Asian Journal of Information Technology 15 (22): 4584-4595, 2016
ISSN: 1682-3915

Authoritative Synchronized Converge-Cast Protocol for Reducing Packet Collisions in Wireless Sensor Networks

[1]Rajasekar Rangasamy and [2]Prakasam Periyasamy
[1]CMS College of Engineering, Ernapuram, Namakkal, Tamil Nadu, India
[2]United Institute of Technology, Coimbatore, Tamil Nadu, India

Abstract: The sensor nodes in Wireless Sensor Networks (WSNs) are densely structured that are responsible for sensing the environmental condition and sending the information to the sink node. With the sensor nodes distributed in sparse geographical areas, the sink node collects the packets from different sensor nodes. Hybrid Medium Access Control (HMAC) protocol guaranteed fair transmission over the packets but the collision occurred when the packet was transferred to the sink node in the sensor network. Machine-Learning-based Adaptive Routing (QELAR) protocol achieved extensive network lifetime by reducing the energy consumption rate. But, QELAR did not work well with the MAC layer for effective packet retransmission. In order to avoid such limitations in WSNs, researcheritative Synchronized Converge-Cast (ASC) protocol is proposed in this study. ASC protocol integrated with the MAC layer for providing effective channel accessing of packet rebroadcasting. The main goal of ASC protocol is to avoid the occurrence of packet collision when multiple sensor nodes simultaneously transmit over the same channel in a large sensor network. ASC protocol is used Circular Coordination (CC) strategy in a sensor network that adjusts the packet transmission time with the help of quadratic principle. The quadratic principle visualizes the solution in ASC protocol by avoiding the packet collision during the rebroadcasting of the information. With the support of converge-casting on MAC layer with quadratic principle in ASC protocol, the packet collision is reduced in the sensor network which results in increased network lifetime. Experimental evaluation of ASC protocol is done with the performance metrics such as packet collision rate, packet transmission time, bandwidth rate throughput level and execution time. Simulation result shows that the integrated ASC protocol with MAC layer is much more efficient in robustness by minimizing the packet collisions and can also achieve better performance in terms of packet-transmission time, bandwidth rate and throughput level as compared to state-of-the-art methods.

Key words: Converge-cast process, authoritative synchronized, converge-cast protocol, medium access control, circular coordination strategy, packet collision, sensor network

INTRODUCTION

Certain emergency applications in Wireless Sensor Networks (WSNs) include intermittent monitoring of fires in offices, forest, underwater sensor network and so on. The communication protocol designed for specific purpose can be tolerant towards delay that includes normal monitoring designed specifically for energy-efficient problems. However, keeping in mind the occurrence of an emergency event, the efficiency factor for energy becomes less important when compared with the packet-delivery ratio. Accordingly, the design of the communication protocol should adapt in response to the scenarios. Hybrid Medium Access Control (HMAC) protocol, initially discussed by Sitanayah *et al.* (2014) is specifically an interesting protocol for emergency response in a WSN as it generalizes a hybrid approach of TDMA and CSMA to schedule collision-free slots. Though HMAC guarantees fairness during the packet's transmission but collision occurs whenever a packet is transfer to the sink node in the sensor network.

Underwater Sensor Network (UWSN), one of the promising networking techniques has received much attention in recent years due to the development in the specified area. However, the deployment of UWSNs is comparatively more difficult than the WSNs due to the tedious environment and incurrence of high costs. QELAR (Hu and Fei, 2010), protocol was designed with the aim of providing an energy-efficient and routing protocol with increasing the lifetime of the network. QELAR protocol aimed at increasing the lifetime of networks by distributing the residual energy eventually between the sensor nodes in the network. But QELAR protocol did not work well with the MAC layer to support effective packet retransmissions.

Corresponding Author: Rajasekar Rangasamy, CMS College of Engineering, Ernapuram, Namakkal, Tamil Nadu, India

Most of the researchers developed many converge-cast protocols in WSNs. Hyper graph theory and Spanning Hyper-Tree algorithm (Yang *et al*., 2012) was developed to compute the minimum transmitting power delivery path set for WSNs converge-cast. In, fast converge-cast was developed for WSNs where nodes communicate using a TDMA protocol to minimize the schedule length (Incel *et al*., 2012). A new heuristic algorithm was designed for constructing a tree with schedules assigned to nodes for collision-free converge-casting (Annamalai *et al*., 2013).

To improve the effectiveness of packet retransmissions, the allocation of resources in multi hop wireless networks has to combine scheduling with the allocation of power which is very difficult to be implemented. To this end, the researcher in Lee *et al*. (2012), introduced a randomization framework for input-queued switches with an SINR rate-based interference model. Moreover, a distributed power-allocation problem that satisfied the scheduling and allocation of power was studied and achieved 100% throughput. But the results obtained were not optimal for multichannel conditions.

Some of the recent advancements in WSNs have resulted in a unique possibility to sense the environment in a remote manner. Therefore, maximizing the network lifetime with the efficient use of energy has been a key issue in a wireless network. One of the methods to increase the lifetime of a WSN is the deployment of relay nodes that in turn communicate with other sensor nodes, or relay nodes and finally to the base stations.

Artail and Mershed (2009) message-forwarding algorithm was designed on the basis of selecting the nearest nodes from the available sensor nodes in the network using the algorithm, Minimum Distance Packet Forwarding (MDPF). The MDPF algorithm used the routing information for selecting the node with the minimum distance to reduce the average number of hops required to propagate to the node that holds the specific data. The positioning of relay node for WSNs highly relates to the positioning and placing of a minimum count of relay nodes in a WSN to meet the criteria of connectivity. However, in practical scenarios, the problem of physical constraints during the positioning of the relay nodes may also occur. To provide solution to this issue, constrained versions of relay node (Misra *et al*., 2010) was designed at a set of candidate locations which in turn increases the lifetime of the network. But the constraint of relay-node positioning under the weaker connectivity remained unaddressed. Kim *et al*. (2010), the researcher studied the problem of optimization using any cast-forwarding schemes to minimize the packet-delivery ratio between the sensor nodes and the sink nodes. With the help of the results obtained, a solution was then provided for any cast packet-forwarding protocol to increase the network lifetime.

The throughput of a wireless network in a way was derived using the level of interference and the occurrence of collisions. At the same time, higher level of throughput can be achieved if transmissions are scheduled in a proper manner. However, the conventional way of computing the schedules is computationally impossible. Optimal schedules were introduced by Wang and Bohacek (2011), to compute optimal schedules that solve the Maximum Weighted Independent Set (MWIS) problem and result in the minimization of collision but with a limitation of 2048 nodes. The existing results were obtained on the basis of the assumption that negligible overhead occurs in network topology and synchronization of link transmissions. But in case of the large networks, global topology collection and synchronization of links are highly infeasible. Xu *et al*. (2010), a scheduling partition methodology was presented for large wireless network settings to achieve maximum capacity scaling.

