Mobile Services through Tagging Context and Touching Interaction

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***Abstract*— One of main objectives of Ambient Intelligence is the reduction to a minimum of the user's interactive effort, the diversity and quantity of devices with which people are surrounded with, in existing environments, increase the level of difficulty to achieve this goal. The mobile phones and their amazing global penetration, makes it an excellent device for delivering new services to the user, without requiring a learning effort. An NFC-enabled mobile phone will allow the user to demand and obtain services, by touching its different elements in the environment. In this paper we present a proposal where we analyze the scope associated with touch interaction, and where a model to perceive touch interaction through the tagging context is designed.**

Keywords-tagging context; touching interaction; mobile services;context aware.

I. INTRODUCTION

One of the first definitions of smart environment [1] [2] [3] arises from Ubiquitous Computing, which "created a new field of computer science, one that speculated on a physical world richly and invisibly interwoven with sensors, actuators, displays and computational elements, embedded seamlessly in the everyday objects of our lives and connected through a continuous network" [4], although Mark Weiser does not define it explicitly.

The vision of Ambient Intelligence [5], which is an evolution of Ubiquitous Computing, proposes a new way of thinking about computers, which will disappear in the environment, meaning that this perceiving and responding automatically to the presence of people is creating a smart environment.

The Ambient Intelligence (AmI) paradigm visualizes environmental management by applications, which will perceive in a continuous way the characteristics of the entities that comprise it and the natural interaction between them, thereby enabling applications to offer services either proactively or with the smallest possible interactive effort. Another characteristic of this type of environment is that, even with a strong technology, it is "invisible" to people; this disappearance can be obtained by embedding it in daily objects in the environment.

The final objective of a smart environment is to satisfy users' needs by providing services that require minimum interactive effort from them (the ideal service is one which the user receives without explicitly demanding it).

A smart environment must be able to perceive all the interaction techniques that people can develop. From these methods, the interaction of contact (or touch interaction) represents an opportunity area, justifying the design of a system that perceives. This interaction technique is simple, requires minimal effort and it is part of the natural reactions of people when they want to use an element of the environment, if it is within reach (if the device we want to use is near, we say we touched it).

Touch interaction can replace complex techniques and even intricate learning processes, for example: sending a photo to a new device, printing a document on a printer that has never been used, just as an older person will be able to request a meal from a company merely by touching a picture of it, etc. This feature and its ease of use by older people will play an excellent role in certain current issues, such as dependency.

Touch interaction is a simple technique; when it is developed between persons or between a person and an environmental element, it may involve a large amount and flow of information, which would represent a significant contribution to a smart environment.

A system that perceives and administers an environment's touch interaction would be able to offer services to users they could not have imagined and will be fundamental to the construction of the ideal smart environment.

Our work proposes perception of the touch interaction, which will be used to demand services at the moment of interacting with the environmental elements or entities. In order to obtain this perception, the "tagging" of the environment's entities will be necessary. The intention is that, when perceiving this interaction, the application that manages this environment will obtain information on the entities involved that, properly combined with the information in the application's databases, will enable services to be delivered.

II. USER SCENARIO

In the following scenario, we describe some activities at a research group; in these the users obtain services through "touching interaction". This scenario is the support for the application we are developing and testing.

John arrives at the building door, where his office and other workspaces (laboratory, other members' offices, and meeting room) of his research group are located. With his NFC-enabled mobile phone he touches the tag at the side of the main door of the building and the NFC-enabled mobile phone reminds him that he has an important comment for

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George who is already working at his desk. For this reason John decides to go to the laboratory (where George is). At the moment John touched the tag, all the members of the research group, who are working in a computer, receive a message indicating that John has entered the building.

In a corridor, John can observe (on a public display) a summary of the research group's current work, such as deadlines of the congresses in which they will participate, the last versions of the papers being written, the identity and location of each person working in the building, etc.

When John arrives at the door of the laboratory he can observe who is in inside by looking at a little display. He can also see the degree of progress of the different activities (along with notes on projects, programs, articles, etc.) that the members of the group are developing. Before entering he touches the tag of the next door. Inside the laboratory he can observe a reminder of all "notes to comment on", on a public display at the laboratory, which has been stored in his mobile phone. Meanwhile, all users who have "notes to comment on" to John, can see a reminder indicating that John entered the laboratory on their computers.

