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Wireless Sensor Networks (WSN)

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Outline

- Multi-hop Wireless Networks

  MANETs, VANETs, WSNs
- Routing in WSNs
- Opportunistic Routing Algorithms
- Proposed Opportunistic Routing:
  Partitioned Opportunistic Routing

Introduction to Multi-hop Wireless Network (MWN)

- Wireless network that uses two or more wireless hops to convey information.
- Group of nodes which are connected by wireless communication links.
- Broad Military and Civil applications support.
- Low cost of Deployment.

Multi-hop Wireless Network (MWN) Scenarios

- Scenarios of MWNs:
  - Mobile Ad-Hoc Network (MANET)
  - Vehicular Ad-Hoc Network (VANET)
  - Wireless Sensor Network (WSN)

Mobile Ad-Hoc Networks (MANETs)

- A set of mobile devices that are connected to each other by wireless links and are self-configurable.
- The nodes are mobile and can move freely and independently in any direction, resulting in frequent change of network topology and wireless links.
- The primary challenge is maintaining the routing information at each node to be used in routing issues.

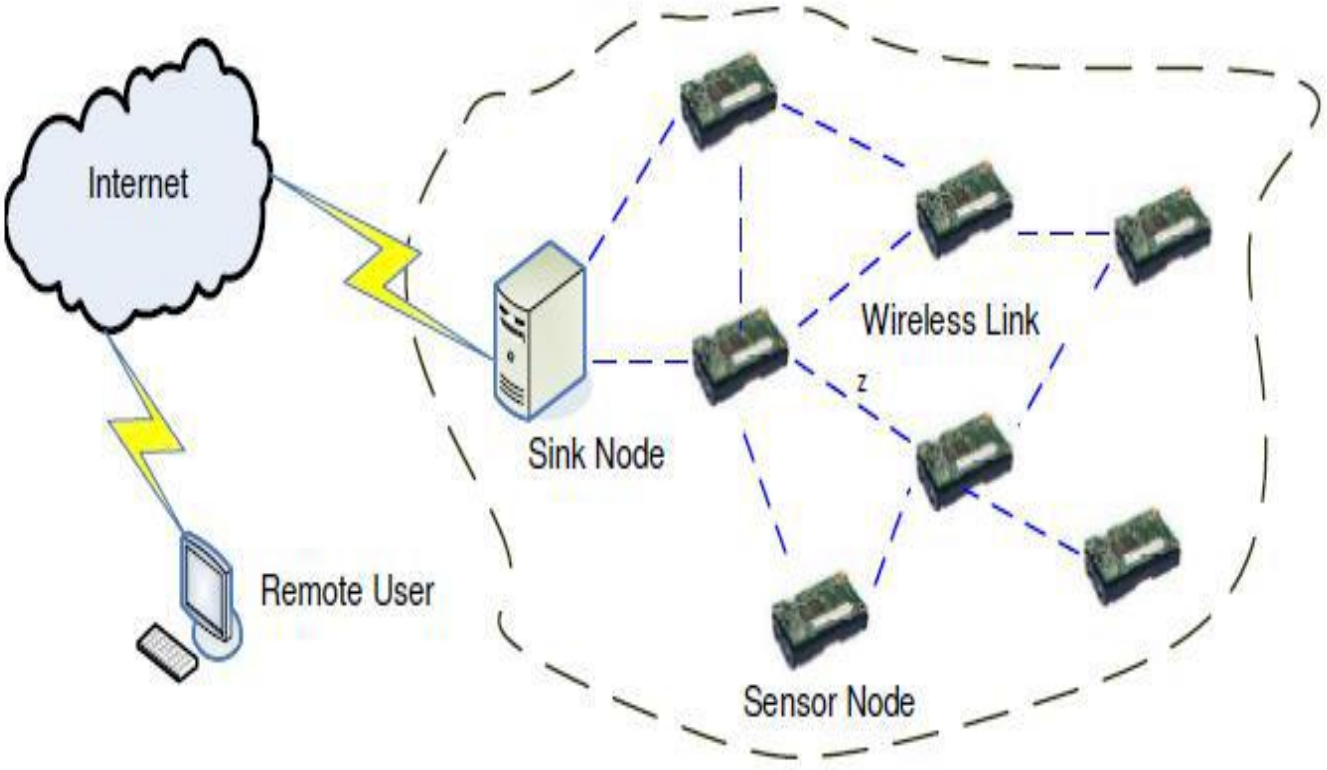
Vehicular Ad-Hoc Networks (VANETs)

