

Field Trial of Photonic Switches for Efficient Fiber Network Operation and Maintenance

Tiejun J. Xia, Michael F. Lane, Timothy E. Lawter and Glenn A. Wellbrock

*2400 N. Glenville Drive, Richardson, Texas 75082
Tj.Xia@Verizon.com*

Richard Jensen, Mike Bitting and Aaron Bent

Polatis Inc., 5 Fortune Dr, Billerica, Massachusetts 01821

Kevin Karch, Jonathan Lacey and David Altstaetter

Calient Networks, Inc., 6620 Via Del Oro, San Jose, California 95119

Abstract: Results of Verizon field trial using MEMS and Beam-steering photonic switching technologies in network operation and maintenance functions. Results show that network operational expenses and downtime can be significantly reduced using photonic switches.

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Introduction

As networks grow by adding more and more optic bandwidth, the number of optical fiber connections is growing at an alarming rate. Highly skilled technicians are required to properly handle today's ever growing number of fiber optic connectors. Reducing operational expenses associated with installing, provisioning and maintaining the embedded fiber plant and especially optical connections is becoming more and more important in today's competitive carrier landscape. Numerous applications for optical switching are emerging to help reduce operation costs associated with optical networks since they can make fiber connections remotely and automatically. Such a fiber optic cross-connection system (FOCS) offers the potential to reduce human error, shorten the provisioning intervals and improve test via quick access to an array of test devices. In this paper we describe field trails in Verizon's long haul network around Orlando, FL using two popular optical switching technologies to verify remote testing concepts in a real network. The results show that downtime and operational expenses can be significantly reduced using photonic switches.

Steady and consistent advances in optical switching technology over the last few years have dramatically reduced optical losses, improved switching speeds and significantly lowered costs. In this field trial we tested two mature and proven optical switching technologies: MEMS and Beam Steering. The technologies offer fast switching (<20ms), low loss (1-2dB) and can scale up to larger sizes today with the potential to grow even larger in the future. Low loss is especially important to minimize impact on transmission impairment budgets. MEMS based optical switches make connections using small movable mirrors to steer the optical beams between fixed input and output collimators. Beam Steering switches make connections using small peizo-electric elements to move input and output collimators so that they point at each other. For the tests we used two Polatis DirectLight OST Matrix Switches and a Calient DiamondWave@FiberConnect FOCS.

Field Trial Focus

There are numerous promising aspects of optical switching that can be tested in the network. In this trial we have focused on the applications related to how the photonic switching can help the field operations team in its daily tasks. Normally each team manages a host of sites. Whenever there is an incident in the network, or trouble ticket, technicians often have to travel to the various sites and coordinate their efforts to sort out and resolve problems. Even routine testing and characterization of spare fibers prior to provisioning often requires truck rolls. One important goal of this field trial was to show that using photonic switching in the network can reduce operational expenses by reducing the number of truck rolls and the time for technicians to perform routine tasks.

Photonic switches can be used to automate remote site measurements so that they can be controlled from a central location. This can reduce both the number of truck rolls and the time to perform each test. The test equipment could be embedded directly in the remote site or the test signals can be switched over spare fibers to the remote site. Either way the test equipment is shared among many lines to reduce and spread out the up-front costs.

Verifying optical performance during installation and provisioning sometimes requires breaking optical connections which is time consuming and problematic on many levels. Also, fault location and other maintenance operations often require technicians to travel to remote locations, identify fibers, break connections and manually connect test equipment. All of this extra effort translates into higher operational expenses. Photonic switches can reduce these costs by minimizing the need to break connections and automatically keeping an accurate database on the embedded fiber plant. Once a fiber, terminal equipment or test equipment connection to the optical switch has been verified during installation, virtually all of the activities that once required breaking these connections can be done by the optical switch.

These are the tests we performed in this field trial to look for ways to help routine field operations:

1. Remote Optical Fiber Testing
2. Routing Test Signals to Remote Sites Over Spare Fiber
3. Equipment Fault Identification Using Optical Loopbacks
4. Remotely Locating Hot Fiber Cuts
5. Switching Traffic and Test Equipment Between Working and Spare Fibers

Field Trial Details

A cluster of four Verizon Business sites in Orland, Florida were chosen for the trial. The site designations are: TES, BCB0, AWM and AWR. Fig. 1 shows the physical interconnection of the sites and the fiber lengths. The distances between the sites are 2 km (AWR – AWM), 12 km (AWM – TES), and 1 km (TES – BCB0), respectively.

