Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 15 Issue 6 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Seamless Heterogeneous Handoff based on SAP Method

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Abstract- Contemporarily there has been a number of techniques being suggested and used for heterogeneous handoff hitch. Different types of decision making methods are being implemented for handoff impediment. Mobile terminals progressing in neighbourhood will incur a handoff when its link capacity decreases below the threshold level. Various types of Multiple Attribute Decision Making methods have been exploited for handoff decision making. Here we have used a novel Reliable Seamless Handoff such as Simple Analytical Process method which uses Analytical Hierarchy Process for predicting the criterion weights and employed Simple Additive Weighting method for handoff decision making. Alternatives such as GSM, CDMA and EDGE networks are used. Data Rate, Packet Loss, Velocity, Bandwidth, Dwell time and Jitter are the parameters applied.

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GJCST-E Classification : *C.1.3*

Strictly as per the compliance and regulations of:

Seamless Heterogeneous Handoff based on SAP Method

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I. Introduction

Handoff in mobile nodes is the process of transforming from one base station to another base station. Inter handoff and Intra handoff are the two major types of handoffs. Handoff performed within same network termed as Intra Handoff. If it is with different Mobile Telephone Switching Office, then it is known as Inter Handoff. Inter handoff encountered as a complicated one which is a step by step process. Normally Heterogeneous Handoff has four stages known as Handoff Initiation, Handoff Probe, Handoff Decision Making and Handoff implementation. Handoff Initiation occurs when Mobile Terminals (MT) Signal strength fluctuates and deteriorates. And when it reaches down the threshold level, the MT decides to send Handoff request to its neighbourhood Networks. This process is termed as Handoff Probe. Mobile nodes in proximity will respond with their quality criteria, MT which has better level of criteria will be considered for handoff process. Finally Handoff implementation is executed after selecting a successful network. In most technologies, the conventional criteria used to reflect the condition of the current network connection are the Received Signal Strength (RSS), Signal to Interference Ratio (SIR), coverage area and the Bit Error Rate (BER). Handoff Decision Making is realized by means of Multiple Attribute Decision Making (MADM) method in [5]. MADM methods such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Elimination and Choice Translating Reality (ELECTRE) method, Grey Relational Analysis (GRA) method are evaluated for network selection based on the given criteria. Parameters such as Bandwidth, Delay and Cost are measured for the given networks such as Wi-Fi, Wimax and UMTS. MADM methods Efficiency analysation is carried out pertaining to its basic operations.

In general, the vertical handoff process can be divided into three main steps namely Handoff Initiation phase, system discovery, handoff decision, and handoff execution. The Handoff Initiation phase triggers the handover process. During the system discovery phase, mobile terminals have to determine which networks can be used. During the handoff decision-phase, the mobile device determines which network it should connect to. The decision may depend on various parameters including the available bandwidth, delay, etc. During the handoff execution phase, connections need to be re-routed from the existing network to the new network in a seamless manner [4]. Handoff decision making is done by implementation of Analytical Hierarchy Process (AHP) and Ordered Weighted Averaging (OWA) method. Rankings of networks are assured by AHP method and weights are ordered decreasingly and processed in reference to Linguistic quantifiers imparted by OWA method.

The remaining part of this article is sectored as Section II – Related work, Section III – Reliable Seamless Handoff based on SAP method, Section IV- Efficiency analysis, V- Simulation Results and Discussions, Section VI- Conclusion.

II. Related Works

In [1] authors proposed a SINR (Signal to Interference plus Noise Ratio) and AHP (Analytic Hierarchy Process) based SAW (Simple Additive Weighting) (SASAW) vertical handoff algorithm which uses the combined effects of SINR, user required bandwidth, user traffic cost and available bandwidth of the participating access networks to make handoff decisions for multi-attribute QoS consideration according to the features of the traffic. In [2], authors proposed a handover decision mechanism using the Simple Additive Weighting (SAW) in a heterogeneous wireless network environment using the IEEE 802.21. The proposed mechanism considered user preferences

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like cost as parameters of the candidate network to choose the best available network. Authors presented some experiments that used a developed simulator to validate the mechanism. In [3] authors proposed the multiple attribute decision making (MADM) methods which are suitable tools to model and study the vertical handoff process. Hence, recently several MADM methods such as SAW, MEW, TOPSIS, GRA, ELECTRE, VIKOR and WMC have been proposed for vertical handoff. Authors presented an extensive performance evaluation and comparative study of the seven MADM methods by means of numerical simulations in MATLAB.

