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Jung, Jiwon; Kleinsmann, Maaike; Snelders, H.M.J.J.

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Jung, Jiwon *; Kleinsmann, Maaike ; Snelders, Dirk

Faculty of Industrial Design Engineering, Delft University of Technology, Delft, the Netherlands
* j.jung-1@tudelft.nl

This paper aims to envision design activities –design task, design process, and designer– for the collective computing era, an upcoming dominance of applications where many people interact with each other through many computing devices (Abowd, 2016). To achieve this aim, the typical design activities over the last two computing eras, personal and ubiquitous, are studied through a literature review. Based on the activities shift discovered there, new design activities for collective computing are envisioned. This study urges designers to change the way to work with user-data: from referring the small but in-depth ethnographical user-centered living-lab data (during the ubiquitous computing era), to create an understanding about both the individual user and the society or crowd as a whole (collective computing era). These different types of data provide designers with a rich understanding on the users in their contexts, both as individual and community levels. Also, the design process that authors envision is a process of co-exploration (merge of problem exploration and solution delivery), and co-evolution (the constant reflection back and forth with exchange of information) of design problem and solution spaces. Moreover, the designers in collective computing era have to take ethical and privacy issues into account. They have to create plans for dealing with the uncontrollability of the data generated and uncertainty about the social impact of the design that come with it. This research can trigger the designers to innovate and remodel their work at the forefront of new computing technologies.

Keywords: envisioning new design activity; reviewing design movement; modern computer development; collective computing;

1   Introduction

When Bayazit reviewed the last forty years of design research, she mentions that there is 'a close relationship between design research and the development in the IT field' (Bayazit, 2004). As an illustration of this, Dubberly noted that networked computers have changed what designers make and the ways designers think (Dubberly, 2008). What both argue is that design activities evolve in a relation to developments in modern computing, where the first generation were mainframes; the second personal computers; and the third defined by ubiquitous computing (Pew, 2002; Want, 2010). For the future, a fourth generation has been

proposed as 'collective computing' (Abowd, 2012, 2016). Since designers have played increasingly active roles in bringing about the previous eras in modern computing, authors believe that the role of design is now likely to change again with the advent of the coming era of collective computing.

The goal of this paper is to envision the new design activities – design task, design process, and designer – for the upcoming era of collective computing, defined by a shift towards multiple interactions between many users, occurring through many computers (Abowd, 2016). In order to achieve this goal, authors first provide a literature review of how design activities have been executed in a relation to the current and past eras of modern computing, focusing on personal and ubiquitous computing. Based on this review, authors then create a vision, future design activities, for the upcoming collective computing era. This vision is presented in a framework (Figure 1) that compares past, current, and future design activities in a relation to developments in modern computing.

The envisioned design task in collective computing era is to design (for) an ever-evolving complex system. User studies are still needed to tackle this complexity, but these can now be done through the integration of community and individual levels of user data. The envisioned design process is co-exploration and co-evolution with changeable problem and solution spaces, due to the real-time-contextual data collection and solution delivery. In addition, designers are envisioned to be attentive on ethical and legal (privacy) issues by considering a governance structure at the societal level to help prevent uncontrollable misuse of data.

This paper provides designers the practical and explicit action points to start designing specifically for collective computing. Thus, this study triggers the designers to innovate and remodel their work at the forefront of new computing technologies.

