A Handover Management Scheme Based on User-Preferences and Network-Centric Approach

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Abstract

With the increase in a number of access technologies and data rates, a continuous connection among different networks is demand of the future wireless networks. In the last decade, user connectivity among different access networks remained a challenging job. Therefore, in this article, we proposed a user-centric and user-perspective based network selection mechanism for fast handover management in heterogeneous wireless networks. The proposed scheme selects the most appropriate network among available networks on the basis of resources i.e. cost, data rate, and link quality. Initially, we load the Media Independent Information Service (MIIS) with the information of cost and data rate provided by different network operators. Similarly, Mobile Node (MN) is also loaded with the user preferred cost and data rate for different applications. The MN obtains the information of cost and data rate from MIIS server upon a predefined threshold, and make a decision for handover according to its current cost and data rate. Furthermore, we employ an optimal threshold mechanism for initiation of the handover execution phase to minimize false handover indications.

The proposed scheme is based on a survey for network selection and its implementation in C programming language to validate its performance and accuracy. The simulation result shows that the proposed scheme performs superior then the schemes present in the current literature.

Keywords: Handover Management, user-centric, Cost, Data Rate, MIIS, MIH Standard.

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1. Introduction

Fourth generation (4G) mobility models have been designed to integrate different wireless technologies such as WLANs, WMANs, and cellular networks in a heterogeneous environment [1]. The integration of these technologies provides support for different services such as generic connectivity, reducing traffic load in different networks, re-associations, etc. Similarly, these technologies have their importance in different fields and areas such as hotels, shopping malls, airports, hotspots, sports stadiums, universities, schools, colleges, etc. Furthermore, every technology has some advantages over other technology, i.e. WLANs support low-cost architecture, and high data rate while cellular technologies provides wide coverage with low data rate.

The interconnection of these wireless technologies gave birth to new emerging concepts such as Machine to Machine (M2M), Internet of Things (IoT), etc. An example of such integration can be found in IoT systems where a mobile user is connected to cellular networks controls its home appliances which are then connected to a WIFI network. Maintaining a continuous connection between these different networks and providing a generic connectivity service is a challenging job. To overcome these challenges, a handover management scheme is needed to be designed with proper tuning of all relevant parameters. These parameters include RSS, SINR, bandwidth, data rate, velocity of Mobile Node (MN), user preferences, etc. A wide range of research studies have been conducted on RSS parameter [2] [3]. With the passage of time the demand of users and network access provider, become widely separated from each other. According to a survey conducted in a latest research shows that user normally demands for less costly network and high data rate services, so in such situation triggering handover on the basis of RSS can lead to the selection of costly network. Similarly, using RSS in heterogeneous networks environment can be a poor choice for handover triggering. Therefore, the researchers divert their focus to other parameters like, bandwidth and communication cost, etc.

Mobility management is classified into two parts i.e. handover and location management. Handover management provides support for transferring an ongoing session from one Access Point (AP) or Base Station (BS) to another AP or BS. The handover management is further divided into two parts i.e. soft and hard handover. In the case of hard handover an MN first breaks its current connection and then makes a new connection with another network. In soft handover, the MN first makes a new connection with the new AP or BS and then breaks its connection with the old network. The traffic during handover is first buffered at new network and then it is redirected through new connection. The soft handover is further categorized in three parts i.e. horizontal, vertical, and diagonal. In horizontal handover, the MN performs handover between the APs or BSs of the same network. This type of handover requires less handover delay compared to the other types of handover. In vertical handover, the MN performs handover from one AP or BS to another AP or BS of a different network. In the case of vertical handover, the route to the destination remains the same, and only the interface is changed. In diagonal handover, the MN performs handover similar to vertical handover, but the interface and route to the destination both are changed. Different operators and manufacturer already implement the diagonal handover for technologies such as WIFI and GPRS. In all of these types of handover, the vertical handover is the most recent and advanced technique for handover management in heterogeneous wireless networks. Different operators adopt the services of such handover, and the researchers are working hard to integrate it with the new technologies such as IoT and M2M systems.

