From Centralized interactive tabletops to Distributed surfaces: the Tangiget concept

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Abstract

After having outlined the uses of new technologies such as Smartphones, touchscreen tablets and laptops, in this paper we present the *TangiSense* interactive tabletop, equipped with RFID technology tagged on tangible objects, as a new paradigm of interaction for ambient intelligence. Within the framework of this article, we aim to distribute surfaces (tables) interacting mainly with tangible objects. Leads for interactive surface distribution such as interactive tables are given. In the article, we propose to describe some tangible objects, which are the interaction supports; these are called *Tangigets*. They are defined according to an augmented Presentation-Abstraction-Control (PAC) structure in order to take the tangibility element into account. We also propose six categories of *Tangigets,* which are *tangible* objects, and the supports of distributed collaboration. In order to validate the Tangiget concept and its use on the *TangiSense* tabletop, we propose illustrations in centralized and distributed configurations. A first evaluation is also presented. To finish, the article presents the directions under consideration for our future research.

Keywords: tabletop, distributed surfaces, tangible objects, tangible interactor, scenarios

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1. Introduction

New interactive surfaces, such as touchscreen tablets, are currently being studied a great deal. These surfaces allow interactions based on tactile technology. The principal uses of the tablets are: Internet access, consultation of books, and visualization of films or photographs. Smartphones, being smaller and thus more mobile, and also having access to the Internet albeit with less ease of navigation due to the size of the screen, are used when there is a need for mobility. As for laptop computers, they are increasingly small (e.g. netbooks), but they remain the least mobile and thus are used mainly in fixed situations. They allow a wider range of activities than the tablets, such as the easy use of an editor for text documents, or running applications which necessitate more resources. The arrival of mobile platforms such as the PDA, Smartphones and others has been the subject of many research projects. The objective is to facilitate the migration of applications when the context changes.

In the field of Human-Computer Interfaces, the objective is similar, following the idea of the plasticity of the interfaces which was then adapted to distributed interfaces (Bandelloni & Paterno 2007), (Demeure et al., 2008), (Grolaux et al., 2004), (Larsson et al., 2007). The user wanted to be able to move from one platform to another one without loss of coherence in the use of his/her application, with no loss of data (e.g. he/she wanted to continue to deal with his/her e-mails or surf on the Internet while being mobile). The Cameleon model became a framework for the modeling /transformation of the HCI (Calvary et al., 2003). Within this framework, the transformation is done according to the characteristics of a context, i.e. of a user, a platform and an environment. In our research, we aim to extend this work to the simultaneous use of several users (collaborative context), several platforms and consequently several environments (Kubicki

et al., 2010). In this article, we focus on the possible interactions with an interactive tabletop and other supports.

We propose in this paper to add another technology to this range of products: the Interactive Tabletop (Figure 1). Interactive tabletops have existed for a few years now. They are similar to the touchscreen tablet, but are larger, being more the size of a coffee table for example, around 1m square. These tabletops are mainly based on tactile or vision technology and allow the same uses as the tablets; they thus handle mainly virtual objects. The users can use one system or another in turn but they rarely share the use over two or more systems.

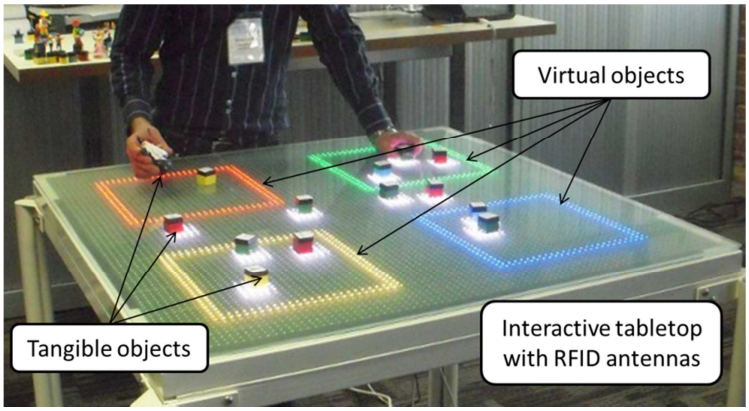

Figure 1 TangiSense: an interactive table using RFID technology, case of an application of children learning

In this paper, we plan to share an application between several users, and several platforms using several types of interaction. In this context, the user interface becomes distributed. The users wish to share information and interfaces with other users, who are not necessarily using the same platform, not having the same needs/constraints. These problems based only on the virtual have already been approached by (Tandler et al., 2004) and (Sakurai et al., 2009).

The second section of the article aims to introduce centralized tables and in particular the TangiSense table and the distribution strategies of interfaces in line with these tables. Section 3

concentrates on the objects handled by these interfaces. They can be tangible or virtual and they can play different roles within the interaction. Tangible objects, which are the supports of the interaction with the tangible tabletop and supports of the distribution, named Tangigets, are mainly described. Section 4 illustrates representative Tangigets using scenarios. The description of a preliminary study and a discussion compose section 5. Finally a conclusion and research prospects end the paper.

2. From centralized tabletop to new concepts of distributed surfaces

2.1. Centralized Tabletops: the tangiSense tabletop

Interactive tables have already been and are still the subject of many research projects (Cf. the growing interest in new conferences, such as ACM ITS “Interactive Tabletops and Surfaces” Conferences 2009, 2010, 2011). The main themes tackled are the innovations concerning hardware, software, design, and application projects. Recent works aim to distribute the interfaces based on interactive tables (Lepreux et al., 2011a and 2011b). Within the framework of our research project, we use a particular interactive table as a basis because it uses RFID technology in order to interact, not only with the fingers on virtual objects but also directly with tangible objects which have been RFID tagged (Finkenzeller, 2003). This tabletop, called TangiSense, detects objects equipped with RFID tags when they are placed on it (cf. Figure 1). The use of RFID makes it possible firstly to detect objects present on the surface of the table, secondly to identify them thanks to one or more tags stuck underneath the object (because RFID tags are unique), and finally to store information directly in these objects or to superimpose different objects. It is thus possible to work with a set of objects on a table, to store data in these objects (for example their last location, or their possible owner) in order to be able to re-use them subsequently on another tabletop at another moment and with the user’s own embedded

information (example: the last state of a game of chess). The interaction is completely managed by these objects and this can influence virtual objects (which cannot be directly manipulated). It provides different uses of the other technologies presented previously because it uses RFID characteristics as well as the advantage of tangible interaction (Holmquist et al., 2004), (Shaer et al., 2004), (Blackwell et al., 2007), (Rivière et al., 2010).

2.2. Distributed User Interface strategy

There are two manners of distributing surfaces seen as user interfaces (Lepreux et al., 2011). In the first manner, the interactive tabletop is declared to be the master and the other devices are slaves. In this case, the table manages the information transfer according to the objectives of each platform and it centralizes all the information available in the distributed system (Cf. *Figure 2* left part). The interface distribution can be seen in the form of a tree. The master surface is the root of the tree (in the figure, this surface is the interactive tabletop). The other platforms correspond to the nodes or leaves. The relationship means that the child interface corresponds to a subset of the interface of the parent node.

