The IoT Design Deck: A Tool for the Co-design of Connected Products

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Abstract. The Internet of Things (IoT) does not only refer to technology but is a new paradigm in the relationship between human and computers. Connected and smart devices will be pervasive in our life and, for this reason, the design of the User Experience will be very important for this brand new kind of products. This scenario offers new opportunities but also big challenges to UX designers, moreover it requires a multidisciplinary team due to its complexity. In this work the authors propose a method for the co-design of the user experience of Internet of Things products and services. The key elements of this methods are: it help multidisciplinary teams sharing ideas using a common language, it helps to take into account opportunities and threats of the IoT scenario, it is based on a lean approach, encouraging the team to prototype and test ideas with users.

Keywords: User experience design · Internet of things · Human computer interaction · Co-design · User centered design

1 Introduction

The Internet of Things (IoT) is a topic of great interest and it is addressed as a paradigm that can change relationship between people and computers [1]. There is a fervent research activity about the technical aspects of the IoT but a limited exploration about the User Experience Design and the HCI related issues of IoT devices. These kinds of studies are usually domain specific and linked to the perspective of ubiquitous and pervasive computing [1, 2]. Adding interactivity to an everyday life object (i.e. shoes, a fridge) means having a deep impact on the life of the users, not only in terms of interaction but involving issues and implications related to human values [3] as privacy, trust, social relations and many others.

C. Rowland [4] calls these devices "connected products" to underline that the user doesn't focus on technology rather on the relationship with the object and on the functions it enables.

The User Experience design methods, used for websites and mobile apps, should be expanded and mixed with other disciplinary fields as product design, service design, engineering and architecture.

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In this scenario we propose the IoT design deck: a method for the co-design of products or services built upon the IoT paradigm. It is aimed to be used during design sprints [5] to define the main characteristics and the boundaries of a project, to help multidisciplinary teams to share ideas using a common language, to take into account opportunities and threats of the IoT scenario, and to encourage the team to prototype and test ideas with users in a lean approach. The method is still in a development phase and in the present work will present its main feature with the aim to open a discussion about the methodologies for the design of the User Experience in the IoT scenario.

2 User Experience Design for the IoT

The term User Experience (UX) is used in many contexts and it is difficult to find a unique definition [6]. It refers to an holistic concept that, according to Norman [7] "encompasses all aspects of the end-user's interaction with the company, its services, and its products". In the work of Garrett [8] we can see a stack of elements that contribute to create the user experience of an interactive product. While the work of Garrett may seems to be based on the design of web sites or systems based on a graphical user interface, it can be expanded to every kind of products. The design of the user experience is based on the user-centered design process [8] with its methods and techniques. It is based on the concept that the user should be understood and involved in the design process. However it comes from a desktop based approach and sometimes methods and techniques show some limits and have to be updated to face the new challenges. As an example if we compare the difference between the design of the interaction with a desktop system and with a mobile system, in the second case we will intuitively understand the importance of the context and look for a technique or a method to understand it in order to achieve a better UX.

The IoT scenario offers enormous opportunities but also many challenges for the design of the User Experience. The IoT is pervasive in our life. As, in this scenario, we will constantly use connected products our life experience will be deeply characterized by the interaction with this new kind of computers, embedded in the physical world. If we choose to consider the visionary work of Mark Weiser [9] as a statement for the relation between humans and computers we can imagine the final purpose of the design of the IoT in making the technology disappear in the everyday experience. For this reason we should take into account not only the single experience of use but the experience of life, in which the single interaction takes place, in a seamless flow.

As outlined by Rowland [4] in her work there are some important differences in the design of the experience of connected products as:

- Context: interaction could take place in many different contexts. The designer should imagine what the user would need and how he/she will be able to use a certain device in a specific context;
- Novelty of technologies: IoT is a new concept, technologies are new and buggy and users are not used to the new paradigm of interaction;

– Complexity: functionalities can be distributed across multiple devices and the paradigm of interaction is quite new. The complexity of the system should be hidden to the user.

Moreover there are many other important implications: IoT is asynchronous, we can send a command that will be executed in another place or time; the overall experience is a result of the service that is provided through the IoT touchpoints; artificial intelligence could simplify tasks but automation could put the user out of the loop; the user is asked to make complex actions like programming (i.e. configuration of an home automation system); some products, like a smart home system, are shared by users with different needs that might be in conflict.

The proposed method has the objective to help designers to take into account all this elements even if they are not technology experts but it has to be general and not domain specific, to let the design team express their creativity without limiting new solutions.

3 The Importance of Co-design

Co-design can be defined as a design process where collective creativity "is applied across the whole span of a design process" [10] to generate ideas and innovative solutions on a given topic.

