"A Review on Power Efficient Energy-Aware Routing Protocol for Wireless Sensor Networks"

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Abstract

The most important issue that must be solved in designing a data transmission algorithm for wireless sensor networks (WSNs) is how to save sensor node energy while meeting the needs of applications/users as the sensor nodes are battery limited. While satisfying the energy saving requirement, it is also necessary to achieve the quality of service. In case of emergency work, it is necessary to deliver the data on time. Achieving quality of service in WSNs is also important. In order to achieve this requirement, Power-efficient Energy-Aware routing protocol for wireless sensor networks is proposed that saves the energy by efficiently selecting the energy efficient path in the routing process. When source finds route to destination, it calculates α for each route. The value α is based on largest minimum residual energy of the path and hop count of the path. If a route has higher α, then that path is selected for routing the data. The value of α will be higher, if the largest of minimum residual energy of the path is higher and the number of hop count is lower. Once the path is selected, data is transferred along the path. In order to increase the energy efficiency further transmission power of the nodes is also adjusted based on the location of their neighbor. If the neighbors of a node are closely located to that node, then transmission range of the node is decreased. Therefore it is enough for the node to have the transmission power to reach the neighbor within that range. As a result transmission power of the node is reduce which subsequently reduces the energy consumption of the node. Our proposed work is simulated through Network Simulator (NS-2). Existing AODV and Man-Min energy routing protocol also simulated through NS-2 for performance comparison. Packet Delivery Ratio, Energy Consumption and end-to-end delay

(Quality of Service metric) are chosen as performance metrics. Performance of the proposed protocol is compared with the existing AODV and Max-Min energy routing protocol by based on the metrics. Our proposed protocol provides lower energy consumption than AODV and lower delay than the Max-Min energy routing protocol. Thus, our proposed routing protocol saves the energy and also achieves the good quality of service by providing lower delay for data transfer.

Keywords: Power-efficient Energy-Aware routing protocol, AODV, Max-Min energy routing protocol, the largest of minimum residual energy, hop count, Packet Delivery Ratio, Energy Consumption, end-to-end delay.

"1.Introduction"

A wireless sensor network consists of light-weight, low power, small size of sensor nodes. The areas of applications of sensor networks vary from military, civil, healthcare, and environmental to commercial. Examples of application include forest fire detection, inventory control, energy management, surveillance and reconnaissance, and so on. Due to the low-cost of these nodes, the deployment can be in order of magnitude of thousands to million nodes. The nodes can be deployed either in random fashion or a pre-engineered way. The sensor nodes perform desired measurements, process the measured data and transmit it to a base station, commonly referred to as the sink node, over a wireless channel. The base station collects data from all the nodes, and analyzes this data to draw conclusions about the activity in the area of interest. Sinks can act as gateways to other networks, as a powerful data processor or as access points for human interface. They are often used to disseminate control information or to extract data from the network. Nodes in sensor networks have restricted storage, computational and energy resources; these restrictions place a limit on the types of deployable routing mechanisms. Additionally, ad hoc routing protocols, for conventional wireless networks support IP style addressing of sources and destinations. They also use intermediate nodes to support end-to-end communication between arbitrary nodes in the network. It is possible for any-to-any communication to be relevant in a sensor network; however this approach may be unsuitable as it could generate unwanted traffic in the network, thus resulting in extra usage of already limited node resources. Many to-one communication paradigms is widely used in regard to sensor networks since sensor nodes send their data to a common sink for processing. This many-to-one paradigm also results in non-uniform energy drainage in the network. Sensor networks can be divided in two classes as event driven and continuous dissemination networks according to the periodicity of communication. Routing protocols are usually implemented to support one class of network, in order to increase energy savings. In continuous dissemination networks, routes will be periodically reconstructed, while in event-driven networks routes will be constructed only when an events occurs, since the cost of constant updates is prohibitive in this scenario.

