State-based WSN-Specific Routing Protocols: A Comparison

Tej Bahadur Chandra[1], Pushpak Verma[1], A.K. Dwivedi[2]

[1] Assistant Professor, MATS School of Information Technology, MATS University, Raipur, Chhattisgarh, India
[2] Assistant Professor, Govt. Vijay Bhusan Singh Deo Girls Degree College, Jashpur Nagar, Chhattisgarh, India

---***---

Abstract - ***Wireless Sensor Networks (WSNs) are highly dynamic, application specific and coexisting in nature. The communication between sensor nodes are governed by specially designed routing protocols. The selection of an efficient routing protocols for WSN is the key challenge as it greatly affects the performance in term of single node and/or in term of WSN as whole. The present research contribution is organized around an analytical comparison of some existing state-based WSN-Specific routing protocols. The focus of this study is on the basics of state-full and state-less approaches for WSN.***

Key Words: *Wireless Sensor Networks, Routing Protocols, State-based protocols, State-less protocols, State-full protocols.*

1. INTRODUCTION

A typical wireless sensor network consists of large number of resource constrained, domain specific, tiny devices which communicate the collected data hop by hop to the sink. Several WSNs routing protocols are designed and implemented [1] and the researches shows that, the routing protocol deployed in the sensor nodes affects the performance too. [2]

Many routing protocols have been proposed for WSN for specific application scenario [3] and these routing protocol can be classified as state-full and stateless based on the usage of state as a set of condition at a given moment of time. In state-full protocol, to establish the communication link, the routing protocols needs information that spreads with the number of active path. Being a state-full protocol, it is vulnerable to mobility or other changes in the topology, which can cause routes to become inaccessible.

The term stateless means a communications protocol that treats each request as an independent transaction. It doesn't contains the record of any previous communication and each such request has to be handled based entirely on information that comes with it. The stateless routing protocol doesn't persist the information. Sensor networks presents a number of novel routing protocols but these protocols may not necessarily be an efficient protocol for application specific scenario. One aspect to improve the performance is the appropriate selection of routing protocol.

2. PROBLEM FORMATION

Traditional ad hoc network routing protocols have proven inadequate for WSNs due to specific resource constraint nature of wireless nodes. A lot of routing protocols have been proposed and implemented for ad-hoc network in order to enhance the minimum utilization of energy [4], produces high throughputs and lesser overheads per packet, and minimum bandwidth utilization and others but these protocols are not necessarily fit for WSNs under specific application scenario.

In the current era, application of WSNs are increased rapidly due to availability of different types of sensors as well as increase in computational power of sensor nodes. These new application scenarios demands fast and reliable protocol to meet the basic constraints of wireless networks such as End-to-End delay, maximum packet delivery ratio etc. These special requirements demands new routing protocols that fits only for WSNs rather than MANET.

These routing protocols are responsible for sustain route and route discovery in the WSNs and also has responsibility of reliable communication between the multi-hop sensor nodes that may have limited transmission range. This paper presents analytical comparison of the state based routing protocols of WSNs by splitting the criteria as multiple disjoint path routing, multi-path routing and single path routing compare the strength and limitations of state-full and stateless routing protocols.

3. STATE-BASED WSN-SPECIFIC ROUTING PROTOCOLS

3.1 State-Full Routing Protocols

The state-full ad-hoc routing protocols require node to maintain some routing information that is collected using the routing protocol (e.g., through route request propagation or by reversing paths taken by the query). State-full routing protocols requires the routing information maintained at each intermediate node through the data forwarding path. More specifically, state is kept at some nodes about non-local areas in the network (the node whose state cannot be directly observable). State-full protocols are also an inappropriate for the applications where the communication patterns are not that of data gathering. DSR, AODV, DSDV, etc. are the examples of State-full ad-hoc routing protocols [5]. The state-full can be categorized into single path and multipath routing protocol [6].

DSDV [7]
The Destination Sequenced Distance Vector routing protocol is table driven, proactive routing protocol. In DSDV, each nodes maintains a routing table where each node acts as a router and a sequence number is associated with each node which is chosen randomly and it is usually an even number also nodes exchange updates with neighbors; if the two nodes have the same sequence number then route with the best metric is used. DSDV maintains only the best path selection instead of maintaining multiple paths to every destination. It reduces the amount of space in routing table maintenance, route looping and increases convergence speed, and eliminates control message overhead.

AODV [8, 9]
The Ad-hoc On-demand Distance Vector routing protocol is effective and efficient reactive protocol for ad-hoc networks. In AODV, each node sustains a route table which stores routing information for other nodes in the network. In this route are established on-demand and destination sequence numbers are used to find the newest route to the destination. Minimal space complexity, most current and loop free routes, ability to cope with dynamic topology and broken links and high scalability are some features that make AODV enviable for ad-hoc networks.

