QUALITY OF A COMPOSITE SERVICE AS A FUNCTION OF THE QUALITIES OF THE COMPRISED SUB-SERVICES A SURVEY.

Anna Otsetova, Emiliya Saranova

Abstract: *Today more and more complex services are proposed by the companies. At the same time customer needs are changing rapidly over the time. In all service sectors the service providers used to provide services satisfying Quality of Service (QoS) requirements. In this paper we present results of conducted literal review related to composition of services, quality of composite services and the functions of the qualities of the comprised sub-services.*

Keywords: *Service composition, sub-services, quality of services*

ITHEA Keywords: *Introductory and survey*

Introduction

In the era of growing demand of services, service providers have started to offer different service levels in order to meet the different users' needs. Dealing with the increased changes arising from the competitive business environment service providers is attempting to survive by developing flexible composite services using various technologies and tools. They usually propose different service qualities based on user qualification and service cost.

The nature of services creates the opportunity for building composite services by combining existing elementary or complex services (referred to as sub-services) and in turn offering them as value added services.

The composite services can be presented as a result of multiple interactions of its internal components. The composite services are group of sub-services that create value by transforming inputs into more variable outputs. A composite service is defined as a coordinated and logically sequenced set of sub-services.

Information composite service aim to power the next generation data transfer so that customer are able to access and use them from anywhere in the world on demand at competitive costs depending on users' QoS requirements.

QoS has received much interest in service research because of the rapid increase of the number of services and the approximate equal qualities of the services.

Nowadays QoS has many aspects which depend on the aspect that is crucial for the user [Karawash, Mcheick, Dbouk, 2014]. Some of the QoS aspects are: response time, throughput, delay, security, service availability, reliability, timeliness, price etc. Such qualities are of interest to service providers and service consumers alike. These QoS aspects are very important, but they do have one flaw: they are exclusively inward-looking. They examine network performance, which is only one half of an increasingly important equation - and the reason that most service providers are now shifting their focus from QoS to Quality of Experience (QoE).

QoE is defined as the overall acceptability of an application or service, as perceived subjectively by the end-user. The overall acceptability may be influenced by user expectations and context [ITU-T Rec. P.10/G.100, 2006].

The agreement between the customer and the service provider is referred to as the Service Level Agreement (SLA). A Service Level Agreement is a formal agreement between two or more entities that is reached after a negotiating activity with the scope to assess service characteristics, responsibilities and priorities of every part. A SLA may include statements about performance, tariffing and billing, service delivery and compensations. Every performance reporting may include only the QoS parameters agreed in the correspondent SLA [ITU-T Rec. E860, 2002].

The QoS attributes that are frequently part of an SLA vary repeatedly and to implement the contract, these parameters need to be carefully controlled.

The quality of composite services is measured by its end-to-end quality, rather than the quality of individual service components [Yu, Lin, 2004].

QoS is increasingly significant when composing services because a degrading QoS in one of the sub-services can dangerously disturb the QoS of the complete composition.

Today's service selection solutions do not focus on QoS support from the service requester view point, but they depend on service provider interpretation. Indeed, the current form of service composition is provider driven. A consumer may interact with a composite service without knowing much about the qualities of the services that underlie it [Karawash, Mcheick, Dbouk, 2014].

For composite services, the most important QoS issue is to define the service integration model and identify the optimal service selection to meet a user’s QoS requirement.

The purpose of our paper is to present results of conducted literal review related to composition of services, quality of composite services and the functions of the qualities of the comprised sub-services.

Composition of Services

In general there are two types of services – simple services and composite services. A simple service realized offered actions directly, whereas a composite service can invoke sub-services in order to meet the users` needs.

According to reference [Pichanaharee, Senivongse, 2008] service composition is a process that selects units, called sub-services, and composes them into a workflow that represents a business process. The service composition process determines how and when sub-services should run and prepares them for execution. It presents the interdependency between the sub-services and their synchronization and prioritization.

A composite service model was presented in *Figure 1*.

