OVSF CODE ASSIGNMENT SCHEMES IN WCDMA ACCORDING TO CALL ARRIVAL DISTRIBUTION

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MAY-2007

Submitted in partial fulfillment of the Degree of Bachelor of Technology

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CERTIFICATE

This is to certify that the work entitled, "Code Assignment Scheme According to Call Distribution" Submitted by Sunny Gakhar (031018), Prakhar Gupta (031039), in partial fulfillment for the award of degree of Bachelor of Technology in May 2007 of Jaypee University of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

[Mr. Davinder Singh Saini]

ACKNOWLEDGEMENT

We wish to thank our project guide Mr. D S Saini for his generous support. Many people have contributed to this project in a variety of ways over the past few months. We express our appreciation to the organization and the individuals who helped us at each and every step. We also acknowledge the many helpful comments received from our teachers of the Electronics & Communication Department and our friends. We are indebted to all those who provided reviews and suggestions for improving the materials and topics covered in our project.

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LIST OF ABBREVIATIONS

3G- Third generation

UMTS- Universal mobile telephone system

WCDMA- Wideband Code Division Multiple Access

BS-Base Station

BTS- Base Transceiver Stations

DCA- Dynamic Code Assignment

FCA- Fixed Code Assignment

HCA- Hybrid Code Assignment

MMCA- Multicode Multirate Compact Assignment

UE- User Equipments

OVSF- Orthogonal Variable Spreading Factor

SC- Scrambling Codes

CC- Channelization codes

PN- Pseudo noise

UL- Uplink

DL- Downlink

IMT- International Mobile Telecommunication

WAP- Wireless Application protocol

NMT- Nordic Mobile Telephone

AMPS- Advanced Mobile Phone System

CT- Cordless Telephone

CDMA- Code Division Multiple Access

GPRS- General Packet Radio Service

GSM- Global System for Mobile Communication

DECT- Digital European Cordless Telephone

DCS- Digital Cellular System

D-AMPS- Digital AMPS

PDC- Personal Digital Cellular

ABSTRACT

3G systems utilize the WCDMA system to provide a wide range of services including telephony, messaging, internet and broadband data in addition to global mobility The WCDMA system uses OVSF codes to provide variable data rates to flexibly support applications with different bandwidth requirements. But these codes require careful assignment to the various users of multiple data rates. Several code assignment schemes have been proposed earlier which are based on code reassignments thus having increased computatational complexity. The objective of this project is to propose OVSF Code assignment schemes without doing code reassignments so as to support as many users as possible and utilizing the code tree in an efficient way. This was achieved by proposing an idea of assigning priorities to different call arrival rates according to their bandwidth requirements (real time or non - real time)

CHAPTER 1

INTRODUCTION

Third generation wireless system are carrying multimedia applications. Such systems are required to support variable transmission rate for different users. Third generation wireless standards UMTS/IMT-2000 use wide band CDMA to address the higher and variable rate requirements of multimedia applications.

Wireless systems are called "wide-band" if system bandwidth is comparable to or larger than bandwidth over which channel transfer function can be considered constant (typically, on order of 100 kHz).

The use of OVSF codes in WCDMA systems has offered opportunities to provide variable data rate to flexible support applications with different bandwidth requirements. Two important issues required to be considered in such scenario are code assignment and re-assignment schemes.

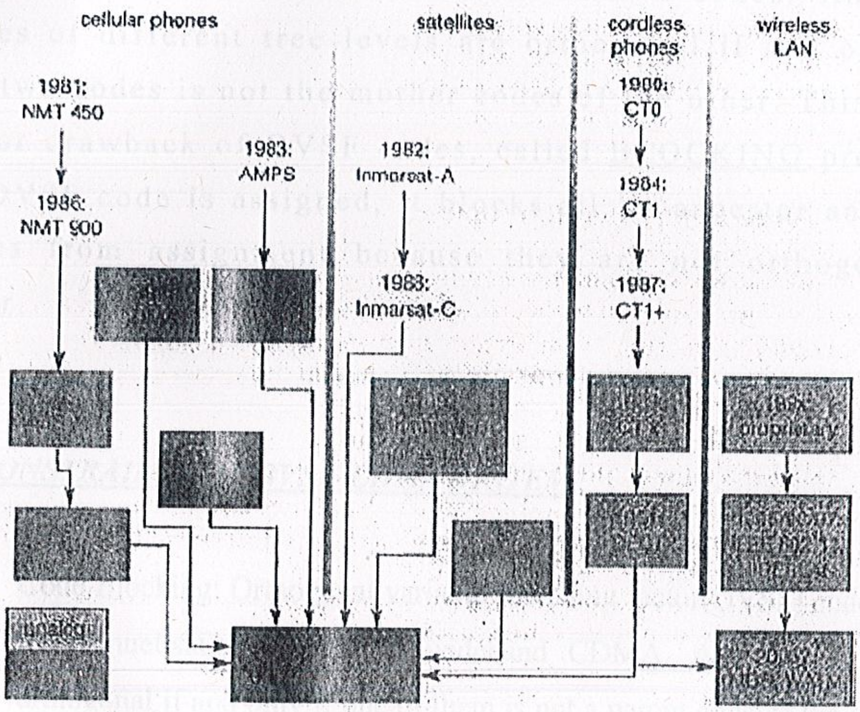
In an OVSF-CDMA system, each base station manages a code tree for downlink transmission. The resource units in an OVSF code tree are codes. So the base stations are responsible of utilizing their code trees efficiently to increase the performance of the system.

From a user's perspective, traffic can be classified as either real time calls or best-effort data packets. Real-time calls require real time transmission with a fixed bandwidth or at fixed data rate. This traffic class includes audio and video telephonic, online

TV/movie watching and so on. Best-effort data packets are those generated from Internet and audio and video file transfers. Real-time calls have priority over data packets in code assignment.

From system's perspective, users are heterogeneous. First, they have different Quality of Service (QoS) requirements, real-time or best effort transmission, fixed or variable bandwidth assignment, fixed or variable packet size. Second, mobile terminals have different capabilities in supporting multi-code transmission.

1.1 OVERVIEW OF WIRELESS COMMUNICATION SYSTEMS



1.2 ORTHOGONALITY

Two codes are said to be orthogonal when their inner product is zero. The inner product, in the case of codes with elements value +1 and -1, is the sum of all the terms we get by multiplying two codes element by element. The inner product of two vectors a and b is defined as

$$A*B=\sum_{i=1}^{n} Ai*Bi \quad \text{(where i varies from 1 to n)}$$

1.3 Blocking Probability :

Orthogonal variable spread factor (OVSF) codes are employed in the third generation (3G) wideband code division multiple access (W-CDMA) wireless system as channelization codes. Any two OVSF codes of different tree levels are orthogonal if and only if one of the two codes is not the mother codes of the other. This result is the major drawback of OVSF codes, called BLOCKING property: When an OVSF code is assigned, it blocks all its ancestor and descendant codes from assignment because they are not orthogonal to each other.

1.4 CONSTRAINTS OF OVSF-CDMA SYSTEM

- Code Blocking: Orthogonal variable spreading factor(OVSF) codes are employed as channelisation codes in wideband CDMA. 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 its ancestor and descendant codes from assignment because they are not orthogonal to each other. Unfortunately, this code blocking problem of OVSF codes can cause a substantial spectral efficiency loss of up to 25%.

