Intervention and EUD

A Combination for Appropriating Automated Processes

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Abstract. Intervention is a new concept for human-computer interaction to help users to cope with the increasing complexity of automated processes in socio-technical settings. We relate the paradigms of End-User Development with it and show the differences, commonalities and emergent areas through a theoretical analysis of a smart home setting. Implications for the design of intervention user interfaces are derived and the interplay of interventions with and their support of End-User Development is shown.

Keywords: End-User Development, Human-Computer Interaction, Intervention, Socio-Technical Systems.

1 Introduction

Many end-users are confronted with systems that offer largely automated processes. They are embedded into a socio-technical context and increasingly replace systems that require fine-grained interactive control. This affects not only industrial settings but also end-user domains like e-commerce, data exchange in social network systems, or smart home settings. For most end-users, these systems and the underlying processes are hard to understand and therefore it is difficult to maintain the experience of being in control. When the number of systems being used and the options to pre-configure their procedures is steadily increasing, End-User Development (EUD) becomes challenging. We argue that in a relevant number of cases, end-users do only realize their need for adapting an automated process after it has already started. Once in progress, users occasionally may want to modify steps of the automated process, stop one or all of them, or at least want to understand the scope and effect of available alternatives. These needs for increased influence are not completely covered by EUD but require a specific type of interaction that we describe as "intervention" after Schmidt and Herrmann [1].

An intervention is a type of interaction where an automated process is modified by carrying out a more fine-grained control over a technology-supported process or where the process is completely interrupted [1]. The scope and effect of this intervention is limited – after a specified amount of time, the original process is resumed. The intervention helps users to adapt a process to their needs or to explore alternatives. Schmidt and Herrmann [1] employ the example of parking fully automated vehicles to explain the necessity of such an interaction paradigm. If the user only leaves the car, it will park itself. If s/he wants to control the parking location, e.g. to avoid a certain area, s/he has to intervene. The objectives of intervention are similar to those of EUD but interventions are ad hoc and their effects are not sustained.

With the following analysis, we theoretically investigate the differences and commonalities between intervention and EUD. EUD supports users who do not have a background in programming to develop or modify their own applications. Regarding Lieberman et al. [2] “End-User Development can be defined as a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify or extend a software artefact” (p. 2). We draw from this that a broad scope of possibilities can be provided to empower users with more or less technical skills.

We share the perspective of Fischer [3] that EUD takes place in a socio-technical context. This is true for intervention as well [4]. The use of technological infrastructure is intertwined with a social dimension represented by communication and collaboration of human actors, their interests, practices, competences, various role taking etc. Consequently, EUD and interventions are not mainly conducted individually but together with others. They do not only influence technical infrastructure but also the behavior of others within social interactions.

Intervention is a phenomenon that mainly occurs in exceptional cases and it is difficult to make it the subject of systematic empirical field studies. Therefore, we start with a theoretical analysis based on literature and by considering smart homes as an exemplary field that provide a rich collection of interrelated automated processes that cannot be a subject of fine-grained control, but where intervention is needed from time to as well as adaptation. Thus, we consider infrastructure as a web of relations (cf. [5]) where we focus on the dynamics of those relations that are represented by ongoing processes. They are also a subject of “… the tension between local, customized, intimate and flexible use on the one hand, and the need for standards and continuity on the other” ([5], p. 112).

Smart homes are a typical example for such an infrastructure with the following characteristics [6–9]:

- Many different appliances and services are running in parallel;
- smart home applications are used by multiple household members;
- service providers from outside can be connected to smart home arrangements;
- the needs of using smart home functionalities are changing, depending on contextual influences and are hard to anticipate;
- we can assume various and rich practices of employing smart home features.

Apparently, smart homes are socio-technical settings that include collaboration and dealing with privacy issues [7, 8]. Furthermore, multiple end-user development tools for the smart home are available, but lack support for collaboration and rule management [10]. Smart homes are also used to help elderly people to extend the time they live in their own homes [8]. This example suggests that a wide range of smart home users need an easy to use interface – also covering the possibility of including the help of others – for influencing the technical functionalities.

