

**Exh. RA-1CT
Docket UT-181051
Witness: Dr. Robert Akl**

**BEFORE THE WASHINGTON UTILITIES AND
TRANSPORTATION COMMISSION**

**WASHINGTON UTILITIES AND
TRANSPORTATION COMMISSION,**

Complainant,

v.

**CENTURYLINK COMMUNICATIONS,
LLC.,**

Respondent.

DOCKET UT-181051

REPLY TESTIMONY OF

ROBERT AKL, D.Sc.

ON BEHALF OF

**STAFF OF
WASHINGTON UTILITIES AND
TRANSPORTATION COMMISSION**

August 31, 2022

TABLE OF CONTENTS

I. INTRODUCTION 1
II. SUMMARY OF CONCLUSIONS..... 2
III. DISCUSSION 2

LIST OF EXHIBITS

RA-2 Dr. Robert Akl CV

RA-3 Broadcom Storage Area Networking Design and Best Practices Design Guide

1 I. INTRODUCTION

2

3 Q. Please state your name, and address.

4 A. My name is Robert Akl. My address is 3030 McKinney Ave, #2301, Dallas, TX 75204.

5

6 Q. By whom are you employed and in what capacity?

7 A. I am a tenured associate professor in the computer science and engineering department at
8 the University of North Texas (UNT).

9

10 Q. How long have you been employed by UNT?

11 A. For 20 years.

12

13 Q. Have you testified previously before the Commission?

14 A. No, I have not.

15

16 Q. What is the purpose of your testimony in this proceeding?

17 A. I testify on behalf of the Washington Utilities and Transportation Commission staff
18 (Staff). My testimony provides an independent evaluation of: (1) the causes of the
19 outages on CenturyLink Communications, LLC's (CenturyLink) Red network in
20 February 2018 and Green network in December 2018, as well as the relationship between
21 those two events; (2) the foreseeability of the Green network outage after the occurrence
22 of the Red network outage; and (3) CenturyLink's responsibility for failing to take the
23 necessary action, following the February 2018 Red network outage, that it knew or

1 should have known would have prevented the Green network outage, and therefore the
2 resulting Washington E911 service outage, in December of 2018.

3
4 **Q. Have you prepared any exhibits in support of your testimony?**

5 A. Yes. I offer two exhibits:

- 6 1. Exh. RA-2 is a copy of my CV; and
- 7 2. Exh. RA-3 is a copy of the Broadcom Storage Area Networking Design
8 and Best Practices Design Guide.

9
10 **II. SUMMARY OF CONCLUSIONS**

11
12 **Q. Do you agree with the general conclusions that Staff Witness James Webber reaches**
13 **on those issues, referenced above, in his testimony?**

14 A. Yes. I agree with the general conclusions that Witness Webber reaches on each of those
15 issues in his testimony. I also provide additional insights into why those conclusions are
16 correct.

17
18 **III. DISCUSSION**

19
20 **Q. Did you review the response testimony and exhibits submitted in this proceeding by**
21 **CenturyLink Witnesses Stephen Turner, Martin Valence, and Thomas McNealy?**

22 A. Yes, I have. My review focused on their testimony and supporting exhibits concerning
23 the causes of the December 2018 failure of CenturyLink's Green transport network and

1 its relationship to the February 2018 Red network failure, as well as how the Green
2 network's failure impacted the delivery of 911 calls in Washington State during
3 December 27-29 of 2018. In addition, I reviewed Witness Webber's direct testimony and
4 exhibits offered on behalf of Staff, as well as his cross-answering testimony and exhibits
5 filed simultaneously with this testimony.

6
7 **Q. Please summarize your findings from that review.**

8 A. While I reserve the right to modify or augment my findings should new relevant evidence
9 be introduced in this case, at this time I summarize my findings as follows:

10 1. CenturyLink's two digital long-haul transport networks at issue, the Green and
11 Red networks, had architectures that relied upon [REDACTED] switching
12 nodes and related hardware and software supplied by the equipment vendor
13 Infinera Corporation (Infinera). Infinera's practice had been to provision its
14 [REDACTED] nodes with certain communications paths between their associated
15 line modules, known as Infinera General Communications Channels (IGCCs),
16 enabled ("unlocked") by default.¹ CenturyLink knew that the IGCCs on both its
17 Red and Green networks were enabled, but neither configured nor used them, and
18 left them in their enabled/unlocked state. By neglecting to disable/close those
19 unused IGCCs, CenturyLink left both networks vulnerable to the debilitating
20 effects of a packet storm. An engineer can easily disable unused IGCCs with very
21 minimal software provisioning, just a few lines of code.²

¹ Webber, Exh. JDW-4 at 6, 14. *See also* Webber, Exh. JDW-37C at 1.

