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Distance Based Mobility Anchor Point Selection Scheme with Dynamic Load Control in Hierarchical Mobile IPV6

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Abstract: Hierarchical Mobile IPv6 (HMIPv6) was introduced to support mobility management in the next generation Internet Protocol (IPv6). The new concept of HMIPv6 is the usage of Mobility Anchor Point (MAP) located at any level routers in a hierarchical network to support Localize Mobility Management (LMM) and seamless handover. Therefore, the furthest MAP selection in this protocol causes the overloaded MAP and increase frequent binding update as the network extends. To solve this issue, present study proposed an enhanced MAP selection scheme that combines the distance MAP selection scheme and dynamic load control mechanism (DMS-DLC). The proposed scheme has been validated through the performance evaluation using computer simulations. By the experimental results showed that the proposed scheme works efficiently and also supports the best distribution of MAP's load.

Key words: HMIPv6, mobility anchor point (MAP), MAP selection scheme, distance-based, dynamic load control

INTRODUCTION

In IP based Next Generation Networks (NGN), mobility management is the most important requirements to provide seamless handover services in micro-mobility management. IPv6 need a mobility support to ensure packets destined to a Mobile Node (MN) is reachable while it is away from its home address (Johnson *et al*., 2004). Mobile Internet IPv6 (MIPv6) allow transparent routing of IPv6 packets to MNs. In MIPv6 all packets sent to MN must be routed first to the MN's home subnet and then forwarded to the MN at its current location by its Home Agent (HA).

Although, MIPv6 supports mobility, it has problems on supporting seamless handover due to high delay (Habaebi, 2006). Every time MN move to new access router, it acquires new Care-of-addresses (CoA) and must notify Binding Update (BU) to HA and Correspondent Node (CN) for each handover. This delay cannot be avoided when the distance growing among MN and it's HA.

Soliman *et al*. (2008) suggested Hierarchical Mobile IPv6 (HMIPv6) with the objectives to reduce the amount of signalling cost and to improve the speed during handover. By the usage of a new node called Mobility Anchor Point (MAP), it can support a micro-mobility management. Therefore, the furthest MAP selection in HMIPv6 can be a MAP overload and increase frequent binding update problem as the network extends. Without specific an efficient MAP selection scheme can affect the system performance and supporting seamless handover.

Present study was investigated an improvement of MAP selection scheme by MN operation in HMIPv6. The new scheme was proposed to reduce the BU delay and to achieve the network performance. Further, this study also designed for the distance MAP selection with the dynamic load control mechanism. The experimental model that has been developed will reduce the overloaded MAP as the MNs increases and the network grows.

Hierarchical mobile IPv6 (HMIPv6): In general, MIPv6 supports mobility management issue but it does not attempt to solve all general problems related to the use of MNs or wireless networks. Specifically this protocol does not solve local or hierarchical forms of mobility management (Johnson *et al*., 2004). Since MIPv6 only support global mobility, a hierarchical scheme that separates micro-mobility from macro-mobility is preferable. In HMIPv6 the usage of a new node, called MAP as shown in Fig. 1 situated in the foreign network. It can be located at any level in a hierarchical network of routers so that it can be classified as a micro-mobility. The employment of MAP in HMIPV6 acting as the Local Mobility Anchor (LMA) is compliant with Localized

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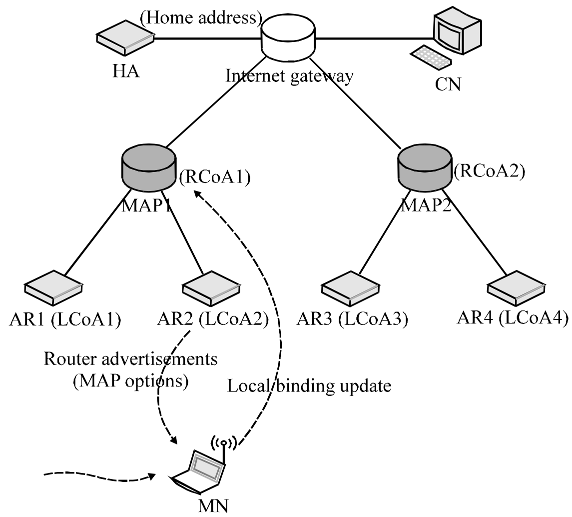


Fig. 1: HMIPv6 operations

Mobility Management (LMM) for supporting local registration of MN (Kempf, 2007).