Sanders and Stappers point out that "we are no longer simply designing products for users, we are designing for the future experiences of people, communities and cultures", and shaping human experiences means getting closer to the users, until they become part of the design process.

The practice of including customers during the whole design process, from the ideas generation to prototyping, has a powerful outcome in any type of business but especially in service design. Indeed the combination of different perspectives is essential to understand both a service's demand side, i.e. users' and customers' needs [11], obtaining a better user experience.

Steen [11], while describing the benefits of co-design, concurs with Roser and Samson [12], who proved that co-design within a multidisciplinary team offers different benefits: access to customers' experiences, which improves idea generation through shared knowledge, increased speed to market, and better quality of products. A heterogeneous team provides different points of view and approaches to solve a problem.

These authors point out that co-design also have positive effects on the effectiveness of the process, improving the "quality and speed at which decisions are made in relation to the development and filtering of ideas".

Co-design users might be a variety of people with different experiences, habits, and professionals from different fields, so it's important to create a shared understanding: according to Bittner and Leimeister [13], group members have to be able to integrate their knowledge bases in order to share a common language during the design session, where knowledge can be of various structures and contents.

According to this, co-design seems to be functional to the design process of an IoT solution as it: facilitates multidisciplinary teams to work together, creating a common language to share knowledge and ideas; helps in engaging and understanding different kind of users and stakeholders.

4 Using Cards to Design Interactive Systems

The use of visualization methods in collaborative design can facilitate the collaboration between team members with different background or expertise and can help to generate new ideas or changes. For example sketching something can help to explain and share ideas and to explore concepts. Visual artifacts help to: physically store mental representations improve thinking capacity; group together relevant information showing how ideas and concepts are related [14]. Several kinds of design materials may be used during a co-design session, like video, paper documents, mock-ups, prototypes, posters or small paper documents like Post-it [15]. Among these kind or visual material inspirational or method cards could be useful tools for collaborative design as low-tech tangible idea containers, triggers of combinatorial creativity and collaboration enablers [16]. Moreover the "card" form allows to easily exchanging pieces of information between the participants of a co-design session. This method is often applied in participatory design to inspire action and reflection and to produce new ideas [17].

The cards can be employed with different sets of rules and are classified by Wölfel and Merritt [19] in terms of five design dimensions like:

- Intended Purpose and Scope (General/Repository cards, cards focused on Participatory Design, Context specific/Agenda driven cards).
- Duration of use and placement in design process (Anywhere/Any time cards, cards used as needed, cards used at the beginning of the process, cards used at a specific point).
- Methodology of use (no methodology, suggestion for use, specific instructions).
- Customization (no customization, trivial customization, optional customization, customization required).
- Formal Qualities (only text or only images, text and images combined).

Lucero et al. [19] identify deck of cards that have as their main purpose to stimulate the inspiration in the process of user-centered design, like Inspiration Cards [15], Plex Cards [18], and Ideo Method Cards [7].

The Inspiration Cards [15] are composed by two categories of semi-structured inspiration cards, Technology Cards (descriptions of technologies and their applications) and Domain Cards (information about the reference domain, like people, situations, etc.). During an Inspirational Card Workshop participants combine the Technology and Domain Cards on posters and integrate it with short descriptions and scenarios.

The Plex Cards [18], based on 22 categories of a Playful Experiences framework, are used to facilitate user-centered design activities to develop solution based on the concept of "playfulness" in different contexts. This method has specific instruction of use and the cards can't be customized. The IDEO Method Cards [20] is a collection of

techniques (divided in four categories Learn, Look, Ask and Try) useful to better understand the user and keep him/her at the center in the design process. The team will use card as a quick reference or a way to discover new techniques.

There are other card decks that are domain specific and some of them are tailored for the IoT scenario.

Know Cards [21] allows different participants, with limited hardware background, to combine different electronic components, (divided into Power, Input, Output and Connection), to create new ideas. It can be used to facilitate communication between designers and engineers, or to provide some basic knowledge about technology during the design process or in a brainstorming session.

Tiles Cards [22] is a set of six decks of cards (Missions, Things, Human Actions, Feedback, Data Channels, Criteria) and are a part of a mission-based game, that can be played individually or in a team, as part of a workshop. The Tiles Cards' aim is to make the design of IoT solutions and tangible interfaces more accessible to non-experts and to include end-users in the design process. The cards can't be customized, but the authors provide also blank cards that can be personalized.

