Reliable Seamless Handoff across Heterogeneous Networks based on Location aware M-PROMETHEE Method

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Abstract: - A Mobile Terminal may undergo signal inconsistencies based on the contextual dependency. Context dependencies include location identification, mobility, rate of change of data in motion, velocity of the mobile device etc. The frequency reuse is the main feature for augmenting the coverage area of a base station or access point and to improve the capacity of a mobile terminal. These are the main criteria that must support preventing any handoff failures which occur in a mobile terminal. Presently Seamless Mobility is the main concern. For overcoming the signal paucity in certain areas, the option of heterogeneous networks integration is the solution. In this Paper, we have implemented a Reliable Seamless Handoff Solution that comprises of a novel MADM method known as Modified Preference Ranking Organisation Method for Enrichment Evaluations (M-PROMETHEE) which is compared with the traditional Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE) method. M-PROMETHEE results show satisfactory improvement over the conventional PROMETHEE method. Parameters used here include Data rates, Packet loss, Velocity, Bandwidth, Dwell Time and Jitter.

Keywords: - Heterogeneous Networks, Location Management, Modified Preference Ranking Organisation Method for Enrichment Evaluations, Multiple Attribute Decision Making, Mobile terminal, Reliable Seamless Handoff.

1. Introduction:

Signal to interference ratio plays a vital role in mobile terminals. When the signal level decreases and gets below the threshold level, the link capacity decreases and attempts to do handoff. If the same networks signal is very weak, then the device tries to accommodate with other networks available in proximity. For the horizontal networks handoff, signal to interference ratio (SINR) is the only parameter concerned. Heterogeneous Handoff is based on several parameters which includes SINR, Bandwidth, Data Rate, Velocity etc. Distinctly the consideration of Mobility Management, Location Management, User preferences are also has to be envisaged.

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 based on modifications of some criteria value, such as signal strength, link quality. During the system discovery phase, mobile terminals equipped with multiple interfaces have to determine which networks can be used and the services available in each network. The networks may also advertise the supported data rates for different services. 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, jitter, access cost, transmit power, current battery status of the mobile device, and the user’s preferences. During the handoff execution phase, connections need to be re-routed from the existing network to the new network in a seamless manner. Thus, the vertical handoff decision is taken based on the Home Network’s (HN) conditions and parameters offered by the Visiting Networks (VN) [4]. The rest of this article comprises of Section 2: related work, 3: MADM method, in which sub sections comprises of Reliable Seamless Handoff Techniques (M-PROMETHEE implementation).
2. Related Work:

The strengths and weaknesses of the Preference Ranking Organisation Method for Enrichment Evaluations (PROMETHEE) and analytic hierarchy process (AHP) methods are analysed in [1]. Building upon this analysis, recommendations are formulated to integrate into PROMETHEE a number of useful AHP features, especially as regards the design of the decision-making hierarchy (ordering of goals, sub-goals, dimensions, criteria, projects, etc.) and the determination of weights. In [2], authors formulated a multi-criteria vertical handoff system sensitive to various mobile-terminals’ mobility parameters including distance and velocity in a heterogeneous wireless network is analytically formulated and validated via simulations. It is targeted to estimate the essential handoff parameters including outage probability, residual capacity, and signal to interference and noise threshold as well as network access cost.

In order to avoid the ping-pong effect in handoff, a signal evolution prediction system is formulated and its performance is examined. Moreover, the handoff scheme is triggered using an on-line handoff-initiation-time estimation scheme. When initiated, the handoff procedure begins with a network scoring system based on multi-attribute strategy which results in selection of potentially promising network parameters. Simulation results are shown to track well the analytical formulations. 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 [3]. 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 [5]. 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. Scrutinization 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. The PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluation) algorithm is applied in the vertical handoff decision technology for heterogeneous wireless networks and researched on its performance in [6]. Four 3GPP defined traffic classes are considered in performance evaluation. An attribute matrix is constructed by considering the SINR in the source network and the equivalent SINR in the target network, the required bandwidth, the traffic cost and the available bandwidth of participating access networks. Handoff decision meeting multi-attribute QoS requirement is made according to the traffic features. The weight relation of decision elements is determined with Least Square (LS) method. Finally decision is made by using PROMETHEE algorithm based on the attribute matrix and weight vector.

