1. PROBLEM AND MOTIVATION
Providing uninterrupted internet services in heterogeneous wireless networks is a difficult job to accomplish. Traditional approaches are limited to specific scenarios. Therefore, to provide a generic connectivity in heterogeneous wireless networks, we proposed a vertical handover management scheme based on the data rate of a mobile user. The proposed scheme performs handover triggering using Simple Additive Weighting (SAW) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to select the optimal network for the handover. The proposed scheme is compared with Media Independent Handover (MIH) standard in the context of handover delay, packet loss ratio, throughput, and failed handovers. The proposed scheme outperforms MIH standard and due to its simple architecture it can be used with existing technologies.

2. BACKGROUND AND RELATED WORK
Fourth generation (4G) mobility models have been designed to integrate different wireless technologies such as WLANs, WMNs, and cellular networks in a heterogeneous environment [1]. The integration of these wireless technologies birth to a few new emerging concepts such as M2M, IoT, etc. An example of such integration can be found in IoT systems where a mobile user is connected to a cellular network controls its home appliances which are then connected to WIFI network. Maintaining a continuous connection between these different networks is a challenging job. To cope with such issues, a handover management scheme can be designed with proper tuning of all the relevant parameters. These parameters include RSS, SINR, bandwidth, data rate, velocity of Mobile Node (MN), user preferences, etc. In the last decade, a wide range of research studies have been conducted on RSS parameter [2]. The breakthrough has been made by IEEE in Nov 2008 by publishing a new standard called IEEE 802.21: MIH standard [3]. 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 upper layers through different events. The standard has still many challenges and issues which can be addressed. These challenges include the wrong handover triggering and inappropriate selection of new network on the basis of RSS. Employing RSS for handover triggering can create some problems that can ultimately lead to severe packet loss and breaking of the connection. The problems due to RSS in recent technologies are illustrated in Figure 1.

![Figure 1. Too early, too late, and wrong cell handover](image)

3. APPROACH AND UNIQUENESS
3.1 Handover Triggering Phase
In order to address the aforementioned challenges and issues in existing MIH standard, we proposed a handover management scheme based on two different decision models i.e. SAW and TOPSIS. The proposed scheme efficiently addresses the challenges present in the MIH standard.

3.2 Network Selection Phase
The optimal selection of new network is carried out by using TOPSIS. The TOPSIS decision model has remarkable results in selecting the best network for handover. We proposed seven different parameters for selecting the best network. These
parameters include delay ($\alpha$), jitter ($\beta$), Bit Error Rate (BER) ($\gamma$), packet loss ratio ($\delta$), communication cost ($\epsilon$), response time ($\sigma$), and network load ($\omega$). Let $N_1, N_2, \ldots, N_m$ represent the networks available in a heterogeneous scenario, and let $Z$ denote the normalized decision matrix with weights assigned to each parameter. Similarly, $P$ represents a parameter used for network selection where $P_j = \max_{1 \leq i \leq m} (x_{ij})$ and $P_j = \min_{1 \leq i \leq m} (x_{ij})$ denote the maximum and minimum value of a parameter in a network, respectively.

$$Z = \begin{bmatrix}
      P_1 & P_2 & P_3 & P_4 & P_5 & P_6 & P_7 \\
      w_1a_1 & w_2b_1 & w_3c_1 & w_4d_1 & w_5e_1 & w_6f_1 & w_7g_1 \\
      \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
      w_1a_m & w_2b_m & w_3c_m & w_4d_m & w_5e_m & w_6f_m & w_7g_m \\
      N_1 & N_2 & N_3 & N_4 & N_5 & N_6 & N_7
    \end{bmatrix}$$

As we know, that all of the criterion considered for the selection of a network is indirectly proportional to QoS of that network, therefore, the maximum and minimum value in each column of matrix $Z$ represent the negative ($I^-$) and positive ($I^+$) ideal situation, respectively. These situations can be obtained numerically as follows:

$$I^+ = [\min_{1 \leq i \leq 7} (x_{ij})] = [p_1, p_2, \ldots, p_7]$$

$$I^- = [\max_{1 \leq i \leq 7} (x_{ij})] = [p'_1, p'_2, \ldots, p'_7]$$

where $j = 1, 2, 3, \ldots, 7$

Once the positive and negative situations are identified then it is necessary to compare it with a hypothetical ideal situation. Resulting, TOPSIS ranks each criterion defined for the selection of a network according to their distance from the hypothetical ideal situation. Therefore, it is important to calculate the distance of each criterion from the positive ideal situation ($H^+$) and negative ideal situation ($H^-$). This computation is done through following relation.

$$H^+_i = \sqrt{\sum_{k=1}^{7} (x_{ik} - p_k)^2}, i = 1, 2, \ldots, n$$

$$H^-_i = \sqrt{\sum_{k=1}^{7} (x_{ik} - p'_k)^2}, i = 1, 2, \ldots, n$$

Finally, we calculate the relative approach degree ($R_i^*$). This degree will help in finding the optimal network for handover. It is calculated using following relation.

$$R^*_i = \frac{H^-_i}{H^+_i + H^-_i}$$

If there are multiple networks available in a heterogeneous environment then it necessary to calculate the degree of each network and then sort it to get the optimal network with the highest degree. Following are the three possible cases:

1) If $N_1 = I^+$, then $H^+_i = 0$, degree becomes $R^*_i = 1$, 2) If $N_1 = I^-$, then $H^-_i = 0$, degree becomes $R^*_i = 0$, and 3) If $N_1 \rightarrow I^+$, then $H^+_i = 0$, degree becomes $R^*_i \rightarrow 1$. So from all of these cases, we conclude that $0 \leq R^*_i \leq 1$. Thus once we get the degree of each network, we will arrange it in the order of $N_i$ depending on $R^*_i$.

4. RESULTS AND CONTRIBUTIONS

The National Institute of Standards and Technology (NIST) has implemented MIH standard in NS2 2.29 V3. Therefore, we also simulate the proposed handover scheme in the same version. The proposed scheme is tested on different number of nodes ranging from 10 to 100. The number of applications is randomly assigned to each node during its creation, and the user can close and open an application at any time. The proposed scheme is simulated for a longer duration, in order to check its performance for a high number of handovers. The performance analysis shows that the proposed triggering scheme performs better than RSS based triggering. The number of failed handovers and throughput are significantly reduced due to proposed triggering scheme as shown in Figure 2 and 3, respectively.

![Figure 2. Failed Handovers](image)

![Figure 3. Throughput](image)

Similarly, the proposed selection scheme performs better in context of minimizing handover delay and reducing packet loss as shown in Figure 4 and 5, respectively.

![Figure 4. Handover Delay](image)

![Figure 5. Packet Loss Ratio](image)

The proposed handover triggering and network selection provides a simple platform for the MNs to switch between different networks in a heterogeneous environment. Moreover, the simulation results show that the proposed scheme performs better than the MIH standard, and it can be easily implanted for handover management in the next generation of networks.

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5. References