"SAVIO": Benefits and Issues of Cloud Computing for Public Government

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Abstract
There is a growing global awareness that harnessing the potential of information and communication technologies (ICTs) can foster innovation, progress, and economic development. Through this process, a transformation takes place that aims at country growth, employment, improved life quality as well as simplification, and greater active democratic citizen participation. In this rapidly evolving scenario, cloud services for Public Administration seem to be one of the most cost-effective means to overcome system limitations, providing those features of effectiveness, efficiency, transparency, participation, sharing, cooperation, interoperability, and security needed for today's challenges. In this research, we present an approach based on distributed systems and ontologies for creating virtual assistants that leverage artificial intelligence and machine learning to save time and public money by providing better services, increasing effectiveness, efficiency and transparency. We developed a framework to guide cloud consumers in selecting cloud technologies through opportunity and risk analysis to reach this objective. The results demonstrated reduced support costs, improved tracking of provided services, and simplified work for public officials with the goal of re-balancing bargaining power between the small organization and the cloud service provider.

Keywords
ChatBot, Cloud Computing, Ontology, Public Government

1. Introduction

Today, technologies related to cloud systems and artificial intelligence (A.I.) are areas of considerable interest and subject to huge investment and development. With the progressive development of new ways to produce knowledge, these technologies define new approaches to business activities [1] and new systems of relationships in the value creation processes. All this translates into competitive and economic advantages for companies and regional systems. Governments and political institutions, as well as private organizations, must do their part by investing in strategic capabilities that enable the development and use of digital solutions [2, 3]. They must aim for interoperability in digital infrastructure such as, for instance, Super computing [4], Quantum Computing [5], Big Data [6, 7, 8], Blockchain [9], Cloud technologies [10, 11, 12, 13, 14], Artificial Intelligence [15, 16, 17, 18, 19, 20], and next generation networks [21], ensuring security[22], effectiveness and efficiency. These are all technologies that will become increasingly relevant in our lives in the future.

With this in mind, the giants of technology have developed platforms capable of interpreting expressions in natural language and offer virtual assistants such as Google Assistant; Amazon Alexa; Siri; Cortana, and IBM Watson. Such platforms are capable of performing human dialogue, answering questions on topics of different nature, and performing complex tasks. With this technology, it is possible to guarantee to e-Government characteristics of effectiveness, efficiency, transparency, participation, sharing, cooperation, interoperability, and security. While it is reasonable to assume that cloud computing could be a solution for the public government to many localized problems, it is also true that this choice raises a debate about the technical and legal aspects. Arise security issues that are not only technical and IT-related, but rather linked to the negotiation and contractual aspect, related to the ability, the necessary skills and the strength of the client to impose on the cloud service provider: binding directives, limits, service levels and compliance with data protection legislation. In addition, it is necessary to precisely establish the contractual liability of the provider in the event of non-compliance or non-conformity of services. A.I. can work alongside public government to improve services to citizens and businesses, to improve the relationship between citizens and public government, between public government and its employees. In 2020, the university Polytechnic of Milan conducted a census of the main international initiatives in the field of A.I. to survey the ecosystem of artificial intelligence applications

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developed in the public context. This survey shows that virtual assistants and chatbots gain a share of attention equal to 16% of total A.I. solutions.

However, despite this growth of interest, the level of maturity of these solutions, in many cases, has stopped at the simple Proof of Concept, while in other cases there were only theoretical developments never put into operation. This research aims to analyze cloud-related issues for public government, developing a prototype model that supports the public government in the wise approach to the cloud services market. Hence, the name "Sàvio" (from the Latin sapius "to be wise"), a cloud supply management model that integrates not only best practices and proven strategies but also artificial intelligence, to obtain a system adapted to the reality of public administration. Sàvio proposes a scheme for governability of cloud services for the public government through:

- the development of a back-end web app that takes into account specific contractual indicators and supports the public government in their detailed detection and tracking;
- the development of a virtual assistant/chatbot to intelligently govern the conversation scenarios envisaged as part of a cloud provider for the public government, and also offer a targeted help system;
- the tracking of Service Level Agreements (SLA).

The Sàvio model allows:

- reduce support costs;
- trace the details of cloud services/products supply simplifying the work of public government officials;
- re-balance the bargaining power between small organizations and cloud service/solution providers by setting up an automated reputational center that allows any consumer, through cooperation, to report issues concerning their cloud service provision and assess the risk parameters resulting from the adoption of a specific cloud solution.

