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RESEARCH ARTICLE

Earliest Detection of Cluster Head Failure in Wireless Sensor Networks

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Abstract— This paper considers detection of cluster head failure problem in WSNs and resolved in proposed system by efficient detection of cluster head failure mechanism to identify the head failure more with accuracy. Cluster head broadcasts a "heartbeat" messages to its members and each cluster members identifies independently received "heartbeat" message. Further-more to identify cluster head failure with more accuracy co-operative detection of cluster head failure with neighbor nodes.co-operative detection confirms head failure at earliest by checking members status information at each member through independent and co-operative detection mechanisms. Simulation results shows that failure detection probability and efficient detection of head failure performance in terms of the failure detection and the detection time and in turn shows energy efficiency plots.

Keywords— cluster;CH- cluster-head; TDMA; failure detection; wireless sensor network

I. INTRODUCTION

A wireless sensor networks (WSNs) are on-the-air communication between densely deployed sensor nodes in the network of communication and region of interest.WSNs are motivated by military applications, security and industrial applications. Sensor nodes collects surrounding data and performs data fusion at each member and processes the fashioned data and diffuse the processed data to the respective destination. Sensor nodes are light weighted hence energy conservation at each node is more important. Clustering reduces the energy dissipation at each node by tuning the communication through cluster head and with other cluster head's through the sink. Cluster head failure problem caused due to physical damage or any external attacks which in turn caused network connectivity failure hence entire network disrupted. To resolve this problem it is more important to recover from the failure by collecting status information from its members when head failure detected.

A simple technique is to broadcast "heartbeat" message periodically to all its members. Each members independently collects the status information from its head and detection of head failure is efficient at earliest. In-cluster communication is achieved through the time-division multiple access (TDMA). In-cluster communication is performed in its own time slot of each cluster members and head broadcasts its "heartbeat message in reserved initial time slot. Clustering is an efficient way to reduce energy consumption in WSNs. In it, a network is subdivide into smaller groups called cluster members and one is head, and members diffuse the data to head and to sink through hierarchy. This significantly reduces the energy consumption, because transmission is much more costly than the computation.

One important concern is with independent detection technique may arise false detection of cluster head failure because of signal interference, physical damage or channel uncertainty. Hence recovering method triggered because of false detection of head failure which lead to unnecessary energy dissipation at each level of communication. It is more important to detect head failure more accurately in occurrence of cluster-head failure. In this paper we considering that head failure detection through efficient head failure mechanism with the neighbor status information. Independent detection mechanism has drawback of false detection and it is overcome through proposed method along with the existing system. This paper demonstrates the failure detection vs. time, throughput, packet delivery ratio, and energy conservation

II. NETWORK DISGN

This section defines the network design considered in this paper and demonstrates the proposed method.

A. Network architecture

Here we assuming that one sink node which is center of communication in network with cluster members in the network through their cluster head. Figure 1 shows the architecture of the network and nodes are distributed uniformly in the region interest. All sensor nodes are homogeneous and have same energy and assuming that clusters are single hop clusters and in-cluster communication is through the TDMA scheme at the MAC layer. Each frame has defined time slots and are communicating within the defined time slots and also detects the status the cluster head within the same. Since it is using timeslots initial timeslot is reserved for cluster head to broadcast "heartbeat" message.

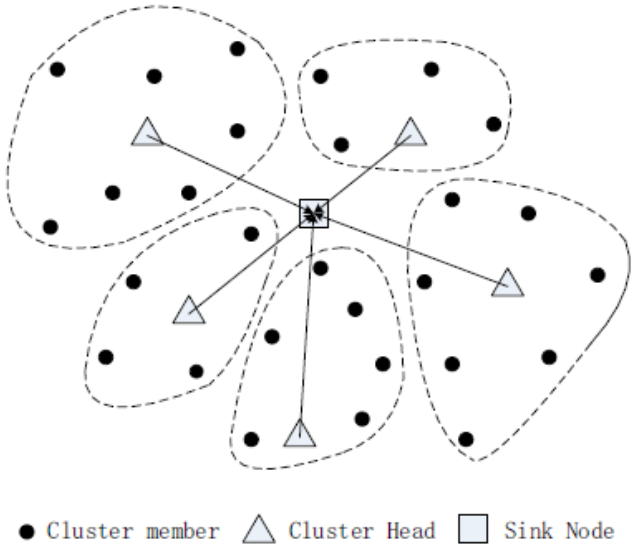
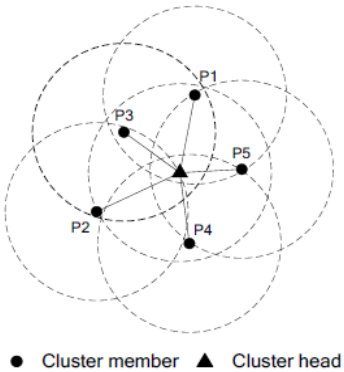


