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Comparing Leach protocol and its descendants on transferring scalar data

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ABSTRACT

In the last years, The CMOS was developed and miniaturized rapidly, which, made sensors very fast, small and accurate. Hence, the creation of wireless sensor network (WSN) which are a network of nodes that exchange the data between them until it reaches the sink (base station). It is responsible for treating the data and transfer them to other servers linked to the internet for further treatment or storage. Therefore, everything related to WSN is a big topic of research for scientific community, especially transferring scalar data. In fact, many factors enter into account when it comes to send data like a radio, range of transmission, energy consumption and routing protocol. Routing protocols are very important in transferring data. They also have a big impact on energy consumption by nodes. Many categories of routing protocols exist: planning and level routing. Each type has its strength and weakness points. So, using a routing protocol in high-density environments is very challenging in energy consumption and data delivery. In addition, since level routing protocols like Leach are known for their energy efficiency. We choose three level routing protocol (Leach, MLD-Leach and MRE-Leach) to put them in a harsh environment to test their energy consumption and data transferring. We found that MLD-Leach has better energy consumption and data delivery.

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1. INTRODUCTION

The in the last years, the continuous development in electronic circuits has allowed the low cost of miniaturized sensors. These sensors are used to collect information from the environment. After that, they process the collected data. Then, they send them through the network wirelessly. The physical data that is captured from the environment (temperature, weight, and light intensity) are converted to numeric data. After

that, they are processed by the CPU [1]. The result of This process is either sent to the sink through intermediate nodes or stored in local memory. Actually, the most important resource that should be managed is energy. Since, most of the time we cannot charge batteries of these sensors. So, we should make sure that the sensors on the network stay longer along with keeping them more efficient [2]. Figure 1 shows the basic components of a sensor.

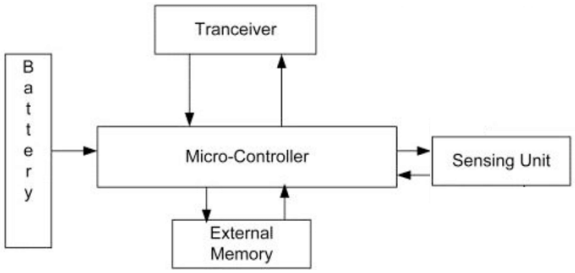

Figure 1. Basic elements of a sensor

A WSN is a network that is composed of nodes, which capture information about the surrounding environment using scalar data. The collected data is then being sent to the sink. The Figure 2 shows the connection between nodes in WSN. A wireless sensor network (WSN) can be use used in many applications such industrial applications [3], health care analysis [4], [5], traffic control [6], agriculture monitoring [7], and home automation [8], [9]. This network is characterized by some limitations: higher bandwidth demand, the limited resources and the application specification. Nevertheless, the energy issue remains the most important problem. Because, it affects directly the lifetime of the network. One of the factors that affect the energy consumption is the routing layer (routing protocols). They are two big categories of routing protocols (planning, routing and level routing). In the first category, we can find the following protocols: directed diffusion (DD) [10], sensor protocols for information via negotiation (SPIN) [11], and sequential assignment routing (SAR) [12]. In the second category, we can find the following protocols: Leach [13], Teen [14], ICH-Leach [15], and M-Leach [16], and MLD-Leach [17].

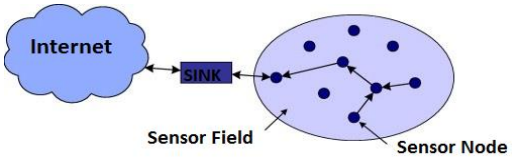

Figure 2. Interconnection between different nodes

WSN is used in many applications that requires an intensive transferring of packets. They are many applications that use scalar data like disaster management [18], internet of things (IoT) [19]-[21], healthcare [22]-[24] robotics [25]. This kind of applications requires more energy, memory, processing and bandwidth. In fact, routing protocols play a major role in preserving energy. That is why, we decided to compare multiple routing protocols in intensive transmitting mode. We choose to compare three level protocols (Leach, ML D-Leach and M-Leach) in term of energy consumption, life of the network, and the number of received packets. Actually, we simulated these protocols using Omnet++/Castalia. In this article, we are going to see the next chapters. First, we will cover the basic routing protocols After that, we will give the results the simulations and explain them. At the end, we are going to conclude our research.

