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METHODOLOGICAL ASPECTS OF DIGITAL TRANSFORMATION APPLIED TO PUBLIC SERVICES

Abstract. The article covers outputs of the research on development of methodological aspects applied under digital transformation of public services and based on the procedures suggested for formalizing the reengineering process used for related service provision administrative processes in accordance with the capacity delivered by advanced information technologies.

The Introduction outlines the issue in general, which is mostly related to the fact that the most of the general population enjoy no public services at all despite the implementation of the e-governance concept. It also analyzes the reasons resulting in a problematic situation described above which, among others, include complicated procedures used to both provide and access public (administrative services); lack of related information; lengthy terms of service provision caused by unavailability of information systems capable of ensuring proper data exchange between state electronic information resources and administrative bodies or agencies; lack of state standardization efforts in public service provision, etc. The analysis used to study recent research and publications confirmed that only general aspects of administrative processes used prior to public service provision in the electronic format has been more or less fully processed so far. As for the formalization of public service digitalization implemented through methodological approaches deemed as compatible for use, the matter at hand remains open and requires further research. With the above in mind, the paper states the purpose of related research formulated as the development of methodological support to digital transformation of public services while objectives of the above are focused on the formalization of the reengineering process for public services and development of related procedures fit for practical use.

The outputs of the research describe the general methodological approach to digital transformation of public services based on “as is” and “to be” models. The paper proposes to consider the Administrative Service Register as the information basis used to develop an “as is” model. A register as such contains unified service names, documents, standardized administrative process descriptions as well as results of an audit covering state electronic information resources. The developed “as is” model should be used as a frame to define service information links, to



implement audit and streamlining (reengineering) of public service provision procedures (administrative processes) as well as to integrate real life services. As a result, there will be designed the vision of public service provision (a “to be” model) to be implemented further on. The vision is defined as a technical option used to provide public services as a synthesis of service provision administrative processes and information processing tools. At the same time, the objective implying the vision development for a set of public services involves the selection of a specific option used to implement a set of related administrative processes while ensuring ultimate performance in terms of provision of a public service set concerned. The idea of the formalized objective is to select a set of administrative processes used for public service provision at service providers and data exchange between them with the use of related technologies ensuring minimum costs for the whole service set. According to the objective defined and aggregative–decomposition method applied, a respective solution is brought down to two stages: building a graph-based structure for administrative process options used under a certain set of public services (the “as is” model) in accordance with their links; afterwards, the above graph-based structure allows tracking the shortest route to define the appropriate option for administrative processes to be applied under the whole set of public services with the use of respective information technologies (the “to be” model, vision).

The Conclusion describes the major research outputs and further explorative prospects.

Keywords: public services; e-governance; interoperability; state electronic information resources.

1. INTRODUCTION

General problem statement. Ukraine has recently performed a bulk of work to improve the quality of public service provision for both its citizens and legal entities. At the same time, 37% citizens state the quality of services as satisfactory [1]. In the following years, the activities in this field will be continued to extend a network of Administrative Service Centres (hereinafter also referred to as “ASC”) and ensure 30 minute road traffic reach to the closest ASC via a solid roadwork. There are also parallel plans to continue activities related to simplification and transfer of all the services into the electronic format (starting with the major priorities), including smartphone access.

Relevant surveys [1] demonstrated that public administrations and local self-governance bodies provide more than 2,000 public services, but 91.5% of Ukrainian population use no electronic public services at all.

The reasons at the roots of the problem include overcomplicated provision and access to public (administrative) services; lack of related information; long provision deadlines due to the lack of information systems (hereinafter also referred to as “IS”) capable of ensuring exchange of data between state electronic information resources and administrative bodies. The problem is only worsened by the fact that not all the public services are available in the electronic format and low trust or awareness level of the electronic format used to access public services as well as low quality level of provided public (administrative) services in general.

Moreover, there is no state standardization for public service provision. For instance, the list, names and procedure used to provide administrative services are approved by local self-governance bodies (hereinafter also referred to as “LSGB”). As a result, depending on different LSGBs, different ASCs may have different names for the same service and require different lists of documents while the same documents might have different titles. In their own turn, the above cases both complicate the public service provision and enable subjective influence on service outputs.

Therefore, the majority of electronic public services provided in Ukraine belong to the EGDI Levels 1-3 under the UN Online Service Index [2] and commonly implement only



automated submissions of required documents by an applicant when direct performance of officials remains non-automated or automates inappropriate administrative processes while ignoring their analysis and reengineering.

With the above in mind, one of the goals set by the Cabinet of Ministers of Ukraine (Goal 14.1) considers that, “Ukrainians have access to all public services online” [3]. Specific objectives and activities defined to reach the Goal 14.1 consider systematic digital transformation (digitalization) of public service provision processes focused on filling and sorting the Administrative Service Register’s content (hereinafter also referred to as “ASR”), defining linked services and their combining with real life situations, performing the audit of public service provision procedures and related reengineering, verification of SEIR data and streamlining their operations as well as ensuring their connections to the electronic interaction system of SEIR.

Considering the scale of the above objectives, related implementation requires respective methodological support to facilitate performance of involved activities as well as final outputs. The **analysis covering the latest research and publications** proves that development of public services is currently covered by further expansion of the e-governance concept and introduction of related tools.

