IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834, p- ISSN: 2278-8735. Volume 4, Issue 6 (Jan. - Feb. 2013), PP 09-16
www.iosrjournals.org

Improving Energy Efficiency Using LEARN Algorithm for Wireless Sensor Networks

Srigitha.S.Nath (Ph.D)[1], Suviga.K[2]
Associate Professor/ECE [1] , M.E (Computer & Communication)[2] Saveetha Engineering College, Chennai, India

Abstract : *A number of energy-aware routing protocols were proposed to seek the energy efficiency of routes in Multihop wireless networks. Among them, several geographical localized routing protocols were proposed to help making smarter routing decision using only local information and reduce the routing overhead. However, all proposed localized routing methods cannot guarantee the energy efficiency of their routes. In this article, we first give a simple localized routing algorithm, called Localized Energy-Aware Restricted Neighbourhood routing (LEARN), which can guarantee the energy efficiency of its route if it can find the route successfully. The critical transmission radius in random networks which can guarantee that LEARN routing finds a route for any source and destination pairs asymptotically almost surely. So by using LEARN algorithm the energy efficient of the source and destination pair is thus may be maintained and the attacks occurs in the wireless network can also be reduced. One can also extend the proposed routing into three-dimensional (3D) networks and derive its critical transmission radius in 3D random networks.*
Keywords*: LEARN, Localized routing, 3D network, Multihop, CRT, Energy Efficient*

I. Introduction:

A Wireless sensor network is a distributed autonomous sensor to monitor physical or environmental conditions, as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi- directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. Energy conservation and scalability are probably two most critical issues in designing protocols for Multihop wireless networks, because wireless devices are usually powered by batteries only and have limited computing capability while the number of such devices could be large. In this paper, we focus on designing routing protocols for multihop wireless networks which can achieve both energy efficiency by carefully selecting the forwarding neighbours and high scalability by using only local information to make routing decisions. Numerous energy aware routing protocols have been proposed recently using various techniques (transmission power adjustment, adaptive sleeping, topology control, multipath routing, directional antennas, etc). Most of the proposed energy-aware routing methods take into account the energy-related metrics instead of traditional routing metrics such as delay or hop count.

The problem of energy-efficient reliable wireless communication in the presence of unreliable or loss wireless link layers in multi-hop wireless networks. Prior work has provided an optimal energy efficient solution to this problem for the case where link layers implement perfect reliability. However, a more common scenario of a link layer that is not perfectly reliable, was left as an open problem. In this paper we first present two centralized algorithms, BAMER and GAMER[1], that optimally solve the minimum energy reliable communication problem in presence of unreliable links. Subsequently we present a distributed algorithm, DAMER[2], that approximates the performance of the centralized algorithm and leads to significant performance improvement over existing single-path or multi-path based techniques. Wireless communication networks have been deployed at an increasingly fast rate, and are expected to reshape the way we live in this physical world. For example, wireless ad hoc networks in paper [2] and [3]combined with satellite data networks are able to provide global information delivery services to users in remote locations that could not be reached by traditional wired networks. There are two well-known ways to achieve end-to-end reliability on multi-hop paths. The first approach employs hop-by-hop retransmissions each link layer hop retransmits lost frames as and when necessary. The secondly [3] assumes that link layers are unreliable and retransmissions are performed end-to-end. It is also possible to consider a mix of the above as a third approach, where link layers perform a few retransmissions if necessary, but perfect reliability is only guaranteed through end-to-end mechanisms. However, link layer retransmission actually cannot guarantee reliable delivery, due to various reasons. In the end-to-end retransmission model where some link in the communication path is unreliable, we rely on TCP-like transport protocols to initiate end-to-end retransmissions.

Since in paper [3]sensor networks can be composed of a very large number of nodes, the developed protocols for these networks must be scalable. Moreover, these protocols must be designed to prolong the battery lifetime of the nodes. Typical existing routing techniques for ad hoc networks are known not to scale well. On the other hand, the so-called geographical routing algorithms are known to be scalable but their energy efficiency has never been extensively and comparatively studied. For this reason, a novel analytical framework is introduced. Ina geographical routing algorithm, the packets are forwarded by a node to its neighbour based on their respective positions is given in paper[4] and [5] . The proposed framework allows to analyze the relationship between the energy efficiency of the routing tasks and the extension of the range of the topology knowledge for each node. The leading forwarding rules for geographical routing are compared in this framework, and the energy efficiency of each of them is studied. Moreover Partial Topology Knowledge Forwarding, a new forwarding scheme, is introduced. A wider topology [6] knowledge can improve the energy efficiency of the routing tasks but can increase the cost of topology information due to signalling packets that each node must transmit and receive to acquire this information, especially in networks with high mobility. The problem of determining the optimal Knowledge Range for each node to make energy efficient geographical routing decisions is tackled by Integer Linear Programming. It is demonstrated that the problem is intrinsically localized, i.e., a limited knowledge of the topology is sufficient to take energy efficient forwarding decisions, and that the proposed forwarding scheme outperforms the others in typical application scenarios. For online solution of the problem is resulted in paper [6] and [7], a probe-based distributed protocol which allows each node to efficiently select its topology knowledge, is introduced and shown to converge to a near-optimal solution very fast.

