QuEEN

Quality of Experience Estimators in Networks

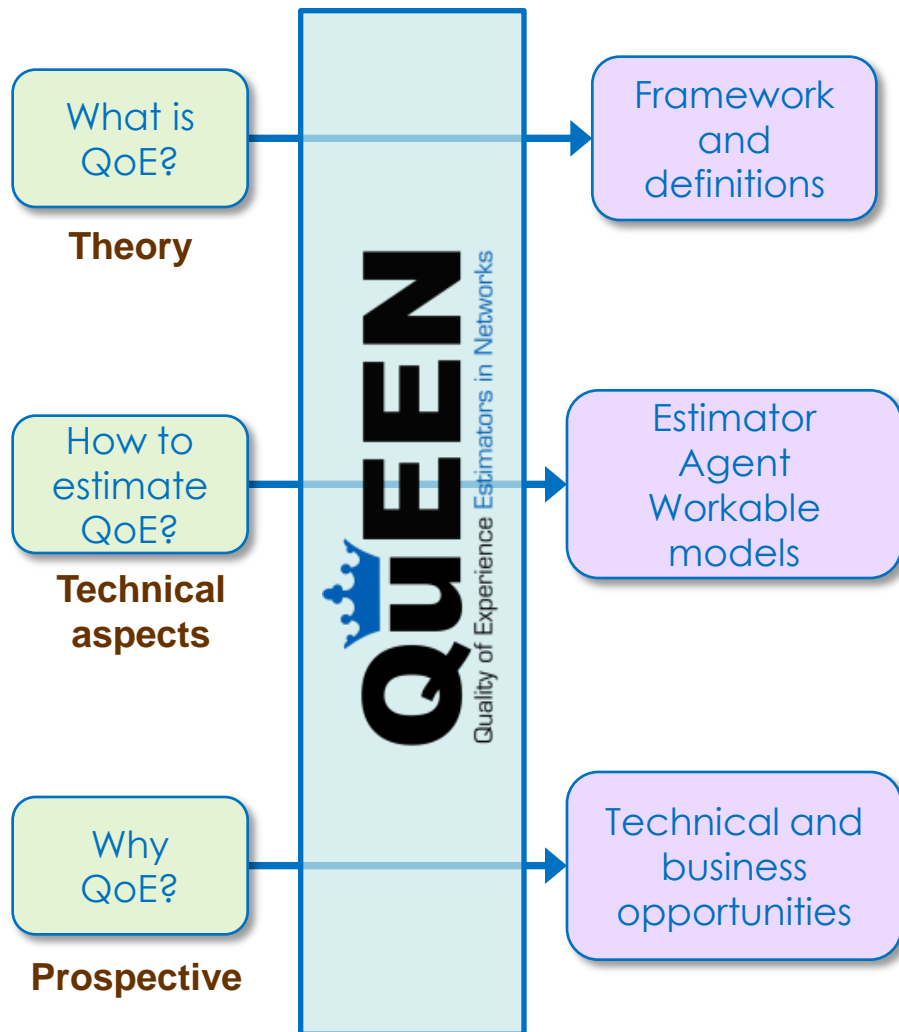## January 2012 - January 2015

QUALITY OF EXPERIENCE
STATE OF ART BEFORE THE PROJECT (2000-2009)

- Analysts (Forrerster, Gartner ...) enlighten QoE Market relevance
  - "*Customer Experience Correlates To Loyalty*", 2009, Forrester

- Increasing scientific and technical activities focusing on perceived quality/quality of experience

- Many different terms and concepts but no established consensus
  - No satisfactory definition of Quality of Experience (QoE)
  - Very spread results and contributions
    - ergonomics, emotional neurosciences, marketing, technology and IT, artificial intelligence, human and social sciences, etc.

