OVSF based fair and multiplexed priority calls assignment CDMA Networks

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Abstract: Code division multiple access (CDMA) networks uses orthogonal variable spreading factor (OVSF) codes to support different transmission rates for different users which suffers from code blocking limitation. Multiplexing in digitized world is used for data selection. In this paper, calls are multiplexed to share the capacity of the network fairly and with priority using OVSF codes for assignment. A multiplexer is used to provide each call their share of capacity. The different layers shares their capacity with other layer in order to minimize code blocking. Simulation results prove dominance and fairness of our design over other novel schemes.

Keywords: OVSF codes, code blocking, code searches, single code assignment, single code assignment, wastage capacity.

1. Introduction

The third generation wireless standards UMTs/IMT-2000 [1,2,3] use wide-band CDMA (W-CDMA) to address the higher and variable rate requirements of multimedia application. Three different schemes of DS-CDMA transmission were proposed: single orthogonal variable-spreading-factor code (OVSF CDMA) [4], multicode CDMA (MC-CDMA), and the hybrid method [4]. MC-CDMA requires multiple transceiver units, but OVSF-CDMA requires only a single transceiver unit. Therefore, in terms of hardware complexity, OVSF-CDMA is preferred over MC-CDMA. However, the code-blocking problem in OVSF-CDMA results in a higher call-blocking rate for higher data rate users. Thus, the OVSF code management becomes an important design consideration in wireless networks, and has received a lot of attention [5]. The bandwidth requirements of current wideband signals are high. One way to achieve high bandwidth is to use specialize modulation as given in [6]. This is particularly useful for multipath propagation in urban mobile radio communication in next generation systems. A novel configuration with match filters is given for efficient and reliable synchronization under multipath environment. In 3G and beyond CDMA systems, the high bandwidth requirement can be tackled using multicarrier communication [7] and OVSF [1] codes are used to handle variable rate which utilizes limited bandwidth efficiently. In general, a higher data rate service can be achieved by assigning a code with smaller spreading factor (SF). The OVSF codes are generated from a class of codes called Hadamard matrices. The Hadamard matrices has many applications along with OVSF based CDMA systems. One such application is given in [8], where construction of optical ZCZ codes is described with the use of Sylvester-type Hadamard matrix. The construction of two categories of codes namely ROM-type and non ROM-type codes is detailed. Basically, the optical ZCZ code is a set of pairs of binary and bi-phase sequences with zero correlation zone. Any two OVSF codes are orthogonal if and only if one of them is not a parent code of the other. Therefore, when an OVSF code is assigned, it blocks all of its ancestor and descendant codes from assignment because they are not orthogonal. This results in a major drawback of OVSF codes, called *blocking property* [8]: a new call cannot be supported because there is no available free code with the requested spreading factor (SF), even if the network has excess capacity to support it.The OVSF codes are assigned to handle calls to preserve the orthogonality between different calls using physical channels. The SF of a code decides the rate of the call that can be supported by an OVSF code. Lower is the position of a code in tree, higher is SF and vice versa. Once a code is assigned, all its ancestors and descendants are blocked. It limits the number of OVSF codes. So, OVSF codes should be allocated efficiently. Further, the fair allocation of codes become difficult as the scattered lower rate codes block high rate codes [9,10]. In OVSF based networks, the treatment of voice calls and data calls is different. The voice calls require single code for full call duration at fixed rate, while the data calls have the flexibility of variable data rate. The treatment of real time and on real time calls in most of the systems including GSM, CDMA etc. is different. In [11], the voice calls and real time calls are handled with either complete partitioning (CP) or partial partitioning (PP) methods. The voice traffic, the traffic model used is Erlang Law for both cases CP and PP. On the other hand for data traffic, the models depend upon the scheme used for resource allocation. For CP, the model used is either Erlang law or modified Engset law. For PP, the two models used are bidirectional Markov chain model and modified Engset law. The rate handled by a code in layer $l, 1 \leq l \leq L$ of OVSF code tree is $2^{l-1}R$, where R is 7.5*kbps*. if a non quantized call is assigned to these quantized codes it will lead to internal fragmentation [5]. The external fragmentation occurs due to scattering of busy codes in the code tree which reduces the amount of high rate codes available. The internal and external fragmentation produce code blocking, a situation where the new call will be rejected although the system has enough capacity to handle it. As the OVSF code is a scarce resource, some strategies [12-21] have been proposed to reduce the effects of code blocking. Those strategies can be categorized for the two major groups. There are the code assignment strategies (or code placement strategies) and the code reassignment strategies (or code replacement strategies). The major function of the code assignment strategies is to find an appropriate code to a call, and the major function of the code assignment strategies is to relocate the codes in the OVSF code trees when code blocking occurs. Although, the code reassignment strategies proposed in [12] can completely solve the problem of code blocking, it will incur code reassignment costs. The strategies proposed in [12-21]are focused on the code assignment strategy under a single-code-per-request environment. Some of those researches had been extended under a multiple-code-per request environment. As a consequence of those researches, the OVSF code management strategies and the amount of transceivers involved in UEs play an important role in achieving the resource utilization of the UMTS system. There still have some problems that need to be studied, such as the amount of codes to be assigned to a request, the sequence of the code assignment, the relationship between the allocated codes, and resources waste ratio. These schemes are divided into two categories namely single code and multi code schemes Single-code-per-request assignment problem has been taken great interest and many assignment strategies have been proposed, including the Left-most strategy [13-23], Compact Index strategy [14,15], Regional division assignment strategy [16], Crowded-First strategy (CF) [17,18], weight crowded-first strategy [19], and Crowded-Group First strategy (CGF) [20,21]. The goal of these strategies is to reduce code blocking probability and to improve code utilization. The computation complexity of these strategies is improved from O(NlogN) [14,15] to O(log2(N)) [20,21]. However, all these strategies proposed in [12,21]mainly focused on the problem of selecting the best code, among several candidate codes, and have not considered the issue of fair access. It means that when the traffic load increases, a request with a higher bit rate will have difficulty obtaining an appropriate code in these strategies. In order to improve the access fairness among users with different rate requests, OVSF code tree partitioning schemes have been proposed in the literature [13,24–28]. The main idea of these

