논문 2008-6-12

Implementation of FTTH System based on G-PON Technology

G-PON 기술 기반 FTTH 시스템 구현

박천관*, 송한영**, 전병천**

Chun-Kwan Park*, Han-Young Song, Byung-Chun Jeon****

요 약 본 논문은 G-PON 기술 기반 FTTB/H 시스템 구현에 관한 것이다. 이 시스템은 TDM 및 데이터 경로가 10msec내에 절체할 수 있는 이중화 기능을 지원한다. 이 시스템은 OLT와 ONU/ONT로 구성되었다. OLT는 시스템당 최대 32개의 2.5Gbps 라인 인터페이스를 지원하며, 향후 디지털 통신 방송 융합 서비스를 고려한 설계로 융통성과 확장성을 가지고 있다. OLT 시스템은 스위치 모듈, 가입자 모듈, 프로세서 모듈, 그리고 G-PON 링크 모듈로 이루어져 있으며, 리눅스 운영체제를 탑재하고 있다. ONT는 가입자 댁내에 실장되어 TPS 서비스를 제공할 수 있다. 또한 ONU는 IP-TV 신호 전달 특성을 개선하기 위하여 IP-TV 전용 인터페이스를 가지고 있다.

Abstract This paper addresses the implementation of FTTH system based on G-PON technology. This system supports the duplication function that can switchover both TDM and data routes within 10msec. This system consists of OLT and ONU/ONT. G-PON OLT supports the maximum 32 2.5Gbps interfaces, and then has the flexibility and the scalability for supplying digital communication and broadcasting convergence service in the near future. OLT system consists switch module, subscriber module, processor module, and G-PON link module, and has the operating system based on Linux. ONU is installed in customer premise to supply TPS (Triple Play Service). Also ONT has the dedicated interface for IP-TV to improve the transmission characteristics of IP-TV signal

Key Words : G-PON, OLT, ONT, ONU, FTTH, TPS

Ⅰ. Introduction

PON (Passive Optical Network) system delivers signals to end user through optical fiber network. So it can be classified as FTTC (Fiber To The Curb), FTTB (Fiber To The Building), or FTTH (Fiber To The Home) according to which position PON should be terminated at. PON system consists of OLT (Optical Line Termination) and many ONU (Optical Network Terminal)s. OLT is be installed at CO(Central Office) of communication company, and ONUs are installed at location around user. Above 32 ONUs can be connected to one optic interface of OLT. PON provides many users with downstream/upstream bandwidth, and these bandwidth can be assigned to user. Also PON can be used as trunk line between large scale one, such as cable TV system, and Ethernet network for neighboring building, or home using the coaxial cable[5][6][7][8][9]. E-PON transfers the data using Ethernet frame, But G-PON has ATM and GEM transfer part. ATM part treats ATM service, and GEM part treats the services except of ATM one. B-PON and G-PON uses the frame of fixed length, but E-PON uses one of variable length. E-PON does not allow the frame to be segment, But G-PON allows the frame to

*종신회원, 국립목포해양대학교
**정회원, (주)넷비젼텔레콤(Netvision Telecom Inc.)
접수일자 2008.9.20, 수정완료 2008.12.5

be segment,

G-PON system provides user with very high performance as for the communication equipment for FTTH. it provides the maximum 1.5Gbps for upstream from user to CO, and the maximum 2.5Gbps for downstream from CO to user. And it can accommodate the maximum 64 users through one G-PON interface. Only G-PON system is adapted as ITU standard of equipments for FTTH. So it is very excellent in the mutual compatability between communication companies, and then can support the new IP (Internet Protocol) based services, such as high-speed Internet, IP-TV, and VoIP (Voice over IP), as well as the diverse multimedia services, such as leased line, general phone, and video[14][15].

To support broadcasting and IP-TV based on IP, and voice delivery service based on VoIP, and Internet one simultaneously in home, the technologies has to be applied to configure OLT and ONU/ONT optimally[15][16].

This paper addresses the design and implementation of G-PON system. this system can delivery both data and TDM signal, and supports the duplication function having the path switchover performance of 10msec between end users. For this, the high-speed switchover technology is applied to this system. As this system has POTS (Plane Old Telephone Service) for voice and CATV (Cable television) delivery function, it can be distinguished and then configured for home that needs only data and for enterprise that needs TDM (Time Division Multiplexing).

This paper consists of the following; chapter 2 addresses the operation of G-PON system, such as G-PON network configuration, G-PON protocol layer architecture, and activation of G-PON ONU. chapter 3 addresses G-PON system design and implementation, such as overall architecture of G-PON system and implementation of G-PON system, chapter4 tests the performance of G-PON system that we has developed and speculates the results, And chapter 5 includes the conclusion.

II. G-PON system and operation[1][2][3][4]

1. G-PON Network Configuration

FTTH is the infrastructure that installs the optic fiber to all user premises and then provides the services through this. Nowadays, it is considered as the ultimate access network that can provide the real-time multimedia services without technical limitation. the real-time multimedia services requires QoS (Quality of Service) and bandwidth guarantee. Therefore, the development of FTTH solution has been issue worldwide and the technology of user access network is required urgently.