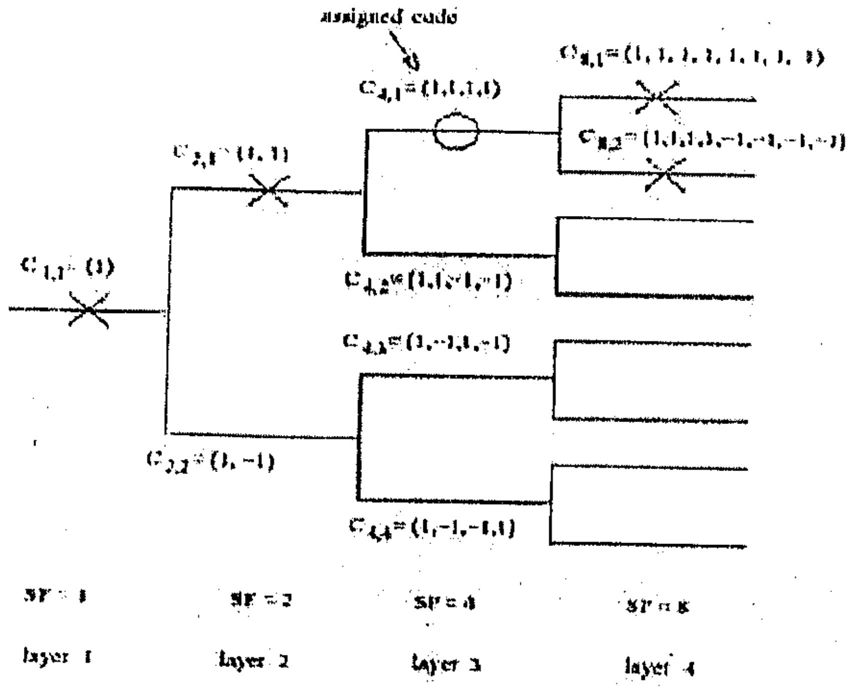


Figure 1: OVSF code blocking.

- Coarsely quantized data rates: The assignment of the basic rate OVSF code is limited to a multiple of 2n , which causes coarsely quantized data rate as well as leading lower data rate efficiency.
- Due to minimum spreading factor requirement, there is limitation on maximum data rate.
- Code blocking in OVSF-CDMA system leads to a higher call blocking rate for higher data rate user.

1.5 BENEFITS OF OVSF-CDMA SYSTEM

- Only a single transceiver unit is required per user.
- In terms of hardware complexity for mobile handsets, OVSF-CDMA is preferred over MC-CDMA for higher data rate transmission.
- More secure transmission because of wideband nature of WCDMA.

1.6 UTILIZATION OF OVSF CODES

Third generation wireless networks such as WCDMA aims to provide multimedia services for mobile users any where at any time. These networks need to transmit not only voice but also images; videos and multimedia data. They are required to support bursty traffic, which is significantly different from voice traffic carried in the existing 2G wireless system. To support a variety of multimedia application the system must support variable transmission rate for different users. OVSF codes are used as channelization codes in third generation wireless system.

1.7 REQUIREMENTS FOR THE THIRD GENERATION AIR INTERFACE

The 2nd generation mobile networks were built mainly to provide voice services to subscribers. However, nowadays subscribers are no longer content with just voice-based services. Value-added services are being offered to subscribers of the Second Generation systems by enhancing these networks with additional network elements and resources. Support for multimedia services, at higher bandwidths, places the first requirement on the air interface of a Third Generation System. Some primary requirements:

- Support of bit rates of upto 2 Mbps.
- Mechanisms to efficiently support 'Bandwidth on demand' and Variable Bit Rate (VBR) services.
- Support for services with different quality requirements, eg. Speech, video, packet data, etc.
- Simultaneous coexistence with 2G systems with support for inter-system handover.
- Higher spectrum efficiency.

1.8 WCDMA

Wideband Code-Division Multiple Access (W-CDMA) is one of the main technologies for the implementation of third generation (3G) cellular systems. The complexity of W-CDMA systems can be viewed from different angles; the complexity of each single algorithm, the complexity of the overall system and the computational complexity of a receiver. W-CDMA link level simulations are over 10 times more compute intensive than current second generation simulations. In W-CDMA interface different users can simultaneously transmit at different data rates and data rates can even vary in times. UMTS networks need to support all current second generation services and numerous new applications and services.

1.8.1 DIFFERENCE BETWEEN WCDMA AND 2G

- Bit rates up to 2Mbps
- Variable bit rate to offer BW on demand
- Multiplexing of services with different quality requirements on a single connection (speech, video, data)
- Quality requirements from 0.1 FER (frame error rate) to 10-6 BER
- Coexistence of 2G and 3G and inter-systems handovers
- Support of asymmetric uplink and downlink traffic

1.8.2 DIFFERENCE BETWEEN WCDMA AND GSM

	WCDMA	GSM
Carrier spacing	5 MHz	200 kHz
Frequency reuse factor	1	1–18
Power control frequency	1500 Hz	2 Hz or lower
Quality control	Radio resource management algorithms	Network planning (frequency planning)
Frequency diversity	5 MHz bandwidth gives multipath diversity with Rake receiver	Frequency hopping
Packet data	Load-based packet scheduling	Time slot based scheduling with GPRS
Downlink transmit diversity	Supported for improving downlink capacity	Not supported by the standard, but can be applied

Main differences between WCDMA and GSM air interfaces

1.9 BASE STATION

Base stations (or BS) are low power multi channel two way radios which are in a fixed location.

They are typically used by low-power single-channel, two-way radios such as mobile phones, portable phones and wireless routers.

1.10 ACCESS SCHEMES

For radio systems there are two resources, frequency and time. Division by frequency, so that each pair of communicators is allocated part of the spectrum for all of the time, result in Frequency Division Multiple Access (FDMA). Division by time, so that each pair of communicators is allocated to all (or at least a large part) of the spectrum for part of the time results in Time Division Multiple Access (TDMA). In Code Division Multiple Access (CDMA), every communicator will be allocated the entire spectrum all of the time. CDMA uses codes to identify connections.

1.11 CODING

CDMA uses unique spreading codes to spread the base band data before transmission. The signal is transmitted in a channel, which is below noise level. The receiver then uses a correlator to dispread the wanted signal, which is passed through a narrow band pass filter. Unwanted signals will not be dispread and will not pass through the filter. Codes take the form of a carefully designed one/zero sequence produced at a much higher rate than that of the base band data. The rate of a spreading code is referred to as chip rate rather than bit rate.

1.12 SCRAMBLING CODES (SC)

Scrambling is an operation where the spread chips are multiplied by a PN (pseudo noise) sequence. It improves the spectral properties of the signal by virtue of the PN. The scrambling code is unique for each sender and separates all senders (UE and base station) a cell.

1.13 SC AND CC IN UPLINK AND DOWNLINK

	Synchronization Codes	Channelization Codes	Scrambling Codes,UL	Scrambling codes,DL
Type	Gold Codes Primary synchronization Codes(PSC) and Secondary Synchronization Codes(SSC)	Orthogonal Variable Spreading Factor(OVSF) Codes/Walsh Codes	Complex-Valued Gold Code Segment(long) or Complex –Valued Codes(short)	Complex-Valued Gold Code Segments PN Codes
Length	256 chips	4-512 chips	38400 chips/256 chips	38400 chips
Duration	66.67 μs	1.04 μs-133.34 μs	10 ms/66.67 μs	10 ms
Number of codes	1 primary code/16 secondary codes	= spreading factor 4…256 UL,4…512 DL	16,777,216	512 primary/15 secondary for each primary code
Spreading	No, does not change bandwidth	Yes, increases bandwidth	No, does not change bandwidth	No, does not change bandwidth
Usage	To enable terminals to locate and synchronize to the cells' main control channels	UL: to separate physical data and control data from same terminal DL: to separate connection to different terminals in a same cell	Separation of terminal	Separation of sectors

Chapter 2.

CHANNELIZATION CODE & ITS ALLOCATION

WCDMA uses channelization codes to increase spectrum efficiency and provides various data rates based on code assignment.

2.1 OVSF Codes

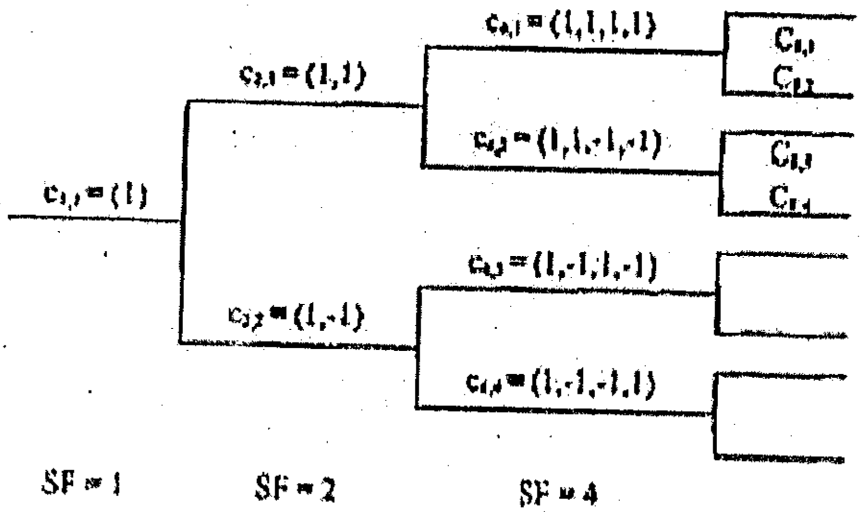


Fig. 1 OVSF Code Tree

According to the request data rate, the system assigns channelization code that employ orthogonal spreading to distinguish data from the physical channel and thus prevent data transmission interference from varying sources.

