One of the key goals of digital transformation in Europe is to transfer 100 % of public services online, in particular, by 2030, all key public services should be online.

This process requires the creation of comprehensive services that combine several services provided to the user on one application. The introduction of comprehensive services significantly unloads work of the bodies providing services and significantly simplifies the process of obtaining the results of services for users. Thus, the introduction of comprehensive services significantly improves the process of providing public services for all participants in the process.

The formation of complex services is carried out solely on the principle of combining according to a life (business) event or situation.

However, as practical experience shows, users often apply for several services at the same time, and these services are not connected by one life event. This can be seen by analyzing statistics on the provision of services by service centers.

The use of statistical analysis methods makes it possible to identify a hidden relationship between services. Based on this, a new principle of combining services is formulated. The object of this research is the process of forming a portfolio of services based on this principle.

An algorithm for forming a portfolio and providing recommendations for a decision maker has been developed. Recommendations are represented in the form of sets of services that can be included in the portfolio. The application of this principle will expand the range of comprehensive services at the expense of new portfolios. This will simplify and improve the process of providing services for both authorities and users.

An example of creating a portfolio of services is considered and recommendations for the application of the proposed methodology are given. Dataset of 84 services was analyzed, it was recommended to create 2 portfolios

Keywords: comprehensive public service, principle of association by life event, portfolio of services, interconnectedness of services

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THE PRINCIPLE FOR FORMING A PORTFOLIO OF PUBLIC SERVICES BASED ON THE ANALYSIS OF STATISTICAL INFORMATION

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1. Introduction

The European Union's strategy is aimed at increasing digital competitiveness and increasing the digitalization of society and the economy. This makes the issue of digital transformation of all sectors of the economy especially relevant, including in the field of public services.

Any country that cooperates with or is aimed at integration into the European Union should take into consideration in its priorities the development of e-governance and the digital economy. The economy of European countries has both an applied and theoretical and legislative basis in order to strengthen its position among the countries of the world. Under conditions that complicate the access of most users to the provision of public services (pandemic, martial law, etc.), the development of digitalization in this area is especially relevant.

That is why research in the area of digital transformation in the field of public services will ensure the quality of their provision, which will increase the competitiveness of the country as a whole.

A mandatory requirement for the national economy in the field of digitalization is the combination of theoretical research with the modern needs and capabilities of stakeholders. Thus, under the conditions of the new economy, during the fierce competition, the rapid aging of technologies, professions, ideas, the penetration of the Internet into all spheres of the economy, digitalization has reached a new level of importance for enterprises and businesses. To maintain competitiveness, enterprises need to use the possibilities of digitalization in all possible areas and forms:

– customer experience;
– partnership and collaboration;

– work with data;
– introduction of innovations;
– HR strategy and culture;
– value management, etc.

Public service, according to [1], is defined as a legally or socially significant action of the subject of providing a public (electronic public) service. Including an administrative service, on the application (appeal, request) of the subject of the appeal or without such an appeal. As a result of this action, rights are acquired, transferred, rights are terminated and/or obligations are performed by the subject of the appeal. The relevant material and/or intangible goods are also provided to the subject of the appeal.

Paper [2] defines an electronic public service that is provided by state authorities, local self-government bodies, enterprises, institutions, organizations under their management. In particular, this is an administrative service (including under an automatic mode), which is provided using information and telecommunication systems on the basis of an application (appeal, request) submitted in electronic form using information and telecommunication systems, or without submitting such an application (appeal, request).

An event that is the basis for the provision of a public (electronic public) service is a life situation, the occurrence of which is an unconditional basis for the provision of this service.

The process of providing public services is associated with the appeal of users to service centers or to the web portal, including its mobile application, submission of an application, filling out forms, providing and verifying the documents provided, etc. If several services are associated with one life event – accordingly, there will be several requests, in this case, the burden on service centers increases if these services are not automatic. For example, the life event of the birth of a child is associated with the registration of birth, as well as the need to receive a number of public services related to this event. This may be the appointment of assistance at birth, registration of the child's place of residence, etc.

Therefore, in order to simplify the process of providing services and ensure the convenience of users, comprehensive services are introduced. A comprehensive electronic public service, according to [2], is an electronic public service, as a result of which several electronic public services are provided to the subject of the application based on one application (appeal, request).

