Using Virtual Worlds for Collaborative Business Process Modeling

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Abstract

Purpose – Process modeling is a complex organizational task that requires many iterations and communication between the business analysts and the domain specialists. The challenge of process modeling is exacerbated, when the process of modeling has to be performed in a cross-organizational, distributed environment. In this paper we suggest a 3D environment for collaborative process modeling, using Virtual World technology.

Design/methodology/approach – We suggest a new collaborative process modeling approach based on Virtual World technology. We describe the design of an innovative prototype collaborative process modeling approach, implemented as a 3D BPMN modeling environment in Second Life. We use a case study to evaluate the suggested approach.

Findings – Based on our case study application, we show that our approach increases user empowerment and adds significantly to the collaboration and consensual development of process models even when the relevant stakeholders are geographically dispersed.

Research limitations / implications – We present design work and a case study. More research is needed to more thoroughly evaluate the presented approach in a variety of real-life process modeling settings.

Practical implications – Our research outcomes as design artifacts are directly available and applicable by business process management professionals and can be used by business, system and process analysts in real-world practice.

Originality/value – Our research is the first reported attempt to develop a process modeling approach on the basis of virtual world technology. We describe a novel and innovative 3D BPMN modeling environment in Second Life.

Keywords – Collaborative Process Modeling, BPMN, Second Life, Virtual World Technology

Paper type – Research paper

About the Authors

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1. Introduction

Information Technology has enhanced many work practices within large and small organizations. Specifically, the introduction of networked environments has provided organizational staff with the opportunity to engage in remote forms of collaboration, first by email, then via attachments in email, chatting, from text to multimedia forms involving audio and video, and, recently, to collaborative virtual environments, so called virtual worlds (Davis et al., 2009).

Collaborative technologies have found widespread use by analysts in decision making (Kiesler and Sproull, 1992) as well as in requirements engineering (Brouse et al., 1992) and design (Kamara and Pan, 2004), suggesting the adequacy of collaborative technology to many organizational tasks. Most of the approaches typically in use to date, however, are still constrained due to a lack of spatial references when engaging in online collaboration, and due to a prevalent use of a two-dimensional (2D) representation of important business or informational objects.

This limitation is significant especially in the context of remote collaborative design work. This is because human teams, when physically located together, are facilitated in their collaboration by the spatial juxtaposition of the artifact being created and the human resource performing the work. The surrounding collaborators are able to intuitively perceive that the person is working with the item, or a component of it, what it is that is being performed with the item, and they can offer further insight into its manipulation and improvement, via gestures, discussion or even non-verbal cues.

Existing virtual collaborative environments, envisaged to enable collaborative work in distributed environments, lack support for deep collaborative immersion with the design object, due to the use of 2D representations. However, with the advent of 3D networked collaborative virtual worlds, in games and in commercial domains, there has been an increase in the ability of these environments to support collaborative teamwork using three-dimensional representations to support a variety of tasks, be it straightforward communication in virtual conferences, or even complex design tasks (Davis et al., 2009).

Virtual worlds offer a number of superior affordances to the process of collaboration, especially for complex tasks that involve the generation of artifacts as outputs of a work process. In particular, they provide many of the visual and spatial queues that enable better collaboration in virtual worlds, as the user’s representation in the system is of a synthetic human form, that occupies a location in a 3D space, thus creating an intuitive interface that mimics physical collaboration amongst partners (Redfern and Naughton, 2002).

We are interested in exploiting how virtual worlds can be used to enhance Business Process Management practices, especially the key exercise of process modeling. Process modeling is typically performed using so-called process modeling grammars (Recker et
al., 2009), semi-formal notations that provide graphical elements to map out business processes using 2D representation forms such as rectangles, circles and diamond shapes. While a variety of tools are available to create and analyze these 2D models of business processes, studies and anecdotal evidence still report challenges in the process of process modeling, most notably in the phases of eliciting business process information from relevant stakeholders, and formalizing them in a process model (Koschmider et al., 2010). Some authors have argued that this challenge is due to a lack of support for the process of process modeling, i.e., support for the collaboration between business analysts and domain experts in the development of process models (Frederiks and van der Weide, 2006).

