Towards an Understanding of Smart Service: The Case Study for Cultural Heritage e-Tourism

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***Abstract*—e-Tourism covers a wide niche of the digital services market. The existing services, although being presented in the large amount in today's Internet, do not achieve high intelligence level. The user still needs to perform a lot of operations manually: to solve a given problem she/he finds and accesses appropriate Internet services or uses mobile applications. A lot of information fragments are linked by the user her/himself, in the mind. In this paper, we discuss the problem of smart service development for the e-Tourism domain. The considered use-case scenario comes from cultural heritage tourism, which is an area of growing application interest. We identify smart service attributes that allow a service to achieve a new level of the intelligence. The user becomes more focused on the substantial aspects of solving the problem. We contribute architectural solutions to service design. For the given use-case we show how the service-oriented system can be implemented in the form of a smart space deployed on user-surrounding devices based on the usage of external Internet services and multiple data sources.**

I. INTRODUCTION

Nowadays e-Tourism covers a wide niche of the digital services market [1], [2], [3]. Its particular subarea—cultural heritage tourism—becomes an essential part of it [4], [5]. In contrast to many existing e-Tourism services, cultural heritage tourism and its history-oriented variants need to involve large amount of diverse information about the target region, and the information is subject to more delicate analysis of points of interest (POI) that the tourist visits. In this paper, we focus on the particular problem for cultural heritage e-Tourism: the case of mobile and personalized trip assistance services for tourists.

The traditional service development approach is to create a standalone digital service for a narrow class of problems. For example, a map service with a search function lets its user find the location of a given POI or of another object. This approach does not support provision of the user with such semantic information as relations between objects and appropriate information from the related objects intentionally. Another difficulty is a low level of service personalization that is allowed by traditional approach. A promising way to digital service development is to consider so-called smart spaces and smart services, which are recently emerging to intelligently support human in everyday activity [6], [7], [8].

A smart service can be considered as an extension of regular services, which are numerous in today's Internet. The amount of available information and the number of services that feed their users with this information are growing very fast. The users can't efficiently utilize the multitude of digital resources now. Information produced by one service is not easily accessible in another one. The distinctive characteristic of a smart service is its intentional aim at making everyday human activity more automated and digitally assisted [9], [10]. A smart service is able to connect other services and information fragments; the work made earlier by human her/himself when consuming regular services and browsing Internet resources. In particular, this notion supports such smart service attributes as operation with multiple data sources, service construction composing appropriate existing services, personalized situation-based service construction and adaptation, and proactive service delivery [11].

This notion of a smart service is very wide. In particular, some criteria are needed to decide either a digital service is smart or non-smart (regular). The study presented in this paper makes a step towards our understanding what is a smart service in cultural heritage e-Tourism. We identify and discuss several smart services attributes. This elaboration of the smart service concept and design is two-fold. First, it provides a view on possible benefit for tourists from the advanced mobile and personalized trip assistance services. Second, presented smart service attributes support service developers and with certain understanding what services and with which properties the tourists need.

The rest of paper is organized as follows. Section II introduces the studied scenario of mobile and personalized trip assistance in cultural heritage tourism. Section III studies the concept of a smart service based on smart service attributes and explains them with an example. Section IV presents our system design solution to development of smart services for cultural heritage e-Tourism based on the smart space programming paradigm. Section V summarizes and discusses the contribution of the paper.

II. MOBILE AND PERSONALIZED TRIP ASSISTANCE

The notion of a trip is central for the e-Tourism problem domain in general. Tourist's trip-related activity can be divided into the following basic phases, in accordance with our previous work [12]. In different subareas of e-Tourism, such as cultural heritage tourism, the phases are concretized with information that the activity involves in the given phase.

Trip elaboration: In this phase, the tourist elaborates the concept of the trip identifying such restrictions as the target region, trip budget, time interval, geographical areas of interest. The tourist analyzes available information about the target region and reviews potential POIs such as attractions. As a primary result of this phase the tourist selects a list of

POIs that she/he would like to visit. Actually, the elaborated trip concept should answer to the question "what".

Trip planning: In this phase, the tourist finds an answer to the question "how", i.e., details of the trip are elaborated. She/he decides a way of transportation, sorts the list of selected POIs according to the personal preferences and interests, and constructs a route of the trip from the POIs. Based on the route, the tourist selects accommodation and plans appropriate stops during the trip (gas stations, eatery, etc.).

