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Robot Repair Algorithm for Automatic Hole Detection and Coverage in Wireless Sensor Networks

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Abstract: The emerging recent technology of Wireless Sensor Network (WSN) is projected to offer a wide range of real-time applications such as battle field surveillance in military, environmental condition monitoring, security system, smart spaces and so on. In this scenario one of the main problems is coverage area of the network. Many researches are focusing on hole detection and healing in coverage area of WSN. This study also indent to deal with the effort of hole detection and healing in such kind of environments. The proposed approach requires no location information and works even for dense networks. This proposed algorithm is called robot repair algorithm for automatic hole detection and healing. It is a modified method for hole detection and healing that might eliminate the drawbacks of the existing algorithms. There are three phases involved in this method, namely information collection phase where each node exchanges information to build a list of x-hop neighbors, path construction phase where communication links between sensor nodes in the list of x-hop neighbors are identified and finally path checking phase where paths are examined to infer boundary and inner nodes. Unlike the existing algorithms, the proposed method uses the same algorithm for both hole detection and healing which provides better efficiency, high packet delivery ratio, improved network life time, reduced delay and throughput. Hole attacks in WSN environments are also highlighted.

Key words: Wireless sensor networks, hole detection, healing, coverage area, robot repair algorithm

INTRODUCTION

The wireless sensor network has developed by the recent year advancements in electronics and wireless communication. A capability for battle field monitoring and environment deploys large number of sensor nodes and this potential is possessed by the WSN. A typical sensor node includes sensing, processing, communication, storage and power units (Senouci *et al*., 2014; Yu *et al*., 2013; Fang *et al*., 2006). The sensor nodes measures several physical quantities, possible process the measurement in a collaborative manner and the results are routed the sink node. A fundamental issue in WSN is the coverage problem because it is directly related to optimization of resources in the field. The problem of coverage is divided into three categories namely, coverage occurring due to area, barrier and target. Sufficient covering the whole sensor field is the objective of area coverage. The objective of target coverage is the way of setting target that are discrete with known locations. Detection of intruders attempting to cross the network is the aim of barrier coverage (Ghosh and Das, 2008; Wang, 2011).

Node failure occurs due to energy depletion or damage which is physical, after deploying a sensor network. The formation of coverage holes deteriorates the quality by the network structure changes and those changes denoted by path that are preach and routes of communication. The coverage holes may affect the network connectivity and may result in losing the sensed data (Yan *et al*., 2003; Wang and Wang, 2005). So, it is necessary to determine the number and size of network holes and fill them with other redundant nodes to keep the desired coverage. In this paper, we first propose level set-based coverage holes detection algorithm. This algorithm could estimate not only the number of holes but also the size of holes. After deciding the existence of the coverage holes and their size, the base station awakens the mobile nodes and arranges them to move to the appropriate locations to heal the network. A robot repair algorithm-based holes healing algorithm is proposed.

Literature review: Hole detection and healing is a solution which is a very comprehensive and has low complexity and is used to avoid some drawbacks. Local healing approach based on distributed virtual forces will make the healing area of the hole very effective (Wang and Wang, 2005). The evaluation of heal design is a locally distributed and comprehensive two phase protocol

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that will enhance the coverage area in mobile WSN. Hole and border detection algorithm is more suited to the energy containment of WSN and is distributed locally and light weighted. The various researchers have given a lot of techniques which are time-consuming and the coverage and connectivity of each node to the neighboring node is not checked effectively (Ahmed *et al*., 2005; Chang *et al*., 2013; Sharma *et al*., 2011; Wenqing *et al*., 2006; Kulothungan *et al*., 2012; Ren *et al*., 2011). Tseng *et al*. (2012) presented the K-Angle object coverage method. In this proposed technique two different contribution functions are defined.

The first fixes sensors providing addition of overall contribution where is the second one fixes sensors that adds covered angle. This proposed technique has advantages of high feasibility and can freely rotate to any direction to cover a particular angle. But, the limitation of this method is that each sensor can only cover a limited angle and range. Salehi and Jadbabaie (2010) presented the distributed coverage algorithm. In this technique, three distributed algorithms for coverage verification in sensor networks have no location information and also they detect the redundancies in the network. But, this algorithm is more complex because each problem uses three different methods. Ram *et al*. (2007) presented the path coverage algorithm. In this proposed technique, the network coverage of two-dimensional areas is analyzed. This is one of the simplest methods. The limitation of this method is that it is not clear to analyze if this result carries over to k>1. Gupta *et al*. (2006) presented the self-organization techniques. This proposed technique is analyzes the algorithms for self-organization of a sensor network to reduce energy consumption. The main advantages of this method is power saving of nodes. But, this method does not provide any guarantee on the size of the connected sensor. Ammari and Das (2012) presented the centralized and cluster k-coverage protocols. This proposed method analyzes the problem of k-coverage such that in each scheduling round, every location in a monitored field is covered while active sensors are connected. This is one of the efficient methods, but needs more mathematical knowledge for analysis.

