IEEE Access
Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

Received July 8, 2020, accepted August 13, 2020, date of publication August 20, 2020, date of current version September 1, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3018331

From Things to Services: A Social IoT Approach for Tourist Service Management

GEORGE ALEX STELEA[1], VLAD POPESCU[1], (Member, IEEE), FLORIN SANDU[1], (Member, IEEE), LANA JALAL[2], (Member, IEEE), MASSIMO FARINA[2], AND MAURIZIO MURRONI[2], (Senior Member, IEEE)

[1]Department of Electronics and Computers (DEC), Transilvania University of Brasov, 500019 Brasov, Romania
[2]Department of Electrical and Electronic Engineering (DIEE), CNIT Reasearch Unit, University of Cagliari, 09123 Cagliari, Italy

Corresponding author: Vlad Popescu (vlad.popescu@unitbv.ro)

This work was supported by the Autonomous Region of Sardinia-Italy (Piano Sulcis Research Grant SULCIS-821101 and Marinanow 3.0 Research Project).

ABSTRACT In the context of Internet of Things (IoT), the cooperation and synergy between varied and disparate communicating objects is strained by trustworthiness, confidentiality and interoperability concerns. These restrictions can limit the development of IoT-based applications especially considering the emergent boost in the number of communicating objects and their growing itinerant nature in a collective service context. A new perspective arises with the paradigm of Social Internet of Things (SIoT), that relies on the implementation of semi-independent communicating objects with cooperation assessed by social relations and social feed-back. In this article, we present the development and expansion of the IoT concept towards SIoT in the context of the interactions between tourist services as communicating objects. As a proof-of-concept we propose a composition of services as virtualized social objects and the interaction between them, by taking into consideration the balance, trustworthiness, cooperation and synergy of services. Furthermore we present a solution to integrate also accessibility in SIoT services. The presented concept is presented using a demonstrator build for tourist services.

INDEX TERMS Enhanced accessibility in SIoT, socially active virtual services, services as virtual objects, socially aware trustworthiness, the social Internet of Things, tourist service management.

I. INTRODUCTION

The advancements in communication technology has been dramatic in the last decade. The increase of data traffic and sharing has changed the scenario where beside humans also objects have been allowed to be part of the play. The Internet of Things (IoT) concedes any device which can be uniquely recognized to interact with a user. The interactions and connections between the devices and their users can be largely intricate [1], requiring new concepts for the management, trustworthiness and the interaction hierarchy [2]. The new ''social'' paradigm added to the IoT (Social IoT - SIoT) concept means applying a social structure to the things by mapping natural social links to the digital space. In this perspective, data science become fundamental to enable reliable communications for trusted and secure data sharing.

The associate editor coordinating the review of this manuscript and approving it for publication was Rakesh Matam.

The social cooperation among people follows the interaction among them and defines the connection that unites them. The type of connection mirrors the social link among the interlocutors, and the strength of kinship that binds them. It can strongly influence the nature of their interactions [4]. The SIoT allows devices to exploit the social interactions and links among humans to achieve reliable navigability. The SIoT can be expanded beyond the original IoT boundaries, to extend the benefit of the paradigm as to include, besides things, also services, creating an extended applicability in social strategy for highly effective mobile marketing [3]. In the service scenario of SIoT, the end user does not intervene in the process of things, but only gets the service it needs at the end of the chain, the intermediate steps being taken away from the organizational complexity [5]. The potential applications can be extended to all areas, such as environmental management, inventory, home automation, surveillance, tourist services and so on [6], [7].

The interest for the advancement of the knowledge of the developed service models lies in the use of the SIoT paradigm that was so far aimed only at the modeling of physical objects through virtualization, identifying social relations, oriented to services to their virtualization and their dynamic composition based on rules of social interaction [8]. The main novelty of the present paper consists in the translation of the Social IoT paradigm from things to services, enabling the services to exploit social links and interactions of humans so as to achieve reliable feedback and navigability. As far as the author's knowledge, this approach is new in the SIoT theme, and simulations or implementations are not yet covered by scientific studies. By putting services in a social relationship, the SIoT paradigm can change orientation, from an approach focused on the objects on which the most recent studies and implementations have been concentrated, to an approach oriented towards the application the and user.

An interesting application field for the SIoT paradigm can be the management of tourism and cultural heritage, which nowadays is still anchored to a traditional approach that has consequences on the mobility and travel sector, in consideration of the change in habits towards a growing independence of the tourist, with increasingly ''social'' and ''digital'' behaviors [9]. To overcome these problems, a SIoT approach can be adopted to allow tourist and cultural heritage services to interact dynamically with the end users. The ''social'' concept, promoted among others by Twitter, Facebook and Instagram, applied to tourist services, would allow these services to become intelligent, cooperating social entities, capable of interacting with each other and with end users using the now daily rules of ''digital friendship'' [10]. Using these forms of socialization, the relationships between services can evolve towards autonomous structures that maximize the benefits in terms of research and filtering, managing their reliability and the data on which they are based [11].

The main objective of this paper is to create the models and methodologies for cooperative services based on the concept of social interaction between users and services and between the services themselves. These models and methodologies are based on the SIoT paradigm and the related interaction methods, extended from the world of objects to that of services [12].

The specific objectives of this work are the enhancement of service trustworthiness, composition and social interaction and the development of a demonstrator on a SIoT platform for the dynamic composition of services for the tourist and cultural heritage sector. The paper is structured as follows: section II presents the related work and introduces also the concept of services as virtual objects, section III describes the architecture used for the dynamic composition of services, while section IV discusses the parameters for the trustworthiness of the services. Section V is dedicated to the implementation of the demonstrator and section VI draws the conclusions and presents the future work to be done.

