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## NETWORK MANAGEMENT SYSTEM OF MULTISERVICE NETWORK

*Significant increasing of number and diversity of provided services in multiservice networks, as well as permanent increasing of user requirements for a quality of service, leads to the need of developing new management methods of multiservice networks. This article is aimed to solve this problem by improving the structure of the network management system and management algorithm of user requests in multiservice network. Also to improve availability of services the dynamic replication method, which has been modified in accordance with the characteristics of the proposed structure of the network management system, has been proposed.*

**Keywords:** *multiservice network, network management system, availability, SOA, dynamic replication method, ensuring of data consistency.*

### Introduction

The opportunity of integrating different types of services within a heterogeneous network and necessity for ensuring the required quality of service are the key challenge for building of multiservice network. Fundamental factor which will influence on the achievement of this goal is the quality of management system of multiservice network.

For today the existing management systems in multiservice network increasingly difficult to cope with the increasing complexity and heterogeneity of services, especially with regard to multimedia services (ITU-T Recommendation Y.2011, 2004).

One of the most perspective solutions for improving efficiency of management system in multiservice network is a partial transfer of means that ensure the required quality of service, from a transport layer to service management layer (Open Networking Foundation, 2012).

In modern multiservice networks practical implementation of the service management layer is performed by using several technological approaches: CORBA (Specification 2008), DCOM (Remote Protocol Specification 2009), SOA (Westerman 2004) and others. And one of the most promising technologies, that ensure effective services management in the network, is SOA.

SOA architecture and features of its application are discussed in a large number of articles such as: Westerman (2004), Channabasavaiah et al. (2004), the means that ensure quality of service in SOA is represented in Kim et al. (2011), Hilari (2009).

The main advantage of SOA is the ability to build loosely coupled applications, focus on open standards, representation services in such way that they can be discovered and accessed by the end user or application.

### I. Formal description of the interaction of the management system components in the process of searching, locating and providing services to the user

Designing of management system for multiservice network with service-oriented architecture requires the introduction of basic structural elements of SOA (service provider, service consumer, service registry) (Westerman 2004). To design management system of multiservice network with service-oriented architecture the basic structural SOA elements (service provider, service consumer, service registry) should be implemented (Westerman 2004). Their interaction is represented by relatively simple scheme: a user sends a request to the registry to get the address of the required service instance. If the requested service instance is found in the registry, the response is sent to the user with information about the location of this service. Next, the consumer directly addresses to service for performing a specific task.

Within a geographically distributed heterogeneous multiservice network a set of local service registries  $R_v$  can be arranged. In multiservice network the services communicate via central service registry. Central service registry is a managed access directory, which stores information about the location, quality metrics, description, etc. of all available services in the network and also greatly facilitates the search of requested information.

Each registry has its own service area  $MR_j$  defined by a network administrator:

$$\text{Net} \supset R = \{CR, R_1, R_2, \dots, R_v, \dots, R_h\},$$

$$\text{Net} \supset MR = \{MCR, MR_1, MR_2, \dots, MR_j, \dots, MR_h\}$$

$$\text{Net} \supset S = \{S_1^1, S_2^1, \dots, S_1^1, S_{i+1}^2, \dots, S_n^j\},$$

where  $R$  is a set of local service registries that are located in the multiservice network  $Net$ ;  $MR$  is a set of service areas, from which multiservice network is composed;  $S$  is a set of services that are provided in multiservice network;  $v$  is a number of service registry;  $j$  is a number of service area,  $h$  is a number of service registries and service areas in the multiservice network. The number of service registry is the same as the number of the service area for which it is responsible:  $v = j$ .

