Embedding Human Values into Information System Engineering Methodologies

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Abstract Many people are concerned about how information systems deal with human values such as privacy and trust. In this paper, we discuss the role of human values in the design of information systems. We elaborate on the nature of human values and discuss various approaches on how to address human values, including value-sensitive design, worth-centered design and understanding as an additional step to prepare for systems design. We discuss the meaning of values like 'privacy' and 'trust' in the area of healthcare and public safety. Subsequently, we illustrate our considerations, exemplifying how privacy and trust might be embedded in a healthcare system to monitor dementia patients and how privacy might be embedded in a public safety system. Finally, we discuss how human values may be addressed in the process of developing and implementing information systems.

Keywords: human values, trust, privacy, healthcare, public safety, system engineering methodologies.

1. Introduction

Through the years we have witnessed many failures of information system projects due to several reasons, ranging from communicational and organizational issues to technical ones. One such issue is a lack of communication and cooperation between technical- and business-oriented people and the (end) users of the systems. Business-oriented people usually focus on their wishes with regard to information system applications rather than on the feasibility of the system functionalities. It has turned out to be difficult to convince them of the unfeasibility of certain functionalities in an information system application. On the other hand, technical-oriented people work on information system applications from their own point of view and understanding and may implement all kinds of novel and advanced functionalities without conferring with the (end) users about their needs. Often, these functionalities are considered as obstacles by the (end) users.

To deal with these issues, the research and business communities have proposed many solutions and best practices, such as methodologies and techniques for the development cycle of information systems, project management tools and frameworks for the socio-technical approach. While the methodologies and techniques to support the development cycle of information systems and project management tools are mainly focused on the development of information systems in a proper way, the socio-technical approach focuses on developing a proper information system that should be of use to its users. The socio-technical approach encourages successive meetings in which developers, users and stakeholders discuss the functionalities/requirements of the information system to be built. These meetings are required until the proposed functionalities/requirements of all groups fit seamlessly (Laudon & Laudon, 1999). Recently, research questions related to a successful introduction of information systems in an organization drew the attention in many fields, such as healthcare, government, education and so on. Some issues that have been identified in the successful introduction of information systems in organizations are modelled in the so-called Technology Acceptance Model (TAM) (Davies, 1989; Venkatesh, 2000; Venkatesh et al., 2003). In the basic TAM, the influence of

determinants on technology acceptance is mediated by two individual beliefs: perceived ease of use and perceived usefulness. Perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort and perceived ease of usefulness refers to the degree to which a person believes that using a particular system would enhance her job performance. Meanwhile more advanced TAMs tailored to specific domains, such as healthcare (Wu et al., 2007; Wu et al., 2008), are reported. Nevertheless, many information systems do not seem to meet important requirements of the user, yet. As a consequence, these systems are often used inefficiently.

In this paper, we focus on the role of human values in the acceptance of technology, especially information systems. In general, human values have a subjective and philosophical nature on a first glance. Furthermore, human values are open to different interpretations depending on the context. However, research in the field of human values has made this notion more seizable and applicable in several disciplines, such as industrial product development and marketing. Based on the insights that have been reported about human values we have made a number of them operational and demonstrated how they may serve as (soft) requirements in developing information systems. We have elaborated the value 'privacy' in the fields of healthcare and public safety and the value 'trust' in the field of healthcare. Information systems, in which privacy is a major issue, have a better chance of being accepted if privacy is taken into account as a system requirement from the start of their development. As expected, privacy appeared to be a complex requirement to fulfil and needs to be enforced at a different level in a system. We have found that trust between caretaker and patient in healthcare is an important value that should not be replaced by information systems. The deployment of information systems is accepted in this field as long as it is regarded as an extension of the caretaker or patient. For example, a robot taking patients in a wheelchair to bed may not be accepted by the patients. However, if the robot is perceived as an extension of a human caretaker, the robot seems to be fully accepted.

We have learned from our projects that the interpretation of human values is indeed context dependent and requires an effort to make them operational. Since the interpretations of human values are hard to capture in formal languages, we propose to use the elicited interpretations of human values as a set of guidelines through the design of an information system rather than as hard requirements that can be tested once the system is implemented. We propose to embed the guidelines in each development phase of an information system. Furthermore, after introducing an information system in practice, we argue for an evaluation phase which has a.o. as goal to determine to what extent human values are implemented successfully.

