A Digital Companion for Air Travelers

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ABSTRACT

Digital voice assistants (e.g., Alexa, and Siri) have increased users' acceptance and expectations in getting immediate help from smart agents available in smartphones and IoT devices. However, such assistants are capable of performing simple tasks that can be accomplished with specific commands, and minimum user interaction, e.g., "play some music". A Digital Companion goes beyond assisting to complete a task upon request, a Digital Companion knows its users, the environment they interact with, and their relationship with other users, it learns with time, gathers information from heterogenous sources, analyzes it, and provides relevant and suitable information and recommendations about available services. Thus, a Digital Companion frees users from redundant, boring tasks; allowing them to focus on the meaningful parts of their activities. In this paper, an instance of a Digital Companion is presented, which combines semantic technologies and speech recognition to provide air travelers with a tool that enhances their experience at airports.

CCS CONCEPTS

• **Human-centered computing** → Ubiquitous and mobile computing; Ubiquitous and mobile computing systems and tools; • **Information systems** → Information systems applications; Spatial-temporal systems; Location based services; • **Theory of computation** → Semantics and reasoning.

KEYWORDS

Digital companion, semantic technologies, knowledge graph, voice interfaces, digital assistants, human computer interaction

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1 INTRODUCTION

The financial accessibility of smart devices has increased everyday user's engagement and expectation on devices and applications that provide assistance on daily tasks. In the home automation domain specifically, assistance is becoming ubiquitous, users are accustomed to give orders to a device using voice commands (e.g., Amazon Echo, and Google Home) and to have an immediate response from such a device; users can even trigger the assistance of a set of devices, e.g., "Alexa turn on the lights", "Hey Google play Grace and Frankie from Netflix". However, the type of interactions and assistance offered by such devices is still limited [8]. Industry and academia are working on providing more natural interactions by enhancing speech recognition [4] and creating a sense of personality for such voice interfaces [2]. Thus, in order to take advantage of the current users' acceptance, willingness, and excitement on Voice User Interfaces and the services they can provide, we propose to look into technologies that can bring users experience a step further towards smarter assistance able to provide personalized services. To this end, we propose the creation of Digital Companions that could assist, guide, and support users in different parts of their lives; whether it is to perform a task that is part of their professional job, or by assisting them in an activity at home.

A Digital Companion (DC) is a smart entity that knows its user, learns from her experiences, preferences, and likes, considers her relationships to other people and organizations and it is constantly assessing available data from heterogenous sources (i.e., sensors and connected devices) in order to contextualize and customize its interactions with and responses to the user [5]. Thus, a DC empowers its user by bringing data, services, and even machine capabilities closer to her, in order to facilitate her life. In this paper, we present a prototype of the DC for the air traveler, which aims at exploring the enhancement of a traveler's experience at the airport by relating information from different sources to respond to the user's request with highly personalized recommendations. Moreover, the DC for the air traveler has a Voice User Interface as embodiment, showing that current Digital Assistants could be made smarter by incorporating semantic and link data technologies to their approaches.

2 THE DIGITAL COMPANION VISION

Digital assistants such as Alexa, Siri, Google Assistant, and Cortana are good examples of how humans are increasingly relying on devices to connect and automate their home, in order to simplify actions through voice commands, and some screen interactions. Such digital assistants have significatively advanced the state of the art for goal-directed conversations. However, the challenge of creating assistants able to hold human-like conversation is still relevant. The aforementioned digital assistants can handle specific, precise requests, but they can be frustrating to interact with due to

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their lack of flexibility in understanding vague requests or using information that was given in previous interactions to handle the latest command [8]. On its side, popular customer services chatbots might be perceived as more user friendly, since they allow for different ways to phrase a request. However, their limited capabilities often direct users to contact human help [3].

To contribute to enhance users experience while receiving personalized assistance, the Digital Companions vision was created. A DC is a helpful cognitive agent that knows the habits of its users, talks to them, support them, and can assist them in performing tasks. Such a companion is able to understand the situation a human is in, understands the role the human is currently playing, her needs and goals. Moreover, a Digital Companion is contextually aware of the environment that surrounds its user. Thus, a Digital Companion is much more than a digital assistant, since it is able to digest, integrate, share, and act upon information, and events, allowing its user to focus on meaningful tasks. A DC should take advantage of the data being produced, and the human interfaces available, in order to customize the user experience, and provide relevant contextualized responses. To this end, the companion should have access to various modalities of presentation and explanation. Thus, when voice is enough and convenient to communicate, it should be used, but when additional information is required, visual modes or other appropriate means of presentation should be considered and used.

