

ARCHITECTURE AND PERFORMANCE EVALUATION OF NFV AND BLOCKCHAIN ENABLED 5G FOR ULTRA-RELIABLE AND LOW- LATENCY COMMUNICATIONS IN INDUSTRY

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Abstract- The fourth generation Internet of Things have been deployed or are soon to be deployed in many countries. However, with an explosion of wireless mobile devices and services, even 4G systems cannot adequately address issues such as the spectrum crisis and high energy consumption. Wireless system designers have been facing demand for increasingly higher data rates. 5Th generation (5G) wireless systems will address these needs and more and are expected to be deployed by 2020. This article proposes cellular architectures that separate indoor and outdoor scenarios. In addition, it discusses various promising technologies for 5G Internet of Things, such as massive MIMO, energy-efficient communications, cognitive radio networks, and visible light communications.

There are several challenges for 5G designers. One of the most crucial challenges is the physical scarcity of radio frequency (RF) spectra allocated for cellular communications. These frequency spectra have been used heavily, and there is no more to spare in the existing cellular bands. Another challenge is the deployment of advanced wireless technologies comes at the cost of high energy consumption. In addition to environmental concerns, it has been reported by cellular operators that the energy consumption of base stations contributes to over 70% of their electricity bill. Other challenges include but are not limited to: increasing spectral efficiency, high data rate coupled with high mobility requirements, seamless coverage, diverse quality-of-service (QoS) requirements, and fragmented user experience (incompatibility of different wireless devices/interfaces and heterogeneous networks).

Key Words: 5Th Generation (5G), Radio Frequency (RF), Quality-of-Service (QoS).

I. INTRODUCTION

Next generation mobile communication system (4G) will provide all time access and seamless mobility across different heterogeneous networks like WLAN, Wi-MAX, UMTS and WWAN etc. In wireless networks, mobility of a Mobile Node (MN) can be defined as “changing the point of attachment without losing its ability to communicate in the network” with correspondent node (CN). Whenever a MN changes its point of attachment, handover occurs. A common goal among all the approaches for mobility management is that mobility should not break the existing connections between two hosts and also the MN should not become unreachable for future connections.

The admission control procedure across heterogeneous networks is much more complicated than in a homogeneous network. If multiple networks are available to a user at any one time, then choosing the most optimal network for a particular service delivery and choosing the correct time to execute a vertical handover to improve the QoS for all users are important factors. A mobility management system can be used to control the migration of users from one system to another. The user, network or both can govern the mobility management and admission control procedures. Giving total control to the user can result in network instability as users compete for network resources; while a network controlled system will ignore user preferences and QoS requirements.

1.1 HANDOVER

Mobile networks allow users to access services while on the move so giving end users “freedom” in terms of mobility. However, this freedom does bring uncertainties to mobile systems. The mobility of the end users causes dynamic variations both in the link quality and the interference level, sometimes requiring that a particular user change its serving base station. This process is known as handover (HO).

1.1.1 Types of handover

There are four different types of handovers in mobile networks. They are:

Intra-system HO occurs within one system. It can be further divided into Intra-frequency HO and Inter-frequency HO. Intra-frequency occurs between cells belonging to the same network carrier, while Inter-frequency occurs between cells operate on different network carriers.

Hard Handover: It is a category of HO procedures in which all the old radio links of a mobile are released before the new radio links are established. For real-time bearers it means a short disconnection of the bearer; for non-real-time bearers HHO is lossless.

Soft Handover: During soft handover, a mobile simultaneously communicates with two (2-way SHO) or more cells belonging to different BSs of the same RNC (intra-RNC) or different RNCs (inter-RNC).

