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Required Quality of Service attributes in the context of various types of Web Services

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***Abstract*—Nowadays, many business units are based on network solutions on the Internet. Various industry branches are entering the Web and offering their services. Customers differ a lot in terms of what services quality requirements they want to be ensured. Functional conditions are defined at the level of business process implementation, but quality issues are also very important there. This study concerns the analysis of non-functional requirements for different groups of users of Web Services. The main objective is to identify differences in user expectations in the context of distinct services offering various functionalities on the Internet. The research was carried out via a systematic literature review within the Web of Science database using keyword chains. As a result of this work, 21 publications describing case studies of the implementation of Web Services and their qualitative attributes were identified. In the context of 20 different types of Web Services, a total of 23 quality attributes were listed.**

I. Introduction

A Web Service is a self-describing, self-contained module providing a certain kind of functionality on the Internet [1]. The module is independent of the user's hardware or software configuration, and the implementation ensures operation on a black box basis – the service reacts to user input and returns a certain result [2]. A very important factor in the analysis of the service operation is the Quality of Service – QoS [3], which can be defined as a set of certain non-functional attributes that should be maintained at a fixed level in order to make the functionality of the service as friendly as possible to the end user.

The subject of QoS criteria is a very broad area, which is described in more detail in [4]. This paper presents a list of identified authors who proposed various sets of quality attributes relevant to application contexts in which they studied the use of Web Services. Most often, the groups of quality attributes consisted of five metrics. In general, the most popular criterion was the time metric (usually formulated as response time), followed by availability, reliability, price and throughput [5-7]. The analysis of the publications showed that the vast majority of the works are related to Web Service selection, composition, optimization and prediction in the field of QoS.

No doubt, in today's world, almost all areas of life are affected by Internetization [8]. Private and public institutions provide more and more services and web applications with more and more functionalities. Many of them operate on the user's private and secret information, hence they should be secure and guarantee protection against attacks from potential hackers. Others, on the other hand, due to their specificity, should work quickly and guarantee an instant response to human actions. Some should be available basically non-stop and have a sufficiently developed Continuous Integration/Continuous Delivery (CI/CD) process so that when a new version is deployed on the servers, continuous operation is guaranteed for the user [9].

The areas in which the services operate are different, the users are different, and the functionalities are different – hence it can be assumed that customer groups have quite different expectations regarding each service. The aim of this paper is to analyze the types of Web Services studied by researchers and draw conclusions, using case study examples, as to what quality characteristics are taken into account in the context of which service. Unraveling the problem of which quality parameters are most important for various services can be a key aspect of a multi-criteria optimization of complex services.

The paper has the following structure: in the next section, we describe the context and the methodology of the study; then the research results are presented and discussed; finally, directions for further research and future works are described.

II. Research Context and Methodology

Every Web Service should meet several requirements. The basic ones are, of course, functional. Each Web Service operates in a certain context, usually the scope of an organization, a company or an operational unit. On the other

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hand, non-functional quality requirements also have to be satisfied. After all, no one is able to use even the best-adapted functionality if it is unavailable to customers or if the system response time is too long.

The importance of non-functional features of Web Services can be identified on the basis of the following questions: Are all users willing to allow a one-second delay at the expense of greater transaction security in the context of a banking service? And in the field of a purchasing service, will such an exchange not be acceptable? Do customers measure the login sub-system and the medical appointments ordering sub-system within the same medical application with exactly the same quality metrics? Do users have different quality requirements for order approval in a food-ordering application and order approval in a clothing store system? With the help of a reasonable systematization, we may not be able to answer those doubts with specific, numerical outcomes, but we will surely obtain an overview of the situation and a clue to correctly identify the problem.

Based on these considerations, the following research questions emerged:

RQ1. Which QoS metrics are the most important in the context of which types of services?

RQ2. What are the differences in quality requirements in the context of the same functionality but different Web Services?

RQ3. What are the differences in quality requirements in the context of different functionalities within a single Web Service?

A systematic literature review was conducted to identify answers to these research questions. The study was carried out according to the procedure described below.