The breakthrough has been made by IEEE in Nov 2008 by publishing a new standard called IEEE 802.21: Media Independent Handover (MIH) standard [4]. The MIH standard provides a generic platform for integration of different technologies such as all families of IEEE and 3GPP. MIH standard provide a connection between the lower layers with the upper layers through different events. These events are clearly explained and documented in MIH standard. Moreover, MIH standard uses different services to exchange the events between different modules of the MIH Function (MIHF). MIHF is the core entity resides in the heart of the MIH standard. MIH performed all of the important functionalities using the MIHF. The services provided by MIH include Media Independent Event Service (MIES), Media Independent Command Service (MICS), and Media Independent Information Service (MIIS). MIH standard also uses different Service Access Points (SAP) for the exchange of messages and functional planes of one technology with another. These services are further categorized in three parts: MIH_SAP, MIH_NET_SAP, and MIHME_SAP [5].

The MIH standard has still many challenges and issues which can be addressed. These challenges include the handover triggering and selection of a new network on the basis of RSS. Employing RSS for handover triggering can create different problems that can ultimately lead to severe packet and connection loss. The problems caused due to RSS in recent technologies are illustrated in **Fig 1**.

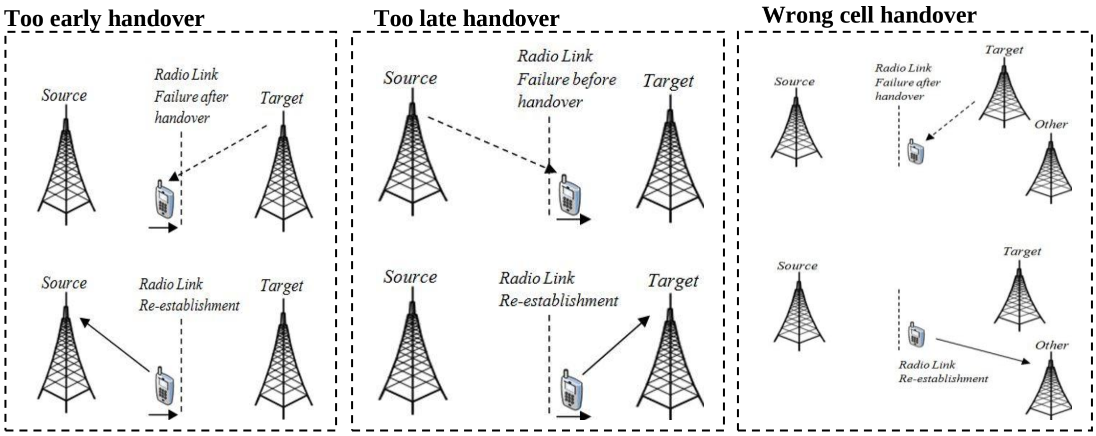

Fig. 1. Too early, too late, and wrong cell handover

Connecting to WIFI network in case of fast moving vehicle require frequent handover and thus leads to the consumption of high energy. Similarly, frequent handover also causes high handover delay and packet loss and in the absence of optimal network it can lead to breaking of the connection. These challenges need to be addressed before designing a generic handover model for the next generation of networks. In the last couple of years, the intensity of new data and internet users are increased dramatically. Therefore, providing continuous internet and data services in a mobile environment should be carefully designed.

In order to address the aforementioned challenges and issues in existing handover management models, we proposed a hybrid handover management scheme based on both user and network centric approaches. We further divide the working mechanism of the proposed scheme into two parts. The proposed handover management scheme selects an optimal network on the basis of cost and data rate of the new network, and the execution part is done using MIH standard. The rest of the paper is organized as follows. Literature review is presented in section 2. The proposed scheme is explained in section 3. Simulation results are presented in section 4, and finally the conclusion is given in section 5.

