Modelling the quality of user perceived experience

STSM - Action CA15212 (Citizen Science to promote creativity, scientific literacy, and innovation throughout Europe)

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- University of Žilina – Science park - **March 2018**, Slovakia

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The aim of COST Action Citizen Science

- How citizens can contribute to the science.
- Measure the potential of citizen science as enabler of social innovation and socio-ecological transition.
- The practice of public participation and collaboration in scientific research to increase scientific knowledge.

WG5 - Improve data standardization and interoperability

- **WG5** will create an ontology for describing citizen-science projects, observations and analyses.
- Explore ways for integrating data and knowledge related to citizen-science initiatives
- Will improve the technical foundations to foster the impact of citizen science globally.

How citizens can help determine the quality of user perceived experience

- Rapid development of ICT
- Cloud computing services
- Personalized smart phone apps.
- Intelligent transport systems.
- Use different types for “data-aggregation methods”

Cloud computing as a Service

Cloud service delivery models

- IaaS (Infrastructure–as–a–service)
  - offers raw network, computation and storage infrastructure
- PaaS (Platform–as–a–service)
  - provides development and deployment of applications without having to take care of hosting them.
- SaaS (Software–as–a–service)
  - uses a provider's applications running on a Cloud infrastructure allowing for limited configurations by the user.

Cloud computing organizational perspective

- Public Clouds - providers offer their resources, to the general public over the Internet.
- Private clouds are designed for exclusive use by a single organization.
  - It provides highest degree of control over performance, reliability and security.
- Hybrid clouds represent a combination of public and private cloud models.
- Community clouds

Why Cloud Computing

- Software, hardware and communication infrastructure are **setup** cost resources.
- Cloud computing is stable, reliable and encapsulated environment.
- Transform search, mining and analysis tools.
- **Scientific computing** is revolving around data.
- Easily accessible to **anyone** from **anywhere**.
- **Large-scale data** and **cloud computing** are closely linked.

Mobile devices

- Limited computing resources
  - Battery, CPU, memory, storage, bandwidth
  - Therefore, we can not use PC solutions right out of the box
- User education
  - Broader range of users compared to PCs
  - More prone to social attacks
- Ubiquitous
  - Less expensive, outnumber PCs
- More interfaces for connectivity
  - Bluetooth, infrared, WiFi, cellular, USB, tethering

Why Mobile Cloud Computing (MCC)

- Mobile phones are logging user behavior data through sensors.
- Handling **user-generated** content imposes problems more related to data volumes, privacy, and delivery latency.
- **The multimedia** processing can only be delivered by using the “unlimited” on-demand computing power of the cloud.

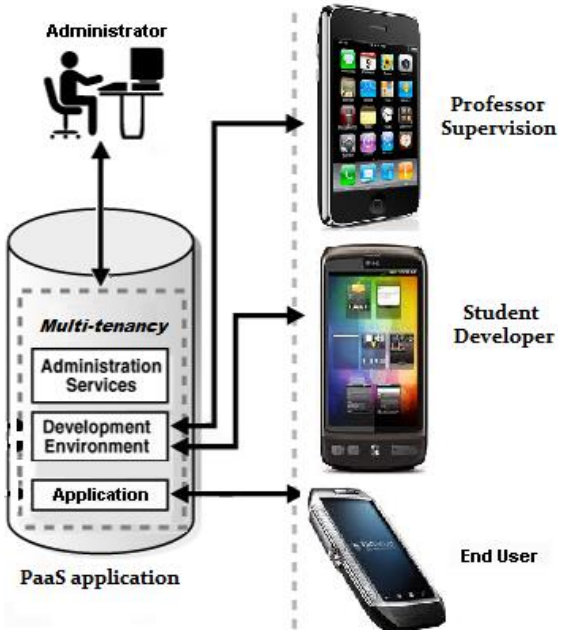
Mobile learning in the Cloud

- Integration of mobile devices in learning increase the collaboration, availability and scalability of the students.
- Multimedia learning systems includes resources such as audio, video, images, text etc.
- The MCC enhance the power of mobile devices.
- New standards and protocols like HTML5 and APIs provide better cross-platform collaboration.

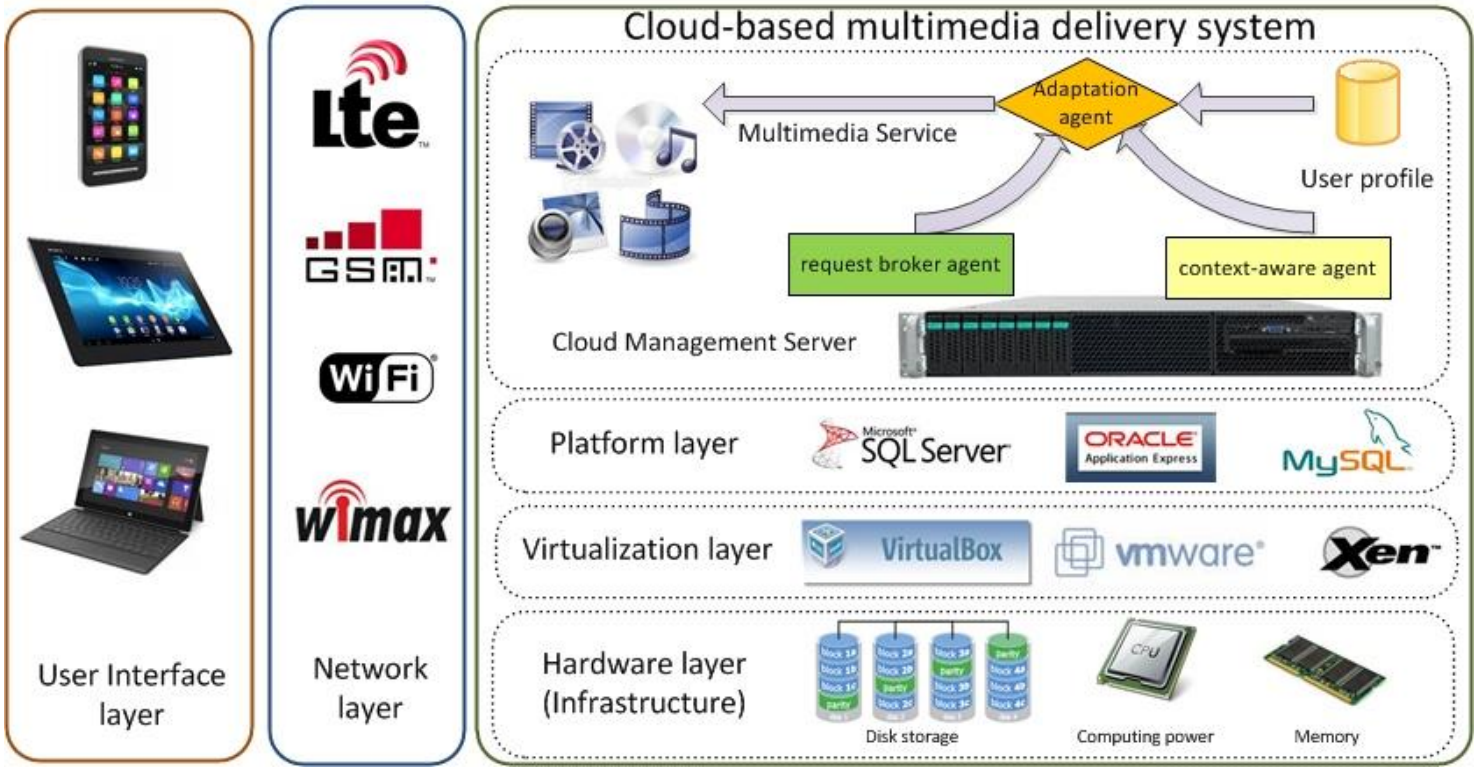
Platform as a service for distance learning

- The platform-oriented approach provides a multi-tenant environment where students and professors can access the cloud-based platform simultaneously.

