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Performance Evaluation of Energy Efficient and Scalable BeeSensor Routing Protocol of Wireless Sensor Networks

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Abstract—now days the use of wireless sensor network (WSN) is very common and it's widely used in many important day to day applications such health monitoring, disaster detection, weather forecasting etc. Wireless sensor network is group of sensor nodes which are tiny and small in size with limited battery. The basic constraints of WSNs are that it is resource limited. As battery is most vital resource for WSNs, hence it defines the overall lifetime of wireless network. To improve the WSNs lifetime, there are many methods presented over power saving based on routing protocol, MAC protocols or physical layer methods. In this paper, we are presenting and discussing once such routing based method which achieves the better energy efficiency with other routing performances. This routing protocol is named as Bee Sensor, which significantly improves performance of energy consumption and increase the network lifetime of overall WSNs. The goal of this paper is to discuss methodology of Bee Sensor, practical analysis using NS2 and future work.

Index Terms—AODV, Bee Sensor, Hop, Energy Consumption, Wireless Sensor Network, Packet Delivery Ratio.

I. INTRODUCTION

Wireless sensor network is nothing but group of number of small tiny sensor nodes. Sensor nodes are resource constrained in WSNs. The limited resources of these sensor nodes are basically battery power, memory required for data storage etc. [2]. Hence this allows researchers to work on resource constraint WSNs with goal of achieving the efficiency of using these resources. Many routing protocols are designed by different researchers with goal of achieving the better energy efficiency in WSNs. Security is also important aspect of WSNs. Therefore while providing the data security, energy consumption is required to be minimized so that network lifetime is extending. This security mechanism is efficiently presenting through the routing protocols. It means that routing protocol should provide the security while gaining goal of efficient energy consumption [3].

In addition to routing protocols, there are also other parameters which packet protocols in WSNs [4] [5], Mac scheduling such as wireless sensor networks are useful for managing significant resources. In this paper we explore and thus as overcoming the limitations of wireless sensor networks attempt: limited energy resources, energy consumption location, transmission, high cost of and limited processing capabilities vary depending upon. All of these characteristics of wireless sensor networks with their wired network counterparts are completely opposite, which energy consumption is not an issue, the transmission cost is relatively cheap, and lots of network nodes processing capabilities. Routing approach that so well as traditional network has worked for twenty years in the network will not be enough for this new generation.

Besides maximizing the lifetime of the sensor nodes, it ispreferable to distribute the energy dissipated throughout the wirelesssensor network in order to minimize maintenance and maximizeoverall system performance. Any communication protocol thatinvolves synchronization between peer nodes incurs some overhead ofsetting up the communication. So here, we attempt determinewhether the benefits of more complex routing algorithms overshadowthe extra control messages each node needs to communicate. If they complete all the network nodes network topology and power levels had full knowledge of each node in communication options make the most informed decision about can. It's really if synchronization messages are not taken into account proves to yield the best performance. Since all nodes will always need global wisdom, however, will ultimately be very expensive cost of synchronization message. Both diffusion and clustering algorithms, we gain more insight into the merits of both approaches to analyzing both realistic and optimal plans.

In this paper we are investigating the performance of recently presented efficient and scalable WSNs routing protocol called Bee Sensor. The practical evaluation of this protocol is compared against existing AODV using different network scenarios. In below sections, section II take review of different energy efficient routing protocols presented for WSNs. In section III, we will discuss the BeeSensor routing protocol, and finally in section IV practical analysis of it presented.

II. RELATED WORKS

In this section we are discussing different routing protocols presented for WSNs with main objective of energy efficiency and extending the overall network lifetime. Depending on application of WSNs, routing technique is selected. Some routing protocols are specific to applications, while some are generalized. Basically routing protocols are divided into three main categories such as location based data centric and hierarchical routing protocols. The aim of this section is to take review of different routing techniques presented so far.

2.1. Data-Centric Routing Techniques

In this category of routing protocols, the functionality of all sensor nodes is same and performing routing based on query received from base station upon event. Below listed are some well know routing protocols into this category.