2. ROUTING PROTOCOL

2.1. Leach protocol

The professor Wendi B. Heinzelman proposed a routing protocol in 2000 called Leach. This protocol uses the notion of a round which is an equal period of time. Around is formed of two phases: cluster setup and steady phase. In the first phase, nodes choose to be cluster head (CH) or node based on a random

number in an interval between 0 and 1. The picked number will help to determine the status of the node (CH or node). This number is compared with the threshold T(n). The following formula shows how to calculate T(n).

$$T(n) = \begin{cases} \frac{P}{1-P*(r*(\text{mod } 1/\text{p }))}, & n \in \text{G} \\ 0, & else \end{cases} \quad (1)$$

P is the percentage of CHs that we want, or is the current round and G is the non-selected node list of nodes for CH in the last 1/P rounds. Once a node is selected as a CH, it must not be elected again for the next 1/P rounds.

Once a node becomes CH, it advertises itself by inviting other nodes to join it by broadcasting a message. When a simple node receives a message, it chooses the CH which has the strongest signal. After all nodes join their CH, the setup-phase ends. By the end of this phase, the cluster is formed. After that, each member of a cluster will send its data in a specified time named frame to its cluster head using TDMA. Then, each CH sends its data directly to the base station (BS). Figure 3 shows the process of transmission in this protocol.

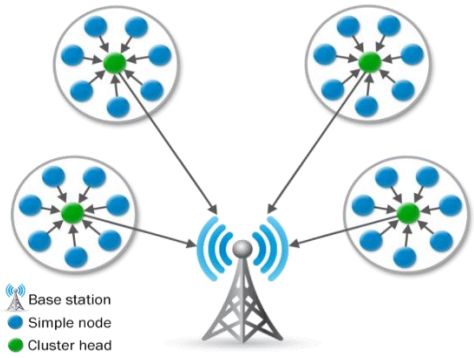

Figure 3. Data transmission process in Leach protocol

2.2. M-Leach protocol

The Leach protocol is a powerful routing protocol in terms of saving energy. Nevertheless, this protocol has many drawbacks. First, the cluster-heads use one hope to the sink which causes congestion, loss of packets and high energy consumption due to transmission. Then, the CHs that are far from the base station will not be able to send packets to the sink. That is why, multiple versions of leach were developed to solve these problems. The M-leach protocol is one of them. It uses multiple intermediate CHs to reach the sink (multipath). The intermediate cluster-heads that are chosen follow the rule of the shortest path.

2.3. MLD-Leach protocol

The MLD-Leach organizes the clusters in layers form starting from the base station (layer 0). After the creation of clusters, CHs of upper layers have a continuous update of delays with CHs of lower layers as shown in Figure 4. When a cluster-head wants to send its data, it chooses the cluster-head of the lower layer by applying the following rules: i) choose the CH which has the minimum delay and ii) choose the CH which has the minimum distance.

2.4. ICH-Leach protocol

ICH-Leach is a routing protocol is an improvement of Leach protocol that covers some weak points of leach. It can send more data and extend the lifetime of the network at the same time. In fact, this protocol uses the same procedure and the same percentage of CH as Leach. In this protocol, a CH check its position and the position of the sink. If this distance is too far, it uses an intermediate CH. This way, any CH can reach the sink whatever the distance from the base station. Also, we can economies energy by avoiding long distance transmission. The most important phase of this protocol is the initiation phase. In this phase, the sink diffuses its position to all nodes by sending a packet. After that, the nodes who receive the packet Save the position of the sink and the strength of signal of the packet. Then, the creation of clusters begins. Figure 5 shows the transmission process in ICH-Leach.

