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ADAPTIVE LOAD BALANCE METRIC FOR OPPORTUNISTIC MULTIMEDIA WIRELESS MESH NETWORKS

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ABSTRACT

Opportunistic Routing (OR) is a novel routing prototype that carries benefit of the transmission characteristic of a wireless channel for video data distribution in a Wireless Mesh Network (WMN). In a WMN, the communication efficiency diminishes due to the limitation of channel interference, packet loss, and bandwidth. However, most of the existing OR focused on a suitable conniving solution for electing the forwarder node. As a result, several nodes may become overloaded with high traffic and seriously congested. To overcome these problems, we introduce an Adaptive Load Balance metric for Opportunistic Multimedia (ALBOM) WMN. The main objective of this scheme is to reduce overload and increases OR efficiency in WMNs. In this scheme, the adaptive load balance metric is measured by channel access overhead, protocol overhead, the rate of video data transmission and transmission state time. This metric computation that helps to reduces traffic congestion and improves overall network throughput. In this scheme, the best forwarder node is elected by the cuckoo search algorithm. This algorithm finds the best node from the forwarder list based on the Adaptive Load Balance metric, the packet received ratio and deviation time. The ALBOM maximizes the progress each packet to guarantee that the most desired relays the packet with less overload. The simulation results illustrate that ALBOM mechanism increases the throughput and reduces the network delay in WMN.

Keywords: *Opportunistic Routing, Adaptive Load Balance Metric, Forwarder Node, Cuckoo Search Algorithm, Wireless Mesh Network.*

1. INTRODUCTION

This WMN has attracted growing consideration and preparation as a high-functioning and low-cost resolution to broadband Internet access [1]. In WMN, every node functions as a host and a router, progressing packets to other nodes still reach the destinations. The OR is increasing as a capable concept to alleviate execution degradation in WMN due to lossy links and changing channel conditions. OR develop the broadcast nature of the wireless medium to achieve hop-by-hop route creation, and to obtain the benefit of path diversity [2]. OR can promote sparse networks or highly concentrated traffic networks [4] in cooperative packet flow for a decided destination. Rather than proving that a particular next-hop musts end packets OR is by a set of nodes mentioned to as forwarder list. Every forwarder has a priority level that finds the appropriateness of that best forwarder over others to operate as the next-hop intermediate.

The source contains its forwarder list in the header of each data packet; once it has been disseminated, each forwarder that obtains it can perform as the next-hop intermediate. Forwarders that have received the packet coordinate with each other to choose which one necessity transmits the packet. In this way, only the most appropriate candidate among all those that have obtained the packet will forward it, while residual forwarders will reject it [5].

In WMN, the communication efficiency diminishes due to the limitation of channel interference, packet loss, and bandwidth. Also, the significant challenge of routing packets throughout a multi-hop network comprising of traffic and wireless links while ensure bounded expected delay. In addition, most of the existing OR designed by distance, scheduled transmission time. These schemes can improve the performance of opportunistic routing. However, these metric based select the forwarding nodes become overloaded with high traffic. Therefore, the nodes may be seriously congested and have to lose huge packets owing to buffer restrictions. Hence, adaptive load balancing in OR is a significant problem in WMNs.

In this paper, we introduce an Adaptive Load Balance metric for Opportunistic Multimedia (ALBOM) scheme to reduces the routing overload and increases the OR efficiency in WMN.

The significant contribution of ALBOM scheme is listed as follows.

(i) Here, the forwarder list nodes are the straight neighbor node of the source and it is nearer to the destination.

(ii) This scheme uses the cuckoo search algorithm for finding the best node from the forwarder list based on the Adaptive Load Balance metric; the packet received ratio and deviation time. This increases the OR efficiency in WMN

(iii) The adaptive load balance metric is computed by the overhead of channel access, the overhead of protocol, rate of video data transmission, test frame bits and transmission state time. This Adaptive Load Balance metric computation helps to reduce both the routing overload and network congestion.

(iv) We perform simulation analysis to demonstrate that ALBOM scheme can offer better throughput and minimizes the network delay.

The paper is structured as follows. In Section 2, we depict the existing routing algorithm. In Section 3, we describe an Adaptive Load Balance metric for Opportunistic Multimedia WMNs. Section 4 illustrates our simulation results; finally, presents the conclusion in Section 5.

