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ENERGY EFFICIENT LINK-DELAY AWARE ROUTING IN WIRELESS NETWORKS

Dr.Arumugam Sivakumaran[1] ,Rohitha[2], K.Gnana shreeya[3] , K.Namratha[4]
[1]Associate Professor, Department of CSE, Malla Reddy Engineering College for Women, Hyderabad, sivakumaransns@gmail.com
[2,3,4]UG Students, Department of CSE, Malla Reddy Engineering College for Women, Hyderabad, TS, India.

ABSTRACT:

This paper investigates the problem of energy consumption in wireless sensor networks. Wireless sensor nodes deployed in harsh environment where the conditions change drastically suffer from sudden changes in link quality and node status. The end-to-end delay of each sensor node varies due to the variation of link quality and node status. On the other hand, the sensor nodes are supplied with limited energy and it is a great concern to extend the network lifetime. To cope with those problems, this paper proposes a novel and simple routing metric, predicted remaining deliveries (PRD), combining parameters, including the residual energy, link quality, end-to-end delay, and distance together to achieve better network performance. PRD assigns weights to individual links as well as end-to-end delay, so as to reflect the node status in the long run of the network. Large-scale simulation results demonstrate that PRD performs better than the widely used ETX metric as well as other two metrics devised recently in terms of energy consumption and end-to-end delay, while guaranteeing packet delivery ratio.

I.INTRODUCTION

WIRELESS sensor networks have attracted great attention due to their various potential applications in the area of forest fire detection, transportation, and industrial automation, etc. [1]. Generally, sensor nodes are deployed in a specific region and cannot move after deployed. The main task of the sensor nodes is to periodically sense the environment and transmit the information to the data center known as the sink. Sensor nodes are usually battery-powered, and it is difficult to replace or recharge the battery. Due to the limited energy, sensor nodes drain their energy quickly, leading to the sensing area uncovered. Therefore, energy conservation becomes a critical concern in

WSNs. In recent years, many energy-efficient techniques for wireless sensor networks have been developed to extend the network lifetime, including duty-cycle scheduling [2], medium access control techniques [3] and compressive sensing [4].Previous studies demonstrate that the communication consumes most of the energy, and transmitting information takes about two thirds of its total energy consumption, while the count of transmissions depends to a great extent on the routing strategy [5]. In other words, an energy efficient routing protocol helps extraordinarily to save energy and extend the network lifetime. On the other hand, many applications such as WSNs used in the fire alarm systems are delay sensitive. Thus it is necessary to design a routing metric that is aware of the residual energy of each sensor node as well as end-to-end delay. Many routing protocols have been applied for WSNs [5] [6]. Tree based routing has become a popular protocol for WSNs [7]. In a routing tree, each sensor node chooses a parent to forward the data, and eventually all data are sent to a single collection point, i.e. the sink. One significant issue in tree based routing is how to design a viable metric used for a sensor node to determine its parent node. ETX [8] and ETT [9] are widely used in real WSNs. ETX reflects the expected transmission counts including retransmissions needed for a packet to reach its destination, whereas ETT is the expected transmission time of a packet over the link related to the bandwidth and the packet length. Basically, ETX captures the link quality of a routing path and helps to choose a path with the best link quality, whereas ETT captures the end-to-end delay of a routing path and serves to select a path with the shortest end-to-end delay. Nevertheless, neither ETX nor ETT take the residual energy of each sensor node into account, leading to the quick death of sensor nodes with low energy level. To strike a balance between energy efficiency and delay, it is necessary to combine both link quality and end-to-end delay together for routing metric design.