2 The Framework Development: Design Activities in a relation to Modern Computer Development
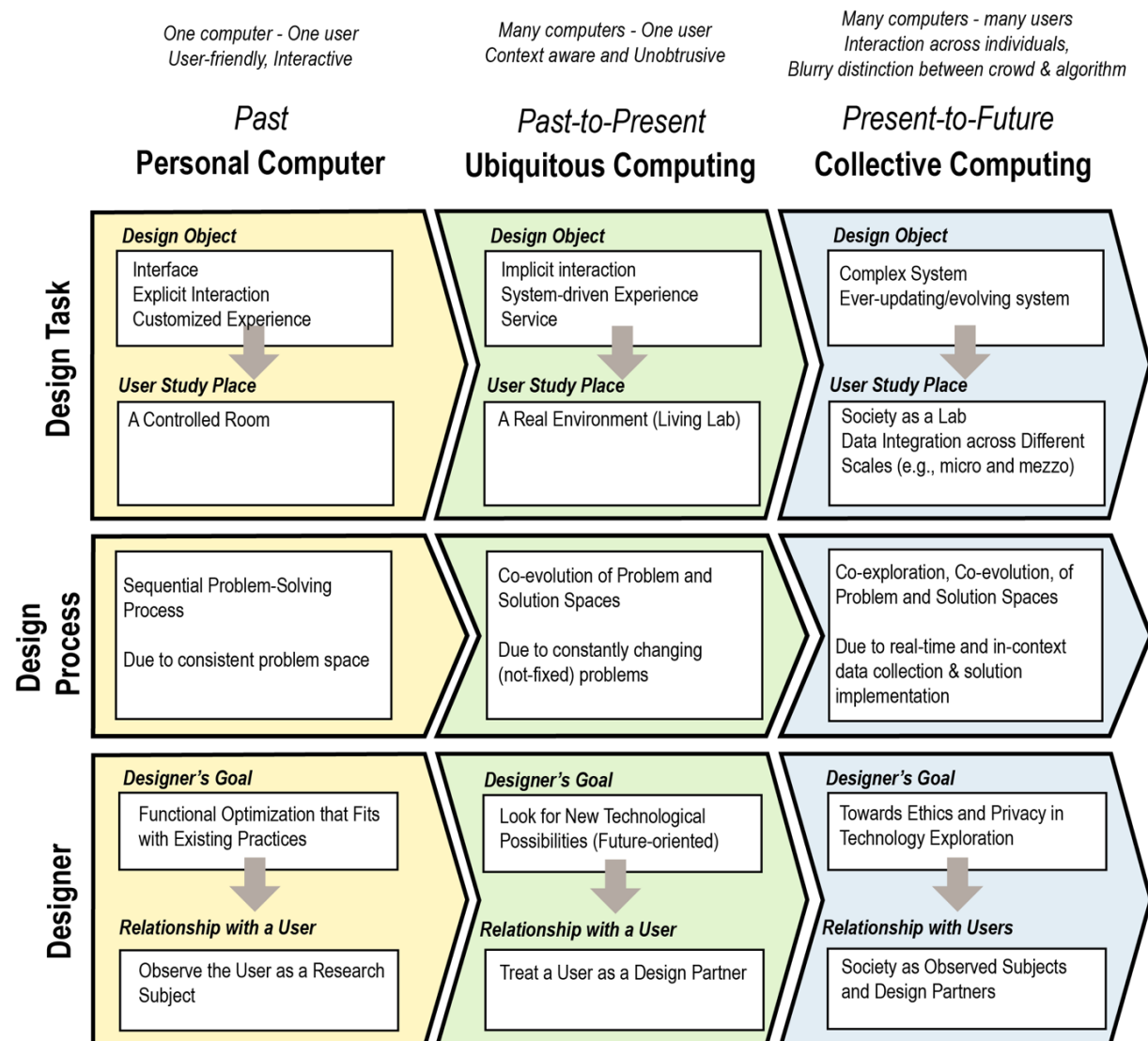

Figure 1. Framework describing Design Activity Changes in a relation to Modern Computer Development

