Increasing the number of IOT devices for given bandwidth by combining FDMA with CDMA

Devanshu Agarwal
160020018
Electrical Engineering
Indian Institute of Technology
Dharwad
Dharwad, India
160020018@iitdh.ac.in

Tushar Singh
160020022
Electrical Engineering
Indian Institute of Technology
Dharwad
Dharwad, India
160020022@iitdh.ac.in

Raj Kumar
160020038
Electrical Engineering
Indian Institute of Technology
Dharwad
Dharwad, India
160020038@iitdh.ac.in

***Abstract*— Using CDMA we can multiplex users but that will require more bandwidth and therefore more power consumption, but using FDMA and CDMA both we can distribute same bandwidth to more number of IOT devices**

Keywords—CDMA, FDMA, bandwidth

I. PROCESSING IN A SINGLE IOT DEVICE

A. TRANSMITTER

The first step in sending the information will be CDMA (Code Division Multiple Access). In this the information will be mapped to a corresponding codeword. This codeword will be a binary string. After this, the process of FDMA (Frequency Division Multiple Access) will be implemented. In this the information will be further divided on the basis of their frequency. To achieve this, each signal will be changed from base-band to pass-band signal with different values of carrier frequency. Now, all the information will be sent to a transmitter which shall forward it to the channel.

B. CHANNEL

The channel will mostly be air. The channel will fade slowly and will introduce AWGN (Additive White Gaussian Noise). Thus the overall Signal that is propagating now is- the information plus the noise.

C. RECEIVER

The receiver at the other end demodulate the receiving signal (using PLL – Phase Locked Loop). The next step will be CDMA Receiver correlation. And at last FDMA Receiver. The resulting information will be the final output.

II. ASSUMPTIONS FOR CHANNEL

• Channel is introducing multipath effect that will result in different values of power received for LOS (Line of sight) signal.

• Increase in multipath effect (i.e., lesser value for Ricean factor K) will result in lower power of LOS signal.

• There is additive white Gaussian noise in the channel (because of heating effect in circuits).

III. THE PROCESS

The limit of input frequency(freq) to FDMA is 300 last and the max is bounded by f_sampling. Using 16 QAM ; bs = { +-1 , +-3} and bc = { +-1 , +-3} bc + bsj, so 4bits per symbol :

Information	***Code***
(+1,+1)	0000
(+1,-1)	0001
(+1,+3)	0010
(+1, -3)	0011
(-1, +1)	0100
(-1, -1)	0101
(-1, +3)	0110
(-1, -3)	0111
(+3, +1)	1000
(+3, -1)	1001
(+3, +3)	1010
(+3, -3)	1011
(-3, +1)	1100
(-3, -1)	1101
(-3, +3)	1110
(-3, -3)	1111

We are using 16QAM

$$U(t) = Uc(t) + J*Us(t)$$

$$[Uc(t),Us(t)] \in (\pm 1, \pm 3)$$

We mapped our bits to symbols using the look-up table.

Next, we modulated the signal with sinc pulse.

We now obtained pass-band signals by multiplying the modulated signal with cosine(2*pi*Fc*t) = Uc(t)*p(t)*cos(2*pi*Fc*t)

And sine(2*pi*Fc*t) = Us(t)*p(t)*sin(2*pi*Fc*t)

; p(t) = sinc pulse

Next the frequency modulated signal was passed to AWGN signal.

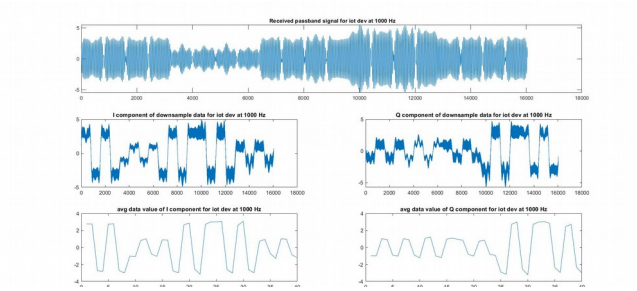
User at base station are supposed to provide two keys (1) frequency of operation of IOT dev and (2) its walsh code , using this user at base station can access data of desired iot dev.

2. Symbol received after ML estimate is stored is decoded_cdma_data_I and decoded_cdma_data_Q.

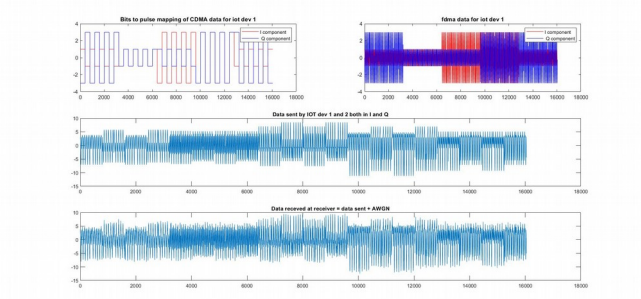
3. The raw binary data is stored in final_data.

The receiver will select the frequency of the desired IOT device by using a Band-pass filter.
Now to down sample the signal, the receiver will multiply I component to 2*cosine function and Q component to 2*sine function and pass them through a low –pass filer.
Average amplitude of every pulse of the desired signal is calculated to avoid high frequency which was induced due to noise.
Using ML rule we decided what CDMA encoded symbol it corresponds to.
We got I and Q from above.
If the received data does not correspond to our walsh codes then it will become zero.
After this, the received signal is passed through CDMA decoder to get corresponding data symbols.
Now the data symbols are further decoded using look-up table to get binary data.

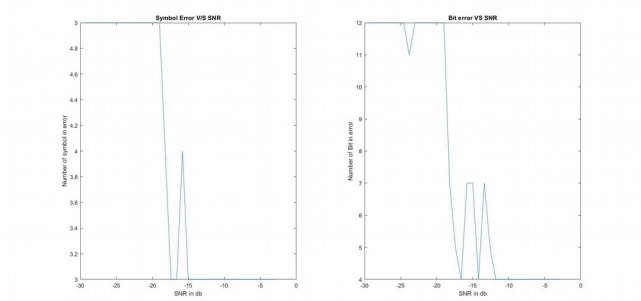
RECEIVER SIDE PLOT



SENDER SIDE PLOT



ERROR VS SNR PLOT



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