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Handover Management Algorithm

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Abstract: ***In wireless networks with mobile stations dependent on a central master controller (base station/access point), an important aspect of reliable service is in the maintenance of reliable and good radio link quality between the mobile station and the fixed controller. For this to suitably happen, we must be able to switch control from one base station to another at the cell boundary to maintain the quality and existence of the call. A major bottleneck in ubiquitous, always best service occurs at handoff, with several instances of false handoff initiations resulting in network congestion and subparutilization, and of handoff failures, due to inordinate delay in completion of handoff, resulting in termination of old connection before the new one is established. In this paper we give concept of Handover Management Algorithm (handover Importance, handover Phase, and handover Algorithm).***

Keywords: Handover, handover Importance, handover Phase, handover Algorithm

1. Introduction

In telecommunications there may be different reasons why a handover might be conducted when the phone_is moving away from the area covered by one cell and entering the area covered by another cell the call is transferred to the second cell in order to avoid call termination when the phone gets outside the range of the first cell when the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell in non_CDMA networks when the channel used by the phone becomes interfered by another phone using the same channel in a different cell, the call is transferred to a different channel in the same cell or to a different channel in another cell in order to avoid the interference again in non-CDMA networks when the user behaviour changes, e.g. when a fast travelling user, connected to a large, umbrella-type of cell, stops then the call may be transferred to a smaller macro cell or even to a micro cell in order to free capacity on the umbrella cell for other fast travelling users and to reduce the potential interference to other cells or users (this works in reverse too, when a user is detected to be moving faster than a certain threshold, the call can be transferred to a larger umbrella-type of cell in order to minimize the frequency of the handovers due to this movement) in CDMA networks a handover may be induced in order to reduce the interference to a smaller neighboring cell due to the "near-far" effect even when the phone still has an excellent connection to its current cell.

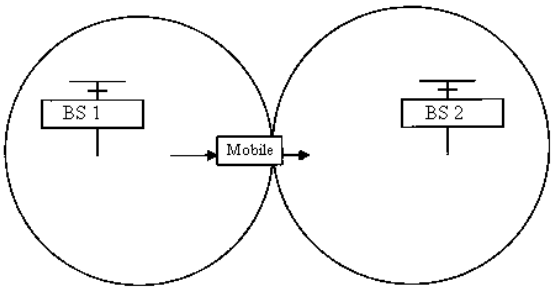

Figure 1: Two basic types of handoff are defined _hard handoff and soft handoff

2. Types of Handover

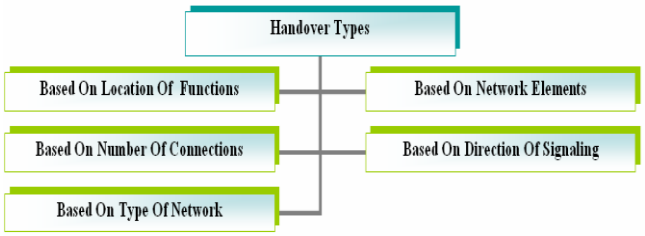

Figure 2: Types of Handover

The handover procedures attempt to maintain the connections of the mobile user as it moves from one network to another. The classifications of the handover processes are based on various criteria. These classifications, as shown in Figure2, are described as follows:

The handover procedures can be classified based on the location of the handover functions

a) **Mobile Initiated Handover:** In this type of handover, the mobile user has to manage the handover. That is, it takes the measurements on the downlink, processes them, takes the decision to do the handover and decides the target access router.
b) **Mobile Evaluated Handover**: This is similar to the mobile initiated handover except that the decision to do the handover lies with the network.
c) **Network Initiated Handover:** In this type of handover, the network manages the handover, which includes taking measurements on the uplink, processing them, deciding to do the handover and deciding the target access router.
d) **Mobile Assisted Handover:** This is similar to the network initiated handover, except that the mobile assists the network by taking measurements along the downlink and relaying them back to the network.

The handover procedure can also be classified based on the network elements involved in the handover:

a) **Intra Cell:** This type of handover is done within the current coverage area, i.e. cell. The used channel, e.g. the time slot, is only changed for this type of handover.
b) **Inter Cell:** If the mobile user crosses the cell boundary, then it is referred to as inter cell handover.

c) **Inter Network:** If the handover is done between two different networks then it is referred to inter network handover.

