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Enhancement of Bit Error Rate using TDM OFDM in Passive Optical Network

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Abstract
Orthogonal frequency division multiplexing (OFDM), as the original form of various DSP methods with frequency-domain equalization (FDE), is chosen for both upstream and downstream transmissions.Accurate channel estimation is required for FDE. There are several FDE techniques are used to reduce the bit error rate (BER) and enhancement of transmission rate in combination with Orthogonal Frequency Division Multiplexing (OFDM). A hybrid TDM OFDM PON introduces a cost-effective, reliable and efficient access network. It can achieve maximum compatibility with current TDM-PON and achieves high spectral efficiency transmission over a fiber optic communication.

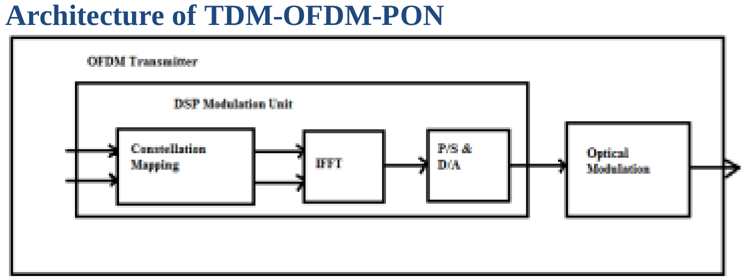
Introduction
Orthogonal frequency division multiplexing (OFDM) combined with time division multiplexing (TDM) so,called TDM-OFDM-PON, which allocates the resource only in time domain.Each of the multiple subscribers connected to the PON occupies the whole available bandwidth and transmits OFDM frames at dedicated time slots.

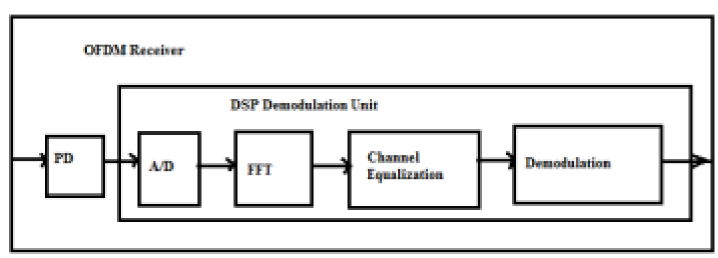
For the upstream transmission, only one ONU transmits OFDM signal at each time slot to avoid the interference with other ONUs. For the downstream transmission, OFDM frames are continuously broadcast to all ONUs, and each ONU selects its own packets according to the address.

A well-known channel estimation scheme is pilot-based channel estimation that uses periodically transmitted pilot signals. The OFDM symbols are transmitted in different time. To improve the bandwidth demand for next generation optical access network a hybrid PON environment is developed.The PON is an optical point-to-multipoint access network. The TDM-OFDM architecture consists of OFDM transmitter and OFDM receiver.

- The OFDM transmitter consists of a modulation unit based on DSP method.It has constellation mapping,inverse Fast Fourier Transform (IFFT),parallel to serial converter or digital to analog converter and optical modulation unit.
- The OFDM receiver consists of PD and DSP demodulation unit consists of,analog to digital converter,Fast Fourier Transform, channel equalization,demodulation

Architecture of TDM-OFDM-PON





There are several Various FDE techniques, i.e., zero forcing (ZF), maximum ratio combining (MRC),minimum mean square error (MMSE), amplitude clipping, selective mapping,fuzzy logic,channael estimation and dynamic bandwidth allocation (DBA) algorithm.These methods are used to reduce the bit error rate(BER).

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Frequency-Domain Equalization:
The high peak-to-average power ratio (PAPR) problem of orthogonal frequency division multiplexing (OFDM) while improving the bit error rate (BER) performance, the OFDM combined with time division multiplexing (TDM) using frequency-domain equalization (FDE) was recently proposed. In this paper,the theoretical BER analysis of the OFDM/TDM in a frequency-selective fading channel is presented. A conditional BER expression is derived, based on the Gaussian approximation of the residual inter-symbol interference (ISI) after FDE, for the given set of channel gains. Various FDE techniques, i.e., zero forcing (ZF), maximum ratio combining (MRC) and minimum mean square error (MMSE) criteria are considered. The average BER performance is evaluated by Monte-Carlo numerical computation method using the derived conditional BER expression[1].

Orthogonal frequency division multiplexing (OFDM) combined with time division multiplexing (TDM),called OFDM/TDM, can bridge the conventional OFDM and single-carrier (SC) transmission by using the frequency-domain equalization (FDE). Accurate channel estimation is required for FDE. A well-known channel estimation scheme is pilot-based channel estimation that uses periodically transmitted pilot signals. If channel estimation error is present, the inter-symbol interference (ISI) is produced in OFDM/TDM. In this paper,we apply a Gaussian approximation to the channel estimation error and theoretically investigate the impact of the imperfect channel estimation on the average bit error rate (BER) performance of OFDM/TDM[2].

