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Efficient Handoff for QoS Enhancement in Heterogeneous Wireless Networks (UMTS/WLAN Interworking)

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Due to different behaviors of these integrated networks however, some difficult challenges such as Quality of Service may be degraded during network changes referred to as vertical handoff for integrated UMTS and WLAN networks. For QoS to be achieved therefore, handoff in such networks must be good. In addition, mobility management could also be in position to assure of connection especially when the user is roaming in heterogeneous wireless networks. In order to minimize QoS degradation, mobility protocols such as MIP (IPv4 and IPv6), mSCTP, SIP have been studied to verify and evaluate how they are affected when Real-time applications such as Video Conferencing and Non-real-time applications such as FTP are used in UMTS/WLAN interworking. The simulation results show the best mobility protocol to take into account when operating under UMTS/WLAN interwoking scenario.

Keywords: cellular networks, 3G (UMTS), 802.11 WLAN, heterogeneous wireless networks, handoff, QoS enhancement, mobility management.

I. Introduction

In the telecommunications environments presently with rapid growth in wireless technologies in relation to the user demands, force researchers to focus on how to provide better services to both subscribers and network operators. These services that we refer to as ubiquitous services, we mean connectivity anywhere and at anytime for mobile users and permanent internet as well as to corporate or private networks. This has steered the communications industry developments in the past several years. This has actually evidenced in the quick growth and evolution of cellular networks and wireless local area networks. The Cellular networks such as third generation governed by Universal Mobile Telecommunication Systems (UMTS) and CDMA known for IS-95 A/B and CDMA2000 are known for their higher mobility and wider coverage but lower bandwidth that are still not enough for satisfaction of many data intensive applications. Wireless local area networks are oppositely known for their high speed data support but with small coverage area and limited mobility.

It is in this regard that the integration of UMTS and 802.11 WLAN offers benefit to both operators as well as to subscribers. This wireless communications environment is referred to as Heterogeneous wireless Networks (HWNs). However, an important and major problem is how to provide a reliable or guaranteed end-to-end quality of service (QoS) in a scalable behavior with seamless roaming in Heterogeneous Wireless Networks (HWNs) for multimedia service. In heterogeneous networks, according to the diverse characteristics and advantages, we could handoff to a new wireless communication system with better QoS provisioning by received signals. This enhances the performance of the networks and keeps the connection stable. Between Cellular mobile (UMTS) and WLAN networks, from previous researches, several couplings have been researched on. Consider figure 1 below where the two networks can mostly be integrated in tight coupling, loose coupling, or open coupling network arrangements. In the tight coupling approach of which is actually the focus of this thesis, the 802.11 WLAN coverage area appears like another SGSN coverage area to the UMTS CN. For security reasons as well as seamless handoff between WLAN and UMTS tight coupling is the only and best solution as UMTS compared to loosely coupled, peer and hybrid coupled and this can also be depicted in[1], [2].

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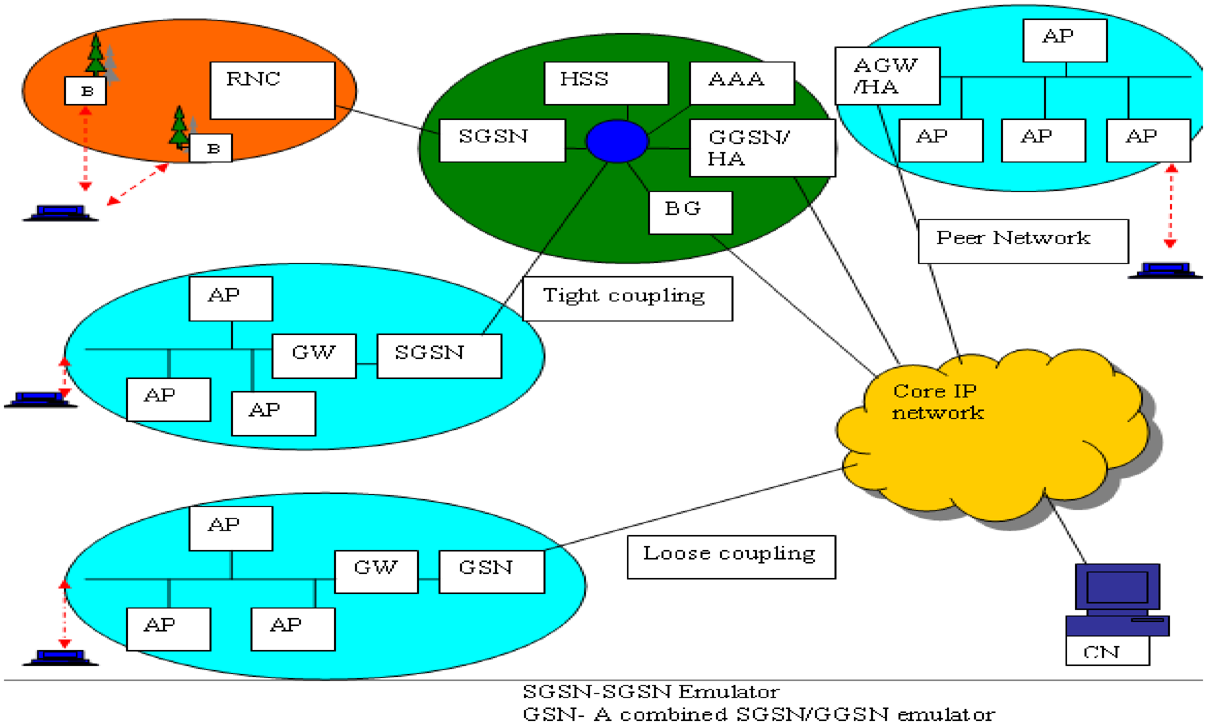

Figure 1: UMTS/802.11 WLAN general architecture

Contrary with the loosely coupled approach, the gateway directly connects the WLANs to the Internet backbone, and there is no direct link between the WLANs and the cellular core network. Due to network heterogeneity, the handoff between the cellular network and WLANs is referred to as vertical handoff, in contrast with horizontal handoff between base stations (BSs)or access points (APs) within a homogeneous wireless network.

Under the QoS considerations, the vertical handoff decision algorithm is an important aspect in cellular (UMTS)/WLAN interworking and is quite different from that in horizontal handoff. Additionally, mobility management is also an important aspect for ensuring that the user could stay connected or even reach better transmission capability when the mobile device changes the position. Handoff is a process of transferring a mobile device's communication from the old base station to a new one as this could also be discussed in [3]. The two (Vertical handoff and mobility management) being efficient can enhance the QoS in heterogeneous wireless networks.

a) Problem Statement

As we can observe from the trend of wireless communication networks and the market demand, we see that future generation wireless networks are expected to be the integration of heterogeneous wireless networks (HWNs) with Internet Protocol based infrastructure and support multiple bearer services. As a result, this will empower the service provider with the ability to capture advantages of different technologies to support different needs of mobile users. However, a major problem is the means to provide end-to-end quality of service (QoS) guarantee with seamless roaming in HWNs for multimedia service in a method that is scalable. Actually many researches using various protocols on QoS provisioning have been studied, however QoS has still been a challenging problem in heterogeneous wireless networks. In addition to the above, seamless vertical handoff is also one of the major challenges in the next-generation heterogeneous wireless systems as good handoff decisions and implementations is one of the most important issues Quality of Service provisioning depends on. Here, by seamless we mean that the handoff procedure should be transparent to applications in upper layers. In normal aspects we should expect two directional handoffs, one from WLAN to Cellular (UMTS) networks and vice versa. In order to achieve Quality of Service, issues for seamless handoff such as handoff metrics and handoff decision algorithms should be put under considerations and also mobility handling for maintaining on-going user connections. The impact of the above will be shown by performing simulation by using Optimal Network Simulator (OPNET).

b) Purpose of the research paper

As mobile communications technologies have evolved so rapidly even the number of mobile users and service providers has considerably increased. This being combined with many wireless LANs setup at hotspots in public areas like airports, conference halls, university campuses, hotels and cafes could significantly benefit from the integrated local and cellular communication technologies. Thus interworking between cellular (UMTS) and WLAN networks has been a popular issue to utilize benefits of each system. However, to achieve this, it would be vital that proper handoff mechanisms be established to realize internetwork roaming.

