On the use of Chatbots and Knowledge Graphs for Public Service information provision based on Life Events: The case of Travelling Abroad

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Abstract

Citizens during different stages of their lives seek information about Public Services (PS) related to life events. To accommodate this need, the public sector provides PS information around life events, such as getting married or travelling abroad. This information is often provided through structured web pages and web-based dialogue systems. However, chatbots and knowledge graphs are two technologies that can be also used for the same purpose due to their advantages. The aim of this paper is to investigate chatbots-knowledge graphs integration for PS information provision based on life events. For this reason, we develop and evaluate a proof-of-concept chatbot-knowledge graph integration based on CPSV-AP for PS information related to the "Travel Abroad" life event.

Keywords

Chatbots, Life events, Knowledge Graphs, Core Public Service Vocabulary (CPSV), Rasa, TypeDB

1. Introduction

Every day citizens need information about Public Services (PS) related to various events in their life, such as getting married and travelling abroad. This increases the need of PS information provision gathered around life events [1]. The public sector usually provides PS information to citizens through one-stop government portals, dedicated web pages, and web-based dialogic systems (e.g., benefits.gov in the USA). These approaches however face several challenges. One challenge is the lack of interoperability, which has significant cost for the European Union (EU) [2]. Another challenge is the lack of a natural interaction between citizens and websites. A third challenge is the lack of personalisation in PS information provision.

In recent years, efforts have been made to address these challenges. Regarding interoperability, one possible solution is the use of the Core Public Service Vocabulary (CPSV) [3]. CPSV is a European Union vocabulary that can capture the fundamental characteristics of a Public Service and related Life Events. The interoperability offered by the model as well as its ability to link different information using Linked Open Data (LOD) makes it a suitable solution for providing PS information.

Regarding interaction, artificial intelligence (AI) and more specifically chatbots seems a promising solution for use in the public sector [4]. Chatbots enable dialogue in natural language between humans (users) and computers. Furthermore, they are interactive and easily integrated into both simple websites and social media (e.g., Facebook) [4]. This fact favors their use to inform citizens since most have access to smartphones and social media. Summarizing, the use of chatbots can possibly (a) save resources from governments since public servants will be freed from the obligation to inform the citizens and will become more efficient in the rest of their work [5], (b) increase the satisfaction of

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citizens as the use of chatbots can reduce the time and effort needed to search for information in existing portals [5][6].

Regarding personalisation, knowledge graphs are a possible solution [7,8]. Knowledge Graphs can describe real life concepts and the relationships between them. Schematically each element, entity or user is represented by a node. These nodes interact with each other through edges [9]. A Knowledge Graph can be used as a database for a chatbot due to its flexibility and more efficient search capabilities due to the use of rules.

The aim of this paper is to investigate chatbots-Knowledge Graphs integration for PS information provision based on Life Events. For this purpose, we develop a proof of concept chatbot-Knowledge Graph integration based on CPSV for provision of information related to the "Travel Abroad" Life Event.

The rest of this paper is structured as follows. Section 2 provides background work. Section 3 presents the followed approach. Section 4 describes the proof of concept chatbot and finally, section 5 contains the conclusions and future work.

2. Background Work

The term life event (LE) refers to "government services that a citizen needs at specific stages in life" [10]. These services may be provided by different public authorities and respond to an event in citizen's life. A citizen for a specific life event needs personalized information, such as supporting documents (i.e., evidence) for all relevant Public Services.

Public sector provides LE information usually through two types of web portals. The first is based on directories with a defined subject hierarchy (passive portals) [11]. In passive portals the user usually navigates to a specific LE by selecting categories and subcategories. The second type is more user-friendly and provide LE information through web-based dialogues (active portals) [11, 12] [12].

In recent years, artificial intelligence and especially chatbots is increasingly used for information provision. Chatbots are already used in different fields (e.g., education [13], health [14], etc.) as well as in the public sector [4, 15]. The environment (i.e., interface) of a chatbot is simple. In addition, chatbots through natural language processing can detect the user's intent and offer a much more personalized communication, triggering the corresponding life event [16].

