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A Distributed Mobility Management Scheme based on Software Defined Networks

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Abstract— Software Defined Network is used to simplify network management by separating network control logic and forwarding mechanism which is gaining popularity as a Network in the recent years. Distributed Mobility Management is an efficient Mobility Management technique which ensures network based Mobility Management, eliminates Single Point of Failure. On the other hand, Software Defined Networks increase scalability by separating Control and Data plane unlike traditional network system. In this paper, we implement DMM scheme by distributing Control and Data plane for Mobility Management in IPv6 based networks. This scheme is expected to minimize tunneling overhead due to encryption/decryption of the data packet and minimize signaling cost. Here, we distribute both control and data plane into multiple entities and provide a suitable algorithm for selecting an appropriate agent for incoming digital Mobile Node. The performance of the selection algorithm is planning to analyze in term of handover delay, signaling costs, packet Delivery cost end to end delay and throughput**.**

Keywords— Software Defined Network Centralized Mobility Management, Distributed Mobility Management, Single Point of Failure, Tunneling overhead

I. Introduction

The traditional network architectures which are hardware centric network are not suitable for dynamic computing and storage. Need to reexamine traditional network architectures due to the explosion of mobile devices and content, changing the traffic pattern, the "consumerization of IT", server virtualization, and the rise of cloud services. The complexity in existing network architecture leads to a few disadvantages that include vendor dependence, inability to scale and inconsistent policies [1]. The traditional network is based on packet accessibility. To fulfill the requirements of security, scalability, reliability and QoS for various applications, we need to design different network protocols and developed independently to solve individual application problems. Nick McKeown from Stanford University, proposed new paradigm software defined network (SDN) [2]. The Concept of Software Defined Network is emerging network paradigm proposed to overcome limitation of existing traditional network infrastructure. The complex design of traditional network is due to the tight coupling of Data Plane and Control Plane in term of network switches and routers [3]. Software Defined Network is "an emerging network architecture where the network control is decoupled and separated from the forwarding mechanism and is directly programmable" [4]. To separate the control plane and the data plane, we can use a well-defined application programming interface (API) between the switches and the SDN controller. The OpenFlow [5], [6] is mostly used API. OpenFlow is the first standard communications interface that allows direct access to and manipulation of the forwarding plane of network devices such as routers and switches, both physical and virtual.

The rest of the paper is organized as follows. Section II is related work. Section III describes the three methods for mobility management studied in this paper with our proposed scheme and anchor selection method. Section IV presents mobility cost analysis with signaling cost and packet delivery cost and section V presents numerical result and analysis.

II. Related Work

There are ample of research proposals funded for providing mobility solutions. Many of such methods are like host based CMM, network based CMM, Fully DMM, Partially DMM and some are in new directions. In this section a few relevant research works are discussed.

The proposed scheme [8] suggested distributing mobility management scheme supported by using SDN concept based on PMIPv6 by a splitting local mobility anchor (LMA) into two parts as Control plane LMA and Data plane LMA. D-PMIPv6 improve performance in term of the packet delivery cost compare to other mobility management scheme as CMM and DMM. Researchers [9] suggested Mobility approach by using SDN concept as distributed control over a network for efficient mobility functionality. This approach avoids problems like the leaking of route optimization and the single point of failure. Reserchers presented [7] explaination of mobility management mechanisms for different OSI protocol stack layers which are based on a centralized mobility management entity which is in charge of both data and control plane unlike Distributed mobility management.

Authors [10] provided Integration of SDN/Openflow in the virtualized LTE System to support DMM and compare with other DMM enabling technologies such as IETF based DMM enabling technologies, Inter-domain DMM, Double NAT, Distributed Mobility Anchoring (DMA). In [11] proposed partial OpenFlow based DMM and introduces a set of Functional Entities (FEs) which are required to support IP address continuity in a network with distributed mobility anchors.