Figure 1 shows PON network configuration. In this figure, PON network consists of OLT in network part, ONU/ONT in user part, passive optical splitter that branches one line optic fiber into many ones, and optic fibers. In downstream from network part (OLT) to ONU (users), the strength of optic signal is decreased by 1/N in passive optical splitter, and then the signal is sent to all ONUs. On the contrary, in upstream from ONU to OLT, after the optic signal sent from ONU having many users passes the passive optical splitter, its strength is decreased by 1/n, and the signal reached at OLT. In upstream, the optic signal can not be delivered to other ONUs because of unique characteristics of passive optical splitter. Therefore, PON network has broadcasting architecture for downstream, and point-to-point one for upstream.

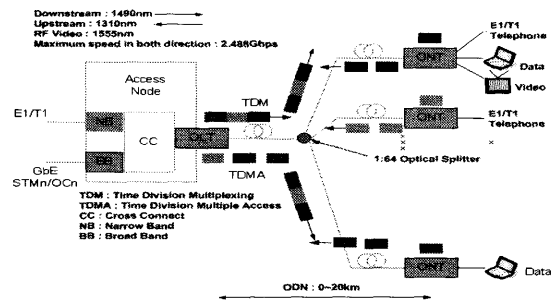


그림 1. G-PON 망 구성도
Figure 1. G-PON network configuration

In this configuration, OLT is the access system having PON interface in network side, ONU is the unit having PON interface in user side, and ONT has the function terminating network in addition to terminating PON, and is installed in end user premise to FTTH. ONU can be used to connect many users through UTP (Unshielded Twisted Pair wire), xDSL (Digital Subscriber Line), and to install FTTB network. Data collision can be avoided by having each ONU and ONT send their data in different time through TDMA in upstream.

2. G-PON Protocol Layer Architecture

G-PON protocol layers consist of physical, GTC (G-PON TC layer specification), and data link layer. In this configuration, the diverse data link services are converted into G-PON frame, and then its frame is sent. The physical layer performs many functions, such as optic-electric conversion, bust frame reception, and clock recovery. GTC layer consists of TC (Transmission Convergence) Adaptation sublayer and GTC Framing sublayer.

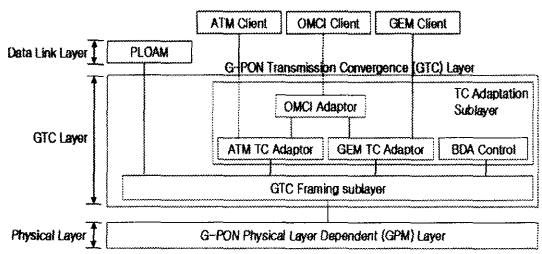


그림 2. G-PON 프로토콜 계층 구조
Figure 2. G-PON protocol layer architecture

GTC Framing sublayer performs the multiplexing/ demultiplexing functions of GTC frame (GTC, G-PON TC) every 125usec by using PLOAM (Physical Layer Operation Administration & Maintenance), DBA (Dynamic Bandwidth Allocation), and synchronization information in the frame received from ATM (Asynchronous Transfer Mode) and GEM (G-PON Encapsulation Method) TC interface. TC Adaptation sublayer recognizes VPI/VCI for ATM service, and port-ID for GEM service, and then performs the function that connects the related services in the upper layer, and the filtering one. And it performs the time slot assignment for the upstream transmission of ONUs, and ONU management function.

OMCI (ONU Management and Control Information) is a means to discover ONT capabilities and manage them. it establishes connections, monitors alarms and performance, manages faults and security.

3. Activation of G-PON ONU

Figure 3 shows the activation process of ONU. In other PON system, the built-in mechanism is prepared to activate new ONU added to network. This is called activation process. the perfect activation process also have to regulate the power level in ONU to measure the power in ONU and reduce the dynamic bandwidth of OLT receiver. The activation process also is to measure the phase relationship for ONU by considering the downstream frame. This information for phase relationship is delivered to the relevant ONUs by OLT to avoid collision during upstream transmission. The activation process begins with OS command, the cyclical polling for new ONUs, or the discovery of new ONU through ONU reactivation. During this step, the data exchange of client is suspended temporarily.

OLT requests the serial ID of all ONUs by opening the window for upstream transmission called the ranging window. In this window, new-added and unregistered ONUs sends their ID and physical information to OLT. As there are more than one ONU that wants to activate, the collision can be occurred during this step. Each ONU waits for random time before transmitting data to avoid the collision.

On receiving serial ID, OLT binds serial ID to ONU_ID, and then sends this information to the relevant ONU for mutual operation in future. Also, OLT measures power and phase during this operation, and then returns the related control information to ONU. all registration process is completed through these processes, and information can be delivered.