strategies is to resolve some codes to serve one specific data rate service. According to the time the policy is employed, the single-code per-request reassignment strategies can be grouped into proactive policies and reactive. The proactive policies perform the code reassignment procedure when a call departs, or when a predefined or a periodic timer expires. The main drawback of the proactive policies is that it may perform a large number of unnecessary code reassignments. The reactive policies only perform the code reassignment procedure when a code blocking occurs. Most of the reactive policies were adopted from the dynamic code reassignment algorithm (DCA) proposed in [17]. It reduces code blocking compared to single code assignment schemes but the cost and complexity is more. However, the computational overhead of DCA is very high, and the cost comparison table is hard to improve for general cases and needs to be computed off-line. Thus, we propose a new code reassignment strategy for general case [21] referred to as the crowded-branch first strategy. The main objective of the crowded-branch first strategy is to reduce the number of reassigned calls with low computational overhead. Recursive fewer codes (RFCB) [28] blocked selects a code for assignment which blocks minimum number of higher layer codes, excluding those which are already blocked by previous calls. The adaptive code assignment (ADA) [29] makes the code tree division adaptive to arrival distribution. Some multiple-code-per-request assignment strategies have been proposed in the past few years [5,22,23,28,30,31,32,34]. The proposed which can find a available code set, called a code word, and assign these codes to the request. In the first, those strategies will find several code words for a request. The code word with the least codes used should be the preferable choice. Although those strategies are efficient and consider the allocation of multiple codes, what code and what branch should be chosen remains unclear. Moreover, the question of which code word is the best number of OVSF codes to be used is not even considered in those strategies.The multi code mechanism requires the complex transceiver, which may increase the complexity of user equipment (UE). To reduce the complexity of a UE, single codes assignments are preferred. A time based scheme proposed in [33] selects a vacant code on the basis of maximum remaining time. A quality based assignment method in [35] proposes three assignment and reassignment strategies including fixed service data rates and considering a code limited system capacity. The paper in [36] carried out code assignment on the basis of available and guaranteed rate. OVSF codes support call rates that are powers of two *i.e quantized rate* and do not support many intermediate call rates. This reduces some flexibility in the allocation of code resources, and if *non-quantized rates* are assigned OVSF codes it may result in increased internal fragmentation. A fast OVSF code assignment design is given in [37] which aims to reduce number of codes searched with optimal/suboptimal code blocking. The code assignment scheme uses those vacant codes whose parents are already blocked. This leads to occurrence of more vacant codes in groups, which ultimately leads to less code blocking for higher rate calls. The integration of calls is done in [38**]** for allocation of OVSF codes when a quantized or non-quantized call arrives, and further, the voice calls and data calls are treated differently as former are delay sensitive and later can be stored in buffer.The single code assignment schemes are simpler, cost effective

