I J C T A, 9(11) 2016, pp. 5111-5118

VERTICAL HANDOFF DECISION MAKING ALGORITHMS-AN OVERVIEW

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Abstract: Wireless communication is possible due to various technologies, but with increase in number of users it is becoming challengeable to provide a dedicated access point all over the area. So for having seamless communication handoff is required between similar and different technologies. This transferring is established on the open accesses, QoS restraints, operator strategies, user likings and existing system capability and consumption. This paper grants an overview of handoff types, handoff process, and sorting of vertical handoff, parameters requisite.

Key Words: Handoff, Vertical, RSS, GRA, SAW, TOPSIS, AHP.

1. INTRODUCTION

Handover denotes to a procedure of transferring an on-going call from one base station to other base station. The process of handoff should takes place in a way that quality of service should not degrade. Handoff can be made in terms of time slots or frequency bands. It can also be grouping of time division multiple access and frequency division multiple access. It is essential to have a decent decision making algorithm to select the best network for a mobile terminal while moving from one station to other station which decides the best network for a exact application that the user wants based on QoS parameter[1].Based on the speed of a mobile node, an improved network selection scheme is presented. The MN performs handoff to a specific network, if the speed of a mobile node is greater than any of the threshold. To select the best Point of attachment of the selected network GRA is used[2].To select the best network from the available visitor networks for the continuous connection by the mobile terminal, weighted product model and simple additive weighting method are used. To reduce the processing delay and a trusted handoff decision, the observation of schemes is done in heterogeneous wireless network[3].The switching of on-going connections from one radio contact network to another is based on the user preferences, QoS and utilization and available system capacity.

To address the VHO problem, a decision maintenance system is established. To the difficult of VHO, this system associations fuzzy logic and TOPSIS [4].To satisfy the demands of network's traffic capacity and data rate, heterogeneous network concept was introduced which consist of various networks with several radio access technologies. The single criteria received signal strength is used to accomplish the vertical handoff. There can be service interruption, unbalanced network load and inefficient handoff due to single criteria vertical handoff [5].Our main aim is to analyse how handoff takes place in between two WLAN, WiMAX and UMTS networks. To

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calculate the variance of parameters such as bandwidth, packet loss, delay and jitter for several networks, a variance based algorithm is used to take vertical handoff decision and the network having most of the parameters with minimum variance is selected [6].

To fulfil different types of user service level contracts and to enable the delivery of high quality services, a multi criteria access network selection algorithm is applied. To obtain the final access network ranking, TOPSIS is used and to determine weights of the criteria AHP technique is used [7]. The vertical handoff decision may depend on the bandwidth available for each wireless access network, cost for accessing network, the power usage requirements, user preference, Quality of Service (QoS), and security. Hence vertical handoff decision may be solved using multi attribute decision making (MADM). Multi attribute decision making (MADM) problems involve evaluating a finite number of alternatives with multiple, attributes [8].

