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Cluster Based Routing Architecture Using PSO for ZigBee Mobile Wireless Sensor Networks

[1]B. Meenakshi and [2]D. Karunkuzhali
[1]Department of Electrical and Electronics Engineering,
Sri Sairam Engineering College, Chennai, Tamil Nadu, India
[2]Department of Information Technology, Panimalar Engineering College,
Chennai, Tamil Nadu, India

Abstract: In wireless sensor network, security and energy efficiency is the main issue during transmission of the packet. In order to overcome these issues, a cluster based routing architecture using PSO for ZigBee mobile wireless sensor networks is proposed. In this studr, first clustering is done based on Particle Swarm Optimization (PSO) technique. The selection of best emissary node is done based on PSO technique to increase the number of reliable node in the cluster. To maintain the energy efficiency, modelling of sleep period is done. To increase the security during transmission, each information is encoded using channel coding with XOR operation.

Key words: Efficiency, optimization, echnique, transmission, encoded

INTRODUCTION

Mobile wireless sensor networks: WSN is a collection of several wireless sensor nodes forming a multi-hop and self-organized network via wireless communication (Wang *et al*., 2012). Wireless sensor mote is a node in WSN that can gather sensed data; process on the data measured and communicates the processed information with the connected network nodes (Mugelan *et al*., 2011). The sensor radios and CPUs are coordinated into an effective, robust secure and flexible network forms the individual constitution of motes. They have low power consumption and advanced communication and computation capabilities, one or more sensors, a communication device (typically a radio), a microcontroller (with memory) and a power supply (battery) (Wang *et al*., 2012; Singh *et al*., 2011). Hence, it has a wide range of applications in industry, national defense, environmental monitoring, traffic control, medical services and the household (Wang *et al*., 2012).

The typical WSN consists of sensor nodes, sink nodes and management nodes. Sensor nodes are of two types: static sensor node and mobile sensor node. Static senor nodes mostly traditional wireless sensor network nodes and communication between them depends on their own limited resources and surrounding environment causing communication disruption and lack of dynamic networking. The drawbacks of static wireless sensor networks like poor adaptability, lack of dynamic networking etc can be compensated by deploying a number of mobile nodes in wireless sensor networks (Wang *et al*., 2012).

Issues of MWSN: However, WSNs proper behavior is affected by its large scale and communication/computing and energy limitations (Jurcik *et al*., 2008). In addition, nodes mobility in ad hoc networks is a critical issue because of the overhead and complexity created during mobile nodes management which affects the limited resources in Wireless Sensor Networks (WSN) (Mouawad *et al*., 2013).

ZigBee networks: Wireless sensor networks require the assistance from a wireless network protocols. There are various wireless communication technologies like Blue tooth, Wi-Fi, Zigbee, etc. Among them, ZigBee a short distance wireless network protocol specifically designed for low data rate sensors and control networks for wireless connectivity in inexpensive, portable and mobile devices which is preferred due to its low power consumption, low rate, low cost and short time-delay, especially suitable for WSN. Unlike other wireless protocols, ZigBee provide low complexity, reduced resource requirements and most importantly, a standard set of specifications. Also, it provides three frequency bands of operation along with a number of network

Corresponding Author: B. Meenakshi, Department of Electrical and Electronics Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India

configurations and optional security capability. ZigBee is a proper alternative to the existing control network technologies like RS-422, RS-485 or proprietary wireless protocol. Zigbee has a wide range of applications in building automation networks, home security systems, industrial control networks, remote metering and PC peripherals, etc., (Wang *et al*., 2012; Cheng and Huang, 2013; Xiao *et al*., 2009; Huang *et al*., 2012a, b).

ZigBee, a wireless communication standard is built on the IEEE802.15.4 low-rate Wireless Personal Area Networks (WPAN) standard for monitoring and control is proposed and maintained by Zigbee alliance. The physical layer (PHY) and Media Access Control (MAC) layer are defined by the IEEE 802.15.4 (Cheng and Huang, 2013). Excellent peer to peer communication can be provided by ZigBee utilizing the IEEE 802.15.4 assisted communication components. Zigbee can extend the network range with ZigBee specified upper network layer. Star, tree and mesh topologies supports Zigbee (Yang and Yang, 2009).

However, ZigBee wireless applications face delivery failures constantly because of node movements and network topology changes (Shih *et al*., 2013).

Cluster based routing in MWSN: The WSN mobility problem can be handled using routing protocols by updating the routes at a costly price (either using a pro-active or a reactive routing protocol) (Mouawad *et al*., 2013). And clustering can reduce data packet collision probability occurring at network layer. Also, cluster based routing reduce network loads and limit most of communications in network (Shih *et al*., 2013).

