

Utility Functions, Quality-of-Experience and the Weber-Fechner Law

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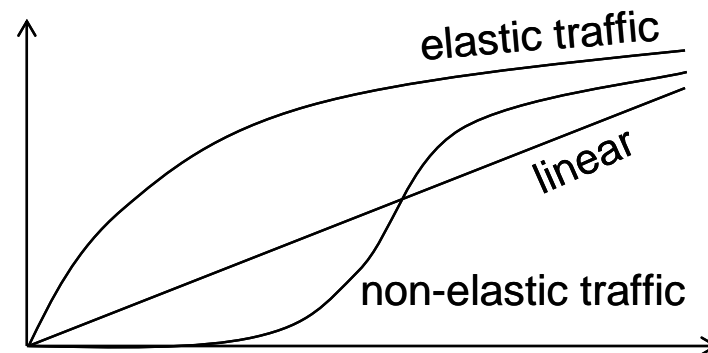
Agenda

- The notion of utility
- Quality-of-Experience – towards an Anti-Copernican Revolution
- Example 1: VoIP quality under PSQA
- Example 2: the ACE project and QoE of mobile broadband
- Excursion: the Weber-Fechner Law
- Example 3: the IQX hypothesis
- Conclusions

Utility Functions Revisited

- **Basic question:** what is the „worth“ of a resource/service for the end customer?
 - willingness-to-pay
 - revenue for reselling
 - value for the user

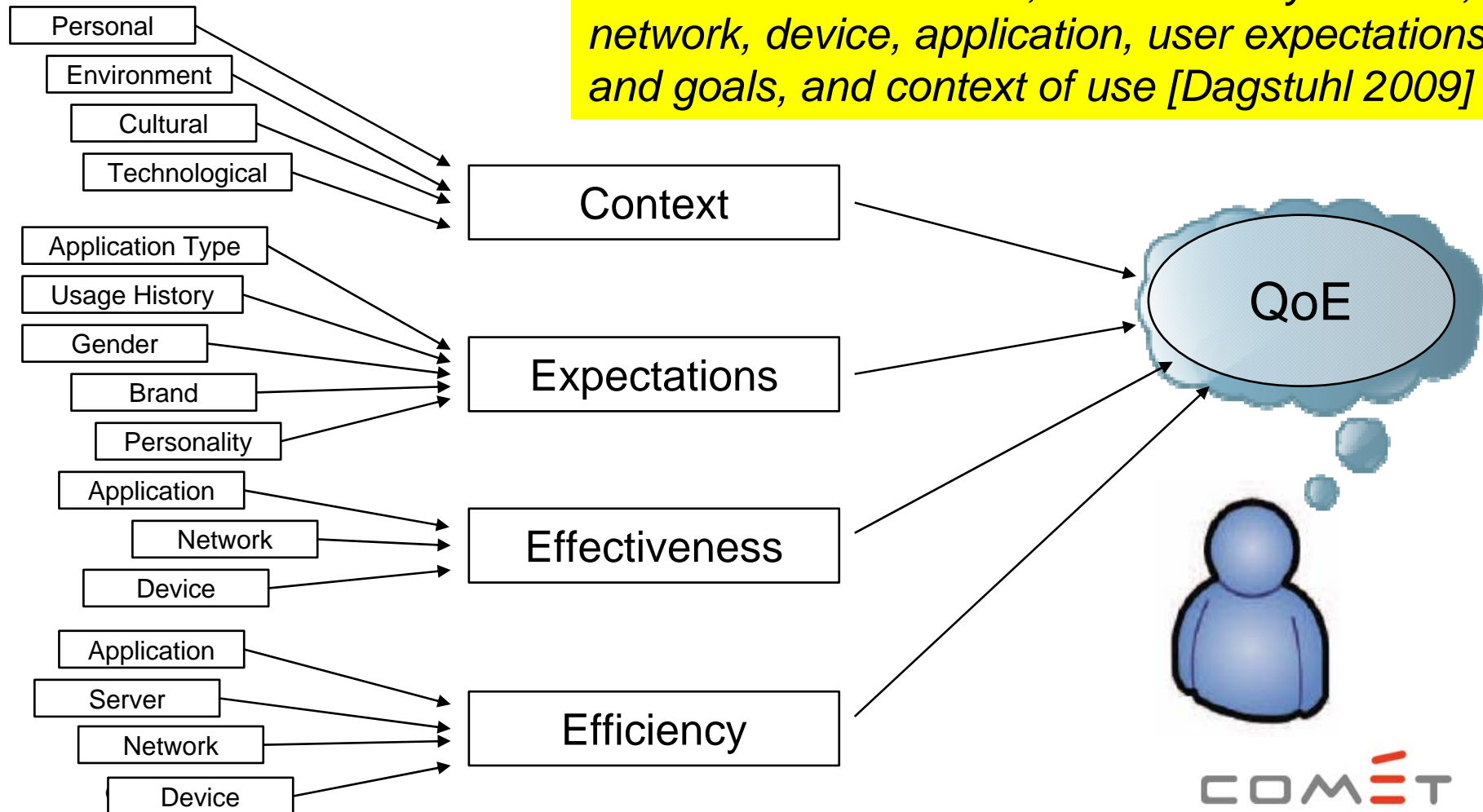
- **Formally:** $u_i(x) :=$ **utility function** for customer i to have service x