The transformations which can happen between the master interface and the slaves, for example a transformation from a tangible interaction on a tabletop into a virtual interaction on a tablet, are specified in the relation between the two nodes.

The master tabletop takes responsibility for choosing the adequate mode of representation to transmit to the target platform. For instance, the placement of an object on the master tabletop which represents a choice is represented by a list on the smartphone concerned by this choice. The users use objects on the master tabletop in order to connect it to other platforms and select the UI to share. This strategy is useful when the UI is complete on one support with priority and if UIs have to be distributed to other supports. The disadvantage of this strategy is that

breakdowns are not tolerated. In the second way of distributing a user interface (UI), all the platforms are autonomous and on the same decision level (Cf. Figure 2, right part). The set forms a graph where n corresponds to the number of distributed interfaces (in *Figure 2*, n=4). Here, a relation between two platforms means a distributed interface.

There can be several ways of distributing user interfaces between two surfaces.

Either the two parts of user interface (UI) are complementary, or there are common parts to both interfaces. As an interface can be linked to several others, it must compose the set of the concerned interfaces. The interesting functions for distribution and collaboration are complete duplication, partial duplication, the part extraction, etc. (Lepreux et al., 2006) see also (Melchior et al., 2011).

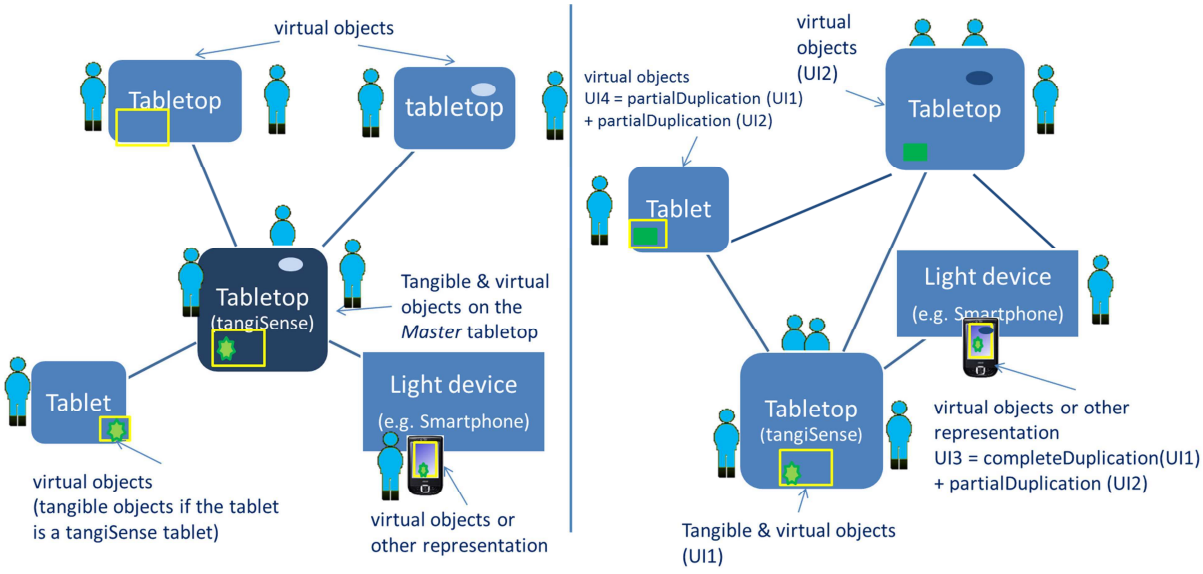

Figure 2. Centralized distribution of UI (left part) vs. Network of Distributed UI (right part)

For example UI (on a Smartphone) can be the fusion of the complete duplication of UI1, partial duplication of UI2. Each platform is responsible for being connected to the platform with which it interacts and all of the exchanges are done in pairs. In this case, each platform must manage several UIs distributed with several platforms. When the user needs to move or to share a UI

with another user, the platforms have to connect them and the UI is deployed according to the local context (Platform, User, and Environment).

The table architecture which was chosen to support the distribution is shown in Figure 3. It is based on a Multi Agent System (MAS) developed with the JADE platform (Bellifemine et al., 2007). In this system the agents are associated to each virtual or tangible object. In the architecture suggested, the traces reflect the human activity and are enriched by software agents and norms; the norms result in a set of signs "situating" the activity; they operate at three levels: infrastructure (consistency of tangible object handling), individual (private objectives and interests), and group (public goal and agreed rules). The software aspects making it possible to manage the data and the exchanges between platforms are managed by the MAS. These aspects are not dealt with in this article but are developed in (Garbay et al., 2012).

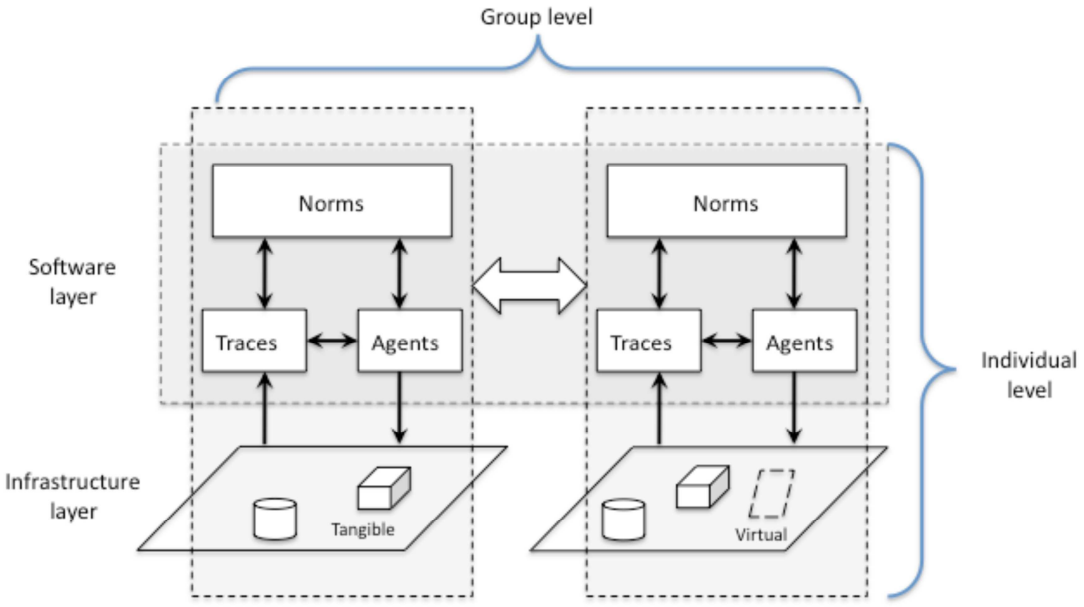

Figure 3. Collaboration as an exploratory process driven by norms (Garbay et al., 2012)

3. From tangible application objects to tangible interaction objects

Among the tangible objects used on interactive tabletops, we can distinguish two different types of object: (a) the tangible objects which are application-dependant and (b) the objects which make it possible to deal with generic functionalities likely to be commonly used in applications on a tabletop (the tabletops can be distributed or not); they are called tangigets. The first section focuses on tangible application objects. The second one introduces the tangigets which are grouped into six categories.

