A STUDY OF DEVELOPMENT OF SECURE & ENERGY EFFICIENT OPPORTUNISTIC ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORK

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Abstract: *Opportunistic Routing (OR) is a new promising paradigm that has been proposed for wireless networks. OR has gained a lot of attention from the research communities for its ability to increase the performance of wireless networks it benefits from the broadcast characteristic of wireless mediums to improve network performance. The sensor nodes communicate together by wireless techniques, and these communication techniques are handled by routing protocols. The resource limitation and unreliable low power links between the sensor nodes make it difficult to design an efficient routing protocol. The sink may be either static or mobile in the network. In many scenarios, static sink causes hotspots, where the sensor nodes near to the sink die out soon due to transmission overhead. On the other hand, the mobile sink improves the lifetime of a network by avoiding excessive transmission overhead on the nodes that are close to the sink. Further, an attempt is made to resolve the issues of sensor nodes and sink mobility by proposing energy-efficient routing techniques for wireless sensor network Due to a battery constraint in wireless sensor networks (WSNs), prolonging their lifetime is important.*

Keywords: Secure & Energy Efficient, Wireless Sensor Network, Opportunistic Routing, Protocol, Wireless Networks, Wireless Sensor Networks

Introduction

In recent days, researchers have proposed various routing schemes and challenges for enhancing real-time properties of WSN to provide reliable transmission. In that, one-hop information is used to select forwarding nodes. ETAR does not recognize the whole network topology of WSN. In ETAR, each node selects the next hop forwarding node, its neighbors, and destination based on its location. The Efficiency of the cost field is established in ETAR in which each node can find a minimum cost path to the destination. The cost metric is the hop count between two nodes.The source node finds the minimum hop count in routing path. The purpose of ETAR is to maximize transmitting distance of each hop and to reduce maintenance information and energy consumption. ETAR cannot optimize the number of hops that is the main reason of energy expenditure and delay. TAOR allows a minimum message exchange overhead when affording on demand acquisition of neighborhood information among forwarding paths. In order to achieve optimal reliable routing, TAOR and ETAR are combined in terms of the number of hops and energy efficiency.

This work describes the ETARP routing protocol designed for the WSN applications mentioned. The routing protocol aims to simultaneously consider energy efficiency and security to avoid routes that are inefficient and risky. In order to simplify the description, we assume for the moment a "normal" condition absent of attacks in the network. In this case, ETARP works to discover and select the most energy efficient routes. In the next this work, attacks on the network will be taken into account to show how ETARP factors trustworthiness of nodes into the route selection. Because energy efficiency and security are two different problems, ETARP takes a novel approach of factoring both using the notion of expected utility. A basic example to demonstrate the idea of ETARP is in fig... After the enemy appears in the WSN covered region, their activity can be detected by a nearby sensor node (e.g., acoustic or seismic sensor) which will send warning information back to the data collection point. Usually this process cannot be accomplished in a single hop transmission; ETARP serves to find the most energy efficient multichip route while simultaneously avoiding any (perceived) compromised nodes. The status of nodes is estimated by a Bayesian network that collects data about observed node behaviors and calculates the probability that each node is compromised or not.

LITERATURE REVIEW

Deep Kumar Bangotra, (2020) The lifetime of a node in wireless sensor networks (WSN) is directly responsible for the longevity of the wireless network. The routing of packets is the most energy-consuming activity for a sensor node. Thus, finding an energy-efficient routing strategy for transmission of packets becomes of utmost importance. The opportunistic routing (OR) protocol is one of the new routing protocol that promises reliability and energy efficiency during transmission of packets in wireless sensor networks (WSN). In this paper, we propose an intelligent opportunistic routing protocol (IOP) using a machine learning technique, to select a relay node from the list of potential forwarder nodes to achieve energy efficiency and reliability in the network. The proposed approach might have applications including e-healthcare services. As the proposed method might achieve reliability in the network because it can connect several healthcare network devices in a better way and good healthcare services might be offered. In addition to this, the proposed method saves energy, therefore, it helps the remote patient to connect with healthcare services for a longer duration with the integration of IoT services.

