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A Fast Inter-Domain Mobility Scheme for Reducing the Transient Data Loss

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Abstract: Mobility management schemes such as Mobile IP rely on handling the transient data after the Mobile Node (MN) moves into a new domain. In this way the transient data arriving at the old location will get dropped and thus result in loss of important data. We introduce the idea of Boundary Access Point in conjunction with the buffering capability at the Home/Foreign Agent or the gateway router. This helps in transferring the transient data to the new location in a minimum amount of time in addition to reducing the data loss. The key idea is to use the access points present at the boundaries of an administrative domain that we call Boundary Access Points to monitor the mobile device movement. Buffering helps in preserving the incoming data for the duration when the MN cannot receive it.

Key words: Mobile networks, mobility management, inter-domain mobility, mobility handoff, transient data loss

INTRODUCTION

In today's world where a lot of mobile internet enabled devices are emerging, there needs to be some mechanism that can support the mobility of devices from one place to another while they are communicating. This mobility in a WLAN environment can be of two types i.e., Intra-domain mobility and Inter-domain mobility (Li, 2004). A lot of techniques have been proposed to handle Intra-domain mobility (Hsich *et al.*, 2003; Ramjee *et al.*, 2000; András, 1999) and Inter-domain mobility (Buddhiket *et al.*, 2003; Khan *et al.*, 2003; Perkins, 2002). Intra-domain mobility protocols emphasize on reducing the handoff latency and eventually minimizing the data loss during the handoff, as the mobility is local. In Inter-domain mobility, where long registration/handoff delay is still an issue, are widely left to Mobile IP.

There needs to be a mechanism to transfer the transient data to the new location in a minimum amount of time backed by a buffering mechanism to minimize the data loss.

Mobile IP being an Internet Engineering Task Force (IETF) standard communications protocol allows mobile device users to move from one network to another while maintaining their permanent IP address. This is achieved by having a permanent home IP address and temporary Care of Address (CoA) acquired from the foreign network (Perkins, 2002). The reason for using two IP addresses per host is because whenever a mobile device with one IP address initiates a session and after that changes IP address, the ongoing sessions tear down. It results from the fact that the IP address is overloaded with two functions i.e., host identification by TCP layer and network attachment information for routing purposes (Bhagwat *et al.*, 1996).

A hierarchical design approach has been proposed to optimize mobility in Mobile IP networks by Perkins and Johnson (2001) in their internet-draft document, while a mechanism to eliminate transient data losses by buffering at the Base Station Foreign Agents has also been presented (Perkins and Wang, 1999). The old Base Station Foreign Agent maintains buffers for every MN and if MN changes its Base Station Foreign Agent, the old one sends this buffer to the new Base Station Foreign Agent. A similar approach using Route Optimization has been utilized by Erom *et al.* (2002).

Mobile NAT is a mobility management scheme that incorporates Network Address Translator (NAT) to provide transparent mobility and also to minimize the usage of public IP address space for Ipv4 by using private IP addresses (Buddhikot *et al.*, 2003). Similar to Mobile IP, it also uses two IP addresses to locate the mobile device. Whenever a mobile device moves from one administrative domain to another during a session with a correspondent node (e.g., a web server), an entity called Mobility Manager in the visited domain contacts the Mobility Manager of the home domain for that particular session to get the session parameters and informing the home AN to forward the packets arriving from the

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correspondent node to the new AN through a tunnel. This technique however does not handle the problem of transient data arriving from the home NAT domain to the previous NATed domain.

Another buffering scheme by Khan *et al.* (2003) proposes a buffering method in which the transient data is buffered for each MN on the Foreign Agent for a specific period of time, called the absence detection interval. If the MN is found absent from the Foreign Agent coverage area, even after the absence detection interval expires, then all the data destined for the MN is sent back to its Home Agent (HA). HA on receiving the MN's new registration, tunnels the data to the new location in addition to the data arriving at the HA from the Correspondent Node (CN). Problem with this technique is that it only buffers the data after it detects the MN absence from the Foreign Agent coverage region thus resulting in loss of data. This scheme can also increase the overall handoff time if the home domain for a mobile node is far away from the previous Foreign Agent.

It is, therefore, intended to devise a method by which we only need to buffer data for those MN that can possibly leave the current domain and enter a neighboring domain, greatly improving the efficiency. By using the access points at the boundaries of a domain we can speedup the process of transferring the transient data to the new location.

