# AN OVERVIEW OF VERTICAL HANDOFF DECISION BASED ON MADM FOR HETEROGENEOUS WIRELESS NETWORK

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**ABSTRACT**

Future generation wireless networks (FGWN) consist of heterogeneous networks managed by different operators. In heterogeneous network the provision of continuous service for mobile nodes is a main issue for FGWN. Handoff process enables a mobile node (MN) to provide such a facility by transferring an active call from one base station (BS) to another BS. The heterogeneous wireless networks (HWN) will support the vertical handoff mechanism. In this paper, we present an overview about the vertical handoff for heterogeneous wireless network and detail about multiple attribute decision making (MADM) based handoff decision to select a best network.

***Keywords-*** Handoff, Handoff initiation, Handoff decision, MADM, Always best connected (ABC), Network selection.

## 1. INTRODUCTION

Future generation wireless networks (FGWN) are expected to support heterogeneous access technologies than homogeneous wireless networks. The present trend towards ubiquity of network and global mobility of services, network access is provided by a large diversity of technologies with coverage overlaps. In this HWN environment, always best connected (ABC) [3] which requires dynamic selection of the best network and access technologies when multiple options are available simultaneously.

In FGWN, the vertical handoff (VHO) is used for convenience according to user choice for a particular service rather than the connectivity reasons. VHO is mainly used to support between different air interfaces techniques during inter-network movements, a mobile terminal (MT) is moving from one network to another network in heterogeneous network which has different air interfaces techniques. So VHO is a main thing in HWN.

Vertical handoff challenges performance optimization like reducing overhead signalling, low handoff latency, power saving, low bandwidth overhead. These requirements may fulfil by always best connected (ABC) concept, of being connected in the best possible way in an environment of heterogeneous wireless networks. Thus, a vertical handoff management solution can mostly concern the handoff decision phase: The decision for the appropriate time to initiate the handoff and for most suitable access network selection from the available network.

To select the best network there are large number of proposals are used. Some proposals are gaming model[9], Knapsack model[10], Markov decision[11] process model. These proposals try to solve the network selection in different ways. Among all the proposals, MADM is one of the popular models for the network selection in the literature [1] [2]. Therefore, in this paper, we demonstrate the MADM models in theoretically.

## 2. HANDOFF TECHNIQUES

Handoff is the process by which an MT keeps its connection when it moves from one BS or access point (AP) to another BS or AP. The transfer of a current communication channel could be in terms of a time slot, frequency band or a code word to a new BS.

If a new BS has some unoccupied channels, then it assigns one of them to the handoff call, however, if all of the channel was in use at the handoff time there are two possibilities, one is to drop the call and another one is delay it for a while.

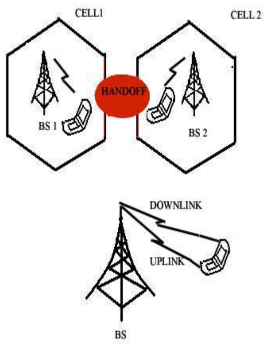


**Figure1. Handoff**

Handoff can be classified into horizontal (intra-system) and Vertical (inter-system) cases. Horizontal handoff means handoff within the same wireless access network technology. Vertical handoff means handoff among heterogeneous wireless access network technology. The Vertical handoff decision may depend on the bandwidth available for each wireless access network. There are several challenging issues on vertical handoff The Vertical handoff operation should provide authentication of the mobile users, a low control overhead and maintain the connection such that packet loss and transfer delay are minimized.

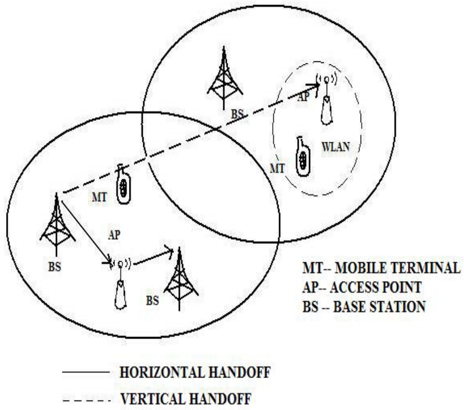


**Figure 2. Vertical handoff vs. Horizontal handoff**

In general, the vertical handoff has three steps of process [12] [13], namely System discovery, Handoff decision and Handoff execution.

