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An Effective Prediction Model for Generating Link Going Down Event of IEEE802.21

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Abstract: The next generation of wireless networks intend to offer any service using any device through any network at any time and from anywhere which requires integration of heterogeneous networks. As different access technologies may offer various features, it is important to provide users with access to the most suitable network. To achieve this goal, the IEEE has developed a standard known as IEEE802.21, namely Media Independent Handover (MIH) with the aim of easing seamless mobility between these technologies. IEEE802.21 defines layer 2 events to make upper layer work well; these events are mainly divided into two categories, state change events and predictive events. In this study, we present an effective model of generating the predictive event Link Going Down (LGD) by taking into consideration two network parameters Mobile Node (MN) velocity and Round-Trip Time (RTT). The simulation of the proposed scenario using the network simulator NS2 shows that the time taken by the handover process is noticeably reduced using the proposed model.

Key words: Next generation wireless networks, prediction, MIH, handover, MIPv6, LGD

INTRODUCTION

Next generation wireless networks (Kim *et al*., 2009) will be based on all-IP infrastructure. The MNs are able to utilize any radio access technologies while roaming across the heterogeneous networks, this process known as vertical Handover (HO).

The MIPv6 and IEEE802.21 are considered as the backbone of Next Generation Wireless Networks (NGWN) to reduce the handover delay and packet loss in the next generation all-IP heterogeneous wireless networks.

The Institute of Electrical and Electronic Engineers (IEEE) developed this standard as an abstract logical layer which sits between layer 2 and 3 to integrate different access technologies and roaming between them with higher throughput. MIH offers a framework of the message flows between handover-related entities to provide information on handover candidate networks and to deliver handover commands.

MIPv6 is one of the mobility management solutions to keep ongoing communications of the MN by hiding the movement from the higher layers.

LITERATURE REVIEW

Handover latency is the time that elapses between the moment the MN receives its last packet from old Point of Attachment (PoA) and the moment that it receives its first packet in the new PoA (Gang and XiuHua, 2013).

Unfortunately, mobility protocols in their current forms do not provide seamless handover. Since, the 802.21 provides only the overall framework, the actual algorithms to be implemented are left to designers. To fill this gap, numerous Vertical Handover Decision (VHD) algorithms have been proposed in the research literature to achieve the following goals:

- Minimum handover latency
- Reducing unnecessary handovers
- Reducing handover failure
- Low packet loss

The Received Signal Strength (RSS) based algorithm are used as a handover strategy (Mhatre and Papagiannaki, 2006). They investigate the use of signal strength as part of the trigger mechanism by using a fixed

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value of the received Power (Pr) to generate the LGD event. These algorithms are widely used in horizontal handover because RSS is easy to measure and implement and the direct relation between RSS and Quality of Service (QoS). While in vertical handover, RSS is not the most important factor and RSS thresholds are different for different wireless technologies.

A new handover algorithm is introduced which uses the available bandwidth, coverage radius, battery power and RSS for interface selection. But these algorithms don't address some important factors like user preferences and cost. Additionally, the implementation of these algorithms requires a modification to broadcasted beacon message.

A MIH QoS model is combined with Multiple Attribute Decision Making (MADM) handover decision to provide seamless mobility between WiFi and WiMax networks (Yang *et al.*, 2008). They divide user traffic into four QoS classes; each traffic class has five weighted QoS parameters (price, bandwidth, delay, PER, jitter). The main drawback of these algorithms is that it is too difficult to estimate some parameters like jitter. Hence, any new parameter is taken into account will increase process complexity. Furthermore, it doesn't include how and when to start the handover process.

BACKGROUND OF THE IEEE802.21

IEEE802.21 is a framework that enables seamless handover between heterogeneous technologies. This framework is based on a protocol stack implemented in all the devices involved in the handover. IEEE802.21 provides a framework that allows higher levels to interact with lower layers to provide session continuity without dealing with the particularities of the each technology.

IEEE802.21 provides three services, Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS). MIH users make handover decision based on inputs from MIHF. Figure 1 illustrates the MIH architecture.

The MIES aims to provide and predict link changes such as Link_Up, Link_Down, Link_Going_Down, etc. These events are propagated from lower layers to upper layers through the MIH layer. MIES is divided into two categories, link events and MIH events. Link events are generated from the lower layer and transmitted to MIH layer. The MIH events are the events forwarded from MIH to upper layers.

MICS refers to the commands such as initiate handover and complete handover, sent from higher layer to lower layers. It enables handover mechanisms. MICS includes MIH command and link command. MIH commands originate from upper layers down to MIHF. Link commands are specific to the lower layers. MIIS provides a framework by which MIHF can discover homogenous and heterogeneous networks existing within a geographical area and facilitate seamless handover when roaming across these networks. The MIIS provides a bidirectional way for the two layers to share information such as current QoS, performance information and availability of service.