3.1. Tangible application objects

The idea of exploiting tangible objects is not new. Thus, tangible objects associated with virtual objects were proposed by Rekimoto and his colleagues who presented Datatiles (Rekimoto et al., 2001), a modular platform mixing physical and graphical objects. The idea influenced Walder and his colleagues who proposed works in relation with those of Rekimoto through an evaluation of the tangible interface (Walder et al., 2006). Researchers then became interested in the objects, especially in if it was possible to include them in interactive systems. It is the case of Weiss et al. who propose in their work a tangible widgets system (Weiss et al., 2009a, Weiss et al., 2009b) usable on an interactive table; this system is called SLAP (Silicone iLluminated Active Peripherals). Interactive tables can allow new types of interaction or even new manners of working in relation to physical objects. For example, Patten et al. propose the *SenseTable* (Patten et al., 2001), a wireless object tracking platform for tangible user interfaces. In the tangible interfaces, the logic of interaction is to use objects to start actions or to obtain information. These objects (also called business objects) are dedicated to the application for which they are designed and used. For example in the field of road traffic management (cf. *Figure 4*), objects representing the possible traffic flow modifications are proposed: e.g. traffic

lights, stop sign, give way sign, speed limit, prohibited direction, etc. Another example (cf. *Figure 1*) in the educational field proposes to teach the recognition and learning of colors to children who have to move and place a set of objects (for example, a representation of a tomato pasted on a cube) which have "lost their color" into the suitably colored frame (i.e. a black and white tomato should be placed inside the red frame) (Kubicki et al., 2011b). These objects are not easily generalizable with different types of applications.

3.2. Proposition of tangible interaction objects: Tangigets

Unlike the business objects (*i.e.* objects dedicated to the application), it is possible to propose generic tangible objects, which we call "T*angigets*" (Caelen et al., 2011). They allow a greater ease of programming applications using tangible objects and make it possible to preserve an intra-application coherence and a compatibility which are two traditional usability criteria in HCI (ISO 9241.1998 & 2008).

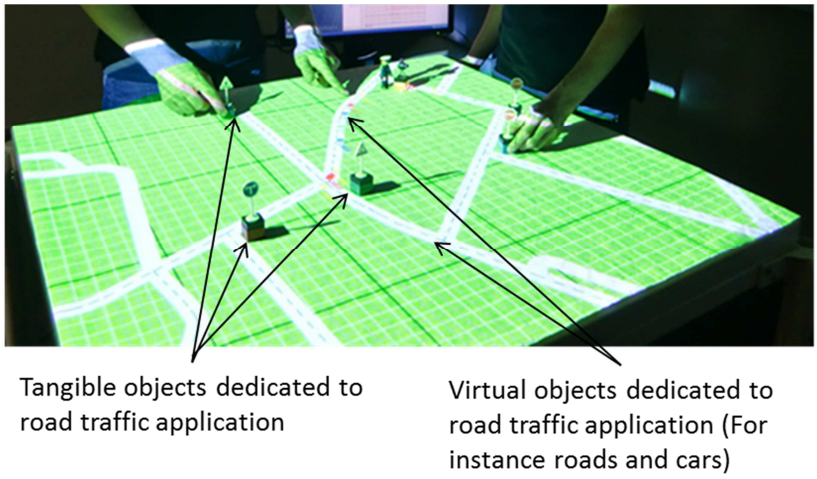

Figure 4. Application of road traffic management on TangiSense with business tangible and virtual objects dedicated to this application

Figure 5. The *Zoom* Tangigets used in the road traffic application, also usable in other types of applications

The *Tangigets* are carried by tangible objects. They can be described, like the widgets, according to the three facets composing PAC agents (Presentation, Abstraction, and Control) (Coutaz et al., 1987).

- A *Presentation* facet defines the user interface, *i.e.* the physical aspect of the object(s) (form, matter, etc.) and the RFID tags associated (in order to guarantee their unicity, and allowing their automatic localization). In order to take into account the specificities of the tangible interfaces, we distinguish two parts in the presentation, such as in TAC (Token and Constraints) Paradigm (Shaer et al., 2004), the materialization of the Tangiget (*i.e.* its concrete representation; it can come from one or several combined tangible objects) and the interaction gesture (placing, pressing, superimposing, etc.),
- an *Abstraction* facet which manages the domain concepts, in particular the reactions to the user actions generally, as they are virtually impossible to parameterize (except in the event of writing in a RFID tag stuck under the object) in a dynamic way. The objects will be persistent or ephemeral.
- a *Control* facet which manages the links and constraints between its two surrounding facets (i.e., the Presentation and the Abstraction facets) as well as its relationships with other agents. This control facet establishes the bond with the application via the virtual elements; it manages the notification of the state changes.

A set of Tangigets is then defined according to six categories which are (1) control objects of the application, (2) context objects of the application, (3) control objects of the interface, (4) communication objects, (5) coordination objects and (6) creation objects[1].

3.2.1. Tangible control objects of the application

Control objects of the application make it possible to control the execution course of the applications, e.g. *Start*, *Stop*, *BeginTask*, *StopTask*, *Save*, *Print*, etc. When a user wishes to start (resp. Stop) a task, it sticks its identification object to the object representing the task. The task is launched (resp. stopped) on the current platform (cf. Figure 6).

