Issues in Designing Middleware for Wireless Sensor Networks

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The authors

- This presentation is based on:

"Issues in Designing Middleware for Wireless Sensor Networks"

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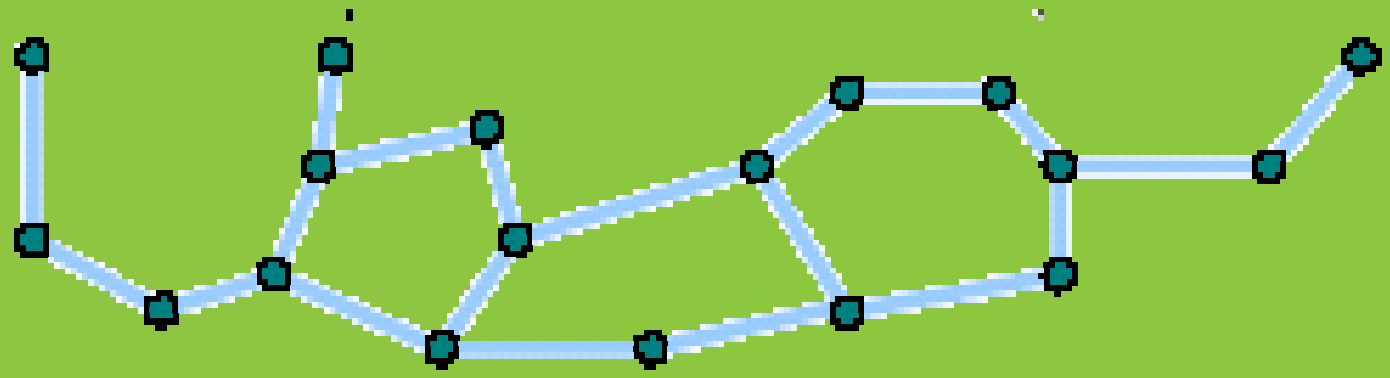
Plan

- Introduction of Wireless Sensor Networks
- Middleware
  - Middleware Design Principles
  - Cluster-based Middleware Architecture
  - Design Issues and Challenges
- An illustrative Technique for Energy-Efficient Resource Allocation
- Conclusion

Wireless Sensor Networks(WSN)

- Consists of hundreds to thousands of tiny sensor nodes that communicate over wireless channels and perform distributed sensing and collaborative data processing.



Wireless Sensor Networks(WSN)

- Developed for a wide range of civil and military applications,such as:
  - Infrastructure monitoring
  - Battlefield surveillance
  - Object tracking
- Charactiristic
  - A great number of nodes
  - Limited battery
  - Rapid changes in enviremment dynamics

Middleware

- Middleware is required to provide:
  - A runtime environment that can support and coordinate multiple applications.
  - Standardized system services to diverse applications.
  - Mechanisms to achieve adaptive and efficient utilization of system resources.
- Traditional distributed middlewares are heavyweight and not suitable for WSNs

Application Challenges

Knobs---To conserve energy, sensor nodes can operate in several working modes.

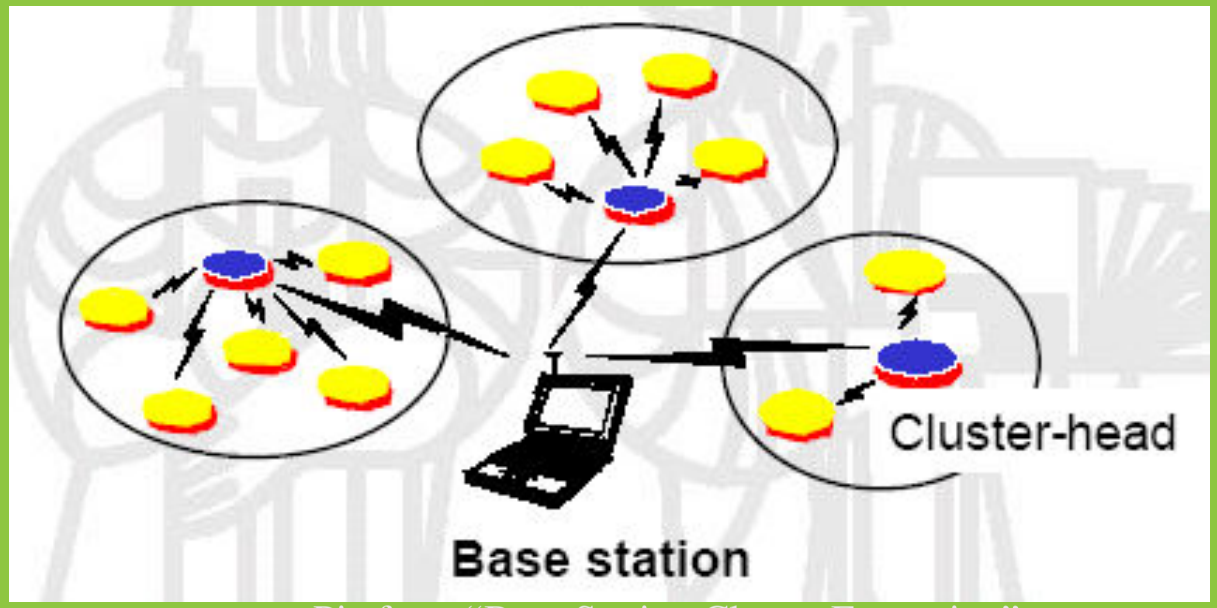
- Mechanisms for Selectively activate sleeping nodes with appropriate positions around the target and most remaining energy.
- Activated nodes need to cooperate together for distributing the required signal processing tasks, aggregating the results and routing the final decision to the base station.
- QoS requirements must be satisfied.
- The management can be complicated due to sensor heterogeneity.

