# Handover Algorithm for Multiple Network Access Enabled Mobile Devices

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**Abstract -** *For the last few years, the next generation wireless networks have been received a considerable attention in the communication engineering community because of its feature that it will support the vertical handoff mechanism in which users can maintain the connections by switching from one network to another (e.g., from IEEE 802.11b to CDMA 1xRTT or UMTS network, and vice versa) without any discontinuity. According to vertical handoff mechanism, on the arrival of a service request from a smart space user, the network must assign one of the available access networks based on either operator policies or user preferences or a combination of both by employing a suitable decision algorithm. In this article, a vertical handover algorithm is proposed so that the switching between networks can be carried out according to the state of the current operation of the mobile node as well as user preferences, which would benefit the users and ensure the Quality of Service (QoS).*

**Keywords:** vertical handoff, heterogeneous network, decision algorithm.

## 1 Introduction

Handover is the process of going from one cell to another in the middle of a call without the call being drop in cellular mobile system. This type of handover is commonly known as horizontal handover. This handover allows mobile device the facilities of intra-domain mobility [1]. No single wireless technology can provide low latency, high bandwidth and large coverage areas, from which the concept of vertical handover came [2]. Vertical handover is the process of using different kind of wireless networks in the middle of a process running in the mobile device. It gives mobile device the facility of inter-domain mobility [3].

Broadband access of information is the aim of next generation wireless networks. From the initial 1G version of cellular system it is about to enter 3G version or even higher, where support for not only voice but also high-speed data transmission is one of the main priority [4]. To keep availability of bandwidth and data service in mind, the researcher is trying to integrate cellular network and WLAN so that users can enjoy the uninterrupted data service anywhere and anytime. In doing so, an important consideration is to decide when to switch between networks without being disconnected from the internet. This kind of switching is called vertical handover [5], where mobile nodes switch between different wireless networks.

Recently, switching between networks is carried out according to a score function [6], where the network has the maximum score is selected as the best network to switch to. But this work is very much dependent on the data provided by the users. According to this work, all the decision of switching to a particular network is dominated by the weight values such as link capacity, power consumption and cost of accessing a particular network. This can be a major drawback in case of real-time operation, since it requires larger bandwidth compared to non-real-time operations. But if the values provided to calculate the score function has more emphasis on parameters such as power consumption or cost of using a network, might never switch to the network which can provide high bandwidth. In [7], switching between networks has been done by comparing only the Received Signal Strength (RSS) with a predefined threshold value without considering the QoS factor. Although this technique is independent of user preference, but comparing only the RSS with a predefined threshold value without considering the QoS might not be a feasible technique to follow for switching between two networks. With these in mind, in this work a modified vertical handover algorithm is proposed by taking both RSS and QoS into consideration.

In our proposed handover algorithm, switching between networks is carried out according to the state of the current operation of the mobile node as well as user preference, which would benefit the users and ensures the QoS. Initially, we assume that the coverage of the cellular network is present everywhere the mobile node is moving to. So the target is to switch to WLAN network when it is present and when it is required.

## 2 Review of WLAN and UMTS

The increasing demand of high bandwidth for data, voice and video has led to the development of Wireless Local Area Network (WLAN), which is also known as IEEE 802.11. WLAN focus on the Physical and Data link Layer of the Open System Interconnection (OSI) network model. Physical layer of WLAN uses narrowband radio, infrared, Spread Spectrum and Orthogonal Frequency Division Multiple Access (OFDM). The Medium Access

Control (MAC) ensures the error control and synchronization. Commonly WLAN has three standards, 802.11b, which is most common, 802.11a and 802.11 g. 802.11b works in the frequency band of 2.4 GHz ISM band and can provide a bandwidth up to 11 Mbps. Among the remaining two standards, 802.11a can operate in the frequency band 5 GHz with a throughput up to 54 Mbps and 802.11g operates in both 2.4 GHz and 5 GHz frequency band and it can operate with other standard [8]. A typical block diagram of WLAN is shown in Fig. 1.

