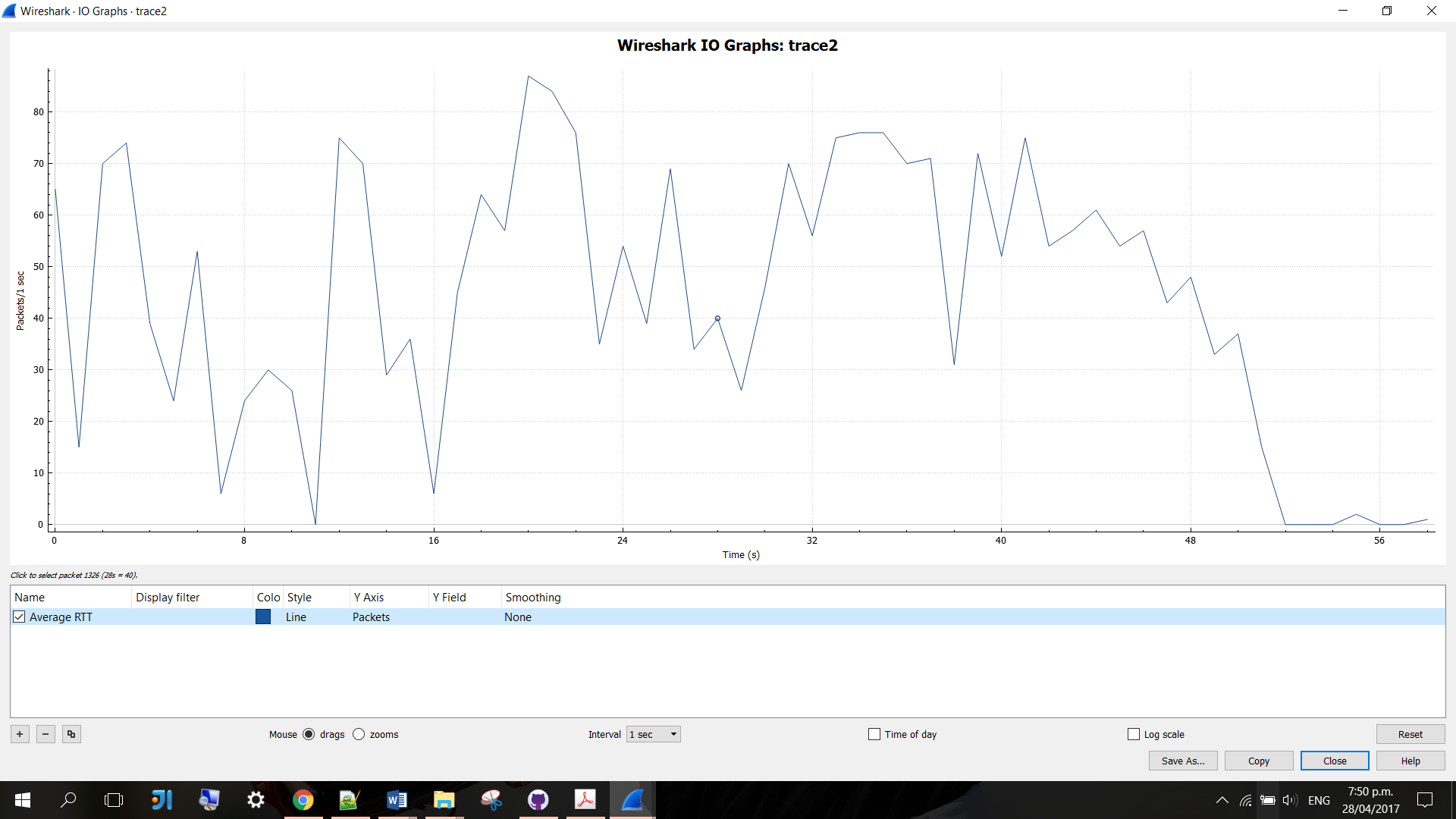
SOFTENG 364 Assignment 1

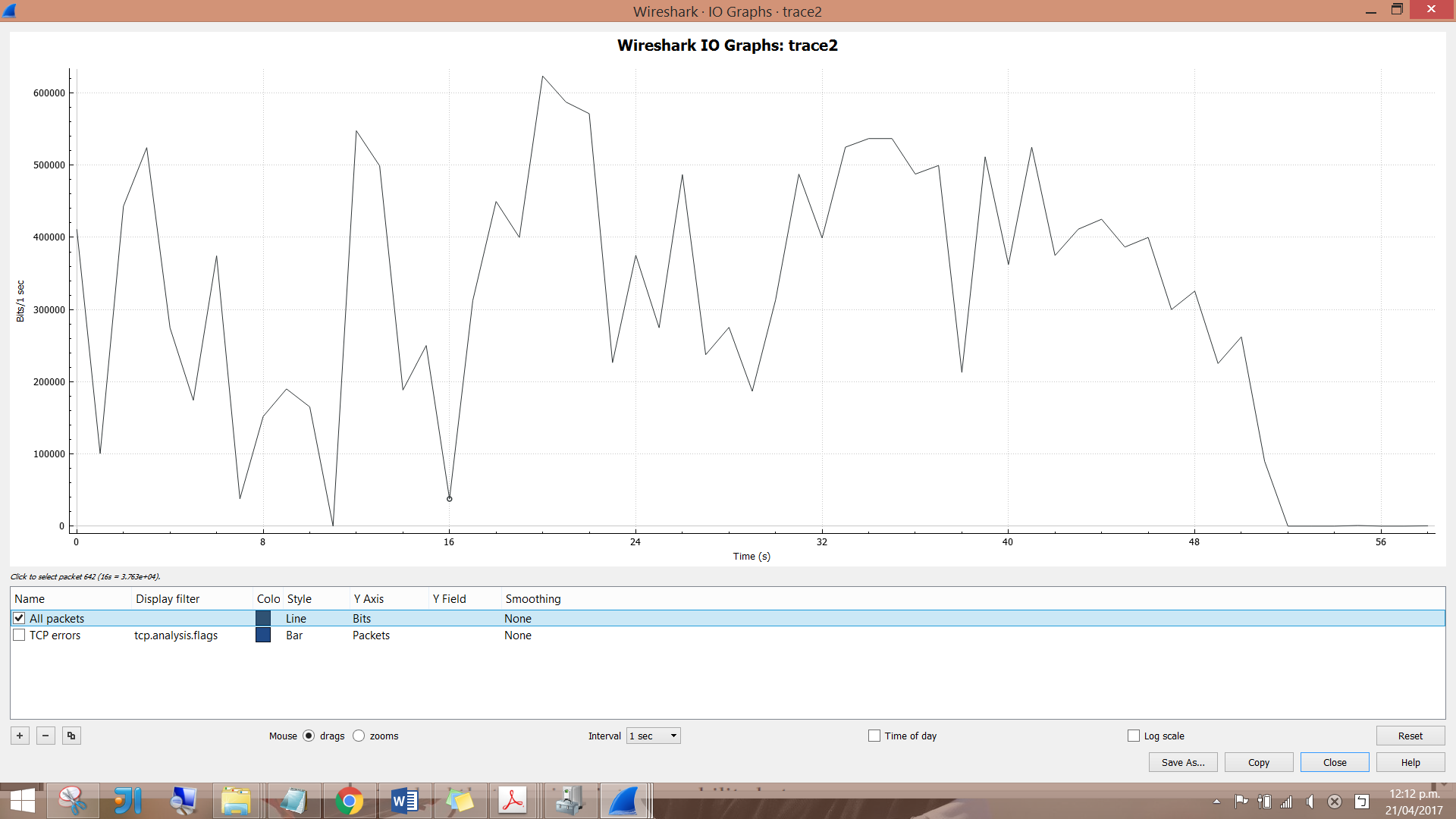
840454023, elee353

Task 2. Q1.



The highest packets-per-second value seen was 87 packets per second and it occurred in the 20th second.

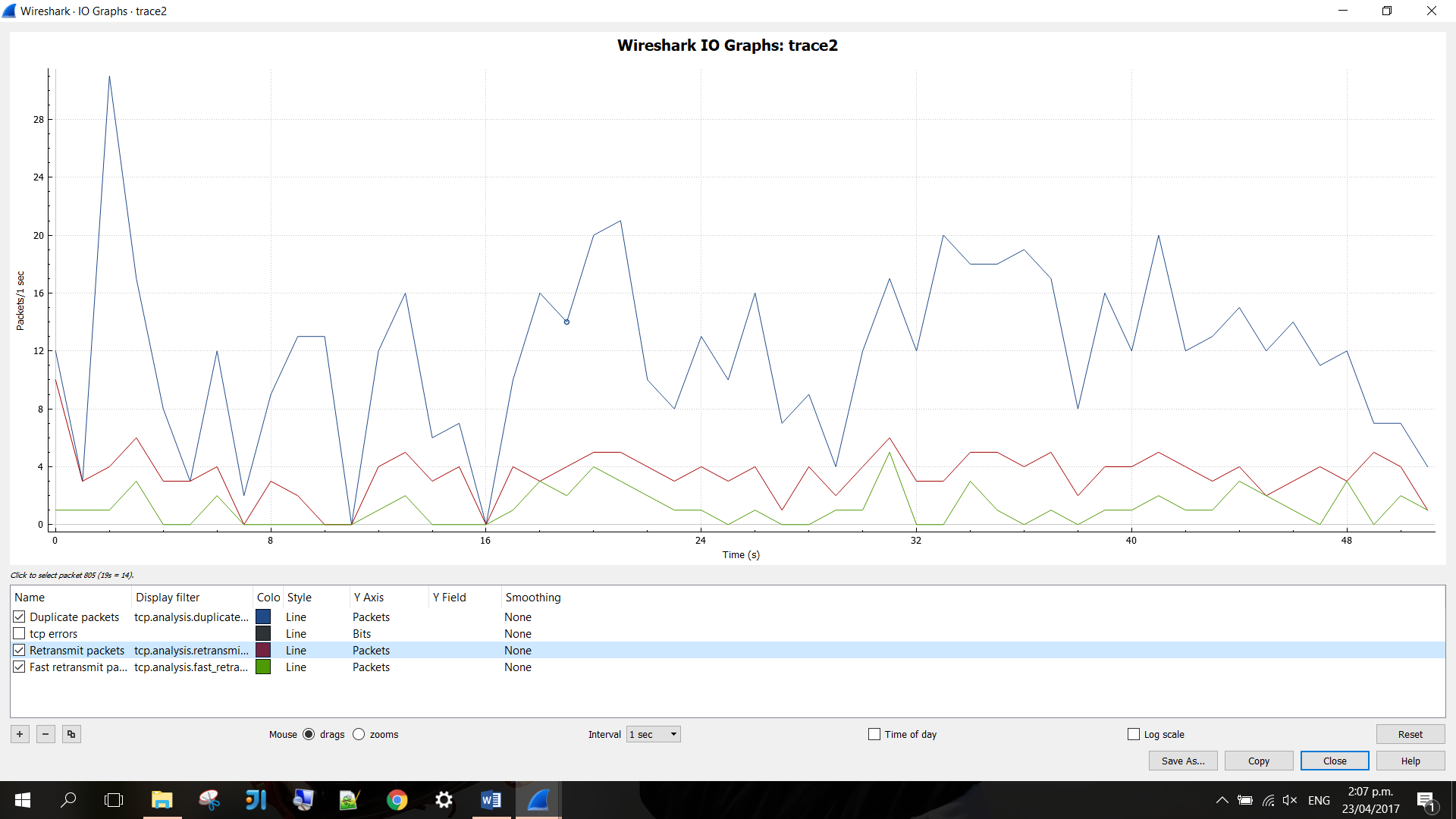
Task 2. Q2.