The question to be answered with respect to the possibilities and scenarios of smart home usage is: How can the difference and the commonalities between EUD and intervention be understood with the goal to integrate both of them from a socio-technical perspective? Furthermore, we want to point out that this theoretical analysis influences practical considerations of employing technology, of dealing with privacy requirements, and of guiding technical design.

In what follows, we first describe different concepts found in the literature that are related to the concept of intervention. Subsequently, we outline the various applications and their interplay in the case of smart homes to clarify the paradigm of intervention in a socio-technical context. Based on this we outline the interplay between intervention and EUD. The following discussion derives practical, privacy-related, and design-oriented implications from the theoretical considerations.

2 Related Work and Concepts in the Context of Intervention

The most recent theoretical descriptions of intervention in the context of human-computer interaction is given by Schmidt and Herrmann [1]: "Intervention in human-computer interaction is an action by the user that takes place during the usage of an automated system and initiates a diversion from the predefined behavior. Intervening interaction allows the user to alter the behavior of a process that is regularly highly automated, and continuously proceeds according to a plan or to situational awareness without the need for any interaction. This ad hoc change through exceptional control takes place in accordance with emerging user needs or situations" (p. 42). Furthermore, an intervention interface has to be provided that allows for awareness to identify the need for interventions and supports activities by tools or communication media to execute an intervention [1].

An earlier version of intervention within the context of human-computer interaction was coined by Herrmann [11] who relates this concept to the non-anticipated modification of dialogue sequences: "[...] the user aims at an anticipated subgoal using a non-anticipated dialogue-sequence, or […] aims at a non-anticipated sub-goal by her/his own methods" (p. 290). This concept differentiated between "regular task performance" – as it has been anticipated by the designers of an interactive system – and "non-anticipated use". The intervention according to Herrmann [11], and Schmidt and Herrmann [1] is also characterized by the interrelation between modification and exploration: An intervention can also be conducted to answer what-if-question, such as "What will happen if the system is used in an alternative way that has been neglected by the designers?". While Herrmann [11] suggests that users just employ the regular features of an interactive system to carry out irregular actions, Schmidt and Herrmann [1] suggest investing research for the design of an intervention interface.

2.1 Intervention in the Context of Implicit Interaction

The phenomenon of intervention is closely related to such types of automated systems that do not repeat the same procedure all the time but adapt to situations and behaviors of users. Therefore, they continuously exploit the contextual development of their environment. This concept is described as implicit interaction [12]. Schmidt [12] defines it as: "[...] an action, performed by the user that is not primarily aimed to interact with a computerized system but which such a system understands as input" (p. 191). Apparently, implicit interaction relies on sensors that register the development of a system's context and take it as input instead of requiring a user's control. Thus, implicit interaction enables a flow of automated behavior that is closely linked to the users' intentions without requiring continuous and explicit interaction – we describe this with our words as "interaction-free usage". However, it is expected that the context interpretation is not continuously appropriate, therefore interventions into the flow of implicit interaction are necessary. Thus, interventions represent the opposite side of implicit interaction.

To give an example, Schmidt and Herrmann [1] refer to automatic parking of a car: The granularity of control decreases from self-controlled to highly assisted to completely automated parking of a car. In an autonomous car, the user exits the car, and the car autonomously finds a parking space, parks, and comes back in time to pick the person up. If the driver wants to avoid that the car will park itself at a certain spot or area, s/he has to intervene.

We suggest that this concept of implicit interaction can also be transferred to the socio-technical level: For example, deriving hints from a customer's purchasing behavior to guide other customers is a result of implicit interaction. And apparently, there is a lack of intervention possibilities to suppress such exploitation in certain cases, e.g. if users do not want that their behavior is understood as a recommendation to others.

