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# Handoff Decision for Multi-user Multi-class Traffic in MIMO-LTE-A Networks

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**Abstract**

LTE-A networks do not have a central controlling system or node and is made up of several networking technologies. Handover is a method to assure that users can move freely within a network without losing the network connection. Thus, handoff is important in LTE-A to maintain the quality of service. But, handoffs in LTE-A face numerous issues like rapid change in network topology, failure in calls maintenance, etc. Thus, making efficient handoff decision is important. So, in this paper we develop a vertical handoff decision model on the basis of the utility model such that the handoff occurs only to the suitable cells in order to avoid any problem in maintaining the network connectivity.


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Keywords: LTE-A Network, Handoffs, Benefit function, Utility Function, Penalty Function, and Vertical handover decision.

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## 1. Introduction

LTE network consists of numerous wireless technologies like 2G and 3G mobile network, Adhoc network, WLAN and radio networks and hence is considered as a hybrid network. In LTE, the interconnection between the different networks is provided by IP backbone network [1]. The basic characteristics of the 4G LTE are good usable features that can be used everywhere and at all times in connection with every possible technology, and helping the intelligent service at reasonable price. In LTE, the major attribute is the system integration in which the services of the existing technology's like WLAN, UMTS and CDMA are combined and a new wireless system is developed [2] [3]. Instead of substituting the existing technologies by a different single standard, the 4G LTE combines all the current technologies to form a well enhanced communicating network [4].

In case the mobile user moves out of the cellular range, then the communication becomes incomplete since the radio signal is out of range. Then there is a need of signal transition and this procedure is known as handoff. During handoff, there is a change in the base station that takes care of the communication between two users, but no modification in the allotted frequency band. Hence, handoff can be considered as a procedure in which there is a change in the base station from one to another or change in the cellular range boundary from one to a different one [5]. The cellular handoffs are divided in to intra cell and inter cell handoff. If the mobile terminal alters its channel when it is still inside a single network and under the influence of the same base station so as to reduce the inter channel interference, then it is considered as inter cell interference. When a handoff happens among the APs or BSs belonging to a single network, it is considered as horizontal handoff or intra system handoff i.e., it happens among the member cells of a particular system. Vertical handoff means changing from one base station to another that belongs to different networks. This handoff is used in heterogeneous environment. This handoff is also called as inter system handoff occurring at various parts of networks following different technologies [5].

In this paper, we propose to design efficient handover decision model for multi-class users of LTE networks based on the parameters latency, power, network cost, throughput and user preferences.

## 2. Related Works

Toni Janevski et al [6] have evaluated the performance features for the vertical handover with respect to various real time video streamed in different wireless network by considering the vertical handover from UMTS to the WiMAX network and vice versa. For vertical handover, IEEE 802.21 protocol is applied and real time video is used for the assessment of the performance metric. It is found that with the increase in the mobile user speed, the handover delay and also throughput among the UMTS and WiMAX networks keeps increasing.

Issaka Hassane Abdoulaziz [7] have proposed a technique to calculate the handover requirements in the WLAN cell in two steps. They are by determining the travel time and then the threshold for estimation. On the basis of the RSS calculated and the MT speed, the travelling time is determined. According to network attributes like tolerable handover failure probability or un-necessary handover probability, the radius of the WLAN cell and the handover latency, the time threshold is determined. By following this technique, the handover failures and redundant handovers are decreased to a larger extent of 80% and 70% when considered with respect to the traditional RSS threshold and hysteresis based mechanism.

Ardian Ulvan et al [8] have proposed the handover procedure on LTE-based femtocell has been investigated and analyzed in three different scenarios, i.e., hand-in, hand-out and inter-FAP. The hand-in and inter-FAP scenarios are quite demanding than hand-out since plenty of target FAPs were involved in the handover process. It is a challenge to make a selection of the target FAP. The mobility prediction mechanism can be used to predict the heading position of the UE and then estimate the target FAP to which the UE may be connected. The reactive handover is the potential mechanism to mitigate the unnecessary handover. The further work is needed to find the most optimize handover procedure by integrating the proposed scheme and algorithm with the handover decision criteria specified by the standard.

