User Experience Analysis in Service Co-Creation: A Living Lab Approach

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Abstract

The social and psychological analysis of the Human-Computer-'Thing' (H-C-T) interaction that occurs within an IoT (Internet of Things) service or application environment encompasses emotional, empathical and interpersonal aspects. We propose a Living Lab approach to evaluate these, and introduce to this purpose a novel measurement framework, built on an ontological model and resulting into an appropriate taxonomy of indicators. An experiential platform is currently under development, whereby users are directly involved in co-creating, exploring and experimenting new ideas, concepts and technological artefacts related to IoT applications and services. Experimentation is under way within three European Living Labs, each composed of a physical place, an information architecture and a societal space (user community). Various usage scenarios are concurrently taken into account in three different domains, namely Logistics, Health/Wellbeing and Green services.

KEYWORDS: IoT (Internet of Things), HCI, HCT (Human-Computer-'Thing') Interaction, Living Lab Approach, Experiential Platform

Introduction

Recent reflections conducted both at theoretical and practical level highlight the fact that a social, as well as a psychological, dimension is implied by the analysis of the Human-Computer-'Thing' (H-C-T) interactions that occur within an IoT (Internet of Things) service or application environment. Leveraging on these interactions, one can think of improving and/or refining the assessment of an IoT service/application, by means of:

The collection of experiential data regarding the ability of the researched IoT service/application to generate personal rewards for the user; rewards that can either be expressed in qualitative terms (e.g.: Poor, Fair, Good, Excellent) or with quantitative means (e.g. by normalised scores), to be compared along various observed instantiations with the progress of time;

The formulation of analytical judgements on the specific aspects of H-C-T interaction, in terms of behavioural intensity and persistence; judgements that can provide guidance for further improving the IoT service/application at hand.

Unfortunately, a well-known limitation of social and psychological research (see Polkinghorne, 2005) is that data about human experience is not comparable with data about human behaviour. Because experience is not directly observable *per se*, data about it depends on the people's ability to reflectively discern aspects of their own experience and effectively communicate what they perceive through the symbols of language. As a result of the above limitation, a combination of experiential with verbal data – the former obtained by monitoring the interaction of human beings with the external world and the latter from direct reporting of involved actors – has been proposed to derive the most complete, realistic and meaningful representation of a given social environment (Andrews et al. 2009).

This intermediate approach to gathering information on personal experience may prove impractical, however, particularly in virtual communities – whereby the collection of inputs is "filtered" by a Human-Computer interaction (see Suchman 1987) that protects anonymity and dilutes feedback over time – not to speak of the case of "non verbally communicating actors" (such as children), who can be of little help in providing any rationale for their documented actions.

This paper introduces an alternative approach to user experience analysis (see Forlizzi and Ford, 2000; Forlizzi and Battarbee, 2004) that is currently under development in the context of a EU funded ICT research project, ELLIOT. The proposed action workflow is based on the mapping, recording, and interpretation, of the (one-off or recurrent) behaviour of actors, in association with a range of emotional, empathical and interpersonal aspects that are deemed to be relevant for the context of analysis. Acting in this way, one can approximate and ultimately measure, albeit in terms of variations between AS-IS and TO-BE parameters and indicators, some key psychological and social dimensions of human interaction that would remain otherwise obscure (Schachter and Singer, 1962; Desmet, 2003). An experiential platform is being tested and validated in support to the action workflow, whereby users are directly involved in co-creating, exploring and experimenting new ideas, concepts and technological artefacts that are particularly related to IoT applications and services. Experimentation is under way within three European Living Labs, each composed of a physical place, an information architecture and a societal space (user community). Various usage scenarios are concurrently taken into account in three different domains, namely Logistics, Health/Wellbeing and Green services.

