# Management Strategies for Voice Based Communication towards Emerging Networks

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*Abstract—* **LTE focusses on increasing both the upload and download speeds compared to its predecessors. This mobile technology has created an environment in which application developers can create more options that will better the user's experience. Gaming, banking, streaming to mention a few will all be seamlessly working together on your mobile phone. In 4G cellular networks, call admission control (CAC) has a direct impact on quality of service (QoS) for individual connections and overall system efficiency. Reservation-based CAC schemes have been previously proposed for cellular networks where a certain amount of system bandwidth is reserved for high-priority calls, e.g., hand-off calls and real-time new calls. Traditional reservation-based schemes are not efficient for 4G vehicular networks, as the reserved bandwidth may not be utilized effectively in low hand-off rates. We propose a channel borrowing approach in which new best effort (BE) calls can borrow the reserved bandwidth for high-priority calls. Later, if a hand-off call arrives and all the channels are busy, it will pre-empt the service of a borrower BE call if there exists any. Our focus in this paper is on the system modeling and performance evaluation of the proposed scheme. We present two system models that approximate the operation of the proposed scheme.**

*Index Terms—* **Long-Term Evolution, high-speed wireless communication, mobile phones, data terminals, GSM/EDGE and UMTS/HSPA.**

## I. INTRODUCTION

The next big thing in mobile technology is recognized as LTE which is short for Long Term Evolution. LTE is the fourth generation mobile technology that has evolved from its predecessors 3G, 2G and 1G. Mobile carriers from all around the globe have upgraded or starting to upgrade their networks to the latest technology. In simple terms LTE networks are the mobile connectivity equivalent to what broadband is to dial up connectivity. With LTE it is now possible to anything on the Internet using mobile phones as if we are connected to a fixed broadband line. LTE focusses on increasing both the upload and download speeds compared to its predecessors. This mobile technology has created an environment in which application developers can create more options that will better the user's experience. Gaming, banking, streaming to mention a few will all be seamlessly working together on your mobile phone.

LTE is an all IP system that turn calls into digital data and sends them over the networks. This shift in technology will decrease traffic on networks improving your call sessions and conversations. When there is lack of capacity LTE can in real time reallocate bandwidth between different callers. This mobile technology is taking us to a point in which more people will access faster Internet through their mobile phones than fixed lines. Safety applications often require fast message exchanges but do not use much bandwidth where vehicles are enabled to communicate with one another, i.e., vehicle-to-vehicle or vehicle-to roadside communications [1-9].

On the other hand, evolution of vehicular networks is aimed to support non-safety multimedia applications which require high-speed Internet for mobile users. Fortunately, the telecommunication industry landscape for cellular networks is growing rapidly from 2G to 4G to accommodate the increasing usage of multimedia applications and users' mobility.

In 4G, Worldwide Interoperability for Microwave Access (WiMAX) and Long-Term Evolution (LTE) are two emerging broadband wireless technologies aimed to provide high-speed Internet of 100Mbps at a vehicular speed of up to 350 km/h [1, 2]. Recently, research on the performance evaluation and improvement of 4G/5G vehicular networks has been under the focus of researchers in the field of vehicular networking [10-15]. In 4G vehicular networks, call admission control (CAC) is considered as one of the radio resource management (RRM) functionalities and has a direct impact on quality of service (QoS) for individual connections and overall system efficiency.

The goal of the CAC mechanism is to regulate the admission of new users, while controlling the quality of current connections without any call drops. In the traditional mobile networks, e.g., cellular and vehicular networks, CAC schemes have been designed to handle the voice traffic. On the other hand, design of practical and efficient CAC schemes for 4G vehicular networks [16-21]. Challenging task due to the heterogeneous nature of multimedia traffic, user mobility, etc. However, CAC design is left open for innovation in 4G wireless network standards, such as WiMAX and LTE. In the design of CAC schemes, the most common QoS parameters for performance evaluation are call blocking probability (CBP) and call dropping probability (CDP). Call blocking means denying new calls due to insufficient bandwidth in the network or the QoS requirements. Call dropping means dropping an existing call during a hand-off process due to users' mobility (vehicular or pedestrian). Forced termination of a call in progress is more frustrating than blocking a new call.

