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Preface

This is a non-exhaustive selection of extended abstracts from talks and presentations at the **KSS Research Workshop: Designing the Digital Transformation** – held from September 21 to 22, 2017 in Karlsruhe, Germany.

The KSS Research Workshop was hosted by the Karlsruhe Service Research Institute (KSRI) to provide a service innovation hub for researchers and practitioners in the fields of business engineering, economics, computer science, information systems, operations research, logistics, and social sciences. The objective of the third KSS Research Workshop was to foster academic and interdisciplinary collaboration and discourse amongst different generations of researchers from the field of service science.

We would like to thank all authors who submitted and presented their work at the KSS Research Workshop on Designing the Digital Transformation. Furthermore, we would like to thank all members of the program committee as well as the Karlsruhe Institute of Technology (KIT) which made the publication of this research possible. We believe that this collection provides interesting insights into research on digitalization and hope that readers will find it as interesting and insightful as we do.

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The EEG-attention cycle and the diffusion of solar energy technologies

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Abstract. The paper addresses the interrelation between renewable energy policy, technology diffusion and public acceptance as it is assessable via newspaper articles as a proxy. Additionally, governmental publications are analyzed. It is found that media coverage of the German renewable energy act follows an issue-attention cycle and that technology diffusion is strongly correlated with the frequency of media coverage.

Keywords: Energy technology diffusion, Issue-attention cycles, Content analysis, Media/Newspaper.

1 Introduction

Since the German renewable energy act (Erneuerbare-Energien-Gesetz; EEG) was implemented in the year 2000, Germany has seen a successful market uptake of solar energy technologies, specifically photovoltaics (PV). During this period, the EEG got amended several times in reaction to the (surprising) success in supporting individual investment decisions. At the same time, German PV-cell producing companies experienced a strong boom preceding the collapse of the entire PV producing sector in Germany. After a period of slower development, new technologies as solar battery storage and new regulations as the possibility for landlords to sell self-produced PV power to tenants [1] might lead to another upsurge in PV installations, a new demand for electricity services and further challenges to traditional utilities.

The paper at hand is attempting to shed light onto the interaction of policy changes, the diffusion of PV and public perceptions mediating between adopters and policy makers. A link is drawn between socio-political and market acceptance contributing to social acceptance research [2]. Research on policy driving technology diffusion in the energy sector [3] is complemented with a quantitative view of public perception. In this paper, firstly, an overview of media effects research and innovation diffusion is given (Section 2) followed by a quantitative analysis of the media coverage of the EEG and PV, complemented with a qualitative review of governmental publications supplementing the legislation process (Sections 3 and 4). It closes with a short discussion and outlook to future research (Section 5).

2 Media effects and innovation diffusion

The functions of mass media in a social system are manifold: mass media has social, political, economic and informational functions [4]. Mass media transports social norms, offers a virtual space to discuss political opinions and positions, contributes to the circulation of goods and submits previously unknown information [5]. Theories concerned with the effects of mass media include the Agenda-setting approach [5, 6] which hypothesizes that media determines which topics are discussed in public. Media *frames* different topics by discussing a message in a certain context providing an interpretation of the underlying issue [7]. *Priming* is based on psychological concepts: the reception and processing of information leaves “memory traces” and makes those issues more accessible to the individual [8]. Downs [9] conjectures that public opinion reacts to societal issues in different stages ranging from enthusiasm over the realization of costs solving the issue towards a phase of declining interest. The issue-attention cycle coincides with policy addressing the problem and interacts with public opinion.

On the other hand side, Rogers [10] describes the diffusion (accumulated adoption) of innovations as a process, in which communication between the adopting individuals plays a major role. The communication is transported via two communication channels. Firstly, mass media can create knowledge and information and lead to changes in attitudes [10, p. 198]. The second channel is interpersonal exchange which involves direct interaction between individuals. They are argued to play a bigger role in later stages of the decision process, while mass media can raise awareness and provide information. Furthermore, Rogers goes on to postulate that communication flows are often transferred via opinion leaders who are more exposed to media information [10, p. 272ff].

The vast literature stream of media effects research and diffusion of innovations cannot adequately be covered at this place. However, the authors hope that the evidence provided up to here convinces the reader of the various relationships between media coverage of a certain topic and the diffusion of innovations.

As was pointed out also by [11], the public acceptance of a technology thus not only crucially depends on public opinion, but also on the generated narratives and the ways how reality is perceived, even constructed.

3 Methodology

The methods applied in this study where twofold. To assess the public discourse on the EEG and photovoltaics, the frequency of publications was analyzed. Accompanying the frequency analysis, a review of governmental publications was undertaken.

The data base *Nexis* was used to access the German language media coverage of the time period from 2000 to 2016 [12]. The database contains regional and national newspapers, as well as online publications of the most relevant publishers (e.g. Spiegel Online). Since a goal of this study was a comprehensive overview of media coverage of the EEG and the impulses that might have reached potential PV-adopters, it was decided to draw from all the German media available in the database.

This choice might face one critique: the database does not cover all newspapers from 2000 onwards. A few newspapers are only covered from 2009 onwards. This critique can be answered as follows: the number of articles is not increasing over proportionally in the year 2009. The subsequent growth of the number of articles after 2009 is in line with the growth beforehand. For these reasons, it is assumed that this inconsistency in the database has no severe impact on our findings. Searching only within newspapers that were recorded in the database over the whole period, essentially revealed the same attention structure.

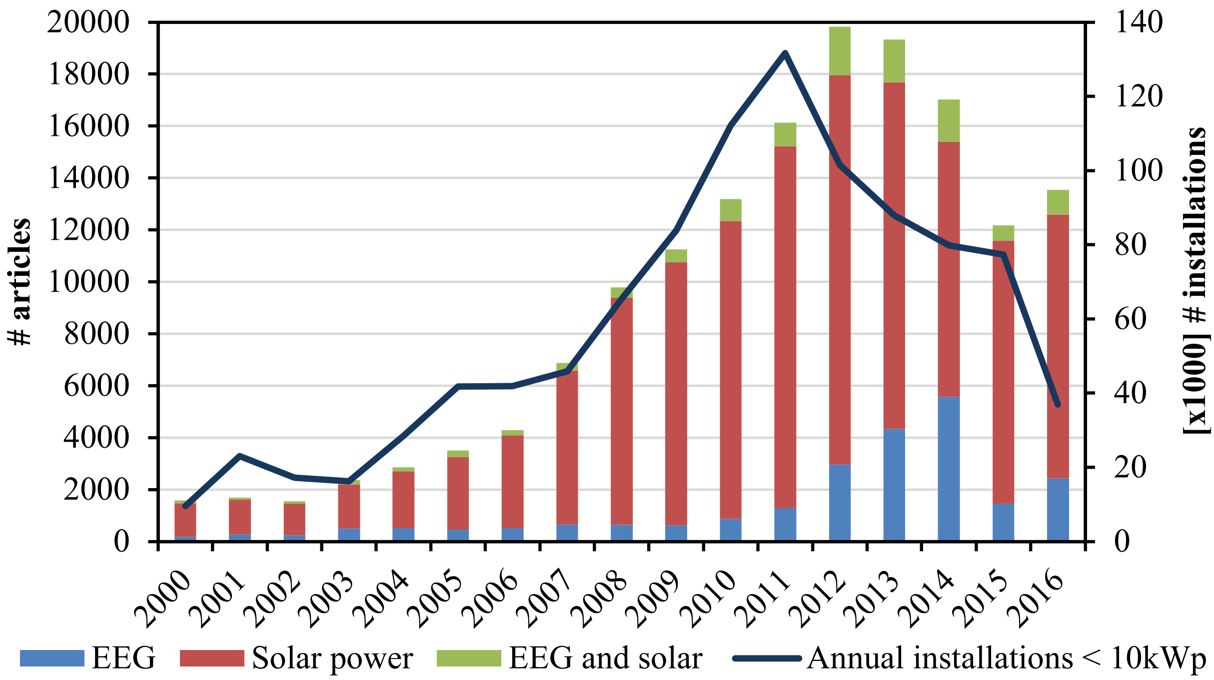
The three categories of interest *solar*, *EEG* and *solar battery storage* were defined, prepared and tested as queries to the database including the various synonyms of the three concepts.

In the analysis, by "*EEG or solar*" we refer to articles containing one or both of the concepts. "*EEG and solar*" refers to only those articles that contain information on both concepts. "*Only solar/EEG*" refers to search results containing **only** the named concept. The research approach followed mainly [13]. Additionally, political decisions and related governmental publications where assessed in order to supplement the frequency data with qualitative insights of the changes in the EEG policy regime and to underline the similarity to Downs' issue-attention cycles [9].

4 Results

Fig. 1 shows the media coverage and the annual installations since the year 2000 in which the EEG became effective. Similar to the installations, media coverage remains on a low level in the first years. Most of the articles cover solar power detached from the EEG support scheme. Rogers characterizes early adopters of innovations as having a high affinity towards media [10]. Thus, even if coverage is low, information might have been provided to them on this channel.

Fig. 1. Media coverage and annual installations of solar power [12, 16]



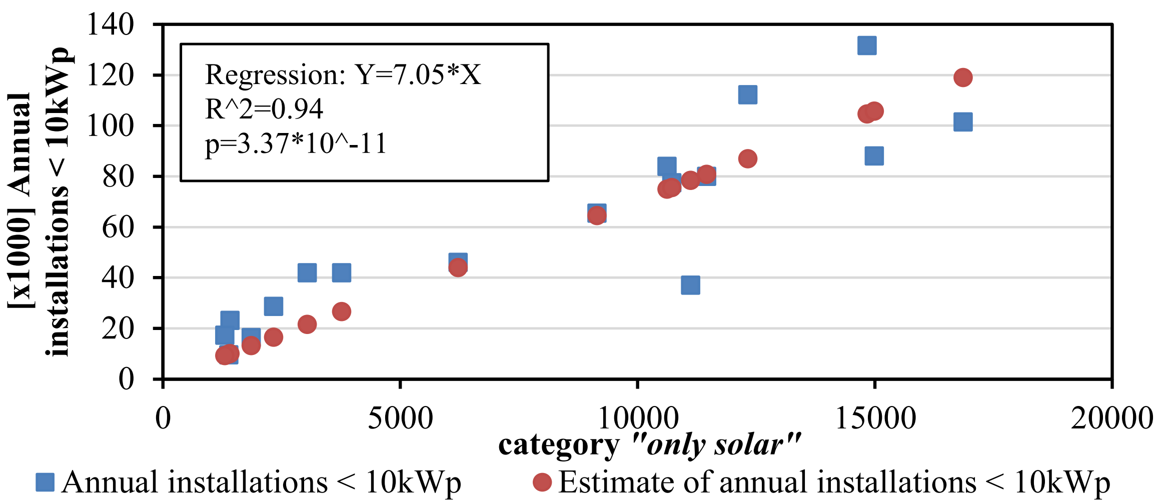
Heras-Saizarbitoria et al. [11] hypothesize that in the case of renewable energies, policy change is driving media attention. Those findings are confirmed by the fact that the first increase of coverage in the observed period falls into the years of 2003 and 2004, when the

"100,000-roofs program" [14] faded out and the first EEG amendment proclaimed RES targets, raised the Feed-in Tariff (FiT) for 2004 and determined a degression rate of the FiT of 5 % per year [15].

While the pace of diffusion is picking up from 2007 onwards, also the total amount of articles is growing rapidly. In the years 2009 and 2010, the EEG is amended twice, leading to an increased coverage of the EEG and solar. The EEG amendment 2012 introduced new RES targets, a monthly FiT regression and a cap on yearly added solar capacity [17]. It is only after 2013 that the media coverage on "*EEG or solar*" declines again, while installations slow down. At the same time, the EEG is increasingly discussed, articles on the "*only EEG*" and "*EEG and solar*" increase until attention drops rapidly after the amendment of 2014, the "relaunch of the Energiewende" [18] acknowledging the growing pressure onto grid stability and the rising EEG-levy [18].

The frequency of the media coverage in the time period of 2000 to 2016 exhibits the patterns of a long issue-attention cycle [9] similar to the ones found in the British farming press on RES [19]. Evidence for the different stages of issue-attention cycles is also found in the review of government publications supplementing the EEG amendments. Following the enthusiasm of the first years, the realization (*and framing*) of costs is noticeable (amendment 2014). The decline of interest indicated by the decrease of media attention in the years after 2014 indicates Downs' [9] "post-problem" phase towards the EEG amendment of 2016.

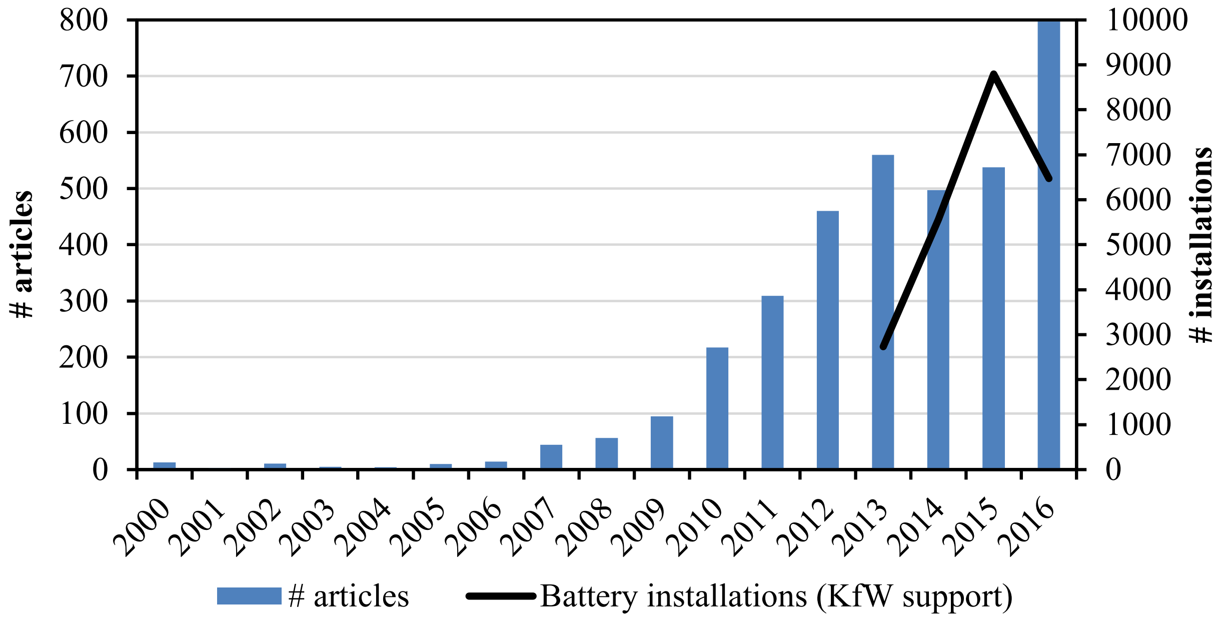
Fig. 2. Regression analysis: Annual installations as dependent variable, explained by the articles covering *only solar* (depicted in red in **Fig. 1**)



The close interconnection of media coverage and PV installations is also reflected in high correlation coefficients. The number of yearly installations highly correlates with "*EEG and solar*" with a coefficient of ρ=0.81 (Spearman, significance $p = 9.09 * 10^{-5}$) and even higher with the number of articles containing the term of *"solar power"* (ρ=0.9). An econometric modelling exercise proves the close connection between the variables as well (see **Fig. 2**).

