Appendix A

Jeffrey S. Wheeler

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JEFFREY S. WHEELER

OBJECTIVE

Secure a full-time C-level, Senior-level Technical Architect, Consultant or Technical Management role either short term contracts or long term roles.

SKILLS & ABILITIES

Emergency Communications Solutions Designs;
Technology and Product Architecture Development;
Business Process Integration;
Patent Review and Processing;
Standards Development and Product Integration;
IP Networking Routing and Routed Protocol Expert;
Cloud, Virtualization, Data Center and Network Architecture;
Telecom SME with IVR, Contact Center, SIP Conversions and Legacy Experience;
Design and Implementation of Telecom and Network Systems and Services;
Product and Project Management;
Mentoring and Training;
Security Expert;
Software Development and Model Driven Architecture and Engineering.

EXPERIENCE

Emergency Services / NG9-1-1 Consulting
May 2019-current
Responsibilities:

- RFP / RFI creation, review and response
- IP Network, Security Architecture, VoIP, Wireless and NG9-1-1 designs
- Emergency Services solution architecture and design
- Contract review
- SME for Emergency Services as required
- Security reviews, audits and pen testing
- Standards development and implementation
- GIS

Involvement as principal engineer / architect on (current to date) 12 state-wide NG9-1-1, routing, carrier and other projects as well as a myriad of pure carrier / service provider projects.

General Dynamics Information Technology (GDIT)
Sr. Principal Solutions and Systems Engineer / NG9-1-1 RFP Response
May 2016- May 2019

Responsibilities:

- Architecture and systems for onsite, hosted and virtual services including telephony, SIP and IP routed and routing designs and implementation.
- SME for a team of engineers focused on end-to-end systems for audio, video, multi-modal communications with high security in E9-1-1 and NG9-1-1 systems and solutions for state and nation-wide designs and deployments.
- Standards development and compliance participation in IETF, NENA and APCO among others.
- Technical product and solutions development and design.

Tactical Duties:

- Analysis of all related regulatory, architectural, and operational requirements of customer's NG911 solution set and identify technical challenges and risks
- Assess and document technical strategies to meet Service Level Agreement, System Availability, Capacity Management, and Performance based Key Performance Indicators for customers' IP routing, cloud and hosted solutions
- Conduct, document, and present customer technical solutions to meet all customer/NG911 system requirements
- Develops, documents, and presents one or more NG911 IP-based system engineering solutions to include technical analysis, functional analysis, high level design, BoE, and LoM to be used in response to customer request.
- Develops SOWs for hardware, software and services suppliers required for solution and evaluates and negotiates scope, pricing, delivery schedules, etc.
- Develops, documents, and presents NG911 initial technical implementation plan & schedule for the chosen proposal solution
- Lead technical resource for proposal response and if assigned, leads other engineers to develop NG911 system technical response, writes and edits technical sections of proposals and provides guidance, mentorship, and training to less-experienced engineering personnel.

Secondary Duties (as assigned or time allowed)**:**

- Designs and defines system architecture for new or existing computer systems.
- Performs complex systems development and design work that may include logic design, I/O design, firmware development, model formulation, manufacturing and development cost projections, computer architecture analysis and design, and analog or digital systems engineering.
- Performs systems modeling, simulation, and analysis.
- Plans upgrades of operating systems and designs systems enhancements.
- Develops and conducts tests to ensure systems meet documented user requirements.
- Identifies, analyzes, and resolves system problems.
- Provides system/equipment/specialized training and technical guidance.
- Determines system specifications, input/output processes, and working parameters for hardware/software compatibility.
- Provides guidance and work leadership to less-experienced systems

engineers and may have supervisory responsibility.
- May serve as a technical team or task lead.

ALSBRIDGE Consulting
Managing Consultant- Sr. Consultant
(Contract Consultant- 1099)
April 2014- December 2015

Summary of Key Responsibilities:
- Provide Subject Matter Expertise (SME) on IT enterprise architectures, designs, and implementations
- Provide SME on Security, Cloud, and Virtualization technologies
- Design, develop and implement IT architectures
- Produce White Papers, Architectures, and Design documents for large enterprise IT customers.
- Provide SME guidance for wireless, LTE and Broadband networks
  - Design and Implement SIP and VoIP Architectures
- SME at engineering and architectural level for IT and Network related projects.

Tactical Duties
- Serve as in-house resource for Alsbridge customers acting as global SME for standards, networking, IT, technology refresh, SIP and VoIP, virtualization and Cloud architectures and deployments.
- Architect integration strategies and designs for legacy technologies and new cutting edge technologies.
- Optimize ROI and COO for Alsbridge customers integrating Business language policy into technology architectures and solutions.

SME on specific technologies and projects include:
- Cloud architectures and deployments
- Big Data, Hadoop
- Open Source tool chains
- Technology and applications management and integration
- VoIP, SIP and integrated multimedia communications over converged networks
- Routing and Routed protocol architectures, designs and management
- Global fiber Internet extensions, architectures and designs
- Data Center architectures, designs and integration with both Container and AWS Cloud DC models
- Lab architectures and designs
- Statewide Fiber Optic Backbone feasibility study
- Unified Communications architecture review

HUAWEI / FUTUREWEI TECHNOLOGIES
Distinguished Engineer, Chief Architect- Cloud and Virtualization Management
Technical Lead- Standards

January 2011-January 2014
Summary of Key Responsibilities

- Lead Huawei's strategic and tactical efforts for product design and development in IT, Carrier Cloud and virtualization technologies as well as management solutions.
- Represented Huawei on numerous IT, Telecoms and Networking Standards Organizations including the DMTF, IETF, TMForum, ETSI and liaisons between the SDOs.
    - The focal point of my Standards work was to take Huawei IPR into Standards and to take Standards back into Product Development life cycle.
- Develop and implement Proof-of-Concept and Reference Implementations of IPR and Standards for Product design and development.
- Serve as Subject Matter Expert for Architects and Developers. Work includes White Papers, Tutorials, Coding, Examples and Heuristics.
- Standards and technology development for Storage and Storage Services in a Cloud and Virtualization environment in both IT and Carrier domains.

Accomplishments

- Successfully brought Huawei into the Board of the DMTF and represented Huawei in various Committees (leadership) and Working Groups (contributor and leadership)
- Designed, evangelized and POC effort for Cloud and Virtualization Management Architecture
- Led Open Source efforts in POCs and Product roadmaps
- Integrated standards into Product lifecycle and architectures
- Huawei Patent Review Board member.
- Board of Directors for DMTF, V.P. for 2 Committees, organized the China Chapter for the DMTF
- Leader of Software Defined Data Center Incubator

CISCO SYSTEMS, INC.
Technical Lead- Architect- NMTG CTO

May 2005- January 2011
Brief Summary of Key Responsibilities

- Architecture development of common management and control planes across Cisco products.
- Aligned product management offerings and functionality to industry standards
- Served as Routing and Routed Protocol expert across product lines owning especially IPv6 integration and management.
- Represented Cisco in numerous Standards Bodies including IETF, ITU-T, DMTF, TMForum and IEEE.
- Model Driven Architecture and tool development across Cisco product lines.
- Design and implementation of Web Services integration across product lines.
- Publish, mentor and train. Frequent speaker at Cisco events and IEEE events.

- Team leadership roles across departmental and BU boundaries.
- Cisco Patent Review Board member.

Accomplishments

- Chair of DMTF Network and Telecoms Working Group
- Web Services integration into management planes of products
- Virtualization of IOS
- UCS project lead
- MPLS Framework Editor
- DMTF CIM development and integration

INTUIT CORPORATION
Network Solutions Architect

September 2003- May 2005

Summary of Key Responsibilities

- The development and implementation of Next-Generation technical architectures.
- Aligned Architectures to implementations and Business Processes
- Mentored and taught new and innovative technologies to internal staff
- Participated in Standards Bodies for product benefit
- Served as liaison between Executive Management and Engineering
- Published
- Participated in several internal Architecture Councils
- Moved Intuit towards a converged, cost-effective network architecture, and resulting designs, that focused on high ROI and lower COO
- Responsible for all network engineering design reviews and project implementation
- Acted as Technical Liaison across Product Groups and Networking

Accomplishments

- Virtualization Expert for DC networks
- Innovative technical architecture development and implementation
- Product analysis and testing
- Standards implementation into Product Groups and Networking

DATA TECHNICAL SERVICES CONSULTING
CTO / Principal Engineer

2002-September 2003

Summary of Key Responsibilities

- Technical and Product Architecture development and deployment
- Network engineering, design, deployment, and analysis
- Protocol design and development
- Wireless infrastructure and services development
- Object Oriented modeling design and development
- Carrier, ISP, and Enterprise OSS development and deployments
- Project and Product management services
- Wireless J2ME application and protocol services development for PDAs and mobile platforms
- Security Services, Audits and Implementations

Accomplishments

- Mobile platform product design and development for advanced data and video services
- Mobile network design and integration
- Software architecture design and data modeling for mobile services DC
- Embedded architecture and development for advanced and innovative multiple carrier communications and integration of GPS

AHAZA SYSTEMS, INC.
Chief Scientist
2001-2002
Summary of Key Responsibilities

- IPV6 Product, Software, Services, IPR and Technical Architecture creation
- Technology Research and Development
- IPV4 and IPV6 Protocol and Network application services development
- Provide technical leadership and direction for both hardware and software
- Participate in the Industry Standards Bodies for IPV6 arena
- Develop key vendor partnerships strategic to Ahaza's strategies and vision
- Develop and implement routing and routed protocols for IPV4 and IPV6
- Develop and host technical training classes for IPV6 and Security
- Represent Ahaza's interests to National and Foreign Investors

Accomplishments

- Product architecture design and development
- IPV6 security and routing development
- Partnership development and maintenance

PFN, INC.
Chief Technology Officer
2000-2001
Summary of Key Responsibilities

- Policy Based product design and development
- Guide hardware and software development teams
- Develop and integrate Open Source software for IPV6, PBM and Security
- Participate in IPV6 and PBM Standards in IETF, TMForum and IEEE
- Develop Intellectual Property

Accomplishments

- Opened R&D Lab
- Created 'Dynamic VPN' platform using Open Source
- Developed and integrated IPV6 and MPLS solutions
- Develop and presented technical courses Nationally and Internationally
- Integrated Policy Based Management Architecture into Product
- MDA and MDE aligned to Standards Information and Data Models

MICROSOFT CORPORATION

Sr. Network Architect

1999-2000

Summary of Key Responsibilities

While in this director-level position as ITG Architect I performed a wide range of duties including:

- Led an ad hoc strategy group directing vendor technical relationships and solutions into Microsoft properties, networks, and solutions.
- Led a world-wide rollout of Quality of Service deployments after lengthy lab testing of numerous vendors' offerings
- Developed and deployed compression solutions over WAN links
- Oversaw and reviewed all network designs, router configurations, moves, adds and changes world-wide
- Participated in and represented Microsoft strategy in Industry Standard's Bodies
- Worked closely with the software product development groups on the roll out of advanced features for QoS and RSVP in Windows2K
- Directed and led vendor (on-site) and contractor technical efforts
- Managed Microsoft staff, performed performance reviews, etc.
- Provide all technical documentation as required

Accomplishments

- Early implementations of DEN and CIM into Windows
- Developed advanced QoS capabilities and product roadmaps
- Standards contributions and product alignments to Standards

NORTEL NETWORK AND BAY NETWORKS

Various roles including Principal Engineer, Principal Consultant, Senior Member of Architecture Labs, Professional Services Manager

1996-1999

Summary of Key Responsibilities

- Network Architectures and Designs for Carrier, Telecoms and IT Enterprise customers
- Implementation of Network Designs and Architectures and full Project Management
- Developed product requirements and feature sets aligned with Industry Standards
- Participated in numerous Standards Organizations for Bay and Nortel
- Routing, Routed and Security protocol and services development and implementation
- Managed Western Region for Professional Services Organization
- Participated as lead in technology integration via Nortel acquisition
- Architecture and Research Labs Senior Member for Bay and Nortel

Accomplishments

- Designed several global network infrastructures and led implementation teams
- Protocol and Services architecture and development like MPLS, Frame Relay, IPV4 OSPF and BGP
- Frequent Technical Trainer
- Led the Policy Based Management standards work and products

GCI CORPORATION

Various roles including Network Manager, Project Manager, Communications and Network Analyst, Sr. Network and PBX / LAN Engineer

1991-1996

Summary of Key Responsibilities

- Design, deployment and management of voice and data solutions for the Enterprise
- TCP/IP data and SCADA data for process control through PLCs.
- Design, development and implementation of a large number of networking infrastructures including LAN and WANs using various topologies and technologies.
- Full network communications support for an IBM 3090 Mainframe host environment including the support for the communications front-end FEPs.
- Design and ordering of all circuit types from satellite based through simple voice-grade trunk groups.
- Provide full support for internal and external Rolm telephone switches including administration technical support.
- Oversight of employees and contract staff including all duties normally associated with managing staff
- Budget development and adherence in all projects and departments
- Full analysis and operational support on all installed systems and networks state-wide
- Technical documentation as required

Accomplishments

- Full design, implementation and management of voice, data, telemetry and SCADA network infrastructures across the Alaska Pipeline and accompanying oilfields.
- Analysis, design and implementation of innovative and leading edge technologies for multiple vendors

ALYESKA PIPELINE

Senior Network Services Specialist

1990-1991

Summary of Key Responsibilities

- Responsible for LAN/WAN designs, implementation, and management
- Responsible for full support of IBM Mainframe environment communications including FEP support for 12000 seats.