The horizontal axis of the framework distinguishes three computing generations derived from Weiser (Weiser, 1991), and Abowd (Abowd, 2012, 2016): (1) personal computer era (past), (2) ubiquitous computing era (past-to-present), and (3) collective computing era (present-to-future). Although the literature starts with an earlier mainframe era, we excluded it from the framework, because designers were not that much involved in, and influenced by developments of mainframe computers. The vertical axis lists three groups of design activities -design task, design process and designer- which are based on Dorst's argument on the nature of design methods and techniques (Dorst, 1997). According to Dorst, the basic elements of design methodologies are not only design processes, but also design activities that include dimensions of design task and designer.
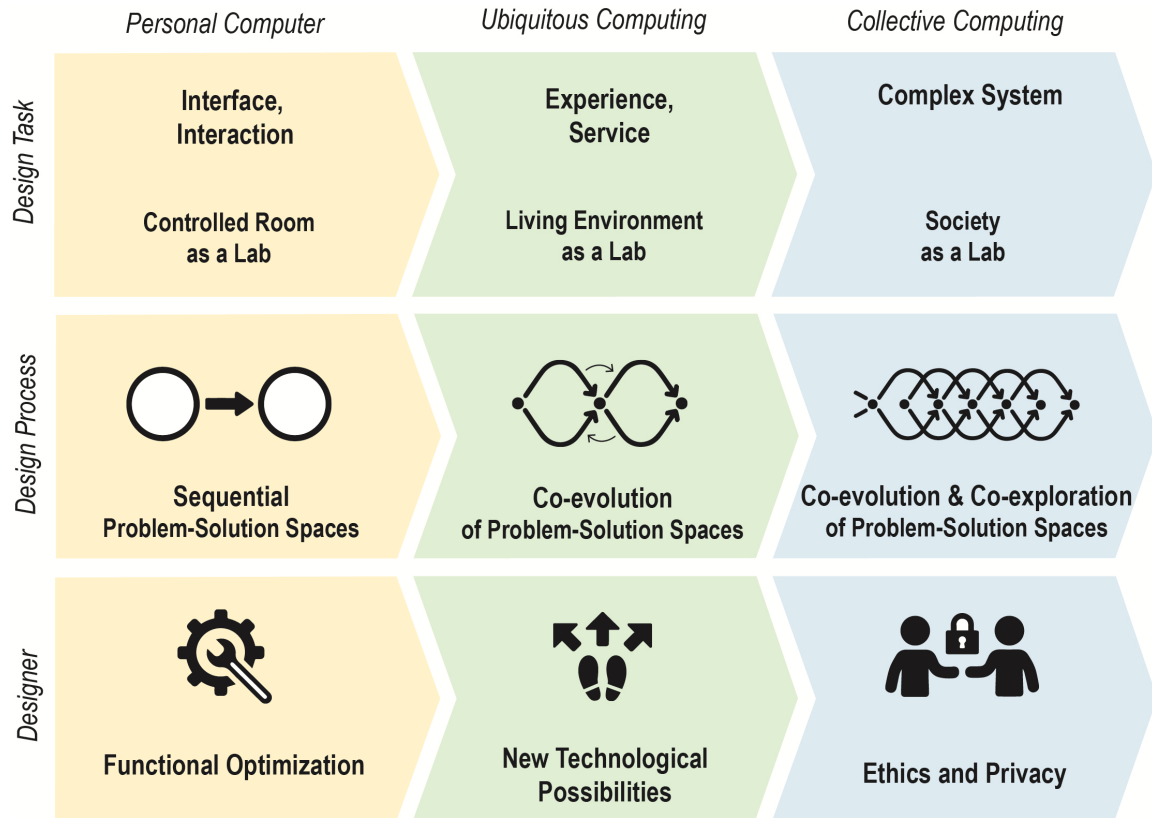
	Personal Computer	Ubiquitous Computing	Collective Computing
Design Task	Interface, Interaction — Controlled Room as a Lab	Experience, Service — Living Environment as a Lab	Complex System — Society as a Lab
Design Process	Sequential Problem-Solution Spaces	Co-evolution of Problem-Solution Spaces	Co-evolution & Co-exploration of Problem-Solution Spaces
Designer	Functional Optimization	New Technological Possibilities	Ethics and Privacy

Figure 2. Framework describing Design Activity Changes   in a relation to Modern Computer Development, Simplified Version

3   Past: Personal Computer

3.1   Brief Product Characteristics of Personal Computer

This brief explanation about personal computer (PC) era is based on the historical reviews of Human Computer Interaction evolution by Pew, and Grudin (Grudin, 2008; Pew, 2002). The PC era started in the beginning of the 1980s as a result of two technological developments. First, companies started introducing less expensive but highly capable mini computers on the consumer market. Examples are the IBM PC 5150 in 1981, Xerox Star 8010 in 1981, and Apple Lisa in 1983. Second, the public commercial Internet was released in 1989. With these technological aspects, not only programmers, but also everyday people started to use the computers for work efficiency and entertainment. The release of the Internet also brought various Internet-applications such as instant-messaging, music players, and weblog tools. Also, asynchronous and distant communication, such as online discussion and email, became mundane.

As a consequence of the everyday use of PCs, there was a need for user friendly computers. This is because the everyday users had little to no formal training in the use of PCs. Therefore, the structure and flow of the computer system interface had to be intuitive so that users would not feel frustrated or confused when using PCs (Grudin, 2008; Pew, 2002). A PCs superiority in user-friendliness and intuitiveness became the key selling point for all computer vendors. Moreover, users no longer had full control over computers as they had had with mainframes. Instead, they interacted with the computers through an affluence of software and Internet applications (Ritter, Baxter, & Churchill, 2014).

3.2 Design Task

Design Object: Interface, Explicit Interaction, Customized Experience. During the PC era, it became more and more important for companies to compete on the user-friendliness of their products (Grudin, 2008; Pew, 2002). This created possibilities for designers, since they were known for considering human factors during their (product) design works (Löwgren, 1995; Pew, 2002; Shneiderman, 1980; Winograd, 1996). The role of designers was also amplified through the increased importance of Graphical User Interfaces (Burns, Cottam, Vanstone, & Winhall, 2006; Winograd, 1996). Consequently, designers were equipped with the design of graphical interfaces (e.g., icon or web interface), explicit human-computer-interactions (e.g., natural usage of menu selection), and customization-based experience (e.g., providing an option to change the interface color, based on personal preference).