A different approach is used by the IoT Deck [23]. It is based on the Maslow's need-hierarchy theory composed by four categories (Physiological, Emotion, Interaction, Self-actualization) and available in two versions, normal cards and digital cards, which requires the use of a digital table to see the extra contents as images, sounds, videos. The analogue mode privileges conceptual approach and doesn't requires infrastructure, while the digital mode allows to work more with images and allows to structure moodboards, sharable or savable as a digital file for further use. IoT Service Kit [24] allows teams to explore a wide range of user-centric scenarios related to Smart Cities, Public transportation and other digital services that merge physical and digital realities. It is an open-source and co-creative kit created for who is interested to create digital services within the IoT paradigm and consists of different game boards (public square, neighbourhood, supermarket, etc.), 3D model pieces ready to print and five card decks (Sensors, User Cards, City Open API, Service Cards, Interaction).

As we can see, only in the card methodologies applied at the IoT field we can find different solutions:

- Technology-centred (Know Cards);
- Process-oriented, addressing user-experience and technology elements in a "mission based" approach (Tiles Cards);
- Focused on users' needs and behaviour, inspired by the Maslow's hierarchy (IOT Deck);
- Domain-centred (IOT Service Kit).

A common element that emerges from this various approaches is to make technological aspects of the IoT more accessible to non-experts and make end-users more involved from the beginning in the creation process.

5 The IoT Design Deck

The IoT Design Deck is a method composed by different tools. It was inspired by the professional and academic experience of the authors and by a review of the literature about co-design methods and about the design of IoT enabled interactive products. The objective of the method is to help multidisciplinary teams to co-design products or services that use one or more IoT features, from the idea generation to the experience prototype [25]. It can be useful especially in the early stages of the design process, to speed up the process that leads from the idea generation to the definition of the main characteristics and boundaries of a project. Then it is useful to help the team to visualize and focus on some aspects (i.e. user journey, touchpoint matrix, system map etc.) driving from the concept to the definition of the most important touch points, focusing on the user experience more than on the technology. Technical aspects are taken into account just to evaluate their effects on the experience of use (i.e. is a wearable sensor perceived as "intrusive" by the user?, are the input/output device suitable for the physical/social context?). The method ideally ends up with an experience prototype of the single touchpoint to iteratively test the design choices.

As the design of connected products is a complex journey and involves many competencies, a co-design workshop with a multidisciplinary team can help to reach a common vision to speed up the design process.

For this reason it is conceived to help different professionals to work together, sharing their knowledge and ideas, as it requires a background on UX techniques and methods only for the facilitator.

5.1 The Cards

The method uses some well-known techniques as well as custom defined ones. The main tool that supports the method is a deck of card. There are two main kinds of cards:

- Schemas: card with fields to be filled up with text or sketches. Each schema represents a fundamental element in the project (i.e. personas, contexts, functionalities, touchpoints);
- Reference: cards with tips and bits of information about topics relevant for the design in the IoT scenario (i.e. a non exhaustive list of possible IoT touchpoints, inputs and outputs);
- Facilitation cards: used by the facilitator to inspire the team or to focus on specific issues (i.e. techniques, opportunities and threats).

The reference cards may be used as facilitation one or vice versa according to the decision of the facilitator as she/he can decide when give a card to the team or the cards can be used directly by the team as a reference.

The reference cards are not meant to be a closed set but it can be expanded by users and the new cards can be shared and become part of the deck.

The different kind of cards could be also be categorized according to the different design phases they are used into: to define the basic elements of the UX, to better

understand users and contexts, to outline the functionalities and the interaction paradigms of the touchpoints, and to focus on opportunities and threats.

The team can play with the cards and arrange (and re-arrange) them on a whiteboard (or a big surface where is possible to draw/write). There is a set of "game boards" provided in the method to help the team to visualize or focus on specific aspects, drawing relations and writing annotations as:

- User Journey;
- System Map;
- Touchpoint matrix.

The deck is open as it can be extended by the team or by the facilitator according to the specific characteristics of the project. Indeed, playing with the cards and arranging them in different ways may help to find out relations between the project's elements or changing the point of view. For example using all the touchpoint cards the team can see the touchpoints matrix and use other cards to visualize the matching between functions and touch points, or how many personas use a specific touchpoint and which one is the most important for a certain category or in a specific context. Once the cards are drawn on the board and the relations/annotations written or sketched down, the team could take a picture and use the cards again. In that way they can easily produce project documentation but also keep records of all the changes and the choices made during the design process.

5.2 The Design Phases

The method is articulated in three main phases:

1. Concept definition: from the creative generation of ideas to the definition of a clear concept;
2. Project development: from the early concept to a more detailed description and design of the main features and elements of user experience;
3. Touchpoint design and prototyping: designing and testing the characteristics and the user experience of the touchpoints.