[12] introduced, three-tiered SDN architecture for DenseNets for DMM by decouples control decisions and the data plane. Authors [13] suggested a mechanism of DMM schemes to solve problem of CMM such as dynamic routing and IP address allocation by applying the SDN concept to DMM architecture, defines the procedures of mobility support and analyzed signaling coast using numerical analysis. DMM required tunneling that causes overhead and non-optimal routing. Out of all the methods discussed above, the proposal suggested in [8] is about applying distributed mobility management scheme in PMIPv6 and in [7] presented defined single CLMA. Our proposal is quite different from that of [8] in many aspects. We are splitting LMA into multiple DLMA (Data Plane Mobility Anchor) and CLMA (Control Plane Mobility Anchor). We used more than one DLMA and CLMA for scalable, reliable and efficient mobility management. We proposed Anchor selection algorithm based on two parameters as the load on the anchor and hop count between router and that anchor.

III. MOBILITY MANAGEMENT SCHEME

A. Centralized Mobility Management (CMM) Scheme

In CMM, every data packet must need to pass through single mobility anchors that provide mobility support for all registered Mobile nodes (MNs) in a more efficient manner. The mapping information for the stable session identifier and changing IP address of the mobile nodeis kept in this centralized anchor [14]. The mobility management system is centralized for both data plane and control plane. This approach has been developed in both Network and Host based solution.

1) Host based Centralized Mobility Management scheme

Host based approach involves the mobile node itself in mobility management operation. Mobile IPv6 is host based mobility management protocol in which required high message overhead and modification of the mobile node when the mobile node frequently hands over between subnets. There are some problem involve in MIPv6 as: Signaling overhead, Location privacy and Binding update latency.

2) Network based Centralized Mobility Management scheme

Network based approach doesn't involve the mobile node in mobility management, but it includes MAG and LMA for mobility functionality. Proxy Mobile IPv6 is a network based protocol that reduces signaling overhead. PMIPv6 introduced two new entities as Local Mobility Anchor (LMA) and Mobility Access Gateway (MAG) that manage all mobility related signaling for the mobile node. This approach generates a single point of failure problem due to single mobility anchor when a mobile node moves during handover.

B. Distributed Mobility Management (DMM) Scheme

In order to address limitations of CMM solution, a new paradigm has been proposed called DMM. In DMM, mobility management functionality is distributed over the network. In the DMM functionality of LMA is splitting into multiple MAG which are placed at the edge of the network that perform address allocation functions.

1) Fully Distributed Mobility Management scheme

In Fully DMM, several routers are used for both routing and managing functionality and not have a central entity for mobility management. To exchange mobile node information some approaches used ad broadcasting method or maintaining last prefix MN information is exchanged between routers so generate signaling overhead.

2) Partially Distributed Mobility Management

In Partial DMM, control plane and data plane are decoupled. Centralized method is used for control plane and Distributed method is used for data plane. MAAR is used for routing functions in which node information is stored in centralized database called Centralized Mobility Database (CMD) so it reduce signaling overhead. This approach has some disadvantages as tunneling overhead and non-optimal routing.

C. SDN based DMM Scheme

Here we apply the SDN concept to DMM to support efficient Mobility management by separate control and data plane. DMM based SDN also have some limitation such as the load on single controller and CLMA and DLMA selection problem. So Proposed architecture modified existing SDN based DMM architecture by adding more than one CLMA and DLMA for scalable and reliable movement of a mobile node during handover. In Fig 1 proposed architecture is explained below.

As shown in Fig.1, the proposed scheme decouples the mobility routers and controller, Mobility router send data based on controller policy and controller operates like an SDN controller. Local Mobility Anchor (LMA) is separated into Control plane Local Mobility Anchor (CLMA) and Data plane Local Mobility Anchor (DLMA). In proposed scheme we used more than one DLMA and CLMA for scalable, reliable and efficient mobility management. CLMA is used to manage signaling message of binding registration by using the Proxy Binding Update (PBU) and Proxy Binding Acknowledgement (PBA) between CLMA and MAAR (Mobility Anchor and Access Router). CLAM allocates DLMA to MN and maintain BCE (Binding Cache Entry) for the MN. DLMA is responsible for forwarding the data packets.

