ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 11, November 2016**

# Graph Theory Based Vertical Handoff Decision Model for Cognitive Radio Terminals

Dr. K. Radhika, G.Gayathri

Associate Professor, Dept. of I.T., Chaitanya Bharathi Institute of Technology, Gandipet, Hyderabad, India

M.Tech Student, Dept of I.T, Chaitanya Bharathi Institute of Technology, Gandipet, Hyderabad, India.

**ABSTRACT:** The aim of the next generation wireless network is seamless mobility with best quality of service (QoS). In future there could be several heterogeneous wireless networks available for which continuous connection will become a great challenge. Handoff plays an important role in heterogeneous wireless network. To achieve this, an efficient vertical handoff decision algorithm is required. There are many algorithms existing for Vertical Handoff Decision. In this paper, a vertical handoff decision based on graph theory and Analytical hierarchy process is proposed to select the optimum network from all the available networks. Further Principal Component Analysis (PCA) is used to identify the prominent parameters and the proposed method is applied on these parameters to verify the correctness of the decision. It is observed from the results that the execution time of the algorithm for PCA is reduced by 68% compared to the results of the pure Graph Theory method.

**KEYWORDS**: Wi-Fi, Wimax, UMTS, Bandwidth, Throughput, Network Priority Index.

## I. INTRODUCTION

The mobile communication has revolutionarized the way people communicate. The 1st Generation offered analog standard with basic voice service. The 2nd Generation offered digital standards with limited data service. The 3rd Generation offered multimedia and Internet. The 4th Generation was designed for High speed data services [1]. In future it is expected to provide multimedia and internet services anywhere anytime with seamless mobility and Good QoS. There are different wireless standards available today like satellite networks, Wide Area Network (WAN), Local Area Network (LAN), Personal Area Network (PAN), and Metropolitan Area Network (MAN). The deployment of various types of wireless network overlapping over one another in an overlaid arrangement is termed as Heterogeneous Wireless Network (HWNs) [2].

Handoff is defined as a process of transferring an ongoing call from one base station to another during an active communication without any interruption of service.

Vertical handoff decision process consists of three phases. They are Handoff triggering, Handoff decision, Handoff execution. Handoff triggering, is the first phase in which device decides when to perform handoff. Handoff decision, is the second phase in which the device decides to which network it must get connected after handoff is performed. Handoff execution, is the last phase in which the mobile node gets connected to a new base station, and packets intended for the mobile node must be rerouted for the new base station from the old base station.

There are many issues in integration of heterogeneous network in present scenario. They are multi-mode terminals, development of interworking architecture, mobility management, integrated billing and authentication schemes, new MAC and routing schemes. Mobility management is one of the key research issues among these.

Mobility management consists of two phases. They are location management and handoff management. Location management takes care of tracking and locating the mobile device. Handoff management controls the change of mobile node point of attachment from one base station to another in an active communication.

The rest of the paper is organized as follows Section 2, explains the previous work done and concepts related to present work, Section 3, explains the Vertical handoff decision using Graph Theory and PCA. Section 4, shows result analysis and Section 5 followed by conclusion and future Work.

## II. RELATED WORK

A number of algorithms have been designed for vertical handoff decision making. Few of them have been explained with their significance in this literature. Jyothi madaan et al.[3] have proposed a vertical handoff decision algorithm using Predicted Received signal strength and Dwell time. Battery power, network performance, and cost of service are the Parameters considered. Unnecessary handoffs are reduced by using this method, User preferences are not considered. Ms.Ashima et al. [4] have proposed an algorithm based on fuzzy logic quantitative decision algorithm with QoS fuzzy rule. Bandwidth, End-to-End Delay, Jitter, and Bit Error Rate (BER) are the parameters considered. Handoffs are reduced by using this method User preferences are not considered.

Nikhil Patel et al. [5] have proposed an algorithm using vertical handoff decision function. Bandwidth and Power consumption are the parameters considered. The algorithm maximizes the user satisfaction but Network parameters are not considered. Eshanta et al. have proposed an algorithm based on Received signal strength. RSS, Cost of service, Bandwidth, power consumption, Security are the parameters considered. This algorithms runs with less complexity but User preferences are not considered. The disadvantages in all the above algorithms have been overcome in the proposed method.

