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Proposed Coordinating Multiple Sampling Tasks in Sensor Field Using Geometric Progression Algorithm for Efficient Data Collection in Wireless Sensor Networks

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Abstract This paper proposes a new coordinating multiple sampling tasks in sensor field using geometric progression (CMSTGP) algorithm technique for enhancing the mobile sampling in wireless sensor networks. It is possible by the sensor nodes to have multiple sampling tasks, initiated by the same or different mobile objects, whose sampling regions overlap. Hence, it is desirable to have an efficient coordination mechanism such that overlapped regions need reply only once for the sampling tasks. A geometric progression technique is proposed in this research work as a coordination mechanism to coordinate the multiple sampling tasks to facilitate the rebroadcast scheme by consuming minimum energy. Experimental simulations have been conducted to estimate the performance of the proposed coordinating multiple sampling tasks in sensor field. The performance of the proposed algorithm has been analyzed in terms of average number of messages, overlap percentage and Throughput. From the simulated results it has been reported that the proposed CMSTGP algorithm reduces the overlapping percentage upto 8 % and increases the throughput of 70 % when compared with existing Band-based Directional Broadcast method.

Keywords Wireless sensor networks · Data sampling · Rebroadcast scheme · Multiple sampling tasks · Coordination · Geometric progression

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1 Introduction

Nowadays, in wireless sensor network, mobile sinks have been used to gather a set of samples from sensor field. Inexpensive and small sensor devices have many resource limitations that introduce new challenges for data collection and aggregation in sensor networks. Among these limitations, energy dissipation plays vital role when designing an in-network algorithm. The main task of sampling the sensor field is to manage the energy efficiency of the sensor source nodes while distributing the data to the target node. Hence, in recent past, various techniques have been developed by many researchers [1,3,7,12] for expressing a sensor node proficiently to a preferred data at a given point of time period.

At present, the notion of utilizing mobile objects (at times referred to as mobile sinks) is modified to process a sensor network. Requests can develop this mobility to vigorously model a sensor field. One high-level submission set-up can be demonstrated by Fig. 1. In the wireless sensor networks, sensor fields are normally processed using the band based approach [10] for broadcasting the sensor data in the respective environment for specific applications. A mobile object is wandering all along a path, and at some precise time (T_0) it chooses to obtain a model of the sensor field, i.e., gathers sensor data from close by sensor nodes.

In Fig. 1, the larger circle indicates the sampling region of sensor field. Each sensor in the sampling region will accordingly be initiated and respond with its nearby sensed data. As the mobile object persist its journey, it achieves another position at time T_1 from which it commences another sampling task. A scenario including a complicated jammer that squashes a region [11] in which a single-channel arbitrary admittance based wireless sensor network activates have been presented. The jammer pedals the prospect of jamming and the communication range so as to source maximal injure to the system in terms of dishonored transmission links. The essential information of the jammer so as to optimize its advantage comprises of facts concerning the net channel admittance possibility and the number of neighbors of the examine node.

There are two appealing features related with the mission of sensor field data sampling. At first, owing to the mobility of the sampling entity, there are numerous alternatives for choosing a sampling region, as divergent to the fixed sampling region connected with a fixed sink. Then, it is achievable to utilize generally presented mobile objects, for instance vehicles, to assist augment the treatment of the sensor field. So, it is probable to intentionally decide a mobile object and translucently fit its sampling regions to optimize a sampling task. A possible settlement of incorporating the directional antennas in wireless sensor networks has

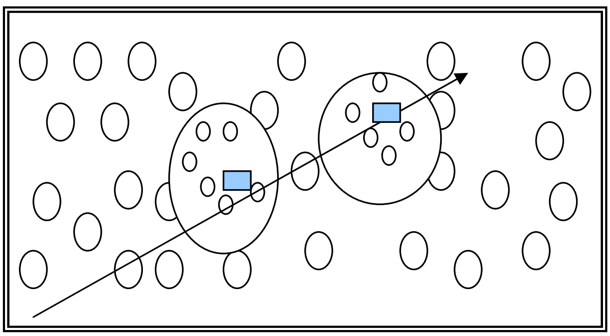

Fig. 1 Sensor sampling field

been designed [9]. An optimal routing and data aggregation scheme to increase the lifetime of the network has been presented by combining the data aggregation and routing [6]. An efficient technique to increase the lifetime of the nodes in the wireless sensor network (WSN) is to provide with the relay nodes in order to communicate between the sensor nodes, relay nodes and finally the base stations. A constrained version of relay node [13] has been provided where relay nodes were placed at a set of candidate locations.

