Peter Liggesmeyer, Präsident der GI.

GI-Präsident Liggesmeyer hatte hierbei die Gelegenheit mit hochrangigen Vertretern der EU, des BMWi, des BMBF und VOICE sowie mit Vertretern der Zivilgesellschaft zu diesem Themenkomplex zu diskutieren. Die Konferenz wurde von Staatssekretärin Brigitte Zypries eröffnet und diente als Auftaktveranstaltung für das Technologieprogramm „Smart Data – Innovationen aus Daten". (http://www.bmwi.de/DE/Themen/Digitale-Welt/Digitale-Technologien/smart-data.html)

EU-Kommissar Günther Oettinger unterstrich in seinem Impulsstatement nochmals die Rolle dieses Themenkomplexes und die Notwendigkeit der gemeinsamen Anstrengungen von Europa und den Mitgliedsstaaten in diesem Bereich erfolgreich werden zu können und stellte den sogenannten „Digital Single Market" in seiner Rede in den Fokus.

Abb. 2 EU-Kommissar Günther Oettinger

Unter Leitung des FZI Forschungszentrum Informatik als Konsortialführer fungiert die Gesellschaft für Informatik e. V. (GI) in dem Technologieprogramm des BMWi in den kommenden drei Jahren als Netzwerkpartner im Rahmen der Begleitforschung. Das maßgebliche Ziel der geförderten Begleitforschung bei „Smart Data" ist die Unterstützung der Projekte im Bereich der wissenschaftlichen Projektbegleitung, der Vernetzung sowie des Technologie- und Wissenstransfers. Hierbei bilden die Schwerpunkte der Rechtsrahmen, wirtschaftliche Potenziale und gesellschaftliche Akzeptanz sowie Sicherheit und Datenschutz. „Es brauche klare Regeln mit Opt-in, welche Daten für wie lange für welche Zwecke genutzt werden dürften", erörtert GI-Präsident Peter Liggesmeyer in einem Zitat auf heise online.

Bereits im Jahr 2013 hatte die Gesellschaft für Informatik e. V. (GI) im Rahmen der Big Data Days (http://www.big-data-days.de/), gemeinsam mit dem Fraunhofer-Verbund IUK Technologie und dem BMWi Fragestellungen aus der Grundlagenforschung und aus der angewandten Forschung sowie Strategien zur Qualifizierung von Big Data-Fachexperten in einem zweitägigen Kongress diskutiert.

Eine Videozusammenfassung des Tages ist unter nachfolgendem Link zu finden: http://www.bmwi.de/DE/Mediathek/videos,did=701824.html

Dagstuhl Manifesto

Schloss Dagstuhl is a place where computer science researchers and practitioners meet to discuss research outside the strict format of traditional conferences. Founded in 1990, it has earned an international reputation as an incubator for new ideas. Schloss Dagstuhl hosts over 70 seminars each year, which are organized by leading researchers in a field. In this series, they present their results and visions.

SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Quality of Experience: from Assessment to Application

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Quality of Experience (QoE) has, over the past few years, gained much traction both in research and industrial circles, becoming a trending topic.

Starting in 2009, a series of three QoE-focused Dagstuhl seminars have been held, with very interesting and influential outputs coming out of them. Herein we briefly report on the main outcomes of the latest of these seminars, Dagstuhl seminar 15022 "Quality of Experience: from Assessment to Application".

Background and Motivation

The previous seminars, 09192 "From Quality of Service to Quality of Experience" and 12181 "QoE: From User Perception to Instrumental Metrics" had focused on conceptual and practical issues related to QoE, and in particular with fundamental aspects such as providing a suitable working definition for QoE – something

much more challenging than one would imagine at first. At the confluence point of various disciplines, QoE needs to be understood from multiple perspectives, and it was the work done in seminar 09192 that provided the first usable definition for it, giving it a truly multidisciplinary basis, and departing from more networking-oriented views that prevailed at the time (e. g., coming from ITU-T). In seminar 12181, a refined definition for QoE, built upon work done in COST Action IC1003 Qualinet resulted in the currently prevalent definition for QoE, to wit: "the degree of delight or annoyance of the user of an application or service. It results from the fulfillment of his or her expectations with respect to the utility and/or enjoyment of the application or service in the light of the user's personality and current state". Seminar 12181 also resulted in a significant inflection point in the transition from QoS to QoE, shifting the focus from traditional performance evaluation towards the user-centered perspective that QoE implies.