This challenge is exacerbated further in situations in which cross-organizational processes need to be designed. This is because in these contexts, required modeling stakeholders (e.g., analysts, project managers and domain experts) are often geographically dispersed and need to engage in the process modeling effort from remote locations. Yet, while such remote collaborative work could, theoretically, benefit from collaborative virtual worlds as in use in other organizational tasks such as team (Horton and Biolsi, 1993) or project management (Lee-Kelly, 2006), to date, existing tool solutions fail to provide adequate support for collaborative process modeling.

In this paper, we describe a novel process modeling approach using recent 3D virtual world technology. Specifically, we extend a number of 3D tools so as to provide, a complete and usable collaborative environment for collaborative (re-) design of business processes. Business process re-design is noted as the perennial top priority of chief information executives (Gartner Group, 2010) and concerns the analysis and change of existing business processes to achieve operational excellence, process efficiency or business innovation.

The sections that follow first describe related work in the areas of 2D and 3D collaborative systems, relevant to process modeling. We then present our new approach, incorporating an analysis informing the design of an effective process modeling toolkit in 3D networked spaces. A case study is then presented detailing the application of the approach by a group of junior analysts that use the environment to build a BPMN process model in a virtual world. We conclude the paper with a review of contributions, implications and limitations.

2. Background

A) Prior Research on Process Modeling

Over recent years, the documentation of business processes and the analysis and design of process-aware information systems has gained attention as a primary focus of modeling in information systems practice (Davies et al., 2006). The practice of process modeling has emerged as a key instrument to enable decision making in the context of the analysis and design of process-aware information systems (Recker, 2010a). Process
models are designed using so-called process modeling grammars (sometimes called notations or techniques), i.e., sets of graphical constructs and rules how to combine these constructs. Such grammars are widely available and differ considerably in terms of ‘how’ process models can be designed (Rosemann et al., 2006). Yet, invariably, all available grammars are essentially 2D representation schemes that make use of basic shapes such as rectangles or circles, and arcs. This representation scheme, notably, is also used in the current industry standard for process modeling, the Business Process Modeling Notation BPMN (OMG, 2009) - the grammar that has enjoyed a wide uptake in industry practice (Recker, 2010b).

Process modeling grammars are implemented, and used, as part of a process modeling tool suite (Ami and Sommer, 2007). These tools typically provide a 2D graphical model editor, and sometimes complementary functionality enabling simulation, reporting, analysis or even execution of the process models stored (Recker et al., 2010a). Recent experimental environments have appeared providing some collaborative process modeling via a web-based modeling environment integrated with a social networking interface such as Google Wave (Hahn et al., 2010).

Yet, no commercial tools available to date explicitly support collaborative process modeling – i.e., the activity of collaboratively designing process models from remote, distributed locations. We argue that this situation is unsustainable, especially in light of the noted increase of process modeling for cross-organizational process design – for instance, in the context of supply chain processes, B2B commerce or global process standardization (Adamides and Karacapilidis, 2006).

A) Prior Research on Collaborative Technology and 3D Environments

We argue that the characteristics of collaboration (distributed participants around the globe) pose different requirements to the modeling process and its tool support. For example, Rittgen (2007) suggested that collaboration during modeling follows the notion of negotiation models that shows patterns of human interactions in the process of process modeling. Ssebuggawo et al. (2009) examined collaborative modeling by looking for rules, goals and interactions proposing the notion of Modeling Games.

Looking at how advanced technology might support collaborative modeling, we note that collaborative technology has already been applied and examined in related areas such as design or learning. For example, Susman et. al. (2003) synthesized and extended existing theories on the appropriation of collaborative technologies in new product development by “recognizing misalignments between technology, task, organization and the group.” Marjanovic (1999) validated an interactive methodology for learning and teaching in a synchronous electronic collaborative environment emphasizing the necessity of understanding collaborative processes in order to design better methodologies.
Our interest in this study is to look how collaborative *virtual* technology can be used for process modeling, and specifically how *advanced, three-dimensional* representation approaches within these virtual worlds can be effectively leveraged.