Hence, [4] studies the “public service” concept and defines intrinsic specifications of public services to review them under a related system approach. The above research also binds public services to other service types (state, administrative, municipal and social).

The textbook [5] provides the general concept of public, administrative, electronic, electronic administrative services, principles used to arrange integrated administrative service offices, processing of prerequisites and issues in the use of electronic administrative services as well as reviews the implementation of the above services both in Ukraine and beyond. However, the handbook mentions no methodological basis to be used for automation of public services.

[6] publishes outputs of the latest studies covering Ukrainian electronic registers to analyze the most popular 23 SEIRs in terms of their quality, validity and access to information stored therein. The research also provides results received as outputs of decomposition of specific administrative services. At the same time, it misses the issue related to the development of a methodological basis to be used.

The monograph [7] studies the legal nature of electronic services, their essence and specifics in activities of Ukrainian public administrations. It also defines the concept, features and criteria used for classification of electronic services and tools used to ensure their provision. It discloses the content of administrative procedures used by a public administration to provide electronic services. The work also studies international experiences in electronic service provision by public administrations and possibilities to apply it in Ukraine. It contains general recommendations on required analysis of the administrative process used in public service provision for high quality implementation of services in the electronic format.

The textbook [8] covers the organizational and management basis to implement electronic state services, issues related to the implementation of portals into the state governance system as an information and technological platform for provision of electronic state services for both citizens and businesses. It provides examples to be used for modelling electronic state service provision processes and their description standards. The work suggests using both “bottom-up” and “top-down” processing while formalizing the service provision in accordance with a UML notation.



Hence, recent research and publications prove a discussion currently ongoing within the scientific community regarding further development of electronic public services. At the same time, the analysis of the above surveys and works demonstrates that only general feasibility aspects of analysis and reengineering activities for administrative processes of public service provision have been fully researched so far before their implementation in the electronic format. As for the formalization of the public service digital transformation process with the use of methodological approaches fit for practical use, it remains open and requires further studies.

With the above in mind, the **general purpose of this article** is to develop methodological support to efficient digitalization of public services, with its objectives focused on the formalization of the public services reengineering process and development of related procedures fit for use in practice.

2. OUTPUTS

Digital transformation of public services under the e-governance concept considers the transfer from the analysis of functions, as tools for objective performance, to the analysis of processes and regulations to be used for performance of the above functions. The latter to be used for making decisions on those ISs which are deemed as required by the state in order to implement the processes involved.

At the same time, formalization and standardization of state service and administrative process descriptions ensures significant benefits for public administrations, local self-governance bodies and public service users, which include a general structure used to describe all the services available for a service provider, use of unified national information support (ASR, service references, documents, etc.) simplifying IS development processes for public service provision and state information management while ensuring high quality interoperability; the above enable related users simpler navigation in a set of various public services while service providers obtain simpler management decision-making processes [7].

As a matter of the general concept (at the aggregation meta-level), the objectives posed under the digitalization of public services may be presented as “classical” model development objectives (“as is” and “to be”).

ASR [9] is more feasible for use as source data for “as is” modelling. In addition to ASR, inputs on public services might as well be contained within pre-developed automated ISs for public service provision on the national level. The latter may include the Software Complex for Administrative Service Centres (the “Vulyk” Information System), as a subsystem of the Electronic Interaction System of Executive Bodies (hereinafter also referred to as “EISEB”) [10]. Therefore, the primary objective is to fill and sort the current ASR to acquire relevant, valid and systematized data on available public services. In order to perform the above, there is a need in ensuring an opportunity for inserting the whole list of public services provided by both public administrations and LSGBs.

At the same time, the analysis of public services in terms of their unification and standardization regarding related service names and lists, required data and document titles, be it provided or submitted, should be arranged as a separate stage. The analysis should result in ASR synthesis based on unified information support to be further used as the basic infrastructural element for providing both administrative services and the whole list of public services considered.

SEIR audit outputs should be also applied for “as is” modelling in terms of their interoperability and use in public service provision. SEIR interoperability aspects involve available electronic interaction with other SEIRs, including the use of the “Trembita” Electronic Information System for SEIR [11] described by related exchange protocols (the “request-response” structure). Information on SEIR’s use for public service provision should be also available: a list of services using SEIR data as well as list of documents generated and based on SEIR information.

A fully designed “as is” model should be used as the basis to determine the information links between services, to audit and streamline (reengineer) the procedures (administrative processes) for the provision of public services as well as to integrate services related to real life situations. The above activities would result in a vision of public service provision (the “to be” model) for further introduction.

The vision mentioned above is a technical option used to provide a set of public services defined as an output of synthesis between service provision administrative processes and capacity of information processing tools [12, 13]. At the same time, the objectives used to define IS’ structures are closely related to their streamlining objectives. Therefore, the objective covering the provision of a set of public services is to select an option as such for related administrative processes and achieve the ultimate performance when providing a set of public services. Respective solutions are partially defined in [14], but we are going to state the basic provisions of the scope of public services to ensure integrity of the presented materials.