If the MN is HMIPv6-aware, then MAP Discovery should choose the HMIPv6 implementation. Besides the uses of MAP in HMIPv6, an MN will also have to configure two new types CoAs: A Regional Care-of-address (RCoA) and an on-link Care-of-address (LCoA). The LCoA is a local address to the MN received from Access Router (AR). The RCoA is an address on the MAP's subnet, configured when an MN received a Router Advertisement (RA) message with the MAP Option during MAP Discovery.

The MAP performs the function of a "local" HA that binds the MN's RCoA to an LCoA. After an MN get new RCoA and LCoA addresses then it sends a Local Binding Update (LBU) to the MAP in order to establish a binding between the RCoA and LCoA.

Local Binding Update (LBU) and MAP option: When an MN enters a new MAP domain, it will receive RA containing information about one or more local MAPs in MAP option fields. The additional fields in MAP option formats are distance, preference and 'R' flag. The 'R' flag indicate the MN must place its RCoA as the HoA in the binding update message and bind to the LCoA in the MAP's binding cache. During RA, an MN will also detect whether it is still in the same MAP domain. If the MAP domain is different it needs to have two addresses from AR (LCoA and RCoA) otherwise only the LCoA will change. The MN can bind its current location (LCoA) with an address on the MAP's subnet (RCoA). Acting as a local HA, the MAP will receive all packets on behalf of the MN it is serving and will encapsulate and forward them directly to the MN's current address.

If the MN changes its current address within a local MAP domain, it only needs to register the new LCoA with the MAP. Hence, only the RCoA needs to be registered with CNs and the HA. The RCoA does not change as long as the MN moves within a MAP domain. This makes the MN's mobility transparent to CNs it communicates with and better handover compared to MIPv6.

MAP discovery and MAP selection scheme: The process of MAP Discovery continues every time an MN received RA including a MAP option and should start register with any new MAP through Neighbour Discovery (Narten *et al.*, 2007). The MN needs to consider several factors to optimally select one or more MAPs where several MAPs are available in the same domain and this process need a specific MAP selection scheme (Soliman *et al.*, 2008). During this MAP discovery the MAP will be selected that is most distant or furthest, provided that its preference value and valid lifetime did not reach a value of zero. This phase will also inform the MN of the distance of the MAP from the MN and store in a MAP Option. An MN should register with the MAP having the highest preference value. A MAP with a preference value of zero should not be used for new LBUs. A MAP option with a valid lifetime value of zero indicates a MAP failure. When this option is received, an MN must choose another MAP and create new bindings. If no other MAP is available, the MN must not attempt to use HMIPv6.

Related works: In multiple MAPs scenario, the MN may need sophisticated scheme to be able to select the appropriate MAP. In designing that scheme, the criteria of the MAP, MN, CN and the network topology have to be identified (Kusin and Zakaria, 2010). Without a proper selection scheme will be seriously degrade the network performance and seamless handover. Numerous researches have been carried out to deal these issues such as mobility based, adaptive based and dynamic based (Pack *et al.*, 2004b; Hu *et al.*, 2005; Taleb *et al.*, 2005; Pack *et al.*, 2006). A technique such as load balance (Bandai and Sasase, 2003) combined with the preference field in the MAP option can be adapted to solve overload problem.

A comparative study for the above MAP selection schemes has been conducted by Pack *et al.* (2004a). The results showed that the mobility-based and the adaptive MAP selection schemes achieve better performances than the distance scheme. Also, the adaptive MAP selection scheme performs better in terms of load balancing than the mobility-based MAP selection scheme.

