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Design of Collision-free Nearest Neighbor Assertion and Load Balancing in Sensor Network System

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Abstract

Collision free transmission of raw sensor signal in application like detection and estimation of environmental problems is difficult and one of the major challenges is to balance the load and identify the interference nodes to achieve high performance. Ensuring multipath transmission among the nodes guarantees end-to-end packet transfer. However, such multipath transmission also gives rise to multiple copies of same packet resulting in interference and collisions among the nodes. While, certain routing protocols have high probability of delivery by maintaining an accurate neighbor list, they fail to achieve load balance which extensively degrades the performance of the network. In this paper, we present a Collision-Free Nearest Neighbor Assertion (CNNA) method to avoid collision and interference by significantly identifying the multiple copies sending nodes CNNA method initially identifies the collision and interference nodes in the sensor networks using the n-d tree data structure. The n-d tree search uses the binary search tree mechanism to easily identify the collision and interference nodes with minimal search time. A genetic optimization approach is formulated with an objective to balance the load on the neighboring nodes of the sensor network by measuring the weighted variance for the collision free n-d tree data structure. With the weighted variance using n-d tree data structure, Crossover and Mutation operation is applied to balance the load on the nodes. Extensive simulation results are carried out through analysis to show that the proposed algorithm satisfies both load balancing and collision removal in sensor network system. CNNA method achieves highest performance rate and performance measure is done on the factors such as collision removal rate, load balancing efficiency and search time taken for identifying the collision in network.

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Keywords: Genetic operator; Wireless sensor networks; Collision Free network; Weighted variance; n-d tree data structure.

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1. Introduction

Current Wireless Sensor Networks are deployed on different environments. Depending on the environment, the sensor nodes involved in the wireless sensor network poses several constraints and limitations. One among them is the design of collision-free network. Multipath Power-control Transmission (MPT)[1] scheme with cross layer approach guarantees end-to-end packet transfer in underwater sensor networks. However, MPT scheme drive multiple copies of same packet thereby increasing the rate of interference and collision occur among the nodes. Greedy Perimeter Stateless Routing (GPSR) Protocol[2] broadcasts an accurate neighboring node list periodically, maintained on the basis of geographic routing. But, GPSR fails to achieve load balance among them.

In the proposed scheme, we consider two types of problems into two different classes, that is, (i) identify the collision and interference nodes in the network system and (ii) to balance the load on neighboring nodes. The collision and interference of nodes is caused by maintaining multiple copies of same packet whereas absence of load balancing on neighboring nodes is caused by broadcasting periodically the same packet to the neighboring nodes . Therefore, in this paper, a Collision- free nearest neighbor assertion method based on n-d data structure that minimizes the collision and interference nodes in the network system using segregate procedure and ultimately results in increasing the collision removal rate. With the help of genetic optimization approach, each node balances the load with the neighboring nodes using the weighted variance. This innovative collision-free nearest neighbor assertion method provides load balancing efficiency to network and also minimizes the rate of collision in wireless network system.

A design of data aggregation based on TDMA[3] was presented for fault-tolerant network for wireless sensor networks (WSNs) to improve the latency. However it does not consider the transient faults. ALBA-R[5], was designed on the basis of converge casting in wireless sensor networks that includes integration of geographic routing with contention-based MAC to ensure fairness in load balancing. Though fairness and packet delivery ratio were provided, latency was not included. To improve the rate of latency, Distributed Coordination Function (DCF)[4] was introduced in WSN with a modified proportional fairness criterion.

A Random Access Compressed Sensing (RACS) scheme[6] was introduced that significantly reduces two factors, namely, usage of power consumption and bandwidth rate in large networks resulting in power and bandwidth efficiency. However, collision free network was not ensured. A collision-free network model[7] was designed by applying polynomial time algorithm to obtain optimality. Though the technique is collision-free but it cannot be applied in distributed environment. To derive a solution in distributed manner, set of communication topologies were designed in[8] and applied to several data collection cycles which not only provided flexibility but also was proved to be energy efficient in a distributed manner. Time Sharing Energy Efficient Congestion control (TSEEC)[9] was designed for mobile wireless sensor network, which was mainly based on the hybrid protocols namely, time division multiple access protocol (TDMA) and statistical time division multiple access (STDMA) protocol. TSEEC included the information regarding when to be idle and when to be active in order to minimize the energy consumption.

