A Reference Architecture for On-Premises Chatbots in Banks and Public Institutions

Guidance on Technologies, Information Security and Data Protection

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Abstract: Chatbots have the potential to significantly increase the efficiency of banks and public institutions. Both sectors, however, are subject to special regulations and restrictions in areas such as information security and data protection. The policies of these organizations therefore, in some cases, reject the use of cloud and proprietary products because in their view they lack transparency. As a result, the implementation of chatbots in banks and public institutions often focuses on open-source and on-premises solutions; however, there are hardly any scientific guidelines on how to implement these systems. Our paper aims to close this research gap. The article proposes a reference architecture for chatbots in banks and public institutions that are a.) based on open-source software and b.) are hosted on-premises. The framework is validated by case studies at TeamBank AG and the German Federal Employment Agency. Even if our architecture is designed for these specific industries, it may also add value in other sectors – as chatbots are expected to become increasingly important for the practical application of artificial intelligence in enterprises.

Keywords: Chatbots; Machine Learning Architecture; Enterprise Architecture; Reference Architecture; Capability Map; Banking; Public Sector

1 Introduction

In scientific literature there are numerous works on the use of chatbots in enterprises and their potential. On one hand, the technology can be used to improve external communication with customers and business partners. Examples are self-service and automated help [Mc21, p. 13]. On the other hand, chatbots offer the possibility of applying artificial intelligence to facilitate internal processes, such as daily work in customer service, sales teams or in

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administrative workflows [Ko20, p. 129]. The $11 billion valuation of the German startup Celonis in 2021 impressively demonstrated that process mining and process optimization are capable of adding significant value to businesses [Ko21]. According to Celonis, chatbots often serve as a starting point for so-called Robotic Process Automation (RPA), which leads to a rationalization of company workflows [Sc19].

When implementing chatbots in banks and public institutions, both technological and non-functional challenges need to be addressed. Due to their extremely sensitive data, it is obvious that the two sectors have special requirements regarding information security and data protection. In the European Union, the storage of personal data is governed by the General Data Protection Regulation (GDPR) [Eu16]. With member states acting as role models in implementation, their public agencies pay strong attention to compliance with the regulation. The same is true for banks. As a consequence of the subprime financial crisis in 2008, European banks are subject to close supervision by national as well as international authorities. The European Central Bank (ECB) and the European Banking Authority (EBA) hold key roles in this context. Together with their national counterparts, they oversee compliance with both general and specific regulations to banks such as BCBS 239 [Ba13]. The focus of banking authorities has increasingly expanded into the area of big data and advanced analytics in recent years [Eu20]. At the official level in Germany, the Federal Commissioner for Data Protection (BfDI) and the Federal Office for Information Security (BSI) act as supervisory authorities [De19] [Fe21].

Establishing a chatbot architecture in banks and public institutions is therefore not a purely technology-driven decision. Non-functional requirements such as information security and data protection are equally important. Success depends on both factors. In-house compliance departments have an essential function in this regard to ensure that regulations are being met and have a right of co-determination. Their policies, however, in some cases reject the use of cloud and proprietary products, which in their view lack transparency. As a result, the implementation of chatbots in banks and public institutions often focuses on open-source and on-premises solutions. Yet there are hardly any scientific studies on this special case which is what this article aims to address.

The paper outlines a reference architecture for chatbots in banks and public institutions that are a.) based on open-source software and b.) are hosted on-premises. In the first step, the functional requirements for chatbots are analyzed in the form of a capability map. Secondly, we define system components that cover these requirements. In this context, we describe which frameworks offer the identified elements. Finally, we validate our architecture with real use cases from TeamBank AG and the German Federal Employment Agency. We explain how the functional and non-functional requirements were met in the institutions and which frameworks and technologies were used for the implementation.

2 Related Work

Existing literature categorizes business capabilities enabled by chatbots in various dimensions. Examples are *modes of communication* and *industry vertical*, see Kahn and Das [KD18, pp. 98-105]. The authors distinguish between different dimension attributes. Modes of communication include business-to-business (B2B), business-to-consumer (B2C), consumer-to-consumer (C2C), business-to-employee (B2E), and employee-to-employee (E2E). Examples of industries using chatbots are banking, financial services and insurance (BFSI), travel (especially booking bots), food and restaurants, e-commerce, and utility services – among many others.

