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RESEARCH PAPER

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OPTIMIZING ROUTIGN IN WIRELESS SENSOR NETWORKS BY LABTE ENERGY AWARE PROTOCOL BASED ON LEARNING AUTOMATA

Gisou bakhshzadeh*, Amir masoud rahmani and Bafrin zarei
Azad Islamic University, Tabriz, Iran
Gisou.bakhshzadeh@gmail.com
rahmani@srbiau.ac.ir
bafrin.zarei@gmail.com

Abstract: An approach to lengthening lifetime in sensor networks is balancing energy usage in network nodes. This can be done by selecting appropriate paths for sending data and monitoring the amount of passing traffic. In this paper, we propose an energy aware protocol, LABTE, which uses learning automata in order to find appropriate paths for sending data packets to balance energy usage in nodes. Results have been compared with other protocols. Simulation results show that proposed protocol in field of energy usage in nodes and as a result lengthening network lifetime and also by monitoring the amount of passing traffic, in field of data sending delay show better performance than others.

Keywords: wireless sensor networks, dynamic routing, learning automata, reliability

INTRODUCTION

Sensor networks recently becoming interesting are made up of so many small and cheap sensors with low capability and power. These sensors can collect data from their own environment and send it to their adjacent sensors. Since their special application in networks, their energy usage is so important. This is important especially in applications such as army and the environment of nuclear experiments.

We have restrictions such as low resources, low bandwidth, weak relations between internal nodes, low calculating capability and low energy capacity in every sensor network. Extracting data from all sensors at any time, uses a lot of energy. So, being aware of energy, long lifetime, tolerance against errors and scalability in sensor networks are vital factors that must be considered while designing protocols.

An approach to lengthening life of sensor networks is to balance energy usage in nodes. This can be done through choosing appropriate path for sending data. Choosing a path with low power can cause energy discharge in nodes at that path and this means network breakdown.

In this paper, we propose an energy aware protocol, LABTE, which uses learning automata to find appropriate paths for sending data packets in order to balance energy usage between nodes and therefore lengthening network lifetime. In this protocol, nodes try to build their routing tables through flooding which the destination node does. Whenever a node requests to send a packet, it selects a path between available ones and sends them through that path.

If the selected path was an appropriate one, learning automata will reward this selection, so its choosing possibility for the next rounds, increases. Otherwise, selection will be fined and its choosing possibility decreases. The rest of the paper is organized as follows. In section 2, the research history is presented. In section 3, learning automata and in section 4, proposed protocol is introduced. Finally, simulation results about proposed method and its comparison with multipath energy aware method are presented in section 5 and conclusion in section 6.

RESEARCH HISTORY

One of the most important energy aware routing protocols is Ear, which uses request and propagation messages to find every possible path to its destination. Each node, by considering energy usage and its distance to next node in its path, calculate a possibility for each path. By the time of sending data from each node, that node chooses a path based on calculated possibilities. In this way, instead of choosing one special path for sending data packets, we send them through several paths. This can increase network lifetime. Another protocol is PGR. This protocol utilizes location data and energy of nodes to find an appropriate path to destination node. In PGR it is supposed that each node knows the location of destination node. First adjacent nodes, exchange their data in a way that each node can builds a list of its adjacent nodes which are located in θ angle from its and destination location. After finding these nodes, possibilities are allocated to them based on their energy and capabilities. According to possibilities, a node is selected for sending data packets. That node also chooses another node in a same way. This process continues until that packet reaches its destination.

LEARNING AUTOMATA

Learning automata is a machine that can do finite actions. Each selected action is evaluated by a possibilistic environment. Evaluation results are given to automata through positive and negative signals and automata uses these results to choose the next action. The ultimate goal is that automata can learn to choose the best among all. The best action is an action that has a greater possibility to be rewarded by the environment. Functionality of learning automata is shown in picture 1.

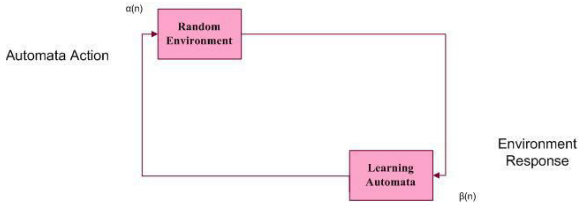

Fig 1. Relation between automata and environment

We can show environment through a triple $E \equiv \{\alpha, \beta, c\}$ in which $\alpha \equiv \{\alpha_1, \alpha_2, \ldots, \alpha_r\}$ is our input set, $\beta \equiv \{\beta_1, \beta_2, \ldots, \beta_m\}$, output set and $c \equiv \{c_1, c_2, \ldots, c_r\}$ is called penalty set. C_i is the possibility that α_i action causes an unfavorable result. In static environments, c_i values remain constant but in dynamic environments, they will change through time. Learning automatas are divided into two groups: constant and variable structures. We introduce learning automata with variable structure in here.
Learning automata with variable structure can be shown by a quadruplet $\{\alpha, \beta, p, T\}$ in which $\alpha \equiv \{\alpha_1, \alpha_2, \ldots, \alpha_r\}$ is the set of automata actions, $\beta \equiv \{\beta_1, \beta_2, \ldots, \beta_m\}$is the set of automata inputs, $p = \{p_1, \ldots, p_r\}$ is possibility selection vector for each of actions and $p(n+1) = T[\alpha(n), \beta(n), p(n)]$ is learning algorithm in here. Below is an example of linear learning automata algorithm. Suppose that action α_i is being selected in nth round.

