International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 06 | Sep-2015 www.irjet.net p-ISSN: 2395-0072

Comparison of Sensor Node Scheduling Algorithms in Wireless Sensor Networks

Sunita Gupta[1], Dr.K.C.Roy[2]

Ph.D. Research scholar, Department of Computer Science Engineering, Suresh Gyan Vihar University, Jaipur.
Professor & HOD, Department of Electrical Engineering, Kautilya Institute of Technology & Engineering, Jaipur

***Abstract-* The main advantage of wireless sensors networks (WSNs) is their ability to operate unattended in harsh environments in which contemporary human-in-the-loop monitoring schemes are risky, inefficient and sometimes infeasible. In some application scenarios, replenishment of energy resources might be impossible, and therefore sensor node lifetime shows a very strong dependency on battery lifetime. So an important issue in sensor networks is power scarcity, which depends on battery size and weight limitations of WSN node.**

The design of energy-aware algorithms is an important factor for extending the lifetime of wireless sensor network. Different mechanisms can be used to optimize the energy of sensors and they have a great impact on prolonging the network lifetime. Various algorithms have been proposed for energy minimization by scheduling sensor nodes activity. Some of them also satisfy the Q-coverage and P-connectivity requirements, which are necessary for reliable wireless sensor network. In this paper comparison of various sensor nodes scheduling algorithms are done and results are analyzed. Comparisons are done based on different properties. Pros and cons of each algorithm is also analyzed. Further improvements can also be done to improve these cons.

***Keywords*:-**Wireless sensor network, Connected target Coverage, Network Lifetime, Network architecture, Cover set, Coverage, Connectivity, P-Coverage, Q-Connectivity.

1. INTRODUCTION

Advances in Micro-Electro-Mechanical Systems (MEMS), digital electronics and wireless communications have developed Wireless Sensor Networks (WSNs) [1, 2]. WSN are application specific and all design and requirement considerations are different for each application especially when it is used for military application. Each node is consist of devices which are used to sense, collect and process the data before transmitting to the adjacent nodes. Finally the data is send to the base station, from which it is send to the user through the satellites or internet.

Wireless sensor networks are now used in wide range of applications related to national security, surveillance, home and office application[3],habitat monitoring[4,5],health application[6,7],environment forecasting and military etc.

Sensors are dropped by a helicopter and they collectively form a network in an ad-hoc manner [8, 9]. Sensor node lifetime is strongly dependent on battery lifetime [10]. Sensors are energy constrained and their batteries cannot be recharged.

2. ARCHITECTURE OF A WIRELESS SENSOR NODE

A sensor is the main component of a Wireless Sensor Node. In addition to a sensor, each node in a wireless sensor network is typically equipped with some main components. Few of them are microcontroller, transceiver, sensors, actuators, memory and power unit.

The sensor node senses the environment, collects the relevant data, process the information collected, store it in a buffer and forward this information to other nodes or base station in a wireless manner. An energy source (Power unit) supplies energy to the memory, sensing unit and transceiver. The processing unit is used to process incoming data and assemble them into packets to be transmitted using the wireless transceiver.

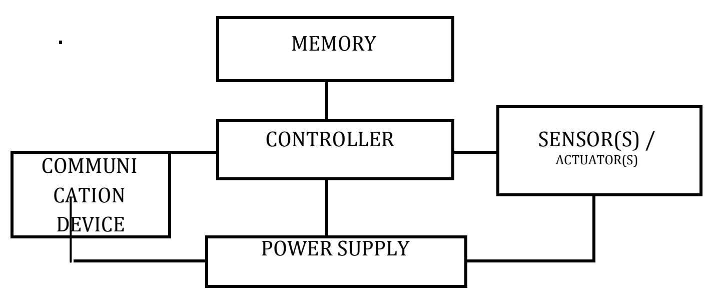

Fig. 1 The components of a sensor node

3. COVERAGE, CONNECTIVITY AND LIFETIME IN WIRELESS SENSOR NETWORKS

Coverage is a fundamental issue in a WSN, which determines how well a phenomenon of interest (area or target) is monitored or tracked by sensors [11, 12]. Means up to how much distance a node may sense the information. Each sensor node is able to sense the phenomenon in a finite sensing area. The sensing area of a sensor is normally assumed to be a disk with the sensor located at the center. The radius of the disk is called the sensing radius (Rs) of the sensor, up to which a sensor may cover the area.

