Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 4, Issue. 7, July 2015, pg.204 – 211

RESEARCH ARTICLE

EVALUATION OF TREE BASED DATA AGGREGATION TECHNIQUES

Manpreet Kaur[1], Er. Varinderjit Kaur[2]

[1]**P.G Student, Department Of CSE, RIET, Phagwara**

[2]**HOD, Department Of M.TECH CSE, RIET, Phagwara**

[1]**Email: kmanpreet928@yahoo.com**

[2]**Email: vari006rupi@gmail.com**

ABSTRACT: The quick growth in network multimedia equipments have allow additional real-time digital services such as video-conferencing, online games and distance education to grow to be the conventional internet tasks. WSNs have become major area of research in computational theory due to its wide range of applications. But due to limited battery power the energy consumption has become major limitations of WSNs protocols. Though many protocols has been proposed so far to improve the energy efficiency further but still much enhancement can be done. In this paper, a survey on various routing protocols has been discussed. From the survey, it has been concluded that none of the protocol performs effectively in all fields. Therefore the paper ends with the future scope to overcome these issues.

KEYWORDS:- WSN, BASE STATION, GSTEB

1. INTRODUCTION

A Wireless Sensor Network (WSN) [1] contains large number of small sensor nodes with restricted computation capacity, low memory, limited power, and limited range communication device. All nodes send their data to a Base Station (BS) or sink, which performs calculation and decision-making, and can be compared with the functionalities of server or in some cases as a gateway in a computer network.

These sensor nodes are deployed over a large geographical area to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. WSN has emerged as an important area for research and development. They are presently at an accelerated deployment stage, with huge potential for numerous applications. So it won't be reasonable to state that they are expected to cover a substantial part of the world in the coming decade.

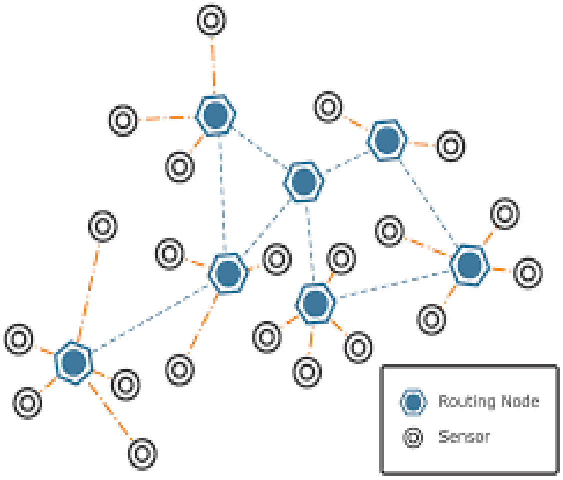

Fig 1: A sensor network[1]

2. COMPONENTS OF WSN

Sensor nodes

The Sensor Node is a basic element of WSN and it consists of Sensing, Computation and wireless Communication unit. Therefore sensor nodes are able to observe physical phenomenon, process the observed and received information and communicate the observed or processed information to the nearby sensor nodes to form a network of sensor nodes called Wireless Sensor Networks (WSNs). The wireless networking capability of the sensor enabled nodes, have resulted in various interesting applications ranging from surveillance, smart homes, precision agriculture, disaster detection and supply chain management applications. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

A typical sensor node consists of four components:

- A power unit, responsible for supplying energy to other components;
- A sensing unit, that actually contains the sensor, for instance, of light, humidity, temperature, etc;
- A computing unit, composed of RAM and flash memories and a processor that typically uses a set of analog-to-digital converters (ADCs) to obtain data from sensors and communications protocols;
- A communication unit, used to send and receive radio signals.

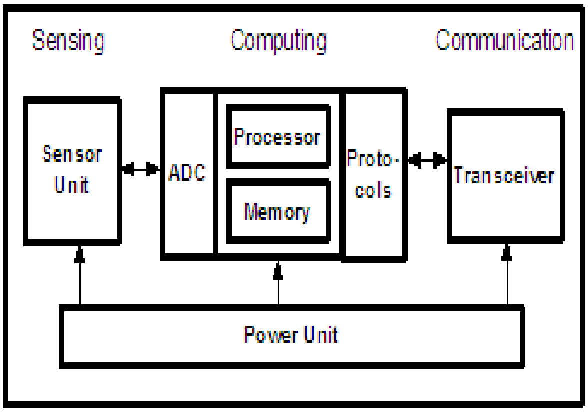

Fig 2: General schematic of a typical sensor node hardware. [2]

