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Evolution of FTTH Networks for NG-PON2

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Keywords: Optical Fibre, Passive Optical Networks, GPON, XGPON, NG-PON2.

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Summary

For the last years there has been a clear evolution in the implementation and development of the optical fibre at home (FTTH). This technology enables the offer of applications to a high flow rate per client and, therefore, it is the technology with the highest capacity of generating revenue.

Currently FTTH networks are the main differentiator among operators. Another advantage of FTTH is the fact that this technology allows more operational efficiency when compared to other access technologies, mainly due to reduction of maintenance and operational costs. Besides that, it requires less space in centrals and presents lower energu concumption.

As a consequence, FTTH networks were standardised and developed in the whole world, but the need for bandwidth by users and new services makes this type of network need to evolve, from the current standardised technologies GPON and XGPON to NG-PON2. In this way and for operational costs reduction and protection of initial investment, operators should keep the current wavelength planning, so that there is a coexistence in the same fibre of the current GPON and the future access networks, taking into account power division, distance and loss.

In this article we intend to review the system requirements and study its needed adaption to optical fibre access besides the current GPON and XGPON networks. A possible evolution scenario for NG-PON2 will also be discussed, taking into consideration the planning of optical bands and new architectures that take advantage of WDM technology's maturity.

Introduction

Ultra broadband and coexistence with the existent technologies are the general requirements of network operations for direct evolution of PON networks. Operators all around the world seek to increase the revenue through the development of services based on the increase of bandwidth. A service that works as an example is HDTV, which requires about 20 Mbit/s per channel. In a near futute, new business models, such as house video editing, online games, interactive e-learning, telemedicine services and the next generation of 3D TV will dramatically increase the need for bandwidth.

The rollout of PON networks involves significant initial investment and with slow return. The protection of investments, by taking advantage of the existing optical distribution networks (ODN), is essential to operators.

FTTH networks based on PON passive optical networks have been largely developed since 2004, when ITU-T Study Group 15 Q2 completed the recommendations that define a GPON system [ITU-T series G.984].

As the services of high bandwidth are maintained by the massive development of PON networks in the whole world, operators expect even more this type of passive optical networks. This includes increase of bandwidth and service support capacity, as well as a better performance of the access nodes abd the support equipment of the existing PON networks, making PON evolution a key element for the telecommunication industry.

Full Service Access Network (FSAN), along with ITU-T, are the forum and standardisation organisation with the greatest activity in the study of this type of networks. In their point of view, next generation networks are now divided into two stages, NG-PON1, better known as XGPON, and NG-PON2. XGPON is considered to be the short-term evolution, standardised since 2010,

while NG-PON2 technology is considered to be a medium-term technology (2015), having initiated its standardiation in ITU-T in the middle of this year (Figure 1).

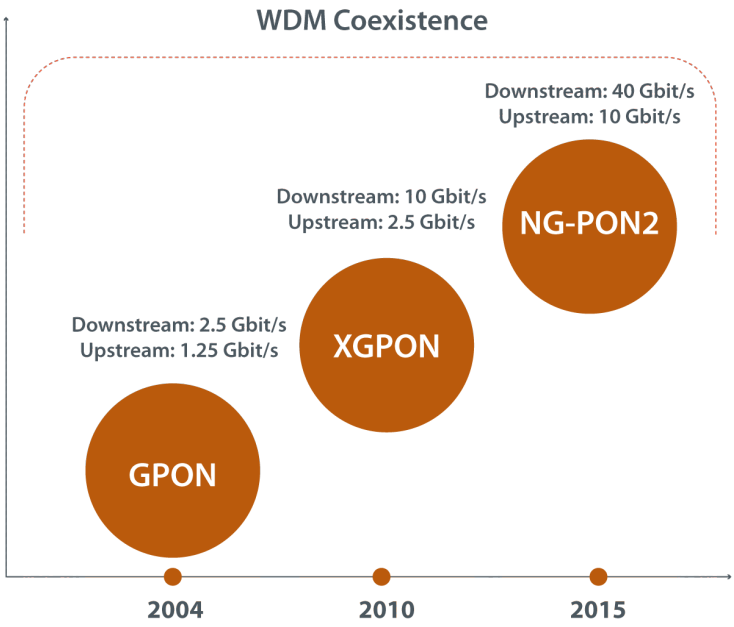

Figure 1: PON Evolution

The main requirements of these two technological evolutions, XGPON and NG-PON2, are, namely, the coexistence with the already developed GPON systems and the reuse of the outside plant, taking into consideration that the ODN represents 70% of the sum of investments in the PON rollout. Therefore, it is essential for NGPON evolution to be compatible with the rolled out networks.