Muhammad Ilyas (2020) Internet of things grew swiftly and many services, software, sensors-embedded electronic devices and related protocols were developed and still in progress with full swing. Internet of things enabling physically existing things to see, hear, think and perform a notable task by allowing them to talk to each other and share useful information while making decision and caring-on/out their important tasks. Internet of things is greatly promoted by wireless sensor network as it becomes a perpetual layer for it. Wireless sensor network works as a base-stone for most of the Internet of things applications. There are severe general and specific threats and technical challenges to Internet of things–based sensor networks which must overcome to ensure adaptation and diffusion of it. Most of the limitations of wireless sensor networks are due to its resource constraint objects nature. The specified open research challenges in Internet of things–based sensor network are power consumption, network lifespan, network throughput, routing and network security. To overcome aforementioned problems, this work aimed to prolong network lifetime, improve throughput, decrease packet latency/packet loss and further improvise in encountering malicious nodes. To further tune the network lifetime in terms of energy, wireless harvesting energy is suggested in proposed three-layer cluster-based wireless sensor network routing protocol. The proposed mechanism is a three-tier clustering technique with implanted security mechanism to encounter malicious activities of sensor nodes and to slant them into blacklist. It is a centred-based clustering protocol, where selection of cluster head and grid head is carried out by sink node based on the value of its cost function. Moreover, hardware-based link quality estimators are used to check link effectiveness and to further improve routing efficiency. At the end, excessive experiments have been carried out to check efficacy of the proposed protocol. It outperforms most of its counterpart protocols such as fuzzy logic–based unequal clustering and ant colony optimization–based routing hybrid, Artificial Bee Colony-SD, enhanced three-layer hybrid clustering mechanism and energy aware multi-hop routing in terms of network lifetime, network throughput, average energy consumption and packet latency.

AzlinaKamaruddin (2019) The surface of the earth consists of 71 percent water. In recent years, research has focused on using underwater sensor networks (USN) to monitor and manage these aqueous environments. Research on the communication protocols in Terrestrial sensor networks (TSN) has been well investigated and various protocols proposed. In contrast with terrestrial wireless sensor networks, the characteristics of acoustic communication lead to challenges in deploying fully functional and operational USNs. In our proposed architecture, we present a new energy efficient opportunistic routing protocol (EE-OR). The proposed protocol is a novel energy-efficient opportunistic routing algorithm for USNs. The protocol deals with the issue of ranking of nodes during candidate set selection while reducing energy consumption and keeping the packet delivery ratio at a satisfactory level. In order to evaluate the performance, we used two common metrics that have been used for routing protocols in USNs; energy consumption and packet delivery ratio. Simulations were carried out in NS-2 with Aqua-Sim. The performance of the proposed protocol is compared with the standard DBR protocols. The comprehensive performance evaluation attests the benefit of EE-OR as compared to the mentioned protocol in terms of energy consumption, end-to-end delay and packet delivery ratio.

Varun MENON (2020) Recently, underwater acoustic sensor networks (UASNs) have gained wide attention due to their numerous applications in underwater surveillance, oil leakage detection, assisted navigation, and disaster prevention. With unique characteristics like increased propagation delay, constant mobility of sensor nodes, high error rate, and limitations in energy and interference, efficient routing of data packets from the source node to the destination is a major challenge in UASNs. Most of the protocols proposed for traditional sensor networks do not work well in UASNs. Although many protocols have been specifically proposed for underwater environments, the aim of most of them is to improve only the quality of service (QoS) in the network. The security of the transmitted data, energy efficiency of the participating nodes, and handling of communication voids are three significant challenges that need to be adequately addressed in UASNs. In this research work, a secure and energy-efficient opportunistic routing protocol with void avoidance (SEEORVA) is proposed. This protocol uses the latest opportunistic routing strategy for reliable data delivery in the network and also provides priority to the nodes having energy above a specific threshold in the forwarding process, thereby increasing the lifetime and energy efficiency in the network. The transmitted messages are encrypted using a secure lightweight encryption technique. The protocol is also integrated with a strategy to handle the communication voids in the network. Simulation results with Aqua-Sim validate the better performance of the proposed system compared to the existing ones.

