MOBILITY MANAGEMENT IN MPLS BASED WIRELESS NETWORK BY A SEAMLESS HANDOFF SCHEME

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Abstract: Enterprise level networks are designed to provide a fast way of communication across the globe. One of the most popular protocols used for such a network is known as Multi-Protocol Label Switching (MPLS). The fast packet forwarding mechanism from source to destination with Quality of Service (QoS) feature, MPLS is capturing a significant attention in the related market of network protocol. End nodes are expected to accomplish mobility behavior more frequently nowadays. The aim of this study is to explore, examine and propose a smooth mobility handling technique that helps in the deployment of MPLS based wireless network. There are already some proposed solutions for this problem of mobility handling, but they have certain drawbacks which are highlighted in background section. In this research work, a complete MPLS packet life cycle is described, from entering inside the MPLS clouds to reaching its destination without compromising QoS and layer overlapping. Presence of a stack at every Edge Router (ER) helps to manage packet information of missing or moved MN for future use. Simulation of the proposed idea is performed in Network Simulator (NS-2), and User Datagram Protocol (UDP) is used as the source for packet transmission from the MPLS cloud to the MN that noticeably illustrates that how the new proposed scheme is better than already proposed models. By concentrating on the packet life cycle in entire communication best results are obtained from the simulation and compared with previously proposed models. The proposed scheme has performed better with respect to packet loss, Packet Delivery Ratio [Fraction] (PDF), Normalize Routing Load (NRL) and Delay as compared to the existing solution.

***Keywords* – MPLS (Multi Protocol Label Switching), QoS, Datagram, Edge Router, Mobile Node, (MN), Handoff.**

I. INTRODUCTION

MPLS is one of the rapidly growing backbone network protocols for the enterprise level environment. Its architecture and functionality improves the packet forwarding mechanism between the ingress and egress of the network. Ingress is an entry point on MPLS network where Internet Protocol (IP) [1] packets enter inside MPLS clouds, at this point MPLS label is pushed on IP packet, and the packet is converted from the IP packet to MPLS packet. Egress is an exit point for MPLS packets, at this point label is popped from the packet, and packet converts back into its original shape as IP Packet. The label of the MPLS packet consists of 32 bits (4 bytes) which take very little time at Label Switch Router (LSR) [3] for processing (taking decision). These 32 bits are further split into 4 sections for quick, secure and intelligent packet switching between MPLS cloud. i. Label Value (20 bits) ii. Class of Service "Experiment or future Use" (3 bits) iii. Stack (1 bit) iv. Time to Live (TTL) (8 bits). The whole 4 bytes of MPLS label are known as "shim" which resides between the layer two and the IP layer headers. Based on the label of 20 bit value it is very easy and fast for an LSR to decide which is the subsequent hop for the packet. The next 3 bits are experimental bits that maybe used as QoS or Class of Service (CoS) [4]. The stack bit of shim is used as a 0 for additional labels and 1 for the end of the stack. TTL bits are similar as in the IP header for countdown routers, and if it reaches 0, then the packets are dropped. Today's main challenge for an engineer is to handle mobility when an MPLS based network is deployed as a backbone and the Mobile Node (MN) frequently moves between different networks. Following are the core components of mobile communication with MPLS protocols, which must be handled when the MN performs a handoff operation:

1. Signaling (Handoff initiation)
2. Creation and selection of new LSP
3. Minimize packet loss
4. Providing QoS

Mobility management in a distributed environment is very helpful to end bottlenecks and reduces processing overhead by core devices [5]. So it is important to introduce an architecture that can manage mobility in a distributed environment where a single device is not responsible for handling every single entity. Processing work is shared among different devices to minimize the delay during communication and especially during handoff operation. Carmona-Murillo et al., in his research have proposed the concept of MDA [6] in which MDA was an anchor entity and used as a single device for signaling, packet storage and data forwarding. MDA was also used as the temporary storage device (create multiple buffers) rather than as a routing device. MDA was in addition responsible for the redirection of the LSP when the MN moves to a new network. Distributed Mobility Management in MPLS (DM3) [6] proposed a solution that distribute data and control plane while the MN moves from one LSP to another, centralize nature of operations are performed in this solution by the MDA. From the already proposed solution to handle mobility in MPLS based environment, the main challenge is keeping track of MN and to handle in-flight data is the main challenge to be addressed while keeping in mind that MPLS based network connection from the Correspondent Node (CN) to the MN follows a specific path for data transmission. Centralized solutions, multiple buffers and involving MN as the service device all lead to a new type of problem. The rest of the paper, work is organized and distributed in following subsections: In section 2, the overall research area and related work done by the researchers is discussed in detail, the design of the proposed mobility management in an MPLS based network is presented in section 3. Network Simulator version-2 (NS-2) backgrounds and actual simulation of the proposed idea with graphical results are presented in section 4. In section 4, normal working scenario of a similar type of wireless network is presented and compared with the proposed idea. Section 5 presents the conclusion of the research from the obtained results and discussions related to research on contributions, limitations and deployment of the proposed idea.