While John talks to George, John places his mobile phone near the tag on the display of George´s computer to show a file. After commenting on it, they decide to show it to everyone in the laboratory. To this end, John touches the public display with his mobile phone.

Before John leaves the laboratory, George decides to send him a paper for checking, but, due to its large size, it does not fit in the mobile phone's memory. He therefore, decides to send the file to John so that it can be checked from any computer in the AmI environment.

When John leaves the laboratory, he runs the exit service in his mobile phone to aware the AmI environment that he is coming out of the laboratory. When John arrives at his office and touches the tag in the door, his mobile phone shows the list of people who came to see him while he was out, as well as the messages left for him.

III. ENVIRONMENT ENTITIES

The model we are proposing would endow an environment with the capability of perceiving the touch interaction between environment entities, which we define as: The intentional approach of two entities in order to obtain a service. This implies that when an entity approaches another one, the touch interaction arises. The objective of this model is limited to the touch interaction, which involves only two elements, of which one is a person. This is the reason why the touch interaction of interest to us is defined as: A person's deliberate touching of an environmental entity (the latter can be another person) for the purpose of obtaining services.

One of the most popular and referenced context and entities definition is given by Anind K. Dey, who states that "any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and application themselves" [6].

Owing to the fact that we are interested only in a specific interaction technique between a person and an environment element or another person, we have adapted Dey's definition so as to define the context limited to touch interaction as: any information on the involved entities that is required to deliver the services offered by the touch interaction.

A. *Entities*

The PICTAC (it perceives touch interaction through tagging context, in Spanish) objective is to develop a system that manages the touch interactions of an environment in which at least one person takes part. This is the reason why the entity "application" will not be considered by us.

Since the capacity to participate in a touch interaction that is perceived by the environment is not a person's natural ability and so that a system can take into account a person, their data must have been captured previously. If we add these capabilities to the "person" entity, we create the "user" entity (which would be a subset of the entity proposed by Dey), as used in our model.

Dey's "object" entity has proved to be too general for the purpose of the model, since from the standpoint of the service it can provide, we can distinguish two categories of objects: Devices, those whose service can be demanded through a touch interaction (basically electronic or computer equipment), and Objects, those whose service is not "suitable" or cannot be demanded through a "touch" (e.g., a desk, furniture). However, in the case of the latter, through their location and continued use, we can take advantage of them to integrate some in the model we are proposing and offer services. This is the reason why we have broken down the object category into two types of entities: "object" and "device". It must be remembered that an object does not even have the capacity to process and communicate which is the reason why the capacities that it could have will depend on the available computer device that allows it to participate in a touch interaction and on the user's capacities.

TABLE I. COMPARISION BETWEEN DEY ENTITIES AND OURS

Dey entities	**Adaptation**	**PICTAC Model**	
		Entities	**Description**
Person	Only the person or equipment are considered	**User**	Person with the capacity to participate in a touch interaction
Object	They are divided into two, depending on the form given to the services	**Object**	Those whose service is not "suitable" or cannot be requested through "touch"
		Device	The service can be demanded through a touch interaction
Place	Idem	**Place**	Represents a part of a smart environment or even the entire environment
Application	Not relevant	Not used	

TABLE II. SUMMARY OF TAGGING CONTEXT PROPERTIES

Tagging Context Properties	
Contact	As it is the user which makes the touch, it must have contact property to carry out the touch interaction.
Identification	This will be given to other non-user entities, which will be responsible for responding to the touch made by the user
Context	This can be one of two types: the context limited to the touch interaction, which is the information about the entities involved in the interaction, or the environmental context.
Services references	So as not to keep all the information in the touched entities, only these are placed.
Memory	Although our model will focus primarily on data, the memory property is implicit and necessary.
Processing	It processes the services references.
Communication	Linking the entities involved with the environmental infrastructure.

"Place" is an entity that will remain and will allow us to represent a part of a smart environment or even the entire environment, since it will have the capacity for self-inclusion, in which the place may contain entities (or even another place). Although, in the first instance, a user has the capacity not to associate the service offered by a place, this could be considered because, on touching the place it will provide the service, entering the smart environment and the user could even obtain the opening of the door. A summary and comparison of PICTAC and Dey entities is shown in Table 1.

