IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 9, September 2016

Study and Analysis of Vertical Handover Algorithm in 4G

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Abstract: The rapid increase and development of mobile communication network system has accelerated the data transfer speed. These technologies are expected to provide services like voice, data, web browsing, video conferencing, video streaming and telemetry with mobility of the end users. The horizontal handoff is available in 2G, 3G, 4G and 5G to provide mobility for all kinds of services. So to provide mobility within such types of network generations, the vertical handoff is essential to avail uninterrupted services. In this research, we aim to find such an approach which provides results in reduced call drop rate with less handover failure. Such kinds of handoff process failures incur maximum communication loss. Recent studies that have been done for reducing call drop problem, provide different algorithms and approaches to reduce call drop rate. As in 4G networks, vertical handover is performed, so our main aim is to reduce handover failure and improve the quality of communication in 4G.

Keywords: GSM, HHO, KWHN, RSS, VHO etc.

I. INTRODUCTION

The wireless telephony system has changed with advancement of the technology according to the demand of end users. The first such impact was voice telephony system in 1G. The need of the end user was shifted to avail the voice communication mobility. After this the wireless technology evolved as GSM, 2G in which the data service was embedded with mobility. Due to increase in demand of data services the evolution of wireless technologies from 3G to 4G and 5G developed.

The evolution of wireless technologies can meet the demand of the end users to provide services which can be applicable for health, education, science and technology, telemetry, business, social media etc. The growth prediction depicts the exponential increase of mobile services in Fig. 1.

So the trend of mobile application goes on increasing across all spheres of human life. These technologies are expected to provide services like voice, data, web browsing, video streaming and telemetry with mobility of the end users. The feature of horizontal handoff is available in 2G, 3G, 4G and 5G to provide mobility for all kinds of services. In today's scenario, all the technologies are embedded to form a heterogeneous wireless network. So in order to provide mobility within such heterogeneous network the vertical handoff is essential to avail uninterrupted services.

Though 2G and 3G wireless services co-exist, they don't possess the feature of vertical handoff. 4G has the vertical handoff feature but this is not extended to all kinds of wireless networks. Hence it becomes essential to improve the performance of mobility in a heterogeneous wireless network through the improvement of vertical handoff.

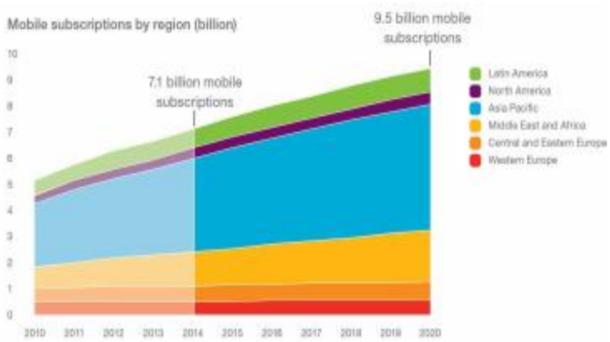

Fig 1: Mobile subscription growth

Every mobile user in the world is keen in accessing information while maintaining the mobility. So the role of mobile hand-held devices to perform all kind of tasks in various fields for better communication, improved productivity in business and reduced operating costs, making the process faster and efficient. Telecommunications service providers and other companies providing various services are looking for ways to streamline and optimize the operations.
The top priorities of all service providers is to deliver seamless mobility in next generation heterogeneous wireless networks, which can provide seamless communications with a diversity of services for all preferred locations comprehensively.

The problem associated with the wireless mobile hand held devices is now transforming the ability to do remote management in the field of education, health, security, business and social relations. For these requirements novel handoff techniques are based on following parameters like bandwidth, Signal to Noise Interference Ratio (SINR), handoff latency, power consumption, network cost, user preferences, network throughput, network load balancing, network security, RSS and velocity of the User Equipment(UE) [9]. Several investigations have been made on VHO, taking individual parameters for GSM, WLAN and UMTS networks under consideration. However majority of these find a scope for having an integrated solution for VHOS in heterogeneous networks including LTE (4G) taking into account all the parameters [14, 15].

