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Research Article

Scalability of Voice Traffic in OLSR and AODV Mesh: Preliminary Experiments

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Abstract: Community Wireless Mesh Networks (WMNs) have emerged as a cost-effective 'last-mile' solution to network services in rural low-income regions primarily located in Sub-Saharan Africa and Developing Asia. However, researchers have often criticized the WMNs for experiencing degraded Quality of Service (QoS), particularly in terms of latency, jitter, and packet loss, as network size and number of users increase. This study investigates the performance of latency, jitter, and packet loss in a multi-hop WMN environment using QoS sensitive voice traffic and two widely used routing protocols - Optimized Link State Routing (OLSR) and Ad hoc On-Demand Distance Vector (AODV) – to determine the most suitable mesh routing protocol for future scalability experiments. Given the strict QoS requirements of voice traffic, the research assumes that a WMN that scales well under voice traffic has the potential to scale well for a broader range of network applications. Using Network Simulator-3 (NS-3), one-way latency, jitter, and packet loss percentage (PL%) were evaluated for up to five simultaneous VoIP calls over a 9-hop WMN topology. The results indicate that while both OLSR and AODV maintained packet loss below 1%, OLSR consistently outperformed AODV in terms of lower latency and jitter. The findings suggest that OLSR is better suited for supporting real-time voice applications in WMNs. Future work will extend this research to analyse WMN scalability under video traffic, explore alternative network topologies (e.g., grid-based WMNs), integrate mobile phones, and evaluating the impact of MIMO routers and varying signal strengths. This study contributes to the ongoing efforts to quantify WMN scalability so that they can be optimally deployed as a community-driven Internet infrastructure.

Keywords: Wireless Mesh Network (WMN), VoIP, OLSR, AODV, Latency, Jitter, Packet Loss, Network Scalability.

1. Introduction

Wireless Mesh Networks (WMNs) function as dynamically self-organizing and self-configuring systems, where routers autonomously establish and sustain mesh connectivity within the network [1], [2]. These self-configuration and self-organization capabilities offer several advantages over conventional Wireless-Fidelity (Wi-Fi) infrastructures, including lower initial costs, simplified network maintenance, enhanced resilience, and dependable service coverage. Such networks provide valuable opportunities for end-users in rural and low-income communities as they provide an opportunity to establish community-driven Internet infrastructure with mobile data rates customized as per their economic conditions. Rural low-income regions in sub-Saharan Africa and developing parts of Asia account for a significant portion of the global population with the lowest Internet penetration [3]. Community driven WMNs present a viable solution to bridge this digital divide, enabling these communities to gain access to affordable and sustainable Internet connectivity. Some examples of community WMNs, and their deployment reasons and services provided are as follows :

1. Zenzeleni, Mankosi, South Africa [4]. The key deployment reason was the unaffordable cost of mobile data. The services provided started off with intra-mesh-network voice calls to community members, and then later expanding to the Internet.
2. Mesh Bukavu, Bukavu, Democratic Republic of Congo (DRC) [5]. The deployment reason was the unaffordable cost of Internet. Services provided are Intranet, cached content sharing, and local chat.
3. Wireless Ghana, Akwapim, Ghana [6]. This network was deployed in response to a community request aimed at bridging the digital divide and addressing the region's digital isolation. The services offered include online libraries and Internet.
4. Macha network in Macha, Zambia [7]. The deployment reasons were the unreliable presence of GSM and expensive data rates. The services provided were Information and Communication Technology (ICT) training to locals and the Internet.
5. The Peebles Valley mesh, Peebles Valley, South Africa [8]. The network was deployed to explore least cost 802.11

network for clinic, school, homes and farms. The service provided was the Internet.

6. Gram Marg, Palghar, India [9]. The deployment reasons were the absence of mobile coverage in the area and no Internet. The service provided was the Internet.
7. Dharamsala community WMN (DCWMN), Dharamsala, India [3]. The deployment was aimed at providing affordable and reliable telephony and data services in the challenging mountainous landscape of the Dharamsala region. The services provided are the Internet, cached content sharing, and Voice over Internet Protocol (VoIP). It has evolved to AirJaldi.
8. Taknet, Tak Province, Thailand [3] [10]. The networks were deployment in multiple villages with the aim of providing affordable broadband and increase literacy level in the area. The services provided are the Internet, Video-on-demand and VoIP.
9. Alternative Solutions for Rural Communities, Myanmar (ASORCOM), Siyin Valley, Myanmar [11]. The deployment reason was to address the absence of mobile network coverage in the area. The services provided are the Internet and cached content sharing.