II. LITRATURE REVIEW

Work has been done in literature review to solve the problem of mobility, while MN moves from one access area to another. There are many authors that proposed their understanding of handling mobility with the well-known techniques in MPLS based or similar kind of networks which is discussed in this paper. As a whole, the paper highlights the existing models with their pros and cons. In the MPLS mobile network, main issue arises when the MN moves from one BS to another BS and to cater that, in this proposed solution, an agent is introduced known as the Bandwidth Agent (BA) to handle handoff operation [7]. The initiation of handoff operation and the creation of new LSP for MN take a considerable amount of time and during this process handling of data is not targeted and results in a large number of packet losses. In this proposed solution, the author introduces DM3 (Distributed Mobility Management in MPLS-based access or wireless networks) and tries to handle this 12 issue without using network layer information using a buffering technique in MDA (Mobile Data Anchor). The author also introduces MPLS with MIPv6 to handle mobility without using network layer information while packets are between ingress and egress of the MPLS network [6]. The process of a MN registration through the binding updates (BU) message with information of its current location is proposed in [15] and this process continues communication without disruption. It's an impressive quality of higher handoff latency scalability and signaling issues. This approach solves some problems related to mobility and resource provisioning, but when Mobile IP is used, it means implementation of a centralized environment (HA) in nature [6] not a distributed model. So the author is not fully implementing distributed architecture. Another author proposed enhancement in the label edge router called Label Edge Mobility Agent (LEMA) supporting chain LSP-redirection. Its FH-Micro mobile MPLS features are handled by L3 handoff using L2 characteristic and reduces signaling cost of fresh LSP [9]. In this model, some routing information is shared with MN and traffic between LER/FA masters and hosting FA is handled by multiple tunnels where the chance of QoS compromising, the main problem in this solution is higher delay and under-utilization of existing LSPs from the MN and CN. While maintaining routing path table (buffer) at MN is also not a good approach. The proposed model by the author focuses on keeping track of the mobile node; it is not the responsibility of a single LER/FA. Keeping track of all visiting LER/FA is the responsibility of the MN. This process introduces difficulties in mobility and network management.

Author proposes capability of MP-BGP overlay MPLS labels [8] that helps to handle mobility. The mobility label of MP-BGP is the time assigned by MPLS LER. The architecture does not need further mobile IP for handling mobility. No HA registration or CoA is required for continuing communication that helps to eliminate triangular routing. This is a type of Mobile-to-mobile direct communication [8]. In this approach exposing of MPLS label information outside MPLS clouds, while the MN moves from the access area to another access area. MP-BGP is aware of MPLS labels of MN. Issues with this approach are managing networks, avoiding un-authenticated communication and troubleshooting the error in such communication. Some of the concepts of this approach are used in the proposed idea while the handoff operation is handled and location update information between MN and ER/FA are exchanged. Handling mobility in heterogeneous environments is proposed by the author with administratively handling handoff operations [10]. This approach does not offer a smart solution for handling handoff with miss-utilization of bandwidth for unnecessary use. The reserved band with for LSPs is being wasted when handoff operation does not occur frequently. For maintaining reserve LSPs, every ER and LSR sends update information to all paths. It is not an intelligent approach and also not a smart solution for enterprise level networks. Micro-mobility MPLS uses its functionality between the Internet and ingress of the network, while macro-mobility handles mobility management between egress and MN. In the proposed model, a simple concept is implemented which separates L2 handoff operation and L3 handoff operation [11]. When a MN enters into an overlap area, it initiates a layer two handoff operations, which is handled by the local access points [11], if a LER/FA is involved in handoff operation, then a new LSP is required to create and update accordingly. In this approach chance of packet loss is high as MN has to wait for the new LSP to update; in-flight packets could be discarded at previous LER/FA.

In [12] author proposes a mix version of MIPv6 and MPLS with some revision in MIPv6. In the default configuration of the MIPv6 protocol MN uses Care of Address (CoA) for communication with CN when it is no longer in the home area. This process creates triangular routing between MN and CN for every packet must pass through the HA. In the modified version of MIPv6 when the MN communicates with CN or IP Host it maintains HASH for CoA. If the MN moves from its home area, then the already available CoA (in HASH) is updated with new CoA from the new access point which results in a quick, smooth and secure handoff. After the CoA is updated in [12], MN sends the registration data packet towards the HA and gets NAT details through searching the CoA in MPLS labels communicating with the target IP host directly. In [13] a model is proposed that combines MPLS and Micro mobility feature of Mobile IP and is collectively called Micro Mobile MPLS architecture. In [13] the Mobile IP could serve as a basic mobility management protocol but it has several drawbacks that include long handoff latency and long signaling load for more frequent handoff operation. So mobile IP is a powerful protocol to handle mobility issues but some area needs more improvement. The proposed model [14] is also very helpful for eliminating triangular routing problem because LCA directly updates the current location of the MN without contacting with HA. Packets are transmitted without extra node visiting from CN to MN that minimizes delay and finishes triangular routing problem, this process also includes the key factors of route optimization. In [14] for route optimization actual work is performed by some binding messages that are requested that may include warning and update messages. LCA is located at each ER and maintains its cache with Label Edge Router Home Agent LER/HA (LHA) that helps to authenticate the binding update message. The proposed model works similar to normal MPLS with wireless network support. The only addition is LCA that helps to manage mobility with the route optimization features. In this proposed scheme [15], smooth handoff operation is performed and scanning process performed by the mobile station is handled inside AP. But to deploy this scheme it is must to have Multiple Wireless Network Interface Cards (WNIC) at every AP and more than one channel should be available without overlapping each other. The control and data signals are handled separately when mobile station performs handoff operation. One WNIC is used for signaling purpose while the other is used for data communication. In this scheme one WNIC is reserved for scanning purposes only and packet loss is not highlighted during handoff operation. The concept of using more than one antenna at AP is now popular that helps to reduce signaling cost when handoff operation is performed. The mobile station (STA) that sends Probe Request to neighboring AP to perform handoff operation and before that it requests the serving AP to buffer data. In this proposed scheme handoff operation is handled smoothly and focus is on minimizing packet loss. In [16] multiple antennas are used at AP but there is no focus on packet loss when handoff operation is performed. In [16] handoff operation with minimizing packet loss is focused but in this model decision of performing handoff operation is proposed again at mobile station end. The buffering technique issued at serving AP and after handoff operation is completed, stored packets are transmitted to mobile station.

