Journal of Research Administration
Society of Research Administrators International

Pointer Based Qos Enabled Mobility Management Algorithms For Wireless Mesh Networks

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Abstract:

To enable Wireless Mesh Networks (WMN), The IEEE 802.11s standard be created by a focus on incorporating the hybrid wireless mesh protocol (HWMP). for routing between mesh stations. However, IEEE 802.11s did not address the mobility of exterior station. To tackle client mobility, numerous mobility management schemes were introduced, including ANT, Mesh Mobility Management (M3), Infrastructure Mesh (iMesh), SMesh, MEsh networks by MObility management (MEMO), Wireless mesh Mobility Management (WMM), Static Anchor Scheme, Dynamic Anchor Scheme, LM Mesh, Session-to-Mobility-Ratio base method, with Forward Pointer-Based Mobility Management method (FPBR).Remarkably, not any of these scheme, apart from FPBR, contain seamlessly incorporated through IEEE 802.11s to support mobility for external stations. FPBR, though, was designed primarily for internet traffic. In the context of WMN, it's crucial to address both internet and intranet traffic for external stations. In this study, we introduce an enhanced version of FPBR, referred to as Enhanced FPBR (EFPBR) Scheme, capable of managing both internet as well as intranet transfer. We conduct a comprehensive statistical study and simulation of both HWMP and EFPBR schemes, comparing their performance metrics. Our results demonstrate that EFPBR outperforms IEEE 802.11s in terms of throughput, end-to-end delay, routing overhead, standard handoff cost, with the amount of route managing packet transfer for each handoff.

1.1. INTRODUCTION

In Wireless Mesh Networks (WMNs), mesh clients are typically mobile, while mesh routers and gateways remain stationary. The gateway assumes the role of WMN's central coordinator, storing addresses for both mesh clients (MCs) and mesh routers (MRs). As an MC moves, it must disassociate as of its subsequent MR and set up a link by a latest MR, a process referred to as changing its attachment point. Traditionally, this change triggers the transmission of a signaling message toward the gateway (GW) to modernize it by the MC's new position information.

present a procedural approach aimed at reducing the frequency of signaling messages. We introduce Quality of Service-based Mobility Management (QBMM) algorithm designed specifically intended for wireless mesh network. These algorithms leverage the concept of forwarding a pointer. When an MC shifts its attachment point between MRs, a pointer is established between the previous MR and the newly visited MR. This pointer setup process eliminates the necessity of sending a location update message to the GW for the MC's current whereabouts. Consequently, this approach minimizes the number of wireless connections needed to maintain MC services. Our analysis encompasses the proposed algorithms in the context of both internet and intranet sessions.

1.2 PROPOSED MOBILITY MANAGEMENT ALGORITHMS

introduce a Quality of Service (QoS)-based mobility management algorithm designed for Wireless Mesh Networks (WMN). Within this algorithm, the Gateway (GW) maintains a record of each Mesh Client (MC) and its corresponding Anchor Mesh Router (AMR) address. The Anchor MR functions as the leader of the MR chain responsible for connecting to the MC.

When an MC seeks to initiate an internet session, it forwards a request to the currently associated MR. This MR then relays the request to the GW through multiple MRs. Consequently, data packets destined for the MC are routed through the designated AMR for that MC. To illustrate this process, let's consider a scenario where the MC is currently receiving service from MR3, as depicted in Figure 1.1. The MC's internet access follows a connection sequence that traverses the following path: GW - MR1 - MR2 - MR3 - MC.

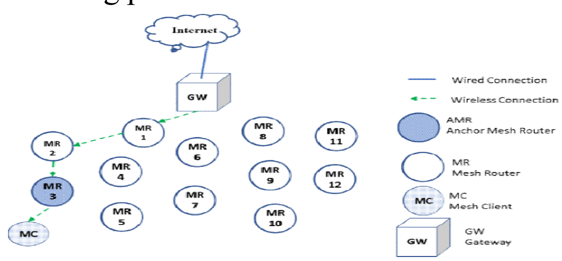

Fig.1.1 Internet access in WMN using pointer forwarding

If the Mesh Client (MC) relocates to MR5, and the ETX and distance values between the Gateway (GW), Anchor MR (AMR), and Current MR (CMR) are lower than those of the GW - CMR path, a pointer is established between MR3 and MR5 without updating the GW about the MC's new location. This pointer setup involves an exchange of signals between the old MR and the new MR. Consequently, MR5 takes on the role of the Current Serving MR (CMR), while MR3 continues as the Anchor MR (AMR). information packet anticipated for the MC be initially routed toward the AMR and then forwarded to the CMR. The internet connection sequence to reach the MC becomes GW - MR1 - MR2 - MR3 - MR5 - MC. The forward length of the pointer is now 1, as depicted in Figure 1.2