Authors proposed a new Decision making algorithm based on Analytical Network process and Ordered weighted Averaging algorithm for network selection based on different criteria in [4]. Rankings are assured by AHP method and weights are ordered decreasingly and processed in reference to Linguistic quantifiers. The "best" network is selected using by comparing AHP-OWA Procedures, defined on multiple attributes (Data Transmission rate, Frequency, Velocity and Computer Connection Speed). Authors employed Markov Decision Process approach for seamless handoff in [6]. In which optimum results were obtained for selecting a network when compared to other Multiple Attribute Decision Making processes. Network cost function for selecting the network for handoff and Connection reward function which is based on the values of Quality of service parameters was used. Scrutinizing of the Constant Bit Rate and Transmission Control Protocol Packet delivery ratio was done. The Policy iteration Algorithm was used for determining the optimal policy.

Heterogeneous Network Requirements such as seamlessness, low blocking probability, High Bandwidth utilization which are the essential things discussed in [7]. Internetworking issues such as Signal quality, Data rates, Coverage discovery are conferred. Handoff management between UMTS and WLAN schemes are deployed in a step by step manner such as Agent discovery, Agent solicitation, Authentication and so on. Handoff management is based on SAW method in [8]. The handover efficiency in which it is a distributed scheme, is compared with an"802.11 Preferred" scheme. Only handovers between Wi-Fi and WiMAX are considered. But the handover framework is general and can be extended to consider other wireless and mobile communication networks like 3G, CDMA etc. The handover algorithm considered in this article is based on Simple Additive Weighting (SAW). The main reason of opting for SAW is that despite being simple its efficiency and accuracy is still similar to other heterogeneous algorithms like MEW and GRA [8].

III. Reliable Seamless Handoff: Simple Analytical Processing (SAP) Method

SAP method is an enhancement of SAW method. In which we merge AHP weights and SAW processing. SAW is a type of MADM method. Usually all decision making methods decide upon assumption of criterion weights. In which it lead us in unexpected outcome. Parametric weights play a significant role in decision making. It is required that weights should be precisely defined. AHP method works on the basis of pairwise comparison. Since it gives accurate upshots, Employment of AHP for the calculation of weights results in better consequence.

Step1: Construct the Decision Matrix D_{ij}.

Step2: Normalize the decision matrix by their corresponding benefit and cost criteria.
Benefit Criteria is given by

$$R_{ij} = d_i / Max(D_{ij}), \text{ where } d_i \in D_{ij},\ i = 1,...n \quad (1)$$

Cost Criteria is given by

$$R_{ij} = Min(D_{ij}) / d_i, \text{ where } d_i \in D_{ij},\ i = 1,...n \quad (2)$$

Step3: Apply the AHP method for estimating the criterion weights $W_{ij.}$.

Step4: Measure the Resultant matrix

$$N_{ij} = \sum R_{ij} * W_{ij.}$$
$$\text{where } i = 1,...n,\ j = 1,...m. \quad (3)$$

a) SAP Method Implementation

Step 1: Construct the Decision matrix $D_{ij.}$

Table 1 : Decision Matrix

	Data Rate	Packet Loss	Velocity	Bandwidth	Dwell Time	Jitter
GSM	115MB	19	42.7s	200MB	20m	1.5ms
EDGE	474MB	17	30.9s	250MB	22m	0.9ms
CDMA	144MB	21	16.67s	125MB	15m	1.8ms
GSM2	200MB	18	41.2s	180MB	23m	1.3ms
EDGE2	300MB	15	22.4s	220MB	20m	0.9ms
CDMA2	200MB	20	17.3s	140MB	18m	1.3ms

Step 2: Normalize the decision matrix.