There are broadly three types of coverage classified based on what is to be covered, namely area coverage, discrete points coverage and barrier coverage [11].In area coverage, the monitored space is divided into small areas called fields [13] and each field is identified by a set of sensors covering (monitor) the field. The area coverage problem is closely related to the point coverage problem [14], as the fields are equivalent to the points. The requirement can be extended to K-coverage where each point in the area should be covered by at least K different active sensors. The K-coverage requirement improves the accuracy and reliability of the observations [15], and is necessary for many applications such as localization and target classification.

However, in barrier coverage [16,17], the sensing capability of a sensor is presented as the probability that a sensor detects the phenomenon, and is assumed to be related to some other factors such as the distance between the sensor and interested phenomenon. The barrier coverage concerns with determining the probability that an undetected penetration passes through the barrier (area where sensors deployed).

Connectivity means the sensor network should remains connected so that the information sensed by sensor nodes can be send back to the base station. Rc (Connectivity radius) is the radius up to which a sensor may communicate its data with other sensor nodes in WSN. Connectivity is as critical as sensing coverage. Multi-hop communications are necessary when a sensor is not connected to the sink node directly. Two sensors are called neighbors if they are within each other's communication range. Along with coverage, connectivity is also important. Moderate loss in coverage may be tolerated by applications but loss in connectivity can be fatal as it can render an entire portion of the network useless as their sensing data cannot reach to the base station. Therefore, it is desirable to have higher degrees of connectivity in wireless sensor networks. But, the problem of determining the optimal deployment pattern that achieves both Q-coverage and P-connectivity for general values of P,Q and Rc (connectivity radius) and Rs (sensing radius) is an open problem.

The time till the sensor network remain active and provide the information of the coverage area is called lifetime of WSN. In the absence of proper planning, the network may quickly cease to work due to the network departure or the absence of observation sensors deployed close to the interested phenomenon. Experiments show that wireless communication (data transmitting and receiving) contributes a major part to energy consumption rather than sensing and data processing [20]. Therefore, reducing the energy consumption of wireless radios is the key to energy conservation and prolonging network lifetime.

4 . Q-COVERAGE AND P-CONNECTIVITY PROBLEM IN WSN

Coverage and Connectivity are most fundamental requirement of a wireless sensor network. Each and every target in the WSN should be sensed by more than one sensor node so that WSN may remain connected even if one sensor fails. Higher order of connectivity is also required for appropriate communications up to the base station. So for reliable WSN, there should be Q-Coverage and P-connectivity.

Q-coverage: Every point in the plane is covered by at least q-different sensors [21].

P-connectivity: There are at least p disjoint paths between any two sensors [21].

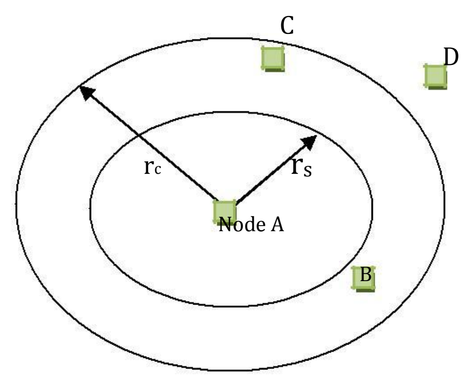

Fig. 2 Coverage and Connectivity diagram

As it can be seen from the figure that there are four sensor nodes A, B, C, D. Rc is the communication radius of node A and Rs is the sensing radius of node A. So node A can sense the data within this radius only .Node B and node C are under the communication radius (range) of node A. Mean's node B and node C can communicate with node A easily and exchange the information with each other. Node D is not under the communication radius (Range) of node A. So node D cannot communicate with node A.

V. ENERGY EFFICIENT SCHEDULING

To increase the lifetime, the WSN, sensor nodes can be divided into a number of different subsets, called cover sets and each cover set should cover all the targets. In node-disjoint sets, each sensor is allowed to participate only in one cover set. But in non-disjoint sets, a sensor may participate in multiple cover sets. There are many techniques of solving the problem of active node selection in WSNs [22, 23]. Some of them are given and compared below.

In [24], a centralized and node disjoint heuristic algorithm (BGOP) is proposed. No concern regarding connectivity is given in this proposed algorithm. Here a sensor may have number of sensing capabilities, with minimum sensing range r. If the distance between a sensor and target is less than sensing range r, then all such sensors are neighbors of the target.

