SUBMARINE CABLE SYSTEM APPLICATIONS TOWARD NEXT GENERATION NETWORKS (NGN)

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Abstract: Along with the rapid popularization of broadband applications and world wide mobile services, the structure of the telecommunications industry infrastructure is shifting toward Next Generation Networks (NGN). This paper will discuss various technologies for submarine applications in NGN in view of the latest requirements from the submarine cable system operators. Diversification of the application as shown in the trend of terrestrial products is required for submarine cable system to support the growth of NGN. We present a solution for the next generation submarine cable system as well as several technologies supporting the migration toward NGN.

1 NEXT GENERATION NETWORKS (NGN)

In its infancy the internet was used for services with light traffic and little immediacy as typified by the browsing of web sites and the sharing of e-mail. However, in recent years, the capacity of the access network has exponentially expanded by the popularization of Asymmetric Digital Subscriber Line (ADSL) and Fiber To The Home (FTTH) services. The numbers of internet users and traffic volumes are rapidly increasing year after year, due to the improvement in the internet access environment and the improvement in data transfer rates, as well as the popularization of many new high-capacity applications. Another factor contributing to the growth in IP traffic increase is the migration of enterprise networks to IP networks and also the rapid growth in broadband mobile data communication.

As an example, the increase of internet traffic in Japan has been phenomenal. The number of broadband service subscribers now exceeds 24 million people, and around 6 million of those 24 million people subscribe to FTTH service. Internet traffic is increasing twice as much during the course of the year.

While IP networks are rapidly being expanded by the increase of internet users and traffic volumes, each carrier has enforced the measure towards reservation of a new income source and reduction in Operational Expenditure (OPEX) due to intensity of competition among carriers, and so NGN discussed and defined in ETSI and ITU-T is offering a lot of attention.

The NGN is a packet-based network capable to provide services including Telecommunication Services and to make use of multiple broadband, QoS-enabled transport technologies in which service-related functions are independent from underlying transport-related technologies. It offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users. Since NGN by definition is two tiered networks, one the transport layer and the other the service layer, it has become imperative to develop ways to integrate the existing networks into the packet based transport networks in order to realize a reduction in OPEX, and also to provide a flexible and quick way to introduce new applications and services on the service layer. Many carriers are currently employing and managing a large number of diverse networks, such as IP network, Asynchronous Transfer Mode (ATM) network, Frame Relay network, Ethernet network, TDM network, and Telephone network. This is because in the past it was necessary to introduce a new network each time a new service was developed and slated for introduction. Obviously with many different networks in place the operation and maintenance fees of these existing networks have become a source of concern for the carriers. Therefore, migration to IP packet based networks is considered essential for OPEX reduction and new service introductions.

2 MIGRATION OF SUBMARINE CABLE SYSTEM

It is obvious that the major traffic will be shifted from Time Division Multiplex (TDM) to IP packet in the near future because of the rapid increase of internet traffic, and the migration to IP network by NGN. For this reason, it becomes more important for submarine cable systems which support the current backbone networks to be optimized for and in conformity with IP traffic transmission.

The submarine cable industry has experienced phenomenal growth in the past decade. Suppliers of submarine cable systems, in their endeavor to meet customers' ever increasing capacity requirements, have developed a series of new, ever more robust, technologies based on Dense Wavelength Division Multiplexing (DWDM) systems. As a result, submarine cable system operators took advantage of these technologies, and built many high capacity transoceanic systems. Furthermore, the intense supplier competition induced by the recent market slump of the last few years has created opportunities for equipment manufacturers to further refine submarine cable system products and relevant applications.

While the market is showing rapid recovery from the downturn of recent years, pressure for reduced Capital Expenditure (CAPEX) and for reduced OPEX will continue and is a prime concern of submarine cable system operators. This pressure is encouraging further simplification, optimization and enhancement not only for products, but also for operation and maintenance.

