

Decision Support in the Management of Instant Payment Services

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Abstract—The paper touches upon the issue of improving the efficiency of the process of providing services for the payments payment by the population through a distributed system of instant payments. Improving the efficiency of the service delivery process is achieved by supporting decision-making managers, system administrators at three stages of the service delivery process: creating a service, making a payment, and evaluating the service effectiveness. A scheme of management of rendering services process in the system of instant payments, a block diagram and an algorithm of the DSS work describing decision support in the system in question are presented. The process of instant payment system operation was formalized, which allowed developing a distributed system architecture and software based on web services technology. In order to describe the network services, it is proposed to use WSDL using the SOAP protocol and the UDDI interface, which will ensure the interoperability of software systems regardless of platform, as well as the ease of development and web services debugging. Thus, load testing of the instant payment system software was carried out and its reliability was evaluated on the basis of La Padula, Jelinsky-Moranda and Mills models.

Keywords—*improving the efficiency, managing the process of providing services, decision support, payment services, instant payment system, decision support system, software reliability*

I. INTRODUCTION

Modern researchers of the world economy notice the increased role of the service sector, which is associated with the goods market glut. A service is a result of direct interaction between the contractor and the consumer, as well as the contractor's own activities to meet the consumer's needs. Furthermore, a special role in the modern economy is played by financial services related to the payment of goods and services. Effective management of the process of payment services is a difficult task, because the risks of errors in this process are significant, having both economic and social consequences.

The paper discusses the issues of decision support in managing the process of providing services in the system of instant payments (IPS), based on intelligent

technologies. The software decision support system (DSS) is developed and its reliability is assessed.

II. STATE OF ART IN EFFICIENCY OF DECISION SUPPORT IN SOCIO-ECONOMIC SYSTEMS

It is generally agreed today that socio-economic system focuses on the relationship between social behavior and economics. It shows how social standards influence consumer behavior and form the economy. Moreover, it uses social sciences to predict potential results from changes for society or the economy. According to Solomon et al. [1] there is a general acceptance of a broad definition of social institutions as accepted rules of conduct in agent interactions. There are overlapping views on how institutions come into being and change throughout time. The paper develops an analytical framework that views the economy as a social system with interactive subsystems that initiate and maintain their own subsystem institutions. Also, it illustrates the validity of the social system perspective via reviewing a timeline that highlights the changing and evolving dominance of the major subsystems.

One must admit that service sphere is necessary for development of socio-economic system. Tsionas et al. [2] introduce a new model that is suitable for measuring both service efficiency and technical efficiency when both bad and good outputs are present. The model is developed with an output distance function, using Bayesian methods of inference organized around Markov chain Monte Carlo (MCMC). It is clear from these observations that modern techniques are required for service efficiency estimation. Havas et al. [3] are convinced that there are various approaches to measuring business innovation with the aim of drawing lessons for evaluating social innovations. The author offers several methodological conclusions. The result of study shows that analysts and policy makers need to be aware of the differences in measuring social innovation activities.

Decision support systems have undoubtedly brought about a revolution in the sphere of service management. Making the right decisions is of

paramount importance for modern population. This issue has been widely tackled by a lot of authors in their articles recently.

Shrestha et al. [4] point out that an innovative Software-mediated Process Assessment (SMPA) approach based on the Design Science Research methodology that automates assessment of ITSM processes and supports the decision-making of IT Service Managers is developed. The SMPA approach includes process selection, an online survey to collect assessment data, measurement of process capability and specific recommendations for managers to commence process improvement.

Candea and Filip [5] suggest using new concepts and information technologies in the field of computer supported group decision-making. They emphasize that iDS (intelligent Decision Support), a practical IT platform that supports the activities in the group decision-making, is used as a tool to illustrate the methodology.

Lukashevich and Garanin [6] consider the problem of credit process management and credit decisions support for small business. A higher growth rate of defaulted debt for small business indicates a low efficiency of applied methods for credit risk assessment management. It should be noted that it is rational to apply decision support systems for credit process management.

It is undeniable that it is extremely important to have a special decision support system in many areas of service. In some related work, Winkler and Horvath [7] pay attention to intelligent decision technologies which can support travelling as well as planning transport systems. This paper gives an overview of decisions in both individual and public transport. Then it shows some examples of how intelligent cognitive info-communications can support these decisions and how they can be built into passenger information services.

