The State of the Art on Process Virtualization: A Literature Review

Completed Research Paper

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Abstract

The growing world-wide globalization and the possibility to use new innovations of the digital economy leads to the fact that more and more processes and services are being virtualized. The purpose of this paper is to describe, synthesize, evaluate, and integrate the results of prior research on Process Virtualization Theory by conducting a systematic literature review. We selected six academic databases and search engines as adequate with respect to the IS field, covering the period of time from 2008 to date. We created an initial catalogue of existing research and approaches that focus on process characteristics or characteristics of the IT-based virtualization mechanisms. We categorize, consolidate, and discuss the relevant papers accordingly. The results show that empirical studies of Process Virtualization Theory are lacking and the theoretical research is still the most used method.

Keywords


Introduction

Our modern society is increasingly characterized by the possibilities of information technology (IT) (Overby 2008). In many areas of life, we observe that activities, which required a personal contact between the process participants a few years ago, are now handled via the Internet or otherwise in virtual and not physical ways (Boughzala et al. 2010). The technical possibilities and especially the Internet have led to an ever-increasing number of virtualized processes in recent years (Barth and Veit 2011). In this day and age, virtualization is still emerging, although for some it has already become indispensable in everyday life. Our society is becoming transformed into a digital or “virtual society” (Woolgar 2002) which orders products over the Internet, makes or terminates friendships in social media networks, does administrative procedures online, and works in virtual teams. We assume that this change will continue and even be accelerated in the future (Overby 2012).

All of this leads to the question what factors influence the transition from physical processes to virtual environments. Why are some processes suitable for process virtualization (e.g., the sale of books or music on the Internet) and others tend not to be (e.g., the sale of wedding dresses)? How to make a prediction on how the virtualization of processes will continue to develop? Within a seminal paper, Overby (2008) presented a theory and research model – process virtualization theory (PVT) – which tries to determine the influence of process characteristics on virtualization in order to provide an answer to this question. Our paper presents a literature review concerning the state of the art of PVT. It discovers and illustrates in what way preceding research has given attention to virtualization of processes, what the current state of the art of the topic is, and ultimately represents and proposes its implications and limitations as well as a concluding discussion. Based on the development of the corresponding state of the art, the purpose of this review is to identify the role of PVT, to expose gaps within this domain, and eventually to provide suggestions for improvement.
More specifically, the goals of our study are:

- to identify, categorize, and critically display the existing approaches used for measuring and evaluating PVT;
- to provide an overview of the most important dimensions which influence PVT;
- to reinvestigate PVT’s conceptualizations based on the level of knowledge on PVT.

For the purpose of achieving this research aim, we identify, gather, and classify the relevant data and existing approaches in order to obtain a useful and goal-oriented data base for the next stage. With this base literature, one can create a combined united catalogue that provides a synthesized overview of the matter in this regard and eventually develop suggestions and incentives for future work. As a result, this literature review is intended to be accessed in order to assist further and proceeding research.

The rest of the paper is organized as follows. Section 2 introduces the theoretical background and related work that serves as a fundament for the framework, analytical research, and review. Section 3 illustrates how the literature review was planned and introduces the framework for analysis. Section 4 presents the data analysis and the relevant findings in detail. Section 5 summarizes our findings and discusses future research directions.

**Related Work and Theoretical Background**

The foundation of this literature review consists of the work of Eric Overby who introduces and establishes a respective model with regard to process virtualization in Overby (2008). Introducing the theoretical background serves as a starting point to investigate existent literature about the state of the art of PVT.

PVT is concerned with the virtualizability of processes. It considers the factors that influence virtualizability from a user perspective (Barth and Veit 2011). The relevant processes are reflected not only in business processes, such as the development of products, but also in private processes, such as learning a new language (Overby et al. 2010). Therefore, Overby (2008) defines the process in general terms, as a sequence of steps to achieve a certain goal (Overby 2008). To describe the process of virtualization, a differentiation is made between a physical and a virtual process. In a physical process, various people or objects interact with each other physically (Overby 2008). A “virtual” process is a process in which physical interactions have been removed (Overby 2008). The transition from a physical to a virtual process is called process virtualization (Overby 2008). This is illustrated by virtualized processes such as online shopping, distance learning, or relationship building on social networks (Overby 2012).

The main assumption of PVT states that the transition from a physical to a virtual process is more accessible for some processes than for others, and thus not all processes are equally well virtualizable (Overby 2012). Therefore, “process virtualizability” is the dependent variable in PVT (Overby 2008). It can be measured by the quality of the result of the virtual process or the use of the virtual process (Overby 2008). There are two types of independent variables which influence the virtualizability of a process and thus determine the degree of virtualizability: process characteristics and characteristics of the virtualization mechanism (Overby 2008).