ISSN:1539-1590 | E-ISSN:2573-7104
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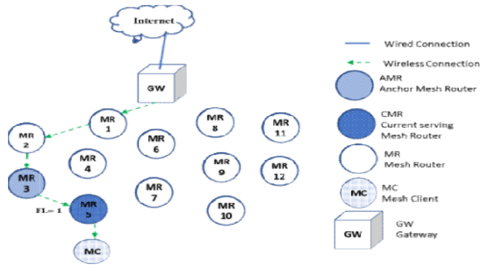


Fig.1.2 Pointer setup in WMN for FL=1

If the Mesh Client (MC) relocates to MR7, and the ETX and distance values between the Gateway (GW), Anchor MR (AMR), and Current MR (CMR) are lower than those of the GW - CMR path, a pointer is established between MR5 and MR7 without updating the GW about the MC's new location. This pointer setup repeats between two routers without GW receiving updates on the MC's location. As a result, the pointer forward length increases to 2. MR7 becomes the new CMR for the MC, while MR3 continues to serve as the AMR. The internet access connection sequence for the MC now follows this path: GW - MR1 - MR2 - MR3 - MR5 - MR7 - MC, as visually depicted in Figure 1.3.

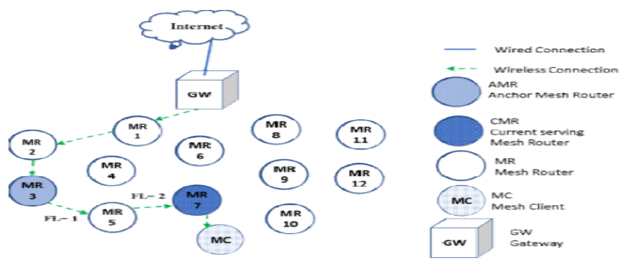
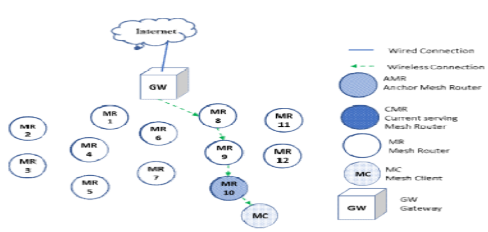


Fig.1.3 Pointer setup in WMN for FL=2

The pointing process persists until two conditions are met: first, the distance of the GW-AMR-CMR path must be shorter than that of the GW-CMR path, and second, the ETX of the GW-AMR-CMR path must be lower than that of the GW-CMR path.

If the conditions mentioned earlier are not satisfied, a position update communication containing the MC's present location is dispatched to the GW. This prompts an update of the MC's present CMR toward align with AMR, and the Gateway retains the new MC AMR address. Subsequently, data packets destined for the MC are redirected to this updated AMR.

For instance, if the MC relocates further away, such as to MR10, and the distance and ETX criteria are unmet, a location update is initiated, designating MR10 as the MC's new AMR. The MC's Internet access connection then follows the path GW - MR8 - MR9 - MR10 - MC, as depicted in Figure 1.4.



ISSN:1539-1590 | E-ISSN:2573-7104
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Fig.1.4 Location update in internet session of QBMM

1.3 QBMM AND ITS SYSTEM MODEL

Mesh routers play a central role in establishing the infrastructure of a wireless mesh network (WMN). Illustrated in Figure 1.5 is a grid-based WMN with 25 nodes, where each encircled number signifies a mesh router. Within this proposed network architecture, MR3 operates as the gateway (GW), responsible for storing the addresses of both mobile clients (MCs) and mesh routers (MRs).

