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Enhancing Seamless Communication Through a user Co-designed Wearable Device

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***Abstract*—**This work aims to describe the process of developing services and applications of seamless communication within a Telecom Italia long-term research project, which takes as central aim the design of a wearable communication device. In particular, the objective was to design a wrist phone integrated into everyday life of people in full transparency. The methodology used to design the wristwatch was developed through several subsequent steps also involving the Personas Layering Framework. The data collected in this phases have been very useful for designing an improved version of the first two concepts of wrist phone going to change aspects related to the four critical points expressed by the users.

***Keywords*—**Design, Interaction, User Centred Design, Wrist phone.

I. Introduction

THE traditional way of communicating is changing rapidly in recent years and in the near future, increasingly, it will move towards a seamless model of communication and media fruition which will clear the problems arising from context changes heading towards a full transparency and continuity. Seamless communication is a set of patterns where the user maintains a continuous communication or media fruition by means of an application when roaming among distinct areas and / or different spaces among the same ambient - using a set of devices available in such a surrounding in a "seamless" gear configuration, i.e. without that he / she has to take any explicit action in order to accomplish his / her task. Is given to the user the opportunity to communicate, share and enjoy media always "at best" at any moment of his daily life, eliminating the elements of discontinuity in the transition between different environments. The premise for enabling this communication paradigm lies in the current evolutionary trends happening in different technological areas, whose convergence will sustain such a realization in a synergic way. From a centric approach the intelligence of service is progressively moving from the core of the network to its periphery, making use at best of the increased connectivity and processing capabilities of current user terminals. Such a shift intersects also with the connectivity trends which see continuous increase in the broadband network bandwidth, both mobile and fixed – reshaping the landscape of how communication and media production/consumption are carried out by the users. Moreover, the realization of a seamless user-experience involving all the aspects of digital media lifecycle (production, sharing, consumption) and integrated communication – across multiple devices and multiple networks - is being tackled by standardization initiatives. Among these, promising are those related to the evolution of Consumer Electronics (CE) devices which are progressively shifting towards an interconnected and interoperability approach. For instance the DLNA consortium is among the most active in issuing a set of interoperability guidelines, pursuing a lowest-common denominator approach for empowering the sharing of digital content among a broad spectrum of CE equipments, PCs and mobile handhelds.

The goal is to create an interaction "on a human scale" in which its needs, its habits and its own anthropomorphic characteristics are the reference requirements designing the whole system. The "seamlessness" is thus not only at a physical level, due to the increasing miniaturization and pervasiveness of the sensors and terminals, but also at the perceptive level, through simplification, naturalness and intuitiveness of interfaces and interactive devices to access and use services. Therefore, in order to provide the best “user experience”, solutions can span without interruption from situations where all the communication is mediated by sensors/actuators available in the surrounding environment up to the opposite one where are used only the sensors and devices “worn” by the user. In order to “communicate”, the user is able to take advantage from the surrounding environment, technologically equipped with different resources: audio/video elements (e.g. TV-set, microphones), sensors (e.g. proximity sensors), haptic interaction devices (e.g. gestures). Likewise the user is able to utilize sensors and devices “located on his/her own body” in those situations where the surrounding environment does not offer any elements supporting communication.

This last approach enabling the seamless communication paradigm can be described as “wearable computing”: it can give people a continuous experience of communication, eliminating the adoption of dedicated communication device in favour of a complete integration of the functionalities within objects already carried by the user on a daily basis (like a wrist watch). Wearable computing provides an active, virtually invisible, and intelligent personal assistant system

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solving problems of size and manageability of many devices available on the market today [1]. These systems should allow users to wear what are virtually mini-computers, allowing continuous, uninterrupted access to connected systems supporting users' daily life activities [16]. From many studies necessary requirements for wearable computing to be successful can be identified in the low energy consumption, low weight, context awareness, network connectivity [24, 25], and in an aesthetic pleasantness derivable from the size, the shape, and the adjustment within the personal dressing habits [17]: the external layout, in fact, seems to be a crucial success factor for this kind of device [25]. Furthermore, as computing becomes more intimate and individual, one size will not fit all. The wearable interfaces of the future will be based on an appliance-based design whose individual components will be chosen by the user to suit their lifestyle and desired application [2]. This studies are well known but not all those findings are exportable *"tout court"* outside the time and the space of the single research, so we decided to initiate a design work on this topic on a user centred basis and specifically centered our timeframe and our localization.

