A Causality Space Model of the Web Service Quality Based on Fuzzy Theory

Jolanta Miliauskaitė[1,a], Diana Kalibatienė[2], Asta Slotkienė[1,b]

[1] Institute of Data Science and Digital Technologies, Vilnius University, [a]jolanta.miliauskaite@mif.vu.lt, [b]asta.slotkiene@mif.vu.lt

[2] Department of Information Systems, Vilnius Gediminas Technical University, diana.kalibatiene@vilniustech.lt

ABSTRACT

- The Quality of Web Services (QoS) is an essential characteristic in selecting a web service (WS) in terms of end-user expectations and satisfaction (QoE).
- Authors have proposed various attributes to determine the QoS at different layers of software systems development (SSD), such as business service layer, business process layer, WS layer, component layer, infrastructure service layer and network layer.
- There is a need for an approach describing and determining the causality relationships among QoS attributes in different layers.
- We present the Causality Space Model that identifies QoS/QoE attribute relationships at different layers, models them using a Fuzzy Set Theory and suggests the most suitable WS for the end-users.

CONTEXT OF A LAYERED APPROACH

- Figure 1 presents a layered approach for assessing multi-dimensional WS quality. It is based on the Archimate framework [1] and four viewpoints by ITU-T E800-series Recommendations [2].

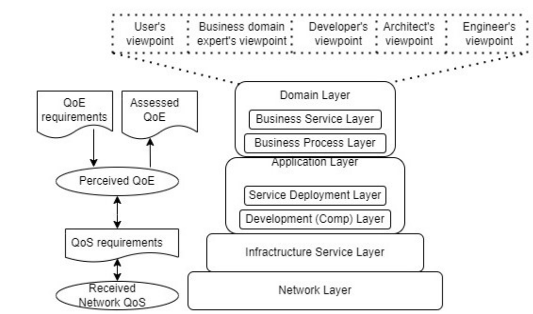


Figure 1. A layered approach for assessment of a multi-dimensional Quality of WS

- Based on [3-4] WS QoS tree is developed in Figure 2.

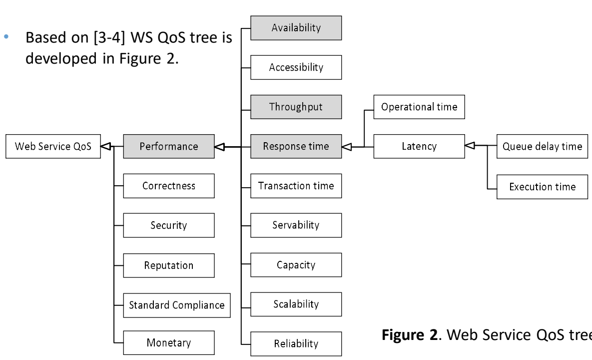


Figure 2. Web Service QoS tree

WS QUALITY CAUSALITY SPACE MODEL

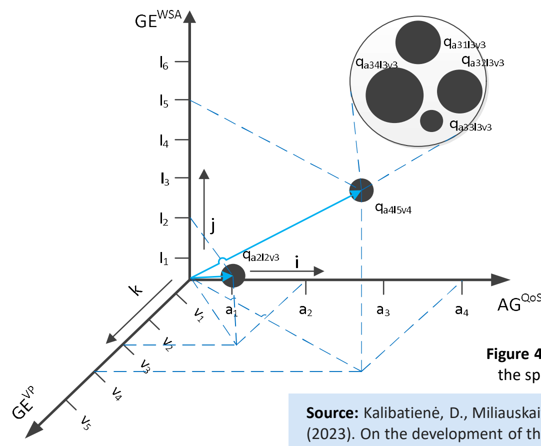


Figure 3. The WS Quality modelling space

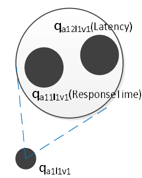


Figure 4. An example of a point in the space model of WS quality

Source: Kalibatienė, D., Miliauskaitė, J., Slotkienė, A., & Gudas, S. (2023). On the development of the web service quality modelling space. *Expert Systems with Applications*, *211*, 118584. https://doi.org/10.1016/j.eswa.2022.118584