Currently, the most widespread solutions available focus on the development of systems or products for interpreting natural language expressions based on supervised learning techniques, without further benefits. In addition, the systems proposed to the public administration are limited almost exclusively to offering Software as Service (Saas) solutions-oriented mainly to electronic procurement (eProcurement) and therefore limited to the simple management of the assignment of works, services, and supplies (these are simple management systems tailored to customer needs). Such systems seldom integrate virtual assistants/chatbots and in the few cases where they do, their use is oriented to provide simple first-level support, without collecting valuable information on the governance of supplies. Therefore, such systems are of little support in decision-making and in monitoring the whole procedure.

The “Sàvio” model overcomes all these limitations, as the proposed solution guides the buyer to choose the best solution for its needs by analyzing risks and opportunities, through a process and control model that is adequate and adapted to the context of the specific public government. Sàvio Agent is based on IBM Watson, the same technology used in the City of Markham – Canada’s high-tech capital – where are using the artificial intelligence-driven virtual agent "IBM Watson Assistant for Citizens" to offer 24-hour customer service for residents looking for COVID-19 information. The solution use machine learning to deliver reliable, consistent, and accurate information via online text chat and voice calls – anywhere, anytime. This article discusses a combined and innovative approach to the use of cloud and A.I. systems for the public government. Moreover, the model presented is easily expandable and applicable to different domains, both public and private.

The document is structured as follows: in section II, we explain the state of the art and the reasons why we chose the technologies used in the project; in section III, we introduce the Sàvio project, describing the model, the case study, and the application. At last, in section IV we summarize our work, draw conclusions, and outline possible future works.

2. Related work

Cloud computing provides opportunities for government transformation. As defined by the National Institute of Standards and Technology (NIST), cloud computing is a pool of computing resources such as servers, storage, networks, applications, and services (NIST, 2012). These resources are available on-demand with little or no interaction with the cloud service provider. Cloud computing is growing rapidly as it can be used in any industry without many obstacles [23], some of which involve contractual implications.

According to Gartner [24], the utilization of cloud computing is growing and governments have started to capitalize on the cloud. Worldwide end-user spending on public cloud services is forecast to grow 18.4% in 2021 to total $304.9 billion, up from $257.5 billion in 2020. The large adoption of Cloud technologies has demonstrated the effectiveness of this new paradigm to simplify data centers management. The Public Administration will use multi-tenant services, shared and managed by different organizations. Cloud computing for the public government is enabled through Government Application Stores (e.g. Fedramp marketplace in the U.S.A., AgID in Italy; Gov.uk in the U.K.) where services can be purchased, used, reviewed, and reused across the public sector. The objective of the Government Application Store is to: provide an open and transparent market in terms of costs for the public sector; allow the public government to have information on the accreditation status of the service and the characteristics of the service; allows public government users to easily find, compare, purchase, deactivate and change services.

Cloud consumers are confused when they choose to select a cloud service provider (CSP) to build cloud services. The Cloud Services Broker (CSB) is an entity capable of solving choice problems. The market surveys clearly show which are the main CSP players: in 2020 according to Gartner, we have Amazon Web Services (AWS), Microsoft, Google, Alibaba Cloud, Oracle, IBM. Using the search engine www.mendeley.com and setting different keywords for the search such as "Cloud Broker", "Cloud Service Broker", "Cloud quality problems Service Broker", "Cloud Services Broker for Cloud Services Provider Selections" etc. It appears that a lot of research is based on the selection of cloud service providers based on quality and cloud brokering. The contractual relationship between Cloud service providers (CSPs), their customers, and, above all their customer's end users, are generally defined in a standard. Within cloud computing contracts, there may be conditions such as free vs paid services; US versus EU jurisdictions; IaaS vs Software-as-a-Service (SaaS).

Because cloud computing is a distributed model, data may be stored and processed on multiple data centers and in multiple jurisdictions. The general principle is that information risk owners will remain responsible for the information risks that the department owns or guards. The only resources the public government owns are the information in the service, the information assurance, and the associated reputational risks. Risk management, the relationship between small public government and large cloud service providers, and the governance of service delivery are certainly the biggest issues to be addressed.

At present, the following research areas exist about cloud aspects, application interoperability, and chatbots:

- Systems that analyze and aggregate web services [25];
- Chat-bot for Public Government [26]
- Tender documents for public government-oriented cloud services [27].