Let us introduce the following definitions:

S – a set of public services;

A – a set of administrative processes (options) to provide services concerned; and

IT – a set of information processing tools to cover information technologies (hereinafter also referred to as “IT”), national and sectoral ISs, SEIR, electronic information systems, automated working stations, software applications, etc. Since IT is a kit of systematically coordinated hardware-software elements, this enables, firstly, cutting the extent of the vision development objective, and, secondly, acquiring pre-developed partial “to be” solutions.

Then the vision development objective would generally consider finding the \mathfrak{R} mapping of the S public service set on the A administrative processes, their provision and IT information processing tools:

$$\mathfrak{R} : S \rightarrow (A \times IT), \quad (1)$$

ensuring the provision of the grand total of linked public services at minimum costs $Z \rightarrow \min$.

According to the need in developing an “as is” model and vision, the \mathfrak{R} mapping should be represented as follows: $\mathfrak{R} = \mathfrak{R}_1 \circ \mathfrak{R}_2$, wherein

$$\mathfrak{R}_1 : S \rightarrow A, \quad (2)$$

$$\mathfrak{R}_2 : (A \times IT) \rightarrow A_{opt}. \quad (3)$$

The mapping (2) – is the mapping of the S public service set on the A administrative process set used for their provision; and the mapping (3) is the mapping of the A administrative process set and IT information processing tool set on a vision based on the appropriate A_{opt} option to implement administrative processes used for the whole set of S public services.

Hence, digital transformation of public services under (1)-(3) is the selection of an A_{opt} option for implementation of administrative processes and reaching the ultimate provision

performance for the whole set of the S public services. All the above requires solutions to two interrelated objectives:

- to define administrative processes in a set of public services (the “as is” model); and
- to define an appropriate option for administrative processes under the whole set of public service provision with the use of IT (the “to be” model, vision).

Let us introduce and detail the following definitions for further review:

$S = \{s_i | i = \overline{1, N}\}$ – a set of public services;

$E_i = \{e_{ij} | j = \overline{1, n_i}\}$ – a set of options (solutions) for the i -th public service;

$D = \{d_k | k = \overline{1, K}\}$ – a set of organization structure elements (nodes) – ASCs and service providers (departments, services, offices, sectors, units, etc.);

$B_k = \|\beta_{ijk}\|$ – the provision cost matrix for the i -th service with the use of the j -th option at the k -th node;

$\Gamma = \|\gamma_{kk'}\|$ – the inter-node information transfer cost matrix (for non-linked nodes $\gamma_{kk'} = \infty, \gamma_{kk} = 0$).

As a rule, when implementing administrative processes, information flows currently auto-circulate mostly within local units of a single service provider which is not connected to other service providers in terms of information transferred. The above cases generally have negative influence on generation and making of decisions related to public service provision.

In order to account for the above drawback, let us introduce the $A = \|\alpha_{ii'jj'}\|$ information link matrix for different solutions ($i \neq i'$). The e_{ij} and $e_{i'j'}$ options are deemed as linked with the use of final or intermediary solution outputs for the i' -the service with the j' -th option when providing the i -th service with the j -th option.

Let us introduce the following definitions to consider the IT capacity which can be used under the public service provision and information exchange between different nodes:

$IT = \{it_l | l = \overline{1, L}\}$ – a set of information technologies;

$V_l = \{v_{lc} | c = \overline{1, C_l}\}$ – a set of specifications defined for the l -th information technology;

$W_{ij} = \{w_{ijf} | f = \overline{1, F_{ij}}\}$ – a set of requirements to the i -th service with the j -th option; and

$R_{kk'} = \{r_{kk'h} | h = \overline{1, H_{kk'}}\}$ – a set of requirements to inter-node information transfer (k and k').

With the above in mind, the objective is to select an option of administrative process for public service provision in specific nodes and transfer information in-between with the use of related ITs allowing for minimum costs for provision of the whole set of services.

This objective may be formalized in the following way:

$$\min_{\{x_{ijk}, y_{ijl}, b_{kk'l}\}} \left[\sum_{\{i'j'k'\}} z_{ijk'i'j'k'} x_{ijk} x_{i'j'k'} \right], \quad (4)$$

wherein $z_{ijk'i'j'k'} = \begin{cases} \beta_{ijk} \cdot y_{ijl} & , \text{if } ijk = i'j'k' \\ \alpha_{ii'jj'} \cdot \gamma_{kk'} \cdot b_{kk'l} & , \text{if } ijk \neq i'j'k' \end{cases}$

$x_{ijk} = \begin{cases} 1, & \text{if the } i\text{-th service is provided with the } j\text{-th option at the } k\text{-th node;} \\ 0, & \text{reverse;} \end{cases}$
 $y_{ijl} = \begin{cases} 1, & \text{if the } j\text{-th option of the } i\text{-th service is provided with the use of the } l\text{-th IT;} \\ 0, & \text{reverse;} \end{cases}$
 $b_{kk'l} = \begin{cases} 1, & \text{of information between the node } k \text{ and the node } k' \text{ is transferred with the} \\ 0, & \text{use of the } l\text{-th IT;} \\ & \text{reverse,} \end{cases}$

under the following restrictions:

$$\sum_{\{j,k\}} x_{ijk} = 1; \quad (5)$$

$$\sum_{\{f\}} w_{ijf} \leq \sum_{\{c\}} v_{lc} \cdot y_{ijl}; \quad (6)$$

$$\sum_{\{h\}} r_{kk'h} \leq \sum_{\{c\}} v_{lc} \cdot b_{kk'l}. \quad (7)$$

Within (4), the $z_{ijk'i'k'}$ value defines the costs for the i -th service provision with the j -th option at the k -th node with the use of the l -th IT if $ijk = i'j'k'$, and costs of inter-node information exchange with the use of a related IT – when reverse. The restriction (5) prevents provision of the i -th service with different options at different nodes at the same time, and restrictions (6) and (7) define compliance with requirements to service provision or information transfer by related ITs.