With the specification of coexistence of systems and reuse of ODN, the only hold-up of the migration from GPON to NG-PON1 and NG-PON2 is the maturity of technology and the need of higher bandwidth.

1. XGPON

XGPON technology is already standardised in the ITU-T Rec. G987.x and defines a mechanism of migration to acquire a signal for the 10 Gbit/s user and 2.5 Gbits of the user.This type of technology is still evolving, presenting few technological suppliers, few interoperable equipment between manufacturers and few interested operators, since NG-PON2 technology is expected within 3 years.

Figure 2 shows the planning of wavelengths defined in the ITU-T Rec. G987 standard.

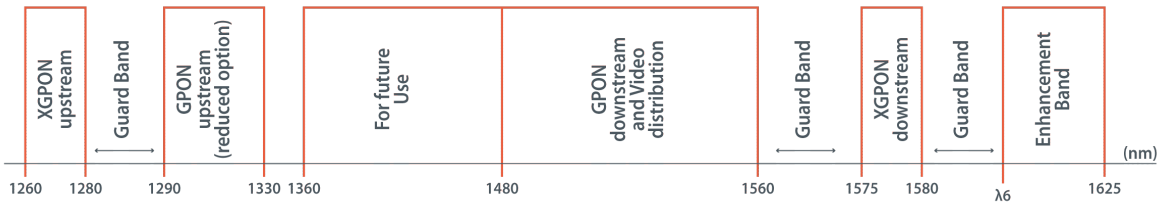

Figure 2: Allocation of GPON and XGPON wavelenghts [2-5]

The signal for the XGPON user is defined in the range from 1575 nm to 1580 nm and the signal of the user from 1260 nm to 1280 nm. For the coexistence of XGPON and GPON technology on the same fibre, the central needs a WDM filter that combines the signal for the user and the video signal (Figure 3).

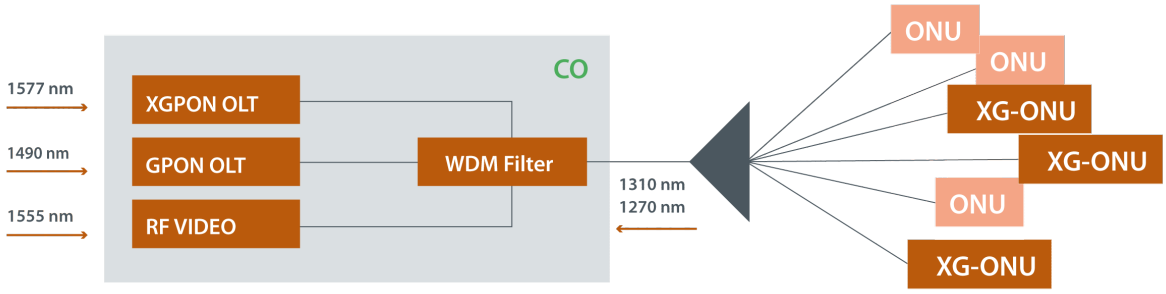

Figure 3: GPON and XGPON coexistence

2. NG-PON2

The general requirements for NG-PON2 point to supporting at least 40Gbit/s of aggregate capacity in downstream for residential and commercial applications, mobile backhaul and other applications.

FSAN has considered several options for NG-PON2. Among the studied technologies suggested to support the requirement for 40 Gbit/s bandwidth, there were the following options: WDM-PON; coherent ultra-dense WDM-PON (UDWDM PON); Orthogonal Frequency Division Multiplexing (OFDM) PON; 40Gbit/s TDM PON; and TWDM-PON (TDM/WDM-PON), a hybrid system that piles up four 10GPON in only one fibre to have an aggregate capacity of 40Gbit/s. Among these, TWDM-PON technology was considered by FSAN to be the solution for NG-PON2, because in the operators' point of view it is considered less risky, less disruptive and less expensive than the other solutions, which contributes significantly to a great advance in the NG-PON2 standardisation.

