Networks Lab
Assignment 4

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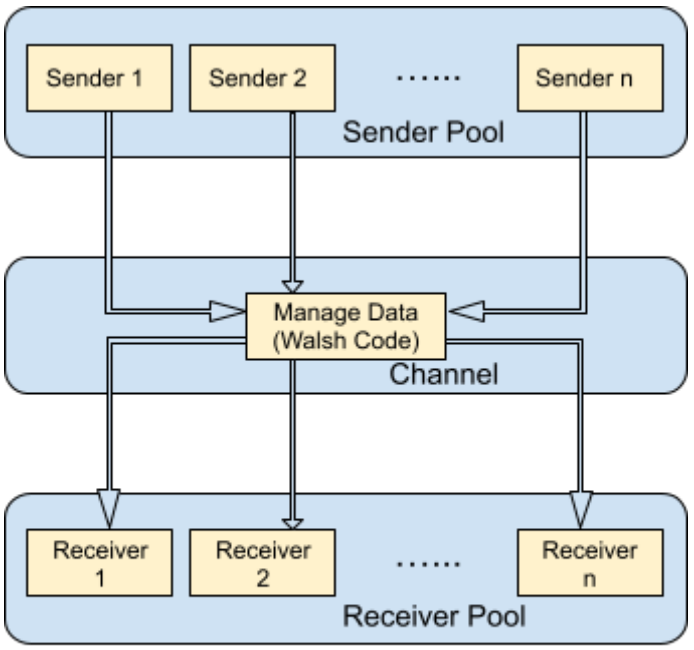
Problem Statement:

Implement CDMA for multiple access of a common channel by n stations. Each sender uses a unique codeword, given by the Walsh set, to encode its data, send it across the channel, and then perfectly reconstruct the data at n stations.

Design:

- Sender:
  - Read each character(byte) from the data file.
  - Send bit by bit for every character.
  - For every bit, multiply it with the Walsh code for the respective sender.
  - Wait for the timeslot(50ms) before sending the next bit.
- Channel:
  - Receive data from the senders in respective threads.
  - Manage the received data in another thread, i.e. generate the Walsh code for all the data received.
  - Send the cumulated Walsh code to the respective receiver in the sender threads.
- Receiver:
  - Connect with the channel.
  - Receive data(cumulated Walsh code) from the channel.
  - Calculate the multiplication and summation of the data received and the Walsh code of the respective receiver, and divide it by no. of stations to get the data bit.
  - Generate the characters from each 8 data bits, and store them in the output file.



