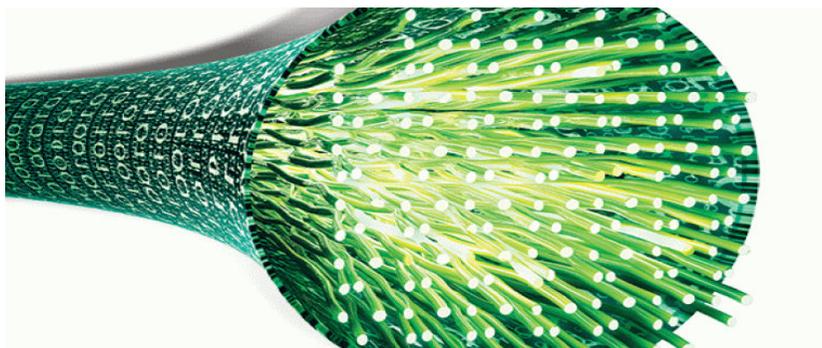




Tutorial Semana da Infra Estrutura – 8 de dezembro de 2017

Overview de Medidas em Redes Ópticas



Eduardo Ken

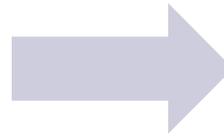
eduardo.ken@precisionsolutions.com.br

Tópicos

- 1) Monitoração de Rede Óptica 24x7 com Geo Referenciamento
- 2) Evolução dos Transceivers Ópticos
- 3) Conceitos de Testes em Redes Ópticas foco em DWDM
- 4) Testes Práticos em Rede DWDM

Dia a Dia Manutenção de Fibra

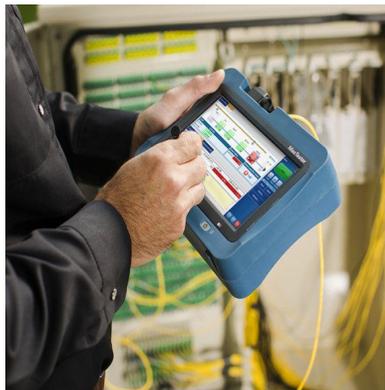
1) Evento no NOC



2) Deslocamento para Identificação



3) Medida OTDR



4) Localização Falha

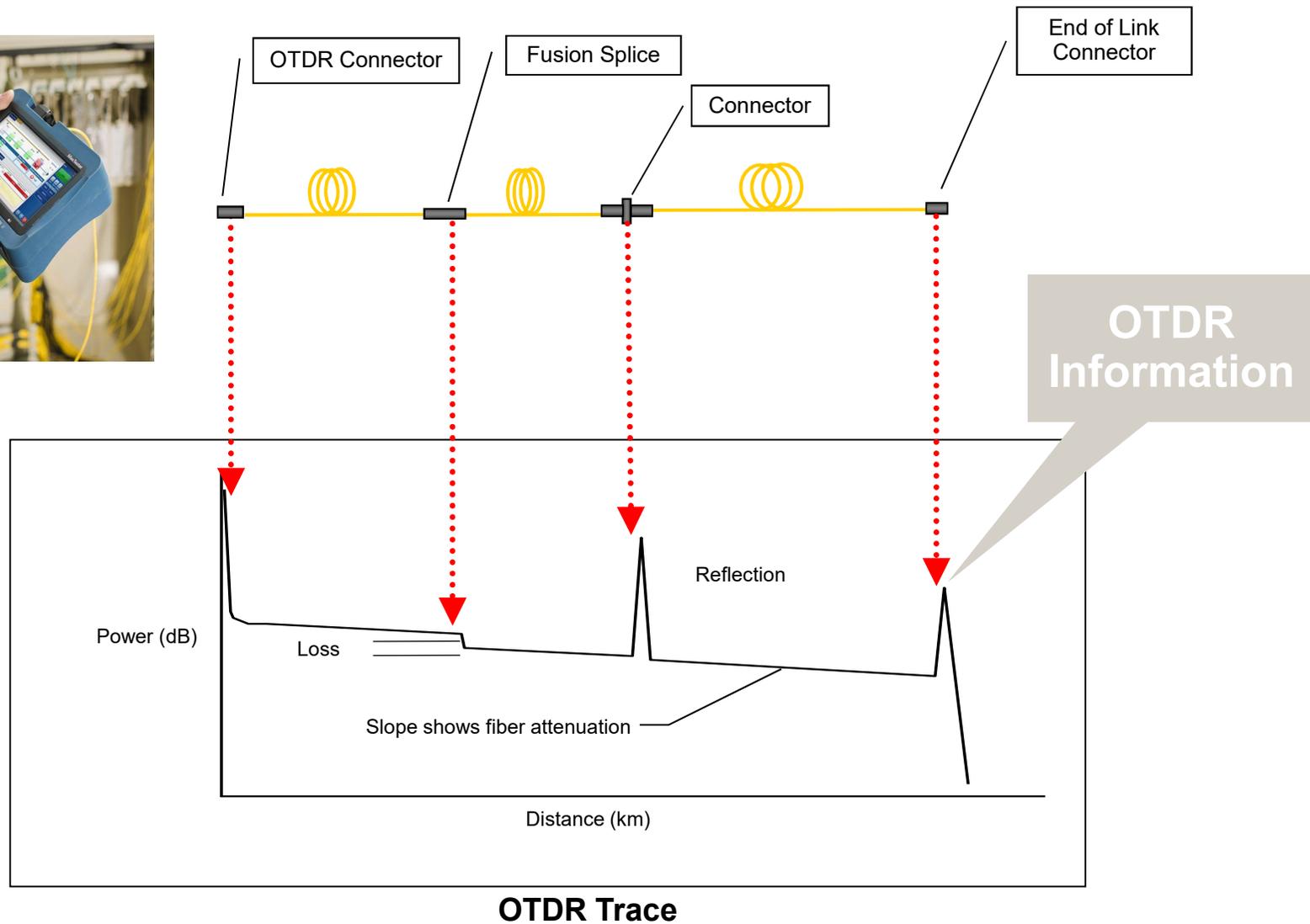
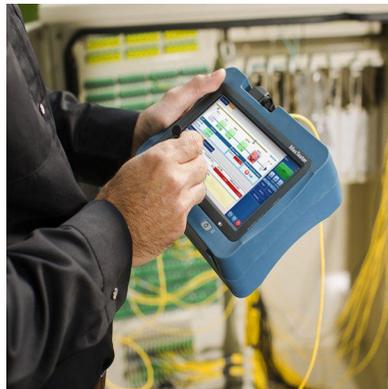


5) Reparo

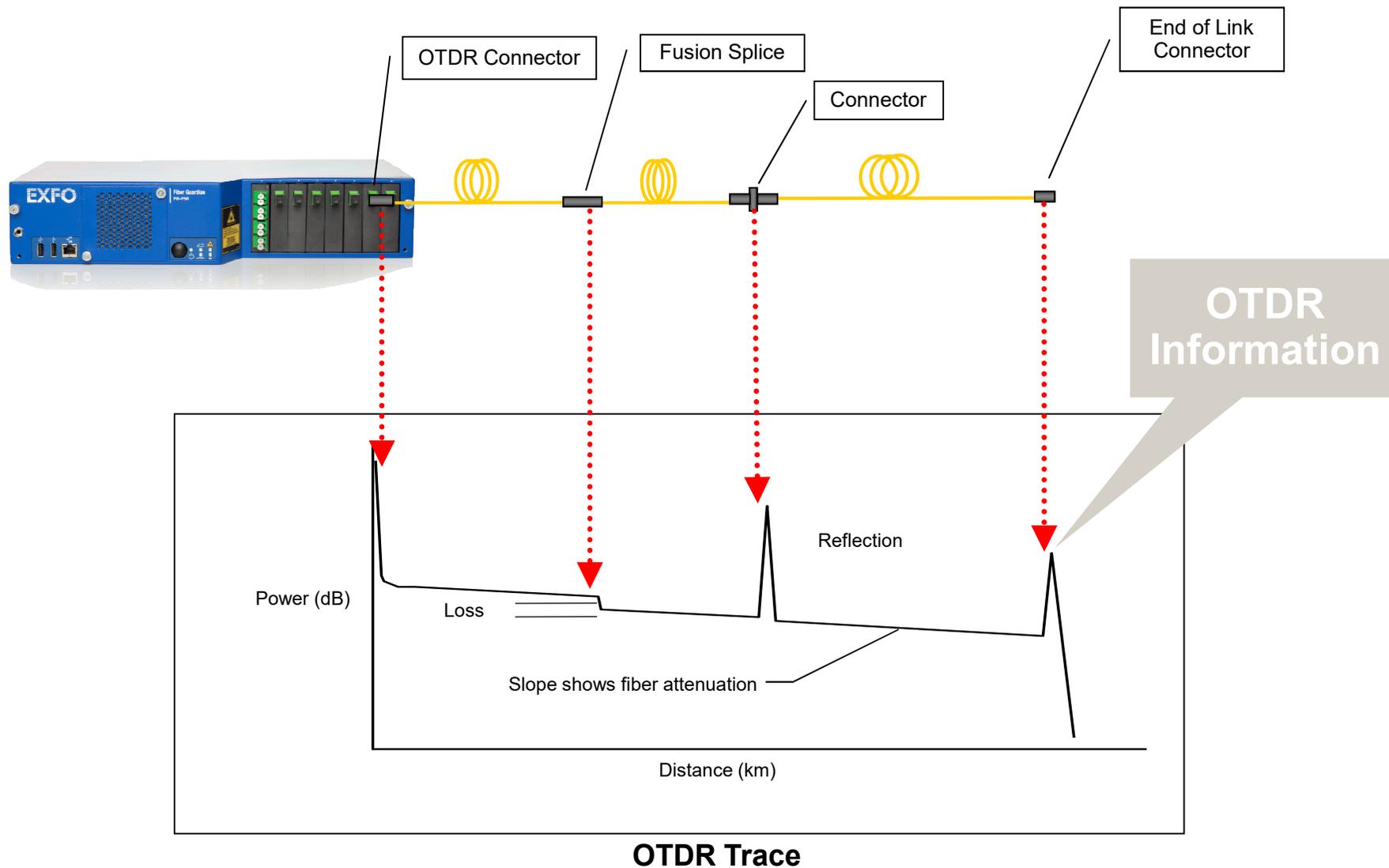


HORAS entre Alarme e Localização!!