We proceeded to verify the design of calls suitable for the chatbot implementation after conducting a preliminary analysis of the documents published and peer-reviewed [28] [29] [30]. Further investigation was carried out with the help of the AGID Italian marketplace to identify solutions similar to our solution illustrated in the paper (Sàvio BO). This survey led to the identification of SaaS solutions mainly oriented towards e-Procurement, understood as a service composed of integrated functions to support the public government in the computerized and telematic management of the entire process that goes from the collection of requirements, programming, awarding, and testing of a service/work.

Although these solutions have been announced as interoperable, they do not include architectural components such as those found in Sàvio. The Supervisor allows interacting in real-time with other deployments of the same product in the Back Office, offering to the community of consumers useful information about the service provider, while the Agent communicates with end-users through a database-driven chatbot, to offer them a tool to support, guide and facilitate access to services.

The study also analyzed the development of chatbots for public government, based on the Osservatorio Agenda Digitale [31] of the Polytechnic of Milan. In particular, it emerged that most chatbots and virtual assistants designed for a public government offer first-level only information to users without actually interacting with back-office systems.

An example of a chatbot for public government is the Roma Capitale project called 'Romolo'. This virtual assistant, managed with artificial intelligence tools, based on NLP (Natural Language Processing), conveys information and FAQs to accompany citizens in their use of services in the territory. The Municipality of Milan launched its information chatbot on WhatsApp. A more advanced experience is represented by the Municipality of Siena [32], which allows users to make requests in addition to having immediate and advanced information (such as certificates).

Other chatbots are used in the City of Markham [33] (Canada's city) to answer COVID-19 questions. The Maricopa County Clerk's Office deployed the virtual assistant to improve efficiency for its employees and residents [34]. The Government Technology Agency of Singapore (GovTech) and Smart Nation and Digital Government Office (SNDGO) [35] have been exploring the use of virtual assistants (VA) and A.I. to improve government services. The chatbots, just listed, do not allow contributing to the governance of the provision and/or service. Our solution fulfills these prerogatives by providing valuable support for internal users within the organization. The analysis of the Sàvio model was conducted based on the AGID guidelines [36]. In particular, the tenders issued by Consip [37] were analyzed, from which, in addition to the details of the cloud services, regulatory ideas emerged that led the study towards the definition of a detailed technical-regulatory scenario. Concerning the Sàvio model, national and international regulations were contextualized, paying attention to the issue of the responsibility of all actors in the field of cloud services between PA-Supplier-

Professional. The study also emphasized the importance of academic and post-academic training of the resources needed to carry out tender/contracting activities. This aspect is often ignored in the tender process.

In the following paragraphs, we will describe the approach used to manage the cloud services provisioning integrated with database-driven virtual agents. We will also present the service created to support public administration in managing shared risk. More specifically, we are going to describe the approach used for building a database-driven virtual assistant in IBM Watson. In addition, we will introduce the additional service created to support the Public Administration in the adoption of cloud solutions that can integrate the functions of digital marketplace services.

3. Sàvio

Sàvio is a framework that guides the cloud consumer in the adoption of cloud technologies through opportunities and risks. Our solution offers the following advantages: decrease assistance cost; track the cloud services delivery, simplifying the work of government officials and re-balance the bargaining power between small organization and cloud service provider by creating an automated reputational center.

The key cloud players are:

- cloud consumer (CSC): who uses cloud computing and signs a contract with the cloud provider;
- cloud provider (CSP): subject responsible for making the service usable to interested third parties; CSP provide cloud services;
- cloud broker: intervenes between Cloud Consumer (Public Administration) and CSP by offering brokerage services, aggregation of necessary cloud services with existing resources and arbitrage;
- cloud auditor: perform audits about privacy, performance, security, regarding the services provided by the CSP expressing opinion on the merits;
- cloud carrier: cloud broker that provides connectivity, transport and interconnection tools between the cloud consumer (PA) and CSP.

