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Extending the Lifetime of Wireless Sensor Networks with Threshold Sensitive Stochastic Election Approach

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Abstract

Wireless sensor networks are composed of a broad array of independent sensors called nodes. These nodes are inexpensive and are used in data gathering usually in hostile environments. They collect data physical or environmental conditions, such as temperature, pressure, etc. And send it to a base station. They are limited in efficiency, secure routing, load sharing, etc. To overcome these issues clustering is performed in WSN, which partitions the network into groups. Each group selects a cluster head which gathers data from all the nodes and sends it to the base station. These groups head are selected using various algorithms which are based on residual energy, distance, etc. The proposed algorithm suggests the usage of a stochastic election approach to effectuate the improvement in load balancing of clusters in wireless sensor networks which also improves the network lifetime. The proposed system is a modified version of the SEARCH algorithm which is adapted with data thresholding to increase the network lifetime and remove redundancy of the data sent. The simulation results show that the proposed approach is more efficient than other distributed algorithms. This technique can be easily extended to large-scale wireless sensor networks.

Keywords: Wireless sensor networks (WSN), the stochastic election of appropriate range cluster heads (SEARCH), stochastic election, residual energy, data thresholding

Wireless sensor network (WSN) also known as wireless sensor and actuator network (WSAN) are highly distributed independent sensors to monitor all physical and environmental factors like sound temperature etc. In WSN sensor nodes sense the environmental condition and use their relevant component to transmit the sensed/collected data over the wireless channel to another/other nodes, sometimes referred as base station/sink. The base station receives the data to act as supervisory control processor or as an access point for human interface and gateway to another network. Due to the use of DC power, the lifetime of WSN becomes limited and is difficult to restore the power regularly due to the position of WSN at are remote place. From past several years, many steps have been taken to increase the lifetime of WSN to satisfy energy utilization and efficiency requirements. Now due to much recent development, we can say efficiency, scalability and lifetime of WSN can be improved by using hierarchical routing. Here sensors are structured or organized themselves in a cluster, where each group head consists of the group head. The team head provides data communication between sensor nodes and base stations.

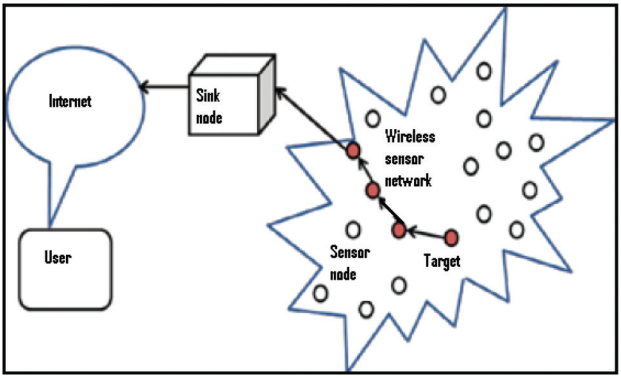


Fig. 1: Architecture of wireless sensor network

Wireless sensor network allows the ability to observe the previously unobservable at an excellent resolution over a large scale. It has abroad range of applications to industries, science, transportation, infrastructure, and security.

The technology used for wireless sensor networks focuses on both hardware as well as software requirements. The schematic diagram of sensor node (device) given below.

