ANALYSIS OF DATA TRANSMISSION SCHEME FOR WIDE BAND CODE DIVISION MULTIPLE ACCESS WITH RAKE RECEIVER

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Abstract

Fifth generation systems are required to fulfill the objectives like compatibility, flexibility, high speed data rate and low cost. Universal Mobile Telecommunication System (UMTS) use WCDMA as the air interface for 4th generation mobile system. The performance of wireless communication system is often limited by the radio channel models. In urban areas, channel is modeled as Rayleigh fading channel. This channel causes multipath channels and other problems resulting degraded performance. Hence, channel estimation before receiver helps to receive the transmitted signal using rake receiver. Rake receiver is a conventional receiver for DS-CDMA system. In this, channel is estimated adaptively using LMS algorithm and performance of this algorithm is studied for various multipath channels and step sizes. Moreover, the channel introduces Inter Symbol Interference (ISI) and channel equalizers are used to compensate for the ISI. In this work, BER vs. SNR performance of Zero Forcing Equalizer (ZFE), Minimum Mean Square Error (MMSE) and MMSE- Decision Feedback Equalizer (MMSE-DFE) in WCDMA downlink system are compared with conventional rake receiver for various spread factors in Rayleigh multipath fading channel with Additive White Gaussian Noise.

Keywords*: WCDMA, UMTS, DS-CDMA, LMS, ZFE.*

INTRODUCTION

WCDMA standard has two modes for the duplex method, Frequency Division Duplex (FDD) and Time Division Duplex (TDD). The frequency bands allocated for UTRA are shown in Figure 1-1 .In UTRA there is one paired frequency band in the range 1920 -1980 MHz and 2110 - 2170 MHz to be used for UTRA FDD. There are two unpaired bands from 1900 -1920 MHz and 2010 – 2025

MHz intended for the operation of UTRA TDD. In this work we only consider the FDD mode of operation for the receiver.

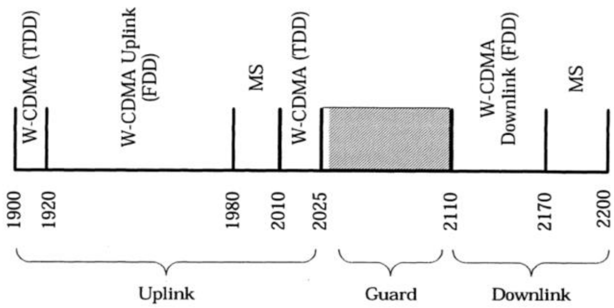

Figure 1-1: The frequency spectrum allocations for UTRA

Channel bandwidth	5 MHz
Duplex mode	FDD and TDD
Downlink RF channel `	Direct Spread
Chip rate	3.84 Mcps
Frame length	10 ms
Spreading modulation	Balanced QPSK (downlink) Dual-channel QPSK (uplink) Complex spreading circuit.
Data modulation	QPSK (downlink) BPSK (uplink)
Channel multiplexing in downlink	Data and control channels time multiplexed
Spreading factors	4-256 (uplink), 4-512 (downlink)
Spreading (downlink)	OVSF sequences for channel separation Gold sequences 218-1 for cell and user separation (truncated cycle 10 ms)
Spreading (uplink)	OVSF sequences, Gold sequence 241 for user separation (different time shifts in I and Q channel, truncated cycle 10 ms)

Table 1-1: Standardized Parameters of WCDMA

Table 1-1 shows the most important parameters of the UTRA FDD.As can be seen in Table 2-1, the chip rate for the WCDMA standard is 3.84 Mcps and Spreading consists of two operations. The first operation is the channelization operation where the spreading code is applied to every symbol in the transmitted data. Thus the bandwidth of the data signal increased. In this channelization operation, the number of chips per data symbol is called the Spreading Factor (SF). The second spreading operation is the scrambling operation, scrambling code is applied to the already spread signal. Both the spreading operations are applied to the so called In-phase (I) and Quadrature phase (Q) branches of the data signal. In the channelization operation, the Orthogonal Variable Spreading Factor (OVSF) codes are independently applied to the I and Q branches .The resultant signals of I and Q branches are then multiplied by a complex-valued scrambling code, where I and Q correspond to the real and imaginary parts respectively.