***Related Concepts***

QoS is the capability of a network to provide better service to selected network traffic over various underlying technologies like Frame Relay, ATM, IP and routed networks etc.

The various metrics to measure QoS are

1. Service Availability: The reliability of users' connection to the internet device.
2. Delay: The amount of time taken by a packet to travel through the network from one point to another.
3. Jitter: The variation in the delay encountered by similar packets following the same route through the network.
4. Throughput: The amount of data moved successfully from one point to another in a given period.
5. Packet loss rate: The rate, at which packets are dropped, lost or become corrupted while going through the network.
6. User Preferences: The user preference could depend upon the type of application (real-time, non real-time), service type (voice, data, video), Quality of service, preferred networks etc. other attributes such as network load, packet delay and bit error rate should be taken into account for a good vertical handoff decision (VHD) algorithm.

***Classification of Handoffs***

Handoffs are classified into different types. They are horizontal handoff and vertical handoff. Horizontal handoffs are again classified into intra cell and inter cell handoff. Vertical handoff is again classified into upward, downward, hard and soft handoff [6] .

If the mobile device moves from one base station to another of the same network is called as Horizontal handoff. If the mobile device moves from on base station to another, under the control of the same base station controller then it is termed as Intra System Handoff. If the mobile device moves from on base station to another, under the control of the different base station controller then it is termed as Inter System Handoff.

If the mobile device moves from one base station to another of different network is called Vertical handoff. If the mobile device moves from higher coverage to lower coverage area is termed as downward handoff. If the mobile device moves from lower coverage area to higher coverage area is termed as upward handoff.

If the mobile device connected to source channel is first broken before making connection with target channel is termed as hard handoff. If the mobile device connection is retained with the source channel before making connection to the target network is called as Soft handoff.

***Assumptions***

*Availability of Multi-mode Terminals:*

This proposed work assumes the existence of multi mode mobile terminals which are equipped with Media Independent Frame work and are able to communicate with multiple radio access technologies. These are capable of switching seamlessly between different interfaces during an active connection.

*The Integration Is Based On Overlaid Architecture:*

It is assumed that the integration of heterogeneous wireless networks is based on an overlaid architecture. According to this, the low coverage networks are overlapped by high coverage networks.

*Network Context Is Gathered Using IEEE 802.21 Framework:*

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

# International Journal of Innovative Research in Computer and Communication Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 11, November 2016**

The network context is assumed to be obtained by using the three components of IEEE 802.21 Media Independent frame work that is required to decide about the target network selection.

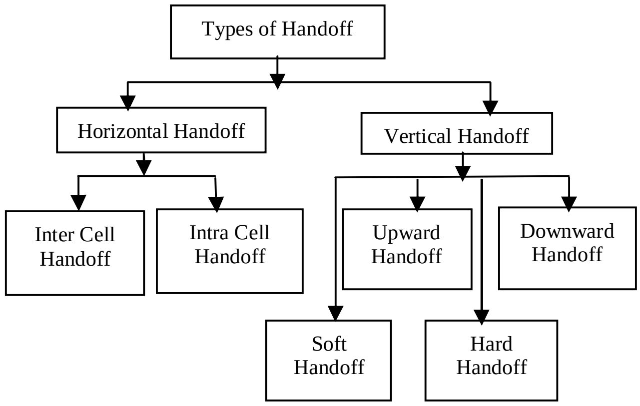


Fig.1 Classification of Handoff

## III. PROPOSED ALGORITHM

The Multi Criteria Decision Model (MCDM) methods which are used presently tend to be complex and less effective in dealing with the multi criteria assessment of alternative networks. The present work aims at developing a hybrid multi attribute evaluation model for assessment of alternative networks using graph theory and AHP method. The proposed approach has been employed to identify those attributes that influence the selection of alternative networks, and to select the most appropriate alternative network for a given application. Principal component analysis is applied to attributes to identify most prominent attributes.

Graph theory and matrix approach (GTMA) have been developed to model and analyze different engineering systems. GTMA helps in identifying different attributes and offers a better appraisal of the attributes and their interrelations. The same approach is used in our present work for assessment and selection of alternative networks for network application. AHP is an analytical tool that can be applied to multi criteria problem that involve large number of alternatives and it allows checking the consistency of relative importance judgment of the attributes. A methodology which combines both GTMA and AHP methods is proposed for evaluation and selection of alternative networks.