This paper focuses on the routing metric design for the applications of WSNs where the environment changes drastically, e.g. the intertidal environment. Our experiments of a WSN system deployed in the intertidal environment exhibit long end-to-end delay and unbalanced energy consumption among sensor nodes, which will be described in detail in the next section. Yet, designing such a routing metric poses several challenges. The first challenge is how to overcome the environment variations and reflect the status of the sensor nodes. In the harsh environment such as the intertidal area, the status of sensor nodes deployed for monitoring temperature and sea creatures are impacted by the tide, sea waves and the sea wind. Sensor nodes may change between above water and under water due to the change of the tidal level, bringing about variations in link quality and end-to-end delay. The second challenge is how to combine several factors together into the metric so as to achieve a better performance. Generally, a good routing metric should help to select the next hop which is with the best link quality, the shortest end-to-end delay and the highest residual energy. The last challenge is to balance the energy consumption among the sensor nodes so as to prolong the lifetime of each sensor node. Sensor nodes with low energy die quickly if the energy consumption is unbalanced, leading to a short lifetime and poor network performance.

To overcome those challenges, we propose a novel design of the routing metric combining the link quality, the residual energy, the distances and the end-to-end delay. The main contributions of this paper are summarized as follows.

• We introduce *Predicted Remaining Deliveries* (PRD), a novel link and delay aware routing metric for WSNs with harsh environment such as intertidal environment. PRD reflects the ability of the sensor nodes to successfully deliver packets to the destination within one unit delay.

• We analyse the properties of the proposed metric and demonstrate that it is guaranteed to find the lightest paths, and it is loop-free and consistent, when applied with hop-by-hop routing.

• We analyse the average energy consumption of sensor nodes related to their average distance to the sink and give a closed form of the average energy consumption, which can give an instruction for the design of areal WSN.

• We implement and evaluate the performance of PRD with large-scale simulations. Simulation results demonstrate that PRD improves energy consumption and end-to-end delay performance, while guaranteeing packet delivery ratio.

PROBLEM DEFINITION

A WSN system with 26 nodes is deployed in the intertidal area in Zhoushan (29◦56 43N, 122◦5 10E, an island city in Zhejiang Province, China) to periodically monitor temperature changes. The status of sensor nodes changes between above water and under water. Sensor nodes suffer from link quality changes frequently in the intertidal environment due to tides and sea waves. Two neighbour nodes, even with close distance, encounter poor link quality when tides rise, and the link quality turns well when tides ebb. Therefore the link qualities of the sensor nodes vary with time frequently. On the other hand, due to the change of the environment and the node status, the number of packet retransmissions and the queueing length in the buffer may both increase, leading to the increase of end-to-end delay.

II.LITERATURAL SURVEY

1.An industrial perspective on wireless sensor networks—A survey of requirements, protocols, and challenges, A. A. Kumar S., K. Ovsthus, and L. M. Kristensen, Wireless Sensor Networks (WSNs) are applicable in numerous domains, including industrial automation where WSNs may be used for monitoring and control of industrial plants and equipment. However, the requirements in the industrial systems differ from the general WSN requirements. In recent years, standards have been defined by several industrial alliances. These standards are specified as frameworks with modifiable parts that can be defined based on the particular application of WSN. However, limited work has been done on defining industry-specific protocols that could be used as a part of these standards. In this survey, we discuss representative protocols that meet some of the requirements of the industrial applications. Since the industrial applications domain in itself is a vast area, we divide them into classes with similar requirements. We discuss these industrial classes, set of common requirements and various state-of-the-art WSN standards proposed to satisfy these requirements. We then present a broader view towards the WSN solution by discussing important functions like medium access control, routing, and transport in detail to give some insight into specific requirements and the classification of protocols based on certain factors. We list and discuss representative protocols for each of these functions that address requirements defined in the industrial classes. Security function is discussed in brief, mainly in relation to industrial standards. Finally, we identify unsolved challenges that are encountered during design of protocols and standards. In addition some new challenges are introduced and discussed.

