Performance Evaluation of IEEE802.21-Media Independent Handover for Heterogeneous Networks

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Abstract: This paper presents an evaluation based on media independent handover (MIH) that addresses the handover requirements. This research addresses the analysis of handovers by mobile devices for switching. Simulation experiments are performed for performance analysis in ns-2. Performance parameters for analysis are throughput, delay, packet loss ratio, speed and number of nodes. Two scheduling algorithms are selected for evaluation named proportional fair and exponential proportional fair. From observations it is deduced that overall EXP-PF performs better whereas PF shows higher throughput for a network of high speed nodes.

Keywords: Media independent handover, PF, EXP-PF and Ns-2.

I. INTRODUCTION

Recently, a number of wireless communication technologies are migrating towards heterogeneous wireless networks. Wireless Local Area Networks (WLANs) based on the IEEE 802.11 standards, Wireless Metropolitan Area Networks (WMANs) based on the IEEE 802.16 standards, third-generation Wireless Wide Area Networks (3G WWANs), and other technologies are interconnected with each other to offer the Internet access to users anytime, anywhere, with better Quality of Service (QoS). Each technology has its own characteristics that complement others, so users can select the most appropriate interface according to their needs. The integration of heterogeneous wireless networks raises interesting issues such as network discovery, admission control, security, and power management for multi-mode terminals. With the growing importance of those issues, there have been several research and standard group activities. For example, the integration of WLAN and 3G networks has actively been studied by the 3GPP/3GPP2 consortium, IEEE, and ETSI. However, these solutions cannot be directly adapted to other heterogeneous networks such as integrated 802.11/802.16e networks. The upcoming IEEE 802.21 standard defines the MIH (Media Independent Handover) mechanism that enables the optimization of handovers in heterogeneous networks including both IEEE 802 and non-IEEE 802 networks. One of the main purposes of the IEEE 802.21 standard is to provide a media independent interface between media-specific link layers and upper layers such as Mobile IP (MIP), Session Initiation Protocol (SIP), and applications. Through the media independent interface, the MIH events, commands, and information services can be provided to the upper layers.

Media independent handover (MIH) framework has been proposed in IEEE 802.21 to provide a common interface for managing events and control messages exchanged between handoff decision module and different network devices. That framework is useful to efficiently implement solutions for inter-technology seamless handovers. However, conventional context aware handover methods have not completely utilized MIH services, probably due to the lack of this framework in truly providing dynamic context of underlying access networks. The information provided by MIH information service is intended to be mainly static, primarily used by policy engines that do not require dynamic and updated information.

II. RELATED WORK

The authors of Yang et al. (2008) proposed a handover decision algorithm using MIH services in Wi-Fi and WiMAX networks with QOS provision. The simulation results show that the proposed algorithm provides smaller handover times and lower dropping rate than the basic vertical handover method.

In Wang et al. (2008), the authors proposed two novel weighted Markov chain (WMC) approaches based on rank aggregation, in which a favorite network is selected as top one of rank aggregation result fused from multiple ranking lists based on decision factors. These approaches can easily integrate a priori knowledge and/or human experiences into vertical handover. Simulation results demonstrated the effectiveness of the proposed approaches.

Connection Manager (CM) which utilizes MIH services was introduced in Lim et al. (2009). Two main roles of CM are supporting seamless vertical handovers and efficient access point (AP) discoveries. From the experimental results in the real test-bed, it was shown that the MIH services can be used to reduce packet losses during a vertical handover and to reduce the AP discovery time and energy consumption of mobile nodes.

In Taniuchi et al. (2009) authors discussed how the IEEE 802.21 standard framework and services are addressing the challenges of seamless mobility for multi-interface devices. In addition, they describe and discuss design considerations for a proof-of-concept IEEE 802.21 implementation and share practical insights into how this standard can optimize handover performance.
The authors of Márquez-Barja et al. (2010) presented an overview of VHO techniques, along with the main algorithms, protocols and tools proposed in the literature. In addition they suggested the most appropriate VHO techniques to efficiently communicate in VN environments considering the particular characteristics of this type of networks.

In Liu Bin et al. (2010) the authors proposed a novel MIHF (Media-Independent Handover Function) variant, which is renamed interworking (IW) sublayer. IW sublayer provides a seamless inter-RAT handover procedure between UMTS and WiMAX systems. It relies on a new intersystem retransmission mechanism with cross-layer interaction ability providing lossless handover while keeping acceptable delays.

The authors of De la Oliva et al. (2011) [6] discussed the main challenges and functionalities required to create a Media Independence Service Layer, through the analysis of scenarios within the working group: 1) Wireless Coexistence, and 2) Heterogeneous Wireless Multihop Backhaul Networks.

A review on the vertical handover mechanism focusing mainly on the services provided by the IEEE 802.21 Media Independent Handover Standard was provided in Khan Farah M. et al. (2012). The Handover Execution stage is dependent on the media-specific technology. They also provide a brief discussion to the various approaches used to carry out the handover process depending on the parameters involved in the particular technologies and the handover decision algorithms.