Based on the aforementioned techniques and methods presented, in this research we propose an Researcheritative Synchronized Converge-Cast (ASC) protocol to reduce the packet collision and to support the effective packet retransmission in WSNs.

Literature review: The next-generation WSNs are designed in a way that different applications involving content have to be served instead of just forwarding the packets from one end to the other. To provide these types of services, high quality of service is required at different network nodes. But the processing of packets by different types of processors with the same flow results in the change of order and high delay for the outgoing traffic. An Ordered Round Robin (Yao *el al*., 2008) scheme was introduced with the assumption that the load was distributed which followed a fair schedule depending on the reservations. But provisioning of optimal mapping was not included. An algorithm referred as the packet-loss concealment was designed by Park *et al*. (2014), to minimize the amount of packet loss in WSN using modified discrete cosine transform. But the time involved was high.

Future wireless networks such as Ultra-Wideband (UWB) have different features that differentiate with the other types of wireless communication technologies. One among these features is the possibility for capturing fewer packets simultaneously which results in the improvement of performance of MAC layer. Celik *et al*. (2010), a design is made in such a way that the physical layer provides multi-packet reception and presents alternative back-off mechanisms via Markovian analysis that achieves both throughput and fairness. But the design for multi-hop setting remained a challenging issue.

An important application in WSNs includes in-network aggregation to minimize the energy consumption on sensor nodes. Subsequently, the packets that have similar destination are joined in a specific routing path and these packets are then sent. Though these types of arrangements are adequate for conventional type of multipoint-to-point sensor-network applications, it is not suited when the sensor nodes are connected in a mesh topology. Therefore, Troubleyn *et al*. (2014) broadcast aggregation was designed to aggregate packets independent of their destination. WSNs with the ability of event-driven nature results in network load which is highly unpredictable. Because of this, congestion may arise at sensor-node levels that obtain higher amount of data than they can forward, resulting in waste of energy, reducing the level of throughput and ultimately loss of packet. Rate-based Fairness-Aware Congestion Control (FACC) protocol (Yin et *al*., 2009), controlled the congestion and achieved fair bandwidth allocation for different flows.

Two non adaptive and adaptive broadcasting scheduling algorithms are developed in that take the energy consumption of the sensor nodes into account with the aim of improving the network's lifetime. A new algorithm was developed for controlling base station movements that reduced energy consumption and improved WSN lifetime (Rahbar, 2014). The impact of disabling suspicious nodes communications on network lifetime through a Linear Programming (LP) framework are addressed by Pala and Inanc, 2016).

Broadcasting of data or packet is one of the efficient methods for information delivery over asymmetric wireless networks where the performance of each client is independent of the number of clients located in a similar region (Xu and Wang, 2009). This condition was achieved without the entire performance of the system being significantly affected. But timely transmission of packet was not assured. To ensure timely transmission, each packet in Gong *et al*. (2010) was associated with a delay constraint by using a dynamic programming algorithm to achieve optimal results. But priorities were not provided for each packet is remained unaddressed. Random-deployment strategies were applied in Xu *et al*. (2010) to relay data packets from sensor nodes to the base station for balancing the energy consumption and extending the network lifetime. A Medium Access Control (MAC) scheme (Abichar and Chang, 2011) was presented to minimize the collision rate and to improve the throughput level using constant number of slots and resolved the problem of contention in an efficient manner.But it worked only on a short-term basis which cannot be extended for a longer period of time.

In Energy-aware optimization of the power control, the packet transmission and the topology control in WSNs was presented to address the problem of minimizing the energy consumption. Collision control algorithm was developed in to reduce the effects of congestion and to compromise delay and collision (Xenakis *et al*., 2016).

In this research, ASC protocol is integrated with the MAC layer to reduce the packet collision in wireless networks. The main aim of the ASC protocol is to follow a strategy called Circular-Coordination (CC) strategy in a sensor network that adjusts the packet-transmission time using the quadratic principle. As a result, the ASC protocol is reduces the packet loss and at the same time increases the throughput level.

MATERIALS AND METHODS

ASC protocol in WSN: The main objective of the ASC protocol is to reduce the packet collision rate when the packets are rebroadcasted from the sensor nodes to the sink node. Normally, this happens using the same communication channel. The converge-casting process in ASC protocol helps in performing the inverse operation during packet broadcasting (i.e., rebroadcasting). The ASC protocol is integrated with MAC layer to perform higher throughput level while broadcasting the packet information. The overall architecture diagram of ASC protocol is illustrated in Fig. 1.

As illustrated in Fig.1, the sensor network consists of multiple sensor events to monitor and coordinate the multiple sampling tasks. The multiple tasks are integrated

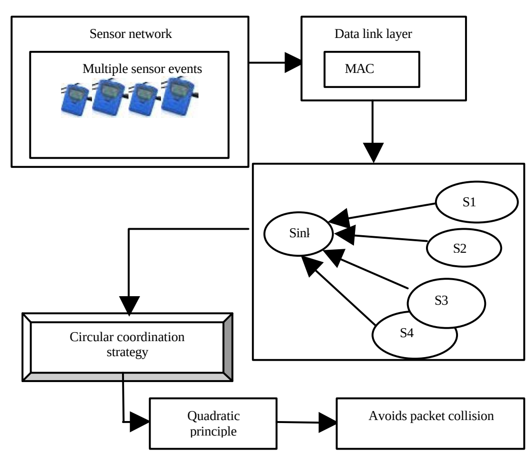

Fig. 1: Overall architecture diagram of ASC protocol

and the process is carried out in the data link layer of the WSN. The data link layer with MAC in sensor network provides effective channel accessing for the packet diagram of ASC protocoldiagram of ASC protocol rebroadcasting. With this, the MAC integrates the proposed ASC protocol for easy rebroadcasting of packet without any packet collision. Here, the sink nodes receive all the reverse broadcasted sensor packet information in the ASC protocol. From Fig. 1, the sensor nodes used for packet rebroadcasting are S1-4 in WSN.

In WSNs, Converge-Cast is used to retransmit the packet information in an efficient manner from the sensor nodes to the sink nodes. The sink nodes receive all the information from the sensor nodes concurrently. Here, with the concurrent arrival of packets, the possibility of packet collision leads to serious crisis. To overcome the packet collision, CC strategy is used in ASC protocol to reduce the rate of packet collision. The CC strategy in ASC protocol adjusts the packet-transmission time using the quadratic principle. With the application of Converge-Casting on MAC layer with quadratic principle in ASC protocol, the packet collision is reduced in the sensor network with increase in the lifetime of the network. The elaborate process involved in the design of ASC protocol is briefed in the forthcoming subsection.