- Same situation for Standardization bodies (ITU, ETSI, TMF)
  - Conclusion of *ETSI Workshop on QoS/QoE/User Experience focusing on speech/multimedia conference tools*, September 2010 :

  "Quality of Experience is not a universally well understood concept"

GOALS OF THE PROJECT

3 axes of equal interest

What is QoE? **Theory**	→	**Framework and definitions**
How to estimate QoE? **Technical aspects**	→	**Estimator Agent Workable models**
Why QoE? **Prospective**	→	**Technical and business opportunities**

- Provide a framework (concepts, terminology)
- Identify key technical and contextual parameters
- Promote a multi-domain approach

- Design workable QoE models
- Design a software agent implementing the models

- Identification and exploitation of technical and economical opportunities

PROJECT CONSORTIUM

Research Institutes

SWEDISH ICT ACREO — ITAINNOVA INSTITUTO TECNOLOGICO DE ARAGON — Inria INVENTEURS DU MONDE NUMÉRIQUE — iMinds CONNECT.INNOVATE.CREATE — ftw Creating Communication Technologies — VTT

Universities

BLEKINGE TEKNISKA HÖGSKOLA · BTH — FER — Technische Universität Berlin — universität wien

Telecom Operators

embou Nuevas Tecnologías — orange — PPO — telenor group

Industries

EXFO — ERICSSON — indra — VOLVO

SMEs

hiberus TECNOLOGIA — info24 — ip-label — MOBISOFT — RUGGEDNET TOOLING — TCO DEVELOPMENT — TELNET Redes Inteligentes

MAIN PROJECT ACHIEVEMENTS
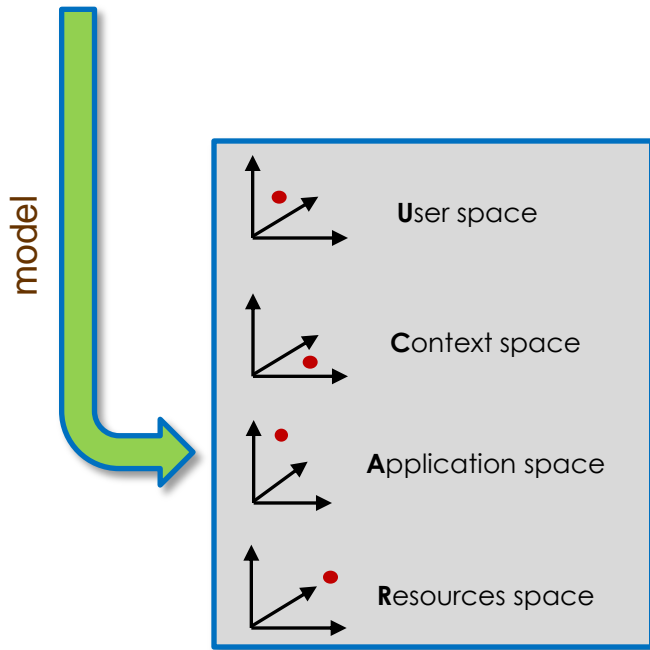
- **What:** Standardized QoE Framework
  - A common terminology for quality concepts and, in particular, for QoE concepts
  - A theoretical model: the ARCU model (vector-space like abstraction)
  - An operational model: the QoE-layered model (approximation of ARCU model)

- **How:** Specifications for a software implementing the QoE-layered model
  - process of QoE estimation
  - standardized communication and information exchange interworking

- **Reference implementation**: the QuEEN-Agent (available publicly as open source)

  - QuEEN-agent is proven technology with already real deployment (QuoTe - VTT)

- Numerous publications
  - Publications related to QoE models
  - Publications and a database of results on subjective tests (publicly available)
  - 3 standards related to web-browsing (ETSI TS 103 256, ITU-T G.1031, ITU-T G.1501)

ETSI TS 103 294 (2014-12)
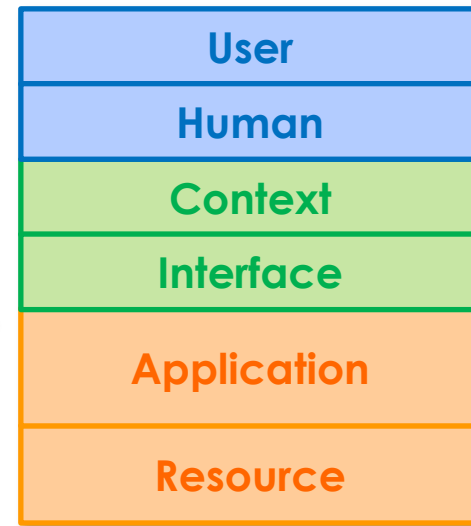
QoE Framework concepts and terminology

