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AUTO-RATE ADAPTIVE MECHANISM FOR TRAFFIC-CONTROL IN SENSOR NETWORK

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ABSTRACT

Each sensor node in wireless network comprises of different processing ability with multipath energy sources, resulting in traffic while performing routing. Control of traffic through multipath routing in sensor network poses a serious challenge during packet transfer due to different characteristics of sensor nodes like beam, temperature and seismic sensors minimizing the desired throughput. If multi-hop traffic occurred on wireless network, the percentage of delay is also increased and fails in achieving robustness with inefficient packet transfer rate. In order to achieve the desired reliability during packet transfer over wireless network, a new mechanism is proposed in this paper. The mechanism Traffic-control using Auto-rate Adaptive with Medium Access Control (TAAd-MAC) is designed to improve the efficiency of packet transfer rate on sensor network. Initially, TAA-MAC creates a route with instantaneous transmission queue length and identifies the traffic level of nodes in wireless sensor network. The traffic level of nodes is identified using Fuzzy Markovian Queue based Random Node Distributed Traffic point. Next to increase the robustness of packet transfer in sensor network by controlling the traffic, Auto-Rate Adaptive MAC mechanism is designed. Auto-Rate results in achieving higher throughput according to the changes observed in the network behavior. Finally, TAA-MAC mechanism uses the Auto-rate Distributed Contingency Algorithm to reduce the delay on multipath packet transfer in wireless network. Auto-rate Distributed Contingency algorithm also helps to reduce the traffic on emergency dynamic routing on sensor network zone. Experiment is conducted on factors such as traffic-control routing effectiveness, average delay time on multipath routing sensor network, and throughput rate.

Keywords: *Medium Access Control, Auto Rate, Distributed Contingency Algorithm, Wireless Sensor Network, Traffic-Control, Fuzzy Markovian Queue*

1. INTRODUCTION

A wireless sensor network comprises of a group of sensor nodes, each sensor node include one or many sensor nodes with a processor for each sensor node, a radio, and a battery. With the cost efficient and wireless medium, these sensor networks are increasingly used. As the radios consume much traffic, the network's medium access control (MAC) protocol, which determines how the traffic can be controlled and operated, has higher influential rate on overall traffic control system.

Maximum Weighted Matching (MWM) scheduling policy [1] analyzed upper and lower bounds to optimize the throughput by introducing appropriate scheduling policy. However, with multi-hop traffic occurring on wireless network, the rate of delay is also increased and hinders the robustness on packet transfer rate. Multi attribute decision-making (MADM) process [2] designed two-layer network architecture, for effective decision making to meet the user requirements. However, control of traffic through multipath routing poses

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serious problem during packet transfer minimizing the desired throughput. Beaconless Forwarder Planarization (BFP) [3] for guaranteeing delivery in Wireless Sensor Network using Circlunar Neighborhood Graph (CNG) minimizing the delay.

The sensor nodes in wireless sensor network obtain the information regarding physical world, base station to perform actions according to the environment. Enhanced Real Time with Load Distribution (ERTLD) [4] was designed to increase the packet delivery ratio with the aid of corono mechanism and optimal forwarding metrics. A Hierarchy Energy Efficiency Reliable Transport Protocol (HEERTP) [5] was introduced to improve the latency and reliability using hop-by-hop acknowledgement scheme. Another method, Decentralized Multiuser Diversity [6] was designed to increase the SNR of successful packets using Rayleigh fading and reception of packets based on collision model. However, multipath routing remained unaddressed. In [7], a load distribution model was presented to minimize the end-to-end delay during packet transfer.

For certain applications in WSNs, users require data in a continuous manner. However, extraction of data in an accurate manner is highly difficult to be performed. An energy efficient cluster based mechanism with adaptive model to control prediction was introduced in [8] increasing the number of packets being transmitted reducing the consumption of energy. But with increasing number of sensor nodes, computational overhead also increased. To reduce the computational overhead and to increase the rate of throughput a method with multi packet reception was designed in [9]. But, multi-access access remained unaddressed. To improve the multi access mode, an approximation algorithm was introduced in [10]. MT-Deluge [11] designed a coding-based data dissemination protocol to increase the total number of data packets at less interval of time.