Amongst the previously mentioned community WMNs, examples 1–5 are from sub-Saharan Africa, while examples 6–9 are from developing Asia.

However, related works have frequently reported that the Quality of Service (QoS) of a WMN is impacted negatively with addition of new nodes and new users, leading to drop in throughput, latency and jitter, and increase in packet loss. On the contrary, from the examples of community WMNs presented, even though such networks present scalability concerns, they have been constantly deployed all across the globe as a cheap 'last-mile' access solution to network services such as the Internet.

This research advocates for the deployment of community WMNs and is therefore initiating experiments to explore and enhance the scalability of WMNs, beginning with the selection of an efficient routing protocol for such networks. The rest of the paper is organised as follows: Section 2 identifies related work; Section 3 details the experimental procedure; Section 4 presents and discusses the results; and Section 5 outlays the conclusion a future work.

2. Related Work

The section reviews work that investigate performance of WMNs; compare mesh routing protocols; and highlight QoS requirements for multimedia traffic.

2.1 Performance of WMNs

The QoS in a WMN is frequently impacted by the addition of new nodes and users, as these changes alter the network topology and traffic flow. Table 2 shows a list of experiments to support this claim. The WMNs often experienced a decline in performance metrics such as delay, packet loss, and jitter due to factors such as: (a) an increased number of hops, which modifies the network's topology and scale; (b) heightened interference; (c) overhead from the routing protocol; and (d) the half-duplex nature of single-radio mesh routers.

Table 1 - Related Work Showing Performance Degradation in WMNs

Authors	Issues	Reasons
[12]	Decrease in packet delivery ratio (PDR), increase in delay, drop in goodput, and increase in routing overhead.	Increase in node density and node velocity.
[13]	Rise in delay, jitter and packet loss; drop in bandwidth	Increase in number of hops
[14]	VoIP call drops	Multiple hops, self-interference and high protocol overhead.
[15]	Rise in packet loss, delay and jitter.	Increase in number of hops
[16], [17], [18]	Drop in throughput	Increase in number of hops

The next section presents related works comparing WMN routing protocols.

2.2 Comparison of Mesh Routing Protocols

As presented in [19], there are more than 70 routing protocols for routing packets across WMNs. Therefore, to commence investigations on scalability of WMNs, this research considered the process of selecting an appropriate routing protocol for future experimentation a vital step for future research forms.

As mentioned in [20] WMN routing protocols can be can be classified as proactive, reactive and hybrid. Proactive routing protocols operate similarly to traditional wired network routing, ensuring that at least one path is always available to reach any destination. In contrast, reactive protocols establish a path only when there is a packet to be transmitted. If a node has no data to send to a specific destination, it does not initiate a path request. Hybrid protocols combine the characteristics of both proactive and reactive routing approaches, adapting to network conditions for optimized performance. Examples of reactive routing protocols are Dynamic Source Routing (DSR) protocol, Ad hoc On-Demand Distance Vector (AODV) protocol and Link Quality Source Routing (LQSR) protocol; examples of proactive routing protocols are Destination-Sequenced Distance-Vector routing Protocol (DSDV), Optimized Link State Routing Protocol (OLSR); and an example of hybrid routing protocols is Hybrid Wireless Mesh Protocol (HWMP). Related works of [12], [21], [22] have extensively reviewed performance of different mesh routing protocols. In [12], performance of DSDV, AODV, and OLSR in Vehicular Ad-hoc Networks (VANETs) is investigated with the overall conclusion of OLSR performing better than DSDV and AODV. The related work of [21] compared AODV and OLSR performances in Mobile Ad-hoc Networks (MANETs) and showed AODV to perform better than OLSR overall. In [22], performance metrics of AODV, DSDV, DSR, and Temporary Ordered Routing Algorithm (TORA) were compared using File Transfer Protocol (FTP) traffic in an ad-hoc network and a

WMN with the overall conclusion that each routing protocol is best suited for a specific network environment. The work of [22] concluded that in a WMN: (a) DSDV provides higher throughput under heavy network loads; (b) DSR and AODV give low end-to-end delay for low and high load; (c) AODV experiences lesser packet loss at lower mobility conditions, while DSDV performs better under higher mobility conditions. In the case of ad-hoc networks, the work of [22] concluded that: (a) DSR delivers superior throughput performance; (b) at lower bit error rates, almost all the protocols exhibit similar end-to-end delay, while AODV performs better at higher bit error rates; and (c) DSDV performs better as the number of nodes increase in the network, while AODV performs better in less congested networks.