II. RELATED WORK

The myriad of smartphones, with their increasing capabilities, boosted up and complemented by the new 5G networks, can boost applications in many domains, allowing enhanced correlation between the user surrounding context and the applications based on the context-awareness in smart systems [13].

In [14] Kasnesis *et al.* introduced the use of smart software agents in order to enable SIoT in the Cloud and to define smart objects profile and life cycle using semantic rules and embedded descriptive files. SIoT applications come with some intrinsic problems in terms of navigability, search response time and link selection [15]. The latter SIoT problem is tackled in [16] using algorithms that follows the key properties of navigability in so-called ''Small World'' networks for enhancing object navigability in the SIoT by restricting the number of connections for objects. Another approach for enhancing navigability is an enhanced information searching algorithm for SIoT [17] inspired on information searching algorithms from drone networks [18]. Within this context, the authors of [19] investigate the search of suitable friendships and requested services in the SIoT world without human involvement, so typical for an SIoT scenario.

The evolution of cooperative services and the social interaction between users have in a certain sense ''opened the borders'' also from a tourism point of view: travelers have now the possibility to choose the destination in advance, to study the best solution according to their journey type (transportation means, choice of accommodation, food, entertainment, etc.) thanks also to the experiences of others and, at the end of the experience, to provide their opinion [20] as a feedback. Digital platforms for tourism such as Tripadvisor and Booking classify tourist facilities based on the reviews of their users, providing their clients with a parameter for assessing the reliability of the requested service.

Following the same principles, Wise *et al.* are presenting a concept of developing smart tourism destinations and its potential for smart cities and are outlining the need to integrate social media and content marketing concepts in the emerging smart tourism paradigm [21].

The willingness to share information by tourists and their ''social'' vein is most of the times misaligned with the reduced knowledge or even unawareness by the tourist service providers (especially the institutionalized ones) of the benefits that a certain type of networking could bring in terms of visibility [22]. Diversification based on demand and on different categories of users would open new market segments that could also guarantee benefits in terms of seasonal adjustment of demand. End-user satisfaction inevitably passes through the quality of the service offered and for this reason the service provider must always be present, competent and available, and to ensure that he is active also in a ''social'' key [23].

Forging direct relationships with end users is the first step in involving users in the destination promotion process. In this

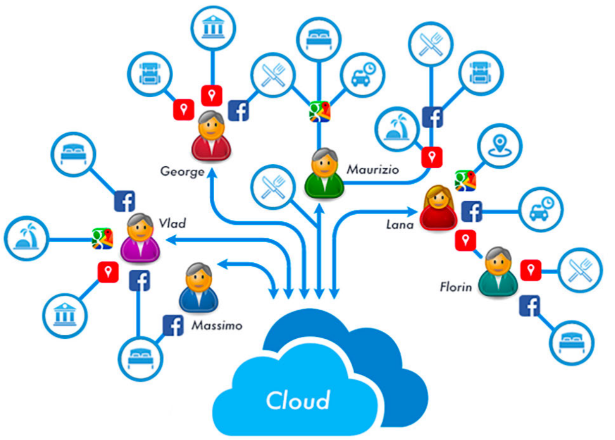


FIGURE 1. Diagram of SIoT architecture.

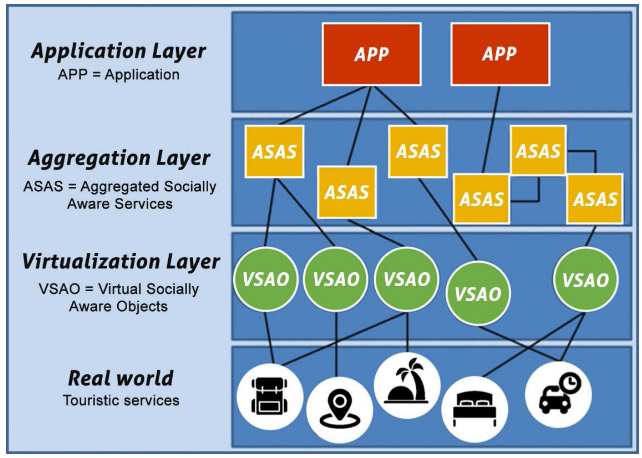


FIGURE 2. Functional levels of the proposed architecture: Real World, Virtualization, Aggregation and Application.

direction, a wide range of frameworks and digital implementation of the SIoT concepts have been recently proposed to strengthen the sustainable mobility in tourism development based on proactive participation of tourists, local citizens and city administration to enhance safety, reduce fraud and the lack of feed-back and availability of proper information about resources and tourist attractions [24], [25].

Despite the evolution in this field, the synergies between the various tourist services are still weak and unable to exploit the vast possibilities offered by the new technologies. The management of tourism and especially cultural heritage is in fact anchored to a traditional approach, based on the dissemination of information in both printed and digital form, but which generally does not allow exploiting all the new applications available for mobile devices and, above all, does not take into account the greater information content that could be generated by the sharing and interaction between end users [26].

Therefore the need emerges for a new, transversal approach based on technological innovation for the distribution of tourist services. Furthermore, technological innovation could also permeate the cultural heritage sector, a primary source for tourism, where, however, the obsolescence of supply models compared to private tourism makes the development path more tortuous and complicated.

III. ARCHITECTURE

The SIoT architecture for the dynamic composition of services is composed of 4 functional levels: the lower level is formed by real-world services, which are digitized in the level of virtualization above. This second level consists of Virtual Socially Aware Objects (VSAO) that represent the abstraction of a real world service in terms of functionality and contextual information [27]. The third level, aggregation, is responsible for combining one or more VSAOs in order to create entities with increased functionalities called Aggregated Socially Aware Services (ASAS) that can inherit all or part of the functionalities of the VSAOs from which they are composed. The last level is the application level where the macro services for users are composed [28]. By macro service we mean a service formed by the composition of the services provided by the ASAS and represents the service as perceived by the user. The social behavior in virtual socially aware objects is implemented through the Socially Aware Parameters (SAP) extending the functionality of the VSAO with enhanced trustworthiness and management [29].