Due to the fact that a multiservice network can include a set of geographically distributed subnets with different sizes, the service area may consist of multiple subnets or be a part of one large subnet (Fig. 1):

To account the service's quality metrics it is of-

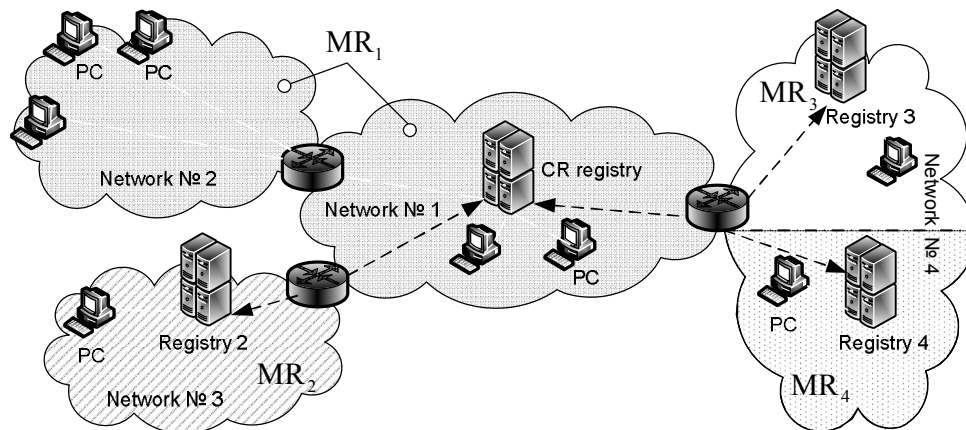


Fig. 1. The placement of service registry in multiservice network

If user wants to get access to the specific service, then all functionally equivalent services (FES) that are registered in the UDDI registry are scanned to select the instance that satisfies user requirements.

At the implementation stage of new service in multiservice network, service provider publishes information about this service (location, the values of quality metrics, etc.) in a central service registry CR:

$$I(S_i) = \{add, c, t, th, a, r, \dots\},$$

$$\forall (S : S \in Net) \exists (add, c, t, th, a, r) \in I(S_i)$$

where  $Net$  is a set of elements in multiservice network,  $I(S_i)$  is a set of records in the registry about service  $S_i$ , like  $(add, c, t, th, a, r, \dots)$ , where  $add$  is service location  $S_i$ ,  $c$  is a cost of service,  $t$  is response time,  $th$  is service performance,  $a$  is availability,  $r$  is reliability, etc.

Elements  $(c, t, th, a, r) \in L$ , where  $L$  is a set of  $S_i$  quality metrics, based on which the search for service with the required QoS parameters is performed,  $L \subset I(S_i)$ . After registration new service is available for using.

During service registration serial number ( $i$ ) and service area number ( $j$ ) is assigned to it. If some service is removed from the registry, the serial numbers of other services may change. However, the service area number

remains the same number throughout their entire life cycle.

fered to use UDDI registry (Universal Description, Discovery and Integration). UDDI registry provides a standard mechanism for classifying, cataloging and management of services that allows finding and using them by user (Majumdar et al., 2006).

The description of each service instance in standard templates is created in the UDDI registry. Information about the service instance is stored in the UDDI registry as an XML-document, which defines the meta-types.

Meta-types are displaying different aspects of the service functioning (the destination area, the owner, terms of use and various technical parameters (address, protocols, the values of quality metrics)).

remains the same number throughout their entire life cycle.

## II. Development of network management structure of user requests

Another important requirement for the developed management system is the efficiency of network management organization of user requests (ITU-T Recommendation Y.2011, 2004).

To solve this problem the management algorithm of user requests in multiservice network is proposed. According to the algorithm (Fig. 2) management of user requests will be carried out as follows: when a user wants to access a particular service, it sends a request to the central service registry. If the information about the requested service is not detected in a central service registry, the message about absence of service is sent to the user. In case the requested service is detected than the central service registry forwards the request to location server that is situated closer to the user. After that the user request is processed and the answer is formed.

## III. Development of functional network management scheme of user requests

In accordance with the developed algorithm a functional network management scheme in a multiservice

vice network, built on the basis of SOA, is proposed (Fig. 3). The key elements of this scheme are the central service registry, local service registries, location servers and service instances.