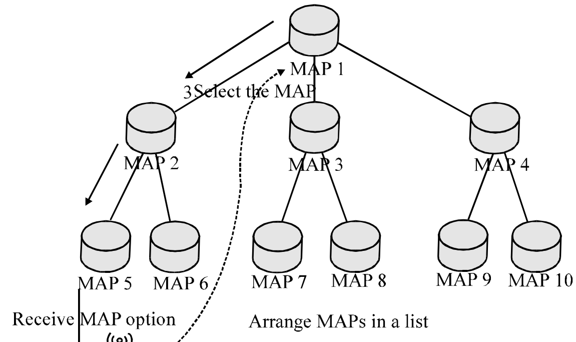
Distance based MAP selection scheme: In HMIPv6, a distance-based was recommended where an MN may choose the furthest MAP in order to avoid frequent re-registrations (Soliman *et al*., 2008). Figure 2 shows the process will be continued until the MN find the valid preference value and valid lifetime of the MAP. This algorithm is suitable for fast MNs that will perform frequent handoffs because the fast MNs reduce the probability of changing the serving MAP and informing HA and CNs of this change.

Although, HMIPv6 tries to improve the binding update between local MAP and CN, it will lead to the complexity of network management and more network entities such as MAP, additional address and LBU process. The scheme however creates a bottleneck as the site grows larger since the corresponding MAP suffers from the overload due to the increased data traffic to be tunnelled as well as binding update signalling. In situation where MN is registering with the furthest MAP, the registration delay will be increased because the hop distance between the MAP and the MN is greater compared to the nearest MAP. The preference value set in HMIPv6 is a static 4 bits integer and no specific procedure to set up the characteristic.

MAP load control mechanism: In previous research for MAP selection scheme, many adjusting algorithms and techniques adapted to solve load control problem. Most existing work focuses on load control or control mechanism from the view of MNs. The MN mobility properties such as velocity and speed are deployed to reduce and relieve MAPs overloaded.

Bandai and Sasase (2003) introduced a load balancing mobility management by average BU interval in both AR and MN is adopted. When the interval of sending BUs in MN is shorter than that of receiving BUs in AR, the MN selects a MAP with largest distance because the MN's movement is estimated to be fast. If the interval of sending BUs in MN is longer than that of receiving BUS in AR, the MH selects a MAP with the second largest distance. To keep the transparency to HMIPv6, this average BU interval in AR is mapped into the 4-bit binary preference value in the MAP option.

Ito *et al*. (2005) proposed a scoring method to select a MAP and to achieve load balancing. The score is calculated from two kinds of values, the historical handover frequency and the holding time. Each MAP holds the management list of MNs sorted by the score. Then the MAP compares the load with another MAP by requesting the management of MN. The request is to manage MN with the smallest and the highest score on a list until load becomes balanced.



MAP ID	Pref.	Distance (hop)
MAP 1	14	3
MAP 2	4	2
MAP 5	5	1
MAP 6	7	1

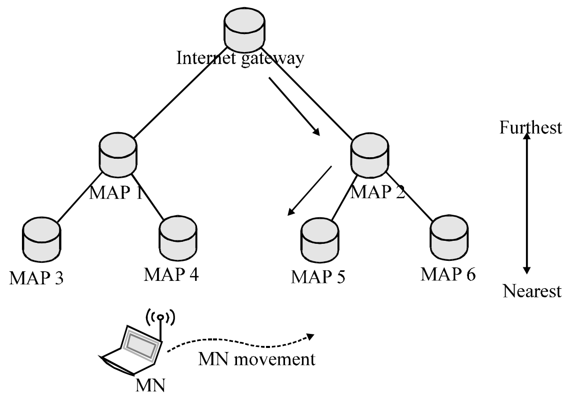
Fig. 2: Distance MAP selection scheme

In MAP load control mechanism, Wang *et al*. (2008) designed the MAP Load Table (MLT) to record the load condition of neighbor MAPs. When MN selects the MAP in the situation that already overload to register, the MAP sends message to its neighbor MAPs and refreshes it's MLT. When the MN receives the MLT, it will choose the MAP which has minimum load value to register. The study proposed a MAP selection mechanism that takes the MN's particular characteristics which include the mobility velocity and quantity of communication services.

