Design Thinking Applied to Data Storage Innovation: A Case Study

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Abstract: This paper presents part of a larger study that seeks to investigate the potential of the Design Thinking (DT) approach when applied to innovation processes especially on product and service development in the ICT industry. In particular, the DT approach is applied to the case study of a backup and storage service as a distributed, fog-computing infrastructure. Its functionality is based on sharing the available disk storage of personal and organizational devices.

The case study presents the process of applying the DT approach and the way this can contribute not just to improve the solution in terms of customer desirability and market viability, but also the collaborative way of current technological design process. In particular, the DT approach, apparently hard, fuzzy and time consuming during the initial steps of the design process, proved successful in studying the relationship between the value propositions and the target clients of the innovative data storage service.

A first co-design session helped to understand that the most important features enabled by the fog-computing paradigm, such as data security and privacy could be more valuable for a corporate context; thus the proposed solution shifted to a Business-to-Business (B2B) model. Other co-design sessions helped better understanding the service value proposition and final users.

Keywords: Design Thinking; Design Process; Data Storage Innovation

1. Introduction

Historically, the design activity considered one of the last steps in an innovation or product development process; a down-stream activity focused on improving the appeal of a product just prior to launch to the market.

Today, however, more and more organizations are pulling the design activity further upstream, applying Design Thinking (DT), as a way to employ the designers’ skills, toolkits and also mindsets (Cross, Dorst and Roozenburg, 1992, Johansson and Woodilla, 2009) to help create solutions to complex problems or to build processes and systems able to optimize the outcomes (Shannon et al., 2015). Design thinking is an interdisciplinary, participative and human-centered approach. It seeks to involve all stakeholders affected by the product or service, since the early stages of design process.
Furthermore, it emphasizes the iteration way of problem solving instead of the linear way. It allows finding the solution in diverse fields of application, especially where there is a complex problem. By gathering information from potential users, stakeholders and the field studies, project team iteratively change and improve a product or a service. Doing so by using different tools and methods such as co-design sessions, customer journey, stakeholder mapping, field studies, survey, interviews, market analysis and many others throughout the DT process.

The objective of this paper is to present the application of the DT methodology to design and develop an innovative data storage service. In particular, here we present a project, which has been conducted at TIM Joint Open Lab, in collaboration with ISMB.

Although the case study, originated from a technology-push approach – which stands for designing products for the existing technology – we applied DT, in order to challenge and modify the existing design approach towards a human-centered approach – which stands for designing with technology, or design of technology.

In particular, the new data storage service is enabled by fog-computing. The Fog-computing paradigm, which inspires from the collaborative economy principles, is a decentralized computing infrastructure, which permits to share available and idle computing resources within a network of connected devices. Collaborative or sharing economy helps to create a sustainable value chain among different stakeholders, saving costs and reduce the environmental impacts (Puschmann & Alt, 2016, Botsman & Roos, 2011). In collaborative economy the focus shifts from offering a stand-alone product, to creating services that enable people to make the most of the resources around them. Fog Computing can enable the collaborative economy through sharing the distributed and available computing resources among different devices and clients.

In fact, fog computing is becoming a promising technology for data storage. This new technology proves to be more efficient compared to cloud computing as long as it reduces the amount of data moved to the cloud in order to process, analyze and store. Although fog computing is often used to increase data storage efficiency, it can also enhance data security and privacy thanks to data encryption.

The paper is structured as follows. After a brief introduction to the Design Thinking methodology, we present the existing method already applied to the technological design process in Swarm Joint Open Lab. Then the new methodological approach, which is inspired by DT will be presented and finally, we present and discuss the main results and track future research steps.

2. Background

Design Thinking approach in literature has been defined both as a fuzzy, and analytical process for problem solving in business, learning, health and organizational contexts among others. However, there seems to be a common point of view with respect to Design Thinking as a process applicable to the involvement of both analytical and experimental studies (Simon, 1969, Rylander 2009). The Design Thinking can provide a powerful way to interact (Teal, 2010) and may even go beyond the limits of imagination and overcome innovation barriers (Buchanan, 1992).