The remainder of this paper is organised as follows. In section 2, we elaborate on the nature of human values. Then, in section 3, we illustrate how privacy and trust are embedded in a healthcare system and how privacy is embedded in a public safety system. In section 4, we discuss how to embed human values in system engineering methodologies. Finally, section 5 concludes the paper.

2. Human Values

A widely used definition of human values has been given in (Rokeach,1973). He defined a human value as "an enduring belief that a specific mode of conduct or end state of existence is personally or socially preferable to an opposite or converse mode of conduct or end state of its existence". (Schwartz,1992) elaborated on the work of (Rokeach, 1973) and determined that values refer to desirable goals, that values are ordered by their importance relative to one another and that the relative importance of multiple values guides the actions of people. In (Bourdieu, 1984) it is revealed with an extensive empirical study, how human values determine amongst others people's attitudes and opinions, lifestyle choices and consumption preferences. This is how one feels connected to others with similar value profiles and how one can distinguish oneself from others with different value profiles. That is why human value research proved to be an excellent way to make consumer segmentations in order to develop products and business

propositions that suits one's personal goals in life at best (Kahle et al., 1986; Gutman 1982; Reynolds & Gutman 1988; Ascheberg and Uelzhoffer 1991).

In the field of Human Computer Interaction (HCI) Friedman coined the term *value-sensitive design* (VSD) (Friedman 1996, 2006). Friedman argued that computer systems are biased by the values of their designers and engineers which may not match the value profiles of their users, but do enforce the worldview of their makers. Shneiderman already made a call to designers before, in 1990, to be aware of their responsibilities for designing systems that empower human values rather than endanger them (Shneiderman, 1999). It could even be observed that computer code was sometimes functioning as regulation of society and laws were derived from this practice afterwards (Van den Hoven, 2007). Van den Hoven concludes that Information technology has become a constitutive technology and partly constitutes the things to which it is applied. What healthcare, public administration, politics, education, science, transport and logistics are and will be within twenty years from now, which values will be expressed in it, will in important ways be determined by the ICT applications we decide to use in these domains" (Van den Hoven, 2007).

When values are ordered by their importance relative to another and when this ordering distinguishes individuals from each other, then the question arises how system design should meet user values of larger populations. Conflicting value systems may occur when one person finds privacy more important than safety where for another person it may be the other way around. What implications would this have for, for example, safety control at airports where rather intrusive technology might be used for the sake of safety? Would it be possible to design this system in such a way that it respects the value profile of both persons? As the next step in the shift from the system, via the user, to the context of use, (Cockton 2004, Cockton, 2005) propose *value-centered design* (VCD). Compared to VSD, VCD does not try to put human values in the centre of the design process, but rather focuses on the value that is delivered as a result of the system, and that is perceived as valuable by people. Since value is a broad term that encompasses human values, value of use as well as economical value, Cockton later renames VCD to *worth-centered design* (WCD) (Cockton, 2006) to distinguish it better from VSD. It is clear that WCD then is able to avoid the ethical aspects of design but also focuses less on a solution to resolve the issue of conflicting human value systems.

In 'Being Human' (Harper et al., 2008), it is argued that technologies can be designed to support human values but also to violate them. Given conflicting values, systems should be acknowledged as well as the context for which the technology is designed: privacy in a family context differs from privacy in a working environment. Therefore, we propose to extend the research and design cycle of study-design-build-evaluate with an initial and new stage of *understand* in which the human values designed for, are researched and considered (Harper et al., 2008). An interesting attempt to overcome conflicting values in design processes has been conducted by (Iversen et al., 2010). In a Participatory Design project stakeholders were facilitated by the designers to negotiate their value standpoints continuously in a dialog. This complies with the idea of *meaningful design* (Van Waart, 2011) that discusses the requirements for systems design to facilitate social interaction between people and aid people's goals in life.

In our approach, we investigate the underlying human values of privacy and trust issues. Depending on the context of use and the personality of the users, it can be argued that trust and privacy are reflections of human values (Schwartz, 1992) such as conformity, security and self-direction. We have taken the participatory design approach to make the values privacy and trust operational in order to come up with a number of requirements that a healthcare and public safety information systems should meet. In the next section, we discuss these requirements and how they are enforced in designing and implementing the systems.

