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A Comparative Analysis of Vertical Handover Decision Process Algorithms for Next Generation Heterogeneous Wireless Networks

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Abstract— Increasing consumer demand for access to services anywhere and anytime is driving a hastened technological progression towards the integration of a variety of wireless access technologies. Therefore one of the chief interest points of Next Generation Wireless Networks (NGWNs), refers to the capability to support wireless network access equipments to guarantee a high rate of services between dissimilar wireless networks. To answer these problems it is essential to have decision algorithms to decide for every user of mobile terminal, which is the most excellent network at some point, for a service or a precise application that the user needs. Therefore to make these things, many algorithms use the vertical handoff technique. A series of algorithms based on vertical handoff technique with a categorization of the different existing vertical handoff decision strategies, which tries to resolve these issues of wireless network selection at a specified time for a specific application of an user has been discussed in this paper. Also few parameters that are to be considered during vertical handover have been discussed briefly.

Keywords— Handoff, horizontal handover (HHO), vertical handover (VHO), WIMAX, WiFi, quality of service (QoS), heterogeneous networks, parameters.

I. INTRODUCTION

NGWN mobile terminals (MT) are outfitted with multiple interfaces and can access a broad range of applications provided by multiple wireless networks in an Always Best Connected (ABC) mode. To access the communication services anytime, anywhere with finest Quality of Service (QoS) at a bare minimum price, the most excellent solution is the heterogeneous wireless communication system. Numerous wireless networks have been evolved recently. Each network has been developed for definite purpose with different features to guarantee that users equipped with multimode mobile terminals (MTs) in the next generation wireless network (NGWN) environment will experience an excellent seamless mobility [3], enjoy good seamless communications and ubiquitous access to applications in an always best connected (ABC) mode that utilizes the most efficient combination of the existing access systems. Seamless communication involves the capability of the MT to effectively or simultaneously attach to different points of attachment in NGWN infrastructure.

Heterogeneous wireless networks has dissimilar access technologies, overlapping and coverage, network architecture, protocols for transport, routing, mobility management [6, 7]. Also different operator recommends different service demands from mobile users (voice, video, multimedia, text, etc.) in the current market. Because of these disparities, when the mobile user moves there is a must to handover the communication channel from one network to another by considering its user requirements. Channel handover between two diverse networks is attained by vertical handoff. Considering the heterogeneous networks, the basic and foremost functionality of handoff initiation and decision phases are quite different, but in homogeneous networks, the functionalities of handoff initiation and decision phases are both pooled together into a single phase called handoff initiation phase.

In case of homogeneous networks, the handoff is amid different cells of the same wireless technology, there is nothing to be mentioned as "selecting the best network". In case of the homogeneous networks, it is generally adequate for the received signal strength value to decline below a definite threshold value to quick off horizontal handoff. But in heterogeneous networks, the handoff decision phase cannot depend only on received signal strength, but dissimilar characteristics of the network like bandwidth, coverage, latency, power consumption and cost etc., should also be taken into account.

Counting on the user demands, the mobile terminal features and the network conditions, most excellent network will be selected for vertical handoff process. During handover there is a need to choose the best network. Thus, Vertical Handoff Decision Making is an important research issue to be accounted. The vertical handoff process involves three main phases: the system discovery, the vertical handoff decision and the vertical handoff execution. In the first phase, the system discovery phase, the mobile terminal (MT) decides which networks could be used. These networks make advertisement on the supported data rates and the QoS parameters. As the users are mobile, this phase might be invoked periodically. During vertical handoff decision phase, the MT decides whether the connections should need to be continued using the existing selected network or be switched to other network. The decision might depend on a variety of parameters including, type of the application, minimum bandwidth and delay required by the application, access cost, transmit power and the preferences of end users.