The designer's attention further widened to the people's interaction with PC or Internet applications (March, 1994; Zimmerman, Forlizzi, & Evenson, 2007). During the PC era, companies such as Intel, Thomson Consumer Electronics, and Apple changed their view on usability by paying more attention to the user experience. Design for experience included both 'how logical and natural a product is to use?' and 'how people feel about using it?' (March, 1994). In 1996, at the COMDEX computer trade show, an Intel chairman mentioned for example that 'Intel is not a company simply selling personal computers but now it is the business of delivering information and interactive experiences'(Pine II & Gilmore, 1998). Some software functions at that time could be customized by users according to their preferences and needs, such as creating shortcut icons, and changing the color of the interface (Lee, 2013).

The role of designers in the PC era expanded substantially with the release of the Internet (Grudin, 2008; Pew, 2002; Ritter et al., 2014). This is because the design and architecture of webpages or software applications were directly related to information retrieval time. Internet applications such as World Wide Web (www), email, and online games created a lot of attention from users, because it changed entirely the ways users work, communicate, and entertain themselves. This created new interaction and experience design opportunities considering the user psychology in building computer design (Winograd, 1996). As a result, in the mid-1990s, designers took over the most roles of software design from the software programmers because the designers created the interfaces in more imaginative and innovative ways (Abowd, 2012).

User Study Place: A Controlled Room The designers of PC conducted their user exploration mostly in a controlled room, so called laboratory format (Hughes, King, Rodden, & Andersen, 1994; Rogers, 2011). The controlled room format was appropriate for conducting user studies of design interface and explicit interactions. This is because the design areas dealt with certain moments in computer usage, such as the moment of finding menu button on screen (Mayhew, 1999). The lab format kept users from being distracted or from anything else that could confound the user testing results (e.g., family assistance, etc.) (Rogers, 2011). This approach allowed designers to achieve their goal of functional optimization with objective, numerical results.

3.3 Design Process

Sequential Problem-Solving Process A dominant view of the design process in product and software design is 'the design as a problem-solving process' (Lawson & Dorst, 2013;

Shneiderman, 1980; Simon, 1988).   Problem and solution spaces in the design process were seen as independent and could therefore be handled sequentially. A likely reason for this is that the problem space in PC design was often already defined and formulated by software developers, as a form of user-requirements (Burns et al., 2006; Pew, 2002). Thus, from the start of design process onwards, designers often were already dealing with relatively well-defined and consistent design problems, which were often about usability efficiency (Jokela, Iivari, Matero, & Karukka, 2003). On the basis of this, the designers often provided solutions to improve the efficiency and provide functional optimization, through lab-based usability studies (Ritter et al., 2014). This design process also fitted in a company strategy clearly separate tasks between software engineers and designers.

3.4   Designer

Designer's Goal: Functional Optimization that Fits with Existing Practices The designer's goal in the PC era was functional optimization of current practices, and evaluation of final design proposals (ISO/IEC., 1998; Ritter et al., 2014). The goals of functional optimization in software design meant to have simplicity, power of command, user satisfaction, and reasonable costs to sustain the system (Shneiderman, 1980). With the designer's goal of functional optimization, design standards, structured principles, and guideline were often developed to guide other designers to improve the user experience of user interface (Ritter et al., 2014; Shneiderman, 1980). Examples are 'criteria for effective interaction design' by Alben (Alben, 1996) and 'Macintosh human interface guideline' by Mills et al. (Mills, Bonn, & San Juan, 1992).

Relationship with a User: Observe the User as a Research Subject To achieve the designer's goal of functional and experience optimization, designers carried out controlled usability studies, in which they observed users in practices that they simulated in a laboratory setting (Rogers, 2011; Sanders, 2006). From these controlled settings, designers derived insights about the potential for optimization, which they formulated as design requirements (Abras, Maloney-Krichmar, & Preece, 2004; Sanders, 2006).

