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April 1, 2019
VIA ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

REDACTED – FOR PUBLIC INSPECTION

Re: Notification of Oral *Ex Parte* Presentation
Applications of T-Mobile US, Inc. and Sprint Corporation for Consent to Transfer Control of Licenses and Authorizations; WT Docket No. 18-197

Dear Ms. Dortch:

Pursuant to Section 1.1206(b) of the Commission's Rules, 47 C.F.R. § 1.1206(b), notice is hereby provided of an oral *ex parte* communication in the above-captioned docket. On March 28, 2019, Ankur Kapoor, Vice President, Network Technology, Karri Kuoppamaki, Vice President, Technology Development and Strategy of T-Mobile US, Inc. ("T-Mobile"), Mark A. Israel, Senior Managing Director of Compass Lexecon, and other representatives of T-Mobile and Sprint Corporation ("Sprint")[1] met with members of the FCC Transaction Team (a list of FCC participants is provided in Attachment A).

During the meeting, Mr. Kapoor and Mr. Kuoppamaki discussed the attached presentation that provides additional details about the loading curve used within the engineering model including: (1) what role it plays in the 5G engineering model, (2) why it has the shape it does, and (3) what process was used to develop it. They also discussed real-world examples that demonstrated the 5G loading curve is consistent with how the wireless network deals with ongoing traffic events.

[1] Those representatives included Kathleen O'Brien Ham and Steve Sharkey of T-Mobile, R. Michael Senkowski, Nancy Victory (by phone) and Thomas Dombrowsky of DLA Piper LLP, Daniel Culley of Cleary Gottlieb Steen & Hamilton, LLP, Joshua Soven of Wilson Sonsini, Tom Peters of Hogan Lovells US LLP, Chris Helzer of Quadra Partners LLC, Vonya McCann of Sprint, Regina M. Keeney and A. Richard Metzger of Lawler, Metzger, Keeney & Logan, LLC, Matthew Hendrickson of Skadden, Arps, Slate, Meagher & Flom LLP, Bradley Lui of Morrison & Foerster LLP, Johanna Thomas of Jenner & Block LLP, and Bryan Keating (by phone) of Compass Lexecon.

Finally, Dr. Israel discussed the second presentation deck attached to this *ex parte* filing that described the regression analysis used to develop and test the loading curve.

This filing contains information that is "Highly Confidential" pursuant to the Protective Order filed in WT Docket No. 18-197. Accordingly, pursuant to the procedures set forth in the Protective Order, a copy of the filing is being provided to the Secretary's Office. In addition, two copies of the Highly Confidential Filing are being delivered to Kathy Harris, Wireless Telecommunications Bureau. A copy of the Redacted Highly Confidential Filing is being filed electronically through the Commission's Electronic Comment Filing System.

Please direct any questions regarding the foregoing to the undersigned.

Respectfully submitted,

DLA Piper LLP (US)

/s/ Nancy J. Victory

Nancy J. Victory
Partner

NV

cc: David Lawrence
Kathy Harris
Linda Ray
Catherine Matraves
Jim Bird
David Krech
Individuals listed in Attachment A

ATTACHMENT A

LIST OF FCC PARTICIPANTS

David Lawrence
Charles Mathias
Catherine Matraves (by phone)
Donald Stockdale
Ronald Repasi
Katherine LoPiccalo (by phone)
Saurbh Chhabra
Matthew Collins
Robert Pavlak
Ziad Sleem
Thuy Tran
Weiren Wang
Patrick Sun
Aleks Yankelevich
John Henly
Marcus Maher

ATTACHMENT B

PRESENTATION DECKS

Proposed Merger of T-Mobile Sprint

Loading Curve

March 28, 2019

Agenda

1. Loading Curve
   a. Why does the 5G model have a loading curve?
   b. What does the loading curve do in the 5G model?
   c. Why does the loading curve have the shape that it does?
   d. What was the process that led to the current loading curve?

Why does the 5G model have a loading curve?

Executive Summary

In order to assess congestion and customer experience, the network model requires an understanding of how 5G throughput changes with loading. This information also was required for the economic analyses prepared for the Commission.

