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SALT – Situation-sensitive Sustainable Service and Product Alternatives: Vision, Conceptual Application & Challenges

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Abstract: The field of environmental informatics can clearly contribute to the achievement of the Sustainability Goals set up by the German Government. To do so, it has to investigate not only environmental aspects but also integrate social and economic aspects. In this work-in-progress paper this will be done by proposing a system for visualizing **s**ustainable service and product **alt**ernatives (SALT). Starting from the observable gap between the intention to behave more sustainable and its transformation into sustainable behavior, it is elaborated how a SALT-system can help to bridge the gap in this domain. After introducing a conceptual architecture, the example application of a browser plugin for presenting lending alternatives to online shoppers is described.

Keywords: sustainable by ICT, service and product alternatives, intention-behavior gap, sustainable behavior

1 Introduction

In 2002, the German Government submitted the national strategy for Sustainability Goals of Germany, called "Perspectives for Germany – Our Strategy for Sustainable Development" [Fe02]. Thus, the German Government points out that its governance wants to follow the principles of a sustainable development on the one hand and reports about the progress regularly on the other hand. Until now, much effort to achieve the goals of 21 topics of sustainable development in Germany has been invested. Especially regarding the first goals addressing the saving of resources, climate protection, renewable energies, and information and communication technologies (ICT) can make a contribution to the strategy for sustainable development.

So far, the research of environmental informatics mainly focuses on the environmental aspects of sustainability. However, the movement should also take the coherencies and effects of ICT on the different dimensions of sustainability, i.e. environmental, economical, and social into account. Regarding software, one of the additional aspects

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next to the environmental impacts caused by software is the development of sustainable software products. Penzenstadler et al. [Pe14] define sustainable software as follows: "The term Sustainable Software can be interpreted in two ways: (1) the software code being sustainable, agnostic of purpose, or (2) the software purpose being to support sustainability goals, i.e. improving the sustainability of humankind on our planet. Ideally, both interpretations coincide in a software system that contributes to more sustainable living." Whereas (1) is commonly referred as Green (in) IT, (2) is known as Green by IT.

Hence, there are two directions within the research activities in the context of environmental and sustainable informatics that can support a strategy for sustainable development: approaches dedicated to Green (in) IT address the question of how software can be sustainable and how the sustainability of software can be measured (e.g. [Ab15], [ANC12]). Activities belonging to the Green by IT field aim to support a sustainable development by using ICT [Pe13]. If including more than just the environmental aspects of sustainability one can talk about "Sustainable (in) ICT" and "Sustainable by ICT".

The following article concentrates on "Sustainable by ICT". It deals with the problem of the divergence between the growing awareness for sustainability issues on the one hand and the missing sustainable behavior (the intention-behavior gap [AD07]) on the other hand (e.g. [Fu05]) and proposes a tool, which can support sustainable behavior.

In the next chapter, we outline different it-related approaches trying to foster sustainable behavior. Following we introduce a model that helps to explain the intention-behavior gap (Section 3) and argue why the presentation of **s**ustainable service and product **alt**ernatives (SALT) could help to bridge this gap (Section 4). Section 5 is dedicated to the introduction of a conceptual architecture for a SALT system and Section 6 shows an example application of such a system. Finally, we will conclude this work-in-progress article by a conclusion and consideration of future challenges in Section 7.

2 IT-approaches to foster sustainable behavior

The field of sustainable human-computer interaction is rich of approaches, which try to promote a change in behavior towards a more sustainable lifestyle [DSB10]. Ambient awareness systems visualize the impact of a user's behavior on particular aspects of sustainability (e.g. [Hu10]). Persuasive technologies [Fo02] go one step further and try to persuade users to act in a more sustainable way.

Although DiSalvo et al. [DSB10] count in its survey of sustainable human-computer interaction about 45% of all work to the subgenre of persuasive technologies, the question arises if persuasion is the right strategy to change behavior. In [HH15] several limitations of these approaches are listed, including the inherent technology paternalism and the insufficient account of individual differences and social context. As a way to overcome these limitations, Hubel et al. [HH15] concentrate on gamification as a method to promote sustainable behavior and develop requirements for such types of systems. Examples of a system that combines gamification elements with the attempt to foster sustainable behavior are the WeAct Challenge [We15] and the Power Agent [GKB09]. Gustafsson et al. [GKB09] proof in his evaluation that gamification can improve the motivation to act more sustainable. However they could not show that gamification can lead to a long-term behavior change.

The approach presented in this paper concentrates not on motivational aspects or the distribution of general information about sustainability, but far more on the problem of converting intentions to behavior in the domain of sustainability.

