A Cluster Based Optimization Technique with Adoptive Framework for ZigBee WSN

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Abstract - ZigBee is a current wireless standard based on IEEE 802.15.4 used in Wireless Sensor Networks (WSNs) stimulates many interests. In a built WSN, the information about some part of interest may need further research such that more traffic will be generated. Earlier work presented adoptive-parent-based framework for a ZigBee cluster-tree network which provided more flexible routing and increase bandwidth utilization without violating operating principles of ZigBee cluster-tree protocol. However, sensed data collectors may vampire the optimality and convergence rate of bandwidth utilization demands. In this paper presents an Enhanced Distributed Adoptive Parent (EDAP) framework for ZigBee cluster tree topology which handles varying traffic load communication in any given instant for WSN communication. In EDAP framework, traffic load conditions are tested at real time mode i.e., bursty ones. Divergent traffic load minimizer technique is employed to evaluate the actual required bandwidth on traffic load instances of ZigBee cluster tree communication. Sensed data collectors are appropriated to traffic load demand for efficient WSN communication. Simulations are carried out to evaluate the efficacy of EDAP framework for WSN communication in cluster tree topology in terms of Traffic Load, Frequency of Load variance, Bandwidth rate, Communication overhead and Load-Bandwidth Divergent Rate.

Keywords- ZigBee, Cluster Tree, Adoptive Parent, Traffic load, Divergent traffic load minimizer.

I. INTRODUCTION

ZigBee is a well-known set of specifications for wireless personal area networking, that is, digital radio connections between computers and linked devices. WPAN Low Rate or ZigBee gives specifications for devices that contain low data rates, use very low power and are therefore characterized by long battery life. ZigBee creates probable completely networked homes where all devices are proficient to converse and be restricted by a single unit. ZigBee is a modern wireless standard based on IEEE 802.15.4.

The IEEE 802.15.4 protocol is an assuring standard for WSN applications since it pays exacting notice to energy efficiency and communication overheads. Founded on the Physical (PHY) and Medium Access Control (MAC) layers of IEEE 802.15.4, the upper-layer (comprising the network and application layers) specifications are described by the ZigBee protocol stack. The applications hold by ZigBee includes home automation schemes, remote control and monitoring schemes, and health care devices.

Amongst the famous ZigBee topologies, the cluster tree is particularly appropriate for low-power and low-cost WSNs since it supports power saving processes and light-weight routing. In the ZigBee cluster-tree topology, the power saving process is managed by the IEEE 802.15.4 MAC super frame arrangement; and a light-weight tree routing protocol is allowed under a distributed address assignment policy configured by several system parameters. Although the ZigBee cluster-tree network is effective for WSNs, the topology suffers from restricted routing and poor bandwidth utilization. In a tree structure, any link failure will suspend data delivery totally and the recovery operation will incur a substantial overhead.

The topology also avoids the utilization of many possible routing paths, which means that a substantial amount of bandwidth cannot be used. In a built WSN, the information about some area of attention may need further investigation. Consequently, the sampling rate of the sensor nodes organized in the area of interest will be enlarged, and more traffic will be generated abruptly in the network. Though, as the ZigBee cluster-tree topology may not be capable to grant adequate bandwidth for the increased traffic load, the further information may not be delivered effectively.

This paper proposes an Enhanced Distributed Adoptive Parent (EDAP) framework for ZigBee cluster tree topology. Our objective is to handles varying traffic load communication in any given instant for WSN communication. It offers more flexible routing and increase bandwidth consumption without violating the working principles of the ZigBee cluster-tree protocol. The EDAP framework is well matched to networks in which there are unexpected requirements for enlarged bandwidth to deliver further information. Based on the offered cluster-tree topology, the EDAP framework allows a ZigBee node to demand bandwidth from adjacent routers called adoptive parents as well as from its original parent router. Divergent traffic load minimizer method is employed to assess the definite requisite bandwidth on traffic load instances of ZigBee cluster tree communication.

II. LITERATURE REVIEW

In the literature, there is a rich body of investigation on ZigBee cluster-tree networks. For instance, master-slave [2] and slave-slave [3] methods are offered bridge access modes for the interconnection of IEEE 802.15.4 beacon-enabled network clusters, and implemented theoretical analysis to examine their performance. In [4] demonstrated the benefits of ZigBee tree routing regarding reactive routing in typical sensor network applications.

In [5] conducted a wide-ranging performance evaluation of ZigBee cluster tree networks and offered significant insights into engineering systems for developers. Authors in [6] proposed an algorithm that configures cluster-tree parameters optimally and guarantees all the end-to-end deadlines of sporadic real time flows deterministically. In [7] developed shortcut tree routing to decrease the transmission latency. The general drawback of the existing approaches is that they do not deal with the poor bandwidth consumption problem in ZigBee cluster-tree networks consequently it is tricky to enlarge the system throughput.

