UMTS and LTE Interfaces Utilization Improvement with QoS in Mobile Communication Systems

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Abstract- **To provide support for both data and voice is essential requirement of present mobile networks both LTE and UMTS networks. The proposed scheme in this paper differentiates assignment of requested calls on: *speed, direction of motion* and *type of requested call*. It also checks the used capacity threshold of LTE and UMTS before assignment. Different communication interfaces are used in hybrid mobile communication to address these issues, the UMTS uses VSF-OFCDM interface for assignment of orthogonal codes from orthogonal variable spreading factor (OVSF) code tree in two dimensions. The LTE interface assigns resource blocks. The UMTS is prone to high probability of packet loss and less spectral efficiency too. The LTE has problem with moderate reward with unbalanced loads. The proposed scheme reduces these issues considerably by differentiating requested calls related to interference and movement. The proposed scheme addresses these issues considerably as compared to other schemes in literature.**

***Keywords-** LTE; VSF-OFCDM; OVSF; mobile communication; UMTS; 2D spreading.*

I. INTRODUCTION

In order to meet the increased demand of traffic, the fourth generation (4G), mobile communication systems provides data rates support of up to 100 Mb/s for higher mobility user and up to 1 Gb/s for lesser mobility users [1-4]. 3GPPs' [1], Variable Spreading Factor Orthogonal Frequency and Code Division Multiplexing (VSF-OFCDM) [5], the long term evolution (LTE) and LTE-Advanced [6]etc., several communication technologies have been used. The proposed variable spreading factor OFCDM (VSF-OFCDM) in [7] combines OFCDM with a variable spreading factor and used for downlink transmission scheme. The advantage of OVSF and OFCDM communication technology are taken by VSF-OFCDM and adopts a 2-D spreading in the time and frequency domains to control certain parameters like the channel load, delay spread, interference and increase the spectrum utilization. The voice and data calls arrives in network randomly, 3G (UMTS) handles both voice and data calls while high mobility data calls are handled using LTE.

II. BACKGROUND

The UMTS and LTE architecture is illustrated in Figure 1[4]. The UMTS provide support to both data and voice calls with mobility (less). The radio access network (RAN) of UMTS has radio network system (RNS) in order to allow access. The central part of it contains (a) Gateway Mobile Switching Center (GMSC) which pilots and establishes the voice calls with mobile users; (b) home location register (HLR) which has user information and its visitor location register (VLR); the VLR knows HLR details of users; (c) the 3G gateways which routes data packets between the RAN and the internet. The LTE network only offer services to high mobility data users. The central part of it consists of mobile stations (MSs) and RAN. The RAN of MS uses eNodeB (which is base station) for allowing access of radio spectrum to MSs. The network core of LTE is using internet protocol (IP), it consists of (a) Mobility Management Entity (MME) which is used to handle mobility of users and 4G gateways which routes data traffic between 4G RAN and internet.

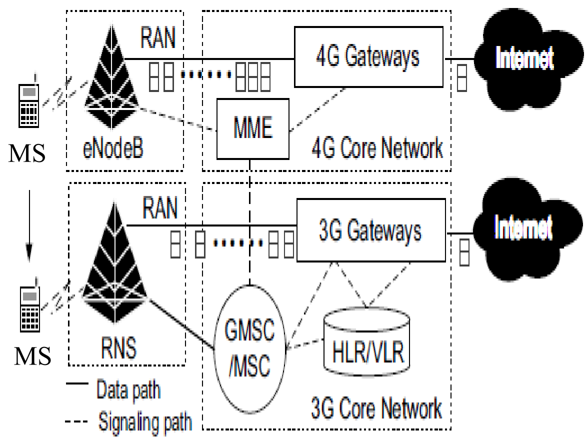

Fig. 1 Architecture of 4G-3G networks.