- **Example:** elastic vs non-elastic traffic
- **Usual assumptions:** monotonically increasing, concave, ...
- **Typical candidate:** logarithmic utility \Rightarrow proportional fairness
- **Idea:** Quality-of-Experience

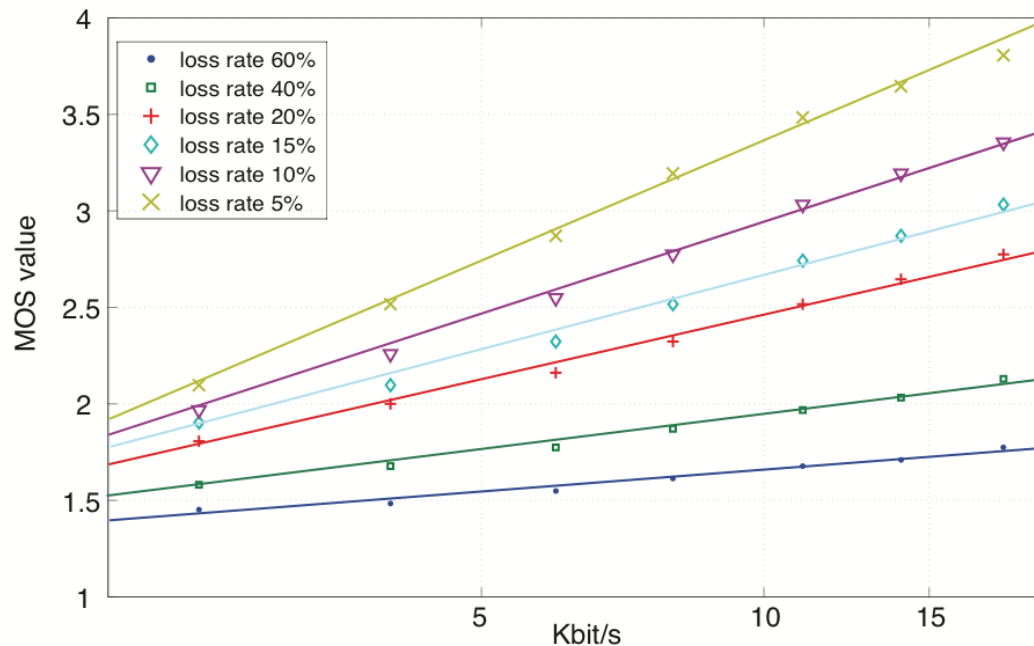
An Interdisciplinary Approach to Quality of Experience (QoE)

Hedonistic version: QoE = degree of delight of the user of a service, influenced by content, network, device, application, user expectations and goals, and context of use [Dagstuhl 2009]



Example 1: VoIP Quality under PSQA

- Rubino, Varela et al.: Pseudo-Subjective Quality Assessment
 - automated evaluation tool for QoE of multimedia applications
 - basic approach: 3-layer feed forward neural network
- **Scenario:** Speex codec, bitrates varying from 2.4 to 24.8 kbps
- **Results** under logarithmic scaling