Based on the aforementioned techniques and method, a mechanism called Auto-rate Adaptive with Medium Access Control (TAA-MAC) is designed. The mechanism TAA-MAC achieves desired reliability during packet transfer where focus is made on identifying the transmission queue length and traffic level of nodes in sensor network. This in further increase the robustness of packet transfer increasing the rate of throughput. To reduce the delay time, the proposed mechanism uses the auto-rate distributed contingency algorithm dynamic route for efficient transmission of packets. TAA-MAC also applies packet arrival time to identify the neighboring non route nodes and obtain inferences using packet waiting count. As a result, TAA-MAC reduces the average delay on multipath routing and attains the increased throughput rate.

This paper is organized as follows: Section 1presents the relevant theoretical background of different types of multipath routing in wireless sensor network and different techniques applied to improve the packet transfer rate. Section 2 discusses the issues related with other state-of-art methods. Section 3 presents the design of Auto-rate Adaptive with Medium Access Control (TAA-MAC) with the help of a neat architecture diagram. Section 4 and Section 5 presents the detailed empirical evaluation of TAA-MAC mechanism with the help of simulations and results discussed. Finally, Section 6 includes concluding remarks.

2. RELATED WORKS

The main goal of wireless sensor network is to estimate event features from information provided by sensor nodes. There have been a significant number of efforts that aim in developing a collaborative networking protocol to increase energy efficiency. A Cross Layer Protocol (XLP) [12] integrated the functionalities of all layers in sensor networks to increase the packet delivery ratio.

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However, topology control remained unaddressed. In [13], to address topology control, coordination and communication problems were studied to increase the data delivery process. A novel traffic modeling scheme was included in [14] to improve relay node traffic using efficient resource provisioning strategy. Multipath routing with multi sink network was introduced in [15] to increase the transmission success rate using link weight estimation.

With the higher rate of changes observed in network topology, a congestion control algorithm was designed in [16] to minimize the rate of congestion and to increase the throughput rate. However, measures for bandwidth allocation remained unaddressed. For efficient bandwidth allocation, adaptive traffic light control scheme was presented in [17] according to local traffic and predicted data. But, dynamic speed remained unaddressed.

Transmission of packets with arbitrary size was introduced in [18] the power control and rate adaptation was solved using an Integer Programming (IP) problem. However, multiple objectives were not concentrated. To solve multiple objectives, Mixed Integer Linear Programming (MILP) problem was considered in [19]. The dynamic nature of the network remained unsolved. An Energy Dynamic Distribution and Optimization (EDDO) [20] was designed to solve dynamic adaptability.

Based on the above mentioned methods, an efficient traffic-control auto-rata adaptive mechanism in wireless sensor network is designed.

3. TRAFFIC-CONTROL AUTO-RATE ADAPTIVE MECHANISM IN WIRELESS SENSOR NETWORK

In this section, we explore the problem of efficient packet transfer in sensor networks and describe our proposed mechanism, Traffic-control using Auto-rate Adaptive with Medium Access Control (TAA-MAC). Our problem setup consists of a number of sensor nodes with the primary responsibility to collect user data or the packet information through predefined protocol (DSDV).

The volume of traffic is increasing at a larger rate. So a mechanism has to be developed to control the traffic on sensor network structure. Different types of randomly distributed sensor nodes are used to transmit packets to the sink nodes. On the routing path, there is a possibility of occurrence of traffic due to congestion. The occurrence of traffic on sensor network field during packet transfer is shown in Figure 1.

