THE IMPACT OF CONVERGENCE ON SUBMARINE CABLE SYSTEM DEPLOYMENT

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Abstract: A review of recent submarine system deployments and upgrades has revealed a significant influence on design from equipment convergence and new transmission protocols. This influence has been particularly significant in the unrepeatered market but such concepts lend themselves to repeatered systems. Until the advent of this trend, submarine cable system technology was based on specialist or even bespoke system design; however, the submarine industry does not exist in isolation and is influenced by wider change in the telecommunications industry. The broadband revolution is rapidly using up surplus capacity and driving future traffic growth. New ownership models for common carrier submarine systems will be needed to reflect the change in aggregate layer technology away from the Synchronous Digital Hierarchy (SDH) towards Internet Protocol (IP) based technologies. The distinction between terrestrial and submarine equipment is becoming less marked. Submarine systems will increasingly be seen as extensions of the terrestrial network, rather than special networks in their own right. Terrestrial-based technology is increasingly being used on submarine systems, removing Owners' dependence on the traditional specialist submarine suppliers.

1 TRAFFIC TRENDS

Although submarine cable systems have historically been a specialist niche industry, wider change in telecommunications is influencing the future direction of submarine cable system procurement. Future growth in telecommunications networks, and hence submarine cable system demand, is being driven by the growth of the IP network. The largest consumer of submarine cable system bandwidth is internet traffic, while the burgeoning global appetite for broadband will augment future demand. Services such as High Definition Television (HDTV), video-on-demand, interactive gaming, video uploading and downloading, high-speed internet access and Voice over Internet Protocol (VoIP) will all drive the need for additional capacity. The Next Generation Networks of individual Operators will need to be supported by Next Generation Submarine Cables, utilising new protocols and new technology.

2 SHORTCOMINGS OF SDH-BASED MODEL

From an operator's perspective, several unsatisfactory features of the traditional SDH-based submarine system model also encourage such a shift.

Traditionally, common carrier submarine cable systems have been distinct networks in their own right, operated separately from the networks of their Owners. Historically, this stemmed primarily from the regulatory regime that was in place. The total traffic capacity of a system was typically divided up on the basis of Minimum Investment Units (MIUs), "chunks" of capacity offering seamless transmission continuity to support voice traffic. Systems were based on specialist or even bespoke design. While traffic was usually presented to Owners as SDH capacity, highly specialised Submarine Line Terminating Equipment (SLTE) was essential on the line side. Systems were operated as separate networks, often available with their system-specific Network Operations Centre and also providing network and tributary protection for Owners' capacity as it passed through the system. Some systems were operated as SDH rings, such as 4f MS-SPRing with transoceanic application (G.841 Annex A), with capacity reserved for protection.

Such a model has several undesirable features from an Owner's viewpoint. Firstly, each individual Owner has effectively out-sourced the operation of its submarine links to the numerous committees that manage each of its submarine cable investments. It is therefore difficult for an Owner to have complete visibility of and control over its entire network. One solution widely adopted to date is the use of "manager of managers" tools; other techniques include web-based network management interfaces.[1] Nonetheless, in an ideal world each Owner would prefer to have greater control of their own networks than can be provided by the traditional model.

Moreover, SDH is becoming increasingly uneconomic as an aggregate layer: providing ultra-reliable paths using G.841 protection mechanisms is expensive in terms of bandwidth utilisation; dedicating large amounts of capacity to protection is wasteful and unnecessary when carrying data traffic.

The inappropriate use of SDH ring architecture can sometimes lead to additional problems, if the capacity drop in each station is uneven. This issue is particularly acute in systems where there are multiple cables, with more than one cable station in each country, such as the example shown in Figure 1. Concerns with regard to Round Trip Delay can make shorter links more popular than longer ones; in the example, the northern link AB would be more heavily loaded than the longer southern route CD. Even in an ideal situation where northern and southern links are equally loaded, the domestic links AC and BD would be very lightly utilised, but these links are necessary to complete the SDH ring. The loading of an SDH ring system can be further forced away from the ideal by the variation in cost of gaining access to the Terminal Stations. If backhaul prices vary considerably within a country, traffic flows can be further distorted. In this way, backhaul prices can act against the concept of common carrier systems providing open terminal access. For instance, if backhaul costs are higher in station A than station C, station C will attract more traffic that station A. Such distortions of traffic flows can eliminate the advantages of a ring system and can lead to wasteful provision and use of system terminal equipment. These disadvantages have been seen in the Atlantic and Pacific, and have pushed Owners towards Direct Wavelength Access (DWA), which will be discussed below. (See Figure 1)