The particularly high number of articles on solar power is explained by the fact that solar power is not necessarily the main topic of the analyzed article. Solar power might be mentioned in a different context than the EEG support scheme. Nonetheless, the increase of references to solar power is striking. In comparison, articles in the category "*EEG and solar*" are mostly discussing the topics of interest as a central theme as the two search concepts limit the scope adequately.

Fig. 3. Number of articles mentioning solar battery storage and number of installations [12, 21]



As the economic driver of residential and SME solar installations shifts from the FiT towards self-consumption as grid parity of solar power is reached since 2012, a new technology comes to the fore. The German development bank *Kreditanstalt für Wiederaufbau* (KfW) is supporting the adoption of solar battery systems with low interest loans and investment subsidies [20]. Very recently, adoptions have taken up speed (**Fig. 3**). At the same time, an increasing number of articles mention solar battery storages. The public discourse is picking up especially after 2015 and the beginning of 2016, when for a short time the support program was suspended and debated intensely [21]. It is estimated, that the actual level of diffusion of solar battery systems is as much as twice as high as the KfW data suggests due to the non-registration of not-supported systems [22].

5 Discussion and outlook

The main results of this research are the insights that could have been drawn into the interplay between policy, diffusion of technology and the mass media in its literally role as a mediator. It was shown that the attention towards technology and policy goes along with the adoption choices made. Evidence for a long term issue-attention cycle was gathered. From these results, a general connection or theory of policy driven technology diffusion can be conjectured.

Additionally, a look ahead was casted how the diffusion of solar battery storage could foster a new wave of PV installations. Batteries play a major role to circumvent the customer's issues of self-consumption and the connected necessity of habit change in electricity usage [23].

Nonetheless, the findings leave much space for further research. Future research can analyze the public discourse by assessing media coverage qualitatively. Such research can ultimately prove the hypothesis of the issue-attention cycle and lead to a deeper understanding of the public debate and public acceptance or rejection of technology. Framing and priming effects might hinder the uptake of technologies.

Conclusively, we would like to empathize that the described processes are correlated which should not lead to premature conclusions on causality. Policy making, public discourse and technology are strongly interdependent which makes conclusions to causality difficult.

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Introducing an energy flexibility indicator and evaluating an industrial energy storage system

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Abstract. An industrial energy storage system presents unique opportunities to profit from various energy flexibility markets. Aggregators operating an energy storage system on different industrial sites can co-create profits through different flexibility options. In order to properly assess the effectiveness of initiated flexibility measures a flexibility indicator is required. In this paper, we postulate two indicators, $flex_{Imp}$ and $flex_{Pot}$, to evaluate the flexibility increase with a storage system and to determine the economic value of such a system. Further, we apply these indicators in an energy optimization model and combine five industrial load profiles with four different battery sizes to analyze them against a set of random flexibility prices.

Keywords: Energy Flexibility, Indicator, Industry, Battery Storage System, Optimization, Aggregator

1 Introduction

The imbalance between producers and consumers in the German energy system has grown over the past years as more renewable energy sources have come on-line. This calls for several integration measures, including more flexible energy demand and supply [1]. Today's energy and power markets offer various flexibility products, including balancing power, intraday and day-ahead trading [2-5], and two-party agreements between a large consumer and a grid operator [6].

Because of its high energy demand, industry can profit from these flexibility product by implementing demand side management (DSM). Many researchers have analyzed the potential of DSM in industry [7]. To tap this potential, one must generally intervene in production process(es), however, which often represents an insurmountable barrier. Another way to increase flexibility is to combine a production process with a battery storage system (BSS).

Such industrial energy storage systems (IESS) allow temporal decoupling of supply and demand, and thus permit industrial companies to meet the pre-requisites for selling flexibility on the above markets. Here, flexibility market participants must have available a critical amount of energy demand or power production and power storage capability[1]. To achieve this critical size, aggregators can combine different IESSs, which creates value for both the aggregator and the industrial company. Both can profit from flexibility marketing on the spot market or the balancing power market, and the company gains some independence from volatile energy prices

In the literature, researchers have introduced several flexibility indicators to characterize different flexibility measures. Existing indicators found in [8] and [9] focus on the technological potential without considering the systemic service. [8] extends the flexibility quantification method of [10] and is more suited to ex-ante characterization of a system. Moreover, its indicators are highly complex, since they consider not only energy flexibility, but other dimensions as well. Against this backdrop, we introduce here an indicator to evaluate the flexibility provided by a BSS and validate it in the industrial context. For both the aggregator and the industrial company, the indicator is a useful and easy to apply proof of the flexibility concept that can be used to supplement the purely economic results. As an ex-post evaluation tool, it shows how energy flexibility has increased and to what degree the potential has been exploited, given the underlying economic framework. The indicator shows the effectiveness of different markets to incentivize industry to offer higher electric flexibility.

2 Two flexibility indicators, $flex_{Imp}$ and $flex_{Pot}$

The flexibility indicator, *flex*, aims to evaluate the effectiveness of energy flexibility measures. One of the roles of *flex* is to compare different marketing strategies of flexibilities. Considering that an aggregator runs an IESS, it is of a special interest to the industrial company to compare the situation before and after the installation of an IESS. Therefore, we postulate the following definition, equation (1), of a flexibility indicator of improvement,

[1] For example, to offer primary balancing power participants can offer the provision of power in discrete 1 MW steps.

$flex_{Imp}$. As explained later, the $flex_{Imp}$ cannot fully display the potential of an IESS. Therefore, we added a second indicator, $flex_{Pot}$, defined in equation (2). For both indicators we consider two cases of flexibility, positive and negative . This aligns with the definition for the German balancing power market. The two cases are represented by positive and negative prices, c_{flex}. In the positive case, there exist an undersupply of power in the electricity system. The IESS can provide positive flexibility through reducing the power demand from the grid and satisfy the production load through power from the BSS and not the grid. In the negative case, there exists an oversupply of power in the electricity system. The IESS can provide negative flexibility through increasing the demand from the grid and charge the BSS. To illustrate the flexibility indicator, Fig. 1 shows the graphical model and helps to define the parameters of the indicator. The production demand $\tilde{P}$ is either covered by power directly from the grid, P^*, or power from the BSS, $P_{BS,Prod}$. The BSS power is limited by its power capability $P_{BS\,max}$. The BSS is charged by power from the grid, $P_{BS,Grid}$. The total amount of power drawn from the grid is P_{grid}, which combines the power flowing to the production and charging the BSS.

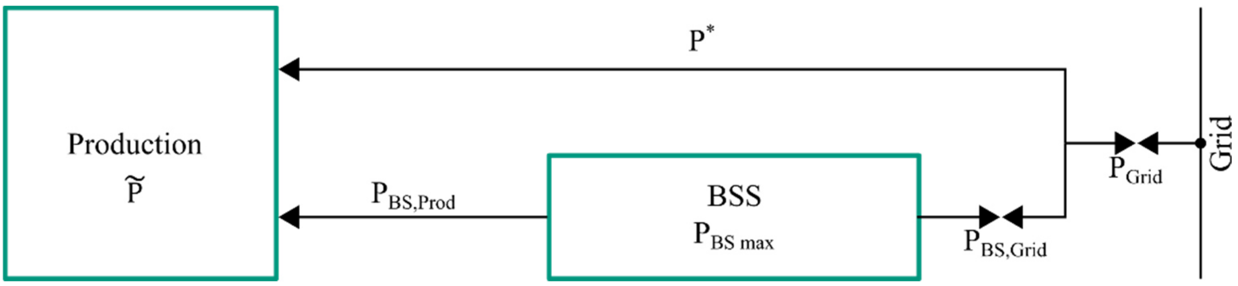

Fig. 1. The industrial energy storage system model

2.1 Flexibility improvement indicator, $flex_{Imp}$

The flex_Imp is intended to show how the installation of a BSS changes the load of the production demanded from the grid and how this increases the flexibility . The reference power value is P˜ which equals the load on the grid before the installation of a BSS. Table 1 considers the essential cases. A flex_Imp of 0% implies that no flexibility is provided. 100% indicates that the production is now 100% more flexible than before the use of a storage system. Negative values imply that the IESS increases the imbalance between power demand and supply in the electricity system.

$$flex_{Imp} = \begin{cases} \frac{\tilde{P}-\mathrm{P_{Grid}}}{\tilde{P}} & , c_{flex} \geq 0 \\ \frac{\tilde{P}-\mathrm{P_{Grid}}}{\tilde{P}} \cdot (-1) & , c_{flex} < 0 \end{cases} \quad (1)$$

The same definition can be applied to the case of $c_{flex} < 0$. However, the informative value is limited[2]. Having $\tilde{P}$ as the reference value, the indicator shows by how many percent the installation of a BSS increases the demand[3]. Furthermore, the flexibility improvement indicated depends on the ratio between the production load and battery size.

Table 1. Different cases of positive flexibility provision

1	$\tilde{P} = P_{Grid}$	$flex_{Imp} = 0$	No flexibility provided
2	$\tilde{P} > P_{Grid} = 0$	$flex_{Imp} = 1$	Production load covered by BSS
3	$\tilde{P} > P_{Grid} > 0$	$0 < flex_{Imp} < 1$	Production load partly covered by BSS

2.2 Flexibility potential indicator, $flex_{Pot}$

To quantify the used flexibility potential we introduce a second indicator, $flex_{Pot}$:

$$flex_{Pot} = \begin{cases} \frac{\tilde{P}-P_{Grid}}{P_{BS\,max}} & , c_{flex} \geq 0 \\ \frac{\tilde{P}-P_{Grid}}{P_{BS\,max}} \cdot (-1) & , c_{flex} < 0 \end{cases} \quad (2)$$

Thereby, the indicator compares the provided flexibility to the maximum possible flexibility[4]. In case of the IESS, the potential flexibility is the same as the maximum power capability of the BSS. 100% indicates that the full potential of the BSS is used to provide flexibility.

[2] For further understanding, see the results for s a single day in the appendix A4.
[3] It needs to be discussed further if the reference value is suitable to describe the percentage of flexibility increase.
[4] $P_{Grid} > 0$, power flow from the grid. $P_{Grid} < 0$, power flow into the grid.

3 Preliminary results: $flex_{Imp}$ and $flex_{Pot}$ for five industry cases

We constructed random prices for flexibility between -130 €/MWh and 130 €/MWh[5]. Thereby, we can demonstrate an alternating need for positive and negative flexibility on the grid level. Allocating the prices between 0 and 130 weights the importance for a flexible energy demand for each time slot. We then compared the load of five anonymous manufacturing companies in Germany for the month of May 2016. The peak loads of the companies are between 0.5 MW and 10.1 MW[6]. The yearly energy consumption ranges from 12.5 MWh until 1,286 MWh. To demonstrate the effect of the battery size relative to the peak load we optimized the load profiles for four different battery capacities, 250 kWh, 500 kWh, 1000 kWh and 2000 kWh. In accordance to this, the power capability is set at 250 kW, 500 kW, 1000 kW and 2000 kW.

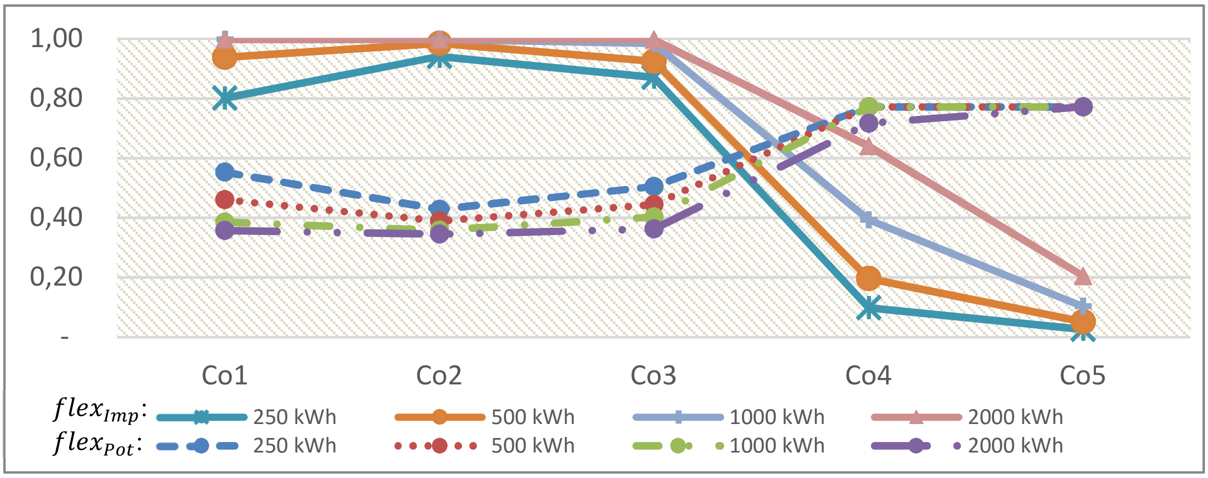

Fig. 2. Mean positive $flex_{Imp}$ and mean total $flex_{Pot}$ for the five different industry cases in order of increasing peak demand for different battery capacities.

The different industry cases revealed different results. Fig. 2 shows the mean $flex_{Imp}$ for the five industry cases with the different battery capacities for positive flexibility prices. Additionally, the dashed and dotted lines show the mean total $flex_{Pot}$, which includes positive and negative flexibilities. The $flex_{Imp}$ shows how the positive energy flexibility increases through the installation of the BSS. For the cases Co1 to Co3 the flexibility has improved

[5] These price limits are based on the spot market prices for May 2016. The prices are randomly allocated within these boundaries, the real distribution has not been considered. For the proof of the abstract concept, we consider such random prices as sufficient.

[6] For a detailed table on the peak load of the companies see appendix A2.

between 80% and 100%. Simultaneously, the full potential, $flex_{Pot}$, barely surpasses 50%. This indicates that the BSS is covering most parts of the production load but the battery's capacity is only exploited up to 55%[7].

It can be observed that the $flex_{Imp}$ depends on the ratio of production load to battery size. A small battery can only cover small parts of a high production load. Considering the cases Co1 to Co3 this relationship does not hold. Although Co3 has a peak demand twice as high and a 20% higher energy consumption, the BSS is still covering a higher share of the production load compared to the case Co1. This shows that the flexibility of an industrial company is strongly linked to the fit between production load profile and the grid's flexibility demand profile. This is interesting for reserve market cases where only the capacity but not the energy price is paid. Furthermore, it can be observed that negative values for $flex_{Imp}$ and $flex_{Pot}$ are a regular occurrence. As the model is minimizing the system cost, it is focusing on fully exploiting time slots of high flexibility prices. Thus, a weighted indicator, for example according to the price level, needs to be developed for a future analysis.