model
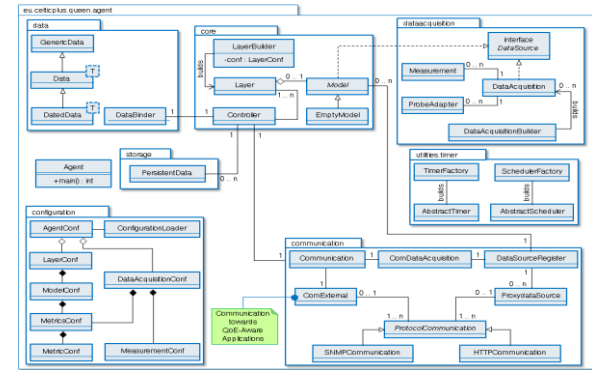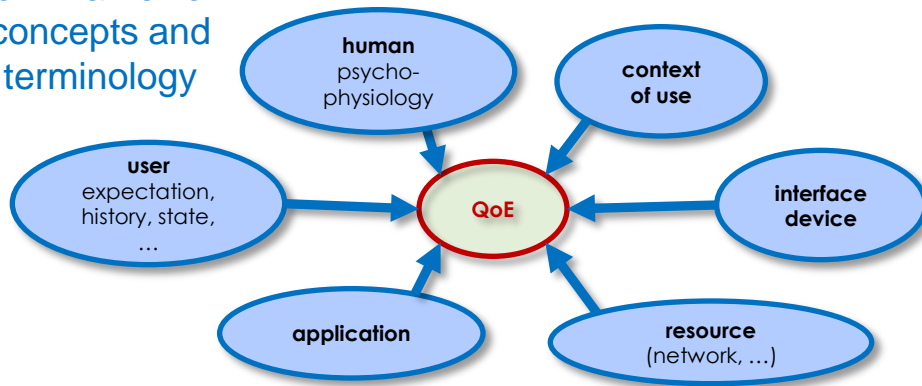
operational model

specification implementation

ARCU model

QoE-layered model

User
Human
Context
Interface
Application
Resource

- Why: New knowledge on economical aspects of QoE

- Introduction of QoE into charging schemes

- Introduction of QoE into value networks

  - Value network: A qualitative methodology for understanding, visualizing and optimizing interactions between interactions among (economic) actors for their mutual benefit.
  - New quantitative method for value network analysis
    - Evaluate benefits and revenue distribution
    - Evaluate the strength of dependency of actors

- Introduction of QoE into SLAs
  - QoE as a driver for SLA selection and formulation
  - Research lines towards "Experience Level Agreements"

