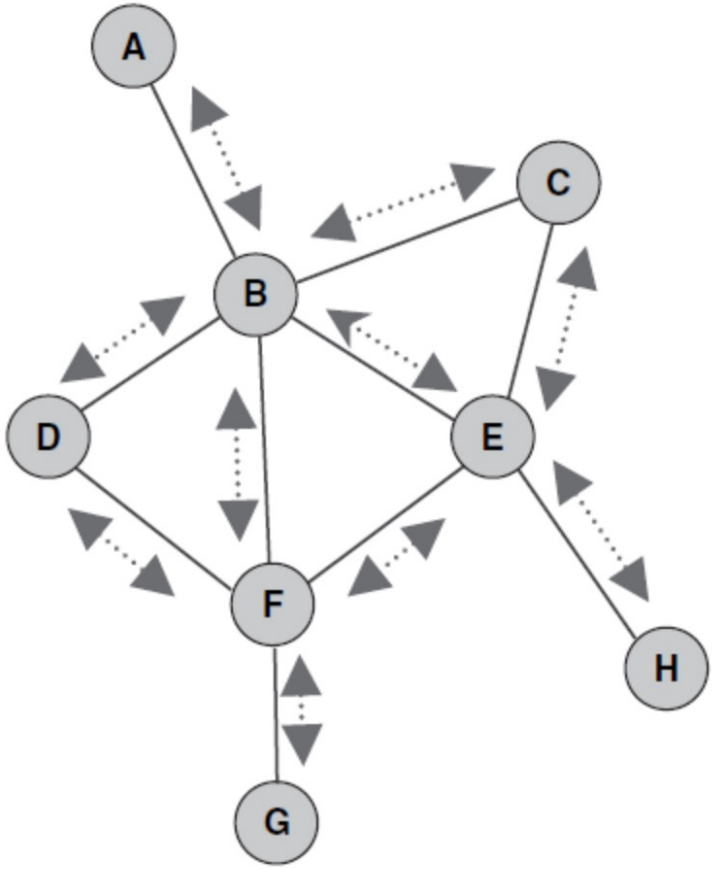
- Structural network architecture to achieve energy efficiency, stability, and scalability
  - network nodes are organized in clusters
  - Cluster head
    - Node with higher residual energy
    - Responsible for coordinating activities within the cluster and forwarding information between clusters.
    - Reduces energy consumption and extend the lifetime of the network

Location-based routing

- Useful in applications where the position of the node within the geographical coverage of the.
- With GPS
- GPS free
- Queries in a specific area where a phenomenon of interest may occur or the vicinity to a specific point in the network environment

