Selection of Optimum Routing Protocol for 2D and 3D WSN

Robin Chadha
Department of Electronics and Communication
DAVIET, PTU
Jalandhar, India.

Love Kumar
Department of Electronics and Communication
DAVIET, PTU
Jalandhar, India.

ABSTRACT
A Wireless Sensor Network is a network of sensor nodes with sensing, conditioning and communication capabilities. All these sensors nodes are deployed in the wireless sensor network in distributed manner. These Sensor nodes rely on their onboard batteries for the energy required for performing their operations. Recharging or Replacement of these batteries is quite difficult. So Several Research efforts are made from many decades to introduce the Wireless Sensor Network (WSN) routing technology with energy efficient manners. In this paper, an experimental evaluation of energy efficiency of routing protocols like dummy, adaptive probabilistic broadcast and adaptive flooding is presented for both 2 dimensional and 3 dimensional scenario of 100 nodes WSN. The computation of energy efficiency of these routing protocols is totally based on the comparative results of parameters like mean energy consumption, average dropped frames and latency of nodes with respect to number of packets transmitted. The computation of these wireless sensor networks are performed using OMNET++ 4.5 with MIXIM module.

Keywords
2D & 3D WSN, Energy consumption, latency, routing protocols, OMNET ++.

1. INTRODUCTION
Wireless Sensor Network (WSN) is an automated environment of thousands of wireless sensors whose parallel working leads to the accomplishment of specific application. They are designed and deployed in very large numbers to gather the information especially in applications where human existence is negligible. These nodes have to work together to accomplish their tasks as, usually, a single node is incapable of doing so and wireless communication helps them to enable this collaboration . Different standard agencies and governing bodies are trying to integrate a wide variety of proposals for Wireless Sensor Network technology. Recent advances in the area of wireless communication and embedded systems have enabled the development of low cost, small size, low power, multi-functional sensor nodes that can communicate over short distance through autonomous wireless environment [11].Each node in a WSN has the capability of sensing, processing and propagating the sensed data to other nodes and all the processes in WSN communication system requires energy and for this, each node have to rely on onboard batteries shown in Figure 1. Recharging or Replacement of these batteries is quite difficult. So for maximizing the lifetime of node in the network, energy efficient positioning based methods should be used while deploying the network. Similarly use of energy efficient routing protocols makes the network more reliable. Research efforts are made from many decades to introduce the Wireless Sensor Network (WSN) routing technology with energy efficient manners.

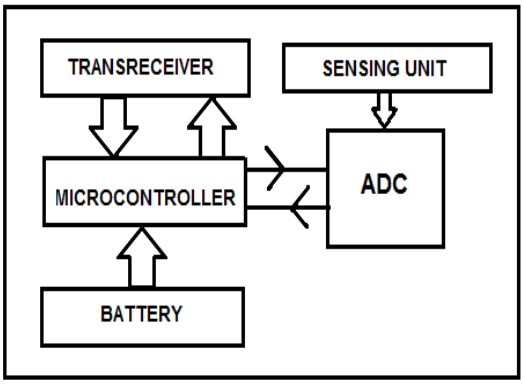

Figure 1: Typical sensor node

The positioning of nodes in the WSN environment should be either 2 dimensional positioning or 3 dimensional positioning [8]. In 2D positioning, all nodes in the network are located at zero height or at equal height with respect to the ground level as shown in Figure 2. Each nodes in 2D has positional coordinates as (x,y,0) or (x,y,a) where a is some constant.