4   Past-to-Present: Ubiquitous Computing

4.1   Brief Product Characteristics of Ubiquitous Computing

Ubiquitous computing was firstly coined by Weiser in 1988 (Weiser, 1991), and started to attract a lot of attention in the 1990s when companies started to explore the potential of small networked portable computer products. Examples of products that resulted from these explorations are Appel Newton, EO pad, Palm Pilot, and Sharp Zaurus (Grudin, 2008; Pew, 2002; Want, 2010). Ubiquitous computing got past its exploratory stage and became adopted by markets in the 2010s (Want, 2010). From that period onwards, users owned many computers such as smart phones, PDAs, and embedded computers. The miniaturization of computers pushed the rise of ubiquitous computing. Moreover, cheap sensors, actuators, and easy programming platforms lowered the barrier for developing embedded computing applications (Grudin, 2012; Pew, 2002; Want, 2010).

The two main characteristics of ubiquitous computing are context awareness and unobtrusiveness (Grudin, 2012; Pew, 2002; Want, 2010). Context awareness means that devices can incorporate the user's context into their operations, in order to provide the best possible user experience. To create contextual awareness, developers use on-platform sensors that can detect for example the location of a device, others devices close by, as well

as environmental factors such as sound, motion, and temperature (Grudin, 2012; Pew, 2002; Want, 2010). Unobtrusiveness refers to the seamless integration of computers with everyday objects such as a table or a floor matt (Barton & Kindberg, 2001; Kidd et al., 1999). Therefore, a key quality of ubiquitous computing products is that they allow users to use the product unobtrusively without becoming detached from their surrounding context (Grudin, 2012; Pew, 2002; Want, 2010)

4.2   Design Task

Design Object: Implicit interaction, System-driven Experience, Service. The tagging and sending technologies of ubiquitous computing have created a thin line between the digital and physical world (Want, 2010). Since computers have become portable, designers could not limit themselves to explore user's behavior only on digital activities anymore. They also have had to consider the user's physical activities. This has even led to new human-computer interactions such as gesture design for wearable devices and voice user interface for AI speakers (Helms, Brown, Sahlgren, & Lampinen, 2018; Maeda, 2018). Designers have aimed for these kind of interactions to create unobtrusive yet engaging user experiences with the product that does not demand the constant input or attention of users (Ju & Leifer, 2008). The interaction has happened without the explicit command but with awareness of user' natural behavior and context (Ju & Leifer, 2008). An example is the Google Nest which is a product that can automatically change the temperature in a house based on the predicted presence of its inhabitants by anticipating their needs (Helms, 2017; Helms et al., 2018). The main challenge for designers to create human-product/computer interactions in the ubiquitous computing era has been the implicitness of the interaction to be developed. To deliver a holistic and univocal experience, designers have started to develop tools and methods to systematically deliver a personalized user experience that infers the user's implicit needs, preference, and traits (Lee, 2013; Tseng, Jiao, & Wang, 2010). Moreover, the product automatically tailors to the user's behaviors during product use (Pariser, 2011). These advanced human-computer interactions have increased the attention on experience design and triggered the development of service design in the 2000s (Lee, 2013). This is because during the ubiquitous computing era, the device itself does not mean much, but service systems around the device have acquired a greater value-in-use. After being a new design discipline for 20 years, service design is now entering a stage of young maturity (Secomandi & Snelders, 2018).

User Study Place: A Real Environment (Living Lab) Designers in the ubiquitous computing era more often conducted user research in the actual living environment of users, because they aimed for an unobtrusive user experience with greater context-awareness (Brush, 2016). They often conducted these user studies in close collaboration with computer scientists. Together they created so-called living labs (Rogers, 2011; Taylor, 2016). A famous example is ENoLL (European Network of Living Labs). One of the projects they have done is the Mobile City Bregenz project where they provided mobile broadband infrastructure to explore new innovative public services (Dell'Era & Landoni, 2014). Aware Home(Kidd et al., 1999) and the Cooltown project (Barton & Kindberg, 2001) are traditional examples of living labs where they explored how embedded computational technologies implemented in the home could support everyday activities of users. These kinds of user studies in real environment allowed for explorations of how users behave naturally, in computer enhanced environments. Thus, it allowed designers to explore the user's longer journey of using computing devices in computer enhanced environments, instead of

exploring only a single moment of use as in the PC era. An example is the exploration of the use of wearable devices throughout a day in the user's life, which is very different from studying the moment of touching a menu icon on a screen. Thus, user studies have been conducted more natural ways with less intrusion by researchers.

