Prolonging Sensor Network Lifetime with Energy Provisioning and Relay Node Placement

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Introduction

- Wireless sensor networks have limited network lifetime.
- Network life time even on maximizing may not be able to meet mission requirements.
- Here the emphasis is on energy provisioning for a two tier wireless network.
- The paper considers energy provisioning as well as relay node placement.
- The paper formulates a joint EP and RN placement as a MINLP.
MINLP is NP-hard in general.

The state of art techniques are not able to provide a solution.

They discuss a heuristic technique called SPINDS.

They transform a MINLP into an LP using efficient design techniques.

They conclude by showing their simulation results are better than existing techniques.
Topology

- Two tier architecture.
- Each cluster is deployed around a strategic location and consists of number of small Micro sensor nodes (MSNs) and Aggregate forwarding nodes.
- MSN sends data to AFN which performs aggregation function.
- The AFN relays the information to the base station using either a single hop or multihop communication.
- The focus of recent technology is to optimize flow routing in AFN.
Topology

- MSNs are not reprovisioned with energy
- MSNs are of low cost and large in number thus its plausible not to reprovision.
- Reprovisioning is done for AFN nodes
- However limiting energy provisioning only to AFNs may not yield an optimal solution.
- Network lifetime and energy utilization highly dependent on network geometry.
- Thus they devise the strategy of using Relay Nodes (RN) to mitigate the energy efficiency problem.
- The relay nodes are similar to AFNs however they do not perform any data aggregation.
SPINDS a Heuristic solution

- SPINDS: Smart Pairing and Intelligent Disc Search
- Iteratively works on where to place Relay nodes.
- MINLP is transformed into Linear Programming (LP) problem using such an approximation.
- LP can be solved in Polynomial time.
- SPINDS is a heuristic polynomial time solution for the Joint EP – RN placement problem.
Problem formulation and System Modeling

- Three types of nodes AFNS, MSNs and Base station
- MSNs application specific cheap cost and large in number
- AFNs, there exists one per cluster of MSNs, performs data aggregation and forwarding to the base station.
  - AFN can act as relay for other nodes as well
  - Upon AFN depletion the area covered is lost.
  - These are the nodes where energy provisioning is done
- The base station is the sink of all data from all AFNs
Joint Energy Provisioning and Relay node Placement

- For a network where the AFNs generate data at a constant bit rate then a solution to Linear programming problem suffices to devise an optimal schedule.
- The problem here is that network life time not adequate.
- Thus energy provisioning required.
- Rather then provisioning energy on existing nodes use technique of relay nodes to mitigate the problem.
- Figure shows the placement of relay nodes.
Joint Energy Provisioning and Relay node Placement (Contd)

- RNs are similar to AFNs they only do not generate data.
- The question arises where to deploy the RNs.
- In case the RN coincides with AFN what needs to be done?
- We solve the above problem by provisioning energy to the existing AFN.
- Thus we need to solve the given problem with following constraints discussed on the next slide.
SPINDS: Procedural Description

- SPINDS: Smart Pairing and Intelligent Disc search.
- Start with initial location of RNs if not optimal then relocate.
- Eventually after several iterations if network life time does not increase then we realise that this place is optimal.
- The proposed algorithm consists of two phases
  - Smart Pairing
  - Intelligent Disc search.
SPINDS (Contd)

- Initially all the RNs at same position that is at the Base station.
- At the beginning of each iteration we first obtain the best flow routing, this can be done by looking at the incoming packets.
- The node with smallest lifetime is identified.
- A list of RNs with increasing energy is made.
- We pair an RN which is farthest from the distance of the AFN under consideration.
- This is the pairing step in SPINDS.
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Conclusion

• The joint problem of Energy provisioning and Relay node placement was studied.
• Polynomial time heuristic algorithm was developed.
• SPINDS increases network lifetime by trying to move the RN to an optimal position
• The polynomial time algorithm was achieved by converting the given MILP to an LP.
• Network geometry insights were also provided along with EP and RN placement.