Table 2 : Normalized Matrix

	Data Rate	Packet Loss	Velocity	Bandwidth	Dwell Time	Jitter
GSM	0.8086	0.3297	0.4428	0.2494	0.2964	0.0667
EDGE	3.333	0.295	0.3204	0.3117	0.326	0.04
CDMA	1.0126	0.3644	0.1729	0.1559	0.2223	0.08
GSM2	1.4064	0.3123	0.4273	0.2245	0.3408	0.0578
EDGE2	2.1096	0.2602	0.2323	0.2743	0.2964	0.04
CDMA2	1.4064	0.347	0.1794	0.1746	0.2667	0.0578

Step 3: Estimate the AHP Weights.

Table 3 : Calculated AHP Weights

Data Rate	Packet Loss	Velocity	Band width	Dwell Time	Jitter
0.2662	0.182	0.1357	0.1317	0.1610	0.1234

Step 4: Calculate the resultant matrix $R_{ij.}$. By applying the SAP method, which incurs AHP weights, we obtained the following results

Table 4 : SAP Method Results

GSM	EDGE	CDMA	GSM2	EDGE2	CDMA2
0.8047	0.9044	0.5279	0.7180	0.6962	0.5534

By applying the traditional heuristic weights with the conventional SAW method, we secured the following results.