Among the well known ZigBee topologies, ZigBee cluster-tree topology is well suited for low-power and low-cost wireless sensor networks among well known ZigBee topologies since it supports power saving operations and light-weight routing. IEEE 802.15.4 MAC super frame structure manages the power saving operations and a distributed address assignment policy configured by several system parameters enable light-weight tree routing protocol (Huang *et al*., 2012a, b).

However, the restricted routing of a ZigBee cluster tree network could not provide sufficient bandwidth for the increased traffic load so the additional information may not be delivered successfully. Also it failed to provide QoS guarantee for critical packet deliveries in mission-critical networks (Huang *et al*., 2012).

Literature review: Wang *et al*. (2012) proposed a scheme to design mobile wireless sensor node based on ZigBee. Also the mobile node designed into mobile indoor wireless temperature sensor system details are presented as well. Anyhow, the hardware circuit design is complex.

Shih *et al*. (2013) proposed a ZigBee node deployment and tree construction framework. The mobility patterns' regularity is considered while routing tree construction and node deployment. An overhearing mechanism is included for mobile nodes for further enhancing delivery ratio. The proposed algorithms were proposed for node deployment and tree construction in the framework. However, the delay increases for all trees as the speed increases.

Diallo *et al*. (2010) proposed an analytical model relying on LQI derive an optimally one-dominating set where the smaller distance separating two cluster heads is improved. Each caryomme chose its one hop neighborhood some nodes which are its emissaries while clustering Then two adjacent clusters is related by the best emissary node located between the two respective cluster heads. However, the scheme is not energy efficient.

Huang *et al*. (2007, 2012) proposed clustering technique which extend the network durability and decrease the energy waste while frequent reconstruction of cluster, according to the proxy transferring data of cluster using two thresholds. However the number of alive nodes decreases with increasing rounds.

Tavakoli *et al*. (2013) presented an elaborate traffic model due to sensing and clustering algorithm in the network. The energy consumption of message exchanges were modeled associated with ALEC algorithm. However it cause power consumption and delay overheads on the network.

Alrajeh *et al*. (2013) proposed a novel multi-radio multichannel framework for efficient communication among devices in WBAN for energy efficient and reliable communication in WBAN. However, more energy is consumed in multi-radio multi-channel mechanism because of operation of extra radios.

Nabi *et al*. (2011) presented a comprehensive configurable mobility model MoBAN for evaluating intra and extra-WBAN communication. Intra- and extra-WBAN protocols were simulated using the model. The communication between the sensor nodes within a WBAN on a body is considered in Intra WBAN. Meanwhile Extra-WBAN protocols concentrate on communications between a WBAN and its environment, with potentially several body area networks as well as an ambient network. The model is configurable making it open to various applications. However collision occurs due to WBAN's interference.

Chen and Pompili (2011) proposed a novel in-network solution for prioritizing the transmission of patient vital signs using wireless body area networks and the solution based on a distributed priority scheduling strategy according to the current patient condition and on the vital sign end-to-end delay/reliability requirement. However, error occurs due to loss of data increasing the delay.

Chen *et al*. (2010) proposed a novel wireless communication solution seamlessly supporting patient mobility and prioritizing vital signs transmission using Wireless Body Area Networks (WBANs). However, it takes more time to set up communications between mobile BANs using Bluetooth.

Movassaghi *et al*. (2013) proposed a novel cooperative transmission scheme via network coding for Wireless Body Area Networks (WBANs) for enhancing reliability and throughput. The proposed Random XOR Network Coding (RXNC) enable each relay to demodulate the received signal from each sensor node and different coded symbols and XORs were chosen amongst them to generate a network coded symbol. However the scheme becomes inefficient with a large number of source nodes.

Hara *et al*. (2011) proposed a cooperative scheme to ensure reliable data transmission in a WBAN. A sensor node is assigned autonomously by the scheme for each sensor node on a human body as a cooperator out of other sensor nodes and packets were retransmitted by the cooperator retransmits packets from the sensor node for a coordinator instead of the sensor node when the direct link between them is blocked. However, the overall result was affected much by the walking motion case.

Shih *et al*. (2013) proposed random incomplete coloring (RIC) with low time-complexity and high spatial reuse to overcome in between Wireless Body Area Networks (WBAN) interference, leading to serious throughput degradation and energy waste. Interference-avoidance scheduling of wireless networks can be modeled as a problem of graph coloring. For example, high spatial reuse scheduling for a dense sensor network was mapped to high spatial-reuse coloring; fast convergence scheduling for a Mobile Ad hoc Network (MANET) was mapped to low time-complexity coloring. However for a dense and mobile WBAN, Inter-WBAN Scheduling (IWS) should simultaneously satisfy high spatial-reuse and fast convergence requirements which are tradeoffs in conventional coloring. Moreover, increased coloring number leads to decrease in effective transmission per slot.