2. Related Work

Recently, several research works have been carried out to enhance the efficiency and performance of existing MIH standard. A scheme based on Signal to Noise and Interference Ratio (SNIR) is presented in [6]. The proposed scheme performed handover triggering on the basis of SNIR of the current network. The scheme performed better in case of minimizing extra traffic load during handover then the schemes that triggered handover on the basis of RSS [7]. But, unfortunately, SNIR and RSS can only be used to set a threshold for the MN to perform handover it cannot perform better in case of selecting a new network. Thus, the schemes based only on RSS and SNIR lacks the selection of an optimal network for the handover. A similar scheme based on the SNIR and bandwidth has been proposed in [8]. The proposed scheme compares the available bandwidth of current network with bandwidth of the new network. The scheme efficiently balanced the two bandwidths and executes handover using handover execution phase of the MIH standard. The proposed scheme only checks the available bandwidth of a new network. Handover management based on a single parameter is not a good choice in real time systems. Therefore, a scheme based on multiple parameters can be considered as a best handover management scheme for real-time communications.

A vertical handover is further divided into three phases 1) handover triggering/initiation, 2) network Selection, and 3) handover execution phase. The handover triggering is the most important part to initiate a handover at a right place and time. If the handover is triggered at right time, it can highly reduce the packet loss and handover delay in heterogeneous network environment. A scheme based an optimal handover triggering approach has been proposed in [9]. The scheme divides the coverage area around an AP or BS in multiple zones. Each zone is attached with a particular event to handle the communication between the MN and AP or BS. The scheme reduces the handover delay and time up to a great extent. A similar scheme based on the data rate management in heterogeneous vehicular ad hoc networks have been presented in [10]. This scheme checks the available data rate in the new network, if the data rate is not equal with the MN's current data rate it checks for the approximate data rate in new network and selects that data rate for handover. The drawback in the previous scheme is that selecting a new network for the handover on the basis of data rate is not an optimal choice for the end user. The reason is that if a network provides high data rate for more cost, then it cannot be possible for the MN to connect to an expensive network.

MIH selects a network on the basis of RSS, but RSS based handover selection have been suffered from high packet loss and delay during handover. A scheme for network selection based on the velocity of MN has been proposed in [11]. The proposed scheme in significantly reduced the packet loss ratio and number of failed handover in a heterogeneous network environment. A similar vertical handoff decision scheme in heterogeneous network is presented in [12]. The new network for the handover is selected on the basis of bandwidth, VoIP call dropping probability, and cost. This scheme is based on the network-centric approach. The information of bandwidth, VoIP call dropping probability, and cost required for MN is selected by access network operator. But, still the user is obliged to follow the access network operator's choice. A similar scheme based on user-centric approach has been proposed in [3] [13]. Both of these schemes is based on user's preferences and thus do not get benefits from the network centric advantages.

Accessing more than one network using a smart phone required high energy. In the case of WIFI network the energy per unit time is comparatively higher than other technologies. A handover scheme based on the energy consumption is presented in [14]. In this scheme, an efficient energy network is selected by an MN and then it performs handover to it. A scheme needs to be dependent on the applications using by an MN. But, unfortunately, it is based on network centric approach. A similar approach based on the efficient utilization of energy of an MN has been presented in [15]. The scheme minimizes the handover delay required during a handover process and thus save energy.

Recently most of the network selection methods are based on the speed of an MN, during its movement in a heterogeneous networks environment. Therefore, an MN must be provided with a dynamic QoS during a handover process in fast movement scenarios. Researchers have introduced different schemes based on a similar approach in [16] [17]. The schemes perform better in fast MN movement scenarios but, unfortunately, lacking the user preferences in the context of cost, data rate and other parameters. Sometimes the user is running an application that requires less data rate and hence performing handover to a network with high data rate for less time can use the resources of a network in an inappropriate way. A research work has been carried out on user profile based handover in [18] [19]. These schemes improve the weight assignment to different handover parameters. The user can be able to build a profile of low and high priority applications and then assign weights of their own choice. Thus, it helps in selecting an optimal network of user choice.

