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Research Article

An Optimized Network Selection and Handover Triggering Scheme for Heterogeneous Self-Organized Wireless Networks

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Optimizing the balance between different handover parameters for network selection is one of the challenging tasks for seamless communication in heterogeneous networks. Traditional approaches for network selection are mostly based on the Receive Signal Strength (RSS) from the Point of Attachment (PoA) of a network. Most of these schemes are suffered from high handover delay, false handover indications, and inappropriate network selection for handover. To address these problems, we present an optimized network selection scheme based on the speed of a mobile node. A mechanism based on two different thresholds on the speed of a Mobile Node (MN) is integrated in the proposed scheme. If the speed of an MN is greater than any of the threshold, the MN performs handover to a particular network. We employ Grey Relational Analysis (GRA) in the proposed scheme to select the best PoA of the selected network. Similarly, to deal with false handover indications, we proposed an optimized handover triggering technique. We compare our proposed scheme with existing schemes in context of energy consumption for scanning, frequent and failed handovers, packet loss ratio, and handover delay. The proposed scheme shows superior performance and it outperforms existing schemes used for similar purpose. Moreover, simulation results show the accuracy and performance of the proposed scheme.

1. Introduction

The aim of 4G networks is to provide generic connectivity among heterogeneous networks. With the advancement of new networks such as Long Term Evaluation (LTE), WIFI ac draft and WiMAX rel 2 provide high data rate and better connectivity to the end users. To access multiple networks an MN must be equipped with multiple interfaces. To ensure continuous connection among heterogeneous networks an MN must perform seamless switching from an Access Point (AP) or Base Station (BS) of a network to another AP or BS. This seamless transfer from one network to another can be possible if either an MN is already registered with all of the networks or there is a central system responsible for the registration of an MN. A seamless transfer of an ongoing session from one network to another network is called Vertical Handover (VHO). The VHO enables an MN to move inside heterogeneous networks and perform handover to any network regardless of the breaking of connection.

There are a number of parameters affecting a network selection process during VHO; these are velocity of an MN, RSS from the current PoA, energy required for scanning different networks through different interfaces, network connection time, and so forth. A handover process can be categorized in three stages, (1) handover initiation, (2) network selection, and (3) handover execution. Handover initiation is the task of starting a handover process when the connectivity between MN and current AP/BS drops below a particular level of RSS. Network selection is the task of selecting an appropriate target PoA, radio link transfer, and channel assignment. Handover execution illustrates the indication of successful completion of the entire VHO process. The RSS from an AP/BS is the most widely used criterion for network selection because of its simple measurement and its direct relation with Quality of Service (QoS) of a network.

The IEEE 802.21 Media Independent Handover (MIH) provides seamless mobility between all families of IEEE technologies and 3GPP [1]. The MIH standard transfers the information of handover from lower layers (logical link layer) to upper layers (network layer). In the heart of MIH standard their lies a MIH function. The main functionality of MIH standard is performed by the MIH function. The MIH

function provides interconnectivity between different services of MIH standard. But, the standard requires dynamic update of Media Independent Information Service (MIIS), which stores the geographical information of all access network operators available in a particular region. The MIH standard triggers a handover process on the basis of RSS, which is mainly suffered from false handover indications. Similarly, MIH standard selects a new network on the basis of RSS; that is, if the RSS from available networks are strong enough to hold the incoming connection, the MIH standard selects that particular network for handover. The selection of a new network on the basis of RSS leads to some critical problems like the following: (1) a network can provide better RSS with no space for new connections, (2) network with low QoS, (3) a network can be selected with high handover delay, and (4) frequent handover in case of smaller radio coverage. When an MN is moving with high speed inside the coverage area of a WIFI AP, it performs frequent handovers. To avoid frequent handovers a number of schemes were proposed in literature but unfortunately these schemes do not provide a generic seamless transfer of an ongoing session from one network to another. Therefore, in a heterogeneous network environment a dynamic network selection mechanism will provide an MN with seamless connectivity and better QoS.

In last couple of years, various network selection schemes have been proposed. Most of the schemes do not consider the current context and preferences of a user. Similarly, these schemes perform handover on the basis of single parameter. Considering more than one parameter for network selection leads to two-dimensional cost functions. The first dimension enables a user to request different services from a network and second dimension represents the total cost of the network against the requested services. The cost based network selection can be further categorized in three different parameters: weighting parameters, QoS parameters, and network priority parameters. The context of all of these three types of cost is different and it varies according to network situation and availability. A network selection method can be based on one of the types from these parameters. In last decade, researchers introduce a number of schemes based on these parameters [2, 3]. Multimedia technologies are rapidly growing these days and researchers are trying hard to develop sophisticated algorithm for transferring multimedia traffic from one network to another. Softly transferring multimedia traffic during handover can be achieved by employing high performance adaptive deblocking filters [4]. In future generation of networks motion estimation techniques will be used for transferring lesser amount of data during video traffic over internet [5]. These techniques will help an MN during handover from one network to another and thus it will take less amount of handover delay and packet loss. But unfortunately, none of the scheme considers the radio coverage of an AP or BS for the handover initiation. Using any of the above parameters can require high network connection time and thus applying such schemes for fast moving MN will lead to high packet loss and handover delay.