Components of a sensor node [2] are:

- **Power Unit:** Power is stored either in batteries or capacitors. Batteries, both rechargeable and non-rechargeable, are the main source of power supply for sensor nodes. The sensor node consumes power for sensing, communicating and data processing.
- **Sensing Unit:** Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. A sensor node should be small in size, consume extremely low energy, operate in high volumetric densities, be autonomous and operate unattended, and be adaptive to the environment. Sensors measure physical data of the parameter to be monitored.
- **Computation Unit:** A computing unit, composed of RAM and flash memories and a processor.
  - Microcontroller**:** The controller performs tasks, processes data and controls the functionality of other components in the sensor node. Some characteristics of microcontroller are: low cost, flexibility to connect to other devices, ease of programming, and low power consumption.
  - External Memory**:** From an energy perspective, the most relevant kinds of memory are the on-chip memory of a microcontroller and Flash memory—off-chip RAM. Two categories of memory based on the purpose of storage are: user memory used for storing application related or personal data, and program memory used for programming the device.
- **Communication Unit:** The functionality of both transmitter and receiver are combined into a single device known as a transceiver. The operational states are transmit, receive, idle, and sleep.

Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors or MEMS (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and a power source usually in the form of a battery. Other possible inclusions are energy harvesting modules, secondary ASICs, and possibly secondary communication interface (e.g. RS-232 or USB).

Base Station (BS)

The base stations are one or more components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables.

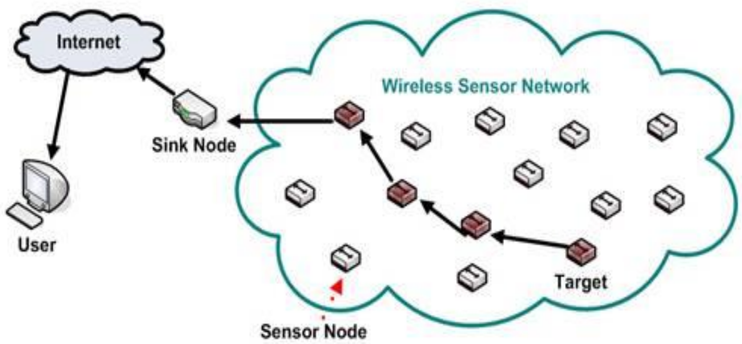

Fig 3: A Typical Wireless Sensor Network

Characteristics of WSN:

The main characteristics [3] of a WSN include:

- Power consumption constrains for nodes using batteries or energy harvesting
- Ability to cope with node failures
- Mobility of nodes
- Communication failures
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use

Platforms

Hardware

Major challenge in a WSN is to make cheap and small sensor nodes. There are an increasing number of small companies producing WSN hardware and the commercial situation can be compared to home computing in the 1970s. Many of the nodes are still in the research and development stage, particularly their software. Also they need to use energy efficient methods for signal transmission and data gathering.

In many applications, a WSN communicates with a Local Area Network or Wide Area Network through a gateway. The Gateway acts as a bridge between the WSN and the other network. This enables data to be stored and processed by devices with more resources, for example, in a remotely located server.

Software

WSN nodes are usually deployed in remote areas so it is not feasible to recharge them often so these nodes mostly suffer energy constraints as a result in a WSN energy is the scarcest resource and it decides the network. For this reason, algorithms and protocols need to address the following issues:

- Lifetime maximization
- Robustness and fault tolerance
- Self-configuration

Lifetime maximization: Energy/Power Consumption of the sensing device should be minimized and sensor nodes should be energy efficient since their limited energy resource determines their lifetime. To conserve power the nodes normally turn off the radio transceiver when not in use. Different protocols such as LEACH, HEED, PEGASIS and GSTEB etc. are developed so as to achieve even distribution of load among nodes and maximize network lifetime.

Operating systems

Operating systems for wireless sensor network nodes are typically simpler as compared to general-purpose operating systems. They mostly resemble embedded systems because of two reasons. First, wireless sensor networks are typically deployed with a particular application in mind, rather than as a general platform. Second, a need for low costs and low power leads most wireless sensor nodes to have low-power microcontrollers ensuring that mechanisms such as virtual memory are either unnecessary or too expensive to implement.

3. APPLICATIONS

- Area monitoring

  The most straightforward application of wireless sensor network technology is to monitor remote environments for low frequency data trends. For area monitoring, the WSN is deployed over an area where some event is to be monitored. Examples include use of sensors to detect enemy invasion in military or we can consider the geo-fencing of gas or oil pipelines.