The schemes presented in the above literature do not provide a handover management scheme, which can be based on both user preferences and network centric approach. A single parameter cannot be used for selecting an optimal network among other networks. As new technologies such as IoT and M2M are growing with time, a handover scheme only based on network operator choice is not enough to control the user mobility in the future generation of networks. Thus, a generic handover management scheme is still need of the next generation of networks.

3. Proposed Scheme

The proposed model operates in two stages where in stage one a network selection is performed using user centric approach and in stage two handover executions is performed using the MIH standard.

3.1 Network Selection on the basis of user centric approach

Now-a-days people use a number of different applications for chat, call, and video streaming, etc. These applications require different data rates depending on the nature of these applications. The imbalance of data rates required for different applications causes several challenges during a handover process. Therefore, to avoid such issues, we categorize these applications on the basis of cost and data rate into two groups. The first group contains those people who prefer cost than data rate, and the other groups prefers data rate than the cost. Every user is configured with user preferences in the context of data rate and cost. After an MN perform handover to a particular network, the MN store the feedback of handover experience in a priority table. If the experience is good then for future handovers, the user uses the priority table at the same place. The main advantage of introducing the idea of the priority table is to provide an MN with an appropriate network. For example, a user is always moving on the same route from his home to his office. During the movement, it performs several handovers between different networks. Every time the MN performs a handover, its feedback is recorded in the priority table. Similarly, the recording is continuing for a particular duration of time. We divide the recording of handover experience into two different classes 1) one week and 2) one month. The reason of dividing a user experience into two classes is to separate a guest user from a normal user. Once the user feedbacked the handover information, the system updates the appropriate network requirement for that specific user. Thus, we finally achieve a handover model which is completely based on the user requirements. After the priority table information is updated, the next step is to configure the user preferences. Therefore, every access network sends their respective data and cost packages to the MIIS server. The MIIS server contains the geographical and location information of the available access network operators. When the MN is moving inside heterogeneous networks it uses this information to connect to locate a PoA of the available networks and then decide handover to the one with providing highest RSS. In the proposed scheme, we modified the working of MIIS server, and we include a database to store the cost and data rate information of available networks. In fourth-generation models, every network is supposed to be providing a particular data rate for a particular application. For example, a video streaming application requires high data rate compared to elastic applications. Thus keeping this approach in mind we built a system that dynamically selects a target network on the basis of the user requirements. The user access the information of cost and data rate of the available networks and then selects one that providing appropriate cost and data rate.

There are two cases which can be taken into consideration, 1) if an access network needs to modify the data rate and billing package information, it contacts the MIIS server and updates its package information and 2) if an access network operator wants to completely delete a package, it will also delete it from the MIIS server.The MIH standard does not provide with the functionality of the MIIS server. A theoretical documentation is present in the literature but no implementation is yet available. Therefore, we proposed a structure for MIIS server that consists of a number of arrays to store the information of available networks. The proposed structure is dynamically designed, because we want to provide access to every network operator to modify its cost and data rate information in the MIIS server. Thus, the MIIS server remains updated and hence an MN gets the full benefit from the MIIS server. After configuration of MIIS server, the MN then selects a network by comparing its current cost and data rate to the cost and data rate of the available access networks. The MN obtains the information from the MIIS server and then uses algorithm 1 to select the appropriate cost and data rate for the MN during network selection phase. In algorithm 1, the MN checks the cost of the available networks comparing to its current cost. If the available networks does not provide with the appropriate cost or the cost does not acceptable to the user then the MN selects the appropriate cost from the MIIS server.

