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USER PREFERENCES AND EXPERT OPINIONS BASED VERTICAL HANDOFF DECISION STRATEGY

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ABSTRACT

Handoff decision is the most vital phase in the entire vertical handoff process for mobility management in heterogeneous wireless systems. Picking out the most beneficial network amongst the alternatives is the goal of the handoff decision operation. Multi criterion decision frameworks are few among the effective models for fashioning vertical handoff decision schemes. In this paper, user preferences and expert opinions based strategy is advised with the accompaniment of analytical hierarchy process (AHP). Motivation for the proposed model and also simulation and results are acknowledged examining the vantages of the suggested mechanism.

Keywords: *Heterogeneous Wireless Networks, Vertical Handoff, Analytical Hierarchy Process, User Preferences, Expert Opinions*

1. INTRODUCTION

Heterogeneous networks are formed by the interworking of networks with totally different technologies. One network might not be able to offer end to end services to mobile users for a complete session. This downside may be solved by permitting mobile terminals to move from the regulated realm of one wireless technology to a different wireless technology by providing uninterrupted services that is actually known as vertical handoff. Vertical handoff is recognized in 3 phases namely: handoff induction, handoff decision, and handoff implementation [1]. During this paper we focus on handoff decision. The aim of this phase is to pick out the optimum network among totally different wireless networks. In homogenous networks, handoff decision part doesn't exist since mobile terminals move solely from one cell to a different cell of an equivalent network technology. Further in homogenous networks, only received signal strength (RSS) is taken into account while a mobile terminal moves among the cells. Within the case of heterogeneous networks, handoff decision is done by considering several network parameters like information measure, jitter, delay, and power consumption, RSS etc., that makes the handoff decision advanced [2]. Optimum network is chosen by using multi criteria decision making models (MCDM). This paper illustrates an MCDM model called analytical hierarchy process (AHP).

Complex decision tasks are unriddled by decision accompaniment tools like AHP [3]. AHP applies a multi-level decision tree with objectives, multiple decision criteria, sub criteria and alternatives. In AHP composite tasks can be fractioned into easy tasks. Pair wise comparisons are performed on the easy tasks one by one. AHP is a mathematical technique for computing the weights for the alternatives grounded on the user's preferences. Comparison of the weights of the alternatives emerges out the optimal networks. Simple additive weighting (SAW) which is also addressed as scoring technique or weighted liner combination [4] is grounded on the weighted average. The weights for the alternatives are estimated by concerning the expert's judgment on 1-9 scale. Based on the weights of alternatives the best network is selected. In this paper we computed weights for network parameters like bandwidth delay and jitter. Finally ranks are calculated for networks UMTS, GPRS and WLAN to pick out the optimum network.

The remaining paper is organized as follows: Section 2 reports related work. Section 3 contains motivation for the proposed approach. Section 4 gives detailed explanation of proposed approach.

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Section 5 gives details of simulation setup. Section 6 comprises of numerical results and Section 7 contains comparison and discussion; and eventually section 8 concludes the paper.

2. RELATED WORK

The network quality of service (QoS) parameters and handover measures carry a significant role in choosing the most effective network. Handover measures information is gathered from the handoff induction phase and QoS parameters are thought of by the particular application [5]. In [6] vertical handover algorithm for conveyance communications was projected. In this they used intelligent transit to boost the safety policies. In [7] Ishizaka Alessio et al. projected edges and limitations of skilled decisions. The advantage of AHP is it follows the structural hierarchy of criteria, sub criteria and alternatives. And the disadvantage is - pair wise comparisons are written as positive reciprocal matrix however it's not appropriate for a few applications that involves currency.

In [8], SAW was planned for person selection problem. The limitation of SAW is within the higher cognitive process throughout judgment section, it ignores the fuzziness of the executives. However the advantage of SAW is that the relative order of magnitude scores remains same [4]. In [9] sensitivity analysis was performed to determine the sensitive attributes. In [10], merging of multiple parameters like user parameters, terminal parameters, and network parameters so as to pick out the most effective network was projected. In [11] context aware higher cognitive process model was instructed. This model takes context data from terminal aspect and network aspect so as to pick out the optimum network. In [12] a milling tool system for complicated issues like road and railway infrastructure was suggested. In this they used SAW for comparing attribute values of latest product to the attribute values of leader in this branch.