2. RELATED WORK

For more than a decade, numerous opportunistic approaches have been introduced for WMNs. A lot of literature on Quality of Service (QoS) routing, but the current algorithms have some insufficiencies, for example, poor scalability, high complexity, and flexibility. A flexible and adaptive opportunistic routing [3] can exploit the opportunistic efficiency benefit. Therefore, forwarding determinations are vigorously modified to deviations of network conditions, assuring well-organized trade-off among reliability and opportunistic gain. A simple opportunistic adaptive routing protocol (SOAR) for increasing the progression of every packet makes by utilizing priority-based timers to make sure that the chosen node transmits the packet with small coordination overhead. Also, SOAR reduces both the resource utilization and the duplicate transmissions by thoughtfully choosing forwarding nodes to avoid routes from deviating [6]. Also, defend against packet losses; it uses local revival to retransmit a packet when an ACK is not obtained within a particular time.

Node Deployment optimization Scheme, the node position is find out based on the CS algorithm. This scheme minimize the energy expenditure and enhance the coverage zones [7]. Hierarchical Cuckoo Search-based routing scheme, the network zone is separated into a reasonable effective grid. Then the data is forward to the sink by using the CS algorithm [8]. Ant-cuckoo optimized energy-efficient data aggregation method is used for extend the lifespan. Ant colony optimization idea is functional for formation of network. The data aggregation function is accepted by cuckoo search principle[9]. The CS approach applies a lengthy distance search to successfully jump out of local ideals. In this scheme, a coverage hole retrieval method by CS that maintenances coverage hole precisely via the global search to confirm the coverage performance [10]. DV-Hop algorithm has the accumulative errors during the sensor positioning procedure. To rise the DV-Hop locating accuracies, the CS approach to optimize the locating errors [11]. PSO combined CS optimization algorithm for minimizing the transmission distance also saving energy in the network [12].

Cooperative assortment has increased much interest owing to its capability to alleviate multipath fading lacking utilizing the multiple antennas. The cooperative communication can develop the routine of the physical layer. A cross-layer cooperative routing mechanism is used to the collision possibility focus to the outage chance restraint in the networks. The collision minimization method by joining cooperative communication, efficient power assignment, and selecting the route. The Minimum Collision

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Cooperative Routing chooses the route that bases lowest collision probability in the network. This scheme can mainly minimize the collision possibility when maintaining the outage probability under the targeted value [13].

Cooperative multiplicity capability to alleviate multipath fading lacking using multiple antennas. In multi-hop wireless networks, per-node traffic weight assistances to deliver significant perceptions into conniving well-organized network protocols. In this scheme, an analytical model is sued to evaluate the per-node traffic load in the network [14].Cooperative communication to knowingly rise the capability of networks and alleviating fading by manipulating spatial diversity. The assistances of Cooperative communication to exploit the minimum rate between a set of parallel transaction sessions. In this scheme, the centralized algorithm is intended within a branch-and-bound outline by utilizing the moderation of the framed mixed-integer programming that can discover a global ideal solution. In addition, the distributed algorithm contains two sub algorithms such as a cooperative route collection sub algorithm and a fairness-aware route alteration sub algorithm [15].

A cross-layer cooperative routing approach is introduced for reducing the collision possibility subject to an end-to-end outage probability restraint. The minimum collision cooperative routing (MCCR), chooses the route that origins minimum collision probability. The collision reduction algorithm provide cooperative communication, ideal power allocation, and better route selection. The MCCR can considerably decrease the collision possibility[16].

Cooperative communication to alleviate multipath fading. The cooperative routing algorithm intended to diminish the collision probability. The branch-and-bound algorithm amplified with minimizing the search space. This approach makes the optimal routes from every sender to the receiver by offering the better set of hops in every route, the better set of relays, and the better power assignment for the accommodating communication links. This scheme also diminish the computational complexity [17].The cooperative routing algorithm is used to improve the performance of networks. In this scheme, the sender communicate data independently by elected relays between their neighbors depend on their hop count, signal-to-noise ratio, and time of arrival and to the receiver [18].

The multi-radio and multi-channel (MRMC) method and cooperative transmission method to conflict co-channel intervention and enhance the network performance. This method concurrently considers relay node selection, channel assignment, and cooperative routing proceeds benefit of both MRMC technique and spatial diversity to enhance the throughput. The contention-aware channel deployment metric to detention the interference cost from both direct communication and cooperative communication, and traffic awake channel situation metric to measure the channel load situation. The interference-aware cooperative routing, local path and relay adaptation and local channel modification correspondingly to confirm high performance transmission in the networks. This scheme can efficiently moderate co-channel interference and achieve accommodating assortment gain[19].