3 THE DIGITAL COMPANION FOR AIR TRAVELERS

For the past three decades the financial importance of the retail industry in airports has increased significantly, what once was a utilitarian infrastructure, has become an experiential one [6]. A wide range of restaurants, shops, and unique services are offered to travelers that expect to be treated as high value customers once they have passed the security check points. This financial relevance has been the driver of numerous studies to rate and enhance the air travelers experience [1][9]. Technology has played an important role in providing travelers with easy access to flight, and location information through large displays installed across terminals and online access to relevant information about flights.

However, airport visits remain stressful; travelers need to proactively get informed of all the required procedures, and the time it takes to complete them in order to board their flight. In the best scenario, the time spent at those procedures only includes baggage check-in, security filters, and time to get to the corresponding departure. Travelers should be prepared, in case time is scarce, to not complete additional desired activities, such as being able to get something to eat, browse the shops, or go to duty free for last minute gifts. In less ideal but common cases, travelers face change of gates, congestions at the security filters, and hours of waiting due to delays or loss of connecting flights. To provide passengers with a better experience, airlines are slowly making progress in informing travelers about gate and flight time changes through SMS or apps notifications. However, this communication remains constrained to the airline information. There is no integration of different sources of information that comprehend airport operations (e.g., security checkpoints, and passport control), commercial spaces, and waiting-spaces affluence. Thus, it is not rare to see angry, exhausted travelers running around the airport, trying to gather all this information themselves.

3.1 Approach

As digital assistants (e.g., Alexa and Google Assistant) improve their voice recognition, and natural language processing capabilities; they are able to search for terms on the web and are getting better in following simple commands, e.g., "Call Mr. Federer!", "Turn on the TV!" However, their capabilities are still limited when users give complex commands or ask questions that require gathering information from different sources. Moreover, their contextual scope is limited, since in the best case, these assistants are able to recall a few immediate interactions to respond to the current command.

The proposed DC takes advantage of the power of semantic technologies and uses the convenience of a popular digital voice assistant to communicate with travelers, as well as the efficiency of visual displays to convey messages. Following, we present two versions of the DC: a kiosk, and a mobile version.

On the one hand, we envision ubiquitous instances of DCs across the airport in the form of digital help desks, which can be conveniently used by travelers without having to download an app. These kiosks provide general information about the airport and its operation, such as security check point times, status of flights, location of commercial areas, and services available. This information is provided to the travelers upon explicit requests for what they are looking for. On the other hand, travelers can benefit from a personalized version of the companion. The mobile version of the companion provides relevant and customized information to the traveler by considering the user's schedule, preferences and likes, habits, and location, matching this information to the current operations of the airport, and the known commercial establishments.

The DC for air travelers is able to answer general questions such as "How long does it take to pass the security filters in Terminal 1?", "What is the status of the AF87 flight?" and questions that require personalized information about the traveler, such as "Where can I buy my favorite chocolate before my flight takes off?" or "Are there any shops where I can get a gift for my husband?" To answer the questions in both DC versions, information is retrieved from different sources, such as:

- Knowledge about the airport, including location of gates, shops, and restaurants
- Contextual information about airport operations, shops, and user (e.g., current waiting times at security checkpoints, shops currently open, and user location)
- Knowledge about shops (e.g., which shop is known for selling chocolate)
- Knowledge about flight departures times and gates (i.e., the DC should suggest a shop to buy chocolate on the way to the traveler's gate or close to it)
- Knowledge about the traveler, her habits, and preferences. (e.g., scheduled flight, type/brand of favorite chocolate, knowledge about her family, and their likes).