In order to perform the objective (4)-(7) in practice, the aggregative-decomposition approach [15] is commonly used to define an appropriate option for service provision as a solution to linked objectives: generation of a set of possible options for the whole set of services to be provided and selection of an option from the above set which considers minimum costs.

Graph theory methods are currently the most common solutions to this class of objectives and tasks, which allow formatting the objective at hand as follows.

Let us define $S = \{s_i | i = \overline{1, N}\}$ as a set of public services, $E_i = \{e_{ij} | j = \overline{1, n_i}\}$ – as set of administrative process options for provision of the i -th service, and $A = \|\alpha_{i'ij'}\|$ – as the information link matrix between public service provision options ($i \neq i'$). Each E_i set is defined by the estimated graph $G_i(X_i, Y_i)$, wherein $X_i = \{x_{il} | l = \overline{1, n_i}\}$ is a set of vertices – information processing operations used for administrative process options of the s_i service, and $Y_i = \{y_{ilk} | k = \overline{1, m_i}\}$ is a set of edges defining the procedure used to perform the above operations. Each e_{ij} option is a respective path under the G_i graph considering the z_{ij} costs for implementation thereof. It is necessary to track the same e_i path per G_i graph to acquire the minimum total cost Z for implementation of their set $\mathring{A} = (e_1, e_2, \dots, e_N)$: $Z = \min \sum_{i=1}^N z_i$, wherein z_i are costs to implement the e_i option.

At the same time, selectable options are restricted. Should any option of an administrative process used to provide the s_i service have links with several options of the $s_{i'}$ service, only one of the options for the i' -th service shall be selected when providing the i -th service with this option, which is

$$\text{if } \alpha_{ijj'} \neq 0 \ \& \ e_{ij} \in E, \text{ then } e_{ij'} \in E. \quad (8)$$

The economic component of costs spent for public service provision reflects the value of information processing tools and implementation of ITs used in therein.

With the above in mind, the z_{ij} costs spent to implement the e_{ij} option to perform the i -th objective shall be calculated as follows:

$$z_{ij} = t_{ij} \cdot \lambda_t + c_{ij} \cdot \lambda_c, \quad (9)$$

wherein t_{ij} is the time estimated to implement an administrative process for the i -th service with the j -th option ($\sum_{i,j} t_{ij} = 1$); c_{ij} are estimated costs to implement the e_{ij} ($\sum_{i,j} c_{ij} = 1$) option; λ_t and λ_c are weight ratios for timeliness and cost indicators ($\lambda_t + \lambda_c = 1$).

Therefore, in accordance with a set objective, a related solution shall be implemented in two stages: the initial generation of a graph structure for options of administrative processes for a set of public services (the “as is” model) while accounting for their links; subsequently, the minimum path shall be tracked within the graph structure to define an appropriate option of an administrative process used to provide the whole set of public services with the use of an IT (the “to be” model, vision).

The graph structure shall be initiated by decomposing an administrative process of each s_i public service down to the r_{ij} information processing functional operation level. The r_{ij} functional operation is defined as an information processing action (function).

A technological and information card of a related public service [16, 17] as well as other inputs from a unified and standardized ASR should be used to decompose. According to [17], a technological card contains information on a procedure used to provide a public service by a related service provider. Information contained within a technological card shall comply with regulatory and legal acts setting a procedure, deadline and terms for a public service provision.

A technological card contains:

- 1) stages of processing an application (request) for an administrative service;
- 2) a responsible official at an administrative service provider's;
- 3) structural units of an administrative service provider responsible for specific stages (action, solution); and
- 4) stage deadlines (action, solution).

Processing stages for provision of a public service shall be defined in accordance with regulatory and legal acts setting a procedure for service provision. They commonly include the following activities:

- 1) registration of an application (request) submitted by an applicant;
- 2) processing of an application (request) and formalization (approval) of an output of a public service provided by structural units and officials of a service provider and other involved agencies and bodies to acquire information, solutions or responses required to provide a specific public service as well as administrators – when a related service is provided by an ASC – while defining the deadlines for involved activities; and
- 3) public service output and registration thereof.

Each functional operation r_{ij} of the service s_i shall be assigned with possible it_{ij} tools for its implementation. The latter can be selected in accordance with logical equivalence of functional activities. Let us define r_{ij} as the j -th functional operation of the i -th service, $IT = (it_1, it_2, \dots, it_m)$ - as a set of information technologies, and $\Psi(r_{ij})$ and $\Psi(it_k)$ - as functional

actions (functions) implemented by the r_{ij} operation and it_k technology, respectively. The $it_k \in IT$ technology is deemed as the one capable of implementing the r_{ij} functional operation only if $\Psi(r_{ij}) \parallel \Psi(it_k)$, wherein „ \parallel ” is the logical equivalence sign of functional actions concerned. The selection of possible information technologies to implement each r_{ij} functional operation results in generation of e_{ij} options of administrative processes used to provide the s_i service.