- Use of a transceiver for communication.
- Used to inform other vehicles of emergency situations and avoiding vehicle collisions.
- Types of VANETs:
  - Vehicle to Vehicle (V2V)
  - Vehicle to Infrastructure (V2I)

Wireless Sensor Networks (WSN)

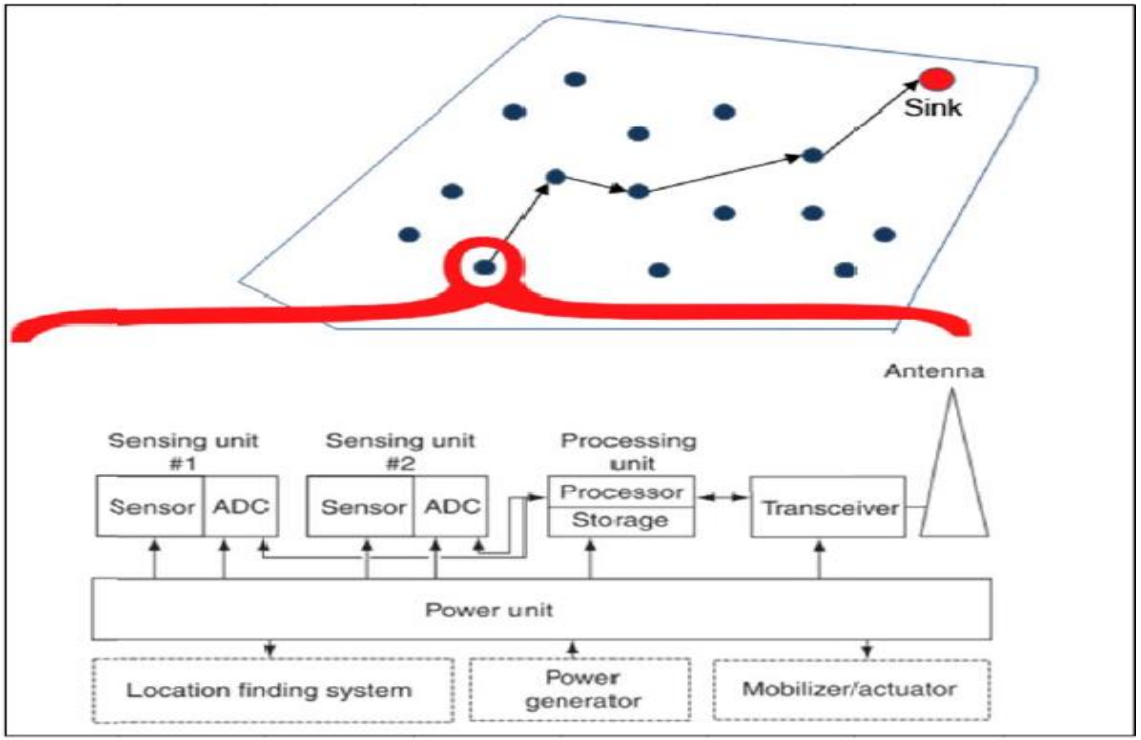
- A Wireless Sensor Network (WSN) is composed of a large number of distributed “sensor nodes” and one or more “base stations”.
  - Sensor Nodes are in charge of gathering information
  - Base Station is responsible for storing and processing data
- Used in monitoring various physical or environmental conditions.
- Large scale networks; The key challenge: energy efficiency.

WSN Architecture



Components of a Sensor Node in WSN

- Processing Unit
- Sensing Unit
- Transceiver
- Power Unit



Wireless Sensor Networks

Routing Protocols and Routing Challenges in WSNs

- Routing protocols are proposed to find a path from a source to destination.
- Main goal: Finding paths with minimum energy consumption.

Challenges due to distinct Characteristics:

- Global addressing scheme; High number of nodes results in high overhead of ID maintenance.
- Data Collection; Impossible use of GPS in sensor nodes (up to now).

