

Fibre-Optic Network Testing: Avoid clogs and pains in Smart City & IoT projects



Jean-Baptiste Letang, Application Engineer @ EXFO
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EXFO & ALT booth #314





Agenda

- Understanding the Smart Cities needs
- Infrastructure changes and challenges
- Benefits of testing
- Summary and Q&A



The ongoing bandwidth explosion...

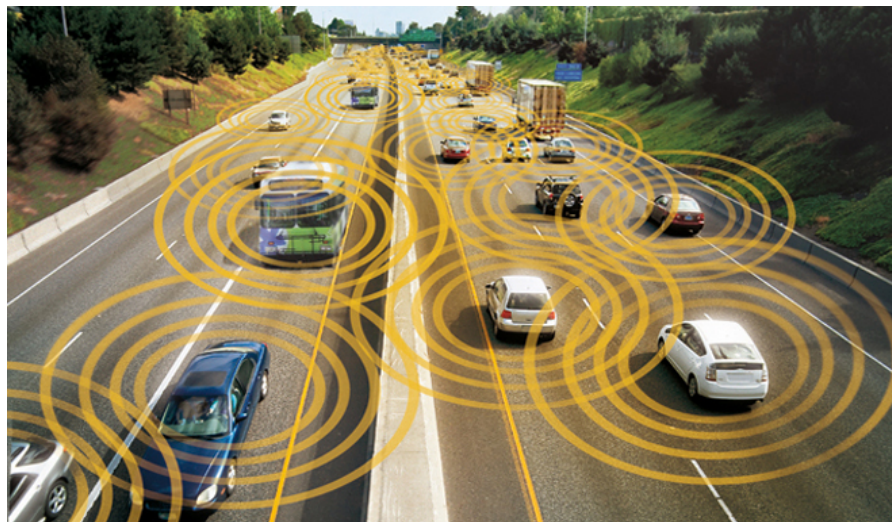
EVERYONE...



Image: Sonymobile.com

...WANTS HIGH-QUALITY

Image: U.S. Department of Transportation/Wired.com



EVERYWHERE, ANYTIME...



Image: Amanda Kooser/CNET

AND ON MULTIPLE DEVICES!



...powered by Smart Cities

*“Develop systems merging IT, Geographic information, databases and sensors () for the benefits of both **Citizens and Municipalities** to aim a **better quality of life**”*

Key elements required for a successful Smart City project :

Connected
populations

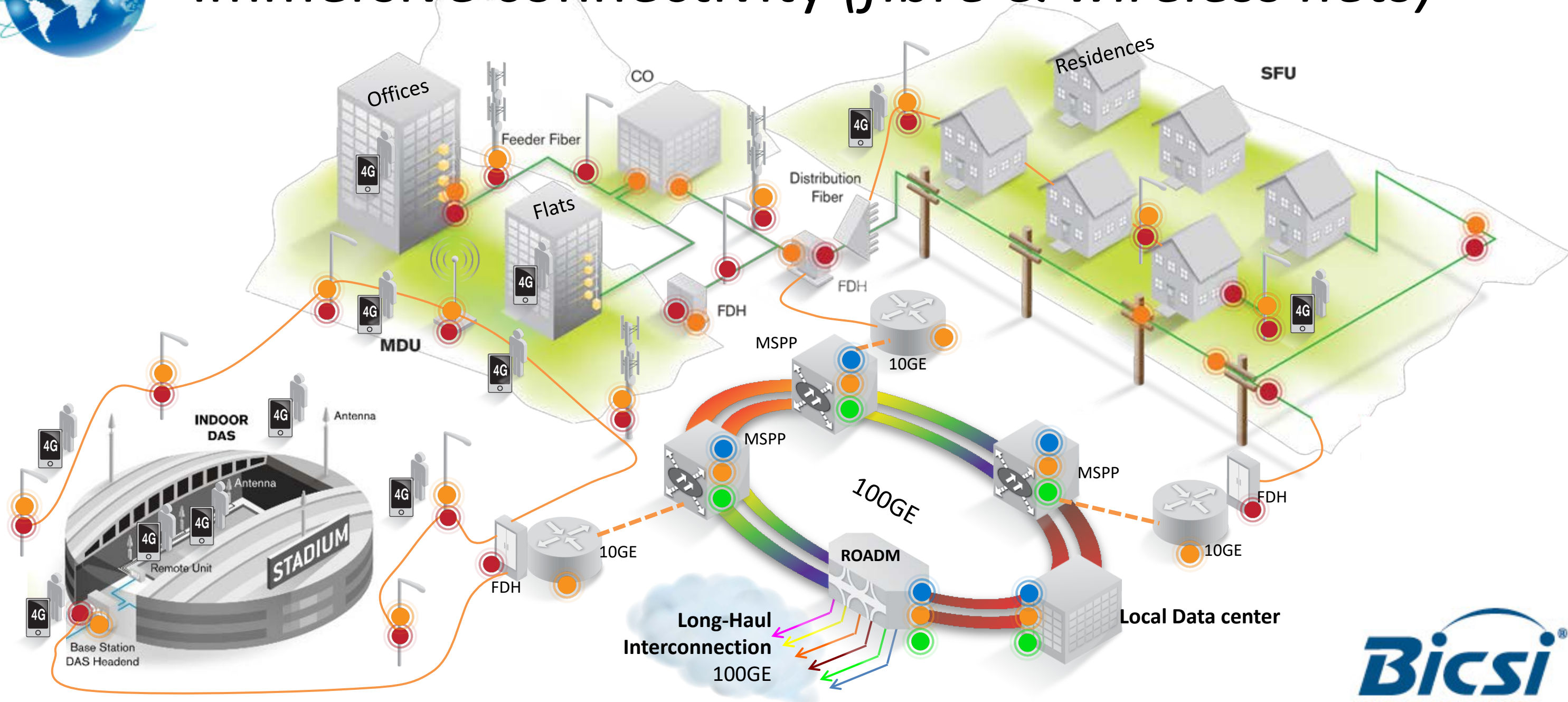
Fibre Network &
immersive
connectivity

Basket full of Apps
& IoT services

Monetisation of
municipal
investments

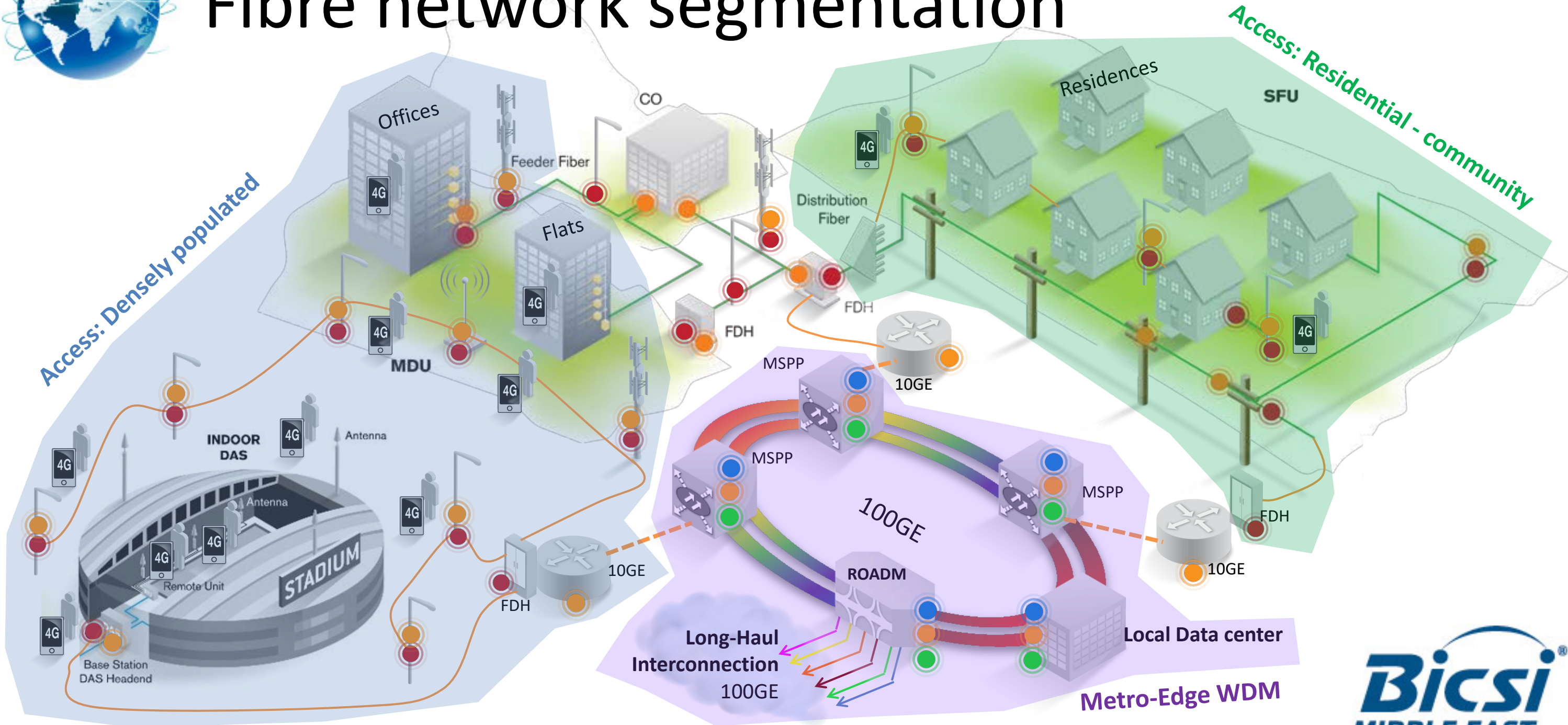


Immersive connectivity (*fibre & wireless nets*)