Algorithm 1. Cost and Data Rate selection

```
While (Weak RSS) {
If (Cost_ON < Cost_NN){
   Cost_DIFF = Cost _NN – Cost _ON
   NEW_Cost = Cost_DIFF + Cost _ON
   While (MAX_USER_COST! = 0)
          If (NEW_Cost = = MAX_USER_COST){
                    select NEW_Cost from the Cost table of the new network in MIIS server
                    select the access network operator and data rate against the NEW_Cost
                    network
                    end while 2}
          else{
                    MAX_USER_COST= MAX_USER_COST-1}}
else {If (Cost_ON > Cost_NN) {Then
   Cost_diff = Cost_ON - Cost_NN
   NEW_Cost = Cost_diff + Cost_ON
```

```
select NEW_Cost from the Cost table of the new network
 in MIIS server
 select the access network operator and data rate against the
 NEW_Cost network}}
 end while 1}
```

Where Cost_ON, Cost_NN, Cost_DIFF represents cost of old network, cost of new network and cost difference respectively.

MIH standard perform handover on the basis of RSS of a new network, but unfortunately selecting a network on the basis of RSS is not a good criteria because a network can provide strong RSS but maybe it is already overloaded by a large number of connections. Therefore, we enhance the functionality of MIH standard by concatenating user centric approach with MIH standard. The aim of the integrating MIH standard with the user preferences is to divert more towards the user centric approach for handover initiation. In traditional approaches as well as in MIH standard the main problem is of performing handover on the basis of network centric approach. Because every network operator is wanted the users to utilize its network with full potential. But, with the passage of time new concepts are rapidly growing such as IoT and M2M, which require mobility and handover management on the basis of user preferences. For example, if a user does not get the required information, then the user initiates the handover process. Similarly, if a user experiences lack of bandwidth from the current AP or BS, then the user performs handover to the AP or BS with sufficient bandwidth.

The network selection phase of the proposed scheme is elaborated in **Fig. 2**. An MN is supposing to move inside heterogeneous environment. The MN is initially connected with access network operator number 1 (ANO). After some time when the MN is ready to perform handover, then the MN selects a network on the basis of cost and data rate information obtained from MIIS server during handover. Upon handover triggering the MN, sends a request to the MIIS server to fetch the information of available networks. In the case of **Fig. 2**, when an MN sends a request to the MIIS server it gets the cost and data rate information of ANO2, ANO3, and ANO4. When the MN obtained this information, it compares it with its information as stated in algorithm 1. The MN selects a network of its choice and sends a request for connection. This all process is done within the network selection phase. We set only two parameters, because fetching information from MIIS server and comparing it for optimal network selection consumes more energy on the MN side and fast providing of information on the network side. When the number of MNs in a particular area grows, it can be handle easily by processing only two parameters. These advantages reduce the complexity level of our proposed scheme. On the other hand, the decision of selecting an optimal network on the basis of several parameters requires high processing time. Therefore, we avoid using multiple parameters for the selection of a network. Recently, researchers introduces different decision models to optimize the working of a handover management in heterogeneous networks. These schemes are still young and require more enhancements to fulfill the requirement of fast handover support. As these schemes are not relevant to our proposed approach. Therefore, we avoid using these schemes for selecting an appropriate network during handover. Moreover, these scheme are failed in a fast user movement because it requires significant time to decide a network for the handover.

