Energy-Efficient Vertical Handover in Heterogeneous Networks

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***Abstract*—In heterogeneous networks, vertical handover plays a major role in providing seamless connectivity to the mobile users that are passing through different network access technologies and connecting to different point of network attachments. A mobile node scans all of its interfaces to find a suitable network with which it can connect. However, scanning of a large number of networks requires a huge amount of energy thereby the mobile node drains the battery very fast. The Media Independent Handover (MIH), which was introduced by IEEE, to facilitate seamless and energy efficient handover of mobile nodes across heterogeneous networks. The MIH Information Service (MIIS) offers a variety of criteria and services that can be used to avoid network scanning. But sometimes scanning avoidance leads to inconsistent handover, that is, increased handover failure rates. Thus, an optimal network scanning procedure, which can maintain a consistent handover and should consume the energy as least as possible is required. Our proposed work incorporates two additional functional units into MIH – one is responsible for making an optimal network scanning decision (it could be either full scanning, partial scanning, or avoid scanning) and other one is responsible for computing handover decisions by taking both network conditions and user preferences into account. In the second functional unit, we have introduced a utility function based TOPSIS algorithm that computes the handover decisions. Whereas, in principle, MIH users make the handover decision. Almost all of these existing methods suffer from severe ping-pong effect, unnecessary handovers, handover failures, and excess energy consumption due to inaccurate scanning method and ineffective network choice, whereas the performance analysis of our proposed work indicates that the suggested scheme performs better and consumes less amount of energy than existing works.**

***Index Terms*—Vertical Handover, Heterogeneous network, IEEE 802.21, MIH, Energy, TOPSIS, Utility Function**

I. Introduction

Heterogeneous networks [1] have been designed to include several access technologies of diverse forms aimed at providing better network coverage and capacity to mobile users. A mobile node should use an enhanced mobility management technique to make use of the access technologies in best way for meeting it's requirements [2]. Due to better handover management, a mobile user can retain its connectivity while switching from one point of network attachments to other [3]. As the handover takes between different access technologies, it is called as Vertical Handover. From now on, handover refers to Vertical Handover. Since handover consumes a lot of resources for managing it, hence it can greatly impact the overall efficacy of the networks unless managed aptly.

In order to serve multiple web applications in heterogeneous systems, next-generation communication systems must integrate multiple network interfaces (NICs) [4]. The usage of multiple interfaces opens up various ways to overcome many of the limits of transmission networks and provide numerous exciting new opportunities like Resource Sharing, Bandwidth Aggregation, Mobility Support etc. Using multiple interfaces at the same time a mobile node can extend the communication across the interfaces that reduce the risk of an interruption of communication. The increase in numbers of network interfaces and emergence of various standards, leads to compatibility issues and consumes excess energy during handover [5, 6]. IEEE 802.21 [7], a standard for Media Independent Handover (MIH), was developed to address these challenges. The handover protocol proposed in this standard is capable of communicating with all types of IEEE 802.x networks and other mobile networks (non-IEEE) like LTE, GSM etc. [8]. It fits in between Layer 2 and Layer 3. The central and logical entity of MIH known as, MIH Function (MIHF), operates as an intermediary layer between top and bottom layers, whose primary purpose is to manage the transfer of commands and data between various devices participate in the decision-making and the execution of handover process. MIHF offers three types of services to handle a seamless handover between various technologies. They are Media Independent Event services (MIES), Media Independent Command services (MICS), Media Independent Information services (MIIS). These services enable users of MIHF to obtain information relating to handover process, and to send commands to L2 Layer or to the network. The events created in L2 layers are transferred and delivered to MIHF, asynchronously, whereas the commands and data produced by request/response method are delivered synchronously. The MIIS is used to enable the mobile node to carry out a handover procedure without any network scanning [9]. As the MIIS includes the Information Elements (IE) that incorporates the network attributes, in compliance with the norm, the mobile node can conduct a handover instead of using any scanning procedure. In real scenarios, the updation of IE happens after a complete scanning procedure. If a mobile node is carried out a handover process by avoiding any scanning process then it fails to deliver the IE update notification to the Information Server (IS). This suggests that the information about the network and the IS are not consistent, which could lead to handover failures. Consequently, scanning is required or not required can be determined. During the network discovery process of handover, the mobile terminals conduct the total network scanning procedure by continuously activating all network interfaces. The energy usage of a given mobile node directly depends on the number of network interfaces it uses [10]. The existing network scanning methods are of the following types: Always active scheme (conventional method), periodic scanning, and adaptive scanning [11]. Always Active scheme performs better in terms of handover delay, but it fails to address the issue of energy efficiency. Periodic scanning [9] is another network scanning approach, where a mobile node scans the neighbouring network periodically over a timeframe. In order to conserve energy, a mobile node enters into an idle slate when scanning process is not carried out which prevents vertical handover decisions from being taken in real time. Therefore, the existing approaches may not be suitable for heterogeneous networks. Different algorithms based on the IEEE 802.21 architecture have been reported by various researchers in order to solve and optimise the challenges of vertical handover. Such algorithms are categorized into many groups

