CHATBOT IN THE ONLINE PROVISION OF PUBLIC SERVICES

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Abstract: The provision of Public Administration (PA) services has been challenging due to their complexity. Citizens use digital channels to obtain generalized information and perform simple services, but many still prefer traditional channels such as face-to-face or telephone for more complex and ambiguous request scenarios. This work presents a chatbot prototype as a new digital channel for services provided in the form of dialogs. It uses Natural Language Processing (NLP) to interpret the intentions of citizens, allowing greater expressiveness in the more complex requests. To provide services in the informative phase, the chatbot provides information structured according to the Core Public Services Vocabulary (CPSV) model. This simplifies the data model of services while making it reusable and extensible. The research method used in this work is Design Science Research Methodology (DSRM). The proposed artifact is the instantiation of the prototype, SIGMA, which is evaluated by the results it presents in the context of the Portuguese National Portal for Government services.

1. INTRODUCTION

In the past decades, Artificial Intelligence (AI) became more and more relevant. One of the emerging technologies that use AI is chatbots. They can interact with users through conversation interfaces (text or speech) and provides information, services, assistance or entertainment [1][2].

The idea of creating a computational program conversing with humans was first presented by Alan Turing [3] and the Turing Test aims to determine if a program can appear human. One of the earliest chatbots was ELIZA [4]. More chatbots were created by time, with ALICE (Artificial Linguistic Internet Computer Entity) being one of the most popular chatbots that won the Loebner prize (attributed to the best chatbots that appear human) in 2000, 2001 and 2004.

Nowadays chatbots can integrate components such as Natural Language Processing (NLP) to identify patterns, intentions, and concepts during conversations. It can also use knowledge bases\footnote{1 A store of information or data.} use keywords and synonyms to provide information [5].

Although By monitoring the conversations and by registering user feedback, it’s possible to perform continuous supervised training. This improves the chatbot’s interpretation and response capacity which improves their service provision.

The complexity of Government services makes its provision in digital channels difficult. An effective and efficient provision can reduce the costs from traditional channels (face-to-face or telephone). It can also reduce the time citizens spend to be physically present at the public service counters [6]. Citizens use digital channels to obtain non-personalized information and to perform simple service transactions. But many still prefer traditional channels when the request is more specific [7].

Chatbots have also been researched in the public sector [8][9]. As a new digital channel, it can improve the communication between citizens and the government and it allows greater expressiveness [10]. Through dialogs, chatbots can provide Government services even under specific circumstances [11][12].

Another challenge in the provision of services is the structuring of information. The Core Public Service Vocabularies\footnote{2 https://joinup.ec.europa.eu/solution/core-public-service-vocabulary/about} (CPSV) is a model that simplifies and normalizes the Government services data model, improving reusability and extensibility.

This research studies the impact of chatbots on Government service provision. The research method used in this work is the Design Science Research Methodology (DSRM) [13].

This work presents the case study of SIGMA, a chatbot implemented for the Portuguese National Portal for Government services (ePortugal.gov.pt). SIGMA aims to facilitate the provision of services using NLP, to allow greater expressiveness to cover the more complex citizen
service scenarios. It provides information obtained from the Catalog of Entities and Services (CES), which is an application developed by the Administrative Modernization Agency (AMA). CES provides information structured according to the CPSV model.

This work evaluates the preliminary results of the chatbot prototype, showing its capacity to evolve in terms of interpretation and service provision.

1.1 Objectives

This work’s objective is to define the architecture of a chatbot solution that serves as a new digital channel, thereby facilitating the provision of Government services by using NLP and a simplified information structure based on the CPSV model.

It also aims to implement a prototype and evaluate its results in the context of the National Portal for Government services.

2. RELATED WORK

2.1 Chatbots

A chatbot is a software application that can appear human and assist its users to achieve different goals during interactions. The application receives and processes the text extracted from the messages from the users and replies according to its interpretation.

There are different techniques and approaches that chatbots can use to process the extracted text [5]:

- **Parsing**: text analysis and manipulation using NLP functions.
- **Pattern matching**: pattern detection using matching types, such as natural language inquiries, simple statements, or semantic meaning of inquiries.
- **Interaction flow**: determination of the chatbot interaction flow using pattern matching such as Artificial Intelligence Markup Language (AIML), or ChatScript.
- **SQL and relational database**: response improvement by using data from previous interactions.
- **Markov Chain**: response construction based on correspondence probability.
- **Language tricks**: predefined responses that improve the simulation of human responses, such as chitchat\(^3\), typing indicators, or alternate responses.
- **Ontologies**: use of semantic networks (set of concepts interconnected relationally and hierarchically) to process text using synonyms, hyponyms and other conceptual relations found in natural language.