**System discovery:** MT equipped with multiple interfaces has to determine which networks can be used and the services available in each network. The network may also advertise the supported data rates for different services.

**Handoff decision:** The mobile device determines which network it should connect. The decision may depend on various parameters including the available bandwidth, delay, jitter, access cost, transmit power, etc.,

**Handoff execution:** The connection need to be re-routed from the existing network to the new network in a seamless manner.

Vertical handoff initiation is the process of deciding when to request a handoff. Handoff decision is based on the received signal strength (RSS) from the current BS and neighbouring BSs. In Fig 3, RSS gets weaker as the MS moves away from BS1 and get stronger as it gets closer to BS2 as a result of signal propagation .We examine four main vertical handoff initiation techniques. They are Relative signal strength, Relative signal strength with threshold (T1), Relative signal strength with hysteresis (h), Relative signal strength with threshold (T2).

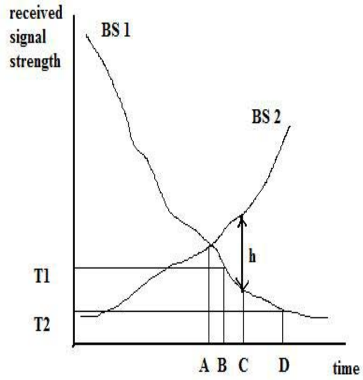


**Figure 3. Movement of an MS in the Handoff Zone**

## 3. HANDOFF DECISION

The networks in HWN have various attributes like monetary cost, bandwidth, signal strength, etc., MTs have various properties and application has various QOS requirements, it was difficult to define the best network in the network selection.

The network attributes compose a large category, which are generally used as decision criteria to characterize different aspects of networks capabilities. Since these criteria have different measurement units, utilities and inexactness, the values need to be adjusted before combining together. For these adjustments' normalization, utility theory and Fuzzy logic are used in[4][5]. In order to combine multiple criteria together, weights are required, so analytical hierarchy process is used to evaluate their weights.

After all the attribute are adjusted their weights are calculated, they are combined together as a total cost or utility based on certain multiple attribute decision making (MADM) algorithm[4]-[8]. In the end, a rank of these networks is obtained and the first one in the rank will be decided as the best network.

## 4. MADM ALGORITHMS

In Fig. 4, network ranking module integrates all the information coming from weighting and adjusting modules, and obtains a rank of all the networks. MADM algorithms that have been used for network ranking include simple additive weighting (SAW), multiplicative exponential weighting (MEW), technique in order to preference by similarity to ideal solution (TOPSIS), grey relational analysis (GRA), elimination and choice translating reality (ELECTRE) etc., The first four algorithms rank networks based on their coefficients calculated by combining adjusted values of all the criteria. In the present literature these four algorithms are mainly used in the VHO.

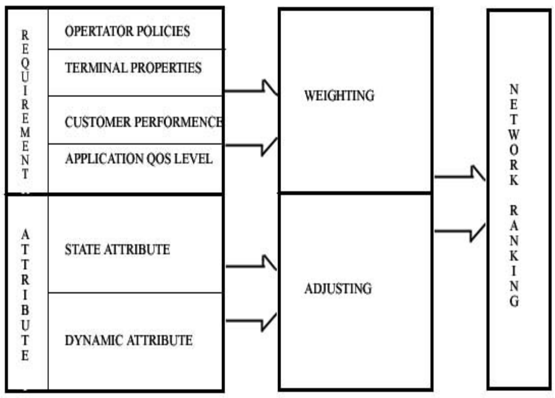


**Figure 4. MADM-based network selection**

*A. Simple Additive Weighting (SAW) algorithm:*

This algorithm is otherwise called as weight linear combination or scoring method. The following equation was used in order to calculate the coefficients.

$$C_{SAW} = \sum_{j=0}^{n} \omega_i r_{ij} \quad (1)$$

where $\omega_i$ represents the weight of the $j^{th}$ criterion, $r_{i,j}$ represents the adjusted value of the $j^{th}$ attribute of the $i^{th}$ network.

