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# The Utility based AHP& TOPSIS Methods for Smooth Handover In Wireless Networks

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**Abstract** – *The Utility based AHP & TOPSIS methods for smooth handover in wireless networks is presented in this paper. In the future, people have even more flexibility when true wireless internet and real-time multimedia are provided seamlessly over heterogeneous wireless network. Also, various applications demand different quality of service (QoS) parameters. The goal is to select the best network that can support the required service(s) and avoid excessive switching among different networks in order to minimize service interruptions and power consumption. The vertical handover scheme is proposed for conversational, streaming and interactive applications. In this multi- hierarchy decision making process the best suited Analytical Hierarchy Process(AHP) is applied for the decision making process in vertical handover. The proposed scheme of vertical handoff provides higher QoS than the earlier than the earlier algorithms. All the unnecessary vertical handover we controlled by proposed scheme. The results show that the proposed scheme provides low traffic applications and overall system throughput with a control of unnecessary handoffs for all kinds of services. Also, parameterized utility functions are used to model the different Quality of Service (QoS) attributes (data rate, delay, jitter, ) and user preferences (cost) for three different types of applications. Finally, scores are calculated exclusively for each network by two MADM (Multiple Attribute Decision Making) methods , TOPSIS (The Technique for Order of Preference by Similarity to Ideal Solution) and AHP (Analytic hierarchy process). A single-criterion utility function that rates user satisfaction and captures sensitivity for each decision criterion. As well, an adaptive multi-criteria utility function is defined according to user preferences. Obtained results show that our strategy outperforms other handover decision schemes, which confirm the suitability and the efficiency of our solution.*

***Key Words***: QoS, AHP, TOPSIS, Utility functions, Handover, Smooth handover.

## 1. INTRODUCTION

Wireless communication has increased rapidly in recent years. Wireless technology has helped to simplify networking by enabling multiple computer uses to simultaneously share resources in a home or business with additional or intrusive wiring. Wireless networks allows you to access the internet while on the move; you can remain online while moving one area to another, without a disconnection or loss in coverage. So, user wants to connect to another network that provides better services. The process of switching from one network to another network is called handover. When this switching happens in same type of networks, it is called horizontal handover. When a mobile device roams in these heterogeneous environments, it undergoes vertical and horizontal handovers continuously. In order to provide Always Best Connected (ABC) property, an optimal Vertical Handover Decision (VHD) is required. This paper, Analytic Hierarchy Process (AHP)based network selection technique and The Technique for Order of Preference by Similarity to Ideal Solution(TOPSIS) is presented in heterogeneous wireless networks for conversational, interactive, and streaming applications. Also, with the utility-based MADM methods unnecessary handovers can be avoided as in comparison with traditional MADM methods. Also, parameterized utility functions are used to model the different Quality of Service (QoS) attributes for different applications with AHP and TOPSIS methods.

## 2. Related Work

Tran and Boukhatem[1] considered the case of multi-homed terminals in heterogeneous wireless environment where instead of hanging over from one network to another, the mobile terminal is using simultaneously, several interfaces for different application according to the application characteristics, the network characteristics and user preferences. P. Bellavista et al.[2] have considered that, with signal strength, other factors like handover awareness, QoS awareness and location awareness are also some of the crucial factors to be considered for handover decision. But more parameters introduce more delay, which may not be very suitable for applications like video streaming. Kang et al [3] seek to improve QoS service continuity and mitigate interruptions to voice transmission over IP, video streaming as well as other applications that may arise during vertical handoffs between heterogeneous wireless networks. Dwell[4] time calculation has been proposed depending on the user speed and moving patterns as a selection metric. It outperformed in reducing the number of vertical handoffs and grade of service while increasing the average utilization per call of WLAN/ WiMAX networks. Sharma and Khola [5] presented a network selection algorithm based on the TOPSIS algorithm. The proposed algorithm besides the usual parameters it also takes a prediction of the Received Signal Strength (RSS) into account for the network selection. Sanjay Dhar Roy et al.[6] have proposed received signal strength (RSS) based strategy for handover in heterogeneous networks which considers RSS and bandwidth. Further these strategies have been modified by considering averaging of RSS. For comparison purposes, the performance of the VHO algorithm also considers hysteresis and dwell timer. Raman Kumar Goyal and Sakshi Kaushal [7] have proposed analytic hierarchy process(AHP) method has been used for network selection in heterogeneous environments for moving vehicles. The method has been applied for various types of applications like conversational, streaming, interactive, and background applications. From the results, it has been found that WLAN's performance degrades significantly when the vehicles are moving at higher velocities while Universal Mobile Telecommunication Systems (UMTS) performs best for fast moving vehicles. Detailed network selection scheme is presented in Sect. 3.