3. MOTIVATION

In this section, we furnish motivation for proposing the user preferences and expert opinions based strategy for vertical handoff by defending the proposed approach against Always Best Network (ABN) selection strategy and Always Cheapest Network (CAN) selection strategies. ABN selection strategy always selects the network that offers highest bandwidth; whereas ACN selection strategy always chooses the network that charges lowliest cost for the user. From Fig.1, it can be clearly seen that there is a huge untraveled space lying between these two strategies. The proposed strategy can give an opportunity for the users to roam flexibly in the space between ABN and ACN by allowing users to express their priorities over the chosen criteria based on which a network is selected. We also involve the expert's panel in making the decision in order to prevent the users from experiencing worst case performances.

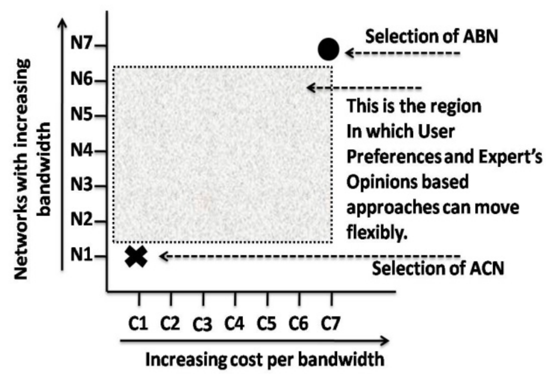

Figure 1: Networks Vs Cost per Bandwidth graph

4. PROPOSED STRATEGY

User preferences and expert opinions based approach considers both users' preferences along with expert's opinions. The reason for considering expert's opinions is to prevent the users from experiencing unwanted performances. It works in accompaniment with AHP with consistency ratio which is a proven mathematical framework for multi criteria decision making models [7]. It ranks all the candidate networks based on users' preferences and expert's opinions. The network with highest rank will be the chosen network for vertical handoff to take place. The whole process is carried out in five steps which are given below.

Step 1: Forms structural hierarchy among the chosen criteria.
Step 2: Develops users' preferences matrix for the chosen criteria.
Step 3: Computes weights for the criteria based on users' preferences.
Step 4: Computes weights of the candidate networks over the criteria based on expert's opinions.
Step 5: Ranks are computed for the candidate networks.

Two important stages in the whole process are

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Stage 1: Calculates weights of the chosen criteria. This stage is based on the users' preferences.

Stage 2: Calculate weights of the candidate networks for the chosen criteria. Usually this stage is also built with users' preferences. But we suggest that this stage should be developed with expert's opinions in order to protect the users from unwanted performances.

In this paper we have considered three parameters such as p1, p2, p3 for developing both user preferences and expert's opinions approaches. The only precaution is that any three non-dependent parameters should be chosen based on the users' preferences. For any 'n' criteria chosen and valued on a 1-9 Saaty's scale (1 – equal and 9 – extremely strong) the user preferences matrix contains $n(n-1)/2$ entries. The user preferences matrix (U_0) can be given as follows.

$$U_0 = \begin{matrix} & p1 & p2 & p3 \\ p1 & 1 & w1 & w2 \\ p2 & w3 & 1 & w4 \\ p3 & w5 & w6 & 1 \end{matrix}$$

In the above matrix *(w1, w3), (w2, w5), (w4, w6)* are reciprocals.

4.1. Calculating Weights for the Criteria based on User preferences

The steps for calculating the first set of Eigen values E_1 for the parameters p1, p2 and p3 are as follows.

Step 1: Square the user preferences matrix U_0.

$$U_1 = U_0 \times U_0 = \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ u_{21} & u_{22} & u_{23} \\ u_{31} & u_{32} & u_{33} \end{bmatrix} \quad (1)$$

Step 2: Calculate the intermediate variables R_{p1}, R_{p2}, R_{p3} as follows

$$R_{p1} = u_{11} + u_{12} + u_{13} \quad (2)$$
$$R_{p2} = u_{21} + u_{22} + u_{23} \quad (3)$$
$$R_{p3} = u_{31} + u_{32} + u_{33} \quad (4)$$

Step 3: The first set of Eigen values can be computed as follows

$$E_1 = \begin{bmatrix} R_{p1}/C_{t1} \\ R_{p2}/C_{t1} \\ R_{p3}/C_{t1} \end{bmatrix} \quad (5)$$

Where $C_{t1} = Rp1 + Rp2 + Rp3$ (6)