The highest bits-per-second value is 623500 bits per second and it occurred in the 20th second.

Task 2. Q3.

Apply filters: tcp.analysis.duplicate\_ack, tcp.analysis.fast\_retransmission, and tcp.analysis.retransmission.



Task2. Q4.

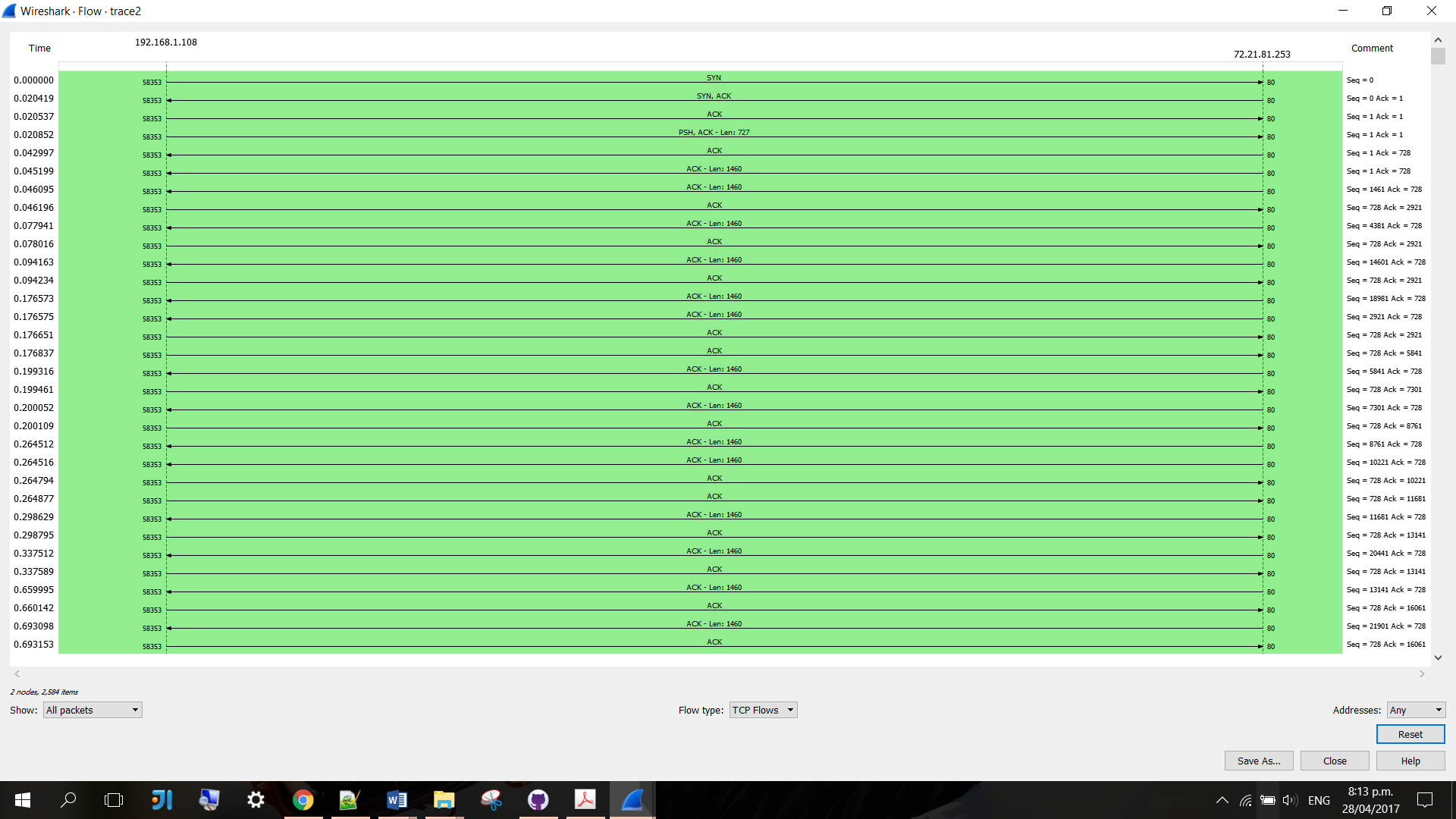
Duplicate ACKs are two or more acknowledgements containing exactly the same information. They are sent when the receiver sees a gap in the packets it receives. The gap can be caused by a lost segment or just a reordering of segments.

The sender will wait for a small number of duplicate ACKs to be received. If there is only one or two duplicate ACKs received before the reordered segment is processed, there is just a reordering of the segments and a new ACK will be generated. If three or more duplicate ACKs are received in a row, it is a strong indication that a segment has been lost. Consequently, fast retransmission will occur.

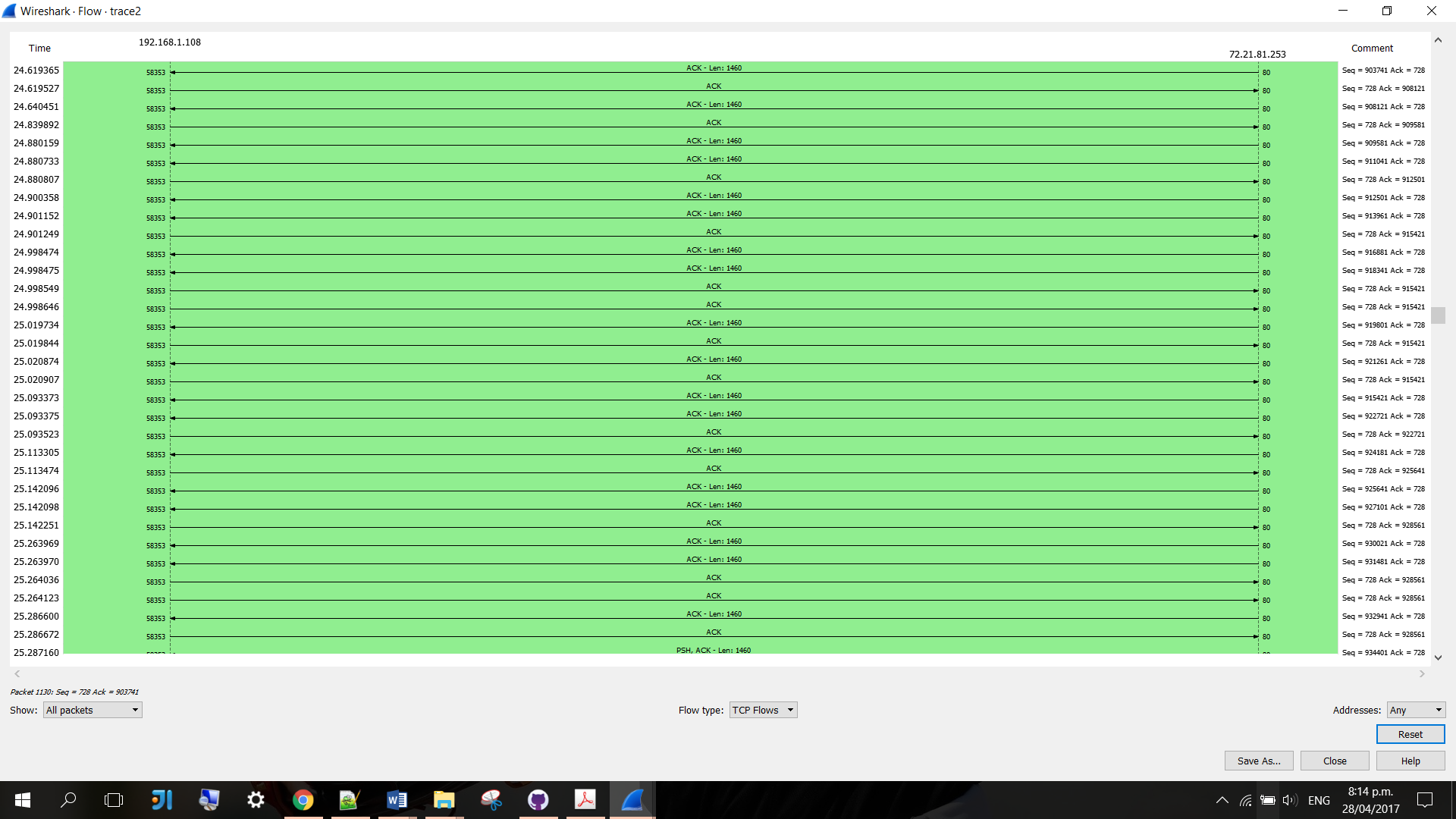
Task2. Q5.