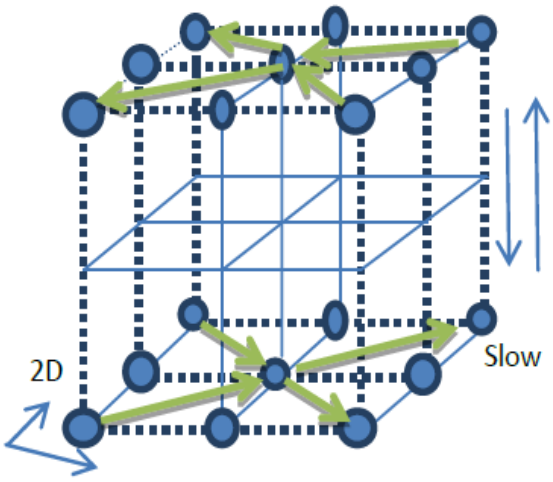

Figure 2: 2D WSN[1]

Now if user want to deploy nodes in 3D environment like underwater sensor networks or weather monitoring systems, then user have to deploy the nodes at different depths with respect to ground or with respect to other nodes as shown in Figure 3 thus makes the network three-dimensional. Each nodes in 3D has positional coordinates as (x,y,z). Moreover,

for selection of the optimum routing protocol for communication, it is necessary to optimize the energy efficiency of the whole sensor network by using different routing protocols like Adaptive flooding, Dummy and Adaptive probabilistic broadcast [18].

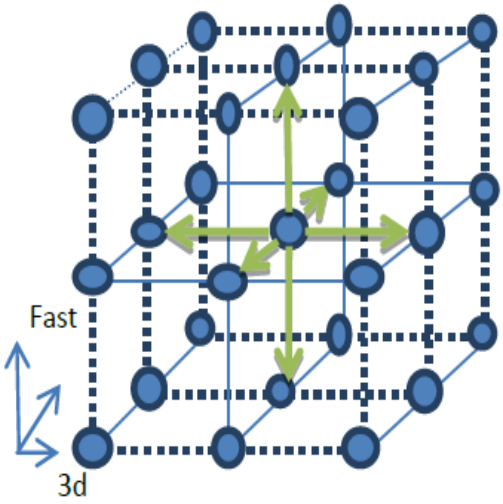

Figure 3: 3D WSN[1]

1.1 Adaptive flooding

Adaptive flooding[18] is basically the enhancement of conventional flooding technique. In conventional adaptive flooding, each sensor node firstly keep a copy of the received message and then transmit it towards other nodes and this cycle repeats until the sink node receives that message[18]. It is a simple and reliable routing method to route the information towards each node in the network. As message will be transmitted to every host atleast once so it guaranteed the delivery of message to its destination. But the unlimited broadcasting of the packets will cause problems like broadcast storm, implosion, overlay and resource blindness. These problems are minimized by Adaptive flooding technique in which each node "remembers" (stores) already broadcasted messages in a list and does not rebroadcast them again, if it gets another copy of that message. Moreover default time to live of node is also depends on number of hops which makes it more superior than conventional adaptive flooding technique.

1.2 Dummy

Dummy routing technique simply "translates" netwControlInfo to macControlInfo before transmission which means it filter out the requested frame from the whole packet and transmit it in place of whole packet[18]. The false acknowledgments are also ignored by the intermediate nodes in this technique. In this way it will decrease the network load and also save the energy wasted in transmitting the whole packet rather than the desired frame of data. It will also increase lifetime of the nodes in the network. This technique enhances the real data delivery ratio and decreases the data overhead load as well as data packets collision.

1.3 Adaptive Probabilistic Broadcast

It is a Multi-hop ad-hoc data distribution protocol which is based on adaptive probabilistic broadcast, with adaptive parameters. This protocol performs network-level broadcast using an adaptive probabilistic mechanism in which node uses broadcast mechanism to send a message to a set of randomly selected nodes and the node receiving the message will further resend it through broadcast to another set of randomly selected nodes. This mechanism ensures the high throughput but each node must have communication routes with other nodes in the network. This method reduces the number of packets sent on the channel (reducing the broadcast storm problem) at the risk of some nodes not receiving the data. It is particularly interesting for mobile networks. This version of adaptive probabilistic broadcast automatically adapts transmission probabilities depending on the estimated number of neighbors.

Section 2 describes about the 2D and 3D WSN system architecture designed in OMNET++ modeling framework. Comparative results of analysis of average power consumption, latency and dropped frames for different routing protocols are shown in Section 3. Finally, our concluding remarks are presented in Section 4.