[12] such as: RSS based, distance based, cost function based, utility function based, multi attribute decision making (MADM) based etc. Utility function-based algorithms are widely used to define the mobile node's degree of satisfaction with the various functionalities provided by network technology [13]. The contributions of the paper are outlined as follows:

1) An efficient vertical handover is proposed to minimize the energy consumption of a mobile node by improving the network scanning process of MIH protocol.
2) Although the complete scanning procedure for the heterogeneous network is very heavy, the objective of our approach is to limit or avoid the number of scans on each NIC with a purpose of ensuring lower energy usage. Here we have considered a heterogeneous network consisting of numerous access points and base stations, and suggested an optimal network scanning approach intended to make the network very energy-efficient.
3) This work also employees a partial scanning method which is based on application's priority level to speed up the scanning process and reduced energy consumption by minimizing unwanted scans.
4) In our proposed handover technique, the handover decisions are computed by taking both network conditions and user preferences into account. To take care of user demands along with handover consistency, a hybrid approach of utility function and TOPSIS is considered in this work.

The remaining portion of the paper is organized as follows: Section II includes Related Work. Section III describes the Proposed Methodology. In Section IV, the Performance Analysis of our proposed handover technique is discussed using the simulation results along with simulation settings. Section V lastly concludes this paper.

II. Related Works

A) *Energy efficient handover techniques*

In heterogeneous network the transmission ranges of most of the point of attachments are overlapped due to their random deployments which leads to higher interference and packet loss rate. The co-existence of point of attachments often lead to unnecessary energy consumption even at the time of low traffic condition as the communication systems does not have an uniformity in terms of energy usage relative to traffic loads. For example, even though these nodes are in idle condition, they continue to consume considerable amount of energy [14]. Here some earlier study has been carried out on the channel scanning method. Moon et al. [15] suggested a scanning method, focused on Received Signal Strength (RSS) and dwell time. This method extends the scanning period when the dwell-time time is sufficiently long and the RSS is enough for communication. Many studies mentioned MIH for energy consumption purposes [16, 17] but most solution approaches only referred to the life-span of mobile node batteries while the actual energy usage of the system was ignored. The authors of [16] suggest a fuzzy logic-based algorithm that involves multiple criteria for network selection. This work gives a good QoS and encourages the mobile nodes to utilize low energy power. The authors in [17], proposed an algorithm in which network scanning is carried out by considering channel coherence time to conserve MN battery life. In Ref. [18], the MIIS is used to handle the scanning process. The goal of the suggested approach is to reduce energy consumption by minimizing the number of network scan. Xenakis et al. [19] proposed a context aware vertical handover framework to reduce energy consumption in MN. Liu et al. [20], suggested an energy-efficient handover method in which they used IEEE 802.21 MIIS for information gathering. In their work, handover is triggered only when power consumption level, RSS, and cost exceeds a predefined threshold. Although conventional network scanning techniques are improving the accuracy of the scanning performance they consume a lot of energy. In this context, the periodic [21, 22] and adaptive scanning mechanisms [23] were proposed.

