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December 31, 2015

VIA ECFS

Marlene H. Dortch, Esq.
Secretary
Federal Communications Commission
445 Twelfth Street, SW
Washington, D.C. 20554

Re: ***Applications of AT&T Inc. and DIRECTV for Consent To Assign or Transfer Control of Licenses and Authorizations*****, MB Docket No. 14-90**

Dear Ms. Dortch:

Pursuant to the Appendix B.V.2.c.(iv) of the Commission's Memorandum Opinion and Order in the above-referenced proceeding,[1] AT&T Inc. ("AT&T") hereby submits this report describing the Independent Measurement Expert's ("IME") proposed methodology for the measurement of interconnection performance metrics ("Proposed Methodology").

On October 1, 2015, the Commission announced that the Center for Applied Internet Data Analysis ("CAIDA") would serve as the IME. Since November 1, 2015, when CAIDA's engagement became effective, AT&T has cooperated with CAIDA to provide data and information about AT&T's network to facilitate CAIDA's development of the Proposed Methodology. CAIDA's Proposed Methodology is attached hereto for inclusion in the public record.[2]

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[1] *Applications of AT&T Inc. and DIRECTV for Consent To Assign or Transfer Control of Licenses and Authorizations*, Memorandum Opinion and Order, FCC 15-94, App. B (rel. July 28, 2015).

[2] The Proposed Methodology does not include any AT&T Highly Confidential and Confidential Information.

In summary, CAIDA has proposed the following methodology:

1. AT&T will measure from its border routers the prescribed performance characteristics of the interconnection circuits between AT&T and its Internet peers and on-net only Managed Interest Service ("MIS") customers whose traffic exceeds a *de minimis* threshold ("Interconnection Partners").

2. AT&T will ask all of its Interconnection Partners to enable active measurement capabilities using TWAMP/ISLA that will produce more accurate measurements.

3. If an Interconnection Partner does not agree to enable the active measurement capabilities, AT&T will take measurements using an ICMP-based passive approach.

4. AT&T will ask Interconnection Partners to provide certain data about interconnection points and the Interconnection Partners' traffic management. If an Interconnection Partner supplies the requested data, AT&T will submit it to the Commission.

AT&T appreciates the efforts of the IME to develop this Proposed Methodology in the short time frame required by the Internet Interconnection Disclosure Requirements (the "Condition"). This general framework is acceptable to AT&T.

However, AT&T has raised with CAIDA concerns regarding the following specific aspects of the Proposed Methodology:

1. The IME proposes that AT&T (a) be required to integrate any data provided by its Interconnection Partners with the data that AT&T collects pursuant to the methodology and (b) be required to perform calculations using the Interconnection Partners' data. (*See* Proposed Methodology § 3, ¶ 6; § 4, ¶ 11; § 5.1, ¶ 14; § 6.3, ¶¶ 24, 27). This proposal goes beyond the requirements of the Condition. AT&T does not object to asking its Interconnection Partners to provide certain data to AT&T, in which case AT&T will separately forward that data to the FCC, or to the Interconnection Partner forwarding that data to the FCC on its own volition, but AT&T has no way to verify the accuracy of the Interconnection Partners' data or to determine (or change) the methodologies used by the Interconnection Partners to collect their data (which may be incompatible with the methodologies specified in the Proposed Methodology), and AT&T should not be required to attempt to integrate the Interconnection Partners' data with AT&T data or to perform calculations utilizing the Interconnection Partners' data.

2. The IME proposes that AT&T be required to share its measurement data with its Interconnection Partners and to make changes to AT&T's networks based on information

provided by the Interconnection Partners. (*See* Proposed Methodology § 3, ¶ 4; § 4, ¶¶ 9, 11; § 5.1, ¶ 14; § 6.1, ¶ 22; § 6.5; § 7). These proposals are beyond the scope of the Condition. The FCC has established rules and procedures that govern the submission of confidential data and the circumstances under which third parties may obtain access to such confidential data submitted to the FCC. The FCC should rely on these established rules and procedures, to the extent necessary in connection with AT&T's reporting obligations under the Condition.