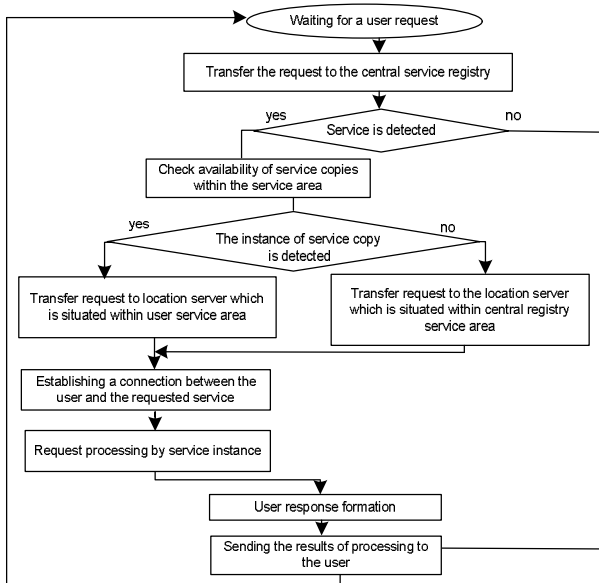


Fig. 2. Management algorithm of user requests in multiservice network

Location server is responsible for establishing connection between the user and the requested service instance. It monitors the status and location of service instances in its service area.

When a user sends a request to get access to some service first time his request is being processed by central service registry according to the management algorithm of user requests shown previously. If the user sends the request again and a copy of the service instance or functionally equivalent service within the user service area exists, the request is immediately sent to the location server that is situated within this service area. This leads to reduce request processing time and unloading central service registry.

The first advantage of the proposed structure of network management system is the ability to scale because the implementation of new types of services and increasing the number of existing services instances will not require changing the structure of the network management system. The second advantage is fault tolerance improving (for example in case of DOS-attacks) of the network management system at the expense of distributing query processing and availability of copies or functionally equivalent service instances.

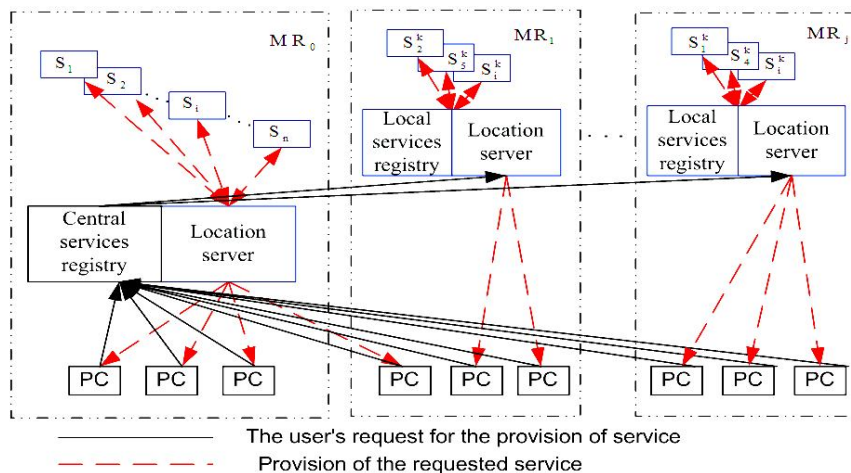


Fig. 3. Block diagram of the network management system of user requests

#### IV. Development of the method of increasing the service's availability in multiservice network with SOA architecture

Increasing of intensity of requests to service may lead to server overload and the denial of service, in other words, to a deterioration of service availability. This also leads to lower value of quality metrics of network's services and reducing network competitiveness.

Nowadays, special methods to ensure availability of services are not used for SOA, therefore the system uses only existing advantages of architecture to improve service available (Hilari 2009). To solve this problem the existing methods for increasing the quality of service should be improved or new ones developed.

One of the most effective methods of ensuring availability of services is replication. Possibility of using this technology and the effectiveness of its implementation is presented in Stantchev V. (2008), Yousefi et al. (2011).

To increase the services' availability for the proposed structure of the network management system, the dynamic replication method, discussed in Demchenko et al (2013), is proposed to use.

The basis of the replication method is performing replication of service instance in case it is necessary. Therefore, the load of users requests on the current instance (server) is reduced and this leads to reduction of quantity of service denials (availability increase).

It is necessary to solve three main tasks to organize replication of services (Fig. 4):

1. Moment of decision-making about replication;
2. Choose the location for replica;
3. Ensuring of data consistency.

Decision about service instance copying is made based on the analysis of the intensity of user requests to

the service. The key parameters of the method are the replication threshold  $rep(S_i)$  and deletion threshold  $del(S_i)$ . The values of these parameters affect on the intensity of replication and the server overload of unclaimed replicas.

