IoT
Sensor Networks – Routing Protocols

Dr Priyanka Bagade, IITK

CS698T, Lecture 11

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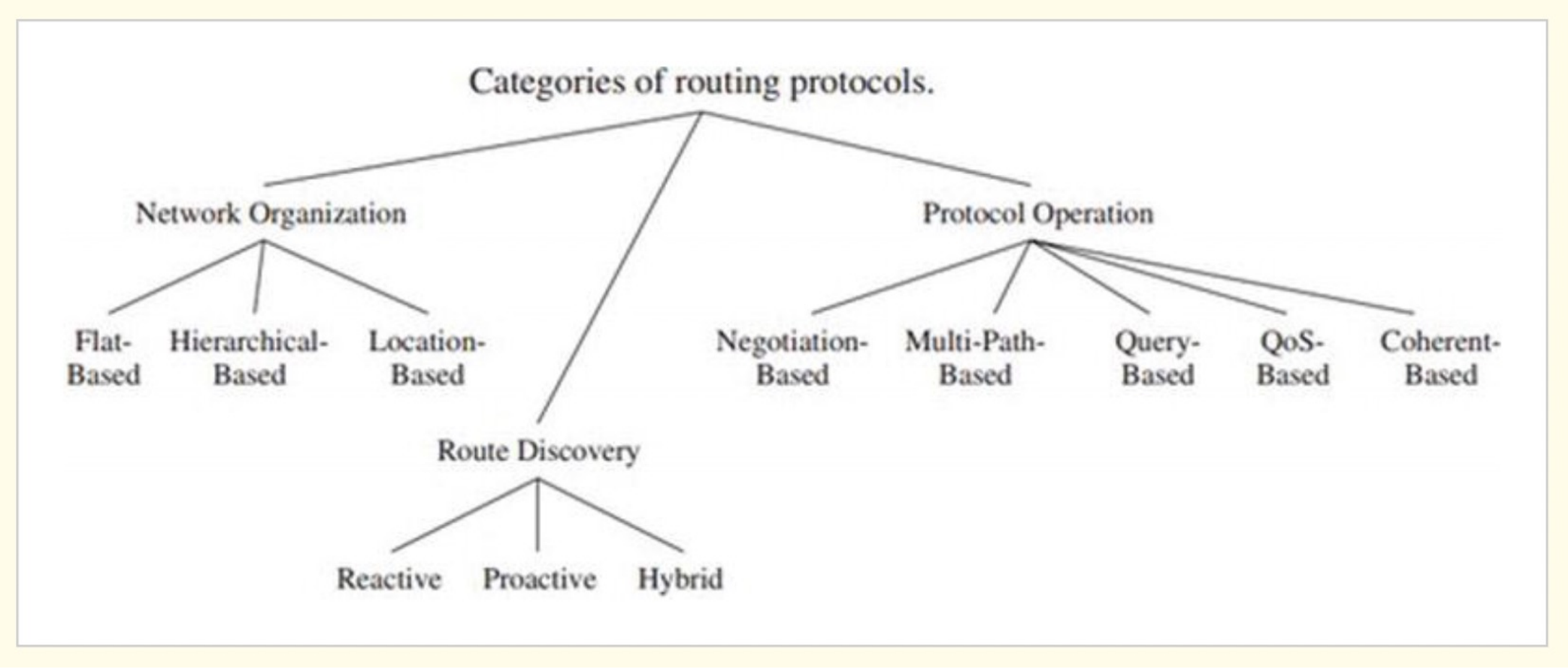
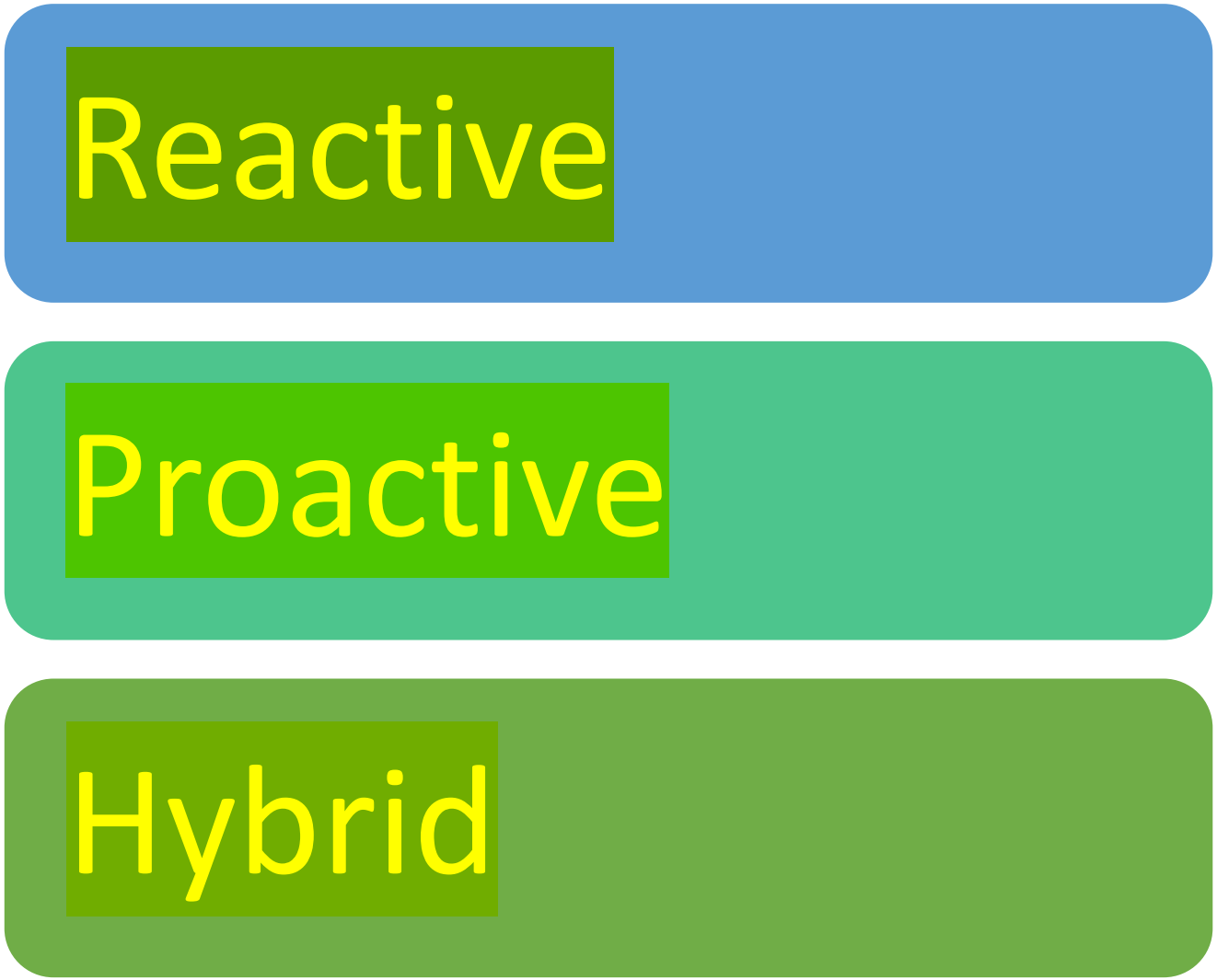
Classification of WSN routing protocols