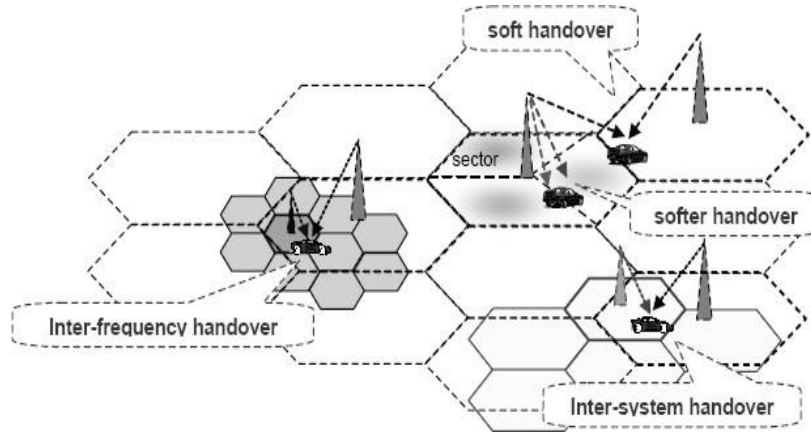


Fig 1.1 Types of Handover scenarios.

Parameters	Hard handover	Soft handover
Connection type	Break before Make	Make before Break
HO Latency	High	Less
Packet loss	High	Less
Supplementary Hardware	Not Required	Required
Complexity	Less	High
Number of BS involves	Only one	Many

Table 1.1 Hard handover and Soft handover Comparison

1.1.2 Horizontal handoff Vs Vertical handoff

Handoff between homogenous networks where one type of network is considered is called horizontal handoff. On the other hand, handoff between different types of networks is also possible. A handoff in such a heterogeneous environment is named vertical handoff.

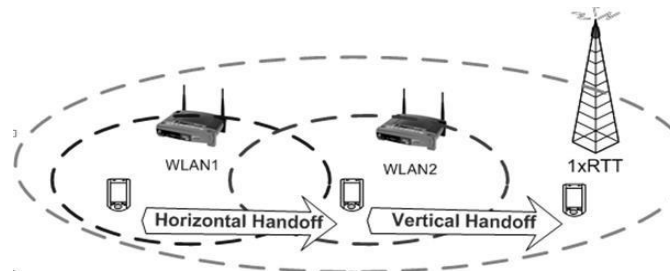


Fig 1.2 Horizontal and vertical handoff

1.1.3 Handover procedure

The handover procedure can be divided into three phases: measurement, decision and execution phases. In the handover measurement phase, the necessary information needed to make the handover decision is measured. In the handover decision phase, the measurement results are compared against the predefined thresholds and then it is decided whether to initiate the handover or not. Different handover algorithms have different trigger conditions. In the execution phase, the handover process is completed and the relative parameters are changed according to the different types of handover.

1.2 HANDOFF IN 4G NETWORKS

Nowadays, there are various Internet of Things existing for different services, users and data rates such as GSM, GPRS, W-CDMA, Wireless LAN etc. Fourth generation (4G) wireless systems integrate all existing and newly developed wireless access systems. It refers to universal wireless access, which makes the ability of a user to connect anywhere at any time any network.

II. RELATED WORK

2.1 END-to-END MOBILITY MANAGEMENT

Mobility can be handled at different layers of the traditional TCP/IP protocol stack but in any case link layer support is necessary for providing meaningful information to initiate the handover. It can be handled at Network layer (Mobile. Etc.), Transport layer (SCTP, variants of TCP etc.) and at session layer (SIP, SLM etc.). At each of these layers mobility management schemes have

strengths and weaknesses. At Network layer mobility management has several shortcomings e.g. an intermediate entity is introduced between MN and CN.

Drawbacks

- Handover performance for SIP, Mobile IP, and SCTP Protocols is made but SIP and Mobile IP are not based on end-to-end philosophy.
- A comprehensive performance analysis of Mobile IP, TCP-Migrate, and SIP is done with the derivation of mathematical model, but the analysis is not made for TCP based connections.
- A comparison of host mobility for IP networks using TCP Migrate, HIP and Mobile IP is done but it does not consider end-to-end mobility.

Advantages

- Solutions for end-to-end mobility management for TCP based communication.
- A comprehensive analysis is made for different TCP under some common parameters and strengths and weaknesses are identified on the basis of these parameters.
- An analysis of some approaches is done on the basis of handover delay and throughput degradation and solutions are made to make use of parallel TCP connections between communicating nodes

2.2 A QOS-SUPPORT MOBILITY MANAGEMENT

Mobile IP mainly handles the management of the movement of MHs on a global scale, which is referred to as macro-mobility management. In addition, intra-domain mobility protocols are required to provide for fast and seamless intra-domain mobility management of MHs, thereby reducing the delay, packet loss and signaling overhead. Such protocols become especially important when the wireless Internet is deployed for Real-Time multimedia applications. The design of intra-domain mobility management protocols stands out as an important challenge in integrating wireless networks into the IP-based Internet.

