Analysis of VHO Parameters based on Polynomial Regression

[1]Siddharth Goutam, [2]Srija Unnikrishnan, [3]Pradeep Singh, [4]Aradhana Goutam

[1]Dr. B. R. Ambedkar University of Social Sciences, Dr. Ambedkar Nagar (Mhow), Indore (M.P)

[2,3]Father Conceicao Rodrigues College of Engineering, Mumbai, Maharashtra, India

[4]Research & Business Analytics, Prin. L. N. Welingkar Institute of Management Development and Research, Matunga, Mumbai 400019

[1]sgoutam07@gmail.com, [2]srija@frcrce.ac.in, [3]pradeep@frcrce.ac.in, [4]aradhana.goutam@welingkar.org

Abstract

The continuous & ever growing demand of high data rate various mobile applications can be dealt by Next Generation Networks (NGNs). This demand of high data rate is also coupled with least cost for the mobile user. This combination is feasible by considering Vertical Handover (VHO) in NGNs. This research paper aims in capturing the design and simulation of an algorithm for Vertical Handover. The input parameters considered are Received Signal Strength (RSS), bandwidth, cost and user velocity. The statistical analysis based polynomial regression model is also presented in the research paper

Keywords. Vertical Handover (VHO), Vertical Handover Decision Algorithm (VHDA), Received Signal Strength (RSS), Fuzzy Inference System (FIS), Next Generation Networks (NGNs).

1. INTRODUCTION

The nature of Next Generation Networks is heterogeneous, and they will be constituting of IP-based networks. NGNs will be diverse because of the presence of numerous Radio Access Technologies (RATs) [1] [2]. The presence of NGNs is depicted in Figure 1.

Figure 1 Presence of NGNs

Mobile customers' increasing demand for high bandwidth can be satisfied to some extent by NGNs.

Vertical Handover allows for seamless mobility across the various RATs [2] [3].

The paper has been organized as follows: Section II provides the theoretical background. Section III captures the system model. Section IV gives implementation results and analysis. Section V presents the conclusion & future work.

2. THEORETICAL BACKGROUND

2.1. VHO

VHO can be categorized in 3 steps. Fig 2 represents the steps of VHO [4].

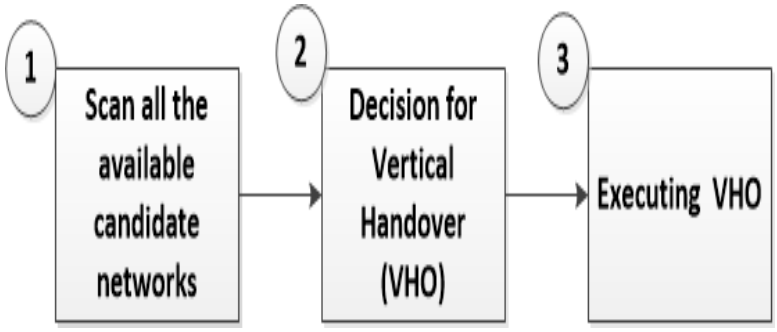

Figure 2. Phases of VHO

Figure 3 captures the i/p attributes for VHO. The handover value of the n/w is described as under by eq (1)

$$HV = f(RSS, Bandwidth, Cost, Velocity) \quad (1)$$

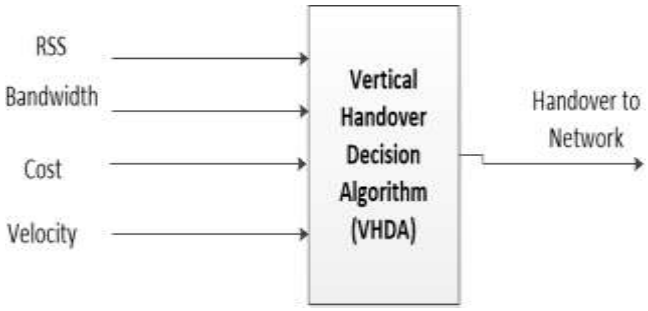

Figure 3. Parameters of VHDA

2.2. Fuzzy Inference System (FIS)

FIS is represented in fig 4.