Since Quality of Service in this integration (heterogeneous wireless networks) has to be highly considered, the main objective of this research is;

- To minimize the service quality decrease such as; longer handoff delay (packet end to end delay), decreased throughput and network disconnection through analyzing the best mobility protocol for UMTS/WLAN interworking.
- To provide clear techniques (an interworking architecture) how handoff can be performed.
- To propose a solution that can enhance service quality during handoffs in UMTS/WLAN interworking.

We understand that there are many problems that do exist in such an interworking architecture however the focus of this research is to analyze the best mobility protocol that will provide efficient handoff which can finally support continuous services to the users.

II. Literature Review

In the past several years, wireless communications field with high speed networks and their respective wireless systems, seem to have been top hot topics of research in the society. With Cellular and WLAN networks' quick evolution and successful deployment widely have been the two promising ones in this area of communications. The primary objective of Cellular networks was high quality circuit switched voice service with wide area coverage and they have been well deployed worldwide. The Global System for Mobile communication (GSM) and IS-95 being second generation cellular networks were a revolution to digital from analogy technology and were additionally enhanced by General Packet Radio Service known as 2.5 generation for packet switched low rate of up to 100Kbps data services. However, with high rate demand increase for services such as multimedia, third generation (3G) evolved as a solution with expectations to deliver 2Mbps maximum bit rate. Contrary to cellular networks, WLANs have shown their capability over local area coverage to provide higher rate at a cheaper cost. This can be evidenced by IEEE 802.11b WLAN Working in the license-exempt 2.4 GHz industrial scientific and medical (ISM) frequency band, offering a data rate up to 11 Mb/s, whereas 54 Mbps data rate is supported by IEEE 802.11a WLAN and European Telecommunications Standard Institute (ETSI) HIPERLAN/2 in the 5 GHz frequency band as this can be well seen and discussed more in [9, 10].

It is in this point of view that the complementary characteristics of 3G cellular systems with low rate but wide coverage and WLAN with high rate but limited coverage make it attractive to provide ubiquitous wireless access when these two technologies are integrated. The integration therefore, of the IEEE 802.11 wireless LANs (WLANs) and 3G networks such as UMTS and CDMA2000 networks becomes a direction and focus in providing wireless services where even mobile IP that needs to be supported by both 3G (GPRS or UMTS) and WLAN is put under consideration. The mobile IP allows a user to maintain the same IP address and maintains connections while roaming between IP networks. This can also be discussed more in [10], [11] and [12].

In [13] and [14], feasible interworking architectures have been suggested to integrate cellular networks and WLANs for next- generation wireless communications, purposely for increasing cellular networks and WLANs with high-rate data services and area of coverage respectively as are of categories such as tightly and loosely coupled as well as peer network approach and hybrid coupled which behaves like tightly in terms of mobility guarantees while users are moving or in need to change their access technologies. This is however discussed more in [15, 16].

a) Mobility Management in HWN

Being one of the most important issues in mobile data networks, mobility management supports roaming users to benefit their services with mobile terminals through wireless networks progress. As a consequence of UMTS being integrated with WLAN, subscribers could be provided with better services. Due to the fact that UMTS is a telecommunication network and supports mobility whereas WLAN is data communication network with no mobility management, it will thus need mobility management functions and this could be achieved through integrating the two network technologies which would finally provide radio resource control functions to WLAN as well.

Terminal mobility happens to occur in three different kinds that include; terminal mobility with respect to user communications that is further divided into discrete and continuous mobility, terminal mobility with respect to change in network access and terminal mobility with respect to administrative domains as this can be well addressed in [17]. The strategy UMTS utilizes are of three-level location management that include; an MS being tracked at cell level during packet transmission session, at the UTRAN registration areas (URA) level during the idle period of an ongoing session, and at the RA level when the MS is not in any communication session. As regards the IEEE 802.11WLAN network can however be treated as a special URA in a special routing area (RA), within which, the 802.11 WLAN mobility management is adopted.

Mobility management is in [15] also addressed for three architectures that include; tightly and loosely coupled, where UMTS network is considered to be the master home network with roaming privileges to WLAN and peer networks whose assumption is that the user may be subscribed to either the UMTS or to the 802.11 WLAN operators.

b) Handoff Strategies

Handoff as has been defined in previous sections, in wireless networks can be classified into two types that are horizontal handoff that occurs when the mobile terminal (MT) is handed-over from the old base station (BS) to the new BS within the same network, and vertical handoff which occurs when the MT is handed-over from the old BS to the new BS in a different network. Furthermore, Vertical handoff is seen to be classified into upward and downward vertical handoff where by definition upward vertical handoff occurs when a handoff is performed from an underlay to an overlay network, and in simple terms it means from high data rate such as WLAN to low data rate such as UMTS networks and downward vertical handoff occurs from low data rate to high data rate networks. Since horizontal handoff occurs in same network, vertical handoff appears a challenge because it occurs in different network technologies that may even happen to have some different characteristics despite their compatibility. Mobility protocols in support after vertical handoff can be used for mobility management purposes. Handoff will in details discussed in later chapters however is also discussed in [7], [18] and [19].

c) Quality of Service (QoS) Strategies

Quality of Service is an important issue to be put under consideration in wireless communications. With Quality of Service provisioning strategies in traditional cellular networks, resource allocation plays an essential role effectively to each MS during its traffic lifetime and efficiently utilizing scarce radio resources. Being known for lack of good QoS, WLAN integrated with cellular networks (3G/WLAN), much more challenge to achieve QoS and efficient resource utilization is expected due to the nature of heterogeneous wireless networks (3G [UMTS] and WLAN) in addition to the limited QoS support in WLANs. The study of how seamless handoff in terms of voice, data and multimedia becomes possible and how QoS can be mapped and guaranteed is highly needed and put under much emphasis. As [10] guides us, this is however done with the emerging IEEE 802.11e standard in the sense that WLANs aims at provisioning QoS in a relative sense, which is similar to and can be mapped smoothly to the relative QoS provided by the DiffServ described more in [4]. Therefore, the fine QoS provisioning in cellular networks and the relatively weak QoS support capability of WLANs need to be taken into account for cellular/WLAN interworking.

d) Authentication and Security Strategies

Authentication and Security such as billing, service continuity and authentication delay are still challenging problems that should be considered as far as integration of 3G and WLAN networks is concerned. The UMTS Authentication and Key Agreement (AKA) discussed in [20] have one drawback which is the need of several message rounds to complete its procedure. This may cause large authentication latency especially when interworking and since the 3G core network is far away from the 802.11 WLAN network, the authentication latency will obviously increase and this is unfavorable for real-time applications especially. Cheng et al. mentioned the identity privacy problem as seen in [20]. They went further in that the WLAN station must pass through the WLAN access control procedure and perform a signaling procedure with 3G (UMTS) core networks. Regardless of roaming or not they proposed a scheme that a user performs authentication and authorization via 3G radio interface. In order to reduce the message round, another researcher, Lin et al. proposed a one-pass authentication procedure for 3GPP IP multimedia core network subsystem (IMS). In addition, Tseng et al. proposed an efficient authentication protocol which adopts the hash-chain technique that happens to include three components that are; authentication server of 3G network (3G-AS), authentication server of WLAN (WLAN-AS), and mobile terminal (MT) which has dual interfaces to the connection with UMTS or WLAN. Authentication and security of this integration is in details discussed in [20]. In addition to the above, joint call admission control (JCAC) algorithm, which is one of the radio resource management algorithms for minimizing call blocking probability in heterogeneous wireless networks and QoS guaranteed requirements is also discussed in [21].