Trip execution: In this phase, the actual trip is performed, i.e., the phase is central for the trip-related activity. During the trip the tourist applies the decisions made on the previous phases. The activity needs orientation on the route in geographical area and operation with situation-based information (e.g., description of the currently visited POI).

Post analysis: In this phase, the tourist examines the facts of activity after the trip. The essential conclusions are stored for further use. For instance, the obtained experience is reflected in social networks and reviews of visited POIs are published for community-based POI ranking.

This paper focuses on the study of personalized trip assistance services that are used for the *Trip elaboration* and *Trip planning* phases. Such services support the need of processing a large amount of diverse information retrieved from many sources before the trip. The activity of *Trip Execution* phase benefits from mobile services, when the tourist makes decisions during the trip depending on the current situation and latest received information.

Let's consider an example of the cultural heritage tourism particularity for the trip-related activity phases. Let a tourist visit Petrozavodsk city to participate in a conference. The following trip restrictions can be defined.

1) Target region: Petrozavodsk city and its surroundings.
2) Budget: non-expensive attractions are preferable.
3) Time period: free 1–2 days.
4) History interests: the industrial history of the region.

These restrictions show a typical case of a short trip: the tourist has few hours or days for leisure activity. An essential point is that the tourist should primarily focus on the analysis of nearby POIs, on historical facts related to those POIs, and on means of visiting the most interesting and easily accessible POIs.

In the *Trip elaboration* phase, the tourist searches information about POIs in the target region, constructs relations between historical facts and objects of the present day. Typically, this activity requires large amount of information to be found in different sources (e.g., Wikimapia or Wikipedia) and retrieved to the tourist. Then the information is processed and analyzed to derive conclusions for trip-related decision-making.

Let the tourist have selected the following POIs. The example reason of the selection corresponds to the tourist's interests in industrial history, as indicated in parentheses.

1) Governor's Park "outdoor exhibition" (it presents the history of industrial development in Republic of Karelia).
2) Lososinka river, Onega Tractor Plant (its former name is Alexander Plant, which was built in 18th century).
3) The fragment of the first Russian industrial railway (it was created for Alexander Plant in 1788).
4) Museum of Fine Arts (it keeps the prints collection of the epoch of Peter I, who is the first emperor of Russia, the founder of Petrovskaya Sloboda, which is Petrozavodsk city now, and the founder of mining and metallurgical industry in Republic of Karelia).
5) Marcial Waters near to Petrozavodsk (it is the Russia's first health resort, which was established by Peter I who had visited it several times).
6) Church of St. Peter in Marcial Waters (it was built due to the plan defined by Peter I).
7) History Museum of Marcial Waters (it demonstrates two chairs, a table and candelabra attributed to the handwork of Peter I).
8) The ruins of iron foundry in Konchezero near to Petorzavodsk (the foundry was founded in 1706 by Peter I).

There are many other objects (in the vicinity of the selected POIs) that the tourist can also visit. Moreover, there are many historical facts that are related to the selected POIs with other objects. This semantic information can effectively influence the tourist's decision-making in constructing the route of the trip or even during the trip execution.

According to our previous work [5], [13], such information on POIs and historical facts can be represented as a semantic network. It's important that a similar structure is formed in tourist's mind when she/he analyzes POIs and related information. This semantic network approach attempts to imitate the human activity of a historian tourist.

A possible manually created semantic network for the considered example is shown in Fig. 1. Most of the presented POIs are located outside of Petrozavodsk, thus visiting them can be expensive. The first four POIs provide a cheap list of POIs for the tourist's leisure trip. The other POIs are marked as "recommended".

In *Trip planning* phase, let the tourist decide to make a walking tour. The route of this tour consists of the following POIs. The example reason of the POI inclusion depends on the tourist's history interests, as indicated in parentheses.

1) The Governor's Park "outdoor exhibition", the monument of G.R.Derzhavin (the first governor of the region).
2) The National Museum of the Republic of Karelia (former governor's house).
3) The square of Eternal Flame (it is not the object of industrial history, but the monument of political and military history located near to the previous POI).
4) The House of Mining Director (the 18th century building when the heads of mining and metallurgical industry leaved).
5) The square of 71st Infantry Division (also the monument of military history), Expocentre (former house of Culture of Onega Tractor Plant).
6) The museum of Industrial History of Petrozavodsk (e.g., there one can see the fragment of the first Russian industrial railway).