The optimal network selection in the vertical handoff is often transferred to be the multi-attribute decision making problem. The network selection may depend on various attributes such as bandwidth, delay, latency, access cost, and transmission power, current battery status of the mobile device and user preferences [7].

The optimal network selection will be more accurate, if the more attributes are selected. However, the complexity and computation cost will also be higher as the more attributes are selected. The analysis is made on relationship among the various attributes, and found they are dependent each other. Such as delay, latency etc, these attributes are interdependent, and some overlap exists among them. This factor seriously affects the accuracy of the network selection. Increasing the number of attributes, leads to higher complexity and computation cost. By using PCA the interdependent attributes are eliminated, by this computational cost and complexity can be reduced.

### *Identify Available Networks and Attributes*

Identify the available networks our device could scan or which are in the coverage area of the device like Wi-Fi, Wi-Max, UMTS. Next, identify the attributes which need to be considered. The selection of attributes depends on user choice and application requirements.

### *Normalization of Network Selection Attributes*

The alternative network selection attributes have performance measures expressed in different units. The attributes are normalized in order to transform their performance measures into a compatible measurement unit. The measures of network selection attributes for the options under consideration should preferably be obtained from available or specified or estimated data. For certain attributes (e.g. efficiency), higher measures are desirable for given

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2016

application. Such attributes are called benefit attributes. An attribute (e.g. fuel price) whose lower values are preferable for the given application is called cost attribute. The normalized values for benefit attributes are obtained using formulae shown below

$$\text{Benefit Attribute} = \frac{u_{bi}}{u_{bj}} \qquad \text{eq. (1)}$$

Where '*ubi*' is the measure of attribute for i-th alternative and '*ubj*' is measure of the attribute for the j-th alternative which has higher measure of the attribute among the considered alternatives. For cost attribute the normalized values are calculated by using the formula shown below:

$$\text{Cost attribute} = \frac{u_{cj}}{u_{ci}} \qquad \text{eq. (2)}$$

Where '*ucj*' is the measure of the attribute for j-th alternative having lower measure of the attribute among the considered alternatives, Where '*uci'* is the measure of attribute for i-th alternative.

In most of the decision making situations the attributes are expressed with objective as well as subjective data. As it is relatively difficult for the decision maker to provide exact quantitative values for the attributes, the evaluation data for the various subjective attributes are usually expressed in linguistic terms. Such uncertainties in human preferences can be efficiently addressed using fuzzy logic which deals with imprecise information. The linguistic information of the subjective attributes can be conveniently represented by crisp values using the conversion scale presented in Table 1 [8]. The subjective measures of the attributes are converted to objective values using the eleven point scale and then normalized as explained below.

***Principal Component Analysis***

Principal component analysis is used to identify the more prominent attributes from all the available attributes. The process used in finding prominent attributes using PCA is shown below [12].First consider the dataset for which Principal Component Analysis must be performed.

*Correlation Matrix:*

Correlation matrix is used to find the dependence between multiple variables at the same time. The correlation matrix is calculated by considering the covariance matrix.

$$cor_{i,j} = \frac{\text{cov}_{i,j}}{\sqrt{\text{cov}_{i,i} * \text{cov}_{j,j}}} \qquad \text{eq. (3)}$$

$cor_{i,j}$ = Correlation of matrix,

$\text{cov}_{i,j}$ = Covariance matrix

*Eigen values and Eigen Vectors:*

In data analysis, the eigenvectors of a covariance (or correlation matrix) are usually calculated. Eigenvectors are the set of basic functions that are the most efficient set to describe data variability. They are also the coordinate system that the covariance matrix becomes diagonal allowing the new variables referenced to this coordinate system to be uncorrelated. The Eigen value is a measure of the data variance explained by each of the new coordinate axis. They are used to reduce the dimension of large data sets by selecting only a few modes with significant Eigen values and to find new variables that are uncorrelated. Formulae used to find the Eigen values and Eigen vectors is shown below:

$|A-\lambda I|$ `

Where 'A' is the matrix for which Eigen values must be found. 'I' is the identity matrix and λ is the constant used.