Step 4: Square the matrix U_1

$$U_2 = U_1 \times U_1 = \begin{bmatrix} w_{11} & w_{12} & w_{13} \\ w_{21} & w_{22} & w_{23} \\ w_{31} & w_{32} & w_{33} \end{bmatrix} \quad (7)$$

Step 5: Calculate the intermediate variables R_{p4}, R_{p5}, R_{p6} as follows.

$$R_{p4} = w_{11} + w_{12} + w_{13} \quad (8)$$
$$R_{p5} = w_{21} + w_{22} + w_{23} \quad (9)$$
$$R_{p6} = w_{31} + w_{32} + w_{33} \quad (10)$$

Step 6: Second set of Eigen values can be calculated as follows

$$E_2 = \begin{bmatrix} R_{p4}/C_{t2} \\ R_{p5}/C_{t2} \\ R_{p6}/C_{t2} \end{bmatrix} \quad (11)$$

Where $C_{t2} = R_{p4} + R_{p5} + R_{p6}$ (12)

Step 7: Eigen vectors should be calculated repeatedly till the difference between the two successive Eigen vectors is close to zero. Keeping performance in mind, we have calculated only first two Eigen vectors irrespective of the difference which is sufficiently enough for calculating the weights of the criteria.

Resultant Eigen vector for chosen criteria is $E_C = E_2$

$$E_C = \begin{bmatrix} \boldsymbol{e_{p1}} \\ \boldsymbol{e_{p2}} \\ \boldsymbol{e_{p3}} \end{bmatrix}$$

Step 8: Now we have to judge whether the user preferences are consistent or not by using the following equation

$$\lambda\_avg = \{(ep1 + w1 * ep2 + w2 * ep3)/ep1, (w3 * ep1 + ep2 + w4 * ep3)/ep2, (w5 * ep1 + w6 * ep2 + ep3)/ep3\} \quad (13)$$

$$CI = \frac{(\lambda\_avg - n)}{n-1} \quad (14)$$
$$CR = CI/(RI(n)) \quad (15)$$

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CI: consistency Index
CR: consistency Ratio
RI: Random Index
λ_{avg} *:* average of Eigen values

Table 1: Random Indexes

n	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4

CR $\leq$ 0.1 concludes that user preferences are consistent.
CR > 0.1 concludes that user preferences are inconsistent in which case user preferences should be taken once again.

4.2. Calculating Weights for Candidate Networks based on Expert's Opinions

In this paper we have considered three networks as candidate networks for vertical handoff. For each criterion, Eigen vectors for candidate networks over each criterion should be calculated. Calculating Eigen values for the three networks N1, N2, N3 over the criterion bandwidth is as follows. It is important to notice that the information in this section is calculated from the opinions collected from the experts.

Collect expert's opinions in the matrix P_0.

$$P_0 = \begin{matrix} & N1 & N2 & N3 \\ N1 & & & \\ N2 & & & \\ N3 & & & \end{matrix} \begin{bmatrix} 1 & a1 & a2 \\ a3 & 1 & a4 \\ a5 & a6 & 1 \end{bmatrix}$$

In the above matrix *(a1, a3), (a2, a5), (a4, a6)* are reciprocals. First set of Eigen values of the candidate networks over the parameters p1, p2, and p3 are calculated as follows.

Step 1: Square the expert's opinions matrix P_0.

$$P_1 = P_0 \times P_0 = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix} \quad (16)$$

Step 2: Intermediate variables R_{a1}, R_{a2}, R_{a3} can be calculated as

$$R_{a1} = r_{11} + r_{12} + r_{13} \quad (17)$$
$$R_{a2} = r_{21} + r_{22} + r_{23} \quad (18)$$
$$R_{a3} = r_{31} + r_{32} + r_{33} \quad (19)$$

Step 3: The first set of Eigen values E_3 are calculated as follows

$$E_3 = \begin{bmatrix} R_{a1}/C_{t3} \\ R_{a2}/C_{t3} \\ R_{a3}/C_{t3} \end{bmatrix} \quad (20)$$

Where $C_{t3} = R_{a1} + R_{a2} + R_{a3}$ (21)

Step 4: Square the matrix P_1

$$P_2 = P_1 \times P_1 = \begin{bmatrix} s_{11} & s_{12} & s_{13} \\ s_{21} & s_{22} & s_{23} \\ s_{31} & s_{32} & s_{33} \end{bmatrix} \quad (22)$$