Thus, the complex service eMalyatko makes it possible to register the birth of a child on one application submitted online and receive up to ten public services from various authorities required at the birth of a child. Thus, the development of electronic services involves the creation of new comprehensive services [3].

The approach of combining services by life event or situation is successfully applied in different countries of the world [4]. However, there are situations when users need to receive a certain set of services that are clearly not related to one life event. Then, to receive these services, the user will need to contact the authorities several times and provide the necessary documents and information. In this case, the consistent execution of services slows down the receipt of the final result. That is, there are hidden dependences that create a reason for comprehensive receipt of services. In this case, it would be advisable to form a comprehensive service that will combine all interrelated services, which will simplify and improve the process of providing them for both the user and the service provider. This will reduce the burden on the service provider, simplify and speed up the process of providing services for the user. Thus, research in the area of creating new comprehensive services is relevant.

The detection of interrelated services is the task of finding hidden dependences in data sets and it can be solved by methods of statistical and data mining. Therefore, identifying the principles that will determine interdependent services and searching for such sets of services based on which one can form a new comprehensive service is an urgent task. For such interrelated services, united on a principle other than a life event or situation, we introduce the concept of «portfolio of services».

2. Literature review and problem statement

The development of public services is directly related to the processes of digital transformation in all sectors of the economy of different countries of the world. Digitalization of this sphere is one of the key goals of the development of leading economies, as shown in the further analysis of literary sources.

Paper [5] offers recommendations for the introduction of digital technologies in the activities of companies. These are general recommendations that can be used in many cases. However, for the sphere of public services, it is necessary to take into consideration the peculiarities of the process in order for the introduction of digitalization to be more effective, which is not shown in that work and requires additional research.

Paper [6] provides an analysis of the introduction of the digital economy, determines the prospects for digitalization and its features from the point of view of public administration. Analysis is provided for different countries of the European Union. However, given that the level of development of countries in the field of digital transformation may differ significantly, the development of the theory and practice of digitalization requires further research.

Works [7, 8] report the results of the analysis of the development of world companies and conclude that the process of digitalization is accelerated, which is caused by the crisis caused by the pandemic in Europe and the world. One of the key goals of European countries in the field of digital transformation is to transfer 100 % of public services online.

It should be noted that these conclusions are general in nature, that is, in order to transfer public services online, it is necessary to investigate the issue of creating comprehensive services.

Works [9, 10] analyze global problems related to the development and implementation of new, modern digital technologies in all spheres of the world economy, in particular, ways out of crisis situations are proposed. However, their specific solutions should be based on a thorough analysis of subject areas. In particular, the introduction of digital technologies in the field of public services requires research on possible ways to improve the efficiency of this process.

Works [11, 12] analyze the state and progress of different countries of the European Union on the way to the digital economy and society. The analysis is carried out on the basis of a system of indicators that characterize various aspects of European digital policy. The results of the analysis make it possible to assess the state and problems that exist in each country at different stages of digital development. However, specific recommendations for the formation of countries' policy in the field of digitalization require more detailed research in the relevant areas.

As the analysis of leading experience has shown, the process of digital transformation in the field of public services is associated with the formation of complex services (for example, eMalyatko and ID14 (Ukraine), E-Business and E-Tax (Estonia)). Therefore, the issue of creating comprehensive services requires further research.

Study [4] analyzes the development of a model of an electronic state that is indicative of users. In that work, it was concluded that the approach of combining services for a life event in different countries of the world was successful. For example, Denmark, Italy, Great Britain, the United States of America adopted an approach based on life events to create and develop an electronic state. It is shown that this approach is an effective means of covering the high share of service users in the target group. However, the possibility of combining services on other principles is not considered in the study.

Laws [1, 2] define the formation of complex services on the principle of combining according to a life event or situation but there are no other principles for combining services.

The reports of international experts of the EU4DigitalUA project (Ukraine, Estonia) [13] provide the basic principles for the provision of electronic services. Recommendations for adapting the methodology of service design based on life events are also provided. However, these reports do not cover the formation of comprehensive services based on other principles.

In the report of the international expert of the EU4DigitalUA project (Mihkel Lauk. Task research results – Methodologies for public administration process reengineering. 2021) [13], which was created as a result of the implementation of tasks within the EU4DigitalUA project, provides a number of principles for the formation of a portfolio of services. However, it is worth noting that not all of them correspond to the specifics of providing services in each particular country and not everyone has access to the necessary data.