A composite service can be defined as a directed graph, which specifies the order in which the sub-services are executed:

$SS = \{ss_i, i= 1 \dots n\}$ is the sub-services, where ss_i is the *i-th* sub-service, and n is the total number of sub-services;

$L = \{l_k=(ss_i, ss_j), ss_i \neq ss_j\}$ is the set of links, where the element (ss_i, ss_j) indicate that ss_i immediately precedes ss_j.

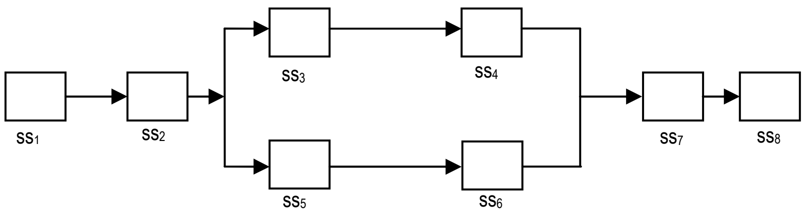

Figure 1. A composite service model with sequential and parallel sub-services

Sequential composite sub-services comprise a relation in which once a sub-service completes, another sub-service stars its execution (ss_3, ss_4).

Parallel sub-service comprises a relation in which two different services are going on in parallel (ss_3, ss_5) and synchronized at a certain point (ss_4, ss_6).

A composite service can involve loop sub-services too (*Figure 2*). A block of one or more sub-services is executed repeatedly with some probability, up to a maximum number of *k* executions.

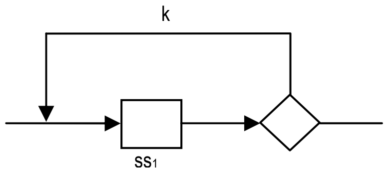

Figure 2. Loop

Another kind of services is substitute services, offered from other service provider. A substitute service is a service that performs the same or similar function as another service. If a service has more substitutes the demand for the service is more elastic. There are some conditions that increase the threat of substitutes:

- An attractive price of substitutes: The price of substitutes acts as a “ceiling” to the price of the subject service.
- Increased quality of substitutes: If the quality of a substitute is high, there is increased pressure to increase the quality of the subject service.
- Low switching costs to consumers: Switching costs to users can come in the form of monetary costs (transferring cell phone service) or lifestyle switching costs. Monetary costs effectively increase the price of the substitute services whereas lifestyle costs are more subjective and difficult to identify.

The evaluation of a service depends on its entire structure and the quality of the other sub-services invoked to compose such service.

Quality of Composite Service as a Function of the Quality of the Comprised Sub-Services

For the purpose of our study we proposed following QoS attributes:

- response time (RT);

The response time is defined as “A time period between the time when a sending of response request is triggered and the time when its response is received by the response confirmation role object [ITU-T Rec. X.748 (1999 E)].

The response time is the interval of time between the moment when a user requests the service and the moment when the user receives the response. Usually the response time includes service time (T_{sr}) and transmission time (T_{tr}). In a composite service, the transmission time is the time needed to send a user’s request to the first server, to pass the result of one server to the next server in the sequential model, and to return results to the user from the last server in the server chain.

$$RT= T_{sr}+T_{tr} \quad (1)$$

- cost (C);

Cost includes service cost (C_{sr}) and transmission cost (C_{tr}).

$$C= C_{sr}+C_{tr} \quad (2)$$

- availability (A);

Availability is defined as availability of an item to be in a state to perform a required function at a given instant of time or at any instant of time within a given time interval, assuming that the external resources, if required, are provided. [ITU-T Rec. E802, 2007].

Availability is the probability that a service is available. Usually it is computed from historical data.

$$A = \frac{T_a}{T_t} \quad (3)$$

where T_a is amount of time that service is available; T_t is total time monitored [Yu, Lin, 2004].

- reliability (R).

Reliability is a probability that an item can perform a required function under stated conditions for a given time interval.

Reliability is the probability that a request is correctly handled within the expected time. It is computed from historical data.

$$R = \frac{N_s}{N} \quad (4)$$

where N_s is number of requests successfully responded and N is the number of total requests [Yu, Lin, 2004].