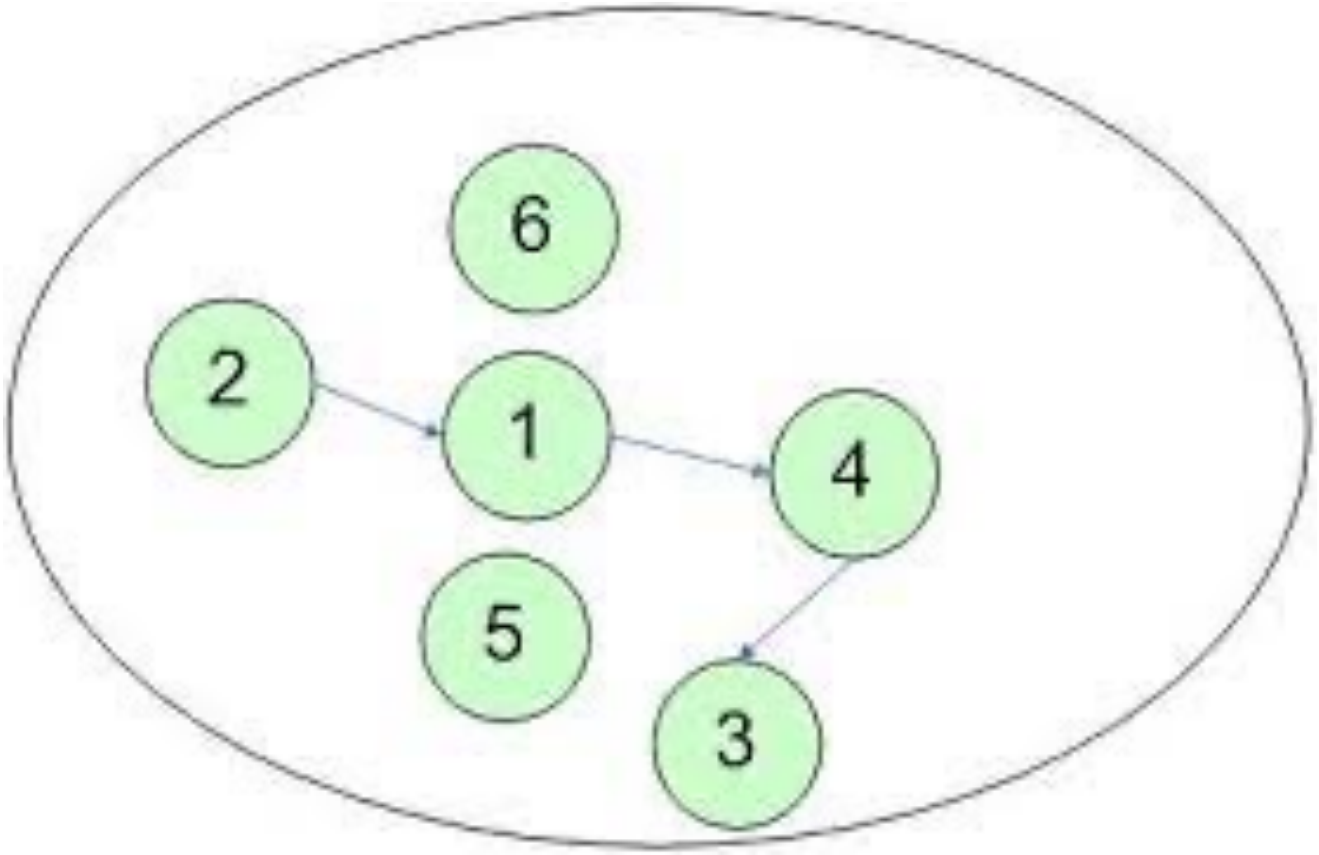
Network Structure – Flat Network Architecture [1]

- Flooding
  - Each sensor node sends data to all neighboring sensor nodes
  - Packet follows all possible paths
  - Packet follows new paths when the network topology changes



