



HANDOFF MANAGEMENT:ISSUES AND CHALLENGES

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Abstract: Mobility management is very essential component for the next generation Wireless networks. Today research studies are focusing on customer satisfaction and user preferences. As technology will grow further handoff process to handle mobility in heterogeneous networks becomes of utmost importance. In this paper, different set of metrics, and issues of handoff have been discussed. The paper discusses underline concepts of handoff and few algorithms based on various methods such as fuzzy logic, genetic algorithms, neural networks, etc. This paper also focuses on issues still remaining and need to be focused for building up of an efficient algorithm for handoff management.

Keywords: Fuzzy logic, Received Signal Strength Indicator (RSSI), Handoff, Heterogeneous Networks

I. INTRODUCTION

The field of wireless networks has seen many new exciting enhancements over the last few years. The future vision of heterogeneous wireless technologies will allow the mobile users to roam freely and have access to internet related services anywhere at any time from any available wireless access network. But handling mobility issues in heterogeneous environment is not an easy task. The increasing user demand for seamless connectivity with guaranteed Quality-of-Service (QoS) requires an efficient mobility framework for next generation heterogeneous networks

Handoff refers to the process by which an active MN changes its point of attachment to the network, or when such a change is attempted. Horizontal handoff or intra-technology handoff refers to handoff between Base Station (BS)'s using the same type of network interface. This is found in homogeneous circuit-switched cellular systems such as GSM and CDMA networks. It is used to maintain the seamless connectivity for various data services.

Vertical handover or inter-technology handoff takes place between varied networks which differ on the basis of their access technologies. It is further categorized as:

- a. *Upward vertical handoff:* An upward vertical handoff occurs when a mobile node moves from a base station with smaller radio coverage to a base station with wider coverage.
- b. *Downward vertical handoff:* A downward vertical handoff occurs in the opposite direction of an upward vertical handover i.e. when a mobile node moves from a base station of wider coverage to a base station of smaller coverage.

The most important requirement of the heterogeneous wireless networks is providing seamless mobility where seamless refers to the fact that handoff from one access network or base station to another is imperceptible to the mobile node (MN) user. While providing continuity of services the desired level of QoS should also be maintained. For satisfying the desired level of QoS for different traffic

classes, an intelligent and efficient vertical handoff algorithm is needed. Moreover, the process of network selection is a very difficult and multifaceted problem, since it involves multiple criteria and uncertain qualitative factors which are difficult to measure. The difficulty in selecting access network for handoff has increased due to the ambiguity of the innovative technology and lack of experts in the field.

Before going into detail about what these algorithms are doing in current scenario, it's very important to understand the working, strategy, management, types and issues concerning the Handoff. Section II discussed the related work in this field. Section III discusses the working of Handoff process. Section IV focuses on issues and challenges need to be focused in next handoff algorithm deal with multiple problems.

II. RELATED WORK

Mobility management in next generation heterogeneous networks is of major concern. No doubt this heterogeneous environment will provide better coverage but its complexity cannot be ignored. A large of researches, surveys and studies have been published before to optimize the Base station selection criteria for handoff.

These researches are based on following strategies:

1. MADM approaches
2. Probabilistic method
3. Markov chains
4. Soft computing techniques like fuzzy logic, neural networks and genetic algorithms.
5. Adaptive algorithms based on certain metrics.
6. Context aware algorithms.

Multi metric based handoff algorithms are being employed in this multifaceted heterogeneous environment such as authors in [2] proposed a vertical handoff algorithm for Intelligent Transportation System. In this procedure, handoff is being triggered on the basis of the value of Received Signal Strength (RSS). Along with AHP, author has used fuzzy logic to remove uncertainties related to condition of real environment. In previous work, author made an adaptable algorithm but added intelligence in this algorithm.

S.Dhar *et. al.* in [3] proposed a context aware vertical handover algorithm which uses TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), for decision making and is tested by simulating a virtual road. The optimal network selection is done on the basis of metrics such as network load, velocity, data rate, usage cost and delay. The networks assumed in scenario are WiMax, WLAN and UMTS.

P. Dhand *et al.* in [4] investigated an adaptive Fuzzy controller for Handoff Optimization (FCHO) considering multiple metrics for decision making. This paper was an author's attempt to remove ping-pong and corner effect by dynamically changing the value of threshold and hysteresis with the change in the RSSI and the velocity of the mobile station. Further, the paper was extended in [5][6][7] to find the application of fuzzy based algorithm in smart cities.