III. Cellular Networks

A cellular communications network has achieved popularity and has experienced explosive growth in the past two decades and this has been evidenced by the current usage of cellular phones that amounts to millions of people around the world. Cellular phones allow and enable a person or user to make or receive a call from almost anywhere. Likewise, while on the move, a person is allowed to continue the phone conversation. Cellular communications is supported by an infrastructure called a cellular network, which integrates cellular phones into the public switched telephone network. A cellular network is a radio network made up of a number of radio cells each served by a fixed transmitter, known as a call site or base station. Since the area of coverage is put under consideration in cellular networks, these cells are used to cover different areas in order to provide radio coverage over a wider area than the area of one cell. Through the above, they serve a number of advantages such as increased capacity, reduced power usage as well as better coverage.

There are requirements for succeeding a cellular network and the prominent one is for it to have developed a standardized method for each distributed station to distinguish the signal emanating from its own transmitter from the signals received from other transmitters. At present, there are two standardized solutions to this issue, one being frequency division multiple access (FDMA) that works by using varying frequencies for each neighboring cell and the other is code division multiple access (CDMA).

In addition, own other methods of multiplexing that include; polarization division multiple access (PDMA) and time division multiple access (TDMA). These however cannot be used to separate signals from one cell to the next since the effects of both vary with position and this would make signal separation practically impossible.

In this chapter, however discuss some GSM, GPRS and UMTS concepts that will facilitate my approach to integrating UMTS technologies with WLAN with specific interest being focused on the handoff mechanisms will briefly be addressed. Otherwise more of cellular networks are discussed in [22] and [23].

a) Basic Cellular Network Concepts

In the field of communications we find multiple concepts behind cellular networks such as cellular mobile phones that include the mechanisms under which cellular phones are connected by radio network towers. The cellular mobile radio network simple structure consists of the mobile switching centre (MSC), radio base station (BS), and public switched telephone network (PSTN).

A cellular network provides cell phones or MSs, to use a more general term, with wireless access to the PSTN. The service coverage area of a cellular network is divided into many smaller areas, referred to as cells, each of which is served by a base station (BS). The BS is fixed, and is connected to the mobile telephone switching office (MTSO), also known as the MSC. The MTSO is in charge of a cluster of BSs and it is, in turn, connected to the PSTN. The GSM system network is actually based on this network. For telephone users to get the desired services, requirements such as mobility management, registration and call setup as well as handoffs must be performed by this network. This will in the end enable MSs communicate with another and even wired line phones in the PSTN with wireless link between MS and BS. Both BS and MS are equipped with a transceiver. The link from an MS to the BS is called an uplink whereas that from BS to the MS is downlink. The cell system allow channel re-use, centralized control and increased system capacity with the capacity of the cell depending on the reuse factor which is also influenced by the signal-to-interference ratio (SIR). In order to avoid the cause of co-channel interference, the group of frequencies cannot be reused in adjacent cells however can be reused in other cells. The advantage of reduced power usage that results in BSs with low transmission power, help minimize interference caused by fading due to mobility and scattering due to reflecting surfaces. D, a reuse distance, is calculated as

$$D = R\sqrt{3N}$$

N is the number of cells per cluster whereas R is the radius of the cell. Cells radius vary where some ranges to 1 km others up to 30 km. The cells however could beof different shapes that include hexagonal, circular or some other undefined irregular shapes. More about cellular concept are in [23].

b) Cellular Networks Evolution Overview

Cellular systems became popular because of radio-frequency reuse, which allows more cell phone users to be supported. The cellular concept was first used in the Advanced Mobile Phone Service (AMPS) developed by AT&T in the United States in early 1980s [23]. The original cellular telephone networks provided analog traffic channels that are now referred to as first-generation systems (1G). As a first generation of cellular systems, AMPS is an FDMA-based analog system. The 2G of cellular systems uses digital technologies. Two interim standards, base on CDMA (IS-95) and IS-136 base on TDMA, are used in the United States, and TDMA-based GSM is used in European countries. It is clear that the 3G of cellular systems will be CDMA-based. However, the GSM community is developing WCDMA to be backward compatible with GSM while the CDMA community tries to evolve CDMA into CDMA2000. Currently researchers are studying technologies for beyond 3G (B3G) or fourth generation (4G) networks.

The Cellular radio systems, implemented for the first time in AMPS, supports more users by allowing reuse of frequencies. AMPS transmits 3-kHz voice signal over 30-kHz channel using frequency modulation and is part of first generation (1G) cellular radio systems. The first-generation systems are voice-oriented analogy cellular and cordless telephones. IS-41 was originally developed to support the operations with AMPS. However, as an analog system, AMPS does not support voice encryption. To overcome the limited capacity of AMPS, especially in large cities, D-AMPS (IS-54) was developed in the early 1990s (EIA/TIA, 1990). Specifically, in D-AMPS, the same AMPS allocation of frequency spectrum is used, and each channel is still 30 kHz wide. However, in D-AMPS, a 30- kHz channel can be shared by three users through the 2G TDMA digital technology. First-generation cellular networks, such as AMPS, quickly became highly popular, threatening to swamp available capacity. Second-generation (2G) systems which are voice oriented digital cellular and personal communication service (PCS) systems and data oriented wireless WANs and LANs have been developed to provide higher quality signals, higher data rates for support of digital services, and greater capacity. It means that D-AMPS allows a service provider to migrate from the first-generation analog technology to the 2G digital technology on a gradual basis [23, 24].

Before the Global System for Mobile Communications (GSM) was developed in 1990 in Europe, the European countries used a number of incompatible first-generation cellular phone technologies. GSM, a 2G system that uses the TDMA digital technology, was therefore developed to solve the incompatibility problem of different first-generation systems in Europe. It is now widely deployed around the world including in the United States. The allocated spectrum is divided into multiple channels of 200 kHz using FDMA, and each 200- kHz channel is shared by as many as eight users using TDMA. One feature of GSM worth mentioning is the SIM card that can be inserted into a cellular phone to provide the owner's identity information. The subscriber identity module (SIM) is a portable device in the form of a smart card or plug-in module that stores the subscriber's identification number, the networks the subscriber is authorized to use, encryption keys, and other information specific to the subscriber. A cell phone without a SIM card inserted does not work. A SIM card can be inserted into any cell phone to make the phone usable. Whereas IS-54, IS-136, and GSM are all TDMA-based, IS-95 is CDMA-based (EIA/TIA, 1995) where each user in CDMA is assigned a unique code to encode the data to be transmitted. CDMA an alternative to TDMA for 2G uses channels that are 1.25 MHz wide, and is able to support up to 64 users with orthogonal codes.

With the evolution of third generation (3G) of cellular wireless communication networks, its aim was to develop an international standard that combines and gradually replaces 2G digital cellular, PCS, and mobile data services. Furthermore, 3G systems were expected to provide fairly high speed wireless communications to support multimedia, data, and video in addition to voice and increase the quality of the voice and capacity of the network as well. The 3G path adopted by the GSM community is first to general packet radio services (GPRS), then to enhanced data rates for global evolution (EDGE), and ultimately to WCDMA (Qualcomm CDMA Technologies). Currently GSM provides data services of 9.6 Kbps using a single TDMA channel.