We have utilized the Access points present at the boundary of a domain to transfer the data to the new location in minimum time.

The study is organized in a way that the Proposed scheme is described in detail with the help of figures and tables and also its comparison with existing schemes is shown. Enhancement of the proposed scheme is also suggested.

PROPOSED SCHEME

The proposed scheme is based on the idea of placing access points at those sections of a domain from where a MN can possibly enter the boundary of the neighboring domain. These access points are a new component called the Boundary Access Point (BAP) as shown in Fig. 1.

In addition to the introduction of BAP we have also incorporated the capability of buffering at the Home agent or gateway router of a domain and on the Foreign Agents thus helping in preserving the transient data during a handoff process. The key concepts and the roles of different components in the architecture are as below.

Tasks performed by a Boundary Access Point (BAP): BAP is responsible for immediately informing the home or

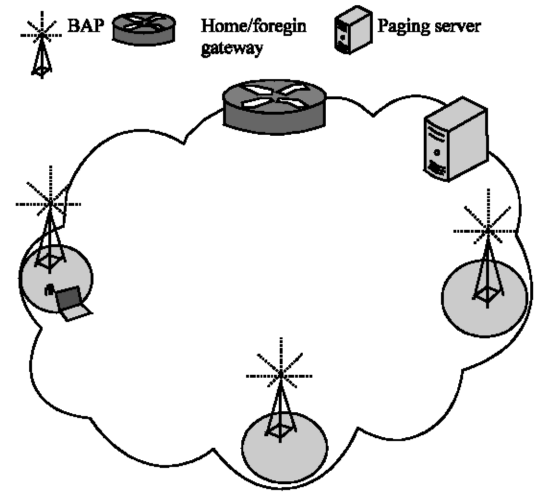

Fig. 1: BAP in a domain

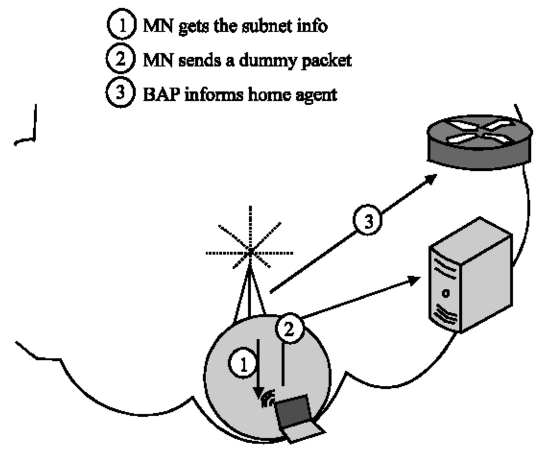

Fig. 2: MN entering a BAP coverage area

gateway router about any mobile device entering or leaving its coverage area in addition to forwarding the dummy packets to the paging server. Every BAP has a unique BAP ID thus helping the gateway router in finding out the neighbor domain where a MN could possibly be heading.

Whenever a MN enters a BAP coverage area it receives the subnet or domain information including the BAP id thus keeping the MN informed about any subnet or domain changes. The above discussion is represented in the Fig. 2.

Paging server: The architecture also contains a Paging Server (PS) to maintain up-to-date location information about a MN. Every MN sends a location update packet whether it has any sessions or not as shown in Fig. 3.

The frequency of sending the dummy packet depends on the presence or absence of a session that is

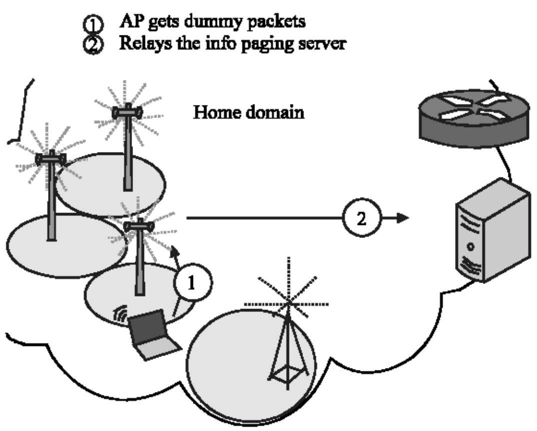

Fig. 3: MN sending a dummy packet under a simple AP

if a MN has sessions then it will send the dummy packet with a higher frequency otherwise with a low frequency.

