IJCTA, 10(8), 2017, pp. 139-147 ISSN: 0974-5572

Efficient Congestion Control and Vertical Handoff Technique for 3GPP LTE Advanced Network

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ABSTRACT

Since from last decade, there is tremendous growth in cellular wireless networks like heterogeneous cellular networks. The heterogeneous networks such as LTE-A in which WiFi, WiMAX networks are communicated frequently. Radio Access Technologies (RATs) through which number of mobile devices having interfaces, similarly mobile devices having number interfaces with different RATs. These RATs are differing in performance, costs and capabilities. The mobile nodes need to be having always best connected depending on availability and requirements. The handover is performed in heterogeneous networks whenever mobile device leaves the present cellular network and joining another network. Such handover operations are utilized to achieve the seamless mobility. The MIH (802.21 standard) is recently introduced standard to perform efficient handover operations in heterogeneous networks. Apart from efficient handover operations for such networks, congestion is another research challenge which is rarely addressed. In this paper, novel MIH method is presented to solve the problem of congestion control and handover efficiency. Main goal is to present efficient approach for congestion detection, congestion prevention and congestion notification. Vertical handover is secondary objective, as congestion control method is concatenate with process of vertical handover during performing the handover decision and selecting the target network using protocol MIH.

***Index Terms*:** Congestion Control, 3GPP LTE-A, Vertical Handover, Efficiency, MIH, 802.21.

1. INTRODUCTION

The Third Generation Partnership project launched the Universal Mobile Telecommunications System (UMTS) first time in 1999. This release is also known as Release 99 (R99). UMTS was deployed and its goals were, among others, enhanced person-to-person communication, high-quality file transmission, and higher data rates. As users start to demand higher data rates, 3GPP specified, in 2005, a solution called High Speed Downlink Packet Access (HSDPA) and after it, High Speed Uplink Packet Access (HSUPA) in 2007. These solutions are known as High Speed Packet Access (HSPA) [1] [2]. Moreover, HSPA Evolution (HSPA+) was specified in order to meet the continuous requirements of users. After this, Long Term Evolution (LTE), also specified by 3GPP, was presented in order to meet present and future users' demands. LTE's main performance focused on the higher peak user throughput, higher spectral efficiency, decreased latency, optimized packet switched, optimized terminal power efficiency, high level of mobility and security, & the frequency flexibility thought the utilization of recent digital signal processing (DSP) method & the modulations. A further goal of this system was the redesign and the simplification of the network architecture to an IP-based system [3].

As time went by, services started to impose new challenges to networks, as they are defined stringent delay & the throughput need that should be fulfilled, i.e., one needs to have Quality of Service (QoS) guarantees provided by the network and therefore amendments continue to be defined. However, the evolution of this technique is not to be sufficient to satisfy the users' demands. As shown in Figure 1.2, mobile traffic

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is growing exponentially [4]. Also, service providers should be available & manages to fulfill those demands. Since the expensive radio spectrum for cellular networks giving limitations for rapid deployment, & the low bandwidth restricts system capacity, the next performance and capacity leap has been getting from the network topology evolution with the use of a mix of macro and small cells [5].

Now days the wireless network (NGWN) for next generation the key is required. It is providing integrated QoS (quality of service) for converted multimedia and mobile services anytime and anywhere [6]. However, the Quality of Service is threatening by various trends such as congestion and load balancing which can disable the whole network. The congestion control mechanism has three phases: 1) congestion prevention. 2) Congestion detection. 3) Congestion notification. In literature, there are many solutions for congestion control in NGWNs, but all of them are turn around to Transmission control protocol (TCP) implemented mechanisms. Which is designed for wired networks and it has weakness to proven in case of wireless networks [7].