III. STATE OF ART IN ELECTRONIC PAYMENTS SERVICE MANAGEMENT

Another vital issue for consideration is electronic payments. It is common knowledge that a vast majority of population has to use various payment systems on a daily basis. According to the paper written by Katamadze and Topuria [8], instant payment system is a secure solution for processing payments by credit cards, virtual wallet or by cash for many types of providers. Beyond the basic payment functionality, current system proposes a set of advanced functionalities providing more flexibility to control its transactions and offering interesting value-added services to the end customer. The authors are of the opinion that this system manages its own centralized platform to provide an interface between different channels for payments or services and the corresponding recipients for processing.

Taking into consideration numerous kinds of payment, Pasquet and Gerbaix [9] try to find similarities and differences between instant payment

and Smartphone payment. On the one hand, new technologies lead to changes in customer habits, which make Internet purchases anywhere and at any time possible. Customers also expect to pay for and receive their purchases without delay. Suppliers, on the other hand, wish to have the certainty to be paid as soon as they release their goods and services. What is more, new technologies stimulate innovation in payments, and contribute to the improvement of instant payments. In addition, D. Pal et al. [10] analyze mobile payments using biometrics and cloud storage. The authors draw attention to the role of analysis and experimental results which show the reliability and efficiency of our proposed solution.

Yaokumah et al. [11] investigated customers' preferences of payment systems and the influence of demography on the attitude of customers towards e-payment services. The t-test and the analysis of variance were employed to examine the differences in perception of security, ICT literacy, customer satisfaction, and the use of e-payment services based on customers' age, gender, and the level of education. The findings revealed no significant differences between the male and female customers in the use of e-payment services. Also, whereas the older customers were more satisfied with e-payment services, the younger customers had more ICT skills and used the services much more frequently. These findings are necessary for formulating strategies for marketing e-payment services.

An important point to remember is that an electronic payment is an example of a distributed system. There are a great number of articles dealing with implementation of distributed systems. Domdouzis et al. [12] believed that the complexity and the intensity of crisis-related situations require the use of advanced distributed systems infrastructures. This paper focuses on the use of Service-Oriented Design techniques for the development of the ATHENA Crisis Management Distributed System. The function of the ATHENA Crisis Management Distributed System is based on the use of data generated by social media for the evaluation of the severity of the conditions of a crisis and the coordination of the appropriate measures in response to the crisis. Moreover, Kumar et al [13] are convinced that tasks allocation is an important step for obtaining high performance in distributed computing system (DCS). This article attempts to develop a mathematical model for allocating the tasks to the processors in order to achieve optimal cost and reliability of the system.

One should accept that the distributed system is a secure system with service-oriented architecture. This fact proves the opinion of experts. Braeken [14] proposes an alternative e-payment system that satisfies all the required security features. In addition, the author shows how similar techniques can be applied to develop a payment system on a vending machine or in a retail outlet for the customer using their smartphone as proxy, allowing not only confidentiality and authentication, but also user anonymity throughout the whole process. Furthermore, Kang et al [15]

emphasize that secure and fair electronic payment systems are an important issue. Combining authenticated encryption and verifiably encrypted signatures technologies, they propose an improvement on Chaudhry's electronic payment system. These changes guarantee the user anonymity, eliminate the advantages of the merchant, and ensure the fairness of the payment system and the effectiveness of the dispute resolution phase.

IV. DECISION SUPPORT APPROACH IN IPS

It is generally accepted in control theory that control systems are created to achieve specific goals, which are defined within the framework of other sciences involved in the study of specific systems. In our case the object of management is the process of providing payment services in the system of instant payments. The IPS provides customers with the ability to receive goods and services and pay for them in any place and in real time. Customers are the population and providers in the system. The IPS administrator, operator or manager can act as a decision maker. The decision maker develops strategical goals that are implemented through the management of the service delivery process. The developed scheme of managing the service delivery process is presented in Fig. 1. At the first stage of managing the process of creating a payment service a request for this process comes from providers. The initiator can be a decision maker, whose goal is to expand the range of IPS services. Decision support in the process of creating a new service is to simplify the procedure for constructing a web service for a new service by a single semantic description of the components stored in the distributed repository of the system without using third-party services.