In summary, the current submarine cable systems principally have the following features;

- Ultra long-haul transmission
- High-speed protection switching & recovery
- High equipment/system availability
- Various Client Interfaces
- 25 year Design Life

In addition to the above principal features, in recent years, the issues related to CAPEX and OPEX become the important topics for the submarine cable system operators, such as;

- Equipment cost reduction
- Reduction of power consumption & footprint
- Effective use of bandwidth

Furthermore, in order to optimize the submarine cable systems for IP traffic transmission toward NGN, it is indispensable to take into account efficient IP traffic transmission and efficient O&M in conjunction with IP network.

Currently, the IP traffic transmission over the submarine cable systems is primarily based on IP over Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH) over DWDM using SONET/SDH interface. However, this configuration does not have an affinity to Ethernet which is the primary interface for carrying IP traffic, and so a more efficient IP traffic transmission is required. For the network management, many carriers currently have adopted two layer structures of the IP network and Optical transport network. The IP network and Optical transport network need to be managed separately. A next generation submarine cable system is required to improve these matters for more efficient IP traffic transmission and network O&M.

In response to these requirements, the transmission equipment for submarine cable systems shall be converged with the equipment designed for terrestrial network use in varying degrees. The reliability and quality of the terrestrial terminal products is to be close to those of submarine terminal products. Additionally; the terrestrial products are being enhanced in light of the applications and client interface types for use with NGN.

This paper will discuss various technologies for submarine applications in NGN in view of the latest requirements from the submarine cable system operators.

3 TECHNOLOGIES SUPPORTING NEXT GENERATION SUBMARINE CABLE SYSTEM

Ethernet should be a primary interface for IP traffic transmission. While Ethernet was originally developed for use in Local Area Network (LAN), it has been widely deployed in many carrier networks with scaling up of IP network and popularization of Ethernet services such as Wide Area LAN. Ethernet technology enables point-to-point and any-to-any connectivity. Customers benefit from more flexibility when setting up international networks, including scalable bandwidth access, multiple service classes and integration into a single platform. The 10 Gigabit Ethernet standardized by IEEE802.3 has been developed, considering use in Wide Area Network (WAN). Also, although the Operation, Administration and Maintenance (OAM) functionality was insufficient so far, this functionality has been improved for the 10 Gigabit Ethernet. Regarding 10 Gigabit Ethernet, there are two kinds of interfaces: LAN PHY and WAN PHY.

10 Gigabit LAN PHY has a data rate of 10.3Gb/s equivalent to Gigabit Ethernet multiplied by ten while WAN PHY is developed so as to be transported on the OC-192/STM-64 frame with the technology of Wide area network Interface Sub-layer (WIS). Since the SLTE in the existing submarine cable systems is designed to multiplex the SONET/SDH interfaces, WAN PHY can be accommodated in the existing SLTE.

Optical Transport Network (OTN) is defined in ITU-T G.709, and describes guidelines of optical transport hierarchy, overhead structure, frame structure, bit rates, and formats for mapping client signals. OTN is defined in order to transport various signals such as SONET/SDH, ATM, IP, and Ethernet on the unified frame structure. The frame structure and format for mapping client signals specified in OTN are basically applied for the design of the current SLTE. By utilizing the OTN based SLTE, it will become possible to accommodate Gigabit Ethernet and 10 Gigabit Ethernet directly, and it will be also possible to connect the IP based equipment such as IP router and switch to SLTE through Ethernet interface. In case of the OTN based SLTE, it is possible to simplify the equipment configuration, and reduce the cost for SONET/SDH equipment (i.e. IP over DWDM).

Next Generation (NG) SONET/SDH is the SONET/SDH equipment advanced for packet traffic transmission. NG SONET/SDH enables efficient transport of Ethernet and IP packet traffic with various technologies such as Generic Framing Procedure (GFP), Virtual Concatenation (VCAT) and Link Capacity Adjustment Scheme (LCAS). GFP is a technology mapping Ethernet frame onto SONET/SDH frame. VCAT provides flexible concatenation functionality for any VC paths. By utilizing GFP and VCAT, Ethernet can be transported on SONET/SDH frame at an appropriate data rate. LCAS is used to realize addition and deletion of VC paths concatenated by VCAT. The adjustment of VC paths can be achieved without any traffic interruption. Thus, flexible bandwidth adjustment is possible according to the actual traffic demand. Also, it is possible to create new services such as bandwidth sharing and bandwidth assurance by employing these technologies. Regarding the protection switching functionality, the packet based ring switch named Resilient Packet Ring (RPR) becomes newly available in addition to the conventional line, path and ring switching. The RPR is applied for a ring topology, and achieves ring switch with switching time of less than 50 msec. The ring switch scheme is very similar with that of transoceanic application specified in ITU-T G.841. Also, since RPR supports several service classes, bandwidth sharing and bandwidth assured services can be provided with the feature of a statistical multiple-effect of traffic.