III. PROPOSED IDEA

In this paper, the proposed idea with a complete dry run of the system is presented. Based on the knowledge about the topic and related work section, in this paper an idea is proposed that combines some features from previous work with optimum results. This paper mainly focuses on the mobility handling for the proposed Multi-Protocol Label Switching (MPLS) [2] based wireless network.

3.1 System Model

Telecommunication is becoming the most important field of today's technological world and everyone wants faster mode of communication. The proposed idea is capable of handling mobility that is based on MPLS network and performs handoff operations that should improve the quality of communication and minimize packet loss. The main purpose of this research is to improve the performance of handoff operation, reduce signaling costs, remove triangular routing and intelligently handle packet loss with better Quality of Services (QoS). In this proposed solution, the MPLS works as the core network protocol because packet forwarding is faster than traditional Internet Protocol (IP) routing and switching. In the entire paper, the focus will remain on improvement in handling handoff operation with QoS. In the proposed scheme, the research works carried out MPLS based network infrastructure that is deployed throughout the backbone network for a mobile communication system. In the aforementioned Figure 1, router egress 3 (Egr 3) has three network ports like every other router for communication with core network, which are named as 3a, 3b and 3c. There are also one or more additional ports on each of the Edge Routers (ER) where Access Points (AP) are shown connected in the Figure 1 shown above at Egr 3, Egr 4 and Egr 5 for communication with Mobile Nodes (MNs) in the access region. With an ER, there could be one or more than one APs that are connected to the ERs depending on the requirement covering a particular area.

At every ER port, 'a' is used as the core connection between Label Switch Path (LSP) and egress (Egr) of an MPLS network. From that port, LSP's information and packets are received from the network (egress) or sent through the network(ingress). Where port 'b' and 'c' is used for sharing the IP Table updates between neighbors and the creation of temporary LSP for sharing MN data. MPLS Gateway (GW) router is used as a core network device to create, remove and update LSP, and it is also broadcasting the update towards the other connected devices. GW router is used as the manager of an MPLS network for both internal and external communications.

3.2 Detailed System Functionality

The proposed idea's working is discussed in detail here with all possible scenarios of handling packet. Here are the scenarios that will help in understanding the proposed system functionality with all possibilities. In the proposed solution, we only cover the hard handoff operation because new LSP could be created from the GW router after the location of the MN is confirmed from the serving ER, meanwhile, in-flight packets stored at the previous ER are sent to MN after initial authentication and registration. The core operation of the proposed scheme is split into two subsections.

i. Normal working

ii. Handoff Operation

3.2.1 Normal data flow without any handoff or Normal Working

Here Egr 3 is selected as the default or home serving base station (BS) of MN, and all communications will be discussed concerning with this node. The normal working of the system is discussed in detail in below mentioned steps.

Step1:

In the first step, a packet is received on the default serving node, and there are two decision tables and one storage table at this step to handle the packet for decisions about packets further routing.

