Conceptual Modelling in 3D Virtual Worlds for Process Communication

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Abstract

Traditionally, conceptual modelling of business processes involves the use of visual grammars for the representation of, amongst other things, activities, choices and events. These grammars, while very useful for experts, are difficult to understand by naive stakeholders. Annotations of such process models have been developed to assist in understanding aspects of these grammars via map-based approaches, and further work has looked at forms of 3D conceptual models. However, no one has sought to embed the conceptual models into a fully featured 3D world, using the spatial annotations to explicate the underlying model clearly. In this paper, we present an approach to conceptual process model visualisation that enhances a 3D virtual world with annotations representing process constructs, facilitating insight into the developed model. We then present a prototype implementation of a 3D Virtual BPMN Editor that embeds BPMN process models into a 3D world. We show how this gives extra support for tasks performed by the conceptual modeller, providing better process model communication to stakeholders.

Keywords: Conceptual Modelling, Virtual Worlds, Process Models, BPMN.

1 Introduction

Conceptual Process Modelling is a visual approach used to represent how an organisation carries out its day to day activities (Rosemann et al., 2006).

Process Modelling uses grammatical notations that represent a conceptual model of the processes within a business, and may include a data model that supports the processes within the enterprise. Business Process Model representations include visual representations for Activities, Choices, Events, Messages, Compound processes. Refined forms of these constructs have been developed into international standards, such as Business Process Modeling Notation (BPMN) (OMG, 2006). Their structure and modelling capabilities are a part of continuing research in the area of BPM (Rosemann et al., 2006).

While these representations are very useful for experts in the field of business process modelling, there is the problem of using these representations to communicate such processes to the rest of the stakeholders who are not cognisant of the visual grammars used.

It may be stated that such representations are focussed on the abstract components of a business model, for in principal, this is the only requirement for the modelling of information within an enterprise, as the data is an abstracted representation of the real enterprise, and is not a representation of physical things, due to its irrelevance to the information processing required.

This is made apparent by research showing that grammars such as BPMN have difficulty with representing physical things, leading to problems with communicating these models to stakeholders (Recker et al., 2007). The approach of removing physical aspects of a business model in conceptual grammars is problematic on a number of counts.

Firstly, every business object that is modelled in a business process model, has a physical representation within the real world, which is interacted with by stakeholders (Rosemann et al., 2006). Such physical objects have physical properties that form a component of how an enterprise performs. For example, the location, and spatial arrangement of tasks being performed in a business, will bring about effects upon those same activities, due to space limitations in a building, or influences on task planning and resource allocations from distances to be covered.

Secondly, when wanting to communicate this business processes to other stakeholders, the process of communication involves a physical representation component, especially to non-process cognisant stakeholders. People perform their work in the real world, not in a conceptual space. It can be argued that stakeholders will not consider their work in a conceptual manner, but in a "hands-on" manner that involves real artifacts in real spaces. Indeed, this has been noted by other researchers in the field, that have sought to use philosophical techniques drawn from ontological research (Bunge, 1977), applied to the process of defining the specifications for Information Systems (Green and Rosemann, 2004). Their belief is that the absence of such object representational abilities hampers the clear specification of an Information System.

It can be argued that this object representational issue still holds for even process cognisant stakeholders, such as business analysts. In the end, their conceptual models at some level are still drawn from physical artefacts, and therefore are influenced in structure and dynamics by the same said physical artefacts.

Therefore that it is logical that a visual simulation of a Physical Model of the enterprise will support and improve communication processes in Conceptual Modelling, as it has in many other data visualisation domains (Tufte, 1983). It is believed that this visual approach also supports the various underlying Process Communication tasks within the Business Process Life Cycle (van der Aalst, 2004). It can be conjectured that many aspects of the process modelling life cycle (eg. Modelling, Improvement and Monitoring) can be assisted, more or less, by the inclusion of an easy to access simulation of the business, implemented as a 3D Virtual Environment (VE), due to the ease of process communication afforded by such representations.