A new mechanism to combine the data aggregation model with the basic routing scheme has been followed and a smoothing approximation function has been presented to solve the problem of optimization.

On the other hand, there are also confronts that happen from utilizing these mobile sinks to collect modeled sensor data. One confront is that sensors employ to react to a demand for sensor data from a mobile sink, or in other words scheming how sensors course their sensed data to the mobile object [6].

At last, the time limitation forced by the mobility of the sink object is the major obligation for sensor field sampling. To make easy the compilation of sensor data from the sampling section, it is supportive if the entire sensor data can be running scared to the mobile object previous to the object has diverged considerably from where it commenced the sampling task. This recommends that sensors should react rapidly upon getting a sampling demand, and the sensor-data broadcast technique should be greatly efficient.

The proposal of utilizing mobile objects to inquire a sensor network has been planned. A study of general framework to provide with the development of distributed mechanisms to achieve maximum utilization of multi-hop wireless networks has been presented in [4].

A mobile object (car) is roving all along a path, and for a while and location (for example, M*) it decides to take a sample of the sensor field, i.e., gather sensor data from "close by" sensor nodes. Energy efficiency is a significant measure for sensor networks, and the means to broadcast represents with the major form of energy node utilization. In [22], rate-based fairness-aware congestion control (FACC) protocol has been presented, that controls congestion and provides with higher and fair bandwidth model for varied types of flow. A dynamic priority resource-allocation (DPRA) scheme [2] for uplinks in IEEE 802.16 wireless communication systems gives priority values to four different types of service traffic on the basis of the urgency degrees and provides with the system radio resources based on their priority. An adaptive low-power slumber [5] forms supported the current traffic circumstances.

Every sensor in that area will accordingly be stimulated and respond with its close by sensed data. As the mobile object persist its journey, it achieves another position at time M* from which it starts an additional sampling task. There are three exciting features connected with the mission of sensor field data sampling.

The first feature is owing to the mobility of the sampling entity, there are numerous alternatives for choosing a sampling region, as different to the stagnant sampling region connected with a stationary sink. Second, it is probable to utilize the coverage of the sensor field. So, it is achievable to intentionally decide a mobile object and lightly adapt its sampling regions to optimize a sampling job. Last, in contrast to sensor nodes, mobile objects have comparatively huge (and modifiable) communication ranges. Sensor nodes contain a considerably smaller broadcast series than mobile objects, sensor nodes have to rely on multi-hop communication of sensor data when they react to the single-hop reaction of the mobile object's sampling sign.

The remainder of the paper is organized as follows: Sect. 2 reviews the related research works reported by various researchers. Section 3 explains about the flow diagram of the proposed algorithm. The sensor wireless network has been modelled in Sect. 4. The multiple sampling task representation in sensor field has been presented in Sect. 5. Section 6 elaborates about the Geometric Progression Coordination Mechanism. The experimental evaluation has been presented in Sect. 7. Section 8 illustrates the simulation results and performance analysis. The conclusion of the research paper is presented in Sect. 9.

2 Related Work

A sensor-data routing procedure is based mainly on transmit, recapitulate numerous fashionable transmit based mechanisms and scrutinize their applicability to the trouble of sensor field data processing by a portable object. In Li et al. [12], an algorithmic method termed as Band-based Directional transmits is commenced to organize the course of transmits that initiate from sensor nodes. The objective is to express each transmit of sensor data to the movable sink, thus dipping expensive on warding of sensor data packets. The method is considered by simulations that believe energy utilization and data deliverability.

Broadcast is possibly the most essential yet demanding procedure amongst all processes of wireless ad hoc networks. The broadcast tempest trouble informs us that naive overflow is merely not sensible, as it sources brutal contention, collision, and jamming. In Huang et al. [7], it reinvestigates this crisis by employing the 2-Disk and the signal-to-interference-plus-noise-ratio (SINR) representations. Devise a stable rough calculation algorithm for the 2-Disk representation and then expand it to the SINR representation.

There are various preceding works that employ parallel ideas of bands, but in diverse circumstances. It is practical to remind that a variety of other, more complicated impact prevention procedures, for instance the techniques used numerous procedures in ad-hoc networks [1]. Employing directional antennas [3], resourceful broadcasting is done in ad-hoc networks and mobility based communication is also being achieved. In the wireless sensor networks, sensor fields are normally processed with band based approach [10] for broadcasting of sensor data in the respective environment with specific applications.