DMS-DLC SCHEME

Proposed design: The difficulty to measure the MN properties prevents the precision selecting a proper MAP. For the reason that MAPs are deployed and not be often changed, the properties of MAP are more suitable into the consideration. This study suggested a design that controls the MAP's load. As shown by the flow diagram in Fig. 3, the MAP option for each MAP will be continually updated to achieve a dynamic load control. Each time the MN perform new binding or release existing bindings, it will update the MAP List (ML) and MAP Option.

This study also suggested a scheme that integrates load control mechanism to any MAP selection scheme which will support modularity. A few fields are introduced to MAP List (ML) as shown in Table 1. The value of field preference in MAP Option will be replaced by the load calculated from ML. This model consists of MAP discovery process, MAP selection scheme and load control mechanism, binding update procedure and handover process. The MAP discovery process, binding update procedure and handover process already



List of MAPs			
MAP ID	Pref.	Distence (hop)	Furthest/ nearest
MAP 1	10	2	Furthest
MAP 2	5	2	Furthest
MAP 3	1	1	Nearest
MAP 4	1	1	Nearest
MAP 5	14	1	Nearest
MAP 6	1	1	Nearest

Fig. 3: Dynamic load control design

Table 1: MAP list (ML)

MAP ID	Global IP address	Pref.	Valid Lifetime	Current load	Thresh-old load	Max. load
LCoA	RCoA	Pref. value	Life time in sec	No .of current load	No. of control load	No. of max. load

described in related works. Present study only describes the proposed load control mechanism. Besides, the MAP selection mechanism also integrates the MAP load control mechanism which improves the drawback of Wang *et al*. (2008).

The preference value is given as:

$$\text{Preference} = (1 - (\text{current load/threshold value})) * 15 \quad (1)$$

where:

$$\text{Current load} = \text{number of MAP Binding Cache} \quad (2)$$

From the (1), the current load is inversely proportioned preference value. In this selection scheme the process will select the nearest MAP with highest preference where the maximum value is 15 in the MAP option.

DMS-DLC algorithm: The proposed design in Fig. 3 will select the most suitable MAP with distance criteria and highest preference value. Information of all MAPs is collected form MAP Options for the purposed of selecting suitable MAP. Priority will be given to the furthest MAP with lowest load. The lower the distance will be the higher

```
MAIN ( )
Begin
    If MN is HMIP6-aware then
       MAP discovery ( )
       MN receive RA (MAP_ID)
       MN receive (MAP options)
       MN receive (MAP domains)
       MAP-selection (DMS_DLC)
       Update ML (MAP_ID)
     Else
       Exit ()
     Endif
       /* Start binding update process*/
       Begin
       Binding update (MAP)
           If MN receive rejected binding update
           repeate MAP_selection ( )
           else
           Process handover at new MAP
           The MN will relase previous binding
           Handover procedure is completed
           Endif
           /* After successful binding update*/
        The load information MAP option in new MAP
               and previous MAP will be updated
        End
End
```

Fig. 4: Distance MAP selection algorithm with dynamic load control

preference value. In case of the value given in the list of MAPs, the MN will select "MAP5" with the preference value of "14". By this mechanism the MAP option for each MAP will continues updating to achieve a dynamic load control mechanism.

The algorithm in Fig. 4 shows the tasks that should be developed in modularity for determines the suitable MAP of based on Distance based MAP selection scheme.

PERFORMANCE EVALUATION

In this section the performance of the proposed scheme will be evaluated in the context of MAP selection scheme in HMIPv6.