To deal with the aforesaid constraints, a network selection scheme can be based on the requirements of an MN. These requirements consist of communication cost, data rate, QoS, and so forth. In last decade, various schemes proposed optimized network selection schemes based on user preferences [6]. But still an MN has very little access to select a network according to their requirements. A generic scheme can be designed while keeping a balance relation between user preferences and network centric approaches. The QoS of a handover scheme can be enhanced while designing a scheme which requires less amount of data for fetching multimedia information to the MN during handover process [7, 8]. Nowadays Internet of Things (IoT) and Cyber Physical System (CPS) are evolving very rapidly. Thus dealing with such system and transferring data from one machine to another with fast handover support are also a challenging task. A generic handover system is needed which efficiently transfers data from one machine to another with less packet loss and without breaking of connection [9]. This proposal can only be possible if a network access operator initiates and executes handover process while network selection is performed by the end user. Similarly, different network selection strategies were developed to select an appropriate network during a VHO process. These strategies are categorized in four different parts, that is, Weight Product Method (WPM), Multiplicative Exponent Weighting (MEW), Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and GRA [10–12]. All of these strategies select a network on the basis of different attributes like bandwidth, delay, packet loss rate, and cost. GRA achieves better throughput and lower handover delay than all of the other three schemes. The focus of traditional network selection schemes was based on RSS and cost. But with the passage of time researchers identify other related parameters which are directly affecting a network selection strategy. A diagrammatic representation of these parameters is illustrated in Figure 1.

In order to optimize the working of a network selection process, we proposed a model based on the speed of an MN. The proposed scheme efficiently selects an appropriate network for handover while considering MN's current speed. Moreover, the proposed scheme adopts GRA decision mechanism for the selection of best PoA of the selected network. The scheme significantly reduces the number of false handover indications and packet loss ratio. Similarly, the proposed scheme successfully reduces the frequent handovers problems present in recent literature. Moreover, we also introduce a handover triggering mechanism which efficiently reduces the number of false handover indications.

The rest of the paper is structured as follows. Section 2 presents the related works of the existing models used for similar purpose. Section 3 describes the working of proposed scheme. Section 4 illustrates simulation and results and finally Section 5 concludes the proposed scheme.

2. Related Works

In this section, we first present detailed study of handover triggering techniques. Then, we discuss network selection models that support our assumptions, focusing on showing the differences from our approach.

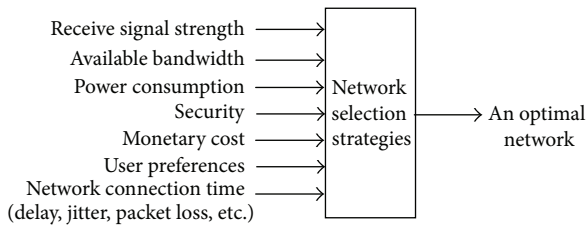

Figure 1: Parameters used for network selection.

2.1. Handover Triggering Techniques. Mobility robustness optimization provides an MN with the support to detect and correct three types of triggering issues, that is, too early, too late, and to a wrong cell. Researchers proposed various techniques to enhance the working of handover triggering, avoid these three types of issues, and reduce the false handover indications. If a handover is triggered too early it uses the network resources in an inefficient way and an MN does not succeed to connect to the target network. Similarly, in case of too late handover the MN moves far away from the current network and hence it disconnects from the current network during handover to a target network. All of these three types of issues are explained in Figure 2. Traditional handover triggering mechanisms are mostly based on RSS from current AP/BS [13–15]. But RSS based triggering mechanisms are unreliable and it is greatly affected by these three types of issues. Therefore, researchers considered other parameters like Signal to Interference and Noise Ratio (SINR), location of an MN, and network conditions for handover triggering, since, none of the schemes provide accurate results and almost all of them suffer from false handover indications.

There are other techniques which periodically scan the available networks. If the RSS of available networks becomes greater than current network the MN triggered the handover [16, 17]. These techniques fail when the RSS of the current network drops below a particular level of RSS and still new networks are not available. A technique based on optimized adaptive handover triggering mechanism has been proposed in [18]. The proposed scheme efficiently minimized the network load to avoid link failure. Moreover, the proposed scheme maximizes the resource utilization and hence an MN can use the network with full potential. This triggering mechanism also significantly reduces handover latency and handover dropping rate. Various handover triggering schemes are based on the location services such as GPS and Location Service Server (LSS) [19, 20]. The MN first checks the RSS level if it drops below a predefined threshold then the MN checks a decision function to determine whether a handover is need to triggered or not. The decision function collects different handover information from LSS. However, these types of handover triggering mechanisms do not evaluate the handover dropping rate. Recently different schemes have been proposed for enhancing the quality of the video and multimedia traffic [21]. These techniques play an important role in triggering handover on the basis of quality of multimedia information. But still different issues exist like estimating the correct amount of data for handover triggering.

2.2. Network Selection Schemes. Recently, various techniques have been proposed for network selection during handover in heterogeneous wireless networks. Most of the schemes are based on the optimization of different parameters necessary for handover. The optimization of these parameters reduces the handover time and latency. With the passage of time the numbers of new access networks are increased rapidly and thus produced signaling overhead and other issues related to a handover phenomenon. Similarly, the new access technologies such as LTE-Advanced and Bluetooth 4.0 low energy were introduced to save communication time and energy. All of the recent technologies try to provide their customer with the best QoS. The QoS of a network can be enhanced if a customer is provided with a continuous connection among different networks.

