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Experimental in-fiber GMPLS fault management for 1:1 OUPSR R-OADM networks

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Abstract *This paper presents a novel GMPLS-based signalling for fault management in 1:1 OUPSR rings tested in the ADRENALINE testbed that solves some lacks of Link Management Protocol for out-of-band in-fiber IP control channels*

Introduction

Fault management includes detection, localization, notification and recovery of failures. GMPLS introduces a new protocol called Link Management Protocol (LMP), which runs between adjacent nodes, responsible for establishing control channel connectivity as well as failure localization. LMP requires at least one active control channel between each pair of node [1], but for an out-of-band in-fiber signalling approach when a fiber link failure occurs it affects both control and data channels. Therefore, LMP does not work correctly in this network context. Moreover, in an 1:1 (or N:M) protection scheme [2] the destination node must notify the source node without using the failed IP control channel in case of fiber failure. To overcome these problems, we propose to use new extensions of GMPLS RSVP-TE signalling for fault localization and notification as well as a method for accelerating the recovery of the control connectivity between the pair of nodes affected. Performance evaluation has been carried out in the ADRENALINE testbed.

ADRENALINE testbed. General Overview

The ADRENALINE testbed (<http://www.cttc.es/adrenaline>) is based on an Intelligent Optical Network constituted by a 1:1 Optical Unidirectional Path-Switched Ring (OUPSR) with nine all-optical R-OADMs (Implemented through sub-divisions of two 32x32 TL1-based optical switches) and a GMPLS-based control plane. ADRENALINE's control plane is based on GMPLS RSVP-TE signaling for dynamic wavelength reservation and lightpath provisioning, and GMPLS OSPF-TE routing for network topology and optical resources dissemination. Each node is equipped with an Optical Connection Controller (OCC) implemented on a Linux-based router with a Pentium IV 2,6 GHz processor. OCCs are interconnected by fast Ethernet point-to-point links, using both emulated and optical fiber links with a distance of 35Km (control channels are carried out-of-band in-fiber on 1310nm). Finally, each OCC has also an SNMP agent for communicating with management entities and a Hardware agent for communicating with the optical node's hardware.

Enhanced GMPLS 1:1 OUPSR fault management.

Let us consider the example of Figure 1 with 5 nodes. In this example there are a working lightpath travelling from node 1 to node 3 passing through node 2, and its associated 1:1 protecting lightpath passing through node 5 and 4. Therefore, if the link between node 1 and node 2 fails, the SNMP-based monitors located at nodes 2 and 3 will report an OMS (fiber) and OCh (only a single channel) alarm to OCC2's and to OCC3's SNMP agents. Each alarm has its own process at the OCCs. The sweep of monitoring is 10ms, but the alarms are received after 30ms at the OCC's SNMP agents.

For OCh alarms, the OCC's SNMP agents send a "Fault Detection" alarm to the GMPLS RSVP-TE (step A) if and only if the channel affected by the alarm finishes in the node. This is due to that in 1:1 OUPSR network, the pairs of nodes involved in the repair procedures are the source (OCC1) and destination (OCC3). In our example, OCC3 must notify OCC1 about the failed channel so that OCC1 can start the repair procedures, but without using the failed IP control channel, since control channels are out-of-band in-fiber and therefore a fiber link failure affects both data and control channels. The IETF Notify message [3] provides a notification mechanism. It is generated if requested by the corresponding LSP, through the insertion of a Notify Request Object in the Path or Resv messages to indicate the address of a node that should be notified on an LSP failure. This message is targeted directly to the specified address, so in case of link failure the Notify message can not reach its destination. In this paper we propose an enhancement to the Notify message introducing an Explicit Route Object (ERO) that specifies a strict path to the source node (OCC1) in the opposite direction to the failed channel, that is, the same route as the protecting channel. Following the example, OCC3 would send a Notify message to OCC1 with an ERO composed by OCC4's, OCC5's and OCC1's IP addresses, and targeted to OCC4's IP address (step B). Note that this Notify message must be processed hop-by-hop, thus it differs considerably from [3], which specifies that Notify messages are not processed at intermediate nodes. After sending the

modified Notify message, OCC3's RSVP-TE agent sends the "Switch" command to the Hardware Controller, in order to configure the local R-OADM for switching the working channel over the protection channel (step C). Once OCC1's RSVP-TE agent receives the modified Notify message it configures the local R-OADM (step D), and sends an alarm to the SNMP agent reporting "Fault Recovery" (step E). Experimental tests in ADRENALINE testbed with nine nodes have shown that optical protection delay is about 100ms (Figure 2), taking into account that switching time of TL1-based R-OADM are about 70ms, therefore obtained protection delays are only used for informational purposes, but not for validating the method.