2.Survey and taxonomy of duty cycling mechanisms in wireless sensor networks, R. C. Carrano, D. Passos, L. C. S. Magalhaes, and C. V. N. Albuquerque,Motivated by stringent power constraints, duty cycling - the practice of turning a mote's radio on and off to conserve energy - has become a fundamental mechanism in the design of Wireless Sensor Networks. Because of its importance, a variety of approaches to duty cycling have emerged during the last decade and are being now proposed with increasingly ambitious goals, such as achieving ultra low duty cycles as low as 0.1%. Such propositions differ mostly in their reliance on nodes' synchronization, which, in turn, translates into different hardware requirements and implementation complexity. However, duty cycling may also differ in other aspects as topology dependency, network density requirements and increase in end-to-end delay. This paper organizes the most important proposals into a taxonomy and provides insights into their strengths and weaknesses in relation to important characteristics of applications, mote's hardware and network deployments.

3.The evolution of MAC protocols in wireless sensor networks: A survey, P. Huang, L. Xiao, S. Soltani, M.W. Mutka, and N. Xi.Wireless Sensor Networks (WSNs) have become a leading solution in many important applications such as intrusion detection, target tracking, industrial automation, smart building and so on. Typically, a WSN consists of a large number of small, low-cost sensor nodes that are distributed in the target area for collecting data of interest. For a WSN to provide high throughput in an energy-efficient way, designing an efficient Medium Access Control (MAC) protocol is of paramount importance because the MAC layer coordinates nodes' access to the shared wireless medium. To show the evolution of WSN MAC protocols, this article surveys the latest progresses in WSN MAC protocol designs over the period 2002-2011. In the early development stages, designers were mostly concerned with energy efficiency because sensor nodes are usually limited in power supply. Recently, new protocols are being developed to provide multi-task support and efficient delivery of bursty traffic. Therefore, research attention has turned back to throughput and delay. This article details the evolution of WSN MAC protocols in four categories: asynchronous, synchronous, frame-slotted, and multichannel. These designs are evaluated in terms of energy efficiency, data delivery performance, and overhead needed to maintain a protocol's mechanisms. With extensive analysis of the protocols many future directions are stated at the end of this survey. The performance of different classes of protocols could be substantially improved in future designs by taking into consideration the recent advances in technologies and application demands.

4.Compressive sensing: From theory to applications, A survey,S. Qaisar, R. M. Bilal, W. Iqbal, M. Naureen, and S. Lee. Compressive sensing (CS) is a novel sampling paradigm that samples signals in a much more efficient way than the established

Nyquist sampling theorem. CS has recently gained a lot of attention due to its exploitation of signal sparsity. Sparsity, an inherent characteristic of many natural signals, enables the signal to be stored in few samples and subsequently be recovered accurately, courtesy of CS. This article gives a brief background on the origins of this idea, reviews the basic mathematical foundation of the theory and then goes on to highlight different areas of its application with a major emphasis on communications and network domain. Finally, the survey concludes by identifying new areas of research where CS could be beneficial.

5.Recent advances in energy-efficient routing protocols for wireless sensor networks: A review, J. Yan, M. Zhou, and Z. Ding. Due to a battery constraint in wireless sensor networks (WSNs), prolonging their lifetime is important. Energy-efficient routing techniques for WSNs play a great role in doing so. In this paper, we articulate this problem and classify current routing protocols for WSNs into two categories according to their orientation toward either homogeneous or heterogeneous WSNs. They are further classified into static and mobile ones. We give an overview of these protocols in each category by summarizing their characteristics, limitations, and applications. Finally, some open issues in energy-efficient routing protocol design for WSNs are indicated.

6.Energy-efficient routing protocols in wireless sensor networks: A survey. N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados. The distributed nature and dynamic topology of Wireless Sensor Networks (WSNs) introduces very special requirements in routing protocols that should be met. The most important feature of a routing protocol, in order to be efficient for WSNs, is the energy consumption and the extension of the network's lifetime. During the recent years, many energy efficient routing protocols have been proposed for WSNs. In this paper, energy efficient routing protocols are classified into four main schemes: Network Structure, Communication Model, Topology Based and Reliable Routing. The routing protocols belonging to the first category can be further classified as flat or hierarchical. The routing protocols belonging to the second category can be further classified as Query-based or Coherent and non-coherent-based or Negotiation-based. The routing protocols belonging to the third category can be further classified as Location-based or Mobile Agent-based. The routing protocols belonging to the fourth category can be further classified as QoSbased or Multipath-based. Then, an analytical survey on energy efficient routing protocols for WSNs is provided. In this paper, the classification initially proposed by Al-Karaki, is expanded, in order to enhance all the proposed papers since 2004 and to better describe which issues/operations in each protocol illustrate/enhance the energy-efficiency issues.

