Survey on Evaluation Models of Vertical Handoff Decision Algorithms

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ABSTRACT

In Heterogeneous systems, Vertical Handoff calculations (VHAs) used to permit mobile terminals (MT) to keep up the system association when versatile hub switch starting with one remote system then onto the next one. The Vertical Handover Decision is NP-Hard issue, thus assessment of all VHA is imperative perspective while working with Vertical Handoff calculations. In this paper, we concentrated on different assessment models which were utilized by past analysts. We likewise concentrated on the different parameters which are imperative for execution examination of VHAs and represent the absence of a legitimate assessment model to look at the different Vertical Handoff Algorithms (VHAs) that have been proposed in the writing.

Keywords

Heterogeneous Networks, Vertical Handoff Algorithms, Mobile Terminals, Evaluation models.

1. INTRODUCTION

The next generation wireless networking (4G) is mindful on accomplishing interoperability between diverse system innovations in a consistent way, and on encouraging the client's versatility through a lasting remote association anyplace and whenever [1].

As of now, a percentage of the advanced cells in the business sector are furnished with numerous system interface cards which can join with distinctive remote systems. However this development represents a fascinating test similar to the handoff between different heterogeneous remote systems seamlessly. This critical portability activity is known as the vertical handoff [2].In the last late years, a lot of exploration endeavors [3] have been engaged in this vital and testing versatility process in heterogeneous remote frameworks.

Distinctive Vertical Handoff Algorithms (VHAs) have been proposed in the writing [4]. In any case, there is no any accord on the best way to assess the execution of distinctive VHAs in the examination group. Albeit a few models have been proposed for assessment of the VHAs, this issue has made fascinating difficulties on the grounds that the VHAs have turned out to be more modern and in this manner assessment models must consider an assortment of parameters.

Different late works show enthusiasm for the assessment of VHAs; however some of them don't assess the entire calculation and concentrate just the choice of system innovation stage, which is thought to be the primary segment in the handoff process [7].

In view of the distinctive proposed VHAs, a few studies have concentrated on characterizing which of these arrangements may be ideal for the system choice procedure. Hence, there are studies that utilization distinctive assessment philosophies to achieve this reason.

2. EVALUATION MODELS

Many decision algorithms based on multi attributes decision making (MADM) methods have been proposed to deal with the vertical handover algorithm (VHA) problem. The MADM have many methods such as analytic hierarchy process (AHP), simple additive weighting (SAW), multiplicative exponential weighting (MEW), grey relational analysis (GRA), technique for order preference by similarity to ideal solution (TOPSIS), the distance to the ideal alternative (DIA), ELECTRE, VIKOR and WMC (weighted markov chain).

2.1 Analytic Hierarchy Process

The vertical handoff decision algorithms considered for comparison needs relative importance of each parameter which is usually given by the set of weights wj. The analytical hierarchical processing (AHP) method is used to determine the weights [23, 24] by comparing a pair metrics with the 1–9 AHP scale. The four traffic classes have different QoS requirements. So, we assigned the different weights according to the importance of parameters in different traffic classes as shown in Table 2.

AHP consists of four steps. One, define the problem and state the goal or objective. Two, define the criteria orfactors that influence the goal. Structure these factors into levels and sublevels. Three, use paired comparisons of each factor with respect to each other that forms a comparison matrix with calculated weights, ranked eigen values and consistency measures. Four, synthesize the ranks of alternatives until the final choice is made.

Individuals and groups use the AHP preference scale in Table 1 to form the comparison matrices.

2.2 Simple Additive Weighting (SAW)

In SAW, the overall score of a candidate network is determined by the weighted sum of all the attribute values. The score of each candidate network i is obtained by adding the normalized contributions from each metric r_{ij} multiplied by the importance weight assigned w_j of metric j. The selected network $A*_{SAW}$ is:

$$A*_{SAW} = \arg\max_{i \in M} \sum_{j=1}^{N} wj\ rij \qquad (1)$$

Where N is the number of parameters, and M denotes the number of candidate networks.