The latest seminar in this series, held in January 2015, was focused on the next logical step on the "way to QoE". Whereas the previous seminars had emphasized basic concepts and operational aspects (in particular measurement and estimation of QoE), the goal of seminar 15022 has been the exploitation of the existing knowledge in the QoE domain to create value. When discussing value, we not only refer to monetary value, which is a critical aspect of most, if not all, services, but also to a wider notion of societal value. Indeed, value can be rather explicit and concrete (e. g., increased revenue, or reduction of number of customer complaints), but it can also be intangible and more latent (e. g., customer loyalty, strengthened relation between a customer and a provider, enabling user empowerment, contributing to well-being).

Implementation

The seminar brought together 27 people from 13 different countries, representing 17 different institutions, and ranging from first-year doctoral students to top-level experts in a variety of fields related to QoE. Each participant was asked to list three challenges related to the topic of the seminar, and those challenges were clustered, resulting in six discussion groups, with the following topics:

– Theory and Modeling
– QoE Methodologies
– User Factors and QoE
– QoE Management
– Economics of QoE
– QoE in New Domains

The topics covered were wide in scope and in degrees of abstraction, resulting in interesting and lively discussions in each of the groups, as well as concrete scientific output: four scientific publications in the three months following the seminar were produced, and more are currently being worked on.

Outcomes of the Seminar

Below we briefly summarize the main outcomes of the seminar, clustered by the topics identified as research challenges.

Theory and Modeling – Approaching QoE Modeling in a New Way. Despite significant advances in our understanding of QoE, existing models tend to focus mostly on perceptual aspects, leaving out important aspects related to user behavior and context. These are very challenging, but necessary aspects to consider when thinking about the value of QoE, as they can have a significant impact on it, just as the perceptual aspects do. The work we did on this topic resulted in a new way to approach QoE modeling[1], allowing the integration of different modeling approaches into one, providing insight into QoE from different perspectives, including the service providers' (in terms of monetary value, or information needed to better understand their users' satisfaction[2]), the users' (e. g., well-being) and the system's performance point of view.

QoE Methodologies – Taking QoE into the Real World. This topic focused on practical issues related to QoE assessment methodologies that are critical for bringing QoE to "the real world". In particular, we discussed the ecological validity of QoE assessment, making QoE operational, and when and where should QoE be evaluated. Ecological validity (i. e., how much a QoE study really applies to real-world usage) is a major issue with current standards of QoE testing, which have been designed for inter-laboratory reproducibility, but in the process losing any resemblance to how users actually use services. This can result in a host of issues when trying to apply those results to actual services. With regards to operationalization issues, there is a mismatch between the QoE definition in terms of "delight or annoyance" and QoE models and estimators that focus on perceived quality. This has implications both for non-media services, where perceived quality might

[1] Peter Reichl, Sebastian Egger, Sebastian Möller, Kalevi Kilkki, Markus Fiedler, Tobias Hoßfeld, Christos Tsiaras and Alemnew Sheferaw Asrese. Towards a comprehensive framework for QoE and user behavior modelling. In *Proceedings of the 7th International Workshop on Quality of Multimedia Experience (QoMEX)*, May 2015.
[2] Tobias Hoßfeld, Poul E. Heegaard and Martín Varela. QoE beyond the MOS: Added value using quantiles and distributions. In *Proceedings of the 7th International Workshop on Quality of Multimedia Experience (QoMEX)*, May 2015.

be a very different thing, as well as in the multimedia domain, where the inclusion of user (hedonistic and utilitarian) and contextual factors are critical for developing models applicable to real use cases. Finally, we discussed the "when and where" of measuring QoE, as well as whether direct user feedback is a suitable approach to collecting QoE data, or more passive approaches (e. g., A/B testing) might be better options.

