TUM

Visualizing and Communicating the Environmental Impact of Business Processes

Master Thesis Proposal

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1 Introduction and Motivation

The destruction of Earth's ecosystems, impacting the atmosphere, land, and water resources (Raskin, 2002) due to human activities, has far-reaching implications for businesses, prompting a heightened focus on 'sustainability.' Sustainability is a social goal for people to co-exist on Earth over a long time (Brown et al., 1987). Especially for environmental sustainability (ES), with its focus on sustaining the living (Goodland, 1995), it is central to the overall sustainability concepts. This means ES has long been more than just a topic on paper, the pursuit of ES has become the megatrend of our time.

Business Process Management is a management approach that focuses on aligning all aspects of an organization with the wants and needs of clients, and it can be described as a 'process optimization process' (Badakhshan et al., 2019). Enhancements and innovations in the core business processes can directly lead to improved organizational efficiency. Recently, researchers in the Information Systems discipline have realized the importance of using information system knowledge to tackle environmental problems (Gholami et al., 2016); researchers tend to extend conventional BPM by adding an environmental sustainability dimension (Seidel et al., 2011). Instead of factors like time and costs, organizations also have been challenged to identify their environmental impacts to address environmental sustainability issues (Roohy Gohar and Indulska, 2020).

Green BPM focuses on specific environmental objectives, emphasizing the measurement and optimization of these impacts within business processes. Key Ecological Indicators (KEIs) play a vital role in this, in order to effectively reduce the environmental impact of business processes. KEIs should be analyzed with a globally agreed set of standards or metrics (Wesumperuma et al., 2011). One good example of such a standard is the GHG Protocol Corporate Accounting and Reporting Standard, which provides requirements and guidance for companies and other organizations preparing a corporate-level GHG emissions inventory (GHG Protocol Website, 2023).

Additionally, for the measurement of environmental objectives, Activity Based Costing (ABC) was first introduced by Kaplan and Cooper, 1992, which provides a systematic cost accounting method. It identifies activities within an organization and assigns costs for each activity (Turney, 2008). ABC has been used mainly for product costing (Sievanen and Tornberg, 2002). However, in the context of green BPM, the ABC method is extended to include environmental impacts (Wesumperuma et al., 2013), (Recker et al., 2011) and measures the environmental factors in terms of business processes.

In order to measure environmental impacts using the ABC approach in business processes, efficient business process modeling and visualization techniques play a vital role in the Green BPM field. A good business process model supports the understanding of an organization's business process (Rittgen, 2010). However, if the visualization of the BPM model is not comprehensive enough, it will lead to misinterpretations and false conclusions drawn by business users. Various visualization techniques and methods for implementation in BPM exist (Stein Dani et al., 2019). Typically, existing approaches usually use methods such as numeric representations or coloring the process model (Cordes et al., 2015) to visualize the environmental impact of business processes. Such approaches can misrepresent the impacts on business users and result in poor business decisions. Moreover, most researchers did not conduct a user study to evaluate the clarity and understandability of their visualization methods and seldom consider users' roles and their accessibility to the process, and there

remains a gap in implementing effective visual analytics in Green BPM, particularly in conveying environmental impacts to business users in an understandable way.

Our research aims to bridge this gap by developing a comprehensive mechanism that not only accounts for environmental impacts but also enhances their communication with business users through effective visual analytics methods. This approach will be evaluated by structured guidelines for its effectiveness and user-friendliness, focusing on gathering insights from user experiences to refine the mechanism further.

2 Objectives and Methodology

As mentioned earlier, there is a lack of clear visualizations for KEIs, making it difficult to understand and use this important data. In our research, we aim to fill this gap by taking a mixed-methods approach, by first identifying the relevant KEIs, developing suitable mechanisms, and conducting evaluations to ensure accuracy and usability. This section outlines the specific research questions guiding our research and provides an overview of the methods we will use to address them.