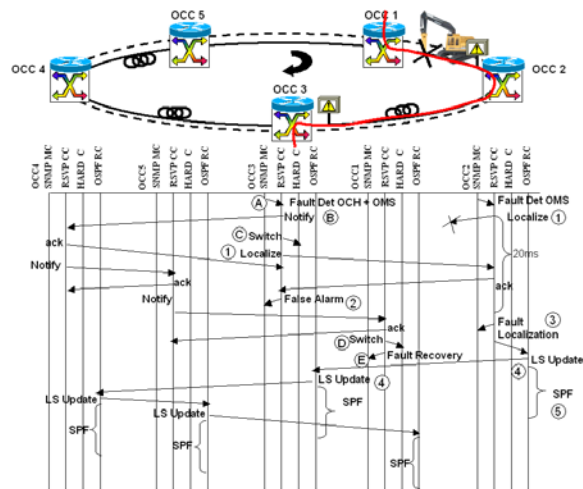


Figure 1. Proposed GMPLS fault management for OUPSR

For OMS alarm, fiber fault localization requires communication between nodes to determine where a failure has occurred. LOL propagates downstream along the connection path and therefore all downstream nodes may detect the failure. LMP protocol responsible for failure localization in GMPLS network does not work in this context due to LMP requires at least one active IP control channel for each pair of nodes [1]. To overcome this problem, we propose to use the GMPLS RSVP-TE signaling also for fault localization using a new GMPLS message named Localize which specifies the identifier of the presumed failed link. Therefore, continuing with the previous example (Figure 1), the OCC2's and OCC3's RSVP-TE agent after receiving the "Fault Detection" alarm generate a Localize message with reliable message delivery encapsulated in an IP packet whose destination is equal to the remote node address of the presumed failed link (step 1), that is, for OCC2 a Localize message to OCC1 is generated, and for OCC3, to OCC2. After that, the RSVP-TE agent wait for 20ms to receive the Localize ACK message from the remote OCC (the Localize message must be resent each 1ms). Upon reception of the ACK message, the RSVP-TE agent sends an

alarm to the SNMP agent indicating "False Alarm", in order to defuse it (step 2). Not receiving the Notify ACK message means localization of the failed link. Once the failure has been detected and localized, the OCC2's RSVP-TE agent sends a "Fault localization" alarm to the OSPF-TE agent and the SNMP agent (step 3). When the OSPF-TE agent receives the alarm, the dynamic IP layer restoration schemes start. With dynamic routing, reachable active OCCs are found dynamically by exchanging (between adjacent routers) control messages that are used to update the OCC's routing tables, thus enabling IP packets to be dynamically rerouted around link and node failures. Therefore, once the OSPF-TE agent receives the alarm reporting the fault in the network, it propagates the occurred changes to its neighboring routers using the Link State Update messages (step 4). Then, SPF recalculates the affected routes and updates its routing tables (step 5). In this experimentation, an estimation of the control restoration delay has been obtained through pings each 100ms from OCC1 to OCC3. Results shows that the control plane is out-of-service only around 5s, due to the elimination of the OSPF-TE HELLO messages used for detecting faults in the network.