Another technology that can assist in personalized information provision is Knowledge Graphs (KG) [16]. The term knowledge graph refers to "large networks of entities, their semantic types, properties and relations between entities" [18]. Lately, KG are increasingly researched by the scientific community in areas such as Knowledge Aware Applications (e.g., Natural Language Understanding, Question Answering, etc.), Knowledge Representation Learning etc. [17]. An important part of Knowledge Graphs that enable the provision of personalized information is the use of rules. The integration of rules (i.e., reasoning) [19] into a knowledge graph schema allows the detection of knowledge that in most cases is hidden.

In previous work, a layered architecture is proposed for the integration of chatbots with life events and a proof-of-concept chatbot prototype was developed that exploits LE information available in link data repositories [20]. Also, in previous research a chatbot was developed to inform citizens about passport issuance using information stored in a relational database (MySQL) [21]. Finally, a chatbot-Knowledge Graph integration application has been developed for the same Public Service [22]. The schema of the developed Knowledge graph is shown at Figure 1. Concluding, although there is research about chatbots and LE as well as about chatbots-KG integration, according to our knowledge there is no research about the integration of chatbots with Knowledge Graphs for the provision of LE information.

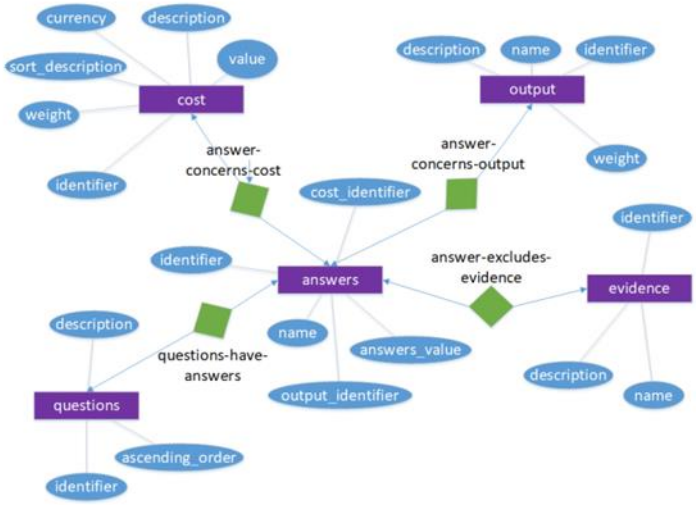

Figure 1. Knowledge graph schema for the chatbot (adopted from [22])

3. Approach

The approach we followed contains the following four steps.

Step 1. Selection of Life Event (LE) and identification of related Public Services (PS). In this step, we select a LE in Greece and identify the PS that are related to it.

Step 2. Analysis of related PS. In this step, we analyse each of the PS related with the selected LE.

Step 3. Development of proof-of-concept for chatbot-knowledge graph (KG) integration. In this step we develop a proof-of-concept chatbot-KG integration that provides information for related PS. The analysis and design of the chatbot is based on the steps proposed by [23]. The KG schema is developed based on CPSV-AP. Rasa [24] and TypeDB [25] are selected for developing the chatbot and the KG respectively. Both tools have an opensource version while Rasa also supports the Greek language.

Step 4. Evaluate proof-of-concept. In this step the proof-of-concept is evaluated using a developed questionnaire [26]. The questionnaire consists of two parts, the first part concerns demographic questions. The purpose of these questions is to explore the characteristics of the respondents in relation to their familiarity with the subject they will be asked to evaluate. The second part concerns questions about the usability of the chatbot after running specific scenarios. For the evaluation, two groups of scenarios are created and carried out by users.

4. Results

This section presents the main results of our work per step of our approach.

4.1. Life Event selection and related Public Services

As first step, we commence with the selection of a Life Event (LE) and identify its related Public Services (PS). Based on the importance of the movement of Greek citizens both to EU and non-EU countries, we decided to choose the “Travel Abroad” LE. For this specific LE, we identified that related PS are these of issuing a passport, issuing a visa and issuing a European Health Insurance Card (EHIC).

