Chapter 1 INTRODUCTION

The development of research on NG-PON2 on standard ITU-T G.989 be the first step for growth of big data, on the access network. The presence of this standard welcome all providers. This is because this technology supports legacy PON and can use the old OLT as the transmission system. In addition, this technology benefits customers, because they do not need to replace the device. Configuration can be set via the server (OLT). A framework proposition for Next Generation-Passive Optical Network (NG-PON) stage 2 was initiated in 2011[5]. The system plan accomplishes fundamental configuration targets like accessible data transfer capacity, system reach and cost [6].

This thesis have developed a system that brings the issue of low cost, the use of arrayed waveguide Grating (AWG) on NG-PON2. Moreover, to overcome the problems of Polarization Mode Dispersion (PMD) due to high speed above 10 Gbps, additional wiring is used in the form of Dispersion Compensation Fibre (DCF)

1.1 Background

Passive optical networks (PONs) are being introduced through a few nations to give broadband administrations. The development of PON frameworks over the years can be connected with the advancement in multiplexing innovations. In the main years with the utilization of ATM-based PON (APON and BPON), the accomplished upstream and downstream total transmission capacities were in the request of 155 Mbps up to 622 Mbps. Later, the utilization of time division multiplexing (TDM) allowed accomplishing limits around 2.5 Gbps and 1.25 Gbps (downstream and upstream) concurring with the ITU-T G.984 G-PON standard. Propelled fast TDM based optical access frameworks up to 10 Gbps for downstream and 2.5 upstream (XG-PON1) or 10Gbps for both downstream and upstream (XG-PON2), agreeing with the ITU-T G.987 G-PON standard, have been created and some field trials have been accounted for. As of now, institutionalized particulars by ITU exist for ATM-based PON (APON and BPON), gigabit-fit PON (GPON) and XG-PON and Ethernet PON (EPON) and 10G-EPON by IEEE.

For quite a while FSAN and IEEE have been taking a shot at the new universal standard ITU-T G.989: 40-Gigabit-capable passive optical networks (NG-PON2). NG-PON 2 technology is the most recent and the last for now. In addition to being the innovation leader in the field of access, high ability are expected to spend a huge cost, especially for providers. Users will be charged also be a problem in the payment of rent to the provider. Many sides that can be taken to reduce the cost. The standard consist of general necessities have been characterized on ITU-T G989.1 standard by March of 2013. However the Physical Media Dependent (PMD) (ITU-T G989.2) and TC layer prerequisites (ITU-T G989.3) are as yet being talked about and are relied upon to be distributed soon. The rapid development of this standard is not free from problems or issues that arise continuously.

Dispersion problems arise when the bitrate is too fast, bringing instability in the material medium flashing past. Light that brings the data very much and quickly, interact with a medium dispersive optical cable. Interactions caused the shift of the bit period due to the instability of optical materials, one of which is optical fibre Single Mode Fibre (SMF) having a dispersion value of about 17 ps/km.nm and the dispersion value slope 0.056 ps/nm^2.km. Shifting the bit period occurs at the pole (polar), making Polarization Mode Dispersion (PMD) is a major problem in the development speed of the bit rate.

Another problem in the NG-PON is the issue of bandwidth efficiency or the use of wavelengths that are not optimum. Becomes a problem, when the needs of a given area traffic access very large bandwidth, even exceeding the needs. There was a waste of bandwidth and have an impact on power consumption disadvantage. In addition, the imposition of the customer could be a result of the provider does not want to lose too much.

PMD and efficiency wavelength issues more apparent, when the bit rate of over 10 Gbps transmission on the fibre SMF [7]. Polarization Meter measuring devices by [8] , prove that the shift of the poles on the optical signal transmission affects performance. The emergence of the problem, made progress in increasing dispersion compensation. One way forward was to use a delay interferometer by [9] .The researchers get a BER of 10^{-3}, although not in accordance with the value of quality as it is called [10], but the value is already meet the power budget.

Taking this scenario as beginning stage, this proposition will assess the new global standard for the FTTx systems actualizing NG-PON2 frameworks working at 4x10Gbps, particularly the PMD prerequisites, with a specific end goal to decide the key business services for its execution. The systems will be demonstrated and the entrance system will be inherent a Personal Computer (PC) test system, diverse tests will be run, and the framework will be upgraded.

