University of Leicester

Aerospace and Computational Engineering Group
Department of Engineering

Distributed Clustering Algorithm for Critical Event Detection using Wireless Sensor Networks

Ameer A. AL-Shammaa, A. J. Stocker

Introduction

- Event detection is one application of wireless sensor networks. Battlefield monitoring, fire detection, nuclear and chemical attack, gas leak, and health surveillance are examples of event detection [1].
- One of the main goals of WSNs is to transmit the sensed data to the sink reliably.
- The required reliability depends on the nature of the application [2]. For example the gas leak, and fire detection systems require a high reliability degree, however, some applications, like weather monitoring system, don't need high reliability.
- In this research project, a new technique to achieve quality based event reliability for critical event detection was implemented on hardware nodes.

Network Set-Up

- The experiments were undertaken indoors in a single room using a hardware testbed that consisted of up to five Waspmote wireless nodes equipped with XBee 802.15.4 Pro radio modules.
- The initial setup method is as follows:

1. One node was used as a coordinator, which broadcast a packet containing time information to synchronize the nodes clocks.
2. The network nodes then discover their neighbour nodes and store this information in an address table to use it for the data routing. Figure 1 presents the total time to scan the neighbour nodes.

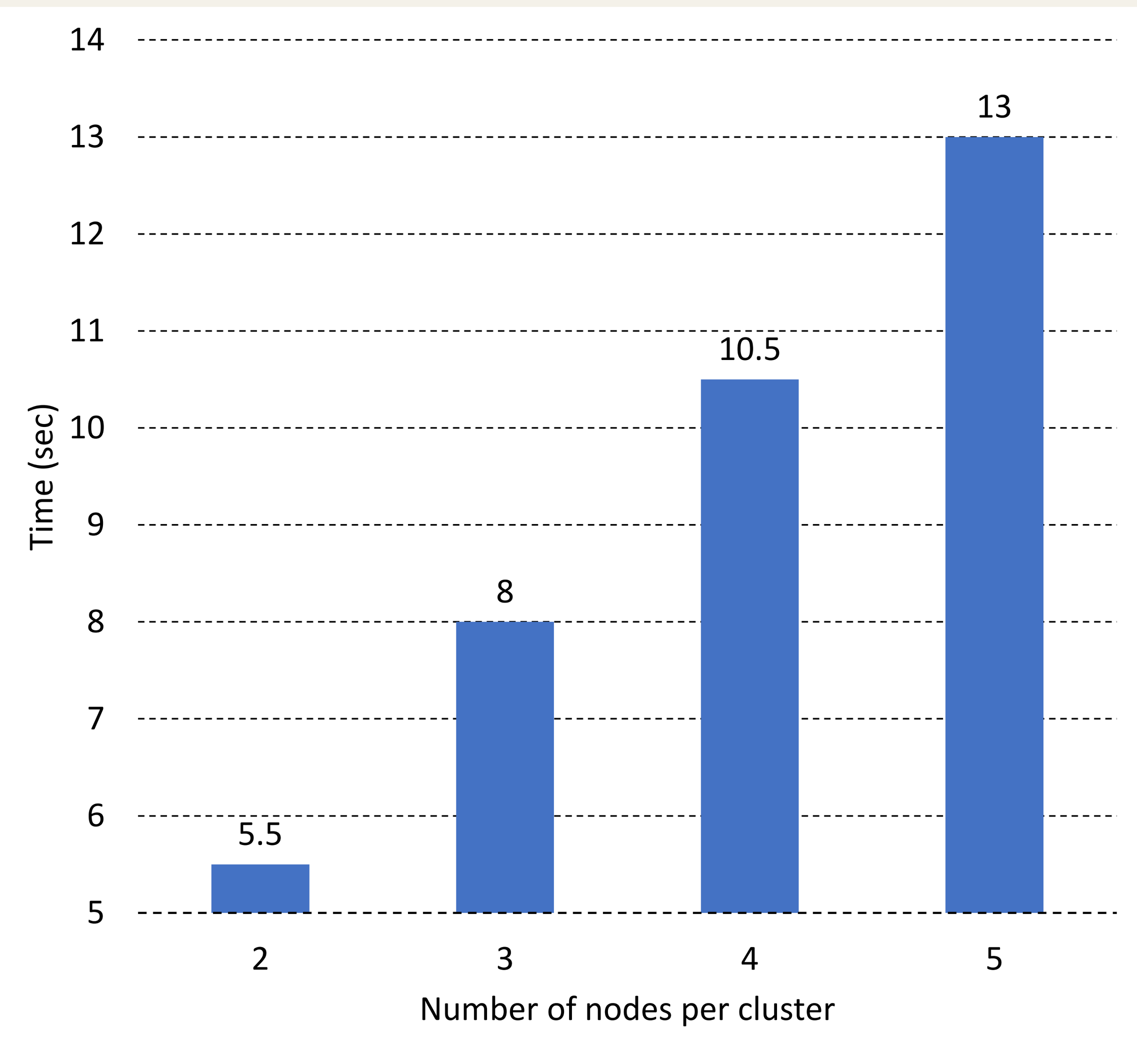

Figure 1: Total scan time with the scan scheduling VS the number of neighbouring nodes

3. Finally, based on the address table and the internal built-in table called the Nodes Locations Table, each node will classify their neighbours as sources, routers, or sink. The Nodes Location Table will help to avoid transmission interference between the neighbour clusters.