A number of 3D approaches for the representation of process models have recently been suggested. Typically these have been simple 3D graph representations that are extensions of the 2D graph basis (Betz et al., 2008). In our own preliminary work we concentrated on the spatial modeling of an enterprise, along with a form of 3D process model based upon the BPMN standard (Brown and Recker, 2009). While this spatial approach has shown promise for its extended representational abilities, it is possible that important informational elements within this process model can be hidden from view, and cannot be discussed with other users in the virtual world.

Analysis of these previous 3D representation techniques shows they have restricted affordance for the task of collaborative modeling, due to a number of factors. A simple 3D extension to 2D may allow interaction with large process models in a spatial context (see Figure 1), but does not specifically enhance collaborative modeling tasks. Collaborative software requires an easy to access shared space for social interactions between the users, that supports interaction processes suitable to the task at hand (Grosskopf et al., 2009). Especially features to support group communication, task organization and information elicitation are required (Hahn et al., 2010). Currently emerging full 3D graph process modeling fails to meet these requirements. They are restrictive due to the need to move and manipulate in 3D. Furthermore, problems exist with viewing and recognizing structural issues in a 3D representation.

![Figure 1. Illustration of initial 3D representation of BPMN Process Models. Based on (Brown and Recker, 2009)](image)

Recently, IBM have developed a BPM training game known as INNOV8 (IBM, 2008). The latest version is an online game for business education that incorporates a collaborative process modeling approach. However, the game environment cannot be
used as a professional modeling tool for business processes, as it lacks the infrastructure for data file exchange, and functional integration with other commercial modeling toolsets. In addition, it does not use standardized visual process design grammars such as BPMN (OMG, 2009), thus increasing the entry barrier for professionals.

In moving forward towards more suitable collaborative process modeling technology, an important part of visualization and interaction design is to align the representations and interactions with the key tasks being performed by the actors in the system, to enable cognitive fit (Vessey and Galletta, 1991). Therefore, the requirements for collaborative process modeling technology are a representation that facilitates concurrent collaboration in a manner that is intuitive, has a low barrier to entry for the participants, and provides the functionality required for a generalized process modeling tool, as present in other 2D process modeling tools.

Presently, concurrent collaborative process modeling is often carried out using large tabletop surfaces with tangible objects such as paper, pens and even actual tactile modeling artifacts (Grosskopf et al., 2009). It is therefore logical to transfer this collaboration model for process modeling into the 3D virtual world, as it meets the key requirements of being intuitive, due to its natural extension from present methods, and presents a low barrier to entry via the utilization of an extended tabletop metaphor for the interface.

In addition to the use of a tabletop metaphor, there is the requirement to support collaboration activities such as organization, elicitation and communication (Hahn et al., 2010). We suggest facilitating such activities on the basis of an active representation of the collaborators. This enables the recognition of gestures by fellow collaborators in the environment, including identification of who is performing the modeling, the focus of attention of the modeler, and the location they are manipulating. Virtual worlds have a high level of affordance for this collaboration task due to their ability to provide a 3D avatar as a representation of the user’s ego centre in the environment, an ability exploited in collaborative scenarios in education (Monahan et al., 2008) or product innovation (Kohler et al., 2009). This representation of the user of the environment is crucial to providing useful collaboration environments, otherwise the disconnect formed by abstract user representations burdens the users with an unnecessary cognitive load in order to understand the actions of other collaborators.