2.2 CRITERIA FOR CODE CHANNEL ASSIGNMENT

In CDMA system, the channelization codes are used to preserve the orthogonality between user's physical channels. OVSF code is one of the candidates that can be used as a channelization code.

For the OVSF code, a code can be assigned to a UE if and only if no other code on the path from the specific code to the root of the tree or in the sub tree below the specific code tree is assigned. Due to this property, a random assignment of large SF, codes to low data rate channel may preclude a large no of small SF codes. It may inefficiently limit the no of remaining codes that can be used by others users. Code assignment deals with the problem how different codes are allocated to different connections. Upon receiving the call setup request, the BS has to decide which codes should be assigned to the UE. The assignment will be based on the available codes currently hold by the BS and the requirement of UE. A proper code channel assignment scheme is required to find the closely related to prevent the BS from running out of codes and utilize the system effectively.

The objective of the code channel assignment is to support as many users as possible with less complexity. Each UE may have capability to use more than one OVSF code to support different data rate.

Following are the different criteria:

- Utilization: The utilization is defined as the ratio of assigned bandwidth and overall bandwidth. A code allocation scheme that preserves more small SF codes has a higher chance to provide a higher utilization.
- Complexity: In the application, the complexity of the system will be increased if more codes are used.
- Fragmentation: Fragmentation means wastage of codes whether its internal or external. In internal the code which is assigned is capable of handling higher data rate but due to quantized nature or unavailability of code the next higher available code is assigned, giving rise to internal fragmentation. Similarly, external fragmentation occurs when we have large number of low rate requirement causing higher layer code to be block to maintain orthogonality.
- Code Blocking: Code Blocking occurs either due to its ascendants or descendants are assigned and to follow the orthogonality principle code gets blocked.
- Throughput: It's a measure by which we try to rate the systems performance, its like performance matrix for the system. It's an important measure to effectively calculate the efficiency of the system.

CHAPTER 3

Review of Different Code Assignment Schemes

3.1 OVSF Code Assignment Schemes

Assignments are of two types:

i) Multi code mechanism: multi OVSF codes are used to serve a user's call. Requires a complex transceiver, which may increase the complexity of the user equipment.

ii) Single code mechanism: single OVSF code is used to serve a user's call. It is preferred for variable data rate services (to reduce the complexity of the user equipment). It consists of two schemes:

3.1.1 Rearrangeable:

This scheme may reassign some calls (being served with low data rate) other OVSF codes to hold a satisfied OVSF code for the incoming call request. This scheme can reduce the call blocking probability. However it has a drawback: extra computation is required to find the served calls to be reassigned OVSF codes, which increases the computation overhead of the system. Also, when rearrangement operations are exercised, some of the served calls have to be 'reassigned' OVSF codes, which introduce extra message exchange, it may cause a served call to be forced to terminate and thus decrease the Quality of Service of the network. Therefore the most considered design issue in the rearrangeable scheme is to reduce the no. of reassignment of the codes serving calls when accepting a new request.

3.1.2 Non-Rearrangeable:

It is considered simple, and with low system overhead for the OVSF code assignment. Here no re-assignment take place, we compromise on account of denying the service to new calls.

First lets discuss what a code blocking means..

3.2.1 Code blocking in OVSF-CDMA

In OVSF-CDMA, the system may not be able to support a user requesting kR b/s even though leaf codes are vacant. Fig. 3 shows an example where codes (2, 1), (1, 3), and (1, 5) are already assigned.

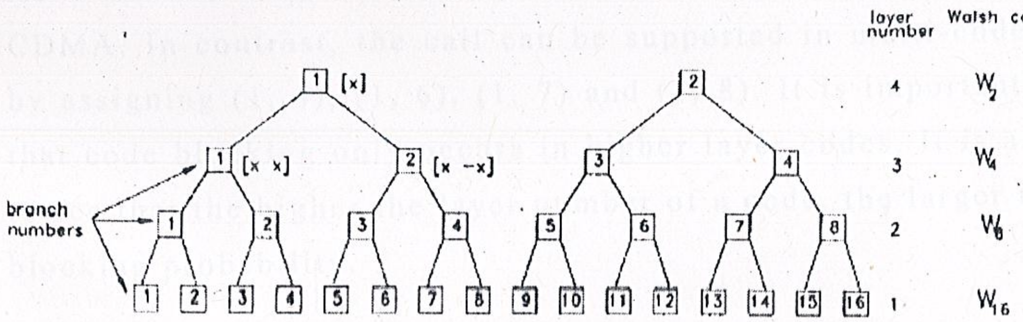


Fig. 2. Tree structure of OVSF codes.

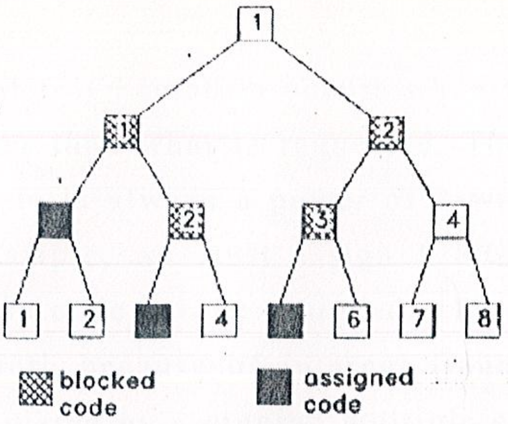


Fig. 3. OVSF code blocking.

Thus, the capacity used is 4R b/s. Assuming an ideal code-limited (single-cell) scenario, the system can support a maximum capacity of $N_{max}R$ b/s, since there are N_{max} leaves and each leaf supports R b/s. Hence, the unused capacity is (8-4)=4R b/s. However, codes (3,1), (3, 2), (2, 2), and (2, 3) are blocked by their respective descendant codes. (Note that code (2, 4) is available for assignment) As a result, a new call requesting 4R b/s is blocked in OVSF-CDMA. In contrast, the call can be supported in multi-code CDMA by assigning (1, 4), (1, 6), (1, 7) and (1, 8). It is important to note that code blocking only occurs in higher layer codes. It is also easy to see that the higher the layer number of a code, the larger the code blocking probability.

Definition: so we define OVSF code blocking as the condition that the new call cannot be supported although the system has excess capacity to support the rate requirements of the call.

3.2.2 *Internal Fragmentation and External Fragmentation*

Internal fragmentation occurs when the allocated data rate to a call is larger than what is requested. The reason is that the allocatable code rate is always a power of 2 with respect to the basic rate R_b. For example, we must assign $128R_b$ to a request for rate 67Rb if only one code can be assigned. There is a waste of 61/67 =91% in bandwidth because of internal fragmentation. Such deficiency can be alleviated by assigning multiple codes to a request. For example, the waste can be reduced to 1/67 =1.5% if we can assign two codes ($64R_b$ + $4R_b$) to the request.External fragmentation occurs when the code tree has a number of low-rate codes such that calls requesting for higher rates can easily get rejected even if there is still sufficient capacity remaining in the code tree system's utilization. One possible solution to external fragmentation is to allocate codes more carefully when requests arrive, to which we refer as the code assignment problem. The other remedy is to conduct code replacement by moving occupied codes around, to which we refer as the code reassignment problem.