SU Fan-jun (2020) In order to prevent potential malicious nodes in the network from being added to the candidate forwarding set of opportunistic routing, reduce network energy consumption and ensure reliable data transmission, a trust-based energy efficient opportunity routing in wireless sensor networks (TBEEOR) algorithm was proposed. The algorithm calculates the algebraic connectivity of nodes according to the topology of the network, then calculates the sincerity of the connectivity of the nodes, and then combines forwarding sincerity and ACK sincerity of nodes to calculate the comprehensive trust degree by using the concept of information entropy. Finally, comprehensive trust of nodes is used to calculate the energy consumption caused by communication and cooperation between nodes, thereby obtaining the expected cost of the network. In addition, the algorithm can effectively identify and judge malicious nodes in the network, further reducing the impact of malicious nodes on network performance. The experimental results show that the TBEEOR algorithm effectively guarantees the reliability of data transmission and helps to prolong the network life cycle, thereby improving the throughput of network, and reducing network energy consumption.

JayavigneshThyagarajan (2020) Opportunistic Routing (OR) scheme increases the transmission reliability despite the lossy wireless radio links by exploiting the broadcast nature of the wireless medium. However, OR schemes in low power Wireless Sensor Network (WSN) leads to energy drain in constrained sensor nodes due to constant overhearing, periodic beaconing for Neighbourhood Management (NM) and increase in packet header length to append priority wise sorted Forwarding Candidates Set (FCS) prior to data transmission. The timer-based coordination mechanism incurs the least overhead to coordinate among the FCS that has successfully received the data packet for relaying the data in a multi-hop manner. This timer-based mechanism suffers from duplicate transmissions if the FCS is either not carefully selected or coordinated. The focus of this work is to propose a hybrid opportunistic energy efficient routing design for large scale, low power and lossy WSN. This design avoids periodic 'hello' beacons for NM, limits constant overhearing and increase in packet header length. There are two modes of operation i) opportunistic ii) unicast mode. The sender node adopts opportunistic forwarding for its initial data packet transmission and instead of pre-computing the FCS, it is dynamically computed in a completely distributed manner. The eligible nodes to be part of FCS will be neighbour nodes at lower corona level than the sender with respect to the sink and remaining energy above the minimum threshold. The nodes part of FCS based on crosslayered multi-metrics and fuzzy decision logic determines its priority level to compute Dynamic Holding Delay (DHD) for effective timer coordination. The differentiated back off implementation along with DHD enables the higher priority candidate that had received data packet to forward the packet first and facilitates others to cancel its timer upon overhearing. The sender node switches to unicast mode of forwarding for successive transmissions by choosing the forwarding node with maximum trust value as it denotes the stability of the temporally varying link with respect to the forwarder. The sender node will revert to opportunistic mode to increase transmission reliability in case of link-level transmission error or no trustworthy forwarders. Simulation results in NS2 show significant increase in Packet Delivery Ratio (PDR), decrease in both average energy consumption per node and Normalized Energy Consumption (NEC) per packet in comparison with existing protocols.

S. M. Mazinani, H. Yousefi, and M. Mirzaie, (2018) one major concern shared by many researchers about underwater wireless sensor networks (UWSNs), with respect to the limitations and particularities of underwater environment, is the problem of routing. These limitations include three-dimensional topology, limited bandwidth, node movement, long delay, limited energy, and construction costs. The new routing protocols for underwater networks have been developed on the basis of voracious routing systems

M. R. Khosravi, H. Basri, and H. Rostami, (2018) Three major problems of wireless sensor networks can be summarized into communication traffic, energy consumption and routing security. In this paper, we analyze performance of an underwater sensor network in dense mode under creation of spherical division-based forbidden regions. Obviously, unnecessary smart node removal from the packet forwarding process of a flooding-based routing policy is theoretically an idea for enhancing the known network parameters.