## 3. Proposed AHP & Topsis Based on Utility Functions

AHP method was proposed by Saaty We have used AHP & TOPSIS for best network selection. The network selection is based on four attributes namely data rate, cost, delay and jitter. Three networks are considered for network selection, i.e., network 1, network 2 and network 3. Three types of applications are considered namely, conversational, interactive and streaming The AHP process for the network selection process is as follows.

Step 1: Determine the objective and evaluation parameters. Select the attributes and alternatives. In our problem following are the attribute values correspond to different types of networks as shown in Table 1.

**Table.1:The Networks and their parameters**

| NETWORK | DATA RATE | COST | DELAY | JITTER |
|---|---|---|---|---|
| NETWORK 1 | 4 | 5 | 35 | 10 |
| NETWORK 2 | 25 | 3 | 110 | 3 |
| NETWORK 3 | 50 | 1 | 120 | 4 |

Obtain the normalized matrix by dividing with the value of beneficial attribute (data rate, ) and dividing the non-beneficial attribute (cost, delay, and jitter) with the value of attribute.

Step 2: Construct a paired comparison matrix using a scale of relative importance. An attribute compared with itself is given a value of 1 and the values 3, 5,7 and 9 corresponds to moderate importance, strong importance, very strong importance and absolute importance. While, 2,4,6 and 8 compromise between these values. Relative importance matrices for different type of applications are shown in Tables.

**Table 2: Relative importance of different attributes in conversational applications**

| Conversational | Data rate | Cost | Delay | Jitter |
|---|---|---|---|---|
| Data rate | 1 | ½ | ½ | 1/2 |
| Cost | 2 | 1 | 1 | 2 |
| Delay | 2 | 1 | 1 | 2 |
| Jitter | 2 | ½ | ½ | 1 |

**Table 3: Relative importance of different attributes in interactive applications**

| Interactive | Data rate | Cost | Delay | Jitter |
|---|---|---|---|---|
| Data rate | 1 | 2 | 1/3 | 1/3 |
| Cost | ½ | 1 | 1/5 | 1/5 |
| Delay | 3 | 5 | 1 | 1 |
| Jitter | 3 | 5 | 1 | 1 |

**Table 4: Relative importance of different attributes in streaming applications**

| Streaming | Data rate | Cost | Delay | Jitter |
|---|---|---|---|---|
| Data rate | 1 | 2 | 3 | 3 |
| Cost | ½ | 1 | 1/3 | 1/4 |
| Delay | 1/3 | 3 | 1 | 1 |
| Jitter | 1/3 | 4 | 1 | 1 |

Step 3: Find the relative normalized weight for each attribute by calculating the geometric mean of the each row in the comparison matrix and normalize the geometric means of rows.

Step 4: Calculate the maximum Eigen value

Step 5: Calculate the consistency index *CI*.

Step 6: Obtain the Random Index *(RI)* for the number of attributes used in decision making.

Step 7: Calculate the consistency ratio *CR= CI/RI.* A *CR* of 0.1 or less is acceptable.

Step 8: Calculate the overall AHP score by multiplying the normalized weight of the attribute.