Converge-casting process in ASC protocol: The purpose behind the application of converge-casting in the design of ASC protocol is to handle the inverse form of broadcasting operation (i.e. from all the sensor nodes to the sink node (or root node)). The ASC protocol uses the global function to review all the sensor-node packets. The purpose of using global function is to eventually review the packets received from the sensor nodes in a wireless network. The algorithmic steps involved in the design of converge-cast are demonstrated with the help of a step-by-step process.

```
//Converge-Casting Algorithmic Steps
Step 1: Initially, let 'Sink' be the root node, S1, S2, S3...Sn be the sensor nodes (i.e. leaf nodes)
Step 2: While Packet 'P' is received from the Sensor nodes
Step 3: Append 'P' on communication channel for reverse broadcasting
Step 4:     If Sink node contains P
Step 5:         Go to Step 8
Step 6:     Else
                Send 'P' until it reaches the 'Sink' node using Global Function
Step 7:     End If
Step 8: Repeat Steps 2-7 for all the sensor-node packet rebroadcasting
Step 9: End While
```

Let us assume that the sink node is represented as the root node whereas all other sensor nodes (i.e., S1, S2, S3… Sn) are the sensor or leaf nodes. The process starts whenever a packet 'P' is instantiated from the sensor

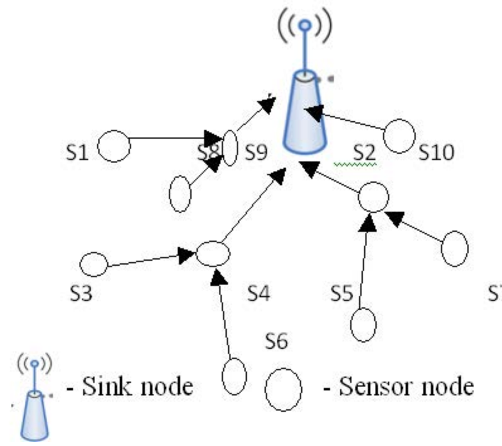

Fig. 2: Converge-casting on MAC sink node

nodes. If a packet 'P' is detected, then the packet is appended into the communication channel for the purpose of reverse broadcasting.

If the sink node contains the packet 'P,' then the process is repeated for all the sensor-node packet rebroadcasting. If the sink node does not contain a packet 'P', then global function is applied until it reaches the sink node. As illustrated in the algorithm, the Converge-Casting step helps to easily understand the packet rebroadcasting from the sensor nodes to the sink node using the ASC protocol. The lesser the intermediate node, the execution time of the ASC protocol in MAC layer is reduced in as significant manner. The diagrammatical representation of Converge-Cast in MAC layer is illustrated in Fig. 2.

Figure 2 shows that the sink node receives all the sensor-node packets in the MAC layer. Subsequently, the sensor-node packet is rebroadcasted using the global function. The global function in ASC protocol takes the vertex points 'S' with the input packets 'P' for computation. Global Function (GF) in ASC protocol is formularized as:

$$GF=\{S1(SS1,SS2),S2(SS3),S3(SS4,SS5),S4(SS6) \quad (1)$$

The Global Function is denoted by 'GF' which is obtained using the Subset (SS) of sensor nodes (S). In Eq. 1 the sensor nodes are denoted by 'S1', 'S2', 'S3', 'S4' with the subset of sensor nodes denoted as 'SS' for effective rebroadcasting of information. From Eq. 1 it is clear that S2 includes only 'SS3' subset nodes that in turn effectively reach the sink node in WSN. Global function also satisfies the associative and commutative rule in the ASC protocol to attain the higher converge-cast result. The integration of ASC protocol with the

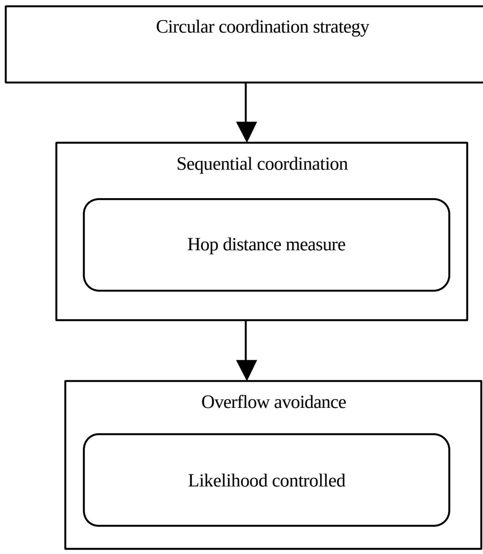

Fig. 3: Circular coordination procedure using ASC protocol

MAC layer is sensitive such that the changes in the sensor-node vertex also change the GF function.

As we have assumed that the sensor nodes are structured in the form of tree, the execution time for rebroadcasting of information depends on the depth of the rebroadcasting tree. The highest sensor node in the vertex tree results in the O(S×depth (tree)) time complexity. The depth identifies the intermediate nodes from the sensor nodes to the sink nodes for measuring the ASC protocol execution time. The success rate of ASC protocol is also higher by using the quadratic function in MAC layer communication.

CC strategy: The CC strategy in ASC protocol is a two-step model that is depicted in Fig. 3 with the aim of reducing the packet collision rate on the wireless communication channel. The first step involved in the design of CC strategy is to find the hop-distance-based sequential coordination. The sequence in the sequential coordination is coordinated in a circular form using ASC protocol to clearly compute the retransmit time without any packet collision. The second step involved in the design of CC strategy is to clearly describe the number of sensor nodes to avoid the overflowing of packets. The overflowing of packets is avoided on the event-driven rebroadcasting using ASC protocol. The CC procedure using ASC protocol is illustrated in Fig. 3.

As shown in Fig. 3, the initial step in the CC procedure is the sequential coordination, which measures the hop distance in a clear manner to avoid packet collision during multiple sampling tasks. Subsequently, the second step uses overflow avoidance to evaluate the likelihood control mechanism. With this the probability of packet-retransmit time is computed to avoid the packet collision in sensor network. The detailed analysis of two steps, sequential coordination and overflow avoidance is detailed explained forthcoming sub section.