G. Tuna and V. C. Gungor (2017) in recent years, wireless sensor networks (WSNs) have attracted the attention of both the research community and the industry, and this has eventually lead to the widespread use of WSNs in various applications. The significant advancements in WSNs and the advantages brought by WSNs have also enabled the rapid development of underwater acoustic sensor networks (UASNs).

M. Aslam, F. Wang, Z. Lv et al (2017) In this paper, we purpose Energy Efficient logical Cubical layered Path Planning Algorithm (EECPPA) and Multiple Sink EECPPA (MSEECPPA) for acoustic 3D Under Water Sensor Networks (UWSNs). EECPPA and MSEECPPA algorithms are completely distributed and highly adoptive in their execution in logical divided 3D networks into multiple cubes. Proposed models are flexible during location variations of sensors and have excellent ability to reconfigure the size of the logical cubes within 3D cubical UWSNs

C. C. Kao, Y. S. Lin, G. D. Wu, and C. J. Huang (2017) The Internet of Underwater Things (IoUT) is a novel class of Internet of Things (IoT), and is defined as the network of smart interconnected underwater objects. IoT is expected to enable various practical applications, such as environmental monitoring, underwater exploration, and disaster prevention. With these applications, IoT is regarded as one of the potential technologies towards developing Smart Cities.

M. Li, X. Du, K. Huang, S. Hou, and X. Liu (2017) Underwater wireless sensor networks (UWSNs) are featured by long propagation delay, limited energy, narrow bandwidth, high BER (Bit Error Rate) and variable topology structure. These features make it very difficult to design a short delay and high energy-efficiency routing protocol for UWSNs. In this paper, a routing protocol independent of location information is proposed based on received signal strength (RSS), which is called RRSS. In RRSS, a sensor node firstly establishes a vector from the node to a sink node

P. Jiang, Y. Feng, F. Wu, S. Yu, and H. Xu (2016) Aimed at the limited energy of nodes in underwater wireless sensor networks (UWSNs) and the heavy load of cluster heads in clustering routing algorithms, this paper proposes a dynamic layered dual-cluster routing algorithm based on Krill Herd optimization in UWSNs. Cluster size is first decided by the distance between the cluster head nodes and sink node, and a dynamic layered mechanism is established to avoid the repeated selection of the same cluster head nodes.

M. Jouhari, K. Ibrahimi, and M. Benattou (2016) Recently Underwater wireless Sensor Networks (UWSNs) have been suggested as a powerful technology for many civilian and military applications, such that tactical surveillance. Geographic routing that uses the position information of nodes to route the packet toward a destination is preferable for UWSNs. In this paper, we propose a New Greedy Forwarding (NGF) strategy using splitting mechanism based on Chinese remainder theorem (CRT) for UWSNs.

Z. Zhou, B. Yao, R. Xing, L. Shu, and S. Bu (2016) with the advance of the Internet of Underwater Things, smart things are deployed under the water and form the underwater wireless sensor networks (UWSNs), to facilitate the discovery of vast unexplored ocean volume. A routing protocol, which is not expensive in packets forwarding and energy consumption, is fundamental for sensory data gathering and transmitting in UWSNs.

E. Felemban, F. K. Shaikh, U. M. Qureshi (2015) there is no escaping fact that a huge amount of unexploited resources lies underwater which covers almost 70% of the Earth. Yet, the aquatic world has mainly been unaffected by the recent advances in the area of wireless sensor networks (WSNs) and their pervasive penetration in modern day research And industrial development. The current pace of research in the area of underwater sensor networks (UWSNs) is slow due to the difficulties arising in transferring the state-of-the-art WSNs to their underwater equivalent.

H. Mythrehee and A. Julian (2015) underwater sensor networks (UWSN) transpires as a powerful technique in marine monitoring that includes various applications such as oceanographic data collection, marine surveillance and pollution detection. Localization in UWSN is very challenging as the sensor nodes are in a 3D space and are always in passive movement. Thus providing scalable and efficient energy aware routing services and localization schemes has always been provocative.

