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SURVEY ON HANDOFF TECHNIQUES

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Abstract:: Today, the world is moving very fast because of latest technologies and its innovations. Out of these technologies mobile communication plays an important role in our daily life, since it offers flexibility and mobility. Mobility is the most important feature of a mobile communication system. Success of mobile communication relies on its continuous service provided to the user. Usually, continuous service is achieved by the success of handoff (or handover) from one cell to another. This paper gives an overview of need for handoff, types of handoff, performance metrics, and handoff process, factors that affect handoff process, handoff schemes and algorithms.

Keywords- Handoff, Forced Termination Probability, Handoff Performance Metrics, Resource Management, Handoff Prioritization Scheme.

INTRODUCTION

In cellular mobile networks, the coverage region is divided into smaller cells in order to achieve high system capacity. Each cell has a Base-Station (BS), which provides the service to the Mobile Terminals (MTs), i.e. users equipped with phones, within its region. Before a mobile user can communicate with other user(s) in the network, a group of the frequency bands or channels should usually be assigned. The MTs is free to move across cells. When the mobile user crossing a cell boundary or by deterioration in quality of the signal in the current channel, handoff process is initiated.

The scope of this paper is to provide an overview of handoff types, performance metrics, schemes and algorithms.

HANDOFF BASICS

Handoff is the process of changing the channel(may be through 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[1]) associated with the current connection, while a call is in progress, to the neighboring cell in order to provide uninterrupted service to the mobile subscriber.

TYPES of HANDOFF

Handoffs can be classified based on several factors, like the type of the network, the involved network elements or the number of active connections and the type of traffic that the network supports. The different types of handoffs are depicted in Table I.

A hard handoff is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before or 'as' the connection to the target is made—for this reason such handovers are also known as *break-before-make*. When mobile is between base stations, then mobile can switch with any of base stations. So, base station bounces the link with mobile back and forth. This is called ping-ponging.

A soft handoff is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken, hence this handovers is called *make-before-break*. Soft handovers may involve using connections to more than two cell,. e.g. connections to three, four or more cells can be maintained by one phone at the same time. The latter is more advantageous, and when such combining is performed both in the downlink (forward link) and the uplink (reverse link) the handover is termed as *softer*. Softer handovers are possible when the cells involved in the handovers have a single cell site.

COMPARISON OF HARD AND SOFT HANDOFF

Hard Handoff

- At any moment in time one call uses only one channel.
- TDMA, FDMA
- perceived by network engineers as an event during the call
- handover event is very short and usually not perceptible by the user
- Simple and cheap
- data do not have to be duplicated and therefore, the data overhead is minimized.
- call may be temporarily disrupted or even terminated abnormally
- used by WLAN, GSM,GPRS,LTE AND WiMAX (mandatory)

Soft Handoff

- use of several channels in the network to support a single call
- CDMA is used
- perceived by network engineers as a state of the call

- simultaneously channels in multiple cells are maintained
- Connection reliability is high
- more complex hardware in the phone
- failed handovers are lower
- UMTS, WIMAX(optional)

Handoffs can also be distinguished into horizontal and vertical, depending on whether a handoff occurs between a single type of network interface or a variety of different network interfaces. In the next generation networks, vertical handoffs are a common phenomenon. Horizontal handoffs in a cellular network can be broadly classified into intracell and intercell handoffs. Intracell handoffs occur when a user, moving within a cell, changes radio channels in order to minimize interchannel interference under the same BS [2]. On the other hand, intercell handoffs occur when an MT moves into an adjacent cell and therefore, all the MTs connections should be transferred to the new BS [2].

Vertical handoff is the process of changing the mobile active connection between different wireless technologies. Vertical handoffs can be further distinguished into *Downward Vertical Handoff (DVH)* and *Upward Vertical Handoff (UVH)*. In DVH the mobile user handoffs to the network that has higher bandwidth and limited coverage, while in UVH the mobile user transfers its connection to the network with lower bandwidth and wider coverage [3].