3 Modeling the intention-behavior gap

An often used and well-known model for predicting behavior is the theory of planned behavior [Aj91]. In that theory perceived behavioral control, subjective norms and the attitude towards the behavior mediate between belief and intentions. It states that if the intention becomes stronger, a behavior is performed more likely. This assumption is challenged by research work that shows that intentions are a bad predictor for a behavior (e.g. [Sh02]). This problem is described in literature as the intention-behavior gap (e.g. [Fe11]).

Carrington et al. [CNW10] try to explain this gap in their intention-behavior mediation and moderation model of the ethically minded consumer (see Fig. 1). In their work they combine the three already existing concepts of actual behavioral control [AM86], implementation intentions [Go99], and situational context [Be75] to explain how a transition from an intention to the actual behavior can occur.

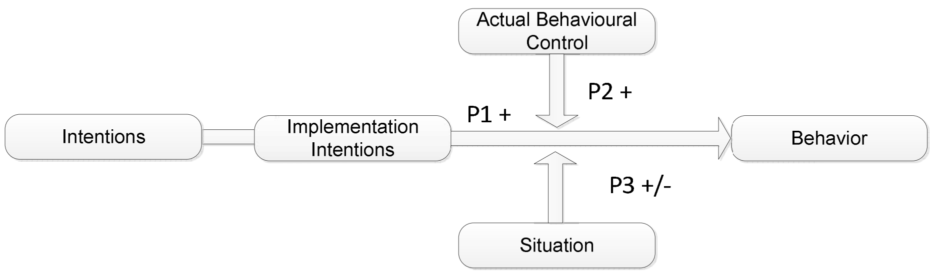

Fig. 1: Intention-behavior mediation and moderation model [CNW10]

Implementation intentions are plans how an intention can be transformed into a behavior. An example for such a plan for the intention “I want to buy more fair-trade clothes” can be formulated in an if/then statement like “If I need a new shirt and I am searching on the web then I will use the online shop of a fair trade clothing company”. Actual behavioral control describes the extent to which a person can control his own actions in a particular situation. This construct includes constraints like time, resources or also knowledge, which could hinder a person from executing an implementation intention. The situational context (referred just as situation in this paper) can be described as the physical and situational environment at the time the intention should be transformed into a particular behavior. According to Belk [Be75], five factors describe a situation: Physical Surroundings, Social Surroundings, Temporal Perspective, Task Definition and Antecedent States.

While the intention-behavior gap is positively moderated by all of the three named constructs, it can be also moderated negatively in the case of the situational context [CNW10]. Examples for the negative influence of the situation, regarding the fulfillment of an intention, are special offers, which could influence people to deviate from their implementation intention.

Based on this model the next section is dedicated to the question why the visualization of service and product alternatives could be a useful tool to support sustainable behavior by reducing this gap.

4 Service and product alternatives and the intention-behavior gap

Presenting sustainable service and product alternatives to a user can – if meeting certain requirements – have a positive impact on all of the three aforementioned constructs.

First, implementation intentions can be supported by the presentation of alternatives in several ways. The alternative can be new to the user thus enabling him/her to form a new implementation intention. Existing plans can be improved or the complete planning process can be performed by such a system.

Through the visualization of alternatives, a situation can be shaped in favor to more sustainable behavior. The presentation, e.g. on a smartphone or on a wearable, can remind users of their intentions and work as a compensator for other visual temptations (e.g. special offers).

At last, applications following the approach presented in the next sections can improve the actual behavioral control over a particular situation. These applications are able to mitigate constraints like time or knowledge; as the knowledge lies in the system and the push structure of these applications supersede the need to actively search for alternatives.

For being successful in supporting users to change their behavior, the proposed alternatives have to be directly actionable, fitting to the situation and of a higher utility in regard to the “status-quo”-behavior. Directly actionable means that the “then” part of an implementation intention is communicated with the alternative (e.g. “go 100 meter further, there is a fair-trade shop for buying tea.”). The accordance of situation and alternative can be captured by the situation-service fitness. This concept is defined by Maass et al. [Ma12] as “a perceived degree of match between a service and a situation.

Following TTF [Task-technology fit theory], SSF [situation-service-fitness] theory hypotheses that the better the match between service and situation, the better the individual or group performance within a situation.” The utility of the alternative relates to the effort to realize the alternative in comparison to given constraints or an induced saving. To exemplify the said: Taking a bus instead of driving a car is in general a better idea as it helps to reduce CO_2 emissions, but if the bus station is too far away for walking under given constraints (e.g. weather or a meeting at a defined time) the alternative is less probable to be chosen.

5 The SALT system

In this section a system is proposed, which enables the presentation of service and product alternatives, as elaborated in the former section. A conceptual architecture for the SALT system can be seen in Fig. 2.