Thus, we can state that the issue of creating comprehensive services is paid very little attention in the literature. Other principles, except for the life event, according to which it would be possible to combine services for the formation of complex services, are not used and, accordingly, no research on this topic has been identified.

In order to improve the quality of electronic services, in addition to the principle of combining services by life event, it is advisable to consider the principle of combining services into a portfolio, which can be established on the basis of statistical analysis of information on the provision of services.

3. The aim and objectives of the study

The aim of this study is to establish the principle of combining services into a portfolio based on the identification of hidden relationships between services. This will make it possible to implement not only comprehensive services based on a life event but also portfolios of services, combined according to a new principle. To receive services combined into a portfolio, it will be enough for the user to provide one application and the necessary set of documents, while reducing the time for obtaining the result. This will simplify and improve the process of providing services for both authorities and users.

To accomplish the aim, the following tasks have been set:

– to develop an algorithm for the formation of a portfolio of services in accordance with the principle of unification based on statistical analysis of information on the provision of services;

– to conduct a statistical analysis for the generated dataset.

4. The study materials and methods

The object of this study is the process of forming a portfolio of services in accordance with the new principle of combining services based on statistical analysis of information on the provision of services.

The information that is needed to analyze the presence of statistical links between services is simple, does not require additional processing and is available. To do this, one needs to know the number of user requests for each service by day for a certain period.

The use of a mathematical apparatus using statistical criteria makes it possible to use this information to determine the relationships between services that arise in the process of contacting users for a certain set of services.

Thus, to form a dataset, the following information is required: a given time period (a month or more), a set of services for which the analysis is carried out. For each service, one needs to know the number of user requests for each day over a certain period.

Statistics for the formation of the dataset were provided by the EU4DigitalUA project (Ukraine, Estonia). They include information on the number of user requests for each day over a monthly period (24 working days) for each service. Dataset contains data for 84 services. A fragment of the dataset is given in Table 1.

Table 1

Source statistical data

No.	Service name	Date of application														
		1	2	3	4	5	8	9	10	11	12	13	15	16	17	18
1	Registration of citizens in need of better living conditions. Making changes to credentials	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
2	Issuance of the survey report	1	0	1	0	1	0	0	1	2	1	0	0	1	3	0
3	Issuance of archival certificates from	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1
4	Issuance of an extract from the economic book	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0
5	Issuance of an extract from the technical documentation on the normative monetary valuation of the land plot	3	0	7	7	0	0	0	0	4	0	0	1	0	6	0
6	Issuance of a certificate to the notary office on the registration of the citizen's place of residence at this address on the day of death (for registration of inheritance, etc.)	2	2	3	0	0	0	3	2	4	2	0	1	4	5	2
7	Issuance of a certificate to the notary office on the composition of registered citizens at this address at the time of alienation of real estate (purchase, sale, gift, etc.)	1	2	0	0	0	2	0	0	0	0	1	1	1	0	2

The rows of Table 1 provide data for 84 services. The time period consists of 24 working days. In the columns with numbers 1–30, the number of appeals for each service on the corresponding date of the month is given. Therefore, the data in the rows in Table 1 correspond to the services of the set that is analyzed.

The dataset formed in this way is the input information for the algorithm for the formation of a portfolio of services.

The basis of the proposed principle of combining services is the establishment of statistical links between services using statistical analysis methods.

To check the availability of a connection between each pair of services, the Pearson correlation coefficient for the distribution series of these services is calculated. For the correct selection of related services and obtaining reliable results of the analysis, only statistically significant values of correlation coefficients are selected. The strength of the relationship between services is determined on the Cheddock scale based on the values of the selected correlation coefficients.

The use of these methods of statistical analysis guarantees obtaining statistically significant reliable results when combining services into a portfolio.

To conduct statistical analysis and obtain results based on these methods of statistical analysis, software was developed in the Python 3.10 programming language.

5. Results of studying the problem of analysis of statistical information for the formation of a portfolio of services

5. 1. Development of an algorithm for forming a portfolio of services in accordance with the principle of combination based on the statistical analysis of information on the provision of services

Mathematical statement of the problem: the set of services $P=\{P_j\}$, $j=\overline{1,m}$ is given. Each P_j service from set P is represented by a set of values:

$$P_j=(P_{j1}, ..., P_{ji}, ..., P_{jn}),$$

where P_{ji} is the number of requests for the P_j service per day, i, $j=\overline{1,m}$, $i=\overline{1,n}$, n is the number of days in the period for which the analysis is carried out, m – the number of services.

