WSN 에서 베이스스테이션을 이용한 계층적 라우팅 프로토콜 최적화

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Base Station Assisted Optimization of Hierarchical Routing Protocol in Wireless Sensor Network

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요 약

센서노드의 에너지를 절약하는 것은 네트워크 수명을 늘리기 위해 필요하다. 센서의 에너지는 파워를 교체할 수 없기 때문에 매우 중요하다. 에너지를 절약함으로써 네트워크의 자원을 절약하고 더 오랫동안 사용할 수 있다. 이 논문에서는 베이스 스테이션을 활용하여 라우팅 프로토콜을 최적화하기 위한 프로토콜인 BSAH 를 제안하였다. BSAH 는 BeamStar 처럼 베이스스테이션이 안테나의 방향을 고려하여 센서를 나눈다. BSAG 는 PEGASIS 나 CHIRON 보다 25%에서 30% 정도 우수한 성능을 보였다.

Preserving energy of sensor node in wireless sensor network is an effort to prolong the lifetime of network. Energy of sensor node is very crucial because battery powered and irreplaceable. Energy conservation of sensor node is an effort to reduce energy consumption in order to preserve resource for network lifetime. It can be achieved through efficient energy usage by reducing consumption of energy or decrease energy usage while achieving a similar outcome. In this paper, we propose optimization of energy efficient base station assisted hierarchical routing protocol in wireless sensor network, named BSAH, which use base station to controlled overhead of sensor node and create clustering to distribute energy dissipation and increase energy efficiency of all sensor node. Main idea of BSAH is based on the concept of BeamStar, which divide sensor node into group by base station uses directional antenna and maximize the computation energy in base station to reduce computational energy in sensor node for conservation of network lifetime. The performance of BSAH compared to PEGASIS and CHIRON based of hierarchical routing protocol. The simulation results show that BSAH achieve 25% and 30% of improvement on network lifetime.

1. INTRODUCTION

Wireless sensor network (WSN) have emerged as the state of the art technology in gathering data from remote locations by interacting with physical phenomena and relying on collaborative efforts by large number of low cost devices. Typically, a WSN comprises of hundreds of thousands of low cost sensor nodes. Each sensor node has an embedded processor, a wireless interface for communication, a non-replenish-able source of energy, and one or more on-board sensors such as temperature, humidity, motion, speed, photo, and piezoelectric detectors. Once deployed, sensor nodes collect the information of interest from their on-board sensors, perform local processing of these data including quantization and compression, and forward the data to a base station (BS) directly or through a neighbouring relay node. The ability to have direct interaction with physical phenomena resulted in the development of a vast number of applications for wireless sensor networks such as, military, commercial, intrusion detection and industrial, healthcare and disaster and rescue operations.

Most deployments of wireless sensor network require unattended operation; therefore, sensor nodes have to rely on batteries for communication and information gathering. Sensor nodes are significantly constrained in available resources including storage, computational capacity, however energy accounts for the most restrictive of all factors because it affects the operational lifetime of wireless sensor network. It is a well-established fact that wireless communication is the major source of energy drainage in wireless sensor network. Therefore, energy efficient communication protocols and topology architectures are highly desirable. In recent years clustering has emerged as a popular approach for organizing the network into a connected hierarchy. By using clustering, nodes are organized into small disjoint

"This research was supported by the MKE (The Ministry of Knowledge Economy), Korea, under the ITRC (Information Technology Research Center) support program supervised by the NIPA (National IT Industry Promotion Agency)" (NIPA-2011-C1090-1131-0004)

groups called clusters. Each cluster has a coordinator referred to as cluster head (CH) and a number of member nodes. Clustering results in a hierarchical network in which cluster head form the upper level and member nodes form the lower level. In contrast to flat architectures, clustering provides distinct advantages with respect to energy conservative by facilitating localized control and reducing the volume of inter-node communication. Moreover, the coordination provided by the cluster head allows sensor nodes to sleep for extended period thus allowing significant energy savings. Despite many advantages of clustering in wireless sensor network such as network scalability, localized route set up, bandwidth management, the fundamental objective centers around energy conservation.