A fair cooperative routing approach [20] described an energy lake to conserve the total amount of energy utilization by cooperative communication. This energy lake shows a character of dealer for fair cooperation. Delay-tolerant networks with cooperative routing [21] introduced a consistent transportation approach that relies on acknowledgements (ACKs) and coding. In this scheme, the buffer management rules are framed and a fluid model by mean-field approximation is resulting for the intended reliable transference approach. This method permits both the energy expenditure and mean file completion time to be articulated up to the distribution of the last ACK at the source.Energy Efficient Opportunistic Routing that depend on the collection of the transmitting list to diminish energy utilization. Range-based Opportunistic Routing that reduce the energy and the number of released packets[22].

Generally, the congestion creates traffic jams as a result truncated throughput and highest packet delay, expressively affecting entire network performance. Therefore the usage of a congestion supervision approach is fetching required in current communication. End-Point Congestion Filter approach is used to eliminate this processes and to permit adaptative routing method to accomplish the predictable concert even in the occurrence of congestion conditions[23].

The Regional Explicit Congestion Notification (RECN) approach using different queues to completely separate the packet flows that donate to congestion, thus stopping the Head-of-

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Line obstructive outcome that these flows may source to others. The Distributed-Routing-Based Congestion Management scheme following the RECN approach thus protects congestion from blocking in the networks[24]. A second-order joint congestion mechanism and routing optimization structure that provides fast merging, utility-optimality, queue-stability, and small latency[25].Congestion-aware routing algorithms for WMNs with shortest-path routing protocol. In this approach, Backpressure Enhanced-Backpressure and Congestion Diversity Protocol are properly altered for execution on 802.11-compatible radios[26].

Fair Bandwidth Allocation scheme evaluates end-to-end bandwidth allotment in multi-radio WMN. It accomplishes a good trade-off among fairness and throughput by using Lexicographical Max-Min fairness model [27]. Multipath routing algorithm based on traffic prediction (MRATP) is to improve the QoS routing in WMNs. It contains three modules such as building multipath routing, a congestion discovery and a load balancing algorithm [28]. Opportunistic SDN-Controlled WMN is used to examine the opportunity of off-loading the traffic throughout Wi-Fi access networks by the use of WMNs [29]. Interference-aware bandwidth scheduling and shortest path routing have solved the congestion in WMN. In this scheme, the TDMA schedule is used for allocating bandwidth and makes the shortest path from source to destination by k-shortest path approach [30].

Channel assignment scheme [31] is used to increasing per-flow bandwidth with fairness deliberation to make equal bandwidth assignment. In this scheme, a heuristic randomized channel assignment algorithm allots channels by the interference level qualified by every flow, that is gained from the given traffic pattern. Cooperative diversity based multi-copy relaying (CDMR) scheme [32] is used for improving network performance. It grants neighboring nodes along a chosen route to helpfully distribute packets to the receiver. CDMR operates in two phases: helper establishment and cooperatively delivery.

Coding-Aware Opportunistic Routing (CORE) [33] aggregates inter-flow network coding and hop-by-hop opportunistic forwarding for enhancing the network throughput in WMN. By opportunistic forwarding, CORE appropriates the next-hop with the most coding get to maintain the packet forwarding. During network coding, CORE tries to exploit the amount of packets that can be passed in a particular transmission. However, this scheme cannot manage congestion and traffic overload.

3. ADAPTIVE LOAD BALANCE METRIC FOR OPPORTUNISTIC MULTIMEDIA (ALBOM) WMN

In WMN, the communication efficiency diminishes due to the limitation of channel interference, packet loss, and bandwidth. The OR increases the routing efficiency in WMN. In OR, the best forwarder node is elected by the Cuckoo Search (CS) algorithm from Forwarder List (FL). The CS measures the best node based on the Adaptive Load Balance (ALB) metric, deviation time and packet delivery ratio. The CS selects the minimum load balance node.

When a source desire transmits the data to the destination, it initially selects a set of FL for its transmission. A node can be picked out into the FL if it satisfies the following terms:

- It is a straight neighbor node of the source.
- It is nearer to the destination than to the source.

Figure 1 shows the method for measuring Deviation Time (DT) value in a node. For each node, the deviation time (time difference between the route request and route reply) is calculated. Delay is calculated for each route request and route reply. All the nodes within the direct communication range will send the data directly to the destination. Node 3 has deviation value 0.8, node 4 has 0.7 and node 6 has 0.6 deviation value.

Figure 2 shows the packet delivery ratio (PDR) is calculated for all the nodes in the communication network. The PDR is calculated by the number of packets delivered and sent.