This paper is structured as follows: Section 2 ("Background") presents the ideal type of social behaviour that is in the focus of our present research. Section 3 ("Vision") outlines the Living Lab environment used as reference framework for experiential measurement. Section 4 ("Action Workflow") briefly summarizes the three-staged action workflow being used for project trial configuration. Section 5 ("Implementation") describes the three testbeds and the preliminary feedback collected from them. Section 6 concludes the paper.

Background

To further clarify what our research is about, let's look at the following picture.

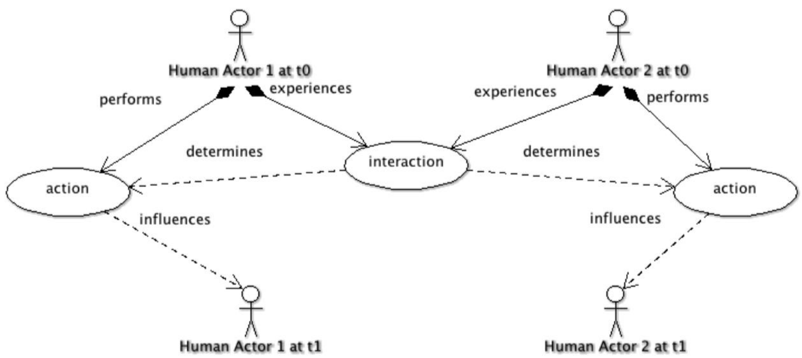

Figure 1 The interaction / action ideal type of social behaviour

What the diagram represents is an ideal-type *interaction* between two human beings, Actor 1 and Actor 2, who are taken in two consecutive moments of time (t_0 and t_1). At t_0, each of them gets her or his own contingent *experience* of that interaction, which we provisionally assume to be immediate, i.e. without any mechanical or instrumental "filter" (like it happens in CMC, Computer-Mediated Communication). After that or in light of that experience of interaction, some kind of *action* is performed, which leads every human being represented in this picture to reach a different mental and/or physical status at t_1.

Thus, *the focus of our research is set on the power of experience in driving and ultimately changing personal behaviour*.

However, this experience is not limited to immediate (face to face) interaction between two or more people, but extends itself to a number of possible scenarios where computers, and eventually "things" (in the meaning assumed by this word in the IoT context), interact with human beings and shape their individual and collective behaviour (see Latour 1996, Hassenzahl 2003), like the following picture shows.

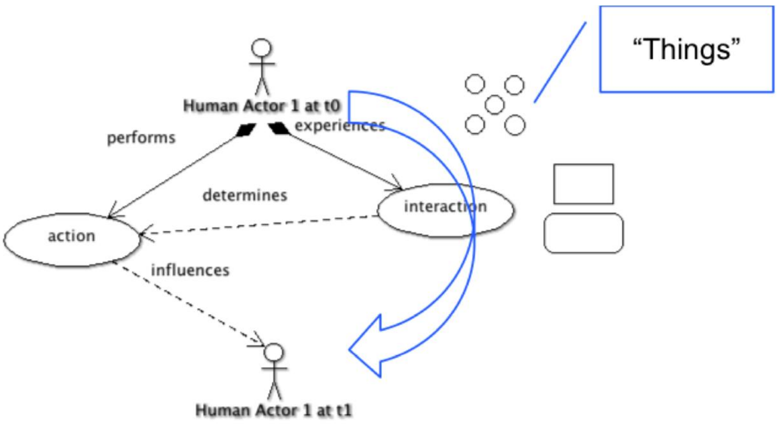

Figure 2 The H-C-T interaction / action ideal type

There are several problems with analysing this type of behaviour, however. The most important one is that any person's experience of whatever material or immaterial object is not knowable or measurable per se, but only through the adoption of one or more "proxies" – like it happens when questionnaires to measure individual satisfaction are distributed. Another related issue is that whatever the initial opinion of a person is when the experience is fresh, his or her memory tends to decay very fast over time. This explains the success of online and particularly mobile user surveys, which try to document personal reactions and feelings going as close as possible to – if not right at the point of – experience. Moreover, surveyed opinions tend to converge towards each other when they are openly expressed, particularly if people are interviewed sequentially rather than in parallel. A variant of this latter statement is that 'context' broadly influences subjective perception, including in this term ('context') all kinds of personal interference and social contamination that one can possibly imagine (see Kolb et al. 1984; Winner, 2007).