2.1.1. Sensor Protocols for Information via Negotiation (SPIN)

In SPIN protocol, the nodes name their data using high level descriptors called metadata. Metadata is used to negotiate and avoid the transmission of the redundant data. The transmission of a node is based on both the application specific knowledge of the data and the knowledge of the resources available to them. This allows the sensors to use their energy and bandwidth efficiently. The classical Flooding has 3 major obstacles as shown in figure 2.1:

1. *Implosion*: A node receives multiple copies of the same data from its different copies of the neighbors, because the sender node has no way of knowing whether the receiving node has already got the information from a different neighbor.

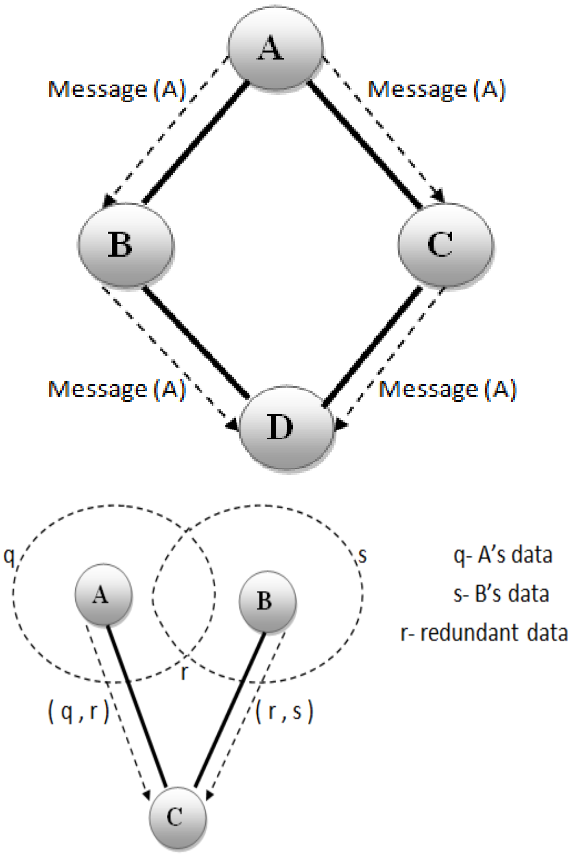

Figure 2.1: Implosion and Overlap

2. *Overlap*: Sensor nodes often cover same geographical area, and nodes gather overlapping pieces of sensed data. Since the nodes send redundant data to the same destination, bandwidth and energy are used inefficiently. Implosion is a function of only the network topology, whereas overlap is a function of both network and sensor attributes, making overlap a much harder problem than the implosion.

3. *Resource blindness*: The nodes are unaware of the status of its resources which makes them die sooner. It can be rectified by using a local resource manager at each node. SPIN families of protocols overcome these limitations by negotiation and resource adaption. Negotiation solves the implosion and overlap problem. It ensures that only relevant information will be transmitted.

In the nodes data transmission to spin his resources poll. Each sensor node keeps track of resource consumption is your resource manager. Check before transmitting the application manager or processed. This sensor back to more prudent third party data forwarded by being on the energy consumption and bandwidth usage allows to cut down. Spin complexity, in terms of energy, computing and communications to achieve high performance at low cost lives up to the promise.

2.1.2. Direct Diffusion

Direct diffusion is a data centric query based and application-aware protocol where data aggregation is carried out at each node in the network. The nodes will not advertise the sensed data until a request is made by the BS, and all the data generated by sensor node is named by attribute-value pairs. By a single or a group of nodes generated events are changes in data. Interest queries the sensor across the network as an interest for the named data are disseminated. Set up the dissemination events to draw gradients within the network. A shield in a direction to achieve an interest state that each node is created. Event within the area with multiple gradient paths return data events node BS sends thought to. Each active BS broadcast messages for interest from time to time. Initial message data to set gradients for enticing a huge gap.