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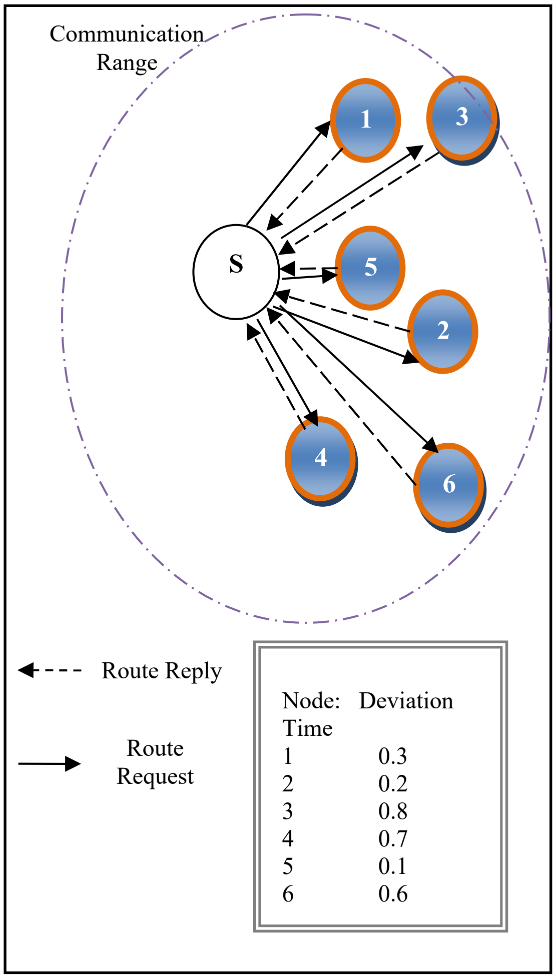

Figure 1: Illustration of Deviation Time Value

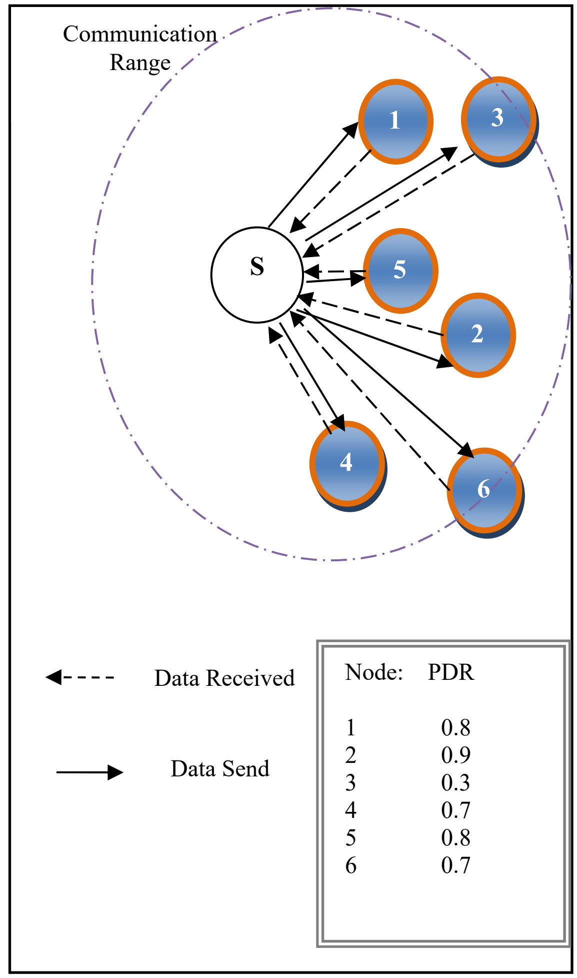

Figure 2: Illustration of packet Delivery Ratio

3.1 Best Forwarder Node Selection

After selecting the FL, and then selects the best forwarder node by CS. The three essential levels guide an optimization system, which is as follows.

- Initially, the cuckoo plays a set of solutions that are arbitrarily located at different nests.
- After that, the best eggs with proper solutions will be allowed to shift into the next step.
- At last, one of the eggs is distinguished as extraordinary, then that solution will be disconnected and a most recent egg will restore this strange in a new nest.

The important process of the CS is given below:

Arbitrarily Initialize Pop host nests, a set of forwarder list Gi.

Measure the fitness value of Gi by ALB, DT and PDR.

$$F(G) = \sum_{i=1}^{n} F(G_i)$$

Cuckoo put an egg G1 on the random nest

Compute the fitness value of G1

Then compute the fitness value ofG2

If (G1<G2) {

G1 is replaced by G2

Finally, highest fitness value node is selected as a forwarder node.

