OIF Carrier WG Requirements for Intermediate Reach 100G DWDM for Metro Type Applications

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ABSTRACT: This document provides a short description of the metro network constraints and architecture evolution and summarizes the OIF Carrier WG requirements on Intermediate Reach 100G DWDM interface.

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1 Table of Contents

0 Cover Sheet 1
1 Table of Contents 5
2 List of Figures 6
3 Introduction 7
4 Disclaimer 7
5 Network constraints and rationales for the requirements 8
5.1 Traffic growth 8
5.2 Metro architecture renewal 8
5.3 Polarization Mode Dispersion (PMD) 11
5.4 Network design trade off 11
5.5 Technical state of art 12
6 Requirements on Intermediate Reach 100G DWDM 13

2 List of Figures

FIGURE 1 EXAMPLE OF CORE AND METRO NETWORKS TOPOLOGIES. 8
FIGURE 2 EXAMPLE OF CURRENT METRO NETWORK. 10
FIGURE 3 EXAMPLES OF METRO NETWORKS EVOLUTION. 10

3 Introduction

The Physical Link Layer Working Group (PLL WG) has started a project on Intermediate Reach 100G DWDM. The project start proposal is documented in the OIF internal contribution oif2012.230.02. The expected output of this project is to produce a framework document with requirements and application scenarios related to low cost, reduced power and high density approach for next-gen 100G transmission.

To help progressing the works on this topic, and to help in the technical choices that have to be made within the PLL WG, the Carrier Working Group have analyzed their network constraints and anticipated on some system requirements.

Therefore, this document provides a short description of the metro network constraints and architecture evolution and summarizes the OIF Carrier WG requirements on such interface.

4 Disclaimer

This document has been reviewed by the Carrier Working Group Members, but may not necessarily represent the position of any particular company participating in the Carrier WG.

This document contains a set of requirements agreed to by all the participants. Individual carriers may have additional requirements.

5 Network constraints and rationales for the requirements

5.1 Traffic growth

This is a recurrent aspect of the telecommunication networks. However, it can be noted that acceleration in the traffic growth has been seen on the metro part of the transmission network during the last few years. The traffic increase is partly due to mobile data, content delivery and video streaming. Today, the transmission rates in the metro network evolve from multiple 1/2,5G to 10G and eventually up to 40/100G.

An excerpt of the executive summary from the Cisco analysis document "The Zettabyte Era—Trends and Analysis" reports that: "Metro traffic will surpass long-haul traffic in 2014, and will account for 58 percent of total IP traffic by 2017. Metro traffic will grow nearly twice as fast as long-haul traffic from 2012 to 2017. The higher growth in metro networks is due in part to the increasingly significant role of content delivery networks, which bypass long-haul links and deliver traffic to metro and regional backbones."

5.2 Metro architecture renewal

While a core networks architecture is traditionally based on mesh topology, a metro networks architecture is often based on ring topology. An example of the topologies is shown in **Figure 1**.

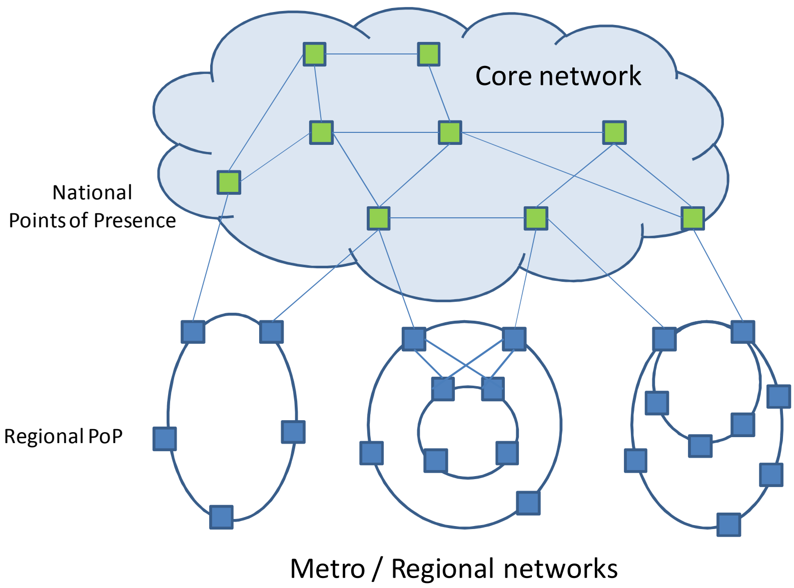

Figure 1 Example of core and metro networks topologies.

However, if we look closely, the actual design of a ring is made of a succession of point to point WDM systems (and even normal fibers) that connect the metro sites located all along the ring (as shown in the **Figure 3**). In this architecture, a high level of PMD on each section is mitigated by the fact that regenerations occur at each point of presence.

