From Charging for QoS
to Charging for QoX

Peter Reichl

1st COST 605 Meeting
Sevilla, 3 April 2008

Agenda

- Research Interests

- QoS is Dead – Long Live QoX?

- How to Measure Quality-of-Experience

- Towards QoX-based charging

- Conclusions: is it worth the effort?

Research Interests

- Topic 1: Internet Economics
  - Focus: Feasible user-focused pricing mechanisms
  - Game theoretic models

- Topic 2: Future Charging Architectures
  - Focus: IP Multimedia Subsystem (IMS)
  - Project series based on OpenSource IMS testbed: CAMPARI – CAIPIRINA – BACCARDI

Our Focus

- Topic 3: User-centric Service Design
  - Focus: intuitive interactive mobile services
  - Quality-of-Experience (QoE/QoX)
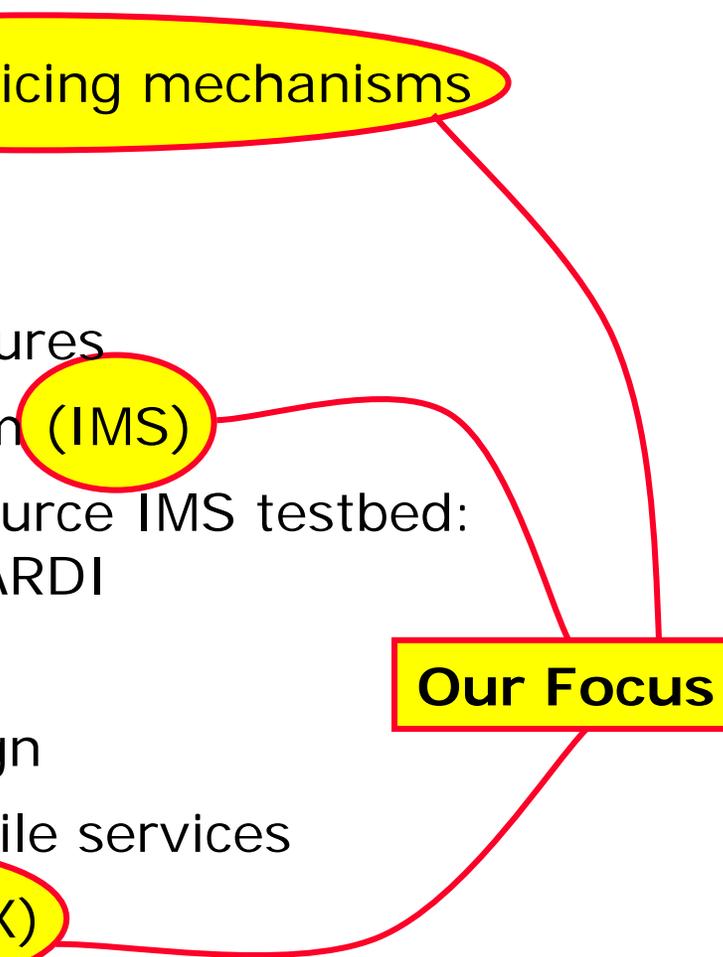
Once upon a time...

- **10-15 years ago:** Internet Economics $\cong$ Internet pricing

- Fundamentally different pricing approaches:
  - charge for functionality
  - charge for scarcity
  - charge for quality

- QoS – an „eternal" source of inspiration
  - Tragedy of the commons
  - Paris Metro Pricing
  - ECN Pricing
  - Effective bandwidth pricing
  - Cumulus Pricing Scheme
  - Contract and Balance Mechanism
  - ...

QoS in the Internet

- But: what has happened to one of our favorite research topics?

- Remember:
  - IntServ → complexity, statefulness
  - DiffServ → valuable add-on, emergency fallback
  - MPLS → not really a QoS architecture

- The pragmatic approach: Sprint et al.
  - Core Network → strict overprovisioning
  - Access Network → natural bottleneck

- Killer question: Any grand QoS research challenges left after all?

- Newcomer issues: resilience, access bandwidth management

- The latest candidate: 3GPP IMS and ETSI/TISPAN NGN

Some Remarks on Lessons Learned

- Due to capacity overprovisioning, congestion pricing has never become a real option.

- Among the classical QoS parameters, only capacity is charging-relevant.

- Since 2-3 years, flat rate schemes (plus „fair use" policies) dominate tariffing landscape.

- Utility functions are useful in theory, but a source of constant criticism in practice.

- User feedback is welcome, but only in a most simple form.

- From a technological perspective, the demand for flexible, scalable and multi-dimensional charging frameworks is still increasing. Most recent example: IMS.

QoS is Dead, Long Live QoX?

