

Performance Analysis on Non-Clustering Routing Techniques for Homogeneous and Heterogeneous Wireless Sensor Networks

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ABSTRACT

Wireless sensor network typically consists of a large number of low power and multiple functions-based sensor nodes that are spread in environment area. These sensor nodes are small/tiny in size but have sensing, computation and wireless transmission abilities. Different types of routing protocols invented for WSNs where energy efficiency saving is main concern for whole network. The performance of WSN depends on the types of routing technique, where it has been implemented. This paper gives comprehensive survey between existing non-cluster-based routing protocols of WSN. Initially in this paper we explain the routing and design challenges for WSN and later on focus on the comprehensive review of different routing protocols. Division of the routing protocols into non-cluster and cluster-based routing protocols for both homogeneous as well as heterogeneous networks. The tabular representation for different parameters for non-clustering routing protocols is explained in this paper.

Keywords: Routing Protocols, Homogeneous and Heterogeneous, Non-Cluster and Cluster based Protocols

INTRODUCTION

In recent trends sensors play a vital role to generate the network of nodes. Where these nodes may be same configuration and different kinds. This is why all sensor nodes create a network known as Wireless Sensor Network (WSN). This network may be multiple types such as homogeneous, heterogeneous and hybrid. In homogeneous all nodes have same features, different features hold by heterogeneous, and combination of both is hybrid nodes. In WSNs each and every node controlled by a station known as base station or also known as main controller or sink is also called sink. These nodes may be communicated in way that minimum energy consumption should be there. There

should be energy efficient approach to make route from each to base station [1]. More research needs to be done in the field of routing mechanism of sensor network. Physically and environmental these are the two inputs from where sensor takes input [2].

Two types of communication take place first is direct transmission between node and BS and second one is node to node transmission. Both consumed the energy of node which leads to load balancing of sensor network. In networking different topologies [3] are used to make the transmission between network nodes. The main challenge in the network is deployment of nodes into hostile environment [4]. In WSNs, network may create the clusters of nodes where cluster member and cluster head play the role maintain and control the whole network. Through clustering energy level of network may also increase which leads to prolong the network. There are two types of routing mechanism one is clustering and non-clustering techniques.

Many papers shown the merits/demerits, areas of implementation and communication protocols in WSNs[5][6][7][8].

ROUTING CHALLENGES AND DESIGN ISSUES IN WSNs

In routing we have different challenges when going to design any routing protocol [7] to be considered first. Ssummarize routing challenges and design issues in [9]. Node deployment [10][11][12] Energy consumption[13][14], Data reporting model[15], Node heterogeneity[16][17], Fault Tolerance[18][19], Scalability[6][20], Network Dynamics[21], Transmission Media[18][22][23], Coverage[6], Data Aggregation[6][24][25], Quality of Service[6][25].

PREVIOUS SURVEYS ON WSN ROUTING PROTOCOLS

WSN has different types of routing protocols which play important role to design the network. There have been some literature's survey or review papers year wise on routing protocols which are as follows: Akyildiz et al.(2001)[8], Jamal N et al.(2004)[6], Kemal Akkaya, Mohamed Younis(2005)[26], Ameer Ahmed Abbasi, Mohamed Younis (2007)[27], Jennifer Yick et al(2008)[28], Jaydip Sen(2009)[29], Luis Javier García Villalba et al.(2010)[30], Changle Li et al. (2011)[31], Adamu Murtala Zungeru et al(2012)[32], Prabhat Kumar et al.(2012)[33], Nikolaos A. Pantazis et al.(2013)[34], Tifenn Rault et al. (2014)[35], Santar Pal Singh, S. C. Sharma (2015)[36], Amit Sarkar, T. Senthil Murugan(2016)[37], Nabil Sabor et al.(2017)[38], Lucia Keleadile Ketshabetswe et al. (2019)[7].