If the composite service involves only sub-services executed in a fixed sequential order (*Figure 3*) the outputs of some sub-services are the inputs of others and the output quality of every sub-service depend on the input quality.

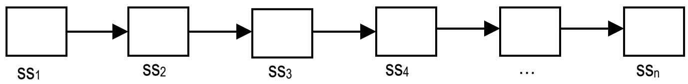

Figure 3. Sub-services executed in a fixed sequential order

In this case the QoS attributes of a composite service are as follow:

$$RT_{cs} = \sum_{i=1}^{n} RT_{SSi} \quad (5)$$

$$C_{cs} = \sum_{i=1}^{n} C_{SSi} \quad (6)$$

$$A_{cs} = \prod_{i=1}^{n} A_{SSi} \quad (7)$$

As stated above, sub-services are considered to be operating in sequential order. If failure of either of the sub-services results in failure of the combination. A composite service can be provided only if all sub-services are available. From this it follows that the combined availability is a product of the availability of all sub-services.

The implications of the above equation are that the combined availability of the composite service is always lower than the availability of its sub-services.

The reliability of the composite service follows a multiplicative rule and is the product of the reliability of every sub-service in the composition.

$$R_{cs} = \prod_{i=1}^{n} R_{SSi} \tag{8}$$

According to reference [Gupta, Londhe, Bhosale, 2011] QoS is a function of many factors having different weights ($w_1 - w_4$).

In the case in point the QoS of a composite service can be presented as shown in equation 9.

$$QoS = f\left(w_1 \times RT_{cs} + \mathrm{w}_2 \times C_{cs} + \mathrm{w}_3 \times A_{cs} + \mathrm{w}_4 \times R_{cs}\right) \tag{9}$$

Weights might be calculated by simulating the end-to-end scenario and calculating the overall contribution of each parameter to QoS.

Limited work has address the more complicated cases when the composite services involve sequential and parallel sub-services but most of them are for web service composition, and for sub-services offered by different service providers.

A review of QoS-based web service selection, proposed methods and evaluation approaches are presented in *Table 1*.

Table 1. QoS-based web service selection - proposed methods and applied QoS evaluation approaches

Authors	Methods	QoS evaluation
Zeng et al., 2003, 2004 Ardagna, Pernici, 2005, 2007	Multiple Criteria Decision Making technique with Simple Additive Weighting and Linear Programming	Simple aggregation function
Liu et al., 2009	Rang based Algorithm with Simple Additive Weighting	Simple aggregation function
Doshi et al., 2004	Markov Decision Processes	Simple aggregation function
Alrifai, Risse, Nejdl, 2012	Hybrid approach	Simple aggregation function
Li, Wang, Lim, 2010	Monte Carlo method	Aggregation function with trust value and trust weight

Conclusion

One of the key issues in service composition is that of predicting and managing the QoS of composite services. QoS is dynamic and depends on many factors. QoS should be measured continuously.

It is important to estimate the QoS of a composite service based on the quality of sub- services to make sure that the composition can satisfy the expectations of end users.

The overall QoS for a composite service is computed by aggregating the QoS of its sub-services according to their structure and relation.

In order to ensure high QoS of the composite service which involves only sub-services executed in a fixed sequential order the special attention should be paid to sub-services with the highest weights. On the other hand, it is necessary to ensure the availability and reliability of each sub-service.

Our future work includes calculating QoS for composite services with more complex types of sub-services (e.g., parallel sub-services, overlapping loops) and extending the proposed method to address the problem of QoS-aware service composition.

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Bibliography

[Yu, Lin, 2004] Tao Yu, Kwei-Jay Lin, Service Selection Algorithms for Web Services with End-to-end QoS Constraints, Proceedings of the IEEE International Conference on E-Commerce Technology, 0-7695-2098-7/04, pp. 1-8, 2004.

