I would DiYSE for it! A manifesto for do-it-yourself internet-of-things creation

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ABSTRACT

This paper presents a manifesto directed at developers and designers of internet-of-things creation platforms. Currently, most existing creation platforms are tailored to specific types of end-users, mostly people with a substantial background in or affinity with technology. The thirteen items presented in the manifesto however, resulted from several user studies including non-technical users, and highlight aspects that should be taken into account in order to open up internet-of-things creation to a wider audience. To reach out and involve more people in internet-of-things creation, a relation is made to the social phenomenon of do-it-yourself, which provides valuable insights into how society can be encouraged to get involved in creation activities. Most importantly, the manifesto aims at providing a framework for do-it-yourself systems enabling non-technical users to create internet-of-things applications.

Author Keywords

Internet-of-things, do-it-yourself, manifesto, guidelines.

ACM Classification Keywords

D.2.2 Design Tools and Techniques.

General Terms

Design, Documentation

INTRODUCTION

The term Do-it-Yourself (DiY) culture refers to a societal movement of doing and making things oneself, originating from dissatisfaction with current society. As McKay [33, p.2] quotes a DiY activist: "DiY culture was born when people got together and realized that the only way forward was to do things for themselves". Although DiY culture originated from a non-digital, 'offline' world it is again gaining momentum due to the rise of social media and other 'online' platforms. One of the key factors in DiY culture is the feeling of belonging to a community. In that context, the internet has had a drastic influence over the last years [18, 39], as Web 2.0 applications allow end-users to create their own digital content [18]. With the developments related to the internet-of-things, the digital DiY culture might be taken one step further, resulting in a situation in which end-users themselves can create applications for smart environments. The intrinsic characteristic of such smart environments is that they exist both in the natural and in the digital world [42, 45]. The Internet of Things (IoT) is a concept in which all objects around us are linked to a network, together creating a connected world. Within the IoT, all objects are given a digital presence using integrated sensors and actuators that generate data and output certain actions about the object and its environment, thereby allowing other devices and objects to communicate with each other through a digital network [45]. A recent update of the Gartner Hype Cycle [14] highlights the importance of the IoT, and indicates that the idea of an IoT is no longer as fictive as it might have been regarded in the past. However, in order for the IoT to really take off, end-users need to participate in the creation process on a larger scale. They need to have the power and control over the creation and use of applications for smart environments.

In previous work done within the domain of human computer interaction (HCI), the potential of combining the DiY phenomenon with IoT-related research has already surfaced and has been valued within the community [4]. Kuznetsov and Paulos [27] explicitly called for more interaction between DiY communities and the HCI community. Moving further along this line of reasoning, this paper presents a manifesto for moving towards a more human-centered IoT world.

In order to make the manifesto aspect stand out, this paper is structured in a non-traditional way. Firstly, the reason for existence of this manifesto is argued. In this section we focus on why the manifesto format is suitable and how the user research from which this work originated was conducted. Secondly, we present the manifesto itself, which consists of 13 statements. We explain each of the statements into more detail by discussing related work and illustrating the statements with specific observations, insights and/or conclusions from the user research activities

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to which the manifesto is anchored. To conclude, a possible future for this manifesto is suggested, focusing on how it can be used in practice and what is needed to refine and validate it further.

WHY A MANIFESTO?

In the last decades, a number of manifestos specifically related to DiY have been published. The first of these manifestos was probably The Hacker Manifesto [44], published in 1986. It is a set of guidelines aiming at providing an ethical framework for novice hackers. Another example is Mau's Incomplete Manifesto for Growth [32] a list of 43 ideas aiming at getting people to do things differently when designing or making things. MAKE magazine has in 2005 published a Crafter's Manifesto [13] and an Owner's Manifesto [34], the latter also referred to as The Maker's Bill of Rights. In 2008, Brett Gaylor presented a Remixers' Manifesto in an open source documentary film about the world of mash-up media [38]. It deals with the future, freedom and control of remixing digital media. In 2009, Platform 21 launched a Repair Manifesto, to "make repair cool again" [37], encouraging people to repair instead of throwing away, and to motivate designers to create more repairable products. Finally, in 2010, iFixit published the Self-Repair Manifesto [23]. This manifesto was inspired on both the Owner's Manifesto and the Repair Manifesto and aims at being able to repair devices to reduce throwaway rates.