Route Discovery



Route Discovery: Reactive routing

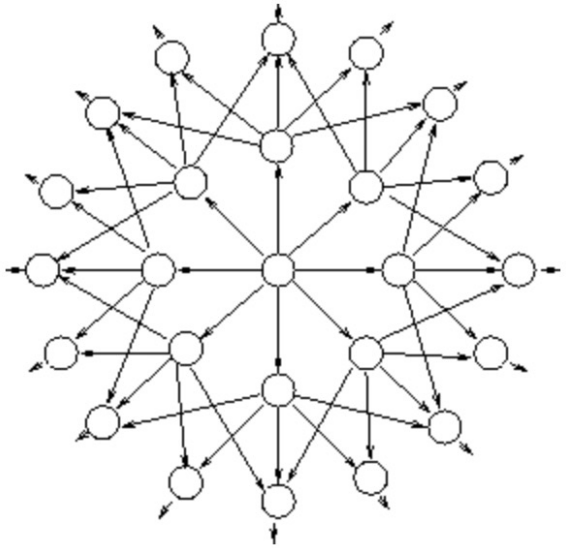
- Does not maintain the whole network topology
- Routes are created when the data is requested
- Techniques
  - Ad-hoc on-demand distance vector (AODV)
    - engineered for Mobile infrastructure-less networks - on-demand routing methodology
  - Dynamic source routing (DSR)
    - Routing information is stored at the node
    - Adv: avoids flooding the network to update the routing table information
    - Disadvantage: as the route information is not updated at the node, there can be a connection setup delay. Higher routing overhead which is proportional to the length of the route