All sensor nodes in a directed-diffusion-based network application-choose the best paths, which spread out empirically, and energy saving by caching and network data processing enables to achieve. Caching efficiency, robustness, and sensor nodes is a summary of the data dissemination paradigm, can increase the scalability of coordination between them.

2.1.3. Rumor Routing

Rumor routing routes the queries to the events in the network and it offers tradeoff between setup overhead and delivery reliability. An event is an abstraction obtained from a set of sensor readings that is assumed to be a localized phenomenon occurring in a fixed region in the network. A query is a request for information, sent by the base station to collect data, and once the query arrives at its destination the data can begin to flow back to the queries originator.

If a significant amount of data to be sent there, the shortest path from source to sink in to invest is advisable. There are various methods which spread, such as directed energy are disabled as they are as long as they have access to only query flooding event location are counting on. But enhanced flood approach that makes more energy efficient uses like rumor routing method. Flooding and flood routing queries event rumored information is a logical compromise. Target path leading to each event to make; while a network-wide gradient field [17] creates a flood event.

2.1.4. Active Query forwarding in sensor networks (ACQUIRE)

ACQUIRE is based on the basic principle that considers query as an active query that is routed through the network in search of solution. At each node, the query is forwarded using the information from all nodes within *d* hops, which resolves the query partially. At the node where the query gets resolved completely, a response is generated and routed back to the queried. Regular data centric protocols work in two stages: query routing and response routing. On the contrary, there are no queries-because it uses a dynamic query to acquire steps in response. I'd look forward to acquire a parameter on each node incorporates not just as active query event to get forward, it also partly on every intermediate node is resolved. An active query that may be a complex query that can consist of many subqueries each one different variable corresponds to the queried issues/interest. Until it is completely resolved query sent through a sequence of nodes. Also known as an active query, take the active node, the node is partly to resolve a query look forward (d) hops from all nodes within the update utilizes. The active node is partially active query is resolved, the It is forwarded to the next node to the active query. The next node can be selected randomly such that the query is resolved as quickly as possible based on other information intelligently chosen.

Thus, the active query gets smaller and smaller as it is forwarded through the network until eventually it reaches an active node which is able to completely resolve the query. The last active node answers the last remaining piece of the original query. At this point, the active query is transformed into the response and is routed back along either the reverse path or the shortest path to the original queried.

If intermediate node stale information about hops away d nodes, one is updated. To update a sensor for all nodes are being sent by the intermediate node hops away d is introduced by. Sensor nodes which received his information request will forward the intermediate node. Such that a given node only once every 1/is likely to occur C queries an update frequency is modelled by an average amortization factor.

Depending on the application, different types of queries used in WSN & Acquire data replicated a shot, the Protocol complex queries is well suited for. To answer a query in average latency is better than a random walk of acquire. In addition, acquire a potential flood Outlook saves energy by using.

2.1.5. Gradient based routing – Routing on finger print Gradient in sensor networks (RUGGED)

RUGGED proposes a novel method to exploit natural information gradient repository, which is a consequence of the fingerprint gradients of the events effect. It is a reactive and fully distributed routing protocol for WSN. Multiple path exploration and controlling instantiation of paths by simulated makes one protocol well suited for broad range of applications including time gradient based target tracking, event boundary detection.

2.1.6. An Energy Efficient ANT Based Routing algorithm (EEABR)

This routing protocol is based on ANT colony based routing algorithm for MANETs. By introducing energy efficiency parameter to this algorithm, it can be adopted in WSN. It is used for multi-hop ad-hoc networks and is based on swarm intelligence and on the ANT colony based meta-heuristic. These approaches try to map the solution capability of swarms to mathematical and engineering problems. This routing protocol is highly adaptive, efficient and scalable. This feature makes it adaptive to energy constraint WSN.