Apart from the congestion control, Mobile devices are created with the Different Wireless interface to connect the internet using different access technology such as Wi-Fi, WiMAX, 3GPP, 3GPP2 [8]. But These wireless interface is not give the methods for the handoff to all networks, for example, Conversely, vertical handoff. User is not directly handoff in between different wireless technology interface when the media types are not supported [9]. Hence many vertical handoff algorithms based on RSS, SINR and bandwidths have been proposed in literatures which are inadequate to provide QoS for real-time applications in Wi-Fi/WiMAX heterogeneous networking environment. We have used the Media Independent Handover Services (MIH) for the speedup Handoff process. The scope of the IEEE802.21 MIH is for implement the proportional that would give the generic link layer intelligence & the another network about the data from the lower layers (MAC & PHY) to the upper layers to optimize handoffs between diversification networking technologies 3GPP2, viz, 3GPP, & both wired and wireless media of IEEE802.21. In the mobile management protocol stack of the both are the MN & the network element of MIH Function (MIHF) is a new function model which operates as a shim layer between the Layer 2 and Layer 3 MIH use the different MAC layers of all networks, manages all are this using the MIH service access points (MIH LINK SAP), and send the information to upper layer users (MIH SAP), such as MIP, SIP [10] [11].

In this paper, our goal is to present the efficient algorithm for congestion control using MIH protocol. This method is based on recently introduced technique. We present the architecture of MIH, and then present the design of algorithm for congestion control and vertical handover process for LTE-A networks. This method is evaluated and compared with previous methods using NS3 software. The preparation of research gap based results achieved and methodology is presented in last. The reminders of sections are: section II discussing on related works, section III presenting algorithm design, architecture along with the basic MIH protocol. Section IV showing the results achieved using this method and based on it research gap or limitations are discussed in section V. Finally, conclusion is added in section VI.

2. RELATED WORK

There are different congestion control methods for LTE-A networks recently presented. We are discussing some of them below:

K. Ki Baek et.al (2003)

In [1], By the active queue management approach in the buffer queue of the router congestion control is achieved at the network level & this is by dropping packets predictably before the formation of a full queue, avoiding deadlock and global synchronization caused by packet loss. In [2]- [5], authors noticed that, congestion control is used the various versions of TCP congestion control mechanism.

H. Zhang et.al (2010)

In [5], TCP is design to employ in wired networks, the bandwidth –delay product is typically low, & any packet loss in the network is assumed the reason the overflow o of router buffers in the bottleneck resource. When the TCP detects any packet loss, it retransmits the lost packet and reduce the transmission rate. It allows the reduction of router queue length. Afterword, it slowly increases the transmission rate to check the network capacity.

However, today, this method is no longer used with the wireless networks such as 3GPP LTE networks. The packet loss is not only by the congestion state, it also happens by bit errors, handover, multipath fading, and interference. In that the more fundamental problems with TCP and its other variants. Which is used to packet lass and queuing delay as a signals of congestion. The packet loss provides the information about the congestion, when queuing delay is hard to be count reliably. The packet loss and delay is necessary to performance metrics; the using signals of congestion notify that action only taken after performance has degraded. For that the TCP mechanism is no longer usable in case of wireless networks.

D. Katabi et.al (2002) & Y. Xia et.al (2008)

In [6]- [7], author's proposed two protocols for the address of performance degradation of TCP, the two new congestion control schemes are: 1) explicit Congestion-control Protocol (XCP) [6] and 2) Variable-structure Congestion-control Protocol (VCP) [7]. In fact, XCP uses multiplicative-increase multiplicative-decrease (MIMD) for efficiency and additive-increase multiplicative decrease (AIMD) for fairness control. When, VCP is used multiplicative enhancement, additive enhancement, & multiplicative decrease (MIAIMD) policies, in three congestion levels, which are: low-load, high-load, and overload regions.

L. Xiaolong et.al (2010)

In [8], author proposed a performance analysis for this three schemes, i.e., TCP, XCP, and VCP, in wireless networks are presented.

