Watching Stars in Pixels: The Interplay of Traffic Shaping and YouTube Streaming QoE over GEO Satellite Networks

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Presenter:

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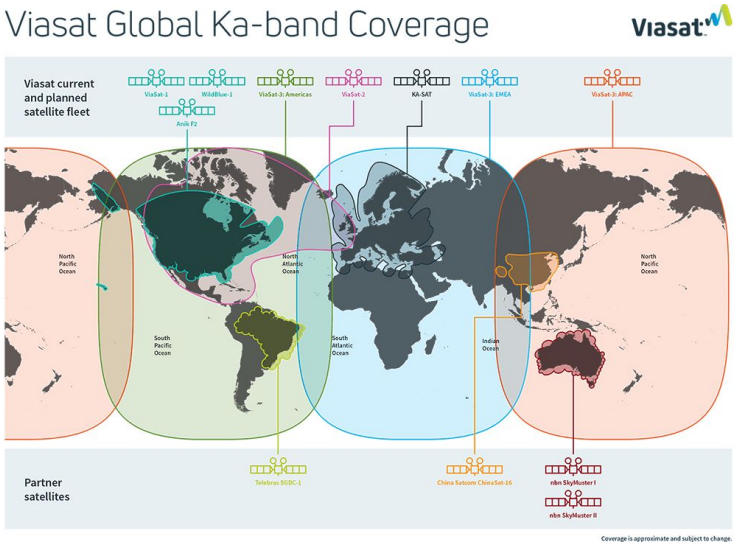
Video Streaming in GEO Networks

Geostationary satellite (GEO) networks:

- a key internet access technology for challenging environments and hard to reach communities
- round trip propagation delay of ~600ms
- user opt-in video traffic shaping option to save their priority data usage.

Because of the high latency and traffic shaping option, it is important to analyze users' quality of experience (QoE) for video traffic

- We focus our analysis on YouTube because it accounts for 15% of total internet traffic.



source:https://graphiclux.com/tips-use-power-youtube-build-traffic

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Research Objectives

Our research goal is to analyze YouTube QoE to better understand the user experience.

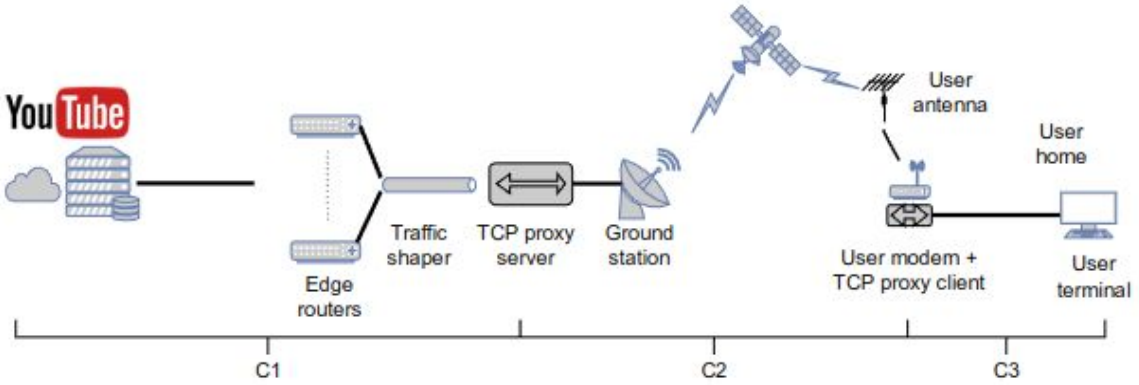
Research approach:

- Collect YouTube QoE and Quality of Service (QoS) measurements from the Viasat production GEO network.

- Analyze the collected production video QoE and compare with expected QoE.

- Analyze any unexpected, sub-par QoE using QoS measurement data.

Experiment Setup

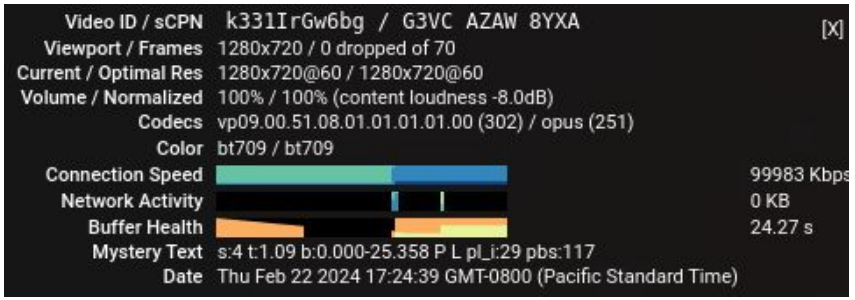


- Laptop at UCSB connects to the production Viasat network.
- Two transport protocol options:
  - Due to the long latency, TCP proxies break the connection into C1, C2 and C3 for TCP traffic to grow the congestion window more aggressively.
  - The default protocol QUIC cannot benefit from the proxies, and the QUIC traffic is simply forwarded.
- The video shaping rate was 900 Kbps, similar rates are used by other satellite/mobile ISPs[1].
- BBRv3 is used by Google as the congestion control algorithm.