With the introduction or expansion of fixed or reconfigurable Optical Add Drop Multiplexers (xOADMs) in the metro networks, optical transparency can be obtained across the entire ring. Like in the core network, the main advantage of a transparent architecture is the savings that can be obtained from the decrease of the transponders needed for an end to end connection (e.g. the red connection uses 2 transponders in the **Figure 3** instead of 4 in **Figure 2**). However, the counterpart is the necessity for the optical signal to cross more than one section of fibers. This implies more distance to cover and more optical impairments to struggle with (for instance the PMD).

Due to higher concentration of sites in metro/regional networks than in the backbone network, a regional ring may have to interconnect a larger number of locations. Thus, an optical signal may have to cross a potentially large number of cascaded xOADMs.

The benefit of transparency may not be limited to transponder savings, and thanks to a possible seamless infrastructure, metro WDM channels could propagate over both metro (possibly dispersion-managed) and core (uncompensated or DCF-free) infrastructures (an example of this case is the orange connection in the right part of **Figure 3**).
Furthermore sharing compatible coherent interfaces between the two networks will help in moving towards core and metro convergence.

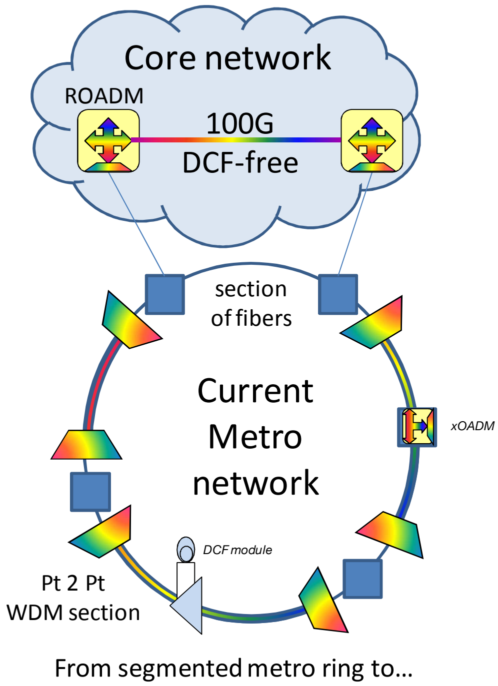

Figure 2 Example of current metro network.

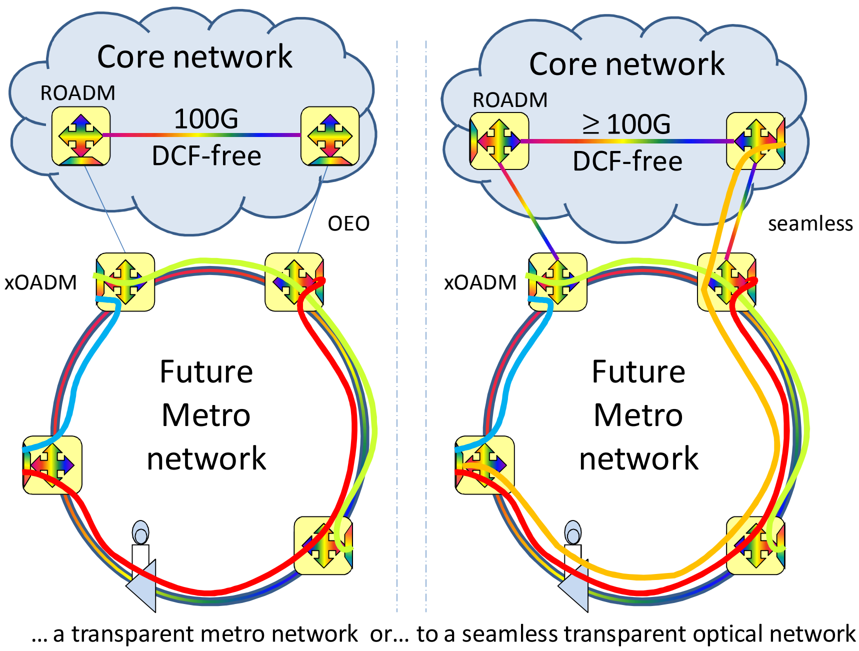

Figure 3 Examples of metro networks evolution.

5.3 Polarization Mode Dispersion (PMD)

Optical fibers have been commonly deployed in the carrier networks since the beginning of years 90. Because the transmission rates were low (compared to today: at a maximum of 2,5 Gbps), the effects of the polarization mode dispersion were not significant to degrade the optical signal. Therefore no special care was taken on the quality of the fibers that were deployed both in the core and in the metro / regional networks. Indeed, a large majority of fibers deployed between the years 1990 and 1995 are impaired with a very high level of PMD.

When transmission rates increase to 10 Gbps, the effects of a high level of PMD are detrimental to the good propagation of an optical signal. With the traditional formats used at this rate (like NRZ) a high level of PMD (>15 ps of mean DGD) prevent the receiver to obtain the right information.