In order to account for possible use of public service outputs, their options are connected information-wise. The above activity involves the aggregative description of each r_{ijk} operation of the e_{ij} option of the s_i public service:

$$W_{ijk} = r_{ijk}(V_{ijk}), \tag{10}$$

wherein $V_{ijk} = (v_1^{ijk}, v_2^{ijk}, \dots, v_{n_{ij}}^{ijk})$ і $W_{ijk} = (w_1^{ijk}, w_2^{ijk}, \dots, w_{m_{ijk}}^{ijk})$ are incoming and outgoing data vectors of the r_{ijk} operations, with documents (certificates, excerpts, copies, etc.) used as elements of the above data.

Afterwards, optional operations of various services are reviewed. If the v_d^{ijk} incoming information elements of the r_{ijk} operation are equivalent to the w_b^{ghl} ($i \neq g$) outgoing information elements of the r_{ghl} operation, the r_{ghl} operation shall be deemed as an alternative source of information for the r_{ijk} user information, with a link set in-between (graph edge), which results in the additional e_{ij} option to provide the s_i service. Such an option is generated in accordance with the user-vertex separation.

Let us define r_{ijk} as the user-vertex within the Graph G_{ij} . This vertex is separated by introducing the new r_{ijq} vertex into the Graph G_{ij} to reflect an operation of receipt of data incoming from an alternative information source. At the same time, the r_{ijq} vertex is linked to the r_{ghl} source vertex as well as the r_{ijk} vertex and the one preceding the preparation of source data for r_{ijk} (Fig. 1).

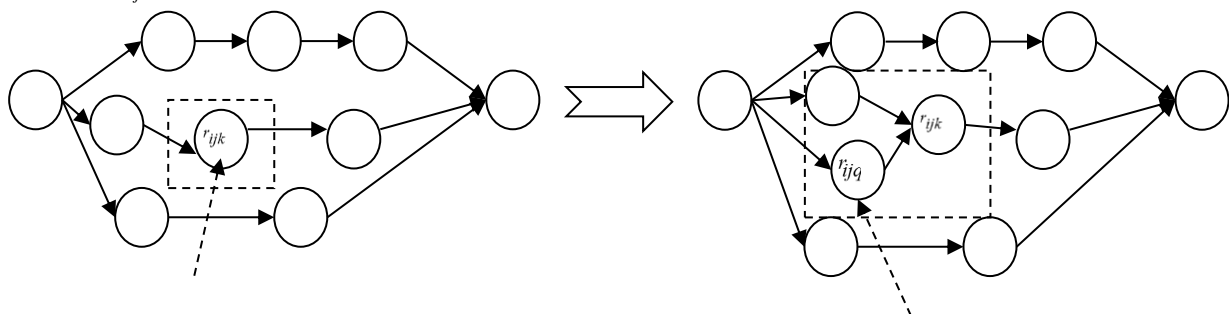


Fig. 1. r_{ijk} User-Vertex Separation

Costs for implementation of generated additional e_{ij} options to provide the s_i service are defined in the same way.

As a result, we have a set of possible options for the whole set of public services described with a related graph (Fig. 2).

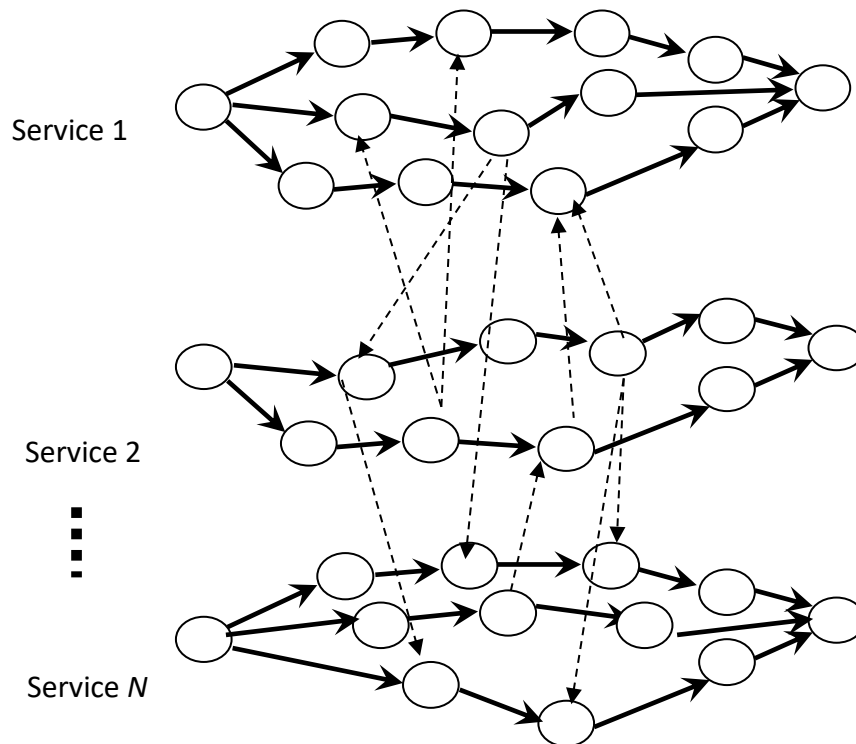


Fig. 2. Solution Graphs

The provided graph structure further *tracks the minimum path* to define an appropriate option for administrative processes used to provide the whole set of respective public services.