Step 5: Intermediate variables R_{a1}, R_{a2}, R_{a3} are calculated as follows

$$R_{a1} = s_{11} + s_{12} + s_{13} \quad (23)$$
$$R_{a2} = s_{21} + s_{22} + s_{23} \quad (24)$$
$$R_{a3} = s_{31} + s_{32} + s_{33} \quad (25)$$

Step 6: Second set of Eigen values are calculated as follows.

$$E_4 = \begin{bmatrix} R_{a1}/C_{t4} \\ R_{a2}/C_{t4} \\ R_{a3}/C_{t4} \end{bmatrix} \quad (26)$$

Where $C_{t4} = Ra1 + Ra2 + Ra3$ (27)

Step 7: Eigen vectors should be calculated repeatedly till the difference between the two successive Eigen vectors is close to zero. Keeping performance in mind, we have calculated only first two Eigen vectors irrespective of the difference which is sufficiently enough for calculating the weights of the criteria.

Step 8: Now we have to judge whether the expert's opinions are consistent or not. It can be known with the help of the following equation.

$$〖\lambda〗\_avg = \{(e\_b1 + a1\, e\_b2 + a2\, e\_b3)/e\_b1, (a3\, e\_b1 + e\_b2 + a4\, e\_b3)/e\_b2, (a5\, e\_b1 + a6\, e\_b2 + e\_b3)/e\_b3\} \quad (28)$$

Calculate consistency index with the help of equations (14) and (15).

CR≤0.1 concludes that the expert's opinions are consistent.
CR>0.1 concludes that the expert's opinions are inconsistent and they should be taken once again.

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For the parameter P1 the Eigen values are

$$E_4 = E_{p1} = \begin{bmatrix} e_{b1} \\ e_{b2} \\ e_{b3} \end{bmatrix} \quad (29)$$

Similarly Eigen vectors for the parameters p2 and p3 should be calculated.

For the parameter p2 the Eigen values are as follows

$$E_{p2} = \begin{bmatrix} e_{d1} \\ e_{d2} \\ e_{d3} \end{bmatrix} \quad (30)$$

For the parameter p3 the Eigen values are as follows

$$E_{p3} = \begin{bmatrix} e_{j1} \\ e_{j2} \\ e_{j3} \end{bmatrix} \quad (31)$$

The final Eigen vectors for the candidate networks and criteria are as follows respectively.

$$E_a = \begin{matrix} & p1 & p2 & p3 \\ N1 & e_{b1} & e_{d1} & e_{j1} \\ N2 & e_{b2} & e_{d2} & e_{j2} \\ N3 & e_{b3} & e_{d3} & e_{j3} \end{matrix}$$

$$E_c = \begin{bmatrix} e_{p1} \\ e_{p2} \\ e_{p3} \end{bmatrix}$$

Rankings of the candidate networks is derived from the multiplication of the above two matrices E_a and E_c. *R1, R2, R3* are rankings of the candidate networks *N1, N2, N3* respectively and they are calculated as follows.

$$R1 = e_{b1} * e_{p1} + e_{d1} * e_{p2} + e_{j1} * e_{p3} \quad (32)$$

$$R2 = e_{b2} * e_{p1} + e_{d2} * e_{p2} + e_{j2} * e_{p3} \quad (33)$$

$$R3 = e_{b3} * e_{p1} + e_{d3} * e_{p2} + e_{j3} * e_{p3} \quad (34)$$

The candidate network which is having the highest Eigen value will become the best candidate for handoff to take place.

5. SIMULATION SETUP

The setup considered for the proposed model constitutes of UMTS, GPRS and WLAN networks with overlapping areas. We begin with the assumption that initially the mobile is connected to GPRS. All the networks contain several mobile nodes developing background traffic. The simulation began with a mobile node built in the intersection area of the three networks. Many mobile nodes are added to the each of the networks later on generating competing traffic thus data and conclusions more authentic.

A mobile terminal having subscription to the three networks is shammed in the overlap vicinity of the networks. The mobile terminal is constructed with suggested scheme for the extraction of the network. The links have negligible retard such that end-to-end hold up is largely dependent on the performance of the selected network. The sink behaves as the server. Throughout this the network selection is based on the proposed strategy. OMNet++, version 4.1 is used for simulation. The algorithm is coded using C++.

6. NUMERICAL RESULTS

In this section we provide numerical examples for the proposed strategy.