However, sensor nodes are constrained in energy supply and bandwidth. Such constraints combined with a typical deployment of large number of sensor nodes have necessitated energy-awareness at the layers of networking protocol stack including network layer. Routing of sensor data has been one of the challenging areas in wireless sensor network research. Current research on routing in wireless sensor networks mostly focused on protocols that are energy aware to maximize the lifetime of the network, scalable for large number of sensor nodes and tolerant to sensor damage and battery exhaustion. Since the data they deal with is not in large amounts and flow in low rates to the sink, the concepts of latency, throughput and delay were not primary concerns in most of the published work on sensor networks. However, the introduction of imaging sensors has posed additional challenges for routing in sensor networks. Transmission of imaging data requires careful handling in order to ensure that end-to-end delay is within acceptable range. Such performance metrics are usually referred to as quality of service (QoS) of the communication network. Therefore, collecting sensed imaging data requires both energy and QoS aware routing in order to ensure efficient usage of the sensors and effective access to the gathered measurement. QoS protocols in sensor networks have several applications including real time target tracking in battle environments, emergent event triggering in monitoring applications etc.

In this study, Power efficient Energy-Aware Routing Protocol for WSN, which is based upon the on-demand ad hoc routing protocol AODV which determines a proper path with consideration of node residual battery powers. The proposed protocol aims to extend the life time of the overall sensor network by avoiding the unbalanced exhaustion of node battery powers as traffic congestion occurs on specific nodes participating in data transfer. The remainder of the paper is organized as follow. Section II deals with related work done on the area of wireless sensor networks in routing. It discusses the various types of routing and the core idea of each kind. Section III discusses the proposed methodology, its architecture, block diagram and description of each module to be implemented in the simulation. Section IV performance of the result comparison of three protocols and analyses the performance of proposed protocol against the existing AODV and Max_Min energy protocol. Section V provides the conclusion of the work and future scope.

"2. Related Work"

2.1 Literature Survey

There are four main categories of routing protocols in WSN. They are data-centric, hierarchical, location-based [5] and multipath:

In data-centric routing, the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute based naming is necessary to specify the properties of data. Five of the main algorithms are SPIN [27] (meta-data negotiation solves the classic problems of flooding such as redundant information passing, overlapping of sensing areas and resource blindness thus, achieving a lot of energy efficiency), Directed Diffusion [25] [28] (each node disseminate the date interest in receive), Rumor routing is another variation of Directed Diffusion and is mainly intended for contexts in which geographic routing criteria are not applicable. Gradient-Based Routing (The difference between a node's height and that of its neighbor is considered the gradient on that link. A packet is forwarded on a link with the largest gradient [14]) and constrained anisotropic diffusion routing (CADR) is a protocol [19], which strives to be a general form of Directed Diffusion. Hierarchical algorithms separate the node in sub-regions called cluster in order to segregate the areas of monitoring environment as LEACH, PEGASIS & Hierarchical PEGASIS [16] and TEEN & APTEEN [15]. The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. Cluster formation is typically based on the energy reserve of sensors and sensor's proximity to the cluster head [18] [19]. Location-Based algorithms (i.e. MECN & SMECN [29] and GAF [18]) rely on the use of routing protocols for sensor networks require location information for sensor nodes. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Since, there is no addressing scheme for sensor networks like IP-addresses and they are spatially deployed on a region, location information can be utilized in routing data in an energy efficient way. Finally, Multipath algorithms uses of multipath routing protocols are based on classic on-demand single path routing methods, such as AODV and DSR. They differ from each other on how to forward multiple route requests and how to select multiple routes. In some papers, node energy is also taken into account when constructing multiple paths [2] (i.e. EECA [2]).