CLASSIFICATION OF WSN ROUTING PROTOCOLS

An effective role of a routing protocol is to find out the multiple paths for nodes to send the data in whole sensor network while gaining network life time as maximum as possible[7]. The network life time is completely depending on the sensor nodes residual energy. The division of distinguish routing protocols is on the nodes how they are going to communicate with BS. There are multi-categorical ways to categorize the routing protocols[33] that can be non-cluster or cluster based (homogeneous/heterogeneous) shown in Fig 1. Many non-clustering[39] and clustering routing protocols have been proposed[27][40][41]. Many survey[8][26][42][43][44] and review papers[37][45][46][47] have been published and showed the different parameters values of different types of communication protocols[48].

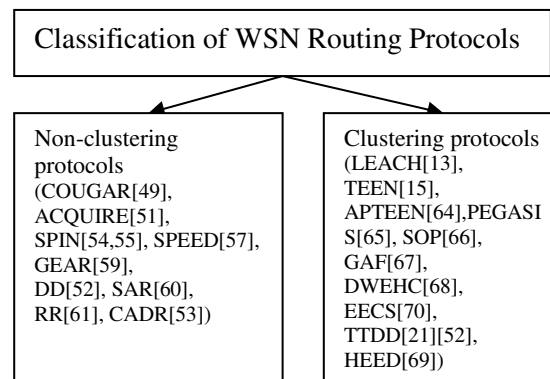


Fig. 1. *Classification of routing protocols of WSN [33]*

A.COUGAR

Cougar[49] is kind of data-centric protocol, sees the entire network as a large distributed database system (DDBS). To obtain the more energy saving, this type of protocol uses the in-network data aggregation. This type of abstraction is originated by some additional query-based layer, work as interface for network application layer of WSN. In this protocol, sensors choose the leader node (LN) to achieve data aggregation and further transmit to BS. Cougar is providing the independent methods for network layer. Later, Cougar has some demerits also, first is overhead will be extra in the case of power utilization and memory occupied due to append a query layer on each sensor node, second is synchronization of sensor nodes, data computation is mandatory, just before transmitting to the leader node.

B.ACQUIRE

As cougar approach, ACtive QUery forwarding In sensoR nEtworks (ACQUIRE)[50] is also seen the entire network as distributed-database system (DDBS). In cougar approach query becomes very complex so, ACQUIRE just break the whole query into several sub queries. Now firstly BS sends query. Through the network, active query is floated, temporary buffer or pre saved information access by in-between nodes to give the partial solution to the nodes. Finally the completed response is sent back by the shortest-path or backtracking to the BS until the query fully resolved. So, ACQUIRE can be used for typical queries by allowing multi nodes can send response. But in case DD[51] cannot used for typical queries because of power consideration, as DD[51] also run on flooding query technique for regular aggregation of queries. Basically ACQUIRE provides reliable querying by maintaining the parameter value of d , where d is network diameter, and parameter d is used for look ahead with multiple hops. If d is less than query has to go ahead with multiple hops. ACQUIRE has mathematical approach was used to calculate the optimal_value of d parameter for sensors grid, here each sensor node has four instantaneous neighbors. So which one sensor node will be next forwarding node for the query, this is completely based on the CADR[52] and IDSQ[52].

C.SPIN

Sensor Protocols for Information via Negotiation [53][54] protocol proficiently spreads information in-between sensor nodes to prolong the network life time. It is part of negotiation-based information spreading protocol for WSN. SPIN protocol focuses on the efficient dissemination of each sensor and assuming that each node has potential to be as BS. This makes each node maintains data about

all neighbor nodes and get the required information easily. SPIN protocol maintains the data in the form of meta-data (data about data) and also performs some negotiation on meta-data before any data transmission takes place. Because this makes that no replication of data will be sends throughout the network. The meaning of metadata is at application specific not part of SPIN. SPIN design for two benefits:

1. It is used to upgrade the fault tolerance of the network system.
2. It can also detect the intrusion and spread alert message to all the nodes.

Previous protocols like as flooding and gossiping based routing protocols[55].

SPIN has 3 steps protocol as each node contains these types of messages DATA (new data), ADV (advertise), REQ (request) for transmit. First of all, when a node holds new data and wants to share with other neighbor nodes, broadcasts the ADV message with meta-data. For new data require by any neighbor, broadcasts a REQ message to all remaining nodes then further again same process apply to all connected neighbors this process will cover all the network area with broadcast the REQ message. Finally receives the copy of new data. SPIN has 2 protocols: first is SPIN1 already discusses above where as second one is SPIN2, which extends the work of SPIN1, only needful data will be sent. Another word done by SPIN2 is resource management. There is resource manager which is responsible for maintaining the catalog about the resource consumption.