Sequential coordination step: Sequential coordination is a circular form that acts as the key strategy to reduce the packet collision. The first task involved during the design process of CC procedure is that the sequential coordination sends the reply once the events are received from the sensor nodes. The reply is sent by using the measured hop distance value in wireless network and as a result, the ASC protocol reduces the packet collision rate on the same communication channel.The hop distance value computed as:

$$\text{Hop Distance} = I1 + I2 + I \tag{2}$$

The hop distance value in the sequential coordination is measured based on the intermediate nodes ‘I1’, ‘I2’, ‘I3’ from the sensor nodes to the sink node. The sequential coordination function is implemented in ASC using the circular topology structure. The circular topology structure waits for the particular hop distance time to avoid the collision rate on multiple events driven WSN. The waiting time based on the hop distance is computed as:

$$WT(S) = 4S(S-1)I - 3S(S-1)I - 2S(S-1) \tag{3}$$

The waiting time of the multiple events is denoted by that is based on the hop distance. The time taken to reach the root, (i.e., sink node) is represented by WT(s) which travels through each intermediate node. S denotes the sensor node containing the packets in MAC layer for effective rebroadcasting.

Overflow avoidance step: ASC protocol avoids the overflow of packets in the communication channel using the likelihood control mechanism. The sequential coordination based packet collision avoidance achieves higher success rate. The higher success rate is achieved even on the overflow avoidance of the packets in the sensor network. In multiple event sampling tasks, ASC protocol bootstraps the sink node to avoid the overflow of packets. Each sensor node in the ASC protocol within MAC layer computes the hop distance to adjust the packet-transmission time and to maintain the higher

Table 1: Simulation setup

Parameters	Value
Protocols	AODV
Network range	900×900 m
Simulation time	50 ms
Number of mobile nodes	10, 20, 30, 40, 50, 60, 70, 80
Mobility model	Two ray ground model
Network simulator	NS 2.34
Mobility speed	10 ms^{-1}
Pause time	15 s
Packets	50, 100, 150, 200, 250, 300, 350, 400

packet flow rate without any collision. Likelihood-control mechanism controls the packet rebroadcast time based on the probability ratio. Likelihood-control mechanism retransmits the packet indicating the higher success rate from the sensor node to the sink node. A sink node, which attains the packet, tries to allocate the communication channel for the next packet transfer from the different sensor nodes in a likelihood (i.e.,) probabilistic manner. With this, the ASC protocol maintains the relative distance time for packet forwarding. Quadratic principle on medium access control-authoritative synchronized converge integration.

Once the procedure of CC is achieved by applying sequential coordination and overflow avoidance, the last step involved in the design of ASC protocol is to design the quadratic principle that effectively integrates the MAC layer with the ASC protocol. The quadratic form is given as:

$$P(S^2) + P(S) = Sin \tag{4}$$

As given in Eq. 4 the packets 'P' on the sensor nodes 'S' are rebroadcasted to the sink node. With this, the result produces a collision-free rebroadcasting of packet information. By integrating the CC strategy with Converge-Casting process, collision is reduced further and eventually the throughput rate is improved.

Experimental setup: The authoritative Synchronized Converge-Cast (ASC) protocol is implemented using NS2 simulator. The NS2 simulation takes 80 sensor nodes and few sink nodes for conducting experimental work. The sensor nodes use the AODV routing protocol to perform the experiment on randomly moving objects. The movement of all nodes is generated over a 900×900 m sensor field with the nodes movement measured at a random speed of 30 ms^{-1} and an average pause of 0.01 s. ASC protocol integrated with MAC layer randomly selected the sensor nodes with a predefined speed with 2.5 m sec. The parametric values for performing experiments are illustrated in Table 1.

The performance of ASC protocol is compared against with the existing Hybrid Medium Access Control (HMAC) protocol (Xenakis *et al*., 2016) and Machine-Learning-Based Adaptive Routing (QELAR) protocol. The experiment is conducted on the factors such as packet collision rate, packet transmission time, bandwidth rate, throughput level and execution time.

The Packet Collision Rate (PCR) is defined as the number of Packet Collisions being Detected (PCD) to the total number of packets transmitted. The packet collision rate is measured in terms of (%) and mathematically formulated as:

$$PCR = \frac{PCD}{\text{Number of packets transmitted}}$$

The Packet-Transmission Time (PTT) for ASC protocol is obtained by dividing the packet Size (in bit) (S) by the Bit Rate (in bit) (BR). The packet-transmission time is measured in terms of milliseconds (ms) and mathematically formulated as:

$$PTT = \frac{S}{BR}$$

The bandwidth rate using ASC protocol defines the packet-transfer rate, i.e., the number of packets that can be transmitted to the sink node. This bandwidth rate is measured in terms of bits per second (bps). The Throughput level (T) using ASC protocol is defined as the product of number of packets transmitted (number of packets) to the sink node and the Cycle Time (CT). The rate of throughput is usually measured in (Kbit/s) and mathematically formulated as:

$$T(\text{time}) = \text{Number of packets} \times CT$$

The execution time using ASC protocol refers to the overall time taken to process the ASC protocol integrated with MAC layer. Execution time is measured in terms of ms.

RESULTS AND DISCUSSION

In this study the result analysis of ASC protocol is evaluated. Comparison is made with the two existing methods namely Hybrid Medium Access Control (HMAC) protocol (Xenakis *et al*., 2016) and Machine-Learning-Based Adaptive Routing (QELAR) protocol (Xenakis *et al*., 2016). To estimate the efficiency of ASC protocol, the following metrics like packet collision rate, packet transmission time, bandwidth rate, throughput level and execution time are measured.