2.2 Intervention into Privacy-Related Processes and Data

A different line of research describes "intervenability" in relation to privacy and data protection, rooted in theories from sociology. Intervenability is considered [13] as a requirement for data protection in designing socio-technical systems. In the data protection discourse, which is driven by legal requirements, "intervenability" refers to the rights of the individual to withdraw consent, object to the results of an automated decision or request the deletion of their data. To implement these rights in the socio-technical processes of organizations, Rost and Bock [13] suggest implementing a single point of contact to which data subjects can address their requests; as well as the need for data flows to allow interruptions without disrupting the overall process. On a higher level, the idea is to allow individuals to infuse contingency into the data and data processing so that possible conclusions drawn from data in the context of other data does not necessarily lead to deterministic or solicited results. In the socio-technical context, for example, it has been argued that tracking users on the web to create profiles has a significant privacy impact as these profiles can affect what services users can access and what price they pay. One successful way of intervening in these profiles, besides blocking the tracking, has been to intentionally obfuscate the data to influence the profile in a specific direction [14].

Privacy-related interventions have seen some intentional adoption by business, too. Facebook uses highly automated processes to determine what advertisements are shown to which users. After these processes have been heavily criticized for being privacy invasive, non-transparent and manipulative, the social network has introduced two levels of intervention. First, users that feel uncomfortable with a particular ad can select it to be hidden from them in the future. Second, those that get the impression that there is something generally wrong with how they are targeted with ads can review and change ("Why am I seeing this ad") the underlying profile Facebook has created about them. Obviously, both types of influence, one being more a spontaneous intervention and the other being more systematic like EUD, do not only serve the purpose of giving control back to users. Facebook also benefits from the feedback as it allows them to adapt their algorithms and to supply more accurately targeted ads in the future. Research has also shown that the transparency provided by the social network about the effects of users' interventions and modifications is often vague, misleading or incomplete [15].

2.3 Interventions and Workarounds in Relation to End-User Development

The definitions cited above describe intervention as interactions that have not been anticipated or allow behavior patterns of users that deviate from predefined flows. Another way to deal with these kinds of situations are workarounds. Workarounds are specific ways of acting that are carried out intentionally to perform a specific task although these ways are not expected or allowed. In some cases, it might be even illegal or seems just to be appropriate by an observer [16]. Workarounds can alter the system. They are unexpected, unplanned and usually not directed to explore the system. Interventions allow to alter the system temporarily but provide revert mechanisms, while attempting to change a system and related automated processes – or at least parts of them – and thus are an endeavor of appropriation (cf. [17]). Workarounds try to get along with tasks without influencing the system but getting around its constraints.

By contrast, EUD has similar intentions as workarounds (to modify the ways of task handling) but by changing the underlying system. Our understanding of EUD is based on the overview by Liebermann et al. [2]. We assume for the context of using automated systems and processes that users are not regularly interacting with the employed technology (but only when doing interventions) and therefore a very low threshold of entering into EUD is necessary. Those kinds of low thresholds are provided by offering a mode of configuring a system for example by setting parameters or by graphical means. We suggest that most needs for EUD-based modification become only apparent during usage and that conducting such a modification appears the more desirable the more the results of EUD are needed.

We share the view of those scholars [18, 19] that emphasize that EUD always takes place in a socio-technical context and does not only influence the technical infrastructure but also the social dimension. Intervention and EUD are part of socio-technical processes and modify them. Thus EUD – as well as intervention – can be a collaborative endeavor that is supported by CSCW-applications [20]. EUD might be delegated to "gardeners" (cf. [21]) that are more experienced with modifying a technical system than regular users. We suggest that these gardeners might also be helpful for interventions. Furthermore, the subjects of EUD and interventions are not only algorithms but also people who routinely run or participate in a socio-technical process.

3 The case of Smart Homes – Overview and Examples of Interventions

With the term "smart home", we refer to an ensemble of applications and services that are based on a growing number of sensors, actors and automated processes that benefit the users. Smart homes offer a broad scope of such benefits in the areas of safety, energy management, and lifestyle support [6–9] such as:

- energy saving by shifting energy-intensive procedures like washing to hours with high and potentially cheap availability of energy
- improving the climate and air-condition of the home e.g. through reducing heating on sunny days or at night
- automatic lighting ranging from a simple motion controlled night-light to complex arrangements of hundreds of individually controllable RGB light bulbs
- increasing safety and the privacy of the home, e.g. by identifying potential intruders or notifying about open windows and doors
- allowing more independence for people with special needs like elderly or disabled people through monitoring of the inhabitants and signaling potential accidents or illnesses, or by supporting them in everyday live (ambient assisted living)