Fibre network segmentation





Infrastructure Solutions for Immersive Connectivity

Metro-Edge WDM

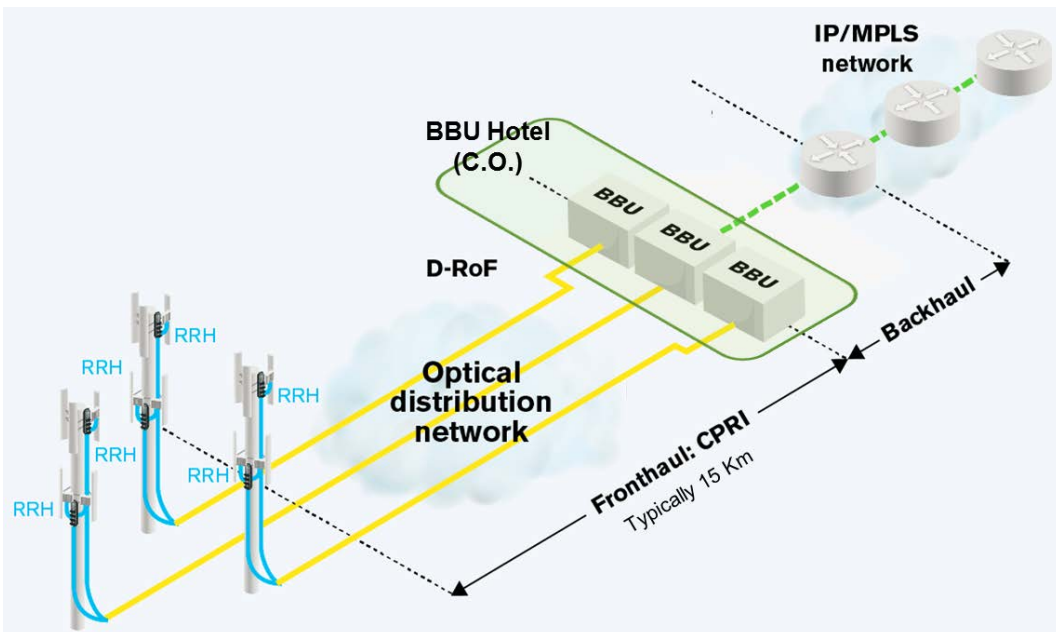
WDM rings

Active/Passive C-RAN deployment

Residential – community & Densely populated area

More small cells to be deployed outdoor (PON + DAS)

Passive Optical LAN (**POL**) & DAS inside large buildings and stadium





To support the associated challenges:

Trouble free & futureproof network

- FO infrastructure reliability
- xWDM
- *etc...*

Bandwidth scaling

- 10G to the cell site
- 100G to the metro
- Landing 400G
- *etc...*

(ultra) low latency and high QoS

- 5G
- DCI
- Ethernet Services
- *etc...*

Setting up a Fibre Optic Network Testing Strategy is key to avoid clogs and pains in Smart Cities & IoT projects



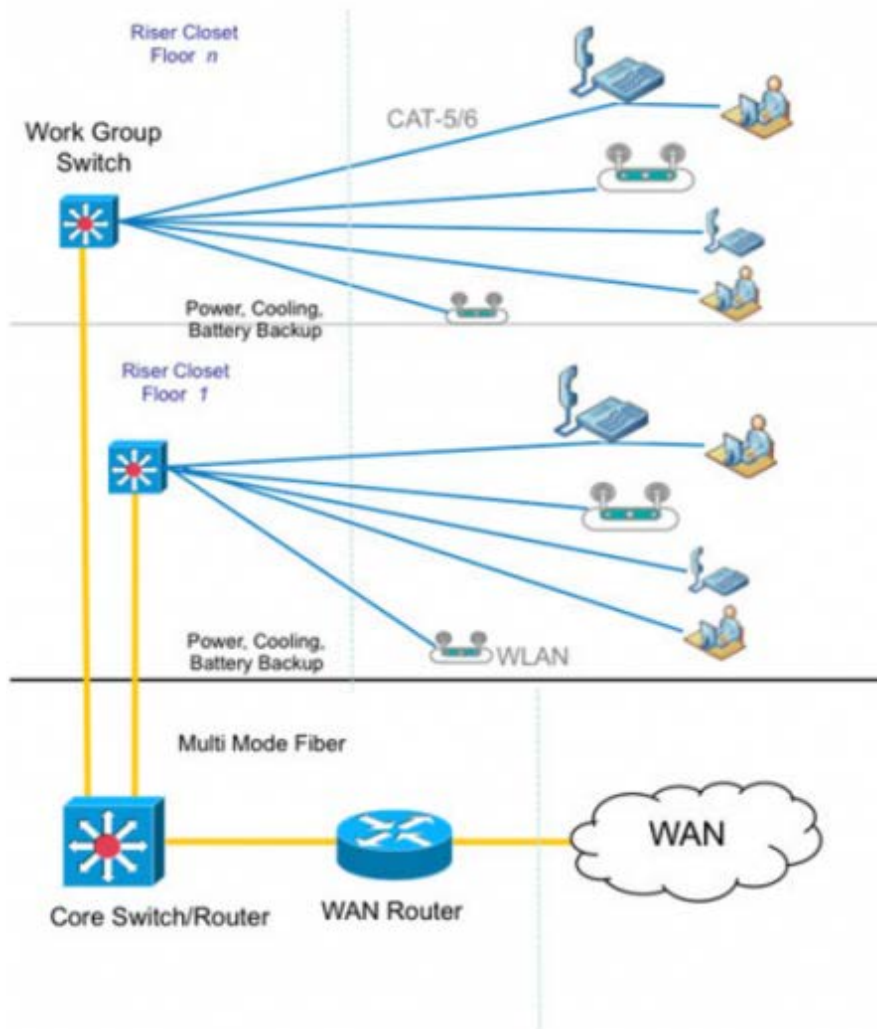
Delivering the quality demanded by Next-Gen networks and services

Introduction to Fibre Optic Testing
Strategies

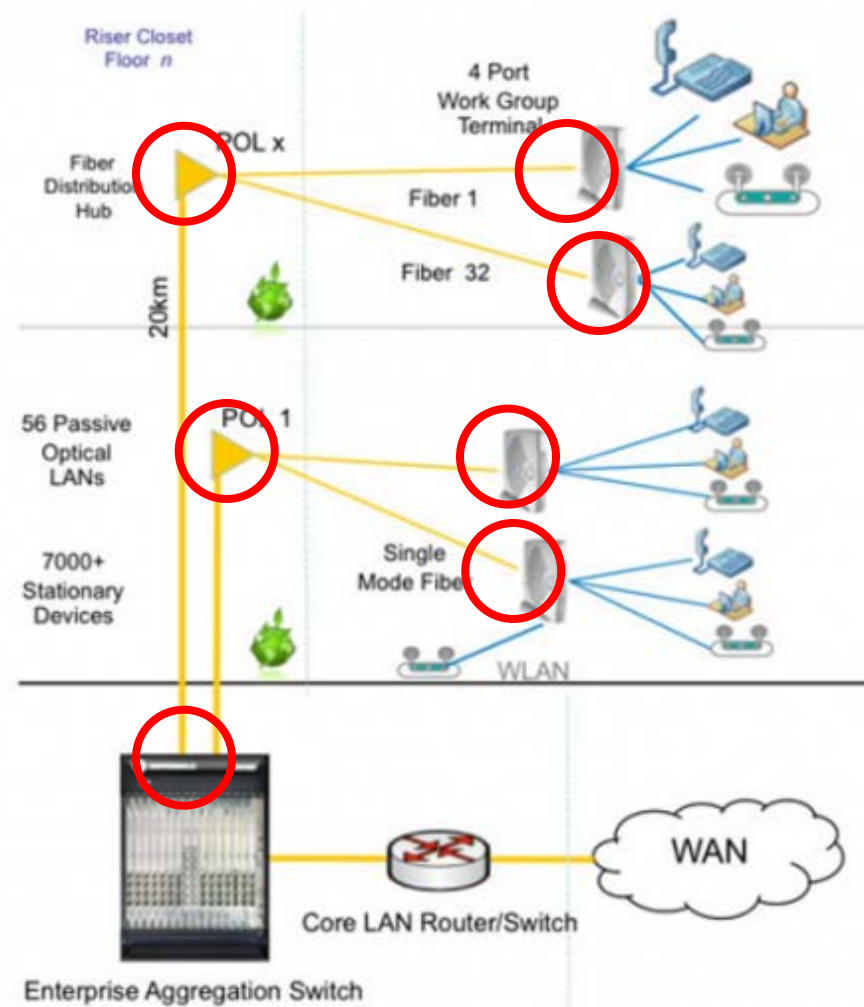


Access: from TLAN to POL

Traditional LAN



Passive Optical LAN



- Indoor POL works on the same principle than outdoor PON.
- POL & PON architecture is future proof, OLT & ONTs can be replaced to migrate to higher speed.
- Traditional LAN (TLAN) uses fiber trunk to feed active switches and copper cables limited in rate and reach; maintenance cost of TLAN is significantly higher.