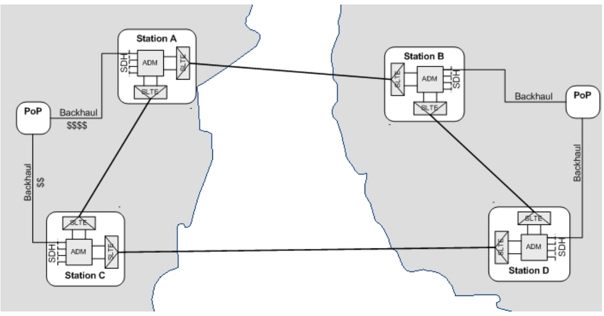

Figure 1: SDH-Based Ring System

3 WAVELENGTH ACCESS FOR LARGE SYSTEMS

The influence of increasingly IP-based terrestrial networks and the shortcomings of the current SDH-based model are leading the submarine cable industry in a number of directions. One possible way forward is for submarine cable systems to become simpler, with the functionality and operational responsibility being transferred to the Owners, giving them more control and flexibility with respect to the traffic they can carry. As shown in Figure 2, the SDH layer of traditional systems is removed, leaving only the line transmission equipment. Capacity is divided up between Owners by wavelength. This model is the ultimate end point of the trend towards Direct Wavelength Access already seen in transatlantic and transpacific systems. Several systems which started life based on SDH have been upgraded by adding DWA wavelengths. A further development already seen is the replacement of SDH wavelengths by Direct Wavelength Access and the rise of systems without any SDH capacity. (See figure 2)

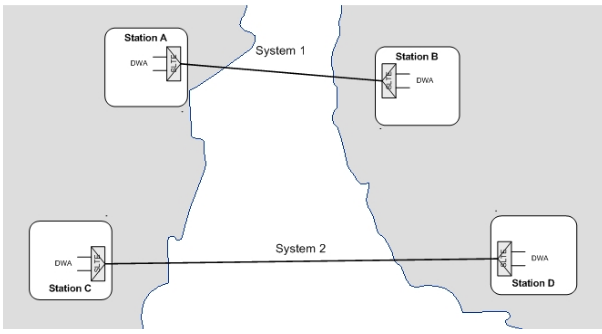

Figure 2: Direct Wavelength Access

Wavelength-based systems are “stupid” networks whereby the control and intelligence is provided by the Owner, not by the submarine cable network.[2] The role of the submarine cable network 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.

A further driver for wavelength access is the move to unprotected capacity. Having multiple unprotected point-to-point links over different submarine cable systems is increasingly being seen as preferable to having protected traffic on a single system; diverse paths are more appropriate for data traffic. Operators can take wavelengths on multiple systems to build up a mesh network.[3]

A MIU on a direct wavelength access system is a full wavelength (usually 10 Gbit/s). Therefore, the trend towards direct wavelength access is only applicable to large transoceanic systems bought by Owners with a large demand for capacity. In regional systems where demand is smaller and capacity is currently divided up at low traffic rates such as E1s, it will be some time before small parties’ ownership is sufficient to justify a complete 10 Gbit/s wavelength. A different model will have to be developed to divide up traffic for these cases.

4 NEXT GENERATION EQUIPMENT FOR REGIONAL SYSTEMS

Competition in terrestrial networks has driven Operators to simplify their networks. Following trends in terrestrial technology, several alternatives to SLTE and SDH equipment exist for submarine networks. The simplest approach is to unify the SLTE and SDH equipment by using SDH equipment with long-haul, coloured interfaces providing the SLTE function within a single card. Another contender is the replacement of the SLTE and SDH layers of traditional submarine cable systems by a Next Generation SLTE based on the Optical Transport Network (OTN), as illustrated in Figure 3. Such an SLTE would be the aggregate medium for all services; for instance, it could directly interface with IP based equipment without using SDH equipment. Such SLTEs have been proposed by suppliers and would solve the technical problem of providing IP-based access in a pseudo-direct access system.[4] (See figure 3)

