一种在 CDMA 网状系统中通过完整分组信息分配 Walsh 码的方法

Method for Allocating Walsh Codes by Complete Group Information Walsh Code in CDMA Cellular System

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Abstract: A method for allocating Walsh codes by group in a CDMA (Code Division Multiple Access) cellular system is disclosed. The proposed system provides a method for grouping, allocating, removing and detecting of the minimum traffic group to minimize the time for allocating a call or transmitted data to an idle Walsh code, thereby, improving the performance of the system and reducing the time required to set up the call. The new concept of CGIWC has been presented to solve the calls or data allocating and removal from the Walsh Code. Preferably, these steps are performed by a BCS (Base station Call control Processor) at a CDMA base station. Moreover, a comparison with the previous work has been shown for the support of our related work. At the end, the future direction in which the related work can be employed, are highlighted.

Key words: DS-CDMA; Walsh code; BCS; CGIWC

1 Introduction

Numerous access schemes exist to allow multiple users to share a communication medium. One such access scheme is known as Code Division Multiple Access (CDMA). CDMA is a form of multiple access employed by spread-spectrum communication systems. In CDMA systems, a Wide band spreading signal is used to convert a narrowband data sequence to a wideband signal. A pseudo-random noise (PN) signal is applied to spread the modulated waveform over a relatively wide bandwidth[1].

The spreading signal typically comprises a pseudo noise (PN) sequence that has a chip rate several orders of magnitude higher than the data rate of the data sequence. The resulting wideband signal occupies a bandwidth in excess of the minimum bandwidth required to transmit the data sequence[2,3].

In CDMA, multiple users may use the same carrier frequency and may transmit simultaneously. Each user has its own PN sequence which is approximately orthogonal to the PN sequences of other users. The receiver selects the desired signal, which combines in the communication channel with unwanted signals, by performing a correlation operation. That is, the receiver correlates the received signal with the PN sequence of the desired signal. All other signals are spread by the PN sequence and appears as noise to the receiver. The Walsh code is utilized to distinguish the signals corresponding to each mobile station in the cell or sector signals after PN coding[4,5].

In the existing CDMA DCS (Digital Cellular System)and CDMA PCS (Personal Communication Services), the Walsh codes are serially allocated according to the generated calls or data being transmitted. This typically involves a long processing time, and, in case of concurrent calls, a caller may have to wait a certain time before his call is assigned to a Walsh code, thereby, increasing the time required to set up the caller's call. In this report a method for grouping the Walsh codes to reduce the load requirements when checking whether the Walsh codes are idle or busy has been presented.

The remainder of this paper is organized as follows. We review the DS-SS and Walsh Code in Section 2, related work about the grouping and system of grouping, allocating and removing the Walsh Codes are described in Section 3 and our proposed CGIWC in Section 4.

2 The Concept of DS-SS and Walsh Code

One spread spectrum technique employed in CDMA systems is known as Direct Sequence Spread Spectrum (DS-SS). In direct sequence spread spectrum systems, the data sequence modulates a PN sequence, which serves as the spreading signal, to generate a wideband signal. Modulation may be achieved, for example, by applying the data sequence and PN sequence to a product modulator or multiplier[6].

In the similar aspect, the Walsh code is utilized to distinguish the signals corresponding to each mobile station in the cell or sector signals after PN coding. Walsh codes as used in IS-95 are a set of 64 binary orthogonal sequences. These sequences are orthogonal to each other, and they are generated by using the Hadamard matrix. Recursion is used to generate higher order matrices from lower order ones; that is,

$$H_{2N} = \begin{bmatrix} H_N & H_N \\ H_N & \overline{H}_N \end{bmatrix}$$

where HN contains the same but inverted element of HN. The seed matrix is

$$H_2 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

Therefore, to drive a set of four orthogonal Walsh w0, w2 and w3, we only need to generate a Hamadard Matrix of order 4, or

$$H_4 = \begin{bmatrix} H_2 & H_2 \\ H_2 & \overline{H}_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{bmatrix}$$

The four orthogonal sequences in this Walsh code set are taken from the rows of the matrix H4; that is

$$w_0 = [0 \quad 0 \quad 0 \quad 0]$$
$$w_1 = [0 \quad 1 \quad 0 \quad 1]$$
$$w_2 = [0 \quad 0 \quad 1 \quad 1]$$
$$w_3 = [0 \quad 1 \quad 1 \quad 0]$$