Cluster formation is a process whereby sensor nodes decide with which cluster head they should associate among multiple choices. After the cluster head are elected, the non-cluster head nodes are faced with the task of selecting a cluster head from a number of possible candidates based on the criteria of optimal energy use. For a sensor node, selecting the cluster head based on a single objective can lead to poor energy use because the nearest cluster head may be located at a greater distance from base station than the other cluster head. Thus for that particular node this may not be the best choice. In addition, factors like residual energy and transmission energy may also be of importance when making a decision.

The rest of the paper is organized as follows. The whole paper is organized as follow: Section II discusses the related work on a clustering method, section III discusses the proposed algorithm clustering protocol with mode selection, section IV discusses the simulation and section V describes the conclusion of the work.

2. RELATED WORK

In recent years clustering for ad hoc and wireless sensor network have been a popular area of research and several algorithms have been proposed. These techniques can be classified in a number of ways such as clustering method (distributed, centralized), network architecture (single-hop, multi-hop), clustering objective (energy efficiency, coverage) or cluster head selection method (random, deterministic).

Clustering techniques have emerged as a popular choice for achieving energy efficiency and scalable performance in large scale sensor networks. Cluster formation is a process whereby sensor nodes decide which cluster head they should associate with among multiple choices. Typically this cluster head selection decision involves a metric based on parameters including residual energy and distance to the cluster head. This decision is a critical embarkation point as a poor choice can lead to increased energy consumption, thus compromising network lifetime.

Shiwen Mao et al, proposed BeamStar : An edge based approach to routing protocol in Wireless Sensor Networks. Beamstar is first used to divide the sensing area into several fan-shaped groups. The sensor nodes within each group are then self-organized into a chain for data transmission. Unlike traditional approaches, instead of taking turns, we consider the node with a maximum residual energy as chain leader candidate.

In 2009, Kuong-Ho Chen et al, proposed a variation of BeamStar routing scheme, termed as CHIRON: An energy efficient chain-based hierarchical routing protocol in wireless sensor network. Main idea of CHIRON is to split the sensing field into a number of smaller areas, so that it can create multiple shorter chains to reduce the data transmission delay and redundant path, and therefore effectively conserve the node energy and prolong the network lifetime.

3. Proposed Algorithm

Our work is closely related to An Energy Efficient Chain Based Hierarchical Routing Protocol in Wireless Sensor Network (CHIRON), which adopts the technique of BeamStar to organize its groups.

The operation of BSAH protocol consists of three phases:

1) Initialization Phase
2) Formation Phase
3) Transmission Phase

1. Initialization Phase

The main purpose of this phase is to gather information of the entire node in the field. After the sensor nodes are scattered, each node transmits its own information to the base station. Since transmitting to base station required substantial amount of energy, this phase is executed only once. Base station receives and gathers all information from each of the node in the field. Base station calculates the average energy level of all nodes. Nodes which have energy higher than average are selected to be candidate node (CN). Base station calculates the angle of two CN located at the farthest left and the farthest right from the base station and also has maximum separation. The angle then split into two equal angles. The nodes are split into two groups, the right group and the left group. Within each group, the splitting process is conducted again the same way as the first splitting process which creates another new group. This process repeated until all the CN are split into group or the angle separation between two CN are less than half of the previous group.