As a result, hand-off calls are treated differently by being given higher priority over new calls in cellular/vehicular networks. Particularly, we may either reserve certain amount of channels from the total available channels in a cell for hand-off calls or dynamically allocate channels for an individual cell, based on the time-varying status of vehicular traffic. The amount of channel reservation for handoff calls is mostly based on users' mobility pattern, i.e., using vehicular traffic modeling that aggregates variables such as traffic density, mean speed, etc. In various research efforts on mobile cellular networks, the hand-off call arrival rate can be derived from the mobility model. CAC designs based on mobility and traffic models will be depended on the assumptions made in modeling of the users' mobility and traffic pattern. In vehicular networks, due to the fast movement of vehicles, the variation range of hand-off rates is large. A good CAC design for 4G vehicular networks should be robust enough to support a vast range of hand-off rates [22-24]. This motivates us to propose a CAC scheme which is robust enough to support a vast range of hand-off rates. We will propose a CAC scheme that irrespective of the traffic model and mobility pattern can improve the CBP considerably while not affecting CDP over a large range of hand-off rates. This motivates application of the proposed scheme for 4G vehicular networks.

## II. EXISTING METHODOLOGIES

This section discusses about the recent research techniques that were published from 2010 till date. Zulhasnine et al. have discussed the spectrum sharing problems on 3GPP-LTE cellular network and analyzed the interference issues owing to faulty transmitter design. Lai et al. have presented an architecture for performing efficient hand-off between IEEE 802.11 and EPS networks using optimized proxy mobile IPv6. The work done by John and Ventura are also seen to use proxy mobile IPv6 to normalize WLAN (Wireless Local Area Network) traffic and attain IP flow mobility. Study toward incorporating access policy and security was seen in the paper of Li et al. The authors have deployed standard cryptographic principles to enhance the authentication process of 3G networks.

The issue of mobile service is emphasized by the research attempt of Ahmed and Choukair for EPS based services. Although the authors discussed that their technique can considerably reduce congestion, there was no significant outcome to prove it. Wang et al. have quantitatively analyzed the transmission behavior of the LTE network using statistical analysis. The authors have considered path-loss and coherence bandwidth to evaluate the outcome accomplished from their study. Aiash et al. have proposed a framework for supporting heterogeneous characteristics of LTE networks.

The study showed that YComm framework is highly suitable to analyze LTE network elements. Significant studies of LTE network from the viewpoint of cloud computing was done by Guasch. The author has studied the virtualization aspects of the LTE network. Swetha et al. have studied the scheduling

problems in LTE network considering video traffic and eventually proposed a fair scheduling technique using round robin to enhance the quality of experience (QoE). Study in similar direction considering scheduling issues was also addressed by Sharma and Chopra [24-30]. Guard Channel-based call admission control strategies are a classical topic of exhaustive research in cellular networks (Lunayach et al., 1982; Posner & Guerin, 1985; Hong & Rappaport, 1986). Guard channel-based strategies reserve an amount of resources (bandwidth/ number of channels/ transmission power) for exclusive use of a call type (i.e., new, handoff, etc.), but they have mainly been utilized to reduce the handoff failure probability in mobile cellular networks.

Guard Channel-based call admission control strategies include the Conventional Guard Channel (CGC) scheme1 (Hong & Rappaport, 1986), Fractional Guard Channel (FGC) policies2 (Ramjee et al., 1997; Fang & Zhang, 2002; Vázquez-Ávila et al., 2006; Cruz-Pérez & Ortigoza-Guerrero, 2006), Limited Fractional Guard Channel scheme (LFGC) (Ramjee et al., 1997; Cruz-Pérez et al., 1999), and Uniform Fractional Guard Channel (UFGC) scheme3 (Beigy & Meybodi, 2002; Beigy & Meybodi, 2004). They have widely been considered as prioritization techniques in cellular networks for nearly 30 years because they are simple and effective resource management strategies (Lunayach et al., 1982; Posner & Guerin, 1985; Hong & Rappaport, 1986). In this section, both a comprehensive review and a comparison study of the different approximated mathematical analysis methods proposed in the literature for the performance evaluation of Guard-Channel-based call admission control for handoff prioritization in mobile cellular networks is presented.