Various protocols for intra-domain mobility management include the HMIPv4, Cellular IP, HAWAII, Tele MIP, Anchor Handover, HMIPv6, MPLS based intra-domain mobility and BRAIN have been proposed. Much of the focus in these proposals has been on the routing and handover issues in intra-domain mobility. With the increasing deployment of wireless Internet for services such as voice over-IP, streaming video, medical imaging and virtual collaboration, providing for QoS guarantees in an efficient manner becomes an important design aspect of intra-domain mobility management. Normally, based on the styles used to forward downlink packets, existing protocols for intra-domain mobility can be broadly classified into three types: hierarchical tunneling, mobile-specific routing and MPLS-based tunneling.

2.3 BANDWIDTH EFFICIENT MOBILITY MANAGEMENT FOR HETEROGENEOUS WIRELESS NETWORKS

Future wireless networking environments will be built up of a variety of access technologies with overlapping coverage areas. At the same time, handsets typically already today support two or more access technologies. Furthermore, the Upcoming 4G type of networks will support heterogeneous. Access and be built up in an all-IP fashion. This way, operators may have the opportunity to perform a smooth transition into new technologies and leverage existing investments. Also, end-users will benefit from having the opportunity to connect to various types of access networks optimizing capacity, cost, or any other parameter of interest.

An Authentication, Authorization and Accounting (AAA) server in the home network, Layer 2 Tunneling (L2TP) or Generic Routing Encapsulation (GRE), both enabling bidirectional tunneling to the home network are used to implement user policies into the MN allowing the end-user to set priorities among various parameters like bandwidth, cost, and/or power consumption to have a make-before-break handover.

III. PREVIOUS IMPLEMENTATIONS

3.1 EVOLUTION OF WIRELESS TECHNOLOGIES

1G Mobile systems: In 1980 the mobile cellular era had started, and since then mobile communications have undergone significant changes and experienced enormous growth. This shows the evolution of the mobile networks. First generation mobile systems used analog transmissions for speech services. In 1979, the first cellular system in the world became operational by Nippon Telephone and Telegraph (NTT) in Tokyo, Japan. The system utilized 600 duplex channels over a spectrum of 30 MHz in the 800 MHz band, with a channel separation of 25 KHz. Two years later, the cellular epoch reached Europe.

2G Mobile systems: They were introduced in the end of 1980s. Low bit rates data services were supported as well as the traditional speech service. Consequently, compared with first generation systems, higher spectrum efficiency, better data services, and more advanced roaming were offered by 2G systems. In Global system for Mobile Communications (GSM) was deployed to provide a single unified standard.

3G Mobile systems: The massive success of 2G technologies is pushing mobile networks to grow extremely fast as ever –growing mobile traffic puts a lot of pressure on network capacity. In addition, the current strong drive towards new applications, such as wireless Internet access and video telephony, has generated a need for a universal standard at higher user bitrates: 3G. Most of the services require bitrates up to 2 Mbit/s.

3.2 4G WIRELESS NETWORK

In the wireless communications community we are witnessing more and more the existence of the Composite Radio Environment

(CRE) and as a consequence the need concepts. The CR Reconfigurability concepts.E assumes that different radio networks can be cooperating components in a heterogeneous wireless access infrastructure, through which network providers can more efficiently achieve the required capacity and quality of service (QoS) levels.

