Abstract

Wireless communications is the fastest growing segment of the communications field. One of the most successful applications of wireless communications has been the cellular mobile communications. Cellular systems have experienced exponential growth over the last decade and there are currently approximately billion users throughout the world. This allows communication from anywhere in the world using a small handheld device generally known as mobile. The mobility management poses a great challenge in current and future wireless communication networks in order to access global information by the users. Mobility causes dynamic variations in link quality and interference levels in the cellular systems and also sometimes it requires change of base station by a particular user. This change is known as a handoff or handover. Handoff facilitates the continuation of an active call when the mobile moves from one Base Station (BS) to another. Handoff makes it possible for a user to travel between various networks or cells while having seamless connection. In general, handoffs are classified as horizontal handoff and vertical handoff. Horizontal handoff occurs when a Mobile Station (MS) is moving out of the coverage area of the (BS) into the coverage area of another BS within the same network, whereas Vertical handoff occurs when the handoff between BS and Access Point (AP) of different wireless networks takes place. Horizontal handoffs are further classified into hard and soft handoffs. A hard handoff follows “break-before-make” approach wherein, a definite decision is made on whether to handoff or not. This process appears in 2G, 2.5G and 2.75G cellular systems like the GSM. The soft handoff, in contrast to hard handoff, follows “make-before-break” approach which commonly appears in 2G and 3G cellular systems such as CDMA, UMTS and Wideband CDMA etc.

Currently, there exist different wireless systems, such as second and third generation (3G) cellular networks (e.g., GSM/GPRS, UMTS, CDMA2000) for wide areas, IEEE 802.16 and WiMAX for metropolitan areas, Wireless Local Area Networks i.e., WLANs (e.g., IEEE
802.11a/b/g, Hiper-LAN) and personal area networks (e.g., Bluetooth, Ultra wideband radio) for buildings/campus areas and satellite networks for global networking. The combination of all these networks is usually called the Beyond 3G (B3G) wireless networks. The complementary characteristics of different wireless networks make it attractive to integrate these various wireless access technologies making the overall network as heterogeneous network. Unlike horizontal handoff which occurs in homogeneous networks, vertical handoff occurs in heterogeneous wireless networks. Vertical handoff facilitates interoperability between different wireless networks and is a seamless handoff process that makes the transfer of a mobile users network connections transparent (without perceptible interruption of services) to upper layer applications.

One of the main challenges for seamless mobility is the availability of simple and robust handoff algorithms, which allow a mobile node to roam among heterogeneous wireless networks so as to meet the challenges for the emerging Beyond 3G (B3G) networks. To achieve this, the traditional Received Signal Strength (RSS) based handoff decision algorithms are not sufficient. The RSS only indicates the usability of a network and is unable to provide more details of a network for example available bandwidth. The bandwidth is one of the important parameter for B3G heterogeneous wireless networks applications. In B3G wireless networks, the vertical handoff process is defined among different wireless networks which are more complicated and RSS is not suitable for handoff management. Therefore, the bandwidth based handoff algorithms are implemented for B3G networks for improving the quality of service (QoS).

Proper design of efficient handoff algorithms is the need to provide the cost – effective way of enhancing the capacity and also for reducing the switching load of the network while maintaining the QoS. In order to achieve this objective, in this thesis, three new handoff algorithms have been developed. These are: “RSS with adaptive hysteresis hard handoff
algorithm for GSM cellular network”, “new soft handoff algorithm for CDMA cellular network”, and “bandwidth based handoff algorithm for the B3G networks”. The first two algorithms are horizontal handoff algorithms in which the first algorithm gives the optimum handoff area of GSM cellular system with adaptive hysteresis and also minimizes the unnecessary handoffs by avoiding the “ping-pong effect” which occurs in traditional RSS based handoff algorithm. The RSS and the handover point observed from current base station to mobile are -112.478 dB, 1000 m and -115 dB, 1188m from the base station to mobile due to RSS and RSS with adaptive hysteresis algorithms respectively. From the results, it is also observed that the delay in handover of a call is 188 m from the handover point and therefore the reduction of signal strength at handoff is found to be -2.522 dB.

The second algorithm is developed to carry out the performance analysis of CDMA cellular system based on estimating the optimum soft handoff parameters (Hysteresis add (Hadd), Hysteresis drop (Hdrop). The estimation of optimum soft handoff parameters is necessary to avoid the forward link, reverses link interferences and for the improvement of QoS. For example, for equal values of hysteresis add and hysteresis drop values (e.g. 12dB), the soft handoff distance observed is 740 m which causes the forward link interference. The corresponding signal strength observed is -85 dBm which is sufficient to maintain call with the current base station, however soft handoff is obtained in advance. From this developed algorithm, the optimum values obtained are in the range of 3dB to 5dB which provides considerable improvements and gives the optimum soft handoff distance as 200 m to 320 m and optimum signal strength as -90dBm.

Finally, mathematical models for bandwidth based handoff algorithm and wrong decision handoff probability for two and three wireless networks have been developed for beyond 3G wireless networks configurations considering the bandwidth as the main criteria instead of RSS. The proposed bandwidth based handoff algorithm is implemented for two wireless
network configuration with equal bandwidths. The results of the proposed bandwidth based handoff algorithm is validated with the three wireless network configuration and results of the three network configuration follows the same tendency as two wireless networks. For two and three wireless network configurations, when threshold is considered to be 1 and traffic load (no. of connections) is 14, then the handoff probabilities observed are 0.37811717 and 0.56474823 respectively. It is also observed that as the number of networks increases the handoff probability increases with constant traffic load and threshold. The performance of the proposed bandwidth based handoff algorithm is also validated by computing the Unnecessary Handoff Probabilities (UHOPs), Missing Handoff Probabilities (MHOPs) and Wrong Decision Handoff Probabilities (WDHOPs). These models have succeeded in minimizing the Wrong Decision Handoff Probability (WDHOP) e.g. for two and three networks configurations, when threshold is 0 and traffic load is 14, the WDHOP is found to be 0.28383065 and similarly in case of three wireless networks configuration when traffic load is 14, the WDHOP is found to be 0.06943223. It has also been concluded that the performance of the two and three wireless networks increase along with the improvements in QoS with the minimum “Wrong Decision Handoff Probabilities” calculated based on “bandwidth based handoff algorithm”. Therefore, it is concluded that the horizontal handoff algorithms developed are useful in analyzing the performance of the existing GSM and CDMA cellular networks and the proposed bandwidth based handoff algorithm in this thesis is useful for estimating the performance and improving the QoS parameters of multiple heterogeneous wireless networks such as B3G.