In light of these observations, we suggest using a 3D virtual world environment as a general and configurable environment in which to implement an advanced collaborative process modeling approach that encapsulates the ability to script and model complete environments with low development time overheads. Therefore, in what follows, we present what we believe is the first 3D virtual world environment, specifically designed for concurrent collaborative process modeling.
3. A Virtual World Approach to Process Modeling

A) Preliminaries

3D virtual worlds are networked virtual representations of real or imaginary 3D spaces (Benford et al., 2001). They provide the ability to electronically simulate the geometry and dynamics of a space. Typical capabilities include geometric modeling of buildings or other objects, scripting of objects for dynamic effects, configuration and operation of avatars as integrated ego representations for the users (Davis et al., 2009). We will now explore these aspects further in light of their contribution to two main areas of interest that relate specifically to collaborative process modeling, namely Communication and Modeling In-world. These two key requirement areas relate to the two named technology requirements to support collaborative modeling, viz., (a) support for the modeling and (b) assisting the collaboration through appropriate communication features (Hahn et al., 2010).

In implementing all required features for communication and modeling in-world, we have used Second Life (http://www.secondlife.com/) as our environment, due to its easy availability through free software, its widespread use, and ability to provide all the collaboration features and capabilities listed in the previous section (Lui et al., 2007).

B) Communication In-world

Virtual world avatars rely on computer-mediated communication (CMC) as their method for communicating with other avatars. Within the virtual world, communication via an avatar falls somewhere between face-to-face communication and text-based communication (Ellis et al., 2008). Human communication is facilitated by the use of gestures, artifacts, images, text information and speech. All of these are possible to implement in virtual worlds, and so they enable an improved form of electronically mediated collaboration. The evolution of online communications from a disembodied text-dominated chat environment and or 2D workspaces, to the physical, nonverbal gestures and facial expressions realized through the body language of an avatar, are possible because of such new virtual world technology (Verhulsdonck, 2007).

These intuitive forms of communication readily support the various tasks required in the collaboration phase of process modeling. Key to these tasks is the communication of process constructs (semantics and syntax) to those present in the collaboration, and maintenance of subjective understanding of the model by those present in the collaboration. Tasks such as user requirements elicitation, real-time validation, workshop organization and consensus building (Hahn et al., 2010) typically hinge upon the ability to use a shared workspace, which contains the process model in question, represented as an artifact. This works in reality around a physical table top with tangible artifacts (Edelman et al., 2009), and by logical extension, translates just as effectively to a virtual space, where the process model is manipulated and discussed in a direct manner.
For example, the validation process can be performed more easily due to the ability to see the process model in the same space as the persons involved in the session, but also support the validation discourse between the client and analyst, by having the avatars in real-time, directly manipulate the components of the model to be validated. This is shown in Figure 2, which anticipates our elaborations below, and which illustrates two participants validating a process by changing the parallel gateway in a BPMN diagram. Note the juxtaposition of the avatars with the artifact being edited.

![Figure 2. Juxtaposition of modeling and collaboration in Second Life Environment](image)

We now analyze each of the communication features provided through computer-mediated communication in Second Life, in turn, for their ability to support collaborative modeling.

- **Gestures**

  Gestures are useful within virtual worlds for reducing ineffective chat that would normally be enacted with a gesture, e.g., waving hello and goodbye or nodding yes and no. This gives the user the ability to draw attention to their spatial location, and a particular section of the process model being edited, thus providing an efficient method to coordinating interactions with other model stakeholders.

- **Text messaging**

  Virtual worlds utilize text chat channels, which can be designed for private or public use. Similar to other task settings, text messaging will allow process model stakeholders to
quickly and efficiently communicate elementary design details without engaging in more elaborate communicative patterns.

- **Audio Chatting**

Virtual worlds also enable networked forms of spatial sound. This spatial capacity, along with the avatar representations, enables better identification of the speaker via integration of gestures and auditory evidence. This support could, for example, be leveraged to form sub-groups in a collaborative settings, which each discuss distinct sub-parts of a process design. Also, the resulting natural communication support will overcome some present restrictions of modeling approaches that rely on textual communication only, which has been shown to be a key obstacle for collaborative modelers (Hahn et al., 2010).

- **Multimedia Representations**

Objects in virtual worlds can support the representation of other digital media in the environment, such as audio, movies, images and text. This media are represented as walls for collaborative viewing by the modeling team, and could, for instance, display interviews with process staff conducted prior to the collaborative process design, thereby allowing access to temporally dispersed information captured in video and/or audio format.