This study has the following objectives

- Carry out an extensive investigation to the research work done in the VHO.
- Propose new techniques for VHOS considering the local terrain, path loss model and RSS for all tiers of wireless networks in a K-tier Heterogeneous Wireless Network (KHWN).
- Analyze the proposed VHOS performance considering different constraints of the environment reported in standard literature.

II. VERTICAL HANDOFF SCHEME TECHNIQUES AVAILABLE

The present vertical handoff decision algorithm of the heterogeneous network is summarized, and existing problems and the future research direction are discussed. It is seen that the traditional handoff algorithm based on pre-defined path loss model with RSS is not suitable for heterogeneous wireless network with different kinds of user services at different terrain across all locations. The decision algorithms which take into consideration, the comprehensive network and decision factors, appeared to provide better handoff performance and improved user satisfaction index with better QOS. On the other hand, Next Generation Wireless Network (NGWN) is of complex structure resulted from the integration of heterogeneous wireless networks. In these networks, the design of an effective vertical handoff balancing algorithm to improve the comprehensive performance of the whole system is a very important issue.

A. Received Signal Strength based Vertical Handoff Scheme in k-tier heterogeneous wireless network

In this chapter we propose the VHOS between each tier of the network, after getting the proficiency and accuracy in the RSS measurement in each network of the KHWN domain. In the literature study we found most of the RSS estimations are based on selected empirical and statistical model with the local terrain data of Indian urban as well as sub-urban environments [5]. The proposed statistical model aligns in accordance to the pre-set data, considering roof height, road width as normal random variables, by taking the real data of Indian urban and sub-urban terrain. The five parameters are modeled statistically, with the terrain information on, road width and roof top height, with height of base station, distance from base station. The model is validated by comparing the simulated results with the measurement campaigns carried out in urban and suburban regions [6]. From the path loss model the RSS has been estimated which gives a better performance [8]. The results of RSS for all networks considered are quite exciting and demonstrated in the simulation results of chapter-3. The new integrated KHWN concept is incorporated to achieve mobility within different tiers of networks using a VHOS based on the results of the RSS.

B. SINR and cost based vertical handoff in k-tier heterogeneous wireless network

The previous studies for vertical handoff in heterogeneous wireless networks such as combined SINR based vertical handoff (CSVH), multi-dimensional adaptive SINR based VHO algorithms (MASVHO) and multi-attribute vertical handoff algorithm with predictive SINR using grey model GM (1,1) use SINR, user required bandwidth, user traffic cost, utilization of each access network, and user preference. However, all these techniques are applied to WLAN and WCDMA networks. Applying these methods for VHOS in KHWN and considering all types of traffics independently, it is found that the results provide fewer throughputs with no remarkable reduction in traffic cost. Hence we are motivated to propose VHOS for KHWN to provide seamless vertical handoff with multi attribute QOS. The proposed method is superior to the existing methods in following performance indices.

- SINR,
- Bandwidth,
- User traffic cost from k-tier access networks,
- User preference criterion to make hand off decision,
- Hysteresis buffer time.

The proposed VHOS deals with different traffic types, provides high system level throughput, as achieves low cost traffic. In this method the handoff is fired when the predicted value of SINR is less than a pre-established threshold value determined based on user's application or QOS restrictions. The result of the proposed SINR and cost based VHOS (SCVHOS) with the previous methods CSVH and MASVHO. The simulation results demonstrate the most optimal performance of the proposed scheme.