Although the existing DiY-related manifestos described above do offer links and starting points, many issues related to DiY IoT creation have not yet been touched upon. Therefore, the aim of this paper is to present a manifesto that aims at systems for DiY IoT creation. The manifesto presented is primarily aimed at developers who design and implement digital creation systems for end users. By presenting the research findings as a manifesto, the authors want to highlight the relation to the maker movement and communicate the findings in the maker tradition.

WHY FOCUS ON DO-IT-YOURSELF INTERNET-OF-THINGS CREATION?

As was hinted at in the introduction of this paper, the need of end-user development or DiY creation of IoT applications has been recognized in different domains, such as end-user programming theories and practices [5, 25]. In addition, the IoT as it exists until now has not yet been adopted by the mass [20]. Furthermore, the focus of IoT has been fading away from the 'things' towards real-life understandable data streams, as can be seen in applications such as Cosm (www.cosm.com) and Noisetube (www.noisetube.net) and in the growth of personal informatics [29]. These trends are in accordance with the idea that the goal of HCI will evolve from just making systems easy to use, to making systems that are easy to develop [46]. It is this development we aim to affect with the manifesto presented in this paper.

An IoT world is a world immersed with context-aware applications. However, most existing context-aware applications do not take into account the meaning the context has for the person using the application. Often, data are made available by products and digital services, but the end-user is not in control of the data sources or how the data are gathered. Not taking the aspect of meaning into account is a result of the fact that context is not something that objectively describes a setting; it is something that people do, the horizon within which the user makes sense of the world [22]. Context-aware applications should therefore be able to take into account the non-modeled concept of context. To solve this, end-users should be enabled to describe their own context model, related to the environment they live in. Therefore end-user development should be a highly important focus when developing context-aware platforms.

Although recently a lot of work has been done to satisfy and enhance this end-user programming requirement for context awareness, applications are usually designed for one specific group of end-users. In fact, most of these applications are based on the structured programming metaphor, which is primarily geared for developers. Recently, methods have been published that attempt to provide alternative input mechanisms to minimize coding effort (e.g. visual programming environments and web-based templates), such as those reported by Interactive Prototyping of Context-Aware Applications (iCAP) [10]. In addition, high-level abstraction models are presented as "easy" programming methods. An example is the UbiPlay project, utilizing a "finite-state-machine" metaphor to enable non-expert users to program a smart playground [31]. The Context-Aware Empowerment Platform (CAEMP) is another example that foresees high-level abstraction models [6]. However, there is still a substantial amount of work to be done in order to allow non-technical users to write a program without requiring any programming skills.

ORIGIN OF THE MANIFESTO

The manifesto for DiY internet-of-things creation that is presented in this paper originated within the context of a European research project called DiYSE: Do-it-Yourself Smart Experiences. This project aimed at enabling ordinary people to easily create, setup and control applications in their smart living environments as well as in the public internet-of-things space [24].

For the purpose of this project, qualitative research was conducted to understand how and why users would create their own smart experiences in an Internet-of-things world. This research included 30 users who engaged in several data collection exercises over a period of eight months (September 2010 - April 2011). Four subgroups of users with different characteristics participated: social crafters (5 persons engaging in craft activities and promoting/marketing their crafts via internet platforms such

as Etsy, Facebook or Twitter), families (2 families consisting of a father, a mother and two teenage children), IT enthusiasts, (2 IT enthusiasts and three tech savvy friends each) and social (h)activists (7 persons engaged in actively reclaiming the streets in the city for playgrounds).

The research period involved three subsequent phases. First, a contextual study was done to collect background information about the participants' current behavior related to electronics, media and DiY. For this purpose, each participant individually kept a semi-structured diary with different questions and exercises, after which group interviews were held to enrich and clarify the diary data. In the second phase, the individual participants received a low-fidelity creation kit that stimulated them to think about creating internet-of-things applications in their own environment and related to their own activities [8]. This kit was a box filled with creative material, both creation material and attachment material. Participants were asked to use this material to generate ideas for smart objects and applications. Idea generation was facilitated by introducing the 'lillidot' concept, which could be described as a very high level sensor [8]. The lillidot was described as something that can tell its owner anything about the object it is attached to. Participants were given the task to create combinations of lillidots that would be useful in their day-to-day activities. This phase resulted in insights into how people envision the idea of being able to create smart objects. Finally, a co-creation session was organized for each of the groups to explore the use of a mock-up sensor kit. This kit consisted of a variety of foam board squares, representing a sensor. Each square had either a symbol or text printed on it, representing its functionality. For example, this could be a thermometer icon, or text stating 'thermal sensor'. Participants were given a case, based on their previously created lillidot ideas, with the task to recreate this idea using the foam board squares. The final goal was to create a manual or set of instructions that allowed other people to recreate and install the case. The results of these sessions showed how the participants in each group approached the creation of IoT applications and which creation paradigm they used (i.e. how they search for information and existing applications, what and how they measure data with the application they created, how they instruct other users to replicate the application, how they install their application, etc.). The foam board squares can be regarded as a lower level version of the lillidots, focusing more on understanding of sensors and actuators and less on idea generation.

