DATA AGGREGATION & DISSEMINATION PROGRAMMING THE ARDUINO

1. What is Data Aggregation & Dissemination?

- **Data Aggregation:** The process of collecting, combining, and summarizing data from multiple sources or sensor nodes to reduce redundancy and data size.
- **Data Dissemination:** The process of distributing this data from the source to other nodes or to centralized systems (e.g., cloud platforms).

1.1 Importance in IoT

In the Internet of Things (IoT), sensor nodes continuously collect environmental data. Aggregation and dissemination strategies are essential for:

- Improving energy efficiency
- Reducing network congestion
- Enhancing scalability and reliability
- Enabling real-time communication

Since most IoT devices are resource-constrained (limited battery, memory, and processing power), efficient data aggregation and dissemination are critical.

2. Arduino in IoT Systems

2.1 Why Arduino?

- Arduino boards (UNO, Nano, Mega) are widely used in IoT for:
  - Collecting sensor data
  - Processing and aggregating data
  - Communicating with other devices or cloud platforms

2.2 Common Hardware Used

Component	**Purpose**
Arduino Board	Core microcontroller unit
Sensors	e.g., DHT11 (Temp/Humidity), Soil Moisture

Wi-Fi Module	e.g., ESP8266 or ESP32 for cloud transmission
Bluetooth Module	e.g., HC-05 for local transmission
Display Units	LCD/OLED or Serial Monitor
Power Supply	USB or Battery Powered

3. Data Aggregation in IoT

3.1 Definition & Benefits

- **Definition:** Merging data from multiple sensor nodes into a single compact representation before transmitting.
- **Benefits:**
  - Minimizes data volume and communication overhead
  - Conserves energy and increases node lifetime
  - Reduces network congestion
  - Improves data reliability by filtering noise

3.2 Aggregation Techniques

a. Centralized Aggregation

- Data from all nodes sent to a central server (sink node/cloud)
- **Pros:** Simple and manageable
- **Cons:** Bottleneck risk, single point of failure

b. Distributed Aggregation

- Aggregation done at intermediate nodes
- **Pros:** Energy-efficient, reduces load on central node
- **Cons:** More complex implementation

c. In-Network Aggregation

- Nodes collaborate to aggregate data locally before transmission
- **Pros:** Low energy use, reduced traffic
- **Cons:** May lose data granularity

3.3 Aggregation Algorithms

Algorithm	Description
LEACH (Low-Energy Adaptive Clustering Hierarchy)	Cluster-based protocol, cluster head aggregates data
SPIN (Sensor Protocols for Information via Negotiation)	Avoids redundant data transmission via negotiation
PEGASIS (Power-Efficient Gathering in Sensor Info System)	Forms data-forwarding chains among sensor nodes

4. Data Dissemination in IoT

4.1 Definition & Benefits

- **Definition:** Sharing data from source nodes to intended recipients or storage systems (cloud, user interface).
- **Benefits:**
  - Enables real-time alerts and actions
  - Supports scalability of large IoT networks

- Improves responsiveness and coordination

4.2 Dissemination Techniques

a. Unicast

- One-to-one communication (source to specific node)
- **Pros:** Reliable, simple
- **Cons:** Inefficient for multi-recipient scenarios

b. Broadcast

- Data sent to all nodes
- **Pros:** Easy for global info (e.g., time sync)
- **Cons:** High overhead, may cause congestion

c. Multicast

- Data sent to a selected group of nodes
- **Pros:** Efficient for subset dissemination
- **Cons:** Complex group management

d. Anycast

- Data sent to any one (usually nearest) node in a group
- **Pros:** Fast and energy-efficient

- **Cons:** May not reach the most appropriate node

5. Programming Arduino for Aggregation & Dissemination

· Sensor Data Collection

· Data Filtering

· Disseminating via Serial/Wi-Fi

6. Case Study: Smart Agriculture System

Objective:

- Monitor soil moisture, temperature, humidity
- Aggregate data and send to cloud for visualization

Setup:

- **Sensors:** Soil Moisture, DHT11
- **Board:** Arduino UNO with ESP8266
- **Cloud:** ThingSpeak

Process:

1. Collect sensor data
2. Apply in-network aggregation
3. Disseminate via Wi-Fi module

4. View data remotely on dashboard

7. Challenges in Aggregation & Dissemination

- **Resource Constraints:** Limited memory and CPU on Arduino
- **Power Management:** Battery drainage in wireless modules
- **Network Reliability:** Loss or delay in data packets
- **Data Granularity:** Loss of fine details due to aggregation