To introduce a fault tolerant multicasting protocol using boltzmann neural network in WSN

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***Abstract* – Wireless sensor networks depend on crucial factors like battery power , memory, communication range and throughput of nodes which affect the network lifetime.These factors act as a challenge to optimize communication among spatially distributed nodes and cause faults in the network compromising lifetime of network especially when deployed in harsh environments. In this paper an improved multicasting protocol with reduced battery consumption has been proposed in which dynamic clustering is done with Boltzmann neural network .Cluster formation before data transmission is done dynamically using Boltzmann learning of neural network where weight adjustment is done according to situation which enhances the efficiency of dynamic clustering. Results of proposed technique show that its more reliable and efficient as well as provides more throughput as compared to existing technique.**

***Index Terms* – Multicasting, Neural network, Boltzmann learning, Fault Tolerance.**

I. INTRODUCTION

A wireless sensor network is a collection of sensor nodes deployed in various physical environments to sense and gather information. Design of routing protocol is critical issue in wireless sensor networks to ensure reliable communication between the sensor nodes[1].Routing Protocols are of three types: unicast, broadcast and multicast. Unicast is one-to-one, Broadcast is one-to-all and Multicast is one-to-many. This paper deals with Multicast communication where source node tries to communicate with multiple destination nodes simultaneously. Multicast is used in areas like audio/video conferencing, distance education, software distribution, etc.

The main design objectives of an effective multicasting protocol are: Minimization of total power consumed while delivering a multicast packet and maximization of network lifetime. Multicast protocols are further classified into two types: Tree based ,Mesh based and Hybrid multicast protocols based on their multicast topologies. In Tree-based only one path exists between source and destination.It provides high data forwarding efficiency and low overhead but can't be used in high mobile environments. They are further classified into two types: source tree based and Shared tree based.In Mesh based protocol ,more than one path may exist between source and destination and offers more overhead. Hybrid protocol is combination of both tree and mesh based protocols.

Some sensor nodes may fail or get blocked due to lack of power ,environmental interference and physical damage. Such failures shouldn't affect performance of wireless network. If faults occur then MAC and routing protocols must accommodate formation of new routes or links for data collection. This could require adjusting transmit powers and signaling rates on existing routes to reduce energy consumption or rerouting packets where more energy is available to make the network fault tolerant.[2]

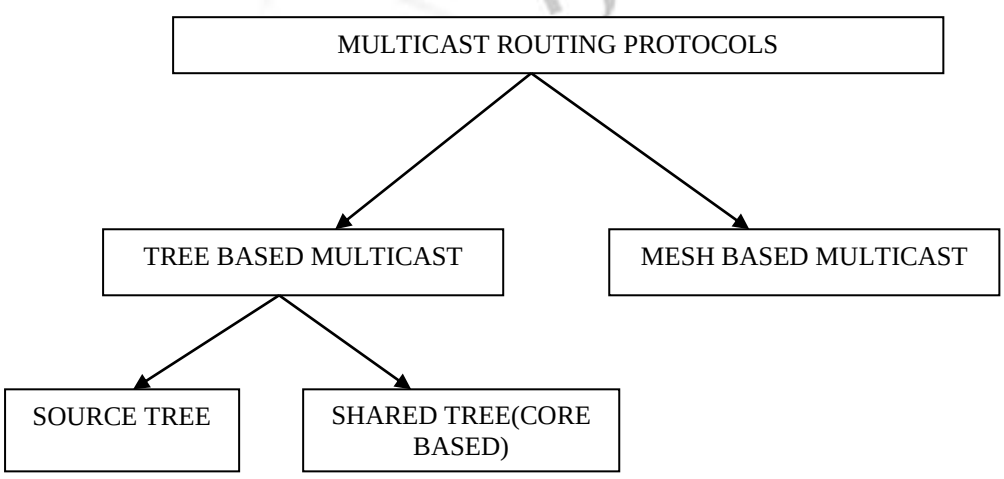

Figure 1: Classification of multicasting routing protocols

In this paper we have considered a Core network supported multicast routing (CNSMR)protocol for wireless sensor networks, a stateful based multicasting routing protocol for wireless networks and uses heterogeneous nodes. The sensor network is grouped into clusters that comprise of Cluster Head(CH) node,Core nodes(CN),Sensor nodes(SN).CN's with CH form the core network and SN's with CN's and core network form the core network supported multicast tree.Within each cluster following tasks are performed(i)CH node maintains the routing path with adjacent CH's and CN's.(ii)CN maintains route path with neighbouring CN's and adjacent SN's. protocol uses data gathering technique to forward data to neighbouring CNs and minimises routing complexity. In multicast routing, the source node primarily initiates multicast session and invites a set of nodes with REQ signal to join the session. After receiving the REPLY signal from target nodes, the source node forms the multicast group and confirms the path[17].

