A Novel Adapative Call Admission Mechanism Based on user Mobility and Spectrum Awareness for Cellular Networks

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Abstract

In this paper, we introduce the effective use of mobile hotspot (MH) with adaptive call admission control and wireless network resources. Mainly MH used for various high speed transportations. MH user have low transmission power, increased channel quality gain and improved QoS with high quality of wireless communication access and services. While using MH, Users equipment (UEs) may have network congestion and QoS degradation due to excessive amount of surge at same time. We proposed adaptive call admission control (ACAC) & Mobility and spectrum aware adaptive call admission control for reduce network congestion, guaranteed QoS, reduce the new call blocking probability and handoff call dropping probability with reserved network resource, which have been compared with the previous non mobility method to prove the results of improved QoS performance by using MH in the network resource.

Key words - *ACAC, CBP, CDP, Handoff, Mobile Hotspot, Markov chain, Quality of Services, LTE-A.*

I. INTRODUCTION

The enormous growth of cellular network provides so many facilities to the user equipments. As well as it needs to face so many challenge to provide services according to the users requirement. For example network connectivity without call dropping and call blocking probability. Improved QoS, constant call connectivity for moving users by handoff calls or new calls. But most challenging in the mobile network is connecting the call over the various speed of the mobility users e.g.; high speed transportations like rail coach, buses and small vehicles. When a group of people's travelling in the indoor moving environment, all users are requesting the handover at same time from one base station to another base station. So several UEs individually request the handover at same time, then there will be network degradation and inefficient resources management due to overheads of signals. To overcome the disadvantage we are using mobile hotspot (MH) networks.

In the form of mobile picocell and femtocell the MH network is implemented. Mobile hotspot base station (MHBS) used to connect UEs. The MHBS is connected as single interface link to the macro base station, here less handover signalling overheads are generated. So it causes network congestion which is leads to undesirable increases in HC dropping and NC blocking probabilities. To avoid network congestions ACAC algorithm is used because it's an essential part of radio resource management (RRM). ACAC ensures the pre-defined level of QoS for ongoing calls through the acceptance or rejection of service requests based on their priorities and also regulates network congestions.

In MH would reserve more wireless resources for handoff calls and new calls than the traditional CAC algorithm is implemented. It's usually a logical thing to do when the MHBS is stationary. Handoff and New calls are generated and offered to the stationary MH by incoming and outgoing UEs respectively. For example, an HSRC (high speed rail coach) with MH at its terminal stations would experience new calls from the domicile UEs. From the DeNodeB to MHBS handoff call occur from the UEs want to board the HSRC at the terminal stations. However, waste of reserve resource for handoff calls when the HSRC is moving and out of its terminal stations, new calls is generated.

The main purpose of traditional CAC algorithm is regulate the traffic by reserving the network resource known as resource blocks (RBs),but it leads to inefficient physical resource blocks utilization for handoff calls when users moving in high speed transportation. In MH network, it have the capacity of total Resource Blocks to utilize for available handoff calls and new calls when UEs in inside an indoor moving environment. In the MH network take benefits of moving network and enhance the QoS of UEs by MH's ACAC algorithm. The problem in the design of improving the QoS provisioning for class of handoff calls and new calls and maximizing the system resource block utilization in MH.

In this paper, it based on LTE-A cellular network to address the problem of enhancing QoS for MH. We proposed to enhance the improved QoS of MH by a Mobility and spectrum aware ACAC algorithm. Here RB refers to an OFDM unit used for the transmission of data. Markov chain is used to reduce new calls call blocking probability (CBP), handoff calls call dropping probability (CDP) and efficient utilization of reserve resource block in network.

The three main contributions of this paper are:

- We proposed a new ACAC scheme for MH that improve the QoS of UEs, reduce CBP and CDP without degrading network. It gives channel resource according to the priorities requires for the UEs.
- MH is used for fast mobility users in the indoor moving environment with efficient HC and NC calls by reserve blocks in the wireless networks.
- An analytical model of Markov chain was developed to measure the performance of the proposed scheme.