The general guidelines of the model presented in most of the listed references are adopted to cast the system considered here in the framework of birth and death processes. A homogeneous multi-cellular system with S channels per cell is considered. It is also assumed that both the unencumbered call duration and the cell dwell time for new and handed off calls have negative exponential probability density function (pdf). Hence, the channel holding time is also negative exponentially distributed. $1/\mu n$ and $1/\mu h$ denote the average channel holding time for new and handed off calls, respectively. Finally, it is also assumed that new and handoff call arrivals follow independent Poisson

processes with mean arrival rates $\lambda n$ and $\lambda h$, respectively. In general, the mean and probability distribution of the cell dwell time for users with new and handed off calls are different (Posner & Guerin, 1985; Hong & Rappaport, 1986; Ramjeeet al., 1997; Fang & Zhang, 2002).

The channel occupancy distribution in a particular cell directly depends on the channel holding time (i.e.: the amount of time that a call occupies a channel in a particular cell). The channel holding time is given by the minimum of the unencumbered service time and the cell dwell time. On the other hand, the average time that a call (new or handed off) occupies a channel in a cell (here called effective average channel holding time) depends on the channel holding time of new and handed off calls and its respective admission rate.

### III. PROPOSED METHODOLOGY

A new call belongs to one of the traffic classes defined in the network. Other than the new call arrivals, there exist hand-off calls which are generated in a cell due to the mobility of users into the cell. Note that the hand-off calls have the same traffic classification. Assuming a wireless network with N traffic classes, the Markov modeling of the system will end up to a Markov chain with 2×N-dimensional state space which makes it unfeasible to analyze mathematically. To show the effectiveness of our proposed reservation-based CAC scheme and to provide an analytical performance evaluation for it, we consider a 4G wireless network with two main priority traffic classes. In our model, we assume that the high-priority class contains only the hand-off calls that is coming from other cells in the cellular network. We may also categorize the real-time new calls in the current cell into this class.
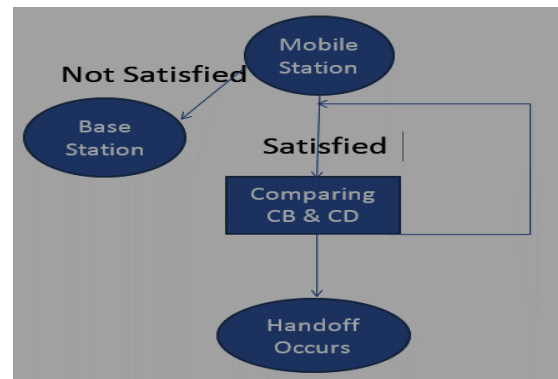


Figure 1: Flowchart of the Proposed Method

The low-priority class contains the new calls generated in the current cell. We assume that the new calls are subcategorized to non-real-time (nRT) new calls and best effort (BE) new calls. Examples of nRT and BE calls are non-real time multimedia traffic (e.g., Youtube video) and web traffic, respectively. Example of real-time traffic is live broadcasting. It is assumed that the arrival processes of hand-off, nRT, and BE calls are Poisson distributed with parameters λH, λnRT, and λBE, respectively. We further assume that the service processes of the hand-off, nRT, and BE calls are exponentially distributed with parameters μH, μnRT, and μBE, respectively.

The system bandwidth is channelized, and the number of channels (bandwidth units) in the system is C. Note that C is not the network capacity in terms of amount of served traffic (which is dependent on the users' wireless channel model and interference). In this model, C denotes the number of physical network resources in a cell which should be allocated to the arriving calls, e.g., number of physical resource blocks in an LTE network.

We build our channel borrowing idea on the new call bounding scheme proposed, and henceforth, we call this CAC as the conventional scheme. We first review the new call bounding scheme and then explain how we incorporate our channel borrowing approach in this scheme.

## IV. CONCLUSION

LTE networks' main challenge is to efficiently use the available spectrum, and to provide satisfying quality of service for mobile users. However, using the same bandwidth among adjacent cells leads to occurrence of Inter-cell Interference (ICI) especially at the cell-edge. A hand-off arrival call can pre-empt the service of a borrower BE call, and the pre-empted BE calls are stored in a queue to resume their service in future. Moreover, we modeled the channel borrowing scheme using a mixed loss-queuing system and introduced two system approximations for the proposed borrowing scheme to simplify the mathematical analysis. By using simulations and numerical analysis, we showed that the two approximations result in very close CBP and CDP values with respect to the actual CBP and CDP values. Furthermore, it was shown that channel borrowing decreases CBP considerably while it only increases CDP slightly. In our study, the number of reserved channels for high-priority calls, i.e., T, is assumed to be fixed. Optimization of T with respect to the number of users in the cell and the arrival rate of high-priority calls can be consider as a future work in this area of research.

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