3. The IME proposes that AT&T must negotiate with Interconnection Partners to enable TWAMP/IPSLA. (*See* Proposed Methodology § 4 ¶ 11; § 5.1, ¶¶ 12, 15; § 7). AT&T will ask its Interconnection Partners to enable TWAMP/IPSLA, but there is nothing to negotiate – the Interconnection Partners will either agree to participate or they will decline. Interconnection Partners should have no right to seek compensation or impose conditions on their participation. If the Interconnection Partner declines to participate when AT&T makes the request, AT&T will utilize the fallback ICMP-based probing method. (*See* Proposed Methodology § 5.1, ¶ 15).

AT&T requests that CAIDA's Proposed Methodology be amended to address these concerns before the Commission approves a final methodology.

Please contact me at (202) 942-6608 or Maureen.Jeffreys@aporter.com if you have any questions.

Respectfully submitted,

Maureen R. Jeffreys
Counsel for AT&T Inc.

Enclosure

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Report of AT&T Independent Measurement Expert Analysis of reporting requirements and proposals for measurement methods

UC, San Diego's Center for Applied Internet Data Analysis
KC Claffy, Amogh Dhamdhere
in collaboration with independent contractors:
David Clark, Steven Bauer
Submit any feedback/concerns to att-ime-feedback@caida.org

December 30, 2015

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1 Introduction

In compliance with the merger agreement between AT&T and DirecTV, AT&T has engaged CAIDA to serve as the Independent Measurement Expert (IME) as described in the Consent Memorandum and Order (CMaO), Appendix B, V: Internet Internet Disclosure Requirements.[1] As described in this appendix, our task is to develop a proposed methodology for measurement and reporting of data, in the context of the following obligation imposed on AT&T:

> *2.b. Reporting Internet Interconnection Performance Metrics. Using a methodology developed and implemented as subpart 2.c., the Company must report, in accordance with the filing and service requirements set forth in Section VII.5. herein, on a schedule established by an Independent Measurement Expert, but no more than on a monthly basis, the following performance characteristics of traffic exchanged at Internet Interconnection Points located within the United States, unless the volume of traffic exchanged with the interconnecting party is less than a de minimis threshold, as specified by the Independent Measurement Expert:*
> *(i) The probability distribution of latency between the border router of the interconnecting network and the Company's border router ("Latency"), as defined by the Independent Measurement Expert;*
> *(ii) The percentage of packets dropped at or between the border router of the interconnecting network and the Company's border router ("Packet Loss"), as defined by the Independent Measurement Expert; and*
> *(iii) The percent usage of each Internet Interconnection Point ("Utilization"), as defined by the Independent Measurement Expert.*
>
> ...
>
> *2.c.iv. The Company, in consultation with the Independent Measurement Expert, will submit for approval by the Commission's Office of General Counsel, in consultation with the Wireline Competition Bureau and the Chief Technologist, a report describing the Independent Measurement Expert's proposed methodology for the measurement of the performance metrics described herein. Such report shall also be submitted to the Independent Compliance Officer. The proposed methodology should, at a minimum, address the following criteria:*
>
> 1. *Identification of Internet Interconnection Points, including the identity of the interconnecting parties and the location and capacity of each interconnection point;*
> 2. *Identification of a disclosure exemption threshold for a de minimis volume of traffic exchanged between the Company and interconnecting parties;*
> 3. *A definition of "Latency," which shall include the disclosure of the probability distribution;*
> 4. *A definition of "Packet Loss";*
> 5. *Time of measurements, which shall, at a minimum, include an identified window within peak usage periods;*
> 6. *For any performance metric contingent upon an interconnecting party's participation in the selected measurement methodology, a process for waiving the disclosure of that metric at points of interconnection where the interconnecting party declines to participate;*
> 7. *Frequency and duration of measurements;*

[1] https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-94A1.pdf

8. *Any devices used for measurement;*
9. *End points of measurements;*
10. *Placement of any devices; and*
11. *Frequency of disclosures.*

A paragraph from the CMaO provides context for our task:

> *217. Discussion. As stated in the 2015 Open Internet Order, "consumers bear the harm when they experience degraded access to the applications and services of their choosing due to a dispute between a large broadband provider and an interconnecting party." Also, because OVD subscribers expect high-quality video, OVDs are vulnerable to degradation at the interconnection point with a broadband Internet access service provider's last mile network. Thus, as stated in the 2015 Open Internet Order, we find that "broadband Internet access providers have the ability to use terms of interconnection to disadvantage edge providers and that consumers' ability to respond to unjust or unreasonable broadband provider practices are limited by switching costs." We appreciate commenters' concerns in this area.*

The FCC has identified a minimum set of criteria to report. While these metrics will generally inform the FCC about the character of current interconnection practices, our understanding is that the FCC selected them based on their relevance to the specific concern of degraded access to third-party applications and services by AT&T customers.