This work aims to describe the process of developing services and applications of seamless communication within a Telecom Italia long-term research project, which takes as central aim the design of a wearable communication device. In particular, the objective was to design a wrist phone integrated into everyday life of people in full transparency. The choice to include the functions of the phone in a wristwatch derives from the idea to embed communication features in everyday use objects: the watch in particular is an object in which the incorporation of technology has always been socially accepted in a positive way. However, the limited size of the object and its particular visibility in the social interactions of everyday pose particular challenges with regard to its aesthetics and interaction paradigms that must support.

II. The User Co-Design Flow

The method used to design the wristwatch was developed through several subsequent steps involving different methodologies (fig.3).

A. Problem Definition

As a first step, our attention has focused on defining the problem through a scouting of the "Technological Landscape" of enabling technologies and through the drawing of a "Services Taxonomy" (e.g. email, voice, browsing, etc.) and a "Functionalities Taxonomy" (e.g. voice interaction, Bluetooth, Wi-Fi, etc.) considered as important to be integrated within an enhanced communication object. A "Market Analysis" was performed to identify what is already commercially available today and the future trends of the market in the CE sector. These factors coupled with the technical constraints resulting from the technologies already or almost available have led to the first design of our concepts.

B. Concept Design

The previous preliminary phases of analysis permitted us to gather enough constraint to come up with two wrist phone concept:

- Concept A (fig.1). It includes most of the hardware and software functionality today available in a high-end smart phone (camera, gps, sd card, Bluetooth, etc.). The user interaction is realized primarily through a trackball embedded in the watch strap.

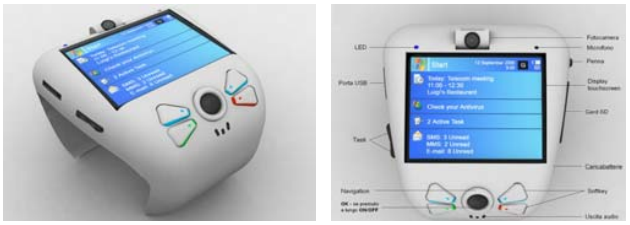

Fig. 1: Concept A

- Concept B (fig.2). It is a lighter version of the concept A but with the same hardware and software functionality. It is less cumbersome in terms of size and weight while remaining realistic in terms of engineering feasibility. It has been studied the possible dimensions of all components like batteries, memory cards, etc. in order to reduce them to the minimum size. In this case user interaction is realized primarily through a removable pen integrated into the wrist phone.

Fig. 2: Concept B

The definition of these prototypes has allowed us, through the 3D modeling, to see how certain technological requirements for this project could have been translated into reality, but especially provided us with material for a first round of device acceptance with the target users, in order to enter into the users co-design phase.