In order to assure required QoS for various applications running by MN and to avoid frequent handover in heterogeneous networks, an Analytic Hierarchy Process (AHP) method for network selection is introduced in [22]. The AHP selects a network on the basis of a decision and then assigns each decision a particular objective. It performs decision on the basis of different handover parameters like QoS, communication cost, availability and reputation of a network, and so forth. The AHP combines the average of each objective and then decides an appropriate network for handover. The AHP method employed by different researchers for network selection and its results are remarkable in selection of WLAN networks. But in case of cellular networks, the network selection decision by using AHP is not up to the mark. A similar scheme has been proposed to enhance the QoS of a network by optimizing different handover parameters like data rate and network connection time (handover delay and time) in [23]. The decision of handover is performed by using fuzzy logic and analytic hierarchy approaches. The proposed scheme obtains the context information like networks related information, user preferences, and service requirements for an efficient handover process. The MN periodically checks the RSS level with the current AP/BS, if the RSS drops below a particular level then the MN initiates network selection phase. A network quality scoring function is defined to evaluate the QoS of a network. The network with highest QoS is selected for the handover.

A scheme based on the optimization of MIH standard has been proposed in [24]. The scheme proposes a hierarchal discovery scheme for network selection. A number of APs/BSs in a particular zone are connected to a zone MIIS server. Similarly, the zone MIIS server is attached to the local MIIS server and then to the global MIIS server. When an MN requires performing a handover, it checks the information of the PoA of available access networks in zone MIIS server and if it is not available in the zone MIIS server it will transfer this request to the local MIIS server. Doing this way the load on single MIIS server is significantly minimized. The appropriate network for handover is selected from nearby MIIS server. The installment of the extra access routers on each level will require more cost and management. If the network information is not available in local and zone MIIS server it will take greater time for network selection.

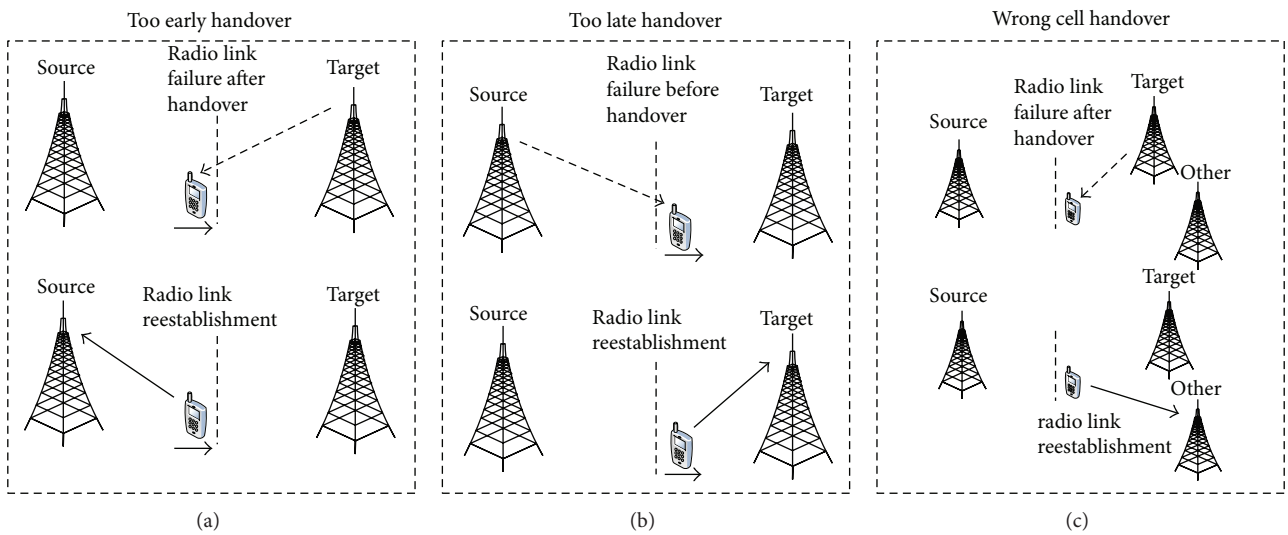

Figure 2: Too early, too late, and wrong cell handover.

The energy consumption during selection of networks is an important parameter and it needs to be considered carefully. The energy consumption by an MN is directly depending on the scanning of available networks during a handover process. Different schemes based on the energy efficient network selection for multimedia based applications have been proposed in [25, 26]. The proposed schemes use the concept of adapt-or-handover for balancing the multimedia traffic during a handover process. The proposed scheme saves energy which is consumed due to the insignificant degradation in quality. The scheme obtains the information of available networks and on the basis of these networks the MN selects one of the appropriate networks for current multimedia streaming. In order to optimize the energy consumption of multiple interfaces, an energy efficient scheme is proposed in [27]. This scheme first obtains the information of bands/channels used in certain areas. Based on the information of bands/channels, the MN designs a two-step scanning mechanism. In first step the MN does not scan those channels which are not used in the area and secondly scans channels with lower network density less frequently. Further each MN is provided with the network density as it enters into a new area. On the basis of previous experience of MNs a new MN is provided with density of the region which is highly and low visited. The MN then designs a scanning mechanism on the basis of available information and thus significantly reduces energy during scanning.

