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An Intercluster-Chaining Protocol with Neighbour Node for Energy Efficient Data Collection in Wireless Sensor Networks

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***Abstract*— In this paper, we propose an Intercluster-Chaining Protocol with Neighbour Node for Energy Efficient Data Collection (ICCPNN) in Wireless Sensor Networks to prolonging network lifetime and low energy consumption and reduce transmission delay of data. ICCPNN using Neighbouring nodes for data collection that are chained with Cluster Head (CH). ICCPNN organizes sensor nodes into clusters by using multiple distance metrics and constructs a chain with Neighbour Node. Neighbour Node is elected based on it's minimum distance between the CH and elected Neighbour Node construct a chain among the sensor nodes within cluster so that each sensor node receives data from a previous neighbor and transmits to a next neighbor. Existing approah that invoves CH is to collect information from all SN nodes that are present in cluster. But ICCPNN approach reduces CH work siginificantly for its data collection and saving energy of CH and reduces delay. Data collection is done by calling Neighbour Node is enough. No need to call all the SN nodes in cluster. If work is reduced energy will saved automatically and prolonging the network lifetime. ICCPNN also adopts a chain based data transmission mechanism for sending non-time critical data packets from the cluster heads to the base station. Our Simulation results explain that our proposed protocol significantly outperforms LEACH, CBRP and PEGASIS in conditions of network lifetime, energy consumption, transmission delay of data and the total number of data received at base station.**

***Index Terms*— Clustering protocol, Chain based routing, Energy efficient, Neighbour Nodes**

I. INTRODUCTION

Wireless sensor networks (WSNs) are gaining worldwide attention in recent years, mostly with the proliferation in Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors [1-5]. These sensors are very small, with limited processing and computing resources, and they are cheap compared to usual sensors. These kinds of sensor nodes used to sense, calculate, and gather information from the critical environment and, based on some local choice process; they can transmit the sensed data to the user. A wireless sensor network is composed of hundreds or thousands of sensor nodes which are usually battery-powered and deployed in an insecure environment to collect the needed information and then transmit report messages to a corresponding remote base station. After that the corresponding base station aggregates and analyzes the report messages received and decides whether there is an unusual or special event occurrence in the deployed region. As sensor networks have limited and nonrechargeable energy resources. Energy efficiency is a very important issue in designing the structure and routing protocols, which is affecting the lifetime of sensor networks greatly [6,7]. Although energy efficiency is usually the primary issue in wireless sensor networks, the necessity of low latency communication is getting more and more important in many applications. Clustering techniques [8] have emerged as accepted option for achieving energy efficiency and scalable performance in large scale sensor networks.

Using a clustering approach, sensors can be managed locally by a cluster head, a node chosen to manage the cluster and be responsible for communication between the cluster and the base station. Clustering provides a suitable structure for resource management and It is to support many important network features within a cluster, such as channel access for cluster members and power control, and also between clusters like routing and code separation to avoid inter-cluster interference[9].

There are a lot of cluster based routing protocols in wireless sensor network which a few of them have considered the quick transmission of data. In this paper, we propose an Intercluster-Chaining Protocol with Neighbour Node for Energy Efficient Data Collection (ICCPNN) in Wireless Sensor Networks to maximize network lifetime and minimize energy consumption and transmission delay of time critical data. ICCPNN considers Neighbouring Nodes for reducing the work of CH. ICCPNN organizes sensor nodes into clusters and forms a chain among the sensor nodes within cluster, and also selecting Neighbouring Nodes based on minimum distance between CH and node.

Each elected Neighbour Node makes chain with SN's, So that each sensor node receives from a previous neighbor and transmits to a next neighbor. CH is elected based on remaining energy of nodes, distance from neighbor nodes and the number of the neighbors of nodes in the cluster [10,11]. ICCPNN also adopts a chain based data transmission mechanism for sending data packets from the cluster heads to the base station. Through the simulation results contrasted with previous works, we explained that our proposed protocol can do better than in network lifetime, energy consumption [15,16], the total number of data received at base station, transmission delay of data transmission and also communication overheads[17,20].