MATERIALS AND METHODS

Problem identification and Solution: In our first study [], we have proposed a fuzzy based energy efficient clustering technique for ZigBee sensor networks. In this technique, fuzzy rules are formed on the input variables number of hops, residual energy, received signal strength and node degree and node rank is obtained as output. The node with highest rank is chosen as cluster head. When the sensor nodes want to transmit the data to the sink, it is compressed in the cluster head and then forwarded to the sink. During the cluster maintenance phase, the node rank is estimated for every time period T. When the rank of existing cluster head reduces, the node with highest rank is selected as new cluster head.

In our second study [], we have proposed cluster based TDMA scheduling mechanism for IEEE 802.15.4 ZigBee Wireless Sensor Networks. This TDMA slot allocation strategy allocates slots to the nodes based on queue occupancy information. It assigns TDMA slots starting from nodes with high queue occupancy value. Nodes that have high queue occupancy value will probably get long TDMA slot period. Our approach fairly allocates slots to the nodes and considerably reduces packet collision rate.

As an extension work, we propose to design a cluster based routing architecture for mobile wireless sensor networks using Particle Swarm Optimization (PSO) technique.

Overview: Particle Swarm Optimization (PSO) technique is rooted on the social behavior metaphor. PSO is also described as a stochastic global optimization method. In PSO, a population of random candidate solutions are initialized in the network, these are syntactically referred as particles called swarm. Every particle is allocated with a random velocity and it is permitted to move in the problem space. The moving particles are attracted towards the best fitness location achieved by itself and the best fitness location accomplished by the entire population. PSO is simpler to implement and every particle has effective memory capability (DeValle *et al*., 2007).

Here, the clusters are reduced by increasing the distance between the cluster heads so as to reduce cluster overlaps, forming an efficient cover of the network using link quality indicator. Now, the clustering technique can be extended by defining emissary nodes (Diallo *et al*., 2010) which are sensors forming weak links with a node and at least one good link with another node outside the node's neighborhood. The best emissary nodes are selected using Particle Swarm Optimization (PSO) technique to form a relation between clusters. This model forms a backbone of set of cluster heads plus set of best emissary nodes.

The energy consumption in this scheme can be reduced by making the cluster heads involved in transmission alone to be awake and making rest of the nodes in sleep mode during transmission (Tavakoli *et al*., 2013). The sleep period was modeled and the node lifetime is estimated. The life time can be increased by choosing higher values of clustering periods and lower values of sensing reliability.

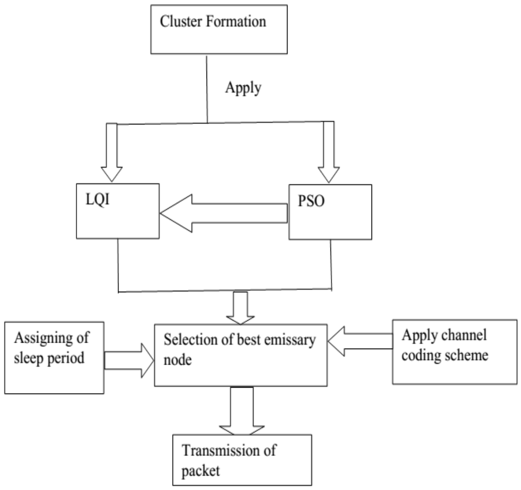

Fig. 1: Block diagram

Following, the noise in the transmission can be reduced and the security of the system can be improved by coding the messages using a channel code (Movassaghi *et al*., 2013). The symbols coded by the source are modulated and transmitted to relays and destinations. The relay nodes on receiving either decode and forward or demodulate and forward to generate network coded symbols. It chooses different decided symbols and XORs them and transmitted to destination. The decided symbol are optimized to reduce the error probability.

Figure 1 represents the block diagram of proposed cluster architecture. In the proposed architecture, cluster formation is done by selecting best emissary node by applying PSO and finding the fitness function in terms of Link Quality Indicator (LQI). After that determine the sleep period for node when no packets are there. To increase the security, information to be sent is coded using demodulate and forward technique along with XOR operation.

Particle Swarm Optimization (PSO): Particle Swarm Optimization is best technique to find the best fitness value based on the swarm intelligence concept. In this technique, colonial behaviors of unexperienced agents interacting locally with their existing environment results in coherent global functional patterns. The technique is mainly based on five fundamental principle of swarm intelligence (DelValle *et al*., 2007).

Proximity principle: According to this principle, the group in swarm need to carry out simple space and time calculation.

Quality principle: The swarm group should respond to all the quality factors present in the environment.

Diverse response principle: The group should never commit any activity along extremely narrow channels.

Stability principle: The behavior of each swarm should be stable and should not change its behavior every time according to changes in environment.

Adaptability principle: The swarm should change its behavior only in case it is worth by considering computational price.