Along with this process, for every egg in the forwarder list, a fitness value for every egg computation is given in Eq. (1)

$$F(G_i)=\begin{cases} G_k+(G_A-G_k), & \text{if } DT\geq 0.5 \\ G_k+(G_k-G_R), & \text{if } DT<0.5 \end{cases} \quad (1)$$

Where G_A→ Ratio of acceptance opportunity

G_R→Ratio of Rejection opportunity

G_k→ALB_{th}- ALB

The Ratio of acceptance opportunity is indicated the PDR value and Rejection opportunity is calculated by (1-PDR).

3.2 Adaptive Load Balance (ALB) metric Computation

The Adaptive Load Balance (ALB) metric computation helps to reduce network congestion. ALB metric based route formation solves traffic congestion and improves overall network throughput. The ALB metric is computed by Eq. (2).

$$ALB(\text{i})=\left[OH_C+OH_P+\frac{B_t}{TR}\right]\frac{1}{1-\gamma_{ST}} \quad (2)$$

Where OH_C represents the overhead of channel access, OH_P represents the overhead of protocol; TR indicates the rate of video data transmission; B_t means the test frame bits and γ_{ST} refers computing transmission state time.

The node desires to transmit the packets to any node, when the node gets the sequence of transmission state time that contains the time of wait (T_W), collision (T_C), back off (T_{Bo}) and success (T_S). In order to precisely compute the transmission state time of nodes for communicating a packet is given in Eq.(3).

$$\gamma_{ST}=\frac{T_W+T_C+T_{Bo}}{T_W+T_C+T_{Bo}+T_S} \quad (3)$$

Where, state TS represents node has effectively obtained the acknowledgement regarding the transmitted packet. The state TC represents the node sent a packet although no acknowledgement is received regarding that packet. The state TW refers the node continues waiting till its turn that represents the observing medium is busy. The state TBackoff represents the node requests to transmit with other nodes also the medium is accessible.

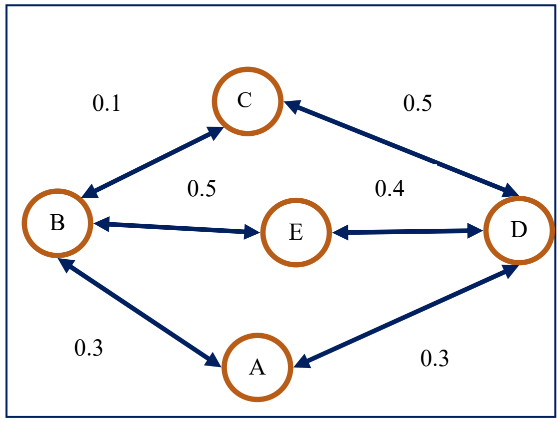

Figure 3: ALB Metric Illustration

For example, figure 3 explains source B selects the route based on ALB metric. In this figure, the node B is a source, D is a destination, and A, C, E nodes are intermediate nodes. The node B to D builds the routes are B→E→D, B→C→D and B→A→D and these path total ALB metric cost are 0.9, 0.6 and 0.6. Here, the route B→C→D and B→A→D costs are the same. But, the route B→C→D load is a difference from B→A→D. Since the load C→D is heavier comparing to B→C, thus congestion will occur at node C, and it creates heavy packet loss. On the other hand, the route B→A→D transmission rate is uniform; therefore the packet loss is decreased.

The load balance condition is similar to irrigate flow in water Pipe. Since the greatest flow of the entire network is inadequate to the link capability, and the node before the link will develop into the bottleneck. As a result, we select the route with the load more equally to diminish the possibility of packet loss. The load balance threshold can be defined as in Eq. (4).

$$ALB_{TH}=\frac{1}{k}\sum_{i=1}^{k}\left(ALB(\text{i})\right) \quad (4)$$

Where,

ALB_{TH}→ Adaptive load balance threshold

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ALB(i)→Adaptive load balance of the route