The presented architecture allows the abstraction of real world services as virtualized objects that can be combined, once registered on the platform, in a static or dynamic manner using models of social relations and socially aware parameters. The "social" functions of the platform can be used both for the composition of new entities, and for the smart interaction between various VSAOs through trustworthiness and recommendation mechanisms.

By modeling tourism services and cultural assets as VSAOs, it is possible to study the relationships between services and their evolution towards autonomous structures that maximize the benefits in terms of search, management and exploitation of the data on which they are based [30]. In doing so, tourism services may be able to interact socially with users and among themselves in an enhanced and smart, socially aware manner.

IV. SOCIALLY AWARE TRUSTWORTHINESS

A. ESTABLISHING SOCIAL INTERACTIONS

Establishing social interactions requires new capabilities attached to communicating objects and services which go beyond the common capabilities of the classic objects [31]. One object needs first to choose the nature of the connection and the trustworthiness that it will build with others in order to subsequently interact according to a social relational paradigm. Hence, we introduce a hierarchy of Socially Aware, Geographical and Service Quality parameters that will allow the virtualized services to choose an appropriate type of relation according to these parameters [32].

Similar to the world of human beings, relationship types can influence social interplay between communicating objects mainly at the levels reliability and of trust between participants. A known object with which we have had more interactions so far is more trustworthy than an foreign object, with which there has never been any interaction.

Also, again in an analog manner to the human world, the connections inside a family create a high degree of confidence among its representatives, as opposed to a connection among colleagues or persons with no connection between them. The more powerful the connection between individuals, the stronger the cooperation between individuals and the higher the levels of trust and management [33].

Based on the aforementioned social considerations, we propose a new metric for characterisation of services, specifically designed for tourist services, called Trustworthiness Coefficient (TC). The formula of the proposed TC includes one geographical parameter (Distance), three socially aware parameters (Rating, Like and Check-in) and one service quality parameter (Content):

$$TC = (D * \alpha)+[(R * \beta)+(L * \gamma)+(Ch * \delta)]+(C * \epsilon) \tag{1}$$

where *D, R, L, Ch, C* are parameters and α, β, γ, δ and ϵ are variables whose value depends on the implementation type (will be detailed in section C).

B. PARAMETERS

The establishment of a relationship with a certain level of trustworthiness relies primarily upon on the attributes and values of the virtualized object, to which are added distinctive types of parameters. These parameters are characterized by the scope and purpose for the realization of its activities.

- *Distance (D):*
  The distance is the geographical parameter in our algorithm and can be associated with a pair or a clusters of services in order to express different types of itineraries. The service cost metric can be defined according to a geographic area, an operating environment or an application, using various methods, from the Haversine formula to an API based algorithm like Google's Distance Matrix API. The distance variable can be calculated as a mathematical sum or as a decision tree as shown below:

$$D = \begin{cases} 1.0 & \text{if} < 100\,metres \\ 0.9 & \text{if} > 100\,metres\,\&\, < 500\,metres \\ \ldots & \\ 0.1 & \text{if} > 10000\,metres \end{cases} \tag{2}$$

  In the presented demonstrator the trustworthiness coefficient is used for tourist services, especially for the purpose of recommendation, therefore next to the socially aware and service quality parameters, which will be presented next, Distance is a necessary geographical parameter to create the aimed recommendations ranking. In the area we have used, the parameter changes its weight in a chosen range from 100 meters to 10 km, but depending on the desired geographical area, it can be modified as appropriate.

- *Rating (R):*
  The rating, a socially aware parameter, is defined in a comparative manner based on performance, characteristic or quality. Depending on who carries out a rating in a crowdsensing context, a distinction is made between internal and external ratings: ratings can be gathered external from third party social media platforms or socially aggregated hyperlinks, or internal as integrated in proprietary systems. Transformation tables provide a comparison of the various rating methods and clusters used by different platforms. In our case, this scale includes 6 rating levels and the rating class assigned to a rating object is the result of the consolidation of individual trustworthiness criteria. Equation (3) presents the formula which evaluates the rating of a service using for example the Google Places API:

$$R = \begin{cases} 1.0 & \text{if} = 5\,stars \\ 0.8 & \text{if} = 4\,stars \\ 0.6 & \text{if} = 3\,stars \\ 0.4 & \text{if} = 2\,stars \\ 0.2 & \text{if} = 1\,stars \\ 0 & \text{if} = 0\,stars \end{cases} \tag{3}$$

  The Rating parameter can be calculated in a similar manner by considering also other rating mechanisms typical for other online platforms such as Tripadvisor or Booking.com.

- *Like (L):*
  With a Like, users of social networks express that they like something or support something (the so-called "liking" mechanism). In many social platform, visitors are given the opportunity to "like" other people's posts via certain buttons. The types of application vary between the option of just casting a positive vote (e.g. on Instagram) or giving a favorable or disapproving rating (e.g. on YouTube). This socially aware parameter can be integrated in the calculation of our TC coefficient coming from well-known social platforms such as Facebook, a decentralized social platform such as Friendica, or as a proprietary function in a custom software.
  For the implementation and computing of the like parameter in this demonstrator we used the Facebook API offered as an open source instrument in the Facebook Developer Tool, which provides the option to analyze and operate social relations between users at the first and second level (e.g. friend or friend-of-a-friend):

$$L = \begin{cases} 1.0 & \text{if} = 100\,Likes\,from\,direct\,friends \\ 0.8 & \text{if} = 100\,Likes\,from\,friends\,of\ \ friends \\ \ldots & \\ 0.2 & \text{if} = 2\,Likes\,from\,direct\,friends \\ 0 & \text{if} = 2\,Likes\,from\,friends\,of\ \ friends \end{cases} \tag{4}$$

As it can be seen in the above formula, the parameter has a higher value for first-hand likes coming from friends, as opposed to the ones arriving from the friends of friends.