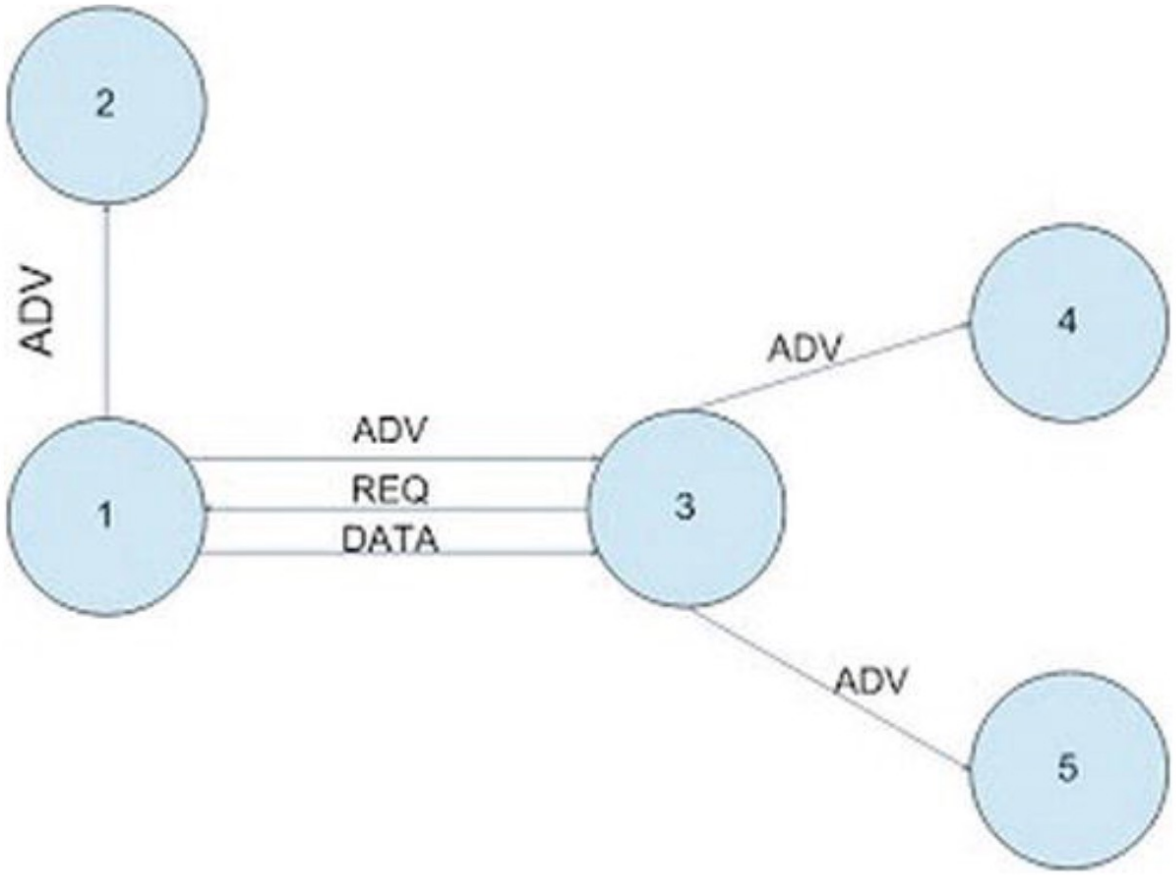
Network Structure – Flat Network Architecture [2]

- Gossiping
  - Uses a simple forwarding rule similar to flooding
  - Sends data packet randomly selected node
  - The process continues until data reaches the base station or the network runs out of maximum hops
  - Shortcomings
    - Takes longer time to reach base station
    - No guarantee of data reception



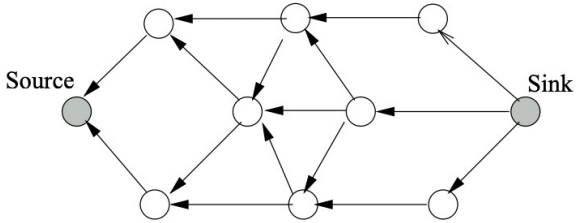
Network Structure – Flat Network Architecture [3]

- Sensor Protocols for Information via Negotiation (SPIN)
  - Sensor node sends data only when the neighboring node is interested in it.
  - Sensor nodes use high-level name to describe the collected data. The high level name gets used in the ADV msg
  - Avoids drawbacks of flooding and gossiping
    - Saves energy by not sending unnecessary information

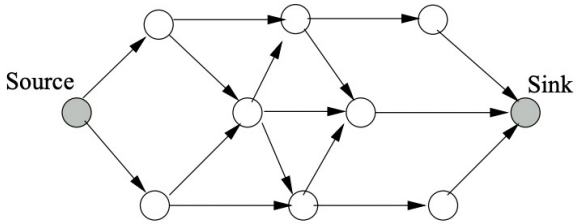


Network Structure – Flat Network Architecture [4]

