

# Investigating the Relationship Between QoS and QoE in a Mixed Desktop/Handheld Gaming Setting

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Innovative software and system development requires a multi-disciplinary approach where technical, objectively quantifiable Quality of Service (QoS) aspects are integrated with and correlated to subjective Quality of Experience (QoE) measures such as usability, user expectations and experiences. To date, QoS and QoE research has however mainly been carried out in an isolated manner. Their exact correlation consequently remains unclear. Using a collaborative multi-platform game as case study, we intend to investigate this relationship and hope to bridge the divide that currently exists between social, user-oriented research and technically-oriented application development by formulating recommendations and guidelines. To implement the QoS and QoE optimizations, we will rely on the NIProxy, a network proxy equipped with network traffic shaping and service provision functionality.

## 1. QoS versus QoE

Quality of Service ↔ Quality of Experience

- Well established concept in software & system engineering
- **Technically-oriented**
- Measure of performance (i.e., guarantee that certain performance level will be met)
- **Objectively quantifiable** through probing and monitoring

- Subjective metric involving human dimensions
- Usability, user expectations
- Experience and satisfaction
- **Social, user-oriented**
- **Not easily quantified** or objectively measured
- Typically acquired through qualitative user studies

QoS and QoE are unquestionably related concepts. However, to date, QoS/QoE research has mainly been carried out in a fragmented manner. **What is their exact correlation?**

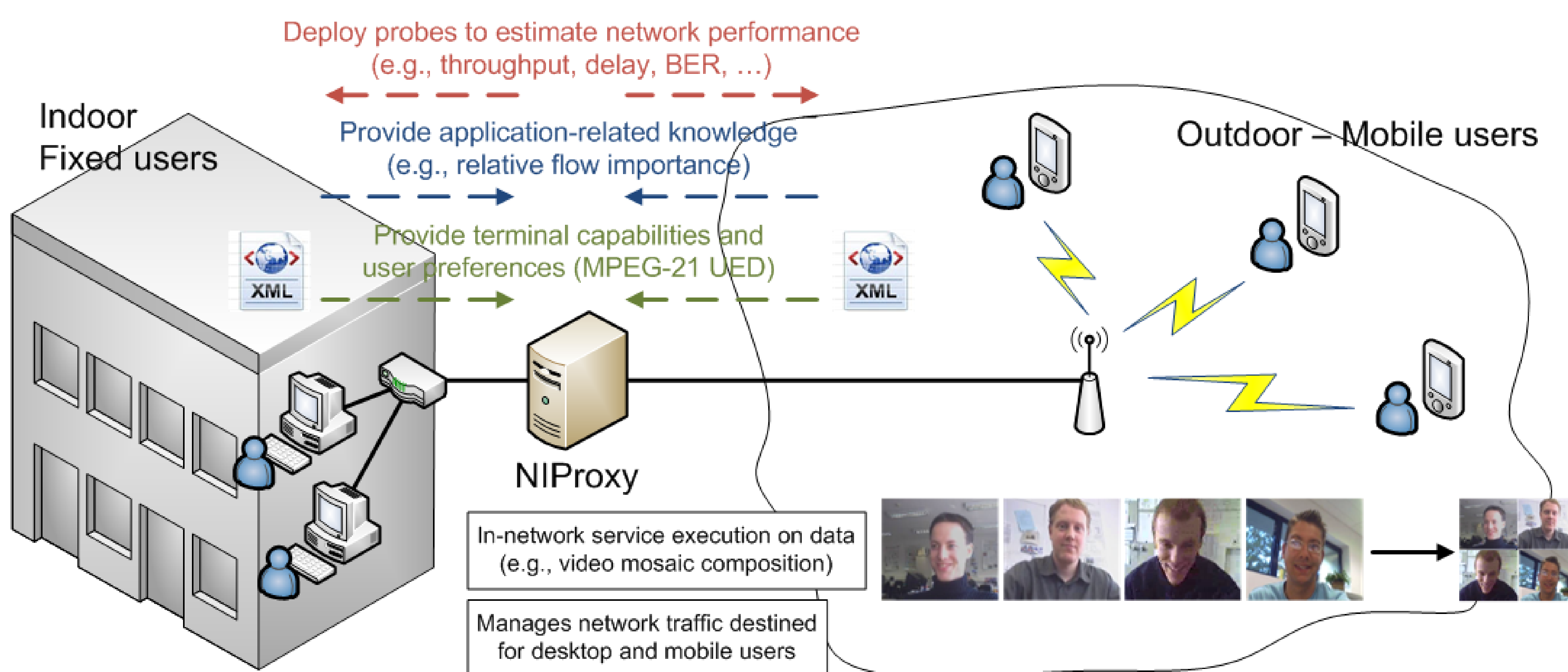
## 2. QoS/QoE Research in a Heterogeneous Gaming Setting Involving Both Desktop and Handheld Devices