The target with the smallest "neighbor-sensor" set is an upper bound for the number of cover sets that would be generated. Such targets are called critical targets. This upper-bound is called, the theoretical maximum. In this algorithm there are four classes of sensors that can be considered for selection in cover set and are given below.

Class Best: The sensor covers all uncovered targets and none of the already covered ones.

Class Good: The sensor covers a subset of the uncovered targets and none of the already covered ones.

Class OK: The sensor covers all of the uncovered targets and a subset of the already covered ones.

Class Poor: The sensor covers a subset of the uncovered targets and a subset of already covered ones.

Best class members are always preferred candidates and are included in the cover sets .If Best class candidate does not exists; then one of the other classes candidate can be tried in the order given as

Good → OK → Poor.

In [25], authors proposed the solution of network lifetime maximization problem as the maximum set covers problem (MSC). In this point coverage algorithm, all sensors have their location determination capability using Global positioning system (GPS). MSC is NP Complete problem. The solution is proposed only for 1 coverage and no concern regarding connectivity is given.

It is non disjoint algorithm. So a sensor can participate in more than one cover set. It is centralized algorithm. So, the Base station (BS) executes the scheduling algorithm and broadcast the schedule to each sensor node. Only coverage is considered here. No connectivity concern is there. Each sensor node schedule itself for active/sleep according to this schedule. All cover Sets are activated for the same time interval (w). Thus sensors may participate in multiple sets without any additional requirements of being disjoint set and equal operating time intervals. In greedy approach, at each stage a critical target is selected. Critical target means the target that is covered most sparsely. After the selection of critical target, a sensor with greatest contribution is selected to cover the critical target. The various greatest contribution functions can be applied to find out the sensor with the greatest contribution. For example, a sensor that covers the larger number of uncovered targets or a sensor having highest residual energy. A target is either covered by the sensors already selected in the set cover, or it becomes a critical target, at which point the sensor with the greatest contribution, that covers the critical target, is selected. This is done till all the targets are covered and thus finally a set cover is completed. Each set cover is active for w unit of time. Thus the network lifetime is w*i, where i is the number of set covers and w is the time each cover is active.

There is always tradeoff between data reliability and network lifetime. So for better reliability over lifetime, MSC problem considering Q-coverage is also defined by authors in [25].In [26], authors introduce the Connected Set Covers (CSC) problem .Here the objective is coverage as well as connectivity. CSC problem is NP-complete and it is proved. Sensor nodes are organized into a different cover sets and all the targets are monitored continuously. The energy constraints and BS-connectivity of each sensor set must be satisfied. This method lowers the density of active nodes and reduces interference at the MAC layer.

MSC problem is a particular case of CSC problem when Rc is equal to the network diameter. Means any sensor can directly communicate with the base station and all sensors of a cover set are BS connected.

The network lifetime increases with the number of sensors and the communication range. For a specific number of sensors and sensing range, the network lifetime decreases as the number of targets to be monitored increases.

In [27], authors organize the deployed sensors into cover sets covering all targets in the region and each sensor in the cover set is connected to the Base Station (BS) also. The currently active cover set is responsible for monitoring all targets. TPICSC [27], consider both coverage and connectivity together. Finding maximum number of sensor covers is has been proved to be NP-complete and it is an exponential time complexity. By Simulation it is shown that the proposed algorithm get the acceptable solutions with polynomial computation time and improve the performance of the Greedy-CSC heuristic algorithm. First it makes the cover set and then connectivity is made by adding extra nodes. If some nodes are redundant then they are removed in next step called redundancy phase. Finally the energy values of selected sensors in cover set are updated in next phase.

In [28], the authors added QoS requirement to the target coverage problem by adding the constraints of Q-Coverage. An integer vector Q is given. In Q vector, any qi is the minimum number of sensors that simultaneously covers the targets i. The objective of target Q-coverage problem is to maximize sensor network lifetime satisfying Q-coverage requirement. Again the problem is NP-complete. The proposed heuristic called HESL gives solution very close to the optimal solution. This heuristic has two essential features. It uses a greedy heuristic to generate Q-covers by prioritizing sensors in terms of the residual battery life and the algorithm assigns a small constant of lifetime to Q-covers so generated. The small values of lifetime constant means more close is the solution of optimal solution.