The PS can be a separate entity or can be incorporated in a home agent or gateway router.

Tasks performed by the home agent: The Home agent of any domain would have knowledge about its neighbor domains so that when a MN leaves the domain, the neighbor domain agents can be contacted for transferring the transient data.

Every Home agent has the knowledge about a MN present under a specific BAP having any sessions. Based on this information, the HA buffers packets for those MN. The data present in the buffer gets overwritten when the HA does not receive any information from the BAP about the MN exit for a time duration equal to the reception of the dummy packet.

If a MN exits the BAP coverage area, the HA gets informed about that by the BAP. It immediately stops overwriting the buffered data and sends request for the MN to the PS as shown in Fig. 4.

If the information present with the PS regarding that specific MN is old, the HA will send a tunnel establishment request to the neighbor domain agent so that a copy of the buffered data can be transferred in addition to transferring the transient data as presented in Fig. 5.

If the neighbor domain also does not have the info about the MN when the packets arrive through the tunnel, it would drop the packets and it could easily be assumed that the MN is switched off.

Tasks performed by the foreign agent: When the MN enters a FA domain, it gets a new Care of Address (CoA) and informs about its Home ID. The Home

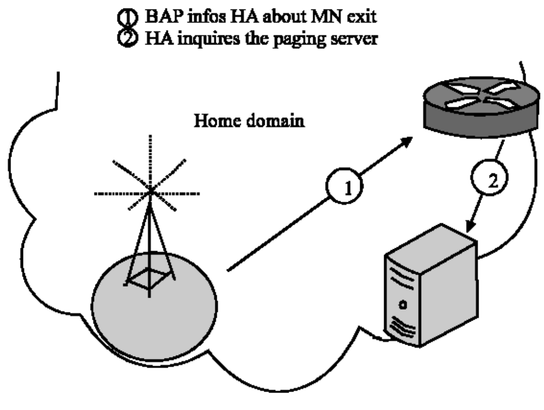

Fig. 4: Steps after MN exit

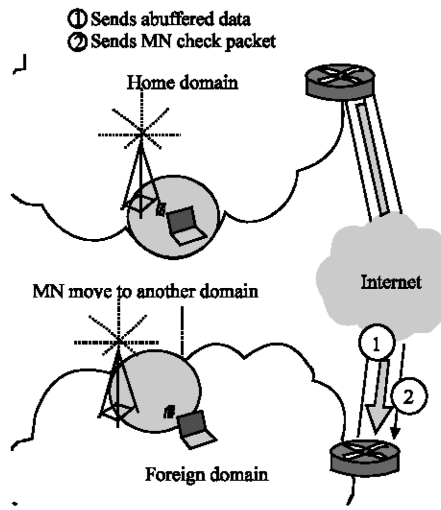

Fig. 5: Tunnel establishment phase

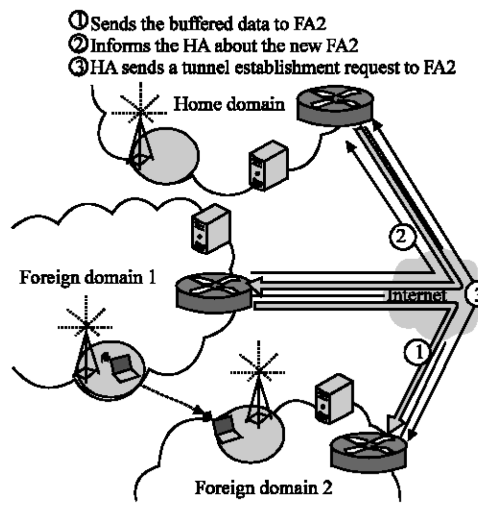

Fig. 6: HA gets informed about FA2

ID helps the FA in contacting with the HA when the MN exits the FA domain and enters a new domain.

Figure 6 shows the steps when a MN exits the FA domain.

After MN node exit, the FA performs the same steps that are performed by the HA. In addition to that, FA1 also informs the HA about the new domain so that the transient data can be directed to the new location. When the HA gets the new domain info, it creates a tunnel with the new domain.

After that the transient data starts flowing to the new FA2. If the FA2 has info about that MN, it will deliver the data to it, otherwise informs the HA that the MN has not entered in its domain after dropping the packets.