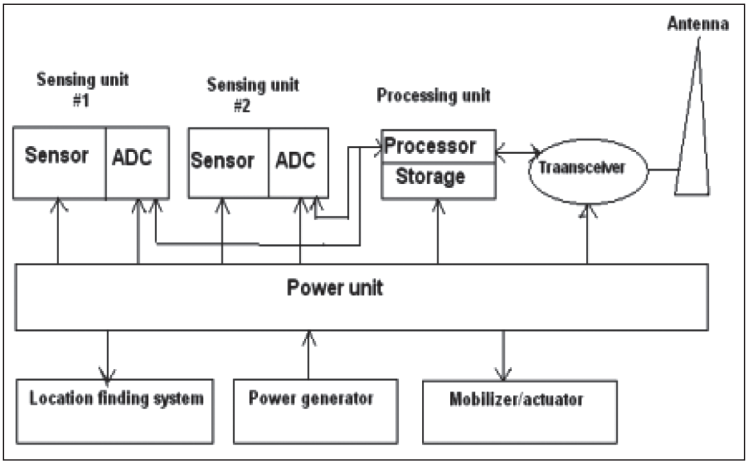


Fig. 2: Schematic of a typical sensor node hardware hierarchy

The computational power of embedded processor are often substantially limited (upto small MHz area). Due to this limitation of such processors, devices normally run specialized component based operating system, such as TinyOS. They incorporate advanced low-power design techniques, such as sleep mode and dynamic voltage scaling to provide energy savings. In the storage, both program memory and data memory are included. The size of the memory used is often varied due to economic reasons. As radio transceiver, WSN comprises of low-rate, short-range wireless communication of 10-100kbps. Radio communications are the most robust operation in WSN operation. In WSN, it mainly supports low-data-rate sensor due to a limitation in energy and bandwidth. A small battery is used as a power source in WSN. The limited battery or DC power is likely to be the blockage in most of the WSN applications. The schematic diagram of sensor node (software) given below.

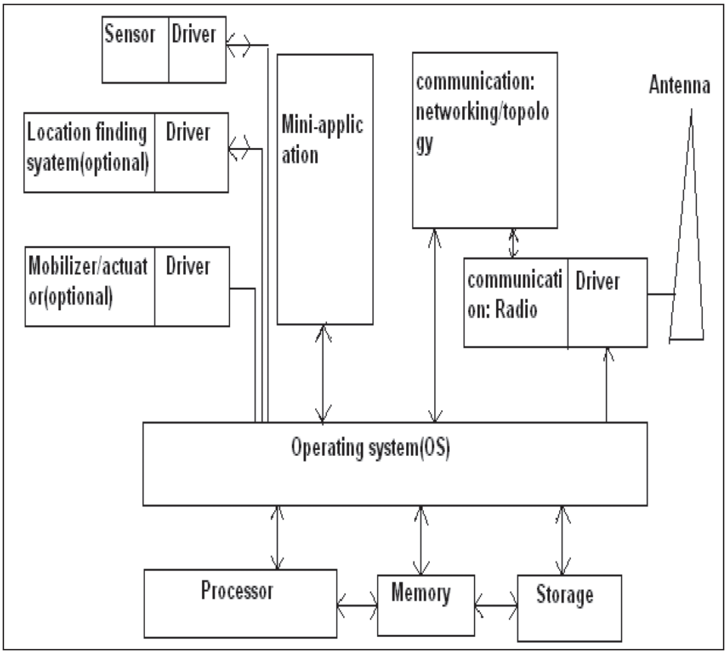


Fig. 3: Schematic of a typical sensor node software hierarchy

Operating System Microcode (middleware) represents the code that is used by the software module to support different types of functions. Sensor driver are referred as a software module that manages essential duties of the transceiver. They manage in uploading configuration and setting on it. The role of the communication processors is to control the communication functions, packet buffering, routing, and encryption, etc. Communication drivers operate the details of the radio channel transmission link. Sensors are capable of detecting/sensing changes in temperature, pressure, sound, etc. To increase the lifetime of WSN heterogeneous nodes are mostly used.

