User trust in Adaptive Systems

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Abstract

While investigating user requirements in adaptive systems, we found that adaptivity, though meant to increase usability, seems to challenge user trust. We have further investigated reasons why user trust in adaptive systems might be low, and how such systems should be designed in order to be trustworthy. Not only privacy, but also user control, consistency, and system competence have strong inter-relationships with user trust. We applied qualitative empirical methods, especially scenario-based interviews and focus groups. As a result, we indicate a set of user requirements that shall guide the design of trustworthy adaptive systems.

1 Introduction

For more than 10 years now, the scientific community strives to develop systems that adapt automatically to what users prefer and context of use. It is a challenging technology, often based on various AI approaches to modeling and reasoning. The goals of adaptivity that are mentioned most frequently are to ease usage of systems and to provide individualized services.

During requirements analysis for an adaptive system we discussed scenarios with users, in order to get feedback on what we plan to develop. Adaptivity shall be based on user modeling, and the scenarios illustrated several ways how the user model can be exploited, such as retrieve more interesting information, default settings, pro-actively remind users, or perform "the usual" actions.

Not surprisingly, users discussed privacy issues with reference to the system observing their dialogue, and building and updating a user model. Clustering all trust-related issues, we found that privacy was the second-most dominant issue, next to data security. We also found some more surprising aspects in trust concerns that suggest trade-offs between adaptivity and user trust. We think these issues are inherent to adaptive technology, and not specific to the application in question. Several aspects are mentioned in published trust research results, though, to the best of our knowledge, hardly any empirical trust research has been published concerning adaptive systems in particular.

The remainder of this paper is structured as follows: The next section clarifies what we understand by "adaptivity" and gives two application examples. In Section 3 our empirical methods are explained. Section 4 is the main section, where I report trust issues related to adaptive systems, refering to literature and our own empirical work. This section also states user requirement in trustworthy adaptive systems. The final section draws conclusions and indicates open questions.

2 Adaptivity

As said above, adaptivity means the system is automatically adapting its behavior according to its assumptions about the user and her/his situation, current interest, or current context of use. Some adaptive system features have meanwhile found their way to daily support of users, e.g. personalized recommendations in eCommerce, and location-aware mobile Guides.

There are two core constituents of adaptivity: one is that users or their context is observed and modeled, and that the model is updated from the observation data. The second one is that from this user or context model the system infers which system behavior would be preferred by this user or would be appropriate in this context. Both the modeling and the adaptation need to be designed and evaluated for user trust.

I want to give two application examples:

A personalization for an information retrieval system, for instance, might observe what this user searches for and looks at over time, building and updating a user model of this user's interests in certain topics or types of information. It can then rank or filter retrieval results according to assumed user interest. It could also give recommendations of incoming content concerning this user's interest.

A context-aware system might watch a user's current position in space, perhaps also this user's speed. It can adapt information that the user requests to his or her current position and velocity, e.g. a map might center around the current user location, and its scale might be high and showing less details for fast moving users (car drivers), while lower scales with more details might be rendered to slowly moving users (walking).

3 Applied methods of research

3.1 Concepts of trust

Empirical studies should be based on an explicit concept of what is investigated. Several definitions of user trust have been suggested. My intention is to investigate the role of user trust for acceptance of systems.

The technology acceptance model (TAM) suggested by Davis (Davis 1989) claims that user acceptance is a product of perceived usefulness and perceived ease of use. Meanwhile, this seems established in principle but considered too simple, i.e. there are more factors that influence user acceptance, user trust being one of them. Trust

as a precondition to acceptance has been investigated thoroughly in connection with Internet services, especially with eCommerce, and has also been clearly established.

With respect to this research focus, I understand trust as a user's feeling or believe: Trust is the believe that in interacting with another party or system, one is vulnerable but one's own interests are adequately respected and protected by the other party or system, and the other party or system is capable of performing. This is called "credibility" in (Fogg and Tseng 1999) and "trusting believe" in (Grabner-Kräuter and Kaluscha 2003).

