CAPACITY PERFORMANCE EVALUATION OF RADIO OVER FIBER ON HYBRID WDM/TDM GPON ARCHITECTURE

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To
my beloved family and friends,
especially
my Mother and Father.

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ABSTRACT

The implementation of radio over fiber in wireless communication achieved high data rate and high capacity due to utilization of high capacity optical fiber and the flexibility of wireless network. Gigabit- Passive Optical Network (GPON) is the most important PON. The Time Division Multiplexing (TDM) technology was the basic technology for GPON, and Wavelength Division Multiplexing (WDM) PON is the most popular Access Network (AN) which utilized multiple wavelengths on a single fiber. But now, the most important AN technology is Hybrid WDM/TDM GPON technology. The WDM/TDM Hybrid GPON offers better performance than TDM PON, and satisfy the Quality of Service (QoS) requirements of WDM/TDM Hybrid GPON. This work Study the possibility of distribution 4G Base Stations hybrid WDM/TDM- GPON architecture for downlink, The aim of it is to design the network model using Optisystem simulation tools. The performance of the system was analyze in term of eye diagram, OSNR, error vector magnitude (EVM) and power budget. The design of hybrid WDM/TDM system is employing DPSK as the RF modulation scheme. In this design, the transmitter presenting eight input signal and serve 32 users. The network model have been modeled and simulated successfully and achieved the good performance network.

ABSTRAK

Pelaksanaan radio ke atas fiber dalam komunikasi tanpa wayar mencapai kadar data dan kapasiti yang tinggi disebabkan oleh penggunaan fiber optik yang berkapasiti tinggi dan rangkaian tanpa wayar yng be fleksibel. Gigabit Passive Optical Network (GPON) adalah PON yang paling penting. Time Division Multiplexing teknologi(TDM) adalah teknologi asas bagi GPON, dan Wavelength Division Multiplexing (WDM) PON adalah Access Network (AN) yang paling popular di mana panjang gelombang berganda digunakan ke atas jath gentian tunggal. Namun kini teknologi AN yang paling penting adalah teknologi Hybrid WDM / TDM GPON . WDM / TDM Hybrid GPON menawarkan prestasi yang lebih baik daripada TDM PON, dan memenuhi Kualiti Perkhidmatan(Quality of Service, QoS) bagi WDM/TDM hybrid GPON.Kerja ini udalah untuk mengkaji kemungkinan seni bina untuk 4G pengedaran Asas (Base Stations, BS) hybrid WDM/TDM- GPON untuk pautan turun (downlink). Objektifnya adalah untuk merekabentuk model rangkaian yang menggunakan alat simulasi optisystem. Analisis sistem prestasi adalah berdasarkan eye diagram analisis , OSNR, ralat magnitud vektor (error vector magnitude, EVM) dan bajet kuasa. Reka bentuk sistem hybrid WDM / TDM in adalah menggunakan DPSK sebagai skim RF modulation. Dalam rekabentuk ini, pemancar tersebut membentangkan lapan input isyarat dan berkhidmat kepada 32 pengguna. Model rangkaian ini telah berjaya dimodelkan, disimularikan dan telah mencapai prestasi rangkaian yang baik.

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3G	-	3rd Generation
4G	-	4th Generation
A/BPON	-	Asynchronous Transfer Mode Based Passive Optical Network
ADSL	-	Asymmetric Digital Subscriber Line
ATM	-	Asynchronous Transfer Mode
BS	-	Base Station
BER	-	Bit Error Rate
CDMA	-	Code Division Multiple Access
CO	-	Central Office
DAS	-	Distributed Antenna System
DE-MZM	-	Dual-Electrode Mach Zehnder Modulator
DWDM	-	Dense Wavelength Division Multiplexing
EFM	-	Ethernet First Mile
EMI	-	Electro-Magnetic Interference
EVM	-	error vector magnitude
FEC	-	Forward Error Correction
FTTH	-	Fiber To The Home
FSAN	-	Full Services Access Network
GbE	-	Gigabit Ethernet
GPON	-	Gigabit Passive Optical Network
IEEE	-	Institute of Electrical and Electronics Engineers
IF	-	Intermediate Frequency
IMT	-	International Mobile Telecommunications
ITU	-	International Telecommunication Union
LO	-	Local oscillator

