Assessing the Need:

The Business Impact of a Fiber Management System

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Introduction

The need for efficient, secure network infrastructure has never been greater than in today's difficult economic environment. Network operators, service providers and enterprise organizations need to protect their revenue streams and network integrity on a 24 hour basis. This is a difficult task given increased competition, the number of evolving technologies and the ever expanding

customer expectations placed on an organization. As information becomes the world's most valuable resource, the integrity of the infrastructure becomes paramount. To survive in today's

competitive marketplace, each operator must operate an efficient, yet reliable network that provides leading edge services with

minimal downtime. With the growing competitiveness, carriers and service providers have begun to invest strategically in their infrastructure with a significant focus on automated management, maintenance and monitoring solutions for their networks. Traditionally, automated management was considered a means to achieve greater internal efficiencies. Today, network management is seen as a vital business strategy necessary to achieve rapid deployment of new high quality services to grow in the face of intense competition. Herein, we discuss some of the benefits of deploying a fiber management system.

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Network Management

The primary challenges facing carriers today are:

- Dealing with fiber quality issues from installations which were completed too rapidly several years ago
- Higher fiber count cable resulting in documentation problems
- Higher bandwidth communications equipment delivering more revenue per cable
- More competition forcing a greater focus on QoS
- Increased reliance on leased physical plant resulting in a dependence on others to solve problems
- Increased reliance on contracted OSP maintenance crews resulting in less control and assurance of network quality
- A greater diversity of services and applications running on networks originally designed for a single type of service

1.0 Network Management

Historically, optical fiber was restricted to backbone or trunk networks. However, in the last few years, fiber has been deployed deeper and deeper into the network including local access and "to the curb" applications. The challenges of maintaining such a complex network continues to increase at a rate that make traditional maintenance and repair strategies inefficient and thus costly for many carriers and service providers. Carriers and service providers need to become more efficient in managing their networks. The primary challenges facing carriers today are:

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- **Higher fiber count cable resulting in documentation problems**
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- **Increased reliance on leased physical plant resulting in a dependence on others to solve problems**
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2.0 Fiber Management Benefits

In a typical Remote Fiber Test System (RFTS) application, there are many operational features that enhance both day-to-day and long term network reliability, with two features being key: Fault detection-isolation and early detection of physical plant degradation. In this section, we discuss how these two features may lead to decreased network downtime and increased operational efficiency.

2.1 Fault Detection and Isolation

Fault detection and isolation represents one of the strongest features of the RFTS. In the event of a cable break, the monitoring system is able to detect the physical problem (the fault), diagnose the problem, and then correlate this information with the Geographical Information System (GIS) documentation system to isolate the fault in less than a minute. This information is then broadcast to a number of systems with which the RFTS integrates (alarm manager, trouble ticketing system, direct dispatch through pager or SMS, etc…) In many cases this time may be further reduced through integration with transmission management or other alarm management systems. The net result is immediate dispatch of restoration personnel to the fault location. Users of Fiber Monitoring Systems often realize a 4-6 hour decrease in repair time.

2.2 Early Detection

Proactive maintenance and care of network infrastructure are two of the best ways to provide peak network performance. With networks becoming larger and more complex, network operators are faced with the daunting task of maintaining the network with fewer resources. As designed, the RFTS provides a time stamped characterization of the network segments. In particular, the OTDR trace provides a measure of attenuation, reflectance and discontinuities along the entire length of the cable for the fibers under surveillance. This data, from day one of system deployment, provides a benchmark from which to continually assess network quality.

Through generation of appropriate system reports, operators can identify and track potential hot spots. This allows for improved work crew prioritization. In situations where work crews are contracted, the reports may be transferred to the maintenance company as well. The RFTS reports therefore compliment standard OSP inspection techniques. In the case of buried cable, the RFTS may provide the only indication of cable quality. In general, the overall effect of early detection through RFTS will be reduced operating costs through proactive network maintenance.

2.3 Other Benefits

- RFTS can be used as a Sales and Marketing tool, where the RFTS owner uses the system to convince their customers that their network is the most reliable available
- RFTS can be used as a construction tool, where not yet commissioned cables are being monitored from time of deployment until initiation of traffic
- RFTS can be used as a documentation tool, that holds the outside plant (and inside plant) network topology and geographic information
- RFTS can be used as an archive of all test data for the optical cables
- RFTS allows operators to integrate the optical layer into their Operational Support System (OSS)

3.0 Workflow Impact

In the event of a catastrophic fault, the RFTS reduces the time for fault diagnosis and restoration response through a series of automated functions built into the system. In this section, we present a basic cable fault situation comparing workflow with and without RFTS. The following examples are generic. Specific procedures will vary from operator to operator.