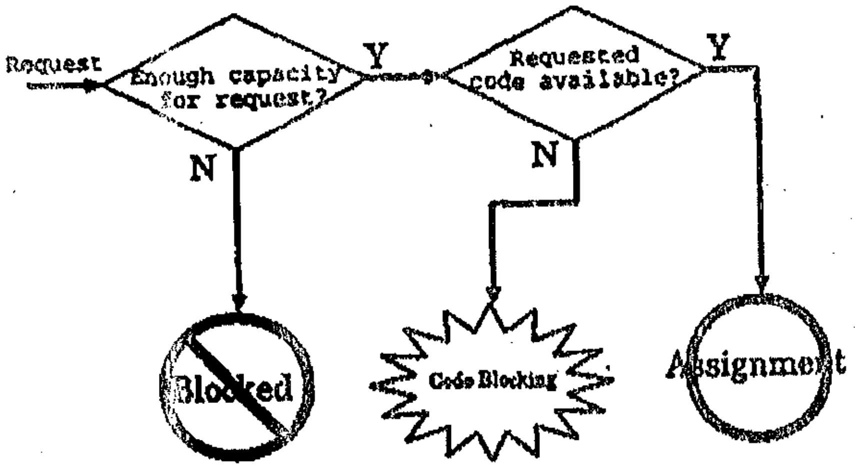
3.3 Schemes under Review

There are four types of code assignment schemes:

1. Optimal dynamic code assignment (DCA)
2. Optimal Hybrid code assignment (HCA)
3. Multicode Multirate Compact Assignment(MMCA)
4. Fixed Code Assignment(FCA)

3.3.1. *Conventional OVSF-code Assignment Scheme:*

The CCA assign an OVSF code only when the system has enough capacity for serving the requested rate and there is one that maintains orthogonality for already assigned codes. The algorithm for CCA is given as:



This algorithm faces the problem of code blocking. Due to this, high call rate requests have a high call blocking probability.

3.3.2 *Optimal dynamic code assignment scheme:*

In this scheme, OVSF codes are dynamically reassigned, and as a result code blocking is completely eliminated. This scheme is optimal in the sense that it minimizes the number of OVSF codes that must be reassigned to support a new call.

Code blocking leads to an increase in call blocking rate for higher data rate users and a reduction in spectral efficiency. It is evident from the code tree (Fig. 3) that the higher is the requested data rate, the larger is the blocking probability. To circumvent this problem we propose a scheme that dynamically reassigns OVSF codes and, as a result, code blocking is completely eliminated. This scheme is optimal in the sense that it minimizes the number of OVSF codes that must be reassigned to support a new call. For the example shown in Fig. 3, it is easy to see that the system can support code (2, 3) or (3, 2) by releasing code (1, 5) and assigning (1, 4) in its place. Before code reassignments are carried out, it is necessary to first check whether the system can support the rate requirement of a new call. If the system does not have excess capacity to support it, the new call will be blocked and no code will be reassigned.(Note that a call—not a code—is blocked when its rate requirement is larger than excess capacity.)

The goal of this algorithm is to minimize the number of necessary reassignments of occupied codes to support the new call. The key idea underlying this optimal algorithm is to associate a cost function with each candidate branch, and to assign the root code of a minimum-cost branch to the new call. The cost function is only defined when there is excess system capacity, i.e., when (2) is a strict inequality (before the new call is considered).

Given that the system has enough excess capacity, the cost of reassigning an occupied code is defined as the minimum number of code reassignments (including itself) necessary to assign to some other branch so that and all descendant codes of are left vacant. Since the reassignment of a leaf code of rate results in no additional code reassignments (because there is excess system capacity), by definition its cost is 1. Cost depends on the topology of other branches. When there is an immediate vacancy in another branch, the cost is only 1 [Fig. 4].

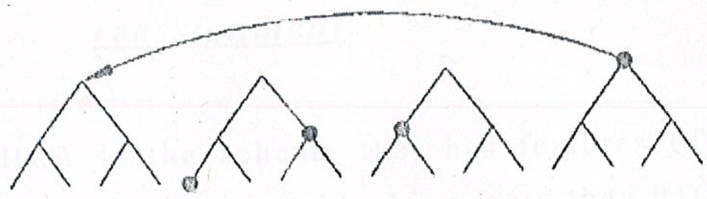


Fig.4 Cost of reassigning a 4R code =1

The steps in the execution of the optimal DCA algorithm.

1) Check if the new call with rate kR b/s can be supported, i.e., its requested rate is within the system capacity. If so, go to Step 2. If not, block the call.

2) Find a minimum-cost branch where the root code supports rate kR b/s.

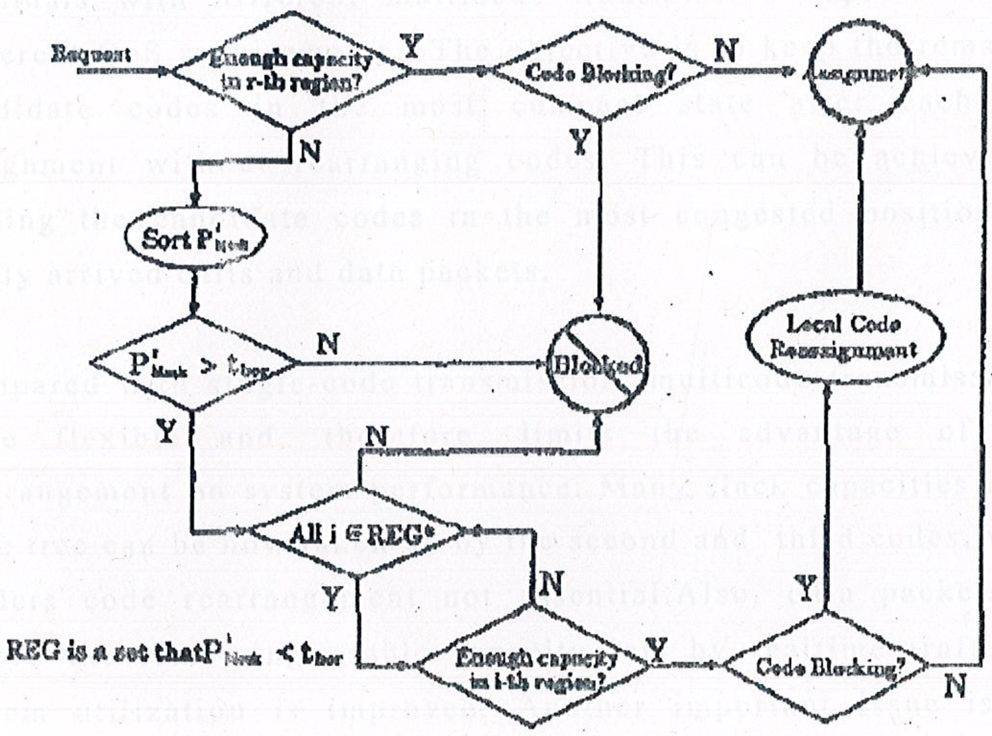
3) Once a minimum-cost branch is found, the root code of the branch is assigned to the new call. If the branch is empty, the root code is assigned to the call and the process is complete. Otherwise, it is necessary to reassign the (occupied) descendant codes of the branch as described in Step 4.

4) Reassign to another branch the code with the highest data rate among the descendant codes first. If there is more than one descendant code with the highest data rate, it can be chosen arbitrarily among them.

5) To reassign a code (with the highest data rate among the descendant codes), go back to Step 2 by treating it as a new call requesting its rate

3.3.3 Hybrid OVSF code assignment scheme with local reassignment:

HCA is the scheme that has features of both DCA and RDA.and mitigates the code blocking more than RDA. HCA, at first, performs RDA. And then if code blocking happened, reassigns codes in the region which borrows a code (Local Reassign-ment) and assigns a code to the request. The algorithm of HCA is shown in Fig.



3.3.4. Multicode Multirate Compact Assignment(MMCA)

The design of MMCA is based on the concept of "compact index" and takes into consideration mobile terminals with different multimode transmission capabilities and different quality of service (QoS) requirements. Priority differentiation between multirate real-time traffic and best-effort data traffic is also supported in MMCA.Analytical and simulation results show that MMCA is efficient and fair. MMCA allows the coexistence of mobile terminals with different multicode transmission capabilities and different QoS requirements.. The objective is to keep the remaining candidate codes in the most compact state after each code assignment without rearranging codes. This can be achieved by finding the candidate codes in the most congested positions for newly arrived calls and data packets.

