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Development and Evaluation of a Service Bot for the e-Government Sector

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Declaration of Authorship

I, MOHAMED MEGAHED, hereby declare that the thesis submitted is my own work, completed without any unpermitted external help. Only the sources and resources listed were used.

The independent and unaided completion of the thesis is affirmed by affidavit:

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Abstract

Though not a recent phenomenon, chatbots and voice assistants are increasingly gaining unprecedented attention as a successor for mobile and web applications. While still emerging and with no defined standards or set protocols, as a growing hype on the rise, industry giants with products like Amazon's Alexa, Apple's Siri or the Google Assistant unveil new examples of ways to provide an enriched user experience for consumers and businesses alike. The surrounding ecosystem also plays a major role in spreading the platforms available, while exposing new horizons with alternative approaches and business models. Today, voice assistance is already present in indoor spaces, in the car or in our pockets on the go. They live inside smartphones, on fancy TV sets or even as stand-alone devices. Yet, they are still a new terrain to discover and have great potential to unleash in numerous contexts.

One such scenario involves the public sector. In this work, we create an Alexa Skill, taking a critical approach to the artefacts provided by Amazon in combination with respective services and components provided from earlier development of a chatbot, to develop a voice assistant for the local city council and giving a parallel experience to its current VIRTUAL CITIZEN ASSISTANT - *Virtueller Bürgerassistent* available on the Berlin City Portal website. We touch on the technical challenges and possibilities in implementing a Software as a Service (SaaS) solution for e-Government inquiries and analyse its usability as well as its effectiveness as an additional option to traditional information lookup. Based on goals identified in a survey we conduct, conclusions about a high potential to adoption rate of the Skill are drawn.

With a critical approach to our use case given the APIs and SDKs available at the timeof development, we are able to make the Skill simulate the telephone hotline D115 for many simple Berlin services, providing a proof-of-concept that more complex issues can be handled through simple content management with no need for redeployment. We also report on the opportunities, challenges and limitations faced in the development process.

With our study of the current state of voice assistants and service bots on the market, we give recommendations on best practices for developing one.

Zusammenfassung

Chatbots und Sprachassistenten haben ein wachsendes Interesse in den letzten zwei Jahren erhalten. Im Gegensatz zum öffentlichen Email-Protokoll, konkurrieren Groß- und Kleinunternehmen auf eine universale Systemausprägung und diversifizieren mithilfe von künstlicher Intelligenz den Rahmen für den persönlichen Assistenten der Zukunft. Ob es durch Apples Siri, Cortana von Microsoft oder den Google Sprachassistenten hervorgeht, zeigen sich zahlreiche Beispiele, wie die Nutzererfahrung auf privaten oder geschäftlichen Ebene weitgehend bereichert werden kann. Der steigende Nutzen von Sprachassistenten zuhause, im Büro und unterwegs erlaubt viele neue Erkenntnisse und Erfahrungen, die dem Marktumfeld zu verdanken sind.

Auch auf staatlicher Ebene wird dieser Nutzen dank einer wachsenden Rolle von E-Government in der Gesellschaft vertreten. Der Beitrag von Sprachassistenten hat einen direkten Einfluss auf dem Onlinedienstindex eines Landes und trägt zu einer wichtigen Modernisierung im öffentlichen Wesen bei.

In der folgenden Recherche untersuchen wir Alexa von Amazon im Zusammenhang mit anderen verfügbaren Plattformen und Artefakten. Wir erweitern die Fähigkeiten des Sprachassistenten durch den Webauftritt des berliner Stadtportals (BerlinOnline) sowohl für die vielfältigen und mehrsprachigen Einwohner der Hauptstadt als auch der Senatsverwaltung des Landes. Als Grundlage wird auf die Funktionalität des VIRTUELLEN BÜRGERASSISTENTEN Berlins zurückgegriffen. Anhand dieses Anwendungsfalls werden die prinzipiellen Möglichkeiten und Herausforderungen bei der Implementierung eines Sprachassistenten für die Stadtverwaltung aus technischer und organisatorischer Sicht analysiert. Zusätzlich wird die Usability des Systems als Ergänzung für einen Abfragedienst in Erwägung gezogen. Lösungen aus dem Chatbot der Stadt Wien sowie des Sprachassistenten von Georgia, USA werden zum Vergleich betrachtet.

Produkt dieser Arbeit ist ein Alexa Skill, welches die Basis des vorhandenen Bürgerassistenten nutzt, um Anfragen an die berliner Verwaltung zu beantworten sowie eine Umfrage zur vorläufigen Erfolgsbemessung des Produkts. Der Skill simuliert die Behördennummer D115 für einfache Anfragen und zeigt, wie komplexere Themen auch nur durch Content-Management gehandhabt werden können. Die Umfrage unterstützt die Entwicklung der entstandenen Software und zeigt, dass die Inbetriebnahme des Sprachassistenten in der Verwaltung einen hohen Erfolgspotential hat.

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Chapter 1

Introduction

With over a third of the world's population projected to own a smartphone in 2018 [43] and a substantial fraction thereof using smarthome gadgets and appliances on a daily and even hourly basis, the role of Artificial Intelligence (AI) has become more interesting than ever in many disciplines including but not limited to productivity and entertainment. Many technologies we take for granted today, such as dictation and word prediction, recommender systems or other digital analytics depend on Machine Learning (ML) and Natural Language Processing (NLP) techniques that were only made possible thanks to the high computational power shipped in most devices gradually overtaking the consumer market. This transition also facilitated the introduction of a new form of interaction through conversation with the hardware, paving the way to an aspiration modern societies have been striving globally [23]. Whether in blockbuster 60s dramas, such as in "Breakfast at Tiffany's" (1961) or in Sci-Fi romance in the movie "Her" (2013), an obsession with voice technologies is featured throughout from an answering machine on tape to a fully personalized but mass-produced voice-based operating system even becoming a protagonist.

Conversational bots were already prevalent since the 80s in the form of Question Answering Systems based on query programming languages like PROLOG and SQL. ELIZA, considered as the world's first chatbot and though quite superficial as an NLP-based programme for psychoanalysis, already at its early stages demonstrated how humans can become emotionally attached to machines, transcending over the anomaly of making conversation *not* with a human [52]. Today, combining ML with retrieval-based approaches allows a more advanced interaction with the system and yields smarter and more personalized conversations between man and machine. Consequently, it is no longer a surprise that chatbots acquire social skills to make Xiaoice, the empathetic bot from China, possibly a new kind of friend made of silicon revoking the fiction element from "Her".

So far, voice assistants represent an additional layer of abstraction from software beyond the graphical user interface (GUI) and are hence the closest we have come to-

wards human communication. They deconstruct another barrier between the user and the hardware as voice communication generally does not require profound computer literacy and the conversational models rely on our inherent ways of expression. As they simulate the human aspect and imitate its behaviour for instance with small-talk abilities [41], voice assistants are regarded as a convenience for daily tasks and are on their way to becoming a de-facto replacement to sophisticated actions we perform on the screen. In fact voice searches now compose a large market segment with over a billion voice searches per month [1] and are predicted to make up about "1 Billion Voice Assistant enabled devices in circulation by the end of 2018" [1] and 30% [16] [45] of all searches by 2020 with currently highest rates coming from the youngest generations based on a survey [54] by Global Web Index. According to the Alpine.ai 2017 Voice Labs report there were 33 million voice-first devices in circulation in 2017 worldwide [3] with tremendous shifts in number of units sold between 2015 and 2017. This and more statistics hint at a revolutionary change towards our use as much as the introduction of the GUI and mouse were to the Command Line Interface (CLI). Increasingly, we recognize voice as a *new* user interface, also known as Voice User Interface (VUI), and analyse good practices and design guidelines for it.

Since sound and voice are primal stimuli in the human brain [19], using them becomes more instinctive, making us in turn process our ideas starting with an "inner voice" that translates easiest into words when we speak it before routing or "funneling" it to actions [8]. Arguably, on a market scale, this gives voice assistants today a competitive innovation advantage (CIA) for they are hence more accessible to further demographic groups with a growing wider acceptance.

Meanwhile, statistics from BusinessInsider [27] show that time spent on messaging applications (apps) already surpassed average uptime on social media, which indicates how the former is more desirable as a communication format on mobile platforms and how having a conversation is an easier way to interact with a device instead of downloading an app for every task. Further, the speech-to-text/text-to-speech domain has become more powerful with steadily increasing processing power, an effect of Moore's law we only get to understand lately in addition to the gradual lessening of the dominance of Chomskyan theories of linguistics (e.g. transformational grammar) [10]. With an integration in most modern operating systems, speaking to a device has become no longer a absurd novelty. Inadvertently, the Google voice assistant built into its Android OS currently with the highest usage shares among computer and smartphones [12], supports understanding of multiple languages in the same sentence for multilingual interaction. Moreover, the Echo Dot recorded the peak for best-sellers for 2017 on Amazon with unprecedented numbers showing a high customer retention and satisfaction rate [36].

As we constantly challenge our expectations towards technology, our imagination makes us question the ability of AI to make a machine able to react to everything we say, which can be not too far-fetched in a near future. Although we are still far from

this step, at least for the consumer level, we dedicate a lot of effort to make it happen with examples like IBM's Watson or other Uses of big data analytics. We can probably conclude though, that as long as we still do not exactly understand human intelligence in detail yet, it is hard to fathom AI as a holistic field. As such, it is therefore more realistic to consider the current works in the field as *intelligence amplification* [8] empowering humans to take better decisions beyond their normal brain processing power and not overtaking human intelligence as some might claim.

1.1 Motivation

With the aforementioned, we try to think how voice assistants could become useful and why we want to invest in such technology, juxtaposing it to available alternatives. If we consider human workforce (i.e. customer service agents) on one hand, it is commonplace that these are more expensive, less available due to restrictive working hours and not always aware of the full circumstances related to an issue they are supposed to fix or a question they are to answer. Sometimes knowing more about a person could almost become a dangerous tool since it gives room to manipulate them. A client in a shop for instance can have their decision influenced by the seller and eventually get tricked into buying a product based on wrong advice. Although there is practically little the client can normally do to circumvent misinformation if that seller is replaced by an algorithm, having an automated system like a voice assistant step in gives at least a more neutral impression since it are not directly expected to act with malicious intentions like a vendor who abuses the client's trust.

Since the point of availing voice assistance is to act in a person's interest, we also want an information system not to confuse us or to limit our cognitive abilities. Besides, we can at least ensure in a system design that a voice assistant will not become moody and intentionally want to make our lives harder for this reason as opposed to a human. And so, although a voice assistant or a chatbot may not potentially answer every question we throw at it, we want to at least presume that it would give us no information instead of partial truths or lies while keeping a certain level of neutrality and "decency" in terms of the wording. This is why most credible companies elaborate explicitly in their terms, conditions and privacy statements on what makes them accountable on the the services they offer. A consumer therefore feels more empowered to assert any faults originating from an automated system than from a human and conditionally has an assurance that they can prevent any violations more systematically.

Eventually a person is more likely to develop a certain kind of trust in a machine more than in a human once the technology is established and widespread. Cars, email, and other gadgets or services we take for granted today are living proof of how inevitably this trust grows, for the better or worse and depending on the degree of affinity to the related technology, aversion or ignorance in a business sector. Trust in a system can

grow once it is certified to have little to minimal exceptions. Besides enriching the value chain, it is a key in setting a technology to become an industry standard. Therefore, if a voice assistant is shown to deliver reproducible results disregarding a person's profile, this definitely contributes towards the credibility of the system. This is however not an easy case, since an advanced voice assistant is not expected to be deterministic in most situations, otherwise it becomes boring! We elaborate later in this thesis how we handle this problem.

On the other hand, Information Retrieval Systems range from web pages (e.g. frequently asked questions section (FAQ), forums or a search engine). These are in some cases even less effective than contacting a human as getting the proper information takes a lot of time, or the level of trustworthiness or participation levels in a forum are particularly low, the problem stated is too broad or too specific compared to the answer we are seeking. A user also could come unintentionally across false positives in a search and rely on irrelevant information without knowing. Furthermore, some case-related information might be required to have a proper understanding of a situation or a scenario and provide adequate answers. For example, if a user would like to know if a certain accessory is compatible with their mobile device, they might need to give a model number, which they may or may not know. Consequently, it is of high interest to maintain a system that could determine all these factors autonomously or with the least possible human interference such that a system supersedes the abilities of the classical Q&A approach.

Internationalization is also another factor to take into account. Since languages differ not only in their vocabulary but also grammar, word and sentence structure (e.g. false friends, nuances, phrases, idioms), developing a voice-first device requires a flexible infrastructure and software stack both able to accommodate these deviations. In that respect, not only is region-specificity important, but also being able to cater for people in a region who do not speak its official language or are residing there temporarily. Especially in businesses where it's difficult to hire skilled foreign-language speaking personnel, a voice assistant can overcome this challenge as it would communicate more accurately and will not have language problems. The customer is then given the option to avoid an inconvenient experience with the typical scenario with a call centre representatives where neither of both parties understands the other. For those who have minimal understanding of the language, there are possibly also options to provide help in the native language if the user is given the options he/she can answer a prompt with. At the very least, a VUI could still give feedback to the user of whether it understands the language or not, since algorithms for detecting a language are not as complex as answering the question once the language and its dialect (also known as locale) is deciphered. All of which are optimal use cases for ML approaches and algorithms such as term weighting or based on simpler approaches to localization from an original text, such the corpus-based mapping approach. WordNet is one such example. Finally, giv-

ing the user clues on what to answer with is also a helpful tool, as we will also discuss in bot design (Chapter 7)

1.2 The Analysed Scenario

Berlin.de is an online one-stop-shop for approximately 3,7 million residents of the German capital [4] with thousands of visitors daily for information lookup, appointment bookings and even access to local news. As part of a federal modernization procedure with the help of the German Ministry of Interior, D115 was launched in 2009 [18] as a phone service to help residents find relevant information about a public service or municipality, something that can be tricky if a person has no overview of the local government structure and still not always easy even with the help of search engines nowadays with the array of public services provided. To promote information accessibility, D115 continuously aims at expanding its reach and services. It is therefore worth exploring, how to offer D115 services in a fashion that takes advantage of conversational abilities beyond its human personnel or online city portals.

For now, although local authorities rely heavily on their websites to communicate information to the public, the challenge is mainly finding the right service even with an vague query since most of the time a person requesting a public service is not fully aware of the exact service name in the catalogue of services offered or cannot differentiate between two similar public services or even know if one of them is required in their case. In a metropolis with a high influx of incomers, it is also very likely that certain services are frequently pursued, meaning that helping find the right public service or authority is a repetitive task. In this context, thinking of a voice assistant as a public service could have several advantages, like offloading some traffic from the phone service, getting over the language barrier in the case of non-German speakers, expatriates or simply helping native customers formulate the right wording for a query in a more intuitive way than using a search box.

All of which leads to thinking how providing voice assistants and/or a chatbots for public services could make us reap the benefit of available technologies and extend it aiming for continuous modernisation of our connected living to blend into a seamless digital lifestyle [17].

1.3 Approach and Goals

In the following thesis, we take the aforementioned factors into consideration and narrow them down to fit our scenario tailored for the e-Government sector. We start by surveying industry-standard voice assistants platforms and frameworks and present a solution that caters for the local municipality of Berlin, Germany. Funnelling the choice

of implementation between a text-messaging chatbot and a voice assistant, we choose to present our solution using the Alexa platform based on our criteria in Section 5.2.

With an agile approach, we present functional code for running and deploying the aforementioned service on Amazon's voice assistant through a so-called ALEXA SKILL (referred to here from here on as 'Skill') and analyse the strengths and weaknesses of choosing this option. We start by exploring information on the public services offered through https://service.berlin.de to understand how to implement our Skill. We then choose a set of exemplary public services use cases with different levels of implementation difficulty to prototype how all current and future Berlin.de's services should be handled using knowledge from an existing database operating the current VIRTUAL CITIZEN ASSISTANT discussed in Section 3. Difficulty is expressed as the required knowledge by the Skill to perform a user's request. This includes for instance the system's abilities to understand the district location intended by the user through only a postal code input.

Further, we test the Skill using some unit tests for the code, runtime scenarios and usability tests (mainly in the form of A-B Tests) for the interaction model especially with the ability to identify and deal with different inputs from various users]. In the implementation, we already have the advantage of being part of Alexa's system to entertain the user with many small-talk abilities which allows us to build on its existing and continually expanding database for question-answer models.

In summary, these goals were defined for the system:

- We want to understand user's requests about public services through different sentence formulations.
- We want to deliver differently relevant parts of information based on the service requested (e.g. cost, processing time).
- We want to produce a scalable, modular system that can be extended in the future.
- We want our solution to be voice-first.

Also, among the technical requirements to be achieved are:

- Communication with an API should be possible.
- The endpoint used is the same of the service catalogue of Berlin.de's Virtual Citizen Assistant .
- Synonyms should be supported
- The software should use an underlying ML-based intelligence.
- content management should be minimal

Further requirements with respect to the programming platform are discussed in Chapter 7.

1.4 Structure of the Thesis

This thesis is organised as follows: In Chapter 2 we talk about use cases of chatbots and voice assistants in the public sector, show related work and introduce comparative examples through e-Government solutions in Vienna, Austria and Georgia, USA. We compare them to the current chatbot application (the VIRTUAL CITIZEN ASSISTANT) available on service.berlin.de [1], which we build our work on with the same underlying technology using Apache Solr as we discuss in Chapter 3.

Going beyond a theoretical analysis of the voice user interface paradigm in Chapter 4, we shed light within the State of The Art context in Chapter 5 on the available platforms and explain why we choose Amazon, going over the idea behind Alexa's Skills and explain the structure of Amazon and Amazon Web Services ecosystem to operate Alexa in Chapter 6.

In Chapter 7 we introduce our design of the Skill and discuss how it addresses redundant boilerplate code, small-talk abilities and briefly highlight some limitations of the system. We also present the frameworks and Application Programming Interfaces (APIs) we use in our own implementation, the prerequisites and artefacts provided initially through a breakdown into several cases simulating top common uses on Berlin's City Portal.

Chapter 8 explains our implementation solution. We elaborate in particular on how we deal with individual public services in the interaction model from front-end and back-end perspective, how we connect the web services together and analytically document the code structure and endpoints, in addition to the deployment process.

The related implementation code is available on GitHub [2] with a digital copy attached to this work.

Chapter 9 evaluates our implementation with respect to our target in the defined use cases. We base our evaluation models on a survey we conduct that helps us specify requirement details, as well as automated tests provided by the framework we use in addition to usability, performance and unit tests.

In Chapter 10, we conclude the work focusing on how our implementation is attainable through Alexa and where future works can be directed for an e-Government solution.

[1] `https://service.berlin.de/virtueller-assistent/`
[2] `https://www.github.com/megantosh/AlexaImAmt`

Chapter 2

Background and Related Work

As our motivation stems from the continuous worldwide trends in digitalisation, we discuss in this chapter current application categories with respect to chatbots and voice assistants and talk about governments' efforts in keeping up with these trends as part of their modernisation stream in the age of social media, Internet of Things (IoT) and the interaction between both. We then show relevant examples in our context of voice assistants.

2.1 Topology of Chatbots and Voice Assistants

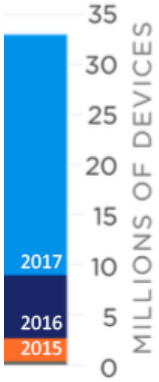
Chatbots and voice assistants come in numerous mouldings; on the web, in apps, through smartphones or as a combination of those and beyond. In Barot and Oren [49] we observe in which different purposes the industry caters for promoting chatbots as a replacement to apps and the voice-first design. As we witness the integration of chatbots in retail, productivity, entertainment and create more possibilities to integrate them in our daily lives, it is obvious that the trend will persist for a while before the market is saturated. Unlike app marketplaces like Apple's App Store and the Google Play Store which have become a commonplace term despite their slow stagnation in the recent years, chatbots and voice assistants are predicted to remain trendy until at least 2020 as per VoiceLabs predictions.

Moreover, SearchMetrics' upcoming report is expected to include a a dedicated part on voice searches as the analytics company advises on SEO tweaks for Google Voice Search [22] and argue how voice assistants are becoming a ubiquitous market. In fact, with hundreds of thousands of chatbots only on Facebook and tens of thousands of voice assistants only on Alexa the two major platforms are serving for an array of categories. Through these, leisure becomes possible by playing a game [48] or making a holiday booking through a chatbot just as productivity does not get any less serious with another bot taking appointments. Although their markets differ, chatbots and voice assistants are

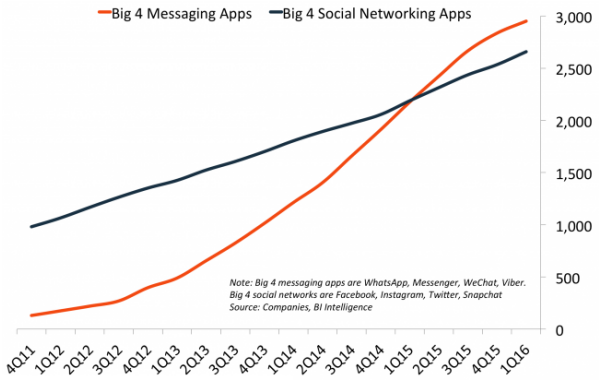
becoming prominent around the same concept of doing or delegating one task without the need to leave the same interface or requiring additional resources (apps or even a screen).

Figure 2.1: Trends of increasing use of voice as an interface are shown with an increasing in number of devices and user base in the last seven years. These and further statistics [1] show the necessity of developing for voice.

(a) Voice-First Device Footprint [3]



(b) Global Monthly Active Users in Millions [27]



2.2 Digitalisation in the Public Sector

There is no doubt that social media has changed the shape of our society in the last twelve years. Not only by affecting the way we communicate, but also by generating immense amounts of data, creating new jobs and disrupting economies en masse. Meanwhile, governments are continuously striving to market their image in more creative ways than ever to target more segments in society. From politicians' tweets being a novelty to now making headlines, the sudden interest of governments in social media platforms can be seen as an attempt to become more transparent and reach more public awareness. It is more likely for instance that people from narrower fields of interest or of wider age range would find out about a public figure by follwing them and finding them on their feed rather than by reading news about them on dedicated news website. This now goes as far as country leaders curating stories on Instagram and existing on platforms that are not only for the politically active.

This is ultimately because the social media platforms, as part of many new technologies, are designed with the focus of reach in mind much more than only availing information to the target. We distinguish between the pull-based model of information

[1] e.g. `http://www.kpcb.com/blog/2016-internet-trends-report`

retrieval, where a person would actively look for a certain piece of information usually through looking it up through search, vs. the push model, where the information is 'thrown' to the user without them actively asking for it, usually by subscribing to the source or news outlet and more likely through audiovisuals than through text. Unsurprisingly, such platforms become a key player in redefining fame, identity, image and even cognitive behaviour.

The push-model is a new strategy for the dissemination of knowledge, which local and national governments embrace [29] to bridge the gap in their outreach to the public. Although the digitalisation trend in governments generally emerges from the desire to expand infrastructure for information exchange and availing publicly accessible data (e.g. open government data) [50] or classified data (e.g. the Schengen Information System [2]), digital media has now become an integral part of it, too, making it inseparable from many institutions' compositions and their decision-taking process.

The amount of digital media we use daily everywhere would not be possible without having an expansive digital infrastructure. In Germany, many advanced milestones in digitalisation were attained in the last years. From eliminating paper in many administrative workflows to funding research or successful businesses including start-ups in high-tech fields and seeking renewable energy as a foundation to power the exponentially growing number of devices in the country with a reduced carbon footprint, the aspect of digital media has been relatively neglected compared to other countries.

Figure 2.2: Top Ten Countries for E-Government Development Index in Europe based on [50]. Germany is 8th in the list with a decreasing development rate compared to previous years (lower range within EU countries). High rank drop tendency as opposed to increases at counterparts (NL, FR)

Country	Region	Sub-Region	OSI	HCI	TII	EGDI	EGDI Level	2016 Rank	
United Kingdom	Europe	Northern Europe	1.0000	0.9402	0.8177	0.9193	Very High	1	
Finland	Europe	Northern Europe	0.9420	0.9440	0.7590	0.8817	Very High	5	
Sweden	Europe	Northern Europe	0.8768	0.9210	0.8134	0.8704	Very High	6	
Netherlands	Europe	Western Europe	0.9275	0.9183	0.7517	0.8659	Very High	7	
Denmark	Europe	Northern Europe	0.7754	0.9530	0.8247	0.8510	Very High	9	
France	Europe	Western Europe	0.9420	0.8445	0.7502	0.8456	Very High	10	
Estonia	Europe	Northern Europe	0.8913	0.8761	0.7329	0.8334	Very High	13	
Germany	Europe	Western Europe	0.8406	0.8882	0.7342	0.8210	Very High	15	
Austria	Europe	Western Europe	0.9130	0.8396	0.7098	0.8208	Very High	16	
Spain	Europe	Southern Europe	0.9130	0.8782	0.6493	0.8135	Very High	17	

*Note: The Ranking Trend lines display the country rankings, with 1 being the top ranked and appearing at the bottom of the vertical axis, and 193 being the lowest ranked and appearing at the top of the vertical axis. Therefore, the lower is the graphical point, the higher is the ranking. The horizontal axis represents the survey periods of the *UN E-Government Survey*, i.e. 2003, 2004, 2005, 2008, 2010, 2012, 2014 and 2016.

[2] https://en.wikipedia.org/wiki/Schengen_Information_System

According to numbers from the United Nations' E-Government Development Index in 2016, Germany ranked 15th worldwide and 8th within Europe with an average of 0.82 out of a maximum of 1, substantially outranked by the United Kingdom, the United States, Singapore and France. Outperforming its previous statistics from 2014 where its index scored 0.79 with a world average of 0.47, it was also outranked by Austria, Israel and Bahrain [6] in addition to the aforementioned countries as listed in Figure 2.2. Germany's ranking went up from 21st to 16th worldwide in the last two years.

The E-Government Development index (EGDI) is composed of a calculation based on proportionally normalised averages of the Online Service Index (OSI), the Human Capital Index and the Telecomunication Infrastructure Index. When it comes to engagement through e-participation, Germany performance lies also in the top quartile. Its Online Service Index performed 21st worldwide (Figure 2.3), which shows the continuous strive to maintain relatively many rights to access government information online and an open data government policy on the web.