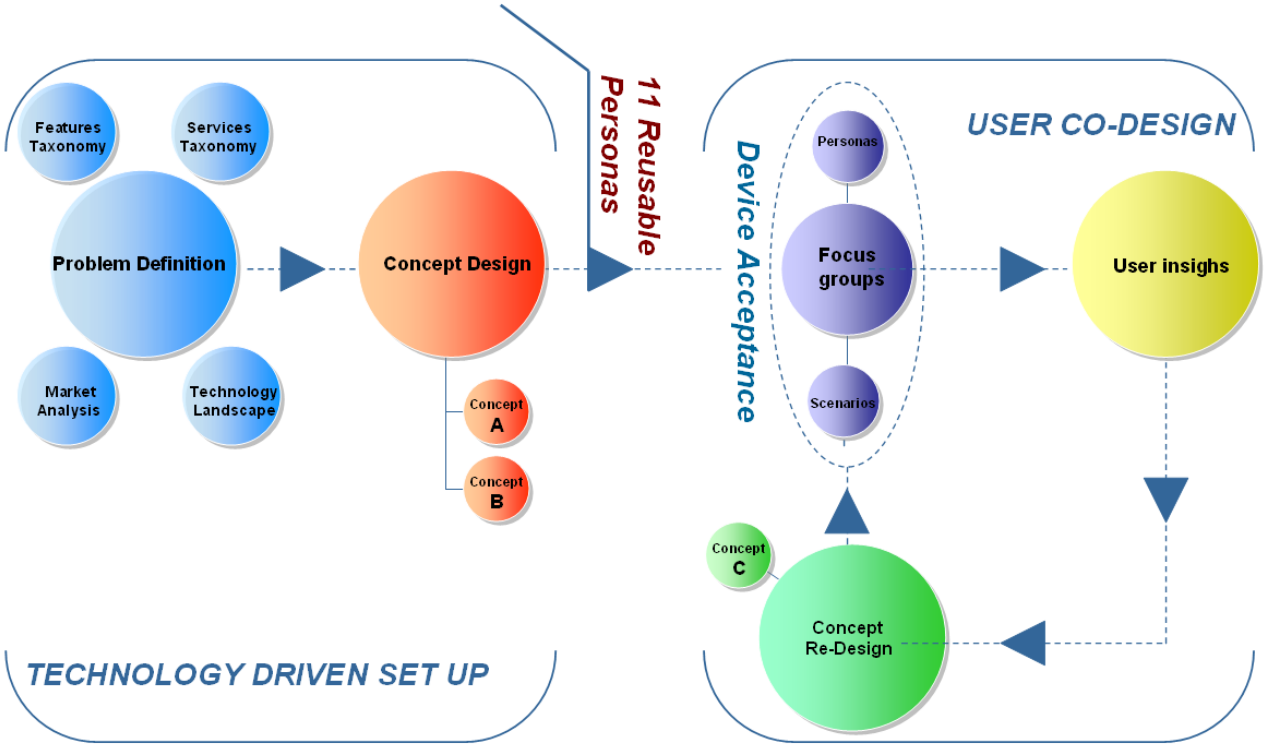

Fig. 3: the complete flow of the research

C. User involvement for co-design

At this point we started the stage of user involvement to check out how the ideas developed by designers could be reflected in an external impression. The intended target groups to be involved in the process of validation has been selected according to the user centered design best practices of our research [15] that we describe briefly below in its form and its motivations.

Device acceptance tools

The difficulty of involving users in the early stages of the design of highly innovative services lies primarily in the possibility of obtaining incorrect or ambiguous data due to the difficulties that users have in the envisioning of future services which have no immediate feedback in the usual contexts of their lives [9]. To design a set of services based on future technological solutions that can both meet the needs of the people both helping them in achieving their every day goals, we adopt the “Personas” methodology [7, 21, 22]. Because we strongly believe in the suitability of the Personas methodology for the medium-long term research projects we developed and refined during the years a proprietary “Personas Layering” methodological framework [15] that standardize how to build reusable personas, specify them for certain application domain, build specific scenarios and validate them with real people through focus groups. In this specific project, because the application domain is pervasive we injected all our available 11 *"consumer and early adopter of ICT and telecommunications services"* personas in the co-design phase (fig.3).

Personas

Personas are hypothetical archetypes of actual users [7], which are attributed with socio-demographic (e.g. name, date of birth, family relationships) and behavioral characteristics (e.g. lifestyles, interests, values). Personas are also equipped with needs, goals and tasks: they allow focusing design on specific users and their specific and concrete needs and desires. Through analysis of quantitative data from the major Italian research institutions (i.e. CENSIS [6], ISTAT [10, 11, 12]) we identified eleven Personas, differentiated by socio-demographic characteristics and life-styles, oriented to the adoption of new technologies in the ICT and TLC. All Personas were defined in detail through the construction of a card containing all the socio-demographic data, their values, their aims and their typical behavioral traits. Particular emphasis was given to the relation of single Personas with communication technologies: we identified how the Personas integrated the communication and media interaction in the context of their daily lives. Finally, have been defined both practical goals, tied to the immediate needs that the Persona faces into specific moments of the day, both the "emotional goals", i.e. the objectives related to a more long-term perspective and a construction project of his identity and his networked relationships. For this work these Personas have been instantiated in real people to check the acceptability of

the realized concept. In this case, as we will see 11 focus groups have been carried out, each one corresponding to a specific Persona.

Scenarios

To get the material to be submitted to the users, specific scenarios have been built for each Persona. Scenarios are essentially stories about the characters and what they do in their daily life [5] having a plot that marks actions and events. They can encourage reflection during the process of design but especially are very flexible and can be quickly revised according to change in design needs [4]. The Personas, which are used as round characters within them, may focus the attention of the designer on the desires and needs rather than on the mere actions, helping in the designing of future services where there are no specific *"a priori"* requirements defined [18, 19].

