SmartApp Salemo:
an Adaptive Context-Aware App for supporting e-tourists

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Abstract

The Italian towns have a cultural heritage that often do not succeed in being completely enhanced. The natural, artistic and cultural resources present in the Italian towns, above all the smallest ones, many times remain hidden and are not enjoyed by the tourists. The experience of a touristic visit is a learning process very fascinating and interesting. The emotions can change according to the interests of the individuals, as well as of the physical, personal and social-cultural context. The objective is to attract the user, introducing to him/her the content filtrated tailored, opportunely mixed with the context, to determine what part of the information is significant respecting the environmental conditions, with the purpose to get a visit experience more and more rich. In this paper, it is introduced an Adaptive Context-Aware app able to support a tourist inside a town. The system can guide the tourist in the discovery of a town proposing him/her resources and services mainly interesting for the user according to his/her interests and the position where he/she is. The objective is reached through the use of a system of description of the context with a graphical formalism named Context Dimension Tree. The App collects information also from social environments adapting the proposed itinerary taking into account the communities and the interests of the user. The entire approach has been tested inside the town of Salerno (Regione Campania, in Italy) with very interesting results.

Keywords: Context Awareness, Mobile App, Tourism and Cultural Heritage

1 Introduction

The Italian towns have a cultural heritage that often do not succeed in being completely enhanced. The natural, artistic and cultural resources present in the Italian towns, above all the smallest ones, many times remain hidden and are not enjoyed by the tourists. This problem typology becomes even more important when the tourist has few hours to visit a town: think, for instance, about some passengers of a cruise who in few hours have to visit an unknown place. The problem arises also for those people who, for work, live an experience in a town that they can visit in little time. Where eating? What seeing? How moving? These are the typical questions that such a user makes when he/she is in a station, an airport or a harbor. If in the big towns there are pre-constituted itineraries that can be easily made by the tourists, this is not always true in towns of little or medium dimension that, even if they have a sure interesting cultural heritage, often risk of not enhancing it completely.

On second thoughts, information necessary for the enhancement of the resources of a town are, in many cases, already present on the web: the social networks have much information about the resources present in a town. On the other hand, also the public institutions, usually, develop some contents in support of the cultural resources present in the territory, but not present in places not easily reachable by the tourists, above all the foreign ones. Moreover, often, there are also services that can be useful for a tourist who unlikely knows where finding them. Therefore, it is necessary to create a framework that can integrate contents and services to support a user inside a certain territorial context.

The adoption of Future Internet (FI) technology and of its most challenging components like the Internet of Things (IoT) and the Internet of Services (IoS), can constitute the basic building blocks to progress towards a unified ICT platform for a variety of applications within the large framework of smart cities projects [2]. In addition, recent issues on participatory sensing, where every day mobile devices like cellu-

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lar phones form interactive, participatory sensor networks enabling public and professional users to gather, analyze and share local knowledge [20], seem to fit the smartness requirements of a city in which also people have to play an active role. Eventually, the cloud computing technologies provides a natural infrastructure to support smart services [8].

One of the fields that can take great advantages from such technologies is the tourism [28]. In this scenario, persons (citizens, tourists, etc.) and objects (cars, buildings, rooms, sculptures, etc.) equipped with appropriate devices (GPS, smart-phone, video cameras, temperature/humidity sensors, etc.) constitute a particular social network in which all the mentioned entities can communicate [21].

Exchanged and produced data can be exploited by a set of applications in order to make the system "smart". From a more general point of view, the social network can be seen as composed of a set of Single Smart Spaces (S3) (indoor museums, archaeological sites, old town centers, etc.), each needing particular ICT infrastructure and service that transforms the physical spaces into useful smart environments. Here, one of the most challenging and interesting research problem is to model context-awareness in a S3 and design context-aware applications able to provide useful data and services depending on the current context occurrences [7][9].

Context is not just a simple profile that describes the surroundings of data. Rather, context is better described as any piece of information that can be used to characterize the situation of an entity such as a person, a place, or any other relevant object/aspect in the interaction between a user and an application.

On the basis of what has been previously described, this work will be organized in this way: in the following paragraph, we will describe the concept of context and how it can be declined in a modern way thanks to the use of new technologies. Later, we will present related works. In this paper, we will try to give an answer to the problem of the context representation using the Context Dimension Tree formalism [35][37]: we will introduce a context-based approach able to give services and contents useful for the user.

Then, we will present an Adaptive Context-Aware App able to support different typologies of users inside an urban context. Some experimental results will be presented in the last part of the paper.

2 Context Awareness and ICT

The importance of the context in the Information Technology is increased in the last few decades so like the computers has become more and more pervasive in the daily life. The Context Awareness, or rather, the idea that the computers may notice and react to a situation of the user, has been a popular topic of research for a few number of years.

One of the most diffuse instruments in the progress of the Context Awareness has been the mobile device; its enormous popularity and pervasion in the daily life, concurrently with to a more and more sophisticated hardware, it has remarkably improved the potential about the context awareness.

The human being has always used the concept of context, which belongs to that kind of concepts known by the majority of people, but that are difficult to describe with words. In [29], there is the first attempt to describe the relation between the context and the context awareness in the field of information technologies.

Many interpretations of the context concept are emerged in the several areas of search, like the psychology, philosophy [5] or computer science, in particular: the artificial intelligence, the Human Interaction Computer (ubiquitous computing, user interfaces and project concentrated on the customer); the telecommunications (sensor and nets of sensors wireless) and the mathematics (statistics, inference, data structures and project of the algorithm).

While the computer science community has initially considered the context like an issue of position of the user, as it is discussed in [15], during the last few years this concept is considered like a continuous process where the users are involved [14].

The context does not have a rigorous definition, and its interpretation can vary according to the application. Even if there are multiple approaches to the classification of the context in literature, there is a common agreement on some its aspect: the definition of Dey [15] is seen like the standard de facto in the field of Information Technology. Dey defines the context like "an information that can be used in order to characterize the situation of an entity. The entity is a person, a place or an object who is considered important for the interaction between a user and an application, comprised the same user and the application.", supporting that the key categories are the position, the identity, the time and the activity [16].