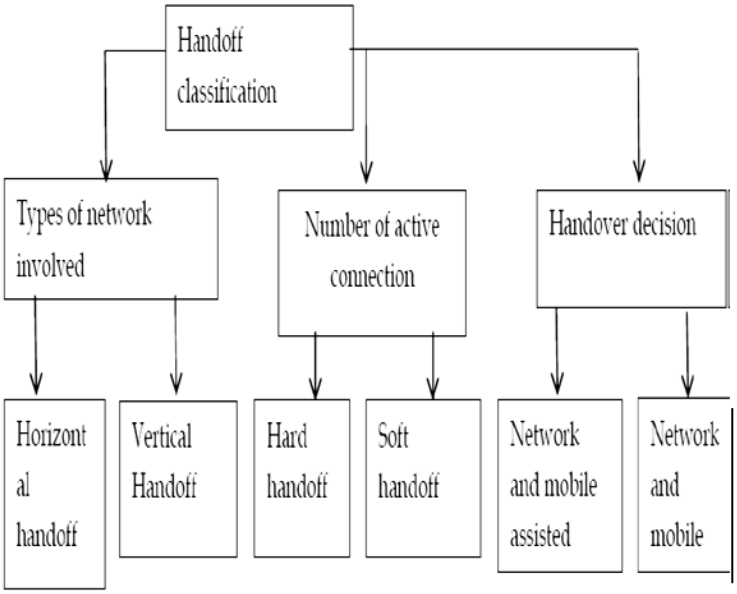

Figure1. Handoff types

1. **Horizontal and vertical handoff:** Vertical Handoff is said to be taken when it is performed between different wireless access technologies. e.g. handoff is in between access point of Wimax and BS of WLAN,while Horizontal handoff is performed in between two neighbouring cells of same homogenous network. e.g. handoff between two WiMAX cells. Vertical handoff includes networks with different bandwidth, operating frequencies and modulation technique, so it is more complicated than horizontal handoff.

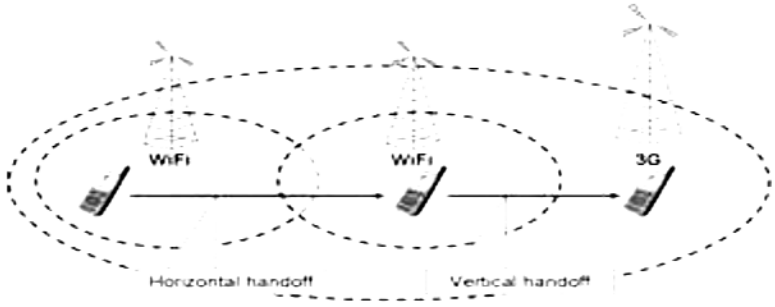

Figure 2. Horizontal and Vertical Handoff [1]

2. **Hard handover and Soft handover**: Hard handover is based on the principle of Break−Before−Make (BBM) which means that an MN can be associated to one BS at a time. In

other words, the MN can be connected to the new link only after previous link is broken. The service is disrupted for a finite duration of time in case of hard handover. While in case of soft handover or make−before−break handover, the MN is capable of communicating with multiple access networks simultaneously. The connection to new link is established before the old connection is released thus services are not interrupted in case of soft handover.

3. **Network and mobile controlled handoff:** In network controlled handoff, network has primary control over the handoff process, it is centralized handoff. In this to minimize the handoff duration a bridge is made between old and new base stations. Due to delay in this, it cannot be used for highly changing environment and large number of users. While in mobile controlled handoff mobile has control over the handoff process in case of mobile controlled algorithm. In this mobile from all the surrounding base station keeps measuring the received signal strength. When a certain threshold level reached i.e. signal strength received from new base station is greater than previous base station, then handoff should be considered to new base station.
4. **Network and mobile assisted handoff:** When the handoff is performed by mobile with the assistance of network, then the handoff is called network assisted handoff but when network execute handoff by extracting information from mobile it is called mobile assisted handoff and in this decision is taken by MSC. In this mobile measures the received signal strength, bit error rate of different channels and the handoff is made to best suitable base station.

3. HANDOFF PROCESS

There are three phases involved in handoff process as described below[1]:

1. **Handoff initiation phase:** To initiate the handoff process, the first step of it is to estimate the handoff requirement. The initiation is suggested only after verifying the need of a handover. Depending upon system requirements, handoff may be network initiated or mobile initiated. Whenever there is degradation in radio link quality dignified in terms of received signal strength, then mobile node will initiate the handoff while for resource management and maintenance reasons network will initiate the handoff. The handoff initiation was based on RSS traditionally. While in heterogeneous networks RSS is not sufficient parameter for handoff as mobile has to move in different networks having different parameters like cost, bandwidth. The decision about time to have a handover trigger is also taken at this stage.
2. **Handoff decision phase:** In this phase the decision about selection of the target is made to which the MN will be transferred. At this level, measurements on neighbouring radio transmitters are taken and last network policy information is also collected. By taken into account the measurement of single or multiple parameters, the best network can be selected. The existing network selection schemes are network− centric, user−centric and collaborative method. To take decision about the access network selection for its benefit the network centric approach is used, whereas to select an access network to enhance performance of user without considering load balancing or the benefit of other users, the user-centric approach is used. While the benefits of both user-centric and network-centric approach are taken into account the collaborative method. Based on the score found for all probable alternatives the most proper choice is selected by using Multi-Attribute Decision Making algorithms fall into categories of user-centric and collaborative method. Several MADM techniques such as Multiplicative Exponent Weighting (MEW), Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) and Grey Relational Analysis (GRA) are designed in demand to choice an optimal target network which would confirm the best probable services agreeing to the demands of the user at any time. The factors, that can effect a

decision, are allocated different significances which are converted into weights by weight assignment strategies such as Analytic Hierarchy Process (AHP).