M. R. Ahmed, M. Aseeri, M. S. Kaiser, N. Z. Zenia, and Z. I.(2015) Information transmission in the marine scenario utilizing wireless communications is unique method that empowering the technology for the evolution of imminent marine-surveillance systems and sensory networks. Under-water wireless sensor network (UWSN) in one of the auspicious technology for marine observation. The applications of underwater sensing have several domains that range from oil industry to aquaculture.

M. R. Ahmed, S. M. Tahsien, M. Aseeri, and M. Shamim Kaiser (2016) Under-water wireless sensor network (UWSN) in one of the auspicious technology for marine observation. The applications of underwater sensing have several domains that range from oil industry to aquaculture. Some of the UWSN applications include device checking, underwater ecosystems monitoring, forecasting of natural disasters and disturbances, exploration and survey missions, as well as study of oceanic life.

S. Srinivas, P. Ranjitha, R. Ramya, and G. Kumar Narendra (2013) Investigating coastal oceanic environment is of great interest in pollution monitoring, tactical surveillance applications, exploration of natural undersea resources and predicting wave tides. Deployment of underwater sensor networks for real time investigation is the major challenge. Acoustic communication intends to be an open solution for continuous wireless sensor network in underwater scenarios.

F. A. Salti, N. Alzeidi, and B. R. Arafeh (2017) Routing in underwater wireless sensor networks (UWSN) is an important and a challenging activity due to the nature of acoustic channels and to the harsh environment. This paper extends our previous work [Al-Salti et al. in Proceedings

of cyber – enabled distributed computing and knowledge discovery (CyberC), Shanghai that proposed a novel multipath grid-based geographical routing (MGGR) protocol for UWSNs.

J. Jiang, G. Han, H. Guo, L. Shu, and J. J. P. C. Rodrigues (2016) In Underwater Wireless Sensor Networks (UWSNs), the geographic routing is a preferred choice for data transmission due to the unique characteristics of underwater environment such as the three dimensional topology, the limited bandwidth and power resources. This paper focuses on underwater routing protocols in the network layer, whereunderwater sensor nodes can collaborate with each other to transfer data information.

Energy Efficiency Routing in Absence of Attacks

For the moment, attacks on the network are ignored to present how ETARP operates to discover and select energy efficient routes. Previous studies have found that the ad hoc nature of the network dictates an on-demand routing protocol such as AODV. However, AODV aims to minimize hop count without consideration of energy costs. ETARP is based on AODV but adds awareness of transmission energy costs. The route discovery by ETARP operates similarly to AODV except for a different format of the routing messages: route requests (MATLABs), route replies (MATLABs), and so on. The format of the MATLAB message in the original AODV is shown. In ETARP, the field "hop count" is replaced with "energy count." "Energy count" here implies the prediction of average transmission energy to successfully deliver a data packet from the originator node to the node handling the request.

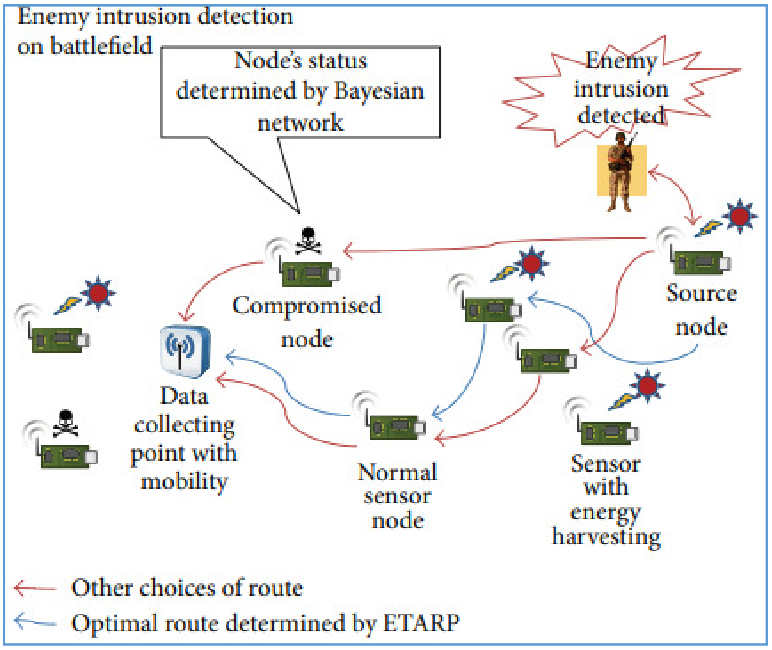

Figure 1: Example of WSN application scenario.