I. Ayyub Qazi et.al (2011)

In [9], the other solution to congestion control named Multi Level Feedback Congestion Control Protocol (MLCP) is designed. Other solutions presented before, MLCP is use 3 equipment for execution at the same time: an MLCP sender, an MLCP router, and an MLCP receiver. In fact, every router classifies the level of congestion in the network used 4 bits, when employ the load as a congestion signals. Every router computes the mean round –trip time(RIT) of flow for passing through to it & dynamically judgment to load factor measurement interval. These two pieces hold the information and tagged onto every packet using 7 bits. The receiver getting back this information to the source using acknowledgment packets. Based on this feedback, every source applies any one given following window adjustment policies: multiplicative increase (MI), additive increase (AI), inversely proportional increase (II), and multiplicative decrease (MD).

3. METHODOLOGY

Before presenting the proposed methodology, first MIH architecture and its services are discussing in below section.

3.1. MIH Architecture

The IEEE 802.21 (MIH) specification defines the function that improves handovers to heterogeneous media. The handover enhancement is achieved through:

A protocol entity with instances in the mobile terminal and in the RAN. The Media Independent Handover (MIH) protocol entity is to increase a new protocol layer that resides into the Network Layer (Layer 3) & interface specific lower layers (MAC and PHY in the IEEE interfaces, RRC & the LAC into the things of the 3GPP or 3GPP2 interfaces).

A Media Independent Information Service (MIIS) is includes policies and directives to the home network, the same network that initially provisions the new function. The perform handover decisions the terminal use home network policies.

Service Access Points (SAPs) that enable the change in between the MIH layer and adjacent layer and functional planes for primitive services. The MIH-terminated SAPs are logically divided into input and output SAPs.

A decision engine within the MIH object that resides in the terminal that recognize the best available access technology for current connectivity. The decision engine is a state machine that choose the best link using available interface, policies, & Quality of service and security parameter passing.

A transport mechanism is easy to the communication in between the terminal MIH instance and the IS instance in the access network. When the IS instance resides in the network termination of the first access hop (e.g., the Base Station), the transport mechanism can rely on Ethernet MAC frames. In the more general and typical case where the IS instance is located deeper in the WSP home network; the transport mechanism is IP-based.

Figure 1 depicts the logical network elements that compose the 802.21 architecture:

As shown in the figure above, there are three logical locations where the MIH layer could be placed depending on the functionality that is provided. These are a) within the access terminal, b) within the network elements of the access network (for example, 802.11 AP in the case of WiFi and BTS, BSC, PDSN in the case of CDMA2000 etc.), and c) the Information Services (IS) MIH layer which could reside deeper within the network.