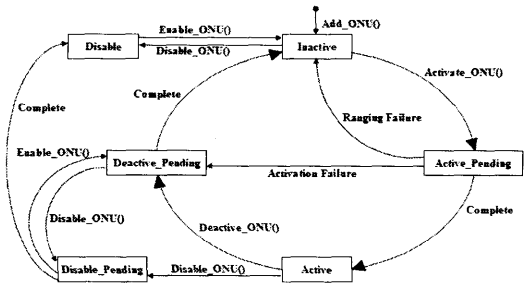


그림 3. ONU 활성화 과정
Figure 3. The process of ONU activation

Ⅲ. G-PON system design and implementation

1. Overall architecture of G-PON system

As G-PON is expected to accommodate all diverse services, such as data and TDM services, a new transmission method called GEM (G-PON Encapsulation Method) has been adopted to encapsulate those services. G-PON can transmit TDM service using the original ATM cell without additional overhead. GEM provides a variable-length frame with a several bytes control header.

G-PON can accommodate voice service efficiently through frame transmission control of 125usec(8kHz) period, and provide the maximum 2.488Gbps bandwidth for both upstream and downstream. As it supports the characteristics, such as TDM, ATM, and diverse transmission frame speeds of payload, and loss budgets, it has the excellent compatability with services or network environment having different technology standard. Therefore, it can advance into FTTx market fast.

Data packets including Ethernet frames are also mapped using GEM procedure. Fragmentation and Reassembly, i.e dividing the large frames into smaller fragments and combining them again at receiver, facilitates reducing the delay variations of real time traffic and TDM traffic in case of large data packets. The data traffic can comprise Ethernet frames, IP packets, IP-TV, VoIP and any other type, making the GEM frame transport capability attractive, efficient and simple.

G-PON provides varying rates of transmission in both the upstream and the downstream directions. In the downstream direction, the transmission rate can be either 2.488Gbps or 1.244Gbps. Whereas in the upstream direction, the rate can be selected from 622Mbps or 1.244Gbps. G-PON provides the different types of client services. The ATM client is mapped transparently into the GEM frame in both the directions. The TDM client is mapped using G-PON Encapsulation Method (GEM) procedure. This is identical to GFP framing. Fixed number of bytes in each frame are reserved for the TDM transportation in both the directions.

As G-PON technology has diverse transmission frame speeds (TDM, ATM, and packet) and loss budget, it has excellent compatability in service and network environment having different technology standard. So G-PON technology can be advanced into FTTx markets quickly.

Figure 4 shows the overall architecture of G-PON OLT system. it consists of L2/L3 switch of 48 ports, 8 G-PON line cards, TDMoIP line card of maximum 32 T1/E1 interfaces, main processor, and L2 switch. Main processor managers the overall of G-PON OLT system, and L2 switch helps main processor manage each line card through EMS function.

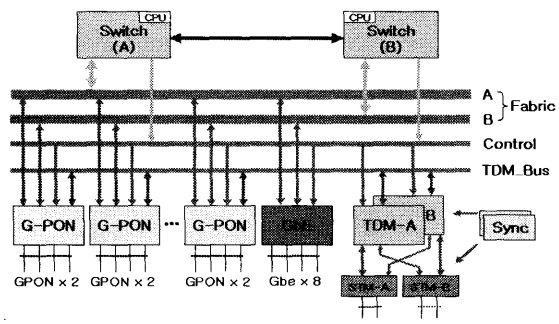


그림 4. G-PON 시스템 젠체 구조
Figure 4. G-PON system overall architecture

The main characteristics of this system are the following;

- Switching capacity : above 96Gbps
- Supports L2/L3 switching and IPv4/IPv6 function
- Supports maximum 32 G-PON interfaces (one G-PON link supports 32 ONUs
- Supports maximum 16 GbE interfaces
- Supports two STM-1 interfaces for TDM connection
- Supports 8 T1/E1 interfaces for V5.2
- Supports Video Overlay module (Optional)

Figure 4 shows the duplication configuration for the reliability of G-PON system. Each line card is connected to switch through the duplicated link. In this configuration, active/standby method is applied to G-PON system, and active link is used. if there ares problems over active link (link, or switch), all line cards receives the signal for duplication state, and then are switched to standby link immediately.

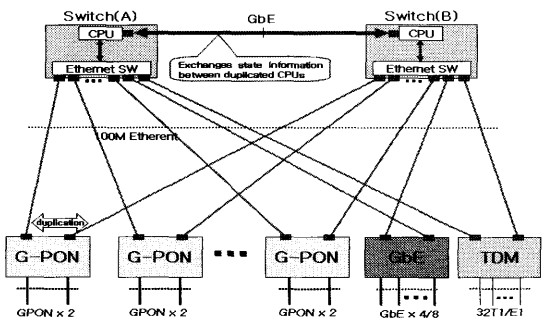


그림 4. G-PON 시스템 이중화 구성도
Figure 4. The duplication configuration of G-PON system

2. Implementation of G-PON system

G-PON network consists of OLT (Optical Line Terminal), ONT (Optical Network terminal), and ONU (Optical Network Unit). G-PON OLT is PON system for FTTH based on FTTH (Fiber to The Home), and can support maximum 32 G-PON line interfaces. And one G-PON line interface can accommodate maximum 32 ONTs. ONT is the unit that can provide end-user with TPS (Triple Play Services) in customer premise. ONU supports 12 Ethernet ports, T1/E1 ports, and POTS interfaces for suitable FTTH configuration.