- *Check-In (Ch):*
The Check-In is the third socially aware parameter used for the social trustworthiness management. Some social networks allow their users to ''check-in'' to a real location, telling friends or other users where they are. Check-In takes place via a mobile app on a smartphone, or a custom progressive web application [34]. The basis is the localisation of the user via the integrated GPS of the used device. The operators of the social networks evaluate the actions and in particular the ''check-ins'' of their users in order to offer individual customer profile suggestions or recommendations. In our approach these transactions carried out by the users are continuously stored in the data processing system and used for user relationship management purposes.

$$Ch = Value \quad \text{if} \quad Friends > F \quad \text{in} \quad Time \tag{5}$$

where:
$Value = 0$ or 1, $F =$ Integer (number of friends) that checked in a certain *Time* interval (expressed in hours). The structure of the check-in parameter is presented in equation 5. The parameter is calculated by our demonstrator using the Facebook API and taking into account the time of the day when the check-in was performed. For example, in our formula we took into account the minimum value $Ch = 0$ if no friend checked in at the specified location and the maximum $Ch = 1$ if 10 friends checked in in the last 10 hours. We chose these values for demonstration purposes depending on the size of the geographical area in which we tested the demonstrator. The number of these constants can vary depending on the area in which it is desired to implement it. For example, in a relatively large city the number of check-ins in a location in a short time will be higher than the number of check-ins in an area where the population density is lower. The *Ch* parameter influences the trustworthiness coefficient positively only if the check-ins of friends are detected, if those are absent and $Ch = 0$, it will be considered null in the formula and will not negatively influence the coefficient.

- *Content (C):*
For characterising the content of a service we can take into consideration both quantitative (e.g. photos) and qualitative (e.g. website, phone) factors. The ''Photos'' parameter has been chosen as a quantitative parameter, assuming that more pictures of a service implies greater care and an increased level of information, whereas for example the ''Website'' parameter is considered a qualitative parameter due to the effort submitted for the creation of a web page, thus assuming that the service offered is of higher quality. Each parameter has different weights in the coefficient depending on the importance of each one for the implementation type.
Below is presented the content parameter formula based on the usage of the Google Places API.

$$C = (C_1\,(0.2 * F) * 0.45) + (C_2 * 0.30) + (C_3 * 0.25) \tag{6}$$

where

$$\begin{aligned} C_1 &= from\,0\,to\;1,\; each\,photo\;F\;counts\,0.2 \\ C_2 &= boolean,\; existence\,of\;\; website \\ C_3 &= boolean,\; existence\,of\;\; phone\,number \end{aligned}$$

C_1 is a parameter that takes values from 0 to 1: 0 (if no picture is present in the Google Places API), 0.2 (if 1 picture is present), 0.4 (for 2 pictures), 0.6 (3 pictures), 0.8 (4 pictures) and 1 (if 5 or more pictures are present). C_2 and C_3 can take the value 0 or 1 if the website and the contact phone are present or not.
In the worst case, if the location does not have any picture, website or phone number, we assume that it does not offer a high quality service and C wa value of 0, if instead a location has both website and contact number, as well as at least 5 images then $Ch = 1$ (maximum value) considering that it is a location that has been taken care of in terms of interaction with tourists and offer valuable services and the level of trust is high.

VARIABLE	CIRCUIT	A to B
α	0	0.35
β	0.30	0.20
γ	0.25	0.15
δ	0.25	0.15
ε	0.20	0.15

FIGURE 3. **Touristic itinerary: circuit versus A-to-B route.**

C. VARIABLES

In order to compute the Trustworthiness Coefficient (TC) presented above, each parameter has an associated variable that actually represents a weight depending on the implementation type of the desired itinerary. Thus we defined the following weights: α for Distance (D), β for Rating (R), γ for Like (L), δ for Check-In (Ch) and ϵ for Content (C).

As a use case of tourist implementation of the TC we have chosen two types of itineraries, one from a point A to a point B, thus creating a path with a starting point and a final one, and as an alternative a circuit type itinerary, where the user will return at the end to the point of departure. The value of the parameters for the two cases is different because each type of implementation has its own representative features.

The weights of each associated parameter were chosen experimentally depending on the type of circuit and the geographical area. Based on the type of tourist service and the region in which these weights are applied, they may have values that can be modified and adapted according to the local particularities.

D. ACCESSIBILITY AS ENHANCED VALUE

Another sore point of tourist services concerns promotion policies, too generalist and not oriented to the needs of the demand: new categories of potential tourists, such as the elderly and disabled, that would be willing to travel in case the service offers are in line with their particular requests [35] are in most cases not taken into consideration [36]. The diversification in function of different categories of users would open new market segments that could guarantee significant benefits. This could be accomplished by merging data, as well as its subsequent analysis and purpose-based evaluation [37].

The principle of development in our solution is in fact the versatility, so that whatever the field of application, the rules that will determine the accessible trustworthiness social relations between services, applications, users and any other social element of the system considered, will generally be the same. Regardless of the type of relationship, both horizontal and vertical [38], there is always a layer of social relations and socially aware parameters integrated with the accessible trustworthiness dictated by the same model developed within the project and integrated on the platform [39].