More recently, Zimmermann et al. [40] have extended the approach of Dey including one social aspect, that is with entity relations, and a temporal aspect ulterior, or rather the idea that the context classification changes in the time.
Another definition of context has been proposed in [26] where the context is defined as a series of environmental features, such as, for example, the place, the temperature and the considered user's identity.
Directly linked to the definition of context, there is that of Context Awareness applications: applications that in some way are aware of the context where the user is and the capability to detect and react to the changes in the environment where it is located [11]. Again in [15], there is a definition of the context-aware system: 'A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task.'
In practice, a system can be defined context-aware when it takes advantage of the context to give important information and/or services to the user, where the importance depends on the user's request and features. If we wanted to classify the context-aware applications, we could consider that presented in [29]:
1. Proximate Selection, which literally means 'selection of proximity', is an interfacing technique that considers that the user gets close to a particular place to receive some relevant information and/or to make elaborations, both on request and automatically.
2. Automatic contextual reconfiguration is the process of addition of new components, removal of already existing components or alteration of the connection among the components of a system. In actual fact, there is the change of the system according to the context. Typically, the components can include: driver modules directly downloadable by the user, modules of programs.
3. Contextual information and commands: often the operations that people make can be predicted. In fact, usually, there are some recurring operations made in particular places (e.g. universities, libraries, offices, etc.). The applications that use this kind of 'contextual information' are made to accomplish certain orders (contextual commands) in place of the user according to the context.
4. Context-triggered actions are those applications that automatically carry out an operation when there is a particular condition (trigger) in the context.
Although as time goes by new classifications have been introduced, the previous ones are still valid. It is important to precise that a context-aware application has not to necessarily belong to one of the listed categories, but it is possible to have some 'hybrid' applications that have features belonging to more categories.
In the management of the information, the Context-Aware systems mainly are dedicated in determining which part of the entire information is important with respect of the environmental conditions. While in a traditional system the context data are not dealt like special information and the system includes implicitly every the various behaviours without being aware of the multiple aspects of the ambient of the application, in a context-aware system, the context data are used in order to personalize the input treated.
In this scene, the date tailoring based on the context [36] can be defined like the activity of filtering of the portion of data to the aim to supply to the user in appropriate way a whole of data made-to-measure.
What are the context-aware applications for? For some years, more and more often we hear talking about smart environments aimed to the improvement of the quality of life, both in domestic environment (domotics) and in city environment. In particular, there is an expression that recurs a lot in the several mass media: 'smart city'. The smart cities are the so- called intelligent cities. This subject is interdisciplinary and encompasses all the fields: from the energy saving, to the improvement of life and the fastest and more natural access to information. It is exactly in these two latest fields that the context- aware applications insert themselves. In fact, in the future cities, there will be more and more smart spaces (domestic and not), which will take care of the users making easier and more immediate their access to information and, under determined conditions, will be able to foresee the user's desires and therefore to anticipate some operations on behalf of the user. As an example of smart environment, we can think of a room that has the capability of automatically regulating the temperature of the environment according to the user's preferences, or, through a centralized stereo system, can change music according to the user's tastes. And moreover, we could think to a public park where people, by tagging, can leave their own messages on a virtual wall, so that in the future the users of this same park can take advantage of the advices of who has been previously in that place. A further example could be that of a smart shopping center, where when a user enters in a shop directly receive information about the products on sale that he/she could be interested in. This processing can be made on the basis of the previous purchases and/or of a series of indications given by the same user (for example, through an electronic questionnaire made available by the shopping center). This kind of applications can become very important also in the field of the improvement of disabled people's life. In fact, it is possible to study some areas that change according to the specific need. For example, let us consider a blind person that enters a smart public building, this environment, after having

received context information about the user, has to be able to guide him/her towards his/her destination using audio messages.
One of the greater fields of search of Context-Aware is that of the cultural heritage: in the last the 20 years, the investigators have experienced different technologies to the vanguard.
Currently, with the convergence between Internet and the wireless technology, and the increasing adoption of the Web like platform for the publication of information, the visitor is able to take advantage of the material of the cultural patrimony before, during and after the visit, having different purposes and requirement in each phase. The exploration of the cultural patrimony becomes therefore a continuous process, beginning the visit before and finishing it never ideally: the experience of the cultural patrimony is seen like a continuous experience for all the life.
However, the sites of the cultural patrimony have an enormous amount of present information, that they must be filtered, personalized and contextualized to the aim to allow to the single customer to approach there easily. The personalisation of the information of the cultural heritage demands therefore a system that is able to model the user (for instance, on the base of the interest, the knowledge and other personal characteristics), as well as contextual aspects, selecting the more appropriate content, so as to guarantee it in the more opportune way.
The idea is that to realize a Context-Aware application that acts as automated support for the tourists, equipped of a mobile device, which reacts to a change of context adapting user interface for the different abilities of the tourist; supplying different informative contents based on the various profiles/interests of the visitor and on his/her position; supplying to the visitor adequate services.
In the next paragraph, we will present the main related works to Context-Aware paradigm.

3 Related Works

In the last decades, there have been different works tied to the mobile context-aware in the field of the cultural heritage: the objective of this section is that to furnish a brief panning on the systems studied existing, remembering the key points, but without getting into the details.
When appeared the mobile technology, it adopted for the disbursement of the information of context-aware of the cultural heritage both indoor and outdoor. Some projects tried to cover both the cases, for instance, MUSA and Smartmuseum [27], but the greatest part they specialized in one or in the other.
Abowd et al. [1] introduced the Cyberguide system, a tourist guide context-aware that used the position in real time and the history of the position to drive the visitors. The content of the information was selected by the system on the basis exclusive of the context, for instance current position or time, but it was not able to suit for the characteristics of the user.
The accurate determination of the position of the visitor in indoor brought to the idea of interaction through the physical movement, introduced for the first time by Hyperaudio [24], considered one of the pioneers of the mobile guides toward the end of the years '90.
The visitor is equipped with a palmtop computer (PDA), endowed with a system of location, and he/she wears some headphones to listen to the remarkable descriptions. The interpretation of the behaviour of the visitor is not limited to near to an exhibition, but can be extended to the ample variety of physical movements in the space. So, to stay for long time in front of an object reveals interest, while walk away during a description represents indifference or tiredness.
Smaller than a tablet, the aspect of the PDA opened the road for a big number of prototypes, both indoor and outdoor.
The idea of "to interact with the space", introduced for the first time turned by Hyperaudio, has been widened in HIPS, that classified the visitors on the basis of their behaviour during the visit [3]: the position, captured on the PDA, sent to the visitor for the elaboration and the dynamic presentation.
In accord to the ethnographic studies of Véron et al. [38], the visitors of the museums can be classified in four categories. The ant visitors who follow a specific run and spend a lot of time to observe almost every exhibits; the fish visitors who stir the greatest part of the times to the centre of the room, without looking at the exhibit in the details; the butterfly visitors, who don't follow a specific run, but are guided by the physical orientation of the pictures and they stop frequently examining their details; the grasshopper visitors, whose visit contains specific pre-selected exhibits and they spend a lot of time observing them.
HIPPIE, a spin-off of the HIPS project, used a dynamic model of users on the basis of own interests deducted and of the knowledge to the goals of the personalization [25].