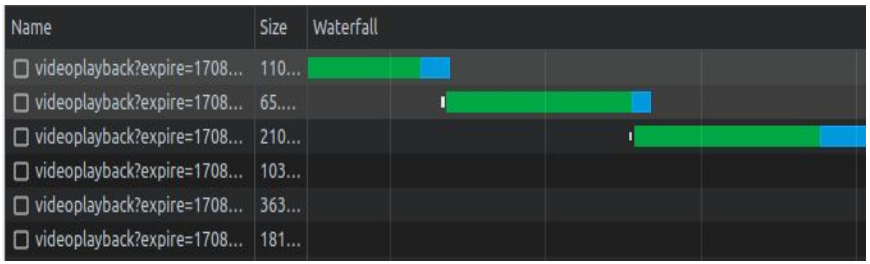
1.Fangfan Li, Arian Akhavan Niaki, David Choffnes, Phillipa Gill, and Alan Mislove. 2019. A large-scale analysis of deployed traffic differentiation practices. In Proceedings of the ACM Special Interest Group on Data Communication (SIGCOMM '19)

Methodology

- Stream 13 videos from 16 categories for a total of 208 distinct videos.
  - 5 times with QUIC and 5 times with TCP as the transport protocol.
- Collect YouTube "Stats for Nerds" for QoE analysis.
- Collect HTTP performance logs for video chunk QoS analysis.



Stats for nerds



HTTP performance Log

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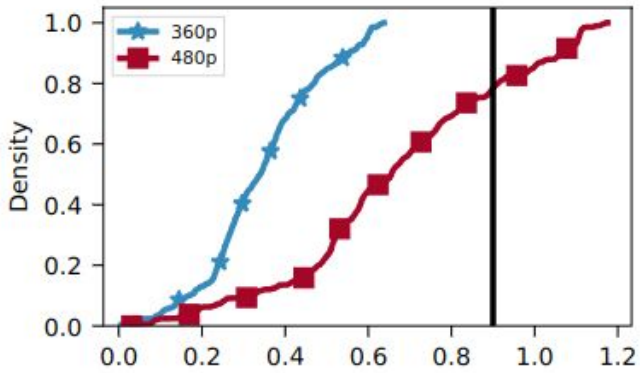
Collected QoE is below our expectations

Expectation:

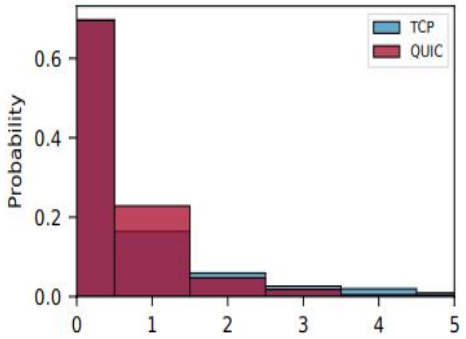
- Average video bitrate of 360p is well below 900Kbps, and Adaptive Bitrate Algorithm (ABR) should enable streaming at more than 360p without many (or any) rebuffering events.

Collected measurements:

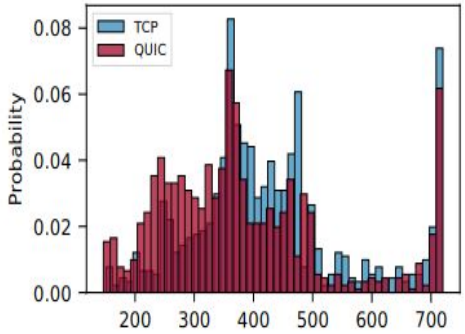
- 30% of both TCP sessions and QUIC sessions experience rebuffering events.
- Average resolution is only 404p for TCP and 360p for QUIC.