Bit rate 40 Gbps has evolved gradually, meaning that the entire request will not be fully 40 Gbps. One is the system Mux/Demux is initially 2 static devices, into one dynamic device with Arrayed Waveguide grating [11]. One of the advantages of the AWG is used on NG-PON technology 2 is tunable wavelength. Smaller segments are needed to increase the need and availability. What if the total network access only requires a total bitrate of 20 Gbps. This excess of AWG, with a tunable filter, four stacked X-GPON can be broken down into two wavelengths. It could be an advantage for the providers in the provision of bandwidth and traffic efficiency. The reason that makes this study was undertaken, in order to calculate the performance of AWG in NG-PON with various bitrates.

This research also has developed methods to reduce the influence of PMD in high bitrate NG-PON2, using fibre Dispersion Compensation Fibre. It resembles SMF fibre, has only a dispersive properties starting back with SMF. The value of DCF dispersion around -80 ps/km.nm, with hypotheses and calculation long it will be found a combination of SMF and DCF to get the value of dispersion that is almost close to zero. Calculation of the characteristics of each fibre is calculated through software Optisystem 14

At the end of the study, methods for making AWG tuneable wavelength by utilizing changes in temperature and material properties of the Silicon. With the value of widening the bandwidth of 0.1 nm/°C ,four wavelengths can be transmitted with a temperature of 65. The temperature of 40 and 55 are two and three wavelengths, while one wavelength using a room temperature of 25. The value of the base transmit power by 3 dBm, this system can not reach the standard Q factor. Thus, with appropriate power optimization changes that have been planned range, the stability of the Q factor starts when all Line Card valued 9 dBm. This stability is not perfect, because if we use 1 Line Card / one wavelength, has a value of Q factor below 6. So the researchers suggest, use bitrate to 10 Gbps using the TDM system, not recommended for this system.

1.2 State of the art

The purpose of this section is to show a summary of the different experimental setup is done by different scheme, in order to meet the considerations taken into account in real tests, to verify tolerance and performance in terms of BER, the reach of the fibre and the number of users NG-PON2 architecture. The technology used, the device and some setup parameters will be displayed.

Research [12] that almost resembles the author of TWDM research has been published, there are some differences. Differences in these studies is the use of delay interferometer to overcome dispersion, and the use of DML as transmitter system. Research by the author is, using fibre DCF for dispersion compensation in this case PMD, as well as the use of EML as suitable for transmission distance of 40 km and high bitrate. EML chromatic dispersion section has the advantage that relatively small compared to the DML.

Study [13] brings directions of research to issues of low cost. By using the transmitter DML and with a 0.2 nm-FSR DI, the reshaping spectra, this study compares the performance of up to 100 km. In addition to the relatively long distance to the access network, also splitters used up to 256. High scalability that carried shortcomings, namely the achievement of the minimum BER is 10^{-3}. Differences with research by the author is, at the transmitter and distance. transmitter is used EML, while the distance up to 40 km. To overcome the dispersion, the study adds fibre DCF and do not use the Delay-Interferometer(DI) as did previous studies.

Yiran [14] show TWDM-PON prototype with a capacity of 40 Gbps downstream use four 10 Gbps wavelengths at a distance up to 20 km and 512 splitting ratio. A complex network made by analyzing the downstream and upstream. Upstream in the set of 10 Gbps using 4x2.5 Gbps aggregate.