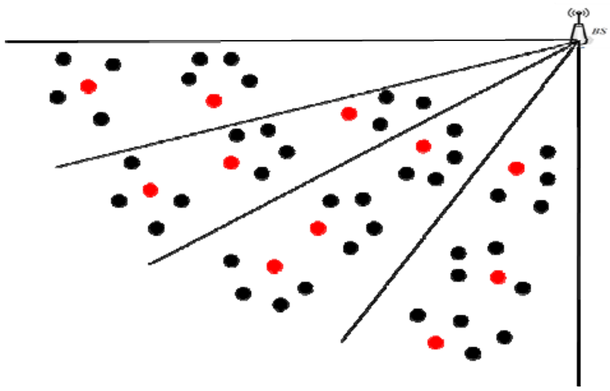

Fig. 1: Split Process

Next process is creating layer. In our algorithm, we use similar approach, as in BIDRP, using the signal strength from the base station to form level. The level divided according to the signal strength receives by the base station. The clusters are formed after two process conducted.

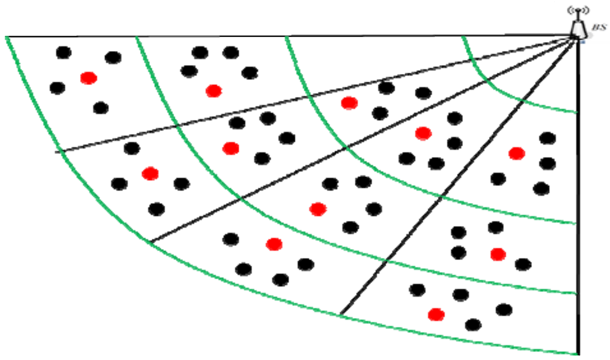

Fig. 2: Layer Process and forming cluster

3.1 Formation Phase

In this phase, the nodes within each cluster will be linked together to form a chain. The chain formation process is the same as that in CHIRON scheme. A leader node in each cluster must be selected for collecting and forwarding the aggregated data to the cluster head. An election of leader node, as in CHIRON, based on the maximum value of residual energy where it chosen as cluster head (CH). For each cluster, each the node sends sensing data to CH. To reduce the amount of energy dissipation, leader CH must be elected to aggregate data among the CH and substantial amount of energy required to send final data to the base station. In order to elect leader from the CH, the base station calculate transmission energy required to send data and residual energy for each CH. The CH which has the maximum residual energy and minimal transmission energy is elected as Cluster Leader (CL).

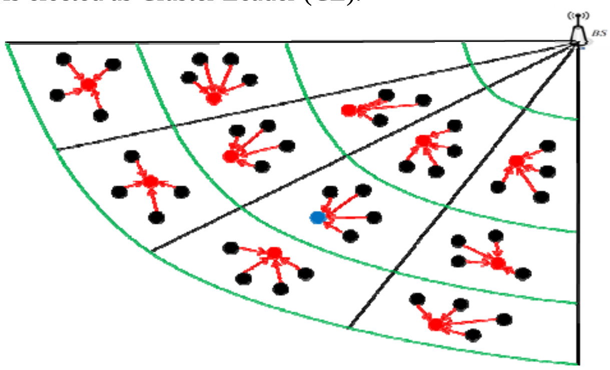

Fig. 3: CH and CL election and data collection

3.2 Transmission Phase

After completed the previous phase, the data collection and transmission phase begins. The data transmission procedure is similar to that in CHIRON scheme. The CH that is farthest away from the base station is initiated to create chain. The CH collaboratively relay their aggregated sensing information to the base station, in a multi hop, CH by CH transmission manner. In the interest of reducing the energy dissipation to elect relaying CH, there are several criteria needs to be determined. The following are criteria to assort relaying CH:

1) The chosen relaying CH is in the same layer or led to CL layer
2) The distance of the chosen relaying CH is closer to the CL

The transmission energy / weight cost (considering the distance and residual energy) from the CH to the chosen relaying CH is minimum.