- Health care monitoring

  Medical applications can be of two types: wearable and implanted. WSNs can be used for both kinds of medical applications. Body-area networks can collect information about an individual's health, fitness, and energy expenditure.

- Environmental data collection

  The term Environmental Sensor Networks has evolved to cover many applications of WSNs to earth science research. This includes sensing volcanoes, oceans, glaciers, forests etc. Some of the major areas are air pollution monitoring, landslide detection, forest fire detection etc.

- Machine health monitoring

  Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionality. In wired systems, the installation of enough sensors is often limited by the cost of wiring. Previously inaccessible locations, rotating machinery, hazardous or restricted areas, and mobile assets can now be reached with wireless sensors.

- Data logging

  WSNs are used for compilation of data for monitoring environmental information. This can be as basic as the monitoring of the temperature in a fridge to the level of water in overflow tanks in nuclear power plants. The statistical information can then be used to show how systems have been working.

4. A General Self-Organized Tree-Based Energy-Balance Routing Protocol for Wireless Sensor Network (GSTEB)
General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB) [4] constructs a routing tree by means of a method in which, for every round, Base station (BS) chooses a root node and broadcasts this choice to each node. Then, every node chooses its parent node by taking into consideration just itself and its neighbors' information. This makes GSTEB a dynamic protocol. Goal of GSTEB is to increase network lifetime of different applications. There are two definitions for network life time and two extreme case of data fusion are considered in the paper under consideration which are described as follows:

- Network lifetime can be defined in two ways:

a) The time from the beginning of the operation until first node dies.
b) The time from the beginning of the operation until last node is dead.

- Also two cases in data fusion are considered:

a) **Case (1)** The data among sensor nodes can be completely fused. Every node transmits the same amount of data regardless of the amount it receives.
b) **Case (2)** The data cannot be fused. Each relay node sends data which is an addition of its individually sensed data and data received from its child nodes.

5. LITERATURE SURVEY
Stephanie Lindsey et al. [2002] [5] in paper "PEGASIS: Power- efficient gathering in sensor information systems" have proposed a protocol named PEGASIS . It is near optimal chain base protocol and is better than LEACH protocol. In the proposed protocol each sensor node communicates with a neighbor only and sends data to the BS in turns, hence minimal energy is spent in each round. PEGASIS is based on greedy chain algorithm and is near optimal for data gathering problem in sensor networks. As load is distributed between nodes network lifetime and quality of network is improved. Results in the paper show that PEGASIS perform better as compared to LEACH. Ossama Younis et al [2004] [6] in paper HEED: "A hybrid, energy- efficient, distributed clustering approach for ad hoc sensor networks" have proposed a novel distributed clustering approach for long-lived ad hoc sensor networks. Proposed approach does not make any assumptions about the network infrastructure or about node potential, other than the existence of the multiple power levels in nodes. A protocol named HEED (Hybrid Energy-Efficient Distributed clustering) is proposed in the paper, that periodically selects cluster heads according to a hybrid of the node residual energy and a secondary parameter, such as node proximity to its neighbors or node degree. Approach is hybrid: Cluster heads are probabilistically selected based on their residual energy, and nodes join clusters such that communication cost is minimized. It is assumed that quasi-stationary networks where nodes are location- unaware and have equal significance. A key feature of this approach is that it exploits the availability of multiple transmission power levels at sensor nodes. Simulation results demonstrate that HEED prolongs network lifetime, and the clusters it produces exhibit several appealing characteristics. HEED incurs low message overhead, and achieves fairly uniform cluster head distribution across the network. Authors of the paper prove that, with suitable boundaries on node density and intracluster and intercluster transmission ranges, HEED can asymptotically almost surely guarantee connectivity of clustered networks. Simulation results show that proposed approach is effective in extending the network lifetime and sustaining scalable data aggregation. HEED parameters, such as the minimum selection probability and network operation interval, can be easily tuned to optimize resource usage according to the network density and application requirements. HEED achieves a connected multihop intercluster network when a specified density model and a specified relation between cluster range and transmission range hold. Proposed approach is suitable for the design of several types of sensor network protocols that require scalability, prolonged network lifetime, fault tolerance, and load balancing. Authors suggest that although paper only provided algorithms for building a two-level hierarchy, we can extend the protocols to multilevel hierarchies. This can be achieved by recursive application at upper tiers using bottom-up cluster formation. Wendi B. Heinzelman et al. [20002] [8] in paper "An application- specific protocol architecture for wireless microsensor networks" have developed and analyzed low energy adaptive clustering hierarchy (LEACH) protocol for WSN that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to improve network lifetime and quality. LEACH is based on a distributed cluster formation technique that is capable of self-organization of nodes, algorithms for adapting clusters and rotating cluster head positions for even distribution of the -+-load among nodes, and techniques to enable distributed signal processing to save communication resources. Results in the paper show that