The authors of Tamma et al. (2012) proposed an architecture which addresses several challenges involved in unified heterogeneous network system such as context-aware handover, load balancing and signaling overhead. They also presented comparative mathematical analysis of proposed architecture with respect to the current MIH standard.

In Khattab Omar et al. (2013) the authors surveyed the VHO approaches and classifies them into two categories based on mobility management protocols (MIPv4 and MIPv6) for which they compared their performances and characteristics. Finally, through this survey, they concluded that MIPv4 under MIH is expected to continue in the future.

A policy-based context-aware handover model based on the proposed extension was presented in Ghafarrokh et al. (2013). A well defined policy format is proposed for straight description of users’, devices’, and applications’ preferences and requirements. In contrast to traditional policy-based methods, a multi-policy scheme was proposed that exploits rank aggregation methods to employ a set of matching policies in target point of attachment selection.

To approach a better and enhanced advancement and improvement for mobility management, an enhanced handoff technique with combined DSR Flow and Extremely Trust Opportunistic Routing (E2TX) Protocol was proposed in Manimaran et al. (2017). The proposed mechanism of cross-layer is making an intelligent decision over handoff which transmit the packet information to the available link obtaining by handoff services and layer information as QoS (Quality of Service) required parameter. The proposed technique DSR Flow and E2TX showed better result in mobility management over the IEEE 802.21 network; where these two protocols played a crucial role to select the packet and finding the perfect shortest path.

In Swapna et al. (2017) the authors performed security analysis of IEEE 802.21 Media Independent Handover (MIH) mechanism for Software Defined Wireless Network (SDWN). They conducts architectural and functional analysis of MIH integrated with SDWN interface for mobility management of the wireless nodes. The outcome specifies a possible integration with future deployment opportunities in information exchange of IEEE 802.21 MIH for programmable network devices.

III. MIH MECHANISM

The MIH function at the terminal is continuously supplied with information regarding the environmental conditions that are relevant to the access performance of the available heterogeneous networks. The MIH function receives the information through dedicated interfaces with the individual layers of the protocol stack or by exchanging messages with the Information Services entity positioned in the home network.

The home WSP of the mobile subscriber provides the initial MIH policies. A mobile subscriber is typically equipped with a mobile terminal whose credentials enable its access to the service provider RAN. The MIH functional framework also assumes that the mobile terminal includes a software driver that enables seamless handover capabilities in compliance with the 802.21 standard.

Another key element of MIH is the initial bootstrapping mechanism. During the bootstrapping stage the MIH driver in the mobile terminal is supplied with the initial WSP policies, which indicate to the mobile terminal the initial preferred access technologies. The MIH driver in the terminal is associated with a WSP home network. The home network is the terminal’s MIH trusted environment where new policies can be found and updated. As data services are not free, the home WSP will attempt to collect most of the revenues associated with a user access. The home WSP may not own or operate all the access technologies that is available to a given user. Therefore, WSP policies will allow accessing visiting networks, or other service provider’s networks, only when revenue sharing agreements are in place between the home WSP and the visited provider.

In visited networks where revenue sharing agreements are not established between the home WSP and the visited provider, a user will obtain MIH access services only when the MIH policies of the home WSP allow it. Alternatively, the user can turn off the MIH function and directly subscribe to the available access technology provided by a visited network. Updates to SLA agreements between the
home networks and the visited networks will extend and modify the policies provided to the terminal. Once bootstrapped, these updates can be obtained by either accessing the home IS database or by periodic MIH updates controlled by the home network.

IV. SCHEDULING ALGORITHMS

Packet scheduling schemes aim to maximise system performance. Performances of scheduling strategies are measured in terms of system metrics, such as throughput, packet loss ratio, packet delay, fairness index, and spectral efficiency (Blough, D. M., 2010). Real-time (RT) applications are delay sensitive and requires GBR (Guaranteed Bit Rate) (Piro, G. et. al., 2011). In contrary, non-real time (NRT) services are less delay sensitive and require high throughput and low error rates (Brehm, M., et. al., 2013). The packet scheduling algorithms being considered in this work are described are as follows.

Proportional Fair (PF)

Proportional Fair is a channel-aware/QoS-unaware strategy that takes into account both the CQI and user’s past average data rate while allocating resources to the user. The goal of this algorithm was to maintain a trade-off between the fairness and network throughput. It chooses an UE whose metric M is highest. The priority metric, M is given in the following equation.

\[ M = \arg \max \left( \frac{R(t)}{\bar{R}(t)} \right) \]

and

\[ \bar{R}(t) = \frac{1}{1 - \epsilon} \cdot R(t - 1) + \frac{1}{\epsilon} \cdot R(t) \]

where, \( R(t) \) is the instantaneous achievable transmission rate
\( \bar{R}(t) \) is the average data rate of user i at time t,
\( \epsilon \) is the update window size
\( R(t - 1) = 0 \) if user i is not selected for transmission at time t-1

Proportional Fair (PF) properties provide higher priority not only to the users with good CQI but also to the users with low average data rate.

