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# C-LNRD: A Cross-Layered Neighbor Route Discovery for Effective Packet Communication in Wireless Sensor Network

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***Abstract*—One of the problems to be addressed in wireless sensor networks is the issues related to cross layer communication. Cross layer architecture shares the information across the layer, ensuring Quality of Services (QoS). With this shared information, MAC protocol adapts effective functionality maintenance such as route selection on changeable sensor network environment. However, time slot assignment and neighbour route selection time duration for cross layer have not been carried out. The time varying physical layer communication over cross layer causes high traffic load in the sensor network. Though, the traffic load was reduced using cross layer optimization procedure, the computational cost is high. To improve communication efficacy in the sensor network, a self-determined time slot based Cross-Layered Neighbour Route Discovery (C-LNRD) method is presented in this paper. In the presented work, the initial process is to discover the route in the sensor network using Dynamic Source Routing based Medium Access Control (MAC) sub layers. This process considers MAC layer operation with dynamic route neighbour table discovery. Then, the discovered route path for packet communication employs Broad Route Distributed Time Slot Assignment method on Cross-Layered Sensor Network system. Broad Route means time slotting on varying length of the route paths. During packet communication in this sensor network, transmission of packets is adjusted over the different time with varying ranges for controlling the traffic rate. Finally, Rayleigh fading model is developed in C-LNRD to identify the performance of the sensor network communication structure. The main task of Rayleigh Fading is to measure the power level of each communication under MAC sub layer. The minimized power level helps to easily reduce the computational cost of packet communication in the sensor network. Experiments are conducted on factors such as power factor, on packet communication, neighbour route discovery time, and information (i.e., packet) propagation speed.

***Keywords*—Medium access control, neighbour route discovery, wireless sensor network, Rayleigh fading, distributed time slot assignment

## I. INTRODUCTION

SENSOR nodes collaborate with one of the wireless sensor networks in order to operate in an entirely wireless nature, and as a result create an ad hoc network in a spontaneous manner. They configure the network by themselves to adapt the failure in the device in an adaptive manner, by successful coordination of the sensor nodes and respond to the requirements of the network in a random way. There are many issues in wireless sensor networks. In our work, we, particularly, address the concern related to cross layer in wireless networks.

Secured Antennae Medium Access Control (SAMAC) [1] ensures communication of the sensor network with the help of an integrated cross-layer protocol to ensure energy efficiency. But, the time for the neighbour route selection has not been considered, which our paper addresses through dynamic route neighbor table discovery. Cross layer protocol and Traffic-adaptive scheme, with Code Division Multiple Access (CLT-CDMA) [2] consider Bit Error Ratio (BER) and the overall Frame Loss Ratio (FLR) with the help of an approximation scheme, called rate-adaptive scheme to address the issues related to traffic load. However, the traffic load is reduced at the rate of computation cost. Our method C-LNRD ensures minimum computational cost via Rayleigh Fading Model.

A significant work on underwater sensor networks has received greater attention in the last few years due to the increase in the use and interest in the networking community. A cross-layer design for under water sensor networks is designed in [3] with the objective of providing a fair bandwidth using cross-layer communication solution. But, mechanisms for congestion are not included; however, C-LNRD addresses them through DSR protocol with MAC sub layers. A cross-layer communication model for internet of things in [4] ensures reliability and end to end communication through optimization framework. Full utilization of multi hop wireless sensor networks is ensured through distributed mechanisms [5]. However, with distributed mechanisms, the computational cost increases which we have addressed in C-LNRD through Rayleigh Fading Model. A cross-layer model for jamming detection is presented in [6] using an optimized scheme. For efficient communication in wireless sensor networks, XLP [7] based on the concept of initiative determination is used to increase the network performance. However, topology control remains unaddressed which has been addressed in our work, using Dynamic Source Routing based MAC sub layers.