As regards the characteristics of the process, PVT proposes four main factors that can be used to assess how suitable a specific process is for virtualization: sensory requirements, relationship requirements, synchronism requirements, and identification and control requirements (Overby 2008). Each of these requirements is proposed to have a negative effect on process virtualizability; as each requirement increases, the process becomes less amendable for virtualization. (Overby 2008; Overby 2012).

The first construct of PVT is “sensory requirements”. They describe the needs of the users to experience the process and the other process participants and objects with all their senses (Overby 2008). “Relationship requirements” form the second construct of PVT. They include the necessity felt by an user to be in direct physical contact with another person (Overby 2008). The third construct of PVT is “synchronism requirements”. They reflect the need for the individual process step to be run with minimal time delay (Overby 2008). “Identification and control requirements” form the final construct of PVT.
They describe the need for the identification of process participants and the ability to exercise control over them (Overby 2008).

In addition to the four process characteristics, all of which adversely affect the virtualization of a process, Overby (2008; 2012) includes also the role of IT in his model. In recent years, many processes have been successfully virtualized through the use of IT (Overby 2012). Three constructs are related to IT: representation, reach, and monitoring capability. “Representation” reflects the ability of IT to reproduce relevant information about a process. “Reach” describes the capacity of IT to allow process participation across both space and time. “Monitoring capability” is the capacity of IT to authenticate process participants and to track activity (Overby 2008). These characteristics of the IT-based virtualization mechanism are proposed to negatively moderate the relationship between the four process characteristics and the virtualizability of a process (Overby 2008). Furthermore, these IT-related constructs are suggested to have a direct positive influence on the virtualizability of a process and are therefore independent variables within the PVT model (Overby 2012).

A brief visual summary of PVT, its constructs, and their proposed relationships is given in Figure 1.

![Figure 1. Constructs and Proposed Relationships of PVT (Overby 2012).](image-url)

**Literature Review**

**Framework for Analysis**

Our review is guided by the intent to summarize existing research on the constructs and relationships of PVT, aiming for studies that address PVT directly. Therefore, we created an initial catalogue of existing research and approaches that focus on process characteristics or characteristics of the IT-based virtualization mechanisms. The review investigates the categories that serve as necessary preconditions for the formation of the concepts of PVT. The aim of this catalog is to show and categorize the current state of research in the field of process virtualization, and especially on PVT.

The catalog thus consists of categories we identified as key factors with respect to PVT. Therefore, our literature study is primarily based on an investigation framework that we created for the classification of the selected literature. The catalogue is used in order to evaluate and assess the relevant publications in a proper way. Moreover, it improves the overview and facilitates a corresponding appraisal of results. Bearing these notions in mind, the following passage highlights which items and elements are identified as appropriate and eventually checked.

First, we examined the classification schemes of similar studies on the “state of the art” of research and adapted relevant categories for the present study (Pahlke et al. 2010; Urbach et al. 2009). The resulting framework comprises two categories: “data basis” and “data analysis”. The category “data basis”
distinguishes between empirical and non-empirical research. Moreover, these two types can be divided into subparts. Non-empirical publications are either commentaries or speculative research that is based on the experience of the author or a literature review and can be classified as “research on the basis of already existing research”. Empirical data includes surveys, interviews, field studies, and other practices in order to collect relevant data. It is important insofar as it enables to verify theoretical models and their hypotheses. In the case of an empirical approach, the type of used “data analysis” has to be examined. One has to check whether confirmatory methods (deductive), exploratory methods (inductive), both methods (inductive-deductive), other methods, or none of the above were executed for analyzing the empirical data. We have to highlight that the appearance of one method is not exclusive because empirical data can also be analyzed via a combination of methods. The confirmatory methods can, for example, either be regression analysis, structural equation modeling, or variance analysis. The exploratory methods include, for example, factor analysis, text analysis, or qualitative content analysis.