Over years authors have proposed several schemes for minimizing handoff latency in IEEE 802.11 wireless LANs. In [8] authors have reduced handoff latency by decreasing the number of scanned APs. This is achieved through cell sectoring and distance assessment using GPS. However, their scheme was not successful in removing ping pong effect.

Authors in [9] examined handover latency in Wireless Local Area Networks by which using signalling process for traffic control between AP and MN.

Authors in [10] authors also proposed a new scheme to reduce handoff latency for IEEE 802.11 wireless networks. Using the channels and 8 others by selective scanning the authors were successful in reducing the handoff off delay, authentication as well as re-association delay.

III. HANDOFF PROCESS

Handoff is the process by which a link is transferred from one base station to another due to lack of signal strength. Handoff process involves many operations including initiation of handoff, allocation of channel, breaking with old base station, choosing the new base station, loading, unloading etc. [11]. The design of handoff process has a complete life cycle starting from requirements and analysis phase to maintenance. It involves:

- (i) Requirement and Analysis
- (ii) Availability of network resources
- (iii) Measuring of signal strength
- (iv) Measuring of other performance metrics

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

- i. **Mobile-controlled-handoff (MCHO):** The mobile node keeps on monitoring the signals of the current and neighbouring base stations and triggers handoff as and when required.
- ii. **Network-controlled-handoff (NCHO):** The base stations monitor the signal between mobile node and the network. It initiates handoff process when there is weakening of signals as mobile node moves away from the station.
- iii. **Mobile-assisted-handoff (MAHO):** The mobile node assists network to measure the signal strength between the mobile node and the base station. The networks make the handoff decision based on reports from the mobile node.

A. Delays in handoff

Handoff is a process which involves the contribution from many layers of OSI model. Physical layer is used to collect the values of RSSI, SINR and other environmental parameters. Datalink layer executes horizontal handoff. Network layer is responsible for vertical handoff. Many protocols like SIP, MIP which support handoff sit at session layer and SCTP which helps in multistreaming during soft handoff is at transport layer [12].

The complete handoff process is carried out by co-ordination and co-operating entities of different layers of OSI model. But this does not leave a process without delay [13]. When data has to be passed between different layers many kind of delay is introduced which may hinder in QoS of handoff.

1. **Link layer delay:** This layer is responsible for horizontal handoffs. Before the mobile node switches to neighbor base station, scanning is done. During scanning, mobile node scans the nearby base stations if available. It takes some time and sometimes mobile disconnects and then connects to new base station. This kind of delay which is introduced during scanning and call setup with new base station is link layer delay
2. **Network layer delay:** This layer is responsible for vertical handoff which involves obtaining the IP address of new network and then switching the call from one network to another which may take more delay .further congestion in the network introduces more delay. Thus this kind of delay is called network delay.
3. **Transport Layer delay:** Many protocols sit at this layer to monitor and manage transport layer handoff. Most important protocol in this case is SCTP which is responsible for multihoming and multistreaming during handoff. SCTP makes new connection with the neighbor network/base station while maintaining connection with the old. As new connection gets stable, it breaks the old connection. This disconnection can be delayed due to re-authentication or re-association phase.
4. **Application layer delay:** this delay occurs when certain properties of application layer get modified e.g. change in IP using Session initiation protocol [14].

B. Handoff Phases

The vertical handoff process can be divided into three main steps [15], [16], namely

1. Handoff initiation phase
2. Handoff decision making phase, and
3. Handoff re-authentication or re-association phase (also called Handoff execution phase)

1. Handoff Initiation Phase

This phase decides the requirement of handoff. It triggers handoff on the basis of information collected about network, mobile node and user preferences from different layers likes' network layer, transport layer and application layer. These layers provide the information such as signal strength, bandwidth, link speed, throughput, jitter, cost, power, user preferences and network subscription etc. Based on this information, handoff is initiated at appropriate time.

2. Handoff Decision Phase

After initiating handoff in first phase, the decision making phase decides the optimal networks for handoff. The comparison is made between the current and neighbouring networks based on parameters such as QoS, signal strength, velocity, direction, cost, etc. There are many methods proposed to take decision about networks such as MADM approaches, fuzzy logic, genetic algorithms, for deciding the destination network. The decision making phase chooses the optimal network for transfer but the actual link transfer takes place in the next phase.