- Integrated developer tools, database management system and Web server



The collaborative cloud-based architecture

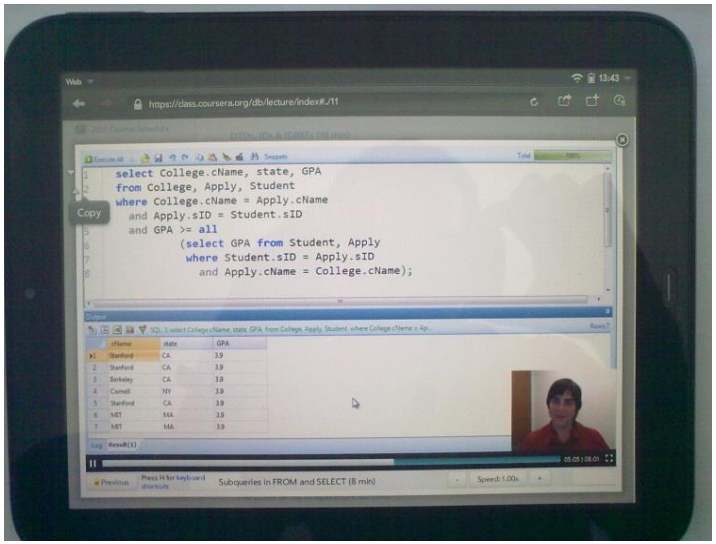


Multimedia content in distance learning

- The collaborative cloud-based architecture provides high interactive delivery of personalized multimedia content in a multi-tenant environment.
- The Questionnaire for User Interaction Satisfaction (QUIS) was used to measure users' satisfaction with the human-computer interface and to examine the relationship with the users' knowledge [13].
- It has 22 questions, using a 9-point response rating scale.

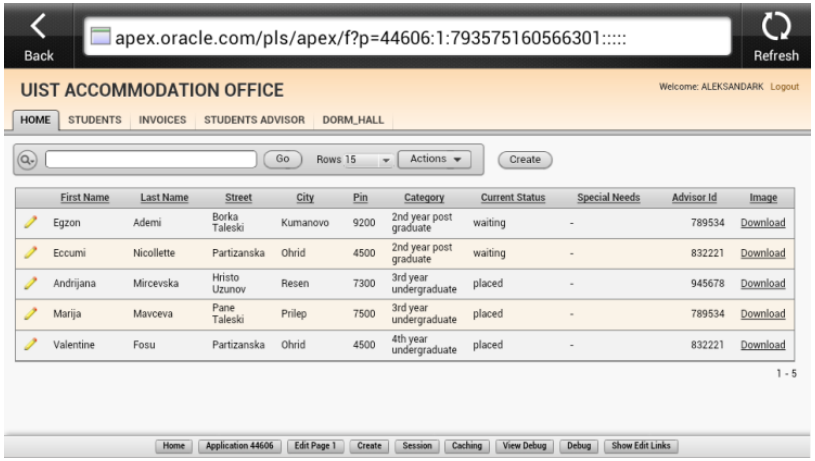
[13]. QUIS website, [Online] Available at: http://lap.umd.edu/quis

- control group of students



Study the database handling of multimedia content via distance learning course

- experimental group of students



Used collaborative multi-tenant environment to develop and deploy database application.

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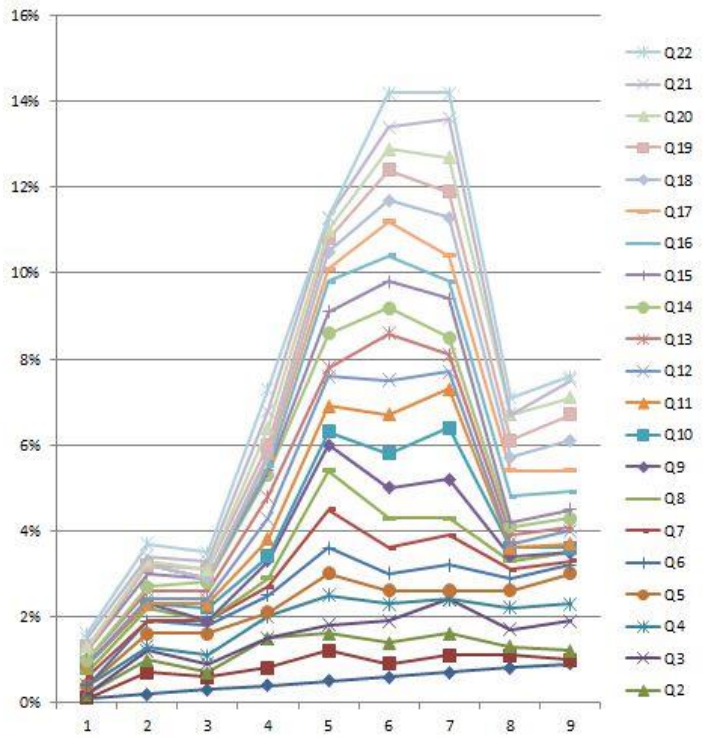
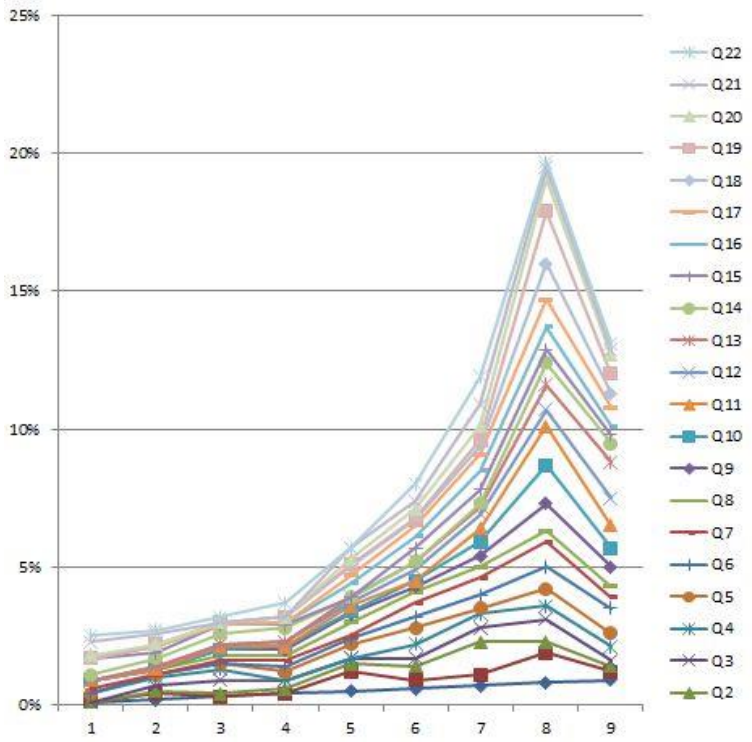
Results of the survey