USABILITY OF BAP SCHEME WITH OTHER SCHEMES

BAP scheme can be used to make the other inter-domain mobility schemes perform even better. The BAP scheme can easily be mapped to the Mobile Ipv4 as it contains the same components as the HA and the FA. The proactive buffering scheme can also get benefit by buffering for only those MN that is present under the BAP. Mobile NAT can also use the same idea to improve the handoff process in addition to having a NAT-ed domain concept.

ENHANCEMENT TO THE PROPOSED SCHEME

Buffering for only those MN that are present under a BAP and are expected to move to a new domain can further enhance the proposed scheme. As there may be some MN that would not move at all during an established sessions having present under a BAP, we need not to buffer packets for them. We shall only buffer data for those MN that are present under BAP and will most probably move to a new domain.

Incorporating a profiling or a configuration software approach that can define a MN session as Static session or a Mobile session can achieve this goal.

COMPARISON WITH SEQUENCE DIAGRAMS

Figure 7 shows a normal MIPv4 approach that does not provide any buffering capability. In this approach the transient data gets dropped until a new binding update is not received.

Figure 8 shows the sequence diagram of Mobile NAT scheme that clearly shows that this scheme also does not provide any buffering capability.

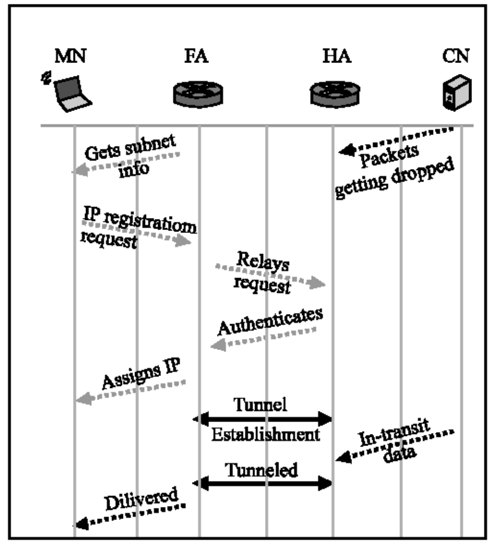

Fig. 7: MIP flow chart

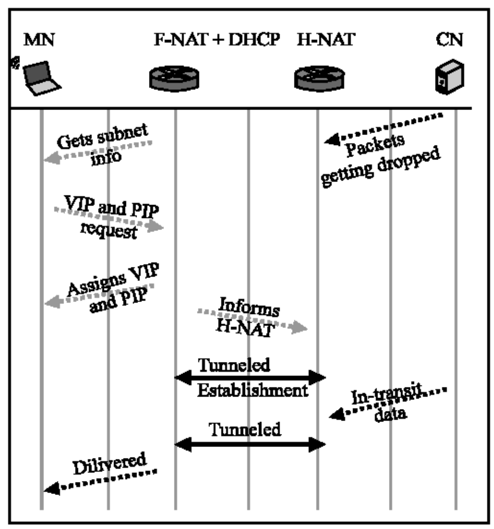

Fig. 8: Mobile NAT flow chart

As a MN uses Physical IP (PIP) and a Virtual IP (VIP) so after entering a new NAT-ed domain the MN sends a request to the DHCP server so that it can allot the requested IP's.

Figure 9 shows the sequence diagram of the Proactive buffering approach.

This approach has the problem of dropping the transient data before detecting that the MN has exited its domain as shown.

The other problem with this scheme is that when a MN moves to a new domain and the Absence Detection Interval expires, the old FA needs to send the buffered