LEACH can improve system lifetime by an order of magnitude compared with general-purpose multihop approaches. When designing protocol architectures for wireless microsensor networks, it is important to consider the function of the application, the need for ease of deployment, and the severe energy constraints of the nodes. These features led to the design of LEACH protocol in which local computation is done so as to minimize the amount of data transmission, network configuration and operation is done using local control, and media access control (MAC) and routing protocols enable low-energy networking. Results from experiments show that LEACH provides the high performance needed under the tight constraints of the wireless channel. Huseyln Ozgur Tan et al. [2003] [9] in paper "Power efficient data gathering and aggregation in wireless sensor networks" have proposed two new algorithms named PEDAP (Power Efficient Data gathering and Aggregation Protocol), which are near optimal minimum spanning tree based routing schemes, where one of them is the power-aware version of the other. Results in the paper show that proposed algorithms perform well in both cases where base station is far away and where it is in the center of the field. PEDAP achieves between 4x to 20x improvement in network lifetime compared with LEACH , and about three times times improvement compared with PEGASIS. PEDAP and PEDAP-PA are two power efficient data gathering and aggregation protocols based on minimum spanning tree routing scheme.. PEDAP performs better than existing previous protocols, LEACH and PEGASIS, by constructing minimum energy consuming routing for each round of communication. PEDAP-PA promote it further and attempts to balance the load. Low energy consumption and even distribution of load among sensor nodes improves system lifetime. This is confirmed through simulations. Simulations show that if keeping all the nodes working together is important, PEDAP-PA performs best among others, regardless of the position of the base station. On the other hand, if the lifetime of the last node is important or the nodes are not power-aware, PEDAP is a good alternative. Proposed algorithms also perform well when the base station is inside the field. There have been no approaches so far for this scenario except direct transmission. Weifa liang et al. [2007] [10] in paper "Online data gathering for maximizing network lifetime in sensor networks" have considered an online data gathering problem in sensor networks. It is assumed that there is a series of data gathering queries arriving one by one. The system constructs a routing tree for responding to each arriving query . In the tree the volume of the data transmitted by each internal node depends on the volume of data sensed by the node and also the volume of data received from its children. The objective is to maximize the network lifetime without any knowledge of future query arrivals and generation rates or we can say the objective is to increase the number of data gathering queries answered until the first node dies. Paper presents a generic cost model of energy consumption for data gathering queries if a routing tree is used for the query evaluation. Then it is shown that the online data gathering problem is NP-complete if the length of the message transmitted by each relay node varies, so heuristic algorithms for the problem are projected. The experimental results prove that, among the proposed algorithms, one algorithm that takes into account both the residual energy and the volume of data at each sensor node significantly outperforms the others. The experimental results showed that algorithm MNL performs far better than the other algorithms proposed such as MDST, MMRE, SPT, and BT. Basma M. Mohammad El-Basioni et al. [2011] [11] in paper "An optimized energy-aware routing protocol for wireless sensor network " has studied A hierarchical clustering routing protocol introduced for data assembling software in WSN called Energy-Aware routing Protocol (EAP) which fulfills various significant necessities for a clustering algorithm. EAP has various advantages, it is proven that it increases network lifetime significantly. So, this protocol should be considered for big interest therefore in this paper authors evaluate EAP in connection with network lifetime, end to end delay, packet loss percentage, and throughput, and introduces an improved protocol that performs better. The modified protocol has improved characteristics of packets loss, delay, and throughput, but decreases lifetime a little. It is shown in the paper that the modified protocol performs better than EAP in terms of packet loss percentage by an average of 93.4%, and also improves throughput and delay. M.J. Shamani et al. [2013] [1] in paper "Adaptive Energy Aware Cooperation Strategy in Heterogeneous Multi-Domain Sensor Networks" studies heterogeneous multi-domain WSNs. These are the systems in which different networks are members of different domains and sensor nodes are deployed at the same physical location and their topology is heterogeneous. It seems that, domains life time can be maximized by mutual aid in packet forwarding; but selfishness is unavoidable from rational viewpoint. Paper explores this problem to find out cooperation of the system while their sensors are energy aware. Spontaneous cooperation is not possible in energy aware sensors. For that reason an Adaptive Energy Aware strategy is proposed in the paper which is a novel algorithm based on TIT-FOR-TAT, begins with generosity and ends up with conservative behaviour. Results show that this algorithm can increase its network lifetime as compared with other networks. The adaptive energy aware approach enforces cooperation among networks and minimizes the generosity slowly past