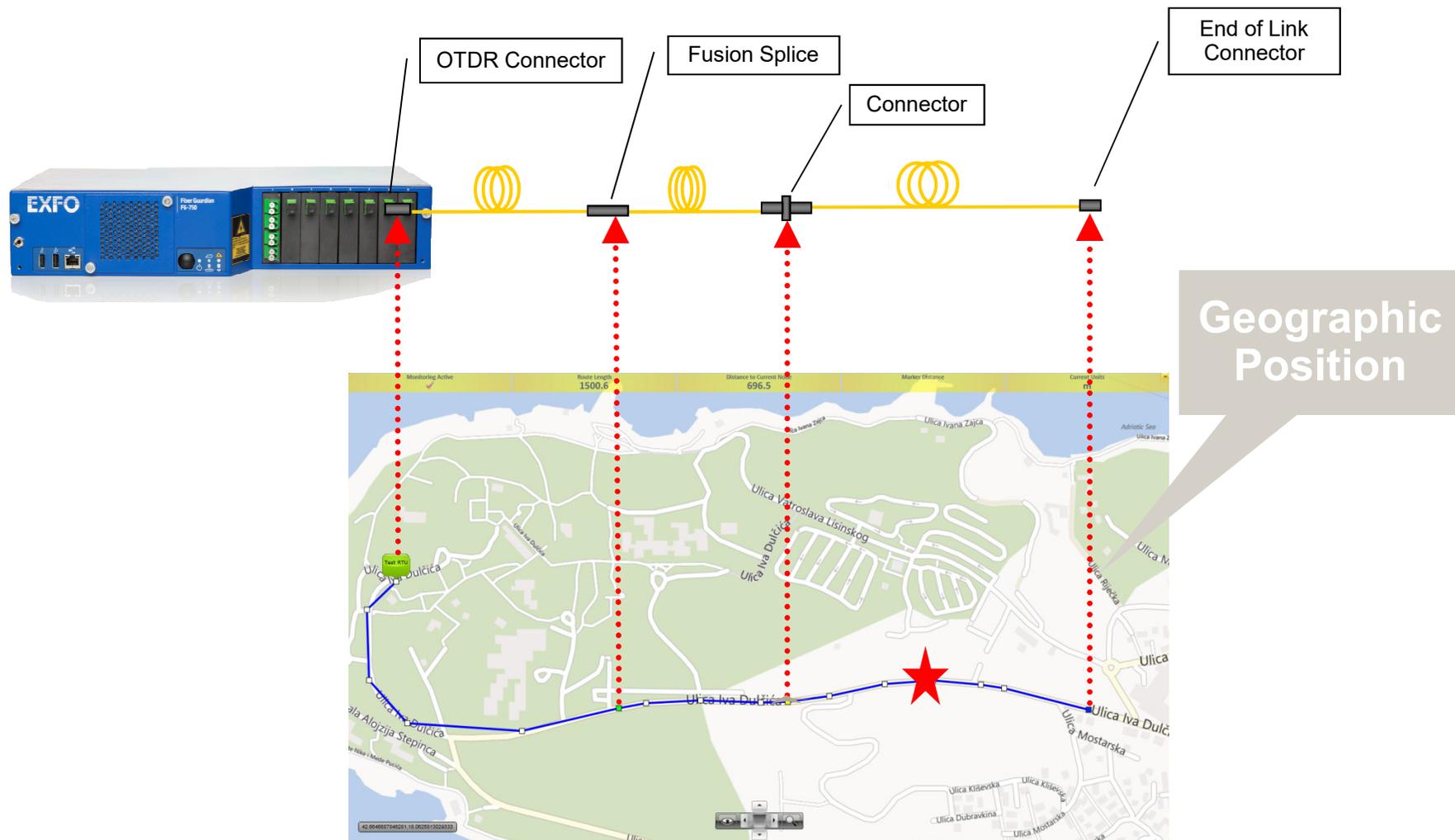
Medida Tradicional com OTDR



Monitoração de Rede Óptica 24x7



Monitoração de Rede Óptica 24x7

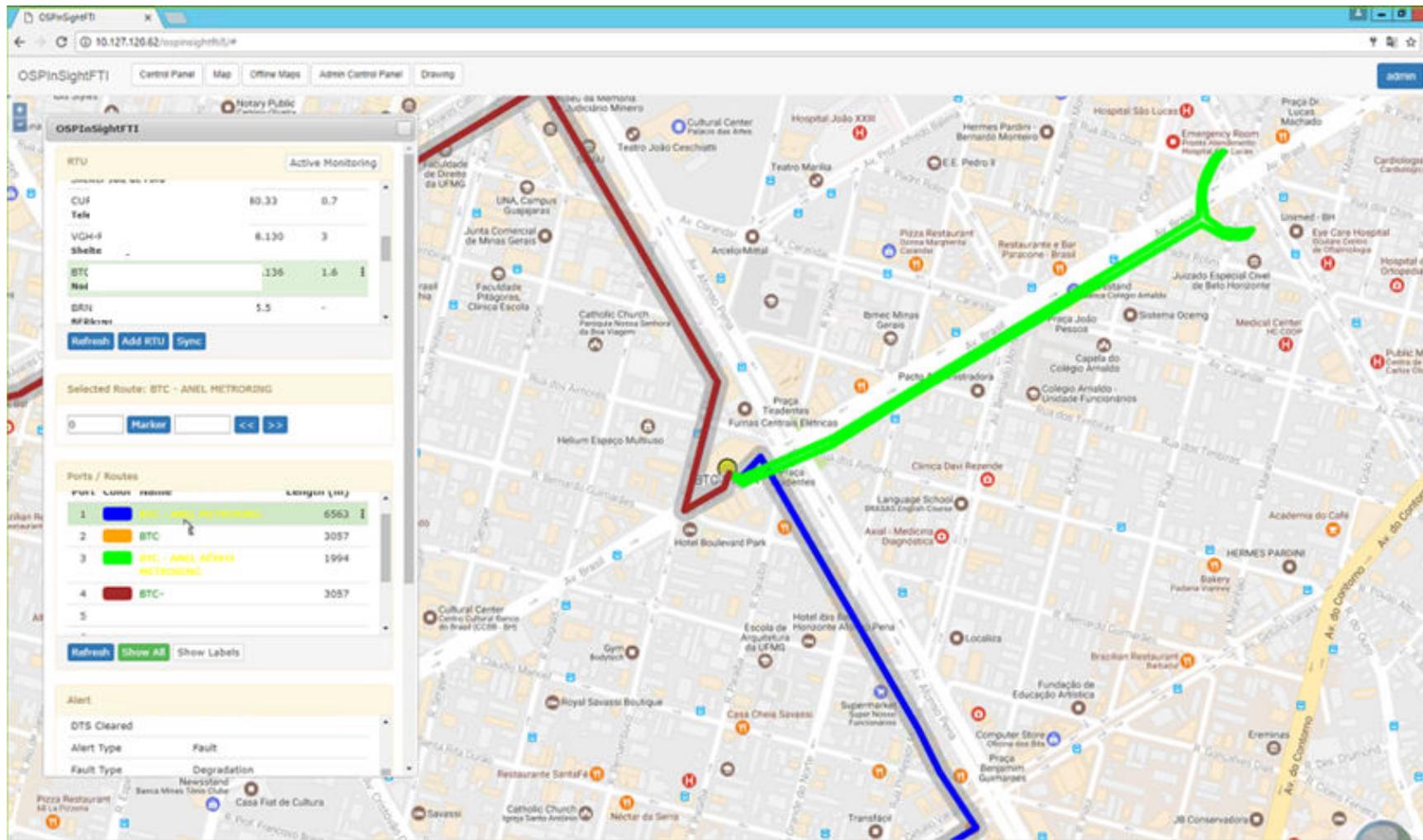


FAULT ON MAP

Monitoração de Rede Óptica 24x7



Monitoração de Rede Óptica 24x7



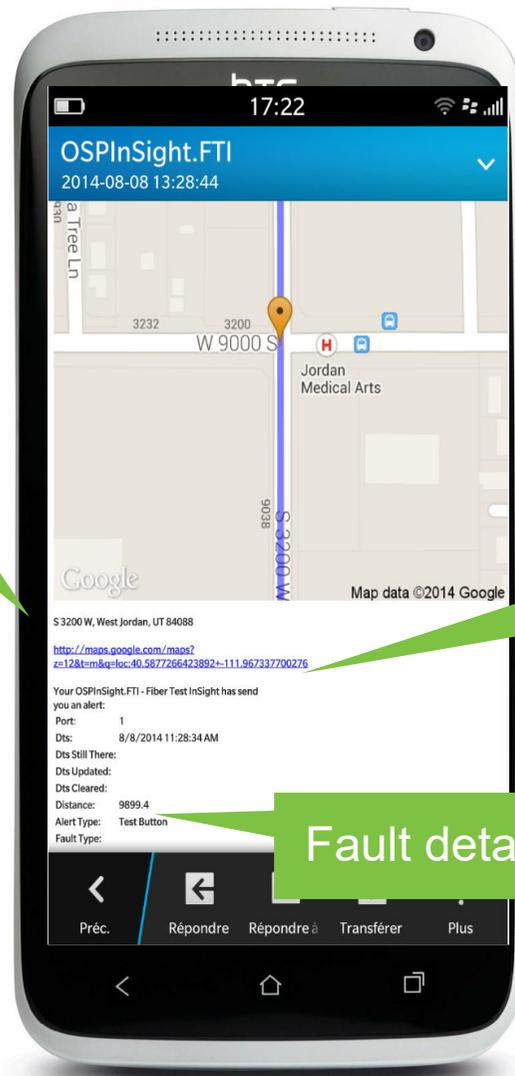
Monitoração de Rede Óptica 24x7

Notificações por email e sms

TEMPO	Tradicional	Sistema 24x7
Tempo Localização	3 a 5h	10min!

Não é necessário envio de equipes para varias localidades para realizar medidas com OTDR.

Equipe de Campo recebe alerta com posição geográfica do evento e pode ir diretamente fazer o reparo da fibra óptica.



Reversed geo-coded address

Link to google maps for smartphones

Fault details

Transceivers: Evolução

Long span/Inter-building

10G SFP+
LR/Bidi/CWDM
10km SMF



25G SFP28 LR
10km SMF



40G QSFP+ LR4
10km SMF



100G QSFP28
CWDM4/LR4
2/10km SMF



100G CFP4 LR4
10km SMF



100G CFP2 LR4
10km SMF



100G CFP LR4
10km SMF



100G CFP DWDM
30km+ DWDM SMF



CFP2-ACO
Metro/Long Haul
DWDM SMF



Inter-rack

10G SFP+ SR
400m OM4 MMF



10G SFPwire*
Up to 20m



25G SFP28 SR
100m OM4 MMF



40G QSFP+ SR4
400m OM4 MMF



40G Quadwire*
Up to 100m



100G QSFP28 SR4
100m OM4 MMF



100G Quadwire*
Up to 100m



100G CXP SR10
150m OM4 MMF



100G C_wire*
Up to 100m



Intra-rack

10G SFP+ SR



25G SFP28 SR



4x10G QSFP+ SR



4x25G QSFP28 SR

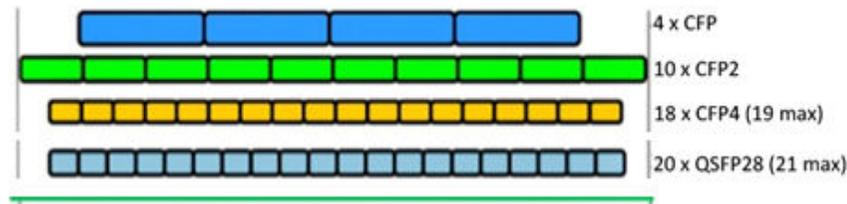


Transceivers: Evolução

100G/40G

	1 st Generation		2 nd Generation		
Market Availability	2010	2010	2014	2015	2015
Approximate Module Dimensions (Length x Width to Scale)					
Front Panel Density (1 RU)	4 Ports	12 Ports	8 Ports	22/44 Ports	16/32 Ports
Electrical Signaling (Gb/s)	10 x 10 CAUI-10	10 x 10 CPPI	10 x 10 CAUI-10 4 x 25 CAUI-4	4 x 25 CAUI-4	4 x 25 CAUI-4
Media	MMF, SMF	Twinax, MMF	MMF, SMF	MMF, SMF	MMF, SMF
Power Consumption (W)	< 24 W (100GBASE-LR4) < 20 W (2 nd Generation CFP)	< 6 W (100GBASE-SR10)	< 12 W (100GBASE-LR4)	3.5 W	9 W
Industry Standard Modules	 CFP (82 mm Wide)	 CXP (27 mm Wide)	 CFP2 (41.5 mm Wide)	 QSFP28 (18.35 mm Wide)	 CFP4 (21.7 mm Wide)
Cisco Proprietary Module			 CPAK (34.84 mm Wide)		

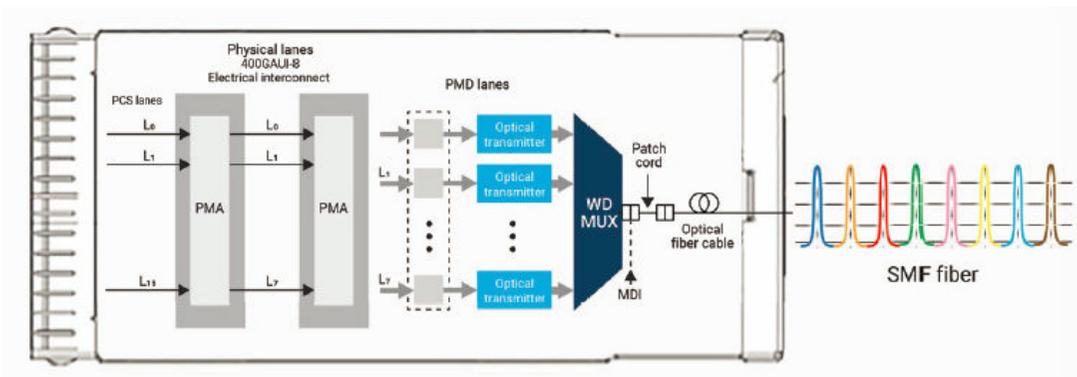
Transceivers: Evolução



MPO em interface cliente

Transceivers 400G

Optical interfaces	PCS lanes	Optical lanes	Modulation	Rate	
400GBASE-SR16	16	16	NRZ	26.5625 Gbit/s	100m MMF
400GBASE-DR4	16	4	PAM4	106.25 Gbit/s	500m SMF
400GBASE-FR8	16	8	PAM4	53.125 Gbit/s	2 km SMF
400GBASE-LR8	16	8	PAM4	53.125 Gbit/s	10 km SMF



Transceivers - Teste

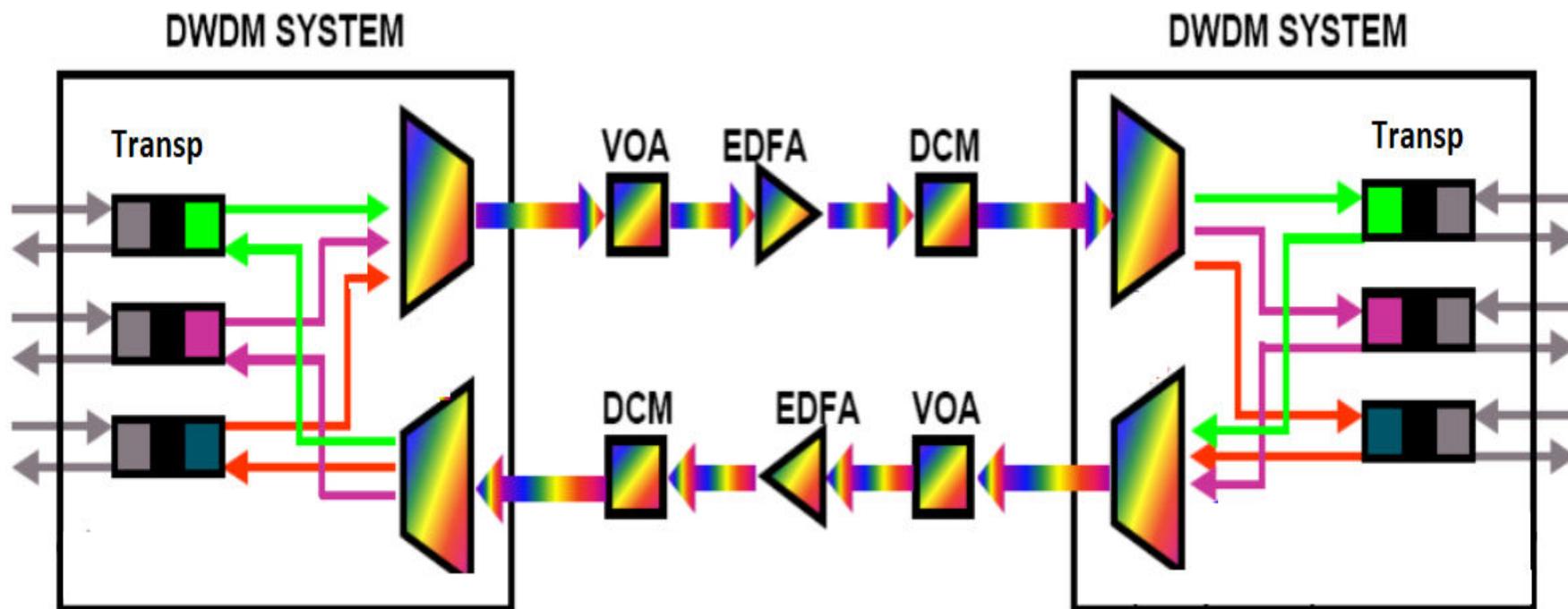
Prática: Validação de Transceivers

The screenshot shows the iOptics software interface. On the left, under 'Optical Device Under Test', there are two device icons: P1-CFP4 and P2-QSFP (checked). Below them, 'QSF' is checked. The 'Rate' is set to 'OTU4 (4 Lanes)'. Other fields include Vendor Name (FINISAR CORP), Part Number (FTLC9551SEPM), Serial Number (XV20RCL), Connector Type (MPO), and Mode (MMF (OM3 + OM4)). A 'More...' button is at the bottom. On the right, under 'Test Sequence', various thresholds are set: Power Threshold (W) at 4.5, Temp. Threshold (°C) at 70, TX Power Range (dBm) at -4.5 to 4.9, RX Power Range (dBm) at -10.5 to 10.5, BERT Duration at 1 minute, BERT Threshold at 0, and Skew Threshold (Bits) at 928. A 'TX' label with a curved arrow is on the left, and an 'RX' label with a curved arrow is at the bottom left. A blue arrow points from the 'Part Number' field to the 'RX Power Range' field.



Atualmente existem métodos e equipamentos para teste de transceivers. Evitando identificar o problema após instalação.

Medidas DWDM



Que medidas e testes realizar em cada etapa e ponto da rede??