It is necessary, based on available information, to establish a relationship between the services of the set P. Based on the analysis of the strength of the established relationship, it is necessary to form recommendations for linking services into one or more service portfolios.

Theoretical justification of the approach: each P_j service from the set P can be considered as a discrete random variable, which is represented by its own series of distributions. Then the relationship between these quantities can be established on the basis of the analysis of the coefficient of the paired Pearson correlation [14, 15].

Pearson correlation coefficient for a pair of random variables P_k, P_j can be calculated from the formula:

$$r\left(P_k,P_j\right)=\frac{\sum_{i=1}^{n}\left(P_{ki}-\overline{P_k}\right)\left(P_{ji}-\overline{P_j}\right)}{\sqrt{\sum_{i=1}^{n}\left(P_{ki}-\overline{P_k}\right)^2\sum_{i=1}^{n}\left(P_{ji}-\overline{P_j}\right)^2}}, \quad (1)$$

where $\overline{P_k}$, $\overline{P_j}$ – sample averages:

$$\overline{P_k}=\frac{1}{n}\sum_{i=1}^{n}P_{ki},\ \overline{P_j}=\frac{1}{n}\sum_{i=1}^{n}P_{ji}.$$

One can check the statistical significance of the calculated correlation coefficient by calculating the value of the Student's t-criterion:

$$t=\sqrt{\frac{r\left(P_k,P_j\right)^2}{1-r\left(P_k,P_j\right)^2}(n-2)}, \quad (2)$$

where $r(P_k, P_j)$ is the coefficient of correlation of random variables P_k, P_j, n is the sample size (the number of days in the period), and comparing it with the critical tabular value of this criterion t_{tab} (which is taken from the Student distribution table [14, 15] taking into consideration the given level of significance $\alpha=0.05$, which is a sufficient level for obtaining reliable results, and the number of degrees of freedom $k=n-2$).

If the calculated value $t>t_{tab}$, then the corresponding correlation coefficient is statistically significant.

It should be noted that in order to obtain reliable results of the analysis, it is necessary to establish a statistical relationship between services, using only statistically significant values of correlation coefficients.

The value of the correlation coefficient $r(P_k, P_j)$ is in the interval [–1; 1] and determines the strength of the relationship between quantities (Table 2).

Table 2

Cheddock scale for detecting the strength of the relationship by the value of the paired correlation coefficient

The value of the correlation coefficient (per module)	0.1–0.3	0.3–0.5	0.5–0.7	0.7–0.9	0.9–0.99
Characteristics of the strength of connection	weak	medium	pronounced	strong	very strong

Note that at the value of the correlation coefficient $r(P_k, P_j)=1$, there is a very strong (to functional) direct proportional relationship between random variables. At the value $r(P_k, P_j)=-1$, there is a very strong (to functional) inverse relationship between random variables.

Thus, when forming recommendations for combining services, it is advisable to take into consideration the connections, the strength of which is determined by the range:

$$0.7\le r(P_k, P_j)\le 1.$$

From the above theoretical substantiation of the approach, it follows that in order to search for interrelated services, it is necessary to analyze services in pairs, and for each pair to calculate the correlation coefficient and check its statistical significance. According to the values of statistically significant coefficients, the strength of the relationship between services should be established. After that, it is necessary to form recommendations for the creation of service portfolios based on the choice of services that have a strong statistical connection.

Fig. 1 shows an algorithm for the formation of the portfolio of services offered.