Cem Dilmegani [Di21] differentiates between two types of business capabilities. *External capabilities* include patient engagement, drug information, adverse events reporting and social media interaction, as well as collecting customer feedback. Examples for *internal capabilities* are expert lookup, internal help desk, enterprise Q&A as well as virtual sales assistants that integrate with the enterprise's customer relationship management system to notify and guide personnel and thus simplify lead creation and updates. Another internal capability mentioned by Dilmegani is pulse monitoring through chatbots connecting with the company's collaboration environment (e.g., Slack) to monitor satisfaction and productivity.

Hajjar [Ha21] classifies capabilities by *reactive* and *proactive* functions. Moreover, he provides statistics on chatbot usage. Farkash [Fa18] examines chatbots in government. He describes five ways of how bots are capable of personalizing public services.

A study on chatbot applications in government, using the example of public administrations in Latvia, Vienna, and Bonn has been conducted by van Noordt and Misuraca [NM19]. The European Commission published in 2019 an architecture for public service chatbots, authored by PwC [Pw19]. Their basic design serves as a foundation of our component model in section 3.2, adapted for our specific case. Analogously, there are publications with focus on chatbots in the banking sector. For instance, Li et al. [Li20] have analyzed a three-month conversation log of 1,685 users with a task-oriented banking-bot. Considering that information security has become a vital issue for the financial sector, Lai et al. [LLL19] describe a security control procedure for chatbots. Their method aims to protect the security and privacy of user data. Sağlam and Nurse [SN20] address the issue of GDPR compliance and the corresponding aspects that need to be considered when designing agents.

In general, there is plenty of literature on chatbot technology. We find articles on how to build bots and which frameworks and platforms are available in the cloud and on-premises. Kohne et al. [Ko20, pp. 67-79], for example, describe various platform types. Examples of *conversational platforms* are Cognigy.AI, Amelia, kore.ai, and Rulai. *Code platforms* include API.AI/Dialogflow, AWS.AI, Luis.ai, Rasa, recast.ai, reply.ai and IBM Watson. Instances of *klick-chatbot platforms* are MessengerPeople, Botmaker, Spectrm, CharterOn, Chatfuel and Manychat. Finally, *flow platforms* are based on such technologies as Cacoo, Creately, Draw.io or Botsociety.

Lokman and Ameedeen [LA18] conduct a technical review of modern chatbot systems. For this purpose, the authors investigate five technologies, namely DeepProbe, AliMe, SuperAgent, MILABOT, and RubyStar.

Galitsky [Ga19] describes chatbot components and architectures as well as how to implement them using machine learning techniques such as Bayesian networks, neural networks and Markov models. Garga [Ga20] introduces a conversational UI technology maturity model that can be used to classify frameworks and chatbot components along different dimensions. This model serves as a basis of our reference architecture in section 3.3.

Currently, there is limited literature with a special focus on open-source and on-premises solutions. Singh, Ramasubramanian and Shivam [SRS19], for example, provide their insights into the open-source world of chatbots. The authors examine processes in the banking and insurance sectors, which are related to the use cases in our article. Moreover, they identify publicly available data sources that can be used by developers to train bot models. The authors evaluate popular open-source NLP and NLU tools as NLTK, spaCy, CoreNLP, gensim, TextBlob, and fastText. Finally, Singh et al. describe the chatbot frameworks IRIS, Microsoft Bot, Rasa and Google Dialogflow. A great added value of their book is that it guides developers through practical implementation and contains Python code snippets.

Sharma and Joshi [SJ20] focus on Rasa and provide an analytical study and review of this open-source framework. Nayyar [Na19] offers a brief overview on the open-source frameworks Botkit, Botpress, BotMan, VISEO Bot Maker, Rasa and Microsoft Bot. A similar, but more scientific overview of chatbot technologies is provided by Adamopoulou and Moussiades [AM20].

In the following, we build on the discussed literature and further study open-source and on-premises chatbots from a practitioner's perspective. The result will be a draft of a reference architecture for this particular setting.

3 Construct a Reference Architecture

3.1 Capability Map

As a basis for our reference architecture, we analyze the functional requirements for chatbots from a business view in the first step. Therefore, we establish a capability map that outlines use cases in three different application areas, namely Customer Relationship Management, Product & Service Development, and Marketing Services. Figure 1 shows the result. The map is based on the literature reviewed in the previous section and our practical experience.