- The meaning of QoS
  - „Quality-of-Service: The collective effect of service performance which determine the degree of satisfaction of a user of the service" [ITU-T E.800, 1995]
  - „QoS is … used to define the network's capability to meet the requirements of users and applications" [Kilkki 1999]
  - „Quality-of-Service is defined as the ability of the network to provide a service at an assured service level" [Soldani 2006]
  - "QoS provided by a transport service is defined in terms of the way a traffic stream is affected when it is transported through the network. This is typically in terms of the probability of cell loss, delay, and cell delay variation." (Courcoubetis 2003)

- Observation: QoS nowadays reduced to technical context (in contrast to the original intention!)

- Hence: need for a new end-to-end user-centred quality concept

- Recent proposal: Quality-of-Experience (QoE/QoX)

Quality-of-Experience

- What QoX is about

  - "QoE has been defined as an extension of the traditional QoS in the sense that QoE provides information about the delivered service from an end-user point of view." [Lopez et al. 2006]

  - "QoE is how a user perceives the usability of a service when in use – how satisfied he/she is with a service in terms of, e.g., usability, accessibility, retainability and integrity." [Soldani '06]

  - "QoE is defined as overall acceptability of an application or service, as perceived subjectively by the end user. It includes the complete end-to-end system effects (client, terminal, network, services infrastructure etc). Overall acceptibility may be influenced by user expectations and context." [ITU-T SG 12, 2007]

  - "Quality of Experience includes everything that really matters." [Kilkki's Mission Statement on LinkedIn, 2008]

How to Measure QoX

- First question: Can „quality" be measured at all?
  → Galileo's principle: „Measure what is measurable, and make measurable what is not so."

- User tests and Mean Opinion Score (MOS)

- Subjective vs instrumental metrics

- PESQ and TOSQA: the standard way

- PSQA: a neural network approach

- The E-Model (ITU-T Rec. G.107)
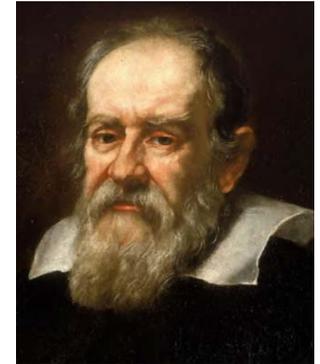
$$R = R_0 - I_s - I_d - I_e + A$$

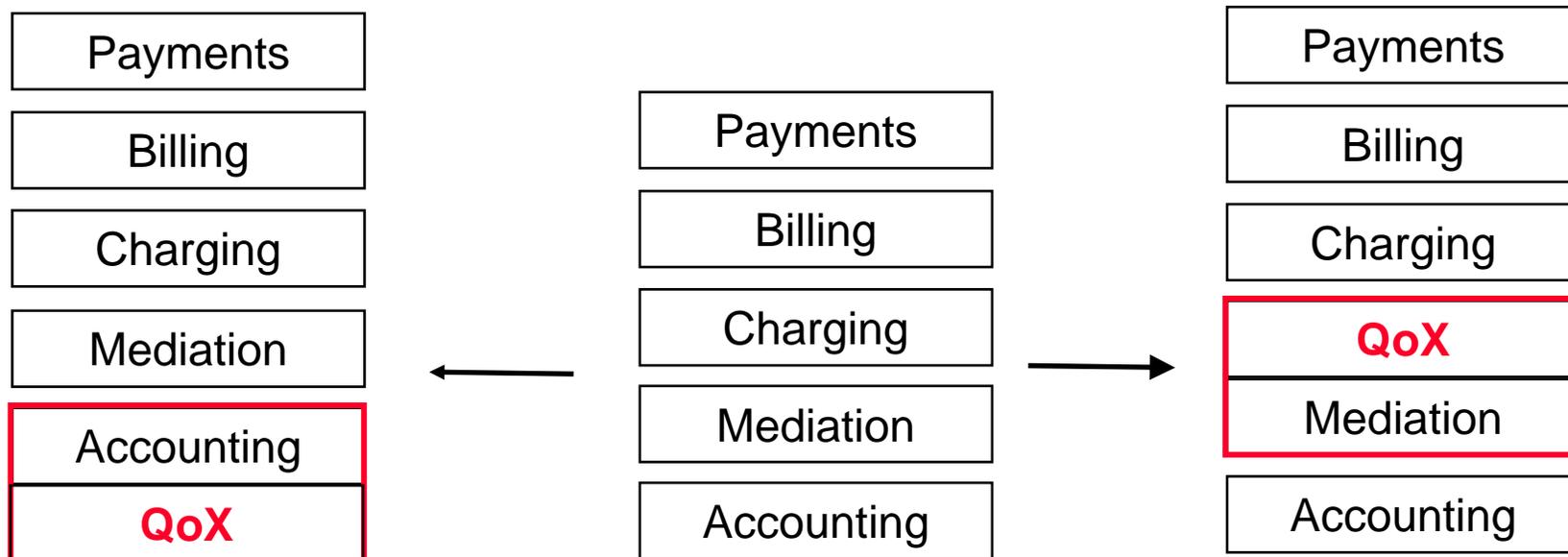| Reference value | Voice signal quality | Delay impairments | Codec distortion | Expectation factor |