Till now, generally all heuristics presume that the state of a sensor covering targets is binary: success (covers the targets) or failure (cannot cover the targets).But actually, a sensor covers targets with a certain probability. To improve

WSNs' reliability, this probability factor should be considered. To solve this problem, authors in [29] introduce a failure probability concept for the target coverage problem and it improves the system reliability. The solution is modeled as α-Reliable Maximum Sensor Covers (α-RMSC) problem and a greedy algorithm is designed that efficiently computes the maximal number of α-Reliable sensor covers. For extending the lifetime of WSN efficiently with a user's pre-defined failure probability requirements, only the sensors from the current active sensor cover are responsible for monitoring all targets, while all other sensors are in a low-energy sleep mode. By Simulation the performance of this algorithm is validated and shown that the user can precisely control the system reliability without sacrificing large amount energy consumption. A table of comparison of all algorithms given above is presented.

Table 1.Comparison of sensor node scheduling algorithms

	BGOP	MSC	CSC	TPICSC	HESL	Reliable Target Coverage
Order of Coverage	1-Coverage	1-Coverage	1-Coverage	1-Coverage	Q-Coverage	Q-Coverage
Order of Connectivity	Not Considered	Not Considered	1-Connectivity	1-Conneyctivity	Not Considered	Not Considered
Centralized Vs. Distributed algorithm	Centralized	Centralized	Centralized/Distributed	Centralized	Centralized	Distributed
Lifetime of all generated Set covers Granularity constant (w)	Same	Same	Same	Same	Different	Different
Reliability consideration	Not Considered	Not Considered	Not Considered	Not Considered	Not Considered	Considered
Target's Criticality Consideration	Considered	Considered	Considered	Considered	Not Considered	Not Considered
Upper bound calculation of WSN Lifetime	Done	Not Done	Not Done	Not Done	Done	Not Done
Point Coverage/Area Coverage	Point Coverage	Point Coverage	Point Coverage	Point Coverage	Point Coverage	Point Coverage
Non disjoint/Node disjoint	Node disjoint algorithm	Non disjoint algorithm	Non disjoint algorithm	Non disjoint algorithm	Non disjoint algorithm	Non disjoint algorithm

algorithm						
Pros/Cons	Cannot be used for Q-Coverage. No guarantee of Connectivity with BS. So reliability decreases. Life time of network is less as node disjoint algorithm is used	Cannot be used for Q-Coverage. No guarantee of Connectivity with BS. So reliability decreases.	Cannot be used for Q-Coverage and P-Connectivity. So reliability decreases	Cannot be used for Q-Coverage and P-Connectivity. So reliability decreases	Cannot be used for Q-Coverage. No guarantee of Connectivity with BS. So reliability decreases.	No guarantee of Connectivity with BS. But probability factor of Coverage is given. Thus reliability of network somehow increases.

6. CONCLUSION

In this paper, comparisons of various node scheduling algorithms are done. Comparison of well known standard algorithms like BGOP, MSC,CSC TPICSC,HESL α-RMSC have been done and results are analyzed. Comparisons are done based on the properties of algorithms like order of coverage, order of connectivity, Reliability, type of algorithms (node disjoint/non disjoint algorithms) etc. Pros and cons of each and every algorithm is also given. Future work can be done by improving the order of coverage and connectivity and by improving the reliability of the network. There can be many variations of the problem with additional constraints of coverage, connectivity or directional sensing [30, 31, 32] etc.

7. REFERENCES

[1] I. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "Wireless sensor networks: A survey", Computer Networks, vol. 39, no. 4, pp. 393-422, 2002.

[2] A. I.F., S. Weilian, S. Y. and C. E., "A survey on sensor networks", IEEE Communications Magazine, vol. 40, no. 8, pp. 102- 114, 2002.

[3] Mani B. Srivastava, Richard R. Muntz, and Miodrag Potkonjak. Smart kindergarten: sensorbased wireless networks for smart developmental problem-solving environments. In Mobile Computing and Networking, pages 132.138, 2001.

[4] A. Cerpa, J. Elson, D. Estrin, L.Girod, M. Hamilton, and J. Zhao. Habitat monitoring: Application driver for wirelesscommunications technology. In Proceedings of the 2001ACM SIGCOMM Workshop on Data Communications in Latin America and the Caribbean, April 2001. 2001.

[5] Alan Mainwaring, Joseph Polastre, Robert Szewczyk,1`David Culler, and John Anderson. Wireless sensor networks for habitat monitoring. In ACM International Workshop on Wireless Sensor Networks and Applications (WSNA'02), Atlanta, GA, September 2002.

[6] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E.Cayirci, ―A Survey on Sensor Networks‖, IEEE Communications Magazine, (Aug. 2002), pp 102-11.