DSR [10]
The Dynamic Source Routing protocol is on demand, reactive protocol, particularly designed for use in multi-hop wireless ad-hoc networks. In DSR protocol a route is established only when it is required and hence the need to find routes to all other nodes is eliminated. The intermediate nodes utilize the route cache information to reduce the control overhead. The route is maintained with the help of two main mechanism- Route Discovery and Route Maintenance. Minimum routing overhead, both unidirectional and bidirectional link support, multicasting, QoS (quality of service) and resource management are some important features of it.

MCP [11]
Multicast based Code redistribution Protocol is a state-full protocol known for achieving power efficiency. Each node in MCP sustains a record of interesting information in a small table for known applications. The table helps in sending out multicast-based code propagation requests such that only a subset of neighboring sensors contribute to code propagation. MCP when compared to broadcasting based schemes greatly reduces signal collision, propagation time and number of propagation messages.

3.2 State-Less Routing Protocols

State-full routing may not be efficient or even possible for very large-scale networks with limited sensor node capabilities. In order to tackle this, stateless routing protocols have been proposed which do not maintain per-route state. These kinds of protocols only track the position of their neighbors and select among them a neighbor that is most likely to be closer to the destination. Stateless routing protocols are known for their lack of memory about the route, so they continue to repeat the same mistakes.

Stateless routing protocol scale effectively in terms of routing overhead because the tracked routing information does not grow with the network size or the number of active sinks. Geographic (and more generally location based) routing protocols are the main type of stateless routing protocols. Examples of Stateless Geometric Ad Hoc routing algorithm/protocols are: Greedy/Geographic Forwarding, Face Routing, GPSR, COMPASS etc. [12]

Geographic Routing
Geographic routing (also known as position-based routing or geometric routing) is a technique to deliver a message to a node in a network over multiple hops by means of geographic location information. In this messages are directly sent towards the destination location and rout resolutions are independent of network addresses and routing tables. The information about neighbors' location helps in selecting the next hop neighbor that is closer to the destination, and thus advances towards the destination in each step. [13]

GPSR
The Greedy Perimeter stateless Routing Protocol is most prominent geographic routing protocol, and it is based on greedy/geographic forwarding routing. For packet forwarding decision it uses position of routers and packet destination. The GPSR consist of two methods for forwarding packets, the first is greedy forwarding which is

used wherever possible and second is perimeter forwarding, which is used in regions, where greedy forwarding cannot be. It uses only immediate neighbor information in forwarding decision. It is used to solve dead-end problem. [14]

FACE ROUTING

Face routing assures the messages to be delivered without the need of control packets to be flooded throughout the network and is generally applicable to planner connected geometric graphs. It is loop free uses only the planer sub graph out of the original graph. [15]

COMPASS

A Compass Routing provides a technique to find paths between pairs of points in planar geometric graphs. The main agenda was to develop routing algorithms that uses only "node level local information", the position of destination and a finite amount of extra memory; it finds a path from a starting position to our destination. The development of "compass routing" is based on routing algorithms for trees, Delaunay triangulations and orthogonal convexly embedded geometric graphs. [16]

GRASP

A Gradient Ascending Stateless Routing Protocol is a stateless WSN routing protocol which is free from the underlying communication model, but it provides approximate optimal result, with respect to the self-deployment of sensors over a given region. It is built with new packet forwarding method called Footprint-Based Forwarding (FBF) in which each node maintains a Bloom filter whose packets were relayed through the filter. . GRASP ensures for the(a) in a mobile WSN irrespective of the number of sensors, routing is always possible and (b) above a given number of sensors in a considered zone the protocol eventually enables the routing to no longer require sensors to move, which yields to self-deployment. With GRASP, sensors autonomously reach a stable full coverage following geometrical patterns. This requires only 1.5 times the optimal number of sensors to cover a region. [17]

SPEED

SPEED is stateless real time communication protocol which provides a way to control on overhead of end–to–end soft real time communication which can be achieved by maintaining a desired delivery speed across the sensor network through a new combination of feedback control and non-deterministic geographic forwarding. It is efficient and highly scalable protocol in which resources of each node are rare. It also provides the few communication services such as unicast, multicast and real time area any-cast [18].