Table 1. Preference Model

AHP Scale of Importance for comparison pair (aij)	Numeric Rating	Reciprocal (decimal)
Extreme Importance	9	1/9 (0.111)
Very strong to extremely	8	1/8 (0.125)
Very strong Importance	7	1/7 (0.143)
Strongly to very strong	6	1/6(0.167)
Strong Importance	5	1/5(0.200)
Moderately to Strong	4	1/4(0.250)
Moderate Importance	3	1/3(0.333)
Equally to Moderately	2	1/2(0.500)
Equal Importance	1	1(1.000)

2.3 Technique for order preference by similarity to ideal situation—TOPSIS

In Technique for Order Preference by Similarity to Ideal Solution Algorithm (TOPSIS) [4] with M alternatives that are evaluated by N decision criteria is viewed as a geometric system with M points in the N dimensional space. Here, the chosen candidate network is the one which have the shortest distance to the ideal solution and the longest distance to the worst case solution. To compute the network ranking-list, TOPSIS requires the following steps:

Step 1: Construct the normalized decision matrix, which allows comparison across the attributes, this matrix is given by:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}$$

Step 2: Construct the weighted normalized decision matrix as vij = wj∗rij.

Step 3: Determine ideal and negative-ideal solutions by:

$$A^{+} = \{(\max_{i\in M} v_{ij} | j\in J), (\min_{i\in M} v_{ij} | j\in J')\},$$

$$A^{-} = \{(\min_{i\in M} v_{ij} | j\in J), (max\, v_{ij} | j\in J')\}$$

Where J is the set of benefit parameters, and J ′ is the set of cost parameters.

Step 4: Calculate the separation measure between the networks and the positive and negative ideal networks by:

$$s_i^{+} = \sqrt{\sum_{j\in N}\left(v_{ij} - v_j^{+}\right)^2}\ ,\ s_i^{-} = \sqrt{\sum_{j\in N}\left(v_{ij} - v_j^{-}\right)^2}$$

Step 5: Calculate the relative closeness to the ideal solution

$$c_i^{*} = \frac{s_i^{-}}{(s_i^{+} + s_i^{-})}$$

A set of alternatives can now be preference ranked according to the descending order of c ∗i . Then the selected network A∗TOP is:

$$A_{Top}^{*} = argmax_{i\epsilon M}\ C_i^{*}$$

2.4 Multiplicative exponential weighted MEW

Using this technique, vertical handoff decision can be expressed as a matrix where each row i corresponds to the candidate network i and each column j corresponds to an attribute (Bandwidth, Delay, etc.). The score Si of network i is

$$S_t = \prod_{j=1}^{N} x_{ij}^{w_j}$$

Where xij denotes attribute j of candidate network i, wj denotes the weight of attribute j and $\sum_{j=1}^{N} Wj = 1$

wj is a positive power for benefit metrics (xwjij), and a negative power for cost metrics (x−wjij). Since the score is an upper bound, it is convenient to compare each network with the score of the positive ideal network A∗∗. This network is defined as the network with the best values in each metric. (For a benefit metric, the best value is the largest. For a cost metric, the best value is the lowest.) The value of ratio Ri between network i and the positive ideal is:

$$R_i = \frac{\prod_{j-1}^{N} x_{ij}^{w_j}}{\prod_{j-1}^{N} (x_{ij}^{++})^{w_j}}$$

The selected network A∗MEW is obtained as:

$$A_{MEW}^{*} = \mathrm{argmax}_{i\epsilon M}\ R_i$$

2.5 Gray Relational Analysis—GRA

In Grey Relational Analysis (GRA) [6] algorithm, grey relational coefficient (GRC) is used as the coefficient to describe the similarity between each candidate network and the best reference network (an ideal network formed by choosing the best value of each attribute). GRA is usually implemented following three steps: normalization data, defining the ideal sequence, and computing GRC. The normalization of the sequence data is performed according to the three situations (larger-the-better, smaller-the-better, and nominal-the-best) as follows:

$$r_{ij} = \frac{x_{ij} - l_j}{u_j - l_j}\ ,$$

$$r_{ij} = \frac{u_j - x_{ij}}{u_j - l_j}\ ,$$

$$r_{ij} = 1 - \frac{|x_{ij} - m_j|}{\max_{u_j} - m_j, m_j - l_j}$$

Where uj = max i∈M xij ,lj = min i∈M xij , and mj is the largest value in the situation of nominal-the-best, for j = 1, 2, 3, ..., N. The ideal sequence x0 is defined to contain the upper bound, lower bound, or moderate bound respectively in larger-the-better, smaller-the-better or nominal-the-better situations. The GRC can be then calculated as following:

$$GRC_i = \frac{1}{m}\sum_{j=1}^{m} \frac{\Delta_{min} + \Delta_{max}}{\Delta_i + \Delta_{max}}$$

Where$\Delta_i = |x_{0j} - r_{ij}|$,

And $\Delta_{max} = \max_{i\in M, j\in N} \Delta_i\ ,\ \Delta_{min} = \min_{i\in M, j\in N} \Delta_i$

The larger the GRC, the more preferable the network will be. The selected network A∗ GRA is:

$$A_{GRA}^{*} = \arg\max_{i\in M} GRC_i$$

2.6 The Distance to the Ideal Alternative DiA

DIA uses the Manhattan distance to calculate the distance between the attribute values and the positive and negative ideal values of each attribute:

$$D_j^{+} = \sum_{j=1}^{m} |v_{ij} - a_i^{+}|$$

$$D_j^{-} = \sum_{j=1}^{m} |v_{ij} - a_i^{-}|$$

Then, DiA considers the minimum value of D+ and maximum Value of D-.

$$\min D^{+} = \min D_j^{+} = \min_j \sum_{j=1}^{m} \left| v_{ij} - a_i^{+} \right|$$

$$\max D^{-} = \max D_j^{-} = \max_j \sum_{j=1}^{m} \left| v_{ij} - a_i^{-} \right|$$

If we consider the (D+, D−) plane, the point (min Di+,max Di-) is defined as the “positive ideal alternative” (PIA).

The best alternative has the shortest distance to the PIA. This absolute distance is calculated as follow.

$$R_j = \sqrt{(D_j^{+} - \min(D^{+}))^2 + (D_j^{-} - \max(D^{-}))^2}$$

The alternative having the smallest Rj value has the shortest distance to the PIA.

2.7 ELECTRE

In Elimination and Choice Translating Priority(ELECTRE) algorithm [7], a reference attribute vector is used to adjust the raw attribute values for the alternative networks before they are compared. The value of each of the attributes in the decision matrix is compared with a corresponding reference attribute value xrefj. An absolute difference between the two values is taken to calculate a new matrix as follows.

$$r_{ij} = \left| x_{ij} - x_j^{ref} \right|$$

Now in this matrix all attribute values can be considered to have a monotonically decreasing utility. Since a lower value for an adjusted attribute in (1) is considered an indication of a better network in the selection process, each attribute in (1) can be normalized as follows,

$$\hat{r}_{ij} = \frac{\max_{i \in M} \{r_{ij}\} - r_{ij}}{\max_{i \in M} \{r_{ij}\} - \min_{i \in M} \{r_{ij}\}}$$

Now, is necessary take into consideration the relative importance of each of the attributes involved in the decision about network selection? For the j-th attribute is assigned a weight wj, such that $\sum_{j=1}^{N} \mathrm{W}j = 1$ using the weights, an updatedmatrix is calculated by,

$$\bar{r}_{ij} = w_j \hat{r}_{ij}$$

In order to compare the network alternatives, the concept of concordance and discordance has been introduced in ELECTRE, which are measures of satisfaction and dissatisfaction of the decision maker when one alternative is compared with another. It firstly uses pair-wise comparisons of networks to obtain the concordance set CSet(k, l) indicating the attribute of network k is better than network l and the discordance se tDSet(k, l) indicating the attribute of network k is worse than network l. The concordance and discordance sets are formed as follows,

$$\mathrm{C}Set_{kl} = \{ j | \bar{r}_{kj} >= \bar{r}_{ij} \}$$

$$\mathrm{D}Set_{kl} = \{ j | \bar{r}_{kj} < \bar{r}_{ij} \}$$

Using the concordance and discordance sets, corresponding matrices are constructed. The elements of the concordance matrix C can be represented as,

