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Truth/Devil is in the Details:

The Fusion of Design and Telemetry Information in Access Networks

A Technical Paper prepared for SCTE by

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Table of Contents

List of Figures

1. Abstract

‘The Truth/Devil is in the Details” is a common saying referring to the mysterious or hidden elements knowable only with infinite parsing of all obtainable information. And truth be told there are many places where valuable information about a network as vast as Comcast’s resides. To obtain, visualize and correlate all these pieces of information requires innovation in hardware and software – in intersecting cycles that virtuously enhance each other.

Comcast serves tens of millions of residential customers and businesses. In our efforts to increase capacity and enhance reliability, Comcast has a host of hardware and software telemetry tools that monitor various factors that affect the performance of our network.

This paper will focus on ways we are taking advantage of our highly digitized network to automate wavelength management, speed up fiber event resolution, and enhance fiber construction. We will detail how real-time fiber management and auto-calibration of new fiber links are essential to maintaining complex networks and delivering exceptionally reliable services. We will also review how we are addressing fiber repairs. We all know that fiber outage events and wavelength management are significant industry challenges because we rely on multiple data sources and integration of the data for accurate records and expedient repair. We also rely on the identification of the location and distance of events to speed the arrival of repair agents. With our solution, learn how utilizing telemetry, multiple data sources, and innovative technology, a fiber event can be detected, assessed, and dispatched to an accurate location.

2. Introduction

Our networks are becoming more fiber-rich every day. We have smaller node sizes as we are driving fiber closer to the customer in both residential and commercial solutions and the amount of fiber connecting our facilities has only increased. In the past when there was a suspected fiber cut, our operations teams would notify the necessary employees or contractors to deploy to troubleshoot the fiber to determine if there was a fiber cut and if so, the associated footage so the fix agents could get to the repair location as quickly as possible. With XMF, (Xfinity Meter Fiber), a solution that automates traditionally manual fiber impairment analysis work, we have saved considerable time because there is no need to dispatch someone to perform the OTDR (Optical Time Domain Reflectometer) measurement of the fiber, assess the distance, then review the prints to identify the location. Instead, this solution provides the necessary details in minutes, allowing fix agents to be deployed more quickly and reducing MTTR (Mean Time To Repair), and improving the customer experience. But it is not just the fiber that is driving the MTTR enhancements, it is the combination of fiber-intelligent network devices, tooling, process sameness, and automation that drives improved network reliability.

3. Digitization of Data

The documentation of fiber has varied throughout the industry and each group, even within organizations, may have different methodologies to track information. The key areas of fiber documentation are (1) the physical design location (plant maps), (2) the fiber amount or size, and (3) the assignments of what is traversing each fiber. When focusing on repair efforts, the digital analysis and resulting determination of the physical location is crucial to minimizing outage repair time and the digital analytics are the catalyst for making this possible. These analytics define the digital transformation of fiber outage analysis. Digital transformation relies on 4 key business competencies, technology, data, process, and organizational change capability [5].

Technology must contribute not complicate the transformation process and be adaptable to the needs of the business [5]. The first aspect of fiber technology is the fiber itself and how it is utilized within the system architecture. The technology architecture is key to reducing latency and driving resiliency. The fiber location documentation must be captured in a centralized and consistent system that becomes the source of the truth repository. In the past, much of this documentation was maintained in multiple formats, sometimes even as a drawing on the wall of fiber engineers. Digital transformation of the fiber requires that the information be accurately captured in a tool that can then be utilized to provide key location information in the event of a fiber outage.

Data integrity standards may vary, and transformation requires understanding unstructured or invalidated data [5]. Many know that data is important, but sometimes data quality is lacking. Understanding the integrity of fiber information data is an important investment in ensuring the expected impact of digital fiber cut detection is realized. Implementing methodologies to define fiber metadata, automate the capturing of such data, and wavelength management is key to accomplishing data proficiency.

Process transformation requires innovative thinking to envision a new way of utilizing data to evolve manual processes into automation [5]. In many areas, fiber triage requires multiple manual reviews and physical confirmation of the stance of the breakage. Horizontal process management breaks down traditional hierarchal triage methodologies and the results are the implementation of a process-driven by digital and technological capabilities. For XMFR, the remote version of the XMF solution, this requires a detailed review of current processes and alignment with the updated processes to support integration.