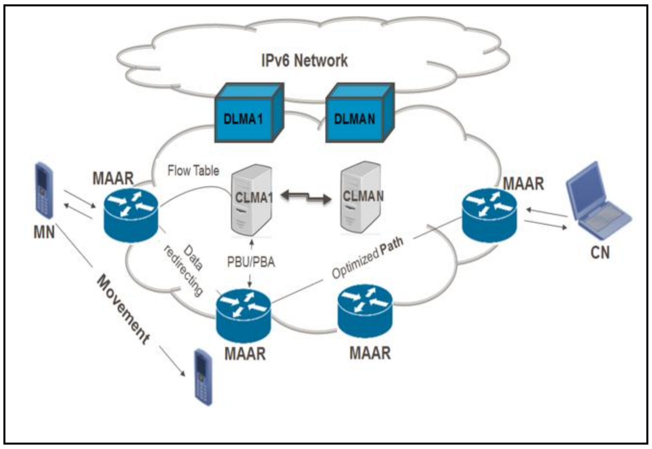

Fig. 1 SDN based DMM model

In DMM used CMD for routing information so for communication tunneling is required. Tunneling causes overhead and non-optimal routing problem. In contrast, our proposed scheme can set up data paths without tunneling, because the data path is set up by flow table made by Controller. Proposed approach procedures two ways as before the handover initially mobile node is attached to initial router and after the handover mobile node move to another router.

1) Procedure of proposed scheme message before handover

Fig.2 shows message scenario whena mobile nodeeconnectst to initial router. Stepwise procedure describes as follows: (1) Initially mobile node is attached to an initial router means Primary MAAR (P-MAAR).

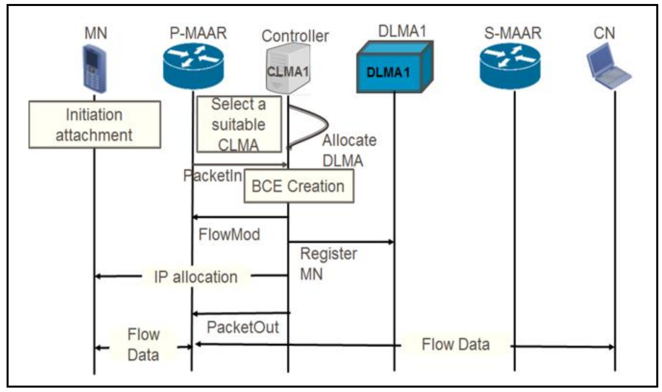

Fig. 2 Message scenario when a mobile node connects to initial router

(2) MN selects less loaded and nearest CLMA by using CLMA selection methods. (3) P-MAAR send pocketing message to CLMA to get flow information and flow table. (4) After receiving Pocketing Controller, select DLMA and allocate IP address and send node information to DLMA for mobility support. (5) DLMA stores the mobile node status and IP information in Binding Cache Entry (BCE). (6) To establish data path, CLMA sends a FlowMod message to set up a flow table in the router. (7) For route optimization FlowMod message also sends to the corresponding node (CN).

2) Procedure of proposed scheme message after handover

Fig. 3 shows message scenario when a mobile node moves to the new router.

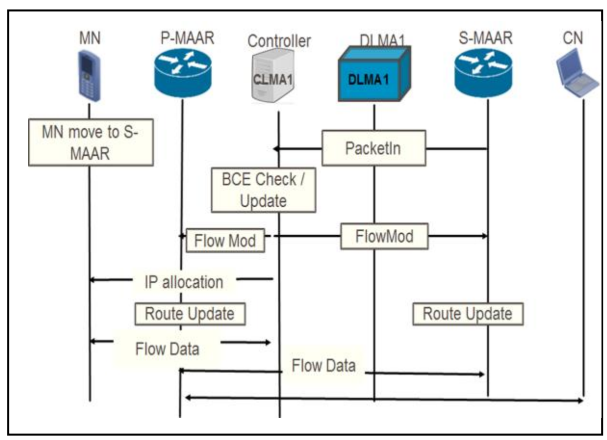

Fig. 3 Message scenario when a mobile node connects to the new router

Stepwise procedure describes as follows: (1) When mobile node move to the new router, the new router sends pocketing message with mobile node's ID, prefix and new location means new router information as Secondary MAAR (S-MAAR). (2) After receiving pocketing message, CLMA check and update Binding Cache Entry (BCE). (3) To establish the data path, CLMA sends a FlowMod message to both previous router and the new router to set up the new data path. (4) On receiving FlowMod message, the new and previous routers will update their routing tables and finally data session will flow from previous router to new router and finally to the mobile node. (5) For route optimization, S-MAAR also send FlowMod message to the corresponding router (CN) that includes information that contain the flow table between the CN and MN.