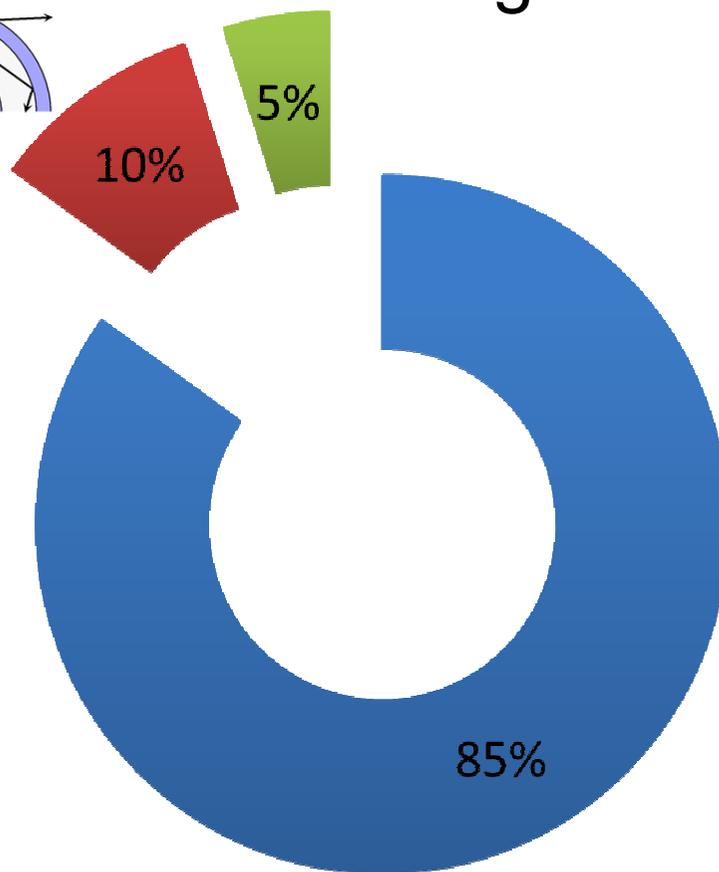
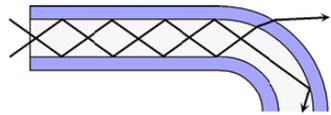
Medidas Redes DWDM: Resumo

Medidas e Testes em Redes Ópticas

Parâmetro	Longo Alcance	Metro	Acesso
Inspeção de conectores	√	√	√
OTDR	√	√	√
Dispersão cromática	√	√ >40 km	
PMD	√	√ >40 km	
Frequencia de Canal	√	√	√
Potência de Canal	√	√	√
OSNR	√	√	
BER	√	√	√

Inspeção de Conectores Ópticos

■ Connector cleanliness and macrobending



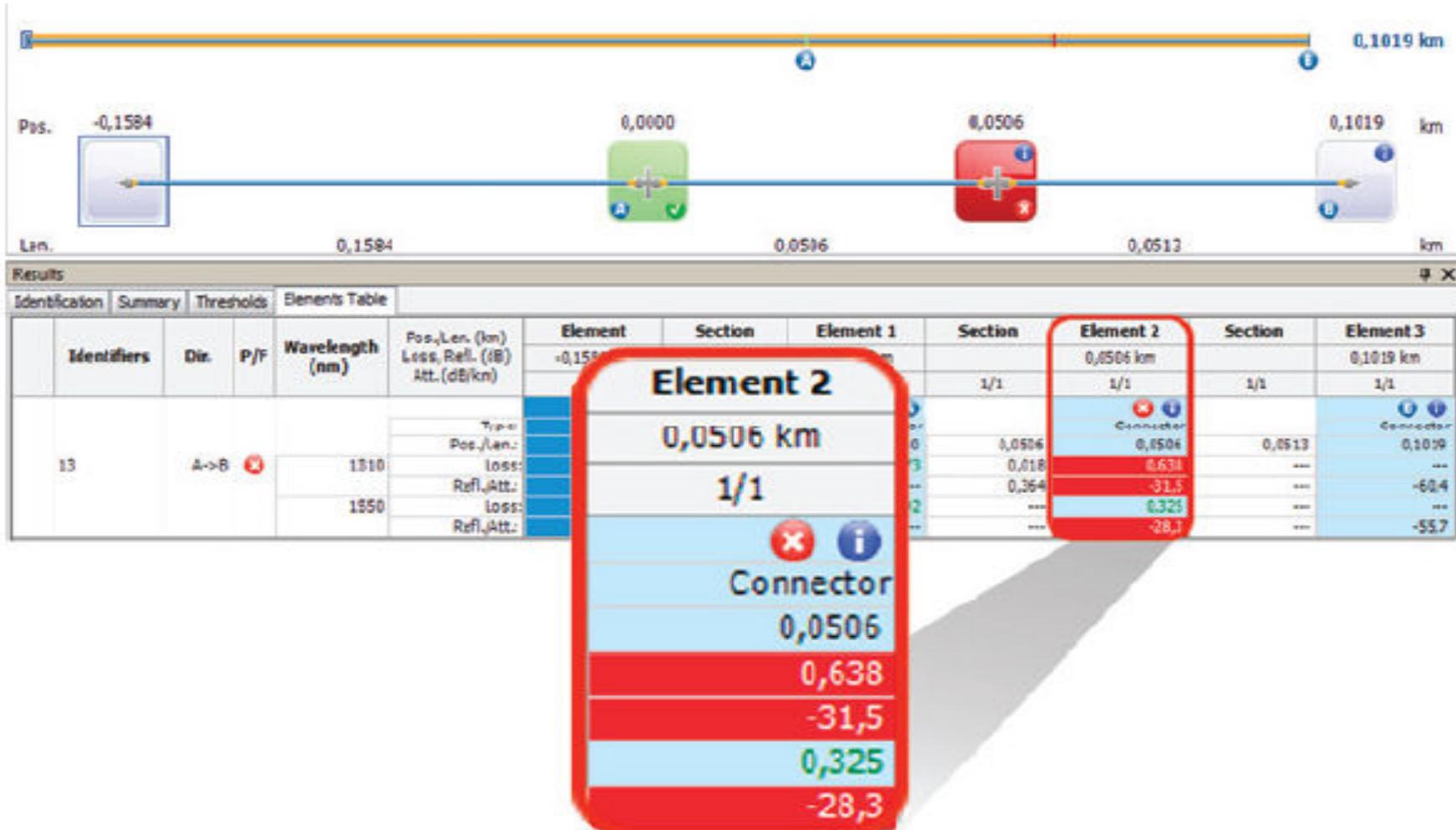
■ Dirty/damage optical connection

■ Macrobends

■ Other

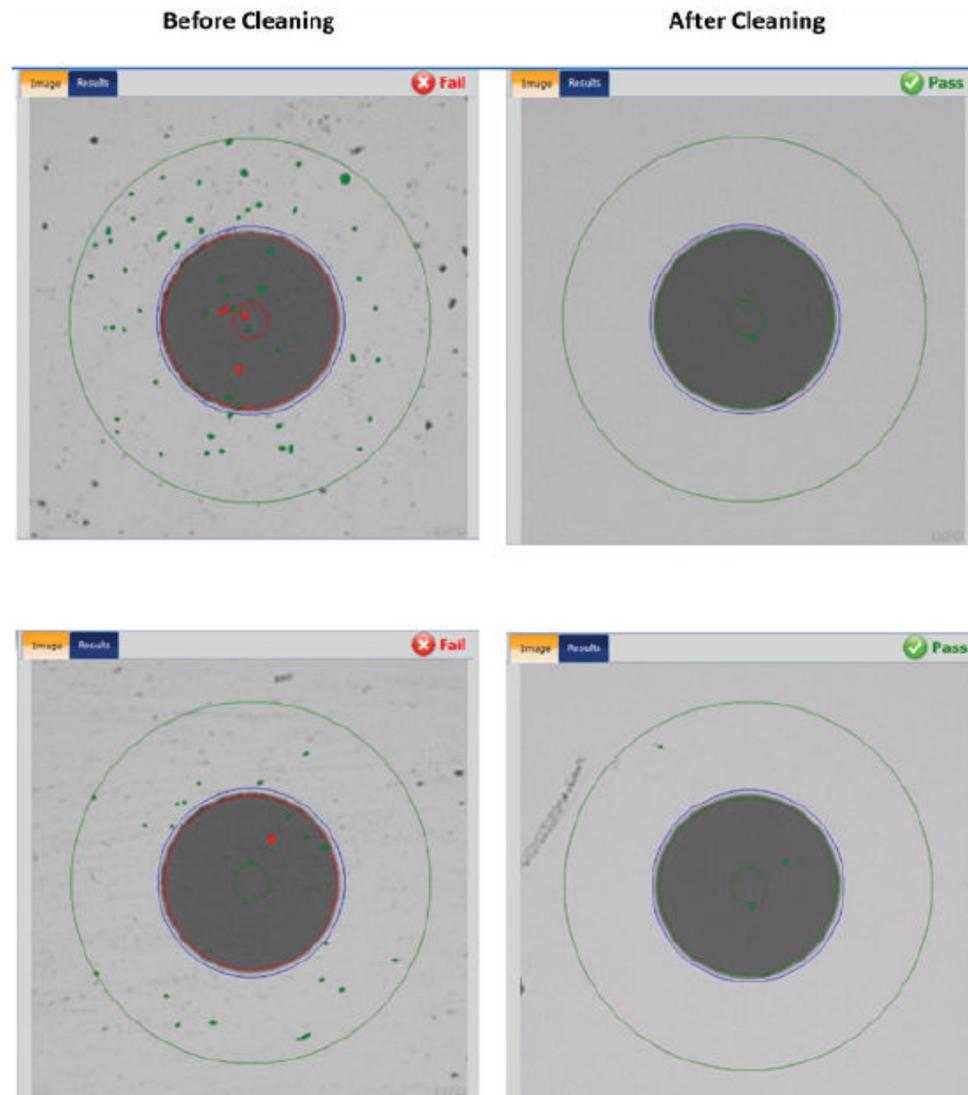
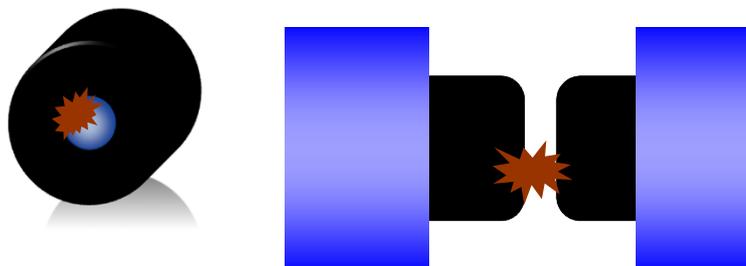
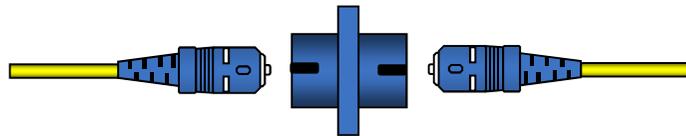
Inspeção de Conectores Ópticos

- Contaminants in a connection will impact



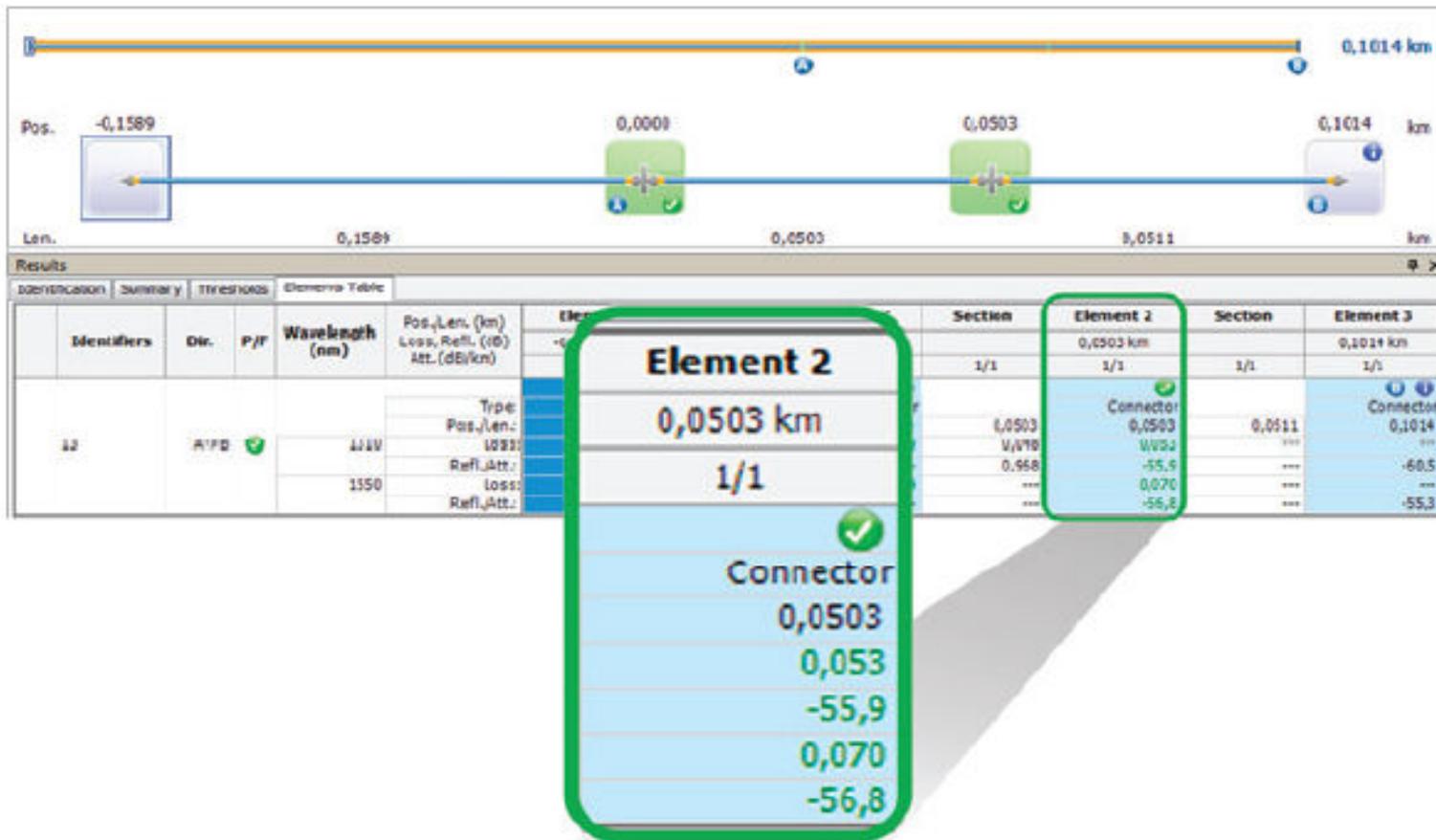
Inspeção de Conectores Ópticos

- A connection is made of 2 connectors....
- They should both be inspected and cleaned if needed.