4 Conclusion and outlook

The two postulated indicators $flex_{Imp}$ and $flex_{Pot}$ are well suited to evaluate the effectiveness of flexibility measures in industry. The first describes how strongly the production load can be reduced and indicates how well a production profile fits a positive flexibility demand profile. The latter evaluates the effectiveness of the installed BSS and can represent negative flexibility demand as well. In our study, the flexibility prices c_{flex} resemble the systemic value of an energy flexibility measure. The results show that the IESS model considers these prices and creates negative $flex$-values in time slots of low flexibility prices in order to exploit time slots of high prices. This has a negative impact on the mean $flex$-indicator. For future research, a high flexibility demand or critical time slots for the stability of the grid need to be weighted and integrated into the indicator.

To evaluate the effectiveness and implications of the indicator further, the model needs to be extended to a greater number of industry cases and battery size combinations. Especially

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[7] Results of the $flex_{Pot}$ analysis are discussed further in the appendix A3.

in the case of positive flexibility, the interactions of various production load and flexibility demand profiles in combination with different battery sizes are interesting to investigate, as the BSS covers the production's energy demand. Furthermore, the flexibility markets need to be depicted in more detail and closer to reality. The questions of how minimum bid sizes on the energy market, special prerequisites on the balancing control market and the operation through an aggregator influence the results need to be answered in future studies. Eventually, it is interesting to study to what degree the proposed indicators are applicable to other storage technologies.

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Appendix

A1 Energy model for an industrial energy storage system

To illustrate the *flex* indicator we modeled a simple IESS and optimized the energy dispatch plan of the BSS for one month in 2016 in 15-minutes-time slots. The power flows in the system are graphically explained in **Fig. 1** on page 3.

$$\min_{t} cost = \sum_{t=1}^{2688} \left(P_{grid}(t) \cdot c_{el} - \left((\tilde{P}(t) - P_{grid}(t)\right) \cdot c_{flex}(t)\right) \cdot \frac{1}{4} \quad (3)$$

s.t.
$$\tilde{P}(t) = P^{*}(t) + P_{BS,Prod}(t) \quad (4)$$

$$P_{grid}(t) = P^{*}(t) + P_{BS,Grid}(t) \quad (5)$$

The objective function, equation (3), is the energy cost minimization of the production. The power for the production ($\tilde{P}$) can either be supplied directly by the grid (P^*) or by the BSS ($P_{BS,Prod}$), equation (4). This price alternates for every time slot. The power provided to or drawn from the grid (P_{grid}) represents the amount of flexibility and combines the power flowing directly from the grid to the production and the power that charges the BSS, equation (5). Further constraints are not shown for brevity, but are briefly mentioned here. The capacity of the BSS (Cap_{BSS}) restricts the amount of energy that can be stored within and the power capability ($P_{BS\ max}$) limits the charging and discharging power of the BSS. The energy to power ration of the BSS is 1:1. c_{el} is the energy price for energy from the grid, 0.15 €/kWh. Additional revenue can be created by providing flexibility at the price of c_{flex}. A negative price, $c_{flex} < 0$, implies that there is an energy oversupply in the grid and the market is paying a premium for anyone who is willing and able to absorb additional energy through an increased demand. In the IESS, this means the BSS is charging. A positive price, $c_{flex} > 0$, indicates an undersupply of energy in the grid and a premium is payed for anyone willing and able to decrease their demand or provide additional energy to the grid. In the IESS this means, that the BSS is providing parts of the energy needed in the production and might even discharge into the grid. A flex price of zero, $c_{flex} = 0$, indicates that the grid is balanced and no flexibility is needed.

A2 Industry data

Table 2 shows the peak load of the five manufacturing companies. We considered Co1 and Co2 as they present a similar peak load level but a different total energy consumption during the one considered month. Evaluating Co3 is interesting as it shows a similar energy consumption as Co1 but more than double the peak load. We included Co4 and Co5 to analyzing the differences of higher peak load and total energy consumption.

Table 2. Peak load of the five manufacturing companies in MW

Company No.	Co1	Co2	Co3	Co4	Co5
Peak load in MW	0.45	0.53	1.08	6.60	10.12
Energy total in MWh	26.5	12.5	30.3	473.2	1286.1

A3 $flex_{Pot}$ analysis

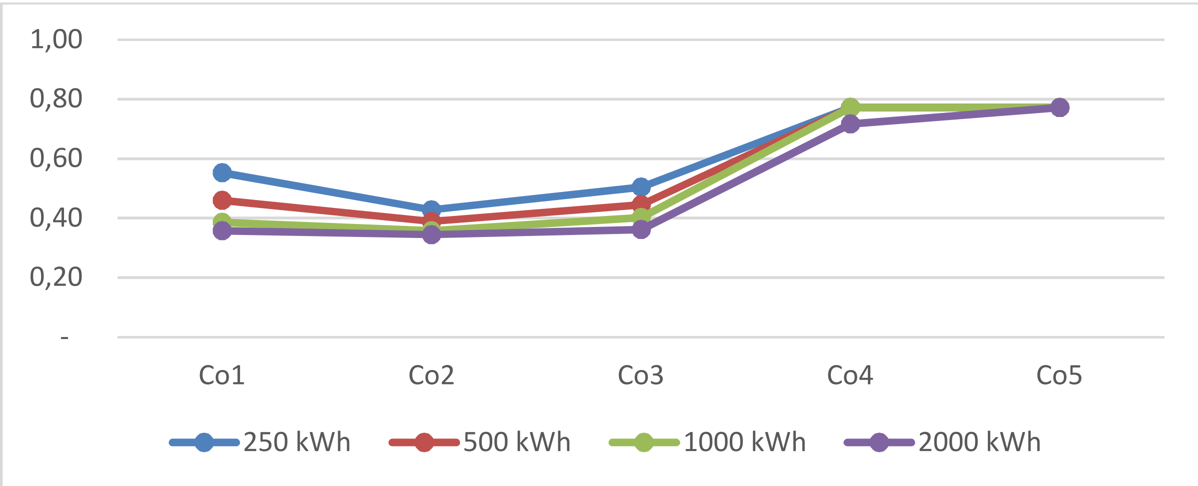

Fig. 3. Mean $flex_{Pot}$ in order of increasing peak demand for different battery sizes

It is interesting to observe that the mean $flex_{Pot}$ is not reaching 100%. This is because the utilization of the full technological potential does not resemble the economic maximum. Especially for the cases Co4 and Co 5 the model uses time slots of negative flexibility prices to charge the battery and supply the production with power from the BSS in times of positive prices. For the most of the industry cases, the indicator also shows that a bigger storage system does not increase utilization of the BSS potential. The mean $flex_{Pot}$ indicates the overall flexibility performance, but the time slots of extreme flexibility prices need to be considered as they theoretically indicate times of high stress in the grid. For example, in case Co1 for the 10% highest flexibility prices the $flex_{Pot}$ equals to 78%. For the 1% highest prices, it goes up until 86%. A weighted indicator needs to be considered for future research.

A4 $flex_{Imp}$: Time-dependent analysis

To get a deeper understanding on how the model and the indicator work, **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the development of the $flex_{imp}$ for one day, first Wednesday in May, in a 15-min resolution. The considered battery capacity is 250 kWh and the power capability is 250 kW. To understand the interdependencies between the price for flexibility, c_{flex}, the production load and the state of charge of the BSS, there depicted in the graph simultaneously. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the advantages and short comings of the proposed indicator $flex_{Imp}$.

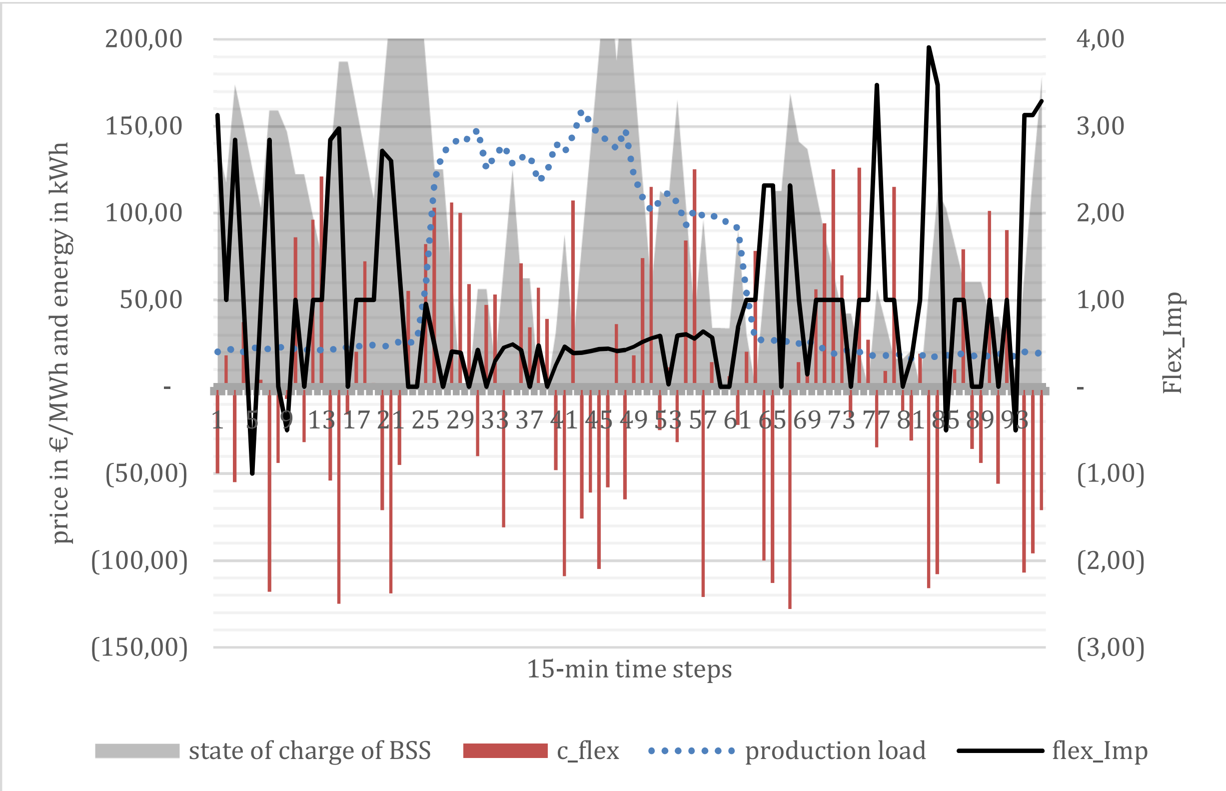

Fig. 4. : Time-dependent$flex_{Imp}$, first Wednesday in May 2016, for a BSS with a capacity of 250 kWh and a power capability of 250 kW

During many time slots, the $flex_{Imp}$ takes values greater than 1. This indicates that the IESS is providing 100% more flexibility than before the installation of a BSS. As we can see in the first 25 time-slots, this only occurs in times where the IESS is providing negative flexibility. During these times, the BSS is charging and drawing additional energy from the grid. A higher battery capacity and a higher power capability lead to a higher $flex_{Imp}$ for negative flexibility. The influence of the battery size is even greater in case of low initial production load. Theoretically, $flex_{Imp}$ values greater than 1 in times of positive flexibility are possible as well. Due to the prices, the model tries to satisfy the production load by the stored energy from the battery. Thereby, the IESS can avoid regular energy charges and profit from flexibility revenues. The IESS is reluctant to feed energy into the grid as it aiming to utilize the stored energy in its own production process. For other company cases and battery sizes, values greater than 1 in the case of positive flexibility can be observed. Therefore, the ratio between battery capacity and production load need to be considered carefully. To derive conlcusions to what extend the potential of the BSS is exploited one need to look at the $flex_{Pot}$-Indicator.

The values of $flex_{Imp}$ are modest in times of a higher production load and range between 0 and 1, to be observed in the time slots between 25 and 61. In this time, the IESS is capable to utilize its capacity completely to satisfy the production in load. We can observe that the BSS is fully discharging. This occurs during times of positive flexibility demand. Furthermore, we observe negative values of $flex_{Imp}$ during five occasions. In these cases, the model is working against the demand of the flexibility market. The prices indicate a need for negative flexibility, but the IESS is feeding its stored energy into the production and thereby providing positive flexibility. This is a model decision because of low flexibility prices in these times and the overall objective to minimize cost. As a result, we can deduce that the effectivity of an IESS to provide flexibility is linked strongly to the load profile of the production and the price profile for flexibility.

A Framework for Electric Mobility Services for a Car Park

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Abstract.

Electric vehicles (EV) are seen as one promising technology which can provide flexibility to the demand side in the electricity market. One promising application might be a car park where an operator schedules the charging processes of EV.

This paper outlines a conceptual framework to enhance this demand side flexibility of EV customers with incentives through diverse service designs. Thereby, the development of a business model takes both sides into account: the offset between cost and benefits for the operator as well as tariffs with attractive incentives for customers. We focus in the following on a car park and give a comprehensive outline on the design of services for different groups of EV customers.

Keywords: EV fleets, mobility services, car park operator.

1 Introduction and background

Currently, grid stability is primarily provided by the conventional supply side. However, due to an increasing uncertainty and volatility of renewable energy sources (RES) an arising probability of imbalances exists which could be offset through demand side flexibilities. The idea of scheduling the charging of electric vehicles (EV) when RES are available increases both, the environmental advantages of EV and the reliability of the electricity system. There is already a broad literature on this issue [1]. New business model may foster the value for customers and therefore increase the willingness to provide load shifts.

So far, several studies focus on the possible flexibilities of EV in the grid regarding the supply side. Most studies assume that a certain amount of EV will be managed by an aggregator and hence existing flexibilities could be offered at an energy market (which is linked to an independent system operator (ISO)) to e.g. reduce peak load or provide ancillary service

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etc. (e.g. [2]) A car park operator is such an intermediate operator – acting as an aggregator – being the interface between supply and demand (see Figure 1).