[Pichanaharee, Senivongse, 2008] Koramit Pichanaharee, Twittie Senivongse, QoS-Based Service Provision Schemes and Plan Durability in Service Composition, DAIS 2008, LNCS 5053, pp. 58–71, 2008.

[Karawash, Mcheick, Dbouk, 2014] Ahmad Karawash, Hamid Mcheick, Mohamed Dbouk, Quality-of-Service Data Warehouse for the Selection of Cloud Services: A Recent Trend, Z. Mahmood (ed.), Cloud Computing, Computer Communications and Networks, Springer International Publishing Switzerland 2014, pp. 257-276, 2014.

[Dan et al, 2004] Dan A, Davis D, Kearney R, Keller A, King A, Kuebler D, Ludwig H, Polan M, Spreitzer M, Youssef A, Web services on demand: WSLA-driven automated management. IBM Syst J 43(1):136–158, 2004.

[Gupta, Londhe, Bhosale, 2011] Priya Gupta, Priyadarshini Londhe, Arvind Bhosale, IPTV End-to-End Performance Monitoring, Advances in Computing and Communications, First International Conference, ACC 2011, Kochi, India, July 22-24, 2011, Proceedings, Part IV, 2011.

[ITU-T Rec. X.748, 1999 E] ITU-T Rec. X.748 (1999 E), Information technology – Open Systems Interconnection – Systems management: Response Time Monitoring Function, 1999.

[ITU-T Rec. E802, 2007] ITU-T Rec. E802, Framework and methodologies for the determination and application of QoS parameters, 2007.

[ITU-T Rec. E800, 2008] ITU-T Rec. E800, Definitions of terms related to quality of service, 2008.

[ITU-T Rec. E860, 2002] ITU-T Rec. E860, Framework of a service level agreement, 2002.

[ITU-T Rec. P.10/G.100, 2006] ITU-T Rec. P.10/G.100, Definition of Quality of Experience (QoE), 2006.

[Zeng et al., 2003] Zeng, L., Benatallah, B., Dumas, M., Kalagnanam, J., and Sheng, Q. Z.,. Quality driven web services composition. Proceedings of the 12th international conference on World Wide Web. 12-14 May. ACM. pp. 411-421, 2003.

[Zeng et al., 2004] Zeng, L., Benatallah, B., Ngu, A. H., Dumas, M., Kalagnanam, J., and Chang, H., QoS-aware middleware for web services composition. Software Engineering, IEEE Transactions on. 30(5), 311-327, 2004.

[Ardagna, Pernici, 2005] Ardagna, D., and Pernici, B., Global and local QoS constraints guarantee in web service selection. 2005 IEEE International Conference on Web Services (ICWS 2005). July 11-15. Orlando , Florida, USA, IEEE Computer Society. pp. 805-806, 2005.

[Ardagna, Pernici, 2007] Ardagna, D., and Pernici, B., Adaptive service composition in flexible processes. IEEE Transactions on Software Engineering. 33(6), 369-384, 2007.

[Liu et al., 2009] D. Liu, Z. Shao, C. Yu, and G. Fan.,A heuristic QoS-aware service selection approach to web service composition. In: Proceedings of the Eigth IEEE/ACIS International Conference on Computer and Information Science, Phoenix, Arizona, USA, pp. 1184-1189, 2009.

[Doshi et al., 2004] Doshi, P., Goodwin, R., Akkiraju, R., and Verma, K., Dynamic workflow composition using markov decision processes. Web Services, 2004. Proceedings. IEEE International Conference on. 6-9 July. San Diego, California, USA : IEEE. pp. 576-582, 2004.

[Alrifai, Risse, Nejdl, 2012] Alrifai, M., Risse, T., Nejdl, W. A hybrid approach for efficient Web service composition with end-to-end QoS constraints. ACM Transactions on the Web (TWEB). 6(2), Article No. 7, 2012.

[Li, Wang, Lim, 2010] Li, L., Wang, Y., Lim, E.-P., Trust-Oriented Composite Service Selection with QoS Constraints. J. UCS. 16(13), 1720-1744, 2010.

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