A. Akhtar et. al. [1] has presented "Energy Aware Intra Cluster Routing for Wireless Sensor Networks", in 2010. In this research work, authors proposed a new technique for intra cluster routing which is more energy efficient than a well known routing protocol *Multihop Router* that performs multihop routing. They proved their idea by simulating a network of 30 nodes in TOSSIM. While justifying the idea through results of the simulation had been considered the parameters that include: number of packets sent in the network, energy consumed by the network, remaining energy level of nodes at specific time and network lifetime of the network. By using proposed technique shows that they had increased the network lifetime and number of packet sent in the network.

Zijian Wang et. al. [2] has presented "Energy Efficient Collision Aware Multipath Routing for Wireless Sensor Networks", in 2009. They proposed an energy efficient and collision aware (EECA) node-disjoint multipath routing algorithm. The main idea of EECA is to use the broadcast nature of wireless communication to avoid collisions between two discovered routes without extra overhead. Additionally, EECA restricts the route discovery flooding and adjusts node transmit power with the aid of node position information, resulting in energy efficiency and good performance of communication. They used NS-2.33 simulator to evaluate the proposed scheme in terms of the average packet delivery ratio, the average end-to-end delay, the average residual energy and the number of nodes alive. Their preliminary simulation results show that ECCA algorithm results in good overall performance, saving energy and transferring data efficiently.

Ming Liu et. al. [3] has presented "An Energy-Aware Routing Protocol in Wireless Sensor Networks", in 2009. The authors present EAP, a novel energy efficient data gathering protocol with intra-cluster coverage. EAP clusters sensor nodes into groups and builds routing tree among cluster heads for energy saving communication. In addition, EAP(Energy Aware Routing Protocol) introduces the idea of area coverage to reduce the number of working nodes within cluster in order to prolong network lifetime. Simulation results show EAP outperforms far better than LEACH. Compared to HEED, though EAP performs almost the same as HEED when node density is low, it has far better performance than HEED when node density goes higher than 0.01nodes/m2.

Lu Su et. al. [4] has presemted "Routing in Intermittently Connected Sensor Networks", in 2009. Identify the challenges of routing in intermittently connected sensor networks and proposed an on demand minimum latency routing algorithm(ODML) to find minimum latency (ODML) to find minimum latency routes. They proposed two proactive minimum latency routing algorithms:optimal PML and quick—PML. The schemes proposed in this paper can provide generic routing functionalities for most of the existing scheduling schemes.

K. Akkaya et. al. [5] has presented "A survey on routing protocols for wireless sensor networks", in 2005. This paper surveys recent routing protocols for sensor networks and presents a classification for the various approaches pursued. The three main categories explored in this paper are data-centric, hierarchical and location-based. Each routing protocol is described and discussed under the appropriate category. Moreover, protocols using contemporary methodologies such as network flow and quality of service modeling are also discussed. The paper concludes with open research issues.

Basil Etefia et. al. [6] has presented "Routing Protocols for Wireless Sensor Networks", in Berkeley–Information Technology (SUPERB–IT) 2004. They presented an improvement on the implementation of information routing capabilities in ad hoc wireless sensor networks. Improving the protocols used by each sensor node can increase the network's localization and power conservation abilities. Using novel and creative schemes to generate shortest paths for information routing from source to destination nodes, they had been implemented an approach to limit the inefficiencies of routing protocols used by sensor networks for information transfer.

A.P.Subramanian et. al. [7] has presented "Multipath Power Sensitive Routing Protocol for Mobile Ad hoc Networks" in 2004. The Multipath Power Sensitive Routing (MPSR) Protocol for Mobile Ad hoc Networks has been presented. Providing multiple paths is useful in ad hoc networks because when one of the routes is disconnected, the source can simply use other available routes without performing the route discovery process again. The simulation was done using the Global Mobile Simulator (GloMoSim) Library. The results of extensive simulation show that the performance of MPSR protocol is on an increasing trend as mobility increases when compared to the Dynamic Source Routing and using this protocol is that the end-to-end packet delay does not increase significantly.