Figure 2.3: Online Service Index for Top 30 Countries Worldwide based on The UN Department of Economic and Social Affairs [50] with Germany ranking 21st in 2016

United Kingdom	1	Australia	0.9783	Singapore	0.9710	Canada	0.9565	Rep of Korea	0.9420	Finland	0.9420	New Zealand	0.9420	France	0.9420	Netherlands	0.9275	United States	0.9275	Austria	0.9130	Spain	0.9130	Estonia	0.8913	Emirates	0.8913	Sweden	0.8768
Japan	0.8768	Italy	0.8696	Israel	0.8623	Slovenia	0.8478	Mexico	0.8478	Germany	0.8406	Lithuania	0.8261	Bahrain	0.8261	Serbia	0.8188	Norway	0.8043	Malta	0.7971	Colombia	0.7899	Denmark	0.7754	Uruguay	0.7754	Chile	0.7754

In an age where we take the internet for granted, we also expect to have multiple communication channels open to government representatives and public authorities. Hence, out of public interest, governments are advised not only to focus on digitising their internal structure, but also their representation on the public sphere. Especially at times of change like with the introduction of autonomous driving and the regulations related to it, transparency is a continuous expectation from the people. As stated above, since transparency heavily relies on public presence, which in turn depends on availing more communication platforms, voice assistant services are definitely worthy of consideration in that context.

2.3 Evaluation of Government Presence in the Cloud

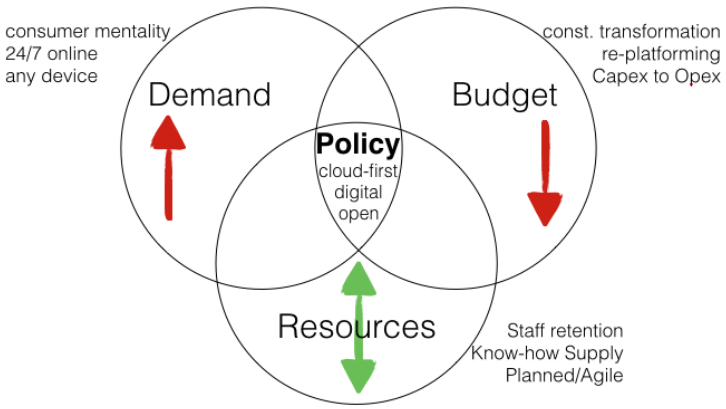
With fast-paced technological advancements, advocacy for a fair use policy is as equally as important to the consumers as to the industry responsible for spreading them. Raising

awareness about the necessity for legal adjustments plays a determining role in policy-making and governance of ICT businesses. As we experience how personal data has become a valuable commodity to enterprises, advocating for tightening regulations to avoid misuse of such sensitive data has become crucial over the last years. In the search for methods of circumvention to new kinds of monopolies, cybercrime as well as other frauds and immoral breaches, several governments worldwide have addressed the potentials and threats of data collection for Information Systems in use with respect to different local contexts.

While passing laws and regulations is a positive action from a general perspective, it is not always easy to guarantee that these will not impede the advancements in favour of keeping a stable status quo or encourage other motives. In many MENA countries, Turkey and Iran for instance, we witness internet censorship in the form of website blocks with no legal basis. Another alarming example is the case of Egypt's laws on cybercrime for it prohibits the use of cryptocurrencies to the public while encouraging its own government to make additional revenues through Bitcoin and ad traffic networks simultaneous to spying on the people e.g. by intercepting the HTTPS protocol nationwide [33]. Reports from Privacy International [21] and The Association of Freedom of Expression [34] shed light through different incidents related to the Egyptian Cybercrime Law on how it can have a negative impact to regulating technology.

As there are very few international regulations, it remains up to each federation or alliance of countries to handle the case of data privacy individually, which can be a tough job. And though positive action should be credited for the attempt, there are still many decisions to take national and International level to secure an ethical handling of personal data.

Figure 2.4: In a common government scenario, increasing demand and degreasing budget push against each other and require flexible resource allocation solution. With all these factors considered, a cloud-first approach can combine all elements in the policy-making decision. Description based on Bockelman in [47]



When it comes to governments' operations in the cloud, we see different degrees of aversion to anticipating this relatively new concept. As cloud infrastructures can be quintessential in scalable operations, governments can be among the number one users of cloud microservices, especially with demand variability in peak times that are not always easy to predict (Figure 2.4). Among the many benefits of cloud services, scalability is arguably the most convincing. By that we mean the ability of an operator to allocate resources or terminate them as needed to avoid extra costs and infrastructure maintenance. Consequently, operating as a government in the cloud and outsourcing the digital infrastructure is an incentive to massive cost reduction. Additionally, as governments operate on strict budgets, cloud operations can accommodate varying expenses more easily instead of waiting for long-term investments in computing infrastructure [47]. Such make-or-buy-decisions have great impact on the way services are offered, as they allow higher degrees of specialisation, which in turn make further services only possible through externalising resources. Further, using off-premise resources enables governments to pilot more projects and adjust to public demand accordingly. This means that services can be expanded or taken down based on how they good or bad they are perceived by their end-users, be they citizens or the government itself. The UK Government G-Cloud Framework[3] is one such example that shows a harmonious cloud operation of government services.

If we consider our presented solution of a voice assistant as such a service, hosting in the cloud is considered as the most desirable solution to test performance and adaptability such that we are able to up-or downscale resources for users in real-time. Yet, the trade-off of cloud computing remains the data protection issue, as infringing such policies cannot be tolerated by the public and could have drastic consequences on legislation.

From EU perspective most recently, the European Union will require several adjustments in order to comply with the General Data Protection Regulation (GDPR) effective May 25, 2018. Of these adjustments, the new norms facilitate a better delegation of responsibility to the operation of the cloud host as well as to the services hosted on it. This comes along with digital infrastructure certifications that can be obtained to give more securities to customers on a microservice, from Software as a Service (SaaS) to Platforms or Infrastructures as a Service (PaaS, IaaS). Among such certifications in Germany is the Cloud Computing Compliance Controls Catalog (C5) Standard, to which AWS as a top cloud microservices operator for example complies to [4]. Since compliance is an major factor in choosing the cloud operator, the company lobbies for its compliance through numerous formats [5].

In short, It is difficult to imagine deploying a competitive service today on a large

[3] https://www.gov.uk/guidance/the-g-cloud-framework-on-the-digital-marketplace

[4] https://aws.amazon.com/compliance/bsi-c5/

[5] https://aws.amazon.com/compliance/germany-data-protection/

scale without utilising the power of cloud computing. Governments have extensive resources to inform themselves on how to approach their utility best from cloud operators and can enforce norms that cater to good ethics of data use.

2.4 Worldwide Examples of Bots in E-Government

Knowing that the Online Service Index of a country consists of the services available to different groups of society, we can argue that vulnerable groups (i.e. the poor, persons with disabilities, older people, immigrants, women and youth) can be easily marginalised despite a high index. Another statistic by the German Federal Statistics Office (Statistisches Bundesamt) shows that most online public services in 2016 were targeting persons of age 25-44 with an equal offer of services for age groups 45-67 and 16-24 with the least amount of services targeted at youngsters between age 10 and 15 comprising 15% of the Federal Catalogue of Public Services (Leistungskatalog, LeiKa) [44]. For that reason, we acknowledge the importance of inclusion especially towards vulnerable groups in the process of expanding a online public service.

This gives us the advantage to promote inclusion in the development process of a chatbot or a voice service assistant especially since the domain is relatively still uncharted. As Zehlike et al. conclude in their research about algorithmic bias and discrimination discovery, given the possible disparity measures ML algorithms can result in [30], a holistic approach is required to have a balanced distribution of services in different fields (e.g. Health, Finance, Administration) for different groups of society (protected and unprotected groups). Already offering a service on platform that offers less constraints to the user than a browser's graphical user interface (GUI) allows per se more options for inclusion but could also be limiting of the system reacts to a vocabulary used only by a certain group for instance.

In terms of functionality and testing of a chatbot or voice assistant system on inclusion metrics, WitLingo [6], a company specialised in voice-driven apps for public and private sector enterprises believes in that sense that "getting feedback [on performance of a voice service to different groups] is more important than measuring ROI" [37] with a report by Voysis / Retail TouchPoints [51] reflecting this statement in the retail sector.

While there are several cities such as Singapore and Los Angeles integrating chatbots and voice assistants into their administration's websites and coming up with all sorts of interactive solutions, for this research we choose the City of Vienna chatbot service WIENBOT[7] given that it uses German and the Alexa Skill GEORGIAGOV[8] for a comparison in US English, as we examine both languages in our development process.

[6] https://www.witlingo.com/

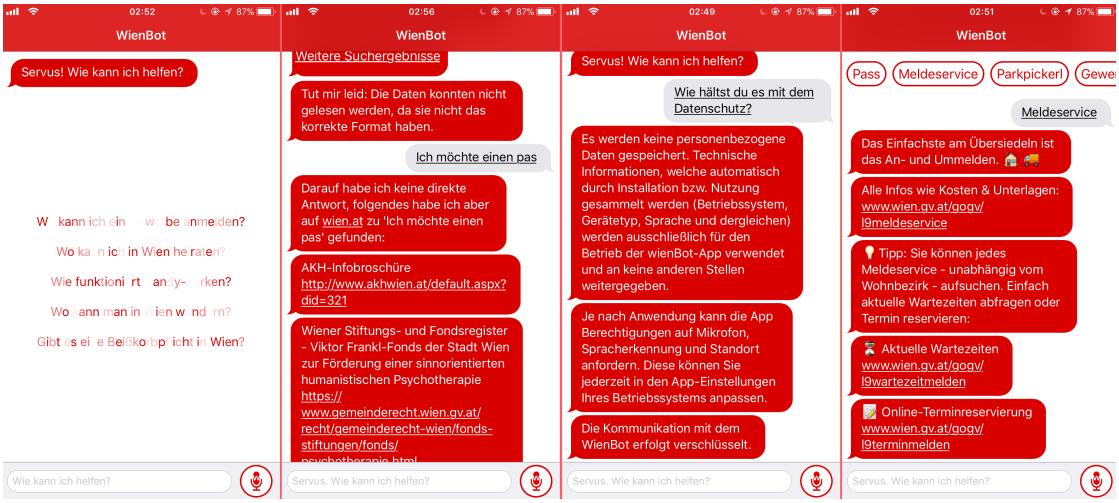
[7] https://www.wien.gv.at/bot/

[8] https://www.amazon.com/GeorgiaGov-Interactive-GTA-Ask/dp/B074XBQGTQ Demo on https://vimeo.com/216737044

WIENBOT

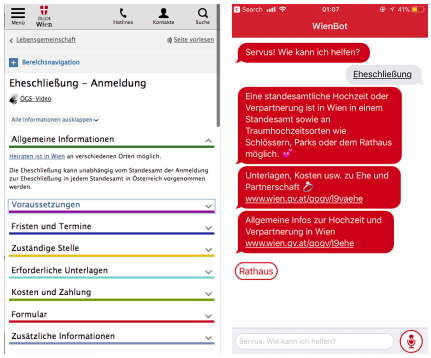
Started out of an amateur project as a Facebook Messenger bot and officially launched in December 2017, the chatbot is developed by and for the municipality of Vienna, Austria with accessibility in mind, for which reason the decision was to create a standalone application. and was the first official chatbot made for a city council. It is famous for its Viennese accent and its witty, verbose (and emojiful, Figure 2.5), yet polite responses in the German'Sie' form.

Figure 2.5: Screenshots of Conversation with WienBot showing the verbose interaction.



With over 200 so-called 'stories' in February 2017, the chatbot started as a query database for the top 100 FAQ. A first look on the Vienna government website beyond the chatbot gives a very complex and crowded impression. This is due to the range of services offered through the centralised website in addition to the text-rich content on all pages. The first clear structure prevails as we get into a specific service. On the German version of the website (the English version has only hyperlinks), the following tabs are consistent:

- Public Service Name
- General Infomration - *Allgemeine Informationen*
- Prerequisites - *Voraussetzungen*
- Deadlines and Dates - *Fristen und Termine*
- Responsible Authority *Zuständige Stelle*
- Required Documents - *Erforderliche Unterlagen*
- Costs and Payment - *Kosten und Zahlung*
- Form - *Forumlar* (includes online reservation links)
- Additional Information (Zusätzliche Information)



Asking for the same service on the chatbot, we get a different overview as shown above.

GEORGIAGOV

Developed for the State of Georgia, USA by Acquia[9] the voice assistant is an Alexa Skill. We introduce Skills later in Chapter 5. For now, it is enough to know that an Alexa Skill is comparable to an app on smartphone that simply extends its functionality and that to operate the Skill an Alexa-enabled device is required.

> The state of Georgia has always been on the forefront of web accessibility. For example, from 2002 until 2006, Georgia piloted a time-limited text-to-speech telephony service which would allow website information and popular services like driver's license renewal to be offered to citizens [13]

While we are less interested in the content delivered through the voice assistant and have no access to the GeorgiaGov Skill (at some point known as AskGeorgia) from the German Amazon Store, we use the US store for our conversation testing purpose to reverse-engineer the relevant design of dialogue flow and eventually pick what is helpful to our own implementation.

Here are a few outtakes of a conversation with the Alexa Skill GEORGIAGOV:

" Alexa, open Georgia Gov "

" Welcome to Georgia Gov. Feel free to ask a quesion "

" How can I renew my license? "

" Marriage licenses. Does this sound helpful? "

" No "

" How about this: Nursing licenses "

" Not really! "

[9] https://www.acquia.com

“ You can call 1-800-GEO-RGIA [...] over the phone. If you have another question, feel free to ask it. Otherwise, you can say exit. ”

“ How do I get food stamps? ”

“ Food stamps. Does this sound helpful? ”

“ yes ”

“ The food stamp program provides monthly funds for families [...]. As of March 2016 [...]. I have a list of related information. Would you like to hear it? ”

“ yes ”

“ “How do I report food stamp fraud”. Does this sound useful? ”

“ No ”

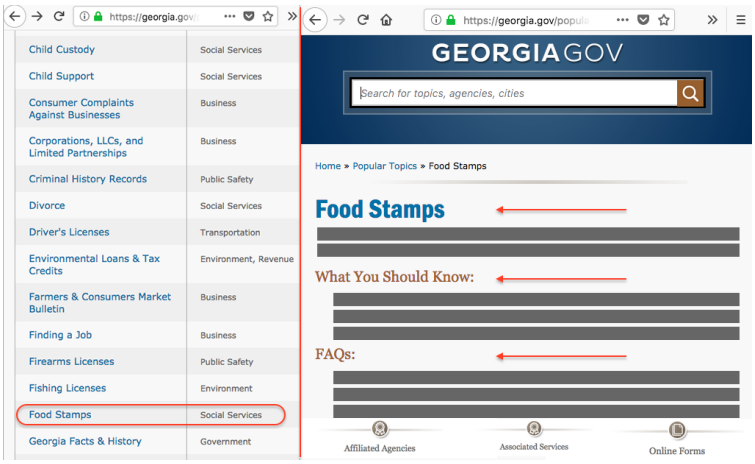
“ That’s the last on the information on this topic. If you need a phone number for further assistance, say “Give me their phone number”. Otherwise, you can ask another question or say “exit”. ”

“ Exit! ”

We compare the Skill to the information on `www.georgia.gov` and realise that Alexa mainly provides a narrowed down version of the website. In some cases, a few spoken paragraphs are very similar in content but not exact to the text on the web page. Noteworthy is that Georgia.gov provides PDF and online forms that can be submitted through the website or domains affiliated with it. In terms of capabilities, the Skill provides objective facts only and no content is customised to the user’s profile (age, sex or location).

As mentioned on the Amazon website, the content data is dynamically generated. After familiarising ourselves with Alexa, we understand this means that the Skill is connected to an API not hosted through Amazon, giving the maker of the Skill the ability to change the information delivered through the Skill without Amazon's permission (more on permissions in Section 5.2).The conversation flows dynamically, with Alexa engaging the user by asking them questions or listing options to which they need to answer with a 'yes' or 'no' to hear information on public service topics that to our knowledge listed on the popular topics section of the website [10]. A view on the sitemap [11] shows that there are no other topics than the popular ones at least on the root level.

Figure 2.6: Georgia.gov Popular Topics - Based on georgia.gov/popular-topics



Each of the available topics is associated with one or many departments and relates to a few search terms (Figure 2.6). By navigating on the website to any of the topics, we see a clear division between a "What You Should Know" section and another "FAQ" section. At the bottom of the page, affiliated agencies, online forms and associated services are listed. The Skill reflects the same structure through conversation. The user starts a dialogue within the Skill with a topic exact or synonymous to any of the listed ones. Once Alexa determines the topic, general information similar to the heading is given, then Alexa prompts the user if they want to know about each item in the list of related services, then ends the dialogue about this topic by asking the user if they want a phone number of the associated department. The user can then ask another question related to the same or another topic. Of course some options are defined within the conversation flow. In Chapter 9 we show in Figure 9.1 a more detailed flow of the conversation.

[10] https://georgia.gov/popular-topics
[11] https://georgia.gov/sitemap

2.5 Summary

The EGDI and OSI measure countries' performance with respect to online services. Germany has been in the top 25 countries for the past three years, maintaining an average position within Europe. With the GDPR in effect starting May 24, 2018, data regulations paving the way towards a fairer use policy in Germany and more governmental engagement online. Our use case can be compared to already existing examples from Wienbot and GeorgiaGov. This work incorporates common strategies between both interfaces, while investigating alternative methods to interact with the user as we look into our specific use case in Chapter 3.

Chapter 3

Berlin as a Use Case

As Schwarzer et al. state, few systems are available that "enable Berlin's citizens to get informed about governmental services" [28]. As part of the modernisation process, the VIRTUAL CITIZEN ASSISTANT - *Virtueller Bürgerassistent* was born in the Information Retrieval and Machine Learning Competence Centre of the Technical University of Berlin's Distributed Artificial Intelligence Laboratory.

This chapter explores the running software of the Virtual Citizen Assistant in detail to analyse which artefacts can be reused. It also explains the context of the software from legal and operational perspectives.

3.1 D115

The German Ministry of Interior which operates the national hotline for citizen services D115[1] argues in its whitepaper on the service [18] that even with the widespread internet use in the country, a telephone hotline is a valuable service. 70 % of the D115 users use the internet according to a survey by the entity (2013). One of the main advantages of the service is that it offloads the lookup of information from the customers to its employees and guarantees that the customer will get the right answer concerning questions related to public services. Depending on the service, appointment bookings can be arranged (sometimes exclusively) through the hotline. Effectively, this means relying more on manual labour, which has a twofold impact for an administrative entity in the government. On one hand, D115 opens jobs in the labour market for public service employees as call centre representatives, strategists, editorial teams throughout Germany inter alia. For a government entity this speaks positively in terms of reducing unemployment rates. On the other hand, with a budget coming from taxpayers, there is a need to choose how to allocate this budget dynamically in a fashion that does not come to the disadvantage of societal segments.

[1] `http://www.115.de`

Despite the heated worldwide debatable about technological advancement eradicating job opportunities, if we advocate to offer services compatible to serving users needs, the necessity to diversify the service catalogue remains prevalent. Including online services as a possible alternative, at least to include minority groups with communication disabilities is inarguably an important step towards a higher Online Service Index and EGDI respectively.

The whitepaper states a few expectations of the D115 service. Taking its promises into account, we set the following goals to our service:

1. 24/7 reliable availability in accordance with underlying Service Level Agreements (SLAs)

2. Avoiding the need to visit a municipality office if possible

3. Clear explanations on what a public service is about, how it is performed and all necessary detail around the public service to make it conform to the Right to Information (Article 19 of the Universal Declaration of Human Rights) in accordance with the German Freedom of Information Act - Gesetz zur Regelung des Zugangs zu Informationen des Bundes [2].

4. Continuous improvements to the voice service offering through learning from new specific cases that can be helpful to solve others in the future.

5. An implementation that tries to help and not repel customers.

6. A service that is friendly and respectful of its target audience

7. An open option to equip customers with more information by triggering them to ask for, in case it could be helpful without them knowing at the time of inquiring.

8. A service that gives facts anonymously to the customer without collecting data that can potentially result in any information bias at the time of service or in the future

9. A flexible service that can respond to the questions answered through analysing the relevant information and omitting unnecessary details.

With the Virtual Citizen Assistant as our starting point, we look at how these expectations are fulfilled through the chatbot. we then touch in Chapter 7 on how we attain the same goals.

[2] `https://www.gesetze-im-internet.de/englisch_ifg/index.html`

3.2 LeiKa

In the German public administration system, most public services are carried out through each of the 16 States with very few services offered on a national level. As each State has a different bureaucratic structure, considered as the E-Government base for Germany, LeiKa [3] is a service catalogue and a way to standardise how different public organs of each State fit into the same legal framework for federal regulations. For instance, it is a requirement for each resident in Germany to register their current (permanent) address at a local authority. Registration differs based on the resident's legal status, e.g. due to a move of house within Germany, within the same State or a move from abroad. For a person who moves from abroad, further regulations apply based on their right to residence and the duration of the stay in Germany (short-term, long-term, permanent). These laws apply to nationals and foreigners (where another differentiation occurs between EU/EEA citizens and nationals of other countries). In that sense, there are different laws that may or may not apply for the same action (a registration of an address), e.g. Section 17 of The Federal Act of Registration [4] - *Bundesmeldegesetz, BMG* in conjunction with Section 22 of The Asylum Act[5] - *Asylgesetz, AsylG*. How this is carried out is left to each state to determine. In many states a foreigner can register themselves at the aliens office. In Berlin, foreigners are required to register only at a Bürgeramt. In order to make sure that the legal framework is covered through the services in every state, ensuring that the law is applied through an appropriate channel, LeiKa serves as a catalogue to keep track of how and through which organs the law is enforced.

Similar to an IBAN without a checksum, LeiKa's key structure is divided into the following identifiers put together (Key System 2.0, Figure 3.1):

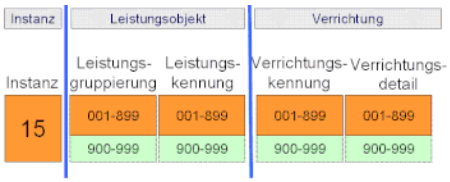


Figure 3.1: Leika Key System 2.0, based on [6], ©CC, Wikipedia

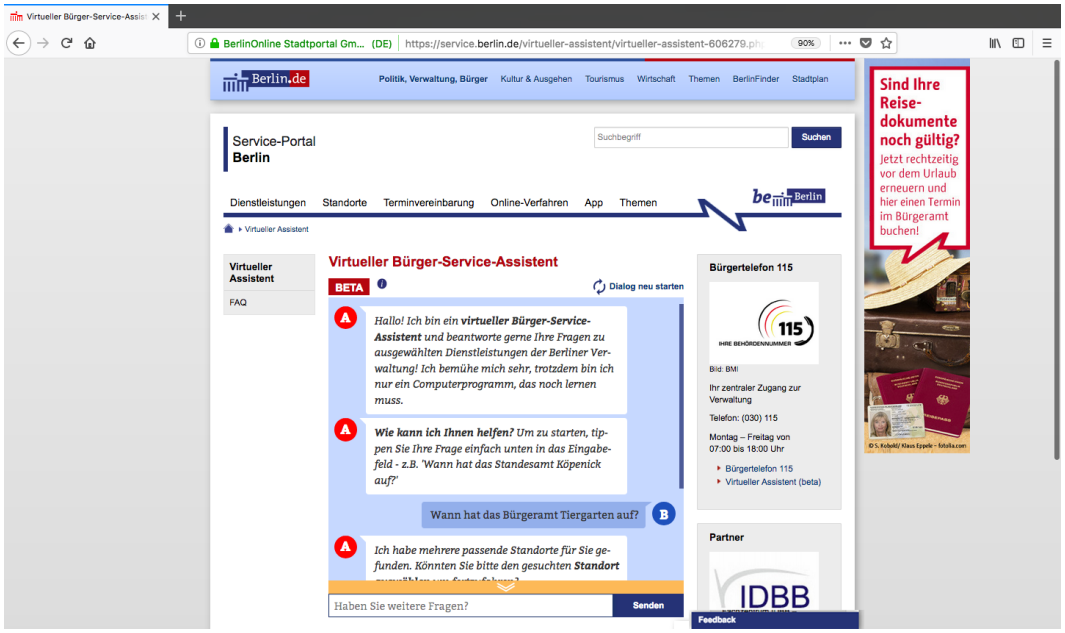
- Instance - *Instanz*
- Service Object - *Leistungsobjekt*
- Service Grouping - *Leistungsgruppierung*
- Service Identifier (ID) - *Leistungskennung*
- Performing Entity - *Verrichtung*
- Performing Entity ID - *Verrichtungskennung*
- Performing Entity Detail - *Verrichtungsdetail*

[3] https://de.wikipedia.org/wiki/LeiKa
[4] https://www.gesetze-im-internet.de/englisch_bmg/index.html
[5] https://www.gesetze-im-internet.de/englisch_asylvfg/index.html
[6] http://www.gk-leika.de/

Leika Keys are part of the data provided to the Virtual Citizen Assistant's back-end and help us carry out an implementation not only for Berlin through its universal identification system using serial numbering.

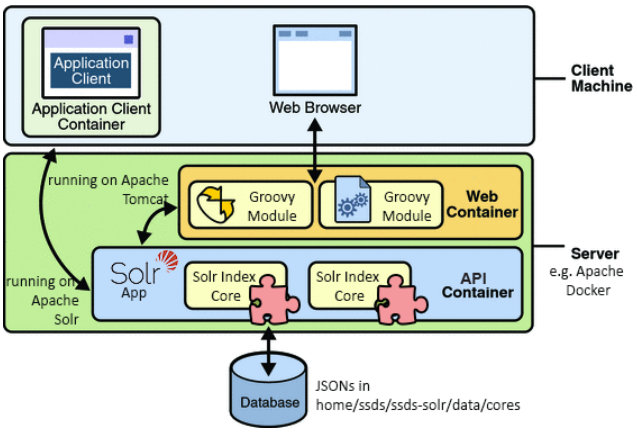
3.3 Understanding The Virtual Citizen Assistant

Figure 3.2: Screenshots of Startup Interface of the Virtual Citizen Assistant showing the initial interaction in a web browser.



The Virtual Citizen Assistant on Berlin.de starts with a greeting and an input field as seen in Figure 3.2. Based on the question text entered by the user, a query goes to the Solr back-end and the responses from there are processed to deliver available options, which the user can choose from. Once a question is answered, the chatbot continues to ask if the user is interested in knowing more about sub-topics related to the service, such as cost or processing time. The chatbot is a rich implementation with many features, e.g. the ability to decipher locations based from input postal codes (Postleizahl, PLZ) and auto-correct among many others. We use such features as an orientation on how our voice assistant should be implemented and what inputs and outputs it needs to support. As we anticipate a voice-first approach, we also demonstrate how these should or should not be adapted in Section 7.3. As such, the logic behind an auto-correct feature for instance has to be re-engineered since spoken word is different than written text.