4.2. Analysis of related Public Services

The analysis of the identified PS is carried out using CPSV-AP as a template for recording information. These PS are complex since they contain a large number of different subcases or versions each. This is mainly because they concern many different countries and therefore many different

legislations. Another important factor is the difficulty that currently exists in finding information from the existing portals offered by each country.

The first PS is issuing a passport. As this PS has been extensively studied before while a chatbot and KG has been already developed for it, we decided to exclude it from further study. We thus concentrate on the other two PS.

The second PS is issuing a visa. For visa, research was focused on the issuance of tourist and transit visas for 12 popular destinations. Also, visa issuance was divided into three categories: issuance at an embassy, electronic visa and issuance on arrival.

The third PS is issuing an EHIC. EHIC is a card that offer access to public medical care for free or at a reduced rate, during an EU citizen's visit to other EU countries. For EHIC, research focused on insured citizens and uninsured students. While for insured citizens there is an online service (e-ΕΦΚΑ [27]), for the uninsured students, information was obtained from universities websites.

4.3. Analysis and Design of the Chatbot

An important consideration in chatbot development was deciding users' intents. We concluded that the chatbot should first identify the LE, then the PS and subsequently the specific intent of the user. This can happen directly with a single message, or through a dialogue between the user and the chatbot. During the dialogue, the chatbot asks a series of questions and based on the answers it provides personalized information. Figure 2 presents how the chatbot handles the dialog.