The next section of this paper is, we provide the overview of the related works in II section, the introduction of the system model of our proposed scheme in section III, the Analytical study is illustrated in section IV, Numerical result and discussion in section V. Finally conclusion of this paper is given in section VI.

II. RELATED WORK

In this section we provide the overview of related work on moving wireless network and efficient use of reserve network resources. In some CAC schemes are proposed [1], [2] which considered bandwidth reservation from mobility prediction is perspective. The Mobility prediction scheme will be developed for the cellular network. These scheme uses Hidden Markov Model (HMM) to analyze users mobility in temporal scale and large spatial. The proposed scheme was combined with threshold-based statistical bandwidth multiplexing strategy to enhance system performance. Initially, mobile reservation protocol starts the session with mobile host sending a service request to the active cell. The active cell verifies whether the available channels are free then request is granted; otherwise, the request is forbidden. In [2] proposed a mobility prediction-aware bandwidth reservation scheme. The scheme estimated the time windows for a user to perform handoffs along the path to his destination. It then estimated the available bandwidth required during the time windows. The scheme achieves low handoff call drops and maintains sufficient new call blocks while keeping effective utilization of resources. However, the estimation accuracy and reservation technique are questionable: how do you distribute resources to diverse kinds of users in a predictive way.

In [5] the concept of moving worldwide interoperability for microwave access (WiMAX) networks for soldiers in military warfare environment which was proposed by group leader of mobile node (MN).the MN integrate the ranging request from group into an individual group leader request to the base stations (BS). The group leader can serve as a local BS and support local communication within the troops when the mobile group nodes are out of coverage range. Advantage of MN is avoiding possible collision and mitigation any contention of back- off. Disadvantage is the size of the group MN increase then the QoS will degrades.

Mobile aware CAC scheme is proposed by Younghyun et al. in [6] which is based on guard band reservation with prioritized handoff queue in Wi-Fi networks. The queue size increases as well as handoff dropping probability show the better result than the performance of non-priority schemes. The proposed scheme is heavily sacrificed to improve the performance of handoff cal dropping probability. However the QoS and security of the Wi-Fi access are not guaranteed.

The predictive group handover (PGHO) with a channel borrowing scheme is proposed by author in [7], to reduce handover dropping and connection blocking probability. From the given information of the location and direction which is used to predict the BS target and pre –inform the target BS about the group-connection information by the mobile group. The predictive scheme can lead to low network RB utilization due to unnecessarily holding down and the non- release of scarce resources.

In [8], the authors investigate two possible candidate architectures for mobile relays in LTE: (i) Alternative 1 (Full–L3 relay) and (ii) Alternative 2 (ProxyS1/X2).).In alternative 1, the serving Gateway (S–GW)/Packet gate way (P–GW) entity serving the relay is separated from the Donor–Evolve Node Base station (DeNB) and the relay is transparent to the DeNB. In alternative 2, S–GW/P–GW functionality serving the relay is embedded in the DeNB and the relay (S1/X2) interfaces are terminated in the DeNB. For mobile relay changing of its backhaul link from source-DeNB to target-DeNB, that the architecture alternative 1 is more advantages than the alternative 2. So the alternative 1 is more suitable and also selected as the baseline architecture in MHBS networks.

The impact of LTE-A in-band and out-band access architectures for MHBS in HSRC scenarios was analysed by Sanchez et al in [9]. In band access implemented requires less bandwidth reservation to setup, but group nodes experience more network delay due to time gap between transmission and receptions. The physical downlink control channel

(PDCCH) imposes further constraints on the in-band access architecture.

Meng-Shiuan et al in [10] propose the enhanced handover scheme, by mitigate against this effect of lengthen and large handover time which is overheads the handover message. When the MHBS detects that the train is moving close to some neighbouring DeNB to enhance the measurement procedure. Then the proposed scheme can effectively reduce mobile relays' handover time and overhead messages.

In [11] Wenyu et al investigate the LTE-A networks for group nodes mobility about the capacity and handover performance gain of mobile relay node over non- mobile relay node for high speed railway system. In the high speed railway system it introduced the mobile relay node to increase the throughput by 24.12% for UEs and with an overall system throughput gain of more than 16.53%; while the radio –link failure ratio s significantly decreased compared with non-mobile relay node.

