Survey on Various Routing Protocols WSN

Pretty Singla[1], Sandeep Kumar[2], Gurbaj Singh[3]
[1,2]GITM Bilaspur, Yamunanagar, Haryana
[1]pretty06singla@gmail.com, [2]Sandeep167@gmail.com, [3]gurbajsingh86@gmail.com

Abstract- This paper surveys recent routing protocols for sensor networks and presents a classification for the various approaches pursued. The three main categories explored in this paper are data-centric, hierarchical and location-based. Each routing protocol is described and discussed under the appropriate category. Moreover, protocols using contemporary methodologies such as network flow and quality of service modeling are also discussed.
Keywords- WSN, Routing Protocols, network

1. Introduction

Recent advances in micro-electro-mechanical systems and low power and highly integrated digital electronics have led to the development of micro-sensors . Such sensors are generally equipped with data processing and communication capabilities. The sensing circuitry measures ambient conditions related to the environment surrounding the sensor and transforms them into an electric signal. Processing such a signal reveals some properties about objects located and/or events happening in the vicinity of the sensor. The sensor sends such collected data, usually via radio transmitter, to a command center (sink) either directly or through a data concentration center (a gateway). The decrease in the size and cost of sensors, resulting from such technological advances, has fueled interest in the possible use of large set of disposable unattended sensors. Such interest has motivated intensive research in the past few years addressing the potential of collaboration among sensors in data gathering and processing and the coordination and management of the sensing activity and data flow to the sink. A natural architecture for such collaborative distributed sensors is a network with wireless links that can beformed among the sensors in an ad hoc manner. sensor nodes are constrained in energy supply and bandwidth. Such constraints combined with a typical deployment of large number of sensor nodes have posed many challenges to the design and management of sensor networks. These challenges necessitate energy awareness at all layers of networking protocol stack. The issues related to physical and link layers are generally common for all kind of sensor applications, therefore the research on these areas has been focused on system-level power awareness such as dynamic voltage scaling, radio communication hardware, low duty cycle issues, system partitioning, energy-aware MAC protocols. At the network layer, the main aim is to find ways for energy-efficient route setup and reliable relaying of data from the sensor nodes to the sink sothat the lifetime of the network is maximized. Routing in sensor networks is very challengingdue to several characteristics that distinguish them from contemporary communication and wireless ad hoc networks. First of all, it is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes. Therefore, classical IP-based protocols cannot be applied to sensor networks. Second, in contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink. Third, generated data traffic has significant redundancy in it since multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Fourth, sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management. Due to such differences, many new algorithms have been proposed for the problem of routing data in sensor networks. These routing mechanisms have considered the characteristics of sensor nodes along with the application and architecture requirements. Almost all of the routing protocols can be classified as data-centric, hierarchical or location based although there are few distinct ones based on network flow or quality of service (QoS) awareness. Data-centric protocols are query-based and depend on the naming of desired data, which helps in eliminating many redundant transmissions. Hierarchical protocols aim at clustering the nodes so that cluster heads can do some aggregation and reduction of data in order to save energy. Location based protocols utilize the position information to relay the data to the desired regions rather than the whole network. The last category includes routing approaches that are based on general network-flow modeling and protocols that strive for meeting some QoS requirements along with the routing function. In this paper, we will explore the routing mechanisms for sensor networks developed in recent years. Each routing protocol is discussed under the proper category. Our aim is to help better understanding of the current routing protocols for wireless sensor networks and point out open issues that can be subject to further research.[1,2,3,4]

2. System architecture and design issues

Depending on the application, different architectures and design goals/constraints have beenconsidered for sensor networks. Since the performance of a routing protocol is closely related to the architectural model, in this section we strive to capture architectural issues and highlight theirimplications.[5]

3. Network dynamics

There are three main components in a sensor network. These are the sensor nodes, sink and monitored events. Aside from the very few setups that utilize mobile sensors , most of the network architectures assume that sensor nodes are stationary. On the other hand, supporting the mobility of sinks or cluster-heads (gateways) is sometimes deemed necessary . Routing messages from or to moving nodes is more challenging since route stability becomes an important optimization factor, in addition to energy, bandwidth etc. The sensed event can be either dynamic or static depending on the application. For instance, in a target detection/tracking application, the event (phenomenon) is dynamic whereas forest monitoring for early fire prevention is an example of static events. Monitoring static events allows the network to work in a reactive mode, simply generating traffic when reporting. Dynamic events in most applicationsrequire periodic reporting and consequently generate significant traffic to be routed to the sink.[6,7,8]