III. WORK IN LITERATURE

There are several schemes given in the literature to minimize code blocking probability of mobile networks using OVSF [9]. These schemes are single code [8-11]and multi code assignment schemes [12-14]. The most common single code assignment schemes are: leftmost code assignment (LCA) and crowded first assignment (CFA) both given in [8], the fixed set partitioning (FSP) [9] and recursive fewer codes blocked (RFCB) scheme proposed in [10]. These schemes uses only one dimensional spreading of codes and consider parameters affecting one dimensional codes, however these suffers from interference as they don't consider the effect of channel load (C*l*) before assignment. The multi code assignment schemes [12-14] uses multiple codes to handle a single call which reduces code blocking at the expense of radio resources wastage and increased complexity. To address aforementioned problems Universal mobile telecommunications system (UMTS) uses the VSF-OFCDM interface to allocate OVSF codes in two dimensions. In [14], a new multi code scheme is proposed which leads to real time calls waiting time zero. The scheme assigns any incoming call without delay to an available free code of same rate and in the meantime divides the incoming rate into quantized rate fractions and searches for the free codes for all quantized fraction. When the free codes for all fractions located, reassign the call to these free codes using multiple rakes. The information of these codes utilized is updated to receiver like existing schemes. An interference avoidance (IA+CF) scheme is proposed in [15] which provide significant improvement of code blocking probability at better QoS. Adaptive reward based selection of UMTS and LTE considering the effect of interference and mobility environments are proposed in [16] which are further used for assignment using multicodes in order to maximize the bandwidth waste [17]. The downlink of the Multi-Rate MC-DS-CDMA networks demands QoS together with efficient utilization of available capacity. The ADCL scheme in this paper assigns call to a code for which $Cl<Cl_{Threshold}$ and offers lesser capacity utilization. The top down scheme proposed in [18], start searching a vacant code from top code and significantly miimize the call establishment delay which depends upon the number of code searches before assignment.

The remaining of the paper is arranged as follows. OVSF, VSF-OFCDM and LTE fundamentals are explained in section II. The OVSF, VSF-OFCDM and LTE fundamentals are given in section IV. The speed type direction (TSD) assignment scheme is given in section V. The results and simulations are given in section VI. The conclusion of the paper is in section VII.

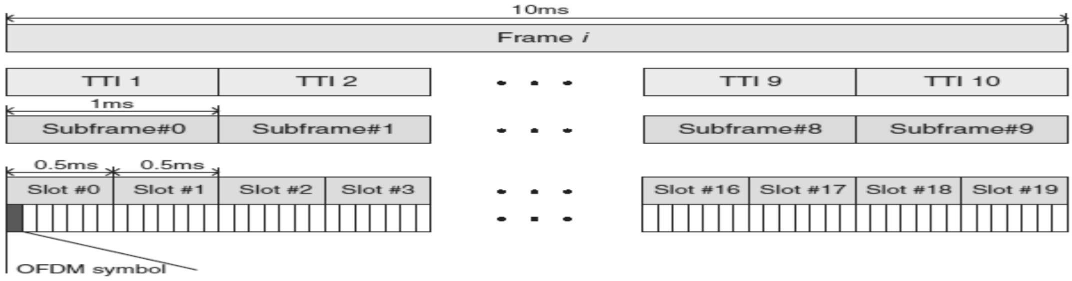

Fig. 2 Frame structure of LTE

IV. OVSF, VSF-OFCDM AND LTE FUNDAMENTALS

The network model for a mobile system using LTE and UMTS is defined here.

For UMTS interface : An OVSF code is denoted as C_{k,n_k}, all the codes in all layers have quantized rates given by $2^{m-1}R, 1 \leq m \leq L$, L denotes the total number of layers in code tree and the spreading factor (*SF*) of a code in layer *m* is 2^{L-m}. The time domain spreading factor is denoted by $TCd^{T}_{sf_t,i_t}$ where $sf_{m_t} = 2^{m_t-1}$ and i_t is the index level of time domain code, also $1 \leq i_t \leq m_t$ and $1 \leq sf_{m_t} \leq (L - m_t)$. The frequency domain spreading factor is denoted by $FCd^{F}_{sf_{m_f},i_f}$ where $sf_{k_f} = 2^{k_f-1}$ and i_f is the index level of frequency domain code, also $1 \leq i_f \leq m_f$ and $1 \leq sf_{m_f} \leq (L - m_f)$. The total spreading factor

$$sf_m = sf_m \times sf_{m_t} \tag{1}$$

for a VSF-OFCDM network.

i : OVSF Code index and $i_f = i - (i_t - 1) \times 2^{m_f-1}$.