—Spectral Efficiency-based models are the common industry practice to address new technologies without measured data

—Given the lack of 5G network measurements, we correlated speeds from observed LTE data and spectral efficiency-based loading to calculate throughput decline

Calculating 5G throughput as a function of loading was an iterative process

- Observed network average speeds for LTE were validated against Spectral Efficiency-based speed calculations
- These evaluations led to the final loading curve used in the network model, which was built with measured speed data and calculated SE-based loading

T-Mobile's ordinary course LTE model uses measured data to predict congestion

— In the ordinary course, T-Mobile measures LTE congestion using network counters that constantly measure the number of connected users per sector

— T-Mobile matches that with Ookla and RAN data, adjusting for device and radio features

— That has shown a stable long-term relationship between [redacted]

[redacted]

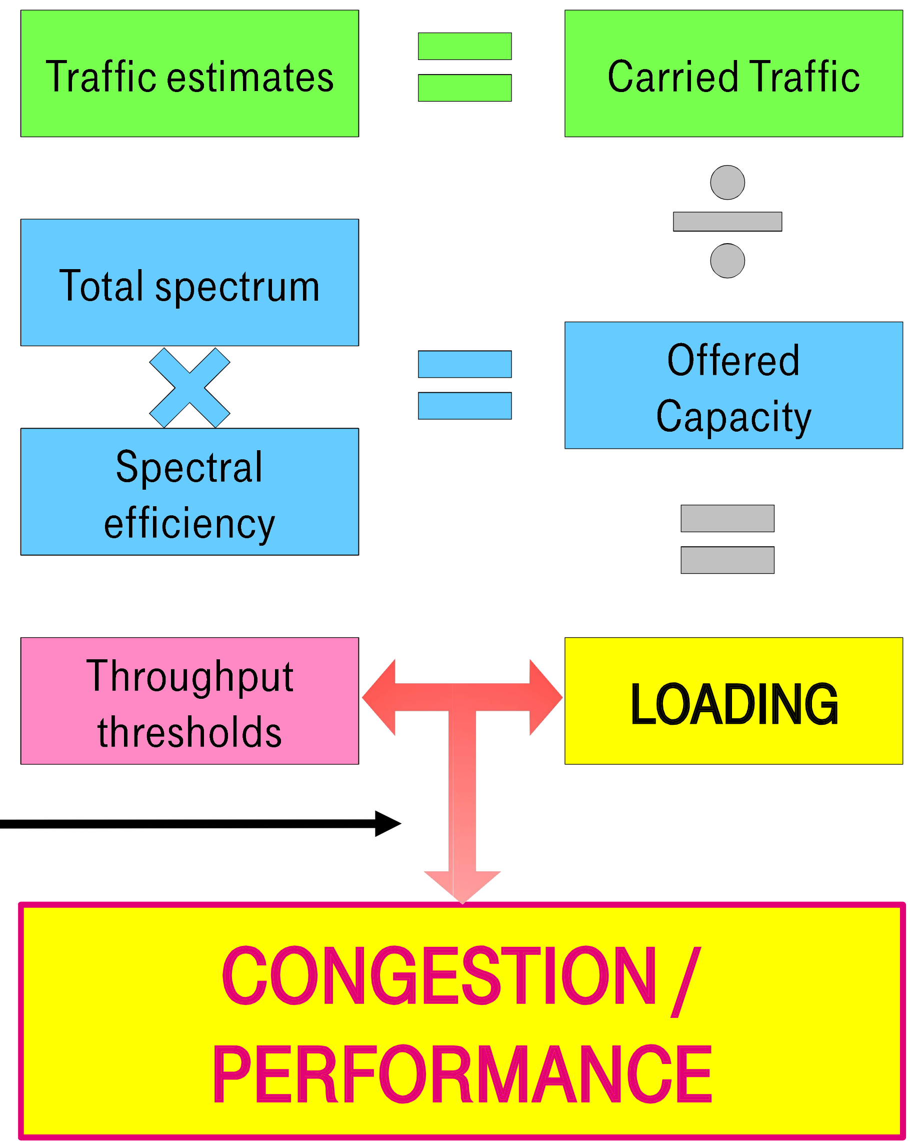
[redacted]

No live 5G network, so must translate 4G data into 5G

Need: Congestion analysis to assess network costs and performance

Issue: Network not engineered to specific loading level but to user experience threshold ([redacted]

Solution: Mechanism relating user throughput to sector loading (carried/offered traffic) so that a determination can be made of the loading level that corresponds to congestion and performance and, thus, **determine congestion/performance from spectral efficiency-based model**



What does the loading curve do in the 5G model?