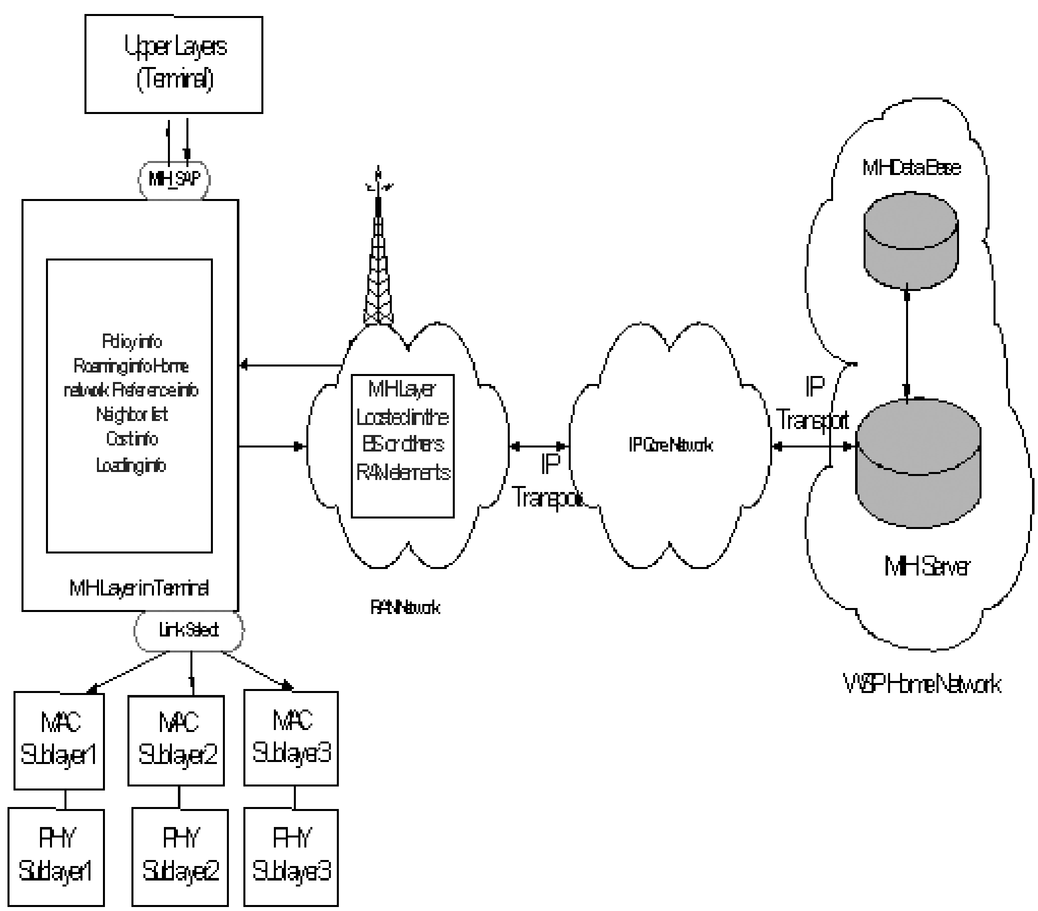

Figure 1: Architecture of MIH Protocol

3.2. Congestion Control MIH Method

In this paper, we modified the existing Weighted Rating of Multiple Attributes (WRMA) method for making the handover decision and target network selection. The existing WRMA method is design to assess as well as assign values to five attributes of network such as bandwidth, jitter, error rate, line cost and delay based on application priority and traffic type. The network capacity is sixth parameters in WRMA in order to support the functionality of congestion control while selecting the target network for moving node. But the criterion for congestion is number of available resources and capacity of network and these are not depending on traffic type and priority of application. Therefore, there will be the similar value for all types of traffic for capacity.

The modified WRMA-based handover algorithm is defined as follows.

Algorithm 1: Efficient Congestion Control

Input:

Define Handover Criteria numbers; // define the input parameter for WRMA

WRMA_TRAFFIC_T; // packet parameter

WRMA_WEIGHT_SET; //WRMA traffic ratio

New Threshold; // set, hands off to eNodeB_AP_BS signal Threshold

HOThreshold; // set value, used to eNodeB signal threshold that connection is break

Output:

Target LTE-A eNodeB; //The selected target for VHO

Target Wi-Fi AP;

Target WiMAX BS;

Step 1:

SET WRMA_TRAFFIC_T; // select WRMA traffic type

SET WRMA_WEIGHT_SET; // select WRMA traffic weight

WRMA_RATIO = Algorithm2 (WRMA_WEIGHT_SET); // for calculating WRMA weight ratio

Step 2: Perform the Handover

While (not handover)

{

If nearby eNodeB_AP_BS' s signal >= New Threshold

Then

Obtain NEW_ eNodeB_AP_BS_Parameter; // Enter the eNodeB_AP_BS parameter.

Save Parameter_list; // # saves eNodeB, AP, BS parameter to list.

End if;

If (Belongs to eNodeB_AP_BS' s signal<=HOThreshold)

Then

get Parameter_list; // enter CRAN parameter is an input's WRMA weight ratio to TOPSIS.

Target_eNodeB_BS_AP=Algorithm3 (WRMA_RATIO, Parameter_list);

If (Belongs to LTE-capacity < Capacity-Threshold)

Then Handover to Target LTE-A_eNodeB

Else

If moving speed in MN>HO_speed_Threshold

Handover to WiMAX_BS from eNodeB_BS_AP;

Else

Handover to Target Wi-Fi AP from eNodeB_AP_BS;

End if;

End if;

End if;

}; # End While

};

Step 3: END

Below two algorithms algorithm2 and algorithm3 are called from algorithm 1.