The structure of the remainder of this document is as follows. Section 2 specifies the disclosure exemption. Sections 4 and 5 catalog the data that AT&T must collect, and methods to collect it. We distinguish the process of collection from the reporting that results from the measurements. Section 6 specifies the nature of the reporting. Section 7 explains our requirements and motivation for data sharing, where required by the methodology. Section 8 describes the continuing role the IME will play in validating the Methodology.

2 Disclosure exemption

The FCC has required AT&T to report on all interconnections with peers and with on-net customers (similar to what has been called "paid peering" in the past). The set of interconnection partners is defined in the CMaO, Appendix B, Section II, as follows:

> *"Internet Interconnection Points" means the facilities over which traffic is exchanged between the Company's network that carries Broadband Internet Access Service traffic and (1) peering networks or (2) customers that purchase on-net only services to deliver traffic to and from the Company's end users over the company's network.*

AT&T is required to report on all such interconnection points "unless the volume of traffic exchanged with the interconnecting party is less than a de minimis threshold, as specified by the Independent Measurement Expert". AT&T has identified a proposed minimum volume criterion to trigger reporting for their interconnection partners, which is that the partner connect with at least 20G of capacity. We have used CAIDA's AS Rank system to infer the list of AT&T peers, determined the difference between this inferred list and AT&T's list of peers and on-net customers, and concluded that AT&T's proposed threshold is reasonable.

1. AT&T will collect data and report on any interconnection partner with at least 20 Gbps of interconnection capacity in sum across all interconnection points at the beginning of each report period. In computing the total capacity, AT&T may exclude from the computation any individual link with capacity of less than 10Gbps.

2. AT&T will update the list of interconnection partners as new entities pass (or fall below) this threshold. AT&T will revise the list of interconnection partners monthly. Measurements and reporting will commence within 90 days of a new partner qualifying based on the threshold.

3 Reporting of interconnection partners, connectivity, and traffic management details

3. For each qualifying interconnection partner (as described in Section 2), AT&T will self-report to the FCC the location and capacity and of all links (or LAGs) to that partner. (Link Aggregation Groups, or *LAGS*, are multiple parallel circuits connecting AT&T to an interconnection partner. In cases where links are combined into LAGs, AT&T will report the required data for the combined LAG. In cases where links are not combined into LAGs, AT&T will report the required data for such individual links. We use the term *link* to capture both cases.)

4. For each interconnection partner, AT&T will share the information above (item 3) information with that partner as described in Section 6. This information is already reasonably available to the interconnection partner and thus not commercially sensitive. This step is required as a mechanism for cross-checking the gathered data, although AT&T is not required to seek feedback from the partner regarding this information. Section 7 provides our rationale for data sharing requirements in this and subsequent sections.

5. AT&T will disclose to the FCC any use of tools for differentiated treatment of traffic across interconnection links. Mechanisms for differentiated treatment of traffic, e.g., diffserv, across an interconnection link, can distort measurement results. For example, probing for packet loss and latency variation may fail if probe packets end up in a preferred service.[2]

6. AT&T will ask its interconnection partners to disclose whether they use such tools, with the overall goal of determining if the probing method being used by AT&T is correctly measuring the character of the link. The partner may disclose this directly to the FCC.

7. AT&T will disclose to the FCC and the IME if any interconnection links are carrying traffic other than Internet, and how the capacity is shared. It is possible that interconnection links may carry traffic not associated with the global public Internet. Such traffic is sometimes referred to as *specialized services*, and mixing it with public Internet traffic will render capacity and utilization values ambiguous. If non-Internet traffic on these links exists during the four-year reporting period, AT&T will work with the IME to refine the reporting method.

4 Collection of existing data on utilization and loss

This section specifies data that AT&T will collect about each interconnection LAG (or link in the absence of a LAG), using information available from routers and related databases.