² Webber, Exh. JDW-37C at 1; Webber, Exh. JDW-42C at 3-4.

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2. And both networks did, in fact, suffer severe disruptions from a packet storm event due to these unlocked IGCCs, the Red network in February 2018 and the Green network on December 27-29, 2018—the latter of which caused the statewide Washington E911 service outage at issue in this proceeding.

Importantly, I note that Infinera’s Senior Director, Witness McNealy, admits that both network outages had [REDACTED]
[REDACTED]
[REDACTED].³ In both events, [REDACTED]
[REDACTED]
[REDACTED].

3. CenturyLink’s managers of the Green network during 2018 bear responsibility for that network’s outage; it was CenturyLink’s decision, and not Infinera’s, as to whether the enabled, yet unused IGCCs should be turned off or disabled on that network following the Red network outage. Furthermore, as revealed by February 2018 emails between CenturyLink network operations managers during the aftermath of the Red network packet storm and outage, [REDACTED]
[REDACTED]
[REDACTED].⁴

³ See McNealy, Exh. TJM-1TC at 9:14-20; Webber Exh. JDW-5C at 24.
⁴ Webber, Exh. JDW-1CT at 30:11 – 31:2; Webber, Exh. JDW-37C at 1-2.

1 **Q. Witness Webber concludes that “the primary and avoidable cause of the**
2 **Washington E911 network outage in December 2018 was CenturyLink’s failure to**
3 **disable certain unused communications paths, known as [REDACTED], between the**
4 **nodes on its [REDACTED].”⁵ Do you agree with Witness**
5 **Webber on that point?**

6 **A. Yes, I agree. CenturyLink [REDACTED]**
7 **[REDACTED] in its February 2019 Root Cause Analysis of that**
8 **incident, stating:**

9 [REDACTED]
10 [REDACTED].⁶

11
12 The Federal Communications Commission (FCC) report on the Green network failure
13 expanded on this in more depth:

14 There are several best practices that could have prevented the outage, or at
15 least mitigated its effects:

16
17 System features that are not in use should be turned off or disabled. In this
18 case, the proprietary management channel [IGCC] was enabled by default
19 so that it could be used if needed. While CenturyLink did not intend to use
20 the feature, CenturyLink left it unconfigured and enabled. Leaving the
21 channel enabled created a vulnerability in the network that, in this case,
22 contributed to the outage by allowing malformed packets to be continually
23 rebroadcast across the network.⁷

24
25 And elsewhere in that report, the FCC made clear that the severity of the outage was
26 caused by the packet storm phenomenon, and not the creation of the relatively small
27 number of malformed packets that triggered the storm:

⁵ Webber, Exh. JDW-1CT at 6:20 – 7:1.

⁶ Webber, Exh. JDW-14C at 2.

⁷ Webber, Exh. JDW-4 at 15 (citing Communications Security, Reliability and Interoperability Council, Best Practices 11-6-5170, 11-8-8000 (2011)).

1 This outage was caused by an equipment failure catastrophically
2 exacerbated by a network configuration error.⁸
3

4 **Q. Do you agree with Witness Webber’s conclusion that “[t]hose ‘unlocked’ (i.e.,**
5 **enabled) [REDACTED] were the primary reason that just four malformed packets could**
6 **propagate and escalate into a debilitating packet storm”?**⁹

7 A. Yes, I agree. In both the Red and Green network outages, if the IGCC channels were
8 disabled instead of being left open while being neither used nor configured for use, those
9 malformed packets could not have propagated across those networks and replicated in
10 exponential fashion, and instead would have had no discernible impact on the networks’
11 performance.
12