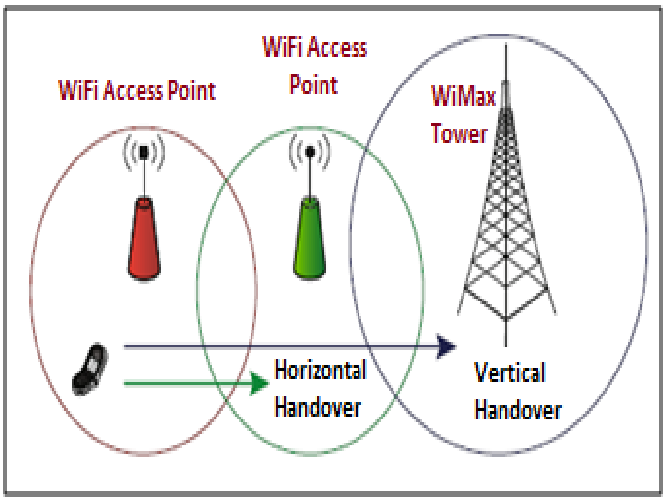

Figure 1: Horizontal and vertical handoff strategy

During vertical handoff execution phase, connections in the MT are re-routed from the existing network to the fresh network in a seamless manner [8]. This phase also comprises the authentication, authorization and transfer of user-context information. The illustration of vertical and horizontal handoff strategy is drafted in figure 1.

II. CLASSIFICATION OF VERTICAL HANDOFFS

A. Upward and Downward Handoffs

Vertical handoffs could be classified on the basis of the coverage of source and target networks as, upward and downward vertical handoffs. If the mobile switches from the network with little coverage to a network of wider coverage, it is referred as upward handoff. A downward handoff basically occurs in the direction reverse to the former one, i.e. from a network of greater coverage to a network of smaller coverage.

B. Hard and Soft handoffs

The vertical handoff process where a mobile node links with the new base station after getting disconnected from the existing base station is termed as hard handoff (break before make). In soft handover, a mobile node maintains the connection with the existing base station until its association with the new base station is completed. This process is also called as make before break, as the mobile node maintains simultaneous connections with both the base stations during the interim period. Soft handoffs are mainly preferred, as they eradicate the problem of disruption of service.

C. Imperative and Alternative handoffs

An imperative handoff happens due to weakening of signal strength from an access point. An alternative vertical handoff is initiated to offer the user with enhanced performance. For imperative handoffs, it is adequate to consider signal strength received from the base station, where as for alternative handoffs numerous other network parameters such as bandwidth and the cost of network are to be accounted in addition to the parameters such as quality of service demanded by the application and the user preference.

D. Mobile Controlled and Network Controlled handoffs

Vertical handoffs can additionally be classified based on who controls the handoff decision. Mobile Controlled Handoff (MCHO) is the handoff, if the mobile node controls the handoff decision. In Network Controlled Handoff (NCHO), the networks control the handoff decision. The handoff decision control is shared by the network and mobile in case of Mobile Controlled Network Assisted (MCNA) and Network Controlled Mobile Assisted Handoffs (NCMA). MCNA handoffs are probably suitable, as only mobile nodes have the understanding about the network interfaces they are equipped with and the user preferences can also be taken into consideration. A summary of classifications of VHO techniques is shown in figure 2

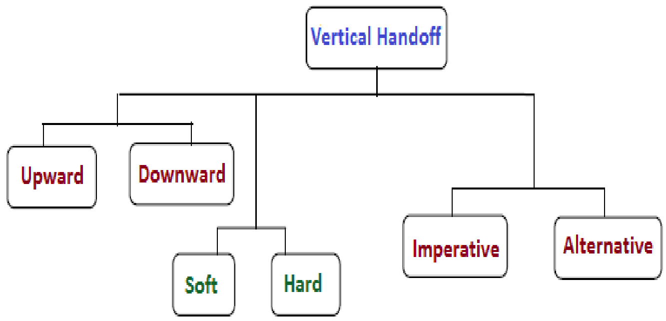

Figure 2: Classification summary of Vertical Handoffs

III. VERTICAL HANDOFF PARAMETERS

The decision for vertical handoff depends on various parameters like bandwidth, received signal strength (RSS), signal to inference ratio (SIR), cost, latency, security, velocity, battery power and QoS. To design a Vertical Handoff (VHO) mechanism for next generation wireless networks, it is mainly essential to have a clear idea over the existing VHO mechanisms [9, 10].

A. Available Bandwidth

Bandwidth is a measure of the width of a range of frequencies (data rate supported by a network connection or interface). It describes how much data could be sent over a specified connection in a definite amount of time. To provide seamless handoff for QoS in wireless environment, it is necessary to manage bandwidth requirement of a mobile node during mobility. Bandwidth is generally referred as the link capacity in a particular network. Higher bandwidth ensures lesser call dropping and call blocking probabilities. Bandwidth handling must be an integral part of any handoff techniques.