Conversely, some distinguished results have been accounted for throughput development in the routing protocols of ZigBee mesh networks. For instance, in [8] conducted a whole performance evaluation of four AODV like routing protocols in terms of the packet delivery ratio, average network delay, network throughput, and normalized routing load.

Additionally, numerous ZigBee mesh routing protocols have been projected to decrease the overhead for route discoveries and route requests, [9] and thus recover the end-to-end delay and packet delivery ratio [10]. Research in [11] proposed an improved AODV routing protocol to amplify the throughput of ZigBee wireless networks. Regrettably, the above models cannot be accepted in ZigBee cluster-tree networks since they make exact assumptions about the system architecture. Even though existing works can attain significant performance improvements in ZigBee cluster tree networks, they do not manage the restricted routing and poor bandwidth consumption problems.

III. ENHANCED DISTRIBUTED ADOPTIVE PARENT FRAMEWORK FOR WSN (EDAP)

In this section, presents an Enhanced Distributed Adoptive Parent (EDAP) framework for ZigBee cluster tree topology. It manages varying traffic load communication in any specified instant for WSN communication. Divergent traffic load minimizer technique is used to assess the actual required bandwidth on traffic load instances of ZigBee cluster tree communication. Sensed data collectors are appropriated to traffic load demand for efficient WSN communication. It presents more flexible routing and enlarges bandwidth consumption without violating the working principles of the ZigBee cluster-tree protocol. The EDAP framework is well coordinated to networks in which there are unpredicted necessities for inflamed bandwidth to deliver further information. Figure 1 shows the architecture diagram of EDAP Framework for WSN Application with ZigBee Cluster Tree Topology.

A. Wireless Cluster Tree Topology

In a wireless cluster-tree network, each ZigBee router with its nearby devices is regarded as a relevant cluster, and each cluster works individually as a star network. In this work assume that sensed data in ZigBee cluster-tree networks is provided by the GTS mechanism because a high-delivery ratio can be guaranteed. It allows multi-hop communication. ZigBee permits association of cluster coordinators to form cluster trees in which one coordinator nodes assumes central role named ZigBee Coordinator (ZC) and other coordinators are ZigBee Routers (ZRs). ZRs retransmit data from any child node (leaf) within their clusters. Existing commercial 802.15.4 compliant modules do not support formation of cluster-tree topologies. So, collision of beacon occurs. It can be resolved beacon collisions with beacon sequencing and super frames. Sequencing of the beacons and Super frames in non-overlapped periods during Beacon Interval, GTS is implemented. Guaranteed Time Slot (GTS) mechanism that makes sure the devices can engage the time slots absolutely for transmission.

B. Adoptive Parent Model

The EDAP framework provides suppler routing and increases bandwidth consumption without violating the operating principles of the ZigBee protocol. Under EDAP framework, when a ZigBee router unexpectedly initiates data transmissions that require much more bandwidth than normal, the router is allowed to demand bandwidth from adjacent routers which is said to be adoptive parents as well as from its original parent router. Additional routing paths are recognized through the transmission links to the adoptive parents in order to enlarge the bandwidth between the source and the sink and thus satisfy the unexpected requirement for additional bandwidth. Distributed algorithm [1] arrive optimality and convergence of sensed data collection by the sink. Pull Push Relabel (PPR) algorithm is designed to adapt ZigBee cluster-tree network of specific scale.

PPR applies compound operation and vertices manipulate initial pre-flow until no overflowing vertex exists. Flow from source to sink will reach the maximum and initial pre-flow is created by subroutines.