Vision

Among other issues, Social Computing as a theoretical discipline deals with the study of contextualised social behaviour within very special environments that are infrastructured by IT systems. As such, it takes benefit from both ideal types of person-to-person communication and of H-C-T interaction depicted above (see Abowd et al., 2002). However, the research focus is currently set more on the joint outputs of this combination (e.g. crowdsourcing, "wisdom of the crowds" – Surowiecki 2004) than on its outcomes in terms of behavioural transformation of the people involved in it. In our vision, this prevents from displaying the full potential of user experience analysis for the assessment of used services and/or applications (Novak et al., 1999; Sengers and Gaver, 2006).

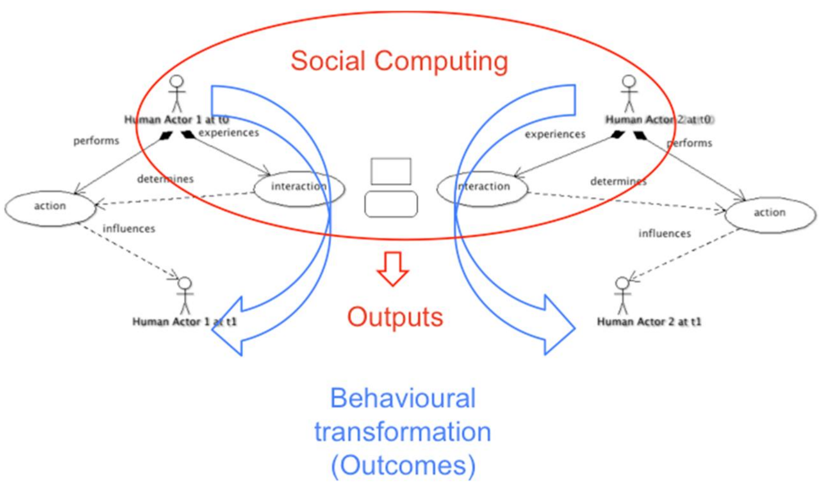

Figure 3 Social Computing and behavioural transformation

In our research, we adopt the Living Lab approach (Mulder and Stappers 2009) to frame and analyse the outcomes of H-C-T interaction for the sake of service co-creation. Living Labs are open innovation environments in real-life settings, where user-driven design and experimentation are integrated within a co-creation process of new services, products and societal infrastructures. Our business case refers to the *collection and measurement of experiential data aimed at the design, development or adaptation a (public or private) IoT service or application in close cooperation with the end users*, as the following picture represents:

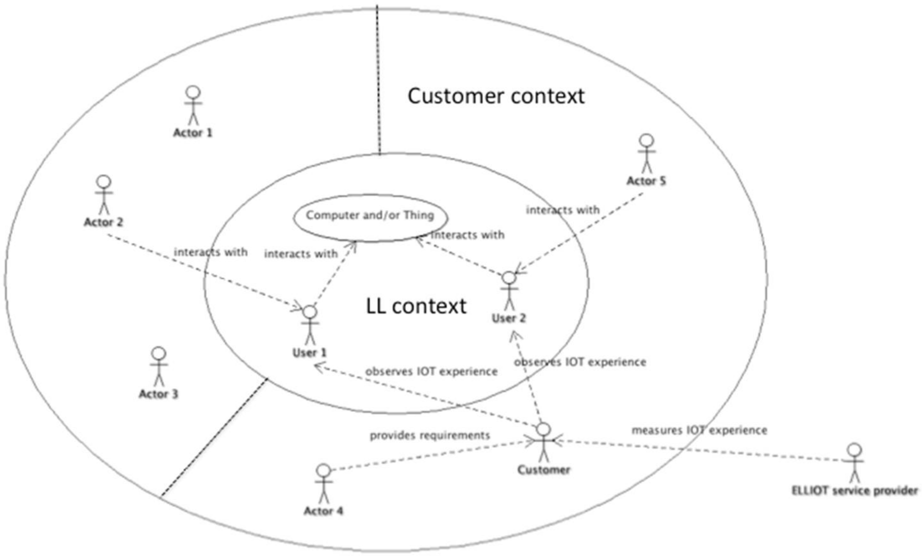

Figure 4 Stylised representation of the business case

The inner circle is the proper Living Lab environment, whereby people interact (among themselves and with external actors, but also) with computing hardware and software (e.g. a game console, a speed meter or a food vending machine) and/or "things" (e.g. sensors, video cameras etc.). The external circle, which we call the Customer context, normally includes the former from the perspective of (business) localisation, and is the one where the commercial relation with the ELLIOT service/solution provider is established. We posit that the identification of all relevant actors in a Customer environment is decisive for proper design and initialisation of a use case scenario, especially because the Customers do often provide and specify their own requirements for the most appropriate trial configuration.

Action Workflow

As stipulated above, the personal experience of a given Living Lab environment (like of any other human environment) is not knowable or directly measurable *per se*. However, as there is some relation between the experience of interaction and individual or collective action, the issues that emerge here are twofold:

First, how to derive meaningful information on the individual and collective H-C-T experiences by means of appropriate "proxies";

Second, how to attach economic value (significance) to this kind of information.

Both aspects can be pragmatically arranged through an appropriate trial configuration, driven by the Customer's business objectives.

In our approach, a solution to the above is provided by a three-staged action workflow, based on:

Concept mapping (general and context independent). Defining the key Social Experience aspects taken as 'leaves' of a taxonomy 'tree'

Association of Indicators to Concepts (part of the IoT Living Lab trial initialisation)

Association of Metrics to Indicators (both specific and context dependent).

To every 1st tier attribute (for instance: an emotional aspect providing social reward) a number of 2nd tier dimensions can be associated. For each 2nd tier dimension, a number of KPI's (Key Performance Indicators) and their related metrics can be designed and the IoT Living Lab trial is configured accordingly.

In the next table, we expand the 2nd tier dimensions of the Social Experience model.

Social Reward Indicators / Metrics (examples)		
Emotional aspects	**Empathical aspects**	**Interpersonal aspects**
- Satisfaction	**- Pleasure**	**- Involvement**
-- Shortened session time	-- Extended session time	-- Participation rate
→ Number of early log outs	→ Session duration	→ Number of users
-- Reduced complaint rate	-- Increased approval	-- Participation intensity
→ Answers to online surveys	→ Answer confirmation rates	→ Average connection time
- Amusement	**- Interest**	**- Communication**
-- Returning visitor's trend	-- Traffic intensity	-- Intensity of dialogue
→ Same user's hits / logs	→ Number of hits / logs	→ Number of posts per thread
-- Increased appreciation	-- Level of attention	-- Promptness of feedback
→ Voice / VCC recordings	→ Eye tracking records	→ Response lag time
- Enthusiasm	**- Surprise**	**- Collaboration**
-- Word of mouth	-- Uncontrolled reaction	-- Amount of co-production
→ Measurement of outcomes	→ Number of outliers / incidents	→ Items per team / thread
-- Proactive behaviour	-- Changed approach	-- Timing of results
→ Effectiveness of engagement	→ Frequency of path deviations	→ Average lead / lag time

Proceeding from left to right in the table's first row, we introduce the distinction between Emotional Aspects (or pertaining to the intimate sphere of a person, and dynamically changing over time as a result of his/her level of "immersion" in the Living Lab's environment), Empathical Aspects (referring to the willingness and capacity of a human being to establish and maintain a purposeful connection and exchange with the external world, which can translate e.g. into the execution of tasks and/or the manipulation of objects, including hardware and software), and Interpersonal Aspects (focused on the various possible degrees of interaction with the other human beings that make up the social context in which the person is immersed, and that can either be filtered or not by computing machines and/or IoT devices).