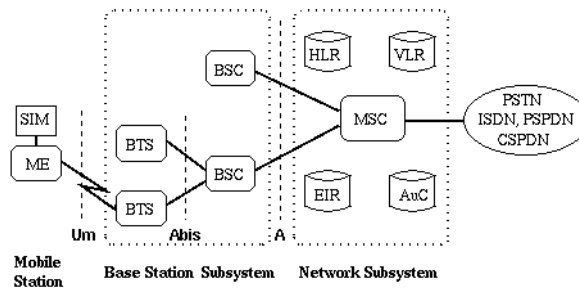
Parameters	2G	3G	4G
Network Architecture	LAN based	Wide area cell-based	Hybrid Network
Driving Architecture	Only Voice	Dominantly voice also data	Converged data and voice over IP
Switching	Packed switched	Circuit and Packet	All digital with packetized voice
Radio Access	FDMA, CDMA, TDMA	WCDMA, CDMA 2000, ICW-136	MC-CDMA, OFDMA
Database	HLR, VLR, EIR, Auk.	EHLR, VLR, EIR, Auk	EHLR, VLR, EIR, Auk
Data rates	9.6 to 384 kbps	Up to 2 Mbps	100 Mbps
Roaming	Restricted	Global	Global
Compatible	Not compatible to 3G	Compatible to 2G, 2G+ and Bluetooth	Compatible to 3G and 2G
Handsets	Dual mode TDMA and CDMA voice and data terminals	Multiple mode Voice, data, video terminaux	Multiple mode voice, data streamed video at higher data rates.
Applications	SMS, Internet	Internet, SMS	Internet, MMS, Multimedia, HDTV, MTV
Bandwidth	25 MHz	5-20 MHz	100 MHz
Frequency band	Tri Band 800, 900, 1800, 1900 MHz	Dependent on country (1800-2400 MHz)	Higher frequency band (2-8 GHz)
IP	No IP Connection	IPv4 & Uses air link IPv5	ALL IP (IPv6)

Table 3.1 Comparison of 2G, 3G and 4G technologies

3.3 HETEROGENEOUS NETWORK

CDMA networks are based circuit-switched data service up to 14.4 Kbps and packet-switched data service up to 64 Kbps. CDMA2000 comes in two versions: 1X and 3X. Operators can readily deploy 1X technology in existing spectrum but may have to wait for new spectrum to deploy 3X, which combines three CDMA 1.25-MHz radio channels for higher-performance services.

Fig 3.1 CDMA Architecture



SIM Subscriber Identity Module BSC Base Station Controller MSC Mobile services Switching Center
 ME Mobile Equipment HLR Home Location Register EIR Equipment Identity Register
 BTS Base Transceiver Station VLR Visitor Location Register AuC Authentication Center

UMTS: Universal Mobile Telecommunications System (UMTS), also referred to as Wideband Code Division Multiple Access (WCDMA), is one of the most significant advances in the evolution of telecommunications into third-generation (3G) networks.

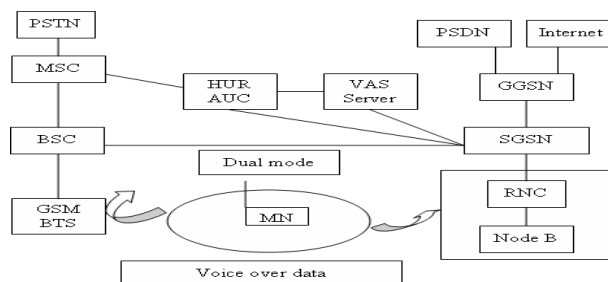


Fig 3.2 UMTS Architecture

IV. SYSTEM IMPLEMENTATION

4.1 Mobility Management

Mobility management enables telecommunication networks to locate roaming terminals for call delivery and to maintain connections as the terminal is moving into a new service area, process known as handoff. The handoff may be executed between different segments (cells) of the same or different systems. Thus, mobility management supports mobile terminals, allowing users to roam while simultaneously offering them incoming calls and supporting calls in progress.

4.1.1 Location management

Location management is a process that enables the network to discover the current attachment point of the mobile user for call delivery. The first segment is location registration (or location update). In this stage, the mobile terminal periodically notifies the

network of its new access point, allowing the network to authenticate the user and revise the user’s location profile. The second segment is call delivery.