Whenever a user touches any of the four entities described above, it will generate one of the four classes of touch interaction managed by PICTAC: user-place, user-device, user-object and user-user, as shown in Figure 1.

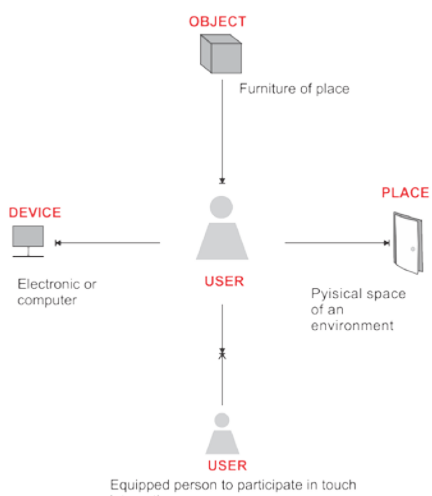

Figure 1. The four types of the PICTAC Model Touch Interaction.

IV. THE MODEL TO PERCEIVE TOUCH INTERACTION THROUGH THE TAGGING CONTEXT

The objective of the model that we are proposing is to be able to develop a system that endows the environment with the capacity to perceive the touch interaction using the *tagging context.*

The model consists of three parts: the properties that the environment must have, the tagging context and the services that can be offered.

A. Environmental Requirements

The PICTAC Model is designed in such a way that the system developed can easily integrate with other applications in a smart environment or it can be the only one of its type operating in the environment. To develop the system that manages the touch interaction and maximize the use of the information flow generated for the delivery of services, the environment must have two properties or infrastructures:

1. Processing and storage (considered together so that they can be offered by one technology)
2. Communication

Although these properties are essential to the development of the vision of an environment that manages the touch interaction, we believe that they will almost certainly exist in any environment in which an application of this type will need to be developed. This is partly due to the fact that the majority of workplaces have them and because the touch interaction is ideal for operating the electronic and computer devices in today's workplaces.

Both infrastructures are the common "technology level", which is shared by all the applications that will make up the ideal smart environment.

B. Tagging Context

If tagging is to put a tag on something and context is any information about entities, tagging context could sound incongruous but the intention of creating this paradox is to give emphasis to the idea.

Tagging will be necessary for two reasons: we will have to indicate the place where the entity must be touched and we must augment the entity with the capacity to perceive another entity's "touch".

The word context is used because we will augment the entities with the data needed to deliver the services originated by the touch interaction.

The tagging context requires generic properties to be developed: perception of touch, containment of information, processing and communication. These capabilities will be provided by different properties, of which all or some of them will be put in the entities. We define the tagging context as:

"Augmentation of the environment's entities with the necessary properties to participate in the touch interaction perceived by a system"

Two properties are necessary for the touch interaction's perception: contact and identification. As it is the user who makes the touch, it must have the contact capability. This is just a way of distinguishing the roles performed by each one of the entities that touch. The identification capability will be given to other entities (non-user) which will be responsible for responding to the touch made by the user. In other words, the entity that is touched is the one which identifies (responds to the touch).

For an entity to contain information, it will require memory capability. Although our model will focus primarily on data, the memory capability is implicit and necessary. The data involve two properties: context and services references.

Context is the information needed to deliver the service and can be of two types: the context limited to the touch interaction, which is the information about the entities involved in the interaction, and the environmental context. The first is saved in the same entities as those involved in interaction and the second in the environmental infrastructure.

In order to deliver a service, some processing of information must be carried out and, because we are not certain where such processing is carried out (in the user, in the environment infrastructure or in a device with processing capability), it was decided that, instead of the entity that is touched containing all the necessary instructions for processing the data, it will contain the necessary services references. The services references are all the necessary information to process and deliver the service to the user.

C. Services

The reason for any device or object in the environment is to offer users, as a minimum, an intrinsic service and in order to obtain it the user must interact with the object. The object of PICTAC is to offer services from the environmental elements by means of the touch interaction and, together with these services, to deliver others in an implicit way.