B) *Network Selection based on Hybrid Algorithms*

Current research [24, 25] suggests a number of vertical handovers schemes focused on MADM approaches for selection of the best target network. The hybrid approach of Simple Additive Weighting (SAW) and Analytic Hierarchy Process (AHP) was used widely in order to make network selection judgments [26]. In [26, 27], the authors formulated the problem of network selection using two approaches named as AHP and Multiplicative Exponential Weighting (MEW). The TOPSIS is extensively used by many researchers to rank the available networks [28, 29]. Even though AHP approach is generally used to assign weights to decision criteria, limitations remain in this method. For this purpose, the authors in [30] have suggested an improved TOPSIS algorithm to rank the alternatives using ANP to assign weights to criteria. As a result, it gives better performance than conventional approaches. Authors in [31, 32], have proposed a hybrid algorithm that uses MADM approaches and utility function to solve the network selection issue where the utility functions is useful in describing the required application specifications and evaluate the state of network resources. Another smart network selection technique based on utility function and MADM approaches was introduced in Ref. [33]. The suggested approaches helped the mobile nodes to choose appropriately a network to connect and reduced the number of ping-pong effects significantly.

III. Proposed Methodology

A. *Problem Formulation*

The network consisting of N base stations, S mobile nodes, each mobile node is assumed to have K number of interfaces and running M different applications on each interface. Before triggering a handover, the network scanning process go on to search for a network which suits well to the requirements of the application which is currently running on the mobile node.

The objective of our work is to minimize the energy consumption of the mobile node due to unnecessary scanning and maximize user preferences during network selection. Mathematically, the objective function is explained as follows:

$$Minimize \quad P_{total} = \sum_{i=1}^{S} (P_{HO})_i \tag{1}$$

Where, P_{total}: Total power consumption due to network scanning, $(P_{HO})_i$: Power consumption of the mobile node due to i^{th} handover, S: The number of handovers.

B. *Solution Approach*

We have introduced two functional units in the existing MIH architecture which will minimize total energy consumption and maximize user satisfactions of the mobile nodes after a handover takes place. Our proposed energy efficient vertical handover framework is illustrated in Figure 1. The functional units are as follows:

1) Energy Consumption Unit (ECU): The purpose of this unit is to reduce the unnecessary network scanning during a handover process. Sometimes scanning avoidance leads to inconsistency in handover process and increases handover failure rates whereas excess network scanning increases energy consumption in the system. So, an optimal network scanning procedure is introduced here to minimize overall energy consumption.

2) Handover Decision-making Unit (HDU): This unit is responsible for taking handover decisions. HDU not only takes handover decisions but also maintains user satisfactions and helps in meeting requirements of the mobile nodes. For this purpose, we have used the idea of utility functions. Finally, a hybrid approach of TOPSIS and utility function is proposed to take handover decisions.

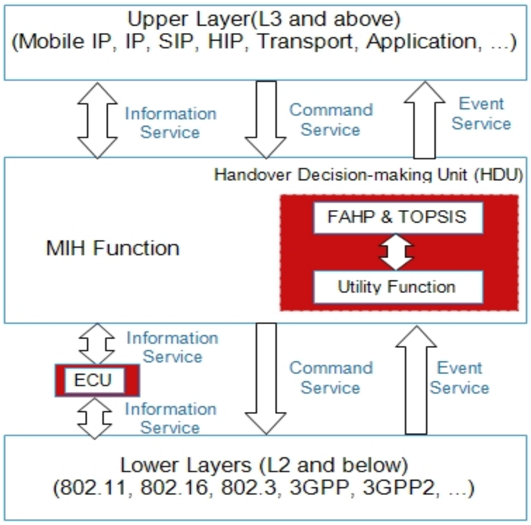

Fig. 1. Energy efficient vertical handover framework

C. Energy Efficient Vertical Handover in Heterogeneous Networks

1) Energy Consumption Unit (ECU)