B. Speed

It is the speed at which the mobile terminal is moving on. In vertical handoff algorithms, the speed factor has vital decisions binding effect than horizontal handoff decision algorithms. When the users travel at very high speed, soon after a short period of time the user will have to go back to the initial network, as it gets out from underlying network host.

C. Received Signal Strength (RSS)

RSS is the most widely used parameter, as it is particularly easy to measure and is directly related to the service quality. Most of the existing horizontal handover algorithms use RSS as the main decision criterion. RSS is a vital criterion for VHD algorithms as well, but it is not completely enough for a decision process. There is an intimate relationship between the RSS readings and the distance from the mobile terminal to its point of attachment.

D. Power Consumption

The wireless devices operating on battery needs to lessen the power consumption. Switching from one network to another network with less power consumption can provide an extended usage time. The power constraint becomes a critical issue especially if the hand held device uses a low-powered battery. In such situations, it is preferably transferred to an attachment point, this will probably extend the battery life. The increase in the number of users generally leads to congestion, and in turn even the nearest AP or BS starts consuming more power.

E. Throughput

Network throughput refers to the average successful data delivery over a specific communications link. Network throughput is generally measured in bits per second (bps). Maximum network throughput equals the TCP window size divided by the round-trip time of communication. As network throughput is considered in dynamic metrics for making decision in VHO, it is considered to be an essential requirement for vertical handoff.

F. Network Load

Network load is to be essentially considered during effective handoff. It is vital to balance the network load, in order to avoid deterioration in QoS. The alterations in the loads among cells will reduce the traffic-carrying capacity. To provide a good-quality communication service for mobile subscribers and to augment a high traffic-carrying capacity, in the midst of variations in traffic, network load must be carefully considered.

G. User Preferences

When handover occurs, users have more preference for heterogeneous networks according to their performance criteria. The user preferences should be preferred networks, user application requirements (real time or non-real time), service types (voice, data or video) and QoS (set of technologies for managing network traffic in a cost effective manner). The user preferences can also be considered for VHO in next generation wireless networks [4].

H. Cost

A multi-criteria algorithm for handoff should also consider the network cost factor as a valuable criterion. The cost is to be minimized during VHO in all the heterogeneous wireless networks. For different networks, there could be different charging policies, hence the cost of a network service should be considered in making handover decision [4]. The new call arrival rates and handoff call arrival rates could be analyzed using the cost function. Next generation heterogeneous networks combine their respective advantages on coverage, data rates and rendering a high QoS to mobile users. In such environments, multi-interface terminals should seamlessly switch from one network to another so as to obtain better performance or at least to maintain a continuous wireless connection. The cost function is calculated for every available access network and the network with the highest utility is chosen. Therefore, network selection cost is vital in handoff decisions. Dissimilar weights are assigned to different input metrics in accordance with the network conditions.

IV. VERTICAL HANDOVER DECISION ALGORITHMS

In this section, a representative set of VHD algorithms [2, 4] are discussed. These algorithms are essentially selected because they make a good representation of their VHD groups [1]. These algorithms are assigned into one of the four categories. Some algorithms use more than one VHD criteria, in such cases, only the foremost criterion is considered.

A. SAW and TOPSIS

The vertical handoff decision is devised as a fuzzy MADM (Multiple Attribute Decision Making) problem [11]. Fuzzy logic is used to symbolize the imprecise information of some of the attributes and user preferences. For example, in fuzzy logic, the time can be represented as (short, long and very long). The fuzzy MADM method consists of two main steps. The first step is to convert the fuzzy data to a real number. The second one is to use classical MADM methods to decide the ranking order of the candidate networks. Two classical MADM methods are available: SAW (Simple Additive Weighting) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). In SAW, the overall score of a candidate network is determined by the weighted sum of all the attributes. The score of each candidate network *i* is obtained by adding the normalized contributions from every metric r_{ij} multiplied by the importance weight assigned w_j of metric *j*. The selected network $A*_{SAW}$ is given by,

$$A^*_{SAW} = \arg\max_{i \in M} \sum_{j=1}^{N} w_j r_{ij} \tag{1}$$

where *N* is the number of parameters and *M* denotes the number of candidate networks. In TOPSIS, the selected candidate network is the one which is closest to the ideal solution (and farthest from the worst case solution). The perfect solution is obtained by using the best values for every metric. Let c_i* denote the relative closeness (similarity) of the candidate network *i* to the ideal solution. The selected network $A*_{TOP}$ is expressed as,

