Power-aware Query Processing over Sensor Networks

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Properties of Sensors and Sensor Networks

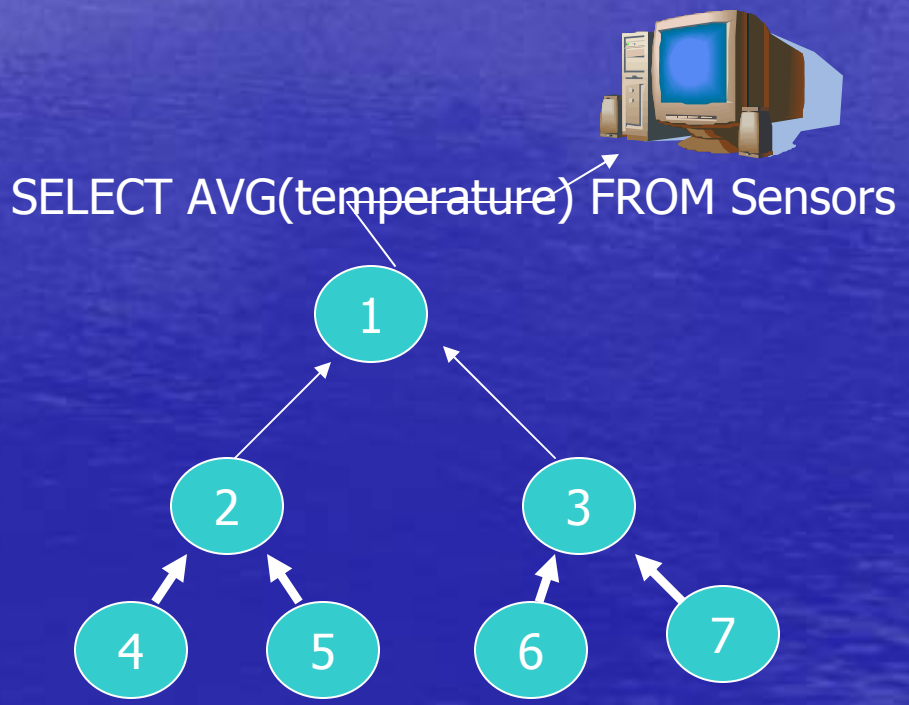
- Full-fledge computers
  - Computation, communication and sensing.
- Inherent properties of sensor networks
  - Limited power
  - high communication cost
  - low bandwidth
  - low computation capability
  - noise in readings
- New information processing techniques are needed.
- Privacy and Security

Proposed Information Processing Techniques

- The cost of query processing is different than database management systems and data stream.
  - Data is already avaliable
- The cost of query execution in sensor network is the cost of data collection.
  - Reduce energy consumption
- Several proposals aiming to reduce data collection cost:
  - TAG and COUGAR use in-network aggregation

TAG: A Tiny Aggregation Service for Ad-Hoc Sensor Networks

- In-network processing of aggregates
- Queries posed at base station
- Query tree is built
- Synchronize the sensors: divide time into slots and assign a slot for each level of the tree
- Each node takes the partial results for the subtrees rooted at its children and sends the partial result for subtree rooted at itself to its parent