C. Difference between VHO and HHO

The main distinction between VHO and HHO lies in symmetry. While HHO is a symmetric process, VHO is an asymmetric process in which the UE moves between two different networks with different characteristics. This introduces the concept of a preferred network, which is usually the underlay in the desired HWNs, which provides better throughput performance, lower latency and error free at lower cost for the users. This is indeed noticeable that the advent of HWN allow for the deployment of non-homogeneous transceivers, with the advantage of improved spectral efficiency per unit area. Emerging archetypes for heterogeneous network architectures revolve around the notion of the heterogeneous wireless Network to provide 'Multiple tier', 'Multi-technology' and 'Multiple services'.

Multiple services

This term refers to the client experience when connecting to the edge of a network. Since there are often multiple

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 9, September 2016

service options, their associated service definitions can be varied based on the underlying network implementations [17]. As demonstrated in the fig 2. the smart home is presented with all types of connectivity through HWNs with the multiple applications.

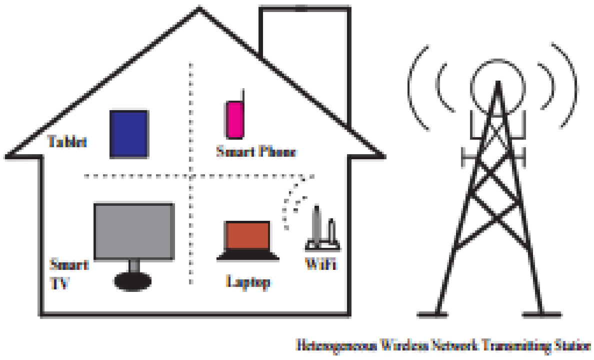

Fig. 2: Multiple services provided by HWN

Multiple technology
The discussed services are based on multiple technologies like time division multiple access (TDMA), frequency division multiplexing (FDMA), orthogonal frequency division multiple access (OFDMA) and IP-routed services as well, from lower layers based on technologies such as multi-protocol label switching (MPLS), wavelength division multiplexing (WDM). Multiple technologies are implemented in HWNs to facilitate the operators to provide technologies such as IP, Ethernet, MPLS, T-MPLS, Synchronous Optical Networking (SONET), next-generation SONET, Asynchronous Transfer Mode (ATM) [16]. Through this technology the end users are availing the applications such as voice, data, multi-media, internet browsing, video streaming, and telemetry [7].

Multi-tier heterogeneous network
A multi-tier wireless system integrates the high-tier wireless systems and the low tier wireless systems into a single system to provide the advantages of both tiers. Such a system is expected to provide better service (more service availability and more cost effectiveness to the users) at the expense of the extra tier- switching management. Examples of multi-tier systems include the interconnection network of a satellite communication network and a terrestrial cellular network, the integration of low-power systems such as wireless personal area networks and cellular systems, and the integration of higher mobility of cellular systems with low- mobility wireless local area networks as represented in the Fig.3.

In such a system, mobility management is critical, because only when the location of a mobile user is known or tracked, can the service quality for the user be guaranteed [8].

A mobile user who is streaming a music video on their smart phone while taking the bus to work will most likely leave the coverage area managed by one of its network provider's base stations and move into the next closest one.

Fig. 3: Multiple wireless networks available are demonstrated

Although the user does not realize it, there is a handshake that occurs and the user's video streaming session is transferred from one base station to the other, seamlessly. In this scenario, because the networks consist of the exact same technology, it is considered to be homogeneous. In the heterogeneous case, the consideration is to move from one type of network technology to another one. The main difficulty here is that each technology behaves based on its own set of rules and languages; as a result, facilitating a common process across all these disparate technologies is no easy feat. The three main technologies leveraged in the experiments related to this thesis are Wireless Interoperability for Microwave Access (WiMAX), Wi-Fi, and UMTS [15].

The history and evolution of mobile service from the 1G (first generation) to fourth generation process began with the designs in the 1970s that have become known as 1G.The earliest systems were implemented based on analog technology and the basic cellular structure of mobile communication. These early systems solved many fundamental problems. The 2G systems designed in the 1980s were still used mainly for voice applications but were based on digital technology, including digital signal processing techniques. These 2G systems provided circuit-switched data communication services at a low speed.