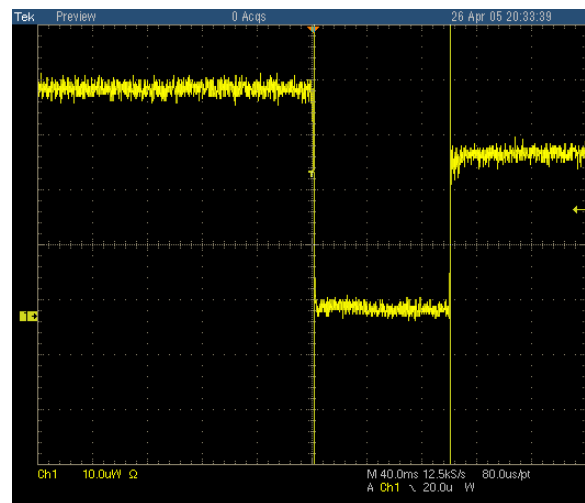


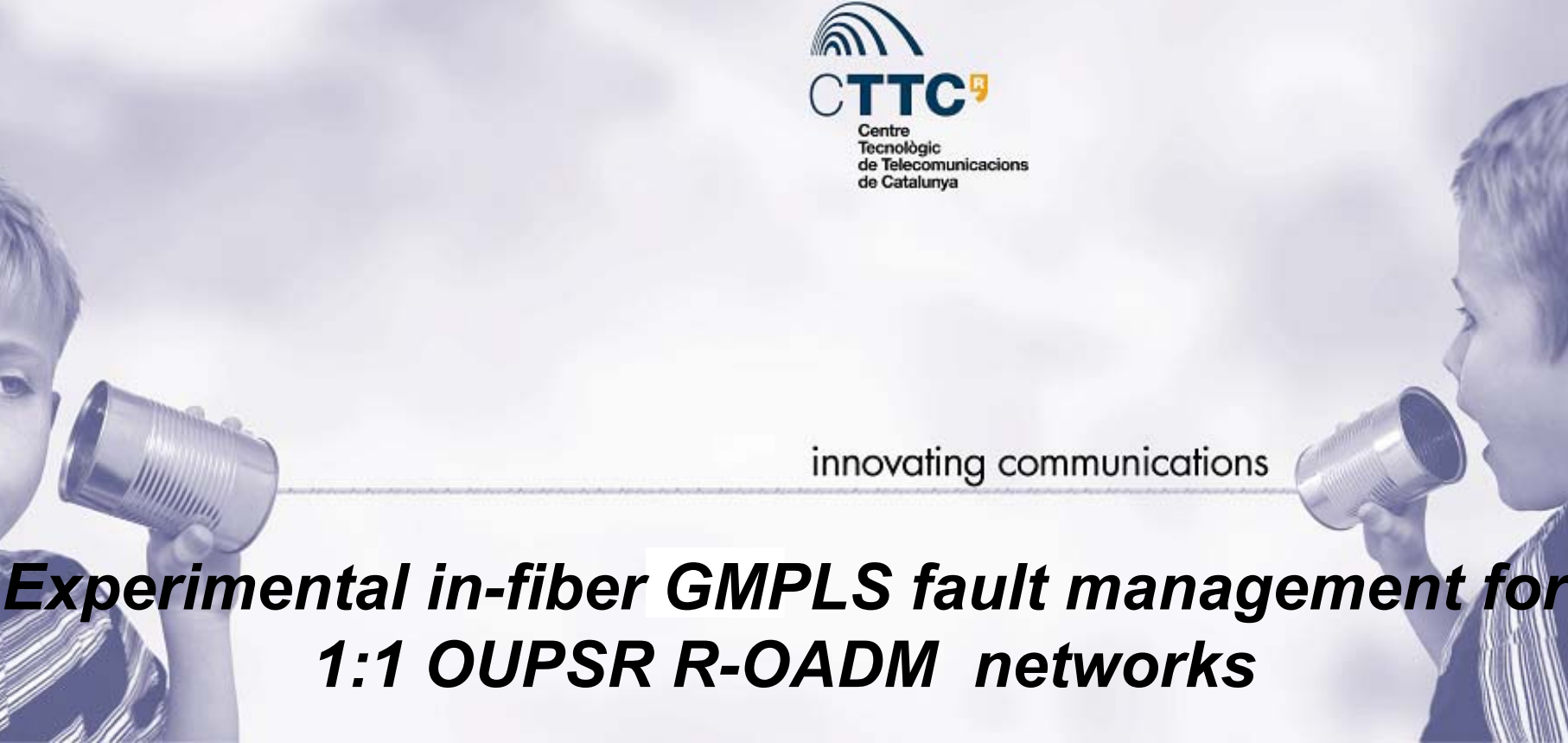
Figure 2. Optical Protection delay (Com. Signal Analyzer).

Conclusions

This paper has shown the lacks that LMP can have when out-of-band in-fiber control channels are used in GMPLS-based networks. We have proposed a novel GMPLS-based fault management architecture for OUPSR networks that has been tested in the ADRENALINE testbed.

References

- [1] J. Lang, "Link Management Protocol (LMP)", IETF draft-ietf-ccamp-imp-10 October 2003.
- [2] J. P. Lang "RSVP-TE Extensions in support of End-to-End GMPLS-based Recovery", IETF draft-ietf-ccamp-gmpls-recovery-e2e-signaling-03, April 2005
- [3] L. Berger, "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource Reservation Protocol Traffic Engineering (RSVP-TE) Extensions.