[2] We have detected this situation in our own measurements, although not in the context of AT&T interconnections.

8. AT&T will collect packet and byte counters in both directions at each router in a LAG at 5-minute granularity, and compute a 5-minute LAG utilization value from these numbers. Any changes to reporting of capacity and byte counts must be synchronized (See Section 6).

9. For each interconnection partner, AT&T will share these per-LAG packet and byte counts with that partner. As above, this information is already reasonably available to the interconnection partner and thus not commercially sensitive. This step is required as a mechanism for cross-checking the gathered data, although AT&T is not required to seek feedback from the partner regarding this information.

10. Using router interface counters and a protocol to retrieve them such as SNMP, AT&T will collect counts of packets sent and packets dropped during each 5-minute interval over the course of the month. Note that packets are dropped at the incoming side of a congested link, so if congestion is on the path *into* AT&T's network, AT&T's routers will not be able to record those losses.

11. To fill this gap, AT&T will negotiate with each interconnection partner with the goal that the partner share with AT&T the loss counters from their routers. If any partners will share loss counters from their routers, AT&T will integrate this data into the other data they gather about the LAG, in order to prepare an overall report on the LAG in a form useful to the FCC. AT&T is not responsible for the accuracy or completeness of this data, or the interconnection partner's failure to deliver this data to AT&T in a timely manner. The details of incoming packet loss data will depend on exactly how the interconnection partner provides it, e.g., it may have a different granularity from what AT&T reports. AT&T will consult with the IME to resolve these details once negotiations with that partner have concluded.

5 Active measurements of loss and latency

In addition to the data capture described above, we define an active probing measurement method that AT&T will implement to provide another measure of packet loss, as well as to provide data about latency and its variation. The general approach is to send a probe that results in a return packet. Failure to receive a return packet provides evidence of packet loss on the link. The timing of the return packet provides a data point about latency. Cooperation from the other side of the interconnection allows one-way measurements that can discern direction of packet loss and provide latency distributions in each direction across the interconnection link.

5.1 Probing methods

We define a primary method that relies on cooperation of the interconnection partner, and a fall-back scheme if AT&T fails to obtain this cooperation. The preferred method uses a measurement protocol, e.g., TWAMP or IPSLA. The fall-back method uses a cruder protocol (ICMP).

12. AT&T must negotiate with each interconnection partner with the goal that the partner enable the far-side router as a responder for TWAMP/IPSLA probes. If the partner agrees to install TWAMP/IPSLA, this protocol will be the first probe method for the active measure of loss and latency.

13. AT&T will use its interconnecting router as a TWAMP/IPSLA client executing measurements. (Alternatively, if AT&T is unable to or chooses not to use the interconnecting router

itself to perform the required measurements, AT&T will install a probe server at or suitably near each location where they interconnect with a qualifying interconnection partner. The path from the probe server to the near-side router must have demonstrated low latency, no jitter and no packet loss. AT&T will report the locations of the measurement servers to the IME per criteria 10 of the FCC's IME conditions, and submit their proposed measurement protocol to the IME for approval.)

14. For interconnection partners that want to execute their own TWAMP/IPSLA measurements, AT&T will support a responding TWAMP/IPSLA port on the interconnecting router.

15. In case TWAMP/IPSLA is infeasible, or if AT&T fails to negotiate an agreement with the interconnection partner on reasonable terms, AT&T will use a fall-back ICMP-based probing method. the FCC will review the reasons for any failure to negotiate cooperation in these measurements to verify that AT&T negotiating position was reasonable (Section 7).

    This fall-back method is subject to several limitations:

    - Some routers may not respond reliably to pings or send TTL-expired responses, leading to an over-estimate of the loss rate.
    - Some routers respond to a TTL-expired event with highly variable delay, leading to a distortion of the latency measure.
    - In some cases, the return route from the far-side router may not be the link under measure, but a path by some other link.
    - The method may require a topology discovery process to identify destinations behind each far-side router.

    The best approach to the fall-back measurement may depend on particulars of each interconnection partner. Furthermore, even if the interconnection partner is not willing or able to enable TWAMP/IPSLA, they may be willing to work with AT&T to devise methods that improve the quality of the fall-back probing method. AT&T will explore these options with their partners. The IME must review and approve the proposed approach.

