A Pandect on MADM in Heterogeneous Wireless Networks

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Abstract-- The Next Generation Wireless Network (NGWN) mobile terminals (MT) are equipped with multiple interfaces and can access a wide range of applications provided by heterogeneous wireless networks in an Always Best Connected (ABC) mode. Each and every network has their own coverage area which is called a cell. When a node moves from one cell to another cell within the same network. The heterogeneous wireless networks will support the vertical handoff mechanism. Multiple Attribute Decision Making (MADM) is used to choose the best network. So In this paper, the vertical handoff for heterogeneous wireless network such as ELECTRE, AHP, PROMEETHI, SAW, MEW, GRA and TOPSIS methods and detail explanation.

Keywords-- *Handoff, Handoff decision, MADM, Handoff process, Handoff classification.*

I. INTRODUCTION

Next generation wireless networks (NGWN) are expected to support heterogeneous access technologies than homogeneous wireless networks. In NGWN, heterogeneous network is managed by different operators like WiMax, Wi-Fi, and UMTS etc. In this heterogeneous wireless network environment, always best connected (ABC) [1] which requires dynamic selection of the best network and access technologies when multiple options are available simultaneously.

Heterogeneous Handoff has four stages known as Handoff Initiation, Handoff Probe, Handoff Decision Making and Handoff implementation. Handoff Initiation occurs when Mobile Terminals (MT) Signal strength fluctuates and deteriorates. And when it reaches down the threshold level, the MT decides to send Handoff request to its neighborhood Networks. This process is termed as Handoff Probe. Mobile nodes in proximity will respond with their quality criteria, MT which has better level of criteria will be considered for handoff process. Finally Handoff implementation is executed after selecting a successful network [2].

The typical scenario of Wi-Fi and WiMax as Wi-Fi with high bandwidth, low-cost and short coverage and WiMax with high-speed mobile, fixed internet access to the end users, it provides services for data, voice and video. Handover network has the two types, horizontal handover and vertical handover [3]. A vertical handoff is the process of changing the mobile connection between access points supporting different wireless technologies. Mean while, in a horizontal handoff the connection just moves from one base station to another within the same access network. The vertical handoff consists mainly in three phases: network discovery, handoff decision and handoff execution. Handoff decision making is done by implementation of simple Analytical Processing (SAW), Multiplicative Exponential Weighting (MEW), Grey Relational Analysis (GRA), Elimination and Choices Translating Reality (ELECTRE), Analytical Hierarchy Process (AHP), and Technique for Oder Performance by Similarity to Ideal Solution (TOPSIS) methods.

II. HANDOFF PROCESS

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 [4]. 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.

Handoff can be classified into horizontal (intra-system) and Vertical (inter-system) cases.

Horizontal handoff or intra-system handoff is a handoff that occurs between the APs or BSs of the same network technology. In other words, a horizontal handoff occurs between the homogeneous cells of a wireless access system. The switching between points of attachment or base stations, that belong to the different network technologies is called Vertical handoff and is required in heterogeneous network.

Vertical handoff or inter-system handoff is a handoff that occurs between the different points of attachment belonging to different network technologies. For example, the changeover of signal transmission from an IEEE 802.11g AP to the BS of an overlaid cellular network is a vertical handoff process[5].

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

A. System discovery phase

It is used to decide which mobile user discovers its neighbour network and exchanges information about Quality of Service (QOS) offered by these networks.

B. Handover Decision phase

This phase compares the neighbour network QOS and the mobile users QOS with this QOS decision maker makes the decision to which network the mobile user has to direct the connection.

C. Handoff Execution phase

This phase is responsible for establishing the connection and releases the connections and as well as the invocation of security service [3].

III. HANDOFF DECISION

In this section we will examine the handoff decision protocols used in various cellular systems.

A. Network Controlled Handoff (NCHO)

NCHO is used in first generation cellular systems such as Advanced Mobile Phone System (AMPS) where the mobile telephone switching office (MTSO) is responsible for overall handoff decision.

B. Mobile Assisted Handoff (MAHO)

In NCHO the load of the network is high since network handles the all process itself. In order to reduce the load of the network, MS is responsible for doing RSS measurements and send them periodically to BS in MAHO. Based on the received measurements, the BS or the mobile switching center (MSC) decides when to handoff. MAHO is used in Global System for Mobile Communications (GSM).