Table 1: MATLAB message format in original AODV

Type	R	A	Reserved	Prefix Sz	Hop count
Destination IP address					
Destination sequence number					
Originator IP address					
Lifetime					

The same change applies to the MATLAB message as well. The field "hop count" in the original AODV MATLAB message is replaced with "energy count" in the ETARP MATLAB message. Again "energy count" refers to the predicted average transmission cost to successfully deliver a data packet from the originator node to the destination node.

Since ETARP uses the same basic messages (MATLAB, MATLAB, etc.) as AODV, it does not incur more overhead compared to the original AODV. The next question is how to define energy consumption.

On any chosen ith route with total number of ji nodes, the expected total transmission cost Ei in terms of energy can be calculated as

$$E_i = E_{i1} + E_{i2} + \cdots + E_{i(j_i-1)}, \quad \textbf{(3.1)}$$

where Eim is the estimated transmission cost from the mth node on this route to its next hop ($1 \leq m \leq ji - 1$).

Transmission cost depends on successful delivery of a packet possibly after a number of reattempts. To be more specific, transmission cost has the form

$E_{im} = Kim\ (P_{im} + P_c + Pr)\ T$, (3.2)

Where K_{im} is the predicted average number of retries after a packet is successfully transmitted from node m to its next hop node m+1; P_{im} is the minimum required radio transmission power level at node m to successfully deliver a data packet to the next hop; Pc is the processing power at node m (consumed by circuits for the preparation of radio transmission including coding and modulation); Pr is the receiving power at next hop m+1 (consumed for receiving data including demodulation and decoding); and T is the transmission time needed for each transmission attempt. At least some of the nodes are assumed to be capable of harvesting solar energy. The harvested energy is considered free and accounted in Eim as

$Eim = Kim\ (Pim + Pc + Pr - \alpha imR)\ T$, (3.3)

Where R is the maximum output power of the photovoltaic power generator and αim is a random number in the range [0, 1] if node m is capable of energy harvesting or $\alpha im = 0$ if node m is not capable of energy harvesting. As mentioned in this work, solar cells are more suitable to be mounted on sensor nodes considering the size (e.g., wind driven generator is too bulky) or energy source accessibility (e.g., motion power is hard to access since nodes operate in severe environment where human activity is rare).

Energy Efficient and Secure Routing in Presence of Attacks

The previous this work dealt with the simple case of energy efficient routing assuming normal conditions without attacks on the network. The possibility of attacks adds complications because nodes can become compromised and interfere with packet forwarding. Our approach to add security awareness into ETARP relies on the concept of "expected utility" from utility theory. Either transmission energy or risk of entrusted nodes will diminish the expected utility of a route.

ETARP seeks routes with high expected utility which will be both energy efficient and trusted. In practical operation, ETARP requires changes in the format of control messages described earlier. For instance, the “energy count” field in MATLAB messages is replaced with “expected utility count” which here means the expected utility of the route from the originator node to the node handling the request. Similarly for the MATLAB message, the field “energy count” is replaced with “expected utility count” where expected utility count refers to the expected utility of the route from the originator node to the destination node.

Estimation of Risk by Bayesian Network

Generally, it is difficult to ascertain whether a node has been actually compromised or not unless it is manifested in the node’s observable behavior. A practical approach assumes that a risk can be estimated by observing the node’s behavior compared to its expected behavior. In order to calculate a “belief” about a node’s trustworthiness, a learning Bayesian network is proposed for this purpose. As addressed in This work 2, unlike the reputation management employed by previously proposed AOTDV or LTB-AODV which only watch a specific behavior, a Bayesian network is meant to organize the entire knowledge about observed node behavior into a coherent whole and makes comprehensive judgments on node status. Perhaps the use of joint probability distribution could be another approach to deal with multiple types of nodes behaviors, but the size of a joint probability distribution would be exponential in the number of nodes behaviors of interest, increasing both modeling and computational difficulties. On the other hand, a Bayesian network can address all of these difficulties in principle, by acting as a graphical modeling tool for specifying probability distributions.