Finally, with the next generation referred to as beyond 3G or 4G is under research and will integrate wireless local area networks (LANS) such as IEEE 802.11 and Bluetooth with wide area cellular networks. The data transmission rate of 4G communications will be much higher than 3G, at 20 to 100 Mbps in mobile mode. More information concerning evolution of cellular networks can however be depicted in [24].

c) Global System for Mobile communication

Originally from Groupe Spécial Mobile, Global System for Mobile communications (GSM) is a cellular network which in the world is the most popular standard for mobile phones. It is an ETSI standard for 2G pan-European digital cellular with ubiquity that makes international roaming very common between mobile phones operators, enabling subscribers to use their phones in many parts of the world. Its promoter, the GSM Association, estimates that 82% of the global mobile market uses the standard and is used by over 3 billion people across more than 212 countries and territories [22]. It uses TDMA as the air-link sharing technique and GMSK as its modulation scheme. In GSM, 8 users share each 200 KHz channel providing 25 KHz bandwidth for registered users. In GMSK, the signal to be modulated onto the carrier is first smoothed with a Gaussian low-pass filter prior to being fed to a frequency modulator, which greatly reduces the interference to neighboring channels known as adjacent channel interference. The ubiquity of the GSM standard has been an advantage to both consumers and also to network operators.

The GSM main architecture is divided into three general parts as [24] depicts:

- The mobile station (MS) with two elements; the first being mobile equipment (ME) which is a piece of hardware containing all the components that include speaker, microphone, keypad, and the radio modem needed for the implementation of the protocols to interface with the user and the air-interface to the BSS. The second element is the SIM which is a smart card issued at the subscription time identifying the user's address specifications and type of service.
- The Base Station Subsystem (BSS) that communicates with the user through the wireless air-interface and with the wired infrastructure through the wired protocols. The BSS lies between the MS and MSC. It often consists of one or more BTSs and a centralized BSC that manages and controls radio resources of the BTSs including frequency hopping, radio channel setup and handoff.
- Network and Switching Subsystem (NSS) responsible for the network operation and provides communications with other wired and wireless networks as well as support for registration and maintenance of the connection with the MSs. The NSS consists of MSC as a hardware part of the switch and four software elements that include visitor location register (VLR), home location register

(HLR), equipment identification register (EIR), and authentication center (AUC).

d) General Packet Radio Service

General Packet Radio Service (GPRS) network is an extension to the global system for mobile communication (GSM) network, which has been introduced to enable packet switched data services via the public land mobile network (PLMN). 2G cellular systems combined with GPRS are often described as 2.5G, that is, a technology between the second (2G) and third (3G) generations of mobile telephony. It additionally provides moderate speed data transfer, by using unused Time division multiple access (TDMA) channels in, GSM system. It was originally standardized by European Telecommunications Standards Institute (ETSI) as an enhancement of the circuit switched GSM network to support packet switched data services, but now is a standard by the 3rd Generation Partnership Project (3GPP). It provides a data rate from 56 up to 114 kb/s to users of GSM and IS-136 mobile phones. A GPRS connection is established by reference to its Access Point Name (APN). The APN defines the services such as Wireless Application Protocol (WAP) access, Short Message Service (SMS), Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access. GPRS is a best-effort packet switched service, as opposed to circuit switching, where a certain Quality of Service (QoS) is guaranteed during the connection for non-mobile users [22].Referring to the overall GPRS architecture below in Figure 3.0, we observe two main building blocks defined by; the core network and the base station subsystem (BSS). Both blocks are important to assess the performance of end-to-end packet data services. The BSS governs the GSM enhanced data rates for global evolution (EDGE) radio access network (GERAN) and provides the wireless interface to the MS. GPRS uses the physical air interface defined for GSM [25].

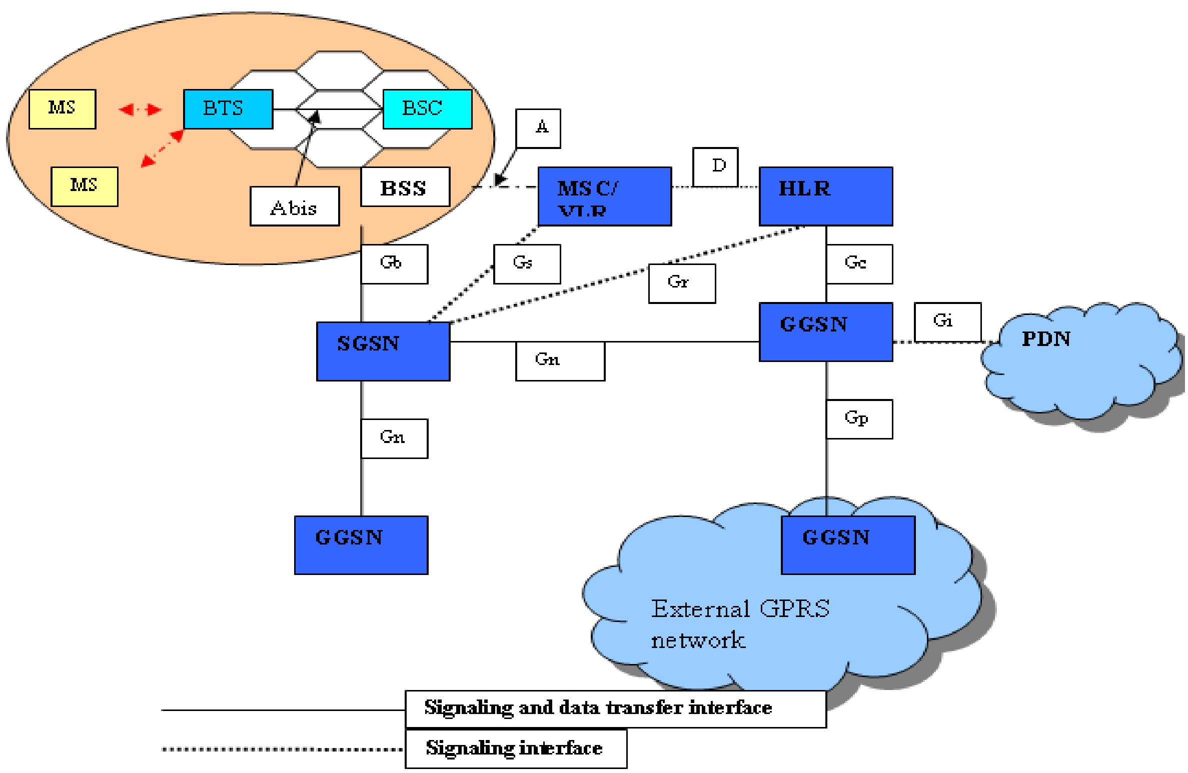

Figure 3: GPRS logical network architecture

The SGSN as clearly seen in the figure 3.0, functions as a packet switching MSC by delivering packets to MSs within its service area. It communicates with the HLR to obtain profile data of genuine GPRS subscribers.

The GGSN corresponds to the GMSC and is the final GPRS network exit node on route to other packet data networks (PDN) like the Internet or intranet. The GGSN's location directory has to be constantly updated about a MS's location by the SGSN. The SGSN and GGSN interact with the MSC/VLR and HLR through Signaling System Number 7 (SS7) / IP gateway (SIG) connected to the IP backbone of the GPRS network.

GPRS Mobility Management

GPRS handles mobility management in same way as GSM does only that GPRS' MS may happens to be in three states that include idle, ready and standby unlike GSM with only ready or idle. Individual or several cells can be grouped in routing areas and every routing area is served by one SGSN. A MS can move to ready state by attaching to the GPRS network and by activating a packet data protocol (PDP) context, which activates GPRS user profiles, including IP addresses and QoS parameters. The core network (CN) of the packet switched domain is essentially a cluster of routers and databases interconnected by different interfaces and protocols. Typically, the network interconnecting the CN devices is referred to as the packet data network (PDN). The Gb interface connects the BSS and the SGSN allowing the exchange of user data and signaling messages. The SGSN relays IP traffic originating from the MS to the gateway GPRS support node (GGSN) and vice versa. Furthermore, it collaborates with the HLR to manage mobility of the MSs. The GGSN provides interworking with external IP networks, such as the Internet. However detailed discussions can be obtained in [22], [23], [24] and [25].

e) Universal Mobile Telecommunication System

Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) cell phone technologies, which is also being developed into a 4G technology. It represents an evolution in terms of services and data speeds from today's second generation (2G) mobile networks such as Global System for Mobile Communications (GSM) and the enhanced 2.5G mobile networks such as General Packet Radio Services (GPRS). Currently, the most common form of UMTS uses W-CDMA as the underlying air interface. It is standardized by the 3GPP, and is the European answer to the ITU IMT-2000 requirements for 3G cellular radio systems. To differentiate UMTS from competing network technologies, UMTS is sometimes marketed as 3GSM, emphasizing the combination of the 3G nature of the technology and the GSM standard which it was designed to succeed.

