Thomas Ludwig, Volkmar Pipek (2015):
Sociable Technologies for Supporting End-Users in Handling 3D Printer.
In International Reports on Socio-Informatics (IRSI),
Proceedings of the CHI 2015 - Workshop on End User Development in the Internet of Things Era
(Vol. 12, Iss. 2, pp. 33-38)

Sociable Technologies for Supporting End-Users in Handling 3D Printer

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Abstract. Recently, digital fabrication technologies such as 3D printers have become more and more common at semi- or non-professional settings, such as university or private households. Such technologies show a high complexity and the close link between hardware and software in this field pose challenges for users how to operate them. With this paper we present first steps towards Sociable Technologies, a concept that encompass hardware with an integrated appropriation infrastructure, for supporting end users in using and understanding such rising 3D printing technologies.

1 Introduction

Over the last years, digital fabrication technologies like 3D printers or laser-based cutting machinery could only be found in specialized industrial companies with expert staff trained in modeling, fabricating and finishing professional artifacts and prototypes. But recently, entry level 3D printers such as RepRaps or MakerBots have also become more and more common in various semi- or non-professional settings such as universities, small businesses as well as in the private hobbyist and Maker scene. While professionals had an excellent training in how to use the machinery, semi-as well as non-professionals often struggle with hardware breakdowns, unexpected effects concerning the printing material, unintuitive modeling tools and complex configurations, which often make the handling finicky and difficult to understand. Especially the mix of IT, hardware as well as the material make it almost impossible to adapt established use concepts from existing IT ecologies like desktop software, mobile devices or ‘2D’ printers [3]. In traditional settings, users have found ways to ‘socialize’ these technologies, but handling contemporary 3D printers cannot be compared to the “plug-and-play” operation of common computer hardware [4]. Users often discover and apply ways of using such technologies that were not anticipated by the designers and manufactures of the machinery while operating 3D printers or laser-based cutters by trying to make sense of those ‘new’ technologies in the context of existing (and changing) practices.

End-User Development (EUD) is defined by the goal of developing “methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify or extend a software artifact” (Lieberman et al., 2006). To focus on a successful establishment of software within practice, central concepts of EUD are customization and tailorability, which refer to the change of “stable” aspects of an artifact [2]. The concept of appropriation [6] goes deeper than that of customization or tailoring of software in that it can encompass fundamental changes in practice and embraces the possibility of users adopting and using the technology in ways not anticipated by its designer and therefore enables the discovery and sense making of an artifact while using it in practice.

There is an ongoing discourse in HCI by researchers studying appropriation and related activities as well as how to design technological support for these appropriation activities [1,5]. The integration of so called appropriation infrastructures directly in the information systems which it is intended to support has been thoroughly investigated, tested and seems to have merit [6,7,8]. However, those studies and concepts usually address software ecologies and omit the physical-material issues coming with technologies like 3D printers. Ludwig et al. [3] therefore try to overcome this gap by envisioning the concept of “Sociable Technologies” that aims at supporting users by integrated appropriation infrastructure directly into the machinery itself. They have shown that the ability to articulate and discuss use and configuration issues would benefit from ‘Sociable Technologies’ that describe themselves on three context levels [3]:

1. Internal context: Providing information about the inner workings, about their current state as well as about their component and behavioral structure.
2. Socio-material context: Providing information about the environmental data like location, surroundings, room temperature, maintenance or user/usage data.
3. Task/process context: Providing information about technology used to build/prepare printed models, the machine’s position in a production chain or process, and the purpose and goal of machine usage.

2 Implementation of Sociable Technologies

To establish appropriation infrastructures integrated directly within the machinery itself and therefore getting started with the overall goal of establishing Sociable Technolgies, we focus on enabling end users of 3D printers to understand the machinery as well as its functionality and behavior with regard to its three types of context. A serious shortcoming that became apparent is that the 3D printer itself is a kind of lack box for the users and lacks in methods or functionality to visualize how it works. In order to overcome this issue, we provided the users with more details about the current printing process. Providing the right kind of information allows them to get a deeper understanding of how the machine works and the users can become more aware of what happens when and where.

