Analysis of Service Delays in Distributed Systems with Service Oriented Architecture

Kovalenko Tetiana, Nyambune Tullah

Abstract – **This work presents the results of analysis of service delays in distributed infocommunication systems with service-oriented architecture (SOA). The proposed mathematical model of a SOA system in the form of hierarchical Petri net allows considering telecommunication network characteristics and their effect on the service provisioning.**

Keywords – **Service Oriented Architecture, distributed system.**

I. INTRODUCTION

Service-oriented architecture (SOA) is currently one of the most popular approaches to building distributed infocommunication systems. This architecture offers one of the most effective solutions to the urgent application integration problem arising in the provision of services based on distributed platforms. The basic principles of building systems with service-oriented architecture are discussed in [1] [2]. SOA systems are complex distributed systems in which provision of service to the end-user often requires network interaction between multiple service providers. Service delays in such systems as well as QoS, productivity and other characteristics of SOA systems are strongly dependent on characteristics of the telecommunication systems and networks (TCSN) providing interconnection of distributed resources. At the same time existing mathematical models and approaches for performance analysis of SOA systems are either don't consider basic TCSN characteristics or mostly based on the application of specialized software for testing specific hardware-software solutions of a certain manufacturer. This work is devoted to the study of servicing delays in distributed SOA systems and their statistical characteristics and dependence on basic telecommunication network throughput. For that purpose we used a system of mathematical models based on hierarchical coloured timed Petri nets [3].

II. MATHEMATICAL MODEL OF SOA SYSTEM BASED ON HIERARCHICAL PETRI NETS

In this work to develop a mathematical model of a distributed SOA system we used timed hierarchical coloured Petri nets (CPN). The top-down approach for system description was used, which involves building a generalized complex system model with progressive specification of models for procedures and processes that require more careful analysis. In this case, any transition of the CPN model can be converted to a substitution transition described with a separate CPN module [3]. The hierarchical structure of the proposed model is shown in Fig. 1.

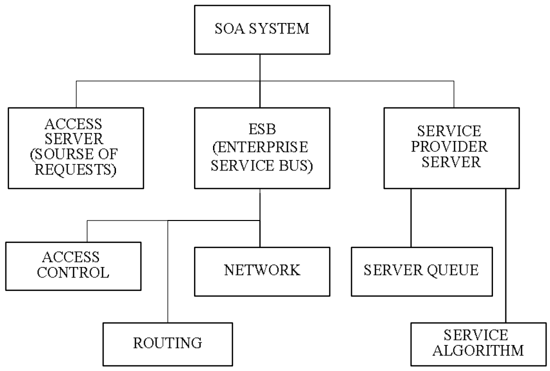

Fig.1. Hierarchical structure of CPN model

Top level represents the generalized model a SOA system that describes its structure and main functional components: access servers, Enterprise Service Bus (ESB) and service provider servers. Each of these components is described by corresponding CPN module of the next lower level of the hierarchy. The CPN module "Access Server" describes the generation of the input flow of service requests to the SOA system, enabling to set the size and intensity of data blocks. The CPN module "ESB" models the interaction of SOA system components in a distributed environment. It consists of three main modules that implement the functions of the ESB: access control for the input flow of requests to the service bus (limitation of flow, service discipline in a queue of requests, etc.); routing procedures (which can implement, for example, the procedures for optimal network resources allocation) and process of message transfer over the network. The last one is modeled by a CPN module "Network", which enables to set the value of network delay for each transmitted message depending on its length, type, source and destination addresses, etc. The model of service provider server also includes two CPN modules describing service discipline in a queue of requests to each server ("Server Queue" module) and the processing of requests for various types of services, taking into account the processing delays ("Service Algorithm" module).

III. ANALYSIS OF SERVICE DELAYS IN A DISTRIBUTED SOA SYSTEM

The hierarchical CPN model of a SOA system described in Section II allows to analyze such system characteristics as service time for requests, length of queues, productivity of a SOA system under consideration, statistical characteristics of the output flow of served requests, etc. The results of

Kovalenko Tetiana - Kharkiv National University of Radioelectronics, Lenina Ave., 14, Kharkiv, 61166, UKRAINE, e-mail: tanya.n.kov@gmail.com
Nyambune Tullah - Kharkiv National University of Radioelectronics, Lenina Ave., 14, Kharkiv, 61166, UKRAINE, e-mail: otieno77@mail.ru

simulation using the proposed approach are shown in Figs. 2–4. In Fig. 2 example of the probability density histogram of service time in the SOA system is shown.