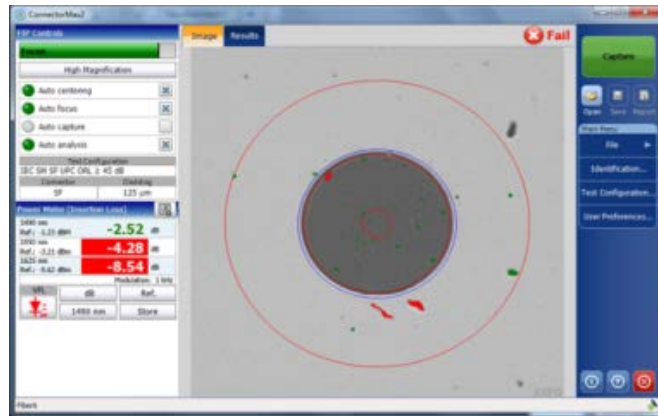
Main elements:

- OLTs and ONTs
- FO connectors
- Singlemode fibre
- Optical splitter



Testing strategy for a quality POL deployment:

Connector Inspection



POL deployments

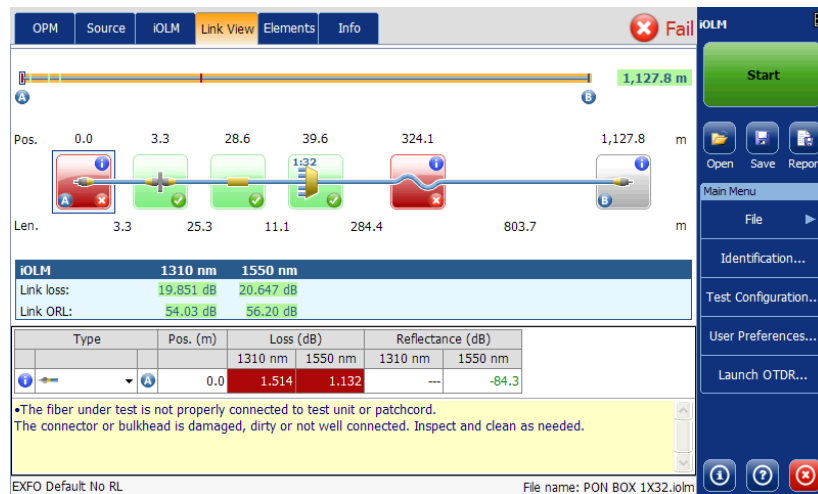
1

2

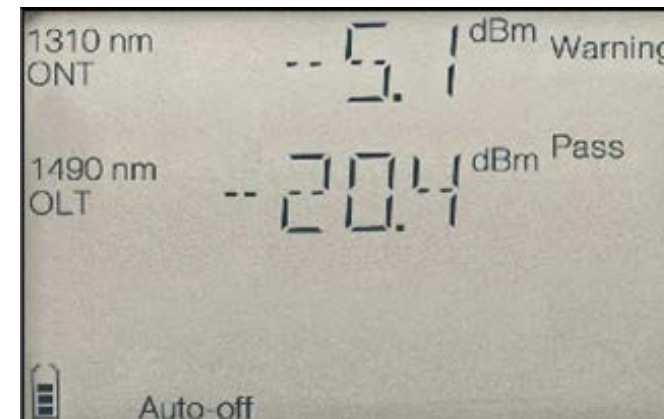
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4

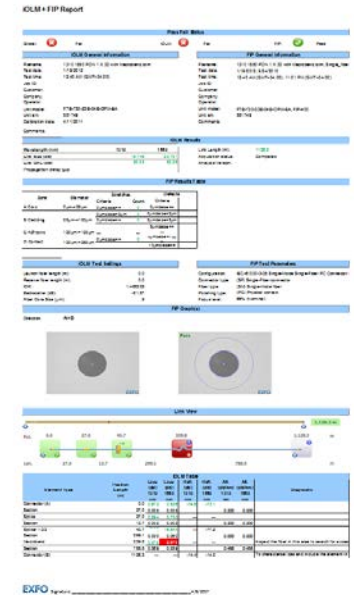
Fibre characterisation OTDR/iOLM/OLTS



Service Activation PPM



Reporting





1. FO Singlefibre Connector Inspection



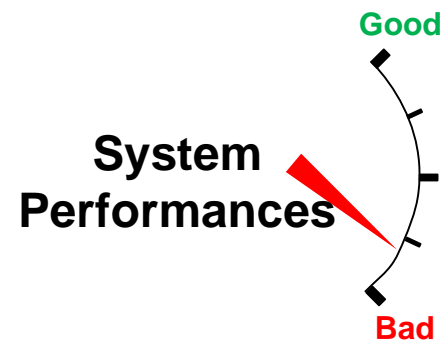
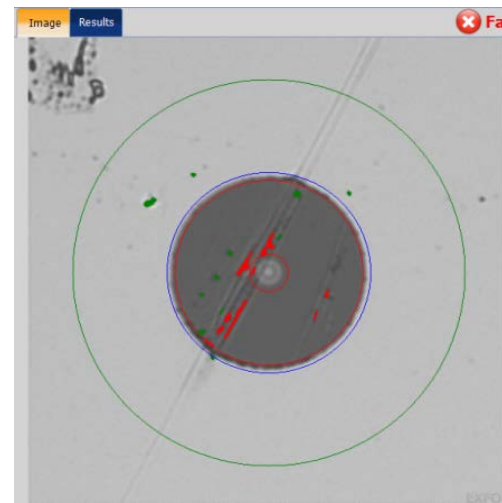
Contaminated connectors is **#1** cause of network failures

Connector Inspection is the first step in any FO handling procedure:



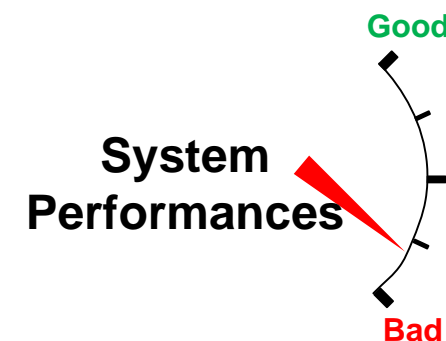
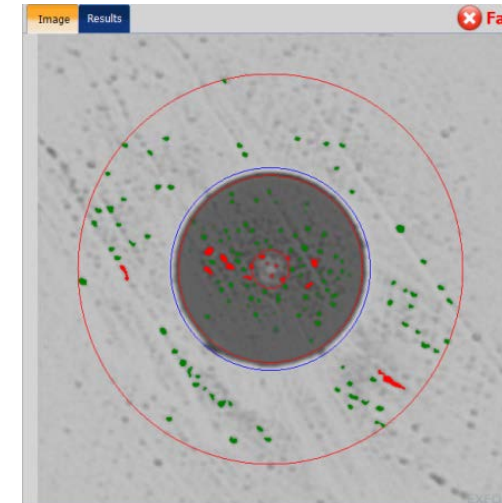
DAMAGED = REPLACE

You CANNOT clean a damaged connector



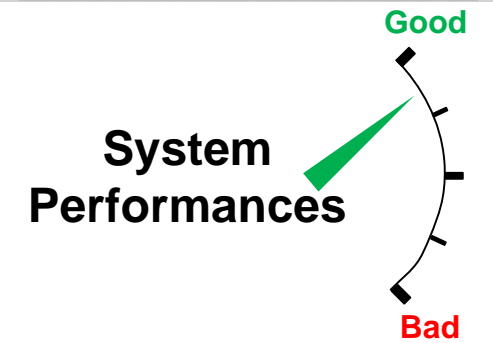
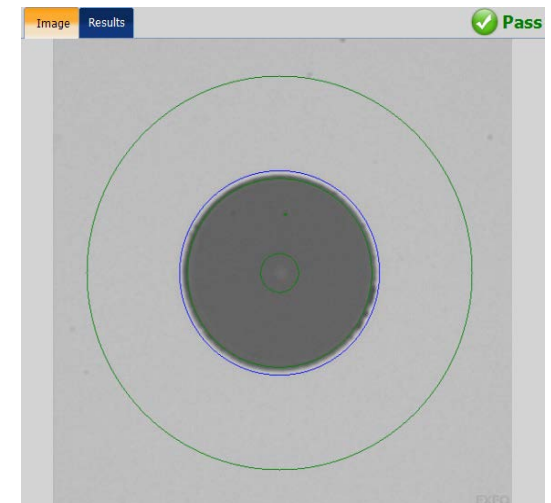
DIRTY = CLEAN

Clean ONLY if needed



CLEAN = CONNECT

NO cleaning required



Only cleaning is not enough...
Or unnecessary!