Routing Challenges in Wireless Networks

Some Routing Algorithms Challenges are:

- Broadcast nature of wireless medium
  - Broadcast medium contention affects delay and throughput.
- Unreliability of wireless links
  - Variation in wireless links might lead to loss of the path.
- Mobility property of Wireless networks
  - Changes in network topology results complicated path maintenance.

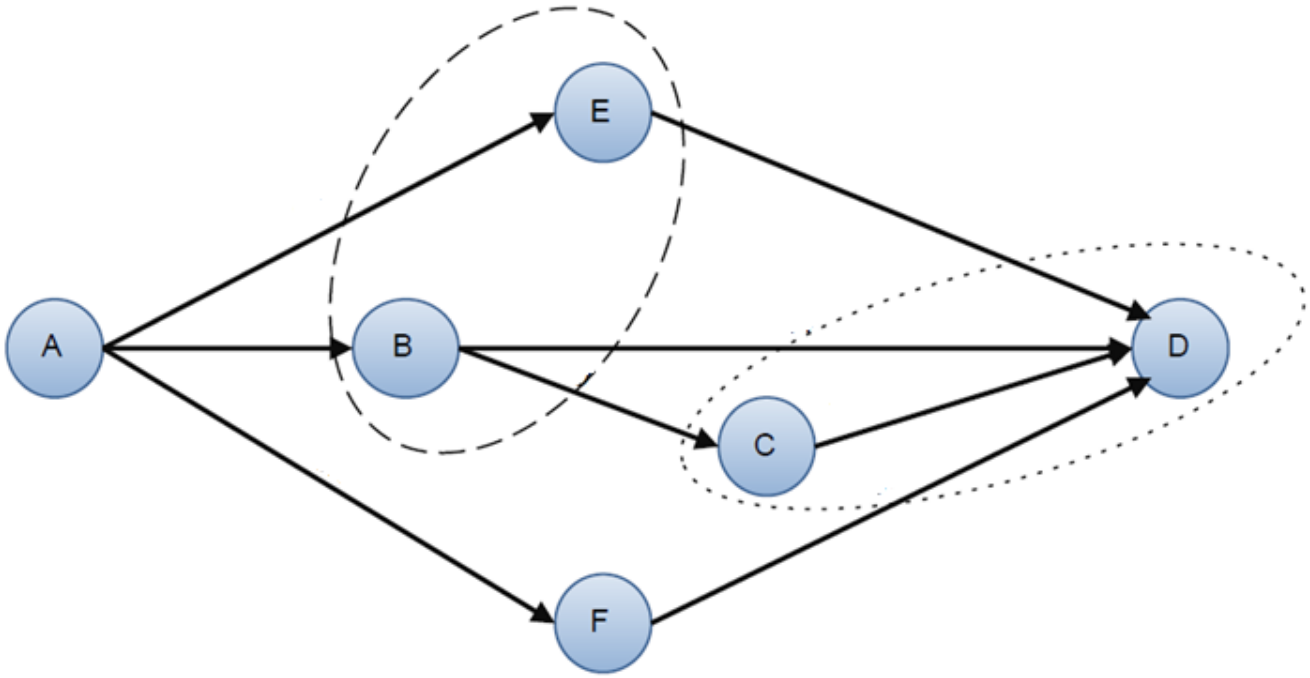
Opportunistic Routing (OR) in WSNs

- The set of all possible paths that packets may traverse from a source to a destination.
- Neighbors can potentially receive the transmitted packet.
- Use of multiple potential paths to deliver packets to destination.
- Candidates coordinate for forwarding the packet.

OR Terminology

- Candidate Set (CS)

Set of nodes selected by network layer to forward a packet.



OR Terminology (Contd.)

- Expected Transmission Count (ETX)
  - The number of expected transmissions of a packet necessary for it to be received without error at its destination.
- Expected Any-Path Transmission (EAX)
  - An extension of ETX in OR
  - The number of transmissions needed to deliver a packet from a source node to destination through OR.

Opportunistic Routing

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- Routing goal: Finding the shortest path with maximum throughput to destination.
- Using Candidate Set as next hop.
- Union of all possible paths from a source to destination.

Opportunistic Routing Performance

- Opportunistic routing performance depends on several issues:
  - Choosing forwarding candidates
  - Prioritization Problem

Extremely Opportunistic Routing (ExOR)

- One of the earliest Opportunistic Routings.
- Selects one of the nodes in Candidate Set as the forwarding relay.
- Process continues until the packet is received by destination.