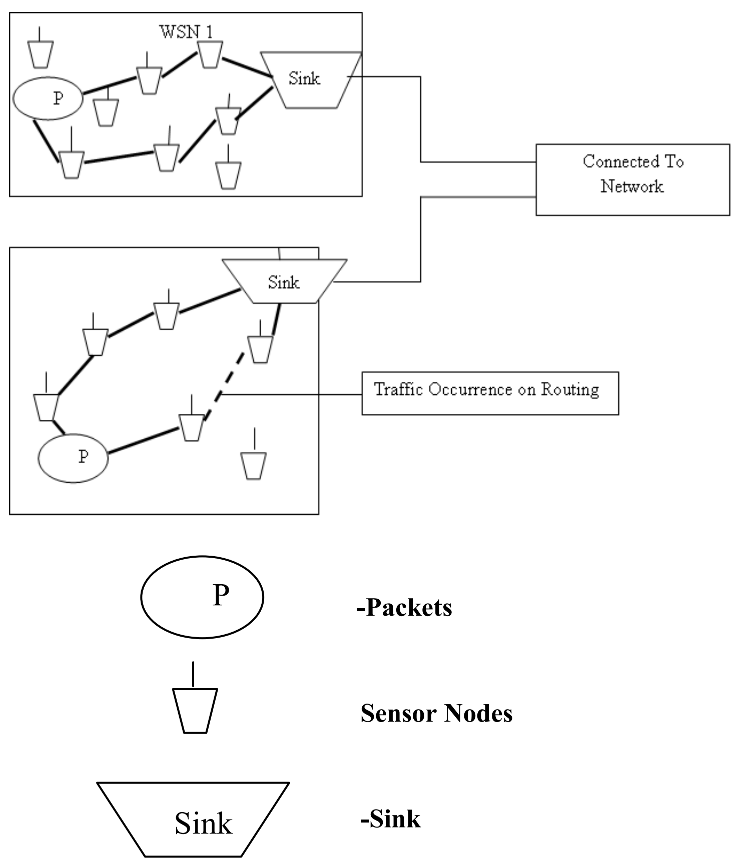

Figure 1: Representation Of Traffic Occurrence On Routing In Sensor Network

Sensor nodes are the easiest way to sense and access the information in wireless medium. With the increasing number of sensor nodes in today's environment, traffic in wireless routing path gets increased drastically. The

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traffic occurrence on routing in sensor network is shown in Figure 1. Packet, sink nodes and different number of sensor nodes are differentiated in the figure using different shapes where each sink node is connected to the network. The packet transfer through multipath identifies the traffic occurrence on routing using Fuzzy Markovian Queue model. The primary goal on identifying the traffic path depends on the sensors and transmitters. For instances, sensor interact with the physical environment (i.e., existing activities are monitored) and transmitter sends the sensed data packets to the central microcontroller (i.e., sink nodes).

Most organizations with different branches on varying areas are connected through wireless medium. The overall organization is managed from remote area. The proposed mechanism, TAA-MAC is employed at centrally hosted head office to identify the malfunctioning activities (i.e., traffic occurrence) on different branches. The malfunctioning activities are identified using the Fuzzy Markovian Queue resulting in fuzzy type of result (i.e., 0 or 1). The identified malfunctioning within the organization is controlled using the Auto-rate Adaptive with Medium Access Control method. Thus, TAA-MAC mechanism minimizes the malfunctions and improves the performance grade within the organizations.

An algorithm, Auto-rate Distributed Contingency is used in TAA-MAC mechanism to fetch the performance result information about different branches. The data are sent through the sensor nodes to the higher authority for easy monitoring of organization with minimal processing time, thereby reducing the delay rate. The overall architectural diagram of Traffic-control Auto-rate Adaptive with Medium Access Control (TAA-MAC) mechanism is shown in Figure 2.