The existing wireless sensor networks are mostly based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and MAC protocol ensuring a common wireless channel. However, it requires mutually exclusive transmissions. A cross-layer communication architecture [8] is designed with the objective of providing reliability and flexibility, through time-hopping impulse technology. Routing and Spectrum Allocation algorithm (ROSA) is designed in [9]

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to increase the throughput and provide fair bandwidth allocation. The throughput here is increased at the cost of time and is addressed in C-LNRD method through neighbour route table. A Cross-layer Reliable and Efficient communication (CREC) protocol is proposed in [10] to improve energy efficiency. Efficient Cross Layer Design Adaptive Protocol (ECLAP) [11] provides mechanisms for performance improvement. However, power factor, during communication, remains unsolved which is addressed in the proposed work through Rayleigh fading model under MAC sub layer.

We present a C-LNRD method to overcome such limitations of the traditional cross-layer communication by enriching communication efficiency with Dynamic Source Routing based MAC sub layers, which is one of the purposes of wireless sensor networks. The cross- layer communication provides information sharing across the OSI communication model ensuring QoS. The shared information between the sensor nodes in the network could be processed by effectively maintaining route selection on the changeable sensor network environment. Our C-LNRD method extends SAMAC protocol by using self-determined time slot, with the aim of increasing the propagation speed to control the traffic rate. The self-determined time slot based C-LNRD method makes dynamic route neighbour table discovery, thereby it can effectively improve the communication efficiency in the sensor network.

The main contributions of our work are summarized as:

- A self-determined time slot based Cross-Layered Neighbour Route Discovery (C-LNRD) method is proposed to improve communication efficacy in the sensor network.
- We propose a Dynamic Source Routing based MAC sub layers to efficiently discover the route to the sensor network with dynamic route neighbor table discovery.
- We employ Broad Route Distributed Time Slot Assignment method on Cross-Layered Sensor Network system to control the traffic rate and ensure significant packet communication for varying length of the route paths.
- For identifying the performance of the sensor network communication structure, we apply Rayleigh fading model to measure the power level during each communication under the MAC sub layer. This minimized power level obtained through Rayleigh fading model helps to easily reduce the computational cost of packet communication in the sensor network.

The rest of the paper is organized as follows: Section II discusses the related works. Section III explains the time slot-based cross-layered communication in wireless sensor network with the aid of neat architecture diagram. Section III *A* describes the DSR based MAC Sub Layer Route Discovery. Section III *B* introduces a Broad Route Distributed Time Slot Assignment method for controlling the traffic rate. Section III *C* presents a Rayleigh Fading Model to reduce the computational cost during packet communication in the sensor network. Section IV shows the experimental setup to simulate the method and a detailed discussion are included in Section V. Finally, in Section VI, we conclude our work.

## II. RELATED WORKS

There has been significant amount of research proposals for designing and implementing a networking protocol to ensure efficient communication with maximum energy efficiency using cross-layer design. Latency and Energy efficient Flexible TDMA (LEFT) [12] is designed with the objective of ensuring latency and energy efficiency through slot seizing. Cross-layer energy efficient protocol [13] to reduce energy and increase the transmission rate has been proposed using efficient protocols. Cross-layer architecture for packet size optimization is provided in [14] using optimization solution. However, the above said methods consume more time which has been addressed in C-LNRD method through Time Slot Assignment (TSA).

Nowadays, wireless sensor networks are not only providing intelligent platform for remote sensing but also minimize human intervention. However, with increased fault, the overall network suffers due to collision. In [15], robust communication architecture was designed for addressing fault during communication. Duty Cycling Protocol and Active Wake-up Circuit are designed to reduce power consumption. The power consumption is reduced at the cost of time, and is addressed in our work through dynamic neighbor table.