The z_{ij} costs used to implement each e_{ij} option shall be defined first in accordance with (9). A network graph shall be designed for each e_{ij} option in accordance with the Program (Project) Evaluation and Review Technique (hereinafter also referred to as “PERT”).

Both dummy and real activities are used to design network graphs: a real activity is the one requiring specific operations for proper performance; a dummy activity requires no costs and only points at a functional link.

The t_{ij} time to implement the e_{ij} option is defined within a designed network graph. The critical path is measured from the initial to the final network vertex under the following formula: $t_{ijk} = \max\{t_{ijk} + t_{ijl}\}$, wherein k defines the current r_{ijk} vertex, and $l - r_{ijl}$ vertex in direct connection to r_{ijk} . Full maximum e path in a related G_{ij} Graph will be defining the t_{ij} time to implement the whole set of operations: $t_{ij} = \max \sum_{k=1}^{n_e} t_{ijk}$, wherein n_e is the number of e path vertices.

The t_{ijk} time to implement each operation is calculated as follows:

$$t_{ijk} = \sum_{l=1}^n v_l \cdot t_{ol}^{ijkl}, \quad (11)$$

wherein t_{ol}^{ijkl} is the estimated time to perform the k -th operation defined by the score of the l -th expert;

n – number of experts;

v_l – weight ratio of the l -th expert ($\sum_{l=1}^n v_l = 1$).

The c_{ij} cost to implement the e_{ij} option is defined as follows:

$$c_{ij} = \sum_{k=1}^{m_{ij}} \frac{c'_{ijk} + c''_{ijk}}{2}, \quad (12)$$

wherein m_{ij} is the number of operations under the e_{ij} option; $c'_{ijk} = \sum_{l=1}^n c'_{ijkl} \cdot v_l$ and $c''_{ijk} = \sum_{l=1}^n c''_{ijkl} \cdot v_l$ are weighted scores of both minimum and maximum costs to implement the k -th operation of this option; c'_{ijkl}, c''_{ijkl} are lower and upper thresholds of the cost estimate for implementation of the k -th option operation defined by the l -th expert; n is the number of experts; and v_l is the weight ratio of the l -th expert ($\sum_{l=1}^n v_l = 1$).

As soon as the z_{ij} costs to implement each e_{ij} option have been defined on the graph structure, there is a need in selecting an option to provide the whole set of public services at minimum costs, which is equivalent to tracking the minimum path for the same graph. At the same time, if a selected option of the same service is linked to an option of another service, these options are included into this path.

Considering the type of the graph at hand and defined restrictions, the minimum path can't be defined with available methods. Therefore, this objective is brought down to a classical task through a graph structure (Fig. 2) transformed into a standard view, whereat vertices represent solutions of information and analytical assignments (objectives), and edges define their links in accordance with the $A = \|\alpha_{ijj'}\|$ matrix as well as related costs spent.

In accordance with an objective set under the graph structure (Fig. 2), tracking the minimum path with the use of common algorithms is deemed as impossible. Therefore, it is suggested performing this objective as a classical one by bringing the designed graph structure to a standard one through aggregation. Specifically, this structure must be used to build the G' graph with its vertices representing solutions of related objectives and tasks as well as arcs representing their links in accordance with the set restrictions (8) under the $A = \|\alpha_{ijj'}\|$ matrix.

Let us assume that $E_i = (e_{i1}, e_{i2}, \dots, e_{in_i})$ is a vector of options to provide the i -th service.

Step 1. Sorting out E_i^T vectors in accordance with service numbers. The E_i^T vector elements correspond to the G' graph vertices (Fig. 3). At the same, there is a difference between basic e_{ij} options of service provision and additional $e_{ij'}$ options derived through separation of related vertices.