The classification established for the services is based on the manner in which their execution is originated or who has put them. The intrinsic services of the elements in the environment (which can be natural to the item or established by the system) are the default services, which are received by the user who touches. The implicit services are those that accompany the above and can be received either by the user who touches or other related users. The optional services are those created by the PICTAC system that can be received by any user and put in any entity. Table 3 gives a summary with the characteristics of each one of the service categories.

1) Default Services

All the environmental elements with which people are surrounded have at least one function or main use for which they were designed. The model that we propose is designed so that such use or service will be delivered to the user at the touch of the entity. These services are called default services and will be delivered to the user automatically whenever it touches an element.

In a device, the default service is intrinsic to it and is easily identifiable (e.g., the printing of the printer, the display of the monitor, etc.).

In an object, default services do not exist because they are not inherently associated with any services that can be obtained through touch interaction (e.g., the desk). The object will only contain optional services.

In a place entity, the ideal default service, which the user would expect to receive, is to open the door, but its implementation will depend on the available technology; however, touching the place is essential for the user to "enter" or "exit" the application that manages the touch interaction and, should it fail to do so, it will not receive the service.

2) Implicit Services

These services are one of the benefits of implementing a PICTAC system. Sometimes and when the system has just been installed, they may not be easily associated by the user who carries out the touch. In other words, they are services under or attached to the default services.

Implicit services are developed to take advantage of the information flow that is generated when a default service is demanded and, like this one, can be delivered automatically.

All the services that are received either directly or indirectly by the related entities and the entities that participate in the touch interaction and/or are in the place where touch interaction is carried out will be implicit services.

3) Optional Services

These services will be put on entities by the users, depending on their requirements; they were originated to take advantage of the foreseeable and daily use of some environmental entities.

These services allow those elements that do not have an intrinsic service (the objects) to be regarded as part of the PICTAC system and offer services to the touch.

They can also be placed in any type of entity, the use of which can be considered structured. For example, when a user reaches its workplace, it will first touch the door of the building before entering its office; any user that pays a visit to the office must touch the door, etc. Thus, optional services can be placed in the entities that take advantage of such use.

Another example of an optional service is to leave a message to any or a specific user on the door of a building, on its desktop or any entity in respect of which we can be certain that it will be touched by the user to whom we wish to communicate something, or a note for a specific user when visiting the office in our absence, etc.

TABLE III. DESCRUIPTION OF SERVICES

PICTAC Services	
Default	The entities' intrinsic services
Implicit	These services accompany the default services
Optional	These will be put on entities by users in the case of elements that do not have intrinsic services

TABLE IV. PROPERTY-TECHNOLOGY CORRELATION

Technology	Properties I	M	Cc	P	C	Interaction technique
Barcode	✓	×	×	×	×	Touch
Passive RIFD	✓	✓	✓	×	×	Not necessary
Active RFID	✓	✓	✓	×	×	Not necessary
NFC	✓	✓	✓	×	×	Touch
Bluetooth ≈ ZigBee	✓	×	✓	×	×	Not necessary
Wi-Fi	✓	×	✓	×	×	Not necessary
Infrared	✓	×	×	×	×	Movement

I=Identification
M=Memory/Context/Services References Cc=Contact
P=Processing C=Communication

V. MODEL TECHNOLOGY CORRELATION

The first method of validating the PICTAC model is to establish a correlation between its properties and the existing technologies with which they could be implemented. As some of these properties are matching, in this section we decided to consider them jointly in two cases: contact-identification and memory-context-services references. The four categories of model-technology correlation are explained below.

A. Information Flow

The automatic identification technologies make it possible to provide the environmental elements with contact and identification capabilities. Some of these technologies (voice, OCR, biometrics, etc.) do not have a relationship with this model, that is the reason why we decided to analyze three: Barcode, RFID and NFC.

Barcode technology has contact and identification properties, meaning that it can be used to add these properties to an entity that could be used in the contact interaction.

Near Field Communication (NFC) technology can establish a link when an initiator-reader is within two inches or less of a tag. This short distance gives the impression that the user is touching the tag (some would touch without problems). So the NFC is appropriate for providing these capabilities to entities in the environment.

B. Memory-Context-Services References

The memory property is essential for storing information whose significance is essential for our model because it will contain two properties: context and services references.