Compared with single-code transmission, multicode transmission is more flexible and, therefore, limits the advantage of code rearrangement on system performance. Many slack capacities in the code tree can be now taken up by the second and third codes, which renders code rearrangement not essential.Also, data packets can absorb the remaining usable capacity left by realtime traffic, so system utilization is improved. Another important issue is that codes in different layers may be assigned to the same mobile user for a single transmission/application.These codes have different spreading factors and hence offer different transmission qualities. This difference should be balanced in code selection.

In summary, MMCA has the following features.

1) MMCA does not perform code rearrangement and is therefore simple.
2) MMCA provides priority differentiation between realtime calls and data packets.
3) MMCA supports mobile terminals with different multicode transmission capabilities.
4) MMCA balances transmission qualities among the multiple codes assigned to the same user.
5) MMCA supports multirate realtime calls and keeps the code tree as flexible as possible in accepting new multirate calls.

3.3.5 *Fixed code assignment scheme(FCA)*

Fixed code assignment (FCA) schemes are designed to avoid code reassignment, thus reducing the implementational complexity. However, under FCA, an incoming call may be rejected because its data rate cannot be supported by any available code of its class, even if the total available system capacity can accommodate it.

The FCA scheme partitions the whole set of OVSF codes into mutually exclusive groups of codes and uniquely assigns a group to each service class determined by the service data rate .Thus, the number of available codes for each service class is fixed, and no code reassignment is allowed.

CHAPTER 4

CODE ASSIGNMENT SCHEMES ACCORDING TO CALL ARRIVAL DISTRIBUTION

In this chapter we have proposed three algorithms for OVSF code assignment, in which we have incorporated the nature of distribution of call arrival rate like whether low rate call arrivals are more or high rate call arrivals are more or call arrival rate is uniformly distributed, by assigning codes according to distribution nature we make system more efficient and flexible. As the need for higher transfer rate is increasing, therefore it becomes essential to come out with ways by which we can optimize the system and bring the best out of it.

Benefits of algorithm in this section:

- Particular layer code requirement are high.
- Scattering reduction.
- Decrease in call blocking and fragmentation.
- Incorporating call arrival nature in code assignment.
- Less amount of code search, fast assignment.

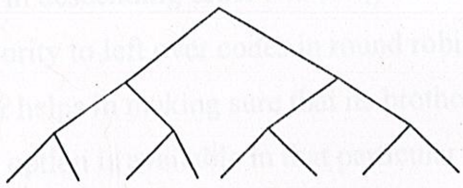
4.1 "Algorithm Design in which priority is given to high rates calls arrivals"

4.1.1 AIM

Decrease the blocking probability taking in account the time duration for which the code is being used for providing service and thereby increasing the probability to accommodate higher call rate/multimedia services.

4.1.2 DESCRIPTION

The code which is assign first, its brother or its neighbors are given (here we have to decide the value of x) lowest priority so that we can make its mother or mother's mother available for assigning higher data rates requests thereby decreasing the blocking of higher call rates requests because the probability of code becoming free which is assign first is more then code which is assign latest. So if we don't assign its brother to new call request we are making its mother available for higher call rates. This algorithms works only when we have traffic demanding more of higher data rates requests then lower date requests. The more the higher data rate requirement the better the algorithms works. Therefore it's a future ready algorithm accommodating 3.5G and 4G standards.



$C_{l,n}$ where 'l' is no of layer in code tree and 'n' is branch no is each layer.

'x' is define as the amount of jump we are require to make in order to make a particular code layer free to accommodate higher data rates. 'x' varies in a particular layer at a time.

4.1.3 ALGORITHM

- Initial scan all the incoming requests at any instant of time say (t_i) for taking down the statistical distribution of arrival date rate requests. This is done to see whether the requirement is more for higher data rates or for less data rates or whatever be the case and setting the value of x, where x is define as the amount of jump required in the algorithm to accommodate the higher data rates.
- Calculate average of incoming call rate requests to set the value of 'x', like, if average comes out near 2R we will set x=1 and if average comes out to be near 5R or so we set x=7 and like wise system goes on assigning value to x, so that the higher layer code's probability that it is free is increased. Maximum rate is 128R so accordingly value of 'x' varies.
- Now scan the tree for time duration for which different codes are assigned in the code tree at (t_i) and sort them in descending order. The code which is assign first has the highest probability to get free and the code which is assign in last have lowest probability that it gets free.
- If value of x=1(according to what the value of average comes out) then take the first code in descending order and assign lowest priority to its brother and then assign priority to left over codes in round robin fashion. Giving lowest priority to its brother helps in making sure that its brother will not be assign in code tree if any other option is available in that particular layer, so that their mother remains free and not get block because of its children is assign and to maintain orthogonality the mother cannot be assigned.
- If value of 'x' comes to be greater then 1 like 3or 7 or 15….then take the code which is first in descending order , assign least priority to its mothers also in upper layer while assigning lowest priority to its 'x' brothers and then assign priorities to left over codes in round robin way in each layer independently.

- Update this table periodically or at every new arrival of call rate request.
- Assign codes.

4.1.4 EXAMPLE1

Suppose in 1st layer from bottom in code tree we have assigned various codes for call rates demanding R rates and if arrival nature is such that it is demanding higher data rates then we use this algorithm.

Suppose arrival statistics shows that 2nd layer data rate request is more and we have assigned codes in the first layer from bottom on sorting them in the duration for which they are being used we find the probability of code which will get free at earliest . Let it be C (1, 1) then we will give least priority to its brother so that the probability of there mother getting blocked decreases.

Similarly, if the statistics shows data rate requirement of 3rd layer codes then we will assign lowest priority to 3 nearest neighbors, as we aim to decrease the blocking probability of codes present in 3rd layer. As C(1,1)is assign then C(1,2),C(1,3)and C(1,4) will be assigned lowest priority .And the left over will be given priority in round robin fashion.

4.1.5 EXAMPLE 2

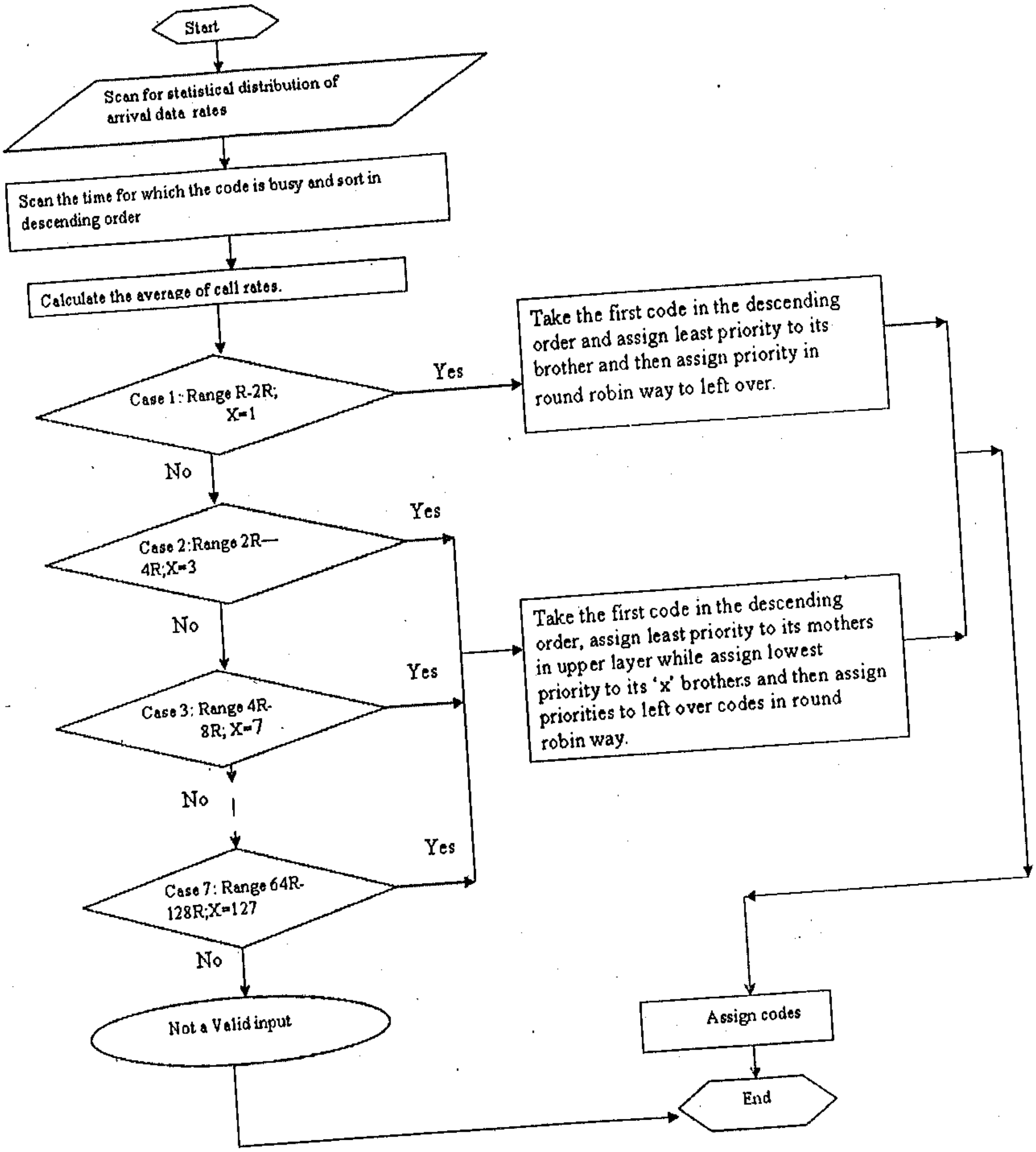
Suppose 16R is given priority, due to data rate requirement or otherwise.