- It consists of three axes:
  - GE^{WSA} – WS architecture layers (see Figure 1),
  - AG^{QoS} – WS QoS attributes (see Figure 2 (grey boxes)),
  - GE^{VP} – business viewpoints (see Figure 1).
- *Note*: A perspective π is selected at the beginning of the QoE analysis when QoS attributes analysed are considered.
- A QoE concept ($Q^{\pi n}$) is presented by a point:

$$Q^{\pi_n} = \{q^{\pi_n}_{a_i l_j v_k} | \forall a_i \in AG^{QoS}, \forall\, l_j \in GE^{WSA}, \forall v_k \in GE^{VP}, \forall \pi_n \in \Pi, i,j,k,n \in \mathbb{R}_+\}$$

- where a point can be semantically understood as a vector (Figure 4):

$$\overrightarrow{q^{\pi_l}_{a_i l_j v_k}} = (a_i, l_j, v_k, \pi_n)$$

- The QoE concept $q^{\pi_n}_{a_i l_j v_k}$ is a function of attributes (a_i), layer (l_j), viewpoint (v_k), and perspective (π_n): $q^{\pi_l}_{a_i l_j v_k} = f(AG^{QoS} a_i, GE^{WSA} l_j, GE^{VP} v_k, Q\pi_n)$

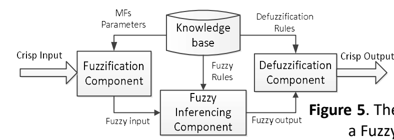


Figure 5. The reference schema of a Fuzzy Control System (FCS)

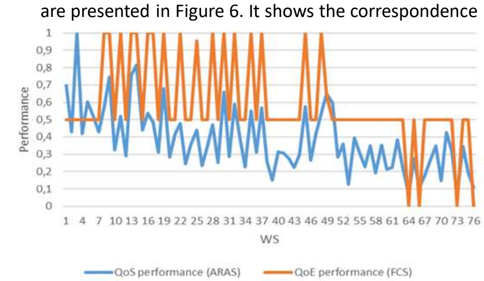
CASE STUDY

- A real-world QWS dataset [5-6] consists of values for 13 attributes.
- A correlation analysis of the attributes to exclude correlating attributes and to minimize processing time and complexity.

Table 1. The Pearson's correlation coefficients for QWS dataset attributes

	Response Time (ms)	Availability (%)	Throughput (invokes/s)	Successability (%)	Reliability (%)	Compliance (%)	Best Practices (%)	Latency (ms)
Response Time (ms)	1	-0,070	-0,282	-0,088	0,043	-0,028	0,038	0,274
Availability (%)	-0,070	1	0,203	0,989	0,1298	0,244	0,057	-0,065
Throughput (invokes/s)	-0,282	0,203	1	0,216	0,269	0,106	0,264	-0,263
Successability (%)	-0,088	0,989	0,216	1	0,121	0,261	0,055	-0,086
Reliability (%)	0,043	0,129	0,269	0,121	1	-0,030	0,689	0,025
Compliance (%)	-0,028	0,244	0,106	0,261	-0,030	1	0,034	-0,045
Best Practice (%)	0,038	0,057	0,264	0,055	0,689	0,034	1	0,025
Latency (ms)	0,274	-0,065	-0,263	-0,086	0,025	-0,045	0,025	1

- The distribution of QoS performance (ARAS) and QoE performance (FCS) of 76 WS are presented in Figure 6. It shows the correspondence of values for the same WS.



ARAS

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}}$$

$$S_i = \sum_{j=1}^{n} \bar{\bar{x}}_{ij}$$

$$K_i = \frac{S_i}{S_0}$$

Figure 6. An example of a point in the space model of WS quality

CONCLUSIONS

- A WS quality modelling space for web service QoE prediction is proposed. It is based on the WS QoS attributes, WS architecture layers and stakeholders' viewpoints from the selected perspective.
- For its verification, a WS QoE performance was predicted employing FCS and experts' judgements, WS QoS performance was determined by ARAS and the real-world QWS dataset.
- There is a strong positive linear and strong positive monotonic relationships between WS QoS performance and WS QoE performance.

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