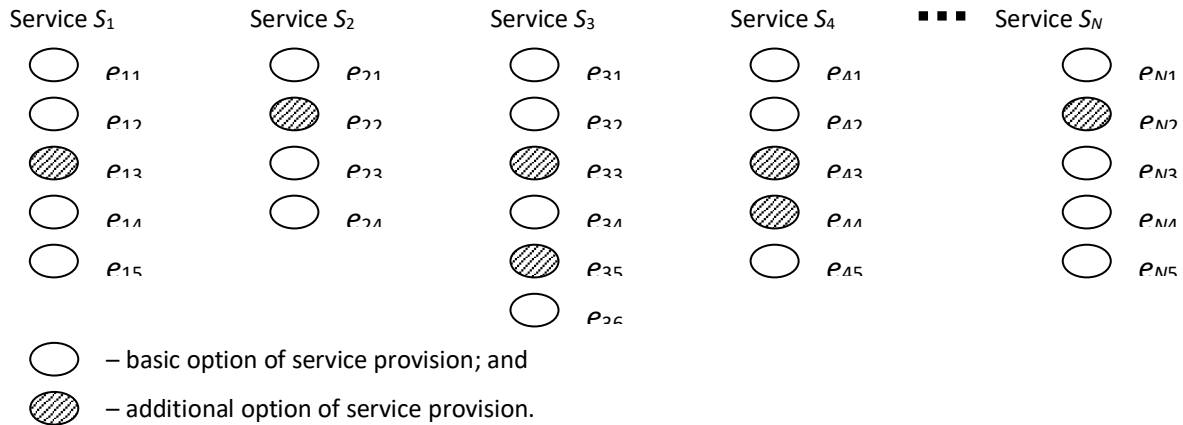


Fig. 3. Sorting Out Service Provision Options

Step 2. Reviewing related services s_i and s_{i+1} ($i = \overline{1, N-1}$) and setting links between their options in accordance with related $M_{i(i+1)}$ matrixes. In addition, links between all e_{ij} options of the s_i service and basic $e_{(i+1)k}$ options of the s_{i+1} service as well as between non-related additional $e_{(i+1)l}$ options of the s_{i+1} service and all basic e_{ij} options of the s_i service (Fig. 4) are set. Afterwards, the next service pair is selected, and the process is reiterated.

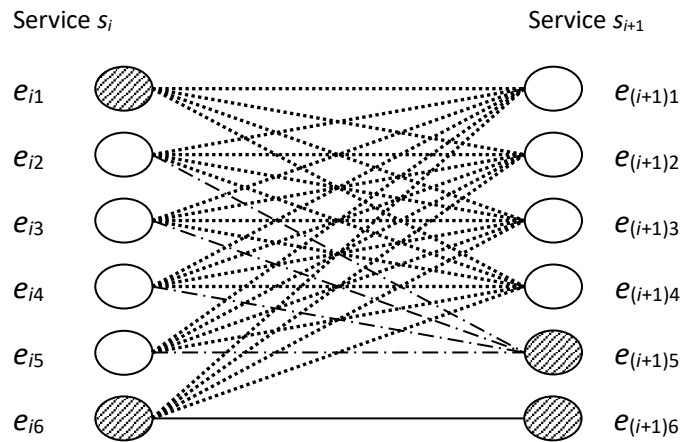


Fig. 4. Connecting Solutions for Related Objectives and Tasks

Step 3. A graph designed in a way described above is extended with the initial and final vertices linked with all options of the s_1 and s_N services respectively (Fig. 5).

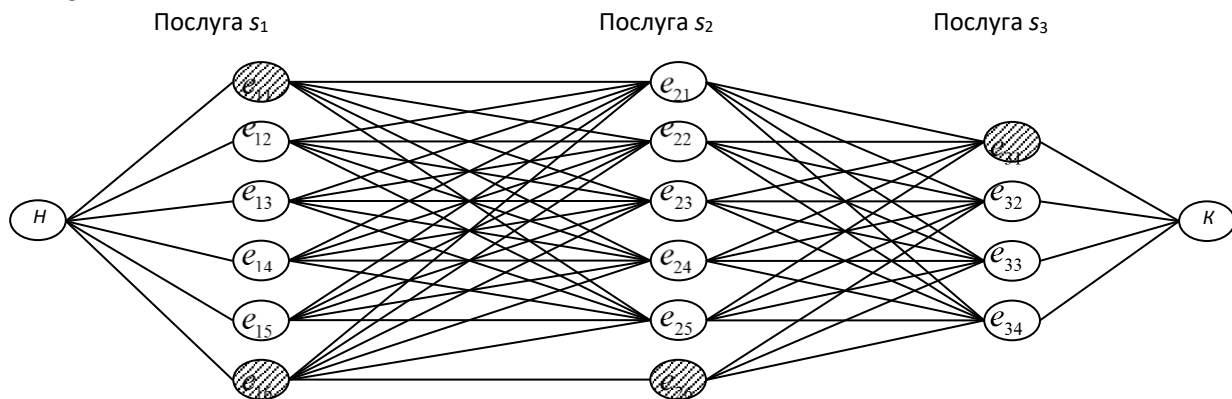


Fig. 5. Sample G Graph for Three Service Provision Options

Step 4. Each u_{ijkl} arc connecting e_{ij} and e_{kl} options is related to z_{ij} expenses to implement the e_{ij} option. The arcs connecting the initial H vertex have zero weight, and arcs from e_{Nj} options to the final K vertex have the z_{Nj} weight.

The G' Graph designed in a way described above has the structure which allows tracking the $E = \{e_i | i = \overline{1, N}\}$ minimum path with the use of common algorithms. Considering the fact that the G' Graph is oriented, as well as due to the calculation complexity to implement such algorithms [18], tracking such a way should be done under the Dijkstra's algorithm [19].

As a result, the E Path will represent an appropriate option for administrative processes used to provide the whole set of public services with the use of respective ITs (the “to be” model, vision).

3. CONCLUSIONS AND FURTHER EXPLORATIVE PROSPECTS

The suggested formalization of the digital transformation process for a set of public services by setting and reaching related streamlining (optimization) objectives enables structuring the reengineering process of public services with a set of procedures which can be used as methodological support in a set.