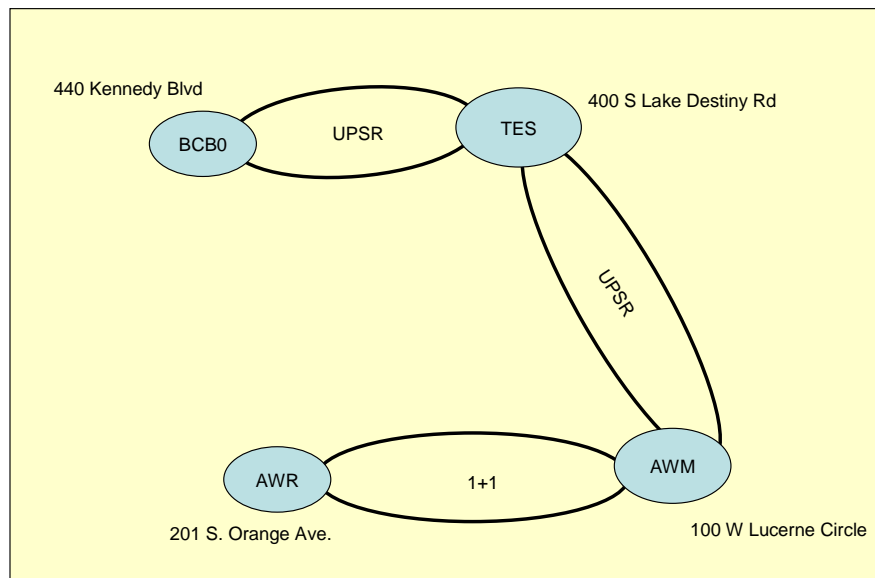


Fig.1 Verizon Business sites involved in the trial

TES was used as a base of operations for the field tests. There are both working fibers and spare fibers connected between sites. The photonic switches were connected to both working spare fibers in the tests. The following optical test equipments were used in the trial: EXFO's OTDR (Optical Time Domain Reflectometer), Model FTC-400; SONET test set, Model TTC T-BERD 310; optical power source (EXFO 53A) and power meter (EXFO 66A); and FiberMatch (Radiodetection). Nortel Optera 3500 and Fujitsu FLM 2400 were used to test line side response. Fig. 2 shows the two SONET terminals used in the trial. Spare fibers between sites TES, BCB0, AWM, and AWR were used for trials to carry test and SONET signals.

Remote Optical Fiber Testing

Ordinarily a truck roll is needed to test spare fibers at a remote site. Once at the site the fibers need to be identified and manually connected one-by-one to the test equipment. After the testing is completed the data has to be manually stored in a paper or electronic database. All of this can be very time consuming.



Fig. 2 (a) Nortel Optera 3500 and (b) Fujitsu FLM 2400 SONET systems

This test demonstrates that both the photonic switch and an OTDR test set can be controlled from a remote location to characterize spare fibers in real time. The test setup is shown in Fig. 3. First Calient’s FOCS was installed in the TES location. An EXFO OTDR was connected to an input port of the optical switch and the switch output ports were connected to spare outside plant fibers. A technician in the AWM site used the overhead data channel network (DCN) remotely control the switch and the OTDR. In our test a technician was able to characterize the spare fibers at the remote site and view the results locally within seconds. The same test was done using Polatis’ Directlight photonic switch in the AWM site and the technician in the TES site with identical results. Both tests showed that significant amount of time and truck rolls can be saved with an optical switch.