- Numerous publications

Willingness-to-pay study

Fixed Point Problem
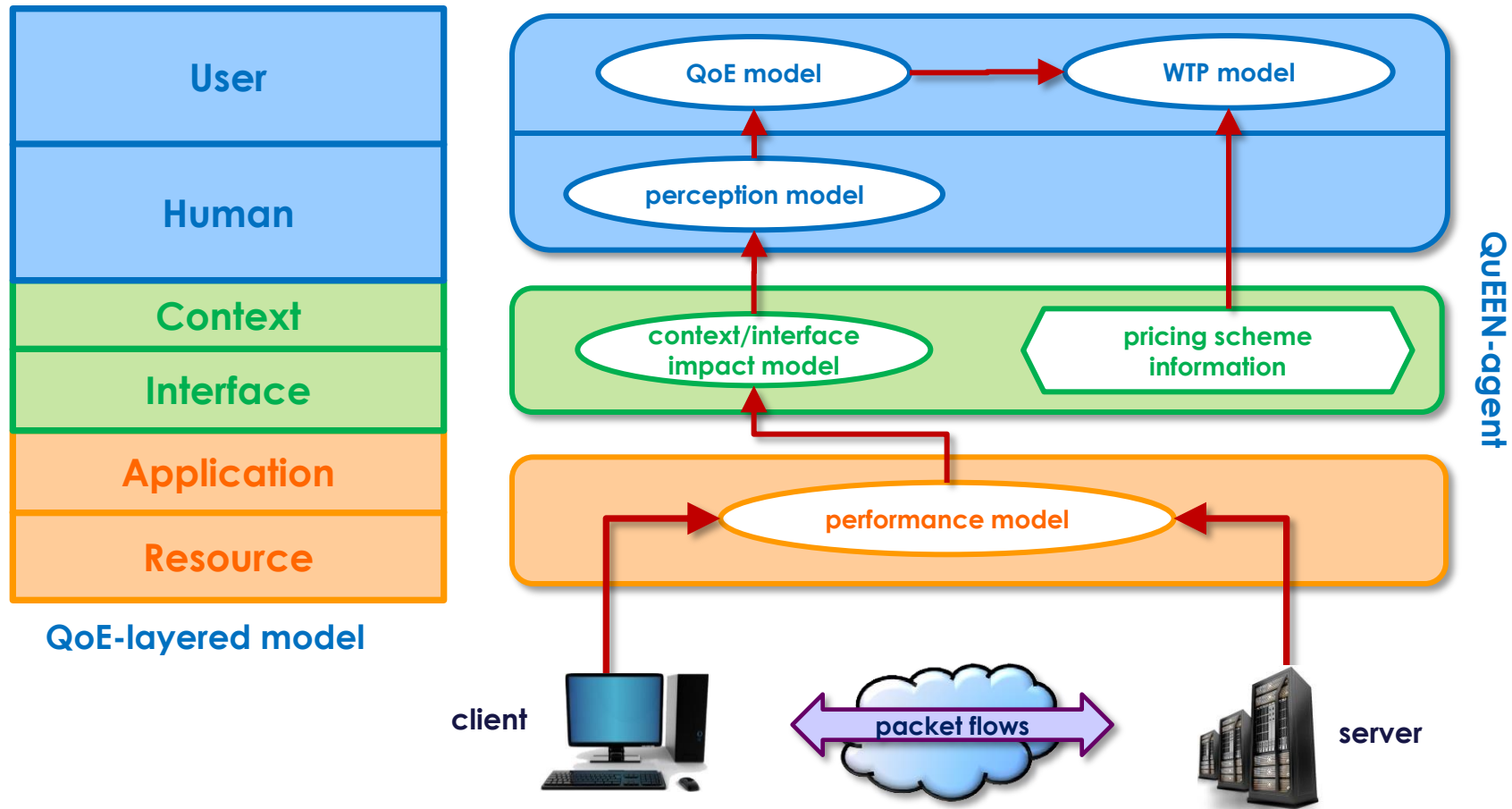
QoS-based pricing

QoE-based pricing
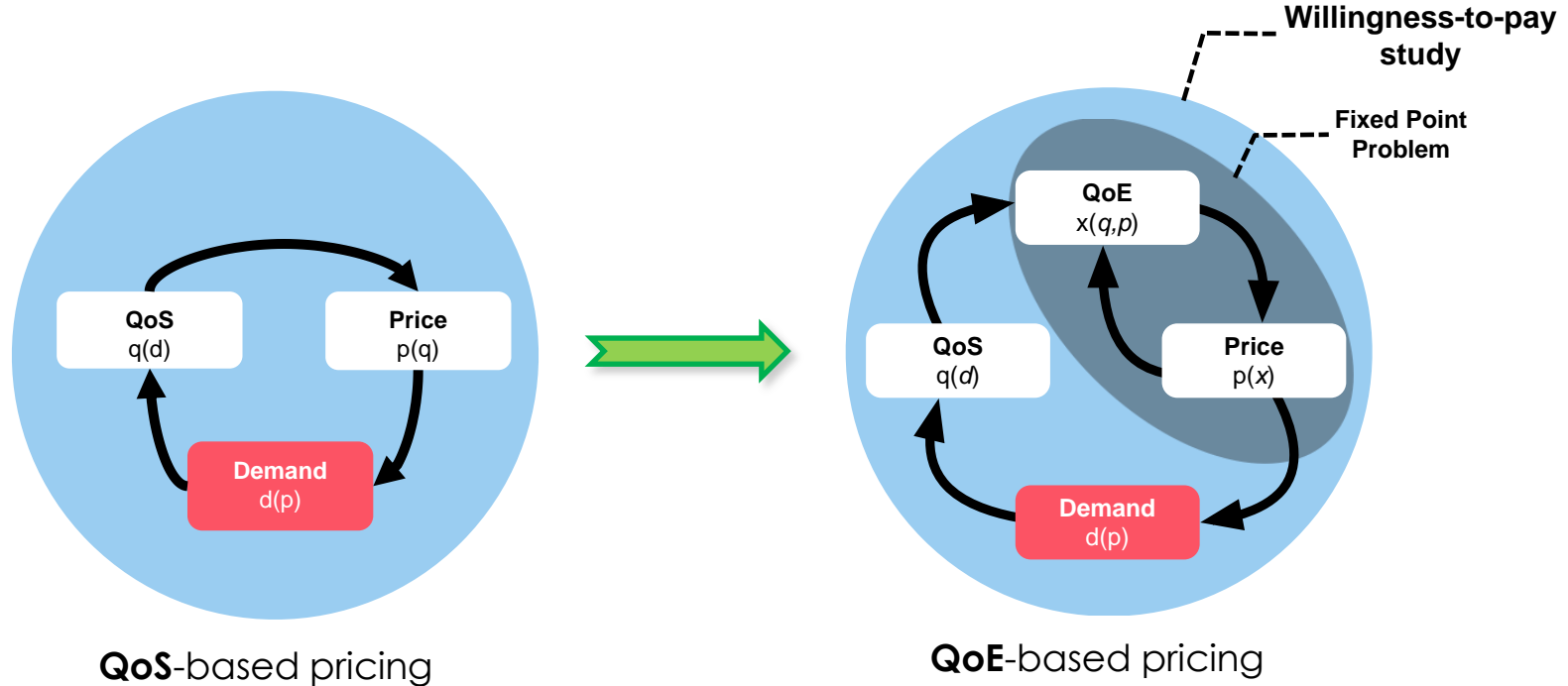
$$\begin{cases} d_0 = d(p_0) \\ p_0 = p(q_0) \\ q_0 = q(d_0) \end{cases}$$