MSC	-	Mobile Switching Centre
MZM	-	Mach Zehnder Modulator
NRZ	-	Non Return to Zero
OAN	-	Optical Access Network
OBI	-	Optical Beat Interference
ODN	-	Optical Distribution Network
OFDM	-	Orthogonal Frequency Division Multiplexed
OLT	-	Optical Line Terminal
ONT	-	Optical Network Termination
ONU	-	Optical Network Unit
OSNR	-	Optical Signal to Noise Ratio
OSSB+C	-	Optical Single Sideband with Carrier
PMD	-	Physical Media Dependent
PON	-	Passive Optical Network
PRBS	-	Pseudo Random Bit Sequence
RBS	-	Remote Base Station
RF	-	Radio Frequency
RoF	-	Radio over Fiber
SCM	-	Sub Carrier Multiplexing
SNI	-	service node interface
SCM/WDM	-	Sub Carrier Multiplexing/Wavelength Division Multiplexing
SDH	-	Synchronous Digital Hierarchy
SONET	-	Synchronous Optical Network
TDM	-	Time Division Multiplexed
WDM	-	Wavelength Division Multiplex
UNI	-	User Network Interface

CHAPTER 1

INTRODUCTION

1.1 Introduction

The Fast growth in capacity demand in access networks, driven by the increasing thirst for service bandwidths, service variety and number of service providers, asks for ever further penetration of fiber towards the end user residences. A number of key technologies are discussed for broadband service delivery through fiber access network infrastructures.

Broadband-wireless networks will probably use a radio over fiber (RoF) architecture to provide wireless connectivity to the users and to meet growing number of mobile subscribers coupled with the increasing demand of broadband services has kept sustained pressure on mobile networks to offer increased capacity For example, from 2 G to 3 G mobile communications,and more can be expected in 4 G mobile communications. RoF technology involves the use of optical components and techniques to allocate RF signals from the control stations (CS) to the base stations (BS). Thus, RoF makes it possible to centralize the RF signal processing function in one shared location (CS) with use of single mode optical fiber that has a very low signal loss to distribute the RF signals to the BSs.

In this project, the study will be focused on capacity performance evaluation of radio over fiber on hybrid WDM/TDM GPON architecture for distribution of 4G Base Stations (BSs).

This chapter included the project background, problem statement, project objectives, project scopes, methodology, and finally the thesis outline.

1.2 Project background

Communication becomes the most important to communicate with others anywhere.Now days,while the development of both communication and technology goes rapidly and the demand of communication growth up, it require network provide high bandwidth and data rate to give a good services for subscribers.

Wireless communications continue to enjoy phenomenal growth, the ever-rising demand for higher data-speeds coupled with the advent of popular bandwidth-hungry applications such as high-definition video are putting pressure on wireless communication systems to offer higher data rates and increasing the traffic, one solution to fix this problem is by using the microcellular system or decrease the cell size, moreover it could be also reduce the power consumption of the mobile station.These can be done by using the optical fiber which is efficient medium for radio network backhaul even in wireless networks offers a good flexibility and capacity.

Increasing demands for data rates in 3G systems and decreasing cell size induce an increase the number of remote sites which have to be installed in the cells,this becomes new problem, many researchers have done the research to overcome this problem. Martin Bouda, Paparao Palacharla, have proposed and demonstrated the cost-effectiveness of a Wavelength-Shared Hybrid PON architecture which is solution of low cost as a number of cell increase[1]. In [2]

demonstrated Combining Gigabit Passive Optical Network (GPON) architecture with Radio over Fiber (RoF) technology could be a cost-efficient and attractive solution of operators for the distribution of 3G Base Stations (BS),Yang Liu et. al. [3], They introduces a WDM/TDM Hybrid GPON technology, analyzed the WDM/TDM Hybrid GPON architecture, consider the evolution about the bandwidth allocation. A new simple Hybrid GPON BA algorithm is used to illustrate Hybrid GPON performance. The simulation results show that the WDM/TDM Hybrid GPON offers better delay performance and QoS performance than traditional TDM-GPON, and this algorithm can satisfy the full service QoS requirements of WDM/TDM Hybrid GPON. But The demand of capacity fast growth in access networks because the huge number of users the (3G) application is not something extraordinary, It is possible to study the integration Radio over Fiber on hybrid WDM/TDM Gigabit Passive Optical Network (GPON) architecture, especially for distribution of 4th generation (4G) Base Station in the wireless communication system.

