Chapter three

Vertical Handover Decision Criteria

3. Vertical Handover Decision Criteria

3.1 Introduction

Every vertical handoff decision strategy consists of two stages; Identifying the handoff decision criteria and choosing the decision policy to be implemented. Handoff decision criteria consist of monitoring the network conditions which can give an indicant of the necessity of handoff. Handoff decision criteria are used to choose the best network. Handoff decision policy uses decision criteria to choose best network by taking into consideration the performance of the handoff decision [15].

In this chapter, the parameters of vertical handover decision making is discussed. The Performance Evaluation Metrics used in VHD is presented. Finally, the different vertical handover decision algorithms is provided.

3.2 Vertical Handover Decision Making Parameters

To evaluate the vertical handoff decision some parameter should be considered [1] as shown in Figure 3.1

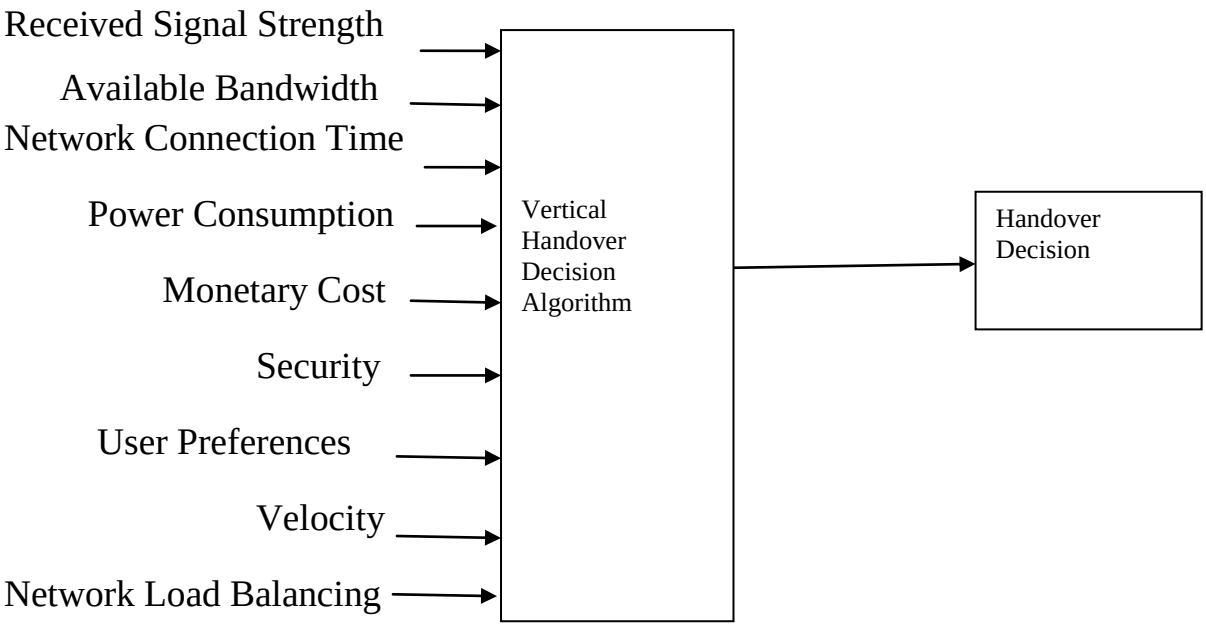

Figure 3.1:Parameters used for Making VHD Decisions

Received Signal Strength (RSS) is the most widely used criterion because it is easy to measure and is directly related to the service quality. There is a close relationship between the RSS readings and the distance from the mobile terminal to its point of attachment. Majority of existing horizontal handover algorithms use RSS as the main decision criterion, and RSS is an important criterion for VHD algorithms as well.

Available Bandwidth is a measure of available data communication resources expressed in bit/s. It is a good indicator of traffic conditions in the access network and is especially important for delay-sensitive applications.

Network Connection Time refers to the duration that a mobile terminal remains connected to a point of attachment. Determining the network connection time is very important for choosing the right moment to trigger a handover so that the service quality could be maintained at a satisfactory level. For example, a handover done too early from a WLAN to a cellular network would waste network resources while being too late would result in a handover failure. Determining the network connection time is also important for reducing the number of superfluous handovers, as handing over to a target network with potentially short connection time should be discouraged. The network connection time is related to a mobile terminal's location and velocity. Both the distance from the mobile terminal to its point of attachment and the velocity of the mobile terminal affect the RSS at the mobile terminal. The variation of the RSS then determines the time for which the mobile terminal stays connected to a particular network.

Network connection time is especially important for VHD algorithms because heterogeneous networks usually have different sizes of network coverage.

Power Consumption: becomes a critical issue especially if a mobile terminal's battery is low. In such situations, it would be preferable to handover to a point of attachment which would help extending valuable battery life.

Monetary Cost: For different networks, there would be different charging policies, therefore, in some situation the cost of a network service should be taken into consideration in making handover decisions.