proposed approach

$$\begin{cases} d_0 = d(p_0) \\ p_0 = p(x_0) \\ x_0 = x(q_0, p_0) \\ q_0 = q(d_0) \end{cases}$$

fixed-point problem

- Practical application: testing willingness-to-pay models

- Several demonstrated proof-of-concepts

  - Video-on-Demand (Embou/Hiberus/**ITA**INNOVA/Telnet)
    - QoE-evaluation in real Wimax/FTTH environments (Embou clients)

  - QuoTe (VTT/ESA)
    - Benchmarking and monitoring of Quality of Experience of telemedicine systems

  - Emotracker (ITAInnova)
    - Automatic tools to measure affect and emotions

  - QoE-aware DASH video (INRIA)

- More than 100 publications

    - 4 ETSI or ITU documents
    - 3 ITU-T drafts recommendations
    - 1 edited book
    - 12 book chapters
    - More than 80 journal or conference papers

- Reference Java implementation: the QuEEN-Agent (open source)

- Database of results on subjective tests (publicly available)

- 6 conferences/workshops directly related to the project (co-)organized by QuEEN's partners (Dagstuhl, IWQM 2013, QoMEX 2013, ...)

- 6 contributing Ph-D

- 1 possible spin-off creation (Emotracker)

- Strong impact on some partner's activities

- **info** 24 Swedish information broker

  - collecting millions of messages from over 3500 snow removal vehicles in Sweden and Norway every 10-15th seconds.
  - The messages are GPS positions and performance data used for administration and billing.
  - distribute the information to multiple recipients from private companies to public authorities.