$$c_{kl} = \sum_{j \in \mathrm{C}Set_{kl}} w_j$$

The entries for the concordance matrix are not defined for the diagonal. ELECTRE defines the elements of discordance matrix as follows:

$$d_{kl} = \frac{\sum_{j \in \mathrm{D}Set_{kl}} \left| \bar{r}_{kj} - \bar{r}_{ij} \right|}{\sum_{j \in N} \left| \bar{r}_{kj} - \bar{r}_{ij} \right|}$$

Similarly, the entries for the discordance matrix are also not defined for the diagonal. A new parameter Ci , called the net concordance index is calculated. Ci is a measure of dominance of an alternative i over other alternatives. It can be calculated as follows,

$$\hat{C}_i = \sum_{j \in N, j \neq i} C_{ij} - \sum_{j \in N, j \neq i} C_{ji}$$

Similarly, the term net discordance index Di, is defined as a measure of relative weakness of alternative i over other alternatives and can be calculated as

$$\widehat{D}_i = \sum_{j \in N, j \neq i} D_{ij} - \sum_{j \in N, j \neq i} D_{ji}$$

An alternative with the highest value of net concordance index C˜ and the lowest value of net discordance index D˜ would be preferred. However, if it is not the case, the alternatives are ranked based on the concordance and discordance indices and each alternative is ranked by taking the average of these two rankings. The alternative with the highest average ranking is considered to be the best alternative. Alternatives with the same average ranking would be considered equally suited.

2.8 VIKOR

For VIKOR [9] method the following steps are required:

Step 1: For each parameter j = 1, 2, 3... N, determine the best and the worst values given by:

$$F_j^{+} = \{ (max_{i \in M}\, x_{ij} \,|\, j \in N_b), (min_{i \in M}\, x_{ij} \,|\, j \in N_c) \}$$

$$F_j^{-} = \{ (min_{i \in M}\, x_{ij} \,|\, j \in N_b), (max_{i \in M}\, x_{ij} \,|\, j \in N_c) \}$$

Where Nb⊂ N is the set of benefit parameters, and Nc⊂ N is the set of cost parameters.

Step 2: Compute the values of Si and Ri for i = 1, 2, 3... M given by:

$$s_i = \sum_{j \in N} w_j \frac{(F_j^{+} - x_{ij})}{(F_j^{+} - F_j^{-})}$$

$$R_i = max_{j \in M} \left[w_j \frac{(F_j^{+} - x_{ij})}{(F_j^{+} - F_j^{-})} \right]$$

Where wj is the importance weight of parameter j.

Step 3: Compute the values of Qi for i = 1, 2, 3... M given by:

$$Q_i = \gamma \left(\frac{S_i - S^{+}}{S^{-} - S^{+}} \right) + (1 - \gamma) \left(\frac{R_i - R^{+}}{R^{-} - R^{+}} \right),$$

Where, $S^{+} = \min_{i \epsilon M} S_i$, $S^{+} = \max_{i \epsilon M} S_i$,

$R^{+} = \min_{i \epsilon M} R_i$, $R^{-} = \max_{i \epsilon M} R_i$,

And parameter γ with 0 ≤ γ ≤ 1 is the weight of the strategy. It also represents the majority of criteria.

Step 4: Given the values for the Q, R and S for all i∈ M, rank the candidate networks in an increasing order. The selected network A∗ V IK is:

$$A_{VIK}^{*} = \arg \min_{i \epsilon M} Q_i^{*}$$

2.9 WMC

The weighted Markov chain (WMC) [8] algorithm includes the following steps:

Step 1: Construction of weighted Markov chain transition matrix MC. Initialize a M × M matrix MC = {mcij} with all element values are equal to 0, in which mcij represents transition probability from alternative pi to the network pj.

Step 2: For each decision factor q, a ranking list is obtained as

$$T_q=[p_1 \geq p_2 \geq \cdots \geq p_M]$$

Where "≥" represents some ordering relation, and τq(p) denotes the ranking of alternative p with regard to factor q.