Table 5 : SAW Method Results

GSM	EDGE	CDMA	GSM2	EDGE2	CDMA2
0.5230	0.9889	0.4289	0.9544	0.5489	0.8969

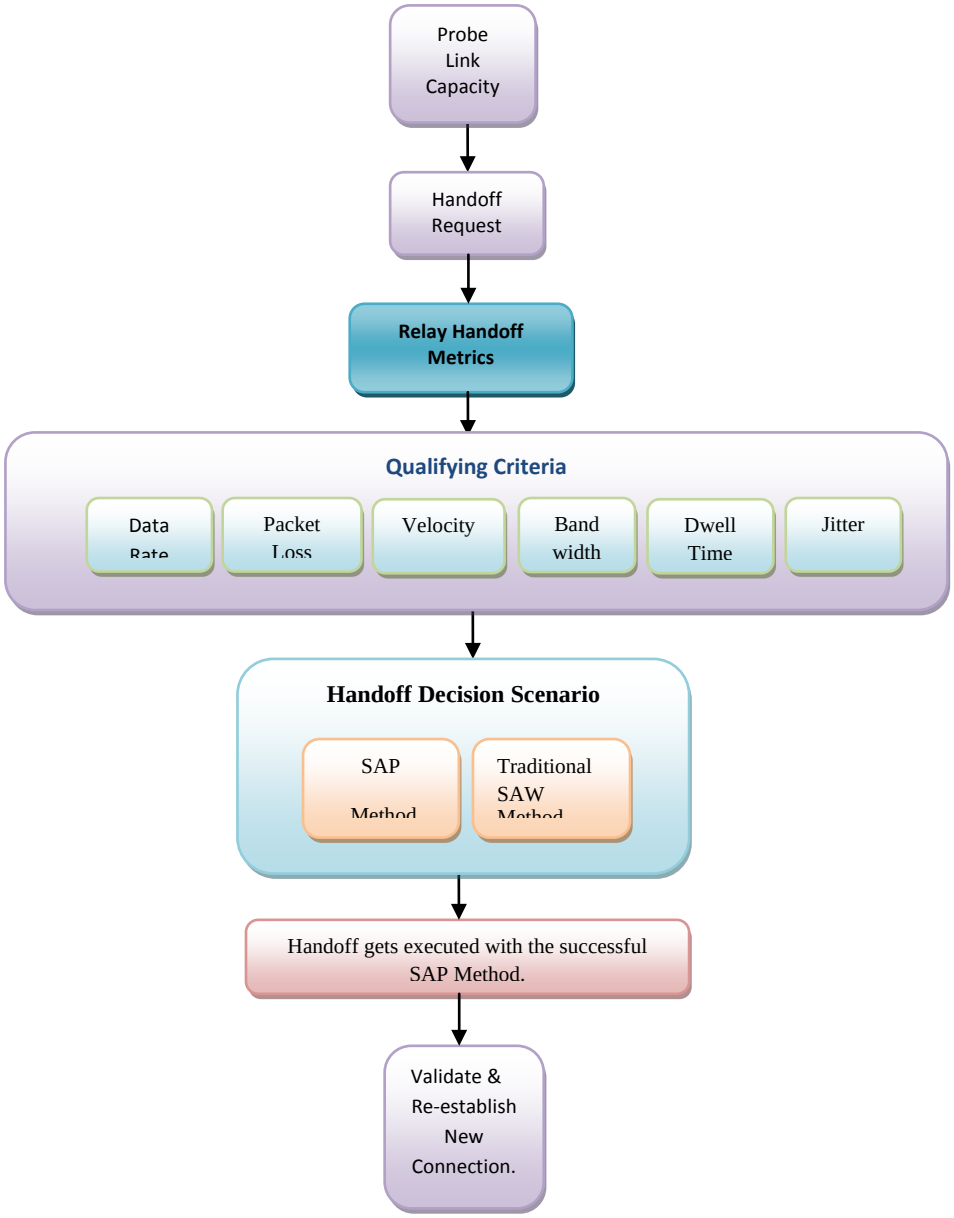

Figure 1 : Handoff Flow

Normally Handoff is segregated into two types such as Horizontal Handoff and Vertical Handoff. For Horizontal handoff, Received Signal Strength is the only measure to consider. Heterogeneous handoff is based on different types of metrics such as Bandwidth, Delay, Cost, Velocity etc,. Handoff request is issued when the signal level gets decreased. MN will maintain a list of available nodes information. Those networks which are in propinquity will respond with their supported data rates, coverage levels etc, Network which meets the required criteria will get selected for handoff.

IV. Efficiency Analysis

Efficiency of an algorithm involves space and time. In practice there is no need to conduct a detailed analysis. Usually it suffices to identify a dominant operation and to estimate the number of times a calculation is executed. The following is an R-code for calculating SAP method.

```
sap<-function(){
dk=read.csv("D:\\Book3.csv")
dk
mcst1<-min(dk[,1])
mcst1
```

```
ncst1<-mcst1/dk[,1]
ncst1
mxban1<-max(dk[,2])
mxban1
nban1<-dk[,2]/mxban1
nban1
mlat1<-min(dk[,3])
mlat1
nlat1<-mlat1/dk[,3]
nlat1
mvel1<-max(dk[,4])
mvel1
nvel1<-dk[,4]/mvel1
nvel1
mdel1<-min(dk[,5])
mdel1
ndel1<-mdel1/dk[,5]
ndel1
mdwl1<-max(dk[,6])
mdwl1
ndwl1<-dk[,6]/mdwl1
ndwl1
nd1<-cbind(ncst1,nban1,nlat1,nvel1,ndel1,ndwl1)
nd1
weight1<-c(0.4,0.15,0.10,0.18,0.09,0.08)
weight1
sw1<-sum(weight1)
sw1
nw1<-weight1/sw1
nw1
v1<-nd1%*%nw1
return(v1)
}
```

The above function is for the calculation of Simple Analytical Processing method. In the program the variables mcst1, mxban1, mlat1, mvel1, mdel1 and mdwl1 are the parameters Data rate, Bandwidth, Packet-loss etc., respectively. ncst1, nlat1, ndel1, nban1, nvel1 and ndwl1 are the processed minimum and maximum criterion values. Finally the calculated weights have to be multiplied with the outcome. The computational complexity involved here is listed in Table: 6