User Factors and QoE – Beyond Basic Demographics and "Good Eyesight". The illusion that there exists a kind of archetypical and representative user ("the user") has already been scattered for quite some time, and the relevance of a wide range of variant and invariant user and human factors in relation to QoE is explicitly acknowledged in the new definition of QoE. Yet, the understanding of how these user factors relate to QoE, is currently still very limited. With this given as starting point, the working group on User Factors and QoE disentangled a number of underlying problems and discussed potential strategies to address this gap of knowledge. More concretely, with the typical flow of an experiment in mind, the discussion resulted in a set of action points and research questions for future research and concrete suggestions to better taking such user factors into account at various levels (methods, measures, analyses) and research stages. For instance, a recent joint study[3] on emotion elicitation in QoE research, in the scope of Cost IC1003 Qualinet and further stimulated by the discussions at the seminar, underlined the

importance of collecting more comprehensive and detailed descriptors of test participants, as they may help to identify human/user influence factors and their potential confounding role.

QoE Management – Towards a Unified Management Architecture. Once QoE can be understood and estimated, managing it is one of the first applications that comes to mind. This can take many forms, from resource management, to cross-layer control mechanisms, etc. There are, however, some basic needs underpinning all QoE management efforts. We proposed a general architecture for implementing QoE management in large-scale, and identified a set of challenges and needs to be met. Among those, the key open issues identified were the intersection with other disciplines (network management, and in particular SDN were prominent here), the identification of the interfaces at which monitoring and management could take place, the identification of the actuators, and determining the properties of the control loop.

Economics of QoE – Selling What is Felt to be Good. One of the stated goals of the seminar was the definition of a roadmap for industrial value creation from the existing knowledge of QoE. Indeed, having proper QoE models is the ultimate way assess and improve customer satisfaction. A number of research items and challenges were identified. Among those, the main issue found was that of conveying what "good quality" should feel like to a customer. If the objective is to sell good (or excellent!) quality to users, a common understanding of what that means needs to be achieved, and this is far from trivial. Another topic addressed was the inclusion

of QoE aspects into SLAs[4], so that they can become more meaningful to end users, and also allow providers to better dimension their systems to provide acceptable quality (as in QoE, rather than QoS) levels. Finally, mechanisms to assess how QoE affects the customers' willingness to pay for a service were also discussed, building on some existing results that show promise in this area.

QoE in New Domains – Moving Beyond the Multimedia Comfort Zone. QoE research has, for a variety of reasons, traditionally focused on multimedia services, while more recently some other types of services such as web browsing, gaming and some cloud services have attracted some attention. While there are exciting new challenges in that scope, there are an increasing number of application domains for which QoE is relevant, and where QoE can be something very different than in the multimedia domain. On this topic, we identified several of those application domains, notably eHealth, education, and smart grids. Among the key research questions identified, the need for developing a notion of what quality actually means for each new service type has been noted, together with the question of how it should be assessed.

Conclusions

The main objectives of this third Dagstuhl seminar on Quality of Experience were to strengthen and go beyond the current understanding on QoE, and to push the transition from the assessment of QoE to the practical application of QoE knowledge and

[3] Jan-Niklas Antons, Sebastian Arndt, Katrien De Moor and Steffen Zander. Impact of perceived quality and other influencing factors on emotional video experience. *In Proceedings of the 7th International Workshop on Quality of Multimedia Experience (QoMEX)*, May 2015.

[4] Martín Varela, Patrick Zwickl, Peter Reichl, Min Xie, and Henning Schulzrinne. Experience Level Agreements (ELA): the challenges of selling QoE to the user. In *Proceedings of the IEEE ICC 2015 – Workshop on Quality of Experience-based Management for Future Internet Applications and Services (QoE-FI)*, June 2015.

mechanisms. In light of the results obtained, we can conclude that significant steps forward were made at different levels.