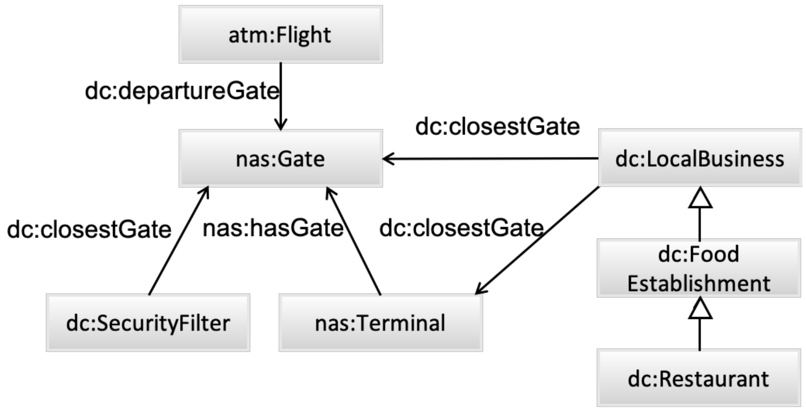

Figure 1: Integrating ontologies by relating their concepts

3.2 Knowledge for the Digital Companion

The Open Semantic Framework (OSF) [7] is an engineering solution that supports the collection, curation, and access to ontologies that encapsulate knowledge and experience in a machine-understandable way. The objective of this framework is to foster the use of semantic technologies by providing non-ontologists with relevant knowledge models that can be reused across different semantic applications. Since significant time and cognitive effort can be saved by using models that domain experts have already agreed upon, the knowledge models that OSF manages are mostly industry standards. Moreover, by incorporating standardized knowledge models into semantic applications, systems and applications become interoperable, which is a fundamental requirement for having ubiquitous services that interact with each other.

OSF provides two types of knowledge models: core and domain specific. The core ontologies include general knowledge models that capture concepts that cut across domains, such as information about units and dimensions (e.g., QUDT), sensors (e.g., SSN), governance (e.g., VoAG) and provenance (e.g., W3C PROV). The domain-specific ontologies are made available to be used in combination with core ontologies in order to create Knowledge Packs (KP) for a specific application (e.g., OpenADR and FSGIM for smart grid and BACnet, and IFC for smart buildings).

In order to take advantage of reusable standardized ontologies, the Air Traffic Management (ATM) ontology developed by NASA was used. The ATM ontology's objective is to integrate data across multiple sources of heterogeneous air traffic data, including the US Federal Aviation Administration (FAA) and the US National Oceanic and Atmospheric Administration (NOAA).

The KP that was created for the DC for air travelers includes: a) the ATM NASA ontology, along with the available instances from the operation of airports in the New York area on July 15th in 2014, b) the friend-of-a-friend schema (FOAF) for describing the travelers, c) concepts from the QUDT ontology for units, and dimension (e.g., meters, and centimeters), d) concepts from schema.org for describing the commercial areas available, and e) some additional concepts that were introduced to complete the traveler's description, and airport facilities that are not described neither on the ATM ontology, nor on schema.org.

As an illustrative example, let us consider Figure 1, which shows the integration of a few classes described in different ontologies.

The `atm` and `nas` namespaces are part of the ATM ontology, while the `dc` namespace corresponds to the DC ontology that imports concepts from schema.org to enrich the airport operation description with commercial and service areas. As shown in Figure 1, the `Flight` class is related to `Gate` through the `dc:departureGate` property, while the `LocalBusiness` class which is the parent of the different commercial places (e.g., `FoodEstablishment`) is related to the `Gate` class through the `dc:closestGate` property. In this way, by just having a flight number, it is possible to find out the shops, and restaurants that are more convenient for a traveler taking the corresponding flight.

3.3 Implementation of the DC for Air Travelers

In order to implement a prototype of the DC for air travelers, we considered the most popular digital assistants: Amazon Alexa and Google Assistant, given that they are native on smart speakers (i.e., Amazon Echo, and Google Home), which could be used for the kiosk version of the companion. We chose Google's solution (i.e., Actions) since it is the preferred assistant for Android devices and can be easily configured to be called from Siri in iOS. Moreover, ease of integration of Google's solution with other software components made the candidate stronger.

An overview of the software components is shown in Figure 2. Through a Google Home device or a smart phone with access to Google Assistant, a user's voice request is received. The request is handled by Google's cloud service, which in turn communicates with the Digital Companion web service in charge of retrieving an appropriate response to the user request from OSF, the component in charge of managing the knowledge.

Given that a map is the most intuitive way to provide directions to a user, it was decided to have a combination of voice and a visual interface to help user's with location. Thus, in addition to the voice response delivered by the Google Assistant, the web service makes the information available on a map shown on a screen near the user, or on a mobile device.