A. "Label Table"
B. "Stack Table"
C. "IP Table"

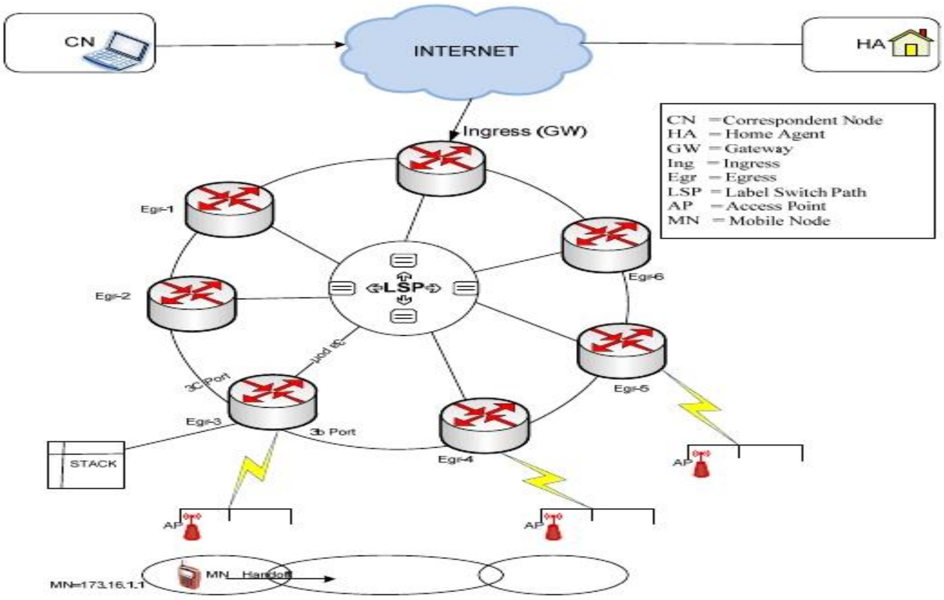

Figure 1: The Proposed Solution

When any packet reaches at any ER, it must pass below mentioned Label Table for lookup in order to determine the next hop for this packet. This table is same as the other Label Switch Router (LSR) which contains the Label Table for packet forwarding. Table 1 contains port information to check for the incoming port of the packet and label information to decide what to do if this label is found in a particular received packet. Prefix column of the Label Table is used for getting more detail about the packet's destination.

Table 1: (A) Label Table

In Port	Label	Out port	Label	Prefix
3a	31	-	-	173.16
3a	32	3c	41	173.16

After processing packet from the Label Table if no out port is found then the label is popped from the packet and that label is stored in a Stack Table with a copy of destination IP address of the packet. This step applies to every packet reaching at any router in the network with the same process. The prefix column is not at any LSR.

After that, the traditional IP table is used for lookup with packet for further routing and switching purposes which are discussed in the next step of this section. These tables are the actual decision points for routing and switching of the packet inside and outside MPLS clouds.

Table 2: (B) Stack Table

Destination IP Address	Reference Label	Packet Info
173.16.1.1	31	-
-	-	-

Stack table is also used for similar functions as the buffer proposed in different research work previously [15]. It is located at every edge router to store packets of a MN that is not in the access area and will be used in the future. By using stack functionality, it is very helpful to minimize packet loss while the MN is moving from one ER to any other ER or from one LSR to another LSR.

Removing a label from a packet is known as pop function. In an MPLS network, there are two possibilities of removing a label. Firstly, if label pop and a new label are pushed on the packet for forwarding to the next hop, this process is also called label swapping, which is performed inside MPLS clouds. Secondly, when a label is pop and IP packet is forwarded to the next hop which is performed at egress of the MPLS network. The first type of removing a label occurs at LSR, and second type occurs at Egr of MPLS network. Stack is designed to store the label information, IP Address and rest of packet for future use if the MN is not being found at that particular moment.

Step2:

After removing the label from the packet, ER processes the packet from the IP Table. The destination IP address field of the packet is matched with the IP Table entries and based on this result, a decision is made that in which direction the packet will be traveling. This is a simple process to match the IP field, check for the next hop and forward packet accordingly.

Table 3: (C) IP Table

Destination IP Address	Net mask	Next Hop	Interface
173.16.1.1	255.255.0.0	Local	-(AP)
173.16.1.2	255.255.0.0	Local	-(AP)
173.16.1.4	255.255.0.0	Egr 4	3b

3.2.2 Handoff Operation

Generally, a complete handoff process consists of following basic operations [17]:
i. Link Layer movement (Layer 2 Handoff)
ii. IP Layer Movement detection (Layer 3 Handoff)
iii. IP (re-) configuration
iv. Authentication, Authorization, Accounting (AAA) accessing the network in the legal way and
v. Handoff management signaling.

Here the focus will be on the handoff operation that is performed from the MN when it moves from one access area to another access area while communicating to a Correspondent Node (CN), and it is also known as an IP layer movement. A layer 2handoff operation is triggered and events related to Layer 2 occur which is an abstraction mechanism that separate upper layer from lower layer [18]. Handling handoff operation is the foremost challenge in the mobile network communication system. There are two types of handoff operations, ‘soft handoff’ and ‘hard handoff’.

The Soft handoff operation requires multiple connection nodes at the MN for creating new connections before removing the old connection for transparent movement. Hard handoff operation is performing opposite functionality; it breaks the old connection and creates new connection when the MN moves to the new access area. The handoff operation is performed in the proposed idea because there are no multiple Points of Attachment (PoA) for MN in MPLS based network. There is a single Label Switch Path (LSP) from the GW router to MN. But in this proposed idea, MPLS features are utilized that improve smooth communication within the system even when the MN performs the handoff operation. In the proposed system MN is not only registered at anew location but it is also assigned a new MPLS path. The in-flight data is also transferred more efficiently, transparently from a temporary LSP created between previous ER and new ER and packet loss is also minimized by Stack table functionality. In the research work, there are two possibilities that could occur when a MN performs handoff operations in the system which are described as follows.
1. “New IP Address registration”
2. “Use existing IP Address”

3.2.3. Case: Handoff Operation with new IP

When a MN moves from its existing ER, it needs registration at the new location; here suppose that upon an arrival at the new location, a fresh IP address is assigned to MN and all its in-flight data across the network is transferred at MN properly. In this case, it is also described how network devices request and response for setup of new LSP from GW router to MN while MN is communicating with CN.