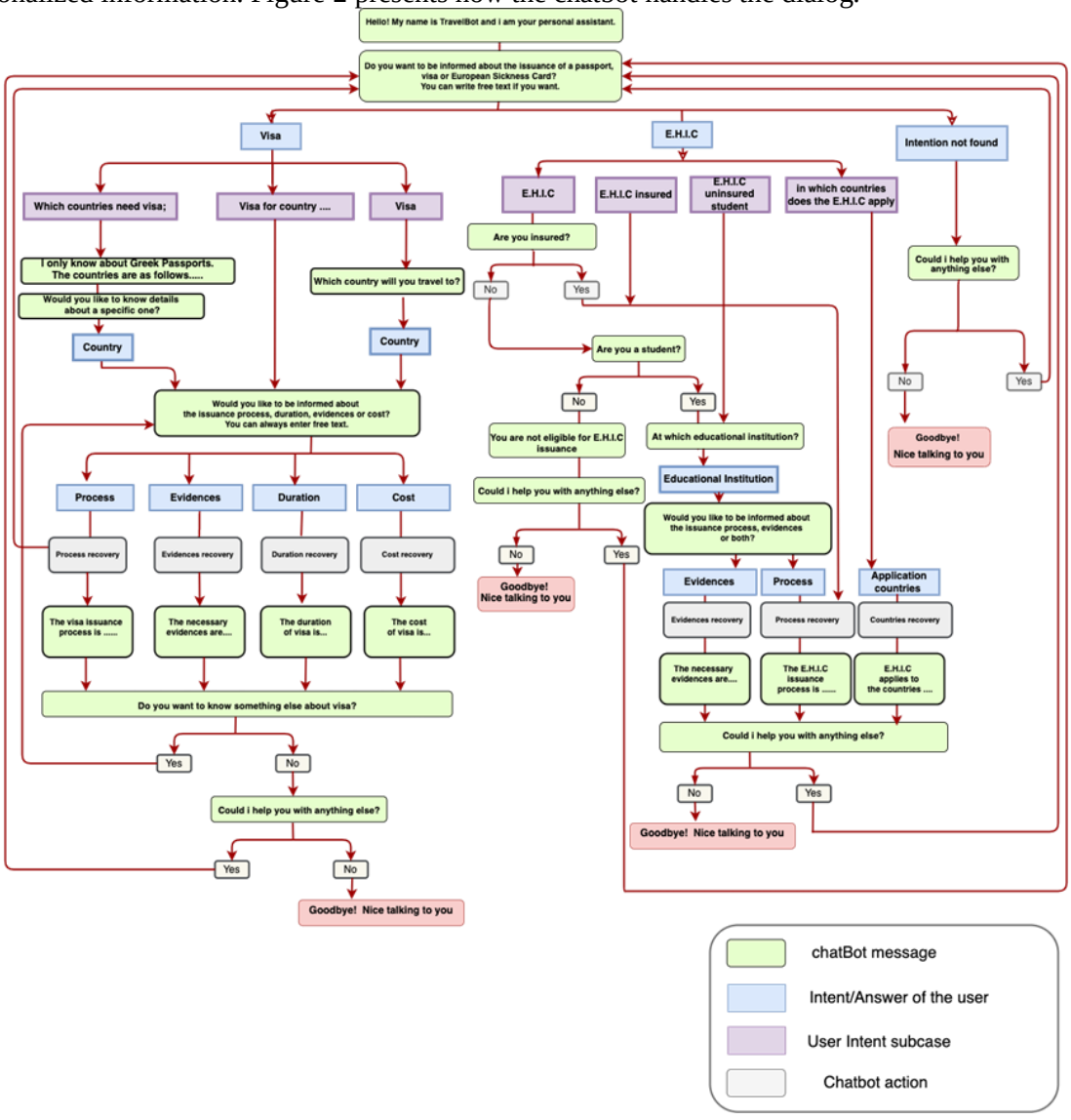

Figure 2. Chatbot dialog flow

4.4. Knowledge Graph development

The Knowledge Graph (KG) schema had to be compatible with the chosen LE. The resulted ontology is shown in Figure 3. In this ontology, every entity and relation come from the CPSV-AP model. Exceptions are the following entities along with their relations: “Question”, “Answer” and “Country”. The first two entities were adapted from [21]. The entity “Country” is our extension to CPSV-AP to serve our purposes for the specific LE. More specifically, "Country" entity is linked to "Public Organization" entity as well as with "Output" entity because a PS can be issued by a public organization located in a specific country and an output can be valid in one or more countries. This entity along with the use of CPSV-AP classes and the KG schema of previous research allows the developed chatbot-KG integration to provide information about the specific LE. Based on this ontology we also developed the final schema of the KG. As a final step, files in csv format passed through a script in Python and then inserted into the KG.

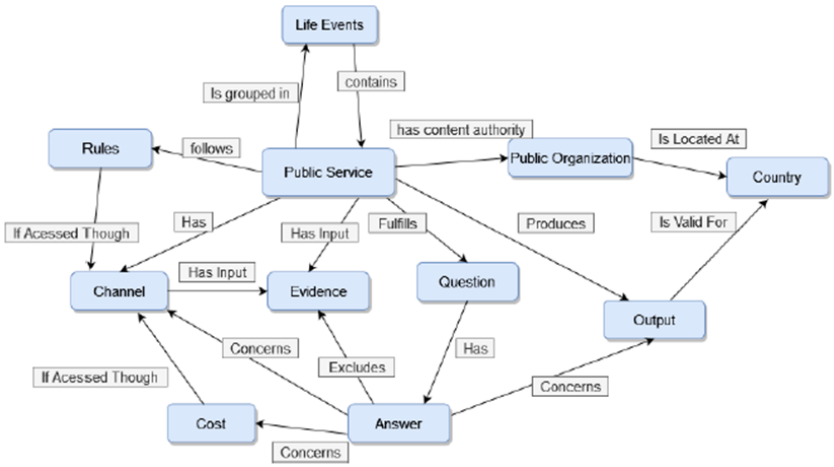

Figure 3. Ontology for the database of the chatbot

4.5. Chatbot development

First, the basic chatbot elements are defined, i.e., user intentions, chatbot actions, and stories. For intentions, we record in natural language different alternatives users could use to express them. Chatbot actions can be simple responses/phrases or can be generated after processing data retrieval from the KG (custom actions). All responses verbatim are set and all methods for custom actions which are executed through a separate server (action server) are created. More specifically, domain.yml file contains 19 entities, 22 slots, 4 forms, 55 utters while nlu.yml file contains 45 intents 2 synonyms and 2 lookups. The rules.yml file contains 57 rules, the stories.yml file contains 91 stories and the actions.py file contains 24 actions.