Least Cost Opportunistic Routing (LCOR)

- OR: Transmits packets to any node in Candidate Set.

Q: How to assign the set of CS to minimize the cost of forwarding a packet to destination

- LCOR: finds the optimal Candidate Set; minimize expected number of transmission.

Some other Opportunistic Routing Algorithms

- Minimum Transmission Selection (MTS)
  - Optimal candidate set for every specific destination
  - Moving backwards to select candidate set
- Geographic Random Forwarding (GeRaF)
  - The sender does not know about the next relay
  - Relaying node is the closest node to destination

Comparison of Opportunistic Routing Algorithms

Routing Algorithm	Papers	Approach	Outperformance reasons (Advantages)
ExOR	Biswas & Morris, 2005	• Uses one of the nodes in candidate set to make forwarding decision • Operates on batches of packets	• More probability of reception for each transmission • Increase total network capacity • Less average number of transmissions
LCOR	Henri Dubois-Ferriere, 2007	• Finds optimal candidate set • Generalization of single-path routing	• Minimize expected number of transmissions
MTS	Yanhua, et al., 2009	• Optimal candidate set for each destination	• Uses the lowest cost node to destination • Maximum number of candidates can be limited
GeRaF	Michele Zorzi, 2003	• Packets are routed in best-effort basis • Uses a type of broadcast address	• No needs of topology information • Small latency

Drawbacks of some Opportunistic Routing Algorithms

LCOR:

Change of routing table and candidate set upon each node's movement.

MTS:

All nodes require to know about general network information.

The Most Important one;

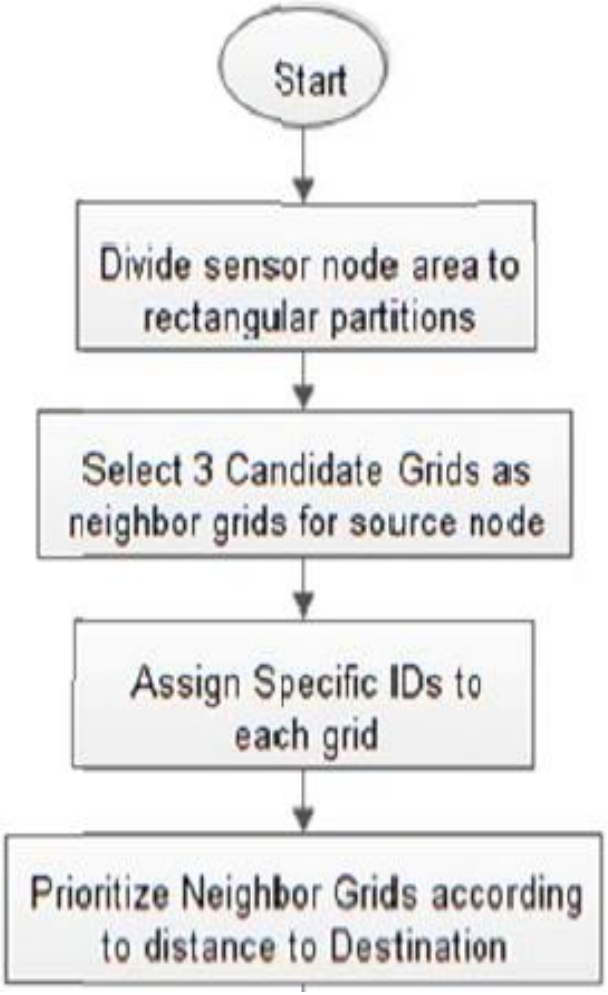
Scalability Problem

Partitioned Opportunistic Routing (POR)