DT as a process in literature has been defined as an iterative, collaborative and human-centered process. It contains usually four essential phases during the process: empathizing with end-user,

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defining needs and problems, ideate and build solutions and iterate to test and improve the solution (Brown, 2009).

Empathizing with end-user in particular, helps designer and developers to fully understand and define the end-users’ needs and problems. The designer’s perception regarding user’s needs and its requirements helps to develop effective alternative solutions. Thus, designers manage different group of people in order to define and identify the alternative means to address needs and to achieve the expected results. Finally, the process enters in an iterative prototyping and testing phase in which different concepts will put into action (Roberts et al., 2015). The key element of DT approach prescribes a human-centered and collaborative way of addressing a problem by taking “people first” (Erzurumlu and Erzurumlu, 2015). In this way, mostly all stakeholders are involved and so able to take into account all relevant aspects that could inspire and improve (Brown and Wyatt, 2010). This approach sometime is based on four crucial questions namely: What is? What if? What wows? And what works? (Liedtka, King and Bennett, 2013). Each question explores a different stage of the DT process.

‘What is’ explores and examines the current situation or the state of the problem, also concerns about a detailed and in depth exploration of all internal and external factors that might have caused it. This phase considers the factors that caused the problem in a very broad context, rather that just focusing on the close context. ‘What if’ analyzes and applies the lessons learnt during the first stage to diverge to as many alternatives as possible and consequently to converge to the definition of achievable solutions. ‘What wows’ supports managers in the choice of what has been selected in the previous stage according to the market viability and technological feasibility of the solution. In the ‘What works’ stage, team create prototypes and test them with the real users of the selected solution (Liedtka, 2014).

DT uses particular tools to support the collaborative and iterative nature of the process such as co-creation, user-journey and field studies. During the whole process it also uses visualization methods such as drawings, diagrams, sketches, video clips, and photos in order to create a responsive environment able to generate empathy and creativity among the team members (Halloway, 2009).

The DT application is more helpful and advantageous during the early stages in an innovation process, whereas problems are not well defined yet. It is becoming more and more appealing because it brings the design to its essence, it is able to bridge the gap between theoretical knowledge and practice in design, promote comprehensive and collaborative ways of thinking and it is applicable in many disciplines such as management, operation research, social innovation, logistics, etc. (Katoppo and Sudradjat, 2015). The unique nature of DT as a collaborative, creative, and human-centered instead of technology-centered methodology has a huge potential within business organizations. It supports them as they face challenges and complex problems and it is able to bring intrinsic values to enhance organizational life (Shannon et al., 2015, Clark and Smith, 2008). Design Thinking as a powerful tool to transform business and organizations has been the subject of many researches. As companies grow in number of employees and projects, they require more effective problem solving methods able to tackle the complex and unknown problems (e.g. Brown, 2009; Martin, 2009; Lockwood, 2010; Cross, 2011; Liedtka & Ogilvie, 2011). Some large sized companies such as IBM and GE have already realized that although the software development is a fundamental part of their businesses; they also need to manage the extraordinary levels of complexity that it might bring. As long as DT is an essential tool for simplifying and humanizing, thus they have realized that it can’t be an extra in organization rather it needs to be a core competence (Kolko, 2015). DT can be used to innovate and solve problems across many professions, and this brought design process
itself into significant conversations and decisions that shape the collective future in the business world (Clark and Smith, 2008).

In particular DT has become appealing for business innovation in organizations, taking inspiration from the way designers work to broaden their repertoire of strategies for addressing the complex and open-ended challenges (Martin, 2009).