- Tasked with management and oversight of contract and employee staff
- Project management
- Systems and Network analysis duties on a daily basis
- Technical documentation as necessary

Accomplishments

- Design and implementation support for multiple remote ‘Pump Stations’ along the Alaska Pipeline
- Senior Technical support for IBM Mainframe and remote systems

ANCHORAGE SCHOOL DISTRICT
Network Manager, Communications Systems Analyst
1988-1990

Summary of Key Responsibilities

- Network design, deployment and management of a large hybrid district-wide network based on both IBM and DEC systems.
- Full WAN development, deployment, and management of over 100 sites.
- Management of employees and contractors assisting in these efforts
- Technical documentation as necessary

Accomplishments

- Network World + Interop Innovative 2nd place award for the design and implementation of a 2000 square mile network infrastructure in hostile environments for the nation’s 2nd largest school system

MOTOROLA CORPORATION
Sr. Field Engineer in Charge (of State)
1982-1988

Summary of Key Responsibilities

- Installation and maintenance of mainframe / mini-computer systems
- Design, deployment, and maintenance of data communications networks
- Customer training and satisfaction
- Technical curriculum development
- Application code development in a variety of disciplines including assembler, COBOL, FORTRAN, and Basic (variants).
- Management of employees as well as contractors
- Project management
- Provide input into product development intending to mature and advance feature and functionality sets
- Full budgetary responsibilities

Accomplishments

- Awards included ‘Pacific Rim Employee of the Year’

ALASKA DATATRONICS, INC.
Sr. Field Engineer
1978-1982

Summary of Key Responsibilities

- Installation and maintenance of a wide range of data processing equipment, mini-computers and mainframes
- Installation and maintenance of a wide range of data communications equipment
- Oversight of technical staff

EDUCATION

HIGH SCHOOL
West Catholic High School, Grand Rapids, Michigan

COLLEGES
Grand Rapids Junior College; Grand Rapids, MI.- Dean's List
Anchorage Community College; Anchorage, AK. Business
University of Alaska; Anchorage, AK. Electronics Technology
American Institute; Los Angeles, CA. Masters in Data Communications

Many and Various Industry Certifications and Acknowledgements including:

- Java Expert
- Security Expert
- Cisco CCIE Written
- Several Telecoms Switch Certifications
- Novel CNE
- Nortel Certifications

Many accredited courses in the fields of Telecommunications and Data

COMMUNICATION

I have been an active speaker or contributor Nationally and Internationally. Here is a subset of my contributions and expertise:

- Cloud and Virtualization Technologies
- Open Source Technologies for Managing Cloud and Virtualization
- IETF- Participation in several Working Groups
- IPv6 Forum Seoul South Korea
- IPv6 Summit Yokohama Japan
- IPv6 Policy Conference Paris France
- IP Policing Conference Paris France
- L'Abrie Conference-Technology and Human Condition
- Networld + Interop- Policy, QoS and DEN Two-Day Tutorial
- Custom Training- OSPF two-day tutorial
- IEEE- both IM and NOMS Tutorial and Session speaker
- Technical Editor

LEADERSHIP

I am an industry recognized expert in many areas. Below is a subset of my active participation in Standards Bodies

- Board of Directors for the DMTF SDO

- V.P. of the Regional Chapter Committee in the DMTF- opened up a ‘Chapter’ in China for the DMTF
- V.P. of Education Committee in the DMTF
- Chair in various Working Groups across SDOs including Network Services Management, Routing and Networks, Telecom, MPLS, PBM.

Appendix C

December 27, 2018 CenturyLink Network Outage Report

A Report of the Public Safety and Homeland Security Bureau
Federal Communications Commission
August 19, 2019

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I. INTRODUCTION

1. In the early morning of December 27, 2018, CenturyLink experienced a nationwide outage on its fiber network that lasted for almost 37 hours. This outage was caused by an equipment failure catastrophically exacerbated by a network configuration error. It affected communications service providers, business customers, and consumers who directly or indirectly relied upon CenturyLink's transport services, which route communications traffic from various providers to locations across the country, resulting in extensive disruptions to phone service, including 911 calling. The effects included dropped calls, disconnected 911 call centers (known as "Public Safety Answering Points"), and fast-busy signals for people who called 911. As many as 22 million customers across 39 states were affected by the outage, including approximately 17 million customers across 29 states who lacked reliable access to 911. Indeed, at least 886 calls to 911 were not delivered.[1] Fortunately, based on discussions with affected service providers and public safety officials from affected states, as well as a review of media reports, the Public Safety and Homeland Security Bureau (Bureau) is not aware of any harm to life or property resulting from the outage.

2. The Bureau investigated the incident, its effects, and the recovery. As part of its investigation, Bureau staff reviewed and analyzed outage reports filed in the Network Outage Reporting System (NORS) and held meetings with relevant stakeholders, including service providers and public safety entities.[2] This report presents the Bureau's findings and recommendations. This outage provides the Commission and stakeholders with the opportunity to learn valuable lessons about network reliability and the implementation of industry-accepted best practices. For example, this outage demonstrates the importance of either turning off or otherwise disabling unused system features to prevent unintentional and unmonitored use of those features that can result in negative, unintended consequences. In addition, network administrators should have secondary network monitoring procedures in place for when primary network monitoring procedures are inoperable or insufficient.

II. BACKGROUND

3. One of the Commission's primary objectives is to "make available, so far as possible, to all people of the United States . . . a . . . wire and radio communication service . . . for the purpose of promoting safety of life and property."[3] In furtherance of this objective, the Commission has taken measures to promote the reliable and continued availability of 911 telecommunications service and

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[1] This total includes eleven calls to 911 handled by CenturyLink, 75 calls to 911 handled by West Safety Services, and approximately 800 calls to 911 handled by General Dynamics Information Technology.

[2] NORS is the Commission's web-based filing system through which communications providers covered by the Part 4 outage reporting rules must submit reports to the Commission. These reports are presumed confidential to protect sensitive and proprietary information about communications networks. *See* 47 CFR § 4.2.

[3] 47 U.S.C. § 151. Congress has repeatedly and specifically endorsed a role for the Commission in the nationwide implementation of advanced 911 capabilities. *See* Wireless Communications and Public Safety Act of 1999, PL 106–81, 113 Stat 1286 §§ 3(a), (b) (1999) (codified at 47 U.S.C. § 251(e)(3), 47 U.S.C. § 615) (directing the Commission to "designate 911 as the universal emergency telephone number within the United States for reporting an emergency to appropriate authorities and requesting assistance" and to "encourage and support efforts by States to deploy comprehensive end-to-end emergency communications infrastructure and programs, based on coordinated statewide plans, including seamless, ubiquitous, reliable wireless telecommunications networks and enhanced wireless 911 service."); *see also* New and Emerging Technologies 911 Improvement Act of 2008 (NET 911 Act), PL 110–283, 122 Stat 2620 (2008) (codified at 47 U.S.C. § 615a-1(a), (c)(1)(B)) (requiring "each IP-enabled voice service provider to provide 9-1-1 service and enhanced 9-1-1 service to its subscribers in accordance with the requirements of the Federal Communications Commission"); Twenty–First Century Communications and Video Accessibility Act of 2010, PL 111-260, 124 Stat 2751 § 106(g) (2010) (CVAA) (codified at 47 U.S.C. § 615c(g)).

telephone service generally.[4] With specific regard to 911 services, the Commission requires telecommunications carriers and commercial mobile radio service providers to transmit 911 calls to a Public Safety Answering Point (PSAP) (or, in rare cases, to another appropriate local emergency authority).[5]

4. The Commission stays abreast of major disruptions to our nation's communications infrastructure through outage reports filed by communications providers in the wake of major disruptions to their networks. As part of this reporting framework, Commission rules require service providers to report communication disruptions affecting major transport facilities.[6] The Commission uses the term "major transport facility" to describe communications infrastructure components that have significant traffic-carrying capacity.[7] Under the Commission's network outage reporting rules, the minimum threshold capacity for outage reporting purposes is defined as an OC3 circuit or its equivalent.[8] An OC3 circuit has the capacity to transmit data at a rate of 155.52 Mbit/s using fiber optics, and is often used to transmit large amounts of data, including multiple telephone calls simultaneously. A major transport provider is required to file an outage report when an OC3 circuit (or its equivalent) that the provider owns, operates, leases, or otherwise utilizes experiences a communication disruption that lasts for at least 30 minutes and meets the 667 OC3 minute threshold.[9]

5. The Commission has adopted PSAP outage notification requirements where service providers discover outages that could affect the delivery of 911 calls.[10] In addition to these network outage reporting rules, the Commission's 911 reliability rules require certain providers – known as originating service providers – to convey all available and potentially useful information to the PSAP during a 911 outage to help mitigate the effects of the outage on those who might call that PSAP.[11] Originating service providers include cable communications providers, satellite operators, wireless service providers, and wireline communications providers – entities that offer the ability "to originate 911 calls."[12] The Commission also requires covered 911 service providers – service providers that offer core

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[4] *See Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems*, CC Docket No. 94-102, RM-8143, Memorandum Opinion and Order, 12 FCC Rcd 22665, 22744 (1997); *Transition from TTY to Real-Time Text Technology; Petition for Rulemaking to Update the Commission's Rules for Access to Support the Transition from TTY to Real-Time Text Technology and Petition for Waiver of the Rules Requiring Support for TTY Technology*, CG Docket No. 16-145, GN Docket No. 15-178, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 13568 (2016) (applying an analogous requirement to common carriers); *see also* 47 CFR § 20.18(b); 47 CFR § 64.3001.

[5] 47 CFR §§ 20.18, 64.3001, 64.3002.

[6] *See New Part 4 of the Commission's Rules Concerning Disruptions to Communications*, ET Docket No. 04-35, Report and Order and Further Notice of Proposed Rulemaking, 19 FCC Rcd 16830, 16895-902, paras. 127-143 (2004).

[7] *See, e.g.*, *New Part 4 of the Commission's Rules Concerning Disruptions to Communications*, ET Docket 04-35, Order Granting Partial Stay, 19 FCC Rcd 25039, 25042, para. 4 (2004).

[8] 47 CFR § 4.7(d).

[9] *2016 Part 4 Order*, 31 FCC Rcd at 5826, para. 17; *see also* 47 CFR § 4.7(d) (defining the OC3-based metric as OC3 minutes, "the mathematical result of multiplying the duration of an outage, expressed in minutes, by the number of previously operating OC3 circuits or their equivalents that were affected by the outage").

[10] *See New Part 4 of the Commission's Rules Concerning Disruptions to Communications*, ET Docket No. 04-35, Report and Order and Further Notice of Proposed Rulemaking, 19 FCC Rcd 16830 (2004) (*2004 Part 4 Report and Order*); 47 CFR § 4.9.

[11] *See New Part 4 of the Commission's Rules Concerning Disruptions to Communications*, ET Docket No. 04-35, Report and Order and Further Notice of Proposed Rulemaking, 19 FCC Rcd 16830 (2004); 47 CFR § 4.9.

[12] 47 CFR § 12.4(a)(4)(ii)(B) (defining an originating service provider); 47 CFR §§ 4.9(a), (c), (e), (f) (detailing parallel PSAP notification requirements for cable, satellite, wireless and wireline service providers); *see also*

911 capabilities or deliver 911 calls and associated number or location information to the appropriate PSAP – to notify 911 special facilities of outages that potentially affect them within 30 minutes of discovering an outage and to update PSAPs within two hours of initial contact to communicate information about the nature of the outage, its best-known cause, its geographic scope, and the estimated time for repairs.[13]

6. Covered 911 service providers are required to take reasonable measures to provide reliable 911 service in three specific respects: circuit diversity, central office backup power, and diverse network monitoring.[14] They must also "certify annually whether they have, within the past year, audited the physical diversity of critical 911 circuits or equivalent data paths to each PSAP they serve, tagged those circuits to minimize the risk that they will be reconfigured at some future date, and eliminated all single points of failure."[15] In the alternative, covered 911 service providers may describe "reasonably sufficient alternative measures they have taken to mitigate the risks associated with the lack of physical diversity."[16] Similar obligations apply to their network monitoring capabilities.[17]

III. INCIDENT AND RESPONSE

A. Architecture of CenturyLink's Network

7. CenturyLink operates six separately managed long-haul networks that provide transport for telecommunications traffic across the country. The CenturyLink network affected by this outage provides high-speed data transport over optical fiber. It is used by individual and enterprise customers for myriad purposes, including 911 services, Voice over Internet Protocol (VoIP), local and long-distance voice, ethernet, Internet Protocol (IP) backbone, consumer Digital Subscriber Line (DSL) and other services.