1.3 Problem Statement

With the huge demand of multimedia data, high data rate and increase the number of users , RoF technologies can meet the increasing bandwidth demands in such wireless systems to provide flexibility and large capacity for wireless services, in this project we proposed the integration of Radio over Fiber network over hybrid WDM/TDM GPON for 4G wireless communications. The performance parameter of the network needed to predict and calculate to understanding the modeling.

The performance analysis parameters such as Error Vector Magnitude (EVM) parameter should be considered as a guarantee for good quality system, Optical Signal to Noise Ratio (OSNR) parameter also important which is can be used to monitor the optical channels, furthermore, the optical loss in the access line should be consider.

In conclusion, the main study in this project is "How to develop the capacity performance evaluation of WDM/TDM hybrid GPON architecture".

1.4 Objectives of Study

1. To study and investigate the performance of candidate architecture GPON for Hybrid WDM/TDM.
2. To analyze and investigate the performance parameters of the WDM/TDM Hybrid GPON network.
3. To increase the capability of network model based on hybrid WDM/TDM network in order to provide full services (including high-bit-rate Internet access) for huge number of users and increase the capacity of network with low cost.

1.5 Scope of Study

The scopes of this project are:

Literature review: Starting from ROF technology, review of current progress on RoF implementation over Gpon architecture and access network technology that have been developed.

Design and simulate: designing the integration network of of WDM/TDM hybrid GPON architecture for distribution of 4G Base Stations,then simulating this design.The simulation tool that will be used to achieve the objectives is Optisystem software.

Performance analysis: Analysis for the work will be focus on performance analysis parameters.The performance evaluation will be in terms of the achieved bandwidth, Optical signal-to-Noise Ratio, , Eye diagram, Error Vector Magnitude(EVM), optical power budget and the number of users that can be served.

1.6 Methodology

This project concentrate on the design of WDM/TDM hybrid - gigabit passive optical network on radio over fiber which provide high quality. Information goes rapidly for huge number of subscriber in term of reliable wireless data rate and good performance of OSNR. The overall project flow is shown in flowchart 1.1

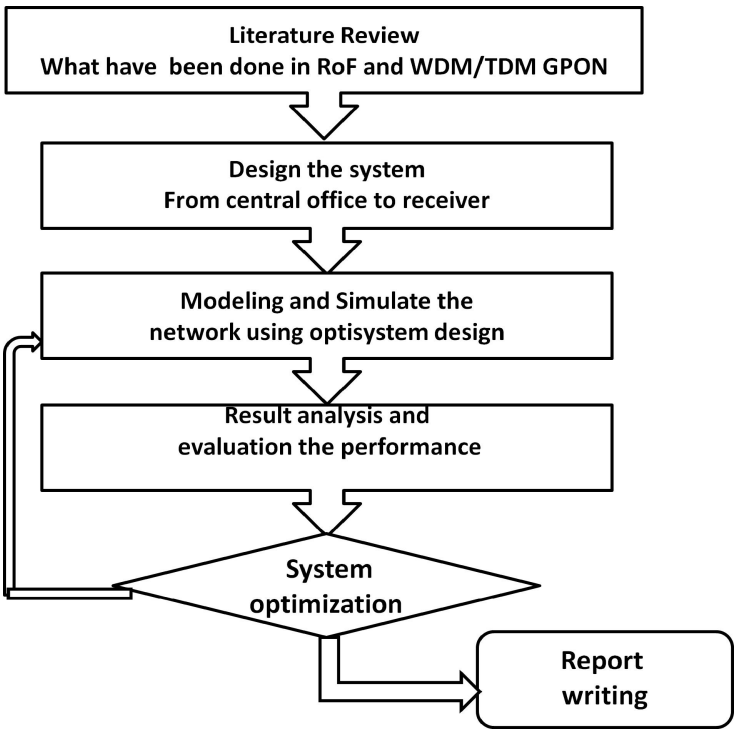

Figure 1.1: Methodology flowchart

The methodology starts with review of radio over fiber and current progress of ROF, then the network design will be done, which is develop the model network combining hybrid WDM/TDM Gigabit passive optical network(GPON) with radio over fiber used for distribution of 4G base station.