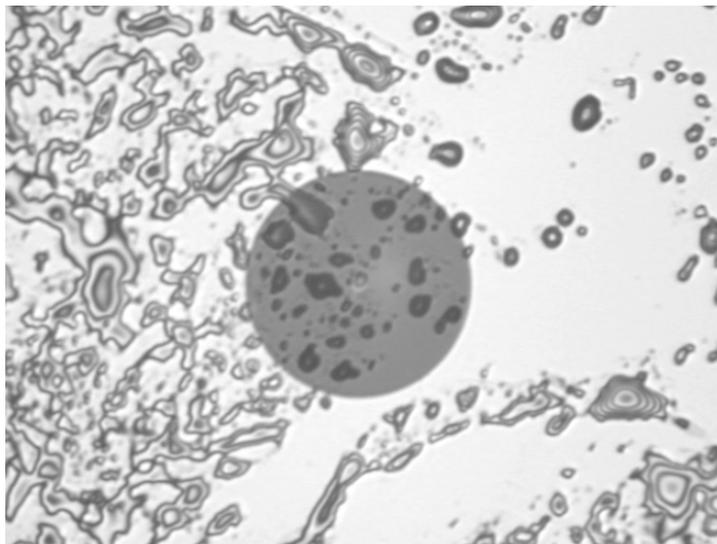


Inspeção de Conectores Ópticos

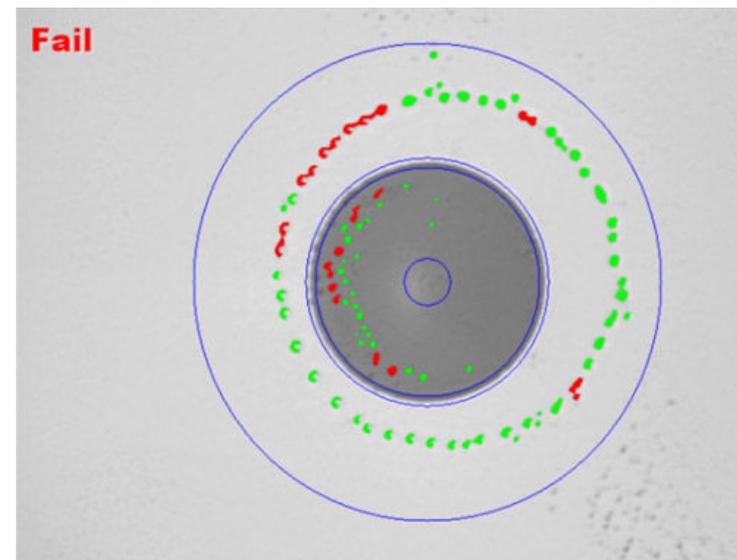
- Acceptable values for loss at 1310/1550nm are :
 - Less than 0.35dB / connection (industry average standard)
 - Less than -50dB reflectance if UPC, less than -65dB if APC



Inspeção de Conectores Ópticos



Óleo



Contaminação
via Conexão

Inspeção de Conectores Ópticos

Norma para Inspeção de Conectores Ópticos:

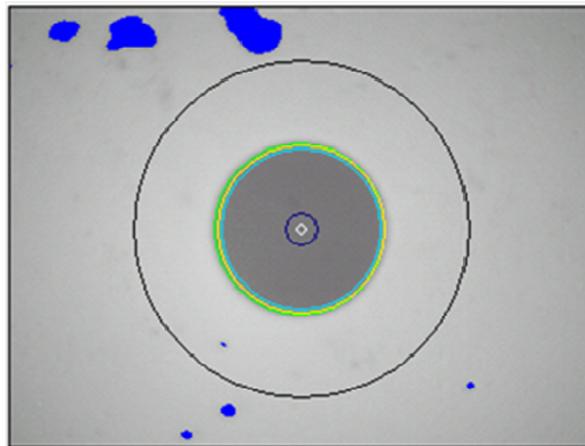
- IEC 61300-3-35

Fiber-Optic Interconnecting Devices and Passive Components—Basic Test and Measurement Procedures