In last decade, researchers work hard to design energy efficient scanning techniques. Traditional techniques were mainly based on scanning through all interfaces. With the passage of time two different techniques become famous for scanning of available networks, that is, periodic and adaptive scanning. These techniques are optimized by different researchers and most of the scanning techniques were based on them. An energy efficient adaptive scanning algorithm is proposed in [28]. The MN adjusts scanning time inside a particular network using its speed. The speed of an MN is changing randomly, but the proposed scheme considered a fixed speed inside a particular network. Maintaining fixed speed inside a particular network is a challenging job. Thus this scheme cannot be adopted for the real world networks. A scheme based on periodic scanning has been proposed in [29]. The BS of a WiMAX network is assumed to broadcast the information of available APs in its coverage. On the basis of this information of available APs, the MN decides whether to scan available networks or not.

All of the above network selection techniques are based on different parameters. These schemes are good in a particular direction but not good for a generic network selection scheme in heterogeneous wireless networks. Next generation networks are growing rapidly and hence network selection on particular parameter and objective will not be enough for future use. Therefore, an MN should be provided with an appropriate network for handover in heterogeneous wireless networks.

3. Proposed Model

The proposed model operates in two stages where in stage one a handover triggering mechanism is developed to reduce false handover indications and in stage two network selection scheme is used to provide an MN with appropriate network and PoA.

3.1. Handover Triggering. A handover triggering mechanism facilitates MN to initiate handover process when it is required. The proposed model adopts threshold based mechanism for handover initiation session. In other words, handover is initiated if RSS from the current network drops below a predefined threshold. The advantages of the threshold based triggering mechanism are reducing the number of false handover indications and hence reducing total number of handover failures to a network with overloaded APs/BSs.

The time t required by MN to remain connected to an AP/BS with a speed v is shown by following equation (1):

$$t = \frac{D_o}{v}, \tag{1}$$

where D_o is the diameter of a serving cell.

Diameter is equal to the double of the radius r; hence (1) becomes

$$t = 2\frac{r}{v}. \tag{2}$$

The radius of the coverage area of AP/BS is not exactly circular and thus the propagation of signals at one direction is different from another direction. Thus to avoid changes of RSS in one direction from another we use an index γ as shown in

$$t = 2\gamma\frac{r}{v}. \tag{3}$$

The total handover time must be less than the time required by MN to remain connected to an AP/BS. Therefore, the handover triggering point must be set as a distance equal to $(1-\gamma)r$. According to [30] RSS w_b at the border of the serving cell is equal to

$$w_b = K_1 - K_2 \log\left((1-\gamma)\, r\right), \tag{4}$$

where K_1 and K_2 are the antenna gain and path loss factor, respectively.

We put a threshold of RSS level on the boundary of coverage area of a PoA of a network. In our scheme, to avoid false handover indications, the threshold δ is computed by removing the path loss factor and the velocity effect on the RSS from current AP/BS. Thus the final RSS (δ) for handover triggering can be defined as follows:

$$\delta = w_b - K_2 \log\left(1 - \frac{vT}{r}\right). \tag{5}$$

When RSS from current AP/BS drops below δ, the MN initiates network selection stage by using a specific interface based on the speed of MN. The proposed triggering scheme integrates the velocity and handover delay for identifying the appropriate RSS for handover.

3.2. Network Selection. When MN is moving at a high speed in a coverage area of WIFI network, it requires frequent switching from one AP to another since the radio coverage of WIFI AP is small. This frequent switching leads to much energy consumption, high packet loss, and breaking of connection. To deal with such situation, an optimized network selection scheme is proposed for handover based on the speed of MN. We assume that MN moving in heterogeneous networks has three different interfaces: WIFI, WiMAX, and Cellular. When the RSS from the current AP/BS drops below a particular threshold, it will initiate handover by selecting a network on the basis of its speed. If the speed is slow, the MN will scan the available networks through WIFI interface and the rest of the interfaces will be in standby mode. Similarly, if the speed is medium or high, the MN will select Cellular or WiMAX networks, respectively. To support energy efficient handover in this way, we implement a monitoring index based on the speed of MN using

$$\alpha = v\left(\frac{\omega}{\delta}\right)^{1/\beta}, \tag{6}$$

where ω represents the RSS level at current location of MN.

We use two thresholds for network selection based on the value of α: α_1 and α_2. If the value of α is less than α_1, then the MN turns on its WIFI interface and the rest of the interfaces is turned off. If the value of α is between α_1 and α_2, it only turns on its cellular interface, and if the value of α_1 is greater than α_2, it only turns on its WiMAX interface and the rest of the interfaces are switched to standby state.

As shown in Figure 3, assume that the MN is moving in a heterogeneous network consisting of WIFI, WiMAX, and Cellular. Initially, MN is connected to WIFI AP1 and gradually it moves away from AP1 and gets closer to BS_w1. When RSS from AP1 drops below the predefined threshold δ, MN initiates network selection phase. If speed of MN is greater than α_2, MN turns off its WIFI and cellular interfaces and only scans WiMAX network. MN finds a WiMAX BS_w1 and sends a connection request to it. If its RSS level again drops below δ inside the coverage area of BS_w1, then the MN checks the speed. If its speed is greater than α_1, then MN scans available networks with one particular interface and rest of the interfaces are turned to standby mode. MN finds BS_c3 and initiates handover to it. Finally, MN performs handover to AP11, and this is because its speed is less than the α_1.