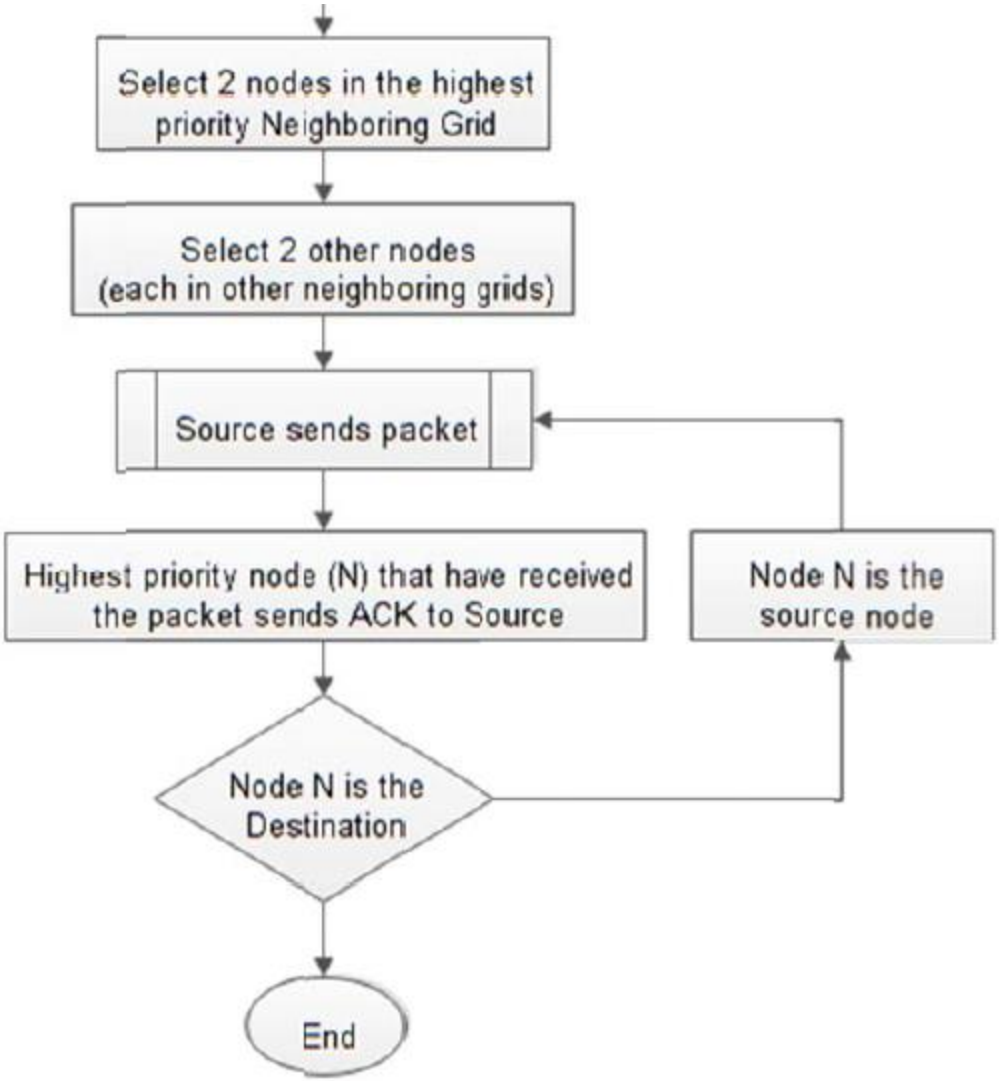
- Each node uses local information and neighbors position
- Very low computational and communicational overhead

Overhead is caused by collection of information from all nodes in the network due to each movement.