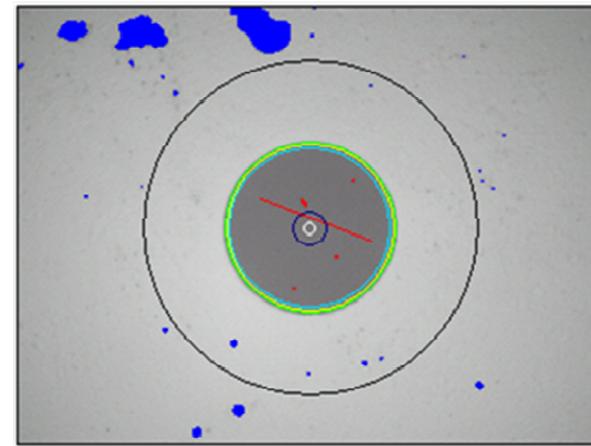
<http://webstore.iec.ch/>



PASS



FAIL



Inspeção de Conectores Ópticos

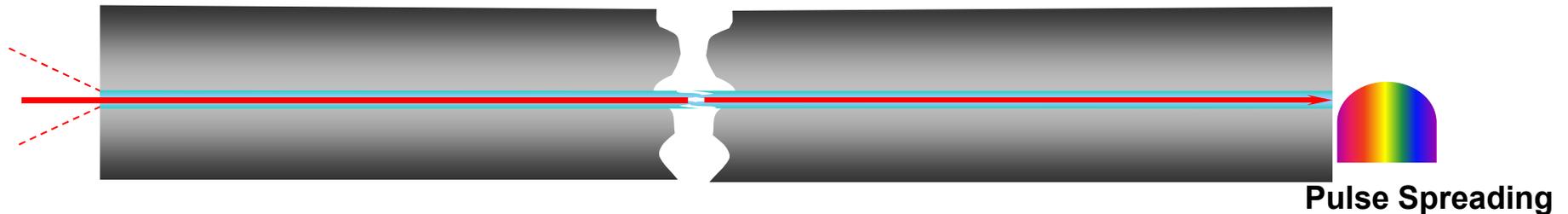
PRÁTICA de Inspeção de Conectores



Dispersão Cromática e PMD

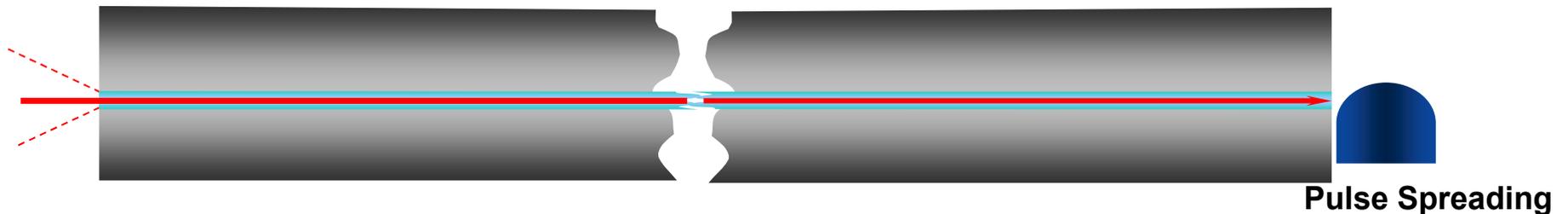
- **Chromatic Dispersion (CD):**

- Comprimentos de onda diferentes viajam em velocidades diferentes

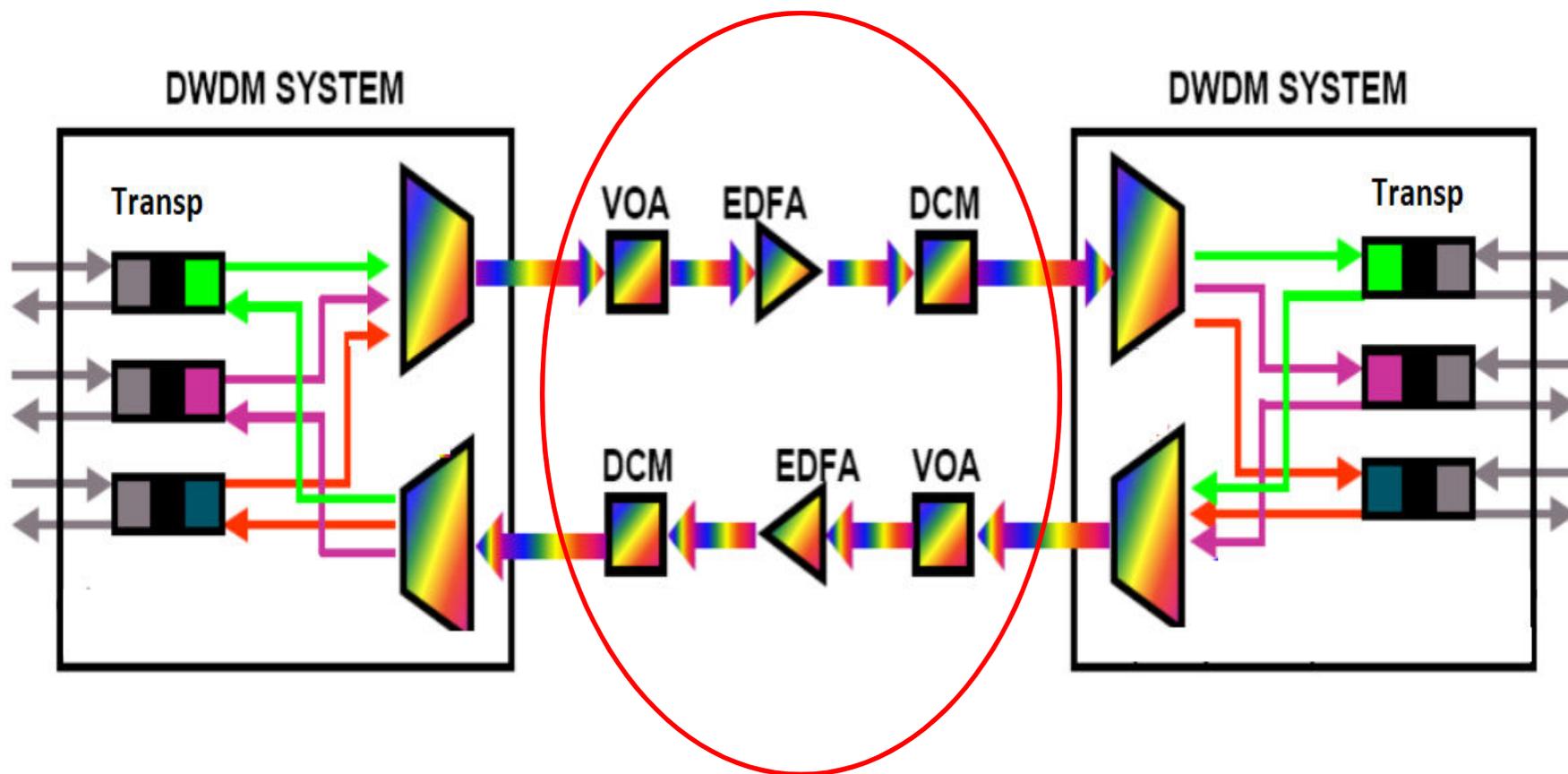


- **Polarization Mode Dispersion (PMD):**

- Modos de polarização viajam a diferentes velocidades



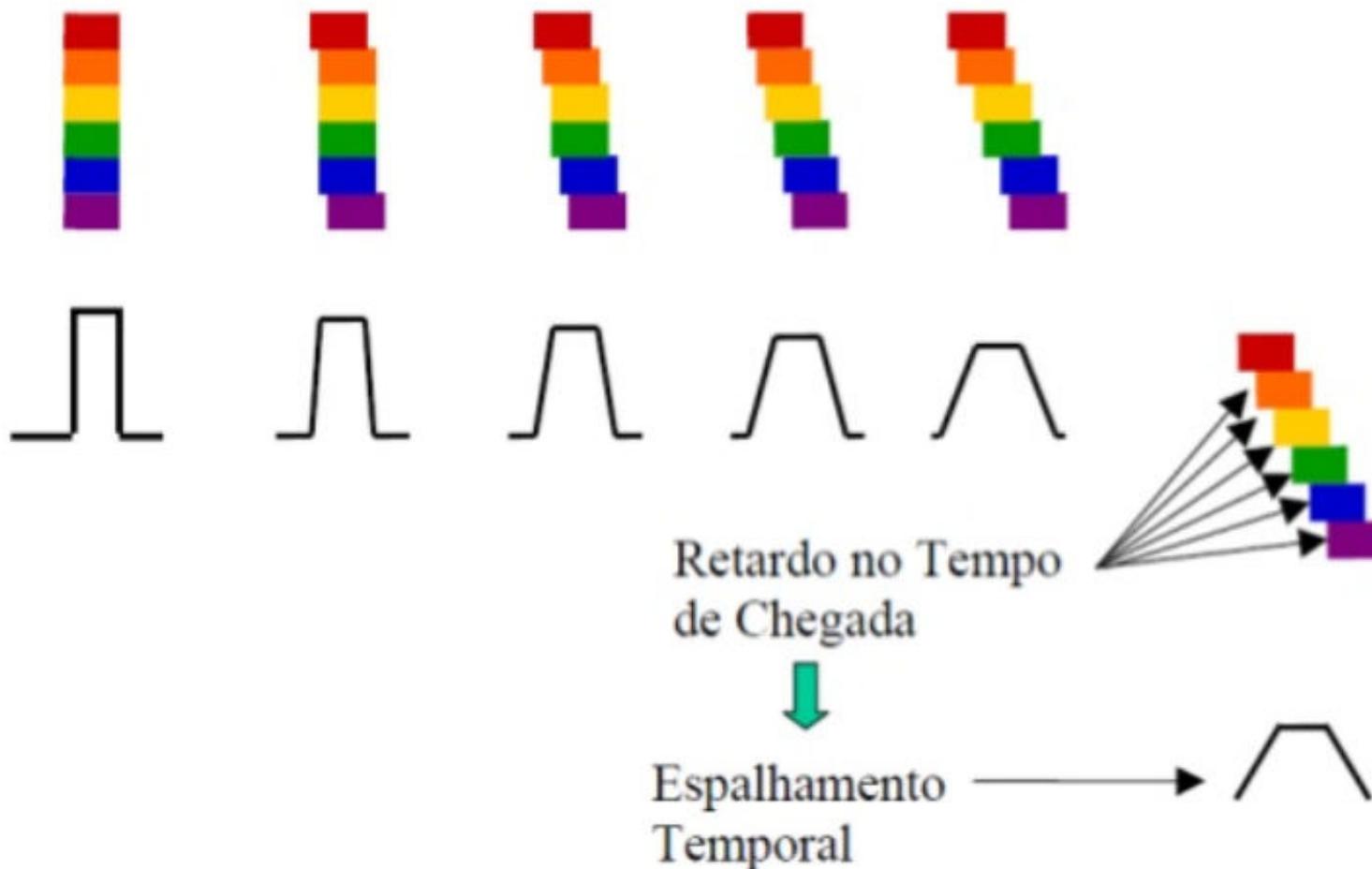
Medidas DWDM - Dispersão



Dispersão

Dispersão Cromática

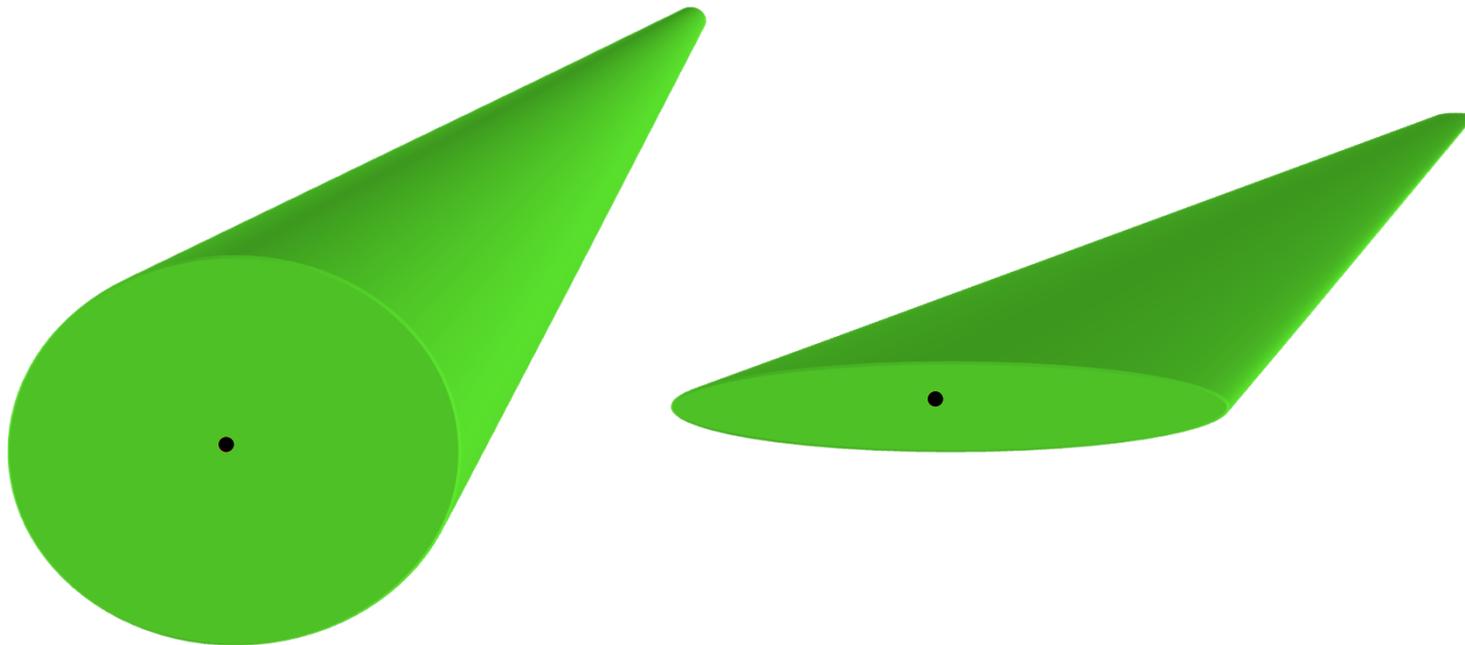
Efeitos da dispersão cromática na forma de onda do sinal



Preditivo: G.652: 17ps/nm.km

Dispersão PMD

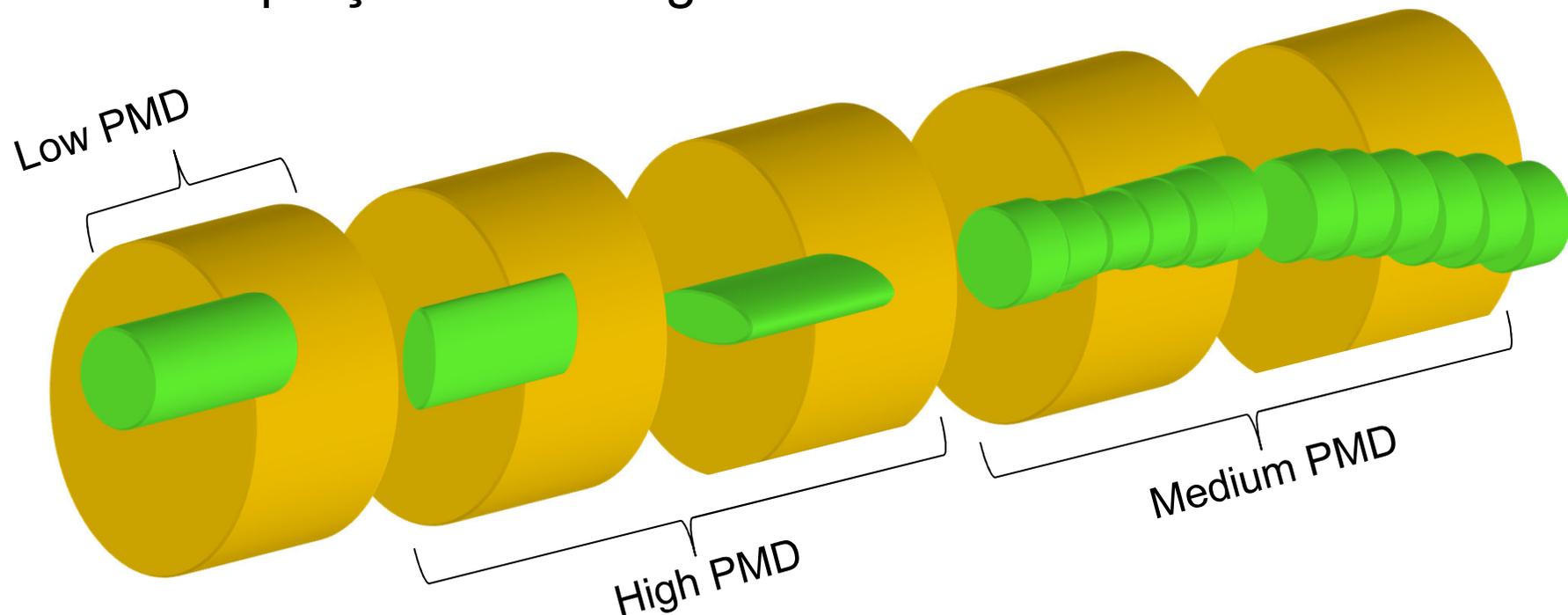
- Os pulsos viajam a diferentes velocidades, dependendo da polarização. Isso é chamado PMD.



- Se $PMD = 0$: os vetores de polarização viajam a mesma velocidade.
- Se $PMD \neq 0$: os vetores de polarização não viajam na mesma velocidade.

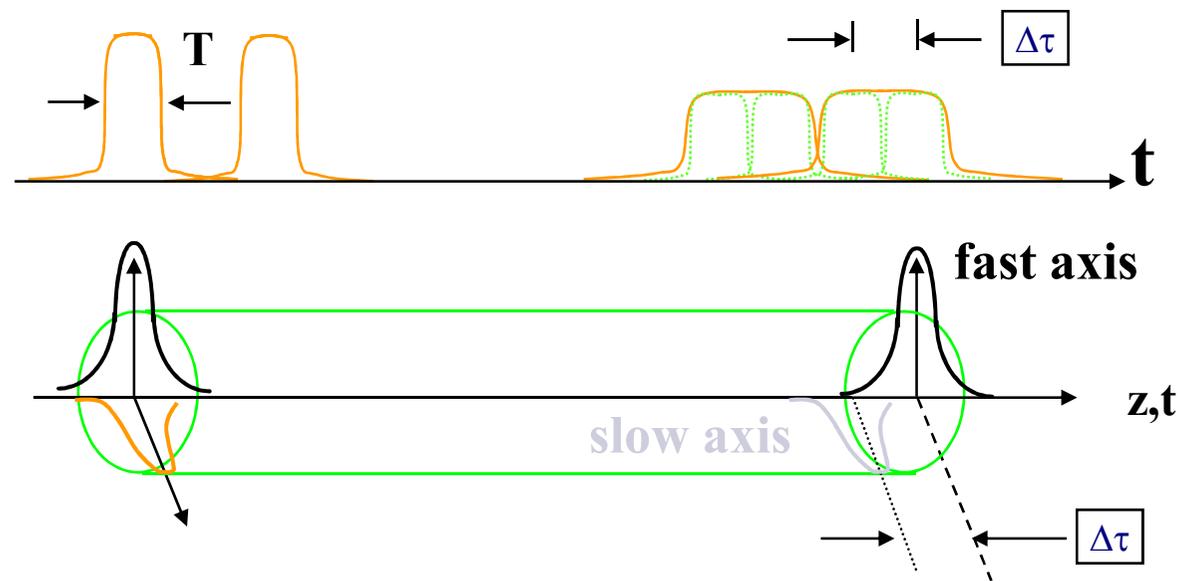
Dispersão PMD

- As assimetrias na geometria do núcleo de fibra e / ou distribuição de tensão criam birrefringência de fibra local.
- Uma fibra "real" é uma adição distribuída aleatoriamente dessas porções birrefringentes locais.

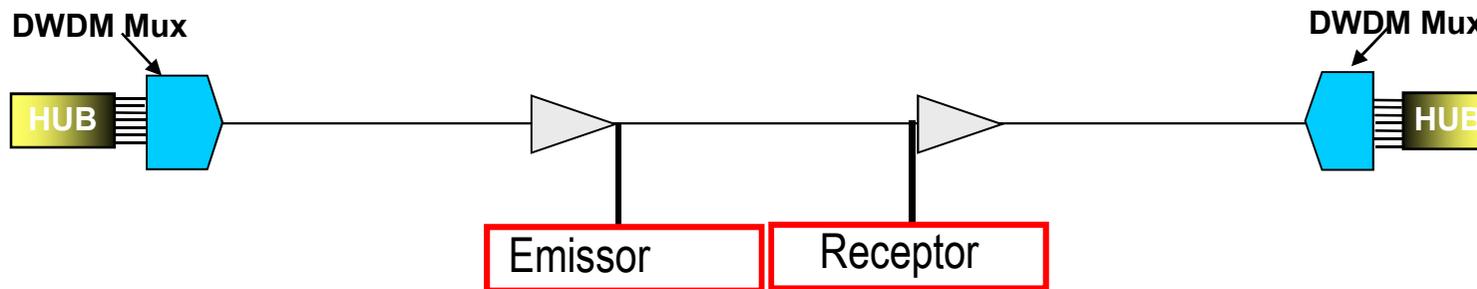


Dispersão PMD

- Eixo rápido: eixo de polarização de modo que o pulso viaja mais rápido.
- Eixo lento: eixo de polarização, de modo que o pulso viaja mais lento.
- Os eixos rápidos e lentos são chamados de estados principais de polarização.
- O atraso entre eixos rápidos e lentos é chamado de differential group delay (DGD).



Teste de Caracterização de Fibra Óptica



The screenshot shows the FTB-5700 Single-Ended Dispersion Analyser software interface. The main window displays the following results:

Measurement	Value	Status
Length	4465 m	
CD Measurement		PASS
Dispersion (1550 nm)	78.16 ps/nm	✓
Dispersion slope (1550 nm)	0.34 ps/(nm ²)	
Coefficient (1550 nm)	17.50 ps/(nm*km)	
Max dispersion	160.14 ps/nm	
PMD Measurement		PASS
PMD	1.15 ps	✓
PMD, 2nd order	0.00 ps/nm	
Coefficient	0.54 ps/√km	

Current Fiber Options:

- CD Details
- Save
- Discard

Measurement:

- CD
- PMD

Information:

- Fiber prefix: Fiber
- Cable ID: Cable
- Fiber suffix: 001
- Thresholds: OC192 - STM64