Charles E.Perkins et. al. [8] has presented "Ad-hoc On-Demand Distance Vector Routing" in 2003. They have presented a distance vector algorithm that is suitable for use with ad-hoc networks AODV avoids problems. Their new routing algorithm is quite suitable for a dynamic self-starting network as required by users wishing to utilize ad-hoc networks. AODV provides loop-free routes even while repairing broken links. They have simulated AODV using an event-driven packet level simulator called PARSEC which was developed at UCLA as the successor to Maisie. And shows that there algorithm scales to large populations of mobile nodes wishing to form ad-hoc networks. They also include an evaluation methodology and simulation results to verify the operation of their algorithm.

Fan Ye et. al. [9] has presented "A Two-Tier Data Dissemination Model for Large-scale Wireless Sensor Networks", in 2002. They described TTDD, a two-tier data dissemination design, to enable efficient data dissemination in large-scale wireless sensor networks with sink mobility. Instead of passively waiting for queries from sinks, TTDD exploits the property of sensors being stationary and location-aware to let each data source build and maintain a grid structure in an efficient way. Queries are forwarded upstream to data sources along specific grid branches, pulling sensing data downstream toward each sink. They implement the TTDD protocol in ns-2 and used the basic greedy geographical forwarding with local flooding to bypass dead ends. Their analysis and extensive simulations have confirmed the effectiveness and efficiency of the proposed design, demonstrating the feasibility and benefits of building an infrastructure in stationary sensor networks.

Maurice Chu et. al. [10] hes presented "Scalable Information-Driven Sensor Querying and Routing for ad hoc Heterogeneous Sensor Networks", in 2002. They describes two novel techniques, information-driven sensor querying (IDSQ) and constrained anisotropic diffusion routing (CADR), for energy-efficient data querying and routing in ad hoc sensor networks for a range of collaborative signal processing tasks. The key idea is to introduce an information utility measure to select which sensors to query and to dynamically guide data routing. There simulation results have demonstrated that the information-driven querying and routing techniques are more energy efficient, have lower detection latency, and provide anytime algorithms to mitigate risks of link/node failures.

Sameer Tilak et. al. [11] has presented **"**A Taxonomy of Wireless Micro-Sensor Network Models", in 2002. This paper examines this emerging field to classify wireless micro-sensor networks according to different communication functions, data delivery models, and network dynamics. This taxonomy will aid in defining appropriate communication infrastructures for different sensor network application subspaces, allowing network designers to choose the protocol architecture that best matches the goals of their application. In addition, this taxonomy will enable new sensor network models to be defined for use in further research in this area.

Ian F et. al. [12] has presented "A Survey on Sensor Networks" in 2002. The sensor networks can be used for various application areas (eg. health, military, home). For different application areas, there are different technical issues that researchers are currently resolving. The current state of the art of sensor networks is capture in this article, where solutions are discussed under their related protocol stack layer section. This article also point out the open research issues and intends to park new interests and developments in this field.

M. Younis et. al. [13] has presented "Energy-Aware Routing in Cluster-Based Sensor Networks", in 2002. This study introduced a novel energy-aware routing approach for sensor networks. A gateway node acts as a cluster-based centralized network manager that sets routes for sensor data, monitors latency throughout the cluster, and arbitrates medium access among sensors. The gateway configures the sensors and the network to operate efficiently in order to extend the life of the network. Simulation results demonstrate that the algorithm consistently performs well with respect to both energy-based metrics, e.g. network lifetime, as well as contemporary metrics, e.g. throughput and end-to-end delay.

C. Schurgers et. al. [14] has presened "Energy Efficient Routing in Wireless Sensor Networks", in 2002. In this paper authors had argued that optimal routing in sensor networks is infeasible and proposed a practical guideline that advocates a uniform resource utilization, which can be visualized by the energy histogram. They also propose a number of practical algorithms that are inspired by this concept. Their DCE combining scheme reduces the overall energy, while their spreading approaches aim at distributing the traffic in a more balanced way. Several techniques, which rely only on localized metrics are proposed and evaluated. This result shows that they can increase the network lifetime up to an extra 90% beyond the gains of our first approach.