Now starting from the bottom layer of R data rate we give lowest priority to its 15 brothers as value of X=15 for 16R.

For second layer from bottom we give lowest priority to its 7 brothers as for data rate of 2R, X=7

Similarly, for third layer from bottom assign lowest priority to its 3 nearest brothers.

Thus making 16R of highest priority.



Start
Scan for statistical distribution of arrival data rates
Scan the time for which the code is busy and sort in descending order
Calculate the average of call rates.
Case 1: Range R-2R; X=1
Yes
Take the first code in the descending order and assign least priority to its brother and then assign priority in round robin way to left over.
No
Case 2:Range 2R—4R;X=3
Yes
No
Case 3: Range 4R-8R; X=7
Yes
Take the first code in the descending order, assign least priority to its mothers in upper layer while assign lowest priority to its 'x' brothers and then assign priorities to left over codes in round robin way.
No
Case 7: Range 64R-128R;X=127
Yes
No
Not a Valid input
Assign codes
End

4.2 "Algorithm design for call rates in which priority is given to lower call rates."

4.2.1 AIM

Decrease the blocking probability and thereby increasing the throughput of system by giving high priority to call arrivals of low rate requirement.

4.2.2 *DESCRIPTION*

The difference between the previous algorithm design in which we incorporate the concept of increasing efficiency of code tree without reassignment and by prioritizing codes and in this algorithm are that here we are sectorizing the code tree in to various sub trees and thus making the search for new code assignment smaller. The net effect will be that wherever codes are assigned in code tree that sector becomes crowded and rest of the tree will be available for code assignment. Hence we are in a way distributing the call rate requests and then reassembling them at one place.

Assumption: Higher call rate request are absent like 8R or 7R etc.

And we have given higher priority to lower call rates requests.

What we are trying to do?

We have divided the code tree into various sub trees; the exact division is like this:

We have assumed that higher call rates are absent therefore the root of code tree is free and also its immediate children also, so layer 8th and 7th are free.

Now highest call rate could be of 128R, therefore dividing the code tree into 16*8 sub tree means 16 sub tree of eight brothers of R call rates or 16 sub tree of four brother of 2R call rates.

Now the concept involved is that in a sub tree their can only be three states possible :

a) Busy

b) free

c) reserved

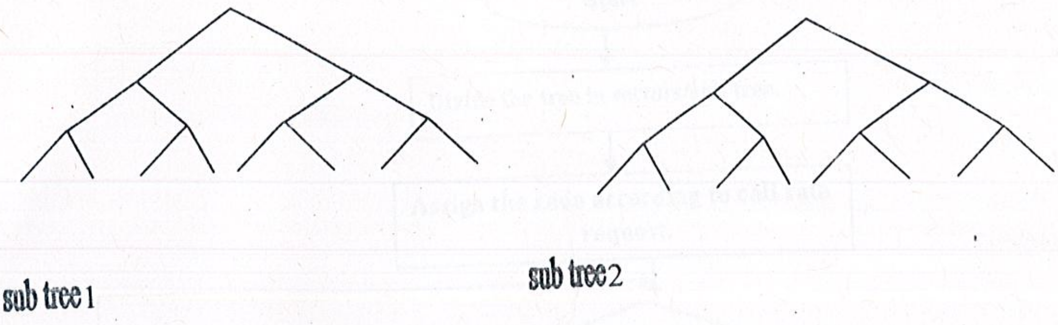
a): busy means that the code from the sub tree already is assigned to the call rates and if incoming call rate is of same level it will be assign in that very sub tree and it don't have to search the complete tree for code assignment.

b): free means that we have not assigned any codes in that layer and all its brother defined early(we have 8 brothers with R rate and 4 brothers with 2R rates.) are all free.

c): reserved means that one of the code is assigned from the sector and all the other codes are now reserved to follow the algorithm design.