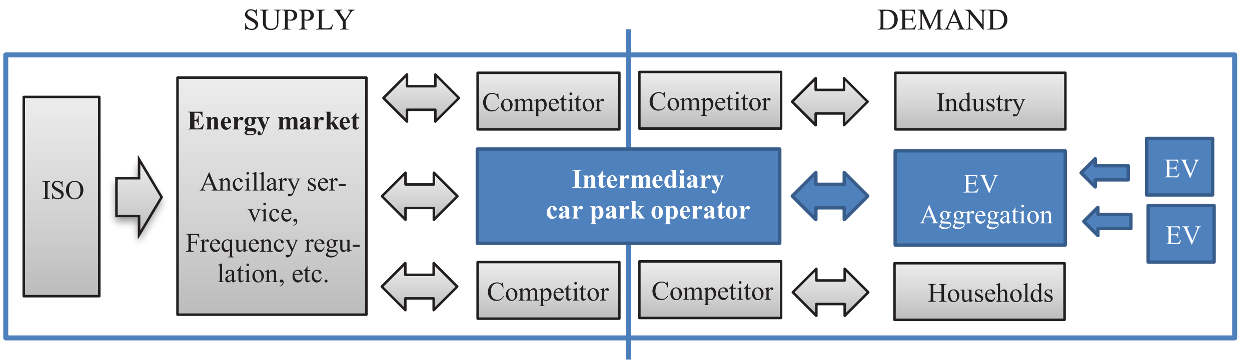

Figure 1: Concept of the market participation of a car park operator based on [3]

The purpose of this paper is to focus on the demand side flexibilities through EV aggregation in the context of a car park. It studies possible service designs which can be offered from a car park operator point of view to their different groups of EV customers to enhance their flexibilities and address incentives. Especially, as reasonable business models are needed to increase the profitability of charging stations.

After a brief overview of relevant related work, Section 3 gives insights of a conceptual framework for electric mobility services in the context of a car park operator. Afterwards, Section 4 ends the paper with a conclusion and an outlook on future work.

2 Related Work

A holistic approach for business models for EV can be found in Kley et al. (2011) [4]. Further development of more specific frameworks exists, e.g. for the design of energy services for customer [5] or for electric mobility services around the usage of EV [6]. These studies use the morphological box as a methodology approach to systematizing the developed business models and the including possible solutions. Another study designed a conceptual framework for various services provided by EV [7].

Methodologies for business models in the context of EV charging infrastructure was analyzed by Madina et al. (2016) [8]. They have a closer look at three different charging locations – at home, highway, semi-public. The latter one can be referred to charging in a car park in which they found out that for profitable reasons a higher usage of the charging stations is relevant. Another finding of their work was that charging at home seems to be the preferred solution with respect to total cost of ownership. Other qualitative business models in the context of EV are e.g. [9], [10].

Salah and Flath (2016) apply a deadline differentiated pricing scheme in the context of a car park to incentivize flexible loads. They identify that price levels are driven by the cost of conventional generation [11]. Brand et al. (2017) investigate a business model in the case of a car park using aggregated EV load to facilitate reserve energy. Their findings with respect to revenues imply that they are very little in comparison to investment costs for IT infrastructure and charging. Hence, associated business models require a closer look to derive robust implications [3].

This paper extends the literature by a detailed look at service design for different groups of EV car park customer to foster their demand side flexibility. This is set into the context of the development of a conceptual business model framework for the demand side perspective in the market for a car park operator that takes the role of an EV aggregator.

3 Business model approach

According to Osterwalder et al. (2005) a business model describes a conceptual tool which contains a set of elements and the respective relationships to represent the business logic of a firm [12]. Bringing this into our context different design possibilities need to be considered when a car park operator evaluates the possible tariffs. The main leverages are provided through flexibility by customers and the corresponding incentives.

Looking at the possible service design in the context of customer flexibility of a car park several aspects need to be considered. Parking is for the most EV customer a necessary process where not too many options should be provided to reduce complexity. However, it should be distinguished between the different types of customer. If one-time appearances or short-term customers (e.g. parking for shopping or leisure time) are considered it’s unlikely that they have a lot of flexibility to offer as their idle time is about 1h to 3h in average depending on the car park or do not provide a regularly projectable demand [13]. In contrast, a recurring customer has the advantage that this demand might be better projectable by a car park operator. Additionally, long-time customer who might have a parking duration of up to

9 h during a day might have more flexibility [13]. Service levels could be dependent on the customer. The more flexibility regarding the load management is offered by an EV customer the more variation exists for the service level which goes together with the complexity of the respective tariffs (see Figure 2).

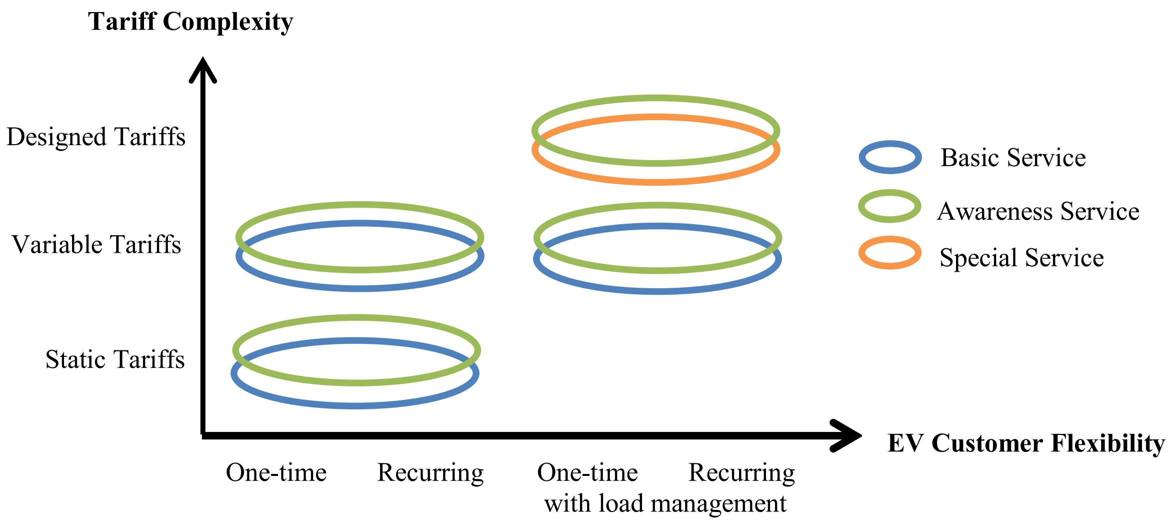

Figure 2: Possible service designs in the context of customer flexibility and tariff complexity for EV car park customers

A static tariff implies fixed rates for charging which could be daily, monthly or per usage. Under variable tariffs, the car park operator could adapt to varying prices as they change over the course of time. Moreover, a linear price concept regarding the energy amount used could be another option in this setting. Additionally, special premium prices for high priority and high demand customer requirements could be included. With load management, a more specific charging is possible, e.g. real-time pricing for the variable tariffs. These concepts are related to different versions of the 'basic service' for customers.

The latter concept of 'designed tariffs' has the prerequisite, that with load management flexible goals could be achieved for the customers. The 'special service' offers an even more selectable version, e.g. customers can give a range for the required energy at the end of a charging process or peak-demand reduction. The customer awareness of aspects like green and RES should be considered for all options. It is possible that customers would change their charging behavior and have a higher cost sensitivity regarding offered price concepts. Therefore, for each service is additionally an 'awareness service' introduced. Overall, all the concepts should satisfy the customer needs with reliability guarantees.

4 Conclusion and Outlook

The development of new business model concepts to foster the demand side flexibilities to ensure the stability of the grid seems necessary. This paper presents the first approach to develop a business model for the use case of a car park operator interacting as an intermediary for aggregated EV charging. Moreover, possible service designs which could be offered to different types of EV customers in a car park were presented to enhance the demand side flexibilities through load management and increase the profitability of charging stations which can lead to an improved economic outcome.

One remaining question is whether individual concepts for the customers are beneficial and whether the customers have the willingness to adapt to such new concepts. Consquently we will try to validate numerical use cases in future work in order to have a better understanding of costs and benefits of individual tariff design possibilities. Analysis of the profitability would need to develop a detailed model to consider several elements, like mobility data of the EV and the according to scheduling, flexibilities of the customer, grid, and energy market data, etc.

In the future, even more specified tariffs and products could be offered if vehicle-to-grid charging will be considered for the EVs as the flexibility increases for the operator. That could be one further enhancement of the demand side flexibility.

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Towards Self-Adaptive Medical Coaching Agents

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Abstract. Clinical pathways and treatment plans generalize disease patterns in the medical domain, but do not sufficiently consider the individual recovery progress and current situation of a patient. Moreover, the lack of a round-the-clock examination of a patient can lead to wrong treatment decisions. This work presents an approach for developing autonomous self-learning agents. Through a synthesis of semantic Web technologies and Machine Learning, the approach is capable of computing dynamically adjusted treatment plans based on current patient capabilities, impairments and recovery progress data. By deducing personalized medical training exercises, it helps to improve the recovery process.

Keywords: Health Care, Machine Learning, Semantic Web.

1 Motivation

A physician has to collaborate with patients, other medical experts and combine different information such as medical records in order to obtain a profound and comprehensive picture of a disease pattern. However, the lack of time and high efforts in acquiring data do not allow for a detailed diagnosis and individual treatment plan in most cases. The development of self-learning agents can help to address these issues in the following ways: a) An agent can continuously observe patients' activities and their vital state regardless of spatio-temporal constraints; b) it can consider individual patient's characteristics (e.g. medical records, capabilities, historical data) as well as the physicians recommendations. c) An agent can learn and deduce individual treatment plans through gathered vital data and observed patient activities as well as by empirically evaluated medical datasets. The presented approach provides a) semantic representation framework for clinical pathways (CP), b) an agent-based system that adapts by Machine Learning (ML), the predefined CPs and c) an avatar that provides activity recommendations in order to foster the recovery. The remainder of this work is structured as follows. Section 2 discusses most relevant related works. The synthesis of semantic Web technologies and Machine Learning (ML) for creating an autonomous agent's behavior is covered in Section 3. Section 4 summarizes this work.

2 Related Work

Several works are dealing with semantic representation frameworks for integrating CPs in medical systems, the most relevant are briefly discussed in the following:

Wang et al. [1] developed a "generic framework for the hospital-specific customization of standard care plans defined by clinical pathways or clinical guidelines". It provides a semantic data model in order to store semantic clinical data and extract ordered treatment procedures. Li et al. [2] simulate a multi-agent system upon a norm-based approach for managing CPs, where norms are represented by rules. The approach aims at the integration of pathway knowledge into treatment processes and hospital information systems. An ontology together with a set of semantic rules for personalizing and adapting health-care processes and treatment plans has been proposed by Alexandrou et. al. [4]. Laleci et al. [5] developed "a clinical decision support system for remote monitoring of patients at their homes". Their outcome is a semantic multi-agent-based interoperability framework for heterogeneous clinical systems. The discussed approaches address the representation and integration of CPs into heterogeneous medical systems. For that reason, multi-agent systems are conceptualized in order to provide CPs supporting systems. However, all these approaches do not address the personalization of CPs as well as the rehabilitation processes continuing at home. The patient's capabilities and context is also not addressed sufficiently.

3 Approach

The presented semantic representation framework models different aspects of CPs, e.g. the patient profile with impairments, capabilities and former diseases. A ML agent uses observed patient data. These data consists of patient activities and vital signs data as well as medical treatment plans, provided by the physicians. Based on these data, the agent computes by simulating the patient's recovery progress, the optimal activities to recommend to the patient. The ML agent publishes these activity recommendations in a Semantic MediaWiki (SMW). A coaching agent observes the patient activity and deduces according to the patient activity and pre-defined capabilities the recovery state of the patient. By this recovery state, the agent retrieves via the SMW the appropriate activity recommendation and forwards it to the coaching avatar, which communicates the recommendation to the patient. The avatar runs on different devices (e.g. smartphone, data glasses, display, headphones) and can communicate according to the availability of the patient. Figure 1 shows the components of the system architecture and their relation to each other.

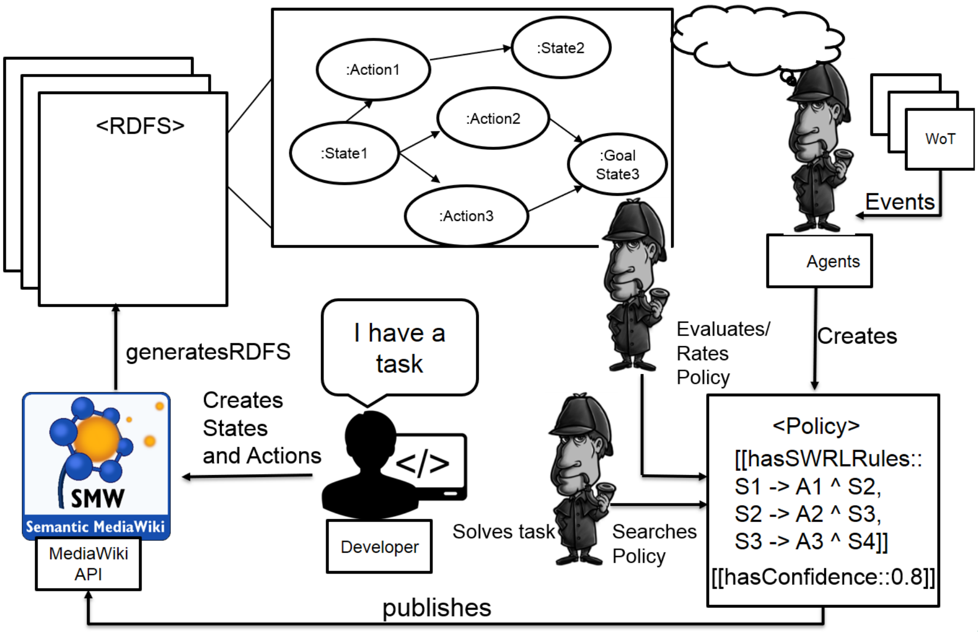

Fig. 1. The medical coaching system architecture

First, the domain expert creates a semantic representation of a medical exercise via the SMW. This RDF(S) representation consists—among other things—of linked states and actions and is used by the RL agent in order to compute the policy of every state. The RL agent transforms these policies into a semantic policy representation which is used by the coaching agent in order coach the patient. The agent subscribes to the Web of Things (WoT) server in order to receive sensor events and recognizes by these sensor events, the patient's activity and current exercise step. Another agent is responsible for gathering and storing all sensor events and performed user actions in a database. The stored observations serve as datasets, which are used by ML agents in order to find general patterns for clinical pathways, matching best to different patient profiles and diseases.

3.1 Semantic Representation Framework

The patient profile covers different relevant aspects of the patient. An example impairment is defined as depicted in Axiom 1.

$$\mathsf{Oblivion} \sqsubseteq \exists\, \mathsf{requiresCapability.RememberThings} \tag{1}$$

The impairment *Oblivion* requires the capability *RememberThings*. This capability is linked via a subsumption to a recovery state (*ImprovedRetentivity*), see Axiom 2. By linking impairments to capabilities and capabilities to recovery states, the coaching agent deduces which capabilities have to be trained in order to accomplish a recovery state.

$$\mathsf{ImprovedRetentivity} \sqsubseteq \exists\, \mathsf{requiresCapability.RemeberThings} \tag{2}$$

A capability is an aggregation of actions, which the patient performs in order to train the capability. Axiom 3 shows the capability *RememberThings*.

$$\mathsf{RemeberThings} \equiv \exists\, \mathsf{consistsOfAction.NameThing} \tag{3}$$

If a patient performs via an application a medical exercise in order to train his/her retentivity, the coaching agent observes through achieved scores, which of the actions are successfully performed. Therefore, the agent requests via the SMW SPARQL endpoint the trained capability. The performed actions provide the capability pattern. Since the recovery state is related to the capabilities, the agent deduces the achieved recovery state and recommends via the avatar the next related training exercise. However, the ML agent has to compute previously the optimal training exercise.