Stores the routing table

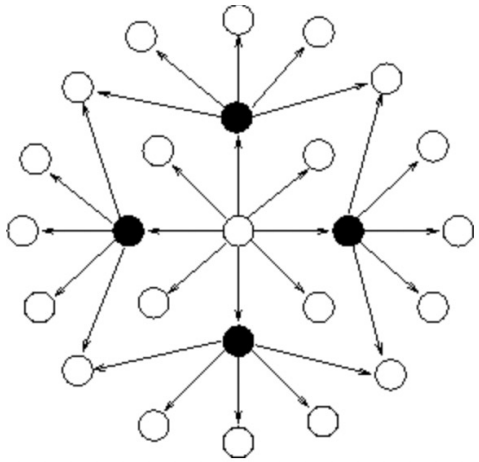
Route Discovery:
Proactive routing

- table driven routing protocols
- Maintain table of the complex network even if there is no data traffic
- Techniques
  - Optimized link state routing (OLSR)
    - uses table focused practice
    - has a massive overhead
    - To compensate this delay, multipoint relays (MPRs) are used to overcome the large overhead
    - For data transmission, three adjutant nodes are used as MPRs by every node.
    - No consistent control information is required as each node sends it alternatingly

We are reducing the traffic to half



Network Flooding



Data transmission with multipoint relays

Route Discovery: Hybrid routing

- have the merits of proactive and reactive routing protocols by neglecting their demerits
- Hybrid protocols are used to speed up delivery and reduce processing overhead by selecting the most efficient routing mechanism to use during packet routing
- Techniques
  - Maintains a table of neighboring nodes
  - Network segmenting into local neighbors
  - Stores preferred list of neighbors and forwards messages to only preferred nodes

Routing Protocol Operation based Classification

- Negotiation based
- Multipath based
- Query based
- QoS based
- Coherent based

Protocol Operation: Negotiation based

- SPIN protocol
  - Send negotiation messages to the neighboring nodes before sending data
  - Reduces network traffic and reception of multiple copies of same data to the base station

Protocol Operation: Multipath Routing Protocol

Use multiple paths to improve network performance

- Send periodic messages to check the working of alternate paths

Techniques:

- Use high residual energy paths
  - The largest residual energy path can consume more power.
  - Solution: select more energy efficient path
- Use alternate path when the node energy goes before certain threshold
- Enhance network reliability
  - Send same message over multiple paths. It can lead to increase in network traffic
  - Solution: split the data packet into multiple subpackets and send them over different paths to the destination. The complete message can be reconstructed even if only a few of the subdata packets are received.
- Directed diffusion is a good candidate for robust multipath routing and delivery
  - Can help with finding alternate paths
  - Breaded Multipath routing (BMR)
    - Find an alternate path such that there should be no or less overlap with the main path nodes.

Protocol Operation: Query Based

- Energy savers
- Adapted to networks where geographic information is not available
- The routing path is a reverse of the path followed by the base station generated query
- Techniques
  - ACQUIRE
    - Each node receiving query from the base station checks for the cached information. If it is updated, it sends back that the partial info using the reverse or the shortest path. Else it forwards the query to the next node to receive the up to date information and send that back to base station.
  - Rumor routing
    - route the queries to the nodes that have observed a particular event
    - Node stores every detected event in the local table and generates an agent
    - These agents updates the local table of distant nodes with the events
    - Nodes can respond to the queries from the sink node by looking at their event tables
    - Adv: No need to flood the entire network with the queries
    - Disadvantage: If the number of events are large, the table size will be very large