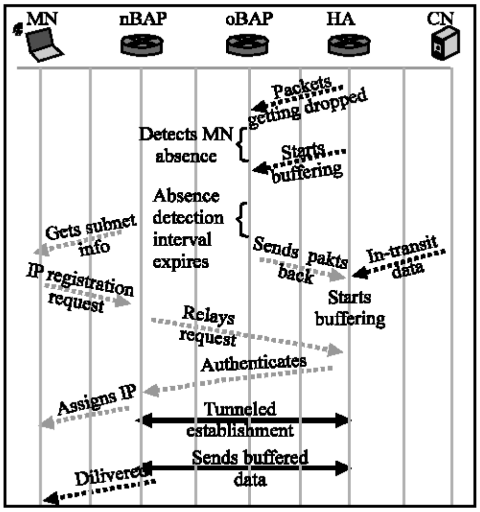

Fig. 9: Proactive buffering flow chart

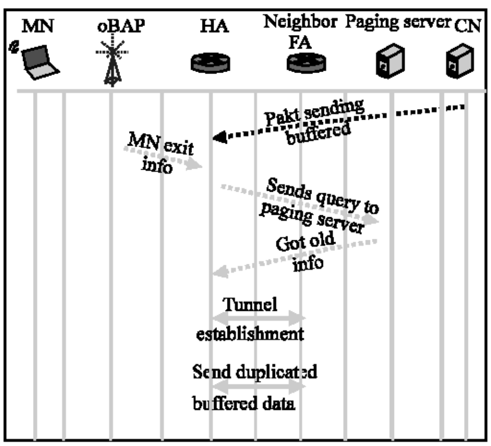

Fig. 10: MN exits from home domain

and the transient data back to the HA without considering the fact that the HA can be at a distant location. This introduces delay, thus preventing the early transfer of transient packets to the MN.

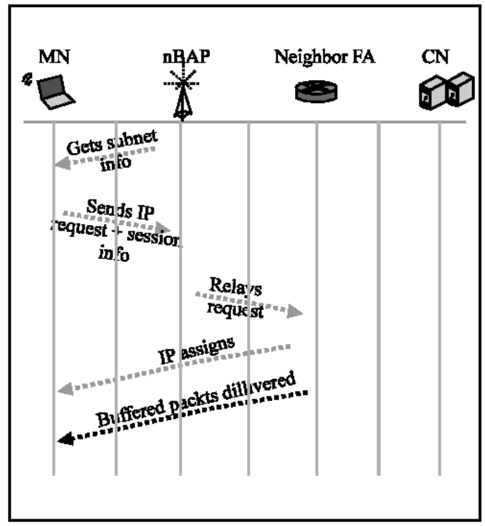

Fig. 11: IP assignment to MN in new domain

Figure 10 shows the proposed scheme when a MN leaves the home domain and it can be observed that the transient data is already being buffered when the MN exit info reached the HA thus reducing the packet losses. Here when the HA is informed about MN exit by the BAP, it contacts the PS. If the PS also has information older than the expected one, the HA will send a tunnel establishment request to the new domain FA and will send the buffered data.

Figure 11 shows the process when the MN enters a new domain. When the MN enters new domain, it gets the subnet information of the new domain and thus sends a request for a new IP address.

COMPARISON SHEET

The Table 1 below shows a comparison of various schemes under certain parameters with the proposed scheme:

Table 1: Comparison of available schemes with proposed scheme

Parameters	Mobile Ipv6	Mobile Ipv4	Mobile NAT	Proactive buffering	Proposed scheme
Movementdetection	Not used	Not used	Not used	Used	Used
Handoff initiator	MN/Network	MN	Network	Network	Network
Buffering	Used	Used	Not used	Used	Used
Soft state management	Not used	Not used	Used	Used	Used
Authentication	Used	Used	Used	Not used	Not used
Addressing scheme	IP based	IP based	NAT based	IP based	IP based
Handoff complexity	Low	Low	Medium	High	Medium
Transitional data loss	Yes	Yes	Yes	Less	No

CONCLUSIONS

We have proposed a scheme that can handle the issue of transient data loss when a MN moves from one administrative domain to the other. This is achieved by introducing a new component called the Boundary Access Point (BAP). The BAP can be used to monitor the MN that could possibly enter a neighbor domain. To support this idea, buffering is done at the Home Agent (HA) and Foreign Agent (FA) so that buffers can be maintained for the MN present under BAP coverage area. Whenever a MN moves, a copy of these buffers is sent to the new location.

Another important aspect of this scheme is the earliest delivery of the transient data to the new location. This also motivates us to name our scheme as a Fast inter-domain mobility scheme. All the inter-domain mobility schemes discussed here except the proactive buffering scheme rely on informing the previous gateway after the MN moves to the new administrative domain. This process greatly increases the delay in transferring the transient data to the new location. Proposed scheme uses BAP to aid in sending buffered and transient data packets to new location as soon as the MN exits the previous administrative domain.

Finally, this scheme can provide benefits to other inter-domain mobility schemes such as Mobile Ipv4, Mobile NAT and proactive buffering schemes.

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