4.3 Design Process
Co-evolution of Problem and Solution Spaces The miniaturization of computers, and the inherent embedding of computers in everyday practices, have increased the degrees of freedom in the design of human-computer interactions (Want, 2010). The design problem in such a complex context cannot be fixed or defined at certain point of design process, but it constantly evolves and changes (Dorst, 2006; Hatchuel, 2001). Therefore, designers constantly refine the design problems and solutions 'through the constant iterative analysis, synthesis, and evaluation between problem and solution design' (Dorst & Cross, 2001). Accordingly, the two design spaces -defining a problem and delivering a solution- constantly change and influence each other. Design researchers termed this as the co-evolution of problem and solution (Burns et al., 2006; Dorst, 2006; Dorst & Cross, 2001)

4.4 Designer
Designer's Goal: Look for New Technological Possibilities (Future-oriented) The designers in the ubiquitous computing era have explored new technological possibilities that can change and even disrupt user behavior, instead of optimization solutions for present-day problem (Brush, 2016; Rogers, 2011). This exploration of future-oriented possibilities has led designers to popularly be involved in speculative design, that talks about the implications of emerging new technologies (Dunne & Raby, 2013). The speculative design, so called design fiction or critical design, is a mean of speculating how things could be, so design becomes provocative rather than predictive or prescriptive (Dunne & Raby, 2013). This designer's future-oriented goal has become possible with the technological development such as actuators, sensors, and easy-programming tools. With such interest, design for ubiquitous computing has not attempted much to develop theories, but to apply technologies in practices (Hekkert & Van Dijk, 2011), and credit the investigation on novel interaction or experience of emerging technology's applied practices (Brush, 2016).

Relationship with a User: Treat a User as a Design Partner The future-oriented designer's goal aiming to explore new technological possibilities has opened-up the relationship between users and designers, since designers have valued the natural use behaviors and opinion of end-users. Consequently, designers have started seeing the users as partners in design process and they have popularly done co-design (Sanders, 2006). Co-creation processes provided designers not only with information on what users can verbally explain what they want, but they create a deep understanding of user needs and behaviors (Sanders, 2006). Through co-design, designers have created empathy for the users, meaning that designers understand the user's hidden needs and behaviors. Moreover, users became innovation sources and unique insight providers. This means that design for ubiquitous computing has moved from user-centric (for users) to user-participatory (with users) (Dell'Era & Landoni, 2014; Sanders, 2003, 2006).

5 Present-to-Future: Collective Computing
Multiple scholars argue that 'collectiveness' is the future driver for computing (e.g., (Abowd, 2016),(Mulgan, 2017),(Oswald, 2018)). However, since the collective computing is a

relatively new concept, there is only limited literature available. Therefore, this section is a combination of existing literature and our own 'meta-speculations' about the role of design in the collective computing era. Our ideas stem from an extrapolation from the historical overview on the design activities in the PC and ubiquitous computing eras.

5.1 Product Characteristics of the Collective Computing Era

Abowd describes collective computing as the era or situation where many computers are owned and used by many people (Abowd, 2012, 2016). In other words, many people interact with many other people through multiple computing devices. There are three technologies that enabled the collective computing: the cloud, the crowd, and the shroud. The cloud is about limitless computation and data storage and access. The cloud supports the integration of different types of data generated through the use of different devices. The crowd is thousands of individuals who complement computer algorithms by providing human computation, cooperatively adding human intelligence. The shroud is a layer of digital technology that connects the physical world to the digital world by continuously updating and reacting to the changes made in physical world. It merges the people's physical data to digital domain through cloud and computing devices.

According to Abowd, collective computing aims to have the human to human interactions between many individuals mediated by multiple computer devices (Abowd, 2012, 2016). This results in societal and community-level research. It allows people to have large data-sets from the start, without long training periods, to ready-to-use systems. Thus, data gathering from the crowd is a core value here. Data can be generated through people's active contribution (e.g., Wikipedia or open-source software), or unobtrusively collected through cameras and sensors. Google Maps is an early example of collective computing, suggesting best driving routes by collecting real-time traffic information from the crowd using GPS on smartphones or sensors on buses, with many individual users having provided inputs (Abowd, 2016; Mulgan, 2017).

5.2 Design Task

Design Object: Complex System (Ever-updating/evolving System) The relationship between many users and multiple devices in collective computing naturally extends design object boundaries to allow for complex system design. This means designers contribute to upcoming large social and economic challenges (e.g., healthcare, environmental issues, sustainability, crime). Currently designers have started to solve the challenges with computational technologies such as e-Health emerged. Thus, design in collective computing can be regarded as designing (in and for) the complex systems that have an impact on society as a whole, instead of on individual users. The involvement of multiple users at the societal level means that the multiple layers of social and economic contexts become a part of the design task.