RQ1: Which indicators can be used for measuring the environmental impact of business processes?
To address the research question, the proposed methodology will involve an extensive literature review. The literature review will follow guidelines proposed by Snyder, 2019, including four phases: design, conduct, data abstraction and analysis, structuring and writing the review. The review aims to identify and extract various environmental impacts that are commonly utilized in current BPM-related research, as well as find exact methods on how to measure them, spanning from direct measurement techniques to indirect estimation methods. Through the literature review, a preliminary literature search has already shown that several articles focus on measuring greenhouse gas emissions, for example, Wesumperuma et al., 2011, Ahlers et al., 2017. Others like Nowak et al., 2013, focus on computing energy usage at the process level. As for the measurement methods we apply in our study, we suggest an Activity-Based Costing approach, since it is widely recognized for its utility in calculating costs at the process level, and research has been conducted by using it to measure the environmental factors (Recker et al., 2011). By using the ABC method based on emission and activity data, we can calculate and visualize the environmental impacts at the process and activity level.

RQ2: What mechanisms with visualization techniques can be used to enhance the clarity of environmental impact visualizations within business processes?
A multi-step methodology is proposed to address this research question. Initially, we will examine the works we found during the literature review in RQ1, since these works also contain visualization methods for the environmental impacts of processes they use. An initial literature search has already revealed that several articles focus on different visualization techniques for business process management. However, few articles are available for visualizing environmental impacts, and the existing ones have shortcomings in their methods. For example, Cordes et al., 2015 proposed a simple visualization method using color-coding to highlight differences, but it can oversimplify complex processes, potentially leading to misrepresentation and overlooking critical aspects. Similarly, Reichert, 2013 introduces a different method of customizing the appearance of process elements based on users' roles, which can still lead to misinterpretation and implementation challenges.

Furthermore, the initial literature search in business process performance reveals visualization techniques like dashboards, which can be used as tools to better understand environmental impacts. The study by Kumar and Belwal, 2017, demonstrates how such a dashboard provides a clear and immediate insight into current performance metrics. Additionally, Microsoft PowerBI, employed by Gonçalves et al., 2023, for developing performance dashboards, stands out with its sophisticated data visualization features, making it a good choice for further exploration in our research.

Therefore, building upon these observations, we will continue to analyze the existing visualizing methods within the Green BPM field and aim to identify methods for enhancing the visualization of environmental impacts. Our proposed improvements will be guided by the 'what-why-how' visualization framework as outlined in Munzner, 2014. This systematic three-part analysis framework comprises questions about what data is shown in the views, why the task is being performed, and how the visualization is constructed regarding design choices. Improve-

ment methods may include adding annotations and interactive features to improve comprehension, especially for business users. Additionally, we will consider Tableau or PowerBI, both of which are data visualization tools, as potential alternatives for visualization within our research.

We will proceed to develop and demonstrate the mechanism for visualizing the environmental impacts within a business process, using a process model in BPMN (White, 2004) as a case study. The selection of the business process for our case study will be based on its task relevance and its ability to effectively represent environmental impacts. To further support the demonstration of our visualization approach, we will incorporate business process simulation (BPS), which provides a dynamic platform to simulate various scenarios. BPS allows us to generate run-time data, which will help demonstrate the practical feasibility of our approach.

RQ3: How can the effectiveness of the developed mechanism improve business users' comprehension of environmental data compared to the existing visualization mechanisms by evaluation?
To evaluate the mechanism accurately, the research will involve designing realistic simulation scenarios based on actual business processes. Utilizing realistic process data will allow us to demonstrate the developed visualization mechanism and its improvement over existing ones. Furthermore, evaluating the mechanism requires gathering qualitative insights, which can be achieved through user interviews or open-ended questionnaires designed to capture user experiences. Drury et al., 2011, outlines key steps in qualitative methodologies, including question formulation and ethical review. In our research, we will conduct the user interview by using the systematic methods proposed by Young et al., 2018, which presents brief basic stages for conducting a good user interview and survey, from initial project design, data gathering to analysis and write-up. The first initialization stages include identifying research questions, selecting the interview type, and devising initial interview questions. The interview step includes sampling, ethical review, pilot/refine interviews, and undertaking interviews. This method will ensure a structural user study process, as well as allow for continuous analysis, improvement, and validation of the visualization mechanism. Regarding suitable users for the study, the focus will be on business professionals who regularly interact with environmental data as part of their job, such as environmental analysts or roles where understanding environmental data is crucial. Including a diverse range of users from different levels of expertise will also ensure a comprehensive evaluation of the evaluation process. The desired outcome of evaluations is listed in the following part: firstly, to gain insights into how the new mechanism improves comprehension of environmental data compared to existing methods, and secondly, to clearly identify areas for further improvement in the mechanism based on the surveys and interviews. The ultimate expected result will be iteratively refining the mechanism, leading to better user satisfaction.