The proposed solution approach is relying on IEEE 802.21, a latest IEEE standard which allows the continuity of service between heterogeneous networks like IEEE 802.x, 3GPP and 3GPP2. In order to minimize the energy consumption of mobile nodes, here we have used the Media Independent Information Service (MIIS) to handle the network scanning procedure. MIH offers the MIIS to enable the mobile node to conduct a handover process by avoiding network scanning [34]. Though the MIIS gives the IE, which includes relevant information related to network, as per the norm, the mobile node can conduct a handover even without performing any scanning process. Initially, the most important concept of the MIH is the reduction of network scanning using MIIS. The data provided by the MIIS are not always relevant because the updation period of the IE is not consistent and there are also not any representatives appointed to perform the duties of updating the IEs. In the real scenarios, the values of IE are updated after a complete scanning phase. When a mobile node conducts a handover by avoiding the scanning phase, then it is unable to transmit the updated value of IE to the Information Server (IS). So, the system information's are not accurate and valid. As a result, there appears a consistency issues between the system and IS which leads to handover failure.

The working procedure of ECU is shown in Figure 2. It's role is to decide the necessities of scanning process in the network. That's why the mobile node always conducts the complete scan process of the network and as a result it works against MIH's main objective. Thus, the criteria for evaluating whether to scan or skip needs to be established. Therefore, in this context, a new functional entity called the Energy Consumption Unit (ECU) has been introduced. The objective of the ECU is to limit the amount of network scans, which is the initial objective of the MIH. The ECU assists the overall minimizing process of the network scanning towards the chosen network.

Once the mobile node is alerted by the Connection Going Down

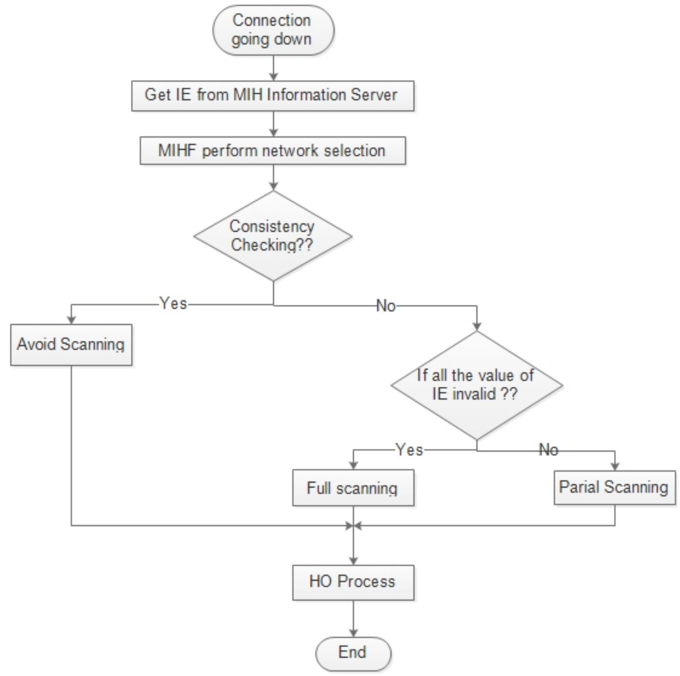

Fig. 2. The Working Procedure of ECU

(CGD) signal, it realizes that the handover mechanism needs to be carried out soon, so, the mobile node requests Information Elements (IE) to the information server (IS) of MIH (All networks are expected to have an access connection to the IS). After receiving the request message, IS then delivers the appropriate IE to the mobile node. When the mobile node obtains the IE, the ECU of the node retrieves the message and produces the membership degree. To verify the validity of the values of IEs, we provided two Time fields to the IE which helps to validate the IE data. It is restored with its initial values, whenever the data is modified. The MIHF conducts the task of network selection using the IE obtained and informs to the ECU. The ECU then measures the consistency of the preferred network. By using the outcome of the consistency checking process, it will determine whether to perform or skip the network scanning phase to trigger the handover process.

- Consistency Checking Unit:

It checks whether the IE values are valid to use or not. It uses a fuzzy theory based mechanism [35] to measure consistency level of IE values. The scheme uses a Normal Distribution Function with mean 1.0 and standard deviation 0.4 as per Ref. [35]. With the help of input value and membership function we get the membership degree. If the value of membership degree is higher than the threshold value then the consistency of the value is still preserved.

