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Ajit Pai
Chairman, Federal Communications Commission
445 12 Street, SW
Washington, DC 20554

RE: Docket No. 17-108, Restoring Internet Freedom

Dear Chairman Pai:

The “Network Neutrality” debate that started in the first decade of this century was sparked by a serious technical problem in the Internet, due to interactions of the basic protocols used in the Internet (e.g. TCP), buffering and packet scheduling. These problems caused very unfortunate actions by many ISP’s, as the issues were not understood nor appreciated by them, or in fact most of the Internet technical community¹. While the bufferbloat problem was seen in the 1990’s, the solutions of that era, though widely deployed, were impractical and went unused: we threw bandwidth at a fundamental issue that can be subtle, and the situation grew worse for 20 years.

Bufferbloat has clouded (and continue to cloud) the discussions on network neutrality and policy, while playing havoc with any application which needs controlled latency. While many interpret low latency to be applications such as telephony, even Web surfing is also very sensitive to latency. One second of latency will slow typical web surfing more than a factor of ten, even if you have all of the available bandwidth.² Such buffering, is unfortunately, not uncommon, particularly at the edge of the Internet: the last mile, and inside user’s homes.

First, some background: my credentials are explained well in my Wikipedia entry³; I have designed high performance network protocols since 1984, and was the editor of the HTTP/1.1 standard. HTTP is fundamental to today’s Internet, and working on the specification enabled me to develop a very broad view of Internet protocols and behavior, and to establish relationships with most other key Internet technologists.

Seven years ago, I noted that my home network did not function as I expected, and took data that exposed the bufferbloat problem, which I circulated among key “gray beards” of the Internet, who diagnosed the issue. We even lacked a word for bufferbloat in 2010: it was referred to as “the big buffer problem.” I assembled the puzzle pieces that had been accumulating before us all; my contribution is primarily recognizing and assembling the pieces⁴ of the puzzle.

- 1 *Bufferbloat and network neutrality – back to the past...* <https://gettys.wordpress.com/2010/12/07/bufferbloat-and-network-neutrality-back-to-the-past/> while written in late 2010, the history recounted here has been found to be accurate in many private conversations with technologists at multiple ISP’s.
- 2 *Bufferbloat: "Dark" Buffers in the Internet - Demonstrations only:* <https://www.youtube.com/watch?v=npiG7E-BzHOU> demonstrates bufferbloat (and a mitigation for it) on a typical home broadband connection.
- 3 Jim Gettys: https://en.wikipedia.org/wiki/Jim_Gettys
- 4 *Whose house is of glasse, must not throw stones at another:* <https://gettys.wordpress.com/2010/12/06/whose-house-is-of-glasse-must-not-throw-stones-at-another/>

As the magnitude, pervasiveness and complexity of the bufferbloat problem became clear during the summer and fall of 2010, on the recommendation of Vint Cerf¹, rather than taking the time consuming path of academic publishing (which came later²), I started blogging about bufferbloat³ to help “wake up” the technical community, and established a web site⁴ to help coordinate the solutions to bufferbloat.

The magnitude of the problem is staggering: in some instances, bufferbloat is causing a factor of ten or even a factor of a hundred in latency over a properly functioning network, making many applications (such as telephony, stock trading, or gaming) essentially impossible over networks that have ten or a hundred times more bandwidth than is required for those applications to work properly. Latency is more important for most application’s performance than bandwidth. Bufferbloat affects all technologies to some degree or another (cable, Fios, DSL, cellular, ethernet switches, routers, satellite links), and no single technique to solve bufferbloat is a “magic bullet.” In bufferbloat’s extreme form, I have data showing bufferbloat exceeding 740 seconds (!) of latency over a satellite link on a commercial airline⁵; needless to say, being charged \$20 for something completely unusable does not go over well with paying customers. Bufferbloat also encourages consumers to buy far more bandwidth than they actually need. More bandwidth is not necessarily better and at times can just increase bufferbloat⁶. Bufferbloat is truly a mistake the entire industry and research community have made together.