each round. When nodes reach to the end of their life they become conservative in cooperation. Paper shows that proposed approach can remove irrational feedback, suspicious strategy and increase network lifetime. B. Manzoor et al. [2013] [2] in paper "Q LEACH: A new routing protocol for WSNs " has stated that now a days WSNs are used for long lasting monitoring of fields and are required to work without sudden changes. Additionally, it is preferred to obtain better coverage of area. In view of these requirements new protocol Quadrature-LEACH (Q-LEACH) is developed which is more efficient in terms of network lifetime and stability. In this protocol nodes are deployed in the region. Network is divided into four quadrants to improve clustering. Division of network into quadrants helps to improve coverage. It also clearly shows accurate distribution of nodes in field. This division of network into quadrants results in better energy consumption of sensor nodes. It also helps to decide best possible positions of CHs. In addition, communication load of other sending nodes is also reduced. In LEACH clusters are not properly defined in terms of size some of the cluster members could be situated far-off. Because of these arbitrary cluster formation distant nodes suffers through high energy drainage and hamper network performance. On the other hand in Q-LEACH network is divided into quadrants and therefore, clusters formed in these quadrants are more deterministic. Consequently, nodes are well distributed within a particular cluster and this causes efficient energy consumption. Above mentioned notion of localized organization is applied in each sectored region of the proposed concept. Q-LEACH, considerably improves network parameters and could be considered a smart choice for WSNs by improving general network quality parameters. Dilip kumar et al. [2009] [3] in paper "EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks" introduce an energy efficient heterogeneous clustered scheme for WSN founded on weighted election probabilities of each node to be chosen as a cluster head (CH) according to the residual energy in each sensor node. Main advantages of Hierarchical or cluster-based routing are scalability and efficient communication. Low-energy adaptive clustering hierarchy (LEACH) is one of the widely accepted distributed cluster-based routing protocol in WSN. Further this paper presents a model of heterogeneous wireless sensor network and explains the effect of heterogeneous resources. The proposed heterogeneous clustering method is more successful in increasing the network lifetime than LEACH. The energy efficiency and ease of use make EEHC an advantageous protocol for WSN. EEHC has increased the lifetime of the system by 10% as compared with LEACH in the same network environment. The proposed system increases the reliability and network lifetime. T.N. Qureshi et al. [2013] [7] in paper "BEENISH: Balanced energy efficient network integrated super heterogeneous protocol for wireless sensor networks " has studied that Clustering is an efficient method to improve energy efficiency. Generally, heterogeneous protocols use two or three energy levels of nodes. However actually, heterogeneous WSNs have large number of energy levels. After studying energy utilization by the clusters and large number of energy levels in heterogeneous WSN, BEENISH (Balanced Energy Efficient Network Integrated Super Heterogeneous) Protocol is introduced. It considers WSN having four energy levels of nodes. In this protocol Cluster Heads (CHs) are selected by considering. residual energy level of nodes. Results in the paper prove that it is better than previously developed clustering protocols in heterogeneous WSNs. BEENISH uses the similar perception as in DEEC, regarding selection of CH. In these protocols CH is selected based upon residual energy level of the nodes with respect to average energy of system. Main difference between the two protocols is that, DEEC has two types of nodes; normal nodes and advance nodes whereas BEENISH is based upon four kind of nodes; normal, advance, super and ultra-super nodes. CH is selected according to residual and average energy of the system. Hence , the nodes with higher residual energy have greater probability to become cluster heads than that with the low residual energy. In the paper BEENISH is proved more efficient than other protocols such as DEED, DDEEC and EDEEC for all types of WSNs in regard to stability period, network lifetime and throughput. Zhao han et al. [2014] [4] in paper "A general self- organized tree-based energy-balance routing protocol for wireless sensor network" have proposed General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB) which constructs a routing tree by means of a method in which, for each round, BS selects a root node and broadcasts this selection to every sensor node. Then, every node chooses its parent bearing in mind only itself and its neighboring nodes information, hence allowing GSTEB to be a dynamic protocol. It is also shown in the paper that proposed protocol has an improved performance than other protocols in load balancing, therefore increasing network lifetime. The results in the paper prove that when the data gathered by sensors can be fused, GSTEB performs better as compared to other protocols such as LEACH, PEGASIS, TREEPSI and TBC. Since GSTEB is a self-organized protocol, it only utilizes very low amount of energy in each round to alter the topography for balancing the energy utilization. GSTEB extends network lifetime by 100% to 300% as compared to PEGASIS in case of lifetime being defined from the start of operation to the time when first node dies. When the data gathered by nodes cannot be fused, GSTEB gives a simple concept to balance the network load.