By using this formula λ value is calculated which becomes the Eigen values. By substituting the λ values in the same formulae Eigen vectors are calculated [13].

*Scree Plot:*

A Scree Plot is a simple line segment plot that shows the fraction of total variance in the data as explained or represented by each Principal component (PC). The PCs are ordered, and by definition are therefore assigned a number label, by decreasing order of contribution to total variance. The PC with the largest fraction contribution is labeled with the label name from the preferences file. Such a plot when read left-to-right across the abscissa can often show a clear separation in fraction of total variance where the 'most important' components cease and the 'least important' components begin. The point of separation is often called the 'elbow'.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2016

A scree plot is drawn which displays the Eigen values associated with a component or factor in descending order versus the number of the component. Identify the PC above the elbow those are the important Principal Components.

**Table 1: Crisp values for subjective attributes [8]**

| Subjective Measure of Attributes | Crisp Values |
|---|---|
| Exceptionally Low | 0.045 |
| Extremely Low | 0.135 |
| Very Low | 0.255 |
| Low | 0.335 |
| Below Average | 0.410 |
| Average | 0.500 |
| Above Average | 0.590 |
| High | 0.665 |
| Very High | 0.745 |
| Extremely High | 0.865 |
| Exceptionally High | 0.955 |

*Product of Eigen vectors and Parameter values:*

The products of Eigen vector and parameter value are calculated. The resultant matrix after performing multiplication becomes the PCs. From scree plot the important PC are identified. From the resultant matrix Identify those PC and select the values which are far from Zero, if both positive and negative values are found in the product then select the positive and negative value which are far from Zero. Those become the most prominent attributes. After finding the prominent attributes, on those attributes Graph theory and Analytical Hierarchy Process is applied.

***Digraph Model***

An attribute represents the characteristic which enables the alternative network to be compared among them from a specific viewpoint. The digraph model presents a graphical representation of the alternative network selection attributes and their interrelationships. The digraph model consists of nodes and directed edges where, a node '*ni*' represents i-th network selection attribute and edge ('*eij'*) represents the relative importance of attribute 'i' over another attribute 'j'. The number of nodes N is same as the number of network selection attributes.

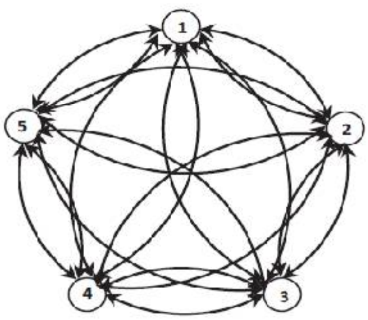


Fig. 2: Digraph model for network selection attribute

The relative importance of an attribute i over another attribute j is represented by an arrow drawn from node i to node j. Similarly, the arrow drawn from node j to node i represents the relative importance of attribute j over attribute i. A digraph model for five network selection attributes is illustrated in Fig.2. The nodes 1, 2, 3, 4 and 5 represents the alternative network selection attributes and the directed edges connecting the nodes represent the relative importance of one attribute over another.

***Matrix Model of Digraph***

As the number of network selection attributes and their interrelation increases, the digraph representation becomes complex and presents difficulty in its visual analysis. To overcome this difficulty, the digraph is converted to an equivalent matrix (Z) which stores the deterministic values of all the identified attributes and their interrelationships. The matrix Z, for the digraph model shown in equation (4).

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

**International Journal of Innovative Research in Computer and Communication Engineering**

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 11, November 2016**

$$Z = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{pmatrix} X1 & Y12 & Y13 & Y14 & Y15 \\ Y21 & X2 & Y23 & Y24 & Y25 \\ Y31 & Y32 & X3 & Y34 & Y35 \\ Y41 & Y42 & Y43 & X4 & Y45 \\ Y51 & Y52 & Y53 & Y54 & Y5 \end{pmatrix} \end{array} \quad \text{eq. (4)}$$

where the diagonal element *('xi')* is the performance measure of the i-th attribute represented by node *'ni'* and the non-diagonal element *'yij'* is the relative importance of the i-th attribute over the j-th attribute represented by the edge *'eij'*. The size of this matrix corresponds to the number of network selection attributes and considers all the attributes (*xi*) and their relative importance (*yij*). The matrix model is one-to-one representation of the diagraph and represents decision maker preferences and value judgments. The matrix model is easy to understand and can be processed by the computer in an efficient manner.

