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ABSTRACT

Process modeling is a complex organizational task that requires many iterations and communication between the business analysts and the domain specialists involved in the process modeling. The challenge of process modeling is exacerbated, when the process of modeling has to be performed in a cross-organizational, distributed environment. Some systems have been developed to support collaborative process modeling, all of which use traditional 2D interfaces. We present an environment for collaborative process modeling, using 3D virtual environment technology. We make use of avatar instantiations of user ego centres, to allow for the spatial embodiment of the user with reference to the process model. We describe an innovative prototype collaborative process modeling approach, implemented as a modeling environment in Second Life. This approach leverages the use of virtual environments to provide user context for editing and collaborative exercises. We present a positive preliminary report on a case study, in which a test group modelled a business process using the system in Second Life.

Keywords

Collaborative Process Modeling, BPMN, Second Life, Virtual Environment Technology

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 (Benford Greenhalgh Rodden and Pycock 2001).

Naturally, collaborative technologies have found widespread use by analysts in collaborative work (Dustdar 2000), decision making (Kiesler and Sproull 1992) as well as in requirements engineering (Brouse Fields and Palmer 1992) and design (Kamara and Pan 2004). Most of the approaches typically in use to date, however, are 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 environments, 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 straight forward communication in virtual conferences via remote lectures, or even complex design tasks, where prototypes can be displayed and interacted with as a group (Davis Murphy Owens Khazanchi and Zigurs 2009).

Virtual environments 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 environments, 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 simulates physical collaboration amongst partners (Redfern and Naughton 2002).

Process modeling is typically performed using process modeling grammars (Recker Rosemann Indulska and Green 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 process model (Koschmider Song and Reijers 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). We postulate that a virtual environment, with its previously mentioned superior collaboration capabilities, will further enhance the process of distant collaborative process modelling to make it closer to copresent human collaboration.

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 environments 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.

This research seeks to answer the question of whether the use of virtual environmentss, with clear user spatial context representations, is a superior approach to real-time distance collaboration in process modelling. In this paper, we describe as a first exploration into answering this question, a novel process modeling approach using the latest 3D virtual environment 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 preliminary case study is then presented of a group of people using the environment to build a BPMN (Business Process Modeling Notation) (OMG 2009) grammar based process model in a virtual environment. We conclude the paper with a review of contributions, limitations and an outlook to future work.

RELATED WORK

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 Green Rosemann Indulska and Gallo 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 (Dumas van der Aalst and ter Hofstede 2005). Process models are designed using so-called process modeling grammars (sometimes called notations or techniques), ie., 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 Recker Indulska and Green 2006). Yet, invariably, all available grammars are essentially 2D representation schemes that make use of basic shapes such as rectangles or circles, and arcs.

Process modeling grammars are implemented, and used, as part of a process modeling tool suite (Hill Cantara Deitert and Kerremans 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 Indulska Rosemann and Green 2006). 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.[1]

[1] http://www.sapweb20.com/blog/2009/10/sap's-gravity-prototype-business-collaboration-using-google-wave/

No commercial tools available to date explicitly support collaborative process modeling – ie., the activity of collaboratively designing process models from remote 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 Karacapilidis Pylarinou and Koumanakos 2006).

A number of 3D approaches for the representation of process models have recently been suggested (Brown and Recker 2009; Streit Pham and Brown 2005). Typically these have been 3D graph representations.

As part of their initiative into virtual environment research, IBM have developed a BPM training game known as INNOV8 (IBM 2008). The latest version incorporates a collaborative process modeling approach. However, the game environment cannot be used as a professional modeling tool for business processes, as it lacks functional integration with other commercial modeling toolsets, and does not use standardised visual process design grammars such as BPMN.

In our previous work we concentrated on the spatial modeling of an enterprise, along with a form of 3D process model based on the BPMN standard (Brown et al. 2009). While this full 3D approach has shown promise for its extended representational capabilities (Brown et al. 2009), it is entirely possible that important informational elements within this process model can be hidden from view, and preventing collaboration with other users.

Our intent in this research is to focus on the process of collaboration; we therefore propose a method that, instead of using a full 3D representation, utilises a 2D version embedded in 3D space. This approach can be interacted with by a number of avatars at once, facilitating collaboration in a much more intuitive manner than present 2D flat screen systems.