Chi Sun et al [9] have proposed a vertical handoff decision algorithm for 4G wireless networks. Our work considers the connection duration, QoS parameters, mobility and location information, network access cost, and the signaling load incurred on the network for the vertical handoff decision. The algorithm is based on CMDP formulation with the objective of maximizing the expected total reward of a connection. The constraint of the problem is on the user's budget for the connection. A stationary randomized policy is obtained when the connection termination time is geometrically distributed. Numerical results show that our CMDP-based algorithm outperforms another scheme which does not consider the user's velocity in making the decisions

## 3. Proposed utility based vertical handover decision model for LTE networks

### *3.1. Overview*

In this paper, we propose to design efficient handover decision model for multi-class users of LTE networks. The target cell is selected based on the benefit and penalty functions [9]. The benefit function is based on the parameters bandwidth, delay such that the cell with maximum bandwidth and minimum delay is selected. The penalty function is represented based on the parameters battery power and load. (ie) The handoff decision should consume less battery power and load. Finally a utility function is derived and if it is less than a threshold value, another cell with better utility will be selected.

### *3.2. Estimation of Benefit Function*

When an MT chooses an action *a* in state **s**, it receives an immediate reward *r*(**s**, *a*). The reward function depends on the benefit function and the penalty function, which are explained below. For the benefit function of the MT, two aspects are considered: bandwidth and delay.

Let the *bandwidth benefit function* represent the benefit that a MT can gain (in terms of bandwidth) by selecting action *a* in state **s**:

$$f_b(s,a) = \begin{cases} 1 & \text{if } b_i = \max_{k \in M}\{b_k\},\ a = i \\ 0 & \text{if } b_i = \max_{k \in M}\{b_k\},\ a \neq i \\ \dfrac{b_a - b_i}{\max_{k \in m}\{b_k - b_i\}} & \text{if } b_i \neq \max_{k \in M}\{b_k\},\ b_a > b_i \\ 0 & \text{if } b_i \neq \max_{k \in M}\{b_k\},\ b_a \leq b_i \end{cases} \qquad (1)$$

Here b is the available bandwidth at each network and M is the set of available networks.

The benefit is being assessed as follows. Given that the MT is currently connecting to network *i*. If network *i* is the one which offers the highest bandwidth among others, the strategy is to keep using network *i*. However, if the MT is not using the network which has the highest bandwidth, the benefit that it can obtain is represented by a fraction, in which the numerator is the MT's actual increase of bandwidth by choosing action *a* in state **s**, and the denominator is the MT's maximum possible increase of bandwidth.

Similarly, a *delay benefit function* is used to represent the benefit that an MT can gain (in terms of delay) by choosing action *a* in state **s**:

$$f_d(s,a) = \begin{cases} 1 & ,\text{if } d_i = \min_{k \in M.}\{d_k\}, a = i \\ 0 & ,\text{if } d_i = \min_{k \in M.}\{d_k\}, a \neq i \end{cases} \qquad (2)$$

$$= \frac{d_i - d_a}{\max_{k \in M}\{d_i - d_k\}} \qquad , if\ d_i \neq \min_{k \in M.}\{d_k\}, d_a < d_i$$

$$= 0 \qquad , if\ d_i \neq \min_{k \in M.}\{d_k\}, d_a \geq d_i$$

Here d is the delay at each network and M is the set of available networks.

As a result, the total *benefit function* is derived using Exponential Weighted Moving Average (EWMA) :

$$f(s,a) = \omega\, f_b(s,a) + (1-\omega) f_d(s,a) \tag{3}$$

where $\omega$ is the importance weight given to the bandwidth aspect with $0 \leq \omega \leq 1$.

### 3.3. Estimation of Penalty Function

We consider two factors for the penalty of the MT. They are battery power and load. So based on the battery power penalty function and load penalty function, the overall penalty function is calculated.

The battery power is the power consumed by the battery and is represented as the sum of the transmitted power and received power.

The transmitted power, $P_{tx}$ is given by

$$P_{tx} = P_x + 10\log(M) + \alpha.\ PL \quad (dBm) \tag{4}$$

The received power, $P_{rx}$ is given by

$$P_{rx} = psd_{rx} + 10\log(M) \tag{5}$$

where

$psd_{rx}$ is the power density

The power density at each node i is given by $psd_{rx}^{i} = \frac{psd_{tx}^{i}}{pl_i}$ [mW/PRB]

The power density during transmitting is given by $psd_{tx} = p_0.(pl^{\alpha})$ [mW/PRB]

The battery power penalty function is obtained by adding equation (4) and (5)

$$P_{battery} = P_{tx} + P_{rx} \tag{6}$$

The load of a cell i at a given time t is given as

$$load_i(t) = \frac{S_i^c(t)}{S_i(t)}$$

where
$S_i(t)$ is the total resources available,
$S_i^c(t)$ is the resources utilized by the users.

Therefore, the load penalty function is given as

$$load = \sum_{i=1}^{n} load_i(t) \tag{7}$$

where n is the maximum number of cells in the network.