Implementation of PSO: In the network, for each individual in group possible solution can be found by the movement of particle in the neighboring environment. The position of each particle in group is established by vector and based on velocity of the particle.

$$\vec{y}_i(t) = \vec{y}_i(t-1) + \vec{v}_i(t) \quad (1)$$

The information for each individual is obtained based on its own experience and by observing the performance of other individual in its neighboring circle. The importance of getting information based on the above mentioned two factors vary from one decision to another, hence it is a wise decision to apply two random weight to each part and hence the velocity can be determined by:

$$\vec{v}_i(t) = \vec{v}_i(t-1) + \phi_1.\text{rand1}(\vec{P}_i - \vec{y}_i(t-1)).....\phi_2.\text{rand1}(\vec{P}_i - \vec{y}_i(t-1)) \quad (2)$$

Here, ϕ^1 and ϕ^2 represents two positive numbers. Rand 1 and rand 2 represents two random numbers with uniform distribution. Equation 2 represents velocity update equation which represents mainly three major component:

- The first component is called as "momentum" or "inertia". It means the tendency of movement of the particle will be in the same direction. It is represented by a constant in the modified PSO
- The second component represents the best position found by the moving particle. The fitness value is called as Particle's best (P_{best}) found by random weight. This component is called as "memory", "remembrance" or nostalgia
- The third component represents linear attraction of the particle towards best position whose fitness value is called as global best (G_{best}) which is represented by other random weight. This component is called as "social knowledge", "group knowledge" or "cooperation"

Based on the above derivation, the following steps can be used for implementing PSO algorithm:

- Step 1: Initiate swarm by allocating a random position in the real space to each particle in group
- Step 2: Estimate the fitness function of each particle in the group
- Step 3: Fr each particle present in group, compare each particle's fitness value with its P_{best}. In case the current value is better than P_{best} value, then set this value as P_{best} and also the current particle's location y_i as P_i.
- Step 4: Determine the particle with best fitness value. The fitness value for this particle is described as G_{best} and its position as P_g
- Step 5: Update the position and velocities of each and every particles using Eq. 1 and 2
- Step 6: Repeat step 2-5 until all the best fitness value is found

Cluster formation: This section describes about the formation of the cluster by considering Link Quality Identifier (LQI) as best fitness value and selecting best emissary node by applying PSO algorithm.

Selection of best emissary nodes in cluster

Definition

Emissary node: Emissary nodes (Diallo *et al*., 2010) are the nodes which have at least one good link outside the vicinity of the network. In study, Diallo *et al.* (2010), selection of emissary nodes are mainly based on the LQI to avoid any kind of overlap with the clusters. But in this paper, selection of emissary node is enhanced by applying PSO algorithm. PSO provides best solution with each iteration and make it possible to reach the best solution in terms of LQI.

Link Quality Identifier (LQI) The LQI (L) is defined as link between the nodes with strong received signal strength. The received signal strength at emissary node n_j based on path loss model can be given as:

$$V_{n_i, n_j} = O_{n_i, n_j} x_{n_i} + a_{i,j} \quad (3)$$

Here, o_{n_i, n_j} represents channel coefficient which is determined by path loss model. $A_{i,j}$ represents additive zero mean white Gaussian noise with variance τ_n^2:

$$L \propto V_{n_i, n_j}$$

Here node with good received signal strength will have good LQI. Consider a Cluster C1 with a set of node N that means $N = \{n_1, n_2, ..., n_n\}$. This study describes about the selection of best emissary node in the cluster based on the PSO algorithm. The selection of emissary nodes in the cluster by the Cluster Head (CH) is explained in the following steps.

Step 1: Define the nodes set in the cluster.

Step 2: Define the minimum LQI threshold to select the node which have good links with neighbors. For each $n_i \in N$ where, I = 1, 2, ..., n, the set E_1 of participating emissary node can be defined as:

$$E_1(n_i) = \{n_j \in K_1(n_i) \setminus \{n_i\}, 0 \leq L(n_i, n_j) \leq L_{max}\} \quad (4)$$

where, $K_1(n_1)$ is denotes neighborhood of the node n and node n forms a link with each $n_j \in K(n_1)$. LQI in this case is represented by. $L(n_i, n_j)>0$.L represents the LQI between the nodes.

Step 3: Determine the link of $n_i \in N$ where I = 1, 2, ..., n nodes, for each $n_j \in E_1(n_i)$, the set $L(n, {}_in)$ of the neighborhood of n and which establish a very good link with n_j can be defined as:

$$\overline{E_1}(n_i, n_j) = \{n_k \setminus K_1(n_j), L(n_j, o) > L_{max} \quad (5)$$

where, n_k represents the neighboring node.