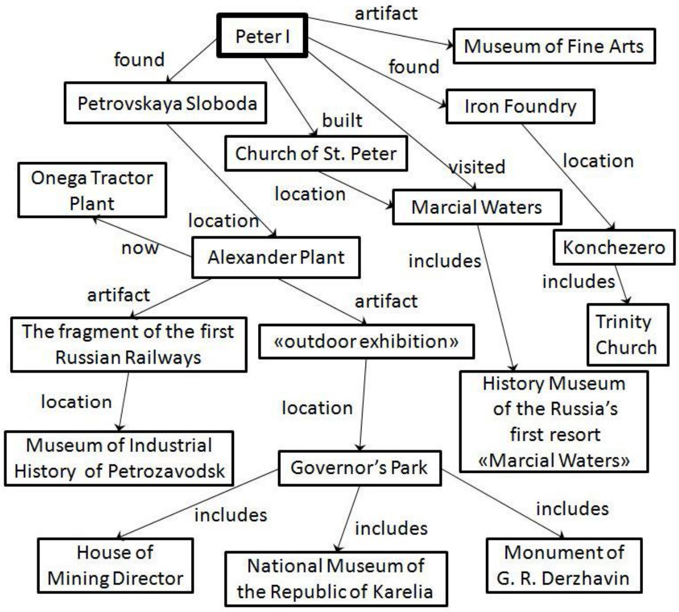

Fig. 1. Example of a semantic network of POIs in Petrozavodsk. History interest is the industrial history of the region

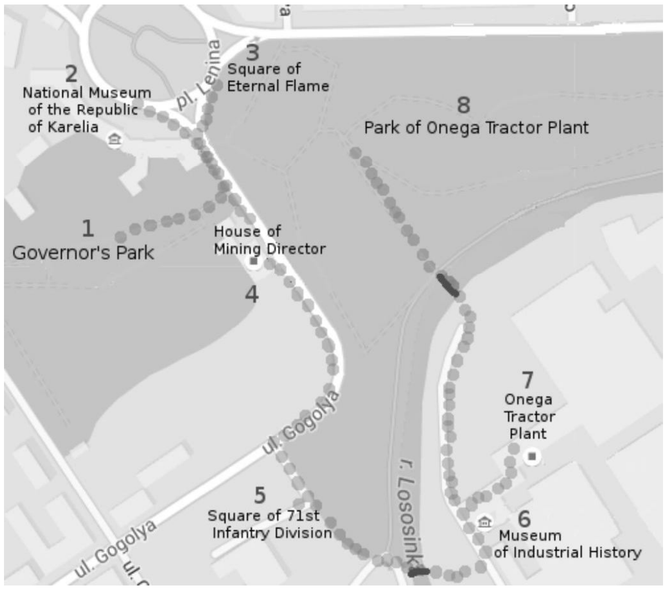

Fig. 2. An example of route for walking tour in Petrozavodsk

7) The directorate of Onega Tractor Plant (it was built in the end of 19th century and it is the only ancient building survived from Alexander Plant, which is used as business center now).
8) The park of Onega Tractor Plant.

An example of geographical map for trip assistance is shown in Fig. 2. The map describes the manually defined route for the planned walking tour.

During *Trip Execution* phase, the tourist uses own mobile device and visits the POIs sequentially. Typically, the mobile device is used for navigation and gathering data about target POIs. For example, the tourist listens audio guide during the walk. The mobile device can be used to modify and adapt the route, e.g., by adding other POIs located nearby.

Another task in *Trip Execution* phase is to collect information about experienced tourist trips. Typically, the tourist wants to save photos, videos, and notes about visited POIs. Another interesting data source is the tourist route itself. It can be used to detect popular tourist routes, level of interest in POI, and the estimated time to visit POI. This task also can be supported by the use of mobile device running specialized applications.

III. Smart Service Attributes

The notion of a smart service is very wide. In this section, we identify and discuss several smart services attributes. Our aim is at certain understanding which advances to make a service smart compared with regular services. The attributes are derived from the analysis of existing services for e-Tourism.

A. *The notion of a smart service*

We consider the class of informational services [7]. They aim at information provision to the user, who makes own decisions based on the provided information. Services are constructed within an ubiquitous computing environment, where both surrounding devices and external Internet resources (or other remote information systems) can be used.