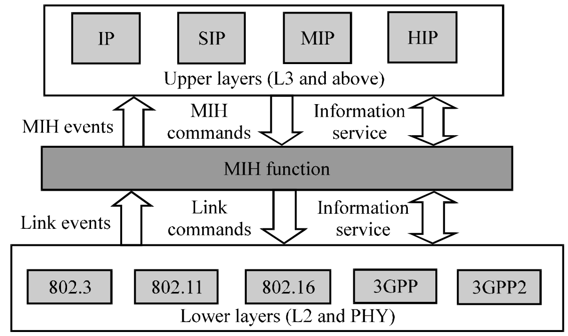

Fig. 1: Media independent handover framework

MIH BASED, INTELLIGENT HO DECISION

The existing network architecture like WiMax, WiFi can't support vertical handover between them. The IEEE802.21 standard is introduced to enable MN to perform seamless handover between different networks technologies (Yang *et al.*, 2008). Figure 2 illustrates a basic vertical handover algorithm between WiFi and WiMax.

Indeed, in order to ensure an effective and efficient handover, we need to consider other factors in besides RSS; therefore, LGD event will be more efficient and more effective. These factors are Maximum Round Trip Time (MaxRTT) and Estimated Time to leave coverage area (ET).

The generation of Link Going Down is achieved using the power level of the received packets. To configure the power level threshold, we use a coefficient namely LGD_Factor_, so the minimum power threshold before sending LGD event would be defined by RXThresh_ x LGD_Factor_. LGD_Factor_ should be ≥1. Two cases are distinguished here:

- LGD_Factor_ = 1 Link Down (LD) will be generated
- LGD_Factor_ >1 Link Going Down (LGD) will be generated

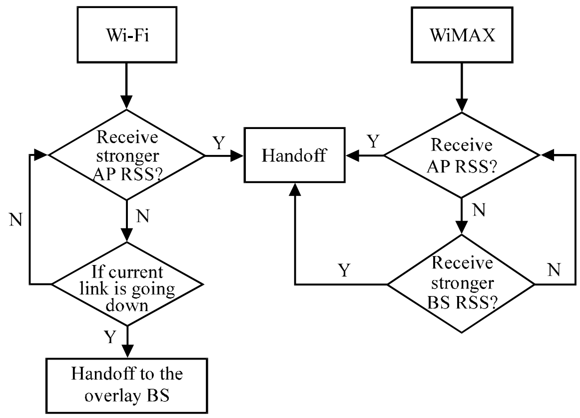

Fig. 2: Basic handover decision algorithm for vertical handover between WiMAX and Wi-Fi networks

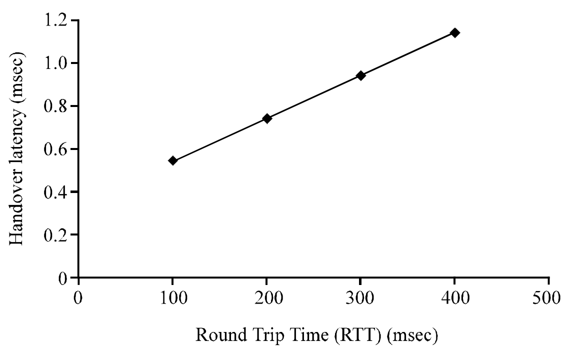

Fig. 3: The average handover latency for different round trip time

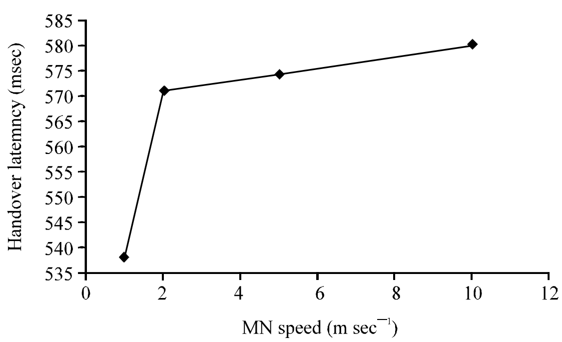

Fig. 4: The average handover latency for different MN speed

By running a simulation using NS2 we found that handover latency, thus LGD_Factor, depends on the two factors MN velocity (v) and Round Trip Time (RTT) (Fig. 3 and 4). Consequently, we can see that:

$$\text{LGD\_Factor\_} = F(v, RTT)$$

MN velocity: Coverage radius of the attached Access Point (AP) can be known from information server defined in IEEE802.21. Therefore, MN can estimate the Time Elapsed (ET) to leave the coverage area as defined in Eq. 1:

$$ET = \frac{D}{v} \tag{1}$$

Where:

v = MN velocity
D = The distance between the MN and the border of coverage area

MN can calculate D by knowing the transmission Power (Pt) and coverage Radius (R) which can get from information server and by using free space loss formula (Stallings, 2002) as given by Eq. 2:

$$P_r = P_t \times G_t \times G_r \left(\frac{\lambda}{4\pi d}\right)^2 \tag{2}$$

Where:

G_t = The transmitting antenna gain
G_r = The receiving antenna gain
λ = The wavelength
d = The distance between the AP and MN, repectively

Thus, D is equal to (R-d).