UMTS Network architecture

The network architecture of the UMTS system shown in figure 3.1 below consists of three parts that include The User Equipment (UE) domain, the UMTS Terrestrial Radio Access Network (UTRAN) domain and the Core Network (CN) domain.

The UE domain represents the equipment used by the user to access UMTS services while the UTRAN domain which is introduced for efficient radio resource control (RRC), together with the Core network (CN) domain, known as the infrastructure domain, consist of the physical nodes which perform the various functions required to terminate the radio interface and to support the telecommunication services requirements of the user.

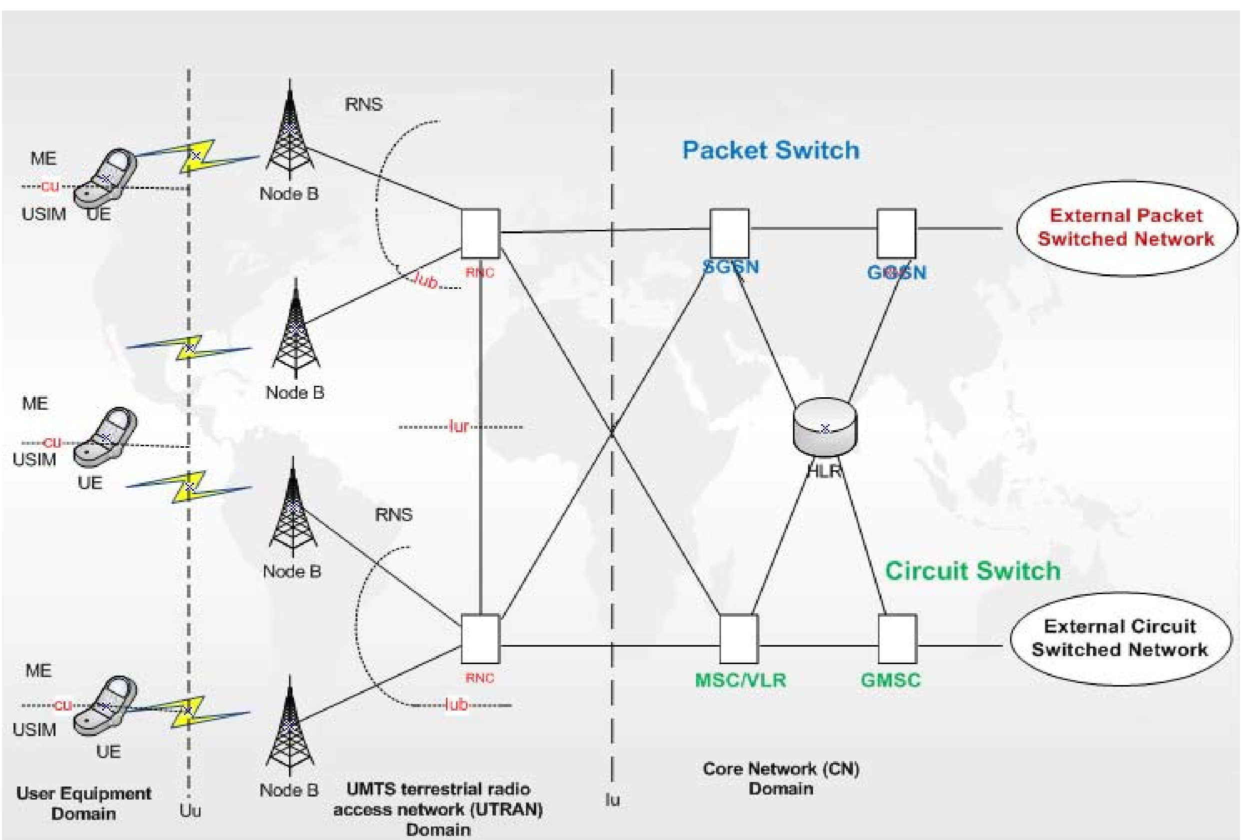

Figure 3.1: UMTS network architecture

The UE domain encompasses a variety of equipment types typically referred to as user equipment with different levels of functionality such as cellular phones, personal digital assistants (PDAs), laptops etc.

It consists of two parts; The UMTS Subscriber Identity Module (USIM) which is a smartcard that contains user-specific information and the authentication keys that authenticates a user's access to a network, and the Mobile Equipment (ME) which is a radio terminal used for radio communication with the UTRAN domain over the Uu radio interface. The USIM is also physically incorporated into a SIM card and linked to the ME over an electrical interface at reference point Cu. The UTRAN domain that consists of one or more Radio Network Sub-systems (RNS) where each RNS consists of one or more Node Bsand one Radio Network Controller (RNC) handles all radio-related functionality. The Node B, also known as a Base Station and equivalent to the Base Transceiver Station (BTS) from GSM, converts the signals of the radio interface into a data stream and forwards it to the RNC over the Iub interface. It is also responsible for controlling data flow between UE and RNC, Channel coding and interleaving, rate adaptation, radio resource management and power control. Further more, in the opposite direction, it prepares incoming data from the RNC for transport over the radio interface. The RNC controls one or more Node Bs over the Iub interface and is responsible for the management of all the radio resources in the UTRAN. It is the central node in the UTRAN and equivalent to the Base Station Controller (BSC) from GSM. The RNC interfaces the CN domain over the Iu interface thus performs access point services from UTRAN to CN [26, 27, and 28].

The CN domain which is divided into a Packet Switched network (PS), a Circuit Switched network (CS) and a Home Location Register (HLR) is responsible for switching and routing calls and data connections between the UTRAN domain and external packet and circuit switched networks.

Mobility management in UMTS

In wireless networks where the terminal may be anywhere, a mechanism must be in existence to locate the terminal in order of delivering communication to it. All this is handled by mobility management where mobile communication systems like UMTSby definition are meant to handle mobility management. It involves two mechanisms that include; location management and handoff management. Location management is the mechanism a wireless network uses in keeping track of a user's location outside an active connection, whereas handoff management is the mechanism of handing over an active connection from one cell to another. Both mechanisms together are commonly referred to as Mobility management.

Location Management

Location management involves tracking of MS's location as it moves for the message voice or data delivery to it. Location management generally consists of three parts that include; location updates, paging, and location information disseminating. When an incoming connection's transfer to an inactive user, the network must continuously be up-to-date with where the MS is. The location updates are messages that the user sends regarding its changing points of access to the fixed network, and is defined for both CS and PS services. In terms of CS services, the network is divided into Location Areas (LA) that consists of a number of cells between which the user can move without updating his location whereas with PS connections services, the UE will receive short data packets more frequently than is the case with CS connections. For the delivery of an incoming message to the user (MS), the network will have to page MS in such a group of cells and the paged terminal will respond through the point of access that is providing the coverage in its cell. Consequently, the location update for PS connections divides the network into even smaller areas called Routing Areas to limit the amount of paging as this can also be referenced in [24, 26].

