A Microscopic View of Congestion Control Behavior in Video Conferencing Applications

Nathaniel Cherian *, Akhil Prasad *, Sonia Fahmy

** Equal Contribution*

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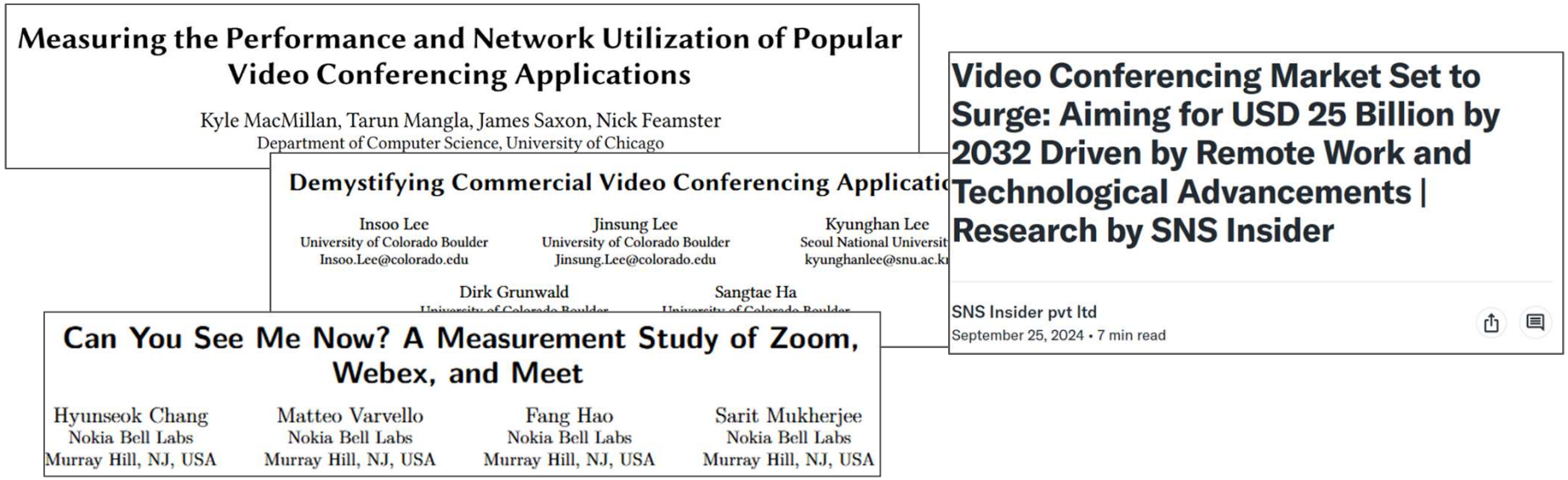
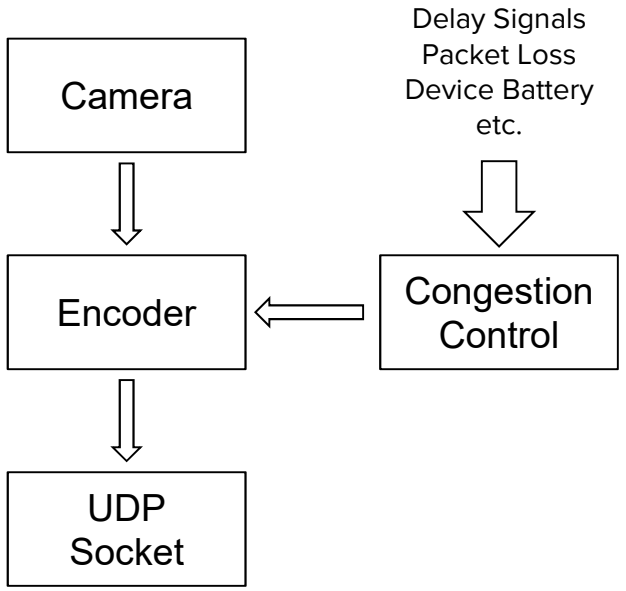


Video Conferencing Applications (VCA) are popular with a variety of implementations

MacMillan, Kyle, et al. "Measuring the performance and network utilization of popular video conferencing applications." *Proceedings of the 21st ACM Internet Measurement Conference*. 2021.
Lee, Insoo, et al. "Demystifying commercial video conferencing applications." Proceedings of the 29th ACM international conference on multimedia. 2021.

VCA Congestion Control

- Application level rate-controller
- Issues sending rate to encoder
- Published algorithms
  - Google Congestion Control (GCC) [1]
  - SCReAM (Ericsson Research) [2]



[1] Carlucci, Gaetano, et al. "Analysis and design of the google congestion control for web real-time communication (WebRTC)." *Proceedings of the 7th International Conference on Multimedia Systems*. 2016.
[2] Johansson, Ingemar. "Self-clocked rate adaptation for conversational video in LTE." Proceedings of the 2014 ACM SIGCOMM workshop on Capacity sharing workshop. 2014.