During 1990s, two organizations worked to define next, or 3G, mobile system, which would eliminate previous incompatibilities and become a truly global system. The 3G system would have higher quality voice channels, as well as broadband data capabilities, up to 2Mbps. An interim step is being taken between 2G and 3G, the 2.5G. It is basically an enhancement of the two major 2G technologies to provide increased capacity on the 2G RF (Radio Frequency) channels and to introduce higher throughput for data service, up to 384 kbps. A very important aspect of 2.5G is that the data channels are optimized for packet data, which introduces access to the internet from mobile devices, whether telephone, PDA (Personal digital assistant), or laptop. However, the demand for higher access speed multimedia communication in today's society, which greatly depends on computer communication in digital form at, seems unlimited.

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

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Vol. 5, Issue 9, September 2016

Traditional phone networks (2G cellular networks) such as GSM, used mainly for voice transmission, are essentially circuit-switched. 2.5G networks, such as GPRS, are an extension of 2G networks, in that they use circuit switching for voice and packet switching for data transmission. Circuit switched technology requires that the user be billed by airtime rather than the amount of data transmitted since that bandwidth is reserved for the user. Packet switched technology utilizes bandwidth much more efficiently, allowing each user's packets to compete for available bandwidth, and billing users for the amount of data transmitted. Thus a move towards using packet-switched, and therefore IP networks, is natural.

3G networks were proposed to eliminate many problems faced by 2G and 2.5 G networks, like low speeds and incompatible technologies (TDMA/CDMA) in different countries. Expectations for 3G included increased bandwidth: 128Kbps in a car and 2 Mbps in fixed applications. In theory, 3G would work over North American as well as European and Asian wireless air interfaces. In reality, the outlook for 3G is neither clear nor certain. Part of the problem is that network providers in Europe and North America currently maintain separate standards' bodies. The standards' bodies mirror differences in air interface technologies. In addition there are financial questions as well that cast a doubt over 3G's desirability. There is a concern that in many countries, 3G will never be deployed. This concern is grounded, in part, in the growing attraction of 4G wireless technologies.

A 4G or 4th generation network, a new generation of wireless is intended to complement and replace the 3G systems. Accessing information anywhere, anytime, with a seamless connection to a wide range of information and services, and receiving a large volume of information, data, pictures, video, and so on are the keys of the 4G infrastructures. 4G infrastructure [10] will consist of a set of various networks using IP as a common protocol so that users are in control because they will be able to choose every application and environment. A 4G or 4th generation network is the name given to an IP based mobile system that provides access through a collection of radio interfaces. A 4G network promises seamless roaming/handover and best connected service, combining multiple radio access interfaces (such as WLAN, Bluetooth, GPRS) into a single network that subscribers may use [11]. With this feature, users will have access to different services, increased coverage, the convenience of a single device, one bill with reduced total access cost, and more reliable wireless access even with the failure or loss of one or more networks.

4G was simply an initiative by R & D labs to move beyond the limitations, and address the problems of 3G which was having trouble meeting its promised performance and throughput. In the most general level, 4G architecture includes three basic areas of connectivity: Personal Area Networking (such as Bluetooth), local high-speed access points on the network including wireless LAN technologies, and cellular connectivity. 4G calls for a wide range of mobile devices that support global roaming. Each device will be able to interact with Internet-based information that will be modified on the fly for the network being used by the device at that moment. The roots of 4G lie in the idea of pervasive computing [12].