Khedo *et al*. (2010) presented a aggregate novel data deserved as Redundancy Elimination for Accurate Data Aggregation (READA). This technique applies compression and mechanism of grouping to move the data that is duplicate in the aggregated data set. This data is then sent to the base station without any loss in the final aggregated data's accuracy. This proposed method has high efficiency and high accuracy. But, the demerits of this method are that the data sensed exhibits in high correlation and some sensor nodes are deficient in memory capacity. Yangy *et al*. (2007) proposed a scan based movement assisted method of sensor deployment in WSNS .Sensors move around to self delay in a locomotive network. The sensor deals with moving from unbalanced to balanced state in the movement assist sensors. The scan based sensor method deploys dimension and scan exchange to achieve a state that is balanced. But this method has low resolution and more energy consumption. Wang *et al*. (2005) presented the efficient deployment algorithm for ensuring coverage and connectivity of WSNs. This research deals with field sensing especially arbitrary shaped region with obstacles. The constraints of the existing results are eliminated besides the relationship between communication and sensing ranges. This method has full cover area of networks. But, this method is fragile. Yan *et al*. (2014) presented the accuracy of homology-based coverage hole detection for WSN on sphere. This method investigates hole detection on sphere. When rips complex may miss coverage, hole is identified in this case. Then, we choose the proportion of the area of coverage holes missed to evaluate the accuracy. This proposed technique has high accuracy. But, the limitation is the radius of the sphere has little impact on accuracy. Neethu Ann and Manjor presented the hole detection and energy efficient hole healing for WSN. In this method light weight solution which is comprehensive and energy efficient is addressed the elements that are mentioned for effective coverage. First is the hole detection and second is healing of holes as per the residual energy that has remained. This method has advantages of high packet delivery rate and less packet drop ratio. But, this approach cannot be used in for large holes.

To reduce the limitation of the above existing methods and overcome their limitations, in this paper we propose the Robot repair algorithm. The obtained results are compared with the existing methods.

Problem definiton and objectives: An area where a group of sensor nodes stops working and does not take part in data sensing and communication is termed as a hole in the network. Holes are the barriers for communication. Holes have a huge impact on the performance of the network. Hole detection identifies damaged, attacked or inaccessible nodes. If a hole is in the network detection, then the data along the node boundaries will be repeated routed leading to premature exhaustion of energy present at the nodes. This will ultimately increase the size of the hole in the network. Detection of holes avoids the additional energy consumption around holes because of congestion. It assures long network life and adequate

quality of service. One of the most prominent problems in wireless sensor networks is detection of network boundary, that is, the nodes that are present on the boundary of the network and hole boundary. The main objectives of the proposed method are:

- To detect the fault/attack using robot
- To identify the exact sensor location and target
- To reduce the battery usage for each sensor node
- To minimize the energy consumption for overall network process

MATERIALS AND METHODS

The proposed design

System architecture: Figure 1 shows the abnormalities that occur in WSN's that lead to function impairments. The following three phases are involved in the proposed method. They are:

- Information collection phase where each node exchanges information to build a list of x-hop neighbour
- Network path construction phase where communication links between sensor nodes in list of x-hop neighbours are identified
- Path checking phase where paths are examined to infer boundary and infer nodes

Robot repair algorithm: The various modules created are as follows:

- Sensor nodes deployment and creation of sink nodes
- Coverage and connectivity between nodes
- Greedy multi-hop forwarding
- Network partition occurrence
- Mobile robot navigation

The following procedure are followed to implement the proposed method.

Sensor node deployment and creation of sink nodes Sensor nodes are created and deployed in the network with the help of ns2 and sink node with higher efficiency. Here, the sensor nodes are deployed in the coverage area of the wireless sensor networks of dimension 1000 X 1000 whereby the number of sensor nodes used is 58 and the address used is IEEE 802.11. The communication coverage in the network is 1000 m and the simulation time is 48 sec with the transmitted data size is 1024 kb along with the packet delivery rate in kb.