- Network Scanning:

In this section, various types of scanning mechanism are explained that we have considered throughout the handover process by taking consistency level into account. After going through validity checking process, if all the IE values are consistent then the mobile node ultimately avoid the scanning process. Secondly, If some fields of IE values are valid i.e., partially valid, having some basic network related parameters, e.g., Service Set Identifier (SSID), location etc., then the mobile node goes for partial or fast scanning method, where, network scanning is performed only for the chosen network (not for all enabled networks).

a) Application's Priority-based Scanning Method

It actually falls under the category of partial scanning method. It is expected to have various applications operating on a single interface. During this, for each interface the mobile node is allocated with various time slots for scanning, which is based on the importance of applications that are running on the mobile node at that time. Usually, a higher prioritized application requires a lot of energy relative to a lower one. A mobile device typically has various applications including conversational (e.g., VoIP, video telephony, video game), streaming (e.g., watching multimedia), interactive (e.g., web surfing) and background class (e.g., WWW, emails) [36]. While travelling through heterogeneous wireless networks, each interface of a mobile device uses various types of applications. When an interface uses a prioritized application, then that will become the first choice for scanning. The application's importance level in terms of their priority is described in Table 1. Algorithm 1 describes the partial scanning method. According to algorithm, when a mobile device detects a high prioritized application then the node proceeds to scan that interface. Before the maximum time limit expires if that interface identifies a suitable target network then that time mobile node proceeds to scan a different interface having second prioritized application. Likewise, every interface executes their scanning processes. Finally total power consumption during partial scanning is calculated by adding each interface's power consumption in one scan time together.

TABLE I
APPLICATION'S PRIORITY VALUES

Various Applications	Priority Level
Conversational Class (e.g., VoIP, video telephony, video game)	High=1
Streaming Class (e.g., watching multimedia)	High=1
Interactive Class (e.g., web-surfing)	Low=0
Background Class (e.g., news, WWW, Emails, file transfer)	Low=0

Algorithm 1: Partial Scanning Method

```
Input: M, K, t_inf=0, t_max=0, p_scan=0, p_inf
//M:Number of applications, K:Number of interfaces, t_inf:Interface
scanning time, t_max:Maximum scanning time, p_scan:Power con-
sumption during total interface scanning, p_inf:Power consumed by
an interface in one scan time
Output: Scanned networks
// P:Priority, // inf:Interface
high ← inf1;
for inf = 1 to K do
    if (P[inf] > P[inf − 1]) then
        high ← P[inf];
    end
    inf++;
end
while (t_inf < t_max) do
    Scan(high); // Scan the interface having highest prioritized
    application.
    p_scan = p_scan + p_inf;
    if (Scan(high) == finish) then
        Scan the interface having 2^nd highest prioritized application
    else
        t_inf++;
    end
end
```

b) Full Scanning Method

Lastly, if all IE values are inconsistent/invalid then complete network scanning process is conducted. Here complete scanning means all the enabled target networks are scanned. The total power consumption due to network scanning throughout a simulation having multiple handover process is calculated as follows:

$$P_{Total} = \sum_{i=1}^{H} P_{FS} \cdot (N_{FS})_i + \sum_{i=1}^{H} P_{PS} \cdot (N_{PS})_i \quad (2)$$

$$P_{HO} = P_{FS} \cdot N_{FS} + P_{PS} \cdot N_{PS}$$

$$P_{FS} = P_{AP} \cdot t_{real\_scan} \cdot N$$

$$P_{PS} = \sum_{inf=1}^{K} p_{inf}$$

Where, P_{Total}: The total power consumption due to network scanning, P_{HO}: Power consumption due to a single handover, P_{FS}: Power consumption due to full scanning, P_{PS}: Power consumption due to partial scanning, N_{FS}: Number of full scanning, N_{PS}: Number of partial scanning, P_{AP}: Average R_x of different access technologies involved, t_{real_scan}: The actual scanning time per scanning period, K: Number of interfaces, H: Number of handovers in a simulation, i: Current handover number, inf: Current interface number, p_{inf}: Power consumed by an interface in one scan time.

2) Handover Decision-making Unit (HDU)

HDU is divided into three phases as shown in Figure 3.

