ESTIMATING HANDOFF MINIMUM LATENCY BASED ON SIGNAL STRENGTH AND HYSTERESIS IN MOBILE COMPUTING

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***ABSTRACT*:** Handoff is the process of maintaining a user's active sessions when a mobile terminal changes its connection point to the access network, while Handoff latency refers to the duration between the initiation and completion of the handoff process. Handoff commonly produces packet loss, delay and jilters, thereby significantly degrading the network performance and places additional burdens onto the internet infrastructures. The design of handoff minimum latency for mobile networks based on signal strength and hysteresis margin is considered. To demonstrate the working effectiveness of our scheme, we illustrated by way of a real world scenario where a coverage service of 3G network is available and a Java Modeling Tools for performance evaluation. It is clear that the time of handoff is critical in mobile networks and we would not tolerate the delay that comes with the hysteresis windows. The performance analysis on windows environment showed an improvement in minimizing the latency times.

***KEYWORDS*:** Latency, signal, strength, hysteresis, mobile Networks.

1. INTRODUCTION

There have been many challenges in the face of computing in the past decade, one of which is the undoubtedly the introduction of mobile computing. With an increasing number of wireless hotspots, cellular networks and featured mobile devices, mobile computing has become widely accepted as a useful and dependent tool. When a Mobile Station, MS, moves out of reach of its current Access Point, AP, it must be reconnected to a new AP to continue its operations. The search for a new AP and subsequent registration under its constitute the handoff process, which takes enough time called "Handoff Latency" to interfere with proper functioning of many applications [D+11]. Handoff is defined as the processes required for transferring the physical layer connectivity of a Mobile Node (MN) from one access point (AP) to another. In order words, a handoff in a cellular communication is the process whereby a mobile subscriber communicating with one base station is switched to another base station during a call [ZH94]. The design of handoff minimum latency for mobile computing based on mobile signal strength measurements is the core of our discussion in this paper. The design of a reliable handoff is crucial to the operation of a cellular communications system and is especially important in cellular systems, where the mobile may have to transverse several cells during a call. However, the time of handoff is critical in cellular mobile systems and we may not tolerate the delay that comes with hysteresis windows. The occurrence of handoff is the major source for degradation in mobile network performance and places additional burdens onto the Internet Infrastructures. This amount of delay and packet loss severely hinders the quality of interactive and streaming applications that are tolerant of delay and packet loss beyond certain threshold. Reducing their frequencies thus promises to ease roaming and to reduce infrastructural costs. Therefore, any handoff should aim to reduce handoff delays, as packet loss during handoff which affect end – user's applications [SS10]. The delay between the action and reaction of a measuring instrument is referred to as Hysteresis [D+11].

2. OVERVIEW OF HANDOFF PROCESSES

Handoff is the process of maintaining a user's active sessions when a mobile terminal changes its connection point to the access network called "point of attachment. Following the access network that each point of attachment belongs, the handoff can either be horizontal or vertical. A horizontal handoff takes place between points of attachment supporting the same network technology [SS10]. While, a vertical handoff occurs between points of attachment supporting different network technologies. A handoff process can be split into three stages: handoff decision, radio link transfer and channel assignment. Handoff decision involves the selection of the target point of attachment and the time of the handoff. Radio link transfer is the task of forming links to the new point of attachment, and channel assignment deals with the allocation of channel resources [KH10].

3. VERTICAL HANDOFF CRITERIA

Received Signal Strength (RSS) is the most widely used criterion because it is easy to measure and is directly related to the service quality. There is a close relationship between the RSS readings and the distance from the mobile terminal to its point of attachment. Majority of existing horizontal handoff algorithms use RSS as the main decision criterion for the VHD algorithms as well. Network connection time refers to the duration that a mobile terminal remains connected to a point of attachment. Determining the network connection time is very important for choosing the right moment to trigger a handoff so that the service quality could be maintained at a satisfactory level: for example, a handoff done too early from a Wireless Local Area Network (WLAN) to a cellular network would waste network resources while being too late would result in a handoff failure. Determining the network connection time is also important fir reducing the number of superfluous handoff, as handing over to a target network with potentially short connection time should be discouraged. The network connection time is related to a mobile terminal's location and velocity. Both the distance from the mobile terminal to its point of attachment and the velocity of the mobile terminal affect the RSS at the mobile terminal. The variation of the RSS then determines the time for which the mobile terminal stays connected to a particular network. Network connection time is especially important for VHD algorithms because heterogeneous networks usually have different sizes of network coverage. Available bandwidth is a measure of available data communication resources expressed in bits/s. It is a good indicator traffic conditions in the access network and is especially important for delay sensitive applications. Handoff delay refers to the duration between the initiation and completion of the handoff process. Handoff delay is related to the complexity of the VDH process and reduction of the handoff delay is especially important for delay sensitive voice or multimedia sessions.