13 **Q. Do you agree with Witness Valence¹⁰ and Witness McNealy¹¹ that the December**
14 **2018 outage on the Green Network was not foreseeable?**

15 A. No, I do not. Witness McNealy’s foreseeability analysis minimizes the IGCC links and
16 their role in the outage – [REDACTED]
17 [REDACTED]
18 [REDACTED].¹² Witness Valence’s
19 testimony simply echoes Witness McNealy in asserting that the two outages “were
20 extremely different, and had different root causes”—and that “the December 2018 outage
21 was not foreseeable.”¹³ Witness Valence fails to supply relevant new documents or other

⁸ Webber, Exh. JDW-4 at 3.

⁹ Webber, Exh. JDW-1CT at 7:1-3.

¹⁰ See, e.g., Valence, Exh. MDV-1TC at 11:2-3 (“...the December 2018 outage was not foreseeable.”).

¹¹ See McNealy, Exh. TJM-1TC at 2:14-15 (stating that “the Green Outage was not foreseeable or predictable,”); *id.* at 8:14 – 9:13.

¹² McNealy, Exh. TJM-1TC at 4:8 – 5:2; *id.* at 9:14-20; Webber, Exh. JDW-5C at 24.

¹³ Valence, Exh. MDV-1TC at 10:20 – 11:3.

1 evidence to support these claims and instead relies almost entirely upon excerpts from
2 Witness McNealy's testimony.

3
4 **Q. Is it your opinion that if CenturyLink disabled (locked) the IGCCs on the Green
5 Network that the outage could not have occurred?**

6 A. Yes. It was the packet storms, and not simply the creation of a few malformed packets,
7 that drove the Red network, and later the Green network, to fail. And in both networks'
8 failures, their vulnerability to a packet storm was directly caused by the fact that
9 CenturyLink left the IGCCs on those networks enabled (i.e., open to transmit packets),
10 even though it was not using them. As mentioned above, [REDACTED]

11 [REDACTED]
12 in its February 2019 Root Cause Analysis of that incident, [REDACTED]
13 [REDACTED]

14
15 **Q. Do you agree with CenturyLink's assertion [REDACTED]
16 [REDACTED]?¹⁵**

17 A. No, I do not. CenturyLink erred [REDACTED]
18 [REDACTED] rather than taking the simplest and most direct
19 preventative measure of disabling the unused IGCCs to block all types of packets.

¹⁴ Webber, Exh. JDW-14C at 2.
¹⁵ See, e.g., McNealy, Exh. TJM-1TC at 7:15 – 8:2 [REDACTED]
[REDACTED]; *id.* at 8:3-6 (' [REDACTED]
[REDACTED]).

1 In fact, the FCC reached the same conclusion in its report on the Green network
2 outage, finding that “leaving the channel [IGCCs] enabled created a vulnerability in the
3 network”¹⁶ and that:

4 In this case, filters were designed to only mitigate specific risks. Thus,
5 catch-all filters should be designed to only allow for expected traffic. In
6 this event, the filter prevented transmission of packets 64 bytes or fewer
7 over the proprietary management channels [IGCCs], regardless of packet
8 content. Because other characteristics of the packet were not considered,
9 the malformed packets were able to propagate.¹⁷
10

11 **Q. In your opinion, did CenturyLink’s [REDACTED]
12 [REDACTED], render manual disablement of the
13 IGCCs on the Green Network unnecessary?**

14 **A.** No. This conclusion follows from the explanation provided above regarding the
15 circumstances in which software-based packet filtering is and is not appropriate. In the
16 circumstances of the Green network in 2018 (i.e., having enabled but unused IGCCs on
17 that network), it was neither reasonable nor was it appropriate—due to industry standards
18 at the time and the relative ease of the fix (i.e., disabling the unused IGCCs)—[REDACTED]
19 [REDACTED]
20 [REDACTED]. Instead, disabling the unused
21 IGCCs was the most reasonable, appropriate, and necessary course:

22 The first and simplest line of defense is to persistently disable all unused
23 ports, preventing someone without management privileges from
24 connecting to the fabric. It is vital to use the persistent disable option to
25 ensure that disabled ports remain disabled after a reboot or power cycle.
26 Otherwise, an attacker could unplug the switch to re-enable unused
27 ports.¹⁸

¹⁶ Webber, Exh. JDW-4 at 15.