The concept definition phase has the objective to define the fundamentals statements of the project. At its beginning it has to stimulate the creativity of the team drive the team, using brainstorming techniques and sketching. Then there is a refinement process that will help to sort and select ideas defining the main elements of the project as people involved (users and stakeholders), the problem(s) they have, and the solution they will use to solve it. Trying to synthesize a short and understandable value proposition. As the method can be used for training designing skills there are some brief that the team can choose from, studied to force the team to face specific design problems.

The second phase is aimed to help the team to better define the elements of the project. It starts with user research, defining personas and contexts of use (e.g. in the office, at the park, in the pool, while cooking etc.). Using the "action deck" the facilitator can suggest the team a wide range of research methods. For example a user

diary could be helpful to identify the users' micromoments [26] to choose the right touchpoint that can fit the specific context, or using some object (i.e. a pair of glasses) can help the team to empathize with a specific category of users.

There are four kinds of fillable cards that can be used in this phase: Who - Personas, Where - Contexts, What - functionalities, How - touch points.

By filling up the fields of the Personas and Contexts cards the team is forced to point out some elements that could be important for the development of the project. For example objectives, frustrations and abilities of a Persona, or opportunities and limits of a context of use. The team can also write a more complete Persona or Context description, summarizing the information on the card and using it as a quick reference.

After the definition of users and context then the design team will define the functionalities and the type of touchpoints used.

The team will write every desired functionality using the Functions cards. In this phase probably the team needs to make a selection and choose only few of them. Several techniques can be used. The team can create a forced ranking of the functionalities, or can group the card according to the personas or the context they refers to, discovering the most useful ones.

In a similar way they can imagine and select the touchpoints to be used. In this phase it is not necessary to consider the technical specification of the touchpoints but just their effect on the UX (i.e. A wearable device can be suitable for a personal use while a totem can be used in a public context). Moreover there is a set of "reference" cards with some touch points already described (i.e. mobile app, totem, wearable device etc.) with tips on the usability and User Experience implications.

At this point, using all the 4 kinds of cards, the team can visualize different aspects of the projects using the game boards as described above.

The third phase is focused on the design and prototyping of the user interaction with the physical touch points. There are two set of reference cards, one for user inputs and one for user outputs. These are defined in terms of interaction and experience. For example "A led can deliver information using blinking and colour, but it requires the user to remember its meaning unless labelled"; "A touch input can be used for fine interactions but requires a lot of user attention and is not suitable for certain context".

Using a whiteboard the team can draw/write the behaviour of a certain touchpoint, linking inputs, outputs and functions (i.e. motion sensor - turn the light on) describing it with a narrative text i.e. Paula touches her necklace for 2 s, then a message is sent to her friend and the necklace gently vibrate to give confirmation that the message has been sent and red, or with a timeline, or with a use case diagram [27].

A specific board encourages the team to sketch and describe also the physical characteristics and aesthetical appearance of the touch point.

The team is encouraged to build and test an experience prototype. Especially in the first iterations of the design process it should be a low fidelity prototype, build with paper or cardboard. The main objective of the prototype is to understand the overall experience of the main functions/touchpoints to check if the product helps the user to reach her/his goa, if is suitable for a specific context, and is desirable. Several techniques can be useful at this point: role playing and bodystorming [27], asking to the team to act as the product was real and simulating the key aspect of the context; wizard of oz [27], simulating the functionalities of the system with a human operator hidden

behind the scenes; guessability study [28], presenting the prototype to someone that has not took part to the design process, asking her/him to understand what the product is for or how is used. In a more mature iteration of the process is it possible to use some electronic toolkits, as Arduino, and digital fabrication techniques as 3D printing, to build hi-fidelity prototypes. The team can also test the look and feel and the ergonomics aspects of the project building prototypes using the dimensions, weight and materials (i.e. smooth, hard etc) that the product will have once finished.

6 Future Works

The method is still in a development phase. A testing phase is currently underway using the method in several workshops with multidisciplinary teams. The main objective of this phase and of the future works is to fine-tune the method especially regarding:

- Usability: ability of non UX expert to understand the labels, ability to successfully complete all the phases designed;
- Adaptability to different contexts: as IoT is present in many domains (e.g. smart home, smart cities, e-health etc) the method has to be flexible and suitable to the different applicative domains (Fig. 1).

Fig. 1. A co-design workshop to test the method.

A meta-objective of the testing phase will be also finding key indicators to detect if this method can facilitate the interaction inside the design team, the expression of creativity and if it contribute to a better project quality.

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