3. STATEMENT OF THE PROBLEM

Mobile computing is becoming an increasingly important and popular way of providing global information access to users on the move. In a mobile environment, it is expected that a Mobile Node (MN) may experience a period of no network connectivity during its movement form one network to another. Therefore, packets in transit destined for the MN will most likely be lost during the handoff period (HP). Handoff in mobile networks commonly produces packets loss, delay and jilter, thereby significantly degrading the network performance. Hence, the occurrence of handoff is the major source for degradation in mobile network performance and places additional burdens onto the internet infrastructures. Mobile computing requires efficient mobility management to cope with frequent mobile handoff, because the handoff function is considered to be one of the mobile network issues having the greatest impact on mobility network. Therefore any handoff should aim to minimize the handoff delays, as packet loss during handoff will affect the end – users' applications. This is what we set to address in this paper.

4. LITERATURE REVIEW

A lot of work has been done to reduce the handoff latency when roaming between different subnets and many new schemes for mobile internet protocol (IP). In this paper, we focus on reducing handoff latency at MAC layer. MAC layer handoff latency is divided into three components: probe delay, authentication delay and association delay. The re-association delay which is the core of this study is reduced by using a caching mechanism on the access point side [SS10]. To eliminate unnecessary handoff in the method presented, [A+12] developed a VHD algorithms that takes into consideration the time the mobile terminal is expected to spend within a WLAN travelling time (i.e. time the mobile terminal is expected to spend within the WLAN cell and the calculations of a time threshold [VK97]. Handoff is the process of maintaining a user's active session when a mobile terminal changes its connections point to the access network called "point of Attachment", for example, a base station or an access point [ZH94]. The network connection time is related to a mobile terminal's location and velocity [Akh13]. Both the distance from the mobile terminal to its point of attachment and the velocity of the mobile terminal affect the RSS at the mobile terminal [Sin07]. The variation of the RSS then determines the time for which the mobile terminal stays connected to a particular network. [Akh13] suggested that available bandwidth is a measure of available data communications resources expressed in bit/s. It is a good indicator of traffic conditions in the access network and is especially important for delay – sensitive applications. Therefore, RSS and network connection time based decision criteria are widely $BS_{(s)}$ used. Now recall that in order to initiate a handoff, the movement of the mobile station form one cell to another must be detected. A reliable method to make this detection and to accommodate the movement is to measure the received signal strengths to the base stations and from the user. In order to avoid excessive and inaccurate handoff, an averaging of the received signal levels is performed as well as implementing a hysteresis margin. The total handoff delay is the sum of the signal averaging delay and the Hysteresis delay. We seek to determine this small delay. [D+11] developed an analytic approach to select the signal averaging time and hysteresis delay in order to obtain an optimum tradeoff between the total delay time and the number of allowable unnecessary handoff. In [SS11], some important parameters are given mathematical expressions.

5. METHODOLOGY

Our propose approach uses the received signal strength (RSS), threshold (T), Hysteresis margin (H), and weighted priority. Handoff is performed when new connection point (CP) has more weight than the old connection point i.e. $CP_{new} > CP_{old}$ and includes the following factors:-

1. RSS plus threshold; the RSS of a new CP exceeds that of the current one and the signal strength of the current CP is below a threshold, T, i.e. if $RSS_{new} > RSS_{old}.and.RSS_{old} < T$.
2. RSS plus Hysteresis: Rss of a new cp is greater than that of the old cp by a Hysteresis margin, H, $(i.e.if.RSS_{new} > RSS_{old} + H)$
3. RSS, Hysteresis and Threshold: RSS of new cp exceeds that of the current cp by a hysteresis margin, H, and the signal strength of the current cp is below a threshold, T, $(i.e.RSS_{new} > RSS_{old} + H.a_{old}nd.RSS_{old} < T)$

Figure 1 shows a MS moving from one BS (BS_1) to another (BS_2). The signal of (BS_1) decreases as the MS moves away from it. Similarly, the mean signal strength of (BS_2) increases as the MS approaches it. This scheme allows a user to handoff only when the BS is sufficiently stronger (by Hysteresis Margin, h, in figure 1), than the current one. In this case the handoff would occur at point C. The first handoff, T_1, however, may be unnecessary if the serving BS is sufficiently strong [KH10].