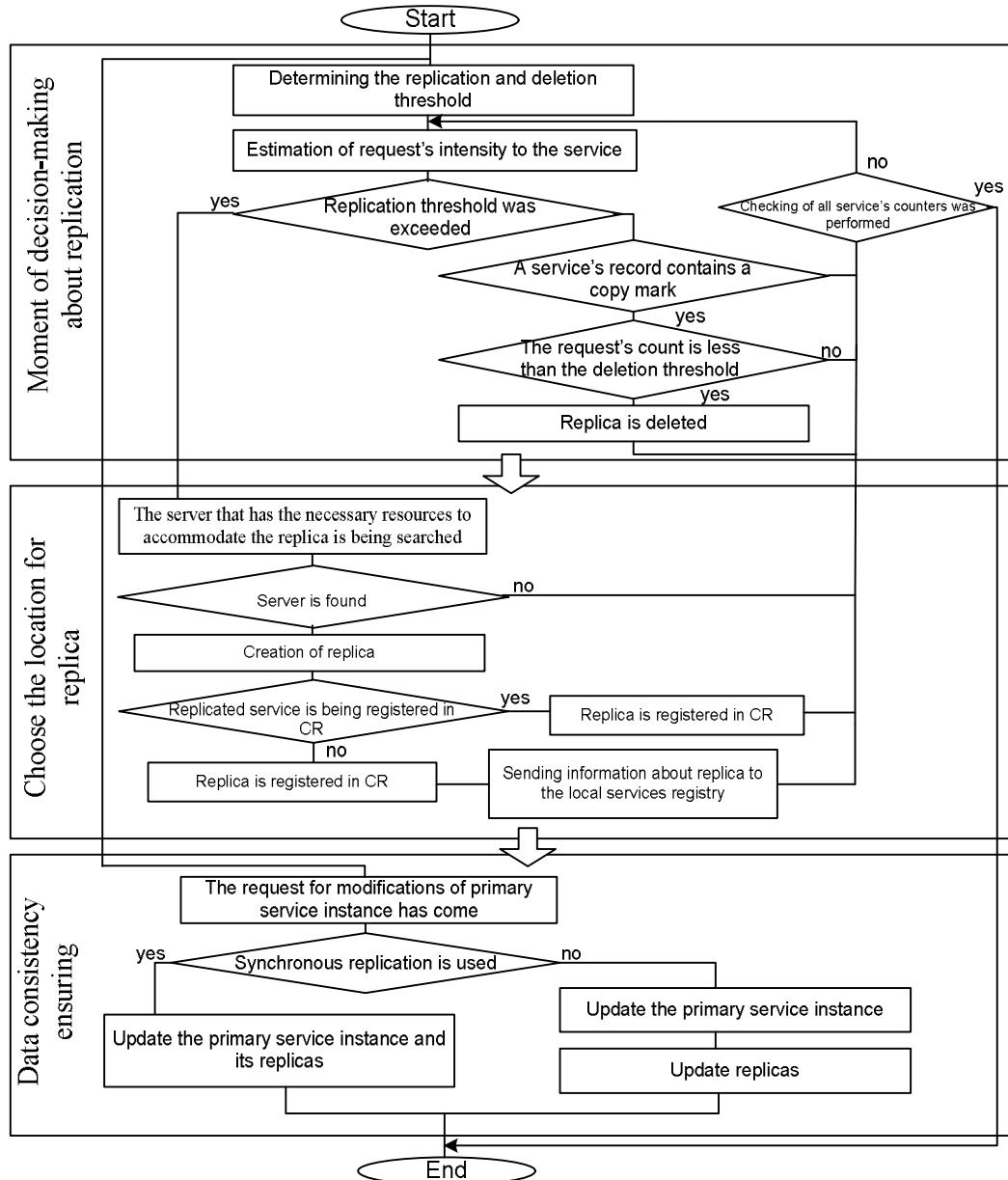


Fig. 4. Complex algorithm of service replication

The central registry service monitors the number of requests for each service. If the requests count to any of the particular service in some service areas (including service areas CR) exceeds the threshold then a decision about replication is made. To accomplish this, future replica location must be determined. For this purpose, in the specified service area, the server that has the necessary resources to accommodate the replica must be defined. If the required server is found then the registry sends a request to the service  $S_i$  to create a copy. In the request it specifies the location for future copies.