Organizational change capability is the final key talent that requires courage to change what is historically rooted in current technology, data, and process [5]. Building new technology solutions is key to digital transformation, but without organizational change, adoption and adaptability will not happen within the business. Committing to understanding the human factor is critical to adoption and success.

All four of these elements are key to the integration of XMFR. The technology platform is the engine that delivers the capability. Data integrity is what fuels the engine to provide key accurate information to fix agents. The process is how we guide the organization to achieve consistent positive results. And organizational change is how we bring all these things together for a successful implementation that is recognized for its value to the business and impact on positive customer experience.

4. Operational Logic, XMF-R

Once the organization is aligned on the digital transformation plan, the operational logic reviews the high-level flow of how an outage is managed and identifies key automation opportunities. In many cases today, fiber outage events are not easily discernable from another outage event. The first step in the operational logic is to identify how to utilize the XMFR capability to create a specific alarm type that indicates a fiber outage event which reduces triage times for the operations center. The next step in the logic is to determine how to eliminate the need to dispatch a headend tech to OTDR the fiber to identify the distance to the fiber event. Direct dispatch of this automated information to the fix agents/persons creates speed to resolution and utilizes the technology and data information to confirm the location of the fiber breakage. The fiber logic flow in Figure 1 illustrates the value of reducing the total number of steps required to drive restoration.

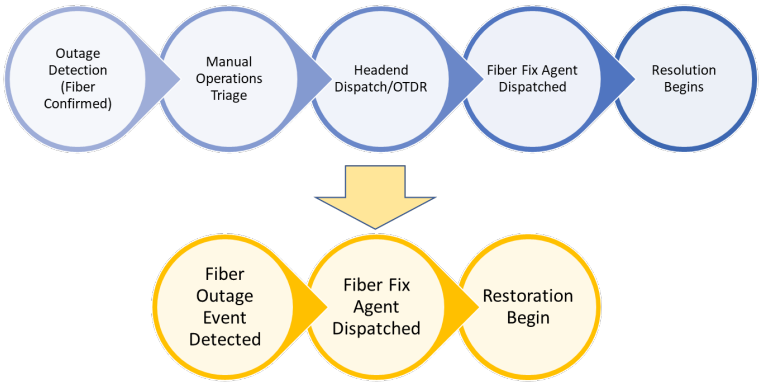

Figure 1 - Operational Logic

Within the operational logic, the reduction of steps optimizes performance, but data and payload provided to the fix agents are essential for optimized restoration. The fix agents require clarity of the event, breakage distance, and location accuracy. These three elements are guides to building the technology, data, and process for operational integration. This one event message then includes:

- Fiber Outage Event
  - Clarity for the fix agent this is a fiber event and not another type of system impairment
- Distance Payload (XMFR OTDR)
  - The XMFR performs an OTDR measurement, and that information is integrated into the event messaging
- Fiber Design Reference
  - Latitude and Longitude information that is referenced to design systems to provide a specific location for the fiber outage event

5. Acting on Real-time Data

5.1. Process Changes

Our operations centers react to many diverse types of alarms and alerts. When a fiber cut is suspected, our normal response for many years was to contact the appropriate teams, based on location, and dispatch them to the appropriate location to troubleshoot the fiber, determine if there was a cut or major impairment, providing the footage details once they were obtained. The Operations Centers would then update the ticket with the footage and dispatch the appropriate fix agents to the site to make the repairs.

With the introduction of XMF, we focused first on deploying the technology between facilities, headend to the headend. This had an immediate operational impact in saving us the time we used to spend sending someone to the facility. This is especially valuable in the instance of an unmanned facility, where, if an issue occurred at night, the time to dispatch, troubleshoot the fiber, and obtain footage could easily be more than an hour. With the XMF solution, the alarm is received in seconds and within a minute or two the operations team receives the distances electronically, updates the ticket accordingly, and dispatches the fix agent.

The second focus included deploying the XMF technology at the node level (XMF-R), in the access network, as we upgrade and shift our nodes from analog to digital. As each node upgrade is implemented, the XMF-R solution is also introduced, allowing for the same benefit across all digital nodes.