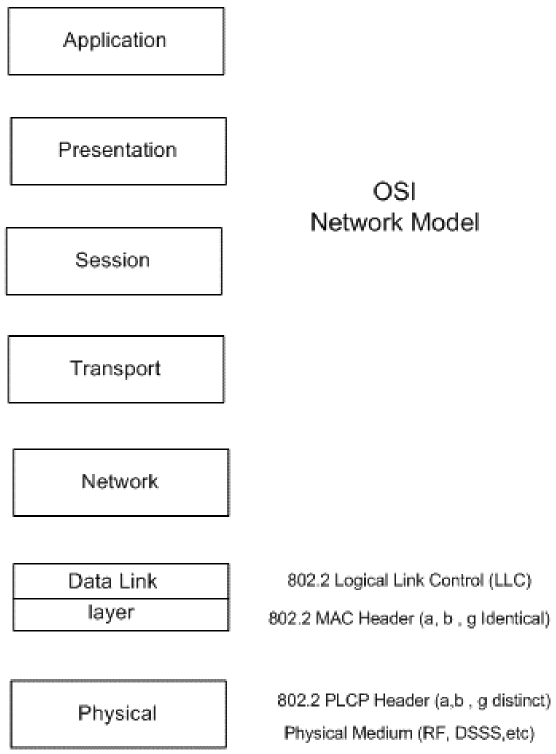


Figure 1: WLAN and OSI model

The Universal Mobile Telecommunication System (UMTS) is a third generation (3G) mobile communications system that is developed to provide a range of broadband services to the mobile phone users. A typical block diagram of UMTS network is shown in Fig. 2. The aim of UMTS is to deploy an all-IP based network using Wide-band Code Division Multiple Access (WCDMA) technology [9]. UMTS is able to provide both circuit switch and packet switch communications [10]. UMTS can provide following data speeds [11]:

- 144 kbps—Satellite and rural outdoor
- 384 kbps—Urban outdoor
- 2048 kbps—Indoor and low range outdoor

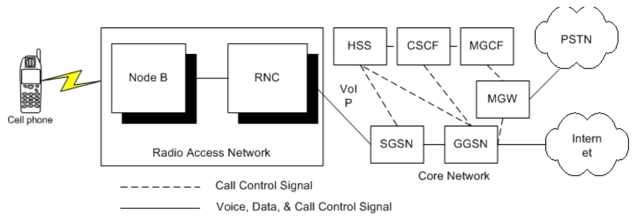


Figure 2: Main entities of UMTS network [12]

## 3 Proposed Vertical Handover Algorithm

To execute the vertical handover at the appropriate moment an effective vertical handover algorithm is a must. In order to overcome the limitations of the works presented in [6,7], we have propose a modified vertical handover algorithm by considering RSS and user preference into account before making a handover. Another important consideration of the proposed algorithm is that, before making the handover it checks the current status of the ongoing operation of the mobile device. If the current operation is a real-time one, then preferred handover network is WLAN, when the device in the cellular network otherwise it will remain in the WLAN network. For non-real-time operation, we used the cost function used in [6]. According to the value of the cost function best network is selected. The algorithm is described below, the flowchart of which is shown in Fig.3.

1. Scan the current working network. If it is WLAN then jump to step 2, otherwise switch to step 3.
2. Scan the Received Signal Strength (RSS).
   a. If the RSS is higher than the threshold value turn on the UMTS interface in a power save mode and switch to b, otherwise switch to step 3.
   b. If the current operation is a real-time operation switch to step 2, otherwise switch to c.
   c. Calculate the value of the score function. If WLAN network has the maximum value for its score function, switch to step 2 otherwise turn on the UMTS interface in active mode and switch step 3.
3. Scan RSS of WLAN
   a. If the signal strength is higher than threshold value then switch to b otherwise switch to step 3.
   b. If the current operation is a real-time operation switch to step 2 otherwise switch to c.
   c. Calculate the value of the score function. If WLAN network has the maximum value for its score function switch to step 2 otherwise switch to step 3.