7.A high-through put path metric for multi-hop wireless routing. D. S. De Couto, D. Aguayo, J. Bicket, and R. Morris, This paper presents the expected transmission count metric (ETX), which finds high-throughput paths on multi-hop wireless networks. ETX minimizes the expected total number of packet transmissions (including retransmissions) required to successfully deliver a packet to the ultimate destination. The ETX metric incorporates the effects of link loss ratios, asymmetry in the loss ratios between the two directions of each link, and interference among the successive links of a path. In contrast, the minimum hop-count metric chooses arbitrarily among the different paths of the same minimum length, regardless of the often large differences in throughput among those paths, and ignoring the possibility that a longer path might offer higher throughput. This paper describes the design and implementation of ETX as a metric for the DSDV and DSR routing protocols, as well as modifications to DSDV and DSR which allow them to use ETX. Measurements taken from a 29- node 802.11b test-bed demonstrate the poor performance of minimum hop count, illustrate the causes of that poor performance, and confirm that ETX improves performance. For long paths the throughput improvement is often a factor of two or more, suggesting that ETX will become more useful as networks grow larger and paths become longer.

8.Routing in multi-radio, multi-hop wireless mesh networks. R. Draves, J. Padhye, and B. Zill. We present a new metric for routing in multi-radio, multi-hop wireless networks. We focus on wireless networks with stationary nodes, such as community wireless networks. The goal of the metric is to choose a high-throughput path between a source and a destination. Our metric assigns weights to individual links based on the Expected Transmission Time (ETT) of a packet over the link. The ETT is a function of the loss rate and the bandwidth of the link. The individual link weights are combined into a path metric called Weighted Cumulative ETT (WCETT) that explicitly accounts for the interference among links that use the same channel. The WCETT metric is incorporated into a routing protocol that we call Multi-Radio Link-Quality Source Routing. We studied the performance of our metric by implementing it in a wireless test bed consisting of 23 nodes, each equipped with two 802.11 wireless cards. We find that in a multi-radio environment, our metric significantly outperforms previously-proposed routing metrics by making judicious use of the second radio.

9. Wireless sensor network localization techniques. G. Mao, B. Fidan, and B. D. O. Anderson. Wireless sensor network localization is an important area that attracted significant research interest. This interest is expected to grow further with the proliferation of wireless sensor network applications. This paper provides an overview of the measurement techniques in sensor network localization and the one-hop localization algorithms based on these measurements. A detailed investigation on multi-hop connectivity-based and distance-based localization algorithms are presented. A list of open research problems in the area of distance-based sensor network localization is provided with discussion on possible approaches to them.

10. ATPC: Adaptive transmission power control for wireless sensor networks. S. Lin, J. Zhang, G. Zhou, L. Gu, J. A. Stankovic, and T. He. Extensive empirical studies presented in this article confirm that the quality of radio communication between low-power sensor devices varies significantly with time and environment. This phenomenon indicates that the previous topology control solutions, which use static transmission power, transmission range, and link quality, might not be effective in the physical world. To address this issue, online transmission power control that adapts to external changes is necessary. This article presents ATPC, a lightweight algorithm for Adaptive Transmission Power Control in wireless sensor networks. In ATPC, each node builds a model for each of its neighbors, describing the correlation between transmission power and link quality. With this model, we employ a feedback-based transmission power control algorithm to dynamically maintain individual link quality over time. The intellectual contribution of this work lies in a novel pairwise transmission power control, which is significantly different from existing node-level or network-level power control methods. Also different from most existing simulation work, the ATPC design is guided by extensive field experiments of link quality dynamics at various locations over a long period of time. The results from the real-world experiments demonstrate that (1) with pairwise adjustment, ATPC achieves more energy savings with a finer tuning capability, and (2) with online control, ATPC is robust even with environmental changes over time.