For LTE interface: A normal PHY frame structure for LTE is having subframes=10 in the time domain with two slots in each, 14 OFDM symbols can be carried in each subframe as given in Figure 2. The frequency domain subchannel has 12 carriers. Number of subchannels varied with bandwidth like each channel of capacity 1.4 MHz and has six subchannels. For a mobile station (MS) in LTE, the transmission unit is called as a resource block (RB) within a subframe (in time) and a subchannel (in frequency).

V. PROPOSED SCHEME

The problem associated with OVSF codes is that they suffer from code blocking problem. UMTS uses VSF-OFCDM which assigns channelization code to a call from OVSF code tree. For LTE numbers of RBs are assigned to a new call. Using both interface in 4G give an advantage of additional spectrum, the mobility in users force careful use of them. The main disadvantage of unmanaged assignment of calls will lead to reduced spectral efficiency and will provide less profit to mobile operators. Thus, a TSD scheme is proposed which assigns calls to UMTS and LTE, considering factors related to user like speed, call type and direction of motion. It also checks the used capacity of UMTS and LTE.

$$C^{UMTS}_{Used} = \sum_{m=1}^{L} n_m \times 2^{m-L} \tag{2}$$

$$C_{Used}^{LTE} = \frac{n_{Used}^{RB}}{n^{RB}} \tag{3}$$

Where n_m denotes number of codes of layer m assigned in UMTS, n^{RB}, n_{Used}^{RB} denotes total and used RB in LTE interface respectively. The modulation schemes used in UMTS are: BPSK used for longest distance, QPSK moderate distance and 16-QAM or 64-QAM for close area to base station (BS) [25]. The TSD scheme is defined any $max\ (n^{RB})$ which can be assigned according to location when user is going away from BS.

Algorithm of TSD scheme

1. Generate a new call of rate $kR, 1 \leq k \leq 16$
2. Check the call type *voice* or *data*.
3. If (*Voice*)
   Find a suitable UMTS code using TD[26] and update $C_{Used}^{UMTS} = C_{Used}^{UMTS} + kR$.
4. Else (*Data*)

(a) Find its speed, direction of motion and location from BS.

(b) Case 1: High Speed, moving towards the BS
If $C_{Used}^{LTE} < C_{Th}^{LTE}$
Assign call to LTE interface and update $C_{Used}^{LTE} = C_{Used}^{LTE} + n_{Used\ for\ kR}^{RB}$.
Else $C_{Used}^{LTE} > C_{Th}^{LTE}$ and $C_{Used}^{UMTS} < C_{Th}^{UMTS}$
Assign new call to UMTS interface and assign codes using TD multi-code approach [21] and update $C_{Used}^{UMTS} = C_{Used}^{UMTS} + kR$.
Else if $C_{Used}^{LTE} > C_{Th}^{LTE}$ and $C_{Used}^{UMTS} > C_{Th}^{UMTS}$
Block the call.
End.

(c) Case 2: Moderate Speed, moving away from the BS
If $C_{Used}^{LTE} < C_{Th}^{LTE}$
Assign call to LTE interface and update $C_{Used}^{LTE} = C_{Used}^{LTE} + n_{Used\ for\ kR}^{RB}$.
Else $C_{Used}^{LTE} > C_{Th}^{LTE}$ and $C_{Used}^{UMTS} < C_{Th}^{UMTS}$
Call can be handled using UMTS interface, divide kR into no. of fractions< $max\ (n^{RB})$ and assign codes using TD multi-code approach [24] and update $C_{Used}^{UMTS} = C_{Used}^{UMTS} + kR$.
Else if no. of fractions< $max\ (n^{RB})$ or $C_{Used}^{LTE} > C_{Th}^{LTE}$ with $C_{Used}^{UMTS} > C_{Th}^{UMTS}$
Block the call.