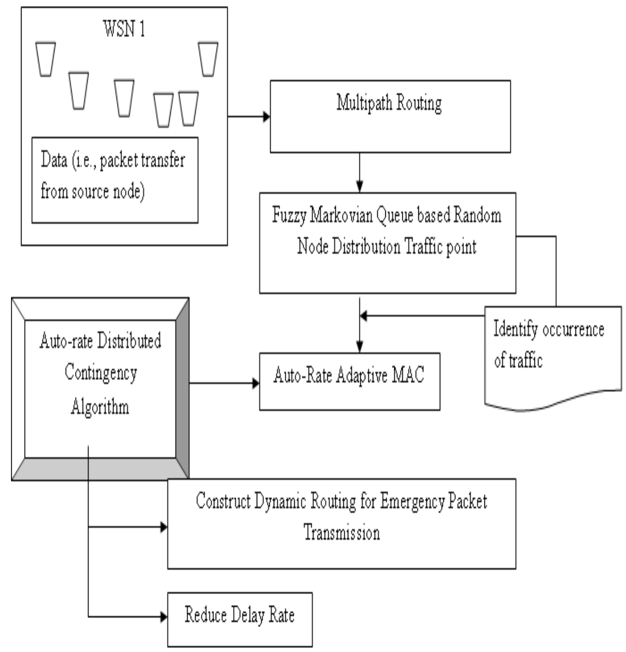

Figure 2 Overall Architecture Diagram Of TAA-MAC Mechanism

As illustrated in Figure 2, sensor network is used to implement our proposed mechanism. Initially, multipath routing is constructed for packet transfer. The routing path connects all the sensor nodes with the radio link line. The radio link line helps to transmit the packets to randomly placed sensor nodes with varied distance ranges. The node connected with radio link sometimes results in the occurrence of traffic. The occurrence of traffic is identified using Fuzzy Markovian Queue based Random Node Distributed Traffic point.

Fuzzy Markovian Queue is a mathematical model developed to measure the packet arrival time between the sender and receiving point. The delay in packet arrival time denotes the traffic occurrence on routing path in sensor network. With the application of TAA-MAC mechanism, the occurrence of traffic is easily identified. The traffic rate is controlled by introducing an Auto-rate Adaptive with medium access controlling method. Auto rate automatically changes the network routing path as per the need of the sensor nodes, thereby increasing the traffic-control routing effectiveness. With this, the traffic using TAA-

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MAC mechanism is controlled adaptively with increased throughput rate. TAA-MAC mechanism is constructed with Auto-rate Distributed Contingency algorithm to perform the packet transfer on instance condition.

3.1 Traffic Identification on Multipath Routing

The first stage of TAA-MAC is to identify the traffic for efficient packet transfer on multipath routing. During packet transfer between the source sensor nodes and the destination node, a multipath routing is established. The source node transmits the packet through intermediate sensor nodes using RREQ request. In order to determine packet transfer with higher efficiency, the TAA-MAC mechanism sends the RREQ request message to all the intermediate nodes. The identification of traffic is done using Fuzzy Markovian Queue model. TAA-MAC mechanism produces the fuzzy result as '0' if the network is traffic control or '1' on occurrence of traffic. The design of Fuzzy Markovian Queue model is explained in the following subsection.

3.1.1 Fuzzy Markovian Queue Model

In TAA-MAC mechanism, the Fuzzy Markovian Queue model is developed using the exponentially distributed Poisson process to measure the arrival time. The start sensor node (i.e., birth node) time and end sensor node point (i.e., death node) time are initially monitored to identify the traffic route path. The start sensor node time is computed as,

$$Start\ (Birth\ Node\ 1) = S\lambda_1 \Delta t \quad (1\ (a))$$

$$Start\ (Birth\ Node\ of\ (n)) = S\lambda_n \Delta t + n(\Delta t) \quad (1\ (b))$$

From (1), the start node is and

is the start time of node '1' up to 'n' node of packet transfer in the sensor network structure. The birth time computation of single sensor node is represented in (1(a)) whereas the birth node of the 'n' sensor nodes in network structure is symbolized in (1(b)). Simultaneously, the end time (i.e.,) death rate is computed as,

$$End\ (Death\ Node\ of\ (n)) = E\mu_n \Delta t + n(\Delta t) \quad (2\ (a))$$

$$End\ (Death\ Node\ 1) = E\mu_1 \Delta t \quad (2\ (b))$$

The death time of each node is also noted using (2(a) and 2(b) where is the death

time computation for the identification of the traffic route on the sensor network. The packet arrival time between the sender and receiving point in TAA-MAC mechanism is formularized as,

$$PAT = [S\lambda_n \Delta t + n(\Delta t)] - [E\mu_n \Delta t + n(\Delta t)] \quad (3)$$

The packet arrival time ' 'is

measured using (3) from the source to the destination node by counting different intermediate nodes. The application need to know the traffic occurrence route path based on the time dependent arrival time.

3.2 Traffic Controlling Scheme

Once the identification of traffic is performed using Fuzzy Markovian Queue model, to increase the robustness of packet transfer a traffic controlling scheme using Auto-rate Adaptive MAC mechanism is designed. The method of controlling the traffic is briefly explained in section 3.2.1.