In this WMN configuration, MCs have the flexibility to seamlessly switch between any of their four neighboring MRs. The quality of wireless links in the WMN is assessed through two primary metrics: expected transmission count (ETX) values and delay values. ETX specifically quantifies the anticipated number of transmissions required to ensure a successful packet transfer over a given link

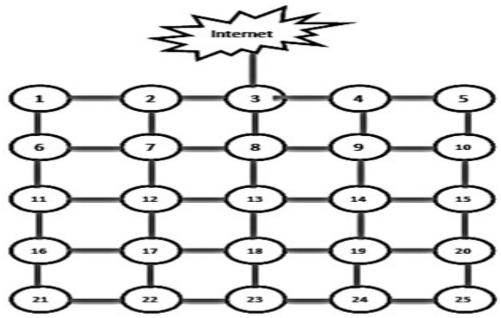

Fig.1.5. A 5×5 grid based WMN

The calculation of the path's Expected Transmission Count (ETX) is determined by the following process. Let P represent the probability to a packet transfer as of node 'i' to node 'j' will fail. In cases of unsuccessful transmission, the 802.11 MAC protocol initiates packet retransmission. Consequently, we calculate P using equation (1.1).

$$P = 1 - \left(1 - P_f\right) \times (1 - P_r) \quad (1.1)$$

P_f represents the probability of successfully receiving a packet at the receiver's end, while P_r signifies the likelihood of receiving a successful acknowledgment at the sender's end. Equation (1.2) is employed to denote the probability of a packet being delivered successfully from node 'i' to 'j' after k attempts.

$$S(k) = P^{k-1} \times (1 - P) \quad (1.2)$$

Finally, ETX, given in equation (1.3), denotes the amount of expected transmission needed on the way to transport a packet commencing ' i ' toward ' j 'successfully.

$$ETX = \sum_{k=1}^{n} k \times S(k) = \frac{1}{1-P} \quad (1.3)$$

The entire ETX of several random pathway be the amount of the ETX of every connection that constitutes the pathway, given through equation (1.4)

$$ETX(path) = \sum_{n=i}^{j} ETX(n) \quad (1.4)$$

1.4 SERVICE DELIVERY AND LOCATION UPDATE IN INTERNET SESSION:

During internet sessions, the Gateway (GW) initially receives all packets destined for mesh clients, effectively assuming the role of the source Mesh Router (SMR). When an MC transitions

ISSN:1539-1590 | E-ISSN:2573-7104
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to a new MR, we utilize equations (1.5) to (1.7) to assess the ETX and distance values along the path.

$ETX(CMR, AMR) \geq ETX(GW, CMR)$(1.5)

$ETX(CMR, AMR) + ETX(GW, AMR) \geq ETXth$ (1.6)

$d(CMR, AMR) \geq d(GW, CMR)$ (1.7)

where, $ETX(i, j)$ is the expected transmission count between the $i^{th}$and j^{th} MR and $ETX_{th}$is the ETX threshold value and $d(i, j)$ is the distance between the i^{th} and j^{th} MR.

If the conditions outlined in equations (1.5) to (1.7) for ETX and path distance are met, the new Mesh Router (MR) will transmit a location update to the Gateway (GW) to record the current location of the mesh client. Consequently, the Mesh Client's (MC) Current Mesh Router (CMR) is updated to match its new Anchor Mesh Router (AMR). The address of this new AMR is then stored in the gateway.

In cases where the conditions for ETX and path distance in equations (1.5) to (1.7) are not satisfied, a pointer is established between MRs to avoid sending a location update to the GW. Algorithm 1 outlines the Quality of Service-based Mobility Management (QBMM) approach for internet sessions in Wireless Mesh Networks (WMN).

Algorithm:1

Step1: if (MC enters into new MR region)

Step2:if $ETX\ (CMR, AMR) > ETX\ (GW, CMR)$ &&$ETX\ (CMR, AMR)\ +\ ETX\ (GW, CMR)\ \geq ETX_{th}$

Step3: if $d\ (CMR, AMR)\ \geq d\ (GW, CMR)$

Step4: Trigger location update

Step5: Reset pointer sequence length (K)

Step6: Update CMR the same as AMR

Step7: else

Step8: place a pointer

Step9: end if

Step10:end if

Step11:end if

1.5. RESULTS AND DISCUSSIONS

The presented algorithms undergo analysis for both intranet and internet sessions, with a comparison against the Pointer Forwarding Algorithm (PFA), Without Pointer Forwarding Algorithm (WPFA), and Dynamic Mobility Management Scheme (DMMS). The evaluation encompasses various performance metrics, including total communication cost, end-to-end wait, plus network throughput. table 1.1 illustrates the replication settings for the QBMM.