In this scheme, we also proposed a temporary LSP creation between previous and new ER for transferring in-flight data which is stored in Stack Table and share updates accordingly. In Figure 2, a complete picture is represented while a MN moving towards new access network and re-registering its identification on the network. If the MN is performing a data or voice communicating while moving to a new location, all of its data will be sent after the basic registration within the network. Meanwhile, this operation performed by the data is stored in the previous ER in stack and will dispatch after location confirmation at new ER. At new location, ER Foreign Agent (FA) sends new and old registration identity to previous ER. Update information is exchanged between both ER and also transferred to the remaining or in-flight data of MN. As described in Figure 2, a temporary LSP is being established between previous and new ER for exchange of data, and it will remain established until the new LSP between MN and GW router is setup completely that works properly. The hard handoff operation of the proposed system works so efficiently that not a single packet is lost in the obtained results. Following are the steps to be performed for this handoff operation.

Step1:

Egr 4 receives hosting request from MN with its existing IP address after a solicitation request and advertisement response. Egr 4 performs following steps to entertain MN with network services in its access area.
i. Egr 4 sends the MN registration request to GW router.
ii. Egr 4 receives a new IP address with LSP information.
iii.Egr 4 sends information of MN with old and new IP to Egr 3 at port 3bthat MN is located in my area and available for communication with network.
iv.Egr 4 holds old IP Address of MN until the new LSP information is confirmed by the GW router and packets are received via newly established LSP.

Message to Egr 3 from Egr 4 = MN Old IP Address + MN New IP Address
Here are the descriptions of old and new IP address:
Old IP Address = IP-A
New IP Address = IP-A1

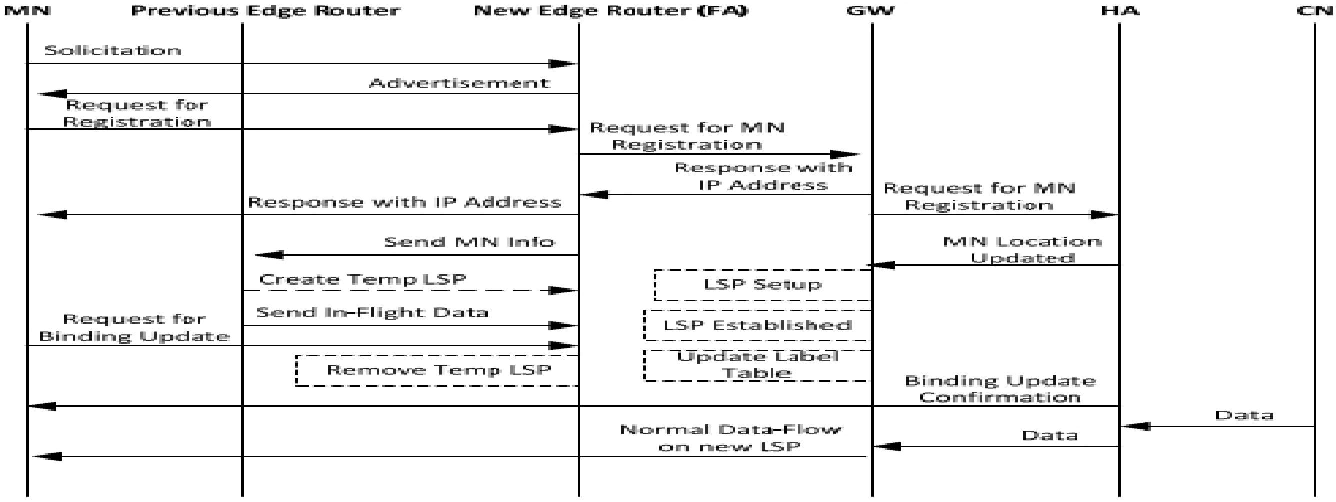

Figure 2: Handoff Operation with New IP Address

Step2:
Egr 3 receives a message from the Egr 4 and search contents in the Stack Table, if a message (IP-A) does not match with the stack destination IP address field, then the traditional IP Table will get updated (Replace the old IP address of MN withIP-A1 in IP Table).If the old IP address is found with destination IP address field in Stack Table, then following steps are taken at Egr 3:
i. Create a new temporary LSP between Egr 3 and Egr 4.
ii.Sort all packets of matched MN and push a new label for every packet.
iii.Forward all MPLS packets towards Egr 4 by using temporary created LSP.
iv.Update Egr 3 Label Table.
For updating the label in Label Table, stack label field is matched with Label Table's label field and Label Table is updated with fresh out port and new label. Updating of the Label Table at Egr 3 is processed because in-flight packets do not spend more time at this node and are quickly forwarded to Egr 4.

