# Wi-Fi Implementation Using LabVIEW: Midterm Report

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## Introduction

One of the predominant schemes for wireless communication, Wi-Fi enables the majority of all internet traffic.As internet use increases, the need for Wi-Fi systems to provide higher throughput rates has persisted since its inception, leading to its implementation of Orthogonal Frequency Division Multiplexing (OFDM), first seen in the 802.11a standard. To gain a better understanding of this technology, the student proposes developing a limited-feature implementation of a Wi-Fi physical layer. Core elements such as modulation and demodulation, Orthogonal Frequency-Division Multiplexing

## Topic Background

Modern physical-layer Wi-Fi implementations incorporate a number of modulation and coding techniques to maximize throughput and robustness. Figure 1.1 illustrates the overall architecture.

A screenshot of a cell phone

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Figure 1.1: General Physical-Layer Architecture for Wi-Fi Systems

At its core, OFDM is a specialized technique of grouping up to 64 (default) or 128 subcarriers (introduced in 802.11ac) into a single channel. Each subcarrier sends individual data streams on a specified carrier frequency, in such a way that they are both tightly-packed and non-interfering.While most of the subcarriers present are data-bearing, there are four pilot subcarriers which provide a fixed, repeated signal for estimation processes. The layout of these subcarriers can be seen in figure 1.2.

It should be noted that the orthogonality of these subcarriers can be affected by changes in the physical space of transmission, whether that be the medium of the channel or movement of the devices; in both cases, the interference caused by this loss of orthogonality is known as *fading*, and is addressed via Forward-Error Correcting (FEC) schemes discussed later.

The transmission of bits of data by each subcarrier leverages the broad modulation scheme of Quadrature-Amplitude Modulation (QAM). In order to utilize this modulation technique, the transmitter and receiver must be synchronized, expecting a character to be transmitted at a fixed interval of time based on the period of the lowest-frequency subcarrier – the *symbol rate* of the channel. Synchronization is accomplished during a guard-time prior to transmission; typically, guard-times simply transmit the first symbol for an extended period, known as a *guard time* or *integration time*.

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Figure 1.2: Subcarrier Layout of 52-subcarrier Wi-Fi system

Given this synchronization, in-phase and quadrature (90-degree lagging) components of the subcarrier are used to determine bit values. Atransmitter is able to increase the complexity and bitrate of its subcarriers by increasing the resolution of the phase modulation and the range of amplitude modulation possible for these bits.A graphical representation (1.3) of the supported modulation techniques is provided to better illustrate this.

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To support the robustness of signals in non-ideal environments, Wi-Fi systems allow for the use of FEC codes. These codes add an amount of redundancy to transmitted frames by various checks and algorithms. wireless communications is specifically concerned with convolutional codes, which allow for a non-fixed data size; Wi-Fi in particular uses what is known as a *Viterbi code*. While further coding information will be considered outside the primary scope of this project, it should be noted that Wi-Fi systems typically support a coding rate (the ratio of data bits to redundant bits) of ½, with increases up to ¾ using a technique called *puncturing*.

## Deliverables

The student proposes the following deliverable goals of this project, whereas primary and mandatory goals are prefixed with “will provide,” and secondary and time-permitting goals are prefixed with “may provide.”

* Will provide capabilities for all subcarrier QAM modulation schemes in figure 1.3.
  + These will be selectable, based on a front-panel input.
  + This will be visible via a front-panel constellation diagram.
* Will effectively implement OFDM on a 52-subcarrier system.
  + This will be illustrated with an FFT and potentially a time-domain sink.
* Will provide a guard time for the beginning of each transmission.
* Will provide a hierarchical design that develops QAM, OFDM, and other potential system components in respective chains of subVIs.
* May implement Viterbi or other applicable FEC convolutional codes.
  + The implementation details will be discussed during the student’s midterm report.
  + Each implemented convolutional code will be its own subVI.
* May implement simulations, estimations, and recovery techniques for channel fading.
  + These will be visible through additional constellation and FFT sink diagrams.
  + A subVI or hierarchy of subVIs will be developed for each above aspect.

While the student may use the RF Communications toolbox to provide appropriate graphs/indicators, all features within this project should be implemented

## License and availability

The student intends to develop and publish this project to his Github page under a General Public License. This is intended as a way of providing academic and professional reference, as well as to receive feedback.

# References

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