The total penalty function of an MT is the sum of the battery power penalty function and load penalty function.

$$Penalty\ Function = w.P_{battery} + (1\text{-}w)\ load \tag{8}$$

where w is the weight value with $0 \leq w \leq 1$.

### 3.4. Derivation of Utility Function

Some users allow vertical handoff in order to obtain better QoS although there is a risk that the connection may be dropped during handoff, whereas some others may refrain from switching. Finally, between two successive vertical handoff decision epochs, the utility function, U is defined as:

$$Utility\ Function = Benefit\ Function - Penalty\ Function \tag{9}$$

After the utility function for the target moving cell is estimated, it is compared with the utility value of other cells. The cell with maximum utility value will be selected as the target cell.

## 4. Simulation Results

### 4.1. Simulation Parameters

We use NS2 [10] to simulate our proposed Handoff Decision technique for Multi-user Multi-class traffic (HDMMT). The area size is 1200 meter x 1200 meter square region for 50 seconds simulation time. The simulated traffic is Video, Constant Bit Rate (CBR) and Exponential (EXP). We compare the Constrained MDP-based Vertical Handoff Decision (CMDP) algorithm [12] with the proposed HDMMT protocol. We evaluate performance of based on the metrics Bandwidth Utilization, Average Packet Delivery Ratio, Average end-to-end delay and Throughput.

### 4.2. Results & Analysis

**A. CBR Traffic**

The CBR traffic rate is varied from 2 to 4 Mb for 12 users.

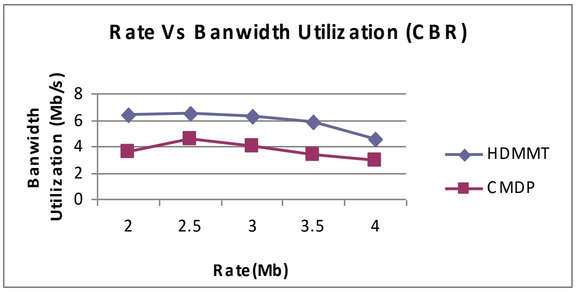


Fig 1: Rate Vs Bandwidth Utilzation

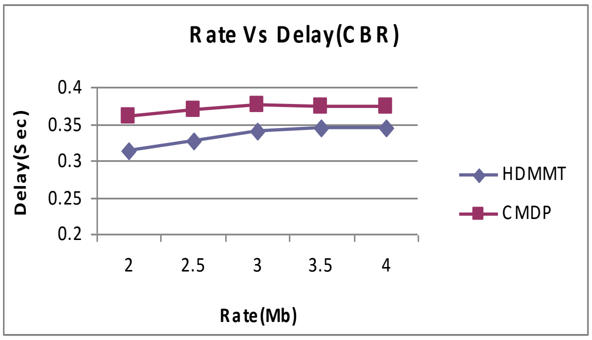


Fig 2: Rate Vs Delay

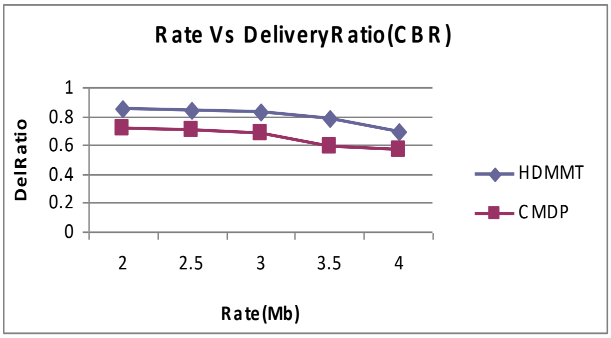


Fig 3: Rate Vs Delivery Ratio

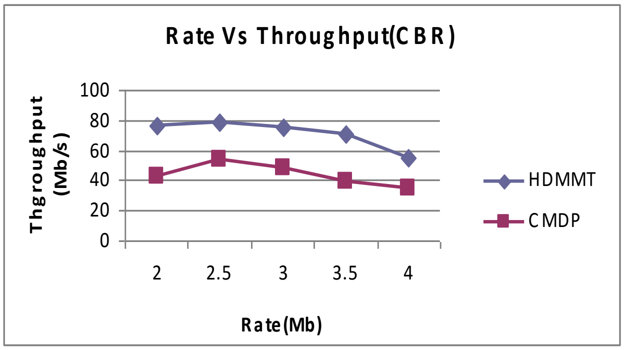


Fig 4: Rate Vs Throughput

Figures 1 to 4 show the results of Bandwidth, delay, delivery ratio and throughput by varying the rate from 2Mb to 4Mb for the CBR traffic in HDMMT and CMDP protocols. When comparing the performance of the two protocols, we infer that HDMMT outperforms CMDP by 38% in terms of bandwidth utilization, 9% in terms of delay, 18% in terms of delivery ratio and 38% in terms of throughput.

