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Quantitative Evaluation for PMPIv6 Multicast Fast Reroute Operations

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Abstract

This paper evaluates Proxy Mobile Internet Protocol Version 6 (PMIPv6) multicast fast reroute operations using quantitative analysis. The motivation is to cater the fast growth of mobile data traffic consumption and its networking technologies. Hence it is significance to enhancing the present techniques. Multicast enabled PMIPv6 is a mobile multicast networking management protocol that is highly acceptable in handling mobile data traffic. This paper briefly highlights the methodology, architecture and processes involved to produce the quatitative equations for each parameter. The quantitative parameters discussed are packet loss cost and handover latency.

Keywords*: handover latency, packet loss cost, PMIPv6*

1. Introduction

Multicast communication is known as data traffic distribution to a group of designated receivers. Multicast delivers efficient group communication and diminishes packets duplication distribution issue. Mobility is defined as the movement of a node from a network to another network. When a receiver changes its location, certain services that are established at the old location need to be continued. Maintaining receiver's reachability and simplicity is a problem, as the network changes from one network to another. It is very challenging to deal with collections of mobile services in highly heterogeneous receivers with effective handover performance. A receiver is known as a mobile node. When a mobile node changes its point of attachment it is described as a mobile node handover process. After the handover the mobile node is no longer attached to the same network as it was previously.

The recent increase in mobile data traffic makes the integration of multicast with mobility more challenging. Though multicast communication is introduced to optimize mobility, there are issues that aroused and need to be addressed. According to [1] current infrastructure is not prepared to cater these issues and problems. Despite the fact that there are many solutions based on MIPv6 and PMIPv6, yet still exists many service performance issues in terms of high handover delay, high packet loss, low throughput, high service recovery time, high signaling cost, scalability and etc. [1] categorized those issues as routing issues, receiver issues, source issues and deployment issues.

Tree construction is categorized as one of the routing issues. In mobile multicast, the reconstruction of multicast delivery tree is the main problem. It is the job of the multicast routing protocol and depending on the multicast membership protocol information. Multicast Listener Discovery (MLD) [2] state has to be reconstructed in the new location when mobile multicast subscriber moves into another subnet. But this mechanism is not provided by the MLD protocol. The performance of multicast services is affected by the transfer of the MLD state between new location and old location. Furthermore the MLD does not consider the mobility of nodes, only focused on the dynamic group membership and designed for fixed nodes. Hence, MLD cannot maintain multicast group membership continually this causing high service recovery time.

Multicast delay that is caused by handover latency is categorized as receiver issue. The multicast latency is described as when a mobile node experience extra time interval in reception of multicast packets due to reasons such as multicast tree computation, multicast membership protocol, handover and etc. Packet loss is considered as source and receiver issue. Packet loss is defined as packets that could not reach the destination. During the handover, the MN needs

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to continue receiving multicast packets. So, forwarding mechanism is required to support seamless handover.

As to improve this issue, proposals are introduced. Some of these proposals are Mobile IPv6 (MIPv6) [3], Fast Handovers Mobile IPv6 (FMIPv6), Hierarchical Mobility IPv6 (HMIPv6) and Proxy Mobile IPv6 (PMIPv6) [4]. PMIPv6 is chosen because it has the capability of providing future acceptable mobility support.

The Internet Engineering Task Force (IETF) has defined PMIPv6 as network mobility management protocol to reduce the host Mobile IP signaling load. These loads are due to the interchange of registration or routing information. Network mobility management protocol does not require a host participation in any of its mobility signaling [4]. The IP mobility management is handled by the network on behalf of the host. This includes initiating the required mobility signaling and the host movements tracking by the mobility entities in the network. One of these entities called the Local Mobility Anchor (LMA). It is the highest rank router located in the hierarchy of a PMIPv6 network. The LMA is used by the mobile node as a local home agent (HA) [4]. PMIPv6 is initially developed to support high performance mobile unicast communication. However it has high potential of supporting mobile multicast communication. Procedures such as Context Transfer Protocol (CTP) [5-6] and Multicast only Fast Reroute (MFR) [7] is available to enable multicast support in PMIPv6.