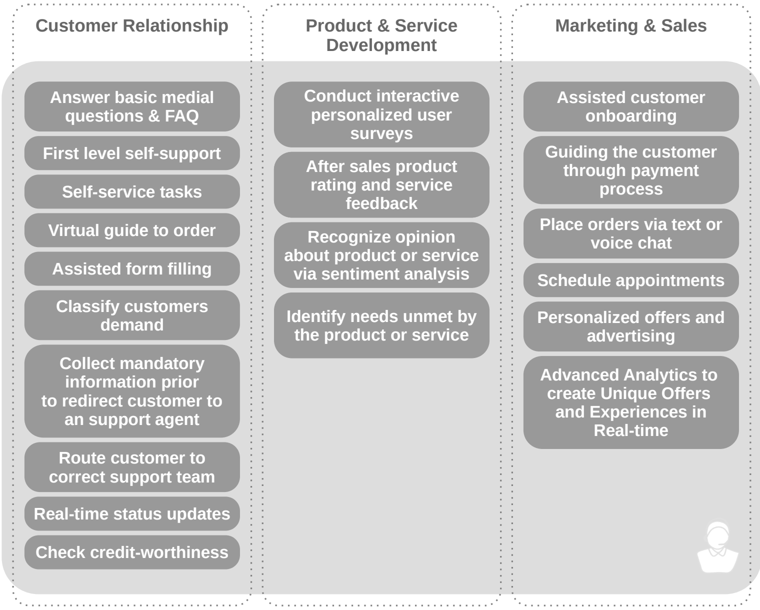

Fig. 1: Business Capability Map for Chatbots

Even though the capability map is primarily oriented towards commercial enterprises, the capabilities can in principle be transferred to public services too. As our map shows, chatbots are being used in a variety of different fields. Hajjar, for example, describes customer support, product suggestion and offering of discounts via conversational interfaces [Ha21]. He highlights the prevention of churn as one of the most important goals for subscription-based industries. According to Hajjar, the top five sectors which benefit from chatbots are real estate, travel, education, healthcare and finance.

3.2 System Components

Let us now analyze the system components needed to implement the capabilities described in section 3.1. For this purpose, we build on an architecture for public service chatbots issued by the European Commission [Pw19]. The high-level design of the study serves as basis for our system components, shown in Figure 2.

According to the above-mentioned study [Pw19], chatbot applications typically consist of three elements: a.) different types of user interfaces such as websites or messengers, b.) the actual digital assistant, and c.) a knowledge base that incorporates, for example, core and analytical systems of an institution. For our specific research question, we extend the model

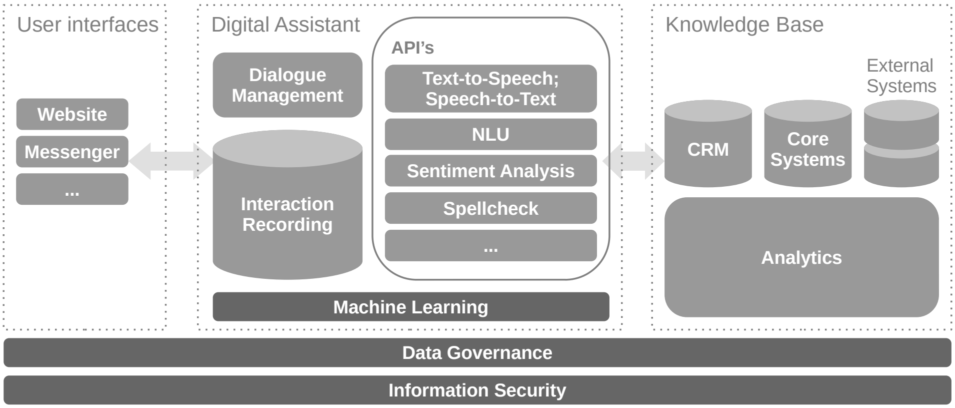

Fig. 2: Chatbot System Components

to include components for data governance and information security, which play a vital role in banking and public administrations. In the next section, we provide an overview of technologies and frameworks that can be used to implement these components.

3.3 Technologies & Frameworks

Our technology overview is based on the categorization of Smriti Garga [Ga20]. She distinguishes chatbots according to a.) their maturity and b.) the mode of interaction, integration and intelligence. In our reference architecture we use Garga's model to structure frameworks along these dimensions as displayed by Figure 3. In line with our research question, the technologies are (free) open-source and can be operated on-premises.

