무선 센서 네트워크의 라우팅 프로토콜 비교 분석

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Comparative Analysis of Routing Protocols for Wireless Sensor Networks

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요 약

무선 센서 네트워크의 센서 노드는 다양한 최소형 센서로 구성된 저전력, 저메모리, 저컴퓨터 능력을 갖고 있다. 따라서 최근 무선 센서 네트워크의 이슈는 실용적인 응용 분야에서의 에너지 보존과 네트워크 수명을 만족하는 설계 및 개발을 요구한다. 이러한 에너지 소비량과 네트워크 수명을 만족하기 위해서 효율적인 라우팅 프로토콜 연구가 지속되어야 한다. 본 논문에서는 무선 센서 네트워크의 LEACH, LEACH-C, MTE, 그리고 PEGASIS 라우팅 프로토콜에 대해서 비교 분석하였다. 각각의 프로토콜의 운영 시간, 밧데리 소모, 총 에너지 소모량을 비교한다.

ABSTRACT

Wireless sensor networks consist of thousands of sensor nodes that have low power, low footprint and low computational capacities. So the burning issues in the design and deployment of these sensor nodes in the practical application areas include the energy conservation and network lifetime. Efficient routing schemes can help reduce the energy consumption and thus increase the network lifetime. This paper deals with the comparative analysis of popular routing protocols such as LEACH, LEACH-C, MTE, and PEGASIS. The protocols are compared by using performance metrics such as system lifetime, the time for first node death, and total system energy.

Keywords

Wireless Sensor Networks, Sensor Nodes, Microsensors, MAC Protocol, CSMA, TDMA, Single-hop, Multi-hop, leader node, Cluster Head

I. Introduction

With the advances in the technology it has now become possible to design wireless sensor networks with small, low-power and relatively inexpensive sensors called microsensors. These microsensors are capable of sensing and extracting data from the environment and transmitting the same to the sink or base station. The main application areas include battle field surveillance, habitat monitoring, healthcare, chemical or biological detection, and etc. The main issues that affect the design and implementation of WSN based applications are: communication bandwidth and energy [2].

Routing in WSNs is challenging due to some inherent characteristics that distinguish them from other traditional networks. First, due to relatively high number of sensor nodes, it is not possible to build global addressing scheme for the deployment of large number of sensor nodes because of the possible increase in overhead. Second, the sensed data flows through multiple sources to the sink or base station [6]. Third, sensor nodes are tightly constrained in terms of energy, processing and

storage capability [6]. Fourth, in most applications sensor nodes are stationary after deployment [6]. Fifth, position awareness is important, since data collection needs localization. It is not possible to use GPS system to find the position because of hardware limitations. Methods based on triangulation [10] may be applied to find the position from few known points. Finally, data collected through different nodes in the network have same properties. This may result in redundant data transmission [6]. Routing schemes have to be designed taking into considerations of all of these factors if possible.

Many routing protocols and algorithms have been proposed. These protocols take into considerations of inherent factors as well as the application requirements, but the basic theme being the overall network lifetime. Broadly, these routing schemes can be classified as below:

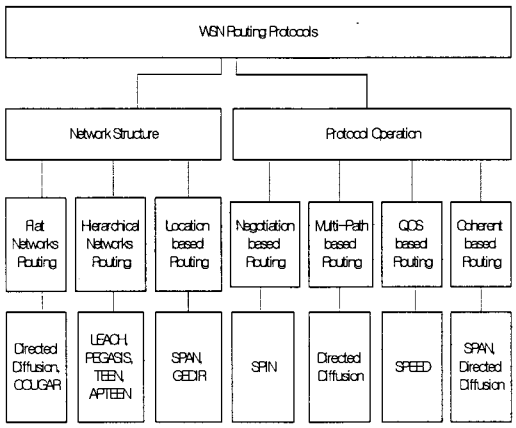

Figure 1: Routing protocols in WSNs

Furthermore, based on the mode of functioning, the sensor networks can be divided into: Proactive Networks and Reactive Networks [11]. Proactive Networks are the networks in which sensor nodes periodically sense the data and send to the base station [11]. For example LEACH [1]. On the other hand, reactive Networks are networks in which the sensor nodes send the data if there is certain change in value of sensed attribute beyond a pre-determined threshold value [11]. For example TEEN[7].

Among the various protocols proposed, LEACH is the most popular one, and is considered to be the basic protocol for hierarchical routing. Many protocols since then are somehow based on hierarchical topology as proposed in LEACH [1]. Similarly, LEACH-C [2], PEGASIS [4], Concentric Clustering Scheme [5], TEEN [7], APTEEN [11], and HEED [8] are some popular protocols.