In summary research on Mobile IPv6 which involves Multicast IP is still an on-going process. There is no single Mobile Multicast protocol developed which could satisfy all the requirements since each application has its own key parameters. Therefore, the task of improving the existing Mobile Multicast protocols has great potential as future research.

2. Research Methodology

The first stage o this paper is a deep review of multicast enabled PMIPv6 and Multicast Fast Reroute (MFR) protocol. The standard architecture of PMIPv6 is then modified to be able to work with MFR. As for the next second stage, the enhanced architecture is then developed with the process flow for mobile node handover operation. The third stage, referring to the process flow operations, mathematical equations for the parameters are derived. The final stage is to calculate the values using data. Figure 1 shows the research methodology. Figure 2 shows the architecture with the process flow.

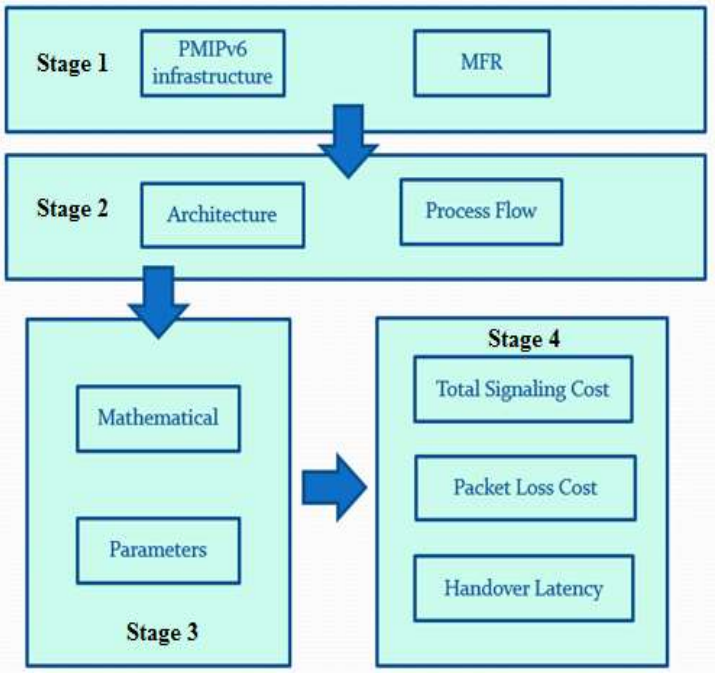

Figure 1. Research methodology overview

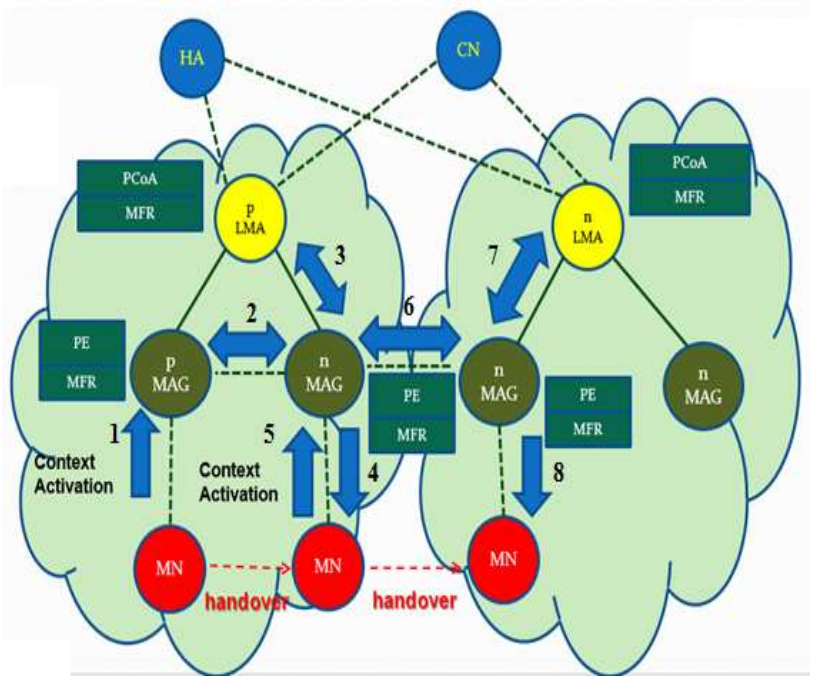

Figure 2. Architecture and process flow

3. Results and Analysis

In this section the PMIPv6 multicast fast reroute denoted cmfr is evaluated with the standard PMIPv6 denoted as m in the equations. The performance parameters are packet loss cost and handover latency.