At the second stage of managing the payment services process decision making is supported in choosing a method of making payments. The distributed architecture of the SMP makes it possible to make payments on different routes of a distributed network, with different financial and technical characteristics of each route. This process is ensured by conducting a transaction through several payment systems in the module for selecting a payment method. This increases the reliability of the payment system,

which is necessary in the case of socially important financial services.

The third stage of management is the stage of monitoring the efficiency of payment services by assessing the integral indicator of efficiency. If the level of efficiency does not match the expected level of the client, the decision maker implements adjustments to the service delivery process. To increase the effectiveness of decision support in the IPS

a structural diagram of the DSS was developed (Fig. 2), which includes components of interaction with decision makers and components of the IPS.

The DSS structure contains an information support module which interacts with the service creation module, the payment module and the analysis and statistics module. This module provides a dialogue with the decision maker and implements three-stage management of the process of providing services for the payment of payments by the population in the IPS. The process of the DSS work is presented in Fig. 3. In accordance with the objectives of the system development it is necessary to expand the range of services. The IPS manager researches the market and connects prospective services, or the provider goes with his request to the IPS. The request is processed in the web-based administrator interface. In the dialogue with the provider, the requirements for the new service, are specified.

The decision maker, using the information support module and the service creation module, creates a new web service that meets the requirements of the provider. Then this service is added to the range and recorded in the repository.

The process of carrying out services is launched upon the request of services from the customer arriving through the terminal software. Further, the requirements for the service which are recorded in the database are specified in the dialogue with the client. The client is provided with a range of services from the repository. The decision maker decides on the method of making a payment through the information support module. Then the payment itself is made by using the

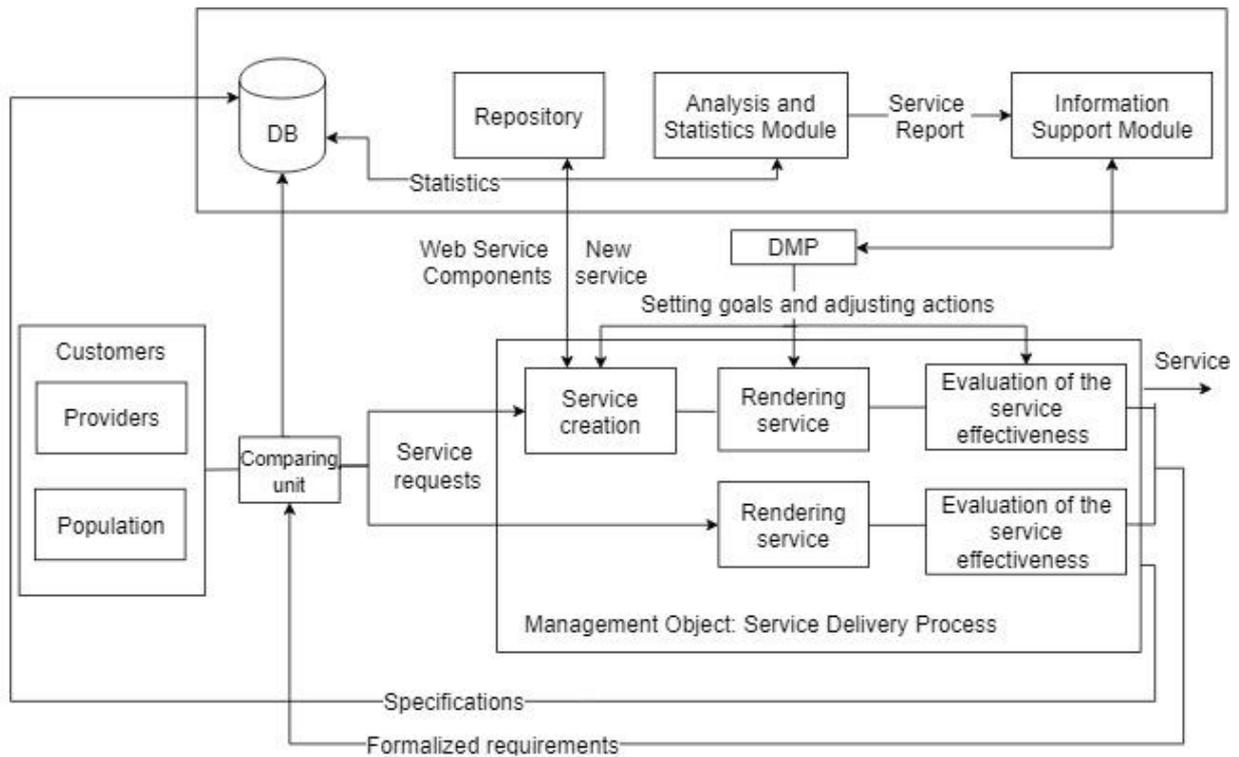


Fig. 1. The scheme of the service delivery process.