The outdoor personalization launched by GUIDE [6], who used a tablet able to furnish information on the points of interest of the city of Lancaster (United Kingdom), exploiting the WiFi technology for the positioning. The profile used in GUIDE included the list of preferred attractions, the user's interests, the current position and the visited places.
In the last two mentioned systems (HIPPIE, Guide), together with AVANTI, UbiquiTO, Gulliver's Genie, Marble Museum, the visitors compiled some questionnaires with the purpose to determine their context, the interests and the preferences and to set up the user model. However, very soon was clearly that many of the functions in the questionnaires do not prejudice the style during the visit [23] and that the compilation of the modules was not this that the visitors wanted to make before [17].
The experience of the mobile cultural heritage personalized was very rich, but not complete. The social experience of a group visit has been hindered by an individualistic approach. In this sense, answering to this gap, AgentSalon [33] used virtual characters who accompanied the visitors in public places in order to encourage the interaction face to face between the people. When the visitors approached themselves the screen of great dimensions, the virtual characters transferred from own mobile device to the screen (with their user profile), began to interact to the aim to activate the communication face to face between the human beings about issues of reciprocal interest.
CRUMPET [30] used PDA in order to supply dynamic and interactive maps which showed the current position, recommendations, information about the attractions, and suggestions during the visit. In this system, positioning was based on GPS data.
As the mobile and the communication technology are advanced, so also the mobile guides: PEACH [31], created in dynamic way some video clips based on the animation taking into consideration the preferences of the user. A virtual personage migrated from PDA to a big screen at the beginning of the visit and accompanied the visitors, introducing information, throughout the visit. At exit time, a personalized synthesis was generated, mentioning at what seemed to be most interesting content for the visitor and suggesting future activities.
A more effective interaction, even if not personalized, was sought by Cena et al. [4], where “the Carletto spider” dramatised the presentations for the visitors, with the objective to move away from the idea “to guide them” towards more involved “to tell to them the history”.
A different type of service has been supplied by the tour guide iCITY, which offered notifications of personalized events for the visitors that used their mobile phones. The interaction with the space introduced from HyperAudio, further explored in LISTEN [41]: the user wore a pair of wireless headphones and walked around the exhibitions in the space enjoying dynamically 3D audio presentations. The project ec(h)o [19] had a completely different approach, experiencing a tangible and personified interaction, applying it based on localization and arranging it with technology RFID.
Another step forward was taken by Stock et al. [32] who introduced adaptive and dramatized information presentations into a museum visitors’ guide in execution on smartphone.
The opening to the social context for visits indoor was also the focus of PIL [22]: the group members were modelled singularly, but with the objective to attract them with in the sharing of the exhibitions of interest (for example, by messaging each other or by proposing various objects to see), promoting talks of verification after the visit.
With evolving of the technology, emerge new possibilities. Augmented reality could improve the visitors’ sense of being present inside of the museums and their enjoyment during the visit [34], and body interaction can control the visualization of artworks [39].
Affective computing and personalisation techniques could be arranged to tailor the environments during the visit of the user, on the basis of own style, humour, and objectives, thus creating a unique and involving experience.

4 Motivating example

In this section, we describe a typical application in the tourist domain in order to better understand the main features of the proposed system. In particular, we consider a tourist that during her/his vacation in Campania desires to visit Salerno, a beautiful town located in the South of Italy. To be considered smart, the environment related to the town of Salerno should provide a set of smart services for:

- suggesting the visit of the most important cultural places in Salerno;
- having information about the restaurants in Salerno;
- accessing to proper multimedia guides describing the main artworks that are in Sa-

lerno;

- recommending special visit paths (trekking paths, bicycle tours, …);
- monitoring the weather condition;
- showing the timetable of the transport services located in Salerno;
- saving the visit in a multimedia album;
- accessing to information about public services in Salerno (Post Office, Pharmacy, …).

For improving their effectiveness, these services and contents have to be furnished to the user in the right context and at the right timing. Therefore, it is important the context awareness of the framework and the opportunity to use it by mobile devices 12. Another important feature of the system is the ability to suggest resources that usually are not considered as mainstream.

In order to give the most suitable contents to the users, in this paper we introduce a context- aware system able to tailor data and services depending on the context and the users' needs. For example, if the user declared as preference the use of the transportation when he/she is close to a bus stop the timetable will be automatically downloaded on his/her smartphone. The same will happen when the user is close to restaurants: if he/she loves food based on fish, only this kind of restaurant or menu will be proposed. Data about resources and services are collected from a knowledge base built by a group of experts and collecting information from the various social networks.

In the next paragraphs, more details about the system architecture and the application of the proposed approach in real context will be furnished. In particular, we will present an approach to the management of the context and its associated services to make the previously introduced approaches concrete.

