1. LEACH Protocol

LEACH (Low Energy Adaptive Clustering Hierarchy) is a hierarchical routing protocol designed for energy efficiency in WSNs. It uses clustering, where cluster heads are chosen randomly to aggregate and transmit data, reducing direct communication with the base station.

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2. TRAMA Protocol

TRAMA (Traffic-Adaptive Medium Access) is a MAC protocol that reduces energy consumption by scheduling sleep times for nodes and enabling collision-free transmissions using a traffic-based adaptive scheduling mechanism.

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3. IEEE 802.15.4

This standard defines the physical and MAC layers for low-power, low-data-rate wireless networks, forming the basis of ZigBee. It supports star, mesh, and cluster-tree topologies.

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4. Code for ARQ and FEC

ARQ (Automatic Repeat Request) retransmits corrupted packets, while FEC (Forward Error Correction) uses coding techniques to detect and correct errors without retransmission. Implementing these depends on error-correction algorithms (e.g., Hamming Code for FEC).

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5. Types of Unicast Routing

1. **Flat routing**: Every node has equal roles (e.g., Directed Diffusion).
2. **Hierarchical routing**: Nodes have different roles (e.g., LEACH).
3. **Location-based routing**: Uses geographic information (e.g., GPSR).

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6. Types of Multicast Routing

1. **Tree-based multicast**: Maintains a tree structure (e.g., MAODV).
2. **Mesh-based multicast**: Provides redundancy through multiple paths (e.g., ODMRP).

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7. Block Packet Delivery Mechanism

It aggregates data packets into blocks to reduce communication overhead and energy consumption. Useful in applications like video streaming over WSNs.

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8. Link Quality Estimation

Measures the reliability of a communication link using metrics like RSSI (Received Signal Strength Indicator), ETX (Expected Transmission Count), and packet delivery ratio.

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9. Naming and Addressing

In WSNs, nodes are named and addressed based on:

1. **Flat addressing**: Numeric identifiers.
2. **Hierarchical addressing**: Multi-level identifiers.
3. **Content-based addressing**: Query-specific naming.

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10. Trilateration, Triangulation, and Multilateration

1. **Trilateration**: Determines position using distances from three known points.
2. **Triangulation**: Uses angles between known points for position estimation.
3. **Multilateration**: Uses signals' Time Difference of Arrival (TDOA).

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11. Time Synchronization and Node Clocks

Ensures that nodes have synchronized clocks for coordinated operations. Techniques:

1. **RBS (Reference Broadcast Synchronization)**: Uses broadcast signals.
2. **TPSN (Timing-sync Protocol for Sensor Networks)**: Pairwise synchronization.

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12. Functionality of LTS and RBS

1. **LTS (Lightweight Time Synchronization)**: Focuses on low-overhead synchronization.
2. **RBS**: Synchronizes nodes using broadcast reference messages for minimal communication overhead.

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13. Power Control in Flat Network Topology

Techniques include:

1. **Transmission power adjustment**: Reduces power to conserve energy.
2. **Duty cycling**: Turns off nodes when idle.
3. **Adaptive topology control**: Reduces active nodes dynamically.

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14. Content-Based Addressing

Matches data based on attributes (e.g., temperature > 30°C). Operates using attribute-value pairs in data queries.

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15. Repeated Interaction Problem and Directed Diffusion

Directed Diffusion addresses repeated interactions in data-centric routing by establishing gradients and reinforcements, reducing redundant communications.

16. Position Estimation Techniques with Beacon Nodes

1. **Range-based methods**: Use distances (e.g., RSSI, TOA, TDOA).
2. **Range-free methods**: Use proximity or hop counts (e.g., DV-Hop). Position is calculated by triangulating distances from multiple beacon nodes.

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17. Single-Hop Localization Techniques

Nodes estimate position directly using proximity or signal strength from a single beacon. Accurate for small, dense networks but less scalable.

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18. Positioning in Multi-Hop Environments

Involves relaying information across multiple nodes to estimate a node's position. Common methods:

1. **DV-Hop**: Estimates distance by hop count.
2. **Multilateration**: Uses multiple nodes' data for accuracy.

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19. Data Aggregation Operations

Data aggregation combines data from multiple sensors to reduce redundancy and conserve energy. Examples:

1. **Max/Min**: Collects maximum or minimum values.
2. **Average**: Computes mean data values.

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20. Topology Control through Hierarchical Methods

Hierarchical methods (e.g., LEACH, PEGASIS) cluster nodes and elect cluster heads for efficient communication and energy conservation.