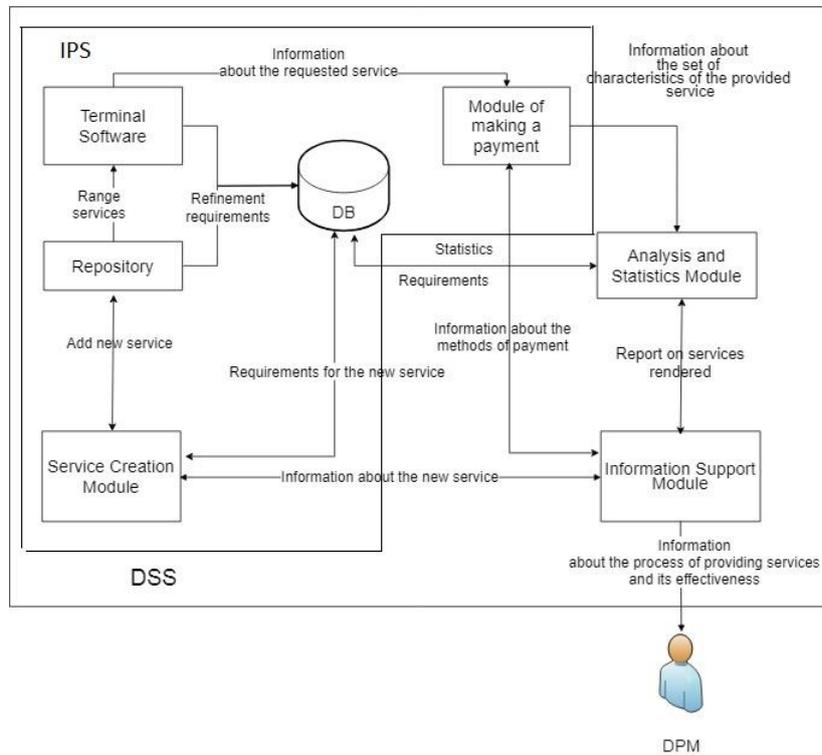


Fig. 2. Structural diagram of the DSS.

