THE EFFECT OF DATA EFFICIENT TRANSMISSION TECHNOLOGIES ON SUBMARINE CABLE SYSTEM OPERATING MODELS

Gavin Doyle (Cable and Wireless Submarine Systems Engineering)

Email: gavin.doyle@cw.com

Cable and Wireless ,4th Floor Addison House, 32 – 43 Chart Street, London N1 6EF, United Kingdom

Abstract: Submarine cable systems continue to be based on SDH architectures whilst many telecommunications operators' core networks have evolved to accommodate both traditional telecoms traffic and the increasing volume of data traffic. In this changing environment, SDH-based submarine cable systems are at a disadvantage due to wasteful and inflexible bandwidth utilisation and expensive protection architectures.

Therefore this paper will attempt to answer the following questions:

- What is the alternative architecture and operating model for submarine cable systems that most efficiently accommodates both traditional telecommunications traffic and the rising amount of data traffic?

- In a data based ownership system, how would operators invest in these 'next generation' systems and what would be the next generation equivalent of the Minimum Investment Unit?

1. INTRODUCTION

International telecommunications operators are now focusing on the next generation of products and services to take advantage of capacity hungry high profit margin IP and data services. In addition to this, the increase in internet traffic driven by the explosion of home broadband services has significantly increased the amount of data traffic in international telecommunications networks and has raised questions over the current operating model of international submarine cable systems. As an example, Figure 1 shows the trend in telecoms traffic observed in the United Kingdom [1].

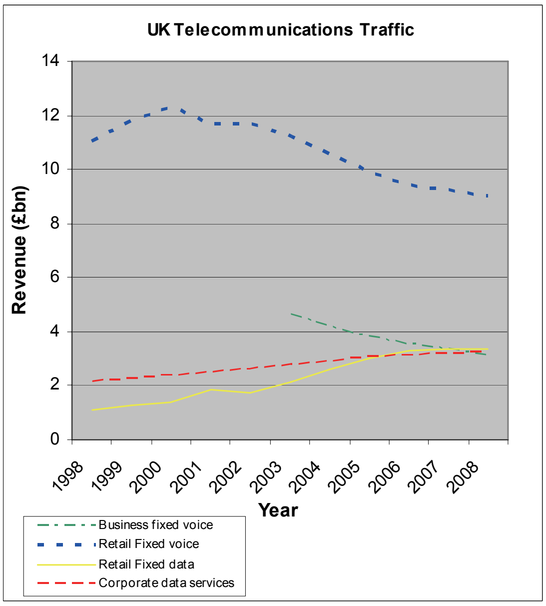

Figure 1: UK telecoms traffic trend[1]

2. THE RISE OF DATA-CENTRIC TRANSMISSION TECHNOLOGIES

While terrestrial networks have evolved into Next Generation Networks (NGN) to accommodate traditional fixed voice and also new data and IP based services, submarine telecommunications cable systems have continued to be predominately based on SDH architectures. SDH systems are typically based on the following principles:

- Traffic is mainly aggregates of traditional voice channels and not ‘bursty’ data traffic.
- An SDH based cable system needs to be capable of managing the traffic that it transports.
- The SDH based cable system should provide 1+1 protection paths to ensure high system availability.

On the other hand, telecoms operators’ next generation networks are typically based on the following principles:

- Data efficient IP-based transmission technologies such as Ethernet.
- Network control and traffic management is at the higher levels of the network.
- Protection architecture is based on ‘mesh’ network.

Other more general shortcomings of SDH with respect to submarine cable systems are as follows:

- Control of the submarine link is out-sourced to the operations and maintenance committee that own the cable system, reducing the visibility and control that operators have over their own traffic.
- Capacity bottle-necks caused by popular SDH drop points.
- Protection schemes causing poor bandwidth efficiency.

SDH networks brought reliability and manageability to optical transport networks, but lack efficiency for packet based transmission services and new high-speed private line services such as Gigabit Ethernet (GbE) and Fibre Channel (FC). Ethernet has brought flexibility, simplicity, high bandwidth and cost-effectiveness to local area networking, but has lacked the performance monitoring and management facilities to be considered for transport.