3. A Case Study

3.1 The Current Design Process

To understand the current state of design process, we first conducted a series of interviews with three main open-ended questions among six professionals who are currently involved in different stages of the design process in Swarm Join Open Lab. Our sample consists of a Telecommunication engineer (male, 39 YO), a computer scientist (male, 43 YO), a software engineer (male, 42 YO), two psychologist and user experience specialists (UX) (female, 33 and 31 YO), and a junior graphic designer (female 25 YO).

On the basis of the results of the analysis of the interviews, it is evident that the design process mainly consists of six phases. First, they receive a brief, requesting the development of a new technology, and then the technical team develops the new technology on the basis of available resources. Then, a concept idea will be generated, principally through running short brainstorming sessions among the technical team members.

At that point, the team develops a demo or proof of concept and then test it along with user study specialists and end-users. To this aim, a user study consultant team, run questionnaire and usability tests, in order to understand not only the technical functionality, but also the efficiency and performance of the demo. The demo then will be again tested through running a field trial testing and validation. This step consists of testing the demo among a group of pilot users in a real context, which could vary from home environment to work spaces, depending on the target context of the project.

After testing the concept, on the basis of the received feedbacks from end-users or trial users, the demo will be improved and refined and again tested through an iterative process loop. When the concept is ready in terms of the functionality and usability, the process can continue in two distinctive and sometime parallel directions: whether to submit the product as a patent if it is eligible, or follows by the conduction of the market and deeper end user analysis. Joint Open Lab does not usually conduct this phase, and it consists of conducting further questionnaires and focus groups in order to understand how this new technology can facilitate the design of a new service or product.

Then, if applicable, they go through business modeling and planning. The focus groups in particular serve for understanding and testing the feasibility of the potential service or product among homogeneous experienced professional group who have expertise in a particular field related to the service or product prior to lunch to the market. (Figure 1)

3.2 The Design Thinking Process

Although the solutions ideated previously were technologically innovative and mostly patent eligible, they face some problems regarding the product’s desirability among people and the market viability.
As an attempt to overcome these difficulties, we involved not only the end users, but also the designers in the project team since the early stages of design process.

As an experiment to improve the design process, the DT approach has been applied to a new project, which develops a distributed data storage service based on fog-computing technologies.

We have started the project with a first hypothesis, assuming that people are concerned mostly about the privacy of their personal data, when they choose to use a new data storage service. Therefore, users would be interested to adopt an innovative technological service, which addresses this issue. In order to validate this first hypothesis, the DT process and steps have been set within an interdisciplinary group consisting of technical staff and a design researcher. The DT process applied to this project consists of seven main phases (Figure 2).

I) To empathize with people who are mostly affected by the service: we did this through two co-design sessions, the first one has been conducted among end-users who had previously answered to a very short questionnaire on their habits regarding the frequency and quality of data storage service usage; the second co-design session has been conducted among IT managers of five big companies and institutions;

II) To analyze user needs and to define suitable service value propositions. User needs and service value propositions have been defined mostly through designing a business model, using Business Model Canvas and Value Proposition Design tools, based on the most important value propositions emerged mostly from the second co-design session (Osterwalder and Pigneur, 2010, Osterwalder, et. al., 2014);

III) To conduct a market analysis, by exploring the current services, which are already available in the market, understanding their value propositions, target clients and the service specifications;

IV) To ideate alternative solutions, to evaluate the solutions and to select the most feasible, viable and desirable alternative, doing this through another co-design session, involving designers, technical team and marketing specialists.

V) Prototyping the selected solution;

VI) To conduct field tests with pilot-users;

VII) Submit a patent, if eligible, and/or launch to the market.
3.3 The first co-design session with end-users

A multidisciplinary group has been created to follow this project, involving people from Joint Open Lab. The group consists of telecommunication, software and management engineers, a design researcher, a graphic designer, mathematicians and operation researchers.

