A Research on Vertical Handoff for Next Generation Wireless Networks

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Abstract: - Today, the world is moving very fast because of latest technologies and its innovations. Every user expects the best service network rather than best connected network. At the same time everyone would like to be connected seamlessly anytime anywhere. The Next Generation Wireless Networks (NGWN) must have the capability to provide high data transfer rates, quality of Services and seamless mobility. In NGWN, there are a large variety of heterogeneous networks. The users for variety of applications would like to utilize heterogeneous networks on the basis of their preferences such as real time, high availability and high bandwidth. Success of mobile communication relies on its continuous service provided to the user. It is possible only through handoff process. In this paper, we have extracted the requirements of a vertical handoff from the literature surveyed, various proposals of handoff decision strategies, the evaluation of the existing work is also being done on the basis of required parameters for vertical handoff.

Keywords- VHO, seamless handoff, handoff performance metrics, next generation wireless networks, handoff classification, handoff decision.

I. INTRODUCTION

Mobility is the most important feature of today's wireless networking system. Mobility can be attained by handoff mechanisms in wireless networks. Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of them for TDMA, FDMA, CDMA, or a Hybrid Scheme) associated with the current connection while a call is in progress in order to provide uninterrupted service to the mobile subscriber. The wireless technology beyond 4G is known as NGWNs, Which will provide support for heterogeneous access technologies. The mobile node can connect to any available network (e.g. GPRS, UMTS, WLAN, WI-MAX, BLUETOOTH etc.) These wireless networks are combined to offer high data rate and best services to the mobile nodes, but for accessing different wireless networks there is a need for vertical handoff decision.

A seamless handoff is defined as a handoff scheme that maintains the connectivity of all applications on the mobile device when the handoff occurs. Seamless handoffs aim to provide continuous end-to-end data service in the face of any link outages or handoff events the rest of the paper is organized as follows: Section II explains types of handoffs. Section III explains three phases of vertical handoff process. Section IV depicts the structured classification of VHO on various scenarios Section V discusses the various static and dynamic parameters which should be considered during vertical handoff decision making. Section VI describes the existing algorithms to make vertical handoffs. Section VII gives the reasons for handoff failures. Section VIII presents the assessment of the existing work. Finally, section IX concludes the survey.

II. TYPES OF HANDOFF

Handoff can be classified into two types: Horizontal Handoff (Symmetric), which means the handoff within the same wireless access network technology. Vertical Handoff (Asymmetric) means handoff among heterogeneous wireless access network technology.