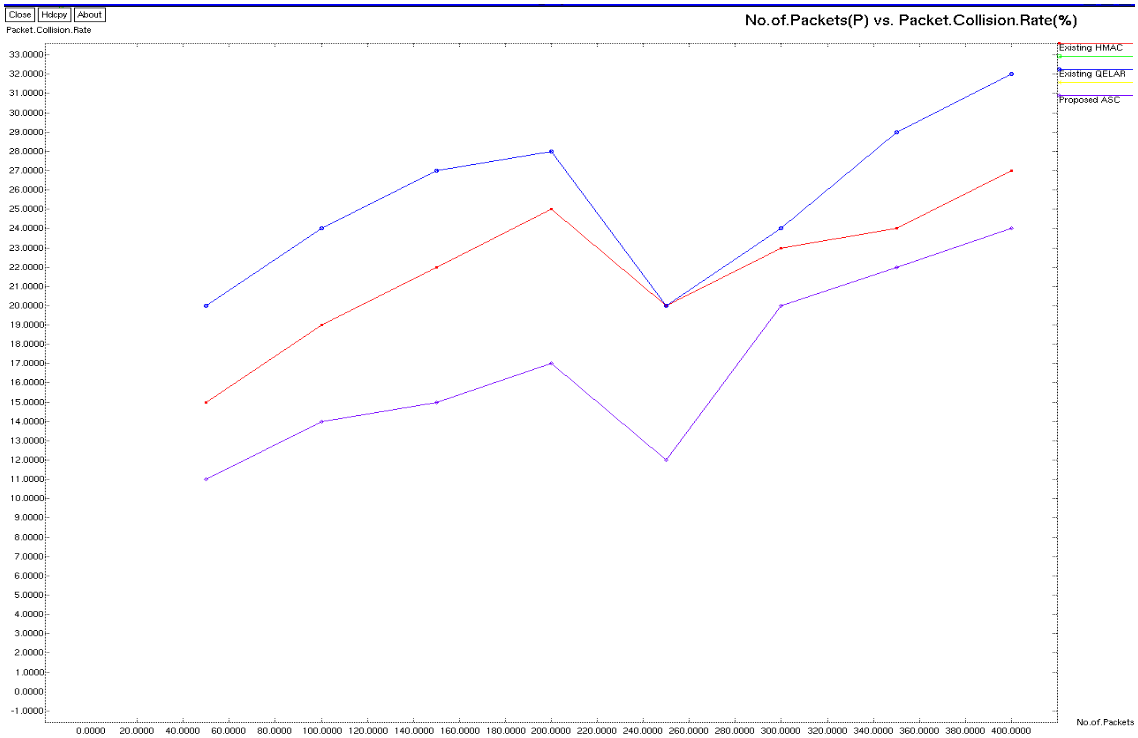

Fig. 4: Measure of packet collision rate

Table 2: Tabulation of packet collision rate

	Packet collision rate (%)		
No. of Packets (P)	ASC	HMAC	QELAR
50	11	15	20
100	14	19	24
150	15	22	27
200	17	25	28
250	12	20	20
300	20	23	24
350	22	24	29
400	24	27	32

Table 2 shows the packet collision rate of ASC protocol with respect to the different number of packets in the range of 50-400 and comparison is made with two existing methods namely, Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al*., 2016) and Machine-Learning-Based Adaptive Routing (QELAR) Protocol From the table value, it is illustrative that the packet collision rate using ASC protocol is reduced as compared to the other existing protocols (Xenakis *et al*., 2016).

Figure 4, illustrates the packet collision rate observed using the proposed ASC protocol with MAC layer and comparison made with two other existing methods. As shown in Fig. 4, the packet collision rate using the ASC protocol is performs relatively well when compared to the Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al*., 2016) and Machine-Learning-Based Adaptive Routing (QELAR) Protocol. This is because of the fact that the circular coordination strategy is used in ASC protocol that results in the minimization of packet collision by 9-40% when compared to HMAC (Xenakis *et al*., 2016). Further with the application of CC strategy in ASC protocol, the hop distance is identified based on the sequential coordination that minimizes the packet collision by 30-80% than compared to HMAC (Xenakis *et al*., 2016).

Table 3: Tabulation of packet transmission time

	Packet transmission time (m sec)		
No. of Packets (P)	ASC	HMAC	QELAR
50	4	7	10
100	9	12	15
150	12	14	19
200	14	20	22
250	18	23	28
300	20	24	32
350	22	27	35
400	25	30	42

Table 3 represent the packet transmission time with respect to the number of packets in varies in the range of 50-400 and compared with two other methods. From the table values, it is descriptive that the packet

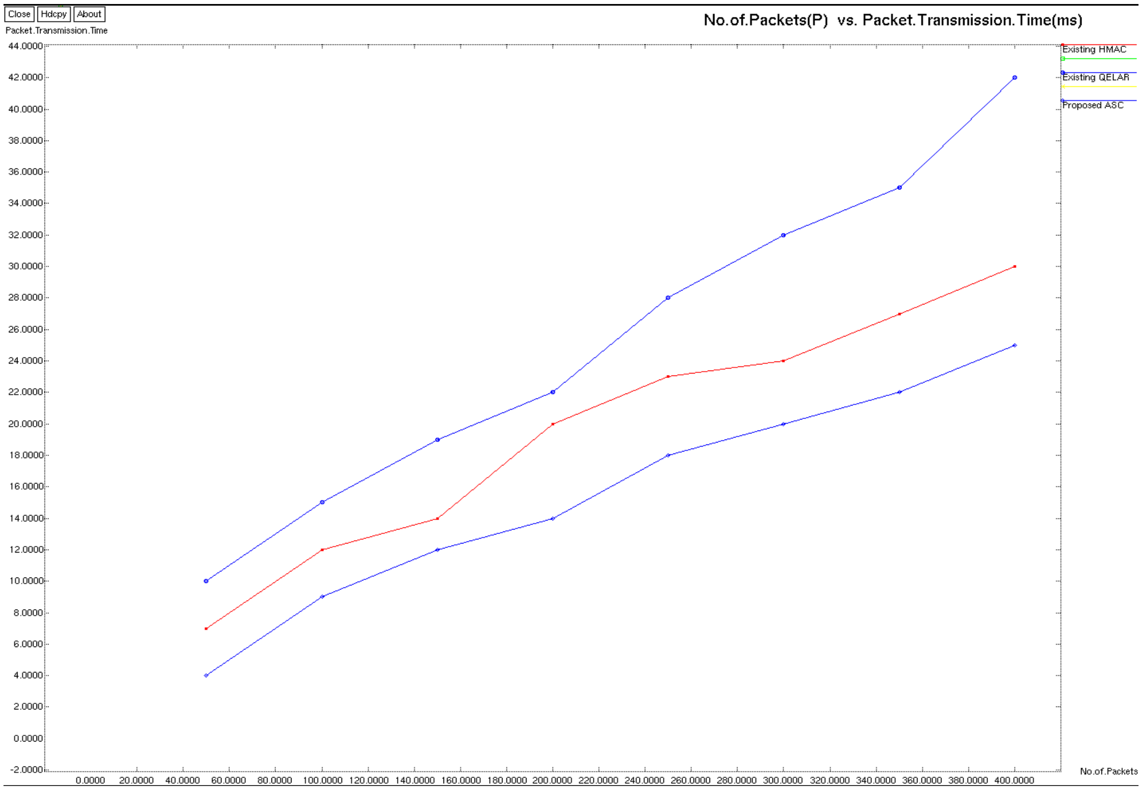

Fig. 5: Measure of packet transmission time

transmission time using ASC protocol is reduced as compared to other existing methods (Xenakis *et al*., 2016).