We considered three criteria and three candidate net-works for the user preferences and expert's opinions based approach. The three criteria are band width (B), delay (D), jitter (J) and three alternative networks are UMTS, GPRS and WLAN. Initially we collect preferences information from the user and calculated weights for the criteria and check the consistency in user preferences.

6.1. Calculating Weights for the Criteria based on User Preferences:

$$U_0 = \begin{matrix} & B & D & J \\ B & 1 & 1/3 & 1/2 \\ D & 3 & 1 & 2 \\ J & 2 & 1/2 & 1 \end{matrix}$$

Convert the fraction into decimals

$$U_0 = \begin{matrix} & B & D & J \\ B & 1 & 0.3333 & 0.5000 \\ D & 3 & 1 & 2 \\ J & 2 & 0.5000 & 1 \end{matrix}$$

Here *w1*=0.3333, *w2*=0.5000, *w3*=3, *w4*=2, *w5*=2, *w6*=0.5000

The Eigen vectors for criteria are $E_C = \begin{bmatrix} 0.1634 \\ 0.5396 \\ 0.2969 \end{bmatrix}$

Consistency ratio (*CR*) is 0.087. Since it is less than 0.1 so the user preferences are consistent.

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6.2. Calculating Weights for the Candidate Networks based on Expert's Opinions

In terms of bandwidth, delay and jitter, pair-wise comparisons determine the preferences of each alternative over another.

BANDWIDTH

$$A_b = \begin{matrix} UMTS \\ GPRS \\ WLAN \end{matrix} \overset{\begin{matrix} UMTS & GPRS & WLAN \end{matrix}}{\begin{bmatrix} 1 & 1/3 & 1/2 \\ 3 & 1 & 2 \\ 2 & 1/2 & 1 \end{bmatrix}}$$

DELAY

$$A_d = \begin{matrix} UMTS \\ GPRS \\ WLAN \end{matrix} \overset{\begin{matrix} UMTS & GPRS & WLAN \end{matrix}}{\begin{bmatrix} 1 & 4 & 3 \\ 1/4 & 1 & 2 \\ 1/3 & 1/2 & 1 \end{bmatrix}}$$

JITTER

$$A_j = \begin{matrix} UMTS \\ GPRS \\ WLAN \end{matrix} \overset{\begin{matrix} UMTS & GPRS & WLAN \end{matrix}}{\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}}$$

The Eigen values for the above alternatives are as follows.

$$E_b = \begin{bmatrix} 0.6483 \\ 0.2296 \\ 0.1220 \end{bmatrix} \quad CR=0.034 \leq 0.1$$

$$E_d = \begin{bmatrix} 0.6298 \\ 0.2186 \\ 0.1515 \end{bmatrix} \quad CR=0.10 \leq 0.1$$

$$E_j = \begin{bmatrix} 0.3333 \\ 0.3333 \\ 0.3333 \end{bmatrix} \quad CR=0 \leq 0.1$$

The weights of alternatives on each criteria is

$$E_a = \begin{matrix} UMTS \\ GPRS \\ WLAN \end{matrix} \overset{\begin{matrix} B & D & J \end{matrix}}{\begin{bmatrix} 0.6483 & 0.6298 & 0.3333 \\ 0.2296 & 0.2186 & 0.3333 \\ 0.1220 & 0.1515 & 0.3333 \end{bmatrix}}$$

$$E_c = \begin{bmatrix} 0.1634 \\ 0.5396 \\ 0.2969 \end{bmatrix}$$

Calculate *R1*, *R2* and *R3* values as described in section 3.

R1=0.5447, *R2*=0.2544, *R3*=0.2006

The best network is *R1* i.e. UMTS because UMTS network has the highest Eigen value.

7. COMPARISION AND DISCUSSION

In this section, we compare and highlight few merits and demerits of the proposed strategy.

i. The advantages of the proposed strategy over traditional RSS are its flexibility, intuitive appeal to the decision makers and its ability to check inconsistencies.

ii. Additionally, the proposed strategy has the distinct advantage that the importance of each element becomes clear since it decomposes the decision problem into its constituent parts and builds hierarchies of the criteria.

iii. The proposed model is uniquely positioned to model situations of uncertainty and risk since it is capable of deriving scales where measures ordinarily do not exist.

iv. The proposed strategy can give an opportunity for the users to roam flexibly in the space between ABN and ACN by allowing users to express their priorities over the chosen criteria based on which a network is selected.

v. The proposed strategy can maximize user satisfaction since it considers both user preferences and expert's opinions. The reason for considering expert's opinions in this approach is only to protect the naïve users from experiencing unwanted performances.

vi. The performance of the proposed approach sometimes can become unpredictable and may lead to poor user satisfaction in spite of expert's opinions when the user preferences are bad.

vii. If user preferences for individual criteria are replaced with expert's opinions then the proposed approach can promise maximized service performance.