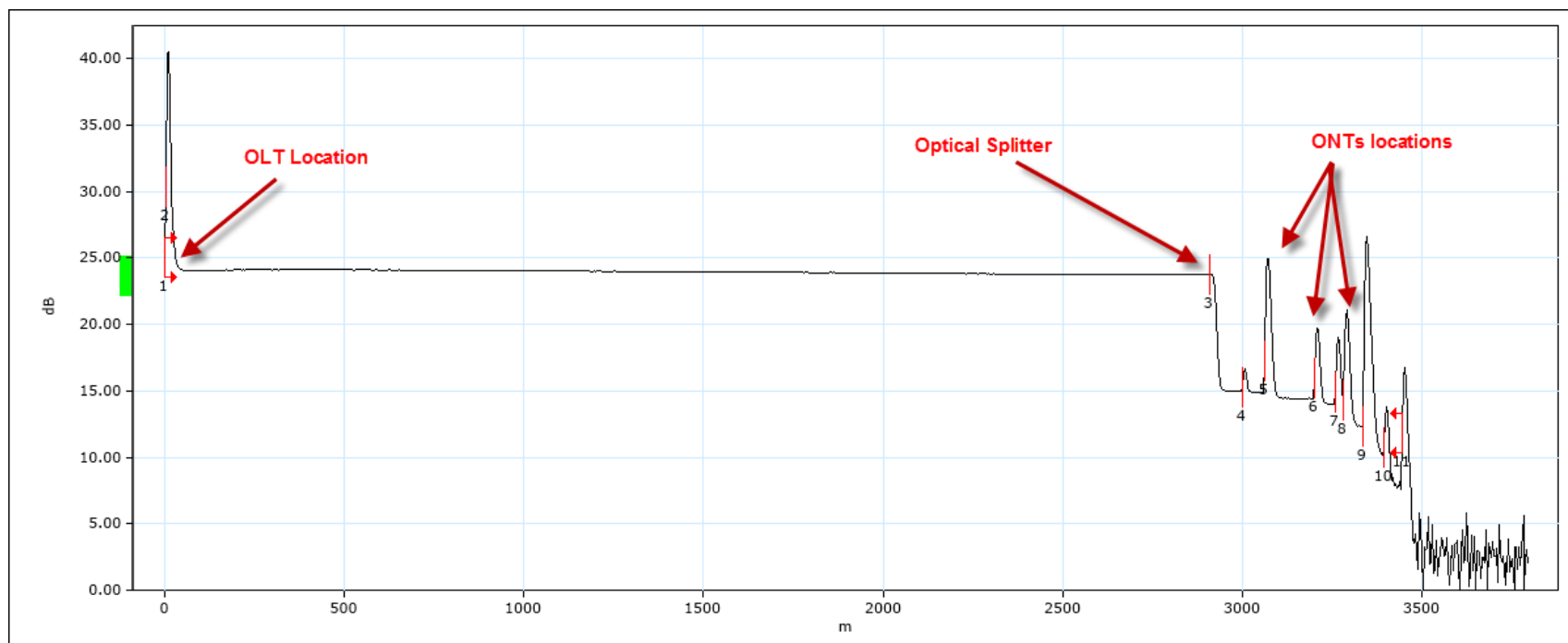




2. Elements Characterisation

- By design, splitters show high loss depending of the ratio (will vary with manufacturers):
- Testing from the OLT cannot provide accurate elements characterisation due to RBS from all legs:

Splitting Ratio	IL (dB)	Uniformity (dB)
1x2	3.6	0.5 - 0.9
1x4	7.7	0.5 - 0.9
1x8	10.8	0.8 - 1.2
1x16	14.5	1 - 1.7
1x32	18	1.3 - 2
1x64	20	1.3 - 2



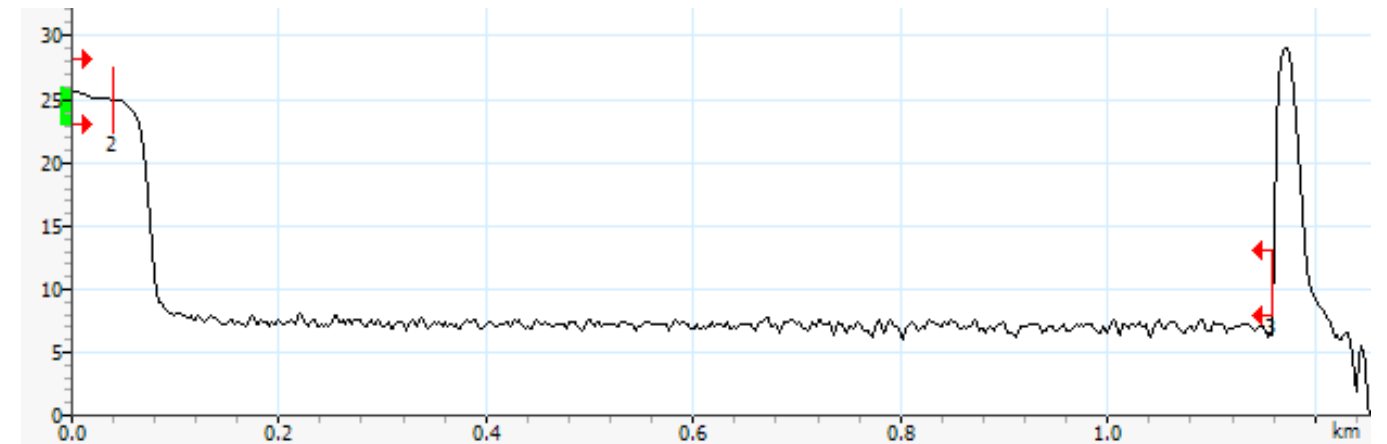
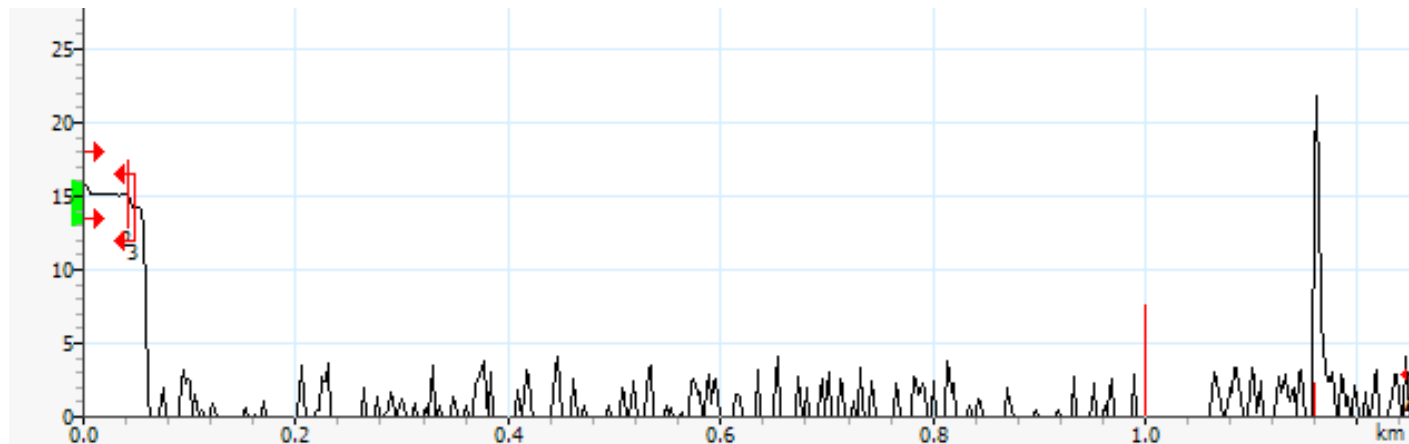


2. Elements Characterisation

Classic OTDR is a trade-off between Power and Resolution. It becomes even more challenging when measuring through Splitter:

Short PW will give resolution up to the splitter

Large PW will give enough power to see full span



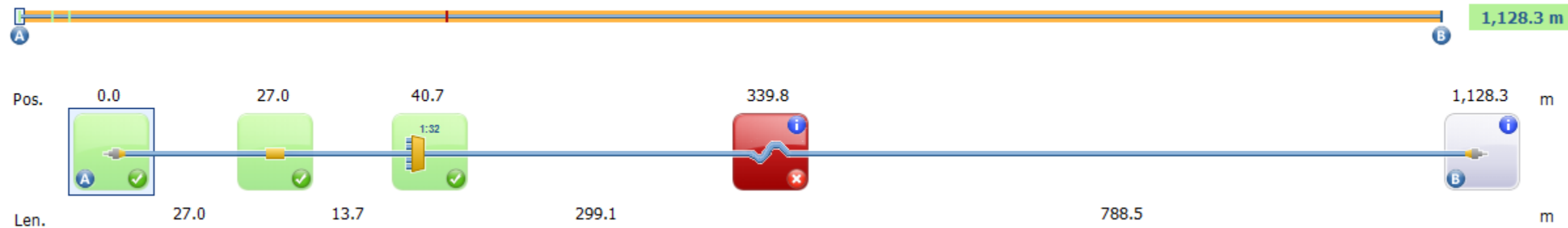
Splice is characterised but not splitter -> fibre break?

What about the splice?