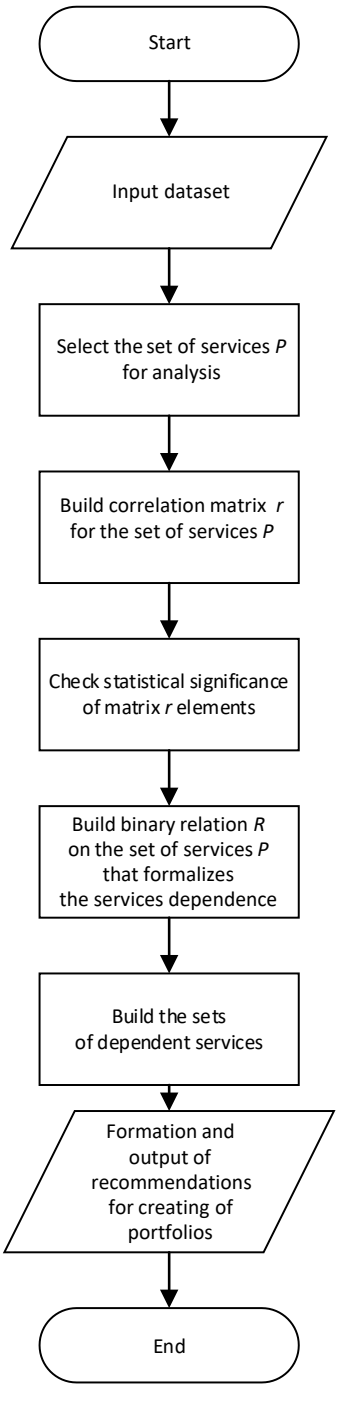

Fig. 1. Algorithm for forming service portfolios

The following is a description of the main steps of the algorithm.

Select a set of P services for analysis.

If one needs to analyze not the entire set of services that is present in the dataset but only services related to a certain category or thematic area, then one needs to select a set of services that meet the selected criterion: $P=\{P_j\}$, $j=\overline{1,m}$.

For example, in the Service Guide (Register of Administrative Services [16]), the category «Architectural and Construction Activities» as of 07.04.2022 has 80 services.

Build a correlation matrix r for a set of services P.

For each pair of P_k, P_j services from set P ($k=\overline{1,m}$, $j=\overline{1,m}$, $k\neq j$), calculate the Pearson correlation coefficient (1) and build a correlation matrix $r=[r(P_k, P_j)]$.

Verification of the statistical significance of the elements of matrix r.

For each correlation coefficient $r(P_k, P_j)$ from matrix r, follow these steps:

Step 1. Calculate the value of the Student t-criterion for $r(P_k, P_j)$ using formula (2).

Step 2. From the Student distribution table for a given level of significance a=0.05 and the number of degrees of freedom $k=n-2$, take the value of t_{tab}.

Step 3. Compare the calculated value of the t-criterion with t_{tab}. Only those correlation coefficients for which the calculated values of the t-criterion exceed the value of the table will be considered significant.

Construction on a set of services P of the binary relation R, which formalizes the interconnectedness of services.

The binary relation R, which formalizes the relationship of the interconnectedness of services, is given as follows:

$$\{\forall k\forall j,\ k\neq j\ (P_k, P_j)\in R\}\Leftrightarrow\{r(P_k, P_j)\geq 0.7$$

and the significance of the coefficient is established $r(P_k, P_j)\}$.

That is, the relation R is true for all pairs of services, between which there is a statistically significant strong relationship.

Formation of sets of related services.

For each P_j service from set P, form a set P_j^c of candidate services for linking to the P_j service. To do this, in the R relation matrix, analyze the string of the P_j service, and for all columns at the intersection with which there are single elements, include the services corresponding to these columns to set P_j^c.

Formation of recommendations for the creation of portfolios.

Recommendations for the decision maker on the implementation of service portfolios take the form of a list of P_j services, for each of which a set P_j^c of services is provided, which are recommended to be combined together with the P_j service into a portfolio.

5. 2. Statistical analysis for the generated dataset

To establish the presence of a connection between each pair of services, a matrix of paired correlation coefficients is constructed, which is shown in Fig. 2. Taking into consideration the symmetry of the matrix relative to the main diagonal, Fig. 2 shows half the matrix. The values of the coefficients corresponding to noticeable and strong relationships are highlighted in red. Thus, the correlation coefficient value for a pair of services 34 and 37 is 0.7, which, according to the Cheddock scale, indicates the presence of a strong statistical relationship between these services.

In general, the choice of services for analysis is recommended to be carried out by the number of appeals exceeding the sample average. In the example, 24 out of 84 services were selected, the number of applications for these services was 2173, or 91 % of the total number of applications.

To obtain reliable results of the analysis, it is necessary to test the hypothesis about the statistical significance of the obtained values of correlation coefficients from Fig. 2. To do this, select the tabular value of the Student criterion for $n=24$ (degree of freedom, $k=22$), $\alpha=0.05$, which is equal to $t_{tab}=2.07$.

Fig. 3 shows a matrix of values calculated according to formula (2) of the t-criterion to check the statistical significance of the calculated correlation coefficients (here $n=24$, r is the correlation coefficient, the significance of which is checked).