The glue for all this is likely to be software defined radio (SDR) [13]. SDR enables devices such as cell phones, PDAs, PCs and a whole range of other devices to scan the airwaves for the best possible method of connectivity, at the best price. In an SDR environment, functions that are formerly carried out solely in hardware – such as the generation of the transmitted radio signal and the tuning of the received radio signal – are performed by software [14]. Thus, the radio is programmable and able to transmit and receive over a wide range of frequencies while emulating virtually any desired transmission format. As the number of wireless subscribers rapidly increases guaranteeing the quality of services anytime, anywhere, and by any-media becomes indispensable. These services require various networks to be integrated into IP-based networks, which further require a seamless vertical handoff to 4th generation wireless networks. And as one of the next generation mobile communications, the 4th generation mobile communications provides various services, such as high-speed data services and IP-based access to Radio Access Network, etc. Various interface techniques such as WLAN, Bluetooth, UTMS, and CDMA2000 are integrated into the IP-based networks as an overlay structure. In this structure, the optimum services are provided to mobile hosts. Mobile hosts in this structure can be connected to the network through various access points. Moreover, a seamless handoff should also be supported between different air interface techniques during internetwork movement.

III. FEATURES OF 4G NETWORKS

4G network have following features:-

- High Speed - 4G systems should offer a peak speed of more than 100Mbits per second in stationary mode with an average of 20Mbits per second when travelling.
- High Network Capacity – Should be at least 10 times that of 3G systems. This will quicken the download time of a 10-Mbyte file to one second on 4G, from 200 seconds on 3G, enabling high-definition video to stream to phones and create a virtual reality experience on high-resolution handset screens.
- Fast/Seamless handover across multiple networks – 4G wireless networks should support global roaming across multiple wireless and mobile networks.
- Next-generation multimedia support – The underlying network for 4G must be able to support fast speed volume data transmission at a lower cost than today

The goal of 4G [15] is to replace the current proliferation of core mobile networks with a single worldwide core network standard, based on IP for control, video, packet data, and voice. This will provide uniform video, voice, and data services to the mobile host, based entirely in IP. The objective is to offer seamless multimedia services to users accessing an all IP based infrastructure through heterogeneous access technologies. IP is assumed to act as an adhesive for providing global connectivity and mobility among networks. An all IP-based 4G wireless network has inherent advantages over its predecessors. It is compatible with, and independent of the underlying radio access technology [15].

An IP wireless network replaces the old Signaling System 7 (SS7) [16] telecommunications protocol, which is considered massively redundant. This is because SS7 signal transmission consumes a larger part of network bandwidth even when there is no signaling traffic for the simple reason that it uses a call setup mechanism to reserve bandwidth, rather time/frequency slots in the radio waves. IP networks, on the other hand, are connectionless and use the slots only when they have data to send. Hence there is optimum usage of the available bandwidth. Today, wireless communications are heavily biased toward voice, even though studies indicate that growth in wireless data traffic is rising exponentially relative to demand for voice traffic. Because an all IP core layer is easily scalable, it is ideally suited to meet this challenge. The goal was a merged data/voice/multimedia network.

IV. CHALLENGES IN 4G NETWORKS

4G Networks are all IP based heterogeneous networks that allow users to use any system at anytime and anywhere. Users carrying any integrated terminal can use a wide range of applications provided by multiple wireless networks. 4G systems provide not only telecommunications services, but also a data-rate service when good system reliability is provided. At the same time, a low per-bit transmission cost is maintained. Users can use multiple services from any provider at the same time. Imagine a 4G mobile user who is looking for information on movies shown in nearby cinemas. The mobile may simultaneously connect to different wireless systems. These wireless systems may include Global Positioning System (GPS) (for tracking users current location), a wireless LAN (for receiving previews of the movies in nearby cinemas), and a code-division multiple access (for making a telephone call to one of the cinemas). In this example, the user is actually using multiple wireless services that differ in quality of service (QOS) levels [13], security policies, device settings, charging methods, and applications. There are number of challenges faced by 4G networks in integrating all the services.

V. HANDOFF IN 4G NETWORKS

The services provided by the public switched telephone networks (PSTN) [16] are leveraged by wireless mobile telephone network of public land mobile networks (PLMN). PSTNs ate backbones to PLMNs. Infrastructure for wireless access, mobility management and external network gateways are provided by the network elements of PLMNs.