The three research phases described above resulted in a collection of highly qualitative, very rich data such as stories from the diaries, answers to interview questions, observations, ideas for IoT applications (including motivations and explanations), etc. All data were structured using NVIVO, which enabled the identification of several commonalities amongst the groups. These common items were translated into user requirements for a system for DiY IoT creation. Based on these user requirements and on available literature, a first draft of the manifesto was created. At this point, all partners of the DiYSE project were involved in several workshops to further refine the manifesto. In terms of formulation, statements were made as univocal as possible keeping in mind that the manifesto aims at providing a framework for developers of DiY systems enabling users to create IoT applications.

The analysis of the data gathered during the user research activities resulted in the model (Figure 1), which laid out the foundation of the manifesto. It shows the framework for an ideal creation platform for DiY IoT applications. Although it is a high level abstraction, this model visualises the train of thought behind the manifesto on the one hand and introduces some specific vocabulary on the other hand.

The smallest entity in the system is called a 'useful component' (e.g. a hardware light sensor that can transmit values to a system). Useful components can be combined together to form 'sets of useful components' (e.g. a light sensor connected to a buzzer that makes noise when a certain lighting threshold is reached). By using such sets, users can create projects (e.g. an application that makes a tune play when one opens a jewelry box). Depending on the level of creativity within a certain domain [40] users can create with and contribute to the system.

In order for a wide variety of people to be able to engage with an IoT creation system, we found that there is a need for a variety of ways to 'enter' the creation process. We identified at least three of such entry points. A first entry point is a leftover, which can be an unfinished project or (set of) component(s) that users started to make but never finished. As a second entry point, materials could allow people to start a creation process based on things they have seen from others or have collected in the past. A third entry point is based on ideas, which are descriptions of (sets of) useful components or projects without actually making them or starting to make them.

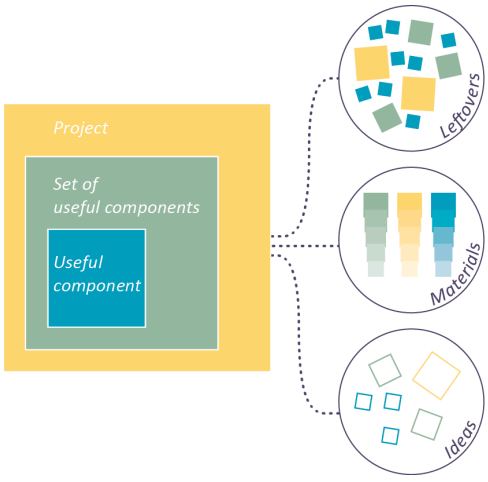

Figure 1 : Overview of the terminology and central concepts in an ideal internet of things creation system

MANIFESTO ELEMENTS EXPLAINED

In the next section each statement made in the manifesto (presented in Figure 2) will be explained in detail. We refer both to literature and to our own research findings in order to clarify each aspect's value in the manifesto.

A Do-it-Yourself internet-of-things creation system should:

1. Inspire to be creative

The system should be a platform that inspires and supports people to be creative, to self-actualize in their projects. It should motivate them to think out of the box, to generate innovative ideas, solutions or content, constrained as little as possible by existing technology or conventions. The project process should be fulfilling.

As Bannon [3] argues, in order to open the design space for ubiquitous technology, forgetting about how technology works and what boundaries there are to it should be considered as a design strategy. There should be a way to put common conventions aside in order to come up with fresh ways to interact and talk about the world around us, of which digital technology is increasingly becoming a part. Regarding the importance of a constructing platform for creation, Ackermann, Gauntlett and Weckstrom [1] refer to Keith Sawyer's socio-cultural advices for creativity. The central point made here is that ideas should be shared by like-minded colleagues [41] in order to position the role and origin of inspiration: "Creativity doesn't happen in isolation any more than it is innate, it relies on both individual input and reflection as well as inspiration from peers, society and contemporary culture. The group surrounding the individual has a huge influence in inspiring creative expression, whether recognized or not" [1, p 24].