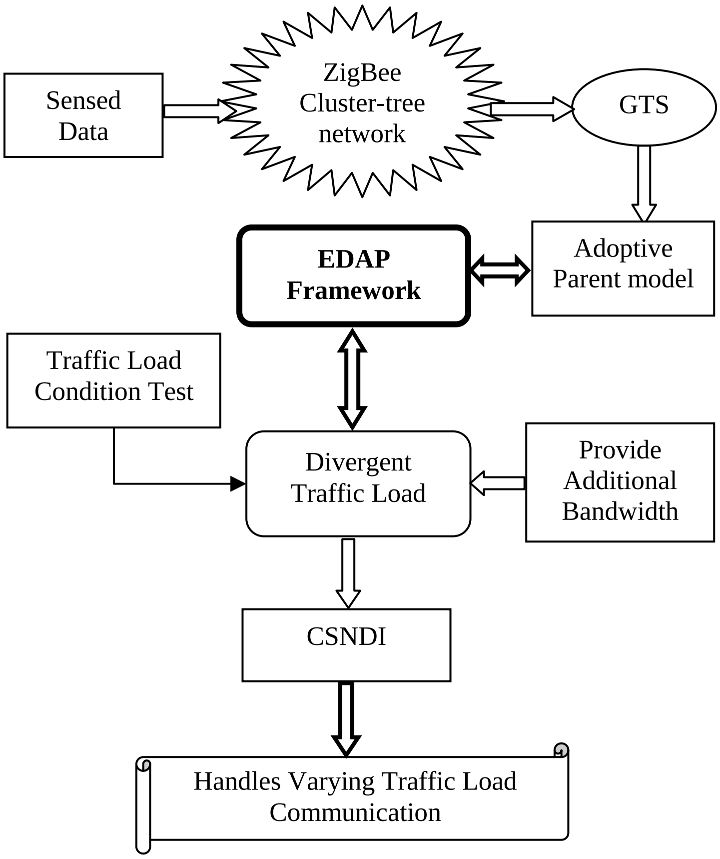

Figure.1 EDAP Framework for WSN Application with ZigBee Cluster Tree Topology

C. Traffic Variation

Network topologies are developed as three-layer hierarchy. Leaf nodes (those generating traffic) do not have any children. Different traffic loads are initiated based on upstream traffic. Traffic variation is classified into three types, as Coordinator support same traffic than router, Coordinator Support Several Routers, Routers Support Different Traffic. Network performance is evaluated by good-put and battery consumption. Good-put is measured as mean bit rate at which the ZC receives data from the leaf nodes.

D. Divergent Traffic Load

Divergent traffic load is done on bandwidth appropriation on traffic instances. In this process, actual required bandwidth is calculated based on the traffic load instances of ZigBee cluster tree nodes. ZC is listed down with traffic rate of incoming data from source and nearby routers. ZR is checked with the bandwidth load and demand conditions. Load-demand variance error is minimized by diverging the inflow traffic to other routers (ZR) with less traffic loads.

E. Sensor Node Distribution

Sensor node distribution is done with ZC by adoption parents with varied bandwidth demands of ZR. New parent is chosen to provide additional bandwidth need of ZR. Adoption potential of set of available new parents is assessed. Controlled sensor node distribution indicator (CSNDI) depends on Link Quality Indicator, depth of the candidate parent in the tree, traffic load and, energy indicator. Higher values of depth of parent and traffic load indicate less potential of the candidate parent. Suitable parent have highest indicator value. Measured link quality is bounded between maximum detected and time of detection of ZR for adoption parent.

TABLE I: PSEUDOCODE FOR THE EDAP FRAMEWORK

```
Coordinator sends beacons to the nearby nodes with GTS;
If the nodes receives beacons then
Begin
        Nodes response to the coordinator;
        Form cluster tree topology;
End
For all ZR do
If ZR is the source then
        If ZR have enough bandwidth for transmission then
        Transmit data to designated device;
While there exist any overflowing do
Begin
        For all ZR do
        If upper vertex ZR is overflowing then
        Lower vertex ZR pulls the flow;
        Function Relabel();
        If lower vertex ZR is overflowing then
        Upper vertex ZR pulls the flow;
        Function Relabel();
        Function Relabel()
        begin
        Check good put of each ZR for varying traffic loads;
        Then calculate required bandwidth;
        For adjacent ZR do
        ZC checks demand condition from list;
        If Adoption potential is assessed then
        ZC selects suitable ZR to adopt;
End
```

IV. PERFORMANCE ANALYSIS AND DISCUSSION

In this section, evaluate the performance of the proposed Enhanced Distributed Adoptive Parent (EDAP) framework via a series of simulation experiments. The cluster tree topology under investigation is based on the ZigBee specification, i.e., it is assumed that each device associates with the parent router at the lowest depth. The ZigBee coordinator is placed in the center of the square and serves as the data sink to collect the sensed information in the network. In the simulation, adopt the same channel model as used in the NS 2 simulator. Based on the two-ray ground propagation model, the transmission power and receiving power threshold are set to achieve a specific transmission range.

In the performance evaluation, analyze the Traffic Load, Density of sensor nodes, Bandwidth rate, Communication overhead and Load-Bandwidth Divergent Rate. The following experiments demonstrate the performance improvement achieved by proposed Enhanced Distributed Adoptive Parent (EDAP) framework.

