Knowledge Graphs for Public Service Description: The Case of *Getting a Passport* in Greece

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Abstract. An important part of electronic Government is the provision of high quality Public Services (PS) to citizens. Towards this goal, the European Commission has proposed the Core Public Service Vocabulary (CPSV), as a PS data model to be used across the public sector. CPSV is adequate for use in the case of simple PS however its effectiveness is questionable in the case of complex PS. A complex PS is one having many (often complicated) rules interrelating its concepts, e.g. dictating citizens have to submit different documents to invoke a PS based on their profiles and circumstances. The aim of this paper is to investigate the use of Knowledge Graphs (KG) for providing personalized information on PS modeled using CPSV. For this purpose, we develop and evaluate a KG for PS "*Get a passport*" in Greece as a proof-of-concept to study mapping of CPSV to KG. For simplicity, we limit our scope to developing a KG that can provide the input documents and the relevant cost required for obtaining a passport by citizens based on their profile and circumstances. Free software GRAKN.AI was employed for the development of the KG.

Keywords: E-government · Knowledge graph · Public service provision · CPSV · Get a password · Grakn

1 Introduction

During the past 20 years, electronic Government (eGov) has become a political priority worldwide [1–3]. To a large extent, eGov refers to the provision of better Public Services (PS). Increased PS quality is related to personalised, citizen-oriented services.

PS provision is based on an underlying *PS model*, i.e. a data model proposed for describing and/or developing PS. A PS model includes concepts such as title, description, cost, legal framework, required documents (input), output etc. Adopting a universal, standard PS model could accelerate eGov systems development thus saving billions of Euros [4] and resolve eGov interoperability obstacles, which cost 68 billion Euros per year to the EU economy [5]. Recently, EC and EU member states introduced Core Public Service Vocabulary (CPSV) as a proposed standard PS model to be used across the EU. CPSV has high potential to resolve significant interoperability problems however its use is limited. Recent research revealed that although CPSV is useful for simple PS it is not equally useful to accommodate complex PS [4, 6]. A *complex PS* is

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one having many (often complicated) rules interrelating its concepts, e.g. dictating citizens have to submit different documents or suffer different costs to invoke a PS, based on their profile or other legal conditions.

PS provision can be divided into two phases: the informative phase where citizens (or businesses) seek information about PS (e.g. documents to be submitted, cost etc.) and the performative phase where they actually invoke the PS and obtain its result [7]. In this paper we concentrate on the PS informative phase.

Information about PS is often provided by public authorities in their websites or using PS catalogues. This approach however faces significant challenges, as these websites do not provide personalised information particularly regarding complex PS.

Recently, knowledge graphs (KG) have started to attract attention due to their interesting characteristics [8]. KG can help citizens, employees and public servants make better decisions by identifying knowledge faster and easier [9]. KG inherently support rules thus seem a potentially interesting technology for providing personalized information on complex PS. This however has not been yet exploited particularly for PS based on CPSV.

The aim of this paper is to investigate the use of KG for providing personalized information on PS modeled using CPSV. More specifically, we develop and evaluate a KG for PS *Get a passport* in Greece as a proof-of-concept to study mapping of CPSV to KG. For simplicity, we limit our scope to developing a KG that can provide the input documents and the relevant cost required for obtaining a passport by citizens based on their profile and circumstances. For this reason, our study does not include all CPSV concepts e.g. Output, Public Organization etc. For KG development the free software GRAKN.AI was employed.

The rest of this paper is structured as follows. Section 2 outlines background work related to methods for providing personalized PS information, CPSV, Knowledge Graphs and Grakn. Section 3 presents the methodology. Section 4 illustrates the development of a KG for "Getting a passport" in Greece. Finally, conclusions are drawn in Sect. 5.

2 Background Work

2.1 Methods for Providing PS Information About Public Services

Information about PS is often provided in websites or PS catalogues. An example is www.passport.gov.gr providing information about getting a Greek passport. National one-stop government portals also contain PS information including PS descriptions. Dialogue-based systems have been also investigated by researchers (e.g. [10]) and operationally used by the public sector, e.g. benefits.gov in the USA. Interactive Voice Response (IVR) systems and chatbots [11] have also been employed by public authorities for the same purpose [12].