3.2.1 Auto-Rate Adaptive MAC

In TAA-MAC mechanism, adapts the auto-rate procedure, when the fuzzy result output is '1'. The medium access control restricts traffic with the greatest influence carried over the communication system using Auto-rate Adaptive with Medium Access Control mechanism. The traffic is controlled in this layer, so that the error rate is reduced with higher ratio of robustness factor. The sequence diagram followed in the design of Auto-rate adaptive traffic controlling is shown in Figure 3.

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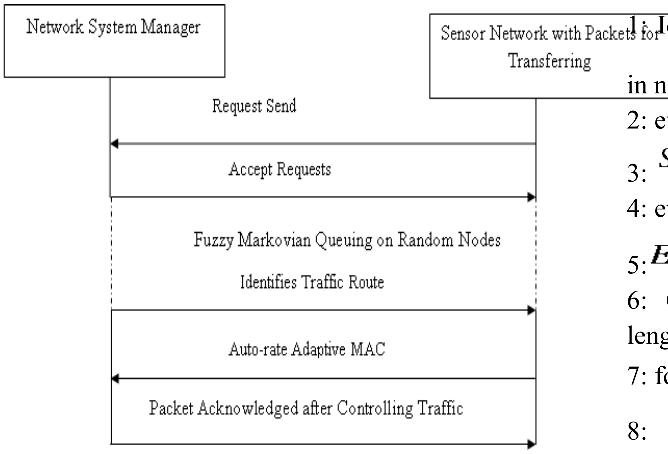

Figure 3 Auto-Rate Adaptive Traffic Controlling Procedure

Figure 3 shows the sequence diagram of auto-rate adaptive traffic controlling procedure in wireless sensor network. Medium access control focused mainly on controlling the traffic in TAA-MAC mechanism improves the robustness factor. MAC layer based controlling of traffic produce average result of about '1' or '0' over wireless medium. MAC also controls the traffic by reducing the waiting time in the queue. The auto rate fixes the timer on the traffic routed path in identifying whether the traffic is controlled between the packet transfers or not. TAA-MAC mechanism produces higher throughput results by changing the network behavior using the auto-rate distributed contingency algorithm as briefed below.

3.3 Auto-rate Distributed Contingency Algorithm

TAA-MAC mechanism uses the Auto-rate Distributed Contingency algorithm to construct the dynamic multipath traffic control routing structure in wireless sensor network. Auto-rate Distributed Contingency algorithm is described as,

Procedure Auto-rate_Distributed_Contingency()
Input:Packet, $Pi=P_1,P_2,\ldots,P_n$, **Sensor** Node $SN_1,SN_2,\ldots,SN_n$
$RL_j=RL_1,RL_2,\ldots,RL_n$i,j,S=1,$SSNT_n$,$ESNT_n$
Begin
1: Identify radio link between sensor nodes in network structure
2: evaluate Start Sensor Node Time
3: $SSNT_n = S\lambda_n\Delta t + n(\Delta t)$
4: evaluate End Sensor Node Time
5: $ESNT_n = E\mu_n\Delta t + n(\Delta t)$
6: Compute packet waiting count on queue length
7: for each packet ' '
8: $PAT = [S\lambda$
Sensor Network with Packets for Transferring
9: Cons
route path for
10: if then
11: 'Traffic is controlled'
12: else
13: Identify neighboring non route nodes to create path to control the traffic on sensor network structure
14: end if
15: end for
End

The above algorithmic steps describe the Auto-rate Distributed contingency Algorithm which is used in TAA-MAC mechanism whenever the fuzzy result output is '1'. Here, contingency denotes the construction of the route path in the crisis time. When the queue length increases, to control the traffic, this algorithm is developed in order to minimize the delay factor. The packet waiting time is minimized in TAA-MAC mechanism by reducing the traffic congestion on the multi-route paths.

4. EXPERIMENTAL EVALUATION

Traffic-Control Auto-Rate Adaptive Medium Access Control (TAA-MAC) mechanism performs the experimental evaluation on NS2 simulator. In the simulations, 90 sensor nodes are constructed in sensor network environment. The sensor nodes use the DSDV routing protocol to perform the experiment on

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the randomly moving objects. In the Random Way Point (RWM) model, each sensor node moves to an irregularly chosen location and random distributional node traffic occurrence rate is also measured. The RWM uses typical number of sensor nodes for scheduling the nodes.