Design principles

- The middleware shoud provide data-centric mechanisms for data processing and querying within the network.
- Application knowledge can be used to tailor the design and implementation of softwares.
- Localized algorithms should be used to collectively achieve a desired global objective while providing good system scalability and robustness.
- Lightweight, in terms of the computation and communication requirements.
- Smartly trade the Qos of various applications against each other.

Cluster-Based Middleware Architecture

- Cluster--- a set of spatially adjacent sensor nodes that reside around the target phenomena and are capable of detecting and/or processing the data of interest.



Pic from "Base Station Cluster Formation"

Cluster-Based Middleware Architecture

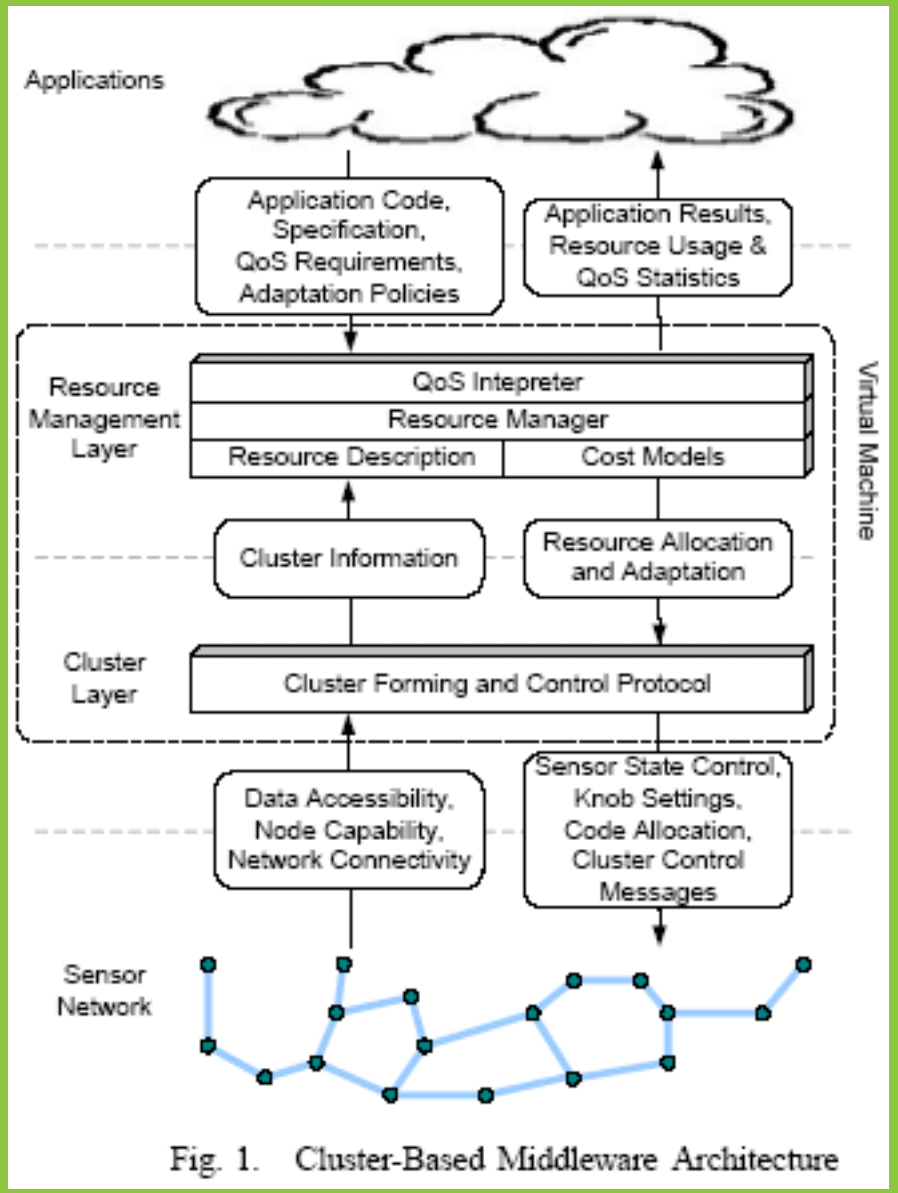


Fig. 1. Cluster-Based Middleware Architecture

Design Issues and Challenges

- Cluster Control
  - A cluster needs to change its location so that moving phenomena can be tracked. The key problem is to dynamically determine the membership of nodes in the cluster as the phenomena moves.
  - Efficient mechanisms for maintaining the cluster information at the cluster head and hide control messages from the head to cluster members.

Desion Issues and Challenges

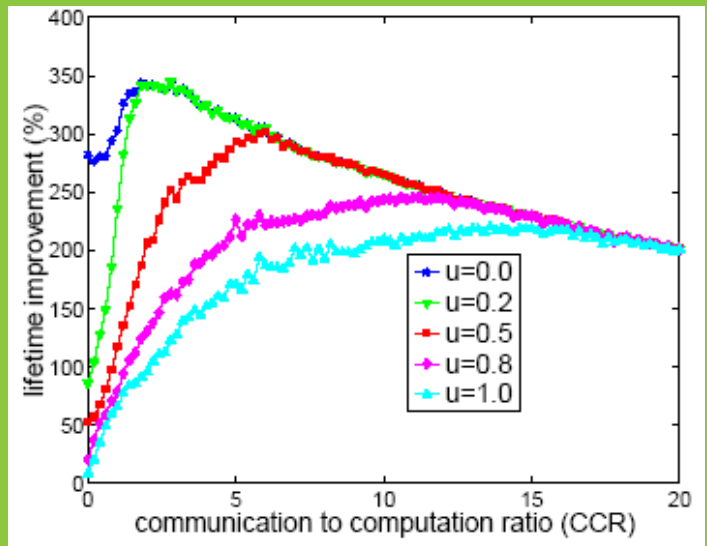
- Resource management
  - Periodically gather and update the cluster information.