Li et al. [11] measured a situation where a complicated jammer squashes a region in which a single-channel arbitrary admittance based wireless sensor network activates. The jammer pedals the prospect of jamming and the communication range so as to source maximal injure to the system in terms of dishonored transmission links. The essential information of the jammer so as to optimize its advantage comprises of facts concerning the net channel admittance possibility and the number of neighbors of the examine node.

Wireless sensor networks have been employed to collect data and facts in numerous varied request settings [9,15,16]. The capability of such systems leftovers a basic obstruction in the direction of the version of sensor network schemes for complex requests that need superior data rates and throughput. In Felemban et al. [5], the author discovered possible settlement of incorporating directional antennas into wireless sensor networks. Energy efficiency is a essential confront in sensor networks, and the broadcasting is a main supplier to general energy node utilization. Wang et al. [20] proposed adaptive radio low-power slumber forms supported on present traffic circumstances in the network.

Spyropoulos et al. [18] introduced a new way of routing schemes which spray a few message copies into the wireless network, and then made a routing each copy independently towards the destination. But it has a bottleneck of lower average delivery delays than existing schemes. Practically pairwise key distribution scheme is necessary for wireless sensor networks since sensor nodes are susceptible to physical capture and constrained in their resources [17]. They investigated a simple and practical scheme that achieves higher connectiveness and perfect resilience with restricted resources, even in case of deployment errors. Xiao et al. [21] proposed a new scheme called reliable anchor-based localization (RAL), that can reduce the localization error due to the irregular deployment areas. Also from the simulation results it can be observed that RAL can effectively filter out unreliable anchors and therefore improve the localization accuracy. Joohwan et al. [8] interested in minimizing the delay and maximizing the lifetime of event-driven wireless sensor networks for which events occur infrequently. But it has been failure under practical scenarios where there are obstructions, e.g., a lake or a mountain, in the coverage area of the wireless sensor network.

VEBEK [19] is a safe transmission structure where intellect data is prearranged by employing a system supported on a variation code created using RC4 encryption technique. To attain a greatest competence, cross-layer communication is a main devise pattern to develop the compound communication amongst the sheets of the procedure stack. This is demanding since latency, dependability, and power are at likelihood, and resource-constrained nodes sustain only uncomplicated algorithms [14]. This kind of algorithm does not provide reliable organization to the network model.

In this paper, a geometric progression technique as a coordination mechanism to coordinate the multiple sampling tasks to facilitate the rebroadcast scheme by consuming minimum energy has been proposed and simulated.

3 Proposed Algorithm

The coordination in multiple sampling tasks in sensor field is achieved by implementing the geometric progression technique. The geometric progression acts as a coordination mechanism in the sensor field which coordinates the multiple sampling tasks rebroadcast by the sensor nodes at the appropriate time. While the sensor nodes keep on rebroadcast the data for one region to attain the mobile sink, then the region overlap occurs. If overlap occurs, the data packet might get lost. The architecture diagram of the proposed coordinating multiple sampling tasks in sensor field using geometric progression (CMSTGP) is shown in Fig. 2.

From Fig. 2, it is being observed that the proposed CMSTGP broadcast the packet data to the sink node by consuming less energy. While performing the rebroadcast scheme in one region of sensor field, then there might be a chance of mobile objects to rebroadcast more than once to the same destination node. If same or different mobile objects performed the multi sampling tasks in the same region, then the regions get overlapped. So, it is necessary to coordinate the sampling tasks based on the geometric progression technique to avoid overlapping. The subsequent section will describe deeply about the CMSTGP scheme.

4 System Model

The sensor network system model and the solution framework for CMSTGP scheme make the following assumptions:

A WSN is modeled with a set of nodes N which is made up of WSN devices. An Arc set AS is formed between the set of sensor nodes a and b by denoting as AS(a, b) lies within the communication range. With this concept of communication network, the setback of routing from numerous sources to sinks can simply be planned to the service network design problem.