Maximum Round Trip Time (MaxRTT): Round Trip Time (RTT) is a very effective parameter in handover process. As RTT varies, due to several reasons, handover prediction module must estimate the maximum value MaxRTT. This estimation is done similarly to that performed by TCP (Kurose and Ross, 2011) based on the Eq. 3:

$$\text{EstimatedRTT} = (1-\alpha).\text{EstimatedRTT} + \alpha.\text{SampleRTT} \tag{3}$$

The new value of EstimatedRTT is a weighted combination of the previous value of EstimatedRTT and the new value for SampleRTT. The recommended value of is 0.125 (that is 1/8) (Paxson and Allman, 2000) in which case Eq. 3 becomes as given by Eq. 4:

$$\text{EstimatedRTT} = 0.875 \cdot \text{EstimatedRTT} + 0.125 \cdot \text{SampleRTT} \tag{4}$$

In addition to having an estimate of the RTT, it is also valuable to have a measure of the variation of the RTT. A common definition of that variation (DevRTT) (Paxson and Allman, 2000) defines it as an estimate of how much SampleRTT typically deviates from EstimatedRTT as given by Eq. 5:

$$DevRTT = (1\text{-}\beta) \cdot DevRTT + \beta \cdot SampleRTT\text{-}EstimatedRTT \quad (5)$$

DevRTT is an Exponential Weighted Moving Average (EWMA) of the difference between SampleRTT and EstimatedRTT. If the SampleRTT values have little fluctuation, then DevRTT will be small; on the other hand, if there is a lot of fluctuation, DevRTT will be large. The recommended value of is 0.25. Clearly, the MaxRTT should be greater than or equal to EstimatedRTT as given by Eq. 6:

$$MaxRTT = EstimatedRTT + DevRTT \quad (6)$$

So, LGD_Factor_ is calculated, using Eq. 1 and 6 as expressed by Eq. 7:

$$LGD\_Factor\_ = 1 + \frac{MaxRTT}{ET} \quad (7)$$

Two cases can be distinguished:

- MaxRTT>ET: the time to leave coverage area is less than MaxRTT. LGD_Factor_ will be >2 and this value will accelerate the generation of LGD event
- MaxRTT≤ET: the time to leave coverage area is more than MaxRTT. The LGD event will be generated in the suitable time

SIMULATION MODEL

The simulation results presented in this study are obtained using Network Simulator NS-2, NIST mobility add-on package which supports two of MIH functions events and command and WiMAX patch.

The simulation model is a heterogeneous mobile network allows vertical handover between 802.16e BS and 802.11b AP. The 802.16e and 802.11b parameters are shown in Table 1 and 2.

Proposed scenario: Our simulation model as shown in Fig. 5 and 6, consists of one 802.11b AP, one 802.16e BS and a Mobile Node (MN) moving between the two cells. During simulation, the mobile node exchanges with the Correspondent Node (CN) internet traffic.

Simulation results: The handover decision depends on the MIH triggers/events. The events provided by the lower layers to MIH can give an indication of any change that may occur when a MN moves to a different network. For instance, it can send a predictive trigger in case of decreasing WLAN signal strength to indicate the loss of link connectivity in the near future or it can send a state change trigger when layer 2 connection is established for the specified link interface. Table 3 illustrates the variation

Table 1: 802.11b AP parameters

IEEE802.11b	Parameters
Coverage radius	100 m
Radio Propagation Model	Two-ray ground
Frequency	2.4 GHz
Transmission Power (Pt_)	0.0027 W
RXThresh	$2.64504e^{-10}$ W

Table 2: 802.16e BS parameters

IEEE802.16e	Parameters
Coverage radius	1000 m
Radio Propagation Model	Two-ray ground
Frequency	3.5 GHz
Transmission Power (Pt_)	15 W
RXThresh_	$7.59375e^{-11}$ W