In [7], authors proposed Internet-based WLAN community information and advances in Location Enabling Servers together with Mobile IP-based roaming client capabilities to provide a solution on how to tackle the problem of WLAN access network selection and (pre-) registration. Context-awareness is a key ingredient in any ubiquitous and pervasive system and provides intelligence to the system, allowing computing devices make appropriate and timely decisions on behalf of users. The use of contextual information is essential in optimizing services in a heterogeneous mobile network environment. Context awareness in mobile computing refers to internal and external adaptation of the environment and applications to the context state of each other. Multi Attribute Decision Making (MADM) is one of the successfully used methods in the literature to solve decision making problems. Weighted product method is an MADM method that penalizes the unreliable
attributes in making a decision. In [8] authors proposed an algorithm for a context-aware network selection that is based on WPM. Two well-known decision making methods, namely analytic hierarchical process (AHP) and Vlse Kriterijumska Optimizacija I Kompromiso Resenje (VIKOR) are combined in order to make the best use of information available, either implicitly or explicitly in [9]. In addition, the Delphi method is utilized to select the most influential criteria by a few experts. The aim of using the AHP is to give the weights of the selected criteria. Finally, the VIKOR method is taken into account to rank potential alternatives [9]. In [10] authors proposed a vertical handoff decision algorithm which considers the technology type as well as the Signal to Interference Ratio (SIR), the Mobile Station (MS) velocity, the user preferences, the applications requirements and the terminal capabilities as the most important factors to make vertical handoff decision. In order to minimize handoff costs, the decision algorithm uses the dwell timer concept. The handoff costs are analyzed in terms of unnecessary and unbeneﬁcial handoffs rate.

3. Multiple Attribute Decision Making (MADM) Method:
Several MADM methods are proposed earlier for decision making. If the number of alternatives and criterion exceeds certain limits, then it’s a tedious process to make decision on selecting a suitable particular primitive. Here we have various MADM methods and we can opt for the best suite one for our environment. The implementation of the traditional PROMETHEE requires two additional types of information, namely:
• Information on the relative importance (i.e., the weights) of the criteria considered;
• Information on the decision-makers preference function, which he/she uses when comparing the contribution of the alternatives in terms of each separate criterion. The above information determines the preference structure of the decision-maker [1]. We have implemented a novel Modiﬁed Preference Ranking Organization Method for Enrichment Evaluation (M-PROMETHEE) is the Multi criteria method and its steps are as follows:

3.1 Reliable Seamless Handoff (M-TOPSIS Methodology):
Step1: Construct the Decision matrix \( D_{ij} \) (Alternatives vs. Criterion)
Step2: Normalize the Decision Matrix. Calculate the Row-sum for each alternative/criteria. Find out the Benefit criteria and Cost criteria for each alternative then perform the normalization.
\[
N^+ = \frac{d_i}{\max(d_i)} \quad (1)
\]
\[
N^- = \frac{\min(d_i)}{d_i} \quad (2)
\]
Step3: Measure the Outranking relationship between each alternative by calculating the difference between each alternative. Here we identify the preference function. The preference function \( P_j \) translates the difference between the evaluations (i.e., scores) obtained by two alternatives (a and b) in terms of a particular criterion, into a preference degree ranging from 0 to 1. Let
\[
P_j(a,b) = G_j[f_j(a) - f_j(b)], \quad (3)
\]
\[
0 \leq P_j(a,b) \leq 1, \quad (4)
\]
be the preference function associated to the criterion, \( f_j(.) \) where \( G_j \) is a non-decreasing function of the observed deviation (d) between \( f_j(a) \) and \( f_j(b) \). Promethee preference function falls under six types known as U shape, V shape, Usual, Level, Linear and Gaussian. Here our criterion comes under V shape. Same follows in M-PROMETHEE.
Step4: Calculate the column sums and construct the resultant matrix \( R_{ij} \).
Step5: Multiply the weights with the corresponding criterion for determining the score matrix
\[
S_i = P(i,j)^w_a. \quad (5)
\]
The weights can be determined according to various methods. Here we have used Analytical Hierarchy Process for determining the weights. In which AHP uses pairwise comparison of all the given criteria based on ranking methodology. \( w_a \) is the weight calculated for each criterion through AHP Method. AHP method is based on Pairwise comparison of given criteria. It gives ranks for
each criteria and the criterion values are measured.