5 A Context Dimension Tree based approach for contents contextualization

Therefore, it is extremely necessary to create a framework that can integrate contents and services to support a generic user inside a certain territorial context. One of the methodologies that in this scenario promises particularly significant results is the one that takes into consideration the analysis of the context 1013. In fact, the approach that allows an application to gather and react to the changes of the environment where it is situated is defined Context-Aware Computing. This kind of approach, starting from a certain context, which can be defined through a series of environmental characteristics, aims at a management of information, connected to that particular context, able to select the mainly significant ones for the user in a certain moment 18. In this way, the data tailoring based on the context can be defined as the activity of definition of the data views present in a knowledge base. Therefore, the problem consists in filtering the data to supply to the user a tailor-made set of data according to the position and the time.

A key element in the planning of Context-Aware systems is the representation and the management of the context. The goal is to provide a mechanism of dynamic and automatic invocation of services considering the context through the Context Dimension Tree 37.

CDT is a tree composed of a triad <r; N; A> where r indicates its root, N is the set of nodes of which it is made of and A is the set of arcs joining these nodes.

CDT is used to be able to represent, in a graphic form, all possible contexts that you may have within an application.

Nodes present within CDT are divided into two categories, namely dimension nodes and concept nodes. A dimension node, which is graphically represented by the color black, is a node that describes a possible dimension of the application domain; a concept node, on the other hand, is depicted by the color white and represents one of the possible values that a dimension may assume. Each node is identified through its type and a label.

The children of the root node r are all dimension nodes, they are called top dimension and for each of them there may be a sub-tree. Leaf nodes, instead, must be concept nodes. A dimension node can have, as children, only concept nodes and, similarly, a concept node can have, as children, only dimension nodes.

In addition to nodes, you can use other elements: the parameters, which may arise both from a dimension node (graphically represented by a white square) and from a concept node (white triangle), submitting them to particular constraints. In fact, a concept node can have more than one parameter, while a dimension node can have only a parameter and only in case it has not already children nodes. The introduction of parameters is due to their usefulness in shaping the characteristics that can have an infinite or very high number of attributes. For example, a node representing Cost dimension risks having a high number of values that should be specified by as many concept children nodes. In a similar case, it is therefore preferred to use only one parameter, whose value will be specified in each case. Leaf nodes, in addition to concept nodes, can also be parameters. In general, each node has a parameter corresponding to a domain, dom(nP). For parameter nodes connected to concept nodes, the domain can be a set of key values from a relational database, while in case of parameter nodes connected to dimension nodes, the domain is a set of possible concept nodes of dimension.

The CDT allows interrogating a knowledge base subtended to a certain context through the Five Ws and One H method 29:

- Who: 'Who is using our application?: the 'who' aspect refers to the identity of the user who stays in a certain context. 'Who' can be extended also to other people who can be interesting for the user's situation, for example, friends of a social network, co-located people, or other users of an application.
- What: 'What does the user do or want to do?'. The 'what' aspect refers to the potential activities of interest for the user present in the context.
- Where: 'Where is the user?'. This dimension tries to understand where the user is inside the context through his/her locating and tracking.
- When: 'When does the user stay in the context?'. The aspect of the temporal context has been recently explored looking for models and routine in the daily life of people and assumes a fundamental role in the selection of services and contents.
- Why: 'Why does the user make this?'; 'Why is the user here?'. Very similar to the 'when' aspect, probably this is the most complex aspect of the context to analyze because it includes aspects such as the meaning of the action, the intention or the emotion.
- How: 'How does the user make this?: 'How is the user here?'.

In figure 1, it is shown a general designed CDT, called Meta CDT, which is the starting point for the design of a specific CDT that can be exploited in contextual applications.

To better understand formal concepts, it has been carried out in the paper an example based on a simplified citizen domain, on which it is now being developed a Context-Aware System that assists residents and tourists in their activities.

You may note six top dimensions, which correspond to the questions of the 5W1H method: Location (WHERE), Role (WHO), Time (WHEN), Situation (HOW), Interests (WHAT) and Utilization (WHY). In particular, there are two types of users and eleven categories of interests.

A context element is defined as an assignment $d\_name_i = value$, where d_name_i indicates a possible size or undersize of CDT (it is the label of a dimension node), while *value* may represent the label of one of the concept nodes that are children of the considered dimension node or the value of a parameter referring to one of these concept nodes or the value of a parameter referring to the considered dimension node.

For example, these assignments are possible context elements: Interest = tourism, Location = LocationID (ID = 3), Role = user, Utilization = holiday.

A context is specified as: $\wedge (d\_name_i = value)$.

It is defined as an "and" among different context elements.

Several context elements, combined with each other by means of an "and", damage, therefore, the origin of a context.

For example, a possible framework that can be obtained from the previously seen CDT, through the context element that we have listed, is:

C = (Location = locationID (ID=3)) ∧ (Role= user (ID=15)) ∧ (Time = now) ∧ (Situation = routine) ∧ (Interest = tourism) ∧ (Utilization = holiday)

The context is defined as a user, interested in tourism, who uses the contextual app on vacation, in a called place.

Therefore, through the Context Dimension Tree, it is possible, after analyzing the domain of application, to express the size characteristics and values they can take in a graphical way by, respectively, dimension nodes and concept nodes or parameters. The assignment to a dimension of one of its possible values is a context element. The context element can be considered the main feature of the application, by which a context can be decomposed. The moment you make the formulation of the context, you must specify all the context elements that are part of it and that enable its creation. Any context is expressible by an "and" combination of the context elements to which they are peculiar.

By definition, you can begin to understand how you will create views based on data relating to each context; in fact, they will be built starting from the portions of the database and then from the partial views, associated to the context element that takes part into context information.

In the next two subsections, we will treat the system architecture and methodology to obtain contextual service.