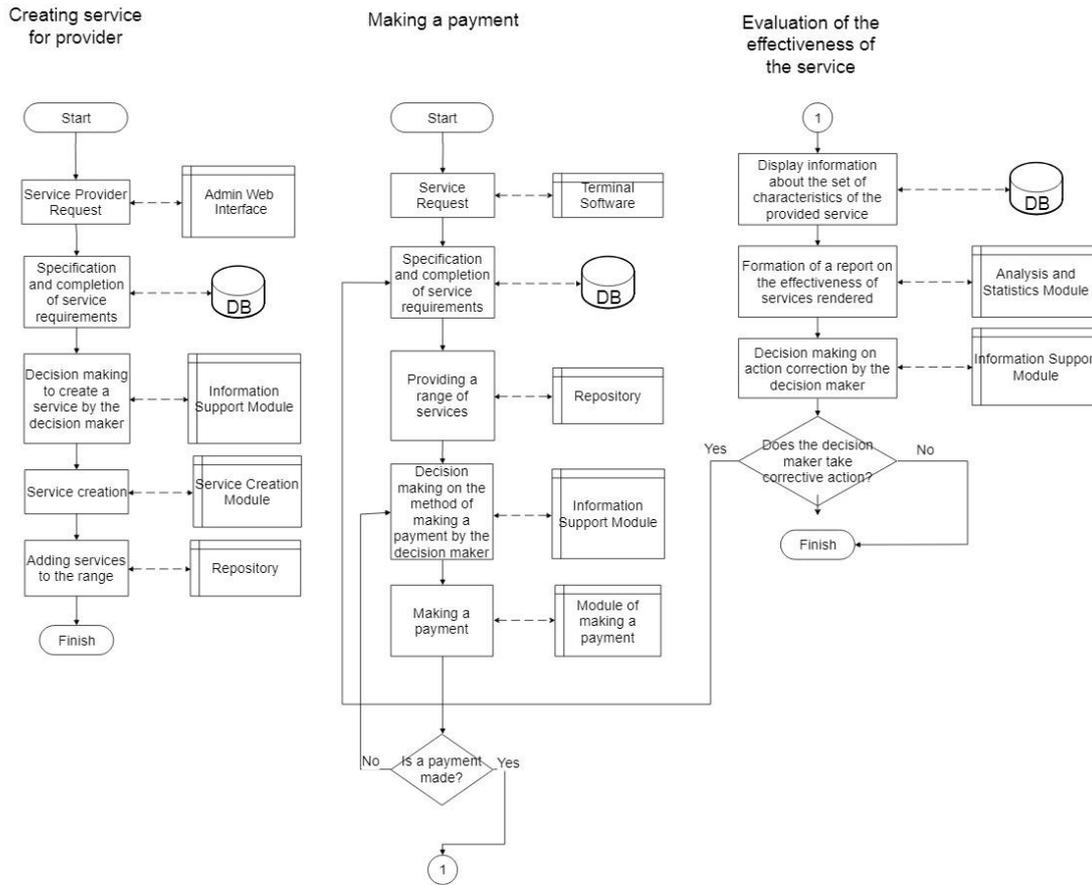


Fig. 3. Algorithm of DSS functioning.

payment module. If the payment is not made, the system returns to making a decision on the method of making the payment by the decision maker. If the payment is made, all the information about the set of characteristics of the provided service recorded in the database is displayed. Then all the collected information is structured in the analysis and statistics module, from which a report on the provided services is generated. The decision maker analyzes the information about the proposed change in the service delivery process and decides on further adjustment of actions. If the decision maker takes corrective action, the requirements for services are clarified. If corrective actions are not needed, the payment service is completed on this process. The presented algorithm allows the development of decision support software. The designed algorithm allows the development of decision support software. It shows what steps should be taken in the course of the DSS work.

V. SOFTWARE DEVELOPMENT

It is important to note that the decision support system is a software add-on over a distributed instant payment system. Mechanisms in the developed system should be implemented to select a service provider, register and record services rendered, and implement an interaction protocol. The functioning of the IPS is presented in detail in Fig. 4.

In the first block the customer selects a service available in the repository and starts the mechanism

for selecting a supplier or intermediary service based on financial priorities and technical capabilities of the system.

In the second block in accordance with the laws and rules of the payment system, a request for a client service is registered and the data are transferred to the block of interaction with the supplier or intermediary.

In the third block in accordance with the information exchange protocol and the information security protocol, interaction occurs with the service provider or intermediary, data is recorded, and the response is transmitted to the second block, in which the results of the interaction are recorded. If it is impossible to provide the service through the selected provider or intermediary of the service, the registered information is available for the provision of the service at the next request and the "service route" can be adjusted.

The specific of the system is associated with the processing of a large number of customer requests. Therefore, it is extremely important to ensure secure and reliable operation of Web servers. As the system develops, there is a shortage of communication line capacity from the WWW server to the Internet service provider. With such growth of the Network the main concern of Web developers is the need to serve the client's request on time. The search for a solution leads to the idea of creating a distributed Web-server and a distributed information system and knowledge bases.