Step 3: For each mcij in MC, update

$$mc_{ij}=mc_{ij} + \frac{w_q}{T_q(p_i)} \text{ , if } T_q(p_i) \geq T_q(j)$$

Step 4: Computation of stationary probabilities:

$$\pi_j = \sum_{i=0}^{M} \pi_i mc_{ij} \;,\; \sum_{j=0}^{M} \pi_j = 1$$

The selected network A∗ WMC is:

$$A_{WMC}^{*} = \arg\max_{j\in M}(\pi_j)$$

3. PERFORMANCE OF MODELS

One of the most important criteria is the total bandwidth and corresponds to WiMAX1, methods as WMC, ELECTRE and VIKOR select this. On the other hand, the available bandwidth is necessary for data transmission, but in the simulation, WLAN2provides a higher available bandwidth than the rest. This causes that methods as SAW, MEW and TOPSIS perform a vertical handoff to WLAN2 to achieve the best connectivity.

On the other hand, GRA algorithm selects WLAN2 for all the vertical handoff decision points.

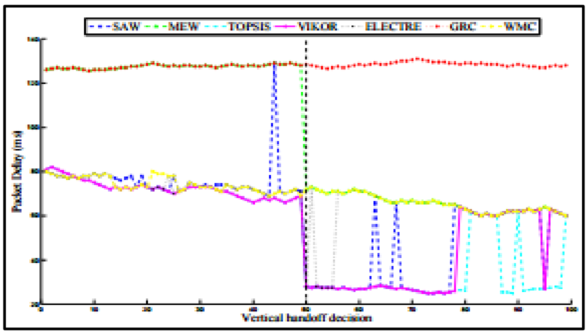

Figure 1: Values of packet delay selected by the decision methods.

Figure 3 shows the available bandwidth achieved by the seven vertical handoff algorithms, decision points 1 to 50 corresponds to case 1 and decision points 51 to 100 to case 3.

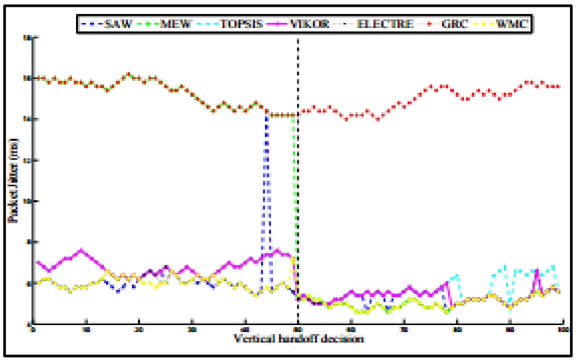

Figure 2: Values of packet jitter selected by the decision methods.

We can see that in case 3 MEW and GRA are able to obtain the highest values of available bandwidth followed by SAW and TOPSIS. On the other hand, VIKOR, ELECTRE and WMC reduce their available bandwidth compared.

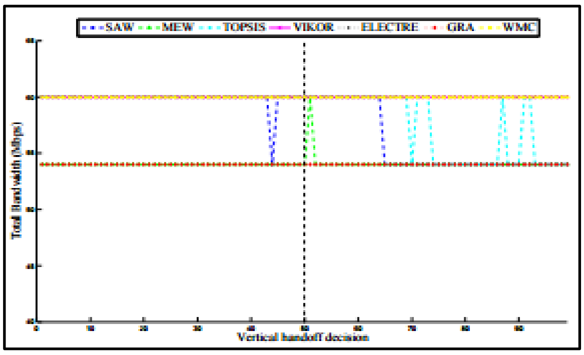

Figure 3: Values of total bandwidth selected by the decision methods

4. CONCLUSION

In this paper, we provide a study of several vertical handoff decision algorithms, with the aim of understand its performance for different user applications. Methods as SAW, VIKOR and TOPSIS are suitable for voice connections, these algorithms provide a compromise for achieve the lower values of jitter and delay packet available in a 4G wireless network. In a data connection case, GRA and MEW algorithms provide the solution with highest available bandwidth necessary for this application.

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