C. Mobile Controlled Handoff (MCHO)

MCHO extends the role of the MS by giving overall control to it. The MS and BS, both, make the necessary measurements and the BS sends them to the MS. Then, the MS decides when to handoff based on the information gained from the BS and itself. Digital European Cordless Telephone (DECT) is a sample cellular system using MCHO [5].

IV. DESIRABLE HANDOFF FEATURES

An efficient handoff algorithm can achieve many desirable features by trading off different operating characteristics. Some of the major desirable features of a handoff algorithm are described below:

Fast: A handoff algorithm should be fast so that the mobile device does not experience service degradation or interruption. Service degradation may be due to a continuous reduction in signal strength or an increase in co-channel interference (CCI).

Reliable: A handoff algorithm should be reliable. This means that the service should have good quality after handoff. Many factors help in determining the potential service quality of a candidate BS or AP.

Communication quality: The communication quality should be maximized through minimizing the number of handoffs. Excessive handoffs lead to heavy handoff processing loads and poor communication quality [8].

Traffic balancing: The handoff procedure should balance traffic in adjacent cells, thus eliminating the need for channel borrowing, simplifying cell planning and operation, and reducing the probability of new call blocking.

Interference prevention: A handoff algorithm should minimize global interference. Transmission of bare minimum power and maintenance of planned cellular borders can help achieve this goal.

Context-awareness: A handoff algorithm should be context-aware. The algorithm should adapt to its surroundings and acquire and utilize user, mobile terminal, and network information to improve QoS, connectivity and maintain a high level of user satisfaction.

Successful: Free channels and resources must be available at the target access network in order to make the handoff successful.

Number of Handoffs: The number of handoffs must be minimized. Excessive number of handoffs results in poor QoS and excessive processing overheads as well as power loss, which is a critical issue in MSs with limited battery power.

Multiple Criteria Handoffs: The target access network should be intelligently chosen based on multiple criteria.

V. MULTIPLE ATTRIBUTE DECISION MAKING (MADM) ALGORITHMS

The MADM algorithms that have been used for network ranking include is based on ELECTRE, AHP, PROMEETHI, SAW, MEW, GRA and TOPSIS however we apply it in a distributed manner. The first four algorithms rank networks based on their coefficients calculated by combining adjusted values of all the criteria. Thus, we place the computing processing in the visited networks rather than on the mobile terminal. MADM allows the mobile terminal to choose the best network towards which it will be connected [6].

A. Elimination and Choice Translating Reality (ELECTRE) algorithm:

To rank a set of alternatives, the ELECTRE method as outranking relation theory was used to analyze the data of a decision matrix. The Elimination and Choice Translating Reality (ELECTRE) method was the most extensively used outranking methods reflecting the decision maker's preferences in many fields. The ELECTRE I approach was then developed by a number of variants. We have ELECTRE II, III, V and many types. ELECTRE method reflects the dominance of relations among alternatives by outranking relations.

B. Analytic Hierarchy Process (AHP) algorithm:

The available data is broke up into a hierarchy of choices and criteria. Data is then synthesized to find comparative ranking of the available choices [9] [10]. It involves structuring various criteria into a hierarchy, evaluating the relative importance of criteria, finding alternative based on criteria and calculate overall ranking of the alternative based on criteria [11].

C. Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) algorithm

PROMETHEE method is proposed by Brans and it is based on ranking comparison relation between pair of alternative. First, it's compare rank of alternatives on each criteria. The PROMETHEE make the preferential function to relate the preference difference between set of alternative on each criterion [12][13].

D. Simple Additive Weighting (SAW) algorithm:

Simple Additive Weighting (SAW) which is also referred as weighted linear combination or scoring methods or weighted sum method is a simple and most often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria[7].

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

Where w_j represents the weight of the j^{th} criterion, r_{ij} represents the adjusted value of the j^{th} attribute of the i^{th} network.

