

Next Generation Optical Access Trends and OKI's Activities

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According to the Ministry of Internal Affairs and Communications' statistics data¹⁾ shown in **Figure 1**, at the end of September 2012 there were over 46.5 million broadband service subscribers in Japan (+11% from previous quarter) and still increasing.

The number of FTTH (Fiber To The Home) subscribers has grown to 23.2 million and accounts for 49.8% (+1.6% from previous quarter) of the total. On the other hand, DSL (Digital Subscriber Line) subscribers at just over 6 million (-4.7% from previous quarter) continues to decline.

Recent trend is characterized by the sharp increase in the number of subscribers for 3.9th generation mobile service known as LTE (Long Term Evolution), which at 7.3 million subscribers is up 102% from previous quarter, and shows the explosive growth of mobile broadband subscribers coinciding with the popularity of smartphones.

In terms of service and traffic, number of IPTV (Internet Protocol Tele-Vision) over FTTH has reached over 1 million subscribers in 2012 and continues to grow²⁾.

Additionally, a policy was announced by the Ministry of Internal Affairs and Communications stating the start of the next generation high-definition 4K TV broadcasting in summer of 2014 and test broadcasting of even higher-definition 8K in 2016 followed by full-scale broadcasting in 2020. This is likely to increase FTTH bandwidth use centering on video services including contents viewing via Ethernet and smart TVs capable of handling applications that interact with broadcast programs.

On the other hand, due to the rapid spread of smartphones and expansion of LTE service, mobile broadband traffic is more than doubling each year³⁾. The Ministry of Internal Affairs and Communications estimates the traffic demand for mobile in 2015 will be 20.8 to 39.1 times greater than in 2010⁴⁾.

In light of this situation, mobile operators are installing additional access points to public wireless LANs to offload traffic. However, wireless LAN technology is forecasted to shift from the current IEEE802.11n compliant products to IEEE802.11ac with throughput over 1Gbps⁵⁾ prompting public wireless LAN access points and access networks that accommodate the access points to also go high-speed.

Standardization of next-generation optical access is also taking place with work to standardize 10Gbps and 40Gbps PON systems as a follow-up to the GE-PON (Gigabit Ethernet Passive Optical Network) currently implemented in Japan's FTTH service networks. In addition to traditional FTTH and FTTB (Fiber To The Business), OKI believes a next-generation optical access system applicable to mobile networks and public wireless LAN access points is necessary, hence working on its development.

This article introduces the standardization trends of next-generation optical access and the actions OKI is taking.

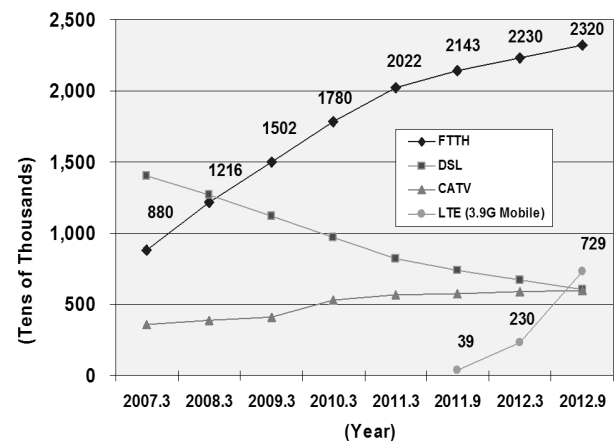


Figure 1. Changes in Number of Broadband Subscribers

Next-Generation Mobile Service Trends

LTE-Advanced is the wireless access technology planned for deployment after LTE, which is currently being used for mobile service, and development is slated for completion around 2015. The maximum downstream and upstream speeds of LTE-Advanced are 1Gbps and 500Mbps, respectively. Research of post-LTE-Advanced mobile service is already underway with the goal of reaching downstream speeds of 10Gbps⁶⁾.

For next-generation mobile, when considering the use of next-generation PON on the backhaul connecting

the wireless base station to the core network, the possibility is high the backhaul will exceed 1Gbps per base station since the maximum downstream speed supported by LTE-Advanced is 1Gbps. Additionally, for the base station to accommodate multiple sectors, backhaul network capacity might be expanded further in which case a 10Gbps PON system would not provide sufficient accommodation for the base station. Even higher speeds are being studied for mobile service beyond LTE-Advanced, and therefore flexible expansion of capacity, efficient bandwidth allocation and scalability for new services will become important factors to consider in coping with the foreseen traffic increase.

Next-Generation Optical Access Standardization Trends

For 10Gbps optical access, IEEE (Institute of Electrical and Electric Engineers) has completed standardization work on 802.3av (10G-EPON: symmetric 10Gbps downstream/10Gbps upstream, asymmetric 10Gbps downstream/1Gbps upstream) in September 2009. ITU-T (International Telecommunication Union-Telecommunication standardization sector) completed its work on the G.987 series standard (XG-PON: asymmetric 10Gbps downstream/2.5Gbps upstream) in June 2010.