I also share the concept with several authors from a background in social sciences, who claim that trust is a multi-dimensional relation, where users perceive the complexity of socio-technical systems including technology and various stakeholders (Braczyk, Barthel et al. 1999). We indeed found a high user awareness of different technical, human and organizational "players" in providing a service, which contributes to an overall perception of a system's credibility.

3.2 Empirical research

Our research aimed at gaining requirements early in a project, before users could be shown a working prototype. This is common practice in user-centred design as recommended by (ISO_13407 1999). We first applied a scenario-based research method. We created context scenarios in order to illustrate the use and handling of the future system in a concrete and realistic context, i.e. for certain user groups, their typical goals and tasks, in a typical environment (Dzida and Freitag 1998). Representatives of those user groups were presented with scenarios, and asked to give us feedback: is the context captured adequately (validation of context), would they like to have such system support (usefulness), how should it be designed to be really useful (requirements), and do they see issues (constraints, issues that need to be solved). About the method of scenario-based requirements engineering see, for instance, (Sutcliffe 2003).

We had interviews with 40 users, from two different user groups. The sample included 19 female and 21 male users, covering ages between 20 and 60. A sample of 40 users would not be enough to support a statistical analysis, but it is more than enough to validate scenarios and identify issues and requirements. As we know from usability evaluation, a small sample of 3-5 typical users will already detect 75% of all usability issues in a prototype[1]. Identifying issues and requirements in scenarios is basically the same.

However, our scenario-based interviews raised a couple of questions we wanted to investigate in more detail. We conducted two focus groups, with 5 and 3 users, respectively, and discussed trust issues with respect to adaptive systems. The results from the focus groups supported some hypotheses we had built, and also made us better understand some interdependencies and trade-offs.

Our empirical research has been planned and discussed with reference to related theoretical and empirical work published by other researchers. There is meanwhile large amount of trust research, many of it based on empirical research. The majority of papers are focusing on eCommerce, and there mainly on the transactional aspect, where a lack of trust has economic consequences. We have hardly found trust investigated with respect to adaptive systems, with one exception. Adaptive systems are inherently difficult to test and to submit to user evaluation, which was already discussed in (Chin 2001). Chin states a serious lack of evaluating adaptive systems within 10 years of development and publishing. Concerning personalization of web sites in eCommerce, there is meanwhile a plentitude of evaluation results published, but predominantly from the commercial point of view (Fink and Kobsa 2000).

4 Findings and recommendations

4.1 Personalization versus privacy

From the scenario-based user interviews we could clearly identify a privacy issue concerning personalization. On principle, collecting data of system usage violates the user's right of privacy. Most of our focus group users thought that it is common practice in eCommerce to build customer profiles for various purposes. In spite of this knowledge, most do use eCommerce but do not like this aspect and do not think that user modeling in this case is especially useful for clients. They did like the Amazon "users who bought X also bought Y", which they considered unobtrusive and often inspiring. They suggested it would be good style of "trustworthiness" to let clients see the user profile a web site has built so far, and also make their privacy policy available for inspection.

Some professional clients of content repositories even considered their manner to search for content and the topics they research to be part of their professional skills and company secrets, which they do not wish to disclose to anybody. In such cases privacy can have an economic dimension.

Users considered modeling at client side to be harmless and would prefer this to server-side modeling. This is also relevant for location-aware systems where the current user position is observed by sensors. Some positioning technologies are inherently server-based (e.g. GSM, some of the WLAN technologies), while others keep the sensor data at the client until it needs to be used as a parameter (e.g. GPS, some of the WLAN positioning technologies).

Overall, users are willing to disclose personal data when they see a benefit for themselves or if the partners has a rightful interest to do so. They expect however a fair privacy policy and wish to stay in control of when, why and what data they disclose.

User requirements: Users wish to inspect their user model. Users wish to be able to switch off the observation. User want to know where their data go to, and to be able to restrict the usage of such data to specific purposes, excluding any other use. Some users want to set up several user models, such as a private one vs. a professional one, or models for different roles they have and that request different system usage. If possible, consider maintaining the user model at client side.

