THE FTTH ARCHITECTURES AND EVOLUTION OF PON AND POINT-TO-POINT

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INTRODUCTION

The state of deployments of fiber to the home (FTTH) is moving at a rapid pace – seeing different markets deploy fibre across the access network and provide far more bandwidth whilst also enabling unrestricted applications to be delivered to consumers and businesses.

FTTH deployments are being carried out by municipalities and utilities, large incumbents and new challengers alike.

This paper will discuss the different access network architectures and their likely evolution with a focus on GPON and Point-to-point indicating their evolution and promise.

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SERVICES AND BANDWIDTH REQUIREMENTS

Higher Internet access speeds are needed by ever more demanding applications. Bandwidth intensive, video and multimedia content and peer-to-peer applications consume increasing amounts of bandwidth in both the access and core networks. This race between application requirements continues with streaming video content considered by many as the ultimate bandwidth-hungry application.

The initial FTTH services supplied 10Mbps but soon had to rise to supply 50 Mbps. However it is now apparent that the trend is to be able to supply at least 1Gbps in what is now known as the Gigabit network era. Indeed, some service providers are already offering 2 Gbps access to residential customers today, and there are some substantial deployments of 100-Mbps in Europe and APAC.

ETHERNET-BASED POINT-TO-POINT ARCHITECTURES

The requirements for rapid time to market have enabled network architectures based on Ethernet connectivity and switching. Ethernet transmission and switching equipment have become commodities, leading to attractive entry costs and rapid innovation cycles.

Some Ethernet architectures have been based on switches located in the basements of multi-dwelling units (MDU's), interconnected by Gigabit Ethernet in a tree or ring structure. This enables sharing a bandwidth over each access ring of 1 Gbps.

Ethernet star architectures have been able to provide dedicated fibers (typically single-mode, single-fiber with 100BX or 1000BX Ethernet transmission) from every endpoint (POP), where they are terminated on a switch. These may be single family residences, apartments, or multi-dwelling units (MDU's) where a switch in the basement connects to the apartments using any type of cabling.

These deployments are likely to evolve to 10Gbits access point to point architecture to deliver a 10Gbps pipe to business or commercials or buildings - a bandwidth that is likely to be shared at the customer end point by a home or local network.

PON-BASED GPON ARCHITECTURES

PON architectures for FTTH deployments are currently based on passive optical splitters to distribute the bandwidth to each customer using fiber splitters providing ratios ranging up to 1:64 or even 1:128. The physical PON FTTH architecture typically supports the Ethernet protocol. PON network feeds a variety of optical network terminations (ONTs) or optical network units (ONUs). ONTs are usually dedicated to an individual end user.
An ONU typically is located in a basement or even on a curb-side and shared by a limited number of users. Voice, data and video services are distributed over appropriate transmission media within the customer premises from the ONU or ONT (e.g. using existing in-building copper cabling).

There are different benefits for service providers that deploy PON architectures, although some of these reasons are becoming less interesting. Saving on fiber between the optical splitter and the central office or POP locations is the most significant aspect for PON FTTH deployments.

First, the fact that there is a dedicated optical interface per customer in a point-to-point scenario may imply that this architecture is inherently more expensive than an architecture sharing ports among a larger number of customers. Experience with a large number of projects, however, has shown that dedicated Ethernet ports are price-competitive given the greater expense of PON ports. Second, assuming a 100 percent take rate of an FTTH offering, the POP for a PON architecture would have less than half as much equipment compared to Ethernet FTTH. But assuming realistic take rates, as discussed below, the difference disappears. This is due to the fact that already the first customer on a PON requires an optical line termination (OLT) port, and thus, the number of OLT ports cannot be reduced based on a lower take rate.

ISSUES WITH PON AND P2P ARCHITECTURES

There are a number of issues associated with PON architectures that can be summarized in the following points:

The Shared Bandwidth for the PON fiber is based on tree topology shared among as many customers as possible in order to benefit from potential cost savings on a per-subscriber basis. GPON technology provides 2.5 Gbps of aggregate downstream capacity and half that downstream. However, it can now deliver the faster speeds based on a TDWDM PON upgrade that increases the wavelength options on outside plant.