METHODOLOGY

Physical layer or L1 functions are the data transmission and presentation of required service presentation to higher layer. In the other word, this layer executes the commands which come from higher layer only and has no deciding about data transmission quality .In UMTS terrestrial radio access (UTRA), received information from higher layers in air interface has been carried by transport channel that mapped on physical channel in physical layer. Also physical layer must be support transport channel with variable rate for different services and multiplexing in a connection. The physical channels of the WCDMA systems are structured in layers of radio frames and time slots. There is only one type of downlink dedicated physical channel (downlink-DPCH). The structure layout of the downlink dedicated physical channel (DPCH) of the WCDMA signal can be seen in Figure 1-2.

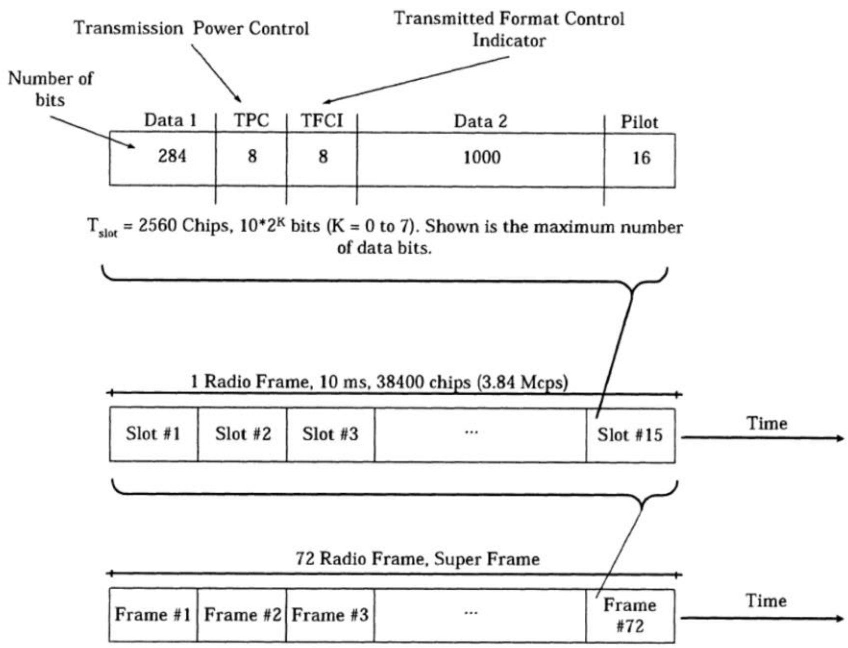

Figure 1-2: The Radio frame structure downlink DPCH of WCDMA

As shown, every WCDMA radio frame is 10 ms long. Each frame is then divided into 15 slots i.e. 2560 chips/slot at the rate of 3.84 Mbps .In addition; every 72 frames constitute one super frame. The frame is a time multiplexed data and control bits from the Dedicated Physical Data Channel (DPDCH). The Radio frame structure downlink DPCH of WCDMA and Dedicated Physical Control Channel (DPCCH). The DATA 1 and DATA 2 are data bits that belong to DPDCH, while bits of Transmit Power Control (TPC), Transport Format Combination Indicator (TFCI), and Pilot belongs to the DPCCH. The number of bits in each field varies with the number of bits in each field is shown .The TPC bits are used by the base station to command the mobile transceiver to increase or decrease the transmission power.

TFCI bits are the indicators of slot format. The bit count shown in Figure 1-2 is the maximum possible number of data bits that can be transmitted in one slot. In a frame 15x $10x2^K$ bits can be transmitted in every slot, where k is an integer in the range from 0 to 7. The parameter k is related to the Spreading Factor (SF):

$SF=512/2^k$ - (1)

Thus the spreading factor SF may range from 512 down to 4.

The WCDMA communications system is based on the DS-SS baseband data modulation. This implies that the signal's spectrum is expanded, i.e. the signal energy is distributed over a much larger bandwidth than the minimum required for transmission. In direct sequence spread spectrum (DS-SS), the signal is spread by multiplying it with a PN sequence with a much higher chip rate.