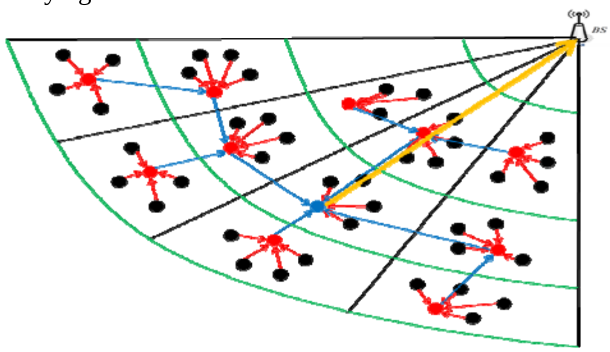

Fig. 4: Transmission phase to Cluster Leader and Base Station

4. SIMULATION

In this section, we present simulation studies for proposed BSAH protocol. To assess the performance of BSAH, we simulate performance using NS2 to conduct several experiments. The objective of this simulation study is to compare its performance result with other clustering based routing protocol such as PEGASIS and CHIRON. In our simulation, we consider two different size of sensing area: 100 m x 100 m and 200 m x 200 m, each with 100 randomly deployed sensor nodes. The base station is located 1000 m and on the corner of the sensing field. The value of energy parameters are assumed as follows:

$E_{elec} = 50$ nJ/bit
$_{fs} = 10$ pJ/bit/m^2
$_{mp} = 0.0013$ pJ/bit/m^4

Every sensor node is initially equipped with 0.5 joules power. We define the simulation round as a duration time in which all sensor nodes sent a 2000-bit packet to the base station. For each simulation scenario, the results are drawn by the average value of 10 runs.

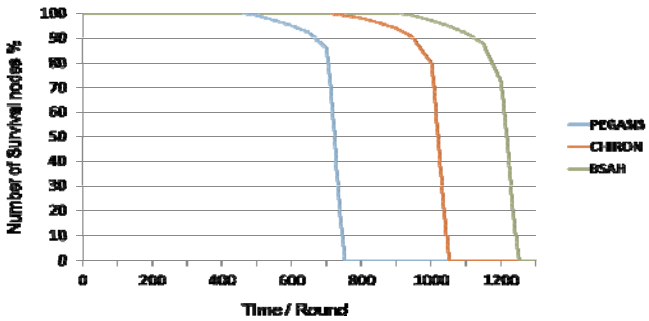

Fig. 5: Network lifetime comparison 100 x 100 m^2 sensing area

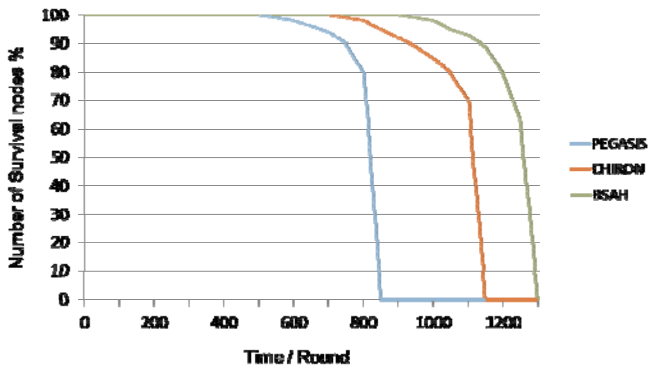

Fig. 6: Network lifetime comparison 200 x 200 m^2 sensing area

The simulation results show simulated network lifetime derived from PEGASIS, CHIRON and BSAH scheme, under two sensing area. It could be observed that that our proposed BSAH protocol performs better than PEGASIS and CHIRON. The improved extents can be achieved to about 25% and 30% of network lifetime respectively, compared to PEGASIS and CHIRON protocol, under small and large simulation areas.

5. CONCLUSION

In this paper, we presented OBSEAH, a novel optimization of energy efficient base station assisted hierarchical routing protocol in wireless sensor network. We exploited the capabilities of directional antenna and power control at the base station to assist routing and clustering. As a result, the functions of each sensor node can be made much simpler, enabling considerable cost and size reduction on sensor node.

Simulation results demonstrate that OBEASAH achieved significant energy savings and enhances network lifetime compare to PEGASIS and CHIRON. We show that BSAH achieves better performance than other clustering based routing protocol. As a result, the size and cost of a sensor node can be substantially reduced.

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