Further, the systems have the abilities to constantly update and evolve, based on user-data collected. In other words, systems are now adopted to users' usage behavior and modify its system. As Fischer and Giaccardi mention, system cannot be completely designed prior to use; they must be evolved from users' actual use (Fischer & Giaccardi, 2006); 'the information and functionality in system can never be complete because the user behaviors change and new requirements emerge.' This is because the users' understanding and use of a system will be very different as time passes.

User Study Place: Society as a Lab (Acquiring Community Data) Because of the contextual complexity designers face in the collective computing era, designers need to have a deep and overarching understanding of users. Thus, designing complex system requires to acquire both societal and personal understanding about users (Whitworth, Ahmad, Soegaard, & Dam, 2006). Collective user behaviors such as social dynamics or collective goals are importantly considered, in addition to personal user behaviors such as individual user psychology or interaction behavior with computing devices (Whitworth, 2011). Thus, designers also have to think about issues of scale, and ask a question such as 'how can we apply this specific technology in a large network of interconnected systems, potentially with billions of users and across diverse contexts?' (Brown, Bødker, & Höök, 2017; Gardien, Djajadiningrat, Hummels, & Brombacher, 2014; Maeda, 2018). Design in collective computing means designing the complex systems that have an impact on society as a whole, and the individual users collectively. Thus, the notion of a 'lab' now extends to the community and society.

To achieve these goals, designers need to consider to integrate different scales and abstractness of data in their user studies. There are some researches that tried to complement different scales and abstractness of data each other and blend into one another. One known approach is 'a thing-centered approach' introduced by Kuijer et al. (Kuijer, Nicenboim, & Giaccardi, 2017). The thing-centered approach includes things (products) in the ethnography by embedded sensors and cameras on the thing. Consequently the thing can observe and record what happens around them (Giaccardi, Speed, Cila, & Caldwell, 2016). At the same time the thing can interpret the data through machine learning. Kuijer et al. applied the thing-centered approach while designing socio-technical systems for elderly people. The paper argues that machine learning techniques in user study can provide a novel way to uncover patterns in data, because it can gather the data beyond the human capacity and skills. Another example of the thing-centered approach is the 'Listening to an Everyday Kettle' project in which designers, ethnographers, and computer scientists worked together to speculate how ethnographic data and machine learning data can complement one another in design process of creating more meaningful IoT products (Clia et al., 2015) . They discovered that ethnographic data initially lead to questions that could thereafter be studied with machine learning techniques. Subsequently, ethnographic research could support the interpretation of the data generated through machine learning since ethnographic studies include a holistic picture of socio-cultural situations.

5.3   Design Process
Co-exploration and Co-evolution of Problem and Solution Spaces Design problems are complex in the collective computing era: messy and ambiguous in nature, and with each complex problem connected to other problems. This is because the design task, designing complex systems, is ever-becoming and continuously updating based on new user behavior data collected. Also, the ways to solve design problems are only knowledgeable and constructed in the mid of the design process (Fischer & Giaccardi, 2006). This means that the problem- and solution spaces of design process do not only co-evolve together with interchange of information (Dorst, 2006; Dorst & Cross, 2001), but they also have to be explored together (Stienstra, Bogers, & Frens, 2015). In other words, designers implement possible design solution in an actual environment as soon as possible, and disrupt the solution at multiple levels (e.g., economic, cultural and organizational). Only then, the

problem can be observed and explored to propose new solution based on the problem observed. Thus, the designers let the design problem and solutions to co-evolve first, then they explore which solution is needed due to the new problem observed.

Some design researchers provide the guidance on how to do this, such as Stienstra et al.'s work of Double Loop of Exploration (Stienstra et al., 2015). In the 'Double Loop Exploration' method, designers reflect in real-time on the data derived from user studies in the user's context (Stienstra et al., 2015). While reflecting on the data, they detect design problems to tackle that they directly solve and deliver to the user's context. Implementing solutions lead to a redefinition and/or refinement of the problem which lead to a new problem-solving loop. In this way, the problem space and solution space merge and get coupled to each other; it becomes hard to separate the two spaces.

Practical example is Connected Bottle project of Philips Design and Eindhoven University of Technology (Bogers, Frens, Kollenburg, Deckers, & Hummels, 2016; Van Kollenburg et al., 2018). The project is an actual project in industry (executed with real users in their natural habitat) that embraces the idea of co-exploration and co-evolution of the design problem and solution. To do so, the design team created a smart baby bottle hood that allows them to remotely collect the real-life baby bottle feeding data. The designers could see the feeding data in real-time and continuously on their computers. They used an algorithm that visualizes the data as soon as it is collected: time of feeding, movement of feeding, temperature of milk in bottle. Then, the designers quickly ideated new design problems, and provided users with newly modified design solutions. This phase was repeated multiple times. In other words, the designers implemented their design ideas and insights to the system, as soon as the data are collected so the users could experience the changes in the design right away and change their behavior accordingly.