Exponential Proportional Fair (EXP-PF)

EXP/PF was proposed to support both RT services with different QoS requirements and NRT data services in an AMC/TDM (Adaptive Modulation and Coding and Time Division Multiplexing) system. It is a composite of EXP Rule and PF algorithm. PF properties ensure the maximization system throughput and EXP properties guarantee the delay constraints of RT services. The scheduling metric, M is based on the service type (i.e. RT/NRT) of each user.

\[ M = \arg \max \left\{ \exp \left( \frac{w(t) - \alpha(i) - \beta(i)}{\gamma(i)} \right) \right\} \]

where, \( w(t) \) is the average number of RT packets waiting at the eNodeB buffer at time t
\( \alpha(i) \) and \( \beta(i) \) are constants
\( \gamma(i) \) is the maximum HOL packet delay constraint of all RT service users

Experiments are divided into following cases:

Case 1: Simulation experiments are performed by varying Number of user equipments (UE) from 10 to 50 (i.e. 10, 20, 30, 40 and 50) for performance evaluation in terms of throughput. Here PF scheduling algorithm and Best efforts flows using parameters are used. Then experiments were performed for another scheduling algorithm called EXP-PF. Simulation results are shown in Figure 1.

V. SIMULATION RESULTS

For performing simulation experiments following configuration is used.

Table 1: Configuration table for experiments

<table>
<thead>
<tr>
<th>Name of Parameter</th>
<th>Configuration Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Type</td>
<td>Best Effort Flow</td>
</tr>
<tr>
<td>Radius</td>
<td>1 km</td>
</tr>
<tr>
<td>Number of Users Equipment</td>
<td>10 to 50</td>
</tr>
<tr>
<td>Simulation Duration</td>
<td>60s</td>
</tr>
<tr>
<td>Max. Delay</td>
<td>0.1s</td>
</tr>
<tr>
<td>Video bit rate</td>
<td>128kbps</td>
</tr>
<tr>
<td>Scheduling Algorithm</td>
<td>PF and EXP-PF</td>
</tr>
<tr>
<td>Speed</td>
<td>0.3,30,120 m/s</td>
</tr>
</tbody>
</table>
Figure 1: Graph for Throughput wrt number of nodes.

Throughput for EXP-PF is more for higher number of nodes as compare to PF algorithm.

**Case 2:** In this case Simulation experiments are performed by varying Number of user equipments (UE) from 10 to 50 (i.e. 10, 20, 30, 40 and 50) for performance evaluation in terms of Delay. Configuration mentioned in Table 1 is used. Here also PF scheduling algorithm and Best efforts flows using parameters are used first. Then experiments were performed for another scheduling algorithm called EXP-PF. Simulation outcomes are shown in Figure 2 below.

Figure 2: Graph for Delay wrt number of nodes.

There is no difference in delay value for the two algorithms wrt speed.

**Case 3:** Here, Simulation experiments are performed by varying Number of user equipments (UE) from 10 to 50 (i.e. 10, 20, 30, 40 and 50) for performance evaluation in terms of PLR. As in previous case PF scheduling algorithm and Best efforts flows using parameters are used first. Then experiments were performed for another scheduling algorithm EXP-PF. Results are shown in Figure 3 below.

Figure 3: Graph for PLR wrt number of nodes.

PLR in case of PF is more for higher number of nodes as compare to other algorithm EXP-PF.

**Case 4:** It is different case as simulation experiments are performed by varying speed of equipments instead of Number of user equipments (UE) for performance evaluation in terms of throughput. Here PF scheduling algorithm and Best efforts flows using parameters are used. Then experiments were performed for another scheduling algorithm called EXP-PF. Simulation results are shown in Figure 4 below. Here number of nodes is equal to 10.

Figure 4: Graph for Throughput wrt number of nodes.

Throughput for PF algorithm is more as compare to EXP-PF.

**Case 5:** It is similar case where simulation experiments are performed by varying speed of equipments for performance evaluation in terms of Delay. Here PF scheduling algorithm and Best efforts flows using parameters are used. Then experiments were performed for another scheduling algorithm called EXP-PF. Number of mobile nodes are 10. Simulation results are shown in Figure 5.
There is no difference in delay value for the two algorithms w.r.t. speed.

Case 6: Finally in this case experiments are performed w.r.t. speed of equipments for evaluation in terms of parameter called Delay. Here PF scheduling algorithm and Best efforts flows using parameters are used. Then experiments were performed for another scheduling algorithm called EXP-PF. Total number of equipments used here are 10. Simulation results are shown in Figure 6 below.

VI. CONCLUSION

In this paper several experiments were conducted for performance evaluation of MIH with two scheduling algorithms i.e. PF and EXP-PF. Total six cases were analyzed after performing simulation experiments on ns-2 and it is found that overall EXP-PF is giving better results whereas for high speed PF is showing higher throughput. There is no difference in delay value for selected scheduling algorithms and value is low so both can be considered for MIH.

REFERENCES