Coverage and connectivity between nodes: This is an approach that is possibility deterministic for recognition of boundary which does not rely on a uniformly distributed node but requires high density of nodes. A mechanism called DHD, is proposed to discover the boundary nodes and holes. A frame work is used for self organizing for determination of boundary nodes and network topology based on topological consideration. Thus, the network coverage and the connectivity between nodes are done.

Greedy multi-hop forwarding: The proposed technique is a boundary detection algorithm that assumes geographic information of two hop neighbors. New hole discovery

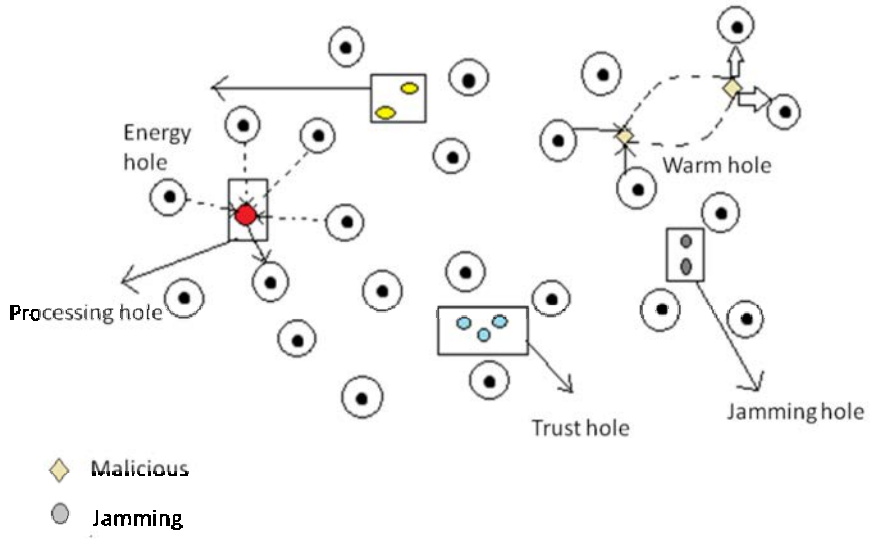

Fig. 1: The proposed method system architecture scenario

packet is created by the stick nodes with its ID. The mission is collection of information. Thus, this identifies the hole.

Occurrence of network partition: The network architecture compares the sensor node energy. The WSN gets partitioned or isolated when energy depletion occurs. The partitioning of network can be formulated by assigning varied nodal energy and creating data simulation by aggregation. The give tree topology can be partitioned by defining the loss of energy for each transmission activity.

Mobile Robot navigation (MR): Acquiring information by communicating with the sink by including the time and location of Nd and Nnd in the requirement of MR. .The MR collects the sensed data and control packets during the phase of collection from the sinks. Stacking the information of Nd and Nnd the control packets must me collected and updated. During this phase next sensor node computation will be done by MR.

RESULTS AND DISCUSSION

Unlike, the existing algorithms, the proposed method uses the same algorithm for both hole detection and healing which provides better results. In this proposed method, implement Robot detection algorithm is implemented for continuous transmission to the neighbor node in the different paths. Each and every node checks coverage and connectivity mean distance between the nodes and uses the same frequency match for available neighboring nodes. There are many holes like coverage, worm hole, trust hole, block data hole and multiple processing at the same time. The hole is an attack involved in transmission from the sender node to the receiver node to heal those attacks. Robot detection technique moves frequently in entire network to detect automatically any holes occurring in the process. Minimum numbers of techniques are used to detect the holes. Less time is taken for processing and check each node coverage and connectivity to the neighbor nodes. The proposed Robot repair algorithm is compared with the existing algorithms such as redundant elimination algorithm, scan-based deployment algorithm, coverage and connectivity algorithm, vector-based coverage algorithm and hole repair algorithm and the comparative analysis is given.

The performance of proposed method is analyzed by the following parameters with the existing different algorithms, hole attack rate energy consumption. Throughput efficiency packet delivery ratio network lifetime and time delay. The obtained results are given in Fig 2-8. It is clearly proved that the proposed method gives better results in all aspects.

Figure 2 shows the minimized rate of hole attack when compared with the other existing algorithms and the reduced way of the hole attacks in the network. The above graph shows the improved throughput when compared with the other existing algorithms and the improvement in the efficiency of throughput in the network.