IEEE is currently developing the P1904.1 SIEPON (Service Interoperability in Ethernet Passive Optical Network)⁷⁾ system standard based on the physical/data link layer specified in IEEE802.3av for the purpose of improving multi-vendor device connections of a PON system, and OKI is actively submitting various Contributions to the work. Technical Specifications are almost complete and standardization is expected to be completed in June 2013.

At ITU-T, they are applying their management specification, OMCI (ONU Management and Control Interface), to IEEE's SIEPON Package B specification. The resulting G.epon recommendation is due for completion in 2013. This recommendation is considered vital for system expansion in emerging countries, and here too OKI is vigorously making Contributions.

In Japan, interoperability testing of IEEE P1904.1 SIEPON Package B compliant 10G-EPON equipment was organized by the HATS Conference's (Promotion Conference of Harmonization of Advanced Telecommunication Systems) Optical Access Ad Hoc WG and conducted in February 2013⁸⁾. OKI participated with its already developed 10G-PON equipment and confirmed the signaling of ONU (Optical Network Unit) linkup and OLT (Optical Line Terminal) – ONU interconnection.

With the continuing increase of network traffic to consider, FSAN (Full Service Access Network)/ITU-T have started standardization work on a 40Gbps next-generation PON also known as NG-PON2 (Next Generation PON2). The main system requirements are shown in **Table 1**.

For the implementation of NG-PON2, TWDM (TDM/WDM)-PON, which uses TDM (Time Division Multiplexing) and WDM (Wavelength Division Multiplexing) hybrid technology, was adopted. This technology multiplexes four 10Gbps waves to economically enable the achievement of a 40Gbps optical access system.

Table 1. NG-PON2 System Requirements

System Capacity	Downstream 40G (10G×4 waves) Upstream 10G (2.5G×4 waves) ~ 40G (10G×4 waves)
Number of Splits	Maximum: 256 splits
Transmission Distance	40km/60km (including optical amplifier use)
Coexistence with Existing Systems	GE-PON, GPON, RF-Video, 10G-EPON, XG-PON1
Applications	FTTH, FTTB, mobile backhaul, public wireless LAN access point accommodation

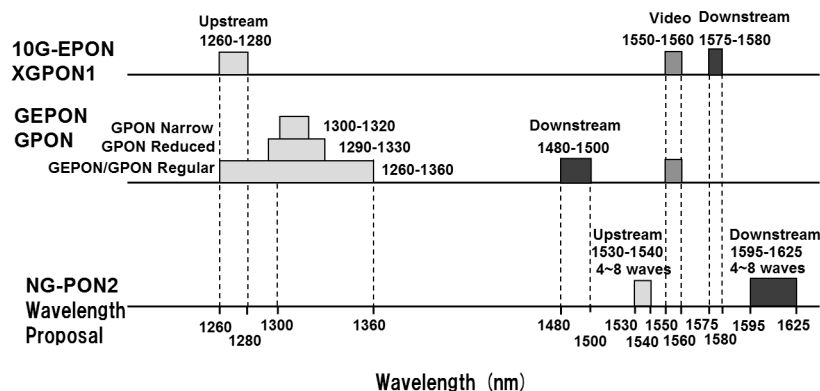


Figure 2. NG-PON2 Wavelength Allocation Proposal

Currently, downstream/upstream wavelength allocation for NG-PON2 is under investigation to achieve system coexistence with GE-PON, RF (Radio Frequency)-Video, GPON, 10G-EPON and XG-PON as shown in **Figure 2**. NG-PON2 standardization (G.989 series, 1) requirements, 2) physical layer specification, 3) control layer specification, 4) wavelength control specification) is expected to be carried out with completion targeted for 2015.

10G-EPON System Development

To the present, OKI has been working on the development of a 10G-EPON system with the following features⁹⁾⁽¹⁰⁾⁽¹¹⁾.

- 1) IEEE802.3av PR30 compliance (loss budget 29dB)
- 2) OLT that coexists with GE-PON ONU and 10G-EPON ONU
- 3) Supports a maximum of 128 ONUs
- 4) Proprietary dynamic bandwidth control (DBA: Dynamic Bandwidth Allocation) developed Example: Guaranteed bandwidth/guaranteed max bandwidth/guaranteed min bandwidth etc.
- 5) Long distance 10GONU through the use of EDC (Electronics Dispersion Compensation)
- 6) Sleep function that implements the Power Saving protocol compliant with SIEPON
- 7) Network synchronization (Synchronous Ethernet) function that takes into account mobile applications and existing leased line accommodations
- 8) 10G aggregation function for small/economical OLTs



Figure 3. View of Developed 10G-EPON ONU

Figure 3 shows a view of the developed 10G-EPON ONU. The goal for the 10GONU development was to achieve a size equivalent to the initial commercially introduced GE-PON ONU. The target has been achieved through ASIC adoption including SIEPON compliant sleep mode implementation.