Step 6: Determine all the emissary node with good link with neighboring nodes. Determine the fitness function in terms of LQI:

$$f(L) = f(V_{n_i, n_j}) \quad (6)$$

Step 7: Apply the PSO algorithm (described in this study) to choose the best emissary node. Equation 1 and 2 is used to select best emissary node and determining the fitness function in terms of LQI:

$$\vec{y}_i(t) = \vec{y}_i(t-1) + \vec{v}_i(t)$$

$$\vec{v}_i(t) = \vec{v}_i(t-1) + \varphi_1.\text{rand1}(\vec{P}_i - \vec{y}_i(t-1))$$

$$.....\varphi_2.\text{rand1}(\vec{P}_i - \vec{y}_i(t-1))$$

Here, the particle represents emissary node E. Hence, the E_{bset} will be selected as the best emissary node in the cluster by the Cluster Head (CH) by applying the PSO technique. Until sufficient emissary nodes are collected do the iteration. Figure 2 represents the clustering technique with selection of best emissary node. Here node 3 and 4 in CH1 are the emissary node which strong LQI with node 7 and 8. They have weak link with 5 and 6. Hence, the strong link for transmission can be through emissary node through 3-7 or 4-8. Similarly in CH2 node 13 and 14 represents the best emissary node. The node 13 has a good link with node 10 and node 14, hence the strong link for transmission can be 13-10 or 14-11.

Modelling of sleep period during clustering: This study describes modelling of sleep period (Tavakoli *et al*., 2013) in order to increase the lifetime of node. To model the sleep period consider that sleep is geometrically allotted based on parameter T_{Sleep}. Also, assume buffer of a node in cluster as M/G/1/K queuing model along with vacations. The sleep modelling mainly depends on 1-limited service policy according to which if there exists any packet in the buffer, then immediately node transmits only one packet at a time and immediately after transmission goes to sleep. The modelling of sleep period is explained in the following steps.

Step 1: Define the Probability Generating Function (PGF) for one geometrically allotted sleep period as:

$$G(z) = \sum_{k=1}^{\infty}(1-T_{sleep})T_{sleep^{z^k}}^{k-1} = \frac{(1-T_{sleep})^Z}{1-T_{sleep^z}} \qquad (7)$$

Step 2: Determine the average value of one sleep period as:

$$\overline{G} = \frac{d}{dz}(G_Z)\,|\,z=1=\frac{1}{1-T_{sleep}} \qquad (8)$$

Step 3: Determine PGF of number of packet arriving to buffer at the time of sleep period of a node. For this assume that number of arriving packet follow the Poisson process at the rate, then determine PGF as:

$$H(z) = G^*(s)(\eta-\eta_z) \qquad (9)$$

where, $H^*(s) = (1\text{-}T_{sleep})e^{-s}/1\text{-}T_{sleep}e^{-s}$ represents the Laplace-Stateltjes Transform (LST) of the sleep period which can be obtained by substituting variable z with e^{-s}.

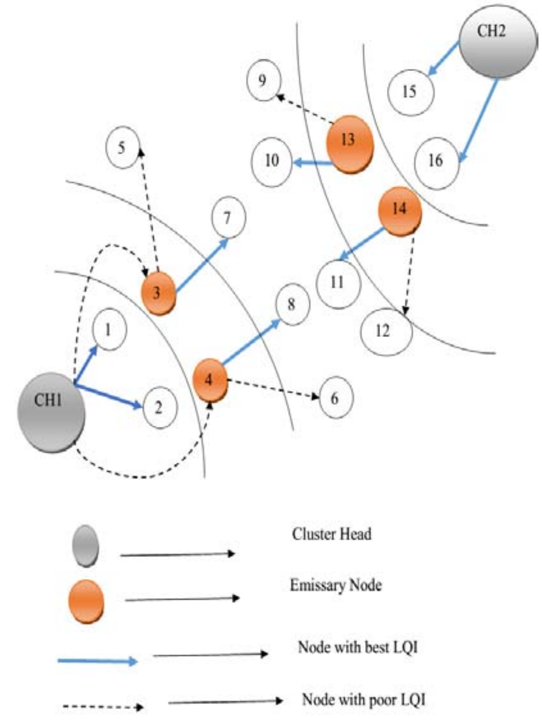

Fig. 2: Cluster formation with best emissary node

Step 4: Determination of successive sleep period for small buffer size. In case, there is no packet in buffer, the node in the buffer starts another sleep period immediately. As the packet service period is much smaller than node's sleep period, hence the new sleep starts only in case there were zero packet arrival at th time of sleep period with the probability H (0) = G* (η). Hence, PGF of consecutive sleep period can be given as:

$$J(z) = \frac{(1-G^*(\eta))(G(z))}{(1-G^*(\eta))(G(z)} \qquad (10)$$

Also, the average value of sleep period can be given as Eq. 11:

$$\bar{I} = \frac{1}{(1-T_{sleep}(1-G*\eta)} \qquad (11)$$

Channel coding scheme using XOR operation: This study describes about reliable channel coding scheme based on demodulate and forward technique along with XOR operation.