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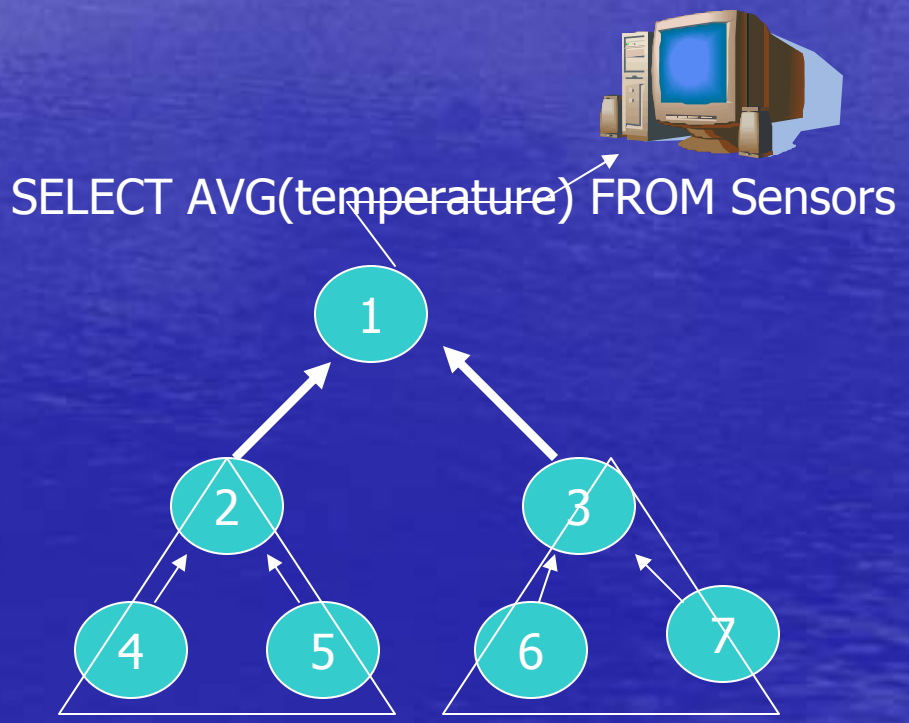

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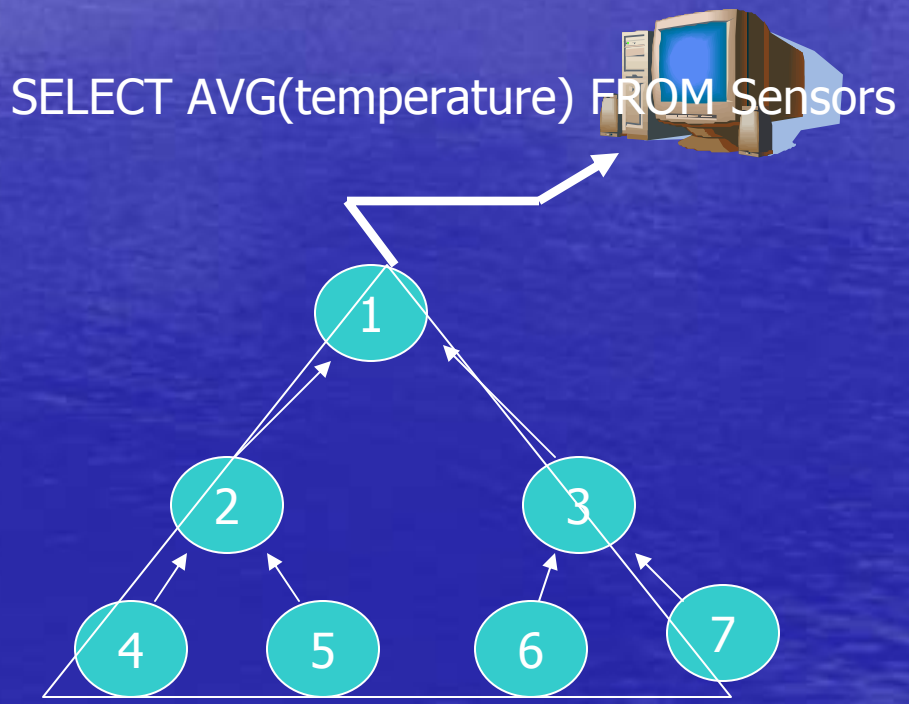


Power-aware Queries

- Declarative SQL queries over data generated by sensors
- Give the tradeoff between energy usage and precision to the user.

```
SELECT AggregateFunction
FROM Sensordata s
WHERE s.loc in R
DURATION D
EVERY t
PRECISION P
```

- An example:

```
SELECT AVG(s.temperature)
FROM Sensordata s
WHERE s.loc in R
DURATION D
EVERY t
PRECISION P
```