## B. Exponential Traffic

The Exponential traffic rate is varied from 2 to 4 Mb for 6 Users.

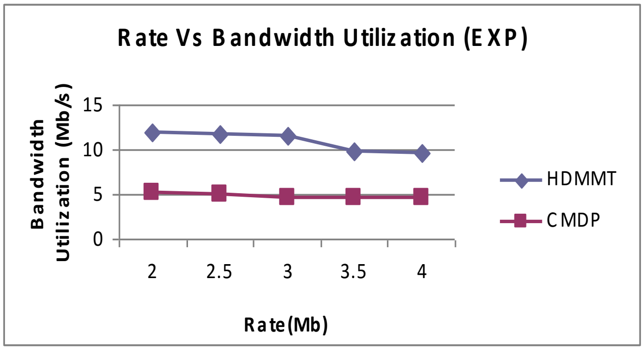


Fig 5 : Rate Vs Bandwidth Utilization

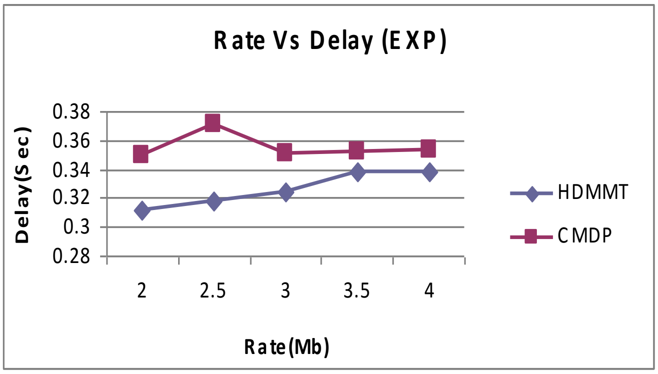


Fig 6: Rate Vs Delay

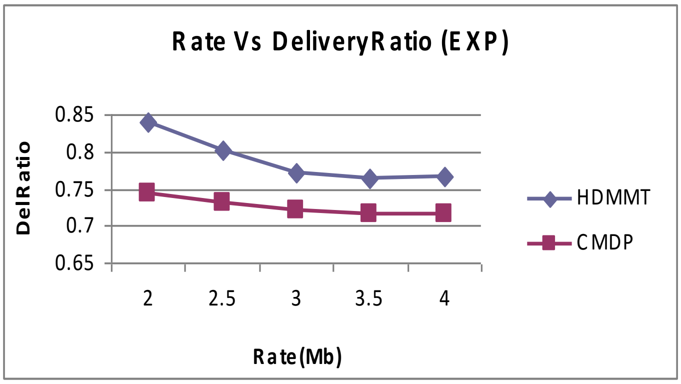


Fig 7: Rate Vs Delivery Ratio

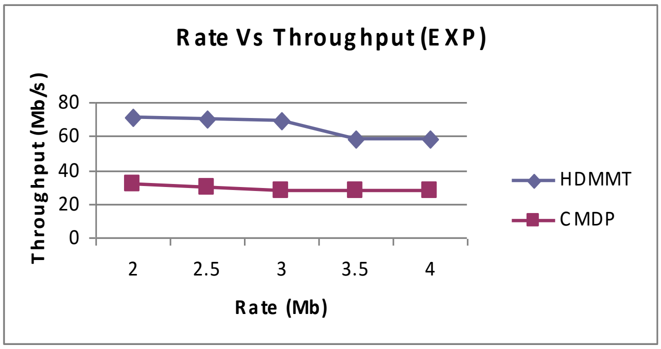


Fig 8: Rate Vs Throughput

Figures 5 to 8 show the results of Bandwidth, delay, delivery ratio and throughput by varying the rate from1Mb to 3Mb for Exponential traffic in HDMMT and CMDP protocols. When comparing the performance of the two protocols, we infer that HDMMT outperforms CMDP by 56% in terms of bandwidth utilization, 8% in terms of delay, 8% in terms of delivery ratio and 56% in terms of throughput.

## 5. Conclusion

In this paper, the utility based handoff decision is made in three steps. Initially, the serving cell maintains a database which contains information about all the cells. Based on the suitable entries in the database, the serving cell selects some neighbor cells. Next the benefit function and the penalty function of the selected cells is estimated to determine its utility function. If the utility function of a cell is satisfies the required condition then it is selected as the target cell, else the serving cell searches for a new target cell. Once the target cell is chosen, then the handoff is performed either in proactive or reactive mode.

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