In position A, the decision is based on a mean measurement of the received signal, and it is observed to produce too many unnecessary handoffs, even when the signal of the current BS is still at an acceptable level. $T_2\ (Threshold_2)$, the MS would delay handoff until the current Signal strength crosses the threshold at position, B. Whereas in T_3, the delay may be so long that the MS drift too far into the new cell, thereby reduces the quality of communications link from BS_1 and may result in a dropped recall that in order to initiate a handoff, the movement of the mobile station from one cell to another must be determined.

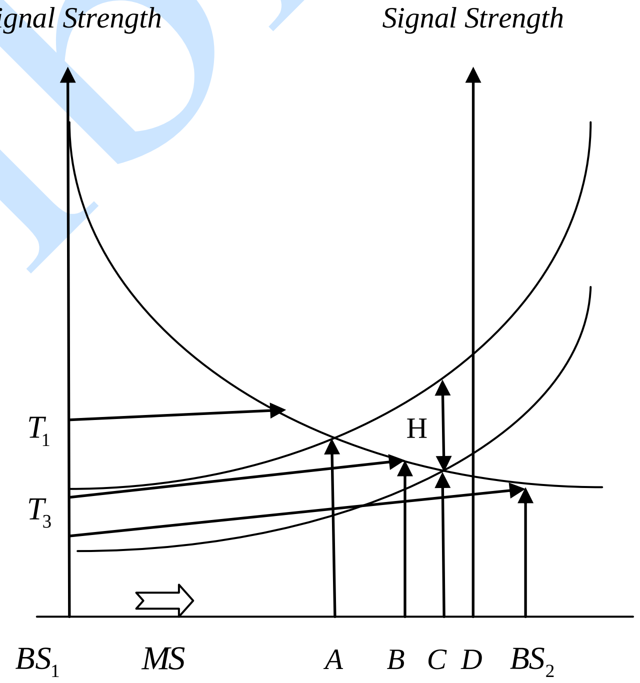

Figure 1: Signal Strength and Hysteresis between two adjacent BS for Potential Handoff