Table 6 : Computational Complexity of SAP method

1.	mcst1<-min(dk[,1])	3 Comparisons
2.	ncst1<-mcst1/dk[,1]	3 Divisions
3.	mxban1<-max(dk[,2])	3 Comparisons
4.	nban1<-dk[,2]/mxban1	3 Divisions
5.	mlat1<-min(dk[,3])	3 Comparisons
6.	nlat1<-mlat1/dk[,3]	3 Divisions
7.	mvel1<-max(dk[,4])	3 Comparisons
8.	nvel1<-dk[,4]/mvel1	3 Divisions
9.	mdel1<-min(dk[,5])	3 Comparisons
10.	ndel1<-mdel1/dk[,5]	3 Divisions
11.	mdwl1<-max(dk[,6])	3 Comparisons
12.	ndwl1<-dk[,6]/mdwl1	3 Divisions
13.	nd1<-cbind(ncst1,nban1,nlat1,nvel1,ndel1,ndwl1)	1 column binding
14.	weight1<-c(0.4,0.15,0.10,0.18,0.09,0.08)	1 summation
15.	sw1<-sum(weight1)	1 assignment

16.	nw1<-weight1/sw1	1 Division
17.	v1<-nd1%*%nw1	36 multiplications.
18.	return(v1)	

From the above Table: 6, it is clear that the dominant operations here involve Comparison, Division and Multiplication. The weights were calculated through AHP. In which, additional processing of AHP is mainly pair wise comparison and iteration. Perhaps the complexity of SAP method is more than the conceptual SAW method. Significant difference is through AHP method. However it shows robust results in network selection compared to SAW method.

V. Simulation Results and Discussion

SAW method is a very old method and its implementation projects over different fields. However the combination of AHP method with SAW method gives adequate results compared with other methods. SAP method yields improved outcomes than the conventional SAW method. In SAP method we have used AHP method for predicting the criterion weights. In which it uses pairwise comparison of each criterion. A pair wise comparision of a parameter relates its importance and efficiency with other parameters. And the ranks we use to give is based on each criterions significance over other. In the following Fig: 2 and Fig: 3 illustrate the performance of SAP and SAW methods.