According to the participants in our own research, ideas for DiY projects come from somewhere close by. Summarized by Risa (social (h)activists group): "in the end, inspiration is a fusion of everything you know and see; it brings together all those things you have seen and experienced and translates it to something new." A more concrete example was observed during the co-creation session in one of the family groups where the mother repurposed a specific prototype made by her daughter with small changes.

2. Support a spectrum of expertise in computational thinking by offering different layers of computational abstractions

Users have different levels of computational thinking. The system should support a least three different types of users (the amateur, the professional-amateur and the professional) in order to reach an equal level of computational complexity.

In his work on professional amateurs, Leadbeater [28] argues that the population can roughly be divided in three categories: amateurs, professional-amateurs (pro-am) and professionals. Depending on a person's skills in a certain area, his or her expectations will be different. Sanders makes a similar point [40] when she talks about levels of creativity. Both authors state that depending on one's level of expertise, one's way of doing things in a certain area is different. For instance, when you first start cooking, you are capable of sorting your spices but you are not capable of making highly creative combinations of recipes. Related to computational systems, Grufberg [19] illustrates how abstraction can be taken from a computational system, in order to allow people without a profound technological background to participate in the design of such systems.

Our group of participants consisted of people with different levels of technical skills and from different DiY domains. There were several participants who could be labeled as professional amateurs because of their level of knowledge in their respective domain, motivation to DiY or use of resources (time, money). The differences in the computational levels of thinking of the participants became apparent during the co-creation exercises. Carrying out a fairly simple measurement of a variable in the environment was approached in very different ways. Even for the technically advanced participants, their skills did not result in similar solutions, as their personal preferences, opinions and viewpoints still differed. In the end, what comes naturally to one, may be foreign to another.

This was illustrated by Henri – from the IT enthusiasts group, who admitted that: "I've never been a big crafting fan. It's not really what I… I can do it, I have enough imagination to craft, but I'm not going to start crafting such things, because by nature I like to play with more technical material.." By contrast, the pro-am Risa from the social (h)activist group stated that "[At] the same time I would say that I am not into gadgets and technology. At home we have almost nothing of new technology..

3. Help people to create useful components

The system should guide users to reformulate or organize ideas, solutions or content into useful components. These useful components, that are essentially small applications with fractal characteristics, can be compared to a LEGO brick in terms of reusability and composability. Users do not make their own LEGO bricks, but they can combine bricks into a LEGO construction, which can be shared and reused.

A DiY project does not have to be a significant undertaking every time. Sometimes, it is enough to just add something small or tweak the existing components just enough to make it look like the creation is yours. It all comes down to expressing yourself and making the world your own [17]. Ackermann [1] also refers to the LEGO brick as a component of a creative system: "the LEGO System enables constructive play, which, like playing a musical instrument, helps children bring their imagination to life through a process of open exploration, or intelligent form-giving, both alone and together with others. This process is both free and constrained, loose and principled."

Sometimes, a small piece of work can make a big difference. By customizing it just a bit, you can make it uniquely yours. Hanna, from our IT-enthusiasts group, adds her personal touch to Christmas cards to let her friends know, just by looking at it, that "this has to be from Hanna". On a practical level, most or our participants struggle with a lack of time. There is seldom time to concentrate fully on one's DiY project. The time to DiY is made up by stolen moments here and there. Even so, things get done. According to Risa (social (h)activist group), she often feels that she has no time to make anything, but in the end, she notices that things do get made, although these are small things, made with little effort.

4. Not teach how to program, but should provide an ecosystem to support people in creating ideas, solutions

Instead of requiring programming skills from every user, the system enables the users to start from (sets of) useful components made by others with more computational skills, such as professional amateurs and professionals. The ecosystem should present the (sets of) useful components in such a way that their purpose is evident and that combining (sets of) useful components is easy, for example by offering templates. The system facilitates incentives for creators of (sets of) useful components. These are not necessarily monetary incentives.

The idea of an ecosystem that allows users to create their own solutions or content without requiring specific technical skills is similar to the notion of open design. In open design, the role of both the designer and of the user changes. Here, the designer does not design objects anymore, but becomes a 'meta-designer', creating a design environment for unskilled users, or creating design blueprints, allowing users to design their own products [7; 2]. An increasingly popular example of open design can be found in 3D printing, where downloadable designs can be shared, allowing users to easily adapt the design to their own tastes and print their design via 3D printers (cf. democratizing manufacturing [36]).