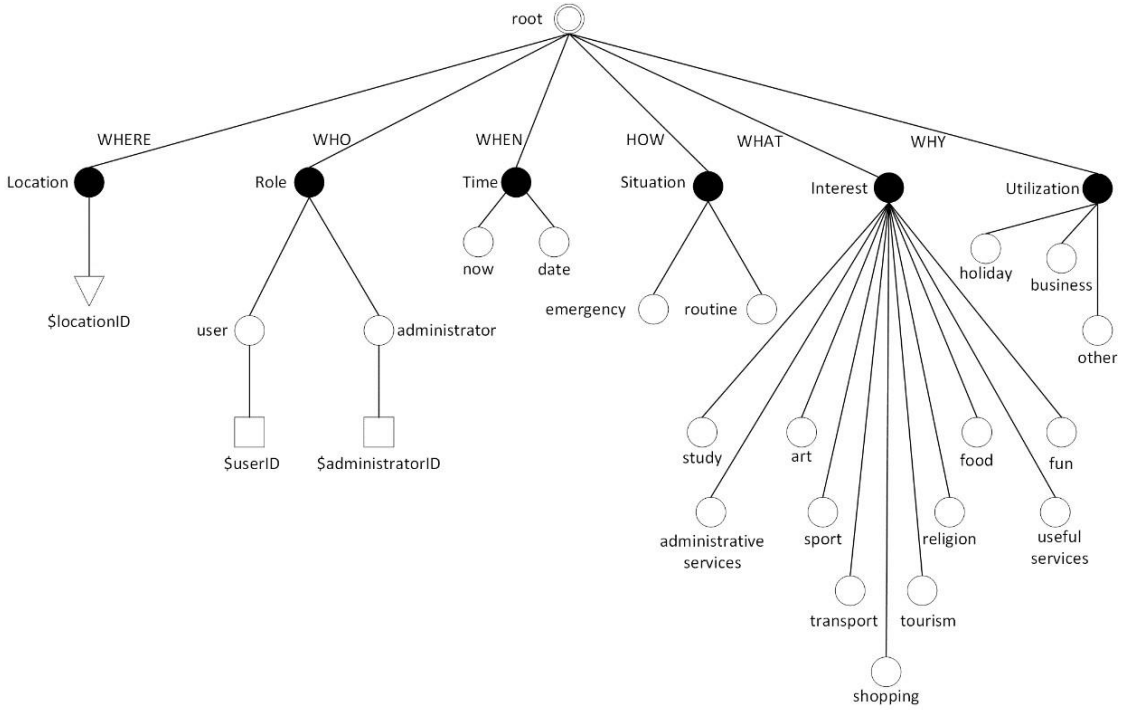

Figure 1: Meta CDT for contextual applications

5.1 System Architecture

We have made a Context-Aware System, whose architecture is shown in figure 2, able to adapt useful data and services to users based on the context. Context awareness of interaction is particularly important in ubiquitous systems and mobile applications for groups of users.

In fact, given the ever-increasing variety of interaction devices (fixed and mobile) and application use contexts, it becomes increasingly necessary to develop Context-Aware systems that manage information that makes unique and distinguish each human-machine interaction.

The architecture of our model is composed of: the Context-Aware Module (CAM), which is the main engine and considers the context in reference to the obtained data (contextual information), in particular position (GPS location), interests and role (obtained during registration) of each user; the Knowledge Base Module, a special type of database for the management of knowledge and information: in particular "Users", representing all users of the application, "Services", which describes all the services of every possible application context, "Resources", which forms all the points of interest and "Events", which describes all events; and finally the Management Module (MM), used both by the administrators of the app and the users themselves.

This module deals with some important issues, including: POIs management, where the insertion can be done directly from map, manually or by search of interests, interacting in the last two cases with Google Maps; services, comments and events management, interacting with TripAdvisor and Facebook/Twitter API.

In figure 3, for a greater immediacy, it is shown a deepening of the architecture realized: the set of user profile, such as preferences and interests, of user context, such as his/her GPS location, of CDT, which provides the rules and allows the representation of the specific context in which he/she is located, of data, including the points of interest and services, allows obtaining the contextual resources tailored for the user, through the use of a contextual application.

On this subject, for the different environments described, we have realized hybrid mobile applications, both in Android and iOS, with many features, some of which are shown in figure 3: contents, including descriptions, images and services, tailored to interests, profile and location users,

planning a route based on user's interests and his/her preferences of travel, exploration of the surroundings from the current position, custom QR Code reader, weather and news on the site, search and insertion of events, the comments section, display position and points of interest on the map, with integration of the navigator on the smartphone to reach specific ones.

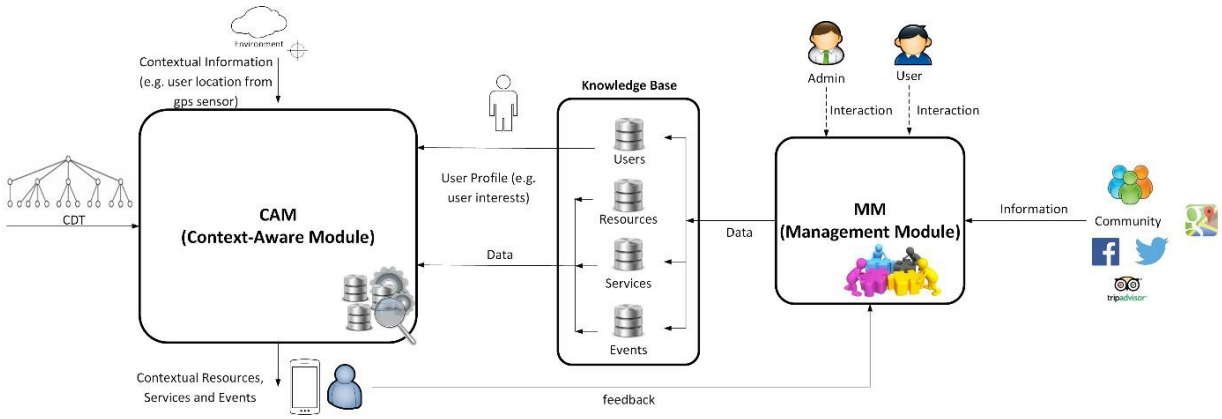

Figure 2: System Architecture

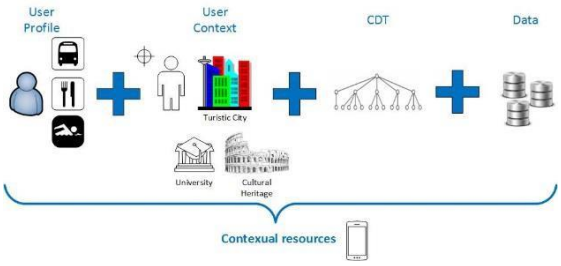

Figure 3: Contextual resources as final result of App

5.2 Methodology and phases to obtain contextual service

The methodology, shown in figure 4, has been realized in order to manage the database and to carry out reductions of their content based on the context.