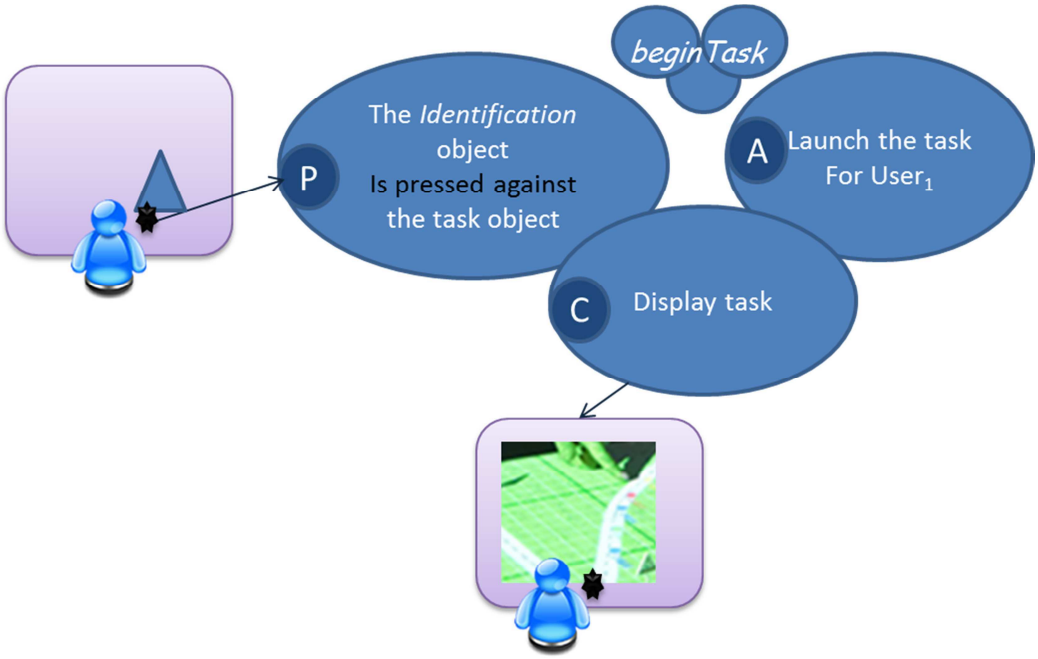

Figure 6. The *BeginTask* tangiget used in the road traffic application. In this situation, two tangible objects (*identification* and *task* objects) are implied. A human action leads to the activation of the resulting tangiget.

3.2.2. Tangible context objects of the application

Context objects of the application are used in order to request help, to configure preferences. The help can be provided about virtual or tangible objects. The *HelpOnVirtualObject* Tangiget given

[1] The categories 1,2, 3 and 6 can be used in centralized (only one tabletop) and distributed (several surfaces) interactions. The categories 4 and 5 concern more particularly distributed interactions.

in ***Figure 7*** concerns the help about a virtual object in the road traffic application by placing the help Object on the virtual object). The contextual help envisaged in the application is searched and displayed with the best representation mode according to the context. The same principle could be adopted using a *HelpOnTangibleObject* tangiget in order to provide the user with help about tangible business objects or even other tangigets, by pressing the *Help* object against the tangible object.

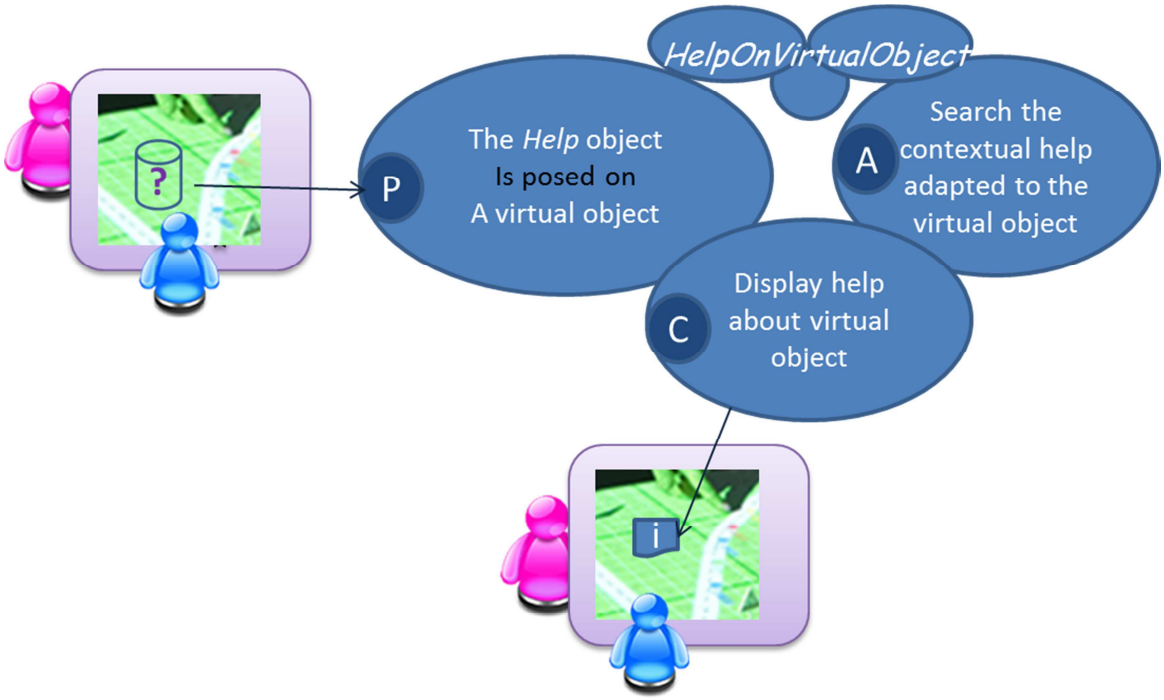

Figure 7. The *HelpOnVirtualObject* tangiget used in the road traffic application. In this situation, one object (the *Help* object) is implied and in relation with a virtual object, already displayed on the tabletop.

3.2.3. Tangible control objects of the user interface

Control objects of the user interface make it possible to manage the user interface of the table according to different goals e.g. Identification (named *Me*), *Zoom* (as used in the traffic application, shown in Figure 5), *Focus* which is used to position the interface on the table, etc. For example the Tangiget *Me* can be defined as in *Figure 8*. The *Me* tangiget is constituted, in

the presentation part, by a material representation which should be defined during the creation. This Tangiget does not have an associated gesture. The material representation can be one of several forms such as a small statue, an identification card, a personal object, which we call in a generic way: identification object. When the *Identification* object is placed on the table then the Tangiget *Me* is automatically detected. The behavior described in the abstraction part identifies the user and can maybe launch the display of the avatar or another feedback associated to the object representing the user. The control facet transmits the information to another layer in the system (in TangiSense, the Multi-Agent System (MAS) manages this information).