Case Study

- The nodes in the experimental area have been divided into two types according to their work in the network which are sources and sink.
- The sources nodes were closely separated and therefore they were all able to communicate with each other and with the sink directly with received signal strengths of at least −75 dBm.
- The TDMA slot for each node Ts= 300 ms, and the packet size used to report the events to the cluster head (CH) was 85 bytes (one packet was sent per TDMA slot).
- The new method is divided into a CH selection phase and a transport phase.

Cluster-Head selection phase

- In the CH selection phase each source node will generate an event value (EV) and send it to the other sources in the same cluster to check which source among them has the highest EV.
- The node with the highest EV will become the CH and it will forward sensor readings from the other nodes to the sink.
- To avoid packet collisions, each node will use an internal TDMA assignment to obtain a transmission slot time.
- The time required to allocate the TDMA slots is given in Figure 2.
- The slot time should be increased with more sensing nodes in the cluster.

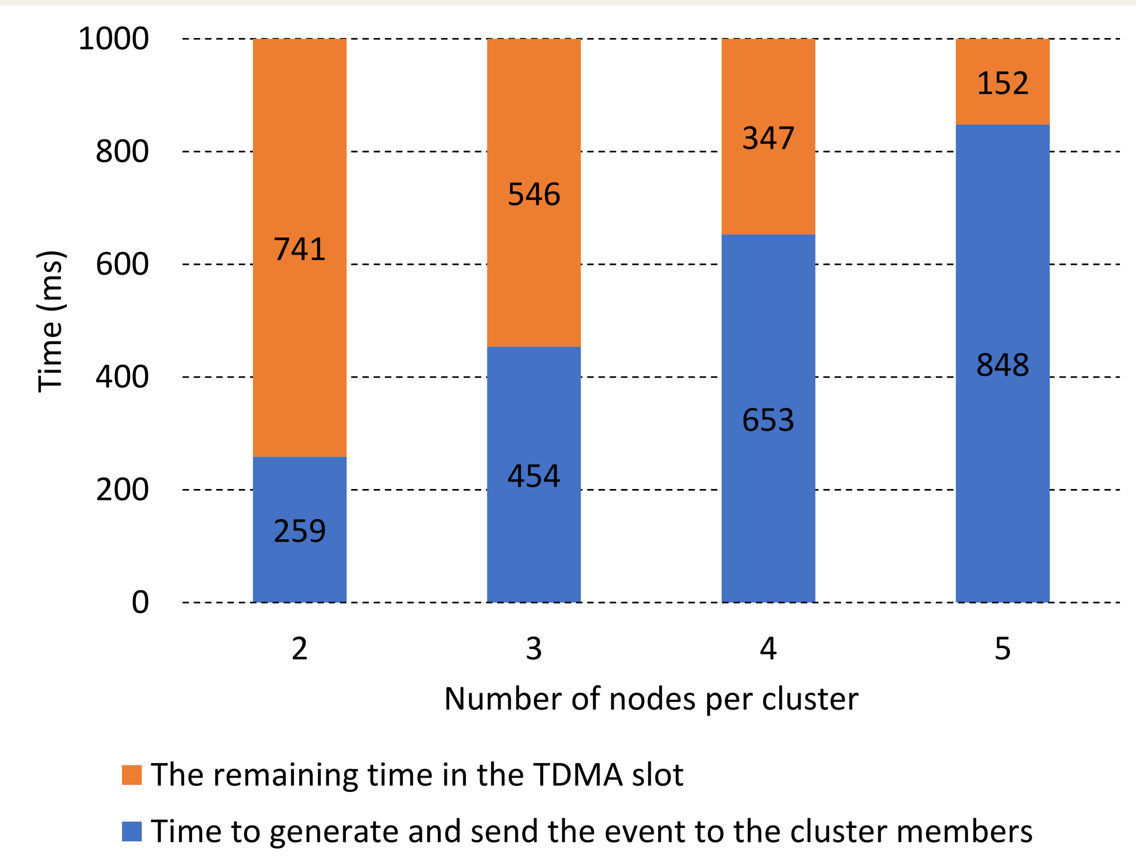

Figure 2: TDMA slot node usage VS cluster size

- The required time by the nodes to form a cluster and to select a CH depends on the number of nodes in each cluster (Figure 3).