3.1 Workflow Without RFTS

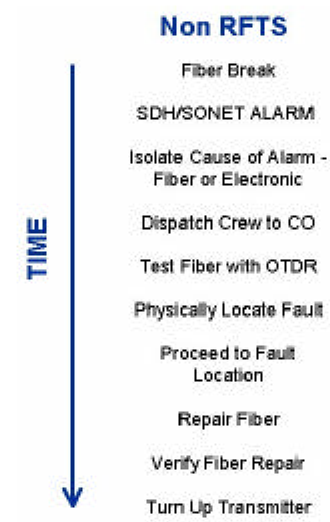
In the event of a cable break, a series of events take place that leads to final fault resolution. In the accompanying figure, we summarize a series of events typical to many operators today.

The key element for fault resolution lies with problem identification. In the event of a fiber break, there will be transmission alarms along with other equipment alarms. The first step upon receipt of these alarms is to diagnose the cause.

After determining that a fiber break has occurred, a technician with an OTDR must be dispatched to the closest access point with visibility to the fault in order to determine the optical distance to the fault.

Next, the optical distance must be correlated to a physical location.

Upon finding the fault location, appropriate action must be taken to remedy the fault and restore service as quickly as possible.



Typical workflow in the event of a catastrophic network fault

3.2 Workflow With RFTS

In the event of a cable break, a series of events take place that leads to final fault resolution. In the accompanying figure, we summarize a series of events that occur when an RFTS is utilized to automate fault diagnosis and isolation.

The key element for fault resolution lies with problem identification. In the event of a fiber break, there will be transmission alarms along with the RFTS alarm.

The RFTS will automatically diagnose and locate the fault location within a minute. This eliminates the time needed to investigate the cause and determine a search area.

Customer feedback indicates that this saves 4-6 hours per fault.

Upon finding the fault location, appropriate action is taken to remedy the fault and restore service as quickly as possible.

Typical workflow in the event of a catastrophic network fault with an RFTS

4.0 Cost Reduction and Revenue Generation

Considering the cost of a cable break, it is possible to calculate the annual cost reduction users of RFTS obtain under certain assumptions. For an operator, the cost of a cable break consists of the following contributing factors:

1. Loss of revenue during the time of the network outage
2. Penalty due to service contracts with special customers. The operator may have a contract with an affected customer that dictates a certain penalty if the annual network down time exceeds a certain time
3. Government penalties in case of network outage. In some countries, operators are penalized by their government depending upon duration of outages
4. Loss of reputation!

For carriers[1] the situation is similar. In this case, factor number 2 and 4 are dominating.

Carrier's carriers may lease fibers or bandwidth to operators while guaranteeing a certain Quality of Service typically expressed as network uptime. In most cases, the guaranteed levels of QoS can only be achieved with use of an RFTS. The RFTS will provide an early warning, preventing the cable break altogether or when the cable break occurs it will pinpoint the location of the cable break within minutes making the outage shorter. In some cases, fibers are leased with monitoring included, and this is provided at a premium. In this manner the RFTS can be used to generate revenue.

4.1 Cost Reduction

The cost of an RFTS installation can be compared with that of the alternative - portable OTDR equipment - by assuming that the cost per site is about 2 times that of an OTDR, that the number of RFTS sites is about the same as the number of portable OTDRs needed to maintain the network, and that the RFTS equipment will be replaced at a rate less than half as frequent as the portable OTDR equipment.

Applying the above assumptions results in an annual RFTS cost similar to that of using portable OTDR equipment. Using a conservative approach, we consider the annual equipment cost of an RFTS installation as twice that of using portable OTDR equipment.

As an example, 1,200 kilometers of fiber optic cable may be monitored with an RFTS consisting of 4 sites. If each site monitors a total of four inactive fibers, the cost per site is approximately $30,000 including cost of computers and software, for a total of $120,000. The same network can be maintained using a total of 4 portable OTDRs. With an approximate OTDR list price of $15,000 for comparison, the cost of the OTDR equipment becomes $60,000.

[1] Companies leasing bandwidth or fibers to operators

The cost of a cable break can be approximated using the following worksheet:

Test Equipment Purchase Cost			
Portable OTDR Equipment		**Remote Fiber Test System**	
Cost of Equipment	$200,000	Cost of Equipment	$400,000
Annual Service Level Agreement Cost	6%	Annual Service Level Agreement Cost	7.5%
Ammoritized Cost Period	3.0 years	Ammoritized Cost Period	3.0 years
Mean Annual Cost of Ownership	**$74,667**	**Mean Annual Cost of Ownership**	**$153,333**
	Annual Cost Difference	**$78,667**	
Fiber Cut Data			
Number of Cuts per Year			2
Portable Equipment		**Remote Fiber Test System**	
Time to Locate Fault	2.00 Hours	Time to Locate Fault	0.10 Hours
Dispatch Time for Crew to Fault	0.70 Hours	Dispatch Time for Crew to Fault	0.70 Hours
Mean Time to Repair at Fault Site	4.50 Hours	Mean Time to Repair at Fault Site	4.50 Hours
Mean Time to Turn Up System	0.20 Hours	Mean Time to Turn Up System	0.20 Hours
Average Total Outage Time	**7.40 Hours**	**Average Total Outage Time**	**5.50 Hours**
	Time Savings With RFTS	**3.80 Hours**	
Revenue Impact			
Average Revenue per Cable per Hour			$100,000
Portable Equipment		**Remote Fiber Test System**	
Revenue Lost Due to Cut	**$740,000.00**	**Revenue Lost Due to Cut**	**$550,000.00**
	Revenue Savings With RFTS	**$190,000**	
QoS Penalty Impact			
Regulatory Penalties	0.00 Hours	Hourly Charges	$0
QoS Downtime Limit	4.00 Hours	Hourly Penalty	$50,000
Portable Equipment		**Remote Fiber Test System**	
QoS Revenue Lost	**$170,000.00**	**QoS Revenue Lost**	**$75,000.00**
	QoS Revenue Impact Savings with RFTS	**$95,000**	
Summary			
Net Annual Outage Decrease			3.80 Hours
Net Annual RFTS Cost			$78,667
Net Annual Revenue Protection with RFTS			$380,000
Net Annual QoS Revenue Protection with RFTS			$190,000
Total Annual Revenue Protection with RFTS			**$491,333**