a) QUIS analysis for control group of students



b) QUIS analysis experimental group of students

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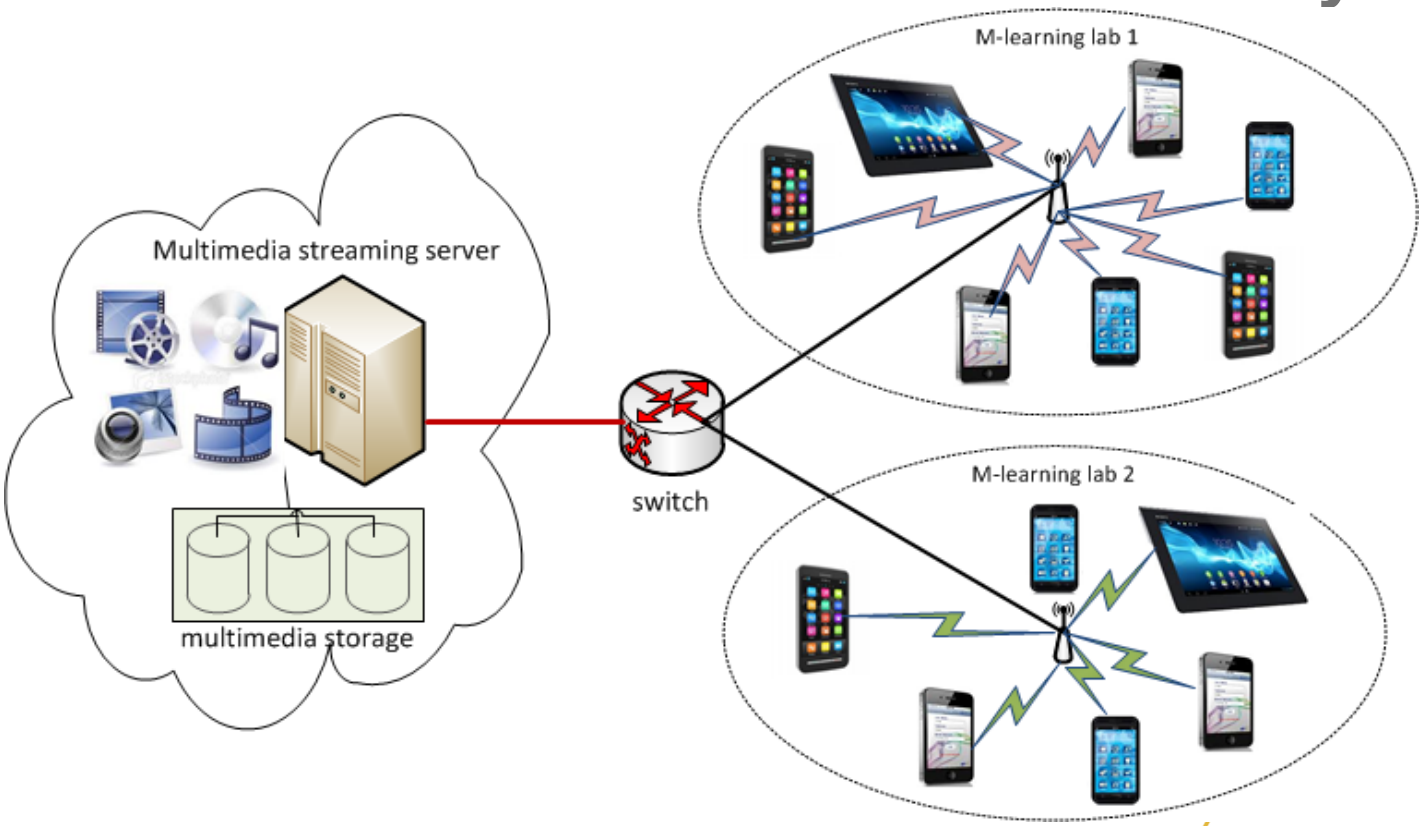
Adaptive multimedia content delivery

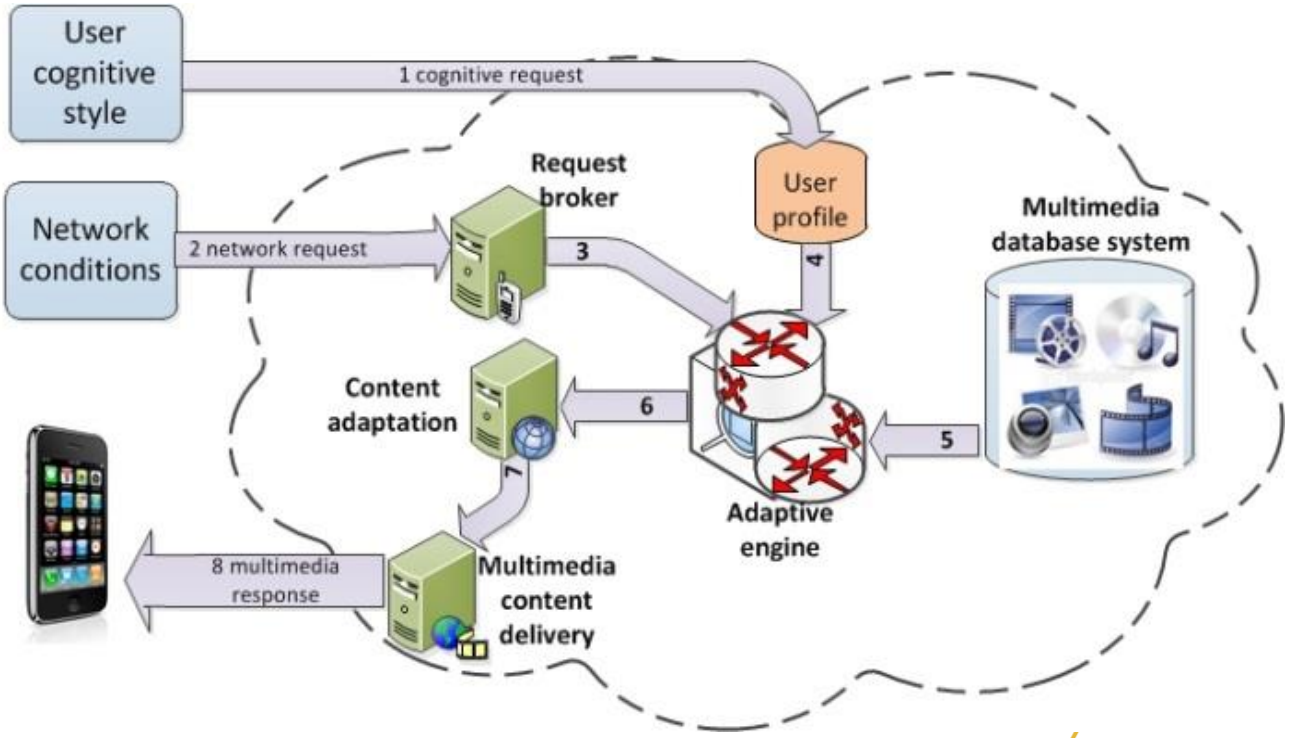
- Personalization of the multimedia content
- Defining a user profile (Verbalizer, Visualizer, and Bimodal)
- Required to understand the relationships between systemic objectively measurable parameters and the specific individual user preference.
- Cognitive theory of multimedia learning [14].

[14] R. Moreno and R. E. Mayer, "Role of guidance, reflection, and interactivity in an agent-based multimedia game," *in Journal of Educational Psychology*, Vol 97(1), Feb 2005, pp. 117-128.

Architecture of an intelligent m-learning system



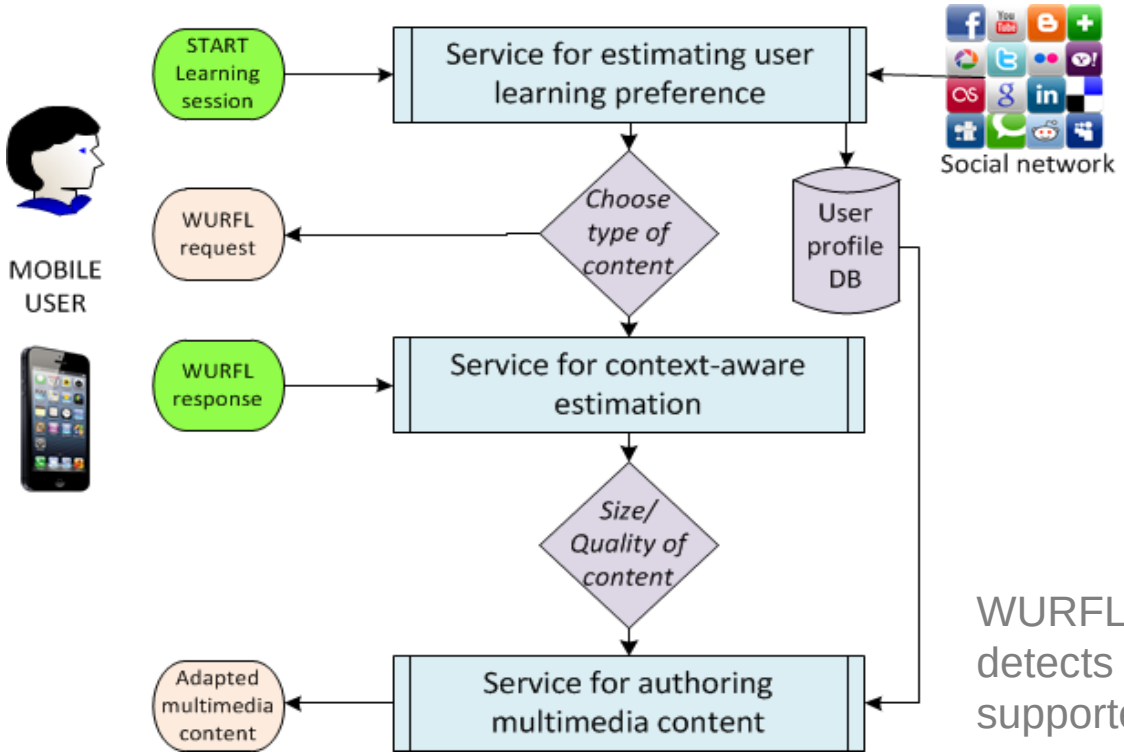
Framework for adapted-multimedia content delivery in the mobile cloud



Application of cloud based computing services

- The **mobile cloud** provides leverage, storage, and mobility for processing for a large number of mobile devices anywhere, at any time, via Internet communication, regardless of heterogeneous environments and platforms.
- The mobile cloud allows complex calculations that use significant resources on the mobile device to be **offloaded** to the processing cloud.