In a localized routing algorithm, each node currently holding message makes routing decision solely based on the information about itself, its neighbours and destination given in paper [8]. In a unit graph, two nodes can communicate if and only if the distance between them is no more than the transmission radius, which is the same for each node. In paper [9],a localized routing algorithm that guarantees delivery in connected unit graphs has been described recently. Also, several power, cost and power-cost aware metrics and localized loop-free routing algorithms for wireless networks based on the exact power needed for transmission between two nodes, and/or remaining battery power at nodes were proposed. This paper[10] and [11] proposes such localized routing algorithms, aimed at minimizing total power for routing a message, or maximizing the total number of routing tasks that a network can perform before a partition. The efficiency of proposed algorithms is verified experimentally by comparing their power savings, and the number of routing tasks a network can perform before a node loses all its energy, with the corresponding shortest weighted path algorithms, and localized algorithms that use fixed transmission power at each node. Significant energy savings are obtained. In the paper [12] was to examine power consumption with respect to power non-aware protocols and provide basis for further study. Power efficient methods tend to select well-positioned neighbouring nodes in forwarding the message, while cost efficient methods favour nodes with more remaining power. The performance of internal node based routing also improves with mobility (if the cost of location updates is ignored), since mobility changes the dominating set frequently. When the nodes are static, the fixed choice of internal nodes becomes routing bottleneck, since these nodes are used more often than others in routing messages.

Greedy forward routing in wireless ad hoc networks is a localized geographic routing in which each node discards a packet if none of its neighbours is closer to the destination of the packet than itself, or otherwise forwards the packet to the neighbour closest to the destination of the packet. If all nodes have the same transmission radii, the critical transmission radius for GFR is the smallest transmission radius which ensures that packets can be delivered between any source-destination pairs. In this paper[13],[15], we study the asymptotic critical transmission radius for GFR in randomly deployed wireless ad hoc networks. We assume that the network nodes are represented by a Poisson point process of density n over a convex compact region of unit area with bounded curvature .Greedy forward routing is a localized and memory less geographic routing. However, it cannot guarantee the delivery of a packet from its source to its destination if the transmission of the nodes are not large enough. The smallest transmission radius which ensures the successful delivery of any packet is referred to as the critical transmission radius. In this paper, we provides tight bounds on the critical transmission radius when the networking nodes are represented by a Poisson point process. As a future work [10]-[13], one may investigate a number of other parameters related to GFR. These parameters include the average of one-hop progress, the expected number of hops between a source and destination, the ratio of the total length of the path to the Euclidean distance between the source and the destination. It is also interesting to study the asymptotic of other localized geographic routings.

Provide relevant information about the state of nature to a fusion centre. Set of identical binary sensors is asymptotically optimal, as observation per sensors goes to infinity. Dependence across sensors leads to the existence of multiple bits. Non identical sensors over identical binary sensors leads to error bit information. Neyman-Pearson type probability of error is fixed and can be minimized. Neyman-Pearson criterion relates both the energy consumption in routing and detection performance .Routing metric for a balance between consumed energy and detection performance by aiming for a route with maximum mean detection probability to energy ratio. Not directly indicate the amount of energy need to achieve a detection performance. Does not reflect the lifetime of sensor node. For cross layer design is scalable with respect to network size and greatly reduce the dependence on central fusion center. Clustering infrastructure with cluster heads in distributed manner. Capable of attaining energy efficiency at different network. Through cluster heads[14] only information can be passed by consultation with immediate neighbour .No centralized computation or control for routing .The Location based routing protocol address by the distance between neighbour nodes on the basis of incoming signal strength. To save energy, some location based scheme demand the node should go to sleep state if there exist no activity. Geographic Adaptive Fidelity (GAF): Increase network lifetime as the number of nodes increases. Saves energy and packet loss. Randomly Distributed sensor network. Modified Monte-carlo integration method used for obtaining the matrix and computing the weight of edge Modified LS algorithm [15] used to find the routing path with maximum sensing coverage and K hop constraint. Only hop constraint is considered. A send/no-send scenario for transmission led to a tractable and realistic problem formulation where likelihood-ratio-based detectors are optimal. Randomization of the measurement and choice of transmit rate could be used to meet a constraint on the expected cost and to optimize detection performance. Its fail to explain the dependent observation for finding the probability of error I terms of K-L distance.