A simple PLMN consists of the following components:

- Base stations
- Mobile switching service centers (MSC)
- Home Location Register (HLR)
- Visitor Location Registers (VLR)
- Authentication Centre (AUC)
- Equipment Identification Register (EIR).

Handoff Strategies

An event when a mobile station moves from one wireless cell to another is called Handoff. Handoff can be of two types: horizontal (intra-system) and vertical (inter-system) cases. Handoff within the same wireless access network technology is considered as Horizontal handoff, and handoff among heterogeneous wireless access network technologies is considered vertical handoff. The terminology of horizontal and vertical reflects the wireless access network technology instead of the administrative domain in comparison to macro- and micro mobility. There are different subclasses such as follows:

- Vertical macro mobility refers to mobility among different administrative domains using different wireless technologies
- Horizontal macro mobility refers to mobility among different administrative domains using the same wireless technology
- Vertical micro mobility refers to mobility within the same administrative domain using different wireless technologies
- Horizontal micro mobility refers to mobility within the same administrative domain using the same wireless technology.

Handoff Methods

Handoffs have several methods and they are technology dependent. The two main handoff methods are:

- Hard Handoff: It has a brief disruption of service as it has to break before a making a switching action. Hard Handoffs are used by Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) systems.
- Soft Handoff: It has no disruption of service action as it makes a switching action before the break. Multiple network resources are used by soft handoffs. Soft handoffs are used by CDMA system.

Possible Handoff Scenarios

As mobiles traverse cell or sector boundaries, majority of handoffs support calls. The following are scenarios where Handoff processes are required:

- Intra-MSC - Involve crossing cell boundaries within a MSC's service area
- Inter-MSC - Involves crossing cell boundaries between MSCs
- Roaming - Involves crossing cell boundaries between different network operators
- Intra-cell – Involves crossing sector boundaries within a cell

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 9, September 2016

- Switching channels to circumvent persistent interference

Support for Vertical Handoffs
The current IPv6 specification does not support vertical handoffs. Since IP is the common protocol, everything below it is abstracted from the application. For the application, it is always connected as handoffs occur. To provide this support in IPv6 a daemon can be run at the network layer which takes care of switching between different radio accesses technologies. The mobile device might be having separate interface cards for each of the networks or may use a single multimode card which works in different modes at different times. The protocol stacks of each of the different radio access technology are stored in the mobile device. The daemon in the network layer will then choose which radio access network (RAN) to use on the basis of network speed, quality of service, cost of usage and other similar criteria. The selection policies are customizable and changes between different RANs are automatic and transparent to the user and depend on coverage and network load conditions. After selecting the RAN, the daemon then initializes the appropriate protocol stack before starting to use that interface. This way the IP datagrams being passed down get encapsulated in the correct format of the radio access technology in use. This model allows the device to utilize any interface as long as the hardware is present by just installing the necessary stack protocols.

A seamless handoff should also be supported between different air interface techniques during inter-network movement. This type of handoff is called a vertical handoff, because the mobile is moving to another network (heterogeneous network) which has a different air interface technique. Various wireless LAN services are being introduced in hotspot areas such as campuses, hotels and offices. IEEE802.11 WLAN services having high bandwidth are used to cover limited hotspot areas. If the mobile host (MH) goes out of the hotspot coverage, the call will be dropped. In the 4th generation, a WLAN cell is overlaid within a CDMA2000 cell that is constructed into an ALL-IP based network. A seamless handoff is supplied through the vertical handoff process even if the MH goes out of the WLAN coverage area. The minimized cell size in 4th generation networks results in frequent handoffs.

