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A FLOW-BASED MOBILITY ARCHITECTURE IN MULTIHOMED NEMO TO MINIMIZE REGISTRATION DELAY

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ABSTRACT

With the growing development of Different Access Technology Type (DATT), a serving Mobile Router (MR) is capable to connect with multiple interfaces concurrently during handoff among DATT. Correspondingly, a shared prefix-based based flow movement in multihomed Network Mobility (NEMO) can be achieved in order to transfer real time application flows among the most appropriate Access Technology Type (ATT) dynamically to provide better Quality of Service (QoS) for real time scenarios in NEMO. Although Multiple Care of Address (MCOA) registration between serving MR along with its Home Agent (HA) can overcomes some of the multihoming issues for NEMO, but still required a dynamic flow redirection mechanism leads to signaling overhead issues to support mobility management in NEMO. The aim of this paper is to propose a Shared Prefix-based Flow mobility scheme in multihomed NEMO (SPF-NEMO) which is based on PMIPv6 to reduce registration delay during inter mobility handoff as well. Moreover, numerical framework is formulated to evaluate the outcomes of the SPF-NEMO scheme. Through the performance analysis with results, it is confirmed that SPF-NEMO provides better solution related to extra registration delay during handoff among DATT.

Keywords: NEMO, MR, access technology type, multiple care of address, registration delay.

1. INTRODUCTION

The concept of making use of a single address introduces the hazard of network failure leading to Internet connection shut down. This occurs only if that specific single interface link fails and no options are remained to continue the connectivity. Nevertheless, users are able to switch between multiple interfaces with the introduction of multihoming technique. To be precise, multihoming is a networking concept which is addressed as the concurrent use of several interfaces or IP addresses on a single mobile node or mobile router. It aims to improve the entire Internet connectivity as well as widens the reliability of network applications (Romain, 2013). To perform upon failure at a single attachment point, the functionality of a system component are presumed by secondary system workings if the main component is unavailable (e.g. failure). In few cases, a specific flow can be duplicated via various interfaces. Flow Bindings is an addition of MCoA in NEMO that allows a MR to enclose distinct flow to a care-of address without having an effect on other flows via the identical home address (Sarikaya, 2013). In addition, it can integrate a distinctive flow to a particular CoA exactly via Correspondent Node (CN) with Home Agent (HA) and Local Mobility Anchor point (LMA) (Tsirtsis, 2011), (Sarikaya, 2013), (Bernardos, 2012). Thus, it is expected to reduce packet loss with delivery delay for real time applications (Tsirtsis, 2011), (Sarikaya, 2013), (Chen, 2004). Therefore, several proposals (Devarapalli, 2005), (Tsirtsis, 2011), (Sarikaya, 2013), (Bernardos, 2012) of flow mobility on Proxy Mobile IPv6 (PMIPv6) have already leaded to reduce registration delay during handoff among Same Access Technology Type (SATT). However, the existing solutions still provide an extra registration delay during handoff among Different Access Technology Type (DATT) (Bernardos, 2012). In order to avoid this drawback, a Shared Prefix-based Flow mobility scheme in multihomed NEMO (SPF-NEMO) is proposed in this paper with performance estimation outcomes. It is confirmed from the outcomes that, SPF-NEMO provides better results than the standard NEMO BSP regarding higher registration delay during handoff among DATT. The remaining part of the paper is structured as follows: related work on flow mobility scheme in multihomed NEMO is illustrated in section 2. The details of SPF-NEMO scheme is proposed in section 3. Then, in section 4, the SPF-NEMO scheme is evaluated through cost investigation and conclusion is given in section 5.

2. RELATED WORKS

Despite the fact that NEMO-BSP offers session connectivity and reachability for mobile nodes which are attached to an MR, its handover performance is often unacceptable (Devarapalli, 2005). Nevertheless, very recently, researchers have realized that NEMO mobility can be easily supported through expanding mobility service provision entities initiated in PMIPv6. The probable cases and issues for NEMO with PMIPv6 have been offered and studied in (Tsirtsis, 2011), (Sarikaya, 2013), (Bernardos, 2012). However these preliminary techniques integrating PMIPv6 and NEMO suffer from extreme packet losses during the operation of handovers. Furthermore, a complete performance analysis has not been studied yet.