3.1. Packet Loss Cost

The packet loss cost is calculated from packet arrival rate, handover delay and service recovery time. Packet arrival rate is the number of packets per unit time. The packet loss cost is noted as δ. Table 1 describes the parameters referering to [8] and [9].

Table 1. Parameters for Packet Loss Cost

Parameter	Description	Value
P_{AR}	packet arrival rate	10–100 packet/sec
T_{RS}	the time to send the RS message from MN to nMAG	12ms
T_{RA}	the time to send the RA message from nMAG to MN	12ms
T_{BU}	the time to send the PBU from nMAG to LMA	10ms
T_{BA}	the time to send the PBA message from LMA to nMAG	10ms
T_{MLDq}	the time to send the MLD query message from nMAG to MN	12ms
T_{RD}	time taken to discover nMAG	25ms

The packet loss cost for standard PMIPv6, δ_m, is described in equation 1:

$$\delta_m = P_{AR}(T_{RS}+T_{RA}+T_{BU}+T_{BA}+T_{MLDq}+T_{RD}) \quad (1)$$

As for the case of PMIPv6 multicast fast reroute, δ_{cmfr}, is expressed in equation 2:

$$\delta_{cmfr} = P_{AR}(T_{CTAR}+T_{BA}) \quad (2)$$

Table 2 describes the values for metric increment for x-axis.

Table 2. x-axis Metrics Increament

Metrics Increment	Router Discovery Delay (ms)	Packet Arrival Rate (packet/s)
1	25	10
2	50	20
3	75	30
4	100	40
5	125	50
6	150	60
7	175	70
8	200	80
9	225	90
10	250	100

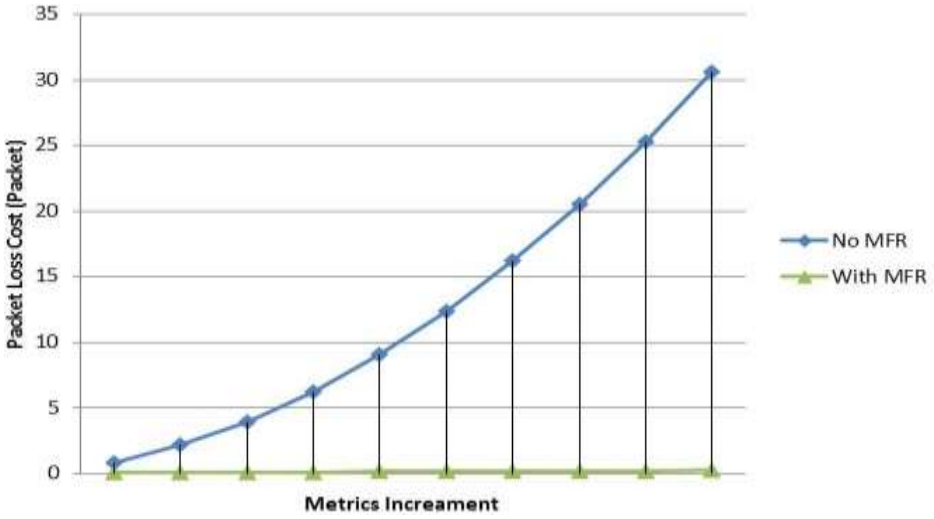

Figure 3. Packet loss cost versus metrics increament

In Figure 3, the router discovery delay is set to increase by 25ms and the packet arrival rate is set to increase by 10 packet/s. When both of these parameters increase, it can be seen that for the standard, the packet delivery cost increases exponentially. While for PMIPv7 with MFR, linear increment for the packet loss cost as both parameters increase. This is because PMIPv6 MFR depends only on the packet arrival rate, but the standard depends on both parameters the packet arrival rate and the router discovery delay.