There are various open-source tools and frameworks available which can be used to build or supplement a chatbot architecture. The graphic shown in Figure 3 does not claim to include all open-source frameworks, it is rather an attempt to categorize a selection of technologies and demonstrates a possible grouping method. Similar to our capability map, the choice of frameworks in Figure 3 is based on a literature review and our hands-on experience.

While certain open source frameworks incorporate multiple features into a single package, others specialize in a certain domain. According to the number of GitHub forks and stars, some of the most popular and most comprehensive open-source technologies are Rasa (11.5k GitHub stars) [Bo17], Microsoft Bot Framework (6.5k) and DeepPavlov (5.2k) [Bu18]. These frameworks are designed to support a wide set of chatbot features, including functions for interaction, integration and intelligence. Each of the frameworks is capable of NLU. Their strength is that they can be integrated with other technologies in a variety of ways when certain functionality is missing. For example, incorporating a chatbot into a website is possible through the customer experience (CX) tools shown in the upper-left corner of Figure 3, if the framework does not support it out of the box. Likewise, any chatbot can be upgraded with voice support to become a voice assistant by converting the user's audio input to text and the bot's text response to audio, using the tools depicted in the CX-Voice and Bot-2-Human rectangles.

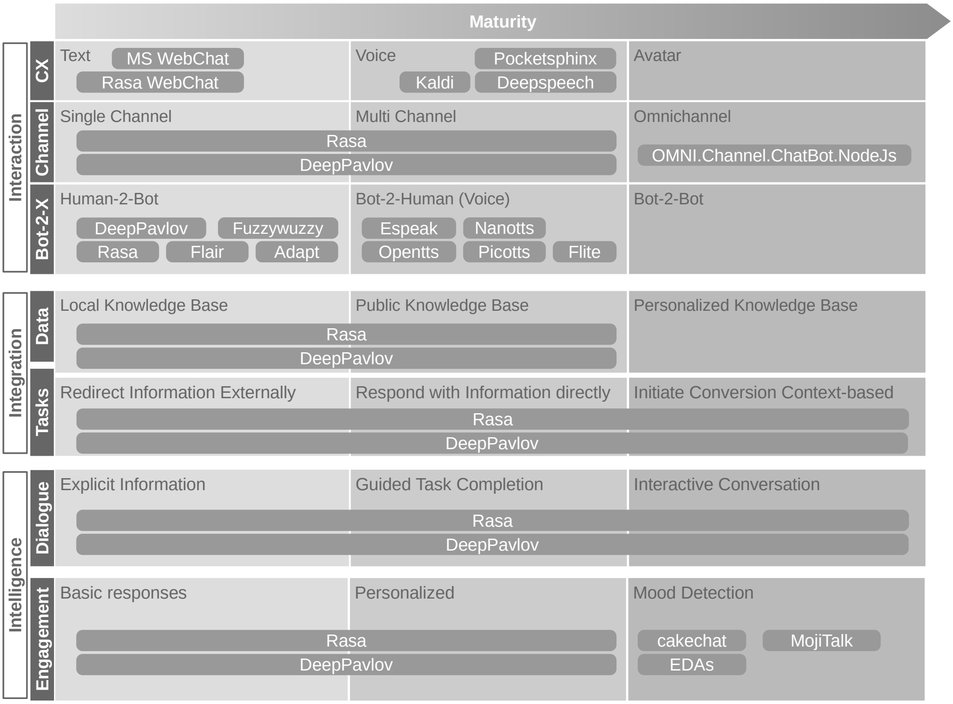

Fig. 3: Chatbot Technology Overview

In order to provide a deeper insight, we discuss technical details of a chatbot implementation with the most popular framework Rasa below. The analysis is based on real use cases from banking and public administration, validating our architecture.

4 Real use cases

4.1 Customer Service at TeamBank AG

TeamBank is the competence center for modern liquidity management in the German Volksbanken Raiffeisenbanken cooperative financial group (Genossenschaftliche FinanzGruppe).

The bank counts about one million clients. Its business activities are carried out in Germany and in Austria by approximately 1,000 employees. Their most popular product, easyCredit, is distributed mainly by cooperative partner banks and online. The processes of the company are highly automated and digitization plays an important role in its business strategy.