The formula below illustrates the proposed Accessible Trustworthiness Coefficient (ATC), including the previously introduced TC and a new parameter, Accessibility (A):

$$ATC = (TC * 0.45) + (A * 0.55) \tag{7}$$

The Accessibility (A) parameter was introduced to ensure a reliable amount of trustworthiness for people with different degree of disabilities who are in need of assistive technology or features in order to take advantage of the offered services:

$$A = \begin{cases} 1.0 & \text{if } \textit{has full equipment for the disabled} \\ 0.7 & \text{if } \textit{has } 70\% \textit{ equipment for the disabled} \\ \ldots & \\ 0 & \text{if } \textit{has no equipment for the disabled} \end{cases} \tag{8}$$

V. PRIVACY ASPECTS

All technologies based on big data must deal with the legislation dedicated to the circulation of information. The biggest problem arises when the information being processed is data related to real persons. In SIoT, the large amounts of data that is exchanged concerning the services offered to people might include user data or user behaviors. The risk is very high because the behavioral patterns of each human person could be concentrated in larger databases and used for illicit purposes [40]. To avoid these problems The European Parliament adopted precise rules which are contained in the Reg. (UE) 2016/679 (in short GDPR) [41] and which were already tacked by the European Union (EU) years before. Article 25 of the GDPR provides a general obligation to be respected when designing goods or services: this rule is called ''data protection by design and by default''. According to this rule, a preliminary study on the project to be developed is always necessary in order to identify whether personal data is involved and, if so, to apply the rules to guarantee the rights contained in art. 5.1 of the GDPR: lawfulness, limited purposes, minimization, accuracy, limitation of conservation, integrity and confidentiality. With GDPR, privacy becomes a design constraint and, as a result, protection measures must be implemented by default. The architecture and the demonstrator presented in this paper are based on the interactions between online services, consequently it was subject to a preliminary analysis in compliance with the ''data protection by design and by default'' rule. The first aspect considered was related to the type of information processed, in order to understand if it personal data or not. This detail is fundamental, because the presence or absence of personal data [42] is the determining element to understand if the GDPR is applied. This first analysis revealed the possible presence of personal data only in the initial phase, i.e. in the phase in which the analysed services make available information related to the identity of real persons. However, this type of information is not collected by our platform. All the collected data does not require connection to a specific person: e.g. we gather information on how many (and not which) people have been satisfied with a given service; a score is attributed based on the relationships between people but without know their identity. At this point it was necessary to understand if the dissociation between identity and information takes place definitively (anonymisation) or if it is possible to have a connection between them again (pseudonymisation). Our preliminary analysis has revealed that the proposed demonstrator is based on an anonymisation process, because, after collection from the original database, the data definitively loses any connection with the identity of the person. Furthermore, not all the data sources used make available information on the identity of people. Many of them are already anonymised. This first result would have been sufficient to exclude any subsequent step of the ''data protection by design and by default'' evaluation. Despite this, we preferred a very cautious approach because we are aware that even from the intersection of anonymous data it is sometimes possible to deduce the personal identities. For this reason, in compliance with art. 32 GDPR, we have applied every appropriate measure to prevent this risk. The legal aspects of our project are not limited to personal data but concern all types, even non-personal ones. Their rules are contained in Reg. (EU) 2018/1807 [43], which uniformly regulates the free circulation of non-personal data within the European Union and which represents the first concrete step towards the elimination of territorial barriers that hinder the development of data-based technologies such as IoT.

VI. IMPLEMENTATION

In order to prove the functionality of the previously presented approach for modelling services as social object, we developed a demonstrator specifically for tourist and cultural heritage services. The architecture of the demonstrator is presented in figure 4.

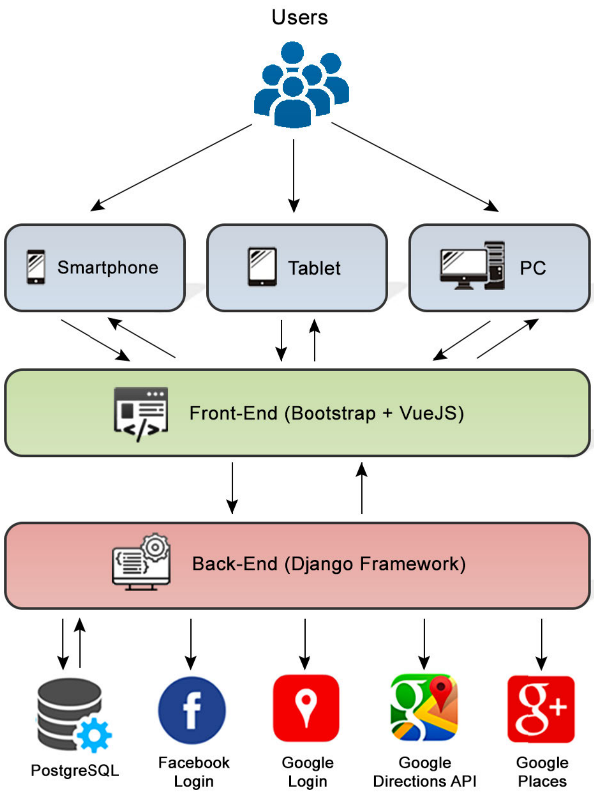


FIGURE 4. Layered architecture of the demonstrator.

It is composed by a front-end application and a back-end engine developed in the Django Framework, interacting with a PostgreSQL, a complete object-based Database Management System (DBMS) released with a free license (BSD License style) Database. Django is a free and open source web application framework written in Python. The use of Python Virtualenv is necessary to isolate the configuration of multiple Python / Django projects residing on the same server. To make server setup as simple as possible, Docker was used, an open source platform that automates the deployment of applications within software containers. The server resides on Amazon Web Services (AWS). The main technologies used in the Front-End are: HTML, CSS, Javascript, jQuery, Bootstrap and VueJS.