*B. Multiplicative Additive Weighting (MEW) algorithm:*

This algorithm is also called as weighted product method (WP) in MADM scoring method. The following equation was used in order to calculate the coefficients.

$$\sum_{j=1}^{n} \omega_j = 1 \quad (2)$$

$$C_{MEW} = \prod_{j=1}^{n} x_{ij}^{\omega_j} \quad (3)$$

Equation (3) can be modified as

$$C_{*MEW} = \frac{\prod_{j=1}^{n} x_{ij}^{\omega_j}}{\prod_{j=1}^{n} (x_j^*)^{\omega_j}} \quad (4)$$

*C. Technique of Order Preference by Similarity to Ideal Solution (TOPSIS) algorithm:*

In this algorithm two artificial alternatives are hypothesized: positive ideal alternative, negative ideal alternative. TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal solution.Normalization of values can be carried out by

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}^2} \quad (5)$$

Where $r_{ij}$ denotes the normalized performance rate and $x_{ij}$ denotes attribute j of candidates.

Construct the weighted normalized decision matrix

$$v_{ij} = \omega_j r_{ij} \quad (6)$$

Determine the ideal and negative ideal solutions.

**Ideal solution:**

$$A^* = \{ v_1^*, v_2^*, \dots \dots \dots, v_n^* \} \quad (7)$$

Where

$$v_j^* = \{ max_i(v_{ij}) if\ j \in J; min_i(v_{ij}) if\ j \in J' $$

**Negative ideal solution:**

$$A' = \{ v_1', v_2', \dots \dots \dots, v_n' \} \quad (8)$$

Where $v_j' = \{ min_i(v_{ij}) if\ j \in J; max_i(v_{ij}) if\ j \in J'$

Calculate the separation measures for each alternative

The separation from the ideal alternative is

$$S_i^* = [\sum_j (v_j^* - v_{ij})^2]^{\frac{1}{2}} \quad (9)$$

The separation from the negative ideal alternatives is

$$S_i' = [\sum_j (v_j' - v_{ij})^2]^{\frac{1}{2}} \quad (10)$$

Calculate the relative closeness to the ideal solution $C_i^*$

$$C_i^* = \frac{S_i'}{(S_i^* + S_i')} \quad (11)$$

*D. Grey relational Analysis (GRA) algorithm:*

This algorithm offering the measurement for quantification is suitable for performing dynamic course analysis.

Calculate the difference series

$$\Delta_{ij}(k) = |x_i(k) - x_j(k)| \quad (12)$$

Calculate the maximum and minimum of the difference series

$$\Delta_{max} = \underset{\forall j \in i}{max}(max \Delta_{ij}(k)) \quad (13)$$

$$\Delta_{min} = \underset{\forall j \in i}{min}(min \Delta_{ij}(k)) \quad (14)$$

Calculate the grey relational coefficient

$$\gamma(x_i(k), x_j(k)) = \frac{\Delta_{min} - \varsigma\Delta_{max}}{\Delta_{ij}(k) + \varsigma\Delta_{max}} \quad (15)$$

Where $\varsigma$ =0.1, Calculate the grey relation grade to develop matrix R

$$\Gamma_{ij} = \frac{1}{k}\sum_{k=1}^{k} \gamma(x_i(k), x_j(k)) \quad (16)$$

$$R = \Gamma_{ij} \quad (17)$$

Develop matrix G, which is presented below and is known as grey relation clustering

$$G = [g_{ij}] \quad (18)$$

Where $g_{ij} = [\Gamma_{ij} + \Gamma_{ji}]/2$

$\Gamma_{ij}$ and $\Gamma_{ji}$are grey grade with the form

$$\Gamma_{ij} = \gamma(x_i, x_j), \quad \Gamma_{ji} = \gamma(x_j, x_i) \quad (19)$$

Identify the two points of the most near

$$\max_j g_{ij} \quad (20)$$

The above algorithms are mostly used for vertical handoff decision in [1] [7].

**5. CONCLUSION**

We firstly provided in this paper a brief theoretical explanation about vertical handoff for heterogeneous wireless network using MADM based handoff decision, in this paper we explained MADM main four algorithms. We proposed to do these MADM algorithms in a Vertical handoff algorithm for heterogeneous wireless to recover handoff delay, cost, low bandwidth, etc.,

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