These processes and services rely on implicit interaction to ease and automate common procedures. The user's regular interaction or usage history with the appliances of the household is collected to find repeated patterns which an intelligent agent could automate [9, 22]. Furthermore, these processes can be interrelated, for example by technical means if a motion sensor or speech recognition support various of those processes or if they are dependent on each other. Another type of interrelation can be provided by service providers that react on security issues as well as in the case that somebody needs help. The various processes might also be logically connected for example if the alarm system states that people are at home, but the light controlling motion detectors do not register any movement this could be interpreted as an indicator that help is needed. Such logical connections can be configured in advance using Event-Condition-Action (ECA) rules, e.g. "At 10 pm [event] if any windows are open [condition] remind me to close them [action]", and are employed to support EUD in smart homes [10, 23].

3.1 Interventions to Stop or Change Processes

A simple example of intervention support is the "Party Button" of many central heating systems. When pressed it keeps the heating in the whole house on during the night instead of turning it down earlier in the evening. It is designed as an exception. The system's behavior is changed only for this night and the default configuration is resumed the next day. This behavior is hard to design using ECA rules or implicit interaction since it occurs only exceptional. The conditions are not fully known in advance and it is hard to derive from people's behavior how long they will be present or active.

Heating systems in smart homes enable more fine-grained control such as separate rooms or individual radiators than the central ones considered before. Therefore, the design of an intervention interface could aim on a more precise and versatile control. Only specific areas like the living room or kitchen can be targeted. This allows limiting the intervention to a specific *scope*. Targeting only the living room for an evening of video streaming or the kitchen for a dinner party.

Misinterpreting the changes made to a heating system usually do not lead to severe consequences. This is different, however, with smart home appliances that are focused on safety and security as in the domain of ambient assisted living. Fall detectors can be integrated into the floor or put under the carpet. If the monitored person falls, an alarm is triggered without the need for pressing a button or using the phone. The system might be turned off on rare occasions to avoid false alarms e.g. if the grandchildren visit and jump and roll on the floor. If the systems are not turned back on afterwards, the expected monitoring and protection are not in place and an emergency can remain unnoticed. An intervention must be designed as such that the safety-related behavior is resumed if certain conditions are met. Either conditions can be an elapsed timer or the start of a new day or as needed in the latter example that the person is alone again and monitoring needs to be resumed. Therefore, a sensible intervention would allow pausing the monitoring for as long as the person is under supervision but resume operation otherwise. Having a *resumption condition* is critical in safety-related systems and a typical aspect of intervention design.

3.2 Interventions in Shared Settings

Furthermore, interventions need to consider context and actors, and their understanding of the system and the automated processes. Consequences of the intervention need to be immediately visible. This visibility allows exploring the system and trying out what-if-scenarios. "How does my energy consumption change if the average temperature is raised by 2°C for a certain time span?" Immediate means to revert such changes in the event of unintended consequences are needed e.g. if the intervention will close the window blinds in all rooms of the house to avoid additional heat from the sunlight, it should be clear whether other residents are affected who might need daylight. All in all, exploration of possible adaptation and what-if-scenarios can be an important reason to intervene with the data of the usage or interaction history. E.g. if the user wants to see how the system would adapt if he worked a full time job instead of half time. Such explorations are usually not intended to change the systems configuration and end-users need to be confident that they can revert their actions. Therefore, undo-mechanisms are required to support the end-users to return to a known and working state.

Most smart homes are shared spaces and needs can be different among its members. Intervention can cause conflicts. Lifting all window blinds at 8:00 am is the default behavior. If a teenager applies an intervention to keep all blinds down until 2:00 pm to sleep in this can cause conflicts. E.g. if the scope of the intervention is not limited to the teenager’s room and all members are affected which rely on the open blinds to wake up early. Therefore, applied interventions must not only be visible but potentially negotiable between the affected actors.

Interventions can also serve as a means to share control temporary with visitors. For the duration of their visit, certain interventions are allowed for the visitor. Like deactivating appliance like virtual private assistants (VPAs) to allow for private conversations. Control the intensity of light and genre of music played in the bathroom as well as the sink’s water temperature. However, any changes made by the visitor are generally non-permanent and can be reverted when s/he leaves.