The contractual relationship between CSPs and other actors, including the public administration, is typically defined in a standard form which includes the following components: Terms of Service (TOS); Acceptable Use Policy (AUP); Privacy Policy; Service Level Agreement (SLA). The TOS set out the provisions that define and regulate the overall relationship between a CSP and the client. The SLA [38] details the level of service to be provided, often in the form of specific quality of service (QoS) metrics, and the mechanisms for auditing service delivery and QoS, and compensating clients for under performance. The AUP, sometimes called a 'fair use policy', is a policy to protect CSPs from the actions of clients, and in the case of enterprise clients, their end users, by detailing prohibited uses of the contracted cloud service. Privacy Policy details the CSP's policy for handling and protecting personal data, in line with data protection law requirements. The migration phase to a cloud infrastructure can be greater than the cost of managing an existing infrastructure. The consumer or the public administration calculates whether the migration costs and the fully operational costs in the cloud environment will be able to offset the costs of the existing infrastructure. The return on investment (ROI) of cloud infrastructure adoption can be calculated through the formula ROI=

$$\frac{Bt + Bi - TCO}{TCO}$$

Bt are the tangible benefits, Bi are the intangible benefits and TCO is total cost of ownership (TCO) that is obtained from the sum of initial costs (Ci), recurring costs (Cr) and termination costs (Ct). If the On-Permise solution is used, the TCO can be converted into production cost considering the following factors: cost and average local hardware duration; current costs for servers and networks; total invested capital; structural costs (costs of electricity, rent and management of the premises); cost of human resources for infrastructure management; cost of application migration; cost of staff training; cost of partners and third party tools; costs not mentioned but resulting from monthly invoices. It is possible to estimate the effort in moving software solutions to the cloud through the WideBand Delphi Techniques [39].

3.1. Sàvio Model

Organizations need to approach the cloud with responsibility. The cloud consumer or the Public Administration must consider and negotiate Service Level Agreements (SLAs) to avoid the worst scenarios such as: increase in costs upon renewal of the contract; interruption of commercial operations by the service provider or supplier without any migration plan to other, more economically advantageous platforms; commercial disputes between the service provider and the cloud service provider; drastic reduction in the quality of services. The present research analyzes the governance aspects of the provision of cloud services and builds a model of process and control of the supply: the Sàvio model. This model requires that SLAs are described by measuring a set of target values (SLO: service-level objective) and performance, reliability and result indicators (SLI: Service Level Indicator).

The Sàvio process designs the following phases o the provision of cloud services: pre-contractual anal ysis and initialization of the Sàvio model; onboarding pre-production and production; contractual terminatior In the initialization phase of the model, Sàvio analyze the contract and identifies the SLA indicators. The pre production, on-boarding and production phase include constant monitoring of the SLA indicators. In this phase failure to comply with the SLA determines contractua actions consisting of: application of contractual remark (R), application of contractual penalties (P), suspensior of contractual effect (S) additional actions (request fo damages, early termination of the contract, etc.) In the Sàvio model, any action is promoted by the cloud cor sumer, or by the Public Administration, in relation to a single objective (for deadlines not met).

Common metrics for SLAs are the mean time be tween/to failures (MTBF), the mean time to repair/re covery (MTR), and Mean Time to Failure (MTTF: average time to failure that measures the average time of oc currence of a system failure or malfunction or the time average uptime). MTBF = MTTF + MTR. Assuming tha the first fault occurs at time t1, it will take a time t = MTR for the repair to take place and a further time t = MTTF for the second fault to occur at time t2, therefore: MTBF = t2 - t1 = MTR + MTTF. We will therefore have that:

$$MTBF = \sum \frac{(downtime_n+_1 - downtime_n)}{numero\ di\ failures}$$

In a Sàvio model MTBF just gives a yardstick by which a given company's SLA can be compared against another in the Sàvio supervisor. The probability that the cloud system is in an operable and usable state when the service is requested at a random time is the availability:

$$Availability = \frac{MTBF}{MTBF+MTTF}$$

After the study of the Sàvio model, the architecture of the software system was designed through interoperability schemes. Sàvio software is a system that manages an application and a chatbot with user-generated content as well as an advisor system for monitoring the risks, quality of services, costs of cloud services adopted by the Public Government. The chatbot guides users to the correct representation of the problems that affect the significant parameters for the consulting system. Three Sàvio software modules have been built: Sàvio supervisor, Sàvio back office (BO), and Sàvio agent (figure 1). Sàvio Supervisor is the external interoperability application component that allows you to automatically establish, by means of information flows from the N deployments of Saviò back office, the reputation of the cloud service / product provider according to predetermined parameters.