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Sung-Ju Lee et. al. [20] has presented "Split Multipath Routing with Maximally Disjoint Paths in Ad hoc Networks", in 2001. They presented the Split Multipath Routing (SMR) protocol for ad hoc networks. SMR is an on-demand protocol that builds maximally disjoint routes and using two routes for each session; the shortest delay route and the one that is maximally disjoint with the shortest delay route. They implemented the simulator within the Global Mobile Simulation (GloMoSim) library. There protocol uses a per-packet allocation scheme to distribute data packets into multiple paths of active sessions. This traffic distribution efficiently utilizes available network resources and prevents nodes of the route from being congested in heavily loaded traffic situations.

L. Subramanian et. al. [22] has presented "An Architecture for Building Self-Configurable Systems', in 2000. This paper proposed a generic architecture for a specific subclass of sensor applications which is define as self-configurable systems where a large number of sensors coordinate amongst themselves to achieve a large sensing task. This paper lists the general architectural and infra-structural components necessary for building this class of sensor applications. The algorithm consists of four phases: Discovery phase, organizational phase, Maintenance phase and Self-Reorganization phase. Some of the basic goals of their algorithm include minimizing power utilization, localizing operations and tolerating node and link failures.

K. Sohrabi et. al. [32] has presented "Protocols for Self-Organization of a Wireless Sensor Network", in 2000. In this paper presented a set of algorithms for establishing and maintaining connectivity in wireless sensor networks. A simulation testbed for the above protocols was implemented in Parsec. The algorithms exploit the low mobility and abundant bandwidth, while coping with the severe energy constraint and the requirement for network scalability. The algorithms further accommodate slow mobility by a subset of the nodes.

V. Rodoplu et. al. [29] has presented "Minimum Energy Mobile Wireless Networks", in 1999. These authors described a distributed protocol to find the minimum power topology for a stationary ad hoc network. Because the topology is found via a local search in each node's surrounding and argued that this is applicable to a mobile ad hoc network. The choice of the SetSearchRegion function in the search algorithm, which is optimized to perform the minimum energy neighbor search, is a topic of our current research. These result shows that simulated the performance of the protocol for a mobile network and found that the average power consumption per node is significantly low.

D. B. Johnson et. al. [31] has presented "Dynamic Source Routing in Ad Hoc Wireless Networks", in 1996. This paper presents a protocol for routing in ad hoc networks that uses dynamic source routing. The protocol adapts quickly to routing changes when host movement is frequent, yet requires little or no overhead during periods in which hosts move less frequently. Based on results from a packet-level simulation of mobile hosts operating in an ad hoc network, the protocol performs well over a variety of environmental conditions such as host density and movement rates.

K. Akkaya et. al. [32] has presented "Energy and QoS aware Routing in Wireless Sensor Networks". In this paper, authors proposed an energy-aware QoS routing protocol for sensor networks which can also run efficiently with best-effort traffic. The protocol finds a least-cost, delay-constrained path for real-time data in terms of link cost that captures nodes' energy reserve, transmission energy, error rate and other communication parameters. Simulation results have demonstrated the effectiveness of their approach for different metrics with respect to the baseline approach where same link cost function is used without any service differentiation mechanism.

"3. Proposed Methodology"

3.1 Existing system:

AODV is a typical routing protocol for MANETs. When a node wants to find a route to another one it broadcasts a RREQ to the entire network till either the destination is reached or another node is found with a fresh enough route to the destination. Then a RREP is sent back to the source and the discovered route is made available. Nodes that are part of an active route may offer connectivity information by broadcasting periodically local Hello messages (special RREP messages) to its neighbors. If Hello messages stop arriving from a neighbor beyond some time threshold, the connection is assumed to be lost. When a node detects that a route to a neighbor node is not valid it removes the routing entry and sends a RERR message to neighbors that are active and use the route; this possible by maintaining active neighbors lists. This procedure is repeated at nodes that receive RERR messages. A source that receives an RERR can reinitiate a RREQ message. This routing process will not consider about the energy of the node and it only considers the hop-count along the paths.