2. Elements Characterisation

A multipulse OTDR testing approach is mandatory for a right first time test through Optical splitter from the ONTs location and easy understanding:



Small pulsewidths to characterise what is before the splitter

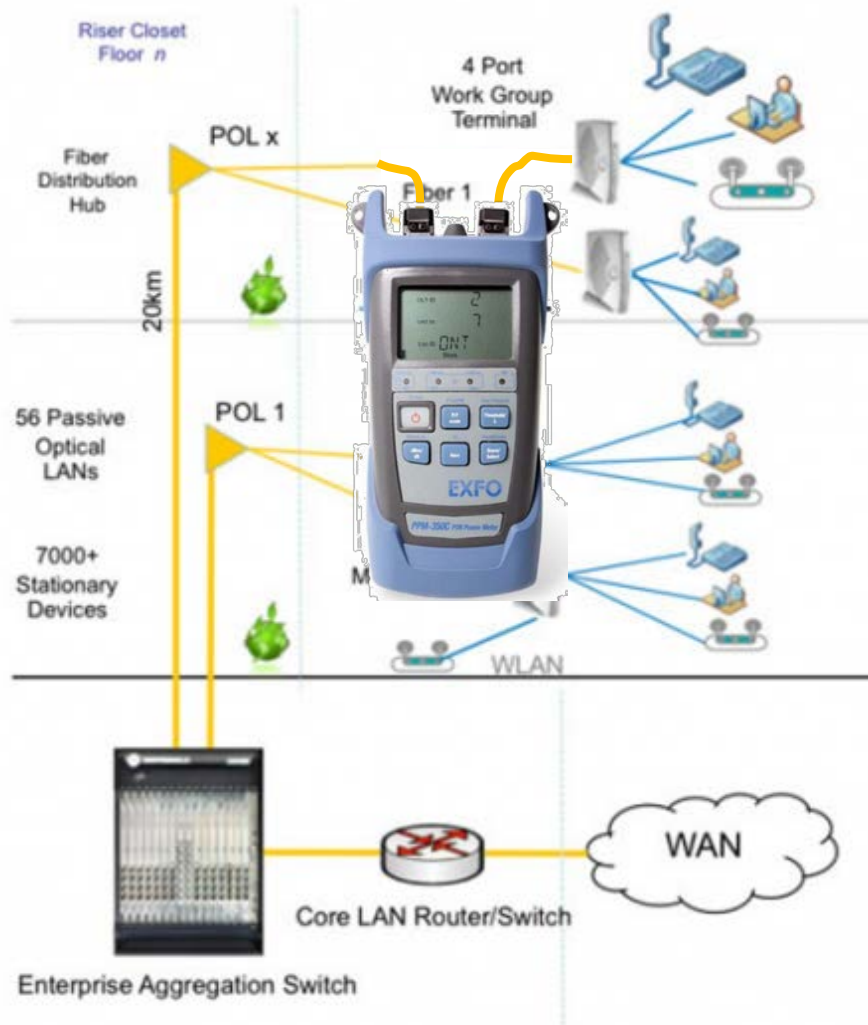
Medium to large pulsewidths to characterise the splitter itself and elements around

Large pulsewidths to characterise total loss, total length and end of fiber elements



3. Service Activation

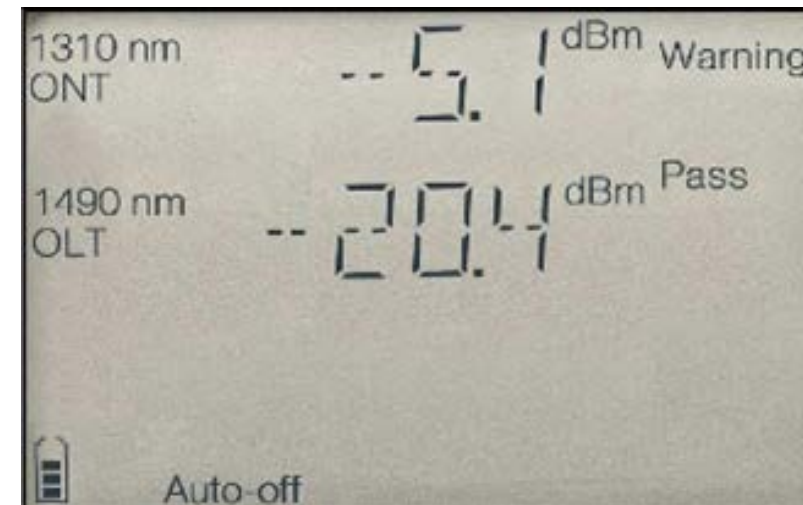
Passive Optical LAN



Standard PM will not work as “hand-shake” is required between OLT and ONT

Birth certificate of each “leg”: power level from both OLT and ONT at the same time.

A pass-through Power Meter will enable the sync between OLT and ONT and will measure the Optical levels:





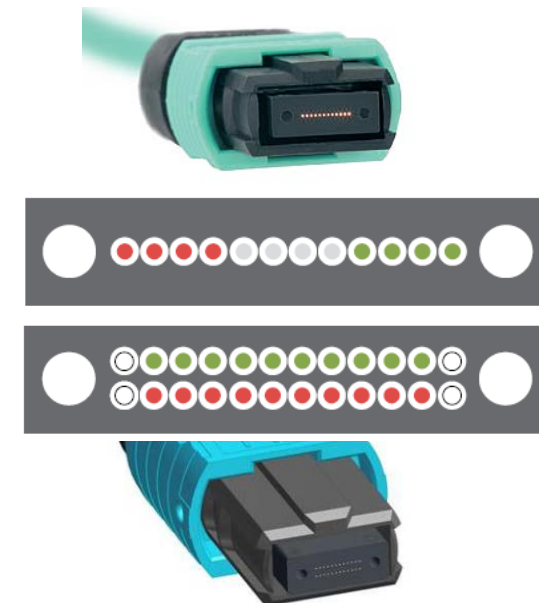
POL Testing summary

- POL networks are very similar to FTTH in terms of testing
- Proper testing tools and MOPs help deploying POL networks with a trouble-free 25-year warranty
- Documenting physical layer tests before activating the service gives a birth certificate of the link



Metro-Edge: Meeting the network KPIs

- High Speed Ethernet as Services is the trend
 - DataCenter, smaller carriers, etc...
- Driven by 40G and above, new pluggables & connectors :





Typical Transceiver Problems

Invalid/Imbalanced Power Measurement

Test Applications Test Configurator Timer System

Port 2 - 40GE (4 Lanes) [41.25 Gbit/s]

LINK

Local Fault Detected Local Fault Received Remote Fault

LOA HI-BER Remote Fault Emulation

Physical Interface

Optical Lane	Laser	TX Power (dBm)	Wavelength (nm)	RX Power (dBm)	Min RX Power (dBm)	Max RX Power (dBm)
0	ON	1.05	1271.00	-15.30	-15.30	2.40
1	ON	1.17	1291.00	--	-11.24	2.17
2	ON	0.83	1311.00	--	-20.66	1.94
3	ON	1.56	1331.00	-25.69	-25.69	2.04

Laser ON/OFF Laser OFF at Start-Up Power Range (dBm) -17.0 To 3.0

Interface Frequency Network QSFP

P2 40GE (4 Lanes) LINK Power

Missing Optical Channel Detection

Test Applications Test Configurator Timer System

Port 2 - 40GE (4 Lanes) [41.25 Gbit/s]

LINK

Local Fault Detected Local Fault Received Remote Fault

LOA HI-BER Remote Fault Emulation

Physical Interface

Optical Lane	Laser	TX Power (dBm)	Wavelength (nm)	RX Power (dBm)	Min RX Power (dBm)	Max RX Power (dBm)
0	ON	1.76	1271.00	--	-15.30	2.94
1	ON	1.78	1291.00	-5.10	-11.24	2.78
2	ON	1.84	1311.00	-5.41	-20.66	2.37
3	ON	1.75	1331.00	-5.87	-25.69	2.04

Laser ON/OFF Laser OFF at Start-Up Power Range (dBm) -17.0 To 3.0

Interface Frequency Network QSFP

P2 40GE (4 Lanes) LINK Power



Testing transceivers in all scenarios

- New deployment and avoid truck rolls
- Troubleshooting before changing the card!



MPO loopback and w/ Attenuation

CFP
4 ports/chassis
24W

CFP2
8-10 ports/chassis
8W

CFP4
16-18 ports/chassis
5W

QSFP28
18-20 ports/chassis
3.5W

Smart applications can perform a series of test (I/O Interface check, Optical Tx/Rx test, BERT, skew, etc...)
While monitoring Temperature and Power consumption.

Summary | **Logger**

Start Time: 8/31/2016 11:39:26 AM

Sub-Test Sequence

I/O Interface Quick Check ✓	Optical TX Power Range Test (dBm) ✓	Optical RX Power Range Test (dBm) ✓	Bit Error Test ✓	Excessive Skew Test
Completed, Pass	Completed, Pass	Completed, Pass	Running...	--
I2C ✓	Min -1.4	Max 0.0	Min -0.6	Max -0.2
Pins ✓	Count 0		Max Skew --	

Monitoring

Power Consumption ✓

Temperature ✓

	Actual	Maximum
Power (W)	2.7	2.9
Current (A)	0.8	0.9
Temperature (°C)	29.8	29.8

P2-QSFP Power ⚠

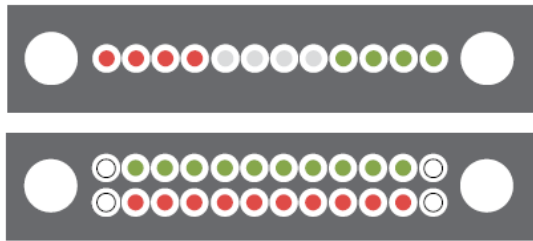


Multifibre Optical Connectors

Provides high density capability and easy bandwidth scaling.