- **Environmental Objects**

One powerful aspect of virtual worlds is the use of 3D artifacts in world to promote discussion. Process modeling traditionally uses diagrammatic artifacts as part of the modeling tasks. Often, either paper diagram sketches or computer generated displays are drawn of the business (Recker et al., 2010b). In our approach, the process model itself becomes a digital artifact that can be shared in a 3D space, and can be edited by a number of people at once in real-time, which is inherently superior to the collaboration approaches offered in other systems.

**C) Modeling In-world**

While a number of tools have been created to assist the interaction between avatars and their surroundings, they are still often realized through two-dimensional interface options that may include menus, toolbars, buttons, maps and/or Heads Up Displays (HUDs) (Irani et al., 2008). The challenge is to leverage these options for collaborative modeling, while at the same time developing tools that are simple, intuitive and easy for business analysts unfamiliar with virtual technology to learn and use in an efficient manner. The key challenge is to adapt the existing look-and-feel of classical process modeling (typically on basis of 2D semi-formal graphs) to the 3D environment.
A 3D environment, such as the one provided by Second Life, is typically composed of 3D Euclidean spaces organized into an array. Each element in this array is called a region, and is measured out in standard metric units. Users who are allowed to create content, can select several shapes to that purpose. Once the user has selected a particular shape, the system generates a default instance of that shape, which is known as a primitive. Figure 3 gives the example of an avatar creating an object (highlighted cube in centre) and applying a script program (window on the right with text) to modify the functionality of the cube. More complex objects, such as those used in our editor, will require the user to link many different primitives together. Each primitive has a storage space (inventory) for images, scripts, data and even other primitives. Users can create scripts for a primitive by navigating to its inventory and selecting an option for new scripts, which creates a new script item in the inventory (see the Right-hand side of Figure 3).

By default, users write scripts in the Linden Scripting Language (LSL), which is a strongly typed scripting language native to Second Life\textsuperscript{1}. This functionality has been utilized to implement all of the process modeling tools in this paper, which we discuss below. In addition, useful tools can be purchased or gifted in such a virtual world, so we were able to garner artifacts developed by other programmers, and modify them to suit our needs.

Figure 3. Illustration of modelling and scripting capabilities within Second Life

We now describe how we used these capabilities to generate a complete modeling environment. Figure 4 displays the collection of new tools that were developed and collected for collaborative process modeling. The tools we focus on in this paper are the Power Point Wall at the back, and the Process Modeler, Mind Mapper and Holodeck at the front of Figure 4. Of the five tools displayed, the two biggest ones standing at the back provide the ability to browse web-sites (1) and deliver slide show presentations similar to Microsoft Power-Point (2), while the three smaller objects in the front represent from left to right a Process Modeler (3), a Mind Mapper (4), and an Information Holodeck (5). These small foreground objects expand into 3D user interfaces to be used

\textsuperscript{1} The official wiki for LSL can be found at: \url{http://wiki.secondlife.com/wiki/LSL_Portal}. 

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by the modeler, and are shown in more detail below. It should be noted that the Mind Mapper and Holodeck tools were purchased in Second Life, and modified for our process modeling application. The collaborative Process Modeler was designed and built entirely by the authors. We explain each of the tools, in turn.

Figure 4. Available virtual world tools for collaborative process modeling

- Process Modeler

This new approach to virtual world process modeling presented in this paper, addresses the height and hidden element concerns of previous approaches (Brown, 2010) by restricting the model to only be used at ground level. The new approach uses a flat surface divided into interactive squares, upon which the model can be laid out in a regular grid. The avatar literally walks on top of the model and has an extensive view range that can take advantage of zooming in for a more detailed look at any specific aspect of the model or zooming out to get an overall view of the size of the model. This approach therefore takes full advantage of the default view port that is available to the avatar upon login.