Figure 2 shows the better packet delivery when compared with the other existing algorithms and the improvement in the packet delivery ratio in the network. The time delay factor is compared with the other algorithms and here it shows an improved performance in the time delay. From Fig. 2 indicates less energy consumption when compared with the other existing algorithms.

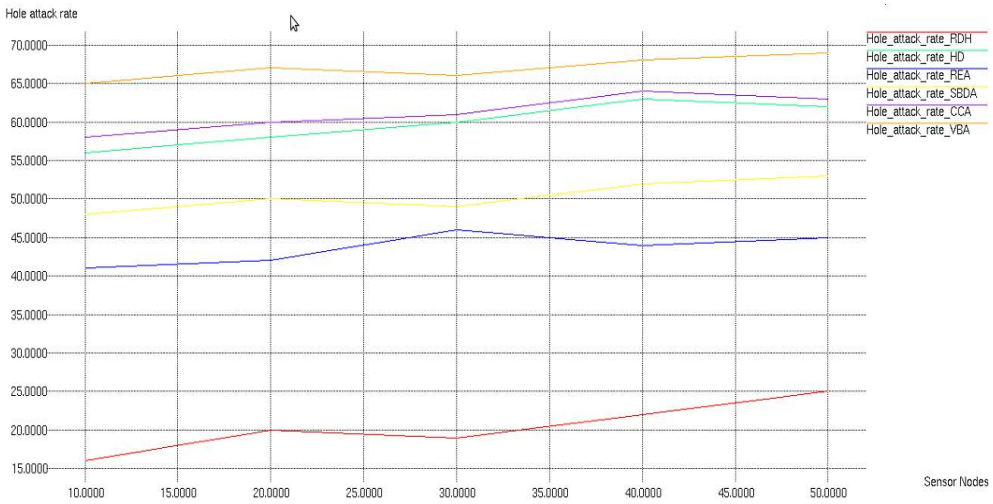

Fig. 2: Hole attack comparison of different algorithms

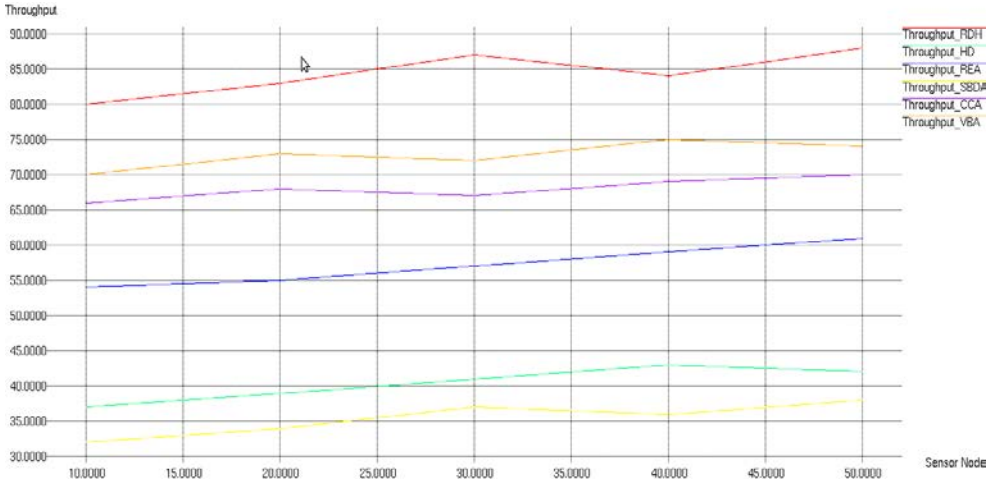

Fig. 3: Throughput comparison of different algorithms

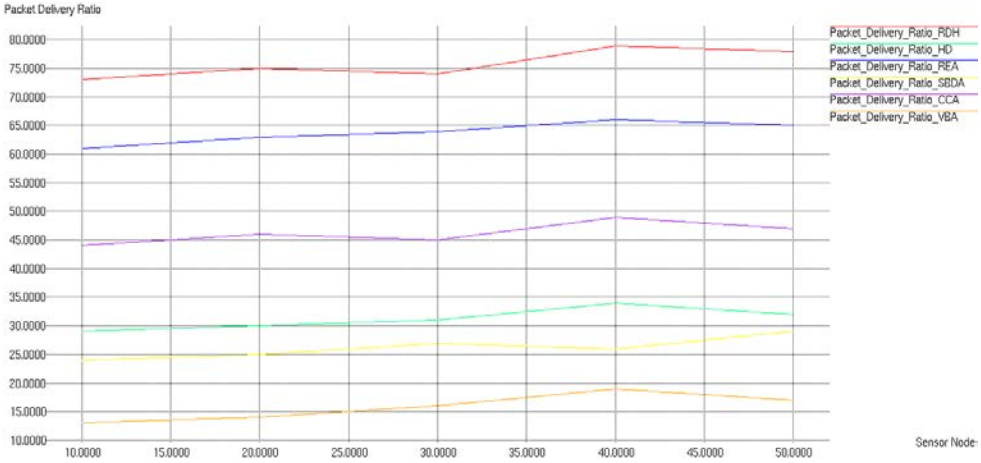

Fig. 4: Packet delivery ratio

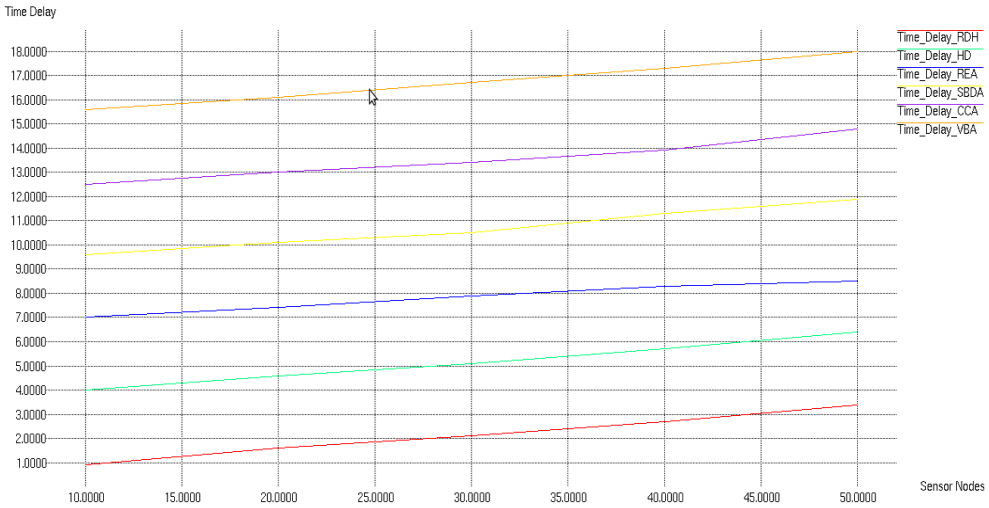

Fig. 5: Time delay comparison

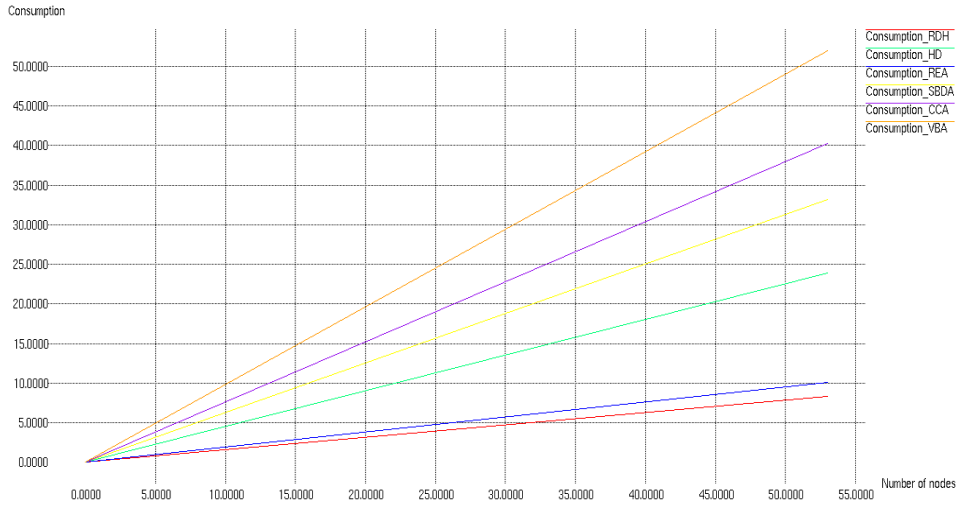

Fig 6: Energy consumption of different methods

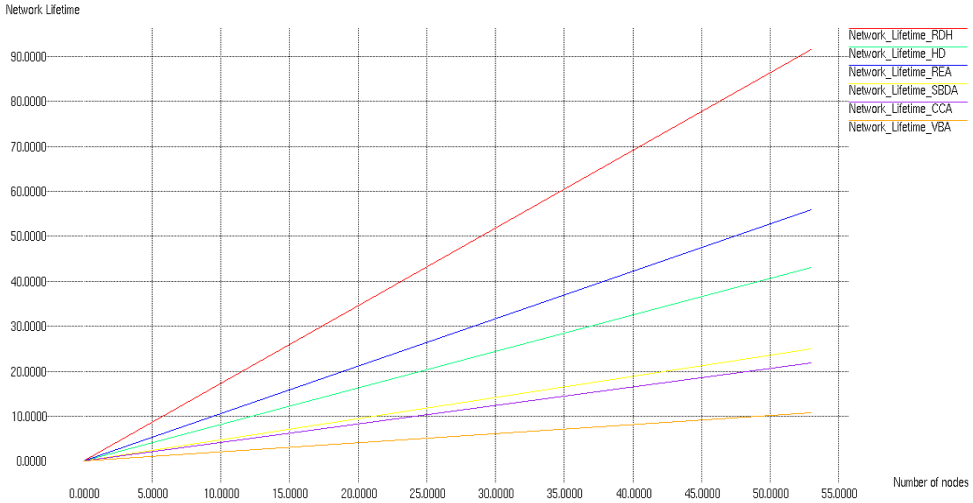

Fig. 7: Network life time

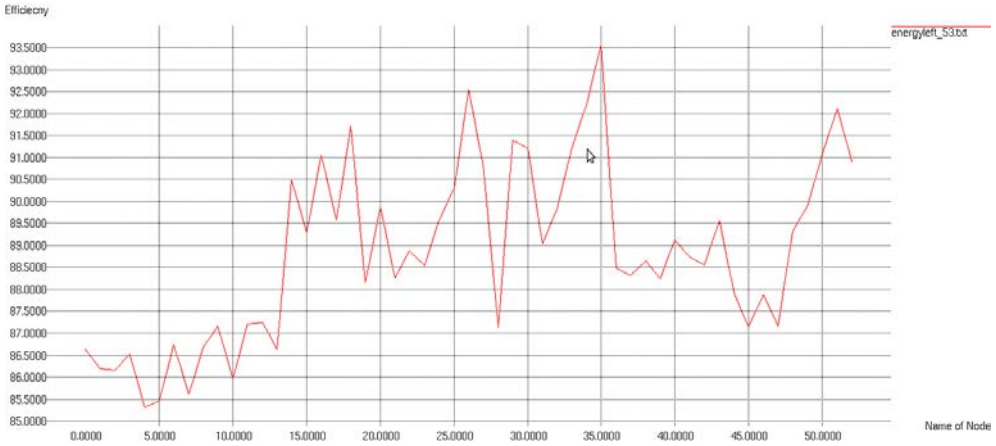