Figure 5 shows G-PON OLT system. this consists of GigaBit Etherent switch board Assembly (GESA), many G-PON line board Assemblies(GLIA), and the line board Assembly for TDMoIP (Time Division Multiplexing over Internet Protocol)(TLIA).

The main switch board is controlled by GMPA through local bus, and can communicate with GMPA through DMA channel. This board is the core part of OLT system, and is responsible for all additional service functions including the switching function.

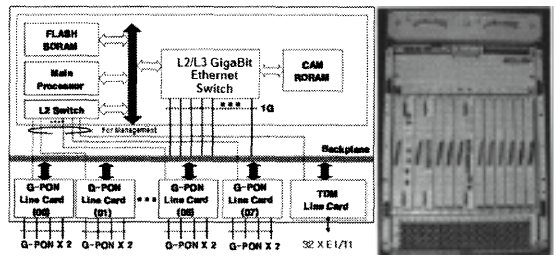


그림 5. G-PON OLT 시스템 구성도
Figure 5. G-PON OLT system configuration

Figure 6 shows GESA of G-PON OLT system. GESA consists of switching module, memory module, PHY module (including 10Gbps PHY), IPC module, and separate processor module (GMPA).

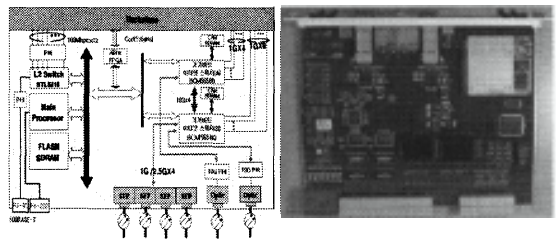


그림 6. 스위치 보드 구성도
Figure 6. Switch board configuration

In GESA, its capacity is above 80Gbps, and two switch chips for Ethernet switching function share the load through two 10Gbps ports against the failure. Also this board consists of four 1GBE or 2.5GBE ports for

upstream, two 10GBE ports, L2 switch chip for IPC (Inter Processor Communication), and GMPA (G-PON Main Processor Assembly) module for managing GESA. GMPA is interfaced to Ethernet switch of main switch board(GESA) through 32bits local bus, and exchanges user information with GLIA through IPC channel. And GESA supports 48 port GigaBit Ethernet interfaces, The main functions of GESA are the following;

- the architecture that can switch IPv4 and IPv6 packets simultaneously
- supports classification and QoS through L2/L3/L4 header
- supports the queue for 2,048 flows
- supports 802.1p, IP ToS, DiffServ(DSCP), MPLS EXP/COS
- the policing function is applied to for ingress flow, ingress aggregate, egress flow, egress aggregate
- supports 256K IPv4 routing entries (supports 128K IPv6 routing entries)

As GESA supports the diverse switching functions based on hardware, GESA can have higher price competitiveness than the system based on network processor as the switching system of large capacity.

Figure 7 shows the configuration of G-PON line board assembly(GLIA). GLIA is line card for G-PON master, and has two G-PON interfaces. one side of each interface is connected to GESA through backplane in serial method, another is connected to G-PON line through optical connector. The processor module of GLIA controls and manages G-PON line card, and exchanges GESA with system information through IPC. The main of G-PON OLT MAC chip are the following;

- G.984.x function
  - o. implements G.984 TC using GEM
  - o. ONT/ONU ranging/activation
  - o. multi-rate : 1.25Gbps/622Mbps. 1.25Gbps/1.25Gbps. 2.5Gbps/1.25Gbps
  - o. FEC is applied to downstream/upstream
  - o. AES encryption, Key exchange
  - o. upstream bandwidth scheduler
- packet services for downstream
  - o. packet data queue
  - o. CPU data queue
  - o. PLOAM data queue
  - o. 2,048 port-IDs
  - o. mapping port-ID/ONT-ID
- packet services for upstream
  - o. 4 priority queues according to port-ID
  - o. CPU data queue
  - o. PLOAM data queue
  - o. 2,048 port-IDs
  - o. 1,024 T-CONTs (Alloc-ID)
- optical interface
- packet interface
- CPU interface
- memory interface

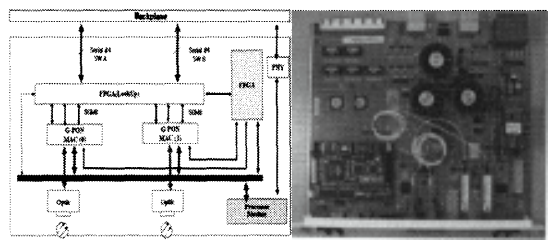


그림 7. GLIA 보드 구성도
Figure 7. GLIA board configuration

Figure 8 shows TLIA board to provide TDM interface in G-PON OLT system. This provides 32 port T1/E1 interfaces and supports Ethernet ports through 10/100/1000 MAC. And this is connected to GESA through backplane in serial method. CPLD of TLIA decides the memory map of board, generates the signals (selects chip) for this through address decoding function, and provides the interface that can deliver information for each interrupt to CPU. In TLIA, T1/E1 ports can be expanded in the unit of 4 ports, and then accommodate maximum 32 ports. 32 T1/E1 ports of TLIA board can be interfaced to outer through Z_pack connector.