But,it suffers from faults due to static clustering approach where cluster heads are chosen on basis of maximum energy and minimum distance.So, irrespective of energy required to transmit data in every round node with maximum energy is chosen as cluster head due to which network has inefficient use of energy leading to shorter lifetime.In this paper a dynamic clustering technique based on Boltzmann learning to choose cluster heads has been proposed.

II. LITERATURE REVIEW

Multicast routing protocols optimize parameters such as bandwidth,channel utilization,throughput rate and quality of service(QoS). Multicast routing in WSN is primarily based on node location and uses the parameters such as node GPS attributes and neighbour node distance. GPS navigation devices trace the network routes, find the path failures and establish the routing paths in the network.

The table shown below lists the work related to multicasting routing protocols :

Table 1: Review of various multicasting protocols

AUTHOR	YEAR	DESCRIPTION	OUTCOME
Qingfeng, Chenyang Lu and Gruia-catalin[3]	2004	Design and analysis of Spatio temporal multicast protocols for wireless sensor networks introduced Mobicast based on forward zone selection	As data delivery zone move from dense to sparse network forward zone expands and vice versa Limitation: Random toplogy and complexity in network compactness
Juan Sanchez,Pedro Ruiz,Ivan Stojmenovic[4]	2006	Geographic Multicasting Routing protocol(GMR) used relay nodes(neighbouring nodes) selected on basis of greedy cost aware approach	Outperformed previous multicasting schemes in terms of cost of tree and computation time Limitation: Node mobility and network scalability
Shibo Wu,K. Selcuk Candan[5]	2007	Distributed GMR(D-GMR) constructs radio range familiar euclidean steiner trees	Offered low complexity,total no. of hops required and redudced energy consumption Limitation:Unbalanced network density
Dimitrios Koutsonikolas,Saumitra Das,Y. Charlie Hu[6]	2008	Hierarchical GMR(HGMR) uses forwarding efficiency of GMR and scalability of hierarchical rendezvous point multicast(HRPM)	Improves scalability and energy efficiency compared to GMR and HRPM Limitation: varying cell size and node density
Gang Zhao,Xiangqian Liu and Anup Kumar[7]	2007	Destination clustering GMR(DC-GMR), scalable unicast routing protocol based on destination node clustering	Better than GMR in total no. of transmissions Limitation:computational complexity and redundant clusters in network
Guokai,Zeng,Wang and Li Xiao[8]	2007	Grid Multicast protocol (GMP) is location guided grid routing method which eliminates multicast routing table for intermediate nodes	Reduces packet header size Limitation:Network bandwidth increases with multiple alternate routes
Lu Su,Bolin Ding,Yong Yang,Guohong Cao and Jennifer hou[9]	2009	Energy Optimal routing protocol(oCast) consider centralized and distributed approaches for small scale destination nodes	Improved range of multicast Limitation : works in scenario where sensor reports to small no. of base stations
Nedal Ababneh,Antonio M. Ortiz,Nicholas Timmons and Jim Morrison[10]	2012	Intelligent Multicast tree construction protocol with optimal bandwidth allocation for WSN's uses fuzzy logic approach to evaluate node	Efficient bandwidth utilization and achieves maximum throughput rate in network