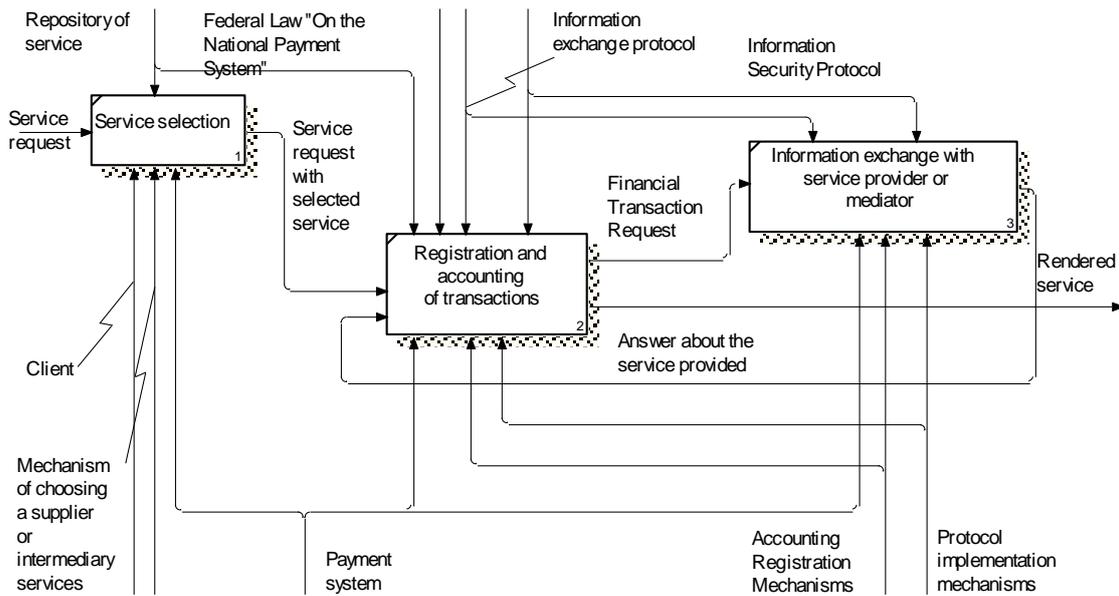


Fig. 4. Payment process of the instant payment system.

The payment system and service providers ensure network services for financial transactions. It is necessary to unite all participants of the interaction into a single information space for effective work in the context of decentralization of the system. While finding a solution to this problem, the question of the presentation and implementation of the subject area in the form of ontology arises. To ensure the expansion of the list of services without changing the software, it is necessary to describe the services which will be stored in the repository as ontology, allowing all system participants to put data into it and receive information.

The most well-known languages for the description of network services are WSDL, OWL-S,

WSMO and DSD. The system proposes to use WSDL with the help of SOAP protocol and the UDDI interface, which will ensure the interoperability of software systems regardless of platform, ease of development and web services debugging.

The software architecture has been developed to implement the system. (Fig. 5), it includes components that interact with clients (population) software for payment receiving points and components of a distributed system server.

The distributed system of instant payments in contrast to the centralized one, ensures the fail-safe operation of the system when parts of the system are unavailable.

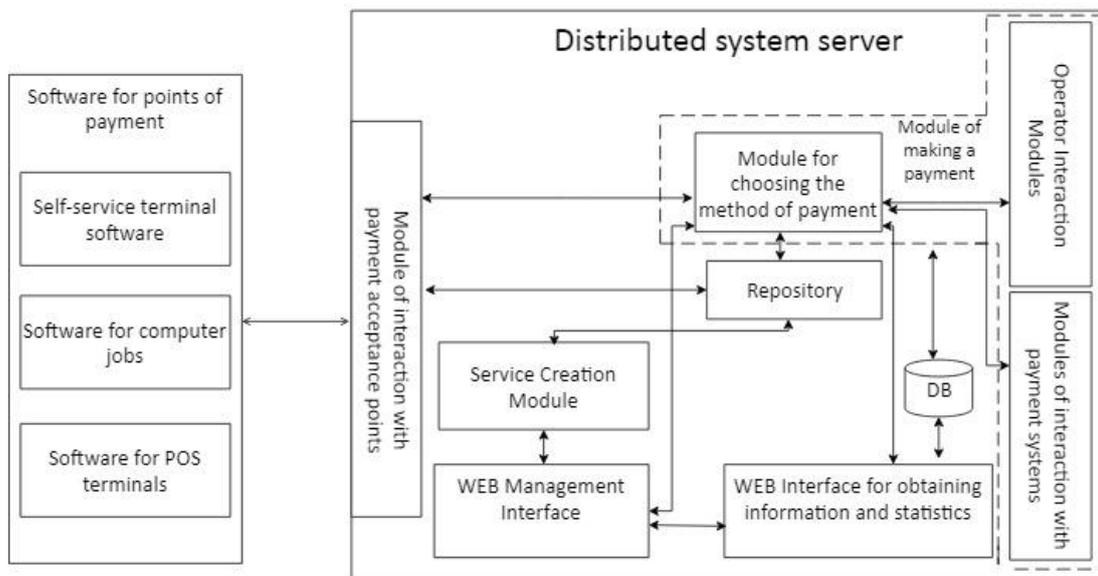


Fig. 5. Distributed architecture of the instant payment system

The use of a unified description of network services in the form of ontology allows reducing the time required for connecting additional services and the costs of this process by supporting the decision making of the administrator when creating the service without involving developers.

