PERFORMANCE ANALYSIS AND ISSUES OF MOBILE SENSOR NETWORK

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Abstract: *Wireless sensor networks are expected to be one of the key enabling technologies in the next 10 years. Protocols for such networks should be highly flexible in order to adapt to topology changes due to node mobility. Dynamic changes in the cluster structure leads to performance degradation of the network. Nodes in WSNs are generally assumed to be static. However, many recent applications make use of mobile sensor nodes. This poses some unique challenges to WSN researchers. Depending on their roles in WSNs (sinks, routers, or sensors), nodes may move individually or in groups with respect to some reference system. This mobility changes network topology. Topology changes occur in a dynamic WSN when nodes disconnect or connect from/to all or some of their neighbours, whether forced by changing of locations of nodes or adding/removing nodes. In this paper, we will explore the impact of mobility over wireless sensor network and various solutions offered by the researchers.*

Keywords: *Cluster, Energy Consumption, Mobility, MSN, Wireless Sensor Network*

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1. INTRODUCTION

Wireless sensor networks have been deployed in mission-critical applications such as target detection, object tracking, and security surveillance. A fundamental challenge for these wireless sensor networks is to meet stringent Quality-of-Service requirements including high target detection probability, low false alarm rate, and bounded detection delay. [11]

Applications of WSN

Sensors are used in variety of applications which require constant monitoring and detecting specific events. Following are the different application areas: [11][12][13]

1. Defence
2. Environmental studies
3. Medical
4. Commercial industries and home appliances
5. Robotics

Sensor Network Architecture

Design of WSN is influenced by factors such as scalability, fault tolerance and power consumption. The basic kind of sensor network architecture: [13]

1. Layered Architecture: In this type, there is a single base station. Base station acts as access point and it is connected to the wired network. Base station collects all the data from the nodes for further processing [13].
2. Clustered Architecture: In this type, nodes are arranged in clusters and these are governed by a cluster head. Each cluster group exchanges the messages in between their groups only. Cluster heads can communicate with each other and they are responsible to send the data to base station. [13]

Issues and Challenges in WSN

Sensors are randomly deployed and also support the dynamic topology. This is the infrastructure less network which requires a routing protocol for the distributed network operations. Hardware design for sensors should consider the energy consumption constraint. Limited energy is a major issue for designing a routing protocol for WSN.

WSN should support the real time communication with QOS parameters like minimum delay and maximum throughput etc. Sensors should be able to synchronize the data communication with other nodes and they should be capable to adapt the changes in connectivity due to the failure of nodes or due the scalability. [11][12][13]

Issues due to Highly Mobile Environment

1. Mobility leads to deterioration in the quality of an established link and, therefore, data transmission is prone to failure, which in turn increases the rate of packet retransmission.
2. Mobility leads to frequent route changes, which result in a considerable packet delivery delay.
3. A mobile node cannot immediately begin transmitting data upon joining a network, because its neighbours should first discover its presence and decide how to collaborate with it. This requires sometime.
4. In contention-based MAC protocols, mobility may increase packet collision while in schedule-based MAC protocols, two-hop neighbourhood information becomes inconsistent once nodes enter or leave, leading to schedule inconsistencies. [3]

2. LITERATURE SURVEY

Wireless sensor networks (WSNs) are distributed systems of nodes with sensing, data processing and storage capabilities, wireless communication interfaces, and limited power. They are used for surveillance and control applications in a diverse range of micro and macro environments, such as wildlife habitats, urban environments, and technical and biological systems and structures. One of the central goals in WSNs is the design of energy-efficient protocols, optimized to maintain connectivity and maximize network lifetime. Usually, the connectivity condition is met by deploying a sufficient number of sensors or using specialized nodes with long-range capabilities to maintain a connected graph. Network lifetime is related to how long the power sources in network nodes will last. [13]

Mobility is characterized by concurrent node joins and failures as well as physical movement of nodes. Physical mobility is caused by the deliberate movement of objects or persons to which sensor nodes are attached. Similarly, it can occur when nodes are carried by external forces such as wind, water, or air. In some applications, strong mobility plays a key role. For example, biomedical sensor nodes can be attached to the bodies of patients and nurses to monitor their activities; workers in disaster recovery scenes and oil extraction and refinery areas can carry sensing devices to avoid dangerous situations; mobile sensor nodes can also be employed to report or debrief soldiers the events encountered during a mission. [3]

Researchers have discovered lot of solution to work with the mobile environment. Now we will discuss the solutions provided by them. Y.Y Shih, W.H. Chung, P.C. Hsiu and A.C. Pang [1] proposed a scheme that exploits the regularity to improve the data delivery ratio in ZigBee wireless sensor networks. The scheme deploys the network nodes and constructs the tree topology by using the mobility regularity imposed by the physical environment. In a ZigBee network, packets are forwarded to mobile end-devices via routers. The primary objective of the proposed approach is to deploy the routers and construct a tree topology that enables mobile end devices to move with high probability in the direction of the routing paths.