Digitalization of a set of public services considers selection an option of an administrative process used for provision to be defined in accordance with service costs under the organization structure concerned as well as information exchange in-between with the use of related information technologies to ensure minimum costs for provision of the whole set of public services.

In accordance with an objective set and aggregative-decomposition approach used, the related solution should be handled in two stages: firstly, the graph structure for options for administrative processes to be used for provision of a set of public services is designed (the “as is” model) in accordance with respective links. Further, the minimum path is tracked within the graph structure to define an appropriate option of administrative processes to be used for provision of the whole set of public services while applying related information technologies (the “to be” model, vision).

The Administrative Service Register is suggested as source data for “as is” modelling. The analysis of public services in terms of their unification and standardization by names and



service lists, required data and document titles submitted and received, etc. is another stage. It is also proposed to use the outputs of an audit covering state electronic information registers in terms of their interoperability and use under the service provision for building an “as is” model.

In accordance with the “as is” model and using pre-developed procedures, information links between administrative processes of public service provision are defined, options of administrative processes are formed in accordance with alternative information sources and information technologies used for implementation. The above should result in the development of a vision for public service provision (the “to be” model).

The further field of research should involve the development of simulation models and digital transformation technologies for public services based on the suggested mechanisms.

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МЕТОДИЧНІ АСПЕКТИ ЦИФРОВОЇ ТРАНСФОРМАЦІЇ ПУБЛІЧНИХ ПОСЛУГ

Анотація. В статті розглянуті результати дослідження щодо розробки методичних аспектів цифрової трансформації публічних послуг на основі запропонованих процедур формалізації процесу реінжинірингу адміністративних процесів їх надання з урахуванням можливостей інформаційних технологій.

У вступі окреслено проблему в загальному вигляді, яка полягає у тому, що не дивлячись на значні результати із впровадження концепції електронного урядування, переважна більшість населення не користується електронними публічними послугами. Проаналізовані причини такої проблемної ситуації, серед яких слід відмітити надмірно складні процедури надання та отримання публічних (адміністративних) послуг, недоступність інформації про них; тривалі строки надання послуг через відсутність інформаційних систем, які здатні забезпечувати обміну даними між державними електронними інформаційними ресурсами та адміністративними органами; відсутність державної стандартизації надання публічних послуг. Аналіз останніх досліджень та публікацій засвідчив що на цей час достатньо повно опрацьовані тільки загальні аспекти доцільності проведення робіт з аналізу та реінжинірингу адміністративних процесів надання публічних послуг перед їх реалізацією у електронному форматі, що ж до питання формалізації процесу цифрової трансформації публічних послуг за рахунок придатних для практичного використання методичних підходів, то воно як і раніше залишається відкритим і потребує подальших досліджень. З урахуванням цього сформульовано мету досліджень, яка полягає у розробці методичного забезпечення цифрової трансформації публічних послуг, а завдання дослідження полягає у формалізації процесу реінжинірингу публічних послуг та розробці відповідних процедур, які придатні для практичного використання.

У результатах дослідження описується загальний методологічний підхід до цифрової трансформації публічних послуг, який полягає у побудові моделей «як є» (as is) і «як потрібно» (to be). Запропоновано в якості інформаційної основи побудови моделі «як є» розглядати реєстр адміністративних послуг, який містить уніфіковані назви послуг, документів, стандартизовані описи адміністративних процесів, а також результати аудиту державних електронних інформаційних ресурсів. Після побудови моделі «як є» на її основі необхідно визначити інформаційні взаємозв'язки послуг, провести аудит та оптимізацію



(реінжиніринг) порядків (адміністративних процесів) надання публічних послуг, а також комплексувати послуги, які пов'язані за життєвими ситуаціями. В результаті буде побудовано обрис надання публічних послуг (модель «як потрібно»), який далі необхідно впровадити. Під обрисом розуміється технічний варіант надання сукупності публічних послуг, який визначається в результаті синтезу адміністративних процесів надання послуг і можливостей засобів обробки інформації. При цьому завдання побудови обрису надання сукупності публічних послуг полягає у виборі такого варіанту реалізації сукупності відповідних адміністративних процесів, при якому досягається максимальна ефективність надання сукупності публічних послуг. Здійснено формалізацію завдання, яке полягає у виборі такого варіанта адміністративних процесів надання публічних послуг у суб'єктах надання послуг і обміну інформацією між ними з використанням відповідних інформаційних технологій, при яких досягається мінімум витрат на надання всієї сукупності послуг. Враховуючи постановку завдання та застосування агрегативно-декомпозиційного підходу, його вирішення здійснюється в два етапи: спочатку будується графова структура варіантів адміністративних процесів сукупності публічних послуг (модель «як є») з урахуванням їх взаємозв'язку, а потім у цій графовій структурі знаходиться мінімальний шлях, який і буде визначати оптимальний варіант адміністративних процесів надання всієї сукупності публічних послуг з використанням інформаційних технологій (модель «як потрібно», обрис).
У висновку описані основні результати дослідження та перспективи подальших розвідок.

Ключові слова: публічні послуги; електронне урядування; інтероперабельність; державні електронні інформаційні реєстри.

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