Table I: TYPES CLASSIFICATION

Types	*Classification*	
Horizontal	Intracell	Intercell
	Soft	Hard
Vertical	Downward	Upward
	Soft	Hard

HANDOFF PERFORMANCE METRICS [4]

- New Call Blocking Probability
- Handoff blocking probability
- Handoff probability
- Call dropping or forced termination call probability
- Probability of unnecessary handover
- Rate of handover
- Duration of interruption
- Delay

STEPS IN HANDOFF PROCESS

There are four steps involved in handoff process which is depicted in a flow chart.

Measurement: During this phase link measurements (e.g. Received Signal Strength (RSS), Signal to Interference Ratio (SIR), distance measure, Bit Error Rate (BER)) are carried out at both parts: the BS and the MT.

Initiation: In this phase, it is decided whether a handoff is needed and if so, to initiate the process.

Decision: The objective of this phase is the selection of the new channel, based on actual resource availability and the network load. Different kinds of handoff decision protocols are used[6]:

i)Mobile-Controlled HandOff (MCHO): In the MCHO handoff, the MT continuously monitors the signals of the surrounding BSs and requests a channel from the target BS with the lowest interference. This type of handoff has a short reaction time (of the order of 0.1 second). MCHO is used in DECT (Digital Enhanced Cordless Telecommunications) standard.

ii) Network-Controlled Handoff (NCHO): In the NCHO, the surrounding BSs measure the signal from the MT.

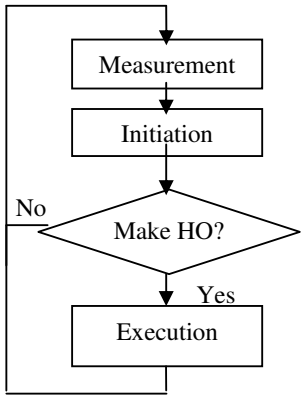

Figure 1: Redrawn from [5].

The network handles RSS measurements and handoff decision. The mobile telephone switching office (MTSO) is responsible for the overall handoff decision. Network-controlled handoff is used in first-generation analog systems, such as AMPS (Advanced Mobile Phone Service), TACS (Total Access Communication System), and NMT (Nordic Mobile Telephony).

iii) Mobile-Assisted Handoff (MAHO): In the MAHO, the network requests the MT to measure the signal from the surrounding BSs. The network makes the handoff decision based on reports from the MT. MAHO is used in the GSM and in cdmaOne or IS-95 CDMA.

Execution: In this phase, the network allows the MT to communicate with a BS in one of its cells, to transfer its communication into another channel or another cell. During this phase, the over-the-air and network process signaling is performed, as well as, authentication, database lookup and network reconfiguration.

HANDOFF REQUIREMENTS [7]

Handoff may affect many aspects of wireless networks such as, quality-of-service (QoS) and the capacity of the network. So there are a number of desirable features and requirements to reduce the adverse effects of a handoff:

- The handoff should be fast enough
- The handoff latency should be low.
- The total number of handoffs should be minimal
- Successful handoffs to total attempted handoffs should be maximized.
- The effect of handoff on QoS should be minimal.

- The additional signaling during the handoff process should be minimized.

REASON FOR HANDOFF FAILURE

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 where in signals from two base stations add up destructively.

RESOURCE MANAGEMENT [7]

Resources in wireless networks are frequency channels, timeslots, code channels; transmission power, battery energy; the number of transceivers. The radio resources should be managed in an efficient manner which can help service provider in saving cost and increasing revenue; increasing quality of service and the effectiveness and efficiency of wireless networks. Resource management can help handoff in wireless networks in reducing handoff drop probability and keeping QoS during and after the handoff.

Some of the resource management related handoffs include admission control, bandwidth reservation, and power control.

In admission control, new calls and ongoing calls can be treated differently. It helps to keep the system from being overloaded. For new calls queuing can be consider and handoff request may be prioritized. Admission control can be centralized and distributed.