The command to start this modeling process is advertised to the new modeler in the form of some floating text instructions that hover above the actual model building prim (refer to foreground of Figure 5). This building prim is shaped as a pool that awaits the command to create a new process design pool in the form of a rectangular set of tiled squares, textured to represent the water in the new pool. The user, via the avatar, touches a tile within the pool and is then automatically presented with a dialog menu of options.
The options provide the avatar with the ability to re-texture the tiles with the nominated process design symbol, which, in our case, is based on the industry standard modeling grammar BPMN.

![Figure 5. Screenshot Process Modeler](image)

Aside from dragging the initial process design prim into the environment and issuing the command to create a new pool, the avatar does not require any more specific knowledge other than that pertaining to the modeling notation that is a requirement for all modelers (in our case, BPMN).

Figure 5 shows an avatar modeling with the new process model builder. The tool provides the user with 65 image selections that resemble the constructs in the BPMN standard, through a dialog menu. Figure 6 shows some of the dialog menu options for choosing BPMN icon tiles in the modeling tool. The interactions are similar to other packages, but in this case the icons inserted are viewable by another network-linked avatar, and can thus be manipulated in a collaborative fashion in real-time.

![Figure 6. Process Modeler Dialog Menu Options](image)

To solve the problem of displaying 65 BPMN image options to the modeler, a menu system was created to sub-divide the image selections into categories. The dialog menu
works by having the user touch the model element, to raise the cube, exposing the menu. Each of the 65 choices (e.g., events, activities, gateways, etc.) is shown as a clickable image on the side of the process model graph nodes.

- Mind Mapper

Mind mapping and brainstorming tools are of key relevance to process re-design activities, where, often, analysts and process stakeholders are brainstorming to develop improved design blueprints to enable process innovation (Davenport, 1993) or re-engineering (Hammer, 1990). Typically, people use simple approaches such as post-its or brainstorming sessions (Rosemann, 2006). When engaging in a collaborative process design exercise, a virtual mechanism to support such re-design activities is of benefit. The Mind Mapper is an open-source application available for Second Life, to allow for virtual representations to be used in collaborative mind mapping and brainstorming activities.

Figure 7 shows the Mind Mapper in use, using a combination of colored cubes, connected to each other and identified using floating text. This tool facilitates a quick and intuitive combination of thoughts by different process stakeholders, with every member able to participate by interacting with the 3D spatial mind mapping system. As with the process model builder, the mind mapper tool can be concurrently used by more than one avatar.

- Information Holodeck

Figure 8 provides a view of a Holodeck (Linden Research Inc., 2009). Holodecks are a virtual world construct used to store created scenes within a pre-configured space or room. By touching a prim and making a menu selection, the old scene is cleared and the new one appears. For process modeling, the Holodeck can, for example, be used to...
organise and arrange Structure English displays of business processes for viewing and discussion. Specifically, there are three aspects to the Holodeck concept that can be seen as advantageous in promoting new ideas or concepts to a collaborative process modeling group.

![Figure 8. Holodeck in Use](image)

- **Proximity** – it is easier to control and maintain communication with a group of avatars that are visible within the walls of the Holodeck.
- **Navigation** – as Holodecks can change their scenes, there is no need for avatars to navigate the terrain of the island to visit different sites.
- **Information Sharing** – you can place information into a pre-defined space so that user avatars can learn about the business process in question.

**Synopsis**

In summation, the three tools facilitate key collaborative tasks during process modeling. The Holodeck provides a space to display information regarding the description of business processes in an enterprise, for group viewing and information sharing. The Mind Mapper tool, allows collaborative creation of mind maps to support choices and arguments as they pertain to a process model. Finally, the Process Modeler tool allows the collaborative creation of the actual process model as a design artifact developed during the collaborative exercise.

A key feature of our approach is the ability to include the modeling stakeholder avatars at all times in the stages of collaboration, and to refer explicitly to all relevant artifacts being used for modeling, spatially juxtaposed with the avatar of the person doing the work. Therefore, we believe this method will facilitate better collaboration by minimizing the confusion involved with teams of people working on distributed modeling projects in real-time. We will in the following, report on a case study in which we attempted to evaluate the outcomes and efficiency of this approach in a case study designed to collaboratively build a business process model within the virtual world.
4. Case Study Application

Following is a discussion of the experiences of a test modeling team in designing and developing a process model of a Credit Application Process within the virtual world Second Life, using the previously described tools. Five people were involved in the test session, one member being one of the authors of this paper, as the facilitator. The other team members were post-graduate students enrolled in a Business Process Modeling unit. All team members, except for the facilitator, were novice Second Life users, having little to no experience of 3D networked virtual worlds.