3. **Handoff execution phase:** To perform handoff execution, handoff requirement should be achieved and target network should be achieved. Handoff process is achieved by making new links between Target base station and mobile node, at this stage. Here from previous access network to new access network, the routing and other related information is transferred. The MN is disconnected from previous access network and attached to new access network. The order of disconnect and attach events depends upon the type of handover (soft and hard handover). The re−routing of connections, acquisition of a new Care of Address (nCoA) and the registration procedure in Mobile Internet Protocol (MIP) are provided in this segment[10].

4/ HANDOFF CRITERIA

Each network have following important parameters, those are the basis of handover decision:

1. **Received signal strength(RSS):**Link quality can be measured according to the received signal strength at the mobile node from the different base station. RSS is taken as main criteria for handoff decision by the existing handoff algorithms. As the distance between mobile node and base station increases, the RSS decreases. So the path losses are directly proportional to the distance[1].
2. **Quality of Services:** Throughput, jitter, bit error rate and packet loss rate measures the QoS. Type of application such as voice, data and streaming varies the requirements of QoS. To guarantee successful delivery of packets, the packet loss should be minimized. In multimedia applications like video screaming, main feature is data rate. The time required for packets to reach from source to destination address is called end to end delay. In some delay sensitive applications, the variation in delay due to multipath is not tolerable.
3. **Available bandwidth:** Another important criterion to be considered in handover decision is a measure of available network i.e. bandwidth. The type of the service and demand of users varies the requirement for bandwidth[11].
4. **Energy efficiency:** While deciding for handoff, the energy efficiency is also considered as handoff criteria. The more energy efficient networks are required when various applications run simultaneously.
5. **Monetary cost:** The different charging policies varies the cost of different networks. While making network selection the cost of network is also taken into account[1].
6. **Security:** The most significant role is played by the security i.e. provided by the access network while taking the handover decision. Security is most desired in military applications which are providing confidentiality of the transmitted data.
7. **Number of active users:** To avoid network congestion, the system controller balances the load on co-existing networks. So it is also important criteria in handoff decision.

5. VERTICAL HANDOFF DECISION MAKING ALGORITHMS

An M×N decision matrix expressed the MADM decision problem, where x_{ij} represent the j^{th} attribute of the i^{th} network. To rank alternatives scoring methods are used by the MADM methods. By taking into account the involvement from each parameter, score is calculated. To deal with different units, standardization of the parameters is required before the calculation of score.

1. **SAW (Simple additive weighting):** SAW is also known as weighted sum method or linear combination and it is most widely used multi attribute decision making algorithm because it is very simple method. The weighted average is the basis of this method. The weighted sum of all the attribute values determines the overall candidate score. The normalized criteria value for each alternative is multiplied with the weights associated with the criteria. e.g. For each network if there are M network and N number of parameters, then by adding the contributions from each attribute r_{ij} and by multiplying the importance weight[3].

   The method requires identification of objectives and alternatives, purpose of sub-objective weights, additive combination of weighted partial preference values, sensitive analysis. Only in purely qualitative attributes, it uses direct rating on the standardised scales. To match the standardized scale, score are calculated by normalized values for numerical attributes[8]. For all alternatives, SAW requires a comparable scale, which is obtained by r_{ij} for benefit Eq.(1)and worst criteria Eq.(2),

$$V_{ij}=\frac{x_{ij}}{x_j^{max}} \tag{1}$$

$$V_{ij} =\frac{x_j^{min}}{x_j} \tag{2}$$

2. **GRA(Grey relational analysis):**The problems between multiple factors and variables with complicated inter relationships can be solved by using GRA (Grey relational analysis).Grey lies between black and white information which means it is also suitable for model where the information is incomplete. i.e. It can provide solution for problems with poor information. To the uncertainty, multi input and discrete data problem GRA provides an efficient solution. By combining the entire range of performance attribute values for every alternative into one single value, GRA solves MADM problems. So the original problem is reduced to a single attribute decision making problem[8].

