Delivering Tomorrow's Increasingly Interactive Streaming Services

Niklas Carlsson Linköping University, Sweden

@ Students, May, 2021







Much of the work here in collaboration ...

• Former PhD Students at LIU

- Vengatanathan Krishnamoorthi (now at Ericsson)
- Rahul Hiran (now at Ericsson)
- Anna Vapen (now at Mindcamp)

Other research collaborators (alphabetic):

- Martin Arlitt (HP Labs, USA)
- Youmna Borghol (NICTA, Australia)
- György Dan (KTH, Sweden)
- Derek Eager (University of Saskatchewan, Canada)
- Phillipa Gill (UMass, USA)
- Ajay Gopinathan (Google, USA)
- Emir Halepovic (AT&T research, USA)
- Patrick Lambrix (LiU, Sweden)
- Anirban Mahanti (NICTA, Australia)
- Carey Williamson (University of Calgary, Canada)
- ... and more ...

Before I start ...













































Design, modeling, and performance evaluation of distributed systems and networks



Design, modeling, and performance evaluation of distributed systems and networks



Design, modeling, and performance evaluation of distributed systems and networks



Design, modeling, and performance evaluation of distributed systems and networks



Design, modeling, and performance evaluation of distributed systems and networks



Design, modeling, and performance evaluation of distributed systems and networks



Design, modeling, and performance evaluation of distributed systems and networks

Design, modeling, and performance evaluation of distributed systems and networks

Design, modeling, and performance evaluation of distributed systems and networks

First some background ...

Background: HTTP-based Adaptive Streaming (HAS)

- HTTP-based streaming
 - Video is split into chunks
 - Support for VoD (Video on Demand) functionalities

Background: HTTP-based Adaptive Streaming (HAS)

- HTTP-based streaming
 - Video is split into chunks
 - Support for VoD (Video on Demand) functionalities
- HTTP-based adaptive streaming
 - Each chunk in multiple bitrates (qualities)
 - Clients adapt quality encoding based on buffer/network conditions

Example research to address the aforementioned problem include ...

Research overview

Design, modeling, and performance evaluation of distributed systems and networks

360 HAS with tiles

"Chunk 1"

•

- In addition to chunks, we have
 - Tiles of different quality in each direction

- In addition to chunks, we have
 - Tiles of different quality in each direction
- Clients adapt quality encoding of each chunk and tile based on **both**
 - buffer/network conditions, and
 - expected view field

- In addition to chunks, we have
 - Tiles of different quality in each direction
- Clients adapt quality encoding of each chunk and tile based on **both**
 - buffer/network conditions, and
 - expected view field

ACM MMSys 2018

... branched video ...

ACM MM 2019 ACM MM 2014 ACM CCR 2013

... branched video ...

ACM MM 2019 ACM MM 2014 ACM CCR 2013

... branched video ...

ACM MM 2019 ACM MM 2014 ACM CCR 2013

... stream bundles ...

Research overview

Design, modeling, and performance evaluation of distributed systems and networks

... HAS/DASH-aware proxies ...

IEEE/ACM MASCOTS 2013 ICPE 2020

... HAS/DASH-aware proxies ...

IEEE/ACM MASCOTS 2013 ICPE 2020

... HAS/DASH-aware proxies ...

IEEE/ACM MASCOTS 2013 ICPE 2020

... to cache or not to cache (optimal caching policies under "elastic" conditions)...

IEEE TPDS 2017 IFIP Performance 2018

... cost-efficient delivery ...

... determine who should serve who ...

IFIP Performance 2014

... cap-based optimizations ...

Research overview

Design, modeling, and performance evaluation of distributed systems and networks

... model+understand popularity

Young videos

Popularity dynamics

... popularity dynamics and tails ...

IFIP Performance 2011, IPTPS 2010, PAM '2011, 2 x ACM TWEB 2011, IEEE Network 2013, ...

... long tails and caching ...

Fi

IEEE TPDS 2017 IFIP Performance 2018 IFIP networking 2020 ... and some brief examples from the final three categories ...

Research overview

Design, modeling, and performance evaluation of distributed systems and networks

... HTTPS trust landscape + CT ...

IEEE ComMag 2017 PAM 2017, 2018, 2021 IFIP Networking 2020

... securing wide-area routing.

... securing wide-area routing.

Research overview

Design, modeling, and performance evaluation of distributed systems and networks

... energy efficient routers/servers ...

ACM/SPEC ICPE 2011, 2013, 2015, 2016

Research overview

Design, modeling, and performance evaluation of distributed systems and networks

Characterization, analytics, modeling

... third-party information leakage

Hvbrid case

... fake news ...

... sports analytics ...

MLSA 2018, 2019, 2020 MathSport 2019, 2021

... sports analytics ...

... or just another attempt to win the Stanley Cup ??

MLSA 2018, 2019, 2020 MathSport 2019, 2021

... sports analytics ...

1st attempt ...

2nd attempt ...

MLSA 2018, 2019, 2020 MathSport 2019, 2021

... "interactive" front-row seat ...

... "interactive" front-row seat ...

... to watch **my** favorite team win the Stanley Cup ...

... "interactive" front-row seat ...

... to watch **my** favorite team win the Stanley Cup ...

... securely, from anywhere in the world!

Thanks for listening!

Niklas Carlsson (niklas.carlsson@liu.se) Research overview and pubs: www.ida.liu.se/~nikca89/