Minimum Mean Square Error Frequency Domain Equalization
In a performance evaluation of OFDM/TDM using MMSE-FDE with pilot-assisted channel estimation over a fast fading channel is presented.To improve the tracking ability against fast fading a robust pilot-assisted channel estimation is presented that uses time-domain filtering on a slot-by-slot basis and frequency-domain interpolation.We derive the mean square error (MSE) of thechannel estimator and then discuss a tradeoff between improving the tracking ability against fading and the noise reduction. the OFDM/TDM using MMSE-FDE achieves a lower BER and a better tracking ability against fast fading in comparison conventional OFDM.There are two approaches to estimate the channel state information.In one approach, the channel estimation is done by time-domain multiplexed pilot (TDM-pilot), but the tracking ability against fast fading degrades. In another approach, the channel estimation is done by frequencydomainmultiplexed pilot (FDM-pilot) to improve the tracking ability against fast fading, but the bit error rate (BER) increases due to increased noise after frequency-domain interpolation. This paper deals with the channel estimation forOFDM/TDM using MMSE-FDE over a fast fading channel. a pilot-structure for SC transmission and apply recursive least-square (RLS) algorithm in timedomain[3].

A pilot-assisted channel estimation (CE) for orthogonal frequency division multiplexing combined with time division multiplexing (OFDM/TDM) using minimum mean square error frequency-domain equalization (MMSE-FDE) over a nonlinear and frequency-selective fading channel. Joint use of time-domain filtering to increase the signal-to-noise ratio (SNR) of pilot signal and frequency-domain interpolation for OFDM/TDM is presented. OFDM/TDM with proposed pilot-assisted CE provides a better performance than OFDM since the peak-to-average power ratio (PAPR) problem can be reduced.The BER performance of OFDM/TDM in a frequency-selective fading channel can be improved when minimum mean square error frequency-domain equalization (MMSE-FDE) is applied[6].

Orthogonal frequency division multiplexing (OFDM) is adopted for several wireless network standards due to its high capacity and robustness against multipath fading. OFDM, however, has a problem with high peak-to-average power ratio (PAPR) that strictly limits its application. Recently, OFDM combined with time division multiplexing (TDM) using minimum mean square error frequency domain equalization (MMSE-FDE) was proposed to improve the transmission performance of conventional OFDM in terms of the bit error rate (BER) while reducing the PAPR. In this paper, the trade-off for OFDM/TDM using MMSE-FDE between the channel capacity and the PAPR in a nonlinear and frequency-selective fading channel. The OFDM/TDM using MMSE-FDE achieves a larger capacity with a lower PAPR in comparison with the conventional OFDM[7].

In a wireless channel, a signal propagates over a number of different paths that give rise to a frequency-selective fading, which produce severe inter-symbol interference (ISI) and degrades the

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transmission performance .orthogonal frequency division multiplexing (OFDM) for broadband wireless transmission due to its robustness against multipath fading. However, OFDM signals have high peak-toaverage power ratio (PAPR), and thus, a power amplifier must be operated with a large input power backoff (IBO). Recently, OFDM combined with time division multiplexing (OFDM/TDM) using minimum mean square error frequency domain equalization (MMSE-FDE) has been presented to reduce the PAPR, while improving the bit error rate (BER) performance of conventional OFDM.The OFDM-based schemes in a nonlinear and frequency-selective fading channel.It achieves a lower peak-power and capacity,which means significant reduction of amplifier transmit-power backoff, but with a slight decrease in signal bandwidth[11].

Amplitude clipped and filtered OFDM/TDM

The OFDM combined with time division multiplexing (OFDM/TDM) to alleviate the high peak-to-average power ratio (PAPR) problem of OFDM. To further reduce the PAPR, amplitude clipping can be used. However, the bit error rate (BER) performance degrades and the out-of-band (OoB) power spectrum grows. Therefore, filtering is necessary to suppress the OoB power growth, but the PAPR will regrow.This method used to find the how much, clipping affects the OFDM/TDM transmission in terms of PAPR, the power spectrum density (PSD) and the BER degradation. The OFDM/TDM can be used to reduce the clipping level and the required Eb/N0 for the given BER in comparison to OFDM with slight increase in OoB emission[4].