By using the historical movement data of mobile nodes, they construct the tree so that most movements are highly probabilistic to move towards the root, i.e., the opposite direction to downlink transmissions. By enabling mobile end devices to overhear the packets during movement, the data delivery can be completed if the destined mobile end-device is located along the path of the data delivery. The proposed ZigBee routing tree topology deployment and construction framework incorporates the mobility information, and algorithms are developed to implement the framework. Compared to existing approaches, this framework achieves higher data delivery ratios and longer path duration with much lower routing overheads in the scenarios where the movements of mobile end-devices are with regularity.

Q. Ren, L. Guo J. Zhu,M. Ren, J. Zhu [2] studied the problem of processing aggregation queries over a large scale MSN with the group mobility model. They presented a distributed clustering algorithm to divide the mobile nodes into several mobile groups. Then, they further presented the distributed Distance-AGG and Probability-AGG algorithms for inter-group aggregation. Distance-AGG chooses the proper forwarding nodes according to the distance to the sink and Probability-AGG takes the transmission probability and nodes' residual energy into consideration. They evaluated the performances of the algorithms in terms of communication cost, query delay, and aggregation result accuracy by varying group velocity and nodes density. The simulation results show that the proposed methods outperform the existing data aggregation algorithms for MSNs.

Q. Dong, W. Dargie [3] did a survey of mobility estimation and mobility supporting protocols in wireless sensor networks. They explored the difficulties caused by mobility at various layers, particularly, at the MAC layer. To efficiently address the problem of mobility, a classification of mobility patterns and models was described and several mobility estimation techniques were discussed. Finally, they investigated six mobility-aware MAC protocols and compared their merits and demerits.

F. E. Moukaddem, E. Torng, and G. Xing [4] proposed a holistic approach to minimize the total energy consumed by both mobility of relays and wireless transmissions. Most previous work ignored the energy consumed by moving mobile relays. When they modelled both sources of energy consumption, the optimal position of a node that receives data from one or multiple neighbours and transmit it to a single parent is not the midpoint of its neighbours; instead, it converges to this position as the amount of data transmitted goes to infinity. They started with the optimal initial routing tree in a static environment where no nodes can move. However, their approach can work with less optimal initial configurations including generated using only local information such as greedy geographic routing. Their approach improves the initial configuration using two iterative schemes. The first inserts new nodes into the tree. The second computes the optimal positions of relay nodes in the tree given a fixed topology. This algorithm is appropriate for a variety of data-intensive wireless sensor networks. It allows some nodes to move while others do not because any local improvement for a given mobile relay is a global improvement. This allowed them to potentially extend their approach to handle additional constraints on individual nodes such as low energy levels or mobility restrictions due to application requirements. Their approach can be implemented in a centralized or distributed fashion. Simulations show that it substantially reduces the energy consumption by up to 45 per cent.

X.Li, N. Mitton, I. S.-Ryl, and D. S.t-Ryl [5] proposed a novel Deterministic Dynamic Beacon Mobility Scheduling (DREAMS) algorithm, without requiring any prior knowledge of the sensory field. In this algorithm, the beacon trajectory is defined as the track of Depth-First Traversal (DFT) of the network graph, thus deterministic. The mobile beacon performs DFT dynamically, under the instruction of nearby sensors on the fly. It moves from sensor to sensor in an intelligent heuristic manner according to Received Signal Strength (RSS)-based distance measurements. They proved that DREAMS guarantees full localization (every sensor is localized) when the measurements are noise-free, and derive the upper bound of beacon total moving distance in this case. Then, they suggested to apply node elimination and Local Minimum Spanning Tree (LMST) to shorten beacon tour and reduce delay.

Further, they extended DREAMS to multi beacon scenarios. Beacons with different coordinate systems compete for localizing sensors. Loser beacons agree on winner beacons' coordinate system, and become cooperative in subsequent localization. All sensors are finally localized in commonly agreed coordinate systems. Through simulation they showed that DREAMS guarantees full localization even with noisy distance measurements. They evaluated its performance on localization delay and communication overhead in comparison with a previously proposed static path-based scheduling method.