If the value $t>t_{tab}$ is calculated, then the corresponding correlation coefficient is statistically significant (in the matrix in Fig. 3, such values of the t-criterion are highlighted in red).

	2	3	5	6	7	13	14	24	26	30	34	37	40	45	46	47	50	56	63	69	71	74	76	84
2		0	0.2	0.5	0	-0	0.2	-0	0.3	-0	-0	-0	0.2	-0	-0	-0	-0	-0	0	0.4	0.2	0	-0	-0
3			0.1	0	0.1	0.2	-0	-0	-0	0.1	-0	-0	-0	0.1	0.1	0.1	0	-0	-0	0.1	-0	0.1	0	0.2
5				0.3	-0	0.2	0.1	0.1	0.2	0.5	0.2	0.3	-0	0	-0	0.1	-0	0	0.4	0.4	0.1	0.2	-0	0.2
6					-0	0.2	0.1	0.1	0.3	-0	0.2	0.4	0.4	0.4	-0	0.2	-0	0.1	0.1	0.5	0.2	0.1	-0	0.4
7						0.1	0.2	0.1	0.1	-0	-0	-0	-0	-0	-0	0.3	-0	0.2	-0	-0	0.2	-0	0.2	0.4
13							0.1	-0	0.3	0.3	-0	0	0.3	0.1	-0	0.1	0.3	0.4	-0	0.1	0.1	0.1	0.1	0.4
14								0.1	0.1	0.1	-0	0.1	0.3	0.2	0	0.4	0.3	-0	0.5	0.3	0.3	0.2	0.5	-0
24									0.3	-0	0	0	-0	0.2	0.4	0.2	-0	0.3	0	0.3	0.4	0	-0	0.4
26										-0	-0	-0	-0	-0	0.2	0.2	-0	0.1	-0	0.4	0	0.1	-0	0.4
30											0.1	0.1	-0	-0	0	0.2	0.1	0.3	-0	0.1	0.2	0.3	0.2	-0
34												0.7	0.2	0.2	0.3	0.1	-0	-0	0.1	-0	0	0	-0	0
37													0.2	0.5	0	0.1	-0	0.1	0.4	0,1	0	-0	0	0.2
40														0.2	0.1	0.2	0.4	-0	0.1	-0	-0	0	0.2	-0
45															0.2	0.1	0.4	0.2	0.3	0.2	-0	-0	0.5	0.1
46																0.3	0	-0	-0	-0	0	0	-0	0.1
47																	-0	-0	-0	0.1	0.1	0	0.2	0.3
50																		0.1	0.2	0.1	-0	0.3	0.6	-0
56																			-0	0.1	0.5	0.2	0	0.3
63																				0.3	-0	0	0.1	-0
69																					0.4	-0	0.2	0
71																						0.2	-0	0.3
74																							-0	0
76																								-0
84																								

Fig. 2. Matrix of paired correlation coefficients

	2	3	5	6	7	13	14	24	26	30	34	37	40	45	46	47	50	56	63	69	71	74	76	84
2		0.1	1	2.4	0.1	0.8	0.9	0.3	1.3	0.8	0.8	0.8	0.7	0.1	1.1	0.9	1.1	0.6	0.1	2.2	0.9	0	0.3	0.2
3			0.5	0	0.5	1.2	0.3	0.5	0.3	0.2	1.6	1.4	0.2	0.3	0.5	0.2	0	0.3	1.5	0.2	0.2	0.3	0.2	0.9
5				1.5	2.1	1	0.3	0.6	1	2.4	0.8	1.3	1	0.2	0.3	0.2	1.2	0.1	2.1	1.8	0.3	1	1.3	0.7
6					0.5	0.9	0.5	0.3	1.6	0.7	1	2.2	2	1.9	0.5	0.9	0.2	0.3	0.4	2.6	0.8	0.4	0.3	1.9
7						0.7	0.9	0.5	0.6	0.9	2.3	1	0.6	0.7	0.9	1.4	0.9	1.2	1.5	0.3	1	1.6	1	2.2
13							0.5	0.1	1.4	1.3	0.7	0.1	1.3	0.4	0.5	0.4	1.5	1.9	0.3	0.5	0.3	0.6	0.3	1.9
14								0.5	0.6	0.4	0.8	0.5	1.3	1.2	0.1	2.3	1.6	0.3	2.4	1.5	1.3	0.9	2.5	0.1
24									1.4	0.3	0.1	0.2	2.3	1.1	1.9	0.7	0.7	1.3	0.1	1.5	2.1	0	0.8	2.1
26										0.1	1.2	0.8	0.7	0.9	1	1.1	0.2	0.3	0.6	2.2	0.1	0.6	1.1	1.8
30											0.6	0.6	0.1	0.3	0.2	1	0.3	1.4	0	0.3	0.7	1.2	1	0.1
34												4.7	0.9	1.1	1.4	0.3	0.4	0.3	0.7	0.2	0	0	0.6	0.1
37													1	2.4	0.2	0.5	0.3	0.5	1.9	0.4	0.1	0.6	0.1	1.1
40														1.1	0.3	0.7	1.9	1.1	0.4	0.1	0.8	0	1.2	1
45															0.8	0.3	1.9	1	1.3	1.2	0.2	0.3	2.5	0.4
46																1.3	0.2	0.6	1.2	0.3	0.1	0.1	0.6	0.4
47																	0.5	0.7	0.1	0.5	0.6	0.1	1.1	1.3
50																		0.5	1	0.3	1.2	1.4	3.3	0.8
56																			1	0.5	2.6	1	0.2	1.6
63																				1.3	1.1	0.2	0.6	1.6
69																					1.8	0.3	1	0.1
71																						1	0	1.3
74																							0.7	0.2
76																								1
84																								