Mobile devices
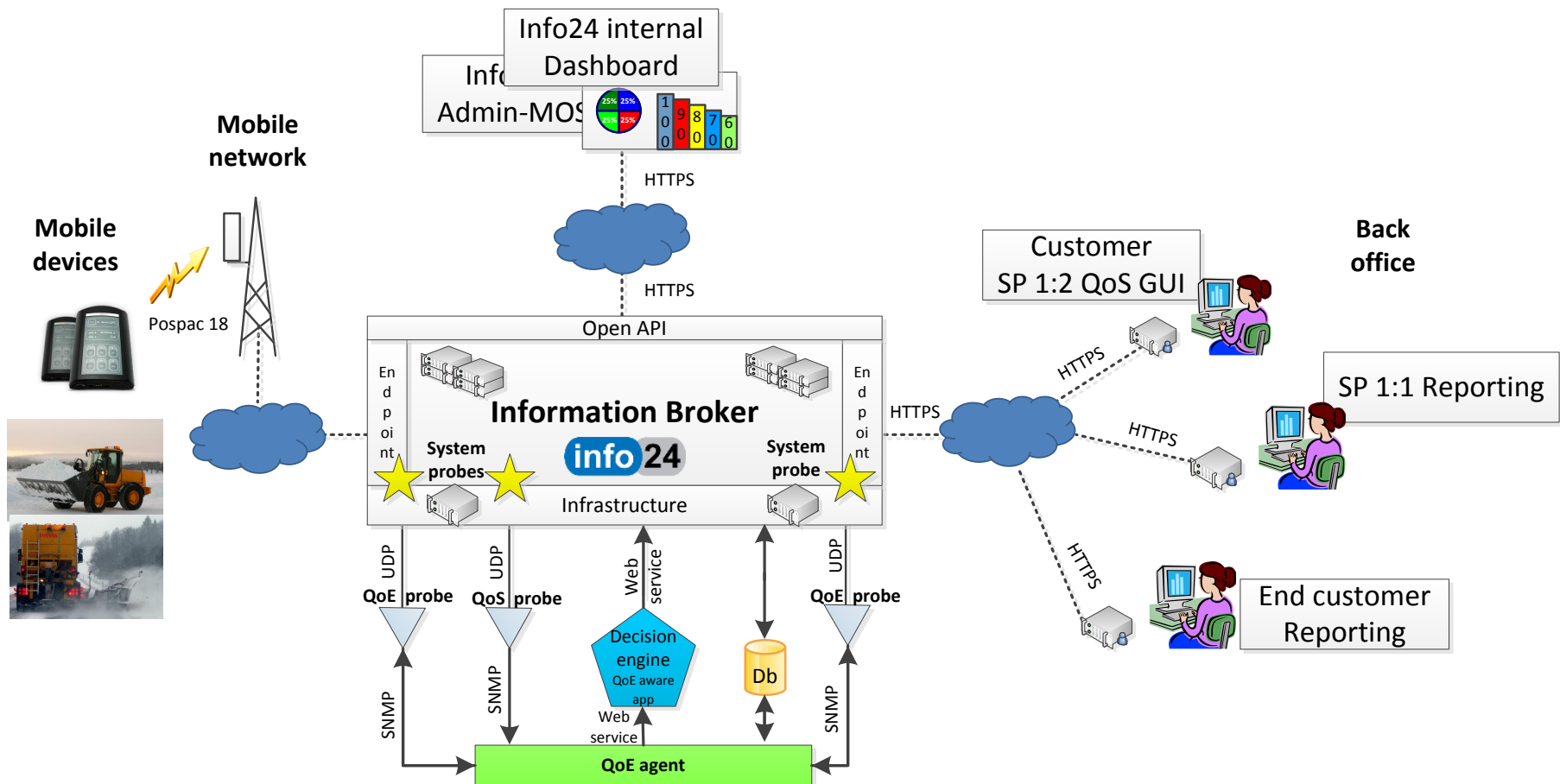
End point

Information Broker

info 24

End point

Infrastructure

Back office
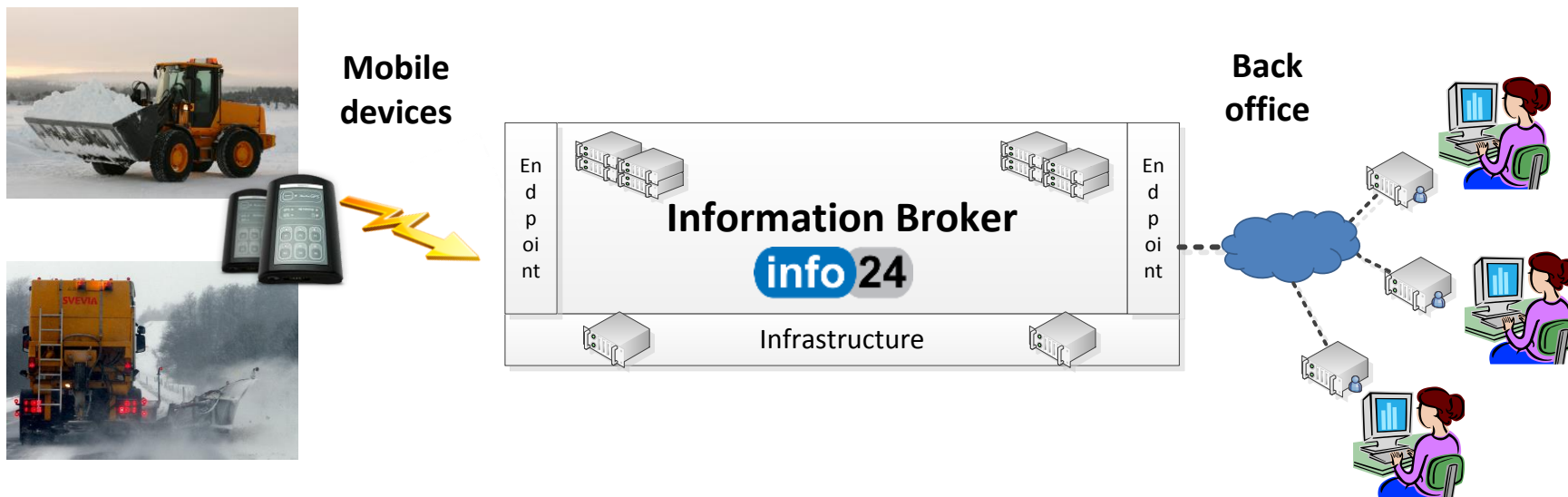
- QoE ?   Latency !