2. SYSTEM ARCHITECTURE

OMNET++ 4.5 with MIXIM 2.3 is used for the designing and computation of all parameters of 100 node WSN as shown in Figure 4. MIXIM is an OMNET++ modeling framework created for mobile and fixed wireless networks. IEEE 802.15.4 is the required low cost and low power communication standard between sink node and other sensor nodes [2]. The unlicensed frequency band of 2.4 GHz is used in this network as it has the highest data rate of value 250Kbps. All these nodes are deployed under 2 scenarios in the environment:-

a. 2 Dimensional WSN

b. 3 Dimensional WSN

These scenarios are designed on the basis of positioning of WSN nodes in 2D(x,y) and 3D(x,y,z) environment. Environment size of (500m ,500m) is used in case of 2D scenario and (500m,500m,500m) in 3D scenario. The evaluation and comparisons of energy consumption, latency and average dropped frames of both 2D and 3D WSN using different routing protocols (dummy, adaptive probabilistic broadcast and adaptive adaptive flooding) are shown below in latter sections.

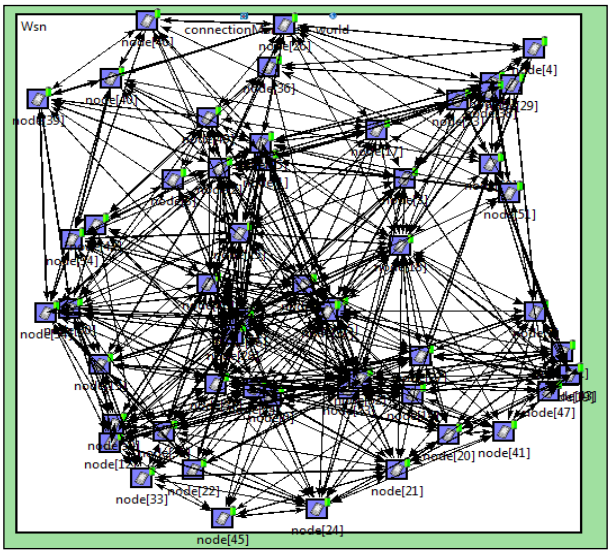

Figure 4: Multi Node WSN

3. SYSTEM ANALYSIS AND RESULTS

3.1 2D WSN

In this scenario, all 100 nodes are positioned in 2 dimensional environment of size 500m x 500m. Each node has 2 positional coordinates(x,y) which leads to ground wave communication between different sensor nodes as each sensor is positioned along ground(x,y). The simulation time for each analysis is 10s and the routing methods used are dummy, adaptive flooding and adaptive probabilistic. The analysis is based on the parameters like average power consumption, latency and dropped frames.

3.1.1 APC

Figure 5 shows the variation in average power consumption per node for all three protocols in 2D WSN scenario. Dummy routing protocol consumes very limited energy as compared to adaptive probabilistic broadcast and adaptive flooding protocol as each data frame is filtered by the WSN nodes & only required data is routed towards destination in case of dummy routing protocol.