3.2 Learning Optimal Treatment Plans

A treatment plan defines several training exercises depending on the patient's disease or impairment. The ML agent acts upon a state-action diagram which represents the training exercise of a treatment plan. The states are representing the exercises steps which are related to appropriate required capabilities, while the actions represent the exercise recommendations. Based on this representation, the agent computes via a Q-function the optimal policies of a treatment plan. We decided to use a Q-function because it is simple and has proved its worth in RL. Moreover, it reproduces the cumulative character of reinforcing the agent by rewards. The agent is enabled to learn iteratively to choose in a certain state the action with the highest expected cumulative reward value. The state-action diagram is thereby just a model used for learning the best action path within an exercise. A policy prescribes optimal recommendations depending on recovery- and exercises states.

The coaching avatar is an application which runs on different platforms (e.g. smartphone, tablet, data glass). It uses different communication channels to the patient, while it considers the patient's impairments. The avatar decides context-aware by which medium it interacts with the patient. Therefore, it considers device characteristics as well as patient capabilities in its deduction.

4 Conclusion

This paper introduced a semantic clinical pathway representation framework upon that an agent-based system dynamically computes and recommends wrt. the patient's recovery progress, optimal exercise steps in order to train missing capabilities. Thereby, the patient's impairments are considered and incorporated individually into treatment plans. We showed initial steps for synthesizing semantic Web technologies and Machine Learning in order to provide a better quality of service. As human-computer interface, an avatar interacts with the patient and communicates the computed recommendations in an appropriate manner.

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Towards a Testing Framework for Location Problems in EMS Logistics

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Abstract. Planning problems for Emergency Medical Services (EMS) span from strategical to operational decisions and are usually informed by historic demand. Mathematical models to support these decisions, however, usually consider one exemplary demand setting as proof of concept. It has not been discussed whether suggested planning approaches work equally well for different demand structures, e.g. rural versus urban areas. Hence, we develop a framework to help set up testing instances for location problems in EMS logistics. The aim of this framework is to capture differences in demand structures and EMS systems and also to allow researchers to benchmark newly developed approaches.

Keywords: EMS logistics, ambulance location, test instances, framework.

1 Introduction

The locations of ambulances are crucial for arriving at the scene as soon as possible in order to allow for the best possible care in case of an emergency. Operations Research models can determine optimal locations given a certain demand. In the light of a growing number of models to support EMS logistics, a general way of testing new approaches appears to be useful but has – to the best of our knowledge – not been addressed in the academic literature. Many of the models suggested are tailored to individual settings rather than being tested for a range of heterogeneous supply and demand configurations. Hence, we propose a generic framework to generate test instances in order to assess the suitability of newly developed models for different supply and demand structures.

2 Background

Since the introduction of the first models to locate ambulance bases by Toregas et al. [10] and Church and ReVelle [3], numerous studies have been added to the literature. Early models on EMS logistics focused on strategic location problems of the bases while models to specifically locate and re-locate ambulance vehicles have been developed subsequently. We refer the reader to [1,2,8] for recent and comprehensive reviews of models to support EMS logistics.

2.1 EMS Systems

Worldwide there are two main EMS systems, namely the Anglo-American system and Franco-German system [5]. Whilst the Anglo-American system employs paramedics that focus on bringing the patients to the hospital as fast as possible, but are able to administer necessary treatments for basic life-support until then, the German-Austrian system starts the treatment at the scene and includes so-called emergency doctors for severe cases that are the only ones allowed to deliver certain kinds of treatments. In addition, each country has its own set of laws and specific regulations, especially concerning the payment structure, response time targets and being either organized by private organizations or public institutions. An overview over the systems can be found in Dick [5], the British, the Dutch and the German EMS system are also presented in [8].

2.2 Planning Problems

EMS logistics include planning problems at three planning levels. At a strategic level decisions for the construction of base locations are usually made for years or even decades. The number of ambulances per base location is a major decision at a tactical level and often fixed for one year. Regularly, the problem of locating ambulances and bases is solved simultaneously for both levels at once. At an operational level, ambulances are dispatched to calls and also the relocation of ambulances has to be decided in real-time. Reuter-Oppermann et al. [8] present and discuss the planning problems at the different levels in more detail.

3 Design of the Testing Framework

The required data sets for test instances should reflect the different regional structures and the two EMS systems mentioned earlier. In addition, there are two main representation forms that can be found in the ambulance location planning literature, namely a network and a grid structure [9]. In the first case, the considered region is expressed as a set of representative nodes. These are connected by edges that are weighted by the driving times or distances. In the second case, the region is divided into a number of quadratic cells e.g. of 1km^2 size. Distances between two cells are usually based on the Euclidian distance between the centres. Location models are proposed for either one of the structure, e.g. [4,7], and hence comparisons across structures are difficult. Therefore, it is of interest to have instances available for both structures to make approaches comparable.

The data set provided by Ingolfsson [6] for the Canadian city of Edmonton presents relevant information for location planning within EMS systems: demand (origin, time, and frequencies), supply (e.g. number and capacities of bases, ambulance utilisation – i.e. response times and busy times), and regional characteristics (i.e. driving distances, catchment areas). The characteristics of this information are not necessarily identical across different regional structures. Hence, we add the dimension *regional structures* to it and distinguish urban areas, rural areas, and also combinations of both. Urban areas typically have a dense network of roads and potentially a more homogeneous demand structure. Differences between urban areas can occur when comparing smaller cities and larger cities, or cities with unique settings, such as rivers or a difficult road network with asymmetric driving times, due to one-way streets and road closures, for example. Rural areas typically have fewer demand origins and their spatial distribution can vary across different rural areas. Also, road networks are usually less dense and have fewer supply points (i.e. ambulances bases). Besides, the planning region could feature both urban and rural areas. Here, a large variety of unique structures can be of interest, e.g. rural areas (such as counties or federal states) with a few bigger cities spread across, or rural areas with only one – yet quite large – city in the centre. Table 1 outlines data requirements for test instances and highlights potential differences for the regional structures.

Finally, the set of test instances should also reflect the different types of EMS systems, so that different regional structures can be analysed with the Anglo-American and the Franco-German system. To this end, the test instances should be applicable for as many countries as possible. This means that the tasting framework includes information on different types of vehicles, i.e. not only ambulances, but emergency doctors or rapid responders, for example. While some instances will include potential/fixed locations, the framework is designed in such a way that instances can easily be extended. Even though the majority of existing location models considers only ambulances, this might not be true for future research on new approaches or extensions of existing models.

With those two dimensions added, the data types as specified in [6] can be used to model the differences and in particular the resulting difficulties for model development and use. First instances for the Franco-German system have been presented in [9]. The authors also describe how these test instances for German EMS regions have been designed.

Table 1. Data requirements for test instances

Data type	*Different types of regional structures*		
	Urban areas	**Rural areas**	**Hybrid areas**
Demand origins	Many	Few	Combination of characteristics from both urban and rural areas
Time of demand	Daily profile	Daily profile	
Busy time of ambulances	Short/medium	Medium/long	
Requests per demand node	Daily profile, higher average for most origins	Daily profile, lower average for most origins	
Response times	Daily profile	Daily profile	
Driving distances	Short/medium	Medium/long	
Capacities for stations	High/medium	Medium/low	
Neighbourhood, coverage	Smaller and often overlapping	Larger and often non-overlapping	

As prior comparisons of ambulance location models, e.g. in [11], distinguished between urban, rural areas and hybrid areas, we will use the same wording for our framework. While this is not necessary from a theoretical point of view, it will be helpful for practitioners and decision makers. Again, in order to be applicable for many countries worldwide, varying definitions of “rural” for a number of countries will be used. That means that for the same basic instance different variations are included in the framework, regarding the number of edges between nodes or the demand profile in each node / grid point.

4 Discussion and Outlook

In this paper we have presented the design of a testing framework for ambulance location models. The described set of instances will allow for a comparison of different approaches. The next steps are therefore to build and collect further test instances, to use those for designing the test framework and, finally, to solve different models and compare the results. We envision a classification scheme showing the most appropriate model for each type of EMS region based on the combinations presented in Table 1 as the final aim of this research.

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Maximizing the Value of Smart Service

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1 Introduction

Generally, *Smart Cities* are characterized as innovative cities that use ICT in order to improve the citizens' quality of life and the overall efficiency. In a smart city, *Smart Services* are considered as one of the integral components, since they are capable of connecting service providers, users, infrastructures, and communities in a common ecosystem to support the value co-creation. Therefore, smart services are key for promoting economic growth, quality of life and supporting the evolution of cities.

It is evident that more intensive usage of ICT does not automatically result in greater value or utility for the user. As the complexity of many services is rapidly growing and there exist multiple variables in a given user context, how smart services are related to ICT services, how they are correlated among each other and what is the impact for the utility of the user – these questions remain up to date largely unexplored.

To this end this paper proposes a *Wise Data Interface (WDI)* that can dynamically select the services best suitable to the user's specific context. This wise data interface can be considered as a meta-layer on top of the service pool and can select the relevant services from this pool in a smart way. In contrast to traditional service configuration, which adjusts the service based on certain rules to fulfill the defined requirements, the wise data interface pro-actively proposes or recommends, which services can be used in an individual context. The proposed services may even exceed the user's expectations. We can thus maximize the value of the smart services.

2 Service Scenario

Considering the service of route planning, which usually has a clear requirement, which is to find **optimal route**. Optimal route can be defined as the optimal way from point A to point B, best fitting to the requirement within the given context. To be more specific – when one user is looking for the best way from home to the office, this may depend on many factors, for example, the type of transportation (car, bike, walk), weather (sunny, rainy) and further conditions (air pollution, time of the day).

The final route plan depends not only on the shortest route but also on the context, which also defines the information and supporting services that the route planning service needs to use to maximize the client's utility. One of the state-of-the-art and widely-used solutions for offering such a service design is to use the Smart Web Service, which is detailed in the following section.

3 Smart Web Services

The concept of Smart Web Services (SmartWS) [1] has been introduced. SmartWS rely on standard Web Service technologies such as e.g., Uniform Resource Identifiers (URIs), Representational State Transfer (REST), and Hypertext Transfer Protocol (HTTP) and thus provide remote access to resources and functionalities. However, in addition, they also encapsulate 'intelligence' by implementing autonomous decision logic in order to realize or adapt services that automatically perform tasks on behalf of the user, without requiring his/her explicit involvement. Smartness features can include, for instance, context-based adaptation, cognition, inference and rules that that automatically suggest patients' diagnosis, determine an optimal traveling route, or updating the temperature settings of all heaters in a house. Figure 1 visualizes how SmartWS provide access to sensors, databases, social web feeds, etc. in order to realize pasts of or complete client applications with user added-value.

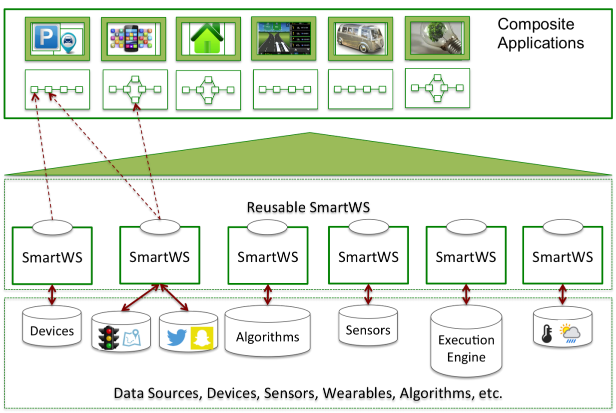

Fig. 1. Structure of services.

To analyze the structure of the services, beginning from the services as they are seen by the final user or customer, going deeply into the structure of supportive services that are used to provide the final value. Based on the framework, which is developed in *Value-driven Conceptualization of Services in the Smart City: A Layered Approach* [3], we see the final value of the service depends on optimal set of different services of the lower level.

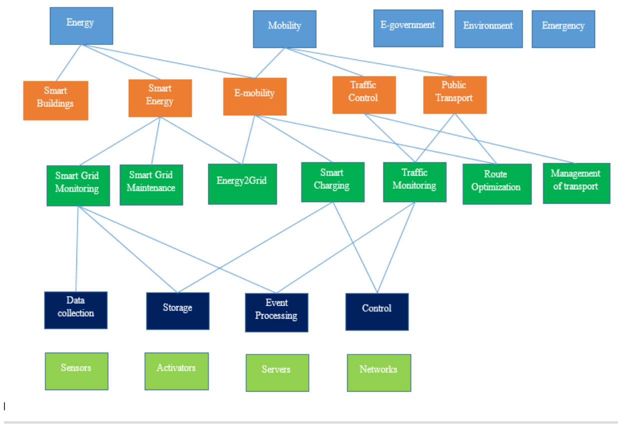

Fig. 2. Concept of layers [3]

The services, preparing outputs only for the services from upper layer, are called Supportive Services. The services that are able to provide the value for the more complicated services as well as for the final user, are called Smart Services. The related services are using the result of the services from bottom layers. As it is described, there are more than one layer of the services between hardware devices (sensors) and final user. The question is how used data are reflecting the increasing level of complexity and what exactly their contents are. From the structure showed on Figure 2, it follows the final utility of the service that depends on the way the outputs of supportive services are used and combined.

With the current smart web services modeling, the solutions are based on the configurations among the supportive services. The configuration is to fulfill a clear requirement that may consist of a set of fixed constraints. However, for the same requirement, the context may change based on different users and the smart web service cannot understand the contextual dynamics. For example, one user usually prefer to go shopping between home and work. Thus a simple home and work route planning can fulfill the general requirement but cannot increase the service utility.

4 Wise Data Interface

To bridge the gap, we propose to follow the idea of *What Makes A System Smart? Wise?*, written by Jim Spohrer ac. [2]. The whole system of particular service provision needs to be viable - in the way so that it is able to adapt dynamically the set of the used services and react to the different context of the same requirement. To enable this function, it is necessary to insert a new interface between the layer of Smart Services and Supportive services. This interface, in this paper which is defined as Wise Data Interface, helps the Smart Services to recognize the context and offers the most effective set of outputs of supportive services to bring possibly higher level of the value for the final user of the Smart Service.

With such an interface, the communication within the layers of the services would be more effective and more useful for all participating services, because the WDI is able to understand the changing context and select the supportive services for the smart web services. Thus, continuing with the proposed scenario that due to the good weather, a user prefers to walk instead of using a car from A to B, WDI serves as an intelligent agent to pro-actively propose the possible supportive services for smart web services. Note that WDI is not to replace smart web service but to complement the smart web services.

5 Conclusion

In this short paper, we present the idea of the layered approach to the service structure, seen from two different perspectives. According to this we propose the establishing the special interconnecting layer with specific functionality - to interconnect the data from bottom layers with the ability to recognize the context of the service request.