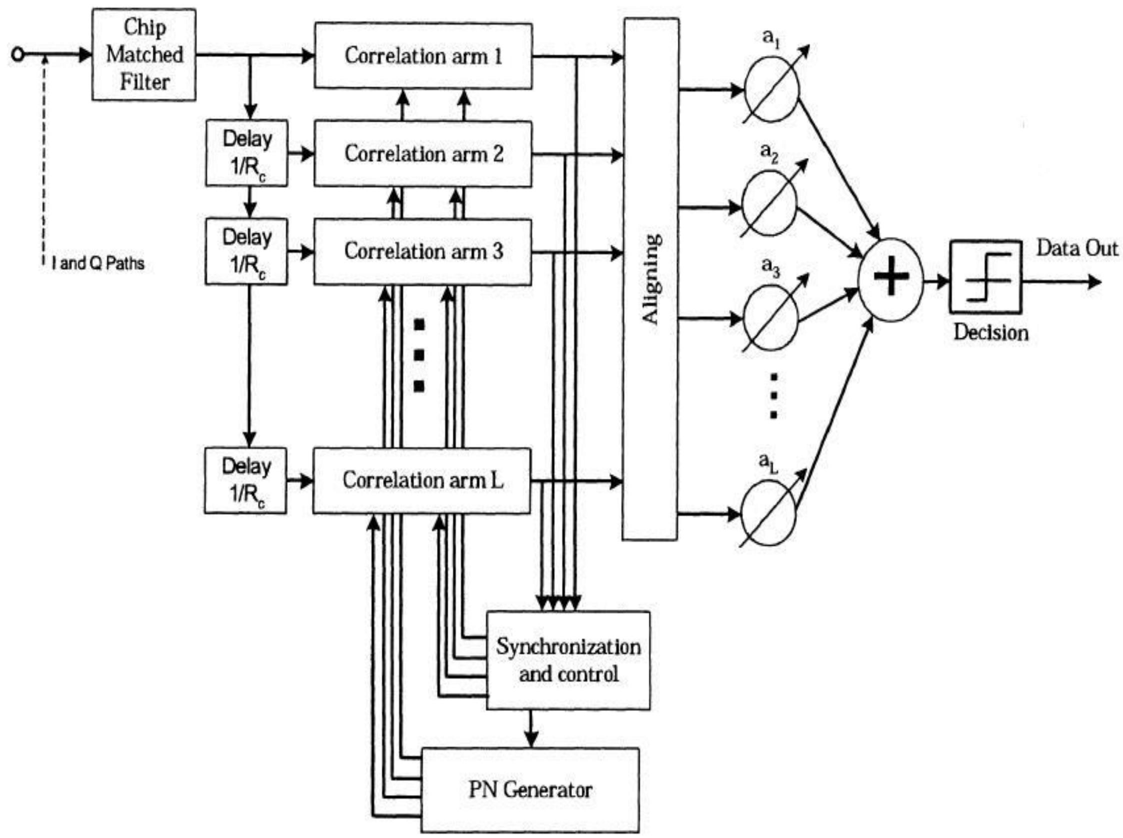

Figure 1-3: A block diagram of L arms Rake receiver

In the transmitter, the signal is multiplied by the spreading sequence which causes a spectral spreading of the original narrow band signal. At the receiver the signal is multiplied by the spreading sequence again. If the reference sequence of the receiver is synchronized to the data modulated PN sequence in the received signal, the original signal can be recovered. The RAKE is a special type of receiver that takes advantage of the multipath propagation. If the time spread of the channel is greater than the time resolution of the system then different propagation paths can be separated, and the information extracted from each path can be used to increase the signal to noise ratio (SNR). The time spread of the channel is given by the maximum delay between the arrivals of a transmitted signal on different propagation paths. The time resolution of the system is given by the inverse of the bandwidth of the radio frequency signal, or is equivalent to the chip period of the PN sequence. Figure 1-3 is a block diagram of L-arm RAKE receiver. The RAKE receiver is composed of two or more correlation arms, which extract the signals, arrived on different propagation paths. This is possible because the correlation between two versions of the

PN sequence delayed by one or more chips is almost zero. Therefore the propagation paths are separable. As shown in Figure 1-3, once the different paths are resolved, they are combined based upon their relative weights. Various techniques are known to combine the signals from multiple diversity branches. In Maximum Ratio combining each signal branch is multiplied by a weight factor that is proportional to the signal amplitude. Therefore, branches with strong signals are further amplified, while weak signals are attenuated.

DISCUSSION

This section shows the performance of WCDMA system with a rake receiver in a multipath Rayleigh fading channel with AWGN noise for spreading factor, SF=16 and 32. When spread factor factor, SF=16 then number bits transmitted in a frame is given by:

No. of bits transmitted in a frame= $15*10*2^k$

Here, k = 5 (Since, $SF=512/2^k$)

Therefore, No. of bits transmitted = $15*10*2^5$ = 4800 bits/frame

In this simulation, 10 DPDCH frame is transmitted, hence, total number of bits transmitted in 10 frames = 48000.