D.SPEED

Stateless Protocol for End to End Delay [56] is type of Quality of Service routing protocol. This protocol specifies that each node should contain the information about all related neighbor nodes and also find outs the possible paths by using geographic forwarding technique. Congestion avoidance can also provide by SPEED protocol when congestion occurs in the networks. There is SNFG routing module under the SPEED protocol and add-on with other 4 modules at the network layer. And mechanism is to gathering information regarding the nodes and their co-ordinates position. Though delay assessment or estimation mechanism, any node finds whether the congestion has occurred or not. Delay finds at the end of sender side which timestamps that particular packet inserting into the network pipeline and find outs the whole cycle single hop delay for that packet until ACK will received. At the end of receiver side, the time when receiving ACK is planted inside the ACK packet. As SPEED is compared to the well-known routing protocols DSR and AODV[57] both are performing well from one end to another end delay and miss-ratio also. Overhead of control packet is less in comparison to other and complete transmission power usage is less also.

E.GEAR

Geographic and Energy Aware Routing protocol[58] examined the usage of geographic information while broadcasting queries to demanding regions since queries contains geographic parameters. GEAR only considers the specific demanding region rather than spreading queries to the whole WSN. Due to this protocol can save energy consumption than direct diffusion (DD). Each node maintains two types of cost: estimated cost and learning cost; to reach the destination node through the neighbor nodes. The estimated cost will be calculated by the mixture of Res_E. The cost of learning is calculated by the cost of estimation that keeps track for routing around the holes in the WSN. When a node does not have nearby neighbor then a hole occurs. The cost of estimation and the cost of learning both are same when there is no hole.

F.SAR

Sequential Assignment Routing [59] is the finest routing WSN protocol that enables routing decisions. This protocol is depending on the 3 parameters: energy resources, QoS regarding each and every path, the packet priority. Single routing algorithm may generate route failure, so multi routing with multi paths are used. Multi paths will be generated from source node to BS as a tree rooted form. SAR is row column tabular represents multi paths protocol that focus on how to efficient utilization of energy and fault tolerance system. SAR maintains a tabular form metric for weighted QoS overall based on the life time of network. If any node failure occurrences due to topology change then new path computation will take place. So BS takes the responsibility to maintain path computation periodically if there is any change in the topology. If any failure occurs then routing table which has both side routes downstream as well as upstream nodes on each path, will be considered to take alternate path to recover from failure. SAR simulation shows that another min-energy metric algorithm. SAR focuses only on the energy, not consider the priority. A demerit is overhead, to maintain the table and states of each node.

G.DD

Basically Directed Diffusion [51] has main focus on the data aggregation and it is a kind of data-centric protocol. The data aggregation in DD is used to boxing the data which are coming from multiple sources, to eliminate the duplicity and minimizes the transmission numbers for network energy saving time. An event and create gradient of information in their corresponding neighborhoods by DD protocol. Diffuse the interest by each node hop by hop of neighbor nodes. This interest floats to whole network nodes and each node receives the interest by their neighbor nodes and setup a gradient towards the sensor nodes. So finally, according to an interests find outs multiple paths and select one as best path from all paths. DD is completely aware which is used to achieve every saving by selecting good paths and process the data to take further place. Caching is also part of this task. The output of data aggregation method of this protocol may affect by 3 factors: location of the node, number of sources and topology used for communication. If need to work these factors then there are 2 models[51]. In Rs model, k is the sensor nodes selected to be sources. And all sources not to be clustered each other. In both cases maximum number of nodes connected to the sink or BS. As per the application specific both models give minimum energy usage.

H.RR

Rumor Routing [60][7] is type of DD and supports for application where geographic routing is not implemented possibly. RR is type of improvement in DD that balancing the query and event flooding. The demand of flooding is required when events are small and need to perform large number of queries. If nodes sense certain events, then queries are only routed to those nodes, not applicable for whole sensor network nodes. Each node holds the neighboring nodes list and event as well as sending the information to all remained network.