Fig. 3. Student criterion coefficient matrix

According to the data given in the matrix in Fig. 3, we can see that the strong service connection of 37 and 34 is statistically significant. Service 76 is markedly related to service 50. This is evidenced by the value of the correlation coefficient of 0.6 for this pair of services, as can be seen from Fig. 2. This relationship is also statistically significant, as evidenced by the value of the *t*-criterion for this pair of services in Fig. 3.

The list of services related to services 37 and 76 according to our analysis is given in Tables 3, 4, respectively.

Table 3

List of services related to service 37 «State registration of other (other than ownership) real rights to real estate»

No.	Correlation coefficient	Service No.	Service name
1	0.71143376	34	State registration of ownership of real estate
2	0.45735186	45	Providing information from the State Land Cadaster in the form of copies of documents created during the maintenance of the State Land Cadaster
3	0.429127614	6	Issuance of a certificate to the notary office on the registration of the citizen's place of residence at this address on the day of death (for registration of inheritance, etc.)

Table 4

List of services related to service 76 «Appointment of monetary compensation for the cost of one-time natural assistance «baby box»»

No.	Correlation coefficient	Service No.	Service name
1	0.576879259	50	Providing state assistance at the birth of a child
2	0.470902426	14	Issuance of a certificate on the composition of persons registered in the dwelling
3	0.46632422	45	Providing information from the State Land Cadaster in the form of copies of documents created during the maintenance of the State Land Cadaster

Tables 3, 4 give the values of correlation coefficients that are statistically significant.

For the formation of portfolios of services based on the analysis, services are selected for which the presence of a strong statistically significant connection is established.

For the example in question, as a result, recommendations are formed for the creation of two portfolios of services – one includes services 34 and 37, and the other – services 76 and 50.

6. Discussion of results of studying the problem of statistical information analysis for the formation of a portfolio of services

The choice of statistical information and the generated dataset (Table 1) is due to statistical methods that make it possible to solve the problem.

To create a representative sample based on which data analysis will be carried out, taking into consideration the seasonal nature of individual services, it is advisable to take information on the provision of services at a half-year time period. For most services, a quarterly time period will suffice.

The developed algorithmic support («Algorithm for forming a portfolio of services based on determining a correlation between services») makes it possible to conduct a statistical analysis, based on which recommendations are formed for linking services to the portfolio.

The use of the *t*-criterion (2) makes it possible to distinguish links between services that are statistically significant. This ensures that the results obtained are reliable.

As a result of the statistical analysis, sets of services that are related are formed (the relationship of services is determined by checking the values of the paired Pearson correlation coefficient (1), the power of connection is determined from Table 2. The matrix of values of coefficients of correlation is shown in Fig. 2). The statistical significance of established relationships is determined by the Student criterion (2).

As a result of the implementation of the developed algorithm, it is recommended to form two portfolios of services that will further require an analysis of the feasibility of practical applicability:

– state registration of other (other (other than ownership) real rights to real estate; state registration of ownership of real estate (services 34 and 37);

– assignment of monetary compensation for the cost of one-time natural assistance «baby box»; state aid at the birth of a child (services 76 and 50).