***Relative Importance among Network Selection Attributes***

The multi criteria assessment of alternative network involves attributes having certain degree of importance over one another. This relative importance among attributes can be expressed by a relative importance matrix using fundamental scale proposed by Saaty [9,10] in his AHP method. The numbers 1, 3, 5, 7, and 9 represents verbal judgments 'equal importance' 'moderate importance',' strong importance', 'very strong importance', and 'absolute importance'; while 2, 4, 6 and 8 are used for compromise between the previous values. A relative importance matrix is constructed by entering the values of relative importance assigned to the attributes. For N attributes, the pair wise comparison of attribute i with attribute j yields a square matrix of order N, where the relative importance of attribute i with respect to attribute j is represented by yij. An attribute compared with it is always assigned a value 1, so all the diagonal entries of the matrix are equal to 1. A relative importance matrix (Z1) for the attributes considered above is shown by expression below.

$$z1 = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{pmatrix} y11 & y12 & y13 & y14 & y15 \\ y21 & y22 & y23 & y24 & y25 \\ y31 & y32 & y33 & y34 & y35 \\ y41 & y42 & y43 & y44 & y45 \\ y51 & y52 & y53 & y54 & y55 \end{pmatrix} \end{array} \quad \text{eq. (5)}$$

**Table 2: Intensity of importance in Pair wise comparison [9,10]**

| Intensity of importance | Definition | Description |
|---|---|---|
| 1 | Equal importance | Two activities contribute equally to the objective. |
| 3 | Moderate importance of one over the other | Experience and judgments favor one activity over another |
| 5 | Essential or strong importance | Experience and judgments Strongly favor one activity over another |
| 7 | Very strong importance | An activity is strongly and its dominance is demonstrated in practice |
| 9 | Extreme importance | The evidence favoring one activity over another is of the highest possible order of affirmation |
| 2,4,6,8 | Intermediate values between the two adjacent judgment | When compromise is needed |
| Reciprocals | If Activity 'i' has one of the above possible numbers assigned when compared with activity 'j' then j has the reciprocal value when compared to i | |

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2016

The scaling is not necessary 1 to 9 but for qualitative data such as preference, ranking and subjective opinions, it is suggested to use scale 1 to 9.

Table 3: Number of comparisons [9]

| No.of Things | 1 | 2 | 3 | 4 | 5 | 6 | 7 | N |
|---|---|---|---|---|---|---|---|---|
| No.of Comparisons | 0 | 1 | 3 | 6 | 10 | 15 | 21 | n(n-1)/2 |

*Consistency Index and Consistency Ratio:*

Prof. Saaty proved that for consistent reciprocal matrix, the largest Eigen value is equal to the number of comparisons, or $\lambda \max = n$. Then he gave a measure of consistency, called Consistency Index as deviation or degree of consistency using the following formula

$$CI = \frac{\lambda_{\max} - n}{n-1} \qquad \text{eq. (6)}$$

Prof. Saaty proposed that this index used for comparing it with the appropriate one. The appropriate Consistency index is called Random Consistency Index ( $RI$ ).

Prof. Saaty randomly generated reciprocal matrix using scale1/9, 1/8,…, 1, …, 8, 9 (similar to the idea of Bootstrap) and get the random consistency index to see if it is about 10% or less. The average random consistency index of sample size 500 matrices is shown in the table below.

Table 4: Random Index (RI) values [9]

| **Attributes** | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|
| **RI** | 0.52 | 0.89 | 1.11 | 1.25 | 1.35 | 1.4 | 1.45 | 1.49 |

Then, he proposed what is called Consistency Ratio (CR), which is a comparison between Consistency Index and Random Consistency Index, or in formula

$$CR = \frac{CI}{RI} \qquad \text{eq. (7)}$$

If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment.