Based on the findings in related works, this research chose two traditional mesh routing protocols for comparison experiments - OLSR (proactive) and AODV (reactive). Comparison of hybrid routing protocols will be considered in future experiments.

The next section presents the QoS requirements for different types of traffic leading to the choice of type of traffic for comparing OLSR and AODV performance in WMNs.

2.3 QoS Requirements for Multimedia Traffic

Quality of Service (QoS) refers to the overall set of characteristics of a telecommunications service that determine its capability to meet both the stated and implicit needs of its users [3]. The recommended QoS requirements for key performance metrics (KPMs) - throughput, latency, jitter, and packet loss percentage – for essential daily end-user network application traffic, as classified in [3], are compiled based on [3], [23]and are outlined as follows:

- For VoIP - conversational voice – typical data rate of 21-320 Kbps per call; preferred average one-way latency of < 150ms and limit of < 400ms; average one-way jitter of < 30ms; and packet loss percentage < 1%.
- For video – interactive - typical data rate of >= 384Kbps; preferred average one-way latency of < 150ms and limit of < 400ms; average one-way jitter of < 30ms; and packet loss percentage < 1%.
- For video – streaming – varying data rates; average one-way latency of < 4-5s; no jitter; and packet loss < 5%.
- For data – best effort, transactional, and interactive – there is no limit for data rate; preferred latency for a page to load is < 2s and acceptable limit is < 4s; jitter is not applicable; and no packet loss.
- For data – bulk data - there is no limit for data rate; preferred latency for a page to load is < 15s and acceptable limit is < 60s; jitter is not applicable; and no packet loss.

For these preliminary set of experiments aiming to investigate performance of OLSR and AODV, VoIP – conversational voice type traffic was considered for its strict latency, jitter, and packet loss requirements. Video – interactive type traffic also has strict QoS requirements, and the performances will be explored in future works. The next section presents the experimental procedure.

4. Experimental Procedure

The voice call experiments to find out the suitable routing protocol between OLSR and AODV for a WMN were conducted in a simulated environment. Based on the findings in [24], Network Simulator – 3 (NS-3) was used to set up the simulation environment.

For these preliminary set of experiments, the NS-3 simulation consisted of transmitting 160 Bytes packets at the rate of 64 Kilobits per second (Kbps) for 2-minutes over a simple linear 5-GHz mesh network of 10 mesh routers placed 50 meters apart from each other. The 5-GHz backbone was utilized with the aim of providing a high-speed and low-latency network. The payload size of 160B transmitted at the rate of 64Kbps simulated a G.711 voice codec call. The bandwidth requirements of G.711 codec was chosen for simulation due to; (a) its higher bandwidth requirement as compared to other compressed codecs [3]; and (b) its limited suitability for networks susceptible to high packet loss and jitter such as WMNs. Therefore, the experiments assumed that if a WMN can successfully support G.711 voice calls then the network should also be capable of supporting other codecs as well.

The routers, in the NS-3 scripts, were installed with single isotropic antenna (hence, single spatial stream) with minimum and maximum transmission power levels set to 20dBm. Single antenna was used in the simulations to focus on evaluating OLSR and AODV routing and link performance. Usage of 1 spatial stream ensured that performance was dictated by routing and link conditions only. A key aspect of the simulation was the inclusion of propagation loss and delay models in the simulation script to imitate the physical behaviour of signal transmission, including the effects of distance, obstacles, and environmental factors. The NS-3 provides propagation loss and delay modules. After investigating the modules presented in the simulator and considering the initiative of this research, the Log-Distance Propagation Loss (LDPL) module and Constant Speed Propagation Delay (CSPD) Model were chosen for the experiments. The LDPL model accounts for signal attenuation as a function of distance between the transmitter and receiver. While it does not directly incorporate detailed environmental factors, it allows adjustment through parameters such as the path loss exponent and reference loss to indirectly represent environmental conditions. A path loss exponent value of 2.7 was used to represent a rural setting with moderate obstructions (trees, houses) and minimal interference. Also, reference loss of 1dB was selected to simulate an environment with extremely minimal initial signal attenuation at the reference distance where the signal loss is known (default = 1 m). Thus, CSPD used in the experiments represent an environment with minimal interference.