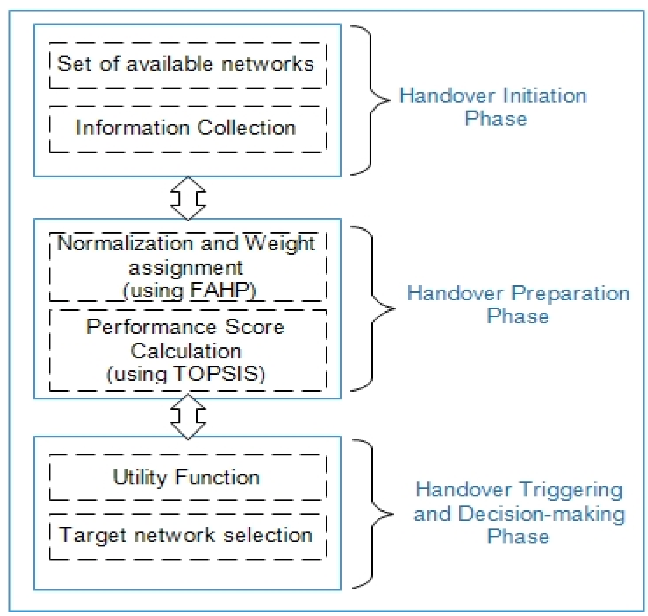

Fig. 3. Handover Decision-making Unit (HDU)

1) Phase1: This phase is known as handover initiation phase. After the completion of network scanning phase, the mobile node gathered necessary information (e.g., network, terminal, and service related information) about the networks. Handover decisions are taken using these information.
2) Phase2: This phase is called preparation phase of handover where all necessary steps are carried before triggering of actual HO process. Here, we have considered multiple decision criteria to make handover decision seamless and consistent. Fuzzy AHP

(FAHP) is used to find the relative weights of decision criteria. Then the performance score of the networks is evaluated using TOPSIS algorithm.

3) Phase3: Lastly this is called the decision-making phase of handover process. With the help of utility function and network performance score (which is calculated in Phase 2), the appropriate target network is decided for a seamless handover process.

The core element of this unit is an integrated module consisting of TOPSIS and utility function. TOPSIS usually picks the BS having highest solution score as the target node, irrespective of whether the user or the system requirements are fulfilled or not. Here the user or system demands and requirements are clearly neglected. To avoid these shortcomings, utility function is used along with TOPSIS to avoid the abnormalities created during the network ranking process. TOPSIS is used to aggregate multiple parameters and finds the relative closeness to the ideal solution or performance score. Then the utility function is used to rank the networks by using the above performance score. Here utility function measures the degree of satisfaction when MN travels from one point of attachment (PoA) to other. The complete procedure of Utility Functions based TOPSIS method is described as follows:

- TOPSIS

This algorithm is used to distinguish the alternatives by ranking them. Then as a result, the highest ranked alternative is known as the best option for handover. But here we have not considered the highest ranked network as the target one. We only use TOPSIS for calculating the performance score of all the networks. We avoid the last step i.e. the ranking step of TOPSIS [37]. First the decision matrix with dimension $m \times$n is constructed to compare available networks using different parameters. Then, the value in each cell of decision matrix is normalized. After that a weighted normalized decision matrix is created. The positive as well as the negative ideal solutions (optimal best and worst values) are evaluated. Then the deviation from the optimal solutions for each BS is determined. Finally, the performance score or the relative closeness to the ideal solution is measured.

- Utility Function

After measuring the performance score of the networks using TOPSIS then Utility function is used to rank the networks. The utility functions is useful in describing the required application specifications and evaluate the state of network resources. Here we have used exponential utility function to identify the appropriate target network. This is described below [38]:

$$\begin{cases} u(x) = \alpha * [\frac{1}{1+e^{-a(x-b)}} - \beta] \\ \alpha = (1+e^{ab})/e^{ab} \\ \beta = \frac{1}{(1+e^{ab})} \end{cases} \quad (3)$$

Where, x: Relative closeness to the ideal solution (computed in TOPSIS algorithm), a: value of anti-ideal solution, b: value of ideal solution.