In 2020, TeamBank launched a chatbot to enhance workflows in its customer service center. A prior analysis had revealed that the most frequently asked question by clients in the live chat referred to the current processing status of their credit request. In order to receive an answer to this question by an employee, the customer must first legitimize themselves by providing personal data and the corresponding application number. While this process is mandatory from a legal perspective, it is tedious for both the live chatter and the prospect because not every customer has their request number immediately at hand.

Together with the analytics department of the company, TeamBank's customer service center therefore developed a chatbot to streamline the process. The bot guides clients through the legitimation workflow and takes away the pressure of having to find their application number spontaneously. Once customers have gathered the necessary information, they are directed to a live chat with an employee. As a result, the latter has more capacity for actual customer consulting due to the time saved by the bot.

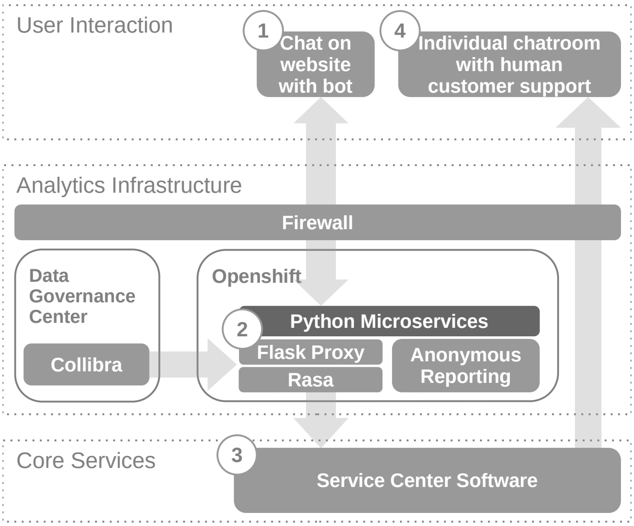

Fig. 4: Customer Service Architecture at TeamBank

In terms of the capability map from section 3.1, the case relates to the area of customer relationship management. Following the technology overview in chapter 3.3, this is an example of human-2-bot communication. Information entered by clients is redirected to human agents. The dialogue flow of the bot is guided and response messages are basic and not personalized. Consequently, the framework Rasa provided a natural choice as a technology for implementation.

Figure 4 shows the components used, as well as the operational flow of the process. Initially, a visitor to the easyCredit website is offered a chat button (1). After clicking this button and accepting the terms and conditions, a secure connection with the Rasa chatbot service is established (2). The bot asks the customer about their question and collects the information required to answer it. Within this process, the client is guided through a dialogue. All user input is validated to ensure its veracity. As soon as the required information is retrieved, a private chat room with a human support agent is created (3). The user is then redirected to this chat room, where the employee awaits them and has the complete information to take care of the request (4).

The scalability of the architecture is ensured by implementing all functions in the form of Python microservices, as shown in Figure 4 at point (2). The services are stateless per se, the state of conversations is persisted in a database by Rasa. Since highly sensitive data is provided by the user, the infrastructure is hosted on-premises. This way, it can be guaranteed that the data is stored, retrieved and also deleted compliant with company policies. As required by BCBS 239 and GDPR, data lineage information and retention periods are maintained in TeamBank's Data Governance Center (DGC). The DGC is implemented on basis of Collibra and builds the backbone of the bank's operational data governance.

A robust firewall secures the infrastructure and all outside connections are encrypted. To ensure user chatbot sessions cannot be manipulated, a pen-tested Cross-Site-Request-Forgery (CSRF) protection is utilized using a custom Python Flask proxy service. This proxy shields the Rasa chatbot and has various other protection mechanisms in place to block malicious attacks and user requests outside of business hours. Moreover, the proxy service decouples the Rasa chatbot sessions from the server-side browser sessions. The browser sessions are then deleted after 15 minutes.

For quality assurance, a bot usage report can be generated by TeamBank's business departments. This report is anonymous by design, as all statistics are presented in an aggregated view. Consequently, no personal data leaves the platform. This pattern is a viable way to gain insights into user information without violating privacy and/or GDPR.

By having a secure connection, a pen-tested architecture, unique random short-living browser sessions, anonymous reporting, and strict retention policies, TeamBank simultaneously maximizes the safety of user-provided data and offers a user-centered chatbot. The reporting has shown that the bot has already saved a significant amount of time that employees could invest in valuable customer service.