Handoff Management

The basic idea behind handoff is to provide the continuous connection when moving among cells (from one cell to another). The handoff is actually realized by changing the radio channel. To forward an active connection from one cell to another, the network must perform a handoff. Therefore, handoff management involves issues and actions that are required to handle an ongoing connection when a mobile terminal moves from the coverage of one access point to another. Similar to location management, the handoff process is defined for both CS and PS services where in terms of CS services, handoffs can be implemented as soft handoffs, softer handoffs and hard handoffs [26]. During soft handoff user equipment is located in the coverage area of two or more different Node Bs. The user equipment simultaneously communicates with two or more Node Bs via two or more radio channels. If the received signal strength from the Node Bs in cells one and two differ by a maximum of an amount called the handoff margin during a certain period of time, a connection is also established to the Node B in cell two. However, when the received signal strength from Node B in cell one is smaller by a certain amount than that of the Node B in cell two, the connection to the first Node B in cell one is cleared. A received signal in Node B is routed to the RNC and compares the signal on the frame by frame basis. The best frame is selected for the next processing and the other frames are discarded [29].

A softer handoff is similar to soft handoff where transmission also runs in parallel over different sectors but of the same Node B. The main difference between these two handoffs resides in the sense that a UE is located in the coverage area of two sectors of one Node B. Also, UE initially communicates with Node B in sector one of cell one. The UE communicates with one Node B

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via two radio channels. As the UE starts to move it also starts to receive a signal from the same Node B in the same cell one but from another sector (two). The signal from sector two is a reflected signal of the direct signal. This can happen if for example a large building is in the line of the direct signal and thus unintentionally relays the signal in another angle. If the received signal strength from sector one and two differ by a maximum of the handoff margin, a connection is established to sector two. When the received signal strength from sector one is smaller than that of sector two, the connection from sector one is cleared and a softer handoff has taken place. Considering figures 3.2 and 3.3 bellow, in the downlink direction, the situation of combining the signals is same as in the case of soft handoff whereas in the uplink direction, the situation is different. The signal received in the Node B is not routed to the RNC; however, the combination of the signals is realized in this Node B's rake receiver.