11. An application-specific protocol architecture for wireless micro sensor networks. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan. Networking together hundreds or thousands of cheap microsensor nodes allows users to accurately monitor a remote environment by intelligently combining the data from the individual nodes. These networks require robust wireless communication protocols that are energy efficient and provide low latency. We develop and analyze low-energy adaptive clustering hierarchy (LEACH), a protocol architecture for microsensor networks that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to achieve good performance in terms of system lifetime, latency, and application-perceived quality. LEACH includes a new, distributed cluster formation technique that enables self-organization of large numbers of nodes, algorithms for adapting clusters and rotating cluster head positions to evenly distribute the energy load among all the nodes, and techniques to enable distributed signal processing to save communication resources. Our results show that LEACH can improve system lifetime by an order of magnitude compared with general-purpose multihop approaches.

III. EXISTING SYSTEM:

- Previous studies demonstrate that the communication consumes most of the energy, and transmitting information takes about two thirds of its total energy consumption, while the count of transmissions depends to a great extent on the routing strategy.
- In other words, an energy efficient routing protocol helps extraordinarily to save energy and extend the network lifetime. ETX and ETT are widely used in real WSNs.
- ETX reflects the expected transmission counts including retransmissions needed for a packet to reach its destination, whereas ETT is the expected transmission time of a packet over the link related to the bandwidth and the packet length. Basically, ETX captures the link quality of a routing path and helps to choose a path with the best link quality, whereas ETT captures the end-to-end delay of a routing path and serves to select a path with the shortest end-to-end delay

Disadvantages of existing system:

- Designing such a routing metric poses several challenges.
- Challenge is how to combine several factors together into the metric so as to achieve a better performance.

- Last challenge is to balance the energy consumption among the sensor nodes so as to prolong the lifetime of each sensor node. Sensor nodes with low energy die quickly if the energy consumption is unbalanced, leading to a short lifetime and poor network performance.

IV.PROPOSED SYSTEM:

- This paper focuses on the routing metric design for the applications of WSNs where the environment changes drastically, e.g. the intertidal environment. Our experiments of a WSN system deployed in the intertidal environment exhibit long end-to-end delay and unbalanced energy consumption among sensor nodes
- To overcome those challenges, we propose a novel design of the routing metric combining the link quality, the residual energy, the distances and the end-to-end delay.
- The main contributions of this paper are summarized as follows.
- We introduce *Predicted Remaining Deliveries* (PRD), a novel link and delay aware routing metric for WSNs with harsh environment such as intertidal environment.
- We analyse the properties of the proposed metric and demonstrate that it is guaranteed to find the lightest paths, and it is loop-free and consistent, when applied with hop-by-hop routing.
- We analyse the average energy consumption of sensor nodes related to their average distance to the sink and give a closed form of the average energy consumption, which can give an instruction for the design of a real WSN.

Advantages

- The system is implemented based on Link-delay aware techniques.
- No Packet Drops