Figure 3.3: Virtual Service Assistant - based on [7]



By deploying an instance of the chatbot locally, we understand that it is built using Java for the Solr server implementation and Groovy, a Java-syntax-compatible OOP language, to operate a web app on top of Solr as an API to handle user inputs and display answers formatted inside a web browser (e.g. links for navigation in the conversation and standard text). We also understand that the implementation is designed to include States other than Berlin. At the time of this research, another chatbot was in the making for the City-State [8] of Hamburg (parallel to continuing development on Berlin Virtual Citizen Assistant). Both chatbots were able to connect with another partition of the web app that can serve in other domains if the user has questions beyond the scope of public services. A nutrition bot is as an example. Domains other than Berlin are not relevant to our work and are excluded from our scope of analysis.

3.4 Building a Voice Service on The Virtual Citizen Assistant - Data Structure I

In the Berlin domain, we narrow down our compiled choice of files for reuse. At this initial stage we cannot depend on reusing code unless we can tailor our platform, yet to be chosen at this stage, to do so. This turned out to be partially applicable as our choice of platform in Section 5.3 shows that we can mostly make the best use of data-containing files relevant to our use-case rather than scripts of application or business logic. Such data files exist in JSON format for the Virtual Citizen Assistant. Data is meant here as content our voice assistant can operate with, ranging from names, URIs to addresses. Complex data types beyond integers and strings needed to be redefined for the new system to understand them. Java and Groovy code were not considered at this stage since we anticipate a different programming language as per Section 5.3. Since JSON is an industry standard, we look for possibilities to parse this information into a system that can read them in and be structured to understand the file format.

[8] https://en.wikipedia.org/wiki/City-state

[8] some graphic elements adopted from Oracle Java Tutorials - https://docs.oracle.com/javaee/5/tutorial/doc/bnabo.html

Starting with `./ssds-data-berlin/json/dienstleistungen/dienstleistung.json` (the file has been reconstructed since this version to be included as a part of the Solr index, i.e. a core), we analyse the content of a few fields (as JSON objects / nodes) in Figures 3.4 and 3.5 to draft Tables 3.1, 3.2 and 3.4. We introduce the remaining Solr index fields below.

Figure 3.4: Primary Nodes of `Dienstleistungen.json` including metadata about each service, e.g. processing time and cost.

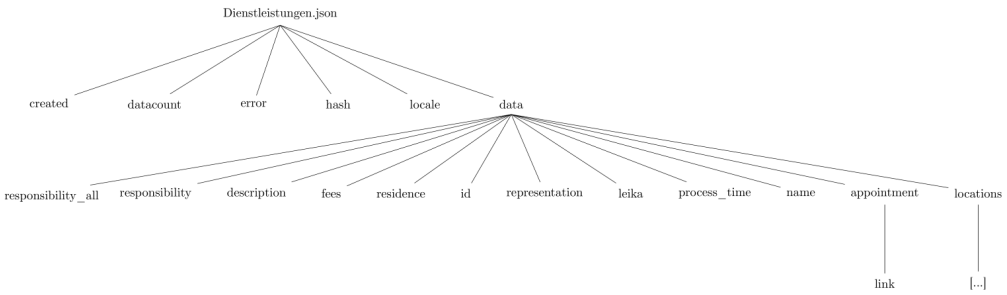
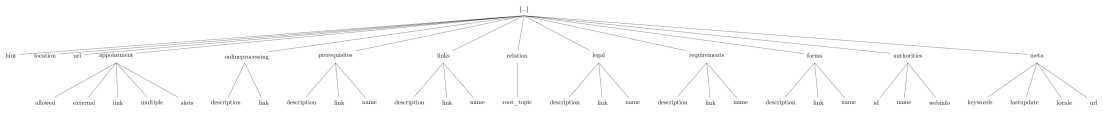


Figure 3.5: Secondary Nodes of `Dienstleistungen.json` show relevant follow-up nodes to the primary node `locations`



From back-end side, the files mentioned above reporesent cores in a Solr index. The latest version of the underlying Solr server (May 2018) contains the following cores:

d115

An index core designed to query the latest public services available on Berlin.de. Example services: "*Personalausweis beantragen* - issuing a passport", "*Blindenhilfe* - monetary relief for the blind".
This core initally included 616 nodes at the beginning of this research and now varies between 670 and 680 services depending on the original LeiKa. We will use this core later on as our primary API.

d115Extern

An index core designed to include external Hyperlinks outside the service.berlin.de subdomain.

Examples: "*Gentechnik* - gene technology" routes to `https://www.berlin.de/lageso/gesundheit/gesundheitsschutz/gentechnik/`

d115Locations

An index core designed to query locations of authorities' offices offering a public service and their opening hours
e.g. "Kfz-Zulassungsbehörde-Lichtenberg"" the authorities' offices and their opening hours.
Based on (`./ssds-data-berlin/json/behoerden/behoerden.json` which will help us indirectly in our implementation later on.

d115Spelling

An index core designed to make the chatbot able to determine spelling mistakes in names of entities (e.g. offices, services) and automatically correct these in the conversation flow

d115Topics

An index core designed to query the database for topics. Each topic collects a set of services that are of the same interest group. For instance, a topic "Ausländerangelegenheiten" comprised of all sorts of visa and residence permit types. Another topic on "Auto und Verkehr" includes services like parking options, paying fines and issuing a driver's licence.

smalltalk

An index core designed to make the chatbot more interactive by including simple questions and answers to them not related to Berlin.de's service catalogue

Tables 3.1 and 3.2 represent the Solr index cores available on `/home/ssds/ssds-solr/data/cores/` and show the fields (child nodes) of each core on Solr, as it is important to have the structure of these files for our implementation.We refer to our Solr instance from now on as the API, since it is built and operates independently from the Groovy web app and only delivers the results to it. Hence, it offers an opportunity to be shared by another programme, rendering it into a standalone API endpoint that can be hosted on its own server as will be discussed in Chapter 8.

In Table 3.4 we cover an excerpt of most node elements we will later use in a similar structure for our own front- and back-end.

After understanding the links between the API and the sitemap of the Berlin City Portal, we draw a few connections summarised in Table 3.3 to understand how we can proceed with the API and eventually modify or expand it with additional parsers such as Apache Nutch or other runtime parsers (e.g. to find the next appointment, since this is not provided by the API) to suit our voice service solution.

Table 3.1: Structure of API - Solr cores 1-5, version (*ver.*) and relevance (rel.) to our implementation. **Boldfaced entries** are explained in Table 3.4

Core Name, *Ver.,* rel.	No. Entries	Fields for each entry (by Order of Child Nodes)
d115 *426,* very relevant	672	**id** **d115Url** **d115Name** ssdsAll **d115Description** d115Synonym d115Position **d115InfoLaw** **d115Prerequisites** **d115Requirements** d115Forms **d115Fees** **d115ProcessTime** d115AppointmentLink d115ServiceLocations d115ServiceLocationsJson d115ServiceResponsibility d115ServiceResponsibilityAll d115OnlineProcessingLink **leikaId** leikaName leikaGruppe leikaKennung leikaVerrichtung leikaVerrichtungDetail leikaSynonym ssdsName ssdsLemma ssdsLongName ssdsGruppe ssdsGruppeDict ssdsKennung ssdsKennungDict ssdsSynonym ssdsSynonymDict _version_
d115Extern *396,* semi-relevant	1488	id d115Topic d115Name d115Link d115Keywords _version_
d115Spelling *678,* semi-relevant	1233	id complex object (irrelevant) _root_ _version_
d115Topics *426,* semi-relevant	167	id d115Name d115Path d115Keywords d115Links _version_
smalltalk *396,* semi-relevant	1366	id smalltalkAnswers smalltalkQuestion _root_ _version_

Table 3.2: Structure of API (cont'd) - Solr cores no. 6 (last), version (*ver.*) and relevance (rel.) to our implementation.

Core Name, *Ver.*, rel.	No. Entries	Fields for each entry (by Order of Child Nodes)	
d115Locations *426,* relevant	560	id	d115Url
		d115Name	d115LongName
		d115Type	d115SuperType
		d115District	d115SuperDistrict
		d115AddressHouseNumber	d115AddressCity
		d115AddressStreet	d115AddressPostalCode
		d115AddressGeo	d115AddressNote
		d115AddressUrgentEndDate	d115TransitTram
		d115AccessibilityElevator	d115AccessibilityAccess
		d115AccessibilityParking	d115AccessibilityWc
		d115ContactEmail	d115ContactFax
		d115ContactPhone	d115ContactWebInfo
		d115ContactCompetence	d115ContactSignedMail
		d115ContactSignedMailLink	d115Payment
		d115PaymentCode	d115AppointmentNote
		d115OpeningTimesMonday	d115OpeningTimesTuesday
		d115OpeningTimesWednesday	d115OpeningTimesThursday
		d115OpeningTimesFriday	d115OpeningTimesSpecial
		d115LocationServices	d115LocationServicesJson
		version	

Table 3.3: Structure of Berlin City Portal URLs. We use these to collect additional information beyond the API's content (i.e. Solr fields).
Base URL: `https://service.berlin.de/`

Web Page displays	URL Path	Suffix
a public service	dienstleistung/	`id`
an authority homepage	behoerden/	variable, no base URL, external link
a service location	standort/	`d115ServiceLocation`

Table 3.4: Relevant nodes in Solr API query results in core `d115`, based on `Dienstleistungen.json` usable in our implementation - at the example of a public service called: "Fiktionsbescheinigung"

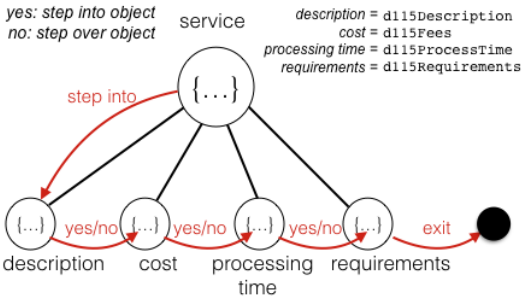
Key<Type >	*[Omitted Text]* in *Example Value* — Description — **Remarks on Syntax**
`id` `<int>`	*326233* public service ID
`d115URL` `<string>`	*https://service.berlin.de/dienstleistung/326233/* link to public service URL **URL structure includes `id` - See Table 3.3**
`d115Name` `<string>`	*Fiktionsbescheinigung* public service name as listed on Berlin.de
`d115Description` `<string>`	*"Eine Fiktionsbescheinigung wird ausgestellt, wenn über einen [...]"* Introductory paragraph about the service web page **incl. HTML tags**
`d115InfoLaw` `<string>`	*§81 Aufenthaltsgesetz - AufenthG ::: false ::: http://www.gesetze-im-inter[...]* Legal base for offering this public service
`d115Prerequisites` `<string>`	*"Persönliche Vorsprache ist erforderlich ::: false ::: ", [...]* Conditions a citizen needs to fulfill in order to obtain the service **incl. non-fluid text (unique patterns, parsed/encoded HTML)**
`d115Requirements` `<string>`	*"Bisheriger Aufenthaltstitel ::: Soweit vorhanden, ist der [...] ", [...]* Required document(-s) citizens need to present to obtain service **incl. non-fluid text (unique patterns, parsed/encoded HTML)**
`d115Fees` `<string>`	*"Ab dem 01.09.2017: [...] "* Cost of the service **incl. non-fluid text (unique patterns, parsed/encoded HTML) variable free Text for same value, e.g. free services cannot be explicitly read as primitive data type** `int/bool`
`d115ProcessTime` `<string>`	*"Die Fiktionsbescheinigung wird bei Vorsprache ausgestellt."* Time required to process the application for the service **incl. non-fluid text (unique patterns, parsed/encoded HTML) variable free Text for same value, e.g. immediate services cannot be explicitly read as primitive data type** `int/bool`
`leikaId` `<int>`	*99010008012000* LeiKa identifier as discussed in Section 3.2

There are other elements not directly available in the Solr index as fields such as objects from `./ssds-data-berlin/json/districts.json`, which displays

each municipality - *Bezirksamt* in relation to the districts - *Ortsteile* and Postal codes - *PLZ* it contains. As these are helpful to our implementation structure, they make good candidates for a new object type (as discussed later in the interaction model, Chapter 7). There are some naming ambiguities in the file structure that will need an implicit type inference. For instance, the type of location is only distinct through the name, e.g. 'Lichtenberg' for the municipality and 'Lichtenberg-sub' for the district.

3.5 The Virtual Citzen Assistant at Runtime

Figure 3.6: Simplified demonstration of how nodes are traversed in Virtual Citizen Assistant



The web app revolves around the following algorithm: once a public service has been caught from the user's input, the chatbot shows the description of the service, followed by a series of questions beginning with a yes/no one to determine if the user is interested in knowing more about the cost of the service, followed by another to pompt if the chatbot should show information of other metadata of the service, e.g. processing time or which authorities are responsible to offering the service. The user navigates by clicking on the links provided inside the chatbot conversation. The yes/no questions are translated as **intents**, which the users either wants to pursue or ignore.

For a yes answer, the chatbot selects child nodes of a node it is currently pointing to, e.g. a service node and checks if it can show their content if these are not empty. If the user chooses not to pursue the intent, the chatbot skips to the next element (or node) in the loaded list from a JSON file as described above. With the modular structure of the nodes, the chatbot is allowed to traverse each service node and metadata nodes to display the proper information as seen in Figure 3.6.

The content of these nodes is provided through the IT Service Centre Berlin - *IT Dienstleistungszentrum Berlin, ITDZ* and is part of LeiKa. In a similar implementation for the Facebook chatbot Berlina (currently in Beta), Hassmann and Müller [38] explore a similar implementation and conclude with the use of JSONs being a flexible foundation for development.

3.6 Summary

The Berlin use case is complex in the sense that there are many entangled entities and relationships between the hierarchy of the municipalities. Representing these in one hierarchical diagram is counter-productive due to the rich attributes to numerous special cases and the independence of each authority type of the other. LeiKa overcomes this challenged through a system of sectioned serial numbers for each office. Yet, understanding how each service operates remains a task to the developer to be able to gather an all-inclusive service strategy for a voice assistant. The modular structure of the Solr API is a helpful tool to send queries and get responses to the software solution we seek. A more in-depth look at the content shows potential adjustments required to adopt it to the solution we present. We discover that Berlin.de shows features of REST architecture such as unique identifiers for pages representing entities (locations, services) and pagination capabilities throughout the website (e.g. for appointment bookings).

As such, operating a voice assistant as a new service could be delegated to D115 as an authority under the realm of the German Ministry of Interior with the help of the ITDZ, since both entities have the knowledge base and the content to power the service. As the content is subject to changes at any time, updates have to happen without the user having to update in order not to give customers obsolete information. This is part of D115's policy of assuring correct and helpful information is given. For any software solution we present, the guidelines summarized in Section 3.1 have to be adhered to. Accordingly, special attention has to be given about data collection. We show in our implementation (Chapter 8) how we address this by not storing user sessions in any persistent form. We categorise our system as semi static, since only the content should be interchangeable through an independent API (Solr in our case).

As per D115's guidelines, we should be able to understand from special cases how to maintain a more well-rounded software that handles more specific cases, and not only give general information. As this requires more detail for requirements engineering (tender and performance specifications), we keep this implement for a future stage. This might involve uses of ML to detect patterns and irregularities

Finally, with human interaction being a favourite option for customers, our software solution competes to present an alternative that is persuasive enough to lure customers to use it. For this, making it constantly available to the user with no waiting time on phone queues or in a public office gives a good starting point. And while the software does not have to understand everything the user says, it should be able to abstain from giving wrong answers at the least in order to yield objectively satisfied customers and no frustrations for receiving misleading or confusing information as discussed in Section 1.2.

Chapter 4

The Voice as a User Interface

We start this chapter by juxtaposing the Voice User Interface (VUI) to the Graphical User interface (GUI) respective to cognition and behavioural design which gets us to define new terminological foundation that will follow throughout this thesis.

4.1 GUI vs. VUI

Visuals and Sounds can both communicate the same message even though they use a completely different medium. One one hand, the premise that "a picture is worth a thousand words" can be valid based on the image but only assumes that we want to give a clear picture to the receiver. Communication through voice, on the other hand, can generally allow more room for interpretation. We think of watching a football game on TV vs. listening to the same game on radio as an example, where listening to it allows each person in the audience group to imagine a different game for themselves, even though the match result are the same.

When we use written text, be it in a document or a street sign, or any label, we seek to mostly assure that all readers understand the same message with a universal codification of what we want to express through the language we use. In this process, language becomes the common denominator for understanding and the short written text becomes purposefully designed to give in the best case a message or instruction not open to interpretation and so a foundation for an agreement or contract between source and destination of the message. It is a good medium of reference.

4.2 Utility of Voice

The utility of Voice with its different paradigm is shown in numerous settings. For a passenger at the airport or an employee between meetings, it can be more effective to

ask questions through conversation than transform them into a query then type them on a screen, or visually navigate on a web page / mobile application until we reach the information we want. In a 2016 Cisco Systems (formerly MindMeld) survey [32], of 1800 users of voice assistants, 61% see that the primary use of a voice assistant is when hands or vision is occupied. Today, this goes further beyond the simple use-cases to become an integral part of our fast-paced life, where we see companies like Ecobee getting around 40 percent of their sales through voice-based AI [5] since their embrace about two years ago. The 10-year-old company's CEO elaborates that their customers "[...] have to fight traffic to get home, and then they have to feed the kids, diaper the baby, and who knows what else. [Ecobee] give them a hands-free way of getting something done while they're in the midst of other tasks" [5] .

Also, in terms of accessibility, blindness could sometimes make voice the only possible way to navigate or be aware of one's surroundings, e.g. a blind person crossing a street depends on the sounds coming from cars and traffic lights. In that sense, voice can allow people to do their activities free-handed and unobstructed by actively engaging into reading activity as is the case when we look on a screen. With our ambitions in connectivity becoming more complex, we have increasingly started depending on our phones in the last decade. This is where the use of a Voice User Interface could come at an advantage in liberating us from the constant usage of our smartphones and moving from one screen to another. However, it is noteworthy that the trade-off between visually and auditory information exchange comes at a price. While both have their own advantages and disadvantages, it is important to understand that the context in which the medium is used determines dependent factors.

Hence, we need to differentiate between GUI design and that of a VUI. Since most computers and advanced electronic devices operate with a GUI or a simpler textual interface displayed on a screen, our acquaintance with GUI trump the know-how we developed with VUI. Therefore, it might not be most intuitive to apply the same concepts on VUI design simply since we start from the mindset that the GUI dictates how to use the software and the user has to understand this interface and deal with it as is.

4.3 Why AIs do not Understand Us

AI has made giants leaps in the last few years. Thanks to neural networks, Bayesian approaches in classification, decision trees and many other theories, we are capable of performing rigorous analyses on datasets. Considering that speech is one of the most complex forms of data, there are still various challenges and no one strategy is able to tackle them all.

> What makes voice-based AI so appealing to consumers is its promise to conform to us, to respond to the way we speak—and think—without

> requiring us to type on a keyboard or screen. That's also what makes it so technically difficult to build. We aren't at all orderly when we talk. Instead, we interrupt ourselves. We let thoughts dangle. We use words, nods, and grunts in odd ways, and we assume that we're making sense even when we aren't. [5]

When speech meets AI, there are a lot of language ambiguities to deal with and multiple contexts to understand. Since this is a field by its own and the amount of problems we can face with understanding natural language is unlimited, it is not the scope of this thesis. We only briefly survey a few categorical examples in the following:

- **Sytanx**: homonyms such as "I *present* you a *present*." or "The *fly* wants to *fly*"
- **Sematics**: metaphors, sarcasm, puns such as "it's raining cats and dogs"
- **Underlying Sentiment**: such as "oh yeah, sounds very exciting" when it's not.
- **Dialects**: enunciation such as [dɪˈvɛ|ɘpmɘnt] *(British)* and [dɘvˈ|ɑpmɘnt] *(Indian)*

While Machine Learning enables us to decode phrases not in the classical way in the past by randomly guessing the whole expression, our speech datasets grow and require analysis in further breadth and depth to deliver a sustainable Natural Language Understanding (NLU) engine. So far, in the past six years our primary approach has changed due to the little progress made with it. Instead of trying to understand exact meanings, we work from "imperfect matches at the outset, followed by rapid fine-tuning of provisional guesses" [5]. The learning part is involved by reinterpreting missed expressions [20]. On one hand, neural networks help us understand language patterns and become better the more frequently we use them, but can fail in the case of homonyms. [24] Thought vectors, on the other hand, complement them by controlling the connection of different words with their related meanings

Mostly independent from the system we use, it is a rule of thumb that most AI-powered personal assistants like Siri or Alexa are still at an early learning phase. In order to be able to make use of them in the future, we need to traverse a period of immaturity teaching the system. This limits us for instance to currently using short sentences to lessen the probability of failure and the system misunderstanding us. And so, naturally, what distinguishes a good system from a better one is how fast it learns.

Interestingly, a side effect of this indeterministic technique is that the voice assistant inadvertently simulates a person who can sometimes not hear us, asks us to repeat a sentence or explain it with different words. Although this is the same idea that a good system should have adequate incoming and outgoing speech fault tolerance, it is unprecedented to tackle a computer system on the consumer level with the idea that we might very much hit or miss the action we want to perform. On the other hand, though

premature, it is evidence that a human has much more authority to a machine-powered (and maybe autonomous) brain.

Yet, although it might seem at the beginning that moving between both paradigms is easy, the more detailed system design gets, the trickier it becomes to transform GUI elements into text. Particularly with long texts. We will go over this in more detail about voice design guidelines in Section 7.3.

4.4 VUI Semantics

Having the visual or haptic interface disappear is therefore a game changer for as soon as the user does not have direct instructions on how to deal with it, they start to improvise, or rather move away from the idea that the interface constrains them to the illusion that they define that interface and can control it. For instance, the user knows that they have to press only on a certain area of the screen to activate a button and actively move the mouse to that part. In other words, when a user sees a 'save' button on a dialogue box, in their head they relate to it the functionality of a commit and keeping a persistent copy of the current state of the parent file to that dialogue. The label 'save' describes in a visually expressive fashion what the user can or cannot do within this *dialogue state*.

In voice on the contrary, a user is uninhibited in what they can and cannot say and the system is supposed to understand the *intention* of the user with the *formulation* they just used.

In order to translate the aforementioned with less ambiguity, we need to define the lexis we use for voice design utilized in most common chatbot and voice assistants constructs. We divide the building model into *intents*, *utterances* and *slots*. The Fulfilment part is taken care of through a back-end and possibly endpoints connected to it containing the programming and business logic to the interface, which also validate the slots before sending it onwards, similar to when JavaScript takes care of checking a box is not empty when we use a form on a website.

4.5 Terminology

We already unveiled in Section 1.3 that Alexa will be the underlying platform. Thus we cap the elementary definitions of voice assistants with distinct Alexa-specific concepts and give meaning to the following terms:

Intent

As the intention the user pursues with a spoken sentence. This translates to the action being executed upon the user's command based on mapping his/her words to this action.

Utterance

As the wording a user picks to express his intent. For instance, to set the volume on a TV to quieter, we could say "turn it down a nudge", "It's too loud" or "lower the volume". Although all three sentences have the same meaning, linguistically, they are fully unrelated and only context makes us understand them, e.g. we have to know that "it" refers to the TV set in close proximity.

Slot

As a variable of a certain type we define in our programme that belongs to a category of items. For instance, when someone says they would like to order a *large* coffee, they assume that there is the option to have a small coffee, too. And so large and small refer both to the size of the coffee. Programmatically, we define `large` and `small` to be of type `size` of the coffee. Similarly, if there is the option to order a tea and a Cappuccino, it would be only fair to define `cappuccino` and `tea` to be of type `beverage`. Consequently, **slots** can be defined to any part of the sentence, where a parameter (here beverage or size) can be grouped into **slot types**.

This idea is to be handled with care, though, since technically in most languages we can define a subject, a predicate and an object. Here is an example in English:

$$\underbrace{I}_{\text{subject}} \cdot \underbrace{would\ like\ to\ have}_{\text{predicate}} \cdot \underbrace{\overset{\text{number of items}}{\square}\ a \quad + \overbrace{large}^{\text{size}} + \overbrace{coffee.}^{\text{beverage}}}_{\text{object}}$$

When we design a voice system from scratch, we might have to make it understand how each of these sentence elements can be interchanged with another one of the same slot type. However, since utterances build on they idea of slot types, we can delegate the system to understand what is important from the sentence through slot types and what other interoperable words are not relevant. In this example, if we say:

$$\overbrace{My\ brother} \cdot \overbrace{wants\ to\ order} \cdot \overbrace{a + tall + coffee.}$$

it is not important to the system to understand at this stage who is going to drink the coffee. It should be more concerned with the intent; making the coffee, e g. sending a signal or instruction to a coffee machine.

Ultimately, it is up to us to draw the line on where we want to define a variable slot, that is relevant to the sentence being said by the user in context at a certain time in the conversation flow and where certain sentences would be as a whole giving the same intent.

Synonym

As a word that has the same meaning of another word that fills a slot. For instance, if we assume that a user says "I want a **cup of jolt**" they system should still be able to understand that they want a standard coffee. If, however, the user defines the type of coffee beans they want, such as 'Java' or 'Arabica', the system should still be able to differentiate between these and not consider them both as the plain 'standard coffee', fulfilling a different intent.

Dialogue State

Like with a state machine, when we have a conversation with Alexa, the dialogue goes into states `STARTED`, `IN_PROGRESS` or `COMPLETED` in the `dialogState` property of the JSONs being exchanged with the Alexa client (e.g. an Echo Dot). This is helpful for delegating the dialogue to Alexa or handling it in our own code especially in a multi-turn conversation (see below). More details about this interaction available in the ASK DOCUMENTATION [1]

Dialogue Directives

Taking advantage of the `DialogState` property, dialogue directives are a concept for dialogue management providing a mechanism to conduct dialogues in a multi-turn fashion via Alexa's interaction model directly with little programming effort Without dialog directives, we need to write the logic to collect all the slots (data) we need from users, effectively maintaing the whole session ourselves. As such, dialogue directives are a clean way to manage sessions with one of three options:

- Delegating the collecting of required slots to Alexa
- handling the multi-turn dialogue in the fulfilment code
- using a hybrid of the above.

Entity Resolution

Entity Resolution enables us to use synonyms for slot values without the need to manage this concept in detail in our implementation code. As synonyms are part of the interaction model, resolving them becomes as easy as finding a canonical value in an object (as a complex data type). The concept of entity resolution additionally simplifies verifying that the user indeed said one of the synonyms to a slot value by confirmation utterances from Alexa.