TOPSIS (for the Technique for Order Preference by Similarly to Ideal Solution) was developed by Hwang and Yoon in 1980 as an alternative to the ELECTRE method and can be considered as one of its most widely accepted variants. TOPSIS method is a popular approach to MADM and has been widely used in the literature. TOPSIS simulation consider the

distances to the ideal solution and negative ideal solution regarding each alternative and select the most relative closeness to the ideal solution as the best alternative. That is the best alternative is the nearest one to the ideal solution and the farthest one from the negative ideal solution. The TOPSIS method assumes that each criterion has a tendency of monotonically increasing or decreasing utility. Therefore, it is easy to define the ideal and negative-ideal solutions. TOPSIS is a practical and useful technique for ranking and selection of a number of alternatives determined through distance measures.
Generally A+ indicates the most preferable alternative or the ideal solution. Similarly, alternative A- indicates the least preferable alternative or the negative ideal solution. Further procedure can be described in 6 steps, as follows:

Step 1: Calculate the normalized decision matrix. The normalized value $r_{ij}$ is calculated as follows:

$$r_{ij} = x_{ij} \sqrt{\sum_{i-1}^{m} x_{ij}^2} \quad \text{i =1, 2, ..., m and j = 1, 2, ..., n.}$$

Step 2: Calculate the weighted normalized decision matrix. The weighted normalized value $v_{ij}$ is calculated as follows:

$$v_{ij} = r_{ij} \times w_j \quad \text{i =1, 2,..., m and j = 1, 2, ..., n.} \quad (1)$$

where $w_j$ is the weight of the $j^{th}$ criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

Step 3: Determine the ideal ( $A^*$ ) and negative ideal ( $A^-$ ) solutions.

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1,2,...,m\} \quad (2)$$

$$A^- = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^- \mid j = 1,2,...,m\} \quad (3)$$

Step 4: Calculate the separation measures using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2}, \ j = 1,2,...,m \quad (4)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}, \ j = 1,2,...,m \quad (5)$$

Step 5: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative $A_i$ with respect to $A^*$ is defined as follows:

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, \ i = 1,2,...,m \quad (6)$$

Step 6: Rank the preference order.

Utility functions are used to obtain the actual utility value of an attribute [117]. Different applications with different QoS preferences will have different utility values. fora same network. Thus, the individual preferences are taken into account in the utility evaluation. The utility value of an attribute is derived based on the requirement of that attribute for a particular application. If two networks are satisfying the minimum and maximum requirements of an attribute required for that application, the utility values of both the networks for that attribute will be closer. The requirement of attributes for different applications is illustrated in Table 5.

**Table 5: Requirements of network attributes for the three applications**

| Applications/Attributes→ ↓ | Data Rate | Delay | Jitter | Cost |
|---|---|---|---|---|
| Conversational | 32-64 Kbps | 100-150ms | 50-80ms | <50 |
| Interactive | 512-5000 Kbps | 100-150ms | 40-70ms | <50 |
| Streaming | 512-5000 Kbps | 100-150ms | 40-70ms | <50 |

The utility values obtained for network attributes for the three applications are shown in Tables 6 -8.

**Table 6: Utility values for Conversational applications**

| | Data Rate | Delay | Jitter | Cost |
|---|---|---|---|---|
| N1 | 1 | 0.9996 | 0.9996 | 0.9 |
| N2 | 1 | 0.5622 | 0.9999 | 0.94 |
| N3 | 1 | 0.3208 | 0.9999 | 0.98 |

**Table 7: Utility values for streaming applications**

| | Data Rate | Delay | Jitter | Cost |
|---|---|---|---|---|
| N1 | 0.9975 | 0.9996 | 0.9996 | 0.9 |
| N2 | 1 | 0.5622 | 0.9999 | 0.94 |
| N3 | 1 | 0.3208 | 0.9999 | 0.98 |

**Table 8: Utility values for Interactive applications**

| | *Data Rate* | *Delay* | *Jitter* | *Cost* |
|---|---|---|---|---|
| ***N1*** | *0.9975* | *0.9996* | *0.9996* | *0.9* |
| ***N2*** | *1* | *0.5622* | *0.9999* | *0.94* |
| ***N3*** | *1* | *0.3208* | *0.9999* | *0.98* |

## 4. RESULT AND DISCUSSIONS

AHP score is calculated as discussed in Sect. 3. The performance of these networks for streaming, conversational and interactive applications of the basis of AHP, TOPSIS and is shown in Figures. AHP-TOPSIS method is also applied for the same network selection problem. Based on the ratios obtained from AHP-TOPSIS method, handover decision is made. Results with TOPSIS method is almost same as with the AHP method. So, the results indicate that the large range networks are always the preferred choices as they can support higher mobility.