The purpose is to help the designer in the definition of all contexts relevant to the considered application and, later, in the association to each context of the portion of the database containing the relevant data about the context.

The methodology consists of three main phases, which we will see in detail later: design phase of the Context Dimension Tree (CDT), definition phase of partial views and composition phase of global views.

1. Design phase of the Context Tree: in this phase, the Context Dimension Tree is designed to identify significant context elements for the considered application. In fact, it focuses on the definition of contexts and on the elements that compose them. These contexts must be identified and shaped, indicating particular elements that characterize each of them. As it has been said, it is available a special tool called Context Dimension Tree (CDT) to make context design. Three CDT were made for specific environments in order to represent and manage a multitude of different contexts and in order to identify, represent, preserve and make available cultural points for each type of user.
2. Definition phase of partial views: after the definition of all the contexts and their context elements, in this step a different portion of the database is associated to each context element, containing the relevant data for it.

In practice, the goal is to find the appropriate value for a given dimension, in order to obtain, by means of the values of all the dimensions, a valid query and specific to the context in which the user is located.

A partial view could be related to dimension "Role", shown in figure 5: once logged in, the application is able to recognize the user and to know more precisely whether he/she is, for example in tourist areas, a resident or a tourist. Thus, the value "tourist" of dimension "Role" is a partial view for the current context: using this knowledge, you can exclude certain services, not suitable or useful to the tourist role.

3. Composition phase of global views: this is the phase where you have the automatic generation of views associated with each context, which is made starting from partial views associated with context elements. After the creation of the global views of the contexts, the answers to questions that will be asked to the system will be developed from these views and, in particular, from the view associated with the context in which you are located when the query is performed.

In particular, once defined the values for each dimension, you can use all the information obtained in order to identify the right context and offer data and services customized for the user. It is assumed the example of a tourist who is walking near a beach who gets initially a notification of his/her proximity. Later, he/she needs to deepen such notification. Therefore, it will propose him/her services that they might be interested in, such as the site of the nearest beach, where he/she can get the price list.

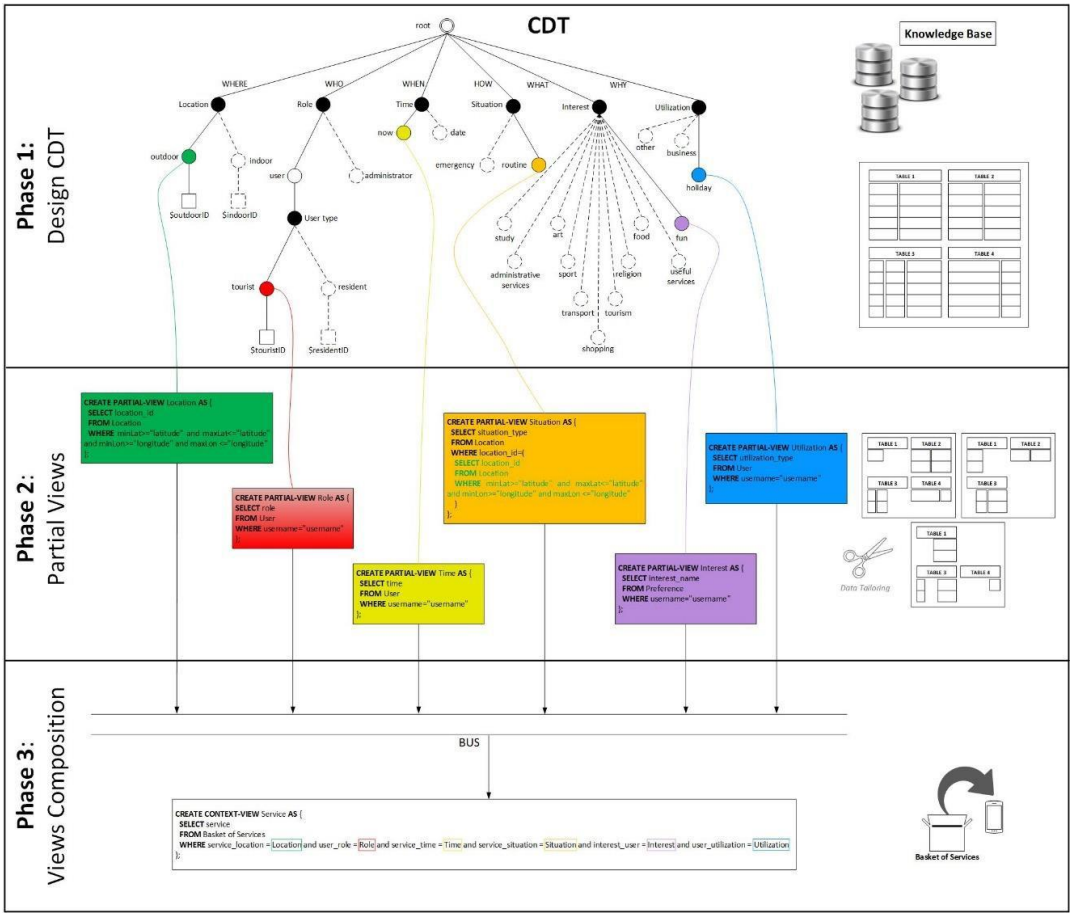

Figure 4: General System Workflow

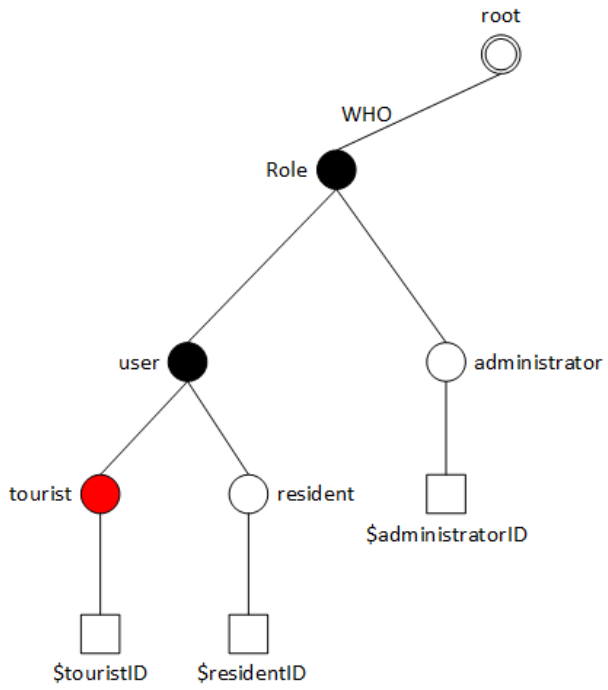

Figure 5: A partial view for dimension “Role”