Except for the IT-enthusiasts, most of our user research participants had no affinity with technology at all. After the low fidelity mock up exercise, it became clear that they were able to come up with valuable ideas but when asked if they saw it feasible to make their ideas into working prototypes most of them saw this as an impossible task. Quoting Hilde (from the social crafters group) "if I need something done with electronics, I call an expert".

5. Equally support starting from ideas, material (new and scrap) or other projects

The system takes into account different purposes, from clear purpose to a vague idea, and different personalities of users. Therefore the system should equally support idea generation, material-inspired projects and projects based on other lingering projects.

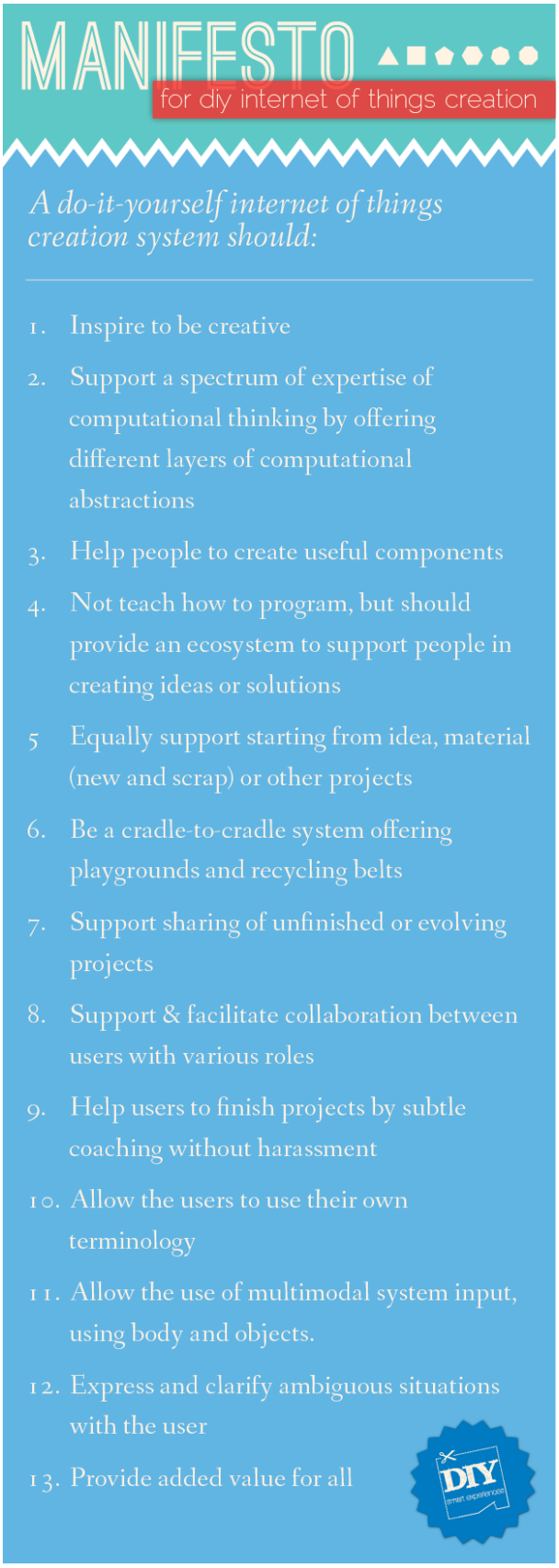

Figure 1 : Manifesto for diy internet of things creation

Allowing a variety of ways to contribute to a system is an underlying concept illustrated by Gauntlett [18] and Fischer [15]. Gauntlett argues that a variety of people need different ways to get motivated to participate in a form of creation. The work on meta-design by Fisher argues that in order to get input and feedback from stakeholders, they need a platform or way to communicate using systems designed for them.

Some DiYers are driven to start their DiY projects with a very clear idea of the end result. They plan and they sketch: "I am always the kind of thinker, 'how can I make it the way I want it?' and then I start with it." (Dana, social crafters group). Some have a vague idea, no plan nor sketch but by starting the process, the end-result becomes clear to them. To many, the material plays an important role here. According to Dieter (IT-enthusiasts group) who's a pro-am in the field of LEGO, it is important to keep working with the material, making things – even useless things – just to try it out. This experimentation with the material leads to making something new.