The Web of Science platform was chosen as the source of articles due to the strictest policy in the peer-to-peer review process and because this database seeks to publish high-standard papers. The queries used to find the articles are defined in Table 1. We limited ourselves to English language articles and abstracts-based searches as the most important parts of the articles in terms of presenting their vision.

The first search focused on the quality requirements in the enterprise context of Web Services. We wanted to understand how researchers define fixed initial QoS metrics in the aspect of different systems. The second search stemmed strictly from the first one – we found that the best way to determine quality requirements is to focus on case studies.

The articles were analyzed in three iterations. The first consisted of reading the abstracts and determining which articles would in any way help answer the research questions posed. The second iteration allowed for digging more deeply into the selected writings and confirming or rejecting the selection. The final iteration involved an in-depth analysis of the full text of selected articles. In total, over the two searches, 21 publications were identified that contributed a lot to the topic of the relationship between services and the required quality in the context of their types (Table A in the Appendix).

TABLE I.
SAMPLE QUERIES TO THE SEARCH ENGINE (WEB OF SCIENCE) CONTAINING PUBLICATIONS

Search Engine	Phrase	Keywords	Date	Quantity
Web of Science	AB=(“web servic*” AND (enterpr* OR compan* OR busin* OR corporat* OR "econom* unit*") AND qos AND (requiremen* OR prerequisi* OR constrain*))	Web Service, Enterprise, Company, Business, Corporate, Economic Unit, QoS, requirements, constraints, prerequisites	02.08.2021	193
Web of Science	AB=("case stud*" and "web servic*" and (quality or qos))	Case Study, Web Service, Quality, QoS	22.08.2021	206

III. RESULTS

The results of the study are two matrixes. The first one (Table A in the APPENDIX) contains a systematic summary of the identified and analyzed publications. The second (Table 2), on the other hand, presents the analysis and relationships between the types of Web Services and the quality metrics. In total, there are 23 quality attributes considered by researchers in the context of 20 different types of Web Services. Many of the quality metrics need to be standardized because, for example, not every “time” is a “response time”, and, for instance, performance or scalability are such broad concepts that they probably consist of several smaller sub-attributes.

The marking key to Table 2 is organized as follows:

- Columns:
  (1) Time (Response Time, Speed); (2) Reliability (Precision); (3) Availability; (4) Cost (Price); (5) Recall (Frequency of Invocations, Answers); (6) Performance; (7) Accuracy; (8) Reputation (Brand, Trust); (9) Security; (10) Accessibility; (11) Integrity; (12) Robustness; (13) Benefit; (14) Capacity; (15) Exception Handling; (16) Regulatory; (17) Interoperability; (18) Privacy; (19) Responsiveness; (20) Scalability; (21) Network-Related QoS Requirement; (22) Successability; (23) Throughput; (No. 2) Number of various metrics within a given service type; (No. 3) Number of times a service type is mentioned in the articles.
- Rows:
  (A) Hotel Service; (B) Medical Service; (C) Purchasing Service; (D) Telecom Service; (E) Travel Agency Service; (F) Insurance Company Service; (G) Language

Translation Service; (H) Social Security Sector Service; (I) Engineering Service; (J) Public Employment Service; (K) Activity (Sport) Service; (L) Film Service; (M) Geospatial Application; (N) Loan Service; (O) Ordering Food Service; (P) Weather Service; (R) Advertisement Service; (S) Bioinformatic Service; (T) Government Service; (U) Industrial Automation Platform; (No. 1) Number of occurrences of a metric among services.

In the next section, conclusions resulting from the conducted research are discussed.

IV. Discussion of the Results

Referring to Table 2., there is no doubt that by far the most important factor for virtually all Web Services is the Response Time – it is omitted by the researchers only in 3 types of services – Advertisement, Bioinformatic and Geospatial applications. The second most popular metric is Reliability, indicated by researchers in 14 different types of services, and in the third place, with 13 references – is Availability. Then there is Price (Cost), which is cited in 8 different types of Web Services. As many as 11 of the 23 metrics appear only once. These are Benefit, Capacity, Exception Handling, Regulatory, Interoperability, Privacy, Responsiveness, Scalability, Network-Related QoS Requirement, Successability, and Throughput.