After replication the answer with the results of operation is sent to the location server of CR service area.

In case the replication was successful in the description of the primary service instance is specified copy mark  $\chi = 1$  and replica's address  $add(S_{ki}^j)$ . In case the server is located in the  $R_v$  service area, this information is also sent to the location server to register the replica. If the available server is not found in the registry database, the replication is canceled and the registry starts checking next service counter.

The location server of  $R_v$  also monitors the intensity of user requests to services. If the rate of requests to the service instance exceeds the replication threshold, the location server decides to create an additional copy of the resource in accordance with the algorithm previ-

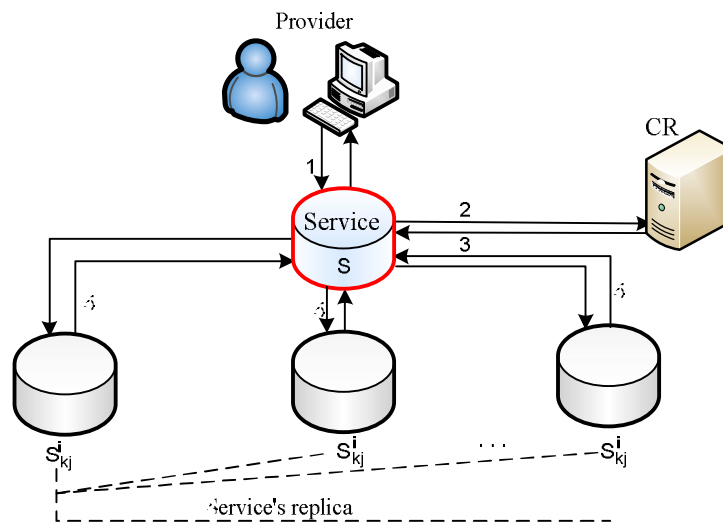
ously submitted. If the rate of requests to the replica falls below the deletion threshold the location server decides to remove the replica for free up space on the server. After removal operation, the information about replica  $S_{ki}^j$  is deleted from the local service registry  $R_i$ . Also, this information is sent to a central service registry. After the message about removal of replica is received, CR deletes information about copy mark and replica's address from the description of the primary service instance.

The effectiveness of the method of dynamic replication is largely dependent on the choice of methods that ensure data consistency. Often the transaction is used to synchronize the replicas (Tanenbaum et al., 2006, Tanisch 2000). According to the type of trans-

action a synchronous or asynchronous replication will be used to synchronize the service replicas.

Today, many methods that ensure data consistency have been developed (Tanenbaum et al., 2006). The usage of these methods depends on the replication strategy, which is used in the network, the type of provided services and the requirement of strict consistency.

According to the fact that SOA always has a primary copy of services, which may change only a provider, it is advisable to use the protocols based on the primary copy to ensure data consistency. To perform synchronous replication as a protocol that ensures data consistency it is proposed to modify the primary backup protocol (Fig. 5).



Notes: 1) a request to change the service, 2) the request to the central services registry to check a presence of copies marks and their addresses, 3) the response to register, 4) the service send the updated data to all its replicas, 5) updating confirmation 6) confirm the changes.

Fig. 5 The primary backup protocol

If a provider wants to change any data it sends a request to the primary service instance  $S_i$  with service updates. Service  $S_i$  sends the request to the central service registry to check for a presence of copies marks and their addresses. If the copies marks do not exist  $\chi = 0$ , the update process is being completed, and the service becomes available again. If the registry's answer will contain information about copies and their addresses, the service will send the updated data to all its replicas. When all update acknowledgments have been received from all replicas, the service sends to provider a confirmation of accepting these changes and the update process is being completed. Update process is performed as a single atomic operation or transaction that ensures service copies consistency.

To perform asynchronous replication as a protocol that ensures data consistency it is proposed to use a non-blocking protocol. The difference between a non-blocking protocol and a primary backup protocol is that

the update of the primary service instance and replicas are made using individual transactions, after which services are available for user.

Thus developed complex method of services replication allows solving a set of tasks which is needed to perform replication and ensure data consistency.