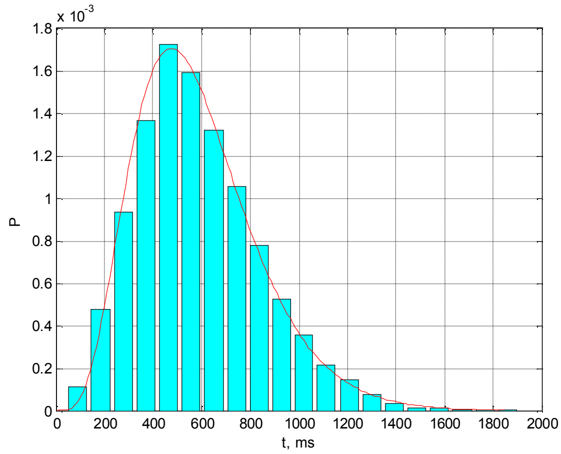

Fig. 2. Probability density histogram of service time

Example of the probability density histogram of time intervals between served requests in the output flow is presented in Fig. 3.

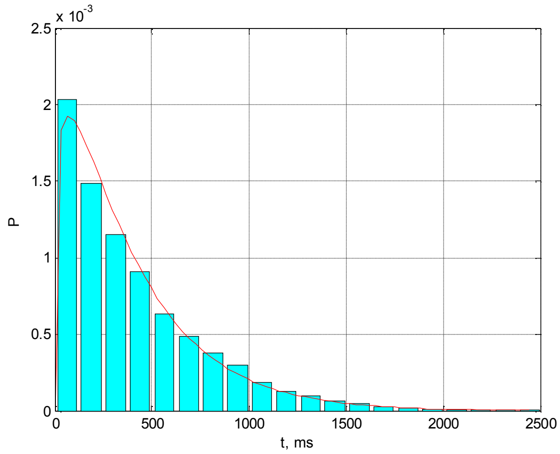

Fig. 3. Probability density histogram of time intervals between served requests in the output flow

Both figures were received for the next input data: bandwidth of the basic telecommunication network between all servers was assumed $C = 10$ Mbps, productivity of all servers $m = 60$ req./sec., intensity of the input flow of service requests from each access server $l = 1{,}8 \cdot 10^3$ req./hour, all delays in a systems were modeled as exponentially distributed random variables. Similar histograms were received for $C = 10..50$ Mbps, $m = 20..100$ req./sec and low level of load (load factor of the system was less then 0,2) For two types of stochastic input flow (when the time intervals between requests were exponentially and uniformly distributed) it was found that regardless of the type of the input flow studied in the work, service time in the distributed SOA system can be approximated by a random variable with Gamma distribution. In the case of Poisson input flow of service requests the output flow of served requests remained also Poisson. For the input flow with uniformly distributed time intervals between service requests the output flow had time intervals between served requests with Gamma distribution. For the SOA system studied the shape parameter of this Gamma distribution remained the same and equal to $b \approx 1{,}2$ when the values of network bandwidth and server productivity were changed.

Fig. 4 shows the diagrams of mean service time in SOA system subject to basic telecommunication network throughput for different values of server productivity.

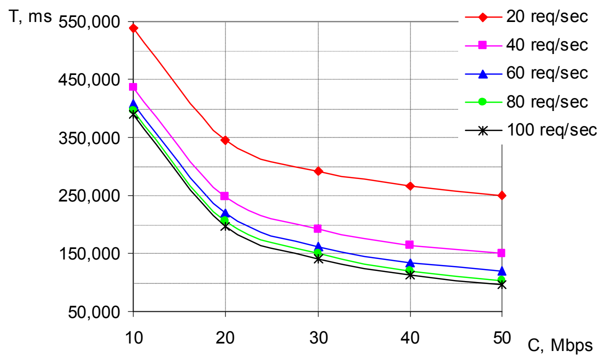

Fig. 3. Mean service time in SOA system

These diagrams may help in formulating recommendations on choice of network throughput and server productivity to improve the SOA system performance. Here for example one can see that increasing the network throughput more than 50 Mbps when server productivity is 20 req./sec. to increase the system productivity will be inefficient as the “bottleneck” of the system is not the network but servers of service provider.

IV. Conclusion

In this work the results of performance analysis of distributed infocommunication system with service-oriented architecture are presented. Statistical characteristics of service time and the output flow of served requests in a SOA system are studied. Effect of both network throughput and server productivity on system performance is analyzed. The analysis of characteristics of distributed SOA systems in the conditions of high level of loading and under the influence of a self-similar input flow are directions for the further researches.

References

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