Interaction diagram for collaborative cloud service model



WURFL is a software component detects the mobile device supported capabilities

Massively Open Online Courses (MOOC)

- The MOOC courses allow hosting university to open its curriculum to a wider audience.
- Simultaneously large number of users from all around the world are using the platform.
- The MOOCs need an optimal distribution of cloud computing resources.
- CloudAnalyst simulation tool is used to provide configuration for cloud computing environment.

Top five MOOC providers by registered users

- Coursera – 30 million
- edX – 14 million
- XuetangX – 9.3 million
- Udacity – 8 million
- FutureLearn – 7.1 million

CLASS CENTRAL

81M Students

800+ Universities

9.4k Courses

By the Numbers: MOOCs in 2017

https://www.class-central.com/report/mooc-stats-2017/

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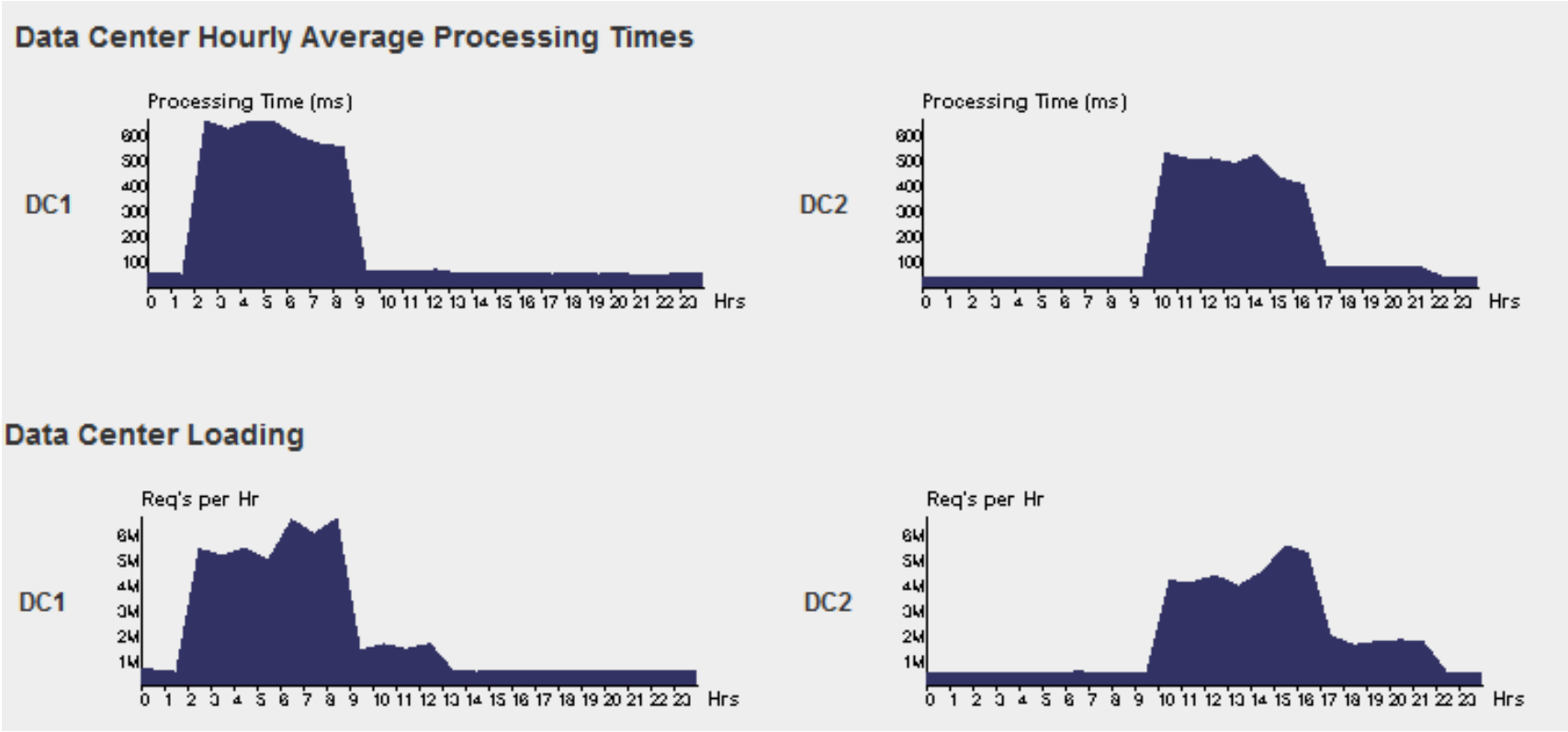
Data center processing and loading times

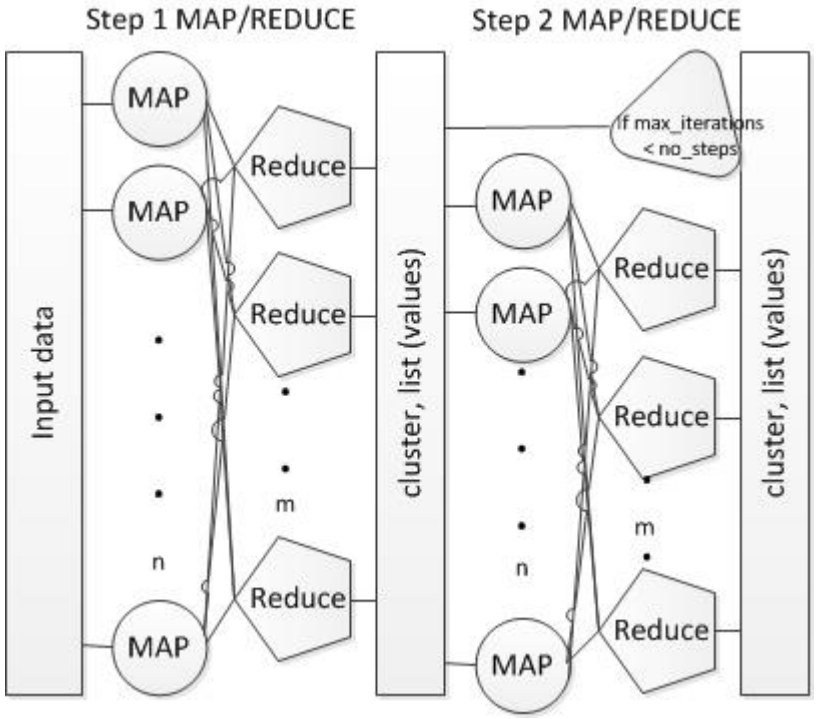


DC1 in North America and DC2 in Europe

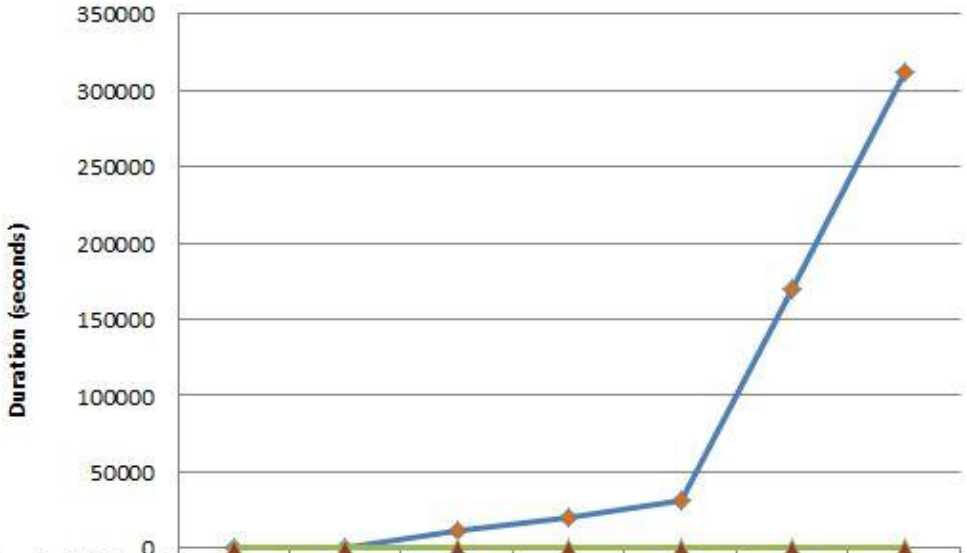
Execution of data mining algorithms as cloud-based services

- The researchers challenge nowadays is not the complexity of the problems to be solved, but the amount of data to be taken into consideration when doing it.
- Map/Reduce - new programming model with parallel execution on a cluster.
- Case study that demonstrates the efficiency of analysing the execution of algorithms for data mining.