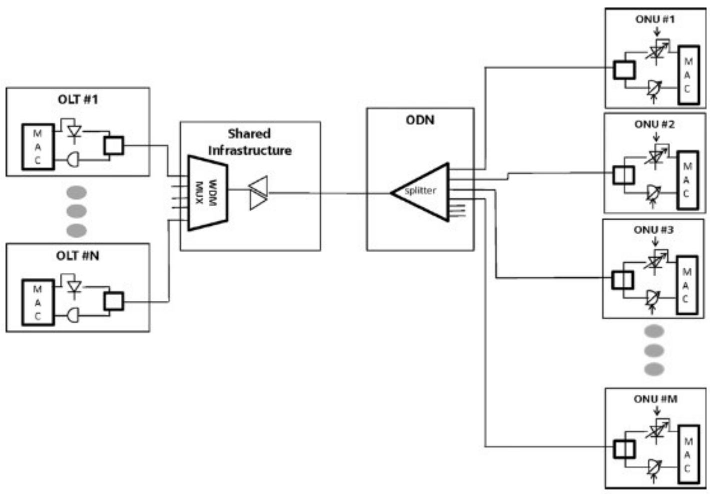

Figure 1.1. TWDM-PON for multiple OLT

Figure 1.1 shows the design of its architecture. Networking on the figure could be developed in terms of external and internal. On the internal side, research has not touched the stage of dispersion and attenuation value changes, while not taking into account the value of the investment required external operators to migrate to NG-PON2.

Bindhaiq [15] experiment with a bit rate of 80 Gbps optical networking standards and achieve the BER is less than 10^{-9}. Experiments starting from the OLT which combines 8 distribution of laser diode with 10 dBm power. Wavelength ranges are used 1570.4 nm-1576 nm with 0.8 nm channel spacing, and externally modulated using a Mach-Zehnder Modulator. OLT is transmitted on a link with a distance of 50 km and given a booster Semiconductor Optical Amplifier (SOA) prior to the photodetector device.

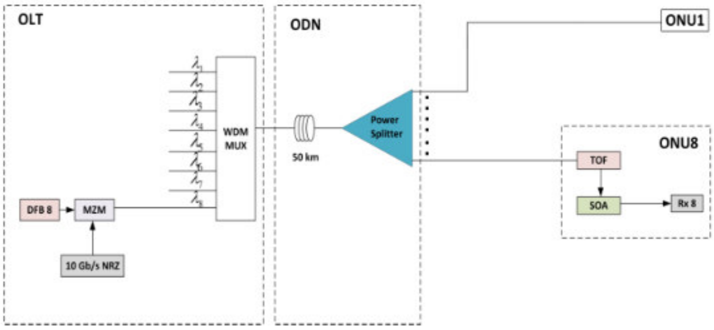

Figure 1.2. Design of 80 Gbps TWDM-PON

Figure 1.2 describes that network designed by the journal. The results of these studies proved that the aggregate 8 XG-PON compatible with existing technologies such as TDM-PON. However, there are shortcomings that can be developed from these journals such as the design and analysis on the upstream side, it is done so TWDM-PON can be applied. In addition, with the upstream, the use of time slots for up to OLT will be used.

Meihua Bi [16] proposed 40 Gbps TWDM-PON network architecture uses four 10-Gbps wavelengths with a ratio of 256 downstream along the 50 km. Several other references discuss NG-PON2 of the ratio, Aggregate NGPON, distance and cost budget. Therefore, this thesis presents a scenario of high data rate transmission to link downstream of TWDM-PON for a total capacity of 40 Gbps by using Array Waveguide Grating (AWG) and an aggregate of four XGPON.

1.3 Research Problem

Today's correspondence system movement is merged voice, video and information system. As per the created applications and administrations already portrayed, client request expands each year making it indispensable for telecom organizations and provider to build their system limit as an essential and most imperative normal for broadband access system.

High Bandwidth demand applications for home user and business applications [17] :

1. Peer-to-peer file transfer like emule, bittorrent, LimeWire and shareaza
2. Video file transfer and Video on demand (VOD) like YouTube, Daily Motion
3. Internet protocol TV (IPTV) applications with different resolutions such as Standard definition TV (SDTV) with 720x576 pixels per frame, High Definition TV (HDTV) with 1280x720 pixels, Full HD with 1920x1080 pixels Ultrahigh Definition TV (UHDTV) known as 4k technology with 4096x2160 pixels, the upcoming 8k standard and Three Dimension TV (3DTV)
4. Voice over IP (VOIP) like Skype and OOVOO
5. Video conference like OOVOO

6. Online Games
7. Cloud computing like Office 365 and Google documents
8. Online storage like OneDrive, UpToBox and mediafire
9. Remote backup
10. Interactive Learning used for online learning like CISCO academy programs and many others
11. Telemedicine Services

Speed and high bandwidth to support all the above requirements will be achieved by NGPON2. However, NG-PON2 with a bit rate of 40 Gbps will bring a new effect in the effect of the polarization of optical signals, called Polarization Mode Dispersion (PMD). Increasing the number of users on a standard NG-PON2 up to 1: 128, meaning that requires adequate system including considerations for saving (energy saving). The complexity will increase with the presence of NG-PON, OLT should be tuneable because the transmitter side, ONU on the side of the receiver must be tuneable, so the selection of appropriate wavelength.