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Outline

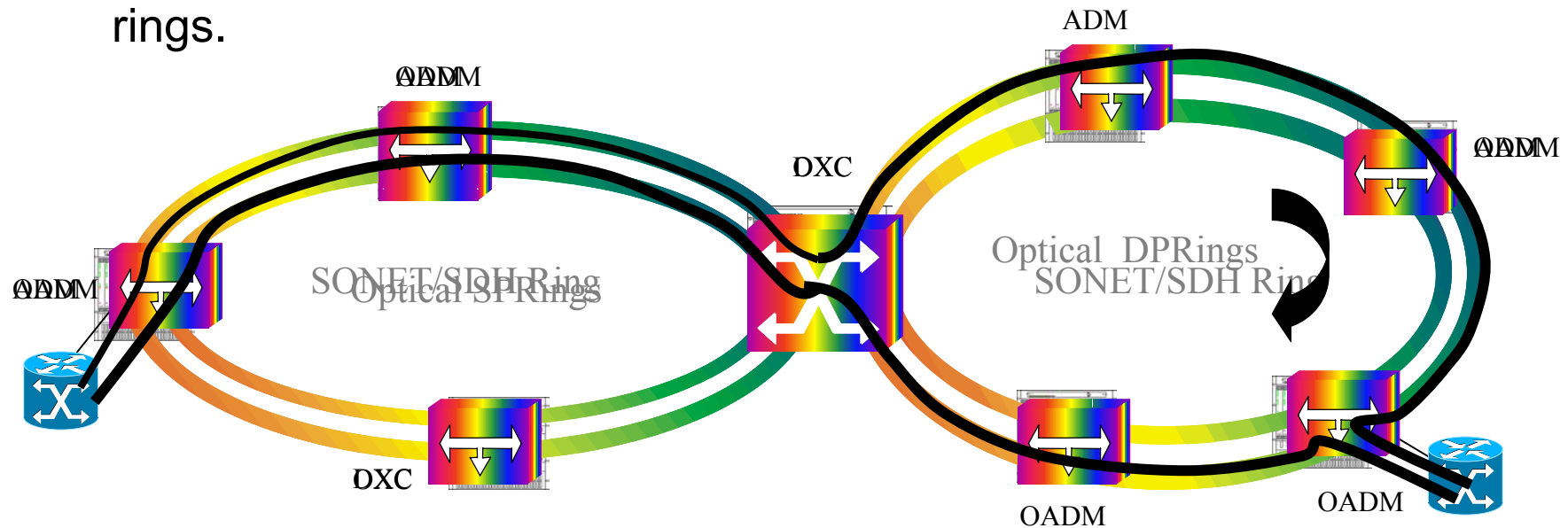
- Problem motivation
- Proposed Enhanced GMPLS fault management
ADRENALINE Testbed
- Experimental Performance evaluation
- Conclusions

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Problem Motivation

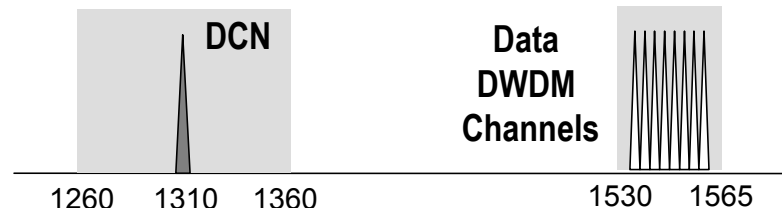
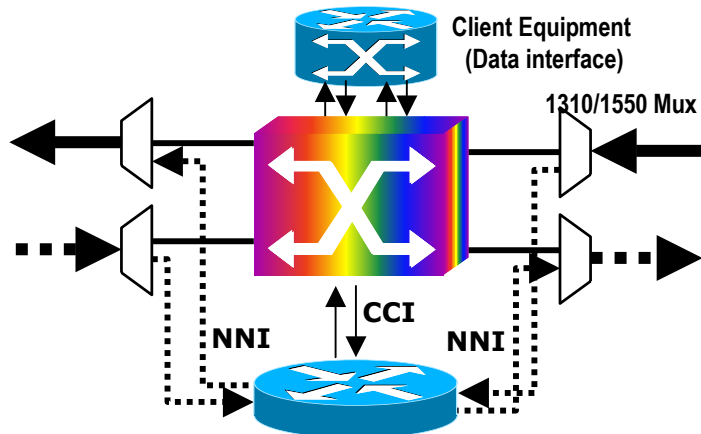
- Most of current metropolitan area networks are based upon fiber-ring architectures, as evidenced by the proliferation of SONET (SDH) rings.



- The automation (provisioning and fault recovery) of the wavelength-routed networks can be achieved by means of a distributed GMPLS-based control plane.