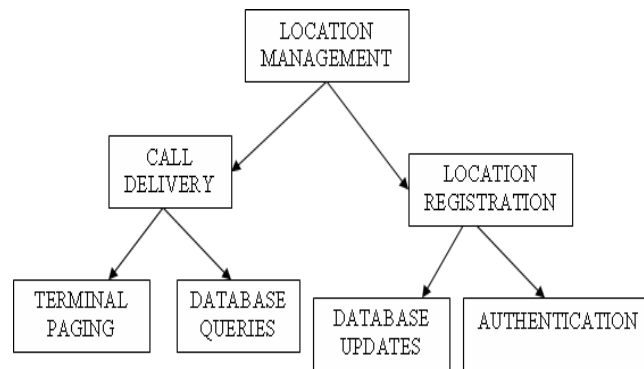


Fig 4.1 Components of location management process

4.1.2 Handoff management

Handoff management enables the network to maintain a user’s connection as the mobile terminal continues to move and change its access point to the network. The three-stage process for handoff first involves initiation, where the user, a network agent or changing network conditions identify the need for handoff.

4.2 MOBILITY MANAGEMENT IN CELLULAR NETWORKS

Mobile terminals (MTs) are free to travel and thus the network access point of an MT changes as it moves around the network coverage area. As a result, the ID of an MT does not implicitly provide the location information of the MT and the call delivery process becomes more complex. The current systems for PLMN location management strategies require each MT to register its location with the network periodically. In order to perform theregistration, update and call delivery operations described above, the network stores the location information of eachMT in the location databases. Then the information can be retrieved for call delivery.

4.3 Mobility Management for Mobile IP

The mobility-enabling protocol for the Internet, mobile IP, enables terminals to move from one sub network to another as packets are being sent, without interrupting this process. An MN is a host or router that changes its attachment point from one subnet to another without changing its IP address. The MN accesses the Internet via a home agent (HA) or a foreign agent (FA). The HA is an Internet router on the MNs home network, while the FA is a router on the visited network. The node at the other end of the connection is called the correspondent node (CN).

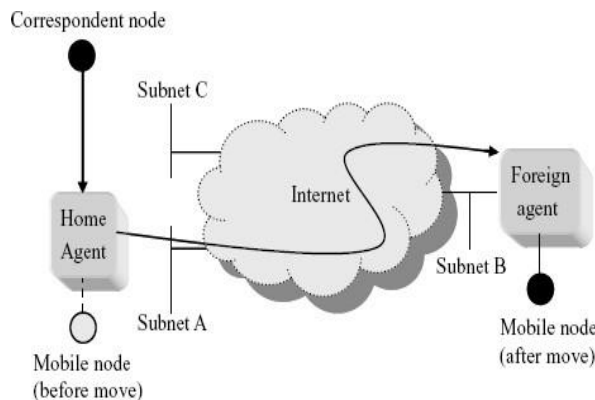


Fig 4.2: A simple mobile IP architecture

4.3.1 Location registration

When visiting any network away from home, each MN must have an HA. The MN registers with its home agent in order to track the MN’s current IP address. There are two IP addresses associated with each MN, one for locating and the other one for identification. In the standard terminology, the new IP address associated with an MN while it visits a foreign link is called its care of address (CoA).

4.3.2 Handoff management

Current routing optimization schemes in IPv4 allow the previous foreign agent (or agents) to maintain a binding for their former mobile visitors, showing a current CoA for each. Then, as packets are sent to the old CoA, the corresponding previous foreign agents can forward the packets to the current CoA of the MN.

4.4 Overview on Mobility Management Protocols

In this sections an overview of IPv6, Host-based mobility and Network-based mobility management protocols.

4.4.1 Internet Protocol Version 6

The new version of IP that is make mobility easier to handle by defines some new features, as follows:

IPv6 Addresses: There are different scopes of IPv6 addresses that can be differentiated by looking at certain bit patterns of

the address prefix.

Unicast: This every unicast address belongs to only one interface.

Multicast: This address belongs to more than one interface. A node with multicast address will receive all packets sent to this multicast address.

Anycast: It is the new types of address, and it is also assigned to more than one interface like the multicast address, but if a packet is sent to such an address, it will only be delivered to one of the interfaces.