By changing the 0s to -1s in each of the four sequences above , that is:

$$w_0 = [-1 \quad -1 \quad -1 \quad -1]$$
$$w_1 = [-1 \quad +1 \quad -1 \quad +1]$$
$$w_2 = [-1 \quad -1 \quad +1 \quad +1]$$
$$w_3 = [-1 \quad +1 \quad +1 \quad -1]$$

We can easily verify that all of the above sequences except wo satisfy the orthogonally conditions. In general, the 0th Walsh sequence consists of all -1s and thus cannot be used for channelization. Equation (3) can be recursively used to generate Hadamard matrices of higher orders in order to obtain larger sets of orthogonal sequences[6].

3 Related Work

The 64 Walsh codes are distinguished as two types: one type being assigned to the overhead channels and the other type being assigned to the traffic channels (see Table 1).

Table 1 Serially allocation

Overhead						Traffic										
	Pilot	Paging			Sync											
W Code / States	W0	W1	……	W7	W32	W8	W9	W10	W11	W12	W13	W14	W15	……… …	W62	W63
S1	B	B		B	B	I	I	I	I	I	I	I		……… …	I	I
S2	B	B	…..	B	B	C1	C2	C3	C4	I	I	I	I	………	I	I
S3	B	B	…….	B	B	C1	C2	C3	C4	C5	C6	C7	C0	………	I	I
S4	B	B	….	B	B	C1	C2	C3	C4	I	C6	I	C8	……….	I	I
S5	B	B	…..	B	B	C1	C2	C3	C4	C9	C6	C10	C8	……….	I	I

The 0th code is assigned to the pilot channel; the 1st -7th codes are assigned to the paging channels; the 32nd code is assigned to the synchronization channel; and the remaining codes, i.e., the 8th -31st and the 33rd -63rd codes, are assigned to the traffics. In the case where the 1st code is only utilized for the paging channel, the 2nd -7th codes (i.e., the remaining six codes) can be used as additional traffics.

In the existing CDMA DCS (Digital Cellular System) and CDMA PCS (Personal Communication Services), the Walsh codes are serially allocated according to the generated calls or data being transmitted. That is, referring to Table. 1, if "n" calls occurred in a cell or a sector, the corresponding BCP (Base station Call control Processor) allocates respective "n" Walsh codes to the available codes code-by-code, except for the Walsh codes used for the overhead channels, i.e., the Walsh codes used for the pilot, the paging, and the synchronization channels.

Referring to Table 1, in the first state (S1), the Walsh codes for the pilot, the paging, and the synchronization are all BUSY (B), and all the Walsh codes for the traffics are IDLE (I).

In the CDMA DCS and CDMA PCS system according to the prior art, when a call occurs, the Walsh codes are searched serially to determine an IDLE Walsh code, i.e., a Walsh code which does not have a call assigned thereto. This typically involves a long processing time, and, in case of concurrent calls, a caller may have to wait a certain time before his call is assigned to an IDLE Walsh code, thereby, increasing the time required to set up the caller's call. In the related work expressed in Ref.[7] a method is provided for detecting the Walsh group having the minimum traffic group to minimize the time for allocating a call or data to be transmitted to an idle Walsh code, thereby, improving the performance of the system and reducing the time required to set up the call. A preferred way for grouping the Walsh codes in a CDMA DCS and CDMA PCS according to the present preposition comprises the steps of initialization, allocation of the Walsh codes, and removal of the Walsh codes.

The step of initialization includes the step of dividing the Walsh codes into a plurality of Walsh groups by assigning the number table of the Walsh codes to correspond to these groups. The step of allocation of the Walsh codes includes the steps of searching the plurality of Walsh groups to determine a Walsh group having the minimum traffic, and allocating an idle Walsh code within the minimum traffic group to a call or data to be transmitted. The step of removal of the Walsh code, after it is determined that the call has been completed, includes the steps of searching the Walsh group; selecting the Walsh code which had the call allocated thereto, selecting the Walsh code for removing, reducing the allocation counts of the selected Walsh group, and removing the selected Walsh code[7].