$$A^*_{TOP} = \arg\max_{i \in M} c_i^* \tag{2}$$

B. GRA

The network selected is on the basis of Analytic Hierarchy Process (AHP) and Grey Relational Analysis (GRA) [12]. AHP crumble the network selection problem into several sub-problems and assigns a weight value for every sub-problem. It is then used to rank the candidate networks and selects the best one with the highest ranking. The ranking of GRA is performed by building up grey relationships with a positive ideal network. A normalization process to deal with benefit and cost metrics is essential and the Grey Relational Coefficient (GRC) of each network is then calculated. The GRC is the score used to explain the similarity between each candidate network and ideal network. The selected network is the one which has the highest similarity to the ideal network. The selected network A^*_{GRA} is expressed as,

$$A^*_{GRA} = \arg\max_{i \in M} \Gamma_{0,i} \tag{3}$$

C. MEW

The Multiplicative Exponent Weighting (MEW) is a different MADM scoring method [13]. The vertical handoff decision problem can be expressed here by a matrix form, where each row *i* corresponds to candidate network *i* and each column *j* corresponds to one of the attribute (e.g., bandwidth, delay). The score S_i of network *i* is generally determined by the weighted product of these attributes (metrics), which could be understood from equation 4 below.

$$S_i = \prod_{j=1}^{N} x_{ij}^{w_j} \tag{4}$$

where x_{ij} denotes attribute *j* of candidate network *i*, w_j denotes the weight of attribute *j*. It must be clearly noted that, in equation (4), w_j is the positive power for benefit metrics x_{ij}^{wj}, and the negative power for cost metrics x_{ij}^{-wj}. As the score of a network obtained by MEW does not have the upper bound, it is convenient to evaluate each network with the score of the positive ideal network A^{**}. Hence it was found that,

$$\sum_{j=1}^{N} w_j = 1 \tag{5}$$

This network is defined as the network with best values in every metric. For the benefit metric, the best value is the largest attribute. For cost metric, the best value is the lowest attribute. The value ratio R_i between the network *i* and the positive ideal is evaluated by,

$$R_i = \frac{\prod_{j=1}^{N} x_{ij}^{w_j}}{\prod_{j=1}^{N} (x_{ij}^{**})^{wj}} \tag{6}$$

The selected network A^*_{MEW} is expressed finally as,

$$A^*_{MEW} = \arg\max_{i \in M} R_i \tag{7}$$

The weights w_j necessary for MEW and other vertical handoff decision algorithms are evaluated by using the eigenvector method. The weight values basically depend on the QoS requirements of the traffic classes.

D. RSS Based VHD Algorithms

In RSS based algorithms Received Signal Strength is the chief criteria [14]. Here comparison is done on the basis of RSS of the current point of attachment with the other to make handover decisions.

The algorithm is basically proposed for attaining handover between 3G networks and WLANs, by merging the RSS measurements either with an estimated lifetime metric or with available bandwidth of the WLAN candidate, with two scenarios. In the first scenario, when the mobile terminal moves from coverage area of a WLAN into a 3G network, a handover to the 3G network is initiated first. When RSS average of the WLAN connection comes below a predefined threshold and the estimated lifetime is less than or equal to the handover delay, the handover is again triggered. In the second scenario, when the mobile terminal moves towards a WLAN cell, handover to the WLAN is triggered if the average RSS measurements of the WLAN signal are quite larger than a threshold and available bandwidth of the WLAN meets the bandwidth requirements of the desired application. An algorithm has been proposed [8], between WLAN and 3G which is based on the assessment of the current RSS and a dynamic RSS threshold, the mobile terminal being connected to a WLAN AP. A travelling distance prediction based algorithm has been developed to reduce unnecessary handovers which is introduced in the above method. The algorithm [9] considers, the time a mobile terminal is expected to use within the cell. This methodology relies on the estimation of WLAN travelling time and the calculation of a time threshold. The handover to a WLAN is triggered if the WLAN coverage is available and the evaluated travelling time inside the WLAN cell is greater than the time threshold. The advantage of this method is: minimizes handover failures, reduces unnecessary handovers and connection breakdowns, however increased handover delay is introduced.