   GRA calculate the similarities between the ideal network and each candidate network. The network which is most similar to the ideal network will be selected. The similarity between the candidate network and ideal network will be calculated with the help of GRC i.e. Grey Relational coefficient. GRC of each network is calculated and to deal with benefit and cost metrics a normalization process is required. By building grey relationship with a positive ideal network, the ranking of GRA is performed [6].

3. **TOPSIS(Technique for order preference by similarity to ideal solution):**The technique for order preference by similarity to ideal solution has various advantages over other multi criteria methods[4]. It is very much simple technique and very much efficient in computation and also it can measure the relative performance of each alternative. TOPSIS can make decision on the basis of one subjective input, weightage, to calculate the decision. Compared to other multi criteria decision making methods, TOPSIS provides higher throughput and lower packet loss[6].

   The ideal solution is calculated in this algorithm. The ideal solution will have shortest distance to the selected candidate network while worst case solution will have longest distance from the selected candidate network[7]. The ideal solution provides a hypothetical solution in each parameter with the best values while the worst case solution is opposite. By using best values for each metric, the ideal solution is obtained.

4. **AHP(Analytic hierarchy process):**By dividing complicated problems into a hierarchy of decision factors which are simple and easy to analyse with goal of making decision about them. The vertical handoff decision assigns a weight value to each of them using AHP decomposes.

The decision is decomposed into following steps to a make a decision in an organized way to generate priorities of the target network[8]:

(i) Determine the kind of knowledge sought and define the problem.

(ii) Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad viewpoint, through the intermediate levels to the lowest level.

(iii) Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

(iv) Use the priorities obtained from the comparisons to weight the priorities in the level immediately below. This is done for every element. Then for each element in the level below add its weighted values and obtain its overall or global priority.

5. **WPM(Weighted product model):** The weighted product model is also called as multiplicative exponent weighting and it is same as weighted sum model. Like another MADM methods it is not using addition mathematical operation while it is using multiplication operation. WPM is a finite set of decision alternatives as with all MADM methods[3], in terms of several decision criteria. The vertical handoff decision problem can be represented as a matrix form and each row i corresponds to the candidate network I and each column j corresponds to the attributes[6]

$$V(A_i)=\prod_{j=1}^{n} x_{ij}^{w_j} \quad (3)$$

Where x_{ij} denotes attribute j of candidate network i,w_i denotes the weight of attributed j.

Table 1 Outline Table of Vertical Handoff Decision Making Algorithms

Name	*Method*	*Parameters Used*	*Advantages*	*Disadvantages*
SAW	MADM	Bandwidth, delay, jitter, packet loss	Trusted hand off and reduced processing delay	Minimum number of parameters are considered
GRA	MADM	Bandwidth, jitter, delay, cost	Procession delay and reduces T-DVHD	Handoff dropping rate is high
TOPSIS	MADM	SINR, data rate, bandwidth, cost	Excellent performance against requirement of traffic and user	QoS are parameters are not considered
AHP	MADM	Bandwidth, delay, jitter, packet loss, cost, security	Reduces computational overhead and handoff latency	RSS<threshold value is not considered
WPM/MEW	MADM	Bandwidth, jitter, delay, cost	Trusted handoff and reduce processing delay	Minimum number of parameters are considered

6. CONCLUSION

Handoff is required to achieve seamless services throughout different network technologies. Handoff is the procedure where varying the channels like frequency, time slot, spreading codes or grouping of them, are related with the current connection during a call. Several vertical handoff decision algorithms have been studied in literature. On the basis of various factors handoff is of many types those are explained above. This paper grants a broad review of vertical handover decision schemes. Today's warm research area in wireless network is to find the best vertical handoff decision algorithm which meets the necessities of both user and network sources.

On the basis of given parameters algorithms take decision of mobile node should handoff to which network. Further, we can compare self-learning algorithm with traditional handoff decision algorithms.

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