Figure 5 shows the measure of packet transmission time using three different methods namely proposed ASC protocol, HMAC protocol, QELAR protocol. As shown in Fig. 5, packet transmission time using ASC protocol is performs relatively well as compared to the other existing protocols namely, Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al*., 2016) and Machine-Learning-Based Adaptive Routing (QELAR) Protocol. Besides, while increasing the number of packets transmitted, the packet transmission time is gets also increased. But comparatively packet transmission time using ASC protocol is lesser. This is because the Converge-Casting process in ASC protocol helps to perform the inverse operation during packet broadcasting, i.e., rebroadcasting and minimizing the packet transmission time by 20-75 % when compared to HMAC (Xenakis *et al*., 2016). Further the global function in ASC protocol eventually review the packets received from the sensor nodes of the wireless network by reducing the packet transmission time by 55-65 % when compared to HMAC.

Table 4: Tabulation of bandwidth rate

	Bandwidth rate (bps)		
Packet size (MB)	ASC	HMAC	QELAR
500	14	12	10
1000	17	15	12
1500	25	18	14
2000	32	23	17
2500	35	27	22
3000	40	33	25
3500	52	38	28
4000	58	42	32

Table 4 demonstrates the result analysis of bandwidth rate with respect to differing packet size of ranges 500 and 4000 MB. From the table value, it is illustrative that the bandwidth rate using ASC protocol is higher as compared to the other existing methods.

Figure 6 shows the bandwidth rate with respect to increasing packet sizes. As shown in the figure, bandwidth rate using ASC protocol is performs relatively well as compared to the other existing protocols namely, Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al*., 2016) and Machine-Learning-Based Adaptive Routing (QELAR) Protocol. Besides, with the increase in the packet size, the bandwidth rate is also gets increased using all the three

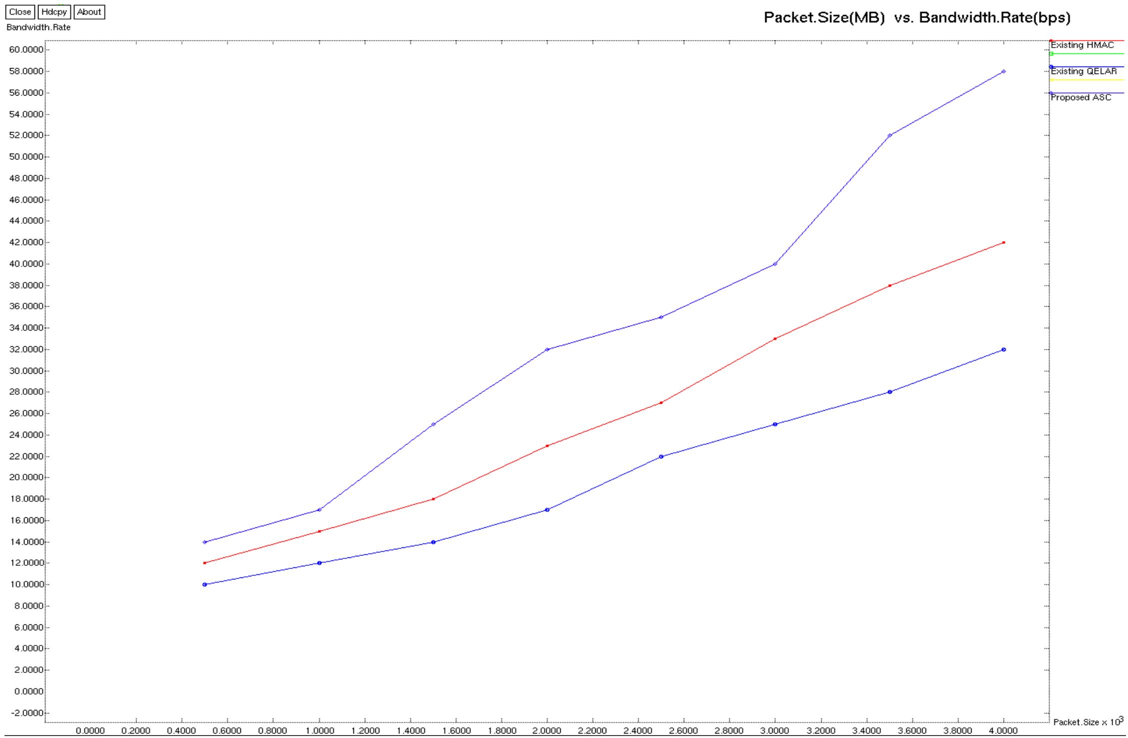

Fig. 6: Measure of bandwidth rate

Table 5: Tabulation of throughput level

	Throughput level (Kbits^{-1})		
Packet size (MB)	ASC	HMAC	QELAR
500	42	32	30
1000	45	35	31
1500	52	38	34
2000	55	40	35
2500	60	45	40
3000	62	50	42
3500	65	52	45
4000	70	55	48

methods. But comparatively, the bandwidth rate using ASC is higher than the other two models. This is because with the application of circular coordination strategy in ASC protocol which avoids the overflow of packets in the communication channel with the help of likelihood control mechanism. This in turn increases the bandwidth rate of ASC protocol by 11-12% when compared to HMAC (Xenakis *et al.*, 2016). Further, the sink node which receives the packet, allocates the communication channel from the different sensor node in a likelihood, i.e., probabilistic manner by increasing the bandwidth rate by 35-46% as compared to QELAR.

Table 5 shows the result analysis of throughput level with respect to differing packet size in the ranges of 500 and 4000 MB. From the table value, it is illustrative that the throughput level using ASC protocol is higher as compared to the other existing methods.

Figure 7, represents the throughput level of ASC protocol and comparison made with two existing methods namely, Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al.*, 2016) and Machine-Learning-Based Adaptive Routing (QELAR) Protocol. In order to measure the value of throughput, packet size is obtained as input in the range of 500-4000 MB. As illustrated in the figure, the throughput level using ASC protocol is performs relatively well when compared to the other existing methods. Besides while increasing the size of packet transmitted, the throughput level is gets also increased. But comparatively throughput level using ASC protocol is higher. This is because with the inclusion of second step in CC strategy which clearly describes the number of sensor nodes to be considered in order to avoid the overflowing of packets and as a result throughput level is improved by 19-27 % than the HMAC protocol (Xenakis *et al.*, 2016). Further, the overflowing of packets is avoided on the event driven rebroadcasting using ASC protocol resulting in 28-36 % improvement than the QELAR protocol.