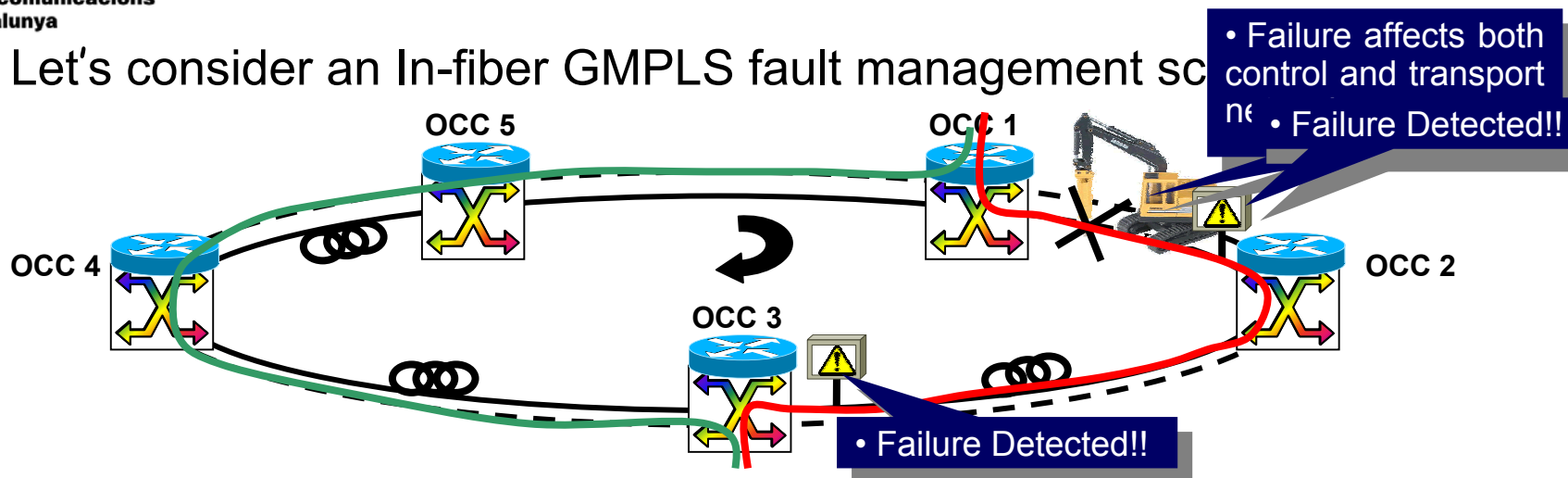
Problem Motivation

- A GMPLS-based control plane is composed by:
 - *Optical Connection Controllers (OCCs)*: Provisioning and fault recovery of optical connections (i.e. signalling and routing).
 - *Data Communication Network (DCN)*: IP-based control channels for enabling exchange of control messages between OCCs.
 - In-fiber In-band: e.g. SONET/SDH's DCC.
 - In-fiber Out-of band: e.g. *Optical Supervisory Channel (OSC)*.
 - Out-of fiber: e.g. Public Internet.



Problem Motivation

- Let's consider an In-fiber GMPLS fault management scenario



- GMPLS fault management comprises four steps

- Detection:** LOL

- Localization:** LMP. It requires at least one control channel between each pair of nodes → LMP does not work!!

- Notification:** Source node must send a Notify Message targeted directly to the destination node. OCC's routing table are outdated → the Notify message can reach the destination!!

- Recovery**

Problem Motivation

- We propose propose to use new extensions of GMPLS RSVP-TE signaling for fault localization and notification.
- Performance evaluation has been carried out in the ADRENALINE testbed.

Outline

- Problem motivation
- Proposed Enhanced GMPLS fault management
- ADRENALINE Testbed
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Proposed Enhanced GMPLS fault management

- **Failure Localization**

- We propose to use a Notify message that differs from the one specified by the IETF:
 - The Notify message provides a mechanism to inform non-adjacent nodes of LSP (lightpath) related events.
 - The Notify message is generated if requested by the corresponding LSP, through the insertion of a Notify Request Object in the Path or Resv.
 - In our approach, we use the Notify message without the Notify session list, that is, without any reference to any LSP session.
 - Once a failure is detected, the proposed Notify message with reliable message delivery encapsulated in an IP packet whose destination is equal to the remote node address of the failed link.
 - The RSVP-TE agent will wait for 10ms to receive the Notify ACK message from the remote OCC. Not receiving the ACK means the failed link has been detected.