4.2 Trust and competence

It has already been suggested that user trust also correlates to a system's perceived competence (de Vries, Midden et al. 2003). Trust relates to your partners' intentions as well as their competence (Fox 1996; Fogg and Tseng 1999). It has also been reported, that system errors, even comparatively small ones such as spelling errors, can de-

[1] See topic in Jakob Nielsen's very recommendable "Alertbox", http://www.useit.com/alertbox/20000319.html

crease user trust (e.g. by (Nielsen, Molich et al. 2001)). We found that perceived competence has one source in the user or context model itself, and another in the way these models are exploited for adapting system behavior.

Adequate modeling

In the user assessment of a personalized recommender system (Westerink, Bakker et al. 2002), users did not expect the system to be able to predict their preference by observing their habits. They believe that they change interests (seasonal, mood, external stimulus) faster than the system would update the model. In our own interviews we found similar user anticipation.

With respect to user modeling, several users we interviewed had doubts whether a model could be adequate to reflect their interests. They feel their interests are changing a lot, and a model based on usage history would not be able to reflect this. Their concepts and understanding/phrasing might not be the same as the ontology underlying the model. Their criteria of being more or less interested might not be reflected in indices available for observation, retrieval or modeling. All in all, they questioned the system's capability to model their interests adequately, as well as the usefulness of adaptation to personal interests.

With relation to context, the localization technology today has not yet achieved the expected precision and reliability. Therefore, users are sometimes presented with information that obviously relies on imprecise positioning data. Here, it has been observed that users might accept such uncertainty when their mental model of the system functioning matches the actual situation. This means, when they are informed that precision of positioning data are low they will more easily accept the resulting uncertainty (Cheverst, Davies et al. 2002).

User requirements: The user modeling needs to be based on empirical research in order to identify relevant criteria and indexes. The system should allow users to inspect and edit the model, in order to let them tune their preferences. The system should calculate the confidence of a user or context model and let users understand uncertainties.

Adequate adaptation to user and context model

Several users we interviewed were concerned that adapting query results to their assumed interest might narrow down what they are presented and thus limit their chance to detect novelties or unusual perspectives. They would appreciate sorting by preference so that most interesting items come first, while all results are completely included in the list.

Several users said they want to control retrieval in detail, and would appreciate an explicit relevance feedback more than automatic ranking by assumed interest.

Some professional clients of content providers want explicitly to find the unusual and gain novel experiences, and expressed a concern that a personalized system might completely miss this.

Concerning personalized recommendations in tourism guides, some users said they want to be open and try what is special in a place; they would not be content to get recommendations restricted to "their usual interests". They also anticipate that the user model is not fine-tuned to their personal criteria, because these criteria are hardly the indices available from content providers.

When localization is used as a parameter of location-based services, there may be cases when a user request should not refer to the current location but to some other place. The functionality should be flexible enough to allow users to override the parameter that is set to "current location" by default.

User requirements: Users sometimes want to get an unfiltered, and complete result. Users sometimes want to be open to new interests, not limited to familiar topics or types of information. Systems should not hamper exploring for the unexpected by filtering out parts of the world. Users might want to switch off adaptive behavior, in order to get un-personalized results.

Users appreciate personalized recommendations, but want to be able to switch these off. System should offer ranking rather than filtering. A retrieval system should offer explicit relevance feedback as an alternative to ranking by assumed interests.

4.3 Adaptivity versus usability

One intention of adaptivity that is frequently stated is to ease use of the system, therefore to increase usability. The user shall be freed from explicitly and in detail expressing goals, specifying parameters that can as well be automatically derived, or filling in painfully long and meaningless questionnaires about settings and preferences. From all dimensions of usability (see (ISO_9241 1996)), especially conformity to expectance and user control have proven to be closely related to user trust. We also identified trust issues related to pro-active behavior, which is often included in adaptive systems.

Trust and control

It has already been discussed that user control is an important factor in usability, and that control is positively correlated to user trust, i.e. users trust more when they feel in control, while a lack of control is decreasing trust (de Vries, Midden et al. 2003).

So when the user model or context awareness is used to interpret user interests this may challenge user's feeling of control. This can be acceptable if system only suggests certain actions or pre-sets parameters, while user sees these recommendations and can override them. This can be more problematic when system assumptions are not made obvious to a user, are not easy to influence, or when actions are triggered while user has little chance to supervise this. A very simple example I can report from is a personalized tourism information system, where tourism attractions were listed ranked by assumed personal preference. While the list was not showing the value of preference, the sorting was not understood and caused distrust; when the sorting criterion was displayed (in spite of eating up space on the small screen), this was much preferred by users (see (Schmidt-Belz 2003)).