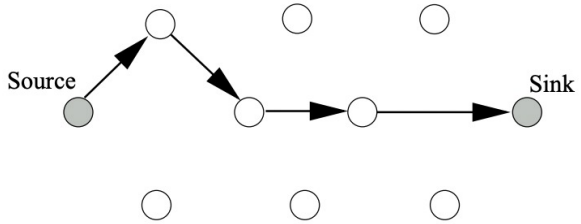
- Directed Diffusion
  - Sink node initiates the interest
  - Participating sensor nodes propagate the interest through the network
  - Nodes setup the gradient with the attribute value (interest) and direction
  - Find the optimal path to send the aggregated data back to the sink node
  - Caching the data paths help with quickly sending data back to the sink node
  - Unsuitable for one-time queries
  - Not efficient for applications which require continuous monitoring



(a) Propagate Interest



(b) Set up Gradients



Network Structure – Flat Network Architecture [5]

- Gradient-based routing: based on the minimum number of hops to reach base station
- Minimum cost forwarding algorithm:
  - Assumption: direction of the routing to the base station is known
  - each node maintains the least cost path to the base station.
  - Node transfers the data forward only when the source node is on the least cost path from the base station
- Energy aware routing:
  - Maintains multiple paths as apposed to directed diffusion routing protocols
  - Chooses different paths each time to avoid depletion of the batteries for the same node

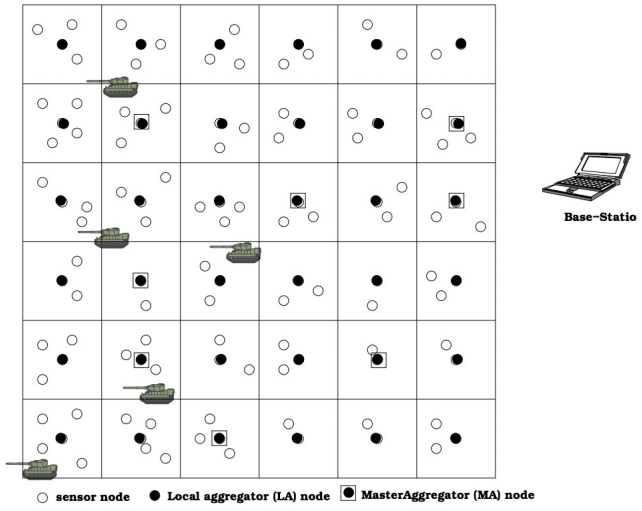
Network Structure – Hierarchical based routing

- LEACH protocol – Low energy adaptive clustering hierarchy
  - Randomly selects and keeps on changing the cluster head
  - Cluster head compresses/processes the data before sending forward
  - Centralized data collection
  - Useful for continuous monitoring applications
  - Based on cluster formation in the network
- Power efficient Gathering in Sensor Information Systems (PEGASIS)
  - Extends network lifetime by allowing communication within only neighboring sensor nodes
  - Sensor nodes take turns to send data to the base station
  - Less bandwidth requirement due to local communication
  - Avoids formation of the clusters
  - Assumption: each sensor node can directly communicate with base station
    - Sensor nodes need to know the energy status of the neighboring nodes
    - Additional delay can be introduced for the distant node in the chain

Network Structure – Hierarchical based routing

- Threshold sensitive energy efficient protocols
  - Cluster head sends the threshold values (hard and soft) of interested values in the network
  - Sensor nodes send data only when the sensed value is within the range of interest

- Virtual Grid Architecture routing (VGA)
  - Uses data aggregation and in networking processing to increase network lifetime
  - Useful for the stationary topology
  - Forms local and global aggregators to collect and process data



Network Structure – Location based routing

- Graphical Adaptive Fidelity
  - Mainly designed for mobile/ad hoc networks
  - Forms virtual grid in the network based on the GPS location
  - One sensor node (cluster head) stays awake for a particular time period
    - Responsible for monitoring and transmitting data to the base station
    - Rest of the nodes sleep
  - Energy efficient
- Direction based routing methods
- Geographic and Energy aware routing
  - Merge directed diffusion with the sensor location
  - Sends data only in the direction of the base station without sending it to the rest of the network

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
- Routing Techniques in Wireless Sensor Networks: A Survey https://www.ece.iastate.edu/~kamal/Docs/kk04.pdf

Questions?