[1] `ask/dialog-interface-reference.html#scenario-delegate`

Example: Using entity resolution, we manage to understand *'Perso'* as a synonym to the word *'Personalausweis'* by defining the relationship between both in the interaction model

Fulfilment

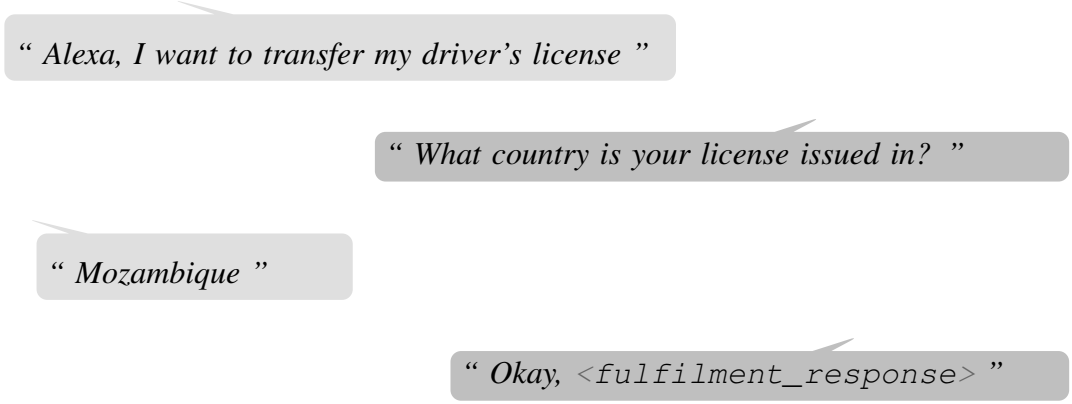
Building on the intents that the user gives to Alexa, we fulfil the command (after all prompts and confirmations) in our back-end code. The code itself can vary in implementation using different programming languages or hosting and the result is what the programme delivers. This is flexible and could range from changing the state of a device, e.g. turning a lamp on to making an API call that delivers text Alexa says.

Interaction Model

This is the Skill configuration, also considered as a front-end for the Skill. It is effectively a JSON file of a strict schema that contains all information about what the user says in terms of Utterances, Slots and their types (enumerations of Lists which Alexa tries to resolve our spoken text to). From Alexa's side of speaking, the interaction model only contains the prompts Alexa says to collect slots in the dialog management process (see dialog directives 4.5)

Multi-Turn Conversation

A multi-turn (or multi-part) conversation is one, where a dialogue of more than one question and answer takes place. In Alexa's context, this is identified through the `dialogState` property and is responsible for collecting / verifying information before it being sent to the back-end for fulfillment.
Example: For the intent `transfer_drivers_license`, which includes a required slot that needs the value `originOfLicense`, which is of type `countryList`, here is a possible



Over-answering

This is what happens when the user provides information that could fill a non-required slot. We catch this information by providing all possible utterances a user can say. In the example above, if the `originOfLicense` was not a required slot, Alexa would not prompt us to tell us where the license is issued. If we say in the first utterance to start the intent the name of the country the driver's license is issued in, we over-answer by giving Alexa that information. Depending on our application logic, we can make use of this to make our conversation smarter and not have Alexa ask for information the user already provided, making the voice assistant sound unreliable and primitive. For this, we need to anticipate this effect and include non-required slots in utterances the user might say.

Persistence and Memory

By persistence we mean retention of information that unfolds during a conversation session. As we do not use this concept, we consider our Alexa Skill having no memory, such that it will ask for information it might have asked for before. This is to comply with the D115 guidelines on providing anonymous information and not keeping record or storing any personal data from the user. In general, persistence can happen by storing the session information in a database. For this Amazon recommends the previously discussed DynamoDB (a NoSQL DBMS AWS microservice). Alternatives are open to developers.

4.6 Summary

In short, language is a construct that exceeds the representation of simple expressions in syntax and semantic rules. Conversation management breaks down the complexity of language and is used in most IVR systems. As we move from building grammars based on Chomskyan theories to resolving parts of a sentence to the nearest elicitations using ML, we introduce concepts and tools to do so. Like in any programming language, concepts need to be defined to have a standardised understanding and not be just related to one language (e.g. type inference is a concept and not a feature in JavaScript). The interaction model of an Alexa Skill handles a generous amount of implementations to these concepts through a compact tree representation. This helps us to delegate the understanding of user's intents to Alexa as a black box and focus our work more on the fulfilment part.

Chapter 5

State of the Art

This chapter evaluates the possibilities we can combine with the previously discussed artefacts of the Virtual Citizen Asistant. Although we do not exclude a communication with web app at the beginning, we exchange the dependency in favour of the underlying API omitting one layer of communication. We start by positioning our expectations from an AI to then compare the Microsoft Bot Framework or Actions on Google to Alexa Skills Kit as potential underlying systems for our final product.

With these introductory definitions we try to lay out a scaffolding to contain a model for a natural language conversation. Hence we make assumptions on our requirements and explore the options that can suit these. We introduce our requirements in the following Section 5.3 after we understand our current standing point.

5.1 Analogies to the Introduction of Web 2.0

Much like when tablets and smartphones were introduced to the market, the languages and framework used to render GUIs to the users had to adapt, which resulted into establishing HTML5 and CSS3 as new standards for the web. In that transition, browsers had to render different versions of the same page or even different pages depending on the client. It started with a fixed amount of screen resolutions that rapidly grew within a few months. Offering a desktop and a mobile version was another transitory solution paving the way to a display agnostic responsive design. Similarly, the MPEG4 H.264 codec accomplished a better adaptability and less battery consumption for video, which were success criteria to toppling the widespread use of Adobe Flash on the web. When screen sizes and aspect ratios became also so diverse that it was hard to keep track of, websites adapted in many ways. The processed can be seen as an organic variation and selection.

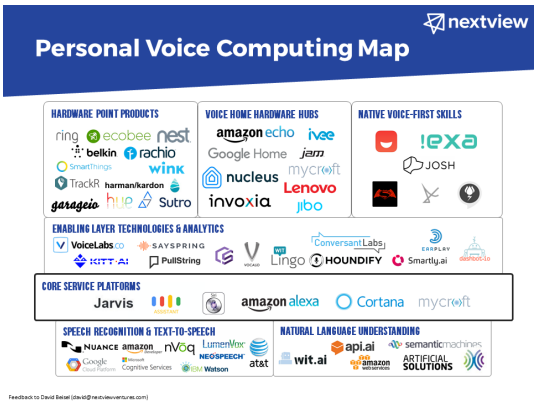
With the introduction of VUI for mass consumption and open development, similar undertakings are expected to happen [8] until we get to acquire an advanced voice user

experience. With diverse APIs available explicitly for VUI design, like Bespoken[1] for performance monitoring and testing of a VUI and Sayspring [2] for voice prototyping, we can utilise a few options which are likely to define new modelling and testing standards for VUI design and implementation. At the same time, we expect a few attempts to disappear in the process. Drawing analogies between RSS feeds and the news feed on all social medial platform, we can put the failure of one standard in perspective to the success of another stemming from the same idea.

As we have seen from previous examples on the web, particularly web searches being the most important, the shift of customers from AltaVista, Lycos, Yahoo! and MSN to Google, Yandex and others shows that marketing, expandability and maintaining quality are key factors to customer retention and survival.

5.2 Development Models and Platforms

Figure 5.1: The VUI-Stack, showing the different layers a voice service can build on. Based on [3]



Chatbots have become available and more accessible to develop through numerous platforms (for the same platform (e.g. Facebook), for our own standalone platform(e.g. Lex), or just a tool (Flask)). We no longer have to come up with the whole infrastructure.

This gets us to understand that while it is possible to build a voice service from the ground up, all major platforms already supply the necessities to develop for an existing platform such that a lot of overhead is already implemented. VoiceLabs defines this as the VUI Stack (Figure 5.1).

Further, with each of the voice assistants platform becoming specialised in a different domain, it is not suprising to see synergy effects on the market. Recent news about Amazon and Microsoft agreeing to make their voice assistants talk to each other [35] is one such comparison to how different operating systems today exchange common file formats to do the same tasks differently.

[1] https://bespoken.io
[2] https://www.sayspring.com

From End-Users' Point (Convenience and Purpose)

Before we evaluate platforms in terms of software development, we research the question of evaluating the platform from the customer's point of view. For this we look into empirical data from previous evaluations, then complement it with our own survey.

In his thesis project, Osman [39] surveys Siri, Cortana and Google Assistants with respect to their user-friendliness using Attrakdiff and other procedures. The research quantifies perceptions of 24 interviewees (13 women and 11 men between 18-35 years of age) about the voice, the human aspect of the voice assistant, pragmatic, hedonistic and other qualities. It also tests the reactance of the subjects with ratios about knowing vs. using the voice assistant.

Though the research does not recommend a certain platform, it hints that different platforms adapt a different characteristic (especially with regard to wit or practicality), which trigger different emotions for different users. Already in 2016, the study shows that the names of the three voice assistants sound familiar to the sampled subjects.

Given its reputation among assistants, Siri has been criticised for its inflexibility and often not understanding more specific commands. Dormhel suggests improvements on translations from English [26] which discourages us to develop for the platform in German if it has a weak foundation.

Other sources indicate that "AI platforms by Google, Apple, Microsoft, and Amazon all show different strengths. Google Assistant is the best on wide-ranging search commands." [5] As Alexa is particularly talented with shopping commands [5], the platform revolves well around sustaining a conversation.

Quoting Microsoft product manager about Alexa, we acknowledge that "Alexa's broader success resides in its ability to alleviate the stresses of an overbooked life. It's the companion that's always ready to engage" [7].

Additionally, there are a few plugins in the making to create a voice profile for Google and Alexa, giving an individual touch of sound based on a profile [9]. This can have a wide-reaching audience, for instance a voice assistant could mimic the sound and language of a person when they are not present. Likewise, a game can have a richer experience with its characters having different sounds.

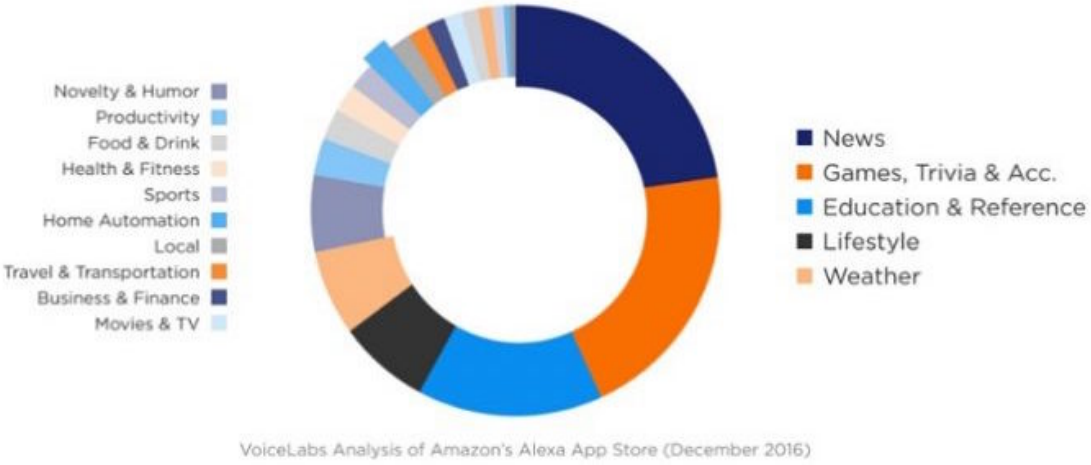
From Developer's Point (Cost and Availability)

The perspective of third-party development focuses mainly on availability of APIs and SDKs. With the exception of Siri, additionally to being tied to a relatively closed platform and requiring knowledge of Swift or ObjectiveC, Siri can only be executed if an app is installed on the iOS device. Moreover, a 99 US$ one-time fee to become an active developer able to publish on the AppStore is a prerequisite. Likewise, Microsoft's Azure Services are available with a 30-day trial period, followed by a subscription scheme. Alexa and Google demonstrate more flexible models with a free tier option until after the

3rd-party software is in production. This is another reason that gets us attracted to both platforms. Further, with Alexa and AWS, promoting ads that play from within the Skill has additional costs, but there is a possibility for developers to make a small profit from the Skill once it gets a substantial user base. A developer's guide is available in English and partly in German.

Also, their larger user base promise a higher likelihood for a developed solution to be used on the respective hardware (Android devices, Alexa-enabled devices). Especially with Amazon Skills launching in Germany only since February 2017, we expect that our solution could fill a market gap. Figure 5.2 demonstrates how an Alexa Skill could cater for an unsaturated market.

Figure 5.2: Alexa Skills by Volume (2016) [1]. Categorised as part of the 'local' section, the percentages demonstrate how an Alexa Skill as a choice could cater for an unsaturated market.



As the motivation behind this project is partly to evaluate development for an e-Government service on a new platform, with the Google assistant the option of using Dialogflow[3] (formerly API.ai) was excluded as it was explored in the equivalent project by Hassmann and Müller [38].

With Amazon having an obscure position to data and privacy as opposed to Apple and Siri, this gets us to question how Amazon protects personal data. During the first AWS Public Sector Summit 2018 in Brussels, Belgium with a considerable presence of the European Commission in panels, presentations and workshops, many answers were provided clearing doubts about the company's compliance to the GDPR and its Cloud Computing Compliance Controls Catalog (C5) attestations as a proof for different forms of data protection (e.g. resale to third-parties and responsibility on cyberattacks) [47]

[3] `https://dialogflow.com/`

Conducted Survey

We surveyed 34 persons to validate our choice out of the preliminary interest in Alexa.

The survey aims at understanding potential customers' expectations while evaluating their current understanding of the possibility of a voice assistant for the e-Government sector. Titled 'Usability of Voice Assistants', it is divided into the following question sets related to:

- Demographics
- Berlin.de City Portal
- Voice Assistant for public services
- Use of a Voice Assistant
- Alexa as a Voice Assistant
- Linguistic Nuances (Utterances)
- Alexa Skills

Figure 5.3: DEMOGRAPHICS & USE OF A VOICE ASSISTANT - Results of conducted survey for 34 participants for the development of an Alexa Skill

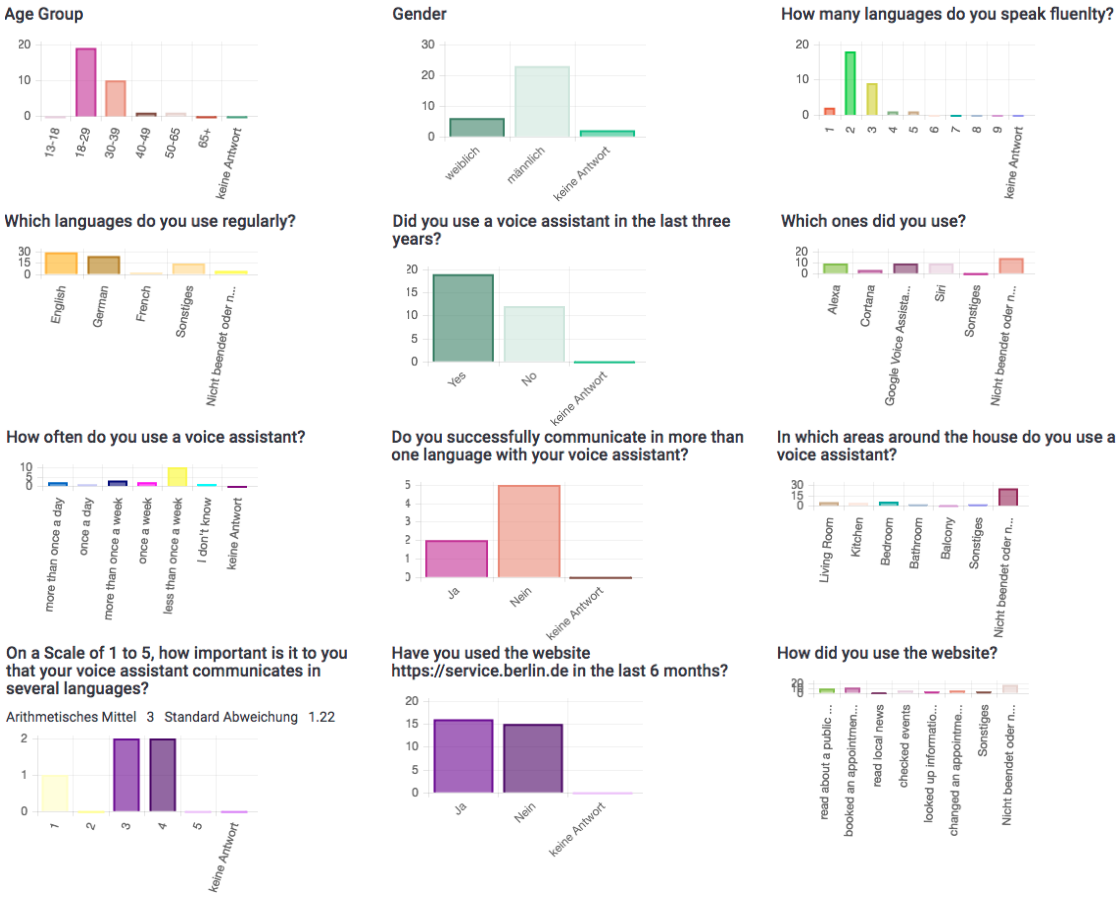


Figure 5.4: BERLIN.DE CITY PORTAL, THE VIRTUAL CITIZEN ASSISTANT AND ACTIVITIES ON ALEXA - Results of conducted survey for 34 participants for the development of an Alexa Skill

Figure 5.5: ACTIVITIES ON ALEXA AND A VOICE ASSISTANT FOR THE CITY'S AUTHORITIES - Results of conducted survey for 34 participants for the development of an Alexa Skill

The survey is carried out using LimeSurvey, an open tool (for educational purposes) with extensive analysis tools and the ability to export to statistics software such as R, SPSS and any tool accepting CSV file format. It lays out a foundation for future metrics if used in parts and on larger amounts of interviewees.

By combining responses from two or more questions, we find correlations that give us the following key findings:

- There is an equal demand for German and English as the VUI language.
- There is an existing user base for the Virtual Citizen Assistant that has potential to grow and extend to a voice assistant.

We therefore decide to build an Alexa Skill after having confirmed that the number of users who have heard of Alexa and are using a VUI is the highest.

5.3 Choice of Platform

After deciding that the voice assistant solution will take the shape of an Alexa Skill, we cover here some structural conditions we anticipate with this decision.

Secure Data Transfer

Using Alexa Skills require a secure HTTPS endpoint. As AWS Lambda is a possible option (as a trusted trigger), we consider it in order not to have to manage any SSL certificates (except for at our API). For Lambda, the first million calls a month are for free. Charges apply per 10ms unit.

Microservices as Building Blocks

While we can use our own building blocks, AWS offers a good combination with the Alexa Skills Kit, from asset hosting to availing virtual machine instances.

Availability based on Language and Local Store

Based on an excerpt from ASK documentation: Availability [4] of a Skill depends on the Amazon store selected. An Amazon store is linked to the primary shipping address on the account if provided, otherwise it depends on the initial settings provided through the device from which an account was set up from (e.g. IP-Address, device language settings). With our configuration set to German, [A Skill hosted on the German store

[4] ask/develop-skills-in-multiple-languages.html

only with an interaction model in locales ‘de_DE’ and ‘en_US’ can be made] available [.. with the] selected country distribution [before deployment] [2]. It can be used with an account linked to the German store to a device language set in German (Germany) or English (U.S.) [It] cannot be used by customers in Germany who have set their devices to use English (U.K.) or any other language and not by an account with German (Germany) or English (U.K.) in any other country, regardless of the language they’ve selected for their devices.

Programming Language

Choosing a programming language is relevant with respect to the already implemented template of Virtual Citizen Assistant intended to extend. At the same time, trying out a new language is a key incentive to start this project. Given that we have the choice with Alexa Skills between Java, Node.js framework (JavaScript), C# and Python, we looked at available resources for each language. Node.js proves to be the most resourceful as will be discussed in Chapter 8. As a secure alternative, the Alexa SDK for Java comes second to Node.js’s as opposed to C#, for which no Alexa SDK exists. With Java and ECMAScript having similar syntax, the arguments to develop on this framework is strengthened.

5.4 Summary

We understand the choice of platform is significant at an initial stage, since it decides on the architecture of the software we develop with. Given that we will have a constraint related to the number of users, we find through the conducted survey that Alexa Skills Kit and AWS are worth embracing as a bilateral ecosystem, to users and developers. Presenting the tangible options that have an interesting relationship with our use-case due to the spread of the platform or our predictions in its relevance as discussed through the comparative literature and preliminary survey results, in the next chapter, we familiarise ourselves with potential and limitations of this choice. We also have a questionnaire available for deeper analysis using the statistical indices obtained. With Likert scales modi and mean, the involved correlations can give us further predictions about potential use.

Chapter 6

Amazon's Ecosystem

After having a sneek peak into Alexa Skills, we proceed by comprehending the backbone that operates it. In this chapter we discuss Amazon's state-of-the-art strategy as it is important to introduce the implementation scope of voice assistants top down prior to exploring the current context after comparing it to other approaches in the larger context of conversational bots as a whole from a technical and user experience point of view.

6.1 Amazon Web Services (AWS) + Alexa

Getting started with Alexa as a platform for the first time might seem a little overwhelming especially since each component of it is being constantly restructured since its debut release in November 2014 and with Q4 2016 being the beginning of its major market penetration success [16]. As throughout the course of this thesis these major changes occurred, we discover that Amazon's philosophy and success is based on the divide and conquer principle on a large scale. This allows loose coupling of all sorts of components of the company, starting from their business logic to even their branding themes.

AWS

Amazon Web Services is a Cloud Computing service provider with a complete set of services to help build and run web applications "reliably and securely at a cost and scale" according to one's independent needs [40]. It comes with agile abilities to adjust to various solution at a flexible scheme with benefits like multiple server farms globally (operating under different legal contracts with respect to data security and user privacy), caching, NoSQL, DevOps and so forth.

Alexa + Skills

Alexa is a cloud-based voice service assistant platform by Amazon powering millions of devices on its own-branded IoT devices like the Echo, Echo Dot, Tap, FireTV as well as cross-platform through mobile apps available through Apple's AppStore for iOS and Google Play Store for Android devices. Unlike Apple's approach with Siri for instance [1], where including support for third-party integration on iOS's Service Development Kit (SDK), Amazon decided with the launch of Alexa to include non-Amazon developers right from the start by introducing a multitude of (SDKs) around the platform as part of AWS, e.g. Alexa Skills Kit SDK discussed further below.

So far, though the separation of AWS and Alexa's environments is not linguistically intuitive with the company's name labelled on every service component [2]. Amazon.com, Inc. offers an array of web services through AWS that summarize all building blocks necessary to operate Alexa as a software for end-users. Of course with the introduction of the aforementioned devices, it becomes intuitive to call these 'Alexa devices' since their primary purpose is to operate as Alexa clients. We refer to Alexa here only as the service offered by Amazon to consumers. Consequently, although Alexa comes as a fully packaged service to end-users, we can reduce it to a compilation of many micro-services provided by AWS. As most of these are available separately in the form of Software as a Service (Saas), we conclude that AWS incorporates the following components required to make Alexa come together and becomes a consumer of its own web services platform.

6.2 AWS Modules as Alexa's Building Blocks

Understanding the operation of the following AWS modules (in order of importance) gives an overview of the building blocks Alexa is composed of as a standalone software.

Lex [3]

Lex is the component for conversational interfaces using Natural Language Understanding, Text-to-Speech and Speech-to-Text.

"a service for building conversational interfaces into any application using voice and text" [40]. Lex is the most important backbone to make Alexa possible and can be a main operator of another software package to create a whole new category of independent voice assistants and conversational bots. Independence denotes that from a VUI

[1] as know from its policy on new software and hardware products like the case with the iPhone, the Mac and its other product lines

[2] see Etymology in Annex 10.3

[3] `https://aws.amazon.com/lex`

Stack like Alexa's with the Echo devices and respective platform, software (Skills and APIs) built on top of it, or with Siri, where the hardware is the iOS-operating device and the software being an extension of the mobile apps using Apple's SDK. It would also mean adopting the Alexa API to a new kind of hardware, such as cars, which goes beyond the scope of this work. And while this independence means more flexibility in developing a solution of our own, this would often mean a much higher effort since we miss the opportunity of taking advantage of the already built and tested artefacts. The most critical argument against development with Lex directly is that it was not available in German at the time of this research. We therefore decide to use the Alexa Skills Kit with Alexa as a product and not as API, which ultimately takes advantage of Lex and the other components described below under the hood while still remaining in a familiar and commonly used environment. Lex and Alexa use the same deep learning techniques for natural language processing with the workflow described with the example in Figure 6.1 below. Lex's difference to Alexa is discussed in Section 10.1.

Polly [4]

Polly is responsible for speech synthesis.
another "service turn[ing] text into lifelike speech, allowing [developers] to create applications that talk" [40] wile harnessing the power of deep learning. It is more or less the mouthpiece of Alexa built on top of speech synthesis algorithms.

Transcribe [5]

Transcribe handles automatic speech recognition using Speech-to-Text.
which "makes it easy for developers to add speech-to-text capability to [...] applications" [40]. With Transcribe we are able to get text out of the user's voice before passing it into a format Alexa's backend would understand.

Lambda [6]

Lambda is Amazon's solution partly for handling the intent fulfilment part in Alexa.
Although Lambda is a versatile "service [built] for a variety of real-time serverless data processing systems" [40], it can be used as an integrated server instance to host back-end code for intent fulfilment.
Pricing: First Million calls are free. Billing charges per operation millisecond.

[4] https://aws.amazon.com/polly
[5] https://aws.amazon.com/transcribe
[6] https://aws.amazon.com/lambda

DynamoDB [7]

DynamoDB can be used for persistence storage.
Acting as a very fast NoSQL database service while also using tables, Dynamo is very scalable and can be primarily used in the context of Alexa as a persistence holder for data collected during the interaction with the user to give Alexa a 'memory'.

S3 [8]

S3 is a host for resource storage.
standing for simple storage service, it is a safe instance for cloud storage using buckets (namespaces) with various access management and encryption options.
Pricing: The first 5 GB can be stored for free.

CloudWatch [9]

CloudWatch manages logging of events, for our use mainly from Lambda.
CloudWatch acts like the console for an operating system (OS). It monitors all low-level events happening within the AWS sphere. In combination with Lambda it comes as handy tool to log events resulting at runtime once a Lambda instance is called and its code being executed and is used for debugging.

IAM [10]

IAM is for identity access management within AWS.
Identity Access Management (IAM) is a secondary service module regulating in the Alexa context in combination with Lambda the routing rights between internal Amazon endpoints. It also ensures compliance policies are enforced within and between AWS modules, as well as between AWS modules and other external services.

Cognito [11]

Cognito is intended for identity access management outside of AWS.
like the rest of AWS's modules, Cognito is a service to perform user authentication and can be used in combination with an external endpoint instead of Lambda.