The main argument of this paper is that simulations of business process models in virtual environments can be an invaluable addition to the toolset available to business analysts, and will support their communication tasks. This paper endeavours to make a first impression on what is potentially a major field of conceptual modelling research, showing a theoretical framework and a proof of concept implementation of a 3D Virtual Environment Modeller.

The rest of the paper is structured as follows. Section Two covers previous work in higher dimensional representations of business processes, utilising richer visual representations than 2D static diagrams. Section Three details a conceptual framework for process models in virtual worlds, indicating their utility and specific tasks and contributions to process modelling. Section Four details our Implementation of a proof of concept BPMN Process Model tool, with an example of a software quality assurance process model developed within the world described in Section Five. Section Six concludes the paper with a discussion on future work.

2 Previous Work

Presently, the state of the art in software technology for conceptual modelling of business processes is embodied in 2D static grammars, implemented via drawing tools. The tools vary between commercial systems such as Visio, to ARIS, over to experimental Grammars developed with research modelling systems (van der Aalst and ter Hofstede, 2005).

Annotations are provided in some cases for non-standard icons, that allow for representations that are closer to real imagery of the activities in question (CaseWise, 2008). Some systems include mapping capabilities, to show the spatial arrangements of process models as reviewed and shown in (Brown and Paik, 2009) and (de Leoni et al., 2008). However, in each case, the work is still limited to 2D.

Three Dimensional representations of process models have been developed. Typically, a graph-based version of process models is extended from 2D to 3D. These have been developed for a number of years now (Schonhage et al., 2000) (Pamplin and Zhu, 2004) (Stefanie Betz et al., 2008) and have been incorporated into swim lane models of process modelling systems (Effinger et al., 2009).

Some commercial experimental systems have investigated 2.5D (oblique projection) and 3D virtual models of process systems (OnMap, 2009) (Interactive-Software, 2004). While very promising, these implementations have not utilised the power of full 3D virtual worlds for representation and remote collaboration across a network, and still do not incorporate a conceptual model into the visualisation as is shown in this paper.

IBM has pioneered visualisations of process models in 3D games systems via their Innov8 project (IBM, 2008). However, their focus has been on games for training, and not tools for the development of integrated conceptual process modelling grammars for process life cycle stages. As a result, the environments are not for general modelling purposes, as is envisaged in this paper.

What is lacking is a conceptual modelling and visualisation approach that integrates the present grammars into the 3D Worlds to provide the ability to effectively provide a 3D visualisation annotation to a conceptual process model.

In this paper just such a framework is developed which integrates together the best of both worlds; conceptual and physical modelling and simulation, to provide an approach to process modelling that enables the practitioner to more easily communicate the newly developed process model to the viewer, via providing object annotations and representations that communicate the process model more clearly.

3 Conceptual Process Modelling Virtual Reality Framework

The newly developed framework seeks to provide support for communicating process models to naive stakeholders. The reason for this is two fold.

Firstly, it has been reported in a number of fora, the difficulty, and potential redundancy, of grammar components, creating a need to ascertain what the main components of such a conceptual modelling framework need to be (Muehlen and Recker, 2008). Such communication problems are related to the complexity of the representations in conceptual models, so an environment that juxtaposes the model with its original physical space will ease understanding of the structure of the process model.

Secondly, it has been shown in other domains that one of the best strengths of virtual environment models is the area of education and communication (Gallagher et al., 2005). Thus the use of VEs for this task is intuitive due to their success in other communication domains.

As previously described, the intention is to model the physical environment surrounding the process model. So there is a need to ascertain the physical modelling requirements, and how this should be embedded into the virtual world.