The current need for every industry and individual is to improve the quality and lifetime of WSN as to have energy saving efficiency. To meet all these requirements on this particular issue, we need extreme research through correct parametric design and technique. The process was influenced by various researchers and personality and found different results. Among them, few types of researchwork as mentioned. Parul Saini, Ajay K Sharma [1] in 2010 proposed an energy efficient cluster head scheme, for heterogeneous wireless sensor networks, by modifying the threshold value of a node based on which it decides to be a cluster head or not, called TDEEC (Threshold Distributed Energy Efficient clustering) protocol. They proposed TDEEC (Threshold Distributed Energy Efficient Clustering) protocol which improves stability and energy efficient property of the heterogeneous wireless sensor network and hence increases the lifetime. Meena Malik, Dr.Yudhvir Singh, Anshu Arora [2] in 2013 presented a detailed review and analysis of LEACH protocol. LEACH is energy efficient hierarchical based protocol that balances the energy expense, saves the node energy and hence prolongs the lifetime of the network. To evaluate the performance of LEACH, they considered a 100 × 100 network configuration with 101 nodes, where each sensor node was assigned an initial energy of 2.0 J, the amount of transmission energy was 50 nJ/bit, transmit amplifier energy (E amp) is 100 pJ/bit. The criteria for performance evaluation were the network lifetime, the power consumption and data aggregated at BS and no. of nodes alive. Each performance criteria was evaluated by varying the number of cluster-heads from 1 to 8. They tracked the rate at which the data are transferred to the base station and the amount of energy required to get the data to the base station. Themain concern of this work was to examine the energy efficiency and performance of LEACH protocol. They compared the lifetime and data delivery characteristics. They found that LEACH provided better results for some cluster heads as 3 and 4. Laxita Lange, Diamond Jonawal [3] in 2014 tested Distributed Energy-Efficient Clustering (DEEC), Developed DEEC (DDEEC) and Enhanced DEEC (EDEEC) with Genetic Algorithm (GA) under several different scenarios containing high level heterogeneity to low-level heterogeneity, in order to conclude the behavior of this heterogeneous protocols. They have examined the current state of proposed clustering protocols, specifically on their power and reliability requirements. Also, they have examined DEEC, E-DEEC with GA and DDEEC for heterogeneous WSNs containing different level of heterogeneity. Simulations proved that DEEC and DDEEC perform well in the networks providing high energy difference between regular, advanced and super nodes. Whereas, they found out that EDEEC-GA performs well in all scenarios. EDEC-GA had the best performance regarding stability period and lifetime.Recently Min-Yi Wang, Jie Ding, Wan-Pei Chen, Wen-Qiang Guan [4] in 2015 presented a semi-centralized stochastic election approach named Stochastic Election of Appropriate Range Cluster Heads (SEARCH), assuringtime lowcost and optimal number cluster heads for each round. SEARCH, by boosting cluster head threshold of a node in a favorable position while deteriorating it otherwise, achieves an aggressive goal on prolonging the round of half alive nodes surviving (notably stable period) as well as slashing weak sensing period. They presented SEARCH, a semi-centralized stochastic election approach for heterogeneous WSNs. Given node type, residual energy, position information as well as cluster head energy dissipation, SEARCH makes much easier a node in a favorable location to serve as a cluster head, while worsening the threshold of a node locating in a disadvantage position. It is remarkable that SEARCH pursued a stochastically sub-optimal solution, assuring optimal number cluster heads for each round. Their protocol, thereby, featured enduring stable period, short, weak sensing and time low cost.

In spite of several experiments on WSN for increasing network lifetime, it is surveyed that more studies on the parametric effect on different variable parameters are necessary to enrich the existing knowledge on this particular topic. In this paper, extensive research has been done on WSN to increase the lifetime of the heterogeneous network.

Experimental work

Parameter Selection

MATLAB 2012 has been used in this research work. The area taken for this network is 100*100 square meter, and 100 nodes are placed on this system. The different types of simulation parameters which are used in this paper sshown below:

Table 1: Simulation parameters

Parameters	Value
Area	100*100 square meter
Base station	(50,50) in meter
Energy for normal nodes	0.25J
Energy for advanced nodes	0.5J
Energy for super nodes	0.7J
Additional energy factor (α, β)	2,3
Multipath amplification energy	0.0013PJ/bit/
Message size	2000 bits
Round	1500
Aggregation Energy	5nJ/bit/packet
Data threshold	2 degree Celsius
(optimal cluster head ratio)	0.1
Fraction of advanced node (m)	0.2

There are some important points which are related to my research work; thoseare given below:

- Used normal nodes, advanced nodes, super nodes with different initial energy.
- By thethreshold applied, cluster head sending data to the base station.

Experimental program-algorithm

Step 1: Initialize four level heterogeneous network with super, advanced and normal node

Step 2: Divide network field into hierarchical structure-calculate upper and lower boundary and divide domain

Step 3: Find the total energy, distance of each node

Step 4: During each round, check whether dead node

Step 5: Calculate the probability of each node and threshold for each node-Select cluster head based on initial, remaining, average energy, distance parameters.