The efficacy of these techniques is demonstrated in chatbots that won the Loebner prize, as well as other chatbots that used the same techniques and approaches [14].

Besides text, chatbots and their users can interact in the form of speech, images, video and audio. It’s possible to implement a more interactive graphics interface, improve usability and have richer and more expressive interactions [1].

Nowadays chatbots can be deployed to different Instant Messaging (IM) channels. The communication can be more stable and asynchronous (users can pause and resume conversations) and it can be available on any platform (operating system or device). Chatbots can even use authentication and have integrated payment processing.

2.2 Application of chatbots in Government

Government service provisioning has been challenging due to its complexity. There are different kinds of provisioning channels, namely:

- **Traditional channels**: face-to-face or telephone interaction.
- **Digital channels**: portals that provide information or ways to perform services.

Citizens use digital channels to obtain general information and perform simple services. To lower their preference for traditional channels, digital channels must be able to cover the more complex requests.

The following studies (Table 1) support chatbots as a new digital channel that can provide a more complex service provision:

Table 1 – studies on chatbots and dialog interactions for Government service provision

<table>
<thead>
<tr>
<th>STUDY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>[10]</td>
<td>Creation of an architecture model of an ICT platform that uses chatbot technology. Government specialists were involved in this creation. The viability of this artifact is validated through simulated service provision scenarios. This validation shows the possibility to contemplate some level of personalization and complexity.</td>
</tr>
<tr>
<td>[11]</td>
<td>Shows the possibility of providing services in more complex scenarios through the form of dialogs.</td>
</tr>
<tr>
<td>[9]</td>
<td>Instantiation of a chatbot solution. The prototype was developed for a public entity and tested with a small group of users. It was effective and efficient in assisting its users to perform services. Many users were not aware of the existing online services, which showed a better communication of existing digital channels is needed. User expectations on chatbot intelligence also influenced their interaction with chatbots.</td>
</tr>
</tbody>
</table>

\(^3\) Inconsequential conversation.
in service provision, it is important to study and validate more prototype instantiations in different scenarios.

2.3 Core Public Service Vocabulary

To provide information about Government services, it must be simplified and structured.

The provision of services can be presented in two phases [11]:
- **Informative phase**: provision of the information required to perform a service.
- **Performative phase**: execution of a service transaction after obtaining the necessary information and conditions.

The provision of services in the informative phase is critical for the optimization of the performative phase. During the informative phase, citizens search for information about the services they need to perform, such as the required conditions or how it can be performed. This information can be structured in the following ways:
- **Unstructured**: information is presented without content structuring, in plain text.
- **Structured**: information is structured according to a normalized model applied to all services.
- **Structured in dialogs**: information is structured in dialog flows and provided to users during a question and answer-based interactions.

The dialog-based structuring allows the contemplation of the more complex scenarios where users need personalized information. Presenting specific information avoids excessive information that is irrelevant to specific scenarios.

The provision of structured information of Government services in a chatbot is presented by a study that presents the CPSV model as a potential solution [12]. The CPSV is a simplified, reusable and extensible data model that captures the fundamental characteristics of public service. This model was presented by the European Union (EU) and it aims to solve interoperability issues.

The referenced study presents an architecture with a web interface layer, a backend layer with AI functionalities, a Resource Description Framework (RDF) layer which contains the structured data according to the CPSV model, and an Application Programming Interface (API) layer which integrates the RDF layer with other layers.

The presented solution aims to improve Government service provision in the informative phase. The CPSV model simplifies and normalizes data structures and the architecture allows content management by the Government. The same content can be provided to other applications using the API layer.

2.4 Discussion

The design and implementation techniques of chatbots have been evolving in the past decades leading to more and more improved chatbot/user interaction. With NLP technologies becoming more sophisticated and precise, now it is possible to integrate chatbots with new digital channels and IM applications to reach more users.

Recently, chatbots have become more relevant in the context of Government service provision, improving the communication between the government and citizens. Because of the service provision complexity in both informative and performative phases, citizens still prefer traditional channels for more complex scenarios. Chatbots with a more sophisticated design can be used as a new digital channel to cover these scenarios, lowering the adherence of traditional channels and therefore lowering the costs for both citizens and the Government.

The CPSV model can simplify and normalize the complex information about Government services.

Considering the more recent trends and functionalities, and the challenges of the Government service provision in digital channels, it’s possible to implement chatbots that better address both the needs of citizens (obtaining information about services and performing them) and the objectives of the Government (improving service provision and reducing its costs).