Favorable result:
$$p_i(n+1) = p_i(n) + a[1- p_i(n)] \qquad (1)$$
$$p_j(n+1) = (1-a)p_j(n)$$

Unfavorable result:
$$p_i(n+1) = (1- b)p_i(n) \qquad (2)$$
$$p_j(n+1) = (b/r-1) + (1- b)p_j(n)]$$

In equations (1) & (2), a is reward and b is penalty parameter. In respect to a and b values, we can assume one of the three options below. When a and b are equal, we call the algorithm $L_{RP.}$ When b is much smaller than a, we call it $L_{R\varepsilon P}$ and when b is equal to zero, we call it L_{RI}.

PROPOSED PROTOCOL

In wireless sensor networks, the most important subject us energy usage in nodes since a sensor node is usable up to the time it has enough energy. For this, one fundamental criteria in routing is the amount of remaining energy in a node. If we don't consider it, a node will soon lose its energy and cause disorder in network. In many papers the remaining energy is the only factor which is considered in routing. High-energy usage is due to sending reduplication to make sure that data will get to its destination. High probability of delay is because of heavy traffic in nodes. In this paper, optimization would be made through considering traffic and measure of node reliability in addition to remaining energy factor.
Passing traffic through each node is a measure for routing in LABTE. Each examines its length of queue and sends it as its traffic parameter. Not considering this parameter will cause delay in sending data and decline protocol efficiency. Another important factor in routing is considering the amount of energy usage in each node in response to decrease in number of unsuccessful data sending. Specifying reliability value, we need to put an integer variable in each node. Its primary value is zero and increases through the passage of time. Each time that a sensor node succeeded in sending data correctly and receives acknowledge from destination node, the value of the counter goes up one point. In order to prevent forming large numbers and waste in sensor memory, nodes located nearby, send their reliability values to each other frequently. All nodes decline the smallest received reliability value from their own value. For example, if reliability values for 5 adjacent nodes were 10,8,9,5 and 4, respectively, reliability value in first node is larger than others, so sending possibility through this node is more likely. Preventing memory waste, we decline 4 points from all reliability values, so new values are 6,1,4,5 and 0 and still first node probability is the largest one. Another parameter which has been used in our proposed protocol, is sending number SN[5] which is resulted from summation of three factors, E for energy, A for reliability and T for the length of each node queue as presented in equation (3):

$$SN = E + A + T \qquad (3)$$

As the time passes, the remaining amount of energy falls as a result, energy has a vital role. So, we have to change the application policy of overall network and the attempt is using nodes which have larger energy amount among others. Thus, application formula would be:

$$SN= nE + A + T \qquad (4)$$

Here, n stands for remaining energy coefficient.
To increase the flexibility of protocol, coefficient for each factor can be used. Thus we get a general form of equation (3) as presented here:

$$SN= nE + mA + kT \qquad (5)$$

In attention to the importance of every factor in a special network, we can reach our desired optimization through alignment of coefficients.
Suppose that reliability has an important role in network and traffic amount is relatively high. Then we can calculate sending number via equation (6):

$$SN= 1E + 5A + 2T \qquad (6)$$

After alignment of coefficients n, m and k, it is time to build routing tables. To build routing tables, this protocol uses three packets, ACK, DATA and FLOOD.
FLOOD packet is just used in building phase of tables. ACK and DATA packets are used in second phase of routing and present data packet and its answer, respectively. Routing tables are made up of 5 fields: number of next field, possibility of selection, energy amount of the next node, reliability value for each node, traffic of each node towards destination and SN. In this protocol, each node has a learning automata with action number equal to number of paths from that node to destination. The protocol uses this to select appropriate path in order to balance energy usage. Here, we explain this in detail.

BUILDING ROUTING TABLES

This phase is started by the destination node. This node makes FLOOD packet and propagates it into network so that all of its neighbors, receive it. This packet includes three fields: number of sender node, reliability value and energy level of sender node. Before sending, sender node assigns value to these fields. This assignment is done in a way that number of sender node is equaled to the number of destination node, reliability value is equaled to zero and energy level is equaled to its own energy level (destination node).

Other nodes when receiving one FLOOD packets, data in that packet is added to its routing table as one record and its selection possibility is equaled to 1.

When a node receives more than one FLOOD packet, all data in those packets are added to its routing table (one record for each path). Selection possibility for each of these paths depends on reliability value of each node.