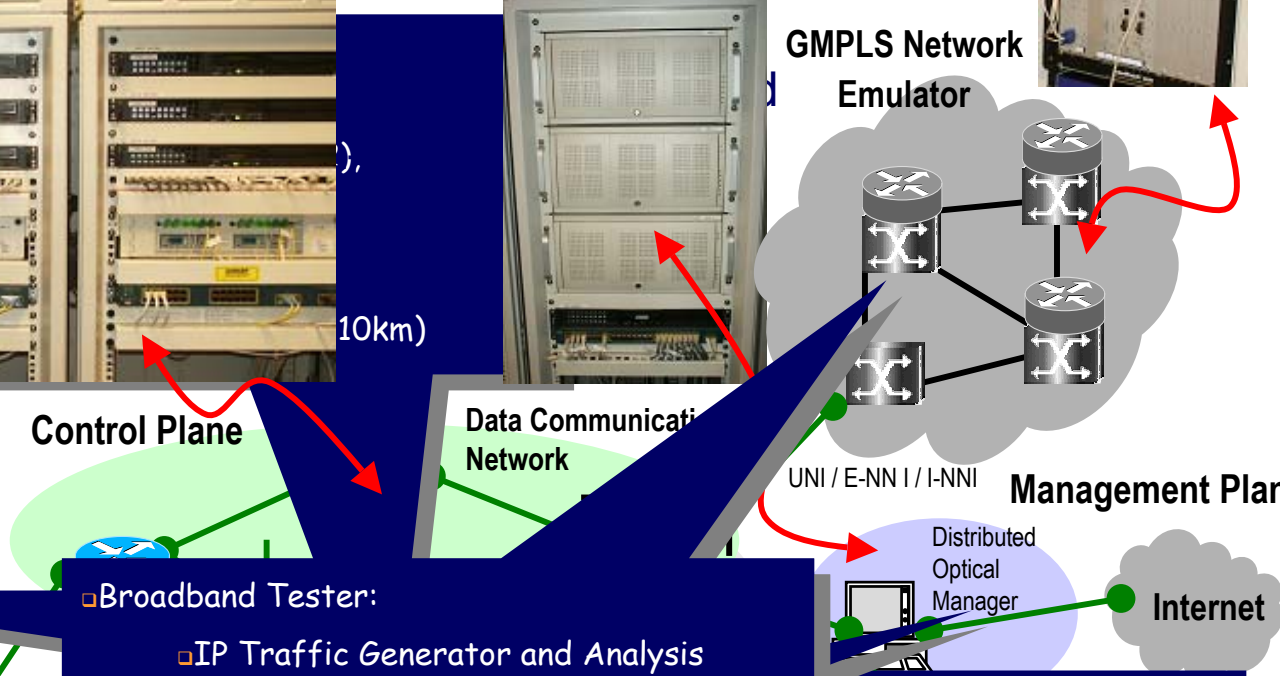
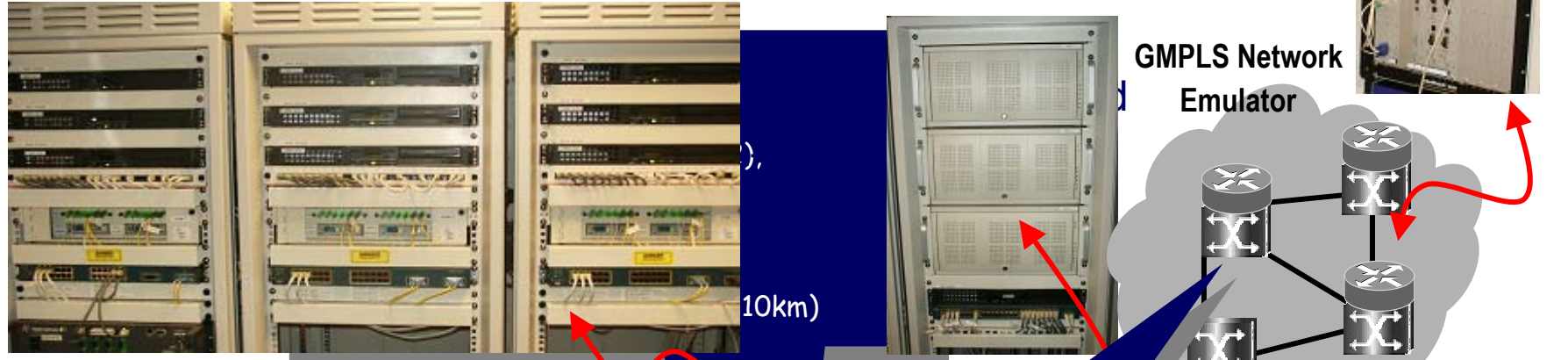
Proposed Enhanced GMPLS fault management

- Failure Notification:
 - Notify message is targeted directly to the specified address, so in case of link failure the Notify message can not reach its destination.
 - We propose an enhancement to the Notify message introducing an Explicit Route Object (ERO).
 - The ERO specifies a strict path to the node responsible for recovery in the opposite direction to the failed channel, that is, the same route as the protecting fiber/channel.
 - Note that this Notify message must be processed hop-by-hop. Thus it differs considerably from IETF, which specifies that Notify messages are not processed at intermediate nodes.