3) Anchor Selection Algorithm

This section described Anchor Selection Algorithm for appropriate selection of Mobility Anchor from multiple CLMA and DLMA. Every time when handover occurs or Mobile Node is attached to the domain, MN connected to MAAR is responsible for selecting CLMA. CLAM is selected by MAAR based on load on CLMA and least hop count between MAAR and CLAM. CLMA periodically sends load information to MAAR. After selecting CLMA, need to select DLMA for storing node information. The DLAM is selected by CLAM. DLAM is selected based on two main factors. One is loaded on DLAM and second one is distance between MAAR and DLAM. CLMA should select the closest light loaded DLMA. There is a threshold value ($N_{threshold}$) for anchor that is loaded on the anchor that denoted as the aggregated MN that can bind to it. The total number of MNs to each anchor should not exceed ($N_{threshold}$) with the consideration of load. Let S_i be the status value of each anchor myself. If the total MN > = $N_{threshold,\ then}$ Si=0 and If the total MN < $N_{threshold}$ then Si=1.

The Network Administrator will determine the value of $N_{threshold}$. D_i is the hop count between MAAR and respective anchor. The output of Anchor Selection Algorithm can be defined as follows:

$CLMA/DLMA_{Selection} = \min \{S_i \times D_i\}$, (i € [1, n])

There are n number of anchors available in the existing network domain. Algorithm 1 Gives Anchor Selection Method for appropriate selection of anchor during handover process.

Algorithm 1 Anchor Selection Method

Input: The anchor Status S_i and hop count between MAAR and anchor D_i

Output: The Selected Anchor (DLMA/CLMA)

1. Min = $S_i \times D_i$;
2. **For** (i = 1; i < = n; i++)
3. **If** $S_i \times D_i$ < Min **Then**
4. Min= $S_i \times D_i$;
5. **End If**
6. **End For**
7. **Return** Min;

C. Analysis and Comparison

In order to analysis performance of SDN based DMM, compare it with other mobility management mechanism. TABLE 1 analyses and compare SDN based DMM with other mobility management scheme.

TABLE I. FUNCTIONAL COMPARISION OF THREE MOBILITY MANAGEMENT SCHEME

	Centralized Mobility Management (CMM)	**Distributed Mobility Management (DMM)**	**SDN based DMM**
Distributed development	No	Yes	Yes
Mobility Anchor	Single	Multiple MAG	Multiple CLMA/DLMA
Separating control and data plane	No	No	Yes
Single Point of Failure	Yes	Yes	No
Route Optimization	No	No	Yes
Signaling Overhead	High	Low	Low
Tunneling Overhead	Yes	Yes	No
Deployment	Modification in protocol stacks and end client	Modification in protocol stacks and end client	Initial SDN infrastructure and Software
Encapsulation/Decapsulation	Required	Required	Not Required

IV. MOBILITY COST ANALYSIS RESULTS

In Mobility causes signaling overhead due to the signaling between the network entities, change the routing path of the data packets, and introduce tunneling between routers.Different cost metrics related to mobility operation of a protocol can be measured by mathematical models in order to identify the benefits and weakness of each solution [16].

TABLE II. GENERAL PARAMETER USED IN COST EXPRESSION

Notation	**Message**
α	Weighted factor for a wired link
β	Weighted factor for a wireless link
$L_{packetIn}$	PacketIn message in Openflow
L_{FMod}	Flow Modification
$L_{packetOut}$	PacketOut message in Openflow
L_{TCpack}	TCP acknowledgement
L_{RS}	Route solicitation
L_{RA}	Route advertisement
L_{PBU}	Proxy binding update
L_{PBA}	Proxy binding acknowledgement
L_p	The Data packet Length
T_{un-s}	The product size of IPv6 tunneling

1) Signaling Cost

Signaling overhead (or cost) denoted by C_S, may be defined as the cost of propagation of the mobility related messages in order to complete the handover of an MN. It is calculated as the product of the hop count and the signaling message size.