In this type of technique, in first step each source encode its I information symbol with help of C channel code for example coding scheme such as LDPC code or any other convolutional code is used in order to generate

G = I/C coded symbols. Once the coding is done all the coded symbols are modulated and transmitted to the emissary nodes. Once coded symbols is received at the emissary node, it performs demodulate and forwards (DMF) in order to generate network-coded symbols. The DMF is an efficient method to create some network-coded symbols and transmits them to emissary node.

Let $f_{n_i,o}$ represents o^{th} bit of coded message of the n_i^{th} source. Based on path loss model, the received signal at n_i^{th} the emissary node can be given in Eq. 12:

$$Z_{n_i,n_j} = C_{n_i,n_j} x_{n_i} + I_{n_i,n_j} \tag{12}$$

After that emissary node n_j calculate the log probability ratio as:

$$\begin{aligned} Q_{n_i,n_j}(f_{n_i,n_j}) &= \ln\frac{\text{prob}\{f_{n_i,n_j} = 0 \mid Z_{n_i,n_j}\}}{\text{prob}\{f_{n_i,n_j} = 0 \mid Z_{n_i,n_j}\}} \\ &= \ln\frac{\exp(-\frac{|Z_{n_i,n_j} - D_{n_i,n_j}|^2}{2\mu_I^2}}{\exp(-\frac{|Z_{n_i,n_n} - D_{n_i,n_j}|^2}{2\mu_I^2}} \\ &= \frac{2D_{n_i,n_j} Z_{n_i,n_j}}{\mu_I^2} \end{aligned} \tag{13}$$

Here, it is supposed that BPSK modulation is used. According to following condition, emissary node n_j obtains all coded message as:

$$\begin{aligned} &f\, Q_{n_i,n_j}(f_{n_i,n_j}) > 0 \\ &\text{then}\, f_{n_i,n_j} = 0 \\ &\text{else}\, f_{n_i,n_j} = 1 \end{aligned}$$

In order to generate different channel coded symbol, emissary node select h different bits randomly from the determined coded symbols and then apply XOR to generate different channel coded symbols. This procedure continues till emissary node generates R coded symbols. Specially, for emissary node n_j, the o^{th} bit of channel-coded bit sequence can be given as:

$$\hat{f}_{n_j,DXC,o} = (\sum_{i=1}^{h} U_{n_j})\text{mod}2 \tag{14}$$

where, U_i's are selected evenly at random from the set $\hat{f}_{1,1}, \hat{f}_{1,2,\ldots\ldots}\hat{f}_{1,R\ldots\ldots}, \hat{f}_{Nu,1}, \hat{f}_{Nu,2,\ldots\ldots\ldots}\hat{f}_{Nu,R}$. Figure 3 proposed technique is described through bipartite graph. In this scheme coded symbols from each source is considered as a variable node and each decided symbol at the emissary node is considered as check node. As shown in Fig. 3 each coded symbols is correctly connected 2 decided symbols. The variable node 11 and 12 is correctly connected with two decided symbol at emissary node 1 and 3. Also, variable node 12 is correctly connected with two emissary nodes 2 and 6.

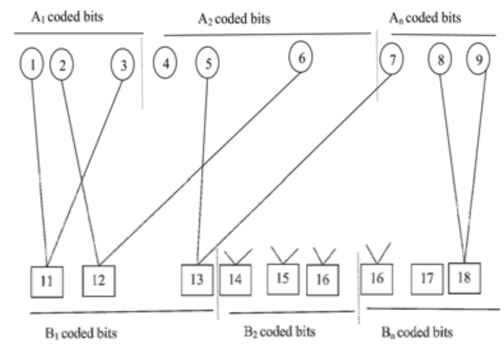

Fig. 3: Bipartite graph for channel coding schemenlsk

The overall Algorithm:

//Selection Emissary
1. Define node set N in cluster C_1
2. Define minimum LQI threshold
3. For $n_i \in$ N where I = 1,2,........, n
4. Check condition (n_i>L_{max})
5. If n_i>L_{max}
6. Select $n_i$as Participating emissary node
7. Repeat condition
8. Collect emissary node with set E_1
9. Apply PSO for set E_1
10. Determine fitness value in terms of LQI
11. Select El_{best} as best emissary node.
.// Modelling of sleep period//
12. Determine PGF for one sleep period
13. If packet is available
14. Then $n_i$transmit one packet and goes to sleep again
15. Else node wakes after average sleep period
16. Compare log probability Q with 0
if $Q_{n_i,n_j}(f_{n_i,n_j}) > 0$
17. Then $f_{n_i,n_j} = 0$
else $f_{n_i,n_j} = 1$
18. Obtain the coded message
19. Transmit the coded message through emissary node

RESULTS AND DISCUSSION

Simulation setup: The performance of the proposed Cluster Based Routing Architecture using PSO (CBRAP) is evaluated using NS2 simulation. A network which is deployed in an area of 100 X 100 m is considered. The IEEE 802.15.4 MAC layer is used for a reliable and single hop communication among the devices, providing access to the physical channel for all types of transmissions and appropriate security mechanisms. The IEEE 802.15.4

specification supports two PHY options based on Direct. Sequence Spread Spectrum (DSSS) which allows the use of low-cost digital IC realizations. The PHY adopts the same basic frame structure for low-duty-cycle low-power operation, except that the two PHYs adopt different frequency bands: low-band (868/915 MHz) and high band (2.4 GHz). The PHY layer uses a common frame structure, containing a 32-bit preamble, a frame length. The simulated traffic is CBR with UDP source and sink. Table 1 summarizes the simulation parameters used.