ISSN:1539-1590 | E-ISSN:2573-7104
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Table 1.1: Simulation parameters for the QBMM.

parameter	**significance**
Simulation period	400s
amount of nodes	25
Traffic source	CBR
packet amount	512 bytes
packet period	20 ms
MAC	802.11
Antenna	Omni directional

1.5.1 PERFORMANCE OF QBMM FOR INTERNET SESSION

Illustrates the total internet communication costs for QBMM. WPFA demonstrated significantly elevated signaling costs due to the necessity of transmitting location updates to the GW each time an MC changes MRs. These signaling messages traverse multi-hop communication paths, resulting in increased costs.

Conversely, while PFA and DMMS exhibit lower signaling costs, their data delivery costs are comparatively higher. Notably, QBMM consistently achieved lower total communication costs when compared to the Pointer Forwarding Algorithm, Without Pointer Forwarding Algorithm, and Dynamic Mobility Management Scheme.

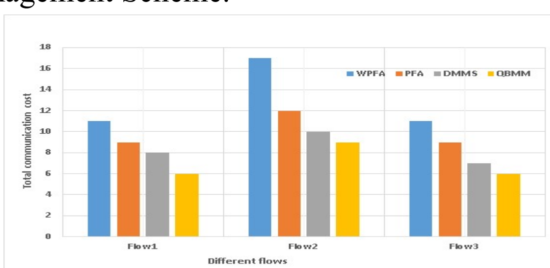

Fig.1.6. - Total communication costs of QBMM for internet sessions

The proposed technique exhibits an enhanced throughput percentage when compared to WPFA, PFA, and DMMS. This improvement stems from QBMM's utilization of ETX as a routing metric and its capacity to update the Anchor Mesh Router (AMR) based on ETX and distance parameters.

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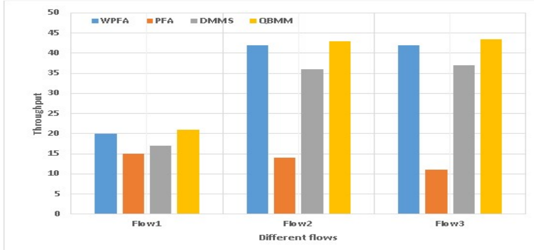
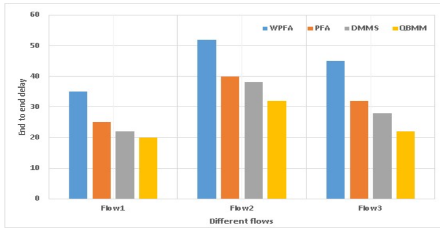


Fig.1.7 - Throughput of QBMM for Internet sessions



g.1.8 - End to end delay of QBMM for Internet sessions

1.6.CONCLUSION

introduces Mobility Management Algorithms (QBMM) tailored for wireless mesh networks. In QBMM, the Mesh Router (MR) instigates GW registration based on path ETX and distance values. When these values are below predefined thresholds, a pointer is established between the MRs to circumvent location updates to the GW. Conversely, if the values exceed the thresholds, a location update procedure is initiated towards the GW.

The network's performance is examined for both internet and intranet traffic. QBMM demonstrates improvements in total communication cost, end-to-end delay, and throughput when compared to the Pointer Forwarding Algorithm (PFA), Without Pointer Forwarding Algorithm (WPFA), and Dynamic Mobility Management Scheme (DMMS).

QBMM demonstrates notable improvements in various performance metrics. The average throughput in QBMM (36.66 Kbps) registers a 20% increase compared to DMMS (30 Kbps) and a 13.33% increase compared to PFA (23.33 Kbps).

For internet sessions, QBMM achieves a noteworthy decrease in the average end-to-end delay (24.6 ms), marking a 23.9% reduction compared to PFA (32.33 ms) and a 16% reduction compared to DMMS (29.33 ms).Furthermore, the average total communication cost in QBMM (3) exhibits a substantial reduction, with a 47.4% decrease compared to PFA (13.33) and a 15.96% decrease compared to DMMS (8.33).In terms of average throughput, QBMM (36 Kbps) demonstrates a 20% increase compared to DMMS (30 Kbps).

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ISSN:1539-1590 | E-ISSN:2573-7104
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