The bufferbloat “call to arms” has sparked a tremendous amount of work in the technical community to solve bufferbloat, resulting in several fundamental new algorithms for queue management (now documented by the IETF aqm working group⁷, e.g. fq_codel and PIE), and a breakthrough in TCP congestion avoidance algorithms (BBR⁸). Google Scholar notes well over 1000 papers referencing bufferbloat⁹. Work to “fix” bufferbloat continues; at last I can say that we have sufficient tools in 2017 to solve bufferbloat properly. Software, firmware and hardware to fix bufferbloat are finally beginning to reach the market¹⁰, though it will take many years to fully fix the existing problem, as many devices in the Internet do not see ongoing updates.

However, while bufferbloat is understood to be a problem among technologists, is not yet understood by management or policy makers: I urge the FCC to understand just how pernicious and universal bufferbloat is, and how it affects policy decisions. The ICSI and other data show bufferbloat to be nearly universal for broadband users. This fundamental problem in the Internet must be fixed, rather than papered over by special “classes of service” and add-on “features” offered

1 Vint Cerf: https://en.wikipedia.org/wiki/Vint_Cerf

2 Bufferbloat: Dark Buffers in the Internet: <https://dl.acm.org/citation.cfm?id=2071893>

3 JG’s Ramblings, starting November, 2010.

4 Bufferbloat.net: <https://www.bufferbloat.net/>

5 Data taken personally, on GoGo in flight, over the Pacific between Hawaii and San Francisco.

6 The Bufferbloat Bandwidth Death March: <https://gettys.wordpress.com/2012/05/23/the-bufferbloat-bandwidth-death-march/>

7 Active Queue Management and Packet Scheduling (aqm): <https://datatracker.ietf.org/wg/aqm/charter/>

8 BBR: Congestion-Based Congestion Control: <https://queue.acm.org/detail.cfm?id=3022184>

9 Google Scholar search for bufferbloat: <https://scholar.google.com/scholar?q=bufferbloat&hl=en>

10 Home products that fix/mitigate bufferbloat...: <https://gettys.wordpress.com/2017/02/02/home-products-that-fixmitigate-bufferbloat/>

by ISP's (that often do more harm than good.)

That bufferbloat can be fixed (and quickly) is now known. For example, in my personal home network, running the latest firmware on my home routers, low latency applications such as telephony and gaming are reliable (even on WiFi), without any configuration, *even when my network is simultaneously loaded* with other bandwidth intensive applications such as file copies and backups. The contrast is startling: worst case latency under load of around 35ms, where the old firmware on the same hardware could easily exhibit a second of latency, more than an order of magnitude worse.

Does this mean that there are no services that an ISP might offer as added value, in a world free of bufferbloat? *No, it does not.* The new bufferbloat algorithms and code do not provide **guarantees** of service; they just make the Internet work the way it was originally designed, and enable most low latency applications to work acceptably over today's Internet. You might certainly pay extra for guarantees of service. For example, if you were holding a teleconference at home for work, you might want guarantees that the bandwidth I need (with low latency) is available even at peak hours, when bandwidth is scarce in some ISP networks. However, you should not have to buy 10 or 100 times the bandwidth you actually need just to get basic services such as telephony and teleconferencing to work properly, which is the current situation.

There is no freedom on the Internet if the network does not work in a timely fashion. Delaying packets by arbitrary amounts of time amounts to "denial of service," over which a user has little or no control. This is at the crux of the debate, but that there is a serious technical problem in the Internet must be faced, or we will continue to wander in useless discussions.

Yours Sincerely,

/s/Jim Gettys

Jim Gettys

P.S. I would be honored to help any of you with your bufferbloat problems at your homes or at the FCC. To see how bad your current bufferbloat is, the DSLreports speedtest¹ (along with several other bandwidth tests) also score bufferbloat while measuring your bandwidth.

1 DSL Reports speedtest: <http://www.dslreports.com/speedtest>