Performance metrics: The performance of CBRAP is compared with the (LQI) [ ] scheme. The performance is evaluated mainly, according to the following metrics.

Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Average packet delivery ratio: It is the ratio of the number of packets received successfully and the total number of packets transmitted.

Packet drop: It is the number of packets dropped during the data transmission.

Energy: It is the average energy consumed by the nodes for the data transmission. The simulation results are presented in the next study.

Based on nodes: In our first experiment we vary the number of nodes as 25, 50, 75 and 100. From Fig. 4, we can see that the delay of our proposed CBRAP is 25% less than the existing LQI protocol. From Fig. 5, we can see that the delivery ratio of our proposed CBRAP is 68% higher than the existing LQI protocol.

From Fig. 6, we can see that the packet drop of our proposed CBRAP is 75% less than the existing LQI protocol. From Fig. 7, we can see that the energy consumption of our proposed CBRAP is 32% less than the existing LQI protocol.

Based on rate: In our second experiment we vary the transmission rate as 10-50 Kb. From Fig. 8, we can see that the delay of our proposed CBRAP is 69% less than the existing LQI protocol.

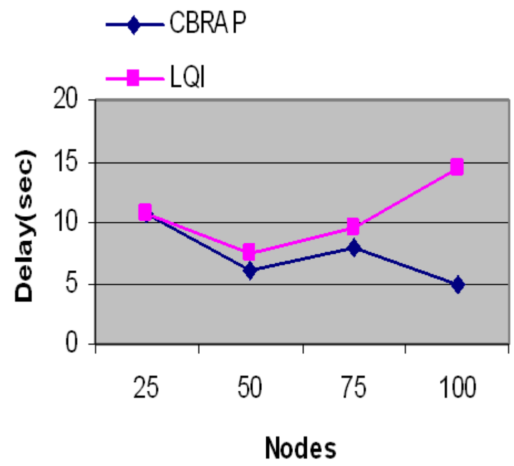

Fig. 4: Nodes vs. delay

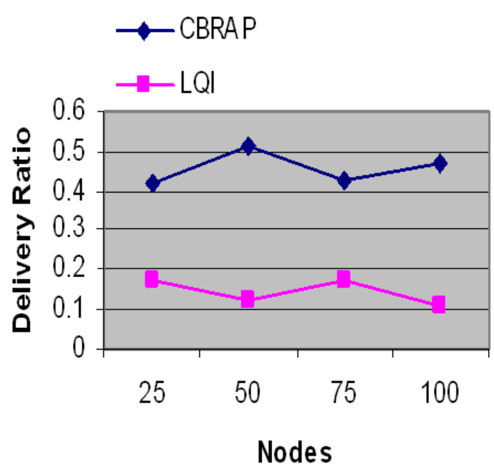

Fig. 5: Nodes vs. delivery ratio

Table 1: Simulation parameters

No. of nodes	25, 50, 75 and 100
Area size	100×100
Mac	IEEE 802.15.4
Simulation time	50 sec
Transmission range	15m
Traffic source	CBR
Packet size	80 bytes
Transmission rate	10, 20, 30, 40 and 50 kb

From Fig. 9, we can see that the delivery ratio of our proposed CBRAP is 60% higher than the existing LQI protocol.

From Fig. 10, we can see that the packet drop of our proposed CBRAP is 90% less than the existing LQI protocol.

From Fig. 11, we can see that the energy consumption of our proposed CBRAP is 26% less than the existing LQI protocol.