VCA Congestion Control...

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... can contribute to differences in high-level performance

Measuring the Performance and Network Utilization of Popular Video Conferencing Applications

Kyle MacMillan, Tarun Mangla, James Saxon, Nick Feamster
Department of Computer Science, University of Chicago
Chicago, IL, USA

(Macmillan et.al, 2021)

... can be modeled as a set of basic parameters

Demystifying Commercial Video Conferencing Applications

Insoo Lee
University of Colorado Boulder
Insoo.Lee@colorado.edu

Jinsung Lee
University of Colorado Boulder
Jinsung.Lee@colorado.edu

Kyunghan Lee
Seoul National University
kyunghanlee@snu.ac.kr

Dirk Grunwald
University of Colorado Boulder
Dirk.Grunwald@colorado.edu

Sangtae Ha
University of Colorado Boulder
Sangtae.Ha@colorado.edu

(Lee et.al, 2021)

Can we highlight strategies that proprietary VCAs use and their effect on high level performance?

Methodology

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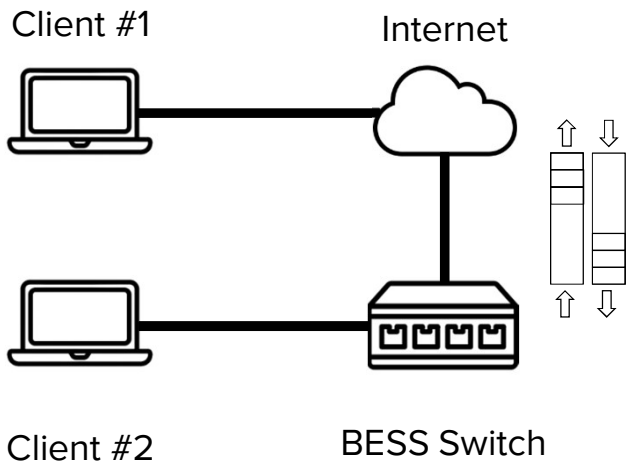
*VCAs respond primarily to **delay** and packet **drops**. Can we isolate and test their response to each of these?*

Experiments

- Constant Bandwidth
- Bandwidth Increase/Decrease
- Background Traffic
  - UDP
  - TCP (Cubic, BBR)
- BESS Queue Sizes (16, 1024)



Dataset of 120+ hours of captures released to the public! (PCAPS + QoE)

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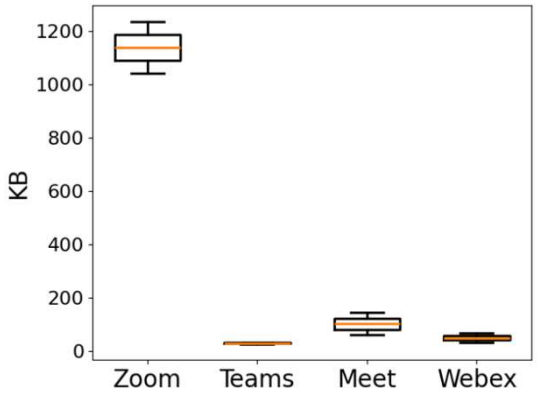
Observation Categories

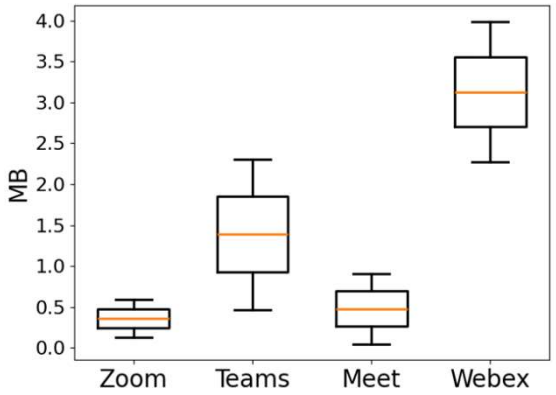
1. Startup Phase
2. Probing for Bandwidth Increase
3. Response to Congestion

Startup

Bandwidth estimation can be used to determine the initial sending rate



Bytes sent before video begins



Bandwidth estimation accuracy

(difference in sending rate between first 200ms and 1s)