3.3 Interventions Offer Fine-Grained Control

Interventions do not only allow ending, pausing and resuming automated behavior but also switch to fine-grained control. When food is spilled on the floor, an autonomous vacuum cleaner can be instructed manually to clean it up. Some devices also allow to be used in a non-anticipated way such as switching it to manual control for cleaning to use it to play with the cat. Afterward, the intervention is stopped and the device is switched back to automated control and proceeds with its predefined routines.

3.4 Interventions in Profiles

To adapt to the users’ needs and automate repeated sequences of interaction, smart homes maintain a history of technology-driven processes or of interactions with them and may create a profile of its user. Those profiles can also be a subject of intervention targeting the data used for automation instead of the automated processes itself. E.g., individual utterances towards a VPA might be deleted because they seem inappropriate afterwards or the users want to obfuscate their habits. Another reason for modifying a profile may be that a visitor of a smart home has special needs, and his/her way of using the smart home causes lasting but unwanted changes in the profiles of inhabitants. For instance, through his/her interaction with the smart home the profile might change and eventually lead to an inappropriate adaptation of services etc. Offering the regular inhabitants an interface for intervening into the underlying data of such an adaptation supports them to maintain control of their automated processes.

3.5 Key Properties of Interventions

Considering the presented examples in the context of smart homes several key properties can be identified which not all have been considered before. The first is the *resumption condition* — when is the automated behavior continued and the intervention stopped. Second the *scope* of the intervention — what is affected by it: a specific area, a system, a certain step of or a whole process and what actions have to be overtaken by the user. Additionally, interventions allow the *exploration* of possible changes regarding the configuration and data and their consequences for the users with accessible means to revert or to keep the changes.

4 The Relation of EUD and Intervention

4.1 Differentiation between Means and Effects

In the following, we clarify the various aspects of how an intervention can take place and what may be affected by the intervention. Furthermore, we explain how the difference between intervention (c.f. Table 1) and EUD-based configuration (c.f. Table 2) looks like. For this purpose, we use the example of automated alarms like the fall detector in the previous section. Other typical alarms in households can be caused by movements in and around the house during certain periods (e.g. at the backdoor during the night) or by heat detectors. Possible interventions are suppressing false alarms or postponing the activation of an alarm before the occupant leaves the house.

An alarm can be the starting point of a complex socio-technical process where social actors are involved as well as social interaction. For example, the alarm of the fall detector triggers a contract-based service taking care of the fallen person. This includes bringing the person to a doctor for a medical investigation in every case because of the service provider's liability. To stop such a procedure, an intervention of social actors (e.g. relatives) who can prove that they are legitimated is required to take over the responsibility. For Table 1, we assume a scenario where a false alarm is triggered e.g. by a sensor that registers that someone has fallen to the ground or by evaluating multiple sensor inputs that indicate that somebody is not able to follow his or her typical everyday routines.

Table 1. Different modes of intervention into a socio-technical system

Intervention into …	**… the technical system**	**… the socio-technical system (affecting social actors)**
Intervention by …		
... employing technical means	a) After an alarm is set off, the supervised person can reset it by entering a 5-digit code within one minute. Such a reset is only possible one time per hour.	b) Instead of entering a code, the supervised person starts an audio-video connection to his room for half an hour. Thus, the service employee can see and hear whether everything is okay.
... including the help of social actors (socio-technical)	c) Like a) but the originator of the false alarm asks a relative or a member of the household to enter the code. This procedure has to be completed within 5 to 10 minutes.	d) The alarm's originator informs a relative who tries to stop the initiated procedure by calling an employee of the service provider.

The nature of the procedures being started after such an alarm is that it runs predominantly automatic and the social actors being involved are instructed to follow pre-specified routines. Interventions, as described above, are an exception. If interventions take place more often, this can be a reason for a modification that is initiated by an end-user.

These modifications in contrast to interventions change the automated behavior permanently. In this scenario, the modification can aim either on avoiding future false alarms or on improving the way of dealing with them. The examples of Table 2 refer to the second option.