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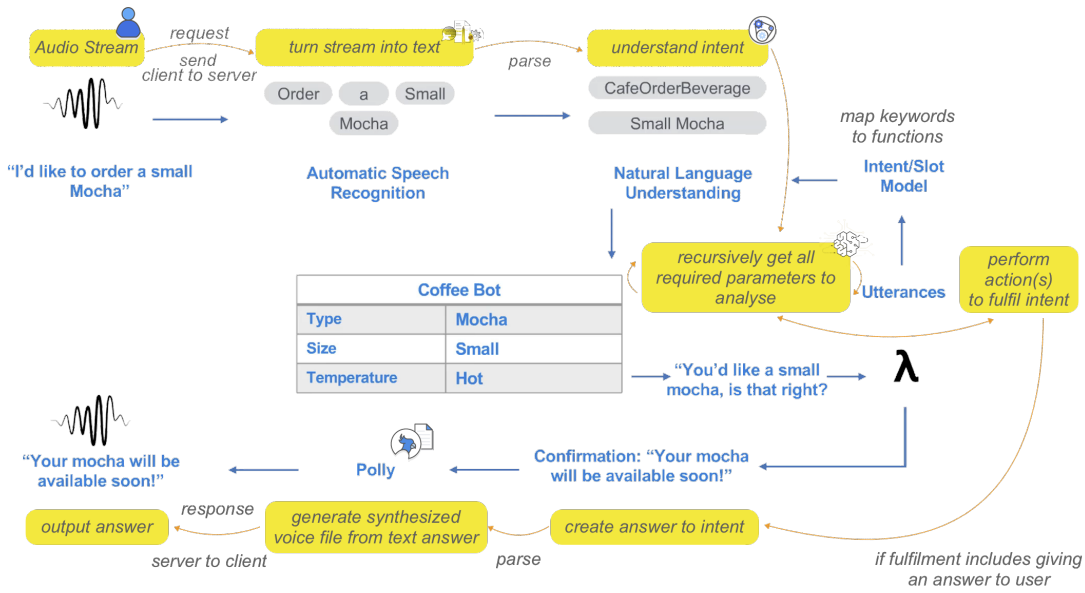
[7] https://aws.amazon.com/dynamodb
[8] https://aws.amazon.com/s3
[9] https://aws.amazon.com/cloudwatch
[10] https://aws.amazon.com/iam
[11] https://aws.amazon.com/cognito

Figure 6.1: Interaction between AWS modules in the use case of a "Coffee Bot" based on Niranjan [20]



Putting different combinations of these and other building blocks interactively together generates the model for Alexa. In a world increasingly operated by Internet of Things (IoT), we describe a possible interaction in the example here for a use case of a hypothetical chatbot that operates a coffee machine using some of these service modules (Figure 6.1). Although this graphic describes how an end user would combine these modules to set up their own chatbot, this is the same workflow that Alexa uses. Hence, with Amazon's use of its own micro-services we infer that it takes advantage of these to build a whole new ecosystem putting Alexa Skill developers as producers, end-users as consumers, and the Amazon website and Alexa App as a marketplace to mediate between the products (Skills) the developers produce to their target customers (end-users, country-specific or worldwide). From a marketing perspective Amazon achieves through Alexa a vertical diversification of its product programme (where existing AWS services result in a new product expanding the value chain) while simultaneously offering an extension of its aggregator model (as opposed to a marketplace model) by playing as a mediator between the developer's role and that of the end-user's.

We can therefore describe the meta-model for Alexa similar as one of an application with several front-end and back-end components acting in a DevOps environment of cloud micro-services. Unlike in most GUI-based scenarios with an MVC design pattern [11], where the user uses the `controller` to manipulate the `model`, which in turn updates the `view` appearing to the user, in a VUI scenario, we need to consider

that the user's paradigm to the `view` component is quite different. Before we dive into the VUI paradigm, we introduce Alexa's own implementation of it for third-party applications (i.e. Skills). These are broken down into the following elements for users and developers:

Alexa Skills Store

The Amazon web pages intended for end-users, where a Skill can be previewed before enabling. Once installed, the own instance of Alexa becomes "smarter" by that Skill, which does not need to update from "client side", since it is only linked to the Amazon account and not hosted on the client (only sends requests through it). This offloads the user from the overhead of thinking about updates since these happen in the back-end. Alexa Skills page is integrated into the Amazon online shop as a search category.

Alexa Skills Kit

Alexa Skills Kit is the SDK for Alexa. Being still in a continuous expansion phase, it is responsible for compiling the loosely coupled tools provided by AWS and others to act as an interface for the Skill from a developer point of view. This fits into the rest of Amazon's scheme of focusing on interoperable micro-services that fit multiple purposes. It includes the following essentials: a developer console accessible through the web or the command-line, and a platform for designing Alexa products.

Alexa (Developer) Console

This is where all the developed Skills live. It is the gateway to the front-end of the Skill or Voice service (described below). It provides a web interface for initial setup of the Skill, a structured representation of the JSON Files that include the LANGUAGE (INTERACTION) MODELS, the SKILL PROPERTIES, the endpoints it uses and accounts it links to. Throughout this thesis, the console has undergone major interface upgrades and additions to its core functionality. Currently it is also the place where submitting the skill for publication happens and where the simulator (discussed below) lives.

ASK CLI

A Command-Line Interface tool that interacts with the Alexa Console skipping the web browser. Although not at a stable release yet, it has numerous functions to creating, deploying and testing our Skills. Available from the Node Package Manager (NPM) [12].

[12] through `$ npm install ask-cli`

Alexa Voice Service

A service for accessing cloud-based Alexa capabilities with the support of AVS APIs, hardware kits, software tools, and documentation. Through the Alexa Voice Service Amazon has simplified the creation of conversational interfaces for device makers, allowing developers to add Alexa and intelligent voice control to new products for mobile phones and cars to smart speakers and home appliances. It simplifies building voice-forward products by handling complex speech recognition and natural language understanding in the cloud [13]

By exploring these products, building blocks, platforms and runtime environments, we have a deeper understanding of how to make use of these in our implementation and which know which tools to prioritise for development and testing. With microservices, the vast options Amazon offers through AWS and the Alexa Skills kit provide a powerful foundation to support DevOps.

6.3 Skill Structure - Data Structure II

After presenting the core stones that take part in administering the Skill, we move on to the Skill structure. Ultimately, the elements discussed above are represented in JSON files that together with the back-end of the skill make up this web-app like composition. Because of its flexible file format, Skills back-ends can be built using one of multiple runtime environments including Node.js, Java, Python, C# and Go. Not coincidently, these are the same languages supported by AWS Lambda.

Disregarding the programming language used for development, the statically generated files included in the code are a Skill manifest, an interaction model for each language and an implementation code.

`skill.json`

The Skill manifest file including its publication name on the Amazon website, invocation name in each language, a description of the Skill readable by a human, author of the Skill and other properties.

`<locale_code>.json`

The interaction model of the respective language. It is named after the locale the file is in and includes all slots, utterances, dialogues, custom defined slot types inter alia (file structure in Table 7.1).

[13] `https://developer.amazon.com/alexa-voice-service`

`<packageFile>`

A manifest file for required dependencies (installable through NPM for instance in the case of Node or Maven in the case of Java) for installation to run the web-app in Amazon's cloud.

6.4 Alexa in the Eye of the Beholder - Interfaces and Operation

Briefly going over the options available to use Alexa, we present and compare the different hardware product lines and software solutions developed by Amazon or compatible with their voice assistant in terms of usability configurations, i.e. presentation of voice and graphical interfaces.

Hardware Interfaces

The following devices are Alexa-enabled out of the box. The voice service is either accessible through voice command within the same room or an active button press on the device.

Table 6.1: Currently Supported Alexa-Enabled Devices in Comparison

	Speaker	Tablet	SmartHome	TV
Models	Tap, Echo - Dot, - Plus	Echo Show Kindle Fire	Echo Spot	FireTV Stick
Screen	No	7.0"	2.5" round	HDMI Display
Line Out	Yes	Show: Bluetooth Kindle: Yes	Yes	via HDMI
Alexa On	Voice Command	excl. Fire HD 10 Button Press	Voice Command	Button Press

Software Interfaces

while the hardware models stated above are possibilities for testing, too, they do not always serve as a primary testing environment. There are sometimes more optimised

ways to automate Skill testing, for instance by running scripts that would send the transcribed text in the appropriate JSON format. This is helpful for multi-turn conversations and retaining sessions, so that one does not need to repeat the full conversation until one reaches the test breakpoint.

Alexa App

Designed to be a control unit that operates most Alexa-enabled devices, is not an Alexa interface, but rather a screen for Alexa devices without one (e.g. Echo Dot) and where account linking happens. Apart from being a tool apart from Amazon's website to install Skills and manage accounts linked to Amazon (for music streaming and other related content-based services), it is a very useful tool to track the history of conversation that took place through a respective Amazon account. We use it mainly to hear what we said and see how the text was interpreted using Lex's NLU engine. It helps for checking homonyms and nuanced utterances.

By being able to listen to the voice recording and transcribed audio as well as the cards displayed, we can understand the context in which Alexa is unable to match the wording to an intent. This option is available through **Settings >Alexa Account: History**

EchoSim.io

"a browser-based online community tool for developers that simulates the look and feel of an Amazon Echo" [14]. Started as an inmplementation in a hackathon, this tool is very similar in use to the Alexa Simulator. At the beginning of this project, Alexa Simulator was not as powerful as it is now, making EchoSim a good variant for testing.

Reverb App

An iOS / Android app, allowing the interaction with the Alexa instance linked to an Amazon account. Perfect option to make a qualifying device Alexa-enabled [15].

Alexa Simulator

Alexa's own web-based online simulator giving JSON responses, card renderings and voice feedback to the requests sent and is part of ASK. We interact with it either through voice or with JSON requests. The JSONs it produces can be used as input for other tests, too.

[14] `https://echosim.io/`
[15] `https://reverb.ai`

CLI Simulator

the command-line tool of the aforementioned simulator. Accepts strings and file uploads from the CLI and returns responses to the same interface. Obviously because the Skill is a web service in the cloud, the CLI also requires an internet connection [16].

Postman

Postman is the request/response simulator we use to interact with our API before our Skill exists. It is primarily helpful in our context to visualise GET/POST requests.

Speaking with Alexa

We end this chapter by explaining how Alexa is designed to operate from the user's point of view particularly for Skills. A full guide is available in the ASK DOCUMENTATION in multiple languages [17].

A conversation starts with any of the four wake words below, followed by the launch request, then the invocation name and lastly the utterance to action. Here is an example in English.:

$\overbrace{Alexa}^{wake\ word}$,	$\overbrace{ask}^{launch\ action}$	$\overbrace{< my\ Skill >}^{invocation\ name}$	$\overbrace{< to\ do\ something >}^{utterance}$
Computer	begin, launch, load	Berlin Serivce	to tell me the costs of a license transfer
Echo	open, play, resume	Georgia Gov	how do I get my license transferred
Amazon	run, start, tell, use		

With this insight we are able to test our Alexa Skill through various methods, depending on the test type. Tests should be run individually and combined. We also have a separation of concerns between development and tests for the interaction model as well as the Skill back-end code.

6.5 Summary

Now that we have a thorough understanding of how AWS modules interact together, we are capable of determining the modules we will need in our Skill. With Lex, Polly, and Transcribe already put together to become the core of Alexa, we will designate our use of Lambda to implement the intent fulfilment and S3 to host stored assets (e.g. audio and images) we will need for the Skill. As we intend not to store sessions nor retain

[16] running command `$ ask simulate --text <inputText> --locale <inputLocale>`

[17] ask`/understanding-how-users-invoke-custom-skills.html`

information from it, we will not use DynamoDB or any equivalent DBMS. Cloudwatch will help us log our Skill for back-end and some front-end tests (e.g. to see if Alexa transcribes our Audio the way we want). IAM is be used implicitly to set up the roles our Lambda function will take. We use all testing software depending on whether we are testing Alexa's understanding, the way it displays information on the screen (using cards), the way speech text sounds like and others. Noteworthy is that as much as the way conversation happens slightly differently with each of the devices in Table 6.1 due to how a session is kept or not (devices with button press do not give a reprompt), images display differently on each of the listed devices. Moreover, with the given Skill structure we know how to approach development and change Skill configurations programmatically or through the web interfaces (Alexa Developer Console - web, ASK and AWS CLIs - locally). Finally, having agreed to develop on Alexa and using AWS, we are aware of the agreements that allow Amazon to retain and process "audio, interactions, and other data in the cloud to provide and improve our services" [18].

[18]UK Conditions and Use of Sale: `https://www.amazon.co.uk/gp/help/customer/display.html/ref=footer_cou?ie=UTF8&nodeId=1040616&pop-up=1`
Other Alexa terms and conditions found here: `https://www.amazon.co.uk/gp/help/customer/display.html/ref=hp_left_v4_sib?ie=UTF8&nodeId=201566380&pop-up=1`

Chapter 7

Skill Design

This chapter lays out the first details of our Skill implementation. We discuss the choices we need to take and why we take them in the first section, going over the framework requirements in which we do this implementation, to finally introduce the interaction model, also known for being the skill configuration, based on which we fulfill the intents in the Skill's back-end implementation (Chapter 8). We also provide guidance on best practices during the whole process in Section 7.3 and 7.3.

Before proceeding, we state that Alexa gives the limitation of recording audio for transcription at a bit rate of 8kHz using the file formats LPCM and Opus for input and MPEG, OGG and PCM for output. Using the Skill is only possible through an internet connection. There are options to keep the context (session) alive for only 8 seconds, extendible by another 8 second for re-prompts to give the user enough time to think and answer. Finally, knowing that Alexa uses term weighting to understand the user, we are able to find out what utterances were missed, e.g. through the options described previously in Chapter 6.

7.1 Design Choices

Skill design is crucial for the later development stages, as it gives us an overview of what we want to achive and how we want to achive it. It is therefore essential to start with before implementing the fulfilment part. A few questions necessary for the design process are:

- **What should the Skill do?**
  In our case: Look up information about services and book appointments.
- **How should it do it?**
  In our case: It should connect to the API, make GET requests to receive the most recent information and read out the relevant parts from the JSON nodes (as

the response's structure was discussed earlier in Table 3.4), while maintaining a conversational flow that is not redundant or too complex to the user. In a next step, it should also be able to create appointments on Berlin.de's endpoint through POST requests and connect to the user's calendar to save these.

- **Through what conversational interaction does the user get to invoke that action?**
  In our case: The user can ask Alexa directly to book an appointment or get to find out more about the service through a series of questions (Multi-turn conversation, see Section 4.5).

Although this process sounds simple, putting oneself in the mindset of a developer and creating a scenario requires extensive preparation, as there are possibly endless options of how a user can describe what they want to do. As we opt for Alexa, we explore what options it offers to minimise the developer's work on predicting utterances and how paths are built to reach the intents. We also discover the role of synonyms in sentence wording. Further, in the process, we touch on the frameworks we can make use of in this step.

Beyond the academic research, with releasing the Skill as a target in mind, Eyal's hook model [46] is of strategic value for reference throughout. In his book "Hooked: How to Build Habit-Forming Products", he describes hooks as "experiences designed to connect the user's problem with the company's product with enough frequency to form a habit" [15]. In our Skill context, we observe from our own questionnaire as well as in another study findings by Experian Information Solutions, Inc. [42] that most tasks in Alexa currently revolve around performing simple actions like setting a timer or playing specific music. Although it would speak as an advantage for a voice assistant if it can automatically determine more context, we use this as a guideline for keeping the actions short and simple.

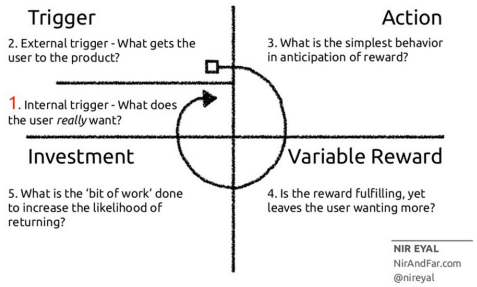


Figure 7.1: The Hook Model: four key steps for creating products that users can crave. Based on [15]

Sentence length

For this we use a maximum of two sentences per action and keep them not shorter than three words (e.g. "I want `service_name`") and not longer than 30 words, with a mode of 10 words that a user needs to make sure they get the appropriate answer. As

we know it is common to miss the correct intent, we implement an `Unhandled` intent. This is not a must but it assures that we attempt to get around the user's frustration by making the bot at least more human in the answers it gives if no intent was found.

Skill availability, languages and dialects used

Since we see the demand for both English and German prevalent in the survey, we start with a German model and implement in the equivalent English model services that are more related to residents of foreign countries, since the service catalogue is more relevant to this audience (e.g. residence permits, transfer of driving licence, registration).

We choose to offer our skill only in Germany because our Skill's functionality is specific only within this geographical region. For that we configure the Skill to handle English (US) and German (Germany). At the time of development, Alexa was more able to understand an American dialect than a British one. Consequently, we draft two interaction models, each with an intent handler, which we register based on the user's device's language. This is to avoid errors in case one intent is found in both language models with the same intent. There are other solutions possible, but this choice remains as a more systematic one for error handling and coherent code placement.

Addressing the user

Although this might conflict with the way Alexa addresses the users in German, we also use the formal 'Sie' since this is the same language our API uses. This is a non-functional requirement we also infer form the D115 whitepaper [18]

Skill extent

With modularity as an underlying concept, we keep the Skill's range to providing information and potentially booking appointments as the major hook element. Any information related to current events in the city should be within the perimeter of another Skill in order not to overload the interaction model, which could result in the Skill not understanding the user. Further, though this could be done by a parser, the API does not support more than providing information at the time of development.

This coincides with giving a hook for this skill and any other skill revolving around the user's entertainment.

Session duration

With A-B tests we determine the optimal duration of a session (8 vs. 16 seconds) based on each question. and do not apply a general rule for it. The upside of keeping a session longer is that the conversation context will remain longer. On the downside, it might

clog the user from using Alexa in a different context as well as giving the impression of 'spying' on the user for an extended time if it is not necessary to keep the session alive. Adjusting whether the session should remain for an extended time happens through the JSON request property `{'ShouldEndSession' = 'false'}`

Alexa's reprompts and utterances

We randomise what Alexa says in some situations, where the user would prefer not to hear the same answer every time they reach a certain conversational path. In other path junctions, we give out the same spoken text for the user to get a sense of familiarity on where they are in the conversation. This keeps a balance between clarity and spontaneity

Help

We offer various ways to provide the user with help. On one hand we implement an extensive `HelpIntent` that gives a help menu to the user, suggests Intents to speak through audio and on the device's display. We also provide contextual help within each intent. Helps usually require randomising sentences to users for them to know what they are capable of with the Skill.

After all, the user should feel the competence of the Skill to be convinced of using it. As such, we need to create an interaction model that takes care of wording order and a fulfilment that has competent error handling paths.

What intents represent

As it is better to separate utterances by intents (Section 7.3), we start with an utterance, then see which intent it can relate to. There are several ways to structure intents, depending on how we define them. After many trials on the categorisation of intents, we group intents based on what a user's question revolves about in each of the topics. Hence, the intents map to the sections of the Berlin City Portal service sections:

- General Inquiry
- Prerequisites
- Required documents
- Costs
- Processing Time

Other sections like 'legal base' or 'forms' are not of added value and will not be spoken out to the user.

Additionally, since many public services are related to one another, we group similar ones by goal. For instance, 'registration' and 'de-registration' could have an analogous sound with 8Kbps, especially in German ('Anmelden' vs. Ambelden or Ummelden). Making a special intent for this service helps determine the right service through confirmation. Other services like Applying for a student loan (BAFöG) is available in the service catalogue under different services depending on the target group (student, school pupils, apprentice, loan for a study-abroad) and requires further questions as not every user is expected to recite the type of BAFöG they want in the first utterance.

Synonyms

Usage of synonyms depends on where the synonym can be used. For instance when we expect the user to ask for 'ID' instead of an 'ID Card' (the full service name), In another example, where we expect the user to answer to the 'kind of doctor', in German the words 'Tierarzt' (Veterinarian), 'Hausarzt' (General Practitioner), 'Augenarzt' (Optician) and 'Zahnarzt' (Dentist) are all derived from the same job description 'Arzt' (Doctor). In our implementation, where the user is not expected to ask a question related to a veterinarian, we omit the synonym 'Tierarzt'.

This is one example that shows how each model should represent no more than one language locale, as synonyms and phrases differ between locales.

Slot Types

Many of the slot types are not available on Amazon, which means we have to create them. We transpose some of the lists obtained from the Virtual Citizen Assistant and create our own based on other formats provided either through csv files (e.g. for PLZ values) or through the parsing the Berlin website directly and importing the list into a slot type with minimal string modifications to match our model requirements (e.g. with Citizenships). Problems with this approach are discussed in Section 8.4.

The complete model is provided with the Skill code as a JSON file named as the locale of the model (`de_DE.json` and `en_US.json`). attached to this research. In Figure 7.2, a representation thereof via Alexa Skills Kit interface. Table 7.1 highlights representative elements included in the model schema.

Figure 7.2: A representation of the designed interaction model

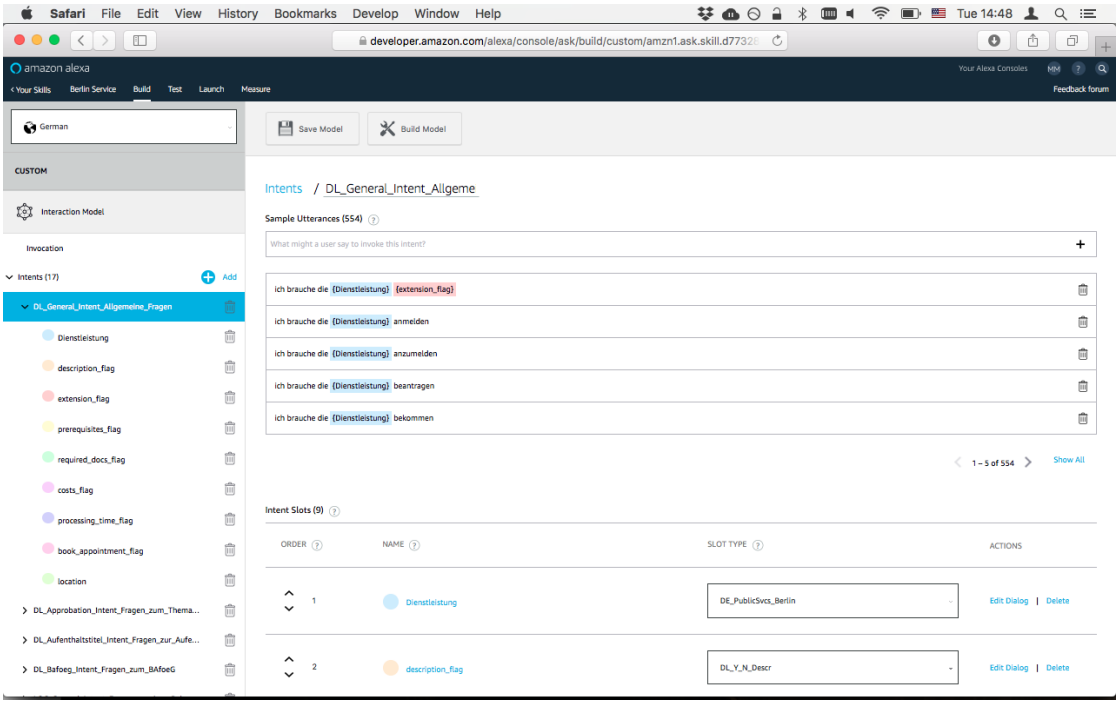


Table 7.1: Interaction Model Schema (Skill Management API) [2]

Field	Type	Description	Required
`languageModel`	object	Conversational primitives for the skill	Yes
`invocationName`	object	Invocation name of the skill	Yes
`intents`	array	Intents and their slots	Yes
`slots`	array	List of slots within the intent	No
`types`	array	Custom slot types	No
`samples`	array	Sample utterances for the intent	No
`dialog`	object	Interaction, slot filling, confirmations	No
`confirmationRequired`	value	flag to set if Alexa will confirm with a statement once a slot is caught	Yes
`elicitationRequired`	value	flag if required	Yes
`elicitation`	value	pointer to elicitation value to register if more than one Intent found for slot	
`prompts`	array	What Alexa says to reprompt for a slot	No
`variations`		deprecated during development	
`type`		deprecated during development	
`value`		deprecated during development	

7.2 Frameworks and System Specifications

This section builds on the data structure and frameworks we explained in Chapters 3 and 6. We introduce ECMAScript as the programming language in the Node.js minting and touch on Solr's capabilities.

Node.js

Out of the languages supported by ASK and Lambda, we decide to use Node.js, a JavaScript (ECMAScript 6) framework due to its event-driven nature and to take advantage of its non-blocking I/O model. Being single-threaded, Node.js guarantees high performance at scale with large volumes of requests considered. With its JavaScript (ECMAScript) foundation, it is becoming a standard for web apps. Hence, the decision also comes due to the richness of develpers' experience with the implementation for Alexa Skills.

The concept behind modularisation in Node.js is to keep Node's core modules small, efficient and tight in terms of functionality it provides. There are three kind of modules:

- **Built-in modules:** that are part of Node core. These are mostly for essential things like reading and writing into the file system, making requests.
- **Third-party modules:** Up for development by the community.
- **Local modules:** developed locally or obtained privately.

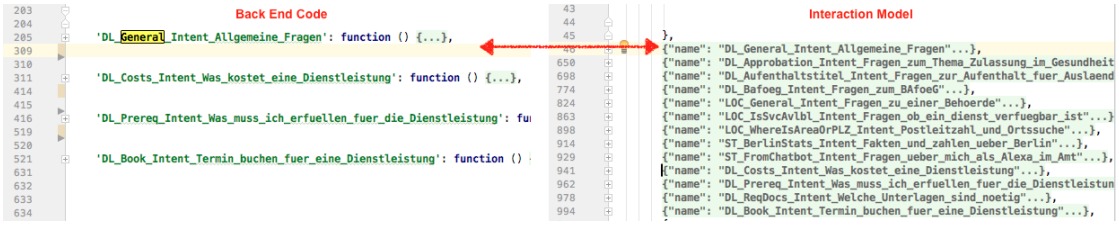
Unique to Node.js is passing functions into other functions. We take advantage of this design pattern using the inner function's callback as a parameter for the outer function. A typical example for this is promises[1]. The callback is what the inner function returns and is usually mapped to a response to the request we send to our API. This optimises our response speed, allowing a good use of the asynchronous model. It could, nevertheless, have the drawback of responding with an unexpected response if not programmed correctly.

Using Google Chrome V8 engine, Node.js also allows reading in large JSON files quickly in memory, which effectively gives us a quick response from the Lambda function. The choice to explore Node.js comes also as an alternative to Python, since this was used in the Chatbot implementation of Berlina by Hassmann and Müller [38] in combination with Flask. From an implementation standpoint, as soon as Alexa was able to find

[1] `https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Promise` `https://gist.github.com/domenic/3889970` and `https://medium.com/dev-bits/writing-neat-asynchronous-node-js-code-with-promises-32ed3a4fd098`

the intent through an utterance we speak to the device, it looks for the intent of the registered handler with the same name on the back-end code (in Node.js, Lambda) matching verbatim with the intent name in the interaction model (`locale_name.JSON`).