Heuristic Ant Colony Optimization (ACO) EEABR protocol based and focused on core WSN & constrains. To maximize the lifetime of WSN & EEABR in that way contributing to both length and are less energy efficient, The WSN & sensor nodes and looking for a destination node travel through half way through artificial uses a colony of ants. EEABR Protocol forward (FANT) in using the shortest path between the source and destination node finds and backward ants (BANT). An Ant from time to time each node to the destination node of the network to find all nodes that store visits identifiers Ant

EEABR can be easily implemented Protocol has the same destination node clustering where. But there are multiple destination nodes, each node's routing table should include the identification of all nodes. For large networks, it's because the lack of memory and computation sensor nodes can be a problem. Reduce the size of the routing tables of the EEABR enhancements significantly and as a result, memory is needed by the node. Sensors and sync nodes, not only in terms of distance, but also energy level path, in case by considering the quality of the network path between the lifetimes can be maximized.

2.2. Hierarchical Routing Techniques

Hierarchical routing is the procedure of arranging routers in a hierarchical manner. A hierarchical protocol allows an administrator to make best use of his fast powerful routers as backbone routers, and the slower, lower powered routers may be used for access purposes.

2.2.1. Low Energy Adaptive Clustering Hierarchy (LEACH)

Low Energy adaptive clustering hierarchy (LEACH) is a popular energy efficient adaptive clustering algorithm that forms node clusters based on the received signal strength. LEACH assumes that the base station is immobile and is located far from the sensors. All nodes are capable of communicating with the BS directly. At any point of time, all the nodes have data to send and nodes located close to each other have co-related data. The cluster head (CH) can perform data aggregation and data dissemination.

Leach efficiently use resources, distributing weight evenly, randomly data CH balanced energy consumption to achieve rotation only meaningful information on overall increases the lifetime of the network. Also, the sensor does not need to know the location or distance information. Depending on the applications, such as Leach-c (centralized), e Leach (enhanced) and MLEACH (multi-hop) brine can be used different variations.

2.2.2. Power Efficient Gathering in Sensor Information System (PEGASIS)

PEGASIS is a near optimal chain based protocol. The basic idea is for the nodes to communicate their sensed data to their neighbors and the randomly chosen nodes will take turns in communicating to the BS. It assumes that the BS is fixed at a far distance from the sensor nodes. The sensor nodes are homogeneous and energy constraint with uniform energy. The energy cost for transmitting a packet depends on the distance of transmission. All the nodes maintain a complete database about the location of all other nodes.

The improvement of PEGASIS, Hierarchical PEGASIS, was introduced with the objective of decreasing the delay incurred for packets during transmission to the BS. Energy balancing PEGASIS is the energy efficient chaining algorithm in which a node will consider average distance of formed chain. PEDAP, Power Efficient Data Aggregating Protocol uses spanning tree approach instead of Greedy approach to form the chain resulting in considerable savings of energy.

2.3. LOCATION BASED ROUTING TECHNIQUES

Routing algorithms based on geographical location is an important research subject in the WSN. They use location information to guide routing discovery and maintenance as well as packet forwarding, thus enabling the best routing to be selected, reducing energy consumption and optimizing the whole network.

2.3.1. Geographic Adaptive Fidelity (GAF)

GAF is a location based routing protocol for WSN. It is also an energy aware routing protocol. GAF works in such a way that, it turns off unnecessary nodes in the network without affecting the level of routing fidelity, this conserves energy. A virtual grid for the area that is to be covered is formed. The cost of packet routing is considered equivalent for nodes associated with the same point on the virtual grid. Such equivalence is exploited in keeping some nodes located in a particular grid area in sleeping state in order to save energy. By doing this the network lifetime is increased as the number of nodes increases. There are three States in this Protocol and they are searching to determine the grid, active in neighboring States when the radio has been turned off are participating in routing nodes and sleeping that. When the state changes from active to so load balanced nodes is changed. GAF by its virtual network, a representative node always activated for each area on the grid node is connected. Although the GAF is a location based protocols in a hierarchical Protocol, where clusters are based on the geographic location could be regarded as.