Fig. 8: Efficiency of the proposed method

Table 1: Parameter comparison

Parameters considered	Proposed method RDH	Existing method HD	SBDA	REA	CCA	VBA
Hole attack rate (in percentage)	15	25	40	40	40	50
Energy consumption (in percentage)	55	60	65	65	65	70
Over head (in percentage)	20	40	60	60	60	60
Efficiency (in percentage)	90	85	80	75	75	70
Packet delivery ratio (in percentage)	95	90	80	70	70	60
Power management	Maximum	Maximum	Limited	Limited	Limited	Not Supported
Mobility	Fixed base station	Fixed base station	Fixed base station	Limited	Limited	Limited
Delay (sec)	0.10	0.55	0.60	0.65	0.60	0.65
Network lifetime	Very good	Good	Less	Less	Less	Less

The proposed algorithm enhances network lifetime and the above graph reveals this. The overall energy efficiency of the proposed method shows the betterment with regard to the increase in the number of nodes and the consistency of giving average better and efficient way of energy utilization. The parameter comparison of different methods is tabulated in Table 1.

CONCLUSION

The robot detection technique is moved frequently in the entire network to detect automatically any holes that occurred in the process and to make automatic coverage in the network. The same algorithm is used for both hole detection and healing. It is used to prevent the nodes from attack and provide the secure data transmission over the entire networks. The obtained results proved that the proposed method takes less time for processing and check each node coverage and connectivity to the neighbor nodes. Our relocation algorithm is completely distributed and it is based on the concept of virtual forces. We are of the view that robot detection technique proposed by us may be used in future along with intelligent algorithms to improve and strengthen the network in real-time applications.

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