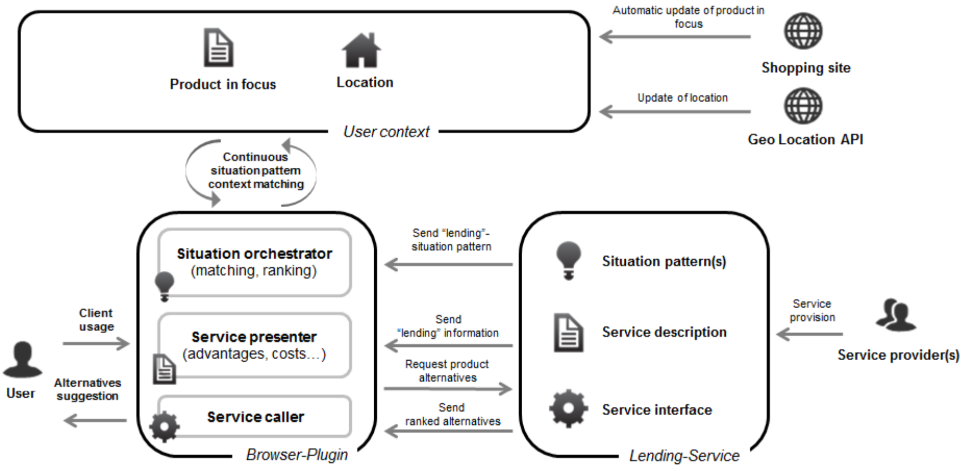

Fig. 2: Conceptual architecture of the SALT system

The starting point of such a system is the user, who is associated with a context. This context consists in conformity with Carrington et al. [CNW10] of the following information: A user profile, environmental information, a social context and revisions of this data over time.

The data describing the user context can be gained from the user itself in two ways: by manually informing the system about facts, preferences or personal goals or by automatically determining it, based on events triggered by user actions. Beside this way of gathering data many other available data sources can be used to describe the context and increase its accuracy. Among these are: basic information about time, location, weather, social information like contacts and appointments of/with friends, colleagues etc., e.g. retrieved from the smartphone of the user, IoT devices, social networks, and more. While the context is always updated with the newest information state, it still holds former revisions over time to enable historical data analysis, e.g. to determine continuous changes, reoccurring patterns over time.

The management of such context-related data is performed by a not further elaborated technical infrastructure, which could be cloud-based or directly on the smartphone of the user, but that's not a focus of this publication.

Based on the user context, a user's personal client, which could be a smartphone app, a web application or also implemented in a wearable will support the process of providing alternatives using three major components: A situation orchestrator, a service presenter, and a service caller. The situation orchestrator is continuously matching the current and former context states with different situation patterns, which are aggregated from the services that want to provide alternatives to the user. These patterns describe situations (= subsets of a context [Ma12]) in which a particular service can possibly compute fitting product or service alternatives. If a pattern match is detected in this continuous matching process, the corresponding service is presented to the user using the service presenter and the retrieved services description. The service presenter is able to provide the information in an attractive way to the user, showing advantages of the service, service costs and more. At the same time, the service caller calls the service and provides the service context information to enable the calculation of alternatives. The service delivers a created list of personally calculated alternatives fitting to the context of the user back to the service caller to enable the presentation of the alternatives next to the general information about the service.

If the user decides to use one of the provided alternatives the service caller also manages the further communication between the client and the service, involving service delivery, payment and more.

The presented procedure requires the services to provide all information and interfaces to be able to take the aforementioned steps. Thus, they need to provide situation patterns describing appropriate usage situations, a service description containing information about the service main purpose, advantages, costs and more. Such information needs to be created and provided by the service providers in a standardized form.

That way, service and product alternatives with assisting information for building implementation intentions can be provided to the user, fitting to his current context. The alternatives can be ranked by the client by different factors (e.g. the service situation fitness, the utility of the alternatives or personal preferences) and visualize the data. The user can give implicit or explicit feedback, which can be used by the client to optimize the proposed alternatives. An example following the proposed approach will be given in the next section.

6 Example: "Lend me"- plugin for online shopping webpages

In this section a simplified example of the proposed system is introduced to shine a light on possible applications and for clarification of the introduced conceptual architecture (see Fig. 3).