The OFDM signals have a problem of high peak-to-average power ratio (PAPR). Hence, a large transmit-power backoff or amplitude clipping is required. The amplitude clipping causes signal degradation and the BER performance increases. A trade-off between the PAPR reduction and the BER performance is present; the PAPR reduces as the level of clipping reduces, but the BER degrades due to signal distortion. Recently, we proposed OFDM combined with time division multiplexing (OFDM/TDM) to alleviate the high PAPR problem, while achieving better BER performance than OFDM. In this paper, a theoretical bit error rate (BER) analysis of clipped OFDM/TDM system in a frequency-selective fading channel is developed.the OFDM/TDM can significantly reduce the amplitude clipping level and the required average signal energy per bit-to-AWGN power spectrum density ratio Eb/N0 for the given BER in comparison to conventional OFDM[5].

Clipping and Selective mapping method (SLM) technique

Orthogonal frequency division multiplexing (OFDM) is a form of multicarrier modulation technique with high spectral efficiency and immunity to interference.the time domain of OFDM signal which is a sum of subcarrier sinusoids leads to high Peak-to-Average power ratio (PAPR). A simple technique used to reduce the PAPR of OFDM signals is to clip the signal to a maximum allowed value, at the cost of bit error rate (BER) degradation and out-of-band radiation.The other method is Selective mapping method (SLM) technique which is a probabilistic technique for PAPR reduction with aim of reducing the occurrence of peaks in a signal.The OFDM is a Multicarrier modulation technique splits the high rate data stream into N sub streams of lower data rate. The parallel systems divide the available bandwidth into N non overlapping sub channels. Each sub channel is modulated with a separate symbol and then the N sub channels are frequency multiplexed[12].

Orthogonal frequency division multiplexing (OFDM) signals have a problem with a high peak-to-average power ratio (PAPR). A distortionless selected mapping (SLM) has been proposed to reduce the PAPR, but a high computational complexity prohibits its application to an OFDM system with a large number of subcarriers. Recently, we proposed OFDM combined with time division multiplexing (OFDM/TDM) using minimum mean square error frequency-domain equalization (MMSE-FDE) to improve the bit error rate (BER) performance of conventional OFDM with a lower PAPR.In this paper, we present an SLM combined with symbol re-mapping for OFDM/TDM using MMSE-FDE. Unlike the conventional OFDM, where SLM is applied over subcarriers in the frequency domain, we exploit both time and frequency dimensions of OFDM/TDM signal to improve the performance with respect to PAPR and BER. A mathematical model for PAPR distribution of OFDM/TDM with SLM is presented to complement the computer simulation results. It is shown that proposed SLM can further reduce the PAPR without sacrificing the BER performance with the same or reduced computational complexity[13].

In a joint selected mapping and clipping method is proposed to reduce the peak-to-average ratio of OFDM signal. Here cyclically shifted mapping data is used to generate a set of data blocks which represent the original information. This will increase the data rate when compared with the conventional SLM technique. Then clipping operation has done to reduce the PAPR further.It provides good performance in the BER compared to other methods and robustness to frequency selective fading or narrowband interference, high bandwidth efficiency and efficient implementation.Various techniques have been proposed to reduce PAPR, which can be categorized into three. First, there are signal distortion techniques, such as clipping, peak windowing, and peak cancellation which reduce the peak amplitudes simply by nonlinearly distorting the OFDM signal at or around the peaks. Second, there are coding techniques that use a special code set that excludes OFDM symbols with a large PAPR ratio. The third technique scrambles each OFDM symbol with different scrambling sequences and selecting the sequence that gives the smallest PAPR ratio[15].

ACF Technique

Orthogonal frequency division multiplexing (OFDM) is a promising modulation radio access scheme for next generation wireless communication systems because of its inherent immunity to multipath interference due to a low symbol rate, the use of a cyclic prefix, and its affinity to different transmission bandwidth arrangements.there are many techniques include Amplitude Clipping and Filtering, Peak Windowing, Peak Cancellation, Peak Reduction Carrier, Partial Transmit Sequence (PTS), Selective Mapping (SLM), Tone Reservation (TR), Tone Injection (TI) etc. In this paper, a relatively better scheme of amplitude clipping & filtering operation (ACF) is proposed.filtering is implemented which shows the significant improvement in case of PAPR reduction while increasing slight BER compare to an present method. Clipping is done in the time domain and after that the clipped signal is passed through the filter which is also composed of FFT, IFFT & band pass filter[16].