Therefore with the industry trend moving away from traditional voice and towards data transmission, there is a strong case that submarine cable transmission systems should also evolve like the terrestrial networks into the ‘Next Generation’ of transmission technology.

3. DATA EFFICIENT ARCHITECTURES FOR CABLE SYSTEMS

If we look at the current trend in transmission traffic it is clear that voice transmission is still very prominent and it can be safely assumed that there is still a large amount of circuit switched transmission equipment still in use by telecoms operators. Therefore any immediate solution to accommodate existing voice and also to improve data transmission efficiency, must take this into consideration.

Two transmission standards exist that are suitable for combining these transmission types into a more efficient transmission system. These standards are:

- Optical Transport Network (OTN)
- Ethernet over SDH

The OTN was defined by the ITU-T in the standards G.872 and G.709 with the intention of bringing together the benefits of SDH and packet based transmission methods. G.872 illustrates the network architecture of OTN, whereas G.709 focuses on structure, interfaces, and mapping and is based on the architecture defined in G.872.

A submarine transmission system utilizing OTN is shown in comparison to an SDH based system in Figure 2 below:

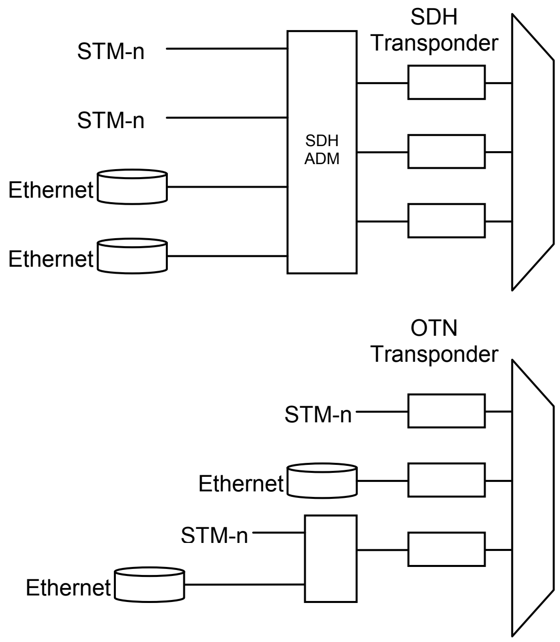

Figure 2: Comparison of SDH and OTN architectures.

The OTN configuration allows a user to multiplex various different types of traffic into the same wavelength for transmission onto the line. The various OTN data rates and their equivalent SDH rates are detailed in Figure 3 below.

	OTN Signal	**OTN rate**	**OTN Payload rate**
STM-1	OPVC1	Mux into OTU1 frame	155Mb/s
STM-16	OTU1	2.66Gb/s	2.4Gb/s
STM-64	OTU2	10.7Gb/s	9.95Gb/s
STM-246	OTU3	42.8Gb/s	39.81Gb/s

Figure 3: OTN and SDH data rate comparison.

OTN also allows the user to manage the traffic at the client side. SDH, unlike OTN, terminates the Data Communications Channel (DCC) at every Add/Drop Multiplexer (ADM) and therefore cannot carry SDH service connections transparently. OTN's transparency enables the carrying of any client service (including SDH) without interfering with the client management connection and therefore removing the need for submarine cable systems to manage this traffic, thus giving control of the traffic back to the client.

It can be seen from Figure 3 that it is possible to multiplex OTN signals down to a client payload rate of 155Mb/s. This is called an Optical channel Payload Virtual Container level 1 (OPVC1). An OPVC1 consists of a payload container with mapping and management overhead, and it transparently carries a SDH STM-1. More importantly, several of these can be concatenated to provide variable sized containers - called OPVCV1-Xn, where X is the number of 155.52 Mb/s timeslots concatenated - to more efficiently carry the full range of services. Therefore 1GbE traffic could be carried using a concatenated OPVCV1-X7 which would result in far less wasted bandwidth than transporting a 1GbE signal over an STM-16 interface.

