Analysis of Routing Techniques Problems in Wireless Sensor Network

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Abstract: Wireless sensor networks are the networks that are characterized by decentralized structure and sensor deployment. Sensor networks have all the basic features of ad hoc networks but to different degrees – for example, much lower mobility and much more stringent energy requirements. In this paper we analyze the current state of research and evaluate open problems in development of routing techniques in wireless sensor networks.

Keywords: General Sensor Network, MANETs, Sensor Devices.

Introduction

Consider a wireless network made up of sensor units as shown in Figure 1 that perform both measurements and communications. These units are totally independent and are capable of recording data from sensors. The mobility of these units is very low but the data forwarding strategy is robust enough to be fault tolerant and to allow occasional mobility among units.

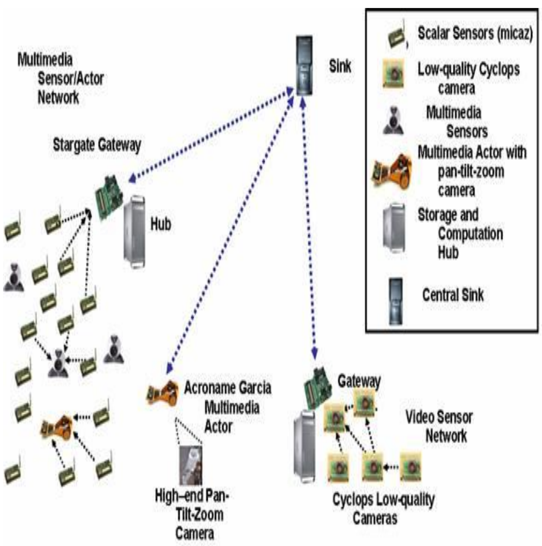

Figure 1: Sink with Sensing Units

For example, we consider the sensor network being developed for the Sensor project at UH Manoa [9]. One of the major objectives of the project is to implement a sensor network to study endangered plants such as "Silene Hawaiiensis", in order to determine what is essential for the plant's survival in its native habitat. The challenge is to implement an ad hoc network comprised of hundreds of small sensors which monitor wind, rain, temperature, light and moisture, and which are used for determining spatial or temporal patterns in the environment of the plant being studied.

Such a real life sensor network is comprised of hundreds of sensors. So the first networking challenge is getting data back with minimal energy expenditure, by choosing energy-efficient paths. The second challenge is to maintain connectivity in case some sensors are moved to a different location or fail to participate due to lack of power, though overall mobility is likely to be more limited than in a network of laptops. The third challenge is that sensor networks can be expected to grow too many thousands of nodes, so any algorithms used in these networks must be scalable. Finally, these networks should use multiple paths whenever possible, both for redundancy and to distribute the energy expenditure of forwarding packets. These requirements distinguish ad-hoc wireless sensor networks from mobile ad-hoc networks (MANETs).

A sensor network also differs from many of the wireless sensor networks considered in the literature. Though some data can be combined and summarized, other data, for example camera images, must be delivered unchanged to a base station. The sensor network is designed to have multiple base stations if possible. In addition, communication is not limited to sending data to base stations: interaction between individual sensor nodes may be needed to allow distributed computation among nodes in close geographic proximity, to support occasional communication from the base stations to the individual nodes, and for a variety of reasons including fault-tolerance. These requirements mean that a Sensor-style network needs to be able to support many to many communications, though the common mode of communication is from nodes to one or more base stations.

The research in wireless routing protocols is increasing day by day. The protocols provide different trade-offs among the desirable characteristics: fault tolerance, distributed computation, robustness, scalability, and reliability. Wireless protocols proposed so far for wireless sensor networks are very limited, generally focusing on communication to a single base station or on merging sensor data. While these protocols are suitable for their intended purposes.

Minimum Energy Consumption

In the wireless sensor network, the minimum energy consumption is an important consideration. The most efficient techniques to achieve energy efficiency in wireless network is power control schemes. The Protocols for mobile ad-hoc networks (MANETs) are designed for communication among units. Even though units are battery-powered, their power budget far exceeds that of a node in a wireless sensor network. Such nodes are often deployed in remote locations. Whether powered by batteries, solar energy, or some other method, reducing energy consumption and extends the lifetime of the package and makes the sensor easier to conceal. The work of each node in a wireless sensor network only needs to record, transmit, and forward data, unlike a laptop which might have to perform much more complex tasks. As a result, the computational unit in a sensor node consumes significantly less energy and communications must likewise use less energy. Many routing techniques have been proposed for both mobile ad-hoc networks (MANETs) and wireless sensor networks [2,4,5,6,8,10,11,12] including protocols that focus on “minimum energy” routing [10]. For example, [13] notes that a route with more, shorter path often requires less total energy than a route using long path. Thus minimization of the power relay route, minimizing the total energy consumption. However, none of these studies focus on practical issues such as the overhead of computing such minimum-energy routes. Why minimum energy routing is hard to implement in practice. Minimum energy routing introduces an overhead cost, the additional routing information is not free, current protocols fail to provide sufficient information for making power level decisions, lower power routes leave less margin for channel fluctuations, minimum energy routes are difficult to find, and minimum energy routes are difficult to maintain its originality. Because of these reasons, it is not currently clear that such “minimum energy” routing is in practice any better than other methods which have lower theoretical efficiency but provide other practical advantages. The limitations, we consider a variety of protocols, not only those which claim to use “minimal” energy.