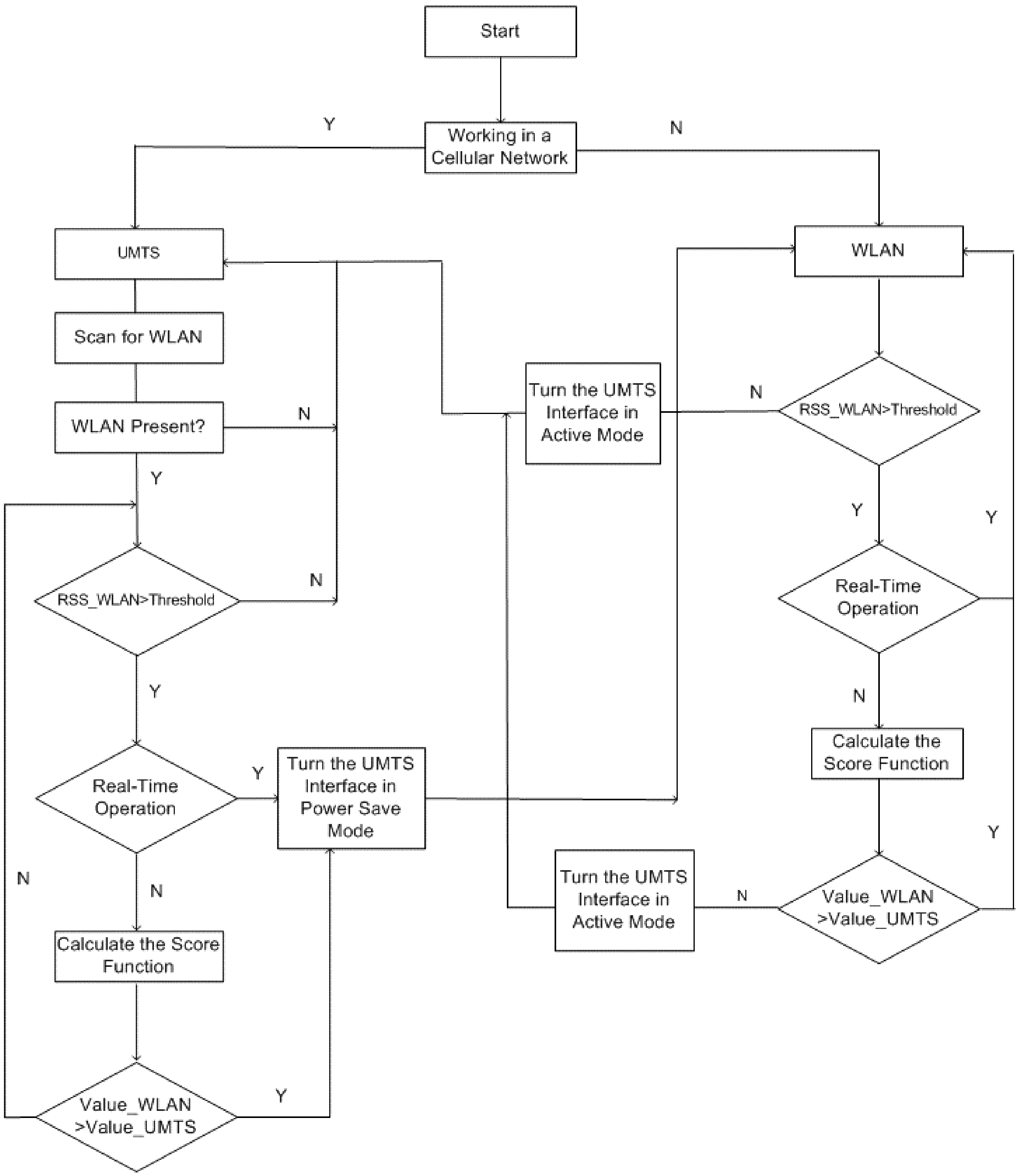


Figure 3: Flowchart of the proposed handover algorithm

## 4 Calculation of the Score Function

The score function used in this work was presented by researchers at the University of California, Los Angeles (UCLA) in 2004 [13]. According to [13], the network that has the highest value of its score function is the best network interface to switch to. The calculation of the proposed cost function $S_i$, is shown below:

$$S_i = \sum_{j=1}^{K} W_j f_{j,i} \quad \text{(for } 0<S<1\text{)} \qquad (1)$$

where $\sum_{j=1}^{K} W_j = 1$.

The normalized policy values for $i$-interfaces are the sum of $k$ weighted function $f_{j,i}$. The weights, $W_n$, are provided by the users according to their requirements. The normalized functions, $f_{j,i}$, are used to provide a score value for network interface *i's* parameter $j$. Parameter $j$ can be, for example, the interfaces monetary expense (*E*), link capacity (*C*), or power consumption (*P*). Using the mentioned factors the score function in (1) will look like Eq.(2).

$$S_i = W_e f_{e,i} + W_c f_{e,i} + W_p f_{p,i} \qquad (2)$$

The normalized functions are illustrated below:

$f_{e,i} = e^{-\alpha_i}$ for $\alpha_i \geq 0$

$f_{c,i} = \frac{e^{\beta_i}}{e^M}$ for $M \geq \beta_i$

$f_{p,i} = e^{-\gamma_i}$ for $\gamma_i \geq 0$

The coefficients $\alpha_i$, $\beta_i$ and $\gamma_i$ are assumed to be:

$\alpha_i = \frac{x_i}{20}$, where $x$ is the monetary expense of interface i.

$\beta_i = \frac{Min(y_i, M)}{M}$, where $y$ is the measurement of the link capacity for interface i's network and M is the maximum demanded bandwidth from the user.