Another solution to data transmission efficiency is Ethernet over SDH (EoS) which refers to a set of protocols which allow Ethernet traffic to be carried over synchronous digital hierarchy networks in an efficient and flexible way.

In EoS, Ethernet frames are passed through a framing process to create a synchronous stream of data from the asynchronous Ethernet packets. The synchronous stream of encapsulated data is then passed through a mapping block which typically uses virtual concatenation (VCAT) to route the stream of bits over one or more SDH paths. Additionally the 'idle' packets of the Ethernet frame are dropped before being passed through the framing procedure which results in an improved throughput. This solution is an extremely efficient way of transmitting Ethernet data however it does not have a transparent communications channel and therefore the submarine path traffic is still managed by the submarine cable system.

If we assume that the trend for telecoms traffic continues and data transmission becomes the dominant type of telecoms transmission in international networks, then it would be advantageous to have a more efficient transmission architecture for data transmission than SDH or OTN. This architecture would ideally be packet based instead of circuit based and structured around the TCP-IP transmission system using Ethernet or a similar data-link layer protocol for transmission. The most suitable solution in this scenario may be Ethernet WAN PHY transmission. WAN PHY is designed for 10Gb Ethernet transmission of data. In this case the submarine cable link would be transparent to the user's network and would simply be a Wide Area Network connection between network nodes. In a consortium cable system, this architecture is suitable for large capacity requirements of over 10Gb/s as discussed in Section 4. However for client interfaces of below 10Gb/s, a new system of allocating investment and a definition of the Minimum Investment Unit needs to be decided. This is discussed further in Section 5.

4. HIGH CAPACITY DEMAND CONSORTIUM SYSTEMS

For consortium submarine cable systems where the demand for capacity is greater than 10Gb/s per client interface, the most simple solution for the submarine cable system owners is to provide Direct Wave Access (DWA) to the transmitted wavelengths using whatever transmission protocol the client requires and the supplier can provide. This way the capacity is broken up into Minimum Investment Units (MIUs) of whatever the line side wavelength is (currently normally 10Gb/s). This wavelength access system is a 'non-intelligent' network as all of the control and intelligence is provided by the owner not the submarine cable system. The role of the submarine cable system is reduced to simply transporting the bits. Wavelength access systems allow the Owners to provision their own paths and configure their own protection using their own management platforms. As such, each Owner is not constrained by the protection mechanism chosen for the system and can tailor its network to its own precise requirements, as a mixture of traffic types can easily be carried by the system. The scope of cable system consortia is reduced as functions are brought in-house by the Owners: there is no requirement for a Network Administrator or Activations, Restoration and Routing Sub-Committee. From each Owner's perspective, the submarine system would be a more integrated part of their global network[2].

5. THE NEXT GENERATION MIU

As discussed in Section 3, in a predominantly data based network, packet data transmission would be the ideal solution to ensure efficient transmission. As an example, this paper suggests that WAN PHY Ethernet would provide a suitable solution. This however raises a problem in consortium cable systems where the individual drop capacity requirement is less than 10Gb/s. This is currently the case in many regional consortium systems. 10Gb/s Ethernet DWA would not be of any use to a small investor that currently requires only 2 x STM-16s. Capacity in some regional systems is still divided up at the E1 level. It is for this reason that it would be useful to define a next generation Minimum Investment Unit that is less than 10Gb/s. For this we can look towards terrestrial networks and specifically the use of IP-

VPNs in telecommunications networks. Figure 4 shows a typical IP-VPN network.

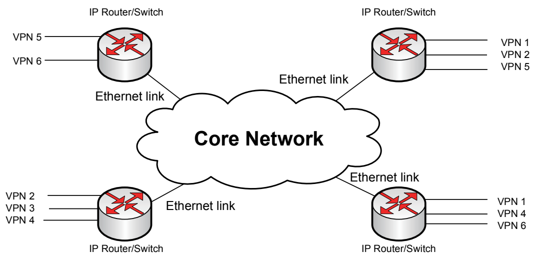

Fig 4: Basic IP-VPN Network. Virtual Private Networks are created to provide private networks within the core network. Any router can be configured with a VPN to allow the VPN owner access to that location.