Based on these initial categories, we extend the analysis by scrutinizing certain traits concerning PVT. First, an essential distinction can be made with respect to the date of publication. For our study, it is beneficial to distinguish between publications from the time frame of 2008 until today and publications from before 2008. The distinction is insofar important as this date marks a cutting transition for the state of the art. Naturally, literature relating to the migration of processes from physical to virtual environments existed before 2008, but Overby (2008) creates with his PVT a significant amplification for progress since none of the preexisting literature offered an extensive approach with an immediate addressing of the matter in such a way. Because of this, we have considered in our investigation only the paper from 2008 up to now. Therefore, the dependent variable “process virtualizability” and the independent variables “process and virtual characteristics” are essential parts of the framework. Recalling their corresponding classification, process characteristics are the sensory requirements, relationship requirements, identification and control requirements, and synchronicity requirements; virtual characteristics are representation, reach, and monitoring. This catalogue of concepts provides an opportunity to check this concern in a well-arranged way. The explicit usage of PVT as a model in the relevant documents is also important to determine. A publication can refer to this model in several ways. The document can be primarily concerned with the theory, provide a distinction and compare it to other models, expand the theory, and add further elements in it, combine the theory with other theories, apply the theory in a certain environment and/or merely mention it shortly.

Figure 2 summarizes the resulting categories of our framework. The literature review is conducted by selecting, extracting and synthesizing data from the selected sources according to this framework.
Figure 2. Investigation Framework and Criteria Catalogue

**Literature search process**

We conducted a literature review following the approach of Webster and Watson (2002) and vom Brocke et al. (2009). In the first step, we selected a detailed list of academic databases and search engines from Wikipedia. The list consisted of a total number of 137 academic databases and search engines. We then selected five academic databases and search engines as adequate with respect to the IS field (see Figure 3). The rationale for the corresponding choice is that these databases depict the most relevant sources with regard to information systems research. This inference can be drawn by examining the currently available literature and tracing back their database source origin as they mostly come from these five databases. Supplementary to this, the cited literature within the results are investigated. Google Scholar, including the results of its function of being able to search through related articles and the literature that cites the selected papers, and other sources (e.g., SSRN) are additionally searched explicitly. The purpose of this procedure is to collect comprehensive, reasonable, and sufficient data for the review. The database search was conducted in December 2013.
Afterwards, we identified topic-related papers from the selected literature sources. An initial list of papers was generated using the following search query: "Process virtual*" OR "process digital*" OR "sensory requirement*" OR "relationship requirement*" OR "synchronism requirement*" OR ("identification" AND "control requirement") OR ("process characteristic*" AND "virtual"). The asterisk stands for a wildcard in the query. A wildcard enables to search for keywords in which variations of the string may occur.

The systematic search was limited to incidences of the chosen search term appearing in the title, abstract, keywords and body of the respective article and the mentioned inclusion criteria. As a result, we identified 2011 papers containing the search query. Figure 3 shows the identified academic databases and search engines and the search results within the respective databases. We then conducted a content-based analysis. We manually reviewed the papers of the initial list and selected only those papers that primarily deal with PVT. This resulted in a greatly reduced list of 35 relevant papers. The resulting 35 papers were afterwards classified according to the criteria of the catalogue (cf. Figure 2).

Figure 4 illustrates from which database the 35 publications and documents come from. It is observable that some databases were able to provide more relevant data for this review than others. However, this eventually does not indicate that a database with more hits can be classified as “better”, as the content of each data source is of more importance.
Analysis and Results

Before observing content-related differences between the 35 publications, it is conducive to take a look at the date of publication. Figure 5 displays the date of publication of the reviewed documents. PVT is a relatively recent and novel model, which debuted as a term in 2005 and eventually established itself in 2008. The peak-year is 2010. The probable rationale for this is the timeliness of the topic in this time period. Even though a downtrend seems to be observable in the last years, this should not result in the inference that PVT has lost its significance. In fact, this notion can be justified by bearing in mind that some authors need a long time to bring their work to an end and it takes another time period for a paper to be published. Additionally, the quantity of publications concerning this theory in the last years is still above the average (=5.83 publications per year over a period of 2008 to 2013).
Furthermore, the base data type is to be scrutinized, as it is a question of substance to assess the concrete kind of each relevant publication (Alavi and Carlson 1992; Urbach et al. 2009). The distinction can be made according to the notion in section 3 (Framework for Analysis), where the difference between empirical and non-empirical data was illustrated. Figure 6 presents an aggregated result of the documentations in terms of their types.

**Figure 6. Number of publications grouped by their base data types**

Figure 7 illustrates which data analysis methods are used. We note that the amount of confirmatory methods is considerably high in comparison to exploratory methods. This is probably due to the fact that some empirical data evaluation is elementary and does thus not require a profound analysis of the data with the aim of an exploratory method. Questionnaires and surveys which merely evaluate answers on the basis of series of questions can be categorized as “confirmatory methods” and are fully sufficient in order to receive applicable results.

