Estimation of Average Transmission Time for an Orthogonal Frequency Division Multiplexing Network

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Abstract

This paper presents an efficient algorithm for estimation of average transmission time of an orthogonal frequency division multiplexing network. The proposed algorithm is based on probability of success of path from source to destination of network and transmission time of orthogonal frequency division multiplexing signal. The presented technique would be helpful for enhancing the transmission time of orthogonal frequency division multiplexing network.

Key Words - OFDM, Average Transmission Time, Directed Graph, Path Tracing.

Introduction

The first orthogonal frequency division multiplexing (OFDM) scheme was presented in 1966. OFDM is digital multi-carrier modulation technique which distributes the data over a large numbers of carriers that are spaced apart at particular frequencies. OFDM is used in most new and emerging broadband wired and wireless communication systems. OFDM is capable of dealing with the severe channel impairments encountered in a wireless environment.

Rosenkranz *et al*., (2009) presented application of the OFDM in optical communication for metro networks by investigating several design parameters for optimum receiver and transmitter design. Rosenkranz *et al*., investigated the interplay between the strength of the DC component (required for direct detection) and the amplitude of the OFDM signal.

Senguttuvan *et al*., (2009) presented current generation OFDM transceivers testing for error-vector-magnitude (EVM). Liang *et al*., (2009) gave MIMO–OFDM systems with time–domain transmit beam formation. Tu and Champagne (2007) presented novel subspace-based estimation method with a faster convergence rate, mainly by exploiting the frequency correlation among adjacent subcarriers through the concept of subcarrier grouping. Oberli *et al*., (2010) presented channel estimation in OFDM using transmission overhead. Liu and Elmirghani, (2009) presented two hybrid detection algorithms for OFDM-CDM systems which are based on a unified detection model.

The literature does not reveal any method for estimating the average transmission time of OFDM network. Therefore, the authors have made effort to develop an algorithm to determine average transmission time for OFDM network.

Problem Formulation

The authors have used following OFDM system model (Fig.1) as the network node for evaluating average transmission time. An OFDM carrier signal is the sum of a number of orthogonal sub-carriers, with baseband data (Armstrong, 2009). At OFDM transmitter, the input serial stream of binary digits are first demultiplexed into N parallel streams, and each one modulated. The Inverse FFT is used at OFDM transmitter to convert frequency domain signal into time domain signal and the digital-to-analogue converters (DACs) are used for the conversion of digital signal into analogous signal to transmit the signal. OFDM receiver works as a bank of demodulators that translates each carrier down to DC. Initially serial to parallel conversion of the signal and then FFT is used to convert back to frequency domain signal. The analogue-to-digital converters (ADCs) are used for the conversion of analogous signal into digital signal. OFDM transmitting and receiving systems must be linear.

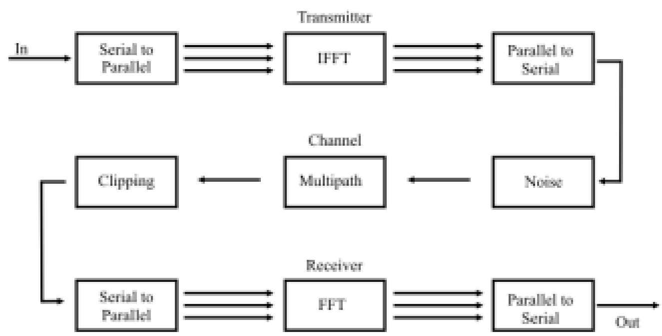

Figure 1: OFDM system model

In the developed algorithm for estimating average transmission time (symbol period) of OFDM network, transmitting time of each path between any two nodes and reliability of the nodes has been arbitrarily chosen. The parameters used for OFDM system model are given in Table 1.

Table 1: Parameters used for the transmitter (Theriault, Roy and Sentieys, 2010)

S. No.	Parameter	Value
1	Sampling frequency	20 MHz
2	Number of sub-carriers	56 (52 data and 4 pilots)
3	OFDM Symbol Period	4 μs (80 Samples)
4	Cylic Prefix Period	0.8 μs (16 Samples)
5	Coding Rates	1/2, 2/3, 3/4, 5/6,
6	Modulation Schemes	BPSK, QPSK, 16-QAM and 64-QAM
7	Data Rates	6.5, 13, 19.5, 26, 39, 52, 58.5, 65
8	FFT Processor	64-point

Service Time

Service time is the amount of time it takes for a bit to reach from source to its destination. The service time is the transmission time for OFDM Signal and in this paper propagation time for all components will be constant or negligible. By taking OFDM symbol duration of each sample to be 4 μs (Table 1), total service time for transaction (OFDM transmission time) for 80 samples can be calculated as follows:

Total service time for transaction (OFDM transmission time) = 4x80 = 320 μs = 0.32 (millisecond) ms Thus, different transmission time can be taken for the calculation of Average Transmission time. For this paper we have taken 0.5 ms transmission time of OFDM between two nodes.