In Port	Label	Out port	Label	Prefix
3a	31	3b	41	173.16
3a	32	-	-	-

Table 4: Updated Label Table at Egr 3

Once the stack is empty, then in flight packets are forwarded by using an updated Label Table via a temporary created LSP between Egr 3 and Egr 4. This LSP is available until packets are traveling on the new LSP from GW router to MN.

Step3:
Packets are now traveling from Egr 3 to Egr 4 with a new label on the top of every packet. Egr 4 receives the packet and matches those packets with Label Table and if no out port is found in the Label Table for received MPLS packets, then the label gets popped from the stack. A copy of destination IP address in the packet also gets stored in a Stack Table as described in section 3.2.1. Now this packet has become IP packet and it will travel down the IP Table with the old destination IP address. The IP Table is matched with packet destination IP addresses, where if found the old IP address (IP-A) in the table, there would a new IP address (IP-A1) found for same MN in IP Table. When two IP addresses are found with the same MAC (Media Access Controller) address then Egr 4 adds an IP Header with the new destination address (IP-A1) to each received packet from the Egr 3 and will send these packets to a local AP to dispatch further to MN. Local AP forwards this packet towards MN and MN checks for destination IP address and receives the packet because the MN current IP address (IP-A1) is same as in the received packet top IP header. MN removes the destination IP address header from the received packet, the packet still contains another IP address header, which is the old IP address (IP-A) of MN. That IP header is ignored by the MN because MN already finds its new IP address (IP-A1) in the packet. The packet is forwarded to the upper layer (Data Link Layer) for further processing.

3.3 Intermediary Nodes
The intermediary nodes between Egr 3 and Egr 4 are used in simulation that serve as a stack table in our proposed idea and also as a repeater for long distance destination. There are total 3 intermediary nodes used between one ER to another and placed at over 200 meter distance to handle the smooth working of the proposed idea.
These nodes might result delay but certainly reduce packet loss while MN move from one access area to another. Hierarchical routing is performed when intermediary node concept is introduced that separates wireless routing from wired routing and management gets also better if we want to extend our network. Mobile Host (MH) issued in simulation to transparently handle handoff operation and things related to mobility management in this proposed idea.

IV. SIMULATION AND RESULTS

4.1 Simulation and Simulation Parameter

The network simulation is a technique that is used to model the behavior of a specific network functionality either by calculating the entities (nodes/hosts/links/packets/delay, etc.) interaction with a different network using mathematical formulas, or actually recording, playing and analyzing with observations from a production environment of the network. The simulation can be time driven or event driven. Both types of scenarios are merged in this simulation work, but the main results are achieved by a specific time period. The simulation work is split into three major sections design, simulation and results. The simulation parameters are defined in Table 5.

Table 5: Simulation Parameters

Simulation Parameters	
Parameters	**Values**
MAC Type	IEEE 802.11
Antenna	Omni directional
Link between ER and AP	Duplex 5Mb 2ms
Simulation Time	150 Sec
Simulation Area	600 x 600
Transmission Range	150 meter
Interface Queue Length	50
Data payload	512 bytes/ packet
Packet Type	UDP
Traffic Type	CBR
Queue (Buffer) Size	100 packets at a time
Node Pause Time	0
Packet rate	50 packets/Sec
No. of Nodes	5
Mobility Model	Random
MN Speed	7.70 meter per second

4.1 Simulation Setup

Simulation section is the representation of how the actual work will be performed in real time. The following nodes for this simulation works are used.

i. Egr 3 as Node0
ii. Intermediary nodes
iii. Egr 4 as Node1
iv. AP 3 attached with Egr 3 as Node2
v. AP 4 attached with Egr 4 as Node3
vi. MN as Node4

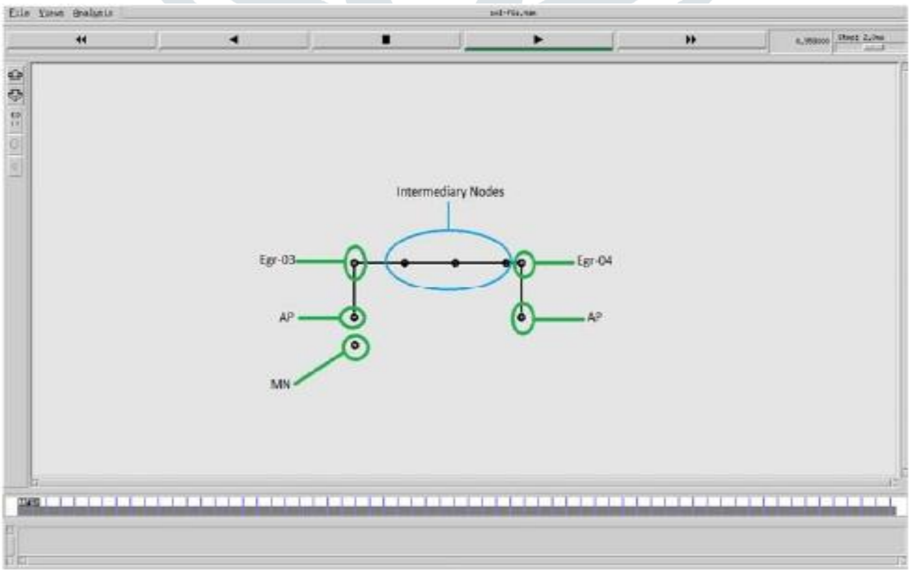

Figure 3: Detailed Simulation Design

In the Figure 3 the NAM interface shows nodes used in this simulation process. The nodes are captioned for understanding, but it looks different in real environment. The MN is currently located at home access area. The intermediary nodes that work as stack/buffer are highlighted in different color and these nodes perform very important role when MN moves from Egr-3 access area to Egr-4.Further detail about these intermediary nodes is presented in next section.