The NS-3 script generated voice traffic streams Router 1. Router 1 started with 1 voice stream to each other node in the network for 2-minutes and scaled up to 5 simultaneous voice streams. The voice streams to router 3 and onwards were transmitted in increasing number of hops that is the traffic traversed the intermediary nodes en route to the destination node. No other traffic was present on the network while the voice streams were being transmitted.

To evaluate the routing performance of OLSR and AODV, the simulation gathered data on one-way latency, one-way jitter, and packets sent and received during transmitted voice streams. The packets sent and received data was used to calculate PL%.

Table 2 below presents a summary of the key experimental aspects and details of the preliminary set of experiments.

Table 2. Aspects and Details of the Simulation Setup

Aspect	**Details**
Experimental Goal	To determine the suitable routing protocol between OLSR and AODV for voice traffic.
Simulation Tool	NS-3.
Topology	Linear topology.
Number of Hops	Up to 9 (10 routers)
Routing protocols	OLSR and AODV
Traffic Type	Voice traffic
Packet Size	160B
Traffic Rate	64 Kbps
Distance	50 meters between each router.
Mesh backbone	IEEE 802.11ac operating at 5 GHz – Mesh backbone
Antenna settings	Transmission Power: 20 dBm (fixed); Antennas = 1; Spatial Streams (Tx/Rx) = 1.
Propagation loss	Loss Model - Log-Distance Propagation Loss; Exponent - 2.7 (typical for rural areas); Reference Loss - 1.0 dB
Propagation delay	Constant Speed Propagation Delay Model
Duration	Two-minute voice streams.
Streams	From 1 up to 5 simultaneous voice streams (hence simulating 5 voice calls) per hop.
Source-Destination	From Router 1 to other routers, on an individual basis i.e., Router 1 to Router 2, then Router 1 to Router 3 via Router 2, and so on.
KPMs assessed	One-way latency, one-way jitter and one-way packet loss.

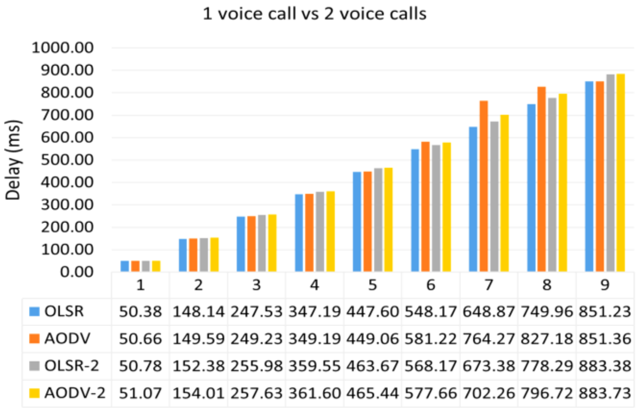
The next section presents the results obtained from the simulations.

5. Results

The section presents results for: (a) latency performance – OLSR vs AODV in Section 5.1; (b) jitter performance – OLSR vs AODV in Section 5.2; and (c) packet loss percentage – OLSR vs AODV in Section 5.3. The results are presented in comparison to the recommended and acceptable VoIP – conversational voice QoS requirements for latency, jitter, and packet loss as presented in Section 2.3 that is a typical data rate of 21-320 Kbps per call; preferred average one-way latency of < 150ms and limit of < 400ms; average one-way jitter of < 30ms; and packet loss percentage < 1%.

5.1 Latency Performance – OLSR vs AODV

The performance results of one-way latency for 1 and 2 voice calls and for OLSR and AODV with increasing number of hops is presented in Figure 1.

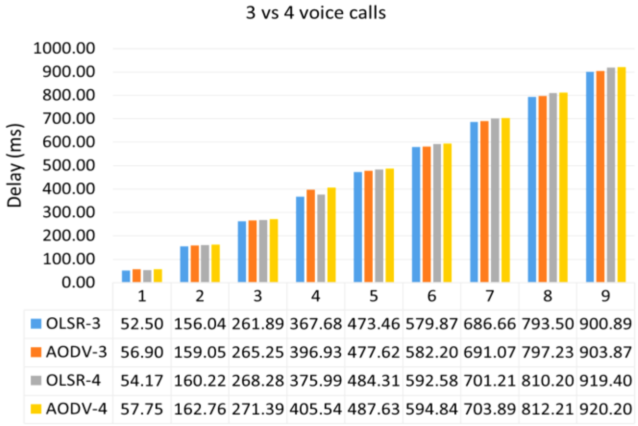


	1	2	3	4	5	6	7	8	9
■ OLSR	50.38	148.14	247.53	347.19	447.60	548.17	648.87	749.96	851.23
■ AODV	50.66	149.59	249.23	349.19	449.06	581.22	764.27	827.18	851.36
■ OLSR-2	50.78	152.38	255.98	359.55	463.67	568.17	673.38	778.29	883.38
■ AODV-2	51.07	154.01	257.63	361.60	465.44	577.66	702.26	796.72	883.73