2.2 Core Public Service Vocabulary

In 2013, the European Commission (EC) in the framework of ISA and ISA^2 programs, proposed the Core Public Service Vocabulary (CPSV) [13] as a modular, extensible, context, syntax and technology-neutral PS data model. Based on CPSV, an Application Profile (CPSV-AP) [14] was developed in 2014 that exploits Linked Open Data (LOD) as an underpinning technology. An Application Profile is a specification that reuses terms from other standards, adding more specificity by identifying mandatory, recommended and optional elements, as well as by defining controlled vocabularies to be employed. The main objective of CPSV-AP is the description of public services and life or business events for the Points of Single Contact which each Member State had to implement in the context of the EU Services Directive (2006/123/EC).

Figure 1 illustrates an extract of CPSV-AP. This diagram contains only those classes with particular interest for our study, namely *Public Service* that represent the PS itself, *Evidence* that represents the needed input documents for invoking the PS, *Cost* that represents the PS cost, and *Rule* that represents a document that sets out the specific rules, guidelines or procedures that the PS follows (it is noted that CPSV-AP does not envisage instances of the Rule class as machine-readable business rules).

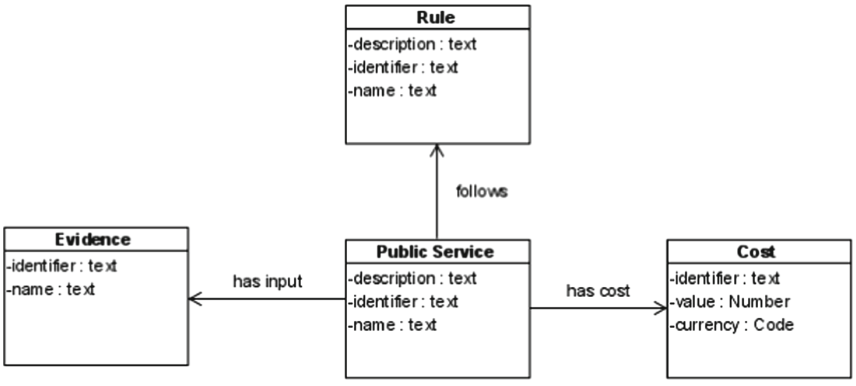

Fig. 1. Extract of CPSV-AP ver. 2.2.1 (adapted from [13])

CPSV has been used in a number of EU members states [15–19]. For example, Belgium has used CPSV-AP to centralize different regional sources into one user-centric portal. Estonia has extended and used CPSV-AP to address local needs. Finland, Ireland, Italy, Portugal, Spain, Netherlands and Slovakia have also used CPSV-AP to create a national data model. Finally, in Greece, the Region of Epirus has used CPSV-AP to model their public services [6].

2.3 Knowledge Graphs

The term *Knowledge Graph* is increasingly used after it was introduced by Google in 2012. Since then, a number of researchers have attempted to formally define it.

According to [20] *"Knowledge graphs are large networks of entities, their semantic types, properties, and relationships between entities."* In other words, a KG represents knowledge using a graph structure. The main elements of a KG are four. *Entities* are the nodes of the graph. *Attributes* are the properties of the entities, i.e. a piece of information that characterizes entities. *Relations* connect two or more entities and are represented as arcs in the graph. The last and most important concept of a KG are rules. The use of rules largely determines the behavior of a graph. *Rules* enable the discovery and derivation of new knowledge that would otherwise be difficult to detect. In order to define a KG, its entities, attributes, relations and rules have to be defined.

In Fig. 2a simple KG is presented as an example. *Public Service*, *Public Organization* and *Country* are entities; *identifier* and *name* are attributes; *is located at* and *has competent authority* are relations of the KG. A simple rule of the KG suggests that if a PS has a Public Organization (PO) as competent authority and this PO is located at a specific country, then the PS itself is located at the same country too.