3. PROPOSED SOLUTION

The prototype presents the following functionalities:
- Government service provision in both informative and performative phase.
- Provision of information about stores and spaces.
- Registration of contact requests.
- Chitchat conversations.

There are two types of Government services provided by the chatbot:
- **Citizen**: services related to the needs of citizens.
- **Business**: services related to entrepreneurship.

In the informative phase, citizen services are provided in two ways depending on their complexity. The information about some services is provided directly with the associated intent4 (see section Data model). For the more complex services, the chatbot asks some questions to provide information specific to the user’s scenario. These services are:
- Renew the Citizen Card
- Change the address on the Citizen Card
- Revalidate the Driving License

In the performative phase, the citizen service implemented so far is the following:
- Change the address on the Citizen Card

3.1 Use Cases

The use case in Figure 1 describes the scenarios of a user that interacts with the chatbot. The user can initiate a conversation and view information about citizen or business services, about stores and spaces, perform a service, request contact or have chitchat conversations.

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4 An intended action from the user.
3.2 System overview

The prototype presents the following components (Figure 2):

- **Chatbot**: this is the main component of the prototype, which processes the interactions between the chatbot and its user and executes the dialog flows after the interpretation of the user’s intention. This component communicates with others, such as the Portal (ePortugal.gov.pt), the Spellchecker, Language Understanding Intelligent Service (LUIS), and Question and Answer (QnA).

- **Portal**: provides a web application for Government service provision. The chatbot’s graphic interface is hosted in the Portal’s web pages, allowing citizens to interact with the chatbot. The Portal also provides information and services execution for the chatbot, allowing it to provide Government services in both informative and performative phases.

- **Spellchecker**: corrects spelling mistakes detected in the texts extracted from user messages.

- **LUIS**: interprets and extracts relevant information from the text extracted from user messages. It uses NLP to process texts and Machine Learning (ML) to improve its interpretation capacity through supervised training. LUIS provides the detected intent and entities (relevant keywords found in the text), which are used to determine the dialog flows to be executed.

- **QnA**: works as the knowledge base that provides a list of available Government services and chitchat. The content is organized as questions and their associated answers. The list of Government services is stored in QnA in the form of service names as questions and service IDs as answers.

- **Analytics**: enables the sampling and monitoring of telemetry data. This enables a better perception and analysis of the chatbot performance, as well as its results from interactions with users, which aids the training and improvement of the chatbot.

The prototype is implemented using Microsoft’s BotFramework. Spellchecker, LUIS, and QnA are cognitive services provided by Microsoft and included in this prototype. Chatbot communicates with other components using Representational State Transfer (REST) APIs and receives messages from the client-side application (chatbot’s graphics interface) through Direct Line API.

3.3 System architecture

Figure 3 describes the dependency between the implementation components. The Chatbot component accesses the functionalities of other components through the available interfaces.

The architectural layers in Figure 4 describe the cross-layer dependencies between the three layers:

- **Technology layer**: technological components of the prototype implementation, such as servers.

- **Application layer**: application elements such as components and the available interfaces.

- **Business layer**: business elements such as functionalities, actors, and roles.

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5 A QnA knowledge base consists of a set of questions and answers pairs to store information.
3.4 Data model

Information about services is provided by the Portal to the chatbot, and it’s imported from the Catalog of Entities and Services (CES). CES is the master repository of the data (structured according to the CPSV model) of organizational entities (both public and private) and their available services.

In the Portal, information about services is separated into different types. Each service is characterized by the following different types of information:

- Conditions
- Contacts
- Cost
- Where
- Why
- Deadline
- When
- Who
- Requirements

This structure facilitates the service provision in the informative phase, as the chatbot can show specific parts of a content related to a service.

Figure 5 describes the simplified data structure of the services provided to the chatbot.

3.5 System behavior

The activity diagram in Figure 6 describes the main sequence of a conversation between the chatbot and a user. The user sends a message to the chatbot, and LUIS interprets the intent and extracts entities to determine which activity to start. In the end, the flow is back to the beginning until a new message is received.

If the user intends to view information about a service or perform a service (Figure 7), a list of services that best match the user question is presented.

The chatbot performs a search of services in QnA using the keywords detected as entities by LUIS, or simply the original text sent by the user in case no entities are detected. In case QnA does not return results that satisfy the minimum match score (either a list of services or a chitchat response), a search in the Portal is performed.

As the user confirms which service is the desired one, the next steps depend on its type (citizen or business).