4.2 Chatbot at the German Federal Employment Agency (Bundesagentur für Arbeit)

As stated in the annual report 2019, "the Federal Employment Agency (BA) sees itself as a customer-oriented service provider in the labor market. Its goal is to provide guidance and support for people in their lives and to facilitate their integration into developments in the labor market. In doing so, it places the concerns and expectations of its clients at the center of its work. (...) The BA counsels people on job-related subjects and supports citizens with financial services such as unemployment benefits and child benefits every day. The human being takes center stage for the BA"[Fe19]. The work of the agency's customer service reflects this claim.

In 2019 BA managed 95,000 customer telephone calls daily, conducted 14,000 guidance sessions daily, and granted 8,900 unemployment benefit applications daily [Fe19]. With the onset of the coronavirus pandemic, customer communication has changed massively for the institution. While face-to-face access was more or less impossible, telephony and online channel have significantly increased in importance. This change in communication between BA and its clients is assumed to continue after the pandemic. Considering the changed customer behavior, the BA vigorously pushed ahead with the development of chatbots to process standardized issues, such as special load peaks and providing a 24/7 availability for simple matters.

The chatbot (Digital Guide, "Digitaler Lotse") is a rule-based chatbot, online since 2020 on the portal website of the BA (www.arbeitsagentur.de). It enables customers to obtain information on specific topics, ask questions and receive automatically generated answers. It offers an initial orientation on their respective concerns about basic security benefits, short-time working allowance, unemployment benefits, and child benefits. According to the capability map from section 3.1, the case therefore relates to the field of customer relationship management.

The entire system consists of multiple topic-bots, each one covering a specific topic area ("Lebenslagen") in the BA portfolio. A bot controller enables handovers between the different topic bots; however, this is usually driven by the user by browsing to another topic area on the web portal. The digital assistants are self-learning, continuously developed and technically optimized; additional topic areas will be added over time. In addition, a central coordinating bot for the landing page is being developed, which deals with general questions and redirects to specific topic bots as needed.

Following the technology overview in chapter 3.3, the case is an example of human-2-bot communication. The system interacts with clients in multiple ways:

- Guided dialogues with buttons, navigate the user through scripted processes, e.g. scheduling an appointment.
- Guided dialogues query backend systems to deliver a specific answer to the user, e.g. calculation of short-time working allowances (Kurzarbeitergeld)
- Answers to free text input queries

All bots are implemented with Rasa as core technology. For language understanding, a custom BERT language model for German was trained and optimized to cope with the domain-specific lingua [DC18]. In selecting technologies, frameworks other than Rasa were excluded for the following reasons:

- The bot had to be ready for production in the shortest possible time (first production release in less than four weeks). Consequently, an existing framework solution was needed that offered as much functionality as possible without the necessity of a time-consuming commercial tender.
- The bot had to be operated entirely on-premises and being capable of running in Docker environments (MESOS, Kubernetes).
- The institute's preference was open-source.

The functionality is implemented in the form of microservices. Each bot is a service, with backend integration and logic services (Kurzarbeitergeld) implemented independently. All services are integrated with the web portal frontend via a middleware service that manages the session and coordinates which bot should connect to which user. Figure 5 shows the core services as well as their data stores.

The integration in the BA web portal is implemented using HTML5 components with launch buttons and in-site popups. The middleware service allows for page-specific configuration to be managed centrally. Each site uses the same chatbot web component, and the middleware configuration determines which chatbot to launch for which page.

A Cassandra database is used to manage the session information and the page-specific configuration. Logging of events for performance reporting is accomplished using a centralized ELK stack. In order to ensure GDPR-compliance, user interaction data and feedback get anonymized by removing user identifiable information and omitting user input where sensitive data is being entered. The data is stored for a limited time to allow for reporting and improvement of the bot performance (retraining) in a database.

