CmpE 58C
Wireless Sensor Networks

Application Layer
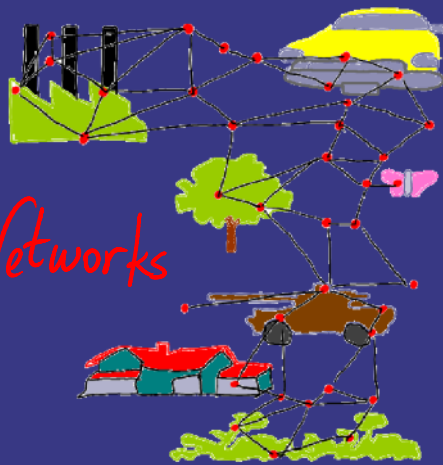
Sensor Networks Communication Architecture

- Application Layer
- Transport Layer
- Network Layer
- Data Link Layer
- Physical Layer

Power Management Plane
Mobility Management Plane
Task Management Plane
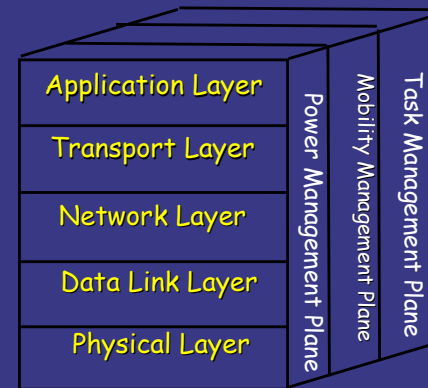
- Used by sink and all sensor nodes
- Combines power and routing awareness
- Integrates data with networking protocols
- Communicates power efficiently through wireless medium and
- Promotes cooperative efforts.

Why Can't We Use Ad Hoc Protocols Here?

- Number of sensor nodes can be several orders of magnitude higher
- Sensor nodes are densely deployed and are prone to failures
- The topology of a sensor network may change frequently due to node mobility and node failure
- Sensor nodes are limited in power, computational capacities, and memory
- May not have global ID like IP address
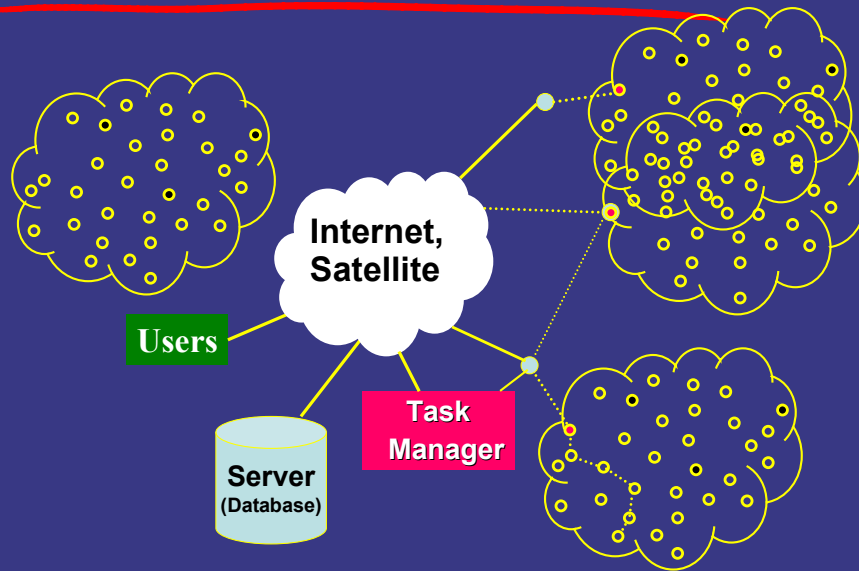- Need tight integration with sensing tasks

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Application Layer Framework

- Sensor Network Management Protocol (SMP)
- Task Assignment and Data Advertisement Protocol
- Sensor Query and Data Dissemination Protocol

Sensor Network Topology

Internet, Satellite

Users

Server (Database)

Task Manager

SMP: Sensor Management Protocol

- System administrators interact with sensors using SMP.
- TASKS:
  - Turning sensors on and off
  - Moving the sensor nodes
  - Querying the sensor network configuration and the status of nodes and re-configuring the sensor network
  - Authentication, key distribution and security in data communication
  - Time-synchronization of the sensor nodes
  - Exchanging data related to the location finding algorithms
  - Introducing the rules related to data aggregation, attribute-based naming and clustering to the sensor nodes

Query Processing

Users can request data from the network
→ Efficient Query Processing
USER Query TYPES:
1. Historical Queries:
   Used for analysis of historical data stored in a storage area (PC)
   E.g., What was the temperature 2 hours back in the NW quadrant?
2. One Time Queries:
   Gives a snapshot of the network
   E.g., What is the current temperature in the NW quadrant?
3. Persistent Queries:
   Used to monitor the network over a time interval with respect to some parameters
   E.g., Report the temperature for the next 2 hours

Application Layer

Sensor Query and Tasking Language (SQTL):
   (C-C Shen, et.al., "Sensor Information Networking Architecture and Applications", IEEE Personal Communications Magazine, pp. 52-59, August 2001.)