8. In the affected network, network traffic transits across nodes, where data enters and exits the network. At the time of the outage, the affected network used nodes supplied by Infinera Intelligent Transport Networks (Infinera).[18] Each node provides optical fiber switching, a process that ensures that network traffic is directed towards the intended network path, between networks components called line modules. Line modules provide the connection points between nodes across the country. Internal to each node, a component called a switching module transfers packets from inbound line modules to outbound line modules. The switching module directs traffic that arrives on a particular port and stream of an

(Continued from previous page)
Improving 911 Reliability; Reliability and Continuity of Communications Networks, Including Broadband Technologies, PS Docket Nos. 13-75, 11-60, Report and Order, 28 FCC Rcd 17476, 17488-89, para. 36 (2013) (*911 Reliability Order*).

[13] 47 CFR § 12.4(a)(4) (defining a covered 911 service provider). *Compare* 47 CFR § 4.9(h) (requiring covered 911 service providers to notify affected PSAPs "no later than 30 minutes from discovering the outage) *with* 47 CFR § 4.9(e) (requiring originating service providers to notify affected PSAPs "as soon as possible"). The Commission's PSAP notification requirements for covered 911 service providers are generally more specific than those that apply to originating service providers.

[14] 47 CFR § 12.4(b).

[15] *911 Reliability Order*, 28 FCC Rcd at 17503, para. 80; *see also* 47 CFR § 12.4(c)(1). Diversity audits check for "single points of failure" in network configurations, while tagging ensures that changes to critical 911 assets cannot be made without rigorous review.

[16] *911 Reliability Order*, 28 FCC Rcd at 17503, para. 80; 47 CFR § 12.4(b). This 2013 proceeding deferred for future consideration whether network reliability requirements should be extended to originating service providers. *See 911 Reliability Order*, 28 FCC Rcd at 17528-29, para. 147.

[17] 47 CFR § 12.4(c)(3).

[18] Infinera provides equipment and professional services to CenturyLink.

inbound line module to the correct port on the correct outbound line module. This report refers to this successful traffic direction as "synchronization." Correct synchronization ensures the line modules internal to the node are mapped correctly. Lack of synchronization would cause network data to drop or be corrupted as either an inbound line module would send traffic to the wrong outbound line module, or an outbound line module would attempt to receive traffic from the wrong inbound line module. Figure 1 conceptually shows how the Infinera nodes, line modules, and switching modules act together to send and receive network traffic from other nodes across the country.

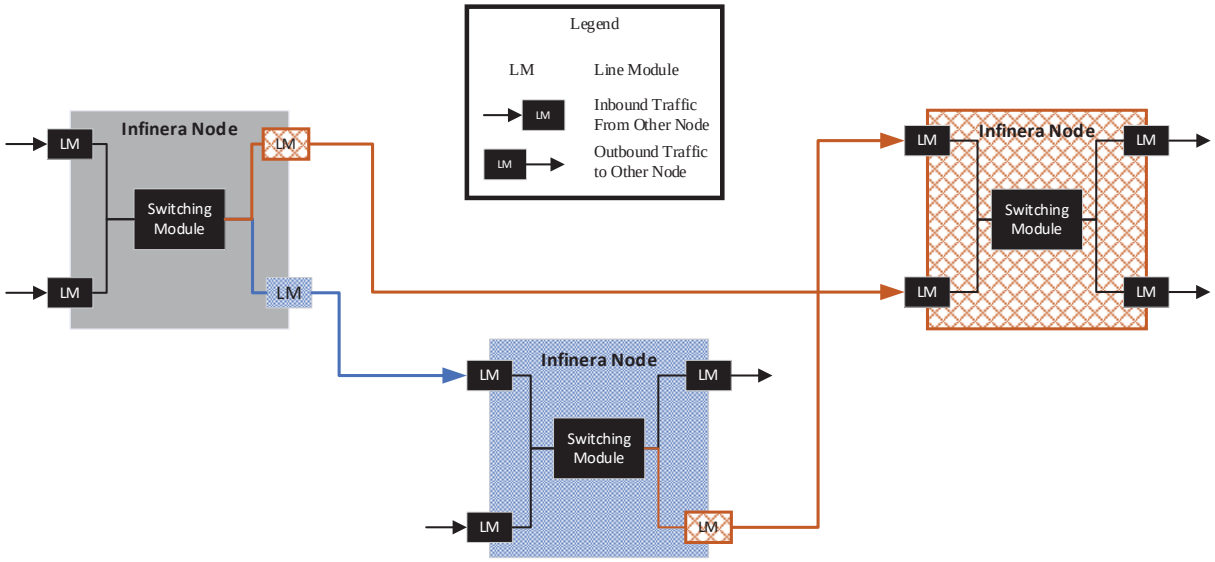

Figure 1: Conceptual Infinera Node Interconnection Diagram

9. The nodes in the affected network possess a proprietary internode management channel. This proprietary management channel is designed to allow for very fast, automatic rerouting of traffic to avoid a loss of traffic during a failure in the network. It does this by enabling line modules to send packets directly to other connected nodes without receiving network management instructions about how to route traffic.[19] To prevent management instructions from being sent to other nodes, the proprietary management channel has a filter that prevents packets that are 64 bytes or fewer from using the channel.[20] As the supplier of these nodes, Infinera provides its customers – including CenturyLink in this case – with the proprietary management channel enabled by default. CenturyLink was aware of the channel but neither configured nor used it.

B. Root Cause and Event Summary

10. In the early morning of December 27, 2018, a switching module in CenturyLink's Denver, Colorado node spontaneously generated four malformed management packets.[21] Malformed packets are packets that, while not rare, are not typically generated on a network and are usually discarded

[19] In the Bureau's discussions with Infinera, Infinera used the term "packet" to describe what some experts refer to as Ethernet frames that are sent between nodes. For the sake of simplicity, this report uses the term "packet."

[20] Network management packets in the affected nodes are exactly 64 bytes in size and are intended to be discarded by the filter. Invalid packet fragments, which are likely to be less than 64 bytes in size, are also intended to be discarded.

[21] CenturyLink does not know the exact time when the switching module generated the malformed packets. However, CenturyLink asserts that its post-outage analysis shows that symptoms of a major network event were present at 3:40 a.m.

immediately due to characteristics that indicate that the packets are invalid. In this instance, the malformed packets included fragments of valid network management packets that are typically generated. Each malformed packet shared four attributes that contributed to the outage: 1) a broadcast destination address, meaning that the packet was directed to be sent to all connected devices; 2) a valid header and valid checksum; 3) no expiration time, meaning that the packet would not be dropped for being created too long ago; and 4) a size larger than 64 bytes. CenturyLink and Infinera state that, despite an internal investigation, they do not know how or why the malformed packets were generated.

11. The switching module that generated the malformed packets sent them as network management instructions to a line module. Figure 2 illustrates how the malformed packets then flowed through the network.[22] The packets were examined through a sequential series of conditions that produced either a "yes" or a "no" response. As shown in Figure 2, the malformed packets were able to pass each condition without being discarded. Because the packets were larger than 64 bytes, they were not stopped by the filter. Finally, while not shown, each malformed packet also passed the checksum condition, which is a test to determine if any errors occurred during the transmission of the packet, such as the changing of one or more bits in the message or if the message was randomly formed. As a result, the packets were transmitted along the enabled and unconfigured proprietary management channel.[23] The arriving malformed packets passed each condition at the nodes at which they arrived.

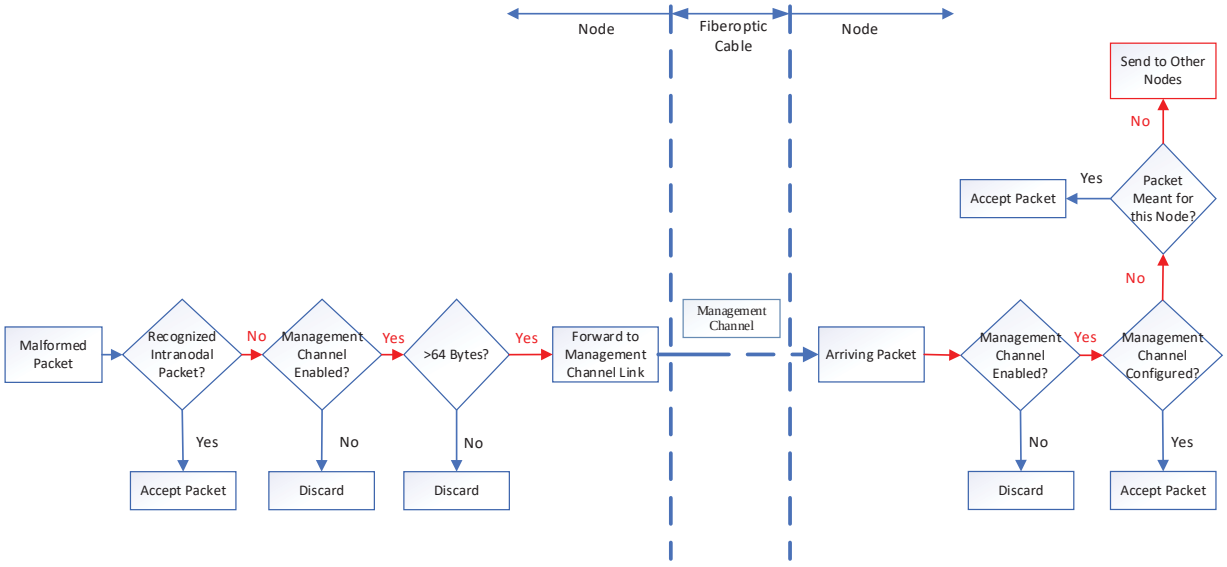

Figure 2: Malformed Packet Distribution Flow Chart

12. Due to the packets' broadcast destination address, the malformed network management packets were delivered to all connected nodes. Consequently, each subsequent node receiving the packet retransmitted the packet to all its connected nodes, including the node where the malformed packets originated. Each connected node continued to retransmit the malformed packets across the proprietary management channel to each node with which it connected because the packets appeared valid and did not have an expiration time. This process repeated indefinitely.

13. The exponentially increasing transmittal of malformed packets resulted in a never-ending feedback loop that consumed processing power in the affected nodes, which in turn disrupted the ability of the nodes to maintain internal synchronization. Specifically, instructions to output line modules would

[22] Figure 2 is intended to be illustrative of the conditions that are implicated in this outage. It is not intended to be representative of all of the conditions on this path, nor their actual order.

[23] In discussions with Bureau staff, Infinera used the terms 'unlocked' and 'locked' to describe the status of the channel. In the interest of clarity, this report instead uses the terms 'enabled' and 'disabled.'

lose synchronization when instructions were sent to a pair of line modules, but only one line module actually received the message. Without this internal synchronization, the nodes' capacity to route and transmit data failed. As these nodes failed, the result was multiple outages across CenturyLink's network.

C. CenturyLink and Infinera Recovery and Restoration

14. CenturyLink first became aware that it was experiencing a major network incident upon receiving an inquiry from a customer near New Orleans, Louisiana at 3:56 a.m. on December 27, 2018.[24] While troubleshooting this customer complaint, multiple alarms indicated an issue with Infinera control modules. CenturyLink determined that the outage was widespread and began investigating. CenturyLink's network administrators were unable to connect to nodes remotely to locate and diagnose the outage or take corrective action because the nodes were overloaded.

15. At 4:25 a.m., CenturyLink network administrators in New Orleans engaged other CenturyLink administrators in San Antonio, Texas, as well as Infinera. By mid-morning on December 27, CenturyLink dispatched network engineers to Omaha, Nebraska and Kansas City, Missouri to log in to affected nodes directly. Network engineers in Kansas City found an address in a captured malformed packet indicating the malformed packets originated in the Denver, Colorado node. At 9:02 p.m. on December 27, CenturyLink network engineers identified and removed the module that had generated the malformed packets. The outage, however, did not immediately end; the malformed packets continued to replicate and transit the network, generating more packets as they echoed from node to node.

16. At 12:09 a.m. on December 28, a CenturyLink network engineer began instructing nodes to no longer acknowledge the malformed packets. CenturyLink network engineers also disabled the proprietary management channel, preventing it from further transmitting the malformed packets. CenturyLink and Infinera worked together to realign paired line modules to communicate through the same switching modules to ensure fiber optic synchronization and stability. By 5:07 a.m., CenturyLink and Infinera had returned much of the network to normal function. CenturyLink restored visibility into the network at 11:30 a.m. on December 28, meaning that all nodes became reachable via remote access. By 11:36 p.m., network engineers had restored all nodes in the affected network, though some customers experienced residual effects of the outage as CenturyLink continued to reset affected line modules and replace line modules that failed to reset.[25] On December 29, 2018, at 12:01 p.m., CenturyLink determined that the backbone network had stabilized.