Algorithm 2: WRMA Algorithm

Step 1: SET TRAFFIC_TYPE=WRMA_TRAFFIC_T;

Step 2: SET TRAFFIC_WEIGHT=WRMA_WEIGHT_SET;

Step 3: Calculate TRAFFIC_WEIGHT into WRMA_RATIO;

Step 4: Return WRMA_RATIO;

Step 5: END;

Algorithm 3: TOPSIS Algorithm

Inputs:

WRMA_RATIO;

Parameter_list;

Step 1: Normalization of Parameter_list & network parameters,

Step 2: Multiply the normalized value with ratio of WRMA_RATIO,

Step 3: Find the ideal Answer and negative-ideal Answer,

Step 4: Compute weighted addition of ideal and negative-ideal networks,

Step 5: Compute score of user networks,

Step 6: Select user network using highest score,

Step 7: Save selected network in Target_eNodeB_BS_AP;

Step 8: Return Target_eNodeb_BS_AP;

Step 9: END

Below figure 2 is showing the simulation work flowchart. DCC is stands for disable congestion control method and ECC stands for enabled congestion control method.

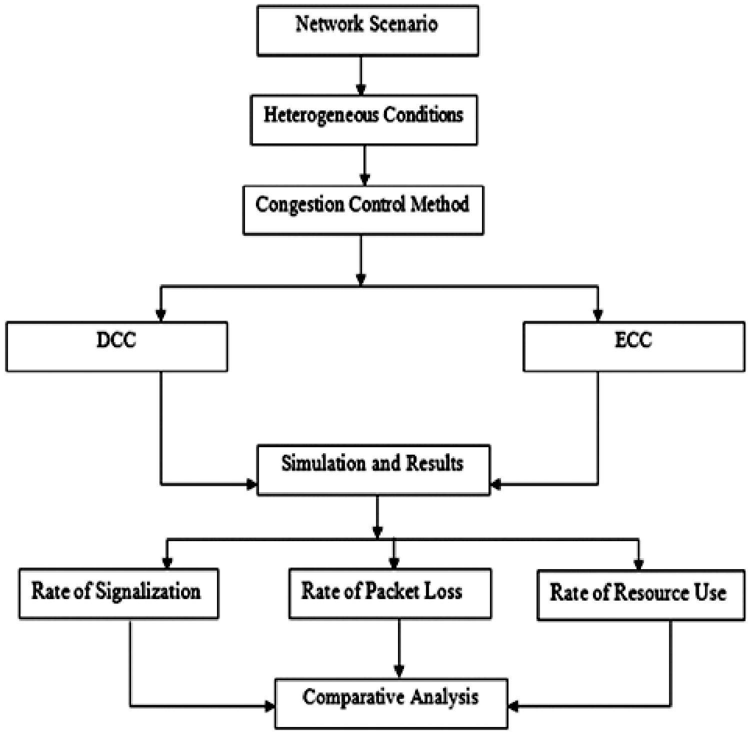

Figure 2: System Flowchart Diagram

4. RESULTS AND DISCUSSION

The practical analysis of designed method is done using NS3 software. We have designed 6 different heterogeneous networks with varying number of mobile stations 10, 20, 30, 40, 50 and 60. Additionally there are 7 eNodeBs, 802.11 access points. There are three important performance metrics evaluated such as: Signalization Rate = Number of signaling packets/Total number of packets (1) Packet Loss Rate = Lost packets /Total number of packets (2) Rate of resources use = Used resources / Total network resources (3)

Figure 3 is showing that designed congestion control method achieving the better performance for signalization rate under different network conditions. This is due to the use of congestion control technique while selecting the target network in handover process.