## V. Estimation of the network management system efficiency

To analyze the efficiency of the developed network management system the simulation model of a multiservice network was developed. The developed system can operate in two modes - with replication and without replication.

Graphical representation of the model is shown in Fig. 6.

In mode without replication, all user requests are sent to the central service registry, which stores information about the location of the requested service. Location server of CR defines the placement of server

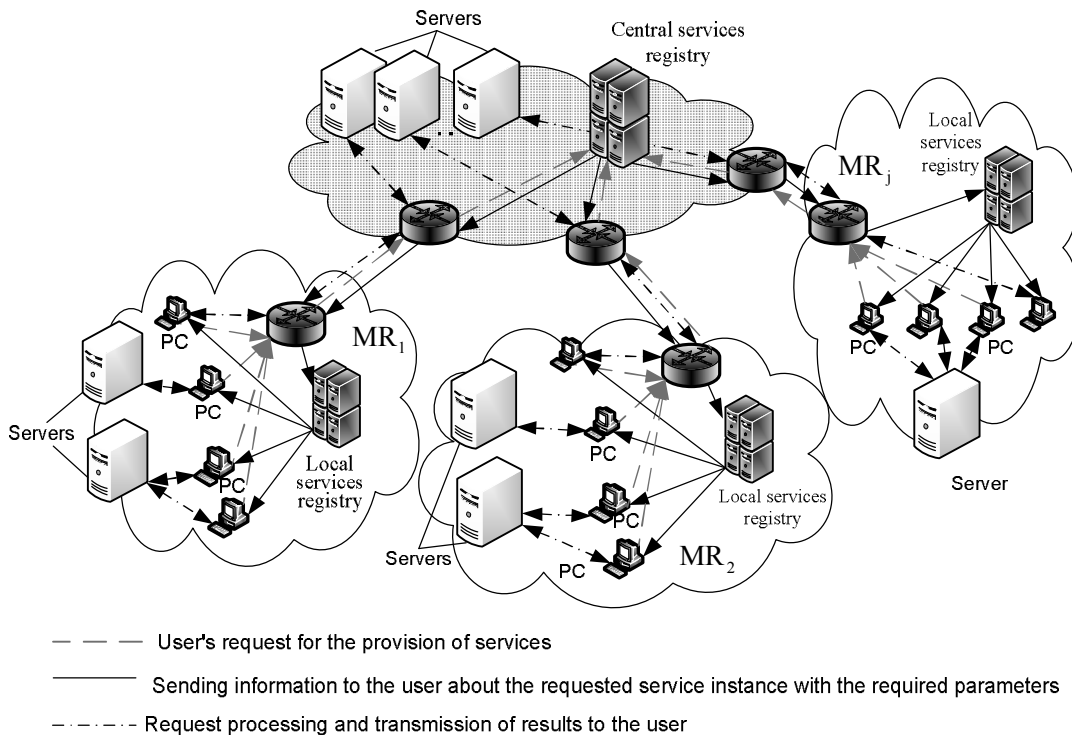


Fig. 6. The simulation model of the multiservice network

which includes the requested service and establishes a connection between the user and the server. At the same time the server that stores the requested service may be in a remote part of the network that brings an additional delay to the delivery of services. In the case of the growing service instance popularity, the level of its availability will be significantly reduced, that negatively affects on the values of quality metrics.

In the second mode, as shown in Fig.6, the load on the some services is distributed over the network by applying of mode with replication. In case the number of requests from a particular part of the network to a remote service instance exceeds the replication threshold, then the decision to create a replica of the requested service near service users will be taken. Thus, in accordance with management algorithm of user requests (Fig. 2), a user requests that was received by the central service registry is redirected to the location server of  $R_v$  registry, where a replica of the service is registered.

Analysis of simulation results has shown that applying of the developed network management system

can increase service's availability on 15% during congestion. Moreover, in case the rate of requests is increased the difference between the level of availability in replication and without replication mode can also be increased and can reach a values close to 30% (Fig. 7).