3. Embedding Human Values in Healthcare and Public Safety Systems

Privacy and trust are important human values in healthcare, while privacy plays an important role in public safety. Trust is an important aspect of relationships between people.
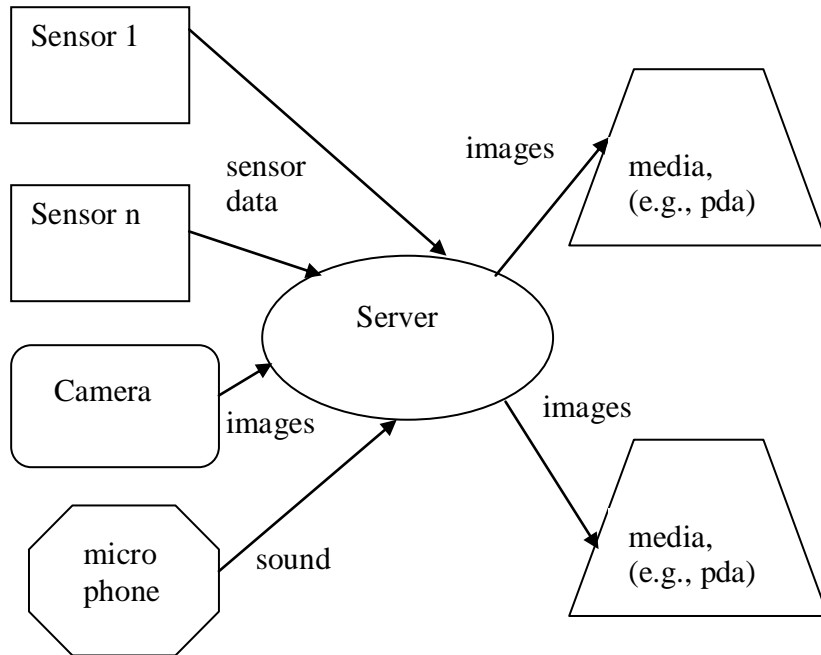When one (who trusts) is vulnerable to harm from someone else but believes that the other will not harm him although he could (trustee), then that is a matter of trust; balancing the harm we risk and the good we expect from others, and behaving upon that (Friedman et. al., 2006). Trust is always a trade-off between benefits and risks. Betrayal or lack of trust jeopardise the relationship people have with one other. In the health sector, the relationship between physicians and patients is extremely important and second only to family relationships, resulting in high expectations of patients, as the ones who trust, in healthcare systems (Erdem & Harrison-Walker, 2006). Interestingly, in an extensive literature review of trust in e-health systems it has been determined that trust influences users' perceptions but does not necessarily affect their patterns of use (e.g. their behaviour) (Hardiker & Grant, 2011).

Although privacy plays a role in healthcare as well as in public safety, the interpretation given to this value differs in these domains as will be illustrated in the two following subsections. While in the context of public safety privacy is primarily focussed toward the disclosure of the identity of individuals, in healthcare the main focus is on the observing and keeping track of someone.

3.1 Healthcare: privacy and trust as system requirements

Today, small-scale housing for dementia patients is gaining interest. The goal of the small-scale housing project is to increase the quality of life of dementia patients by offering substitutes to the traditional nursing home. Approximately six dementia patients live together in such a house. The small-scale houses are often equipped with infrared sensors. These sensors are often used to alert staff in case a psycho-geriatric patient might need assistance, for example, because of a high risk of falling. Falling out of bed may cause fractures, which are costly to recover, especially in the case of elderly people. The frequency of false positive alarms is an often heard complaint. A false positive alarm may occur if for example the blanket or eiderdown falls down to the ground during the sleep. Responding to every alarm will cost valuable time of staff due to the large working area and may cause alarm fatigue. To deal with the problem of false positive alarms, in (Schikhof et al., 2010) the small-case houses are equipped with camera recorders, microphones and a server in addition to the infrared sensors. The microphones are required to distinguish between the falling of a blanket and the falling of a patient, for example, which make different kinds of sound. The server is used to process the signals of the sensors and the microphones. Whenever a threshold value is reached, the camera sends the images to the responsible staff, e.g., on their pda, see Figure 1.

Sensor 1

sensor
data

Sensor n

images

media,
(e.g., pda)

Server

Camera

images

images

micro
phone

sound

media,
(e.g., pda)

In the design of Figure 1, the issues of privacy and trust are taken care of in a manner that is acceptable for the patients and their relatives as well as for the staff. Since the server takes initiative to send pictures to the staff, the patients and their relatives are ensured that the staff cannot watch the movements of the patients when not necessary, and therefore their privacy is not violated. The initial resistance against placing a camera in the house was taken away now the privacy of the patient is guaranteed.