[7] Loren Schwiebert, Sandeep K. S. Gupta, and Jennifer Weinmann. Research challenges in wireless networks of biomedical sensors. In Mobile Computing and Networking, pages151. 165, 2001.

[8] K. Sohrabi et al., Protocols for self-organization of a wireless sensor network, IEEE Personal Communications 7(2000) 16–27.

[9] R. Min, et al., Low power wireless sensor networks, in: Proceedings of International Conference on VLSI Design, Bangalore, India, January 2001.

[10] V. Kawadia, P.R. Kumar, Power control and clustering in Ad Hoc networks, in: Proceedings of IEEE INFOCOM, San Francisco, CA, March 2003.

[11] Mohammad Ilyas and Imad Mahgoub eds.," Coverage Problems in Wireless Ad Hoc Sensor Networks ",(), Handbook of Sensor Networks, chapter 19, CRC Press, 2004.

[12] C.F. Huang and Y.C. Tseng, "A survey of solutions to the coverage problems in wireless sensor networks," Journal of Internet Technology, vol. 6, no. 1, pp.1-8, 2005.

[13] S. Slijepcevic and M. Potkonjak, "Power efficient organization of wireless sensor networks" ,in Proc. of International Conference on Communications (ICC'01). IEEE, June 2001, pp. 472–476.

[14] M. Cardei and D.-Z. Du, "Improving wireless sensor network lifetime through power aware organization," ACM Wireless Networks, vol. 11, no. 3, pp. 333–340, 2005.

[15] H. D. L. and L. J., Handbook of Multisensor Data Fusion, CRC Press, 2001.

[16] M. S., K. F., P. M. and S. M., "Coverage problems in wireless ad-hoc sensor networks," in Proc. of Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM), 2001, pp. 1380-1387.

[17] M. S., K. F., Q. G. and P. M., "Exposure in wireless ad hoc sensor networks," in Proc. of ACM International Conference on Mobile Computing and Networking (MOBICOM), 2001, pp. 139-150.

[18] K. S., L. T. H. and B. J., "On k-coverage in a mostly sleeping sensor network, "in Proc. of ACM International Conference on Mobile Computing and Networking (MOBICOM), 2004, pp. 144-158.

[19] [19]W. K., G. Y., L. F. and X. Y.,"Lightweight deployment-aware scheduling for wireless sensor networks," ACM/Kluwer Mobile Networks and Applications (MONET) Special Issue on Energy Constraints and Lifetime Performance in Wireless Sensor Networks, vol. 10, no. 6, pp. 837-852, 2005.

[20] Y. Yong, Y. Zongkai, H. Zhihai and H. Jianhua, "Energy-efficient scheduling of packet transmissions over wireless networks provisioning in wireless sensor network," Computer Communications, vol. 29, no. 2, pp. 162-172, 2006.

[21] X. Bai, S. Kumar, D. Xuan, Z. Yun and T. H. Lai. "Deploying Wireless Sensors to Achieve Both Coverage and Connectivity". In Proc. of ACM MobiHoc, 2006.

[22] M. Perillo, W. Heinzelman, ―Optimal sensor management under energy and reliability constraints‖, in: Proc. of the IEEE Wireless Communications and Networking Conference, New Orleans, Louisiana, USA, March 2003.

[23] S. Meguerdichian, M. Potkonjak, ―Low power 0/1 coverage and scheduling techniques in sensor networks, UCLA Technical Reports 030001, January 2003.

[24] Dimitrios Zorbas, Dimitris Glynos, Panayiotis Kotzanikolaou Christos Douligeris, "An Adaptive Algorithm for Coverage Problem in Wireless Sensor Networks", "IEEE INFOCOM'05 March".

[25]Mihaela Cardei, My T. Thai ,Yingshu Li ,Weili Wu, "Energy Efficient Target Coverage Problems in Wireless

Sensors Networks ", "IEEE INFOCOM 2005,24th Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE ,Page(s): 1976 - 1984 vol. 3

[26]Ionut Cardei,Mihaela Cardei ,"Energy Efficient Connected Coverage in Wireless Sensor Network", International journal of sensor networks,Volume-3,issue-3,May 2008,Pages201-210,ACM digital library.

[27] Jamali, M.a., Bakhshivand, N. , Easmaeilpour, M. , Salami, D.," An energy-efficient algorithm for connected target coverage problem in wireless sensor networks",Computer Science and Information Technology.