Similarly, when spread factor, SF=32 (k=4) then number bits transmitted in a frame is given by:

Therefore, No. of bits transmitted = $15*10*2^4$ = 2400 bits/frame

Therefore, total number of bits transmitted in 10 frames = 24000

Table 1-2 and Table 1-3 show the number of error bits for a range of signal to noise ratio.

Therefore, No. of bits transmitted = $15*10*2^4$ = 2400 bits/frame

Therefore, total number of bits transmitted in 10 frames = 24000

Table 1-2 and Table 1-3 show the number of error bits for a range of signal to noise ratio.

SNR	Bit Error Rate(BER)	No. of Errors	Total No. of bits Transmitted
0	1.231667e-001	2956	24000
2	1.012083e-001	2429	24000
4	8.033333e-002	1928	24000
6	6.258333e-002	1502	24000

8	5.108333e-	1226	24000
10	3.804167e-	913	24000
12	3.008333e-	722	24000
14	2.454167e-	589	24000
16	1.875000e-	450	24000
18	1.558333e-	374	24000
20	1.187500e-	285	24000
22	9.375000e-	225	24000
24	7.833333e-	188	24000
26	6.250000e-	150	24000
28	4.250000e-	102	24000
30	3.500000e-	84	24000
32	2.750000e-	66	24000
34	2.416667e-	58	24000
36	1.375000e-	33	24000
38	9.583333e-	23	24000
40	7.500000e-	18	24000

Table 1-2: BER for a range of SNR for rake receiver, with SF=16

SNR	**Bit Error Rate(BER)**	**No. of Errors**	**Total No. of bits Transmitt**
0	1.178333e-001	2828	24000
2	9.345833e-002	2243	24000
4	7.354167e-002	1765	24000
6	5.612500e-002	1347	24000
8	4.487500e-002	1077	24000
10	3.516667e-002	844	24000
12	2.745833e-002	659	24000
14	2.079167e-002	499	24000
16	1.558333e-002	374	24000
18	1.254167e-002	301	24000
20	9.958333e-003	239	24000
22	8.000000e-003	192	24000
24	6.166667e-003	148	24000
26	4.833333e-003	116	24000

28	3.583333e-003	86	24000
30	2.666667e-003	64	24000
32	1.791667e-003	43	24000
34	1.208333e-003	29	24000
36	9.583333e-004	23	24000
38	4.166667e-004	10	24000
40	1.250000e-004	3	24000

Table 1-3**:** BER for a range of SNR for rake receiver, with SF

CONCLUSION

A signal simulator according to the physical layer specification of the IMT-2000 WCDMA system is implemented using M-file in Matlab 7.10. The data is transmitted in a frame by frame basis through a time varying channel. The transmitted signal is corrupted by multiple access interference. The signal is further corrupted by AWGN at the front end of the receiver. A conventional rake receiver, ZFE, MMSE and MMSE-DFE are designed for analyzing the performance of each one of them for downlink WCDMA system.

The bit error rate (BER) of rake receiver, ZFE, MMSE and MMSE-DFE are investigated for a range of signal to noise ratio (SNR) for spreading factor, SF=16 and SF=32. The simulation results shows that WCDMA system with rake receiver, ZFE, MMSE and MMSE-DFE performs better with Spreading factor, SF=32 compared to spreading factor, SF=16. When the performance of rake receiver, ZFE, MMSE and MMSE-DFE is compared it is seen that equalizers performs better than rake receiver in WCDMA system. It is also seen that MMSE-DFE is better equalizer than ZFE and MMSE. Also MMSE performs better than ZFE.

In this thesis a WCDMA system with simple rake receiver, ZFE, MMSE and MMSE-DFE are designed to compensate for the ISI. Channel coding is not considered in this thesis, so turbo coding or convolution coding can be used as a channel coding technique to compensate for errors caused due to channel distortions. Moreover, MIMO systems are gaining popularity rapidly and can be used in channel equalization techniques to improve performance in WCDMA systems. The simulation of WCDMA system is done in Matlab 7.10 to analyze the BER vs. SNR performance, this can be done in DSP kit or using FPGA to have better results.

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