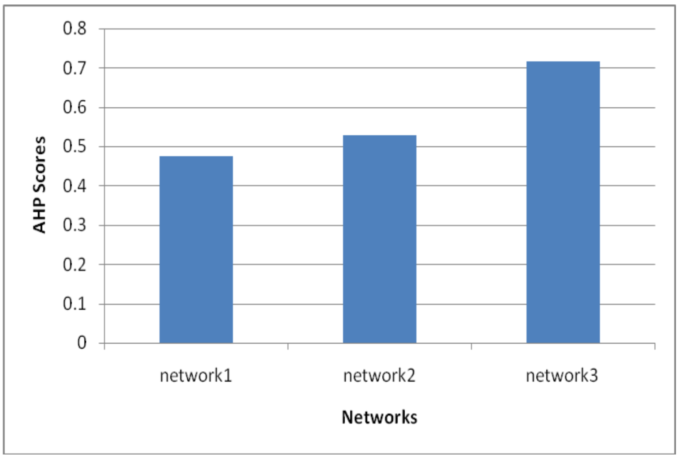


**Fig.1: AHP Scores of networks for conversational applications**

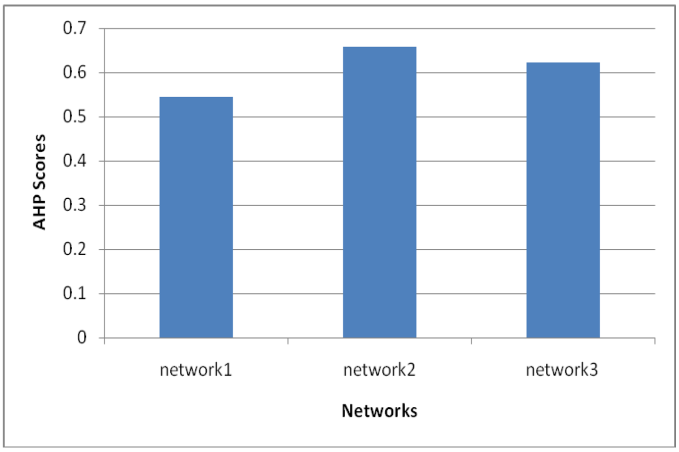


**Fig.2: AHP Scores of networks for interactive applications**

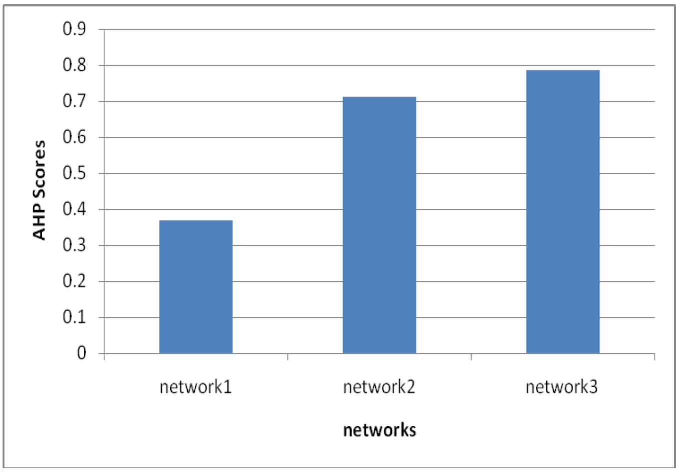


**Fig.3: AHP Scores of networks for streaming applications**

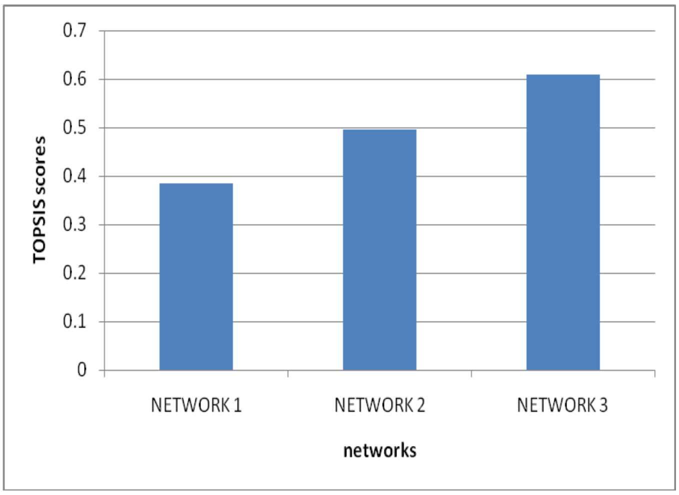


**Fig.4: TOPSIS Scores of networks for conversational applications**

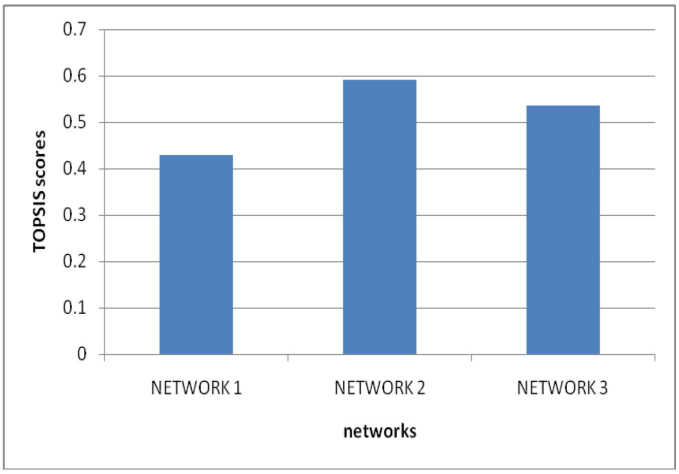


**Fig.5: TOPSIS Scores of networks for interactive applications**

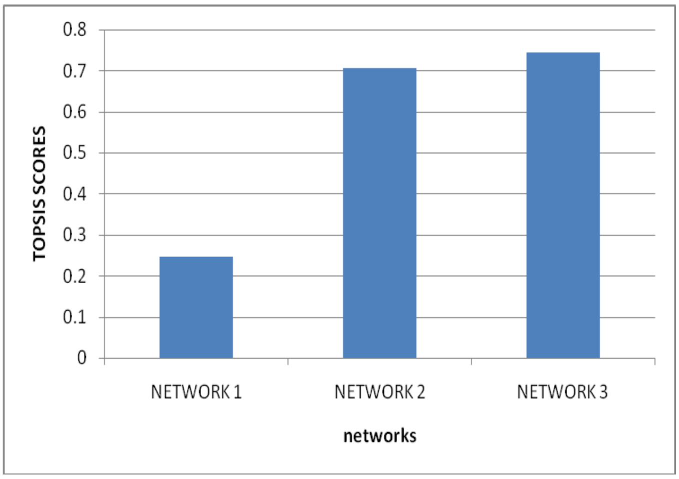


**Fig.6: TOPSIS Scores of networks for streaming applications**

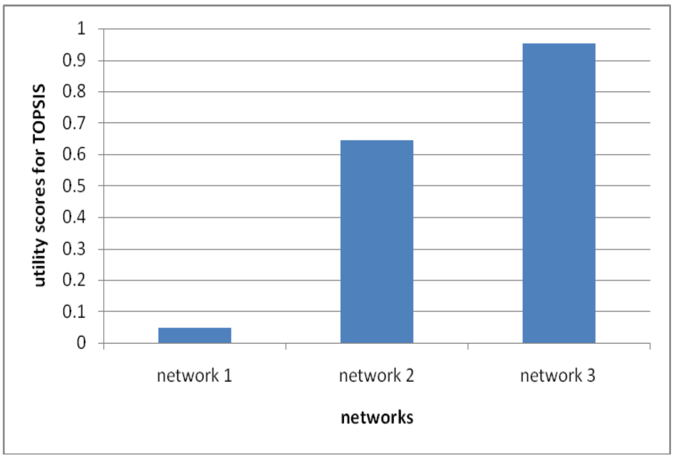


**Fig 7: UTILITY Scores for conversational applications for TOPSIS**

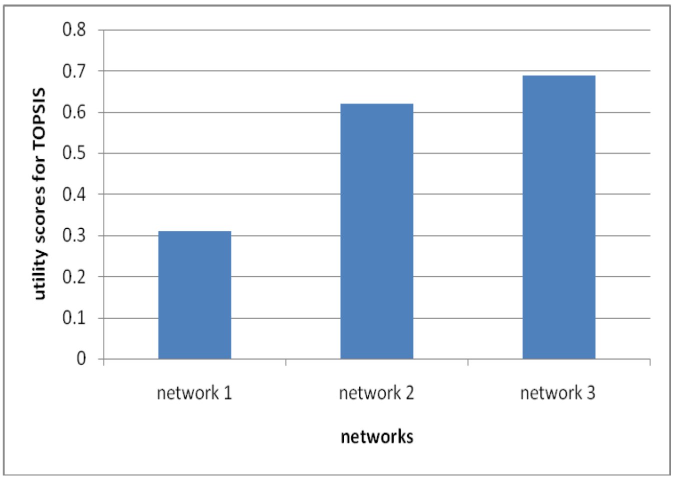