Figure 1: Latency performance during 1 and 2 voice calls over OLSR and AODV mesh, respectively. OLSR and AODV rows show data for 1 voice call and OLSR-2 and AODV-2 show results for 2 voice calls.

It can be observed that: (a) AODV consistently exhibited higher delays than OLSR; (b) for a single voice call, the latency values exceeded the recommended VoIP – conversational voice preferred average one-way latency of < 150ms after 2-hops for 1 voice call for both OLSR and AODV; (c) with 2 voice calls, the latency values surpassed the recommended values of < 150ms after just 1-hop for both OLSR and AODV; and (d) for both OLSR and AODV, the latency values crossed the limit of < 400ms after 4-hops for both 1 and 2 voice calls.

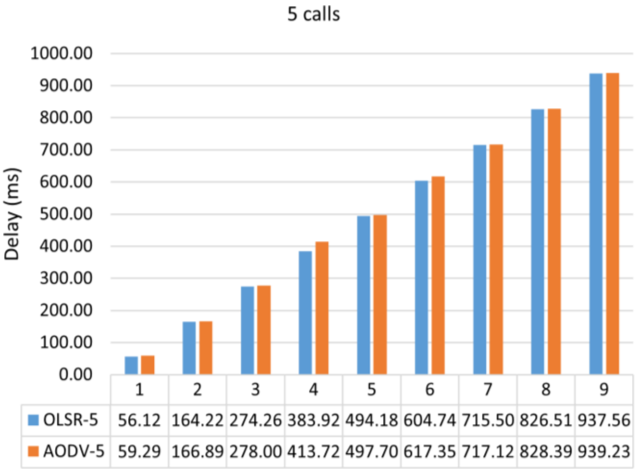
Figure 2 presents the one-way latency performance of 3 and 4 voice calls over OLSR and AODV networks with increasing number of hops. The results indicate that: (a) at each hop, the latency observed for 3 and 4 voice calls was higher than that observed for 1 and 2 voice calls in Figure 1 for both OLSR and AODV; (b) calls over AODV mesh consistently exhibited higher latency than calls over OLSR mesh mirroring the trends seen in the results of 1 and 2 voice calls; (c) for call over both OLSR and AODV mesh networks, the latency values crossed the recommended values of < 150ms after 1-hop; (d) for 3 voice calls, the latency values surpassed the threshold of < 400ms after 4-hops for both routing protocols; and (e) for 4 voice calls, the latency values crossed the limit of < 400ms after 4-hops for OLSR and after 3-hops for AODV.



	1	2	3	4	5	6	7	8	9
■ OLSR-3	52.50	156.04	261.89	367.68	473.46	579.87	686.66	793.50	900.89
■ AODV-3	56.90	159.05	265.25	396.93	477.62	582.20	691.07	797.23	903.87
■ OLSR-4	54.17	160.22	268.28	375.99	484.31	592.58	701.21	810.20	919.40
■ AODV-4	57.75	162.76	271.39	405.54	487.63	594.84	703.89	812.21	920.20

Figure 2: Latency performance during 3 and 4 voice calls over OLSR and AODV mesh, respectively. OLSR-3 and AODV-3 rows show results for 3 voice calls and OLSR-4 and AODV-4 show results for 4 voice calls

The results of one-way latency of 5 voice calls over OLSR and AODV mesh networks are presented in Figure 3. The results show that: (a) latency during 5 voice calls for both OLSR and AODV was higher than the corresponding values for 4 voice calls, as shown in Figure 2; (b) for both OLSR and AODV, the latency results crossed the recommended values of < 150ms after 1-hop which is similar to the results of 2,3 and 4 voice call results; (c) the latency values crossed the threshold limit of < 400ms after 4 hops in the case of OLSR and 3 hops in the case of AODV, similar to the trend observed with the results of for 4-calls; and (d) overall, 5 simultaneous voice calls over AODV network exhibited higher latency than calls over OLSR network, supporting the trend observed with the results of 1,2,3 and 4 voice calls.