Single row (12/16) or Dual row (24/32)

Only the use of an automated Inspection Probe allow to accurately inspect each fibre:



ConnectorMax2 Report Fail

Overview

General Information

Filename: cab1_Fiber.pdf Inspection date: 2/17/2016 10:33 AM
 Analysis version: 1.0.0 Analysis date: 2/17/2016 10:33 AM
 Job ID: Customer: Company: Frame:

Locations

Operator	Location A	Location B
Platform S/N: 093330 Se		

FIP Information

Info.	Value
Model	FIP-435B
Serial number	808559
Firmware version	6.2.0.9

Identifiers

Cable ID	Fiber ID	Location A	Location B	Connector ID
cab1	Fiber1 to Fiber4			

Test Parameters

Configuration: IEC SM MF UPC ORL ± 45 dB (@1300-3.35, 1.0) (Standard)
 Connector type: Multiple fiber Cladding diameter: 125 µm
 Fiber type: Singlemode Polishing type: Ultra-polished physical contact
 Number of fibers: 4 Analysis mode: Outside plant

Results Summary

Fiber1 (Focus level: Good)

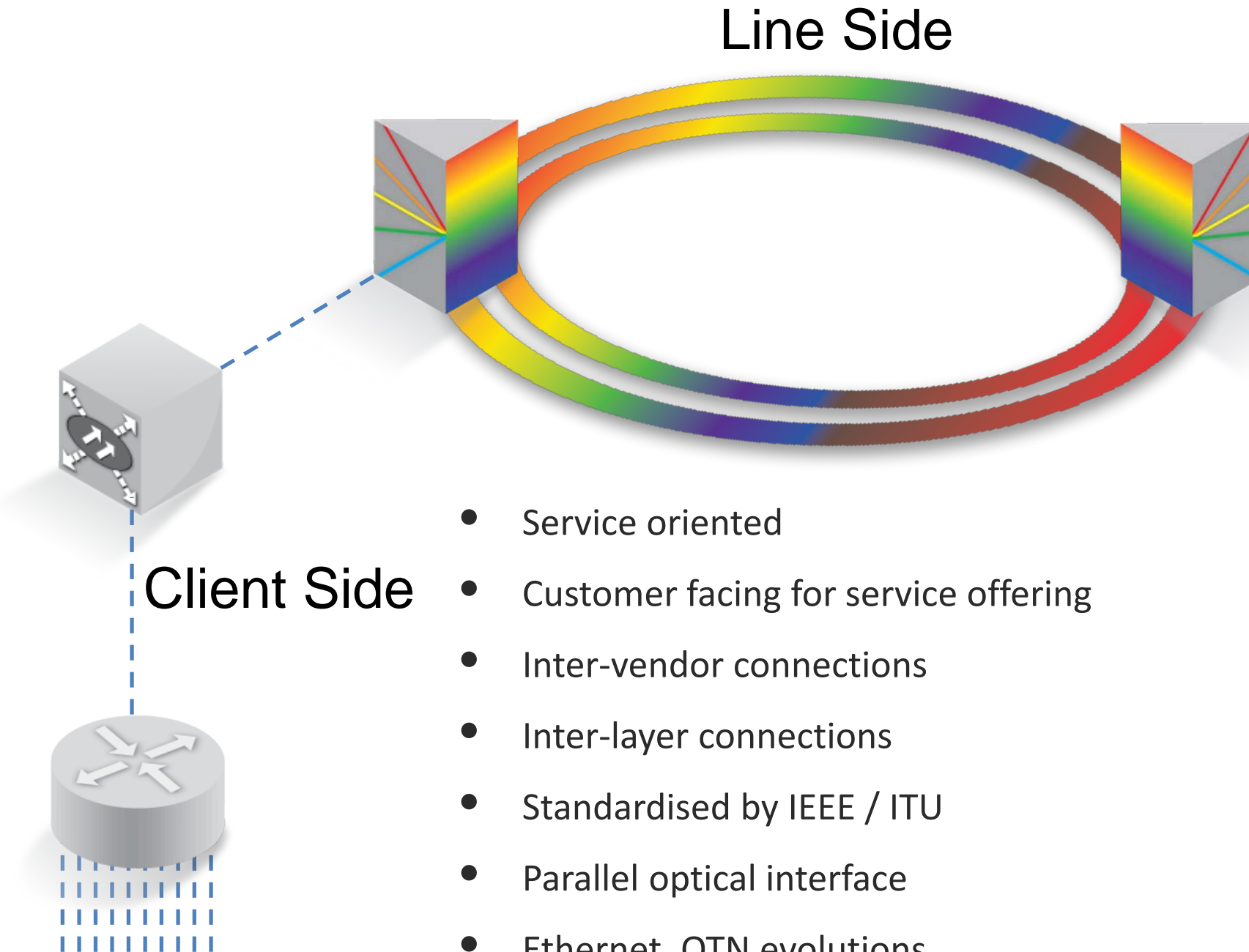
Zones	Criteria (µm)	Thresholds	Count
0-45 µm	0 < size <=	Scratches	0
	0 < size <= 3	Any	0
	3 < size <=	Any	0
65-115µm	0 < size <=	Defects	1
	0 < size <= 3	Any	0
	3 < size <=	Any	0

Fiber2 (Focus level: Good)

Zones	Criteria (µm)	Thresholds	Count
0-45 µm	0 < size <=	Scratches	0
	0 < size <= 3	Any	0
	3 < size <=	Any	0
65-115µm	0 < size <=	Defects	1
	0 < size <= 3	Any	0
	3 < size <=	Any	0



100GE Within The Network



- DWDM core network
- Transport oriented
- Serial optics
- Phase modulated
- OTN

- Service oriented
- Customer facing for service offering
- Inter-vendor connections
- Inter-layer connections
- Standardised by IEEE / ITU
- Parallel optical interface
- Ethernet, OTN evolutions



Which KPIs for switched circuit? QoE engaged...

Throughput

Amount of data traversing the circuit

Latency

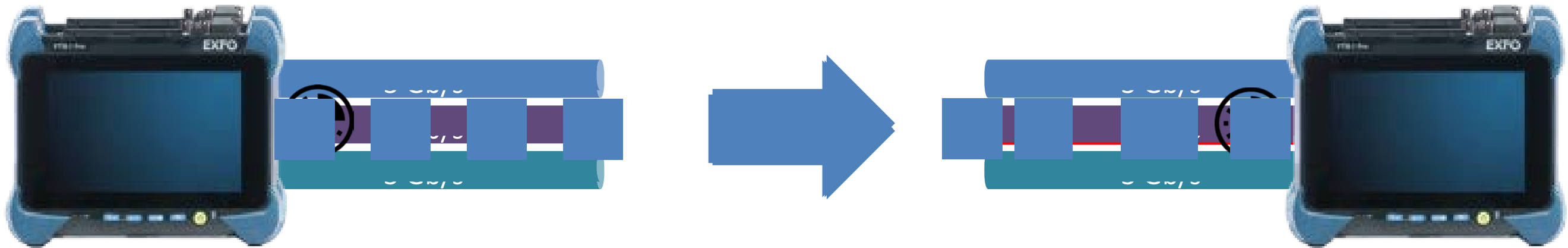
Time it takes data to traverse the circuit

Jitter

Delay between data frames being received

Lost Frames

Data frames being dropped from the network



Applications that require high bandwidth may have degraded performance
 User applications may have enough bandwidth
 Application sessions may fail
 Data may become corrupted



Ethernet Service Activation



ITU-T Y.1564 defines a methodology to successfully validate Ethernet Services versus KPIs in Next-Gen networks:

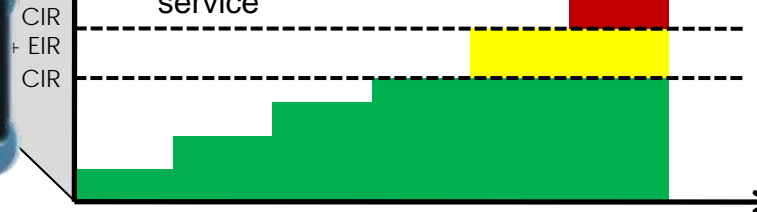
Phase 1: Service Configuration Test (Ramp & Burst Test)

Objective: Validate the network configuration of each defined services (rate limiting, traffic shaping and QoS)

Methodology: For each service, a ramp test is used to gradually reach and exceed the CIR. All KPIs are measured against a threshold



Ramp repeated for each service



All SLA parameters measured at each step (FD, FDV, frame loss (OOS)), with pass/fail result

Phase 2: Service Performance Test

Objective: Validate the QoS of each defined service and the conformity of the SLA

Methodology: All services are generated at once to their CIR, and all KPIs are measured for all services



Service 1

Service 2

Service 3

All pass/fail results of the SLA parameters measured throughout the test (i.e., throughput, frame delay, frame loss, frame delay variation and OOS)



Ethernet Service Activation Summary

Testing in compliancy to ITU-T Y.1564 is recommended to support Next-Gen Networks:

- Validate SLAs between SP and customers

MEF Metro High (FD≤10ms, IFDV≤3ms, FLR≤0.01%)	▲▼
MEF Metro Med (FD≤20ms, IFDV≤8ms, FLR≤0.01%)	▲
MEF Metro Low (FD≤37ms, IFDV Disabled, FLR≤0.1%)	▲
MEF Regional High (FD≤25ms, IFDV≤8ms, FLR≤0.01%)	▲▼
MEF Regional Med (FD≤75ms, IFDV≤40ms, FLR≤0.01%)	▼
MEF Regional Low (FD≤125ms, IFDV Disabled, FLR≤0.1%)	▼
MEF Continental High (FD≤77ms, IFDV≤10ms, FLR≤0.025%)	▼