16. To detect the situation where the return path is not through the link being measured, AT&T will probe the path to the far-side router with the IP Record Route option. (If AT&T prefers not to enable support for the Record Route option for performance or security reasons, they may propose an alternative method for the IME to approve.) The rate of probing does not need to be as high as for measuring loss and latency, but it will depend on the frequency of route changes. We recommend an IP Record Route probe rate of one per hour. If AT&T detects an asymmetric route using the approved method, and AT&T can devise no realistic way to probe the link, AT&T will disclose this condition to the FCC, and annotate the probing measurement data with this information for as long as the routing asymmetry persists.

17. In cases where the interconnecting partner cooperates in the deployment of TWAMP/IPSLA, AT&T will execute both methods above (TWAMP/IPSLA and ICMP-based), with the goals of cross-checking the data and to inform confidence levels in the second method when the first is not possible. If, after an initial period of this dual measurement method, AT&T wishes to suspend the use of the fall-back method in certain cases, they may do so with the concurrence of the IME. If the IME finds compelling evidence that the second method is sufficiently close (TBD based on review of initial data and reports) to the first in accuracy and precision, it has the option of permitting AT&T to select the fall-back method in a particular case. If the

IME finds compelling evidence that the best approach to implementing the second method is demonstrably inaccurate it has the option of permitting AT&T to suspend probing of this connection with this method. This option implies that in certain cases of a non-cooperating peer, there would be no probing to report loss and latency.

5.2 Probing rate

18. For both the preferred and fall-back schemes, AT&T shall use a probing rate with a mean of 1 second, with a Poisson distribution of sample intervals to improve the sampling method. Poisson sampling is described in RFC-2680, *"A One-way Packet Loss Metric for IPPM"*.[3] If AT&T is not able to support Poisson sampling on their routers, they may use periodic (1 per second) sampling.

5.3 Why congestion inferences requires accurate measures for loss and latency

Link utilization thresholds are used to estimate the impending onset of congestion, but there is no threshold that is uniformly accepted as an indication. In some cases, links can run at high utilization without other evidence of congestion (jitter or packet loss). Conversely, links with highly variable traffic mixes may show evidence of instantaneous congestion while the average utilization is substantially less than 100%. Link utilization must be correlated with other measures that indicate overload (jitter and packet loss).

Links that are heavily loaded often show a plateau (flat top) of utilization at or near the actual link capacity. Such a plateau suggests evidence of congestion, but this presumption may not always be correct. Content providers can usually selectively deliver traffic from different sources, and may be able to load links to near capacity without triggering symptoms of actual congestion, e.g., packet loss. Thus, absence of latency variation and lack of packet loss may indicate that a link, even if heavily loaded, is not actually congested. This reality of modern traffic engineering is why utilization metrics alone cannot reveal an accurate picture of congestion; one must also examine sufficiently accurate metrics of loss and latency distributions. One of the drawbacks of a failure to negotiate the use of TWAMP/IPSLA may be that the cruder fall-back probing method may incorrectly report higher levels of packet loss and variation in latency, thus signaling congestion where none is actually present.

We also acknowledge another behavior we cannot observe even with active probing: content providers may also change the amount of data being transferred by adjusting the coding of the data (the quality of video). In this case, the signal of unfulfilled demand may manifest as lower quality video, rather than packet drops or queuing. Observation of packet counters or active probing will not capture this behavior.

6 Reporting requirements

19. As described in Section 3, AT&T will self-report, for each qualifying interconnection partner, the location and capacity of all links (or LAGs) for such partners. (Again, we use the term *link* to refer to the LAG granularity for links aggregated into a LAG.) Changes to capacity, or the number and location of links for a partner must be reported no later than the monthly reporting period following the period within which the change occurred. This requirement means that AT&T will report any changes no later than 60 days after its occurrence.

[3] RFC 2680, G. Almes, S. Kalidindi, and M. Zekauskas, September 1999. http://tools.ietf.org/html/rfc2680

6.1 Reporting byte counts and utilization

20. For each link, AT&T will obtain the inbound and outbound byte counts as described in Section 4, and compute the inbound and outbound utilization (as a ratio of byte counts over link capacity) for each 5-minute interval in the month. AT&T will report the raw data for byte counts and utilization in each 5-minute interval. Any changes to reporting of capacity and byte counts must be synchronized, e.g., if AT&T adds a new link, AT&T must update all metrics at the same time.