II. RELATED WORK

Recently, various clustering techniques to reduce energy consumption of sensor nodes have been developed. Assembling a large number of sensors into clusters and keeping them communicate regularly are quite complex. Here, we mention some of the most recent work in different views of clustering.

Low-energy adaptive clustering hierarchy (LEACH) [14] is one of the most popular distributed cluster-based routing protocols in wireless sensor networks. The important operation of LEACH is divided into rounds, and each round begins with setup phase for forming the cluster, followed by a steady state phase, when data transfers into the base station occur. LEACH is randomly selects a some nodes as cluster heads and rotates this role to balance the energy dissipation of the sensor nodes in the network. The cluster head nodes combine and aggregate data arriving from nodes that belong to the respective cluster and send aggregated data to the base station in order to reduce the amount of data and transmission of the duplicated data. done by the base station and performed periodically. The advantage of LEACH protocol is energy efficient but the expected number of clusters is predefined. Another disadvantage of LEACH is that it does not guarantee good cluster head distribution and assumes uniform energy consumption for cluster heads.

PEGASIS [13] is an improvement of the well known LEACH protocol for clustering based communication in sensor networks. Suppose the forming multiple clusters, In PEGASIS forms a chain from sensor nodes so that each node receives from and transmits to a neighbor and only one node is selected from that chain as leader node to transmit to the base station. The main goal of PEGASIS are to increase the lifetime of network and allow only local coordination between nodes that are close together so that the bandwidth consumed in communication is reduced and also PEGASIS eliminates the overhead caused by dynamic cluster formation in LEACH, and decreases the number of transmissions and receptions by using data aggregation. On the other hand, this achievement faded by the excessive delay introduced by the single chain for the distant node[19].

TEEN [18] designed for time-critical applications to respond to changes in the sensed attributes such as temperature. After the formation of clusters, the cluster head broadcasts two thresholds to the nodes. These are two types of threshold to sense attributes. They are hard and soft thresholds. The hard threshold aims at reducing the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest and the other one is soft threshold, which is further reduce the number of transmissions if there is little or no change in the value of sensed attribute. Individual can adjust both hard and soft threshold values in order to control the number of packet transmissions. The main advantage of this scheme is its suitability for time critical applications and also the fact that it significantly reduces the number of transmission.

A distributed and energy efficient protocol called CBRP [12] proposed for data gathering in wireless sensor networks. The CBRP clusters the network by using new factors and then constructs a spanning tree for sending aggregated data to the base station. simply the root node of this tree can communicate with the base station node by single-hop communication. The main drawback of CBRP is much communication overhead due to a lot of control messages exchanged among sensornodes.

SPIN (Sensor Protocols for Information via Negotiation) [20] protocol works in three stages (ADV-REQ-DATA). Based on this protocol first a node gets a new data and if the node wants to distribute that data, it broadcasts an ADV message containing meta-data to its neighbors. The interest neighbors request for that data by sending a REQ message and then the DATA is sent to the requested nodes. DATA messages contain actual data with a meta-data header..

APTEEN [21] is an extension to TEEN and aims at capturing periodic data collections and reacting to time-critical events. Just a node senses a value beyond hard threshold; it transmits data only when the value of that attributes changes by an amount equal to or greater than soft threshold. The drawbacks of TEEN and APTEEN are the overhead and complexity associated with forming clusters at multiple levels.

III. PROPOSED WORK: AN INTERCLUSTER-CHAINING PROTOCOL WITH NEIGHBOUR NODE FOR ENERGY EFFICIENT DATA COLLECTION (ICCPNN) IN WIRELESS SENSOR NETWORKS

The following are the important model for designing the ICCPNN protocol

A. *Network Model*

In this paper, we consider a sensor network consisting of N sensor nodes uniformly deployed over a vast field to continuously monitor the environment. During the express of cluster initialization, we assume that following are the important properties about the sensor networks.