The services in the context of which the largest number of various features is extracted are Hotel and Medical services (15 and 11 metrics respectively). Each of these service types is mentioned twice in the considered group of articles. This may imply, for example, a not completely considered set of features towards the end customer – we should remember that optimization in terms of multiple criteria is very costly.

Using the Hamming Distance (the number of places where the rows in Table 2. differ), we identified service types that have the most similar quality requirements. Among the services that are mentioned by the researchers a minimum of two times, the most similar quality criteria are used for the Purchasing Service and the Travel Agency Service – the Hamming Distance equals 4. In the second place, with a distance equal to 5, there are two pairs: Language Translation Service together with Purchasing Service and Language Translation Service together with Travel Agency Service.

Answering the first research question (**RQ1**), we can clearly state that the most important quality attributes for almost all types of Web Services are: Response Time, Reliability and Availability. A specific breakdown: of which metrics are most important in the context of which services is presented in the Table 2.

When analyzing the articles, one can come across similar

TABLE II.
AN ANALYSIS OF THE MAPPING OF WEB SERVICES TYPES TO RESEARCHER-SELECTED NON-FUNCTIONAL FEATURES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	No. 2	No. 3
A	■	■	■		■	■	■		■	■	■	■		■	■		■			■	■			15	2
B	■	■	■			■	■	■	■	■						■		■	■					11	2
C	■	■	■	■				■															■	6	2
D	■	■	■			■			■		■													6	1
E	■	■	■	■									■									■		6	4
F	■	■	■	■								■												5	1
G	■		■	■	■		■																	5	2
H	■		■	■		■		■																5	1
I	■	■	■	■																				4	1
J	■			■	■		■																	4	1
K	■	■			■																			3	1
L	■	■			■																			3	1
M		■	■			■																		3	1
N	■		■	■																				3	1
O	■	■			■																			3	1
P	■	■			■																			3	1
R		■	■																					2	1
S		■				■																		2	1
T	■		■																					2	1
U	■																							1	1
No. 1	17	14	13	8	7	6	4	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1		

functionalities in different Web Services. As the first example, we can take the comparison of three ordering functionalities: food, computer and creating an order without an itemized product (respectively in [10], [11], [12]) within Ordering Food and Purchasing Services. Unambiguously, the greatest emphasis, unsurprisingly, is on Response Time, which is found in each of the three services. In the second place, ex aequo, we have Availability (computer and no product specified order) and Reliability (food and no product specified order). Next, Recall, Cost, Reputation, and Throughput are listed.

The next comparison regards functionalities related to traveling in the broadest sense (e.g. renting a car, booking a hotel or flight). Again, the most important factor (4/4 of the analyzed articles) turns out to be Response Time, which is hardly a surprise. In as many as three articles ([11], [13], [14]) Cost plays an important role. In the case of the Hotel Service [10] the authors still mention Recall and Reliability. In the case of three Travel Agency Services (mentioned earlier) we still have Availability, Benefit and Successability.

We can also find similar functionalities in the Travel Agency Service [15], i.e. check user action, and in the Medical Service [16], i.e. login (with email) action. In the first case, Reliability and Time are the most important issues, and in the second – Security.

The last comparison regards search functionalities in the context of the Activity Service [10], the Travel Agency Service [11], the Public Employment Service [17] and the Advertisement Service [18]. For the first three publications, in the context of functionality: the Search for an activity, the Search for an available flight, and the Search for job vacancies in a specified country, Response Time is mentioned, and Recall and Cost are also important (in 2 of the 3 articles). Availability, Reliability (also mentioned in the context of the fourth functionality – the Search for a car from the fourth article) and Accuracy also appear.