With the chatbot development, BA is taking an important step on the path to express digitization, which it successfully took last year under the difficult conditions of the

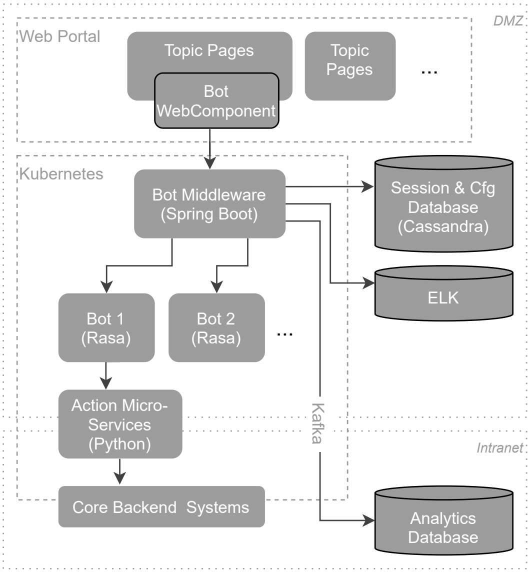

Fig. 5: Bot Architecture "Digitaler Lotse"

coronavirus pandemic. The new technical possibilities that have arisen through the provision of chatbots expand BA's digital service offering. And the customers gratefully accept the new service: About 11,000 unique users had even more unique bot conversations a week (June 2021).

Following the success of the chatbot, subsequent implementation of voice bots for the call center is considered, as well as a re-evaluation of the platform from an editorial point of view: This entails separate interfaces for editors to curate and expand the content independent of the technical chatbot implementation and the introduction of collaboration tooling to foster testing, simulations and enable a systematic handover process between editors and bot technicians.

5 Transferability of our results

Although in this contribution we have focused on on-premises solutions that are open source, the shown procedure is transferable to creating a reference architecture for enterprise chatbots that may be hosted in public clouds and are not limited to be developed using open-source frameworks. Furthermore, the method presented here could be applied to build an enterprise architecture for conversational chatbots incorporating text-to-speech, although this requires a number of adjustments.

While the architecture was designed with specific sectors in mind, it can also add value in other industries. As we have highlighted, chatbots can be a starting point for rationalizing business processes. Aside from finance and public services, they are valuable for many other sectors as well.

6 Limitations

The architecture described here is composed of open-source tools and in contrast to other possibly managed (cloud) solutions, may need a more complex initial setup. The maintenance and development requires expert know-how.

In addition, NLU is an active area of research. Our studied use cases, like most contemporary chatbots, rely on structured training data to follow a conversation. They also depend on user-written plots, so-called stories, to engage in a goal-oriented dialogue. Future generations of chatbots might use artificial intelligence to perform far more generalist tasks with an increased autonomy.

In terms of enterprise integration, the open-source platforms, which have been evaluated in this paper, require manual integration in surrounding systems like artifact management (versioning), monitoring technical and functional/business performance, editorial or CMS systems, databases, other NLP services like text-to-speech, speech-to-text, translation or search (long-tail bots) and channels beyond web (e.g., messenger, telephony). This can be an advantage, as it allows for tailored and best fitting integration but also requires more effort compared to commercial options.

Finally, it is important to emphasize that our reference architecture is a first draft. With two use cases, our sample size is limited. Validating the architecture in a study that includes different cases from several industries could be the topic of a future work.

7 Conclusions and Outlook

The purpose of this paper was to outline a reference architecture for developing and operating chatbots. The requirement was that both training and inference take place on-premises in the form of best-of-breed open-source software.

Based on related work, we provided a technical, methodological, and content structure on required components as well as technologies available from a practitioner's perspective. Subsequently, specific implementations were presented by best practices from the banking and public sector. Rasa served as the framework in both cases, proving the capability to operate high-quality chatbots based on the proposed tooling. However, apart from the technologies and frameworks, the content/stories and (the tuning of) linguistic models constitute a good or bad chatbot. Apart from simple FAQ and decision trees, handling more complex domain-specific services like in finance or public sector would extend the benefit from quantity to quality. Yet, the fine-tuning of huge linguistic transformer models (e.g. BERT or GPT) is resource-intensive and requires appropriate infrastructure.

The next logical steps in many cases, but not covered by this paper in depth, are the enhancement of bot intelligence and the development of voicebots. For the latter, speech-to-text and text-to-speech components have to be added to the applications. Voice also requires dealing with increased semantic complexity and additional challenges in infrastructure (e.g. callcenter integration, SIP handling, performance and lag).

The handling of data by the major cloud providers in accordance with the governing European and German directives will determine to which extent on-premises solutions remain a valid option. Regardless whether chatbots are run on-premises or in a public cloud, we expect them to become a primary medium for the practical application of artificial intelligence in enterprises.

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