CDMA

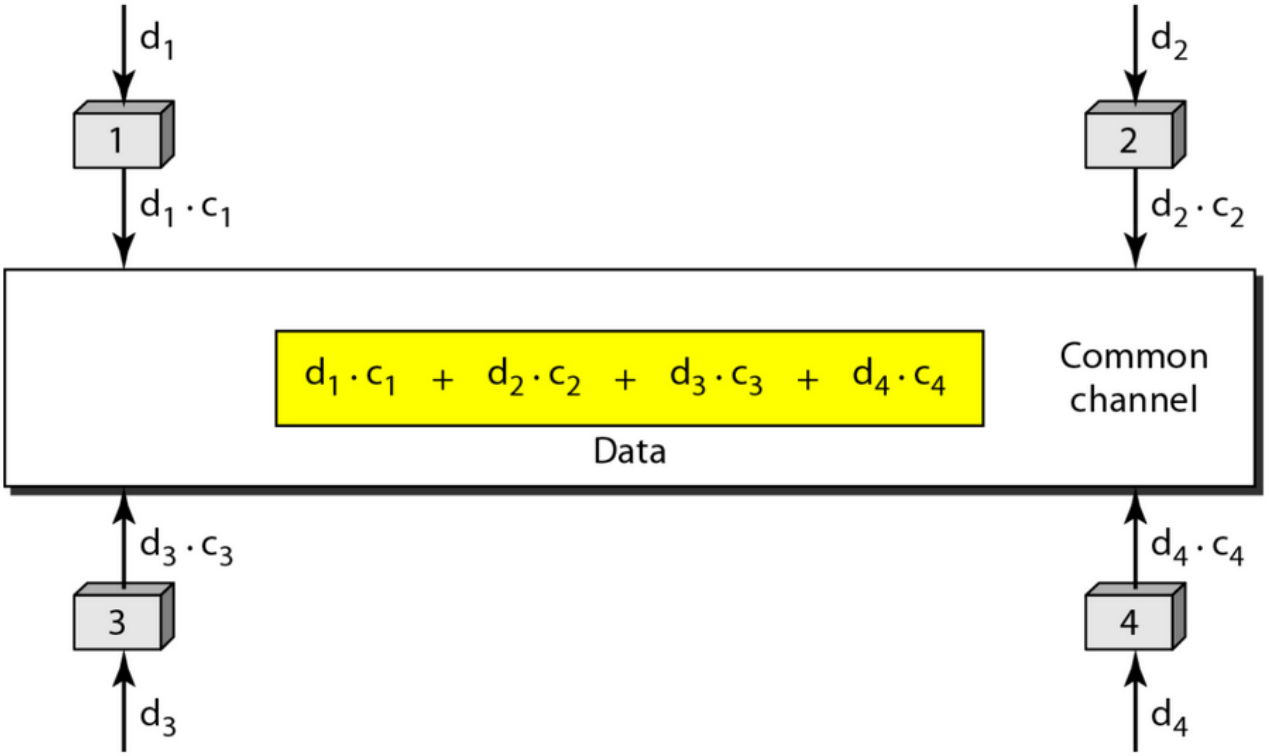
Flow Diagram of the Generalised Network

Implementation:

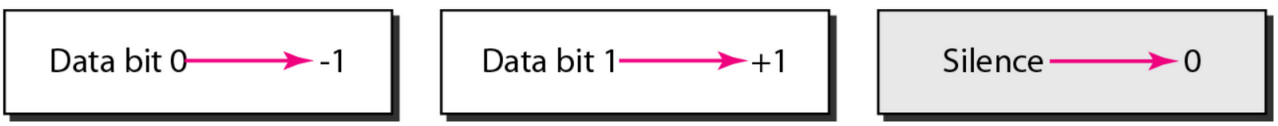
CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code, so it follows exactly along with the transmitter frequency.

CDMA has a number of distinguishing features that are key to spread spectrum transmission technologies:

- Use of wide bandwidth: CDMA, like other spread spectrum technologies uses a wider bandwidth than would otherwise be needed for the transmission of the data. This results in a number of advantages including an increased immunity to interference or jamming, and multiple user access.
- Spreading codes used: In order to achieve the increased bandwidth, the data is spread by the use of a code that is independent of the data.
- Level of security: In order to receive the data, the receiver must have a knowledge of the spreading code, without this it is not possible to decipher the transmitted data, and this gives a measure of security.
- Multiple access: The use of the spreading codes which are independent for each user along with synchronous reception allows multiple users to access the same channel simultaneously.



The idea of communication with code in CDMA



Data representation in CDMA

Function to build Walsh Table:

```
def buildWalshTable(wTable, length, i1,i2, j1,j2, isComplement):
   if length == 2:
       if not isComplement:
           wTable[i1][j1] = 1
           wTable[i1][j2] = 1
           wTable[i2][j1] = 1
           wTable[i2][j2] = -1
       else:
           wTable[i1][j1] = -1
           wTable[i1][j2] = -1
           wTable[i2][j1] = -1
           wTable[i2][j2] = 1

       return

   midi = (i1+i2)//2
   midj = (j1+j2)//2

   buildWalshTable(wTable, length/2, i1, midi, j1, midj, isComplement)
   buildWalshTable(wTable, length/2, i1, midi, midj+1, j2, isComplement)
   buildWalshTable(wTable, length/2, midi+1, i2, j1, midj, isComplement)
   buildWalshTable(wTable, length/2, midi+1, i2, midj+1, j2, not isComplement)
```