2. Related Works

One of the major concerns related to the clustering approach for WSN is to increase the lifetime of each sensor node in the network and altogether the lifetime of the network. However, selection of an appropriate cluster head still remains a challenging and extraordinary tasks for certain network which are highly mobile in nature. Energy efficient Safe Weighted Clustering (ES-WCA)[10] was designed to solve the problem related to the selection of cluster head. The method was proved to be effective with low node density. To address the problem with varied traffic loads, an Improved Hopfield Neural Network (I-HNN)[11] was designed for the main purpose of assigning slot in wireless sensor networks. I-HNN achieves this by adjusting the demands of various slots according to the load occurrence in the traffic based on demand history.

The main objective of designing TDMA protocols is to minimize the consumption of energy during idle time and avoid collision during node communication. In[12], a TDMA scheduling mechanism was designed that reused the time slots or consecutive slot assignment in an efficient manner for WSN. It also developed a negotiation mechanism for slots to minimize the interference nodes during transmission. However, fault tolerance was not considered. As a result, to ensure end-to-end transmission, a mathematical formulation and heuristic mechanism[14] that includes connectivity establishment, conservation of flow, limitation related to end-to-end transmission were included to increase the lifetime and balancing energy.

3. Collision Free Nearest Neighbor Assertion Method

Wireless sensor networks used in the environmental monitoring identifies the collision occurring nodes using the proposed nearest neighbor assertion method. The proposed collision- free nearest neighbor assertion identifies the node which transmits the same packet to the destination node at different time period. Similar packet transmissions made multiple times is identified using CNNA method with the help of n-d data structure with binary tree search. The idea behind using n-d data structure is that it is a multidimensional data structure which decomposes the dimensional shape into hyper squares. The constructed binary tree identifies (i.e.,) searches the collision node using the binary tree where each node correspond to hyper-squares of the sensor network.