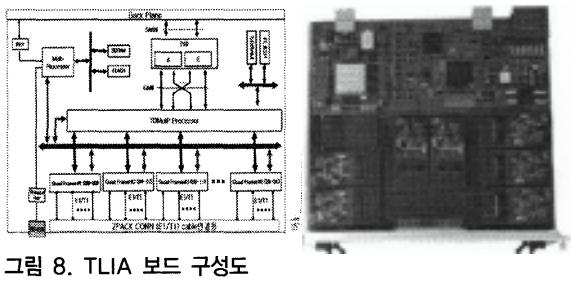


그림 8. TLIA 보드 구성도
Figure 8. TLIA board configuration

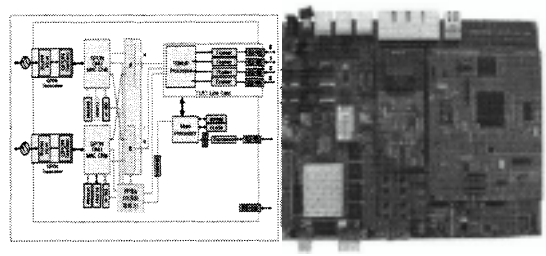


그림 9. G-PON ONU 구성도
Figure 9. G-PON ONU configuration

Figure 9 shows ONU system that duplication function is applied to. User interface consists of dual fast Ethernet 10/100(IEEE802.3/802.3u) or GigaBit Ethernet 10/100/1000 (IEEE802.3ab/802.3z), Native TDM GEM, and Peripheral Bus Interface (PBI) for glueless interface with DSP (Digital Signal Processor). Optical interface consists of the integrated 2,488/1.244 Gbps CDR, glueless interface with G-PON MSA(Multi-Source Agreement) SFF(Small Form Factor) transceiver. And TDM interface consists of native TDM over GEM. In ONU system, MAC interface part for G-PON functions including PCS is implemented in FPGA. ONU system has connector for interface with G-PON OLT system, outer memory for upstream/downstream packets, PMA for serial-to-parallel conversion, and OTRx for transmitting/receiving the optical signals.

ONU system has the integrated G-PON ITU G-984 MAC and GEM function for packet and TDM services. SerDes and CDR circuits of ONU system can be interfaced to optical transceiver. This system is the packet processor based on performance and applications for the packet processing in wire speed as well as flexible classification and data path function filtering. And this system has 10/100/1000 Ethernet MAC through a combination of MII, RMII and GMII ports for IP service, and TDM over GEM interface provides customer connection function for T1/E1/J1 TDM service.

Figure 10 shows ONT configuration that performs the user interface function. G-PON ONT MAC performs the transmission function between ONT and OLT in G-PON system. ONT interwork G-PON network having 2.5Gbps for downstream and 1.25Gbps for upstream with user network based on 10/100Base-Tx. So ONT has G-PON network interface, user interface, broadcasting service function (optical), and separate power supply.

ONT hardware consists of mainly G-PON ONT PHY and G-PON ONT MAC layers. G-PON ONT PHY layer consists of PMD sublayer of optical transceiver, PMA sublayer of SeRDeS function, and PCS sublayer. G-PON ONT MAC layer consists of RS sublayer, MAC control sublayer, and PON bridging function for interface with upper layer.

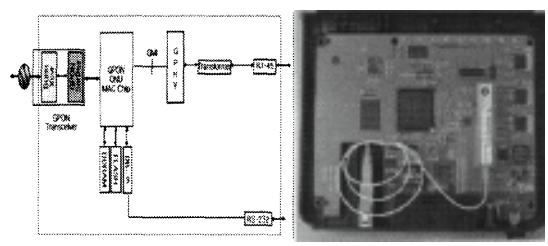


그림 10. G-PON ONT 구성도
Figure 10. G-PON ONT configuration

Ⅳ. Performance Test and Consideration

Figure 11 shows the configuration for test network to measure the performance of G-PON MAC. In this configuration, one G-PON line interface is connected to

maximum 32 ONTs, and then the maximum transmission bandwidth of upstream/downstream is measured. For this test, the parameters for virtual link between OLT and ONT are set up as the following; maximum allowable bandwidth is 100Mbps, and maximum guaranteed bandwidth is 100Mbps. And maximum burst size is 10K bytes. For these values, traffic transmission speed and performance for upstream/downstream are measured.

The detailed contents for test are performance of G-PON system, switchover for duplication configuration, and the jitter characteristics of TDM (Time Division Multiplexing) signals.