Availability

At any time probability of path success or available at time in the network is called Availability or reliability of path in the network. For Example, any network, we take MTTF and MTTR as follows (Teorey and Teck, 1998):

MTTF = 10 hours (36, 000 sec) for each component or node

MTTR = 0.5 hour (1,800 sec) for each component or node

So, MTBF = MTTF+MTTR

= 10+0.5 = 10.5

Availability of single component or node of path in the network

A_i = MTTF/MTBF

= 10/10.5 = 0.9524

For the evaluation of average transmission time we have taken 0.99 availability.

Average Transmission Time

Average transmission time is the total service time for whole interconnected network considering all paths for transmission of OFDM Signal. For this parameter calculation maximum availability of path is required. Thus, we have been considered the path tracing method and 0.99 availability for calculation of Average transmission time. Average transmission time of OFDM has been calculated as follows: Average transmission time = Probability of successful path x service time taken by path

$$\text{Average Transmission Time}=P(p_1)t_1+P(p_2/\bar{p}_1)t_2+P(p_3/\bar{p}_1,\bar{p}_2)t_3+......$$

Where P_1, P_2, P_3….. are different paths for transmission of OFDM.

Where $\bar{p}_1, \bar{p}_2, \bar{p}_3$ ......are failed paths for the transmission of OFDM.

Network Structure Model

The structure model shows the network static characteristics. Structure models are built based on Graph theory, and the relationships of links and nodes are expressed in the form of adjacency matrix. To build topology model, for graph, if the network has n nodes, its topology can be expressed as adjacency matrix of *nxn* order matrix (Li *et al*., 2010).

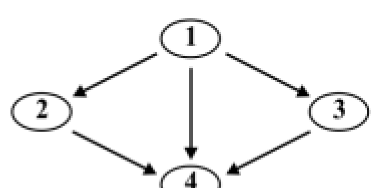

Figure 2: Network structure numbering method

Fig. 2 shows directed graph one link has one direction. In this paper network structure model has been considered unidirectional only. The graph is implemented as a record containing the number of node, the number of edges, the source and destination node, the reliability and transmission time between any two nodes. Adjacency matrix g(i, j) can be expressed as the connectivity of nodes are shown by 1 and if no connectivity between nodes than 0. Adjacency matrix of the graph:

$$g(i, j) = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Now directed graph has been created with all nodes and edges. The node represents the one OFDM system model (transmitter and receiver). The edge represents the connectivity between two nodes. The major drawback of the analytical method is that formulations can become very complicated for large scale network. The more complicated a system is the larger and more difficult it will be to analytically formulate an expression for the system's reliability. For particularly complete systems, this average transmission time evaluation can be quite time-consuming, even with the use of computers. Furthermore, when the maintainability of the system, shortest path or some of its components must be taken into consideration, an analytical solution may be impossible to compute. In these situations, the use of simulation methods may be more advantageous than attempting to develop a solution analytically. So algorithm is an effective way to evaluate this parameter.

Development of Algorithm

Enumerative algorithm has been presented for calculating the OFDM average transmission time.

i. Initially create the directed graph of the network on which OFDM Transmission time will be calculated.

ii. A directed graph has been created with all nodes and edges. The node represents the one OFDM system model (transmitter and receiver). The edge represents the connectivity between two nodes.

iii. The time between two nodes which are connected in directional way has been assigned randomly.

iv. The shortest path in the graph originating from initial node has been determined using minimum time algorithm.

v. Now, determine the single source shortest path from initial node to all other node in graph means determination of single source single destination shortest path from initial node.

vi. Also determine all the paths from node-i to node-j and may give priority to these paths.

vii. Now, calculate the average transmission time of OFDM with transmitting time of OFDM signal.

viii. In whole process availability for all single nodes has been assumed stable and same.