It is important to mention that although technologies exist, that by themselves do not provide these properties, they could be embedded in a device that has them. This is the reason why a technology cannot be discarded only on the basis of not having them and why devices in which it is possible for them to be embedded must be examined. Another important feature is that the memory must be re-writeable since the context is constantly changing.

The barcode is not an appropriate technology for this because of two reasons: saving information in a barcode is unworkable and it would not be possible to modify it.

The RFID and NFC technologies have the memory property by default in the tag, while in the reader the memory can be obtained from the device that controls it.

C. Processing

This property must be obtained from the device (or computational device that controls it) where the technologies that provide the other properties are embedded.

The power of this ability will be what determines the complexity of the services that can be offered, without depending on the environmental structure's processing power.

D. Communication

As in the case of the processing property, communication must be provided by technologies that are embedded in gadgets that provide other properties. To meet this requirement, we considered: Bluetooth and Wi-Fi. The major drawback of Bluetooth is that each connection requires the user's participation, whereas Wi-Fi technology only requires configuration of the first time that the gadgets are linked.

A summary (Table IV) of the analysis made in the three previous sections allows us to observe that none of the technologies considered has processing properties, which turns this into a requirement of the gadget that we use.

The bar code-contact only provides identification, so this can be ruled out.

NFC technology is the solution to the Bluetooth drawback, as it enables the automatic link via Bluetooth.
RFID technology is a good option for implementing the PICTAC system; unfortunately, although the costs of RFID and NFC tags are equal, prices of the antennas and the complete set of RFID make this unaffordable, although trends indicates that these will fall and once this is the case it will be possible to reconsider this option.

E. Technological Suitability Model

In order to adapt the PICTAC model to a proposal that combines different technologies for its implementation, we divided it into two main areas: the "tagging context" and the infrastructure environment. The latter is divided into two parts: storage-processing and communication. These and the tagging context are the three sections of the technological model, which can be summarized as shown in Figure 2 and is explained as follows:

- The gadget technology to implement the tagging context will endow the entities with the properties to participate in the touch interaction perceived by the PICTAC system: contact, identification, memory (which contains the context and services references), processing and communication.
- The communication section, which will allow entities to link with the processing and storage infrastructure in the environment.
- Processing and storage, defined as the distribution and operation of the computer equipment that will execute

the services, similar to the way in which they store the information from the environment (context) and process some services.

The "tagging context" properties can be satisfied by an NFC-enabled mobile phone and NFC-tag; the NFC-enabled phone also offers different communication alternatives (some models have Bluetooth, GSM, SMS, MMS, XHTML, SMTP, POP3, IMAP4 EGPRS and/or GPRS) and a large memory (up to 2 Gb).

The PICTAC model will use computer technology (with the communication, processing and storage properties) that can be found in most of the workplaces where people operate. This is established as a requirement for the environmental infrastructure because we consider it unattractive for the PICTAC system to be developed in an environment that does not have them.

VI. PICTAC VISUALIZATION

To formalize the relationships and elements that have been explained in previous sections that comprise the PICTAC model, we use UML class diagrams.

In the conceptual PICTAC model shown in Figure 3, the largest element is the smart environment that contains the PICTAC system, the normal environment, the communications infrastructure, processing, data storage, context and intelligent interfaces.

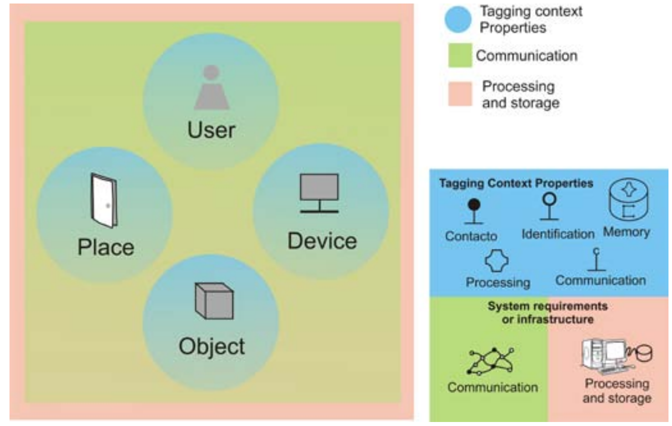

Figure 2. The Technological Sections of the PICTAC Model.