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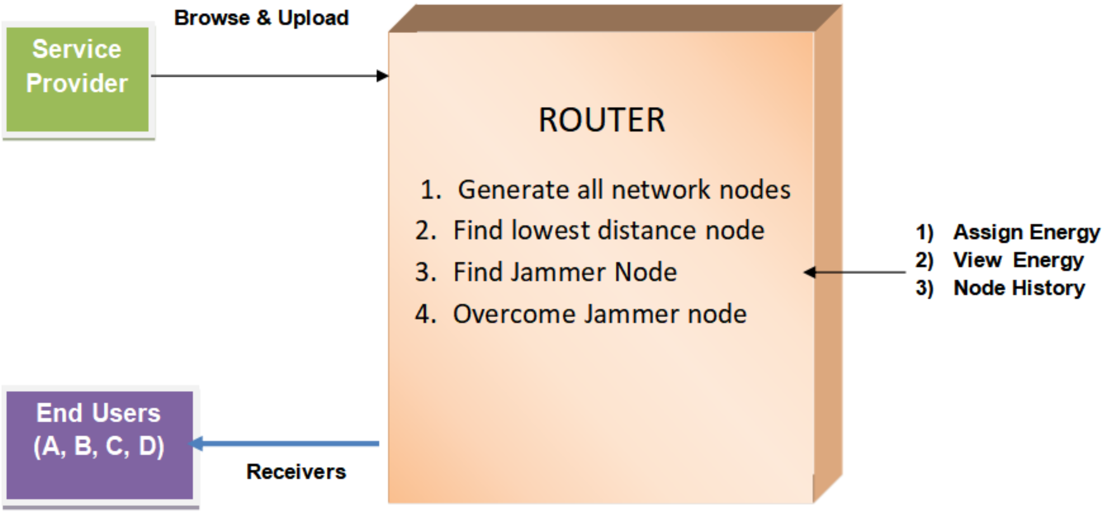

Fig1: System architecture

V. IMPLEMENTATION

- **Service provider:**

  In this module, the service provider will browse the data file path and then send to the particular receivers. Service provider will send their data file to wireless router and router will connect to networks, in a

  network smallest distance sensor node will be activated and send to particular receiver (A, B, C…). And if any jammer node will found, then service provider will reassign the energy for sensor node.

- **Wireless Router**

  The Wireless Router manages a multiple networks (network1, network2, network3, and network4) to provide data storage service. In network n-number of nodes (n1, n2, n3, n4…) are present, in networks every node consists of distance and energy. In a network shortest distance sensor node will communicate first. The service provider can assign energy for sensor node, view energy for all networks and node history details (view routing path, view boundary nodes, view jamming nodes & view total time delay) in router. Router will accept the file from the service provider and then it will connect to different networks; the all networks are communicates and then send to particular

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receiver. In a router we can view time delay, jammed nodes and also routing path.

- **Network**

  In this module the networks (network 1, network 2, network 3 and network 4) consists of n-number nodes. In networks every node consists of distance and energy. In a network shortest distance sensor node will communicate first. The node consists of lesser energy then that node will be jammed by the jammers. And then it will forward to next lesser distance node within the network. In a network last node will be considered as boundary node.

- **Receiver (End User)**

  In this module, the receiver can receive the data file from the service provider via wireless router. The receivers receive the file by without changing the File Contents. Users may receive particular data files within the network only.

- **Jammer**

  In this system, the lesser energy sensor node will be considered as a jammer node. Once the jammer became active, affected nodes lost their neighbors partially or completely, lost all of their neighbors and became jammed nodes.

VI. CONCLUSION

This paper proposes a novel link-delay aware energy efficient routing metric called PRD for the routing path selection tailored for WSNs deployed in harsh environments, where the networks are exposed to extremely long end-to-end delay and unbalanced energy consumption among sensor nodes. PRD captures the *predicted remaining deliveries* within one unit of delay, which reflects the ability of each sensor node to forward packets. PRD also takes the end-to-end delay into consideration. The main purposes of PRD are to balance the energy consumption of the sensor nodes and extend the network lifetime, as well as controlling the end-to-end delay. Large-scale simulations are conducted to evaluate the performance of PRD. The results indicate that PRD outperforms traditional metrics such as ETX, EFW and PTX in terms of end-to-end delay, energy consumption and network life time performance, while guaranteeing high packet delivery ratio. Therefore we can conclude that the proposed PRD metric can be an effective and efficient solution to choose appropriate routing paths for WSNs deployed in harsh environments.

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