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ADRENALINE testbed



IP Traffic & GMPLS Generator/Analysis (GbE, POS)

- Broadband Tester:
 - IP Traffic Generator and Analysis
 - GMPLS emulator (UNI, E-NNI, I-NNI)

- 3 Windows-based (Distributed Optical Managers, DOM).
- Simple Network Management Protocol (SNMP) and user-friendly XML to allow users the dynamic provisioning of lightpaths.

-based control plane

-TE for lightpath

d GMPLS OSPF-TE for

resources discovery

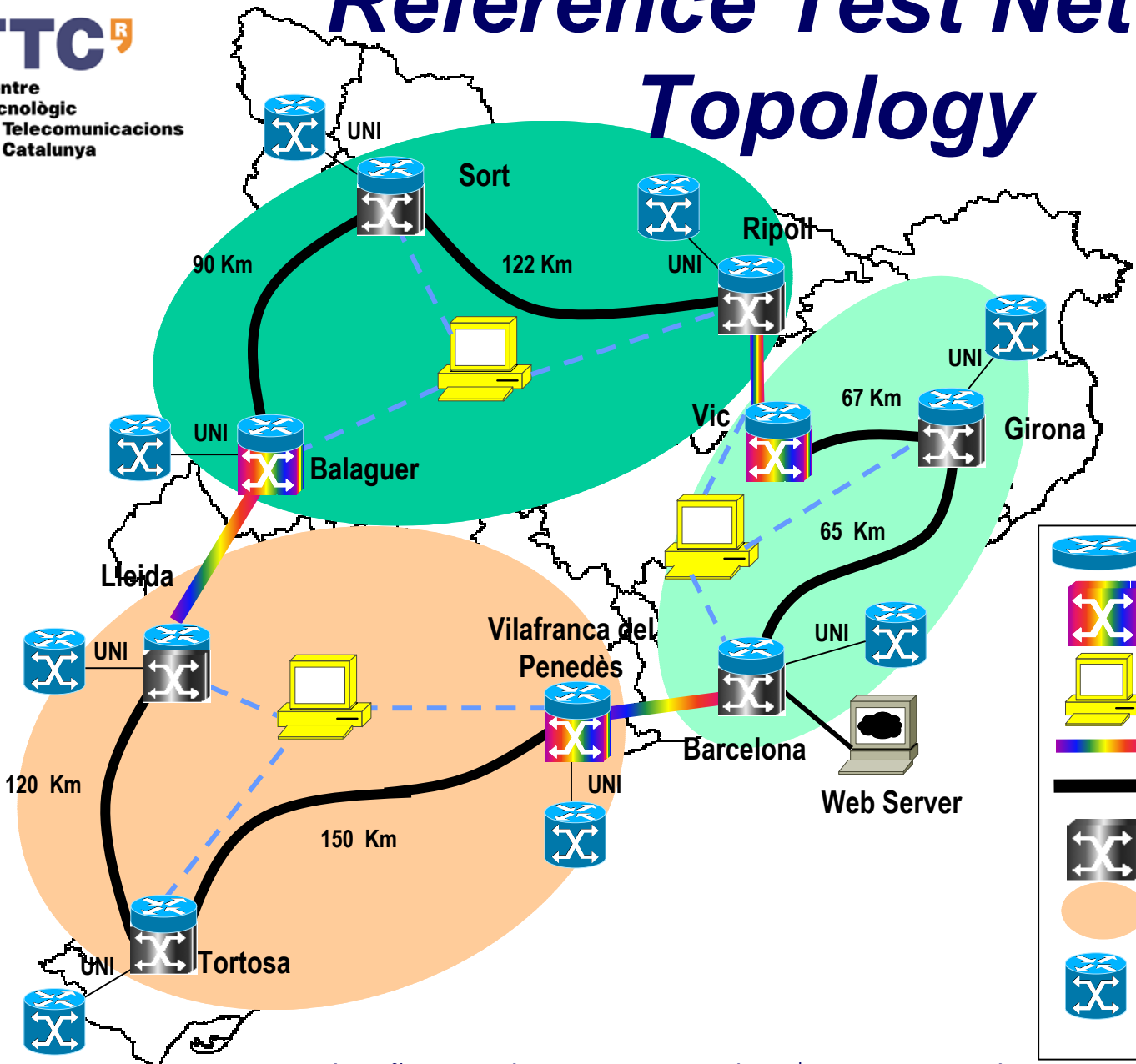
d routers (Optical

controllers., OCC).