3.2 Location Management:
Normally Mobility models defined in a mobile terminal controls the location information. The Home Location Registry (HLR) and Visiting Location Registry (VLR) are the things pertaining to the position information identification of a mobile device. When a call gets initiated, transferring equipment determines whether the mobile device is in home location or other locality. The HLR sends information if the mobile device is in Home area. Otherwise, VLR acquires the Routing information from the Mobile Station Controller. So the location information of the nearby available networks is collected. The Location status of the networks in proximity will get updated periodically. When the link quality of a mobile terminal decreases beyond the threshold level then the collected information of the neighboring networks are used to send the Handoff request. MADM method is applied to calculate the best network for handoff.

Fig 1: Handoff Procedure
3.3 Implementation of M-PROMETHEE Method:
Step1: Construct the decision matrix $D_y$. The subsequent Table: 1 shows the decision matrix.

Table 1: Decision Matrix

<table>
<thead>
<tr>
<th></th>
<th>Data Rate</th>
<th>Packet Loss</th>
<th>Velocity</th>
<th>Bandwidth</th>
<th>Dwell Time</th>
<th>Jitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM</td>
<td>115</td>
<td>19</td>
<td>42.7</td>
<td>20</td>
<td>20</td>
<td>1.5</td>
</tr>
<tr>
<td>EDGE</td>
<td>474</td>
<td>17</td>
<td>30.9</td>
<td>25</td>
<td>22</td>
<td>0.9</td>
</tr>
<tr>
<td>CDMA</td>
<td>144</td>
<td>21</td>
<td>16.67</td>
<td>12.5</td>
<td>15</td>
<td>1.8</td>
</tr>
<tr>
<td>GSM2</td>
<td>200</td>
<td>18</td>
<td>41.2</td>
<td>18</td>
<td>23</td>
<td>1.3</td>
</tr>
<tr>
<td>EDGE2</td>
<td>300</td>
<td>15</td>
<td>22.4</td>
<td>22</td>
<td>20</td>
<td>0.9</td>
</tr>
<tr>
<td>CDMA2</td>
<td>200</td>
<td>20</td>
<td>17.3</td>
<td>14</td>
<td>18</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Step2: Normalized Values are represented in the following Table: 2.

Step3: Preference Relation is calculated and the function is V-shape function.

Table 2: Normalized Values

<table>
<thead>
<tr>
<th></th>
<th>Data Rate</th>
<th>Packet Loss</th>
<th>Velocity</th>
<th>Bandwidth</th>
<th>Dwell Time</th>
<th>Jitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM</td>
<td>0.8086</td>
<td>0.3297</td>
<td>0.4428</td>
<td>0.2494</td>
<td>0.2964</td>
<td>0.0667</td>
</tr>
<tr>
<td>EDGE</td>
<td>3.333</td>
<td>0.295</td>
<td>0.3204</td>
<td>0.3117</td>
<td>0.326</td>
<td>0.04</td>
</tr>
<tr>
<td>CDMA</td>
<td>1.0126</td>
<td>0.3644</td>
<td>0.1729</td>
<td>0.1559</td>
<td>0.2223</td>
<td>0.08</td>
</tr>
<tr>
<td>GSM2</td>
<td>1.4064</td>
<td>0.3123</td>
<td>0.4273</td>
<td>0.2245</td>
<td>0.3408</td>
<td>0.0578</td>
</tr>
<tr>
<td>EDGE2</td>
<td>2.1096</td>
<td>0.2602</td>
<td>0.2323</td>
<td>0.2743</td>
<td>0.2964</td>
<td>0.04</td>
</tr>
<tr>
<td>CDMA2</td>
<td>1.4064</td>
<td>0.347</td>
<td>0.1794</td>
<td>0.1746</td>
<td>0.2667</td>
<td>0.0578</td>
</tr>
</tbody>
</table>
For calculating the high performance preference function, we have taken 3 highest points from the entire criterion and derived the preference function. It reflects the V-shape function. Mostly EDGE and GSM2 values comprise the highest points. And in the Jitter measure, CDMA comes into action. CDMA Shows higher Jitter compared to other networks. Fig2 through Fig 7 illustrates all the criteria performance functions including Data rate, Packet loss, Velocity, Bandwidth, Dwell time and Jitter.