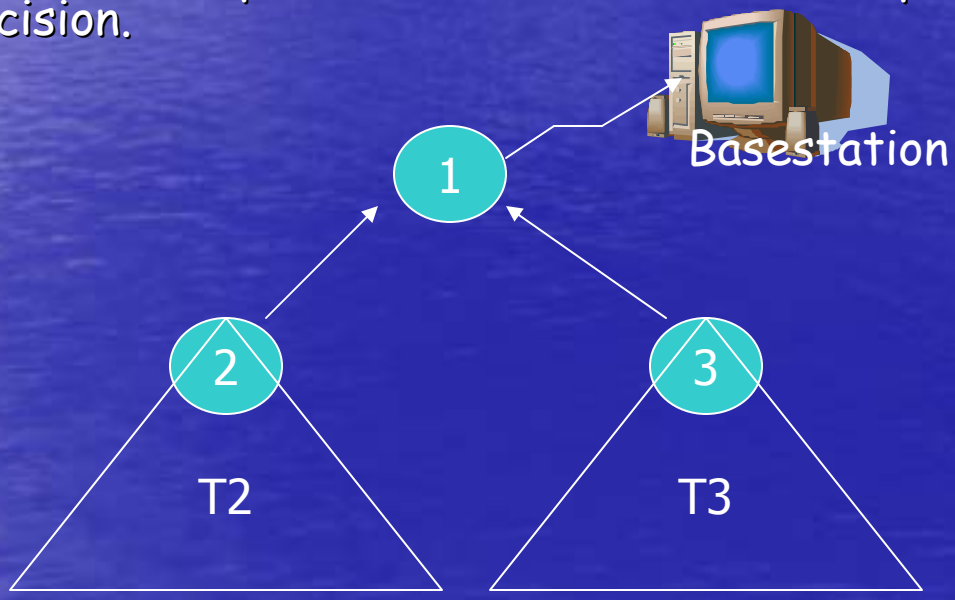
  - Calculate the average temperature in region *R* with precision *P*, and run this query for *D* duration once every *t* time interval. -the result for the query can differ from the actual result at most P.

Idea Behind Power-aware Query Processing

- Basic idea *"It is not news if one can predict it"* .
- Based on prediction
- If the base station can predict the result of the query, there is no need for communication.
- Naive solution:
  - Each sensor sends its prediction function to the base station and base station starts to predict the sensor's value
  - Each sensor sends new prediction function when base station's prediction is out of precision.
- Question: "Can we push this in-network?"
  - Challenge: "final answer to the query has to be within a user specified precision"
- Power-aware query processing uses in-network prediction.

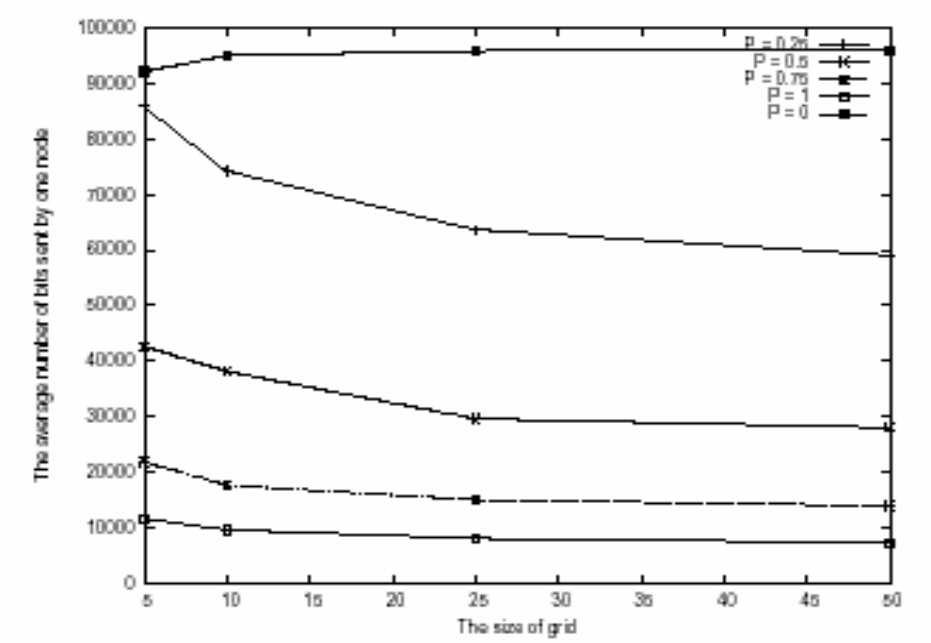
Power-aware Query Processing Technique

- Construct a query tree.
- Each node in the tree sends a prediction function for the subtree rooted at itself to its parent.
- Each parent tries to predict the values for the subtrees rooted at its children.
- Each child sends a new prediction function when the parent's prediction is out of precision.