- Sensor nodes and the base station are all immobile after deployment.
- The base station is located long distance away from the sensors.
- All the nodes in the network are homogenous and energy controlled.
- Nodes are well aware of its current location, i.e. set with GPS capable antennae.
- Radio channel is Bi-direction, i.e., the energy consumption for transmitting a message from one node to another is the same as on the reverse direction.

B. *Radio Model*

In this protocol, we use the first order radio model of LEACH. According to this model, a radio dissipates Eelec=50 nJ/bit to run the transmitter or receiver circuitry and for transmitter amplifier it dissipates εamp= 100 pJ/bit/m2. We consider an r2 energy loss due to channel transmission. The following equations are used for calculating transmission costs and receiving costs for a k-bit message and a distance d.

For transmitting:-

ETx (k, d) = ETx-elec (k) + ETx-amp (k, d)

ETx (k, d) = Eelec *k + εamp *k*d2

For receiving:-

ERx (k) = ERx-elec (k)

ERx (k) = Eelec *k

C. *Delay Analysis*

For the clustering schemes, a popular node scheduling approach is adopted where the intra-cluster communication is scheduled by TDMA (Time Division Multiple Access) and the inter-cluster communication is scheduled by CDMA (Code Division Multiple Access). Assuming there are N sensor nodes in the network and the delay of each transmission is regarded as 1 unit per time. The delay is discussed as follows.

In LEACH, the delay for transmitting data packets to the cluster heads is dependent on the maximum number of nodes in the clusters. All the clusters are similar sizes and there are K clusters present in the network, and the maximum delay of a round is calculated by following equation.

T= ((N/K)-1) + K + C

In these clustering protocols such as LEACH, the maximum delay for transmitting time critical data packets or non-time critical data packets to the base station is T and minimum delay for transmitting the first data packet to the base station is dependent on the cluster sizes.

D. *ICCPNN Network Model*

In conventional clustering protocols [12,22], cluster heads manage the member nodes and collect data from them. Each cluster having CH.Each CH collects data from the member nodes in cluster, collects the data, and then sends the collected data to the base station. Because the cluster heads have responsibility for the collecting, aggregating, and forwarding data to the base station, they consume energy much faster than the member nodes, reducing the network lifetime. If we see other clustering protocols periodically recluster the network in order to distribute the energy consumption among all sensor nodes that are presenting in a sensor network. These kind protocols suffer from cluster formation overhead. Because they consume much energy due to the cluster formation overhead.

In order to avoid this situation, we propose an Intercluster-Chaining Protocol with Neighbour Node for Energy Efficient Data Collection (ICCPNN) in Wireless Sensor Networks to maximize network lifetime and minimize energy consumption and transmission delay of time sensor nodes. For reducing energy consumption of time Cluster Head for collecting data, proposed protocol introduces a Neighbour node with chaining. The proposed protocol organizes sensor nodes into clusters and adopts chain based data transmission mechanism for data transmission within clusters and among cluster head and its sensor nodes. And also the CH selects Neighbour Node based on minimum distance. According that the information collected by Neighbour Node and it's transmitted to CH.The operation of the ICCPNN protocol is organized into cluster. Each cluster of this protocol consists of the following phases: 1) Clustering phase; 2) Neighbour Node Selection 3) Chain formation within cluster 4) Data transmission phase.The following steps explain Phases of ICCPNN algorithm.

Phase 1: Clustering Phase

Cluster head election: In the clustering stage, each node is to broadcast a message which contains information about its current location (possibly determined using a GPS receiver) and residual energy using a non-persistent CSMA MAC protocol within radio range r. every single one node within the radio range of one node can be seen as the neighbors of the another node.Each node computes the distance, after receiving the message to its neighbors and generates CHSV (Cluster Head Selection Value) using Eq. (1)

$$\mathbf{CHSV_i = RE_{i*} \ \Sigma_{j=1}^{number\ of\ nodes} \ (1/dist\ (v_i,v_j))} \ \text{……………………}(1)$$

Where REi = residual energy of node i
dist(vi,vj) = distance node i to node j.

