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A Survey of Handoff Strategy and Fuzzy Logic with Desired Quality of Service

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Abstract

The major goal of reliable wireless technology and network are to provide excellent quality of service (QoS) to the user by enhancing the bandwidth. In traditional algorithm relative signal strength and other parameter are used for execution of the handoff mechanism, for after exploitment of the technique as fuzzy logic. This paper introduces a brief overview of efficient handoff mechanism and handoff related term and gives an overview of the proposed work. The work focuses on intelligent handoff terminology with fuzzy logic as desired Quality of Service (QoS).

Keywords: **Handoff, Wireless Network, Fuzzy Logic, Quality of Service**.

1. Introduction

Cellular communications provides communication facility to users called mobile stations (MSs). A service area is divided into a number of cells. Several such cells constitute a cluster. The available frequency spectrum is used in each cluster. Each cell in a cluster uses an available channels in the spectrum allocated according to a channel assignment strategy and is operated by a base station (BS). Handoff is a process of transferring a mobile station from one base station or channel to another. The channel change due to handoff occurs through a change in a time slot, frequency band, codeword, or combination of these for time division multiple access (TDMA), frequency division multiple access (FDMA), code division multiple access (CDMA) or a hybrid scheme, respectively. The handoff process determines the spectral efficiency and the quality perceived by users. Efficient handoff algorithms cost effectively preserves and enhance the capacity and Quality of Service (QoS) of communication systems.

It is necessary to ensure that handoff should be performed reliably and without disruption to any calls. Failing which, leads to dropped calls and customer dissatisfaction. Thus it is necessary to revive the handoff issues in cellular mobile systems. The process of handoff can be divided into three stages: decision stage, planning stage and execution stage. In the decision stage, predefined matrices parameters are measured by mobile unit to determine whether handoff should be initiated. In planning stage, the necessary resource (e.g. available bandwidth) in the candidate base station that the mobile unit would be handed over to is checked and assigned to the mobile unit. In the execution stage, connection is transferred from the serving base station to candidate base station and the appropriate protocols are performed.

The design of handoff management techniques in wireless networks must address the following issues:
(i) Delay should be minimized,
(ii) QoS level must be raised,
(iii) Network resources should be efficiently used, and they must be reliable
(iv) The handoff mechanism must be fast and initiated only if required after properly analyzing the parameters.

The paper reported here focuses on the decision stage of handoff process. Many of the existing handoff algorithms do not exploit the advantage of multi-criteria handoff, which can provide better performance than single criterion algorithms. This is due to the flexible and complementary nature of handoff criteria. A fuzzy based multi-criteria handoff algorithm is proposed as a solution to handoff decision. Following are the reasons for using fuzzy system:

- Fuzzy systems are conceptually easy to understand
- it brings in intelligence in the system
- Fuzzy system has been implemented in many engineering application with a considerable success
- Fuzzy systems are simple and hence easy to implement in hardware.

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2. Terminology used in Cellular System

Some of the already defined terminology used in cellular communications is explained as follow.
Mobile Station (MS): The mobile station can be a mobile in motion in a Wi-Fi deployed location.

Base Station (BS): The base station is a fixed station used for radio communication with Mobile Stations.

Base Station Controller (BSC): It handles radio channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile and the MSC. It assigns and releases frequencies and time slots for the MS.

Mobile Switching Center (MSC): The mobile switching center coordinates the routing of calls when it switches between different base stations connected to different Base station controllers.

Forward Channel: The forward channel is the radio channel used for the transmission of information from the base station to the mobile station. It is also known as the downlink.

Reverse Channel: The reverse channel is the radio channel used for the transmission of information from the mobile station to the base station. It is also known as the uplink.

When a MS moves out of reach of its current AP it must be reconnected to a new AP to continue its operation. The search for a new AP and subsequent registration under it constitute the handoff process which takes enough time to interfere with proper functioning of many applications.

Three strategies have been proposed to detect the need for hand off:

Mobile-controlled-handoff (MCHO): The mobile station (MS) continuously monitors the signals of the surrounding base stations (BS) and initiates the hand off process when some handoff criteria are met.

Network-controlled-handoff (NCHO): The surrounding BSs measure the signal from the MS and the network initiates the handoff process when some handoff criteria are met.

Mobile-assisted-handoff (MAHO): The network asks the MS to measure the signal from the surrounding BSs. The networks make the handoff decision based on reports from the MS.