This new system will increase PON capacity in at least 40Gbit/s and provide services of 1Gbit/s or more with platforms that may be rolled out in 2015. When the coexistence of the various PON generations is considered, is becomes necessary to take into account the planning of wavelength which NG-PON2 technology has to coexist with. Figure 4 shows the available spectrum for NG-PON2.

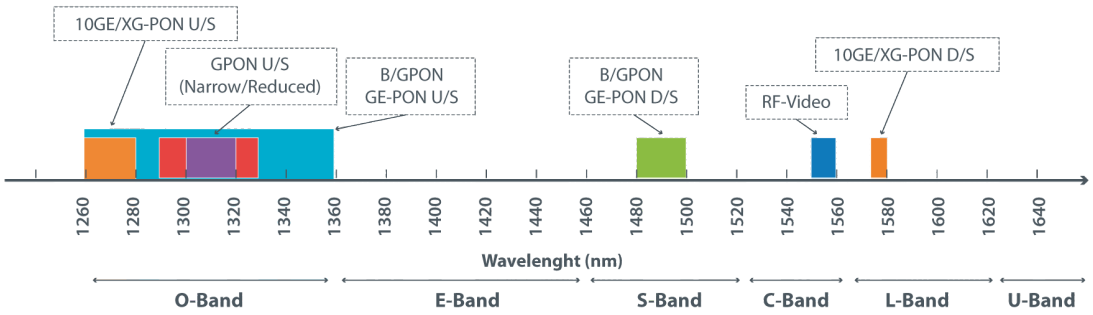

Figure 4: Current PON wavelength plan

Another factor that limits the available spectrum are the characteristics of the existing optical filters in the developed and installed systems. The most considerable one is the filter of the video-overlay signal that requires guard bands that occupy most of C-band, where the loss of fibre insertion is lower and you can put erbium doped fibre amplifiers (EDFA). That is, there is great spectral limitation, since NG-PON2 technology needs to coexist with all the PON. Only a technology that occupies few spectrum per wavelength and is capable of being narrowly controlled, is capable of coexisting. If not, commitments like restriction of coexistence scenarios will be necessary.

Ideally NG-PON2 technology will be able to coexist with current PON. However, technology and cost may restrict this requirement.

Figure 5 shows an example of a TWDM-PON architecture. Four 10 Gbit/s wavelengths are multiplexed in the Cenral Office and routed in the downstream direction. The ONU will select the corresponding operation wavelength, filtering one of the 4 downstream wavelengths.

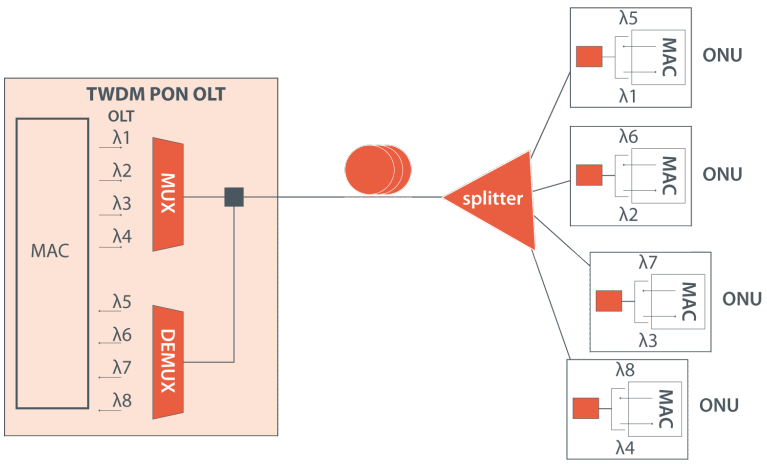

Figure 5: TWDM-PON

In the upstream direction, the ONU/ONT will work in one of the 4 upstream wavelengths, previously selected by the OLT for that same ONU's operation.

The coexistence with the current PON, with this type of technology, will imply the placement of a new WDM filter in the central.

3. Conclusions

In terms of bit rate, XGPON technology is the natural evolution for GPON networks, but the need for larger bandwidth will lead operators to evolve directly to NG-PON2. However, coexistence with current GPON networks, technology and cost of optical components will be determining factors.

4. References

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