6. Be a cradle-to-cradle system offering playgrounds and recycling belts

The system offers a playground providing leftovers from other projects and collectables. It allows both finished and unfinished projects to linger and users to tinker with these projects.

Taylor [43] illustrates how 'pottering' as an activity can be a source of inspiration for designing. When people have things lying about that they unintentionally start to play or tinker with, the activity sometimes leads to new creations. Therefore, a system should support people to potter by providing a free and open platform. Freedom is an important aspect of DiY: freedom to begin when and however one wishes, and freedom to end without finishing. What is equally important, and often is a consequence of pottering, is the process of making and learning new ways of working, new techniques and taking on a challenge (which also is one of the 43 ideas of Mau's Incomplete Manifesto for Growth [32]). Inge, from the group of social crafters expressed it this way: "I'm always open for learning and for new things, and if I come across something that I go 'oh, that technique I am not familiar with', then I'll try it and what comes out of it is not that important. Sometimes I can make somebody happy with it, but in the end, I don't do much with it myself." Another example of this issue was given by Henri, from the IT-enthusiasts group, who defined what DiY means to him: "freedom to learn, to discover, to do, to think, to not finish, to dream".

7. Support sharing of unfinished or evolving projects

Users are able to share their projects in either the seeding phase, the flourishing phase or the finished phase. This allows them to collaborate, stimulate and support each other. Sharing is facilitated at several levels, allowing users to passively 'read' projects and to actively contribute to a project. According to a mixed reality support model, projects can be shown in personal digital galleries as well as in physical events, allowing users to show off their identity and personality.

Sharing creations and talking about them with other people is a key characteristic of DiY culture. [39] It creates a breeding ground for social contact and improved results.

Before starting a project, it is useful to look around to see if the components or even your ideas have already been thought of by somebody else: "You have a 9/10 chance that somebody already made it and that it's posted somewhere on the site. You would be dumb not to use it." (Ilias, IT enthusiasts group). When DiY projects turn out well, most DiYers are happy to share them. If a project turns out for the worst, the process can be shared to be able to find a solution after all, or to hand it over to somebody else to finish. Sometimes, a DIYer knows from the beginning that he/she won't have the time to make it so he passes the idea along to others because, "coming up with the idea is relatively easy" (Henri, IT enthusiasts group). The processes that are useful can be shared with others. In sharing, it is important that the maker remains in control of who to share his/her creations with.

8. Support & facilitate collaboration between users with various roles

Collaboration is supported and facilitated between users with various roles in the creation process: creators, debuggers, cleaners, collectors, spectators/fans, etc. Every user is able to collaborate with other users on a project from their own preferred role.

The reflections of Gauntlett on the work of philosopher Ivan Illich [17] about 'tools for convocality' indicate that when people have access to open systems (such as Wikipedia or YouTube) joy and playful experiences emerge.

Especially the participants in our researchwith higher levels of knowledge in their own DiY domain, mentioned that helping others is a motivator, at least to some degree: "I like to teach things to other people" (Inge, social crafters group). These participants are driven not only by the chance to learn something new but to be able to showcase their own high level of knowledge to other, less advanced users. Though not entirely altruistic, this is a useful trait for the context of DiY IoT creation systems. When participants are lacking in skill, a local expert is called in. However, asking for help does not mean handing over the decision power. As explained by Dana from the social crafters group, when she realized she wouldn't have the time to make a wooden chest, she asked her father to make it for her. However, the concept or larger idea came from her: "Yes, completely mine. I'm not going to outsource ideas, that is. No, those are just manufacturers and then they have to listen. [laughs]".

9. Help users to finish projects by subtle coaching without harassment

To be self-sustainable, the system should reduce barriers that may withhold users to finish their projects, by means of subtle, non-harassing coaching. Motivation is provided by either software actors or by human actors who offer immediate feedback.

In his discussion on the role of creativity in research, the ecologist researcher Loehle [30] refers to the Medawar Zone concept: "There is a parabolic relationship between the difficulty of a problem and its likely payoff. Solving an easy problem has a low payoff, because it was well within reach and does not represent a real advance. Solving a difficult problem may have a high payoff, but frequently will not pay at all." Within the scope of DiY IoT creation systems, the challenge is to get users to understand which projects are likely to produce fruitful results and encourage them to finish those projects.

