A Student Led Debate about Pros and Cons of CDMA and OFDM

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Abstract

A common misperception about education is "stuffing information into the student". Due to this misperception, students are not given enough time to analyze, synthesize, and evaluate the large amount of material they receive through education. According to Socrates, God has put a spark of truth inside each person. Hence, the purpose of education should be to help students find this spark inside them and kindle it to a flame. Active learning techniques such as class debates, project-based learning, and inductive teaching, provide opportunities for students to do something active besides transcribing notes. Most electrical engineering curriculum includes a class covering communication concepts. At xxx this class is offered at the junior level and it introduces students to all the basic analog and digital modulation and demodulation techniques and their behavior in the presence of noise and distortion. The class has an integrated laboratory experience that focus on system design and performance analysis. As part of the class objectives, students are also supposed to research the more advanced communication techniques and present their finding in a term paper. Last year, the instructor of this class decided to add another dimension to the objectives by conducting a student led debate about the pros and cons of Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM). Both techniques are used in the most recent communication systems. But, which technique is superior? Open ended questions like this are, in the author's opinion, a perfect candidate for a class debate. This paper describes how the debate was prepared, conducted and graded. It details the different tasks of the students and the instructor.

Introduction

Wireless communication has become increasingly important not only for professional applications but also for many fields in our daily routine and in consumer electronics. Today most teenagers have a mobile phone and they use it not only for calls but also for data transmission. More and more computers use wireless local area networks (WLANs), and audio and television broadcasting has become digital [1].

Most of these recent communication systems are based on two advanced modulation techniques that are known as Orthogonal Frequency Division Multiplexing and Code Division Multiple Access. These two techniques are usually covered in an advanced communication class that is usually offered as an elective and is focused on wireless communication and optical fiber.

At XXX University, communication topics are covered in a sequence of two classes. The first class is a required class in the electrical engineering program and is offered at the junior level. It covers different analog and digital modulation techniques and studies their performance in the presence of noise. The class also has an integrated laboratory component. The second class is an elective in the electrical, computer engineering and computer science programs. Because of the diverse background of students, this class focuses more on subjects related to source coding, encryption and channel coding. Hence, there is no place in the curriculum to cover CDMA and OFDM in a traditional lecture based teaching.

To solve this dilemma, the author of this paper decided to use an active learning technique which is based on a student debate on the pros and cons of OFDM and CDMA. The following section provides the reader with the necessary background about the two techniques. Section 3 describes the previous knowledge of the students and how it is related to the subject matter. Section 4 explains how the debate was prepared conducted and graded. Section 5 summarizes the concluding remarks.

Background on OFDM and CDMA

Both OFDM and CDMA are based on orthogonality, which is a very important aspect in digital communication. Due to orthogonality, different symbols can be transmitted during the same time slot and within the same spectra without interfering with each other. OFDM uses the different basis functions of the Fourier series to achieve orthogonality, and CDMA uses a Pseudo Random Sequence Generator (PRSG) to achieve different sequences that are approximately orthogonal on each other. In OFDM different symbols are distributed over several orthogonal subcarrier frequencies and, hence, the symbol clock rate is reduced dramatically. In CDMA the spectra of each user is spread by the use of PRSG, and hence, it will be buried in noise and has no effect on other users that are using the same spectrum. Both techniques are considered robust against multipath effect, which is a very challenging distortion property of wireless channels. OFDM achieves its robustness because the symbols' period is longer than the longest multipath echoes. CDMA achieves its robustness because the different time shifts of the PRSG that are caused by multipath echoes are essentially orthogonal on each other.

Previous knowledge of the students

OFDM has its roots in M-ary communication techniques such as orthogonal M-ary Frequency Shift Keying (MFSK), M-ary Phase Shift Keying (MPSK) and Quadrature Amplitude Modulation (QAM). All these techniques are covered in the communication class prior to the student debate. The largest difference is that the constellation diagram in OFDM is multidimensional [2], as shown in Figure 1.