Accordingly, Multiple Mobile Router based scheme in NEMO (MMR-NEMO) has studied in (Romain, 2008), to enhance the band width, network coverage as well as reliability of a mobile network. The conception of this scheme is supported on neighbor discovery and

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remains compliant with legacy IPv6 nodes. Through neglecting the L2 decision in RA (Router Advertisements) messages, a MNN must be able to determine the L2 address for the evade router initially prior to start a link with a distant node.

After receiving consistent Neighbor Solicitation (NS) message, a NA is straighten with the direction of the MNN. It consists of the address of L2 for the MR which has decided for taking in control to MNN. Via the emission of an unsolicited NA, active redirection is attained to inform the L2 address of the evade router for MNNs. Nevertheless, this scheme is not capable to delegate for exclusive downstream communication to MR. Therefore, in addition of the previous scheme the authors has proposed a mechanism which supports upstream as well as downstream traffic where Duplicate Address Detection (DAD) has applied to respond as the declaration of L2 address for default router as an obligatory procedure of the IPv6 stateless auto configuration strategy (Romain, 2013). The extended strategy permits default router assignment when the MNN associates with the moving network. However, need to determine the cost of each NEMO entities for precise evaluation.

(Kim, 2011) presents an improved handoff scheme using Bicasting mechanism for Multi-homing as well as mobility in PMIPv6 domain (IBM-PMIPv6). The simulation results illustrates that the developed IBM-PMIPv6 scheme offers less latency than that of PMIPv6 during handoff since to use bicasting mechanism. Consequently it is likely to diminish the probable packet losses as well as handover latency, while comparing with the current scheme (i.e., PMIPv6 and PMIP with multi-homing) during handover within multi-homing environment. Nevertheless, the authors should determine the cost for precise evaluation for scalability reasons.

Furthermore, a real solution for supporting multihoming in NEMO on the basis of proxy mobile IPv6 has developed to use every MR individually in order to offer flexible multihoming support along with PMIPv6 in NEMO (Li, 2008). Nevertheless, it is required to concentrate on implementation cost to solve scalability issues.

By integrating the concepts of the Shim with PMIPv6 (Shim with PMIPv6) protocols, an advanced Multihoming support scheme has been proposed in (Li, 2009), (Abley, 2012). According to Shim with PMIPv6, every interface inside a multihomed MN gets linked to the LMA domain individually. So, the LMA does not require differentiating among a vertical handover as well as the initial attachment. Additionally, the suggested scheme makes use of Shim locator preferences in order to support a flow distribution and concurrent transmissions through multiple interfaces, along with a vertical handover. In addition to that, the authors in paper (Trung, Jang and Melia, 2011), (Choi, 2012) have proposed some proposals on PMIPv6 domain in order to support flow based routing. However, the implementation of these proposals with PMIPv6 in NEMO environment stills an active research area. Moreover, analytical evaluations need to be done to determine the cost of each NEMO entities. The characterization of existing flow-based mobility management scheme is summed up in Table-1.

Table-1. Existing flow-based mobility management scheme.

Objective of existing multihoming-based mobility management schemes with citation	**Characterization of Existing Flow-based Mobility Management Scheme**					
	Flow Bindings supported?	**Cost evaluation**			**LMM based**	**GMM based**
		LUC	**PDC**	**Entity wise evaluated?**		
MMR-NEMO to enhance the band width, network coverage as well as reliability of a mobile network for downstream communication (Romain 2008)	Yes but not on PMIPv6 in NEMO	No	No	No	No	Yes
Extension of MMR-NEMO to supports upstream as well as downstream traffic. (Romain, 2013)	Yes but not on PMIPv6 in NEMO	No	No	No	NO	Yes
IBM-PMIPv6 scheme uses multihoming based bicasting mechanism to achieve seamless handoff. (kim, 2011)	No	No	No	No	Yes	No
Multihoming based scheme with NEMO on PMIPv6 to select best path among multiple interfaces (Li, 2008)	Yes	No	No	No	Yes	No
Shim with PMIPv6 scheme to support a flow distribution (Li, 2009), (Abley, 2012)	Yes	No	No	No	Yes	No
Multihoming based proposals on PMIPv6 to support flow based routing (Trung, Jang and Melia, 2011), (Choi, 2012).	Yes	No	No	No	Yes	No