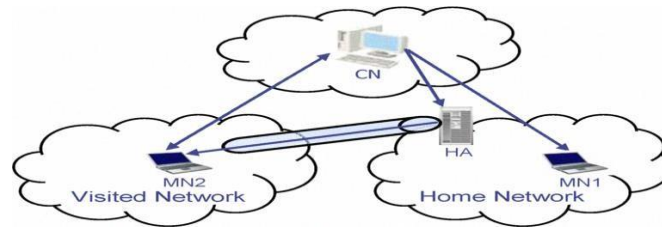


Fig 4.3 Mobile IPv6 Overview

V. IMPLEMENTATION OF EVHD ALGORITHM

5.1 INTRODUCTION

An efficient vertical handoff (VHO) is very essential in ensuring the system performance because the delay experienced by each handoff has a greater impact on the quality of multimedia services. The EVHD algorithm should reduce the number of unnecessary handoffs to provide better throughput to all flows. Research on design and implementation of optimized EVHD algorithms has been carried out by many scholars using various techniques.

EVHD algorithms meet the individual needs and also improve the whole system performance by reducing the unnecessary handoffs and increasing the throughput. The system consists of Mobile node connected to the Base Station of the Network. The MN can move anywhere in any direction in the environment.

5.2 VARIOUS HANDOFF ALGORITHMS

In **RSS based algorithms**, RSS is used as the main criterion for handoff decision. Various schemes have been developed to compare RSS of the current point of attachment with that of the candidate point of attachments. They are: Relative RSS, RSS with hysteresis, RSS with hysteresis plus dwelling timer method. Relative RSS is not applicable for VHD, since the RSS from different types of networks can not be compared directly due to the disparity of the technologies involved.

In **bandwidth based algorithms**, available Bandwidth for a mobile terminal is the main criterion. A bandwidth based VHD method is presented between WLANs and a WCDMA network using Signal to Interference and Noise ratio (SINR). It provides user's higher throughput than RSS based handoffs since the available bandwidth is directly dependent on the SINR.

In user **mobility based algorithms**, velocity information is a critical one for handoff decision. In the overlay systems, to increase the system capacity, micro/Pico cells are assigned for slow moving users and macro cells are assigned for fast moving users by using velocity information. It decreases the number of dropped calls.

Proposed handoff algorithm based on velocity

Step 1: When the velocity is in the range 150 to 250 km/h, the MN is connected to WiMAX, else connect to UMTS.

Step 2: If WiMAX and UMTS are not available then, there are no neighboring networks.

Step 3: When the velocity is in the range 60 to 150 km/h, the MN is connected to UMTS, else connect to WiMAX.

Step 4: If WiMAX and UMTS are not available then connect to CDMA.

Step 5: When the velocity is in the range 5 to 60 km/h, the MN is connected to CDMA, else connect to UMTS.

Step 6: If CDMA and UMTS are not available then connect to WLAN1 or WLAN2.

Step 7: When the velocity is less than 5 km/h, the MN is connected to WLAN1 or WLAN2, else connect to CDMA.

Step 8: If WLAN1, WLAN2 and CDMA are not available then connect to UMTS otherwise to WiMAX.

Step 9: Else there are no neighboring networks.

ALGORITHM	HO PERFORMED	MERITS	DEMERITS
RSS based algorithm	RSS with hysteresis	Minimizes ping pong HO	Other criteria are not considered
Bandwidth based algorithm	Available bandwidth using SINR	Higher throughput than RSS, Excessive HO is reduced	Not consider RSS result in connection breakdown
Cost function based algorithm	Considering only the static parameters	Minimize the cost for HO	Not considered other dynamic factors, such as velocity, position of the MT.
Velocity based algorithm	Using velocity information	Decreases the number of dropped calls	Not reduce the number of unnecessary HO
EVHD algorithm	Combining the static and dynamic parameters	Maximize the throughput by reducing the number of unnecessary handoffs.	-

Table 5.1 Comparison of various vertical algorithms

5.3 VELOCITY BASED HANDOFF ALGORITHM

The system consists of Mobile node connected to the Base Station of the Network. The MN can move anywhere in any direction in the environment. The handoff decision is made when the node is moving away from the BS based on anyone of the parameter such as RSS, bandwidth, velocity of mobile node, etc.