Many mobile ad-hoc network (MANET) protocols focus on fast topology changes, and that a focus on power-aware metrics, location information, and the energy usage of each node can lead to more power-aware routing. Location information is used by some MANET protocols [1, 3, 9, 16] both to improve scalability and, in some cases, also to minimize energy consumption [7, 14].

Low Energy Adaptive Clustering Hierarchy (LEACH) [14] is a single path routing technique whose scalability is provided by its hierarchical nature. Leach proposes a clustering based protocol that utilizes randomized rotation of local cluster heads to evenly distribute energy load among the sensors in the network. In Low Energy Adaptive Clustering Hierarchy (LEACH) each local cluster head performs “local data fusion” to compress the information. LEACH requires a fixed base station to which data needs to be routed. Leach only supports sensors which do not move and send data at fixed rate, with symmetric radio channels, and adjustable transmit power. For a general sensor network it does not address the situation when more than one fixed base station is present, where sensors are not static, and where a node can communicate to another node in an arbitrary fashion. We are interested in, include the use of data diffusion, which is only useful to deliver the data to a single or a few base stations, and do not support communication between arbitrary nodes. The paper [10] showed that a path which is primarily found using location information may not be the most energy efficient path.

Low mobility

A mobile ad-hoc network (MANET) is a more general case where the participating laptops can either be stationary or move randomly with a random speed. As nodes within a MANET move, they move out of range of their neighbors and hence are no longer able to communicate with the old neighboring nodes and come within range of new nodes. Hence the mobility introduces the problem of fault tolerance. An ideal routing protocol for MANET should be able to deliver data packets from source to destination even when some of the intermediate nodes move away from their neighbors range. This makes the design of the routing protocol as this introduces additional routing overhead. In previous work [17], one of the authors related the speed of the movement of the nodes to the packet delivery ratio and routing overhead. The packet delivery ratio worsens as speed is increased for Dynamic state routing (DSR) [18], whereas Ad hoc on –demand distance vector routing (AODV) does not degrade as rapidly when mobility increases. Protocols such as Geographical and Energy Aware Routing (GEAR) and Low Energy Adaptive Clustering Hierarchy (LEACH) assume that the nodes in a sensor network are static.

Self-configuring nature

Ad hoc wireless sensor networks are self-configuring in nature. The network is adaptable to the changing requirements and is able to diagnose when a link / sensor node goes down and when it comes up. There are two main methods to design a Wireless Sensor Network (WSN), the address centric scheme and the data centric scheme. The address centric scheme has been used by various routing protocols. In these schemes we assign IP addresses to each sensor node, simplifying the process of routing. This concept is similar to that of normal wired networks. A unique IP address will help the source sensor node to know the sensor node to which data must be routed.

Multipath desirable

In paper [19] listed qualitative and quantitative independent metrics for identifying the performance of mobile ad hoc network routing protocols. There are a number of different path strategies. One that is very common is shortest path [1, 10] where one copy of the message is in the network at any time. At the other extreme is the flooding based approach [9,15] where the message is flooded through the whole network area. A good example of this approach is the Multi-path On-demand Routing (MOR) Protocol [15] which is on-demand, load balancing routing protocol designed for the Sensor project. MOR may require as little as one network flood to establish necessary routes and its energy efficient and robust in low mobility and low energy networks. It is proved that the use of multiple paths in Dynamic state routing (DSR) can keep correct end to end connections, but they did not study the performance improvement on network load balancing. It is shown in [20] that multipath routing can balance loads. They propose a diversity injection method to find more node-disjoint paths compared to Dynamic state routing (DSR). However, their work is based on multiple channel networks, which are contention free but may not be available in some applications.[7] applies the multipath strategy to DSR's source routing technique and achieves some scalability under mobile conditions. However the energy distribution component of the multipath strategy has not been adequately explored in the paper.

Scalability

An ideal routing protocol for a MANET should be scalable. This means that as the size of the network increases or the number of nodes increases the routing protocol should be able to adapt to the changes and provide consistent performance based on the parameters that we have discussed earlier. [1] Describes three methods, which have been used by researchers to provide scalability to a routing protocol for MANETs. The first method uses hierarchy to provide scalability. The second way to provide scalability is caching. The third way to provide scalability is using geographic information. Using hierarchy to provide scalability is the most widely deployed approach to scale routing as the number of destinations increases. Two main strategies used to combine nodes location and hierarchical network structures are the Zone Based Routing and the Dominating Set Routing. Online power-aware routing routing schemes are example of Zone Based Routing and GRID is an example of dominating set routing.