The handovers can also be classified based on the number of the connections that a mobile user maintains during the handover procedure:

a) **Soft Handover:** In this type of handover, the mobile user is connected simultaneously to two accesses. As it moves from one cell to another, it softly" switches from one access router to another. When connected to two access routers, the network combines information received from two different routes to obtain a better quality. This is commonly referred to as macro diversity.
b) **Hard Handover:** In this type of handover, the mobile user switches the communication from the old link to the new link. Thus, there is only one active connection from the mobile user at any time. There is a short interrupt in the transmission. This interrupt should be minimized in order to make the handover seamless.

The handover procedures can also be classified based on the type of the network:

a) **Horizontal Handover:** This type of handover refers to handovers between cells belonging to the same network. That is, the MN moves within the same network. Horizontal handover also represents a micro level mobility scenario, i.e. intra network mobility.
b) **Vertical Handover:** This type of handover refers to handovers between cells belonging to different types of the network. That is, the MN moves from one network to another network. Vertical handover also represents a macro level mobility scenario, i.e. inter network mobility.

3. Handover Requirements

The general requirements for the handover procedure are listed in this section:

- **Handover Delay:**

The total time for the completion of the handover should be appropriate for the rate of mobility of the mobile user. That is, the handover process should be fast so that the mobile user does not experience service degradation or interruption during handover.

For macro cells, the total delay time is:

$$\delta_{hM} := \frac{T}{2} + K_{rv} \cdot \frac{10^{\frac{h-\sigma}{K_2}} - 1}{10^{\frac{h-\sigma}{K_2}} + 1}$$

T denotes the signal averaging window
K2 represents a path loss constant
Krv represents the normalized distance from the mobile station to base station.
For microcells, the total delay time is:

$$\delta_{hu} := \frac{T}{2} + T \cdot \frac{h-\sigma}{4 \cdot d_{cor}}$$

d_{cor} denotes the drop in signal level experienced at a street corner and is determined experimentally. The analysis shows that there exists compromises between the parameters of averaging time and hysteresis delay. It is evident that for microcells we may wish to choose short averaging time and a larger hysteresis. The converse is clear for macro cells.

Scalability: The handover procedure should support seamless and lossless handover within both the same and different networks. It should also be able to integrate seamlessly with the existing wired networks.

- **Quality of Service (QoS):** The effect of the handover on QoS should be minimal so as to maintain the requested QoS after the handover is completed.
- **Signaling Traffic:** The amount of signaling traffic required to make the handover should be kept to a minimum.
- Handover Performance Issues

Besides these handover requirements, described above, there are some performance issues in order to provide uninterrupted services and continuous communication during handover:

- **Fast handover:** The handover operations should be quick enough to ensure that the mobile user can receive data packets at its new location within a reasonable time interval. Reducing the handover latency as much as possible is extremely important for real time applications.
- **Smooth handover:** The handover algorithm should minimize the packet loss, although the interruption time may be long.
- **Seamless handover:** Combination of fast handover and smooth handover are sometimes referred to as seamless handover.

While the former concerns mainly packet delay, the latter focuses more on packet loss. In certain cases, seamless handover may be impossible. For example, if the mobile user moves among networks where the coverage areas of the two access points do not overlap, there will be a discontinuity which will cause interruption and packet loss.

Importance of Handling Handoff

Customer satisfaction is very important in cellular communication and handling handoff is directly related to customer satisfaction. Effective handling of handoff leads to improved reception and fewer dropped calls and results in customer satisfaction which is very important in Mobile communication.

Handoff is very common and most frequently occurred in cellular communication so it should be handled efficiently for desired performance of the cellular network.

Handoff is very important for managing the different resources in Cellular Systems. Handoffs should not lead to significant interruptions even though resource shortages after a handoff cannot be avoided completely. Thus handling handoffs is very much important for a desired interruption free cellular communication.

4. Handover Phases

There are three phases of handover:

Handover detection:

- Handover may depend move reliably on WEI of the current channel rather than RSSI, If WEI is good then handover is not performed.
- However, it is necessary to accumulate WEI measurements over a period of time, where as RSSI is know instantaneously.
- To make the handover decision accurately and quickly, it is desirable to use both WEI and RSSI.
- RSSI measurements are affected by distance dependent fading, log normal fading (i.e., shadow fading) , and ray ligh fading (i.e., Multipath fading).

Distance dependent fading, or path loss , occurs when the received signal becomes weakerduce to increasing distance between MS and BS. Shadow fading: occurs when there are physical obstacles (e.g. hills , towers , and buildings) between the BS and MS , which can decrease the received signal strength. Multipath fading: occurs when two or more transmission paths exist (due to signal being reflected off building or mountains) between the MS and BS.

Handover Preparation:

In this phase, the handover entity request for the other networks resource availability information.