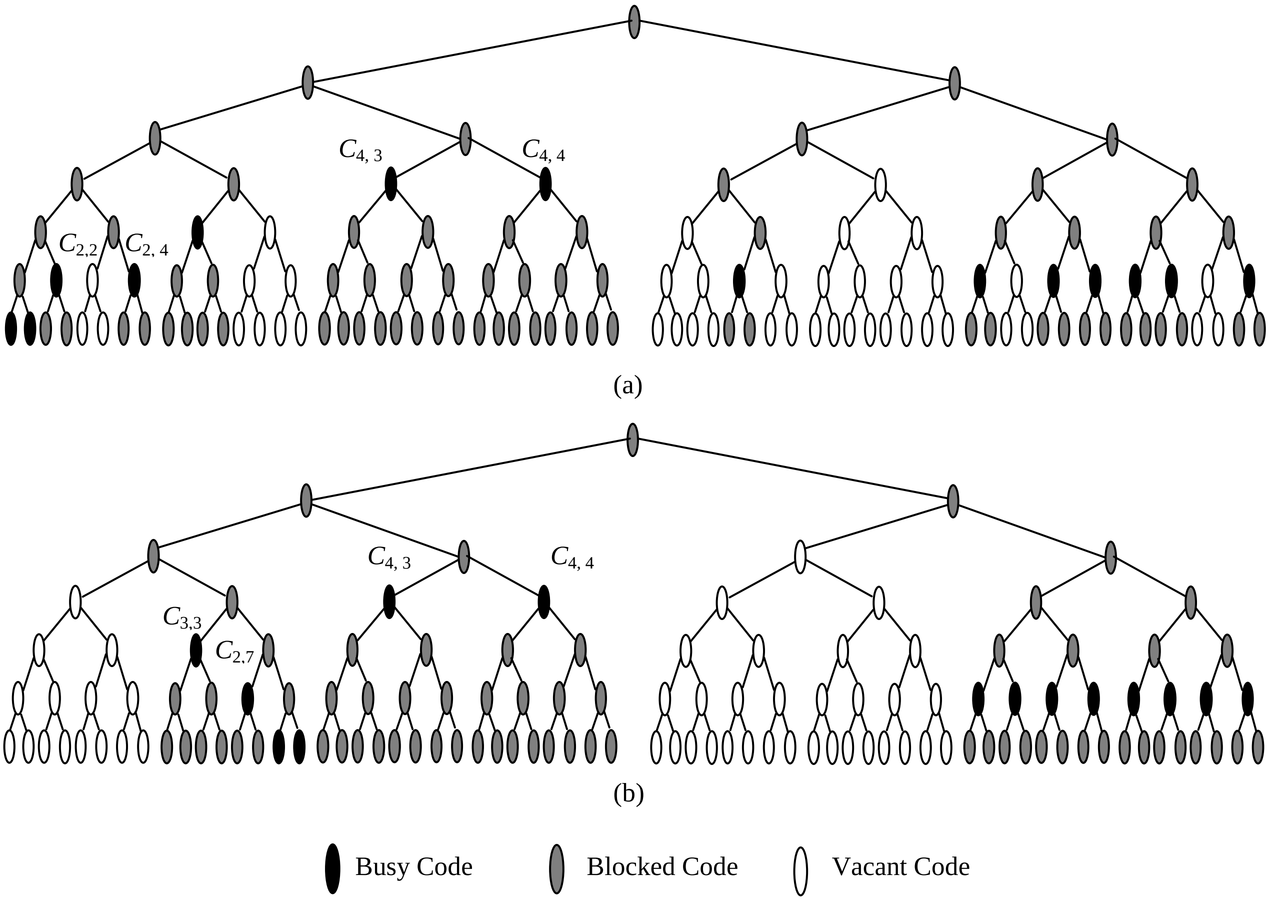


Fig. 1 A seven layer OVSF code tree for illustration of fair capacity sharing design

and require single rake combiner at the BS/UE. The multi code assignment schemes use multiple codes in the OVSF code tree and hence multiple rake combiners to handle single call.

2. OVSF Fundamentals

2.1 OVSF Code Tree Structure

The OVSF codes can be represented by a tree. Fig. 1 shows an L (L=8) layer code tree [1]. The OVSF code tree is a binary tree with L layer, where each node represents a channelization code C_{l,n_l}, l=1,2,…,L, and $n_l = 1..2^{L-l}$, l denotes layer number of code and n denotes its position in layer l. The codes in lowest layer are leaf codes and the code in highest layer is the root code. The data rate that a code can be support is called its capacity. Let the capacity of the leaf codes (in layer 1) be R. The total capacity of all the codes in each layer is $2^{L-1}R$, irrespective of the layer number. We also define the maximum spreading factor $N_{\max} = 128$, the total numbers of codes in layer. All lower layer codes spanned from a higher layer code are defined as descendent codes. All higher layer codes linking a particular code to the root code are called its mother codes [1]. Note that all codes in each layer are mutually orthogonal. Furthermore, any two codes of different layers are also orthogonal expect for the case when one of the two codes is the mother code of the other [1].