Then simulate the network design by using Optisystem software,system performance evaluation and result analysis will be optimize,the performance evaluation will be in terms of: eye diagram, error vector magnitude ,optical power budget,optical signal to noise ratio,the bandwidth achieved and the number of users that have been increased and served. If the optimization satisfying of the system, the report writing can be started. Otherwise, the optimizing in the design has to be done.

1.7 Thesis Outline

Chapter 1 briefly introduces this project by explaining background of the study, statement of the problem,objectives of the study,scope of the study,methodology, and report outline.

Chapter 2 describes about the basic theory of Radio over Fiber and review of the previous work which relate to this project.

Chapter 3 explains the architecture of GPON technology and the integration.

Chapter 4 presents the simulation network model hybrid WDM/TDM GPON architecture consist of the transmitter model, the receiver model, and the transmission link model for downstream transmission. In this chapter also discuss the simulation performance parameters of the network.

Chapter 5 discusses the simulation results and performance analysis based on the plotted graph which was obtained after simulate the network model. The performance parameters which were analyzed are Eye diagram, OSNR, EVM,and Optical Budget for downstream transmission for network model.

Chapter 6 describes the summary of all have been done in this project, conclusion, and suggestion for future work.

REFERENCES

1. Bouda. et. al. Cost-Effective Wavelength-Shared Hybrid Passive Optical Network Upgrade Re-using Both Optical Network Units and Remote Node, Optical Communication (ECOC), 2007 *33rd European Conference and Ehxibition of* , vol., no., pp.1-2, 16-20 Sept. 2007

2. Le Bras, H. and Moignard, M. Distribution of 3G Base Stations on Passive Optical Network Architecture *Microwave Photonics, International Topical*Oct. 2006 :1-4 .

3. Yang Liu. et .al. WDM/TDM Hybrid GPON Technology,*Photonics and Optoelectronics (SOPO)*, 2011 Symposium on , vol., no., pp.1-3, 16-18 May 2011

4. Medeiros, et. al. Radio over fiber access network architecture employing reflective semiconductor optical amplifiers,*ICTON Mediterranean Winter Conference* 2007.

5. Pleros,N. et. al. A 60 GHz Radio-Over-Fiber Network Architecture for Seamless Communication With High Mobility *Lightwave Technology, Journal* June15, 2009 12:1957-1967.

6. LAM, CEDRIC F. Passive optical networks *British Library Cataloguing in Publication Data*2007. 13: 978-0-12-373853-0.

7. R.S, Kaler. Simulation of Fiber to the Home at 10 Gbit/s using GE-PON architecture, *Department of Computer Sciences, Regional Institute of Management and Technology, Mandi Govindgarh, Punjab, India ,Thapar University, Patiala* 2011.

8. Imai, K. Agata, A. Horiuchi, Y. Edagawa, N. 3G Cellular Phone Signal Optical Transmission over Gigabit E-PON System, *Microwave Photonics,International Topical Meeting* Oct. 2005 : 47- 50.

9. Susanti, Rika. Radio over fiber on gigabit passive optical network architecture *universiti teknologi Malaysia*2010.

10. Bakarman, H.A. et. al. Simulation of 1.25 Gb/s downstream transmission performance of GPON-FTTx *Photonics (ICP), International Conference*July 2010 :1-5.

11. Imai, K. et. al.3G Cellular Phone Signal Optical Transmission over Gigabit E-PON System *Microwave Photonics, International Topical*Oct. 2005. :47-50.

12. El-Nahal.and FadyI. Bidirectional WDM-Radio over Fiber System with Sub Carrier Multiplexing Using a Reflective SOA and Cyclic AWGs *Electrical Engineering Department, Faculty of Engineering Islamic University of Gaza* 2011.