If the selected service is a citizen service, then depending on the availability of its performing phase, the user is asked to choose between viewing information or perform the service (Figure 8).
If the user opts for performing the service, then the chatbot validates if the user is already authenticated. If the user is authenticated, then the activity for service performance starts. Otherwise, the user is informed that authentication is needed.

If the user opts for viewing information, then the activity for service information starts (Figure 9).

The intent of the service can be detected at the beginning of the conversation (Figure 6). If not, the chatbot asks the user to select one for the selected service.

After the information is presented, the chatbot asks if the user wants to know more about the same service. If the user confirms, then the same list of intents will be shown again.

Depending on the service, the chatbot gets information from the Portal or its JavaScript Object Notation (JSON) files. The JSON files contain specific and more complex dialog flows for services that present more complex information, as the chatbot needs to ask specific questions to give specific information depending on the scenario.

4. DEMONSTRATION

4.1 Informative phase provision – Revalidate the driving license

This scenario provides information specific to different situations in which users need to revalidate their driving license. The chatbot follows a predefined dialog flow and asks questions to provide the information relevant to the specific scenario (Figure 10, Figure 11, and Figure 12).

If the user opts for performing the service, then the corresponding activity starts. Each service presents different activity steps in the performative phase.
4.2 Performative phase provision – Change the address on the citizen card

This scenario allows users to change the address on their citizen card. The chatbot follows a predefined dialog flow and asks questions to gather the information to perform the service (Figure 13, Figure 14, Figure 15, and Figure 16).

Figure 11 – Demonstration – Revalidate the driving license (2 of 3)

Figure 12 – Demonstration – Revalidate the driving license (3 of 3)

Figure 13 – Demonstration – Change the address on the citizen card (1 of 4)

Figure 14 – Demonstration – Change the address on the citizen card (2 of 4)

Figure 15 – Demonstration – Change the address on the citizen card (3 of 4)

Figure 16 – Demonstration – Change the address on the citizen card (4 of 4)
5. EVALUATION

There are two sets of data samples collected based on the following time ranges:

- First set: from 15th February 2019 01:00:00 GMT to 16th April 2019 01:00:00 GMT
- Second set: from 15th April 2020 00:00:00 GMT to 15th June 2020 00:00:00 GMT

Both data samples show the statistics of the types of results returned to the user after the chatbot receives a message and interprets the text within. The types of results are the following:

- **QnA Services**: list of Government services obtained from QnA.
- **QnA Chitchat**: chitchat response.
- **Search**: list of Government services obtained from the Portal, in case QnA doesn’t return any relevant result.
- **Citizen Map**: information about a store or space.
- **Contact Portal**: registration of contact request.
- **No Result**: chatbot informs the user that it couldn’t understand the user question and asks to reformulate the question.

Both data samples also show the progression of the chatbot’s response capacity, by showing the evolution of the percentage of the times it returns a result.

5.1 First data sample set

For the first time range (from 15th February 2019 01:00:00 GMT to 16th April 2019 01:00:00 GMT), the percentage of each type of response given by the chatbot is presented in Figure 17:

![Figure 17 – Evaluation – First data sample set – Results returned to the user](image)

The percentage of the times chatbot interpreted the user message and returned a result is 82.75%.

To evaluate the evolution of its interpretation and response capacity, this percentage is also calculated for each day of the selected time range (Figure 18).

5.2 Second data sample set

For the second time range (from 15th April 2020 00:00:00 GMT to 15th June 2020 00:00:00 GMT), the percentage of each type of response given by the chatbot is presented in Figure 19:

![Figure 19 – Evaluation – Second data sample set – Results returned to the user](image)

The percentage of the times chatbot interpreted the user message and returned a result is 96.5%.

To evaluate the evolution of its interpretation and response capacity, this percentage is also calculated for each day of the selected time range (Figure 20).

5.3 Results comparison

The comparison between the two data sets related to the percentage of different types of response (Figure 17 and Figure 19) as well as the evolution of the percentage of positive responses (Figure 18 and Figure 20) shows that the chatbot’s capacity to interpret and return results evolved positively. The comparison of the total number of responses shows that the number of interactions with the chatbot has increased over time.
6. DISCUSSION

6.1 Organizational challenges

One of the barriers is related to the organization’s culture. A more progressive culture is generally more open to new
adoptions, whereas a more traditional culture can be more
reserved for changes.

One of the ways to foster receptivity is to involve
employees early in the design and development of the
chatbot. By doing so, it can increase their acceptance of
the delivered solution, and their expertise also contributes
to the betterment of the design.