IV. IMPACT

A. Impact on CenturyLink's Network

17. The event caused a nationwide voice, IP, and transport outage on CenturyLink's fiber network. CenturyLink estimates that 12,100,108 calls were blocked or degraded due to the incident. Where long-distance voice callers experienced call quality issues, some customers received a fast-busy signal, some received an error message, and some just had a terrible connection with garbled words. The outage also affected communications of state government entities: for example, in Idaho, the CenturyLink outage caused the temporary shutdown of phone services at both the Idaho Department of Correction and the state's Department of Education.[26] Four states, Illinois, Kansas, Minnesota, and

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[24] All times mentioned in this report are Eastern Standard Time (EST).

[25] While the nodes had been restored, other services that had been negatively affected did not automatically come back online, necessitating further restoration work by CenturyLink and its vendors. For example, CenturyLink's own cloud services remained unavailable for over 20 hours after the network was restored.

[26] Ruth Brown & Michael Katz, *Widespread CenturyLink outage shuts down phone services at Idaho prisons, education dept.*, Idaho Statesman (Dec. 27, 2018), https://www.idahostatesman.com/news/local/article223619505.html.

Missouri, experienced network isolation for 36 hours, meaning services that relied on access to other parts of the network were disrupted. Fourteen other states, primarily in the western region of the country, experienced network congestion that may have affected service.[27] CenturyLink's IP backbone, which carries VoIP, IP, ethernet, and other services, was also affected. Approximately 250,000 CenturyLink IP service customers were affected or potentially affected by the outage, including approximately 4,000 enterprise customers in Idaho, Louisiana, Montana, Texas, and Wyoming. In addition, approximately 1.1 million CenturyLink DSL customers lost service during portions of the event, with the most significant effects occurring in Idaho, New Mexico, Oregon, and Utah. Another 2.6 million customers may have experienced degraded service. The effect on transport facilities was large: facilities with a capacity of approximately 300,000 OC3s were affected.[28] As described below, this event had rippling effects on other service providers that use the affected long-haul transport network, including service providers that provide 911 service.

B. Impact on 911 Calls Handled by CenturyLink

18. The outage also affected 911 calls handled by CenturyLink. CenturyLink states that it timely notified the PSAPs that it serves and that it was in contact with the PSAPs it serves as a covered 911 service provider throughout the outage. During the outage, CenturyLink failed to deliver eleven 911 calls that had been forwarded to secondary Public Safety Answer Points (PSAPs) that it serves as a covered 911 service provider.[29] CenturyLink also failed to deliver automatic location information (ALI), which provides the PSAP with the caller's location, to fifteen PSAPs that CenturyLink serves as a covered 911 service provider in Arizona, Idaho, Montana, Utah, and Wyoming.[30]

C. Impact on Other Service Providers

1. TeleCommunication Systems, Inc.

19. TeleCommunication Systems, Inc. (TeleCommunication Systems) is a wholly-owned subsidiary of Comtech Telecommunications Corp. that provides 911 service to originating service providers and PSAPs.[31] TeleCommunication Systems relies on the affected CenturyLink network for transport in processing some 911 calls. At 3:48 a.m. on December 27, 2018, CenturyLink's outage affected TeleCommunication Systems' processing of 911 calls from callers in Washington, north central Texas, and Tier 3 wireless service providers.[32] TeleCommunication Systems experienced multiple impairments to circuits provided by CenturyLink, which resulted in loss of circuit redundancy at various times over a combined duration of 49 hours and 32 minutes. This affected the routing of 911 calls to

[27] Network congestion can cause a range of impacts to customers' telephone service, from no effect to marginally degraded voice service to blocked calls.

[28] We note that although CenturyLink reported 52,286 OC3-equivalent capacity was affected, total transport capacity based on circuit outages appears to be closer to ~300,000 OC3s.

[29] A primary PSAP is the initial PSAP that the 911 call is routed to for answering. A secondary PSAP is a backup for the primary PSAP in case the 911 call cannot be routed to the primary PSAP or the 911 call cannot be answered by the primary PSAP. The precise roles of secondary PSAPs may vary depending on how 911 services are organized at the state or local level.

[30] This report describes the effects of the outage on 911 service that service providers and PSAPs reported to the Bureau during its investigation. While some entities provided a detailed description of effects to 911 services, such as the number of failed 911 calls, other entities did not have access to detailed information or did not report that information to the Bureau.

[31] TeleCommunication Systems relies on the CenturyLink transport network to carry 911 calls to PSAPs.

[32] A Tier 3 wireless carrier is a wireless provider that does not own the network upon which it operates.

TeleCommunication Systems' network by its Signaling System 7 (SS7) signaling provider.[33] According to TeleCommunication Systems, once it determined that it was experiencing issues with 911 calls, it notified affected PSAPs.

20. TeleCommunication Systems' networks that connect originating service providers with PSAPs in Washington and north central Texas were fully operational and able to receive calls from CenturyLink throughout the duration of CenturyLink's outage. In addition, TeleCommunication Systems' 911 systems that serve Tier 3 wireless service providers were fully operational and able to receive calls throughout the duration of CenturyLink's outage. However, during the following three time periods, due to the CenturyLink network outage, TeleCommunication Systems' data centers that provide Next Generation 911 services did not receive any 911 calls from callers served by North Central Texas 911 nor from callers in Washington. Simultaneously, its 911 systems did not receive calls that originated from its connected Tier 3 wireless service providers:

Dec. 27, 2018, 3:48 a.m. – Dec. 27, 2018, 4:16 a.m.

Dec. 27, 2018, 11:00 p.m. – Dec. 28, 2018, 6:26 a.m.

Dec. 28, 2018, 9:05 a.m. – Dec. 28, 2018, 9:57 a.m.

21. TeleCommunication Systems estimates that 8.4 million users were potentially affected and potentially could not make 911 calls during the times mentioned above. This includes 5.7 million potentially affected users in Washington, 1.6 million potentially affected users in north central Texas, and 1.1 million Tier 3 wireless customers in Washington and north central Texas.

22. TeleCommunication Systems initially learned of the network issue through its internal alarms and reports from PSAPs in Washington. TeleCommunication Systems' signal transfer points in Seattle and Phoenix sounded alarms. These alarms were triggered when TeleCommunication Systems experienced errors or loss of connectivity between its signal transfer points and SS7-signaling-provider-connected nodes. CenturyLink's outage affected enough of TeleCommunication Systems' SS7 links with its SS7 signaling provider, Transaction Network Services, Inc. (Transaction Network Services), to cause it not to receive 911 calls to then send to PSAPs.

23. TeleCommunication Systems was unable to reroute some calls around the CenturyLink outage. When it reached out to its SS7 signaling provider to investigate possible alternate routing strategies to reach the signal transfer points, Transaction Network Services stated that it was not able to provide any alternate routing.

24. On December 28, 2018, at 2:06 pm, TeleCommunication Systems confirmed that its above-referenced circuits from CenturyLink were stable and operational. TeleCommunication Systems continued to monitor the network for health and stability. On December 28, 2018, at 7:00 pm EST, TeleCommunication Systems performed a network evaluation, after which it declared the incident resolved.

2. Transaction Network Services, Inc.

25. Transaction Network Services provides SS7 service for TeleCommunication Systems and other small service providers. Transaction Network Services has paired signal transfer points in Las Vegas, Nevada and Los Angeles, California. TeleCommunication Systems connects to the Las Vegas and Los Angeles signal transfer points using four physically diverse links. CenturyLink provides TeleCommunication Systems and Transaction Network Services with transport for these links. As discussed above, CenturyLink's nodes intermittently became overloaded over the course of the outage.[34]

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[33] SS7 is the network for traditional telecommunications upon which the exchange of control information associated with the setup and release of a telephone call on a telecommunications circuit occurs.

[34] *Supra* para. 13.

When one of those nodes that supported one of these four links became overloaded, that specific link went out of service. As the outage progressed, all four links were simultaneously down. In addition to the 911-related impacts described above, Transaction Network Services had SS7 connections fail where it relied on CenturyLink transport circuits, but such failures did not affect service due to alternative available routing.

3. General Dynamics Information Technology

26. General Dynamics Information Technology (General Dynamics) is Massachusetts's covered 911 service provider. As such, General Dynamics is responsible for delivering all 911 calls that originate in Massachusetts to the state's 305 PSAPs. General Dynamics relies on TeleCommunication Systems, which in turn relies on CenturyLink, to deliver 911 calls from Verizon, Verizon Wireless, and other service providers to the appropriate PSAPs. General Dynamics reported that the CenturyLink outage affected its ability as a Next Generation 911 (NG911) interconnection vendor to deliver 911 calls to PSAPs from service providers.

27. On December 28, 2018 between 12:30 a.m. and 7:39 p.m., General Dynamics estimates that TeleCommunication Systems was unable to receive signaling for approximately 800 calls to 911 initiating on several different service provider networks in transit to General Dynamics for processing. General Dynamics notified TeleCommunication Systems of these outage impacts around 1:00 a.m. on December 28. General Dynamics reports that it notified all Massachusetts PSAPs it served immediately after becoming aware of the outage. At 2:00 a.m., General Dynamics began regularly updating Massachusetts PSAPs on the outage and its effects. At 11:40 a.m. on December 28, the Massachusetts Emergency Management Agency, in coordination with the Massachusetts State 911 Department and General Dynamics, sent wireless emergency alerts to the public to use PSAPs' 10-digit numbers instead of 911.[35] General Dynamics-maintained NG911 infrastructure remained operational throughout the incident. It continued to process 911 calls as normal for service providers such as Comcast and AT&T Mobility.

4. West Safety Services

28. West Safety Services (West) relies upon CenturyLink's network to route some 911 calls to PSAPs. Specifically, CenturyLink's outage caused a service disruption in an element of West's network that provided access to selective routers that served 17 PSAPs in Texas and 7 PSAPs in Montana. This prevented West from successfully processing 911 calls destined for these selective routers. In Texas, the disruption began at 6:06 p.m. on December 27 and lasted until CenturyLink restored connectivity to the portion of the network upon which West relies at 11:07 a.m. on December 28. In Montana, the disruption began at 8:24 p.m. on December 27 and lasted until CenturyLink restored connectivity at 3:00 p.m. on December 28, 2018. The outage caused the failure of 75 calls to 911 in Texas and Montana. West states that it provided timely notification and updates to its affected PSAPs. West continued to process all other 911 calls in accordance with the originating service providers' pre-defined default routing plans. However, the affected PSAPs were unable to retrieve automatic number information (ANI), which provides the PSAP with the caller's phone number, and ALI, for any VoIP and wireless calls throughout the CenturyLink outage.

5. Verizon Wireless

29. Verizon Wireless uses CenturyLink to transport portions of its wireless network traffic.[36] The CenturyLink outage affected Verizon Wireless's network across several western states, including intermittent service problems in one county in Arizona, twelve counties in Montana, 21 counties in New

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[35] Jonathan Ng, *Nationwide outage knocks out 911 call services in Massachusetts*, Boston Herald (Dec. 28, 2018), https://www.bostonherald.com/2018/12/28/nationwide-outage-knocks-out-911-call-services-in-massachusetts.

[36] *Nationwide internet outage affects CenturyLink customers*, Associated Press (Dec. 28, 2018), https://www.apnews.com/fc612a7689c74b98abd8bd4d1ed848c2.

Mexico,[37] and four counties in Wyoming.[38] One mobile switching center in New Mexico was isolated intermittently for 19 hours and 34 minutes beginning at 8:36 a.m. on December 27, with a total downtime of 10 hours and 48 minutes. In Arizona and New Mexico, this outage potentially affected 314,883 users of Verizon Wireless' network and resulted in 12,838,697 blocked calls (based on historical data). Once Verizon Wireless discovered that it was experiencing an outage, it tried to build a reroute in its network to mitigate the outage's effects. However, CenturyLink restored service before Verizon Wireless completed the reroute.

30. On December 27, the failures in CenturyLink's network caused a wireless network outage in Montana and Wyoming that potentially affected 92,613 users of Verizon Wireless's network and resulted in 1,922,586 blocked calls (based on historical data). In Montana, this event lasted for 24 hours and 19 minutes. In Wyoming, this event lasted for 13 hours and 16 minutes.

31. The CenturyLink outage also affected the ability of users of the Verizon Wireless network to access 911. In Texas, beginning at 12:06 a.m. on December 28, 37,045 potentially affected users were unable to reach 911 if their phones used Verizon Wireless's code division multiple access (CDMA) network that uses the affected CenturyLink network for transport due to the impact of the outage on a Verizon 911 service vendor. The outage lasted 12 hours and 1 minute. In Oregon, Verizon Wireless was unable to support ALI information for 12,673 potentially affected users on its CDMA network due to the impact of the outage on a Verizon 911 service vendor. This service degradation lasted for 29 hours and 26 minutes. However, the CenturyLink outage did not affect Verizon Wireless's ability to successfully process and transmit 911 calls on its LTE network, because the LTE network does not use the affected CenturyLink network for transport.