We assume system of the interconnected service layers has ability to provide higher value than isolated services. The final utility belongs to the final utility, that can be divided into following parts:

1. individual
   (a) Objective
   (b) Subjective - depends on the context
2. Systemic - can be taken as utility of all involved participants

The main issue was identified in the fact the current model is giving the same output in the different contexts. Therefore subjective utility cannot be never maximized.

After adding the feature to recognize context into the system of layer, the system would be able to provide higher, possibly Pareto optimal utility to the all stakeholders, because it would be possible to improve individual utility by using WDI without affecting the utility of others. Also the role of the systemic utility and its relation to the context and thus to the final utility and value of the service needs to be investigated. To prove this ability and verify the idea of WDI is the main aim of our future research.

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Turning Data into Value: Towards an Ideation Tool for Key Activities of Data-Driven Business Models

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Abstract. The amount of data that is created in an industrial context is rapidly increasing. The question of how to capture the business potential associated with data drives researchers and practitioners to investigate how the business model concept is impacted. While the research on new, data-driven business models certainly gains momentum, little research has been conducted on how to develop such data-driven business model. Our research aims to address this issue by investigating how a tool looks like that helps to develop the key activities for such data-driven business models during the business model innovation process.

Keywords: Business Model Innovation, Data-driven Business Models, Design Science.

1 Introduction

The amount of data that is created in an industrial context is rapidly increasing [1]. While academic literature agrees on its inherent potential value, the available data provides an opportunity for companies and their offerings in terms of strategic business differentiation [2]. Hence, the goal of reaping competitive advantages based on a utilization of data drives researchers and practitioners to transform existing businesses into data-driven ones [3].

Some organizations already benefit from the use of data. Previous work in this field has already shown, that the maturity of initiatives exploiting data as a key resource for business model innovation focus on an internal optimization of the companies' value creation [4]. Thus, in order to further drive companies' initial digital transformation, systematical support to trigger new, data-based concepts for creating value within the business model are needed. Following Johnson [5], the business model's value creation consists of the elements *Key Resources* and *Key Activities.*

So far, existing literature focuses on understanding the characteristics of data-driven business models [2]-[4]. However, little research has been conducted on how to support the development of such [6]. While Mathis and Köbler [7] introduce the Data Canvas as a new method for systematically considering data resources in the development of business models, there exists no such method for considering data-related key activities.

Our paper aims to address this literature gap by exploring the specific requirements a tool for the ideation of key activities for a data-driven business model has to fulfill. Furthermore, we derive design elements for such a tool based on these findings. Thus, our research contributes by answering the following research question:

How does an ideation tool look like that systematically supports the generation of possible key activities for a data-driven business model?

2 Methodology

The research at hand aims to introduce a practitioner oriented tool for the ideation of key activity combinations for a data-driven business model. Therefore, we apply a Design Science Research (DSR) approach, since it provides a structured way for creating an artifact. Following Kuechler and Vaishnavi [8], DSR can be distinguished into five, iterative steps that form a DSR-cycle: (1) awareness of the problem, (2) suggestion of key concepts to address the problem, (3) development of a solution proposal, (4) evaluation of the solution proposal and (5) conclusion to decide, which elements of the solution should be adopted and whether further research cycles are needed.

In our first cycle, we conduct a structured literature review of the relevant literature as suggested by Webster and Watson [9]. Through this review we aim to gain an understanding of the specific activities needed in the context of a business model that relies on data as a key resource. Using a concept matrix, we group the identified concepts of necessary key activities. Based on these findings, we then suggest and instantiate design elements an ideation tool for key activities requires in order to support the data-driven business model innovation process. Afterwards, this early prototype is evaluated using focus groups of practitioners.

In the second cycle of our DSR research, we plan to refine the design elements based on the evaluation results of the first cycle. The newly resulting prototype will be introduced to a different focus group of practitioners. These evaluation results are then used to integrate our findings in a final design theory for our intended key activity ideation tool as described by Gregor and Jones [10].

3 First Results

Following our research design, we were able to identify seven categories of activities, that need to be additionally conducted when using data as key resource within a business model (cf. Table 1): *Data collection*, *data organization*, *data selection*, *data preprocessing*, *data transformation*, *data mining* and *interpretation*. Using these findings, we conclude that a key activity ideation tool needs to support the generation of ideas for possible activities within each of these categories.

Author, Year	Data Collection	Data Organization	Data Selection	Data Pre-processing	Data Trans-formation	Data Mining	Interpreta-tion
Hartmann et al. [2]	✓	✓		✓		✓	✓
Otto, Aier [11]	✓		✓	✓	✓	✓	✓
LaValle et al. [12]							✓
Han et al. [13]		✓	✓	✓	✓	✓	
Fayyad et al. [14]			✓	✓	✓	✓	✓

Table 1. Concept matrix of relevant key activities

Additionally, we found out that in an increasingly interconnected world, value is usually not created by a single provider [11]. Following the concept of service systems [12], each actor must understand its role in the system as well as its overall configuration of processes [13]. For this reason, we also adapt the following perspectives for our tool, as suggested by Zolnowski and Böhmann [14]: *Customer perspective*, *partner perspective* and *company perspective*.

Concluding our first results, we propose two basic design decisions (DD) for the intended key activity ideation tool. First, a distinct business activity must be formu-

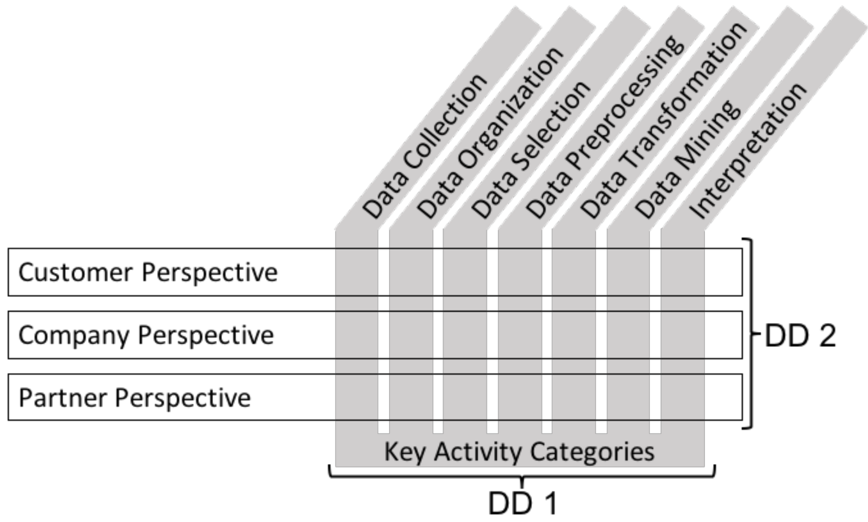

Fig. 1. Synthesized design elements of the initial key activity tool prototype.

lated for each of the 7 key activity categories mentioned above (DD1). Second, these activities must not necessarily be performed by the company itself, but may also be performed by other participants within the companies' service system (DD2). The two design decisions leading to our initial artifact are illustrated in Figure 1.

4 Outlook

Since DSR is a heuristic strategy, which conducts design and test phases iteratively, we aim to evaluate this first prototype of a key activity ideation tool using a workshop with practitioners. The feedback of workshops with focus groups will give vital insights on how to refine our design suggestions of the first DSR-cycle in a second one.

Additionally, besides further developing the key activity tool, it is still of interest how data-driven business models can be developed systematically. Thus, future research may also address the development of ideation tools for other core components of the business model such as the Value Proposition or the Value Capturing. As Hunke et al. [6] already point out, this can eventually lead to a methodological *tool-box* for the development of data-driven business models which can assist practitioners.

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A Process Mining-Enabled Decision Support System for Data-Driven Business Process Standardization in ERP Implementation Projects

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1 Introduction

Organizations operate in increasingly dynamic environments of intense competition, fundamental technological change and innovation in information technology. These changes in the internal or external conditions require organizational transformation to maintain competitiveness. At the same time, organizations increasingly build operations on information systems such as Enterprise Resource Planning (ERP) in their operations [1]. According to organizational contingency theory by Donaldson [2], the organizational effectiveness is determined by the fit between organizational characteristics and context factors of the environment [3]. Thus, organizations are required to transform their architecture including business processes and ERP systems in response to address these changes in the environment. As a specific field of process transformation, business process standardization has experienced a high degree of attention, and has been associated with numerous benefits if properly implemented. Besides, process standardization constitutes a critical step prior to enterprise resource planning (ERP) system implementations. However, ERP implementation projects are frequently considered as failures by both practitioners and academics alike.

Nevertheless, decision-making for the transformation of a business process from a current specification to a target process design requires companies to solidly understand the real-life execution of the as-is process (e.g., [4]), and to take into account the context of the respective business process [5]. As confirmed by both academia and practice, numerous organizations frequently do not possess an exhaustive understanding of their business processes [6]. Traditional “top-down” approaches to business process transformation are “de-jure” and based on manual process analyses instead of “de-facto” and data-driven “bottom-up” approaches such as process mining [6]. Such top-down approaches suffer from several insufficiencies, as they are based on handmade process models which are often biased compared to process reality [7].

To contribute to these outlined issues, this research proposes to harvest ubiquitously available process data from numerous information sources in organizations by using process mining for decision-making in process transformation. Organizations might strongly benefit from a decision support system (DSS) for selecting an appropriate standard process to overcome the outlined weaknesses of top-down process transformation approaches, and which considers the very specific organizational process contexts. In particular, this research proposes a semi-automatic process mining-enabled

DSS which retrieves process models of the as-is process from process mining, and which extends these models with manually added top-down standardization attributes to incorporate company-specific context and standardization-relevant information in decision-making. These extended process models of the as-is process are then matched against a repository of best-practice standard process models using an attribute-based process similarity matching algorithm. Through the reliance on process similarity for process matching, the DSS aims to minimize the degree of organizational change during the implementation of the standard process.

The research question of this project becomes: *How to design a process mining-enabled decision support system to support organizations in the standardization of business processes?*

2 Design Science Research Methodology

This project employs a design science research (DSR) approach to derive, conceptualize, develop, and to evaluate a process mining-enabled DSS in two design cycles as proposed by Hevner et al. [8]. The DSR project is conducted within the context of a business process standardization and ERP implementation project, which comprises the replacement of the current SAP R/3 ERP by the future SAP S/4 HANA Business Suite in multiple companies. In 2017, the corporation consisted of several sub-companies operating globally with more than 8.200 employees and about 1.2bn Euro in turnover. Each of the design cycles comprises a problem awareness, suggestion, development, and an evaluation phase [8]. During the problem awareness, the need for a data-driven approach to process standardization in ERP implementation projects was discovered by a literature review and workshops at the industry partner. In the suggestion phase, design requirements to the DSS were derived from literature and practitioner workshops at the industry partner to conceptualize the DSS. In the development phase, the Apromore prototype was developed and presented in [9]. In the next phase of the project, the DSS prototype will be evaluated in a laboratory experiment to close design cycle 1. In design cycle 2, results from cycle 1 will be used to further concretize design requirements and to further improve the prototype. Cycle 2 will close with a field evaluation with process experts at the industry partner.

3 Instantiation in Apromore

In the proposal phase of the DSR project, we derived design requirements including meta requirements (MR1), and design principles (DPs). Design requirements are derived and published in adjacent research as a BPM 2018 Forum Paper in [9] and illustrated in **Fehler! Verweisquelle konnte nicht gefunden werden.** at the end of this section.

In the development phase of the DSR project, a prototype was implemented according to the design requirements in the process analytics platform Apromore. The prototype is based on a real-life event log and associated standardization attributes for the

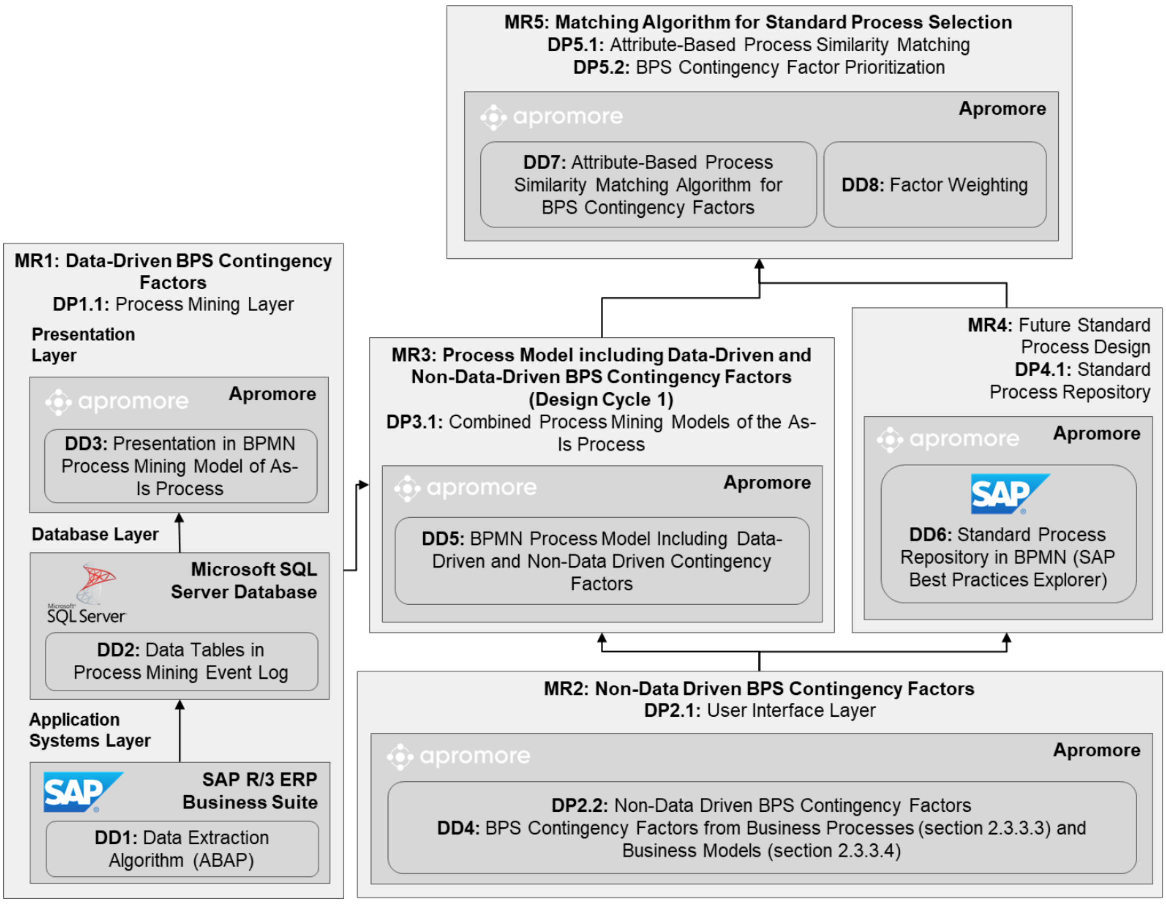
Purchase-to-Pay ("Purchasing") and the Order-to-Cash ("Sales") processes from three SAP R/3 ERP systems of an industry partner.

