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Cluster Based Multipath Dynamic Routing (CBDR) Protocol for Wireless Sensor Networks

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Abstract

QoS of WSN routing protocols are measured in terms of energy-efficiency, end-to-end delay and packet delivery ratio. Multi-path routing provides an easy mechanism to distribute traffic, balance networks load and fault tolerance. However disadvantage of employing multipath routing is delay in path switching and every node has to maintain information of every other node and has to update the whole information periodically which consumes lot of energy. So to overcome this drawback we employ clustering mechanism which divides the entire network in to clusters and multipaths are restricted to these clusters by which traffic will be distributed only to the cluster without propagating entire network and does not cause delay, energy wastage and increases delivery ratio between nodes. Performance is compared between proposed protocol and EQSR protocol by simulating in NS2.

Keywords: CBDR, EQSR, Multi-path Routing, NS2, Quality of Service, WSN

1. Introduction

Wireless Sensor Network (WSN) is a network containing wireless sensors that are widely distributed in a large geographical area which will cooperatively monitor different environmental and physical conditions, such as temperature change, sound pollution, pollutants, pressure etc. There are so many applications of WSN like Acoustic detection, Seismic Detection, Military surveillance, Inventory tracking, Medical monitoring, smart spaces etc.

WSN networks are formed by hundreds to thousands of nodes that communicate with each other updates information from time to time by passing data from one to another. However, design and management of high density networks is a challenging issue due to the unique properties of WSN such as limited power, bandwidth, high failure rate etc. These challenges lead us to mostly focus on developing robust and energy efficient protocols.

For maximizing network life time sensors energy have to be efficiently utilized. Utilization of sensors energy depends up on the type of application sensors are working for example in inventory tracking systems the data generated by sensor network need not necessary to update data continuously and can be done periodically which re queries less energy. On the other hand nuclear reactors and in process monitoring the data generated has to be updated continuously to sink where energy consumption is high and network life time is less. So protocol design varies depending upon application, network density etc.

Many routing protocols for WSN have been designed specifically by considering WSN unique properties. These protocols are classified as Qos based, Multipath based, Query based. In this paper we consider multipath routing protocol which uses multipath to send data from source to sink. In order to improve the performance and life time of network we designed clustered multipath routing protocols which have advantages of multipath protocol and also improve network life time because of clusters. This paper divides in to following phase's 2. literature survey, 3.CBDR, 4.Experimentation 5. Result analysis 6.Conclusion.

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2. Related Work

Some QoS oriented routing works are surveyed in and[1]. In this section we do not give a comprehensive summary of the related work, instead we present and discuss some works related to proposed protocol. One of the early proposed routing protocols that provide some QoS is the Sequential Assignment Routing (SAR) protocol[2].

K. Akkaya and M. Younis in[3] proposed a cluster based QoS aware routing protocol that employs a queuing model to handle both real-time and non real time traffic. The protocol only considers the end-to-end delay. The protocol associates a cost function with each link and uses the Kleast-cost path algorithm to find a set of the best candidate routes. Each of the routes is checked against the end-to-end constraints and the route that satisfies the constraints is chosen to send the data to the sink. All nodes initially are assigned the same bandwidth ratio which makes constraints on other nodes which require higher bandwidth ratio. Furthermore, the transmission delay is not considered in the estimation of the end-to-end delay, which sometimes results in selecting routes that do not meet the required end-to-end delay.

SPEED[4] is another QoS based routing protocol that provides soft real-time end-to-end guarantees. Each sensor node maintains information about its neighbours and exploits geographic forwarding to find the paths. To ensure packet delivery within the required time limits, SPEED enables the application to compute the end-to-end delay by dividing the distance to the sink by the speed of packet delivery before making any admission decision. Furthermore, SPEED can provide congestion avoidance when the network is congested.

Felemban et al[5]. propose Multi-path and Multi-Speed Routing Protocol (MMSPEED) for probabilistic QoS guarantee in WSNs. Multiple QoS levels are provided in the timeliness domain by using different delivery speeds, while various requirements are supported by probabilistic multipath forwarding in the reliability domain.

Recently, X. Huang and Y. Fang[6] have proposed multi constrained QoS multi-path routing (MCMP) protocol[6] that uses braided routes to deliver packets to the sink node according to certain QoS requirements expressed in terms of reliability and delay. The problem of the end-to-end delay is formulated as an optimization problem, and then an algorithm based on linear integer programming is applied to solve the problem.