  - Developement of a formalized general specification for representing the input information from application.
  - Establish accurate time/energy cost models for various CCS operations.
  - Identify appropriate optimization metrics and near-optimal algorithms for resource allocation and adaptation.

Desion Issues and Challenges

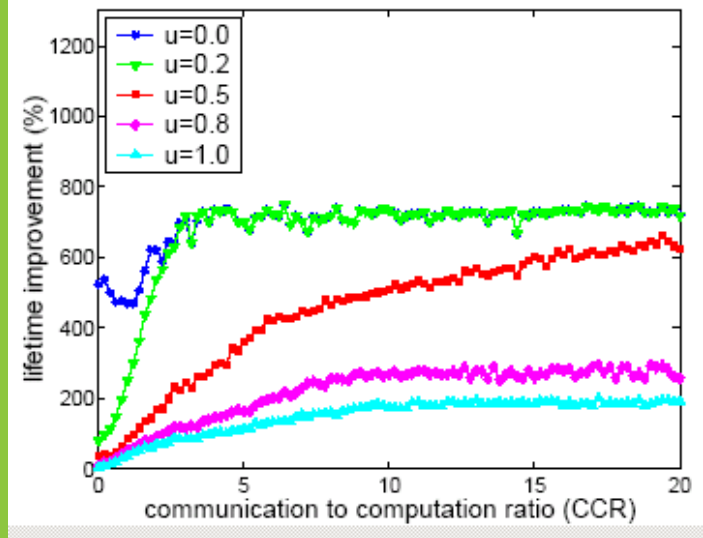
- Inter-cluster coordination:
  - Detecting the existence of overlapped clusters to avoid unfairness, starvation or deadlock during resource competition.
  - Cluster combination can increase resource utilization.
  - Cluster splitting is needed when two close objects tracked by a single cluster begin to move toward opposite directions.

An illustrative technique for energy-efficient resource allocation

- Problem Description
- A 3-Phase Heuristic
  - Ordered Task-groups
  - Assign task-groups, miminized the maximal energy dissipation.
  - Voltage and modulation settings.
- Simulation Results



(a) Use dynamic voltage scaling only



Conclusion

- For the WSNs middleware, Application knowledge direct the operations, distributed algorithms are needed to self-configure, resource management effect efficient tradeoffs between performance of applications.
- Further , an open problem is the validation and evaluation of the design concept and implementation techniques of the middleware in real WSN environments.

Thanks for your attention

Any question?