After building this table, receiver node, assigns new values to fields of FLOOD packet and propagates it into network. Assignment is done like this: number of that node is introduced as the number of sender node and its energy level is assigned to the proper field. Each node is respect to its routing table, makes a learning automata which the number of its actions are equal to the number of path in routing table of that node. Indeed there is a one to one correspondent relation between number of actions in learning automata and paths in routing tables. Selection possibility of each action is equal to the possibility of its correspondent path in routing table. Whenever the learning automata of a node, selects an action, its correspondent path is selected for sending packets towards destination. If the selected action (path) was appropriate, its possibility to be selected later, increases and conversely, if it wasn't, then its possibility, decreases.

At the end of this phase, each node has both a learning automata and a routing table which will be used to direct packets towards destination.

EVALUATION AND COMPARISON

For simulation, each node uses 660mj energy to send any kind of packets and 395mj to receive one. Location of nodes in network is determined randomly. Simulations are done in an environment which was 1500m * 1500m in dimensions and 400 nodes were located in that. The goal for sensor network in here is to collect temperature changes in this environment.

LABTE and 2 other protocols, EAR and PGR are simulated in this environment. These protocols are assessed in respect to the number of sending and receiving control packets at the beginning and end of network lifetime and also the number of received data packets by the destination node during network lifetime. The number of control packets at the beginning (receiving around 50000 data packets in the destination node) for LABTE protocol is lower than others. The reason is that LABTE protocol just needs initial flooding which is done by the FLOOD packets.

EAR protocol also just needs FLOOD control packet for flooding but since its sending type for FLOOD packets differs, this increases the number of control packets in EAR compared to LABTE. In this protocol, FLOOD packet is sent node by node, not in a flooding way. In PGR, increase in the number of control packets is due to initial greeting between nodes in order to find the position of adjacent nodes and to calculate their capability. Picture (2) shows the amount of control packets at the beginning of network lifetime.

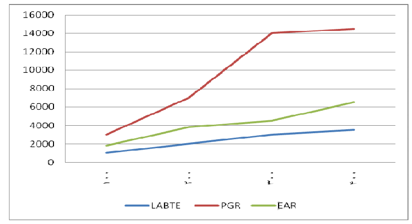

Fig 2. Amount of control packets

The number of sending and receiving control packets at the end of network lifetime for EAR protocol because of repetition in flooding phase, is more than the beginning of network lifetime. For both LABTE and PGR protocols, there is no obvious change and sending and receiving control packets are merely done at the beginning of network lifetime, thus the energy usage in nodes and network traffic decrease. Number of received data packets in the destination node is a good criterion for the amount of network lifetime. Picture 3 shows the number of received data packets in the destination node for all the three protocols.

As you see, the proposed protocol receives more data packets than EAR and PGR protocols. You must consider that higher density of nodes in network, results in longer lifetime for LABTE protocol since energy usage is more balanced then.

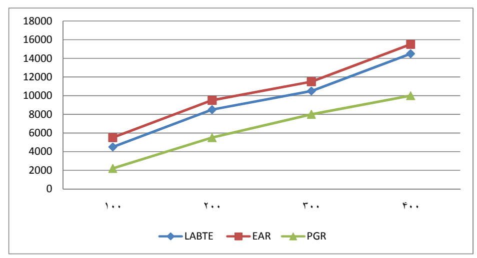

Fig 3. Number of received data packets

CONCLUSION

In this paper, we proposed LABTE, an energy aware protocol which uses learning automata to find appropriate paths for sending data in order to balance energy usage between nodes. Results from simulation show that proposed protocol has a better performance in balancing energy usage between nodes and thus lengthening network lifetime than others.

REFERENCES

[1] I. F. Akyildiz, W. Su, Y.Sankarasubramaniam, and E.Cayirci,. "Wireless sensor networks: a survey",. in Computer Networks,pp. (38)393. 422, 2002.

[2] J.M.Zhang, L.F.G.U, L.M.Wang, "Reliable Transmission Method With Energy-awareness for Wireless Sensor Network", IJCSNS, OL.6NO.58.May2006.

[3] W.liu, H.liu, "Reliability Guaranteed Data Transmission With Adaptive Multi-Coverage in Sensor Networks", IEEE, 2007.

[4] M. Kosanovi ü, M. Stoj þev, "Reliable Transport of Data in Wireless Sensor Network", Proc. 6th international

onference on icroelectronics (MMIEL 008), IŠ, Erbia, 1-14 AY, 2008.

[5] J. N. Al-Karaki and A. E. Kamal. ”Routing techniques in wireless sensor networks: a survey”. In IEEE Wireless Communications, Volume 11, pp. 6-28, 2004.

[6] N. Farajzadeh, M. R. Meybodi, “Learning automata-based clustering algorithm for sensor networks”, Proceedings of CSICC2007, PP. 780-787, 2007.

[7] M. A. L. Thathachar and P. S. Sastry, “Varieties of learning automata: An overview”, IEEE Transaction on Systems, Man, and Cybernetics-Part B: Cybernetics, Vol. 32, No. 6, PP. 711-722, 2002.