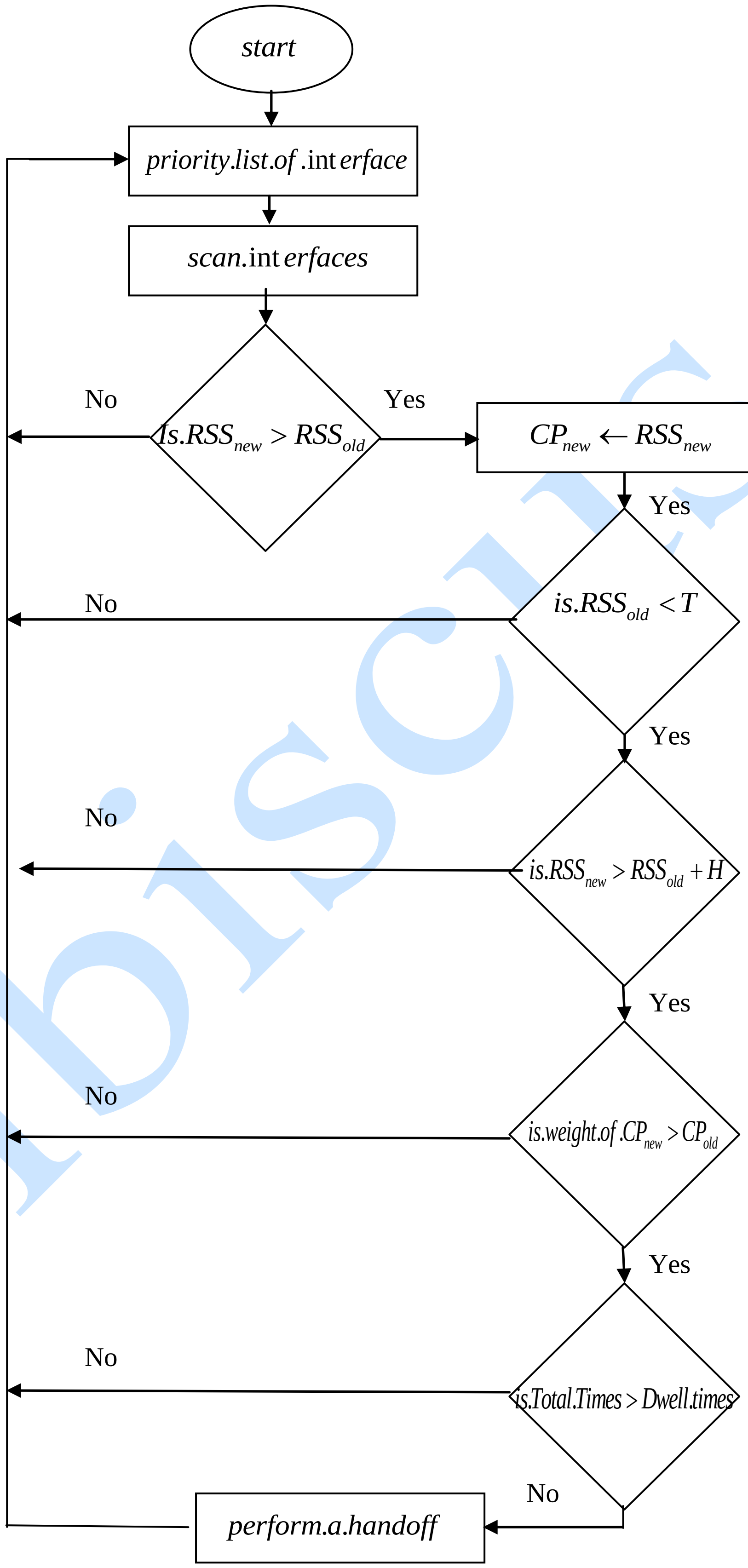

Figure 2: Network Selection Flowchart

A reliable method to make this detection and to accommodate the movement is to measure the received signal strengths to the base stations and from the user. In order to avoid excessive and inaccurate handoff, an averaging of the received signal levels is performed as well as implementing

Hysteresis margin. The total handoff delay is the sum of the signal averaging delay and the hysteresis delay. In [D+11], some important parameters are given mathematical expressions. It is shown that the probability of an unnecessary handoff is given as:

$$P_u = \left[\int_{-\infty}^{\infty} f(x)\left(\frac{1}{2} erf\left(x - \frac{h-\Delta L}{\sigma}\right)\right)dx\right]\left[\int_{-\infty}^{\infty} f(x)\left(\frac{1}{2} erf\left(x - \frac{h+\Delta L}{\sigma}\right)\right)dx\right] \quad (1)$$

where f(x) is the difference between the two received signal levels, h is the Hysteresis level.
For Macro, the total delay time is:

$$\partial_{hm} = \frac{T}{2} + K_{rv}\frac{10^{\frac{h-\sigma}{k_2}-1}}{10^{\frac{h-\sigma}{k_2}+1}} \quad (2)$$

where T denotes the signal averaging windows, K_2 represents a path loss constant, K_{rv} represents the normalized distance from the mobile station to base station.
For micro Cells, the total delay time is:

$$\partial_{hu} = \frac{T}{2} + T\frac{h-\sigma}{4d_{cor}} \quad (3)$$

where d_{cor} denotes the drop in signal level experienced in a street corner and determined experimentally. The analysis shows that there exists a compromise between the parameters of averaging time and Hysteresis delay. It is evident that for microcells, we may wish to choose short averaging time and a larger hysteresis. The converse is clear for macro cells. The main point here is that optimum parameter values may be selected for a tolerable delay in conjunction with some tolerable probability of unnecessary handoff [D+11].

6. IMPLEMENTATION

To demonstrate the working of the proposed approach, we developed a Vertical Handoff (VHD) algorithms that takes into consideration the time the mobile terminal is expected to spend within a WLAN travelling time (i.e. time that the mobile terminal is expected to spend within the WLAN cell) and the calculation of a time threshold. A handoff to a WLAN is triggered if the WLAN coverage is available and estimated travelling time inside the WLAN cell is larger than the time Threshold. The travelling time is estimated as:

$$t_{WLAN} = \frac{R - hs + V^2\left(t_s - t_{in}\right)^2}{V\left(t_s - t_{in}\right)} \quad (4)$$

where R is the radius of the WLAN cell, h_s is the distance between the access points, V is the velocity of the mobile terminal and $t_s.and.t_{in}$ are the times at which the RSS sample is taken. h_s is estimated by using the RSS information and log- distance path loss model. The time threshold T_{WLAN} is calculated based on various network parameters as:

$$T_{WLAN} = \frac{2R}{V} sin\left(\sin^{-1}\left(\frac{V\tau}{2R}\right) - \frac{\pi}{2}P\right) \quad (5)$$

where τ is the handoff delay from cellular network to WLAN and P is the maximum tolerable handoff failure, or unnecessary handoff probability. A handoff to the cellular network is initiated if the WLAN RSS is continuously fading and the mobile terminal reaches a handoff commencement boundary area based on the mobile terminals speed. The main advantage of this scheme is that it minimizes handoff delays, unnecessary handoff and connection break downs. The handoff delay is calculated based on the numerous parameters as:

$$\tau = T_{WLAN} + \frac{\pi R}{V}P \quad (6)$$

where $\left(T_{WLAN}\right)$ is the time threshold? Therefore RSS and network connection time based decision criteria are widely used in both horizontal and vertical handoff decisions. Handoff delay refers to the duration between the initiation and completion of the handoff process.