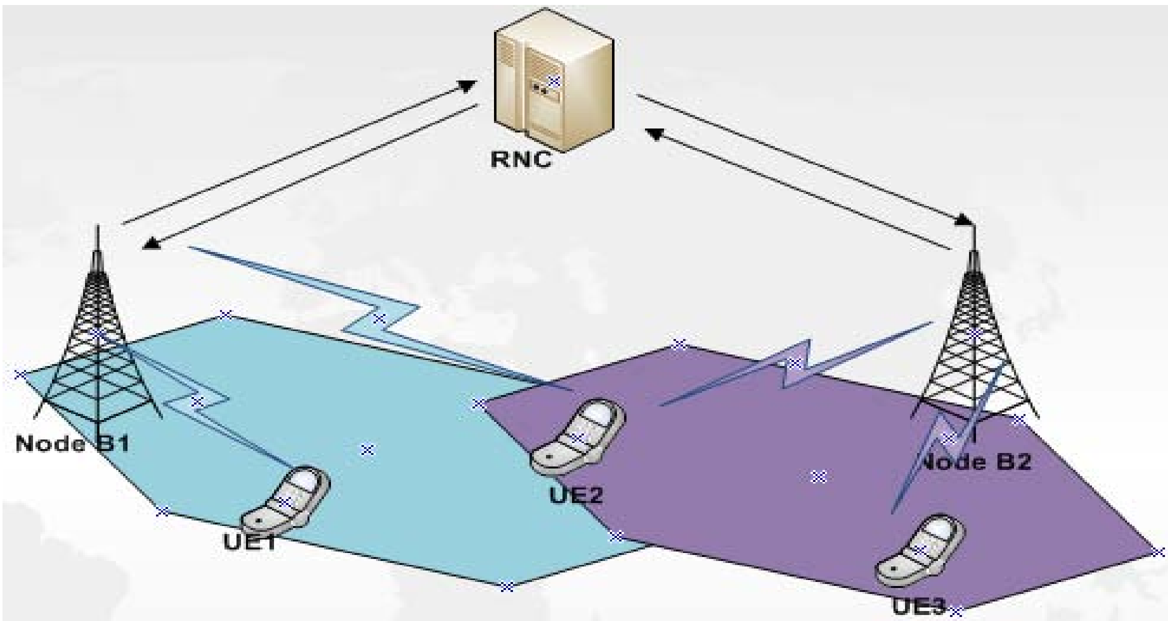

Figure 3.2: Soft handoff

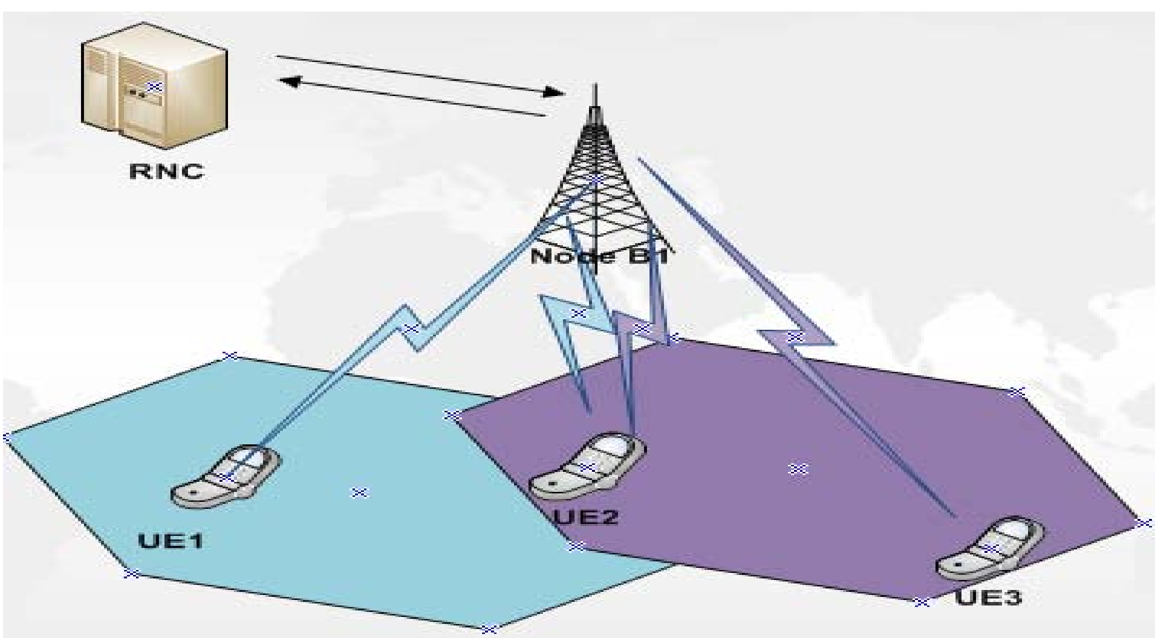

Figure 3.3: Softer handoff

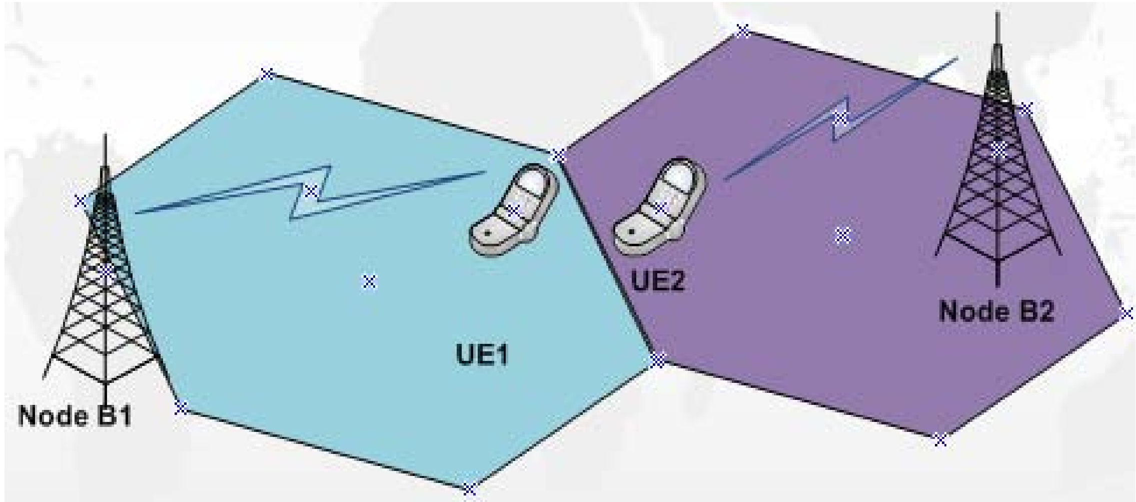

Figure 3.4: Hard handoff

Hard handoff takes place when the connection to the current cell is broken before a connection to a new cell is made, i.e. from one frame to the next one. Handoff is executed after the signal strength from neighbor's cell exceeding the signal strength from the current cell, Figure 3.4. There are different sub-types of hard handoff; inter-frequency, intra-frequency and inter-system. An inter-frequency hard handoff is made between two different frequencies within the same cell or adjacent cells. An intra-frequency hard handoff is performed in situations where the Iur interface between two RNCs is not available for a soft handoff. A hard handoff is then performed from one cell belonging to one RNC to the next cell belonging to another RNC using the same frequency. Finally, an inter-system hard handoff is performed when it is required to change the radio access technology from UMTS to GSM [26].

However, in terms of PS services, there is one type of handoff defined for a UMTS network which is cell reselection. This is where the UE continuously monitors the signal quality from other cells as the user relocates. On this, the UE is instructed to send a measurement report to the serving RNC when the quality of a neighboring cell exceeds a given threshold and thus the quality from the current cell is unsatisfactory.

Finally, when the cell re-selection has been completed, the UE initiates the routing area update procedure as described before [29].

IV. UMTS and WLAN Comparison

Putting into consideration the complementary purposes rather than competitiveness, this chapter shows how the two technologies can be considered complementary. The two previous chapters described some basic characteristics of each of the technologies in terms of network architecture as well as mobility management.

Behind comparisons between UMTS and WLAN a summary in the form of a table (Table1) is shown bellow otherwise more details could be obtained in [32].

Table 1: 3G (UMTS) and WLAN comparison

Characteristics	3G-UMTS	WLAN
Services	Circuit- and packet-switched services	Packet-switched services
Data rates (Speed)	144 kbps satellite and rural areas min 120 km/h, max 500 km/h 384 kbps urban outdoor environments max 120 km/h 2 Mbps indoor and low range outdoor min 0 km/h, max 10 km/h	1 Mbps max 100 m (indoor) max 450 m (outdoor) 2 Mbps max 90 m (indoor) max 300 m (outdoor) 5.5 Mbps max 70 m (indoor) max 150 m (outdoor) 11 Mbps max 30 m (indoor) max 100 m (outdoor) 54 Mbps max 100 m (outdoor)
Coverage	Cellular, national/international coverage	Non-cellular, local coverage
Power control	Flexible power control	Max. effect of 100 mW required
Mobility	High, global (UMTS, UMTS-GSM)	Low, local (WLAN)
Deployment costs	Expensive	Cheap

Standardization bodies	Closed standardization body	Open standardization body
Technological origin	Telecommunication	Data communication
Air interface	WCDMA	HR-DS (High Rate Direct Sequence)
Channel Bandwidth	5 MHz	5 MHz
Chip rate	3.84 Mcps	11 Mcps
Frequency regulations	Regulated frequency spectrum	Unregulated frequency spectrum
Frequency band	WCDMA 1920-1980 MHz (up link) FDD 2110-2170 MHz (down link) 12 channels WCDMA 1900-1920 MHz TDD 2010-2025 MHz 7 channels New band 2500-2690 MHz	2.412-2472 GHz 13 channels
Speed	384 Kbps to 2 Mbps	11 Mbps to 54 Mbps

In a little bit of the above table1 description we find differences between the two network technologies include the range of supported services. The UMTS standard supports a variety of circuit- and packet-switched services whereas the WLAN specification only supports the corresponding packet-switched services.

In addition to the above, data rates is another significant difference where UMTS depending on the traveling speed environment supports data rates ranging from 144 kbps up to 2 Mbps. High mobility users, classed as users traveling over at 120 km/h and max 500 km/h in satellite and rural areas can expect data rates of 144 kbps. Full mobility user, such as at a speed less than 120 km/h and in urban outdoor environments, can expect 384kbps. Finally, low mobility users, those based indoor or at low range outdoor traveling at less than 10 km/h or stationary, in normal circumstances expect data rates of up to 2 Mbps as this could also be described in [33]. Opposite to the UMTS, WLAN depending on a specific environment supports data rates ranging from 1 Mbps up to 11 Mbps. However WLAN goes further to 54Mbps depending on IEEE 802.11 specification. More information about the how this varies can well be seen from the table 1 above.

Other differences such as coverage, power control, mobility, costs etc. are as well summarized clearly from Table 1.

It is thus expected that 3G will benefit over WLAN whose rate is very high, in terms of mobility and connectivity. On the other hand, WLAN benefits over 3G whose coverage area is big, in terms of throughput. Therefore, it is obvious that if the advantages of both technologies are combined, we will have a very powerful network covering the needs of the demanding users. WLAN is currently considered as a complementary service offering for mobile operators. Operator's WLAN solutions may vary but all of them combine the wide area benefits of second and third generation mobile systems, including unlimited roaming and mobility, with additional throughput and capacity in indoor hotspots through WLAN technologies. The complementary architecture for UMTS and WLAN technologies therefore, enables broadband mobile public access to the Internet as well as to corporate intranets with relatively small additional investment. However more detailed discussion can also be found in [34].

The network technology as we are emphasizing on UMTS and WLAN, specifically a connection is initially set to WLAN, which we defined as state 1, and then transitions between states 1 and 2 which is UMTS are governed by the two state Markov model shown in Figure 7.6.

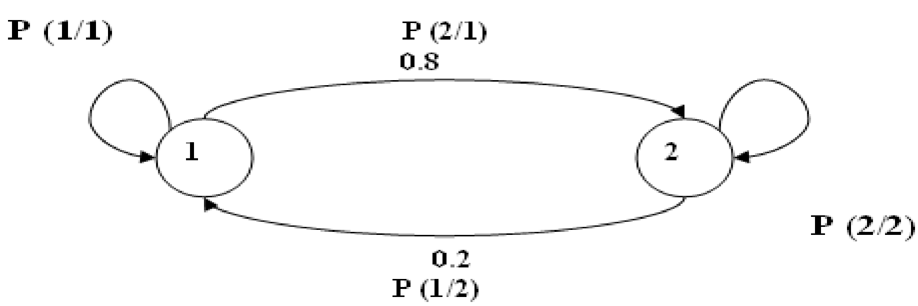

Figure 3.5: Two state Markov model

Transition probabilities are set to 0.8 from WLAN to UMTS and 0.2 from UMTS to WLAN which implies that the state probabilities for UMTS and WLAN are 0.8 and 0.2, respectively, as given by the two Markov equations bellow;

$$P(1) = P(1/2) / \{P(1/2) + P(2/1)\} \quad (1)$$

$$P(2) = P(2/1) / \{P(1/2) + P(2/1)\} \quad (2)$$

Idle State: This is an unforced (red) state which pauses and after, executes its enter executives allowing the simulation to turn its attention to other entities and events in the model. This state is however interrupted by three different events; packet arrival, packet from queue and incoming registration request (location update) at any time. When an interrupt is received, the process transits to the next state.