The bandwidth in a wireless network may be the most precious and important resource. When a bandwidth reservation is done or when a channel is available, a handoff request can be carried out. A simple solution is that each cell should reserve fractional bandwidths of its capacity and this reserved bandwidth should be used only for handoffs and not for the new call requests. Numerous schemes have been proposed to dynamically manage the allocation of bandwidth resources such as Complete Sharing (CS): all traffic classes share the entire bandwidth, Complete Partitioning (CP): bandwidth is divided into distinct portions with each portion corresponding to a particular traffic class.

Power control is a necessary mechanism in all mobile systems because of an important role in spectrum and resource allocation as well as the battery life and safety reasons. Power control schemes can be used to achieve the required CIR level (Carrier-Interference Ratio). They try to reduce the overall CIR in the system by measuring the received power and increasing or decreasing the transmitted power in order to maximize the minimum CIR in a given channel allocation of the system. This helps in increasing the capacity of the network in terms of the number of mobile terminals that can be supported. Power control can be done in either centralized or in a distributed way.

HANDOFF SCHEMES

Resource management is a good solution to reduce handoff drops. Another possible mechanism is using handoff schemes. The handoff schemes can be distinguished into Non-Prioritized Schemes (NPS) and Prioritized Schemes.

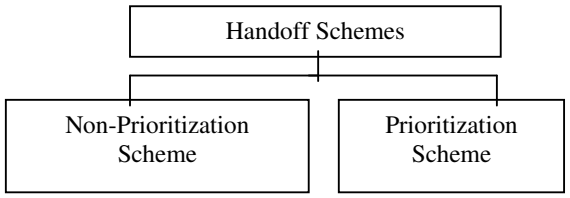

Figure 2: Handoff schemes

In non-prioritized schemes, 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 wther the call is new of handoff. Since, no priority is given to a handoff request over a new call, the CDP(Call Droping Prabability) is increased. Some of NPSs have been present. A Fully Shared Scheme deals with a single class of traffic. All available channels in the BS are shared by handoff and new calls. This scheme results in high channel utilization.

The Complete Sharing (CS) and Complete Partitioning (CP) policies are used as NPS. This policy can lead to waste capacity if the load offered by a traffic stream drops below its allocated capacity. The CP can be divided into two classes: dynamic partition boundaries and static partition boundaries.

On the other hand, prioritized schemes ought to minimize both the CDP (Call Dropping Probability) and CBP (Call Blocking Probability) by giving the priority to handoff calls over new calls in some way. Non-prioritized handoff schemes perform well in terms of CBP comparing to prioritized handoff schemes. Most handoff prioritization schemes have the same mechanism: lowering the CDP while increasing CBP due to the users' QoS perspective, new call would rather being denied than terminating of his ongoing call. Therefore, several handoff prioritization schemes have been proposed until now.

Guard Channels or Early Blocking

The guard channel scheme reserves some fixed or adaptively changing number of channels for handoff calls only. The remaining channels are used by new and handoff calls. So, the handoff calls are better served and forced termination probability is decreased. The scheme increases the call blocking probability and a decrease in total carried traffic. [8]The number of guard channels is determined dynamically by the use of neighboring BSs. Each BS determines the number of MSs in pre-handover zone (PHZ) periodically and informs its neighbor BS related to that PHZ. PHZ is a small area located next to handoff zone and contains the possible users that will enter handoff zone in a short time. When the BS gets the number of MSs in PHZ, it reserves that amount of guard channels for handoff calls. A new call is assigned a channel if no handoff calls are queued in the queue where handoff calls are kept and the total number of free channels is greater than the number of guard channels.