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3. PROPOSED SPF-NEMO SCHEME

A handoff technique must be when the serving MR moves between different domain (Abley, 2013). In proposed Shared Prefix-based Flow mobility scheme in NEMO (SPF-NEMO), the serving MR is capable to perform inter mobility handoff with predictive mode only. The serving MR is the gateway in between access Router (Present MR MR act as access router in Figure-1.) and Local Fixed Node and New (LFN). It is assumed that the serving MR is capable to encapsulate Proxy Binding Update (PBU) message to the Router Solicitation (RS) message (Sarikaya, 2013), (Bernardos, 2012). Moreover, it is also presumed that all nodes are Local Fixed Node (LFN) beneath the serving MR and signaling message for LFN is totally controlled through the serving MR during inter mobility handoff. Otherwise, the MR performs a NEMO BSP handoff. According to the SPF-NEMO scheme, the Proxy Binding Update (PBU) message is wrapped up with the RS

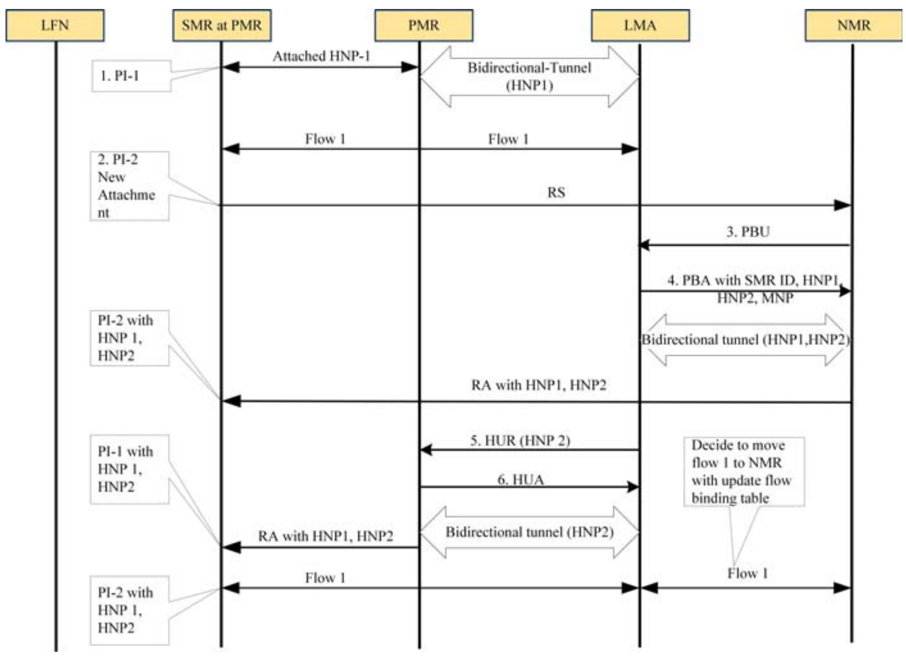

Figure-1. Handoff Framework of SPF-NEMO Scheme.

message earlier to the Layer 2 (L2) handoff. Thus, it is possible to reduce Total Registration Delay Cost (TRDC) for inter mobility handoff. The proposed SPF-NEMO is described stepwise and handoff framework is shown in Figure-1 accordingly:

1. Initially the serving MR connects to the Present MR (PMR) with the Physical Interface1 (PI1) and assigns Home Network Prefix-1(HNP-1) (Devarapalli, 2005).
2. While the serving MR comes near to the access link of New MR (NMR), serving MR will make a decision to attach with NMR using the Physical Interface 2 (PI 2), whereas it is still attached with PMR by PI 1.
3. By using L2 triggering information, handover detachment of serving MR from the present access network is informed by PMR to Local Mobility Anchor Point (LMA) by exchanging De-registration PBU (DeReg. PBU) that contain the serving MR-ID and De-registration PBA (DeReg. PBA) messages.
4. After sending DeReg. PBA message, LMA needs to wait to perform handover registration for serving MR with NMR.
5. After getting the Router Solicitation (RS) message, NMR transmits a Proxy Binding Updated (PBU) message which contains serving MR-ID (*F* flag with set to *1* as shown in Table-2) to LMA for notifying the presence of serving MR movement to support flow based routing on PMIPv6 domain.
6. As the serving MR supports flow based routing, LMA transmits Proxy Binding Acknowledgement (PBA) message (that contains serving MR-ID, HNP-1, and HNP-2 with the MNP) to the NMR that supports flow bindings as well.
7. Hence, a Home network Prefix Update Request (HPUR) as well as Home network Prefix Update Acknowledgement (HPUA) messages is exchanged among PMR and LMA for creating a bidirectional tunnel. The purpose is to forward the incoming and outgoing packets' flows destined for the serving MR and LFNs connected to the serving MR. At the same time, the corresponding Binding Cache Entry (BCE) is updated by the LMA. As a result, the LMA is capable of moving packet flows among multiple interfaces liberally with no additional signaling overhead. Hence, it is possible for the LMA to pass the flow-1 which

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utilizes HNP1, from PMR to NMR directly (as in Figure-1).