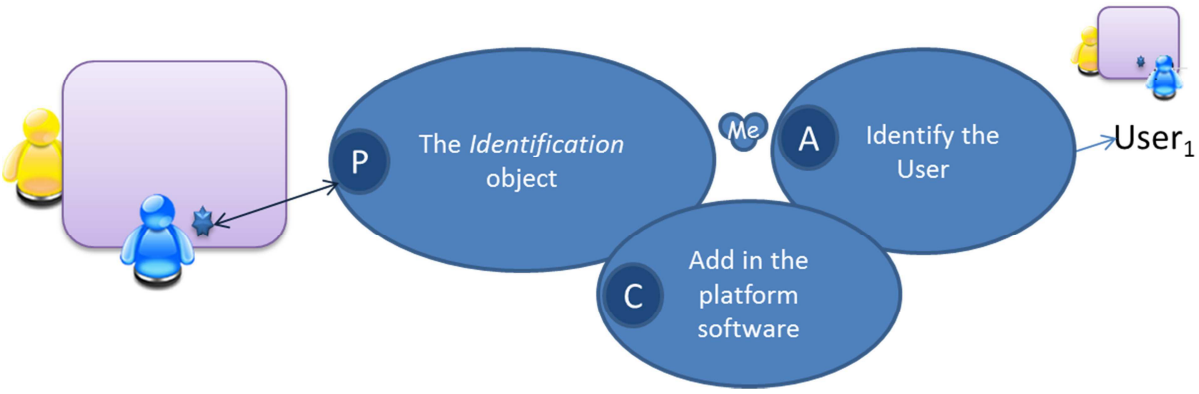

Figure 8. The *Me* Tangiget used to identify a user

3.2.4. Tangible communication objects

Communication objects make it possible to communicate with all or some of the users like *Connect, Disconnect, Absent, Collaboration request,* etc. For example, the *Connect* (resp. disconnect) Tangiget (**Erreur ! Source du renvoi introuvable.**) is detected when the identification object User is physically pressed against a *Start (resp. Stop)* object defined previously. The identified user is added to the collaborative database (in TangiSense, in the Multi-Agent System). From now on, it is possible to collaborate with this user. Information is transmitted to all of the users already connected to all of the platforms of the network. Finally when a user leaves, he/she sticks his/her *identification* object to the *Absent* object. Information is

transmitted to the connected users. New collaborations with him or her cannot be accepted as long as these objects are together. The pause stops when he/she withdraws the *Absent* object from the table or when it is no longer stuck to its identification object.

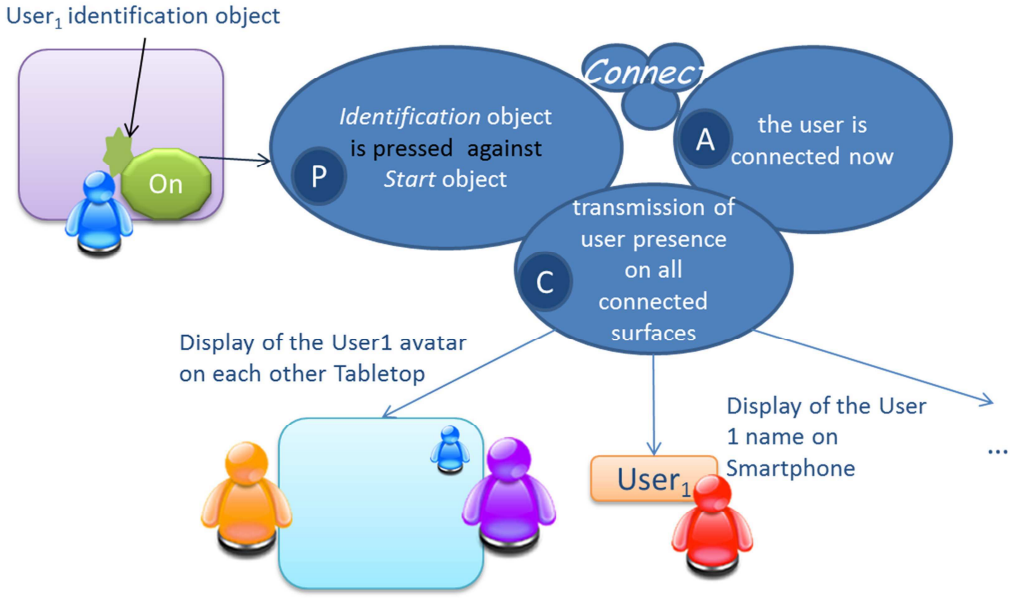

Figure 9. The *Connect* tangiget used to indicate a presence of the user in the distributed system

3.2.5. Tangible coordination objects

Coordination objects make it possible to manage the tasks between partners such as *shareTask, sendMessage, RequestCollaboration,* etc. When a user wishes to make a request for collaboration, he sticks his identification object to the avatar (virtual) of the user connected to a remote platform. They can then decide (by using dedicated object(s)) of the collaboration mode: total, partial, by duplication or extraction. When a task is shared (cf. *Figure 10*), according to the types of task and the user's choices, the tasks can be distributed in a synchronous, asynchronous or exclusive way.

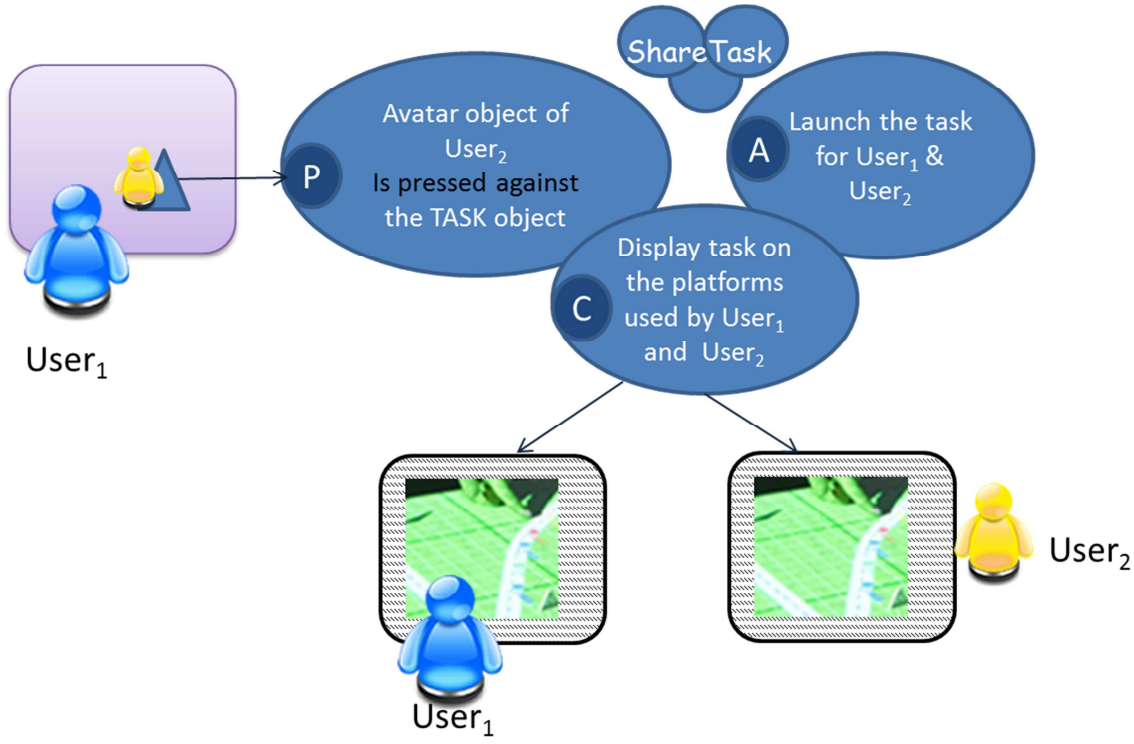

Figure 10. The *ShareTask* tangiget used to distribute a task between two users on different surfaces.