A VIRTUAL ENVIRONMENT APPROACH TO PROCESS MODELLING

3D virtual environments are networked representations of real or imaginary 3D spaces (Benford et al. 2001). Typical capabilities include geometric modeling of buildings or other objects, scripting of objects for dynamic effects, configuration and configured avatars as representations of users (Becker and Niehaves 2007). 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.

Communication In-world

Virtual Environment avatars rely on Computer-Mediated Communication (CMC) as their method for communicating with other avatars. Within the virtual environment, communication via an avatar falls somewhere between face-to-face communication and text-based communication (Ellis Luther Bessiere and Kellog 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 environments, 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 environment technology (Gustav 2007).

Gestures

Gestures are useful within virtual environments 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.

Text messaging

Virtual environments utilise text chat channels, which can be designed for private or public use. Similar to other task settings, text messaging allows process model stakeholders to quickly and efficiently communicate elementary design details.

Audio Chatting

Virtual environments now enable networked forms of spatial sound. This spatial capacity, along with avatar representations, enables better identification of the speaker via integration of gestures and auditory evidence.

Multimedia Representations

Objects in virtual environments 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.

Environmental Objects

One powerful aspect of virtual environments is the use of 3D artifacts in-world to promote discussion. Process modeling traditionally uses diagrammatic artifacts as part of the modeling tasks. Typically, either paper diagram sketches or computer generated displays are drawn of the business (Rosemann 2006). 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.

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) (Lilly C. I. Hayes and Dourish 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.

We have used Second Life (http://www.secondlife.com/) as our implementation environment for these tools 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 (Tsz-Wai Gabriele and Blake 2007). The new modelling environment consists of three tools: a Process Modeler, a Mind Mapper, and an Information Holodeck. It should be noted that the Mind Mapper and Holodeck tools were purchased in Second Life, and modified for our application. The collaborative Process Modeler was built entirely by the authors. We explain each of the tools, in turn.

Process Modeler

This new approach to virtual environment process modeling, addresses the height and hidden element concerns of previous approaches (Brown 2010) by restricting the model to only be used at ground level. 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.

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. 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. 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, resemble the industry standard notation BPMN (OMG 2009).

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 1 shows an avatar modeling with the new process model builder. The tool provides the user with 65 image selections, through a dialog menu, as shown in Figure 2. 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[2].

[2] A video of the BPMN tool being used is available at: http://www.youtube.com/watch?v=25AOAIYVUVs.

Figure 1. The new approach uses a flat surface divided into interactive squares, upon which the model can be laid out in a regular grid.

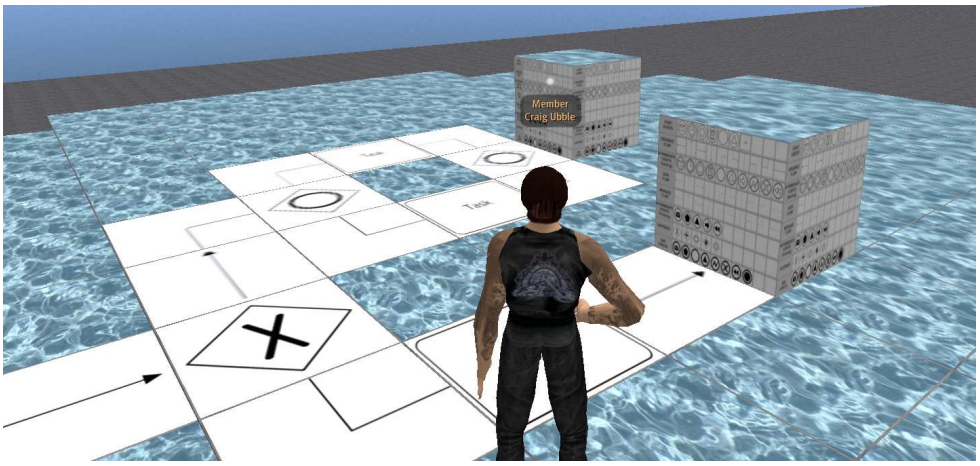

Figure 2. The figure above shows the dialog menu options (shown as images on the faces of the process model item cubes) for choosing BPMN icon tiles in the modeling tool.

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 are shown as a clickable image on the side of the process model graph nodes, as shown in Figure 2.

Mind Mapper

Mind mapping and brainstorming tools are of key relevance to process re-design activities, where analysts and process stakeholders are brainstorming 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. Fortunately, 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 3 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 used by more than one avatar.