Protocol Operation: QoS based

- Required to satisfy QoS metrics, e.g., delay, energy, bandwidth, etc. when delivering data to the BS
- Techniques
  - Sequential Assignment Routing (SAR)
    - Factors considered for routing: energy resources, QoS on each path, and the priority level of each packet
    - Maintains multiple paths from a node to the base station
    - Table driven multi-path protocol - each sensor node creates a tree like structure from source node to destination while avoiding low energy nodes and low QoS
  - SPEED
    - Ensures certain speed of the data packet reaching the base station and estimates end to end delay

Protocol Operation: Coherent and non-coherent based

- Non-coherent based
  - Data processing at the sensor node before data transmission
  - Less data transmission
  - Data processing in 3 phases
    - Target detection, data collection, and preprocessing
    - Membership declaration
    - Central node election
  - e.g. technique - Single winner algorithm

- Coherent based
  - Minimal data processing at the sensor node. There are aggregators which collect data from all the sensors and process it.
  - Large data packets are transmitted – use path optimality to achieve energy efficiency
  - More energy efficient for the node due to minimal processing
  - E.g. technique - multiple winner algorithm
  - Disadvantage - longer delay, higher overhead, and lower scalability

Comparison of WSN Routing Protocols

	Classification	Mobility	Position Awareness	Power Usage	Negotiation based	Data Aggregation	Localization	QoS	State Complexity	Scalability	Multipath	Query based
SPIN	Flat	Possible	No	Limited	Yes	Yes	No	No	Low	Limited	Yes	Yes
Directed Diffusion	Flat	Limited	No	Limited	Yes	Yes	Yes	No	Low	Limited	Yes	Yes
Rumor Routing	Flat	Very Limited	No	N/A	No	Yes	No	No	Low	Good	No	Yes
GBR	Flat	Limited	No	N/A	No	Yes	No	No	Low	Limited	No	Yes
MCFA	Flat	No	No	N/A	No	No	No	No	Low	Good	No	No
CADR	Flat	No	No	Limited	No	Yes	No	No	Low	Limited	No	No
COUGAR	Flat	No	No	Limited	No	Yes	No	No	Low	Limited	No	Yes
ACQUIRE	Flat	Limited	No	N/A	No	Yes	No	No	Low	Limited	No	Yes
EAR	Flat	Limited	No	N/A	No	No		No	Low	Limited	No	Yes
LEACH	Hierarchical	Fixed BS	No	Maximum	No	Yes	Yes	No	CHs	Good	No	No
TEEN & APTEEN	Hierarchical	Fixed BS	No	Maximum	No	Yes	Yes	No	CHs	Good	No	No
PEGASIS	Hierarchical	Fixed BS	No	Maximum	No	No	Yes	No	Low	Good	No	No
MECN & SMECN	Hierarchical	No	No	Maximum	No	No	No	No	Low	Low	No	No
SOP	Hierarchical	No	No	N/A	No	No	No	No	Low	Low	No	No
HPAR	Hierarchical	No	No	N/A	No	No	No	No	Low	Good	No	No
VGA	Hierarchical	No	No	N/A	Yes	Yes	Yes	No	CHs	Good	Yes	No
Sensor aggregate	Hierarchical	Limited	No	N/A	No	Yes	No	No	Low	Good	No	Possible
TTDD	Hierarchical	Yes	Yes	Limited	No	No	No	No	Moderate	Low	Possible	Possible
GAF	Location	Limited	No	Limited	No	No	No	No	Low	Good	No	No
GEAR	Location	Limited	No	Limited	No	No	No	No	Low	Limited	No	No
SPAN	Location	Limited	No	N/A	Yes	No	No	No	Low	Limited	No	No
MFR, GEDIR	Location	No	No	N/A	No	No	No	No	Low	Limited	No	No
GOAFR	Location	No	No	N/A	No	No	No		Low	Good	No	No
SAR	QoS	No	No	N/A	Yes	Yes	No	Yes	Moderate	Limited	No	Yes
SPEED	QoS	No	No	N/A	No	No	No	Yes	moderate	Limited	No	Yes

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
- Comparative Study of Energy Efficient Routing Techniques in Wireless Sensor Networks, https://www.mdpi.com/2078-2489/12/1/42/htm
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Questions?