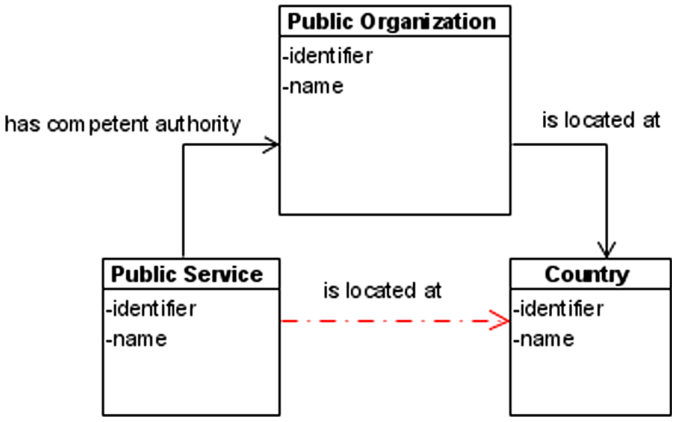

Fig. 2. Knowledge graph example

KG has been used in the public sector in various occasions. For example, Zaragoza city council, since 2003 has been developing its own KG [21] to improve its public service system. KG can also support decision making and sustainability of public finances [22]. In Korea to secure government transparency a KG has been created using open government data [23]. KG have been also employed to address challenges related to overload that can occur from massive government open data [24]. KG have been also used as tools to analyse and supervise government spending [25].

2.4 GRAKN.AI

GRAKN.AI is a free-to-use software application for developing KG [26]. It contains two major parts, Grakn and Graql. *Grakn* is a database in the form of a KG used to model complex datasets [27]. *Grakn schema* is an important part of a Grakn KG that describes the nature of data that are stored in the database as well as how these are

structured [26]. It also provides a high level data structure that offers high integrity and data consistency, thus enabling responses to complex queries. After its creation, a KG schema needs to be populated with data in order to become functional (queryable) and produce results (answers to the queries). *Graql* is the language used by the user to interact with the knowledge graph using queries. Using this language, it is possible to obtain and process the stored knowledge from Grakn. More specifically, queries can be formulated that correspond to some action, such as inserting or deleting entities and relationships, calculating useful information about the graph, statistics etc.

Grakn is mainly operated through the computer console. Once the Grakn installation file has been downloaded and unzipped, the Grakn's server [26] can be started from the console. As long as the server runs, KG can be created and edited in one or more workplaces (keyspaces). There are two options to create a KG. The first is to define every entity, attribute, relation and rule through the console. The second is to create a file with all concepts of the schema and upload it also via console. The same two options also apply to populate the KG schema with data. Querying of the KG can be done through the console. Grakn also offers the Grakn Workbase [26]. This software application is an interface that offers visual display of a KG, creation and editing of a KG as well as querying of a KG. Concluding, once the Grakn's server has been up and running we can connect from any computer with Grakn and Grakn Workbase by using the appropriate host and port numbers.

3 Methodology

The methodology is based on design science research method and includes the following steps.

Step 1. Analyze the "Get a Passport" Service. In this step, information about PS "*Get a Passport*" is gathered and studied. All information is obtained from passport.gov, which is the official website providing information about getting a passport in Greece. This information provides a solid understanding of the PS that is essential for the next steps. For simplicity, we concentrate on input documents and relevant costs based on citizens profile and circumstances.

Step 2. Construct KG Schema. Based on CPSV model constructed in the previous step, we develop a KG schema for "*Get a Passport*". This includes the construction of rules, which is the most challenging activity in the process.

Step 3. Implement KG in Grakn. In this step, the KG is implemented in Grakn.ai. The language used to create the KG and relevant queries is Graql.

Step 4. Populate KG with Data. In this step, we populate the KG schema with actual data for the PS, i.e. on citizen's profile, input documents, and costs.

Step 5. Construct Usage Scenarios. In this step, we construct three usage scenarios to demonstrate the practical use of the constructed KG.