		attributes	Limitation: works only in limited bandwidth scenario
Bartosz Musznicki,Mikolaj Tomczak and Piotr Zwierzykowski[11]	2012	Dijkstra's based localized multicast routing applied in large scale sensor networks uses energy efficient shortest paths and covers maximum geographical area towards the destination node.	Uses radio range of multicast group members to estimate average route cost and delay in multicast trees.
Kai Han,Yang Liu and Jun Luo[12]	2012	Duty cycle aware minimum energy multicast routing where nodes switch between active and sleep states	Minimizes no. of retransmissions and average delay latency of network
Laura Galuc,Giacmo Morabito and Sergio Palazzo[13]	2013	Geographic multicast(GEM) for dense wireless sensor networks based on Euclidean steiner tree	Efficient,scalable and reduced energy consumption
Deying Li,Zewn Liu,Yi Hong,Wenping Chen and Huan Ma[14]	2013	Minimum energy multicast/broadcast routing considers minimum reception cost wrt energy levels of transmission and reception nodes	Multicast route path with minimum reception cost is selected in network
Clifford Sule,Purav Shah,Krishna Doddapaneni and Orhan Gemikonakli[15]	2014	On-demand multicast routing based on clustering approach uses the CH node to act as intermediate multicast source node and forwards data to destination	Increases the connectivity rate and establishes a reliable network.
Do Duy Tan,Nguyen Quoc Dinh,Dong Seong Kim[16]	2014	Gradient based-Traffic aware routing uses multiple sink nodes in the network.Routing paths are established from source to sink nodes using gradient search method that comprises of attributes like hop count,distance and delay between the nodes in network.	Gradient index with minimum value participates in multicast session. Overall end-to-end delay is reduced in heavy traffic networks
Bala Krishan Maddali[17]	2015	Core network supported multicasting routing protocol consists of heterogeneous nodes :cluster heads,core nodes and sensor nodes which construct core network supported multicast tree	Multicast trees balance load in network and improve network performance as compared to existing multicast protocols

III. METHODOLOGY

Core network supported multicast routing protocol(CNSMR) protocol used the concept of static clustering in which cluster heads were chosen on the basis of maximum energy and minimum distance in every round.But this lead to inefficient use of network energy and decrease in network lifetime.So, to reduce energy consumption and to prolong network lifetime we have proposed the use of Boltzmann learning of neural network in ECNSMR(Enhanced CNSMR).Boltzmann learning introduces dynamic clustering in the deployed network where cluster head gets chosen according to minimum battery consumption and maximum data transmission.The main concern is to avoid battery depletion.

Boltzmann learning is a stochastic recurrent neural network comprising of hidden layers and visible layers.The weights between the layers are adjusted according to the situation to give desired output .It is supervised learning and similar to error-correction learning where an error signal is used to train the system in each iteration.Each neuron in input layer is connected to hidden layer neurons and hidden layer neurons are connected to output layer neurons.

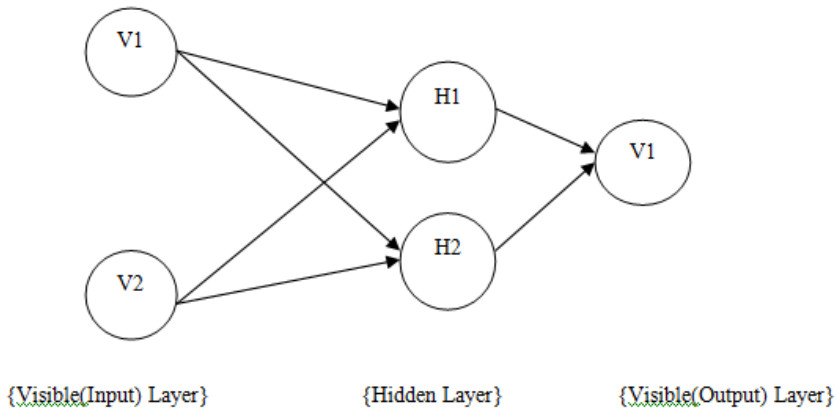

Figure 2: Boltzmann Neural network

III.A. Proposed Algorithm

The proposed algorithm introduces a energy efficient multicasting protocol using following steps:

1. Deploy sensor network randomly with fixed number of nodes.
2. Apply location based clustering for cluster formation of sensor nodes.
3. Select cluster head in each cluster on the basis of maximum energy and minimum distance
4. If (link failure occurs in network)
   {
   1. Apply Boltzman learning to rate sensor nodes
   2. Recover path through sensor nodes which has higher rating

   }
   Else
   1. Start communication from source to destination.

   }

IV. Simulation and Results

The implementation of proposed scheme has been done in MATLAB.The general simulation parameters are:

1. Field dimensions: 100*100 m
2. Base station location: 50*50 m
3. Number of nodes: 100
4. Initial energy per node: 5J
5. Energy model parameter ε_{fs} : $1*10^{-11}$
6. Energy model parameter ε_{mp}:$0.0013*10^{-11}$

The proposed scheme performance is compared with the existing technique through assessment of following metrics:

1. **Number of Alive nodes**:It is defined as the number of nodes that are still working after completion of the rounds of transmission in deployed network.