Each node broadcasts its CHSV using a non-persistent CSMA MAC protocol within radio rang r and the node with the highest CHSV among its neighbors is selected as cluster head.The following figure explain formation of cluster.

Phase 2: Neighbour Node Selection

The selection of Neghbour Node is based on the minimum distance between the cluster head and its neighbour node. If a cluster having more than one neighbour node based on its size of the cluster and number of sensor node's that are available in the cluster range r. The usage of neighbour node is reducing the work of cluster head and saving its energy. If any information need by cluster head, it will call only the neighbour node is enough. Because all the nodes that are chained in the neighbour node.

Phase 3: Chain Formation within Cluster

This phase is divided into Chain formation within clusters and Chain formation among cluster heads.

Chain Formation within Clusters: When the clusters form, each cluster head in the cluster that creates a chain among the sensor nodes within its cluster so that each sensor node receives non-time critical data from a previous neighbor, collects its data with the one received from its previous neighbor and forwarding the collected data to a next neighbor. If all the nodes in the chain within cluster is formed in the order from the furthest to the nearest node from the cluster head. Once the chain formation is done within the cluster, cluster head sends the chain information to the sensor nodes that are present within its cluster.

Chain Formation with Neighbour Node: In this stage, cluster heads send their location information to the sensor nodes. All the sensor nodes response the cluster head message. Based on the received Message Cluster Head calcuate the nearest nodes in the clusters. Those closest sensor nodes are elected as a neighbour node. The chain is formed in the order nearest node from the cluster head, and nearer nodes have better opportunities to be the leader. After formation of neighbour node, each neighbour node makes chain with the nearest sensor node. Each sensor node forms a chain with next nearest sensor node.

Chain Formation among Cluster Heads: In this stage, cluster heads send their location information to the base station. According to that received information, the base station is to create a chain of cluster heads and sends it to the cluster heads. The chain is created in the order from the farthest to the nearest node from the base station, and closer nodes have better opportunities to be the leader. All the cluster heads send their data to the leader node along the chain; finally the leader node transfers the collected data to the base station.

Phase 4: Data transmission phase

Data transmission phase is divided into several frames which sensor nodes transmit and receive data at each frame. The main advantage of ICCPNN protocol is to reduce the work of cluster head and increase the data collection time of cluster head. Using that ICCPNN protocol, cluster head data collection time significantly reduced. Existing system that explains cluster head collects data from all the sensor nodes that are present in the cluster. For that cluster head spend more energy to collect data from sensor nodes.Our proposed ICCPNN protocol reduces the work of cluster head using chaining and selecting neighbouring node. When ever information needed the cluster head just coomunicate with neighbouring node is enough. No need of call all the sensor nodes that are present in clustering. Using this concept we can save the energy of the cluster head and increasing the life time of the cluster head.

The following figure shows the Basic structure of the ICCPNN Protocol. The ICCPNN protocol which contain Cluster Head, Neighbour Node, Sensor Nodes. Cluster Head is mainly ysed to managing all SN that are present in the cluster and Neighbour Node is used to reduce work of cluster head and ti will act as intermediate node between SN and CH.The following figure shows ICCPNN protocol.