Furthermore, the system may be regarded as an extension of the staff and definitely not as a replacement of the staff. The staff can make an assessment of the situation in a house on the basis of the images on distance. When required, the staff can visit the house.

This case illustrates a problem that needed to be solved given the requirements that trust and privacy should be respected. To come up with a solution as in Figure 1, one first needs to make the notions of trust and privacy operational in the context of healthcare. Questions that need to be addressed are: trust between whom and whose privacy? When is it acceptable to violate part of trust and privacy?

By answering these questions and successive questions which were raised from the answers, the notions of trust and privacy are refined such that they can be embedded in the architecture of a system.

3.2 Public safety: privacy as system requirement

Public safety is considered to be one of the cornerstones of an affluent and healthy society. After the 9/11 events, we have seen a tremendous increase in the budget for the enforcement of public safety in many countries. Many organizations directly or indirectly involved in the enforcement of public safety started to collect and to publish safety related data. Policy makers have a practical need for statistical insights into public safety at different geographical levels of a society, ranging from the national to the regional level. For this purpose, data from several sources should be integrated and stored in a uniform manner. In (Choenni & Leertouwer, 2010), a tool is presented

that collects and processes safety related data from relevant sources and presents it in an integrated and uniform way to users. The following types of issues can be addressed by the tool:

1. Simple quantification. For example, the user could ask how many people in a region within a time period responded in a specific way to a specific survey question. The result can be presented as a single figure, or a table presenting the figures and totals for the underlying regional and temporal levels, possibly showing trends.
2. Contextualisation of a quantifier. For example, how does the growth or decline of a specific figure in a geographical region relate to another figure. For example, increasing bicycle thefts in a neighbourhood can turn into a relative decline when local population growth exceeds it. This contextualisation must be considered in order to understand the public safety data.
3. Similarity queries, i.e. looking for regions that are similar in some respect. After querying for a specific data set in which some numbers stand out in some way, the user can query the tool for other regions that show similar numbers or trends.

Major components of the tool are a data warehouse and an interface layer. Aggregated data collected from different databases at various regional levels are cleaned up and stored in the data warehouse (Inmon, 2005). Furthermore, the data warehouse contains only attributes that meet up with the Dutch Personal Data Protection (PDPA) act. The PDPA demands the correct and thorough processing and collecting of personal data for clearly defined, explicit and justified goals. For example, the PDPA distinguishes a category of sensitive data that needs special attention, namely data on someone's religion or life conviction, ethnic origin, political conviction, health, sexual orientation and memberships of employer's organizations (Winter et al, 2008). Data that pertain to these attributes are not stored in the data warehouse. Conceptually, the data warehouse may be regarded as a universal relation **U** with a region identifier as primary key (Elmasri & Navathe, 2004).

The interface layer consists of two modules, an input module, called the mashup module and a presentation module. The mashup module helps a user to define his information need in a user-friendly manner, like click-and-drag facilities or Google-like interfaces. For the user of the tool, no knowledge is needed of either SQL or the underlying data warehouse structure. The user may also specify how the output should be presented. Before presenting the output, the presentation module performs some checks to minimize the violation of the privacy of individuals. For example, if there are just two sexual offenders in a region, this number will not be presented because there is a reasonable chance to deduce the persons concerned with some additional information.

This case illustrates a problem that needed to be solved given the requirement that the privacy law and regulations should be respected. In this case, the notion of public safety should be made operational and how the notion of privacy is related to safety in order to come up with an acceptable solution. To prevent the violation of the privacy of individuals, privacy is taken care of at different components in the tool, and therefore embedded thorough the tool. We stress that only aggregated data and attributes that meet up with the PDPA act are stored in the data warehouse. Furthermore, whenever it appears that there is a risk of violation of a person's privacy at the interface layer, the result will not or will only be partly shown to a user.

