Tentative title: An implementation of IEEE802.11a based OFDM system using Subword Parallelism and Quantization Error Evaluation

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Motivation & Project Highlight:

Orthogonal frequency-division multiplexing (OFDM) is a complex modulation transmission technique, and it has already been accepted for the IEEE WLAN802.11a and many other standards. For high data rates, the IEEE 802.11 standard[1] provides two PHYs - IEEE 802.11b for 2.4-GHz operation and IEEE 802.11a for 5-GHz operation. OFDM is adopted as the baseline technology for 5-GHz WLAN systems because of its superior performance in combating fading multipath.

The FFT can be used to efficiently perform the modulation of data onto orthogonal carriers. Recent advances in very-large-scale integration (VLSI) technology make high-speed, large-size FFT chips commercially affordable. Using this method, both transmitter and receiver are implemented using efficient FFT techniques that reduce the number of operations from N^2 in DFT down to N log N.

In this project, we are going to profile a general IEEE802.11a standard based OFDM transmitter &receiver and try to figure out the evaluations of various specifications defined in the standard. Based on these specifications, first, we will try to employ a PLX simulator to simulate the OFDM algorithms, and efficient subword parallel techniques will be used to maximize the performance of the OFDM system, second, we will try to evaluate the relationship between quantization errors and bit error rate at the receiver.

Prior art:

In the IEEE802.11a standard [1], detailed specifications have been listed, different modulation techniques and parameters are defined for various transmission rates.

Data Rate Mbits/s	**Modulation**	**Coding Rate R**	**Coded bits per subcarrier**	**Coded bits per OFDM symbol**	**Data bits per OFDM symbol**
6	BPSK	1/2	1	48	24
9	BPSK	3/4	1	48	36
12	QPSK	1/2	2	96	48
18	QPSK	3/4	2	96	72
24	16-QAM	1/2	4	192	96
36	16-QAM	3/4	4	192	144
48	64-QAM	2/3	6	288	192
54	64-QAM	3/4	6	288	216

Table 1. Rate-dependent parameters

Parameter	**Value**
Nsd : number of data subcarriers	48
Nsp : number of pilot subcarriers	4
Nst :number of subcarriers total	52(Nsd + Nsp)
Tfft : FFT/IFFT period	3.2 microsec
Tsignal : duration of signal BPSK OFDM symbol	4 microsec(Tgi + Tfft)
Tgi : GI duration	0.8 microsec (Tfft/4)
Tgi2 : training symbol GI duration	1.6 microsec (Tfft/2)
Tsym : symbol interval	4 microsec (Tgi + Tfft)

Table 2 Time related parameters

The PHY parameters are listed in table 3

Information Data Rate	**6,9,12,18,24,36,48 and 54 Mbits/sec**
Modulation	BPSK
	QPSK
	16-QAM
	64-QAM
Error Correcting Code	K = 7(64 states) convolution code
Coding Rate	1/2, 2/3, 3/4
Number of Subcarriers	52
OFDM symbol duration	4 microsec
Guard Interval	0.8 microsec
Occupied Bandwidth	16.6 MHz

Table3 Major parameters of the OFDM PHY

In paper [2], WEINSTEIN AND EBERT first proposed a DFT implementation to do FDM. Since then, the fast Fourier transform has been the central arithmetic kernel of OFDM systems. There are a variety of algorithms and architectures in the design of an FFT. Algorithm choices in FFT implementations include whether the recursive decimation is performed in time or in frequency, and the radix (the number of sub-DFTs per decomposition stage), Radix-2, radix-4, radix-8, split-radix (a combination of radix-2 and radix-4 approaches) and even mixed-radix implementations are possible [3]. However, most of the algorithms did not think from a subword parallelism instruction sets' angle. In paper[4], PLX is shown to be a fully subword-parallel ISA. Subword parallelism has been shown to be critical for achieving high-performance in multimedia applications. Subword sizes in PLX can be 1,2,4 or 8bytes.

Approach:

In our approach, we have several steps as follow:

Step1. Establish an IEEE802.11a based OFDM system with Matlab

Step2. Evaluate various specifications based on the IEEE802.11 standard and analyze different types of transactions data.

Step3. Explore the PLX toolsets to develop the PLX implementation for the FFT/IFFT parts. Subword parallel approaches will be employed to maximize the FFT performance based on the data generated by our Matlab program.
Step4. Simulate and verify correctness of the PLX implementation.
Step5. Performance comparisons will be analyzed between codes with subword parallelism and that without subword parallelism.
Step6. Evaluate the relationship between quantization errors and bit error rate at the receiver

Expected Results:
We expect a basic IEEE802.11a based OFDM system will be establish and the PLX toolset will help us to boost the OFDM processing performance around 8 times compared with that of OFDM processing without subword parallelism.

[1] IEEE 802. 11a - 1999 Supplement to IEEE Standard for Information Technology and Telecommunications and Information Exchange between Systems —part 11 : LAN MAC and PHY Specifications :High Speed Physical Layer in the 5GHz Band , Sep 1999

[2] Data Transmission by Frequency-Division Multiplexing Using the Discrete Fourier Transform

[3] P. Duhamel and M. Vetterli. Fast Fourier transforms: a tutorial review and a state of the art. Signal Processing, 19:259–299, April 1990.

[4] PLX 1.1 ISA Reference