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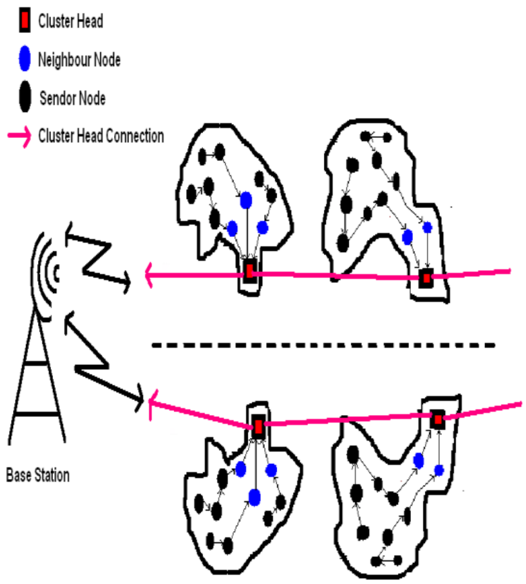

Fig 1.Proposed protocol of ICCPNN

Algorithm: ICCPNN
Phase 1: Clustering phase
Each node broadcasts a message in the range r
Each node receives the messages from all nodes in the range r
Each node computes distance from all neighbors and computes CHSV

$$\mathbf{CHSV_i = RE_{i*}\ \Sigma_{j=1}^{number\ of\ nodes}\ (1/dist\ (v_i,v_j))}$$

if CHSVi > CHSV of all its neighbors nodes (all nodes in the range r)
Node i elected as cluster head (CH)
Clusterheads (i) True
End
CH broadcasts an adv_Msg in the range r
Each non-CH sends a Join_REQ to closest CH
Phase 2: Neighbour Node Selection phase
if clusterheads(i)= True
CH broadcast a dist_msg to cluster range r.
CH receives a res_msg from non-CH nodes (i.e) sensor nodes.
CH calculates the receving time of response message based on its packet information.
CH selects the neighbour node on following way:

$$\mathbf{CHNNS_{nj} = \Sigma_{j=1}^{n}\ (dist\ (v_i,v_j))}$$

Where,
Nj= number of neighbour nodes.
CH sending the chain_msg to all the selected Neighbour nodes.
Neighbour node accepts and makes chain with Elected Cluster Head.
End

Phase 3: Chain Formation Phase:
if clusterheads(i)= True
CH (i) chained with neighbour n_1, chained with neighbour n_2…………….. Chained with neighbour $n_{n.}$
Neighbour node n_1 chained with next sensor node and each nearest node's thar are chained in cluster range r.
Neighbour node n_2 chained with next sensor node and each nearest node's thar are chained in cluster range r.
It will chained upto,
Neighbour node n_n chained with next sensor node and each nearest node's thar are chained in cluster range r.
Sends the chain to the members of its cluster
Sends (Cluster location i) to the BS
The BS creates a chain among CHs and sends the chain to all CHs
if distance (i,BS) < distance of all CH nodes to BS
Cluster Header (i) is true
End
End
Phase 4: Data Transmission Phase
if Cluster Head(i)=true
Send data_msg to Neighbour Node n_1 to n_n
Neighbour Nodes call SN's. SN calls Nest Neighbour in chain for collectind data send tocorresponding Neighbour Node.
Cluster Head calls nearest Neighbour Node and retrieving collected data from its Neighbour Nodes.
End.
if clusterheads(i) =True
if header(node i) = False
CH node i aggregates its data with the data of previous CH node and
Sends aggregated data to the next CH node in the chain of CHs
else
Header node i aggregates its data with the data of previous CH node and sends aggregated data to the BS
End
Each phase can do each work on the ICCPNN protocol.Pahse 1 is to create cluster and is to select the CH. Phase 2 is to select the nearest nodes in CH and these nodes is elected as a Neighbour Node.Phase3 is to make the chain within the cluster. The chain is formed CH to Neighbour Nodes and Neighbouring Nodes to SN.Phase 4 is to maintain the data transmission.

IV. Simulation and Results:

To evaluate the performances of ICCPNN discussed in the previous section, we presented these simulations by NS2 Simulator and compared its performance with other protocols like LEACH, CBRP and PEGASIS. Based on these Existing protcols, we mainly take account the following performance parameters like lifetime of network,low energy consumption, the total number of data messages received at the base station, transmission delay of data and communication overhead.