Start

Open

Close

Delete

Export

Setup

Help

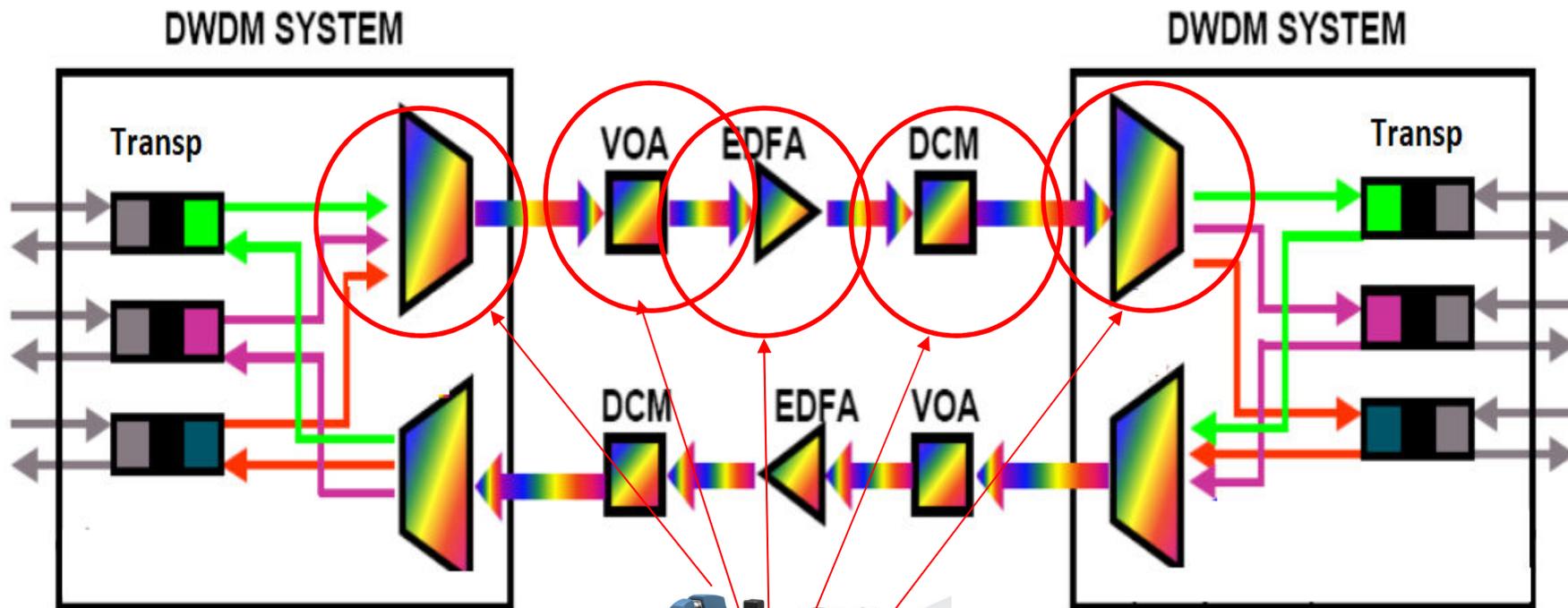
About

Exit

Ready 0% Local 10/2/2007 12:49 PM

- Método 01: Fonte e Analisador
- Método 02: Apenas um Analisador

Medidas DWDM – OSA

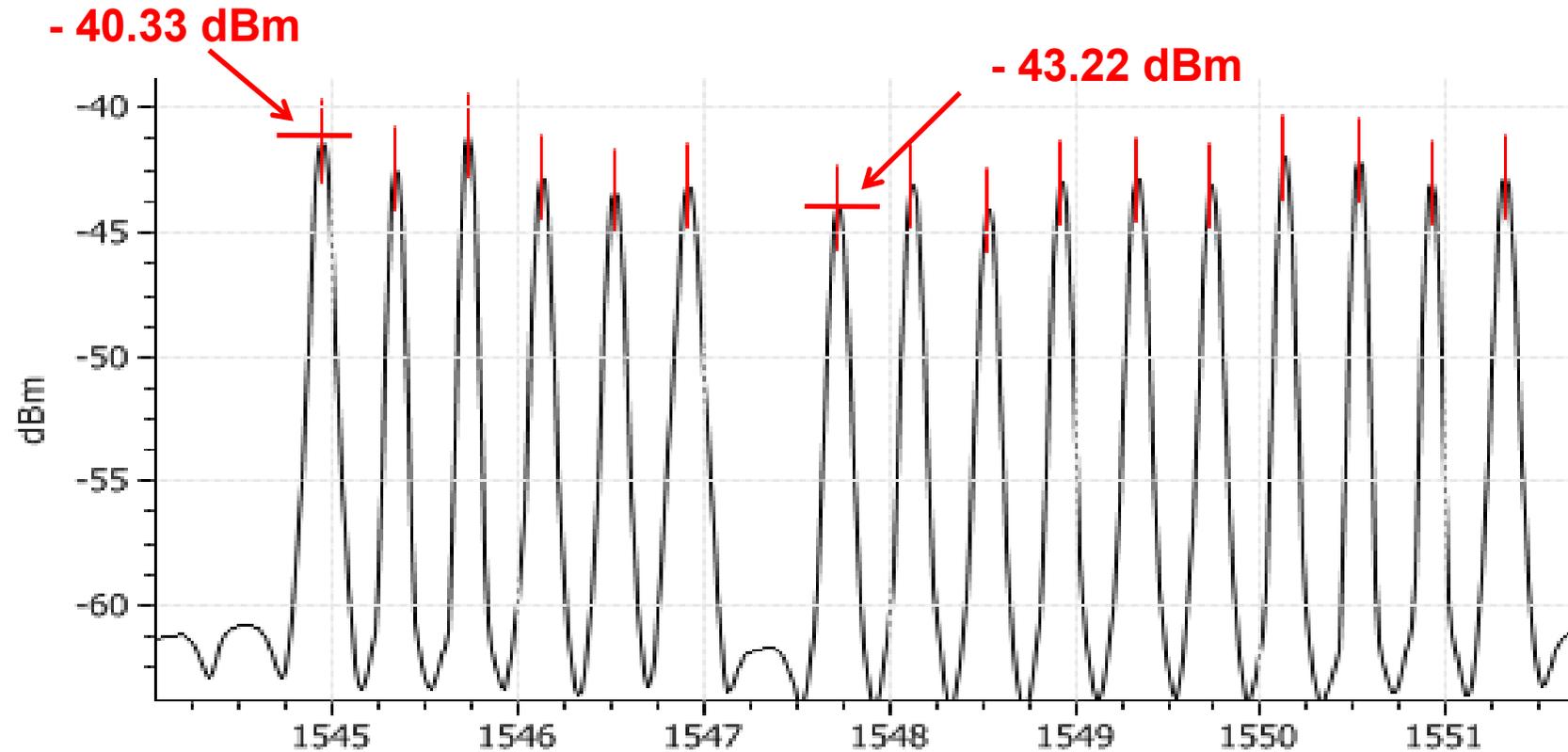


OSA: Optical Spectrum Analyzer
Analisador de Espectro Óptico

OSA

Quais medidas
são obtidas com
um OSA?

Medidas OSA – frequência e potência



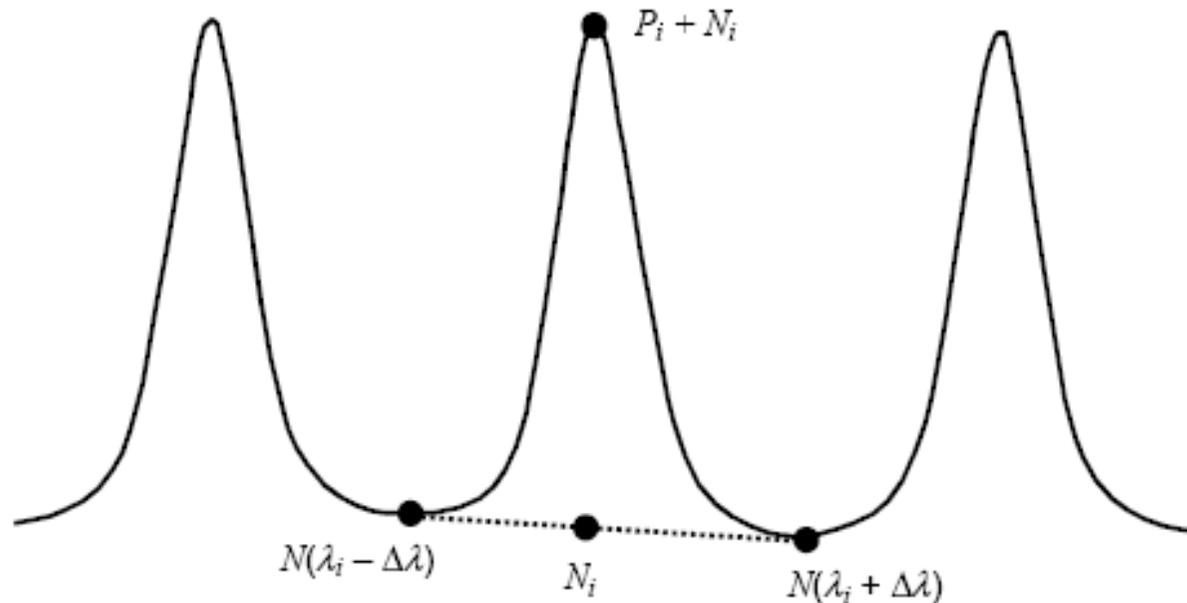
Channel flatness = 3.1 dB

Problema : Desequilíbrio no Ganho dos Amplificadores.

Medidas OSA – OSNR

OSNR: Optical Signal to Noise Ratio (Relação Sinal/Ruido Óptico)

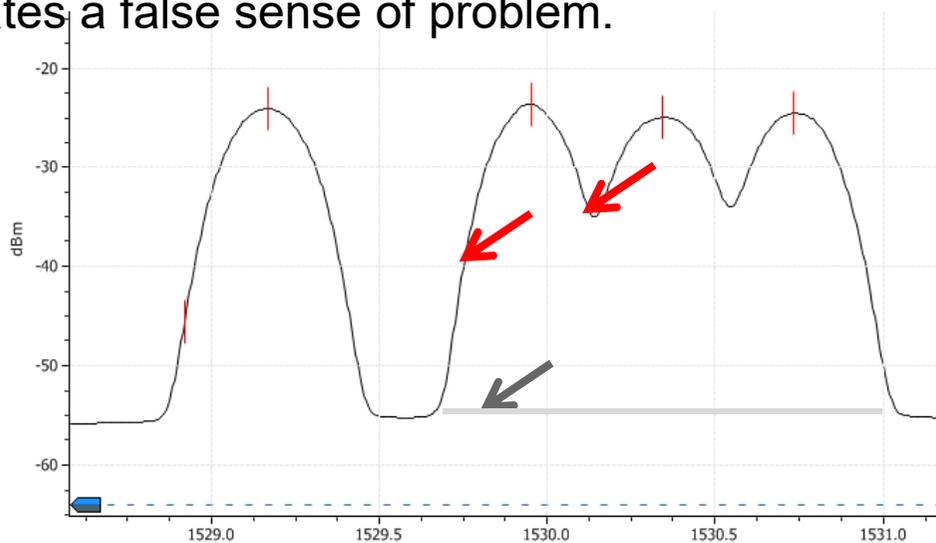
IEC 61280-2-9 OSNR method, also called interpolation method



Medidas OSA - OSNR

Case 1: Wavelength of 100/200 Gb/s

- Coherent 40G/100G/200G signals are closely spaced and overlap.
- The classic IEC interpolation method overestimates the noise level.
- It creates a false sense of problem.



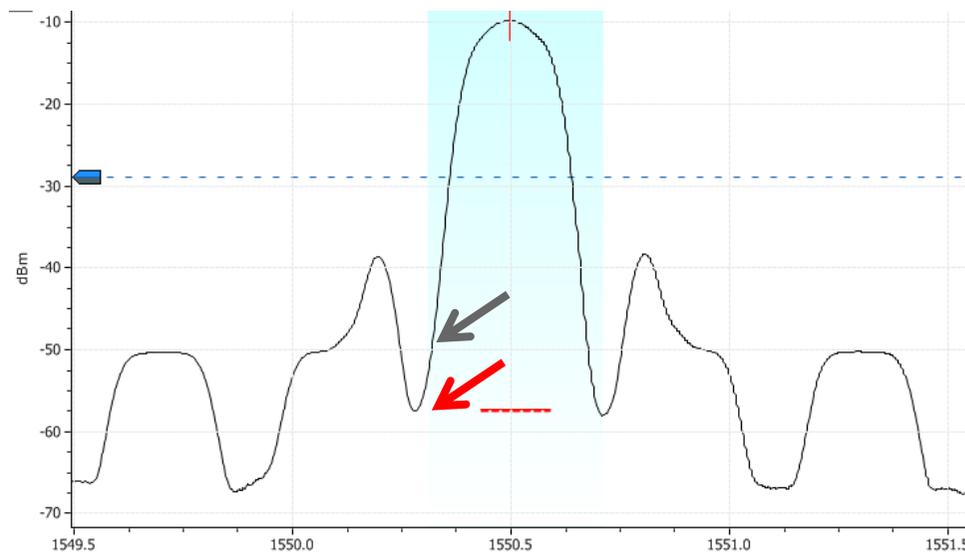
IEC Noise level

Real noise level

Medidas OSA - OSNR

Case 2: ROADM present in network

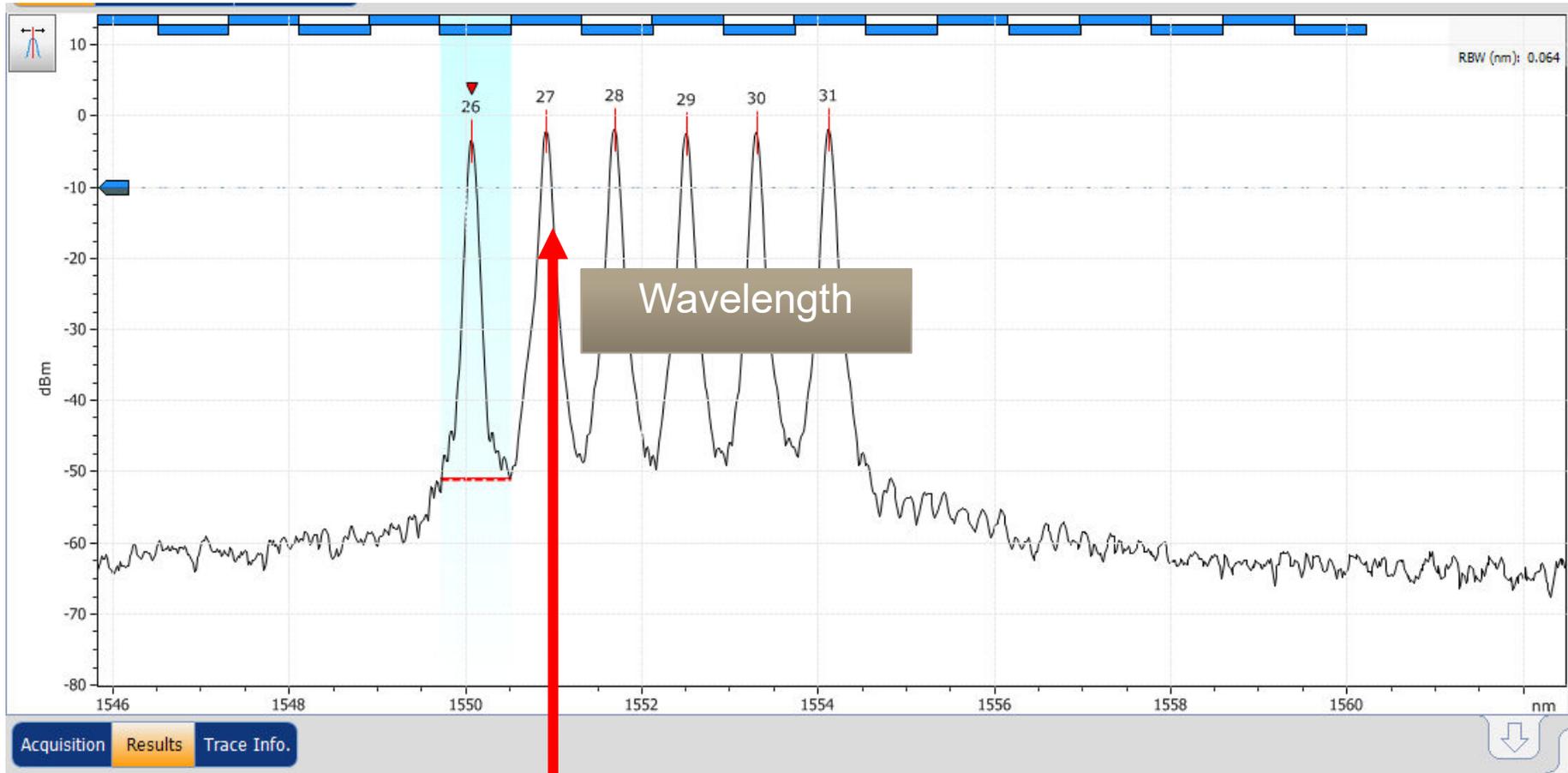
- A ROADM contains filters that reduce inter-channel noise.
- The traditional interpolation method underestimates the noise.
- It creates a false sense of security because it contains 'In Band Noise'.