Performance test is to measure the transmission characteristics for upstream/downstream, such as throughput per packet length. Duplication switchover test is to verify the reliability of G-PON system by switching its functions to standby link when there are the failures over active link. This is to verify the ability of continuous data transmission by measuring the switchover time, And as TDM signals are sensitive to jitter characteristics, the jitter test for TDM ones is to measure the influence of jitter on that signals when transmitting TDM ones through G-PON system.

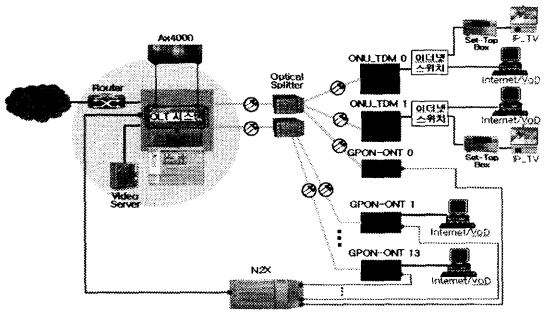


그림 11. 성능 시험을 위한 망 구성도
Figure 11. network configuration for performance test

Figure 12 shows the delay time for upstream transmission. this test is performed for load per packet length. target value is below 375[μsec]. The loads for this test are 500Mbps, 1000Mbps, and 1020Mbps. For these loads, the delay time meets the target value.

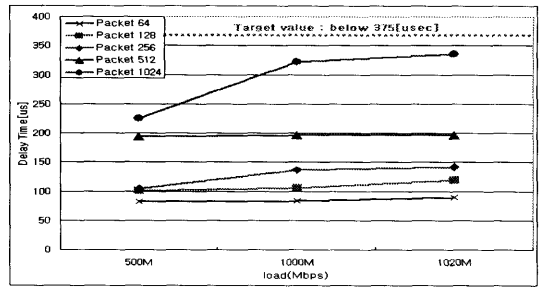


그림 12. 상향 지연시간
Figure 12. Upstream delay time

Figure 13 shows the throughput for upstream transmission. this test is performed per packet length, such as 64, 126, 256, 512, 1024, and 1500bytes. target value is above 995Mbps. This results shows that throughput of upstream meets the target value.

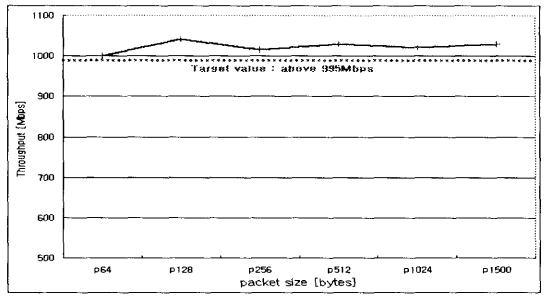


그림 13. 상향 수율
Figure 13. Upstream throughput

Figure 14 shows the delay time for downstream transmission. this test also is performed for load per packet length. The loads for this test are 500Mbps, 1000Mbps, and 1020Mbps. At this test, the delay time is below 110[μsec]. For downstream, there is no problem in delay time.

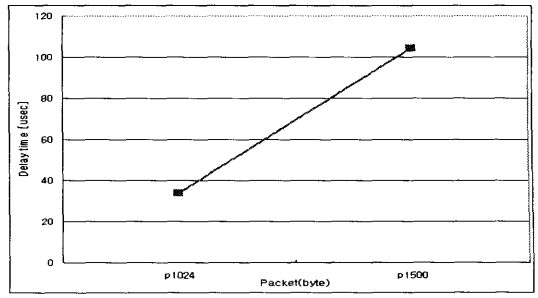


그림 14. 하향 지연시간
Figure 14. Downstream Delay time

Figure 15 shows the throughput for downstream transmission. this test is performed per packet length, such as 1024, and 1500bytes. target value is above 2289Mbps. This results shows that throughput of downstream meets the target value.

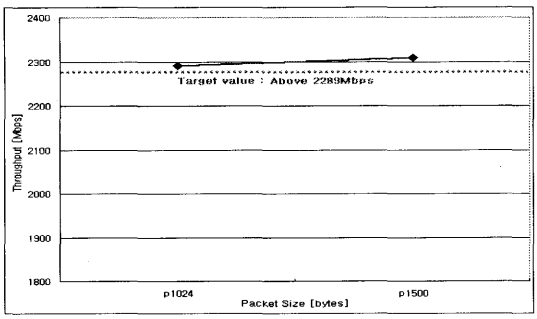


그림 15. 하향 수율
Figure 15. Downstream Throughput

In figure 11, the transmission traffic of G-PON ONT 0 has the same bursty characteristics as one in figure 16. In figure 16, B value is constant, but A value is variation characteristics, such as 1, 5, 10, 20, 30, 40, and 50msec. The size of jitter buffer is set up according to these variable values, and then the influence of jitter on TDM signals is measured. For variable A values, 0th T1/E1 interface of TLIA is connected to 7th interface of TLIA via TDM_ONU 0. In this configuration, the jitter characteristics of upstream TDM signals is measured.