The Digital Companion starts its operation when the traveler interacts with a Google Home device (i.e., kiosk version), or

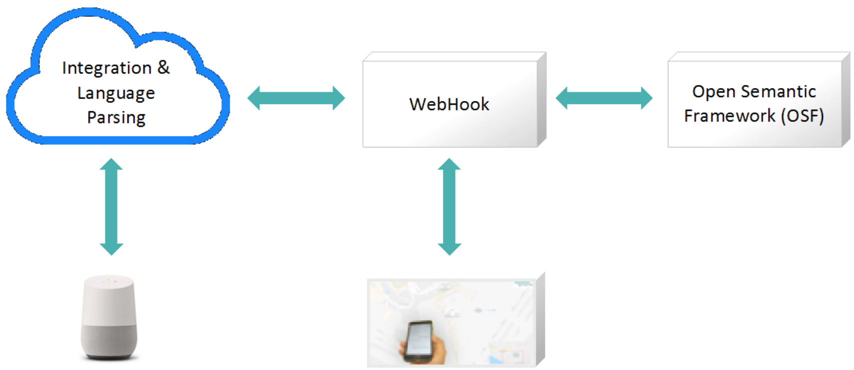

Figure 2: Digital Companion Software

her smartphone (i.e., personalized version). The request is translated into text to activate the corresponding agent on the Google cloud service. The Agent handles the conversation through Dialogflow. Dialogflow maps a user's utterance to an intent, which is a parametrized representation of the user's request. The parameters are extracted by comparing the user's utterance to a set of labeled training phrases. This gives the user more flexibility when phrasing the request (i.e., use words synonyms).

The intent is passed to the DC web service. The DC uses the type of the intent (e.g. "buy food" or "flight information") and the parameters (e.g. type of food like "chocolate" or flight number) to obtain the relevant information from OSF. The advantage of using a semantic backend versus other approaches is that the information that in other cases would be scattered across different sources is found in one place in a structured and connected manner, which gives meaning to otherwise isolated data. Moreover, more knowledge can be inferred, and discovered from single pieces of data, given that the semantic backend holds meaningful representations of the domain at hand (i.e., air traveler).

For the DC for the air traveler, current data about the airport operation is related to airline data in order to determine the time a traveler will take from the security check point zone to the gate assigned to her flight. Moreover, information about the habits and personal preferences of a traveler can be related to commercial spaces, to make recommendations about shops, or restaurant the traveler might like. Finally, as mentioned before, the response to the traveler request is delivered by combining voice directions with a map, which has been implemented as a JavaScript application.

3.3.1 Scenarios. Three scenarios were considered in the built prototype: a general information scenario (i.e., kiosk), and other personalized ones (see https://youtu.be/Jj_jPiHNkiI).

General Information

Through the kiosk version of the Digital Companion (see Figure 3), a traveler asks questions in the traditional *digital assistant* way e.g., "Where can I get something to eat?" or "Show me where Gate A12 is!" Although this DC does not know the traveler, it takes advantage of the semantic backend to answer questions that require information that otherwise would be unrelated and scattered in different information sources. In this case, the companion knows about the location, and status of the airport operation places (e.g., security checkpoints and passport control), commercial spaces, and airlines information (e.g., flights, gates, delays). Even security checkpoints, and passport control waiting time can be considered. If the DC needs to clarify the user's question it does it by asking for context information:

Traveler	Where does my flight depart from?
DC	What is your flight number?
Traveler	My flight number is AF00
DC	Flight AF007 departs from gate A45, terminal 5 at 6pm, check out the map to see the location of the gate

Brad Scenario

The personalized version of the Digital Companion (see Figure 4) creates instances of the `foaf:Person` class to integrate information specific to the traveler. The traveler uses his smartphone to ask questions to the companion, which in turn responds with voice instructions, and shows relevant information on nearby displays. In this case, the companion not only knows the airport operations (e.g., security checkpoints), commercial spaces, and airlines information, but it also has information about Brad's travel plans, likes and preferences. Thus, the companion is able to highlight restaurants, and fun activities that Brad might enjoy, during his time at the airport without having to ask for his preferences. However, the DC does not limit Brad to choices he had made before, the DC is capable of recommending popular local choices that Brad might be willing to try out, giving his current context (i.e., restaurant is open, and located in the same terminal as Brad). The dialogue below shows how Brad's conversation with the DC is shorter and more personalized than in the kiosk version. The DC does not need

