QoE Prediction for Radio Resource Management*

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Abstract. In this paper, we introduce a monitoring tool which measures application-specific parameters. These parameters are used to predict the QoE and to perform resource management based on QoE thresholds. We demonstrate the tool for YouTube traffic in an IEEE 802.11 mesh network. Thereby, the QoE is based on the player video buffer size and the resource management can include rerouting, throttling of best effort traffic, or a gateway handover.

Keywords: QoE, radio resource management, wireless.

1 Introduction

Today's Internet traffic is transmitted on a best effort basis without supporting quality of service (QoS). Normally, there are no service guarantees for the predominant consumer Internet traffic which is composed of applications like P2P or client-server file sharing, web browsing, or video streaming which make up for more than 80% of today's traffic [1]. Technical solutions enforcing quality guarantees exist, but in general the network does neither know which Internet applications it is carrying nor which quality requirements have to be met.

The prerequisite for QoS support for Internet applications is hence to detect the flows/packets belonging to the application in the packet stream which is currently done using deep packet inspection (DPI). However, DPI is rather challenging as it is not very reliable and does not work if the payload is encrypted. In addition, DIP is very resource intensive and hence not suitable for real-time traffic classification. For guaranteeing application-specific QoS parameters, it is moreover necessary that the network knows about appropriate quality parameters. Deriving and monitoring the appropriate QoS parameters for an application on the network layer is also a very complex task. Both the flow classification problem and the difficulties finding the appropriate QoS parameters can be overcome by information exchange between the application and the network. An application can announce its presence to the network and provide a feedback about its current QoS level.

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Even if application demands are known, static resource assignments in IEEE 802.11 wireless mesh networks (WMNs) can cause problems, as the link capacity between two nodes typically changes over time. This can be overcome by using a dynamic resource management. Resource management in WMNs covers routing including gateway selection, channel and interface allocation in multi-radio multi-channel mesh networks, prioritization of medium access through contention parameters, and finally traffic shaping. The user's quality of experience (QoE) can be used to toggle these different measures [2].

QoE is a measure for the subjective quality that a user experiences. Today, a large number of QoE models exist, e.g. for VoIP traffic [3,4] or video streaming [5,6] but these models only allow to quantify the user satisfaction after the application has been carried out. Our goal is however to use QoE as an input for a network management tool. Therefore, we need to know the user satisfaction during the execution of the application. To avoid a QoE degradation, a network management tool has moreover to be notified if a QoE degradation has not yet happened, but is only about to occur. We therefore propose to install a generic tool at the client that monitors and predicts the QoE and communicates this information to the network.

2 Prediction of YouTube QoE

In [7] we introduce a YouTube Monitoring tool (YoMo) which is able to predict the QoE of a YouTube video and uses this QoE information for radio resource management. YouTube videos are distributed via TCP streaming which, unlike UDP streaming approaches, always assures a constant video quality. However, the QoE of a YouTube user is affected by video stallings. For our proof of concept we use a very simple QoE metric assuming the QoE of a user is good as long as the video does not stall and degrades as soon as the video stalls. The length and the frequency of the stallings are not taken into consideration.

The main issue of this approach is to exactly predict the stalling time of the video. The YouTube player offers a programming API which is able to monitor the player state. Monitoring the player state is suitable for detecting a video stalling, but not for predicting a future stalling. Therefore, we focus on the

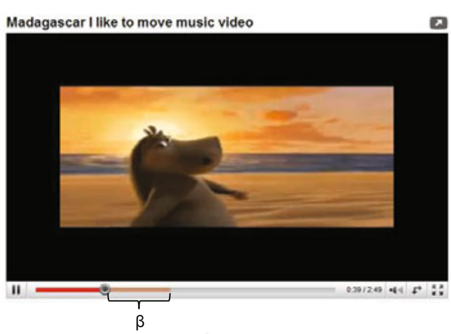

Fig. 1. YouTube player video buffer

filling of the player's video buffer β depicted in Fig. 1. This buffer fills with the beginning of the video download. As soon as a certain threshold γ is reached, the playback begins. β depends on the download rate and the video rate. As long as the download rate is larger or equal to the video rate, β rises respectively remains constant. If the download rate is smaller than the video rate, β shrinks and the video stalls as soon as β=0.

YoMo is able to calculate β by monitoring the client's network traffic and by using information gained from the YouTube player. Fig. 2 shows YoMo's user interface. The upper display shows the current value of β, the display in the middle the progress of β over time, and the bar at the bottom the download progress of the whole file. β is always displayed in seconds and the displays are divided into three areas colored in green, yellow and red. As long as β is within the green range, there is no need to change the resource allocation of the flow. The yellow range indicates that the video might stall in the near future if no actions are taken. As soon as β drops below 5 s, which means only 5 s of video time remain in the buffer, the video is likely to stall if the resource allocation is not changed. A stalling would result in a degradation of the users QoE. With this knowledge of β, YoMo can not only monitor the current QoE of the user, but it can also predict when the video will stall if the current network state is not changing. This enables us to adapt the available resources in the mesh network to avoid stalling. Theses adaptations might include rerouting, throttling of best effort traffic, or selecting a new mesh gateway to forward the traffic to the Internet.

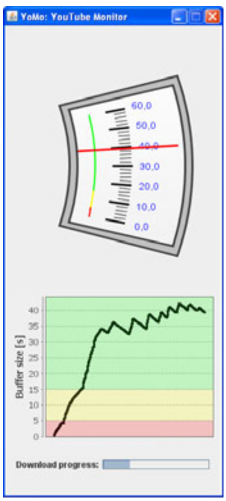

Fig. 2. YoMo GUI

YoMo is a proof of concept which can predict the QoE of a YouTube user and we showed that QoE prediction can be used for radio resource management. Although YoMo is a rather simple QoE prediction tool, the idea can be generalized. QoE prediction can be natively implemented into QoE sensitive applications like streaming players, VoIP, or IPTV software.

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