6 SmartApp Salerno: a Context-Aware App for e-Tourism

In this section, it is introduced an Adaptive Context-Aware App able to support different typologies of users inside an urban context. For instance, the system can guide the tourist in the discovery of a new city proposing him/her mainly interesting resources and services according to his/her interests and the position where he/she is. The App collects information also from social environments adapting the proposed itinerary taking into account the user’s communities and interests. It can also support the citizen who has to get out of the usual everyday activities.

The app has been developed for several urban contexts:

- An Italian town of medium dimension: Salerno
- An Italian village of little dimension: Poggiomarino
- A University campus: the University of Salerno
- An American town: Pittsburgh, in collaboration with the Computer Science Department of the University of Pittsburgh.

For each App, it has been planned and implemented a CDT and a knowledge base of reference. For each user, information about his/her characteristics has been collected and other has been gathered from the social profiles.

In particular, in this paper, we will present SmartApp Salerno, a contextual app designed and implemented according to what was described previously. We have thought to apply the approach to the context of the town of Salerno, a municipality in Campania (Italy) of about 135.261 inhabitants and with an extension of 59,85 square km. Along with the Municipality of Salerno, a reference CDT has been designed. In this phase, we have collected the potentially useful services and contents for the citizens and situated them on the map defining the activation zones (fig. 6).

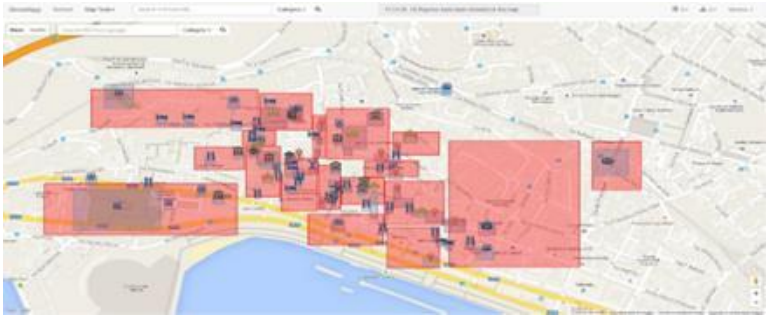

Figure 6: Definition of the activation areas of services and contents

Moreover, we have defined the different typologies of citizens (elementary school's students, users with kids at school, university students, …) associating them to a previously established set of services and contents. Having the town a series of artistic contents, we have developed services and contents in support of them too. A series of services and contents considered transversal, such as the opening hours of the churches and the pharmacies, have been made available to all the typologies of users.

All information about places of worship and shops has been uploaded, for any building or area of potential.

The App has been developed with hybrid technologies (Apache Cordova and Ionic Framework) to allow an easier publication both in Android and Apple environment**.** It was published in the Android and Apple Store in August 2015 and it has been presented to various tourists during 20 workshops.

Some screenshots of the SmartApp Salerno application are present in figure 7 and in figure 8.

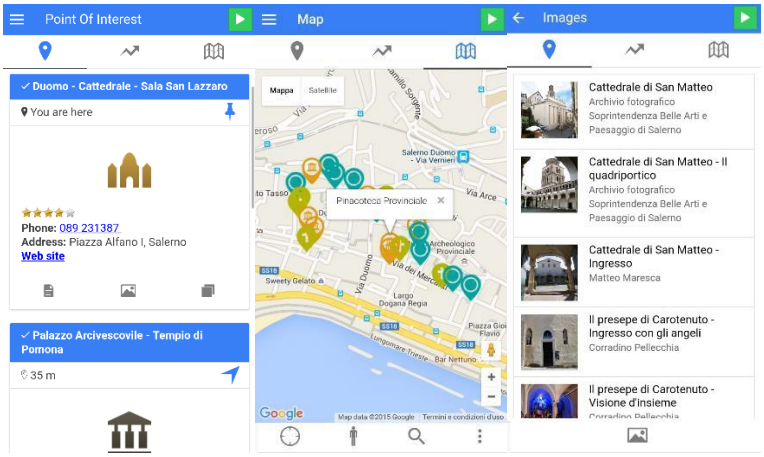

Figure 7: Screenshots with some features of contextual application

a) App home with current points of interest information.

b) Cultural points of interest on the map.

c) Images of selected point of interest.

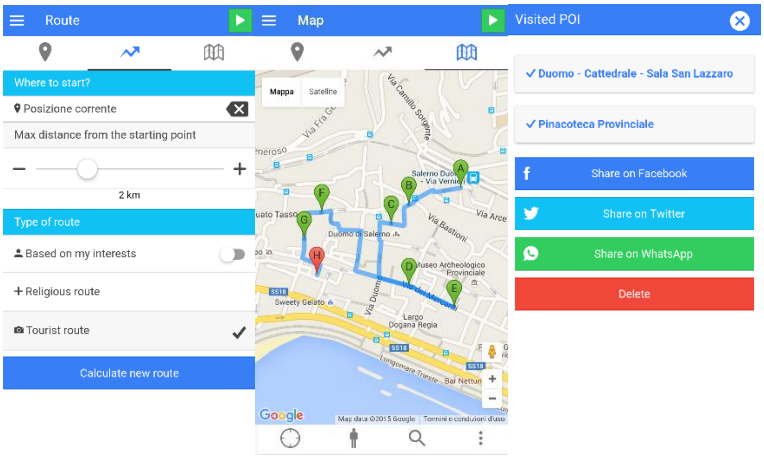

Figure 8: Screenshots with other features of contextual application

a) Choise of preferred route to calculate.

b) Calculated route on the map.

c) Route sharing on social networks.