Handover Execution:

A handover execution message is responsible for triggering the handover to another network and is sent by the handover entity.

Different ways to control handover:

- Mobile- Controlled Handoff (MCHO).
- Network- Controlled Handoff (NCHO).
- Mobile- Assisted Handoff (MAHO).
- There exists basically three (3) different ways to control handovers in cellular networks. Based on these the handover algorithms are characterized to:

Table 1: Based on the handover algorithms are characterized

Mobile controlled	**Network controlled**	**Mobile assisted – Network controlled**
_ Used for example in DECT _ Both serving BTS and mobile measure link quality _ Surrounding BTS measurements obtained only by the mobile and reported to the network _ Link measurements at the serving BTS are relayed to the mobile. _ Mobile makes the handover Decision _ Very low delays	_ Used widely in 1st generation systems _ Link quality is only monitored by serving BTS and surrounding Ones _ Handover decisions are made centrally in ”MSC” _ Typically support only intercell handovers and have massive delays (several secs..)	_ Used widely in 2nd gen. systems (GSM). _ Both serving BTS and mobile measure link quality. _ Surrounding BTS measurements obtained only by the mobile and reported to the network. _ Handover decisions made by serving BTS and MSC. _ Both inter- and intracell handovers supported and typically 1-2 sec delays.

View of handover algorithms

Handovers are made on the basis of algorithms, which are used for comparisons. Different handovers make use of different algorithms to be successful in different situations.

Signal strength based hard handover Algorithms:

- In hard handover the mobile can connect to only one BTS at a time (the connection is interrupted for a short moment).
- Basic hard handover is very simple and inexpensive to implement (no diversity gain possibility, based on imposed hysteresis)
- Most hard handover algorithms are basically optimised via two main parameters;

Hysteris (or handover margin)

Temporal window length (over which the measurements are averaged)

- The optimal window length can be estimated e.g. through theory of analog averaging (Lee)
- Stüber shows that the rule of thumb for number of samples to average within a window is, N =20...40λc/ S□ Where S is the spatial sampling period.

Quality and signal level based handover Algorithm:

- If the handover threshold comparison indicates that a handover due to uplink or downlink quality or level is required, the radio link properties of the adjacent cells are evaluated in order to find a target cell. (For quality, parameters with level are replaced).
- The averaged measurement values of signal quality or level are compared against the set threshold values to trigger the handover.
  E.g. AV_RXQUAL_UL/DL_HO vs. HoThresholdsQualUL
- Parameters such as total number of averages to be taken into account and a number of averages which have to be worse/better than threshold value are often used.

VHD Handover Algorithm:

Vertical handover decision plays very important role in selection of best network.

There are various ways to classify VHD algorithms. Here, we have chosen to divide VHD algorithms into four groups

based on the handover decision criteria used and the methods used to process these.

- RSS based algorithms
- Bandwidth based algorithms
- Cost function based algorithms
- Combination algorithms

Umbrella Handover Algorithm:

- The umbrella handovers are utilised in order to make handovers between different network layers or cell sizes possible when needed. For example between GSM 900/1800 or macro/micro cells.
- In order to be effective, the umbrella HO algorithm should take into account also the power class of the mobile. For example so that selected cells are macro cells for vehicle mobiles and microcells for handhelds.

The basic idea of the faster target cell evaluation is to make the handover rapidly to the better adjacent cell by using smaller averaging windows thus speeding up the handover process.

- **Traffic based handover**
- In order to share the load between cells, a specified number of handovers from one specified cell can be performed. It is usually possible to make traffic reason handovers to cells with better, equal or even worse radio link conditions
- Velocity adaptive handover algorithms:
- Temporal based handover algorithms can give poor performance in diverse propagation environments and with wide range of mobile speeds. This situation is difficult to improve with algorithm parameter optimization...
- Temporal averaging of received signal measurements with short fixed window length gives optimal handover performance for only a single velocity.
- A method for estimating mobile speed is needed in order to keep
- handover delays acceptable.
- Crossing rate algorithm is based on counting the rate with which the
- signal level crosses the averaged signal level due to fast fading.
- The estimations are based on using LCR or ZCR functions
- Velocity can be estimated also e.g. by estimating the auto covariance between faded samples (covariance method) A velocity adaptive handover algorithm must adapt the temporal window
- over which the mean signal strength estimates are taken by either keeping the sampling period constant and adjusting the number of samples per window, or vice versa.
- In principle, high-speed mobile should use shorter average window size, and low-speed MS should use longer average window size. Therefore, all averaging-processes should have two sets of window parameters, one set for high speed mobiles and one set for low speed mobiles.
- By applying various window size, fast-moving MSs have shorter window size and they may handover to target cell faster. For a slow-moving MS, a longer window size is applied in order to prevent it from unnecessary oscillation.
- Velocity adaptive handovers are used to increase the capacity of a cellular network, areas of high traffic density may be covered with a multi-layer network consisting of different sized cells. If a high speed mobile is located in such an area it should be located in a macrocell to decrease the amount of handovers. In other words a high speed mobile locating in a microcell would result in increased signaling load and potentially high amount of dropped calls in the network.