4 System of Grouping, Allocing and Removing the Walsh Codes

Consider a system of grouping the Walsh codes in a CDMA and CDMA PCS. In the step of initializing, the number of groups the Walsh codes are divided into is determined according to the number of Walsh codes which can be allocated for the purpose of traffics.

In the step of allocating an idle Walsh code to a call, the BCP (Base station Call control Processor) of the CDMA base station iteratively checks the numbers of the allocated Walsh codes per group by utilizing the Walsh Group Allocation Count table. This table stores the allocation counts for each of the plurality of Walsh groups. The group which has the minimum allocated Walsh codes is selected as the minimum traffic group. Therefore, the step of allocating the identified idle Walsh code to the call includes the steps of: identifying a starting Walsh code of the minimum traffic group as a starting point and identifying a starting Walsh code of a next group as an ending point using a Walsh group start table (this table stores the starting numbers of the Walsh codes for each of the plurality of Walsh groups); iteratively checking each Walsh code within the minimum traffic group until the idle Walsh code is identified; allocating the call or transmitted data to the identified idle Walsh code in the minimum traffic group; and changing the state of the Walsh code where the call or transmitted data was allocated to in a Walsh code state table from the "idle" to the "busy" state.

In the step of removing the Walsh code, when the removal of the allocated Walsh code is requested, the BCP of the CDMA base station searches the Walsh code group to locate the Walsh code to be removed by utilizing the Walsh Group Start Table.

This table stores the number of the starting Walsh code of the Walsh code group which contains the Walsh code to be removed. After selecting the Walsh code to be removed, the allocation counts of the Walsh code is reduced by reducing the counter of the Walsh code's respective Walsh group in the Walsh Group Allocation

Count table. The selected Walsh code is then removed by converting the "busy" state of the Walsh code to be removed into the "idle" state[7].

Table 2　Walsh code group start table

Overhead						Traffic										
	Pilot	Paging			Sync	GROUP1			GROUP2			....	GROUP8			
W Code / States	W0	W1	......	W7	W32	W8	....	W14	W16	....	W21	......	W58	...	W63	
S1	B	B		B	B	I	....	I	I	......	I	......	I	...	I	
S2	B	B	.....	B	B	C1	....	I	C2	.....	I	.....	C8	...	I	
S3	B	B	....	B	B	C1	....	I	I	...	I	.....	C8	...	I	
S4	B	B	....	B	B	C1	....	I	C9	....	I	.....	C8		I	
S5	B	B	.....	B	B	I	....	I	C9	.....	I	......	I	...	I	
S6	B	B	.....	B	B	C10	....	I	C9	....	I		C11		I	

In the step of allocating the Walsh code to the minimum traffic group, if an "idle" Walsh code is not identified within the minimum traffic group, then this step terminates. Further, in the step of searching for the Walsh code to be removed, if the Walsh code group which contains the Walsh code to be removed is not selected, then the step of removing the selected Walsh code is terminated.

A method of the present report includes the step of dividing the Walsh codes into a plurality of groups. The number of groups the Walsh codes are divided into is determined according to the number of Walsh codes which have been allocated or are available for the purpose of traffics. For example, the number of groups for the most efficient structure is preferably determined by either of two numbers, where one number has the minimum value of the group x (the Walsh code number per group) and the remaining number of the two numbers is assigned as the number of Walsh codes per group. For example, if the number of the Walsh codes available for traffics is 56, the most efficient number for grouping is either 7 or 8. For illustrative purposes herein, the number 8 is selected as the number of groups and the number 7 as the number of Walsh codes per Walsh code group.

5　The New Complete Group Information Walsh Code(CGIWC)

After the Walsh codes are divided into a plurality of groups, a Walsh Code group table (WG_START Table5) is configured to store the starting Walsh Code members, i.e. 8, 15, 22, 29, 37, 43, 50, and 57 of each group. Each member of the WG_START table keeps complete information of all the Walsh Codes of its group and Walsh Codes of all other groups, and is known as Complete Group Information Walsh Code (CGIWC). Furthermore,each CGIWC (CGIWC1, CGIWC2….. GIWC8) has an administrative control to maintain its own status and status of all other CGIWCs - by keeping the number of calls active and the number of calls being removed in each group- by sharing status information with each other CGIWCs.