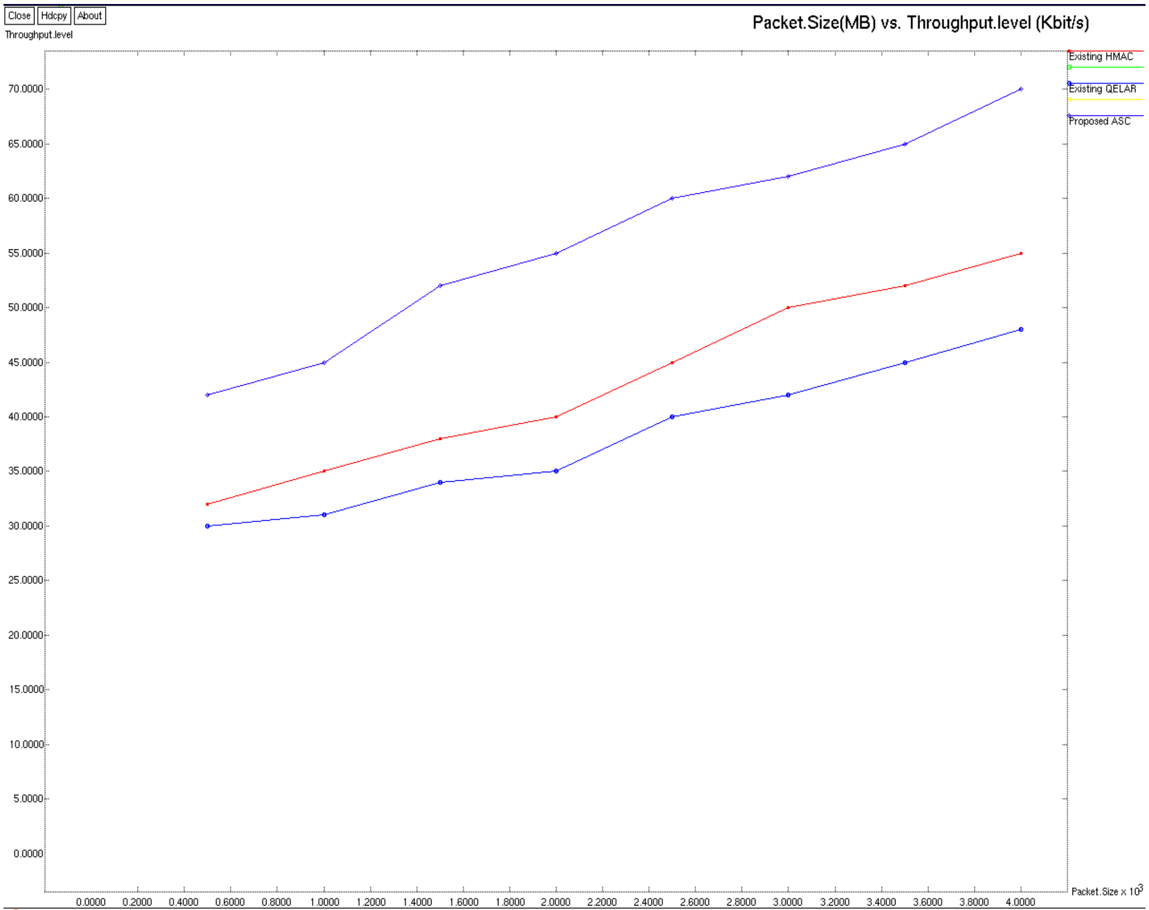

Fig. 7: Measure of throughput level

Table 6: Tabulation of execution time

	Execution time (ms)		
Packet size (MB)	ASC	HMAC	QELAR
500	12	20	15
1000	15	22	18
1500	20	24	22
2000	18	30	20
2500	25	38	35
3000	28	42	32
3500	33	45	35
4000	38	50	40

Table 6 illustrates the execution time of ASC protocol versus different packet size in the range 500-4000 MB. Comparison is made with two other existing methods Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al.*, 2016) and Machine-Learning-Based Adaptive Routing (QELAR) protocol. From the table value, it is descriptive that the execution time using ASC protocol is lesser as compared to the other existing methods.

Figure 8, show the execution time versus different packet size obtained using ASC protocol. As shown in figure, the execution time using ASC protocol is performs relatively well as compared to the existing methods namely, Hybrid Medium Access Control Protocol (HMAC) protocol (Xenakis *et al.*, 2016) and Machine-Learning-Based Adaptive Routing (QELAR) Protocol. Besides while increasing the size of packet transmitted, the execution time is gets also increased. But comparatively the execution time using ASC protocol is lesser.

This is because of Converge-Casting Algorithm in ASC protocol that identifies the intermediate nodes in order to measure the ASC protocol execution time which resulting in 20-66% lesser execution time as compared to HMAC protocol (Xenakis *et al.*, 2016). In addition, the success rate of the ASC protocol is reduced the execution time by 5-25 % than when compared to the QELAR protocol.