Figure 7.3: A representation of intents in our interaction model in conjunction with the intent implementation in the Skill code



An event-driven design pattern for Node.js can be compared to the listener-observer pattern in Java. Alexa also has its own builder pattern (response builder [2]).

Thereupon, Alexa provides its Node.js SDK in the form of a wrapper, which can be imported with the command

```
const alexa = require 'alexa_sdk'
```

Lastly, there are three types of requests that can handled through the Node.js SDK:

- **'LaunchRequest'** to start a new session
- **'IntentRequest'** to match one of the intents in the interaction model
- **'EndSessionRequest'** to manually end a session. It is inculded in the response builder such that we do not need to implement it extra.

Alternative: Java as a Programming Language

Apart from Python as a programming language, Java is a feasible option with extensive documentation and implemented emitters. Setup works in Java using Maven by requiring the Alexa Skills Kit as a dependency [3].

```
<dependency>
<groupId>com.amazon.alexa</groupId>
<artifactId>ask-sdk</artifactId>
<version>2.0.2</version>
</dependency>
```

[2] a list of fireable events: gh/`Readme.md#response-vs-responsebuilder`

[3] gh/`/Setting-Up-The-ASK-SDK`

This makes ASK work as a wrapper analogous to Node.js [4].

In this example, the web service writes information to a log and then calls a method to return a welcome response [5] [2].

```
@Override
public SpeechletResponse onLaunch(final LaunchRequest request, final
 ↪  Session session)
throws SpeechletException {

log.info("onLaunch requestId={}, sessionId={}",
 ↪  request.getRequestId(),
session.getSessionId());
return getWelcomeResponse();
}
```

Apache Solr

As mentioned in Section 7.2, the API endpoint was originally created for the Virtual Citizen Assistant, very likely through a crawler that parses the information from the Berlin City Portal and places it into the respective JSON nodes in one of the 5 cores. The sixth core, `Smalltalk` is maintained manually. The latest information we obtained about the chatbot system entails that the API updates its information periodically, based on the services offered on the Berlin website. Solr's queries build on the TF-IDF index.

With the structure of cores from Tables 3.1 and 3.2, we build on Solr's implementations of spell checking, language detection and approximate string matching (e.g. based on Levenshtein distance between words). With Lucene's underlying technology, our instance can also be extended with Apache Nutch for further crawling of information on the Berlin City Portal. Although this is not part of our solution, since the challenge was to keep the API intact, there is a possibility to expand it in the future, e.g. using Tika for image searches to display information of maps automatically on an Alexa-enabled device with a screen.

Alternative: SwaggerHub

"Swagger is the world's largest framework of API developer tools for the OpenAPI Specification(OAS), enabling development across the entire API lifecycle, from design and documentation, to test and deployment" [6]. If a new more specialised API for the voice assistant is required, SwaggerHub is another option to use to deliver JSON responses for requests we send from within Lambda.

[4] ASK SDK for Java: gh/`/alexa-skills-kit-sdk-for-java`

[5] ask/`handle-requests-sent-by-alexa.html#launchrequest`

[6] `https://swagger.io`

AWS Lambda

Lambda offers an all-in-one solution as discussed in Section 6.2. Conversely, one of its drawbacks is that it does not automatically keep versions of previous deployments. Thereupon, creating own versions can be tedious [7] since deploying to Lambda does not happen infrequently throughout.

Alternative: using another HTTPS endpoint

When deploying a service as an AWS Lambda function on AWS Lambda, its configuration happens through the handler described above. In Java, creating this handler is possible on a self-hosted solution or on any other HTTPS endpoint by extending the provided `SpeechletRequestStreamHandler` class. "The handler then dispatches requests by calling the appropriate Speechlet methods (`onLaunch()`, `onIntent()`, and so on)" [40]. When deploying on a cloud provider, we extend instead the `SpeechletServlet` class. "This class is an implementation of a Java EE servlet that handles serializing and deserializing the body of the HTTP request and calls the appropriate Speechlet methods based on the request (`onLaunch()`, `onIntent()`, and so on) [40].

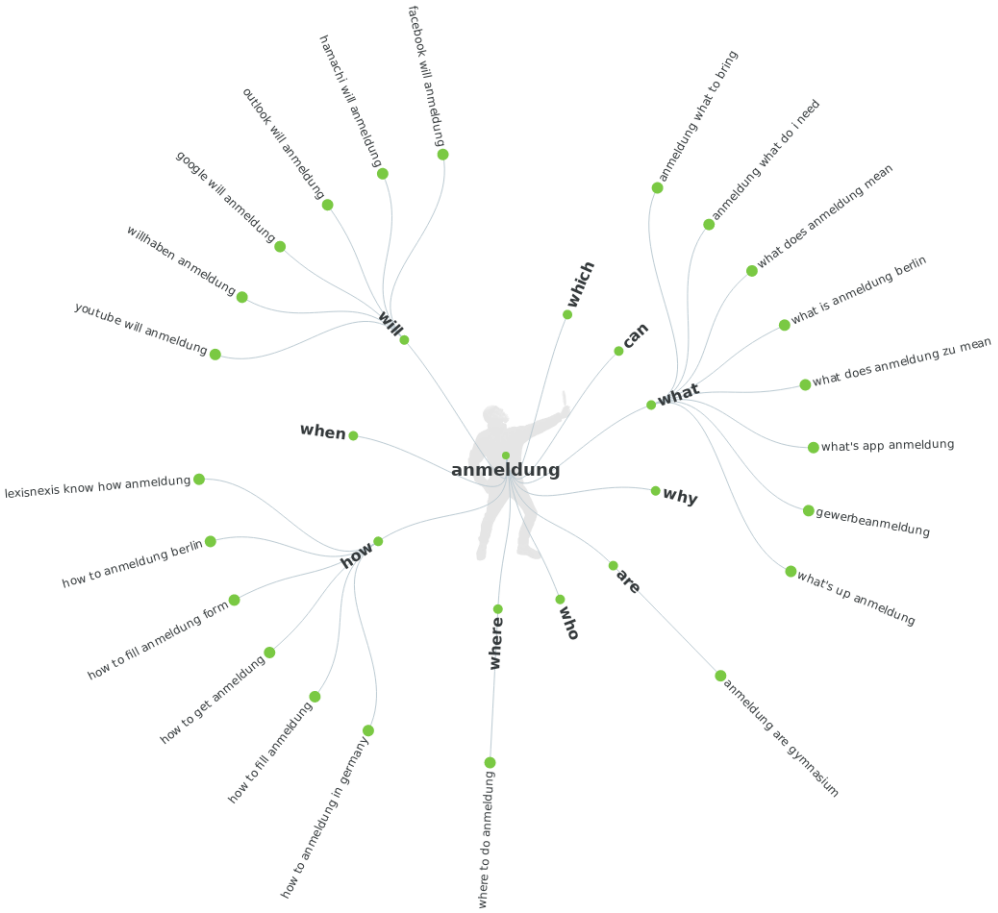
Additional APIs and Services

Of the additional APIs we explore briefly (not implemented in code)

- **Sayspring:** which helps prototyping and building the voice interfaces for Amazon Alexa and Google Assistant apps.
- **OAuth:** for account liking
- **SSML Builder** for correct SSML tags, since these can be misencoded with conversion between UTF8, Hexadecimals and HTML (e.g. `&`) [8]
- **Deutsche Post** for PLZ[9]
- **Utterances generator** [10] to create more utterances using alternate patterns.
- **answerthepublic.com** A tool for brainstorming relevant keywords to a word. This helps in the thinking process for synonyms (Figure 7.4)

[7] âẃs/`lambda/latest/dg/versioning-aliases.html`
[8] `https://npm.runkit.com/ssml-builder`
[9] `https://www.npmjs.com/package/deutsche-post`
[10] `http://alexa-utter-gen.paperplane.io/` andhttps://github.com/tejashah88

Figure 7.4: AnswerThePublic.com is a brainstorming tool to help categorise intents and slot types. This example deals with the word 'Anmeldung', which is common between spoken utterances that are related to different services



7.3 Design Guidelines and Best Practices

In order to publish the Skill, the design process requires a thorough understanding of Alexa's guidelines[11]. A list of relevant documentation is appended to this work in the appendix. Granted that some practices are adopted into the implemented Skill, this section presents extensive cases which we use for our design.

Throughout the model building process, we come across various nuances and details that might look subtle from a programming point of view. These can enrich or heavily

[11] https://developer.amazon.com/designing-for-voice/what-alexa-says/

obstruct the user experience, resulting in the users not returning to use our Skill (or chatbot / voice assistant in general) and consequently result in 1-Star reviews technically killing the product. In this extensive section we survey best practices to consider when building a chatbot or a voice assistant. In some cases it is necessary to separate the former from the latter to obtain better results.

For Voice Assistants in the Use Case of Alexa

It's important to understand and acknowledge that we are at a turning point in VUI design.with the fast progress made, the design process is still not streamlined. This might sometimes require setting our expectations a bit low, as side effects can occur since performance of an AI today is hardly optimised to understand context like a human would.

Based on our own exploration and through a growing voice design guide offered to Alexa developers [12] as well as personal recommendation from Alexa evangelist Memo Döring [31], we share a few good practices to consider before starting and throughout the development process. These are concerned partly with building the interaction model, as well as with the fulfilment back-end. Many of them also apply to voice assistants other than Alexa

Design before Implementation

Since the Skill code usually starts small, it might be tempting to work in iterations, develop for one scenario and then think of what else is needed as we go. As with any complex piece of software, it is very important to have a clear focus on the sequence of our workflow. Design takes an important role in this since it is the base upon which we build our Skill. If we have a bad design, we will end up getting stuck during the implementation. Good voice design means writing down full conversation flows, sentence variations, highlighting order of words, eliminating unnecessary utterances that could result in overfitting, letting Alexa deal with the dialogue management instead of using too many utterances.

In the code part, it might be useful to use routers, intercepts, or both. Routers can be thought of as 'super-handlers' that route our words to an intent, no matter what we say in whichever order. They can be thought of as keyword-sensitive listeners. Intercepts can be thought of blocks as code that would perform before and/or after a certain router takes us to a certain intent.

[12] `https://alexa.design/guide`
`https://developer.amazon.com/designing-for-voice/what-alexa-says`
`https://developer.amazon.com/designing-for-voice//design-process/`
`https://developer.amazon.com/designing-for-voice/voice-design-checklist`

The initial checklist can grow quickly and immensely but can also become very theoretical. It is therefore for every developer to figure out how to adapt to the VUI paradigm based on the fields of implementation and languages relevant to them.

Natural Language Conversation

When we are prompting for values, they are in a canonical order for how words should be structured when we have multiple adjectives. For instance in English we would say:

$$the \overbrace{big}^{\text{size}} \cdot \underbrace{brown}_{\text{colour}} \; bear$$

because saying "big" and "brown" in the reverse order would not make much sense. Similarly, there is the rule of place before time, which results in sentences like:

$$\overbrace{every\ Saturday}^{\text{time}} \cdot I\ go\ to \cdot \underbrace{univerysity}_{\text{place}} \cdot \quad \text{or} \quad I\ go\ to \underbrace{univerysity}_{\text{place}} \cdot \overbrace{every\ Saturday}^{\text{time}}$$

Many other examples are not actual rules, but more de facto in the language, so we would use them because of our linguistic logic justifies it as a sound pattern, which eventually make us speak a language. There are many rules regarding shapes and abstract concepts. When we build an conversation script (interaction model) programmatically, it is possible that one would mix up in the order of words in a sentence or even in the order of sentences. Since this can result for instance in sentences that are too close to each other in different intents, this would confuse the system and should be avoided to keep intent groups apart.

Since this changes in every language, it is important not to take one language model and just fit it into another language, since there is much more that goes into that. For instance, it would not be very common to take a 'en-US' language model and fit it into a French one, where the temperature scales or other units are made for another locale.

Question wording

There is nothing more important a Skill can do, than asking the right questions. This does not only concern the formulation of the question, but also the purpose of the question. E.g. it would not be necessary to get a user's geolocation, if they ask for the weather, since the postal code is enough information to take from them as weather would not change dramatically within a district or an area. Collecting GPS coordinates from an Echo Device for instance is not an option, since these are not equipped with one. So, if we need approximate location, asking for precise location is bad practice.

Further, asking for long numbers, such as Model / Serial numbers is not good either, since the user will very rarely get that right. A Skill for tracking packages, where the user needs to spell out the tracking number is likely to fail and the user might just go and track it in a browser. This translates immediately into a loss since they will no longer use the Skill. We need to make speech happen without pauses so that the system understands it as one sentence altogether. Given that there is a lot more happening under the hood than transcription, Alexa works better with words and sentences than one-off numbers and letters.

Context is King

Alexa provides many tools for handling context, such as session attributes. This makes invoking a Skill for the first time be handled differently than the second time the same Skill is invoked. For instance if we say:

User

"I want to bake a cake"

Alexa should respond with something like

Alexa

"Okay, you need {ingredient1}, {ingredient2}, ..."

then when we get back to Alexa an hour later and resume the conversation with a 'resume' request (simply by saying "resume `Skill_Name`), it should retain the context from last time to continue asking after invocation something like

"Did you get the ingredients?"

and proceed to the recipe only once the user answers with a

"yes"

and not restart the Skill from the beginning. In the meantime, we are not listening to the user. Just as it is embarrassing to a person to forget someone's name right after they meet them, not retaining the context of when the user was last seen using the Skill can make it sound dull and a bad way to communicate since it gives the impression of not being reliable. A user could think if Alexa cannot retain the simplest information, they would not trust doing more complicated things with it.

Maintaining context is important between sessions is just as important as across multiple sessions. For instance, greeting the user the first few times, should not sound

like the same greeting after a month of daily usage. The user does not want to know every time how to use the skill for instance. Removing an extended greeting message saves the user time.

Moreover, retaining session should also be considered within an intent, such that if we say

"Did Tom Hanks win the Oscars this year?"

"No."

and then follow with a question asking

"What about Katja Benrath?"

Alexa should still understand that we are asking within the '`OscarsIntent`' and differentiate between an '`actor`' slot and a '`director`' slot to match it within the same intent to the right query response. This is only doable by retaining context.

Localisation

Before we avail our skill to another country, it is important to check that the other country does not already have its own skill before we do double the amount of work. And as discussed above, things like linguistic and local changes beyond the classical imperial/metric systems (e.g. shoe sizes) could come into account.

Asking for permission

As mentioned above about taking the least necessary information to give the user the right answer, we want to manage a good balance on the trade-off between security on usability. If we ask the user to make complicated passwords and use tokens, no one will use our software. If we make the software too easily accessible, we might jeopardise its success for security problems. The same applies to the downside between functionality to levering specificity. As we do not want Alexa to spill a secret, we would not want to have someone in the room walking accidentally past hearing Alexa say how much money is in our bank account. So Alexa should not in that case start the Skill with your account balance in the greeting message. We also do not want our neighbour next door be able to unlock our car with a generic command or one they may overhear.

One Breath

If we cannot speak out a sentence Alexa can say in one breath, it is too long and should be broken down. Same goes for what Alexa would expect as input. So we should speak out a list in one go, but instead list up to three items and prompt the user to ask for more if they want. Context in that respect is also important. If our Skill wants to list public offices nearby, it does not make sense sometimes to mention the office if it is not open by the time we would get there for instance. That's why APIs have to be studied well before they are just linked to a Skill unlike the case with GUI where the user can scroll

Opposite to the GUI paradigm, more is not necessarily better.

Relevance and Repetition

We want the user to know with subtle hints that we are talking in the Skill about the same thing without repeating our text over and over. Implicit confirmations are good practices sometimes and bad at other times depending on the time and the focus we need to give out to hear a certain sentence. For instance for a purchase, we want to hear it in a full sentence. For just a slot confirmation for instance it may be better to repeat it in the next sentence.
Example:

"What time does today's Lufthansa flight arrive from Cairo?"

"LH 583 arrives to Cairo today at 7:40 PM "

and not just

"7:40 PM"

This allows us without unnecessary back and forth confirmations to make sure that Alexa understood us right, since if it got a wrong airport code for **Cairns (CNS)** instead of **Cairo (CAI)** her answer would be:

"LH 779 arrives to Cairns via Singapore today at 5:40 AM "

It avoids a scenario, where Alexa would sound cumbersome by asking

"Did you just ask about flights from Cairo?"

or even worse

" Are you sure you want to check flights from Cairo today?"

If we want to add session retention to this scenario to make it more relevant, Alexa could also check next time we open the skill if we want to book the flight we just checked since it is likely to be still in our interest.

As for repetition, it makes more sense to remove repeating words that the user has to say and the sentences Alexa says. This can be done by changing boilerplate strings in the code to arrays where it becomes less predictable what Alexa would say next time we open the skill.
Here is a code example from our implementation:

```
GREETING_TEXT: [
'Ich kann dir mit den zahlreichen Dienstleistungen der Stadt Berlin
↪  helfen! ',
'Möchtest Du dich über Öffnungszeiten oder eine Dienstleistung
↪  informieren?',
'Willkommen in dem Hauptstadtportal. Was kann ich für dich tun?'
]
```

```
//choose one Utterance for Alexa to respond with.
exports.getRandomResponseUtterance = function(inputArray) {
const randomUtterance =  Math.floor(Math.random() *
↪  inputArray.length);
return inputArray[randomUtterance];
}
```

To make it even more situation-dependent, think of a Skill for instance that would add to its greeting on Fridays a

" Have a nice weekend."

or if the user was not on the Skill lately, Alexa can present what the Skill can do since his/her last visit.

In short, repetition can make a VUI sound dull or interesting and the choice of what to confirm vs. what to infer is best validated with A-B tests to different user groups.

The Opposite of GUI

Whenever we think of wanting to teach the user to stick to something, we should try to eliminate the thought. With a GUI, it is important to keep the interface consistent. A prevalent example is when Microsoft changed its Office Layout and it was hard to re-teach the users to the new layout, icons and ribbons view. In GUI it is usually preferred to avoid this consistence since it breaks the monotony and the repetition problem mentioned above.

Speech Synthesis Markup Language (SSML) and Other Effects

SSML is a great industry-standard tool to make sound variations and add human-like effects to the conversation and are encouraged. Although not all tags are supported by all systems, Alexa offers an broad range of sounds.

We should hence not exclude use of audio clips, music, music and speech together. Alexa also integrates Speechcons. These are certain words or phrases pronounced by Alexa more expressively. Here is an example of how these look different to a string:

```
<speak>
Sometimes when I think of all those best practices, I just say,
<say-as interpret-as="interjection"> Horray. </say-as>
</speak>
```

Speechcons are available in German [13] and English [14]
Also, Polly can change the sound of the character behind Alexa, which is commonly used in games with multiple users.
Timeline markers are a helpful feature with lists as well, e.g. when saying

> *“ First, ...”, “Second”, “At the end”*

Flavours, Pointers, Acknowledgement of Feedback

Giving the user a feeling that they are not talking to a rigid machine, or even adding more ‘manners’ to the language, like when we want to ask Alexa to buy some clothes for us, it would sound better if it says

> *“ Sure, what size?”*

[13] ask/speechcon-reference-interjections-english-us.html
[14] ask/speechcon-reference-interjections-german.html

rather than just

“ What size?”

Adding pointers like ‘this’, ‘that’, ‘your’, ... personalise the experience and wrap up the sentence more elegantly. Additionally, adding transitions like

*“ **Now**, we’re going to talk about ...”*

Building flexible Paths

Also known as the graph- vs. frame-based design problem, since we have no idea what the user will say and cannot limit their choices through certain buttons on a screen, we want to be as captive as we can to what they say. For instance, a good Alexa Skill should be able to handle when the user says

“I want {blue} {Nike} {Hi-Tops} ”

and also when they say

“What are the trendy sneakers in stores”

Also considering that the user could get too familiar with the Skill and use even more complex thinking with it, they might in the middle want to restart the search process for the perfect product. The Skill should therefore be flexible enough to cope with that. This translates into a more horizontal design as opposed to just following a workflow where the user will be asked only about a colour then a size then an item before they get to their product. Used in many advanced interactive voice response (IVR), there is also extensive documentation on this design field that goes beyond the scope of this thesis.

Voice-First, Voice-First, Voice-First, Multi-Modal

Although there is enough emphasis to the voice-first approach throughout this work, it is also important to take advantage of using a screen whenever **necessary**, not whenever **possible**. Making a screen a supplement that the user does not have to depend on is vital to the user experience, since we need to go from the worst case of a lazy or even almost paralysed user who would not immediately jump to a TV screen when they are asked to do so by Alexa. The cards presented on screen should only reinforce what we say and not diverge at any time or provide important information that is not present in

voice. This is as much GUI as we want to integrate in our VUI using Alexa and might change in a different context for niched markets with special cases for Alexa or other voice assistants.

Modularizing the Skills

It is sometimes better to build small Skills each performing a single action and connect them together with the same APIs rather than building one gigantic skill that expects too many utterances that could render it futile. One example is to make a Pizza menu Skill and another Pizza order Skill that depends on the data from the Pizza menu app. Each would have a separate `LaunchIntent` enforcing a separation of concerns.

Invocation Name

While Alexa's presence in Germany is fairly recent giving a freer choice of names, it is pivotal to the Skill that it has a name users can remember easily. The key is not just in selecting the key, but also testing what Alexa interprets it for. A Skill name like 'four miles' can be mistranscribed as 'for my's' or 'form isles'. Checking the speech history in the Alexa App (for the end-user) helps determine if these mistranscriptions happen too often.

Designing for Natural Conversation

By having other users test the Skill conversation throughout the development process, many unnecessary scenarios can be circumvented and new ones unveil. The way we speak are blueprints of our verbal biases, as the way we use certain vocabulary is related to where we live, our own ideology or character, and who were interact with. We are used to only our own language or way conversation. As flexible as this can be, learning from others' missed intents can be helpful at all times. For instance, if we design a Skill to say a first name, someone might make the Skill say 'Günther' or 'Jacks' while someone else could make it say 'Mama' or 'Daddy', which are not in the predefined slot list `AMAZON_DE.FirstName` (we discuss lists thoroughly in Chapter 8). Checking when and how a Skill fails is of great value to enhancing it.

The aforementioned practices are even more powerful once combined. Before accepting or rejecting the trajectory of a guideline's results, we assess its relevance to our actual design.

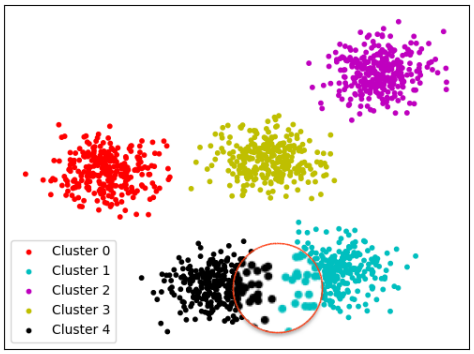
For GUI Chatbots

While chatbots are not the primary focus of this work, here are a few notable considerations in addition to the ones above that go for Alexa Skills and any chatbot (as long as they do not contradict with the GUI paradigm).

Classification of Intents

Filling intents with expressions is equivalent to building a sentence classifier: Whenever a user sends a new sentence to [our] bot, it will be classified into one of the intents. [We] can visualize [our] bot training as a set of [k-means] clusters: large circles in a two-dimensional space, one circle per intent and incoming sentences are assigned to one of the circles as in Figure 7.5 [25].
The key is making the utterances form non-overlapping clusters by maximising inter-cluster distance and avoid shapes like the overlapping between clusters 1 and 4.

Figure 7.5: K-means Clusters of Utterances, based on Deschamps [25]



Keeping it Simple

A Skill or a chatbot that uses 1000 intents or does too many things is more likely to break. If we can break down the tasks into more modular intents / actions, we avoid this risk. Same goes for utterances. In our Skill this could mean we can make one Skill that only books appointments at public authorities and another that only provides information on the services. While it is possible to make a lot of these, it is most of the time better practice to make use of dialogue management and entity resolution and reduce false negatives.

Allowing Surprises

Even when the user says words that do not match to an intent, although we do not want to handle that, we should still be able to respond with an answer that is equally random to the user as the request is to Alexa / the chatbot. For example if we launch a Skill checking for flights and we ask it to order pizza, we can still educate the user about a new thing they were not expected to hear or tell them a joke. Since the user was expecting to challenge or break the Skill/Bo they would get surprised if they end up learning about something new or have a laugh instead.

Moreover, if we are able to find in a log (works in case of using Alexa with Lambda) what are the common 'unusual' uses to our Skill and route them to a response that would make the user laugh or just be surpirsed. Even better would be if the process works through ML.

Showing Clear Structure

One of the revolutionary changes we witnessed since the introduction of GUIs in any major OS was the 'main menu'. Appearing in the form of the Start Menu on Windows, the Apple Menu and the Dock on the Mac, the functionality of this button was so intuitive, that most keyboards include it as a physical button. Similarly, already with the launch of the first mobile phones, the option of going back to a main screen was always present (with the hangup button) and moved on to more advanced operating systems from most Symbian and Blackberry devices to now the Home Button on smartphones. As it is "second nature for us to look for a home button whenever we want a fresh start" [14]. While using keywords like 'help' or 'start over' can be effective, it depends on the how we train the user to adapt to the use of these words. An effective way of giving the user an idea about a possible next step is to provide answers to the questions the bot gives including a small percentage (i.e. one every max. five answers) that would lead the user to a fresh start or even dedicating an extra button for that function.

7.4 Summary

In summary, chatbots and voice assistants are a specific type of computer programme, which are worth developing guidelines for and following certain design patterns to obtain adequate results. Guidelines differ in a case-by-case scenario based on implementation. Hence, it is important to consider these and include them in the design process.

With an established interaction model we are ready to conceptualise the requirements for our fulfilment functions (intent handlers). Separating the implementation of the back-end from the front-end is desirable for work in teams. Yet, the experience in this project showed a gradual shift from front-end to back-end was also helpful in an iterative approach if the speech scenario is incomplete.

Chapter 8

Skill Implementation

In this chapter we present our implementation solution through the code provided. In addition, the project on Github (see Chapter 1) is expected to be maintained beyond the scope of this thesis. A copy is attached to this work, but cannot fully operate as a standalone software given the dependencies it has to Alexa's SDK described in previous chapters. The runtime environment is offered through the ASK. There are many ways to set up the project, several languages we can use to programme our Skill (Chapter 7) and throughout the development process some of these steps were altered from Amazon's side. As mentioned, we settle for the most recent interfaces and implementation possibility using Node.js hosted on AWS Lambda.

8.1 Setup

Collecting the components for the Skill implementation requires account setup with Amazon and local configurations. This section describes our own setup procedure.