For this concern, given a set of packet data P, the goal is to route each packet p $\in$ P through a network model from set of sources $S(p) \subseteq N$ to the multiple destination $D(p) \subseteq N$. Since the packets are transferred from single source which follows the different routes to reach the destination, the multiple sampling task is done based on one too many mapping sources. Once

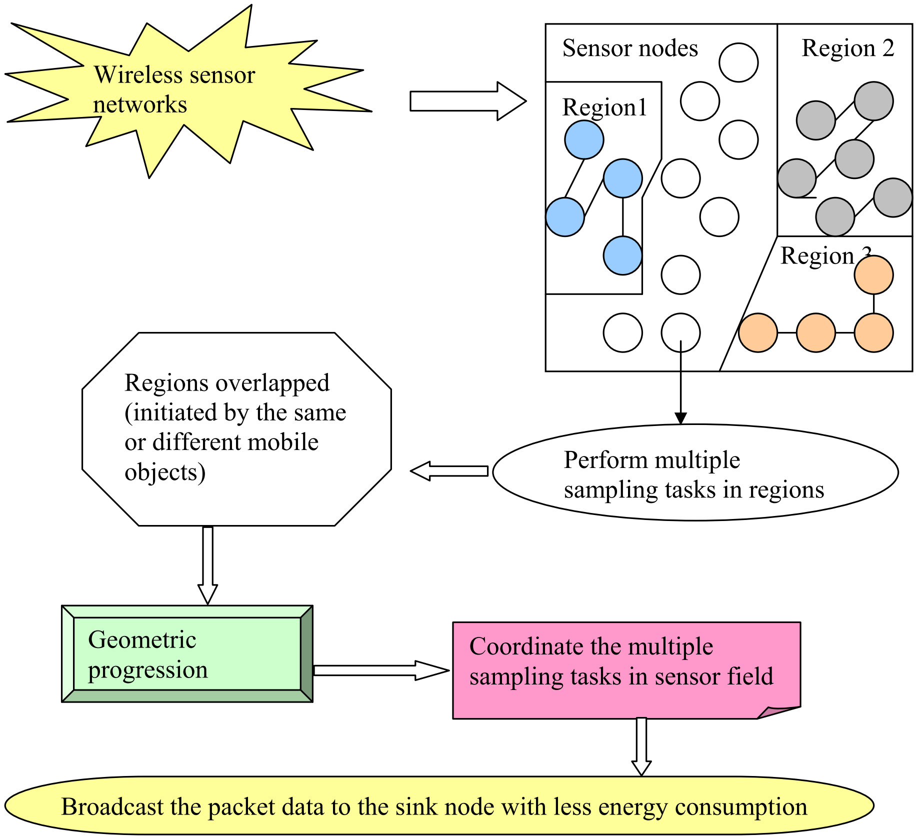

Fig. 2 Flow diagram of the proposed CMSTGP algorithm

the mapping is efficiently done with the corresponding source and destination, the model can be designed.

Packet data can be routed from source to destination with a set of decision variables,

$$r^{p}_{a,b} = \begin{cases} 1 & \text{if the route for the source sin}\,k \text{ pair contains route nodes } i, j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Based on the assignment on route path between the nodes i and j, the packet data will pass onto the S(p) and D(p).

A communication link can be utilized for numerous source-sink pairs to pass the nodes. The reality is that nodes (a, b) is utilized to route as a minimum of one message for a source-sink pair. The determination of communication link from source to destination used to distribute data messages are formulated as,

$$\text{Path}(P, A) = \sum_{(a,b)\in A} u(a, b) \quad (2)$$

Indeed, to minimize Path, promising communication links that have previously been utilized for other source-sink pairs, i.e., for which the charge $u_{a,b}$ is already compensated. In other

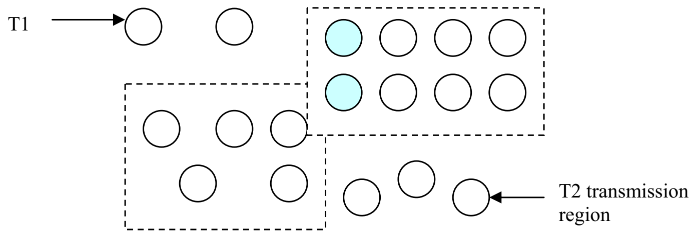

Fig. 3 Multiple sampling tasks

words, the number of communication path utilized by exploiting the process of overlapping among source-sink paths.

- The packets to be sent submit to the similar form of sensor data, for instance the warmth of the environment.
- Several queries that search for diverse types of sensor data can be measured separately, and such query processing can be cut down by utilizing methods like attribute correlation.
- Every node recognizes its geological location and the range of the sensor field.
- A region in the sensor field is recognized as a rectangle associated next to the X and Y axes. For a region that is not united with the axes, then the region is identified by one or more regions that face the region of interest.
- Assume that all queries employ the similar sampling rate

5 Multiple Sampling Task Representation in Sensor Field

At first, the sensor readings of the sensor nodes are noted and form a region to pass the packet data to the sink node. As shown in Fig. 3, with the sensor readings, the identification of nodes in the intersection regions has been noted.