With an increase in the development of the wireless sensor networks, the design and implementation of cross-layer have become key technologies in WSN. The traditional layered concept has been broken with the introduction of design and implementation of cross-layer, ensuring the overall performance of the wireless network communication. To meet the problems related to congestion in [16], directed cooperative path is designed, using Queue Transmission Path of Channel Game (QPGC). However, power factor was not considered during transmission. In [17], power control factor is introduced to identify an effective route between the source and the destination nodes using Receiving Signal Strength (RSS). The end to end delay is addressed in C-LNRD method using the power factor by identifying the packet strength and frequency shift variations. Energy Efficient DSR in [18] considers the power factor to provide QoS, using routing cost estimation.

Based on the above mentioned techniques, in this work, we design an efficient time slot based cross-layered communication in wireless sensor network, which is discussed in the forthcoming sections.

## III. TIME SLOT BASED CROSS-LAYERED COMMUNICATION IN WIRELESS SENSOR NETWORK

The presented C-LNRD modifies the SAMAC protocol by using three steps: Dynamic Source Routing based MAC sub layers, Broad Route Distributed TSA method and Rayleigh Fading Model. They are described below.

In wireless sensor network, the multiple users receive information from the cross-layer communicational sensors. The request from the multiple users is a situation where the traffic is said to occur. Traffic is controlled during sensor network communication and cost-effective communication is ensured using the self-determined time slot based C-LNRD method. The route in C-LNRD is discovered using DSR protocol with MAC sub layers. The cross-layer communication with MAC structure is shown in Fig. 1.

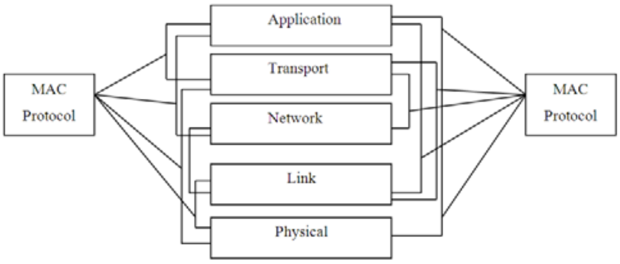

Fig. 1 Cross-layer Communication with MAC Structure

Fig. 1 shows the Cross-layer communication with MAC structure. The packet communication with MAC structure in wireless senor network self-determines the routing and transports the packets through the different layer boundaries. The self-determined system in C-LNRD method reduces the latency rate by sending the packets from the control input layer to the control output layer. The MAC layer is used in the C-LNRD method to take part with active and snoozed state operation. With the use of MAC sub layers, the power consumption is reduced by snoozing the sensor nodes when they are in an idle state. During the time of packet transmission over cross-layer communication, the sensor nodes are in an active state, thereby the power consumption is measured. The MAC layer controls the cross-layer communication path with minimal communication cost.

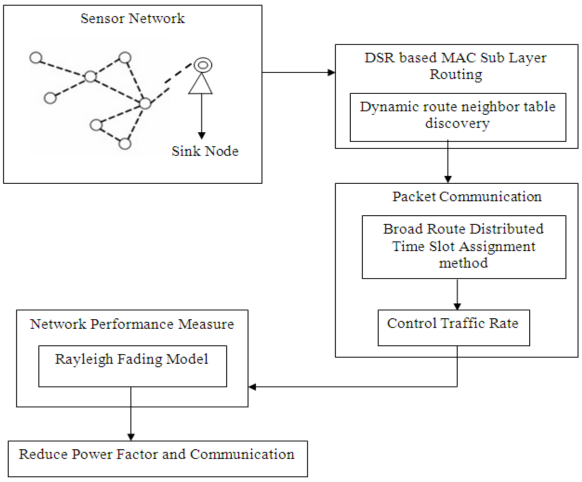

Fig. 2 Block diagram of C-LNRD Method

As shown in Fig. 2, the sensor network includes the sink node across packet communication. The Dynamic Source Routing based sensor nodes sense the packets to packet transmission to the destination node (i.e., users). Dynamic route neighbour table is used to discover and identify the neighbor route path for packet communication. The packet communication is controlled using Broad Route Distributed TSA method. The distributed algorithm completely divides the route path into time slot to reduce collision (i.e., traffic). The Collision removal helps to reduce the traffic rate using C-LNRD Method.