Step 6: if Rand< Threshold, select node as Cluster Head

Step 7: Find the competition radius of cluster head

Step 8: Check the energy of nodes in cluster and choose node with the highest power to be group head

Step 9: Member nodes join the cluster head and plot them

Step 10: Data can be checked, nodes data is tested with data already in group head to remove redundancy of data

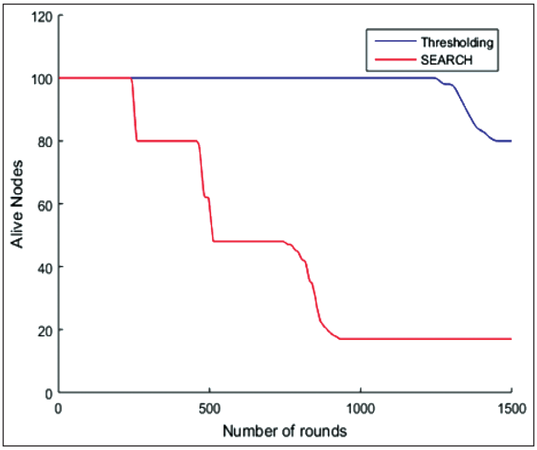
Step 11: Multi-hop transmission of data

Step 12: Energy calculation

Step 13: Plot graph for 1st, 10th node death, a packet sent to the base station, the effect of the number of nodes (plot diagram if the number of nodes increases and decrease), the number of cluster head, energy consumption.

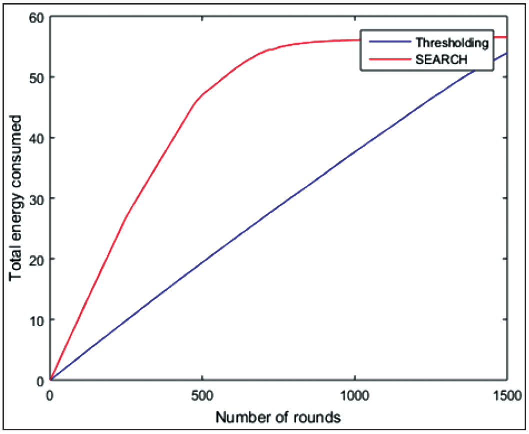
Experimental Result

After performing program on MATLAB 2012, we found graph oriented results which shown below. In Graph 1 we found that using a SEARCH algorithm to improve the lifetime of WSN is not so effective. In fact, if we apply threshold in place of SEARCH we can get have a more productive life in heterogeneous WSN. The graph showing that on using SEARCH algorithm the existing nodes are getting dead quickly at around 200-250 number of rounds. That means they are not so efficient regarding usage. But when we apply a threshold, the existing node are not getting dead quickly. The nodes are still working till 1200-1300 numbers of rounds. This result gives us a big boost in improving the lifetime of WSN.



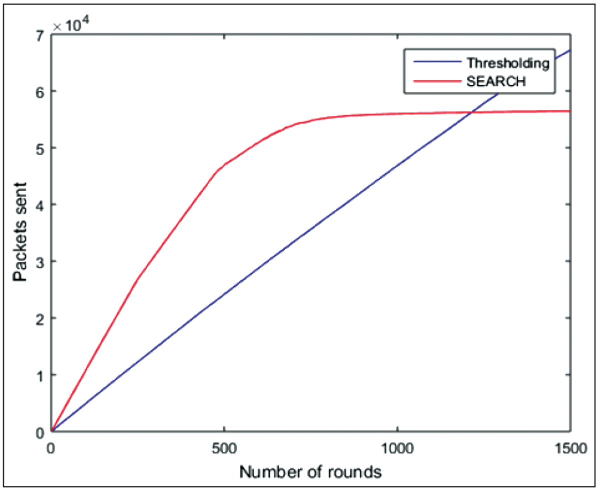
Graph 1: Shows the number of rounds vs. Alive nodes

Graph 2 showing energy consumption by existing nodes during every round by both SEARCH and thresholding. Now initially all the nodes are active so more data will transfer.As a result,power consumption will be more. Now the difference is that in the case of SEARCH, saturation occurs at very early stage of performance, such that no data will be transferred. But in thecase of sudden thresholding saturation doesn't happen in any of the firststages of performance. Instead, it goes on performing uniformly and keeps on transferring more data. As a result, thresholding increases network lifetime.