Soon after the group formed, a co-design session has been conducted among twenty heterogeneous participants. The main objective of this session was to uncover underlying needs and issues regarding usage of data storage service. Prior to the session, participants had answered a short survey about their habits regarding the usage of a sample of existing data storage services. The sample consists of nine women and eleven men (Male: 55%, Female: 45%), who mostly use Google Drive and Dropbox as free data storage services (84%). They wish to have a data storage service, which is free of charge and apparently those services can meet this particular need (84%). Most of them use and log into the data storage services through personal computers applications (92%), through mobile devices applications (63%) or through logging in through the service website directly (60%).

Along with the questionnaire, a brief had been also emailed to the potential participants, explaining the purpose of the co-design session and the key design concepts (e.g. taking advantage of the increased capability of data storage thanks to the resources which are distributed among different devices connected to the Internet, etc.).

The co-design session comprised of five main divergent and convergent steps as follows: empathize, define, ideate, iterate and conclusion, which are the main phases of the design thinking process (Plattner, Meinel, Leifer, 2010).

The main objective of this workshop was to understand better users’ concerns, problems and needs regarding data storage services, even though, participants have been also encouraged to participate for service concepts ideation.

Participants have been distributed in 10 couples in total of 20 participants (Figure 3, 4, 5). In particular, this sample has been selected from Politecnico di Torino’s students (Undergraduate and graduate levels) and Joint Open Labs’ and Mario Boella Institute’s employees.
The session took long about two hours, including two short presentations regarding the project objectives and the brief. Three researchers observed and facilitated the process during the whole session. Participants during each step had a limited time to complete a particular assignment. The process involved both individual and in team working, depending on the objective and the nature of the phase. The individual works mostly concerned about the reflection, observation and decision-making, while the task conducted in team, concerned about the evaluation, correspondence and comparison. A more detailed description of the five phases of the session is brought in Table 1.

**Table 1: co-design session phases: detailed description**

| Phases    | What (process) | How (tasks)                | Why (purpose)                          | Duration (minutes) |
|-----------|----------------|---------------------------|----------------------------------------|--------------------|
| I) Empathise | Diverge        | Interview-writing         | Understanding: User-experience         | 16                 |
| II) Define | Converge (De-briefing) | Observing-Writing | Reflecting: Issues, needs and desires | 12                 |
| III) Ideate  | Diverge        | Sketching, visualizing    | Finding solutions                      | 12                 |
| IV) Iterate | Converge (Decision making) | Interview-writing       | Choosing the best solution; Proofing the idea | 5                  |
| V) Conclude  | Converge (Decision making) | Writing                  | Reflecting, Choosing: enabler technology Cloud or Fog computing? | 2                  |

**3.4 Result of the first co-design session**

After analyzing the output of the session, we have identified six main categories of user needs, which have been emerged during the first phase and interviews.
The user needs categories are mainly related to: 1) access and login procedures to the data storage service; 2) collaborative activities; 3) actions required for sharing files among collaborators; 4) the software performance and the degree of data security and privacy. We categorized these needs in two distinguished interactional levels. While the first level concerns about the issues that occur while user and service interact (Level 01: User-Service Interaction), the second level concerns about the issues occurring while user, service and the network (collaborators) interact together (Level 02: User – Service – Network Interaction). (Table 2)
The results of the first co-design session showed that data security and data privacy, which are the most important features, enabled by the fog-computing paradigm, could be more valuable for big companies rather than end-consumers. However, the result of the first co-design session will be applied on the design of the data storage service, we made the second hypothesis and we shifted the business model from business to consumer (B2C) to the business to business (B2B).