By discussions in our focus groups, we learnt that user control is important on a semantically high level, not on the low-level technical details. Users happily hand over control to a system when it concerns technical details such as formats, device capabilities, networking availability and capacity, and similar issues. But they want to have control of what happens on the functional and logical level, e.g. what information is collected, what is sent to whom, and also what causes costs however small.

User requirements: The system should allow users to understand the modeling and reasoning. Users should be able to inspect the model, and to override or change the

model. The system should offer an option to disable observation and updating of the model. The system should offer an option to disable adaptive behavior. The system should offer an option to compare between adapted and unadapted behavior, e.g., offer an option to inspect what the system has filtered out. The system should offer ranking rather than filtering by assumed interest or context.

Trust and user expectance

Two other aspects of usability strongly related to trust are user expectance and consistency. If system behavior does not comply with user's expectance, if it seems inconsistent in its reactions, this will undermine user trust. This aspect of usability is inherently endangered by adaptivity, i.e. by systems that automatically and dynamically adapt to context and assumed user preferences. E.g., the user model is permanently updated on basis of observations of user interaction, and the assumed user preferences then are used to infer system behavior. So in principle, the same user request can cause different reactions today and tomorrow. This might cause surprise and confusion, if the user's mental model of the system reactions is not adequate to explain this behavior. The system reactions seem inconsistent. What was meant to ease use can thus become a severe usability issue.

Several users believed that if a system were well-designed for usability, there would be no need for adaptivity, which they would prefer.

User requirements: Adaptivity is not a substitute for bad usability design or missing understanding of users and their tasks to support. The system should help users understand the mechanisms of adaptivity so that they can build an adequate mental model of system functioning. The system should display assumed values of interest or location, display accuracy and confidence of these values.

Pro-activity

Often, user modeling or context awareness is used to offer services in a pro-active way. Pro-active system behavior means that an external event triggers a system reaction, instead of an explicit user request. Pro-active services were a special concern for users. They are apprehensive to get unwelcome messages (e.g. spam), be interrupted in an activity, get their attention distracted from something more important, are required to react in order to get rid of such message or assistance. They can imagine getting useful information, but would prefer to "subscribe" to such service, i.e. be asked before it starts offering pro-active services. They also require unobtrusive behavior, not interrupting ongoing activities nor covering more important information on the screen. It should be very easy to stop or quit the proactive service.

User requirements: The system should provide pro-active services only upon explicit user subscription. Pro-active services must be unobtrusive and easy to switch off.

4.4 Trust and acceptance

As already said, we believe that trust is one factor in user acceptance, together with perceived usefulness and usability. So if trust is below a certain threshold, it will negatively influence user acceptance. This also means that a low level of trust may be found in users who do accept and use a technology, because they perceive its usefulness. This has been corroborated by our focus groups: several users said they use certain systems in spite of being suspicious, not trusting them very much. But they want to get the benefits. Here is the main key to user acceptance: *The personalization or context awareness shall provide obvious benefits for the user, and be designed at a high level of usability.*

5 Conclusions

Trust as one factor of user acceptance needs to be carefully taken into account when designing an adaptive application system. As we have seen, user trust is closely related to some well-known dimensions of usability.

User perception of trustworthiness is very complex and has some typical trade-offs concerning adaptive features, as we have seen. Designing an application for trustworthiness in a concrete case needs detailed consideration of the domain, the technology and the target user groups. In a user-centered design the solutions should be discussed and iteratively optimized involving user representatives.

Designing for user acceptance and especially for user trust requires that all detailed decisions of an adaptive system, such as user and context modeling, the way and algorithms of its use to adapt system reactions, be considered with respect to target user groups, to its technical environment, as well as to a certain business model and involved stakeholders. The recommendations given in this paper can guide design decisions, but have to be instantiated and sometimes negotiated in each concrete case.

Don't provide magic, but let users understand the systems' functioning and help them feel in control.

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