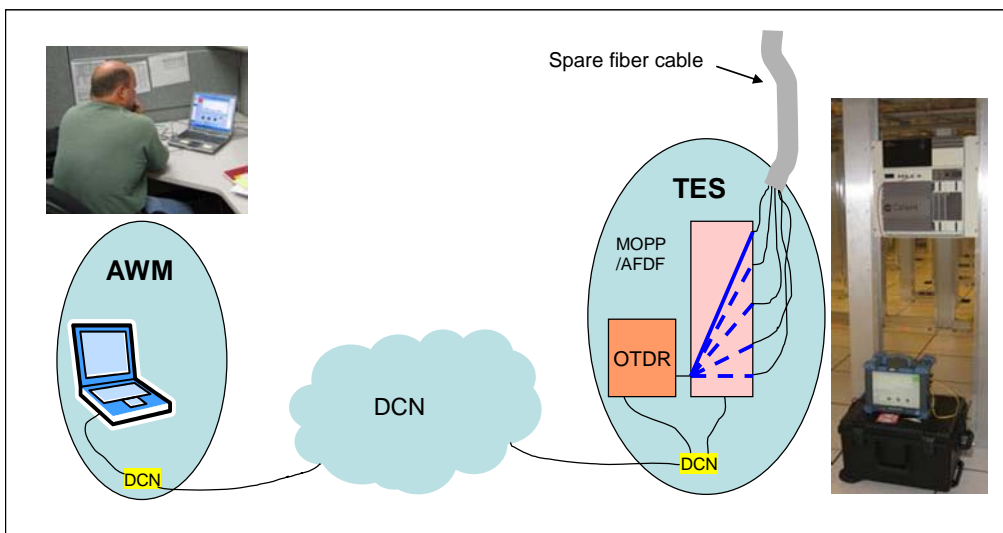


Fig. 3 Set-up for remote switch control and measurement showing savings of time and truck rolls.

Routing Test Signals to Remote Sites over Spare Fiber

This test is to show that a photonic switch can help to deliver optical testing signals to remote network elements (NE) through spare fibers between the two sites. In this test a SONET tester (TTC T-BERD 310) is located in TES. An OC12 testing signal is fed into the Calient switch. The output ports of the Calient switch were connected to a pair of spare fibers between TES and BCB0. Fig. 4 shows the set-up of this test. In BCB0 the pair of spare fibers is connected to the Polatis switch. The output ports of Polatis switch are connected to the OC12 tributary ports of an OC48 transport system (Fujitsu FLM 2400). The OC48 circuit is set up between BCB0 and TES. At TES the OC12 signal is looped back through an attenuator. The results show that the photonic switch can be used to remotely characterize the fibers eliminating the need to carry all the test equipment to remote sites and significantly reducing the test time by automatically connecting the fibers to the test equipment.

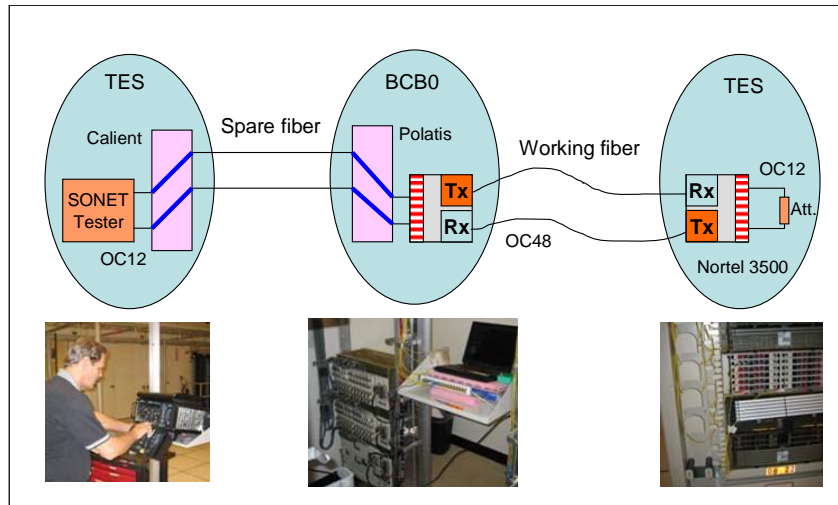


Fig. 4 Set-up for test of feeding optical testing signal to remote sites

Equipment Fault Identification Using Optical Loopbacks

In this test we used an optical loopback at the remote site to identify malfunctioning terminal cards. To perform the test the photonic switch works together with network performance management layer that monitors SONET line performance (which can also be monitored from a central location). The set-up is shown in Fig. 5. An OC48 circuit is turned up between AWR and AWM. In the test it is assumed that a circuit card is down and we cannot tell which transmitter/receiver card is malfunctioning. Normally in this situation both the card in AWR and card in AWM would need to be tested to determine which one is broken. With a photonic switch, our tests demonstrated that a technician in the central location can setup an optical loopbacks to test each card in seconds. Identifying the exact the location of the faulty equipment before sending out a repair crew saves time and reduces disruption to the working network elements.