With only TCP flows selected:

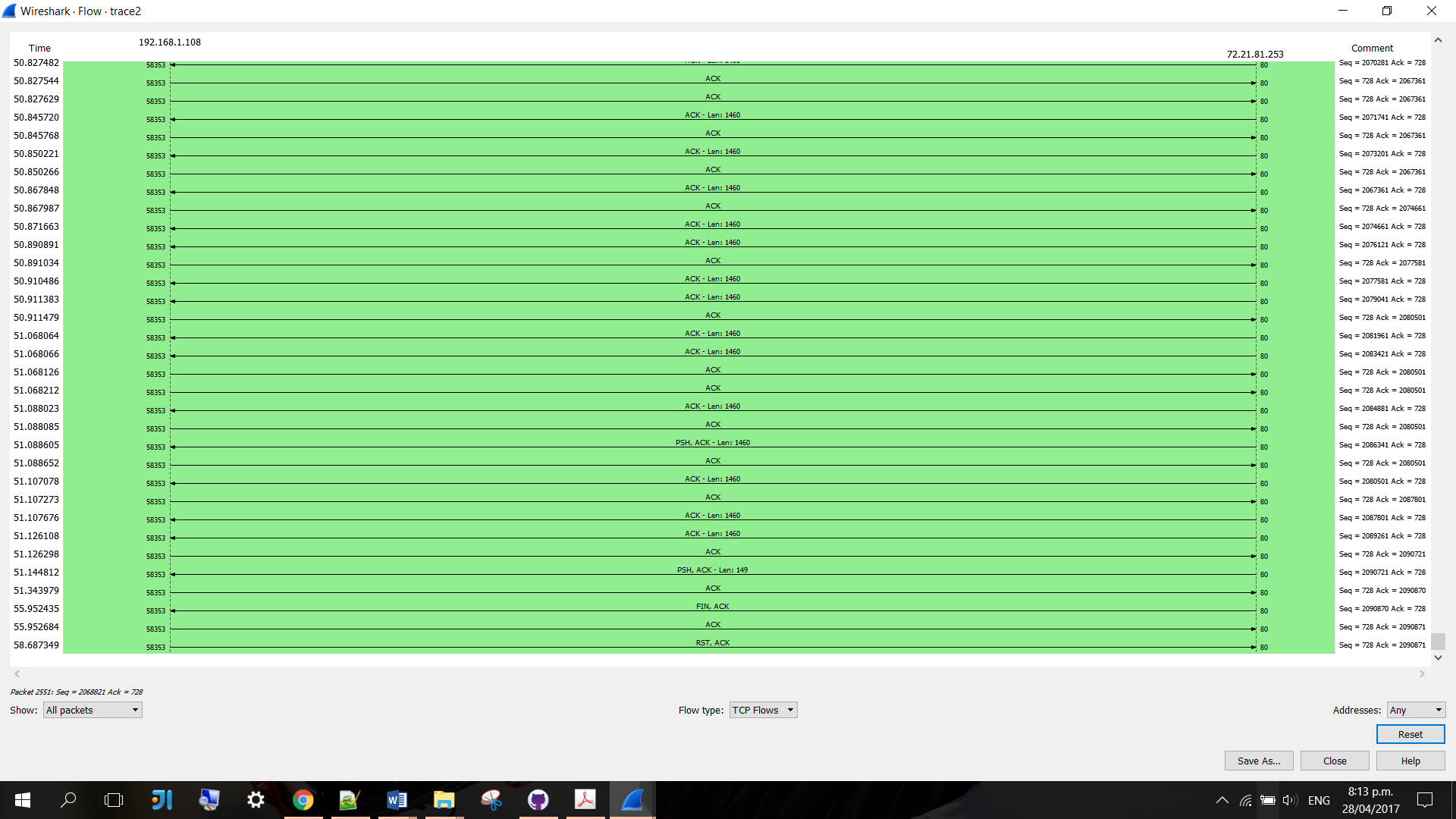
First 30:

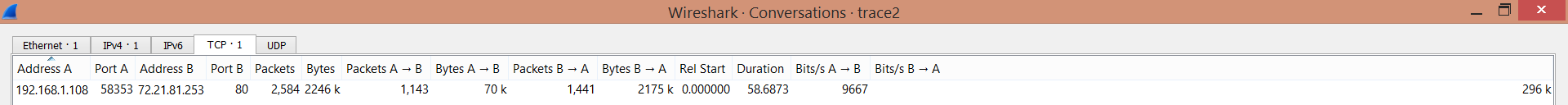


Middle:



Last 30:

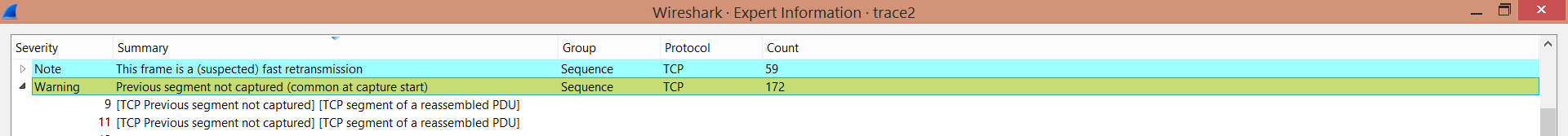


There is one TCP conversation between the two nodes.

Task2. Q6.

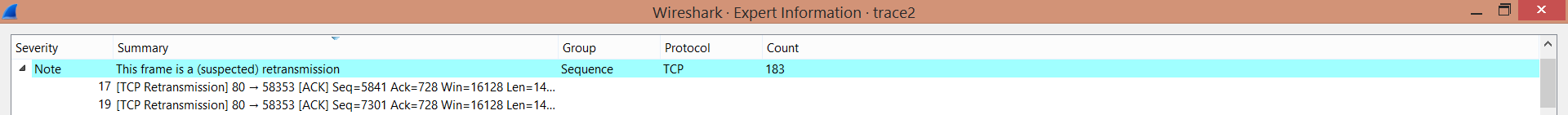
"Tcp previous segment not captured" means Wireshark did not see a packet that should have been in the trace; this means no packet from the same TCP session whose sequence number + byte length matches the sequence number of a present packet.

This is caused by either the packet really wasn't seen on the wire due to a packet loss, or Wireshark did not record the packet fast and timely enough even though it **had been** on the wire.

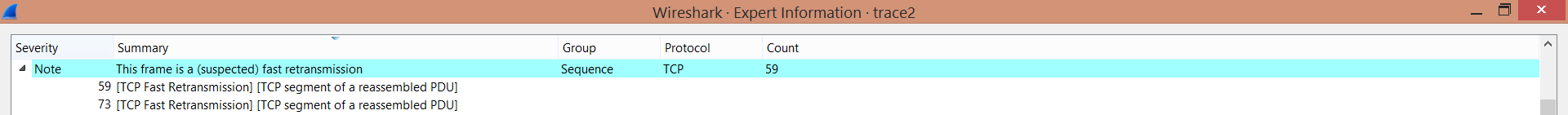


There is 172 times “previous segment not captured” has been detected.

Task 2. Q7.

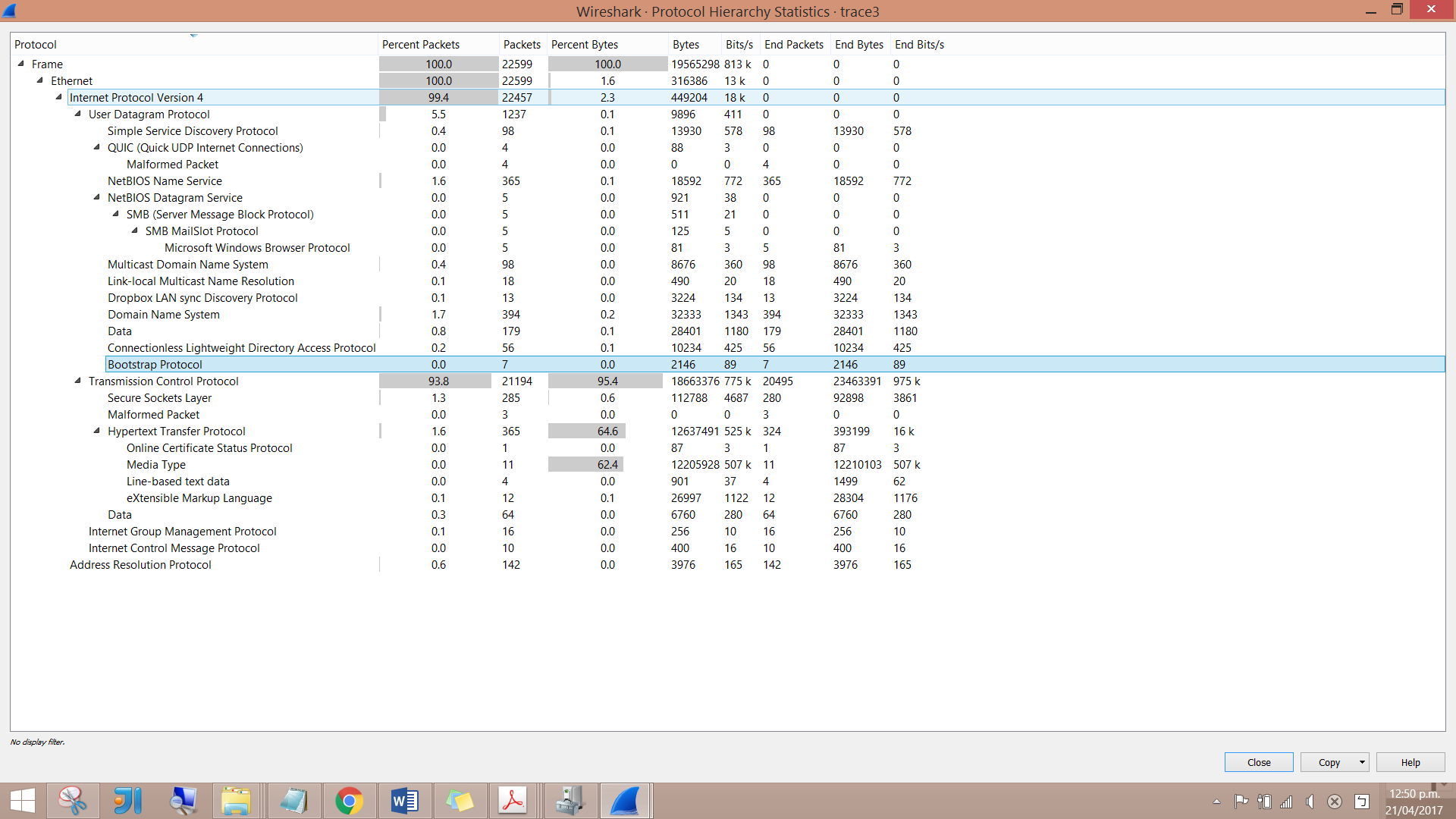


There are 183 retransmissions.