II. System Description And Problem Statement

Problem Statement

` Most of the proposed energy-aware routing methods take into account the energy related metrics instead of traditional routing metrics such as delay or hop count. To select the optimal energy route, those methods usually need the global information of the whole network, and each node needs to maintain a routing table as protocol states. In opposition to these table-driven routing protocols, several stateless routing protocols, particularly, localized geographic routing protocols have been proposed to improve the scalability.

Existing System

The problem of energy-efficient routing for signal detection under the Neyman–Pearson criterion. Considering a set of sensors which are distributed over an area to detect the possible presence of an illuminated target at a specific location through active sensing. The fusion center is assumed to have the knowledge of geographical location of each sensor, and will determine the location to be probed as well as the communications routing (i.e., centralized routing is employed). The observations at each sensor are assumed to be independent conditioned on the hypothesis. Each sensor node makes a measurement to test for a target at the predetermined location, and then transforms the measurement into a likelihood ratio. This can be regarded as one particular type of in-network processing in WSNs; that is, instead of sending the raw data, each sensor node uses its processing ability to transform its measurement into a sensor likelihood ratio, a sufficient statistic for the problems we consider (conditionally independent sensor data) that provides significant compression. After collecting all the likelihood ratios from the sensor nodes along a route, the fusion center will make a final decision.

The work exploits a synergistic approach by incorporating aspects of signal processing,
computer science, and operations re-search, and can be regarded as one special type of the cross-layer network design. To summarize, the novelty and contributions of this paper are threefold.

We formulate the problem of energy efficient routing for detection under the Neyman Pearson criterion, widely adopted for target detection and surveillance related applications. This formulation, as far as we are aware, is the first one which accounts for both the energy consumption in sensing and routing, and detection performance (in terms of detection probability and false alarm probability) at the same time.

We propose three routing metrics, and for each of them, the detection performance and the energy expenditure are considered jointly in a different but interesting way by which an appropriate trade-off between them is attained. We also formulate the routing problems under these metrics into different combinatorial optimization programs, where the objectives are to maximize or minimize a quantity of interest.

We provide algorithms for solving those formulated integer programming problems, based on state-of-the-art operations research results. In cases where the optimum solution is computationally intensive, we provide methods where we can specify the acceptable complexity and a solution that can be made arbitrarily close to the optimum solution when its complexity is increased appropriately. We also present extensive simulation results which help quantify the difference proposed routing metrics.

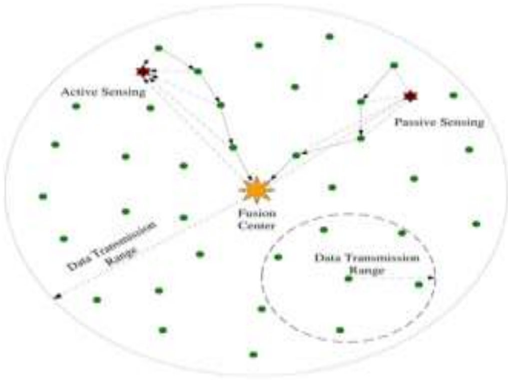

Fig. 1. Routing in WSNs for signal detection

Let us consider a scenario as depicted in Fig. 3.1, where some sensors are scattered over an area to detect the presence of an object. This scenario may correspond to monitoring the presence of people, vehicles, or military targets using radar-like sensors that emanate specific electromagnetic signals into the region of interest. For this active sensing application, the monitored space is typically divided into many range resolution cells. Each range cell could be probed sequentially in turn to deter-mine the presence of a target by using radar pulses that are possibly launched by directional antennas.

We assume the position of each sensor node is fixed. Each sensor node is assumed to be aware of its own position (e.g., by using methods based on triangulation), and has knowledge about the location of the sensors in its local neighbourhood. We assume the fusion center has information about the geographical location of each sensor, and will determine the location to be probed (for target presence) as well as the sensors that will be involved in signal detection and information transmission. This basically is a destination initiated routing, and the routing algorithm can be implemented offline, ahead of time, at the fusion center. The system will sequentially probe each location of interest, and collect the information from sensor nodes lying on a precomputed path in a predetermined order.