3.2.6. Tangible management objects

Management objects permit the association of functionalities to the physical objects really used on table, for instance *CreateVirtual, CreateTangible, DeleteVirtual, DeleteTangible AssociateTangibleWithVirtualObject*, and *DisassociateTangibleObject* (Caelen et al., 2011). For example, *CreateVirtual* allows the creation of a virtual object; an example of a virtual business object can be seen in *Figure 4*: the created object can have a virtual representation (in the example: cars), capacities (to move forward, turn, accelerate, slow down, etc.) and attributes (color, size). The *CreateTangible* tangiget allows the creation of a tangible object; it associates an RFID tag with a role (for instance a *Zoom* tangiget or a *TrafficLight* business object) in the system if this role has already been defined (cf. ***Figure 11***); otherwise it has to be created.

AssociateTangibleWithVirtualObject tangiget allows the association of a tangible object with a pre-existing virtual object (cf. §3.4).

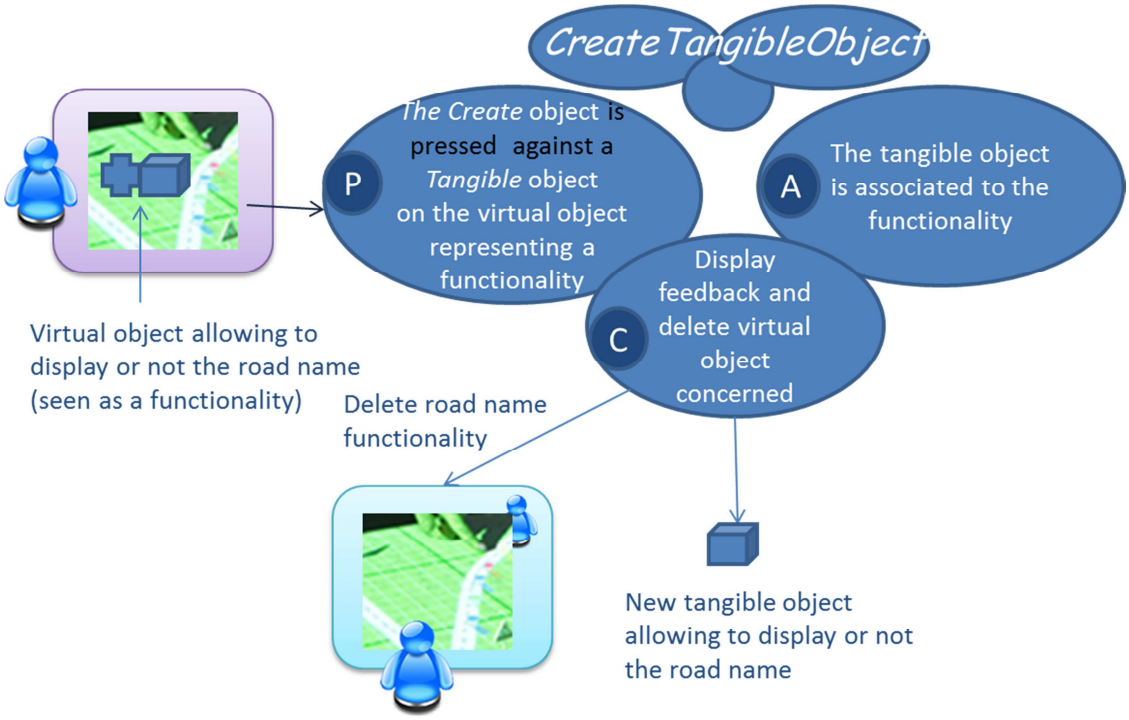

Figure 11. The *CreateTangible* Tangiget used to associate a functionality to one or more tangible objects.

4. Illustration of Tangigets using scenarios

This section illustrates the functioning of tangigets from the point of view of the user(s) and system. Sequence diagrams or textual descriptions are used to show the logical series of actions in order to perform tasks. All six tangiget categories are concerned.

4.1. Scenario based on Tangigets from categories 1 and 2

The scenario described here allows the implementation of tangigets from categories 1 and 2 (cf. §3.2.1 and §3.2.2). Let us recall that these tangigets are useful both in distributed mode (for the management of distributed applications) and in centralized mode. The scenario illustrates a case of use involving the *BeginTask and HelpOnTangibleObject* tangigets (the latter is similar to *HelpOnVirtualObject*, previously presented).

It is assumed that user 1 has already been identified by the table (*cf.* the identification figure on Figure 12). He wishes to launch the task of appointment addition in his diary. It is also assumed that the *Diary* application has already been launched. He presses his identifying object on the business object *AddAnAppointment*. The tangiget *BeginTask* (category 1) is detected. The virtual interface presents him with his diary, for example in the shape of a virtual object. He can then interact in order to add his appointment, for example by selecting the appointment zone with the tangible object. Here the task is carried out in centralized mode (one user on one platform) but it could be distributed in the case of a common appointment (this scenario will be developed in 4.3). If the user does not remember what the *AddAnAppointment* object corresponds to, he can press the Help object with the concerned object so that the tangiget *HelpOnTangibleObject* (category 2) is detected and assistance is displayed.

4.2. Scenario based on Tangigets from categories 3 and 4

To begin, the user connects up to the table in order to be identified (we do not consider the security problems involved in a connection by authentication). This identification is done by the *Identification* tangible object – created beforehand – which, when used alone, makes it possible to activate the *Me* Tangiget *(category 3 described in §2.2.3 and modelled in **Figure 12**).*

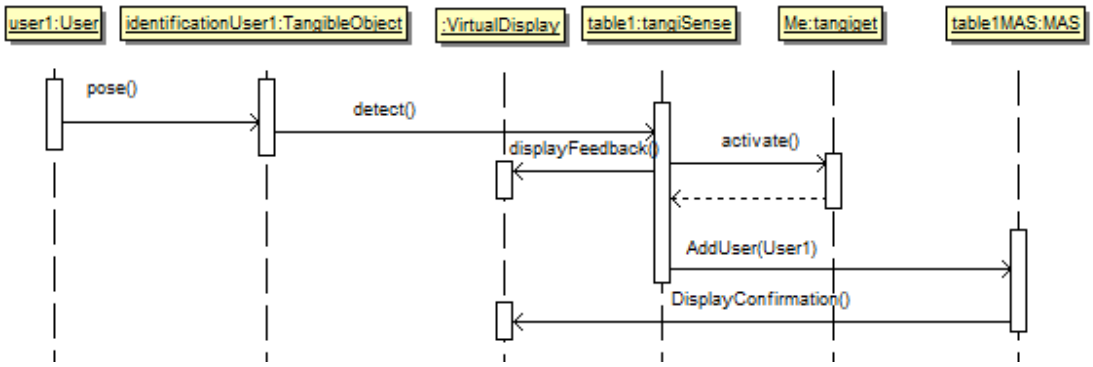

Figure 12. Sequence Diagram illustrating the scenario of User1 identification.

