Experiment No. 05

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AIM:

To implement a basic function of Code Division Multiple Access (CDMA) to test the orthogonality and autocorrelation of a code to be used for CDMA operation.

THEORY:

CDMA is a channelization protocol for Multiple Access, where information can be sent simultaneously through several transmitters over a single communication channel.

It is achieved in below steps:

- A signal is generated which extends over a wide bandwidth.
- The code which performs this action is called spreading code.
- Later on, a specific signal can be selected with a given code even in the presence of many other signals.

How does CDMA work?

To see how CDMA works, we have to understand orthogonal sequences (also known as chips). Let N be the number of stations establishing multiple access over a common channel.

Then the properties of orthogonal sequences can be stated as follows:

- An orthogonal sequence can be thought of as a 1xN matrix. Eg: [+1 -1 +1 -1] for N = 4.
- Scalar multiplication and matrix addition rules follow as usual.
    - Eg: [+1 -1 +1 -1] = [+3 -3 +3 -3]
    - Eg: [+1 -1 +1 -1] + [-1 -1 -1 -1] = [0 -2 0 -2]
- Inner Product: It is evaluated by multiplying two sequences element by element and then adding all elements of the resulting list.
- Inner Product of a sequence with itself is equal [+1 -1 +1 -1].[+1 -1 +1 -1] = 1 + 1 + 1 + 1 = 4
- Inner Product of two distinct [+1 -1 +1 -1].[+1 +1 +1 +1] = 1-1+1-1 = 0

To generate valid orthogonal sequences, use a Walsh Table as follows:

• Rule 1:

$$W_1 = [+1]$$

• Rule 2:

$$W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$$

Where $\overline{W_N}$ = Complement of W_N (Replace +1 by -1 and -1 by +1)

Example:

$$W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix}$$

$$W_4 = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix}$$

Where = Complement of (Replace +1 by -1 and -1 by +1)

Example:

Each row of the matrix represents an orthogonal sequence. Hence we can construct sequences for N = by using orthogonal sequences. Now let's take a look at how CDMA works

Procedure:

1. The station encodes its data bit as follows.
    - +1 if bit = 1
    - -1 if bit = 0
    - no signal(interpreted as 0) if station is idle
2. Each station is assigned a unique orthogonal sequence (code) which is N bit long for N stations
3. Each station does a scalar multiplication of its encoded data bit and code sequence.
4. The resulting sequence is then placed on the channel.
5. Since the channel is common, amplitudes add up and hence resultant channel sequence is sum of sequences from all channels.
6. If station 1 wants to listen to station 2, it multiplies (inner product) the channel sequence with code of station S2.
7. The inner product is then divided by N to get data bit transmitted from station 2.

CODE:

```
from functools import
reduce class User:
    def init (self, code):
        self.code = code
    def mul (self, num):
        return [num * bit for bit in
    self.code] def add (self, oth):
        return [a + b for a, b in zip(self.code,
    oth)] def repr (self):
        return self.code. str ()
    __rmul__=__mul__


def CDMA():
    avail_codes =
    [
        [1] * 4,
        [1, -1, 1, -1],
        [1, 1, -1, -1],
        [1, -1, -1, 1]
    ]
    users = [User(code) for code in avail_codes]
    data = tuple(map(int, input("Enter the data of the four stations:
    ").split())) garbled = [num * user for num, user in zip(data, users)]
    final_code = User([sum(codes) for codes in zip(*garbled)])
    which_channel = int(input('Enter the channel you want to listen
    to[0-4]: '))
    decoded = sum([num * user for num, user in zip(final_code.code,
    users[which_channel].code)]) >> 2 print(decoded, 'is the data.')

if__name__== '_main_':
    CDMA()
```

OUTPUT:

```
============ RESTART: C:\Users\Myl\Desktop\sfit\mcc\exp5\exp05.py ============
Enter the data of the four stations: 17 50 69 33
Enter the channel you want to listen to[0-4]: 2
69 is the data.
>>>
```

CONCLUSION:

From this experiment we learnt about CDMA that is Code Division Multiple Access. CDMA is used in 2G and 3G mobile networks. It is a channelization protocol and allows all stations to have access to full bandwidth of channel. We implemented CDMA by taking orthogonal data as input in Python.