2.2 Problem Definition

When a new call arrives requesting for a code of rate $2^{l-1}R$, vacant code of rate $2^{l-1}R$ is required. If used capacity of the system added with call arrived rate is less than or equal to total capacity of the code tree but no vacant code of rate $2^{l-1}R$. Then code tree has fragmented capacity to support the call even though call is blocked. This is code blocking.

The multiplexing design in this paper does assignment on fair basis and priority. Multiplexing is done in two ways in this paper.

1.*Fair Multiplexing*. The ideal multiplexer should allocate an equal share of the available capacity to each layer call of available code.

2. *Priority Multiplexing*. The ideal multiplexer should allocate share of the total available capacity of a code to each call depending upon its priority and equally among non priority calls.

The rest of the paper is organised as follows. Section 3 explains proposed multiplexing scheme. The simulation results are given in section 4. Finally, the paper is concluded in section 5.

3. Multiplexing Design

For an OVSF based CDMA tree of L layer. We define a code C_{l,n_l} ,where l denotes the layer number and $n_l, 1 \le n_l \le 2^{L-l}$ denotes the code number in layer l, $1 \le l \le L$ and rate of a code in layer l is $2^{l-1}R$. The design proposed in this paper utilizes the unused buffers available at base stations (BSs) for storing amount of capacity utilized by a particular layer (rate) calls. The amount of capacity portion of each layer (rate) is stored in a matrix Z of the form

$$Z = \begin{bmatrix} CP_L,..,CP_1 \\ UP_L,...,UP_1 \\ DP_L,..,DP_1 \\ BP_L,..,BP_{1,} \end{bmatrix}$$

(1)

where,

CP_l specifies the capacity portion or unused capacity of a particular layer l.

UP_l specifies the capacity of the code tree used by calls of layer l.

DP_l specifies the donated capacity to other layer calls by layer l. DP_l is sum of all the elements of the matrix

$[d_l^L \; d_l^{L-1}..d_l^1]$ and $DP_l = \sum_{i=1}^{L} d_l^i$, where d_l^i denotes the amount of capacity donated by l^{th} layer to i^{th} layer.

BP_l specifies the borrowed capacity by codes of layer l from other layers. BP_l is sum of all the elements of the matrix

$[b_l^L b_l^{L-1}.b_l^1]$ and $BP_l = \sum_{i=1}^{L} b_l^i$, where b_l^i denotes the amount of capacity borrowed by l^{th} layer from i^{th} layer.

The proposed design in paper uses these matrices to handle calls at base station, code tree is not searched when $\sum_{p=1}^{L} UP_p = 2^{L-1}$ or $128 - \sum_{p=1}^{L} UP_p < 2^{l-1}$,

where $1 \le l \le L$ and call will be blocked due to capacity blocking. This reduces the usage of resources for a vacant code search when total capacity of tree is not enough to support new call. The design multiplexes calls to a code with and without capacity priority. The code capacity is shared equally among non priority calls after giving share of priority calls to them. There is an upper bound on number of calls which can be multiplexed to a code. If code and calls are of same rate then four calls can be assigned to a code. For higher rate calls assigned to a code of lower layer (rate) $(2^{l-1}R/4)-z,\ 1\le z\le 3$, where $z\ge l$, which is assigned a code of layer *l*.

3.1 Fair capacity sharing

For fair capacity sharing design, the code tree is divided equally among calls of different rates $2^{l-1}R, 1\le l\le L$ and $L=8$ for WCDMA networks with capacity portion of each call $=2^{L-1}/t$, where t denotes the number of different rate calls originating in network. If a new call voice or data of rate $2^{l-1}R, 1\le l\le L$ arrives, the algorithm will first check the capacity matrix stored in buffer of BS. The algorithm checks for a vacant code as follows.