F. Mourad, H. Chehade, H. Snoussi [6] proposed a method that consists of estimating the current position of a single target. Estimated positions are then used to predict the following location of the target. Once an area of interest is defined, the proposed approach consists of moving the mobile nodes in order to cover it in an optimal way. It thus defines a strategy for choosing the set of new sensors locations. Each node is then assigned one position within the set in the way to minimize the total travelled distance by the nodes. While the estimation and the prediction phases are performed using the interval theory, relocating nodes employ the ant colony optimization algorithm. Simulations results corroborate the efficiency of the proposed method compared to the target tracking methods considered for networks with static nodes.

J. Luo and J.P. Hubaux [7] built a unified framework to analyse the maximizing network lifetime (MNL) problem in WSNs. Their investigation, based on a graph model, jointly considers sink mobility and routing for lifetime maximization. They have formally proved the NP-hardness of the MNL involving multiple mobile sinks. They have then identified the sub problem that has a potential to guide routing protocol designs in practice. In particular, they have developed an efficient algorithm to solve the MNL problem involving only a single mobile sink; they have further generalized the algorithm to approximate the general MNL problem. In addition, using the duality theory, they have proved that, for on-graph mobility, moving the sinks is always better than keeping them static. Finally, they have illustrated the benefit of using a mobile sink by applying their algorithm to a set of typical topological graphs.

H. Dang and H. Wu [8] investigated a distributed clustering scheme and proposed a cluster-based routing protocol for Delay- Tolerant Mobile Networks (DTMNs). The basic idea is to distributively group mobile nodes with similar mobility pattern into a cluster, which can then interchangeably share their resources (such as buffer space) for overhead reduction and load balancing, aiming to achieve efficient and scalable routing in DTMN. Due to the lack of continuous communications among mobile nodes and possible errors in the estimation of nodal contact probability, convergence and stability become major challenges in distributed clustering in DTMN.

To this end, an exponentially weighted moving average (EWMA) scheme is employed for on-line updating nodal contact probability, with its mean proven to converge to the true contact probability. Based on nodal contact probabilities, a set of functions including Sync (), Leave(), and Join() are devised for cluster formation and gateway selection. Finally, the gateway nodes exchange network information and perform routing. Extensive simulations are carried out to evaluate the effectiveness and efficiency of the proposed cluster-based routing protocol. The simulation results show that it achieves higher delivery ratio and significantly lower overhead and end-to-end delay compared with its non-clustering counterpart.

Z. Zhou, Z. Peng and J.H. Cui [9] proposed a scheme, called Scalable Localization scheme with Mobility Prediction (SLMP), for underwater sensor networks. In SLMP, localization is performed in a hierarchical way, and the whole localization process is divided into two parts: anchor node localization and ordinary node localization. During the localization process, every node predicts its future mobility pattern according to its past known location information, and it can estimate its future location based on the predicted mobility pattern.

Anchor nodes with known locations in the network will control the localization process in order to balance the trade-off between localization accuracy, localization coverage, and communication cost. They conducted extensive simulations, and the results show that SLMP can greatly reduce localization communication cost while maintaining relatively high localization coverage and localization accuracy.

S. Park, E. Lee, H. Park, H. Lee, and S.H. Kim [10] proposed a novel geocasting, called M-Geocasting (Mobile Geocasting). M-Geocasting provides the representative location information of a sink group to sources. The location information contains information with respect to a restricted region in which all member sinks of the group exist. A source disseminates data to the closest node in the region; then, the node restrictedly floods the data only within the region. Also, to support local movement of member sinks toward out of scope of the region, some nodes on boundary of the region maintain the data and offer it to member sinks out of scope of the region.

The proposed M-Geocasting (Mobile Geocasting) representatively registers location information of a sink group. The location information contains the centre point location information and the radius with respect to the CGR where all member sinks of the group exist. Sources disseminate data to the CGR via the shortest paths; then, the closest nodes restrictedly flood the data only within the CGR. Also, to support local movement of member sinks toward out of scope of the CGR, some nodes on boundary of the CGR, named cache nodes, maintain the data and offer the data to member sinks out of scope of the CGR.