5. End.

VI. SIMULATIONS AND RESULTS

In this section, the proposed TSD scheme performance is compared with 3GPP UMTS popular schemes LCA, CFA, FSP, RFCB and IA+CF in the single cell environment. The user classes considered are kR and $[1 \leq k \leq 16]$. The total capacity of UMTS code tree is $2^{L-1}R, L = 9$. The arrival rate (λ) is Poisson's distributed with mean varying from 0 to 4 calls per minute. The call duration ($1/\mu$) is exponentially distributed with mean value 1. The numbers of users are 10000 and results are average of 10 simulations. Average traffic load

$$\rho = \sum_{i=1}^{16} \lambda_i / \mu_i = \sum_{i=1}^{16} \lambda_i \tag{4}$$

The threshold value of UMTS and LTE interfaces are $C_{Th}^{UMTS} = 0.75$ and $C_{Th}^{LTE} = 0.75$.

Fig. 3, shown the comparison of TSD scheme with other schemes when arrived calls are quantized only *i.e* $2^{m-1}R$ and the performance of all the schemes is better as compared to non-quantized calls arrival due to the increased scattering due to internal fragmentation. The TSD code blocking probability is lowest due to use of multi code and LTE interfaces. The real time calls are handled well as higher speed users are usually handled by LTE interface. The performance of all the schemes degrades with increase in traffic.

Code blocking probability of a 16 class system can be calculated from

$$P_B = \sum_{i=1}^{16} (\lambda_i P_{B_i} / \lambda) \tag{5}$$

the i^{th} class code blocking probability is P_{B_i}.

The average code blocking for quantized call scenario will be

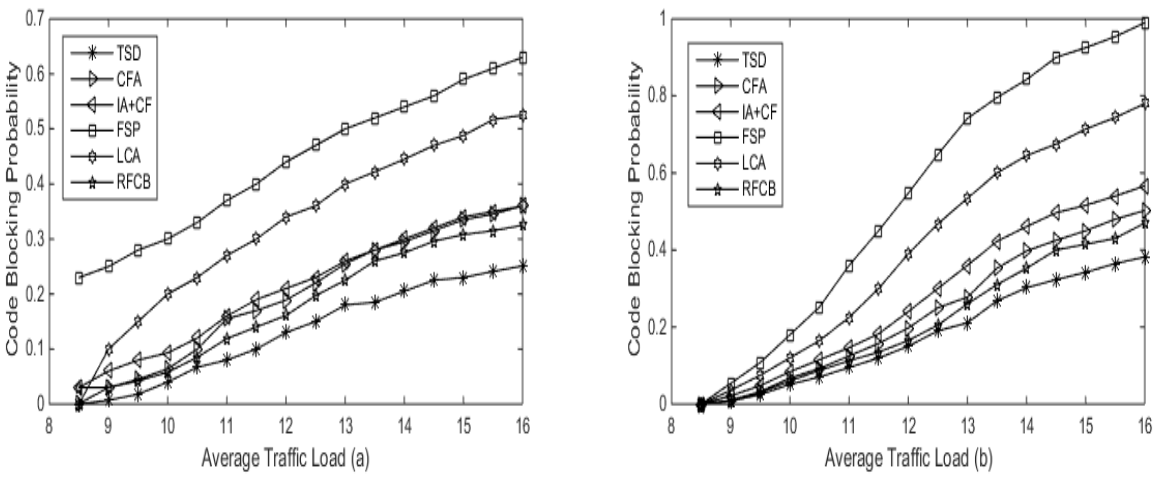

Fig. 3. Code blocking probability comparison of (a) Quantized arrival rates and (b) Quantized rates and Non-quantized rates both [R-16R].

$$P_B = P_{B_R} + P_{B_{2R}} + P_{B_{4R}} \ldots\ldots P_{B_{16R}} \quad (6)$$

VII. CONCLUSION

The simulations and result shows that the TSD scheme is best suited for both quantized and non-quantized calls. It takes the benefit of LTE interface. The results can also be simulated for different traffic distribution depending upon busy hour, rural or urban traffic scenario. There are the problems of handover and complexity related to it. The interference between voice and data calls in present mobile network is inevitable. The voice calls coming at the time of on-going data calls may lead to throughput degradation may lose 4G connectivity, and application aborted while incoming voice calls may be due to data access. The present 4G networks suffer from handover issues arise not due to mobility but inter handover i.e from 3G to 4G and 4G to 3G. The work in future can be done to address these problems.

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