Step 6. Evaluate KG. In this step, the KG is used and evaluated. The evaluation is performed by undergraduate and postgraduate students using a variation of the Technology Acceptance Model (TAM) that was developed for that purpose.

4 A Knowledge Graph for "Get a Passport"

4.1 Analysis of "Get a Passport" Based on CPSV-AP Model

The following information is obtained for the PS.

Public Service: The PS under investigation is "*Get a passport*" in Greece.

Evidence: There are 16 different input documents needed for executing this PS. The exact input documents needed depend on the profile and circumstances of the citizen. Some input documents are identification card, birth or marital status certificate, photographs adhering to specific technical requirements etc.

Cost: The cost can be 84.40 Euros, 73.60 Euros, 68.80 Euros, 63.40 Euros or 58 Euros. The cost depends on the passport duration and whether the citizen applies for a new passport or to renew an existing passport.

Rules: Here, we include all other information that is important to determine which are the needed Evidences and Costs depending on the citizen's circumstances.

Firstly, there are four main categories based on the citizen's need to obtain a passport, namely:

- Issuance of a new passport
- Passport renewal
- Replacement of a valid passport
- Issuance of a new passport due to theft or loss

The age of the citizen is also an important consideration. The input documents differ for various ages and relevant age categories. The relevant categories are:

- Adults
- Minors
- Minors under 12
- Minors from 12 to 14
- Minors under 14
- Minors over 14

Moreover, there are additional categories to which a citizen may belong, as follows:

- Permanent resident of another country (besides Greece)
- Completed military obligations (for males only)
- Conviction by court order
- Temporary ban on leaving the country
- Unfulfilled technical requirements of the photo (due to health condition)

Clearly, most of these cases can be combined e.g. Passport renewal for an adult with permanent resident of another country and uncompleted military obligations.

4.2 Construct KG Schema

The starting point to construct the KG schema is the extract of the CPSV model presented in Fig. 1. Thus, the first draft of the KG schema includes three entities (Public Service, Evidence and Cost), their attributes and their relations. The next and most important activity is the creation of rules. The analysis of the previous step revealed a number of rules that link citizen's profile and circumstances with relevant evidences and cost. We use the entity Rule to accommodate this information.

During the construction of rules, the need to introduce additional concepts emerged. Specifically, a need to also store information on the profile and circumstances of the citizen who is interested to get a passport was identified. To accommodate this need we included a new Entity in out KG schema, called *Citizen*. The creation of attributes for the entity Citizen was also a necessity for the creation of the KG schema. Citizens must include attributes to inform on the categories they belong. Therefore, we decided to introduce all relevant information as attributes of the citizen. The attributes of the entity Citizen are shown in Table 1 (Appendix A). It should be noted that other designs are also possible. However, the proposed one is deemed as appropriate as our main objective was to produce a working KG schema and not necessarily an optimal one.

Furthermore, the entity Evidence in the KG schema had to be slightly different from the one in CPSV-AP. More specifically, in the KG schema we defined the attribute *name* as the unique identifier and not the attribute *identifier*. The reason is that we wanted more than one input documents to have the same identifier. These identifiers depend on the category to which the citizen belongs. For example, input documents required in all cases have identifier equal to "1"; input documents required only for citizens over 12 years of age have identifier equal to "1t"; input documents required only for citizens who want to issue a passport for first time have identifier equal to "1a"; input documents required only for citizens who want to renew their passport have identifier equal to "3", etc. In addition, some new relations were also introduced. These relations can be found at Table 2 (Appendix A). Concluding, the rules that we defined in the schema of the "*Get a passport*" KG are presented at Table 3 (Appendix A). The final KG schema constructed is shown in Fig. 3. In all figures from Grakn Workbase the background color changed from black to white both for better illustration as well as to preserve ink in the case of printing this paper.