Table 2. Main Specifications of the 10G-EPON ONU

UNI	1G	100BASE-Tx/1000BASE-T: 1port
	10G	10GBASE-SR/LR (Pluggable): 1port
PON IF	PMD	IEEE 802.3av PR30: 1port
Authentication Function		Yes
Encryption Function		IEEE802.1AE Compliant (10G: GCM-AES-128)
LLID		1
Priority Control		Downstream 4 Class / Upstream 4 Class
VLAN/Forwarding Rules		Transparent/Assign-Delete/ToS Cos Convert (IPv4/IPv6/IPv4v6)
Power Saving Mode		PON: IEEE P1904.1 (SIEPON) Compliant, UNI: IEEE 802.3az (EEE)
Supply Voltage		AC 100V
External Dimensions (mm)		40(W)x148(H)x178(D)

As OKI works to commercialize the 10G-EPON, additional effort will be given to reducing size/power consumption, making the unit more economical, and enhancing operation/maintenance.

NG-PON2 (TWDM-PON) System Development

Currently, OKI considers the direction of the next-generation optical access system to be the following.

- 1) Larger capacity (10G => 40G)
- 2) Use time division multiplexing and wavelength division multiplexing for efficient bandwidth allocation
- 3) Longer distance reach and multi-splitting for office integration
- 4) Power reduction through office integration
- 5) Low latency

In light of the situation, OKI has started development of a 40Gbps TWDM-PON system in 2012⁽²⁾⁽¹³⁾. An overview of the TWDM-PON system is shown in **Figure 4**. The target specifications of the system are as follows.

- System capacity: 10Gbpsx4 waves
- ONU accommodation: over 512
- Transmission distance: over 40km

The technical challenges that must be addressed for implementing the system include multi-channeling, large-scale MAC (Media Access Control) control and DWBA (Dynamic Wavelength Bandwidth Allocation) technologies for the OLT; wavelength tunable burst transceiver and colorless (upstream/downstream 4-wave wavelength selection) ONU for the ONU; and wavelength multiplexing burst support for the optical amplifier. OKI is currently developing dynamic wavelength allocation technology to make effective use of TDM and WDM hybrid technology, wavelength-tunable burst transceiver and colorless (upstream/downstream wavelength selection)

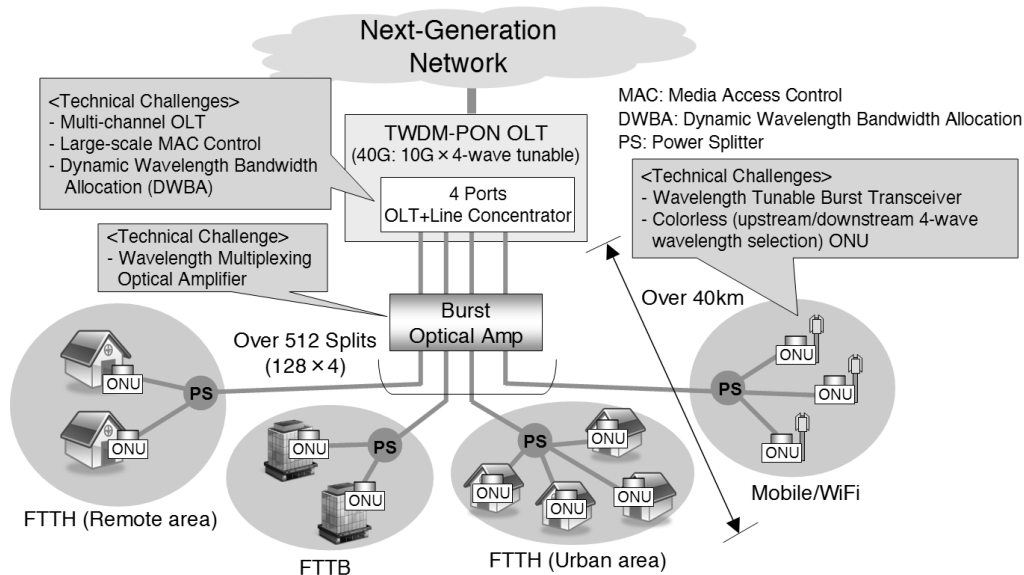


Figure 4. TWDM-PON System Overview

ONU. Based on the developmental results, OKI will actively propose Contributions to FSAN/ITU-T for the standardization of NG-PON2.

Future Prospects

The trend of the next-generation optical access positioned as the successor to OKI's GE-PON and OKI's efforts have been described.

Using the technical expertise built up from the commercialization of previous PON systems, OKI will continue to actively engage in the next-generation optical access standardization work of both the IEEE and ITU while proceeding with the development of products that meet service requirements and other market needs. ◆◆

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