Implementation

This section describes in some detail the three selected experimentation domains of our field research and the preliminary inputs received from the corresponding use case scenarios.

Logistics

The main goal of this use case is to apply IoT technology within logistic processes to enhance efficiency and reduce complexity for operational workers. The chosen example is the (AS-IS) process of a fork lift truck picking up a pallet containing a specific load and moving it to the correct location within a high bay racking. Starting from this process observation, a requirements analysis is performed, which is necessary for the enhancement of the process itself thanks to the adoption of IoT solutions. For the use case actualisation, an IoT construction kit will be provided with several ARDUINO based sensors. The goal of IoT support is, on the one hand, to reduce potential failures and sources of error, and, on the other, to increase process efficiency and increase its level of safety for the workers attending it. These workers, together with managers and experts in the field of IoT, populate the Living Lab and develop relevant ideas and knowledge in a co-creative manner. Based on the knowledge gathered in the Living Lab and on the analysis of the specific ideas developed to enhance the process, different IoT solutions will be built using the ARDUINO construction kit. Then, after their implementation, the solutions will be tested and validated by the people in the factory, till they are permanently adopted within the given process.

Results and Implications

The service co-creation process is supported by experiential information to be collected and interpreted throughout the project trial (experiential data, usage data etc.). In particular, the following table maps the objectives of this information gathering, in relation to the main process stages and to the key social aspects of H-C-T interaction:

Stage No. & Title	Description	Social H-C-T aspects	Objectives of information gathering
1. Process and Requirements Analysis	Participants understand the requirements of the current logistic process and state the areas that will most benefit from IoT technology support.	Interpersonal aspects	Attendance rate Patterns of collaboration
2. Knowledge Generation	Participants increase their knowledge on which they are going to base their ideas and concepts for the deployment of an IoT supported logistic process.	Interpersonal aspects	Feedback on behaviour (AS-IS) or behavioural change (TO-BE)
3. Idea Generation	Participants develop new ideas for enhancing the process using the ARDUINO construction kit.	Interpersonal aspects	Patterns of collaboration Success rate
4. Concept Development	The idea(s) chosen are turned into a fully-fledged concept for IoT adoption within the given factory/industry.	Interpersonal aspects	Patterns of collaboration Adoption rate

Health/Well-Being

This use case supports an extended concept of “Wellbeing”, based on the following scenarios, in which a set of services are made available for the promotion of wellbeing and healthy lifestyles of all citizens:

TV for Paediatrics

Interactive Vending Machine

Intelligent Cycling

Public Transport Information

In the *TV for Paediatrics Scenario*, children hospitalised in a paediatric department are provided with a touch screen TV monitor. Children are usually anxious during their hospitalisation, and the provided system is seen as an aid and comfort thanks to the availability of an extensive communication support. Children are allowed to use the Internet, play videogames and attend school lessons. All the performed choices are recorded and the healthcare professionals (or the parents themselves) have the control of what the children are allowed to do.

The *Interactive Vending Machine Scenario* offers to adult people an opportunity to reflect and react on the benefits related to healthy living through the deployment of an innovative system for the automatic distribution of food and beverage. The Vending Machine does not only provide goods but becomes an educational tool to gather and entertain people, while increasing the awareness and providing motivation to adopt a healthier lifestyle.