User1 then wants to connect up to the system. He/she uses the *Identification* and *Start* objects together to activate the *Connect* tangiget (category 3) and launch the connection. At this time, he/she is still alone in the distributed system. User2 identifies himself on another table; for example, in ***Figure 13*** with the same process as User1 (but it can be different depending on the platforms used). User 2 then connects. The connection information is transmitted to all users. When they are identified, users can launch applications (§4.1) but they have to be connected to distribute applications (or tasks). They can work in synchronous or asynchronous mode (§4.3).

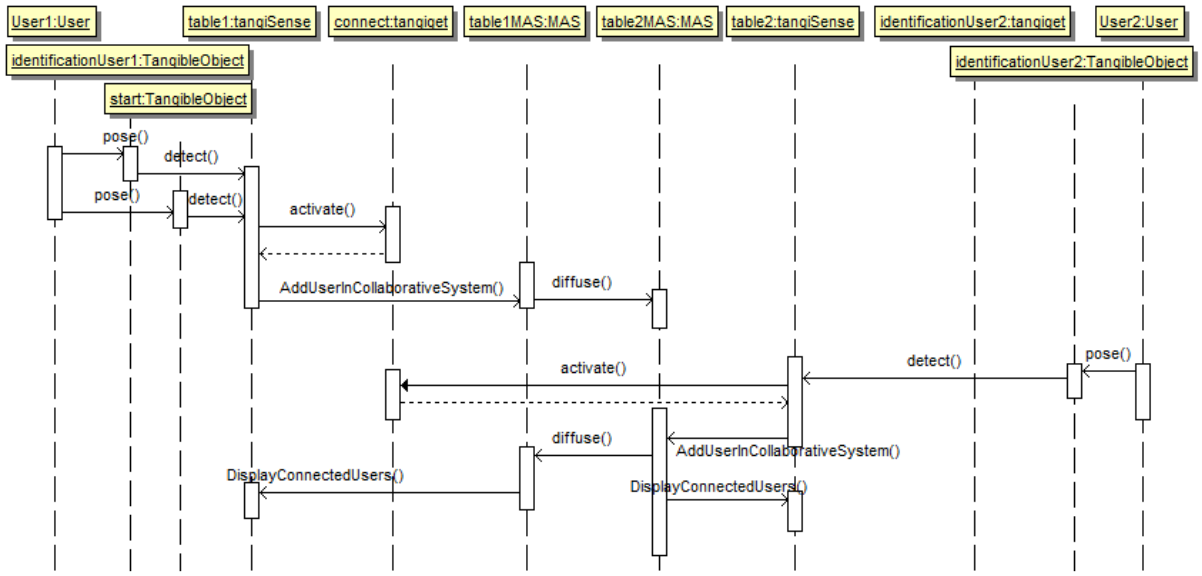

Figure 13. Sequence Diagram involving two users on two different surfaces (two TangiSense tabletops) to carry out a connection scenario

4.3. Scenario based on Tangigets from category 5

Users 1 and 2 have been identified by their platform (for each one according to the principle seen in Figure 12), and are connected. They wish to make an appointment, and therefore need to launch the appointment addition task in their *Diary* application. It is also assumed that the *Diary* application has already been launched. User 1 uses the avatar object representing User 2 (defined beforehand in 3.4) and presses it on the business object *addAnAppointment*. The table detects that the avatar is being used, so it is not a task for User 1 only, but a collaborative task between

the two surfaces (User1 and User2). The virtual interface displays the users' diaries on the respective platforms, for example in the form of a virtual object (but the representation depends on the applications and surfaces). They can then interact in order to add a common appointment, for example by selecting an appointment zone with the tangible object[2].

4.4. Scenario based on Tangigets from category 6

A tangiget from category 6 is useful in the case of remote collaboration and makes it possible to associate the avatar of a remote user to a tangible object. At the time of connection, the avatar of the connected user is transmitted to all of the platforms but in the virtual form (graphic or name, according to the platforms). On the *TangiSense* table, in order to interact with objects, it is useful to associate this avatar to a tangible tagged object. For that, User 1 who wishes to associate User 2's avatar with an object of his choice, not yet used in the applications in progress, places the creation object on the virtual object *Avatar*. The tangiget *AssociateTangibleWithVirtualObject* is detected and the object is associated.

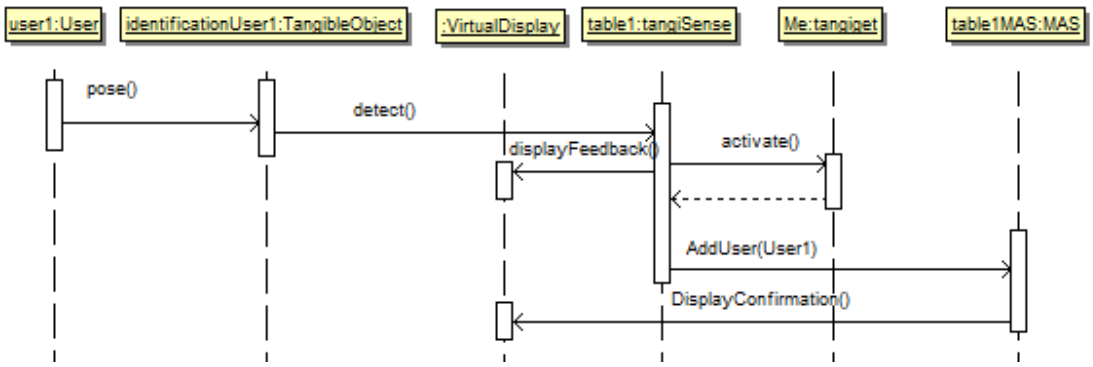

*Figure 14.*Sequence Diagram illustrating the scenario

4.5. Conclusion on the scenarios

A set of scenarios has been developed with the aim of providing a concrete illustration of the functioning of tangigets. The tangigets have not all been involved in these scenarios because

of lack of space and because it would lead to a great deal of repetition. The tangigets presented were selected so as to cover the six categories and to show the concrete usage of these generic objects in common contexts.

5. Preliminary study and discussion

More and more studies currently concern situations implying tangible interactions (Fitzmaurice and Baxton, 1997; Manches et al., 2009; Piper and Hollan, 2009; Kubicki et al. 2011a; Price et al., 2011…).

As far as tangigets are concerned, numerous studies could be set up in the coming years. Indeed, for each of the 6 categories envisaged (§3), many research questions can be asked as regards their representation, which has to be as affordant as possible (in the sense of Gibson, 1979, studied also by Norman, 1999, 2002), as regards their predefined objective(s) (for instance concerning the possibility of suspending a task), their behavior(s), their impact on the users (who can be novices, more or less skilled or experts), to their genericity and their reusability from one application to another.