Table 2: Advantages and disadvantages of algorithms

Advantages and disadvantages of algorithms:

Algorithms		Parameter	Features	Advantages	Disadvantages
VHD RSS Based	Adaptive Lifetime based	RSS	The RSS is combined with the estimated lifetime to decide the handover time	Improvement on the available bandwidth	Long packet delay
	RSS threshold Based	RSS threshold	A dynamic RSS threshold is calculated and compared with the current RSS to determine the handover time.	Reduction of handover failure probabilities	Wastage of network resources
	Travelling Distance Prediction Based	Dynamic time threshold	A dynamic times threshold is calculated and compared with the predicted travelling time to determine the Handover.	Handover failures and unnecessary handovers are reduced.	Extra handover delay
VHD Bandwidth Based	QoS Based	Residual Bandwidth and service requirements	The bandwidth is combined with the RSS, System requirement and application type to make handover decisions.	-Low handover latency for delay sensitive application -high system throughput	high blocking rate for new applications

	SINR based	Signal to Noise Interference Ratio	SINR values are compared to determine the handover decision	-High overall throughput -balance of the network load	-excessive handovers -ping pong effect
WDP Based	Probability of unnecessary and missing handovers	Available bandwidth, network coverage and probability of missing handovers are considered to determine handover	-Reduced WDP -balance of the traffic load	-increased connection breakdown	WDP Based
VHD Cost Function Based	Multiservice Based	Cost of target network	Cost of the possible target network is calculated and network with minimum cost function is selected	-user satisfaction is increased -reduced blocking probability	VHD Cost Function Based
	Cost function with normalization and weights distribution	Network Quality factor	Normalization and weight distribution methods are provided	-high system throughput High user's satisfaction	-difficult to estimate parameters like security and interference level
Weighted Function Based	Weighted function of network	Weighted function is used and handover is delegated to visited network instead of mobile terminal	-Resource of the mobile can be saved -low handover delay -low handover blocking rate -high throughput	-require extra co-ordination between MT and point of attachment	Weighted Function Based
VHD Combination	Multilayer feed-forward ANN based	Cost	Cost function is used to train ANN	-able to find the best available network	long delay during training process
Fuzzy logic based	RSS, Bandwidth	FNQD is used to calculate the PEVs of the networks	-Reduces the number of unnecessary handovers -Avoid the ping pong effect	Fixed weights are assigned to the inputs while calculating the PEVs	Fuzzy logic based
Umbrella the umbrella cells cells use different physical channels	area is also covered	area is also covered by a number of original cells, but obviously the umbrella cells and the other cells use different physical channels	user's behavior shows that it is going to hand over frequently, its call is switched (handed over by the system)	-The mobile speed sensitive handover in a mixed cell environment, the system performance can be significantly improved with respect to both handover load in the fixed network and forced call terminations - architecture provides a balance between max-imizing the number of users per unit area and minimizing the network control load associated with handover. -provide capacity due to greater frequency reuse and cover areas with high traffic density.	Handovers from umbrella into micro cells can be avoided for fast moving mobiles. Correspondingly, slow-moving subscribers are "dropped" from the umbrella into an under laid micro cell and remain served b Score of a candidate. -static algorithm the umbrella cell is always at the same position and covers the same area.
Velocity adaptive	Adopts dynamic handover threshold	RSS	According to different velocity to skip some unnecessary handover stages	-reduces handover delay and enhances the network resource utilization -provides good performance for MSs with die rent velocities by adjusting the effective length of the averaging window -can serve as an alternative to the umbrella cell approach to tackle high speed users if low network delay can be achieved, which can lead to savings in the infrastructure. - additive Gaussian noise are	Velocity adaptive

				also addressed -for microcellular systems capable of providing consistent and near optimal performance are presented and characterized	

5. Conclusion

Handover is a very important process. In this paper the author persent handover management algorithm, Firstly introduction of handover, secondly types of handover, thirdly phases of handover and ways to control handover, fourthly View of handover algorithms, fifthly view Advantages and disadvantages of algorithms.

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