***Network Priority Index***

The Network priority index (NPI) represents the measure of performance of an alternative Network with respect to the Network selection attributes and is computed from matrix model Z using permanent function. A permanent is a standard matrix operation used in combinatorial mathematics, where it is used to characterize configurations of a system or the structure of a graph. The numerical value of permanent of matrix Z is called the NPI. The permanent is similar to the determinant of a matrix with all the determinant terms as positive terms. Moreover, no negative sign appears in the permanent function of a matrix and hence no information will be lost. A permanent function is a complete representation of the attributes of an alternative network selection problem and retains all possible information of the attributes and their interrelations [11].

The NPI of each alternative Network is computed by substituting the respective normalized performance measures (*xi*) of the network selection attributes and their relative importance (*yij*). In order to make the computation simple and fast, a computer program is developed in java language that evaluates the permanent function of a matrix. As the function contains only positive terms, higher values of *xi*'s and *yij's* will result in increased value of NPI and hence it is easy to compare the alternative networks on the basis of their NPI. The alternate Network with the highest NPI represents the most preferred option for the given application. The network priority index is calculated using permanent function. The permanent function for the n by n matrix is shown below:

$$per\ (A) E_1 ...... E_n = \prod_i (\sum_j a_{ij} E_j) \qquad \text{eq. (8)}$$

## IV. SIMULATION RESULTS

The optimum network selection will be more accurate if more attributes are selected. However, the complexity and computation cost will also be higher as the more attributes are selected. This factor seriously affects the accuracy of

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2016

the network selection. With increasing of the number of attributes, the complexity becomes higher and computation cost also increases. X-axis=Data sets, Y-axis = No.of attributes

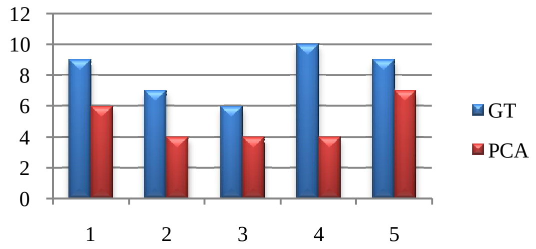


Fig. 3 : Attributes reduced after using PCA

Principal component analysis (PCA) is used to eliminate the interaction among the various attributes and make the less integrated independent attributes to replace the original attributes. The 5 data sets are taken and PCA is applied and is compared with Graph Theory. The graph below shows the paramters reduced after using PCA compared with Graph Theory

***Computational complexity***

The computational complexity for both the methods have been calculated and observed that the computational time for Graph theory is very high compared to PCA.This is plotted in the graph which is shown below. From the graph it is observed that the time taken for calculating PCA is very less comapred to Graph Theory. So, by using PCA Execution time is reduced.

## V. CONCLUSION AND FUTURE WORK

The rapid growth in the field of wireless communications has led to the development of several wireless networks and standards. The mobile handsets with sophisticated features are enabling the mobile users to perform lot of operations ranging from simple voice calls to real-time video streaming through wireless internet. The Network Selection problem which is one of the crucial design issues to provide seamless mobility in cognitive radio environments. X-axis : Data sets taken , Y-axis: Time taken in minutes

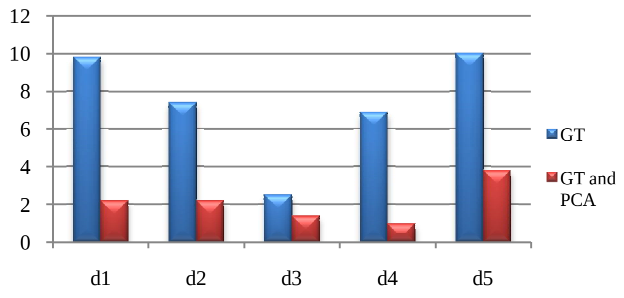


Fig. 4 :Execution time reduced after PCA

In this project, a vertical handoff decision model is proposed for multi criteria assessment and optimum network selection. This model first identifies the prominent attributes by applying Principal Component Analysis. In PCA, Principal components are identified using Scree Plot. The Scree plot consists of number of components on X-axis and Eigen Values on Y-axis. The values which are above the elbow curve those are considered as the important Principal Component. The product of Eigen vectors and the data taken i.e the parameter values forms the principal component values. From the product identify the values which are far from zero, by considering the important Principal Component from scree plot and those become the prominent attributes. These prominent attributes are considered and Graph Theory is applied for finding the optimum network.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2016

From the results, it is observed that the computational time by applying PCA is reduced by an average of 68.2% as compared to pure Graph Theory based approach. It is also observed that consideration of prominent attributes from all the available attributes is not affecting the correctness of Vertical Handoff Decision.