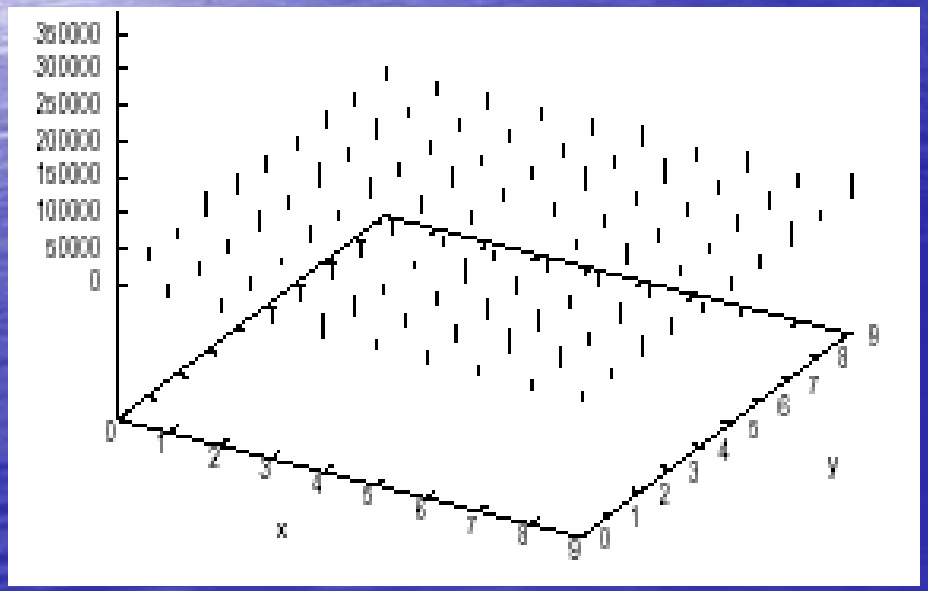
Experiment Results

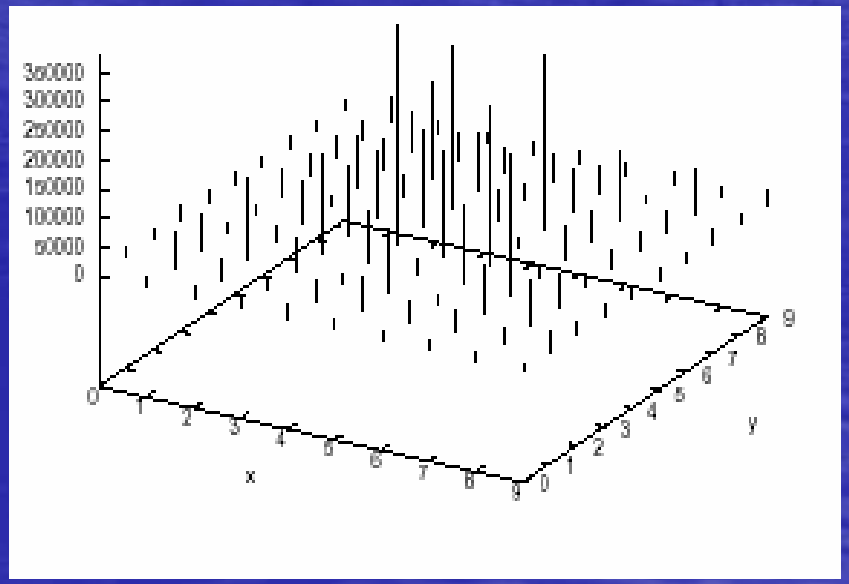
- Comparison of naive and power-aware query processing technique in terms of the number of bits sent in communication.
- Place sensors on NxN grid, each sensor can communicate with its direct 8 neighbors.
- Base station is in the middle of the grid
- Query: "SELECT AVG FROM Sensordata *s* WHERE *s*.loc in GRID *N xN* DURATION 1000 EVERY 1 PRECISION *P*"
- Below graph shows the effect of precision and prediction on communication.
  - Average number of bits sent by each sensor