Probing

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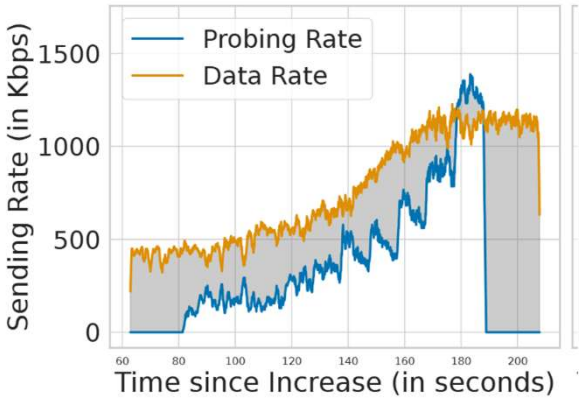
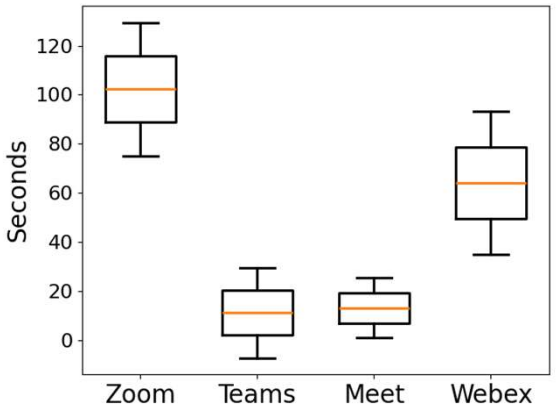
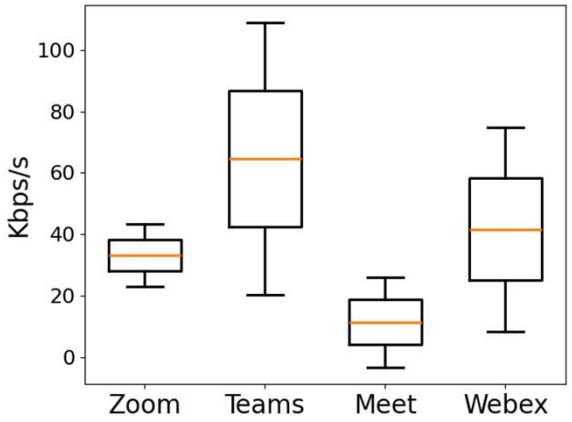
Zoom uses a *canary flow* to probe for available bandwidth by simulating a higher overall sending rate



Zoom Probing Example



Time until reaction after bandwidth increase



Rate of increase of sending rate until peak

Constant Bandwidth

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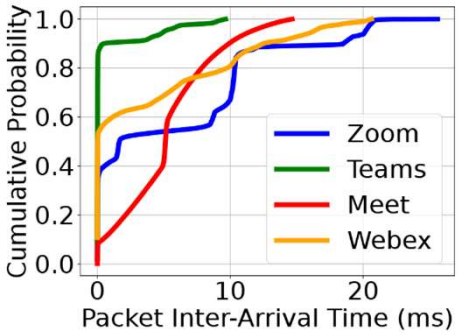
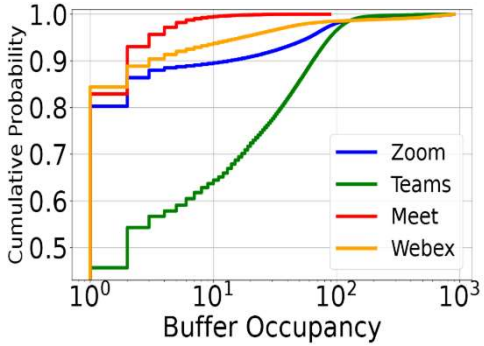
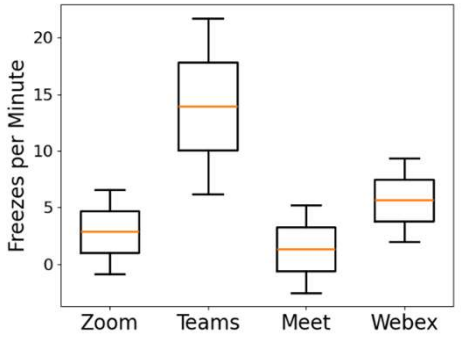
Microsoft Teams suffered from frequent video freezing due to oscillations in the sending rate and bursty video packets.



CDF of Packet Interarrival times (IAT)



CDF of Buffer Occupancy (1024 pkts)