Caching is becoming a widely deployed technique for scaling ad hoc routing protocols in MANET [18]. Caching reduces the routing protocols message load in two ways: It avoids pushing topological information where the forwarding load does not require it (like ideal routers) and it often reduces the number of hops between the router that has topological information and the router that requires it. However, Doshi et al.,[10] demonstrated with their implementation of energy aware Dynamic state routing (DSR) protocol using old routes from the cache does not necessarily mean that a low energy route is selected every time.

The last and most frequently used technique to provide scalability to ad hoc routing protocols is to use the geographic location information. This technique assumes that all wireless nodes know their positions and links are bi-directional. This approach has been adapted in Greedy Perimeter Stateless Routing (GPSR), Geographical and Energy Aware Routing (GEAR) and gradient routing.

For a general sensor network a combination of the above-mentioned strategies would be sufficient to provide scalability, as mobility is limited in these networks.

Conclusion

We have evaluated the necessary features of the routing protocols for general wireless sensor network. Current research into routing protocols for MANETs and ad hoc sensor networks tend to make many tradeoffs in various features and are generally tested in a much regulated environment. It is discussed in the paper that the needs and requirements of routing protocols for general ad hoc sensor networks is very unique compared to routing protocols for MANETs and other sensor networks. Hence, there is a need for further research into this new field as it poses some of its unique challenges and we would be continuing our research in this area in future.

References

1. B.Karp and HT.Kung, "*GPSR: Greedy peimeter stateless routing for wireless networks*", Proc. MOBICOM, August 2000, pp 243-254.

2. B.Krishnamachari et al., "*Modeling Data-Centric Routing in Wireless sensor networks*".

3. Chalermek Intanagonwiwat, R.Govindan and D.Estrin, "*Directed Diffusion: A scalable and robust communication paradigm for sensor networks*", in proc. ACM MOBICOMM, Boston, MA, 2000.

4. D.Estrin, R.Govindan, J.Heidemann, S.Kumar, "*Next century challenges: Scalable co-ordination in sensor networks*", Proceedings of MOBICOM, 1999, Seattle, 263-270.

5. I.D.Aron., "*On the scalability of on-demand routing protocols for mobile ad hoc networks: an analytical study*".

6. I.Stojmenovic and Xu Lin, "*Power-aware localized routing in wireless networks*", IEEE Int. Parallel and distributed processing symp., Cancun, Mexico, May 1-5, 2000, pp. 371-376.

7. K.Wu and J.Harms, “*On-demand multipath routing for mobile ad-hoc networks*”, Computer science department, University of Alberta, AB, Canada.

8. Robert D.Poor, “*Gradient Routing in Ad Hoc Networks*”.

9. S.Basagni, I.Chtamtac, V.R.Syrotiuk, B.A Woodward, “*A distance routing effect algorithm for mobility (DREAM)*”, Proceedings of MOBICOM, 1998, 76-84.

10. S.Doshi, T.X.Brown, “*Minimum energy routing schemes for a wireless ad hoc network*”, IEEE INFOCOM 2002.

11. S.Giordano, I.Stojmenovic et al.,”*Position based Routing: Algorithms for Ad Hoc Networks: ATaxonomy*”.

12. V.Ruduplu, T.Meng, “*Minimum energy mobile wireless networks*”, IEEE JSAC, v.17, n.8, August 1999, pp. 13333-44.

13. S.Singh, M., and C.S.Raghavendra, “*Power aware routing in mobile ad-hoc networks*”, Proceedings of MOBICOM, 1998, pp. 181-190.

14. W., Rabiner, A.Heinzelman, A.Chandrakasan and H.Balakrishnan, “*Energy-efficient communication protocol for wireless microsensor networks*”, in proceedings of the 33rd HICSS, 2000

15. Edoardo Biagioni, Kent Bridges, “*The Application of Remote Sensor Technology to Assist the Recovery of Rare and Endangered Species*”, Accepted for publication in a special issue on Distributed Sensor Networks for the International Journal of High Performance Computing Applications, Vol. 16, N. 3 (August 2002).

16. W.H. Liao, Y.C. Tseng. J.P. Sheu, “*GRID: A fully location-aware routing protocols for mobile ad-hoc networks*”, Proc. IEEE HICSS, January 2000.

17. Nitin Nagar and A.Kongmunvattana, "*Analysis of Routing Protocol Performance on Multi-Hop Wireless Ad Hoc Networks*", The 2001 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'2001), Las Vegas, June 25-28, 2001.

18. D.Johnson , D.Maltz, “*Dynamic source routing in ad hoc wireless networks*”, Mobile computing, Chapter 5, pp. 153-181, Luwer Academic Publishers, 1996.

19. J.P. Macker and M.S. Corson, “*Mobile ad-hoc networking and the IETF*”, Mobile computing and communications review, 2, 1, 1998, 9-14.

20. M.R Perlman, Z.J.Hass, P.Sholander and S.S Tabrizi, “*On the impact of Alternate Path Routing for load balancing in Mobile Ad Hoc Networks*”, Proceedings of IEEE/ACM MobiHoc 2000, Boston, 2000.