It is worth noting that there exist several ways for active sensors to illuminate the target. For example, in one methodology, each sensor transmits exactly the energy it needs to obtain some received signal-to-noise ratio (SNR) if a target is present at a certain location. This means that the sensing unit should be able to dynamically adjust its transmitted power. Alternatively, each radar sensor could transmit the same energy to the region of interest, so that those sensors which are closer to the target will have a better observation. This might be the situation when the sensing unit is extremely simple and does not allow power variation. For brevity, in this paper we only consider the second case, but its extension to the first case is straightforward. Therefore, let us denote e_{tr} as the amount of energy with which each sensor involved in the signal detection uses to illuminate the target. Then the energy received by an antenna at a distance of r meters away will be $\xi.e_{tr}/r^{\gamma}$, where ξ is a known constant. Here a simple geometric path loss model [26] is assumed, and the path loss is proportional to $1/r^{\gamma}$, where γ is the path loss exponent, an environment-dependent constant typically between 2 and 4.

A number of energy-aware routing protocols were proposed to seek the energy efficiency of routes in Multihop wireless networks. Among them, several geographical localized routing protocols were proposed to help making smarter routing decision using only local information and reduce the routing overhead. However, all proposed localized routing methods cannot guarantee the energy efficiency of their routes. Numerous energy aware routing protocols have been proposed recently using various techniques (transmission power adjustment, adaptive sleeping, topology control, multipath routing, directional antennas, etc). Most of the proposed energy-aware routing methods take into account the energy-related metrics instead of traditional routing metrics such as delay or hop count. In opposition to these table-driven routing protocols, several stateless routing protocols, particularly, localized geographical routing protocols have been proposed to improve the scalability.

Energy conservation and scalability are probably two most critical issues in designing protocols for Multihop wireless networks, because wireless devices are usually powered by batteries only and have limited computing capability while the number of such devices could be large. In those localized routing protocols, with the assumption of known position information, the routing decision is made at each node by using only local neighbourhood information. Previous localized routing protocols are not energy efficient, i.e., the total energy consumed by their route could be very large compared with the optimal. All of them cannot theoretically guarantee energy efficiency of their routes in the worst case.

Proposed System

A simple localized routing algorithm, called Localized Energy-Aware Restricted Neighbourhood routing (LEARN), which can guarantee the energy efficiency of its route if it can find the route successfully. Being focus on designing routing protocols for Multihop wireless networks which can achieve both energy efficiency by carefully selecting the forwarding neighbours and high scalability by using only local information to make routing decisions. We theoretically prove that LEARN is energy efficient, i.e., when LEARN routing finds a path from the source node to the target node, the total energy consumption of the found path is within a constant factor of the optimum.

We then theoretically study its critical transmission radius in random networks which can guarantee that LEARN routing finds a route for any source and destination pairs asymptotically almost surely. LEARN routing is the first localized routing which can theoretically guarantee the energy efficiency of its routes. In LEARN, whenever possible, the node selects the neighbour inside a restricted neighbourhood that has the largest energy mileage (i.e., the distance travelled per unit energy consumed) as the next hop node.3D wireless network has received significant attention due to its wide range of potential applications (such as underwater sensor networks).As the classical greedy routing, LEARN routing protocol can be directly applied in 3D networks.

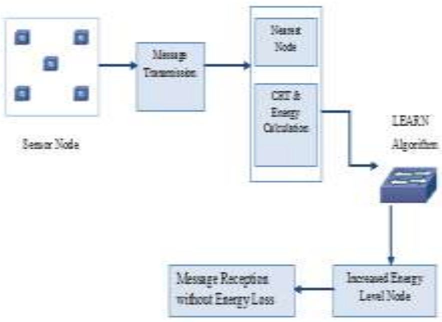

Fig 2 System Architecture

III. Localized Energy Aware Restricted Neighbourhood Algorithm (Learn)

The energy-efficient localized routing protocol for ad hoc networks. Our main contributions are follows. New Localized Routing Protocol: We propose a new localized routing protocol, called localized energy aware restricted neighbourhood routing (LEARN). In LEARN, whenever possible, the node selects the neighbour inside a restricted neighbourhood (defined by a parameter α) that has the largest energy mileage (i.e., the distance travelled per unit energy consumed) as the next hop node. If no such neighbour inside the restricted neighbourhood, it acts as greedy routing. The guarantee of delivery can be achieved by using face routing as the backup.