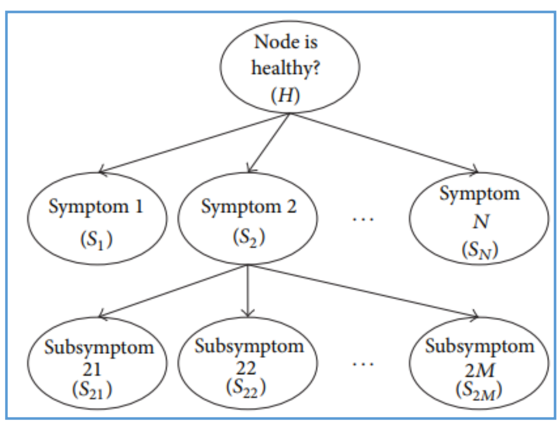

Figure 2: General Bayesian network structure.

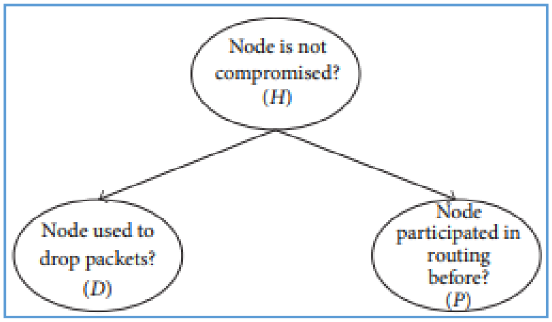

Figure 3: A Bayesian network example.

To be more specific, a Bayesian network is a probabilistic graphical model that represents a set of random variables and their conditional dependencies via a directed acyclic graph (DAG). Our Bayesian network serves to model a set of node status (comprised or not) and their behaviors. It can be used to predict the most likely status of a node based on past observed behaviors. To calculate this prediction, one method is the maximum likelihood approach.

A general Bayesian network structure employed in our case is shown in Figure 2. To determine whether a node is safe (not compromised, denoted by H), we need to observe the node's symptoms; some symptoms may require further observation on their sub symptoms.

Considering a basic practical example shown in Figure 3, the purpose is to determine a node's "health" status (node is compromised or not), denoted by variable H, two symptoms are considered: "node used to drop packets" (denoted by variable D). Note that it is normal for a node to drop packet sometimes for a valid reason, for example, bad link quality, but the term "drop packet" here implies that the number of dropped packets is unusually large.

Efficiency-Based Network Setup

A Efficiency-based network setup takes the minimum hop count and remaining energy of a node while routing data from source node to the sink. The optimal route is established autonomously. The scheme is composed of three this works namely Efficiency setup, height calculation and data forwarding approach.

Efficiency Setup

It can optimize the transmission energy and reduce the energy consumption of each node to prolong the network lifetime. In this, sink broadcasts a packet which contains a counter set to

1 initially. After receiving a packet, the receiving node sets its height equal to the counter in the packet and increases the counter by 1 and then forwards the packet.

Height calculation

The sink sets its height to 0. The heights of other nodes are equal to the smallest number of hops to the sink which reduced the routing overhead because it selects the minimum hop to involve the routing.

Data forwarding approach

Each node calculates joint parameters for forwarding the packets to sink. A node compares with its joint parameters to neighboring nodes and selects a neighbor to relay its packets to the sink semi minor axis of the elliptical region denoted by E_{llipse} is considered and node energy is defined from equation (3.13) as follows

$$H_{ellipse} = \frac{D(s,d)}{2} \times (\frac{1}{h}) + c \times \frac{E_j / E_j^o}{\sum_j (E_j / E_j^o)}, h >= 1 \quad (3.13)$$

Where co-efficient c belongs to (0,1); the minimum value of C leads the traffic to nodes with higher remaining energy. E^0_j is the initial energy of node; E_j is the remaining energy of node. Figure 3.4 shows elliptical region of source and destination to select the neighboring node for forwarding packets.