4. From Human Values to System Requirements

An obvious goal of software development is that the system meets the stated requirements. However, complete and explicit requirements are rarely available, especially for contemporary complex systems. The user and the developers often have an incomplete understanding of the problem, and therefore the requirements evolve during the development of the system, which is expected to be a solution for the problem. To support the development and implementation of a

system, different variants of system engineering methodologies are available. Most of them distinguish more or less the same phases:

- Specification: the functionality of the system and its operating constraints are specified in detail, often in a formal language.
- Design: the overall structure, including the architecture, of the system is defined and specific components of the system are distinguished.
- Implementation: the system is implemented by means of a set of application software, such as programming languages, database management systems and other packages and libraries.
- Testing: the overall system is tested. Often the system is tested by feeding it with a set of input and checking whether the output by the system meets the expected output. In some sensitive branches, such as aircraft or military systems, testing is done by tracking the percentage of code that is walked through for a set of given input, the so-called code coverage method.
- Operation: the system is delivered for using in practice.

We note that in practice the above-mentioned steps are applied iteratively. In developing and implementing an information system, the first phase may be marked as crucial since the successive phases take the output of the first phase as input for further development of the system. Although it is possible to go back to the first phase from any other phase in the development process, large scale changes of the functionality and requirements are often not encouraged, for reasons such as: completion of the system will be delayed, the development of the system will exceed the given budget, and so on. Therefore, it is worth the efforts to define all functionalities and requirements carefully and as extensive as possible. In the following we focus on the requirements. Although there are many tools available to elicit the requirements which a system should meet, ranging from defining several scenarios to protocol analysis, none of them are focussed explicitly toward requirements with regard to human values in the context of system engineering and how to express them in a formal language or embedding them in the architecture of a system.

Mumford's Ethics (1983) is among the first design process methods which pays considerable attention to human values; based on the idea that systems should not be imposed on people but rather address the needs of all stakeholders in a balanced way. In addition to job design goals like job satisfaction, efficiency and knowledge needs, she proposes to distinguish ethical or social values as an additional factor that should fit between what employees want and what they receive. Ethics should specifically be able to address the socio-cultural value-dimensions which Hofstede identified (Hofstede, 1980), like e.g. Individualism / Collectivism and Masculinity / Femininity to distinguish between work- and other social cultures across the globe.

The so-called Scandinavian approach (Kyng, 1994) finds its basis in the worker-emancipation movement of the 1960's. A key principle in the Scandinavian approach is that designs should fit the way of working, thus requiring participatory design practices (Schuler and Namioka, 1993). Apart from participatory design, the approach also insists that attention is paid to the context of use, resulting in contextual design (Beyer and Holtzblatt, 1998) and situated design (Suchman, 1987), and that attention is paid to the working culture, thus giving raise to ethnographic analysis and design (Hughes et al., 1993). The number of different design approaches associated with the Scandinavian approach indicates that design is rather situated and eclectic and that there is no such thing as a structured method (Kyng 1994; Suchman, 1987).

We have learned from our projects that the interpretation of human values is indeed context dependent and requires an effort to make them operational. As illustrated in section 3, privacy is interpreted differently in the case of public safety than in the healthcare case. While in the public safety case privacy pertains to prevent the disclosure of an individual, in the health-care case the identity of the person is fully known. To find the proper interpretation of human values in a given

context is a first step to make them operational and to specify them in a nonambiguous way. Although to our best knowledge there are no specific tools or methods in system engineering that are focussed towards eliciting human values, existing tools and methods for eliciting implicit domain knowledge from experts may be used to elicit human values and its interpretations. So far, our experiences are that the interpretations are hard to capture in a set of formal specifications expressed in language. Therefore, we propose to use the elicited interpretations of human values as a set of guidelines through the design of an information system rather than as hard requirements that can be tested once the system has been implemented.

To learn whether we have captured the proper interpretation of human values and have embedded the human values in a proper way, we propose to engage end users in all of the above-mentioned phases during an iterative design process.

- Specification process: Insights in value profiles can be gained through proven methods such as means-end-chain analysis. This will result in generic insights rather than specific user requirements that would form the basis for system specifications by experts.
- Design: During the design process, design choices are made that involve trade-offs in privacy and trust issues. Several alternatives can be validated by confronting end users with use-scenarios or prototypes and make end users give values to the different trade-off options.
- Implementation: Engineers should keep the end users' human values in mind when developing the system. Also at the level of programming and construction, design choices should not be fed by the world view of engineers only; engineers should adopt a mentality that keeps the values of end users in mind.
- Testing: When testing the system, not only functional features should be tested but also the effects on the end user experience and perception of usage, aesthetics and symbolic meaning (Van Waart, 2011).
- Operation: When the system is implemented in the daily context of use, specific attention should be paid to user acceptance and usage of the system. Does the system really empower end users in their activities and is the system perceived as a contribution to their well-being?