MOS - Value	Quality
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

Example 2: QoE for Mobile Broadband

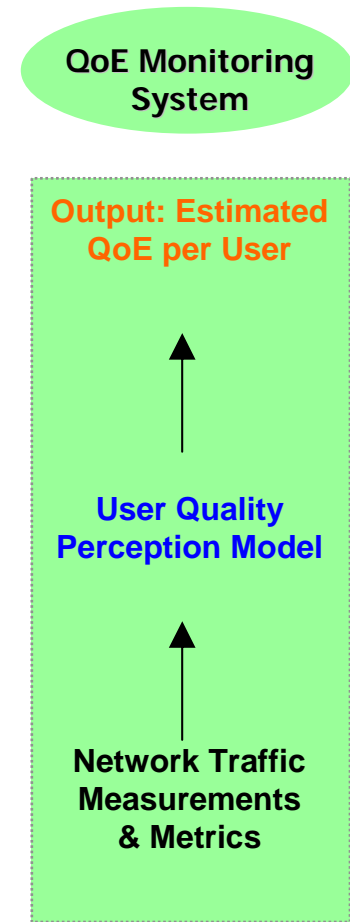
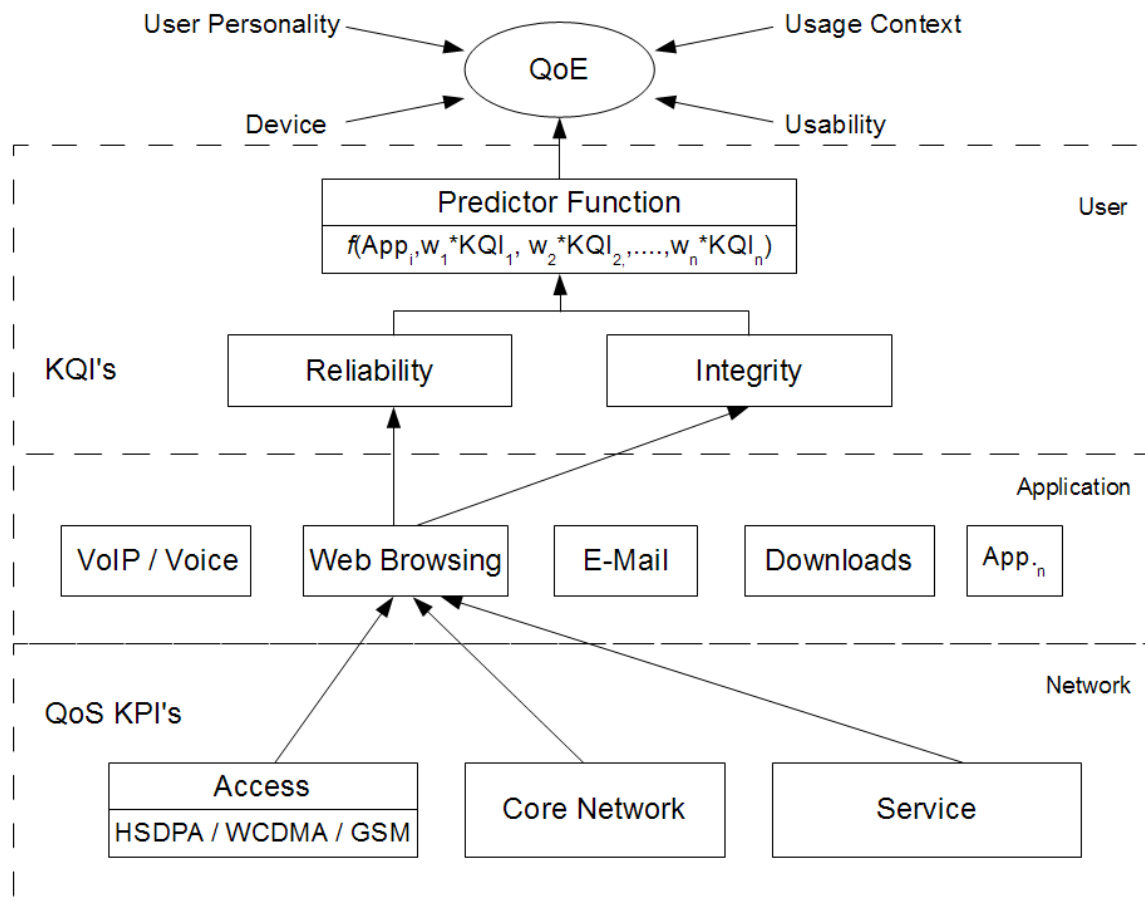


- **Related Project:** ACE – Advancing the Customer Experience
- **Partners:** mobilkom austria, Kapsch CarrierCom, FTW
- **Goal:** **predict how a user is satisfied** with a service by automatically processing related network traffic
→ measure quality from an end-user perspective!
- **Advantages:** user-centric QoE approach allows for
 - better understanding of broadband customers
 - more accurate assessment of network quality