The transmitter and receiver of the OFDM, which are shown in Figure 2, require knowledge of Fourier series, Discrete Fourier Transform and Analog to Digital converters. All these topics are usually covered in pre-requisite classes such as Signals and Systems and Digital Signal Processing.

CDMA is divided into two classes Direct Spreading (DS) and Frequency Hopping (FH) [3]. DS-CDMA has its roots in Binary Phase Shift Keying (BPSK), which is one of the topics covered in the communication class. FH-CDMA has its roots in MFSK, which is also covered prior to the class discussion. Both techniques depend on the PRSG which is usually covered in the digital design class. An example of a PRSG, which is typically a shift register with a feedback, is shown in Figure 3.

The major difference between the two classes is in the method used to achieve the spreading of the spectrum. As shown in Figure 4, DS-CDMA uses direct multiplication to achieve the spreading of the spectrum. On the other hand, FH-CDMA uses a frequency synthesizer to hop the carrier frequencies between different places in the spectrum, as shown in Figure 5. Because of the integrated lab component, students would already have an excellent background about different waveform spectrums and could very easily grasp these ideas with some research effort.

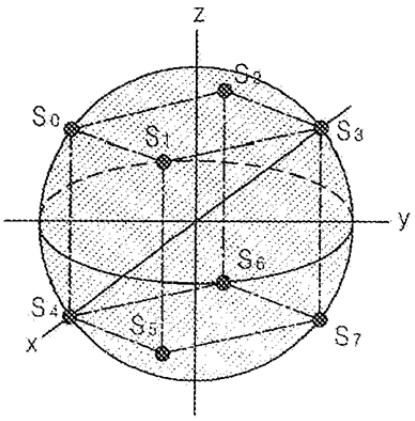

Figure 1. An example of a three dimensional constellation diagram for OFDM

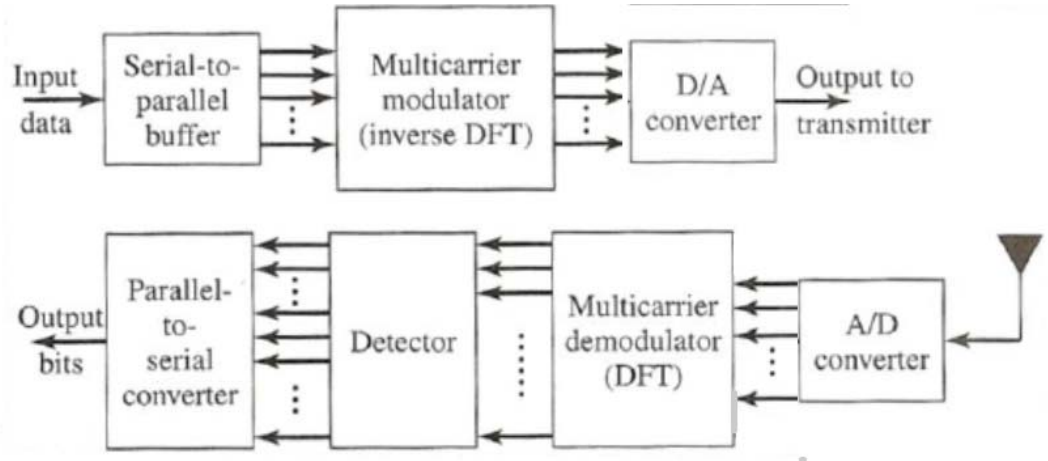

Figure 2. A simplified block diagram of an OFDM transmitter/receiver

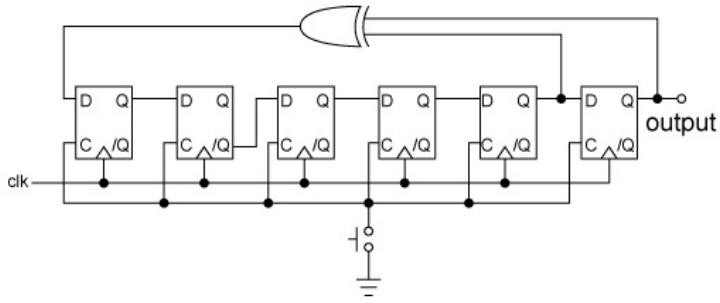

Figure 3. An example of a PRSG

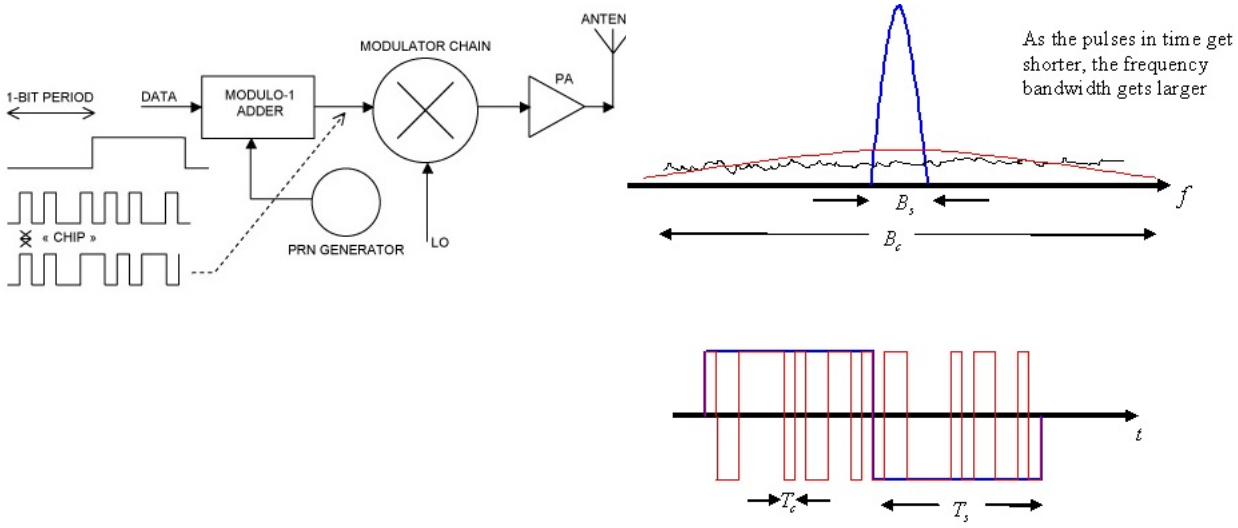

Figure 4. Spreading the spectrum in DS-CDMA

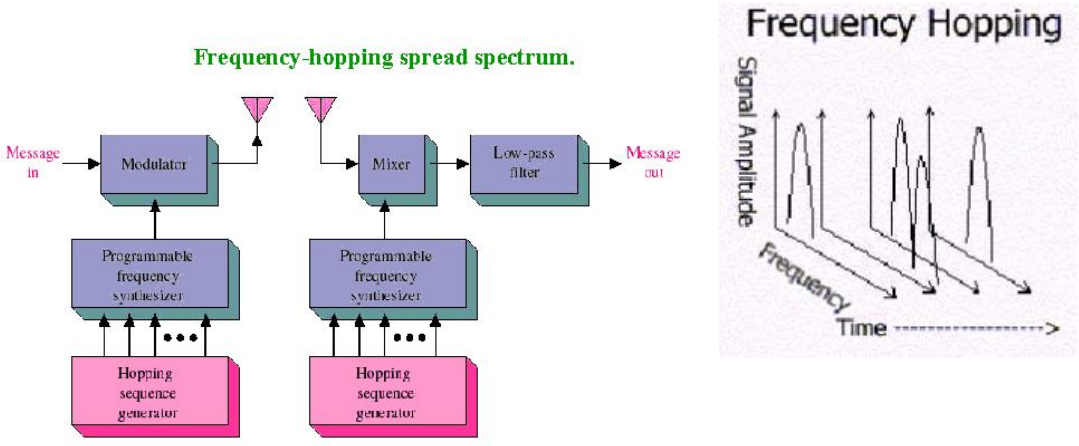

Figure 5. Spreading the spectrum in FH-CDMA

Student Debate

a. Preparation stage

The first and most important step in the preparation of any case study or student led debate is to establish the teaching objectives. The teaching objectives of this debate were as follows:

1. Orthogonality in Fourier Series and PRSG waveforms
2. Relation between OFDM and M-ary communication techniques
    a. Constellation diagram of OFDM
3. How to implement an OFDM transmitter/receiver
    a. D/A and A/D conversion
    b. DFT and IDFT
4. Spread spectrum techniques such as DS and FH
5. Relation between DS and BPSK
6. Relation between FH and MFSK
7. Different applications that uses OFDM and CDMA
8. Performance of OFDM and CDMA in the presence of noise
9. How can different types of distortion such as multipath echoes effect OFDM and CDMA
10. Multi access in OFDM and CDMA

Next, the debate was segmented into two parts basic and advanced. Learning objectives 1 through 6 were considered basic and learning objectives 7 to 10 were considered advanced. Different questions were generated for the two chunks.

The class was divided into two groups. A leader was assigned to each group to divide the research tasks among the different members of the group and achieve consensus on different research topics within the group.

Students were provided with the debate's title and learning objectives and were asked to individually prepare a one page report summarizing their findings. The reports were collected one week before the class debate and were analyzed by the professor. This step is extremely important in achieving a successful class debate. Through the analysis of the reports, the professor can easily find the students' confidence levels in the different learning objectives. This would help him avoid cold calling. Instead, the professor can ask students who are well prepared to answer his questions.

b. Conducting the debate

The professor established a controversy right away by arguing that since OFDM was adopted by the standardization committee of the 4^{th} generation cellphones it should be better than CDMA. This controversy prompted students right away to start speaking about the different applications that uses OFDM and CDMA and raised their interest in the subject. After few minutes the professor backed up the discussion to the basic concepts asking students to explain orthogonality concept and relate OFDM and CDMA to the different topics covered in class. After summarizing the main points on the board, the professor moved the discussion to the different classes of

spread spectrum techniques. Next, the discussion transitioned to the different blocks required to build OFDM and the two different classes of CDMA. Finally, advanced topics such as multiple access and performance of the two techniques in the presence of noise and distortion were discussed. The professor ended the discussion by explaining that the two techniques are similar in nature and picking a winner is really an open ended question. He added that the pros of the two techniques can be grouped together to form a multi-carrier CDMA. At the end of the class period, students were given two minutes to summarize the main points they learned from the discussion focusing on the technique that they didn't have a chance to research.

c. Grading the debate

The debate was graded based on three categories:

- 40% for the one page report
- 10% for the two minute summary
- 50% for the discussion in the class

The one page report was graded based on the number of learning objectives that has been covered correctly with supporting examples and evidence. The two minute paper was graded based on the concepts grasped from the class discussion. Grading the class discussion was the most difficult task, because it was conducted in real-time while the debate was running. To achieve a quick but fair assessment, the professor adapted a +/- rubric from the master teacher program workshop [4], shown in Table 1. After that, students were simply graded based on the accumulative number of +/-.

Table 1. A quick and fair rubric for grading class debates

+	-
Gets key issues	Raises trivial issues
Support claims	Provide no support for claims
Provides practical experience	Takes class off course
Opens new doors to investigate	Attacks others
Does deep analysis	Restate points
Provides insights from previous knowledge	Incorrect statements

Conclusion

This paper summarizes a class debate on the pros and cons of OFDM and CDMA that was conducted successfully in a communication systems class. Although the activity was not followed by a formal assessment, students' feedback was really positive. The activity gave the students the opportunity to learn from researching, as well as debating the topics. In fact, the two minute papers reflected how well students were able to understand both topics regardless of which topic they researched.

Bibliography

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