13. Gupta, Monika. et al.Performance Analysis of FTTH at 10 Gbit/s by GEPON Architecture D*epartment of Electronics and Communication Engineering, SSIET, Derabassi, Punjab, India* 2010.

14. Chan. Chien Aun. Remote Repeater-Based EPON With MAC Forwarding for Long-Reach and High-Split-Ratio PassiveOptical Networks *Optical Society of America*2010.

15. Kwang. et.al. Design of a Hybrid PON System for GPON Reach Extension on the Basis of Colorless DWDM-PON and 3R Regenerator *GLOBECOM Global Telecommunications Conference* Dec. 2010 :1-4,

16. Guido Maier. et.al.Design and Cost Performance of the Multistage WDM-PON Access Networks*JOURNAL OF LIGHTWAVE TECHNOLOGY*, VOL. 18, NO. 2, FEBRUARY 2000.

17. Onn, Haran. et.al. The Importance of Dynamic Bandwidth Allocation in GPON Networks *PMC-sierra, issue*January 2008.

18. Dadrasnia,E and Adikan, F. DWDM effects of single model optical fiber in radio over fiber system *Electronic Computer Technology (ICECT),International Conference*May 2010 :39-41.

19. S.M.Lee,S. et.al. Demonstration of a long-reach DWDM-PON for consolidation of metro and access networks *J. Lightwave Technol* 2007 25:271-276.

20. Alshaer,H and Alyafei, M. An end-to-end QoS scheme for GPON access networks *GCC Conference and Exhibition (GCC),IEEE* Feb. 2011 :513-516.

21. U. Ibrahim, Hassan Abbas, Raja faizan. Performance Evaluation of PhotoReceivers in WDM Passive Optical Networks *Department of Electrical Engineering COMSATS Institute of Information Technology Abbottabad, Pakistan* 2010.

22. ITU-T Recommendation G.984, Gigabit-capables passive optical network (GPON) *ITU* 2008.

23. Shahidah,N. et. al. Optimization for the Best Performance for Wavelength Division Multiplexed Passive Optical Network *2nd Engineering Conference on Sustainable Engineering Infrastructures Development - Management-Malaysia* December 2008.

24. Verma. Nitish and Singhal Ankur. Performance analysis of FTTH Gigabit Ethernet Passive Optical Network (GEPON) system with triple play services *MM University, Mullana, Ambala, Haryana, India*2011.

25. Yang ,Liu. et al.WDM/TDM Hybrid GPON Technology, Photonics and Optoelectronics *(SOPO) Symposium* May 2011.

26. Koenig, S.et. al.Rival signals in SOA reach-extended WDM-TDM-GPON converged with RoF *Optical Fiber Communication Conference and Exposition (OFC/NFOEC) and the National Fiber Optic Engineers Conference* March 2011.

27. Luying, Zhou.et. al. Hybrid WDM-TDM PON architectures and DWBA algorithms Communications and Networking *China (CHINACOM), International ICST Conference* Aug. 2010.

28. R. Q. shaddad .et. al. Performance evaluation for optical backhaul and wireless front-end in hybrid optical-wireless access network backhaul and wireless front-end in hybrid optical-wireless access network *optoelectronics and advanced materials - rapid communications*, Vol. 5, No. 4, April 2011.

29. G. Yan1.et. al. Point-to-Point DWDM System Design and Simulation *Proceedings of the 2009 International Symposium on Information Processing (ISIP'09) ,Huangshan, P. R. China*, August 21-23, 2009.

30. M. Munsor. Radio Access Point Design for Radio over Fiber Technology,*Faculty of Electrical Engineering ,Universiti Technologi Malaysia*, APRIL 2008 .

31. Zhang Qijun; Xu Qinghua; Zhu Wei . Notice of Violation of IEEE Publication Principles A New EVM Calculation Method for Broadband Modulated Signals and Simulation, *Electronic Measurement and Instruments, 2007. ICEMI. 8th International Conference on* , vol., no., pp.2-661-2-665, Aug. 16 2007-July 18 2007.