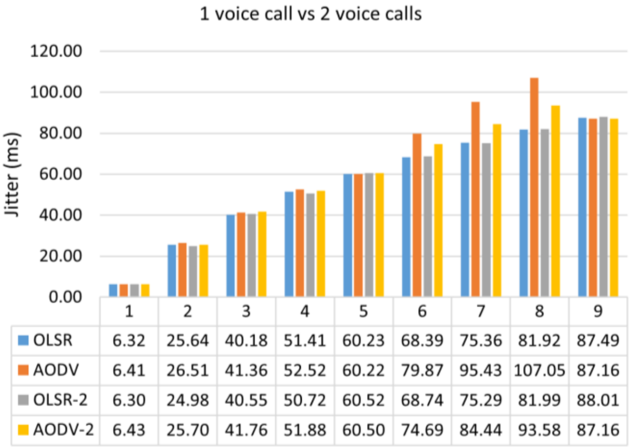


	1	2	3	4	5	6	7	8	9
OLSR-5	56.12	164.22	274.26	383.92	494.18	604.74	715.50	826.51	937.56
AODV-5	59.29	166.89	278.00	413.72	497.70	617.35	717.12	828.39	939.23

Figure 3: Latency performance during 5 voice calls over OLSR and AODV mesh, respectively. OLSR-5 and AODV-5 row show results for 5 voice calls.

5.2 Jitter Performance – OLSR vs AODV

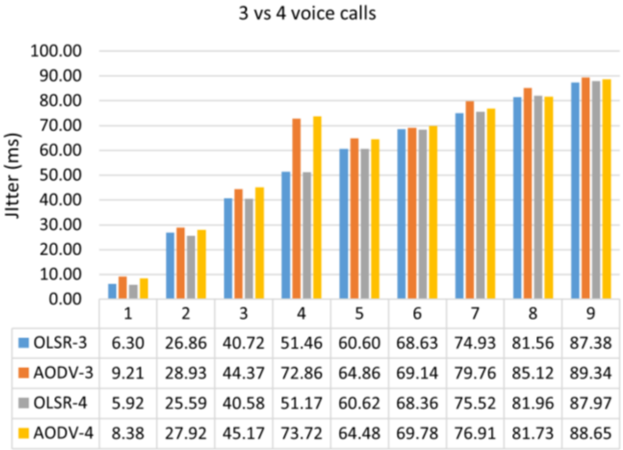
Figure 4 presents the jitter during 1 and 2 voice calls for OLSR and AODV. The results show that: (a) at each hop, for both 1 and 2 calls, respectively, AODV mesh experienced higher jitter than OLSR mesh; and (b) for both OLSR and AODV, calls crossed the recommended jitter value of < 30ms.



	1	2	3	4	5	6	7	8	9
OLSR	6.32	25.64	40.18	51.41	60.23	68.39	75.36	81.92	87.49
AODV	6.41	26.51	41.36	52.52	60.22	79.87	95.43	107.05	87.16
OLSR-2	6.30	24.98	40.55	50.72	60.52	68.74	75.29	81.99	88.01
AODV-2	6.43	25.70	41.76	51.88	60.50	74.69	84.44	93.58	87.16

Figure 4: Jitter performance during 1 and 2 voice calls over OLSR and AODV mesh, respectively. OLSR and AODV rows show data for 1 voice call and OLSR-2 and AODV-2 show results for 2 voice calls.

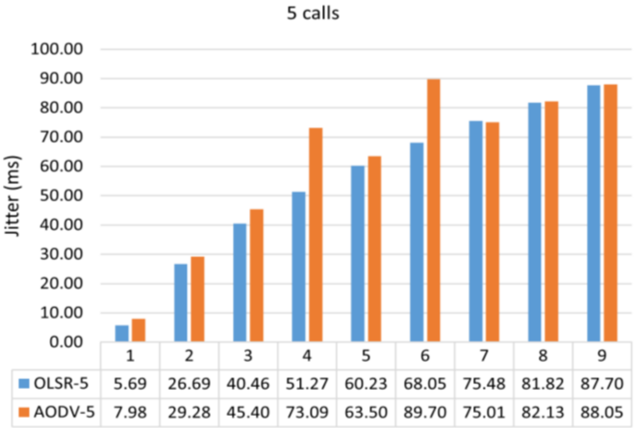
Figure 5 presents the jitter performance during 3 and 4 voice calls for OLSR and AODV. The results show that: (a) like the results of 1 and 2 voice calls, 3 and 4 voice calls over AODV mesh experienced higher jitter than over OLSR mesh at each hop; and (b) both 3 and 4 voice calls crossed the recommended jitter value of < 30ms after 2-hops and showed similar trends as that of 1 and 2 voice calls.