Once MN decides a network for handover based on its speed then it is important to select best PoA of the selected network. There are different decision functions available for this purpose like SAW, WPM, MEW, AHP, GRA, and TOPSIS. AHP and GRA are the well-known mechanisms used for selecting a PoA on the basis of different parameters. We used GRA in our scheme to select the best available PoA. GRA analyzes the relationship rank between discrete sequences. We take one of the sequences as a user defined sequence. A user will first obtain the highest values of each objective and combine them in the user defined sequence. After calculating the user defined sequence, MN will compute the Grey Relational Coefficient (GRC) of each sequence and user defined sequence. MN compares the GRC value of user defined sequence and another comparative sequence of available PoAs. The PoA with highest GRC value is selected for handover. To clearly demonstrate the working of GRA used in proposed scheme, we use n sequences (X_1,X_2,X_3, …,X_n) and each sequence has k different objectives; that is, $X_i = (x_i(\text{obj}_1), x_i(\text{obj}_2), \ldots, x_i(\text{obj}_k))$ where $i = 1, 2, \ldots, n$. In the proposed scheme, we used eight different objectives, on the basis of which we decide rank of a PoA. These objectives include average throughput, delay, jitter, communication cost, bit error rate, availability, response time, and packet loss ratio. The next step in the GRA mechanism is to normalize the sequence data. We therefore set three different conditions for

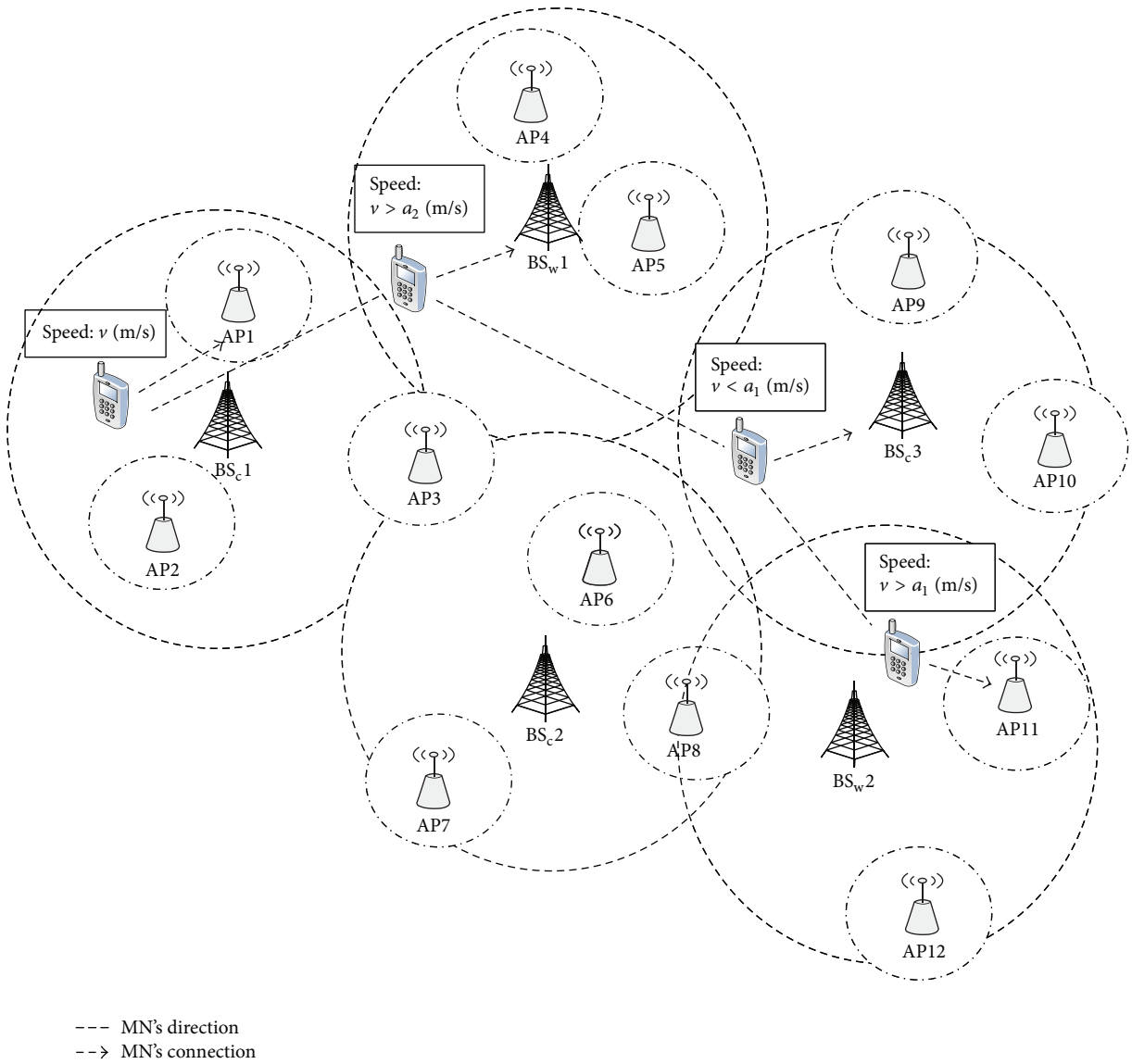

Figure 3: Selection of available networks based on MN's speed.

normalization, that is, highest-the-better, lower-the-better, and nominal-the-best as follows:

$$x_i\left(\text{obj}_j\right) = \frac{x_i\left(\text{obj}_j\right) - l_j}{u_j - l_j},$$
$$x_i\left(\text{obj}_j\right) = \frac{u_j - x_i\left(\text{obj}_j\right)}{u_j - l_j}, \tag{7}$$
$$x_i\left(\text{obj}_j\right) = 1 - \frac{\left|x_i\left(\text{obj}_j\right) - t_j\right|}{\max\left(u_j - t_j,\ t_j - l_j\right)},$$

where $u_j = \max\{(x_1(\text{obj}_j), x_2(\text{obj}_j), \ldots, x_n(\text{obj}_j))\}$, $l_j = \min\{(x_1(\text{obj}_j), x_2(\text{obj}_j), \ldots, x_n(\text{obj}_j))\}$, and t_j is the target value among the different values in a sequence of j objectives.