Summarizing the second research question (**RQ2**), we made the following conclusions:

- In the context of ordering functionalities (food, hardware and no product specified), Response Time is the most important, in the second place in the context of hardware is Availability and in the context of food is Reliability; ordering of a non-specified product combines all features.
- Leaving aside Response Time, for similar related functionalities in the Hotel Service, Recall and Reliability are more important, while in the Travel Agency Services we have Cost, Availability, Benefit and Successability.
- The functionality of logging in and checking the user in the Travel Agency Service focuses primarily on Reliability and Time, while a similar functionality in the Medical Service focuses on Security.
- The search functionality in the Activity Service, Travel Agency Service and Public Employment Service focuses primarily on Response Time, Recall and Cost. The Advertisement Service focuses on Availability and Reliability.

To analyze many different functionalities among the services of the same type, we can focus on the Medical Services. This type of service provides a large variety of functionalities like, for example, presenting relevant medical information in the context of a region [19]. In this case, we listed numerous requirements, such as Reliability, Security, Privacy, Accessibility, Responsiveness, Speed, Availability, Trust, Relevancy, Performance and Regulatory. Hence, unfortunately, we are not able to prioritize them all. However, when we look at the functionalities in [16] – we see that for any action where the patient's (and unit individual) data is processed, Security is by far the most important issue.

To explain **RQ3,** we can focus on different functionalities of Medical Services. Undoubtedly, in all actions where the user data is processed, Security is by far the most important quality requirement, while as far as other functionalities (which are mainly about presenting facts) are concerned, the importance is equally distributed among the most basic metrics like Response Time, Reliability, Availability and so on.

V. Conclusion

This paper presents findings related to the selection of quality metrics in the context of different types of Web Services. The research was conducted based on case study examples found via a systematic literature review. An attempt was made to systematize the non-functional requirements in the context of the same and different types of services and functionalities.

Twenty-one publications were identified that describe the practical implementation of Web Services and the quality attributes important to these services. The publications present 20 different types of services and a total of 23 distinct quality metrics. The most important quality attributes for almost all types of Web Services were found to be the following: Response Time, Reliability, and Availability. When the functionalities involve sensitive data processing, security remains a very important issue.

Further research in this direction should also address the popular services that are missing from our set of case studies, such as online wallet services or social media. Gray literature should also be analyzed (studies carried out by companies providing Web Services). It would also be advisable to conduct interviews and surveys with users (Web Services customers) to determine what quality features are the most important to them in this context. Another direction of research could be focused on different multi-criteria optimization approaches with respect to the quality requirements identified as important for different types of services.

APPENDIX

Table A. Selected publications analyzed by service type, specified functionalities and quality requirements