***E. 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. The main difference is that in its place of addition usually arithmetical operation now there is development. As with all MADM methods, WPM is a fixed set of decision alternatives described in terms of a number of decision criteria. The vertical handover decision problem can be expressed as a matrix form and each row i corresponds to the candidate network I and each column j corresponds to the attributes.

$$A^*_{MEW} = max_i \prod_j rij^{wj} \text{ ------ } (2)$$

Where rij denotes attribute j of candidate network i, we denotes the weight of attributed j.

F. Grey Relational Analysis (GRA) algorithm:

This algorithm offering the measurement for quantification is suitable for performing dynamic course analysis. Calculate the difference series. the performance of all alternatives into a comparability sequence. This step is called grey relational generating. Calculate the maximum and minimum of the difference series

$$x_{ij} = \frac{y_{ij} - min\{y_{ij}, i=1...m\}}{max\{y_{ij}, i=1...m\} - min\{y_{ij}, i=1...m\}} \text{------------- } (3)$$

$$x_{ij} = \frac{max\{y_{ij}, i=1...m\} - y_{ij}}{max\{y_{ij}, i=1...m\} - min\{y_{ij}, i=1...m\}} \text{----------- } (4)$$

There are m alternatives and n attributes, the ith alternative can be expressed as where is the performance value of j attribute of alternative i.

G. Calculate the grey relational coefficient

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_{ij} + \xi\Delta_{max}} \text{ ------------------------ } (5)$$

In Eq. (5), $\gamma(x_{0j}, x_{ij})$ is the grey relational co-efficient between x_{0j} and x_{ij}.

$\Delta_{ij} = |x_{0j} - x_{ij}|$

Δ_{min} =Min {i =1…m, j=1…n},

$\Delta_{max} = Max\{i = 1 \ldots m, j = 1 \ldots n\}$,

ξ is the distinguishing co-efficient, ξ ∈[0,1]

H. Calculated the Grey Relational Grade

$$\beta(x_0, x_i) = \sum_{j=1}^{n} w_j\, \gamma(x_{0j}, x_{ij}) \text{ -------------- } (6)$$

In Eq. (6), $\beta(x_0, x_i)$ is the grey relational grade between X_0 and X_i. The level of correlation between reference sequence and comparability sequence has been represented. The weight has been given by w_j.

I. 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

$$r_{ij} = \frac{d_{ij}}{\sum_{i=1}^{n} d_{ij}^2} \text{----------------- } (7)$$

Where rij denotes the normalized performance rate and xij denotes attribute j of candidates. Construct the weighted normalized decision matrix.

$$v_{ij} = w_{ij} * r_{ij} \text{----------------- } (8)$$

Determine the positive ideal and negative ideal solutions.

J. Positive ideal solution:

$$A^* = \{v_1^*, \ldots v_n^*\} = \{(max_i v_{ij} | j \in J), (min_i v_{ij} | j \in J')\}$$

K. Negative ideal solution:

$$A^* = \{v_1', \ldots v_n'\} = \{(min_i v_{ij} | j \in J), (max_i v_{ij} | j \in J')\}$$

Calculate the separation measures for each alternative

The separation from the ideal alternative is

$$S_i^* = \sqrt{\sum_{i=1}^{m} (v_i^* - v_{ij})^2} \text{ --- } j = 1 \ldots\ldots m \text{-------------- } (9)$$

The separation from the negative ideal alternatives is

$$S_i^* = \sqrt{\sum_{i=1}^{m} (v_{ij} - v_i')^2} \text{ ----- } j = 1 \ldots\ldots m \text{--------- } (10)$$

Calculate the relative closeness to the ideal solution C_i^*

$$C_i^* = \frac{S_j'}{S_j^* + S_j'} \text{ --------- } (11)$$

CONCLUSION

We are considering the vertical handoff process, handoff decision and handoff classicification. In this paper present the brief explain the MADM methods such as ELECTRE, AHP, PROMEETHI, SAW, MEW, GRA and TOPSIS methods. Vertical handoff decision making algorithm for selecting best network in NGWN. Theoretical explanation between four vertical handoff decision algorithms such as SAW, MEW, GRA and TOPSIS methods. We proposed to do these MADM algorithms in a Vertical handoff algorithm for heterogeneous wireless to recover handoff delay, jitter, and data rate, etc.

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