During the prototype design and development phase,
content specialists from AMA have been involved to
assure that the chatbot provides service information with
an efficient dialog flow and the correct content.

6.2 Supervised training

Training is critical for the chatbot’s capacity to interpret
users’ questions and respond accordingly. Depending on
the training platform, supervised training might require a
basic understanding of NLP concepts.

To perform effective and efficient training, it’s
important to define what should be monitored during the
conversations. By collecting specific telemetry data and
projecting relevant queries, it’s possible to understand
how different users interact and what kind of questions
can be incorporated into the training data. It’s also useful
to know where the users found most difficulties and
therefore improve specific content and conversation
flows.

To ensure the evolution of the chatbot prototype’s
capacity to respond to different user questions, content
specialists from AMA have been performing supervised
training frequently.

6.3 User awareness and expectations

Users will not adhere to new service provision channels if
they are not aware of them. Therefore, communication
about such channels is very important.

However, their expectations and interaction experience
might affect their satisfaction and continuous use. Aside
from continuous training, it’s important to pay attention to
the chatbot’s personality, and how they present the
contents. An adequate tone makes the interaction more
engaging, and the right wording can help users understand
that chatbots are programs in progress. At the beginning
of the conversation, a brief introduction of what a chatbot
can do helps users know what to expect. This can lower
their expectations and therefore increase their tolerance
for less accurate interpretations.

An adequate fallback or escalation to human contacts
can also improve the user experience.

The chatbot prototype presented in this work incorporates all these aspects to manage the user
expectations towards it.

6.4 Existing processes and systems

Chatbots should enhance existing processes and systems
as an alternate channel that extends existing services. However, integrating existing services with a chatbot can
present some challenges. One of them is integrating an
existing information provider. The contents need to be
normalized and structured in a way that the chatbot can
use and provide to its users.

In this work, the data model for services is based on
the CPSV model and is simplified and normalized,
making it possible for the chatbot to reuse from the
National Portal for Government services.

6.5 Developmental Challenges

One of the biggest challenges involved in the uptake of
any new technology is the slow adoption rate, particularly
when the technology is seen by end users as a replacement
for traditional methods which they have grown used to
over time.

A greater adoption of the chatbot will only be possible
when more users get more relevant and contextual results
to their queries. However, to provide more accurate results
from the interaction, the chatbot needs to evolve by using
a larger sampling dataset which is only possible when
there are more varied usage patterns. Then this larger
data set can be used for supervised training to make the
chatbot answers more relevant.

This scenario makes it a developmental challenge as
greater efficiency of the platform depends on higher usage
and conversely, higher usage depends on more efficient
responses.

The mitigating factor for this challenge could be the
government actively encouraging more and more users,
particularly the young people to use it as their preferred
medium of interaction.

7. CONCLUSION

Compared to other digital channels, one of the main
advantages of the chatbot is that the users can find the
right service without extensive search and navigation, as
well as the use of specific keywords. They only need to
formulate a question and the chatbot interprets the natural
language and identifies the services to provide.

With the use of an information structure based on the
CPSV model, it is also possible to provide specific
information on different Public Administration (PA)
services according to each user’s specific questions and
scenarios.

While it is not fully mature to cover all the complex
scenarios covered by traditional channels, it can evolve
through supervised training. With the results shown in
evaluation, we can conclude that the chatbot’s
interpretation and response capacity evolved positively.
With this evolution, along with the instant availability,
chatbots can reduce the adherence to the traditional
channels and therefore lower the service provision costs of
the Government. The comparative results of each previous
time period show an increasing number of interactions.
with the chatbot. These advantages can be applied to solve different organizational problems. Chatbots can ease the staffing requirement to provide an increasing number of information or services. Its users can also benefit from having an alternate digital channel that is easy to use and instantly available, any time of the day and online.

7.1 Contribution

This section describes the main contributions of this work. With the chatbot prototype presented as the artifact of this research, it shows that the chatbot can be used as a new digital channel that can lower the cost of other traditional channels used to provide information and services.

The architecture of the prototype can be served as a reference for chatbots that provides services in the informative phase, as it presents a content structure based on the CPSV data model that facilitates its reusability and extensibility. This work also presents different user cases, system components, and behavior models, which can contribute to the design of similar chatbots for service provision.

The validation of the prototype proves its viability, efficacy, and efficiency as it is implemented in the context of the Portuguese National Portal for Government services and it shows a growing capacity to respond to user questions, with a growing number of interactions with users.

The presented solution can be applied to other organizational contexts in which NLP and specific information structures can be used to solve different challenges.

REFERENCES