The first step in the development of the demonstrator was to build up the database. We concentrated on a limited geographical area, situated in the south-west of Sardinia (Italy), a region known as Sulcis - Iglesiente that can be seen in figures 5 and 7. We inserted, starting from a regional open database, a number of 1500 entries composed of tourist services (i.e., hotels, restaurants, beaches, lodges, etc.) and cultural heritage attractions (i.e. museums, archaeological sites, churches) and started to populate these entries with the information found on the web, using well known platforms such as Google Places, Tripadvisor and Booking. The data was retrieved in a semi-automatic manner, by means of Python scripts and subsequently manually checking the results for consistency. Once the services defined as database

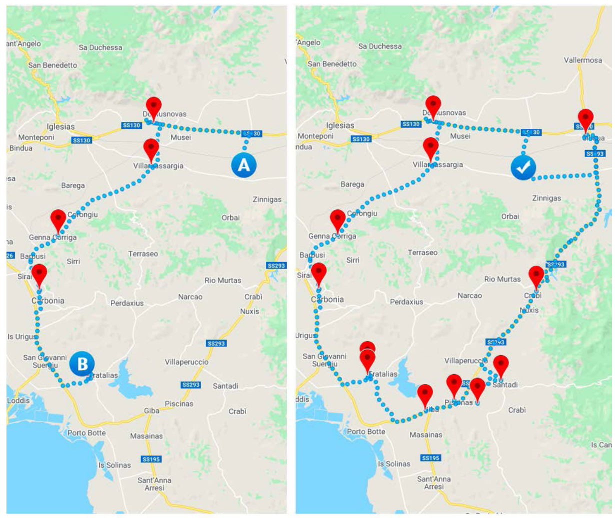


FIGURE 5. A to B itinerary (left) and a circuit type itinerary (right).

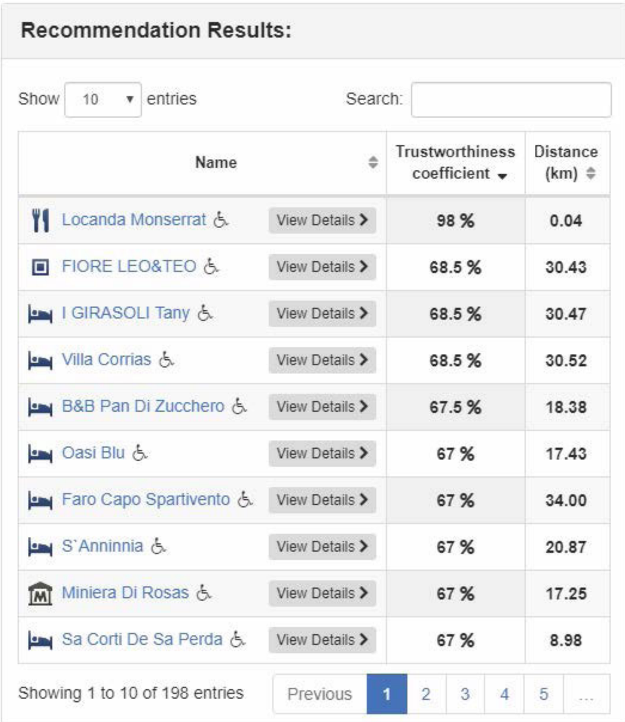
entries, we abstracted them to objects, and started to construct a social group composed by one initial object and the objects with which it has interacted, enriched by the types of relationships and corresponding levels of trust. The social group is renewed from a log timestamp of interactions of the object that stores each of its interactions. We are using a formalization and a parametrisation of the basis of interaction (socially aware parameters), allowing objects to determine their behavior during interactions [44], [45].

The demonstrator is built with a social login, feature that allows each user to access the platform through their Google and Facebook profile. Furthermore, in addition to accessing the platform with social accounts, it is possible to register with personal credentials through the registration module. The Social Functionality in the demonstrator is referred to those services that can be used by the user who accesses the platform: once logged in, the user can declare its appreciation by clicking on the "Like" button, or communicate that he is visiting the structure at that moment by clicking on the "Check-In" button.

These two features are important for those who use the Login through Facebook, because social friends can see how many of them have interacted with the same structure. Calculation of a recommended route can be done in two ways, one from a point A to a point B, thus creating a route with a starting and an ending point, and alternatively a circuit-type itinerary, in which the user will return eventually to the starting point, as presented in figure 5. The type of relationship between the communicating services abstracted as objects reflects the degree of connection between them, and reference to the level of trust in their relationships [46].

The relations between the services allows the diffusion of the geographical, socially aware and service quality parameters in the community of objects.

The prioritization of the hierarchy of objects (shown in figure 6) is done by using the TC and ATC coefficients, which can be associated with the value added and the impor-



Recommendation Results:

Show 10 entries Search:

Name		Trustworthiness coefficient	Distance (km)
Locanda Monserrat	View Details	98 %	0.04
FIORE LEO&TEO	View Details	68.5 %	30.43
I GIRASOLI Tany	View Details	68.5 %	30.47
Villa Corrias	View Details	68.5 %	30.52
B&B Pan Di Zucchero	View Details	67.5 %	18.38
Oasi Blu	View Details	67 %	17.43
Faro Capo Spartivento	View Details	67 %	34.00
S`Anninnia	View Details	67 %	20.87
Miniera Di Rosas	View Details	67 %	17.25
Sa Corti De Sa Perda	View Details	67 %	8.98

Showing 1 to 10 of 198 entries Previous 1 2 3 4 5 ...

FIGURE 6. Prioritization of the hierarchy of objects in an A to B itinerary.

tance of the reliability and trustworthiness. Recommended results can be filtered using a search input, and the number of results for each page is configurable. For easier navigation, only a summary of the results in the table are displayed in the first phase. If a user wants to view more details about one or more services, he can click on the "View Details" button, so that a detailed list of information will be displayed through the "Accordion" module of the jQueryUI library.