Power Efficiency of LEARN: We theoretically prove that LEARN is power efficient, i.e., when LEARN routing finds a path from the source node to the target node, the total energy consumption of the found path is within a constant factor of the optimum. Notice that, LEARN routing is the first localized routing which can theoretically guarantee the power efficiency of its routes. In addition, we also prove that the total Euclidean length of the found path is within a constant factor of the optimum.

Critical Transmission Range for LEARN: We theoretically prove that for a network, formed by nodes that are produced by a Poisson distribution with rate n over a compact and convex region Ω with unit area.

Simulation for LEARN: We conducted extensive simulations to study the performance of LEARN and compare it with a typical localized routing protocol (GPSR) and a global ad hoc routing protocol (DSR). The simulation results show that our LEARN routing protocol has good performances in random networks.

Since energy is a scarce resource which limits the life of the network, a number of energy efficient routing protocols have been proposed recently using a variety of techniques. Classical routing algorithm may be adapted to take into account energy-related criteria rather than classical metrics such as delay or hop distance. Most of the proposed energy-aware metrics are defined as a function of the energy required to communicate on a link or a function of the nodes remaining lifetime. However, to minimize the global consumed energy of selected route, most of minimum energy routing algorithms are centralized algorithms. In this paper, we focus on stateless localized routing. Thus, we only review the following related work about power efficient techniques for "local" routing which address how to save energy when making routing decision.

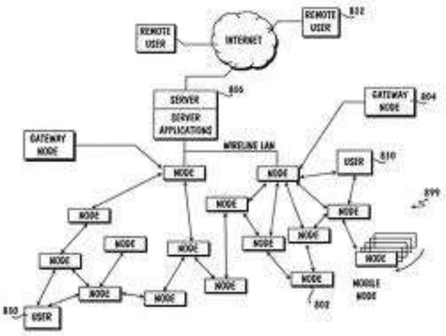

Fig.3 LEARN Algorithm model

Roosta proposed a localized routing method called probabilistic geographic routing to address power-aware routing for ad hoc and sensor networks. It selects the next hop probabilistically among a set of neighbour candidates and the neighbours assign the probability proportional to their residual energy and the link reliability. Melodia et al. proposed a partial topology knowledge forwarding for sensor network, where each node selects the shortest energy-weighted path based on local knowledge of topology. They assumed the neighbourhood discovery protocol provides each node the local knowledge of topology within certain range.

They gave a linear programming formulation to select the range which minimizes the energy expenditure of the network. Since the solution of the linear programming problem is not feasible in practice, they also proposed a distributed protocol to adjust the topology knowledge range. Stojmenovic and Lin proposed a power-aware localized routing which combining the cost metric based on remaining battery power at nodes and the power metric based on the transmission power related to distance between nodes. They proved the loop-free properties of their methods and show their efficiency by experiments. Stojmenovic and Datta further combined the above method with face routing to guarantee the delivery. However, they provide no theoretical guarantee of power efficiency for all of their methods.

Modules Description

Node Creation

When the frame is loading there is no one node has created. By clicking a mouse pointer the nodes created on the regions. Each region have five nodes, even only one region is used for the operation. When the node has created that time node name has added to the node list for selecting the source node and destination node from the regions.

Gathering Information About Nodes

In this module we have to select the source and destination node from the regions, then the transmission of the message to destination starts by clicking the transmit button, then it carefully selecting node for gather the information about each and every node of each region like neighbourhood of source node and who have highest energy in the neighbourhood, etc. Gathering information is based on the shortest or neighbourhood of the source node for calculating the Energy and Scalability. Scalability like transmission power of the nodes.

Calculating CTR, Energy And Scalability

In this module, focus only on designing routing protocols for multihop wireless networks which can achieve both energy efficiency by carefully selecting the forwarding neighbours and high scalability by using only local information to make routing decisions. Thus, to ensure that the routing is successful for every pair of possible source and destination nodes, each node in the network should have a sufficiently large transmission radius such that each intermediate node will always find a better neighbour. Routing method is successful over a network is if the routing method can find a path for any pair of source and destination nodes successfully. Thus calculate the energy of the particular node to transfer the data's and scalability of the node, and also by calculating the critical Transmission Radius(CTR) between the nodes.