IV. Performance Analysis

A. Simulation Settings

To facilitate our illustration, we consider a heterogeneous network scenario consisting of twenty BSs, three access technologies: LTE, WLAN, and WiMax and five MN. Table II contains all the simulation parameters. This framework is implemented in MATLAB. The decision criteria used in this work are grouped as, Network related: RSS, bandwidth, security, network condition, network performance, time to trigger, delay, QoS, velocity; Terminal related: power; Service related: cost, quality factor. FAHP is used to assign the relative weights to these criteria. We have used Empirical Hata propagation model since it is a widely used pathloss model along with all four traffic classes: Conversational, Streaming, interactive and Background traffic class. The Random waypoint mobility model is used in the proposed work to represent the behaviour of mobile nodes in the heterogeneous network. It is a widely used network mobility model [39]. In this model, a node is arbitrarily selected at any point to reside or move in a certain probability. When it decides to travel, the direction, time duration and speed are randomly chosen.

TABLE II
Simulation Parameters

Parameters	**Values**
Area of interest(A)	80 x 80 m^2
Total no of nodes(N)	20
Transmitter Power (PT)	43dBm
Transmitter gain (GT)	18dB
Receiver gain (GR)	-1dB
Loss due to Transmitter (LT)	3dB
Loss due to Receiver (LR)	8dB
Pathloss Type	Urban/Sub-urban Hata model
Number of MS	5
Simulation Time	100s
MS Height	1m
BS Height	40m/50m
MS Speed	10(m/s) / 8(m/s) / 5(m/s)
Threshold value of Bandwidth	1800MHz

B. Result Analysis

In order to make the simulation more accurate, we ran the simulation 10 times and averaged the results. We didn't concentrate on the energy usage of a single node, but rather the entire network's energy consumption. An Optimum energy-efficient vertical handover is being achieved by employing an energy efficient scanning process and user requirements-based handover decision mechanism. Here the mobile node scans the neighbouring networks using the ECU employed in MIH. ECU as described in Figure 2, decides whether to scan or skip. The suggested scanning method is compared with conventional, periodic and adaptive scanning schemes. Figure 4 shows the total energy consumption comparison between proposed and other existing scanning techniques. As a result, the proposed scheme considerably decreases the total energy consumption, occurred due to network scanning process. Figure 5 shows the comparison of network scanning rate between conventional MIH and our proposed method. Simulation results indicate that the proposed scheme lowers network scanning rate profoundly. Due to inadequate scanning technique, the existing schemes suffers from increased unnecessary scanning rate. The conventional technologies scan all the neighbouring networks

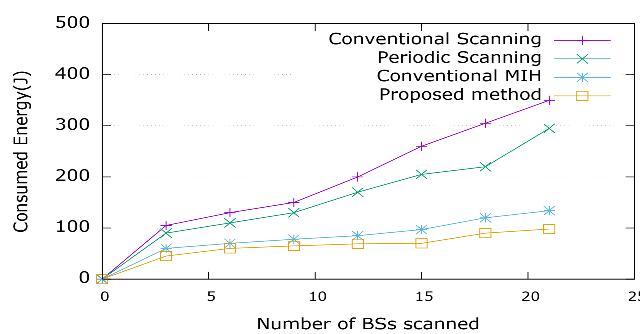

Fig. 4. Comparison of Consumed energy versus Number of Base Stations

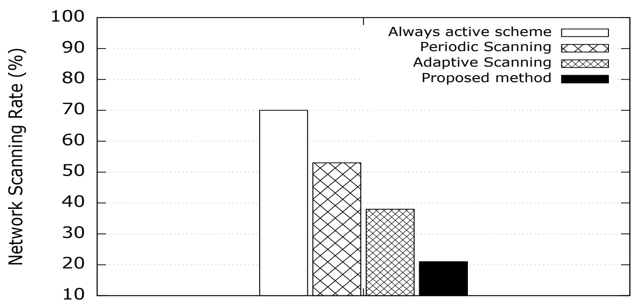

Fig. 5. Comparison of Network Scanning Rate

at the time of handover which ultimately requires a huge amount of energy. There are certain applications which demands continuous connections across heterogeneous networks. So, the proposed technique gives more attention to the highest priority applications as compared to others. This often eliminates repeated handovers, which ultimately saves substantial amount of energy. Figure 6 shows the