When the logged in user has already decided to make a trip from one city to another, or wants to plan one, the web platform prepares the possibility of calculating an itinerary that includes parking in some structures or in any case of the slight deviations from the path already chosen, based on the values provided by the TC or ATC for each structure. ATC (Accessible Trustworthiness Coefficient) is used only when the accessibility filter is enabled by the user, by default the filter is disabled and only TC (Trustworthiness Coefficient) will be used to display the recommendations hierarchy. The Google Directions API was used for the implementation. For example when the itinerary is of type A to B, in our demonstrator we considered the weight of the distance parameter as 0.35 to calculate the Trustworthiness Coefficient for displaying the recommendation results. In the front end view of the application for the purpose of informing the user we display both the coefficient and the distance in tabular mode using the jQuery DataTables plugin, through which the user can sort the results according to the desired parameter (column): Name, Trustworthiness Coefficient or Distance. Figure 7 shows the evaluation of a tourist itinerary based on the reliability coefficient with the accessibility filter enabled.

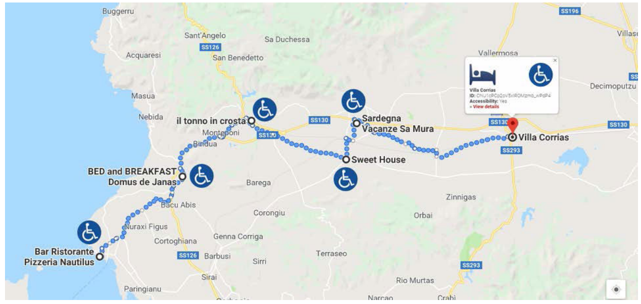


FIGURE 7. Touristic itinerary based on the trustworthiness coefficient with the accessibility filter enabled.

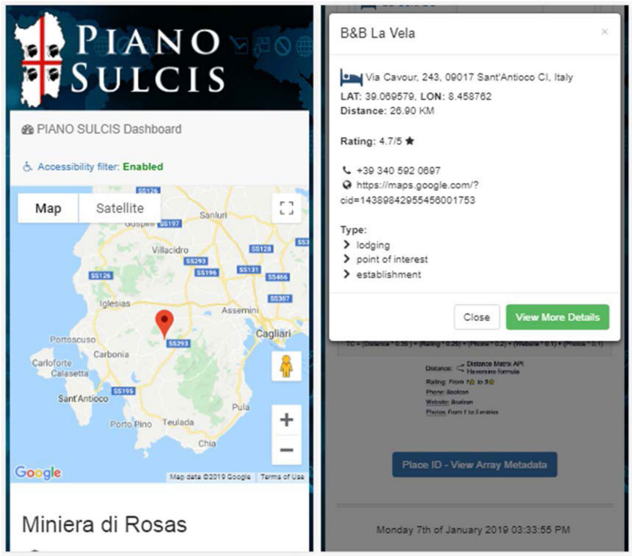


FIGURE 8. Demonstrator front-end view on a smartphone.

The demonstrator application was developed using the content to terminal adaptation and responsiveness paradigms and is thus compatible with all modern devices on various resolutions and operating systems from smartphones up to 4K [47]. The figures 8 and 9 illustrate the the front-end view of the demonstrator on a smartphone and on a laptop.

The demonstrator has custom profiles, in which the user can select which parameter is most important to him, for example: Distance (D), Rating (R), Content (C), Accessibility (A) etc. Depending on the profile selected, the variables for each parameter change their value, the Trustworthiness Coefficient (TC) thus changing it's value according to the user's necessity.

Most of the problems and challenges encountered during the implementation and the validation of the demonstrator were related to the lack of "open" data regarding the structures of the Sulcis - Iglesiente that we used. We used data provided by Google Places which, after an initial automatic script-based collection operation, were corrected by hand to avoid further problems once the data is entered into the database. We have also been able to obtain other data from tripadvisor.com partially using web scraping techniques and

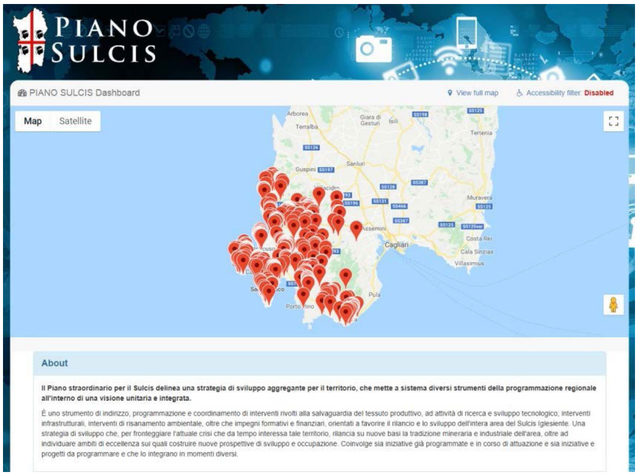


FIGURE 9. Demonstrator front-end view on a laptop.

partially manually, since there is no API type interface to be able to interface automatically via script.

The lack of data was important in the case of facilities and services for the disabled, where information was very scarce. Google Places only provide a Boolean value for this parameter, while the other portals such as Tripadvisor, Booking, etc. provide some specific data, but not directly interpretable, for which further manual classification was required.

The research carried out shows the lack of a classification standard for the disabled of tourist facilities and services. A regional investigation in this sense may be appropriate to allow, at least for the new structures and services registered at the regional level, to specify in an unambiguous way what types of services are available for disabled and elderly people.

VII. CONCLUSION AND FUTURE WORK

The new Social Internet of Things paradigm (SIoT) proposes a new perception on the cooperation and synergy among objects which build up the Internet of Things (IoT). Its intent is to imitate human social behaviors, in order to apply them to connected virtual objects and to deliver new, improved results in the cooperation and transactions between services entities of smart systems.