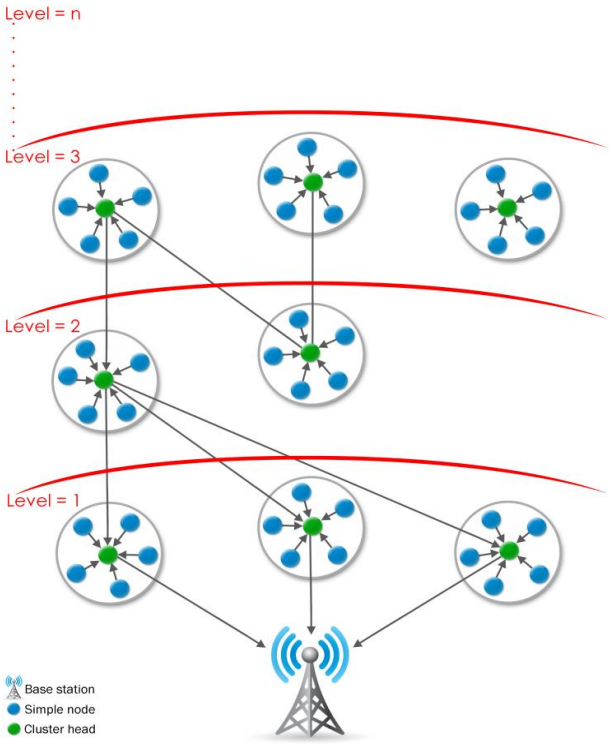

Figure 4. Multi-layer structure in MLD-Leach

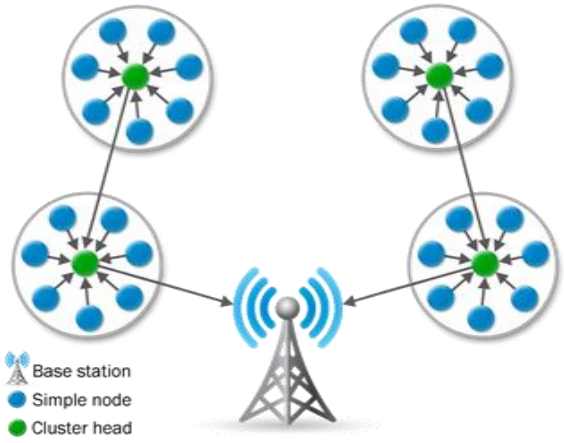

Figure 5. Transmission process in ICH-Leach protocol

3. SIMULATION AND RESULTS

In this paper, we used three routing protocols (M-Leach, MLD-Leach and Leach) to compare them in term of energy consumption and the number of received packets. We used an application that sends packets fastly. We also simulate or tests using the Omnet++/Castalia simulator. As the model radio, we applied the CC2240 model. Table 1 shows the parameters of the simulation.

The Figure 6 shows the energy consumption per round per protocol. It shows clearly that MLD-leach consumes less energy than other protocols followed by M-Leach then Leach. These results could be explained by the fact that MLD-leach uses multiple short transmission to get to the sink. Also, we take the minimum distance in our consideration. On the other hand, M-Leach uses multiple transmissions to get to the sink. So, the nodes use multiple packets of the same origin packet to get to the sink. As a result, energy consumption is reduced but still high compared to MLD-leach. When it comes to leach, it uses one single

hope. As a result, the energy consumption is the highest one compared to MLD-leach and M-leach. The Figure 7 confirms these results. We can see clearly that nodes in Leach protocol die early followed by M-Leach. Then, MLD-Leach. As a result, we can say clearly that MLD-LEACH is more efficient in energy consumption.

Table 1. The parameters of the simulation

Parameter	Value
Topology size	100×100 m^2
Simulation time	2100 s
Number of nodes	100
Period between sending packets	0.2 s
Cluster head probability	0.05
Number of trials	20
Initial power	20j
BS position	(0,0)
MAC protocol	Tunable MAC