The third element that enhances the solution is the end-to-end automation of the ticket and the dispatch with no manual intervention from an operation's center technician. When the XMF solution is installed and configured, many critical details are captured. (The information captured is detailed in the Digitization of our Network section of this paper) This information allows for the autodetection of fiber impairments when our tools see variances based on details captured during configuration (which creates a baseline), versus real-time performance (which either matches the baseline or finds an anomaly to escalate). As tools detect the impairments, tickets are auto-created with all the necessary information and auto-dispatch occurs with no manual, technician intervention. As noted, prior, the result is faster detection and dispatch, and a decrease in fiber troubleshooting/triage and ticketing data entry for the operations center technicians.

5.2. Tool Changes

If the XMF solution only allowed for the time savings associated with removing the need to dispatch and manually shoot the fiber, it would still be worth installing and using. However, we did not stop there! Why capture information automatically and not take advantage of removing manual steps?

Our operations teams utilize National Watch Tower (NWT) for alarming and dispatch activities associated with the Access Network for both demand and planned Maintenance Work. Our NWT teams partnered with engineering to understand the XMF solution and devised a plan to allow NWT to ingest the XMF alerts and payloads, developing the necessary routing solutions to automatically send the demand ticket to the correct fix agent for fiber cuts. Once the fiber cut solution was in place, the NWT team began to develop a similar solution for various types of fiber impairments. Both advancements share the necessary payload details to ensure fix agents have all the needed information to enable the speediest repair.

6. The Access Network

We refer to the access network as the portion of the network from the fiber node to the customer premise. As expected from a top tier service provider, we have been very focused on the reliability of our network. Reliability does not simply mean that the network is ‘up’, and devices are online. It means the network is operating optimally, delivering expected performance and devices are online. To achieve superior network reliability, we are deploying digital nodes with much more telemetry than traditional analog nodes, utilizing our HFC fiber to deliver expected speeds and capacity, and then complimenting that with intelligent tooling to quickly let us know when the network is not operating optimally, and where to go to fix it quickly.

6.1. Coherent Optics in the Access Domain

A practical deployment strategy of fibers is essential at Comcast. The ability to use a portfolio of fibers for some of the emerging low latency markets, while also driving fiber technology deeper into the network, is the essence of our approach in building the industry initiative of 10G. This technology convergence is an essential balance that optimizes the system architecture.

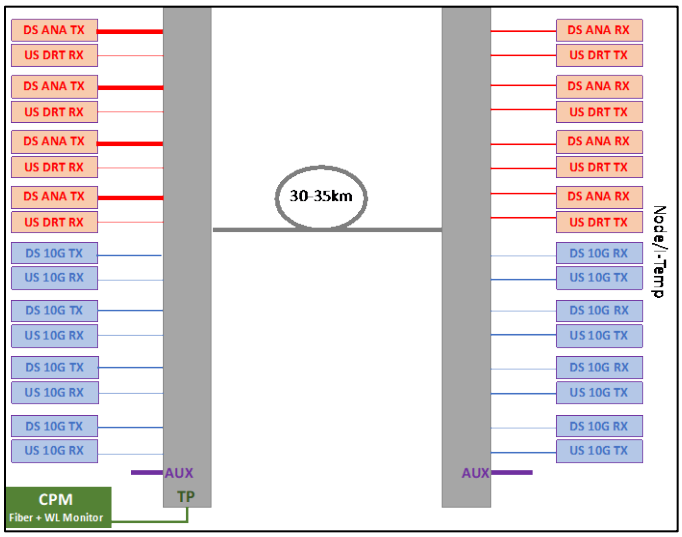

Figure 2 - Access Network Convergence

As the largest broadband company in the US, Comcast serves millions of customers and businesses with a reach that stretches coast to coast. All of this is the result of a large optical network that spans core, metro, and access layers with multiple intersecting points, all intended to increase capacity, reduce latency, and enhance reliability. Operational integration ensures the integrity of the system is maintained with a heightened customer focus.

Photons flood into the Comcast backbone network from the Internet and peer-to-peer traffic through mass-scale routers connected to optical consolidation equipment and reach the various metro centers. At the metro center, the data is reincarnated into photons on a massive IP network and the photons courses thru the highly meshed Converged Regional Area Network infrastructure that terminates in the thousands of our headends. At the various headends, data becomes photons again, traverse access fibers, and light up the many homes, businesses, and fiber nodes eventually completing their journey downstream. A similar process ensures the upstream where photons transmigrate through the access system to the various headends and mesh metro circuits before making their way back through to the internet.