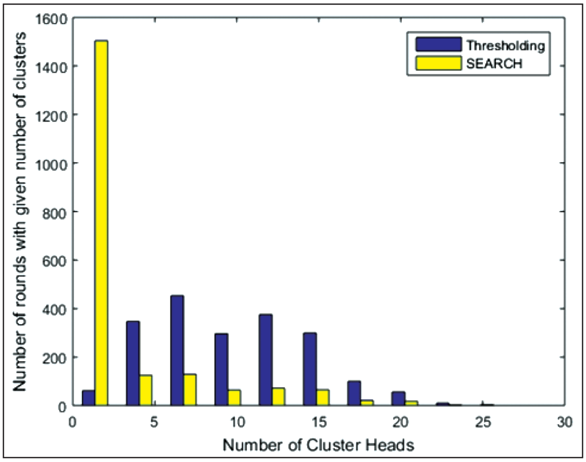
Graph 2: Shows number of rounds vs. Total energy consumed

Graph 3 showing packets being sent to the base station during every round by both SEARCH and thresholding. Initially, all the nodes are alive so more packets will be sentto the base station by the nodes. So the graph is showing a high increase up to 500-600 rounds in case of the SEARCH algorithm. But after this, the operation slow down, as a result the sending of data also slows down due to the nodes get dead. But in thresholding saturation doesn't occur at the early stage of the round so that packets will be transferred until the end of theround. So, we can say that the performance of SEARCH will be better after applying a threshold. As a result, thresholding increases network lifetime



Graph 3: Shows the number of rounds vs. Packets sent

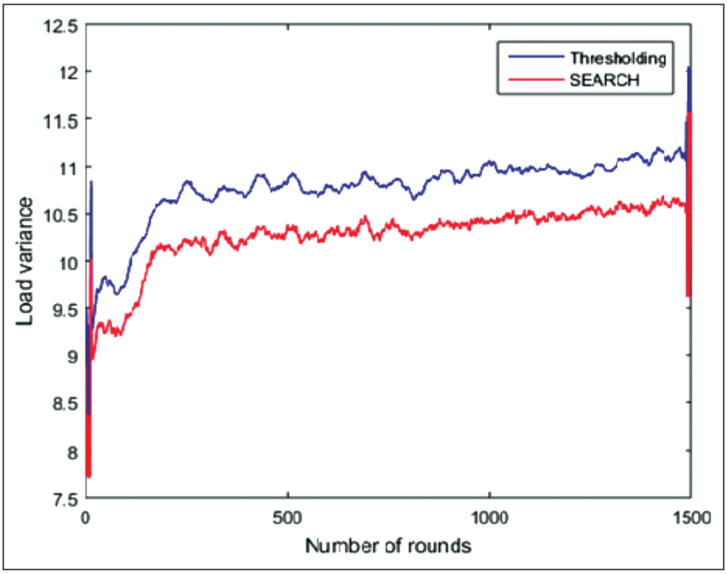
Graph 4 indicating the number of cluster head vs. some rounds with given number of clusters. In the case of thresholding, the probability of node to become cluster head is increased due to the extended stability period of the network but in the event of SEARCH, likelihood of node to become group head is less due to the short stability period of system. Hence, the SEARCH performance becomes stronger after applying a threshold.



Graph 4: Shows the Number of cluster heads vs. Number of rounds with given number of clusters

Analysis

To analyze the positive effect of threshold let's study the graph between load variance vs. Number of shots. In the case of SEARCH, the weight difference is much less. After applying the threshold on SEARCH algorithm, the weight difference increases. So we can say that the proposed algorithm balances the weight and increases the network lifetime.



Graph 4.1: Shows the number of round vs. Load variance

Conclusion

This paper proposes an algorithm for Cluster Heads selection to increase the network lifetime of wireless sensor networks. Based on information such as the number of nodes in the cluster and using the data threshold concept the on times of the nodes are reduced, which further increases the lifetime of the node. The simulation demonstrates that the proposed algorithm balances the load and increases the network lifetime. Because each node can acquire information without additional traffic or complex computations, the proposed algorithm remains simple and practical while prolonging the network lifetime. Therefore, the proposed algorithm can be an effective for data aggregation in WSNs.