Although some projects do not get to be finished due to boredom, or lack of right materials, time, or simply the right circumstances, some projects are important enough to be finished when the time is right. Paul, (IT enthusiasts group), whose hobby is to fix TV's for his family and friends, mentions that he always hopes to finish all the unfinished projects that are racking up. Sometimes, what the DiYer needs, is an extra push. As Dieter, (a pro-am in the IT enthusiasts group) explains, sometimes, having the right materials, the time and the opportunity does not result in making something: "So it's not only the time. It's the combination of time, desire, enthusiasm and finding the right moment".

In the family group, where no real pro-ams were present, the participants took the initiative to check the viability of the ideas they created during the probing session with the researchers during the subsequent interviews. It had been a point of discussion within the families regarding which ideas were feasible or not. They were looking for guidance on which things they should finish or focus on, but did not have a place or person to turn to in order to crosscheck this.

10. Allow users to use their own terminology

Users, with knowledge of any domain can use their own terminology while using the system. The system learns to adapt to this terminology, resulting in a common terminology.

In research related to computational creativity, De Smedt [9] proposes a semantic network of commonsense in order to allow a wide variety of users with various backgrounds to use one common system. Such a system provides the capability of linking computational concepts to, for instance, natural language or a variety of graphical representations.

The language of the system should be tailored to the user group it is targeting. This calls for careful consideration: being too cute can be seen as condescending even by the least technical users – however, even the most commonly used technical terms could be unclear to these users. Clear terms of action should be used – preferably verbs – to describe actions of input and output. Naming should be left flexible – one should be able to edit the title throughout the process.

11. Allow the use of multimodal system input, using body and objects.

The system should provide multimodal interfaces to create (sets of) useful components and projects. Users are not restricted to PC-based applications only. Instead, they are stimulated to make use of their everyday interaction patterns with their body or with objects to provide input.

Physical interactions play a central part in the way humans experience the world, and are obviously a central element of internet-of-things creation as such. [26] The importance of this element is also shown by several hardware prototyping toolkits, such as d.tools [21], which focus on lowering the barrier of physical, interactive prototypes.

During the low-fidelity creation exercise in our research, most participants enhanced or modified an object they already owned. Specifically in the social crafters group, two participants used enhancements as visual features of the products they make. Anke, for instance, creates silver bird-shaped jewelry. Her idea was to use the wings of the bird as physical communication zones that glow or change color depending on several context aspects. Besides that, the need for physical interaction in an IoT world was mentioned several times in the context of interacting with people with a disability.

12. Express and clarify ambiguous situations with the user

By enabling users to create projects and sets of useful components, using their own terminology and interaction patterns, ambiguous situations will rise. In such situations the system should always express the ambiguity to the user, in order to clarify.

This item could be seen as an IoT re-interpretation of Nielsen's usability heuristics with relation to system status. [35] More specifically the heuristics 'Visibility of the system status' and 'Help users to recognize, diagnose and recover from errors'. The major difference is, however, that the item in this manifesto is a consequence of allowing end users to freely use a provided platform, which is not necessarily linked to user interface design on its own.

13. Provide added value for all

Besides the main added value of the system, (the ability to create meaningful experiences by connecting everyday objects via a network), the system should provide added value for all stakeholders. Hence it is necessary to understand the different goals and expectations of all stakeholders in each step of the system. Apart from

monetary value, the system may benefit a larger group or ideal.

As Franke and von Hippel [16] suggest, addressing the average needs of users in major market segments may lead to many users being seriously dissatisfied. In case of DiY IoT creation systems, user needs will be very heterogeneous. To start with, there will be a variety of different types of users in terms of computational levels. In addition, there will be many more types of users in terms of DiY domains. Moreover, in addition to the primary users of DiY IoT systems, there are more stakeholders to be taken into account, such as infrastructure and network owners. Therefore, continuing to perform user research is essential to developing a creation system that pleases each of these user groups.

Overall, the participants in our research got most value out of combining their passion for making, creativity, and the sense of accomplishment, which originates from solving their own problems. This kind of problem solving is mostly aimed at making everyday life easier by managing and optimizing simple things like finding free parking space, managing time, keeping family members safe, etc. More specifically, a comment made by Inge (social crafters group) was that when she started thinking about ideas in an IoT world, they had to serve a larger societal purpose. For instance enabling better communication between patients and doctors or finding you loved ones in an easy way.

APPLICABILITY OF THE MANIFESTO

Initially, the items presented in the manifesto could be interpreted as generic and high level. In order to illustrate their applicability outside of the project they were generated in, we illustrate two manifesto items with an example of how our finding relate to tendencies in ongoing research and internet-of-things creation environments that have recently been launched or are still in development.