In wireless sensor network, the different layers are most likely used in the presented work to make a specific layer decisions about the packets. In particular, locations of the sensor nodes and the topology of the wireless network are commonly used in C-LNRD method for routing and computing packet transmission operations. The redundancy during packet transmission through cross-layer is reduced using Broad Route Distributed TSA method.

The performance of the sensor network is maintained using Rayleigh Fading model. Different magnitudes of the packets have been passed through transmission medium, using Rayleigh Fading distribution function. Rayleigh fading is a model used to work with many sensor nodes in an environment that scatters the packets to the different intermediate nodes, before it reaches the destination end. It clearly measures the power factor and therefore the communication cost is reduced. It clearly measures the power factor and therefore the communication cost is reduced.

### *A. DSR Based MAC Sub Layer Route Discovery*

Efficient neighbour node route discovery in Wireless Sensor Network is ensured using C-LNRD method via Dynamic Source Routing (DSR). In DSR, the MAC sub layers maintain the entire routing information in the routing table and continually perform the updating process, based on dynamic sensor node routing. The route discovery and maintenance over packet communication are carried out using dynamic route neighbor table discovery, as explained in (1).

Initially, the source sensor node sends a request '$Req$' to the communication layer of all the other nodes over wireless network. When a sensor node receives the request, it sends back the '$Rep$' message to the source node for authorization. The C-LNRD method on using the DSR protocol with MAC layer reconfigures the routes whenever they are in an unsteady state.

#### 1) Dynamic Route Neighbour Table Discovery

The C-LNRD method supports packet communication using the Neighbor Table Route Discovery. Initially, the packet is transmitted to the sink node for communication in the sensor network. For easy identification of the best route path in the sensor network, the dynamic route neighbour table is discovered. The discovered table contains route path track, and dynamic topological structure. The sink node provides the information to the requested sensor nodes and the information about the overall intermediate sensor nodes used for packet transfer. The Dynamic Neighbor Table associates with routing information to optimally reach the destination end in the sensor network.

### *B. Broad Route Distributed TSA*

Let us assume that '$n$' packet transmitting route path in the sensor network is necessary for identifying the number of links in the route and the number of free time slots. The C-

LNRD method adopts this broad route distributed TSA to control the traffic rate during packet communication of the sensor network. Time '$T$' is slotted and packet communication '$p(t)$' is fixed through the route path. The broad route distributed TSA identifies the ability of the link route $a_l(p)$when it is in the active state. The finite state routing for effective communication is formalized as,

$$TSA = \sum_p D(p)r(p), \; r(p) \in p(t) \tag{1}$$

From (1), the distributed packets '$D(p)$' are identified and the routing path through which the packet is transferred is provided through '$r(p)$'. The TSA of packet communication in the sensor network controls traffic over the distributed environment. The route path contains the time slot of the packet transfer '$p(t)$', then the measure of communication maximization based on the TSA is formalized as,

$$Communication\ Maximization\ Measure\ (CMM) = \max(\sum_p a_l(p) \rightarrow p) \tag{2}$$

The distributed algorithm identifies the maximum ability of the link for transmitting the packets in the sensor network. TSA algorithm, based on packet transfer over the broad sensor network route controls the traffic and the algorithmic step included in the design of TSA is described below,

```
Begin
Step 1: Sensor Network with Route discovered paths for packet communication
Step 2: Ability of the link route to transmit the data packets is measured
Step 3: Compute the Average sensor network packet communication rate
Step 4: Begin with slotting the time
  Step 4.1: Ability strategy of link 'l'$a_l(p)$ is measured
  Step 4.2: Selects't' time slot points using this $a_l(p)$measure
  Step 4.3:Smallest number of free time slots in between the intermediate linking of the nodes
Step 5: Destination sensor node point is identified based on the route table information
Step 6: Final assignment of time slot result to control the traffic rate
End
```

