Adaptive Protocols for Information Dissemination in Wireless Sensor Networks

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Points to be noted

- Adaptive protocols - SPIN (Sensor Protocols for Information via Negotiation)
- Efficiently disseminates information among sensors
- Nodes having high-level data descriptors - metadata.

1. Introduction

- *SPIN* - suitable for wireless sensor networks.

- Efficient dissemination of individual sensor observations to all the sensors in a network, treating all sensors as potential sink nodes.

- Enhance the fault tolerance of the system

- Disseminating a critical information (e.g., intrusion in a surveillance network)

1. Introduction

Deficiencies of the below approaches render it inadequate as a protocol for sensor networks:

- Implosion :

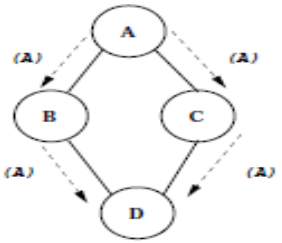

Figure 1: The implosion problem. In this graph, node A starts by flooding its data to all of its neighbors. Two copies of the data eventually arrive at node D. The system energy wastes energy and bandwidth in one unnecessary send and receive.

- Overlap:

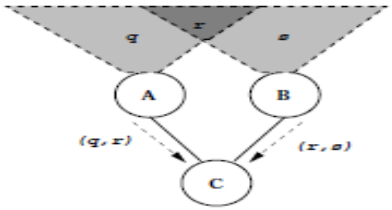

Figure 2: The overlap problem. Two sensors cover an overlapping geographic region. When these sensors flood their data to node C, C receives two copies of the data marked r.

- Resource blindness :

In classic flooding, nodes do not modify their activities based on the amount of energy available to them at a given time.

1. Introduction

- SPIN overcome these deficiencies: *negotiation* and *resource-adaptation.*
- Overcome (implosion and overlap) - SPIN nodes negotiate with each other before transmitting data.
- Negotiation - useful information, describe observed data (meta data)
- SPIN - *resource manager*
- No activity when energy is low - overcome the three deficiencies
- Negotiation - precedes actual data transmission eliminates implosion
- Meta-data descriptors - Eliminates overlap (name data)

2. SPIN: Sensor Protocol for Information via Negotiation

- Operate efficiently + Conserve energy
- Exchanging data *about* sensor data
- Application Level Framing (ALF). With ALF, network protocols must choose transmission units that are meaningful to applications, i.e., packetization is best done in terms of Application Data Units (ADUs).
- ALF - common data naming between the transmission protocol and application (meta data)
- *ALF - routing* decisions are also best made in application controlled and application specific ways, (network topology + application data layout + state of resources) at each node.

2.1 Meta-Data

- Format is application-specific

- Sensors that cover disjoint geographic regions - unique IDs as meta-data.

- The meta-data x would then stand for “all the data gathered by sensor x”. A camera sensor, in contrast, might use (x,y,ø) as meta-data, where (x,y) is a geographic coordinate and ø is an orientation.

- Every application’s meta-data format - different

2.2. SPIN Messages

- SPIN nodes use three types of messages to communicate:
- ADV – data advertisement, ADV message containing meta-data.
- REQ – request, contains meta data
- DATA – data message, actual sensor data + meta-data header

2.3 SPIN Resource Management

- Resource-aware and Resource adaptive.
- Poll their system resources - energy availablability
- Calculate the cost (energy of computations + sending and receiving data)
- Resources effectively
- No energy management policy
- Specifies an interface - applications uses for available resources

2.4 SPIN Implementation

- SPIN is an application-level approach to network communication.
- Middleware application libraries with well defined API.
- Libraries implements - basic SPIN message types + message handling routines + resource management functions.
- Sensor applications can then use these libraries to construct their own SPIN protocols.

2.5 SPIN-1: A 3-Stage Handshake Protocol

- Disseminating data through a lossless network - stages (ADV-REQ-DATA)
- Starts - new data for dissemination (ADV stage)
- Receiving ADV - neighboring node checks if has already the same ADV
- Otherwise REQ - missing data back to the sender (REQ stage)
- Protocol completes - responds to the REQ with a DATA message, containing the missing data (DATA stage)