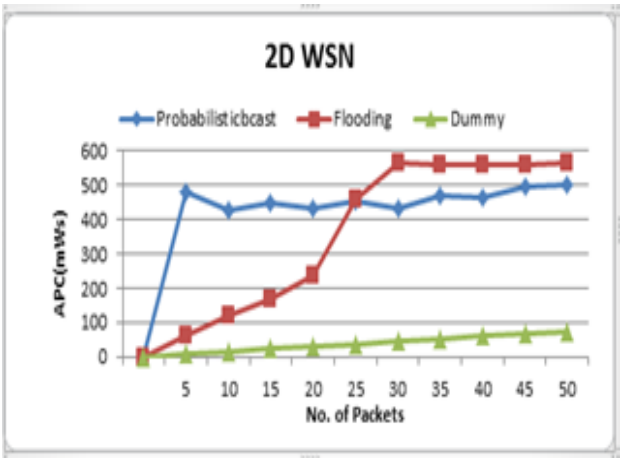

Figure 5: Average Power Consumption in 2D WSN

3.1.2 Latency

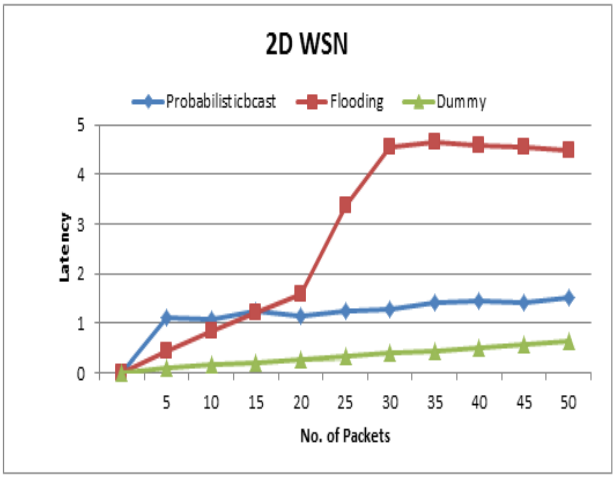

Figure 6: Latency in 2D WSN

Figure 6 shows the variation in latency for all three protocols in 2D WSN scenario. Dummy routing protocol has minimum latency value as compared to adaptive probabilistic broadcast and adaptive flooding protocol. So dummy protocol is required in real time networks where quick response is required.

3.1.3 Dropped frames

Figure 7 shows the variation in no. of dropped frames for all three protocols in 2D WSN scenario. The dropped frame rate in case of Dummy routing protocol is very low as compared to adaptive probabilistic broadcast and adaptive flooding protocol. So very less retransmission of frames is needed which increases network reliability and increases network efficiency.

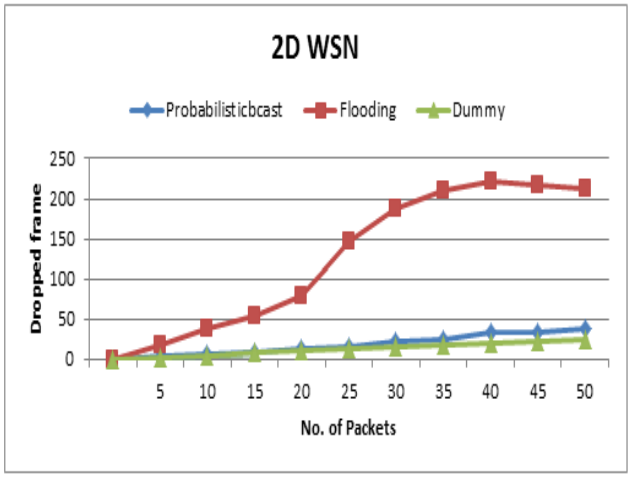

Figure 7: No. of Dropped Frames in 2D WSN

3.2 3D WSN

In this scenario, all 100 nodes are positioned in 3 dimensional environment of size 500m x 500m x 500m. Each node has 3 positional coordinates(x,y,z) which means node is positioned in space and communication between different sensor nodes is space wave. Space wave communication has greater energy efficiency than ground wave as fading effect is more in case of ground wave communication than space wave communication. The simulation time for each analysis is 10s and the routing methods used are dummy, adaptive flooding and adaptive probabilistic. The analysis is based on the parameters like average power consumption, latency and dropped frames.

3.2.1 APC

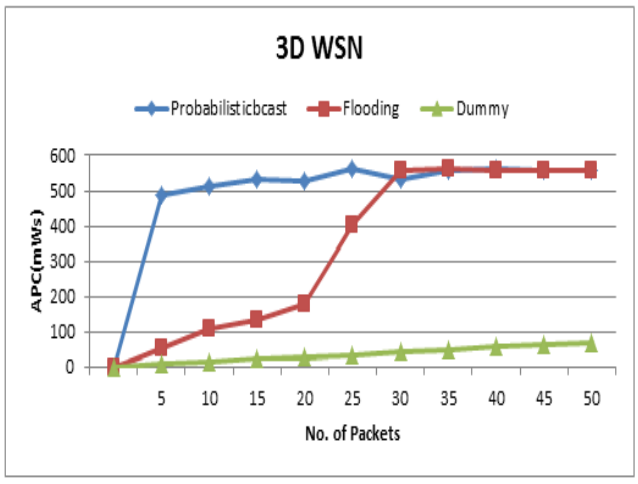

Figure 8: Average Power Consumption in 3D WSN

Figure 8 shows the variation in average power consumption per node for all three protocols in 3D WSN scenario. Dummy routing protocol consumes very limited energy as compared to