A) Conduct

A Credit Card Application process was modeled during the team session, from an English description of the process, previously prepared and mounted on media walls as Power Point slides. All three tools previously described were used in the process. Figure 9 and Figure 10 show two stages of the collaborative test modeling session in Second Life.

Figure 9. Case Study Snapshot: Creating the Process Model

Figure 9 shows the process model taking shape as the test team gather around and create the components of the process model on the floor. The process model is shown as a shared 3D artifact that can be edited by the team concurrently.
In the scene shown in Figure 10, the mind mapping tool is being used to outline process concepts by team members, while the user in front is creating a process model. Note how these tools can be juxtaposed within view of each other, allowing teams to concurrently move from area to area in an intuitive fashion, to follow the modeling task at hand.

B) Appraisal

At the end of the test modeling session, a focus group (Morgan, 1997) was held to invite the team to comment on their experience of using the developed virtual world process modeling tools in their modeling exercise. Participants were asked specifically to evaluate their experiences against their expertise gathered on the use of traditional process design approaches (including Visio, BizAgi, ARIS, Netweaver and other process tools).

Our qualitative analysis of the case study data received indicates a consistent theme to become evident, namely that the novel method of collaborative process modeling indeed facilitated a truly collaborative experience. The *modeling-in-world-features* were received as key to enabling collaborative work:

“Modelers can build a (3D) process while all take part at the same time in the actual modeling.”

“The actual “in world” process modeling experience was highly valuable and much more collaborative than I had envisaged.”

“Compared to other collaborative tools, process participants can meet in the virtual world, discuss a process and model it. Thus, modelers can build a (3D) process while all take part at the same time in the actual modeling”
Notably, even participants with a priori reservations reported, were convinced of the usefulness of the approach:

“When I first heard the term collaborative process modeling I immediately thought it would be impossible to create a process model in real time within a geographically dispersed team. From the first moment of entering second life I knew straight away that this had the potential to be a great platform for modeling.”

Across all case study participants, the data suggests that the approach successfully blended traditional process modeling with natural features of the Second Life environment, and overall resulted in an intuitive tool to use:

“Collaborating with one another was strange, different, but quickly became somewhat natural. I believe that using Second Life for collaborative process modeling is the best/only platform for geographically dispersed teams.”

Aside from the modeling-in-world-features, also the communication-in-world features offered by Second Life were adapted as natural by the case participants, thereby easing adoption and appropriation for the modeling tasks. The collaborative features of the process design environments (collaborative discussion and real-time editing, specifically) were noted as key features of the approach:

“The chat function allowed the project team to easily discuss and alter the process model in real time.”

“This approach is a step beyond the traditional video-conference approach as mannerisms and other non verbal signals can also be used to convey intent.”

On comment specifically suggests that this new approach could lead to benefits such as user acceptance and increased stakeholder participation, two key challenges of present process modeling (Indulska et al., 2009):

“I find the potential for modeling collaboratively among the more interesting areas of BPM as it provides for multi-user input and knowledge sharing. As a user of BPMN models in the workplace I believe this could overcome some of the problems associated with the modeler not getting sufficient user input when undertaking both as-is and to-be modeling.”

Some of the critical case study observations concerned the ability of novice virtual world users to appropriate the features presented, which was mostly found to be due to a lack of expertise in using the Second Life platform rather than the modeling tool. One comment received indicates the importance of experienced facilitators to ease the learning curve, suggesting that, with assistance, novice virtual world users may easily adopt the approach:
“The learning curve for utilising second life in producing models was steep, but quick. Under the guidance of our team leader, who has extensive knowledge of Second Life and the technical ability to script and prim in-world, our experiences were much more seamless.”