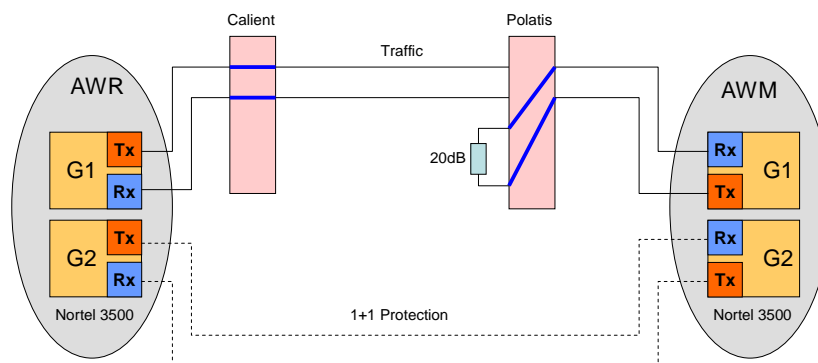


Fig. 5 Set-up for loop-back test

Remotely Locating Hot Fiber Cuts

In the field hot fiber cuts, in which a fiber cable with life traffic has to be re-spliced due to many reasons, for example, local construction, are identified using an Instrument called FiberMatch. Typically the output ports of FiberMatch are connected to the fibers in one site and a technician in remote sites use a handheld device called Fiber Identifier to verify the connectivity of the fibers in each tube of the cable. Each port of FiberMatch has a unique modulated tone carried on the optical signal allowing the Fiber Identifier to uniquely identify the fiber port

connections. This test is very time consuming and error prone due to the need to pull the working patches to connect the FiberMatch to the cable under maintenance.

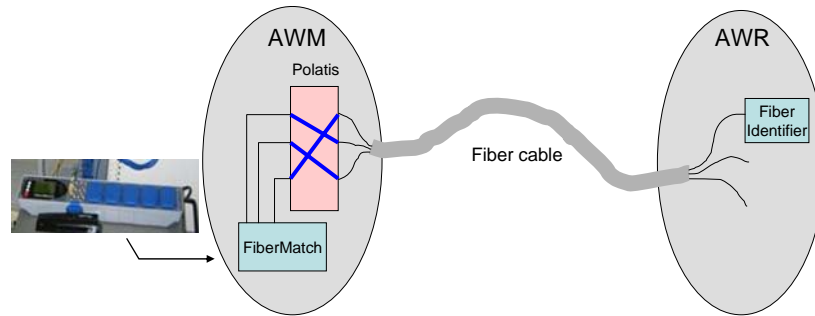


Fig. 6 Set-up for Fiber Identifying test

In this test we use a 36-port FiberMatch connected to a fiber cable spanning AWM and AWR through Polaris optical switch located in AWM as shown in Fig. 6. The Fiber Identifier is in AWR. As the ports of FiberMatch are connected to different fibers in the cable the technician in AWR was able to determine the fibers correctly with the fiber identifier. We envision in near future that the combination of a photonic switch and FiberMatch will make the connection between FiberMatch and outside plant cable faster and more accurate.

Switching Traffic and Test Equipment between Working and Spare Fibers

These tests are designed to show the flexibility of optical switching in the metro SONET environment. Fig. 7 shows the set-up for the test. The Calient switch is installed in TES and the Polaris switch is installed in BCB0. A Fujitsu FLM 2400 is set up as a UPSR circuit. An open fiber between the two nodes is used as the spare fiber. During the test an OC48 test traffic signal will be switched from the working fiber to the spare fiber between TES and BCB0.