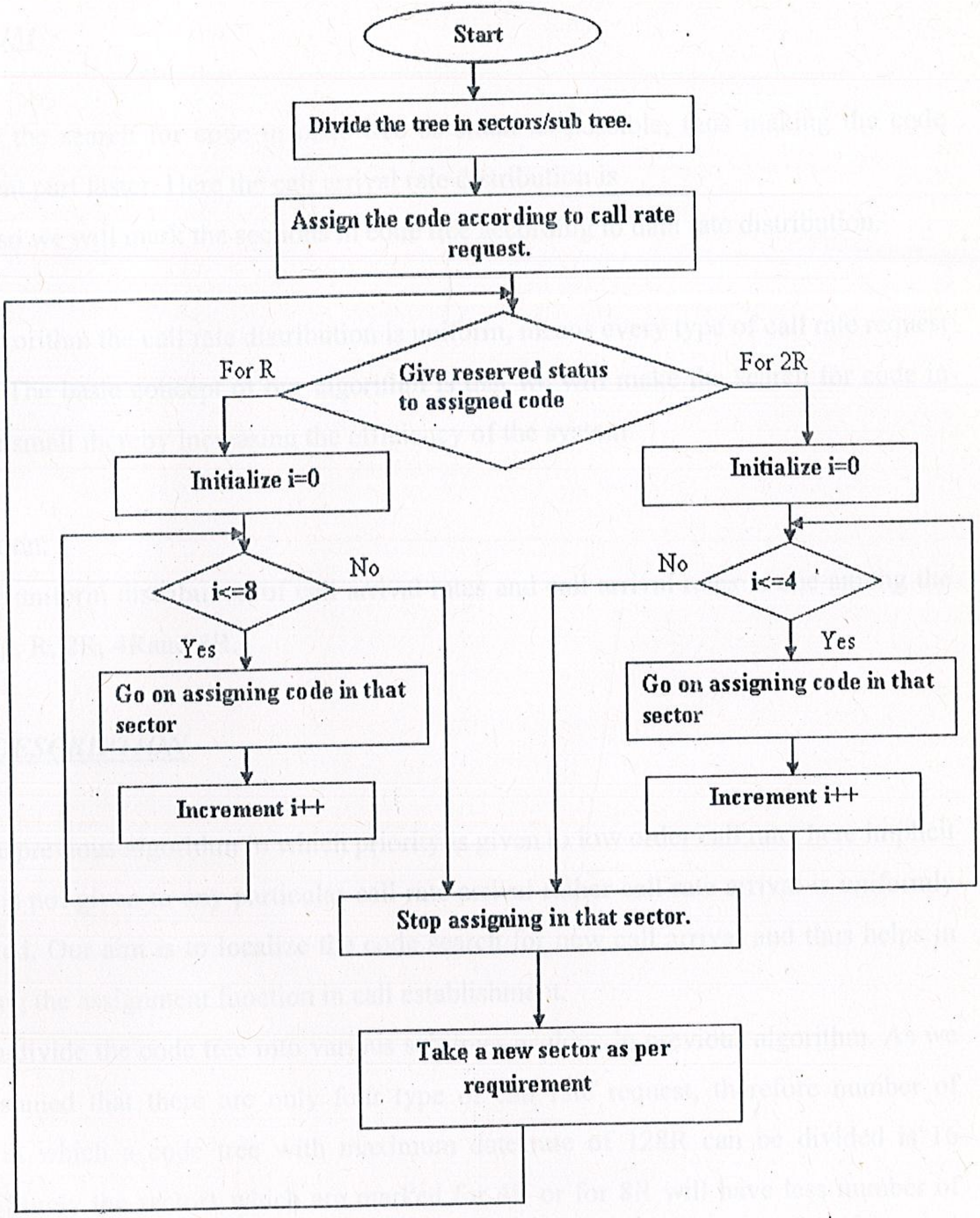
4.2.3 *EXAMPLE*

Suppose we have a sector of code tree containing eight 1R call rate code and one of them is assigned to call. Then it automatically reserved all the eight codes in the sub tree for 1R call rate requests and supposes one more call rate requesting R code rate arrives then it will simply assign one of the codes from the sub tree to that call and will not have to search the entire tree layer for code. Here reserved group was of 1R call rates.
Suppose in some other sector we have a code assign to 2R call rate requests, then it will reserved the three available brothers in that layer for 2R call rate requests and any further need for 2R code will be first tried to satisfied from this sector and if code tree is full then a new sector is formed which will have reserved state as the previous sector.



4.2.4 ALGORITHM

- Divide the tree into sectors, in our case 16 sectors of eight brothers of 1R or 16 sectors of four brothers of 2R , according to the call arrival request.
- Assign the code according to call rate request.
- Give reserved status to that sector in which code is assigned for R or 2R rate requests. If it is for R the bottom layer we have 7 brothers left for assigning and if it is for 2R we have 3 brothers left for assigning.
- Complete the capacity of each sub tree in every sector befor moving to next sub tree for giving it reserved status. When ever the subtree becomes full come out of the loop take a new sector and again carry out the entire processes.


Start
Divide the tree in sectors/sub tree.
Assign the code according to call rate request.
For R
Give reserved status to assigned code
For 2R
Initialize i=0
Initialize i=0
No
i<=8
No
i<=4
Yes
Yes
Go on assigning code in that sector
Go on assigning code in that sector
Increment i++
Increment i++
Stop assigning in that sector.
Take a new sector as per requirement

4.3 "Algorithm design for uniform call rate distribution"

4.3.1 AIM

To make the search for code in code tree as small as possible, thus making the code assignment part faster. Here the call arrival rate distribution is
uniform so we will mark the sections in code tree according to data rate distribution.

In this algorithm the call rate distribution is uniform, means every type of call rate request is made. The basic concept of our algorithm is that we will make the search for code in code tree small thereby increasing the efficiency of the system.

Assumption:
We have uniform distribution of call arrival rates and call arrival rates is one among the following: R, 2R, 4Rand 8R.

4.3.2 DESCRIPTION

As in the previous algorithm in which priority is given to low order call rate, here implicit priority is not given to any particular call rate arrival rather call rate arrival is uniformly distributed. Our aim is to localize the code search for new call arrival and thus helps in improving the assignment function in call establishment.
Here we divide the code tree into various sub trees as done in previous algorithm. As we have assumed that there are only four type of call rate request, therefore number of sectors in which a code tree with maximum date rate of 128R can be divided is 16 sectors. Surely the sectors which are marked for 4R or for 8R will have less number of codes to accommodate call arrival requests as compared to sectors marked by R or 2R. The pictorially representation will prove aid to what we are trying to say by dividing code tree.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1R	2R	4R	8R	1R	2R	4R	8R	1R	2R	4R	8R	1R	2R	4R	8R
1R	1R	1R	1R	2R	2R	2R	2R	4R	4R	4R	4R	8R	8R	8R	8R

4.3.3 ALGORITHM

- Divide the code tree into sectors, such that each sector contains number of sub trees within it. In our case each sector contain 4 sub trees, making the total of 16 sub tree with each sub tree having eight codes for R arrival rate , four codes for 2R arrival rate , two codes for 4R arrival rate and one code for 8R arrival rate.

- We will implicitly mark sectors for varies call rate demands like for R, 2R etc. Here we have defined sectors in two ways in round robin manner (1st row) and second by grouping similar once together (2nd row). Obviously the grouping in second way the similar one is more profitable as in this the searching for code becomes more localized and thus code assignment becomes more faster.

- First four sectors are marked for 1R
  Next four sectors are marked for 2R
  Next four sectors are marked for 4R
  And next four sectors are marked for 8R

- Assign codes to call rate arrival request accordingly as R or 2R or 4Ror 8R.
  - The code from which the code is assign gets reserved status and it will go on accommodating call rate arrival request till its full capacity for its respective ranges.

Here range is like R data rate sector will accommodate R

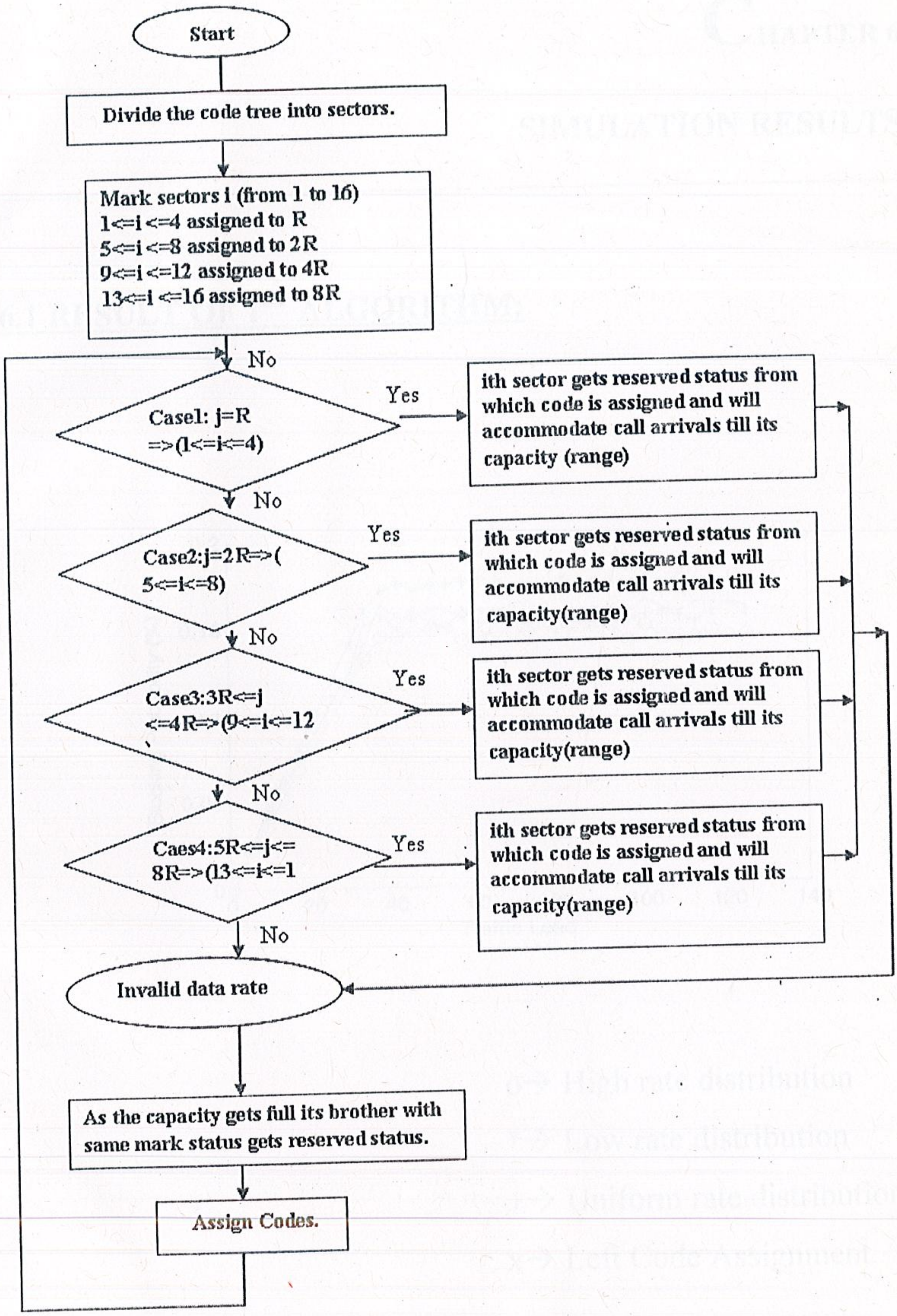
2R data rate sector will accommodate 2R

4R data rate sector will accommodate 3R & 4R

8R data rate sector will accommodate 5R to 8R

By this the code search gets localized in the limited number of sectors and further reduction can be achieved by confining search in reserved sub tree only.