A sequence is more preferable if its GRC value is greater. We computed GRC for every sequence using

$$\text{GRC}_i = \frac{1}{t_{\text{obj}}} \sum_{\text{obj}=1}^{t_{\text{obj}}} \frac{\Delta_{\min} + \Delta_{\max}}{\Delta_i + \Delta_{\max}}, \tag{8}$$

where t_{obj} is the total number of objectives and $\Delta_{\min}$ and $\Delta_{\max}$ represent the difference between two minimum and maximum values of an objective in a sequence.

Once the GRC of each sequence is calculated, the MN then selects the PoA having maximum GRC for handover. The working of the GRA in proposed scheme is illustrated in Figure 4.

The working of the best PoA selection among available PoAs is illustrated in Figure 5. MN with multiple interfaces is moving inside heterogeneous wireless networks which decides access network 2 for handover using proposed

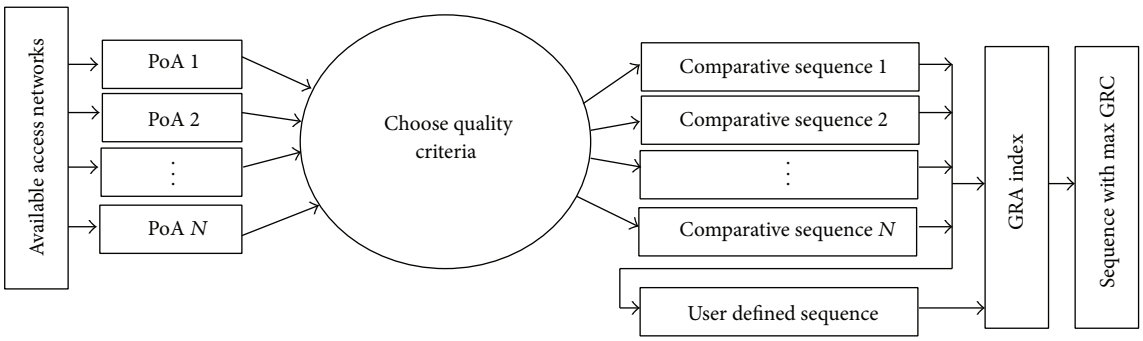

Figure 4: Working of GRA in proposed scheme.

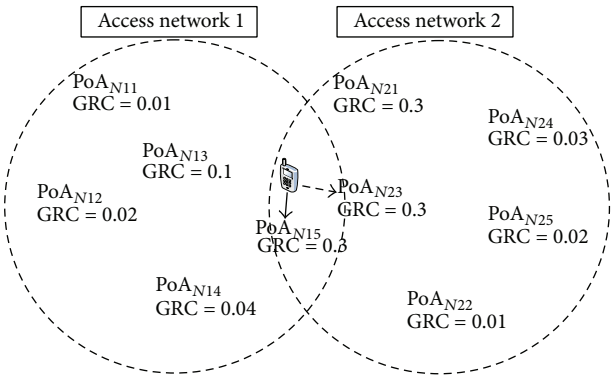

Figure 5: Selection of best PoA.

network selection scheme. Access network 2 further consists of 5 PoAs. MN is currently connected with PoA number 5 of access network 1 (PoA$_{N15}$). The PoA near to the MN has greater GRC values because one of the objectives is throughput which directly depends on RSS level form a PoA. MN uses GRA on eight different objectives listed above for PoA selection. The MN found that the PoA number 3 of access network 2 (PoA$_{N23}$) has greater GRC value among other PoAs. Thus MN selects PoA$_{N23}$ for handover as an appropriate PoA.

4. Simulation and Results

The proposed scheme is compared with existing schemes used for reducing false handover indications and network selection. Extensive simulations were performed to test the accuracy and performance of the proposed scheme. The proposed scheme is implemented in C++ language. The random waypoint mobility model and random movement trajectory are adopted for MN's movement across heterogeneous networks. We assumed the movement of an MN across three different networks, that is, WIFI, WiMAX, and cellular networks. The network selection is tested for different speeds of MN. The MN selects a network during handover on the basis of the speed. The values of two thresholds (α_1) and (α_2) are taken as 4 and 7 m/s, respectively. Similarly, the best PoA is selected while assigning random values to each objective. The range for delay is taken from 10 to 100 (ms) depending on the number of nodes. The response time is depending on the availability and distance from a PoA. The value of jitter is taken from 1 to 10 and its value depends on the network. The average values of different parameters like energy consumption, handover delay, frequent and failed handovers, and packet loss are accumulated and compared with existing schemes. Table 1 represents different parameters used in simulation.