The ECMP protocol trades between minimum number of hops and minimum energy by selecting the path that satisfies the QoS requirements and minimizes energy consumption. Energy efficient and QoS aware multipath routing protocol namely EQSR that maximizes the network lifetime through balancing energy consumption across multiple nodes, uses many protocols have suggested in previous papers for clustering in WSNs. In this section we explain the some celebrated clustering protocols.

LEACH is one of the most famous clustering based routing protocols in WSN[7].Cluster head selection among sensor nodes is done randomly and also data transmitting between cluster heads and base station is done directly in the LEACH. Although this specification of LEACH avoids energy hole problem but causes the energy of cluster heads that are far from the base station be discharge faster than others.

HEED[8] is another well-known clustering based routing algorithms in WSN. Cluster head selection algorithm is based on a relationship between remaining energy and reference energy in HEED.

3. Proposed Protocol

In this section, we describe about basic idea, and various contents of proposed algorithm.
Basic idea:

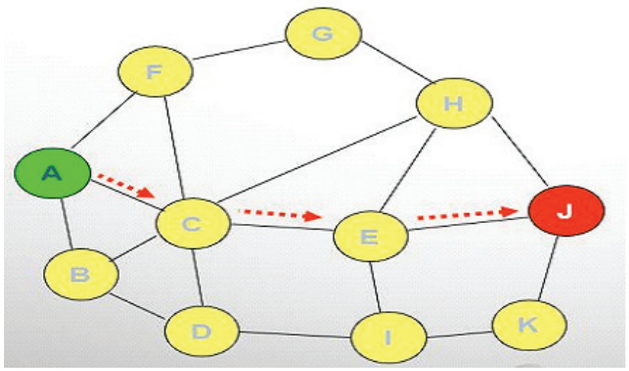

Figure 1. Single path routing.

When we send data from source to destination in the single path the nodes in the path die quickly. In Figure 2 due to single path node C and node E die quickly. So we employ multipath routing between source and destination and the disadvantage of employing multipath routing is every node has to maintain information of every other node for path switching and has to update the whole information periodically which consumes lot of energy. So to overcome this drawback we employ clustering mechanism which divides the entire network in to clusters and multipath are restricted to these clusters. Every cluster will have cluster head (CH) which look after nodes, updates to sink and destination. Here we introduce time parameter for dynamic switching of clusters.

3.1 CBDR

CBDR consists of three phases cluster formation, cluster head selection; dynamic cluster switching. The basic algorithm is shown below

Algorithm(s, d)
While (true)
Initialize threshold // parameter for clustering
Choose CH[i] //CH selection
While (node in CH[i] threshold) //cluster creation
Choose node into cluster
End while
Repeat until all nodes completed
End while
Time= (total time/no: clusters)
While (data transmission)
Generate (I) //generates in random or //sequence order
If (paths =null)
Paths=calculate paths (such [I], d) //gives //Multiple path
End if
j=0
While (j<time)
Transmit data
J--;
End-while
End-while
Cluster head selection:

In network initialisation cluster heads were fixed and as the time progresses CH will die of energy usage. Before that CH will announce new CH based upon the cluster head selection algorithm in HEED .Here basic metric in choosing new CH is highest Residual energy of node and high link capacity.

3.2 Cluster Creation

After selecting CH, it Beacons signals in the network, the nodes which are in the range receives the signal responds to CH to be part of cluster. CH then creates multi-paths between the nodes in cluster which helps in switch the paths in cluster to save energy. In below fig two clusters were created between sources A to sink B.

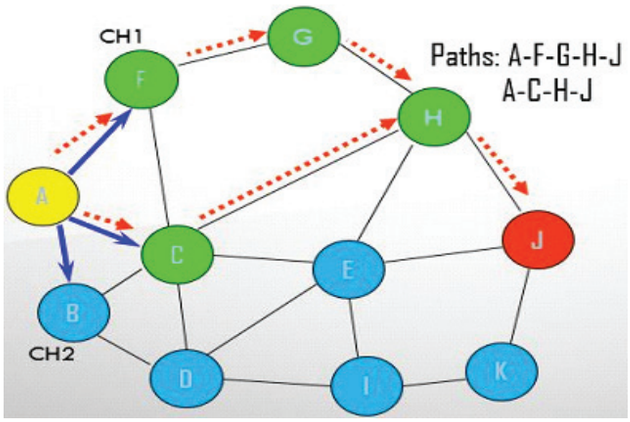

Figure 2. cluster creation.