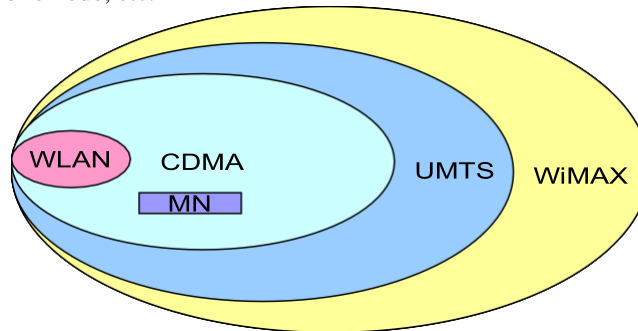


Fig 5.1 System Architecture

5.4 Proposed Efficient Vertical Handoff Decision Algorithm

EVHD algorithm is a combined algorithm that combines the static parameters of the network such as usage cost, bandwidth and power consumption and dynamic parameters such as RSS, velocity and position of the MT. The main objective of EVHD is to maximize the throughput by reducing the number of handoffs.

The functions are illustrated below:

$$f_{e,i} = \frac{1}{e^{\alpha_i}} \quad f_{c,i} = \frac{e^{\beta_i}}{e^M} \quad f_{p,i} = \frac{1}{e^{\gamma_i}}$$

where $\alpha_i \geq 0, M \geq \beta_i \geq 0,$ and $\gamma_i \geq 0$

VI. EVALUATION RESULT:

In the wireless technology integrates to communicate with each other. So Mobility management scheme is required for location management and handoff management in heterogeneous wireless environment. Location management enables to locate the mobile node for call delivery. A handover scheme is required to enable mobility management whenever a mobile node moves from one coverage area to another.

Thus we propose a vertical handoff decision algorithm (EVHD) for heterogeneous networks based on the velocity of Mobile Node and the signaling cost. The algorithm used in this project considers the number of handoff when the velocity increases and the probability of handoff delay. The simulated result shows the effectiveness of the algorithm during handover between different wireless networks.

Using the EVHD algorithm, the best network is selected and the number of handoffs is considerably reduced while comparing to the other algorithms which considers either only the static parameters or the dynamic parameters. The simulation has been performed for velocity based algorithm and our efficient vertical handoff algorithm.

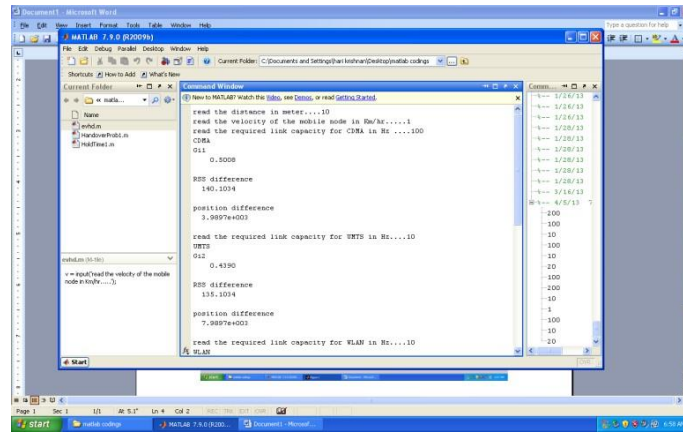


Fig: 5.2 Handover Probability based on Overall gain function For Different Network Of Mobile Node

Fig 5.2 illustrates handover probability of a mobile node based on overall gain function for different network. It shows that handover probability based on overall gain for different network has been reduced when compared with velocity based handover probability. This shows that unnecessary handover has been reduced using EVHD algorithm compare to velocity based algorithm.