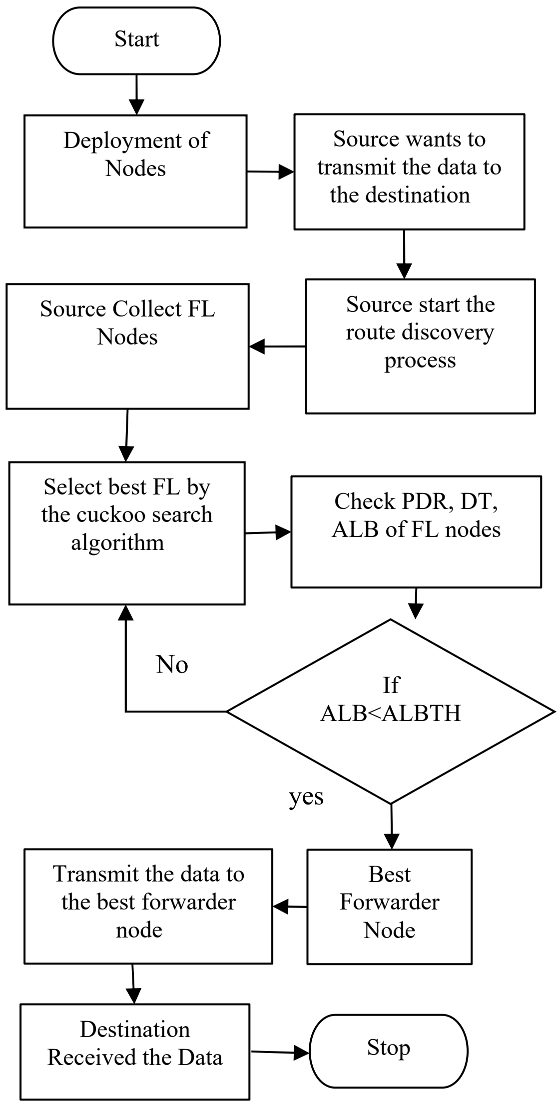

Figure 4: Flowchart of ALBOM Scheme

The source (S) wants to transmit the video data to the destination (D) initially, broadcast a request and obtains a reply via the nodes that can promise send the video data together. The common neighbors of the present source and the next intermediate form a set known as the forwarder list FL*(S, D)*. During data transmission, the source chooses the forwarder nodes based on the CS algorithm. CS elects the best node from FL(S, D) by PDR, DT and ALB metric. The node load has less than the average ALB that node is selected as a forwarder node. This method is repeatedly executed till the video data reached the destination.

3.3 ALBOM Algorithm

The algorithm 1 describes the ALOM scheme in which the selection of highly efficient path is given. Figure 4 illustrates the flowchart of ALBOM scheme.

Begin ALBOM (Source, destination, FL, best forwarder)
Source desires transmit video data to the destination
Do the route discovery process
Collect FL
Best Forwarder selection
Do the Cuckoo Search Algorithm {
Best Forwarder from FL
Check PDR, DT and ALB for available routes
If $ALB<ALB_{TH}$ {
Best Forwarder
Transmit data to the best forwarder
} Else {
Choose Best Forwarder from FL
}
End ALBOM

4. SIMULATION ANALYSIS

In this section, we investigate the performance of ALBOM by simulation using Network Simulator ns-2.35. We compare it against CORE with varying simulation parameters. The simulation parameters are mentioned in table 1. The performance analysis parameters are received packets, lost packets, residual energy and average delay, routing overhead are estimated in ALBOM and CORE.

Table 1: Simulation Parameters of ALBOM.

Parameter	Value
Nodes	30
Model of Antenna	Omni Antenna
Type of Network Interface	WirelessPhy
Model of Radio Propagation	TwoRayGround
Simulation Area	500×600
Simulation Time	50 s
Model of Traffic	Constant Bit Rate
Transmission Range	250m
Type of Channel	Wireless Channel
Type of MAC	802.11
Initial Energy	1 Joule
Video sending	MyUDP
Video receiving	MyEvalvidSink

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The received packets rate RPR is computed using the Eq. (5).

$$RPR = \frac{\sum_0^n PktRcv(n)}{\sum_0^n PktRcv(n) + \sum_0^n PktLost(n)} \quad (5)$$

The Loss of packets rate LPR is computed using the Eq. (6).

$$LPR = \frac{\sum_0^n PktLost(n)}{\sum_0^n PktRcv(n) + \sum_0^n PktLost(n)} \quad (6)$$

Delay per node is measured using the Eq. (7).

$$Avg.Delay = \frac{1}{n}\left(\sum_0^n PktRcv_{TIME}(n) - PktSent_{TIME}(n)\right) \quad (7)$$

The throughput of the network can be calculated using the Eq. (8)

$$Throughput = \frac{\sum_0^n PktRcv(n) * PktSize}{1000} \quad (8)$$

Where,

n→Node Count

Pkt→ Packet

PktRcv→Packet Received

The routing scheme simulation time increases, the node received packet rate also increased because of rate of data packets are added cumulatively. But, the number of packets delivered is higher in the ALBOM technique compared to the CORE mechanism as shown in figure 5. It shows that the ALBOM has a 30% better-received packet rate when compared to the CORE mechanism at simulation time 50 seconds. Due to the cuckoo search algorithm finds the efficient forwarder node. These forwarder nodes increase the received packets rate in the network.