Example: LiLiPUT – A Mobile User Test Environment

- Lightweight Lab Equipment for Portable User Testing in Telecommunications

- Goal: lightweigth, transportable and flexible equipment for user tests in various real life environments

- Idea: use state-of-the-art telecommunications
⇨ fully wireless approach
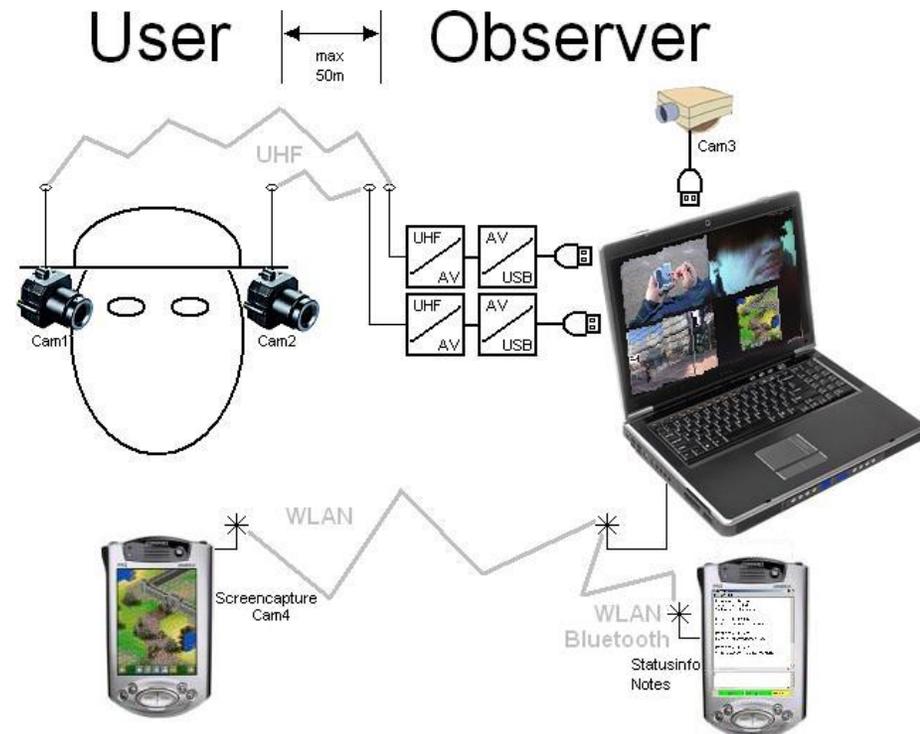
Charging for QoX

- Question: Does QoX make sense without QoX-based charging? If yes, how could QoX-based charging look like?

- Idea I: summarize input quality parameters by single scalar, e.g. through PSQA algorithm [Rubino/Tuffin et al.]

- Idea II: charging based on direct user feedback

Payments
Billing
Charging
Mediation
Accounting / **QoX**

←

Payments
Billing
Charging
Mediation
Accounting

→

Payments
Billing
Charging
QoX / Mediation
Accounting

Conclusions

- QoS is dead – in two ways (at least)

- QoE/QoX – the end user principle re-invented

- Fundamental question: should charging be included in the QoX research agenda?

- Next question: what are the scenarios behind?

- Final question: is it worth the effort?

- And the answer … ?

Some References

- Y. Hayel, G. Rubino, B. Tuffin, M. Varela: *A New Way of Thinking Utility in Pricing Mechanisms: A Neural Network Approach*. Proc. CLAIO'06, Montevideo, Uruguay, Nov. 2006.

- K. Kilkki: *Differentiated Services for the Internet*. Macmillan Publishing, 1999.

- K. Kilkki: *Next Generation Internet and Quality of Experience*. EuroFGI Workshop on Socio-Economic Issues of NGI, Santander, June 2007

- D. Lopez, F. Gonzalez, L. Bellido, A. Alonso: *Adaptive multimedia streaming over IP based on customer oriented metrics*. Intern. Symposium on Computer Networks, Istanbul, June 2006.

- P. Reichl, J. Fabini, P. Kurtansky, B. Stiller: *A Stimulus-Response Mechanism for Charging Enhanced Quality-of-User Experience in Next Generation All-IP Networks*. CLAIO'06, Montevideo, 2006.

- P. Reichl: *From 'Quality-of-Service' and 'Quality-of-Design' to 'Quality-of-Experience': A Holistic View on Future Interactive Telecommunication Services*. Invited Paper, IEEE SoftCOM'07, Split, Croatia, Sept. 2007.

- D. Soldani, M. Li, R. Cuny: *QoS and QoE Management in UMTS Cellular Systems*. Wiley 2006.