In this article, we present a new concept in the SIoT and the aspects of social relations, transposed to tourist services as communicating objects. We propose a new architecture of a communicative virtual socially aware objects (VSAO), which allows to manage the social ties between objects, through principles of interaction and trustworthiness. Through interaction paradigms such as crowdsensing of service between objects we improve the evaluation of services and improved management of tourism and cultural heritage. The proposed model of social interaction is based on a relational model involving 3 types of parameters: geographical, socially aware and service quality enhancing the concepts of trustworthiness and accessible trustworthiness, which can open new research topics for the future of SIoT.

The main result of the research activity within this project was the modeling and definition of tourism services as part of a typical SIoT architecture. Using these models, services can be identified and composed in a dynamic manner, thus creating new aggregated services. By introducing the accesibility parameter, weextended the intital scope of the application, enabling access for people with disabilities or special needs.

The services provide rules and metrics of reliability and quality that affect their characterization using typical indicators for SIoT architectures such as Quality of Experience and Trustworthiness enabling access through the use of assistive technology. Even though the developed demonstrator is dedicated to tourist services, conceptually the developed Trustworthiness Coefficient (TC) and the subsequent Accessible Trustworthiness Coefficient (ATC) can be extended in a wide range of economic and industrial spheres as well as in the non-profit area. The future work will be concentrated to employ an additional machine learning layer to the relational model. The new layer will be used to build a logical interpretation of the processed data, to check for deviations from expected trustworthiness, predict upcoming links and social relations between objects and determine trends in social ties.

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GEORGE ALEX STELEA received the M.Sc. degree in applied informatics and the Ph.D. degree in information and communication technologies from the Transilvania University of Brasov, in 2016 and 2019, respectively. His Ph.D. thesis is in the fields of the Internet of Things (IoT) and multimedia communications. He is currently an Associate Lecturer with the Transilvania University of Brasov. Since 2009, he has been a Web Developer and a Software Programmer in various national and international projects. From November 2017 to September 2019, he was a Visiting Student with the Department of Electrical and Electronic Engineering, University of Cagliari. He is the coauthor of two academic text-books and 11 scientific articles.

VLAD POPESCU (Member, IEEE) received the M.Sc. degree in electronics and computer engineering and the Ph.D. degree in telecommunications from the Transilvania University of Brasov, Romania, in 1999 and 2006, respectively. In 2000, he was with Malmö University, Sweden, specializing in multimedia applications, for a period of four months. From 2001 to 2002, he was a Research Fellow with Technical University, Aachen, Germany, where he finished the experimental part of the Ph.D. studies on wireless communication in underground environments from 2004 to 2005. Since 2009, he has been a Visiting Professor with the Department of Electrical and Electronic Engineering, University of Cagliari, Italy. Since 2000, he has been an Associate Professor with the Department of Electronics and Computers, Transilvania University of Brasov. He has also collaborates on research and didactical level with the Department of Electrical and Electronic Engineering, University of Cagliari. His main research interests include telecommunications, cognitive radio systems, multimedia applications, and data acquisition. He is a member of the IEEE BTS, the IEEE VTS, and the IEEE AES. He serves as the Chair for the IEEE BTS Chapter, Romania.

FLORIN SANDU (Member, IEEE) graduated from the Electronics and Telecommunications Faculty, Politechnical University of Bucharest, in 1984. He received the Ph.D. degree, in 1998. His Ph.D. thesis was in data acquisition optimization. He was with the Carl Zeiss Research/Technical Team in spectro-photometers, University of Brasov, for a period of one year. He was also with IIRUC-SA in service team for mini-computers for a period of one year. Since 1991, he has been with the Electronics and Computers Department, Electrical Engineering Faculty, Transilvania University of Brasov. He received the Governmental Repartition in research (practical period) with the Romanian Aeronautical Industry (IAR), Brasov, and the Radio and Avionics Laboratory, Helicopter and Light Aircraft Factory.

LANA JALAL (Member, IEEE) received the degree in control and systems engineering from the University of Technology, Iraq, in 2004, and the M.Sc. degree in computer and automation engineering from the University of Sulaimani, Iraq, in 2013. She is currently pursuing the Ph.D. degree in electronic engineering and computer science with the Department of Electrical and Electronic Engineering, University of Cagliari, Italy. Her research interests include mobile robot navigation, artificial intelligence, multimedia, and user experience.

MASSIMO FARINA received the M.S. (Laurea) degree in law from the University of Cagliari, Italy, and the Ph.D. (Dottorato di Ricerca) degree in computer law from the University of Bologna, Italy. Since 2006, he has been an Adjunct Professor of computer and new technologies law with the Department of Electrical and Electronic Engineering (DIEE), University of Cagliari, where he is currently a Data Protection Officer. He is also the coordinator of ICT4Law and Forensics. His research interests include data protection, computer crimes, digital forensics, and juridical protection of software.

MAURIZIO MURRONI (Senior Member, IEEE) received the M.Sc. degree in electronic engineering and the Ph.D. degree in electronic engineering and computers from the University of Cagliari, in 1998 and 2001, respectively. He is currently an Associate Professor with the Department of Electrical and Electronic Engineering (DIEE), University of Cagliari. He is also a member with the National Inter-University Consortium for Telecommunications (CNIT). He was the coauthor of the 1900.6-2011 - the IEEE Standard for Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other advanced radio communication systems. He is the coauthor of an extensive list of journal articles and peer-reviewed conference papers. His research interests include quality of experience, multimedia data transmission and processing, broadcasting, cognitive radio systems, and signal processing for radio communications. He is a Senior Member of the IEEE ComSoc, the IEEE BTS, the IEEE VTS, and the IEEE SPS. He is a Distinguished Lecturer with the IEEE Broadcast Technology Society. He received several best paper awards. He served as the Chair for various international conferences and workshops. He serves as an Associate Editor for the IEEE TRANSACTIONS ON BROADCASTING. He served as a guest editor for several journals.