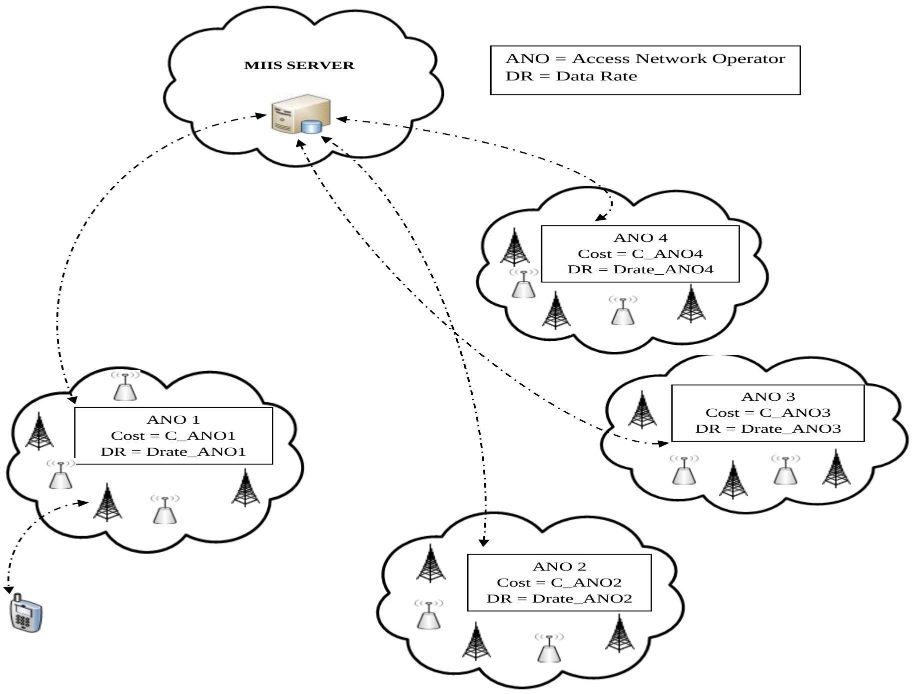

Fig. 2. Working of Network selection phase

3.2 Handover execution based on network centric approach

The criteria for threshold defined in MIH standard are not applicable to our proposed scheme because of the network selection phase. Therefore, we employ a new scheme for initiating a handover process. This scheme divides the total coverage area around an AP/BS into two parts on the basis of RSS. If the total coverage area of an AP/BS is (A), then the threshold 1 (θ1) for initiating network selection phase is set to ¾ (A) in case of AP of a WIFI network and ¾ (A) + 50 meters in case of BS of a UMTS network.

The MN periodically checks the RSS level from an AP/BS and when it drops below θ1 the MN initiate the network selection phase. The next threshold (θ2) is set for handover execution phase and it is defined on the distance equal to ¾ (A) + 10 and ¾ (A) + 75 meters in case of AP and BS, respectively. When the RSS receiving by an MN drops below θ2, it executes the handover using the handover execution phase of the MIH standard. Both of these thresholds are sent to the MN while making the connection with AP/BS in a beacon message. In handover execution phase, the MN's data is redirected through the new network. Moreover, the MN releases the resources of the old network upon availing it from the new network.

4. Experimental Classification Results and Analysis

In order to simulate the proposed scheme for both of the approaches i.e. user and network centric, we performed two different type of experiments. In the case of network selection phase, we performed a survey on a set of 100 people in a moving vehicle like a bus and a train. In this survey we ask people a set of questions regarding different applications like chat, audio call, video call, web browsing, online games and the preferred network for these applications in context of cost and data rate. On the basis of this survey, we identified the preferred network for an MN in context of cost and data rate. The survey is categorized in following **Table 1**.

Table 1. Survey for appropriate network selection phase

Number of users	Application	Preferred Network	Preferred cost or data rate
70 ~ 90	Audio Call	UMTS	Data Rate
50 ~ 75	Chat	WIFI	Cost
20 ~ 50	Online Games	WIFI	Data Rate
15 ~ 30	Chat	UMTS	Data Rate
10 ~ 25	Web Browsing	WIFI	Cost
5 ~ 15	Video call	WIFI	Data Rate
1 ~ 10	Audio Call	WIFI	Cost

Table 1 illustrates that most of the people preferred WIFI network with low cost. Thus on the basis of user preference, we built the network selection phase.

The implementation of the MIH standard is available in NS2 2.29 v3. But this implementation does not have a code for MIIS server. Therefore, we implement the MIIS server in C language to fulfill the simulation requirement of our proposed model. The cost and data rate values are given in following **Table 2**. These values are randomly distributed among WIFI and UMTS networks.