This simulation process is split into two scenarios, where one scenario works as normal working scenario without taking care of

in-flight data, while the proposed scheme work as mobility management of in-flight data and minimize packet loss. The design part of both scenarios is mostly the same, only intermediary nodes introduced in this proposed scheme are part of second simulation process. Initial scenario does not contain intermediary nodes that are helpful for minimizing packet loss while MN performs handoff operation.
The Table 2 shows sent packets, received packets and dropped packets, from both scenarios and the results that include Packet Delivery Ratio [Fraction] (PDF),Delay [19] and Normalize Routing Load (NLR) [19] of the simulation work. These results are extracted from the trace file with the help of AWK script. The PDF, NRL and delay factors are helpful to measure your system overall performance for a certain time frame. In the Table 6 the overall presentation of the system and minimization of packet loss is shown that strengthens the proposed idea mechanism.

Scenario/Variables	Packet Sent	Packet Received	Packet Dropped	PDF	NRL	Delay
Scenario 1	7447	7267	181	97.5829	1.0247	5.2432
The Proposed Idea	7311	7302	09	99.8768	1.0012	0.3765

Table 6: Results of Simulation

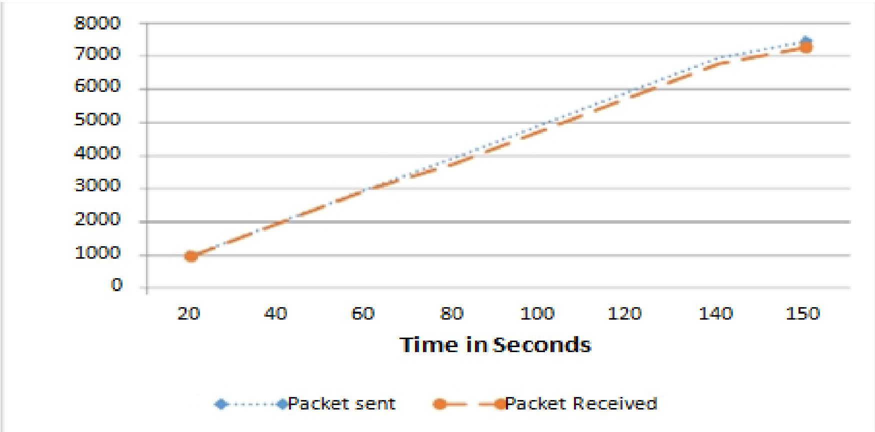

Figure 4: Scenario 1 Packet Sent Vs Packet Receive

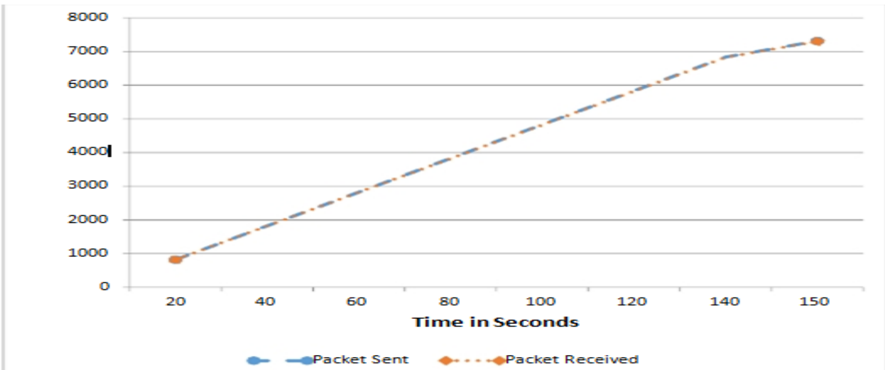

Figure 5: Proposed Idea Packet Sent Vs Packet Receive

Figure 4 shows that within the access area of MN, packets sent and received are almost same but when the MN crosses access area and tries to attach to neighbor access area, in this process massive amount of data is lost. Before handoff process initiation, packet sent line is overlapped by packet received because there is very little bit difference between sent and received.
The graphical results have been shown in Figure 5 that makes the proposed idea prominent over the normal working of MPLS based wireless network. The packet received line overlapping the packet sent, because there is a very little bit difference between packet sent and received.