Real noise level
(in band Noise)

IEC Noise level

Medida de Espectro Óptico



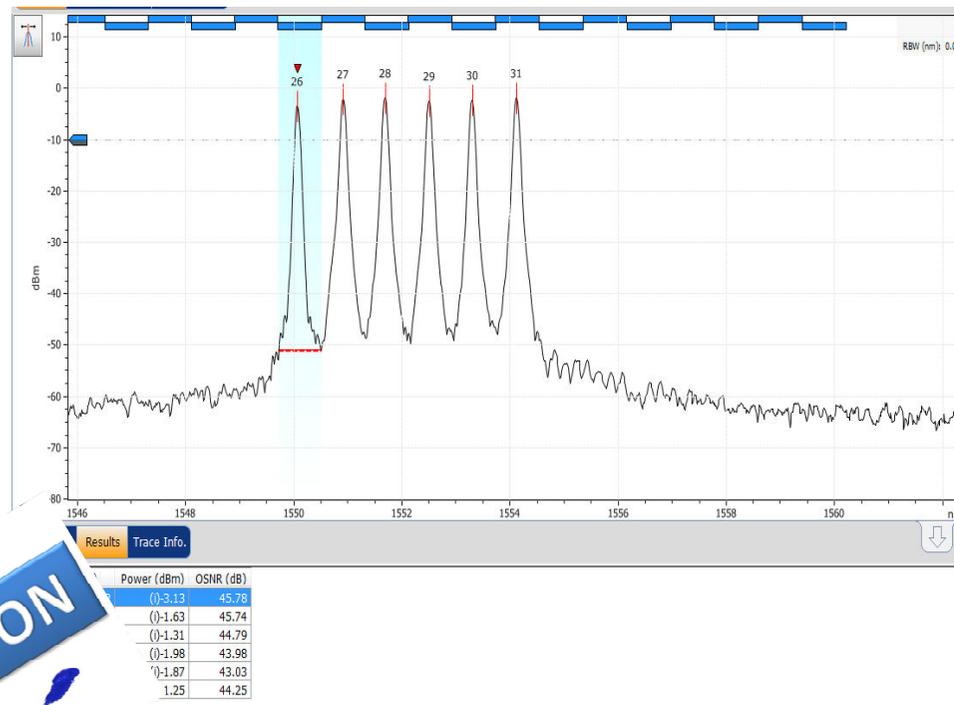
Ch. #	λ (nm)	Power (dBm)	OSNR (dB)
26	1550.072	(i)-3.13	45.78
27	1550.919	(i)-1.63	45.74
28	1551.693	(i)-1.31	44.79
29	1552.506	(i)-1.98	43.98
30	1553.301	(i)-1.87	43.03
31	1554.124	(i)-1.25	44.25

OSNR

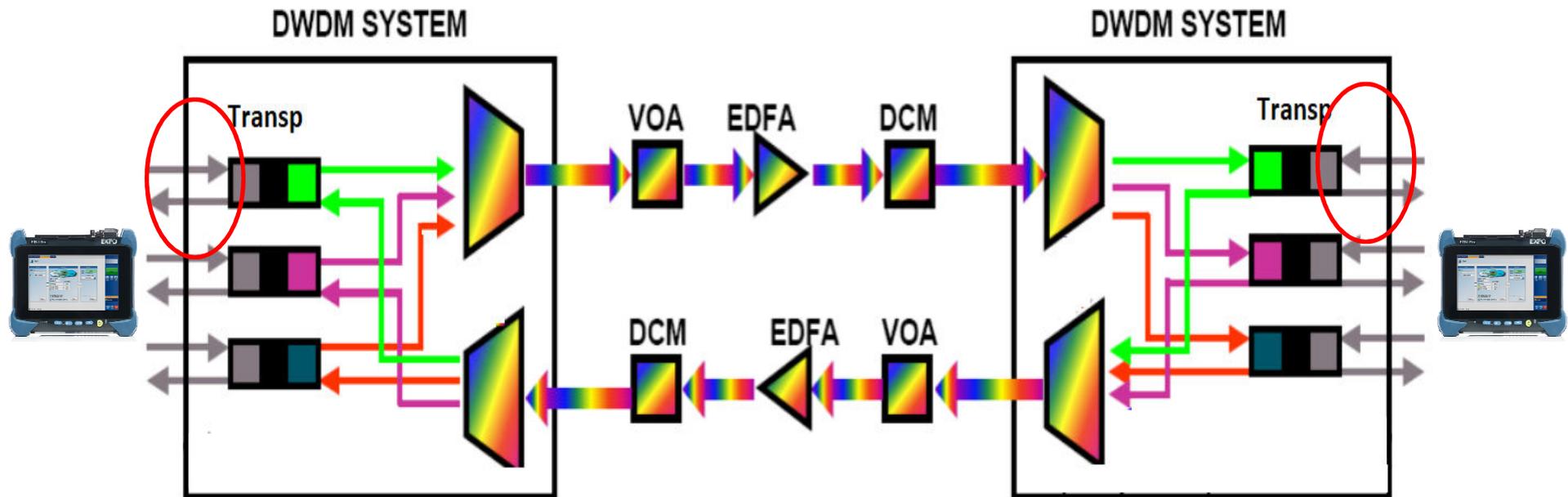
INFORMAÇÃO CONFIDENCIAL

Medida de Espectro Óptico

Prática OSA



Medida de Tráfego e Taxa de Erro



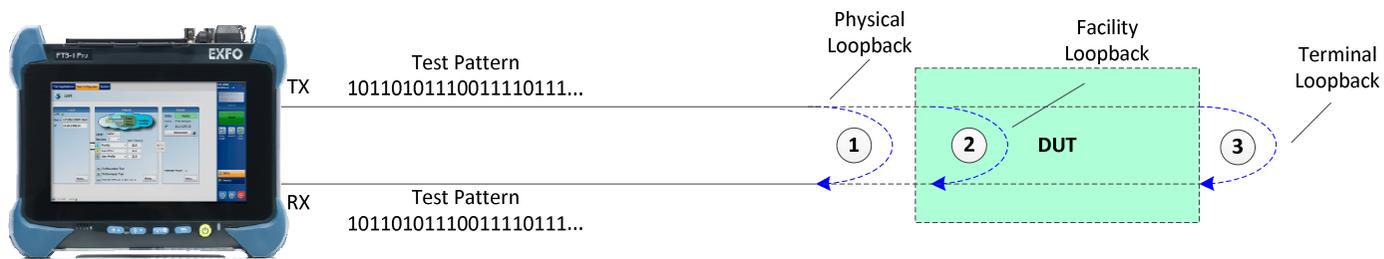
Testes de Desempenho:

- BERT
- RFC2544
- Y.1564
- RFC6349

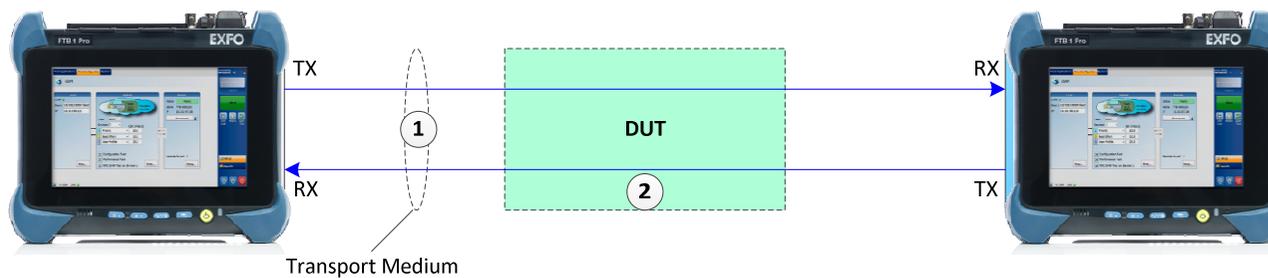
Medida de BER

BER: Bit Error Ratio (taxa de Erro de Bit) = $\frac{\text{Number of Bit in Error Received}}{\text{Total Number of Bits Received}}$

Teste em Loop



Teste Ponto a Ponto



RFC 2544

Published in 1999 by IETF for lab environment testing; still used nowadays

Defines 4 subtests that are performed sequentially

- Throughput
- Back-to-back
- Frame loss
- Latency

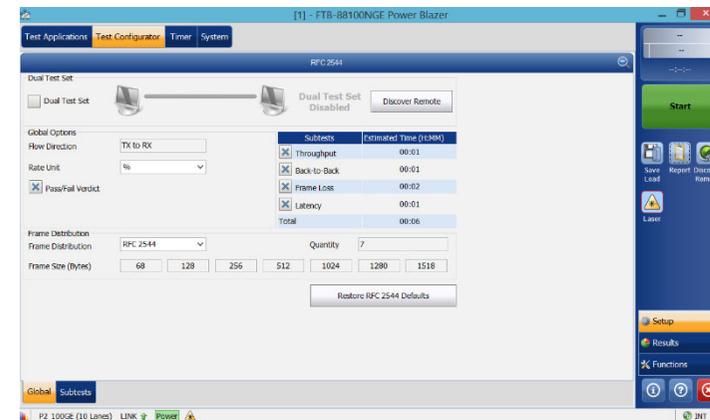
Single data service with specific frame sizes



Frame sizes (bytes):

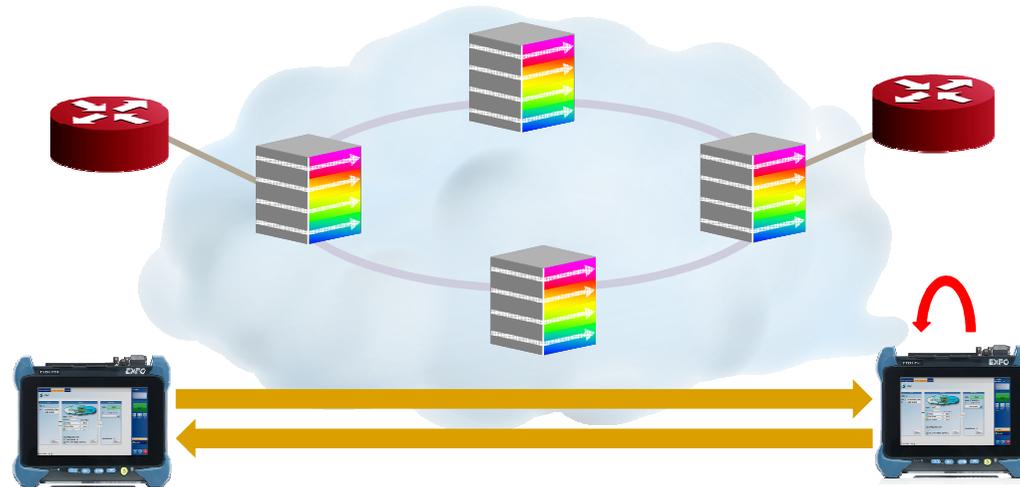
- 64
- 128
- 256
- 512
- 1024
- 1280

Unique flow



RFC 2544 - Throughput

Throughput: **maximum number of frames/s that can be transmitted without errors**

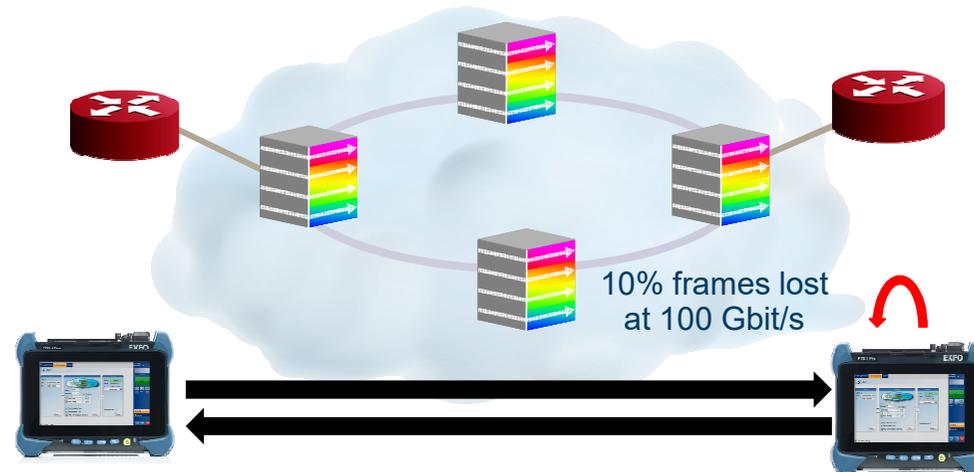


› Procedure:

- › Transmit a specific number of frames
- › Transmit at a specified rate
- › Compare Tx to Rx

RFC 2544 – Frame-Loss

Frame loss: **percentage of frames lost at a particular line rate due to lack of resources**

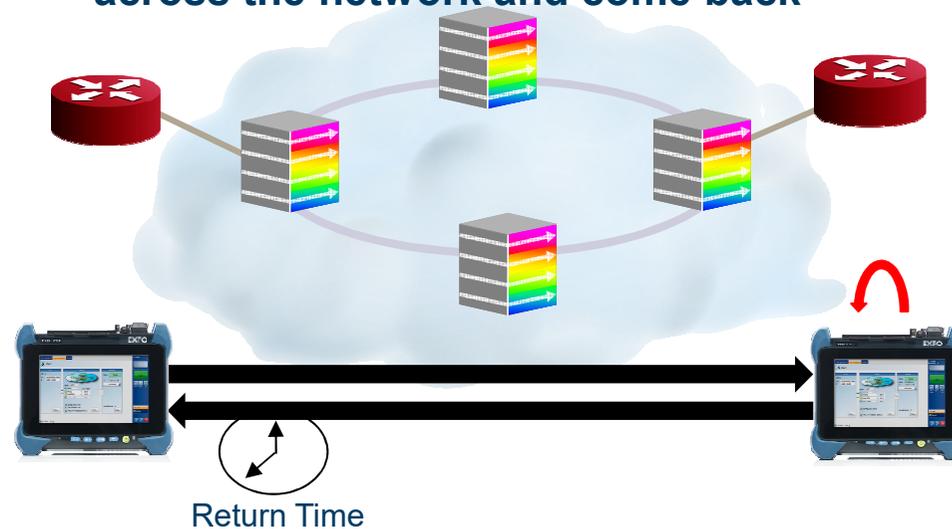


› Procedure:

- › Transmit a stream of frames at a selected size
- › Transmit a known quantity of frames
- › $(\text{Input count} - \text{output count}) \div \text{input count} \times 100$

RFC 2544 - Latency

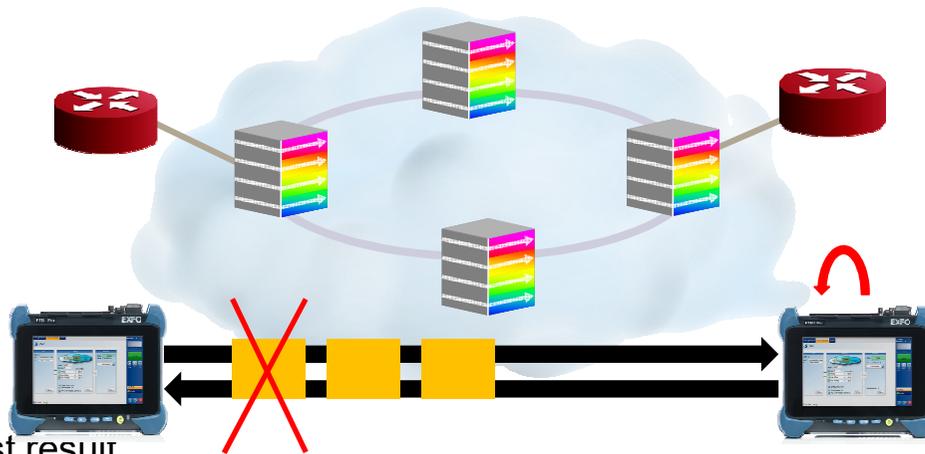
Latency: time it takes a frame to travel across the network and come back



- › Procedure:
 - › Transmit a stream of frames at a particular size
 - › Transmit at the determined throughput rate
 - › Measure difference between time stamps

RFC 2544 - Back-to-back

Back-to-back (Burstibility): **maximum number of frames received at full line rate before a frame is lost**



- Procedure:ine best result
- The ability of a device under test to process bursts of back to back frames (minimum inter-frame gap, 100% frame rate). This test determines the extent and capability of data buffering of the device under test

Y.1564

Y.1564 – Ethernet service activation test methodology

Resumo:

Y.1564 é uma metodologia de teste de serviços , ou seja vai além de teste de circuitos.

Para entender a Y.1564 precisamos ter os conceitos de SLA e QoS

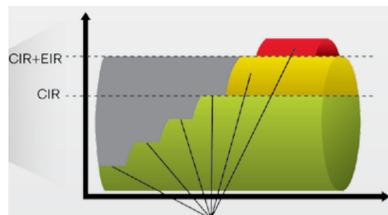
SLA: Service Level Agreement – Determina os Níveis de Serviço que são configurados e entregues para cada serviço e cada cliente.