Ⅱ. Some Popular Routing Protocols in WSN

a. Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is the first hierarchical clustering algorithm proposed for WSNs. It was introduced by Heinzelman, et. al. [1]. LEACH is a cluster-based protocol, which includes distributed cluster formation. LEACH randomly selects few nodes in the network as Cluster Heads (CHs). Each node selected as CH for the current round broadcasts an advertisement message to the rest of the nodes. This phase is called advertisement phase. For this phase, the CHs use a CSMA MAC protocol, and all the CHs transmit their advertisement using the same transmit energy. The non-CH nodes must turn on their radios during this phase to hear the advertisement. After hearing the advertisement, each node decides for the cluster to which they belong to. This decision is based on the signal strength of the advertisement. The CH advertisement with the strongest signal determines the CH to whom the minimum amount of energy is needed for communication. In case of ties a random CH is chosen [1].After each node has decided to which cluster it belongs, it informs the CH node that it will be member of the cluster. Each node transmits back this information to the CH using a CSMA MAC protocol. This phase is called cluster set-up phase [1] All CH nodes must keep their receiver on during this phase. After receiving the information during cluster set-up phase [1], the CH node creates a TDMA schedule telling each node when it can transmit. This decision is based on the number of nodes in the cluster and is broadcast back to the nodes in the cluster. This phase is called schedule creation phase [1]. Once the schedule is created, data transmission can begin. The nodes have to send their data to the CHs during their allocated transmission time. The radios of the non-CH nodes can be turned off until the nodes allocated transmission time, thus saving the energy. When the CH receives all the data, it performs compression operations on the data and compress into single data. This composite signal is then sent to the base station (BS). This phase is called data transmission phase [1]

b. LEACH-Centralized (LEACH-C)

LEACH-C algorithm is similar to LEACH algorithm except for the election of the CHs [2].In LEACH-C, the nodes send their current location and energy level to the BS. The BS determines the best nodes for forming cluster head, so that the energy load is evenly distributed throughout the network. Besides it also takes into considerations of energy level of the node. If the energy level is below a pre-determined threshold value, then the node is not selected as CH. Once the CHs are identified, the BS uses simulated annealing algorithm to solve the NP-hard problem of finding the k optimal clusters.

c. Minimum Transmission Energy (MTE)

In MTE, each node finds the neighboring node which is one hop near to the BS. This process is repeated until a complete chain of nodes is formed. So the data is transmitted from each node to the node closer to the BS [1]. The nodes closest to the BS will be used to route a large number of data messages to the BS. These nodes will die out quickly [1].

d. Power Efficient GAthering In Sensor Infomation System (PEGASIS)

The main idea behind the PEGASIS [4] is for each node to receive from and transmit to the close neighbors and take turns being the leader for transmission to the BS. In PEGASIS, chain construction is started from the node which is furthest from the BS. The chain is constructed using greedy algorithm. If some nodes in the chain die, then the chain is reconstructed by-passing the dead nodes. Once the chain is constructed, one of the nodes in the chain is selected as leader node [4]. Each node in the chain gathers data from its one neighbor, fuses with its own data, and transmits it to the other neighbor in the chain. Finally the leader node gathers data in the chain and transmits to the base station. The leader node in the chain is selected by using the relation i mod N, where N represents the number of nodes and i represents the rounds.

III. Performance Analysis

From the simulation results presented in [2] we can conclude that LEACH-C is more efficient in terms total amount of data received at the BS per given amount of energy as compared to LEACH and MTE. Similarly from the simulation results presented in [4] we can conclude that PEGASIS outperforms LEACH - C, LEACH and Direct Transmission in terms of number of rounds until 1%, 20%, 50% and 100% nodes die. The reason is that in LEACH multiple data aggregation might occur at a node, thus increasing the energy consumption at each node, which results in faster death of nodes. In contrast, in PEGASIS, the number of data aggregation is only two, each from each side of the chain. This results in lesser energy consumption, thus reducing the death of node for number of rounds. The fewer number of nodes death as the number of rounds increases, implies that less energy is consumed for communication and data transmission.

LEACH family of protocols use single-hop or multi-hop communication method to collect the data at the CH. CH might receive data from more than two nodes. CH will have to spend more energy to compress the data received from the nodes. But in PEGASIS, data is received at the leader node at most from two nodes. So the data aggregation and compression operation requires less energy as compared to that of LEACH family of protocols.

Though PEGASIS is energy efficient than LEACH, still there is room for improvements. Considering of residual energy while selecting the leader node, the time for the death of first node can be increased significantly.

IV. Conclusion

While designing the protocol for WSN it is important to take into factors such as applicability, functionality, energy constraints and ease of deployment. Taking these into considerations no protocol can be said to be fool proof. The quest for better protocols still exists and will exist in future too, but the selection of protocols can be made depending upon the specific application requirements. The results from the various simulations and papers show that clustering schemes such as LEACH, PEGASIS etc. are more energy efficient, have less delay and are less tolerant to network failure.

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