1. Check capacity portion of l^{th} layer in matrix *i.e* CP_l.
2. *If* $CP_l>0$,
   Search a vacant code in layer *l* using LCA and assign new call to it. Update $CP_l=CP_l-2^{l-1}$.
3. *Else if*
   Check capacity donated to other layer calls, if $DP_l\ne 0$. Find $\max(BP_i), 1\le i\le L$ for fair capacity sharing and search a vacant code in layer *l* using LCA. Assign new call to the vacant code, update $DP_l=DP_l-2^{l-1}$ and find $CP_{l'}\ge 2^{l-1}, i\le l'\le L$.
   3.1 *If* $CP_{l'}\ne 0, i\le l'\le L$ exists
   Update $DP_{l'}=DP_{l'}+2^{l-1}$.
   3.2 *Else if* $CP_{l'}=0$ *and call is a data call*
   Reduce the capacity of call of layer *i* and data transfer of layer *i* is done at lower rate and longer time.
   3.3 *Else*
   Block call of i^{th} layer to maintain fair capacity sharing of code tree among calls of all layers.
   3.4 *End*
4. *Else if*
   Search a vacant code in layer *l* using LCA and use capacity portion of layer $l', l+1\le l'\le L$ for which $CP_{l'}\ne 0$ and $l'-l$ is minimum. The matrices are updated as follows.
   $CP_{l'}=CP_{l'}-2^{l-1}, l\le l'\le L$
   $DP_{l'}=DP_{l'}+2^{l-1}$ and $BP_l=BP_l+2^{l-1}$.
5. *Else if for a data call*
   Find codes assign to data calls of rate $2^{l-1}R, 1\le l\le L$. Multiplex new call with call(s) assigned to the code handling minimum number of calls and share total capacity of this code equally among all calls.
6. *Else*
   Block call.
7. *End*

The algorithm also distribute shared capacity fairly to all layers. For illustration consider the status of seven layer code tree in Figure. 1 and matrix. Calls arrive of rate *R* to 8*R* only

1. If two calls of rate 8*R* arrives for the code tree of Figure. 1 (a) as $CP_4=0$, it will borrow capacity from 3rd layer, only one will be handled using single code and other will be blocked due to scattered free capacity. Though, other layers have enough capacity to share and it will be blocked. It can handled using multi codes explained in section 3.3.
2. If three calls of rate 8*R* arrives for the code tree of Figure. 1 (a) as $CP_4=0$, it will borrow capacity from 3rd and 1st layer. If a call of rate 4*R*, now to give fair capacity sharing to all layers, one of the 8*R* call will be blocked or its rate will be reduced, if any of them is data call.

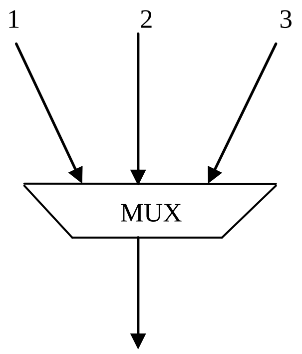
$$\text{Initial status, } Z_7=\begin{bmatrix}0,12,0,12\\16,4,18,2\\0,0,0,2\\0,0,2,0\end{bmatrix}$$

$$1^{st}\ 8R \quad \Rightarrow Z_7=\begin{bmatrix}0,4,0,12\\24,4,18,2\\0,8,0,2\\8,0,2,0\end{bmatrix}$$

$$2^{nd}\ 8R \quad \Rightarrow Z_7=\begin{bmatrix}0,4,0,4\\32,4,18,2\\0,8,0,10\\16,0,2,0\end{bmatrix}$$

$$3^{rd}\ 8R \quad \Rightarrow Z_7=\begin{bmatrix}0,0,0,0\\40,4,18,2\\0,12,0,14\\24,0,2,0\end{bmatrix}$$

$$4R \quad \Rightarrow Z_7=\begin{bmatrix}0,0,0,0\\40,4,18,2\\0,12,0,14\\24,0,2,0\end{bmatrix}$$