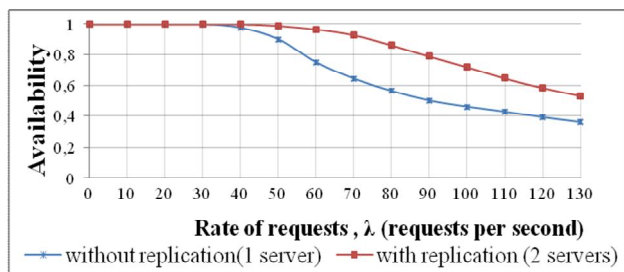


Fig. 7. Level of availability

In case the number of requests from some part of the network to the service instance increases then the applying of replication mode reduces the workload of backbone link (Fig. 8). Residual traffic is formed due to updates that are being sent between replicas.

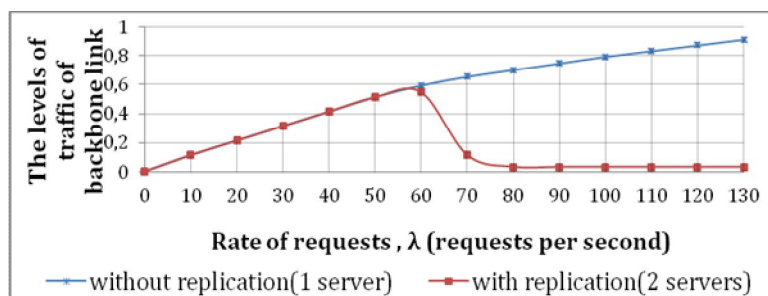


Fig. 8. Level of traffic of backbone link

## Conclusions

In this paper the structure of management system of multiservice network with service-oriented architecture is presented. As the key elements of the structure the central service registry, local service registries, location servers and service instances are proposed to use. Processing of user requests within the proposed structure is performed in accordance with management algorithm of user requests, which is presented in the article. The main advantages of the developed network management system are the scalability and fault tolerance.

To increase the availability of services in multiservice network with SOA architecture the dynamic replication method was developed. This method allows creating, if necessary, additional copies of the requested services near service users. To ensure data consistency the primary backup protocol was modified.

The analysis of the proposed structure of management system of multiservice network was performed using simulation models. The results of research showed that applying of the developed system allows increasing the availability of network services, reducing the access time to the network resources, and reducing the workload of the backbone link and the central service registry.

Thus, using of replication allows performing traffic balancing in the network, and also improving the quality of service in multiservice networks in general.

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## СИСТЕМА УПРАВЛЕНИЯ ДОСТУПНОСТЬЮ В МУЛЬТИСЕРВИСНЫХ СЕТЯХ

Е.В. Дуравкин, Л.В. Демченко, С.А. Соболева

Значительное увеличение числа и разнообразия предоставляемых услуг в мультисервисных сетях, а также постоянное повышение требований пользователей к качеству обслуживания, приводит к необходимости разработки новых методов управления мультисервисными сетями. Эта статья направлена на решение этой задачи, путем совершенствования структуры системы управления сетью и алгоритма управления пользовательскими запросами в мультисервисных сетях. Кроме того, для повышения уровня доступности услуг, был предложен метод динамической репликации, который был модифицирован в соответствии с характеристиками предлагаемой структуры системы управления сетью.

**Ключевые слова:** мультисервисная сеть, система управления сетью, наличие, SOA, метод динамической репликации, обеспечение согласованности данных.

## СИСТЕМА УПРАВЛІННЯ ДОСТУПНІСТЮ В МУЛЬТИСЕРВІСНИХ МЕРЕЖАХ

С.В. Дуравкін, Л.В. Демченко, С.А. Соболева

Значне збільшення числа і різноманітності послуг, що надаються в мультисервісних мережах, а також постійне підвищення вимог користувачів до якості обслуговування, призводить до необхідності розробки нових методів управління мультисервісними мережами. Ця стаття спрямована на вирішення цієї проблеми, шляхом вдосконалення структури системи управління мережею і алгоритму управління користувачькими запитами в мультисервісних мережах. Крім того, для підвищення рівня доступності послуг, був запропонований метод динамічної реплікації, який був модифікований відповідно до характеристик запропонованої структури системи управління мережею.

**Ключові слова:** мультисервісна мережа, система управління мережею, наявність, SOA, метод динамічної реплікації, забезпечення узгодженості даних.