3.1 Extended BCE of LMA

To accomplish the proposed framework, some modifications of the LMA are required (Bernardos, 2012). An extension of the LMA is made in order to permit a serving MR to register multiple Proxy CoA (PCoA). According to the SPF-NEMO scheme, the LMA acts like a local HA of serving MR. Thus, the LMA is able to maintain several cache entries for the serving MR. All entries are delegated for the serving MR's interface as well as connects with a PCoA. Table-2 illustrates the extended LMA binding catch entries. To facilitate shared prefix-based flow forwarding, some information is required on the LMA's Binding Catch Entry (BCE) are mainly: ID of the serving MR, Home Network Prefix (HNP), address of LMA, Flow ID that helps to send selected IP flow and Target Access Technology Type (TATT) of the NMR as well (as shown in Table-2).

Table-2. BCE before and after LMA receiving PBU and flow bindings.

MR ID	BID	Flow ID	Mode	DATT	HNP with MNP	PCoA
MR 1	1	1	Active	WLAN	HNP1 with MNP	IP 1 (PMR)
MR 2	2	2	Inactive	3G	HNP2 with MNP	IP 1 (PMR)

MR ID	BID	Flow ID	Mode	DATT	HNP with MNP	PCoA
MR 1	2	1	Active	WLAN	HNP1 with MNP	IP 1 (PMR)
MR 1	2	2	Inactive	3G	HNP 1, 2 with MNP	IP 1 (PMR)

BCE of LMA
Primary of LMA
PCoA of MR
Flag F=1 for Flow Mobility
Sequence Number

4. COST INVESTIGATION

The cost of SPF-NEMO as well as NEMO BSP is analysed in this section regarding the cost for registration delay (illustrates in Figure-2). The Registration Delay Cost (RDC) is characterized as the total of hop distance as well as signaling message produced in between LMA, PMR and NMR. According to the SPF-NEMO scheme, the serving MR notify its current address to the LMA during L2 handoff.

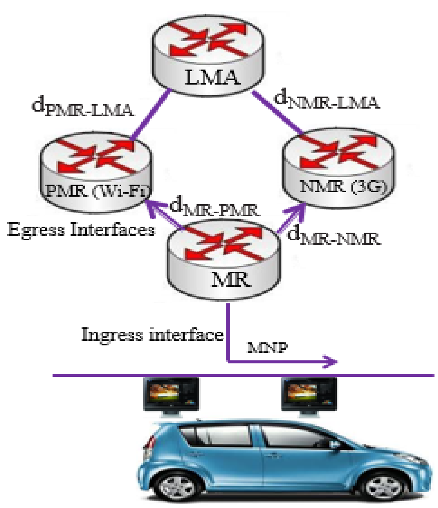

Figure-2. Numerical framework for SPF-NEMO.

Moreover, the handoff performance of the serving MR is affected at the overlapping zone due to higher velocity. According to SPF-NEMO scheme, there are two types of BUs are performed mainly: Registration Delay among Same Access technology type (RDSA) as well as Registration Delay among Different Access technology type (RDDA). The former one is a kind of movement among PMR (i.e. WLAN) whereas the later one is a movement between PMR and NMR (i.e. WLAN and 3G). Thus, two location update events are comprised in the total handoff cost. When the MR with LFN enters into a PMIPv6 domain in NEMO, the Total Registration Delay Cost (TRDC) for the serving MR can be calculated as (Shohrab, 2011), (Shayla, 2012):

$$TRDC_{SPF-NEMO} = N_{MR} \times \frac{P_M \times RDDA + (1 - P_M) \times RDSA}{E(CRT_{MR})} \quad (1)$$

$$RDSA = D_{PMR-NMR} + D_{LMA-NMR} \quad (2)$$

$$RDDA = RDSA + (D_{LMA-NMR} + D_{LMA-CMR}) \quad (3)$$

From Equation 2 and Equation 3, D_{x-y} represents the hop distance among different regions where as P_M refers the probability of performing the mobility among different access technology to notify movement of the serving MR. N_{MR} indicates Number of MR and $E(CRT_{cell})$ indicates average Cell Residence Time (CRT). RDSA and RDDA refers to signaling message exchanged in between same and different access technology for SPF-NEMO scheme respectively. Therefore, the relative registration delay cost gain of SPF-NEMO and NEMO BSP can be defined as:

$$Gain_{TRDC}^{SPF\_NEMO} = \frac{TRDC_{SPF\_NEMO}}{TRDC_{NEMOBSP}} \quad (4)$$

4.1 Results analysis

The values used as system parameters are listed in Table-3 (Shohrab, 2011), (Shayla, 2012). The TRDC of the SPF-NEMO scheme and the standard NEMO BSP is illustrated from Equation (1) as shown in Figure-3. It is observed that as the serving MR with its LFNs speed increases, the TRDC rises linearly with velocity since greater velocity results in small residence time results in recurrent handoffs. Yet, SPF-NEMO achieves better performance because of the presence of LMA. Therefore, it is summed up from Figure-3 that, SPF-NEMO has lower TRDC than NEMO BSP in terms of cell residence time, the number of serving MR with LFN and velocity. In addition, the Figure-4 is inherited from the Equation (4), which turns the cost ratio of the SPF-NEMO and NEMO BSP. It is apparent by analyzing Figure-4 that the cost ratio changes rapidly when the range of cell residence time is between 20 to 30 second. While the cost ratio is wrapping into the value 0.48; it can be considered that the SPF-NEMO has saved the cost by 52%.

Table-3. Parameters for cost investigation (Shohrab, 2011), (Shayla, 2012).

Parameters	Value
Number of serving MR (N_{MR})	30
Number of Correspondent Node (N_{CN})	1
Cell Residence Time of serving MR (CRT_{MR})	[20-180] sec.
$d_{PMR-LMA}$, $d_{NMR-LMA}$, d_{MR-NMR},	1 hop
$d_{HAMR-CN}$, $d_{HAMR-LMA}$, d_{LMA-CN}	6 hops
$d_{CMR-NMR}$	2

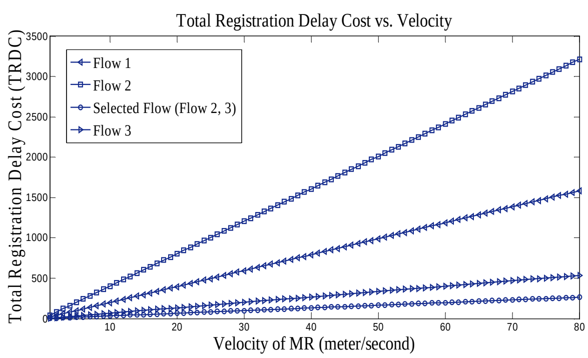

Figure-3. Total Registration Delay Cost of SPF-NEMO scheme.

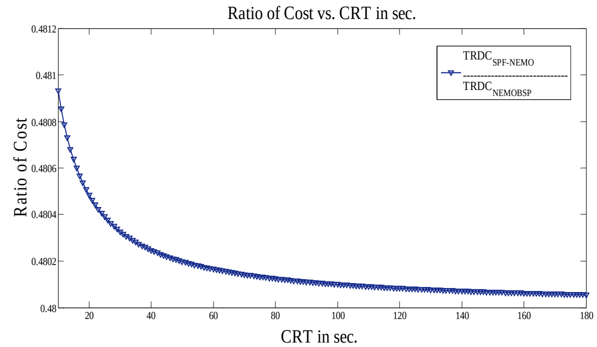

Figure-4. Cost ratio of SPF-NEMO scheme against NEMO BSP.

5. CONCLUSIONS

This paper proposes a Shared Prefix-based Flow mobility scheme in Multihomed NEMO (SPF-NEMO) on PMIPV6 domain in NEMO to support mobility management. The major contribution of this paper is to reduce TRDC by including PMIPv6 in NEMO. Thus, SPF-NEMO scheme eradicates the necessity to apprise the current position of the MR to it's HA before traveling to multiple access routers. In addition to that, through applying a shared prefix-based flow handoff mechanism, it is feasible to reduce packet loss and delay which leads to provide a better QoS. The performance of the SPF-NEMO scheme is evaluated via numerical analysis. Hence, it can be summed up from analytical analysis that the handoff cost of NEMO BSP shows superior than SPF-NEMO scheme due to multiple tunneled packets need to be routed from CN to the MR via the HA of the MR in NEMO BSP. However, experimental test bed is needed to include for more precise evaluation of the proposed SPF-NEMO scheme as future recommendation.

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