adaptive probabilistic broadcast and adaptive flooding protocol in 3D scenario too. Moreover average power consumption of 3D WSN is also lesser than 2D WSN using each protocol as 3D WSN supports space wave communication which consumes lesser energy during communication as compared to ground wave communication used in 2D WSN.

3.2.2 Latency

Figure 9 shows the variation in latency for all three protocols in 3D WSN scenario. Dummy routing protocol has minimum latency value as compared to adaptive probabilistic broadcast and adaptive flooding protocol in 3D WSN too. So Dummy protocol in real time 3D networks provide much quicker response as compared to 2D WSN.

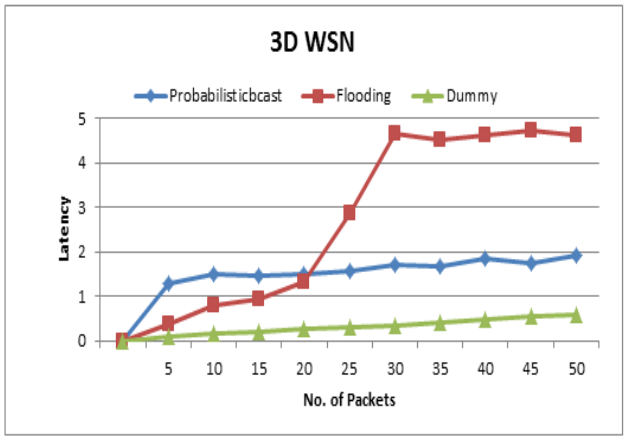

Figure 9: Latency in 3D WSN

3.2.3 Dropped frames

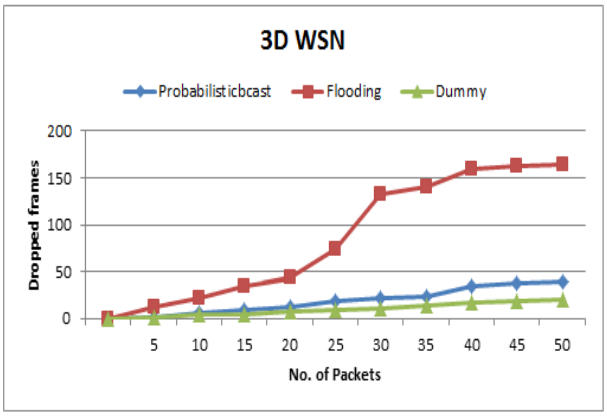

Figure 10: No. of Dropped Frames in 2D WSN

Figure 10 shows the variation in no. of dropped frames for all three protocols in 3D WSN scenario. The dropped frame rate in case of Dummy routing protocol is very low as compared to adaptive probabilistic broadcast and adaptive flooding protocol in 3D WSN too which makes 3D WSN is much more reliable network than 2D WSN.

4. CONCLUSION AND FUTURE SCOPE

In this paper, we have greatly experienced the use of network simulation software OMNET++. Different scenarios were simulated based on variation in number of nodes, routing protocols and position of nodes in WSN (2D or 3D) and analyzed different parameters such as average power consumption, latency and average dropped frames. By analyzing these scenarios, it is observed that Average power consumption, Latency and Number of frames dropped in case of dummy routing protocol is quite lesser than their values observed while using Adaptive flooding protocol and Adaptive probabilistic broadcast protocol in case of both 2D and 3D WSN . So it is concluded that if communication between nodes is performed using dummy routing protocol in both 3D and 2D WSN environment, then reliability and lifetime of nodes in the network increases and a good quality of service is maintained. Some research directions are recommended for consideration for the further enhancement of above parameters in the future.