The above related works show the benefits and challenges of moving wireless networks. We introduced the system model for the MSACAC CAC scheme in the next sections. To enhances QoS provisioning by improving the new call and hand off call dropping probabilities without degrading the RBs with effective utilization in the network and system performances.

III. SYSTEM MODEL OF MSACAC SCHEME

MH is based on a standard cellular network system e.g. Long Term Evolution Advance, Universal Mobile Telecommunications service. MH networks support has become an attractive feature for next generation wireless network like the current Third Generation Partnership Project (3GPP) and Fifth Generation (5G) network. In MH network environment were UEs demand excellent wireless communication access and services with providing diverse and quality multimedia services such as web –browsing , video streaming ,online gaming and also used for military surveillance and disaster relief management.

This scheme is mainly designed for moving users. So the communication quality of vehicular UEs is greatly enhanced by MH with advantage of advance multi- antenna multiple -input multiple-output (MIMO), carrier aggregation (CA), and Co-ordinated multi point (CoMP) techniques in LTE-A networks. Where LTE-A network works on given layer 3 (L3) classifications. Which means Mobility hotspot base station can be handle the signal controlling, resource scheduling and the routing of user plane data towards serving gateway.

The MHBS is mounted on a mobile carriage; it's equipped with indoor and outdoor antenna to reduce the vehicular penetration loss (VPL) [12]. The MHBS can access the DeNB of the macro cell through its outdoor mounted antenna, using Un interface; while the UEs can access the MHBS through the indoor mounted antenna, using Uu interface [13]. Up to 100MHZ bandwidth is delivered by MH for a better QoS experience for UEs [14]. These reduce UEs transmission power, signalling overheads and give better channel quality conditions [5].

However the MH is easily overwhelmed by resource demand surge from a more number of UEs requesting at same time within the vicinity [13]. Due to the relatively small capacity and mobility of MH compared to the fixed macro cells, this may lead to sudden congestion in network and QoS degradation. So we are using the effective ACAC algorithm for MH. This could admit and efficiently regulate the network traffic and also provide guaranteed QoS in the MH network. Two types of handover is used in the MH, they are Type 1 handoffs: this comprises handover calls from macro cell's DeNB to MHBS, and type 2 handoffs: this comprises handover calls from MHBS to macro cell's DeNB. Handoff type 1 is only used in this work.

The MH is operated on open access policy by the network provider. Where the service provider placed the cell in a hotspot and all subscribed users can connect it. We considered HSRC were the MHBS is mounted on it with MH. The HSRC commutes on its routes through various terminal stations. UEs can get on/off the HSRC at the terminal station (stop event). LTE-A network is support the MH and it has the capability to carry out independently, UEs RB allocation and scheduling and call admission control functionalities. The given capacity of RB is allocated to MH by DeNB. The HSRC goes through two sequences of mobility events: (i) zero mobility event at terminal station and (ii) non-zero mobility event at non-terminal station, which is shown in Fig.1 (a), (b).

The call request is accepted, a RB is released for utilization for the call. When handoff calls and new calls request is accepted according to the availability or unused RB is available in the network. The MH can perform handoff call admission control for calls from the DeNB into the MHBS. Where there is no available RBs to serve in the network than the handoff calls are dropped. According to the MH new calls are accepted with a certain probability as long as there are sufficient resources to support them; otherwise the new cal s blocked.

In the HSRC's moving event, handoff calls are not generated and also not accepted by MH because HSRC commuters are not allowed to physically jump into a moving HSRC. It would lead to cause a low resource utilization and poor QoS provisioning to thin out new calls, in order to allow some priority for handoff calls that are not generated during the mobile event. Consequently, a new call is accepted with certainty, as long as there is sufficient resource to support it. The concept of thinning of new calla at the MH is exploit by MSACAC CAC scheme and its adaptively implemented to take full advantage of HSRC's mobility.