The above algorithmic step of TSA describes the broad route distributed TSA. The slotting of time is based on the ability of the link route in the sensor network. The average sensor network packet communication rate is measured for easy assignment of the time slot. It selects the time slot and avoids the smallest number of free time slots between the intermediate nodes. The free timeslots are used by the consecutive discovered route path for packet communication without any collision. The packet is then communicated to the destination with minimal power consumption. This power factor measure is briefly explained in Section III *C*.

The time slots assignment in a similar link is selected according to the order of their free times in the broad route. Broad Route Distributed TSA method completely helps to reduce the traffic rate in C-LNRD. The TSA, based on broad route distribution, is shown in Fig. 3.

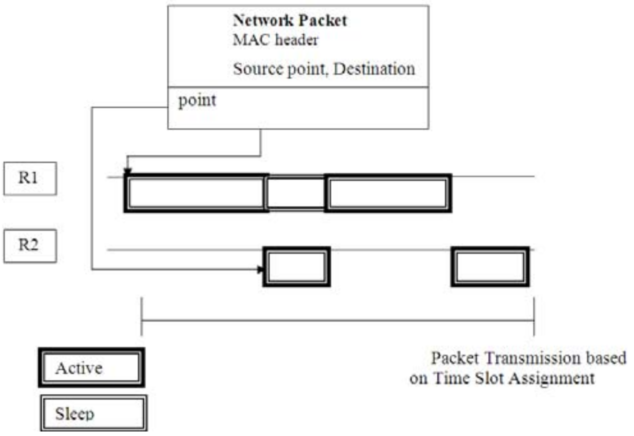

Fig. 3 TSA on Discovered Route Path

The discovered route path from dynamic route neighbor table is presented with a TSA for controlling the traffic in sensor network, using C-LNRD method. A broad route distributed TSA presents a method resulting in the stability and optimality. As a result, the idle time is identified and slotting operation is carried out to correctly utilize the time.

### *C. Rayleigh Fading Model*

In C-LNRD method, Rayleigh Fading is employed to measure the network performance while performing the packet communication over wireless sensor network. Rayleigh Fading is used to measure the power factor, based on the impulse of the frequency domain (i.e., packet transfer rate) domain. The time autocorrelation function is also used for identifying the power factor.

$$Power\ Factor = \frac{1}{\pi f D(p)\sqrt{1-(\frac{v}{fD(p)})^2}} \tag{3}$$

The power factor of the distributed packets measures the packet transfer rate in (3). The packet transfer shifting on the rate factor '$v$' is also noticed to perform the evaluation where $fD(p)$ denotes the frequency of the distributed packet on the discovered route path in the sensor network. The communication over the sensor network, using C-LNRD method, helps to identify the packet strength and frequency shift variations. MAC sub layer based packet communication helps to easily identify the power factor with Rayleigh Fading model. Fast fading occurs in C-LNRD method when consistent assignment of time is carried out. This assignment relatively reduces the power factor. The reduced power factor minimizes the communication cost in the sensor network.

## IV. EXPERIMENTAL EVALUATION

Self-determined Time Slot based C-LNRD method performs the experimental evaluation using the NS2 simulator. The simulation tool is randomly surrounded by a network size of 1000 ×1000 m. C-LNRD method with '$n$' unpredictable sensor nodes holds 30 runs of the simulation which is carried out in 100 seconds. The sensor network here provides effective packet communication and thus improving the communication efficiency. After the completion of the transmission time, it randomly chooses and moves to another movable node location point. Using the Random Way Point (RWM) model, each mobile node is shifted to an erratically chosen location.