Optical Power Requirements are evident at PON architecture as every 1:2 power split causes a degradation of the power budget by some 3.4 dB. Consequently, a 1:64 split can degrade the power budget by 20.4 dB.

ARCHITECTURE CHOICE AND UNBUNDLING

For Local Loop Unbundling where (LLU) is the method enforced by regulation in copper networks today to provide access for challengers to the incumbent's copper subscriber loops.

This regulation has dramatically improved penetration of DSL services and reduced prices for broadband access services to subscribers. PON networks do not immediately support LLU requirements because there is only a single fiber connecting a number of customers, which consequently cannot be separated on a physical level but only on a logical level. PON cannot also realistically support an open-access approach.

PON would only support a wholesale offering by the service provider through bitstream or VULA or on the physical access by the support of a flexibility point in access outside plant infrastructure to enable fiber cable sharing between different operators.

TECHNOLOGY MIGRATION

Point to point has a direct migration path through the upgrading of electronics at the central office from 100Mbps to 1Gbps and then eventually to 10Gbps over the same fiber pair.

For PON the use of a wavelength-division multiplexing (WDM) overlay is needed. As current PON receivers are not wavelength-selective, this requires wavelength filters to be inserted at all the endpoints before the migration begins.
TDWDM allows for 4 wavelengths to be overlaid on the same OSP to increase the capacity to 10Gbps per each wavelength on the GPON system.

ETHERNET FTTH AND PON ASSESSMENT AND PARALLELS

A direct fiber can provide virtually unlimited bandwidth, which offers the ultimate flexibility for future service deployments as bandwidth needs increase. Ethernet FTTH enables a service provider to guarantee bandwidth for each subscriber and to create bandwidth profiles in the network on a per-customer basis.

GPON bandwidth is also upgradable and manageable via different tools where utilization can be monitored and bandwidth allocation is adjusted via dynamic bandwidth allocation. TWDWDM provides an evolution path for wavelength per service provider and even towards wavelength per user offering real flexibility in management and upgrades and more flexible unbundling capabilities (on a wavelength basis).

Deployments of Ethernet FTTH access networks over longer distances use a common single-fiber 100BX or 1000BX technology with a specified maximum reach in excess of 10 km or more.

To support longer distances, there are optical modules available in the market that allow for a higher optical budget, and also duplex fibers with Ethernet optical transceivers that may be inserted into any Ethernet line card port interface.

Very sparsely populated areas can be covered employing various types of Ethernet FTTH optics without affecting other customers on the same Ethernet switch.

With GPON, there are multiple types of SFPs that support higher distance and extend the reach up to more than 20km depending on the combined split ratio to extend the reach of GPON towards the served communities.

FLEXIBILITY AND SECURITY

Customers with a subscription occupy ports on the Ethernet FTTH access switch. As the customer base grows, additional Ethernet line cards and hence customers can be added at low incremental costs.

In the PON architecture, the first customer connected needs a central OLT card just for them and the associated cost per subscriber is only improved by adding customers to the same PON tree. However with more penetration and service uptake, the cost per port is divided across more subscribers.

The ONT/OLT provide encryption based on AES 256 to secure and encrypt the traffic upstream & downstream, but the inter-operability of any ONT with an OLT from another vendor is currently limited.

In the case of point-to-point, the protection is provided by different independent fiber pairs, however an encryption layer is desired to protect sensitive applications from eavesdropping threats.

SYNOPSIS ON DEPLOYMENT SCENARIOS

Point to point is sometimes favoured by challenging operators (and almost always for open access) for its ease of deployment and fast time to market in terms of the cost of equipment and OSP design. It is also well suited for commercial applications and large enterprise needs - having a separate physical layer and fiber to guarantee throughput and data protection.

For mass deployments, GPON has shown traction and adoption providing an advantage with increasing and rising take rates resulting in more effective network economics for passive and active deployments.

In reality, both architectures can exist on the same OLT given that most supplier solutions support both GPON and point-to-point on the same shelf.

With point-to-point addressing large enterprise and Government services while GPON for mass residential and commercial deployment building on scale and reach.

For gated communities both architectures have demonstrated success and good references although the space and power benefits of GPON are less important and the inability of P2P to carry multiple HD channels means open access in countries such as Sweden is 100% P2P.