Table 2. Different modes of configuration of a socio-technical system

Configuration of …	**… the technical system**	**… the socio-technical system (affecting social actors)**
Configuration by …		
…employing technical means	e) The person to whom an alarm relates determines that he or she can reset the alarm by using speech recognition: After an alarm, the systems asks whether a serious incident took place and by the calling of a predefined phrase the alarm can be stopped.	f) The person being supervised modifies her/his contract with the service provider: after an alarm, the audio-video connection is automatically started and transfers pictures for 10 minutes that have to be observed before somebody is sent out.
... including the help of social actors (socio-technical)	g) A relative is asked to modify the alarm triggering mechanism as described in e) and a protocol is signed documenting consent to such modification.	h) A relative negotiates with the service provider to change the procedure as described in f).

The examples of the right column go beyond the usual scope of EUD since the behavior of social actors is influenced instead of those of a technical system. However, this an indirect way of influencing the technology: if the users or their relatives and the service provider agree upon the modification of the procedures or the contract this implies a change of the technical system.

Obviously, the handling of alarms, interventions and the preparation of configuration is accompanied by continuous elicitation of data that includes a significant amount of personal identifiable information. For example, establishing an audio-video channel as mentioned above conveys a lot of data about personal behavior. In many cases, collecting such data along automated or routinized procedures can be helpful to improve the quality of services or the safety of people. However, it can also happen that these possibilities can violate people's privacy. To counteract, intervention interfaces are needed: People can interrupt the automatic establishing of audio-video connections.

4.2 Series of Interventions as a Preparation of EUD-based (Re-) Configuration

From the example of the two tables above, we can generally conclude that a series of the same type of intervention can be an indicator that a reconfiguration of the socio-technical system is necessary or reasonable. Such a point can also be reached in many other cases, for example if the party button presented in the previous section is not only used occasionally but several times a week throughout the year. As soon as the intervention is no longer an exception, the system must adapt or must be adapted. This interplay is outlined by Figure 1: Based on an initial configuration of a socio-technical system, regular usage of or collaboration within a system can be interrupted by casual intervention. Repetitive interventions of the same type can initiate adaptation. When an adaptation is made, the former exceptional state has become the new normality and the former normal state the exception. In such a constellation, the intervention can be used to undo the EUD-based modification. Furthermore, the EUD-based modification can also address the parameters of the intervention. For instance, the time span of delaying the shutdown of the heating system in the case of the party-button could be changed or the time span within which an alarm could be revoked.

The socio-technical view has to include two options. On the one hand, a user can directly execute an adaptation as it is typically suggested by end-user development [2]. This could possibly be supported by the system itself by proposing certain adaptations. On the other hand, a reconfiguration can be delegated to an authorized person or organization. Under certain circumstances, the re-configuration can only take place after it has been negotiated and approved by the group of potentially affected stakeholders. Within socio-technical arrangements, the effects of configuration and re-configuration can also address various roles.

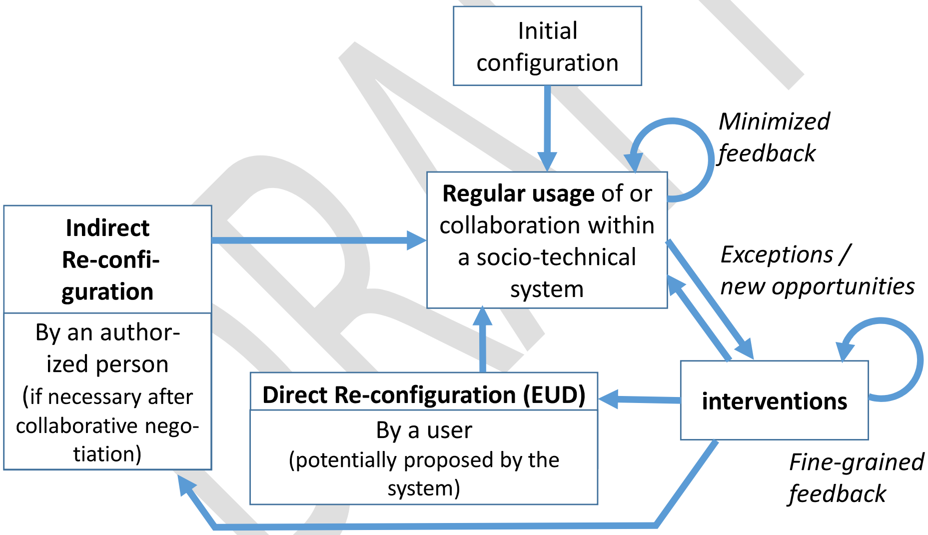

Fig. 1. The relationship between regular usage, intervention, and configuration (derived from Schmidt & Herrmann, 2017)