Table 2. Simulation parameters for Network Selection Phase

Handover Affecting Parameters	WIFI	UMTS
Cost	0 ~ 35	20 ~ 70
Data rate	0 ~ 1500	0 ~ 1000
RSS (θ_1 and θ_2) dBm	(-56 and -62)	(-56 and -62)

Each MN is randomly loaded with the values of cost and data rate from **Table 2**. When the MN is going away from its current AP/BS, and its RSS drops below θ1, then it initiates the network selection phase. The MN sends a request to current AP/BS and obtains the information of cost and data rate of new network. It compares this information with its information of cost and data rate based on the application running at that time i.e. Chat, Audio call, etc. The MN selects the appropriate network for the handover and sends a request to the AP/BS for handover upon its RSS drops below than θ2. The handover execution is done using the handover execution phase of MIH standard. **Table 3** shows the simulation parameters used in handover execution phase.

Table 3. Simulation Parameters for Handover Execution Phase

Parameter	value
Number of MNs	10 ~ 100
MN Movement	Random
UMTS network	500m
WIFI Network	100m
Packet Size	512 bytes
Traffic Type	CBR

Fig. 3 shows the packet loss ratio during handover. The proposed scheme is tested for different speeds of MNs. During fast movement, the MN performed frequent handovers that

increase the chances of packet loss. But in case of proposed scheme the MN selects an appropriate network for the handover that significantly decreases the packet loss. Similarly, the MIH standard performs handover triggering on the basis of RSS and due to it the MNs are provided with inappropriate network that significantly increases the packet loss. Fig 3 illustrates that as the speed of MN increases packet loss ratio also increases. But in case of proposed scheme the packet loss ratio is very less as compared to MIH standard because of the network selection phase. The MIH standard has a high packet loss due to the absences of network selection phase. Sometimes the MN selects a network for a very short duration of time due to which the MN's data is redirected through different networks. This increases the chances of packet loss during a handover. The proposed scheme avoids such problem by selecting a network that provide longer time for an MN. This functionality is added in the proposed scheme using the dual threshold handover triggering scheme.

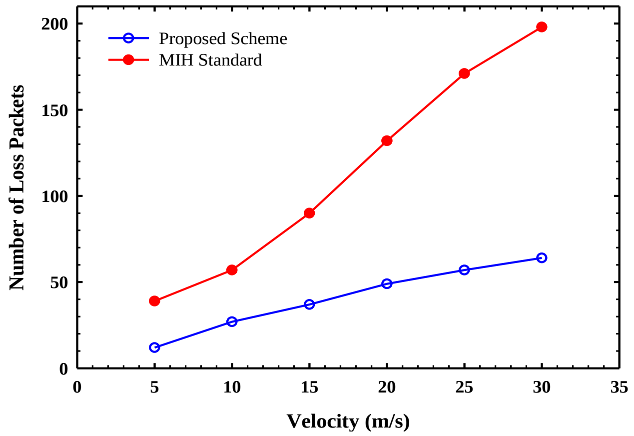

Fig. 3. Packet loss due to handover execution phase

Fig. 4 illustrates the comparison of the proposed scheme and MIH standard in the context of handover delay. The main cause of the increase in handover delay is the time required when a wait for a longer time to connect an access network. The proposed scheme perform handover on the basis of the user-preferences and the application running on an MN's device thus it require less time to connect to an access network. Another reason of handover delay is the scanning of available networks. MIH standard uses RSS to scan available networks, and it takes longer time to connect to an access network. The proposed scheme selects a network using the cost and data rate information of the available networks which significantly decreases the time require for scanning of available networks. In **Fig. 4**, different number of MNs performed handover from UMTS network to WIFI network. The proposed scheme has shown very less handover delay, because of the network selection phase. The MN select appropriate network before handover and thus give less delay against the MIH standard. The MIH standard has shown higher delay because of the selection of inappropriate network on the basis of RSS. An MN can select a network that can provide high cost and data rate on the basis of RSS. If a user is not able to afford such cost or data rate then, the MN will disconnects from such a network. Therefore, the MN will start network scanning again. Similarly, the scanning and disconnection will continue until the MN get connected to a network that provide appropriate cost or data rate.