2.5 SPIN-1: A 3-Stage Handshake Protocol

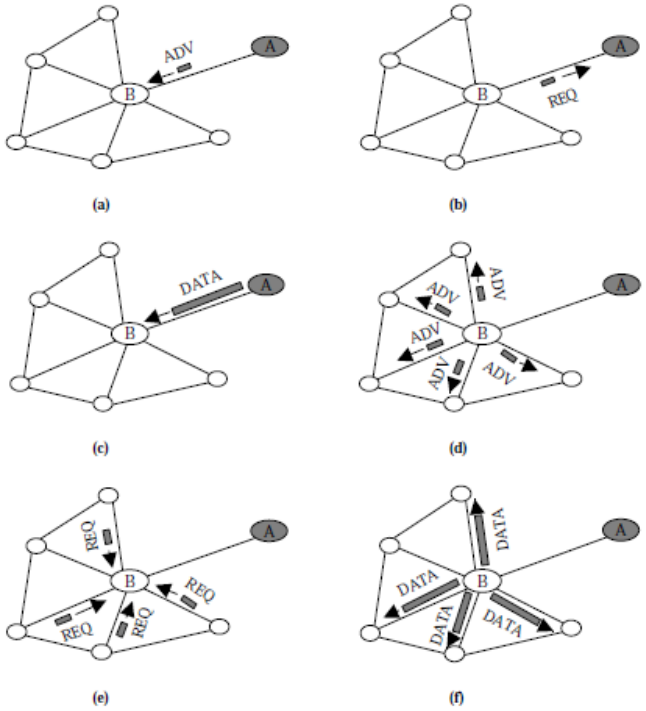

Figure 3: The SPIN-1 Protocol. Node A starts by advertising its data to node B (a). Node B responds by sending a request to node A (b). After receiving the requested data (c), node B then sends out advertisements to its neighbors (d), who in turn send requests back to B (e,f).

2.5 SPIN-1: A 3-Stage Handshake Protocol

- Can adapted to lossy or mobile networks (lost ADV messages by re-advertising periodically)
- Mobile networks - changes in local topology trigger updates to node's neighbor list (re-adv)
- Simple, little decision making (new data), and wastes little energy (computation)
- Each node – need to know (its single-hop network neighbors)
- No topology information required to run the algorithm :
  - run in a completely unconfigured network with a small, startup cost to determine nearest neighbors and
  - if the topology of network changes frequently, only have to travel one hop

2.6 SPIN-2: SPIN-1 with a Low-Energy Threshold

- Adds simple energy-conservation heuristic to the SPIN-1
- low-energy – less participation
- Participate - complete stages (i.f.f. enough energy)
- Allow receiving -ADV or REQ

3 Data Dissemination Algorithms
3.1 Classic Flooding

- Sends copy of data - all neighbors
- A round - time (group of nodes to receive data + forward data)
- Algorithm finishes (converges) – all nodes (copy of data)
- Flooding similar to SPIN1
- Implosion + overlap – cannot solve

3.2 Gossiping

- Randomization to conserve energy
- Data can be sent back to same sender – if randomly selected
- Avoid implosion
- Distributes information slowly - dissipates energy slow
- Distributes data is 1 node/round – one node at a time
- Overlapping

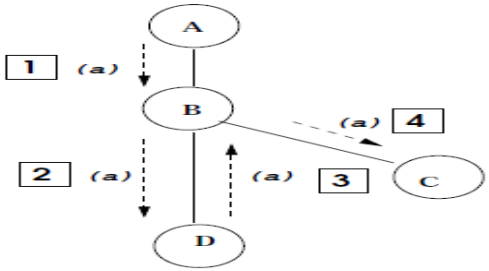

Figure 4: Gossiping. At every step, each node only forwards data on to one neighbor, which it selects randomly. After node D receives the data, it must forward the data *back* to the sender (B), otherwise the data would never reach node C.

3.3 Ideal Dissemination

- Shortest-path route
- Receives distinct data only once.
- No energy waste for useless data
- Network-level multicast, such as IP multicast - nodes build and maintain distributed source-specific shortest path trees + themselves act as multicast routers.

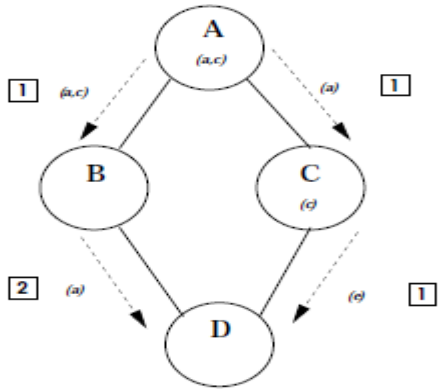

Figure 5: Ideal dissemination of observed data a and c. Potential implosion, caused by B and C's common neighbor, and overlap, caused by A and C's overlapping data, do not occur.

5. Conclusions

SPIN protocols hold the promise of achieving high performance at a low cost in terms of :

- Complexity,
- Energy,
- Computation, and
- Communication

Thank You !!!

QUESTIONS….