Minimum Requirements

For the environment setup, the following tools and credentials are necessary:

Amazon Account

We use it in conjunction with AWS and the Alexa Developer Console. Any account previously created for the Amazon store is usable [1] as well as to test our Skill. Once the account is activated on the developer console, the Skills in development become automatically reachable on any Alexa-enabled device linked to the same account (as an

[1] e.g. from here `https://aws.amazon.com/de/resources/create-account/`

end-user). Their invocation names also precede those of installed Skills. If two Skills in development have the same invocation name, the first registered one will be invoked.

Command Line Tools

For faster and more reliable interaction with Alexa's servers, we use the command-line tools with the following requirements.

- **Python 3** or **Ruby 4** need to be installed as a foundation for ASK CLI and AWS CLI.
- A package manager such as Pip Installs Packages (**PIP**) for Python or **RubyGems** for Ruby.
- Depending on OS, further packages and package managers might need to be installed. (e.g. for macOS: Command-Line Tools for Xcode, Homebrew, easyinstall). These will be prompted throughout the installation process.

API

As introduced in Section 7.2, Our endpoint is a Solr Server that provides us with JSON responses to the queries we do through a RESTful interface from within the Lambda function (hosting back-end code) [2]. Since the API endpoint was originally created for the Virtual Citizen Assistant, we need to readjust its output to meet Alexa's requirements and host a second instance of it to make it reachable not only locally, but also for Lambda. The containing server is secured with SSL to meet with AWS's encryption standards.

Audio

An encoder to create 48kpbs constant bitrate MP3-Format. Audacity [3] or FFmpeg[4] can be used to convert to an Alexa-friendly file format like in the ASK DOCUMENTATION[5].

Managing AWS Credentials

With the Amazon account we just created (or already acquired), we proceed to extend it for developer use by registering with AWS. As we move within the free tier of AWS,

[2] reachable at the time of development on:
`https://newsreel-edu.aot.tu-berlin.de/solr`

[3] `http://www.audacityteam.org/`

[4] convert by running `$ ffmpeg -i <inFile> -ac 2 -codec:a libmp3lame -b:a 48k -ar 16000 <outFile.mp3>`

[5] `https://developer.amazon.com/de/docs/custom-skills/speech-synthesis-markup-language-ssml-reference.html#h3_converting_mp3`

no charges were applied. A credit card might be required for eventual future billings if the tier limitations are exceeded. We mention pricing schemes in Section 5.2. More information on pricing is available on AWS [6]. Developer registration needs to happen on AWS website [7] as well as on the Amazon Developer Portal [8] separately, where some additional information is required such as company name and business sector. A vendor ID required for use with Amazon is generated. From this point on, any code that manages the back-end of our skill will be associated with AWS Modules, primarily Lambda. Skill configuration and interaction model are hosted on Alexa Skills Kit separately, i.e. managed through the Amazon Developer Console. During the development process, Alexa Skills Kit diverged from the Amazon Developer Console and has become a separate entity called Alexa Console. While still hierarchically belonging to the Amazon Developer Console and reachable from the same domain, except for the developer profile, all Skill-related information we need to use are modifiable from within the Alexa Console[9]. The separation from Lambda also means that code we need from the interaction model has to be duplicated from the Skill, since Lambda does not have access to Alexa Skill and can only be used as a trigger

Generating Access Keys

Linking happens through a private and public key pair - the **access keys** consisting of a combination of an *access key ID* (like `AK..7EXAMPLE`) and a *secret access key* (e.g `wJalrXUt..I/K7..G/bPx..YEXAMPLEKEY`). We use access keys to sign API requests made to AWS.

Creating Access Keys is described in the AWS DOCUMENTATION[10]. At this time we interact with the IAM Module from AWS (Identity Access Management) implicitly, which defines roles of each member in an organisation and partners linked to it, who can gain different levels of access to each module capabilities. Since we are only making basic use of AWS modules and our Lambda instance interacts only with our own API, there is no harm in using restricted roles such as `Lambda_Basic_Execution`.

Initialising The Development Environment

As minimum package requirements can vary a lot between one OS and another, using a virtual machine is suggested for teams. AWS offers Elastic Compute Cloud (EC2) as a service for virtual machines in the cloud. Although this step is mainly for performing command-line prompts later on, with this option it is convenient to avail a web browser

[6] `https://aws.amazon.com/de/pricing/`
[7] `http://aws.amazon.com`
[8] `https://developer.amazon.com`
[9] `https://developer.amazon.com/alexa-skills-kit`
[10] aws/`/latest/gr/managing-aws-access-keys.html`

inside the virtual machine instance. Otherwise, for browser communication AWS CLI generates URLs with the `--no-browser` parameter that we paste into a browser outside of the virtual machine to link it with the Amazon account we use.

Creating Lambda Instance

Although the ASK CLI makes it easy to perform multiple setup steps at once, at the time of this project, this option was not available. Having started with an AWS account in North Virginia (`us-east-1`) as the only available server region that accepts Alexa Skills as a trigger for Lambda, changing the server location to Ireland was complex in the sense that both servers are completely separated from one another [11]. Hence the migration had to be done manually. Additionally, all CloudWatch logs are not transferable between regions. At the time of completion of this project, the AWS server based in Ireland (`eu-west-1`) was the most preferable for latency. Moreover, as this project ends before AWS's terms were readjusted to accomodate with the GDPR, hosting on the Ireland server implied different regulations about code ownership and accessibility.

Once a Lambda function is ready to be created, we assign it the role `lambda_Execution_basic` then link the trigger as an Alexa Skill.

To make sure the Lambda instance is not invoked from anywhere else, we tie it to the Skill's resouce number (Skill ID) in the trigger configuration. The Skill ID for the created Skill is available in the appendix.

Verification through Application ID is described in the ASK DOCUMENTATION [12]

Installing Command-Line Tools

This script checks if resouces are available then installs the AWS and ASK CLIs.

```
$ which node      #check if installed
$ which npm       #check if installed
$ which python    #check if installed
$ which ruby      #check if installed if proceeding with rbenv
$ python --version #we use 3.5.3
$ node --version   #we use 7.3.0
$ npm --version    #we use 4.1.1
$ pip install aws-cli #Amazon Web Services Command Line Interface
$ aws --version    #check successful installation. We use
 ↪  aws-cli/1.15.1 Python/3.5.2 Darwin/15.6.0 botocore/1.10.1
$ npm install ask-cli| #Alexa Skills Cit Command Line Interface
$ ask --version    #we use 1.1.6
```

[11] https://forums.developer.amazon.com/questions/87860/ask-cli-eu-lambda-region.html?childToView=164883#answer-164883

[12] ask/handle-requests-sent-by-alexa.html#request-verify

AWS DOCUMENTATION [13] provides more information on special configurations

Understanding the API Query parameters

Solr cores are accessible with the respective core name appended to the base URL. Query syntax can be passed as parameters in the URL, too, like in the following example.

`https://newsreel-edu.aot.tu-berlin.de/solr/d115/select?q=ladenoeffnung*&wt=json&indent=true`

1. **Credentials:** `username:password@`
2. **Base URL:** `newsreel-edu.aot.tu-berlin.de/solr`
3. **Path:**
   - Core: `d115`
   - Query: `/select?q=` QueryText
     - Query Parameters: we can use usual Solr parameters in the API Calls (e.g. wildcards (*), concatenation (+), AND operator) [14].
     - MIME Type: `&wt=json`
     - Other Parameters: e.g. `&indent=true`

Event Emitters

In all Intent handlers, a common pattern is to generate speech output from Alexa with a certain result or question, then allow the user to speak or end the session as discussed in Section 7.1.

As per description in Section 7.2 A `LaunchRequest` always starts a new session. Event Emitters can be categorised in the following Table 8.1. "The difference between `:ask/listen` and `:tell/speak` is that after a `:tell/speak` action, the session is ended without waiting for the user to provide more input" [15].

Table 8.1: Event Emitters

Emitter Type		Emitter Name	Session Ends
Speech Out (only Alexa)	`tell`	`speak` `:responseready`	**`true`** (no wait for response)
Speech Out / Recording	`ask`	`listen` `:responseready`	**`false`** (conversation continues)

[13] aws/`cli-chap-getting-started.html`
[14] Available Syntax: `http://www.solrtutorial.com/solr-query-syntax.html`
[15] gh/`alexa-skills-kit-sdk-for-nodejs/blob/master/Readme.md`

Effectively, an emitter sends a response to a JSON request (example in Appendix 10.2) with parameters that determine whether the session remains on or not, what the response includes and a device token to direct the response to the right Alexa-enabled device.

8.2 Feature Implementations

Intent Implementation

e.g. index.js : DE_handlers : AMAZON.HelpIntent
As the actions resulting from `HelpIntent, StopIntent` and `CancelIntent` have to be decided on, we choose to make the `HelpIntent` for non-contextual help, giving the contextual help as a prompt inside each intent separately. The `StopIntent` terminates the Skill and the `CancelIntent` ask to restart to a new intent within the Skill.

Making the right conversation

In certain intents like with a question about residence permit for non-EU residents, there is a pattern of questions to be asked in a given order as a public official would do. This is related to the law structure, given than certain regulations have precedence over others. In this example, the EU-partner rule is applicable, where EU laws supercede local regulations. As such, if a non-EU/EEA resident wants to apply for a residence permit for any purpose and has an EU-partner (Swiss regulations are similar but have a different legal base), the residence purpose should be the Freedom of movement of an EU-citizen and their family and not the other reason the person is applying with. How EU rules override local ones is codified in Directive 2004/38/EC [16].

Dialogue Management

As we explained dialogue directives in Section 4.5, we use them in our code to delegate a few responses to the interaction model [17]

Guessing the right Location

e.g. index.js : DE_handlers : LOC_WhereIsAreaOrPLZ_Intent
One of the Intents answers the question where a certain PLZ or district is in Berlin. It

[16] `https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02004L0038-20110616`

[17] ask`/dialog-interface-reference.html#delegate`

does not use geocoordinates but is sensitive to nuances in uttering a PLZ, as these are not always pronounced as individual digits but sometimes as a combination between a number and digits. For instance, in German we say "Zehn Eins Eins Neun" for 10119, which is a code belonging to two different districts. Alexa is able to determine this through elicitation as well as dealing with some special cases like when the number is outside of Berlin.

Randomising Alexa's Utterances

e.g. ./lib/helper.js : `randomphrase()`
With word arrays, we are able to generate a random answer, such that every time the user expects a different answer from Alexa, simulating a natural conversation.

Creating SSML and Audio

e.g. index.js : DE_handlers : LaunchRequest
Used to generate sound effects during the conversation such as emphasising certain words or whispering and playing short audio clips [18].

Checking the Next available appointment

With this work as a proof of concept, and an API extension from ITDZ's side, it is equally easy to implement a feature to look up next available appointments. The actual booking would require Alexa to send POST requests and persistently retain these on the API's side with the option to impement another feature to save the same appointment to the calendar linked to the Amazon account used with this Alexa instance. This might require account linking, too, if we need to pass the appointment data through the Skill to an online personal calendar endpoint, bypassing Alexa itself.

Booking an appointment happens for now only through Berlin.de's website by starting at either the appointment booking page [19] which links to the actual booking pages via choosing the service or the location where the service

Card Templates

We can render a different template for each device type. For our purpose, the standard template is sufficient. Customisation can be useful with displaying longer texts. [20]

[18] ask/speech-synthesis-markup-language-ssml-reference.html#audio
[19] https://service.berlin.de/terminvereinbarung/termin/
[20] gh/display-interface-reference.html

8.3 Testing and Deployment

Continuous testing during development is vital before evaluating the system as a whole. With the testing tools introduced in Section 6.4, it is important to test not only every feature indiviually, but also in combination with other features already implemented.

The more complex the Skill gets, the more important to make error handling integrate in the code. Excessive logging does not affect the skill performance per se, as the user does not see the console logs. All logs are visible on CloudWatch, with the ability to set alarms if certain warning levels were reached. CloudWatch logs can also show why some intents are never reached.

The Skill Management API provides short commands to check the intent history [21]

For most tests, deployment is needed. We deploy either the whole Skill or in parts, depending on where we implement a new feature

```
ask deploy -t|--target lambda
```

deploys only the lambda function, shortening the time required for rebuilding the interaction model.

Once a Skill is ready for publishing, it can proceed to approval, the process of Amazon deciding whether each uploaded version / update is still fit for purpose, makes the Skill better or worse in conjunction with other skills on the Store

8.4 Challenges

Throughout the implementation process, many challenges were faced with respect to the runtime environment and the constant changes from Amazon. In the following are some of the encountered obstacles.

Interaction Model

Building the interaction model on the web is a long process. As login sessions need to be refreshed, once a session is expired, changes in the model in the browser can get lost. This was fixed by receiving a warning once trying to save the model only recently. It

[21] $ ask api intent-requests-history <--skill-id <skillId>> [--filters <value>] [--max-results <value>] [--sort-direction <value>] [--sort-field <value>] [--next-token <value>]

https://developer.amazon.com/docs/smapi/ask-cli-command-reference.html#intent-requests-history-subcommand and https://developer.amazon.com/docs/smapi/intent-request-history.html

can also get confusing to deploy from two different locations (CLI and web browser) without knowing which is the most up-to-date.

Interpolation from Virtual Citizen Assistant

Finding a solution to map the structure of the Virtual Citizen Assistant is not straightforward as there exists little documentation resources for the programme. Also, with the data in the API not coherent (e.g. Fees do not have the same data type and structure), makes it not an immediate takeover.

Environment

As many interfaces were changed by Amazon, knowing how to operate the new interface requires an extra amount of time to relearn the new functions and their locations.

Transcription

With only some of the concepts of Alexa's methodology known, the software is a black box and not predictable. How Alexa's NLU engine transcribes a user's voice can become problematic with long constructed words. In German, 'Hohenschönhausen' or 'hohen schön hausen' is one such example.

Provided Data

As the chatbot did not have a list of countries, which are required to fill a slot in the `AufenthaltstitelIntent`, we took the available list from the page source of Berlin.de. This resulted in many misleading values starting with encoding problems, (e.g. with Côte d'Ivoir) to values that are not usually descriptive of a nationality a user would speak (e.g. british overseas territories in Africa).

Outdated Resources

Online resources are rich but are not always up-to-date. With new features from Amazon launched almost weekly, keeping up to date with the trend requires a dedicated amount of time. While outdated resources are not relevant for development, they can provide a good understand on how a Skill operates.

8.5 Summary

In short, the development of a Skill for an E-Government solution is attained with the aforementioned considerations. The back-end code along with the interaction model make up a viable product which can be used for further development. With this example, similiar implementations can be done for other cities of the same information capacity.

Chapter 9

Evaluation

After a completed implementation with all necessary intents and their handlers included, we measure the Skill's performance against our expectations at the early stages of the project, then compare these to WienBot and GeorgiaGov, which we take as qualitative benchmarks.

9.1 Compliance

With D115's promises to its customers, we revisit each of the goals and see how we implemented these:

1. **24/7 availability:** Our Skill server and Lambda are not tied to specific opening hours as opposed to D115.

2. **Avoiding office visits:** While we initially depend on the information on the Berlin City Portal, we expect that customers will have unhandled answers at this early stage. For that we implemented the `unhandled` intent, which tells us what strange formulations and converations happened anonymously.

3. **Freedom and accuracy of information:** The voice assistant as a solution gives explanations as provided by the website. Hence, information accuracy is guaranteed. This information relates to the details around the public service, such as fees, processing time. While implementing answers to the legal base is possible, we did not see in the conducted survey a necessity for it and could add it as a feature in a later version, which speaks for the flexibility of the voice assistant solution.

4. **Improvements:** With the ability to update the software only from back-end side, users do not need to carry out updates themselves. Hence, potentially incomplete

information can be eliminated quickly without the user to take action. The only bottleneck is Amazon's approval, which takes one to two days as stated on their website. Monitoring of their Twitter feed, this seems to be the case.

5. **Helpfulness and Friendliness:** With Alexa already having a positive reputation about being helpful, our Skill extends this character in several ways. The German 'Sie' Form adds a touch of formality, which is expected within the scope of a public service. Implementing a `HelpIntent` and contextual help extends the user's perception of this helpfulness. There is also a possibility with Alexa to be set to speaking short sentences if the user enables this configuration. From programming side we can control texts spoken out in the short and long form, giving more detail in the latter or keeping the minimum necessary information (e.g. in keywords format) in the former. With the ability to keep questions short by asking directly about a certain aspect (e.g. required documents) of the service, this gives user a more well-rounded and understanding experience.

6. **Trigger Inquisitiveness:** Our Skill ends almost every answer with another question triggering the user whether they want to find out more information about another sub-topic.

7. **Anonymity:** With no personal session details stored, we do not have any influence over what Alexa can say to one certain device and we do not collect information about the user. The only information collected is anonymised and time-shifted logs about the use of the Skill only, such as what intents were used.

8. **Flexibility:** With the option to ask subcategorical quesions, and move between question topics freely with the `StopIntent` or after the question has been answered, the user can interrupt Alexa as they would not on the D115 hotline. Alexa's availability also delivers longer uptime for the user, as opposed to a hasty behaviour of on the phone.

9.2 Comparison with Existing Systems

In order to obtain an appropriate position on the market, we use the reference systems as qualitative benchmarks. The following demonstrates a couple of observations made.

WienBot

WienBot is a chatbot that uses speech recognition technologies, hence not a voice-first solution with a screen always present as opposed to Alexa. Therefore the comparison remains mostly on language. On one hand, at the time of this research, WienBot was

not able to understand synonyms. Using the word ‘Perso’ for ‘Personalausweis’ in German (Germany and Austria) should be understandable. This could either mean that the system was not configured to make sense of synonyms or that this particular word was not registered despite its common use as a dialect. As we expect users to use natural language, we consider not only formal language (Hochdeutsch).

With respect to helpfulness, Wienbot searches the web for input it does not have in its own database and does not stop when it cannot resolve the question.

On the other hand, while it does not compare with the use of our Skill, WienBot understands certain Emojis and reacts funnily to them. It also speaks a shorter text than the multiple callouts displayed on the screen. This gives an incentive to understand that the user is not always interested in extensive information. For instance, users do not go through the first few search result pages on a screen, but directly try the first result and check its relevance themselves. If not, they check the second. This is the behaviour WienBot tries to simulate.

Alexa in turn, does not display information on a card that is extra and necessary at the same time. We diverge display from speech so far only in the help menu, where the user still has a way to navigate through the help menu by voice and does not risk a loss of information.

As for anonymity, the makers of the chatbot denote in their fact sheet that “the data protection component in the WienBot app should also be highlighted as it complies with the high standards of the city of Vienna”. No further information was given.

GeorgiaGov

It prevails from our use of the voice assistant, that sessions are relatively long for the use we tested it for (16 sec vs. 8 sec). Comparatively, our Skill makes use of an extended session only when it is necessary. The necessity was determined through A-B tests on two users during the development process. According to the Amazon Skill page, there is no user-specific data stored. Only dynamic content is generated, meaning that the Skill makes API calls as we described in Section 2.4, which also applies to us, guaranteeing in both cases that the information is up-to-date.

Moreover, intent chaining is taken advantage of with Alexa asking whether related question to a topic of interest should be spoken out to the user. We do not apply this feature for this development stage.

With respect to synonyms, canonical value detection and slot elicitation, in some intent invocations, Alexa was unable to understand when a term is common between two intents, such as ‘child’, which we find on the website occurring in the topic ‘child care’ and ‘child custody’. Our Skill is equipped with slot elicitation directly through the interaction model. The prompts are handled in the back-end in German and English separately. As slot elicitation is a concept recently introduced by the Alexa developer

team, its potential is not present in many Skills yet. Figure 9.1 shows our understanding of the GeorgiaGov flow of conversation.

The organisation of the GeorgiaGov Skill differs to Berlin.de's structure as follows:

Services are grouped into categories as seen on georgia.gov. Alexa catches from any sentence you say only the service grouping name, then gives a definition about the service. Afterwards it asks if the user wants to hear more about the related service (which corresponds to the FAQ section on the website). The FAQs are formulated not in imperative form and have a more use-case-based wording. Example: "I am 17 and my parents are blind. How do I renew my driving licence as a minor?" The user replies only with yes/no answers. We infer that Acquia made its own implementation of the `YesIntent` and `noIntent`. Our Skill model has a different approach. The users can proceed with this tree-based understanding of services, giving a definition then asking about subcategories. Additionally, they can also cut the conversation short by asking directly about subtopics, e.g. "What are the required docments for <service_name>. Hence, hierarchical graph design as well as frames are enforced.

Finally, contextual help is not implemented in the GeorgiaGov Skill. Reprompts were not found useful and too repetitive for an interactive conversation, since the same text is spoken out without any nuanced utterance. Conversely, every intent ends with a question whether the user wants to have a phone number for the department related to handling the service. If none is found in its database, the Skill returns a general inquiries hotline (equivalent to D115). A similar implementation can be added to our Skill.

9.3 Skill-Specific Metrics

With Alexa Skills Kit providing various option to measure the Skill performance respective to session length, customer retention rate among other features, before launching the Skill, there is the option for beta-testing through email invitations. Any user with an Amazon account and an Alexa-enabled device can be a tester. Figure 9.2 show some of the available metrics. Noteworthy, further metrics are unlocked through the SDK once the user base gets above 10.

Remarkably, the major drawback with the used API is the latency it causes due to the length of the JSON responses, which can be up to 1.5 Megabytes in size.

Figure 9.1: Drafted activity Diagram of Conversation Flow on Georgia.gov Skill with frames representation

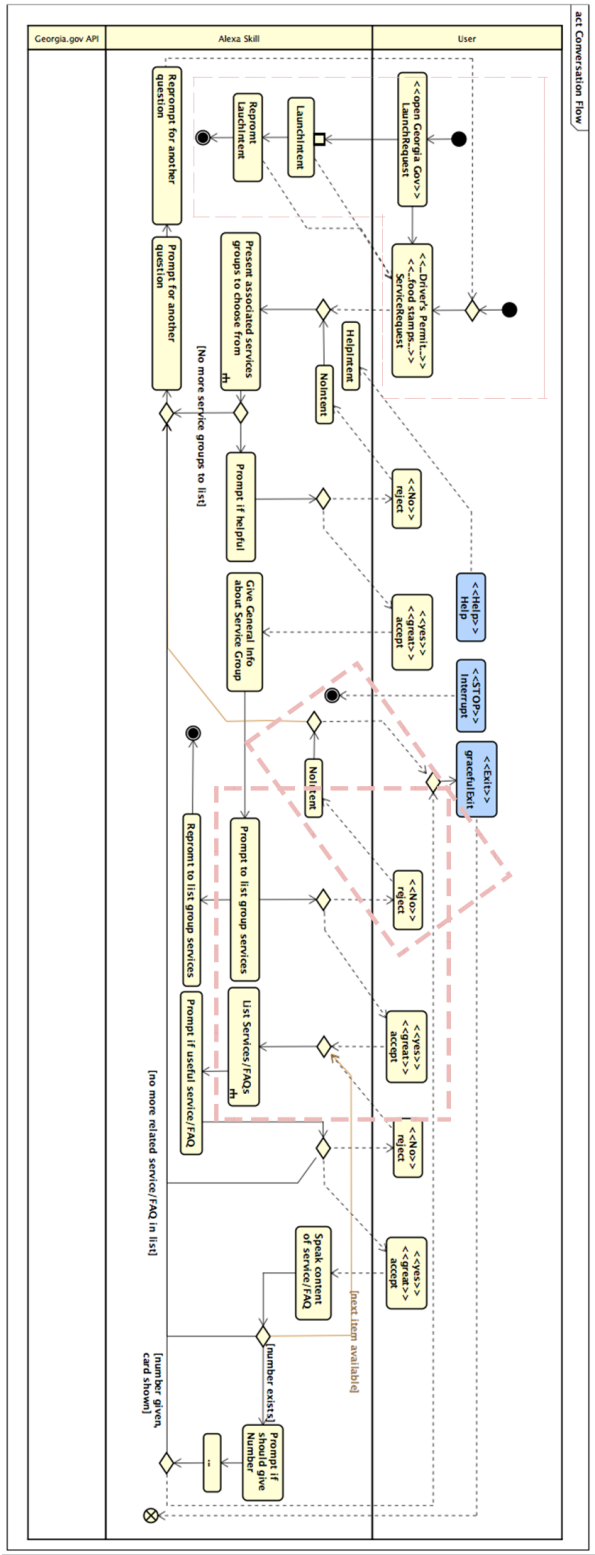
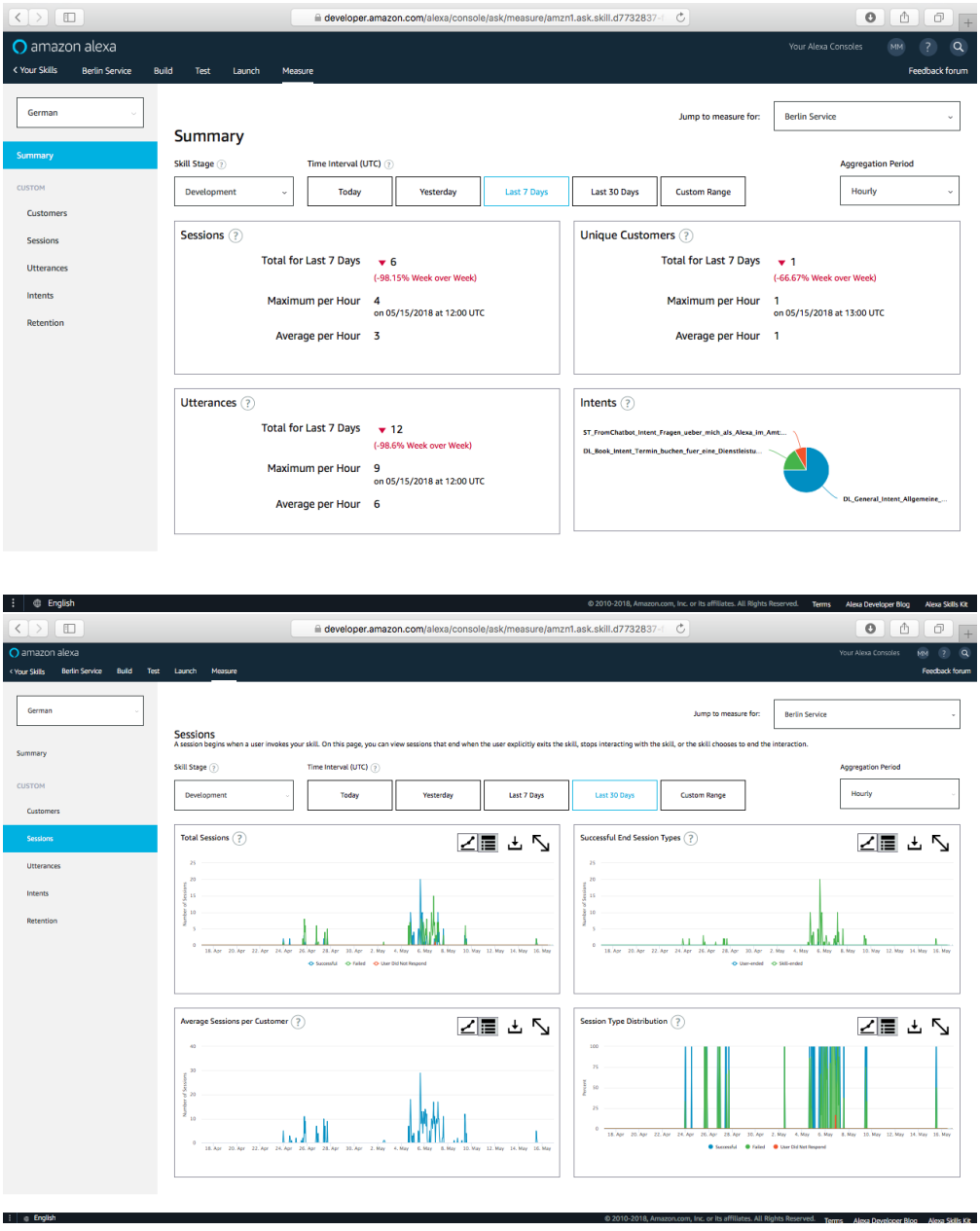
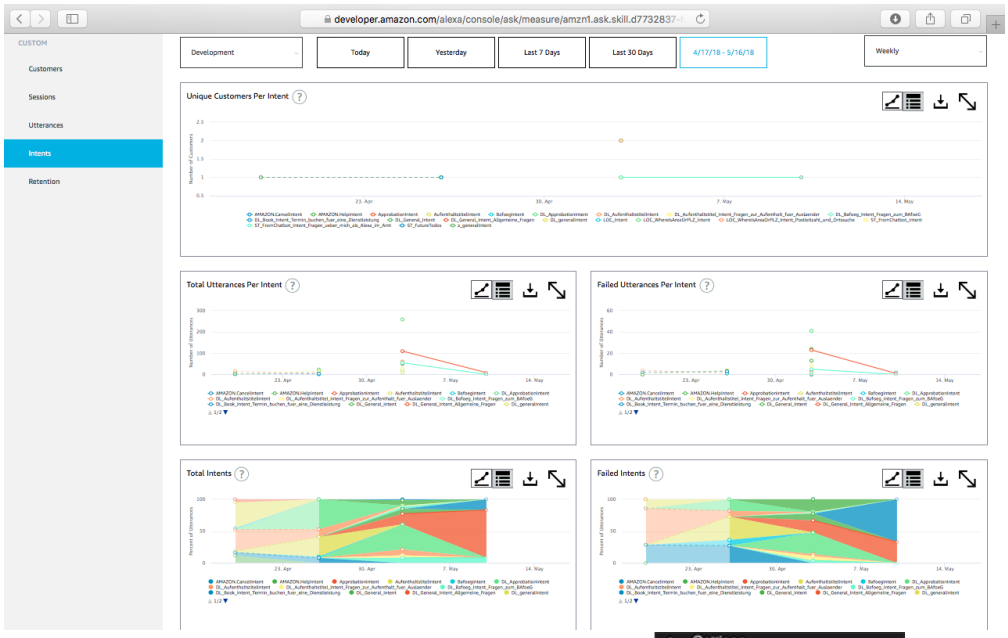
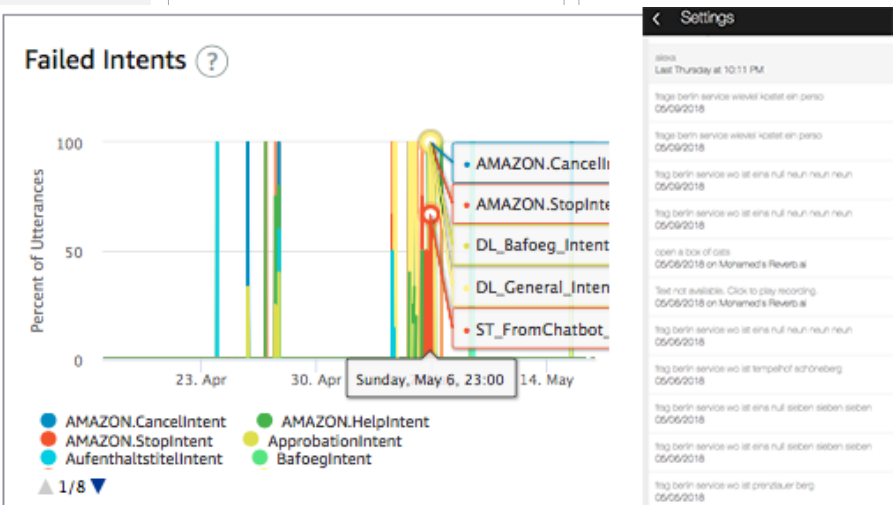