3.2. Handover Latency

The handover latency is defined as the time needed for the MN to change its point of attachment from one network connection to another [9]. Let γ denoted as handover latency, I_{ls} as link switching delay, I_{RD} denoted as router discovery delay. Table 3 summarizes the parameters for γ_m, γ_c, and γ_{cmfr} [10].

Table 3. Parameters for Handover Latency

Parameter	Description	Value (ms)
$I_{pMAGnMAG}$	the time interval between pMAG and nMAG	10
$I_{LMAnMAG}$	the time interval between LMA and nMAG	10
I_{MNnMAG}	the time interval between MN and nMAG	12
I_{RD}	router discovery delay	10

The handover latency for each solution is defined as below:

The handover latency for standard PMIPv6, γ_c, is expressed in equation 3:

$\gamma_c = I_{RD} + 4\ I_{MNnMAG} + 3I_{LMAnMAG}$ (3)

As for the PMIPv6 with MFR, the handover latency, γ_{cmfr} is , shown in equation 4:

$\gamma_{cmfr} = I_{pMAGnMAG} + I_{LMAnMAG}$ (4)

Table 4 describes the values for metric increment for x-axis.

Table 4. x-axis Metrics Increament

Metrics Increment	Router Discovery Delay (ms)	Link Delay (ms)
1	25	10
2	50	20
3	75	30
4	100	40
5	125	50
6	150	60
7	175	70
8	200	80
9	225	90
10	250	100

In Figure 4, all schemes increase as both parameters increases. However the benchmark gives the highest handover latency values compared to the proposed scheme. Link delay increment effect significantly toward PMIPv6 performance compared to router discovery delay increment. As mentioned earlier the router discovery delay increment does not affect the handover latency of the proposed scheme.

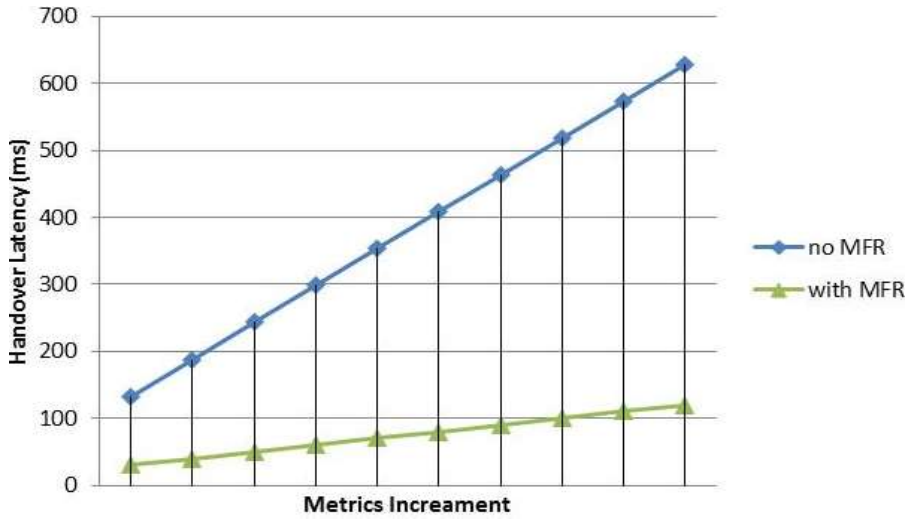

Figure 4. Handover latency versus router discovery delay and link delay

4. Conclusion

Quantitative evaluation is done for standard PMIPv6 and PMIPv6 Multicast Fast Reroute. In the case of PMIPv6 Multicast Fast Reroute, its predictive handover policy provides a better handover for mobile traffic. The packet loss corresponds directly with the service interruption is reduced in the PMIPv6 Multicast Fast Reroute, whereas the standard caused very high packet loss ratio that could affect multicast communication.

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