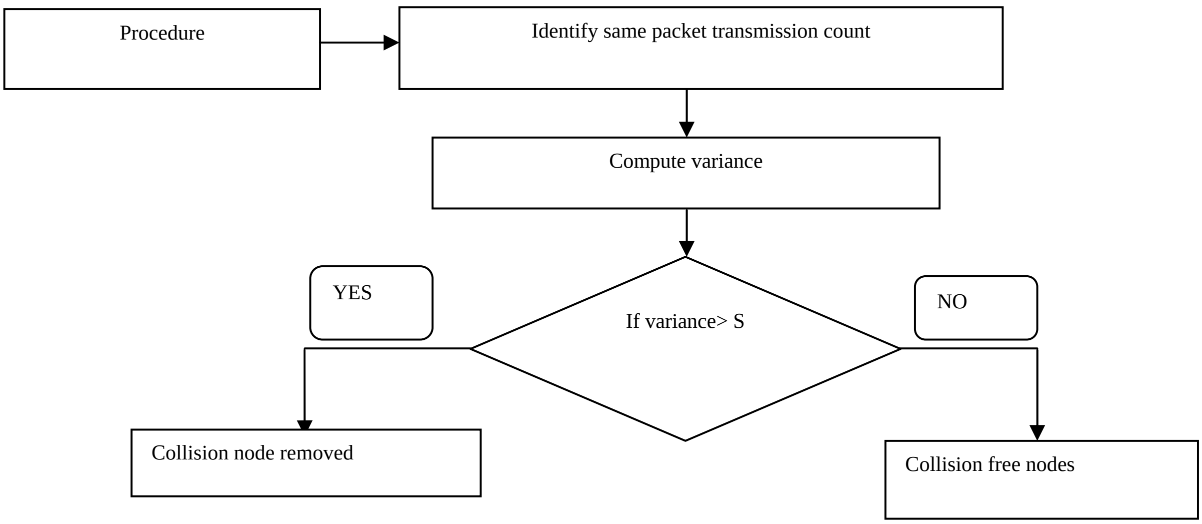

Fig 1 Segregation procedure

In CNNA, if the variance increases in the binary search, then the score also get increased. The increment in score value is removed using the segregate procedure. The binary tree search in CNNA method searches the collision node and removes the collision node using the segregate procedure. Segregation procedure is represented in Fig 1.

Figure 1 clearly describes the segregation procedure with the aid of the flow diagram. The initial step involved in the segregate procedure is to identify the number of times same copy of packet has been sent to the neighboring node. The count is obtained and the value of the variance is computed for each node. Let us assume that the CNNA method has a specified count variance value as ‘S’ and if the computed value of the variance exceeds the specified count variance value during each node computation, then the node is considered as collision node and interference occurred node. Higher the variance of nodes (i.e.,) collided nodes are removed from the network. Load balancing is then carried out using the genetic optimization procedure

The genetic optimization procedure on the n-d data structure in CNNA method carries out the selection, crossover and mutation operation. The genetic operations with the weighted variance help to balance the load factor in sensor network. The genetic approach improves the load balancing factor in CNNA method. The collision free network is selected and then the crossover and mutation operation is processed based on the weighted variance. The overall structural diagram of Collision-Free Nearest Neighbor Assertion (CNNA) method is depicted in Fig 2.