III. METHODOLOGY INVESTIGATED

In this section we discuss about proposed BeeSensor algorithm which were presented to overcome the limitations of existing routing schemes in WSNs with goal of improving energy efficiency.

3.1 Working Procedure

As mentioned in [1], BeeSensor is nothing but reactive, on demand multipath routing protocol with event driven functionality. There are four main phases of BeeSensor routing protocol such as scouting, foraging, swarming, routing loops and path maintenance. Below is short description of each of these phases as described in [1]?

3.1.1. Scouting

This phase is divided into two steps such as forward scouting and backward scouting. Forward scouting is initiated when a path to asink node is not available. Forward scouts explore the network and look for a potential sink node. Once a sink node is found,the backward scouts establish multiple paths between the <source, sink> pair.

3.1.2. Foraging

Once discovered a way to sink the events node foragers transport. During the discovery process in which the source node path generated events, are a small store retains the event cache. A Packer then selects a forager stochastically and in the event it encapsulates. Stochastic selection based on probability distribution table. We maintain a window of m events and different paths around the Sigma values using distributed. If path 1, 2 and 3 Sigma is p1, p2 and p3, for example respectively = (p1 + p2 + p3 where = 1), each number of packets sent along the path p1, p2 and M _ _ _ p3, respectively. Path ID of the next hop in the end Forager is forwarded to use.

3.1.3. Swarming

The foragers should have a return path to get back to the source node from the sink node. Otherwise, the source node runsout of foragers and subsequently loses any path to the destination. A swarm encapsulates allforagers belonging to its own group – foragers with identical path-IDs – in its payload. The swarm is then routed towards thesource node using the reverse link entries (previous hop) in the forwarding tables. In addition to this, a swarm does notadvertise a path if its minimum remaining energy level is below a certain threshold, say Eth, provided that better qualitypaths are available. Consequently, the poor-quality paths are gradually removed from the routing tables [1].

3.1.4. Routing loops and path maintenance

Routing loops: The reward function in BeeSensor is designed to provide loop freedom in the discovered routes. Since backward scouts follow the maximum-reward paths, they keep moving inthe direction of the source node, reducing the probability of selecting a node which is at a larger distance than the currentone (see (1)). Therefore, if a backward scout visits a node for the second time, it is dropped by the node and the corresponding entry isflushed. In this way, we ensure that the discovered paths are loop-free.

Path maintenance: Another important feature of BeeSensor is that, like BeeAd-Hoc protocol, it does not use explicit HELLO or route error(RERR) messages to check the validity of the routes. Swarming is a simple but elegant way of doing path maintenance. A pathat a source node remains valid if it has foragers for it

IV. PRACTICAL RESULTS AND ANALYSIS

4.1 Simulation Platform:

For the simulation of this work we need the following requirements:

1) Cygwin: for the windows XP
2) Ns-allinone-2.32.

4.2 Network Scenarios: For WSNs, there are multiple network scenarios needs to be prepared in to order to evaluate the performance of packet scheduling methods. In our practical analysis we are varying two main parameters such as number of sensor nodes and another one is number of source and destination pairs which we called as traffic flows.

Mac protocol: 802.11
Scenarios-1:49/61/81/100/121/144 Sensor nodes
Scenarios-2: 49/100/150/196/256 Sensor nodes
Routing Protocols: AODV/BeeSensor
Packet Scheduler: FCFS

4.3 Performance Metrics:

- PDR vs. number of sensor nodes
- Latency vs. number of sensor nodes
- Control overhead vs. number of sensor nodes
- Energy Efficiency vs. number of sensor nodes

Below table 1 showing the all network configurations and parameters for network scenario 1 [converge cast scenario] and table 2 shows the network configuration for network scenario 2 [target tracking application of WSNs].