Fig. 4: Concept A usage scenario

In this way the scenarios have the role to explain in narrative traces the life of the different Personas. In them the day of Personas is divided according to different day time slots. They also specifies the environment across the media and the devices are used and the needs and objectives relevant to the various phases of the day. Each scenario provides a basis for the creation of a photographic storyboard. In our research eleven "actors" has been chosen each one interpreting one of the eleven Personas in different moments of their every day lives, allowing the display of their usual behavior and situations experienced in their normal activities. The photos made were then mounted with the inclusion of the designed technology concept into an interactive movie visually rendering the daily activities performed by each Persona (fig.4).

Focus groups

Once completed the phase of scenarios drawing we moved to the true validation with real users in order to test the device acceptance. Eleven focus groups have been planned each one centered on a single Personas: the aim was to evaluate the acceptability of the concepts through the illustration of some specific use cases. In order to instantiate the designed concepts in a usage context as much well-founded as possible have been shown not only the prototypes of the 3D models, but also the photographic storyboard made in the previous phase.

In this way, users could see some concrete situations of usage and impact that the object could have had in their everyday life.

During group discussions the participants, who shared the same social and demographic characteristics of the Persona being its living representatives, were asked to describe their normal day and to associate to each time slot their habits, needs and goals, in order to stimulate the emergence of possible unmet needs and desires. The results has been values, goals and needs shared by all participants that went to confirm/disconfirm, correct and complete the assumptions made during the design phase carried out by designers.

D. User insights

The results show a substantial satisfaction with the concept of the wrist phone. Almost all groups representing the eleven Personas liked the idea of integrating the functions of the phone within an object to be worn on the wrist. However, based on data collected have been defined four points of concern on which to focus for a re-design of the wearable device:

1. key role of aesthetic

The aesthetic seems to play a fundamental role for a particular object that has to be placed on the wrist which is always in view during everyday social interactions. The presented wrist phone design does not seem to fully satisfy this need.

2. Need of one-hand interaction

Another crucial aspect was the interaction manner. All groups highlighted the interaction problems due to small size of the display which do not allow optimal use of the touch screen. But the main concern seems to be the impossibility to use the device with one hand because one arm holds the wrist phone and the other hand operate on it. It emerge, in fact, the idea that, for a wearable object interaction must be the most natural and intuitive as possible and in any way not pejorative than established methods (e.g. use of the phone).

3. Integrated headset

Another critical aspect is related to the need to use an external headset to use the phone complicating in this way the technology pattern that the user must bring with him (two items instead of one).

4. Recharge pad

Finally strongly related to the previous there is the recharging aspect that having to deal with two objects is considered unacceptable. Also was strongly affirmed by the users of the need to transfer even at this stage the concept of seamless, making the process less dependent on wires and cradle ill-adapted in their

opinion to the watch model that we are accustomed to not ever recharge.

E. Concept Re-Design

The data collected in this phase have been very useful for designing an improved version of the first two concepts going to change aspects related to the four critical points expressed by the users.

The first problem that we confronted as it is one that represents a great obstacle into the device adoption was the interaction manner of the device and the aim to transform the interaction model from two-hands to single-handed.

Many researches have focused on the possibility of introducing new interaction manners in wearable wrist device trying to respond to the increasing miniaturization of graphical interfaces, that beyond a certain level become unusable by the users [13]. These devices are usually mere control systems of other devices using a set of sensors to recognize user input through the gestures: i.e. the GestureWrist is a wristwatch that works as input device [23], recognizing the movements of the hand of the person who wears it. Another study shows the feasibility of using the rotation movements of the wrist to control the position of a cursor on the screen of a mobile phone Nokia N95 [8]. The Gesture Watch is a wrist wireless device that allows the user to control different devices through the movements of the hand (the one not wearing the device), using an array of infrared proximity sensors that captures the movements made over the same device [13]. Other studies suggest the use of a data glove as the best way to collect the user gestures in order to use them as commands to control the devices carried on user own body [14, 26]. One of the main problems of these input devices based on the recognition of gestures is related to the difficulties encountered by early users (novices) to acquire the skills required to control them: the feedback that these systems can give are, in fact, often not enough informative [20].