emulator: delay delay,

ket loss, etc

Reference Test Network Topology

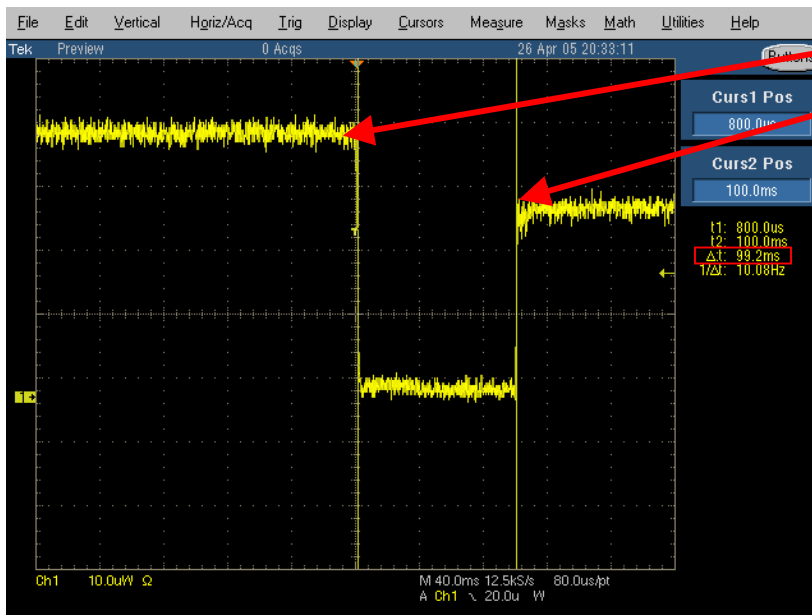
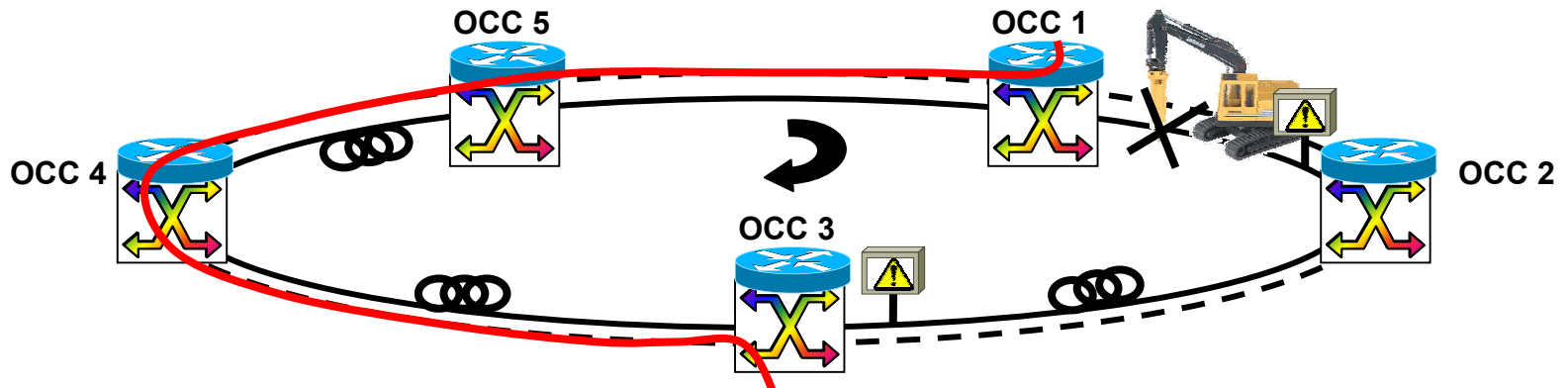


	UNI
	OADM
	Optical Manager
	Fiber pair
	Emulated link
	Emulated switch
	Area (or domain)
	IP Client Equipment

Outline

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Optical Protection Delay




Lost of Light
Optical signal recovery
↓
Optical Protection delay
~ 100 ms

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Conclusions

- LMP requires at least one active control channel between each pair of node, but for an out-of-band in-fiber signalling approach when a fiber link failure occurs it affects both control and data channels.
- In ADRENALINE, the signaling is in-band, thus when a fiber link occurs it affects both control and data channels. Therefore, LMP does not work correctly in this network context.
- Regarding the Notification, the nodes responsible for fault recovery must be notified without using the failed IP control channel in case of fiber failure.
- We have proposed to use new extensions of GMPLS RSVP-TE signalling for fault localization and notification as well as a method for accelerating the recovery of the control connectivity between the pair of nodes affected.
- Performance evaluation, in terms of recovery time, has been carried out in the ADRENALINE testbed.



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THANK YOU

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