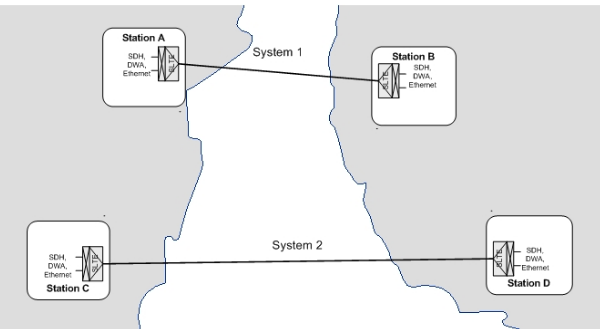

Figure 3: Next Generation SLTE

An alternative option would be to unify the protection switching and IP equipment by removing the SDH layer. The advent of equipment converging OSI layers 1-3 allows this possibility, for instance by using routers equipped with 10 Gbit/s interfaces to connect to SLTEs, as shown in Figure 4. However, for common carrier systems to be able to make use of such technology, the question of how to divide up the capacity must be addressed. (See figure 4)

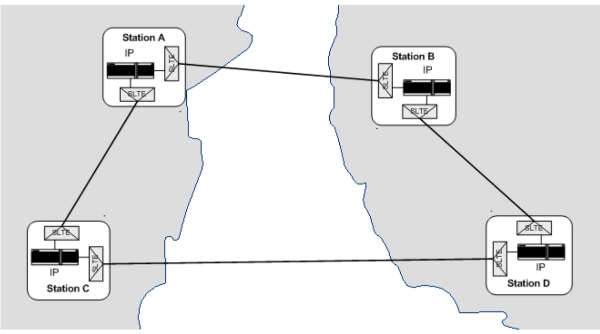

Figure 4: Router-Based IP Network

SDH-based networks structured with Minimum Investment Units provide Owners with a guaranteed amount of capacity, with equal Quality of Service. In contrast, bursty IP traffic can allow overbooking of client port capacity in relation to line side capacity to provide statistical multiplexing gain; statistical modelling can be used to achieve the most optimal and economical ratio. A telecommunications operator can easily realise these benefits by making decisions and trade-offs within its own network, but a consortium environment is different: each consortium member will expect equal treatment. A potential solution to the QoS and bit rate inequality issue is the use of predetermined Virtual Private Network (VPN) bandwidths for each consortium member.[5]

A “next generation MIU” needs to be developed to take into account these technologies so that capacity can be divided into sub-wavelength chunks. One reason why recent submarine cable deployment and upgrades have remained with SDH is that the ownership model is well established and understood. The lack of a data-based ownership model is an obstacle which must be overcome to allow next generation equipment and services to be made available on common carrier submarine cable systems. It is essential for the ownership model to accurately reflect the technology. The pitfalls of not doing so have previously been seen in SDH systems where moves towards more complex protection schemes such as transoceanic 4f MS-SPRing were not always accompanied by an update of the ownership model.

5 IMPACT ON SUPPLY MARKET

Both in the SDH space and also for Next Generation equipment, the distinction between submarine and terrestrial terminal equipment is becoming less marked. SLTE equipment is becoming less specialised, except in ultra-long haul environments. Terrestrial-based technology is increasingly being used on submarine systems; as terrestrial equipment gains a longer reach, it becomes applicable to more submarine markets. Technology such as Forward Error Correction is being used more and more in terrestrial as well as submarine networks, effectively making it a commodity technology. Both these complementary developments reduce operators’ dependence on the traditional specialist submarine suppliers. The traditional suppliers will probably still dominate the long haul market, but submarine system Purchasers will be able to choose from a growing number of potential suppliers of terminal equipment. A new multi-vendor environment will also emerge due to the changes in technology outlined above.

6 CONCLUSION

The impact of IP-based demand and technology in the wider telecommunications industry may cause a fundamental shift in the organisation, funding, operation and implementation of future submarine systems. In the submarine cable world, this is reinforced by dissatisfaction with the traditional ownership model. For large systems, the movement towards Direct Wavelength Access will be promoted by the emergence of next generation SLTEs. The lack of a next generation sub-wavelength MIU ownership model is a stumbling block which needs to be overcome to allow the full benefits of IP-based technology to be realised in regional submarine cable systems.

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