The fruitful discussions amongst the participants resulted in the identification of both points of crystallization concerning our current understanding of QoE and open questions and challenges for future joint endeavors. In addition, several

scientific publications resulted as direct outcomes of the seminar (four publications in under three months following the seminar, with more currently being prepared), and a number of currently on-going, longer-term collaborations were started on the key topics identified by the working groups.

We can therefore conclude that the seminar – building on the legacy

of the preceding Dagstuhl seminars on QoE – successfully reached its main objectives and was particularly successful in raising a number of issues that are likely to stimulate the field to transcend its current boundaries and that open up the need for new/renewed perspectives.

More information on the Dagstuhl seminar can be found at http://www.dagstuhl.de/15022.

Friedrich L. Bauer (1924–2015)

Am Donnerstag, dem 26. April 2015, starb Professor Dr. Dr. h.c. mult. Friedrich L. Bauer, emeritierter Ordinarius der Informatik an der Technischen Universität München, nach langen Wochen der Krankheit im Alter von 90 Jahren. Damit verliert die Informatik in Deutschland ihren ehemals einflussreichsten Pionier. Friedrich L. Bauer hat über viele Stationen entscheidend an der Entstehung einer Disziplin mitgewirkt, die in den letzten 50 Jahren unsere Welt mehr geprägt hat als jede andere.

Nach kurzer Kriegsgefangenschaft führt das Studium der Ma-

thematik und Physik Friedrich Bauer 1946 zu Prof. Fritz Bopp, dem Nachfolger von Arnold Sommerfeld als Inhaber des Lehrstuhls für Theoretische Physik an der Ludwig-Maximilians-Universität München. Bereits nach drei Jahren erfolgt die Promotion. Angeregt durch einen Bericht des Schweizer Professors Heinz Rutishauser zum Thema Elektronische Rechenanlagen studiert Bauer sowohl Claude Shannons Schaltalgebra als auch die Arbeiten von John von Neumann. Bauer wird auf ein Geheimseminar von Robert Sauer, Professor für Ingenieurmathematik an der Technischen Universität München, und Hans Piloty, Professor für Nachrichtentechnik, aufmerksam. Ziel ist die Entwicklung einer elektronischen Rechenanlage, die später unter dem Namen PERM Gestalt annimmt. Gemeinsam mit seinem Freund und kongenialen Studienkollegen Klaus Samelson und Heinz Schecher, einem Physiker, entwirft er die Gleitpunktarithmetik der PERM und schreibt die entsprechenden Microcodes. Schecher entdeckt das wichtige Konzept der indirekten Adressierung und der automatischen Adresssubstitution.

1956 ist die PERM betriebsbereit. Trotz dieses Triumphes müssen die Entwickler feststellen, dass die Hardware mit ihrer Röhrentechnik unerfreulich anfällig ist. Aber nicht nur das – auch die Programme erweisen sich als fehlerträchtig. Programmieren ist bei der PERM, wie Bauer damals sagt, Goldstickerei. Diese Erfahrungen führen dazu, dass er sich ein Thema vornimmt, das ihn sein ganzes Leben begleiten wird: Die Suche nach einer angemessenen Programmiersprache und -methodik. Er und Samelson suchen einen Ausweg aus dem Dilemma der zu komplizierten Programmierung. Programmiersprachen sind eine Lösung. Wie aber sollen die Maschinen die Sprachen verarbeiten, die sich stark in den Befehlssätzen unterscheiden? Die Antwort ließ nicht lange auf sich warten: Compiler, „programmierende Programme" wie Bauers Freund Andrej Ershov aus der damaligen UdSSR zu sagen pflegte: Programme, die Programme in Maschinensprache übersetzen.

Zentral für die Übersetzung ist das Kellerprinzip. Nach dem Kellerprinzip werden anfallende Zwischenergebnisse bei der Auswertung eines geschachtelten Ausdrucks in der Reihenfolge, in der sie anfallen, „gekellert" – im Speicher