Experimental setup: The test network environment is shown in Fig. 5 and the relative parameters, in which the MN is moving across eight ARs in a two MAP domains where each domain contains three MAPs. The wireless diameter is within the range 200 meter with simulation area is 2000×1250 m^2. The total of ten MNs is communicated with the CNs through several of speed from slow to fast movement. The MN will register with the HA and undergoes intra-domain handovers as it move within the same domain. If it changes moving into another MAP domain the MN will do the inter-domain handover. During handovers, the MN is communicating with CN

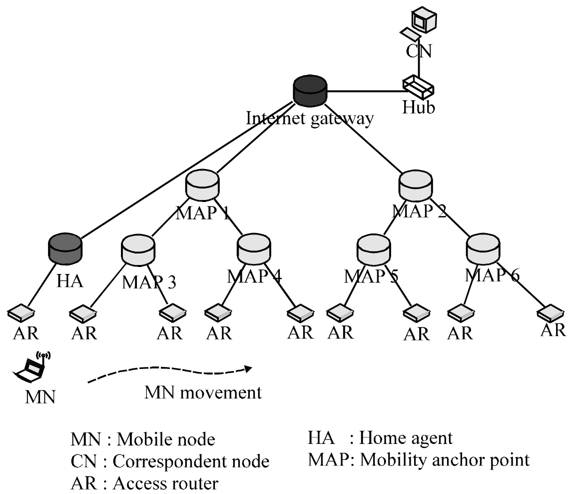


Fig. 5: Network environment

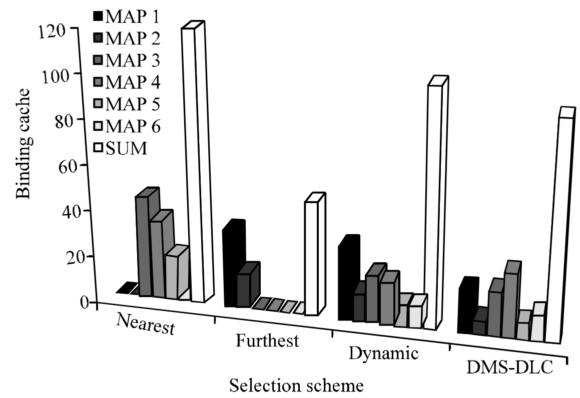


Fig. 6: Load Comparison between MAPs

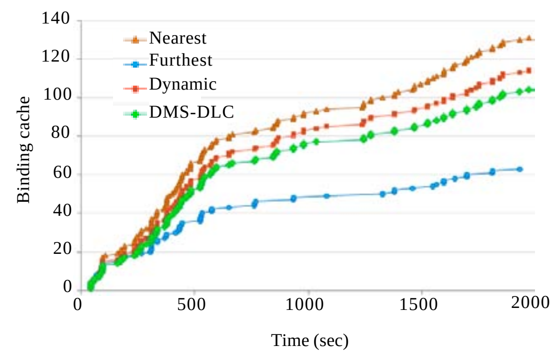


Fig. 7: Home agent's total binding cache

using a TCP traffic stream and will thus establish relevant local bindings with its MAP, HA and the respective CN during the handovers. The traffics is running on ping application with 56Bytes data and 5 sec interval time. The wireless access network is based on the IEEE 802.11b and WLAN standard with a free space channel model. The propagation delay between the MN, the MAP, the HA and the CNs is assumed negligible.

For the evaluation we simulate four performance metrics: load condition of each level MAP, HA's Binding cache, MAP's binding update cost and packet drops. Besides, the proposed scheme will also be compared with the other schemes: Distance-based (Nearest and Furthest) and Dynamic based. The performance of proposed scheme is evaluated by the network topology of simulation using OMNeT++ 4.0 (OMNeT++ Community Site, 2011) in Fig. 5 with the relative parameters mentioned.