2. **Throughput**: It is defined as the ratio of number of packets received by destination nodes to number of packets transmitted by source nodes.

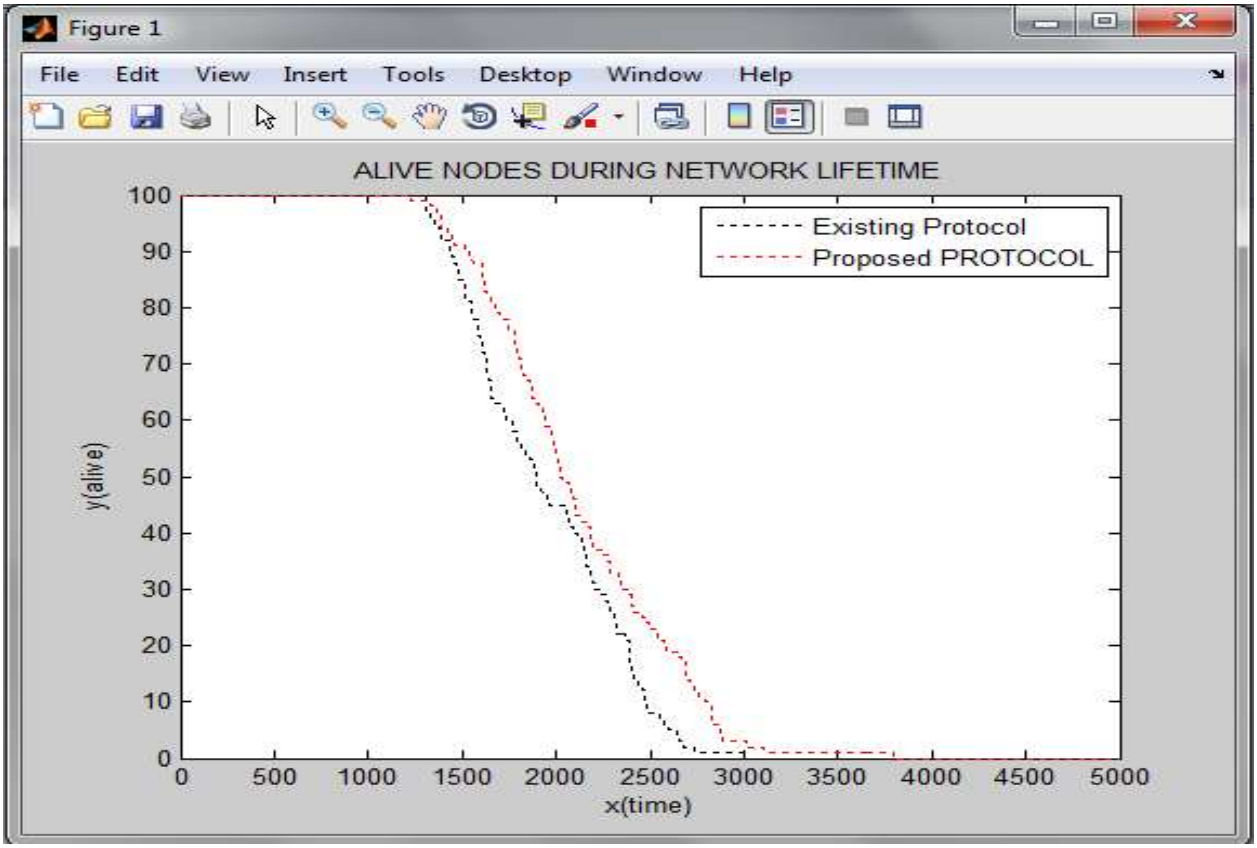

Figure 3: Graph comparing the no. of alive nodes in network for existing and proposed protocol.

The graph in figure 3 clearly shows that there are more number of alive nodes present in proposed protocol as compared to existing protocol.This means the lifetime of proposed protocol will be more as compared to existing protocol as more number of nodes are alive to perform the transmissions.