4. PERFORMANCE COMPARISON OF STATE-BASED WSN-SPECIFIC ROUTING PROTOCOLS

4.1 State-Full

Comparison of the three state-full protocols based on their properties are shown in figure-1 below:

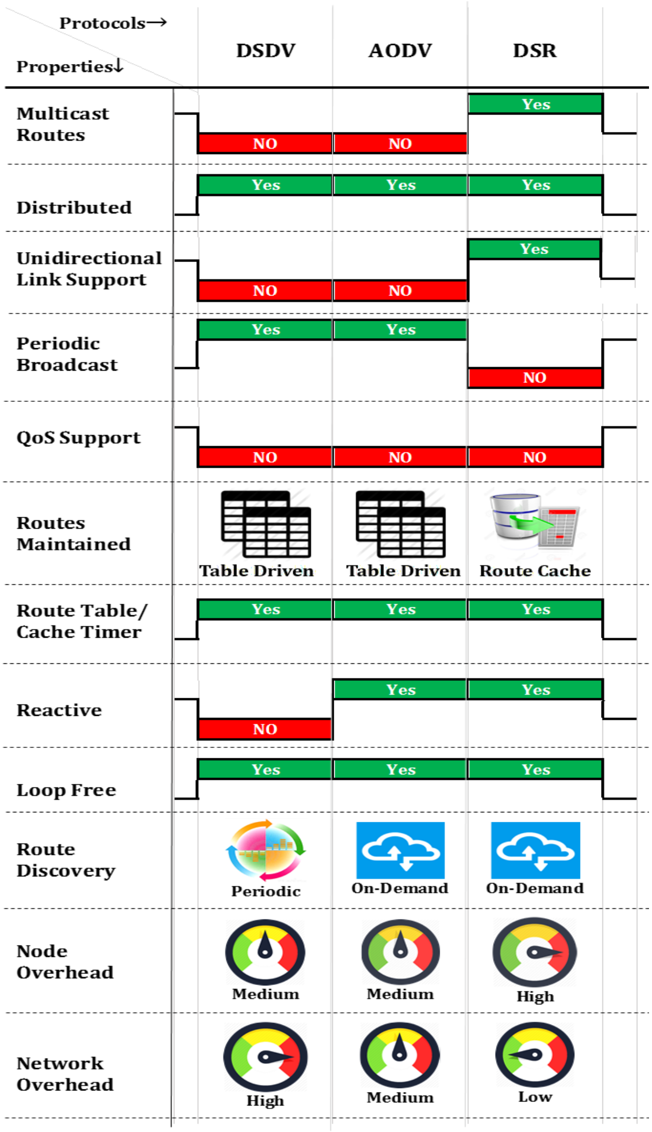

Fig -1: Comparison of the three state-full protocols

4.2 State-Less

Comparison of the three stateless protocols based on their properties are shown in figure-2 below:

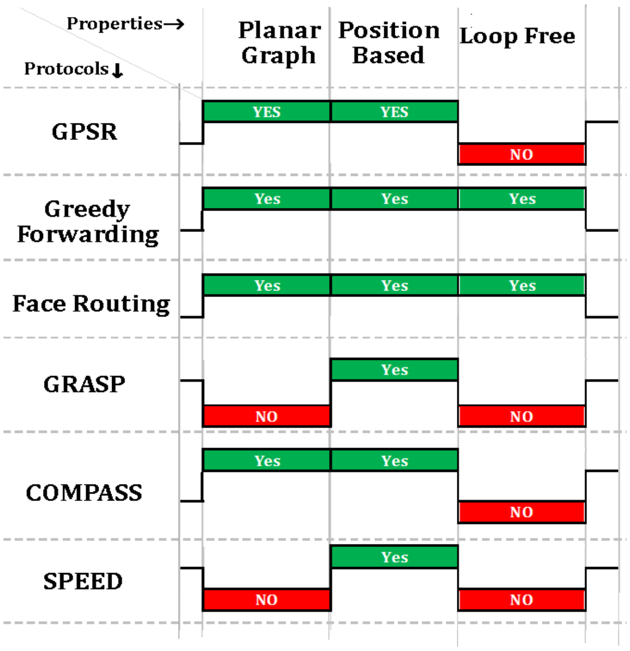

Fig -2: Comparison of the three stateless protocols

5. CONCLUSION

The soul of this contribution is based on the analysis of properties and performance of WSN-specific routing protocols. Many evaluation has been made on the performance of some commonly-known state-based routing protocols however it is difficult to say that the specific protocol or class of protocol is well suited for each and each situations. Each protocol is designed in such a way that it best-fit for specific scenario while it fails for others. This contribution presents an analytical study on performance comparisons of well know state-full and state-less protocols based on the properties they possess and after comparison we infers that in state-full routing protocols DSR performed well than DSDV and AODV protocols and in state-less routing protocol GPSR is frequently useful.