First, as required by MR1, de-facto process information is retrieved in a bottom-up process mining layer (DP1) which extracts process mining event log tables and relevant data from the underlying ERP systems with an SAP ABAP table extractor program developed for this project (DD1.1). Extracted .csv data tables are converted into an event log in a Microsoft SQL database using scripts provided by a German process mining provider for this project (DD1.2). Process mining results are then visualized in BPMN 2.0 notation in Apromore (DD1.3). Second, de-jure process information which cannot be retrieved from data in the process mining layer (MR2) is added manually in the top-down user interface layer (DP2). Such information contains contextual factors and further process characteristics (MR2a), transformation goals (MR2b) and goal prioritizations (MR2c). In particular, process standardization is a multi-dimensional construct which depends on a multitude of different impact factors. Thus, the DSS allows users to supplement the process models with 11 domains of standardization attributes for process matching which were derived in adjacent research of this project in [10] (DP2a). Standardization attributes comprise process execution, inputs and outputs, documentation, data, information technology, governance, people and knowledge, culture, legal factors, collaboration and communication, as well as strategic factors [10] (DD2a). Besides, the DSS requires input concerning the actual goals of the transformation (DP2b and DD2b) as well as a goal prioritization (DP2c and DD2c).

Both de-facto process mining information and de-jure information is combined (MR3) in attribute-extended process models in BPMN (DP3 and DD3) of the as-is process. To propose a suitable standard process specification (MR4), the DSS comprises a database of different possible standard process specifications (DP4). To build the repository, best-practice process specifications from the SAP Best Practices Explorer in BPMN were imported into Apromore (DD4) and assigned with the standardization attributes as candidates for future to-be standard designs. As a next step, the extended as-is process models with the standardization attributes are matched (MR5) against each business process of the same domain in the standard process database using an attribute-based process similarity matching algorithm developed in this project (DP5 and DD5) to select the most similar standard process.

4 Evaluation

After development of the Apromore prototype in design cycle 1, solid design science requires an evaluation of artifact quality. As the DSS comprises several individual modules, the proposed evaluation strategy focuses on three individual parts, namely the attribute-extended BPMN process models, the quality of the attribute-based similarity matching algorithm, as well as the intention of practitioners to actually accept and adopt such a DSS. First, four different forms of visualization of the attribute-extended models were evaluated in terms of process comprehension and user preferences in a lab experiment, including a BPMN model with table attachment, information attached with branches in a static and an interactive variant, as well as a guided tab variant with icons. Second, the attribute-based similarity matching algorithm is to be evaluated by comparison of matching results against the same matching steps performed by process experts at the industry partner. Third and finally, the artifact will be evaluated by means of acceptance constructs such as perceived ease of use, perceived usefulness, or behavioral intention to use [11] in semi-structured expert interviews.



5 Conclusion

Theoretically embedded in the organizational contingency theory as kernel theory, this paper employs a design science approach to design a process mining-enabled decision support system (DSS) which combines bottom-up process mining models with manually added top-down standardization information to recommend a suitable standard process specification from a repository. The DSS aims to reduce the overall costs of process standardization, to optimize the degree of fit between the organization and the implemented processes, and to minimize the degree of organizational change required in standardization and ERP implementation projects. Besides, the absence of academic contributions on the “post-process mining” phase with only few contributions exploring the question of how the insights gained in process mining projects can be used for process transformation decision-making, remains an important research gap. Thus, participation at this Doctoral Consortium would highly benefit this research for both a discussion of the kernel theory, as well as the evaluation strategy as the next crucial step in the research endeavor.

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Towards Identifying Strategic Innovation Capabilities for Smart Services – A Research Agenda

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Abstract. Smart services are among the technologies currently being fostered by the megatrend 'digitization'. Literature suggests, that they not only transform the functionality and value proposition of new solutions but demand for changes in established business environments, structures and roles. This also involves the way organizations, following the path of digital transformation, will innovate. Thus, we design a study aiming to identify strategic innovation capabilities that enable companies to innovate in this new setting. This paper proposes a qualitative research design based on data gathered vai in-depth expert interviews.

Keywords: Smart Services, Innovation Capabilities, Expert Interview Study.

1 Motivation

Digitization is a global megatrend, which is tremendously changing industrial production since the beginning of this century and which will continue to be one of the major future challenges [1]. Whereas digitization primarily describes the technological progress, smart services - interconnected, data-based services [2, 3] - are among the technology concepts currently fostered by digitization [2]. Based on new technical possibilities, smart services represent a radically changed way of product offerings. By using new technical approaches, smart services generate a permanently close customer interaction based on an interactive network including customers and providers [4]. This goes beyond the traditional product development and represents a radically changed way of product offerings. Smart services fulfill the shift from a goods-dominant to a service-dominant logic [5]. Consequently, this architecture demands a completely changed development approach and a new way to innovate. While research activities on smart services primarily focus on their technological aspects, challenges related to developing smart services go far beyond [6]. Researchers state that digitization brings radical change to strategic and structural business aspects [2, 3] such as reshaped work environments [9], new business models [7; 8], and a growing need for collaboration in networks of business partners [12]. Innovation management and capabilities will need to adapt to these changes. With human-centric innovation, DevOps or digital innovation platforms new approaches facilitating innovation in a digitized world are already emerging [13]. The question whether established innovation practices are well suited for innovation in a radically changed environment like the one of smart services and which strategic innovation capabilities might be necessary, is so far unaddressed in literature. Here, the environment of smart services acts like an indicator for upcoming innovation challenges fostered by digitization. We, therefore, will explore how the actuality to innovate in the field of smart services will affect innovation capabilities.

The remainder of the paper proceeds as follows: Section 2 provides related work from relevant domains. Section 3 introduces the research problem and explains the underlying research methodology and design and section 4 completes the paper with a conclusion and its contribution to research.

2 Related Work

To provide an elaborated ground to our research approach and further strengthen our hypothesis of the necessity for novel innovation capabilities to accommodate the new settings smart services generate, we explore related work in literature.

Smart services. Smart services reflect an IT-based approach of offering services based on interconnected products, whereby ‘smart’ stands for context-sensitive services that are suited to customer needs [14]. As literature on smart services merely discusses their need for novel or reinforced innovation capabilities [15], we draw on relevant research from the area of digitization as its umbrella concept. We first focus on literature on changes to work environments and employee qualifications due to digitization. Second, we consider literature on digital innovation challenges and studies covering approaches for digital innovation management.

Changes to work environments. Digitization induced changes to the work environment comprise on an organizational level the emergence of more agile and comparative environments [16], the formation of the new function of Chief Digital Officers [16] and the fragmentation of value chains [17]. For individuals, digitization may lead to physical reliefs [16] but concurrently intensifying cognitive effort due to an increased information flood. Additionally, social skills like creativity, conflict management or open-mindedness gain in importance [17].

Managing digital innovation. Regarding the concept of digital innovation, two different points of view approaching this term can be distinguished: Digital innovation either describes innovation for solutions in the field of digitalization (outcome-oriented) or the application of digital technologies within the innovation process (process-oriented) [18], whereby we follow the outcome-oriented point of view when studying innovation capabilities for the creation of smart services. Smart services, as specific kind of hybrid digital solution, have an architectural design different from traditional products or services as they are hybrid product-service-systems interacting within a network of other solutions [18]. This interconnectedness will be reflected in new ecosystem-wide approaches to managing and creating digital innovations: Multiple partners in business ecosystems and value chains, including equipment vendors, software providers, system integrators and customers will need to collaborate [12]. Thus, fading boundaries between industries and the evolution of cross-organizational and dynamic cross-industry alliances will become an issue [19-21]. Within organizations, responsibilities and players will transform. Innovation is no longer limited to a dedicated unit but distributed across diverse knowledge carriers. Innovation becomes accessible to a previously excluded spectrum of employees resulting in an increasing demand for new connectivity, flexibility and decentral coordination mechanisms [19; 24; 25; 26].

Summing up, literature firmly stresses the tremendous changes in work environments, corporate structure and management that digitization is causing, whereby the majority of them will directly influence the way companies will innovate in the future. Extrapolating from digitization literature to smart services, whose impact on innovation management and its specific capabilities is, if any, only outlined in existing literature, we see a need for further research.

3 Research Problem and Design

As literature indicates, the emergence of smart services will affect the way organizations innovate [13]. To understand, which potential adaptions might be necessary, we formulate the following research question:

RQ: Which innovation capabilities are necessary for firms to successfully innovate in smart service environments?

In order to approach the answer of this research question, we design an exploratory study with the objective to extent the body of knowledge in technology and innovation management by understanding the specific capabilities necessary for innovations in smart service environments. Case data is collected via in-depth expert interviews [23]. A generic purposive sample of experts with diverse backgrounds regarding industries and their firm's position in smart service value chains are chosen [24]. To assure extensive accumulation of knowledge and experience in this field, we only focus on experts currently being engaged in consulting on smart service development, or working for firms that are developing and offering cutting edge smart services. The in-depth interviews are analyzed following Kuckartz (2007) and applying an open coding approach [25].

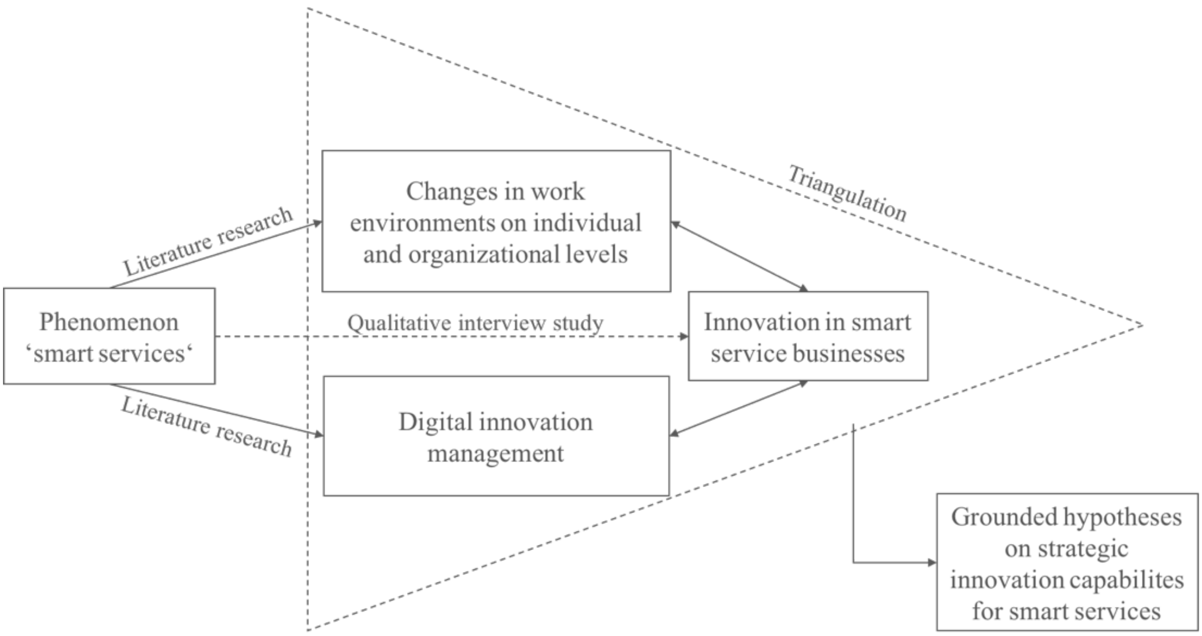

Fig. 1. Research design

Through triangulation of multiple sources of evidence, we intend to determine the consistency of our findings [31; 33] (Fig. 1). Thus, we critically reflect and enrich qualitative interview study evidence with evidence gathered through the literature research [28] outlined in the previous section of this paper to move towards accuracy and credibility of results. As result of this research approach, we aim to deduce grounded hypothesis on the transformation of the innovation capabilities.

4 Conclusion and Research Contribution

The research proposed in this paper aims to explore how activity shifts to the field of smart services will affect innovation capabilities. We therefore propose a qualitative research design based on expert interviews considering multiple cases and backgrounds. As a first step, related research has been extracted in the course of a literature research. Next steps will be the conduction and analyzation of the expert interviews among firms currently consulting on smart service innovation or offering cutting edge smart services. Qualitative study results will further be enriched by knowledge gathered through the literature research analyzing digitization challenges as well as changes in work environment and required qualifications.

Our work contributes to the fundamental understanding of innovation capability transformation in smart service environments and businesses. It can provide guidance to business leaders aiming to innovate in these environment on where to focus considering the strategic development of future innovation capabilities and employee qualifications. Furthermore it provides input for the potential transformation of innovation processes as well as the generation of innovation methods and tools by pointing out the significance of future capabilities.

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Design Thinking for Industrial Services
First Insights from a Joint Project of SMEs and Universities

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Abstract. Due to an increasing demand for industrial services and innovative customer solutions, B2B service providers strive for innovating their offerings. However, especially small- and medium-sized enterprises (SMEs) appear to be challenged by the adoption of systematic innovation procedures and methods, such as Design Thinking (DT). We pursue a publicly-funded project with the objective of developing a specialized DT approach, a method-toolbox, and a digital platform that are supposed to enable industrial service providers to apply an adapted DT procedure time- and location-independently across organizations. In this article, we first examine the specific context of industrial services and outline the challenges concerning an adapted DT approach. Second, we introduce our methodological approach based on Action Design Research. Third, we present our preliminary reflections and learnings after the first year of the project.

Keywords: Design Thinking, Innovation Management, Industrial Services, Action Design Research.

1 Introduction

There is an increasing demand for services and innovative customer solutions in the industrial sector [1–3]. B2B service providers accordingly strive for innovating their offerings, but obviously also face challenges with adopting systematic innovation procedures and methods, such as Design Thinking (DT). Against this backdrop, we pursue a publicly-funded three-year project with the following objectives: First, dedicated to the innovation of industrial services, we develop a specialized DT approach. Second, we generate a method-toolbox that accumulates a variety of given and newly developed DT methods. Third, we develop a digital platform that enables industrial service providers to apply the adapted DT procedure and methods in time- and location-independent teams and across organizations.

2 Research Background

Industrial services are typically offered in combination with goods (i.e. product-service systems) in business-to-business (B2B) settings [3, 4]. Industrial service providers can be manufacturing companies that augment their product portfolio with services as well as pure service companies (e.g., engineering, maintenance, repair, or personnel services). While the main characteristics of services basically also hold true for industrial services, they have a strong association to products or manufacturing processes [4].

DT was originally targeted at developing innovative tangible products that serve a customer's needs. A DT process usually guides through different modes of logic, starting with inductive reasoning (social sciences), over abductive reasoning (design sciences) to deductive reasoning (engineering). Hence, a basic logic to arrange the DT phases exists, but the process might also jump from abductive reasoning to inductive reasoning etc. due to iteration.