- SQTL is a procedural scripting language.
- It provides interfaces:
  - To access sensor hardware:
    - getTemperature, turnOn
  - For location awareness:
    - isNeighbor, getPosition
  - For communication:
    - tell, execute

Application Layer

SQTL (cont'd)

- By using the *upon* command, a programmer can create an "event handling block" for 3 types of events:
1. Events generated when a message is received by a sensor node (RECEIVE)
2. Events triggered periodically (EVERY)
3. Events caused by the expiration of a timer (EXPIRE)

Task Assignment and Data Advertisement Protocol

- Interest Dissemination
  - Users send their interest to a sensor node, a subset of the nodes or the entire network
  - This interest may be about a certain attribute of the sensor field or a triggering event.
- Advertisement of Available Data
  - Sensor nodes advertise the available data to the users and the users query the data which they are interested in.

# Sensor Query and Data Dissemination Protocol

- Provides user applications with interfaces to issue queries, respond to queries and collect incoming replies
- Attribute Based Query
  - "The locations of the nodes that sense temperature higher than 70F"
- Location Based Query
  - "Temperatures read by the nodes in region A"

Attribute Based Query

Query:
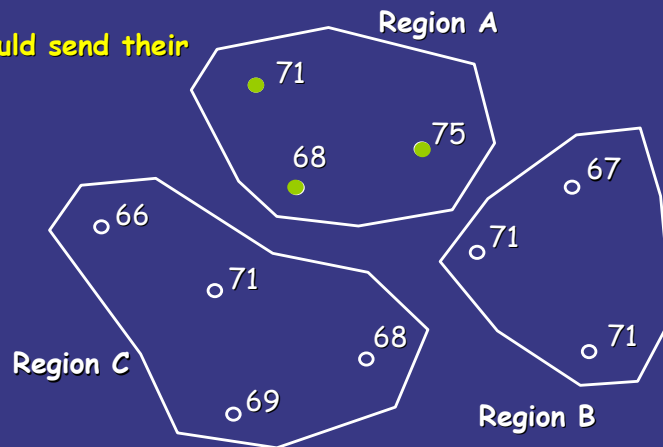**Sensor nodes that read >70°F temperature**
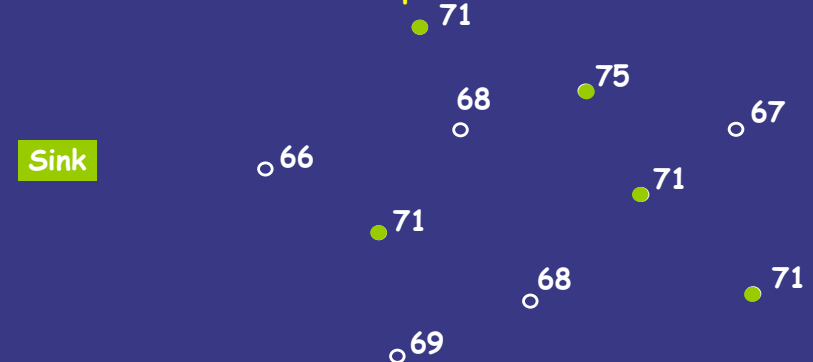
Location Based Query

Query:
Region A nodes should send their temperatures

Region A
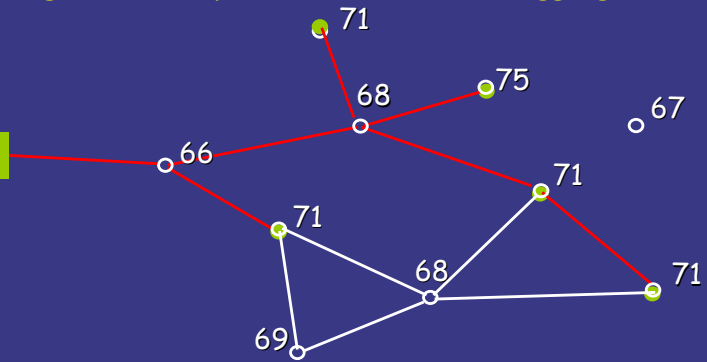
71
75
68
66
71
67
71
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71
69

Sink

Region C

Region B

Important for broadcasting, multicasting, geocasting and anycasting

Data Aggregation (Data Fusion)

- The sink asks the sensor nodes to report certain conditions. Data coming from multiple sensor nodes are aggregated.

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Sink

Query:
Sensor nodes that read >70°F temperature

Application Layer Research Needs

- Sensor Network Management Protocol
- Task Assignment and Data Advertisement Protocol
- Sensor Query and Data Dissemination Protocol
- Sophisticated GUI
     (Graphical User Interface) Tool