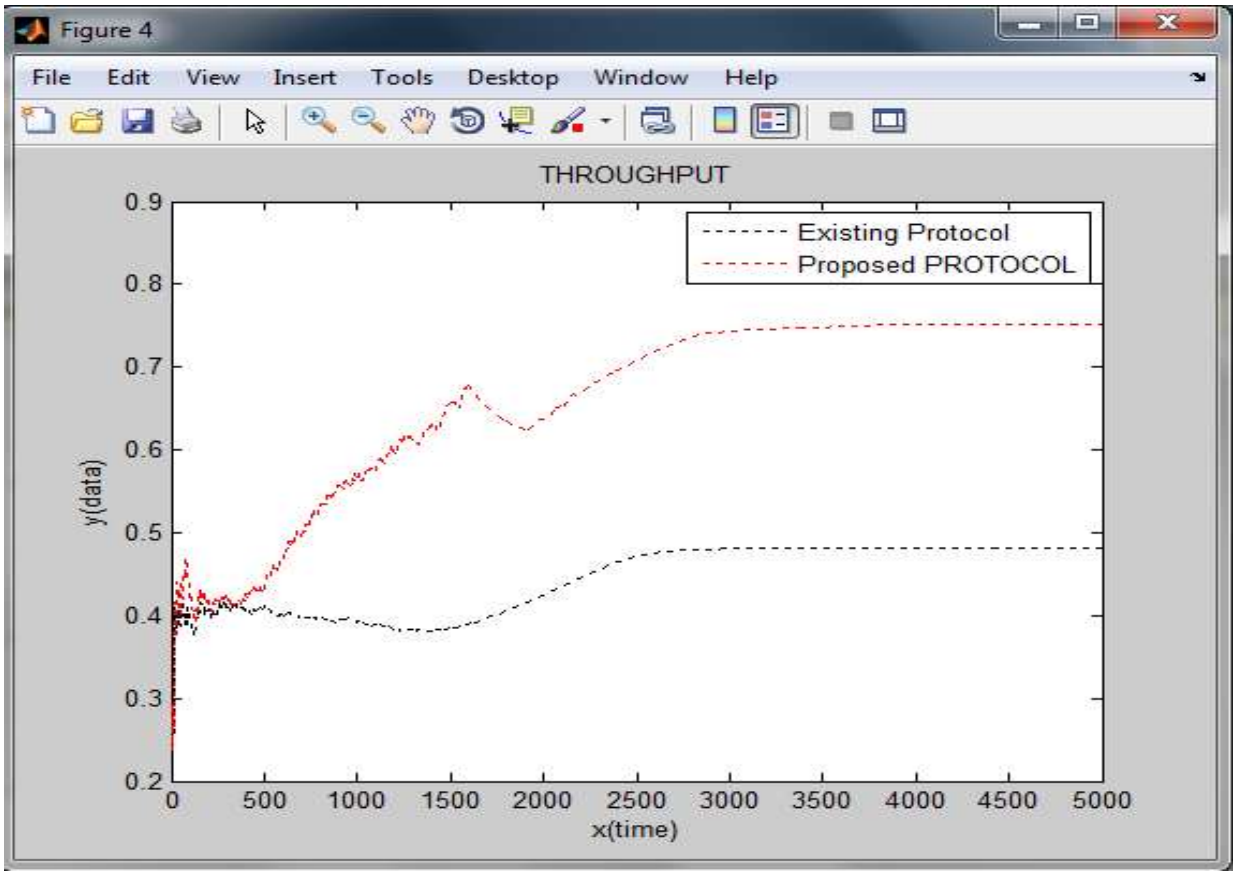

Figure 4: Graph comparing the Throughput of existing and proposed protocol

The graph in Figure 4 shows clearly that proposed protocol offers better throughput than existing protocol. As throughput is better so will be the network efficiency and lifetime.

V. CONCLUSION

In this paper ECNSMR(Enhanced core network supported multicast routing protocol) protocol based on Boltzmann neural network has been proposed. To increase lifetime of sensor network and reduce overhead in dynamic clustering, cluster heads are changed using Boltzmann learning approach of neural network. In the previous work, static clustering has been used. But in this dynamic clustering of sensor nodes is performed which can be adjusted and changed according to situation. Main concern is to avoid battery depletion. AODV routing has been used in network. Cluster heads in each cluster gets changed according to maximum data transmission and minimum battery consumption. The implementation of this research work has been done in MATLAB R2013a.Simulation results show that proposed technique has more number of alive nodes and better throughput than the existing technique which leads to increase in lifetime of sensor network.

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