7. EVALUATION

To demonstrate the working effectiveness of our scheme, we illustrate by way of a real world scenario through a computer simulation, using an integrated frame work of JAVA Modeling Tools (JMT) for performance evaluation [BCS09], (see figure 3). The suite offers a rich user interface that simplifies the definition of performance models by means of graphical design. The parameterization of experiments requires minimal interaction with the users. In order words, [BCS06], (the JMT) hides the complexity of the core algorithms implementations, thus, significantly reducing the learning curve for users. The proposed approach showed an improved overall performance in reducing the number of handoff and minimizing the latency times (see figure 4).

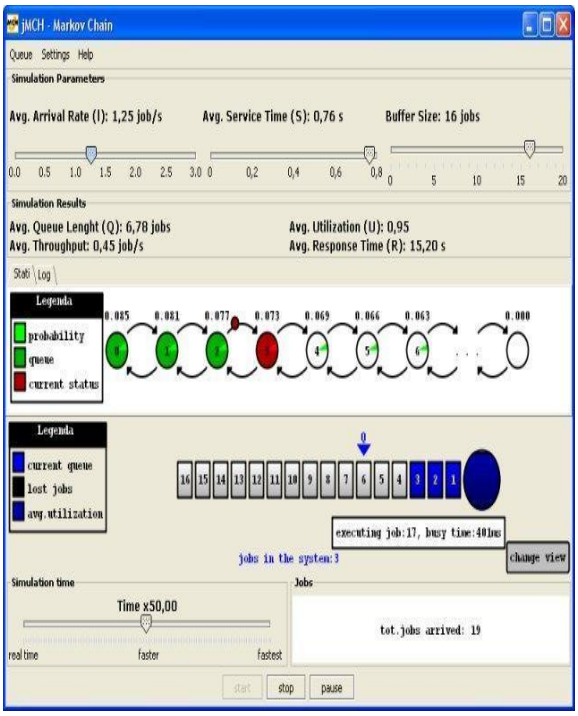

Figure 3: Computer Simulation

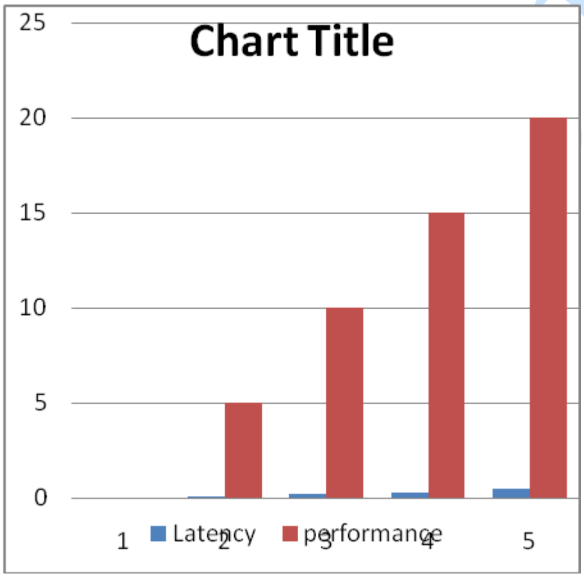

Figure 4: Simulation Result

CONCLUSION

This paper describes the handoff procedure and demonstrates how the handoff latency can be substantially reduced with a scanning algorithm. It is clear that the time of handoff is critical in mobile computing systems and we may not tolerate the delay that comes with the hysteresis windows. In order to initiate a handoff, the movement of the mobile station from one cell to another must be detected and a reliable method to make this detection and accommodate the movement was to measure the received signal strengths to the base station and from the user. The total handoff delay is the sum of the signal averaging delay and the hysteresis delay and we demonstrated how, in the best case, we were able to reduce the handoff latency to a barest minimum, using a scanning algorithm. The performance analysis in windows environment of the proposed approach, showed an improved overall performance resulting in reducing the handoff latency, which validates the effectiveness of our scheme.

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