Improving QoS in web-based distributed streaming services with applied network coding

Patrik J. Braun, Péter Ekler

With the development of the portable devices and sensors by 2020 50 billion devices [1] can be connected to the internet. This enormous increase of devices generates more and more data that has to be transmitted over the network. Conventional content distribution approaches use client-server topology, where one server or a group of server serve all the clients. The main drawbacks of this technology are poor scalability, which can lead to bad Quality of Service (QoS) in case of high client number. The servers are placed at the edge of the network, usually physically far away from the clients, which increases the latency of the network and the server is being a single point of failure. Lately a shift to Peer-to-Peer (P2P) topology can be observed. This alternative topology has several beneficial properties. A fully distributed network is self-scalable, since the more participant in the network means more data source in addition the participant are located in the network, closer to each other. Both characteristic can lower the delay and increase the throughput. In most cases creating fully distributed networks are technically not possible. A minimal central intelligence is needed to store a list of available peers in the network, else the peers cannot find each other. This central intelligence can be a single point of failure, but these servers are lightweight, easy to be replaced, and do not store any important data. The conventional web browsers use *HTTP* protocol to transfer data. The protocol is designed to be used only in client-server topology. Providers use expensive content distribution networks (CDN) for serving static content to load balance their services and lower the serve time. There have been several attempts to achieve browser-based P2P data distribution without installing any browser plugins. Among the first attempts was Adobe with Flash Player based *RTMP* protocol, which later was replaced with *RTMFP* [2] protocol. This can be considered a semi solution, since Flash Player is usually installed on the computer of the user. The first pure *JavaScript* based technology was Web Real-Time Communication (WebRTC) [3], that offers a several protocols for streaming media directly from browser to another browser. The standardization of the protocol still not finished since 2011, but Chrome, Firefox and Opera already implement it. Using these technologies for P2P content distribution, several companies and libraries were created [4] [5] [6].

In this paper we investigated the methods, how browser based P2P streaming can be achieved with the help of *WebRTC*. In our work we focus not just on data distribution, but efficient data distribution. We have applied network coding [7], specifically Random Linear Network Coding (RLNC) in the network, due to its beneficial characteristics, mainly its rate-less nature and its recode ability to create new coded data without having the whole original data. Furthermore, the coding already proved its ability in P2P environment [8] [9] [10]. We propose two protocols for efficient browser based P2P content streaming. The first protocol called *WebPeer* protocol for distributed content distribution. Based on this protocol, we design an extended protocol, called *CodedWebPeer* that support RLNC encoded packets. Both protocols make possible to download the data parallel from the server and from other peers as well. Using our protocol, a testbed is implemented to investigate the characteristic of the protocols. We have carried out several measures in different scenarios. We have investigated the impact of the network size and the clients' storage size on QoS in the network. Both parameter turned out to be important, since low storage size limits the possibilities of sharing content in a distributed network. Small network size limits the number of potential partners.

Through our results, we show that modern browsers are capable of maintaining P2P connections and carrying out complex network coding calculations. We show that employing our protocols for data streaming, more than 300% network throughput can be archived, comparing to conventional server-client topology. We analyze the impact of the two parameters on the network throughput. We show that our *CodedWebPeer* performs at least as good as our *WebPeer* and is much less sensible for the change of the network size and the clients' storage size.

References

[1] Dave Evans, *The Internet of Things:How the Next Evolution of the Internet is Changing Everything*, Cisco Internet Business Solutions Group (IBSG), April, 2011.

[2] M. Thornburgh, *Adobe's Secure Real-Time Media Flow Protocol*, http://www.rfc-editor.org/rfc/rfc7016.txt, February, 2016

[3] A. Bergkvist, D. C. Burnett, C. Jennings, A. Narayanan, b. Aboba, *WebRTC 1.0: Real-time Communication Between Browsers*, https://www.w3.org/TR/webrtc/, February, 2016.

[4] Jie Wu,ZhiHui Lu, Bisheng Liu, Shiyong Zhang *PeerCDN: A novel P2P network assisted streaming content delivery network scheme*,2008. CIT 2008. 8th IEEE International Conference on Computer and Information Technology, Sydney, NSW, 2008

[5] L. Zhang, F. Zhou, A. Mislove, R. Sundaram *Maygh: building a CDN from client web browsers*, EuroSys'13 Proceedings of the 8th ACM European Conference on Computer Systems,Pages 281-294, New York, NY, USA, 2013

[6] Werner, M.J., Vogt, C., Schmidt, T.C. *Let Our Browsers Socialize: Building User-Centric Content Communities on WebRTC*, 2014 IEEE 34th International Conference on Distributed Computing Systems Workshops (ICDCSW), Madrid, Spain, June 30 2014-July 3 2014

[7] Ahlswede, R., Ning Cai, Li, S.-Y.R., Yeung, R.W.: *Network information flow, Information Theory*, IEEE Transactions on (Volume:46 , Issue: 4), pages: 1204-1216,ISSN: 0018-9448, 2000

[8] P. J. Braun M. Sipos, P. Ekler, H. Charaf, *Increasing data distribution in BitTorrent networks by using network coding techniques*, European Wireless 2015; 21th European Wireless Conference, Budapest, May, 2015.

[9] Christos Gkantsidis, Pablo Rodriguez Rodriguez, *Network Coding for Large Scale Content Distribution* IEEE Infocom 2005

[10] Christos Gkantsidis, John Miller, Pablo Rodriguez, *Anatomy of a P2P Content Distribution system with Network Coding*, IPTPS, 2006