3.3 Dynamic Cluster Switching

After creating clusters we will dynamically switch between clusters for total network energy efficiency. By this way we can use entire network efficiently for data transmission.

It named as cluster based Dynamic routing protocol as it will dynamically change clusters as per taking number of clusters and total time. We will divide time by number of clusters and it will be changed as per expression given below

T- Total Transmission time
N- Number of clusters
C- Time to be routed through every cluster
C = T/N

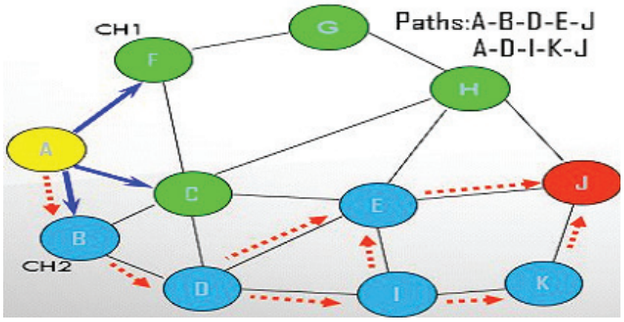

Figure 3. Dynamic cluster switching.

4. Experimentation

4.1 Beaconing

We have implemented beaconing using NS2 by using a command given below.

$ns_ at 0.0 "$node_(0) #sscs startCTPANCoord 0" <#txBeacon=1>#<BO=3>#<SO=3>

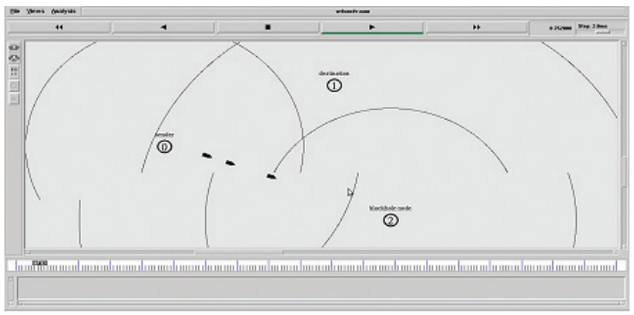

Figure 4. Example to show beacons in NS2.

We have used NS2 in order to implement Dynamic Clustered Multipath Routing (CBDR) protocol, in the experiment above we have used a wireless channel and for propagation we used two ray ground models.

As we simulated WSN network which should be created with Mac type of 802.15.4 for that we have used a MAC type of 802_15_4 in Ns2 which will define through wpan modelling of NS2.34 gives features of beaconing, other parameters are defined in table below

Table 1.

Parameter	Value
Simulator	NS-2(Version 2.34)
Channel Type	Channel/Wireless channel
Radio-Propagation Model	Propagation/TwoRay G round
Network Interface type	Phy/WirelessPhy/802_15_4
MAC Type	MAC/ 802_15_4
Interface queue Type	Queue/Drop Tail/Pri queue
Link Layer Type	LL
Antenna	Antenna/Omni Antenna
Maximum Packet in ifq	100
Area (M*M)	1000*1000
Number of mobile node	25
traffic	FTP
Simulation Time	150 sec
Routing Protocols	CBDR
Scn file	Set.scn
Trace output	Set.tr
Nam output	Set.nam
Initial energy	3J

By taking scn file we have given placement of nodes according to 3-d coordinate system and movement and clustering respectively. By varying number of packets in transmission we have calculated energy efficiency by using awk formatted file names energy.awk.

In NS2 we have created clusters by giving a size of each cluster as 200*200 and total network size as 1000*1000. By using beaconing signals it will self-repair or rearrange cluster head by taking least mobilizing and least weighted node form source node. In cluster it will take shortest path by using distance vector algorithm.

4.2 Node characteristics

Mac- 802_15_4
Model-Energy model
Initial energy- 3 joule
Receiver power- 0.3 dbl
Transmitting power- 0.3 dbl
Channel – wireless

4.3 Awk

AWK is abbreviated from Alfred Aho, Peter Weinberger and Brian Kernighan three scientists who created it in bell labs. Awk file is used to extract data from trace file. It is a programmed code which is used to process data from a trace file where data is been processed in sequence of rows. It will read a line at a time as per given code or mathematical expression it will be executed and gives output in numerical. To extract data from trace files we

have used awk for End to End delay, PDR and Energy efficiency.