There is a lesser number of packets lost in the proposed ALBOM mechanism is shown in figure 6. At simulation time 50 seconds, the loss packet rate of CORE is greater by 16% when compared to that of ALBOM. The ALBOM scheme reduces both the network congestion and overload hence it diminishes the packet losses in the WMN.

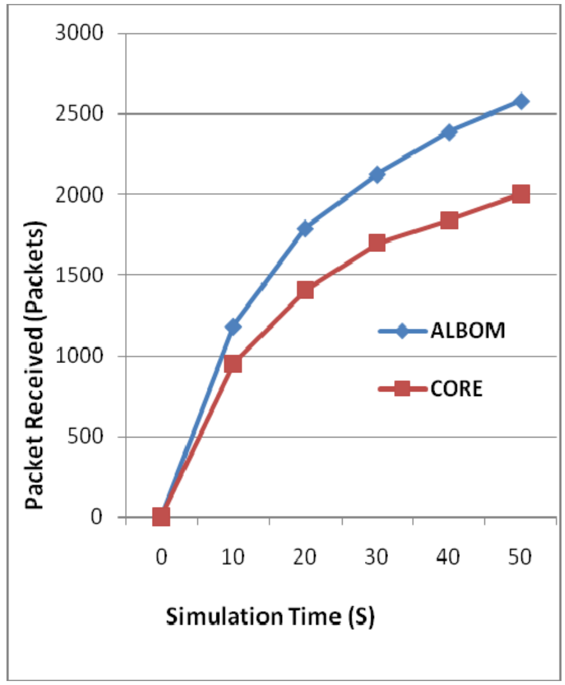

Figure 5: Received Packet Rate

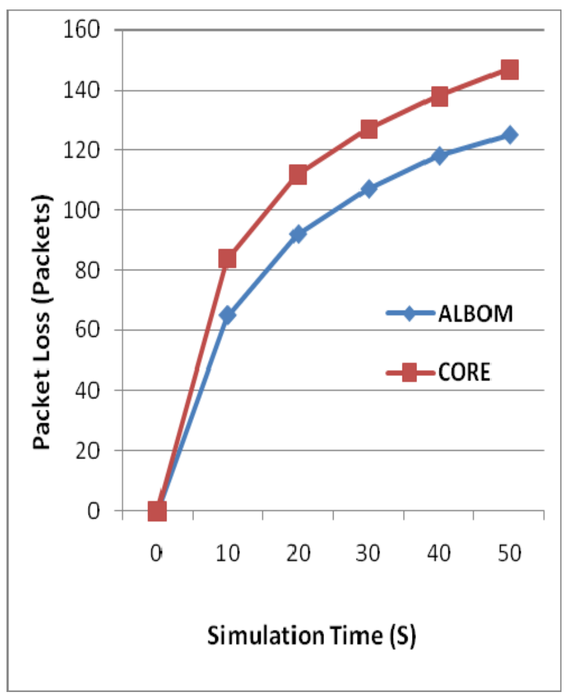

Figure 6: Loss Packet Rate

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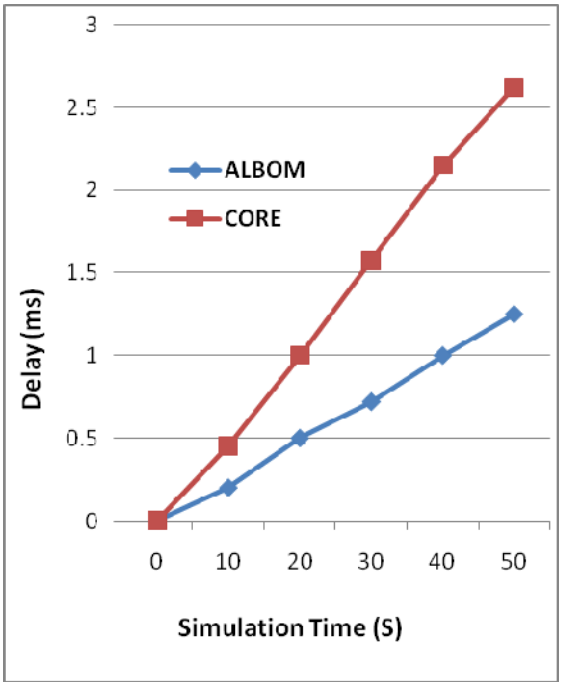

Figure 7: Average Delay

The delay comparison between the ALBOM and CORE is revealed in figure 7. It demonstrates that the ALBOM has a 53% lower delay when compared to the CORE mechanism at 50 seconds. The CORE raises the forwarder total transmission time since it cannot maintain the load balancing. In addition, CORE does not measure the accurate delay value. As a result, the CORE increases network delay. But in ALBOM reduces the overload and network congestion as a result increases the speed of data transmission. Hence minimize the network delay in WMN.