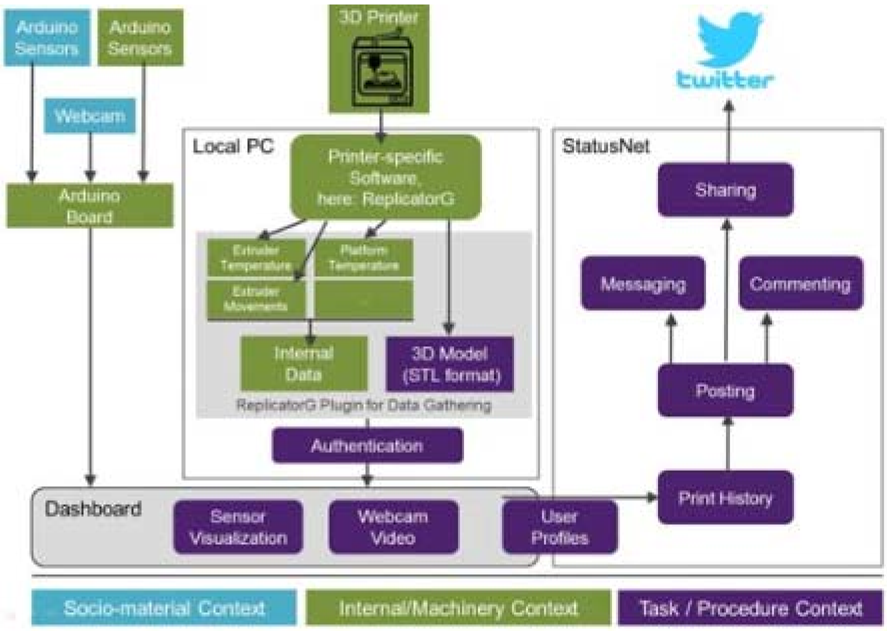

Figure 1: Appropriation Infrastructure for 3D printers

Our concept (Figure 1) encompasses three different steps: (1) a gathering information about the environment as well as the 3D printer itself, (2) a real-time visualizing of all context data about the printer to end users and (3) a storing as well as sharing of details about 3D prints with other end users.

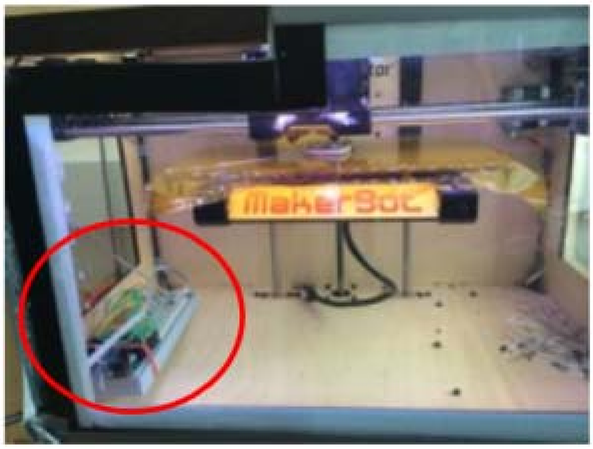

Figure 2: Integrated Arduino Board with different sensor capabilities

To gather information about the socio-material context, we set up an Arduino board with different Arduino sensors for measuring the temperature, brightness, humidity and vibration and integrated it directly within the 3D printer (Figure 2). Further we integrated a webcam that gives details about the progress and the print artifact. By adding those sensors we were able to gather information about the environmental factors of a 3D print. To get insights into the printer's state itself, we implemented a ReplicatorG plugin that sniffs all data of a print process, for instance, the extruder temperature, the platform temperature, the extruder movements or the 3D model in STL format.

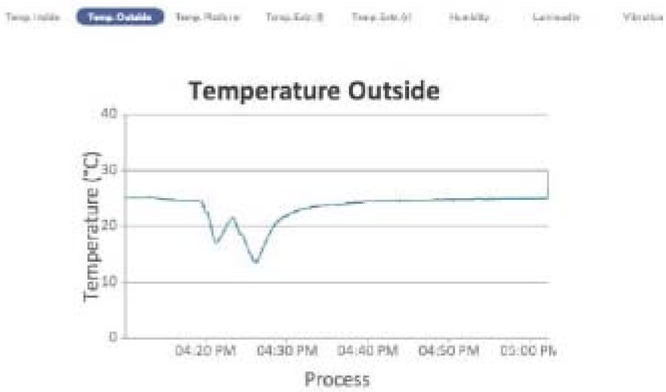

Figure 3: Web-based Dashboard

All the gathered data about the socio-material as well as the internal context of the 3D printer were visualized in real-time on a web-based dashboard (Figure 3). After authentication the users can access the dashboard and see all sensor values, the stream of the webcam and the progress / remaining time of the print. The user has further the option to stop a print if an error occurred.

After a successful or unsuccessful print, the details about the entire process including all sensor data, the configurations as well as 3D models and webcam pictures are stored in a print history. We implemented the print history as part of StatusNet (Figure 4), which is open source microblogging software like Twitter. Within StatusNet all end users have a profile where their prints were saved and published. But not only the user have profiles, the 3D printer itself got also a StatusNet profile. Here, the 3D printer published messages each time after a print process with all details about it.

All users can than comment the different print processes and discuss with other users, which is important for asking for help under the provision of all relevant contextual information, getting support and therefore distributing knowledge and experience to other 3D printer operators. Accordingly, the print histories can be send or post to Twitter where they can reach the appropriate audience and discourse.