5 Discussion

The theoretical comparison between intervention and EUD in a socio-technical context has also practical relevance. Furthermore, it is of special value to not only consider the functionality of a technical system but also the handling of privacy issues from the perspective of intervention and EUD. A key to realize the benefits of intervention is to explicitly design an intervention interface that can cover several automated and interrelated processes as it is the case with smart home applications.

5.1 Practical Relevance

Providing a well-designed intervention interface is a lightweight possibility to help users to adapt automatically initiated or running processes to ad hoc emerging needs. Even more important is the avoidance of risks: Without the possibilities of intervention, people tend to switch off the systems or avoid their usage. An example is the problem with Advanced Emergency Braking Systems (AEBS) that are used in trucks to avoid dangerous collisions. They are frequently switched off since they produce too many false-positive warnings [24, 25]. Intervention avoids these risks since it is its inherent condition that it is only possible within a limited scope, and that the regular process is resumed after a while or if the user remains inactive.

Employing the socio-technical perspective has practical relevance since intervention as well as EUD can be a collaborative matter. Possibly, a person A wants to intervene into an automated procedure that was specified by a user B by employing EUD-support. Thus, negotiation is necessary between the two parties requiring proper means of communication or collaboration to jointly construct a suitable solution. Furthermore, it can be reasonable that interventions are monitored by others; or, intervention could be carried out by two persons and could always be stopped by one person (to minimize risks that can be caused by interventions).

The interplay between EUD and intervention is also of practical interest. For example, if an end-user carries out a series of interventions her/himself while the EUD that is inspired by this series is delegated to another person. For this purpose, a separate handling of those data that logs the interventions and those that support the usage of a technical system has to be established. Another reasonable interplay between both might be that EUD produces a constellation that is desirable in most cases and intervention is used to go back to the initial state that was given before the EUD took place.

5.2 Maintaining Privacy

On the one hand, interventions help to reduce threats to privacy by stopping privacy invasive procedures (such as conveying data to third parties) and automated processes or allow to change and delete collected data to maintain privacy. On the other hand, intervention history is collected to identify details of the users' needs and subsequently areas of interest for end-user development. This possibility adds more data to the profile of the user. The decision not to share certain data at a certain point in time or to subsequently modify and delete certain interactions may provide more sensitive information than normal interaction data. However, the ability to explore what-if scenarios increases transparency and enables effective changes of the profile and introduces contingency.

Users can not only delete or change data in their profiles, but can also add data, such as random times when they might have used particular devices. Consequently, they can not only expand their profile and correct errors but also influence their profile in a particular direction. Service providers can hardly use these profiles for marketing purposes or for determining flexible insurance contributions because the profiles can partly be based on artificial data. It may be reasonable to automate such interventions because they may need to be applied regularly to achieve the desired results. These kinds of automated interventions can be a subject of EUD.

5.3 Implications for Design

The need for intervention interfaces has already been stated by Schmidt and Herrmann [1]. In the following, we draw implications for the design of such interfaces from our analysis and show how this interconnects with the requirements and potentials of EUD.

The recording of interventions that have taken place can help to identify the need for change and possible areas of interest for EUD. The integration of an intervention interface with EUD allows at least for three ways of utilizing the log file data of interventions: by the system itself to propose an adaptation, by the end-users themselves, or by their partners. The system has to be designed to differentiate between two types of data collected – what is needed for the services vs. what is needed to prepare EUD.