Calls	Priority
1	25%
2	25%
3	50%

Fig.2 Multiplexing of three calls with priority

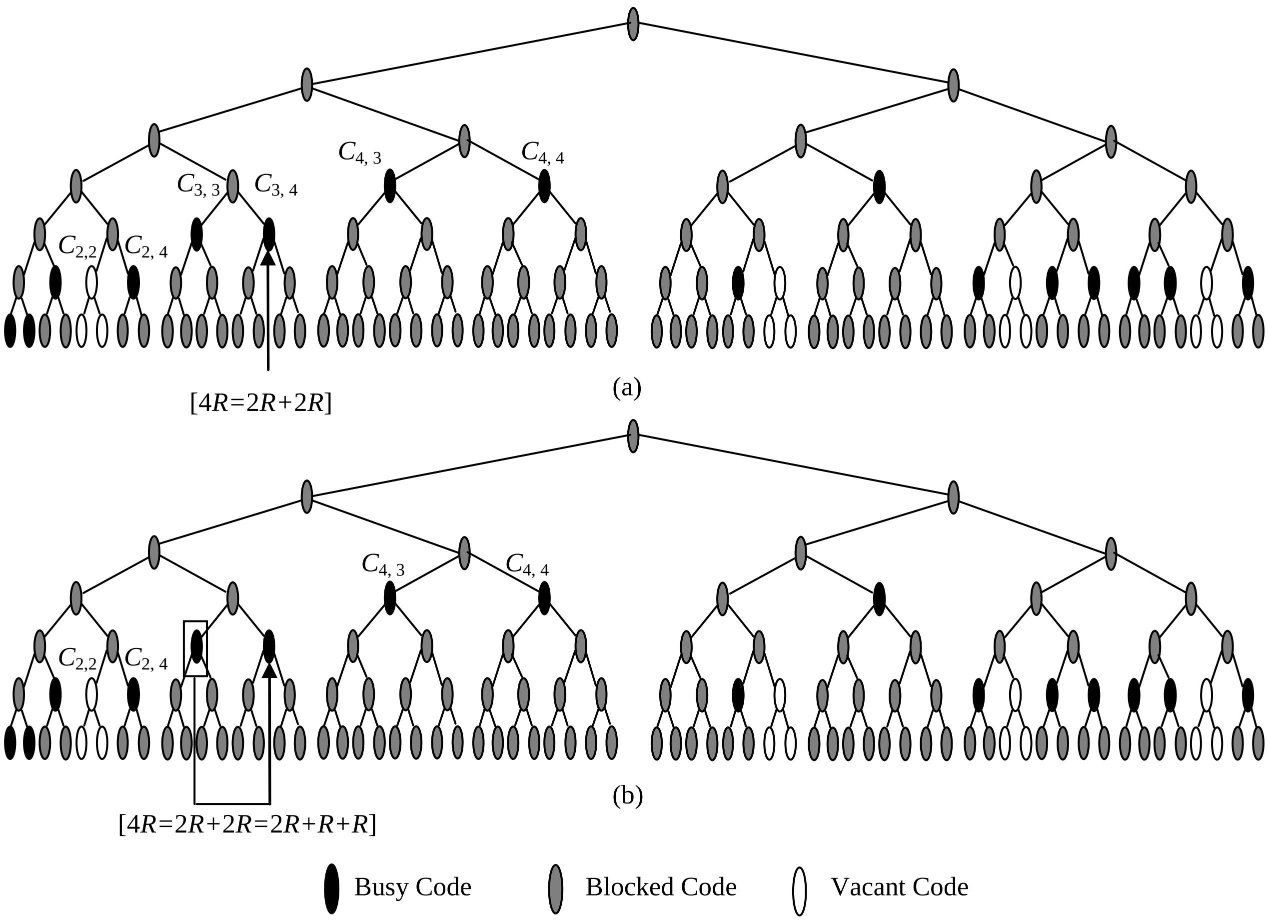


Fig. 3 A seven layer OVSF code tree for illustration of priority and non priority sharing

3.2 Priority and non priority calls capacity sharing

For a network handling both priority and non priority calls. The non priority calls share the capacity left by priority calls equally. However, the priority calls takes their share immediately as soon as there is some data to be sent, even if other calls happen to be in burst period at that time. If some calls do not need to send data, then their reserved capacity is redistributed to other calls. For example, consider three calls with respective priority given in Figure.2 arrives. When 1st call arrives, it initially takes all the available capacity of vacant code. When 2nd call arrives, it shares the capacity with 1st call, which is still transmitting data. As both calls have same priority (25%), the output capacity is shared equally between them. Now, if a 3rd call of priority (50%) arrives, all calls compete for the capacity and the multiplexer allocates half of the capacity to 3rd and remaining half capacity is equally shared by 1st and 2nd call. At some point 2nd call ends. Then, its capacity is shared by 1st and 3rd calls as 6.25% and 18.75% respectively.

For a new call of rate $2^{l-1}R, 1 \le l \le L$, the algorithm checks for a vacant code as follows. Search a vacant code in layer l using CFA for assignment, if $\sum_{p=1}^{L} UP_p < 2^{L-1}$ or $128 - \sum_{p=1}^{L} UP_p \ge 2^{l-1}$.

1. *If call is a priority voice call*
   A vacant code exists, assign new call to it.
2. *Else if*
   Find all codes in layer l handling data call(s). Arrange them in increasing number of data calls they are handling. Assign data call of 1st code from left to the 2nd code and share the total capacity of 2nd code between two calls according to their priority as explained above and code vacate by 1st call is assigned to new voice call.
   End
3. *Else if call is a priority data call*
   Find all codes in layer l handling data call(s). Arrange them in increasing number of data calls they are handling. Assign new call to the code handling minimum number of data calls. It divides total capacity of the code between new call and call(s) that code is handling according to their priority.
4. *Else if*
   Search codes handling data calls in higher layers $l+1 \le l' \le L$, assign $2^{l-1}R$ rate to new call of that code which is handling minimum number of data calls and remaining $2^{l'-1}R - 2^{l-1}R$ will be used by data call(s) already assigned to that code. This multiplexing is priority multiplexing in which a priority call takes required rate and remaining capacity is shared by non priority calls.
5. *Else call is a non priority call*
   If non priority call is a voice call
   Block call.
   Else
   Search data calls in layers $l \le l' \le L$, to a code handling minimum number of data calls.
   End
6. *End*