MultiCarrier modulation (MC) technique with Clipping and Differential Scaling

Multicarrier transmission system such as Orthogonal Frequency Division Multiplexing (OFDM) is a promising technique for high bit rate transmission in wireless communication system. OFDM is a spectrally efficient modulation technique that can achieve high speed data transmission over multipath fading channels without the need for powerful equalization techniques.It has high spectral efficiency and less intensive equalization is low power efficiency. OFDM signals are very sensitive to nonlinear effects due to the high Peak-to-Average Power Ratio (PAPR), which leads to the power inefficiency in the RF section of the transmitter. This paper investigates the effect of PAPR reduction on the performance parameter of multicarrier communication system.Performance parameters considered are power consumption of Power Amplifier (PA) and Digital-to-Analog Converter (DAC), power amplifier efficiency, SNR of DAC and BER performance of the system.the power consumption of PA and DAC reduces and power amplifier efficiency increases due to reduction in PAPR.The BER performance the requirement of Input-Backoff (IBO) reduces with reduction in PAPR[8].

Orthogonal Frequency Division Multiplexing (OFDM) has a popular communication technique for high speed communication.OFDM is an important member of the multicarrier modulation (MC) techniques used for various high data rate wireless communication systems due to its spectral bandwidth efficiency, robustness to frequency selective fading channels, etc. Although it is having many advantages it has two major drawbacks namely high PAPR and inter carrier interference (ICI).This paper is aimed to reduce the effect of PAPR and we proposed two techniques for the reduction of high Peak to Average Power Ratio (PAPR) based on Clipping, Differential Scaling. Multicarrier (MC) is actually the concept of splitting a signal into a number of signals, modulating each of these new signals over its own frequency channels and multiplexing these different frequency channels together in an FDM manner[17].

A Fuzzy Prediction-based Dynamic Bandwidth Allocation algorithm

A Fuzzy Prediction-based Dynamic Bandwidth Allocation (*FPDBA*) algorithm is proposed to enhance the differentiated services for EPONs based on the Prediction-based Fair Excessive Bandwidth Reallocation (*PFEBR*). The PFEBR proposed an Early-*DBA* mechanism which improves prediction accuracy by delaying report messages of unstable traffic ONUs and assign estimation credit to predict the traffic arrival during waiting time. Both Fuzzy Unstable Degree List Controller (*FUDLC*) and Fuzzy Credit Estimator (*FCE*) mechanisms are incorporated to improve the prediction accuracy and enhance the system performance for differentiated services. The FUDLC chooses the second traffic variance and the mean traffic variance of ONUs as input linguistic variables to determine the optimal number of ONUs in the unstable degree list. The FCE chooses the

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degree of traffic variance and the degree of waiting time among ONUs as input linguistic variables for the credit estimation, so that the request bandwidth for the next cycle can be predicted more precisely.Both provides the efficient bandwidth allocation algorithm (EAA) and DBA with multiple services algorithm (DBAM) in terms of wasted bandwidth, gain ratio of bandwidth, throughput, downlink available bandwidth, average end-to-end delay and average queue length, especial in heavy traffic load[10].

Dynamic Bandwidth Allocation

In an EPON system, all Optical Network Units (ONUs) share a common upstream transmission medium with limited bandwidth.An EPON system is a point-to-multipoint fiber optical network with no active elements in the transmission path from its source, i.e.,an optical line terminal (OLT),to a destination,i.e., an optical network unit (ONU).To efficiently utilize the limited upstream bandwidth, an EPON system must employ a medium access control (MAC) mechanism to arbitrate the access to the shared medium in order to avoid data collisions in the upstream direction.bandwidth allocation becomes one of the critical issues in the design of an EPON system and a variety of bandwidth allocation algorithms have been proposed in the literature. The bandwidth allocation for EPON systems and present a survey of the state-of-the-art dynamic bandwidth allocation (DBA) algorithms proposed for EPONs[9].

A hybrid Orthogonal Frequency Division Multiplexed/Time DivisionMultiplexed architecture with a dynamic bandwidth allocation scheme that provides satisfying service qualities to the users depending on their varying bandwidth requirements. Unnecessary delays in centralized schemes occurring during bandwidth assignment stage are eliminated by utilizing a decentralized approach. Dynamic Bandwidth Allocation Solutions depend on the multiplexing mechanism.This mechanism suggested under TDM group are based on multipoint Control Protocol (MPCP). MPCP is a signaling protocol used by both OLT and ONUs during bandwidth allocation process.Another method is an adaptive MAC polling protocol.Scheduling is performed in two domains.First one is the Inter-ONU Scheduling,which is used for transmissions ofmultiple ONUs in the system.ONUs inform the OLT about their bandwidth demands.Another type of scheduling is the Intra-ONU scheduling which is performed by the ONUs in the network[14].

Conclusion

As per the early technique of the Hybrid TDM OFDM PON is used to improve the performance of the Bit Error Rate(BER), Signal to Noise Ratio(SNR) ,Throughput and data rate. Various FDE and DBA techniques have been discussed,which shows the efficient algorithm used to provide the high bandwidth efficiency and its performance improvements.

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