RESULTS

As explained in related works, the furthest scheme is proposed to reduce frequent handover but it is known that the highest level of MAP has largest overloads. Hence, undoubtedly, the MAP load condition of each MAP can indicate the performance of MAP load control mechanism. Figure 6 depicts the performance comparisons in terms of the MAP load distribution (binding cache between MN and MAP) within four different schemes. Although the total binding cache of the proposed scheme is higher than the furthest, it supports the best distribution of MAP load.

From the Fig. 7 show that the HA's Binding cache is increasing as the new MN is registering with the new MAP. The frequent registration can be seen with the increase of binding cache from the time range between 0 and 600 sec. Following time after 600 sec the registration rate slowing to. Although the performance of the proposed scheme is higher than the furthest, it still supports less frequent binding cache of HA.

Figure 8 illustrates the performance of binding update cost between four different schemes. It is obvious to discover that the proposed scheme can reduce the total binding update list and is better than the nearest. Especially in the best case with slow MNs move within the same domain, it is still superior because the proposed scheme possibly let each MN choose the suitable MAP which efficiently reduces the binding update cost.

Figure 9 illustrates the performance ping drop between three different schemes. It is obvious to discover that the proposed scheme can reduce the packet drop amongst the compared schemes. Especially in the best case with slow MNs that move within the same domain, it is still superior because the proposed scheme possibly let each MN choose the suitable MAP which efficiently reduces the packet drop.

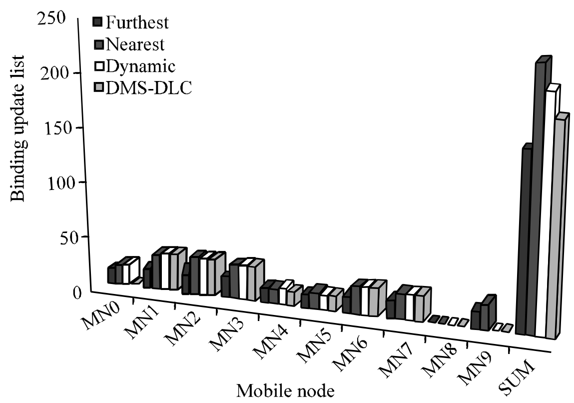


Fig. 8: Total MN's binding update list

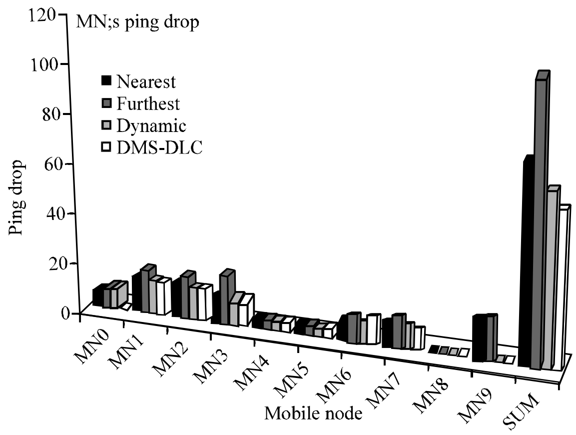


Fig. 9: Total MN's ping drop

CONCLUSIONS

HMIPv6 protocol is one that will support the NGN technology development for micro-mobility or Localized Mobility Management. Present study proposed a dynamic load control mechanism adapted in HMIPv6 MAP selection scheme. The load control mechanism measure on MN and MAP properties. This overload is due to the increased data traffic to be tunneled as well as BU signaling and maximum number of MN connected. Our final result showed that the DMS-DLC scheme gave better distribution of MAP load. The proposed scheme produced the best MAP distribution compared with Furthest-based scheme, Nearest-based Scheme and Dynamic-based scheme. By comparing load for leach level of MAP where for the furthest MAP reduce with 49.02% and for the Nearest MAP reduce to 45.50%.

In the future work will include analysis of MAP selection scheme using dynamic load control mechanism with multiple speeds of MN; integrated on distance based scheme using dynamic load control algorithm. A further study on enhance MAP selection scheme with an improvement of load distribution and form the basis for future research.

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