Appendix: The Catastrophic Event

12:00 AM

Service failure is a network operator's worst nightmare; and scariest of all is that it is completely unpredictable. A typical nightmare scenario begins at the Network Operations Center where scrambling technicians rush to a computer terminal, only to discover a catastrophic network failure. The millisecond response time of the transmission system prevents thousands of calls from being interrupted but now the vulnerable re-route path is the only physical link from point A to point B. A second failure on this link could lead to complete loss of service for a whole section of the network.

12:05 AM

The network technicians begin to troubleshoot the fault by sifting through the logged alarm data. After a careful search a transmission alarm logged for a link in the network is identified as a sign of the failure. Now the technicians have this link as a target for the restoration process. From the NOC they attempt to re-establish communications only to realize that the fault is physical in nature, this means a person has to inspect the site to determine the cause of failure.

12:30 AM

The technicians have been in constant contact with supervisors and maintenance technicians since the start of this scenario, and now that the troubleshooting has identified this link, the local maintenance crew is dispatched. The maintenance crew has to gather their test equipment and travel to the nearest possible point of presence with visibility of the affected link. Waiting for a crew to arrive on-site can feel like a lifetime.

1:15 AM

After arriving, the maintenance crew verifies the working condition of the transmission equipment to rule out any possible transmission faults. Discovering that the transmission gear is functioning properly they can turn their attention to the optical connections between transmission gear and the optical cables that transport the signals. Checking each and every optical jumper takes time, but guarantees that every connection is properly made. Now the maintenance crew knows that the fault lies in the outside plant, and a cable break is the most likely cause.

2:00 AM

The maintenance crew has brought their OTDR, with which they can very accurately find the distance to the fault on the cable. First they must find the proper port, disconnect the transmission jumper and connect the test unit. Disconnecting the wrong jumper would instigate a whole new barrage of transmission alarms and could take down an entire section of the network. The instrument is quickly configured, powered up and patched into the network; the test should only take a few minutes to be completed. Hopefully no problems occur at this point; meaning the unit has power or the battery is full charged, the crew brought the right patch cord, the test unit has enough dynamic range to seek out the fiber fault, etc. Assuming all is well with the test unit, an OTDR trace signature is available within three minutes. The maintenance crew can now evaluate this trace and relay the optical distance to the network technicians at the NOC.

2:10 AM

At the NOC, the technicians there have just heard the worst news possible; the fiber is cut. The good news is that they have an extremely accurate distance to that fault from the maintenance crew. The bad news is that they have to correlate that optical distance to an actual physical location. The extensive records that the network operator created during the outside plant installation phase of the network build-out will help pinpoint the fault. The technicians quickly review the build maps and trace the optical distance to the fault, now the exact location of the break is discovered.

2:45 AM
Again the technicians dispatch the maintenance crew to the fault location, the build maps have illustrated the exact location of the fault including landmarks for finding the fault between telephone poles. The outside plant crew is speeding to the fault.

3:45 AM
The restoration crew is on-site and the downed pole is evidently the cause of the fault. Slack must be released from a nearby slack loop and the two cable ends mated together. Another maintenance crew is en route to this site, bringing the splicing trailer. The cables must be prepared and each fiber fused in order to restore service.

4:15 AM
The splicing crew has arrived with the splicing trailer. The cable is cut back to undamaged fiber and the laborious task of fusion splicing each fiber has begun. The first maintenance crew has left for the nearest CO, they will have to test the cable after splicing to verify the quality of the splice.

4:45 AM
The splice crew has just finished fusing the cable together and the crew at the CO is testing each of the 24 fibers. Barring any unforeseen problems the cable should be repaired soon.

5:30 AM
The OTDR has verified the quality of the splices joining the two halves of cable together; another crew has the responsibility of returning the repaired cable to its location on the new pole. As soon as the test data is checked into the reference file by a supervisor, traffic can be rerouted back along the repaired fiber optic link.

6:30 AM
The link is fully repaired and traffic has been rerouted to the default arrangement.