The prerogatives of Sàvio Supervisor are: to monitor supplies; re-balancing the bargaining strength between cloud consumer or Public Administration, especially small ones, and service / product suppliers through

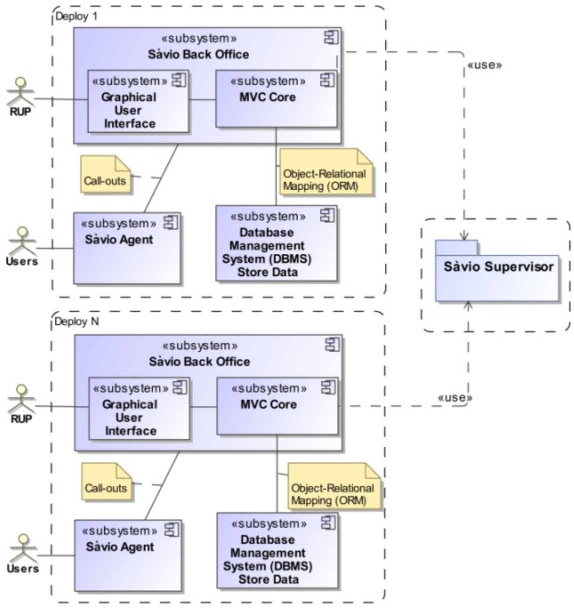

Figure 1: Sàvio architecture.

the establishment of an automated reputational center. In this context of application cooperation, the good performance of the single cloud service supply becomes very important for any service provider. Sàvio identify critical Shop Identification - Unit Time: Average Number of Failures (ANF) - Shows an average of failures occurred in a given time period in numbers; Number of supplier errors - number of contractual reports small customer supply index (SCSI): it is an index imposed by Sàvio which compares the number of small customers supplied with the number of large customers. This index obliges suppliers to serve a predefined number of small public government based on the number of large organizations served. Sàvio also identify of critical software modules - Units of time: Availability; MTBF; MTTR; Failure rate (FR):1/MTBF. Sàvio applies decision-making techniques to execute identification of critical solutions based on the attributes identified above and calculates a cloud service provider ranking based on user feedback using the PROMETHEE method[40].

Sàvio back office is a web app that allows to govern service/product provision, also tracing the events of the supply in a knowledge base. Sàvio Back Office (BO) consists of: Sàvio Back Office Core that contains the business logic of the application and implements all the functional and interface services of the solution; interacts in an authenticated and protected manner with Sàvio Supervisor and Sàvio Agent; Sàvio Back Office Web User Interface

(WUI) that designs the user interface and manages the interaction with it by exploiting the interface services of the core component; Sàvio Back Office Archive, the database with which the Core component interacts to store and consult information. Sàvio Back Office core is based on Spring Model-View-Controller (MVC), one of the most popular open source frameworks for developing high quality java applications. The heart of the framework consists of an Inversion of Control container that manages the entire life cycle of the objects in the application context, from configuration, to finding dependencies and creating individual instances, all through Dependency Injection. Sàvio Back Office Core implements REpresentational State Transfer (REST) ful Application Programming Interface (API) based on the OAuth2 security protocol. An OAuth token is required for any REST API call. Application Programming Interfaces (APIs) are foundational to a modern digital ecosystem. These standards govern how APIs are to be developed across the Government of Canada (GC) to better support integrated digital processes across departments and agencies. Sàvio Back Office WUI is based on the Vaadin framework integrated into the Spring (MVC) pattern. Vaadin Framework is a tool to build good-looking Web apps without working with low-level Web technologies. The framework itself contains all the logic to create the modern Web app while you concentrate on the UI itself, using a familiar component-based approach, almost like you're building a traditional desktop app. Sàvio Back Office Archive is based on PostgreSQL.

Sàvio Agent is a chatbot that uses the public government knowledge base that was built with Sàvio BO. Sàvio Agent invokes Sàvio BO core API services through HTTP calls with post method from one or more dialogue nodes. This mechanism is activated when Sàvio Agent processes a node that has a call-out enabled. The chatbot collects the data during the conversation with the user and saves them in the context variables, subsequently transmitting the data as part of a HTTP post request to the URL of the restful API of Sàvio BO core (listener). The listener performs a predefined action using the information transmitted to it in the definition of the Sàvio Agent call-out. Subsequently, the chatbot optionally returns a response to the user also based on the call-out response.