	1	2	3	4	5	6	7	8	9
OLSR-3	6.30	26.86	40.72	51.46	60.60	68.63	74.93	81.56	87.38
AODV-3	9.21	28.93	44.37	72.86	64.86	69.14	79.76	85.12	89.34
OLSR-4	5.92	25.59	40.58	51.17	60.62	68.36	75.52	81.96	87.97
AODV-4	8.38	27.92	45.17	73.72	64.48	69.78	76.91	81.73	88.65

Figure 5: Jitter performance during 3 and 4 voice calls over OLSR and AODV mesh, respectively. OLSR-3 and AODV-3 rows show results for 3 voice calls and OLSR-4 and AODV-4 show results for 4 voice calls

Figure 6 shows the jitter performance during 5 voice calls for OLSR and AODV. The trend in results are similar to those of 1,2,3, and 4 voice calls. Simultaneous flow of 5 voice calls over AODV mesh experienced higher jitter than over OLSR mesh at each hop. The calls crossed the recommended jitter value of < 30ms after 2-hops.



	1	2	3	4	5	6	7	8	9
OLSR-5	5.69	26.69	40.46	51.27	60.23	68.05	75.48	81.82	87.70
AODV-5	7.98	29.28	45.40	73.09	63.50	89.70	75.01	82.13	88.05

Figure 6: Jitter performance during 5 voice calls over OLSR and AODV mesh, respectively. OLSR-5 and AODV-5 row show results for 5 voice calls.

5.3 Packet Loss Performance – OLSR vs AODV

A chart or table has not been presented for packet loss percentage (PL%) performance. The results for PL% showed that, for all voice call streams over both OLSR mesh and AODV mesh, the PL% was <1% with increasing number of hops, thus falling within the recommended requirements. It is worth mentioning that the results of AODV mesh showed that, being a reactive routing protocol, AODV sent periodic route request (RREQ) and route reply (RREP) packets to find paths, thus introducing higher control overhead.

The results presented in this section provide key insights into the performance of OLSR and AODV in a Wireless Mesh Network (WMN) under increasing voice calls. The next section presents a discussion on these key insights along with comparison with findings from related works reviewed in Section 2.

6. Discussion

The section discusses the experimental outcomes presented in the previous section within the broader research landscape and highlights key observations such as: (a) the performance trends in OLSR and AODV; (b) impact of increasing call volume; (c) packet loss performance; (d) scalability concerns in multi-hop WMNs; and (e) propositions for community WMNs.

6.1 Performance Trends in OLSR and AODV

The experimental results demonstrated that OLSR consistently outperformed AODV in terms of latency and jitter, particularly as the number of simultaneous voice calls increased. This aligns with the results in [12], [13], [22], where OLSR exhibited better efficiency in maintaining low delay and jitter in multi-hop environments. Due to the reactive routing properties of AODV, which involves on-demand route discovery, contributed to higher delays, especially as the network size and traffic load increased.

A key discovery was that both protocols exceeded the preferred one-way latency of 150ms after 2 hops for a single call and after 1 hop for multiple calls, indicating that WMNs inherently struggle with latency-sensitive applications like VoIP. The 4-hop and 3-hop thresholds for exceeding 400ms delay in OLSR and AODV, respectively, confirm prior studies ([14], [15]), which found that multi-hop routing amplifies delay increase, particularly in single-radio mesh networks where half-duplex transmission causes additional queuing delays.

6.2 Impact of Increasing Call Volume

The study emphasized that as the number of simultaneous voice calls increased, mesh network performance degraded significantly, with higher latency and jitter across all hops. This trend was particularly evident in AODV, where latency increased more sharply due additional routing overhead of frequent route discoveries. Similar results were observed in [13] and [16], where AODV exhibited higher control overhead under increasing network loads, leading to elevated delays compared to proactive protocols like OLSR.

Additionally, jitter increased with each additional call, with AODV experiencing greater variations in latency than OLSR. This is consistent with studies[15] and [17], which linked the poor jitter performance of AODV to the routing protocol's variable path establishment times and route maintenance overhead. Voice calls crossing the recommended jitter of <30ms after only 2 hops reinforces the idea that WMNs require QoS-aware routing mechanisms to maintain real-time application performance.