Step4: The resultant matrix is calculated and the weights are multiplied. After performing the preference calculation, AHP weights are multiplied. In the following Table: 3, represents the AHP weights.

<table>
<thead>
<tr>
<th>Data Rate</th>
<th>Packet Loss</th>
<th>Velocity</th>
<th>Bandwidth</th>
<th>Dwell Time</th>
<th>Jitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2662</td>
<td>0.182</td>
<td>0.1357</td>
<td>0.1317</td>
<td>0.1610</td>
<td>0.1234</td>
</tr>
</tbody>
</table>
Fig8: Dwell Time.

Fig9: Packet Loss.

Fig10: Velocity.
From Fig 8 to 13, the criterion measures of all the networks have been depicted. In the X-axis all the networks are displayed and in Y-axis, the performance criterion for each network is presented. EDGE Performance shows improved upshot compared to other networks. Green dotted line represents the EDGE networks. Green line indicates the EDGE2 network, Black
The Simulation is executed under an environment in which six different service providers behaviors are measured and calculated by means of six different criterions such as Data rate, Packet loss, Velocity, Bandwidth, Dwell time and Jitter. Enactment of AHP weights in M-PROMETHEE method makes huge difference in consequence when compared to traditional PROMETHEE method. From Fig 14, GSM Performance in both PROMETHEE and M-PROMETHEE methods are displayed. Velocity is high in M-PROMETHEE compared to PROMETHEE results.

4. Simulation Results:

\[ \text{Fig14: GSM Comparision of PROMETHEE and M-PROMETHEE.} \]

\[ \text{Fig15: EDGE Performance Comparision of M-PROMETHEE and PROMETHEE Methods.} \]
Fig 16: CDMA Performance comparison of M-PROMETHEE and PROMETHEE Methods.

Fig 17: GSM2 Performance comparison of M-PROMETHEE and PROMETHEE Methods.

Fig 18: EDGE2 Performance comparison of M-PROMETHEE and PROMETHEE Methods.
From Fig 15, 16, EDGE and CDMA performance comparisons of PROMETHEE and M-PROMETHEE methods are shown. EDGE Performance is higher in M-PROMETHEE compared to PROMETHEE. M-PROMETHEE has shown enhanced outcome related to PROMETHEE method. CDMA experienced poor performance in both the Methods. From Fig 17, 18 and 19, GSM2, EDGE2 and CDMA2 demonstrates high results in M-PROMETHEE.

5. Conclusion
The Reliable Seamless Handoff Technique comprises of the introduction of AHP weights in M-PROMETHEE method which increases the resultant criteria. Traditional PROMETHEE method has some inconsistencies in which it depends on heuristic weights. There is no well-defined method for calculating weights in PROMETHEE method. EDGE Network shows better outcome compared to other networks. Next to EDGE network, EDGE2 shows high consequences. CDMA has poor effect in relation to all other networks. By selecting the networks through M-PROMETHEE method, a stable consistent solution is achieved which avoids ping-pong effect and handoff failures.

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[6] Liu Shengmei, Pan su, Mi Zhengkun, “Research on Vertical Handoff Decision