Table 2: the six categories of needs in two levels of interaction

| Category               | Needs                      |
|------------------------|----------------------------|
| I) Login/Access        | Simplicity                 |
|                        | Duration login             |
|                        | Direct access              |
| II) Performance        | Synch                      |
|                        | Upload                     |
| III) Security          | Data privacy               |
| IV) Storage            | Back-up                    |
|                        | Free space                 |
| I) Collaboration       | Conflict management        |
|                        | Editing simultaneously     |
|                        | Organizing                 |
|                        | Communicating              |
| II) Sharing            | Preventing errors          |

3.5 The second co-design session with IT-managers

In order to identify the big companies’ requirements and then define the service specifications, another co-design session with IT managers of big public and private companies and institutions has been held (Figure 6). As far as the number of available devices able to connect to the Internet concerns, each company owns more than 4,000 personal computers, both laptops and desktop computers, employees often use also smartphones and tablets. The preliminary questions associated with the current situation, highlight that the solution selected for the back up of the data exploits servers and it offers more than 100 GB. This solution is generally described as easy to use, safe, and quick. The amount of space available usually has been considered as “not enough”. Therefore, according to calculation of the total available data storage (PCs, smartphones, tablets), this new service is able to offer more space to share files and documents without creating congestion and impacting negatively the speed of the system. In addition, the privacy and the security are always guaranteed thanks to the data encryption enabled by fog-computing paradigm.
3.6 Results of the second co-design session with IT managers

The analysis of the second co-design workshop showed, IT managers are principally satisfied with their current data storage service in terms of efficiency and effectiveness. Despite it shows that current services mostly address the company’s requirements, they are willing to test and if necessary, adopt the new data storage service if only it can offer values in terms of real cost saving, the increase of available space, data privacy and environmental sustainability.

![Figure 6: the 2nd co-design workshop: participants discuss about the most important values that service could offer, choosing among value proposition cards.](image)

4. Market research: data storage services

The market analysis involved seventeen main companies that offer data storage services with different related features and different business models - i.e. Business to Customer (B2C), Business to Business (B2B), or both (B2B2C).

Each company has been analyzed through an evaluation sheet. This sheet takes into account the value proposition, the type of service that is offered, the key resources, the functionalities of the service, the eventual external financing and the price.

Each service’s value proposition refers to a specific customer or business segment. The type of service is closely related to the technology used for developing and managing the service, the key resources represent the resources, in terms of materials, staff, and other assets required to develop, advertise and sell the service. The service functionalities represent the features offered by the service that address the customer’s needs. The external financing considers eventual external financial resources such as venture capital, and the pricing strategies shows the different services packages, which are offered by the company.

Currently all companies under examination, offer data storage services based on Cloud-Computing or local servers.

The most important service features are the possibility to create multiple accounts; the management of multiple devices and along with a customer care assistance service. The price often depends on
the service package and the customer requirements, thus it can be adapted and personalised according to the specific customer need.

This short market analysis proved that data storage services available in market run on Cloud-Computing technology mostly, and the most important value that they offer is the data privacy and the extra free space, which they seek constantly to improve.

5. Conclusion and future steps

The case study presented throughout this work illustrated the process of the Design Thinking methodological approach applied to an innovative data storage service up to the market analysis stage. Another four steps will follow in order to ideate and improve the technological features and the business model before launching to the market (Figure 2). In particular, this experiment, has shown that the DT approach, even apparently time consuming and blurry during the initial steps of the design process, it proved successful in studying the relationship between the value proposition and the target clients of the service. In fact, the two co-design workshops helped to pivoting and iterating in order to find out the real service’s value propositions for people who will use it. It was also helpful in understanding of why people might use it and even if really people want or need those kind of services.

The application of DT methodological approach itself faced some difficulties. This was mostly due to the lack of previous attempts and experiences regarding application of this approach. Other factors such as organizational constraints and limitations of the resources caused also frustration moments. This experiment is an example, where for the first times involves designer as a professional practitioner since the very early phases of technological design process, yet proved difficulties and uncertainty to understand the leadership role of design. For instance, technical team members could not understand what is the role of the designer, who is a professional figure that works on the aesthetical aspects of a product. User Experience specialists, on the other hand could not accept the role of the designer in studying the user needs. In short why a designer that shapes the forms of the ultimate product, should be involved since the early stages of technological process, when the product idea is not still clearly defined. Other issues were for instance the difficulty to communicate in an interdisciplinary context where has been for many years dominated by people from technical backgrounds.