3. PROBLEM FORMULATION

Mobility of Sensors Nodes

Mobility is the major factor that affects the performance of the protocol. Due to high mobility of the nodes, unnecessary control information is exchanged that can degrade the performance of entire network. Due to the excessive node movement in the network, it may be unstable and control over head increases. Due to Mobility there may be:

1. Packet loss
2. Routing information loss
3. Congestion
4. Contention
5. Variation in routing load
6. Variation in throughput

All above factors can affect the overall performance of routing load as well as the output of entire network and in the case of clustered network, it becomes more difficult to maintain the performance of network. So there is need to have an efficient mobility control algorithm for the network. Each routing protocol has the following common phases:

1. Neighbour Discovery: In this phase, each node gathers the information about its neighbours

2. Topology Organization: In this phase, each node gathers the information about the entire network to maintain the topological information.
3. Route reorganization: During the topology reorganization, network is required to update the topology information by incorporating the topological changes occurred in the network due to the mobility of nodes or failure of nodes. It includes two different processes, first is the periodic exchange of topological information and second is the adaptability of the new topological information. In case of clustered networks, there is also a need to maintain the group information that causes extra control over head.

Whenever there is any change in topology, routing protocol performs above mentioned steps again and again and it causes control over head in entire network. So there is need to minimize the impact of mobility over network operations and to develop the mobility aware algorithms to enhance the performance of the network.

4. CONCLUSION

In this paper, we discussed the impact of mobility in wireless sensors network and the various solutions offered by different authors. Finally we can conclude that impact of the mobility can degrade the performance of entire network and different types of routing protocols and field environments have different impact of the mobility. Behaviour of the network is also dependent upon the selected mobility model.

REFERENCES

[1] Yuan-Yao Shih, Student Member, IEEE, Wei-Ho Chung, Member, IEEE, Pi-Cheng Hsiu, Member, IEEE and Ai-Chun Pang, Senior Member, IEEE, “A Mobility-Aware Node Deployment and Tree Construction Framework for ZigBee Wireless Networks”, 2013 IEEE.

[2] Qianqian Ren, Longjiang Guo Jinghua Zhu,Meirui Ren, Junqing Zhu, Harbin, China;,” Distributed Aggregation Algorithms for Mobile Sensor Networks with Group Mobility Model”, Tsinghua Science and Technology, October 2012

[3] Qian Dong, Waltenegus Dargie, Member, IEEE,,” A Survey on Mobility and Mobility-Aware MAC Protocols in Wireless Sensor Networks”, IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 15, NO. 1, FIRST QUARTER 2013

[4] Fatme El-Moukaddem, Eric Torng, and Guoliang Xing, Member, IEEE," Mobile Relay Configuration in Data-Intensive Wireless Sensor Networks", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 12, NO. 2, FEBRUARY 2013

[5] Xu Li, Nathalie Mitton, Isabelle Simplot-Ryl, and David Simplot-Ryl, "Dynamic Beacon Mobility Scheduling for Sensor Localization", IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS, VOL. 23, NO. 8, AUGUST 2012

[6] Farah Mourad, Hicham Chehade, Hichem Snoussi, Member, IEEE Farouk Yalaoui, Lionel Amodeo, and Ce´ dric Richard, Senior Member, IEEE, "Controlled Mobility Sensor Networks for Target Tracking Using Ant Colony Optimization", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 11, NO. 8, AUGUST 2012

[7] Jun Luo, Member, IEEE, and Jean-Pierre Hubaux, Fellow, IEEE, "Joint Sink Mobility and Routing to Maximize the Lifetime of Wireless Sensor Networks: The Case of Constrained Mobility", IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 18, NO. 3, JUNE 2010

[8] Ha Dang, Member, IEEE, and Hongyi Wu, Member, IEEE, "Clustering and Cluster-Based Routing Protocol for Delay-Tolerant Mobile Networks", IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 9, NO. 6, JUNE 2010

[9] Zhong Zhou, Student Member, IEEE, Zheng Peng, Student Member, IEEE,Jun-Hong Cui, Member, IEEE, Zhijie Shi, Member, IEEE, and Amvrossios C. Bagtzoglou," Scalable Localization with Mobility Prediction for Underwater Sensor Networks ", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 10, NO. 3, MARCH 2011

[10] Soochang Park, Euisin Lee, Hosung Park, Hyungjoo Lee, and Sang-Ha Kim, Member, IEEE," Mobile Geocasting to Support Mobile Sink Groups in Wireless Sensor Networks", IEEE COMMUNICATIONS LETTERS, VOL. 14, NO. 10, OCTOBER 2010

[11] Rui Tan, Student Member, IEEE, Guoliang Xing, Member, IEEE, Jianping Wang, Member, IEEE, and Hing Cheung So, Senior Member, IEEE," Exploiting Reactive Mobility for Collaborative Target Detection in Wireless Sensor Networks", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 9, NO. 3, MARCH 2010

[12] Yang Xia and Chai Kiat Yeo, "Measuring Group Mobility: A Topology Based Approach", 2012 IEEE

[13] C Siva Ram Murthy,"Wireless Ad hoc Network-Architectures and Protocols",Pearson-2012