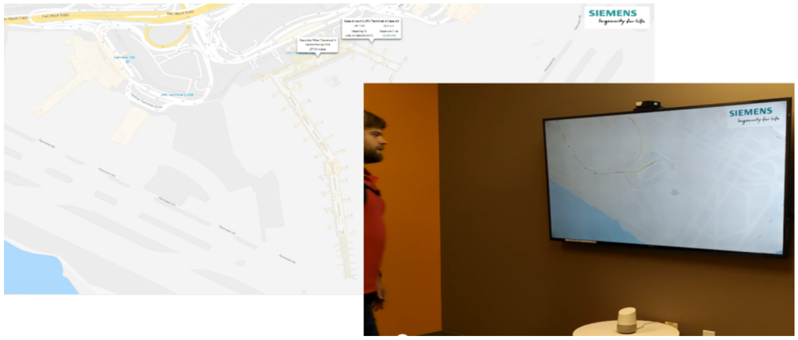

Figure 3: Digital Companion - Kiosk Version

to make clarifying questions to provide Brad with personalized relevant information.

Brad:	I need information about my flight
DC:	Your flight departs from gate A45, terminal 5, at 6pm
Brad:	What if I am hungry?
DC:	Your favorite food is Italian, right? I marked some restaurants on the map for you
Brad:	Are there any fun activities?
DC:	Knowing your preferences, I marked some aquarium locations on the map

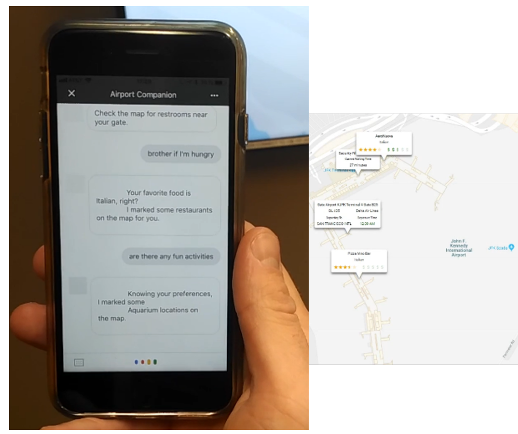

Figure 4: Brad's Digital Companion makes personalized, and convenient suggestions

Claire Scenario

As the Digital Companion gathers more information about the user and aggregates it with other users, and information sources, it is able to provide more personalized and relevant recommendations. The dialogue below shows that Claire's Digital Companion is able to retrieve another person's (her husband Ethan's) information and likes, since the person is related to Claire through a family link.

Claire:	I would like to get a gift for my husband
DC:	Knowing Ethan, I think he would enjoy something from the perfume stores I marked on the map
Claire:	Is there a restroom around here?
DC:	Check out the map to see restrooms locations

As in Brad's scenario, Claire also uses her smartphone to interact with her Digital Companion, who is able to show information on displays near her.

4 CONCLUSION AND FUTURE WORK

In this work, an implementation of an instance of a Digital Companion was presented. A DC is a smart agent capable of providing guidance, support, and aid to users in the different aspects of their lives (e.g., at work and at home). As demonstrated, the DC for the air traveler offers information about personalized convenient places that a user can go to. However, in order to personalize the user experience, privacy should be of high priority. Thus, as part of future work, the following challenges will be addressed: 1) anonymize personal data, as new functionalities that could potentially collect highly sensitive data are incorporated (e.g., data to compute waiting spaces occupancy); 2) incorporate configuration mechanisms to allow users to proactively restrict the people they want to share their information with (e.g., members of my immediate family can see preferred restaurants, but not friends); and 3) add learning capabilities of the Digital Companion as more data is collected when users travel, 4) user studies to address potential user interaction difficulties.

The DC for the air traveler is an example of how users can be provided with an enhanced experience from devices, information, and resources that are already available, but scattered. The implementation of Digital Companions in diverse areas goes hand and hand with the deployment, of connected devices, since they provide the perfect sources and ecosystem for a DC to be able to gather data and provide useful information and services to the users. Moreover, voice interfaces are only one modality to communicate with the user, other user interfaces should be explored.

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