There are 59 fast transmissions.

Task 3. Q1.



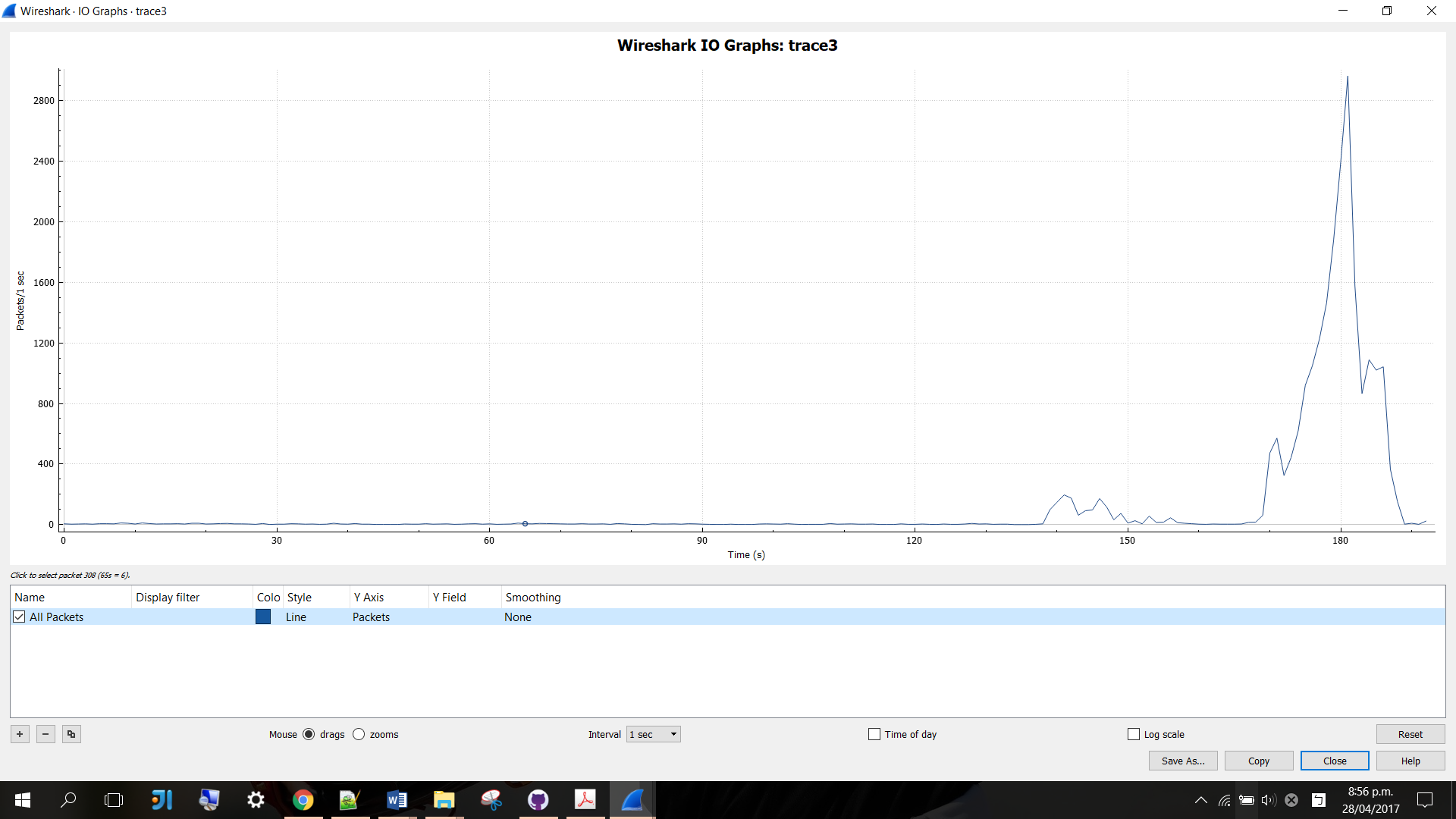
* The protocols include: ARP, NBNS, BROWSER, CLDAP, DB-LSP-DISC, DHCP, DNS, HTTP, OCSP, QUIC, SSDP, TCP, TLSv1, TLSv1.2, UDP
* 0 percent of the total was involved with DCHP messages.
* TCP is used the most here.

Task 3. Q2.

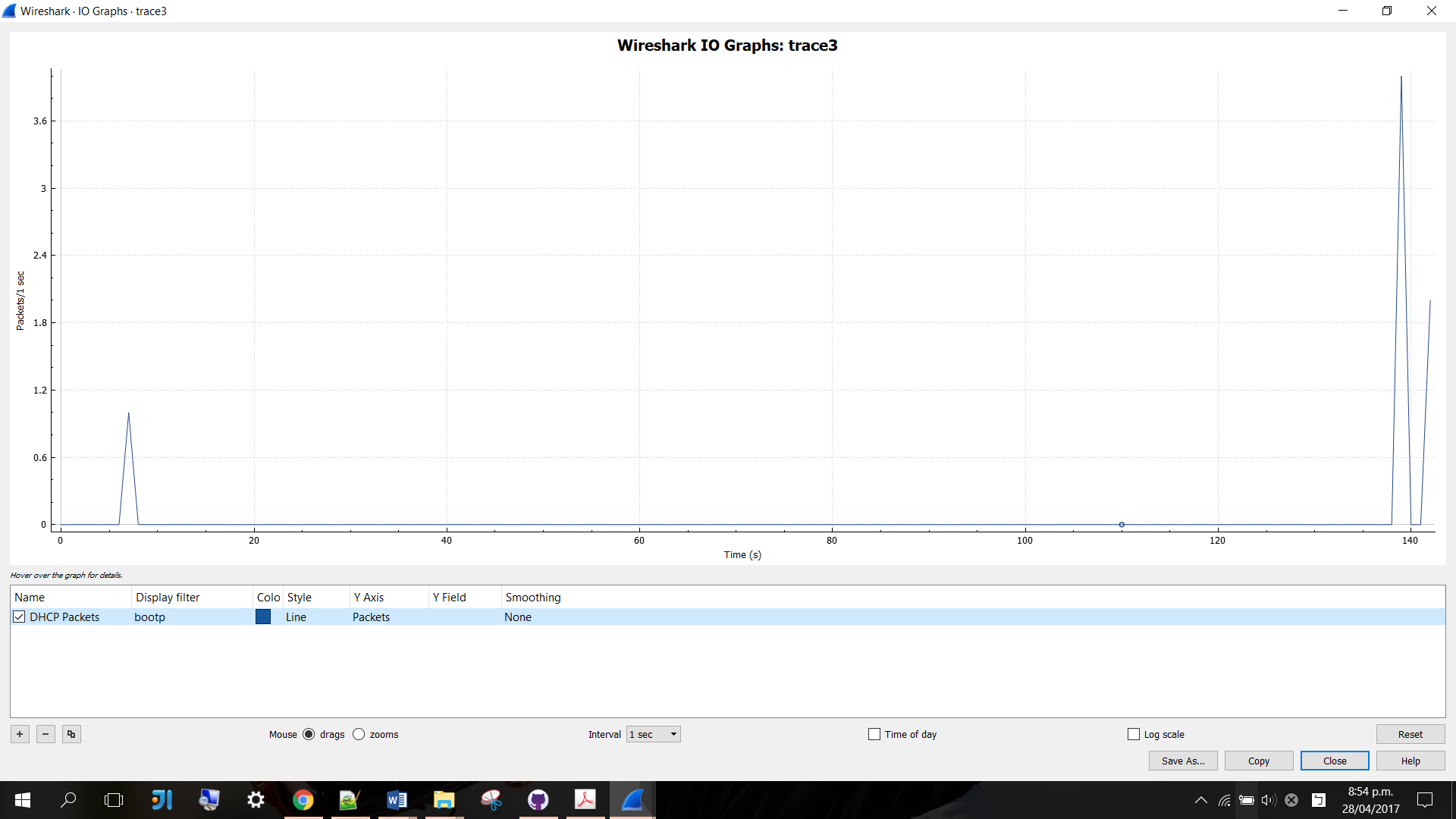
* Apply bootp, dns, tcp, and udp filters.
* Altogether:



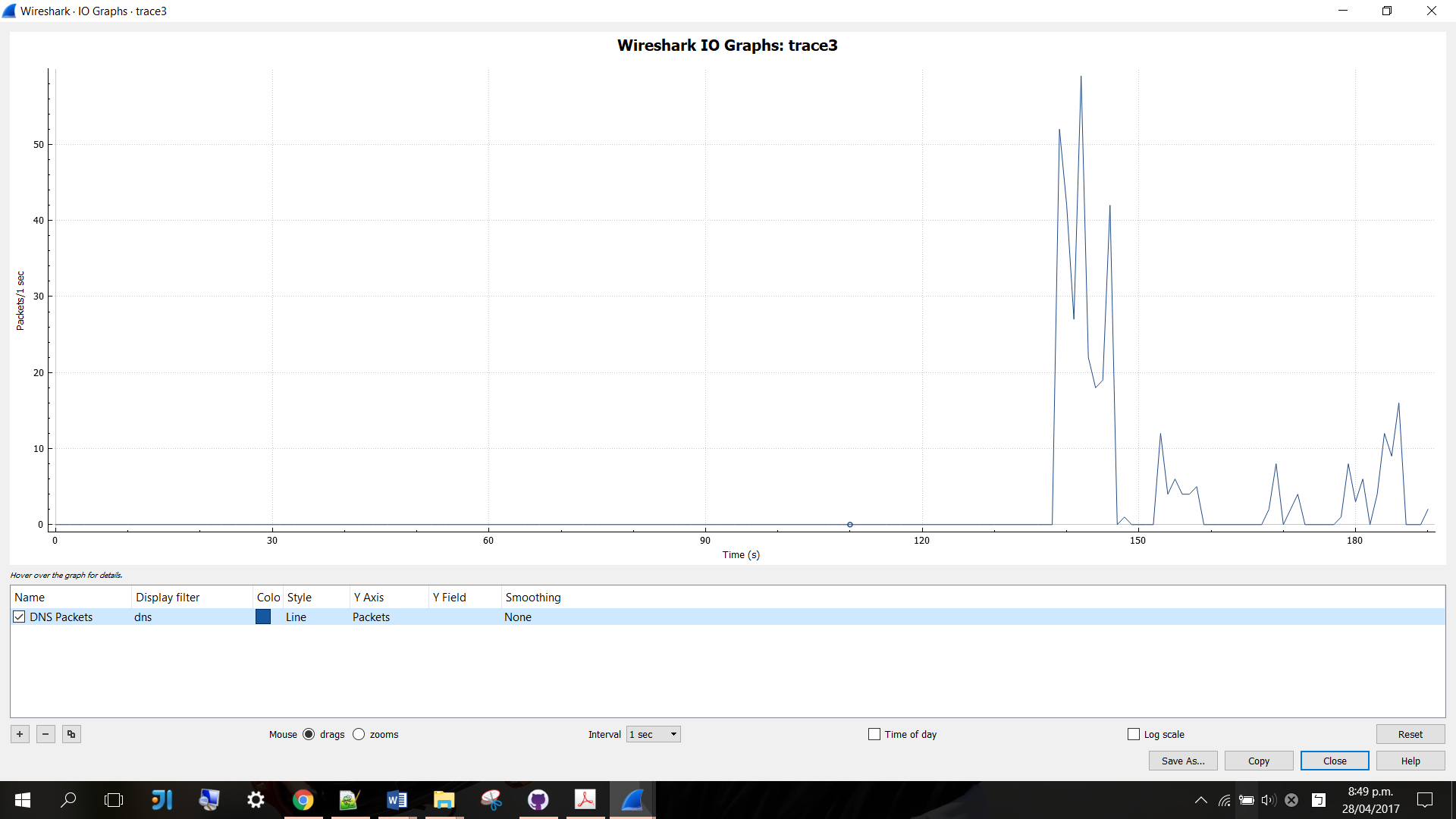
* All traffic:



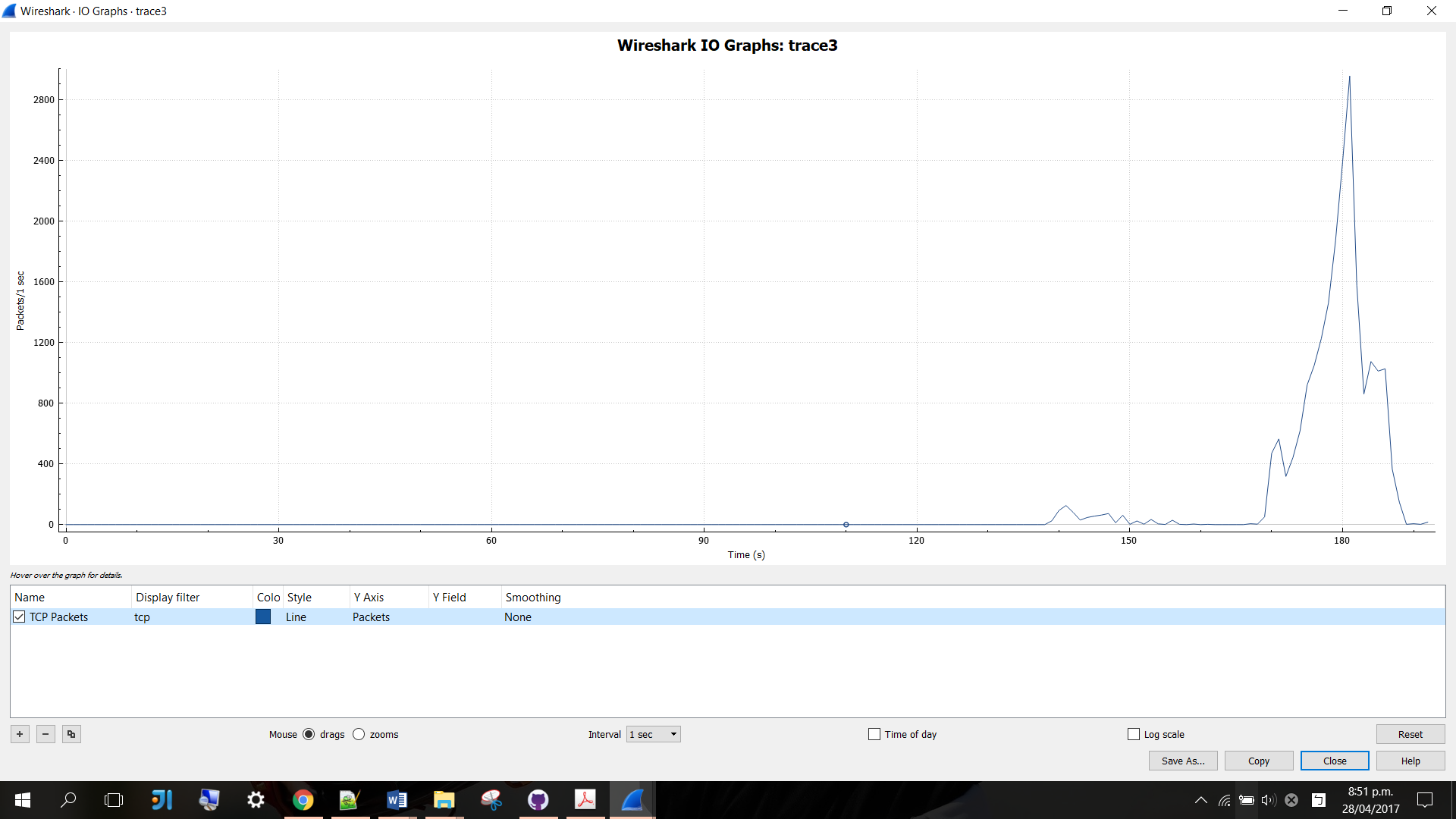
* DCHP filter:



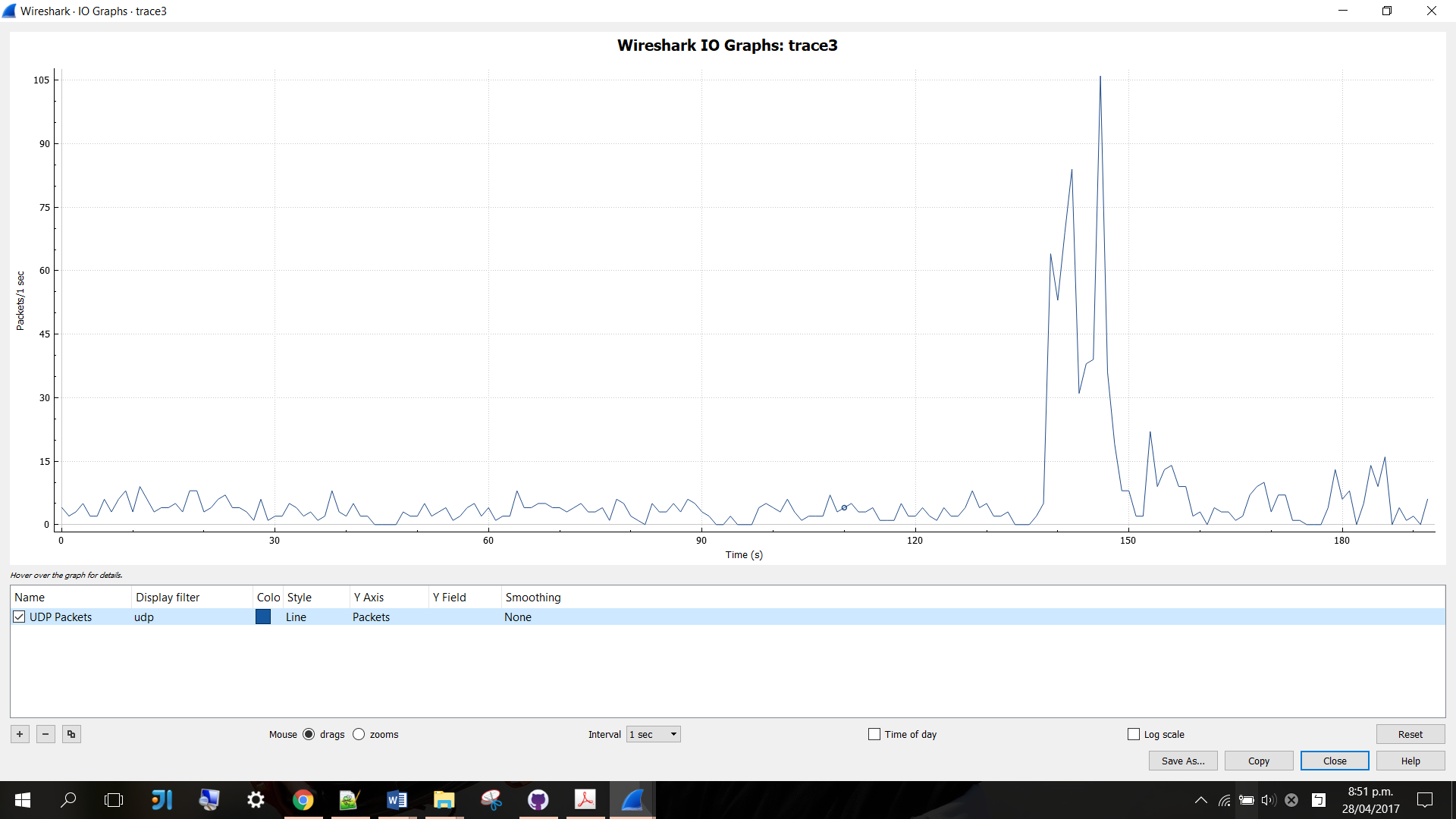
* DNS filter:



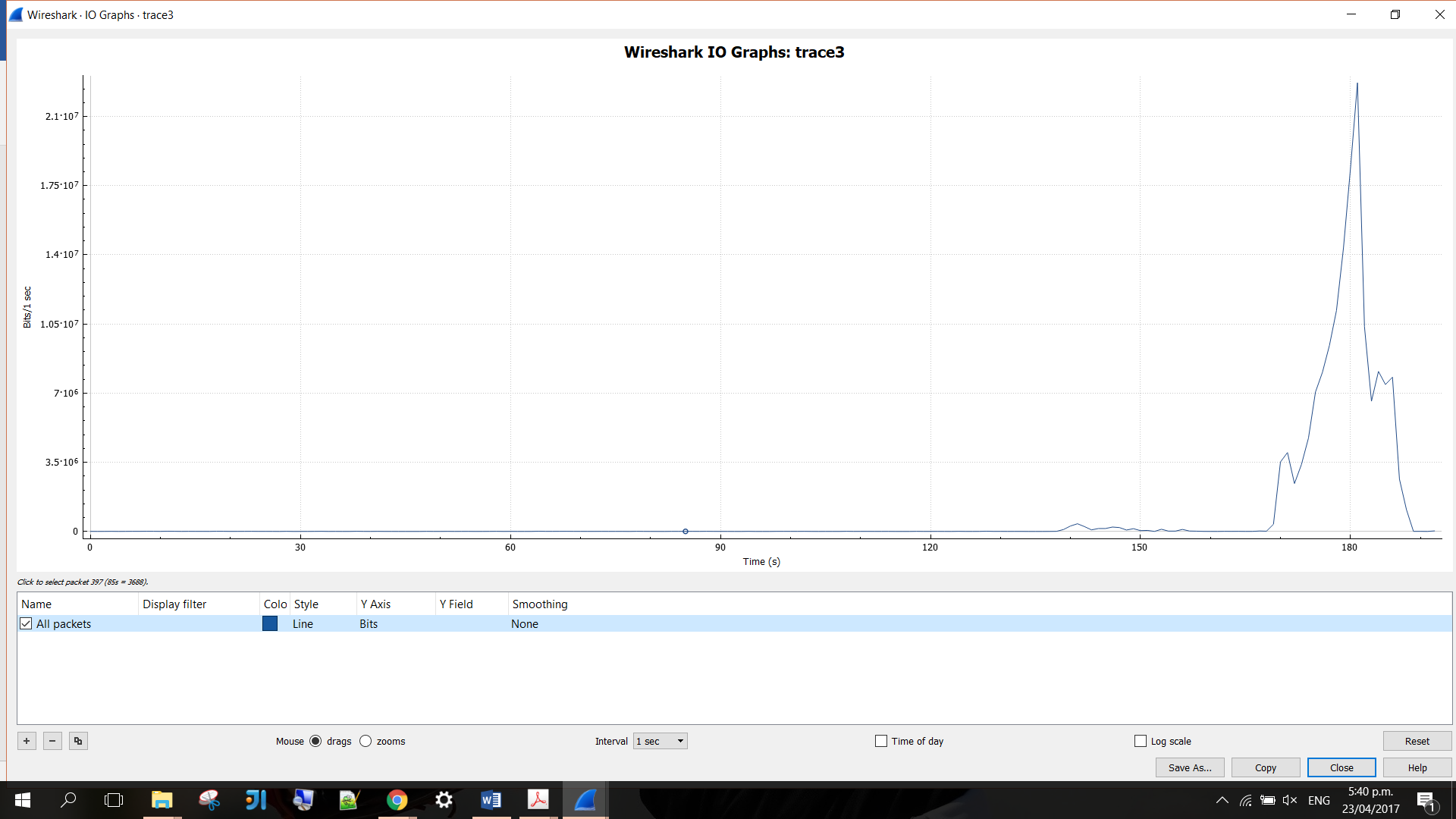
* TCP filter:



* UDP filter:

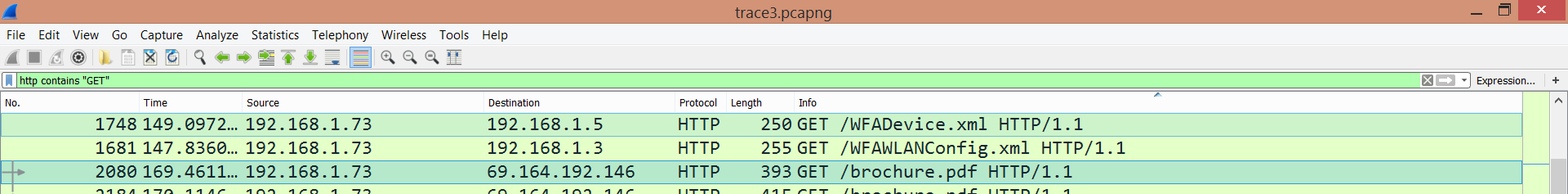


Task 3. Q3.



The highest bits-per-second rate is 22700000 bits per second and it occurred in the 181st second.

Task 3. Q4.



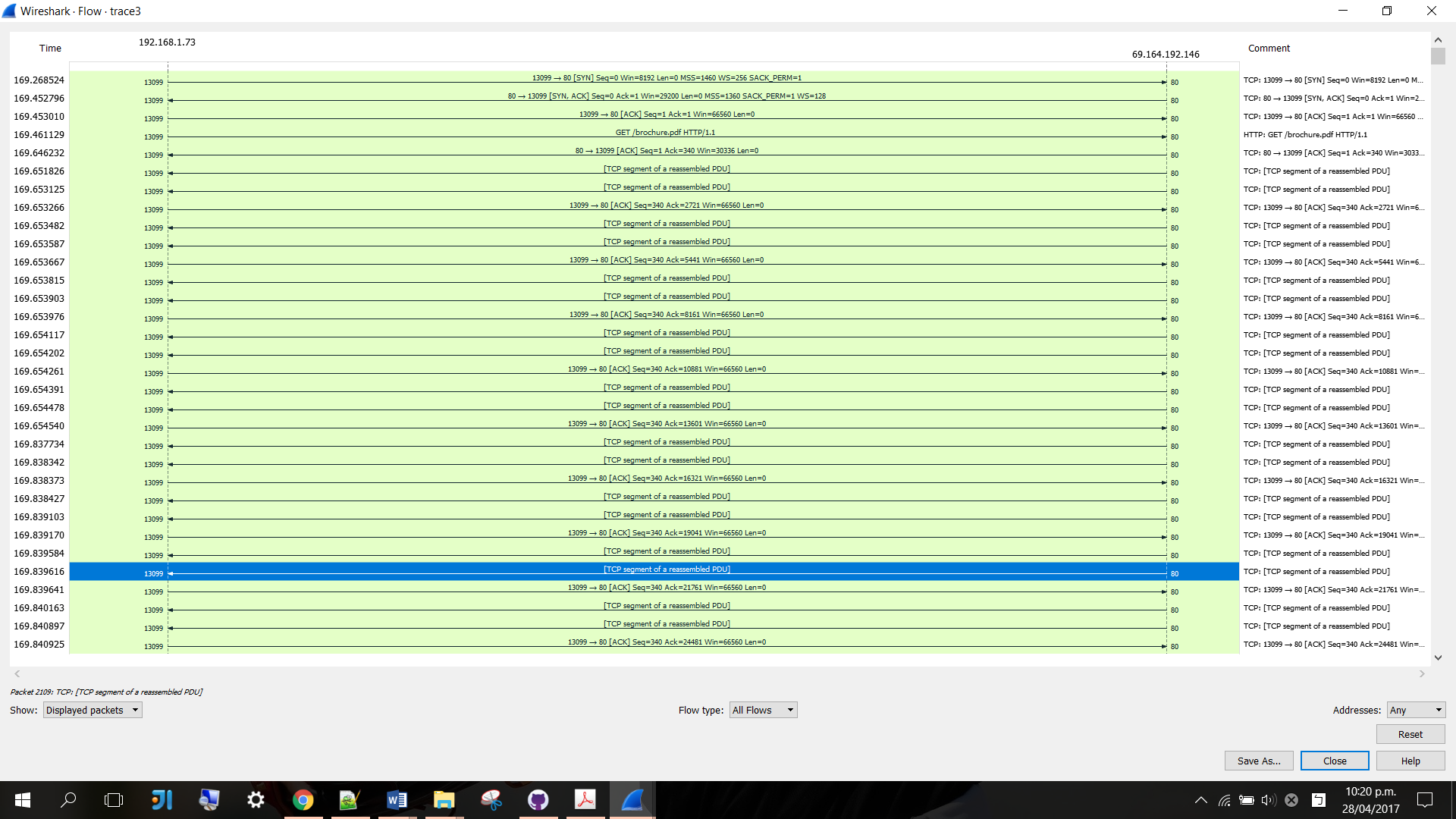
IP address of host: 192.168.1.73

IP address of client: 69.164.192.146

Task 3. Q5.