Test Cases:

We have generated random ASCII strings without whitespaces, of about 23 lengths, and performed all the tests on them.

testgenerator.py

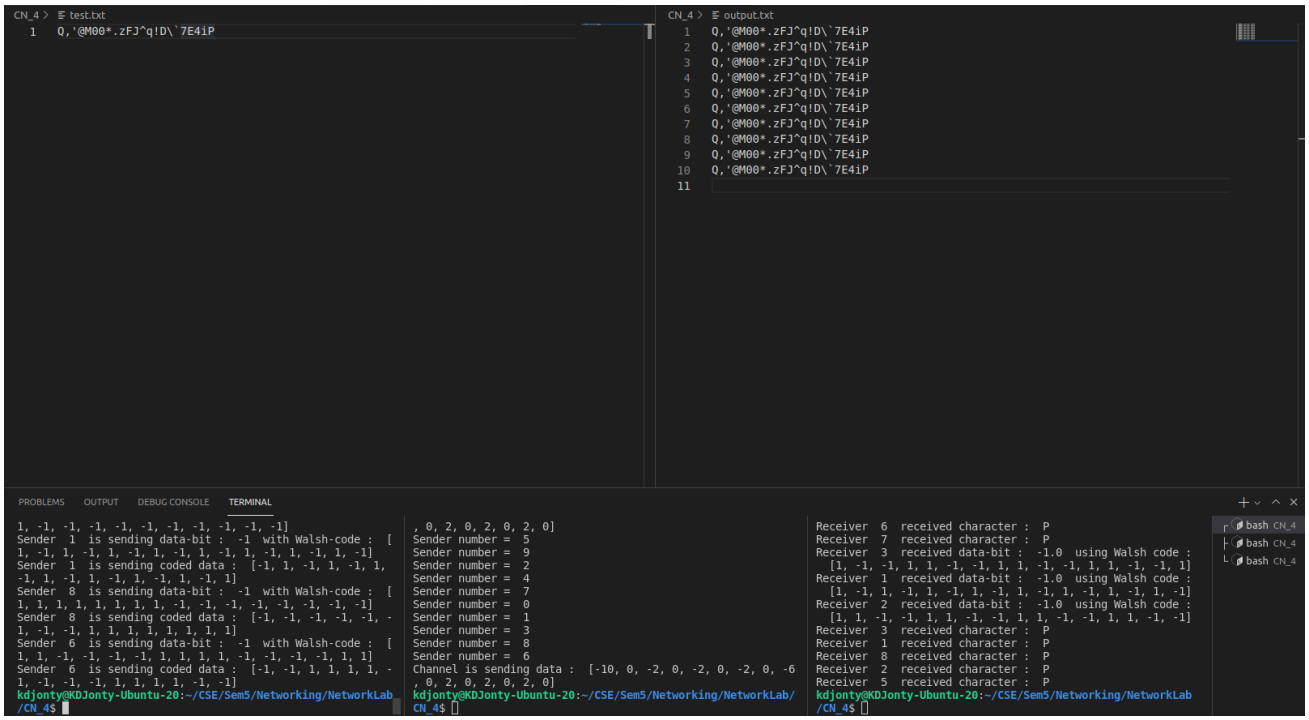
```
import string
import random
import re

n = 23

res = ''.join(random.choices(re.sub(r'\s+', '',string.printable), k = n))

file = open("test.txt", "w")
file.write(res)
file.close()
```

One of the test cases along with terminal output screens is shown below.



