ABSTRACT:

Single carrier frequency division multiple access (SCFDMA) which utilizes single carrier modulation at the transmitter and frequency domain equalization at the receiver is a technique that has similar performance and essentially the same overall structure as those of an OFDMA system. One prominent advantage over OFDMA is that the SC-FDMA signal has lower peak-to-average power ratio (PAPR). SC-FDMA has drawn great attention as an attractive alternative to OFDMA, especially in the uplink communications where lower PAPR greatly benefits the mobile terminal in terms of transmit power efficiency. SC-FDMA is currently a working assumption for the uplink multiple access scheme in 3GPP Long Term Evolution (LTE). In this paper, we give an in-depth overview of SC-FDMA with focus on physical layer and resource management aspects. We also show some research results on PAPR characteristics and channel-dependent resource scheduling of SCFDMA.

INTRODUCTION:

ORTHOGONAL frequency-division multiplexing (OFDM) which was known since the 1950s, was revived in the 1980s with the European Digital Audio Broadcasting (DAB) [1] and Digital Video Broadcasting (DVB) projects. This technique was standardized for both DAB and digital terrestrial TV broadcasting (DVB-T). The technical literature at that time, mostly by authors involved in the DAB and the DVB projects, did not leave much alternative to using OFDM for digital terrestrial TV, particularly for
mobile reception. In 1993, Sari et al. presented a conference paper [2], which reviewed the potential advantages and drawbacks of OFDM and introduced single-carrier transmission with frequency-domain equalization (SCT-FDE) as an alternative technique. The paper suggested that an SCT-FDE system could achieve the performance of OFDM on frequency-selective multipath radio channels while alleviating its peak-to-average power ratio (PAPR) and synchronization problems. This paper, which was contradicting the claims of many authors, started a long debate, which is still not closed. In the 1994-1995 time period, the same authors published several other papers on the same topic, the most well-known of which being [3].

The OFDM vs. SCT-FDE issue in the 1990s was focused on a pure transmission problem in the context of broadcasting (the wireless communications community was not yet a part of this discussion). In parallel with digital terrestrial television broadcasting, the DVB project was also addressing digital video broadcasting by satellites (DVB-S) and by hybrid fiber/coax (HFC) cable networks (DVB-C). After defining the technical specifications for the broadcast part, the group in charge of the specifications of digital cable TV systems started discussing the return channel for interactive services. One of the proposals was based on a simple orthogonal frequency-division multiple access (OFDMA) system, which assigned one
carrier to each subscriber. The carriers were locked to a common source such that the frequency spacing was the inverse of the symbol period used in the transmission. The signals transmitted by the cable modems were therefore singlecarrier signals, but the received signal was an OFDM signal. This proposal was rejected by the DVB cable group, but the concept was published in 1996 in [4], which laid the foundation of OFDMA. The word OFDMA itself was coined in this pioneering paper. Several other papers by the same authors followed in 1996-1998, see e.g. [5] and [6]. The motivation for OFDMA in cable TV networks was related to the presence of narrowband interference which affects the uplink. Indeed, TDMA- and CDMA-based systems are very sensitive to this interference and they cannot operate when the interference level exceeds some threshold. In contrast, in an OFDMA system, the cable head-end which assigns resources to cable modems can discard the carriers that are subject to interference and assign only those which have a good signal-to-interference-plus-noise ratio (SINR). The resulting performance improvement over TDMA and CDMA was shown to be substantial [7].

Single-carrier FDMA (SC-FDMA):

Single-carrier FDMA (SC-FDMA) is a frequency-division multiple access scheme. Like other multiple access schemes (TDMA, FDMA, CDMA, OFDMA), it deals with the assignment of multiple users to a shared communication resource. SC-FDMA can be interpreted as a linearly precoded OFDMA scheme, in the sense that it has an additional DFT processing step preceding the conventional OFDMA processing. SC-FDMA has drawn great attention as an attractive alternative to OFDMA, especially in the uplink communications where lower peak-to-average power ratio (PAPR) greatly benefits the mobile terminal in terms of transmit power efficiency and reduced cost of the power amplifier. It has been adopted as the uplink multiple access scheme in 3GPP Long Term Evolution (LTE), or Evolved UTRA (E-UTRA). The performance of SC-FDMA, in relation to OFDMA has been the subject of various studies. Although the performance gap is not much, SC-FDMA's additional advantage of low PAPR makes it a favorite especially for uplink
wireless transmission in future mobile communication systems where transmitter power efficiency is of paramount importance.

![Diagram of Generalized MC transmitter for SISO transmission.](image)

**Complete System Level Block Diagram:**

**Design and Implementation of Orthogonal Frequency Division Multiplexing (OFDM) Signaling**

This project consists of MATLAB simulation and DSP implementation. Using a graphical DSP design tool such as System View or dSpace, a real-time OFDM transmitter will be built. Figure 1 shows the flowchart of the MATLAB simulation code.
The transmitter first converts the input data from a serial stream to parallel sets. Each set of data contains one symbol, $S_i$, for each subcarrier. For example, a set of four data would be $[S_0 \ S_1 \ S_2 \ S_3]$.

Before performing the Inverse Fast Fourier Transform (IFFT), this example data set is arranged on the horizontal axis in the frequency domain as shown in Figure 2. This symmetrical arrangement about the vertical axis is necessary for using the IFFT to manipulate this data.

An inverse Fourier transform converts the frequency domain data set into samples of the corresponding time domain representation of this data. Specifically, the IFFT is useful for OFDM because it generates samples of a waveform with orthogonal frequency components.

Then, the parallel to serial block creates the OFDM signal by sequentially outputting the time domain samples.

The channel simulation will allow examination of the effects of noise, multipath, and clipping. By adding random data to the transmitted signal, simple noise can be simulated. Multipath simulation involves adding attenuated and delayed copies of the transmitted signal to the original. This simulates the problem in wireless communication when the signal propagates on many paths. For example, a receiver may see a signal via a
direct path as well as a path that bounces off a building. Finally, clipping simulates the problem of amplifier saturation. This addresses a practical implementation problem in OFDM where the peak to average power ratio is high.

The receiver performs the inverse of the transmitter. First, the OFDM data are split from a serial stream into parallel sets. The Fast Fourier Transform (FFT) converts the time domain samples back into a frequency domain representation. The magnitudes of the frequency components correspond to the original data. Finally, the parallel to serial block converts this parallel data into a serial stream to recover the original input data.

**CONCLUSION:-**

In this paper, we have given a historical review of two popular multiple access techniques, which are OFDMA and SC-FDMA. The controversial SCT-FDE vs. OFDM issue, which started in the early 1990s at the time of the European DVB project, continues today as an SC-FDMA vs. OFDMA debate in wireless communications. Whereas OFDMA was selected by the WiMAX Forum for mobile WiMAX systems for both downlink and uplink, the 3GPP project preferred to use OFDMA for the downlink only and favored SC-FDMA for the uplink.

We have also reported the results of some recent work on performance evaluation of these two multiple access techniques, which indicate that both techniques have some virtues and neither of them is better than the other in all conditions. In summary, OFDMA turns out to have better performance with high-order modulations which are used in favorable propagation conditions (typically for users near the base station). Stated differently, OFDMA lowers the SNR threshold above which high-level modulations and high code rates can be used. In contrast, SC-OFDMA is superior with QPSK and low code rates used typically near the cell edge and for users with bad propagation conditions. As a result, OFDMA can be expected to offer a higher cell capacity, while SC-FDMA can lead to cell range extension.
REFERENCES