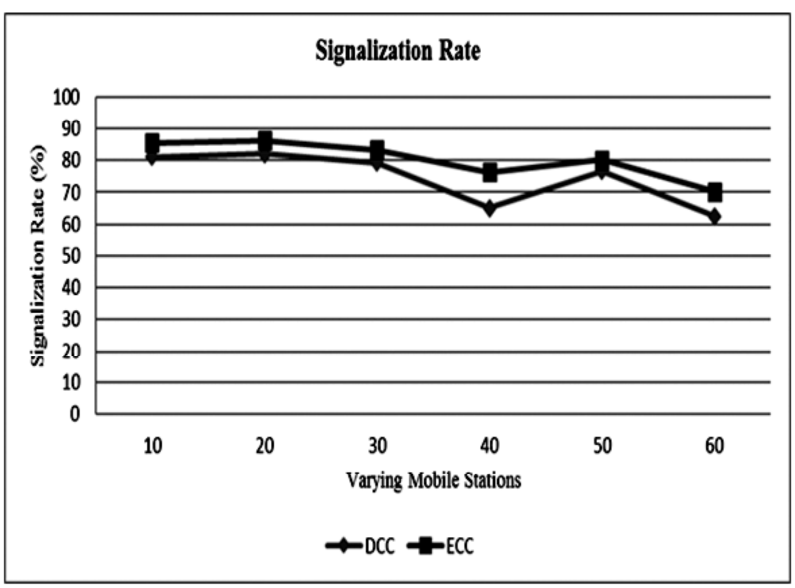

Figure 3: Signalization Rate Performance Analysis

This ECC method not only improves the rate of signalization but also improving the resource utilization efficiency. Resources are utilized according to current congestion in network. This leads to fewer packets drops. Therefore, the packet loss rate is also minimized for ECC method as showing in figure.