Experiment Results

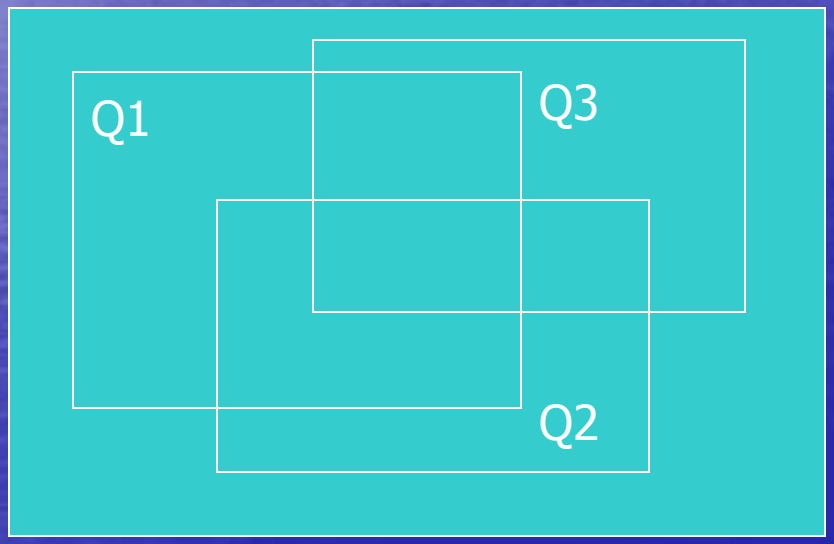
- Below graphs show the number of bits sent by each sensor in 10x10 grid
  - Energy usage is much more balanced in power-aware query processing technique





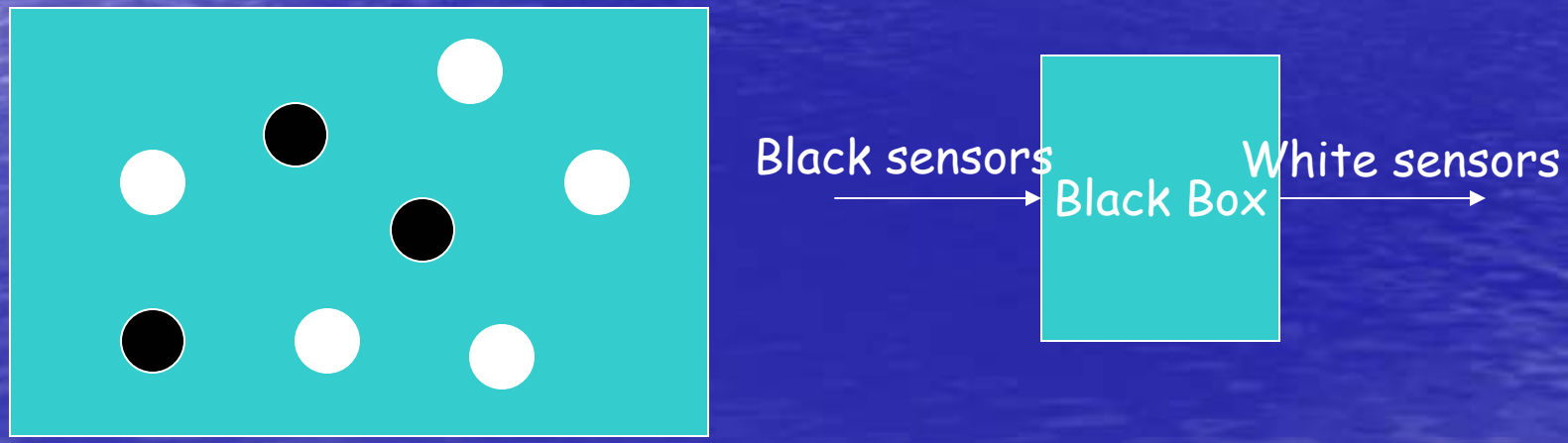
Future Direction I: Power-aware Multi-Query Processing

- Multiple queries each of which has different user specified precision



Future Direction II: Discovery of Physical Rules

- There is a physical rule between readings of sensors:
  - Can we model these rules?
  - Can we use that model in query processing?



Future Direction III: Security and Privacy Support

- Preserve privacy during in-network communication
  - Do not let others know partial results.
- Secure computation of answers to queries
  - Do not let others corrupt partial computation of results.

Q&A

Thank You !