Results:

We have used total time taken, effective bandwidth, and average successful transmission time of a data bit as the parameters to compare the CDMA with increasing no. of senders.

$$Effective\ Bandwidth\ =\ \frac{Total\ no.\ of\ data\ bits\ sent\ by\ all\ senders}{Total\ time\ taken\ for\ the\ transmission}$$

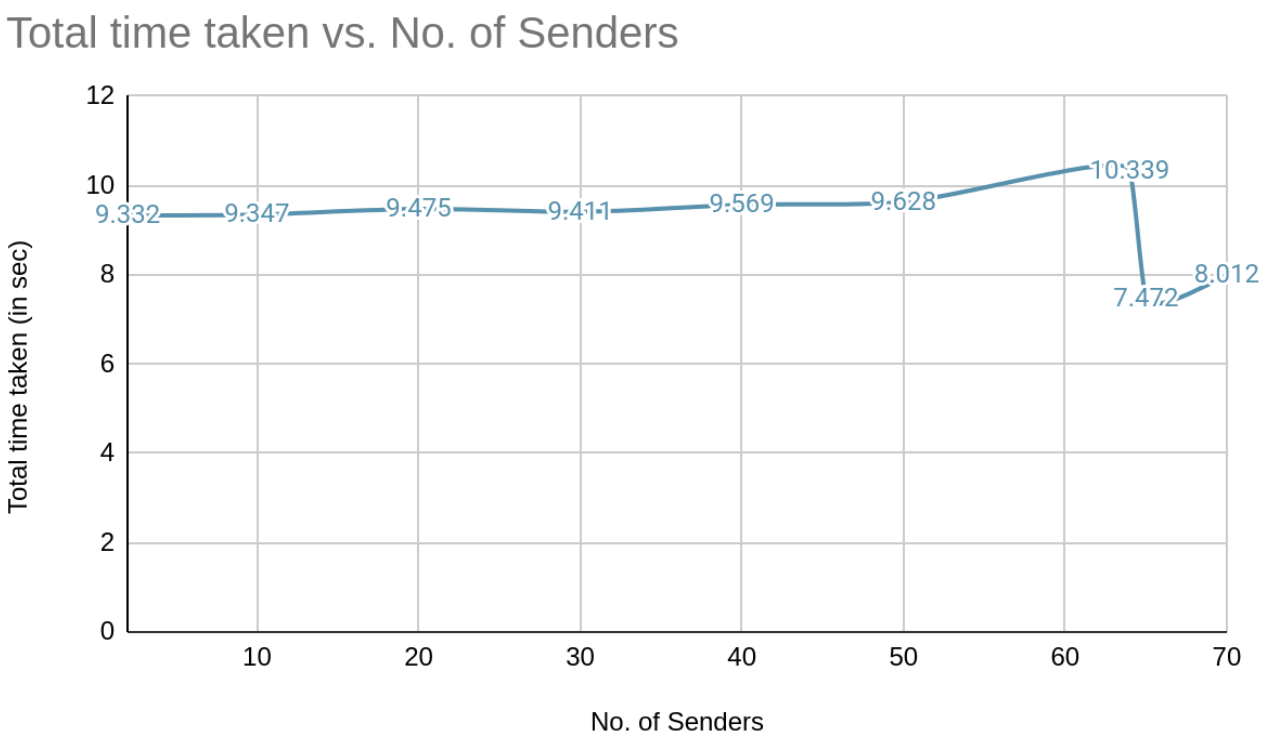
$$Average\ Successful\ Transmission\ Time\ =\ \frac{Total\ time\ taken\ for\ the\ transmission}{Average\ no.\ of\ data\ bits\ sent\ by\ a\ sender}$$

We've sent 184 data bits for the results below.