It is not difficult to make sure that these services can indeed be ordered together or be developed simultaneously (together) with subsequent similar management within the service portfolio. However, it should be noted that the services grouped with the use of this mathematical apparatus require additional analysis for practical feasibility. Therefore, of these two service portfolios, the first (services 34 and 37) will be discarded, although it has all the signs to be used, since in practice such cases of application are rare, and the second (services 76 and 50) will be recommended for implementation.

It is worth noting that it is advisable to recommend linking the services of a joint or simultaneous development group, which, moreover, have a strong statistical connection. This may reduce the cost of reengineering or electronic rendering if these services also include joint documents or data.

The matrix of values of coefficients of the Student criterion is shown in Fig. 3. The recommendations for linking services to the portfolio are given in Tables 3, 4.

The correctness of the obtained results is ensured by the theoretical substantiation of mathematical methods of statistical analysis, which are used in studies [14, 15].

The formation of the received portfolios of services is explained by the choice of services, the relationship between which is strong and statistically significant (Tables 3, 4), which guarantees the reliability of the results obtained.

Our results in the form of sets of related services are recommendations and the final decision on the formation of a portfolio of services should be made by a public authority (bodies) responsible for policy-making in the relevant area.

The relevance of the recommendations obtained depends on the quality and quantity of statistics. Therefore, before using the algorithm, it is recommended to preprocess the data. It may involve the selection for the analysis of services, the number of requests for which exceeds the sample average.

The popularity of different services within the established portfolio of services may vary depending on the region.

The advantage of this approach is that, unlike the principle of the formation of complex services by life events, the proposed principle makes it possible to create a portfolio of services based on the analysis of statistical information on the provision of services. This will take into consideration hidden patterns, or implicit connections between services that are due to other reasons and are not related to one life event. That is, this approach is more flexible and makes it possible to take into consideration the interests of users and the peculiarities of the regions for which the analysis is carried out.

The limitations of the proposed approach are the need to collect and use statistical data on the provision of services. The completeness and quality of this information significantly affects the quality of the solutions received. In addition, the proposed approach can give different results for different regions.

The disadvantages of the approach include that obtaining a result is guaranteed in the case when there are services in the dataset, between which there are statistically significant strong links. If such links are not identified, then it is impossible to obtain recommendations for the formation of portfolios.

The advantage of implementing the proposed service portfolios is the ability to reduce the cost of reengineering

services or transferring services to electronic form, if in addition these services include joint documents or data, or belong to the joint development group.

As a development of this study, it is proposed to consider the problem of predicting the number of requests for services. This will make it possible to determine the priority of services in the reengineering of services.

It should also be noted that if it is possible to obtain various kinds of statistical data, a number of relevant and substantive principles for the formation of a portfolio of services can be formulated. Therefore, in order to improve the provision of electronic services, it is worth to be actively engaged in the collection and processing of such data. Consideration of other principles of formation of the portfolio of services is provided in further research.

7. Conclusions

1. The developed algorithm solves the problem of combining services for the formation of a portfolio by identifying hidden relationships between services. To do this, it is proposed to apply methods of statistical analysis. The principle of taking into consideration hidden dependences between services used in the algorithm makes it possible to combine services when creating portfolios that are not taken into consideration when creating complex services based on a life event. As a result of the algorithm, statistically significant strong links between services are determined, which guarantees the correctness and reliability of the results. Based on the identified links, recommendations for combining services into a portfolio are formed.

The formation of portfolios of services using the proposed algorithm makes it possible to expand the range of complex services. The introduction of service portfolios will enable users to order sets of services on one application, provide documents once and receive the results of services faster. This will unload the work of the authorities that provide services, as well as significantly simplify the process of obtaining the results of services for users. Thus, the introduction of service portfolios significantly improves the process of providing public services for all participants in the process.

2. The statistical analysis of information on the provision of services carried out within the framework of this study is the basis for the formation of recommendations for combining services into a portfolio, in contrast to the formation of comprehensive services based on life events, which is used in world practice. Connections between services are established on the basis of the analysis of the values of the coefficients of even correlation and verification of their statistical significance using the Student criterion. This substantiates the correctness and reliability of the results obtained. To conduct research and obtain the results of statistical analysis, an algorithm for forming service portfolios in the Python 3.10 programming language was implemented.

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