6. Comcast

32. Comcast relies on the affected CenturyLink network for transport to selective routers in Idaho and California. On December 27, 2018 at 6:06 a.m., Comcast network alarms indicated a loss of connectivity on some trunks used in Idaho and California for 911 call transport. Later that day, notifications from Comcast's third-party 911 vendors identified a potential disruption or degradation of 911 calling in multiple PSAPs in Alabama, Arizona, California, Colorado, Florida, Georgia, Iowa, Idaho, Illinois, Kansas, Maine, Montana, Minnesota, Oregon, Nebraska, New Mexico, Nevada, Pennsylvania, South Carolina, Tennessee, Utah, Virginia, and Washington. Comcast relies on CenturyLink-provided selective routers for 911 calls in each of these states. The outage potentially affected 3,552,495 of Comcast's VoIP customers for 49 hours and 32 minutes. Comcast VoIP customers may have experienced a fast-busy signal or diminished call quality if calls were transmitted over affected transport facilities. Upon discovery of the event, Comcast immediately notified potentially affected PSAPs.

33. CenturyLink provides transport for Comcast for its primary and secondary paths to selective routers in Idaho. Comcast also has a tertiary route, provided by a third party. CenturyLink's transport outage disrupted and degraded Comcast's ability to route 911 calls to PSAPs in Idaho over its primary and secondary paths, however, Comcast's backup tertiary route, using 10-digit phone numbers, remained operational. In addition, CenturyLink provides transport for Comcast's primary path to some selective routers in California. Comcast relies on a third party for secondary and tertiary routes. In the affected areas of California, 911 calls routed successfully to the redundant secondary route. ALI and ANI remained unaffected for VoIP calls in Idaho and California.

34. In the other states identified above, while 911 calls that would have relied on CenturyLink transport to reach PSAPs did not drop, some 911 calls may have been sent to fast-busy or

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[37] Stephen Montoya, *CenturyLink, Verizon services disrupted*, Albuquerque Journal (Dec. 27, 2018), https://www.abqjournal.com/1261869/centurylink-verizon-see-widespread-outages-in-abq-area.html.

[38] *Nationwide internet outage affects CenturyLink customers*, Associated Press (Dec. 28, 2018), https://www.apnews.com/fc612a7689c74b98abd8bd4d1ed848c2.

encountered other call quality issues. Comcast Network Operations Center technicians performed test calls during the CenturyLink outage, which sometimes came back with a fast-busy signal. There was an increase in short-duration calls on Comcast's network during the CenturyLink outage, indicating that callers experiencing call quality issues hung up and redialed 911. Comcast reported that it notified its affected PSAPs and continued updating them over the course of the outage.

35. On December 28 at 5:36 p.m., CenturyLink notified Comcast that CenturyLink had removed the faulty module and undertaken additional actions to restore the network. Most services were restored by December 28 and all residual effects were resolved by December 29.

7. Effects on Other Providers

36. The CenturyLink outage also had smaller effects on other service providers. AT&T estimates that 1,778,250 users may have been affected. Some of the potential effects include dropped calls, voice service degradation, and callers receiving fast-busy signals when calling. TDS reported that 1,114 of its wireline users may have been affected. 911 call delivery was also affected for several service providers. Bluegrass Cellular, in Kentucky, reported that the outage potentially affected 911 call delivery for 195,384 wireless users. Cellcom, a Wisconsin-based wireless provider, notified the Commission that 53 calls to 911 were transmitted without ANI and ALI. Cox reported that the outage potentially affected 654,452 VoIP users. In Iowa, U.S. Cellular reported that the outage potentially affected ALI for 911 calls for 94,380 of its wireless users. None of the providers or PSAPs reported any harms to life or property due to the outage.

37. The table below summarizes the effects of the outage on all service providers, as discussed above.

Provider	Provider Type	Number of Potentially Affected Users	Estimated Number of Affected Calls	Potential Effects
AT&T	Wireless Originating Service Provider	N/A	1,778,250	N/A
Bluegrass Cellular	Wireless Originating Service Provider	195,384		911 call delivery disruption
CenturyLink	Covered 911 Service Provider; Wireline Originating Service Provider; Transport Service Provider;	At least 3,750,000	12,100,108	911 call delivery disruption; ALI delivery failure; blocked calls; voice service degradation
Comcast	VoIP Service Provider	3,553,495		911 call delivery disruption
Cox	VoIP Service Provider	654,452		
General Dynamics	Covered 911 Service Provider	3,210,000	800	911 call delivery disruption

Provider	Provider Type	Number of Potentially Affected Users	Estimated Number of Affected Calls	Potential Effects
TDS	Wireline Originating Service Provider	1,114		N/A
TeleCommunication Systems	Covered 911 Service Provider	8,400,000		911 call delivery disruption; ALI delivery failure
Transaction Network Services	SS7 Service Provider	N/A	N/A	
U.S. Cellular	Wireless Originating Service Provider	94,380		ALI delivery failure
Verizon Wireless	Wireless Originating Service Provider	407,496	14,272,966	911 call delivery disruption; blocked calls; voice service degradation
West	Covered 911 Service Provider	499,387	75	911 call delivery disruption

V. CORRECTIVE ACTIONS BY CENTURYLINK AND INFINERA TO PREVENT RECURRENCE

38. After CenturyLink resolved the incident, it replaced the faulty switching module and shipped it to Infinera to perform a forensic analysis. Infinera's investigation is ongoing, but thus far Infinera engineers have been unable to replicate the malformed packet creation. CenturyLink and Infinera have taken additional steps to prevent a repeat of this particular outage. CenturyLink and Infinera reconfigured the nodes in the affected network by disabling the proprietary management channel. Infinera has disabled the channel on new nodes for CenturyLink's network and has updated the node's product manual to recommend disabling the channel if it is to remain unused. The service provider and vendor also established a network monitoring plan for network management events to detect similar events more quickly.[39] Currently, CenturyLink is in the process of updating its nodes' ethernet policer to reduce the chance of the transmission of a malformed packet in the future. The improved ethernet policer quickly identifies and terminates invalid packets, preventing propagation into the network. This work is expected to be complete in fall 2019.

39. CenturyLink also implemented improvements to its monitoring and audits of memory and processor utilization to enhance network engineers' visibility into issues of this type where processor utilization quickly escalates to unsustainable levels. Finally, CenturyLink used the outage as an opportunity to review and improve its customer notification process.

[39] Commission rules require covered 911 service providers to certify to diverse network monitoring. This requirement is unrelated to long-haul transport and the network monitoring discussed in this case. 47 CFR § 12.4(b).

VI. NEXT STEPS

40. The Bureau plans to engage in stakeholder outreach and guidance regarding industry-accepted recommended network reliability best practices to protect against similar outages in the future. There are several best practices that could have prevented the outage, or at least mitigated its effects:

- System features that are not in use should be turned off or disabled.[40] In this case, the proprietary management channel was enabled by default so that it could be used if needed. While CenturyLink did not intend to use the feature, CenturyLink left it unconfigured and enabled. Leaving the channel enabled created a vulnerability in the network that, in this case, contributed to the outage by allowing malformed packets to be continually rebroadcast across the network.
- For unidentified failure modes, implementing filters can alleviate the impact of the failure. In this case, filters were designed to only mitigate specific risks. Thus, catch-all filters should be designed to only allow for expected traffic. In this event, the filter prevented transmission of packets 64 bytes or fewer over the proprietary management channel, regardless of packet content. Because other characteristics of the packet were not considered, the malformed packets were able to propagate.
- Network monitoring should include memory and processor utilization alarms that are regularly audited to ensure functionality and evaluated to improve early detection and calibration. As noted above, the malformed packets quickly overwhelmed the processing capacity of the nodes. This activity, however, did not trigger any processor utilization alarms indicating the rapidly diminishing ability of nodes to process traffic.
- Standard operating procedures for network repair should address cases where normal networking monitoring procedures are inoperable or otherwise unavailable. CenturyLink's network administrators were unable to connect to nodes remotely to locate and diagnose the outage or take corrective action because of node congestion. However, CenturyLink did execute a back-up plan that allowed for physical inspection of the nodes, allowing the company to discover the proximate cause of the outage (*i.e.*, the malformed packets) and to end the outage.

41. In keeping with past practice, the Bureau plans to release a Public Notice, based on its analysis of this and other recent outages, reminding companies of industry-accepted best practices, including those recommended by the Communications Security, Reliability and Interoperability Council, and their importance.[41] In addition, the Bureau will contact other major transport providers to discuss their network practices and will offer its assistance to smaller providers to help ensure that our nation's communications networks remain robust, reliable, and resilient.

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[40] *See, e.g.*, Communications Security, Reliability and Interoperability Council, Best Practices 11-6-5170, 11-8-8000 (2011), https://opendata.fcc.gov/Public-Safety/CSRIC-Best-Practices/qb45-rw2t/data.

[41] *See, e.g., Public Safety and Homeland Security Bureau Encourages Communications Service Providers to Follow Best Practices to Help Ensure Network Reliability*, Public Notice, 33 FCC Rcd 3776 (PSHSB 2018).

Appendix D

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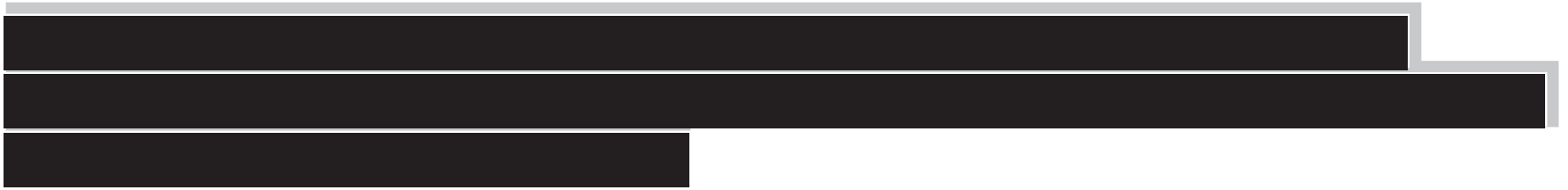
- 

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Appendix E

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Philip E. Grate
Government Affairs Director

January 30, 2019

Transmitted Via Email Only

Susie Paul
Compliance Investigations
Washington Utilities and Transportation Commission
1300 S Evergreen Park Dr. SW
Olympia, Washington 98504

Dear Ms. Paul:

This letter responds to a January 17, 2019 letter from Mark Johnson, the WUTC's Executive Director and Secretary, to me proffering seven information requests on CenturyLink Communications LLC ("CLC") concerning a December 27, 2018 emergency 911 call dispatch systems failure that caused outages throughout the state of Washington.

The following is a general response that is part of the response for the first six questions :

Beginning in the early morning of December 27, 2018, CenturyLink experienced a network event impacting a national transport network operated by CLC. The incident impacted voice (primarily voice over internet protocol), other internet protocol-based services, and transport services for some CenturyLink customers in various parts of the country, including Washington. The event also impacted CenturyLink's visibility into our network management system, impairing our ability to troubleshoot and prolonging the duration of the outage. The outage was caused by a third-party equipment vendor's faulty network management card that triggered invalid traffic replication. Affected services began to restore on December 28, and the network traffic had normalized as of December 29. Steps have been taken to help prevent the issue from reoccurring.

For your reference, CenturyLink's Reason for Outage ("RFO") dated December 31, 2018 is attached as Confidential Attachment A. A public summary version of the RFO is included as Attachment B.

To be clear, the event did not cause a nationwide outage involving CenturyLink's 911 service or a CenturyLink 911 service related outage in Washington for those Public Safety Answering Points ("PSAPs") served by CenturyLink. During 2018 most Washington PSAPs had their respective 911 Service transferred from CenturyLink to Comtech. As of December 27, 2018, CenturyLink no longer provided 911 service to the following Washington PSAPs:

- RiverCom 911
- WHITCOM 911 Emergency Center
- Columbia County Public Safety Communications
- Lewis County 911
- Okanogan County Sheriff's Office
- Pend Oreille County 911
- Lincoln County Sheriff's Office
- Adams County Communications Center
- Garfield County Sheriff's Office (WESCOM)
- King County Test PSAP
- University of Washington Police Department
- Joint Base Lewis McChord (JBLM)
- WSP - Wenatchee
- Bothell Police Dept.
- Issaquah Police Department
- Enumclaw Police Department
- Seattle Police Dept.
- Skamania County Sheriff's Office
- Redmond Police Dept.
- Ferry County E911
- WSP - Bellevue
- WSP - Marysville
- Kitsap County Central Communications (CENCOM)
- San Juan County Sheriff's Office
- Kittitas County 911 (KITTCOM)
- Walla Walla Emergency Services Communications Center (WESCOM)
- WSP - Spokane
- "South Sound 911, SS911 Eastside (fka Puyallup Comm), Tacoma Fire"
- Southeast Communications Center (SECOMM) (Benton)
- WSP - Yakima
- Port of Seattle Police/Fire Communications
- Skagit 911 Center
- TCOMM 911
- Clark Regional Emergency Services Agency
- Wahkiakum County Sheriff's Office
- Yakima Public Safety Communications Center (SUNCOM)
- Seattle Fire Dept.
- WSP - Vancouver
- Cowlitz County 911 Center
- WSP - Tacoma
- Pacific County Sheriff's Office Communications

- Grays Harbor E911 Communications
- Peninsula Communications
- JEFFCOM 911 Communications
- Island County Emergency Services Communications Center (I-COM 911)
- WSP - Bremerton
- Mason County Emergency Communications (MACECOM)

On December 27, 2018, CenturyLink still provided 911 service to the following Washington PSAPs:

- Klickitat Sheriff's Office 911 Center
- Northeast King County Regional Public Safety Communications Agency
- Valley Communications Center (Valley-Com)
- Puyallup Communications South Sound 911 - FireCom
- Whatcom County Communications Center
- Spokane County 911 Emergency Communications Backup
- Stevens County 911
- Spokane County 911 Emergency Communications
- Fairchild Air Force Base FD
- Colville Tribal Police Department
- Yakima County (SUNCOM) Backup
- King County Sheriff's Office
- Multi Agency Communications Center (MACC) - Grant
- SNOPAC911
- SNOCOM 911

Where CenturyLink is an emergency 911 service provider and voice services were functioning, we are not aware of any 911 service impacts in Washington during the event.