Freezes Per Minute for each VCA

Congestion: Google Meet and Microsoft Teams

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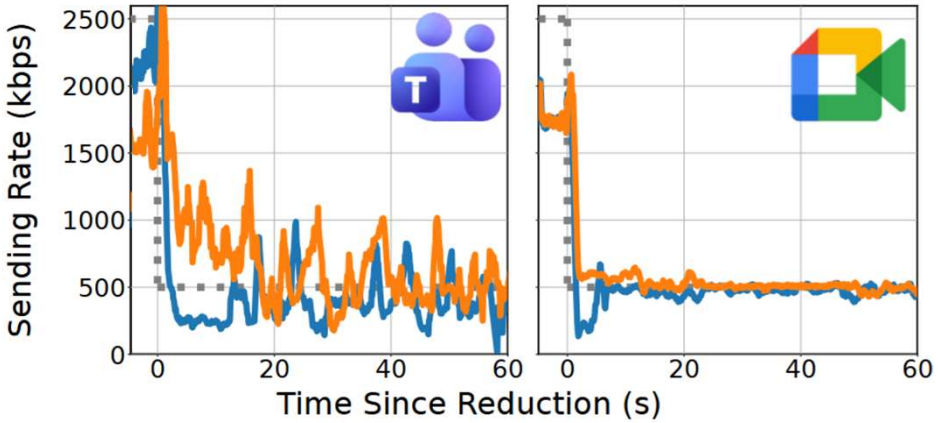
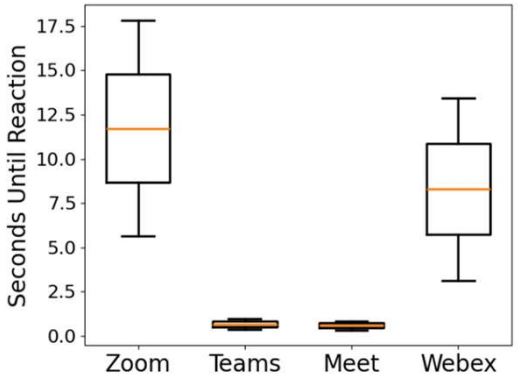
Meet and Teams responded to delay quickly while Zoom waits until a congestion threshold is met



Reaction to bandwidth reduction (2.5Mbps ➔ 0.5 Mbps) Queue size = 1024, 16



Seconds until VCAs reacted to bandwidth reduction

Congestion - Zoom

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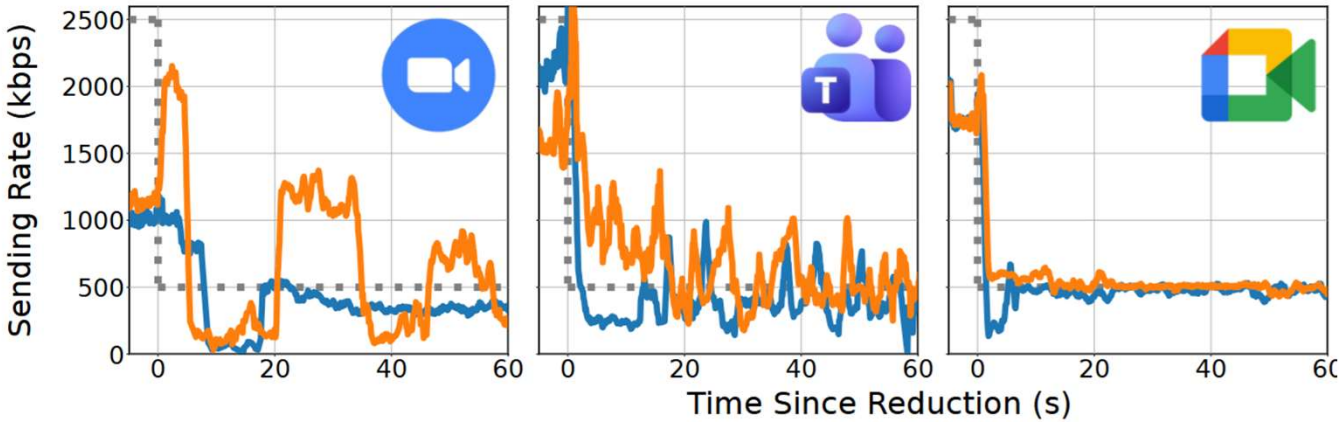
Zoom's delayed response necessitates turning off the flow to reduce congestion.

Under a small queue, Zoom reacts with a distinctive on/off cycling phase



Reaction to bandwidth reduction (2.5Mbps ➔ 0.5 Mbps) Queue size = 1024, 16

Congestion - Background TCP Traffic

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Meet performs poorly when competing over a large buffer with TCP CUBIC background traffic.

VCA	Size	None	C	B
Zoom	16	23.55	19.54	14.12
	1024	23.16	17.84	21.77
Teams	16	20.72	0.68	5.23
	1024	21.24	11.33	16.60
Meet	16	26.03	21.95	22.76
	1024	26.52	15.42	25.63
Webex	16	11.31	0.60	0.95
	1024	11.39	8.06	2.75

FPS of VCAs under short-lived TCP CUBIC (C) and BBR (B) flows

Conclusion

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- Methodology and testbed for measuring VCAs
- Public dataset of PCAPs, Queue Logs, QoE, etc.
- Observations of behaviors in…
  - Startup
  - Probing
  - Congestion Reaction

Dataset: *https://www.cs.purdue.edu/homes/fahmy/datasets/VCAPurdue/*