Localized Routing

Only by calculating the energy and scalability of the nodes can transfer the data's and to save the energy conservation successfully. The main thing is the node should match the source and destination pairs almost surely. Only review the following related work about energy efficient techniques for localized routing which address how to save energy when making local routing decision. We propose the localized energy aware restricted neighbourhood Routing(LEARN) protocol for wireless networks. So to prove that our LEARN routing protocol is energy efficient if it can find a path. In this module Node successfully selects the source and destination with the intermediate nodes that maintains the energy at the constant high rate.

IV. Possible Attacks And The Counter Measures In The Layers Of Wsn

4.1 Physical Layer

The physical layer is concerned with transmitting raw bits of information over wired/wireless medium. It is responsible for signal detection, modulation, encoding, frequency selection and so on, and is hence the basis of network operations.

4.1.1 Attacks in the Physical Layer

Many attacks target this layer as all upper layer functionalities rely on it. In general, the following three types of attacks are categorized as physical layer attacks:

- Device Tampering
- Eavesdropping
- Jamming

4.1.2 Countermeasures in the Physical Layer

Some attacks in the physical layer are quite hard to cope with. For example, after sensors are deployed in the field, it is difficult or infeasible to prevent every single sensor from device tampering. Therefore, although there are some mechanisms that attempt to reduce the occurrences of attacks, more of them focus on protecting information from divulgence.

- Access Restriction
- Encryption

4.2 MAC Layer

Sensors rely on Medium Access Control (MAC) layer to coordinate their transmissions to share the wireless media fairly and efficiently. Node identifications are embedded in the packets to indicate senders and receivers.

4.2.1 Attacks in the MAC Layer

Due to the openness of wireless channels, the coordination's between sensors based on MAC protocols are subject to malicious manipulation. They can also forge MAC layer identifications and masquerade as other entities for various purposes.

- Traffic Manipulation
- Identity Spoofing

4.2.2 Countermeasures in the MAC Layer

To counter attacks in the MAC layer, current research focuses on detection. It allows for many kinds of further actions to stop the attacks, such as excluding the attacking nodes from interactions. There also exist some prevention approaches, which are mainly against spoofing attacks. Many solutions presented below are actually proposed for ad hoc networks. We believe they can be easily extended to wireless sensor networks.

- Misbehaviour Detection
- Identity Protection

4.3 Network Layer

In the network layer, the key issues include locating destinations and calculating the optimal path to a destination. By tampering with routing service such as modifying routing information and replicating data packets, attackers can fail the communication in WSNs.

4.3.1 Attacks in the Network Layer

As in most other networks, sensors collaborate for routing in WSNs. However, the collaboration between sensors are susceptible to malicious manipulation in WSNs.

- False Routing
    - Overflowing routing tables
    - Poisoning routing tables
    - Poisoning routing caches
- Packet Replication
- Black Hole
- Selective Forwarding

4.3.2 Countermeasures in Network Layer

Since the functionalities of the network layer require the close collaboration of many nodes, all these nodes have to be enclosed for security consideration. It is therefore relatively difficult to mitigate attacks. Nonetheless,some countermeasures are available as follows:

- Routing Access Restriction
- False Routing Information Detection
- Wormhole Detection

4.4 Application Layer

The application layer implements the services seen by users.

4.4.1 Attacks in the Application Layer

Attacks in this layer have the knowledge of data semantics, and thus can manipulate the data to change the semantics. As the result, false data are presented to applications and lead to abnormal actions.

- Clock Skewing
- Selective Message Forwarding
- Data Aggregation Distortion

4.4.2 Countermeasures in the Application Layer

Attacks in the application layer rely on application data semantics. Therefore, the counter measures focus on protecting the integrity and confidentiality of data, no matter it is for control or not.

- Data Integrity Protection
- Data Confidentiality Protection

V. Conclusion

Thus we proposed the localized energy aware restricted neighbourhood routing protocol for wireless networks, we theoretically proved that our LEARN routing protocol is energy efficient if it can find a path. We also studied its critical transmission radius for the successful packet delivery. The mathematical formulation can also extends to any routing protocol in which the region to find the next hop node by an intermediate node is compact and convex. We presented a new algorithm for energy-aware on-line routing of messages in wireless sensor networks. The algorithm uses only a single shortest path computation, and can be implemented in a distributed manner. Without making any assumptions regarding future message arrivals, we proved algorithmic competitive ratio for the case where the routing objective is network capacity maximization. Obtaining this competitive ratio result needs the network to allow admission control. However, we showed that admission control is not needed to ensure good performance in practice. We can also extend the proposed routing method into 3D networks.

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