Calculating performance starts with the available sector throughput and load

Every sector in the network has an *available sector throughput*, based on the amount of spectrum deployed on that sector and the spectral efficiency of that spectrum at representative industry loading

— [redacted]

— [redacted]

The *carried traffic* is the amount of traffic that all users demand on that sector

The *loading* is then the ratio of carried traffic to offered traffic

Because reported *spectral efficiency* is measured at representative industry loading, individual user experience can be higher than available sector throughput at low loading

1 [redacted]

Loading curve differs between “busy hour” and rest of day

In ordinary course, T-Mobile determines LTE congestion based on traffic carried during the busiest hour of the day (“busy hour” traffic), but user experience, which reflects average experience on the network, is based on all hours

This is why there are two loading curves in the 5G model:

— The [redacted]

— The [redacted]

- [redacted]
- [redacted]

[redacted]

Loading curve used to determine both congestion and performance

T-Mobile imposes congestion threshold of [redacted] for 5G devices

To calculate whether a sector is congested, model calculates loading, applies [redacted]

— If the sector is below [redacted], the sector is congested

— [redacted]

— [redacted]

[redacted]

[redacted]

Why does the loading curve have the shape that it does?

A rough approximation of how loading impacts performance is 1/x

What does 1/x mean?

—The scheduler has a certain amount of resources that it can allocate to users

—Dividing those resources among users is like cutting a cake

—Thus, if a sector has capacity of 100 Mbps, 1/x would suggest that it can give one user 100 Mbps, two users 50 Mbps each, three users 33 Mbps each, and so on

But 1/x does not take account of realities such as granular radio resource allocation, non-simultaneous users, sporadic data usage, and differing radio conditions

Real-world factors not captured by 1/x

LTE (and 5G) have granular resources

- LTE works in resource blocks that extend 180 kHz in frequency and 0.5 ms in time
- The 5G New Radio (NR) supports 180 kHz by 0.5 ms, 360 kHz by 0.25 ms, and 720 kHz by 0.125 ms for bands below 6 GHz
- Schedulers are not specified by the standard and can vary, but typically work with windows of 1 or a few ms
- The exact number of bits in a resource block varies by the chosen modulation and coding scheme (MCS), which in turn is based on radio conditions, with the effect that in good conditions, more bits can be packed into a resource block

This leads to delays in congested conditions

- If data for several users arrives at the same time, it can exceed the amount of data that can be transmitted in the resource blocks in the scheduling window
- This means some data must be delayed until a subsequent scheduling window
- If data is arriving faster than it is being delivered, the delays will cascade

1/x also overstates performance at low levels of loading

Constraints cause degradation to cascade at high loading

As loading (carried/offered traffic) increases, a sector approaches limits of physical resource utilization

Physical resource utilization cannot exceed 100%

— Even at low levels, given the lumpiness of user data arrival, sometimes there will be delays

— But as physical resource utilization approaches 100%, the delays begin to cascade and the system becomes unusable for at least some users, and congestion is occurring

The curve must become steeper than 1/x as physical utilization nears 100%

— The 1/x curve's slope becomes shallower and shallower, such that it never goes to zero for any loading number, no matter how high

— We know that as the physical loading approaches 100%, the curve must stop getting shallower, as delays build on one another, and very close to 100% physical loading the curve should fall very quickly

— Arguably, the compounding of delays would suggest an exponentially declining curve for the tail, but given the lack of data for the exact loading level that corresponds to 100% physical loading, we viewed a linear extrapolation as conservative from a merger review point, since it would drive less cell splitting than a steeper curve

NRG Stadium – Houston Livestock Show and Rodeo

[redacted]

Ostrich Festival - Phoenix

[redacted]

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Correlation between Connected Users and Loading

[redacted]

Loading Curves: Econometric Analysis

March 28, 2019

CONFIDENTIAL TREATMENT REQUESTED

Empirically Estimated 5G Loading Curve

[redacted]

5G Loading Curve Regression Estimates

[redacted]

5G Loading Curve is Precisely Estimated: Tight 95 Percent Confidence Interval

[redacted]

5G Loading Curve is Robust to Alternative Specifications

[redacted]

Network Marginal Cost Savings are Robust to Alternative Specifications of the Loading Curve

[redacted]

The Conclusion that the Merger is Pro-Competitive is Robust to Alternative Specifications of the Loading Curve

[redacted]

The Conclusion that the Merger is Pro-Competitive is Robust to Alternative Specifications of the Loading Curve

[redacted]