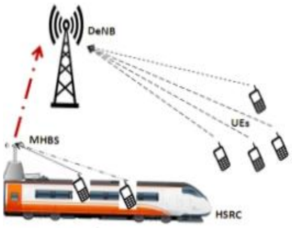


Fig.1.(a) HSRC at terminal station

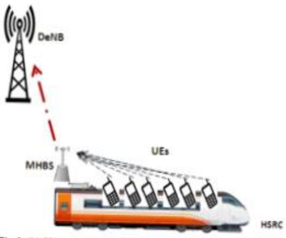


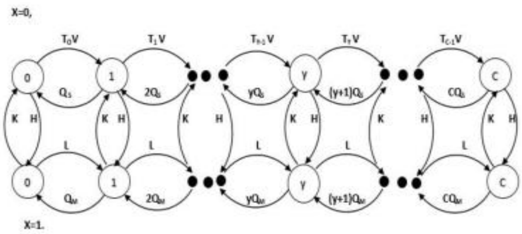
Fig.1.(b) HSRC out of terminal station

Fig 1.MH Networks for HSRC

IV. NUMERICAL ANALYSIS

In this section, we showed the Numerical analysis of Mobility and spectrum aware ACAC mechanism (MSACAC) scheme for MH networks. In figure 2 is given about the Markov chain model for MSACAC scheme. The state space is defined as: S = {(x, y)| x ϵ {0, 1}, 0 ≤ y ≤ C}, where x indicates the mobility events of HSRC (x = 0, when HSRC is stationary; x = 1, when HSRC is moving), y indicates the number of ongoing calls in the HSRC; C is the capacity of the MH of the HSRC. When HSRC is outside the terminal station x = 1 and with y < C, only new calls are accepted, with certainty. The call departure rates for the MH, when HSRC is stationary and mobile are given by yμ_s| y ≤ C and yμ_m|y ≤ C, respectively. To analyze the performance of MSACAC scheme, the arrival rates at the terminal station for the handoff calls$\lambda_{h,s}$, new calls $\lambda_{n,s}$ and the arrival rate at out of terminal stations for new calls $\lambda_{n,m}$ are generated following a Poisson distribution model. The call life time of the handoff call and new call at terminal station and new call out of terminal station are modelled as exponential distribution with mean $\frac{1}{\mu_{h,s}}$, $\frac{1}{\mu_{n,s}}$, $\frac{1}{\mu_{n,m}}$, respectively. The call dwelling time is known as the time over which a call may be maintained within a wireless cell network or without handoff. The dwelling time of calls at the terminal station and out of the terminal station are represented by θ_s and θ_m and it's modelled as exponential distribution with mean $\frac{1}{\theta_s}$ and$\frac{1}{\theta_m}$, respectively.

From the Markov chain model of the scheme in Fig.2; the steady state probability, $P_{x,y}$ of state (x,y) can be derived from the balance equations, where T_0= β_0, T_1 = β_1, T_{y-1} = β_{y-1}, T_y = β_y, T_{C-1} = β_{C-1}, V = $\lambda_{n,s}$ + $\lambda_{h,s}$, Q_s = μ_s , K = ϕ_s , H = ϕ_m , L = $\lambda_{n,m}$ and Q_M = μ_m.



For the HSRC in the stationary event, x = 0, for y = 0, then the balance equation gives

$$[\beta_y \lambda_n + \lambda_h + \phi_s]P_{x,y} = (y+1)\mu_s P_{x,y+1} + \phi_m P_{1,y} \quad (1)$$

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For 0 < y < C, then the balance equation gives

$$[\beta_y \lambda_n + \lambda_h + y\mu_s + \phi_s]P_{x,y} = (\beta_y \lambda_n + \lambda_h)P_{x,y-1} + (y+1)\mu_s P_{x,y+1} + \phi_m P_{1,y} \quad (2)$$

For y = C, then the balance equation gives

$$[C\mu_s + \phi_s]P_{x,y} = (\beta_y \lambda_n + \lambda_h)P_{x,y-1} + \phi_m P_{1,y}. \quad (3)$$