21. For each link, across all links with an interconnection partner in a city, and also overall for an interconnection partner, AT&T shall report the 5-minute peak, 95th percentile, and average utilization over a month, and time-series utilization plots (e.g., MRTG) of 5-minute granularity utilization data, inbound and outbound, over a month.

    To produce aggregate inbound (outbound) byte counts for a single interconnection partner by city, AT&T will add the inbound (outbound) byte counts recorded for each link connecting with the partner in that city. To compute utilization for the interconnection partner in a city, AT&T will divide the aggregate inbound (outbound) byte counts by the total capacity of all link connecting to that interconnection partner in that city. AT&T will follow a similar procedure to compute the aggregate byte counts and utilization for the interconnection partner as a whole.

22. For each interconnection partner, AT&T will share per link packet and byte counts and the time-series utilization graphs with that partner.

6.2 Peak period reporting

23. AT&T will use the data for each link to define the period of peak load for that link. We initially define the peak load period for any link as those times at which the 5-minute sampled utilization is above 80%. AT&T shall report packet loss and latency measurements separately for every link for those periods we define as peak (see Section 6.3 and 6.4). For each link, AT&T will also report the number of 5-minute samples for which the link utilization is over 80%. This data is required to estimate the confidence level of the latency and loss measurements gathered during the peak period.

6.3 Reporting packet loss

24. AT&T will report loss separately during peak and off-peak periods (as defined) for each link. If the interconnection partner agrees to report packet loss counters from their router, then AT&T will report these counts together with packet counts from AT&T's router as a measure of loss in each direction. Specifically, AT&T will compute the outbound loss rate for a link as the ratio of packets dropped to packets sent (from its router) per 5-minute interval. AT&T will use counters from the interconnection partner regarding packets dropped and packets sent to compute the inbound loss rate in the same manner.

25. For active probing methods (either TWAMP or ICMP), AT&T will compute the loss rate as the ratio of probes lost to probes sent during an interval, separately computing and reporting this metric for peak and off-peak times for the link. If using TWAMP/IPSLA, and the available implementation has the capability, AT&T will report inbound and outbound loss rate

separately. For the ICMP-based method, AT&T will report the round-trip loss rate. AT&T will thus report the following numbers for each link.

For router (e.g., SNMP) counters or TWAMP:

(i) Outbound packets dropped, packets sent, and loss rate during a) peak times and b) off-peak times.

(ii) Inbound packets dropped, packets sent, and loss rate during a) peak times and b) off-peak times.

For ICMP probing:

(i) Probes sent, probes lost, and loss rate (round-trip) during a) peak times and b) off-peak times.

26. In addition to collection of router counters (see the discussion above on limitations), AT&T will report the loss rate as indicated by the active probing method(s) separately as a cross-check. In case router counter data from the partner is not available, AT&T will report only the loss rate(s) based on the probing method(s).

27. For each link, AT&T will plot the time series of loss rate computed in each 5-minute interval. If loss data is available in both directions (see above), AT&T will plot two separate time series corresponding to loss rate for the inbound and outbound directions.

6.4 Reporting distribution of latency

28. For each link, AT&T will report the probability distribution of latency, separately during peak and off-peak periods as defined. If using TWAMP, and it provides this capability, AT&T will compute two distributions corresponding to latency in the two directions. For the ICMP-based probing method, AT&T will compute one distribution corresponding to the round-trip latency.

29. AT&T will compute the probability distribution by applying a kernel density estimation process to provide some smoothing of the latency values. The kernel density estimation process requires as input a bandwidth parameter that controls how much smoothing is done to the raw data. To choose the optimal bandwidth we recommend using the method of least-squares cross-validation.[4] The report will include a plot of the resulting probability distribution, as well as the following statistics of the distribution: mean, standard deviation, 10th, 25th, 50th, 75th, 90th, 95th, 99th percentiles, and the maximum. (Note: this requirement assumes that TWAMP can provide individual samples. If it cannot, we must refine this requirement based on additional information about the implementation's capabilities for providing a probability distribution of latency required by the FCC.)

