QoEWeb: Quality of Experience and User Behaviour Modelling for Web Traffic

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I. Introduction

Increasingly many ICT solutions, services and applications, use the web browser as well-known and well-understood user interface. Typically, such services work in an interactive manner, i.e. the user performs some *action* (clicks on some link or button, or enters some information) and needs to wait for the response. As long as the latter arrives within a certain time horizon, e.g. within the reaction time of one second, the user feels the system to react immediately. However, long or heavily varying response times upon user action make the user suffer. The question is now: How patient is a user in such a case, i.e. how does her/his perception sink with time and/or the number of actions performed in case of bad network conditions? This question needs to be related to the type of application, which means considering the expected performance for a fixed web page, a video, a request to a search engine, etc.

For Internet Service Providers or Network Operators, the main application is to detect performance problems (based on user perception) on their network (cf. [Co08]). In case of trouble, they can apply tools to localize, diagnose and correct the problem. These tools build on network measurements (QoS), which need to be linked to user perception (QoE). Some dependencies between network-level performance (loss rate, throughput, etc.) and application-level performance (response time) criteria may be modelled by TCP models. For instance, a large packet loss rate, reflecting unreliable network conditions, leads to very variable response times. Some transfers are still quickly served, while others observe very long response times. So the users should observe varying response time which may be more disturbing than constant long response times. However, a more detailed (multi-factorial) statistical and time-dependent analysis of correlations between QoS and QoE is needed to detect other phenomena such as the decrease of user satisfaction until a point when the service in question is abandoned. Once this timely behaviour is known and modelled, it defines the time frame on which the provider needs to act in order to prevent the users from giving up.

Bad QoE can have serious consequences for an Internet Service, Application Service and Hosting Provider. A user that "cannot get its job done" might consider to "churn", i.e. to abandon the provider/operator in question. Complaining users are the top of an iceberg, many just leave without further notice towards the operator. However, they might spread bad gossip about their negative experience. In other words, the reputation of the operator/provider (from the user point of view) will be affected in a negative way.

As outlined before, the questions of interest are: How does user satisfaction decrease over time and/or the number of unlucky actions? And at which point in time, or after which number of extraordinary response times, does user perception cross a threshold that entails a break of the session? Recent work [Co08,Sh08] provides evidence for this phenomenon: The volumes of sessions get smaller (not necessarily shorter) as loss within TCP connections increases. This indicates that users perform less surfing operations when there is considerable loss. In other words, they abandon their activity quicker (in terms of actions, not of time) when facing quality problems. Similar behaviour was seen from round-trip times and throughput. The latter is confirmed by [Kh02], which revealed that the probability to break a session increased as the perceived throughput decreased.

II. Main Objectives of QoEWeb

The aim of the specific EuroNF project QoEWeb is to model user perceived quality and user behaviour, whereby web traffic is used exemplary. To be more precise, our main objectives are:

- Quantification of QoE for web traffic, based on passive measurements (observations) within an operator's network and active measurements in a test laboratory
- Description of an appropriate model for the (timely) behaviour of web user satisfaction / impatience which builds upon feedback of the user-perceived quality, based on the measurements
- Application of the derived user model to identify impact of QoE on system performance in

business environments like wireless networks with shared capacity

- Quantification of reputation management applying the derived model in order to allow provider/operator to react before the user-related reputation gets critical

III. Scientific Approach

A. Modeling of User Perception and Behavior

Appropriate models of user perception and behaviour will be developed jointly. While a first model targets the perception of single web-surfing actions, the second model will capture the time- and/or action-based dependency of user satisfaction with the session, especially when facing quality problems. To the best of our knowledge, this time-/ action-dependent user perception modelling is new. Of particular interest are potential analogies between both models, for instance whether the same basic shape of the satisfaction as a function of time and/or action appears in different cases. Finally, we will also investigate the probability that a user aborts a session. Some QoE metrics may be defined on each web transfer, eventually depending on the type of transfer, and then a composed QoE metric may be defined on the global web session based on the initial metrics. Web requests may be weighted according to their age. We may also take into account the domains of web servers. In any case, we need to model the composition of QoE metrics.

B. Example: Analysis of Shared Systems

The aim of this analysis is to basically understand and demonstrate the impact of the developed QoE-driven web user model in business environments. As an example, we consider web users in wireless systems with shared capacities like WLAN or UMTS and evaluate the system's performance. In a former study [Ho06], we evaluated the performance of time-based and volume-based web traffic over rate-controlled dedicated channels in UMTS. We showed that the use of rate control should be planned with consideration of the user behavior and with a proper designed admission control in order to soften the unwanted effects in high load situations. More specifically, in case of volume-based user behavior, rate control degenerates in such a way that the rate control mechanism only switches between minimal and maximal possible rates.

Now, we apply an even more realistic user model for web traffic which is neither a pure time-based nor volume-based model. In contrast, the feedback of the network itself as perceived by the user is taken into account. This performance study will lead to new results, since we investigate separated control loops which operate within the network itself and on application layer due to the user behavior.

C. Example: Reputation Management

We will investigate the applicability of the derived models to reputation management as established in the Euro-FGI project SecMon [SecMon]. In order to route an optimal way through the network, SecMon assumed reputation to form a Weighted Moving Average of own experience, recommendations from other nodes and other factors, capturing both performance and security aspects. Suppose a disturbance kicks in which reduces the utility from 1 to 0. That means a geometric decay of the reputation, namely a decrease by a factor $(1 - a)$ after each interval, where the value a denotes the relative weight of the most recent measurement and $(1 - a)$ the weight of the history. If in case of problems, the decrease of the "technical reputation" (derived from network parameters) is chosen to be quicker than that of the "user-related reputation" (as observed active and passive measurements and modelled accordingly), a margin is created that allows the provider/operator to react before the user-related reputation reaches the critical threshold.

Our work aims at quantifying such reputation management. We will propose two new tools for reputation level establishing: a) indirect methods of trust estimation, where the parties that have no direct contact can trust each other and b) short time memory in the statistical approach to QoE, where one can distinguish a sequence of fails of the same user from a number of fails of different user.

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