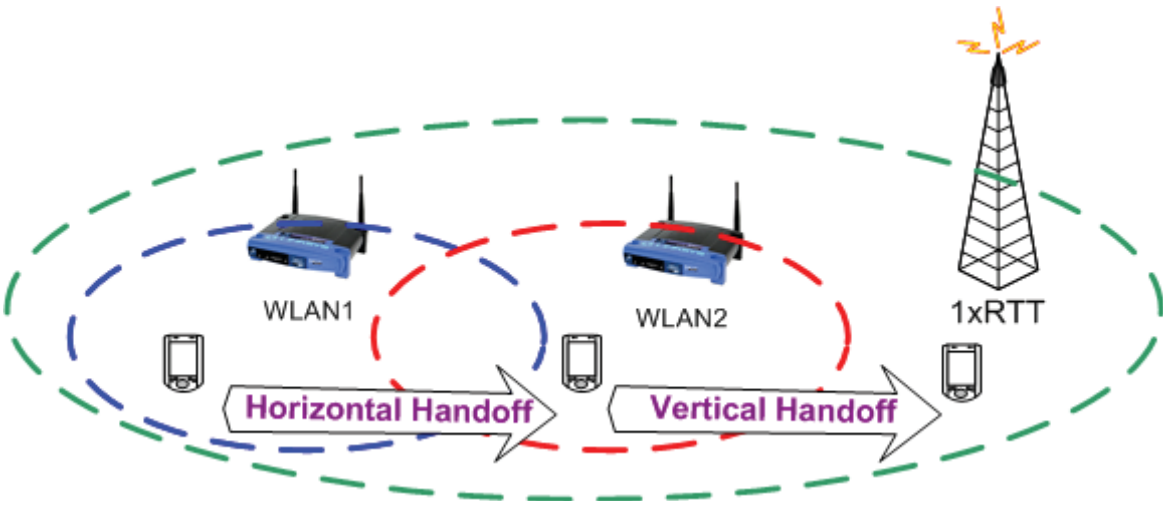

Figure 1: Horizontal & Vertical Handoff

a. *Horizontal handoffs* in a cellular network can be broadly classified into intra system and inter system handoffs.

Intra system Handoff: The horizontal handoff between two base stations (BS), under the same BSC is known as Intra system Handoff.

Intersystem Handoff: In Intersystem, handoff, handoff occurs between two base stations (BS) of different BSC. They occur when an MT moves into an adjacent cell and therefore, all the MTs connections should be transferred to the new BS

b. *Vertical Handoff:* The vertical handoff mechanism allows a terminal device to change networks between different types of networks (e.g., between 3G and 4G networks) in a way that is completely transparent to end user applications Vertical handoff is again classified into upward, downward, soft, hard, mobile controlled, network controlled, mobile controlled network assisted and network controlled mobile assisted handoff. Vertical handoff can be initiated for providing better Quality of service rather than connectivity.

Parameters	**Horizontal HANDOFF**	**Vertical HANDOFF**
Access Technology	Not Changed	Changed
Network Connection	Single	More than One connection
QoS Parameters	Not Changed	May be Changed
IP Address	Changed	Changed
Network Interface	Not Changed	May be Changed

Table 1: Comparison of Horizontal and Vertical Handoffs

III. HANDOFF PHASES

The handoff process can be divided into 3 phases:

Phase I: Handoff Initiation	Collects the information from different layers such as RSS, bandwidth, link speed, throughput, jitter, cost, power, link delay, link cost, user preferences & available bandwidth in order to trigger the handoff etc., based on this information handoff will be triggered in an appropriate time.
Phase II: Handoff Decision	Decides whether the connection to be continue with current network or switch to another. with the help of information collected during phase1
Phase III: Handoff Execution	Includes the authentication and authorization, for transferring of user's context information, from the Existing network to the new network in a seamless manner based on actual resource availability and the network load.

IV. STRUCTURED CLASSIFICATION OF VERTICAL HANDOFFS ON VARIOUS SCENARIO

1. Classification based on the behavior of a mobile terminal for allowing itself for a new connection. They are hard handoff and soft handoff
   a) *Hard handoff***:** Hard handoff also called "break before make", involves only one base station at a time. The mobile terminal must break its connection from the current access network before it can connect to a new network.
   b) *Soft handoff:* It is also known as "make before break", a mobile station can communicate and connect with more than one Access network during the handoff process.
2. Handoff are classified as four types with respect to 'Who controls the handoff decision
   a) *Network controlled handoff (NCHO):* In this, handoff decision is taken by network only But, these types of handoffs cannot be initiated at the right time because they don't have the information about the current circumstances of the mobile terminal. Also, a network cannot be made aware of the characteristics of all other networks. Therefore, it is not suitable for vertical Handovers. A network controlled handoff is suitable for only Horizontal handoff. They are used in 1st generation cellular system and needs approximately 100-200ms time for handoff completion.
   b) *Mobile controlled handoff (MCHO):* In this, mobile terminal takes the handoff decision. As mobile terminals have better knowledge of its current circumstances, this type of handoff is a better choice for vertical handover. They need approximately 0.1 second time for the handoff completion process. They are used in Mobile IP networks.
   c) *Network controlled & Mobile Assisted handoff: (NCMA):* In this, mobile terminal assists the network for handoff decision by collecting the primary information required for handoff this type of handoff is used in 2nd and 3rd generation cellular system. They needs approximately 1 second for completion of handoff process.
   d) *Mobile controlled & Network assisted handoff (MCNA):* In this, network assists the mobile terminal for handoff decision. MCNA handoffs are more suitable because only mobile nodes have the knowledge about the network interfaces they are equipped with and user preferences can be taken into consideration.
3. Handoff can be classified as forced handoff and user handoffs
   a) *Forced handoff:* They are mandatory handoff and are initiated due to poor network conditions. Or they are the handoffs which are stopped from happening due to unavailability of channels
   b) *User handoff:* They are initiated due to user preference rather than an inconvenience.
4. Vertical Handoff can be classified based up on its direction