In summation, the case study data provides some evidence of the suitability of the approach. We further believe that the emergent themes of intuitiveness, ease of application, and enhanced knowledge sharing ability provide interesting conjectures that could be tested in further, more controlled, empirical research.

5. Conclusions

A) Contributions

Easy to use computer-supported networked collaborative process modeling is an emerging important challenge for the process modeling community (Decker and Weske, 2009). In this paper, we showed how 3D virtual world tools can contribute to solving some of the collaboration problems nominally associated with distributed process design activities in corporate scenarios. Preliminary evidence gathered from a case study provides some initial evidence for the efficacy of this approach.

B) Implications

We first discuss implications for research and then implications for practice.

In our research, we have developed and applied a set of tools within a virtual world to facilitate collaborative process modeling in distributed settings. There are several research streams that can build on this work. Notably, future research can focus on the application of our approach in real-world collaborative process design scenarios, to be able to evaluate efficacy and usability, and to examine potential benefits as well as changes to the collaborative design processes normally carried out by business analysts (Hoppenbrouwers et al., 2009). In particular, we see a need for usability analysis to be applied to the modeling interactions to improve their affordance for collaborative process tasks. We further see the potential to employ the systems in empirical studies of collaborative knowledge creation (Damsgaard and Scheepers, 2001), or the affordances the approach offered to the IT-enabled re-design of organizational structures or outsourced processes (Mani et al., 2010).

Another stream of research might want to examine the individual behaviors exhibited by analysts when working with the new approach to collaborative process modeling. Important research questions include how these analysts appropriate the new technology (Carroll et al., 2003), decide upon their continued use of the approach (Recker, 2010a) or adapt the technology in their work (Thomas and Bostrom, 2010).

Last, we note opportunities for research on process modeling quality to examine the final outcomes of the collaborative modeling process, namely the process model produced, in terms of how well it corresponds to established quality notions such as soundness (Wynn et al., 2009), usefulness (Rittgen, 2010) or user acceptance (Maes and Poels, 2007), to mention just a few.
In terms of implications for practice, notably, our design research approach allows practitioners to directly re-use the developed artifacts. Our modeling tools are freely available on all major hardware and software platforms as open source, and so can be provided within any integrated toolset to an organization requiring real-time collaboration capacity. Furthermore, this environment can be used on any standard modern desktop or laptop system, and so a complete enterprise wide roll out is feasible, increasing its potential uptake and impact.

Recently, our prototype system has been ported to the open source virtual world implementation Open Simulator (http://www.opensimulator.org), which opens up further possibilities via the easy creation of locally controlled collaborative worlds, without the requirement to utilize commercial services such as Second Life. The porting of our system to Open Simulator will assist organizations that need high security modeling environments to implement these environments on intranets for further control.

Case study results came from a modeling session, with a standard non-trivial credit card transaction process generated as the output artifact. Such a prototype collaborative process modeling software can be used at this moment to assist with collaborative modeling tasks as is, and therefore provide useful feedback into the theoretical design process from a functional and human computer interaction viewpoint. Along with outcomes from future industrial scale tests, these results will inform the process modeling community regarding the implementation and use of such virtual world collaborative tools.

C) Limitations

Our research and its outcomes have to be contextualized in light of some limitations. While we considered the application of the suggested approach in a case study application, we acknowledge that the utility of our approach could benefit from further empirical testing. We provide some directions for such research above. We further note that we build our tools within the Second Life environment, and some of the boundary conditions of this platform thus migrate to our tools. We note, however, that the process modeling tool developed in this paper can be easily implemented within other virtual worlds, due to the usage of virtual world domain wide concepts, such as avatars, network collaboration and scriptable objects. Last, we note that our implementation remains a proof-of-concept prototype, and further extensions will be necessary to ensure scalability to larger and more complex process scenarios.

In spite of the limitations, we believe that our work provides a long-needed step towards extending traditional process modeling so as to better leverage advanced IT capabilities for the collaborative and distributed modeling of processes within virtual worlds.

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