The proposed scheme requires less energy compared to existing schemes [28, 29]. The MN scans only those networks which are appropriate according to its speed. The rest of the interfaces are in standby mode and hence a single interface scanning consumes very less energy compared to entire interfaces scanning. The existing techniques scan the available networks through all interfaces during a handover process. The proposed scheme selects an appropriate network and hence an MN stays on it for more time. Thus frequent handovers are also reduced due to which a significant amount of energy is saved. The energy consumption of an interface for scanning is computed using following equation:

$$E = \sum_{i=1}^{n} P_i \times t_s, \tag{9}$$

where P_i is the power required by an MN for scanning of a PoA of an access network and t_s is the time required by an interface for scanning. The value of i is incremented until the MN finds a new PoA for handover and n is the maximum number of tries for scanning.

Table 1: Simulation parameters.

Parameter	WIFI	Cellular	WiMAX
Cell radius (m)	100	500	500
Frequency (Hz)	$2.47e^9$	$3.5e^9$	$3.0e^9$
Path loss exponent (β)	4.0	3.0	3.5
Transmission power (dBm)	15	27	25
Threshold (δ) (dBm)	−60	−64	−64
Speed limit (α) (m/s)	>0 & ≤3	≥4 & ≤6	>6 & ≤10

Figure 6 shows the performance of the proposed scheme in context of energy consumption against the existing schemes.

The proposed scheme selects a network on the basis of the speed of an MN. If the speed of MN is higher than α_1, then selecting a WIFI network will lead to frequent handovers. Most of the existing schemes do not consider the speed of MN during network selection which leads to frequent handovers. Therefore, probability of data and connection loss increases due to frequent handovers. The proposed scheme efficiently utilizes the speed parameter for network selection. We compared proposed scheme with the existing scheme in context of frequent handovers. The proposed scheme significantly reduces frequent handovers. Figure 7 shows the comparison of proposed scheme and existing scheme [31] for a simulation time of two hours. The proposed scheme performed very less number of frequent handovers, which shows its accuracy and strength.

The optimal handover triggering scheme efficiently reduces the number of failed handovers. The proposed handover triggering scheme is not affected by too early and too late handover issues. The proposed scheme triggered handover on exact time and hence the MN successfully selects and handover to an appropriate network. The existing scheme is highly affected by too early and too late handover issues because of the poor triggering scheme [31]. Most of the schemes in current literature perform handover on the basis of RSS, which is not a good criterion for triggering a handover. If MN requests a connection to an overloaded AP/BS, the AP/BS provided the MN with information whether it has more space available for new connections or not. Let γ be the number of connections on an AP/BS as follows:

$$\gamma = \gamma + \sum_{i=1}^{N} C_i, \tag{10}$$

where γ represents the number of connections already there on an AP/BS and C represents a new connection arriving on AP/BS.

The probability of blocking of new connections on an AP/BS is given by

$$P_{\text{Block}} = \sum_{i=0}^{C} (1 - \beta_{i+1}) \times P_i, \tag{11}$$

where P_i is the probability of a channel which is either busy or available and β is the state of an AP/BS whether in open or closed state. We restrict the boundaries of β to either 0 (open state) or 1 (close state). In open state an AP/BS accepts new connections and in closed state it does not accept new connections.

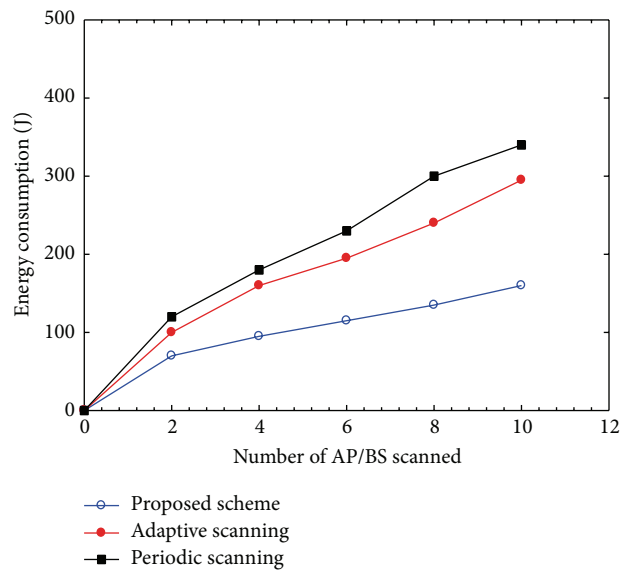

Figure 6: Energy consumption.

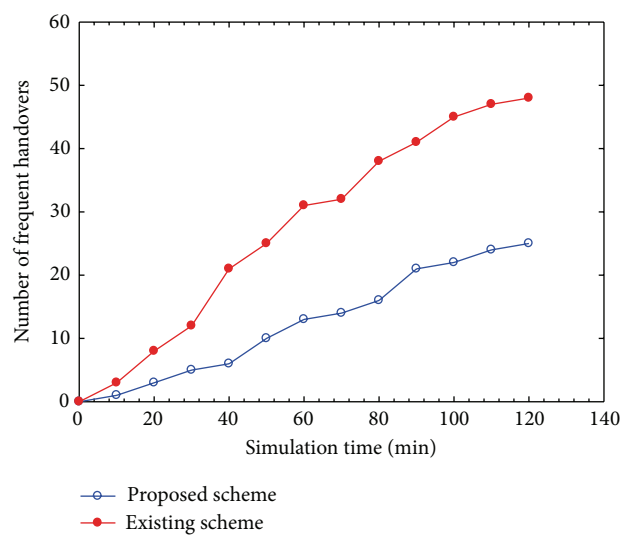

Figure 7: Frequency of handovers.