I.CADR

Constrained Anisotropic Diffusion Routing [52] is general form of DD [61][62]. This is done for the querying the sensor nodes and data routed within sensor network. By doing this, information gathering becomes maximum, minimizes the delay and bandwidth also. Adjusting route dynamically, activating only those sensors that are closed to the targeted event. This protocol is also

considered the two parameters which are communication cost and information gain cost. On the behalf of these parameters, each nodes estimates cost and information objective and routes data in this protocol. IDSQ provides that querying node can find out the specific node which is providing the most needful information with also balancing the energy level as asset added. How data should be routed and how queries are routed, both are not defined by IDSQ between sensor nodes and BS. As simulation shows that CADR protocol is more efficient in case of energy in comparison of directed diffusion[32].

A DETAILED COMPARISON OF DIFFERENT NON-CLUSTERING ROUTING PROTOCOLS

A detailed comparison of the reviewed non-cluster routing protocols based on different criteria is given in Table II and III.

TABLE I. COMPARISON BETWEEN THE ABOVE NON CLUSTERING ROUTING PROTOCOLS BASED ON THE PERFORMANCE METRICS AS CLASSIFICATION, LOCALIZATION, MULTIPATH, POWER USAGE, DATA AGGREGATION, STATE COMPLEXITY, NEGOTIATION. (Y-YES/N-NO)

Protocol	Classification	Localiza tion	Multip ath	Powe r usage	Data aggrega tion	State comple xity	Negotiat ion
COUGAR [49]	Flat	N	N	Limit ed	Y	Low	N
ACQUIRE [50]	Flat/data centric	N	N	Low	Y	Low	N
SPIN[53]	Flat/source intiated/data centric	N	Y	Limit ed	Y	Low	Y
SPEED[56]	Location/data centric	N	N	Low	N	Moderate	N
GEAR[58]	Location	N	N	Limit ed	N	Low	N
DD[51]	Flat/destination intiated/data centric	Y	Y	Limit ed	Y	Low	Y
SAR[59]	Data centric	N	N	High	Y	Moderate	Y
RR[60]	Flat	N	N	Low	Y	Low	N
CADR[52]	Flat	N	N	Limit ed	Y	Low	N

TABLE II. COMPARISON BETWEEN THE ABOVE NON-CLUSTER ROUTING PROTOCOLS BASED ON THE PERFORMANCE METRICS AS CLASSIFICATION, LOCALIZATION, MULTIPATH, POWER USAGE, DATA AGGREGATION, STATE COMPLEXITY, NEGOTIATION. (Y-YES/N-NO)

Protocol	Local awareness	Mobility	Scalability	Query based	QoS	Route selection	Over head	Data delivery Model
COUGAR[49]	N	N	Limited	Y	N	Reactive	High	Query driven
ACQUIRE[50]	N	Limited	Limited	Y	N	Hybrid	Low	Complex query
SPIN[53]	N	Supports	Limited	Y	N	Proactive	Low	Event driven
SPEED[56]	N	N	Limited	Y	Y	Hybrid	Less	Geographic/query and event driven
GEAR[58]	Y	Limited	Limited	N	N	Reactive	Mod	Demand driven
DD[51]	N	Limited	Limited	Y	N	Reactive	Low	Demand driven
SAR[59]	N	N	Limited	Y	Y	Hybrid	High	Continuously
RR[60]	N	Very limited	Good	Y	N	Reactive	Low	Demand driven
CADR[52]	N	N	Limited	Y	N	Reactive	Low	Continuously

CONCLUSION

Routing is a new area of research in wireless sensor network with rapidly growing set of research outcomes. This paper divides the existing routing protocols, named as non-cluster and cluster routing protocols. All types of routing protocols have common objective which is extend the network life time. Initially this paper gives the routing challenges and design issues of routing protocols. Further shows the tabular representation of year wise published research papers on distinguish routing protocols of WSN’s. This paper shows the comparison of routing protocols with different parameters and also represents them into a tabular form. This paper will give aid to the researchers those are interested in the field of development and modification of routing protocols. In future, this comparison of routing protocols can be type of application based.

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