3. Phase of Handoff

Handoff algorithms are designed to work in main three
phases:

3.1 Handoff Initiation phase

We define following notation with reference to Figure-1, which shows handoff from current base station (BS) referred as BS1 to a new base station referred as BS2.

S_{min} **:** It is the minimum Received signal strength (RSS) for acceptable voice quality for communication between Mobile Terminal (MT) and BS1.

S_{th} **:** The threshold value of RSS to initiate handoff. Therefore when RSS of BS1 drops below S_{th} the MT initiate handoff to new base station i.e. BS2.

$\Delta = S_{th} - S_{min}$: This margin is called Δ should not be very large (for unnecessary handoff) or too small (leading to call drop due to weak signal before handoff is completed). During the course of movement, the MT discovers that it is going to move into the coverage area of the BS2 and hence needs to perform hierarchical Mobile IP (HMIP) registration with the BS2. The MT may learn about the possibility of moving into another cell when the RSS of BS1 decreases continuously. Once the MT discovers that it may enter into the coverage area of the BS2, the next challenge is to decide the right time to initiate HMIP registration procedures with the BS2

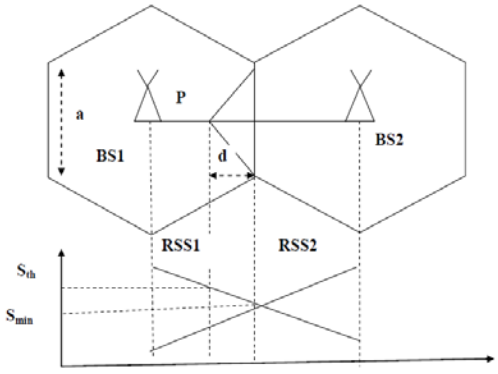

Fig. 1 Analysis of handoff process.

The existing link-layer-assisted HMIP protocols propose to initiate the HMIP registration when the RSS from the serving BS, e.g., BS1 in Figure-1 drops below a fixed threshold value (S_{th}). Below, we analyze the performance of these solutions. We assume that, during the course of its

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movement, when the MT reaches the point P (the distance of P from the cell boundary is d) as shown in Figure-1, the RSS from the BS1 drops below S_{th}. Therefore, when the MT reaches P, it initiates the HMIP registration with the BS2. At this point, the RSS received by the MT from BS2 shown as RSS2 in Figure-1 may not be sufficient for the MT to send the HMIP registration messages to BS2. Hence, the MT may send the HMIP registration messages to BS2 through BS1. This is called preregistration [1]. For a smooth and successful handoff from BS1 to BS2, MT's HMIP registration with BS2 and link and MAC layer associations with BS2 must be completed before the RSS of BS1 drops below S_{min}, i.e., before the MT moves beyond the coverage area of BS2.

3.2 Handoff Decision phase

During this phase, decision about the optimal access point is taken on the bases of parameters like RSSI, bandwidth, Signal-to-noise ratio, data rate ratio, etc. As a mobile node move between different Base stations, a handover process is needed to change its point of attachment to the optimal AP in the network. Traditional methods were based on one metric i.e. Received Signal Strength Indicator) which alone cannot perform well in handover decision making process so it is a pressing need to develop an intelligent approach to predict the handover decision process, thus yielding seamless handovers.

3.3 Handoff authentication and re-association phase

The re-authentication process involves re-authentication and re-association to the selected optimal AP. The re-authentication phase is used by the MS to establish its identity with the new AP with which it is going to establish link during handover.

During this phase, the MS sends a re-authentication frame to the selected AP and receives the re-authentication frame as acknowledgement. Once the re-authentication is completed, the re-association process starts in order to enable the existing established association to be transferred from the old AP to the newly selected AP. The MS sends an 802.11 Re-association Request frame to the AP and receives a re-association response from the AP.

4. Handoff Types

Handoff divided two types:

4.1 Hard handoff and Soft handoff:

Hard handoff term is used when the communication channel is released first and the new channel is acquired later from the neighboring cell. Thus, there is a service interruption when the handoff occurs reducing the quality of service. Hard handoff is used by the systems which use time division multiple access (TDMA) and frequency division multiple access (FDMA) such as GSM and General Packet Radio Service (GPRS). In contrast to hard handoff, a soft handoff can establish multiple connections with neighboring cells. Soft handoff is used by the code division multiple access (CDMA) systems where the cells use same frequency band using different code words. Each MS maintains an active set where BSs are added when the RSS exceeds a given threshold and removed when RSS drops below another threshold value for a given amount of time specified by a timer. When a presence or absence of a BS to the active set is encountered soft handoff occurs. The sample systems using soft handoff are Interim Standard 95 (IS-95) and Wideband CDMA (WCDMA).