Initially, when a request arrives, then a maximum of

$$ALLOCATE = n/2 \tag{1}$$

are assigned to each CGIWC for even number of idle Walsh Codes , and

$$ALLOCATE = (n+1)/2 \tag{2}$$

are assigned to odd number of idle Walsh Codes of CGIWC and the remaining calls are forwarded to other CGIWCs as shown in the Next Pointer field in Table 4., where n is the total number of Idle Walsh Code members in each group. Each CGIWC distributes these information with the other CGIWCs. Through this way the removal and allocating of calls and data to each group maintain a steady flow and all CGIWCs are efficiently utilized (as shown in Fig.3) and hence the required performance for the generated calls can be achieved in an organized manner.

In any time stamp T (unit time), the system will follow the following proposed scheme for allocating the generated calls:

$$P=n/2 \tag{3}$$

$$Q=n/4 \tag{4}$$

$$R=n/8 \tag{5}$$

where, P , Q and R are integer number of calls.

Scheme 1:

If the number of call arrived are less than or equal to P, then using equation (1) and (2), we get:

$$T <= x$$

where, x is the unit time taken by the BCP in assigning a maximum of P number of calls.

Scheme 2:

If the maximum number of calls are P +Q , then using equation (1) and (2), we get:

$$T <= x + y$$

where x + y is the unit time taken by the BCP in assigning a maximum of (P + Q) number of calls, that is P number of calls in the first n/2 and (n+1)/2 scheme and Q number of calls in the second scheme.

Scheme 3.

Similarly, if a maximum of P + Q + R arrives, then, we get:

$$T <= x + y + z$$

where x + y + z is the unit time taken by the BCP in assigning a maximum of (P + Q + R) number of calls using the same scheme as discussed above.

Table 3　Group idle and busy information for each State

Overhead						Traffic										
	Pilot	Paging			Sync	CGIWC 1			CGIWC2			....	CGIWC8			
W Code / States	W0	W1	......	W7	W32	W8	... ...	W14	W16	....	W21	......	W58	...	W63
S1	B	B		B	B	I	...	I	I	......	I	......	I	...	I
S2	B	B	.....	B	B	B		I	B	.....	I	.....	I	....	I
S3	B	B	....	B	B	B		I	B	...	I	.....	I	....	I
S4	B	B	....	B	B	B		I	B		I	.....	B		I

Further, when all the non CGIWCs are allotted then the calls are allotted to the corresponding CGIWCs. And, if the CGIWCs are busy and the non CGIWC member in the corresponding group get free, then idle CGIWC member may inform its group CGIWC, for the allotment of the respective CGIWC's call or data.

State: The call(s) arrival in a specified interval is termed as State.

C arrival: This shows the total call(s) arrived in a given State S.

C removal: The total call(s) removed in a given State S.

Removal Status (CGIWC): Shows the specified CGIWC, where the call(s) are removed.

System Load:

System Load=C arrival-C removal

Acquired Currently: The number of call(s) acquired currently by the given CGIWC.

Internal CGIWC Status: This shows the call(s) acquired information about all the CGIWCs.

Next pointer: This field shows the next CGIWC to whom the call(s) to be acquired. This decision is made on the bases of the formulas given as above.

6 Efficiency of the CGOWC

The efficiency of the prior art from the table 1 to be found to take a maximum of n steps for each allocation and removal of the Walsh code, which increase the complexity of finding the IDLE Walsh Code and respective removal. The improvement given in the related works fits well but in each group the performance and overburden of finding the IDLE Walsh Code still exists. But, according to the concept of CGIWC, the finding of IDLE Walsh Code, usage of each Walsh Group, and removal pattern removes all the mismanagement in the previous work, and improves the time required to set up the caller's call.