This study will examine the model and system-PON2 NG-PON with WDM method. Problems on the increase in the number of users will be controlled by Arrayed Waveguide Grating (AWG), a tunable wavelength that low consumption of energy.

1.4 Problem Limitation

The problem definition to support this research are as follows :

1. The aggregate Downstream bitrate is at least 40 Gbps.
2. The reach distance from central office OLT to the user ONU is over 40 Km.
3. The splitter ratio is Up to 1:128 so that maximum number of users can share the same fibre to reduce the number of fibres serving any area and hence reduce the cost per user .
4. According to ITU-T NG-PON2 system is recommended.
5. Modular design that can be repeated with more interfaces at ISP.
6. Co-exist with previous PON systems (optional for smooth upgrade).
7. Using cable SMF and DCF with combination calculated.
8. AWG value calculation based on a formula and not experiments on materials
9. A system model is built and tested using Optisystem 14.0

1.5 Objective

In this study, the target to be achieved is a system NG-PON2 low cost with tunable wavelength. And reduce the PMD problem with the addition of fibre DCF. The points below are a step to achieving this goal.
The specific objectives are:

1. To review the state of art of optical access networks, looking at changed innovations, gadgets and structures, concentrating on various distributions from optical lightwave diaries, global meetings (ECOC, OFC, and so forth.) and the diverse ITU and IEEE standard for uninvolved optical systems.

2. To examine the new international standard ITU-T G-989 covering diverse themes like the wavelength arrangement, gadget parameters, framework and subsystems least necessities and the WDM-PON PDM layer prerequisites.

3. To design a NG-PON2 architecture model based in the standard configuration utilizing cost-proficient gadgets as a part of request to show signs of improvement and dependable exhibitions. These gadgets and different subsystems (ODN, OLT, ONU) will be demonstrated and math investigated and their resiliences characterized thinking about the business gadgets accessible from various sellers.

4. To compare the reference values and the ones produced in the PC simulations with the software Optisystem, taking into account the outline proposed and some numerical references found in the specific list of sources.

5. To optimize the NG-PON2 proposed outline keeping in mind the end goal to accomplish better transmission quality qualities restricted by the equipment resistances and and reduce the impact of dispersion and compensate the NG-PON2 system using DCF cable, as well as improving the performance of the repair period bit.

6. To analyze on the performance of a Arrayed Waveguide Grating, especially on the issue of low cost, ie taking into account the AWG as a substitute Mux/Demux. In addition, the AWG will be configurable wavelength, so the bitrate issued according to the total needs of the user.

1.6 Hypotheses

This research also methods to reduce the influence of PMD in high bitrate NG-PON2, using fibre Dispersion Compensation Fibre. It resembles SMF fibre, has only a dispersive properties starting back with SMF. The value of DCF dispersion around -80 ps/km.nm, with hypotheses and calculation long it will be found a combination of SMF and DCF to get the value of dispersion that is almost close to zero.

ONU system based on the division of power through the splitter a trend that is not balanced when the distribution of both downstream and upstream bandwidth. AWG proper usage system uses heat (thermally) will clean up the bandwidth is divided. Thus, the margin will be reduced and the number of users can be increased.

The tendency of the AWG is the resulting energy saving. As an initial hypothesis, the use of AWG will reduce the energy required by the MUX and demux. Such devices would require power for the processor that will later serve as the circulator. For example, the Mux-Demux devices from the company JDS Uniphase Corporation (JDSU) has a maximum insertion loss of 11.6 dB, while with specifications and the same company, AWG only have a maximum insertion loss of 6 dB. It is apparent that the changes occurring around 48.2 % in insertion loss. Apart from the AWG, the savings will be created on the use Stacked central XGPON already used beforehand. Thus, the sale of the device is not in need of outside parties, but can be from the ISP in the country.