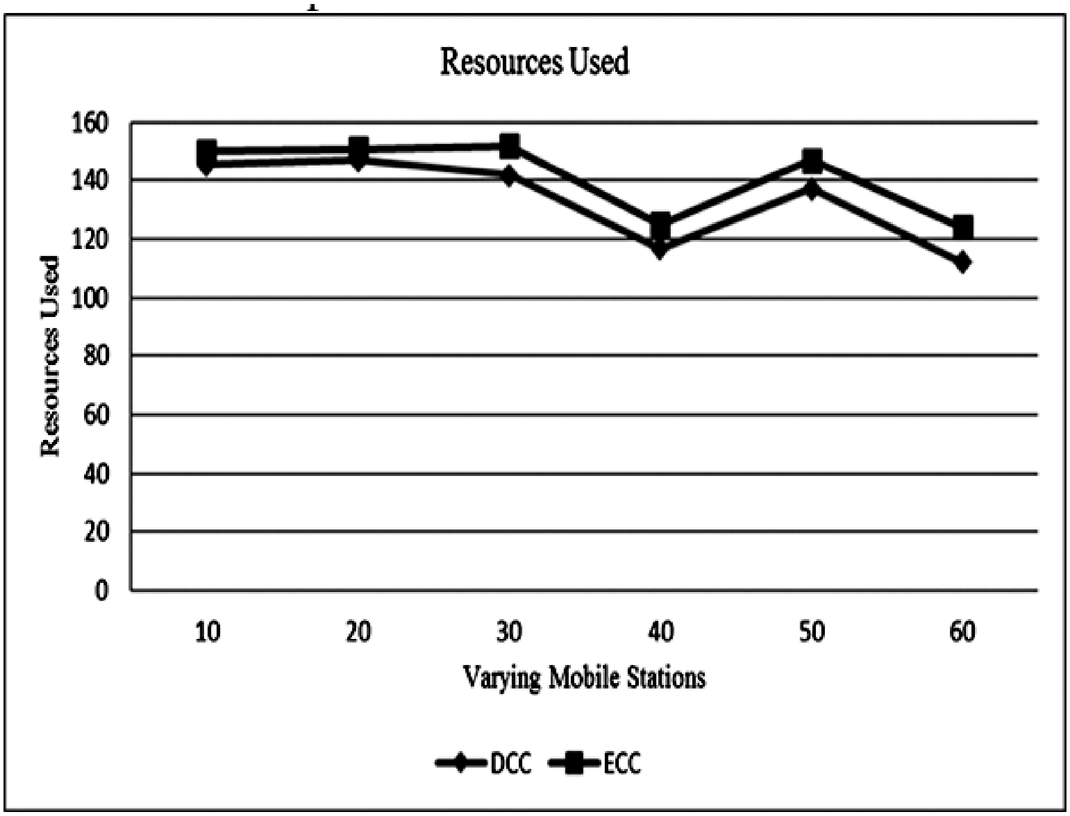

Figure 4: Resource Utilization Performance Analysis

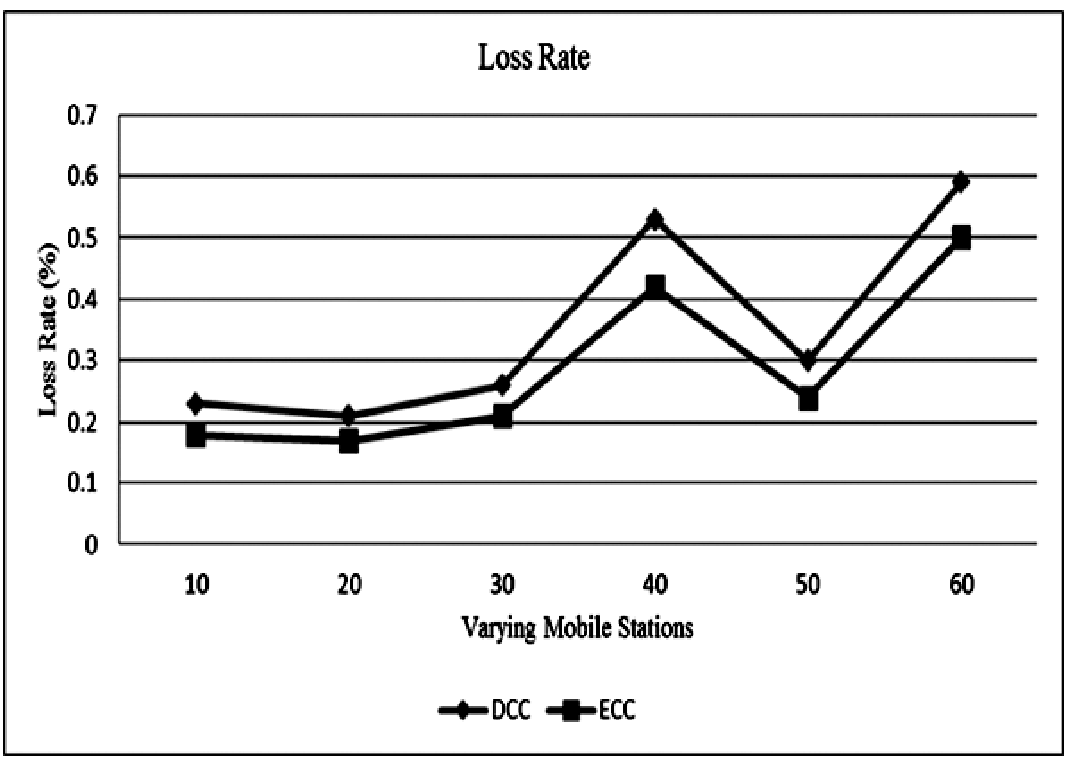

Figure 5: Resource Utilization Performance Analysis

5. LIMITATIONS

In this paper, the congestion control methods are introduced three phases such as congestion prevention, congestion detection, and congestion notification which are joined with process of vertical handover to select the target network. The problem with this approach is that load balancing is not addressed to communicate among the mobile nodes. This may threaten the process of vertical handover and congestion control.

6. CONCLUSION AND FUTURE WORK

The aim of this paper is to present and evaluate the efficient method for congestion control and vertical handover operations in heterogeneous networks. There are very few methods presented for addressing the congestion control problem in such networks as main focus is on efficient handover process only. This paper presenting the attempt in first main goal is efficient congestion control and secondary goal is efficient handover in 3GPP LTE-A networks. We presented the algorithm, its architecture with current simulation results with varying network cases. The results showing that present improves the performance in terms of signalization rate, packet loss rate and resource utilization rate. Future work will be on limitations of ECC method discussed in above section.

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