Mean Opinion Scores – Customer MOS

Score	Opinion	Max value	Sort	Code
5	Exellent	10	Sec	😀
4	Good	15	Sec	🙂
3	Fair	60	Sec	😐
2	Poor	300	Sec	🙁
1	Non acceptable under SLA	>300	Sec	😞

SLA: latency > 300 s ➜ penalty

Mobile devices

Information Broker
info 24

Infrastructure

En d p oi nt

Back office
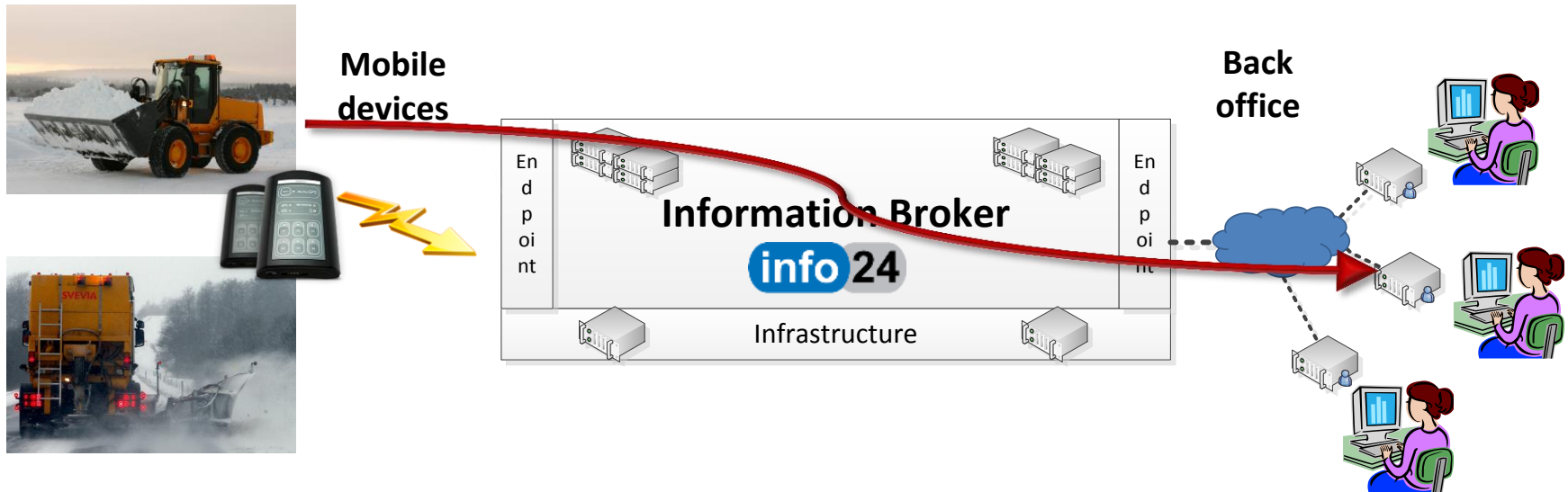
- Complete re-write of integration platform
  "Make it QoE-ready!"

Thank you for your attention

- Wiki site of the project
    - http://celtic-queen.inria.fr/dokuwiki/doku.php

- The Java code of the QuEEN-Agent is available at the Github repository
    - https://gitlab.willab.fi/queen/queen-agent.git

- Results of subjective QoE tests for Web browsing are freely available on FTW website
    - http://userver.ftw.at/qoe/web-dataset/

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