3. Handoff Execution Phase

After the selection is made and decision about the target network is taken, link transfer takes place in this phase in which the existing link is re-routed to the new network in a seamless manner. This phase also includes the re-authentication, re-association and re-authorization, and the transfer of user's context information.

C. Metrics of Handoff process

For horizontal handoffs, only two metrics are used for making the handoff decision - RSSI and channel availability. However, RSSI alone cannot be considered as a sufficient criterion for making the decisions. This may cause effects like ping-pong effect and corner effect, these two effects further lead to increase in the network overhead [17]. To be able to perform intelligent handoff in the next generation heterogeneous wireless environment and provide seamless vertical handoff, the following metrics are suggested:

1. *QoS metrics*: It includes parameters such as traffic, available bandwidth, network latency, and congestion (packet loss)[18] may need to be considered for effective network usage.
2. *System performance*: It includes parameters such as RSSI, channel propagation values, path loss, Inter-channel interference, signal-to-noise ratio (SNR), and the bit error rate (BER)[19].
3. *Application types*: It includes different types of services such as voice, data and multimedia and each of these applications require different levels of data rate, network latency, reliability, and security[20].
4. *Mobile terminal conditions*: It includes parameters such as screen size, portability, weight, performance (processing power, memory, and storage space), bandwidth requirements, networks supported, and dynamic factors such as velocity, moving pattern, and location information [21].
5. *Battery power*: This is a very important metric for handoff because in many situations wireless devices are operating in limited battery power. For example, when the battery level decreases, handing off to a network with lower power requirements would be a better decision [22].

IV. ISSUES AND CHALLENGES

Network selection is vital in future highly integrated pervasive 4G networking environment. A traditional way to

select a target network which is only based on the received signal strength (RSS) is not effective enough to make the best choice for those multimedia applications. The traffic characteristics, the user preference, and the network conditions should all be considered to maximize consumer satisfaction. Though some existing schemes do consider multiple criteria (e.g. QoS, security, connection cost, etc.) for network selection, there are still several problems unsolved. We not only provide a comprehensive way to select the optimal network, but also solve the rank irregularity problem. This proposed approach can be applied in handover scenarios, and also, for a terminal that allows using multiple network interfaces simultaneously, this network selection model can be employed to choose the best link for a specific traffic flow [23].

The upcoming next generation wireless networks will provide mobility in a continuous and seamless manner to its users. Hence, these wireless networks which are going to be based on heterogeneous access technologies must provide features such as inter-carrier handoff, personal mobility, and location management. Several issues and challenges of handoff are as follows:

1. *QoS issues*: These next-generation all-IP wireless networks will need to provide guaranteed QoS to mobile devices with reduced delay and on time service delivery. QoS provisioning will further add new problems to mobility management, such as location management for efficient access and on time service delivery, QoS negotiation during inter-system handoff, etc.
2. *Need of Smart terminals*: the design of a single user terminal that is able to autonomously operate in different heterogeneous access networks will be another important factor. This terminal will have to exploit various surrounding information (e.g., communication with localization systems, cross-layering with network entities etc.) in order to provide richer user services (e.g. location/situation/context-aware multimedia services). This will also put strong emphasis on the concept of cognitive radio and cognitive algorithms for terminal re-configurability.
3. *Problem of overlapping networks*: These networks are going to be hierarchical with access networks having different coverage areas. Mobility management in wireless overlay networks will be a very vital issue to handle in handoff management.
4. *Mobile services*: Complicated 4G service discovery methods will merge location information and context-awareness of the mobile device in order to provide services in an optimal manner. Moreover, future mobile services will require more complex personal and session mobility management to provide personalized services to a user.
5. *Cross-Layer optimization*: These networks will need efficient and effective cross-layer-based solutions for incorporating new mobility management schemes.
6. *Other issues*: These networks will need to handle issues such as fault-tolerance, availability of network services, security, and intelligent packet and call routing schemes, intelligent gateway discovery.

V. FUTURE WORK

1. The work on handoff algorithms started near nineties when only a single metric was involved but soon more metrics were considered. Now it is the requirement to make these parameters more adaptive according to the changing environment and real life.
2. Use of appropriate simulator like Qualnet and Opnet Modeler for comparative analysis of soft handoff and hard handoff can be considered.
3. Along with RSSI and velocity, direction must also be considered for getting the accuracy of the movement of the mobile node.

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