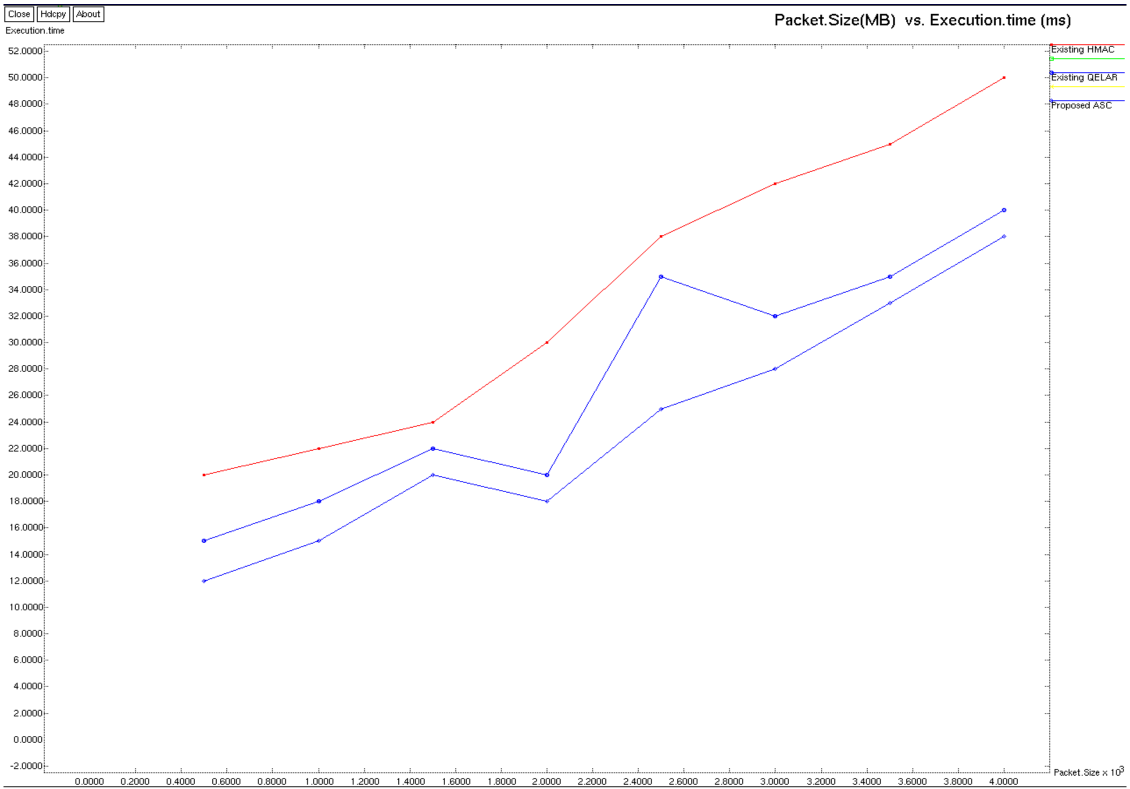

Fig. 8: Measure of execution time

CONCLUSION

In this study, a novel protocol is designed called as Researcheritative Synchronized Converge-Cast (ASC) protocol to explore the use of converge-cast protocol and to reduce the packet loss in WSNs. The key objective of ASC protocol is to avoid the occurrence of packet collision while multiple sensor nodes simultaneously transmit over the same channel in a large sensor network. ASC protocol integrated with the MAC layer for presenting efficient channel accessing of packet rebroadcasting. ASC protocol is employed Circular Coordination (CC) strategy in a sensor network which adjusts the packet transmission time with the aiming at reducing the packet collision by using quadratic principle. The quadratic principle visualizes the solution in ASC protocol by way of avoiding the packet collision during the rebroadcasting of the information. With the aid of Converge-Casting on MAC layer with quadratic principle in ASC protocol, the packet collision is reduced in the sensor network which in increased the lifetime of network. An extensible architecture has been present that maintains the relative distance time for packet forwarding in the probabilistic manner to adjust the packet-transmission time based on the probabilistic ratio. Simulation results showed that the proposed ASC protocol yields up to 25% throughput level improvement. The simulation results show that ASC protocol provides better performance with an improvement of throughput level and also produces the efficiency of packet delivery by minimizing the collision rate as compared to state-of-the-art works.

REFERENCES

Abichar, Z. and J.M. Chang, 2011. A medium access control scheme for wireless lans with constant-time contention. IEEE. Trans. Mob. Comput., 10: 191-204.

Annamalai, V., S.K. Gupta and L. Schwiebert, 2013. On tree-based convergecasting in wireless sensor networks. Proceedings of the 2003 IEEE Conferencwe on Wireless Communications and Networking WCNC 2003, March 16-20, 2003, IEEE, Tempe, Arizona, USA, ISBN:0-7803-7700-1, pp: 1942-1947.

Artail, H. and K. Mershed, 2009. MDPF: Minimum distance packet forwarding for search applications in mobile ad hoc networks. IEEE Trans. Mobile Comput., 8: 1412-1426.

Celik, G.D., G. Zussman, W.F. Khan and E. Modiano, 2010. MAC for networks with multipacket reception capability and spatially distributed nodes. IEEE. Trans. Mob. Comput., 9: 226-240.

Gong, J., X. Zhong and C.Z. Xu, 2010. Maximizing rewards in wireless networks with energy and timing constraints for periodic data streams. Mobile Comput. IEEE. Trans., 9: 1187-1200.

Hu, T. and Y. Fei, 2010. Qelar: A machine-learning-based adaptive routing protocol for energy-efficient and lifetime-extended underwater sensor networks. IEEE Trans. Mobile Comput., 9: 796-809.

Incel, O.D., A. Ghosh, B. Krishnamachari and K. Chintalapudi, 2012. Fast data collection in tree-based wireless sensor networks. IEEE Trans. Mobile Comput., 11: 86-99.

Kim, J., X. Lin, N.B. Shroff and P. Sinha, 2010. Minimizing delay and maximizing lifetime for wireless sensor networks with anycast. IEEE-ACM. Trans. Networking (TON.), 18: 515-528.

Lee, H.W., E. Modiano and L.B. Le, 2012. Distributed throughput maximization in wireless networks via random power allocation. IEEE. Trans. Mobile Comput., 11: 577-590.

Misra, S., S.D. Hong, G. Xue and J. Tang, 2010. Constrained relay node placement in wireless sensor networks: Formulation and approximations. IEEE/ACM Trans. Network., 18: 434-447.

Pala, Z. and N. Inanc, 2016. The impact of disabling suspicious node communications on network lifetime in wireless ad hoc sensor networks. Turkish J. Electr. Eng. Comput. Sci., 24: 4429-4444.

Park, N.I., J.A. Kang, S.R. Lee and H.K. Kim, 2014. A packet loss concealment technique improving quality of service for wideband speech coding in wireless sensor networks. Int. J. Distrib. Sens. Netw., 2014: 1-8.

Rahbar, A.G., 2014. Fault tolerant broadcasting analysis in wireless monitoring networks. Turk. J. Electr. Eng. Comput. Sci., 22: 1437-1452.

Sitanayah, L., C.J. Sreenan and K.N. Brown, 2014. A hybrid MAC protocol for emergency response wireless sensor networks. Ad Hoc Netw., 20: 77-95.

Troubleyn, E., J. Hoebeke, I. Moerman and P. Demeester, 2014. Broadcast aggregation to improve quality of service in wireless sensor networks. Int. J. Distrib. Sens. Netw., 2014: 1-12.

Wang, P. and S. Bohacek, 2011. Practical computation of optimal schedules in multihop wireless networks. IEEE. ACM. Trans. Netw. TON., 19: 305-318.

Xenakis, A., F. Foukalas and G. Stamoulis, 2016. Cross-layer energy-aware topology control through simulated annealing for WSNs. Comput. Electr. Eng., 2016: 1-15.

Xu, K., H. Hassanein, G. Takahara and Q. Wang, 2010. Relay node deployment strategies in heterogeneous wireless sensor networks. IEEE Trans. Mobile Comput., 9: 145-159.

Xu, Y. and W. Wang, 2009. Scheduling partition for order optimal capacity in large-scale wireless networks. Proceedings of the 15th Annual International Conference on Mobile Computing and Networking, September 20-25, 2009, ACM, Beijing, China, ISBN: 978-1-60558-702-8, pp: 109-120.

Yang, T., C. Kang and G. Nan, 2012. An energy-efficient and fault-tolerant convergecast protocol in wireless sensor networks. Int. J. Distrib. Sens. Netw., 2012: 1-8.

Yao, J., J. Guo and L.N. Bhuyan, 2008. Ordered round-robin: An efficient sequence preserving packet scheduler. IEEE. Trans. Comput., 57: 1690-1703.

Yin, X., X. Zhou, R. Huang, Y. Fang and S. Li, 2009. A fairness-aware congestion control scheme in wireless sensor networks. IEEE Trans. Veh. Technol., 58: 5225-5234.