References

Parul Saini, Ajay K Sharma, "Energy Efficient Scheme for Clustering Protocol Prolonging the Lifetime of Heterogeneous Wireless Sensor Networks" International Journal of Computer Applications (0975 – 8887) Volume 6, No.2, September 2010.

Meena Malik, Dr. Yudhvir Singh, Anshu Arora, " Analysis of LEACH Protocol in Wireless Sensor Networks" International Journal of Advanced Research in Computer Science and Software Engineering,Volume 3, Issue 2, February 2013, ISSN: 2277 128X.

Laxita Landge, Diamond Jonawal “Enhanced Distributed Energy Efficient Clustering (E-DEEC) based on Genetic Algorithm”International Journal of Digital Application & Contemporary researchVolume 2, Issue 9, April 2014, ISSN: 2319-4863.

Min-Yi Wang, Jie Ding, Wan-Pei Chen, and Wen-Qiang Guan, “SEARCH: A Stochastic Election Approach for Heterogeneous Wireless Sensor Networks”, IEEE Communications Letters, Vol. 19, No. 3, March 2015.

Anu Rathee, Indu Kashyap, Kavita Choudhary, “ Developed Distributed Energy-Efficient Clustering (DDEEC) Algorithm based on Fuzzy Logic Approach for Optimizing Energy Management in Heterogeneous” International Journal of Computer Applications (0975 – 8887),Volume 115 – No. 17, April 2015.

Wendi B. Heinzelman, Anantha P. Chandrakasan, Hari Balakrishnan, “An Application-Specific Protocol Architecture for Wireless Microsensor Networks” IEEE Transaction on wireless communications, Vol. 1, No. 4, October 2002.

Manjeshwar, Dharma P. Agrawal, “TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks” 0-7695-0990-8/01/$10.00 (C) 2001 IEEE.

Ankita Joshi, Lakshmi Priya.M, “A Survey of Hierarchical Routing Protocols in Wireless Sensor Network”, pp 67 – 71

Susheel Gupta, Ruchi Jain, Ganesh Vishwakarma, “A Comprehensive Study on Energy Efficient Routing Protocol Techniques with Data Aggregation for WSN’s”, International Journal of AdvancedResearch in Computer and Communication Engineering,Vol. 3, Issue 2,February 2014, ISSN(Online): 2278.

Georgios Smaragdakis, Ibrahim Matta, Azer Bestavros, “SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks”.

S. Faisal, N. Javaid, A. Javaid, M. A. Khan, S. H. Bouk, Z. A. Khan, “ Z-SEP: Zonal-Stable Election Protocol for Wireless Sensor Networks”.

Alia Sabri , Khalil Al-Shqeerat, “Hierarchical Cluster-Based Routing Protocols for WirelessSensor Networks – A Survey”, IJCSI International Journal of Computer Science Issues, Vol. 11, Issue 1, No 2, January 2014,ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784.

Razieh Sheikhpour, Sam Jabbehdari, Ahmad Khadem-Zadeh, “Comparison of Energy Efficient Clustering Protocols in Heterogeneous Wireless Sensor Networks”, International Journal of Advanced Science and Technology, Vol. 36, November, 2011.

Li Qing, Qingxin Zhu, Mingwen Wang, “Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks”,Computer Communications 29 (2006) 2230–2237.

Razieh Sheikhpour, Sam Jabbehdari, Ahmad Khadem-Zadeh, “Comparison of Energy Efficient Clustering Protocols in Heterogeneous Wireless Sensor Networks**”** International Journal of Advanced Science and Technology, Vol. 36, November, 2011.

Bhaskar Krishnamachari, Deborah Estrin, Stephen Wicker, “Impact of Data Aggregation in Wireless Sensor Networks”.

Swati Shamkuwar, Prof. Vimal Shukla, “A Review on Energy Efficient Routing Protocols in Wireless Sensor Networks” International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 3, March 2014.

I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, “Wireless sensor networks: a survey”, Computer Networks 38 (2002) 393–422.

Divya Sharma, Sandeep Verma, Kanika Sharma, “Network Topologies in Wireless Sensor Networks: A Review”, IJECT Vol. 4, Issue Spl - 3, April - June 2013, ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print).