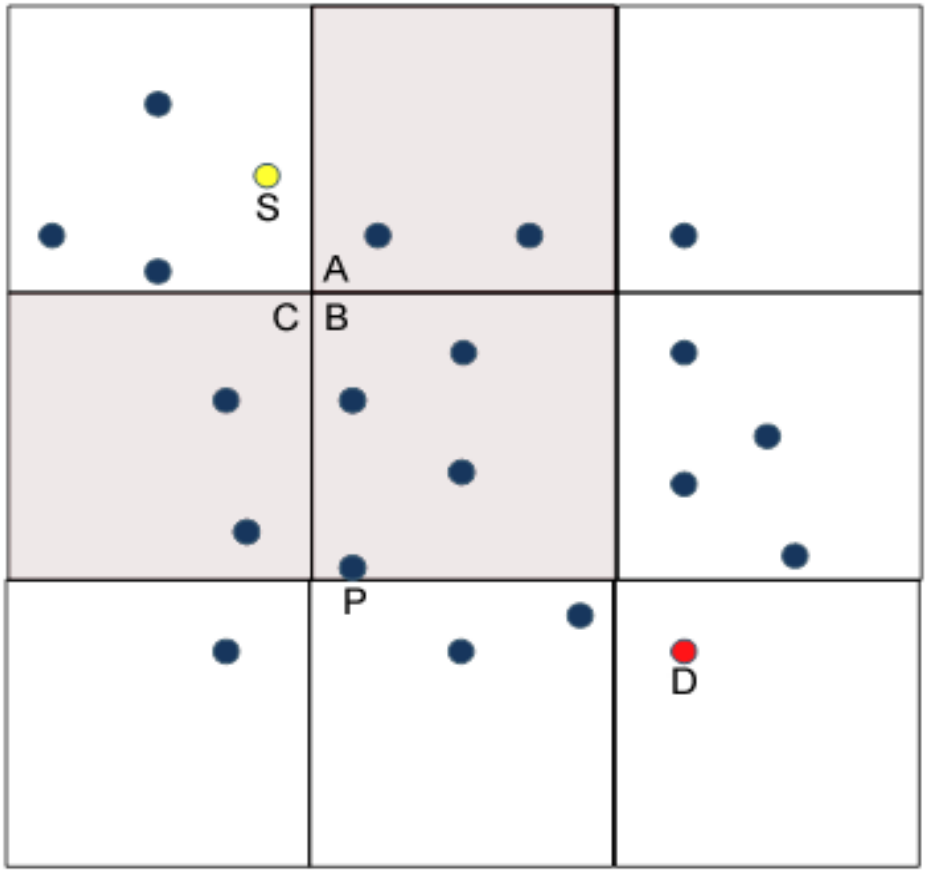
POR Flowchart



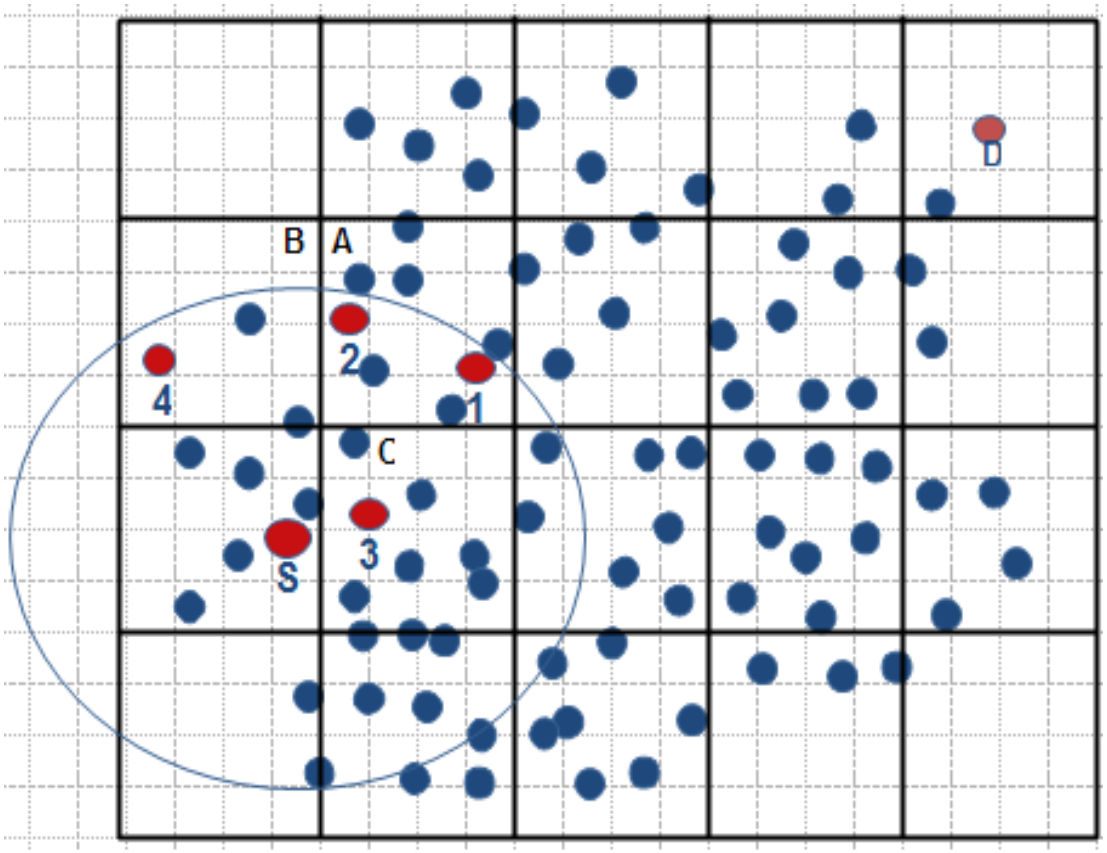
POR Flowchart (Contd.)



