

Comprehensive study of Handoff Strategy-A Survey

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Abstract: No doubt that due to advancement in wireless technologies and networks, more efficient measures has to be taken to enable the mobile users to be always connected to the best available access network depending on their requirements. For efficient delivery of services to the mobile users, the next-generation wireless networks require new mechanisms of mobility management where the location of every user is proactively determined before the service is delivered. Moreover, for designing an adaptive communication protocol, various existing mobility management schemes are to be seamlessly integrated. Efficient handoff mechanisms are essential for ensuring seamless connectivity and uninterrupted service delivery. This paper gives a brief overview of the handoff related terms and gives an overview of the proposed work. The proposed work focuses on handoff algorithm which selects a good quality access point among the available access points.

General Terms

Keywords: Handoff, Wireless Networks, Received Signal strength Indicator (RSSI).

1. Introduction

Handoff management is the process by which a mobile node try to maintain its connection continuously when it moves from one access point to another. Depending on the movement of the mobile device, it may undergo various types of handoff. In a broad sense, handoffs may be of two types:

- (i) Intra-system Handoff (horizontal handoff) and
- (ii) Inter-system handoff (vertical handoff).

An inter-system handoff between heterogeneous networks may take place in following cases:-

- (i) When a user moves out of the current base station range and enters into overlapping area.
- (ii) When a user connected to a network chooses to handoff to because of availability of better service requirements,
- (iii) When the network load is increasing and it is required to be distributed among different systems.

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.

Some of the already defined terminology used in cellular communications is explained as follows.

- **Mobile Station (MS):** The mobile station can be a laptop or 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 (called handoff latency) to interfere with proper functioning of many applications. Three strategies have been proposed to detect the need for hand off:

- i. **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.
- ii. **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.

- iii. **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

2. DELAY IN HANDOFF

All the layers in the communication protocol stack contribute to the delay in a handoff.

- i. **Link layer delay:** depending on the access technology, an MS may go through several steps with each step adding its contribution to the overall delay before a new link is established. For example, a Wi-Fi link goes through the process of scanning, authentication, and association before being attached to a new access point. For intra-subnet handovers, where network layer configurations are necessary, link layer contributes the maximum to the overall delay.
- ii. **Network layer delay:** after completion of the link layer procedures, it may be necessary to initiate a network layer transition. A network layer transition may involve steps such as: acquiring a new IP address, detecting a duplicate address, address resolution protocol (ARP) update, and subnet-level authentication.
- iii. **Application layer delay:** the delay of this type is due to reestablishment and modification of the application layer properties such as IP address while using session initiation protocol (SIP). The authentication and authorization procedure such as extensible authentication protocol (EAP) includes several round-trip messages between the MN and the authentication, authorization and accounting (AAA) server causing delay in handoff.

3. PHASES OF HANDOFF

Handoff algorithms are designed to work in main three phases:

1. Handoff Initiation phase
2. Handoff Decision phase
3. Handoff authentication and re-association phase

1. Handoff Initiation: Handoff initiation is the procedure that tells that when to start the handoff mechanism. The main parameter based on which initiation begins is Received Signal strength Indicator.

Received Signal Strength Indicator roughly corresponds to how strong the signal and noise is in radio's receiver signal strength measured in dBm of both the mobile unit and the base station within a wireless environment. It is used to initiate a handoff. As MS starts moving away from the BS, RSSI value starts decreasing and gets stronger as it gets closer to the other base stations in range. So before signal fades out completely, handoff must be performed. So when to initiate handoff can be done in following four ways:-

1. Choosing strong RSSI
2. RSSI with threshold,
3. RSSI with hysteresis, and
4. RSSI with hysteresis and threshold.

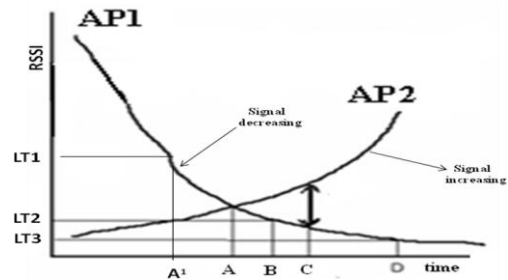


Figure 1: Existing handoff model

1. **Choosing strong RSSI:** The RSSs are measured over time and the BS with strongest signal is chosen to handoff.

In Fig. 1.1 at point A, the RSSI value from both the AP's coincides i.e. is same. But as MS moves away from AP1 further, the value of RSS of AP2 start increasing exactly after point A and handoff is requested.

a. Disadvantage of choosing RSSI

When the mobile station moves near the cell boundary of two base stations, the received signal strengths from the both the base station will be very close (point A in the figure). Moreover, the strength of signal will be more susceptible to shadowing effect, and be likely to cause handoff between the two base stations back and forth constantly. This problem due to which MS switches between two base station and causes unnecessary handoff is called ping-pong effect. No doubt that previous link was well adequate and that handoffs occurred unnecessarily

2. RSSI with Threshold: RSSI with threshold introduces a lowest threshold which is defined as the minimum signal strength required for continuation of services of MS. It is normally assumed to lie between -90dBm to -100 dBm. If RSSI is less than LT2, the call is assumed to be lost, therefore handoff is required in this case. When the MS is approaching the cell boundary, RSSI goes on decreasing. Handoff is initiated if its value drops below LT2. The handoff request is issued at point B in Fig. 3.1.