6. FUTURE SCOPE

As the wireless sensor network are growing and changing rapidly, there are still many challenges that needs to be met. A huge number of WSN state based routing protocols are available having variety of network architecture and operation. Comparison of these protocols can be done with additional parameters to determine how they can tolerate in changing environments, and find out which one performs best in a particular environment, architecture and operations. These protocols may also be simulated or implement in a real time environment which consists of nodes running different routing protocols and evaluate the performance of the protocol under different scenarios on the performance parameter like path optimality, delay overload and energy consumption, packet loss, reliability and robustness etc.

REFERENCES

[1] M. Becker, S. Schaust, and E. Wittmann, "Performance of routing protocols for real wireless sensor networks," in Proceedings of the 10th International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS '07), San Diego, Calif, USA, July 2007.

[2] J. Carlos Cano, P. Manzoni "A Performance Comparison of Energy Consumption for Mobile Ad Hoc Networks Routing Protocols"

[3] Internet Engineering Task Force MANET Working Group Charter. http://www.ietf.org/html.charters/manet-charter.html.

[4] P. S. Karadge, S. V. Sankpal, "A Performance Comparison of Energy Efficient AODV Protocols in Mobile Ad hoc Networks" International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 1, January 2013, ISSN (Print): 2319-5940 ISSN (Online): 2278-1021.

[5] J. Eriksson, Detailed Simulation of Heterogeneous Wireless Sensor Networks, Dissertation for the Degree of Licentiate of Philosophy in Computer Science at Uppsala University, April 2009, Sweden, ISSN 1404-5117.

[6] Sean Michael Lydon, June 2009, General Direction Routing Protocol, Thesis Presented to the Faculty of California Polytechnic State University San Luis Obispo].

[7] Perkins Charles E., Bhagwat Pravin: Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers, In proceeding of SIGCOMM 94-8/94, London England UK.

[8] Perkins, C.; Belding-Royer, E.; Das, S. (July 2003). Ad hoc On-Demand Distance Vector (AODV) Routing. IETF.RFC 3561. https://tools.ietf.org/html/rfc3561. Retrieved 2010-06-18.

[9] Perkins, C.E.; Royer, E.M.;, "Ad-hoc on-demand distance vector routing," Mobile Computing Systems and Applications, 1999. Proceedings. WMCSA '99. Second IEEE Workshop on, vol., no., pp.90-100, 25-26 Feb 1999 doi: 10.1109/MCSA.1999.749281.

[10] J. Broch, D. A. Maltz, D. B. Johnson et.al.", A Performance Comparison of Multi-Hop Wireless Network Routing Protocols," Proceedings of the Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom'98), October 25-30, 1998, USA,pp.25-30.

[11] Weijia Li, Youtao Zhang, Bruce Childers Distributed Computing in Sensor Systems, 5th IEEE International

Conference, DCOSS 2009, vol. 5516, 2009 ,Pages: 259-272 , DOI: 10.1007/978-3-642-02085-8_19.

[12] J. Eriksson, Detailed Simulation of Heterogeneous Wireless Sensor Networks, Dissertation for the Degree of Licentiate of Philosophy in Computer Science at Uppsala University, April 2009, Sweden, ISSN 1404-5117.

[13] S. Rührup, "Theory and practice of geographic routing," book chapter in H. Liu, Y.-W. Leung, X. Chu (eds.), Ad Hoc and Sensor Wireless Networks: Architectures, Algorithms and Protocols, Bentham Science Publishers, 2009.

[14] Rong Ding; Lei Yang; , "A Reactive Geographic Routing Protocol for wireless sensor networks," Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2010 Sixth International Conference on , vol., no., pp.31-36, 7-10 Dec. 2010 doi: 10.1109/ISSNIP.2010.5706734.

[15] Bose, P., Morin, P., Stojmenovic, I. and Urrutia, J., "Routing with Guaranteed Delivery in Ad HocWireless Networks," Proceedings of the 3rd ACM International Workshop on Discrete Algorithms and Methods for Mobile Computing and Communications, pp. 48–55 (1999).

[16] Singh, Harvinder. Source: Masters Abstracts International, Volume: 38-03, page: 0731.isbn-9780612452503, Compass routing on geometric graphs, M.C.S.Thesis (M.C.S.)--University of Ottawa (Canada), 1999.

[17] Jai-Jin Lim; Shin, K.G.; "Gradient-ascending routing via footprints in wireless sensor networks," Real-Time Systems Symposium, 2005. RTSS 2005. 26th IEEE International, vol., no.,pp.10pp.-307,8-8Dec.2005 doi: 10.1109/RTSS.2005.24

[18] Tian He Dept. of Comput. Sci., Virginia Univ., Charlottesville, VA, USA Stankovic, J.A. ; Chenyang Lu ; Abdelzaher, T. Page(s): 46 – 55, Distributed Computing Systems, 2003. Proceedings. 23rd International Conference on .