E. Bandwidth Based VHD Algorithms

In these types of algorithms the available bandwidth is the foremost criteria for handover. A QoS based algorithm has been proposed [10], which takes the residual bandwidth, user service requirements and the state of the mobile terminal into account, for deciding to handover from a WLAN to Wireless Wide Area Network (WWAN) or vice versa. If the mobile terminal is in idle state, handover to the chosen access network is performed; otherwise the handover decision is based on the type of user application. This technique is able to achieve the throughput, as the available bandwidth is considered as the major criteria for VHD.

To perk up the overall system throughput, an algorithm has been developed [11] between WLAN and Wideband Code Division Multiple Access (WCDMA), which considers the Signal to Interference and Noise Ratio (SINR). SINR based handovers can provide higher overall throughput than RSS based handovers, as the available throughput is directly proportional to the SINR and this algorithm results in a well balanced load between the WLAN and WCDMA networks. However, these algorithms introduce Ping-Pong effect. To decrease the unnecessary handovers, Wrong Decision Probability (WDP) prediction based algorithm [12] has been proposed. Here, the probability of unnecessary and missing handovers is combined and WDP is thereby calculated.

F. Cost Function Based VHD Algorithms

The basic thought of a cost function based vertical handoff decision algorithm, is to select a combination of networks and factors like RSS, network coverage area, bandwidth, reliability, security, power and mobility model, and define a cost function based on these factors to assess the performance of the target networks. The handoff decision is made accordingly. In multi-service based algorithm [13], every active application is prioritized and then the cost of each probable target network for the service with the highest priority is calculated.

This methodology is beneficial because of the use of cost function, percentage of user satisfied requests gets increased and the handover blocking probability is reduced. In the cost function based handover decision algorithms [14], the normalization and weights distribution methods are necessarily provided. A network quality factor is used to assess the performance of a handover target candidate. By this method, high system throughput and user satisfaction is greatly achieved. A weighted function based algorithm [15], delegates the VHD calculation to the visited network instead of mobile terminal. The network candidate with the greatest weight function is selected as the handover target. The benefits of this method are: the handover decision delay is reduced, low handover blocking rate and higher throughput.

G. Combination Algorithm

These algorithms merge various parameters in the handover decision, such as the ones used in cost function algorithms. These algorithms are built on the basis of artificial neural networks (ANN) [17] or fuzzy logic. The mobile device gathers the features of available wireless networks and then sends them to a middleware called vertical handover manager through the existing communication links. The vertical handover manager consists of three main components: the network handling manager, the feature collector and the ANN training/selector. A multi-layer feed forward ANN is used to establish the best handover target wireless network available to the mobile device, based on the preferences of the end user. A fuzzy logic based algorithm [18] has been developed, which handles handovers between WLAN and UMTS. Here in this method, a pre-decision unit is used. This algorithm is able to improve the performance by reducing number of unwanted handovers and avoiding Ping-Pong effect.

H. Computational Intelligence VHDAs

Few of handoff decision algorithms use computational intelligence techniques. Computational intelligence based handoff decision algorithms generally choose an access network for vertical handoff, by applying a computational intelligence technique, like Fuzzy Logic (FL). Fuzzy logic deals with uncertainness and is quite better to handle decision process issues. The advantage of such a representation is its capacity to analyze imprecise data such as the behavior of the RSS, the load or the BER.

It is generally combined to other decision methods to determine the best choice [19, 20], Fuzzy Multiple Attribute Decision Making (FMADM), Neural Networks (NNs), and Genetic Algorithm, to some of the vertical handoff decision criteria. Formulating the vertical handoff decision as a FMADM problem permits the use of fuzzy logic to deal with imprecise information that the decision attributes could include, as well as to combine multiple attributes. These handoff decision algorithms have very high efficiency, and improve users-satisfaction while engaging heterogeneous wireless networks [5]. However the main drawback is that, they have high implementation complexity.