6.3 Packet Loss Performance

While latency and jitter degraded with increasing traffic, packet loss remained below 1% across all simulations, which falls within the ITU-T recommended limits for VoIP ([[3], [23]). This suggests that both protocols were able to sustain reliable packet delivery, despite experiencing increased transmission delays. However, it is important to note that while packet loss was minimal, the observed latency and jitter issues indicate that voice quality would still suffer significantly due to increased buffering and potential out-of-order packet arrivals.

Moreover, the higher control overhead in AODV due to frequent route requests (RREQs) and replies (RREPs) may have contributed to network congestion, further worsening latency and jitter. This corroborates findings from [21], where AODV introduced additional signalling overhead in dense mesh topologies, leading to performance degradation under heavy traffic conditions.

6.4 Scalability Concerns in Multi-Hop WMNs

The results confirm the scalability challenges of multi-hop WMNs as network size and traffic load increase. The drop in performance beyond 3-4 hops, particularly in AODV, aligns with previous research ([14], [19]), which emphasized that multi-hop propagation delays become a critical bottleneck in mesh networks. This is especially relevant for voice traffic, where even small increases in latency and jitter can result in noticeable degradation in call quality.

Furthermore, proactive routing (OLSR) exhibited better scalability than reactive routing (AODV), consistent with the conclusions drawn in [12] and [21]. However, while OLSR performed better, its latency still exceeded 400ms after 4 hops, indicating that even proactive protocols face scalability limitations in large WMNs. These findings necessitate further investigations on routing to improve scalability. In future experiments, protocols with hybrid properties such as HWMP [20] will be explored for scalability.

6.5 Propositions for Community Wireless Mesh Networks

Given that community WMNs are primarily deployed in rural and low-income areas to provide affordable Internet access ([4], [6], [9]), the observed results carry important suggestions.

1. Routing protocol matters: The experimental results and discussions, show OLSR as a suitable option for community WMNs due to its lower latency and jitter, making it a better choice for real-time applications like VoIP. AODV may be more effective in lower-traffic networks, but its scalability limitations make it less ideal for large-scale deployments.
2. The rapid degradation of voice quality beyond 3 hops suggests that QoS-aware routing enhancements are necessary. Implementing traffic prioritization and bandwidth reservation could help mitigate the impact of increased load on latency-sensitive applications.
3. Results highlight the need to evaluate the integration of MIMO technology and higher spatial streams to improve capacity and coverage.

7. Conclusion and Future Scope

This paper advocates that community WMNs are a viable option for closing the digital gap in the rural areas of sub-Saharan Africa and developing Asia. However, WMNs present scalability challenges as the network topology changes due to growing number of nodes and users. This paper presents preliminary results of a research aimed at improving scalability of WMNs and promote their integration in rural communities. Latency, jitter and PL% results of up to 5 simultaneous VoIP calls over a 9-hop WMN using OLSR and AODV routing protocols are presented in Section 5 of the paper. The objective of the experiments was to select a mesh routing protocol for future experiments aimed at improving scalability of WMNs. The analysis of results showed OLSR to be a better choice than AODV for WMNs.

However, the scalability experimental setup leaves room for further improvement, which will be addressed in future research. Moving forward, the study will explore the impact of latency, jitter, and packet loss percentage (PL%) in various scenarios, including: (a) scalability of a WMN during video traffic transmission; (b) move from linear to grid WMN topology; (b) introduce mobile phones in the simulation environment with mobility; (c) experiment different types of traffic in the WMN; (d) simulate different types of traffic scenarios such as traffic being generated between multiple nodes simultaneously; (e) utilizing Multiple Input Multiple Output (MIMO) routers for WMN setup; (f) analysing the effect of varying distances between routers on scalability; (g) examining the impact of signal strength variations; (h) scalability with other propagation and loss models; (i) scalability with other routing protocols such as hybrid routing protocols. Through these investigations, the research aims to provide valuable insights into the quantification of WMN scalability.

Data Availability

none.

Conflict of Interest

The Author declares that there is no conflict of interest to report.

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Authors' Contributions

Dr. Shree Om, as the sole author of this research paper conducted the literature review, designed the study framework, developed the methodology, analysed the data, and interpreted the results. The author also wrote the manuscript, reviewed all sections, and approved the final version for submission.

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