Jitter is the measure for delay variation, and the important performance parameter in communication system. So, the test for jitter characteristics is to measure the maximum allowable jitter value with meeting QoS. jitter buffer makes jitter value constant, but generates the additional delay time.

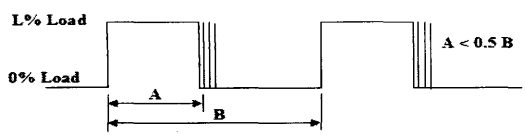


그림 16. 버스트 트래픽 특성
Figure 16. The characteristics of burst traffic

Figure 17 shows the jitter characteristics of TDM signals per SLA (Service Level Agreement) values, At this test, TDM_jitter_NO_SLA indicates the jitter characteristics when SLA of TDM signals does not guarantee the minimum value. TDM_jitter_SLA indicates the jitter characteristics when the SLA guaranteed 50Mbps. And queue size are 90 bytes for TDM signals and 40bytes for other signals respectively. This test shows that if minimum value of SLA is not guaranteed, it has an effect on the jitter characteristics of TDM signals.

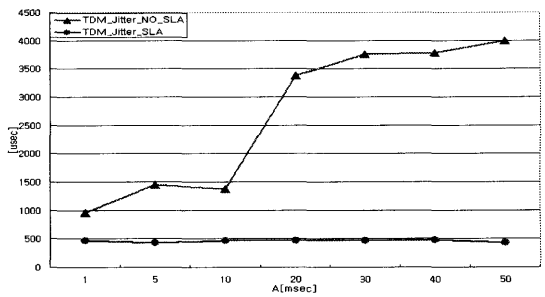


그림 17. SLA값에 따른 TDM 트래픽의 지터 특성
Figure 17. The jitter characteristics of TDM traffic according to SLA value

Figure 18 shows the jitter characteristics of TDM signals when SLA values for TDM and other signals are 50Mbps and 900Mbps respectively, queue size for both traffics is same as previous test (90 bytes for TDM signals and 40bytes for other), and jitter buffer has the variable sizes, such as 32, 64, and 128 bytes. This figure indicates that if minimum SLA value for TDM signals is guaranteed, TDM signals are nearly not influenced by jitter. And jitter buffer size has not nearly an effect on jitter characteristics of TDM signals. Therefore, to transfer both data and TDM signals through G-PON system, QoS for TDM signal, which is sensitive to time delay, must be guaranteed preferentially.

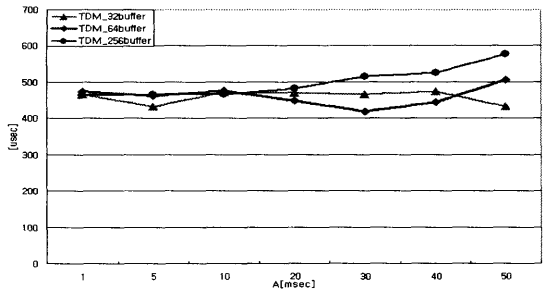


그림 18. 지터 버퍼 크기에 따른 TDM 트래픽의 지터 특성
Figure 18. The jitter characteristics of TDM traffic according to jitter buffer size

Figure 19 shows the switchover time in duplication configuration. In this test, ONUs are connected to G-PON OLT through the duplicated link, and the test equipment transmits the packets of 64 bytes through primary link. Target value for switchover time is less than 10msec. 50000 packets are transmitted per second, and one packet is transmitted per 20μsec. The number of lost packet are measured after disconnecting the primary link during transmitting the packet. At switchover, the time for suspending the communication is about 5~5.8msec. this value meets target one.

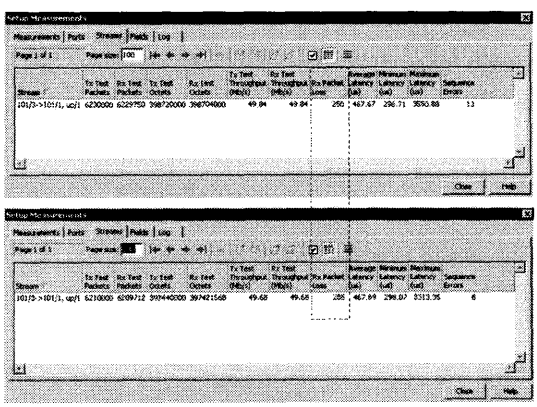


그림 19. 이중화 절체 시간
Figure 19. duplication switchover time

V. Conclusion

As G-PON is faster than 3 times E-PON in transmission speed, and excellent in mutual compatibility, this is the system that can support the diverse multimedia services, such as high-speed Internet, IP-TV, leased line service, telephony, and video.

This paper addresses FTTH system based on G-PON technology. This system consists of G-PON OLT, TDM-OMU, and ONT. This system can transfer both TDM and data, and supports the reliability through duplication function having switchover time within 10msec.