Table 4　CGIWC1's Information

	State	C Arrival	C Removal	Removal Status (CGIWC)	System Load	Acquired Currently	Internal CGIWC Status	Next Pointer
CGIWC1	S1	0	0	0	0	0	CGIWC1=0 CGIWC2=0 .... CGIWC8=0	CGIWC1–4
	S2	6	0	0	6	4	CGWC1 =4 CGIWC2=2 ...... CGIWC8=0	CGIWC2–2
	S3	15	0	0	21	4	CGWC1 =4 CGIWC2=4 CGIWC3=4 CGIWC4=4 CGIWC5=4 CGIWC6=1	CGIWC6-3
	S4	12	0	0	33	5	CGIWC1=5 CGIWC2=4 CGIWC3=4 CGIWC4=4 CGIWC5=4 CGIWC6=4 CGIWC7=4 CGIWC8=4	CGIWC1-1
	S5	14	4	CGIWC5=3 CGIWC8=1	43	6	CGIWC1=6 CGIWC2=6 CGIWC3=6 CGIWC4=6 CGIWC5=6 CGIWC6=6 CGIWC7=6 CGIWC8=5	CGIWC6-1

Call Number	Prior Art	The Advancement	The Present Invention
1	1	8	1
2	2	8	1
3	3	8	1
4	4	8	1
5	5	8	1
6	6	8	1
7	7	8	1
8	8	8	1
9	9	9	1
10	10	9	1
:	:	:	:
38	38	12	2.1875
39	39	12	2.21875
40	40	13	2.25
41	41	13	2.28125
42	42	13	2.3125
43	43	13	2.34375
44	44	13	2.375
45	45	13	2.40625
46	46	13	2.4375
47	47	13	2.46875
48	48	14	3.5
49	49	14	3.552083333
50	50	14	3.604166667
51	51	14	3.65625
52	52	14	3.708333333
53	53	14	3.760416667
54	54	14	3.8125
55	55	14	3.864583333
56	56	15	4.916666667

Fig.1　Comparison of the present invention with the previous work

WG_START Table 5.
Summarized view of All CGIWCs in the given State

Walsh Code Number	CGIWC Name	State	Acquired	Next Pointer
8	CGIWC1	S1	0	CGIWC1
15	CGIWC2	S2	2	CGIWC2
22	CGIWC3	S3	4	CGIWC6
29	CGIWC4	S4	4	CGIWC1
37	CGIWC5	S5	6	CGIWC6
43	CGIWC6	S6	…	…..
50	CGIWC7	S7	….	…..

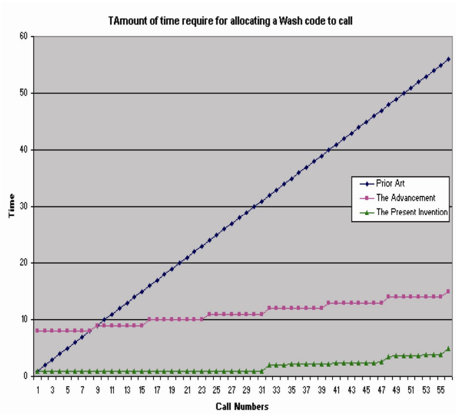

Fig.2　Total amount of time required for allocating a Walsh code to a call request

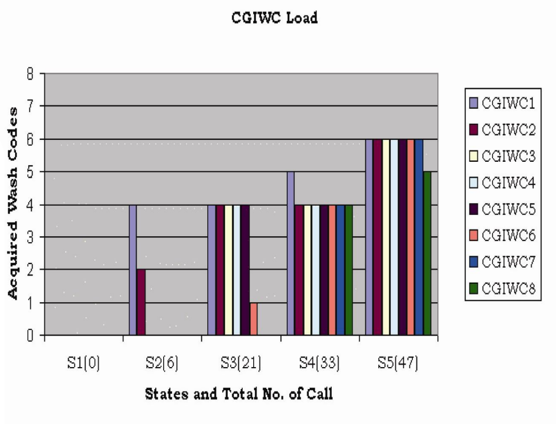

Fig.3　CGIWC load

7　Future Directions

The proposed work will provide a doorstep to the problem of congestion control for data, Congestion in the forward /downlink Direction, and more possibly the flexible bandwidth issue in DS-CDMA.

8　Summary

In this paper, we have proposed a new concept of Walsh Code Grouping known as CGIWC. Method for grouping the Walsh codes to reduce the load requirements when checking whether the Walsh codes are idle or busy has been provided. Further, the improvement to the prior work in the way of detecting the Walsh group having the minimum traffic group to minimize the time for allocating a call or data to be transmitted to an idle Walsh code, thereby, improving the performance of the system and reducing the time required to set up the call has been described.

In the future, issues related to data traffic, downlink congestion, and flexible bandwidth, as discussed in Ref.[8], needs careful examination.

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