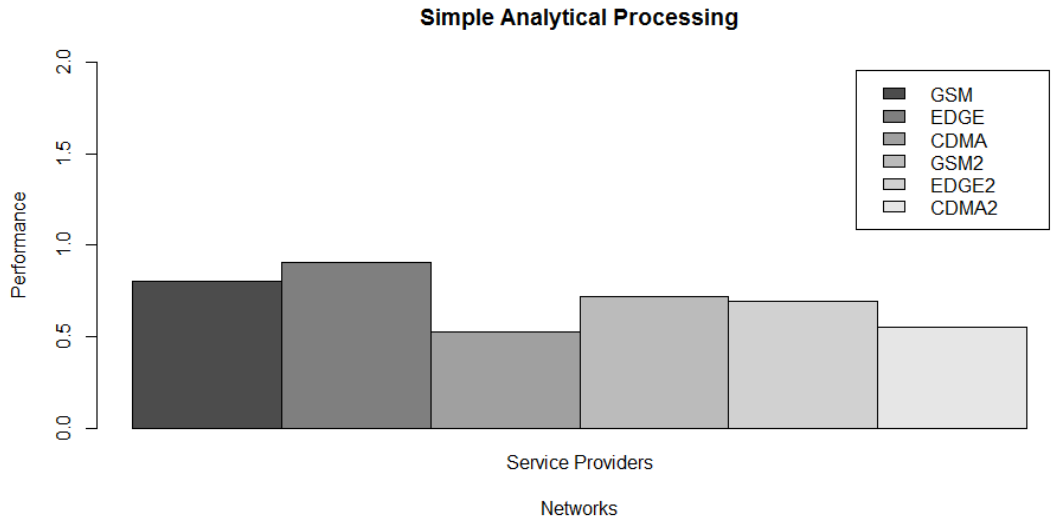

Figure 2 : Simple Analytical Process Method

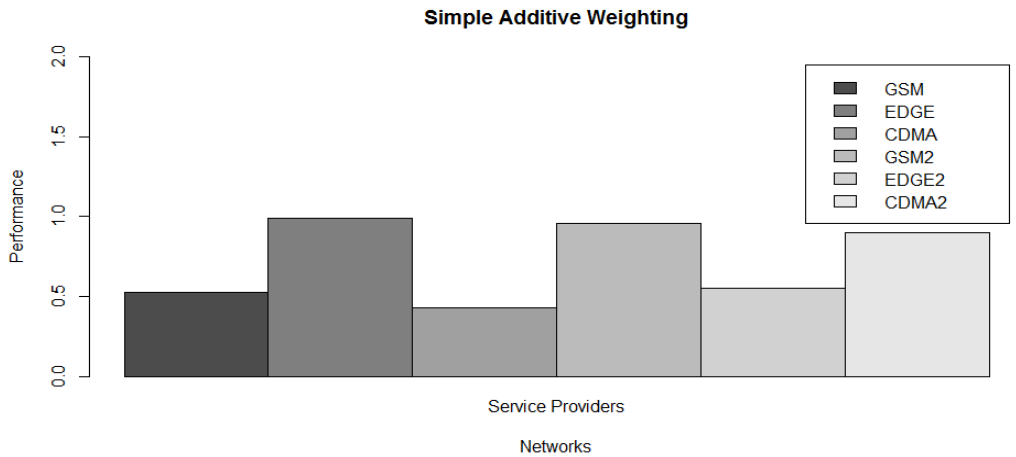

Figure 3 : Simple Additive weighting Method

From the Fig: 2, it is obvious that EDGE has the highest score than other networks. Next to EDGE comes the GSM network. CDMA secures the least importance. However, when the nodes are in mobility, the signal level use to increase and decrease based on the realtime scenario. Signal attenuation will incur in big building blocks and terrestrail areas. So in some situations CDMA network can have full signal support than other networks. So these signal processing levels are context aware. In Fig: 3, again EDGE has scored high. But here next to EDGE comes GSM2. As a overall comparision of all the six networks score, SAW method measurement is less compared to SAP method. And also SAW method uses the heuristic weights which is just a prediction. But in SAP method we have introduced AHP weights which is based on criterions ranking.