- Non harmful test through the network
- Validate SP's network configurations

Test Applications | Test Configurator | System

iSAM

Local: LINK, Port 1: 10/100/1000..., IP: 10.10.204.125

Network: Total: 3.0 Mbit/s, Duration: 10m15s

Layer: L2, Services: 3, CIR (Mbit/s): 1.0

1 Priority, 2 Best Effort, 3 User Profile

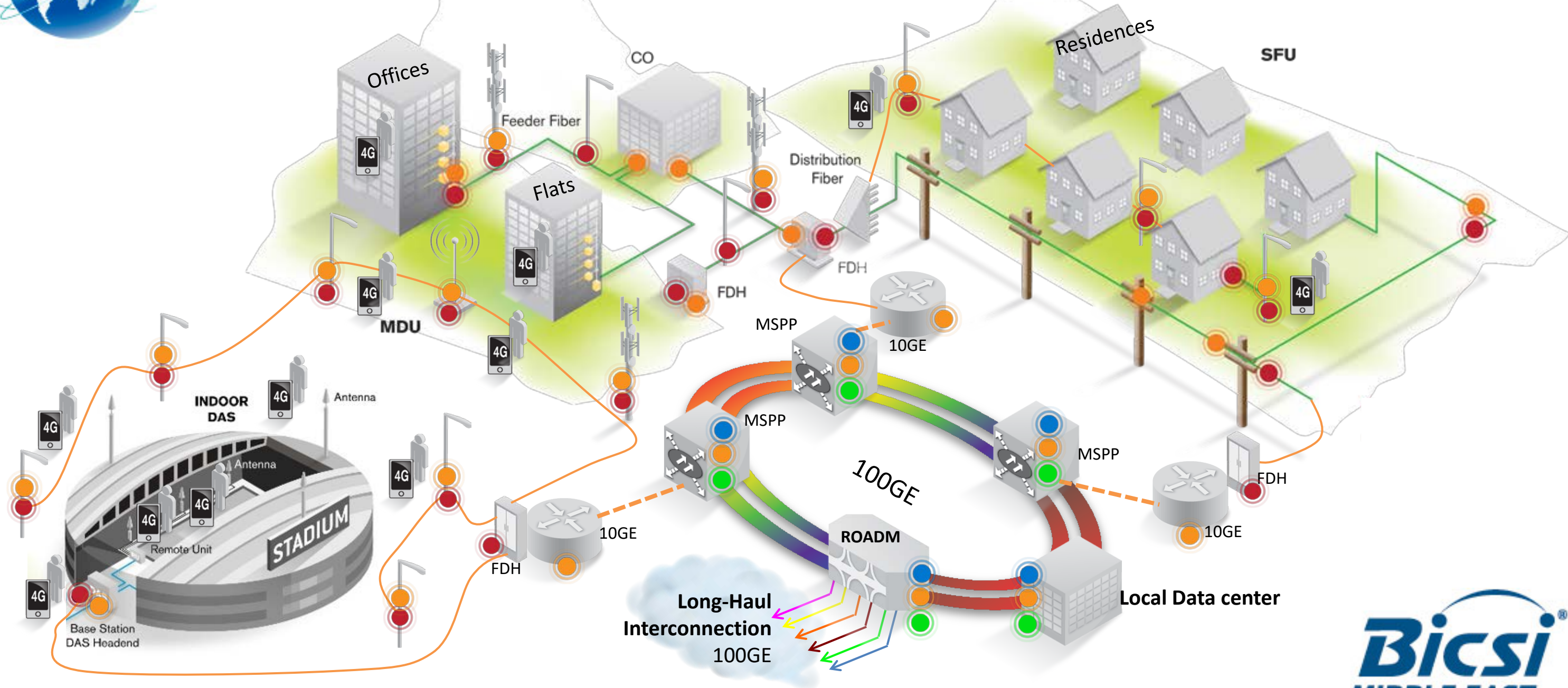
Remote: MAC: FE:FE:FE:FE:FE:FE

Configuration Test, Performance Test, RFC 6349 Test on Service 1

How to maintain QoS?

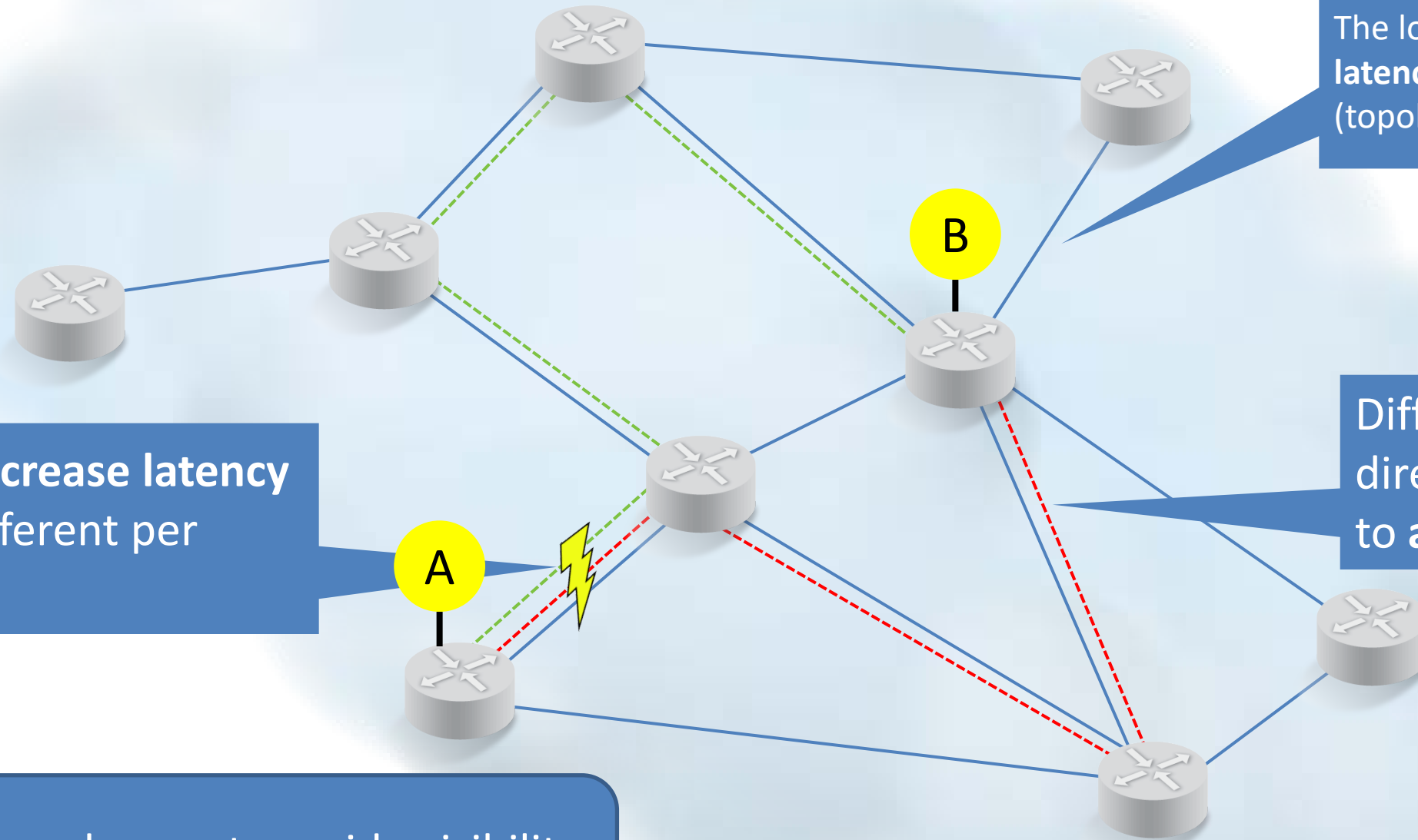


FO Network Testing strategy for Smart City





Latency is not fixed and varies over time



The longer the links the more **latency** the traffic will experience (topology or operations)

Congestion will increase latency and is typically different per direction.

Different route per direction leads to **asymmetrical latency**.

Round Trip Latency does not provide visibility in what path delay degradation occurs



Impacts of latency on QoE

Data Transfer

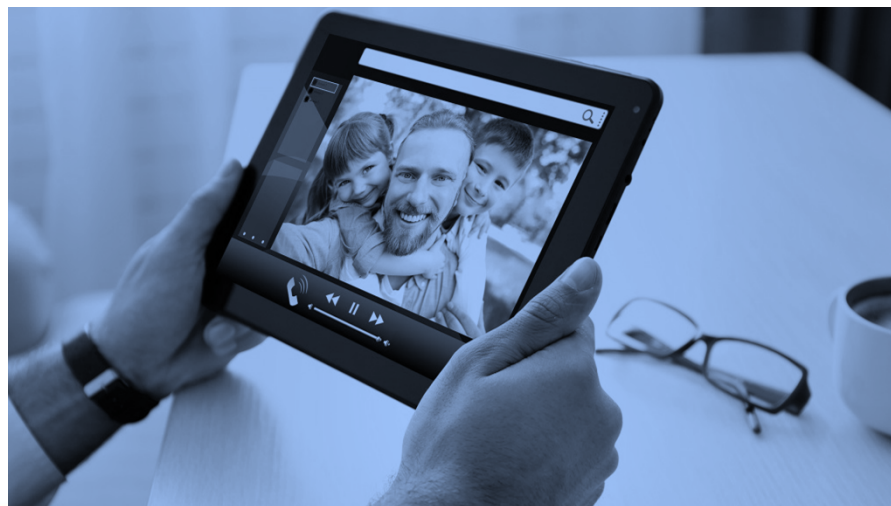
Latency impacts applications using TCP (http, ftp, email, etc...)