VI. EVALUATION OF SOFTWARE RELIABILITY

The international standard ISO 9126:1991 Software Evaluation defines reliability as a set of attributes that bear on the capability of software to maintain its level of performance under stated conditions of use, maintenance, storage and transport for a stated period of time. The problem of reliability in itself has at least two aspects: reliability assurance and evaluation (metrics). It is also obvious that software reliability is much more important than its traditional properties such as time for execution or RAM required. However, to date, there is still no generally accepted measure to evaluate software reliability.

In order to evaluate the reliability of the system in the use and storage of an object, the software needs to be tested. Upon testing, the results are processed using software reliability modelling. As reliability models, the article features La Modula, Mills, Jelinski-Moranda models.

In the course of the software testing, 2 faults were detected, with the number of requests being 100 in 4 steps. The time for failure detection and the time intervals between occurrences of failure were also recorded.

According to the La Padula model, the sequence of tests is run in n steps. Each step ends with making amendments to the software. The increasing function of reliability is based on the number of failures detected in each test run. The software reliability in Step i is calculated by the formula:

$$R(i) = 1 - A/i, \quad i=1, 2, \dots, n, \quad (1)$$

where A is growth parameter.

The ultimate software reliability is then as follows:

$$R(\infty) = \lim_{i \rightarrow \infty} R(i), \quad (2)$$

Unknown values are to be derived by solving the following equations:

$$\sum_{i=1}^m \left[\frac{S_i - m_i}{S_i} - 1 + \frac{A_i}{i} \right] = 0. \quad (3)$$

Fig. 6 shows the calculation of software reliability in a graph. The La Padula model is a predictive model, and the test data analysed suggest high probability of a fault-free program performance further on, i.e. we conclude that the software of the system in question is reliable.

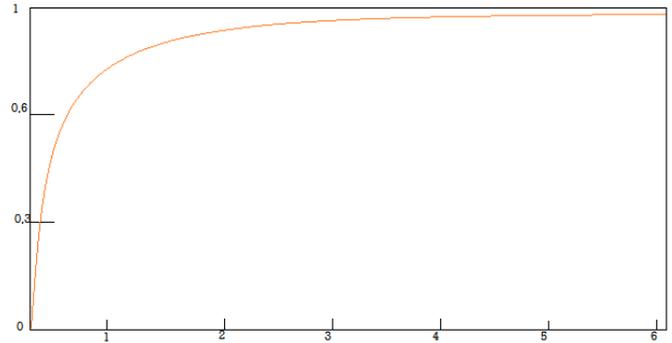


Fig. 6. Software reliability graph according to La Padula model

The Jelinski-Moranda model is referred to continuous-time dynamic models. When testing, the time to next fault is recorded. The basic assumption for this model is that time intervals between two software failures are exponentially distributed, with the failure rate being proportional to the number of failures remaining undetected. Each detected failure gets removed, and the number of remaining failures becomes less by one. The density distribution function for the time of detecting i -th failure that is measured from the time of detecting $(i-1)$ -the failure, is as follows:

$$P(t_i) = e^{-\lambda_i t_i} \quad (4)$$

where λ is failure rate that is proportional to the number of failures remaining undetected in the software

$$\lambda_i = C_D (N - (i - 1)); \quad t_i = 1/\lambda_i; \quad (5)$$

where N is the number of failures that initially exist in the software; C_D is the factor of proportionality:

$$C_D = \frac{\sum_{i=1}^{k-1} \frac{1}{N - i + 1}}{\sum_{i=1}^{k-1} t_i} \quad (6)$$

In the course of the testing, 2 failures of the system's software were detected, with time intervals being, respectively, $t_1=30$, $t_2=63$. It is necessary to determine the probability $P(t_i) = e^{-\lambda_i t_i}$ of the next fault occurrence.

Having quantified the reliability according to the Jelinski-Moranda model, we obtain the probability of the next fault: $P = 0.09$. This suggests a conclusion on the high reliability of the system.