Since T1 is recognized only to node R1, and T2 is recognized only to node R2, then construct the network tree structure for T1 and then regulate the tree construction in the intersection region of the sensor field when Q2 is broadcasted in the network. Nonetheless, this readjustment in the center of processing T1 would be hard and consuming more energy. So the intersection regions are handled by assuming the multiple sampling tasks from same or different mobile objects. If the data packet does not reach the sink node, then rebroadcast is done. The mobile objects will keep on rebroadcast the data packet until it reaches the mobile sink. So, the source mobile object has a tendency to send the data packet more than once to the mobile sink in different route path. This is referred to as multiple sampling tasks. When all source sensors met with this case, then the overlapping occurs. The multisampling tasks in the sensor field is represented as,

- Compute the set of intersecting regions in the sensor field associated with the sensor nodes
- Identify the set of nodes in the particular region to transfer the data in different route path
- If the data packet is rebroadcast to the sink node, identify the path and the starting node to count the number of times the nodes sent the packet data.

6 Geometric Progression Coordination Mechanism

Consider a set of nodes n ∈ N in WSN and a data packet is set as p ∈ P in a route path r ∈ R. Consider a set of regions g ∈ G, under which, the source nodes and the mobile sink node is identified. The multiple sampling tasks via rebroadcast scheme made the network regions overlapping. The overlapping is resolved by the coordination mechanism referred as geometric progression.

The primary step is to identify the source sensor node S (n) in the network along with the data packet p. Then identify the route r through which the data packets are passed. With the values of S (n), p and r, check whether the p reaches the mobile sink. If not, then rebroadcast is done. Count the number of times the R (S (n)) rebroadcast the data packet p to the sink node. It is expressed as,

$$R(S(n)) = p{*}t \tag{3}$$

where R(S (n))—counting variable

p—Data packet
t—no. of time the data packet is routed to reach the mobile sink.

The value of t is set based on the number of times the data packet is routed to reach the destination. Based on this, R (S (n)) is determined. It forms like a loop. Based on this formation, implement the procedure for all source sensor nodes in the network and form a series. The series of the source nodes is determined as,

$$\mathrm{S} - \mathrm{s}_1, \mathrm{s}_2, \mathrm{s}_3, \ldots, \mathrm{s}_\mathrm{n} \tag{4}$$

$$\mathrm{R\,(S\,(n))} - 2, 4, 6, \ldots, \mathrm{C} \tag{5}$$

The series is formed based on the counting value to reach the mobile sink node in the sensor network. The geometric series is obtained by setting the s value as a source sensor node and the (common ratio) dp as number of data packets sent by the source node s and n be the number of times. Then it is represented as,

$$S_n = s{*}dp^{R(S(n))} \tag{6}$$

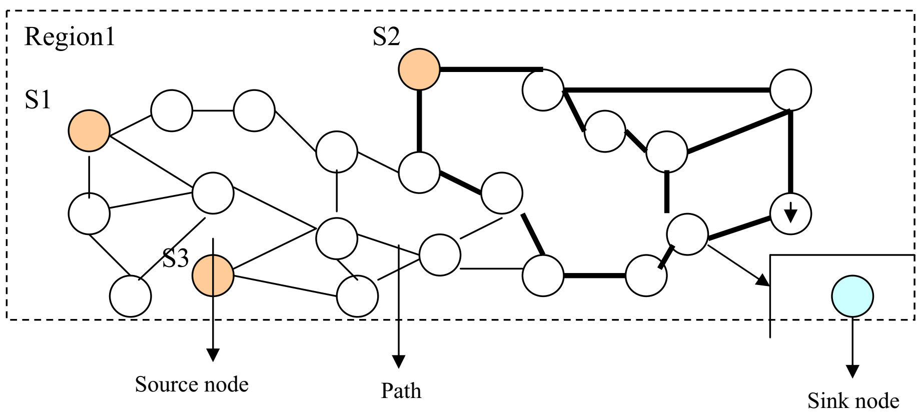

Fig. 4 Process of coordination mechanism

The behavior of a geometric series depends on the charge of the R(S (n)). With the value of R(S (n)), the coordination among the nodes in the network is determined. It is shown in Fig. 4.

Figure 4 describes the process of coordination which has been shown as the routed path. Based on the charge of R(S (n)), the route path is determined. With that path, the data packet is sent by the source nodes are coordinated with each other respectively.