IP-VPN would allow a cable system's capacity to be divided up into separate Virtual Private Networks (VPNs). Each VPN would be assigned to a consortium investor allowing the system capacity to be divided between the consortium members. At this point all consortium members effectively have equal access to the cable capacity, a key requirement for a consortium system. Access to this capacity would be controlled at the client interface. For example a 1Gb Ethernet interface could be provided at a traffic drop point, this interface could then be throttled to the client's required bandwidth. This would be the data rate that the cable system would guarantee at any time to the client. Due to inactivity of other VPNs on the cable system, it may be possible to 'burst' above this data rate if the network resources existed to allow it. It is here that the efficiency of this type of transmission system becomes apparent.
Another issue that Ethernet transmission raises is one of traffic prioritisation. In an SDH cable system traffic is transmitted in a circuit switched system which provides a guaranteed circuit for a data stream which is ideal for real time data (voice calls) but less efficient for other data (email/messaging). An Ethernet network operates on a packet switched system which does not prioritise real time data ahead of other data. Therefore without any traffic prioritisation implemented, all data will be transmitted with equal priority. This issue can be resolved by implementing a Class of Service (CoS) policy on a VPN. Each VPN can prioritise its data by type of traffic thereby ensuring real time and business critical data is given priority over other data types. Figure 5 shows a typical CoS structure.

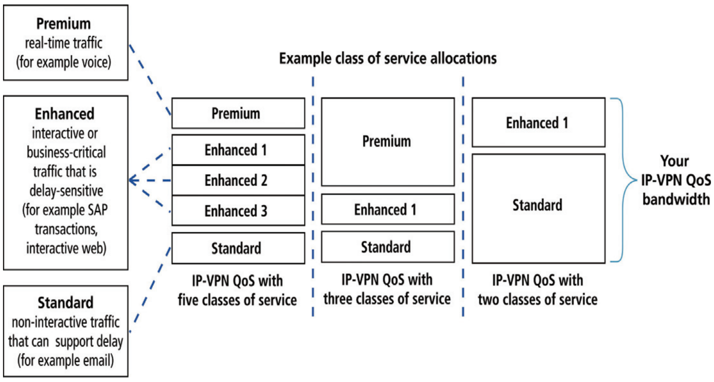

Figure 5: CoS structure.

Also when there is less network use of real time data, the non priority data can use the reserved bandwidth.

This type of cable system architecture may also help to relieve bottle necks in international transmission systems. Under packet based transmission architectures a bottle neck becomes unappealing to investors as it removes the possibility of bursting above the guaranteed data rate. This could have the effect of self regulating international traffic management by encouraging the equalisation of traffic flow across routes. Parties could be attracted to unpopular routes away from bottlenecks by the possibility of bursting above their guaranteed traffic level and getting additional capacity for free.

6. CONCLUSION

The rise of data communications has had a profound effect on terrestrial telecommunications networks however submarine cable systems have consistently been viewed as a separate part of this network instead of an integral part. Therefore traditional operators have outsourced management of their submarine cable traffic to submarine cable networks and submarine cable systems have not yet evolved to using transmission technology that is efficient and suitable for data transmission. This migration from circuit based transmission (voice traffic) is not yet an immediate need for submarine cable systems as voice traffic is still a prominent part of the total data in submarine cable networks. However submarine cable investors could make significant efficiency savings by switching to OTN based technology or Ethernet over SDH utilising 10Gb Ethernet. This would also give telecoms operators back control of their traffic and further reduce the cost of the submarine cable link.

Looking further ahead, in systems where the MIU is 10Gb/s direct wave access will facilitate the integration of the submarine cable system into operators data networks. For sub 10Gb/s MIU systems, advanced IP-VPN services will allow submarine cable systems to transparently provide efficient data transmission whilst maintaining SDH levels of traffic management and transmission quality.

7. REFERENCES

[1] OfCom, The communications market 2008, Part 4 Figure 4.2 pg 198.

[2] E West, "The Impact of Convergence on Submarine Cable Procurement", SubOptic 2007, Baltimore, USA, Paper TuB1.5