Selecting Candidate Grid & Grid Prioritization

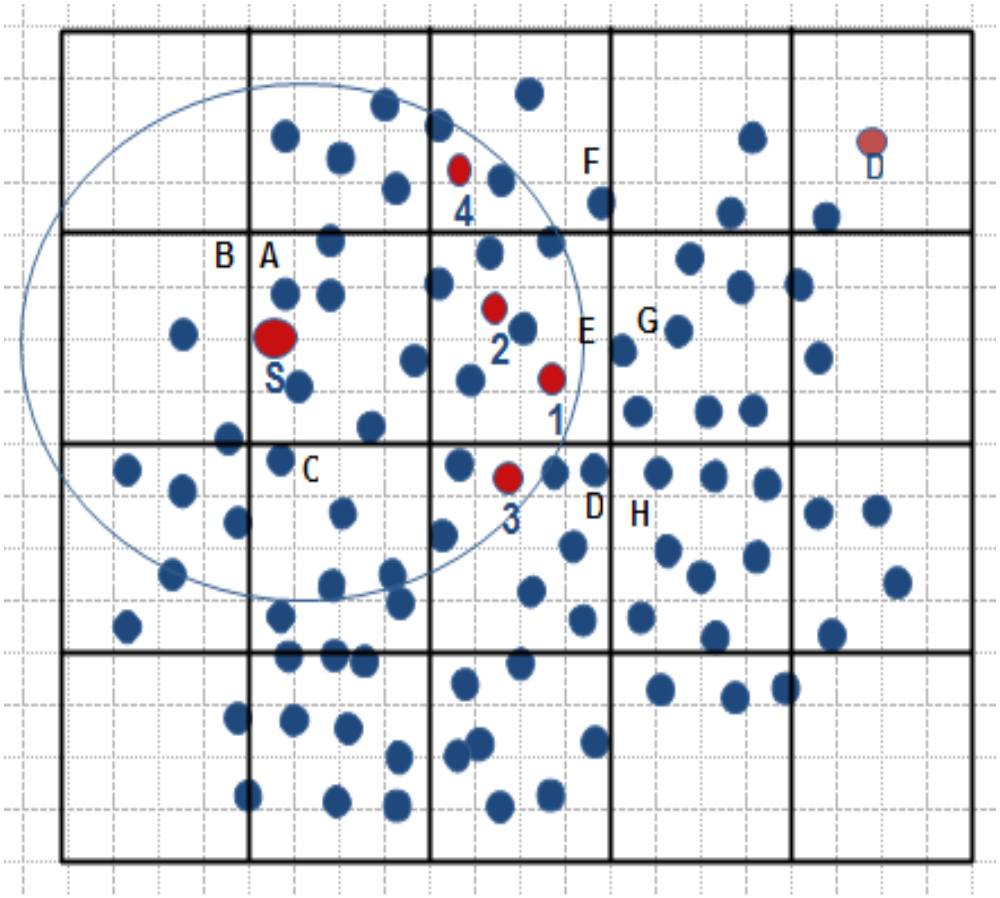


POR Implementation



Neighboring Nodes in Neighboring Grids (Initial Step)

POR Implementation (Contd.)



Neighboring Nodes in Neighboring Grids (Step two and three)

Future Work

- Selection of candidate node in candidate grid.
- Selecting potential candidate nodes.
  In case the candidate node leaves the grid
- Using different grid sizes to improve performance.

Summary

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- Multi hop Wireless Networks (MWN)
- Wireless Sensor Networks (WSN)
  - Architecture
  - Routing Protocols and Challenges
- Opportunistic Routing in WSNs, Comparison and drawbacks (ExOR, LCOR, MTS, GeRaF)
- Partitioned Opportunistic Routing (POR)
  - How POR Works
  - Improvements on POR as future work

References

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Questions ?