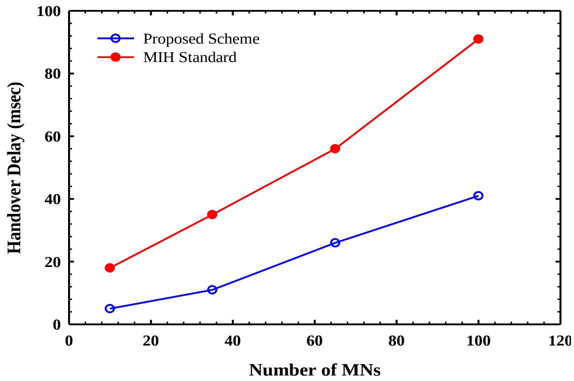

Fig. 4. Number of MNs vs. Handover Delay

Fig. 5 depicted the comparison of the proposed scheme with MIH standard in the context of handover time. The handover time is the sum of handover delay and re-association time. The handover delay takes around 90% of the total handover time while re-association only consists of 10% part. The MIH standard requires longer time to connect to the available networks. It also selects a network for a shorter time that ultimately increases the number of handovers. The frequent switching among available networks directly affects the user movement inside the networks. The proposed scheme uses two different thresholds one for handover triggering phase and another for network selection at the right place. Therefore, the total handover time of require by proposed scheme is less, because the network for the handover is already selected by the MN in network selection phase. The MIH standard some time select inappropriate network and thus needs to perform handover twice and even multiple times unless it gets connected to the target network. The proposed scheme always performs handover only a single time because it has already selected the appropriate network during network selection phase. Fig 5 also reveals that the proposed scheme can be easily adopted for future generations of networks because of shorter handover time than the MIH standard.

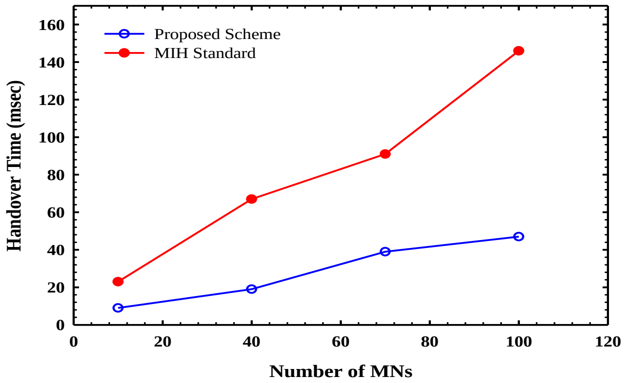

Fig. 5. Handover Time vs. Number of MNs

5. Conclusion

In this article, we present a network-centric and user-preference based handover management scheme. The traditional approaches are either consists of user-centric or network-centric. We combine the advantages of both the approaches in one single system. An optimal network among different networks is selected on the basis of the user preferences, and the handover execution is performed using network centric approach. We performed an extensive survey for network selection phase in different moving vehicles, and we found that most of the users prefer WIFI network as compared to other networks. The WIFI network provides data and internet services on the cheaper cost with high data rate. On the other hand a number of users preferred UMTS network because of its long coverage area and avoiding frequent handovers, thus the user experience less data loss in these networks.

On the basis of the aforementioned survey, we built a system that shows superior performance than the MIH standard. The proposed scheme significantly minimized the handover time and delay by a factor of 10 to 35%. The proposed scheme can be easily adopted for the future networks, because of its simple architecture and compatibility with existing devices.

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