$\gamma_i = \frac{2}{z_i}$, where $z$ is the power consumption by interface $i's$ network.

# 5 Results and Discussion

This section presents the simulation results of the proposed handover algorithm and also compares the result with the reference work described in [7]. Figure 4 shows how long a mobile device stays in both WLAN and UMTS networks using our proposed algorithm. It also shows that the time spent in both WLAN and UMTS networks for our reference work. From the figure it is clear that the mobile device stays longer time in WLAN network in case of the proposed algorithm compared to the reference work, which is desirable. Although for short duration both algorithm shows almost the same result, while for long duration, two algorithms has considerable amount of differences in the amount of time spent in different networks.

From closer observation of the reference algorithm it is clear that the less amount of time spent in WLAN because in this case WLAN is not considered as the target network for real-time operation, and that is why mobile device stays longer time in WLAN, which is clearly depicted in Fig. 4.

Figure 5 shows the number of changes (switches) between two networks. We executed the simulation 10 times, starting from 100 seconds ending at 1000 seconds with an increment of 100 seconds. It is clear from the figure that for reference work number of changes between networks is much less compare to our proposed work. This is because, the reference work didn't consider WLAN as target network for real-time operation.

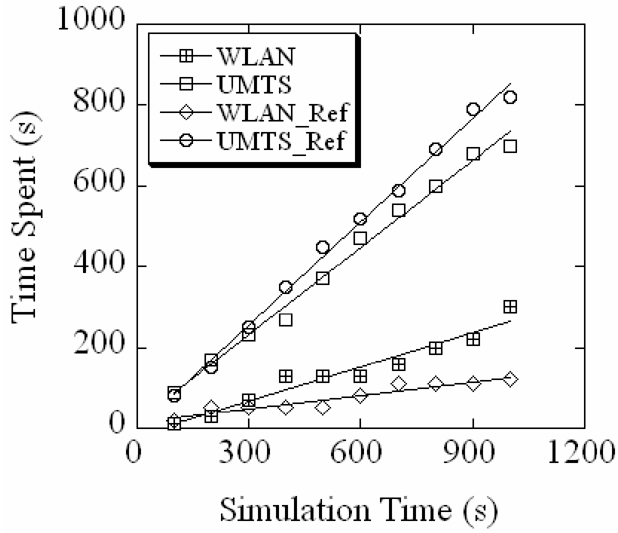


Figure 4: Time spent in different networks for referenced and proposed work.

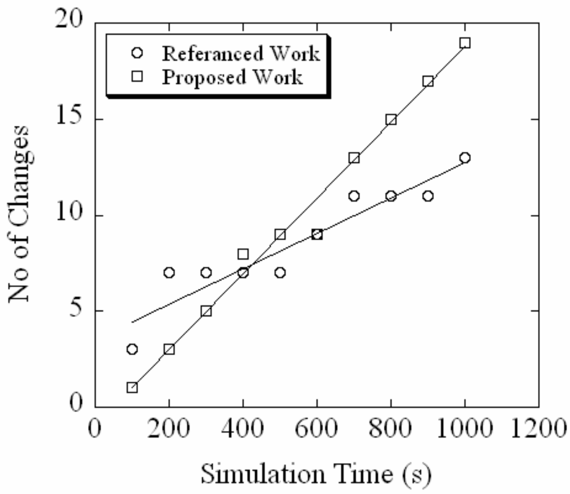


Figure 5: Number of changes between networks for the reference and proposed work.

Comparing the two algorithms, it is clear that the proposed algorithm has much better chance for providing high bandwidth support for real-time operation compare to the reference algorithm, because the proposed algorithm stays longer time in WLAN. Also, since the proposed algorithm compares the of score function before switching between networks which does not considered in the reference algorithm, it provides user the benefits of accessing desired network for non-real-time operation.

It is expected that the proposed algorithm can handle vertical handover operation for multi-network access enable mobile device. Our aim is to provide maximum bandwidth for real-time operation by switching to WLAN network when it is available and switch between networks according to the user preference in case of non-real-time operation. In doing so, we found that the number of switches is higher compare to other reference algorithm. The drawback is to be observed in the subsequent work.

# 6 Conclusions

From the result and comparison with the reference algorithm, it is clear that this algorithm can be a good choice for implementing vertical handover mechanism in mobile devices, because both real-time and non-real-time operations have been taken into consideration before implementing this algorithm. Since almost all the cellular operators have nation-wide coverage, so it has less chance of failing this algorithm. Finally, the large number of handovers might not be a big problem because the user will be unaware of the switches.

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