To sum up the three research questions, the methodology for this thesis will be structured within the framework of Design Science Research (DSR). The design science (DS) process includes multiple steps: problem identification and motivation, the definition of the objectives for a solution, design and development, evaluation, and communication (Ken Peffers and Chatterjee, 2007). In our research, for the first step, the problems have already been established by recognizing gaps in the current relationship between green BPM and visualization techniques. Building on this, in the second step of our research, our objective is to enhance user comprehension of the environmental impacts of business processes through appropriate visualization mechanisms. Moving forward to the third step in DS, our research will create a mechanism, incorporating case study and BPS as well as innovative visualization technologies. The evaluation phase will involve using user-centric evaluation methods such as user interviews and questionnaires as well as BPS. The evaluation will assess the mechanism's effectiveness in improving user comprehension compared to existing mechanisms. For the last step in DS, the research will conclude and analyze the results, and the knowledge that we gained will be shown as a conclusion of the whole DSR process.

By answering these research questions, our study will provide valuable insights into how business users can better comprehend the environmental impacts within business processes. Furthermore, the research questions directly address the significant gap in the field of green BPM and visualization. This gap lies in the limited understanding of effectively conveying complex environmental data within business processes to enhance users' comprehension and decision-making. Our research aims to explore innovative visualization mechanisms compared to existing methods, and the findings from this research will not only contribute to the theoretical

understanding of environmental impact visualization but also offer practical solutions for businesses seeking to integrate environmental impact considerations into their process management.

3 Conclusion

3.1 Expected Contributions

By completing the master thesis, a new mechanism will be proposed for visualizing the environmental impacts on business processes more effectively and user-friendly. Also, the research integrates visualization techniques instead of simply using numeric representations to communicate the environmental impact of business processes, which helps reduce the risk of erroneous interpretation. Last but not least, by using user-centric methods to evaluate the newly developed mechanism, it is possible to provide insight into the impact of the mechanism on user understanding as well as the potential risks of misinterpretations.

3.2 Risks

There are still many potential challenges to finishing the research that may hinder the progress of the thesis. First of all, there is a risk in integrating visualization analysis techniques with green business process management since it requires detailed knowledge in both fields. However, there is little documentation on the interdisciplinary topic. While doing a literature review, we might encounter this problem. However, this risk can be mitigated by conducting a more exhaustive literature review or communicating with specialists in these areas. Another significant challenge is ensuring the robustness and generalizability of the mechanism. Even though it is possible to do a user study to evaluate the mechanism, the results may be skewed by users' subjective views and biases, affecting its robustness. This issue, likely to arise during the evaluation phase of the DS process, can be mitigated by adopting an iterative development approach. Moreover, we can include a wide range of participants in user studies, which can help mitigate potential bias problems. Additionally, the proposed evaluation method in RQ3 faces the risk of a lack of suitable users. To counter this, we can broaden the user pool from business experts to academics with BPM knowledge, such as the members from the information system chair and other BPM experts. By using this method, the user availability concern is addressed. It will also contribute to a more comprehensive and diverse evaluation of the mechanism's effectiveness and applicability. Furthermore, the mechanism based on the business process model we have generated might not be suitable for different business contexts, which limits the mechanism for further application. To address this potential problem, we can develop a mechanism with modularity, which can result in better generalizability.

3.3 Timeline

The following Table 1 shows the rough time schedule for the master thesis:

Task	Duration
Thesis Proposal and Literature Review	01.12.23 ~14.02.24
Official Registration	15.02.24
Data Collection	16.02.24 ~15.03.24
Mechanism Development	16.03.24 ~15.06.24
Evaluation and Conclusion	16.06.24 ~15.07.24
Thesis Completion	16.07.24 ~14.08.24
Official Submission	15.08.24

Table 1 Timeline

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