The chosen location with a random speed contains a predefined amount and speed count. C-LNRD method consists of an estimated value of about 100 neighboring nodes. The RWM uses standard number of sensor nodes for effectively transmitting the packets in wireless sensor network. The randomly selected position provides a predefined speed. The random progression is constant during the simulation period. The minimum moving speed of C-LNRD method is about 2.0 m/s for each node.

From the results obtained by the trace graph of the simulator, the presented algorithms are compared against the Sectored-Antenna Medium Access Control (SAMAC) [1] Cross layer protocol and Traffic-adaptive scheme with Code Division Multiple Access (CLT-CDMA) [2] scheme. DSR Protocol with MAC sub layers are used for the cross layer communication in sensor network. In the RWM model, each sensor node moves to the irregular location. The packet size is of 500 Kilobits per second (Kbps). The experiment is conducted on the factors such as power factor on cross layer communication, neighbor route discovery time, information (i.e., packet) propagation speed and average end to end delay.

## V. SIMULATION RESULTS

### A. Performance Metrics

The neighbor route discovery time is the time taken to discover the neighbor route for communication in the sensor network that includes both route path track and dynamic topological structure. It is measured in terms of milliseconds (ms).

$$NRD_t = Time\ (RP_{track} + Dynamic_T) \quad (4)$$

From (4), the '$NRD_t$' measures the time taken to identify the neighbor route path which includes the summation of time taken for route path track '$RP_{track}$'and dynamic topology structure '$Dynamic_T$'. The information propagation speed is the speed at which the packets or information is communication at the other end. The information propagation speed, using C-LNRD method, is measured in terms of packets/second. The information propagation speed is formalized as given in (2).

The average end to end delay is the time delay taken between the nodes in the sensor network while performing packet communication over the wireless sensor network. The average end to end delay is measured in terms of milliseconds (ms). It is formalized as

$$AEE_D = \sum_{p=1}^{n} \frac{Estimated_{fD(p)} - Obtained_{fD(p)}}{n} \quad (5)$$

From (5), the average end to end delay '$AEE_D$' is the difference between the estimated frequency of distributed packet '$Estimated_{fD(p)}$' and the obtained frequency of the distributed packet '$Obtained_{fD(p)}$'.

### B. Performance Comparison of Neighbour Route Discovery Time

The result of C-LNRD method is compared with the existing Sectored-Antenna Medium Access Control (SAMAC) [1], Cross layer protocol, and Traffic-adaptive scheme with Code Division Multiple Access (CLT-CDMA) [2] scheme. Table I shows the impact of the neighbour route discovery time obtained from the 70 sensor nodes using NS2 simulator and a comparison are made with, the two other methods, namely SAMAC [1] and CLT-CMDA [2]. The corresponding formula is given by,

$$\begin{aligned} Neighbour\ route\ discovery\ time(ms) &= Neighbour\ route\ end\ time(ms) \\ &- Neighbour\ route\ start\ time(ms) \end{aligned}$$

For example,

i. **Proposed C-LNRD** = 317-200=117
ii. **Existing SAMAC** = 327-200=127
iii. **Existing CLT-CDMA** = 335-200=135

TABLE I
TABULATION OF NEIGHBOUR ROUTE DISCOVERY TIME

| No. of sensor nodes | Neighbor Route Discovery Time (ms) | | |
|---|---|---|---|
| | C-LNRD | SAMAC | CLT-CDMA |
| 10 | 117 | 127 | 135 |
| 20 | 131 | 141 | 149 |
| 30 | 140 | 150 | 158 |
| 40 | 132 | 142 | 150 |
| 50 | 147 | 157 | 165 |
| 60 | 138 | 148 | 155 |
| 70 | 140 | 150 | 158 |

A comparison of the neighbour route discovery time is presented in Table II with respect to the different number of sensor nodes in the range of 10-70. With increase in the number of sensor nodes, the neighbor route discovery time also gets increased. But this incremental variation is not linear due to the dynamic topological structure that varies invariably.