TCP conversation

First 30:



Middle:

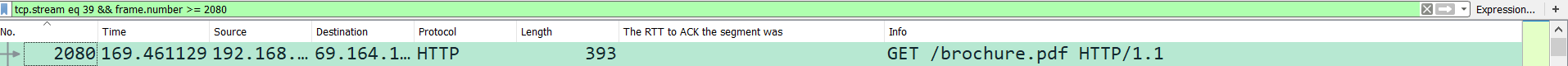


Last 30:



Task 3. Q6.





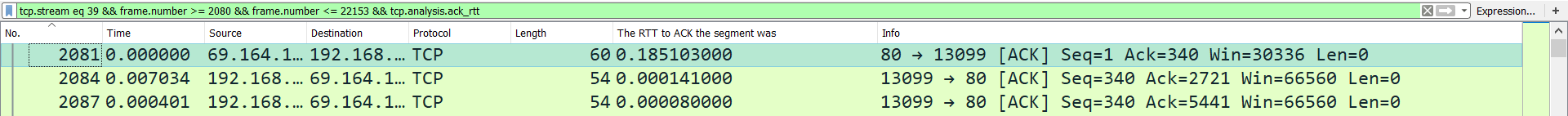


Download time = 187.1269 – 169.4611 = 17.67 seconds

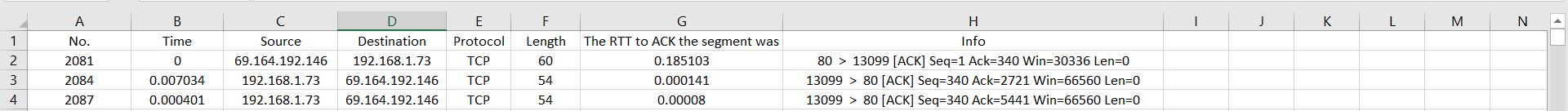
Task 3. Q7.

Apply display filter:

tcp.stream eq 39 && frame.number >= 2080 && frame.number <= 22153 && tcp.analysis.ack\_rtt

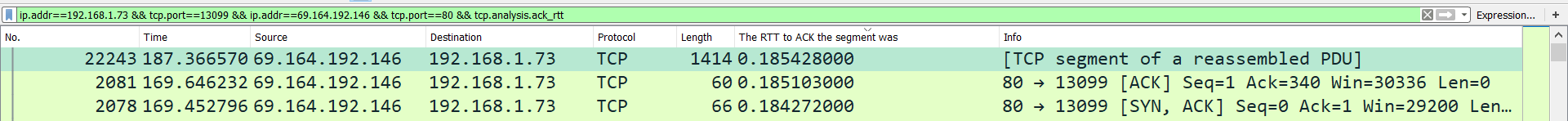


Export to a csv file and use the AVERAGE() function in column G.



The average RTT was 0.000254041 seconds.

Q8.



The longest RTT was 0.185103 seconds and it occurred in the 169.646232 th second.

Task 4

As at 30 June 2016, the number of fibre-optic connections in New Zealand has increased more than double the number of connections at the same time last year. Almost 50 percent of all broadband connections in New Zealand had no data cap. This is in response to a tremendous increase in demand for streaming or on-demand services such as TV or movie streaming, online radio or music streaming, online gaming, and content creation and sharing.

Furthermore, each New Zealand residential connection used approximately 88 gigabytes on average, which equates to approximately 85 hours of streaming TV or movies per month. Additionally, the mobile phone internet connections in New Zealand had an average of 900 megabytes per connection. (Statistics New Zealand, 2016) A considerable proportion of this can result from the video or audio streamings on mobile phones, depending on the quality of streaming.

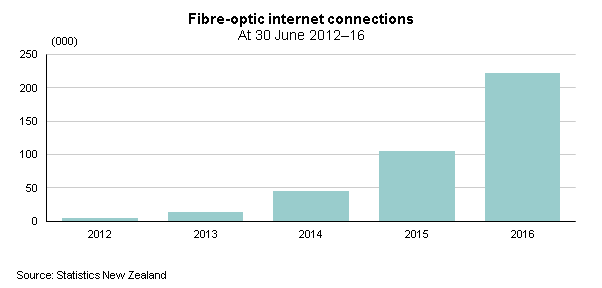


Figure 1 Fibre-optic internet connections between 2012 and 2016

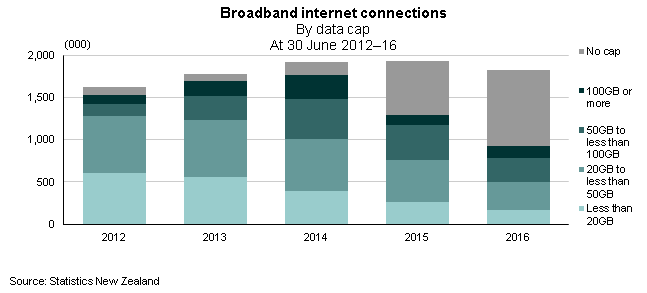


Figure 2 Broadband internet connections between 2012 and 2016

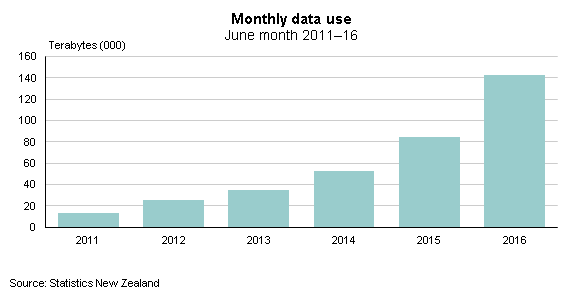


Figure 3 Monthly data usage between 2012 and 2016

**Overview**

Since 2013, New Zealand, like Australia, has seen a proliferation of video streaming services launching. These include global market leader Netflix, Sky-TV’s Neon, Spark’s Lightbox service, as well as Quickflix, Video Ezy on Demand and others. (MacMahon, R., & Milner, M., 2015) Nearly a quarter (24%) of New Zealanders subscribe to digital content such as Netflix and Spotify, and consume content at a time that suits them. (Nielsen, 2016)

Video traffic is the major consumer of internet bandwidth, because multimedia files are generally large in nature. Videos are a sequence of images displayed at a constant rate, while digital images are arrays of pixels.There exist a very diverse range of video communication and streaming applications, which have very distinctive operating conditions or properties. Video communication system designs significantly depend on the characteristics of the communication channel, such as bandwidth, delay, and loss.

Some video channels support Constant Bit Rate (CBR), such as ISDN or DTV. On the other hand, some channels support Variable Bit Rate (VBR), for example, DVD storage and communication over shared packet networks. (Apostolopoulos, J. G., Tan, W. T., & Wee, S. J., 2002) In a video streaming application, a client typically begins playout of the video while the file is being downloaded from the server. This means the client will be playing out the video from one location in the file while it is receiving later parts of the file from the server. Hence, streaming avoids having to download the entire file before beginning the playout, which can potentially incur a longer delay.

Several network protocols have been designed and standardised for communication between clients and streaming servers. The Internet protocol (IP) serves as the network-layer protocol for Internet video streaming. The transport protocol provides end-to-end network transport functions for streaming applications. Transport protocols include UDP, TCP, real-time transport protocol (RTP), and real-time control protocol (RTCP). UDP and TCP protocols support such functions as multiplexing, error control, congestion control, and flow control. RTP and RTCP are upper-layer transport protocols that implement on top of UDP/TCP. The application layer contains several protocols including HTTP and DASH. HTTP is used to exchange or transfer hypertext. DASH (Dynamic Adaptive Streaming over HTTP) is a technique that enables high-quality streaming of media content over the Internet to be delivered from conventional HTTP web servers. It is an extension of the classic HTTP streaming. However, DASH-based streaming is very different from UDP-based streaming as it involves adaptation both by the application and by TCP. (Martin, J., Fu, Y., Wourms, N., & Shaw, T., 2013)

The media content exists on the server in two parts: a Media Presentation Description (MPD) and segments. MPD essentially describes a manifest of the available content and their URL addresses, while the segments contain data segments of the actual multimedia bitstreams. By parsing the MPD, the DASH client learns about the content details and starts fetching the segments using HTTP GET requests. (Sodagar, I., 2011)

The DASH standards focus primarily on the syntax required to describe content manifests and video segments. The standards do not identify speciﬁc encoding methods and protocol behaviours such as the frequency of client request. In order to prevent rebuffering due to buffer starvation, a bit rate level less than the measured available bandwidth is usually chosen. Because of the benefits that HTTP-streaming based technology implies and due to the fact that DASH is a company-independent standard, YouTube and Netflix have implemented DASH as the preferred streaming technology rather than Flash Video streaming.

Furthermore, contend distribution networks (CDNs) replicate stored content and put the replicated content at the edges of the Internet. Techniques such as local caches are used. Given that a large portion of the traffic flowing through the Internet is stored content such as multimedia, CDNs can significantly reduce the traffic loads on the ISPs and the related interfaces between ISPs.

**Netflix**

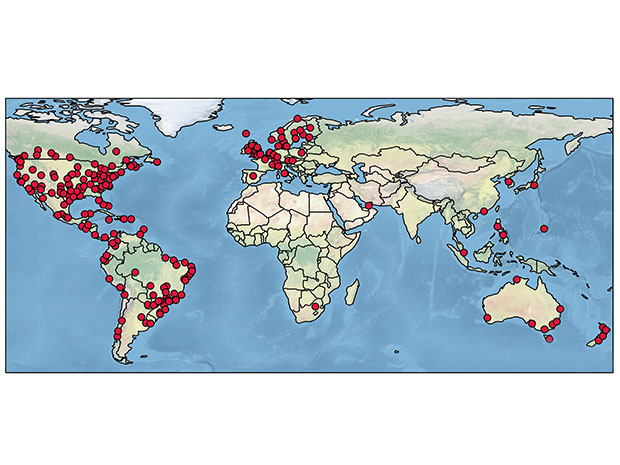


Figure 4 This map depicts the location of Netflix servers found in a recent research

Netflix is the leading subscription service provider for TV shows and online movies. There are approximately 4 Netflix ISP servers in new Zealand, while there are 4669 servers in 243 global locations.(Amy Nordrum, 2016) It is the single largest source of Internet traffic in the US, consuming 29.7% of peak downstream traffic. (Adhikari, V. K., Guo, Y., Hao, F., Varvello, M., Hilt, V., Steiner, M., & Zhang, Z. L., 2012) In March 2016, Netflix claimed to deliver about 125 million total hours of viewing to customers per day. (Netflix Media Center, 2016)

Netflix uses cloud services such as Amazon AWS cloud, CDNs, and other public services. Video streaming of Netflix is served out of multiple CDNs, and UltraDNS, which is a public DNS service used as its authoritative servers. The encoded and DRM protected videos are sourced in Amazon and copied to CDNs. The average bandwidth of CDNs can vary significantly over time and over geographic locations.