At the end, we propose to distinguish an additional phase in system engineering methodologies: the evaluation phase. In this phase, the central question that should be answered is: has the proper information system been implemented? In other words, has an information system been delivered that meets the requirements of the user and which relevant human values are embedded? The measures *perceived ease of use* and *perceived ease of usefulness* might be important ingredients of the evaluation. We note that while in the field of social sciences there is an abundance of literature and methods available to perform evaluations studies, knowledge about how to perform evaluations of information systems is in its childhood. How to set up an evaluation phase in system engineering requires the necessary research. However, good practices from evaluation studies in social sciences may be transformed to the distinguished evaluation phase.

5. Discussion and Conclusions

Systems design involves the cooperation between different stakeholders with different interests and values. In this paper we investigated human values and the role of human values in the area of systems design, in general. We exemplified the role of and difficulties in dealing with human values with two cases, derived from healthcare and public safety, respectively. The cases indicated some of the difficulties in identifying and particularly adhering to human values throughout design processes. Many different approaches have been suggested to deal with the values and interests of diverse stakeholders; an issue which will only become increasingly

important when information systems are not only used to facilitate processes such as registration and administration but also start to have a direct role in people's lives.

Early methods for information system design identify a number of design steps and intermediate results in which human values are not treated different from any other requirement. Satisfactory requirement-gathering and analysis processes are assumed to imply that human values are taken care of. Since then, we have learned a few things, and a number of design methods proposed to better address human interests. The ISO User-Centered Design (UCD) process attempts to enforce a focus on the end user by insisting that design starts with the user considerations and is carried on and eventually concluded when usability evaluations of the design products indicate that end users are able to employ the design successfully, for the purposes and in the context of use that the systems was intended for (ISO, 1999). After UCD many other approaches have stressed different aspects of how to involve users and user values in the process. Ethnographic design (Hughes et al., 1993) and Contextual Analysis (Beyer and Holtzblatt, 1998) stressed the need to understand the users' context of use. Participatory design (Schuler and Namioka, 1993), Co-creation (Sanders and Stappers, 2008) and the Scandinavian Approach (Kyng, 1994) focus on participation as a first pre-requisite for being heard and taking part in the design process in a meaningful way. Also from the field of software engineering, a number of approaches have been suggested, including RAD (Martin, 1991), Agile development and Scrum (Schwaber and Beedle, 2002) to overcome the problem of changing requirements during the process of design and the problem that, often, only with hindsight it becomes clear which requirements should have been stated. Methods like RAD and Scrum focus on rapidly creating tangible design products and a continuous re-evaluation of design activities and goals in close cooperation between developers, users and customers.

On the basis of our analysis of the general area of human values in systems design, the analyses of the examples of human values in actual systems design concerning privacy and trust in healthcare and privacy in public safety systems, and finally, the short overview of how various development methods cope with and might incorporate user considerations and human values into the design process of information systems, we conclude that we need to undertake three things. First, identify the human values in the requirement-gathering and the analysis processes in a good way, such that, early on in the design process, we will able to identify the human values at stake and explicitly agree upon those values that the proposed design should incorporate. In order to identify the human values that a design might affect, incorporate or neglect, we need to develop or adapt the specific tools and techniques that enable us to do so, and presumably, to enable us to monitor the state of the human-value requirements periodically, during the entire design process. Secondly, an additional process step to identify the human values relating to design projects is only useful if the outcomes of such an evaluation process are used to steer the project. What is required here is that, at least, at the start of a design project, all stakeholders should be able to decide whether or not to go on with the design. In addition, an evaluation near the end of the development process, for example, as part of the acceptance test, could be used to assess whether the design has indeed fulfilled its human-value requirements and is 'safe' for use in the real world. Thirdly and finally, especially given that our software systems are increasingly connected to the outside world and are not longer living in the splendid isolation behind the data-entry office, we should extend the employment of human-focussed design methods. We described user and client participation, iteration towards usable designs, prototyping and agile development, as well as regular reassessment of design goals as elements of methods which attempt to ensure that all of the stakeholder's goals are met and their interests served. There is no reason to stop there, indeed, when information systems extend into the real world and stretch out towards unintended interaction with accidental users, including the accidental passer-by whose whereabouts is registered. There is no reason not to include such users, uses and usage-contexts in the requirements analysis, human value assessments and acceptance studies of the information system at hand.

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