4. Node deployment

Another consideration is the topological deployment of nodes. This is application dependentand affects the performance of the routing protocol. The deployment is either deterministic orself-organizing. In deterministic situations, the sensors are manually placed and data is routedthrough pre-determined paths. However in selforganizing systems, the sensor nodes are scatteredrandomly creating an infrastructure in an ad hoc manner. In that infrastructure, the position of the sink or the cluster-head is also crucial in terms of energy efficiency and performance. Whenthe distribution of nodes is not uniform, optimal clustering becomes a pressing issue to enable energy efficient network operation.[9,10]

5. Energy considerations

During the creation of an infrastructure, the process of setting up the routes is greatly influencedby energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi-hop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi-hop routing becomes unavoidable.[11]

6. Data delivery models

Depending on the application of the sensor network, the data delivery model to the sink can be continuous, event-driven, query-driven and hybrid. In the continuous delivery model, each sensor sends data periodically. In event-driven and query driven models, the transmission of data is triggered when an event occurs or a query is generated by the sink. Some networks apply a hybrid model using a combination of continuous, event-driven and query-driven data delivery. The routing protocol is highly influenced by the data delivery model, especially with regard to the minimization of energy consumption and route stability. For instance, it has been concluded in that for a habitat monitoring application where data is continuously transmitted to the sink, a hierarchical routing protocol is the most efficient alternative. This is due to the fact that such an application generates significant redundant data that can be aggregated on route to the sink, thus reducing traffic and saving energy.[12]

7. Node capabilities

In a sensor network, different functionalities can be associated with the sensor nodes. In earlier works, all sensor nodes are assumed to be homogenous, having equal capacity in terms of computation, communication and power. However, depending on the application a node can bededicated to a particular special function such as relaying, sensing and aggregation since engaging the three functionalities at the same time on a node might quickly drain the energy of that node. Some of the hierarchical protocols proposed in the literature designate a cluster-head different from the normal sensors. While some networks have picked cluster-heads from the deployed sensors, in other applications a cluster-head is more powerful than the sensor nodes in terms of energy, bandwidth and memory. In such cases, the burden of transmission to the sink and aggregations handled by the cluster-head[13].

8. Location-based protocols

Most of the routing protocols for sensor networks require location information for sensor nodes. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Since, there is no addressing scheme for sensor networks like IP-addresses and they are spatially deployed on a region, location information can be utilized in routing data in an energy efficient way. For instance, if the region to be sensed is known, using the location of sensors, the query can be diffused only to that particular region which will eliminate the number of transmission significantly. Some of the protocols discussed here are designed primarily for mobile ad hoc networks and consider the mobility of nodes during the design . However, they are also well applicable to sensor networks where there is less or no mobility. It is worth noting that there are other location based protocols designed for wireless ad hoc networks, such as Cartesian and trajectory-based routing. However, many of these protocols are not applicable to sensor networks since they are not energy aware. In order to stay with the theme of the survey, we limit the scope of coverage to only energy-aware location-based protocols[14].

9. Network flow and QoS-aware protocols

Although most of the routing protocols proposed for sensor networks fit our classification, some pursue somewhat different approach such as network flow and QoS. In some approaches, route setup is modeled and solved as a network flow problem. QoS-aware protocols consider end-to end delay requirements while setting up the paths in the sensor network.[15]

10. Conclusion

Routing in sensor networks has attracted a lot of attention in the recent years and introducedunique challenges compared to traditional data routing in wired networks. In this paper, we havesummarized recent research results on data routing in sensor networks and classified the approaches into three main categories, namely data-centric, hierarchical and location-based. Few other protocols followed the traditional network flow and QoS modeling methodology. Protocols, which name the data and query the nodes based on some attributes of the data arecategorized as data-centric. Many of the researchers follow this paradigm in order to avoid the overhead of forming clusters, the use of specialized nodes etc. However, the naming schemessuch as attribute-value pairs might not be sufficient for complex queries and they are usually dependent on the application. Efficient standard naming schemes are one of the most interesting future research direction related to this category.

11. References

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