On-line gaming imposes numerous QoS- and QoE-related requirements that are likely to have a significant impact on the user experience:

- Distribution of real-time game data
- Visualization of game-related data on the end-user device
- Communication capabilities (e.g., audiovisual) between players

To further increase the number of possible QoS/QoE links, a **collaborative multi-platform gaming scenario** is envisioned where **desktop players need to cooperate with mobile gamers carrying a handheld device** to accomplish shared objectives:

- Introduces heterogeneity in the end-user device space (i.e., desktop versus handheld terminals)
- Introduces variability in connectivity and network performance (i.e., wired versus wireless network connections)



## 4. NIProxy

The **Network Intelligence Proxy** is a network intermediary which attempts to optimize the experience of users of distributed applications by **introducing different types of intelligence in the network infrastructure** (network-, application-, terminal- and user-related context). Collected intelligence is exerted to implement **two distinct yet interoperable user experience optimization techniques**, namely **network traffic shaping and multimedia service provision**. The former technique enables the NIProxy to manage the bandwidth consumption of distributed applications and the way bandwidth is distributed among involved network flows. Supporting service provisioning on the other hand unlocks in-network processing of transported data.

The provided optimization mechanisms will enable **adequate response to fluctuations in QoS and QoE parameters** in the envisioned gaming scenario. Its network traffic shaping functionality will allow the NIProxy to **react to variable network connection throughput** by reshuffling network flow bandwidth assignment based on relative flow importance. By applying services, the NIProxy will be able to **streamline data dissemination and to mitigate mismatches between the capabilities of desktop and handheld devices**. Readily available NIProxy services include video transcoding (to reduce bitrate during bandwidth shortage), a service to FEC-protect data (for transmission over error-prone channels) and a **video mosaic service**. Anticipated services include the mixing of multiple audio streams into a single signal to reduce bandwidth consumption and to alleviate load on the (handheld) terminal, content adaptation based on terminal capabilities and altering user preferences, etcetera.

## 3. Methodology

Monitor and optimize QoS as well as QoE parameters:

### QoS measurement and optimization on network level

- Deploy probes to **estimate the capacity and performance of network connections**
- Perform network traffic shaping and bandwidth brokering to ensure optimal use of the available capacity
- Transform and adapt network traffic to optimize network dissemination

### QoS measurement and optimization on device level

- Tools to **determine end-user terminal capabilities** and features (i.e., using MPEG-21 UED)
- Collect statistics related to device performance (e.g., frame rate, battery lifetime, CPU load, ...)

### QoE measurement and optimization

- Allow users to specify their preferences and other contextual information such as environmental factors (i.e., using MPEG-21 UED)
- Automated user profiling
- Obtain QoE feedback through **qualitative user studies in living lab test environment** (determine user expectations using pre-gaming interview, quantify user satisfaction through observation during play and collect user feedback using questionnaire or post-gaming interview)

## 5. Iterative Experimental Evaluation

Based on QoE measurements and user feedback acquired through living lab user studies, the decisions and **actions taken by the NIProxy on the user satisfaction will be evaluated** and, where needed, adjusted. This will be done in an **iterative fashion**, meaning the adjustments implemented based on previous QoE findings will be subjected to subsequent user studies. Our final goal is to uncover the mutual influence QoS and QoE parameters have on each other and to **translate our findings into a set of recommendations and guidelines** for application designers and developers.