Taking also into account these studies, we have tried to respond to users' needs emerged during the first service acceptance round, which showed a strong preference to use one-hand interaction manner to control the phone. So we re-designed the initial concept of the wrist phone, incorporating in it a gesture control based on different kind of sensors. With our solution is possible to control the phone by using the arm and the hand on which the device is worn with immediate feedback shown on to the graphical interface. The interface is structured with vertical menu expressing a graph-tree according to a classical hierarchical paradigm.

The interaction with the menus is done via two specific sensors:

- An accelerometer provides the vertical scrolling of the interface.
- The selection is made via another specific sensor (an electromyographic sensor) registering the closure of the hand and interpreting this as Click / Selection.

Moving the hand with a slight tilt upward or downward, the user can scroll through the vertical menus (fig.5).

Fig. 5: scrolling through wrist rotation

To confirm the selection of a menu option the user has just to close the hand starting from an initial position with the open hand so selecting the preferred item (fig.6).

Fig. 6: click/selection through hand closure

Going in some usage scenarios, for an incoming call simply by closing the fist, the user can answer the call, or if he wants to reject it or to mute the ring tone, he simply must tilt upward or downward the wrist (according to the menu list) and, once chosen the action confirm it closing the hand. Similarly, looking at the media fruition case, to list one own mp3 directory the user must scroll through wrist rotation and select (artist, album, song) just closing the fist. The second critical aspect on which we focused was to completely redesign the layout of the phone as suggested by the users to achieve a higher aesthetic acceptance. Critical dimensions brought by the first device acceptance round suggested working on a smaller, simpler, “cleaner” and fully aesthetically personalizable concept.

We then asked our designers to create a new wrist phone (Concept C) going in these directions in order to bring it in a second round of validation (fig.7 and fig.8).

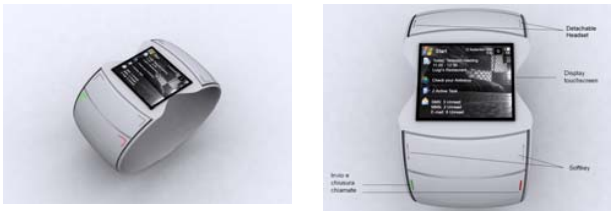

Fig. 7: Concept C

Fig. 8: different personalization of Concept C

Thinking this new concept we had also to take into account what was a third key requirement of the users that is not making your communication patterns more complicated with the introduction of two items instead of one. We had so to think about a concept that integrated the headset in the wrist phone, detachable when necessary (i.e. incoming calls) but part of it and not requiring a separate recharge manner (fig.9).

Fig. 9: the integrated/detachable headset

Finally about the naturalness inherent in the wristwatch object requested by users also the process of recharging was redesigned inserting the possibility of recharging in more seamless manner. Exploiting the almost ready technology for wireless recharging so eliminating the need of plugs and cradles it was proposed a charging pad that works just putting the wristwatch during the night on it.

Second round of device acceptance

After the redesign work it has been possible to re-propose to the representatives of our Personas the result obtained on the basis of their suggestions in order to assess if they were more satisfied and whether the changes were going in the right direction. The work has been carried out like in the first round of device acceptance forming groups representing the Personas involved. Scenarios were designed, storyboards and movies presenting the new concept shoot and a new evaluation of the device acceptance made.

Fig. 7: Concept C usage scenario

III. Conclusions

The work done has allowed us to have a good feedback in the validation of the second concept demonstrating the usefulness of the method and how the user insights have been captured and translated effectively.

Beside that the work cannot be said finished nor on a technological point of view nor on the co-design with user and nor on the business implications. On the technology side some suggested solutions of the final concept (concept C) still have to be tested and certified although all of them are already in the area of feasibility. In particular, some aspects of power supply, batteries, and re-charging are still in the prototyping phase. In terms of co-design, user involvement can not stop here. Although there has been a good response to the proposition of course it remains difficult for the users to evaluate an item without try it in a practical way through a field trial. The movements necessary to operate the device must be evaluated in the real context of use, and the presentation of the concept remains insufficient for a definitive validation of the particular mechanisms of interaction that requires also an application in terms of micro-usability. Finally there is a significant business issue in the decision to produce on a large scale such a disruptive object, tied to the cost of components, patents, and especially the numbers (users) that this paradigm is able to attract in terms of penetration and consequent scale economies. In any case we believe that the wrist phone could be, if well designed a valuable enabler for the ubiquitous seamless communication and media fruition that since so long we see more described than realized.

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