When users employ interventions to explore the system, they can be empowered to eventually start with EUD to replace the temporary effects being achieved by intervention with permanent changes. Based on the collected data of the applied interventions, areas or entry points for conducting EUD can be identified. EUD-support should display the actions and parameters of recent interventions so that they can serve as a starting point for further refinement by EUD.

With respect to shared applications in the smart home context, intervention interfaces could be designed in a way where others are notified or at least aware of an ongoing intervention. In some cases, others should or must have the opportunity to influence an intervention someone else initiated (intervention-into-intervention). Such conflicting interventions and possible needs demand to be negotiated. This can only be accomplished if both actors fully understand the interventions they want to employ and the consequences this will have. Interventions need to be perceived as a closed loop with a clear start and end point. Limiting the interventions with respect to a time span, the parameter scope or the frequency of its occurrence can support this perception.

Designing an intervention user interface is a complex challenge because many parameters and possible variants must be communicated ad hoc to the users without obstructing them. If the user has not fully understood the consequences of her/his actions or does not like the result, simple mechanisms are needed to return to the previous state.

Interventions can be the subject not only of software design before use but also of EUD during use. Allowing to combine several interventions into one or to define events and conditions for specific interventions to ease their repetition can be considered by EUD. Similarly, the parameters that characterize an intervention (like the delay time of party buttons) can be a subject of EUD. As interventions address emerging needs of the users, they cannot be fully specified in advance but must adapt to and be adaptable to the users' needs.

Consequently, an intervention interface has to include several parts:

- Awareness information that indicate a possible need for intervention,
- an easy way to start an intervention (but avoiding unintended starts),

- an immediate and continuing notification about the scope and implication of the intervention,
- possible undo of undesired implications,
- an offer for a transition from an intervention to EUD including a record of the scope and effects of the same type of interventions that took place.

6 Conclusion and Further Work

We relate the concept of EUD and intervention to ensembles of simultaneously used automated processes, as for example smart home technologies. For this realm, we have derived theoretical commonalities and differences that can help to guide the design of this kind of technologies and the organization of their usage.

Commonalities are:

- Both deal with non-anticipated needs and behavior (e.g. allow to use an autonomous vacuum cleaner as a toy)
- They empower the end-users by helping them to be in control (e.g. by temporary overriding the energy saving defaults of a heating system)
- Both can be prepared by meta-design [26]
- They are embedded into socio-technical processes where various people or organizations support or influence each other (e.g. in the case of alarms with its pre-specified routines)

Furthermore, intervention and EUD both influence different areas alike: The technical functionality of a system (e.g. postponing the shutdown of the heating system by a party button), the content represented by data that is processed by functions, and that may be related to privacy concerns (e.g. hiding details of data collected by a smart meter through aggregating it), and the behavior of the people in the socio-technical system that interact with technology – either directly or through delegation – in the course of automated processes (e.g. by informing a service provider that an alarm was falsely activated). It has to be noted that every single instance of intervention or EUD may potentially affect all three of these areas at the same time. Beside spanning all these three areas, the end-user is not required to do EUD on her/his own, but can instruct others actors to do so. In addition, interventions can be launched on behalf of others.

The differences are:

- Intervention has only ephemeral effects on the way a system is used, while EUD aims to achieve a sustainable change of how somebody deals with an automated process
- The effects based on an intervention are only exceptionally desired while the effort being invested into EUD is the more efficient the more it aims at regularly occurring needs of users
- Intervention takes place ad hoc to cause immediate effects while EUD is oriented on future situations

- Possibilities to resume the regular mode and reverse the effects of interventions are necessary for intervention design, while EUD aims at changing of what is considered as regular

Interplay between intervention and EUD:

- Intervention prepares EUD
- EUD helps to pre-specify the effects and limitations of interventions
- The intervention will revise the impact of the EUD if, exceptionally, it is not adequate

The differences and commonalities shown and the derived design implications help to design interfaces for intervention and to prepare their socio-technical integration. In addition, they support the transition from intervention to EUD and provide end-users with lightweight means to adopt EUD. Vice versa, end-users could extend and adapt interventions through means of EUD.

Further research is needed to design intervention interfaces that cover an ensemble of intertwined automated processes, as in the case with smart homes, and evaluate them in a series of design cycles.

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