Fig 5.3 Handover Probability based on Overall gain function For Different Network of Mobile Node

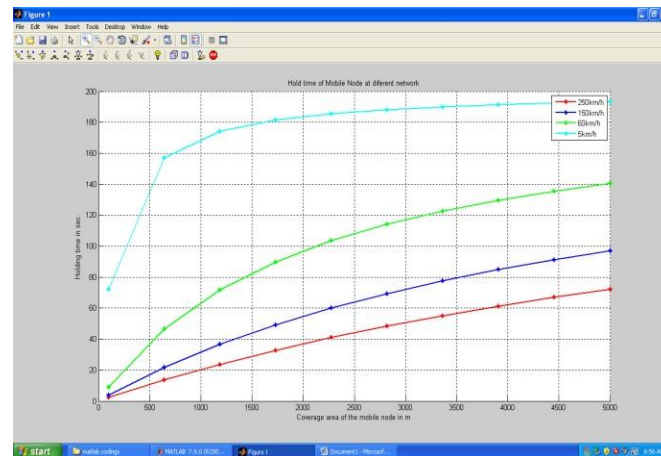


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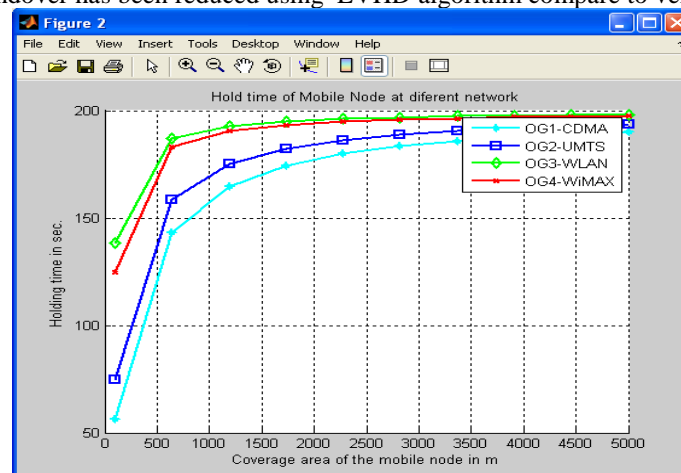


Fig 5.4 Hold time of Mobile node at different network

Fig 5.4 Illustrates hold time of a mobile node based on overall gain function for different network. It shows that hold time based on overall gain for different network has been increased when compared with hold time based on velocity algorithm. This also shows that unnecessary handover has been reduced using EVHD algorithm compare to velocity based algorithm.

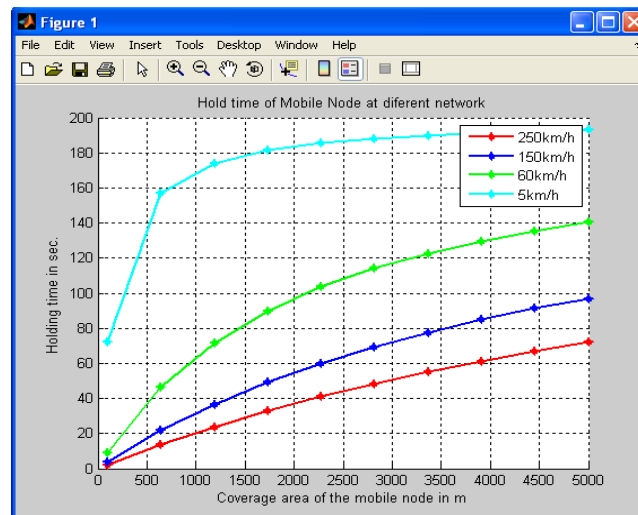


Fig 5.5 Hold time of mobile node at different velocity

Fig 5.5 illustrates the hold time of mobile node before handoff when it travels at different velocity(250km/h, 150km/h, 60km/h, 5km/h,). It shows that the hold time increases as the speed decreases and vice versa.

CONCLUSION

Efficient vertical handoff decision algorithm is a combined algorithm that combines the static parameters of the network such as usage cost, bandwidth and power consumption and dynamic parameters such as RSS, velocity and position of the MT. The algorithm has been implemented successfully using Mat lab simulator. It is proved from the simulated results of both the algorithm that the handover probability of proposed vertical handoff algorithm is considerably less while compared to velocity based algorithm. Thus EVHD has outperformed the other algorithms by providing minimum handoff probability and high throughput and hence it is efficient in enhancing QoS for multimedia applications.

In future, using compare & swap technique in VLSI Signal processing to realize the handover probability operation to reducing latency and unnecessary Handoff with low power consumption, high throughput and enhanced QoS for multimedia applications.

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