Firstly, Manifesto item 4 (Not teach how to program, but should provide an ecosystem to support people in creating ideas, solutions or content) states something several DiY creation systems tend to overlook. In these systems, a starting point is often some form of computational logic. People are requested to make a logical progression of building blocks, which together form a program. An example of this is Scratch (http://scratch.mit.edu/), which provides an easy to learn visual programing language. This works, for a certain audience, but requires a certain computational way of working. Derivative projects like Modkit (http://modk.it/) illustrate that the scratch-like approach opens up programming to a broader audience, but in order to contribute or create people still need to be in a conscious 'digital' mindset. We most certainly do not argue that tools like Scratch lack things, but we do stress that when talking about DiY internet of things creation we need to try to surpass this required 'digital' mindset.

Secondly, related to item number 6 (Be a cradle to cradle system offering playgrounds and recycling belts) we noticed that in DiY projects people often collect lots of random 'things'. For instance, almost all the crafters that participated in our research were avid collectors of materials and artifacts that they did not have a specific use for. At some point in time however, having this collection of 'stuff' was very often a trigger to combine items and materials together in order to create something. This behavior very much relates to what can be observed in the Arduino (http://arduino.cc) community. In this community, people cut and paste bits of code together and create hardware-mashups at the same time (also referred to as sketching in hardware). This approach encourages to work in a slightly chaotic way, the only downside is that most computational systems are less fond of this chaotic approach. Therefore we argue that a DiY internet of things creation system should allow and embody these chaotic ways of working.

DISCUSSION & CONCLUSION

Currently, the notion of internet-of-things runs the risk of developing into a world where people are not in control. To safeguard this, we envision a system enabling every user to create their own meaningful experiences by connecting everyday objects via a network. This paper was written with programmers, engineers, and experts in sensors and actuators in mind. Especially those who would like to contribute to the development of a human-centered internet-of-things world, where people with no to relatively little programming skills are able to create their own smart applications. Thirteen guidelines were formulated in the format of a manifesto to support the development of IoT creation systems for all. With this manifesto, we invite system creators to make the internet-of-things a place where all users are in control and able to create meaningful applications by themselves.

Besides understanding the user point-of-view of IoT applications, the goal of the DiYSE project also was to develop such a do-it-yourself internet-of-things creation system. At the moment of writing, a prototype of this system, called SenseTale (www.sensetale.com) has been developed, which was based on the user research described in this paper. Further research on this prototype has been carried out, but is still in the analysis phase (publication in preparation).

Next to the inspiration and guidance the manifesto has to offer to designers and developers of DiY IoT creation systems, the manifesto has an added value for the research related to such systems as well. As the manifesto targets any type of IoT creation system, its individual guidelines are rather high level. Therefore, it is strongly recommended to perform thorough research into the needs and expectations of the potential users of specific future DiY internet-of-things creation systems, as was also stated in the thirteenth statement. In this respect, the manifesto may

serve as a framework for doing such research. Additionally, the statements listed are relevant outside of an IoT context. Any co-creation platform could benefit from the statements formulated. The statements were, however, constructed based on IoT related research, which is why they are primarily applicable in that area.

Although the work presented in this paper clearly relates to work done on topics such as end user programming and appropriation [11,12,25], the approach taken in the manifesto is different. Where most related work originates from a specific case, the qualitative data analysis to which each manifesto item is anchored, is based on user insights and contextual observations. In this way, the manifesto aims to complement to existing research fields by offering a rich contextual framework to which people might relate to easier.

A few questions related to the practical use of the manifesto presented here still remain. Most importantly, it is not clear yet whether it will be feasible to design a system that matches all of the manifesto's statements. It will be a major challenge to create a system that is accessible for non-technical users whishing to create their own smart environments. However, the manifesto provides a good starting point and a solid framework for this.

In addition, although the manifesto has been highly useful within the context of the DiYSE project, evaluation of its usefulness outside of this project should be further researched. Related to this issue, additional research is needed to validate the manifesto statements on the level of user experience. Although these statements resulted directly from user research, it is not possible yet to evaluate an IoT creation system that applies these statements with users. For example, as was mentioned in the introduction, a core concept of DiY culture is the feeling of belonging to a community. We don't know yet whether a DiY IoT creation system, which was developed in accordance to the manifesto, actually results in such a feeling of connectedness.

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