Generalized Multi Protocol Label Switching (GMPLS) is a protocol developed based on MPLS. GMPLS enables seamless and unified management of both IP and optical transport networks at a single control plane. Also, since GMPLS can realize a path provisioning function in a network composed of different vendors' equipment; it becomes very easy to realize a true mesh network. The current submarine cable systems are configured based on the SONET/SDH equipment. Since the path provisioning and protection switching can not be flexibly applied among different vendors' equipment, it was difficult to configure a mesh network. On the other hand, the already-deployed submarine cable systems have a feature that multiple cables are concentrated at specific landing points, and it means that it is well-suited to traffic exchange among multiple submarine cable systems. By employing GMPLS in submarine cable networks, traffic routing is optimized, and efficiency of bandwidth usage can be improved. Also, it would be possible to reduce the risk of simultaneous failure of working and protection paths by preparing the protection path in a different submarine cable system.

4 A SOLUTION FOR NEXT GENERATION SUBMARINE CABLE SYSTEM

While the presented technologies are usable for the submarine cable systems, it is essential to achieve improvements in CAPEX and OPEX at the same time. OTN based SLTE has an advantage to economically interface with IP based equipment, using Ethernet interface. This feature is convenient to provide diverse Direct Wavelength Access (DWA) solutions. NG SONET/SDH can efficiently transport IP traffic on SONET/SDH frame. Also, NG SONET/SDH can provide high-speed protection switching and various client interfaces from 1.5Mb/s to 10Gb/s. These features realize a highly reliable system, and can support both the conventional TDM traffic transmission and IP traffic transmission.

As a solution realizing further reductions in CAPEX and OPEX together with the above advanced features, integration of OTN based SLTE and NG SONET/SDH is feasible. In case of 10Gb/s transmission in the current submarine cable, it was necessary for the connection between SLTE and SONET/SDH equipment to use 10Gb/s transponder at SLTE and OC-192/ STM-64 interface at SONET/SDH equipment. However, by applying a colored optical interface to SONET/SDH equipment, the connection between SLTE and SONET/SDH equipment can be simplified by eliminating a need of transponder in SLTE. The colored optical interface has been widely deployed in terrestrial networks. This solution utilizes an integrated platform of the SLTE and SONET/SDH equipment by adopting this interface for submarine applications. Generally, the major differences between terrestrial and submarine applications are the transmission distance and optical output power level. In order to apply this solution to various submarine applications, the colored optical interface applied to submarine applications should be designed so that it can support Advanced Forward Error Correction (FEC), Return-Zero (RZ) modulation format and Stimulated Brillouin Scattering (SBS) suppression functionality, which are indispensable for providing ultra long haul transmission and launching high optical output power. This solution can hereby provide ultra long haul transmission capability over Trans-Pacific distances for repeatered systems, and achieve 400km transmission distance for un-repeatered systems. Also, this solution is applicable for capacity upgrades of existing submarine cable systems as well as new submarine cable systems.

Since it supports various technologies for efficient IP traffic transmission, this solution supports not only the current submarine cable systems, but also the migration towards NGN.

5 CONCLUSION

While IP networks are rapidly being expanded by the increase of internet users and traffic volumes, migration to IP packet based networks by NGN is considered essential for OPEX reduction and new service introductions. For this reason, it becomes more important for submarine cable systems to be optimized for and in conformity with IP traffic transmission. In this paper, we presented the latest technologies necessary toward NGN. Also, as a solution for the next generation submarine cable system, integration of OTN based SLTE and NG SONET/SDH is presented.