- For Centralized Mobility Management (CMM),

$$\boldsymbol{C_S^{CMM}} = \beta(L_{RS} + L_{RA})h_{MAAR-MN} + \alpha(L_{RS} + L_{RA})h_{MAAR-MAAR}$$

- For Distributed Mobility Management (DMM),

$$\boldsymbol{C_S^{DMM}} = \beta(L_{RS} + L_{RA})h_{MAAR-MN} + \alpha(L_{PBU} + L_{PBA})h_{MAAR-MAAR} + \alpha(L_{RS} + L_{RA})h_{MAAR-MAAR}$$

- For SDN based Distributed Mobility Management,

In SDN-based distributed mobility management, MN updates its information to DMM service because it manages MN and support mobility. By these conditions signaling cost is given by following expression:

$$\boldsymbol{C_S^{SDN-DMM}} = \alpha L_{packetIn}\, h_{CLMA-MN} + 2\alpha L_{FMod} h_{CLMA-MN} + \alpha L_{packetOut} h_{CLMA-MN} + 5L_{TCPack}$$

2) Data Packet Delivery Cost

Data packet delivery Cost denoted by P_D, can be defined as the cost of delivering data packets to an MN. It can be calculated as the product of the hop count and the size of the data packet.

- Centralized Mobility Management (CMM),

$$\boldsymbol{P_D^{CMM} = E_s * [(T_{un-s} + L_p)h_{MAAR-MAAR} + (L_p h_{MAAR-LMA}) + L_p h_{MAAR-CN}}$$

- Distributed Mobility Management (DMM),

$$\boldsymbol{P_D^{DMM}} = E_s * [(T_{un-s} + L_p)h_{MAAR-MAAR} + (T_{un-s} + L_p)h_{DLMA-MAAR} + L_p h_{DLMA-CN}]$$

- For SDN based Distributed Mobility Management,

In SDN-based distributed mobility management, when the MN moves to the new router, it can support data redirection without tunneling because data path is set up by Flow Table. By these conditions Packet Delivery cost is given by following expression:

$$\boldsymbol{P_D^{SDN-DMM}} = E_s * [L_p\, h_{DLMA-MAAR} + L_p\, h_{DLMA-CN}]$$

V. NUMERICAL ANALYSIS RESULT

In this section, cost analysis result for all three type mobility management schemes are presented. Here we assume $h_{MAAR-MAAR}$ is the distance in hops between MAAR and MAAR as 4, $h_{MAAR-LMA}$ is the distance in hops between MAAR and LMA as 5, $h_{MAAR-CN}$ is the distance in hops between MAAR and CN as 6 and $h_{DLMA-MAAR}$ is the distance in hops between DLMA to MAAR as 4.

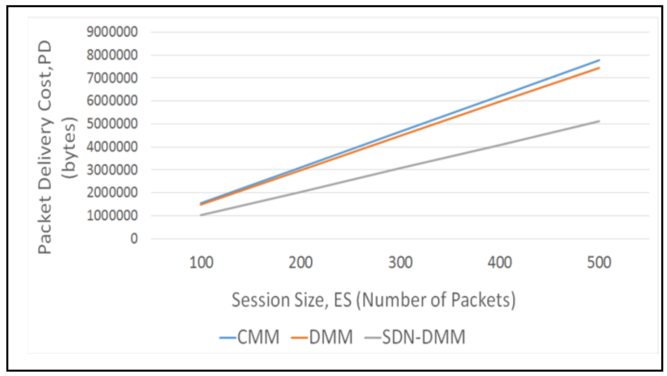

Fig. 4 packet delivery cost versus session time

We also assume that tunneling cost T_{un-s} is 40 bytes and Data packet length L_p is 1024 bytes. In Fig. 4, we changed E_s from 100 to 500 to get packet delivery cost according to session time. As in Fig. 4, our proposed scheme results show that packet delivery cost is lower compare to CMM and DMM.

VI. CONCLUSION

In this paper, we have described three MM mechanism. We applied the SDN concept to DMM architecture by splitting LMA into multiple CLMA and multiple DLMA and also given anchor selection method for appropriate selection of anchor during handover process. We established analytical model and formulated packet delivery cost and signaling cost for all three mobility schemes and confirmed that the proposed scheme is more efficient than other because it avoid tunneling overhead by defining path using flow tables.

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