Finally, the connection with the KG is achieved through a related python Client API. Figure 4 presents the starting screen of the chatbot.

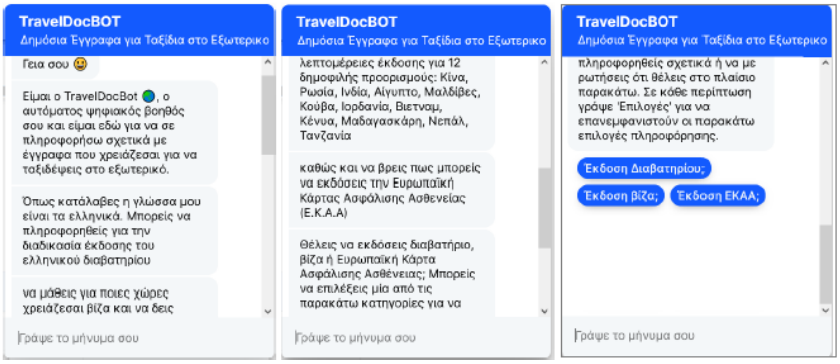

Figure 4. Chatbot starting screen

4.6. Integrate chatbot into a website

After the development of the chatbot is completed, it needs to be made accessible to users. The simplest solution is to create a website for this purpose. A related API is used to integrate the chatbot into the website.

4.7. Evaluation of the Chatbot

In the evaluation of the chatbot, 22 people participated. Figure 5 presents the age and educational level of the evaluators. Most of them are familiar with a computer/mobile usage (77,8%) but only half of them (50%) have used a chatbot before. The results of the evaluation are considered positive overall because most participants (81.8%) got the correct answers from the digital assistant. It is important that even when unexpected (i.e., non-standard) questions were asked, the percentage of the correct answers remained good (68.2%). In addition, 72.7% of the evaluators consider that through the chatbot they received information that they could not have received otherwise.

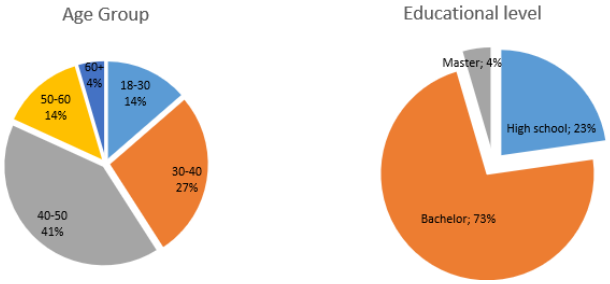

Figure 5. Age group and educational level of the evaluators

5. Conclusions and Future work

The aim of this paper was to investigate chatbots-Knowledge Graphs (KG) integration for the provision of personalized Public Service (PS) information based on Life Events (LE). For this reason, we developed a proof-of-concept chatbot-KG integration based on the “Travel Abroad” LE. Finally, the chatbot was evaluated using two groups of usage scenarios.

As shown by the results, the developed chatbot enables the provision of personalized information to citizens related to the “Travel abroad” LE. This is achieved thanks to the exploitation of chatbots and Knowledge Graphs. Chatbots offer the possibility to inform citizens using natural language as well as a friendly interface for this interaction. KG offer the possibility of storing the available information and through rules personalizing it for each citizen. The integration of these two technologies along with the use of LE, could contribute to resolve existing challenges of PS information provision.

In the future the developed chatbot could be expanded to offer information on all visa types as well as all visa requiring countries. In addition, more chatbots could be developed for different LE to create a grid of chatbots to serve as many needs as possible. Finally, adding voice commands and dialogue

capability would add even more value as it would make the chatbot accessible to a larger number of citizens.

6. Acknowledgements

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