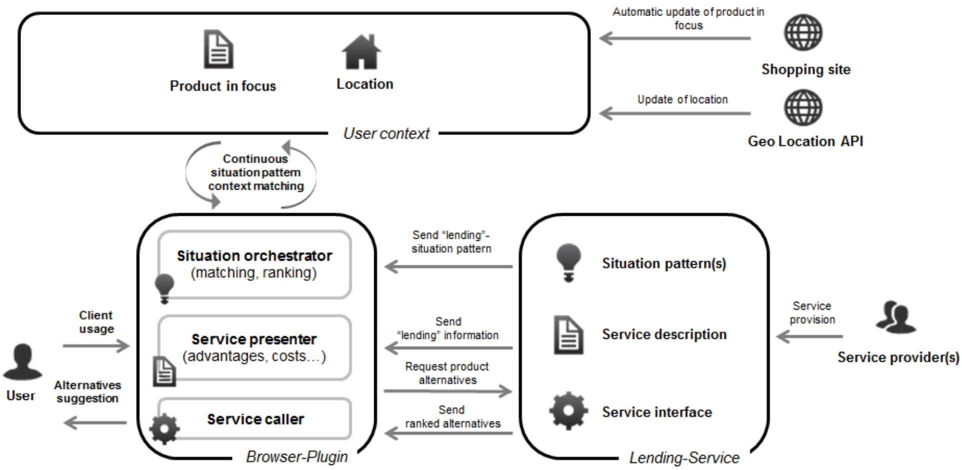

Fig. 3: Exemplary application of SALT

To reduce complexity, the presented example involves only one particular lending service. If several services were involved the question of how the services compete among each other regarding the ranking of appropriate offers would arise. Although this question is not answered yet, it's not in the focus of this publication, but an open issue to be addressed in our further research. The goal of the lending service is to provide the user with information about people who are willing to lend a product, which the user is intending to buy on an online shopping site. The client is therefore realized as a browser plugin, which annotates specific shopping websites with alternatives relevant for the user when the same is currently in an online shopping situation.

The task of the situation orchestrator is to recognize such a situation. Therefore the client-side browser plugin needs at least information about the product in focus, i.e. the current website, a unique product identifier (in this case the EAN, the European Article Number), the product class and the product price. On the other side, the lending service needs to provide situation patterns that can be supported by the service to find an appropriate matching. A simple matching solution based on semantic technologies in particular a rule-based system, is presented in the following. The JENA framework[3] and its included inference engine with a forward chaining RETE [Fo82] rule engine could be

[3] http://jena.apache.org

used to solve the matching. The following example is formalized in RDF[4] using the N3[5] notation.

```
Semantic context information (excerpt):
:c rdf:type :Context ;
  :currentWebsite :shoppingParadise .
:shoppingParadise rdf:type :Website ;
  :websiteType :shopping ;
  :websiteURL http://shoppingParadise.com .
:c :productInFocus :product .
:product rdf:type :Product ;
  "ABC Inc. cordless screwdriver" ;
  :class :consumerProduct ;
  :price 79.00 ;
  :currency :euro ;
  :ean 0123456789012 .

Semantic situation rules of lending service (simplified):
(?c rdf:type :Context), (?c :currentWebsite ?w),
(?w rdf:type :Website), (?w :websiteType :shopping),
(?p rdf:type :Product), (?c :productInFocus ?p),
(?p :class :consumerProduct), (?p :ean ?ean)
  -> service fits to context
```

The context, as described above, contains the information that the user is currently visiting a shopping website and thinking about buying a cordless screwdriver. The rules provided by the lending service are matching because the current context is checked for the user being on a shopping website and visiting a consumer product, which also provides the EAN, which is later on required to provide alternatives.

After a match between the situation pattern and the context is identified the service description of the service is presented via the service presenter, which can appear as an annotation on the shopping website.

Simultaneously the client requests the lending service to construct specific alternatives and embeds the context in this request. The lending service searches the database of the lending system provider for the product EAN and product class and extracts the people who are lending this product.

The next step is the ranking of this set of people, which can be done generally by computing a utility score for each person. A simple way to do this is using a weighted aggregation of different feature scores. For this system three feature scores are proposed, which follow the three dimensions of the sustainability triangle:

Environmental score: The spatial distance between the user and lender divided by the maximal distance between the user and a lender in the set of possible lenders.

[4] http://www.w3.org/standards/techs/rdf#w3c_all
[5] http://www.w3.org/TeamSubmission/n3/

Social score: The rating of this person for this kind of transactions divided by the maximal rating.

Economic score: The cost savings divided by the price of buying this product.

After ranking the alternatives in such a way, the lending service returns this ranking to the client. Finally the client presents the alternatives to the user, who can click on the different alternatives and gets forwarded directly to the lending offer.

7 Summary, challenges and future research

The goal of the paper was to introduce a new type of application in the field of Sustainable by ICT, namely the sustainable service and product alternatives system, the SALT system. Grounded on a psychological and social model of the transformation from intentions to behavior, a conceptual architecture was proposed and illustrated with the example of a browser plugin for the presentation of alternatives to the purchasing of goods in a web-based scenario.

As this paper is a work-in-progress paper, there are open issues, which will be addressed in subsequent work. Among others, a way to rank different services and a feedback mechanism to personalize the presented alternatives has to be developed, as well as the further development of the initial proposals in this paper. Furthermore topics like privacy issues, the usability and the way of presenting the alternatives have to be considered.

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