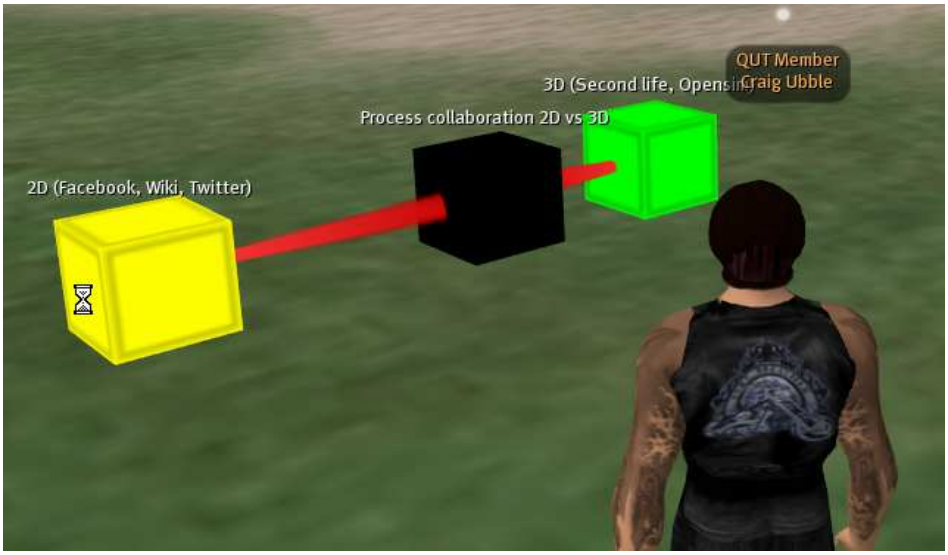

Figure 3. Example of the mind mapping tool in use.

Information Holodeck

Figure 4 provides a view of a Holodeck (Second-Life 2010). Holodecks are a virtual environment 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. 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.

- **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.

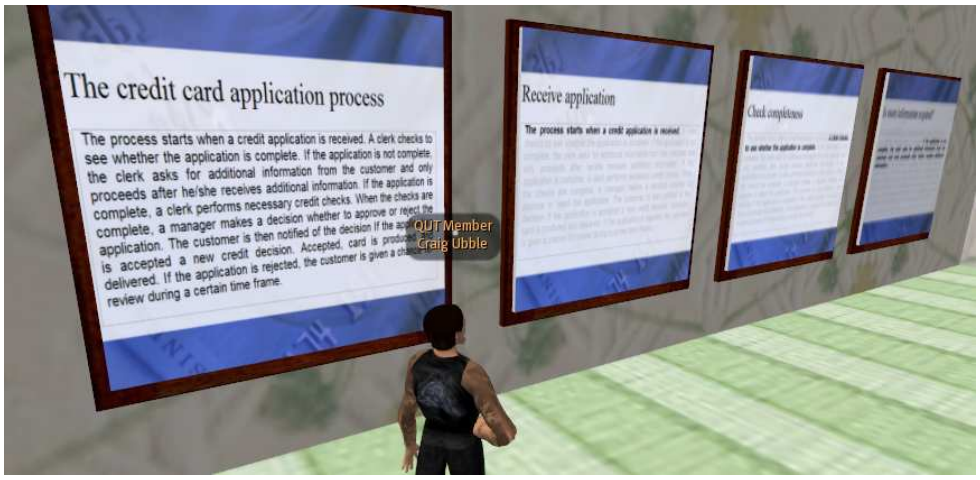

Figure 4. Holodeck, used to organise and arrange Structure English displays of business processes for viewing.

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 this 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 minimising the confusion involved with teams of people working on distributed modeling projects in real-time.

PRELIMINARY EVALUATION

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 environment Second life, to test 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 virtual environments. One member of the team was female, with ages ranges from the early twenties to the early to mid forties. Each of the members were Second Life novices, and were trained in using the system via use of standard hour long orientation classes in Second Life. All reported that this was adequate training, an example of commentary is shown here:

> *... was a novice user of Second Life and had some initial difficulties with the basic functionalities like moving and finding friends and places, but it took her only one virtual session to become familiar with it.*

A previously prepared credit card application process was modeled during the team session. All three tools previously described were used in the modeling process.

Figure 5 and Figure 6 show example stages of the collaborative test modeling session in Second Life.

Figure 5 Example showing 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 shared 3D artifact that can be edited by the team concurrently.

