Tracking Mobile Video QoE in the Encrypted Internet

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Abstract:

Due to the increasing use of encryption by video content providers, a vast majority of global Internet traffic is going to be encrypted soon. While the encryption of video content is positive from an end-user perspective, it negatively impacts the ability of network operators to employ network performance monitoring and management techniques. Network performance monitoring and management is particularly important for mobile network operators who have users competing for shared radio resources at the access link. Most mobile network performance monitoring and management techniques typically require deep-packet-inspection (DPI) and, thus, operate on unencrypted traffic. We propose a methodology for network-side video quality of experience (QoE) measurement and monitoring in mobile networks that works with encrypted traffic. Our methodology uses only standard radio network statistics and/or TCP/IP header information that is readily available to network operators for both encrypted and unencrypted video traffic. Our approach can accurately monitor and predict video QoE very early in a video streaming session. The experiments show that our approach can predict video QoE with 87% accuracy by observing only the initial 10 seconds of a video streaming session.

Details:

As YouTube and Netflix move to encrypt their video content, a vast majority of global Internet traffic is going to be encrypted soon. YouTube already uses HTTPS and, by some accounts, is currently one of the largest sources of encrypted traffic on the Internet. Netflix is also expected to start using HTTPS by the end of 2015. While encryption of video content prevents network operators from observing individual users' video viewing history and is positive from an end-user perspective, it negatively impacts the ability of network operators to employ network performance monitoring and management techniques.

Network performance monitoring and management is particularly important for mobile network operators who have users competing for shared radio resources at the access link. Mobile network operators currently employ various network management techniques, including but not limited to radio resource allocation, compression, caching, LTE multicast. Most mobile network performance monitoring and management techniques currently operate on unencrypted traffic. For example, content compression requires application-layer deep-packet-inspection (DPI) capability. However, content compression would not work for video traffic over HTTPS.

How to conduct network performance monitoring and management in the increasingly encrypted Internet ecosystem? Towards this end, we have conducted research to enable network operators to measure and monitor video quality of experience (QoE) [1]. Prior client-side instrumentation approaches (e.g., [2]) to video QoE monitoring by content providers uses video quality metrics such as buffering and startup delay. This client-side information is not available to network operators. Prior network-side instrumentation approaches (e.g., [3]) to video QoE monitoring by network operators use DPI to extract information beyond TCP/IP headers, which is not available for encrypted video traffic.

We present a methodology for network-side video QoE measurement and monitoring in mobile networks that works with encrypted traffic [1]. Our methodology uses only standard radio network statistics and/or TCP/IP header information that is readily available to network operators for both encrypted and unencrypted video traffic. We first label ground truth QoE of video streaming sessions as completed/abandoned. We then quantify standard radio network statistics and/or TCP/IP header information using a set of 31 features that can accurately predict video QoE (i.e., abandonment/completion) by observing the first few seconds of a video streaming session.

Our evaluation, using a month-long anonymized traffic trace from a tier-1 cellular network covering nearly half a million users, shows that our approach can accurately monitor and predict video QoE very early in a video streaming session. The results show that our approach can predict video QoE with more than 87% accuracy by observing only the initial 10 seconds of a video streaming session. The early prediction capability of our approach can help network operators to decide which users to optimize performance for (e.g., using LTE self-organizing networks). Our prediction model uses the C4.5/M5P algorithm with bootstrap aggregation for building decision/regression trees. Not only our model achieves significantly better accuracy than prior models [2] that require video content provider logs, it uses only standard radio network statistics and/or TCP/IP header information that is readily available to network operators for both encrypted and unencrypted traffic.

References:

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