The movement of all nodes generated over a 900m x 900m sensor field. The nodes moves at the random speed of 5 m/s and an average pause of 0.01s. Traffic-Control Auto-Rate Adaptive Medium Access Control (TAA-MAC) mechanism compares their performance with the existing work such as Maximum Weighted Matching (MWM) scheduling policy and Multi attribute decision-making (MADM) process. The experimental work is conducted on the factors such as traffic-control routing effectiveness, average delay time on multipath routing sensor network, communication overhead on varying sensor node multi-route path, expected sum of the traffic occurrence rate and throughput rate.

5. RESULTS ANALYSIS OF TAA-MAC

To evaluate the performance of packet transfer Auto-Rate Adaptive Medium Access Control mechanism, two well-known data transmission are compared, Maximum Weighted Matching (MWM) scheduling policy and Multi attribute decision-making (MADM) process.

5.1 Impact of traffic control routing effectiveness

Traffic control routing effectiveness using TAA-MAC mechanism measures the rate of data packet transmission for different nodes using Auto-rate Adaptive with medium access controlling method. Higher the rate of traffic control routing the more efficient the method is.

Table 1 Tabulation For Traffic Control Routing

Number of sensor nodes (SN)	Traffic control routing (kB)		
	TAA-MAC	MWM	MADM
15	125	114	103
30	140	129	108
45	158	147	126
60	165	154	133
75	145	134	113
90	172	161	140

The TAA-MAC mechanism is analyzed against Maximum Weighted Matching (MWM) scheduling policy and Multi attribute decision-making (MADM) process. Each method has its own respective traffic control routing effectiveness. Table 1 tabulates the traffic control routing with respect to the number of sensor nodes given as input and comparison of our mechanism TAA-MAC is made with MWM [1] and MADM [2].

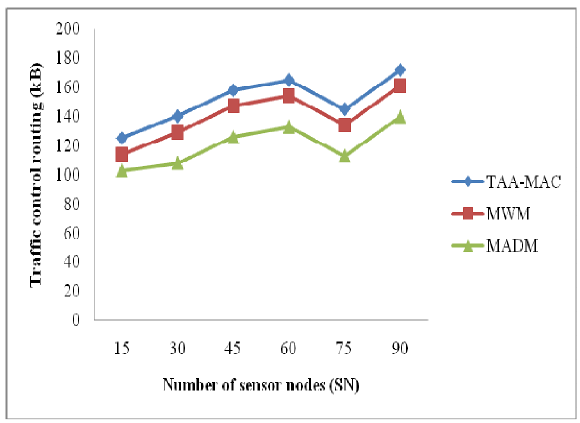

Figure 4 Measure Of Traffic Control Routing

Figure 4 shows the traffic control routing effectiveness to perform an efficient data packet transmission in sensor networks with respect to different number of sensor nodes. In the proposed TAA-MAC, the traffic data at the sink are efficiently controlled by the Auto-rate Adaptive with medium access controlling method. The network routing path is changed as per the need of the sensor nodes. Once the

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network routing path sink is filled with the data packets, the data packet is sent to the non used routing path. After that, the other data packet is allowed to enter. By this way, it traffic control rate is measured in an efficient manner. Compared to an existing MWM [1] and MADM [2], the proposed TAA-MAC in sensor network efficiently controlled the traffic data at the sensor networks by 6 – 8 % and 17 – 22 % respectively.

5.2 Impact of average delay time on multipath routing

The average delay time on multipath routing in sensor network is the average time taken by a data packet to arrive at the destination. The average delay time also includes the delay caused for route discovery and queue observed during the transmission of data packet. The data packets that are successfully delivered to the destinations are alone taken into consideration. The lower value of average delay time on multipath routing in sensor network means better performance of the method.

$$ADT = \sum_{i=1}^{n} \frac{(PA_i - PS_i)}{N} \quad (4)$$

Where ADT is the average delay time observed with PA_i representing the packet arrival time and PS_i representing the packet sent time with packets transmitted in sensor network.