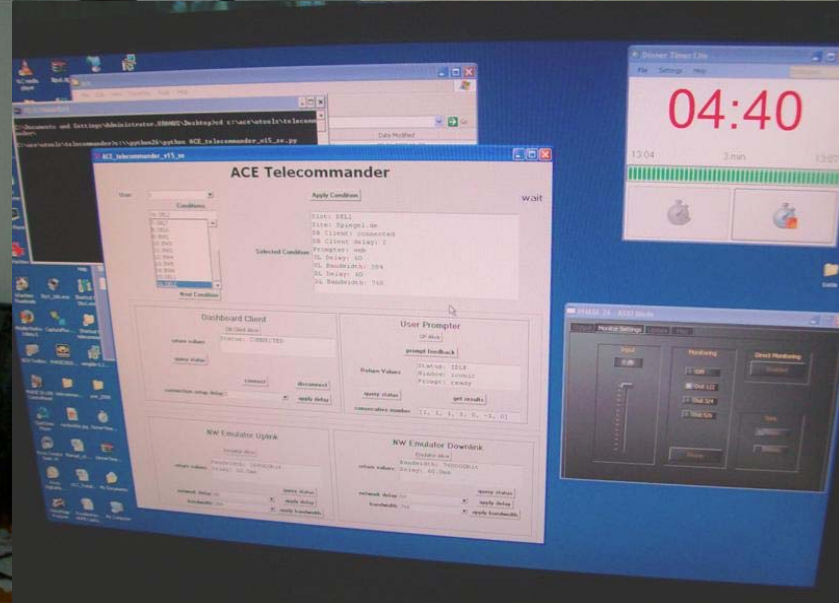


The ACE Approach: Integrate Different Layers and Disciplines

Idea: combine expertise in end-user research *and* network traffic analysis

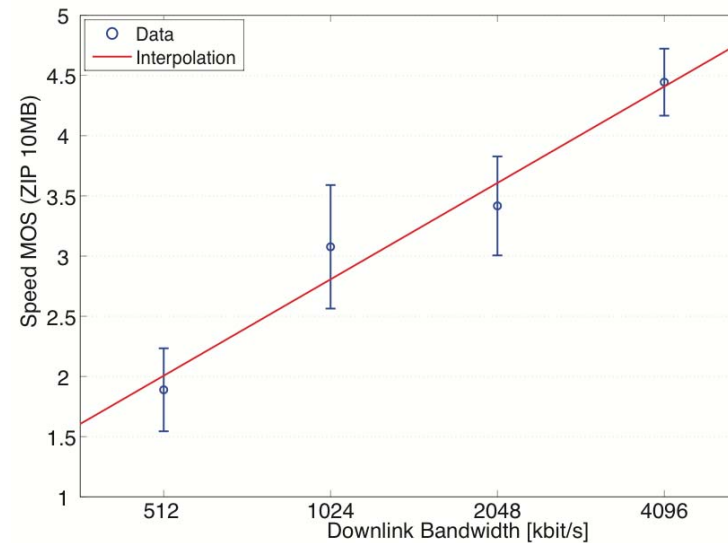
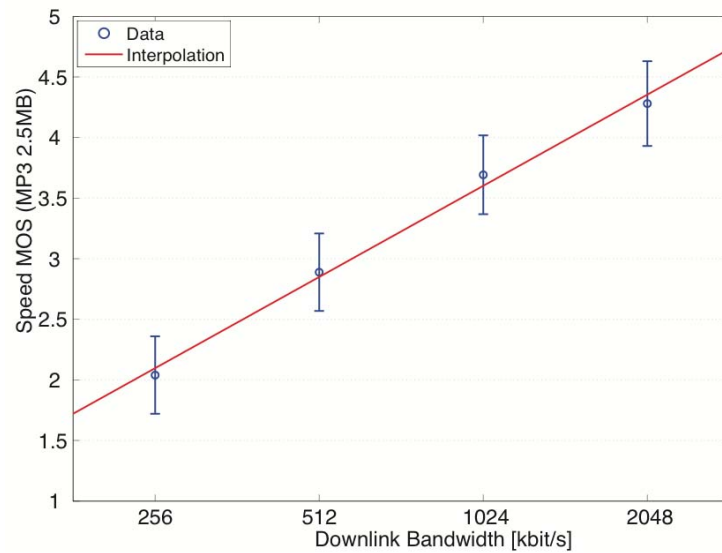


Impressions from Lab User Studies



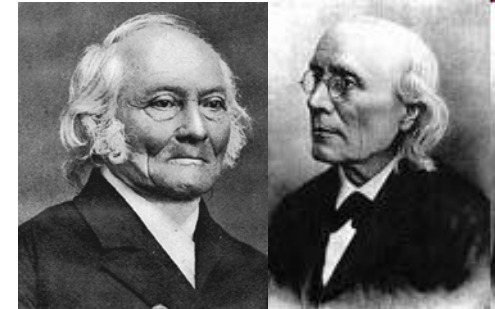
Results: File Download QoE

- **Scenario:** users download single MP3 and ZIP files at different network speeds
- **Observation:** again logarithmic dependencies between bandwidth and quality ratings