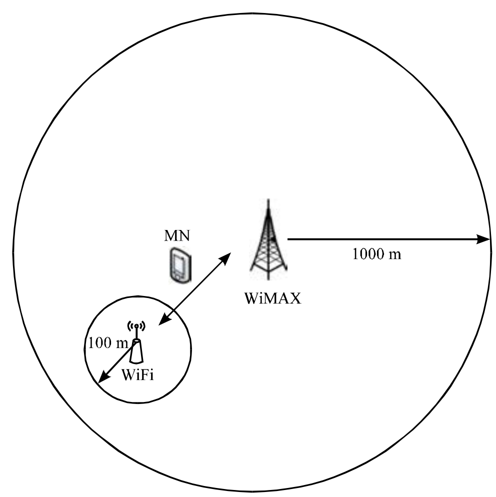

Fig. 5: Simulated scenario

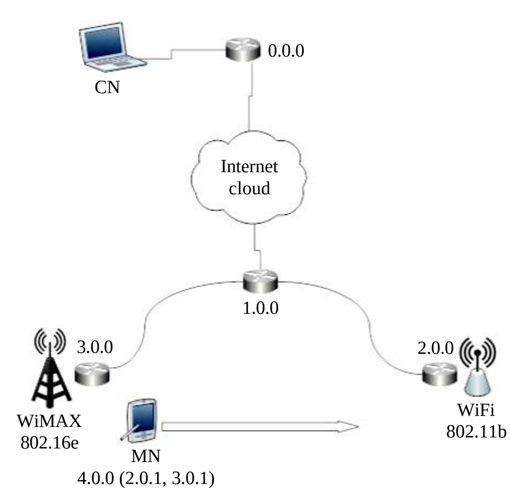

Fig. 6: Illustrates the topology of simulated scenario

Table 3: Variation of LGD_Factor

d	P_r	ET	LGD_Factor	LGD_Factor X RXThresh_	HO decision taken
10	2.64469E-08	9.0	1.02222222	2.70E-10	No
20	6.61173E-09	8.0	1.025	2.71E-10	No
30	2.93855E-09	7.0	1.02857143	2.72E-10	No
40	1.65293E-09	6.0	1.03333333	2.73E-10	No
45	1.30602E-09	5.5	1.03636364	2.74E-10	No
50	1.05788E-09	5.0	1.04	2.75E-10	No
60	7.34637E-10	4.0	1.05	2.78E-10	No
70	5.39733E-10	3.0	1.06666667	2.82E-10	No
80	4.13233E-10	2.0	1.1	2.91E-10	No
90	3.26505E-10	1.0	1.2	3.17E-10	No
91	3.19369E-10	0.9	1.22222222	3.23E-10	Yes

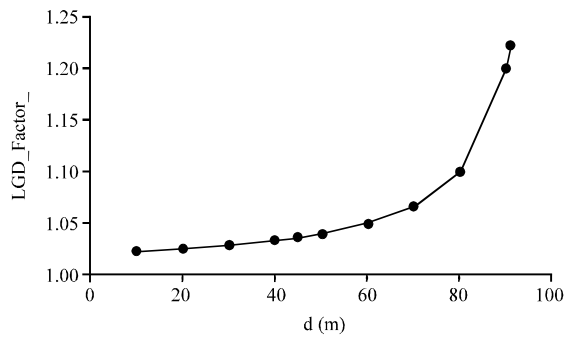

Fig. 7: The increase of LGD_Factor_ while MN is moving out of coverage area

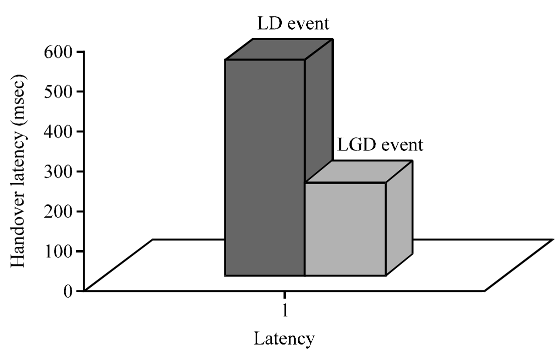

Fig. 8: A comparison of the handover latency between LD and LGD

of LGD_Factor_ when MN moves from WiFi into WiMax, the speed of the MN is 10 m sec^{-1} and the MaxRTT is 200 msec.

Figure 7 illustrates the increase of LGD_Factor_ while MN is moving out of coverage area. The event is triggered when the LGD_Factor_ reaches the value of 1.22. Once the trigger is generated, the MN location would be 8 m away from the border of coverage area.

Additionally, the handover process takes on average 235.608 msec when a LGD event is used. Whereas, it takes >500 msec when a LD event is used as illustrated in Fig. 8.

CONCLUSION

In this study, we proposed an effective predication model for generating a LGD event. The proposed model is designed to reduce unnecessary handover and minimize total handover latency as proved by the simulation results. As a consequence, the handover process will have a lower packet loss.

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