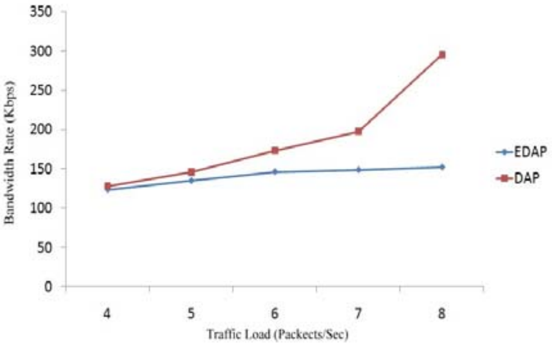

Figure.2 Bandwidth rate

TABLE II BANDWIDTH RATE

Traffic Load (packets/sec)	**Bandwidth rate (Kbps)**	
	EDAP	*DAP*
4	123.46	127.92
5	134.83	145.52
6	146.38	172.98
7	148.73	197.44
8	152.23	295.42

Figure. 2 show the effect of the traffic load of the cluster of interest on the bandwidth rate. Results show that the proposed EDAP framework's bandwidth rate is lower than that of the existing Adoptive-parent-based framework. This result also indicates that a large traffic load requires more bandwidth. We notice that for the uppermost curve in Figure. 2, when the traffic load is less than 6 packets/sec, is sufficient to hold arriving packets. Performance of proposed EDAP framework in terms of bandwidth rate attains 3% to 19% higher than Existing Adoptive-parent-based framework.

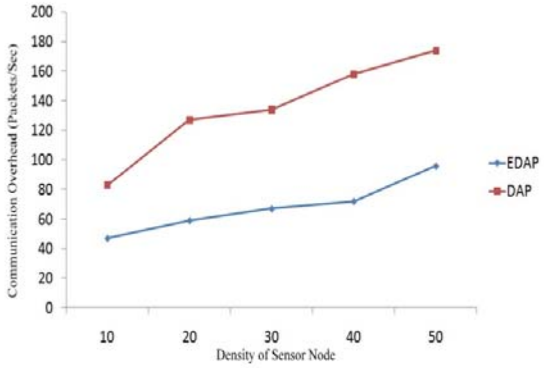

Figure.3 Communication Overhead

TABLE III: COMMUNICATION OVERHEAD

Density of sensor nodes	Communication Overhead (packets)	
	EDAP	*DAP*
10	47	83
20	59	127
30	67	134
40	72	158
50	96	174

Figure 3 compares the communication overhead in terms of bytes on proposed EDAP framework and existing adoptive-parent-based framework for a ZigBee cluster-tree network. The result shows the average communication overhead to build a routing path and the average memory overhead to manage a routing entry. Larger number of sensor nodes induces more communication overhead. Since the EDAP reduces up to 72.1% of communication overhead when compared with existing adoptive-parent-based framework

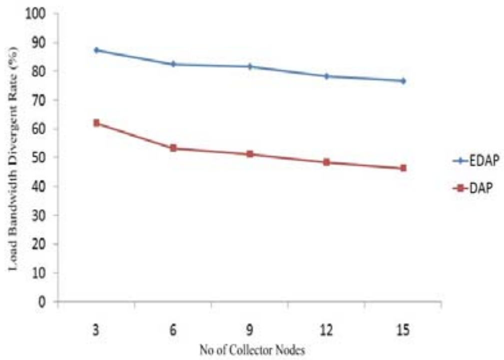

Figure.4 Load-Bandwidth Divergent Rate

TABLE IV: LOAD-BANDWIDTH DIVERGENT RATE

Number of collector Nodes	Load-Bandwidth Divergent Rate (%)	
	EDAP	*DAP*
3	87.34	62.13
6	82.52	53.31
9	81.69	51.25
12	78.36	48.41
15	76.67	46.35

Figure 4 shows the comparison result of Load-Bandwidth Divergent Rate of Proposed EDAP framework and existing adoptive-parent-based framework for a ZigBee cluster-tree network. Proposed EDAP framework. indicates the best performance possible on this metric, because it used Divergent Error Minimization on bandwidth appropriation on traffic instances. Both the curves show a more or less yet steady descendant when number of collector node increases.

Performance results from above graph shows better Load-Bandwidth Divergent Rate of Proposed EDAP framework, it achieves 24% to 29% higher Divergent Rate than existing framework.

V. CONCLUSION

In this paper presented an Enhanced Distributed Adoptive Parent (EDAP) framework for ZigBee cluster tree topology which handles varying traffic load communication in any given instant for WSN communication. Under the framework, a throughput maximization problem, called the Vertex-constraint maximum flow problem has been formulated. Divergent traffic load minimizer technique is employed to evaluate the actual required bandwidth on traffic load instances of ZigBee cluster tree communication. Proposed EDAP framework increased data delivery rate and minimized divergent error for load-bandwidth adoption. Data loss on communication of very high traffic also minimized. The results of simulation experiments reveal a significant performance improvement of proposed EDAP framework over the existing adoptive-parent-based framework.

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