3.2. Case study research and applications

The Sàvio model has been applied to public administrations and local authorities. Local authorities are numerous in every national territory and do not have human resources with the skills to manage the relationship with service providers. Often, cloud service management and service contracting are delegated to the service provider. The study analyzed a number of government digital cloud marketplaces such as: in the UK www.digitalmarketplace.service.gov.uk, in Italy https://cloud.italia.it/marketplace/, and in the USA https://www.fedramp.gov/. The open data available in the marketplaces have been analyzed and then imported into Sàvio's database, after classifying possible anomalies. Specific entities have been built in the Sàvio archive for: recurring themes (thematic areas) such as Taxes, Citizenship, Commerce, Culture, Elections, Family, Public Works, Work, School, Social Services, Sport, Public Construction; management of defects, problems or failures that could compromise the correct functioning of cloud products or services. The user of any system can identify a defect, have a doubt and report it to request help or a solution. The user forwards the reports by telephone or forwards them to Sàvio Agent. The Sàvio BO implementation made it possible to define all the management functions relating to the governance of supply and reporting. The deployment of Sàvio BO was done on IBM BlueMix using the Bluemix CLI and Cloud Foundry CLI. The Application cooperation between Sàvio BO Core architectural components was implemented through RESTful API authenticated with OAuth 2.0 Authorization Framework. An OAuth token is required for any REST API method made available by Sàvio BO Core. The Sàvio Agent chatbot was implemented on the IBM cloud platform where we defined: intents, entity, dialog tree and web-hooks. The first Intent is related to frequent greeting forms such as: "Hello", "Good morning", "Good night", "Good evening". Then two options are proposed: "I am using your services and I have problems", "Other issues". In the study of Sàvio Agent, it was very important to define a guiding node: it is the way to restart the dialogue in case the agent recognizes the #Restart intent. In this context, the first level of interoperability with Sàvio BO Core is defined through the activation of Webhooks.

This mechanism allows you to call a service RestFul API with authentication token in method post HTTP. The webhook calls the resource exposed by Sàvio BO core passing the parameter containing a JSON structured as follows: ""description": "value" where "Value" is the value of the context variable assigned during the dialog interaction with the user. Sàvio Agent sends a callout to Sàvio BO Core and waits for the details of the topic, then proposes the answer with multiple options or as one URL referring to a website for more information. Sàvio Agent also allows users to forward reports to the back office. The user is initially directed to the FAQs registered in the Sàvio BO Archive. Sàvio Agent performs a callout on the resource "/rest/v2/ entities/savio_defect/search". The chatbot allows the user logged in to also forward new reports to the back office.

This technology approach offers the ability to quickly and easily extend system functionality and integrate with multiple interoperable back-office systems. In fact, the virtual assistant embeds interoperability nodes with back office management systems. To add new actions, it is not necessary to modify the dialogue flow, but it is sufficient to use the management functions of Sàvio BO. Supply governance and feedback management with Sàvio Supervisor, would have an extremely positive impact in terms of supporting all organizations in their role as consumers of cloud services. Sàvio Supervisor can support each country's cloud services market for constant monitoring and control of the cloud services market.

4. Conclusions and Future works

This research work has defined a model for governing the provision of cloud services for consumers and the Public Government; an interoperability model between different distributions of the same product and the guidelines that can be used in the design phase of database-driven chatbots. To do this, we have implemented an interoperable software architecture, a database-driven chatbot, designed to meet specific requirements of highly useful use cases.

Sàvio is the result of the integration of the following innovative solutions: back-office solution with Spring MVC and VAADIN web interface; interoperability solution based on ResutFul API; database-driven chatbot solution developed on IBM Watson Assistant. This architecture has been enhanced by introducing the OAuth 2.0 framework and developing core software components for managing users and authentication tokens.

The guidelines for the design of database-driven chatbots have numerous possible areas of applications. Chatbots are also promising to reduce assistance costs and make the execution of recurring tasks easier and more immediate. Tests have shown that the proposed solution can be easily implemented in a cloud environment and provides the following benefits: to the end-users to get immediate and guided access to a help system; to the cloud consumer to have precise control over the individual steps of the cloud service; to the market surveillance authority of the individual country suggests a solution for the constant monitoring of the cloud market.

Thanks to the use of standard and open source products, the experience can be easily replicated to other clouds infrastructure. The final results contribute to the advancement in knowledge of the Cloud computing market and related software as a service.

As future work, we intend to focus on the challenges implementation of risk assessment tools and timely monitoring of the cloud market, starting from the empirical analysis of the development tools adopted, and the concepts identified in Sàvio Supervisor.

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