A. Simulation setup

The simulations are carried out with a random network topology with 100 sensor nodes are randomly distributed in the monitoring area with a size of 100 m*100 m and a base station located at position (50,175). All sensor nodes periodically sense the environment and transmit the data to the next neighbors. The following Table 1. Shows that various parameters. In our simulation set-up, sensor nodes sense the temperatures in different regions. At some stage in each round of simulation runs, each sensor nodes is assigned a random temperature between 0 degree Fahrenheit and 100 degree Fahrenheit.

Parameters	**Values**
Network size	(0,0) to (100,100)
Number of nodes	100
Base station location	(50,175)
Data packet size	500 Bytes
Broadcast packet size	25 Bytes
Initial Energy of Nodes	0.3 J
Eelec	50 nJ/ bit
εfs	100 pJ/ bit/ m2
εamp	0.013 pJ/ bit/ m4
Cluster radius r	20 m

1. Network Lifetime:

Low energy of the sensor node is the main problem of failure of network. Most of Clustering techniques recommend saving the energy of leader node in the cluster that is Cluster Head (CH).

The Leader node is the responsibility os collecting data from sensoe nodes and sends it into corresponding base station.it will happen heavy work of the leader node. Our proposed protcol aims to reduce work of CH and also work shared by all the nodes.In our simulation result shows lifetime performance of ICCPNN protocol.

2. Energy consumption:

It is obvious that ICCPNN uses much less energy compared to other protocols. The reducing of energy consumption of ICCPNN is mainly due to the small transmit distances of most of the nodes as they need to transmit only to their nearest neighbors in the chain instead of transmitting directly to the far away base station or cluster head. ICCPNN protocol is reducing the communication distrance between Sensor Nodes. So energy consumption of SN is saved and also throughput increased.LEACH and CBRP also consume more energy due to the cluster formation overhead. Since ICCPNN does not perform each round in clustering phase and it reduces energy consumption of the network. ICCPNN also has better performance than PEGASIS. This is mainly achieved due to the multiple chains are constructed in ICCPNN which causes the chains to have smaller length than the single chain in PEGASIS. Due to smaller length communication this reduces the amount of data to be aggregated and propagated along the chain which results in more savings in the energy consumption of the nodes.

3. Transmission Delay

Transmission deay is main issue of clustering techniques due to wireless communication between Sensor Nodes.To overcome that problem chaining concepts introduced. In ICCPNN protocol reduce the work of leader node or Cluster Head work in two ways. One for chaining and another one for Neighbour node. If any information need from base station CH called Neighbour node is enough. Neighbour node calls all the chained SN's and collects the information. So the delay is significantly redued dur to chaining of nodes.