Various cases show that DT can be applied for product or for service development [5]. Stickdorn and Schneider [6] show that DT in the service sector – in comparison to DT for products – has specific characteristics and, hence, should use specific methods. We therefore argue that a specific set of methods (and respectively a specific set of phases) must be defined for an "Industrial Services Design Thinking" (ISDT). In order to identify appropriate phases and methods for the ISDT, we pursue and analyze innovation processes in the industrial service sector. For the development of a method-toolbox for ISDT we also identify and match DT requirements with industrial service characteristics. It is our intention to complement this methodological advancements with the development of a virtual platform on which ISDT processes can be carried out in a time- and location-independent manner. We see the advantage of such a platform in that it can bring together representatives from different organizations without having them physically in the same place. It will also allow them to dedicate time for DT projects in a partly asynchronous manner so that they can work on a DT project when time allows or when an idea has just sparked in their minds.

3 Research Setting

Our research applies Action Design Research (ADR) [7] as we address “a problem situation in a specific organizational setting by intervening and evaluating” and we aim at “constructing and evaluating an IT artifact that addresses the class of problems typified by the encountered situation” [7]. Within our project, we extend the organizational setting, which is usually focused on one organization only, to the joint publicly-funded project team that includes researchers from different German universities as well as three small- and medium-sized German industrial service providers (i.e., technical documentation services, hydraulic systems, and personnel services). Hence, the participating organizations not only learn and intervene within their own context, but also work together on the described class of problem and learn from each other in resolving it. With this research project, we aim for an intertwined set of artifacts, including a specific ISDT process and corresponding methods that can be applied in workshops as well as a virtual platform that allows to carry out ISDT in time- and location-independent teams and across organizations.

4 Preliminary Reflections and Learnings

In the first year of the project, we jointly went through multiple series of DT workshops in which we tackled innovation challenges from the industry partners. We began with a six-phase DT process [8], using established methods typically used in a non-digital workshop settings. By applying these existing artifacts and knowledge to innovation management in the industrial services sector, we identified the need for advanced methods and IT support that we will develop as part of the project. Our preliminary reflections address three different levels of innovation management problems:

- (1) *Different innovation mindsets and capabilities in the industrial services sector:* The project partners are SMEs. Before the project, these SMEs had no structured procedures for innovating their service offerings, indicating a limited knowledge about innovation management in general and DT as an established approach in specific. We conclude from this that managers in SMEs generally need an easy access to best practices and guidance to DT methods, as well as to knowledge about organizing innovation teams, applying methods, and time framing for workshop interactions. We also see that DT as an innovation process requires open-mindedness, trust, and the willingness and ability to share knowledge between different stakeholders [9, 10]. However, we found at our partner organizations that this mindset rarely exists in the workforce and that it is difficult to involve customers in innovation activities beyond the actual sales process [11].

- (2) *Need for support for applying innovation methods:* Industrial services require DT methods to be applied differently or they require even completely new DT methods or phases. To give an instance, DT always starts with a specific way of framing a goal for an innovation cycle (design challenge) by asking an open-ended question without targeting a solution (or suggesting a product or service) from the beginning. During our workshops with the three SMEs, we found that managers from SMEs have hard times to frame such open-ended innovation challenges. One key insight for the development of our ISDT procedure was, therefore, that a dedicated phase for defining the design challenge at the beginning of the innovation process is needed. Existing DT phase models do not include such an initial phase.
- (3) *Need for IT support for innovation processes in order to be able to involve dispersed partners:* For the goal of developing a platform that enables time- and location-independent DT, the tasks of the moderator need to be integrated in the functionalities of the virtual platform to be designed. Additionally, most methods need to be digitized and integrated in the platform. Here, transferring the DT mindset to a virtual level is challenging. We, therefore, test our prototypical developments of DT methods with interdisciplinary evaluation approaches, such as shared mental models (SMM), in order to improve the virtual collaboration experience [12]. SMM are the accumulation of diverse mental models and individual representations that fuse during collaboration to create a shared understanding towards, e.g. tasks, goals and requirements [13]. The psychological construct of SMM offers the opportunity to measure the success of creative virtual teamwork when using dedicated tools such as digital whiteboards for collaborative visualization. Our examination revealed that, in order to perform DT virtually, the technological requirements for creative virtual teamwork need to be aligned to teamwork processes.

5 Conclusion

In this paper, we introduced our research project that aims at developing an adapted DT approach for industrial services and a virtual platform that enables time- and location-independent DT for industrial services. We undertake interventions in order to adapt the DT process and methods to better suit the context of industrial services. We also increasingly virtualize the innovation process via virtual DT workshops and reflect on our learnings.

While the project provides a setting in which different researchers and organizations work together, it has already sparked interventions at single organizations, too. Directly with the beginning of this project, one of the service providers defined a systematic innovation process and began to integrate DT methods into their own work routines. The experience they make will inform and continuously shape the ISDT artifacts that we develop in this project. Eventually, our preliminary reflections and learnings from our project reinforce the need for a well-adapted DT approach for industrial services. Further on, we expect our specialized ISDT approach to yield new phases and an adapted process order as well as new and adapted methods that will help industrial service providers in innovating industrial service offerings more successfully.

In the subsequent months, we will devote a main share of efforts on developing the virtual platform including digital DT tools. We will complement this with critical evaluations in order to find out in how far DT projects can actually be transferred to a digital platform without losing the required degrees of freedom and creativity

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Collaborative Ontology-Based Semantic Text Annotator

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Abstract. Ontology-based semantic annotations are in particular used for machines to interpret the information and provide the correct information for a given context. However, most Ontology-based semantic annotations do not capture annotations collaboratively or allow to apply various ontologies. Therefore, we want to present our solution of an Ontology-based semantic annotation tool that allows for capturing text annotations in a collaborative manner and publishes the annotations according to the Linked Data principles. The tool allows for using multiple ontologies and is designed to be easily adapted to capture multimodal formats.

Keywords: Text Annotation, Information Retrieval, Semantic MediaWiki

1 Introduction

Annotations are explanations or comments, added to resources in order to provide additional information. Annotations can be provided to various data modalities including text, web documents, images and videos. Semantic annotations are in particular used in Information Retrieval to provide more accurate search results and in Machine Learning approaches to improve the outcome [1]. Ontology-based semantic annotations brings some avantages to semantic annotations like e.g. disambiguation. Therefore, homonyms can be marked in text documents and the context provided in which they appear. However, most annotation tools either do not allow users to capture annotations collaboratively, do not use ontologies for annotations or do not allow for including various ontologies [2]. Therefore, we want to tackle these issues and provide a solution for (i) annotating text documents collaboratively, (ii) allow for using multiple ontologies, (iii) publishes the annotations according to the Linked

Data principles [4], (iv) is easily extensible to capture addition information and (v) can be easily adapted to capture multimodal formats.

The remainder of the paper is structured as follows. The requirements and the used materials are described in section 2. The evaluation (section 3) of our solution points out how the requirement where fulfilled. Related work is described in section 4. A short discussion and lessons learned is given in section 5.

2 Material And Methods

A key fact in knowledge management is sharing and collaborating information. Various users might bring different kinds of knowledge and annotations. Therefore, we have to apply a **collaborative system**. In this context, the **traceability** of changes is also important. Documents may change over time. Thus, it has to be clarified what should happen with the annotations for changed documents. A **user-friendly interface**, as well as a convenient handling is an important aspect for an annotation tool. Another requirement is the **linguistic independence** of the annotation tool, so that it incorporates with text documents, independent of the language. Ontologies allow for modeling or describing resources and share annotations across organizations. We will not focus on using a particular ontology but allow for including **multiple ontologies**. As further requirement, we will follow the Semantic Web model, which **decouples the content**, stored in a document, and the provided semantics [3]. Furthermore, the created annotations should follow the Linked Data principles [4]. The last addressed requirement is the **extensibility to various formats** (images, videos, etc.). In future, we might extend the usage of the annotation tool to multimodal formats. Therefore, we will consider this requirement in the design and implementation phase of the tool.

Semantic Media Wiki[1] (SMW) [5] serves as collaborative platform to capture and store annotations on documents. SMW is an extension to MediaWiki[2] that allows for storing and querying information in a structured way and publishes them according to the Linked Data principles [4]. Thus various people can access, edit and add annotations into the system in a collaborative manner. We created an extension to SMW,

[1] https://semantic-mediawiki.org, accessed: 2017-09-03
[2] https://www.mediawiki.org, accessed: 2017-09-03

called Semantic Text Annotator[3], to capture annotations on texts, published in wiki articles. We used Annotator[4] as interface for creating annotations. We extended its functionality with Page Forms.[5]. This extension displays a form to facilitate the input of meta-information and store them in a structured way. Our extension allows for selecting different categories, encoded in colors, for each annotation. Depending on the selected category is the corresponding form displayed. Categories can be created by users.

The advantage of our approach is the simplified extensibility with additional categories of annotations, the flexible integration of different annotations, as well as the usage of multiple ontologies by using the SMW Ontology import. The annotations are stored, due to the usage of SMW, according to the Linked Data principles [4]. In addition allows the user interface a simplified add of new annotations. Each annotation is stored on its own wiki page, therefore, we satisfy the Semantic Web model of decoupling the content and the provided semantics. The connectedness of the annotation tool is depicted in figure 1.

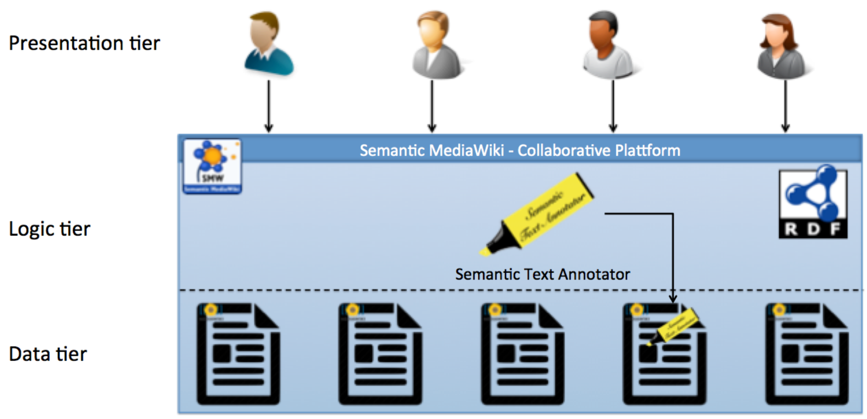

Fig. 1. System overview and integration of the Semantic Text Annotator.

3 Evaluation

In the following, we will evaluate the approach whether the requirements from section 2 have been fulfilled by the Ontology-based semantic text annotation tool. There-

[3] https://www.mediawiki.org/wiki/Extension:Semantic_Text_Annotator, accessed: 2017-09-03
[4] http://annotatorjs.org, accessed: 2017-09-03
[5] https://www.mediawiki.org/wiki/Extension:Page_Forms, accessed: 2017-09-03

fore, we stored abitur essays in a Semantic MediaWiki and captured the comments, and additional information, like e.g. whether a comment has been provided in a positive or negative context, of the teacher about text phrases in the essay by using the Ontology-based semantic text annotation tool. Thus, we could show the proof of concept and ensure the functionalities, including querying the annotations. An examplary query, which counts the number of annotations, marked as positive, in the document GHO-083-1 is depicted below. A sandbox implementation of the Semantic Text Annotator can be found on the SMW Sandbox webspace[6].

```
PREFIX aifb: <http://aifb-ls3-vm2.aifb.kit.edu/DevelopersDay/index.php/Special:ExportRDF/>
SELECT count(?annotation) WHERE {
    ?annotation rdf:type aifb:Category:TextAnnotation ;
    aifb:Property:Annotation_Of aifb:GHO-083-1 ;
    aifb:Property:FeedbackContext 'positive' .
}
```

Due to the fact that the Semantic Text Annotator runs within a SMW and allows multiple users to contribute annotations to wiki pages, is the requirement of a collaborative tool fulfilled. MediaWiki takes care of the traceability by storing the edits of users of each wiki page. Because the annotations are wiki pages itself, the traceability of the annotations is given and therefore, the second requirement fulfilled. The requirement of a user-friendly interface is objectively difficult to measure. Nevertheless, we believe that this requirement is fulfilled by the intuitive application of the tool and the impact in the community. The Semantic Text Annotator allows for annotating any text, independent of the language. SMW allows for importing ontologies. Therefore, any property, used to capture annotations, can be linked to properties from imported ontologies. In addition, categories of annotations can be linked to imported classes. Therefore, every ontology can incorporate with the Semantic Text Annotator. Decoupling the content is achieved by storing the annotations on different wiki pages. Thus the annotated text and the annotations are decoupled from each other, which shows the realization of this requirement. The annotations comply to the Linked Data principles [4] as they are articles in a SMW and thus are identified by using HTTP URIs, published in a standard format (RDF), and provide useful links and information. As last requirement, we wanted to have the possibility to extend the approach to various data modalities. The approach can easily be adapted to capture other formats, which already has been done. Thus, we applied the same approach to capture images in a Semantic MediaWiki[7].

[6] https://sandbox.semantic-mediawiki.org, accessed: 2017-09-03
[7] https://github.com/TobiasWeller/SemanticImageAnnotator, accessed: 2017-09-03

One advantage is the sheer infinity of the annotation-categories, which are highlighted in the texts by using colors. Although this is practical for a few annotation-categories, it might lead to confusion when, with a large number of colors, these flow into one another. However, we felt that another way of marking annotations by using the information of their categories were not useful.

4 Related Work

A variety of previously proposed annotation tools and approaches exist to annotate texts [6], images [7] and videos [8, 9]. An overview of existing annotation tools is given in a published survey [2]. The most basic annotation tools allow users to manually create annotations [10–13]. More advanced annotation tools allow for semi-automatic annotations [14, 15] or automatic annotations [16, 17], which use Machine Learning approaches to recommend annotations.

Focusing on text annotation tools, there are solutions that work on a local system [14]. However, due to the local execution, it is only partly suitable in a collaborative manner. Some web-based text annotation tools, enables users to collaboratively annotate text documents [6]. Existing semantic annotation tools learn annotations by generalizing previous annotations made by users [18] or produces automatic domain-specific annotations by using an ontology [19].

5 Conclusions

We described a tool for capturing ontology-based semantic text annotations. Posed requirements, mentioned in section 2, were considered in the design phase of the tool. We demonstrated the applicability and the realization of the requirements in the evaluation (section 3). The tool runs in a SMW environment, which therefore can be used collaboratively and allows for using multiple ontologies. The captured information by the annotations can easily be extended by users. This tool allows for capturing text annotations, however, the tool is designed in a way to be adapted to capture multimodal formats. We already adapted it to capture images[8].

Future work includes the extension to allow for capturing video and PDF annotations. Thus we support texts, images and videos by using an equal design of the tools.

[8] https://www.mediawiki.org/wiki/Extension:Semantic_Image_Annotator, accessed: 2017-09-03

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