Acknowledgment mechanism is applied to calculate the delay of the packets. A node will stamp the time to identify the delay of packets of each node when it receives the packet and then compare it with the time when the ACK packet is received. The delay estimation of T^i_j for time instant (T + 1) is calculated by

$$\tau_i^{\,j}(t+1) = \alpha M_i^{\,j}(t) + \frac{1-\alpha}{T} \sum_{k=\max(1,t-T)}^{t-1} \tau_i^{\,j}(k) \quad (3.14)$$

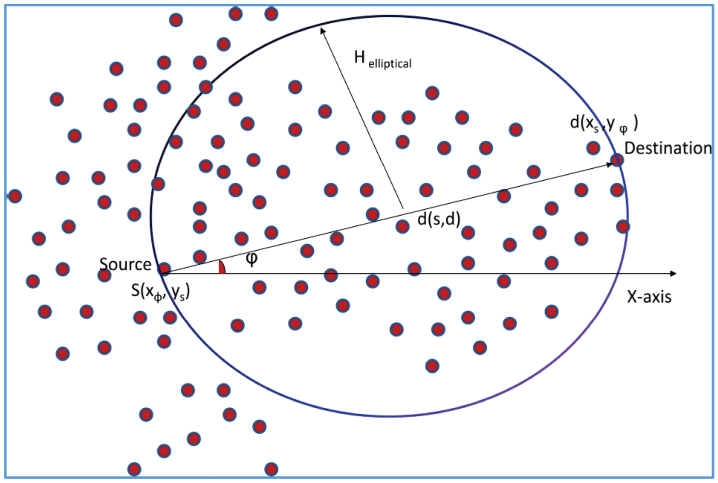

Figure 4: Elliptical region of source and destination

Where T is time window, 0<α <1 is the configurable weighing coefficient. M^i_j is the newly measured delay which is defined by larger value of α. This Efficiency-Based Network Setup is then combined with TAOR to make energy efficiency in WSN which improves the network life time.

CONCLUSION

In this paper, we introduced the ETARP routing protocol forWSN applications operating in extreme environments usuallyfor military use, such as SDT and ASW. ETARP simultaneously considers energy efficiency and security concernsby taking advantage of utility theory. Through simulations,we evaluated the energy efficiency performance and safetyperformance of ETARP in comparison to AODV andAODV. Results show that although AODV hasthe theoretical "lowest" transmission cost, there is no securityin it, while ETARP has the advantages in terms of energyefficiency in transmission while it can still maintain the samesafety performance as AODV.The results obtained were mainly coherent with intuition availability and the improvement was huge when having three paths in comparison with just one. Special focus has been paid to the comparison between connectivity and disjoint path optimization. Connectivity algorithms have been specifically developed to find the best pair of routes in a transmission network. Energy of the two alternative routes was calculated. Route which has maximum energy is selected for transmission in order to increase the energy efficiency. Disjoint Path optimization is performed by using bhandari algorithm for an additive cost where its performance is unsurpassable in practice.In summary, the proposed ELMRS considered as useful scheme to find the two best routes in the network, as proposed when the availability of some links is expected to be low. One particular application could be as a cost-benefit analysis investment scheme, which could quantify the increased availability for an investment in an additional link is going to produce in the network.An energy-efficient optimal gradient-based routing protocol is proposed which is combination with TAOR and a gradient-based routing. Optimal routing path reduces energy consumption of sensor nodes are achieved through look ahead mechanism within elliptic region. Simulation results have shown that the ORP used gradient-based routing and look ahead algorithm within an elliptic region for achieving better performance with respect to energy-efficiency. ORP compare to other two protocols like TAOR-4hop and AODV. In addition, the ORP reduced the computational complexity and enhances the energy-efficiency of the sensor nodes by selecting optimal path and also provides effective routing that increase network lifetime.

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