Security: For some applications, confidentiality or integrity of the transmitted data can be critical. For this reason, a network with higher security level may be chosen over another one which would provide lower level of data security.

User Preferences: Based on the application requirements like (real time, non-real time), service types (Voice, data, video), Quality of service etc. the user may prefer different network according to the network performance which is the important benefit of heterogeneous networks.

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.

Velocity : Velocity of the host should also be considered during handoff decision. Because of the overlaid architecture of heterogeneous networks, handing to the small cell area, travelling at high speeds is discouraged since a handoff back to the original network would occur very shortly after wards.

These criteria can be classified into static and dynamic depending on the frequency and causes of changes. Typically static criteria are user profile and the cost of the different access networks, whereas the MT's velocity and RSS are typically dynamic criteria.

3.3 Performance Evaluation Metrics for VHD Algorithms

VHD algorithms can be quantitatively compared under various usage scenarios by measuring the mean and maximum handover delays, the number of handovers, the number of failed handovers due to incorrect decisions, and the overall throughput of a session maintained over a typical mobility pattern[5][11]. These metrics are further explained below:

Handover Delay: Handover delay is the duration between the initiation and completion of the handover process, and is related to the complexity of the VHD process. Reduction of the handover delay is especially important for delay sensitive voice or multimedia applications.

Number of Handovers: Reducing the number of handovers is usually preferred as frequent handovers would cause wastage of network resources. A handover is considered to be superfluous when a handover back to the original point of attachment is needed within certain time duration and the number of such handovers should be minimized.

Handover Failure Probability: A handover failure occurs when the handover is initiated but the target network does not have sufficient resources to complete it, or when the mobile terminal moves out of the coverage of the target network before the process is finalized. In the former case, the handover failure probability is related to the channel availability of the target network while in the latter case it is related to the mobility of the user.

Network Throughput: The throughput refers to the data rate delivered to the mobile terminals on the network. Handover to a network candidate with higher throughput is usually desirable.

3.4 Vertical Handover Decision Algorithms

There are various ways to classify VHD algorithms. In this research, VHD algorithms are divided into four groups based on the handover decision criteria used and the methods used to process them.

3.4.1RSS Based Algorithms

RSS is used as the main handover decision criterion in this group. Various strategies have been developed to compare the RSS of the current point of attachment with that of the candidate point of attachment [11].RSS can be calculated using equation (3.1):

$$RSS = P_{tx} - PL_{ref} - 10 * beta * \log(d/d0) + \sigma \quad (3.1)$$

where:

P_tx= the transmit power of the network AP or BTS in dBm

PL_ref= the path loss at the reference point in dB

Beta= the path loss exponent

d0= the distance between the AP and a reference point (m)

d = the distance between base station (BS) and MT.

σ =the zero –mean Gaussian random variable

3.4.2Bandwidth Based Algorithms

Bandwidth based VHD algorithms considers available bandwidth for a MT as the main handover criterion for this group .In some algorithms,

both bandwidth and RSS information are used in the decision process Depending on whether RSS or bandwidth is the main criterion considered, an algorithm is classified either as RSS based or bandwidth based[16][17].a bandwidth based VHD mechanism between two networks by employing signal to interference and noise ratio (SINR).SINR measurement of network one signals is then transformed into equivalent SINR, to be compared with SINR of the network two channel.

The maximum achievable 'downlink date rate' *R_AP* and *R_BS* for MTs / users connected with network one and network two respectively is measured with the help of Shannon Capacity formula as:

$$R\_AP = W\_AP \log_2 (1 + \gamma AP / T\_AP) \quad (3.2)$$

$$R\_BS = W\_BS \log_2 (1 + \gamma BS / T\_BS) \quad (3.3)$$

where:

W_AP and W_BS is the carrier bandwidth of network one and network two links.

γAP*and* γBSis the SINR of MT when associated with network one and network two.

T_AP and T_BS is the dB gap between an uncoded QAM and channel capacity, minus the coding gain.

3.4.3Cost Function Based Algorithms

Vertical handover decision cost function is a measurement of the benefit obtained by handing over to a particular network. It is evaluated for each network **n** that covers the service area of a user. It is a sum of weighted

functions of specific parameters [18]. The general form of the cost function *Fn* of wireless network **n** is:

$$\boldsymbol{Fn}=\sum_{\boldsymbol{s}}\sum_{\boldsymbol{i}}\boldsymbol{ws,i}*\boldsymbol{p}_{\boldsymbol{s,i}}^{\boldsymbol{n}} \quad (3.4)$$

$p_{s,i}^{n}$: is the cost in the ith parameter to carry out service **s** on Network n.

ws,i: is the weight (importance) assigned to using the ith parameter to perform services.

3.4.4Combination Algorithms: These VHD algorithms attempt to use a richer set of inputs than the others for making handover decisions. When a large number of inputs are used, it is usually very difficult or impossible to develop analytical formulations of handover decision processes.