Implementation of Clustering algorithm as Map/Reduce job



Comparison of using the cloud-based services for data mining analysis and WEKA



No. experiments in DataSet	1	2	3	5	10	20	30
weka.clusterers.EM	92	597	11323	20409	30904	169501	312561
Ankus.EM_Clustering	302	484	500	544	561	582	673

- referential tool - WEKA

Models for perception of quality

- **Goal**: Identify the users' expectations
- Users are dissatisfied with the speed of access to a particular service.
- Is it reduced network connectivity?

Or

- is subjective quality assessment?

Human perceived quality evaluation

- The subjective research is most commonly using User Experience (UX) and Human-Computer Interaction (HCI) to study the data from empirical and field studies.
- Usually bulky, long and costly surveys for the subjective assessment
- We lack of objective degree of quality assessment.

Measurement of quality

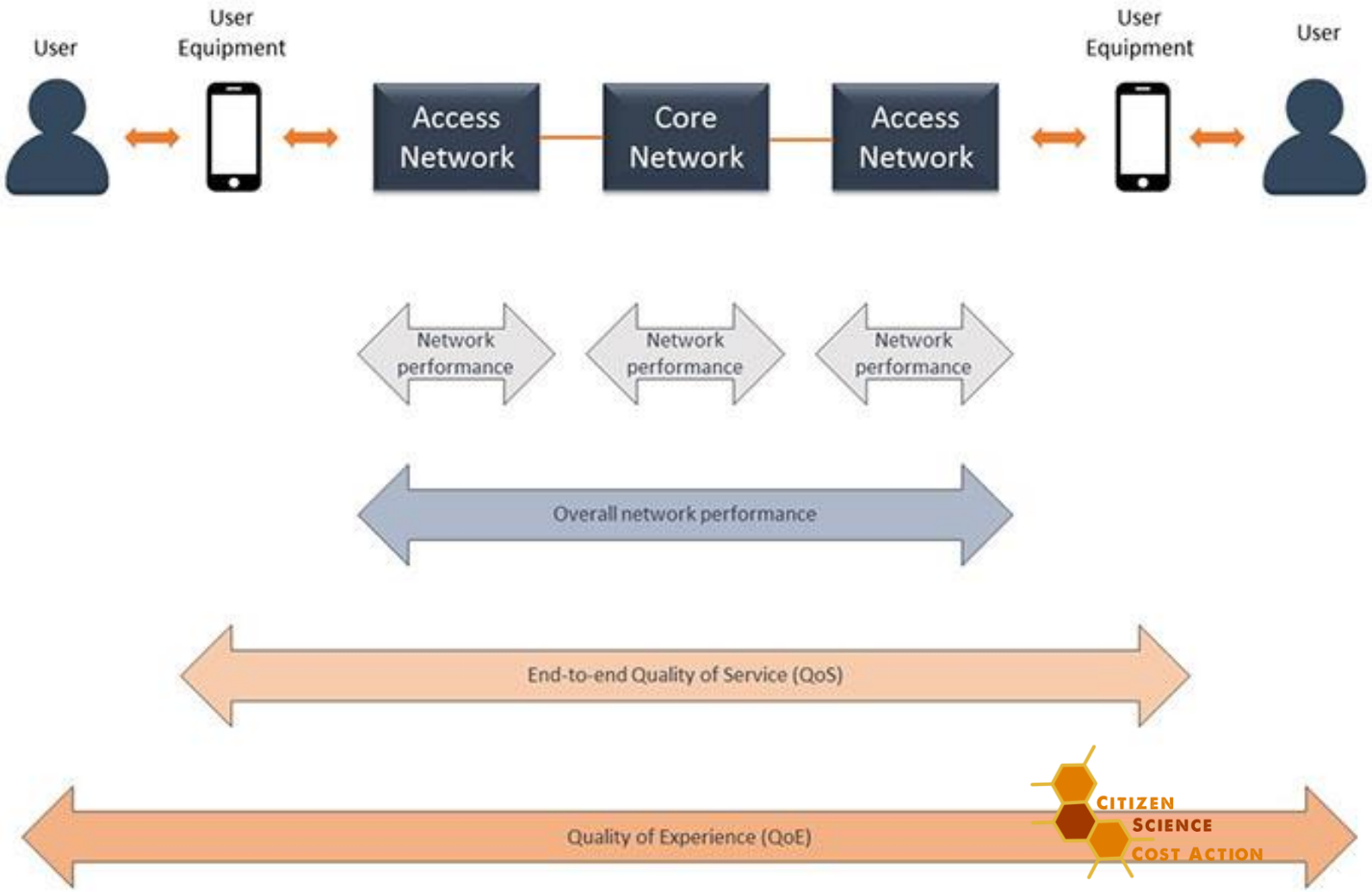
- Quality of Service (QoS), defines the ability of the network to classify its traffic and let them traverse the network based on their priority [4].
- bandwidth, delay, jitter, and packet loss
- To understand the subjective expectations for the particular service – surveys…
- MOS (mean opinion score) is numerical value
- analysed with the standard data statistical techniques, such as mean, variance, linear regression, correlation, ANOVA or Structured Equation Modelling [30]

Quality of Experience (QoE)

- QoE is a measure of the degree of delight or annoyance of the user of an application or service [9].
- It's a multi-dimensional value that gives the perception of quality more broader concept.
- end-to-end perception for the system, including client, terminal, network, services infrastructure, and etc.

[9] P. Le Callet, S. Möller and A. Perkis (eds), "Qualinet white paper on definitions of quality of experience–output version of the dagstuhl seminar 12181," *in European network on quality of experience in multimedia systems and services (COST Action IC 1003)*, 2012.

Different levels of networking quality



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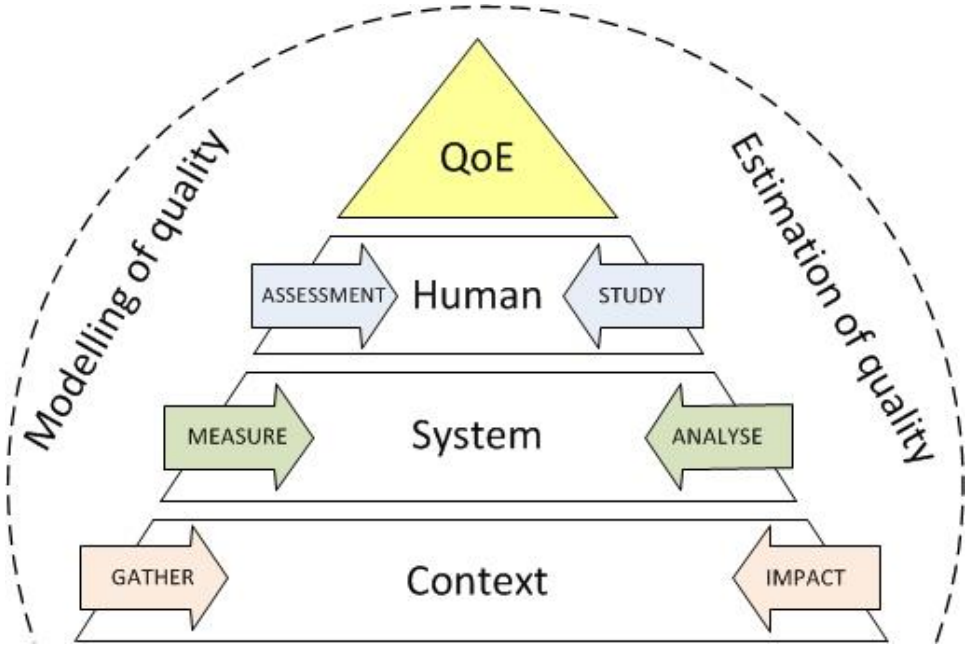
Multimedia quality evaluation methodology



Investigate the influence of the human cognitive style, context-aware factors and the technical system capabilities of the end-user device

Research problem

- How to determine a model that would objectively measure the human perception of quality for cloud-based services?
- To study the process of forming and quantifying the quality of user perception.
- Establishment of the QoE assessment process that will measure and estimate the cloud-based services.
- Model is used to evaluate the quality of the services that are offered.