// Algorithm

Input: set of nodes S

Begin

For each sensor source node S

  Identify the number of packet P it holds

  Count the rebroadcast of data packet R (S (n))

End for

Based on the charge of R (S (n))

  Form a series

  Identify the common counting of data packets the nodes hold

  Choose the shortest route path (r)

  Pass the packet to the sink node

End

With this procedure, the coordination among the sampling tasks is achieved in the sensor network.

7 Experimental Evaluation

In this section, the simulation has been carried out to analyze and to evaluate the performance of the proposed algorithm using NS2 simulator. Also, the effectiveness of the proposed CMSTGP algorithm has been verified with Existing Band-based Directional Broadcast technique. All replication results have been averaged above 100 simulation dashes and comprise 95 % assurance period data. As the simulation experiments only measured a particular sampling job at a time, the supervised location (i.e., sensor field) is situated as a 1,000 by 1,000 m^2, with the sampling indication inserted at the midpoint (i.e., sampling region) was centered at the example section.

For simulating the proposed algorithm, one instance unit symbolized has been assumed as 50 ms and the estimated time to forward a packet on the 10 Kbit radius of Motes. Imagine that sensor data produced by any sensor node is sufficient to robust in one packet. It assumed that sensors contained a 100 % victory speed for transmitting with a mobile object positioned inside 50 m, as the sensor-to-sensor message success rate depended on a chosen message model, by using of two communication representations. It mixed the number of sensor nodes inside the whole sensor field from 300 to 1,100 in addition steps of 200. It is simple to realize that this arrangement communicates to a network degree (average number of neighbors in a node's message) ranging from 2.355 to 8.635. The performance of the proposed CMSTGP is measured in terms of average number of messages, overlap percentage, throughput.

Average number of messages is defined as the total number of messages used in each rebroadcast scheme by the total number of nodes included in the particular regions.

$$\text{Average number of messages} = \frac{\text{tot}(M)}{\sum_R \text{size of}(R)s} \tag{7}$$

where tot (M)—total number of messages

Overlap percentage is defined as the proportion of the nodes in the sensor field present inside the particular regions which is based on the total number of nodes in the regions.

$$\text{OP} = \left(\sum_R (\text{size of}(R)*(\text{num}(P)))/\sum_R (\text{size of}(R)*N(N-1)) \right) s \tag{8}$$

where r is the region

P—Data packet
N—Total number of nodes

The throughput of the any network is defined s the ratio between the total number of replies obtained from the sensor sink sampling region to the total number of sensor sink in a particular sampling region.

$$\text{Throughput} = \frac{\text{total no. of replies obtained from sensor sink sampling region}}{\text{total no. of sensor sink sampling region}} \tag{9}$$

8 Results and Discussion

The proposed CMSTGP algorithm has been compared with the existing Band-based Directional Broadcast method for enhancing the mobile sampling in measuring the average number of messages, overlap percentage of the node sampling in the sensor field, throughput.

8.1 Number of Data Packet Versus Average Number of Messages

The average number of messages is measured based on the number of data packets in the sensor node. The number of data packet versus average number of messages has been simulated for both CMSTGP and existing method and it has been shown in Fig. 5.

For easy clarity and understanding, the same simulation has been represented using Table 1.

Figure 5 and Table 1 describe the average number of messages is measured based on the number of data packets in the sensor node. As compared with existing Band-based Directional Broadcast method, the proposed CMSTGP provides less average in broadcasting the messages. Smaller the value of average number of messages, higher the number of sharing of data packet is done in the network. Existing Band-based Directional Broadcast method controls only the direction of the rebroadcast that initiated from the sensor nodes in the network, does not coordinate with the incoming data packets.

8.2 Number of Data Packet Versus Overlap Percentage

The number of data packet versus overlap percentage been simulated for both CMSTGP and existing method and it has been shown in Fig. 6. For easy clarity and understanding, the same simulation has been represented using Table 2.