3. RSSI with Hysteresis: This technique uses a hysteresis value 'hys' to remove the problem of ping-pong during handoff initiation. Handoff is requested when the AP2's RSS exceeds the AP1's RSS by the hysteresis value. (Point C in Fig 1)[10].

$$\text{If } \text{RSSI}[\text{AP2}] - \text{RSSI}[\text{AP1}] = \text{hys.}$$

4. RSSI with Hysteresis and Threshold: The last technique combines both the threshold and hysteresis values concepts to come with a technique with minimum number of handoffs. The handoff is requested when the BS1's RSS is below the threshold (LT2 in Fig.3.1) and BS2's RSS is stronger than BS1's by the hysteresis value 'hys' (point C in Fig.3.1). If we would choose a lower threshold than LT2 (but higher than LT3) than the handoff initiation would be somewhere at the right of point C.

All the techniques discussed above initiate handoff before point D where it is the "receiver threshold". Receiver threshold is the minimum acceptable RSS for call continuation (LT3 in Fig. 1) [1]. If RSS drops below receiver threshold, the ongoing call is than dropped. The time interval between handoff request and receiver threshold enable cellular systems to delay the handoff request until the receiver threshold time is reached when the neighboring cell does not have any empty channels. This technique is known as queuing handoff calls.

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. 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. IEEE 802.11 supports several authentication schemes such as:-

1. Open System authentication,
2. Shared Key authentication,
3. WPA/WPA2 authentication and
4. 802.1X Port-based Network Access Control.

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. During re-association, the APs involved also exchange station context information via the use of IAPP.

The IAPP ensures that an MS maintains only a single association with the wireless network at a specific time and is used for the secure transfer of state and context information between APs involved in a re-association process. The context of a mobile station consists of the association states, timestamp, sequence number, BSSID, capability, security information, QoS, header compression, and AAA information

The association and re-association phases change an MS's point of connectivity to the network. When an MS first associates to an AP, the AP broadcasts an Add-Notify packet to all other APs, triggering the MS's current association. Upon receiving an Add-Notify packet, the other APs clear all stale associations and state for the specific station to enforce a single point of association for the station.

During the re-association process, the new AP can optionally send a Security Block packet to the old AP in order to establish a secure communication channel for transferring the station context information and receive an Ack-Security-Block packet as acknowledgement. Once the secure communication channel is established, the new AP sends a Move-Notify packet to the old AP to request for the station context information. Then, the old AP replies with a Move-Response packet for acknowledgement.

4. HANDOFF TYPES

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)

2. Horizontal vs. 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 [1]. **D. Sarddar et al. (2011)** have reduced handoff latency by reducing the number of APs to be scanned which is accomplished by cell sectoring and distance measurement with help of GPS but still cannot remove ping pong effect which can be may be minimized by using received signal strength method along with their proposed algorithm and hence left for future[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. 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 (and other evolutionary computing techniques) shown to be very useful in optimization problems such as network design, antenna design and resource allocation [4]. **V.K. Reddy et al. (2011)** presented an analytical framework to evaluate VHO algorithms. This framework can be used to provide guidelines for the optimization of handoff in heterogeneous wireless networks. Subsequently, they extended the traditional hysteresis-based and dwelling-timer-based algorithms to support both VHO and HHO decisions and apply them to complex heterogeneous wireless environment [5].

6. PROPOSED HANDOVER SCHEME

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 AP. 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 [1] 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 7.5.0 for designing FIS and Simulink for fuzzy controller designing. is proposed, and a complete design procedure is described.

The proposed Fuzzy controlled handoff optimization algorithm occurs at Layer 2 and Layer 3. A layer 2 handover occurs when a mobile station signals start decreasing and to enjoy continuation of services it changes its connection changes from one access point to another. This type of handover involves releasing the connection to the old access point, establishing a connection to the new access point and updating the binding between a mobile host's IP address and its temporary layer 2 identifier (e.g. a MAC address) on the subnet work at the access router. If the old connection is released before the new connection is established (break before- make handover), data reception is interrupted for a short period of time. The service disruption can be avoided if the mobile host is capable of establishing connections to multiple access points simultaneously. It can then connect to the new access point before breaking its connection to the old access point (make-before-break handover). . In this case the handover has no effect outside the sub network and is usually fast enough to go unnoticed by the user. If both access points involved in a layer 2 handover are part of the same subnet work, the mobile host's IP address can remain the same. But if they are on different networks then Layer 3 i.e. Network layer is involved.

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