The comparison of failed handovers in proposed scheme and existing scheme [31] is plotted in Figure 8. The proposed scheme performs very less number of failed handovers because of the optimal triggering handover scheme.

The proposed scheme is compared with the existing scheme in context of packet loss [32]. The proposed scheme performs very less number of frequent handovers due to which it suffers from a smaller amount of packet loss. On the other hand, the existing schemes perform frequent handovers due to which they experienced high packet loss. The MN experiences high packet loss due to the frequent

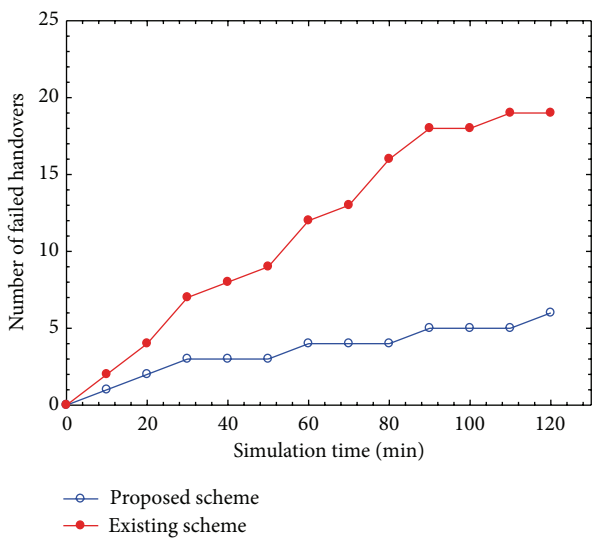

Figure 8: Number of failed handovers.

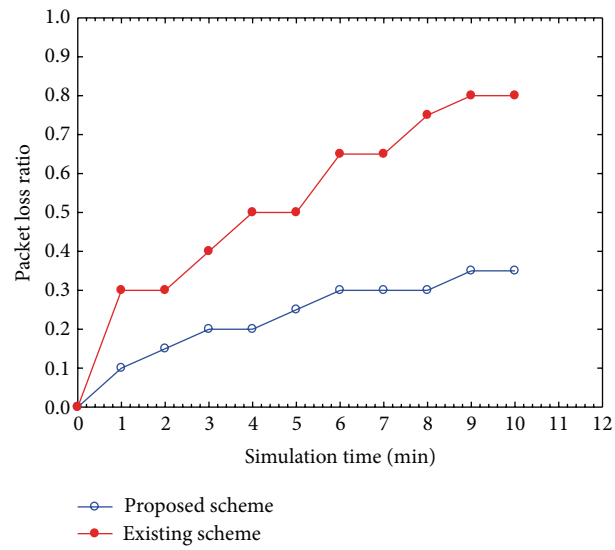

Figure 9: Packet loss ratio.

disconnection. The comparison of the proposed scheme and existing scheme in context of packet loss is shown in Figure 9.

The existing scheme requires higher handover delay because of the selection of inappropriate network for handover [33]. When an MN selects an inappropriate network it either reconnects to the appropriate network or reestablishes the connection to the current network. This takes a long time to redirect the traffic from an inappropriate network and hence an MN suffers from a long handover delay. The proposed scheme selects a network on the basis of its speed and it always selects an appropriate network for handover. The comparison of proposed scheme and existing schemes compared in context of handover delay is shown in Figure 10.

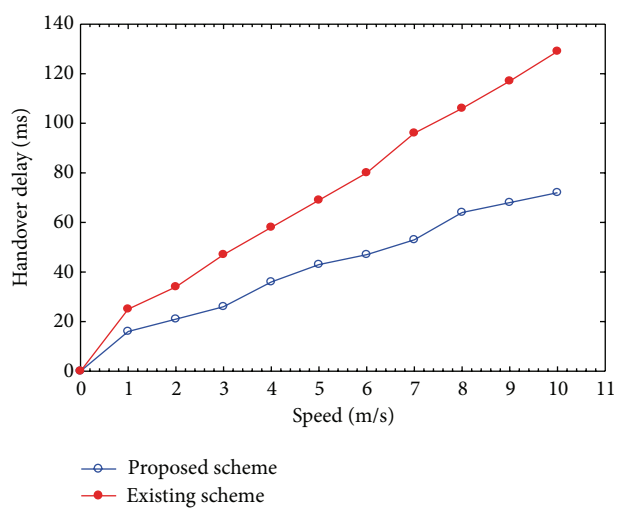

Figure 10: Handover delay at different speeds.

5. Conclusion

In this research work, we proposed an optimized network selection scheme based on the speed of an MN in heterogeneous wireless networks. We proposed two thresholds on the speed of MN. The MN checks its speed against the predefined threshold and according to its current speed it selects the appropriate network. A WIFI network cannot be used for fast MN's movement, because of its smaller coverage area and frequent handover problem. Moreover, the MN only scans a particular network using a single interface. Thus the energy consumption during scanning through all interfaces is significantly reduced. The proposed scheme is compared with the periodic and adaptive scanning in context of energy consumption. The proposed scheme outperforms periodic and adaptive scanning techniques in consumption of energy. We integrate the functionality of GRA in our scheme to select the best PoA for better handover performance. Moreover, the proposed handover triggering mechanism significantly minimized the number of false handover indications, failed handover attempts, packet loss ratio, and handover delay. The simulation results reveal that the proposed scheme achieved 10 to 15% performance gain over existing schemes.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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