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21. Discussion Topics

a. **Bluetooth vs IEEE 802.15.4**:

- Bluetooth: Short-range, high-speed communication.
- IEEE 802.15.4: Low-power, low-speed, better for WSNs.

b. **IEEE 802.11 vs IEEE 802.15.4**:

- IEEE 802.11: High data rates, high power.
- IEEE 802.15.4: Low power, low data rates.

c. **IEEE 802.15.4 vs ZigBee**:

- IEEE 802.15.4: Protocol layer definition.
- ZigBee: Complete stack for WSN applications.

d. **FEC vs ARQ**:

- FEC: Adds error-correcting codes to data.
- ARQ: Requests retransmission on error.

e. **Passive Link Quality Estimation**: Measures link quality without extra overhead using metrics like RSSI and Packet Delivery Ratio.

f. **Code Rate vs Coding Gain**:

- Code rate: Ratio of data to total transmitted bits.
- Coding gain: Signal-to-noise improvement due to coding.

g. **Link Quality Estimation**: Measures reliability using RSSI, ETX, etc.

h. **Flow Control vs Congestion Control**:

- Flow control: Ensures sender doesn't overwhelm receiver.
- Congestion control: Manages network-wide traffic to prevent bottlenecks.

i. **Boolean Sensing vs General Sensing Model**:

- Boolean: Binary detection (e.g., presence/absence).
- General: Provides detailed data.

j. **Single Packet vs Block Delivery**:

- Single packet: Lower latency, higher overhead.

- Block delivery: Efficient for bulk data.

k. **Reinform vs HHBA Protocol**:

- Reinform: Uses reinforcement mechanisms in routing.
- HHBA: Focuses on hierarchical backbone aggregation.

l. **Open vs Closed Loop Backpressure Mechanism**:

- Open: Feedback-less flow adjustment.
- Closed: Uses feedback for dynamic control.

m. **Gossiping vs Agent-Based Unicast**:

- Gossiping: Randomized message dissemination.
- Agent-based: Directed delivery using intelligent agents.

n. **Unicast vs Multicast Routing**:

- Unicast: One-to-one communication.
- Multicast: One-to-many communication.

o. **Interleaving Operation**: Rearranges data sequences to improve reliability over noisy channels.

p. **Framing vs Link Management**:

- Framing: Encapsulates data for transmission.
- Link management: Maintains communication links.

q. **Positive vs Negative Acknowledgement**:

- Positive: Confirms successful reception.
- Negative: Requests retransmission.

r. **Interest Message vs Data Message**:

- Interest: Queries specific data.
- Data: Responds with requested data.

s. **Content-Based vs Geographic Addressing**:

- Content-based: Data-centric addressing.
- Geographic: Location-based addressing.

t. **Anchor Node vs Normal Sensor Node**:

- Anchor: Knows its position; aids localization.
- Normal: Relies on anchors for positioning.

u. **Congestion Control**: Prevents network overload using techniques like rate limiting and queue management.

v. **RSSI vs TOA vs TDOA**:

- RSSI: Signal strength measurement.
- TOA: Time of arrival of a signal.
- TDOA: Time difference of arrival for positioning.

w. **Angle of Arrival (AoA)**: Determines direction of incoming signal for positioning.

x. **Trilateration vs Triangulation**:

- Trilateration: Uses distances.
- Triangulation: Uses angles.

y. **Trilateration vs Multilateration**:

- Trilateration: Requires known distances from fixed points.
- Multilateration: Adds TDOA data for improved accuracy.

z. **RMST vs CODA**:

- RMST: Reliable data transport in WSNs.
- CODA: Congestion detection and avoidance.

aa. **LTS vs RBS**:

- LTS: Lightweight time synchronization.
- RBS: Synchronizes using broadcast messages.

bb. **Apriori vs Postfacto Synchronization**:

- Apriori: Prior synchronization.
- Postfacto: Synchronization post-event.

cc. **Position-Based Routing vs Geocasting**:

- Position-based: Relies on node location.
- Geocasting: Delivers messages to specific geographic areas.

dd. **Congestion Control and Avoidance**: Balances traffic load to prevent bottlenecks using techniques like queuing and rate control.

ee. **Interest Message vs Data Message**: See (r).

ff. **External vs Internal Time Synchronization**:

- External: Relies on external references (e.g., GPS).

- Internal: Synchronization among network nodes.

gg. **Peer-to-Peer vs Networkwide Synchronization**:

- Peer-to-peer: Synchronizes specific node pairs.
- Networkwide: Synchronizes entire network.

hh. **Directed Diffusion and Diffusion Reinforcement**:

- Directed Diffusion: Data-centric routing using gradients.
- Diffusion reinforcement: Strengthens preferred data paths.