8. CONCLUSION

In heterogeneous wireless networks vertical handoff management is a vital part, during which the handoff decision is the crucial step. For handoff decision, a user preferences and expert's opinions based approach is projected in this paper. The planned model work in accompaniment with mathematically established AHP which is a multi criteria decision model. In AHP, priority is given to the user and based on the user constraints the

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weights for the criteria are calculated and therefore the optimal network is chosen. But to prevent the users from unwanted results we also allow the experts to give their opinions for the candidate networks over each criterion. The proposed model settles for solely finite number of criteria and alternatives. Numerical calculations for both the models are also shown. One major downside with the proposed model is that it does not contemplate the context aware information. Hence, the model can be improvised by adding context-aware data such as features of the mobile terminal, requirements demanded by the application etc.

REFRENCES:

[1] Mohamed Lahby, Leghris Cherkaoui and Abdellah Adib "An Enhanced Evaluation Model for Vertical Handover Algorithm In Heterogeneous Networks". IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 3, No 2, May 2012.

[2] Shusmita A. Sharna, Manzur Murshed "Performance Improvement of Vertical Handoff Algorithms for QoS Support over Heterogeneous Wireless Networks". *Conferences in Research and Practice in Information Technology (CRPIT)*, 2011, Vol. 113.

[3] Evangelos Triantaphyllou and Stuart H. Mann "USING THE ANALYTIC HIERARCHY PROCESS FOR DECISION MAKING IN ENGINEERING APPLICATIONS: SOME CHALLENGES". *Inter'l Journal of Industrial Engineering: Applications and Practice*, Vol. 2, No. 1, pp. 35-44, 1995.

[4] E.Manokaran, et al. "Application of Multi Criteria Decision Making Tools and Validation with Optimization Technique-Case Study using TOPSIS, ANN & SAW" *International Journal of Management & Business Studies* Vol. 1, Issue 3, Septemb er 2011.

[5] Enrique Stevens-Navarro and Vincent W.S. Wong "Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks".

[6] Sourav Dhar, Amitava Ray, Rabindranath Bera "design and simulation of vertical handover algorithm for vehicular communication" *International Journal of Engineering Science and Technology Vol. 2(10), 2010, 5509-5525.*

[7] Alessio Ishizaka and Ashraf Labib " Analytic Hierarchy Process and Expert Choice: Benefits and Limitations" *ORInsight, 22(4), p. 201–220, 2009.*

[8] Alireza Afshari, Majid Mojahed and Rosnah Mohd Yusuff "Simple Additive Weighting approach to Personnel Selection problem" *International Journal of Innovation, Management and Technology, Vol. 1, No. 5, December 2010.*

[9] Azizollah Memariania, Abbas Aminib, Alireza Alinezhad "Sensitivity Analysis of Simple Additive Weighting Method (SAW): The Results of Change in the Weight of One Attribute on the Final Ranking of Alternatives" *Journal of Industrial Engineering 4 (2009) 13-18.*

[10] Yulong shen, ning xi, qingqi pei and jianfeng ma "the qos-ensured vertical handoff decision in heterogeneous wireless networks*" journal of information science and engineering xx, xxx-xxx (201x).

[11] Tansir Ahmed, Kyandoghere Kyamakya, and Mar-kus Ludwig "A Context-Aware Vertical Handover Decision Algorithm for Multimode Mobile Terminals and Its Performance" Proceedings of the IEEE/ACM Euro American Confe-rence on Telematics and Information Systems (EATIS 2006), pp. 19-28, ISBN. 958-8166-36-5, February 7-10, 2006, Santa Marta, Colombia.

[12] Milan Kolarević, Aranđel Babić, Nemanja Ilić, Marina Pljakić, "Application of the multiple criteria decision-making for comparison of cutting wheels features", Facta Universitatis Series: Mechanical Engineering Vol. 10, No 1, 2012, pp. 15 - 30".