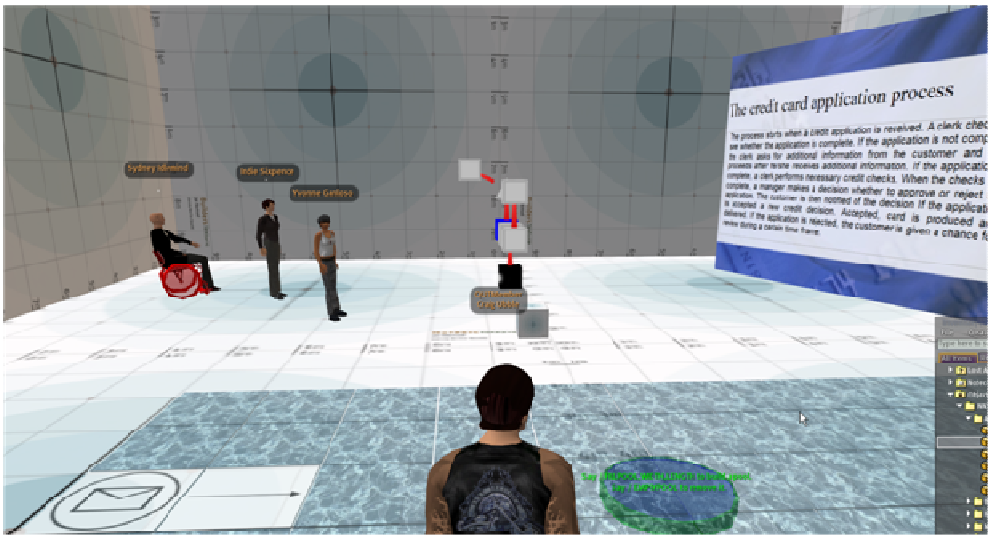

Figure 6 In this view the mind mapping tool is being used to outline process concepts by team members, while the user in front is creating a process model. Note how these tools can be juxtaposed within view of each other, allowing teams to concurrently move from area to area in an intuitive fashion, to follow the modeling task at hand.

At the end of the test modeling session, the team were invited to comment on their experience of using the process modeling tools. 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). A summary of comments written after the session by team members, other than the author, are shown below:

- *Modelers can build a (3D) process while all take part at the same time in the actual modeling.*
- *[we] got an impressive insight into what would be possible if this prototype matured. Second Life can be used for trainings (sic), real life meetings.*
- *The actual "in world" process modeling experience was highly valuable and much more collaborative than I had envisaged. … 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.*
- *If you didn't use the virtual world, how then could you actually collaborate with each other and produce a model?' The answer to this I found was; you can't.*
- *...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.*
- *...it provides for multi-user input and knowledge sharing. As a user of BMPN models in the workplace I believe this could overcome some of the problems associated with the modeler not getting sufficient user input.*

A consistent theme to becomes evident, namely that the novel method of process modeling was deemed intuitive, and facilitated collaborative process modeling by stakeholders in geographically distant regions via a networked virtual environment. Specifically, the communication-in-world features offered by Second Life were adapted as somewhat natural by the case participants. The collaborative features of the process design environments (collaborative discussion and real-time editing, specifically) were noted as key features of the approach. Therefore, we posit that this feedback provides preliminary supportive evidence that the tools we have developed can assist collaborative distributed process modeling tasks, and further are likely to be easily adopted by novice virtual environment users.

CONCLUSION

Easy to use computer-supported networked collaborative process modeling is an emerging important challenge for the process modeling community (Decker Kopp Leymann and Weske 2009). In this paper, we showed how prototype virtual environment tools can help solve collaboration problems nominally associated with distributed process design activities in

corporate scenarios. Preliminary evidence gathered from a set of case users indicates initial evidence for the efficacy of this collaborative approach. We note that the evaluation, while positive in response, is a preliminary source of evidence, which must be substantially increased in depth in order to more completely justify this approach to collaborative modelling.

In the future, the software will be updated to integrate the tool with other process modeling systems, using a standard process design interchange format (XPDL, Workflow Management Coalition 2008), thus making it a production quality system. Our research efforts will focus on the application of the system 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. In particular, usability analysis needs to be applied to the modeling interactions to improve their affordance for such collaborative tasks. We further see the potential to employ the systems in empirical studies of collaborative knowledge creation, or the affordances the approach offers to the IT-enabled re-design of organizational structures or supply chain processes.

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