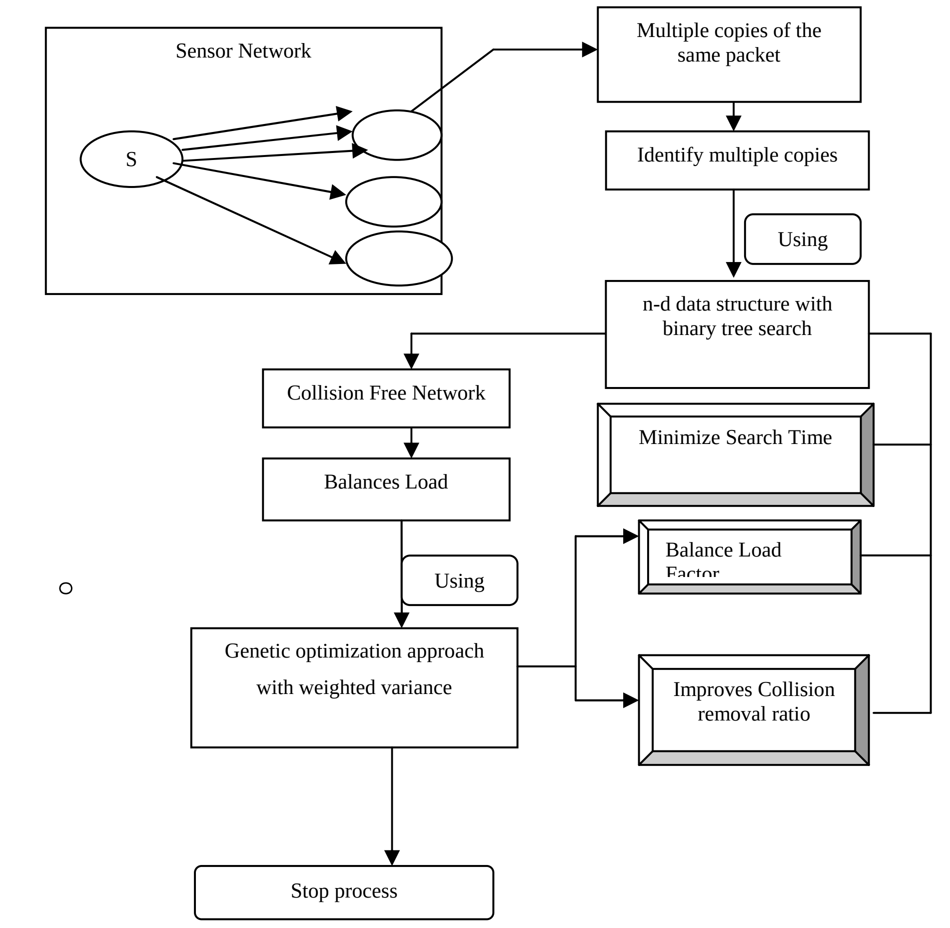

Fig 2 Overall Structural Diagram of CNNA Method

4. Experimental Evaluation

Collision-Free Nearest Neighbor Assertion (CNNA) method in wireless network is simulated using NS-2 network simulator. The network size chosen for simulation is 1000 ×1000 and observed the collision process while transferring the packets on sensor nodes. CNNA hold 100 to 800 (m/s) simulation results and result is compared with the Multipath Power-control Transmission (MPT)[1] scheme and Greedy Perimeter Stateless Routing (GPSR)[2] Protocol.

4.1 Result Analysis of CCNA.

In order to analyze the characteristics and functionality of the CNNA method, we quantitatively accessed the performance with the network size of 1000 * 1000 measured at 100 to 800 (m/s) using Dynamic Source Routing (DSR) Protocol by comparing the outcomes to the results achieved with the Genetic Optimization (GO) algorithm. The Collision-Free Nearest Neighbor Assertion (CNNA) method is compared with the existing Multipath Power-control Transmission (MPT)[1] scheme and Greedy Perimeter Stateless Routing (GPSR)[2] Protocol. The simulation results using NS2 simulator are compared and analyzed using table values and graphical form as given below. To support transient performance, in Table 1 we apply an efficient Genetic Optimization algorithm to obtain the collision removal rate and comparison is made with two other existing techniques, MPT and GPSR.

Table 1 Measure of Collision removal rate & Measure of Load balancing efficiency

Node density	Collision Removal Rate (bps)			Load Balancing efficiency in terms of load		
	CNNA	**CNNA**	**MPT**	**GPSR**	**MPT**	**GPSR**
10	3.255	59.35	48.15	43.10	2.105	2.055
20	4.672	62.45	51.25	46.20	3.472	3.172
30	4.850	68.55	57.35	52.30	3.750	3.650
40	5.125	72.35	61.15	56.10	4.025	4.045
50	6.375	66.45	64.24	41.59	5.275	5.125
60	5.352	78.85	53.45	62.60	4.135	4.225
70	10.235	80.25	70.05	65.00	9.105	9.035
80	12.355	82.13	71.08	66.03	11.255	11.150

Fig 3 shows that the proposed Collision-Free Nearest Neighbor Assertion (CNNA) method provides higher collision removal rate when compared to MPT[1] and GPSR[2]. This is because of the application of collision- free nearest neighbor assertion that efficiently identifies the node which transmits the same packet to the destination node at different time period using n-d data structure with binary tree search. The n-d data structure searches the collision node using the binary tree which minimizes collision occurring nodes by 11 – 35 % than MPT. Moreover, using segregate procedure, the binary tree search in CNNA method searches the collision node and removes it. Hence we get an improved result, namely, the collision removal rate is increased by 9 – 36 % when compared to GPSR.