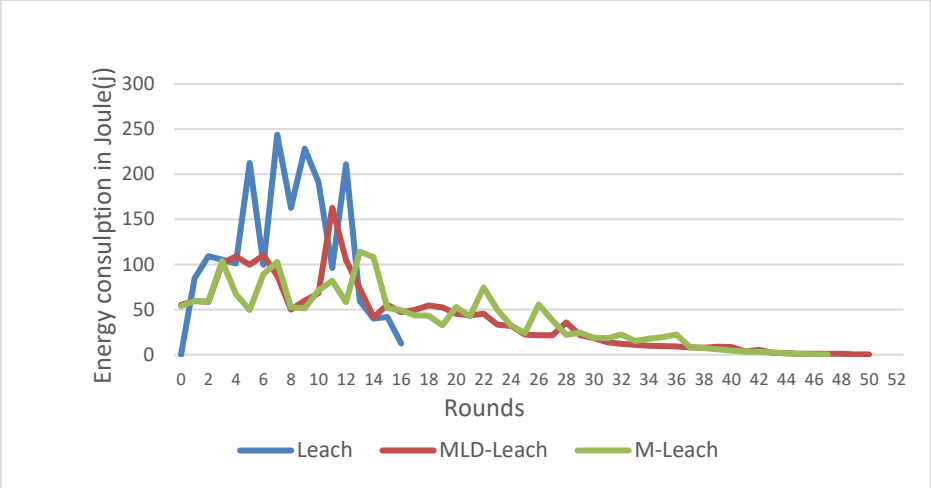

Figure 6. energy consumption per round per protocol

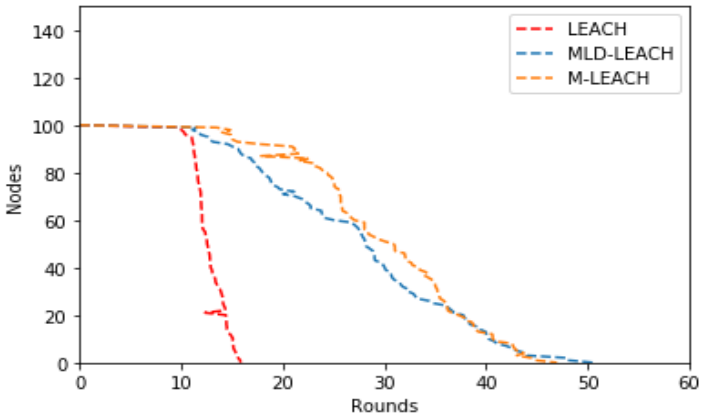

Figure 7. Dead nodes per time per protocol

The Figure 8 shows the number of received packets per protocol. We can notice in this figure that MLD-Leach has the biggest Number of received packets followed by M-Leach. Then comes leach. These results could be explained by the fact that MLD-Leach chooses nodes that have the minimum delay then the minimum distance. This is very important, because that way we avoid congestion. Thus, more packets are delivered to the sink. On the other hand, M-Leach uses multiple intermediate CHs. As a result, more packets

are delivered compared to leach. But a congestion is created. That is why we have a packet lost. As a result, we can say that MLD-Leach can deliver more packets than the other one.

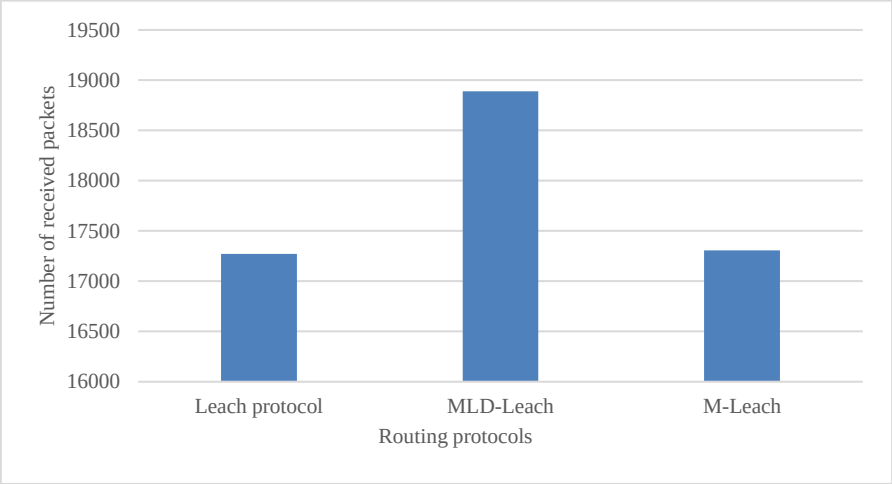

Figure 8. Number of received packets per protocol

4. CONCLUSION

In this paper, we put the three protocols MLD-Leach, M-Leach and Leach in a scenario that include sending a lot of packets in short delay to see which one will be more efficient. We found that MLD-Leach is better in consuming energy and delivering packets to the sink. As a result, we can conclude that MLD-leach can be used in applications that use a lot of scalar data with more energy efficiency. As a perspective, we can use it in more complicated applications like video surveillance. Also, we can adapt my proposed routing protocol (MLD-Leach) with artificial intelligence and make it more flexible.

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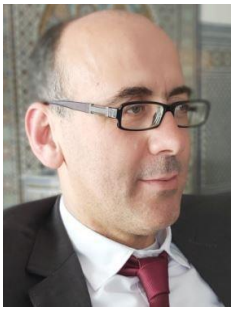

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