Table 1: Network configuration for scenario 1

Number of Nodes	49/61/81/100/121/144
Traffic Patterns	CBR (Constant Bit Rate)
Network Size (X Y)	1000 x 1000
Max Speed	5 m/s
Simulation Time	100s
Transmission Packet Rate Time	10 m/s
Pause Time	1.0s
Routing Protocol	AODV/Bee Sensor

MAC Protocol	802.11
Packet Scheduler	FCFS
Number of Flows	5

Table 2: Network configuration for scenario 2

Number of Nodes	49/100/150/196/256
Traffic Patterns	CBR (Constant Bit Rate)
Network Size (X Y)	1000 x 1000
Max Speed	5 m/s
Simulation Time	100s
Transmission Packet Rate Time	10 m/s
Pause Time	1.0s
Routing Protocol	AODV/BeeSensor
MAC Protocol	802.11
Packet Scheduler	FCFS
Number of Flows	5

4.4 Results Analysis

Scenario 1: converge cast scenario

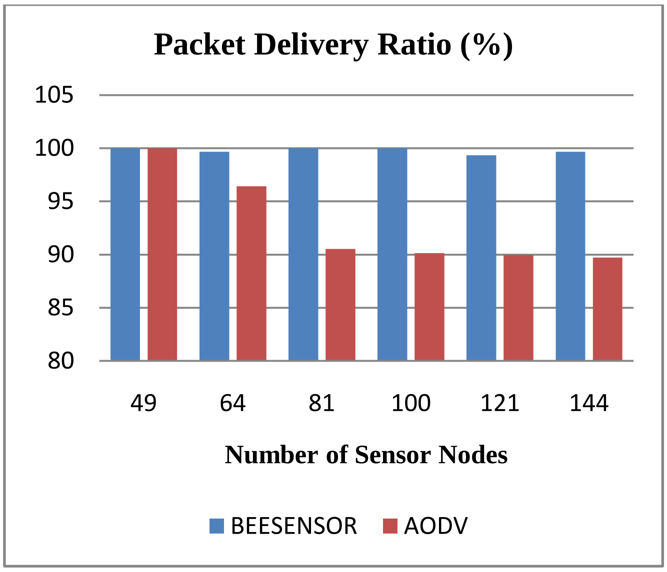

Figure 4.1: Packet Delivery Ratio

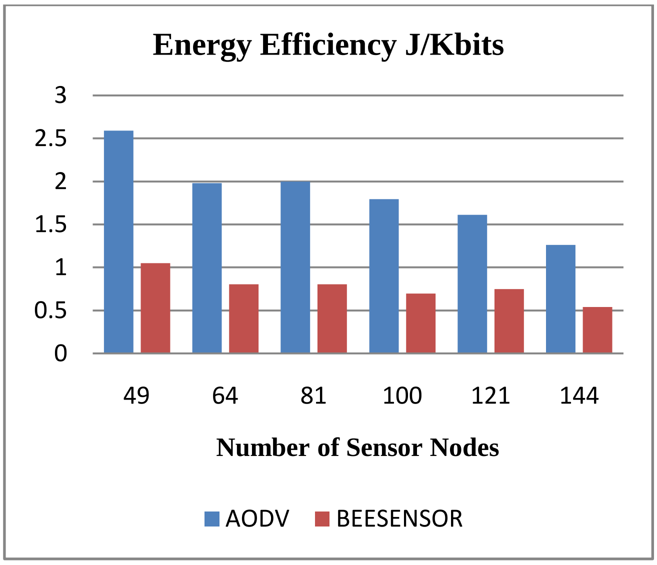

Figure 4.2: Energy Efficiency

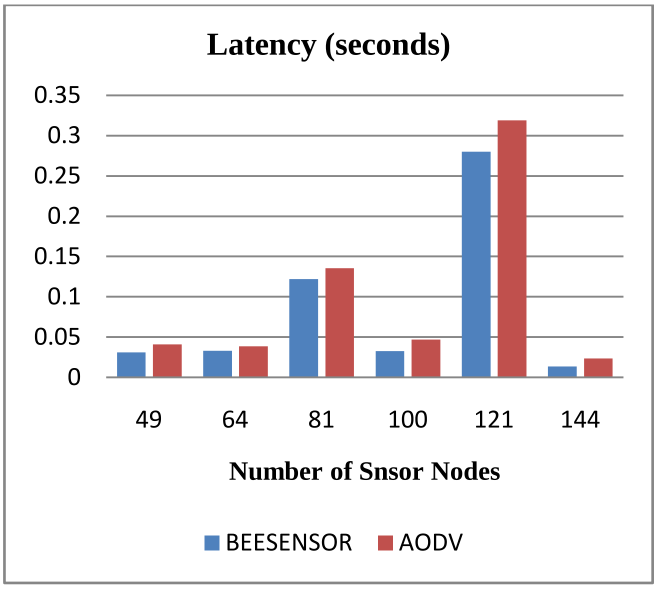

Figure 4.3: Latency

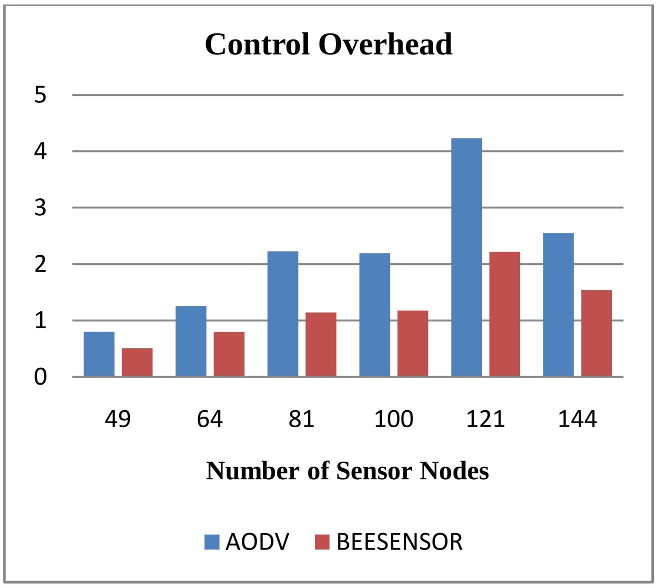

Figure 4.4: Control Overhead

Scenario 2: target tracking application of WSNs

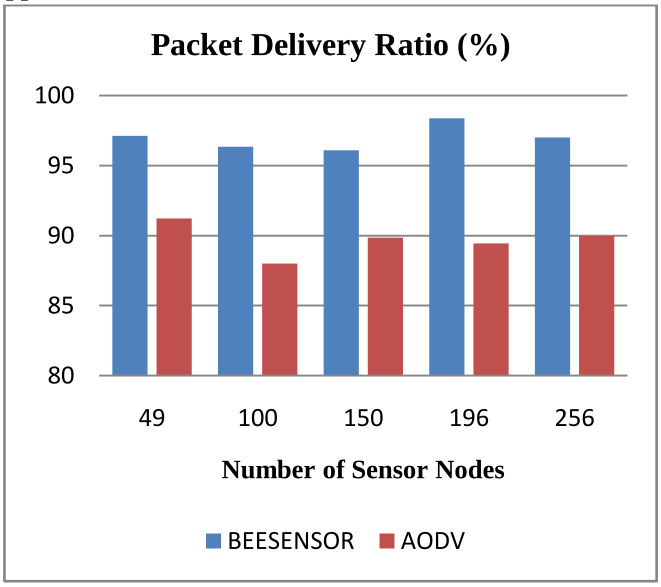

Figure 4.5: Packet Delivery Ratio

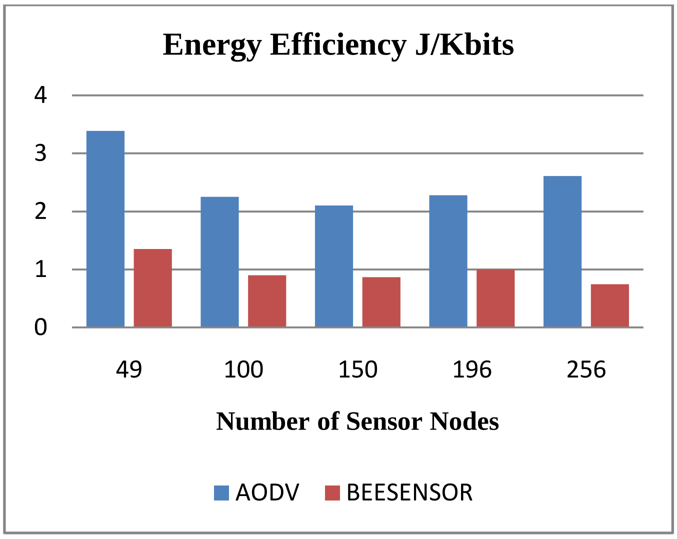

Figure 4.6: Energy Efficiency

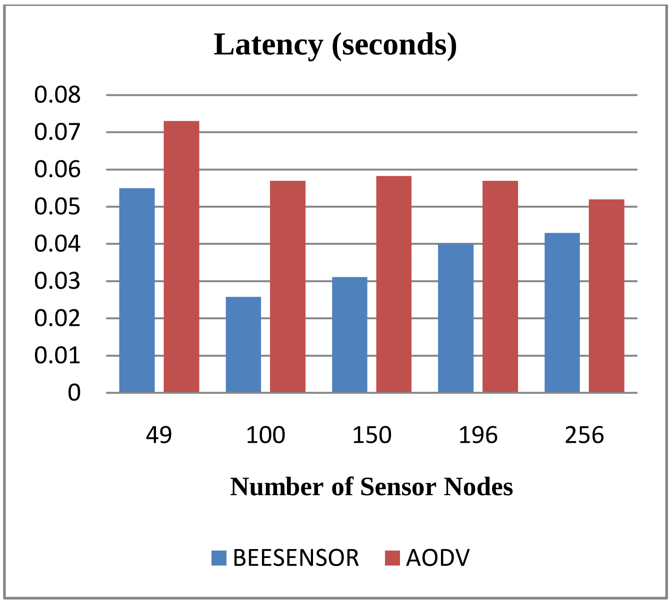

Figure 4.7: Latency

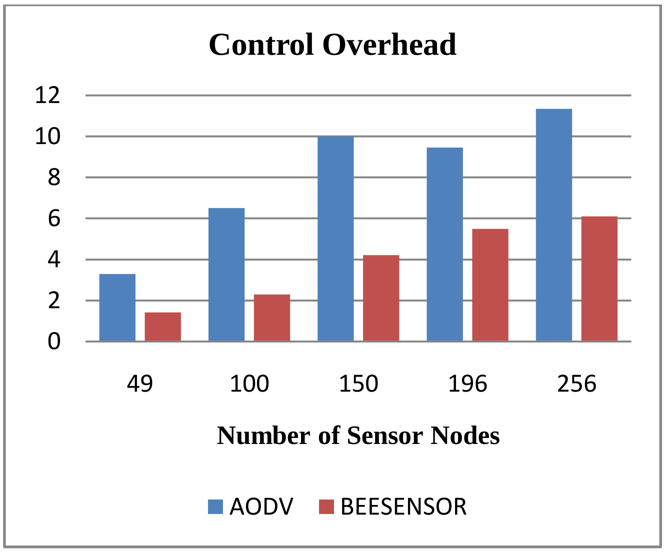

Figure 4.8: Control Overhead

From above practical analysis, it is clear that proposed BeeSensor protocol outperforming existing AODV in packet delivery ratio, control overhead, latency and most importantly energy efficiency.

V. CONCLUSION AND FUTURE WORK

The main aim of this paper is to investigate the performance of recently presented efficient and scalable BeeSensor wireless sensor network routing protocol with different network conditions. The performance showing improved results as compared to existing methods.Future work will be targeted to work on stationary as well as mobile WSNs applications.

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