**Fig 8: UTILITY Scores for interactive applications for TOPSIS**

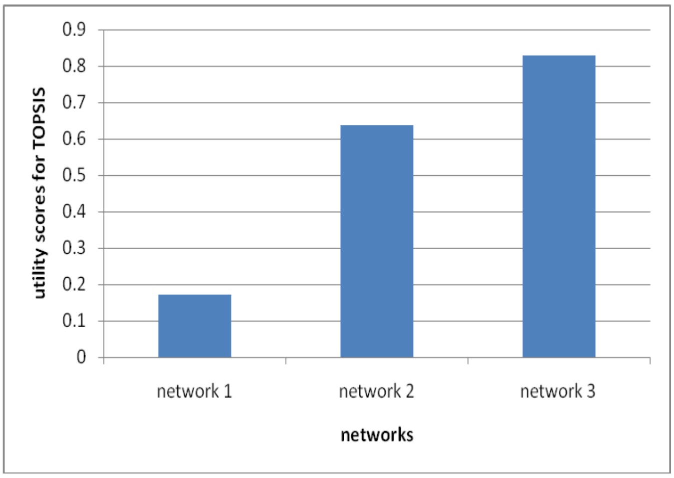


**Fig 9: UTILITY Scores for streaming applications for TOPSIS**

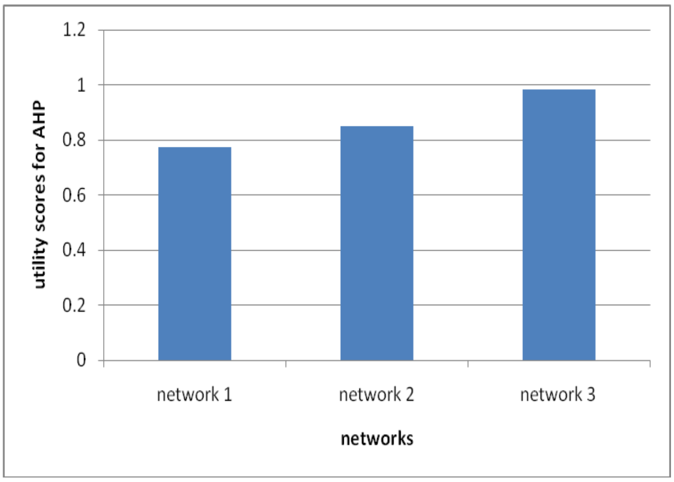


**Fig 10: UTILITY Scores for conversational applications for AHP**

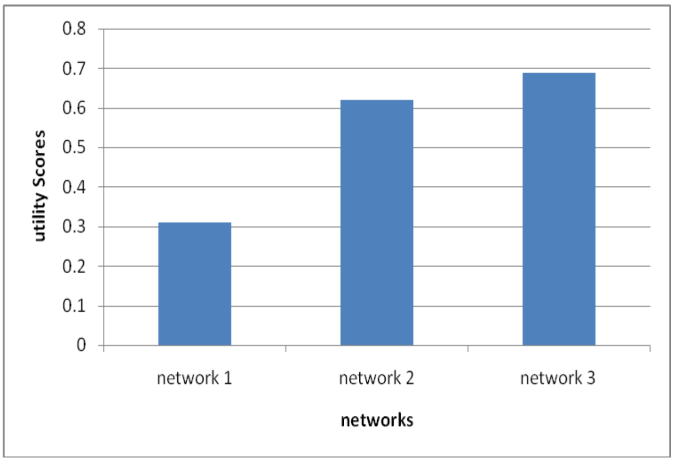


**Fig 11: UTILITY Scores for interactive applications for AHP**

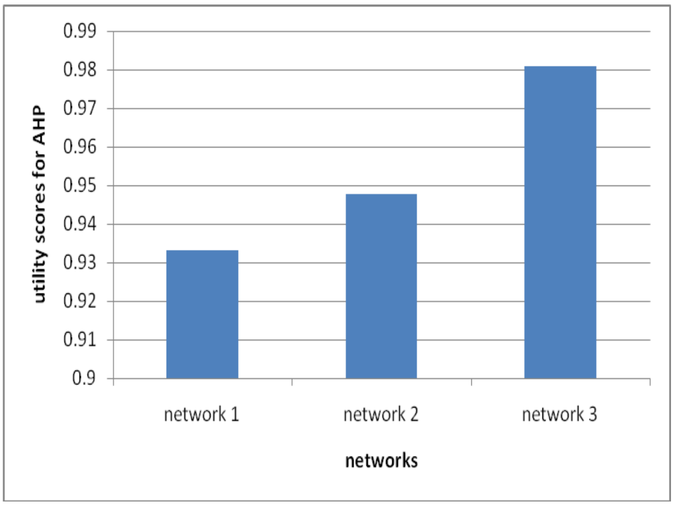


**Fig.12: UTILITY Scores for streaming applications for AHP**

The results shows that in independent application scenario, the algorithm can provide the best ranking, in random scenario, the selected rate of the three networks are similar, and the ranking are more balanced. Also, with the utility-based MADM methods unnecessary handovers can be avoided as in comparison with traditional MADM methods. Also, parameterized utility functions are used to model the different Quality of Service (QoS) attributes for different applications with AHP and TOPSIS methods.

## 5. CONCLUSIONS

The main objective of this paper to developed schemes is to minimize the number of unnecessary handoffs, while maximizing the time with a preferred network, resulting in increased end-user's satisfaction level. Network selection, the decision to select the best network among the available candidates, also plays an important role to maximize the end's user satisfaction levels. The scheme utilizes the parameters, such as, Data rate, Cost, Delay, Jitter, Throughput of the network. Three types of applications: Conversational, Streaming, Interactive, are utilized in evaluating the performance of the proposed scheme. The network selection algorithm finds out the best available network that can support the continuity and quality of current service. It is observed that most of the research work deals with the target network selection, ignoring the handoff and necessity estimation, that are of equal importance, as handoff and its necessity estimation play a vital role in maximizing the end-user's satisfaction. This suggests that more work needs to be done in this area. This algorithm outperforms the other methods by providing less number of handoffs, a low handoff failure rate, the best network, and high network utilization. Utility functions are further used to obtain the actual utility value of each network attribute. Also, with the utility-based MADM methods unnecessary handovers can be avoided as in comparison with traditional MADM methods.

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