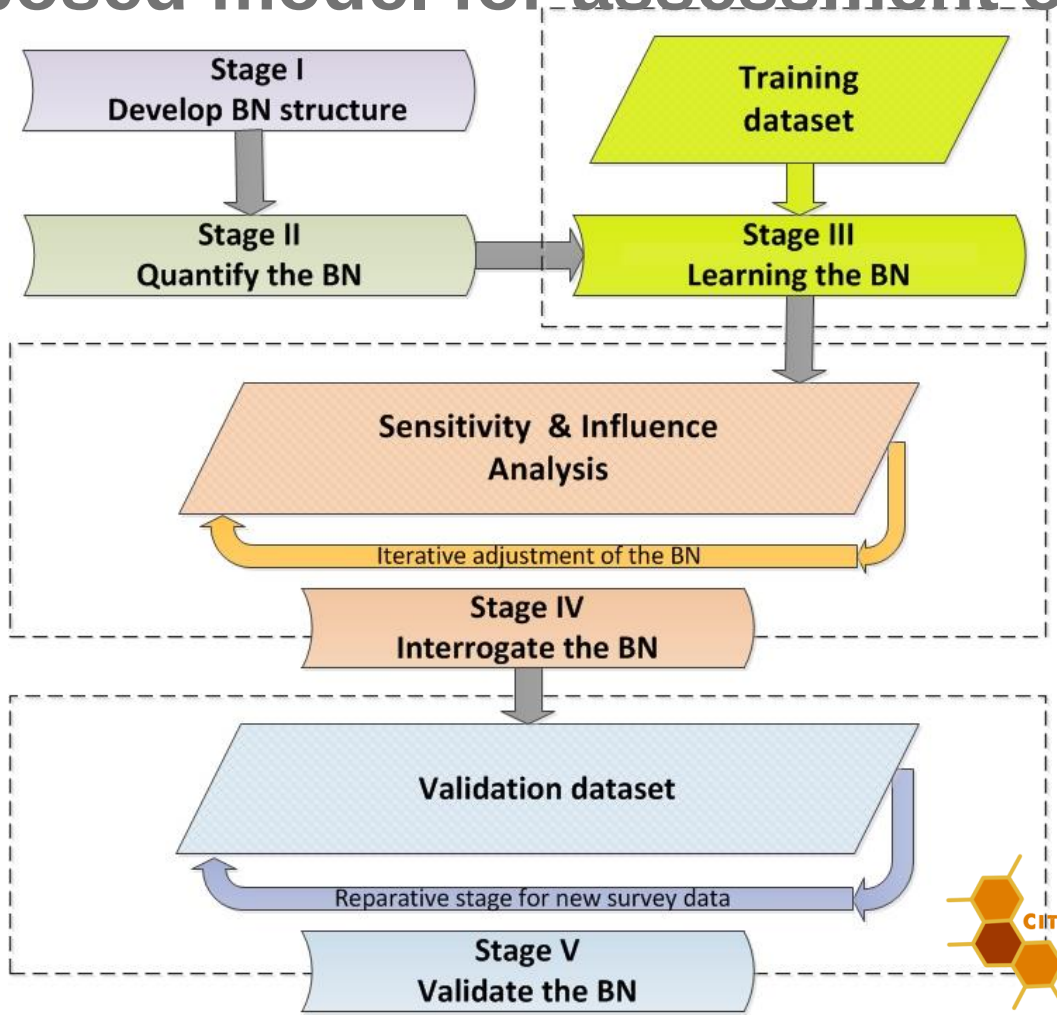
Multimedia content & cloud services

- The multimedia content delivery is even more difficult and challenging using the cloud-based services because the content should be presented as on-demand multimedia service that will meet user expectation of perceived audio-visual quality.
- We propose QoE-based multimedia cloud services quality evaluation methodology using the Bayesian model.

Bayesian theory

- The stochastic nature of human perception.
- Measuring a degree of belief is referred to as a probability assessment.
- The flexibility and adaptation allows to measure the impact of various influencing factors.
- Uses a the clear and intuitive graphical representation of nodes and edges.

The proposed model for assessment of quality



Survey evaluation data used in the model

- Used the continued evaluation with the survey questionnaire for BSc students in the IV year, within the spring semester during 2014, 2015, 2016 and 2017 academic year.
- These datasets reflects student's experience of collaborative activities done throughout the team project.
- The training the developed BN is done with the survey data from the first year - 2014.

Empirical survey on using multimedia cloud-based services

Part 7 user needs

- **7A**. that you need to synchronize versions of your documents stored on different devices?
- **7B**. that you did not in have the document or the last version of document?
- **7C**. to create a collection of your favourite multimedia and use it on different devices?
- **7D**. to share with others and comment on photos or videos in a fast and easy way?
- **7E**. to edit the same documents, presentations, spread sheets with collaborators?
- **7F**. that you need to work with colleagues to develop a joint project?
- **7G**. to share your thoughts, ideas and comment on them with a group of friends?
- **7H**. to effectively and quickly communicate with friends and colleagues, no matter where you are and what kind of device you are using?