4.2 Horizontal and Vertical handoff:

Handoff between homogenous networks where one type of network is considered is called horizontal handoff. On the other hand, handoff between different types of networks is also possible. A handoff in such a heterogeneous environment is named vertical handoff. The study in this paper is based on horizontal handoff.

5. Related Work

P. Dhand et al. (2013) proposed an intelligent handoff algorithm based on fuzzy logic. In this paper, a handoff algorithm termed as Fuzzy controller for Handoff Optimization (FCHO) is introduced based upon fuzzy logic. Traditional algorithms for handoff using fixed values of parameters can perform well only in specific environment but FCHO exploits attractive features of several existing algorithms, and adds more capabilities to provide adaptation to the dynamic environment [2]. **R. Sepúlveda et al. (2012)** designed an algorithm to first determine the Access Point (AP) under whose coverage area the Mobile Station (MS) would enter, then scanning the channels 1, 6 and 11, if present under the next Access Point (AP), to reduce the scanning delay. They also introduced pre-authentication mechanism, which effectively reduce the message processing delay [3]. **A.A. Atayero et al. (2012)** reviewed various applications of the core soft computing methodologies in mobile and wireless communications. The advantages of using soft computing include robustness, cost effectiveness and simplicity.

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Though the application areas can be broadly classified into optimization, uncertainty management and prediction, combining soft computing techniques had shown to effectively solve problems that cut across these boundaries. Genetic algorithm shown to be very useful in optimization problems such as network design, antenna design and resource allocation [4].

6. Overview of Fuzzy Logic

During the sixties, Professor Lotfi Zadah, of the University of California at Berkeley, proposed a mathematical way of looking at the intrinsic vagueness of the human language, he called his approach "Fuzzy Logic"[5] and presented as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership.

Fuzzy logic starts with the concept of a "fuzzy set". A fuzzy set is a set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership. A classical set is a set that wholly includes or wholly excludes any given element.

Fuzzy set theory allows the gradual transition from full membership of a set to full non-membership (though not simultaneously) [6]. Thus fuzzy set theory is a generalization of classical set theory. In fuzzy set an element is related to a set by a membership function μ. As an example, consider a fuzzy set A and an element x, the membership function μA(x), specifies the relationship of x to A. The membership function usually takes on a value between 0 and 1, i.e., μ [0,1] where 1 is for full membership, 0 for the null-membership, while values in between give the degree of membership. Fuzzy logic uses linguistic variables to map the input fuzzy variables to the output fuzzy variable(s) by using fuzzy IF-THEN rules.

7. Proposed Algorithm

Traditional algorithms for handoff using fixed values of parameters can only perform well in specific environment. But in this paper the value of threshold i.e 'MT' and 'hys' are purely changing with the change in the data rate, SINR and RSSI of the current Access Point. This chapter presents an intelligent approach for the design of handoff algorithms that exploits attractive features of several existing algorithms, and adds more capabilities to provide adaptation to the dynamic environment. The improved FCHO algorithm is an improvement over [2] which exploits several fuzzy logic attributes after proper analysis and study of system to be considered and tries to resolve conflicting requirements, and obtain high performance in a multifaceted wireless environment.

So it was found that making the parameters adapted to the changing signal strength and interference in the signal can bring improvement to handoff performance. The conventional handoff decisions are normally a single metric based i.e. RSSI, which alone is not suitable for current mobile system. In order to maintain a continuous and reliable link between the MS and the base station in a PCS system, a new and better handoff algorithms must be needed to keep QoS as high as possible. Handoff algorithms, based on soft computing techniques such as Fuzzy Logic, Neural Networks etc can be used for the same purpose. The purpose of this work is to design and implement a generalized framework for the design of Fuzzy Logic based handoff controller. The tools used are: MATLAB 7.10.0 for designing FIS and Simulink for fuzzy controller designing is proposed.

8. Conclusions

In this paper, we discuss about handoff and its related terminology, phase, types and also a fuzzy logic system. The proposed system aims to help designers decide a proper set of handoff performance metrics that are required to access the software early in process thereby reducing complexity and improving the continuing capability of the design.

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