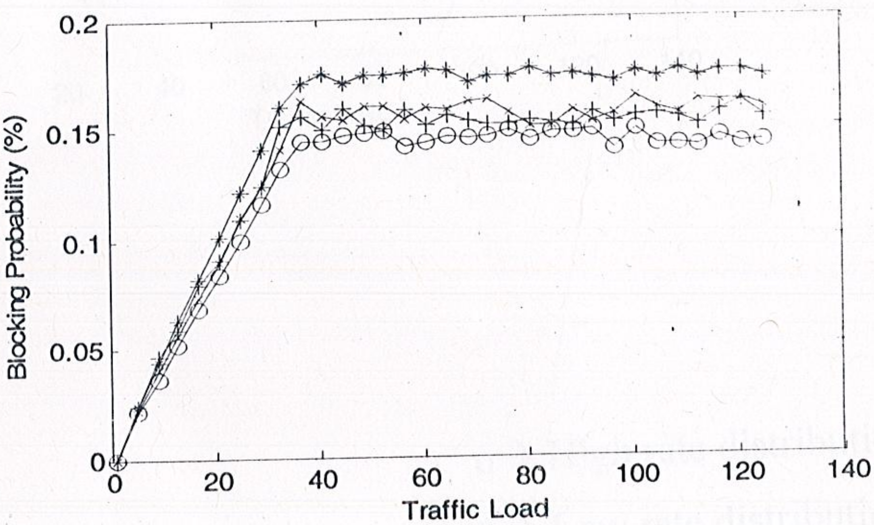
- As soon as one sector gets free its brother of same marked status gets the reserved status and code assignment begins assigning from the new sub tree.
- End.


Start
Divide the code tree into sectors.
Mark sectors i (from 1 to 16)
1<=i <=4 assigned to R
5<=i <=8 assigned to 2R
9<=i <=12 assigned to 4R
13<=i <=16 assigned to 8R
No
Case1: j=R =>(1<=i<=4)
Yes
ith sector gets reserved status from which code is assigned and will accommodate call arrivals till its capacity (range)
No
Case2:j=2R=>(5<=i<=8)
Yes
ith sector gets reserved status from which code is assigned and will accommodate call arrivals till its capacity(range)
No
Case3:3R<=j <=4R=>(9<=i<=12
Yes
ith sector gets reserved status from which code is assigned and will accommodate call arrivals till its capacity(range)
No
Caes4:5R<=j<= 8R=>(13<=i<=1
Yes
ith sector gets reserved status from which code is assigned and will accommodate call arrivals till its capacity(range)
No
Invalid data rate
As the capacity gets full its brother with same mark status gets reserved status.
Assign Codes.

CHAPTER 6

SIMULATION RESULTS

6.1 RESULT OF 1ST ALGORITHM:



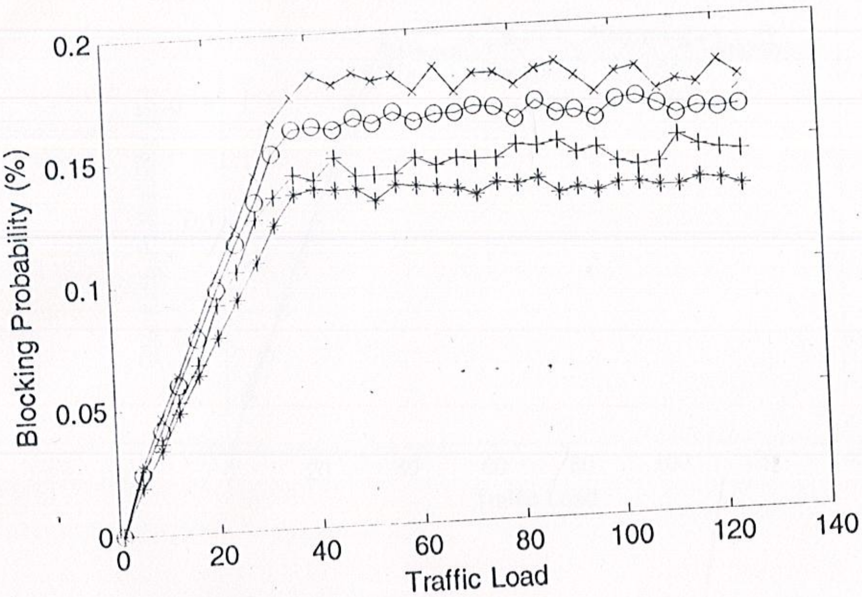
o→ High rate distribution

*→ Low rate distribution

+→ Uniform rate distribution

x→ Left Code Assignment

6.2 RESULT OF 2^{ND} ALGORITHM:



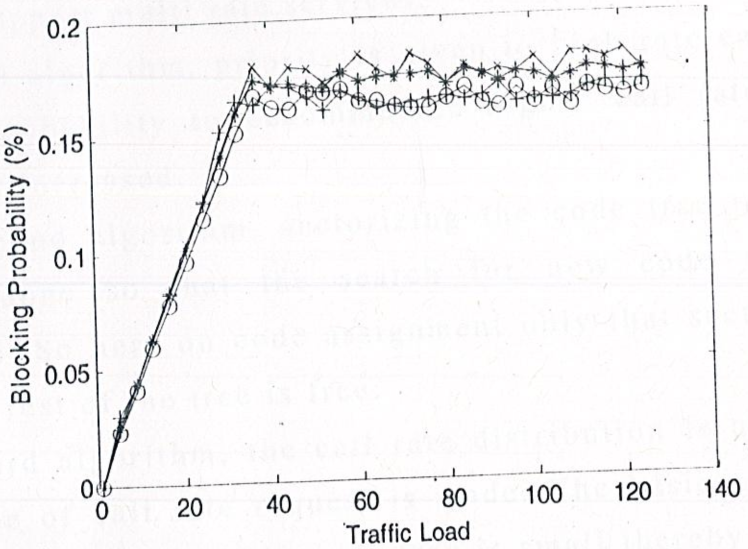
o→ High rate distribution

*→ Low rate distribution

+→ Uniform rate distribution

x→ Left Code Assignment

6.3 RESULT OF 3RD ALGORITHM:



o→ High rate distribution

*→ Low rate distribution

+→ Uniform rate distribution

x→ Left Code Assignment

CHAPTER7.CONCLUSION

In this project, we proposed three OVSF-code assignment schemes so as to support the maximum users with less complexity. We consider the case that a UE has the capability to use multiple OVSF codes to support multi rate services.

In the first algorithm, priority is given to high rate call arrivals so that the probability to accommodate higher call rates/multimedia services is increased.

In the second algorithm, sectorizing the code tree to various sub trees is done so that the search for new code assignment is simplified. So here on code assignment only that sector is crowded while the rest of the tree is free.

In the third algorithm, the call rate distribution is uniform, means every type of call rate request is made. The basic concept here is that the search for code in code tree is small thereby increasing the efficiency of the system.

In the last algorithm, we have tried to efficiently allocate codes to different users from code tree in such a way that internal fragmentation can be reduced to a minimum and thereby increasing the efficiency and decreasing the call blocking probability.

In the simulated output graph, we have shown the difference in blocking probability and throughput using our proposed algorithms in comparison to the previous used assignment algorithms.

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