Average bitrate of selected videos (Mbps)



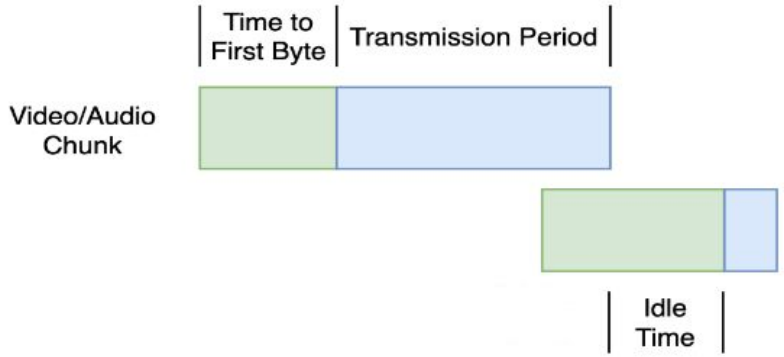
Number of rebuffering events



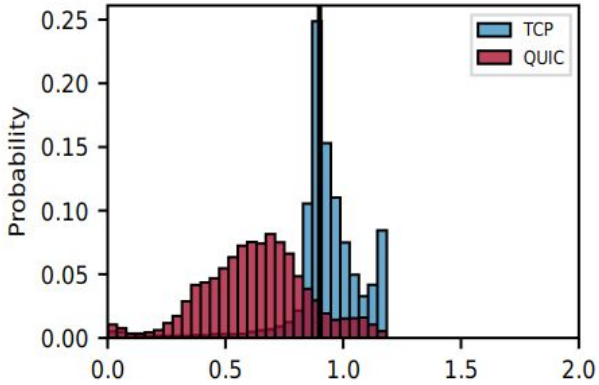
Percentage of time viewed at resolution (pixels)

Below Expectation QoE Diagnosis

QUIC cannot saturate the link during transmission period



Chunk transmission model



Throughput during transmission period (Mbps)

We observe a sequential transmission of chunks similar to previous work. However, the idle time is not negligible due to ~600ms round trip propagation delay.

By calculating the throughput during the transmission period only, we conclude that QUIC cannot saturate the link capacity while TCP can. QUIC's median throughput is 0.63Mbps.

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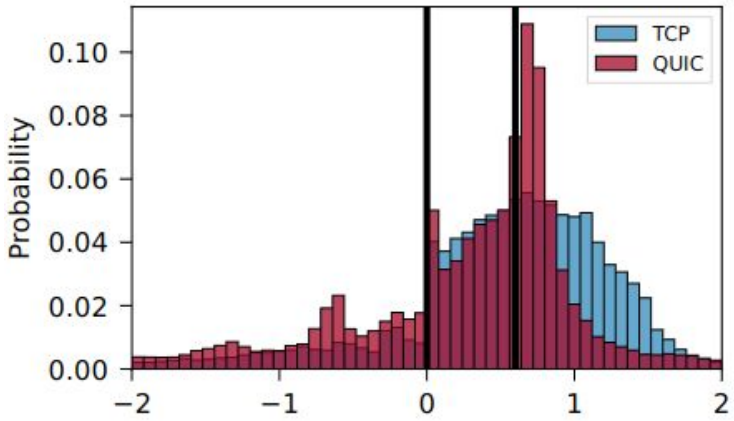
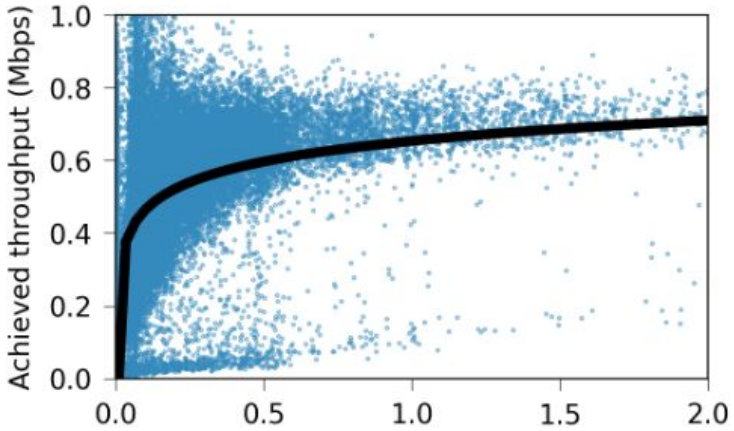
Below Expectation QoE Diagnosis

YouTube chunk request scheduling inefficiencies



Idle time of each chunk (seconds), black lines are 0 ms and 600 ms.

A cluster is formed around ~600ms, suggesting that the high propagation delay is not considered when making the chunk requests.



Chunk size (MB) for QUIC

Smaller chunks suffer more from pipelining inefficiency. YouTube tends to request smaller chunks for lower bandwidth, further exacerbating the problem.

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Conclusion

- Performing traffic shaping to obtain the desired video bitrate can be tricky in GEO networks.
  - Achieved throughput for TCP and QUIC are 0.58 and 0.47 Mbps respectively, quite far from the targeted 0.9 Mbps.
  - Viasat discontinued support for the low-bandwidth data-saving option in U.S. business and residential markets due to the results of this study.

- Content providers, application and protocol designers, should consider a wide variety of network types and characteristics in their product to avoid performance anomalies.

Thank you!

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