Measuring Quality of Experience in Pervasive Systems Using Probabilistic Context-Aware Approach

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Abstract. In this paper, we pioneer a context-aware approach for quality of experience (QoE) modeling, reasoning and inferencing in mobile and pervasive computing environments. The proposed model is based upon Context Spaces Theory (CST) and influence diagrams (IDs) to handle uncertain and hidden complex inter-dependencies between user-perceived and network level QoS and to calculate overall QoE of the users. This helps in user-related media, network and device adaptation, creating user-level SLAs and minimizing network churn. We perform experimentation to validate the proposed approach and the results verify its modeling and inferencing capabilities.

Keywords: Context-awareness, influence diagrams, quality of experience (QoE), quality of service (QoS).

1 Introduction

In mobile and pervasive computing environments, understanding user-perceived QoE is an important and a challenging task. This can be attributed to the fact that QoE about a particular technology, network service or application depends on user expectations, as well as his/her cognitive, psychological and behavioral aspects. There are several stakeholders who are interested in understanding what users think and perceive about the services being provided to them in terms of new products and applications. For example, telecommunication companies want to understand how to minimize network churn by providing better service to the users. From the state-of-the-art we gather that a unifying framework to model, reason and infer QoE is missing. Also, techniques that can simultaneously handle user-centric context, subjective and objective assessment metrics are required. Thus, in this paper we pioneer an approach to integrate context-awareness and decision-theoretic reasoning to model, reason and infer QoE in an efficient manner.

P. Sénac, M. Ott, and A. Seneviratne (Eds.): MobiQuitous 2010, LNICST 73, pp. 330–331, 2012.

2 Context-Aware QoE Modeling, Reasoning and Inferencing

At the lowest level, context information ($a_i^t \in A_i^t$) such as location ($a_{location}^t$) and bandwidth ($a_{bandwidth}^t$) collected from the network, user, device and the surrounding environment. This context information is then modeled using the CST [1] and IDs [2]. At the intermediate level, we define causal mappings of context attributes with the QoE classes represented as context states (S_i^t) such as user satisfaction ($S_{usersatisfaction}^t$) and technology acceptance ($S_{technologyacceptance}^t$) which are hidden. Once the QoE states are inferred probabilistically, they are then assigned utilities. U($S_{usersatisfaction}^t$) and U($S_{technologyacceptance}^t$) as in e.q 1. Where, h_n is the hypothesis and e is the evidence variable. $P(\bullet)$ represents the belief of the agent in a hypothesis and $U(\bullet)$ encodes the preference on the numerical scale.We consider a Likert-like scale of 1 to 5. 1 being “Poor” and 5 means “Excellent”. In order to decide the context state (S_i^t), the agent chooses the decision alternative which gives the maximum expected utility (MEU) as:

$$MEU(S_i^t) = max_{s_i^t \in S_i^t} \sum_n P(h_n|e)U(s_i^t, h_n) \tag{1}$$

At the top-most level, these context states are then fused together to determine the overall situation of QoE (R_{QoE}) of the user which is a global utility as in e.q. 2. We consider a global utility which comprises of several QoE related classes such as cognitive (user satisfaction in terms of the MOS) and behavioral (technology acceptance). Each context state can contribute to the global utility differently. Thus, we assign weights to these states which sum to 1. It can be written as MEU(S_i^t, S_{i+1}^t):

$$MEU(S_i^t, S_{i+1}^t) = \max_{s_i^t \in S_i^t, s_{i+1}^t \in S_{i+1}^t} \sum_{h_i \in H_i, h_{i+1} \in H_{i+1},} P(h_i, h_{i+1}) (U(s_i^t, h_i) + U(s_{i+1}^t, h_{i+1})) \tag{2}$$

Based on the calculated R_{QoE}, we can determine whether the overall QoE is “Poor”, “Fair”, “Good”, “Very good” or “Excellent”. For results evaluation we developed a prototype using GeNIe/SMILE 2.0 platform. We consider several cases like a user using a voice application at different locations such as home and office. At each location the social context is different and thus the QoE inferred also varies where the QoS may or may not vary much. The proposed model correctly inferred the QoE in terms of user satisfaction and technology acceptance and in-turn, the overall QoE is correctly calculated as the MEU.

References

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