Arrival State: This is a state that is invoked when an interrupt is received from the packet arrival event. A delay event is introduced when the packet is scheduled for sending from client to server or vise versa and this occurs while the packet is queued. Furthermore, the statistics for packet delays and packet counts are updated. As soon as the schedule times out the system returns to the idle state.

Send State: This state is entered when an interrupt is received from the packet at the end of the queue event. The packet is then sent on to the destination, and the system returns to the idle state.

Loc State: This state takes place when an interrupt is received from the incoming registration request event. Then from the function block the system executes the function location update during transition. In order to determine change of location and technology as well, the client-server or server-client delay values are slightly altered. As a result, the updated location update delay value occurs and also decides the type of network technology change that has occurred. WLAN network is set first by the initstate. The client probability estimate in WLAN was set to 0.2 whereas the probability of a client being in UMTS network amounts 0.8 as UMTS has a wider coverage. The description behind this scenario is that; when the outcome of the technology distribution function lies within 80%, i.e. less than 0.8, means that the network technology then has changed. Primarily the network technology being WLAN, the delay value increases by 31 ms because the network technology changes to UMTS. With estimations UMTS network is therefore adds an extra 31 msdelay (32 ms minus 1ms) compared to the WLAN which decreases the delay value by 31ms and whose distribution function falls within 20% thus changing from UMTS to WLAN. From the above description, when it occurs that the technology distribution function doesn't fall below the probability for network technology change value, this implies that vertical handoff did not take place, instead horizontal handoff occurred.

Loc Arrival State: During location update, this state is invoked on the packet arrival and the packet is however destroyed. In addition, the statistic for packet drop is updated and thus the system returns to the loc state when it is done.

Loc send State: During location update, the loc send state is invoked if there are any packets in queue. The system takes the first packet out of the queue and sends it on to the destination. It then returns to the loc state. When the scheduled event location update delay from the location update function comes to an end, the event registration request complete takes place. The system consequently transits to the idle state. During the transition the system executes the function location update complete from the function block. The function location update complete involves updating the location update end time statistic.

References Références Referencias

1. Hasham S. Abdel-Ghaffar, Hanaa Abdel-Aziz Ebrahim, and Ahmed A. Khalifa; Efficient Mobility Management Protocols for Integrated UMTS and Outdoor WLAN 802.11g; 2008 IEEE
2. Wei Song, Hai Jiang, Weihua Zhuang, and Xuemin (Sherman) Shen; Resource Management for QoS Support in Cellular/WLAN Interworking; IEEE Network • September/October 2005
3. Ying-Hong Wang, Chih-Peng Hsu, Kuo-Feng Huang, Wei-Chia Huang; Handoff decision scheme with guaranteed QoS in heterogeneous network; 2008IEEE
4. Juan Carlos Fernandez, Tarik Taleb, Nirwan Ansari, Kazuo Hashimoto, Yoshiaki Nemoto, and Nei Kato; Dynamic QoS Negotiation for Next-Generation Wireless Communications Systems; 2007 IEEE
5. Elias Z. Tragos and George Tsiropoulos, George T. Karetsos, Sofoklis A. Kyriazakos; Admission Control for QoS Support in Heterogeneous 4G Wireless Networks; IEEE Network, May/June 2008
6. Abdul Hasib and Abraham O. Fapojuwo; A QoS Negotiation Framework for Heterogeneous Wireless Networks; 2007 IEEE
7. Qian Zhang, Chuanxiong Guo, Zihua Guo, and Wenwu Zhu; Efficient Mobility Management for Vertical Handoff between WWAN and WLAN; IEEE Communications Magazine, November 2003
8. Sungkwan Jung and Dong-ho Cho, Osok Song; QoS based vertical handoff method between UMTS systems and wireless LAN networks; 2004 IEEE
9. International Journal of Wireless and Mobile Computing, http://www.inderscience.com; Towards Ubiquitous Wireless Communication: The Integration of 3G/WLAN Networks.
10. Yang Xiao, Kin K. Leung, Yi Pan and Xiaojiang Du; Architecture, Mobility Management, and Quality of Service for integrated 3G and WLAN Networks; Wiley Journal of WCMC, 2005.

11. Muhammad Jaseemuddin; An Architecture for Integrating UMTS and 802.11 WLAN Networks; 2003 IEEE.
12. Behcet Sarikaya; Architectures for Seamless Roaming in 3GPP-WLAN Integration, Senior member IEEE
13. Sibaram Khara, 'ItiSahamistra and 2 Debashis Saha; An Alternative Architecture for WLAN/GPRS Integration; 2006 IEEE
14. SuKyoung Lee,1 WonSik Chung,1 KunHo Hong,1 and Nada Golmie2;Power-Efficient Communication Protocol for Integrated WWAN and WLAN; EURASIP Journal on Wireless Communications and Networking Volume 2008
15. Vijay K. Varma, Sudha Ramesh, K. Daniel Wong and Jeffrey A. Friedhoffer; Mobility Management in Integrated UMTS/WLAN Networks;2003 IEEE
16. Jee-young Song, Sung-won Lee and Dong-ho Cho; Hybrid Coupling Scheme for UMTS and Wireless LAN Interworking;2003 IEEE
17. Ying-Hong Wang, Chih-Peng Hsu, Jeng-You Lai; A Mobile IPv6 based Seamless Handoff Strategy for Heterogeneous Wireless Networks; 2004 IEEE
18. Ariton E. Xhafa and Ozan K. Tonguz; Reducing Handover Time in Heterogeneous Wireless Networks; 2003 IEEE,
19. Min Liu, Zhongcheng Li, Xiaobing Guo, and Eryk Dutkiewicz; Performance Analysis and Optimization of Handoff Algorithms in Heterogeneous Wireless Networks; IEEE Transactions on Mobile Computing, Vol. 7, No. 7, July 2008
20. Chou-Chen Yang1, Kuan-Hao Chu2, and Ya-Wen Yang2; 3G and WLAN Interworking Security: Current Status and Key Issues; International Journal of Network Security, Vol.2, No.1, PP.1–13, Jan. 2006
21. Olabisi E. Falowo and H. Anthony Chan; Optimal Joint Radio Resource Management to Improve Connection-Level QoS in Next Generation Wireless Networks; 2008 IEEE
22. http://en.wikipedia.org/wiki/Cellular_network
23. Jingyuan Zhang and Ivan Stojmenovic; Cellular networks; WL041/Bidgoli WL041-Bidgoli.cls July 18, 2005
24. Kaveh Pahlavan and Prashant Krishnamurthy; Principles of Wireless Networks; A Unified Approach
25. Dirk Michel and Nathan Ramasarma; GPRS Measurement Methodologies and Performance Characterization for the Railway Environment; IEEE Communications Society / WCNC 2005
26. Anja Louise Schmidt; UMTS and WLAN interoperability; July 2004
27. Yun Won Chung, Dan keun Sung and A. Hamid Aghvami; Steady state analysis of UE state transitions for UMTS; 2002 IEEE
28. UMTS Protocols and Protocol testing; Internet Engineering consortium
29. Z. Becvar, J. Zelenka, R. Bestak; Comparison of Handovers in UMTS and WIMAX.
30. Koutsakis Panagiotis; Wireless LAN Networking.
31. Tao Jia Qiang Hou and Wei (Eric) Peng Simulation of Handoff Procedure based on SIP over Wireless LAN, 2003.
32. Mr. S. Velentzas and Dr. T. Dagiuklas; 4G Cellular/WLAN Interworking, Motorola, ATKE
33. Robert Lloyd-Evans QoS in Integrated 3G Networks, Artech House, Inc., Norwood, USA, 2002.
34. Sung-Eun Kim; Efficient and QoS Guaranteed Data Transport in Heterogeneous Wireless Mobile Networks, May 2006.