5. Result and Analysis

Here we are comparing CBDR – Cluster Based Dynamic Routing protocol with existing protocol EQSR- Energy Based QoS Routing protocol by taking quality of service parameters. Here we are comparing CBDR with EQSR using quality of service parameters like End to End delay, packet delivery and energy consumption.

5.1 End to End Delay

End to End delay is the time taken for a packet to transmit throughout network from source to destination

$d_{end\text{-}end} = N[\, d_{tran} + d_{propag} + d_{process}]$

Where d is the total delay by each respective process as mentioned below are termed as

$d_{end2end}$=end-to-end

d_{trans}=transmission

d_{propag}=propagation

$d_{process}$=processing

N= total no of links (total number of routers + 1)

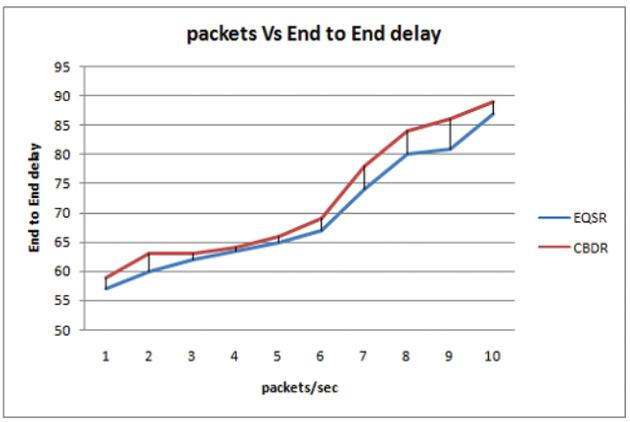

Figure 5. Packet Vs End to End delay.

As in CBDR protocol we are using clusters and changing its routing in and between clusters dynamically it's been getting some delay more than EQSR. As we specifically created this approach for energy efficiency, delay increased as packet number increases comparing to EQSR and graph plotted between End to End delay and packets/sec shown above.

5.2 Energy Efficiency

Energy efficiency is the average energy consumed by a node or sensor in transferring message through network from source to destination

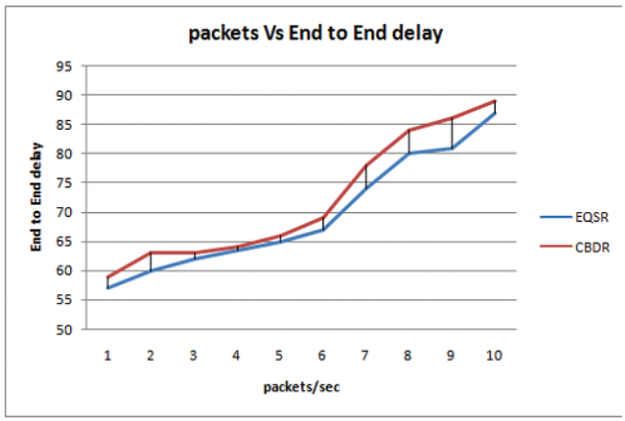

Figure 6. Packet Vs End to End delay.

In above graph we can notify that comparing to EQSR approach energy consumption of CBDR is relatively low, So for long transmitting data CBDR is better approach comparing to EQSR

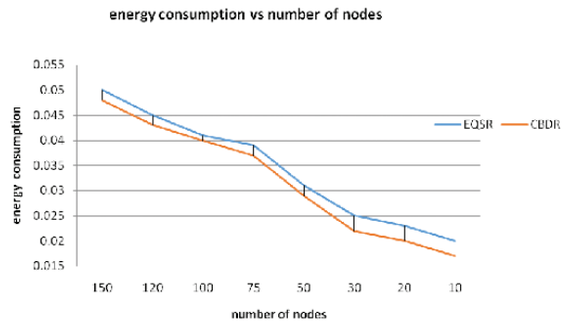

Figure 7. Energy consumption Vs number of nodes.

In above graph we have taken results by increasing number of nodes from 10 to 150 and energy consumption at every instant.

Here we can notify that energy consumption of CBDR is relatively low to EQSR even increasing number of nodes.

6. Conclusion

In this research paper we have designed a new routing protocol for WSN which provides Energy efficient routing

with better quality of service. After implementation this protocol provide better results than existing protocol for energy based routing i.e., EQSR. We have compared CBDR with EQSR and CBDR produces least energy consumption, which was our aim of this research.

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