6. LIMITATIONS OF THE EARLIER WORK

The review has shown that the majority of algorithms has the following limitations.

1. **Compressive sensing:-** The use of the compressive sensing is also ignored in the GSTEB routing protocol.
2. **Reactivity:** The GSTEB is proactive protocol so the use of reactivity i.e. hard and soft thresholding to reduce the number of communications between the sink and the member nodes.
3. **Mobile sink:** The effect of the mobile sink on the GSTEB has been neglected.

7. CONCLUSION AND FUTURE SCOPE

From the survey, it has been found that GSTEB has shown quite significant results over the available WSNs protocols. But it has neglected the use of the three things like the effect of the mobile sink has also been neglected by the most of the existing researchers. The compressive sensing has also been neglected, one can offer level wise clustering to enhance the results further. Moreover the effect of the reactivity has also been neglected as the GSTEB is proactive routing protocol.

Therefore, in near future, in order to overcome the constraints of the earlier work a new improved technique can be proposed which has the ability to overcome the limitations of the GSTEB routing protocol by using the principle of reactivity, mobile sink and the lossless data compression technique.

REFERENCES

[1] Shamani, M. J., et al**. "Adaptive Energy Aware Cooperation Strategy in Heterogeneous Multi-domain Sensor Networks."** *Procedia Computer Science* 19 (2013): 1047-1052.

[2] Manzoor, Basit, et al. **"Q-LEACH: A New Routing Protocol for WSNs."** Procedia Computer Science 19 (2013): 926-931.

[3] Kumar, Dilip, Trilok C. Aseri, and R. B. Patel. **"EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks."** Computer Communications 32.4 (2009): 662-667.

[4] Han, Zhao, Jie Wu, Jie Zhang, Liefeng Liu, and Kaiyun Tian. **"A General Self-Organized Tree-Based Energy-Balance Routing Protocol for Wireless Sensor Network."**, IEEE Transaction, 1-1, 2014.

[5] Lindsey, Stephanie, and Cauligi S. Raghavendra. **"PEGASIS: Power-efficient gathering in sensor information systems."** *Aerospace conference proceedings, 2002. IEEE*. Vol. 3. IEEE, 2002.

[6] Younis, Ossama, and Sonia Fahmy. **"HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks."** *Mobile Computing, IEEE Transactions on* 3.4 (2004): 366-379.

[15] Qureshi, T. N., Nadeem Javaid, A. H. Khan, Adeel Iqbal, E. Akhtar, and M. Ishfaq. **"BEENISH: Balanced Energy Efficient Network Integrated Super Heterogeneous Protocol for Wireless Sensor Networks."** *Procedia Computer Science* 19 (2013): 920-925.

[8] Heinzelman, Wendi B., Anantha P. Chandrakasan, and Hari Balakrishnan. **"An application-specific protocol architecture for wireless microsensor networks."** *Wireless Communications, IEEE Transactions on* 1.4 (2002): 660-670.

[9] Tan, Hüseyin Özgür, and Ibrahim Körpeoğlu. **"Power efficient data gathering and aggregation in wireless sensor networks."** *ACM Sigmod Record* 32.4 (2003): 66-71.

[10] Liang, Weifa, and Yuzhen Liu. **"Online data gathering for maximizing network lifetime in sensor networks."** *Mobile Computing, IEEE Transactions on* 6.1 (2007): 2-11.

[11] Mohammad El-Basioni, B. M., Abd El-kader, S. M., Eissa, H. S., & Zahra, M. M. (2011). **An optimized energy-aware routing protocol for wireless sensor network.** Egyptian Informatics Journal, 12(2), 61-72.