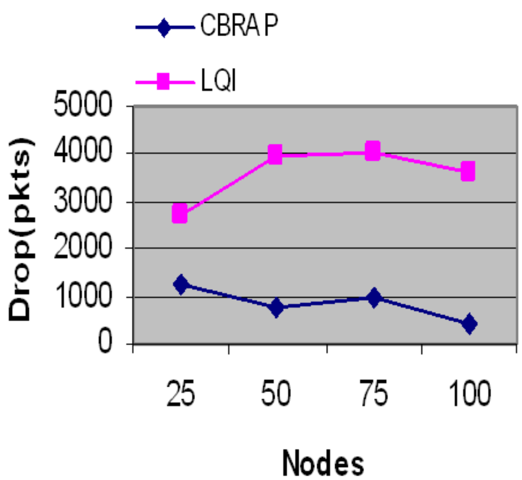

Fig. 6: Nodes vs. drop

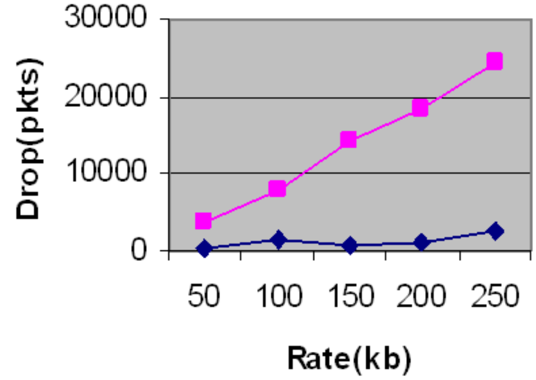

Fig. 9: Rate vs. delivery ratio

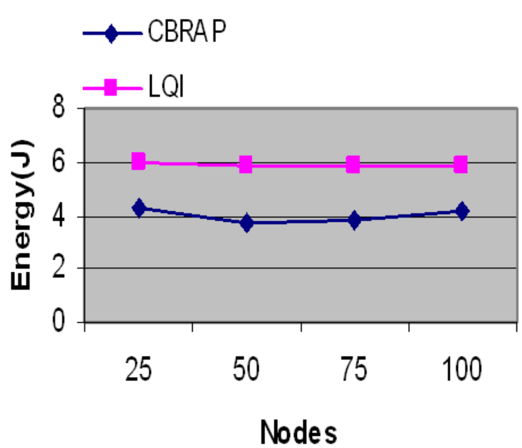

Fig. 7: Nodes vs. energy

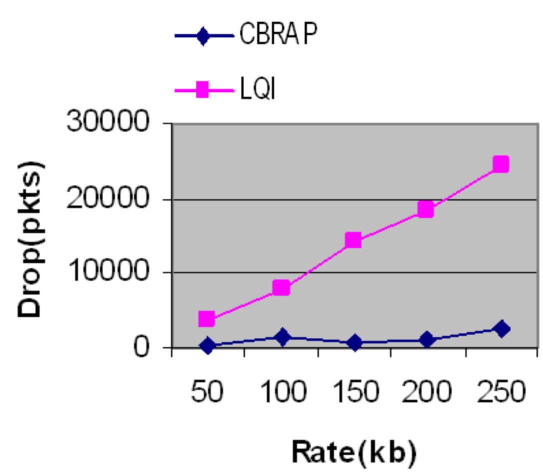

Fig. 10: Rate vs. drop

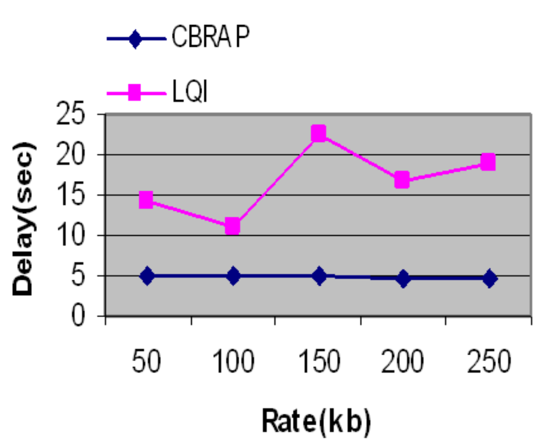

Fig. 8: Rate vs. delay

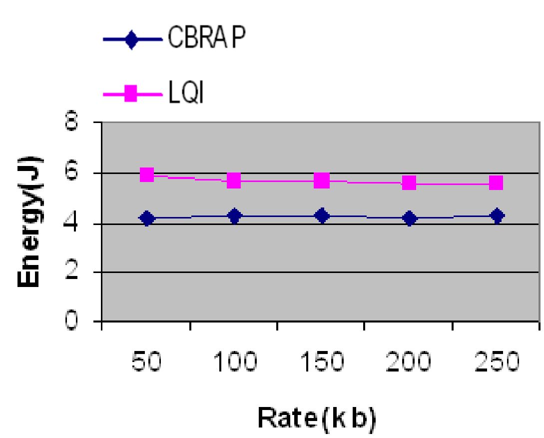

Fig. 11: Rate vs. energy

CONCLUSION

In this study, a cluster based routing architecture using PSO for ZigBee mobile wireless sensor networks is proposed. The main aim of clustering in this paper is to get most reliable node and maintain the energy efficiency during transmission. The selection of best emissary node is done based on PSO technique to increase the number of reliable node in the cluster. To maintain the energy efficiency, modelling of sleep period is done. This technique maintains the energy efficiency by assigning appropriate sleep period for each node. To increase the security during transmission, each information is encoded using channel coding with XOR operation.

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