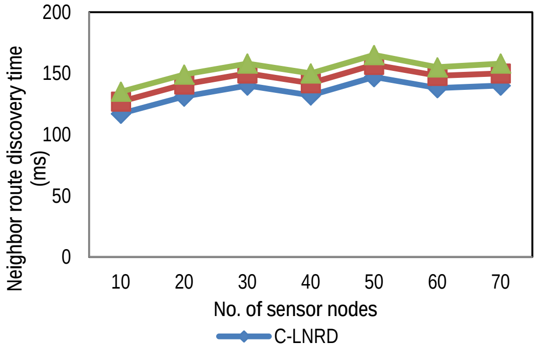

Fig. 4 Impact of neighbor route discovery time

Fig. 4 shows the impact of neighbor route discovery time for the C-LNRD method. This is obtained from a reference of 70 sensor nodes. Also comparison is made with two other methods, viz., SAMAC and CLT-CMDA. The C-LNRD method provides low neighbour route discovery time compared to SAMAC [1] and CLT-CMDA [2]. The decrease in the neighbour route discovery time using the C-LNRD method is due to the incorporation of Dynamic Route Neighbour Table Discovery. The dynamic route neighbor table discovery that contains the route path track and dynamic topological structure helps in identifying and reaching the destination. In addition, the sink node provides the overall intermediate sensor node information for packet transfer which reduces the neighbour route discovery time-using C-LNRD method by 6-8% compared to SAMAC and 12-15% compared to CLT-CDMA respectively.

### *C. Performance Comparison of Information Propagation Speed*

To ascertain the performance of the information propagation speed, a comparison is made with the two other existing methods, SAMAC [1] Cross layer protocol and Traffic-adaptive scheme with Code Division Multiple Access (CLT-CDMA) [2]. The required formula for performance comparison is:

$$Information\ propagation\ speed(Packets/s) = \\ No\ of\ packets\ sent(Packets)/Particular\ time(sec)$$

For example,
i) **Proposed C-LNRD** = 20/5=4
ii) **Existing SAMAC** = 15/5=3
iii) **Existing CLT-CDMA** = 15/5=3

TABLE II
TABULATION OF INFORMATION PROPAGATION SPEED

| **No. of packets sent** | **Information Propagation Speed (packets/s)** | | |
|---|---|---|---|
| | **C-LNRD** | **SAMAC** | **CLT-CDMA** |
| 5 | 4 | 3 | 3 |
| 10 | 8 | 7 | 5 |
| 15 | 12 | 11 | 9 |
| 20 | 17 | 15 | 12 |
| 25 | 20 | 19 | 17 |
| 30 | 27 | 25 | 22 |
| 35 | 31 | 30 | 28 |

The information propagation speed efficiency for C-LNRD method is elaborated in Table III. We consider the method with packets sent of size 5-35 for experimental purpose using NS2 simulator.

In Fig. 5, the number of packets sent for experimental purpose varies between 5 and 35. From the figure it is illustrated that the information propagation speed is higher or increased using the presented C-LNRD method compared to the two other existing methods. The increase in information propagation speed is because of the application of Broad Route Distributed TSA. With the application of Broad Route Distributed Time Slot Assignment in C-LNRD method, the broad route distribution identifies the ability of the link route whenever it is in the active state which results in the increase in information propagation speed by 3-25% compared to SAMAC. Moreover, the distributed packet based on TSA controls the traffic over the distributed environment in an efficient manner by applying distributed algorithm in C-LNRD method by identifying the maximum ability of the link for transmitting the packets in the sensor network and improves the information propagation speed by 9-37% compared to CLT-CMDA.