Netflix’s content delivery strategy stores content at both IXPs and ISPs. In the United States, Netflix is primarily delivered through IXPs. Meanwhile, there are no Netflix servers at IXPs in Canada or Mexico. Customers in those countries are served exclusively by servers within ISPs, as well as possibly through IXPs along the U.S. borders. (Amy Nordrum, 2016) Netflix’s centralised approach outside the U.S. is convenient because it has more control and scalability for the local market.

Netflix uses the DASH protocol over TCP for streaming. The DASH players of Netflix are allowed to freely switch between different quality levels at the chunk boundaries. However, Netflix clients do not try all possible available bitrates when trying to determine the optimal playback rate. Netflix video streaming is controlled by instructions in a manifest file that provides the DASH player metadata. The manifest files are client-specific and delivered via SSL connection. They also rank CDNs to indicate the preferred CDNs. (Adhikari, V. K., Guo, Y., Hao, F., Varvello, M., Hilt, V., Steiner, M., & Zhang, Z. L., 2012) In general, the Netflix client appears to stay with the same CDN as long as possible even if it has to degrade the quality level of the playback, while other CDNs appear to serve only as backups. Furthermore, Netﬂix’s adaptation appears to default to TCP control during periods of heavy, sustained network congestion. However, the application algorithm is clearly intertwined with TCP control during periods of volatile network conditions. (Martin, J., Fu, Y., Wourms, N., & Shaw, T., 2013)

The DASH client of Netflix contains three main functional areas: the HTTP access, the media engine, and the control engine that monitors the arriving video stream and determines the quality of stream to request. (Martin, J., Fu, Y., Wourms, N., & Shaw, T., 2013) The client will maintain a playback buffer that smooths variable content arrival rates to support the video playback. The client requests a new segment tagged with the desired bitrate once the playback buffer drops below a certain threshold. When the playback buffer is almost empty, the client is likely to go into a ‘buffering’ state where it requests segments at a high rate. (Martin, J., Fu, Y., Wourms, N., & Shaw, T., 2013)

Hence, the session operates in one of two states: buffering or steady state. While in a buffering state, the client requests data at a rate up to the available bandwidth over the path between the server and the client. If conditions permit, the session will attempt to ﬁnd a ‘steady state’ where it requests segments at a rate necessary to playback the content at a given encoded bitrate. (Adhikari, V. K., Guo, Y., Hao, F., Varvello, M., Hilt, V., Steiner, M., & Zhang, Z. L., 2012)

**YouTube**

YouTube is one of the most popular services on the internet, being the most visited website in the world. Three hundred hours of video is uploaded to YouTube every minute. (FortuneLords, 2017)

YouTube’s content delivery strategy prefers to store content at IXPs. (Amy Nordrum, 2016) YouTube uses a Flash-based client which is embedded in the web page. The communication between the client and server is done over HTTP. Consequently, YouTube does not have to cope with lost or reordered packets. However, a stalling of the video may be caused by transmission problems. HTTP over TCP privodes two advantages. First, TCP is more firewall friendly compared to UDP as firewalls are more likely to block UDP. Second, the client manages HTTP streaming without having to maintain a session state on the server. (Sodagar, I., 2011)

By using DASH, YouTube is able to switch the video quality based on the recent link capabilities. This enables YouTube’s player quality parameter. If it is set to ‘auto’, YouTube can adapt the bitrate of the video based on the client’s available bandwidth. (Añorga, J., Arrizabalaga, S., Sedano, B., Alonso-Arce, M., & Mendizabal, J. , 2015)

YouTube’s streaming strategy has two phases: a burst phase and a throttling phase. The burst phase is the initial phase where there exists a significant burst of data. After this initial burst, the receiving download data rate of YouTube’s player is considerably reduced. In addition, the transmission rate during the throttle phase influences the amount of data sent by the YouTube server during the burst phase. (Krishnappa, D. K., Bhat, D., & Zink, M., 2013) This strategy reduces congestion in the network by eliminating the transmission of unused data.

DASH provides the advantages in bandwidth and cost saving for YouTube, especially when the majority of users do not watch more than the first 20% of a video. However, one disadvantage of DASH is the amount of storage required to host all the videos in various bit rates and segment lengths on YouTube. (Añorga, J., Arrizabalaga, S., Sedano, B., Alonso-Arce, M., & Mendizabal, J. , 2015)

**Lightbox**

Lightbox is a New Zealand subscription video on demand (SVOD) service owned by Spark New Zealand. The service offers a selection of television shows over a wide range of devices. (Lightbox (New Zealand), 2017) Lightbox was initially launched as ShowmeTV in 2014 and currently faces competitions from other SVOD services including Quickflix, Netflix and Neon. (Keall, Chris., 2014) (Damien Venuto, 2015) According to our previous discussion, Lightbox is likely to utilise the centralised approach, where the customers are served exclusively by servers within ISPs. The ISP here is likely to be the parent company, Spark. Similarily, this approach is convenient because it has more control and scalability for the New Zealand market.

Bibliography

Adhikari, V. K., Guo, Y., Hao, F., Varvello, M., Hilt, V., Steiner, M., & Zhang, Z. L. (2012). Unreeling netflix: Understanding and improving multi-cdn movie delivery. *INFOCOM* (pp. 1620-1628). IEEE.

Amy Nordrum. (2016, August 30). *Researchers Map Locations of 4,669 Servers in Netflix’s Content Delivery Network*. Retrieved from IEEE Spectrum: http://spectrum.ieee.org/tech-talk/telecom/internet/researchers-map-locations-of-4669-servers-in-netflixs-content-delivery-network

Añorga, J., Arrizabalaga, S., Sedano, B., Alonso-Arce, M., & Mendizabal, J. . (2015). YouTube’s DASH implementation analysis. *19th International Conference on Circuits, Systems, Communications and Computers (CSCC)*, (pp. 61-66).

Apostolopoulos, J. G., Tan, W. T., & Wee, S. J. (2002). *Video Streaming: Concepts, Algorithms, and Systems.* HP Laboratories, report HPL-2002-260.

Damien Venuto. (2015, January 20). *Spark continues to evolve, offers another subscriber perk with free Lightbox*. Retrieved from StopPress: http://stoppress.co.nz/news/telco-or-media-company-continued-evolution-spark

FortuneLords. (2017, March 23). *36 Mind Blowing YouTube Facts, Figures and Statistics – 2017*. Retrieved from FortuneLords: https://fortunelords.com/youtube-statistics/

Keall, Chris. (2014, August 28). *Spark's Lightbox launches, with a little surprise from the boss*. Retrieved from National Business Review: http://www.nbr.co.nz/article/sparks-lightbox-launches-little-surprise-boss-ck-161495

Krishnappa, D. K., Bhat, D., & Zink, M. (2013). DASHing YouTube: An analysis of using DASH in YouTube video service. *2013 IEEE 38th Conference* (pp. 407-415). IEEE.

Kurose, J. F., & Ross, K. W. (2010). *Computer networking: a top-down approach* (Vol. 5). Addison-Wesley.

*Lightbox (New Zealand)*. (2017, April 16). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Lightbox\_(New\_Zealand)

MacMahon, R., & Milner, M. (2015). Ultra-fast broadband in New Zealand: Progress accelerating. *Australian Journal of Telecommunications and the Digital Economy, 3*, 12.

Martin, J., Fu, Y., Wourms, N., & Shaw, T. (2013). Characterizing Netflix bandwidth consumption. *Consumer Communications and Networking Conference (CCNC)* (pp. 230-235). IEEE.

Netflix Media Center. (2016, March 17). *How Netflix Works With ISPs Around the Globe to Deliver a Great Viewing Experience*. Retrieved from Netflix Media Center: https://media.netflix.com/en/company-blog/how-netflix-works-with-isps-around-the-globe-to-deliver-a-great-viewing-experience

Nielsen. (2016, April 14). *NEW ZEALAND MEDIA TRENDS REPORT 2016*. Retrieved from Nielsen: http://www.nielsen.com/nz/en/insights/reports/2016/new-zealand-media-trends-2016.html

Rao, A., Legout, A., Lim, Y. S., Towsley, D., Barakat, C., & Dabbous, W. (2011). Network characteristics of video streaming traffic. *Seventh COnference on emerging Networking EXperiments and Technologies* (p. 25). ACM.

Sodagar, I. (2011). The mpeg-dash standard for multimedia streaming over the internet. *IEEE MultiMedia, 18*(4), 62-67.

Statistics New Zealand. (2016, October). *Internet Service Provider Survey: 2016*. Retrieved from Statistics New Zealand: http://www.stats.govt.nz/browse\_for\_stats/industry\_sectors/information\_technology\_and\_communications/ISPSurvey\_HOTP2016/Commentary.aspx

Wu, D., Hou, Y. T., Zhu, W., Zhang, Y. Q., & Peha, J. M. (2001). Streaming video over the Internet: approaches and directions. *IEEE Transactions on circuits and systems for video technology, 11*, 282-300.

Table of Figures

[Figure 1 Fibre-optic internet connections between 2012 and 2016 14](#_Toc481182176)

[Figure 2 Broadband internet connections between 2012 and 2016 14](#_Toc481182177)

[Figure 3 Monthly data usage between 2012 and 2016 15](#_Toc481182178)

[Figure 4 This map depicts the location of Netflix servers found in a recent research 16](#_Toc481182179)