Max_Min energy routing protocol chooses the route with largest minimum residual energy. It does not consider the hop count along the path.

3.2 Proposed system:

In the proposed system it focus on the problem of maximizing the lifetime of a wireless sensor network where the sensor nodes communicate with the sink by delivering the sensed data across multiple hops with different transmission energy requirements. That is, there is flexibility of transmitter power adjustment and the energy consumption rate per unit information transmission is not the same for all neighbors of a sensor, but depends on the choice of the next hop node. The lifetime of the network is defined as the time until a sensor node drains out of battery energy for the first time, a definition commonly used in the literature.

Proposed system implements the energy saving routing protocol in the battery limited wireless sensor network in order the lifetime of the network. The proposed protocol performs a route discovery process similar to the AODV protocol. But it considers the residual energy level of the node and hop count along the path towards the sink. (Minimum Residual Energy) field is added to the RREQ message. The Min-RE field is set as a default value of -1 when a source node broadcasts a new RREQ message for a route discovery process. To find a route to a destination node, a source node floods a RREQ packet to the network. When neighbor nodes receive the RREQ packet and update the Min-RE value and rebroadcast the packet to the next nodes until the packet arrives at a destination node. That is, the proposed protocol collects routes that have the minimum residual energy of nodes relatively large and have the least hop-count, and then determines a proper route among them, which consumes the minimum network energy compared to any other routes. It uses the formula to select the optimum route. The formula is based on the hop count and the Minimum Residual Energy.

3.3Architecture of Wireless Sensor Networks Routing:

Routing in the Wireless sensor network is depicted in the following figure, there are many routes available from source to sink. But our proposed routing protocol will select the path which has minimum hop count and the highest residual energy. All other paths are ignored. Thick lines represent the selected path and dotted lines represent all other available paths. The path (Source – R1- R2- R3-Sink) has the minimum hop count and the highest residual energy. This path is selected by the proposed protocol for routing from source to sink. Sink represents the command node. Command nodes can be stationary or mobile. In a disaster management environment, coordination centers are typical stationary command nodes, while paramedics, fire trucks, rescue vehicles and evacuation helicopters are examples of mobile command node.

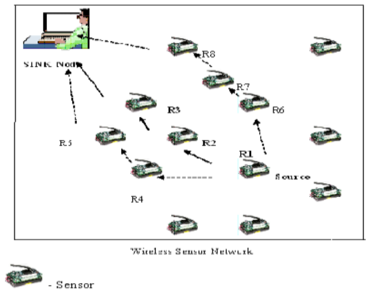

Figure1: Architecture of WSNs Pouting

Block Diagram:

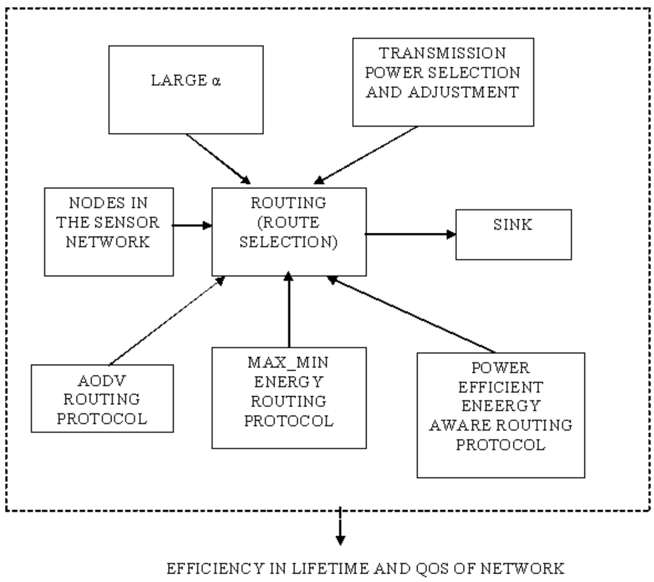

Figure2: Block Diagram

$$\alpha = \text{Min-RE} / \text{No. Of hops} \qquad (1)$$

3.4 Analysis of routing protocols

To understand the operations of the proposed protocol, it considers three different routing protocols for operational comparison:

Case 1: Choose a route with the minimum hop count between source and destination (AODV routing protocol).

Case 2: Choose a route with largest minimum residual energy. (Max_Min Energy (Min-ER) routing protocol)

Case 3: Choose a route with the large minimum residual energy and less hop count i.e. with the longest network lifetime (proposed routing protocol).

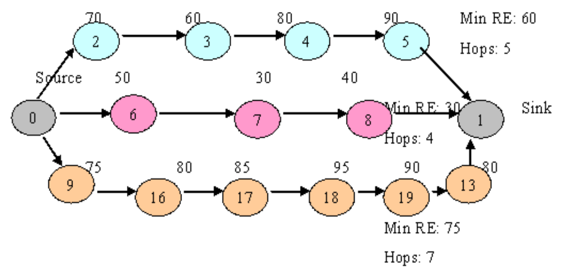

Figure4: A sample network for establishment a routing path

Case 1 considers only the minimum hop count, it selects route < 0-6-7-8-1> which has the hop count of 4. In the Case-2, select route <0-9-16-17-18-19-13-1> which has Min-RE 75 is chosen because the route has the largest minimum residual energy among routes. In this study, proposed model needs to compute the value of α by using formula (1), and selects a route with largest value of α. Thus Case 3 selects route <0-2-3-4-5-1> which has largest α value of 12. Case 1 selects the shortest path without considering residual energy of nodes, which is the same as the AODV routing algorithm. This case does not sustain a long lifetime in the network. Case 2 selects a route with largest minimum residual energy to extend network lifetime but it has serious problem in terms of the hop count. Case-3 improves the drawbacks of Case 1 and Case-2 by considering both residual energy and hop count. It extends network lifetime by arranging almost all nodes to involve in data transfer. The proposed protocol also selects a route with the longest lifetime in the network without performance degradation such as delay time and node energy consumption. Packet delivery ratio, delay and energy consumption are considered as performance metrics. These performance metrics are calculated for the existing AODV, Max_Min Energy (Min-ER) routing protocol) and proposed routing protocol. Packet delivery ratio is similar to both the existing and proposed protocols. But proposed routing protocol achieves minimum energy consumption, and lesser delay than the existing protocols. Thus proposed routing protocol increases the lifetime of the node in the network and also increases the Quality of Service of the communication network.

"4. Conclusion and Future Scope"

Proposed Energy efficient routing protocol for wireless sensor network invokes the residual energy and hop count as parameters. In the routing process path with largest minimum residual energy and least hop count is chosen. Transmission power of the node is adjusted according to neighbor's range of the node. Proposed Energy efficient routing protocol is compared with the existing protocols. Proposed protocol achieves the higher energy consumption. This improves the lifetime of the nodes in the network. Quality of Service of the communication network is also improved by achieving the lesser end-to-end delay. Thus proposed routing protocol provides better lifetime and Quality of Service than the AODV and Max_Min energy routing protocol.

In the future scope new routing algorithms are needed in order to handle the overhead of mobility and topology changes in such energy constrained environment Other possible future research for routing protocols includes the integration of sensor networks with wired networks (i.e. Internet). Most of the applications in security and environmental monitoring require the data collected from the sensor nodes to be transmitted to a server so that further analysis can be done. On the other hand, the requests from the user should be made to the sink through Internet. Since the routing requirements of each environment are different, further research is necessary for handling these kinds of situations.

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