In addition to this information, the following is being provided in response to Staff's information requests:

CP1: The number of Washington affected customers, identified by customer type (commercial or residential) and CenturyLink services affected.

Response: No CenturyLink services under the WUTC's jurisdiction, including CenturyLink's 911 service, were affected.

CP2: A chronology of all internal communications related to the outage, including summaries of telephone calls and copies of any emails or other written correspondence.

Response: Not applicable. CenturyLink is not aware of any 911 service outages in Washington experienced by any entities to which it provided 911 service during the incident.

CP3: A chronology of all communications with stakeholders related to the outages (such as commission staff, other federal, state, county, and local governments), including summaries of telephone calls and copies of any emails or other written correspondence.

Response: Not applicable. CenturyLink is not aware of any 911 service outages in Washington experienced by any entities to which it provided 911 service during the incident.

CP4: A chronology of service restoral by location, number of customers, and service type.

Response: Not applicable. CenturyLink is not aware of any 911 service outages in Washington experienced by any entities to which it provided 911 service during the incident.

CP5: Please provide a copy of CenturyLink's communication plan. Was the communication plan followed during this outage?

Response: Please see the attached CenturyLink Communications Plans to which CenturyLink and Staff stipulated in Docket UT-132234. The second question is not applicable. CenturyLink is not aware of any 911 service outages in Washington experienced by any entities to which it provided 911 service during the incident.

CP6: Please provide a summary of any credits for the outage that were/will be provided.

Response: Not applicable. CenturyLink is not aware of any 911 service outages in Washington experienced by any entities to which it provided 911 service during the incident.

CP7: The name, title, telephone number, and email address of the contact person whom our staff can work with directly for questions that may arise concerning any details of the information provided.

Response: Phil Grate, Director State Government Affairs, 206-345-6224, Phil.grate@CenturyLink.com.

Our investigation into the event is ongoing. Should CenturyLink learn additional information, we will supplement this response.

Sincerely,

Philip E. Grate

PEG/jga

Appendix F

From: Bridges, William
To: Hawkins-Jones, Jacque (UTC)
Cc: Sherr, Adam
Subject: FW: UT-181051 - 911 Outage Investigation
Date: Friday, September 18, 2020 1:48:16 PM
Attachments: image001.png
181051 091820 DR Response 2 CONFIDENTIAL.xlsx
181051 091820 DR Response 2 REDACTED.xlsx

Jacque –

[redacted]

[redacted]

William Bridges
Director of Legislative & Regulatory Affairs
office: 206-806-7339
cell: 206-852-3317
william.bridges@lumen.com

Appendix G

REDACTED VERSION

Shaded Information is Designated as Exempt per WAC 480-07-160

Root Cause Analysis

CenturyLink Network Outage and Related E-911 Call Routing Impairment

Event Date: 12-27-2018
MOR Due Date: 01-11-2019

CONTROLLED DOCUMENT: The master of this document is stored electronically and is write-protected—that is, it may only be altered by authorized persons. Viewing of the master via a computer monitor ensures access to the current issue. Any hardcopies of this document must be regarded as uncontrolled.

Amendment History

Version	Date	Author	Amendment
1.0	12-31-2018	Rebecca Miller	First Draft
2.0	01-10-2019	Agastya Kohli	Final Draft

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2.2 Corrective & Preventative Actions 6

Chapter 1 Introduction

1.1 Purpose of Document

This Root Cause Analysis addresses [redacted]

1.2 Definitions / Terminology

Circuit - A discrete (specific) path between two or more points along which signals can be carried. Unless otherwise qualified, a circuit is a physical path, consisting of one or more wires (or wireless paths) and possibly intermediate switching points. In this document, the term circuit is used to refer to the physical/electrical connectivity provided by third-party vendors like CenturyLink.

1.3 Acronyms

PT – Pacific Time

1.4 References

NA

Chapter 2 Root Cause Analysis

Incident Summary		
Customer Ticket Number	NA	
Comtech Ticket Number	TT-0156084	
FCC Report Number	[redacted]	
Date/Time	**Incident Start Time:**	[redacted]
	Point of Discovery:	[redacted]
	Tier II Escalation:	
	Tier III Escalation:	
	Vendor Engaged:	
	Carriers Notified:	[redacted]
	PSAPs Notified:	
	Restoration Time:	
	Incident Total Time:	[redacted]
Severity	[redacted]	
Product (s)	[redacted]	

2.1 RCA Summary

2.1.1 Description

[redacted]

2.1.2 Impact

[redacted].

2.1.3 Restoration

[redacted]

2.1.4 Cause

A faulty card in CenturyLink's network was sending out invalid traffic, [redacted]

2.2 Corrective & Preventative Actions

Issue No.	Issue Description	Team Assigned	Target Date
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Appendix H

Seattle leaders examine what went wrong, changes after 911 outage

VIDEO: Local leaders dig into problem when 911 system fails

Share Share

Share

By: Linzi Sheldon, KIRO 7 News
Updated: January 22, 2019 - 7:58 PM

SEATTLE — After a widespread CenturyLink outage took out 911 service throughout Washington state, Seattle city leaders are asking emergency experts for a breakdown of what went wrong, lessons learned and what the city needs to change should CenturyLink fail in the future.

Documents from Seattle police reveal there were actually two outages on Dec. 27. The first occurred at 12:46 a.m. and lasted for 32 minutes and the second was reported at 8:22 p.m. and lasted until 7:05 a.m. the next day.

In between the two outages, Seattle Police Department 911 officials reported intermittent outbound dialing issues and, later, that they could not connect to telephone language interpretation services.

Content Continues Below

>> RELATED: AG Ferguson asks Washingtonians affected by last month's 911 outage to share story

Seattle City Councilwoman Lorena Gonzalez said the city and county need to coordinate on how they notify the public during such an event.

“It can be really frustrating and scary for people if they need 911 services and they're being told by one agency to call a certain number and by a different agency to call a different number,” Gonzalez said.

Scroll down to continue reading

More news from KIRO 7

- Edgar Martinez voted into Baseball Hall of Fame
- PHOTOS: Edgar Martinez and The Double, Oct. 8,1995
- Trump says Catholic students 'treated unfairly' after encounter at National Mall
- Man threatens to shoot kids at 5 Edmonds daycares, police investigating
- **Do you have an investigative story tip? Send us an email at investigate@kiro7.com**

“Did you see that happening?” KIRO 7 reporter Linzi Sheldon asked.

“We did see that happen and, in committee tomorrow, we'll see some examples,” Gonzalez said.

She said she wants to hear about opportunities for improvements in the system, as well. Some of that will come from CenturyLink when it releases its report on the incident but other insight may come from city and county emergency experts.

“What contributed to it, from CenturyLink's perspective, and is there something we should be doing at the city to address some of those gaps in CenturyLink's technology?” she asked.

After the outage, KIRO 7 spoke with a woman who was in Tukwila when she heard shots and tried to call for help.

“Once they stopped and we knew we were both OK, I called 911, and that's when we were getting a busy signal,” a woman who identified herself as Kati M. said.

>> RELATED: Nationwide CenturyLink outage impacts 911 service in parts of Washington

The King County Sheriff's Office said it never got a call from the alarm company about a break-in at a Bank of America in SeaTac.

"The day that it actually happened was the same day 911 service was out nationwide, so we never got an alert from anybody—never got a call to 911 saying the alarm was going off," Sgt. Ryan Abbott said.

"People wanted to know: How is this possible? Isn't there a backup system or some sort of redundancies that would prevent this from completely going out?" Linzi Sheldon asked Gonzalez.

"I think the redundancy that we addressed through this is: We now have the capability of allowing people to text 911," Gonzalez said. "I think that it was really helpful for us to be able to have that system up and running. In fact, it was the only system that was up and running."

The challenge, she said, is ensuring people know about Text-to-911, the service that just debuted in King County last month.

And on the horizon is a new state 911 provider that would replace CenturyLink.

King County emergency experts told KIRO 7 on Tuesday that a new network and provider are expected to be in place by the end of 2019.

CenturyLink has another week to provide its report on the outage, which is its second major 911 outage in the area in the last 4 1/2 years.

Appendix I

From: Misty Viebrock <mviebrock@rivercom911.org>
To: ATG MI 911 Outage
CC: Misty Viebrock
Date: 1/24/2019 11:06:44 AM
Subject: 911 Outage - Impacts on RiverCom 911 and the Communities of Chelan & Douglas Counties (WA)

Attorney General Ferguson,

We posted a request on our website requesting citizens to notify you and/or me in regards to any and all impacts during the December 27th 911 outage. I'm not aware if you have received any emails from Chelan or Douglas County citizens. To date, I have not received any additional impacts beyond what I already knew about.

We do know that we received 911 calls up until 1941 hours that night and took no additional 911 calls after that point. At the time, we had a large brush pile fire that was very visible to citizens and had been receiving several 911 calls about it right up to 1941 hours.

We were made aware of the outage on the evening of December 27, 2019 around 2011 hours when we received a business line call from Northern 911 relaying two 911 hang-up calls they had received, originating from a citizen in Chelan, WA. The number was a T-Mobile wireless customer. Once Northern 911 provided us the cell phone number we immediately called it back. We reached a gentlemen who said he tried to call 911 numerous times from a cell phone and a landline but could not get through. His daughter was having a medical emergency and he made the decision to transport her to the hospital in his personal vehicle.

I have not been made aware of any other emergencies or impacts to the two counties we serve. I'm confident there were others and predict there were likely more callers trying to reach us in regards to the above noted brush pile fire.

I will be sure to pass along any additional information we may receive from our citizens.

If possible, I would also appreciate it if you could forward any reports to me that you receive on behalf of Chelan and Douglas Counties.

Thank you very much for your time and for the attention you have placed on this serious matter.

Misty Viebrock, RPL
Executive Director
RiverCom 911
mviebrock@rivercom911.org
Desk – 509 662 4651
Cell – 509 630 9752
Website: www.rivercom911.org

Appendix J

From: as.1973 <as.1973@comcast.net>
To: ATG MI 911 Outage
Date: 1/21/2019 8:47:03 AM
Subject: Affected by 911 outage

Sent from my Verizon, Samsung Galaxy smartphone

-------- Original message --------
From: "as.1973"
Date: 1/9/19 6:29 PM (GMT-08:00)
To: 911outage@atg.wa.gov
Subject: Affected by 911 outage

Hello
I was tod by several people to contact you as we were affected by the 911 .

On morning of dec 28 around 830 am my husband was having breathing issues an thought he may just be hyper ventilating at first .sat him on the bed where immediately writhin 10 seconds he collapsed forward .
I called for our 15 yr old to help me . Grabbed phone to call 911 an got busy signal called the local number that I wrote down night before as my mom has medical issues an may have needed it . It was busy as well. Daughter an I got him dressed carried him on my back to the truck as he collapsed 2 x in process . He weighs around 280 lbs. I got him to the truck and somehow in (we drive a f150) turnedon hazards an drove to hospital in lacey Olympia st Peters.