According to the Mills' error seeding model, prior to testing, a certain number of known errors are introduced (seeded) in the software on purpose. The errors are introduced randomly and registered in a seeded error log. It is assumed that all the errors, both inherent and introduced, have an equal probability of being detected during tests. At the time of reliability evaluation based on the error log, all the errors are classified into inherent and seeded. The Mills' formula shows the initial number of errors in the

software: $N = n \cdot \frac{S}{V}$; where S is the number of seeded errors, n is the number of inherent errors detected, V is the number of seeded errors detected by the time of the evaluation.

Let us assume that the program has K -number of inherent errors and S -number of introduced errors. The test detected S -number of introduced errors and n -number of inherent errors. Following the Mills' formula, we assume then that initially there were $N = n$ errors in the program. The probability that allows trusting the predicted number of errors in the software, is calculated by the following ratio:

$$p = \begin{cases} 0, & \text{if } n > K; \\ \frac{S}{S + K + 1}, & \text{if } n \leq K. \end{cases} \quad (7)$$

Prior to testing the software, $S=17$ errors were introduced for this model. The test detected $n=2$ inherent errors and $V=8$ introduced errors. Further, the system was tested again, upon the assumption that the program had no errors: $K=0$. Besides, $S=20$ errors were seeded and detected in the course of the test, although, no inherent error ($n=0$) was found.

The results of the evaluation according to the Mills' model suggest with probability $p = 0,95$ that the software is free of errors. This also testifies to our premise that its reliability is high.

VII. RESULTS OF PROPOSED APPROACH APPLICATION

It's well known that at the present stage of development of customer-oriented economy the role of services is increasing. Effective management of the service delivery process enhances the competitiveness of the enterprise. Services related to the payment of terminals by the population through the network of terminals of the IPS carry not only an economic but also a social aspect. It improves the quality of life of the population by increasing the availability of payment and wide geographic coverage. It is vital to note that these services are socially significant.

The developed decision support system for managing the process of providing payments for people implements the proposed approach to improve efficiency by supporting management in three stages: creating a payment service, making a payment and evaluating the effectiveness of a payment service. The control scheme, the system architecture and the control algorithm have been developed for the design of the DSS. These schemes show the logic of the system and the place of the decision maker in the process.

A scheme has been proposed for the interaction of service providers with regional and federal payment systems using the distributed IPS architecture and a repository for storing descriptions of the services provided, which makes it possible to ensure efficient operation of the instant payment system in a decentralized environment. This allows increasing the

reliability of the rendering services process for paying payments by the population.

WSDL using the SOAP protocol and the UDDI interface is used to describe the formats and methods for transferring data between elements of the instant payment system, which ensures the interaction of software systems independently of platform, ease of developing and debugging web services.

Within the framework of the proposed system software for making instant payments aimed at three staged management of the payment services process was developed:

- provision of the possibility of creating a new service at the level of the system administrator without the involvement of developers due to a single semantic description of web services stored in a distributed repository;
- ensuring the resiliency of the system when parts of it are unavailable and receiving the maximum possible remuneration from making a payment if it is possible to conduct a transaction through several payment systems in the module for selecting a payment method;
- assessing the effectiveness of payment services by calculating performance indicators in the analysis and statistics module.

The load testing of the developed software was carried out and its reliability was evaluated. According to the La Padula model, the predicted reliability value approaches unity, which indicates that the system has a high level of reliability. Calculations using the Jelinski-Moranda model showed that the probability of having the next failure $p = 0.09$ is not great. According to the Mills model, the developed software has no errors with probability $p = 0.95$.

VIII. CONCLUSION

Improving the efficiency of the rendering the payment services process in the instant payment system is achieved by supporting decision-making with the help of managers and system administrators at three stages of the service delivery process — at the stage of creating a service, at the stage of making a payment and at the stage of evaluating the service effectiveness.

The proposed scheme of the rendering services process management in the system of instant payments, the structural scheme and the algorithm of the DSS work make it possible to organize decision support.

The distributed system architecture and its software are based on web services technology. Using WSDL with the SOAP protocol and the UDDI interface for describing network services provides the interaction of software systems regardless of platform, ease of development and debugging of web services.

The load testing of the instant payment system software and the assessment of its reliability based on

the La Padula, Jelinsky-Moranda and Mills models showed a high degree of reliability and a low probability of failure.

Further research direction is connected with the implementation of a single semantic description space for network services for all participants in the service delivery process in the IPS.

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