The *Intelligent Cycling Scenario* is based on a Web Portal (www.vainbici.it) that was conceived for the promotion of initiatives aimed at a healthier and more environmentally friendly lifestyle, as well as the provision of services for pedestrian-cycle mobility. Their outcomes include: *i)* incentivising the use of the bicycle, *ii)* motivating the bikers to create a social network and to adopt healthier and more environmentally friendly lifestyles, and *iii)* promoting the territory and the tourist services available[1]. The Portal allows exchanging and sharing information and digital content related to the world of bikes and cycling, including audio-visual multimedia content.

The *Public Transport Information Scenario* includes the provision of advisory services for all users of an automatic shuttle that connects the City metro line to the Hospital. The aim is to support patients and improve the mobility of visitors, staff and students in their travel to and from the Hospital. Among other functionalities it will be possible to query the IT system to obtain travel information from remote devices.

Results and Implications

The four scenarios are all supported and enhanced by experiential information to be collected and interpreted throughout the project trials (experiential data, usage data etc.). In particular, the following table maps the objectives of this information gathering, in relation to the main process stages and to the key social aspects of H-C-T interaction:

Scenario No. & Title	Description	Social H-C-T aspects	Objectives of information gathering
1. Media	Children use the Internet, play videogames and attend school lessons	Emotional aspects	Patterns of service usage Feedback on service
2. Personalised Services	Adults receive advice on healthy lifestyles while buying food at the vending machine via LCD touch screen panel	Empathical aspects	Patterns of service usage Feedback on behaviour (AS-IS) or behavioural change (TO-BE)
3. Tourism Services	Participants engage in a social network and a portal for the promotion of cycling	Interpersonal aspects	Patterns of collaboration Feedback on behaviour (AS-IS) or behavioural change (TO-BE)
4. Public Transport	Visitors ask and receive travel information on their mobile devices	Empathical aspects	Patterns of service usage Feedback on service

Green services

Two types of green services are included in the use case: a mobility service (with a vehicle based scenario) and a wellbeing service (with a green watch based scenario). Both of these are based on fixed and mobile sensors. In both scenarios, the objective is to study the impact of citizens' awareness of environmental data provided by IoT devices or by personalised alerts on their decisions related to:

Transportation (modes, paths, destinations or times)

Mobility (in relation to air quality patterns).

Results and Implications

The use case is grounded on an original methodology, which is articulated in three complementary approaches, each being supported by the experiential information to be collected and interpreted throughout the project trials (experiential data, usage data etc.). In particular, the following table maps the objectives of this information gathering, in relation to the main process stages and to the key social aspects of H-C-T interaction:

[1] Such as: bike-specific roads/paths, address books or informative and educational deepening, the geo-database with all the information about the cycle paths (GPS circuit and altimeter's profile), the geographic localization of all the services available on the territory (hotels, hospitals, parking, restaurants, shops, museums…)

Approach No. & Title	Description	Social H-C-T aspects	Objectives of information gathering
1. Participatory/user-centred design methods (for the co-creation of global process)	Cognitive walkthrough, online or face-to-face focus groups, workshop on paper-based mock up, etc.	Interpersonal aspects	Patterns of collaboration
2. Diary studies for IoT experience elicitation during usage	They make experiential learning more explicit and are suitable for the longitudinal aspects of the use case as it is intended that experience should be gathered with IoT over a period of time and not as a one-shot trial.	Empathical aspects	Feedback on behaviour (AS-IS) or behavioural change (TO-BE)
3. Coupled quantitative and qualitative approaches for portal usage analysis, to allow the identification of patterns of service usage and the elicitation of an informed rationale for the observed patterns	May include content analysis, social network analysis and other analyses that are relevant in understanding technology acceptance. May also include questionnaires on attitude changes.	Interpersonal aspects	Patterns of collaboration Feedback on behaviour (AS-IS) or behavioural change (TO-BE)

Conclusions

The above considerations are being implemented into an Experiential Platform, designed and developed to explore ICT/IoT enabled human interaction, including its validation as well as the corresponding impact evaluation (see McCarthy and Wright, 2004). This Experiential Platform will operate as a knowledge and experience gathering environment in the IoT context.

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