

Scalable Network and Transport Supports for QoE-Fairness in Streaming Media Services

Spurred by a confluence of technical advances in video hardware and software, video streaming applications are set to break the network infrastructure that supports them. These applications adhere to industry standards designed to maximize users' quality of experience (QoE). However, models of user interaction with media are shifting away from users in a single room with a single TV, towards one where each user may use multiple devices to interface with multiple applications. In such contexts video streams often compete for bottleneck bandwidth. Recent evidence reveals that the adaptation mechanisms designed to improve QoE, instead generate instability and negatively impact on all notions of fairness.

This project investigates network- and transport-layer supports that bridge software-defined networking, i.e. dynamic and autonomic network controls, with user- and application-level requests for resources [1]. In an increasingly encrypted world, aspects of the network stack must be redesigned to interact with, and accept participation from, higher application layers [2].

[1] Ahmed Mansy, Marwan Fayed, Mostafa Ammar. Network-layer Fairness for Adaptive Video Streams, IFIP/IEEE Networking, Toulouse, France, 2015.

[2] Junyang Chen, Mostafa Ammar, Marwan Fayed, Rodrigo Fonseca. Client-driven Network Layer QoE Fairness for Encrypted 'DASH-S'. In Proceedings of ACM SIGCOMM 2016, August 2016.

On Fit:

There are several benefits to the department, and the University, by supporting this work. First, 2-3 research publications will maintain the high quality (3*+) publications that I have so far produced along this stream [from above, 1,2]. In addition, it will reinforce the collaboration that has started with top-10 US institutions (Brown and GA Tech) that, in the absence of student researchers, is at risk of stagnation. Finally, with respect to funding, this work is a base component in (i) an EPSRC Fellowship application (currently 1st draft complete), and (ii) a planned joint EPSRC proposal that links this research with complimentary work at Glasgow, Aberdeen, St Andrews.

Non-academic Impact:

Three separate streams shall be pursued during this project. First, I have established lines of communication within industry, Netflix among them, an invaluable resource in an otherwise secretive industry. They are quick to promote and adopt promising mechanisms into their own products. Second positive outcomes will be communicated with the IEEE and MPEG, who are responsible for generating multimedia standards; as well as UKNOG, the set of ISP

administrators in the UK that would have to deliver such services. Finally, source code and reproducibility tools will be available to others. The history of the Internet clearly demonstrates that successful technologies must be open and free to use.

Research Programme:

Having demonstrated merit, the next stages must focus on scalable and deployable solutions. There are two independent streams currently that demand immediate attention **(for internal communication only)**.

- [Longer-term] Design, build, and evaluate a network-wide architecture that implements a PLUS-like transport protocol. Packet inspection is no longer viable in an increasingly encrypted environment. Clients using PLUS can choose to reveal information to the network in a safe, secure, and verifiable manner. However, the type and representation of information, as well as network responses, are open questions.
- [Short-term] I have a conjecture that there may exist a interim fix by making small adjustments in TCP, i.e. a local change to TCP behaviour without modifying any of its design. However, this requires substantial measurement, evaluation, and analysis.

Supervisory Arrangements:

My research in this area has developed in collaboration with experts at Georgia Tech (USA), Brown (USA), as well as Glasgow. Any of these would be available for co-supervision, as well as able to support extended research visits for a capable student.

Industry Funding:

In addition to aforementioned research funding applications, this work has immediate application in industry, putting any student in a strong position to pursue internships and placements.