7 Experimental Results

Now, we are going to present the conducted analysis, using the realized App, to understand the influence on the user experience of the proposed Context-Aware model.

The 40 participants, recruited by invitation, are above all students or university professors and do not know the subject of the study. All live in different towns, in Italy or abroad, are between 18 and 60 years old and have an Android or Apple mobile device.

We identified about 140 geo-localized resources and services in Salerno area, grouped in 85 points of interest. Depending on user profile and position, the CAM module suggests resources and services for each user.

The experimental phase aims to evaluate the proposed Context-Aware model. Initially, the App has been distributed and installed by all the participants. After having interacted for some days with the application, the participants have then answered on the basis of the Likert scale to twenty statements, divided into 5 sections. To every question present in the section, 5 possible answers have been associated: I strongly agree – I agree – Undecided (Neither agree nor disagree) – I disagree- I strongly disagree.

The questionnaire in detail is the following:

Section A: SmartApp Salerno – Context

- A1. SmartApp gives the user tailor-made contents and services
- A2. SmartApp allows the user to know several points of interest of the Old Town Center of Salerno
- A3. SmartApp supplies contents and services in the right place
- A4. SmartApp supplies services according to the interests selected in the user profile

Section B: SmartApp Salerno – Usability

- B1. SmartApp is immediate to understand and use
- B2. The registration is quick to do and non- invasive

Section C: SmartApp Salerno – Further aspects

- C1. Information about each point of interest is very useful
- C2. I do not know other applications like SmartApp
- C3. The contents, such as descriptions and images, are of high quality and represent one of the strong points of SmartApp
- C4. The services associated to the points of interest allow a higher immediacy than a classic research on the Internet

Section D: SmartApp Salerno – Functionality

- D1. The map is very useful and well curated
- D2. The plan itinerary service allows easily realizing an itinerary in the Old Town Center of Salerno according to the user's preferences

- D3. The explore surroundings service is very useful to know what there is nearby and eventually reach them
- D4. The functionality of research of points of interest by category of interest is intuitive and practical
- D5. It is useful to know if a certain point of interest is open or closed
- D6. The functionality of QR code in inner environments can be well used
- D7. The tutorial effectively allows learning the main characteristics of SmartApp
- D8. The weather forecast and the news are two very useful services

Section E: SmartApp Salerno – Future developments

- E1. It would be interesting to have a higher integration with the main social networks
- E2. It would be interesting to insert the available time in the plan itinerary service

Table 1 presents a synthesis of the answers of the participants to each declaration.

Likert Scale	**Context**				**Usability**		**Further aspects**				**Functionality**								**Future developments**	
Answer	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**C1**	**C2**	**C3**	**C4**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**E1**	**E2**
Strongly agree	15	22	11	20	14	21	10	11	13	16	15	20	16	12	19	9	12	18	8	19
Agree	24	16	28	17	17	15	27	11	21	15	24	18	21	24	15	23	23	14	26	16
Neither agree nor disagree	1	2	1	3	9	4	3	13	6	8	1	2	3	4	6	8	4	6	5	4
Disagree	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	1	2	1	1
Strongly disagree	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0

Table 1: Experimental results

As shown in this table, of the 40 participants who have interacted with the application, many agree and/or strongly agree that the system gives appropriate contextual information about the place, it is immediate to understand and use, further aspects and functionality are very useful and future developments are interesting.

Instead, only in few cases, the participants do not are particularly satisfied.

As can noticed from the figure 9, users show great appreciation for the app. In general, they appreciated the proposed contents and services.

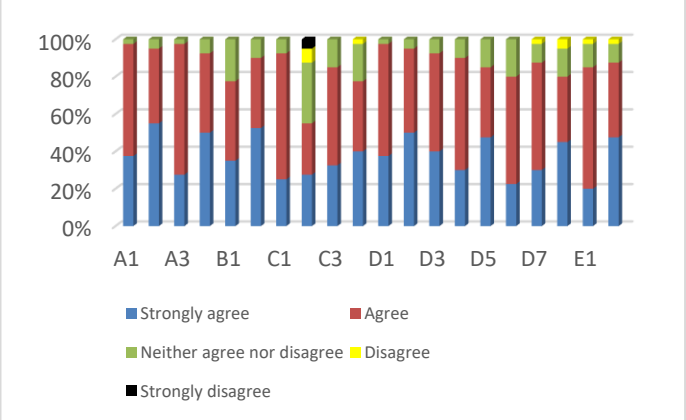

Figure 9: Graphic analysis of experimental results

In figure 10, it is presented the use, in terms of daily requests of the several services, of the app. From a more detailed analysis, we can deduce that generally the most popular services are those linked to the request of opening hours of shops and public offices. Instead, during weekends, the requests of services and contents concerning activities linked to free time become more substantial.

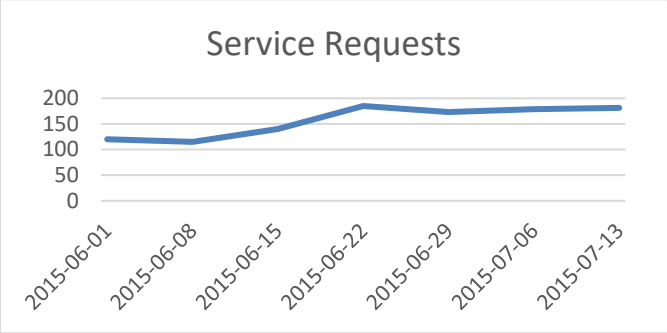

Figure 10: Service Requests in the period 01/06/2016 – 13/07/2016

8 Conclusions

This paper proposes the use of a Context-Aware Approach for the selection of the most suitable services and contents for a user in a certain context. The system is based on the concept of Context Dimension Tree, a graphical formalism able to model a context by the approach of the 5W1H method.
The propose approach has been implemented in an App that furnishes services personalized for the needs of the user according to the context where he/she is. The app has been developed for the needs of an Italian town, Salerno, and the results have been satisfying. The following activities have as purpose the application of the proposed methodology to more complex environments, for dimension and number of potential points of interest to manage.

Acknowledgment

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