The Weber-Fechner Law

- **1834:** Ernst Heinrich Weber, Gustav Fechner and the birth of psychophysics
- **Idea:** operation of the human sensory system traced back to „just noticeable differences“
- **Formally:** differential perception dP directly proportional to relative change dS/S of physical stimulus

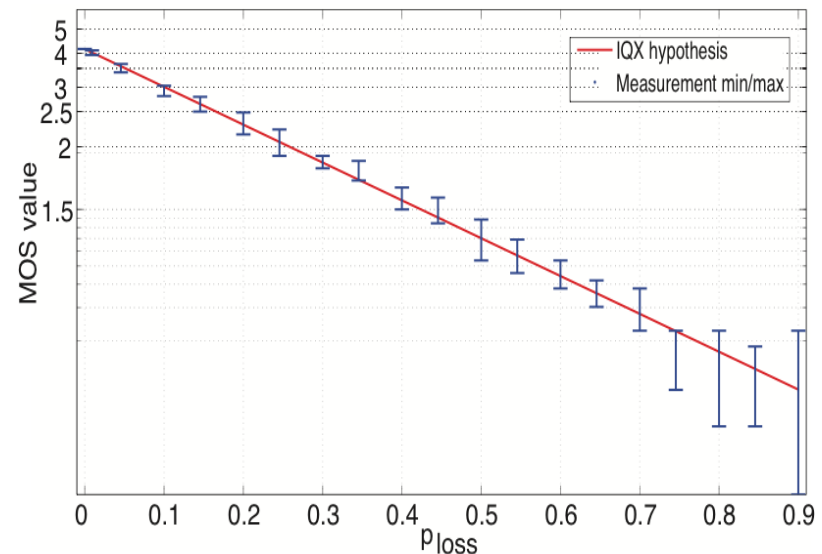
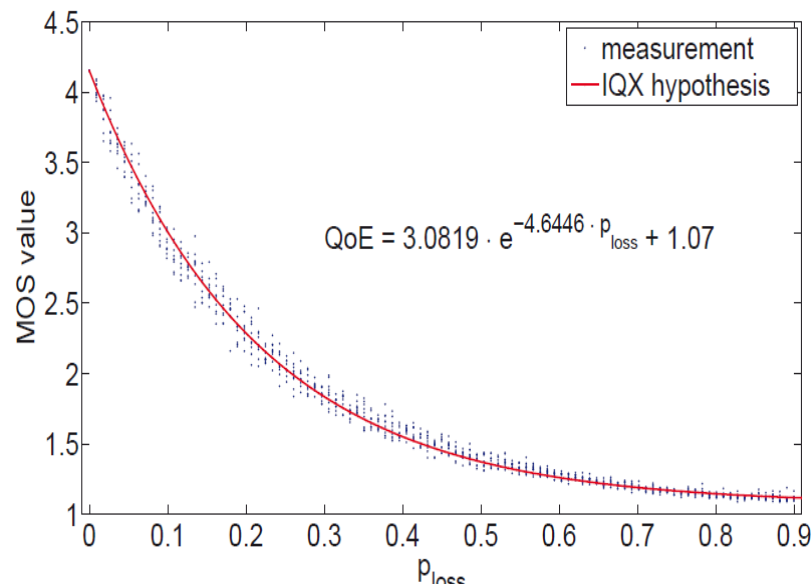


$$dP = k \cdot \frac{dS}{S} \quad \Rightarrow \quad P = k \cdot \ln \frac{S}{S_0}$$

- Well-known principle for human vision, hearing, smelling, touching, even numerical cognition...
- **Question:** valid also in ICT context?

Example 3: IQX Hypothesis

- **Scenario:** QoE as function of single impairment factor (e.g. loss rate)
- **Basic assumption:** user's sensitivity w.r.t. QoE directly proportional to current QoE level
- **Claim** (Hossfeld et al.): negative exponential dependency
- **Note:** role exchange of stimulus (QoS) and response (QoE)
- **Results** (original and logarithmic scaling on y-axis):



Conclusions

- Utility functions as key ingredient to economic modeling
- Recent results confirm logarithmic nature of QoE
- Most important examples: VoIP, mobile broadband
- The special case of the IQX hypothesis
- Conclusion: further justification for using logarithmic utilities

Thank You Very Much For Your Attention!

Questions & feedback always welcome:
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Some References

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