Result and Discussion

As networks are used to transmit energy and information, delay is a common failure mode for many kinds of network, such as communication network, computer network, transportation network, neural network and metabolic network. Therefore, average transmission time of OFDM network can be place forward as an important parameter. To evaluate "average transmission time" algorithm is presented with the case study of CARNET (China Education and Research Network) as shown in Fig. 3.

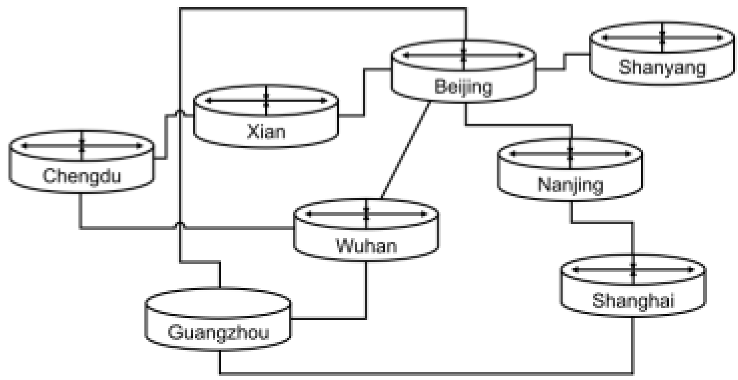

Figure 3: The structure of CERNET backbone network (Li, Huang and Kang, 2010)

The fig. 3 shows that this set of connections is undirected but for developed algorithm we consider in edict graph as shown below in fig. 4. For the evaluation of average transmission time, transmission time of OFDM is 0.5 *ms* and availability of the node is 0.99.

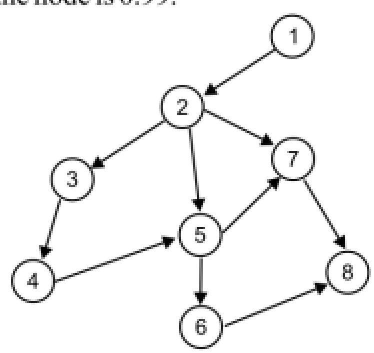

Figure 4: Edict graph of CERNET backbone network

The variation in percentage decrement of transmission time of OFDM between two nodes versus average transmission time of OFDM is plotted in Fig. 5.

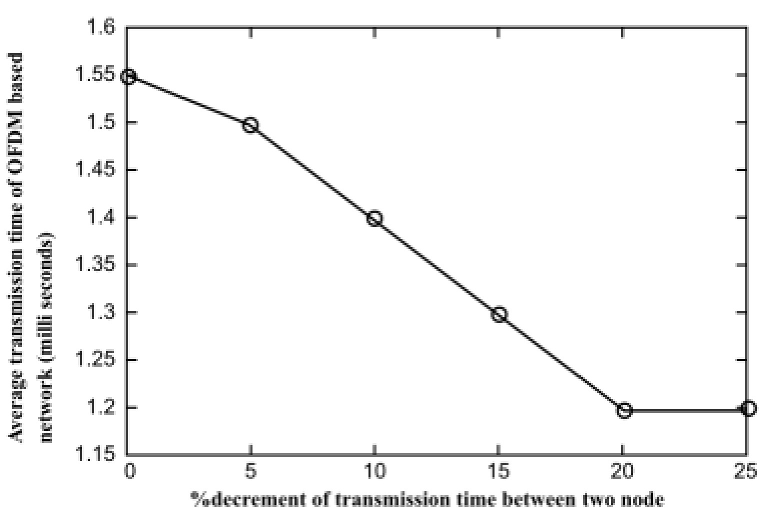

Figure 5: Percentage decrement of transmission time between two nodes versus average transmission time of OFDM network

If the transmission time of OFDM is initially taken to be 0.5 ms then average transmission time has been evaluated to be 1.55 ms. The minimum average transmission time can be achieved by gradually reducing the transmission time of OFDM. To achieve desired average transmission time, specific decrement of transmission time of OFDM between two nodes is required.

Conclusion

A number of researchers have shown that OFDM is also a promising technology for optical communications. To achieve good performance in optical systems OFDM must be adapted in various ways. This paper has been presented the average transmission time of OFDM with invariable availability of path. These facts are beneficial for average transmission time calculation. Algorithms are very much efficient for calculation of average transmission time. It is also less time consuming to enhance transmission.

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