For the HRSC in the mobile event, x = 1, for y = 0, then the balance equations gives

$$[\lambda_n + \phi_m]P_{x,y} = (y+1)\mu_m P_{x,y+1} + \phi_s P_{0,y}. \quad (4)$$

For 0 < y < C, then the balance equations gives

$$[\lambda_n + y\mu_m + \phi_m]P_{x,y} = \lambda_n P_{x,y-1} + (y+1)\mu_m P_{x,y+1} + \phi_s P_{0,y} \quad (5)$$

For y = C, then the balance equation gives

$$[C\mu_m + \phi_m]P_{x,y} = \lambda_n P_{x,y-1} + \phi_s P_{0,y}. \quad (6)$$

Where $\lambda_{h,s}$ = λ_h, $\lambda_{n,s}$ = $\lambda_{n,m}$ =λ_n, $\mu_{h,s}$ = $\mu_{n,s}$ = μ_s and $\mu_{n,m}$ =μ_m.

The $P_{x,y}$ will be computed by using successive over-relaxation (SOR) technique, an iterative algorithm [19]. The proper choice of the over-relaxation factor, w helps to speed up the convergence rate of the iterative solution process for$P_{x,y}$, Where w ϵ (0,2). In this simulation w is set to 0.98.

The new call blocking probabilityP_B^{MSACAC}, handoff call dropping probability P_D^{MSACA} and RB utilization η^{MSACAC} of MSACAC scheme are obtained from$P_{x,y}$. The new call probabilityP_B^{MSACAC} is obtained as:

$$P_D^{MSCAC} = \sum_{y=0}^{C}(1-\beta_y)P_{0,y} \quad (7)$$

Where β_y is defined as the probability that the new call will be admitted, given that there is y ongoing call(s). The handoff dropping probability [8],P_D^{MSACAC} s obtained as:

$$P_D^{MSACAC} = \frac{P_{0,C}}{\sum_{y=0}^{C} P_{0,y}} \quad (8)$$

The RB utilization η^{MSACAC} is given as:

$$\eta^{MSACAC} = \frac{1}{C}\sum_{x=0}^{1}\sum_{y=0}^{C} yP_{x,y} \quad (9)$$

An effective maximum uplink throughput of 18Mbps and a voice application call system which is encoded at 128 Kbps for MH network. The capacity of MH resource is C units, with C = 140(18Mbps/128Kbps). We considered that the MH ACAC improves the quality of services of UEs. It ensures the efficient RRM by dynamically controlling calls and also performed by the MeNB. The $\beta_y \epsilon$ (0, 1) is the simulation result which is obtained from a uniform random distribution and its sorted in descending order with increasing magnitude of y. The simulation parameters are shown in below table I.

Table I : Simulation Parameters

Parameter	Value
Handoff calls	25(calls/unit time)
New calls	[5~ 35](calls/unit time)
μ_s	0.2(calls/unit time)
μ_m	0.08333(calls/unit time)
ϕ_s & ϕ_m	0.07692(calls/unit time)
UE Distribution	Uniform

V. NUMERICAL RESULTS AND DISCUSSIONS

In this section, the performance results of the MSACAC scheme are obtained and compared against the traditional NMAT scheme using NS2 simulation tool. The reduction of CBP and CDP with a efficient use of bandwidth network resources, as a function of new call arrival rate, are presented in Fig 3, 4 and 5.

The main concept of MSACAC is increasing the new call arrival rate with efficient use of RBs in cellular network. So the performance of the RB utilization by MSACAC scheme and comparison of NMAT scheme are shown in Fig.3.