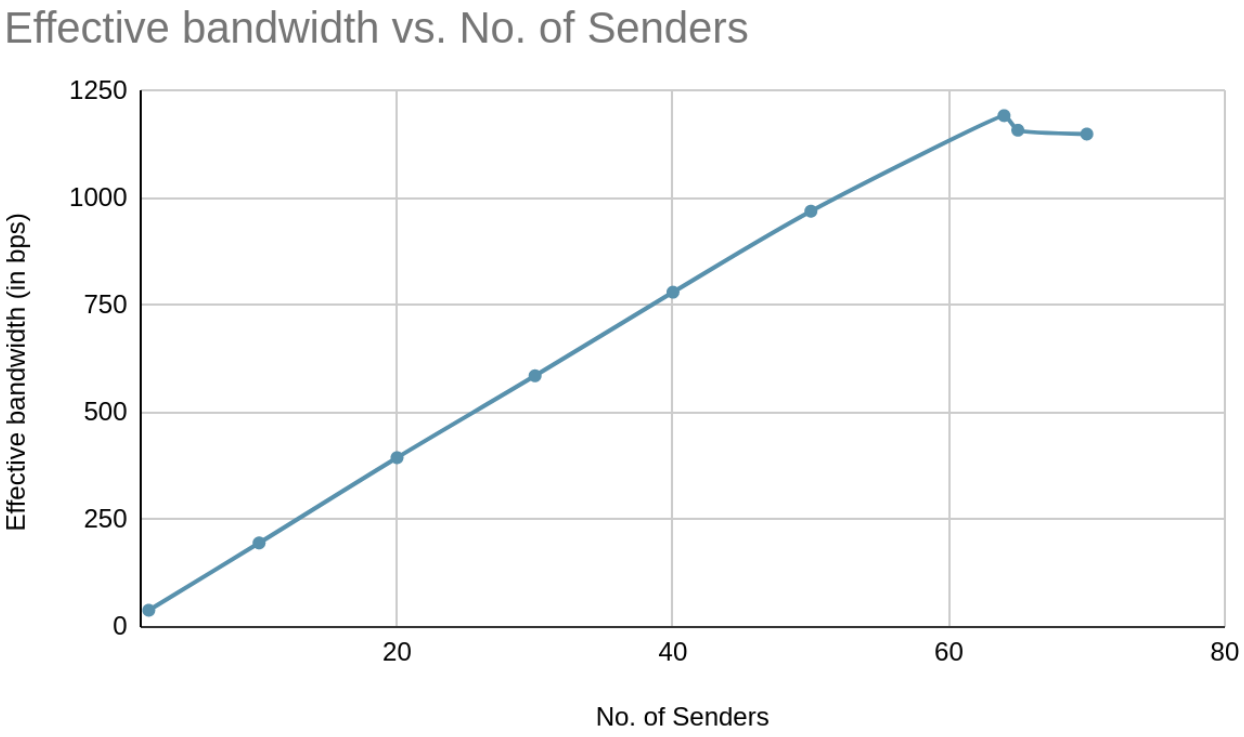
No. of Senders	Total time taken (in sec)	Effective bandwidth (in bps)	Average Successful Transmission Time of a data bit
2	9.332	39	0.0507
10	9.347	196	0.0508
20	9.475	395	0.0506
30	9.411	586	0.0511
40	9.569	781	0.0514
50	9.628	970	0.0517
64	10.339	1193	0.0538
65	7.472	1159	0.0561
70	8.012	1150	0.0611

Analysis:

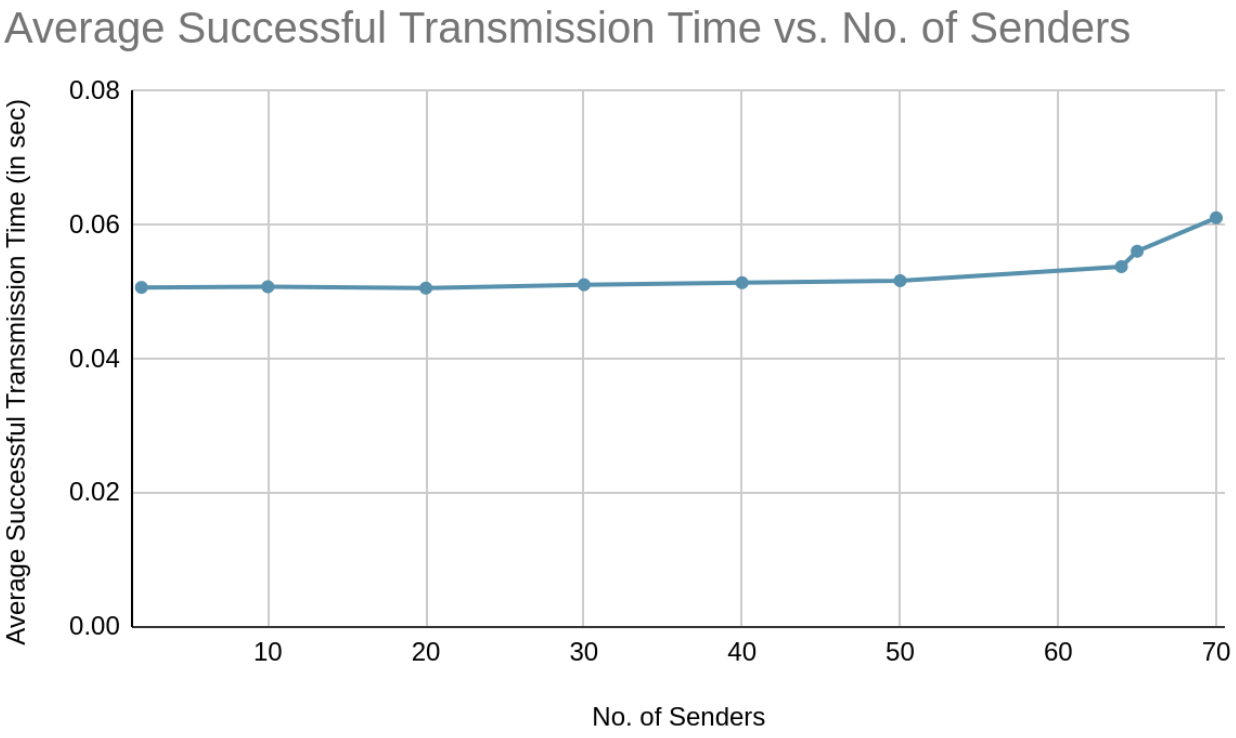
- **Total Time Taken:** From the graph below, we can observe that up to the no. of senders of around 64, the total time taken remains almost constant, and then faces some fluctuations. Theoretically, CDMA should be taking constant time independent of no. of senders, which implies the curve should be a straight line parallel to the x-axis, but they fluctuate gradually with more no. of senders, possibly because of the time slot lapse that occurs due to channel processing time exceeds the time for a time slot.



- **Effective Bandwidth:** Theoretically in CDMA, there is no chance of collision and hence no time slot loss occurs. So the curve should be a linear increasing curve, where the effective bandwidth or channel utilization increases with the no. of senders. This happens exactly the same for up to a certain no. of senders around 64. But, after that, the curve takes a dip, which is possibly due to the channel taking more time than a timeslot (i.e. 50ms here) to club the data. So, some of the timeslots get lapsed without sending any data. This thing is more common when no. of senders is high.



- **Average Successful Transmission Time:** Average Successful Transmission time for a data bit remains almost constant for all types of sender counts, which should be the case for CDMA.



As the number of active sender stations increases, bandwidth utilization for CDMA fluctuates. But at lower numbers CDMA provides a near-perfect throughput. So for a lower number of senders, this seems a good and feasible protocol.

Improvements:

- No flow control protocol is considered, hence an error-free channel is assumed, which is not a practical scenario.
- No frame format for the packets is also considered.
- This would have been more efficient if it was implemented in a language closer to the system such as C/C++.