A computing environment can be enhanced to a smart environment (or intelligent environment), if it provides decision, information, communication, and physical components to construct services [6], [10]. The joint usage of these components supports acquiring and applying knowledge available in the environment to adapt services to consumers in order to enhance user experience, quality and reliability of the provided information. Such services are often referred as smart. Although this description supports our intuition, there is still no common usable understanding what we can define as a smart service. In particular, we need certain criteria to distinguish regular services from their advanced versions.

This concept definition problem is challenging in the general case. Let us consider a particular problem domain of the cultural heritage e-Tourism problem. For this special case we identify several smart service attributes. The more attributes a service has the higher its smart level is. Although this classification approach does not provide unambiguous separation of services onto regular and smart, it leads to understanding what additional features a given service has that makes the service smarter. The proposed smart service attributes are summarized in Table I with references to the exiting work.

B. *Multiple data sources*

A service has this attribute if it uses a set of third-party data sources. Consequently, the service can operate with a huge amount of data, combine different types of information and verification of provided information. On the other hand, the attribute is associated with various implementation difficulties such as merging data from different sources, organizing search requests.

TABLE I. SMART SERVICE ATTRIBUTES

Attribute	Description	Ref.
Multiple data sources	Service uses several third-party sources in the same request. For example, service searches required attractions in various databases.	[14]
Composed services	Service uses several different services in the same request. For example, service determines the coordinates of a city in one service and receives weather forecast from another service.	[2]
Personalized services	Service uses user info for clarification of the request, ordering lists and so on. For example, service uses user location to retrieve a list of nearest obstacles.	[15]
Human–computer interaction	Service provides user interface close to natural. For example, service can understand human speech or natural language texts.	[16]
Self-learning	Service can detect and learn new material like facts, actions and so on. For example, service analyze user requests and detects user preferences.	[17]
Automation	Service provide ability to perform actions without user intervention. For example, service checks the information on the third-party services periodically and notify to user about all updates.	[2]
Collaborative work	Service provide ability to communication between users. For example, service uses social network to do common trip planning.	[18]

A typical service-oriented application organizes a uniform client interface and detects which group of sources is needed [19], [14]. From this point of view, the client interface development is simplified while the algorithmic part becomes complicated.

For the example from Section II a service can request and combine information from different data sources like Wikipedia, Wikimapia, and DBpedia. Although many POIs are duplicated in several sources, each data source has own semantic focus. For the given region, dedicated data sources can be available with rich information on POIs.

C. Composed services

A service has this attribute if it applies external services. The service construction benefits from a service combination. The fallback option is possible by using similar services. On the other hand, this attribute leads to various difficulties like implementation and maintenance of different application programming interfaces of third-party services, the increased computation time, and higher network traffic.

A composed service can be implemented within a multi-agent system. For each external service, a dedicated agent becomes responsible for the interface [2].

Consider examples of service composition. The first one is a combination of a trip planning service with a public transport service [20]. Other examples are for social networking [21] and combination of social network services and trip planning service [18].

For the example from Section II, a composed service combines services like “data search”, “navigation”, and “recommendation”. Also the popular approach is to combine mobile versions for using during the trip execution and web or standalone versions for using in the other phases (i.e., when the tourist has a wide screen and stable Internet connection). This attribute requires implementation of different user interface parts.

D. Personalized services

A service has this attribute if it provides information depending on the user profile or context. The features include the possibility to sort data by user interests, filter uninteresting data [22], [2], [19]. On the other hand, this attribute leads to difficulties like mapping user interests with search results, algorithms of data sorting and data filtering.

Examples of personalization are the following. A popular type of context information is user location, which can be easy retrieved from the mobile device [23], [15], [24], [14]. The user location can be combined further with other information like relationships from social networks [18]. Another type of context is user logs and history of decisions [25]. The history can be combined with rating and recommender systems [25].

Personalization can also be in the form of constructing intersections between user decisions and public information. For example, the intersection between the tourist’s route and available public transport routes in the region. The personalized service proposes an individual route with public transport usage [20]. Another example is intersection between the user profile and POI descriptions [26].

For the example from Section II the service can personalize search results and proposed recommendations. The personalization can be based on user profile and trip restrictions.

E. Human–computer interaction

A service has this attribute if it provides effective human–computer interface. The feature is to create clear user interface that provides information in a user-friendly and readable form (e.g., using advanced visualization). On the other hand, various difficulties appear, like high computation and equipment costs and complicated algorithms.