This G-PON system supports above 56Gbps switching capacity, more than 10 ports G-PON line interfaces, above 155Mbps TDM signals, and maximum 32 ports T1/E1 interfaces. One G-PON line interface supports maximum 32 ONUs. As ONU can supports many users through UTP. xDSL, it can be used to install FTTC/B network.

As this system can be used as the platform that provides both data and TDM service for building and enterprise, This is system that can save the cost by substituting the existing point-to-point network in FTTB/H and enterprise.

Also, to save the cost for establishing the network in access domain, it is used as the equipment for substituting 2.5G TDM transmission network. Furthermore, it can be used as the transmission network in new access domain for transmitting voice, data, and TDM signal, such as the transmission network of new mobile communication vendors.

Reference

[1] ITU-T G.984.1, "General characteristics for Gigabit-capable Passive Optical Networks", 2003.

[2] ITU-T G.984.2, "Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification", 2003. 3.

[3] ITU-T G.984.3, "Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence

layer specification", 2004. 4.

[4] ITU-T G.984.4, "Gigabit-capable Passive Optical Networks (G-PON): ONT Management and Control Interface (OMCI) specification", 2004. 4.

[5] 김광옥, 최현균, 김승환, 권율, 김봉태, "GPON 기술 표준 규격 및 개발 동향" ETRI 주간기술동향 제1294호, Feb. 2006.

[6] 김관중, 유제훈, "FTTH 시장 분석 및 수요 예측", 전자통신동향분석 제 22권 제 1호 PP130~139, 2007년 2월

[7] Joe Fragoso, "Gigabit Passive Optical (G-PON) Access System", FlexLight Networks", http://www.hit.bme.hu/ WDM-WS/4/Pres/ Fragoso.pdf

[8] Hakko Opto, "Passive Optical Network (PON) Fiber-To-The-HomeSolution" Feb, 2005. http://www.hakko-opto.com/pdf/PONet_Presentation.pdf

[9] 유태환, "TDMA-PON 광가입자망 기술", 한국통신학회지, Vol.22 No.6, PP22~43, June 2005.

[10] (주)넷비젼텔레콤, "E-PON 기반 데이터 및 TDM(T1/E1) 전송시스템 개발" 산업자원부 산업기술 사업보고서, 2007.

[11] 박천관, 전병천, "Implementation of FTTH System based on Ethernet PON technology", 대한전자공학회 논문지 제 43권 TC편 제 2호 pp222~pp231, 2006년 2월.

[12] 박천관, 송한영, 전병천, "E-PON 기반 Triple Play Service를 위한 QoS 제어 기능", 대한전자공학회 논문지 제 44권 TC편 제 3호 pp315~pp324, 2007년 3월.

[13] 권정국, 진걸, 박천관, 송한영, 전병천, 이상호 "E-PON 기반 TDM 전송 시스템", 대한전자공학회 논문지 제 44권 TC편 제 12호 pp1222~pp1230, 2007년 12월.

[14] Kumar Shakti Singh, "G-PON -The Next Generation Access Network", Transswitch Corporation, Sep 26, 2005.

[15] Eyal Shraga, FlexLight Networks, "GPON Overview: Architecture and Technology Committee," 2004. 11.

[16] BroadLight, "End-to-End G-PON Development Program". 2004. 6.

※ 본 논문은 지식경제부의 정보통신산업경쟁력강화사업의 지원으로 수행된 것임

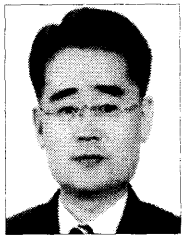
저자 소개

Chun-Kwan Park(평생회원)

Received B.S degree in Electronic Engineering from KumKuk University in 1987. M.S degree in Electronic Engineering from ChungNam University in 1991. and Ph.D. degree in Electronic Engineering from KunKuk University in 1996. In 1997, he joined the division of electronic and communication engineering, Mokpo National Maritime University, Korea, where he is presently professor. From Feb. 2002 to Feb. 2003, he was a research professor at PolyTechnic University in New York. From Feb. 2000 to now, he has been technical director in Netvision Telecom Inc.

His Research interest is in the area of IP QoS, PON Technology, Communication Protocol>

Han-Young Song(Regular Member)



Received B.S. degree in Computer Sciencefrom Chungnam University, and M.S, and Ph.D. degree in Information and Communications Engineering from Paichai University respectively.From Mar. 1984 to Jun. 1998, he was a member of R&D staff of several projects such TDX switching system, Intelligent network system. Currently, he is a director of the Netvision Telecom and is working as a project manager in the field of telecommunication and data communications.

Byung-Chun Jeon(Regular Member)

Received B.S., M.S, and Ph.D. degree in Electronic Engineering from Chungnam University respectively. From June 1987 to Sep. 1988, he was a research engineer in ADD (Agency for Defense Development). After he joined ETRI in 1988, he was a member of R&D staff of several projects such TDX switching system, ATM switching system, and MPLS system. Currently, he is a president of the Netvision Telecom and is working as a technical consultant in the field of telecommunication and data communications.