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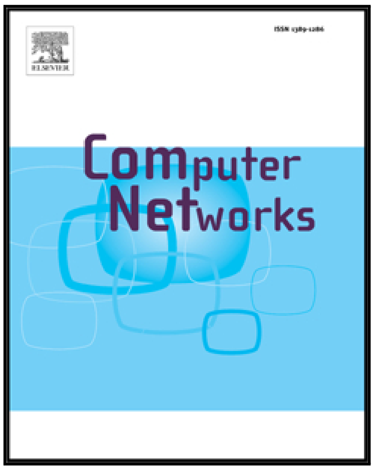


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# Flow-Level Traffic Model for Adaptive Streaming Services in Mobile Networks

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**Abstract**

This paper proposes a traffic model for mobile networks carrying adaptive streaming. The proposed model takes into account the flow dynamics and some application-level parameters influencing the performance of adaptive streaming, such as the presence of a playout buffer, chunk duration configuration and the video bit rate configuration. Paper shows based on flow-level queueing model how to compute performance metrics for a streaming user such as average video bit rate, average service time, average deficit rate, defined as the probability of having its instantaneous throughput lower than the chosen video bit rate and average buffer surplus, related to the amount of video accumulated in the buffer. Since heterogeneous radio conditions and the coexistence of elastic traffic and streaming services make the exact solution intractable, we propose a simple yet accurate approximation that reduces the computational complexity and makes system dimensioning easier for mobile network operators. Our numerical results show the performance impacts of video chunk duration and amount of available video bit rate. These performance impacts obtained by our models give an insight for operators to properly dimension their adaptive streaming service by well configuring both HTTP-level and MAC-level parameters.

*Keywords:* Video Quality-of-Experience, Mobile networks, Adaptive streaming, Flow-level dynamics, Video chunk duration

## 1. Introduction

Video streaming traffic is experiencing tremendous growth and it accountes for the largest proportion of traffic transmitted in mobile networks. Every day, hundreds of millions of Internet users view video with their desktops or mobile devices [1]. Due to the variations in the delivery rate of the transmission network and the volume of other traffic, the achievable quality of experience can vary quite considerably. To counteract this issue, progressive download and HTTP-based adaptive streaming are steadily becoming the most popular video streaming solution. For example since January 2013, YouTube has introduced HTTP adaptive streaming for its desktop version and adaptive video streaming can provide better Quality of Experience (QoE) than the classical one in [2]. Furthermore, HTTP-based adaptive streaming is supported by major industry actors and has implemented in systems such as Microsoft Smooth Streaming [3], Adobe's HTTP Dynamic Streaming and Apple's HTTP Live Streaming (HLS). MPEG Forum also ratified an international standard by ISO/IEC known as MPEG-Dynamic Adaptive Streaming over HTTP (MPEG-DASH) [4] to support HTTP adaptive streaming.

About streaming delivery mechanisms, in [5], authors show a typical system architecture for adaptive streaming, where video files are divided into several chunks (segments) [6] by a constant time and several encoded versions (video bit rates) are saved at the servers' side. With HTTP adaptive streaming, media players are able to download a segment in a quality that matches resource availability both in the networks and on end systems. Video chunks are downloaded by the user at the maximum achievable throughput so that the number of buffered chunks is maximized to guarantee the video smoothness. Furthermore, before downloading a video chunk, users select a video bit rate and the downloaded video segments are stored in playout buffer. Rate-adaptation algorithms for this kind of segmented HTTP streaming have recently become a hot research topic. Different algorithms of bit rate selection are proposed, generally it can be divided into three main categories [7]: 1. *Throughput estimation:* algorithms mainly focus on throughput estimation and based on the estimated throughput, they select the next video bit rate, such as [8]. 2. *Buffer occupancy:* As shown in [9], video bit rate adaptation mainly depends on the users' instantaneous buffer occupancy.