7. Putting it All Together: Role of Orchestration

Deploying an advanced fiber solution and adding intelligence to the network does not immediately deliver the desired benefits. There is a great deal of orchestration across engineering, deployment, tooling/systems development, operations, and, of course, proper people management, required to bring the solution to fruition and maximize the benefit for our employees and our customers. The fiber technology must work together with the operationalization that optimizes event response.

7.1. Deployment and Implementation

Once a new network solution has been developed and tested, it becomes GA (Generally Available) across the network. Engineering teams cannot simply throw it over the fence, expecting adoption by the masses. Engineering partners with the deployment teams to update purchasing plans to acquire the necessary materials and to update our installation plans so the correct materials are ordered, installed, and configured as specified. The solution in this paper includes the fiber purchases as well as the XMF/XMF-R equipment and new policies/procedures for installation and configuration. The operational logic

illustrates how the payload of the OTDR distance and geolocation supports the ability to resolve any post-implementation fiber events quickly and effectively.

7.2. Operational Integration

Once the deployment team has completed their installation and configuration work, they turn it over to operations where validation that the equipment is present within the necessary systems and tools. It is also critical to share these changes and expected benefits with our field teams. We want to make certain everyone is aware of the change and the impact it has on their processes and the customer experience. When deploying the XMF, we communicated the expected reduction in an after-hours dispatch to OTDR fiber, and the fiber benefits regarding reduced latency and increased speed, all of which were well received by the field operations teams

7.3 An Informed Fiber Design

Live fiber information from fiber monitoring tools can improve fiber designs. When teams make design changes to the fiber network, they must have access to real time documentation. Many times, this means a request is made to the Headend or Network Team to validate the fibers or open channels. Utilizing live fiber information, a fiber designer can build a link to a new endpoint knowing what has been provisioned on a mux. This added information improves the speed of design and reduces rework and fiber assignment changes due to the use of outdated fiber system designs.

Use existing fiber information to improve assumptions, resulting in better use of the fiber resource. Fiber designers can utilize real time measured distance and loss to the mux. This new information allows teams to potentially reach further into the network, opposed to using conservative loss or storage assumptions. Fiber teams can also compare system assumptions to better understand the amount of storage or splice loss, from system to system. This new view of the network can ensure that future changes made are based on good information.

7.4 Proper Change Implementation

When implementing process, technological, or organizational changes, it is important to properly lead our people through the change. Detailing what is changing, why it is changing, and understanding the impact on our network and our people is critical to successful implementation and adoption. Recognizing the human factor of change is how organizations optimize evolutionary transformation.

8. Conclusion

Given the general focus on tooling and automation today, it is critical that we analyze all areas of our network to see how we can create better customer experiences and efficient workflows through automation. Given increasingly intelligent alerts and data access, this task becomes increasingly realistic within traditionally manpower intensive areas of the network. This paper discusses the impact of data digitization and the operational logic that is foundational to the technology needed to run advanced fiber networks. The operational logic transforms the manual fiber anomaly analysis procedure from four manual steps to automated processes that reduce troubleshooting time for the business. The process updates drive the development of tool innovation to support automation goals.

The advanced Comcast 400G network described herein, together with the optical monitoring, provisioning, and visualization, we are creating unprecedented robustness and enhancing our customer experience.

At the heart of the Comcast technology evolution is our commitment to our customers and our business goals.

Abbreviations

AP	access point
bps	bits per second
FEC	forward error correction
Hz	hertz
K	kelvin
MTTR	Mean Time To Repair
OTDR	Optical Time Domain Reflectometer
SCTE	Society of Cable Telecommunications Engineers
XMF	Xfinity Meter Fiber
XMF-R	Xfinity Meter Fiber-Remote

Bibliography & References

[1] ANSI C63.5-2006: *American National Standard Electromagnetic Compatibility–Radiated Emission Measurements in Electromagnetic Interference (EMI) Control–Calibration of Antennas (9 kHz to 40 GHz)*; Institute of Electrical and Electronics Engineers

[2] *The ARRL Antenna Book, 20th Ed.;* American Radio Relay League

[3] Code of Federal Regulations, Title 47, Part 76

[4] *Reflections: Transmission Lines and Antennas*, M. Walter Maxwell; American Radio Relay League

[5] https://hbr.org/2020/05/digital-transformation-comes-down-to-talent-in-4-key-areas