QoS: Quality of Service – Define os critérios de tratamento de cada tipo de serviço.

Desta forma a Y.1564 realiza os testes de forma a validar a implementação dos parâmetros de QoS e verifica se o SLA esta sendo atendido.

Esta validação é realizada em duas fases que serão detalhadas a seguir:

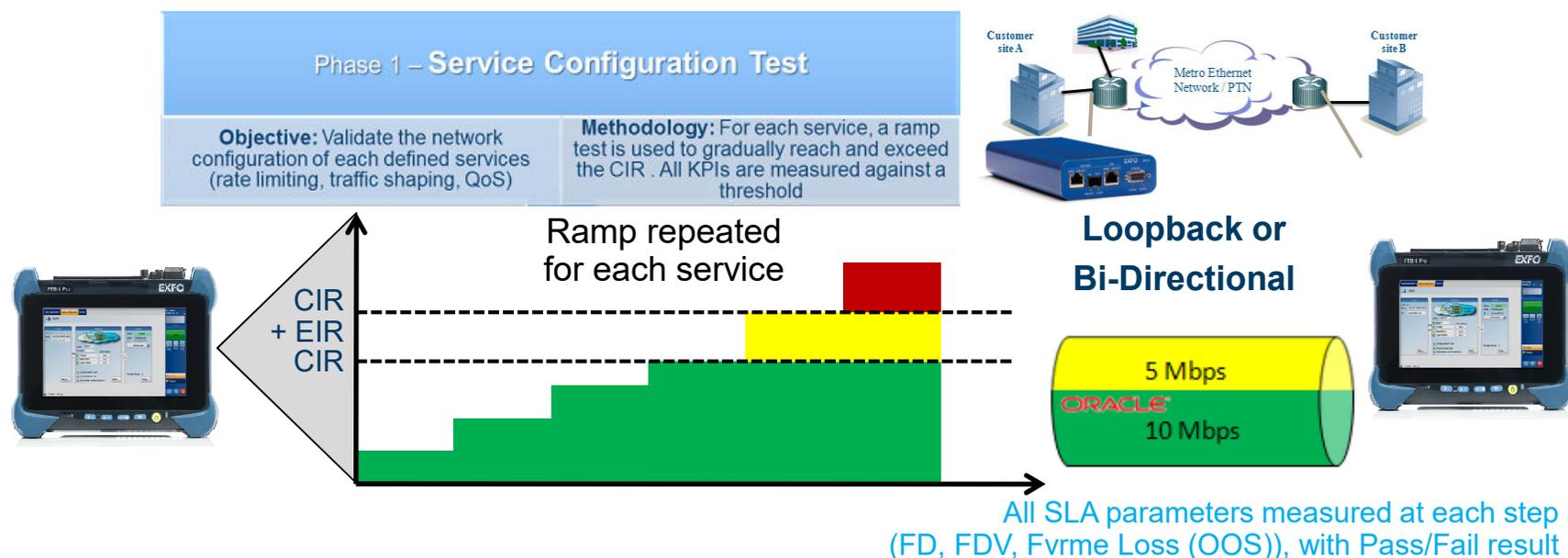
- Service Configuration



- Service Performance



Y.1564 Phase 1 – Service Configuration Test

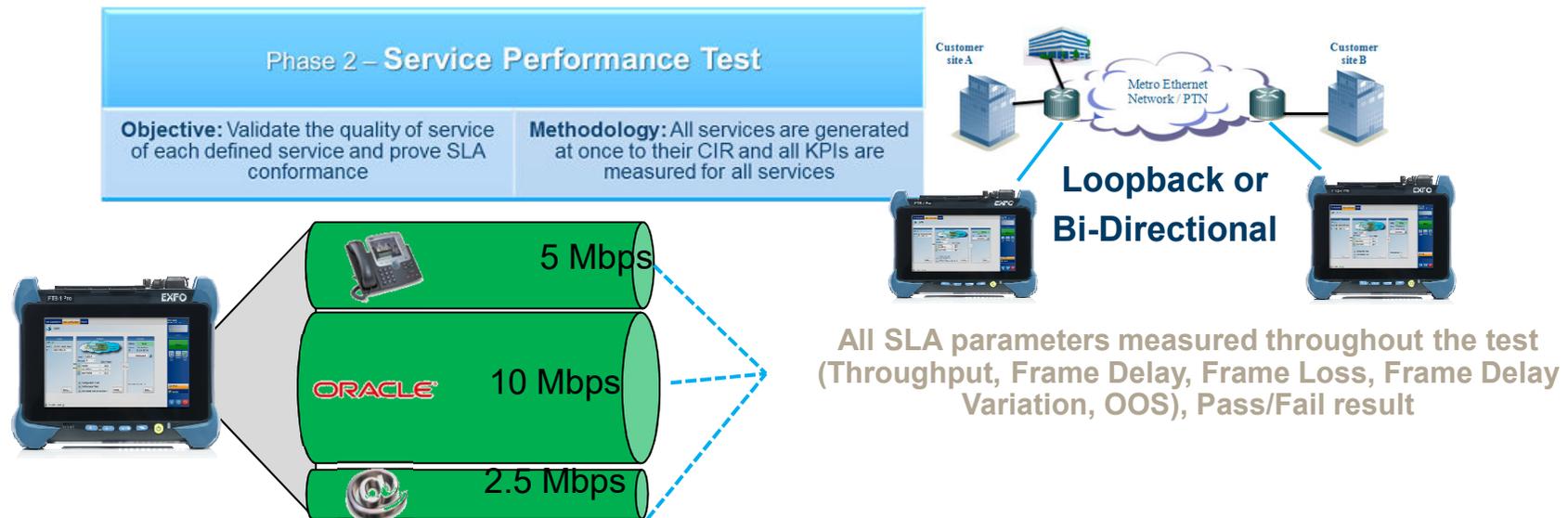


- For each service sequentially, generate a traffic ramp, first up to CIR and then up to EIR (if applicable) and then over EIR
- Verify that CIR and EIR are properly configured
- Verify all SLA parameters at each ramp step (Pass/Fail thresholds for each parameters)

CIR (Committed Information Rate): Taxa que a operadora garante para o serviço.

EIR (Exceeded Information Rate): Taxa adicional ao CIR que pode ocorrer eventualmente porém não é garantida.

Y.1564 Phase 2 – Service Performance Test



- Generate all Services simultaneously at CIR and measure all parameters simultaneously (Throughput, Frame Delay, Frame Delay Variation and Frame Loss)
- Pass/Fail threshold for each parameter (in each direction)
- Suggested Test time: between 15 minutes and 2 hours (dependent on customers, could be as low as 2 minutes)
- Can be scaled to longer term test (ex. 24 hours).

RFC 6349

- **RFC 6349** is a framework for **Layer4 TCP Throughput** testing that has been co-authored by several players in the industry, including service providers.
- It describes a methodology for measuring end-to-end TCP Throughput in an IP network.
- RFC 6349 defines the following steps
 - 0- Conduct a Layer 2/3 turn-up test before TCP testing
 - 1- Path MTU Identification
 - 2- Baseline Round-Trip Time and Bandwidth identification
 - 3- TCP Connection Throughput Tests
- Out of step 3, the following metrics are provided:
 - **TCP Transfer Time Ratio**
 - **TCP Efficiency percentage**
 - **Buffer Delay percentage**

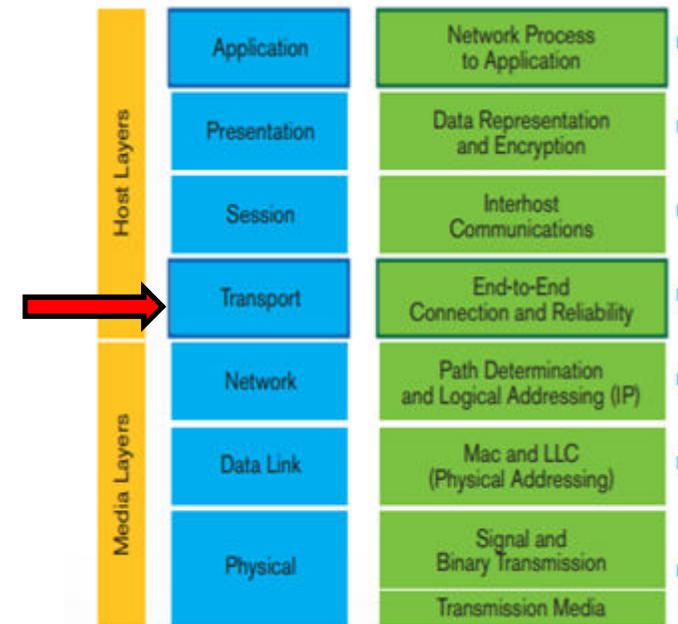


Figure 1. OSI reference model and nomenclature

RFC 6349 – TCP Window

TCP Window

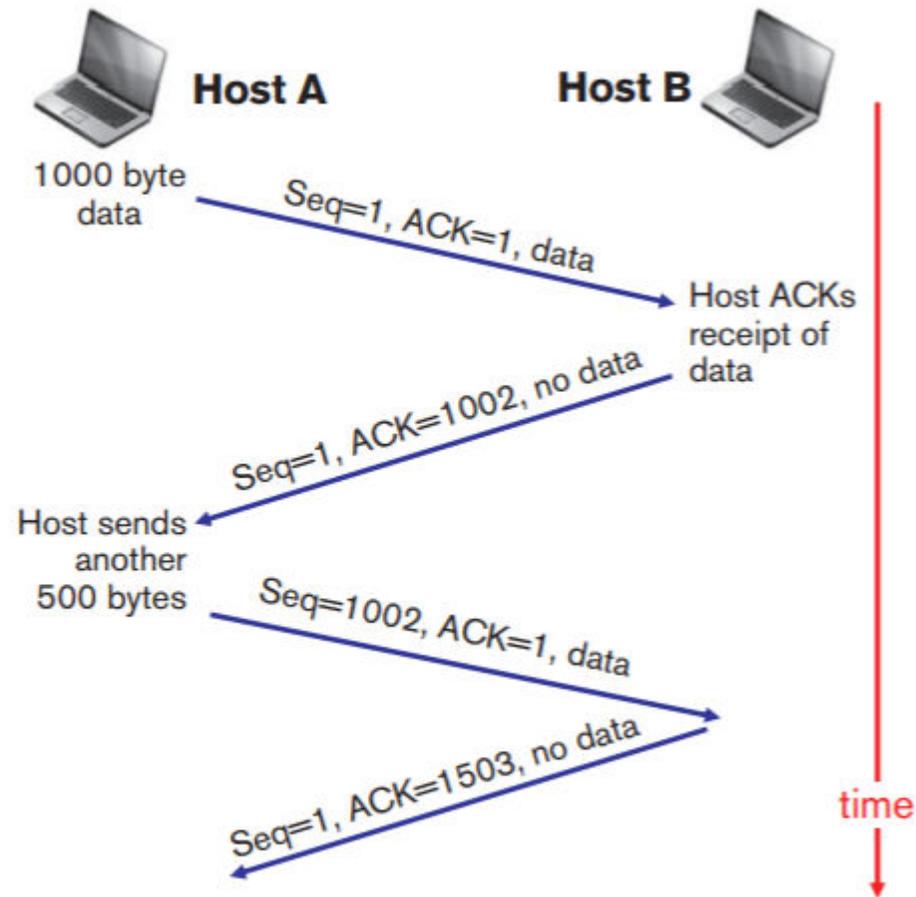


Figure 3: Flow-control mechanism between two hosts

RFC 6349 - Steps

RFC 6349 Steps

- 1) MTU Discovery
- 2) RTT
- 3) TCP Throughput



Testes de Desempenho

Prática: testes desempenho

The screenshot shows the FTB-890 NetBlazer software interface. The main window is titled "iSAM" and has three tabs: "Test Applications", "Test Configurator", and "System". The "Test Configurator" tab is active. The interface is divided into three main sections: "Local", "Network", and "Remote".

Local Section: Shows "LINK" with a dropdown arrow, "Port 1" set to "10GE LAN", and "IP" set to "10.10.0.0". A "More..." button is at the bottom.

Network Section: Shows a cloud icon with "Total: 4.0 Mbit/s" and "Duration: 12m40s". Below this is a "Layer" dropdown set to "L3/L4" and "Services" set to "4". A table lists four services, each with a "Priority" dropdown set to "1.0" and a "CIR (Mbit/s)" field set to "1.0". There are checkboxes for "Configuration Test", "Performance Test", and "RFC 6349 Test on Service 1". A "More..." button is at the bottom.

Remote Section: Shows a warning icon and "Searching Remotes...". An "Add" button is below. A "More..." button is at the bottom.

Right Panel: A vertical sidebar contains a "Start" button, a "Setup" button, and a "Results" button. At the bottom are three icons: a blue circle with a white 'i', a blue circle with a white '?', and a red circle with a white 'x'.

Overlay: A blue handprint graphic is overlaid on a blue banner that says "HANDS ON".

Agradecimento

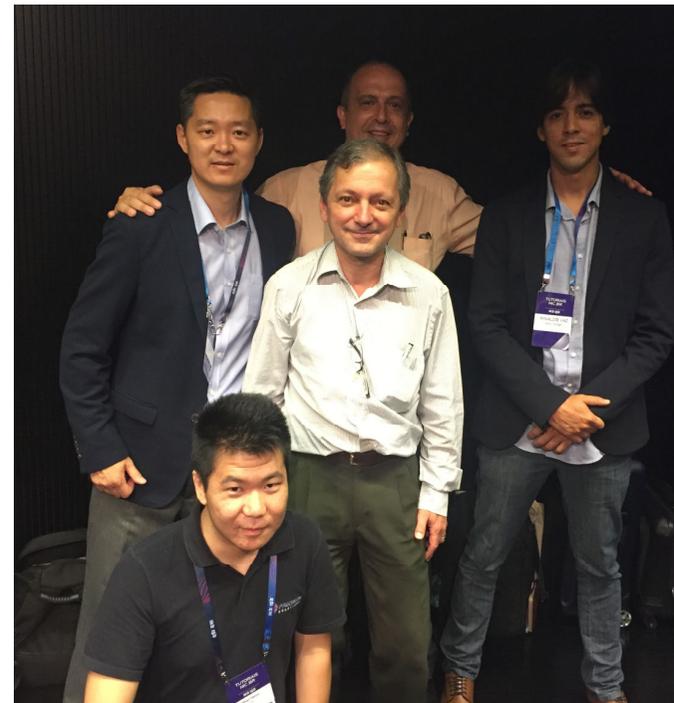
Muito obrigado pela participação ativa de todos os presentes!

Objetivo foi apresentar conceitos básicos de Tecnologia e Testes para o ambiente de redes ópticas mesclando informações teóricas com testes práticos.

Agradeço em especial o convite do NIC.Br.

Até o próximo evento.

Eduardo Ken



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