If using TWAMP:

(i) Plot of probability distribution of outbound latency during a) peak times and b) off-peak times.

(ii) Plot of probability distribution of inbound latency during a) peak times and b) off-peak times.

[4] "Kernel Smoothing", M.P. Wand, M.C. Jones, CRC Press, 1994.

(iii) Mean, std dev, 10th, 25th, 50th, 75th, 90th, 95th, 99th percentiles and maximum outbound latency during a) peak times and b) off-peak times.

(iv) Mean, std dev, 10th, 25th, 50th, 75th, 90th, 95th, 99th percentiles and maximum inbound latency during a) peak times and b) off-peak times.

For ICMP probing:

(i) Plot of distribution of round-trip latency during a) peak times and b) off-peak times.

(ii) mean, std dev, 10th, 25th, 50th, 75th, 90th, 95th, 99th percentiles and maximum round-trip latency during a) peak times and b) off-peak times.

6.5 Format to submit data to FCC

The primary audience for these reports is the FCC, but each interconnection partner will have a limited view of the data gathered and reported about their own network. Presentation of data to interconnection partners must be as easy to use and explore as it is for the FCC.

30. AT&T will submit to the FCC:

(i) a PDF of the graphs and metrics required by Section 6

(ii) an Excel spreadsheet of the calculated values

(iii) digital version of all raw, aggregated, and summary report data in a structured format (e.g. HDF5, RRD, JSON, XML, CSV)

(iv) If AT&T discovers or is notified of an error in data or calculations, AT&T will report the errors to the FCC.

7 Requirements and motivation for sharing limited data with interconnection partners

The Consent Memorandum and Order (CMaO) states (Page 148):

> *This condition will enable the monitoring of the combined entitys future interconnection agreements terms to determine whether the combined entity is using such agreements to deny or impede access to its networks in ways that limit competition from third-party online video content providers. In addition, this condition requires the combined entity to work with an independent measurement expert to report certain Internet interconnection performance metrics, and to the extent possible, make such metrics publicly available.*

This paragraph of the order signals the value of releasing some form of what is learned in this reporting exercise. We agree that there is great value in releasing overall insights and aggregated data to the public, as well as releasing specific data about a given interconnection partner to that partner. The most important role of such sharing is scientific integrity: to support cross-checking and validation of the measurement methods we propose. A secondary role is process integrity: partners need to see what is being reported about them if they are to cooperate in gathering data about their interconnection, and thus we require data sharing as a component of negotiation with the partners. We provide additional details on both of these roles.

All measurement methodologies should include some form of cross-check or validation, in order to detect errors that may arise, whether from a flaw in the measurement method, misconfiguration of a database, or a failure in the measurement apparatus. The goal of this IME effort is to demonstrate with rigorous quantitative measurement that the performance of AT&T's points of interconnection with partners are not the source of performance impairment for consumers. To that end, where possible, we have specified approaches that allow for comparison of different methods for measuring the same parameter, to lend confidence in interpretation of the data.

Since these measurements all relate to behavior of a point of interconnection with another party, one way to increase confidence in the measurements and their interpretation is to allow the other party to see what is reported. We therefore have described a general approach in which data being gathered concerning the interconnection with each partner is shared with that partner, in exchange for that partner's willingness to gather and share with AT&T (and the FCC) data that they themselves gather concerning the measures of the interconnection.

We recognize that sharing of data (in both directions) implies the release to the partner of data that may be considered proprietary to the firm. We have tried to carefully balance the benefits of disclosure with the potential consequences of release of this data to the partner. The final decision as to the merits of sharing vs. protection of reported data must lie with the FCC. However, an important outcome, and indeed the primary objective, of these measurement and reporting conditions is that all parties feel that the process has been balanced and fair to each of them. In our view, data sharing is a necessary component of this outcome, and we urge all parties to consider the balance between protection of data and insuring that this process leads to data reporting that is not in any way seen as potentially biased or reflecting the interests of one party in an unbalanced way. With these concerns in mind, we have integrated the following data sharing requirements into the measurement and reporting methodology.