Designer's Goal: Towards Ethics and Privacy in Technology Exploration Designers of collective computing contribute to changes to complex systems that can have a large impact on society. Taken together with the constant co-evolution and co-exploration of design problems-solutions in complex contexts, this creates a situation in which designers cannot fully control the consequences of their designs. Thus, the designers should curb their natural optimism and be attentive to unexpected and unwanted consequences. Ulrich Beck, the eminent social scientist, argues that the risk from the uncontrollability in modern society can be prevented by a human effort of risk assessment (Beck, 1992). Accordingly, designers, who deal with ever-updating and ever-evolving systems, have to fully consider the ethical and privacy issues in such a way that unforeseen miss use can be dealt with (Benton, Miller, & Reid, 2018).

Until now, cases of data-mining on people's personal data has led to severe public concerns about their privacy (Gardien et al., 2014). An example is Facebook–Cambridge Analytica data scandal that brought up attention on the needs of having more strict user privacy regulation of tech companies (Meredith, 2018). This scandal has ignited many publics to concern their privacy issues and companies to discuss on their ethical standards. As a result, now companies put a lot emphasis on their concerns on privacy issues; Apple just made their advertisement on their strictness on privacy at the Consumer Electronics Show 2019 (Figure 3) (FEonline, 2019). Therefore, governance becomes an important subject for designers in collective computing, since it helps to structure how users and designers can interact with and share data.

Figure 3. The Advertisement of Apple Products that Taking a Care of Privacy Issues (FEonline, 2019)

As a reaction to this, the European Union implemented the General Data Protection Regulation (GDPR) in 2018 that will guide designers on how to deal with ethical and privacy issues. The regulation will impact designers not only by the way designers conduct their user studies (the user data has to be used only for the purpose that was planned at first, it cannot be analyzed for multiple different purposes), but also as a way of thinking about practical design output that can be implemented within a regulatory framework for data collection and use.

Relationship with a User: Society as Observed Subjects and Design Partners
Designing complex systems —the main design task in era of collective computing— demands designers to include societal understanding in their designs. Consequently, designers have to create a deep understanding of the community they design for. Moreover, community members will actively create parts of the design at the same time. Thus, the community is both the subject of study and a design partner (Ten Bhömer, Tomico, Kleinsmann, Kuusk, & Wensveen, 2013).

6   Discussion and Conclusion

This paper starts with the question: 'how will future design activities differ from those in current and past eras of modern computing?' Authors explored this question through literature research on design activities in the PC and ubiquitous computing eras, with the aim to envision the new design activities - design task, design process, and designer- for the upcoming era of collective computing in which multiple people interact with each other through several different computing devices (Abowd, 2016).

The envisioned results are integrating various user data for designing (within or for) complex ongoing-evolving/updating systems at a societal level, having co-exploration and co-evolution design problem-solution spaces, and considering the ethical and privacy issues to prevent the risks from uncontrollability of data collection and processing.

Yet, the framework retains some abstractions that may not fully represent the real world. Therefore, we now have started to conduct expert interviews to validate the presented framework and to obtain additional recommendations and challenges for the collective computing era. Up to the current status, the experts provided further insight about the choice of locations, subjects, and purposes of data collection and analysis, and about working with dedicated communities that can provide constant feedback to designers. The experts also listed some challenges, such as motivating users to share data, and difficulties in identifying

stakeholders in collective computing. As a result, this envisioning design activities is constantly evolving research and this current framework can still become good starting action-points that designers can build on, allowing designers to innovate on their research or design practices for this upcoming computing era for themselves.

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About the Authors:

Jiwon Jung: Ph.D. Candidate at TU Delft. She develops a design guideline to support designers use big user data in a design process. Her research is particularly in the translation phase to find design insights, opportunities, and proposition from big data visualization.

Maaike Kleinsmann: Associate Professor at TU Delft. Head of CardioLab, an initiative of TU Delft, De Hartstichting, and Philips Design. CardioLab develops solutions that support cardiac patients to live a longer and healthier life.

Dirk Snelders: Full Professor at TU Delft. Dirk's current research looks to design as a form of 'care' - whether and how the care for others can be 'designed'. An example research topic is the role of design in care industry eco-system.