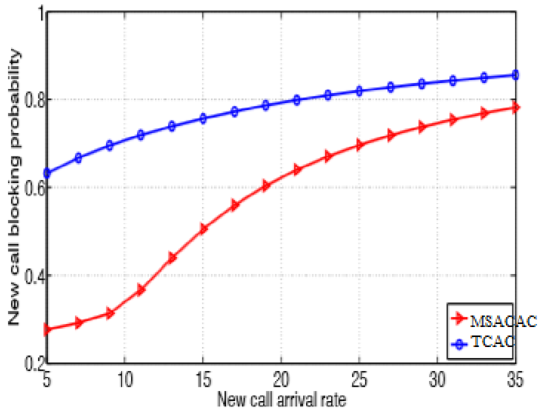

Fig.3 New CBP as a Function of New Call Arrival Rate

The result showed the new call arrival rate and utilization of RBs is increased using MSACAC scheme than the NMAT scheme. When RB utilization at a new call arrival rate of 15 calls/unit time for MSACAC is 99% used than the NMAT which is used only 77%. It can observe that the MSACAC scheme produces a steady increasing performance gain of RBs utilization and also reached saturation level. Where the RBs utilization of MSACAC scheme performance gain is not less than 13% over performance which always achieved by NMAT scheme.

In the MSACAC and NMAT scheme is increased in the new call blocking probability and new call arrival rate which is showed n Fig.4. Because new call in the MH increases and there is more resources are consumed in the network.

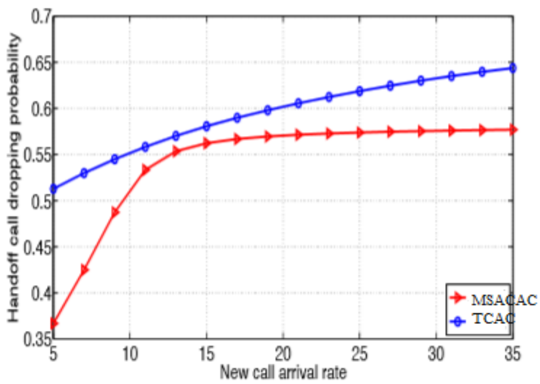

Fig.4 Handoff CDP as a Function of New Call Arrival Rate

The result shown the MSACAC provide efficient utilization of RBs and better than the performance new call blocking probability of NMAT scheme. For example, when high speed transportation like HSRC is in the terminal station MSACAC scheme accepts new calls into the network until the RB capacity is filled. But all resource in MH network is released for new call with certainty when the HSRC is out of the terminal station.

Generally the handoff call dropping probability increases as the new call arrival rate is increases. The MSACAC scheme handoff call dropping probability has higher performance than NMAT scheme. In the MSACAC scheme there is constant increase in handoff call arrival rate, that the probability of an arriving handoff call from DeNB into the MHBS of the high speed transportations finding all the RB utilization is increased.

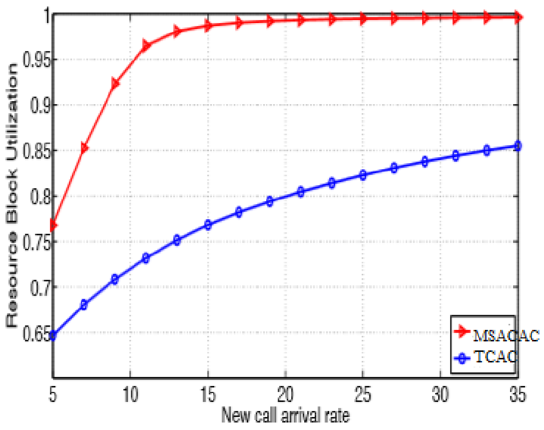

Fig.5 RBs utilization as a function of New Call Arrival Rate

By comparing increasing CDP is better than the CBP for more sensitivity of mobile use and have increased QoS performance. The introduction of well designed and implemented ACAC scheme in MH should regulate the CDP to ensure it. The new call arrival rate is increased beyond 15(calls/unit time) and also have saturation level is just below then 0.58 for MSACAC regulate the degradation of the handoff call. However the Adaptive CAC scheme is provide good performance and regulate the new call in the MH network than the traditional implementation of NMAT CAC scheme which is shown in Fig .5.

VI. CONCLUSION

In this paper, we have proposed a novel MSACAC CAC scheme for MH networks. For mobility event of the high speed transportations MSACAC scheme will be adaptively and smoothly throttles out the new calls. In this scheme the simulation result showed improved RB utilization with lower new call and handoff call dropping than the traditional NMAT CAC scheme. For future research we required to extend the MSACAC scheme to analyze heterogeneous QoS provisioning for both MH and MF with multimedia services.

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