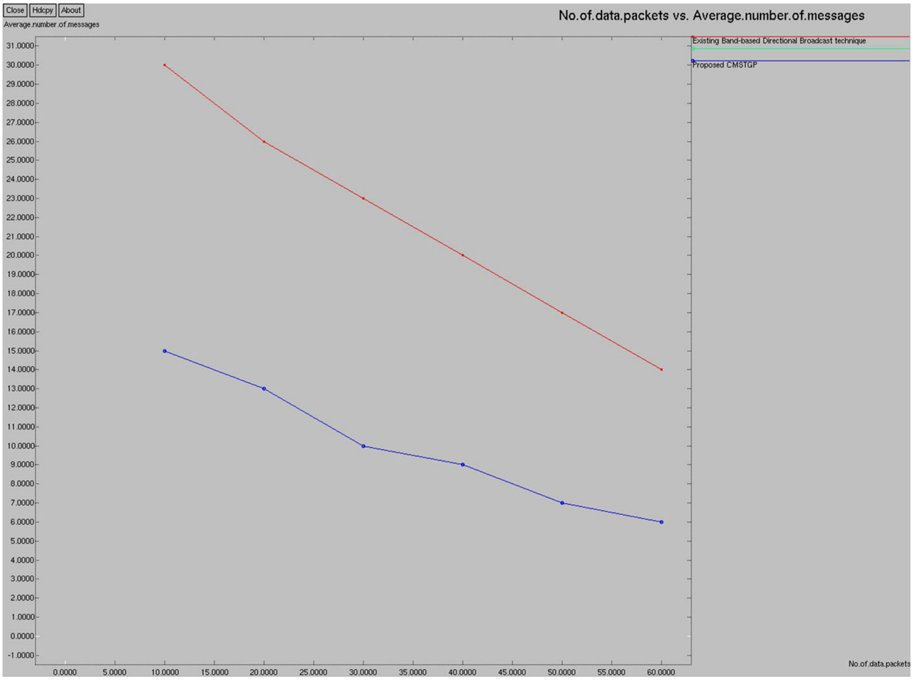

Fig. 5 Number of data packet versus average number of messages

Table 1 Number of data packet versus average number of messages

No. of data packet	Average number of messages	
	Proposed CMSTGP	Existing Band-based Directional Broadcast technique
5	15	31
10	14	30
15	13	28
20	12	26
25	11	24
30	10	23
35	9	21
40	8	20
45	7.5	18
50	7	17
55	6.5	16
60	6	15

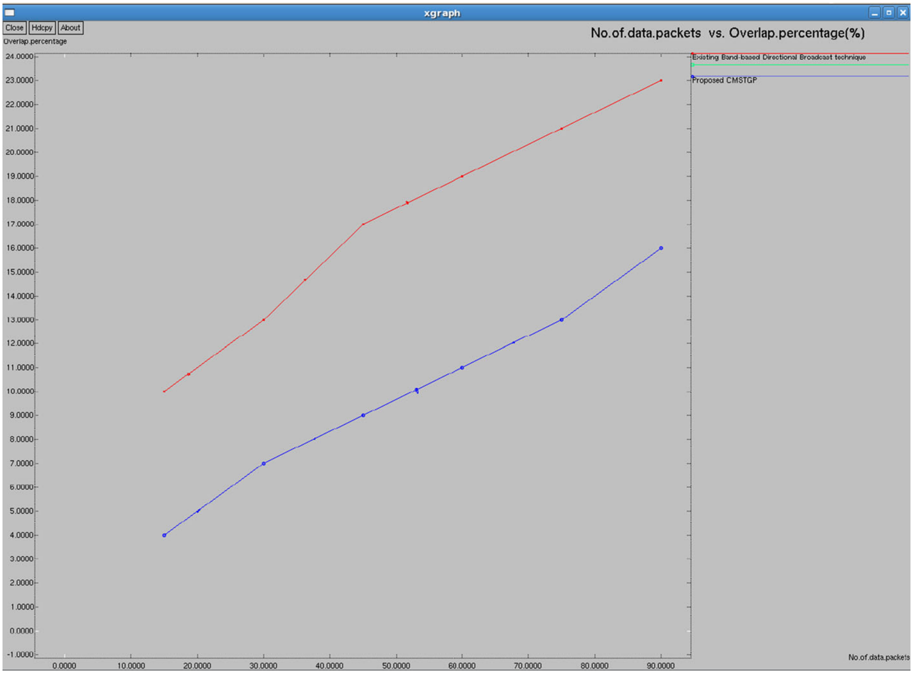

Fig. 6 Number of data packet versus overlap percentage

Table 2 Number of data packet versus overlap percentage

No. of data packets	Overlap percentage (%)	
	Proposed CMSTGP	Existing Band-based Directional Broadcast technique
10	3	10
20	4	11
30	7	13
40	8	14
50	9	16
60	10	17
70	11	19
80	13	21
90	16	24

The percentage of packet overlapping has been measured based on the number of data packets received in the sensor node. Figure 6 and Table 2 illustrate the percentage of packet overlapping measurement based on the number of data packets received in the sensor node.