Real-time service (VoIP, Video)

Latency variation directly impacts QoE
VoIP services very sensitive to **one-way latency**, impacting conversational speech (OTT)

Streaming and interactive applications

Tight **latency** control important for QoE
Latency directly impacts interactivity and responsiveness of application
High latency levels mean frustrating user experience





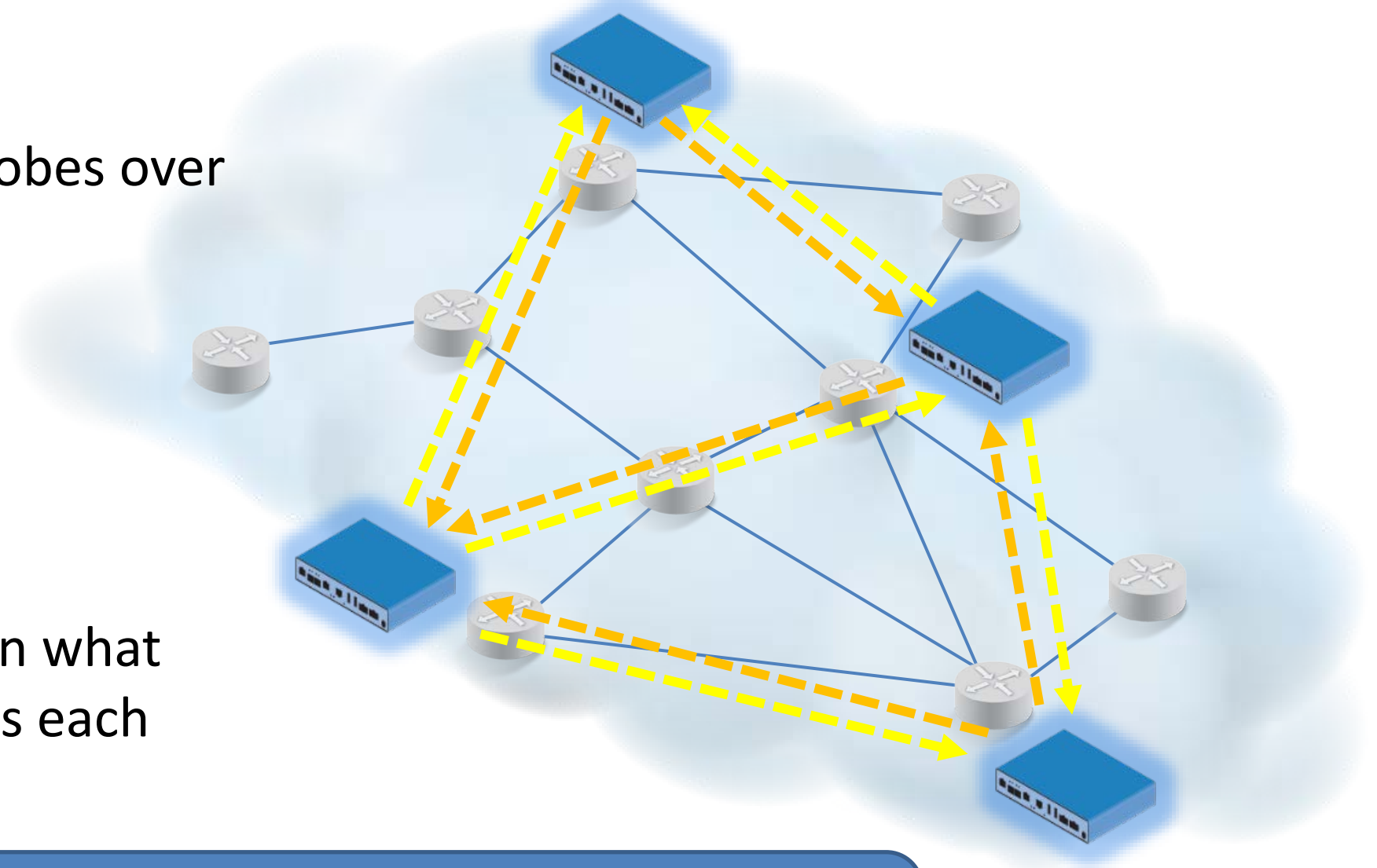
Maintaining Smart Cities QoS 24/7

Strategically deploying Smart/Virtual probes over the network allows to:

- Actively monitor and test KPIs 24/7
- Check real time QoE

Round Trip Latency is not enough:

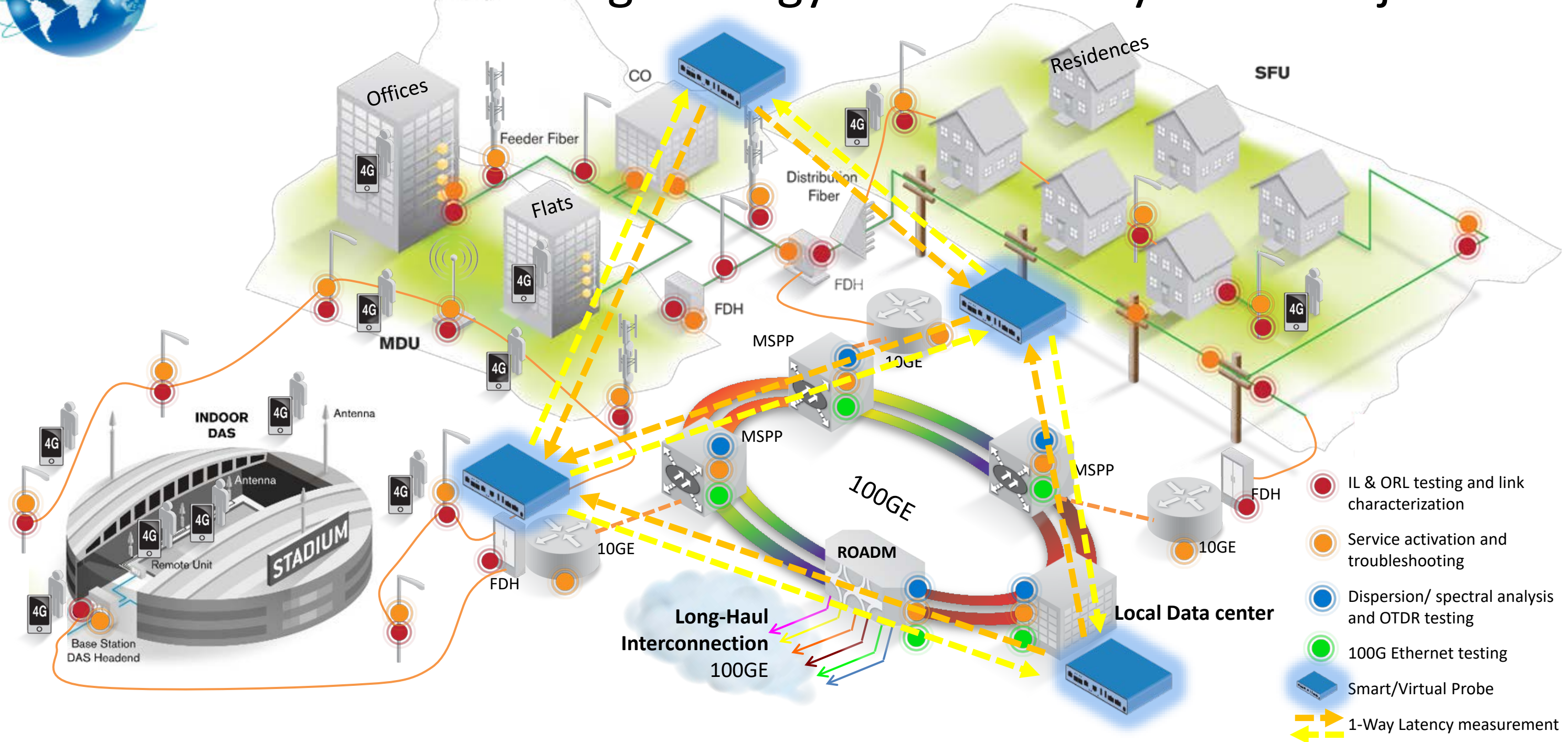
- Only **One-Way Latency** determines in what direction delay degradation occurs as each path is independently measured.



Not only monitoring the KPIs & QoS 24/7 but proactively maintaining the network before Services are impacted



FO Network Testing strategy for Smart City & IoT Projects





Conclusion & Remarks 1/2

- **Immersive Connectivity** is the heart of **Smart Cities** and implies changes in:
 - Bandwidth requirement
 - Infrastructure





Conclusion & Remarks 2/2

- Adopting an adequate **FO Testing Strategy** starting **from L1** ensures to meet the associated challenges:
 - Trouble-free FO network
 - Reliable and high QoS over time
 - Citizens satisfaction using App and IoT services
- Latency is a rising challenge and is becoming more important in the transition to 5G, IoT and NFV



Thank you for your attention, Questions?



Jean-Baptiste Letang, Application Engineer @ EXFO
BICSI Middle East Conference, Dubai, April 18-20, 2017
See you at EXFO & ALT booth #314