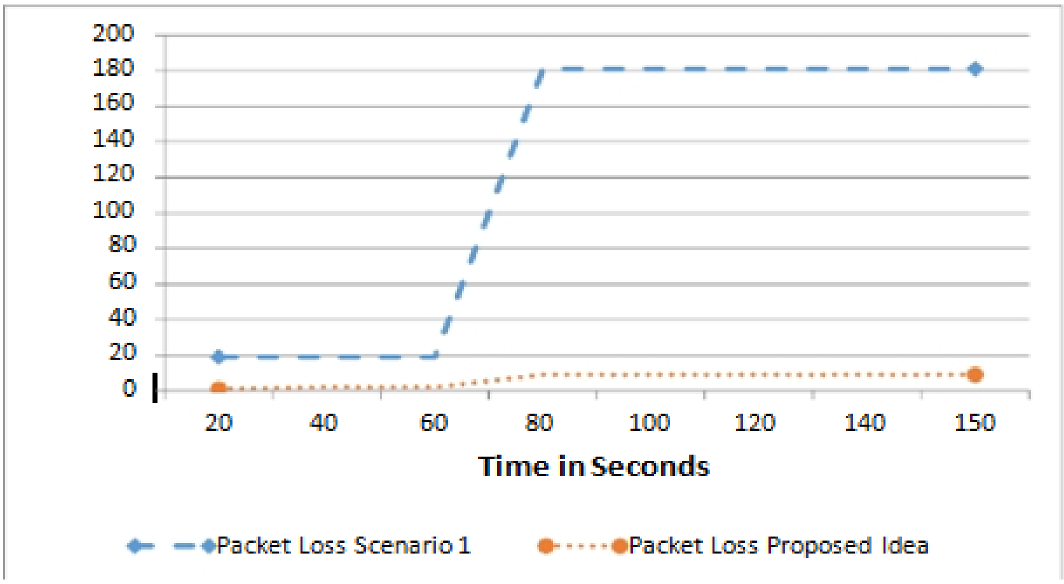

Figure 6: Packet Dropped Scenario 1 Vs Proposed Idea

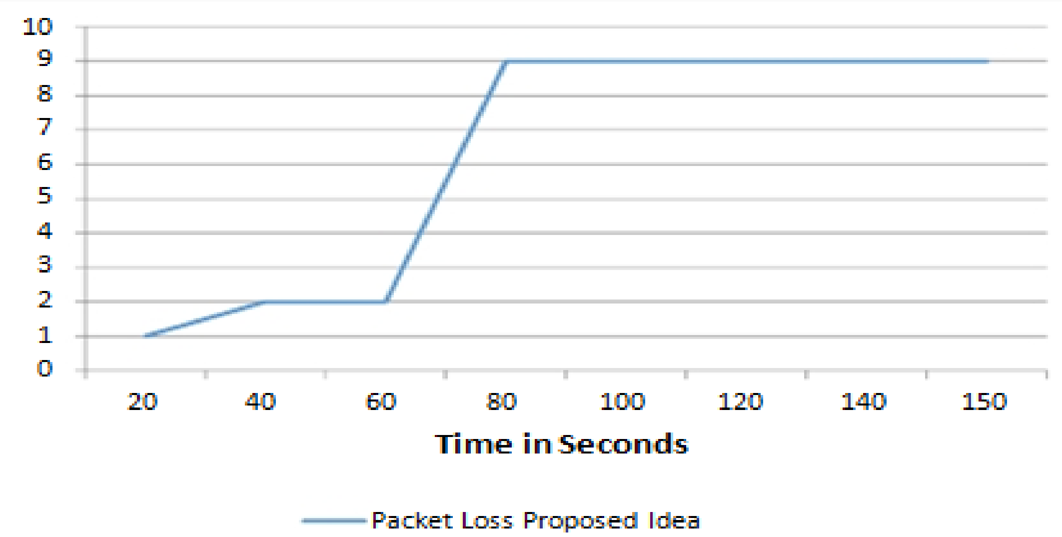

Figure 7: Packet Drop Proposed Idea

There is a very quick increase in packet loss for scenario 1 that is shown in Figure 6 as compared to the proposed scheme. The packet drop rate in the proposed idea is much lower and it is observed in Figure 6 that the packet loss in the proposed idea is around 2 packets at initial stage and a little bit more packet loss occurs when a handoff operation is performed. The in-depth view of the packet drop rate of the proposed idea is represented in Figure 7.

V. CONCLUSION AND FUTURE SCOPE

In this research work packet loss during handoff operation is minimized by using Stack Table at Edge Router (ER) "egress" of the MPLS network which was not intelligently handled in the earlier research work. The main contributions in this research cover minimizing the packet loss, delay and improve handoff operation functionality with minimum signaling cost. Introduction of Stack Table at ER and its efficient packet handling is the very important factor in future research work. Two different methods are proposed for MN re-registration with the network i-e, when it performs a handoff operation that is registered with an existing IP address and the other involves the registration with the new IP address. In both cases, the packet loss is handled very carefully. With new IP address registration, adding new IP header to in-flight data is introduced and an intelligent routing is performed based on new IP header. With existing IP address registration, when the MN performs the handoff operation, the communication process is recorded faster. With some positive developments with this contribution, there are still some limitations which need attention for making more improvements in this area.

The work can be further extended by exploring opportunities for pre-authentic connections for a MN that helps to minimize handoff signaling cost and also reduces stack processing in this scheme. The quick synchronization between MN and ER can help to minimize delay and improve system response time.

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