Figure 1 Network model

B. Frame structure

Here we consider a cluster with N nodes N-1 are members and one s cluster head. Each TDMA frame consists of N slots in a cluster and data transmission allowed in their time slots only. Time slot zero (TS0) is reserved for cluster head to broadcast "heartbeat" message in its cluster. "Heartbeat" message is used for detecting cluster head status. If any member transmitting data in its own timeslot other are in sleep state to save energy. Consider cluster has N=6 and Figure 2 shows node distribution and frame structure.



● Cluster member ▲ Cluster head

(a) Node distribution

The First Frame						The Second Frame						
TS0	TS1	TS2	TS3	TS4	TS5	TS0	TS1	TS2	TS3	TS4	TS5	...

TS = Time Slot

(b) Frame structure (N=6)

Figure 2 Cluster example

C. Status Bit

Status bit is Boolean value to represent the head status and this bit is broadcast with the heartbeat message with setting SB=1 initially at TS0 timeslot. Each cluster member maintains the status information of CH.

SB=1 indicates head is alive

SB=0 indicates head failed.

D. Neighbor list

Along with the status bit information members need to maintain neighbor nodes which one-hop-neighbors and neighboring information maintained by overhearing neighbors confirmation messages sent to its neighbors.

E. Detection methods

The head failure detection process is sub divided into two methods: independent detection and co-operative detection.

1) Independent detection

Consider cluster head broadcasts "heartbeat" message in its TS0 time slot to its members. Cluster members independently detects status bit information if SB=1 head is alive else head failed. But due to physical damage or signal interference chances false of failure detection hence for cross confirmation member overhear the neighbor status bit information for better accuracy detection.

2) Co-operative detection

After independent detection if any node detects head failure to confirm head failure it has to piggyback the neighbor status bit information in its own timeslot by means of an overhear technique.

In this stage, if cluster member need to follow different case study depending on independent detection results in its own timeslot with its neighbors.

Case.1)

If SB=1, transmit data to CH in its timeslot and remain asleep to save energy in other timeslots.

Case.2)

If SB=0, demonstrates cluster head failed. In this case

Member overhears neighbor's status information with its one-hop-neighbors in its timeslot.

Overhear when SB=0, members may have following approaches:

- If member overheard data packet with SB=1 from its one of its neighbors, stop overhearing, set SB=1 and transmit data in its time slot.
- If member overheard packet with SB=0 and no packet with SB=1, transmit data and keep overhearing after data transmission in its time slot. And even at end of time slot no packet with SB=1 then set SB=1 and continue.

F. Algorithm

Step-1. Deploy nodes in network to form Cluster Network

Step-1.1 Assume that one sink node in network and broadcast the message over network

Step-2. Cluster head selection process

Step-2.1. Calculate Energy/Cost values and select higher energy/Cost value node

Step-3.Detect the head failure by sending heartbeat messages containing status bit value using TDMA Scheme. If head alive Go to step-4 for transmission else follow step-3.1

Step-3.1 Independent cluster head failure detection between nodes and head message exchange

Step-3.2 Co-operative head failure detection by overhearing neighbor node message exchange in its time slot

Step-3.2.1 If both neighbor node and current node has head alive status bit value Transmit data in its time slot Go to step-4

Step-3.2.2 If both neighbor node and current node has head failure status bit value Stop data Transmission Repeat step-3 in its slot else sleep

Step-3.2.3If neighbor node has alive status bit and current node has failure then validate with other neighbor node in its slot and repeat step-3.2.1

Step-4 Data transmission using TDMA method to every cluster head along with Status bit value

Step-5 Simulate the results

III. ANALYTICAL MODEL

In this section we are analyzing the performance of the proposed mechanism.

I. False probability detection

Say p_i indicates falsely detected failed by its member. Hence p_i can be written as

$P_i=1-P_i$`

Where P_i` is correct head detection and $1-P_i$ gives failed false head failure detection.

By the above formula we have,

$P_i=p-p.(1-p).(1-p^n{}_i) -p2.(1-p).(1-p^{n}{}_i{}^{-1})+(1-p)^2.p^{n}{}_i{}^{+1}.(n_i-1)$

IV. SIMULATION RESULTS

In this section, we verify the efficiency of proposed method and evaluation of proposed method through the simulation results. The simulation results are performed on NS2.It is observed that simulation results are very near to theoretical results. It is observable point that as packet loss rate simulation result also increases. It notable point that as number of nodes increase packet loss rate and detection rate also decreases. Figure 5 compares the energy plot shows the more efficient energy conservation in ach node level.