## FUTURE SCOPE

Different methods can be explored for reducing the attributes like Artificial intelligence, Linear Discriminant Analysis (LDA), Factor analysis etc. Different methods can be explored for setting Threshold value, which is used for identifying important Principal components from Scree plot.

## REFERENCES

1. The 2nd international working conference on performance modelling and evaluation of Heterogeneous networks, HET-NET's, U.K, July 2004,Evolution of Mobile Communications: from 1G to 4G Vasco Pereira and Tiago Sousa Department of Informatics Engineering of the University of Coimbra.
2. IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 15, NO. 1, FIRST QUARTER 2013, Mathematical Modeling for Network Selection in Heterogeneous Wireless Networks – A Tutorial Lusheng Wang and Geng-Sheng (G.S.) Kuo.
3. I. J. Computer Network and Information Security, 2016, 7, 31-42 Published Online July 2016 in MECS (http://www.mecs-press.org/) DOI: 10.5815/ijcnis.2016.07.05 Copyright © 2016 MECS I.J. Computer Network and Information Security, 2016, 7, 31-42 Vertical Handoff Decision Algorithm Based on PRSS and Dwell Time Jyoti Madaan, Indhu kashyap.
4. International Journal of Engineering Trends and Technology (IJETT) – Volume 13 Number 4 – Jul 2014 ISSN: 2231-5381 http://www.ijettjournal.org Page 191 Fuzzy Rule Based Vertical Handoff Decision Strategies for Heterogeneous Wireless Networks Ms. Ashima, Mr. Prashant Rana, Ms. Neeraj Maan.
5. IJCEM International Journal of Computational Engineering & Management, Vol. 15 Issue 2, March 2012 ISSN (Online): 2230-7893 www.IJCEM.org IJCEM www.ijcem.org 33 Quality Dependent Vertical Handover Decision Algorithm for Fourth Generation (4G) Heterogeneous Wireless Networks Nikhil Patel , Kiran Parmar.
6. International Journal of Novel Research in Computer Science and Software Engineering Vol. 2, Issue 1, pp: (28-35), Month: January - April 2015, An Overview of Vertical Handoff Decision Algorithm in Next Generation Wireless Networks Jyoti Verma, Indu Kashyap.
7. Journal of Information Science And Engineering 30, 875-893 (2014) 875 The qos-Ensured Vertical Handoff Decision in Heterogeneous Wireless Networks* Yulong Shen, Ning Xi, Qingqi Pei And Jianfeng Ma.
8. Rao RV. Decision making in the manufacturing environment using graph theory and fuzzy multiple attribute decision making methods. London: Springer-Verlag; 2007.
9. Saaty TL. The analytic hierarchy process. New York: mcgraw Hill; 1980.
10. Saaty TL. Fundamentals of decision making and priority theory with the AHP. Pittsburg: RWS Publications; 2000.
11. Marcus M, Minc H. Permanents. Am Math Mon 1965;72:571–91.
12. Journal Of Information Science And Engineering 30, 875-893 (2014) 875 The QoS-Ensured Vertical Handoff Decision in Heterogeneous Wireless Networks YULONG SHEN,NING XI, QINGQI PEI AND JIANFENG MA
13. https://onlinecourses.science.psu.edu/stat505/node/54.

## BIOGRAPHY

Dr. K. Radhika is working as Head and Associate Professor in the department of Information Technology in Chaitanya Bharathi Institute of Technology, Hyderabad. She received B.Tech in Electrical and Electronics Engineering from VRSEC, Vijayawada and M.Tech in Computer Science from JNTU, Hyderabad. She completed PhD in Computer Science from Osmania University under the guidance of Dr. A. Venugopal Reddy. Her research interests include mobile computing, Computer Networks and Data Analytics. She is a Life member in ISTE, and IETE and IACSIT.

G.Gayathri is Persuing Masters degree in department of Information Technology in Chaitanya Bharathi Institute of Technology, Hyderabad. She received B.tech in Computer Science and Engineering from Ellenki College of Engineering for Women, Patancheru, Hyderbad.