V. CONCLUSION

Next Generation Wireless Networks (NGWNs) has a very good ability to support wireless network access equipments to ensure a high rate of services between dissimilar wireless networks. It is essential to have decision algorithms to decide for each user of the mobile terminal, which is the most viable network at some point, for a specific application that the user needs. Therefore to make these things to be practically attainable, different algorithms have been proposed for vertical handoff technique. In this paper, a comparative analysis of few vertical handover decision process algorithms for next generation heterogeneous wireless networks has been worked out towards the emerging standard. Also few parameters, that needs to be accounted before proceeding to vertical handover has been artistically illustrated in this literature, thereby guiding the network researchers with a comprehensive idea on user mobility and handovers, which is an integral parameter for mobile wireless communications. Also this article provides documentation on terminologies, concepts, classifications, popular algorithms and their functionalities.

REFERENCES

[1] Abubeker A Yussuf, Wan H Hassan, SinzobakwiraIssa, ”A review of VHD approaches in next generation wireless networks”, IEEE 2012.
[2] Xiaohuan Yan A, Ahmet Sekercioglu A, Sathya Narayanan B, ”A survey of vertical handover decision algorithms in fourth generation heterogeneous wireless networks”, Computer Networks, Science Direct, 2010.
[3] Mario Pink, Thomas Pietsch, Hartmut Koenig, ”Towards a seamless mobility solution for the real world: handover decision”, IEEE 2012.
[4] Dionysis Xenakis, Nikos Passas, Lazaros Merakos, Christos Verikoukis, ”Mobility management for femtocells in LTE-Advanced: key aspects and survey of handover decision algorithms”, IEEE Communications Surveys and Tutorials, IEEE 2013.
[5] Sandra Brigit Johnson, Saranya Nath P, Velmurugan T, ”An optimized algorithm for vertical handoff in heterogeneous wireless networks”, Conference on Information and Communication Technologies, IEEE2013.
[6] Mariem Zekri, Badii Jouaber, Djamal Zeghlache, ”A review on mobility management and vertical handover solutions over heterogeneous wireless networks”, Science Direct, Computer Communications, Volume 35, 2012.
[7] Farhan Siddiqui, SheraliZeadally, ”Mobility management across hybrid wireless networks: Trends and challenges”, Science Direct-Computer Communications, Volume 29, 2006.
[8] Fei Shi, Keqiu Li, YanmingShen, ”Seamless handoff scheme in Wi-Fi and WiMAX heterogeneous networks”, Science Direct-Future Generation Computer Systems, 2010.
[9] Shusmita Sharna, Manzur Murshed,M, ”Impact on vertical handoff decision algorithm by the network call admission control policy in heterogeneous wireless networks”, 23rd International Symposium on Personal Indoor and Mobile Radio Communications, IEEE 2012.
[10] Dhanaraj Cheelu, M RajasekharaBabu, P Venkata Krishna, “A study of vertical handoff decision strategies in heterogeneous wireless networks”, International Journal of Engineering and Technology, Volume 5, Number 3, 2013.
[11] Nilakshee Rajule, Bhavna Ambudkar, Dhande A P, ”Survey of vertical handover decision algorithms”, International Journal of Innovations in Engineering and Technology, February 2013.
[12] Saaty T L, “How to make a decision: the analytic hierarchy process”, European Journal of Operational Research, Volume 48, 1990.
[13] Abirami S, Sathya Priya, Murugan K, ”Improving TCP performance in wireless network during vertical handoff from WiFi to WiMAX”, IEEE – 2013.
[14] Safdar Rizvi, Asif Aziz, Saad N M, ”An Overview of vertical handoff decision policies for next generation wireless networks”, IEEE 2010.
[15] Dhand, Dhillon, “Handoff optimization for wireless and mobile networks using fuzzy logic”, International Journal of Computer Applications, Volume 63, 2013.
[16] Sarddar D, “Handoff latency minimization by using access point by GPS using selective scanning”, International Journal of Computer Applications Volume 45, 2012.
[17] Sepúlveda R, “WLAN cell handoff latency abatement using an FPGA fuzzy logic algorithm implementation”, Advances in Fuzzy Systems, Volume 10, 2012.
[18] Atayero A A, Luka M K, “Applications of soft computing in mobile and wireless communications”, International Journal of Computer Applications, Volume 45, 2012.
[19] Reddy, Krishna V, “Optimization of handoff method in wireless networks” Global Journal of Computer Science and Technology, Volume 11, 2011.
[20] Sarddar D, “Minimization of handoff latency by cell sectoring method using GPS”, International Journal of Computer Applications, Volume 25, Number 4, 2011.

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