In some points, during the process, the DT method seemed as a vague, blurry and very broad approach, however the collaborative and human centered nature of this method has been appreciated among technical team members. In fact, the whole DT process comprised regular moments of collective thinking and decision making. Those moments helped to improve the product constantly, to anticipate the needs for further development. They also improved the communication process among interdisciplinary team members in general and more particularly they helped to develop a “common language” with which team members increasingly improved the way they communicate to each other.

This work can contribute to the future studies regarding not only the application of the DT methodology on digital service innovation but also the way, through which it might improve the collaborative process of design. In fact, this process showed an effective way to involve actively the collaborators from different disciplines who had not been before able to work together. However, in order to validate the collaborative fashion of DT approach, and the way this approach have fostered the collaboration and participation among team members, further analysis is needed and it can be conducted through empirical and field studies upon the project has been completed.
References

Botsman, R. and Roger, R. (2011). What’s Mine Is Yours: How Collaborative Consumption is Changing the Way We Live. HarperCollins Business.

Brown, T. and Wyatt, J. (2010). Design thinking for social innovation, Stanford Social Innovation Review, Vol. 8 No.1, pp. 30-35.

Buchanan, R. (1998). The Study of Design: Doctoral Education and Research in a New Field of Inquiry. Doctoral Education in Design: Proceedings of the Ohio Conference, October 8-11, 1998, (1998).

Clark K. and Smith R. (2008), Unleashing the Power of Design Thinking, Design Management Review.

Cross, N., Dorst, K., and Roozenburg, N. (1992). Preface to Research in Design Thinking. In N. Cross, N., Dorst, K., Roozenburg, ed., Research in Design Thinking. Delft University Press, Delft.

Erzurumlu, S.S. and Erzurumlu, Y.O. (2015). Sustainable mining development with community using design thinking and multi-criteria decision analysis, Resources Policy, Vol. 46 No. 1, pp.6-14.

Halloway, M. (2009). How tangible is your strategy? How design thinking can turn your strategy into reality? Journal of Business Strategy, Vol. 30 N.2/3, pp. 50-56.

Johansson, U. and Woodilla, J. (2009). Towards and epistemological merger of design thinking, strategy and innovation. In the proceedings of 8th European Academy of Design Conference.

Katoppo, M.L. and Sudradijat, I. (2015). Combining Participatory Action Research (PAR) and Design Thinking (DT) as alternative research method in architecture, Procedia – Social and Behavioral Sciences, Vol. 184 No. 20, pp. 118-125.

Kolko J. (2015). Design Thinking Comes of Age, Harvard Business Review, September Issue.

Liedtka, J. (2014). Innovative ways companies are using design thinking, Strategy & Leadership, Vol. 42 No.2, pp. 40-45.

Lindberg, T., Gumienny, R., Jobst, B., and Meinel, C. (2010). Is There a Need for a Design Thinking Process? Design Thinking Research Symposium 8.

Martin, R., (2009), The design of business. Cambridge MA: Harvard Business Press.

Norman, D.A. (2013). The Design of Everyday Things, Revised and Expanded Edition. MIT Press, London.

Plattner H., Meinel C., Leifer L. (2010). Design Thinking: Understand, Improve, Apply. Springer

Puschmann, T., Alt, R. (2016). Sharing Economy, in: Business & Information Systems Engineering, 58, 1, pp. 93-99

Roberts, J. P., Fisher, T.R., Trowbridge, M.J. and Bent, C. (2015). A design thinking framework for healthcare management and innovation, Healthcare.

Shannon, E. Connell, F. and Tenkasi, R.V. (2015). Operational practices and archetypes of design thinking, Research in Organizational Change and Development, Vol.23, pp. 195-252.

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