a) *Upward Handoffs:* In Vertical Handoff, if the mobile switches from the network with a small coverage to a network of larger coverage, it is termed as upward handoff.
b) *Downward Handoffs:* a downward handoff occurs in the reverse direction, i.e. from a network of larger coverage to a network of smaller coverage.

5. Vertical Handoff can be classified based up on its process
   a) *Imperative handoffs:* When there is loss of signal strength an imperative handoff occurs. For imperative handoff the RSS is sufficient to be considered.
   b) *Alternative handoffs:* an alternative vertical handoff is initiated to provide the user with better performance. For alternative handoffs several other network parameters such as available bandwidth, supported velocity and cost of the network are to be considered in addition to the device parameters such as quality of service demanded by the application and user preference.

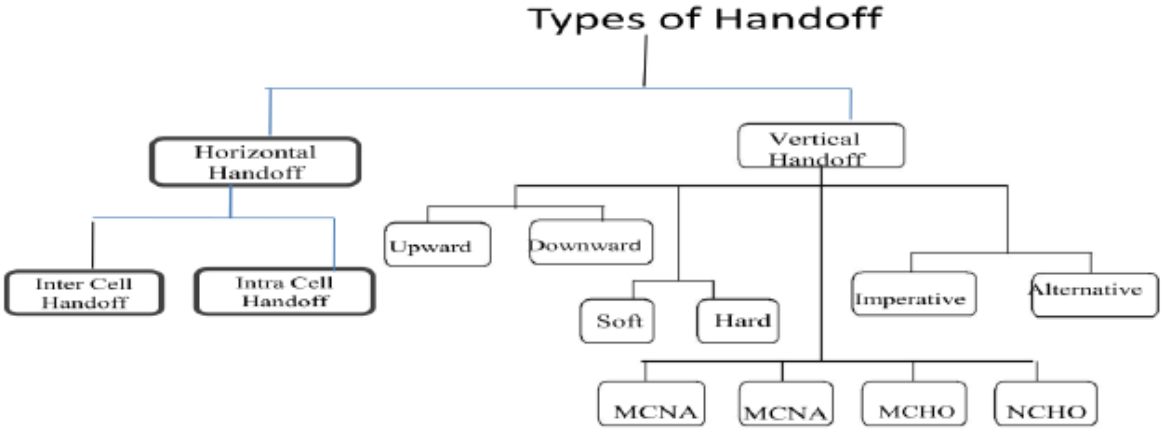

Figure 2: Types of Handoff

V. DECISION MAKING PARAMETERS

Handoff decision is taken based on consideration on various parameters such as:

a. *STATIC PARAMETERS* - Cost, Security, Power Consumption
b. *DYNAMIC PARAMETERS* – Bandwidth, Latency, Received Signal Strength, Throughput (data rate), Bit Error Rate, Reliability, User Preferences, Network Load Balancing, Velocity.
   i. *Bandwidth:* Bandwidth is a measure of the width of a range of frequencies it is generally known as the link capacity in a network. Higher offered bandwidth ensures lower call dropping and call blocking probabilities, hence higher throughput
   ii. *Handoff latency***:** Handoff of calls between two BS is encountered frequently and the delay can occur during the process of handoffs. This delay is known as handoff latency
   iii. *Power consumption:* The issue of power saving also arises in network
   Discovery because unnecessary interface activation can increase power consumption.
   iv. *Network cost:* A multi criteria algorithm for handoff should also consider the network cost factor. The cost is to be minimized during VHO in wireless networks.
   v. *User preferences:* The user preferences could be preferred networks, user application requirements (real time, non-real time), service types (Voice, data, video), Quality of service (It is a set of technologies for managing network traffic in a cost effective manner to enhance user experiences for wireless environments) etc.
   vi. *Network throughput:* Network throughput refers to the average data rate of successful data or message delivery over a specific communications link. Network throughput is measured in bits per second (bps).
   vii. *Network load balancing:* Network load is to be considered during effective handoff. It is important to balance the network load to avoid deterioration in quality of services.

viii. *Network security:* **S**ecurity is required to prevent and monitor unauthorized access, misuse, modification of network-accessible resources.

ix. *Received signal strength:* RSS depicts the power present in a received signal. A signal must be strong enough between base station and mobile unit to maintain signal quality at receiver. The RSS should not be below certain Threshold in a network during handoff.

x. *Velocity:* The velocity of mobile unit must be considered for a successful handoff.

xi. the Number of handoffs should be less

xii. Successful handoffs should be maximum

xiii. The effect of handoff on QoS should be minimum.

Figure 3 : Handoff Decision Criteria

However, it is important to consider maximum number of static and dynamic requirements during VHO but it is difficult to include all the metrics in a single decision model due to complexity of algorithms and conflicting issues of multiple metrics. An efficient VHO decision mechanism can not only enhance the system capacity but also improve the quality of services for a user.

VI. ALGORITHMS FOR IMPLEMENTING VERTICAL HANDOFFS

In the literature survey, various vertical handoff decision algorithms are discussed. These decision algorithms can be grouped as follows:

A. Traditional B. User Centric C. Fuzzy Logic and Neural network D. Context Aware E. Functional based F. Multiple Attributes Decision Making

The handoff schemes can be distinguished into Non-Prioritized Schemes (NPS) and Prioritized Schemes:

a. *Non-prioritized schemes:* in non-prioritized scheme handoff calls and new calls are served equally. When the BS has an idle channel, it is assigned due to first-come first-serve basis regardless of whether the call is new or a handoff call.

b. *Prioritized schemes***:** they ought to minimize both the CDP (Call Dropping Probability) and CBP (Call Blocking Probability) by giving the priority to handoff calls over new calls.

Based on the handoff criteria, handoff algorithms can be classified into two classes:

a. *Conventional handoff algorithms:* these algorithms are based on the signal strength, distance, velocity, power budget, and SIR.

b. *Intelligent handoff algorithms:* these are based on technologies such as fuzzy logic, prediction, pattern cognition, and neural networks.

Conventional Handoff Algorithms:

a. *Relative Signal Strength (RSS):* of BSs are measured over time and the BS with the strongest signal strength is selected to carry out a handoff.

b. *SIR Based Algorithms:* This method allows handoff if the SIR of the current BS is lower than the threshold and the SIR of the target BS is better.

c. *Velocity Based Algorithms:* If the user moves fast, the probability of call drop may be high due to excessive delay during handoff. So, a fast handoff algorithm with velocity adaptation can be proposed
d. *Direction Biased Algorithms***:** Direction biased algorithms are important for high mobility users Intelligent Handoff Algorithms:
a. *Fuzzy logic based handoff algorithm:*

The fuzzy logic based approach allows an organized tuning of the handoff parameters to provide a balanced tradeoff among different system characteristics.

a. *Neural network based handoff algorithms:*

The neural network based approach suggests neural encoding of the fuzzy logic systems to simultaneously achieve the goals of high performance and reduced complexity.

a. *Pattern recognition based handoff algorithms:*

PR identifies meaningful regularities in noisy or complex environments. These techniques are based on the concept that, points in a feature space are mathematically defined and are close enough to represent same kind of objects.