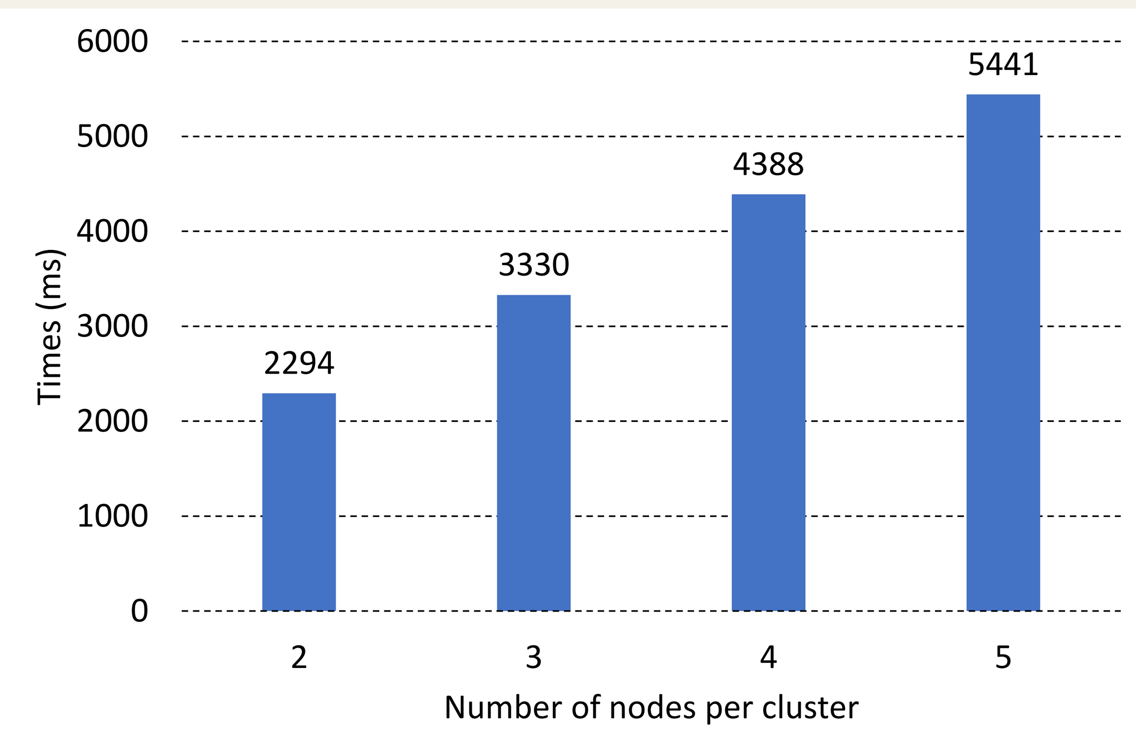

Figure 3: Time for cluster forming and CH selection

Cluster-Head selection (Cont.)

- The CH will rearrange the received events from the cluster members (CMs) in descending order to send the event value according to their priority.

Transport phase

- In the second stage of the proposed algorithm, the CH will forward the events of all cluster nodes to the sink.
- The time to send all the cluster events from the CH to the sink presented in Figure 4.