Table 2 Tabulation For Average Delay Time On Multipath Routing

Network size (m)	Average delay time on multipath routing (ms)		
	TAA-MAC	MWM	MADM
50	23.5	34.6	39.8
100	28.4	39.5	44.7
150	32.6	43.7	48.9
200	40.4	51.5	56.7
250	30.3	41.4	46.6
300	45.8	56.9	61.8

The comparison of Average delay time on multipath routing is provided in table 2 with respect to different network size of range 50 m to 300 m. With increase in the number of network sizes, the Average delay time on multipath routing is also increased though reaches to saturation when the network size is 150 and a drift change occurred when the observation was noted to be 250. This is because of the change in the network size and also the packets sent through different network size are also different. As a result, the variations are also noted.

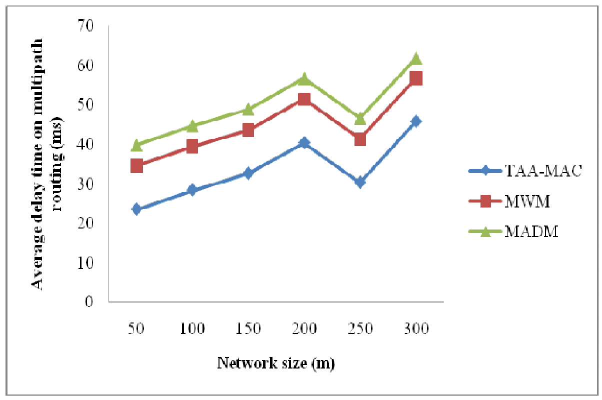

Figure 5 Measure Of Average Delay Time On Multipath Routing

In figure 5, the Average delay time on multipath routing is depicted with respect to different network sizes considered for the simulations using NS2. From the figure, we can observe that the average delay time on multipath routing achieved using the proposed TAA-MAC is lower when compared to two other existing works MWM [1] and MADM [2] respectively. Moreover, we can also observe that by varying the number of network size, the average delay is increased but comparatively improvement is observed using the proposed TAA-MAC mechanism by applying Auto-rate Adaptive contingence algorithm. Whenever there arises a traffic, that is known using fuzzy result output with '0' indicating the traffic is being controlled and '1' indicating the occurrence of traffic. With this, as soon as traffic occurs in sensor network, by applying Auto-rate Adaptive contingence algorithm, the packet is transferred through neighboring non route nodes that controls the

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traffic on sensor network reducing the average delay time on multipath routing by 24 – 47 % and 34 – 69 % improved when compared to MWM [1] and MADM [2] respectively.

5.3 Impact of Throughput rate

Throughput rate is the ratio of the number of delivered data packet from the source node to the destination node. This represents the amount of delivered data packets between the source and destination nodes. The greater value of packet delivery ratio means the better performance of the throughput rate

$$T = \sum_{i=1}^{n} \frac{DPR_i}{DPS_i}$$

(5)

Where represents the rate of throughput, with the ratio of data packet received to the data packet sent .

Table 3 Tabulation For Throughput Rate

Number of sensor nodes (SN)	Throughput rate (kB)		
	TAA-MAC	MWM	MADM
15	145	123	115
30	159	137	129
45	165	143	135
60	179	157	149
75	170	148	140
90	185	162	154

The Throughput rate using TAA-MAC is provided in an elaborate manner in table 3. We consider the mechanism with different number of sensor nodes using NS2 simulator.