Empirical survey on using multimedia cloud-based services

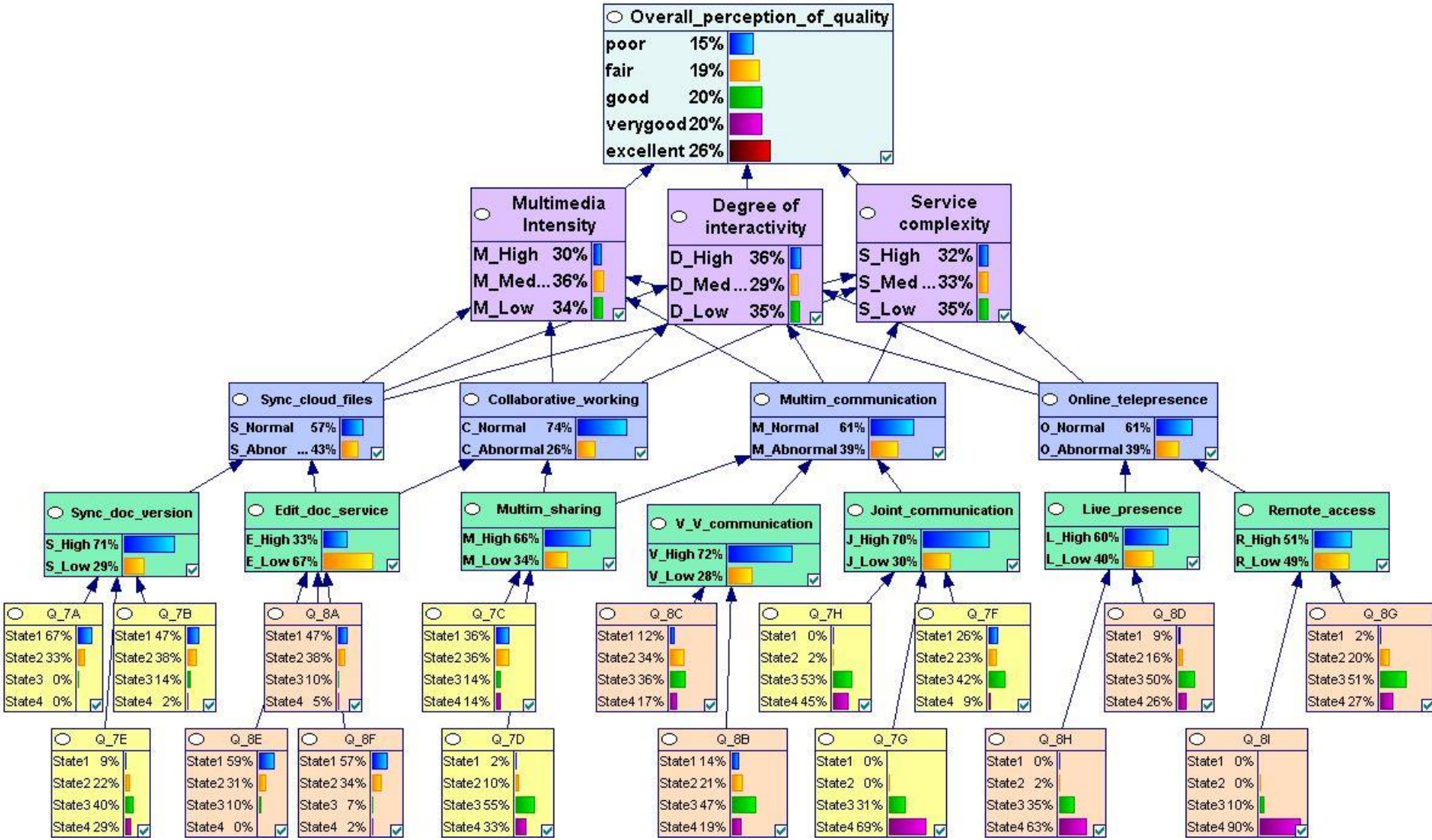
Part 8 frequency of using services

- **8A**. Services for cloud storage sync
- **8B**. Services for voice conference
- **8C**. Service for On-demand video
- **8D**. Service for Live video streaming
- **8E**. Online Cloud based office service
- **8F**. Online Collaborative editing services
- **8G**. Remote Desktop service
- **8H**. Service for HD telepresence:
- **8I**. Cloud gaming service

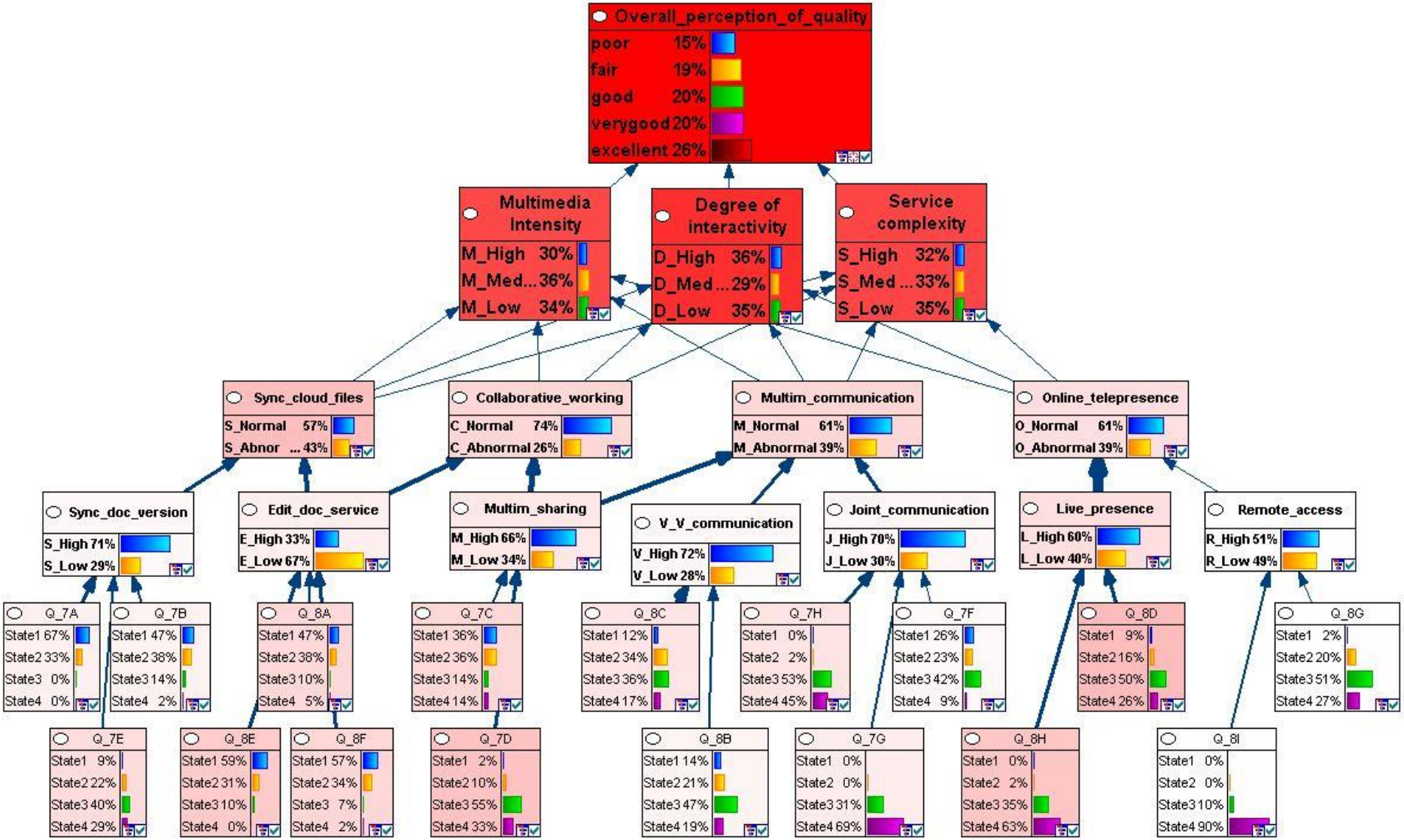
Relational dependencies of nodes in the proposed BN model

Node name	It's a parent of
Sync doc version (SD)	Q_7A,Q_7B,Q_7E
Edit doc service (ED)	Q_8A,Q_8E, Q_8F
Multimedia sharing (MS)	Q_7C, Q_7D
Voice/Video communication (VV)	Q_8B, Q_8C
Joint communication (JC)	Q_7F,Q_7G,Q_7H
Live presence (LP)	Q_8D, Q_8H
Remote Access (RA)	Q_8G, Q_8I
Synchronization of files (SF)	SD, ED
Collaborative working (CW)	ED, MS
Multimedia communication (MC)	MS, VV, JC
Online telepresence (OT)	LP, RA
Interaction degree (ID)	SF, CW, MC, OT
Service complexity (SC)	SF, CW, MC, OT
Multimedia Intensity (MI)	SF, CW, MC, OT
Overall perception of quality (OPQ)	ID, SC, MI