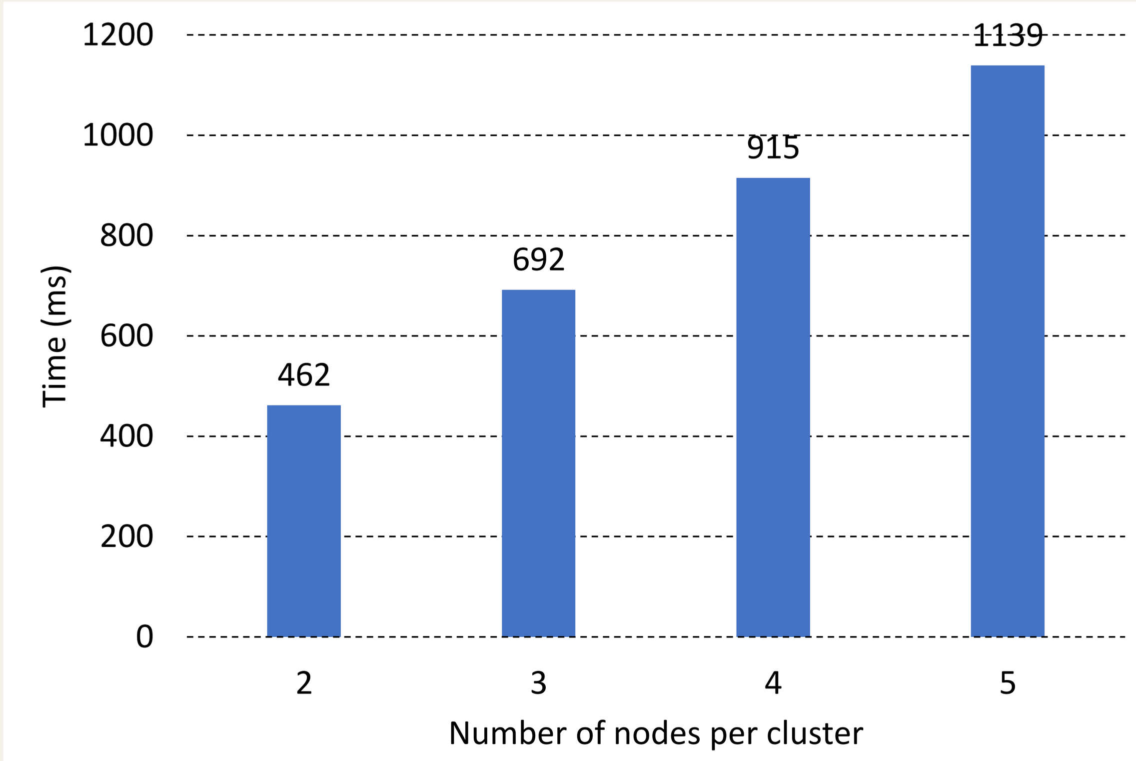

Figure 4: Time to report the cluster events to the sink

- According to Figure 5, the proposed algorithm achieved 100% packet delivery compared to the direct transmission which starts to fall when the number of the nodes (N) sending simultaneously to the sink is more than 2.

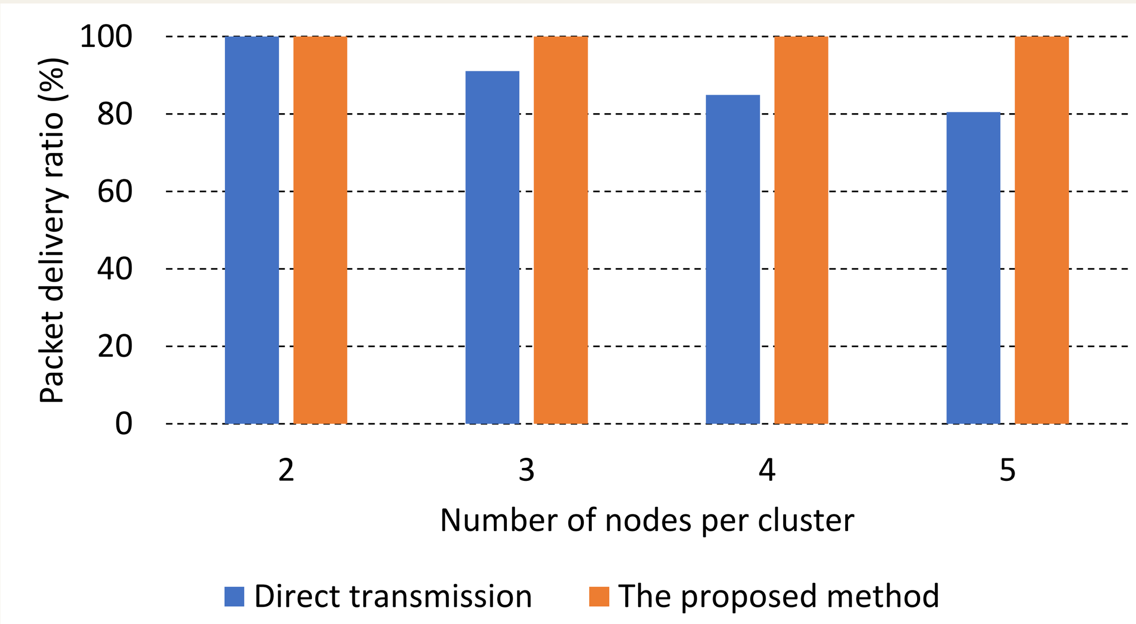

Figure 5: Packet delivery ratio at the sink

Conclusions

- The packet delivery ratio (PDR) is 100% using this new method compared to the transmission without clustering where the PDR starts to decrease when N>2.
- In general, the proposed method achieved higher reliable event detection compared to the direct transmission.

References

1. Mahmood, M. A., Seah, W. K. G., & Welch, I. (2015). Reliability in wireless sensor networks: A survey and challenges ahead. Computer Networks, 79, 166–187.
2. Sankarasubramaniam, Y., Akan, Ö. B., & Akyildiz, I. F. (2003). ESRT: event-to-sink reliable transport in wireless sensor networks. Proceedings of the 4th ACM International Symposium on Mobile Ad Hoc Networking & Computing, 177–188.