Recently proposed network architecture and procedure for the vertical handoff [17] adopts the mobility management concept through the Mobile Agent (MA) and Subnet Agent (SA) functions to minimize the delay during vertical handoff. The first goal of seamless handoff is low handoff latency, power saving, and low bandwidth overhead [17]. WLAN and CDMA 2000 networks have different frequency, maximum data speed and cost characteristics. The time for the handoff procedure to begin in the handoff region is decided by the handoff delay time and throughput according to traffic characteristics. The real-time traffic preferentially takes into account the handoff delay, and the non-real time traffic takes the throughput into account.

VI. RESULTS

The topology of the network using network simulator, one node is the access point and second one is not access point. The communications between these two nodes are UDP and TCL flow. The packet transmission is completely based on the queue size and priority schedule.
For the evaluation considered two protocols- Existing and proposed work is develop and design for comparative study on the basic of QOS performance parameter. Simulation parameter table are mention here.

Table I. Simulation Table with parameters values

Parameters	**Values**
No. of nodes	15
Area size	50m x450m
Transmission range	70m
Data Rate	1 mbps, 2 mbps and 3 mbps
TCP window Size	25
Simulation time	10 sec
Transmission speed	100 bits/sec.
Bandwidth	5000 bits/sec.
Start Simulation time	400 sec

The network is considered by 40m X 450m with numbers of nodes are 15 that are distributed randomly in mobile fields.

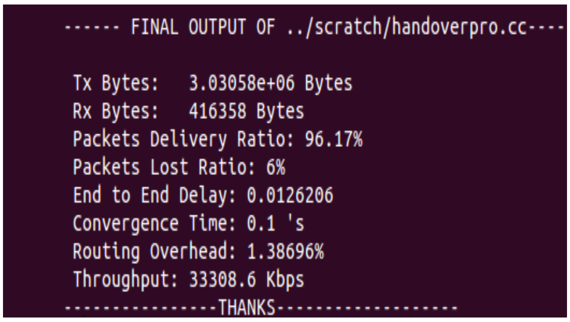

Fig. 4: results from terminal output

VII. CONCLUSION

An implementation of a continuous vertical handoff procedure and the effective handoff algorithm for the handoff transition region among the WLAN and CDMA cellular network is presented. Here, we have gone expansively about the various parameters that govern the smooth operative of the algorithm and how they affect the time spent in WLAN and CDMA networks. We generate the simulation result and vertical handover scenario between the WLAN and CDMA networks and hence would provide quite a useful tool for the device in real time functioning.
A more robust algorithm would also consider the number of times this reset has taken place and would correspondingly switch between the networks. But in spite of these drawbacks if the parameters are chosen correctly the algorithm can perform quite efficiently and a maximum performance can be extracted from the device

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 9, September 2016

given an operating environment. Mobility management using MA and SA was also adopted to minimize the handoff delay in the WLAN-CDMA Cellular interconnection architecture based on IP. In the handoff algorithm number of continuous beacon signals are used whose signal strength from the WLAN falls below the predefined threshold value.

In real-time service, the handoff delay in the handoff transition region must be short, so the number of continuous beacon signals should be lower than that of the non-real-time service in order to reduce handoff delay. The assumption that the load of the WLAN and the CDMA cellular networks is nominal for the purpose of simplification is made in analyzing the average throughput and handoff delay.Handoff delay poses an important QoS-related issue in 4G wireless networks. Although likely to be smaller intranet work handoffs, the delay can be problematic in internetwork handoffs because of authentication procedures that require message exchange, multiple-database accesses, and negotiation-renegotiation due to a significant difference between needed and available QoS [17]. During the handoff process, the user may experience a significant drop in QoS that will affect the performance of both upper-layer protocols and applications. Deploying a priority-based algorithm and using location aware adaptive applications can reduce both handoff delay and QoS variability. Handoff LTE module is described that minimum energy level then it doesn't transmit the packets so the new node will become interacted with the tower node, because the new node has a maximum level of energy. So the proposed algorithm is increased the throughput and decrease the delay that is better than the existing work.

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