Figure 9.2: Metrics for the produced Alexa Skill




developer.amazon.com/alexa/console/ask/measure/amzn1.ask.skill.d773283
CUSTOM
Customers
Sessions
Utterances
Intents
Retention
Development
Today
Yesterday
Last 7 Days
Last 30 Days
4/17/18 - 5/16/18
Weekly
Unique Customers Per Intent
Total Utterances Per Intent
Failed Utterances Per Intent
Total Intents
Failed Intents


Failed Intents
Percent of Utterances
100
50
0
23. Apr
30. Apr
Sunday, May 6, 23:00
14. May
AMAZON.Cancelli
AMAZON.StopInte
DL_Bafoeg_Intent
DL_General_Inten
ST_FromChatbot_
AMAZON.CancelIntent
AMAZON.StopIntent
AufenthaltstitelIntent
AMAZON.HelpIntent
ApprobationIntent
BafoegIntent
1/8
Settings

Alexa as a VUI and a Developer Platform

Throughout the development process, the system proved to have a high accuracy in understanding most common words. Specific terms or foreign dialects (mainly non-english names) are impossible to transcribe if they do not exist in Amazon's NLU engine. Even with the most common command, playing music [42], many track, artist and album names are not found.

Likewise, an important criterion about reusing a Skill is starting the Skill, which happens through the invocation name. After settling for 'Berlin Service' as a name, the Skill did not fail to invoke. Hence, choice of invocation name needs to be assessed during and after the development process.

In General, Skills seem to expand in various domains. From a marketing perspective, there still remains the question, how they can monetise to provide an incentive to developers and business. As such, Alexa is a helpful tool in most VUI use cases discussed in Chapter 4. Since Amazon is expanding with the product in cooperation with car makers, their user base is expected to grow and Skills alike.

9.4 Summary

We were able to reuse some of the artefacts from the Virtual Citizen Assistant. In order to provide a comprehensive software, content needs to be maintained by hand at the beginning as with most other systems. The drawback of having to talk to the device in only one language cannot be changed by the Skill, despite it being able to speak in more than one language with the same language setting. adopting the invocation name by a high user base is one of the key performance indicators to the Skill's success in commercial use. With the help of the previously built systems Virtual Citizen Assistant, WienBot and GeorgiaGov Skill, we were able to explore a new design that still fulfills D115 criteria while only adapting ideas from other interaction models. Among the surprising capabilities of Alexa Skills Kit is its ability to deal with large JSON files in a very short time.

Chapter 10

Conclusion and Future Work

10.1 Overview

Chatbots and voice assistants are redefining our everyday use of technology and have become an adopted trend. Security and open frameworks are still one of the concerns of this technology. As the trend with IoT devices is consumer-driven, Alexa, as an IoT-powering device is a leading platform and advancing at a very fast pace compared to Google and Apple. With the ML drive in Voice Assistants in general, the ability to simulate a human customer experience is unveiling new sides of modernity. Special use cases of bots are also becoming widespread in hotel use. Relay by Savioke is one of the ultra-modern examples of how a system using a voice assistant can revolutionise the service industry.

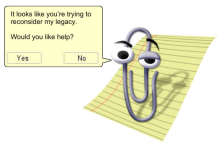


Figure 10.1: Microsoft Office Clippy as an early attempt for an interactive Chatbot

Chatbots and voice assistants are also raising debates about sexism in AI, their ability to supersede human thinking, our acclimatisation to their presence. They symbolise chances and threats. It is unlikely to develop indifference towards the VUI technology or the entrenched sentiment developed towards it. All of which show signs of a disruptive industry that brings a major change forward. And while their use to replace humans in different jobs is becoming reality, it can be regarded as a change that brings other changes with it since it also opens up unprecedented job opportunities in technical and non-technical fields. With respect to the new user experience, the ideas behind making technology have a human-friendly and familiar interface existed since the developments in GUI. A major example is the Microsoft Office 97 Clippy (Figure 10.1).

With the ability to generate synthesised speech sounds and play custom audio, the experience becomes much more immersive. The enriched experience applies mostly on the US-English Alexa, given the generally higher number of users and developers in the

language. Localisation is a top priority in future.

The ability to develop for Alexa is a win-win scenario for developers interested in expanding an existing system. It promises high adoption of the Skill and a bonus of using many conversational features of Alexa as well as 'small-talk', which gains fascination in commercial use. Alexa is taking the 'if this, then that'(IFTTT) concept to voice commands at a large scale, which in turn makes expectations from technology rise beyond the hope of a user to find a solution on their own. Hence, Alexa is perceived as a helping AI for the customer and an enabler in the service industry.

Difference Between Lex and Alexa Skills

Amazon Lex is a service for building conversational interfaces using voice and text. Powered by the same conversational engine as Alexa, Amazon Lex provides high quality speech recognition and language understanding capabilities, enabling addition of sophisticated, natural language ćhatbotsśo new and existing applications. Amazon Lex reduces multi-platform development effort, allowing you to easily publish your speech or text chatbots to mobile devices and multiple chat services, like Facebook Messenger, Slack, Kik, or Twilio SMS. Native interoperability with AWS Lambda, AWS Mobile-Hub and Amazon CloudWatch and easy integration with many other services on the AWS platform including Amazon Cognito, and Amazon DynamoDB makes bot development effortless [1].

10.2 Conclusion

With our Skill we present an uncommon solution for an e-Government system, which promises high usage due to the many customer segments it covers. The ASK offers a wide range of programming concepts, tools, blueprints and documentation that is constantly evolving to make development more focused on programming logic.

Exploring the VUI paradigm through Alexa gives substantial knowledge in the field. The process is well-defined throughout the lifecycle of the software, from building to deployment to testing and publishing, in addition to benchmarking and obtaining real-time measures

. The separation of concerns between front-end and skill logic allows teams to work in DevOps.

[1] More information: `https://stackoverflow.com/questions/42982159/differences-between-using-lex-and-alexa#URL`
`https://aws.amazon.com/about-aws/whats-new/2017/09/export-your-amazon-lex-chatbot-to-the-alexa-skills-kit/`
`https://aws.amazon.com/lex/faqs/`

Attention is given to front-end and back-end elements equally, e.g. with nested handlers and entity resolution. When designing our Skill, there are various design guides that give insight on how to retain customers. Primarily, making the content suitable for voice is the main concern when coming from a GUI approach. For that a design should always start with a flow chart to highlight key breakpoints in the conversation. While it is of high value to be aware of what information Alexa can store during a session, it is also vital to estimate what information the user can keep during a conversation and not only the voice assistant. Designing a dialogue for a Skill is therefore best done with a partner to take turns on the conversation and diversify the thinking process.

With the remarkable growth of VUI, we witness an unprecedented growth rate in adoption of the technology quicker than any modern advancement from punchcards to the command-line interface, graphical or haptic user interface. And so, what distinguishes the quality of a system is how fast it learns. Since languages do not work with a unified grammar and word types (adjectives, adverbs) are not simply replaceable by one another. In that respect, using term weighting, neural networks and thought vectors have led to advancements in nuance detection especially in homophones and homographs and are well integrated in Alexa.

Worthy of mentioning is that with this advancement comes a responsibility of handling the huge amounts of data. Sound, being the most complex data set is in so far different to usual data, as it contains biometric information, which brings dangers in an unsecured cloud environment.

The Berlin Service skill developed thus far already shows promise in the use of VOI for government service delivery. Further steps with it are likely to provide a service that is truly useful for the citizens of Berlin.

10.3 Future Work

This work explores potentials for future work in various tracks. On one hand, with the knowledge collected about Alexa and the way it works, there are many possibilities to expand the developed Skill. With Amazon's introductions to the Echo Button devices, the voice-first experience becomes more expandable. Building on the concepts learned, there is a possibility to develop tools that make Skill development easier and more accessible to users with less programming background. Expanding the API base is an addition to the community that helps technology leap forward.

Finally, as VUI is concept in early adoption, there is a need to explore the security of its use. Lei et al discuss the lack of security in Alexa [53] amid many controversies on the platform. In many IoT devices powered by Alexa and Google Home, the current trend is to have an AI centralised in far away servers with data sent back and forth between continents only to turn off a light bulb. Making autonomous IoT can be a pivotal change by decentralising information collection. We learn that infringing privacy

is a harm to sovereignty and still stands in the way of making the VUI technology widespread. Potential research field is how to seamlessly have a on-device VUI which is (at least not completely) cloud dependent. With commercial solutions already emerging, there is an urgent need for collaboration between the industry and academia in the field for the rising VUI community to flourish organically and in a manner not exploiting the user. Believing that data privacy is crucial to a healthy society, companies like Amazon should be also forced to become more transparent. With the upcoming GDPR, the development of VUI becomes reliant on societal consent. Educating the public about their privacy is a start.

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Appendix

On Etymology of Product Names

Product naming is a branding problem which companies deal with differently. In the case of Apple, with the exception of the 'Apple Watch' and on their consumer products line, they opt for a clever version using the letter 'i' in front of simple common words, like iBook, iPad, iPhone. though this naming convention originally arose from 'i' to stand for 'interactive' celebrating the early adoption of the internet on the Macintosh product line, it has turned into a naming breakthrough since it had two effects: 1) it gives the user of Apple software or hardware product a feeling of personalisation for the letter 'i' would make something sound as belonging to oneself, namely " 'I', as a person" as a prefix for the name of the object create the name of the product, and 2) it is a marketing strategy to associate all products and services carrying the prefix 'i' with Apple without the need to name the company's name. This applies to products and services that came to life even long after people's adoption of the internet and the widespread use of Apple products, like with iCloud as a web service. Another example is with professional software products like AutoCAD combining the company's name (AutoDesk) with the product's functionality (Computer Aided Design). Companies like Adobe clearly prefer to name their products and services with their brand's full name included, as the case with Adobe Photoshop, Adobe Flash (formely know as MacroMedia Flash). Similarly, as the youngest of them, Amazon adopts a combined approach by stating the full name of the company on its consumer line like with 'Amazon Prime', 'Amazon Alexa' and a mix between 'AWS' and 'Amazon' like with 'Amazon SageMaker' or 'AWS Firewall Manager' on its developer B2B line.

Documentation

Submitted Skill ID `amzn1.ask.skill.d7732837-fab2-42ff-a152-4eb0fc4ee646}`

(Base) URLs

To shorten URLs, the following symbols were used in footnotes

Amazon Web Services	a͡w͡s
Alexa Skills Kit	a͡s͡k
GitHub Repositories	g͡h
Node.js Documenation	`https://nodejs.org/api/`
JavaScript Documentation	`https://developer.mozilla.org/en-US/docs/Web/JavaScript` (Mozzila Developer Network)

Amazon Web Services - aws

AWS Glossary	https://docs.aws.amazon.com/general/latest/gr/glos-chap.html

Alexa Skills Kit - ask

Documentation	https://developer.amazon.com/docs/custom-skills/
Guidelines	https://developer.amazon.com/designing-for-voice/what-alexa-says/
Glossary	https://developer.amazon.com/docs/ask-overviews/alexa-skills-kit-glossary.html https://developer.amazon.com/designing-for-voice/glossary/
CLI Reference	https://developer.amazon.com/docs/smapi/ask-cli-command-reference.html
Dialogue Interface Reference (Elicitation, Directives)	https://developer.amazon.com/docs/custom-skills/dialog-interface-reference.html
Interaction Model Schema (Skill Management API)	https://developer.amazon.com/docs/smapi/interaction-model-schema.html https://developer.amazon.com/docs/custom-skills/create-the-interaction-model-for-your-skill.html
SSML and Speechcons Reference	https://developer.amazon.com/docs/custom-skills/speech-synthesis-markup-language-ssml-reference.html
Slot Type Reference (Names, Dates, Times, Durations, Numbers - Language based)	https://developer.amazon.com/docs/custom-skills/slot-type-reference.html
Utterances and Slot Types	https://developer.amazon.com/docs/custom-skills/create-intents-utterances-and-slots.html https://developer.amazon.com/docs/custom-skills/best-practices-for-sample-utterances-and-custom-slot-type-values.html
Handling Requests	https://developer.amazon.com/docs/custom-skills/handle-requests-sent-by-alexa.html

GitHub Repositories - $\widehat{GH}$

A Skill Template with API Calls:	https://github.com/skilltemplates/api-starter-alexa https://http://skilltemplates.com
Node.js code Building Responses in Node.js	https://github.com/alexa/alexa-skills-kit-sdk-for-nodejs https://github.com/alexa/alexa-skills-kit-sdk-for-nodejs/wiki/Response-Building
Alexa Cookbook (maintained by Amazon Team)	https://github.com/alexa/alexa-cookbook/
Handling Responses (Multi-turn conversation)	https://github.com/alexa/alexa-cookbook/tree/master/handling-responses
SSML Audio	https://github.com/alexa/alexa-cookbook/tree/0afbfcb8ddcd911e83216b4528b20f3a1628c99f/handling-responses/ssml-audio
Dialog Management and Entity Resolution	https://github.com/alexa/skill-sample-nodejs-petmatch/tree/66cbb8029863444ffa7b51ce22528f29740854bc
Expanded Utterances from template	https://github.com/alexa-js/alexa-utterances
Alexa Server Simulation (Deprecated)	https://github.com/alexa-js/alexa-app-server/tree/master/examples https://github.com/matt-kruse/alexa-app
ASK for Java	https://github.com/alexa/alexa-skills-kit-sdk-for-java
Sample Skills	https://github.com/alexa/skill-sample-nodejs-fact https://github.com/alexa/skill-sample-nodejs-howto/blob/master/instructions/1-voice-user-interface.md https://github.com/alexa/skill-sample-nodejs-decision-tree
Multi-Turn Conversation (Decision Trees)	https://github.com/alexa/skill-sample-nodejs-decision-tree
SDK Development	https://github.com/alexa/alexa-skills-kit-sdk-for-nodejs

Outtakes from a query response read as JSON by the Skill code (Solr Response for Table 3.4)

HTML Tags inside Text


```
{ "d115Description": "Eine Fiktionsbescheinigung wird ausgestellt,
↪  wenn über einen beantragten Aufenthaltstitel noch nicht
↪  entschieden werden kann, z. B. weil<br />\n<br />\n<ul
↪  class=\"list\"><li> ... Ausländerakte ... liegt,</li> ...
```


Ambiguous words that can be a plus for the Virtual Citizen Assistant but become irrelevant or confusing for the Skill (e.g. `Fiktionsbescheinigung`)


```
{... "d115Synonym": [
"Aufenthaltserlaubnis","Aufenthaltstitel","vorläufig",
"Visum","Fiktionsbescheinigung"] ...
```


Inconsistent or unconventional text encoding (e.g. `::: false :::`)


```
{... "d115InfoLaw": ["§ 81 Aufenthaltsgesetz - AufenthG  ::: false
↪  ::: http://www.geset...net.de/aufenthg_2004/__81.html"] ...
```


Text gets lost in translation from reading to speaking or is hard to read out loud


```
{... "d115Prerequisites": [ "Persönliche Vorsprache ist erforderlich
↪  ::: false ::: ",
"Rechtmäßiger Aufenthalt mit oder ohne Aufenthaltstitel ::: Zum
↪  Zeitpunkt des Antrags muss die Antragstellerin oder der
↪  Antragsteller entweder<br />\n<br />\n<ul
↪  class=\"list\"><li>einen gültigen Aufenthaltstitel
↪  (Aufenthaltserlaubnis oder nationales Visum für längerfristige
↪  Aufenthalte - Kategorie D - ) [...]",
"Antrag auf Aufenthaltstitel ::: Eine Fiktionsbescheinigung wird nur
↪  dann ausgestellt, wenn [...] ::: ",
"Hauptwohnsitz in Berlin ::: false ::: "] ...
```



```
{... "d115Requirements": [ "Bisheriger Aufenthaltstitel ::: Soweit
↪  vorhanden, ist der bisherige Aufenthaltstitel mitzubringen, z.B.
↪  der elektronische Aufenthaltstitel (eAT). ::: ",
"Nachweis über den Hauptwohnsitz in Berlin ::: <ul
↪  class=\"list\"><li>Bescheinigung über die Anmeldung der Wohnung
↪  (Meldebestätigung) <strong>oder</strong></li><li>Mietvertrag und
↪  Einzugsbestätigung des Vermieters</li></ul>Mehr zum Thema im
↪  Abschnitt „Weiterführende Informationen\ ::: ",
"..."] ...
```

Not a single readable item price


```
{...."d115Fees": "Ab dem 01.09.2017:<br />\n<br />\n<ul
↪  class=\"list\"><li>Für Erwachsene: 13,00 Euro</li><li>Für
↪  Minderjährige: 6,50 Euro</li></ul>Gebührenfrei für<br />\n<ul
↪  class=\"list\"><li>Türkische
↪  Staatsangehörige</li><li>Asylberechtigte</li><li>
Ausländer, die im Bundesgebiet die Rechtsstellung ausländischer
↪  Flüchtlinge oder subsidiär Schutzberechtigter
↪  genießen</li><li>Resettlement-
Flüchtlinge im Sinne von § 23 Abs. 4 S. 1 AufenthG</li></ul>" ...
```

```
{...."d115ProcessTime": "Die Fiktionsbescheinigung wird bei
↪  Vorsprache ausgestellt." ...
```

Figure 10.2: Request Body (26.04.2018)

```
{"version": "1.0",
 "session": {
  "new": true,
  "sessionId": "amzn1.echo-api.session.[unique-value]",
  "application": {
   "applicationId": "amzn1.ask.skill.[unique-value]"},
  "attributes": {
   "key": "string value"},
  "user": {
   "userId": "amzn1.ask.account.[unique-value]",
   "accessToken": "Atza|AAAAAAAA...",
   "permissions": {
   "consentToken": "ZZZZZZZ..."}}},
 "context": {
 "System": {
  "device": {
   "deviceId": "string",
   "supportedInterfaces": {
    "AudioPlayer": {}}},
  "application": {
   "applicationId": "amzn1.ask.skill.[unique-value]"},
  "user": {
   "userId": "amzn1.ask.account.[unique-value]",
   "accessToken": "Atza|AAAAAAAA...",
   "permissions": {
    "consentToken": "ZZZZZZZ..."}},
  "apiEndpoint": "https://api.amazonalexa.com",
  "apiAccessToken": "AxThk..."},
 "AudioPlayer": {
  "playerActivity": "PLAYING",
  "token": "audioplayer-token",
  "offsetInMilliseconds": 0}},
 "request": {}}
```

Can be used to generate tests in Lambda.
source: ASK DOCUMENTATION [2]

[2] ask/request-and-response-json-reference.html#request-body-syntax

List of Acronyms and Abbreviations

ACID	Atomicity, Consistency, Isolation, Durability
AI	Artificial Intelligence
ARN	Amazon Resource Name
ASR	Automatic Speech Recognition
ASCII	American Standard Code for Information Interchange
ASK	Alexa Skills Kit
AsylG	Asylgesetz, [German] Asylum Act
AVS	Alexa Voice Service
AWS	Amazon Web Serivces
BAFöG	Bundesausbildungsförderungsgesetz
B2B	business-to-business
B2C	business-to-consumer
BMG	Bundesmeldegesetz, [German] Federal Act of Registration
C5	Cloud Computing Compliance Controls Catalog
CC	Creative Commons Licence
CEO	Chief Executive Officer
CIA	Competitive Innovation Advantage
CLI	Command-Line Interface
CSS	Cascading Style Sheets
CSV	Comma-separated values
DCG	Discounted Cumulative Gain
DBMS	Database Management System
EEA	European Economic Area
EU	European Union
FAQ	Frequently Asked Question
GB	Gigabyte
GDPR	General Data Protection Regulation (EU Law)
GUI	Graphical User Interface
HCI	Human Capital Index
HTML	Hyper-Text Markup Language
IBAN	International Bank Account Number
IoT	Internet of Things
ICT	Informations and Communications Technology
IP	Internet Protocol
ITDZ	IT Service Centre Berlin - *IT Dienstleistungszentrum Berlin*
IVR	Interactive Voice Response
JSON	JavaScript Object Notation
kbps	kilobits per second
KPI	Key Performance Indicator
LeiKa	Leistungskatalog der öffentlichen Verwaltung (Federal Catalogue of Public services)

ML	Machine Learning
MP3	Moving Picture Experts Group Layer-3 Audio (MPEG-3)
MVC	Model-View-Controller
MVP	Minimum Viable Product
NLP	Natural Language Processing
NLU	Natural Language Understanding
NPM	Node Package Manager
OOP	Object Oriented Programming
OS	Operating System
OSI	Online Services Index (not Open Systems Interconnection!)
PLZ	Postleitzahl (Postal Code)
ROI	Return on Investment
REST	Representational State Transfer
SLA	Service Level Agreement
SMAPI	Skill Management API
SSDS	Semantische Sprachorientierte Dialogsysteme (Name of underlying Software for Virtual Citizen Assistant)
SSML	Speech Synthesis Markup Language
TF-IDF	Term Frequency - Inverted Document Frequency
TII	Telecommunication Infrastructure Index
UN	United Nations
URI	Uniform Resource Identifier
UTF	Unicode Transformation Format
VUI	Voice User Interface

appx	approximately
app	(Mobile or web) application
capex	capital expenditure, the cost of developing or providing non-consumable parts for the product or system
cont'd	continued
DevOps	Development and Operations
excl.	excluding
Inc.	incorporation
ms	millisecond
no.	number
opex	operating expense, operating expenditure, operational expense, operational expenditure
rel.	relevance
ver.	version

Term Glossary

As some terms were used repetitively throughout this work, this glossary provides a reference to where the terms were defined.

Term	Definition or Definition Section
Access Key	8.1
Alexa	6.1
Alexa Skill	6.1
Alexa Skills Kit	6.2
Amazon Developer Console	6.2
Application ID	required by Lambda. Skill ID in our context
Intent	4.5
Interaction Model	4.5, 7.1
Lambda, AWS Lambda Function	6.2
Lex, Amazon Lex	6.2
Node.js	7.2
Polly, Amazon Polly	6.2
Public Service	1.2
Slot	4.5
Transcribe, Amazon Transcribe	6.2
Utterance	4.5
Web Service	e.g. AWS