The intelligent interfaces are those involved in user interaction with environmental elements. The environmental elements include objects, places and devices, which together with the user compose the PICTAC model entities.

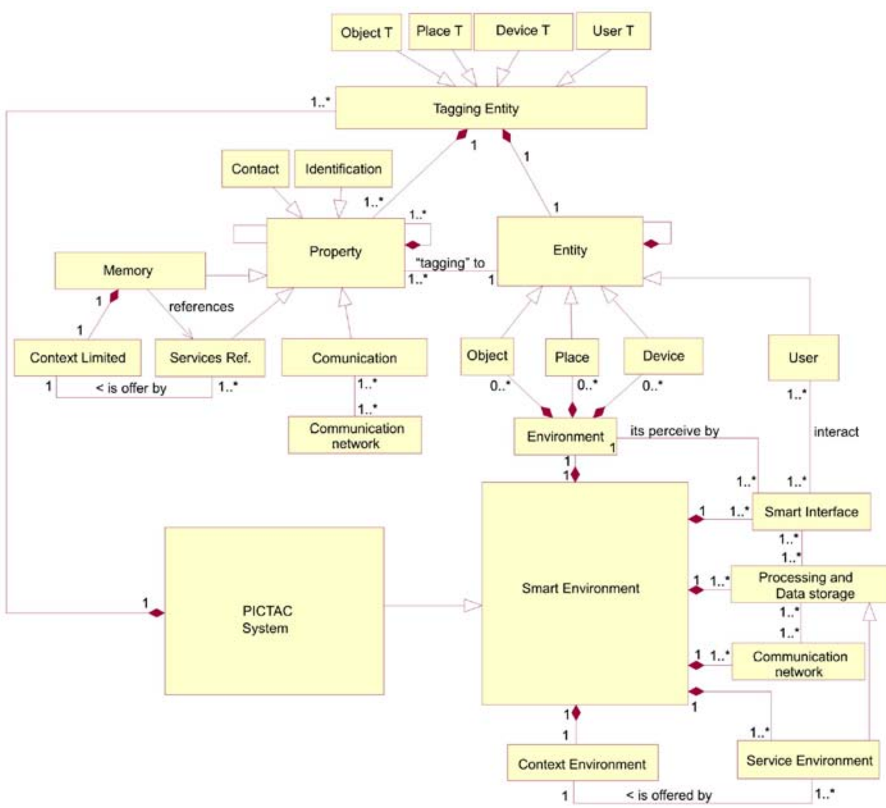

Figure 3. UML Description of the PICTAC Model.

A system that perceives touch interaction through tagging context consists of tagging entities in which a user touches the tagging entity for the purpose of obtaining services. This contact is perceived through properties that obtain and process the necessary data to deliver the service. This information and processing property may be contained in gadgets that can deliver services without needing the environmental infrastructure. However, the quality and quantity of these services depend on the technical characteristics of the technologies used to provide the properties. Within a communications infrastructure, processing and data storage are essential if the goal for the PICTAC system is to be part of an intelligent environment.

VII. CONCLUSIONS

The investigation was possible due to the technological innovations that are currently available; however, technology itself does not include the innovative uses that are involved in our research.

With the PICTAC model, when implementing a managed system, the touch interaction does not only benefit the user involved in the touch interaction but the benefits extend to all users of the smart environment.

NFC technology is an excellent tool to provide services through touch contact, with the real prospect of easier integration with the environmental infrastructure (owing to the fact that an NFC mobile with WiFi is being developed).

The incorporation of contextual information in the tag and the offer of various services is the main difference between our research and from others working with NFC technology.

We have developed the first phase of PICTAC system at the MAmI research group; the TIS (Touch Interaction Services). In the daily use of the system we have observed that putting several services in tags provides advantages but cannot be used in all situations.

Users gladly accept all the services if they save efforts but there are those who are obstinate in accepting the tags where there is no perception of savings. In TIS, when we put a tag in the door so that users may get into or leave the system; for users this represents an over-exertion and sometimes they forgot to do it. This perception of over-effort disappears when we install an NFC-enabled electronic door lock.

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