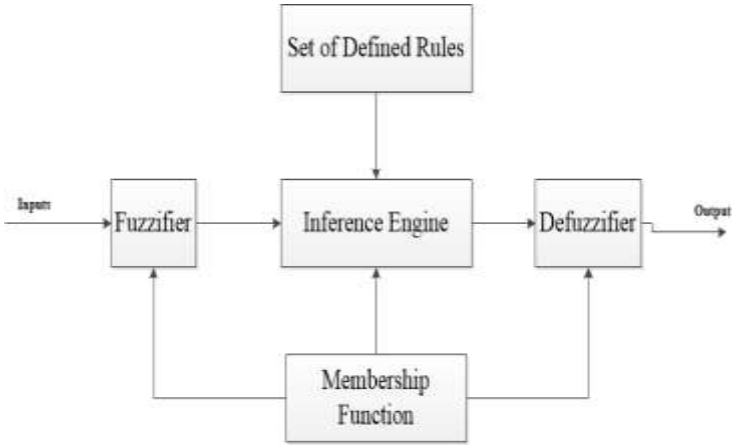

Figure 4. FIS

The membership function is represented in equation 2. [2]

$$\mu(x{:}\, r,s,t) = \begin{cases} 0, & x \le r \\ \frac{(x-r)}{(s-t)}, & r \le x \le s \\ \frac{(t-x)}{(t-s)}, & s \le x \le t \\ 0, & x \ge t \end{cases} \quad (2)$$

2.3. Polynomial Regression Analysis

The polynomial regression analysis is performed for representation of the relationship between two variables which is modeled as an nth degree polynomial in x.

x; independent variable

y; dependent variable

The equation is shown as under:

$$y = a + bx + cx^2 \quad (3)$$

The normal equations are described as under:

$$\sum y = na + b\sum x + c\sum x^2 \quad (4)$$

$$\sum xy = a\sum x + b\sum x^2 + c\sum x^3 \quad (5)$$

$$\sum x^2 y = a\sum x^2 + b\sum x^3 + c\sum x^4 \quad (6)$$

The values of a,b and c is found using above equations [5].

3. SYSTEM MODEL

Figure 5 represents block diagram of FIS [6].

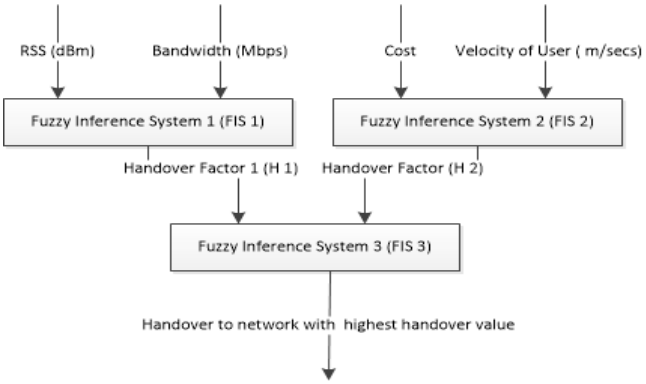

Figure 5. Block diagram for FIS

Figures 6 & 7 represent VHO flowchart & VHDA respectively.