There are several techniques for human–computer interface implementation. The first example is a voice input: several frameworks to recognize human speech&voice are available, e.g., Yandex.SpeechKit (https://tech.yandex.ru/speechkit) or Siri (http://www.apple.com/ios/siri/). The service is enabled to detect and parse phrases in the input voice flow. Another example is voice output when the service provides its information as voice. Currently many mobile devices have certain built-in support for voice output.

Similarly to speech&voice recognition and generation, the service can parse images to extract semantic information based on pattern recognition. Another example is from augment reality when the service provides additional information and functions for base POI [1], [24]. Yet another example is to use social network mechanisms for decisions [16].

For the example from Section II, the service can implement speech recognition interface for analysis of the tourist requests and for generation of the voice output during navigation and POI scoring. Also the service can provide a human adaptable map for more comfortable usage.

F. Self-learning

A service has this attribute if it can recognize and generate new knowledge, e.g., in the form of collection of facts for further recommendations. The feature is in the expansion of the available knowledge, generation of new relations between POIs and so on. On the other hand, various difficulties appear, like computational costs, complex algorithms, and closed area with predefined rules.

A popular type is recommendation services. They analyze user profile and user context to detect preferable objects to visit [17]. Another popular services are ratings when user behavior is analyzed to produce POI ranks or to make personalized propositions [27], [28].

For the example from Section II, the service can collect tourist requests and decisions made in analyzing POI popularity. POIs ratings are regularly recalculated. Although this case requires introduction of many tourists the service achieves more usable results for the trip assistance.

G. Automation

A service has this attribute if it automates operations for human. The feature is to decrease the number of manual operations, to reduce human-made errors, and to increase the overall performance. On the other hand, various difficulties appear, like increased computational costs and more complicated algorithms. The service performs routine procedures of information acquirement and transformation on behalf of the user. This automated assistance allows the end-users to concentrate on the original problem itself, not on technical details of its solution construction.

A popular type of automation is user classification [2], [24], [19]. This classification makes groups of users by similar preferences or demographic data, calculate degree of similarity between the users and the items to be recommended. Another type of automation is information gathering [14] for collecting information and advanced data processing. An interesting case is proactive services that automatically analyze required information and provide notifications about updates or new results [15]. Compared with the reactive approach the proactive services require more computational resources, while they are more useful for the users.

For the example from Section II, the service can automatically detect tourist time plan, notify about interesting POIs and recalculate the route to adapt to the current situation.

H. Collaborative work

A service has this attribute if it provides the ability to cooperate to the users. The feature is to improve the validity of result, to generate compromise solutions, and support communication between users in the manner similar to face-to-face. On the other hand, various difficulties appear, like increased computational costs and storage size, trust issues, and low performance of collaborative decision-making.

One of the popular communication approaches is social networking. Users collaboratively generate information content like object rating, feedback, and preference. The tourist receives travel advices and travel-related information from other users by using the collective intelligence of a web-based social network [16], [19]. Another popular type of collaborative work is organizing group events. For example, a service creates a route for a dynamically created group of users using their mobile devices [18].

For the example from Section II, the service can assist in forming small tourist groups with a fixed time slot to visit POIs with discount. The tourists are self-organized for using this opportunity.

IV. Smart Space Based System Design

Smart spaces is a paradigm for programming computing environments, which are able to adopt to user needs and interests [6], [7]. In this section, this paradigm is applied to development of e-Tourism services with the smart attributes. We propose a system design solution that evolves our previous work [12], [29], [30], [5], [13].

We exploit a particular software platform for creating smart spaces, called Smart-M3 [31], [11]. On this platform, the software part of a smart space includes "agents" and information "hub". Each agent is an autonomous knowledge processor (KP), which is a software module running on some device. A KP can produce some information and share it with other KPs in the hub. Other KP can consume information of its own interest from the hub. Shared content can be represented using the technologies of the Semantic Web. The hub acts as a semantic information broker (SIB), which maintains an RDF triplestore. The description of information space requires constructing of ontological model.

A service-oriented application for e-Tourism services is constructed as a distributed system of KPs interacting via information sharing with SIB (Fig. 3). Each KP typically runs on its own device to implement its piece of service construction. For instance, to support operation with multiple data sources, some KPs are data providers. They access external data sources (e.g., a tourist information service) and convert the information to the smart space. This way, the application can be easily extended by adding new data sources.