a b

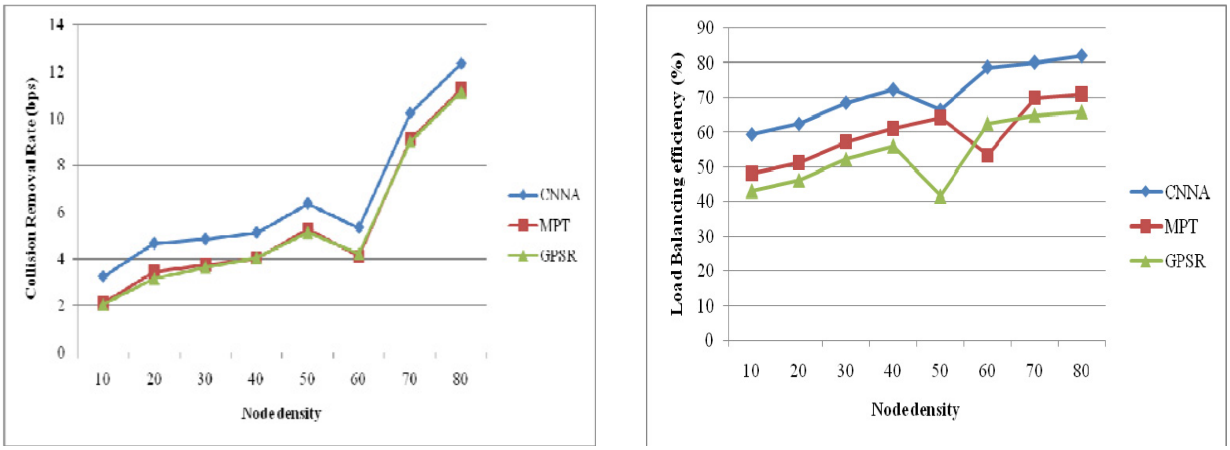

Fig 3 (a) Impact of collision removal rate on CNNA (b) Impact of load balancing efficiency with MPT and GPSR

The comparison of load balancing efficiency in terms of load balancing factor is presented in the second part of table 1 with respect to the varying number of nodes in the range of 10 – 80 with varying speed. It is evident that with increase in the number nodes, the load balancing efficiency to obtain load balancing factor is also increased. To measure the performance of the load balancing efficiency, a comparison is made with two other existing techniques, Multipath Power-control Transmission (MPT)[1] and Greedy Perimeter Stateless Routing (GPSR)[2]. In Fig 1(a), the density of nodes is varied between 10 and 80. From the figure, it is seen that the load balancing efficiency is improved using the proposed Collision-Free Nearest Neighbor Assertion (CNNA) method when compared to the two other existing works.This is because with the aid of collision free network, load balancing is attained by applying the genetic optimization procedure using the selection, crossover and mutation operation that efficiently balances the load on the neighboring packet transfer nodes in the sensor network. As a result, the load balancing efficiency is improved in CNNA method by 3 – 32 % and 19 – 37 % than compared to MPT and GPSR methods respectively. In addition, the genetic operations are performed with the weighted variance which helps to balance the load factor in a sensor network and therefore improving the efficiency of load balancing.

Table 2 Measure of search time for identifying collision node & Measure of Packet delivery ratio

Node density	Search time for identifying collision node (ms)				Speed (m/s)	Packet Delivery Ratio (%)		
	CNNA	MPT	CNNA			GPSR	MPT	GPSR
10	22.35	66.3	72.5		100	60.3	30.25	36.35
20	27.48	59.1	65.3		200	53.1	32.45	42.44
30	32.55	54.2	61.4		300	46.2	38.56	48.52
40	38.42	49.0	55.2		400	43.0	42.35	52.35
50	42.59	66.33	60.26		500	52.33	45.55	55.45
60	50.25	38.53	44.55		600	32.53	55.45	60.45
70	30.38	34.23	40.25		700	29.23	34.45	45.25
80	60.45	33.70	40.72		800	33.70	72.35	72.45

The search time for identifying the collision node using CNNA method is elaborated in table 2. The method is considered with varying number of nodes of network size 1000 ×1000 at different time period for experimental purpose using NS2 simulator