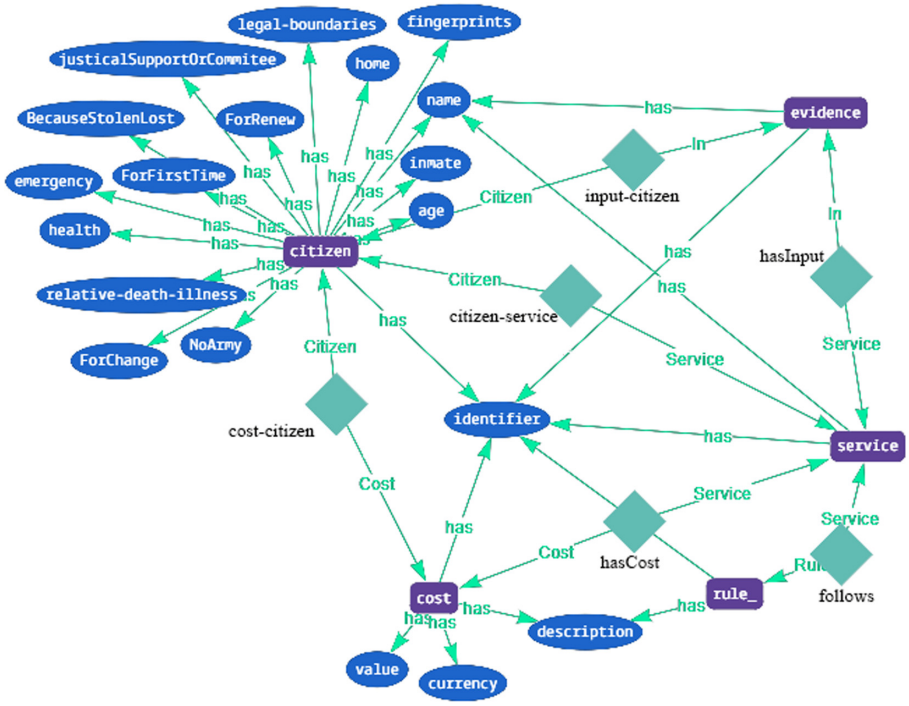

Fig. 3. "Get A Passport" KG schema

4.3 Implement KG in Grakn

In this section the implementation of the KG is presented. The schema of the KG was already conceptually created, so we could start by implementing either the entities or the attributes. Using the results of our analysis in terms of Entities, Attributes and Relationships, we first create attributes (name and type).

The following code example (in Graql) demonstrate how attribute *identifier* is defined.

```
define identifier sub attribute,
        datatype string;
```

Afterwards, we create the entities and assign the created attributes on them. The following code example (in Graql) demonstrates how entity *Cost* is defined.

```
define cost sub entity,
      plays Cost,
    key identifier,
      has value,
    has currency,
  has description;
```

Next, we implement relationships. The following code example (in Graql) demonstrates how relation *hasCost* is defined.

```
define hasCost sub relation,
      relates Service,
       relates Cost;
```

The following code example (in Graql) demonstrates how a rule (namely *auto-relation*) is defined.

```
define auto-relation sub rule,
            when {
            $h1 isa citizen;
           $ser isa service;
               }, then {
(Citizen: $h1, Service: $ser) isa citizen-service;
                        };
```

4.4 Populate KG with Data

To import the data to the KG's schema we use the query language Graql. The following three code examples demonstrate how data are inserted in the KG.

Example 1 shows the code for Evidence ID card.

```
insert $in2 isa evidence, has identifier "1t", has name
"Two-sided photocopy of police identifier card on the
                    same page";
```

Example 2 shows the code for Evidence photographs.

```
insert $in3 isa evidence, has identifier "1", has name "A
    recent (last month) 4x6cm color photo of specific
technical specifications, printed on analog photo paper,
    without the use of inkjet or laser technology.";
```

Example 2 shows the code for Cost 84.40 Euros.

```
insert $cost5Y isa cost, has identifier "5Y", has
        currency "Euro", has value 84.40;
```

4.5 KG Usage Scenarios

In this section, three usage scenarios are presented to illustrate the use of the developed KG. In the first scenario, we assume an adult citizen who wishes to obtain a new passport due to theft of the previous passport. This citizen does not belong to any special category, so the only information that is entered is age and name (a nickname that the citizen chooses for interacting with the system).