a. *Prediction based algorithms*. Handoff algorithms can use the predicted value of handoff criteria such as RSS to make handoff decisions

Traditional method considers only few numbers of parameters. Whereas User Centric approach considers the user related parameter and preferences. On the other hand, Multi Attribute decision Algorithm considers the maximum number of parameters for decision. Some uses Fuzzy based methods .Which is an intelligent approach. The Context aware decision algorithm considers the user and network context information. This is an efficient method, but with more constraints. The cost function based method uses both static and dynamic parameters for decision making. But there are only few papers which consider call dropping rate and handoff blocking rate as a decision parameter.

VII. REASONS FOR HANDOFF FAILURES

If adjacent cells do not have enough channels to support the handoff, the call is forced to be dropped. An important issue is to limit the probability of forced call termination, because from user point of view termination of an ongoing call is less desirable than blocking a new call. Therefore, the system must reduce the chances of unsuccessful handoffs by reserving some channels explicitly for handoff calls. Also, there is a problem of signal interference must be avoided during the handoff.

VIII. ASSESSMENT OF EXISTING WORK

Vertical Handoff Decision Basis

Handoff Decision Strategy	Description of the strategy	Handoff Parameter	Performance criteria	
			Advantages	Limitations
RSS Based Strategy	Reduce handoff call dropping probability Dwell Timer and hysteresis based handoff can be employed for high mobility scenario	RSS, Bandwidth And variation of Rss	-Monitory Cost is low -Signalling Cost is low -Throughputnis high -Reduce Handover Failure probability	-Handover Latency is high -Packet Loss is high -Unnecessary Handover is high -Ping-Pong Effect is high -Reliability is low
Cost Function Based	Make selection quickly, balances the network resources decreases the probability of call dropping and call blocking.	RSS, Bandwidth, Monitory cost, User preference.	-Reduce call dropping and blocking probability -Unnecessary handoff is low -System throughput is high	-Handoff latency is high. -Packet loss is high -Reliability is low
Processing Delay Based	Reduces the processing overhead by delegating the calculation of handoff metric.	Bandwidth, Dropping Probability and Cost.	-Handoff latency is low -Monitory Cost is low -Throughput is high -Packet loss is low -Reduce processing delay	-Unnecessary Handoff is high
Policy Enabled	MAC layer Sensing technique is used.	Bandwidth and mobile host moving speed	-Reduce Handoff latency -Packet loss is less Monitory cost is low	-Unnecessary Handoff is high -Increase Complexity
Context-aware based Strategy	A mobile service is divided into four classes Session service, Interactive services, Streaming services and Background service.	Error rate, Packet loss rate, Packet retransmission rate, Burst error rate, Available bandwidth, Response time, Jitter, Delay, Cost, Distance.	-Handover Latency is low -Packet Loss is low -Unnecessary Handover is low -Ping-Pong Effect is low -Throughput is high -Handover Failure is low -Reliability is high	-Monitory Cost is high -Signalling Cost is high
QOS Based Strategy	Make decision according to users communication type and the performance of the network	RSS, Bandwidth, is Loading Security, low SNR Ratio , low Power, high Velocity, Preference	-Handover Latency High -Monitory Cost is -Signaling Cost is -Throughput is	-Packet Loss is high -Unnecessary Handover is high -Ping-Pong Effect is high -Handover Failure is high -Reliability is low

Table 2: Comparison based on different strategies

IX. CONCLUSION

The vertical handoff will remain an essential component & challenging issue for Next Generation Wireless Networks to allow seamless handoffs, due to switching of mobile users amongst heterogeneous networks, since the aim of heterogeneous wireless network is to offer high quality services. The NGWNs create new handoff challenges due to multiple requirements for vertical handoff. In this paper, the requirements of a vertical handoff for NGWN were proposed. But establishing the requirement of a vertical handoff decision for NGWNs is a critical milestone.

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