Figure 8 shows the performance of throughput between ALBOM and CORE. It can be observed from figure 8 that the number of packets received successfully for every 1000 packets sent. ALBOM is higher than 27% throughput compared to that of CORE mechanism at 50 seconds. The CORE scheme stimulates less capacity of the network; thus it reduces the network throughput. But ALBOM improves the network throughput since the cuckoo search algorithm based select the forwarder nodes to do efficient video data transmission.

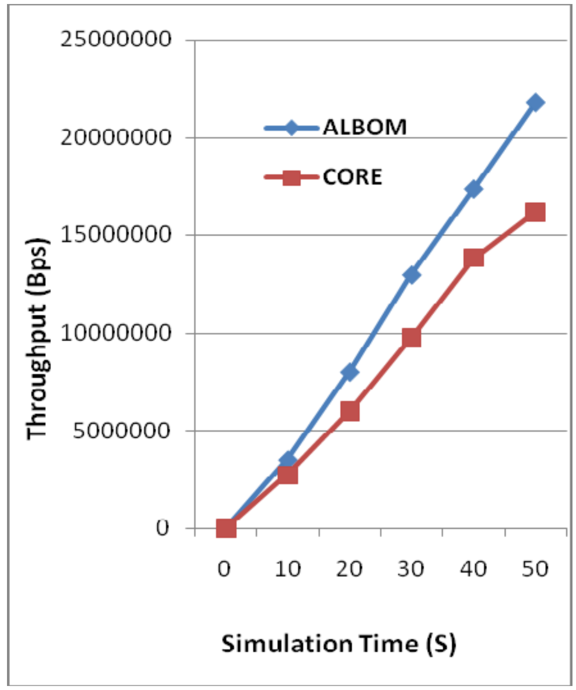

Figure 8: Throughput

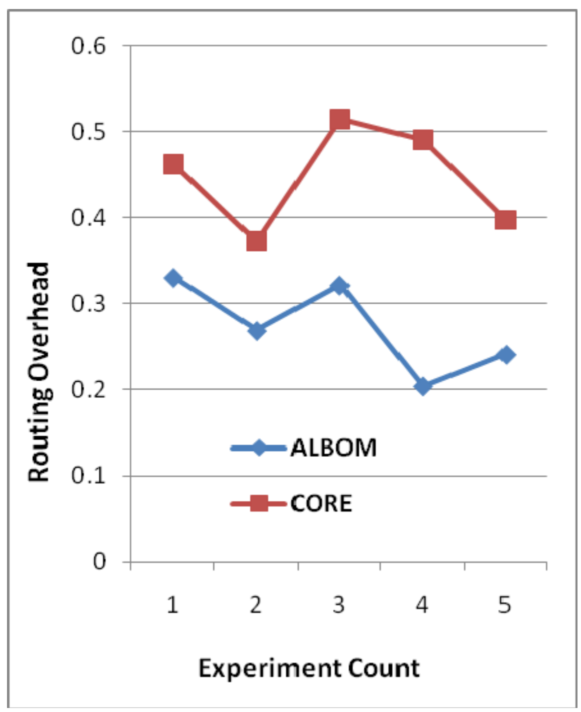

Figure: 9 Routing Overhead

The Routing Overhead is described as the total number of control packets transmitted for generating a data path per data packet. Figure 9 demonstrates that the ALBOM has less overhead than the CORE. Since ALBOM select the route by a cuckoo search algorithm. This route optimization algorithm maximum avoids unwanted flooding during video data transmission.

5. CONCLUSION

In this paper, we have proposed an Adaptive Load Balance metric for Opportunistic Multimedia WMN. The main goal of this paper is to reduces routing overload and increases OR efficiency. In, ALBOM, the cuckoo search algorithm for selecting the forwarder node based on the PDR, deviation time and adaptive load balance metric. In addition, we designed an adaptive load balance metric which considers the traffic load. Hence, this adaptive load balance metric computation helps to reduce both the routing overload and network congestion. Simulation analysis is carried out, and it shows the ALBOM minimizing 53% delay and increases 27% throughput compared to the CORE mechanism.

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