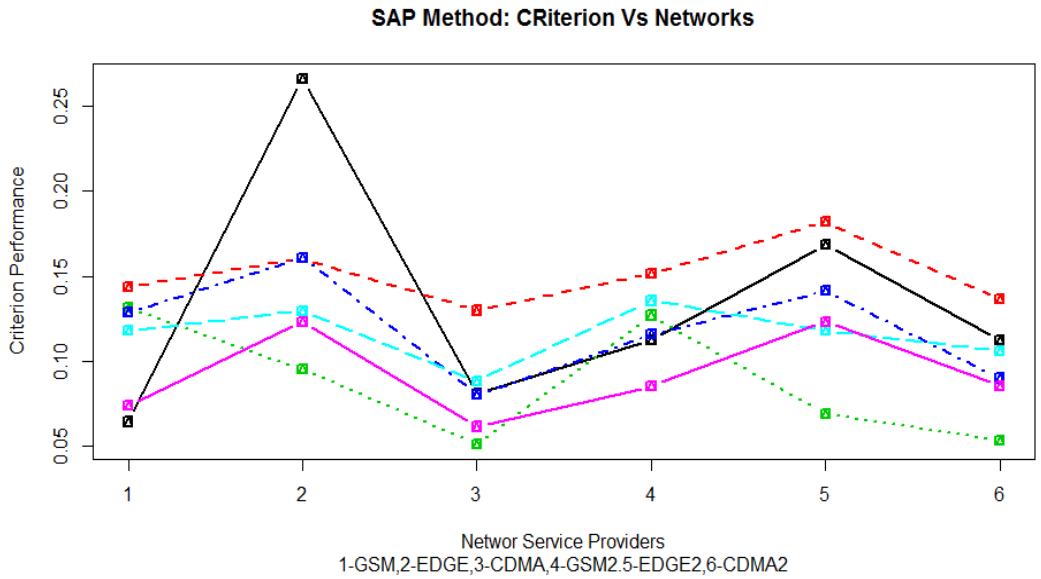

Figure 4 : SAP Method upshot

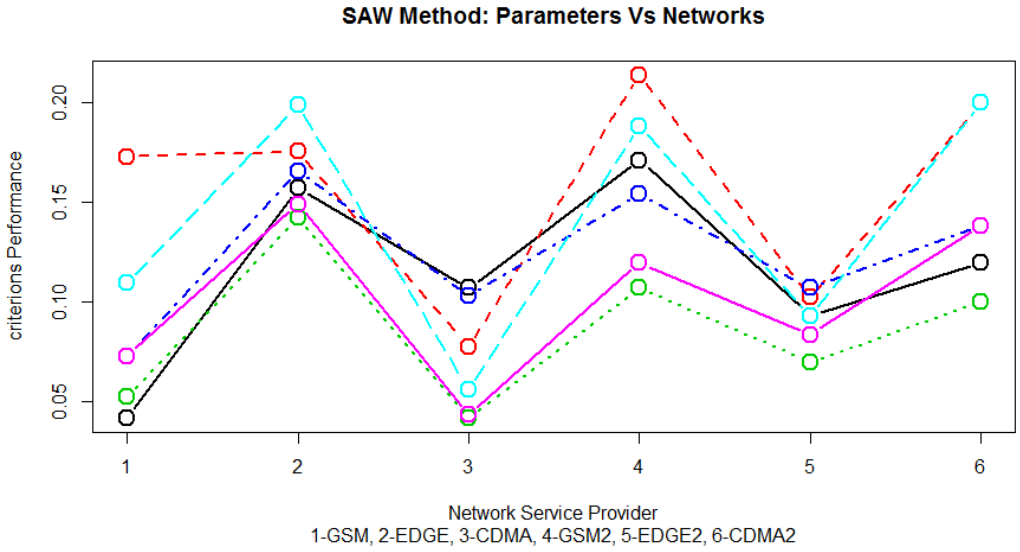

Figure 5 : SAW Method upshot

From the above Fig: 4, Black line indicates Data rate of each networks, in which EDGE is higher. The Datarate is very low in CDMA network. Red line indicates Packetloss. Packetloss is higher in all other networks compared to EDGE. Darkblue specifies Bandiwdth. Bandwidth is higher in EDGE but at athe same time Packetloss also attains the same level. Green line points velocity of all the networks. velocity is very low in CDMA and CDMA2. Velocity is high in EDGE2. Light blue line signifies the Dwell time of each network. And the Dwell time is high in EDGE2 and EDGE networks. Magenta line indicates the jitter measure of all the networks. Jitter is lesser in CDMA, EDGE and GSM networks. In the Fig:5, all six different colored lines indicates the same

paramaters as mentioned in Fig:4. In this SAW Method, almost EDGE and GSM2 aquires the high preference compared to other networks. From the Table: 6 below the simulation parameters are discussed in which normally the packet size is the default 560 kb. Node movements are random and the simulation time is approximately 60 seconds.

Table 6 : Simulation Parameters

Topology Shape	500 Meter * 500 Meter
Radio range of each node	150-200 Meters
Transmission Capacity	2 Mbps
Base Station	Multi Hop / Hierarchical
Node Count	5-8
Average transmission of Packets	2 packets
Maximum speed of a node	5 meters / second
Node moments	Random
Simulation Time	60 seconds

VI. Conclusion

Both the MADM methods such as SAW and SAP methods are executed and results are measured. SAP method shows enhanced results compared to SAW method. SAW method uses assumed heuristic weights which can yield controversies in outcomes. In SAP method AHP weights are used which is based on the ranking of the given criteria. Although the CDMA network uses soft handoff, its performance is very poor compared to all other networks. By applying the SAP method unwanted handoff will be reduced to a large extent. Since the Signal strength is context aware, there is anticipation that in some areas CDMA can also perform well. In the case of efficiency analysis, SAP shows lack of performance, Conversely, it helps to secure the best network for handoff. But the overall performance of GSM and EDGE gets high score compared to CDMA.

VII. Acknowledgement

The First Author extends her gratitude to UGC as this research work was supported by Major Research Project, under grant reference number, 41-611/2012 (SR) , UGC XI Plan.

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