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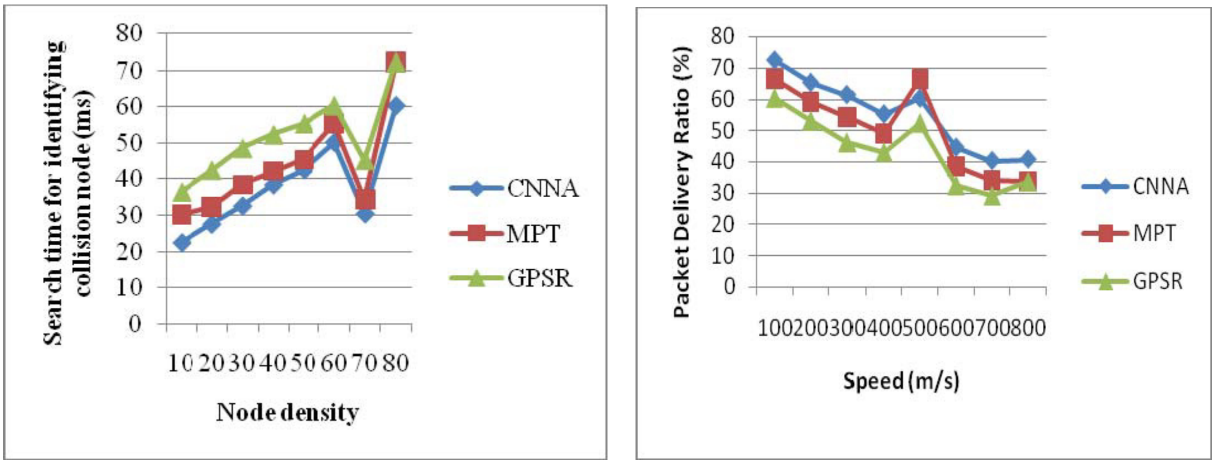

Figure 4(a) Impact of search time with varied node density (b) Impact of Packet delivery ratio on varying speed

In figure 4(a), we depict the search time for identifying the collision node using varying node densities with ranges between 10 and 80 nodes in wireless network. From this figure we find that the value of search time achieved using the proposed Collision-Free Nearest Neighbor Assertion (CNNA) method is lower when compared to two other existing techniques namely, Multipath Power-control Transmission (MPT) and Greedy Perimeter Stateless Routing (GPSR). Besides we also observe that, by increasing the density of nodes, the search time also gets increased though using the CNNA method it is comparatively less than two other methods. This is because with the application of binary search tree, it provides quicker searching process with minimal time count and therefore minimizes the search time taken for identifying the collision in sensor network by 6 – 35 % compared to MPT. Also, the binary search is carried out on a sensor node based data structure with each node having similar variance evaluated with respect to the left and right sub tree which further improves the search time by 19 – 62 % compared to GPSR.

Table 2 second part and Figure 4 (b) illustrate the packet delivery ratio versus the speed measured in terms of m/s in the range of 100 to 800 for experimental purpose conducted using NS2 simulator. From figure 4(b), it is clear that the packet delivery ratio is higher in the CNNA method than other two existing techniques. This packet delivery ratio is higher in CNNA method because the GO algorithm developed in CNNA method improves the load balancing factor by removing the interference node using the binary search tree in the n-d data structure. As a result, the overhead in packet transmission is reduced by removing multiple copies transferring nodes by 8 – 17 % and 13 – 26 % compared to MPT and GPSR respectively.

5. Conclusion

Minimizing the collision and interference of nodes on wireless sensor networks have become the key for environmental monitoring to achieve higher load balancing effectiveness and to improve the search time taken for identifying the collision during packet transmission. In this work, we investigate the performance effects of collision-free networks and to minimize the collision nodes by proposing a framework, Collision-Free Nearest Neighbor Assertion (CNNA). The CNNA method based on n-d tree data structure and genetic optimization approach provides an efficient means of identifying the collision and interference nodes with minimal search time and balances the load. First, we study the use of n-d data structure using the segregation procedure that removes the collision node from the network structure using variance value. Second, the load optimization is achieved using genetic optimization procedure that improves and balances the load with the aid of weight variance. The method is implemented using NS2 simulator and examined the performance of CNNA which shows that CNNA has satisfactory performance in terms of collision removal rate, load balancing efficiency, packet complexity ratio and search time involved during the identification of collided node.

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