One way to solve this issue is to replace the worst sections of optical fibers having high PMD coefficient with optical fibers having better performances. However, replacing fibers in both long haul and metro/regional networks may be unrealistic due to the involved investment cost. Therefore, another way is to rely on system with increased PMD tolerance.

5.4 Network design trade off

When new capacities are to be deployed, network architects face several design trade-off. From a technical point of view, regardless of the possible over provisioning, it makes sense to already deploy coherent 100G WDM interfaces over metro/regional networks due to high levels of PMD which impair metro/regional fiber infrastructure.

Indeed, the other alternatives such like cable replacement, signal regeneration, insertion of compensation module, have a significant cost or add complexity to the network.

To be interesting for deployment, the WDM interfaces should be “low-cost”. Indeed, the "low cost" criterion will definitively be the trigger for investing in a technology that both solves the current issues and can cope with future traffic growth.

While the threshold for cost-effectiveness are always difficult to set because it depends of lot of factors, it is deemed important to provide to the industry the vision of what can be considered as “low-cost”. Indeed, some technical choices have to be made and without a clear cost target these ones would be difficult to take. With a cost significantly below the one of the cheapest 100G LH interfaces and with a cost ratio maintained over the next decade, this will give the network designers the incentive to adopt this solution for a wide scale deployment. The high volume expected would in turn contribute to significantly lower the cost.

5.5 Technical state of art

The effort to reach the 40/100G rates pushed the industry to propose new technologies. One of them is the coherent transmission that demonstrated to be robust to very high level of polarization mode dispersion and chromatic dispersion:

- PMD: typically robust to 30 ps of mean DGD
- CD: typically robust to 35000 ps/nm

However, the current 100G solutions are mostly focused on long haul or ultra long haul applications with a premium cost associated with these solutions. The reuse of the coherent technology and its adaptation to the metro application is seen as the fastest way to address the metro needs. **As counterpart, the tolerance of these WDM interfaces to CD and to accumulation of ASE noise could be relaxed.**

6 Requirements on Intermediate Reach 100G DWDM

Performance requirements

R 1 *PMD tolerance should be at minimum of 25 ps (mean DGD).*

- *R 1.a* *Evolution towards higher PMD levels in the range 30-35 ps is expected.*
- *R 1.b* *Up to 50 ps of mean DGD could be desirable.*

R 2 *CD tolerance should be of several thousands of ps/nm (~ 20000 ps/nm to address the typical longest metro/regional applications but this may be further relaxed to reach power and cost target).*

R 3 *To address all sizes of metro/regional networks (for instance, European/Japan & North America/China), the targeted distance could be in the range [50-1000*] km. It is acceptable that a single solution could be customized to support either [50-500] or [500-1000*] km ranges. Customization could be achieved through line engineering optimization.*
** The distance max is assumed best case (G.652, DCF-free, 100G only).*

R 4 *To address the multiple xOADMs applications in metro/regional networks, IR 100G should be tolerant enough to filtering cascading effect brought by multiple xOADMs. The filtering cascading penalty should be below 1dB after 10 cascaded xOADMs. Lower cascading penalty after more xOADMs is strongly desired.*

R 5 *Power consumption has to stay within the limits of power specifications defined for standardized optical pluggable modules.*
Better power consumption performance than LH in equivalent pluggable modules is expected.

Miscellaneous characteristics requirements

To reach large volume and thus "low-cost" objective, the commoditization of these 100G WDM interfaces requires packaging them into standardized MSA optical pluggable modules.

R 6 *IR 100G DWDM shall be integrated into a standardized optical pluggable module (such as CFP, CFP2).*

R 7 *IR 100G DWDM modules shall:*

- *R 7.a* *Have compact designs to accommodate high port density*
- *R 7.b* *Include as many functions as possible for enabling a broad range of applications*

To allow interchangeability of client and line ports on common board:

R 8 Integration of DSP ASICs into the pluggable module is highly desirable.

As shown in the **Figure 3**, 100G IR DWDM channel may be propagated from the metro network into a short portion of the core network. Therefore, compatibility with the existing infrastructure is mandatory:

R 9 IR 100G DWDM have to support uncompensated and dispersion-managed transmission over any fiber type.

R 10 To cope with co-existence of infrastructure (core & metro/regional), channel spectrum occupancy should be a single ITU-T 50GHz spectral slot.
Channel spectrum occupancy of 50 GHz is compatible with future flexgrid architecture; however flex-grid & spectral shaping features are not required.

Likewise, 100G LH DWDM channel may terminate in the metro network.

R 11 Co-existence into the same fiber of 100G "low-cost" metro with 100G LH or 10G WDM interfaces has to be addressed.
Guard bands and performance penalties are acceptable.

Forwarding Error Code.

R 12 The FEC solutions (FEC encoder, FEC decoder and error decorrelator, etc) proposed for the 100G IR DWDM should be in line with the suggestions provided in the "FEC-100G-01.0 100G Forward Error Correction White Paper".