Queuing Handoff Calls

Queuing handoff calls prioritization scheme queues the handoff calls when all of the channels are occupied in a BS. When a channel is released, it is assigned to one of the handoff calls in the queue. A new call request is assigned a channel if the queue is empty and if there is at least one free channel in the BS. Also, some systems queue new calls to decrease call blocking probability. The time interval between handoff initiation and receiver threshold makes it possible to use queuing handoff calls. Queuing handoff calls can be used with/without the guard channel scheme. In [9], a timer based handoff priority scheme is proposed. When a channel is released at BS, a timer is started. If a handoff request is done in that time interval it is assigned to it. Otherwise, when the timer expires, the channel can be assigned to new or handoff calls depending on the arrival order. A new prioritization scheme called Measurement Based Prioritization Scheme (MBSP). The handoff calls are added to the queue and priorities of the calls changes dynamically based on the power level they have. The calls with power level close to the receiver threshold have the highest priorities. This scheme provides better results from the first-in first-out (FIFO) queuing scheme where the handoff calls are served due to arrival time. The Most Critical First (MCF) policy determines the first handoff call that will be cut off and assigns the first released channel to that call. The first handoff call that will be cut off has the highest priority. The authors proposed a method to predict the first handoff call to be cut off by using simple radio measurements. In [10], a queuing scheme using guard channels is described. Both new calls and handoff calls are queued. A number of guard channels are reserved for handoff calls. When the new calls are congested, a channel from the guard channels is used if it is available. This scheme decreases the call blocking probability while increasing forced termination probability slightly.

***Channel Transferred Handoff Scheme*[6]**

In this scheme, if there are no channel is available to allocate a handoff call request, a channel from a neighboring cell may be transferred. i) Channel Carrying Approach (CCA), that selects its current channel to carry it in the destination cell, and the ii) Channel Borrowing Approach(CBA), selects a new channel from the neighboring cells.

***SubRating Schemes*[6]**

The SubRating Schemes degrade the bandwidth of an existing call in order to accept more handoff calls. In these schemes, some ongoing calls may be forced to operate under a degrade mode in order to accommodate more calls in an overloaded system.

***Genetic Handoff Schemes* [6]:**

This scheme uses genetic algorithm scheme (GAS) in order to assign the channels using local state- based call admission double-threshold policies. The BS keeps track of the state information of a small number of cells and makes decisions based on the abbreviated state information. This GAS provides better admission control policy comparing with other methods.

***Hybrid Handoff Schemes* [6]:**

Hybrid Handoff Schemes are combinations of guard channel, handoff queuing, channel transferred, genetic and sub Rating schemes. Which combines different prioritization policies to reduce blocking probability and to improve the channel utilization? Author surveyed all these schemes in an exhaustive way, the readers can refer for further details.

COMPARISION OF PRIORITIZATION SCHEMES ARE TABULATED IN [6]

HANDOFF ALGORITHMS [7]

Based on the handoff criteria, handoff algorithms can be classified into two classes [11] [12]:

i) Conventional handoff algorithms – these algorithms are based on the signal strength, distance, velocity, power budget, and SIR.
ii) Intelligent handoff algorithms – these are based on AI technologies such as fuzzy logic, prediction, pattern cognition, and neural networks.

Conventional Handoff Algorithms:

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. To select the strongest signal strength several measurements are used. 1) Relative Signal Strength plus Threshold, 2) Relative Signal Strength with Hysteresis, 3) Relative Signal Strength with Hysteresis and Threshold.

SIR Based Algorithms. Signal to Interference Ratio (SIR) is a measure of the communication quality. 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.

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 for urban communication. Corner detection algorithm is also incorporated into the handoff algorithm to speed up handoffs in NLOS scenario.

Direction Biased Algorithms. Direction biased algorithms are important for high mobility users especially in NLOS handoff.

***Intelligent Handoff Algorithms* [11]**

Fuzzy logic based handoff algorithms

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

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.

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.

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

COMPARISON OF ALL THESE ALGORITHMS ARE TABULATED IN [7]

CONCLUSION

This paper provides an overview of handoff types, performance metrics, handoff schemes and handoff algorithms has been provided. This survey gives an idea to us about the existing schemes and algorithms to handle handoffs.

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SHORT BIODATA OF ALL THE AUTHOR

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