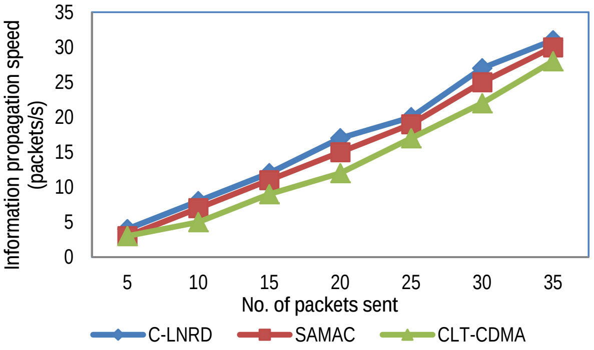

Fig. 5 Impact of information propagation speed

### *D. Performance Comparison of Average End to End Delay*

Table III and Fig. 6 show the average end to end delay observed using the packets sent of size 5 to 35 for experimental purposes. The required formula for performance comparison is:

$$Average\ end\ to\ end\ delay(ms) = \\ Overall\ runtime(ms) - Processing\ time(ms)$$

For example,
i) **Proposed C-LNRD** = 50-27.68 = 22.32
ii) **Existing SAMAC** = 50-19.67 = 30.33
iii) **Existing CLT-CDMA** = 50-12.64 = 37.36

TABLE III
TABULATION OF AVERAGE END TO END DELAY

| **No. of packets sent** | **Average End to End Delay (ms)** | | |
|---|---|---|---|
| | **C-LNRD** | **SAMAC** | **CLT-CDMA** |
| 5 | 22.32 | 30.33 | 37.36 |
| 10 | 25.49 | 33.50 | 40.53 |
| 15 | 31.37 | 39.38 | 46.41 |
| 20 | 28.35 | 36.36 | 43.39 |
| 25 | 30.44 | 38.45 | 45.48 |
| 30 | 27.45 | 36.46 | 43.49 |
| 35 | 29.85 | 37.86 | 44.89 |

From the figure, the value of the average end to end delay achieved using the C-LNRD method is lower when compared to the two other existing methods SAMAC [1] and CLT-CMDA [2]. Besides, we can also observe that by increasing the size of the packets sent, the value of the average end to end delay also increases using all the methods. But comparatively, it is lower in C-LNRD method because of applying Rayleigh

Fading Model and time autocorrelation function, the network performance is improved minimizing the average end to end delay by 25-35% compared to SAMAC and 47-67% compared to CLT-CMDA respectively.

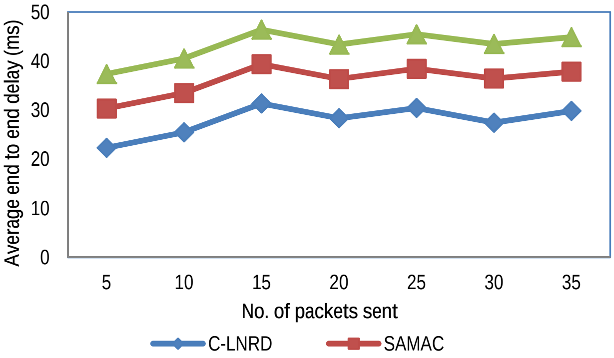

Fig. 6 Impact of Average End to End Delay

## VI. CONCLUSION

Cross-layer architecture and packet transmission have become the key for wireless sensor networks, with the main objective of improving the communication efficacy by reducing the neighbour route discovery time. In this work, the performance effects of cross-layer communication methods are investigated using Cross-Layered Neighbor Route Discovery (C-LNRD) method. The method improves the communication efficacy of the sensor network using Dynamic Source Routing based Medium Access Control (MAC) sub layers that reduces the neighbour route discovery time. First, we have made an analysis using dynamic route neighbour table discovery to identify the best routing path. Second, we developed distributed packet based time slot assignment with packet communication and link route for evaluating the measure of communication maximization that works with the intermediate nodes to increase the information propagation speed. We Lays also integrate Rayleigh Fading Model with the frequency of distributed packet on the discovered route for minimizing the average end to end delay. Simulation results show that the C-LNRD method outperforms in terms of neighbour route discovery time, information propagation speed and average end to end delay when compared to the state-of-the-art methods.

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