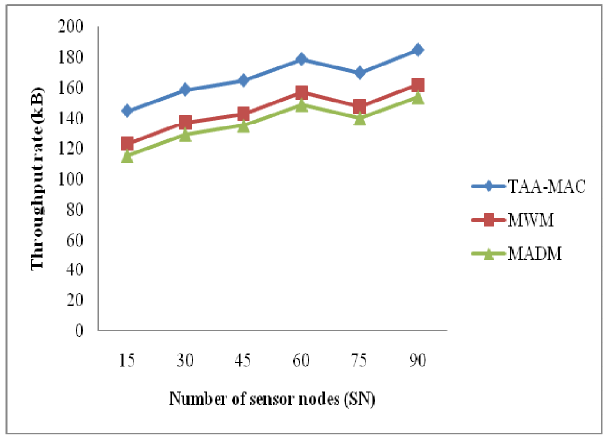

Figure 6 Measure Of Throughput Rate

The targeting results of the Throughput rate using TAA-MAC with two state-of-the-art methods [1], [2] in figure 6 is presented for visual comparison based on the varied number of sensor nodes in the range 15 to 90. Our mechanism differs from the MWM [1] and MADM [2] in that we have incorporated the Fuzzy Markovian Queue based Random Node Distributed Traffic point for handling both fuzzy result output '0' and '1' that improves the throughput rate by 12.43 – 15.17 % compared to MWM. With the application of Fuzzy Markovian Queue based Random Node Distributed Traffic point, the delay in packet arrival time is identified using Fuzzy Markovian Queue that efficiently measure the packet arrival time between the sender and receiving point. This in turn helps in increasing the rate of throughput using the proposed mechanism by 16.75 – 20.68 % compared to MADM.

5.4 Communication overhead

Communication overhead on varying sensor node is the average number of control bits transmitted per data bit delivered. The communication overhead not only includes the control messages in the network layer but also those present in the MAC layer measured in terms of KB. The communication overhead on varying sensor node using our proposed mechanism is obtained from (3).

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Table 4 Tabulation For Communication Overhead

Network size (m)	Communication Overhead (kB)		
	TAA-MAC	MWM	MADM
50	135	154	166
100	148	167	179
150	130	148	175
200	175	194	206
250	165	188	205
300	195	214	226

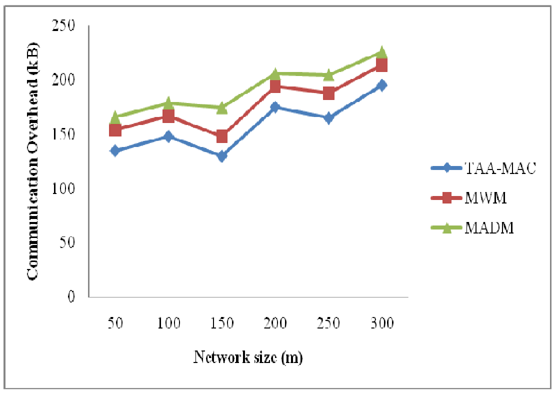

Figure 7 Measure Of Communication Overhead

Table 4 and Figure 7 shows the communication overhead efficiency in terms of kilobytes (kB) and comparison is made with two other existing works namely, MWM [1] and MADM [2] versus increasing number of network size from 50 m to 300 m. The improvement of communication overhead returned by TAA-MAC over MWM and MADM increases gradually with the increase in the size of network . For example with a network size of 100, the percentage improvement of TAA-MAC compared to MWM is 12.83 percent and compared to MADM is 20.94 percent, whereas with the network size of 250 the improvements are around 13.93 and 24.24 percent compared to MWM and MADM respectively. The communication overhead is minimized with the application of Fuzzy Markovian Queue model. This is because an exponentially distributed Poisson process is developed using TAA-MAC mechanism to measure the arrival time. The arrival time is obtained using start sensor node time and end sensor node to identify the traffic. Based on this time the packet transmission between sensor nodes is followed minimizing the communication overhead on varying sensor node by 9 – 14 % and 15 – 24 % improvement compared to the existing method.

6. CONCLUSION

In this work, an Auto-Rate Adaptive mechanism with Medium Access Control (TAA-MAC) to ensure packet transfer rate on sensor network is presented. The TAA-MAC mechanism uses Fuzzy Markovian Queue based Random Node Distributed Traffic point to identify the traffic on multipath routing. With the Fuzzy Markovian Queue model, the arrival time of packets from source node to destination node is measured, the complex traffic occurrence link on multipath routing are addressed that results in efficient multipath routing in sensor networks. Next, with the introduction of Auto-Rate Adaptive MAC, efficient dynamic routing for efficient packet transfer is performed resulting in minimizing the average delay time on multipath routing in sensor network. Finally, with the application of Auto-rate Distributed Contingency Algorithm, efficient control of traffic is obtained, so that the error rate is reduced with higher ratio of robustness factor. Experimental results demonstrate that the proposed TAA-MAC mechanism not only leads to noticeable improvement over the parameters throughput rate and minimizing communication overhead, but also reduce the average delay time on multipath routing in sensor network compared over other state-of-the-art works.

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