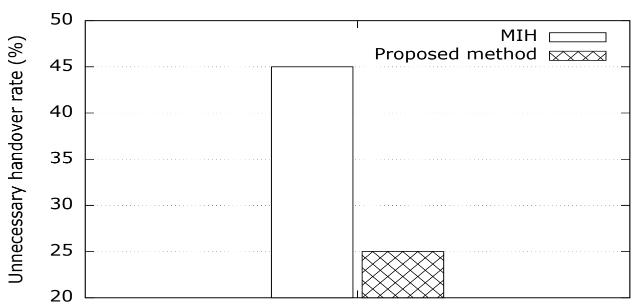

Fig. 6. Comparison of Unnecessary handover rate

comparison of unnecessary handovers, where the proposed scheme performs very well as compared to the conventional MIH standard because our work considered a hybrid handover decision algorithm which avoids the occurrences of unnecessary HOs. The proposed work maintains a good balance between energy consumption and user requirements. Figure 7 shows the comparison of handover failure rate by considering all traffic classes. As a result, our suggested scheme is superior than TOPSIS and utility function algorithm. Figure 8

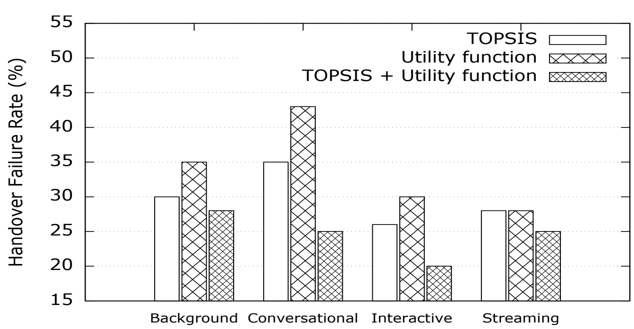

Fig. 7. Comparison of HO Failure Rate versus all Traffic Classes

displays the average ping-pong rate versus all traffic classes. We observed that the hybrid approach of TOPSIS and utility function based algorithm can effectively minimizes the ping pong effect than other algorithms. This figure illustrates that the utility function-based TOPSIS outperforms the traditional TOPSIS. As a result, we conclude that introducing the utility function with TOPSIS will improve efficiency for various types of services.

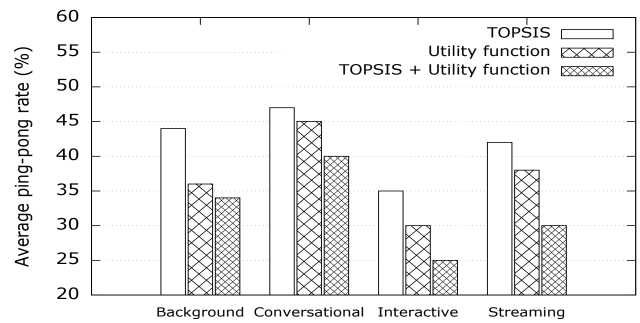

Fig. 8. Comparision of Average ping-pong Rate versus all Traffic Classes

V. Conclusion

To ensure smooth and seamless connectivity and to allow the optimal use of available network resources, it is essential to improve the performance of vertical handover in heterogeneous network in terms of unnecessary handovers and handover failure rates. With this in mind, an energy-efficient improved vertical handover technique is proposed in this work. This work introduces an energy efficient scanning scheme for IEEE 802.21 protocol that considers two functional units : ECU and HDU, to minimize network scanning process as well as meeting user requirements. MIH Information Server offers quick and energy-efficient channel scanning outcomes to the mobile nodes. Now a days, multiple applications are running on a mobile device at a given point of time with different priorities level. The proposed scheme scans the interfaces according to their priority of applications thus avoiding the scanning of entire interfaces which ultimately reduced the energy consumption. From the simulation result, it is confirmed that the suggested TOPSIS and utility function-based hybrid approach lowers the handover failure rate and ping-pong effect for all types of traffic classes. Thus the proposed work reduced the energy consumption, maintaining user preferences and their demands. This work may be further enhanced, by adding prediction and forecasting based handover scheme for better quality of experience of users.

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