To import this citizen's data in the KG, we use the following code:

```
$citizen1 isa citizen, has identifier "1", has name
"Rafail", has age 26, has BecauseStolenLost "yes";
```

Then, with the following query the KG will automatically obtain the necessary documents the citizen must provide to invoke the PS as well as the relevant cost:

```
match $x isa input-citizen; $y isa cost-citizen; get;
```

The result shown by the graph is depicted in Fig. 4.

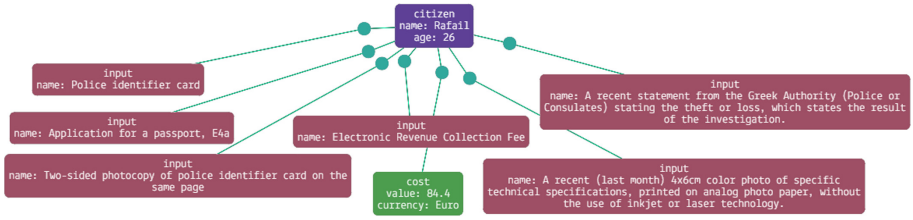

Fig. 4. Matched inputs and cost for Scenario 1

In the second scenario, we assume a minor citizen with permanent residence abroad who wishes to obtain a new passport for the first time.

To import this citizen's data in the KG, we use the following code:

```
$citizen6 isa citizen, has identifier "6", has name
"Susan", has age 10, has ForFirstTime "yes", has home
"NoGR";
```

After running the same query as in the first scenario, the system returns the answer presented in Fig. 5.

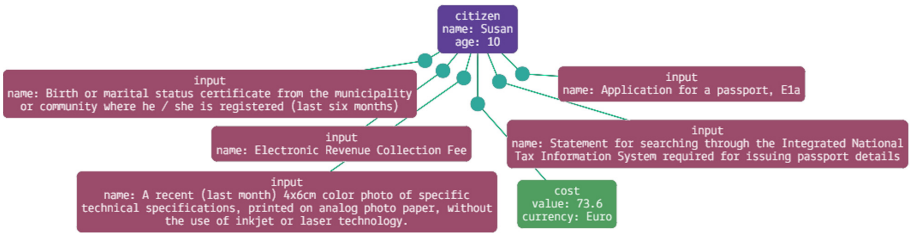

Fig. 5. Matched inputs and cost for Scenario 2

In the third scenario, the citizen is an adult who wants to renew his passport, he has permanent resident abroad and has not fulfilled his military obligations.

To import this citizen's data in the KG, we use the following code:

```
$citizen5 isa citizen, has identifier "5", has name
"Paul", has age 33, has ForRenew "yes", has home "NoGR",
has NoArmy "yes";
```

Running the same query as in the other scenarios, the system returns the answer shown in Fig. 6.

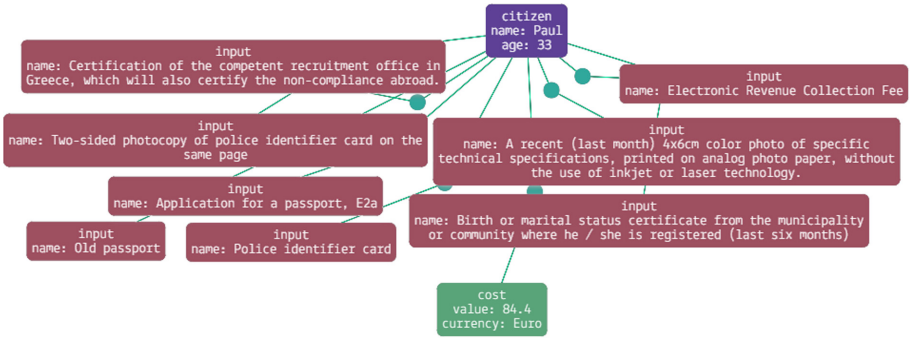

Fig. 6. Matched inputs and cost for Scenario 3

4.6 Evaluation of the KG

For the evaluation, a twenty question Technology Acceptance Model (TAM) [28] based questionnaire was used. These questions are intended to evaluate (a) Perceived ease of use and (b) Perceived usefulness. According to TAM, (a) Perceived ease of use is defined as "*the degree to which an individual believes the using a particular system would be free from physical and mental effort*" and (b) Perceived usefulness is defined as "*the degree to which an individual believes that using a particular system would enhance his or her job performance*" [29]. For this purpose, ten questions evaluate