We require that AT&T share with each qualifying interconnection partner the location and capacity of all links to that partner. Both partners already have this information, thus this sharing requirement should not raise any issues with respect to commercial sensitivity of data. The purpose of the sharing is to allow the interconnection partner to cross-check this data with their own records, should they choose.

Similarly, we require that AT&T share packet and byte counters in both directions at each router in a link at 5-minute granularity. Again, both partners should equally have this information, so this requirement should not raise any issues with respect to proprietary data, and will allow the partner to cross-check this data with their own records, should they choose.

We also require that AT&T share with interconnection partners the results of probing using a cooperative method such as IPSLA or TWAMP. This measurement data is new, required as part of our method but not currently being collected by AT&T, and requires the the interconnection partner to cooperatively implement a protocol responder. In this case, where both parties have cooperated to gather the data, it seems unreasonable and a material barrier to achieving this cooperation if the resulting data is made available to only one of the parties.

We believe that the benefits of holding these measurements private are not commercially significant, and are outweighed by the benefits of sharing. In particular, these measurements will not reveal whether the sender uses some sort of traffic differentiation scheme across this interconnection, but will reveal the treatment of packets in the class of traffic in which the probing is classified. Either party could develop and execute measurements of their own to observe this behavior, if they were so motivated. Because the interconnection partner could reasonably and independently obtain these measurements, we do not consider this information commercially sensitive.

The most valuable and readily available source of data to evaluate our proposed method to measure loss across the interconnection are the interconnection partner's outgoing loss counters

(which reflect packet drops) at the partner's sending end. Specifically, outgoing loss counters on AT&T routers at their border with another network reveal drops due to insufficient capacity in the direction toward the interconnection partner. Conversely, outgoing loss counters on the routers of the interconnection partner's borders with AT&T reveal insufficient capacity in the direction toward AT&T. Based on the merger document and public comments, we understand that the FCC is primarily concerned with performance impairment in the direction toward AT&T, which makes the loss counters from AT&T's routers less important than the loss counters from the interconnection partner's routers. Indeed, loss counters from the interconnecting partner's routers are essential to validation of our method, and we thus consider it imperative that AT&T is successful in negotiating this cooperation with their interconnection partners. However, AT&T should not be required to accept unreasonable terms as a part of this negotiation. The FCC's review of such terms, when negotiation has not led to cooperation, is not strictly a part of the measurement methodology, but we emphasize the need for the FCC to play an active role in encouraging the success of these negotiations, and reviewing the conditions that parties have put forward as reasonable terms of negotiation. We anticipate that these terms may include requests for mutual sharing of data as well as financial compensation for operational costs.

8 Continuing role of the IME

The contract between UC, San Diego (CAIDA) and AT&T describes a temporarily continuing role of the IME in this process:

> *(c) CAIDA and AT&T jointly will review the first report that AT&T must submit to the FCC on Internet interconnection performance metrics resulting from the Methodology (the "Metrics Report").*
>
> *(i) AT&T acknowledges and understands that in order for CAIDA to fulfill its obligations as part of this review process, including to assert confidence as to the validity of the Methodology, CAIDA must have reasonable access to certain underlying data necessary to validate the Methodology. Any method for measurement must be tested and evaluated in practice, and CAIDA must be materially involved in this activity.*
>
> *(ii) If CAIDA and AT&T conclude that there is a problem with the performance metrics contained in the first Metrics Report, CAIDA will (A) propose a revision of the Methodology to resolve the problem(s) that is satisfactory to the FCC and to AT&T, and (B) consult with AT&T on AT&T's explanation of the problem(s) and the proposed revision of the Methodology to the FCC and the ICO. CAIDA and AT&T will repeat this process until there has been a Metrics Report that CAIDA and AT&T agree contains no problematic performance metrics.*
>
> *(d) If CAIDA and AT&T fail to reach such agreement after repeated, good faith attempts, CAIDA reserves the right to terminate this Agreement upon prior written notice to AT&T and the FCC and indicating the reasons therewith.*

An important methodological concern arises from these terms of the contract between AT&T and UC, San Diego. Some operational issues that triggered the reporting requirement, such as overloaded links, may not arise during the period in which the IME is reviewing the measurement method and resulting reporting. Validation of a method to detect an issue is not possible until and unless the condition of interest arises. The FCC needs to understand this concern and its implications for any continuing role of the IME.