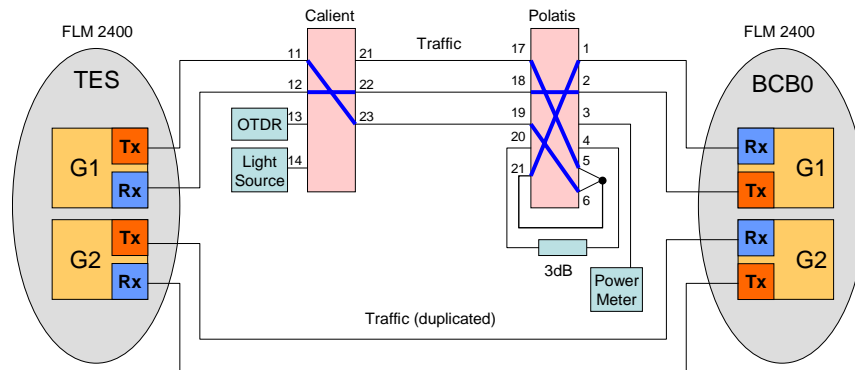


Fig. 7 Set-up for Switching Traffic and Test Equipment Between Working and Spare Fibers

The 3dB coupler is used so that the two switches can be switched in series for the test. The Polaris switch switches first to connect both the spare and traffic fiber to the G1 receiver. The 3dB attenuator is used to avoid a sudden optical power drop when the signal is switched from the configuration without to with the 3dB coupler. To make sure everything is in good working order the OTDR, Light Source and Power Meter are used to verify the optical loss and the switch and fiber connections prior to applying the traffic signals. After the spare fiber is verified the Polaris switch at BCB0 switches first then the Calient switch at TES switches the traffic to the spare fiber. Finally the Polaris switch changes configuration again to complete the switch-over process. The results show that Photonic switch provides a convenient way to remotely connect test equipment (OTDR, optical source, power meter, etc) to the fiber. These tests show that optical switching can save time and reduce human errors. They also show the viability of remotely controlled fiber switchover.

A Real Fiber Fault Case Study

A case study of a real network circuit failure illustrates how photonic switches save circuit restoration time and repair man-hours. In this case study both traffic and spare fibers between two remote stations were damaged by a lighting strike. Before the fault the two stations were connected via 8 traffic fibers and 4 vacant spare fibers as shown in Fig. 8. The lighting strike damaged to one of the traffic lines carrying two OC48 circuits (line 11) and two of the spare fibers (lines 7 and 8). Two technicians were dispatched, one to each station, to check the fiber and to restore the traffic. Upon finding fiber fault on the traffic line 11, they tried use both spare lines 7 and 8 to restore the traffic and found both of them to be damaged, too. They finally chose spare fiber 5 and restore the two OC48 circuits. The total time of the circuit restoration was about 4 hours and involved about 8 man-hours. With remotely controlled photonic switches in both stations it was determined that the circuit restoration could have been done in under 0.5 hours involving only one technician.

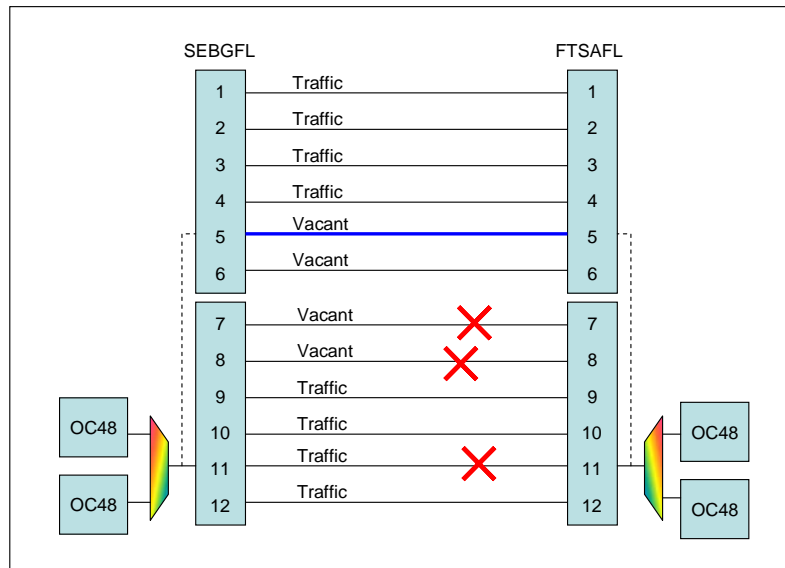


Fig. 8 A real fiber fault case

Conclusion

The trial results match the expectations for optical switching in the real network. The field trial showed that photonic switches can be used to automate remote testing to improve field operation and maintenance. Photonic switches are able to reduce operational expenditures by reducing number of truck rolls, reducing time to prepare and perform tests, reducing human errors, helping to maintain real time accurate fiber connection databases, and shortening circuit downtime.

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