(a) and ten evaluate (b). Furthermore, the answers were a seven-point scale from strong disagreement to strong agreement and the questionnaire was implemented using Google forms.

Twenty one both undergraduate and postgraduate students participated in the evaluation. Initially, information about KG in general and the three usage scenarios shown in the previous section were presented to students. Based on that, the students were asked to evaluate the KG completing the TAM-based questionnaire.

The tenth question of the questionnaire is related to the perceived ease of use, specifically it states "*Overall, I consider that the use of KG seems easy*." Three students strongly agree, two disagree and the rest are in the neutral zone. Also, twelve students believe that the interaction with KG requires small spiritual effort, eleven students believe that finding information for PS is easy with KG, six students believe that the process of learning to use KG is easy.

The twentieth question of the questionnaire is related to the perceived usefulness, specifically it states "*Overall, it seems useful to use KG to obtain information about Public Services*". Sixteen students agree with this.

In conclusion, the answers of this questionnaire were overall encouraging. The participants found KG a useful and easy to use tool for obtaining information about Public Services. The participating students also consider dealing with KG requires small spiritual effort.

5 Conclusions and Future Work

The aim of this paper was to investigate the use of Knowledge Graphs (KG) for providing personalized information on PS modeled using CPSV. For this purpose, a KG for part of PS "*Get a passport*" is presented based on CPSV. The analysis results suggest that KG can offer significant benefits for providing personalized information of complex PS. This is mainly due to KG's ability to model rules enabling them to accommodate complex PS. However, there are still significant challenges to overcome before KG can be used in an operational environment. For example, the whole process of KG development is still complicated and thus cumbersome for public servants. In addition, easy-to-use ICT tools are still missing for public servants to create KG at a large scale.

We should further note that although the study produced promising results, it nevertheless has a number of limitations. First, for simplicity we restricted our work to a small number of classes from CPSV model. Thus, the whole CPSV model should be used for creating the KG. Also, we analyzed only one PS, thus additional PS should be studied. In addition, our development experience and knowledge was gained from using GRAKN.AI thus additional platforms should be investigated. Furthermore, the evaluation of our KG was done by a small number of students so we cannot conclude on how useful and important KG are perceived by citizens in general.

Future work includes working further with KG to overcome this study's limitations. In addition, we are working towards the development of a chatbot which would greatly simplify data entry into the KG thus making it more user-friendly. Additional work includes enhancing CPSV model to incorporate machine-readable rules. By inferring

rules, logic could be applied to the data, thus giving access to new knowledge that is not obvious.

Appendix

See Appendix Table 1, 2, and 3

Table 1. Attributes of citizen entity

Attributes	Definition/description
identifier	Represents a unique identifier for every citizen that uses the Public Service
name	The name of the citizen
age	Represents the age of the citizen
home	Represents the permanent residence of the citizen. If it's in Greece or not and it can take "GR or NoGr" as values
health	Represents the health situation of the citizen. Specifically, it refers to the condition of his face and if his photograph follows the technical standards
relative_death_illness	Declares if the citizen applied for a passport, because of death or illness of a close relative
inmate	Represents if a citizen is an inmate or not
fingerprints	Declares if it's possible or not, taking fingerprints of the specific citizen
legal_boundaries	Declares if the citizen has legal issues that do not allow him to leave the borders of the country
ForFirstTime	Declares if the citizen applies for a passport for the first time
ForChange	Declares if the citizen applies for a new passport because of inappropriateness of his old one
ForRenew	Declares if the citizen applies for a renewal of his passport
BecauseStolenLost	Declares if the citizen applies for a new passport because his old one is lost or stolen
emergency	Declares if the citizen applies for a passport because he is critically ill or he is critically injured or he lost a close relative, from death or disappearance or his property is destroyed due to a physical disaster
justicalSupportOrCommitee	Declares if the citizen applies for a passport because he is a person in a committee or judicial assistance
NoArmy	Declares if the citizen has fulfilled military obligations