For example, consider the status of code tree in Figure. 3(a) when a priority call of rate $4R$ arrives, no vacant code of rate is available. The algorithm will search all data call and assign the call(s) of code handling minimum number to the code (next in number of calls). Suppose $C_{3,3}$ and $C_{3,4}$ are handling one and two data call respectively. $C_{3,3}$ is handling a priority data call of priority 50%. The data call of code $C_{3,3}$ is transferred to $C_{3,4}$, total capacity of $C_{3,4}$ is divided equally after giving priority call its share of the capacity *i.e* $4R$ is divided as $2R+R+R$.

3.3 Multiplexing of calls using Multi codes

For a new call of rate $2^{l-1}R, 1 \le l \le L$, the algorithm checks for a vacant code using single codes as describe in Section 3.1 and 3.2. If a call cannot be handled using single code assignment even though system has enough capacity to handle. Call will be handled with the use of multi codes. The procedure of selecting a code will be same as of a single code.

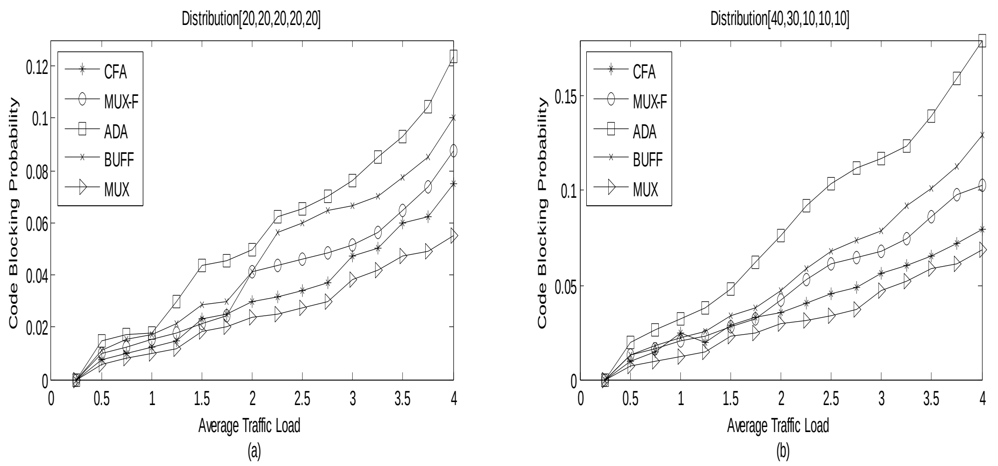


Fig. 4 Comparison of Code Blocking Probability in single code schemes for distribution: (a) [20,20,20,20,20], and (b) [40,30,10,10,10].

1. For a call of rate $2^{l-1}R$, use capacity portion of matrix Z to find total available capacity $\sum_{p=1}^{L} UP_p$.
2. If $CP_l = 0$ and $DP_l \neq 0$, also $\sum_{p=1}^{L} CP_p \geq 2^{l-1}R$, call will be handled using multi codes.
3. If no vacant code of rate available, it implies that no vacant codes of rate $2^{l'-1}R,\ l' > l$ exist in code tree. The total vacant capacity is scattered along the code tree in form of vacant codes of rate $2^{l''-1}R,\ 1 \leq l'' \leq l-1$.
4. Arrange CP's in descending order of available capacity.
5. Find CP's whose capacity can handle the call *i.e*
   $S = 0$, $j = l-1$, $r = 0$;
   While $(S \geq 2^{l-1}R \,||\, j == 0)$
   $S = S + CP_j$;
   $j = j - 1$;
   $r = r + 1$;
6. *End*

where *r* is the number of rakes required to handle the call. It will use minimum number of rakes for the call. For example, consider the status of code tree in Figure. 1(a). If two calls of rate 8*R* arrives for the code tree of Figure. 1 (a) as $CP_4 = 0$, it will borrow capacity from 3rd layer, only one will be handled using single code. Using multi codes 2nd call of rate 8*R* can be handled using codes $C_{3,4}$ and $C_{3,5}$. It was blocked in single code fair capacity sharing.

4. Simulation parameters and results

4.1 Traffic Conditions

The codes blocking probability performance of the integration single and multi code schemes are compared with existing schemes in literature. For simulation, following classes of users are considered with rates *R*, 2*R*, 4*R*, 8*R* and 16*R* respectively.