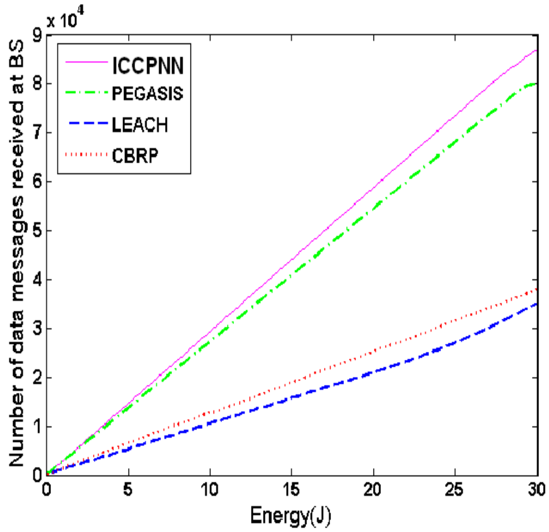

Fig.2 Energy Consumption per Round in chaining

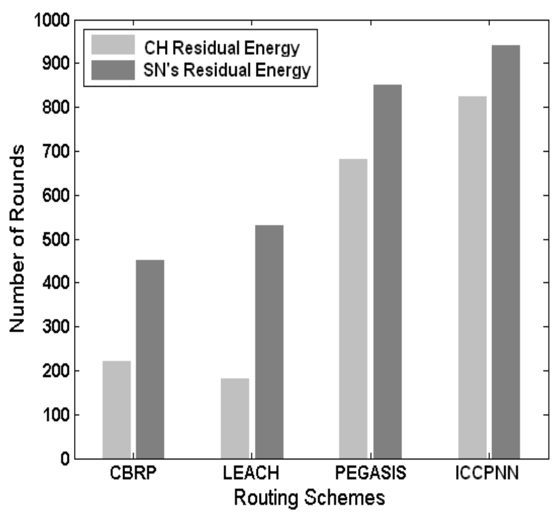

Fig.3 Network Lifetime

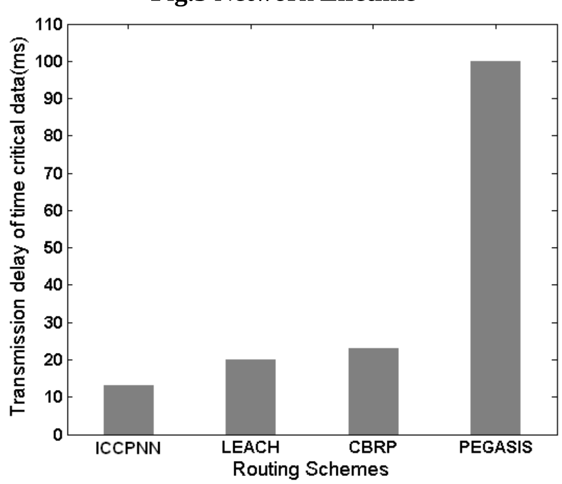

Fig.4 Transmission delay

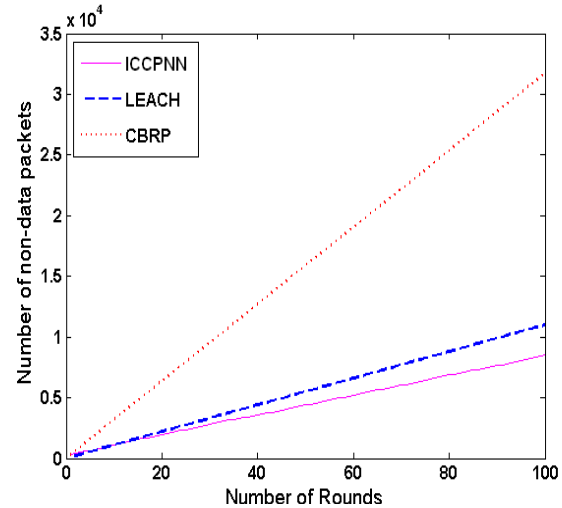

Fig.5 Communication Overhead

V. CONCLUSION

In this paper, an Intercluster-Chaining Protocol with Neighbour Node for Energy Efficient Data Collection (ICCPNN) in Wireless Sensor Networks proposed. The main goal of ICCPNN is to maximize network lifetime and minimize energy consumption and reducing transmission delay of data. For reducing transmission delay of data, ICCPNN introduces a Neighbour Node. ICCPNN organizes sensor nodes into clusters and constructs a chain among the sensor nodes within cluster and also select Neighbour Nodes which is present minimum distance in Cluster Head. So that each sensor node receives data from a previous neighbor and transmits to a next neighbor. Furthermore, ICCPNN improves the data transmission mechanism from the cluster heads to the base station via constructing a chain among the cluster heads and also within clusters. Through chaining the nodes in each cluster and using a separate chain for the cluster heads, ICCPNN offers the advantage of small transmit distances for most of the nodes and thus helps them to be operational for a longer period of time by conserving their limited energy. We evaluated the performance of ICCPNN by simulating and comparing our simulation result with LEACH, CBRP and PEGASIS. The simulation results show that ICCPNN has gives better performance than other protocols in conditions of network lifetime, transmission delay of data, energy consumption of the Sensor Nodes and Cluster Head.

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