It's important that SIB provides semantic level communication means for KPs to interact with each other. The interaction

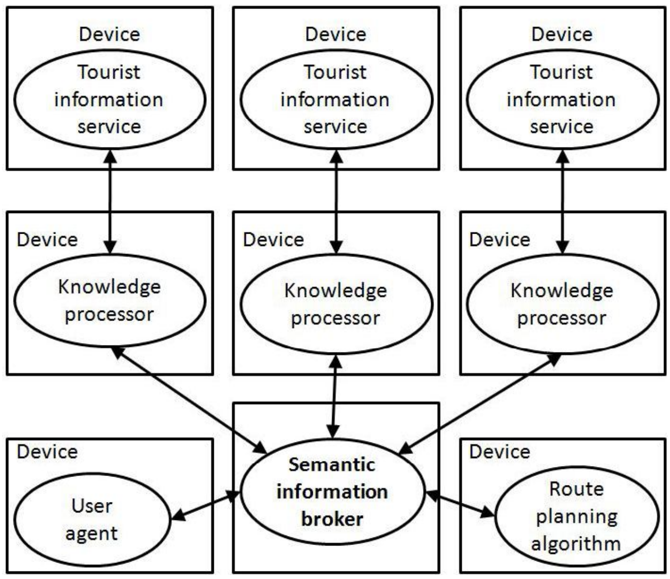

Fig. 3. Distributed system of interacting KPs to form a smart space for service-oriented e-Tourism application

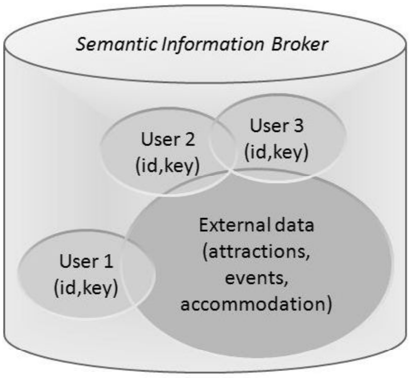

Fig. 4. Shared information space

is indirect, via information sharing and exchange. All KPs work collectively to form a common information space. The information is semantic-oriented. In particular, this space keeps relations between objects of the tourism domain, including representation of the users themselves (Fig. 4).

Consider the previous work on smart spaces based development of e-Tourism service-oriented application. Tourist recommendation system [17] uses multiple set of data sources to acquire information. This system applies personalization in the form of tourist preferences and current situation in the tourist location to implement ranking attractions and POIs. Tourist assistant TAIS [3] uses multiple set of sources to extract images and information about attractions and POIs. The TAIS application consists of several services: combination of services as Wikipedia (https://www.wikipedia.org/) for textual information, Panoramio (http://www.panoramio.com/) for images, Yandex.Schedule (https://rasp.yandex.ru/) for public transport information.

Work [30] presents an ontological model to represent the information on cultural heritage and trip planning process in the smart space. The presented high-level architecture of the cultural trip planning service combines cultural heritage and trip planning approaches. In particular, the architecture supports multiple external data sources and Internet services.

The multi-agent architecture for historical e-Tourism is presented in [5]. The smart space integrates historical and other relevant information including its self-generation by participating agents. The presented recommendation scenario shows the construction and delivery steps of a cultural heritage e-Tourism service.

In this paper we extend the above architectural models to a system design solution. The proposed architecture supports inclusion of multiple data sources and combination of services intentionally (Fig. 5). The general user-oriented view on the smart space is shown in Fig. 6.

A client service publishes personal data and information about the user's preferences. It also subscribes to recommendations related to attractions. A Geo-position service gets GPS coordinates received from the user's mobile device and determines the user's location.

A search service interacts with external Internet services such as Dbpedia (http://wiki.dbpedia.org/),