Table 2. New relations of the model

Relations	Definition/description
input-citizen	Links an input with a citizen
citizen-service	Links a citizen with the Public Service
cost-citizen	Links a cost with a citizen

Table 3. Rules of the KG "Get a Passport"

Rule	Definition/description
emergency-passport	Determines if the situation is an emergency and the passport has to be produced within a working day
auto-relation	Creates an automatic link between a citizen and the Public Service as soon as the citizen is in need of the specific Public Service
citizen-input1	Determines if a citizen should be connected with inputs with identifier "1"
citizen-input11	Determines if a citizen should be connected with inputs with identifier "1t"
citizen-input-First-Time	Determines the connection between a citizen and inputs with identifier "1a". In case a citizen wants to apply for a new passport for the first time
citizen-input-Renew	Determines the connection between a citizen and inputs with identifier "2a". In case a citizen wants to renew his old passport
citizen-input-Renew1	Determines the connection between a citizen and inputs with identifier "3". In case a citizen wants to renew his old passport
citizen-input-Change	Determines the connection between a citizen and inputs with identifier "3a". In case a citizen wants to replace his old passport
citizen-input-Change2	Determines the connection between a citizen and inputs with identifier "3". In case a citizen wants to replace his old passport
citizen-input-Lost-Stolen	Determines the connection between a citizen and inputs with identifier "4a". In case the citizen wants to apply for a new passport because his old passport is lost or stolen
citizen-input-Lost-Stolen1	Determines the connection between a citizen and inputs with identifier "9". In case a citizen wants to apply for a new passport because his old passport is lost or stolen
citizen-input-NoGR	Determines the connection between a citizen and inputs with identifier "2". In case the citizen has a permanent residence outside Greece
citizen-input-army	Determines the connection between a citizen and inputs with identifier "7". In case the citizen is an adult, has permanent residence outside Greece and has fulfilled military obligations
citizen-input-eyes	Determines the connection between a citizen and inputs with identifier "6". In case the citizen has a health situation and the technical standards of the photo are not fulfilled

(*continued*)

Table 3. (*continued*)

Rule	Definition/description
citizen-input12	Determines the connection between a citizen and inputs with identifier "10". In case the citizen's age is "<= 12"
citizen-input-supCom	Determines the connection between a citizen and inputs with identifier "4". In case the citizen is a person in a committee or judicial assistance
citizen-input-legal	Determines the connection between a citizen and inputs with identifier "5". In case the citizen can't leave from the country due to legal issues
cost3m	Determines the connection between a citizen and a cost with identifier "3 M". In case the citizen is an inmate and the produced passport has three months duration
cost5y	Determines the connection between a citizen and a cost with identifier "5Y". In case the citizen has age ">14" and the produced passport has five years duration
cost3y	Determines the connection between a citizen and a cost with identifier "3Y". In case the citizen has age "<=14" and the produced passport has three years duration
cost8m	Determines the connection between a citizen and a cost with identifier "8 M". In case it's impossible to take fingerprints and the produced passport has eight months duration
costChange	Determines the connection between a citizen and a cost with identifier "change". In case the citizen wants to replace his old passport
cost13m	Determines the connection between a citizen and a cost with identifier "13 M". In case the citizen can't leave from the country due to legal issues, he is critically ill or he is critically injured or he lost a close relative, from death or disappearance or his property is destroyed and the produced passport has thirteen months duration
passOut	Determines the connection between a Public Service and an output when the Public Service is already connected with a cost. The identifier of the cost has to be the same with the identifier of the output

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