It has been observed that the proposed CMSTGP provides less region overlapping as compared with the existing Band-based Directional Broadcast method,. This has been achieved due to coordinate the packet in the sensor field based on the geometric series in the proposed CMSTGP algorithm. Hence, the transmission rate is high since the packets are well orga-

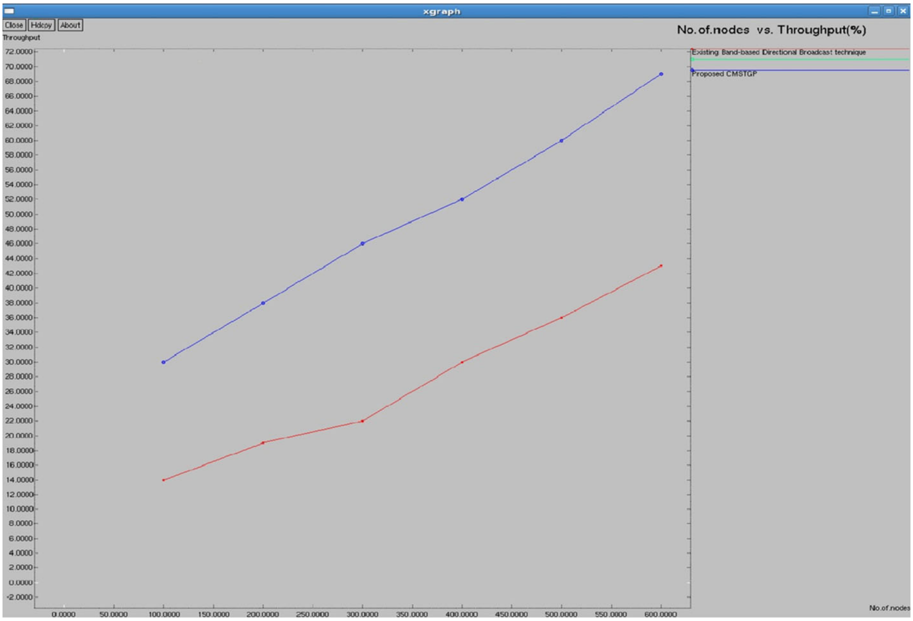

Fig. 7 Number of nodes versus throughput

nized and processed. The deviation in the overlap percentage has been increased when the number of data packets increased. The proposed CMSTGP algorithm reduces the overlapping percentage upto 8 % when compared with existing Band-based Directional Broadcast method.

8.3 Throughput

The throughput of the proposed CMSTGP algorithm and the existing Band-based Directional Broadcast method has been simulated for various nodes ranging from 50 to 600. The simulation result has been illustrated in Figure 7 and the corresponding numeric data has been tabulated in Table 3.

Figure 7 and Table 3 show that CMSTGP algorithm high rate of throughput than the existing Band-based Directional Broadcast method. Because, CMSTGP eliminate some rebroadcasts scheme, so the delivery rate of data packet is somewhat lower. This happens when some association among a sensor node and the mobile object is lost owing to reducing rebroadcasts that attain a higher-numbered band. But in the proposed CMSTGP, the delivery rate is quite high, since it coordinates the set of data packet based on the geometric series. When the number of node increases the throughput of the proposed algorithm is very high as compared with existing Band-based Directional Broadcast method. If the number of nodes is 600, the throughput of the proposed algorithm and existing method is 70 and 40 % respectively. Hence it increases the throughput upto 70 % as compared with exiting method.

From the above performance analysis of various parameters, it has been found that the proposed CMSTGP algorithm provides reliable coordination among data packets by means of geometric progression technique as compared with existing one.

Table 3 Number of nodes versus throughput

No. of nodes	Throughput (%)	
	Proposed CMSTGP	Existing Band-based Directional Broadcast technique
50	27	11
100	29	14
150	33	16
200	38	18
250	40	20
300	45	22
350	48	26
400	52	28
450	58	32
500	60	34
550	64	38
600	70	40

9 Conclusion

In this work, coordination among the sensor nodes is maintained by implementing the geometric progression technique. With the geometric progression technique, the nodes in the sensor network are analyzed and resolve the overlapping conditions of the sampling fields in the sensor network. Since the coordination is done based on the charge of data packets counters, each and every packet reaches the mobile sink node reliably. Simulation is done with the respective network environment and revealed that the CMSTGP provides reliable coordination among the nodes. This reliable coordination brings out high throughput and lessening the region overlapping in the sensor network. From the simulated results it has been observed that the proposed CMSTGP algorithm reduces the overlapping percentage upto 8% and increases the throughput of 70 % when compared with existing Band-based Directional Broadcast method.

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