¹⁷ Webber, Exh. JDW-4 at 15.

¹⁸ Akl, Exh. RA-3 at 75-76.

1 **Q. Was the December 2018 Green network outage sufficiently similar to the February**
2 **2018 Red Network outage, such that it would have been prudent for CenturyLink to**
3 **disable the Green network’s IGCCs following CenturyLink’s analysis of the cause**
4 **of the Red network outage (which involved a packet storm in which malformed**
5 **packets propagated exponentially over the unused but yet unlocked IGCCs on the**
6 **Red network)?**

7 A. Yes, it was. [REDACTED]
8 [REDACTED]
9 [REDACTED]
10 [REDACTED]
11 [REDACTED]
12 [REDACTED]
13 [REDACTED]

14 [REDACTED].²⁰ However, CenturyLink failed to take
15 the same preventative course of action on its Green network prior to its December 2018
16 catastrophic failure—despite its awareness of the problem from earlier that year.

17
18 **Q. Do the specific characteristics of the malformed packets involved in each outage**
19 **change your conclusion in any way?**²¹

¹⁹ Webber, Exh. JDW-4 at 3 (stating that the Green network equipment failure was “catastrophically exacerbated by a network configuration error”); Webber, Exh. JDW-5C at 5 (Red Network).
²⁰ Webber, Exh. JDW-5C at 3; Webber, Exh. JDW-37C at 1-2.
²¹ I note that McNealy and Valence emphasize that [REDACTED]
[REDACTED]). *See, e.g.*, McNealy, Exh. TJM-1TC at 8:14 – 10:6; Valence, Exh. MDV-1TC at 10:20 – 11:2; *id.* at 17:16-18.

1 A. No, they do not. CenturyLink’s witnesses seek to downplay the role of the unused, yet
2 enabled, IGCCs in the two network failures, and instead emphasize that the root cause of
3 the two network outages was the generation of ██████████ malformed packets.²²
4 Based on the evidence that I reviewed in this proceeding, I also conclude that the initial
5 triggering event for both network outages was that malformed packets were generated in
6 error. But, as I explained earlier in my testimony, the presence of the enabled/unlocked
7 IGCCs was critical and directly caused the escalation of that initial error into a network-
8 wide outage. Only by virtue of the fact that the initial set of malformed packets were able
9 to enter the unused yet enabled IGCCs, propagate throughout all connected ██████████
10 nodes, and do so in exponential fashion with no packet expiration, could those packets
11 escalate into a packet storm and disrupt the network. And most central to the inquiry in
12 this proceeding, if CenturyLink network management took the reasonable and
13 appropriate action of disabling the IGCCs on its Green network, based on its experience
14 with and knowledge of the Red network outage, the malformed packets identified as the
15 initial step in that network’s December 2018 outage event—said to be just four
16 malformed packets in total—could not have had any noticeable impact on the Green
17 network’s performance. In other words, but-for CenturyLink’s failure to take the
18 reasonable, prudent, simple, and cost-free step of disabling the unused IGCCs on its
19 Green network, the Washington E911 service outage at issue in this proceeding would
20 not have occurred. CenturyLink’s failure to take reasonable steps in this manner was the
21 direct and foreseeable cause of the Washington E911 service outage.

22

²² See, e.g., Valence, Exh. MDV-1TC at 17:14-21.

1 **Q. Public Counsel’s Witness Rosen has opined that the Green network failure was**
2 **caused by a software defect.²³ Do you agree with that assessment?**

3 A. No, I do not. While Witness Rosen characterizes the Green network outage as the result
4 of a software problem, it was in fact driven by human negligence. CenturyLink’s network
5 managers failed to act to lock down the IGCCs on the Green network, even ten months
6 after the February 2018 Red network outage had revealed to them the vulnerability of
7 Infinera-equipped [REDACTED] networks like the Red and Green networks to packet
8 storms propagated through those unlocked IGCCs.

9

10 **Q. Does this conclude your testimony?**

11 A. Yes.

²³ Rosen, Exh. BR-1CTr at 19:12-14.