Bayes Network Learning



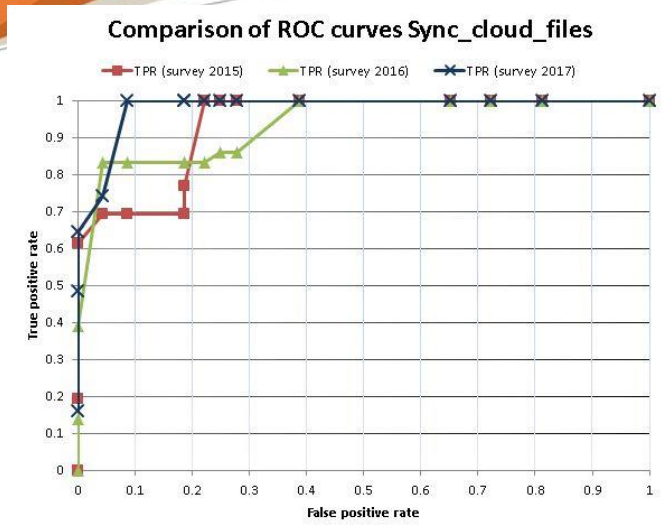
The interrogation stage of the model

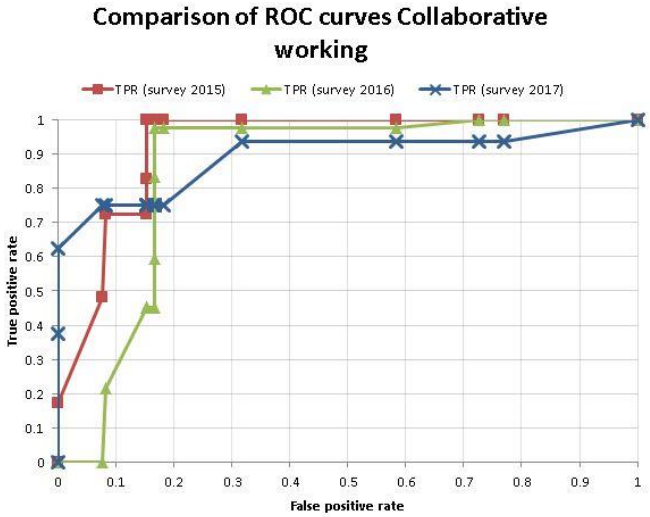


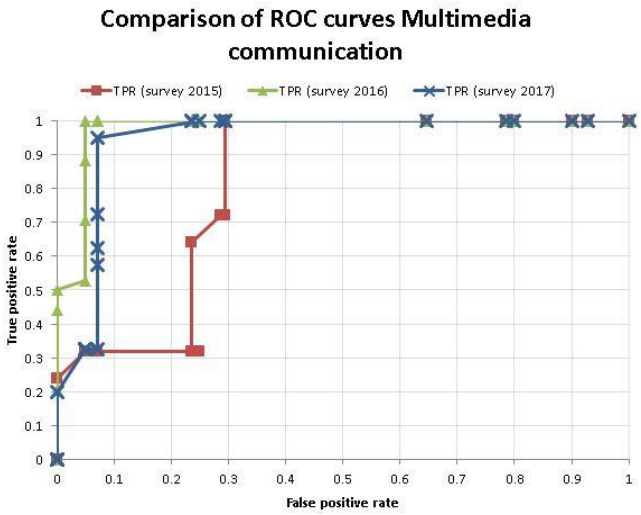
Comparison of the AUC values for the three surveys from 2015 to 2017 year

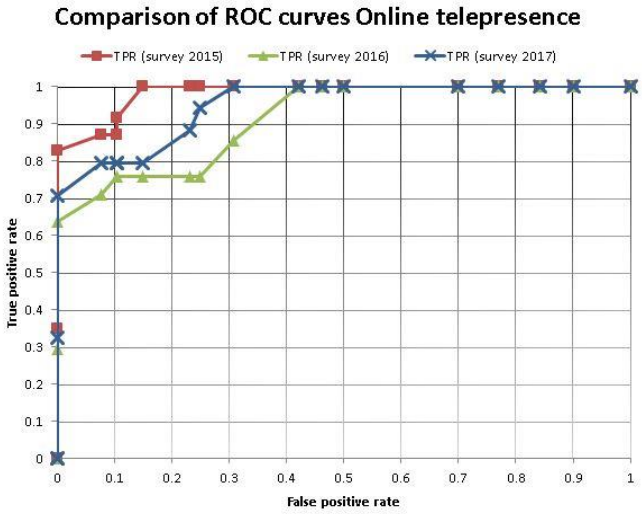
Survey Year	Sync cloud files	Collaborative working	Multimedia communication	Online telepresence
2015	0.941106	0.917772	0.811765	0.970252
2016	0.897377	0.855159	0.975735	0.907129
2017	0.981066	0.887784	0.947321	0.918382

Comparison of the ROC curves

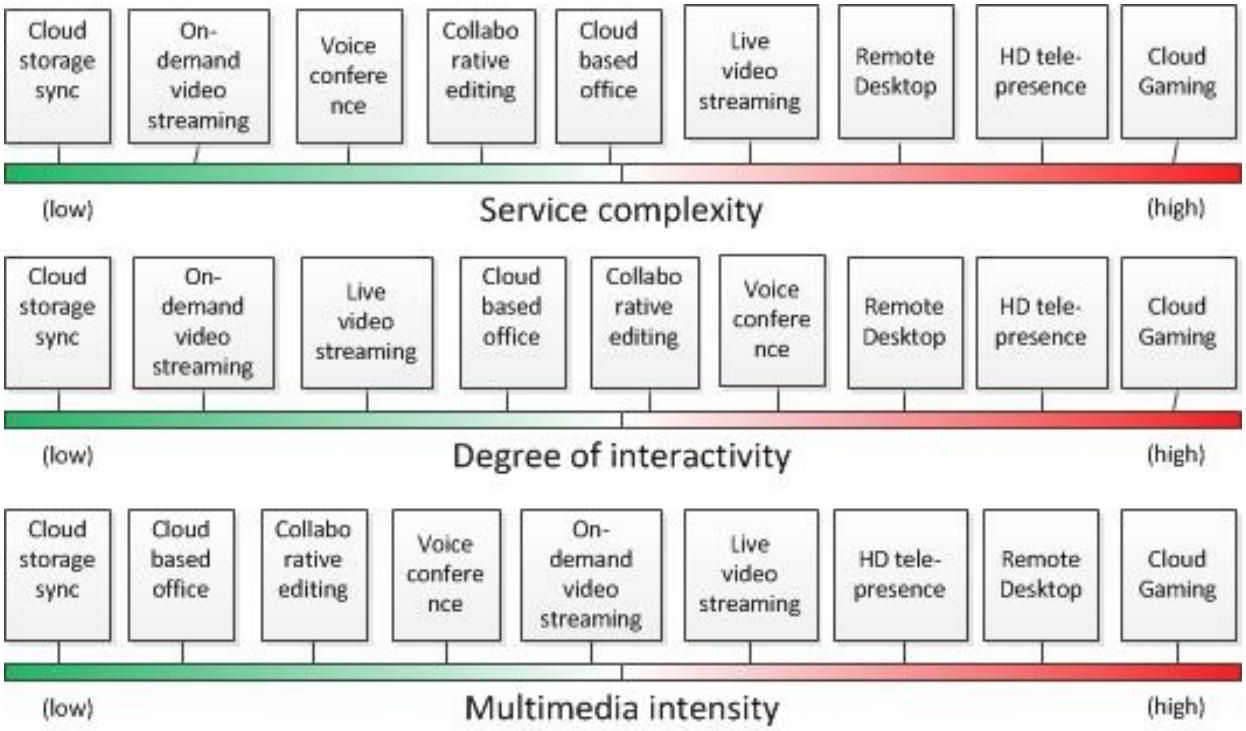








Cloud services from End–User Perspective



Applicability of the model for perception of quality

- For ISP (Internet Providers) the major incentive is cost reduction and efficient usage of resources.
- However, the **OTT** (Over-The-Top) and **users** are interested mainly in good QoE.
- Because of the attractiveness of cloud-based services in the mobile environment, this has brought a challenge for the OTT service providers how end-users perceive the quality of the provided service.

Concussion

- Planning tool by the providers of OTT services to create hypothetical scenarios and simulate results.
- Give service providers with quantitative and visual comparisons when they need to make meaningful decisions.
- Used to identify the most sensitive factors affecting the quality of perception.

Contact

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Conference in Ohrid – ACT 2018

- **International Conference "Applied Computer Technologies" ACT 2018**
- http://act.uist.edu.mk/ Conference dates **21 – 23 June 2018.**
- Full Paper Submission deadline: 25 April 2018
- Deadline for early registration: 15 May 2018
- Camera-ready package deadline: 30 May 2018
- online conference proceedings

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Conference in Ohrid – **ICT Innovations** 2018

- 10th International Conference ICT Innovations 2018
- Topic: **"Engineering and Life Sciences"**
- http://ictinnovations.org/ Conference dates: **September 17-19, 2018**
- Submission of papers due to: **April 29, 2018**
- Acceptance decision: **June 10, 2018**
- Final version of paper submission: **July 11, 2018**
- Publication in Springer in Communications in Computer and Information Science Series (CCIS), ISSN: 1865:0929

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