He was responded to my questions as I was driving asking his name my name bdate. But as we pulled up to hospital he was not speaking as his jaws clenched shut.
Got a dr ti come get him his BP
Was 258 /138 I believe the first one . He was in ER fir 2 days as there was no rooms for him . His BP did not come down for over 14 hours to a "nornal" level .
He remained in the hospital January 3rd

He is now home but will be taking several meds at exact time now an will be doing physical therapy due to BP being so high so long . He will also be seeing a opthamologist as he has lost some vision in his right eye an sensitive to light that causes halos an headaches at least 3 x a day now

If you would like to speak to him my husbands name is David white
253 878 3132
Or
Can email us at
Davidiwhite@comcast.net

Thank u so much as I am writing this fast
Please call with more detailed info

Sent from my Verizon, Samsung Galaxy smartphone

Appendix K

From: Samantha Hovey <samanthahovey@outlook.com>
To: ATG MI 911 Outage
Date: 1/8/2019 5:19:36 PM
Subject: 911 outage skagit county mount Vernon wa

On the night of 911 outage my husband and i came home to catch someone prowling in our yard. I called 911 multiple times only to be met with a busy signal. So i did the only thing i could think of was call my mom in Snohomish county. She called her 911 and was tald ma'am do you know your not callimg the right 911. Meanwhile my husban literally chased the guy off our property. The cop was nice but definitely didnt take my concerns seriously.

Samantha Hovey
360 488 3426

Get Outlook for Android

Appendix L

From: Victor Barajas <vicbarajas509@gmail.com>
To: ATG MI 911 Outage
Date: 1/8/2019 2:28:06 PM
Subject: 911 unavailability

Around 1:40am Dec 28th, I was driving to work on I-182 westbound when I caught ice and rolled my vehicle about 3 times. I was unable to get through to 911 after numerous attempts. I ended up having to call a family member whom contacted the State patrol through the non emergency line. I was still in shock and unable to really process what had happened to the point where I didn't even think about calling the non emergency line. All in all, I believe help did not arrive until about 30 minutes after the incident. Luckily, I was not seriously injured and walked away with minor bruises.

Please feel free to contact me with any questions or comments and I hope this does not happen again as the next person that needs emergency response assistance might not be as lucky as me.

Victor Barajas
(509) 396-1770

CP1. The number of Washington affected customers, identified by customer type (commercial or residential), and Comtech services affected.

In the State of Washington, TCS provides 911 telecommunications services to commercial carriers and state and local government entities. Since TCS does not directly provide any telecommunications services to commercial or residential customers, TCS does not have insight into and is unable to provide the requested number of affected commercial and residential customers.

TCS is able to comment on its impacted services in Washington. Specifically, the large-scale CenturyLink outage produced network connectivity failures such that [redacted]

CP2. A chronology of all internal communications related to the outage, including summaries of telephone calls and copies of any emails or other written correspondence.

A chronology summarizing TCS's internal communications and copies of such emails relating to the December 27, 2018 emergency 911 call dispatch systems failure that caused outages throughout the state of Washington ("Washington Outage") are attached hereto as **Exhibit A**. TCS is unable to provide a chronology or summary of internal telephone calls relating to the Washington Outage as TCS does not maintain records or recordings of telephone calls.

CP3. A chronology of all communications with stakeholders related to the outages (such as commission staff, other federal, state, county, and local governments), including summaries of telephone calls and copies of any emails or other written correspondence.

Copies of emails with stakeholders relating to the Washington Outage are attached hereto as **Exhibit B**. Due to the extensive number of the emails provided in response to the request, over 600 pages in length, TCS was unable to create a chronology of such communications. In addition, TCS is unable to provide a chronology or summary of telephone calls relating to the Washington Outage as TCS does not maintain records or recordings of telephone calls.

CP4. A chronology of service restoral by location, number of customers, and service type.

TCS has multiple customers active in the State of Washington, including commercial mobile relay service ("CMRS") providers, voice over Internet Protocol ("VoIP") service providers, and state-level public safety providers. Each type of customer was impacted differently by the large-scale CenturyLink outage.

[redacted]

	Start Date	Start Time	End Date	End Time	Outage Duration
[redacted]					
[redacted]					
[redacted]					
[redacted]					

[redacted] TCS believes that the root cause of the impairment was a faulty card in CenturyLink's network that was sending out invalid traffic, which caused a series of cascading network failures.

CP5. At the time of the outage, did Comtech have a communications plan in place? If so, please provide a copy.

Each TCS customer agreement contains customer communications procedures designed to address various impairment or outage scenarios. Such communications procedures often vary significantly from customer to customer. During and after the Washington Outage, TCS utilized such communications procedures, and also sought to provide additional customer communication whenever possible.

TCS also has protocols in place for non-customer communications during outages and events. This may include regulatory agencies at the federal and state level, non-customer local jurisdictions or Public Safety Answering Point ("PSAP") entities, infrastructure or networking partners and vendors, third-party entities and, in rare instances, the general public and the press.

CP6. Please provide a summary of any credits for the outage that were/will be provided.

In some instances, individual TCS customer contracts contain service credit terms and conditions. The Washington Outage event, however, did not result in any customers qualifying for service credits under applicable customer contract terms and conditions and, as such, no service credits have been issued.

CP7. The name, title, telephone number, and email address of the contact person whom our staff can work with directly for questions that may arise concerning any details of the information provided.

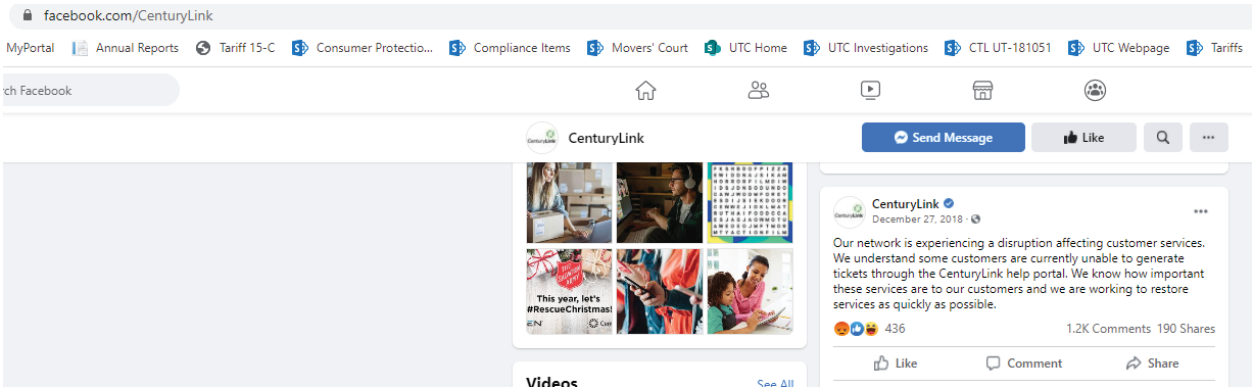
Please direct all inquiries on this matter to:

Susan C. Goldhar Ornstein
Senior Director, Legal & Regulatory Affairs
Safety & Security Technologies
Comtech Telecommunications Corp.
275 West Street, Suite 200
Annapolis, MD 21401
202-794-4102
susan.ornstein@comtechtel.com

CP8. Please provide any and all vendor agreements between CenturyLink and Comtech.

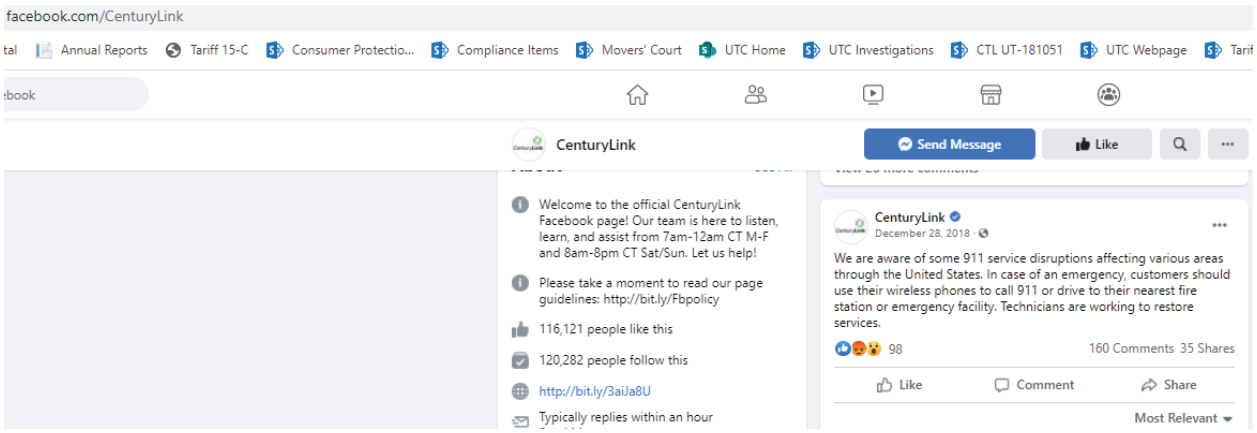
TCS's vendor agreements and circuit orders with CenturyLink that relate to TCS service offers in the State of Washington are attached hereto as **Exhibit C**.

Appendix N



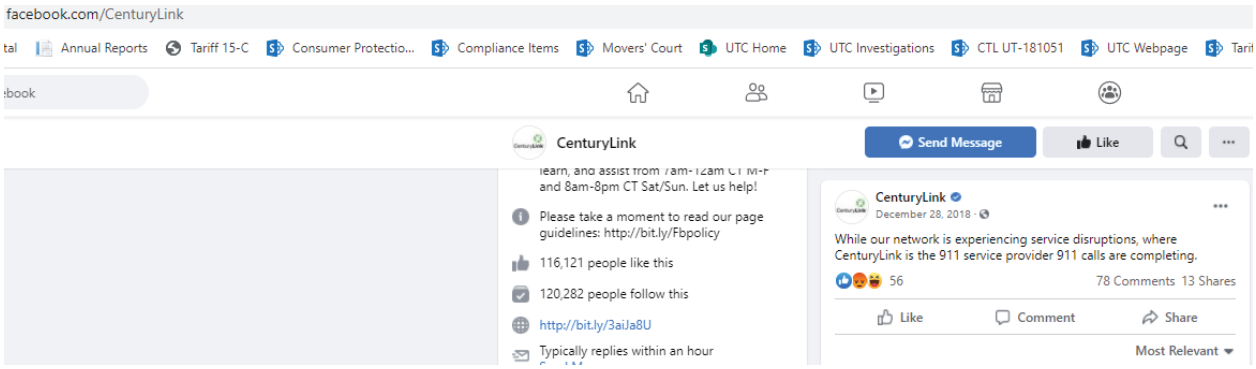
Screenshot of CenturyLink's Facebook page of 10:06 a.m. Dec. 27, 2018, post.

Appendix O



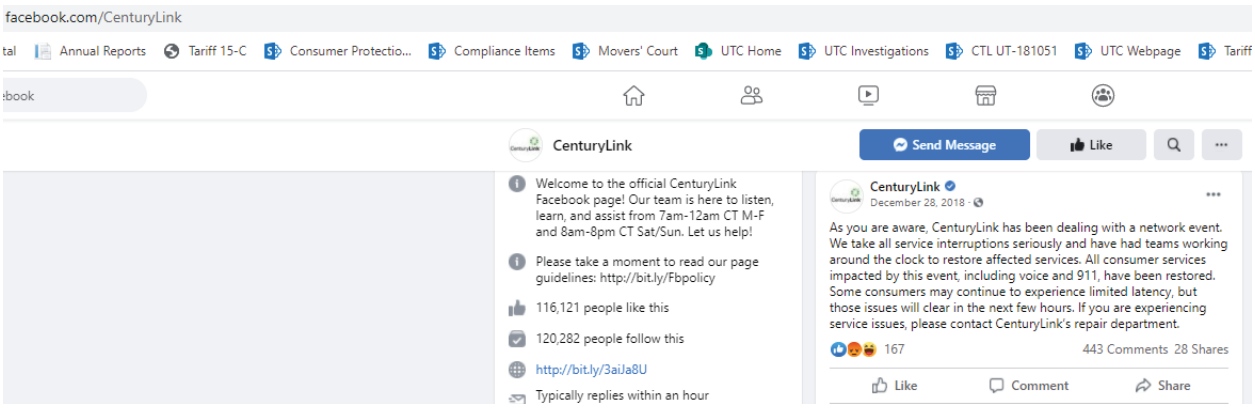
Screenshot of CenturyLink's Facebook page of 10:14 a.m. Dec. 28, 2018, post.

Appendix P



Screenshot of CenturyLink's Facebook page of 11:44 a.m. Dec. 28, 2018, post.

Appendix Q



Screenshot of CenturyLink's Facebook page of 6:09 p.m. Dec. 28, 2018, post.

Appendix R

LOCAL

911 service restored after widespread CenturyLink outage

The FCC is launching an investigation into a CenturyLink outage that impacted thousands of people nationwide. The company says they were not hacked.

Centurylink: outage not related to hacking

Author: **KING Staff**
Published: **8:57 PM PST December 27, 2018**
Updated: **7:02 PM PST December 28, 2018**

CenturyLink consumer service, including calls to 911, was restored as of Friday night, according to a statement. The company says any latency issues related to the outage will be cleared in the coming hours.

A spokesperson says the outage that prevented people across the country from being able to call 911 is not related to hacking. However, the spokesperson would not comment further, according to The Associated Press.

The Federal Communications Commission is launching an investigation into the nationwide CenturyLink outage which impacted the ability for thousands of people to promptly reach emergency services.