- Evaluation can be done with other different modulation techniques.
- The power consumption analysis can be done with other routing techniques.
- Energy efficiency of WSN can be analyzed for different traffic types.

5. REFERENCES

[1] Robin Chadha, Love kumar, "A survey on positioning based energy efficient WSN" in International Journal for Science, Management and Technology, October 2016

[2] Michael Kirsche and Matti Schnurbusch" A New IEEE 802.15.4 Simulation Model for OMNeT++" arXiv:1409.1177v2 [cs.NI] 13 Sep 2015.

[3] Degan Zhang et. al., "An Energy – Balanced Routing Method based on forward-aware factor for wireless sensor networks" ,IEEE ,vol-10 No.1,pp 766-773,2014

[4] G Singh, H P Singh, A Sharma, "Comparative Analysis of Energy Efficient Protocols for Prolonged Life of Wireless Sensor Network", in Third International Conference on Soft Computing for Problem Solving, 2014, pp: 75-85

[5] Jatinder Pal Singh, Love Kumar" Power Consumption Analysis of Wireless Sensor Networks with Different Modulation and Routing Techniques" International Journal of Emerging Technologies in Computational and Applied Sciences, 10(2), September-November,2014, pp. 116-121

[6] Jatinder Pal Singh, Love Kumar" POWER CONSUMPTION ANALYSIS OF STATIC AND MOBILE WIRELESS SENSOR NETWORKS WITH CONVERGE CAST ROUTING" CT International Journal of Information &Communication Technology Vol. 2, Issue 1, 2014

[7] Jatinder Pal Singh, Love Kumar" Power consumption measurement for convergecast routing in Wireless sensor network" national conference on innovations in engineering and technology, march 2014

[8] Antônio Dâmaso et al," Evaluating the Power Consumption of Wireless Sensor Network Applications Using Models" Sensors 2013, 13, 3473-3500; doi:10.3390/s130303473

[9] Haibo Zhang, Pablo Soldati and Mikael Johnson, "Performance Bounds and Latency-optimal scheduling for convergecast in wireless networks", IEEE – 1536-1276 , 2013.

[10] Jatinder Pal Singh, Love Kumar" A Survey on Power Management Techniques in Wireless Sensor Network"

International Journal for Science and Emerging Technologies with Latest Trends" 13(1): 31-35 (2013)

[11] Himanshu Sharma and vaibhav kumar, "Energy Efficiency of the IEEE 802.15.4 Standard in Wireless Sensor Networks: Modeling and Improvement Perspectives" Proceedings of International Journal of Computer Applications (0975 – 8887) Volume 58– No.9, November 2012.

[12] Prabhat Kumar, M.P. Singh and U.S. Triar, "A Review of Routing Protocols in Wireless Sensor Network", International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 4, June - 2012 ISSN: 2278-0181.pp 1-14.

[13] Fengyuan Ren, Jiao Zhang, Tao He and Chuang Lin , "EBRP: Energy Balanced Routing Protocol for data Gathegring in WSN" ,IEEE-1045-9219, 2011. pp 2108-2125, Vol.22 No.12 Dec 2011

[14] Alan W.F. Boyd ,Dharini Balasubramaniam and Alan Dearle ,"A Collaborative Wireless Sensor Network Routing Scheme For Reducing Energy Wastage" , IEEE, 978-1-4244-6826-3 ,2010.

[15] Suraiya Tarannum "Energy Conservation Challenges in Wireless Sensor Networks: A Comprehensive Study", Wireless Sensor Network, Vol. 2, 2010, pp: 483-491.

[16] Jennifer Yick, Biswanath Mukherjee, dipak Ghosal, "Wireless sensor network survey",Computer Networks, Vol. 52, 2008, pp: 2292–2330.

[17] Liyang Yu, Neng Wang, Wei Zhang and Chunlei Zheng, "Deploying a Heterogeneous Wireless Sensor Network", in proceeding of Wireless Communications, Networking and Mobile Computing, 2007, pp: 2588-2591.

[18] MiXiM - SourceForge http://mixim.sourceforge.net/.