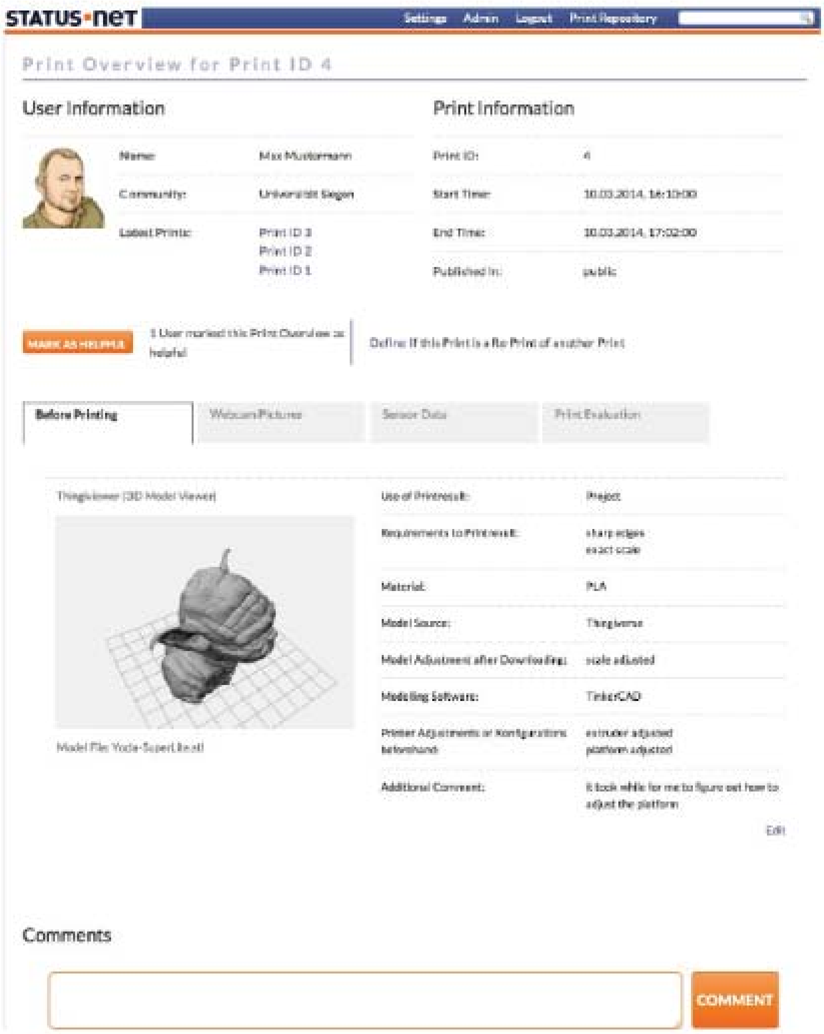

Figure 4: StatusNet (Print Histoy)

3 Outlook

We evaluated our concept of Sociable Technologies for 3D printers (1) technically by testing weather all sensor work appropriately as well as (2) from a usability perspective with four end users coming from the academia field. Concerning its usability especially the documentation and discussion options were praised because now the print settings with regard to the characteristics of a specific model and the can be discussed directly within a situation. As seen in Figure 2 our sensors hardware is not a real integrated part of the 3D printer. As a next step we will therefore build a technology kit that encompasses the presented communication functionalities and can be easily integrated into the building of any machinery to transform it to a Sociable Technology.

4 References

[1] Ehn, P. Participation in design things. Proceedings of the 10th Anniversary Conference on Participatory Design, Indiana University Indianapolis ('08), 92– 101.

[2] Henderson, A. and Kyng, M. There's no place like home: Continuing Design in Use. In J. Greenbaum and M. Kyng, eds., Design at work cooperative design of computer systems. Lawrence Erlbaum Associates, 1991, 219–240.

[3] Ludwig, T., Stickel, O., Boden, A., and Pipek, V. Towards Sociable Technologies: An Empirical Study on Designing Appropriation Infrastructures in Highly Hardware-related Contexts. Proc. of Designing Interactive Systems, Vancouver, Canada (2014).

[4] Ludwig, T., Stickel, O., Boden, A., and Pipek, V. Appropriating Digital Fabrication Technologies – A comparative study of two 3D Printing Communities. iConference 2015, Newport Beach, California, USA (2015).

[5] Pipek, V. and Wulf, V. Infrastructuring: Towards an Integrated Perspective on the Design and Use of Information Technology. Journal of the Association for Information Systems 10, 5 (2009), 447–473.

[6] Pipek, V. From Tailoring to Appropriation Support: Negotiating Groupware Usage. Processing, 2005.

[7] Stevens, G., Pipek, V., and Wulf, V. Appropriation Infrastructure: Supporting the Design of Usages. Proceedings of the 2nd International Symposium on End-User Development, (2009), 50–69.

[8] Yetim, F., Draxler, S., Stevens, G., and Wulf, V. Fostering Continuous User Participation by Embedding a Communication Support Tool in User Interfaces. AIS Transactions on Human-Computer Interaction 4, 2 (2012), 153–168.