RELATED: Washington state to investigate CenturyLink 911 outage

FCC Chairman Ajit Pai released the following statement:

"When an emergency strikes, it's critical that Americans are able to use 911 to reach those who can help. The CenturyLink service outage is therefore completely unacceptable, and its breadth and duration are particularly troubling. I've directed the Public Safety and Homeland Security Bureau to immediately launch an investigation into the cause and impact of this outage. This inquiry will include an examination of the effect that CenturyLink's outage appears to have had on other providers' 911 services. I have also spoken with CenturyLink to underscore the urgency of restoring service immediately. We will continue to monitor this situation closely to ensure that consumers' access to 911 is restored as quickly as possible."

RELATED: Thurston County 911 reflects on service outage and how to plan for disaster

The North East King County Regional Public Safety Communication Agency (NORCOM) says if you dial 911 and receive a fast busy signal, hang up and try using a different phone. If you still experience issues and you are in NORCOM's service area, you can text 911 or call the emergency line at 425-577-5656.

Click here for a map of NORCOM's service area.

In case of an emergency and you can't get through by dialing 911, you can dial the following numbers for dispatch centers:

Chelan/Douglas County 911

Countywide 911 Center for Police and Fire

(509) 663-9911

Clallam County 911

Countywide 911 Center for Police and Fire

360-417-2259/2459 or 360-417-4970

Grays Harbor 911

Countywide 911 Center for Police and Fire

(800) 281-6944

Island County 911

Countywide 911 Center for Police and Fire

(360) 678-6116

Jefferson County 911

Countywide 911 Center for Police and Fire

360-385-3831 or 360-344-9779 EXT. 0 or text 911

King County 911

Bothell Police (425) 486-1254

Enumclaw Police (360) 417-2259

Lake Forrest Park Police (425) 486-1254

Issaquah Police (425) 837- 3200

Redmond Police (425) 556-2500

Snoqualmie Police (425) 888-3333

Seattle Police (206) 625-5011

Seattle Fire (206) 583-2111

Norcom (425) 577-5656

- Fire Departments – Bellevue FD, Bothell FD, Duvall FD, Eastside Fire and Rescue, Fall City FD, Kirkland FD, Mercer Island FD, Northshore FD, Redmond FD, Shoreline FD, Skykomish FD, Snoqualmie FD, Snoqualmie Pass Fire and Rescue and Woodinville Fire and Rescue
- Police Departments – Bellevue PD, Clyde Hill PD, Medina PD, Kirkland PD, Mercer Island PD and Normandy Park Police.

Valley Com (253) 852-2121

- Fire Departments - Valley Regional Fire Authority (Algona, Pacific and Auburn), South King Fire and Rescue (Federal Way and Des Moines), Puget Sound Regional Fire Authority (Kent, Seatac, Covington and Maple Valley), Tukwila FD, Renton FD, Burien /Normandy Park FD, Skyway Fire, Mountain View Fire and Rescue, Palmer Selleck Fire Districts, Vashon Island Fire and Rescue, Enumclaw FD, King County Airport (Boeing Field) and King County Medic One
- Police Departments - Algona PD, Pacific PD, Auburn PD, Des Moines PD, Federal Way PD, Kent PD, Renton PD and Tukwila PD.

King County Sheriff's Office (206) 296-3311

- Town of Beaux Arts, City of Burien, City of Carnation, City of Covington, City of Kenmore, King County Airport Police (Boeing Field), City of Maple Valley, King County Metro Transit, Muckleshoot Indian Tribe, City of Newcastle, City of Sammamish, City of Seatac, City of Shoreline, Town of Skykomish, Sound Transit and City of Woodinville.

Kitsap County 911

Countywide 911 Center for Police and Fire

(360)-308-5400

Kittitas County 911

Lower County: 509 925 8534

Upper County: 509 674 2584,

select 1, then select 1 for KITTCOM

Lewis County 911

Countywide 911 Center for Police and Fire

(360) 740-1105

Mason County 911

Countywide 911 Center for Police and Fire

(360) 426-4441

Pacific County 911

Countywide 911 Center for Police and Fire

(360) 875-9397

Pierce County 911

Countywide 911 Center for Police and Fire

(253) 798-4722

*Except Tacoma, Fircrest, Fife and Ruston - call Tacoma Fire Dispatch (253)627-0151

San Juan County 911

Countywide 911 Center for Police and Fire

(360) 378-4151

Skagit County 911

Countywide 911 Center for Police and Fire

(360) 428-3211

Snohomish County 911

Countywide 911 Center for Police and Fire

(425) 407-3999

Thurston County 911

Countywide 911 Center for Police and Fire

(360) 704-2740

Whatcom County 911

Whatcom County Fire (360) 676-6814

Whatcom County Sheriff (360) 676-6911

Several police departments across Western Washington posted about the problem on social media Thursday.

Appendix S

From:	Beaton, Rebecca (UTC)
To:	Fukano, Harry (UTC); Hawkins-Jones, Jacque (UTC)
Subject:	CenturyLink outage 12/27/18 (Statewide) update 6:00 am
Date:	Monday, December 21, 2020 3:10:53 PM

From: Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov>
Sent: Friday, December 28, 2018 6:32 AM
To: Thomas, Brian (UTC) <brian.thomas@utc.wa.gov>; Maxwell, Amanda (UTC) <amanda.maxwell@utc.wa.gov>; Johnson, Mark L. (UTC) <mark.l.johnson@utc.wa.gov>; Balasbas, Jay (UTC) <jay.balasbas@utc.wa.gov>; Danner, Dave (UTC) <dave.danner@utc.wa.gov>; UTC DL Telecom-Outage <Telecom-Outage@utc.wa.gov>; Rendahl, Ann (UTC) <ann.rendahl@utc.wa.gov>
Subject: Re: CenturyLink outage 12/27/18 (Statewide) update 6:00 am

[redacted]

Thank you,
Rebecca Beaton
Regulatory Services,
Utilities and Transportation Commission
tel: 360.664.1287
cell: 360.464.7236
Rebecca.beaton@utc.wa.gov

Information may be confidential and use by other than addressee prohibited.

On December 27, 2018 at 11:27:39 PM PST, Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov> wrote:

> [redacted]
>
> Thank you,
> Rebecca Beaton
> Regulatory Services,
> Utilities and Transportation Commission
> tel: 360.664.1287
> cell: 360.464.7236

Rebecca.beaton@utc.wa.gov

Information may be confidential and use by other than addressee prohibited.

On December 27, 2018 at 10:55:42 PM PST, Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov> wrote:

[redacted]

Thank you,
Rebecca Beaton
Regulatory Services,
Utilities and Transportation Commission
tel: 360.664.1287
cell: 360.464.7236
Rebecca.beaton@utc.wa.gov

Information may be confidential and use by other than addressee prohibited.

Appendix T

From: Grate, Phil [mailto:Phil.Grate@CenturyLink.com]
Sent: Saturday, December 29, 2018 1:24 PM
To: Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov>; Clow, Jacob <Jacob.Clow@CenturyLink.com>
Cc: Roth, Jing (UTC) <jing.roth@utc.wa.gov>; Vasconi, Mark (UTC) <mark.vasconi@utc.wa.gov>
Subject: RE: UTC Request and Inquiry - Outage Reporting CenturyLink 12/27 outage

Rebecca,

[redacted]

Dec. 28, 2018

Media Contact: (360) 664-1116 or media@utc.wa.gov

State regulators to investigate today's statewide 911 service outage

OLYMPIA, Wash. – The state Utilities and Transportation Commission (UTC) announced that it will open an investigation into this week's statewide enhanced 911 (E911) service outage.

The UTC's investigation will look into the cause of the outage, the company's emergency preparedness and response, restoration efforts, and communication with the public.

E911 services began experiencing interruptions in Washington around 8:30 p.m. on Thursday, Dec. 27. CenturyLink reported this morning that E911 service appears stable in Washington state, although the company's restoration efforts continue.

In the event you cannot reach 911, contact your local police or fire department. For a list of statewide alternate numbers, click here.

The commission is the state agency in charge of regulating landline telephone companies operating in Washington. It is the commission's responsibility to ensure regulated companies provide safe and reliable service to customers at reasonable rates, while allowing them the opportunity to earn a fair profit. The commission does not regulate the rates of broadband services, cellular, cable or Internet service.

###

Please let me know if you have any questions about this.

From: Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov>
Sent: Friday, December 28, 2018 3:48 PM
To: Clow, Jacob <Jacob.Clow@CenturyLink.com>; Grate, Phil <Phil.Grate@CenturyLink.com>
Cc: Roth, Jing (UTC) <jing.roth@utc.wa.gov>; Vasconi, Mark (UTC) <mark.vasconi@utc.wa.gov>
Subject: RE: UTC Request and Inquiry - Outage Reporting CenturyLink 12/27 outage

Thank you,
Rebecca Beaton
Regulatory Services Division, Utilities and Transportation Commission
T (360) 664-1287 | M (360) 464-7236 | E rebecca.beaton@utc.wa.gov
Information may be confidential and use by other than addressee is prohibited.This e-mail states the informal opinions of commission staff and are not intended as legal advice. We reserve the right to amend these opinions and Staff opinions are not binding on the commission.

From: Clow, Jacob [mailto:Jacob.Clow@CenturyLink.com]
Sent: Friday, December 28, 2018 3:45 PM
To: Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov>; Grate, Phil <Phil.Grate@CenturyLink.com>
Cc: Roth, Jing (UTC) <jing.roth@utc.wa.gov>; Vasconi, Mark (UTC) <mark.vasconi@utc.wa.gov>
Subject: RE: UTC Request and Inquiry - Outage Reporting CenturyLink 12/27 outage

Rebecca,

[redacted]

Jacob Clow
Sr. Post Sales Engineer
Customer Lifecycle Management
CenturyLink
310 SW Park 7th Fl.
Portland, OR 97205
Office: 503-425-3328
Cell: 503-349-3587
e: jacob.clow@centurylink.com

From: Beaton, Rebecca (UTC) <rebecca.beaton@utc.wa.gov>
Sent: Friday, December 28, 2018 3:15 PM
To: Clow, Jacob <Jacob.Clow@CenturyLink.com>; Grate, Phil <Phil.Grate@CenturyLink.com>
Cc: Roth, Jing (UTC) <jing.roth@utc.wa.gov>; Vasconi, Mark (UTC) <mark.vasconi@utc.wa.gov>
Subject: UTC Request and Inquiry - Outage Reporting CenturyLink 12/27 outage

Hi Jacob and Phil,

Will you be filing a update report or final with the UTC today? Staff has not received an update since 8:22 am in your usual report format with impact, timeline, agencies notified, etc. Thank you for the call this morning Phil. Jacob, thank you for your availability last night and early this morning.

Jacob Clow
CenturyLink
911 Senior Sales Engineer (WA/OR)

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(503) 349-3587 Mobile
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310 SW Park, 7th floor
Portland Or 97205

Philip Grate, Esq.
CenturyLink
Director, Regulatory and Legis Affairs

(206) 345-6224 Work
(425) 301-8411 Mobile
Phil.Grate@CenturyLink.com
1600 7th Ave
Seattle WA 98191

PUC Report

Report Number :

Impacted Company :

Date and Time :

TIMEZONE :

For Questions Contact :

Reason for Outage Notification :

Cause of Outage :

Location of Outage :

Exchange Name / Wire Center :

Expected Duration :

Actual Duration :

Number of Customers/ Cable pair impacted :

Services Affected :

Agencies Notified :

Significant Update :

Resolution :

Restore Date/Time :

Thank you,
Rebecca Beaton
Regulatory Services Division, Utilities and Transportation Commission
T (360) 664-1287 | M (360) 464-7236 | E rebecca.beaton@utc.wa.gov
Information may be confidential and use by other than addressee is prohibited.This e-mail states the informal opinions of commission staff and are not intended as legal advice. We reserve the right to amend these opinions and Staff opinions are not binding on the commission.

From: Clow, Jacob [mailto:Jacob.Clow@CenturyLink.com]
Sent: Friday, December 28, 2018 8:22 AM
To: UTC DL Telecom-Outage <Telecom-Outage@utc.wa.gov>
Subject: Centurylink 12/27 outage

Ticket notes from [redacted]

12/28/2018 06:19:37 AM PST	[redacted]		ac10002	Comment Ext

[redacted]

[redacted]

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Appendix U

December 27-28, 2018 – Multi-State Outage Summary

Incident Start: December 27, 2018 at 3:40 a.m. (ET)
Incident Stop: December 28, 2018 at 11:36 p.m. (ET)
Note - While most services restored on December 28, 2018 at 11:36 p.m. (ET), residual impact remained for a small subset of customers. Due to the nature of this event restoral times varied; however, all service restored by December 29.

Incident Summary:

- [redacted]
- [redacted]
- [redacted]
  - [redacted]
- [redacted]
- [redacted]

Impacts:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Post Event Actions:

- [redacted]
- [redacted]
- [redacted]