A first preliminary study has been performed with 16 subjects, aiming to evaluate the affordance of the first tangible objects to be usable on TangiSense; cf. (Becker, 2010; Caelen et al., 2011) for a complete description. This study involved:

- objects specific to a musical application (business objects) (Arfib, 2009), considered to be affordant,
- generic objects (belonging to the tangigets), considered to be affordant,
- (specific or generic) tangible objects considered to be less affordant or not affordant at all. They were made using one of these basic geometric forms: hexagon, rectangle, semicircle and cylinder.

A non commercial representation of the objects involved (considered to be affordant) is given in ***Figure 15***[2].

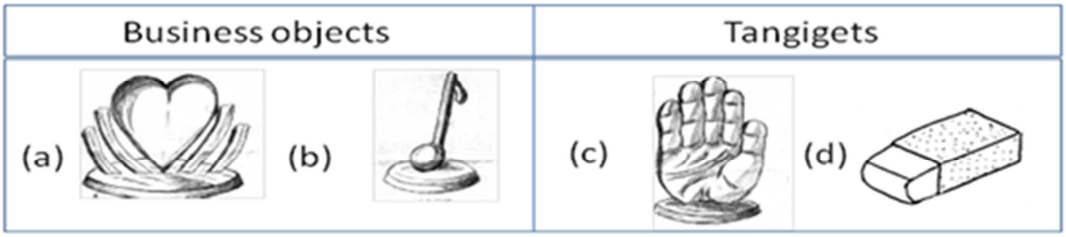

Figure 15. Non commercial representation of four tangible objects studied (considered as affordant) (a) Rhythm object (heart shape), (b) Note object, (c) Stop object (hand-shaped) (tangiget category 1), (d) Delete object (eraser) (tangiget category 6)

In this preliminary study, the objective was to measure the affordance of objects in a work situation with the TangiSense interactive table. The subjects were alone and had to perform tasks with tangible objects that they did not know and which had various degrees of affordance (a situation called direct); or they had to perform these tasks with other people who knew how to manipulate the objects (a situation called indirect). The tasks to perform were linked to a musical application (Arfib, 2009).

Two of the hypotheses were the following:

- H1: in a *direct* interaction situation, the performances in terms of speed (measured time), and ease of understanding (identification of errors and subjective task evaluation) using an affordant object will be better than in an *indirect* interaction situation.
- H2: in an *indirect* interaction situation, the performances in terms of speed (measured time), and ease of understanding (identification of errors and subjective task evaluation) using a non affordant object will necessitate as much

[2] These objects are the result of participatory design sessions with musicians, designers and ordinary people. They were instructed to draw affordable objects for music applications (Becker, 2010). They were validated by all participants.

difficulty and time to understand the purpose of the object as for a direct interaction using a non affordant object.

The study is detailed in (Becker, 2010; Caelen et al., 2011) but it is useful to underline several conclusions, which are interesting within the framework of our paper, and suggest further research.

Hypothesis H1was confirmed: in a *direct* interaction situation, the speed and the ease of understanding of an affordant object are better than in an *indirect* interaction situation. This result can be explained by using the socioconstructivist theories of Piaget (1967) or Price (2008). According to these authors, the learning and the understanding of the outside world necessitate the sense of touch, i.e. the manipulation of the environment; what is more, for Price, the fact of interacting with physical objects encourages task performance and stimulates reflection.

Hypothesis H2 was infirmed. Indeed, even if the subjects feel that the task is more difficult than when the interaction is indirect, they need less time to perform the task and commit fewer errors before validating the function (of the object). Consequently, it is interesting to note that the fact of manipulating an object oneself does not necessarily imply a better understanding. In the case of non affordant objects, the subjects experience less difficulty in the task when someone else manipulates the objects.

These results, even if they seem logical and coherent with the literature (Gibson, 1979; Fiebrink and Morris, 1979) had not yet been highlighted experimentally, not even in the context of a tangible interface.

In addition, this preliminary research project tried to study a new approach to back up the affordance concept; it was a question of concentrating on the object's functionality. Indeed, does the multi (transposable object of tangiget type) or mono functionality (specific object of the

application) influence the affordance perception of an object? In a general way, this set of themes is important in the tangible interface context because it is known that they can be used for several applications and the same object can adopt various functions. Other evaluations need to concentrate more on this question.

In fact, it is a question of taking the following point into account: when it is a question of tangible interfaces, it is the objects used that hold a central role for the interaction. Pejtersen and Rasmussen (1997) declared that each element of the interaction support should be affordant; this research contributes towards showing that it is important for each tangible object to give a transparent display of the technology functionality limits and to materialize the action possibilities in a concrete way.

Moreover, this research also contributed to showing that the tangible object aspect seems to have a real impact on the performances of the individual during an interaction. Indeed, the objects benefit from answering the concept of affordance proposed by Norman (1999; 2002). Affordance was used as a recall support in order to find the function of the objects, the participants based their activity mainly on their experience, which has made it possible to improve the resolution of tasks.

However, when considering the preceding results, the usual precautions need to be taken into account: a) the study is limited to one particular type of table (the TangiSense table equipped with RFID technology) and with a specific application (in the musical field), b) the number of experimental subjects is small (16) and does not cover all socio-cultural categories, c) the conditions are not particularly ecological, within the meaning given by (Hoc, 2001) (study performed in a laboratory). In spite of these restrictions, some tendencies emerge, due to the characteristics of the objects studied: on the one hand the multi-functionality aspect appears in

these objects, which is certainly not easy for the subjects (or certain types of subjects) to apprehend or understand; on the other hand, the question of "technological culture" seems to give rise to other forms of affordance. Finally, collective work seems to encourage and help the transfer of knowledge and co-construction of meaning. These are lines of research which could be developed within the framework of many other studies.

6. Conclusion

These works fall within the framework of the distributed HCI in a context where there is great interest in interactive surfaces. It is possible to make these tables (surfaces) interact, and thus distribute them in space, which brought us to the distribution problems of the HCI which is a new line of research. We are interested in particular in surfaces with tangible and virtual objects (for example the *TangiSense* tabletop equipped with RFID technology); within this framework, a major difficulty lies in the tangibility of the objects. We saw that, as in all applications with tangible objects, whether they are traditional (centralized) or distributed, business objects are necessary. Section 3.1 gave some examples of them. The principal scientific problem relates more directly to the objects of distribution, and to the manner of designing them in the sense of how to characterize them, to represent them (physically and virtually), to distribute them (by duplication, virtualization, etc.). Section 3.2 proposed and illustrated 6 categories of *Tangigets*, by structuring them/characterizing according to PAC adapted to tangibility. Currently, our work concerns the scenarisation phase, leading to first versions of demonstrators in various fields. For example in (Lepreux et al., 2011) the case study proposed is in the field of crisis management. There are still many research questions to be studied in this wide and difficult field, as well as multiple evaluations to be carried out as regards models and prototypes.

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