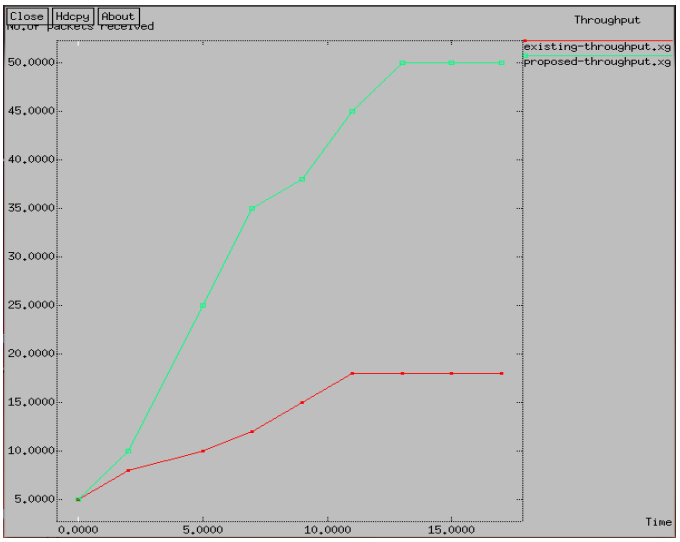


Figure 3

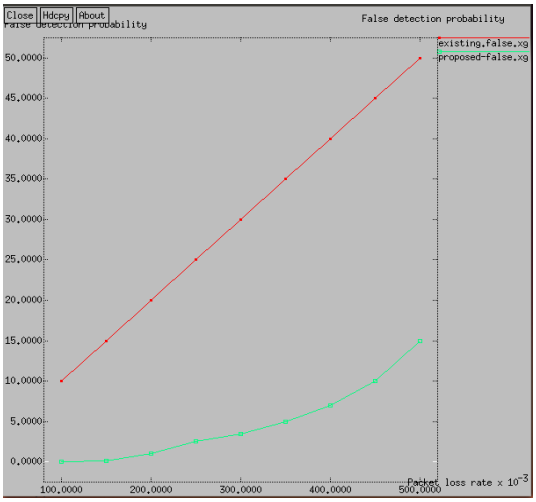


Figure 4

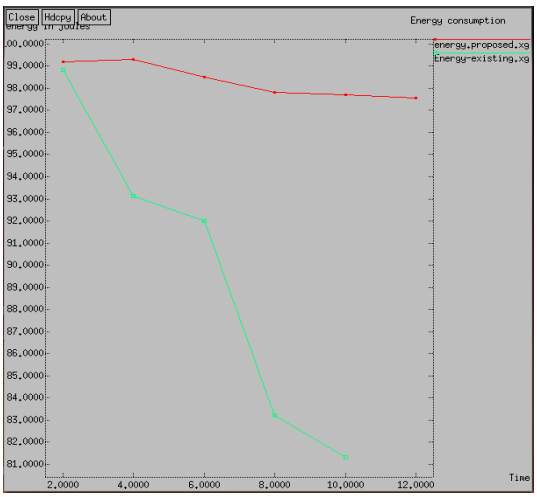


Figure 5

Detection time with proposed method keeps constant at one frame time whereas in tradition system decreases as packet loss rate increases. Consider figure 3 throughput graphs show efficiency of proposed system over existing system. Energy plot demonstrates the energy conservation using proposed method. Figure 4 shows Probability of failure detection and Figure 6 packet loss rate graphs shows comparison between existing and proposed methods.

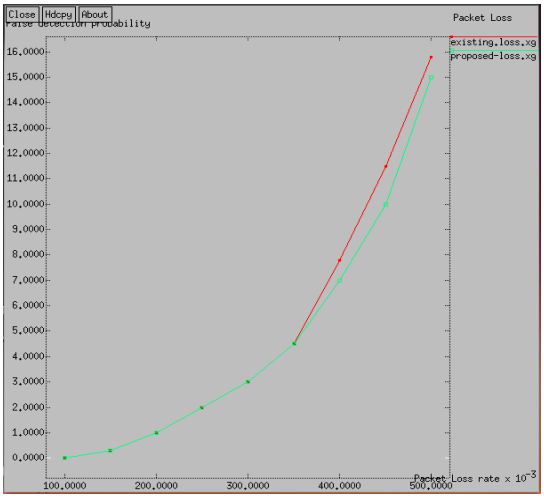


Figure 6

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