Year	Authors	Analyzed Systems	Analyzed Functionalities	Non-functional Requirements
2006	H. Wang, D.G. Yang; Y.H. Zhao; Y. Gao [18]	Advertisement Service	• Search for a car	Reputation (i.e. Availability + Reliability)
2006	F. De Paoli, G. Lulli, A. Maurino [17]	Public Employment Service	• Search for job vacancies in a specified country • Glue together and rank retrieved job vacancies • Translate job offers in different languages • Notify end-users of results via different communication channels	Time, Cost, Accuracy, Answers
2008	J.K. Lee, S.H. Kuk, H.S. Kim, S.W. Park [20]	Engineering Service	---	Cost, Reliability, Availability, Time
2008	C. Riedl, T. Bohmann, M. Rosemann, H. Krcmar [21]	Government Service (Business Name Renewal Service)	• Renew business name registrations • Pay a fee for using a service	Response Time, Availability
2008	W.L. Lin, C.C. Lo, K.M. Chao, M. Younas [22]	Hotel Service	• Book a hotel • Book a flight (integration with other WS) • Rent a car (integration with other WS)	Performance, Reliability, Scalability, Capacity, Robustness, Exception Handling, Accuracy, Integrity, Accessibility, Availability, Interoperability, Security, Network-Related QoS Requirement
2008	V. Patankar, R. Hewett [23]	Insurance Company Service	• View the patient's past medical records	Price, Availability, Response Time, Robustness, Reliability
2008	M. Fantinato, M.B.F. De Toledo, I.M.D. Gimenes, [24]	Telecom Service	• Outsource a charging service from one company to the CRM of Telecom company	Availability, Response Time, Security, Integrity, Reliability, Performance
2009	T. Cucinotta, A. Mancina, G.F. Anastasi, G. Lipari, L. Mangeruca, R. Checcozzo, F. Rusina [25]	Industrial Automation Platform	• Stream multimedia (view from 2 IP cameras): what is going on inside the plant • Start/Stop translation	Response Time
2009	T. Neubauer, C. Stummer [26]	Social Security Sector Service	• Consolidate the existing system architecture based on a given set of business processes	Availability, Performance (Time), Reputation, Cost (Revenue, Initial/Running Costs)
2010	M.A. Serhani, A. Jaffar, P. Campbell, Y. Atif [27]	Language Translation Service	• Translate from static, dynamic, active content (with different sizes) • Control version • Track changes	Availability, Quality of Translation (i.e. Time + Accuracy of Translation), Frequency of Service Invocation
2011	K. Xu, Q. Yu, Q. Liu, J. Zhang, A. Bouguettaya [28]	Bioinformatic Service	• Analyze the colorectal cancer studies	Reliability, Performance
2012	V. Vescoukis, N. Doulamis, S.Haragiorgou [29]	Geospatial Application (Integrated Information System for Forest Fire Management)	• Support the monitoring and decisions in the event of a real forest fire incident • Plan early and develop the scenario	Real Time (i.e. Performance + Availability + Reliability)
2013	R.Z. Xu, B.T. Ji, B. Zhang, P.Y. Nie [13]	Travel Agency Service	• Ensure flight services • Ensure hotel services • Ensure other, independent tourism	Benefit, Cost, Time

			services	
2013	D. Bruneo, S. Distefano, F. Longo, M. Scarpa [15]	Travel Agency Service	• Check user • Check credit card • Book a flight • Pay • Cancel reservation	Reliability, Time
2013	M.M. Chen, T.H. Tan, J. Sun, Y. Liu, J. Pang, X.H. Li [11]	Travel Agency Service, Purchasing Service, Loan Service	• Buy a computer, pay with a credit card • Apply for a loan • Search for an available flight, hotel, transport, local agents' services with given user requirements	Response Time, Availability, Cost
2014	D.H. Lin, T. Ishida, Y. Murakami, M. Tanaka [30]	Language Translation Service	• Translate including human and machine activities	Adequacy (Accuracy), Time, Cost
2015	M. Fahad, N. Moalla, Y. Ourzout [12]	Purchasing Service	• Create order	Availability, Response Time, Reputation, Throughput, Reliability
2015	A. Akhunzada, A. Gani, S. Hussain, A.A. Khan, Ashrafullah [14]	Travel Agency Service	• Reserve a ticket • Reserve accommodation • Reserve a car • Reserve all tickets, accommodation, car • Reserve 2 from 3 services	Price, Successability (Probability of Success), Time
2016	G.Buyukozkan, O. Feyzioglu, F. Gocer [19]	Medical Service	• Provide sufficient medical information within a region	Reliability, Security, Privacy, Accessibility, Responsiveness, Speed (Response Time), Availability, Trust (Reputation), Relevancy (Accuracy), Performance, Regulatory *[Metrics that were not related to strict functionalities of Web Services components themselves, like friendly user Interface were not included]*
2016	I. El Kassmi, Z. Jarir, A. Obaid [16]	Medical Service	• Ensure health authentication action • Ensure login action • Ensure login with email action • Ensure patient permission action • Ensure data permission action • Ensure page permission action • Ensure module permission action	Security
2020	M. Driss, A. Aljehani, W. Boulila, H.W. Ghandorh, M. Al-Sarem, [10]	Weather Service, Activity (Sport) Service, Hotel Service, Film Service, Ordering Food Service	• Search for an activity • Forecast weather • Rent a car • Book a hotel • Watch a film • Order food	Response Time, Recall (Frequency of Invocations), Precision (Reliability)

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