- The arrival rate λ is assumed to be Poisson distributed with mean value varying from 0-4 calls per unit of time.
- Call duration is exponentially distributed with mean value of 3 units of time.
- The maximum capacity of the tree is 128*R* (*R* is 7.5*kbps*). Simulation is done for 5000 users and result is average of ten simulations.

4.2 Results

Define $[p_1,p_2,..p_5]$ as probability distribution matrix where p_i, $i \in [1,5]$, is the capacity portion used by the i^{th} class users. The total codes (servers) in the system for five set of classes are the given by set $G = \{G_1,G_2,..,G_5\} = \{R,2R....,16R\}$. Two distribution scenarios are analyzed for single code:

- [20,20,20,20,20]: Uniform distribution
- [40,30,10,10,10]: High Rate Dominating

and two distribution scenarios are considered for multi code assignments:

- [20,20,20,20,20]: Uniform distribution
- [10,10,10,30,40]: Low Rate Dominating

The calls in a network are blocked due to insufficient capacity in network to handle new call and scattering

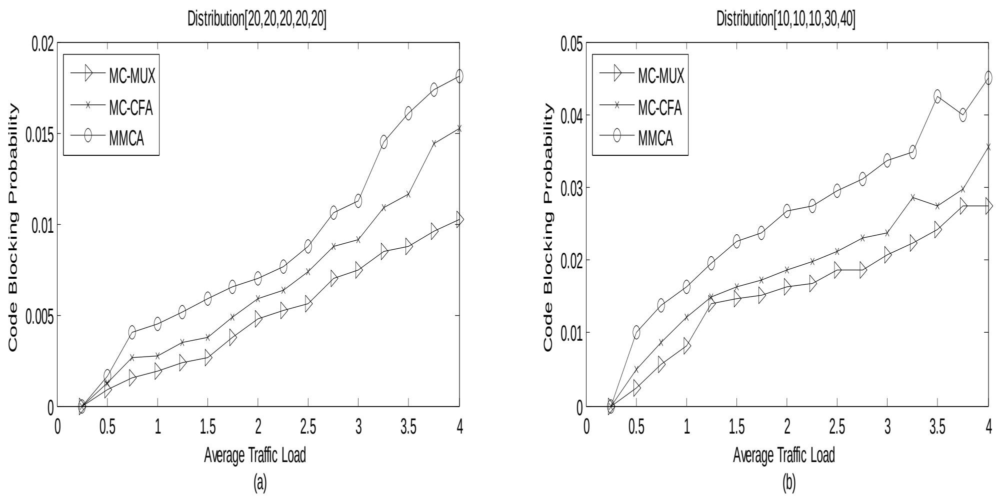


Fig. 5 Comparison of Code Blocking Probability in multi code schemes for distribution: (a) [20,20,20,20,20], and (b) [10,10,10,30,40].

of free capacity in code tree which results in the code blocking probability. Consequently, the blocking probability is composed of the capacity blocking probability and the code blocking probability. The code blocking for a 5 class system is given by

$$P_B = \sum_{i=1}^{5} \frac{\lambda_k P_{B_i}}{\lambda}$$
(2)

where P_{B_i} is the code blocking of i^{th} class and is given by

$$P_B = \frac{\rho_k^{G_k} / G_k!}{\sum_{n=1}^{G_k} \rho_k^n / n!}$$
(3)

where $\rho_k = \lambda_k / \mu_k$ is the traffic load for k^{th} class.

The design proposed in this paper namely Fair Multiplexing (MUX-F) and pure multiplexing (MUX) are compared with other schemes in literature.

Single Code Assignment the design is compared with adaptive code assignment (ADA) [29] , buffering in [32] and crowded first assignment in [17] as shown in Figure 4. Fair multiplexing provides higher code blocking than CFA and MUX as it blocks more calls due to fairness. MUX utilizes maximum codes in a rotation kind of manner and also reduces rates of data calls to reduce code blocking. Code blocking also depends upon the traffic distribution. High rate dominating scenario provides higher code blocking.

Multi Code Assignment the design is compared with Multicode Multirate Compact Assignment (MMCA) [33] and Multi Code–CFA (MC-CFA). Use of multi codes reduces code blocking of all the schemes considerably at the cost of increased complexity and required rakes to handle new call. The MUX design provides minimum code blocking.

5. Conclusion

Based on the concept of a matrix *Z*, a new assignment scheme, is proposed which multiplexes calls to a code fairly and with priority. They can also support different traffic types like real time calls and data packets with different priority and capacity requirements. The proposed multiplexing scheme reduces the fragmentation of available capacity of code tree. This is demonstrated by both analysis and simulation. In addition, proposed scheme is also shown to be a fair code assignment scheme with priority for different service classes.

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