**Figure 7. Number of empirical publications grouped by their method usage**
In the next step, we analyzed and summarized the findings for our main categories “constructs of PVT”, “usage of PVT”, “application areas of PVT”, and “Categorization of theories used in research on PVT”. Figure 8 displays how the distribution in terms of the usage of PVT occurs percentagewise. Three (6%) publications outline a distinction from PVT, 15 publications (29%) expand the model, and 11 (22%) are primarily concerned with its evaluation. 8 publications (16%) merely mention the theory, another 14 (27%) execute a theory combination and apply the theory in a broader sense. The usage is almost uniformly distributed, only the usage of distinction seems to appear more seldom.

![Figure 8. Representation of the usage of PVT](image)

Afterwards, we identified 11 different theories and frameworks which are used as theoretical foundations and related work of studies on PVT. Table 1 represents an overview of the most used theories in the research papers as a theoretical foundation, in addition to PVT itself. From the lower table we can see that most of the 35 identified papers used in addition to the PVT the Technology Acceptance Model and Task-Technology Fit theories.

<table>
<thead>
<tr>
<th>Theories</th>
<th>#</th>
<th>Examples</th>
</tr>
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<tbody>
<tr>
<td>Technology Acceptance Model</td>
<td>7</td>
<td>(Serrano 2011)</td>
</tr>
<tr>
<td>Task-Technology Fit</td>
<td>6</td>
<td>(Overby and Konsynski 2010)</td>
</tr>
<tr>
<td>Diffusion of innovations</td>
<td>4</td>
<td>(Nedbal and Wetzlinger 2012)</td>
</tr>
<tr>
<td>Theory of Planned Behavior</td>
<td>3</td>
<td>(Mburu et al. 2013)</td>
</tr>
<tr>
<td>Unified Theory of Acceptance and Use of Technology</td>
<td>2</td>
<td>(Serrano 2011)</td>
</tr>
<tr>
<td>Collaboration Virtualization Theory</td>
<td>2</td>
<td>(Fan et al. 2012)</td>
</tr>
<tr>
<td>Technology–Organization–Environment Framework</td>
<td>2</td>
<td>(Bose and Xin 2011)</td>
</tr>
<tr>
<td>Media Richness Theory</td>
<td>1</td>
<td>(Felden et al. 2010)</td>
</tr>
<tr>
<td>Extended Process Virtualization Theory</td>
<td>1</td>
<td>(Li et al. 2009)</td>
</tr>
<tr>
<td>Expectation Confirmation Theory</td>
<td>1</td>
<td>(Li et al. 2009)</td>
</tr>
</tbody>
</table>

**Table 1. List of theories and framework used in addition to PVT**

After perceiving how PVT is applied, we take a closer look in which concrete application areas the PVT is used by the data sample. For this purpose, a more intensive investigation with regard to content is necessary and this results in a compilation of certain domains which occur obviously frequently. The following areas constitute the majority of application areas of PVT: information systems in a general
sense, e-learning, e-commerce, communication and/or relationship, business processes, health care, mobile technology and PVT being the key issue of a document. The particular frequency of the domains is illustrated in Figure 9. It is observable that PVT is an inherent part in journals and working papers whose research areas are primarily concerned with communication and/or relationship and information systems in general. A gap in terms of referring to e-learning is recognizable.

![Figure 9. Application areas of PVT](image)

Figure 9 summarizes the findings for our main category “constructs of PVT”. The in-depth analysis of the 35 papers based on the essential categories shows that a very low number of the empirical studies are focusing on PVT’s constructs. The dependent variable “process virtualizability” and the attribute “monitoring capability” have the fewest references in time periods. An explanation for this is that the measurement of process virtualizability and monitoring capability are more problematic because no generally accepted instrument exists. Once more it is important to bear in mind that, due to the recentness of the model, a sample of 35 documents is available and numerical differences among the references of each characteristic may occur, however, is not considered sufficient.
So far, the analysis provides an overview of the topic. For the purpose of representing focal points and detecting research gaps, it is advantageous to create a systematic map according to the pattern and guidelines of Petersen et al. (2008). A systematic map creates a connection between base data types and their references to the essential process and virtual characteristics, and outlines focuses and shortcomings for the very same. The rows display the relevant characteristics, incl. referencing to the PVT as a whole, and the columns stand for the reviewed data types. Examining this map, it is observable that the amount of surveys concerning the theory and its characteristics is relatively low. Research with regard to process virtualization has roughly the scheme of either including all of the process characteristics in a data evaluation or none. Thus, it is visible that there are minor differences according to the amount among each category, which is an acceptable extent of deviation. Yet, we see that research concerning of the dependent variable “process virtualizability” and “characteristics of the virtualization mechanism” are existent, but inferior in comparison to other characteristics.