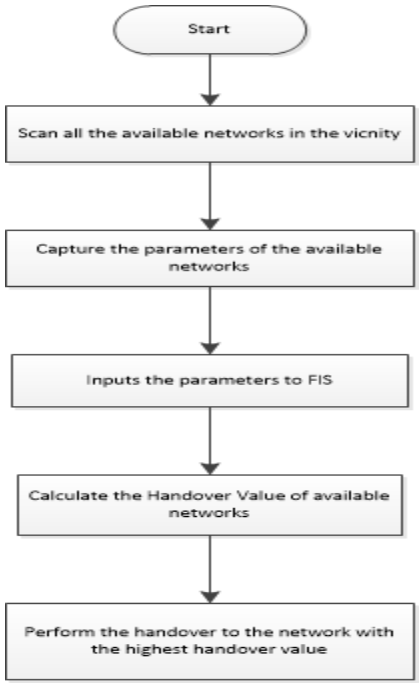

Figure 6. Flowchart of VHO

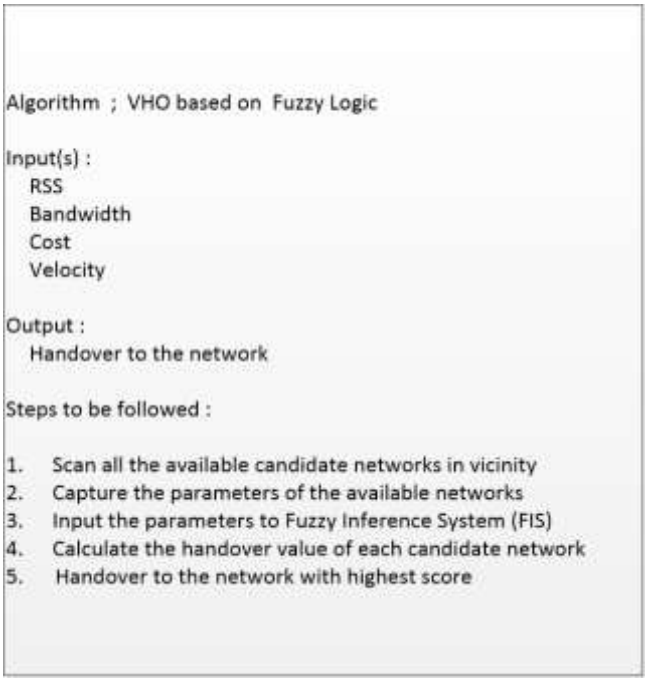

Figure 7. Algorithm for VHO

4. IMPLEMENTATION RESULTS & ANALYSIS

The implementation of algorithm has been performed in Python. . The parameters are captured in Table 1.

Table 1 Parameters used in Implementation

S. No	Parameter	4G	WLAN
1	RSS (in dBm)	-104 to-110	-105 to -110
2	Cost (INR)	10-20	0-4
3	Bandwidth (in Mbps)	1-6	8-10
4	Velocity (in m/sec)	15-30	0-5

The dataset of parameters has been generated by using the values measured. The polynomial regression analysis has been done for bandwidth & handover value (while keeping RSS, velocity cost as constant) for 4G & WLAN. Also, we have performed the polynomial regression analysis of velocity & handover value (while keeping RSS, bandwidth, cost as constant) for 4G & WLAN.

4.1. Polynomial Regression Analysis for Bandwidth & Handover Value for 4G

The values of other parameters have been kept fixed/constant at following values :

RSS (in dBm) = -110

Cost (INR) = 15-20

Velocity (in m/sec) = 25-50
x : Bandwidth
y : Handover value

$\sum x$ = 8580

$\sum y = 2972.26$

$\sum xy = 16411.12$

$\sum x^2y = 115022.5$

$\sum x^2 = 60060$

$\sum x^3 = 471900$

$\sum x^4 = 3951948$

$n = 1560$

Solving normal eq. 3 to eq.6 we will get the following

a=1.8487, b = 0.0196, c = -0.0013

$y = 1.8487 + 0.0196x - 0.0013x^2$

4.2. Polynomial Regression Analysis for Bandwidth & Handover Value for WLAN

The values of other parameters have been kep fixed/constant at following values :

RSS (in dBm) = -110

Cost (INR) = 0 - 3

Velocity (in m/sec) = 0-4
x : Bandwidth
y : Handover value

$\sum x$ = 1090

$\sum y = 417.4108$

$\sum xy = 826.7362$

$\sum x^2y = 2468.115$

$\sum x^2 = 7600$

$\sum x^3 = 59500$

$\sum x^4 = 496660$

$n = 200$

Solving normal eq.3 to eq. 6 we will get the following

a=11.5263 , b= -3.2596 , c= 0.2191

$$y = 11.5263 - 3.2596x + 0.2191x^2$$

4.3. Polynomial Regression Analysis for Velocity & Handover Value for 4G

The values of other parameters have been kept fixed/constant at following values:

RSS (in dBm) = -110

Cost (INR) = 15-20

Bandwidth (in Mbps) = 1-5

x : Velocity
y : Handover value

$\sum x$ = 30600

$\sum y = 2325.5$

$\sum xy = 57887.3$

$\sum x^2y = 1943234$

$\sum x^2 = 1030200$

$\sum x^3 = 39015000$

$\sum x^4 = 1575999960$

$n = 815$

Solving normal eq. 3 to eq. 6 we will get the following

a=-1.0711 , b=0.236816 , c=-0.003929

$$y = -1.0711 + 0.236816x - 0.003929x^2$$

4.4. *Polynomial Regression Analysis for Velocity & Handover Value for WLAN*

The values of other parameters have been keep fixed/constant at following values :

RSS (in dBm) = -110

Cost (INR) = 0-3

Bandwidth (in Mbps) = 7-10

x : Velocity
y : Handover value

$\sum x$ = 20400

$\sum y = 1664.09868$

$\sum xy = 41148.5962$

$\sum x^2y = 1378086.22$

$\sum x^2 = 686800$

$\sum x^3 = 26010000$

$\sum x^4 = 1050666640$

$n = 815$

Solving normal eq.3 to eq. 6 we will get the following

a=2.1274 , b= -0.00455 , c= 0.000034

$$y = 2.1274 - 0.00455x + 0.000034x^2$$

5. CONCLUSION & FUTURE SCOPE

This research paper aims at the analysis of the parameters of Vertical Handover (VHO) based on polynomial regression analysis. The analysis has been presented for bandwidth and handover value, velocity and handover value for 4G & WLAN. The practical values have been considered for analysis. In our future work, we intend to consider more number of parameters for VHO and also intend to consider more number of networks.

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Biographies

Siddharth Goutam completed his bachelor degree in Electronics & Telecommunication Engineering and Masters in Engineering in Electronics & Telecommunication Engineering with specialization in Communication Systems Engineering. He has completed Ph.D. in Electronics Engineering with specialization in Communication engineering.

Dr. Srija Unnikrishnan is Principal at Fr. Conceicao Rodrigues College of Engineering affiliated with the University of Mumbai, India. She has over 35 years of teaching experience at the UG and PG level. She received her Bachelor's Degree in Engineering from the University of Kerala, a Master's Degree from Osmania University, and Ph.D. from the University of Mumbai. Her broad areas of interest are Mobile Communication and Signal Processing.

Pradeep Singh is working as an Assistant Professor in Department of Humanities & Science at Father Conceicao Rodrigues College OF Engineering, Band-stand, Bandra (West),Mumbai from June 2006. He has completed Master of Science (M.Sc.) in Mathematics from Indian Institute of Technology (IIT) – Bombay in the year 2004. He has qualified NET – CSIR with Rank -21. His main area of interest are Linear Algebra, Statistics, Partial Differential Equations, Theory of Complex Analysis

Dr. Aradhana Goutam holds a Ph.D. in the area of Computer Science Engineering & Information Technology, from Faculty of Engineering Sciences, Devi Ahilya Vishwavidyalaya, Indore (M.P.), coupled with a Master of Technology (M.Tech) in Information Technology Degree from the Devi Ahilya Vishwavidyalaya, Indore (M.P.). She has experience in developing software solutions on multiple platforms. Her academics experience spans across M.Tech. Information Technology, Mobile Computing, M.Sc. - Electronics & Communication, Electronics, B.E. Computer Science and B.E. Information Technology . She has been associated with premier and reputed institutions like DAVV Indore, FRCRCE Mumbai and IES MCRC Mumbai.Her 17 years of experience spans across Teaching, Industry and Research domains. She has taught many subjects Like Project Management, Software Engineering, Mobile Computing, DBMS, JAVA, ERP, and many others. She has published 16 research papers in various International and national Journals. Her tryst with academics as a knowledge facilitator has been for the past 8 years. Dr. Aradhana Goutam is currently associated with IES Institute of Management College.