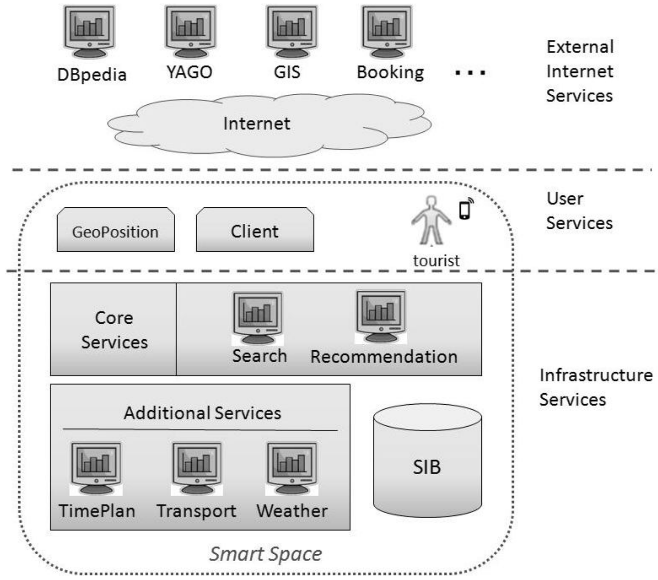

Fig. 5. Smart space as a set of services

GIS, Yago (http://www.mpi-inf.mpg.de/departments/databases-and-information-systems/research/yago-naga/yago/), Booking (http://www.booking.com). Each corresponding KP is associated with a dedicated Internet resource. It is an attribute multiple set of sources. Search service finds information and publishes data (or references to the data) in the smart space (via the SIB) for shared use by other KPs in other services. As a result, these services enable the attribute of multiple data sources.

A recommendation service computes ranks of POIs depending on the user's preferences and the visiting history. This way, the attribute of personalization is enabled. Information about POIs from the various sources is represented in the smart space. Recommendation service analyzes user's preferences and the visiting history. Based on the analysis results the service detects preferable objects to visit. In fact, this property enables the attribute of self-learning.

Various ranking algorithms can be applied. An example is ranking the available POIs by the level of proximity to the tourist's context based on the information on POI categories [29]. Another example is ranking based on the similarity of user preferences and context attributes: time, company in which the tourist visited the attraction, weather [17].

Let a recommendation service construct a list of candidate POIs where each POI is assigned with a rank value. Then the client service can use the values for representation of recommended POIs to the user. This is a particular way to enable the attribute of human–computer interaction. When a client service is notified on new constructed user recommendations then the attribute of automation becomes enabled.

Additional services, such as TimePlan, Transport or Weather, can be added to the smart space based system. TimePlan service implements a route planning algorithm. The route planning algorithm requires estimations for attractions (e.g., schedule, inspection time, attraction size). Transport

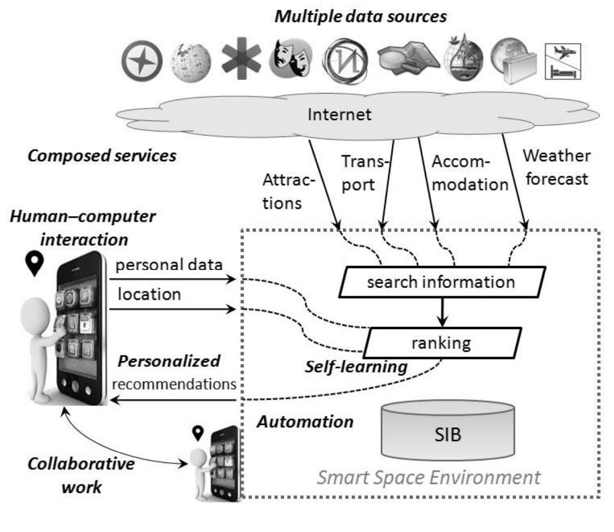

Fig. 6. High-level architecture design supporting the smart service attributes

service provides information about transport routes from third-party services and shows possible routes for the required set of points. Weather service provides current and future weather for requested coordinates from third-party weather service. These services can interact by information sharing to provide tourist recommendations. This way enables the attribute of composed services.

The proposed system design supports a customizable set of services. The minimal configuration (service core) includes client service with GeoPosition, search service, and recommendation service. Adding services of other classes as well as opening the way of combining services enable the considered smart service attributes for advanced e-Tourism services.

V. Conclusion

This paper showed that use of existing Internet services cultural heritage e-Tourism does not always provide satisfactory result and requires high skills for the user. To solve this problem we discussed smart services development based on smart space paradigm. First, we studied a scenario of mobile and personalized trip assistance in cultural heritage tourism. Second, based on this scenario we identified a set of smart service attributes. They can be used as a concept for a smart service. Third, we proposed a system design solution to development of smart services as a smart space where all necessary information is collected, semantically related, and processed. The proposed system design enables the identified smart service attributes and can be used beyond the cultural heritage e-Tourism.

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