Figure 10. Main category “constructs of PVT”
Upon closer inspection of the systematic map, it is further revealed that concrete gaps exist in the research concerning this matter. The probably most relevant insight through the systematic map is that a shortage with respect to empirical data in matters of the PVT as a whole exists. As empirical findings in this context could enable a straight assessment of the PVT in practice by validating the theory and the corresponding hypotheses, it will be conducive to conduct empirical research in this regard for the future.

**Discussion and Conclusion**

This paper was designed to propose an overview of existing literature with respect to the PVT. Various publications were scrutinized in order to identify and assess the corresponding state of the art. A contribution was made to this field of research by means of an extensive and elaborate design of a literature review that was conducted on the basis of a defined framework and concrete selection criteria.

According to the expectations, a major part of the notions and assumptions of the authors resembled each other. The predominant perception within this literature review and its contributing authors was that virtualization has become an inherent part in this day and age for organizations as well as individual users (Balci et al. 2013b; Barth and Veit 2011). The subjective perceptions of users play indeed a decisive role in this domain as this assumption is verified in several empirical studies (Barth and Veit 2011; Overby and Konsynski 2010). Some processes are heavily dependent on certain conditions which are only detectable in physical environments and with the contemporary state of affairs it seems very difficult to migrate these processes into virtual ones (Balci et al. 2013a).

Scholars and scientists can achieve remarkable progress on the basis of virtualization by determining virtualized processes not as their focal point of studies but rather as instruments and means that can be utilized in order to set and achieve subsequent research objectives (Barth and Veit 2011; Li et al. 2009). Various authors allude to Overby’s work in their studies, eventually permitting to draw the deduction that the approaches of Overby are trailblazing and of vital importance (Balci et al. 2013a; Felden et al. 2010). In conjunction with this work, several articles are aimed to assess explanations of and rationales for the

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**Figure 11. Systematic Map - Research on process and virtual characteristics**

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success of virtualization (Balci et al. 2013a; Balci et al. 2013b; Li et al. 2009). Even though the opinions and findings of the authors can naturally diverge in some respects, the widespread conclusion is that process virtualization gains more and more importance in a sense that it has become inconceivable to imagine life without processes that have been migrated from physical to virtual environments.

An analysis of the literature preceding Overby's work illustrates that virtualization has already been an actual and newsworthy subject in that time period. But it was only after the appearance of the PVT to have a standardized approach in this regard at one's disposal. As a matter of fact, PVT comprises a theoretical model which entails a guidance to assess, constitute, and determine the critical factors and pivotal components that specify the migration of processes into virtual environments. The emergence of this model contributes to attracting the attention of some scholars and scientists to the topic, eventually resulting in a trend of increasing concern towards this matter. Moreover, the notion that virtualized processes are used more frequently as instruments becomes particularly apparent in the prospective research, in which the authors of relevant papers take a successful virtualization for granted and are therefore not concerned with the examination of the migration of processes.

On closer inspection of the research results, it is observable that, generally speaking, theories and models concerning this matter lack maturity. However, this should not be seen as an unforeseeable and astonishing claim, since readers have to bear in mind that these works are relatively novel and recent models and approaches, so that correspondingly, the amount of empirical data is not sufficient in order to approve and validate the recently formed theories and their hypotheses. The limitations of the current state of the art are related to the latter observation. The limitation of the literature is in this case relatively clear without ambiguity. Particularly with respect to the findings that can be derived from the systematic map, it can be assessed that the existing theories and approaches, whereupon some more than others, are insufficiently and not adequately supported by empirical data. Even though this is an understandable shortcoming due to mentioned timeliness, it nevertheless restricts to propose necessary empirical validation of the existing work. Hence, the progress of successive research that is based on confirmed models is temporarily reduced until sufficient and adequate empirical data is available. This should rather be considered as constructive criticism and definitely not as dispraise, since currency is indeed a critical factor.

Accordingly linked to the observed limitation are the next steps within this domain. We recommend to conduct further empirical research in order to have a comprehensive data base which allocates empirical findings in this context. Sure enough, this is essential as it permits to find out whether the proposed models and theories are indeed of significant importance or remain without a proof of their informative value. If more satisfactory affirmative data can be collected, it will enable and deliver extensive insight into the field of study of migrating processes from physical to virtual environments.

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