For the purpose of this framework, the intention is to cross the boundary between conceptual models and physical models, by placing the grammars in a virtual world simulation of the physical environment of the process model. This provides a method of showing the conceptual model boundaries and how it will interact with a physical reality of the business, and thus will enable a conceptual modeller and a client to communicate on a better footing, as shown in Figure 1. This extends present modelling practices, whereby the conceptual modeller would analyse the physical model of the business process,

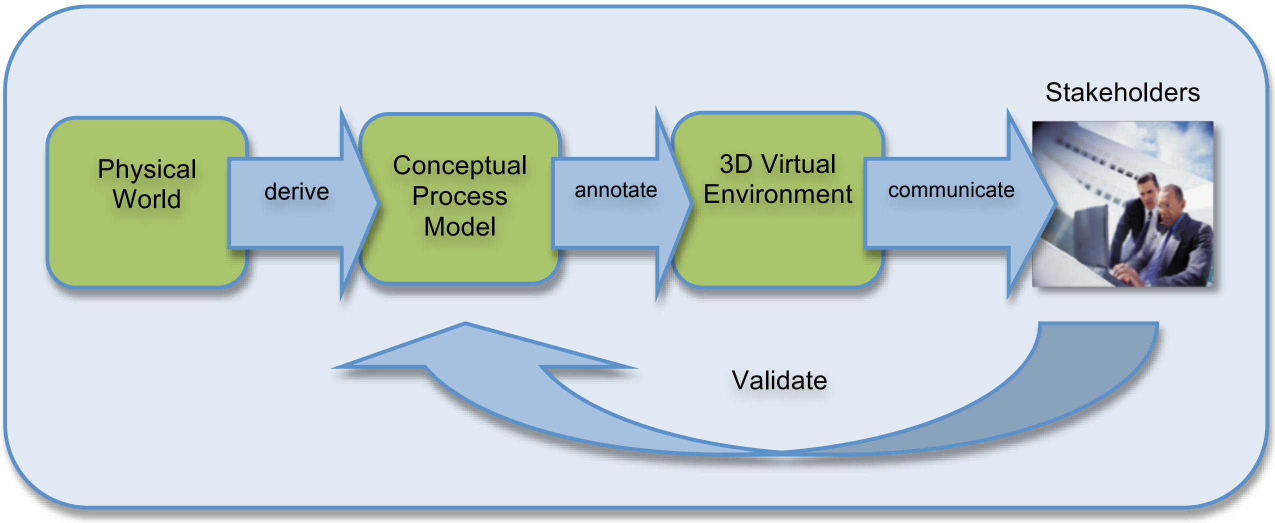

Figure 1 Concept diagram of the Virtual Environment Modelling approach, showing the major processes involved, including the derivation of the Conceptual Process Model, annotation with a 3D Virtual Environment, and using the Virtual Environment to communicate and validate the Process Model.

via monitoring and interviews. In this case the modeller can add a simulation of the physical world to their information sources.

It should be highlighted, that a valuable collaborative feature that comes from the use of such VEs for validation purposes, is the ability to spatially store feedback information about the conceptual process model. So, as well as being able to simulate the business process, we seek to store annotation information in the simulation for validation processes.

We now identify the requirements for a software approach to conceptual modelling in 3D Virtual Environments.

3.1 Task Analysis

The environment can then be used as an additional tool in a number of process modelling tasks that emerge from analysis of the task of communicating. Using a task analysis before deriving visualisations enhances the chances of the visualisations being useful to the stakeholders in question (Treinish, 1999):

- Process Communication - placing the conceptual model in a physical environment, facilitates stakeholder buy in to the new processes by being able to see the process model simulated in that physical environment.
- Validation with Clients - conceptual process models can be embedded in the environment, to facilitate insight in to the conceptual model for the client. And vice versa, the analyst may understand the underlying processes better, if they are able to see the physical reality of the environment, and have it explained to them by the client.
- Spatial Factors - the physical representation of the business in the virtual environment enables insight into how the business site impacts on the implementation of new process models, especially via the spatial location of the activities involved.
- Human Resources - the direct representation of humans as avatars in the VE enables insight into the how the people perform tasks, as groups, and enables them to see interactions between roles, and potential bottlenecks from the resource perspective.
- Process Change – “as is” and “to be” (Jörg Becker et al., 2003) process models can be represented and compared in the environment for stakeholder buy-in and validation purposes.

3.2 Virtual Environment Functional Requirements

A set of technological requirements has been derived to support the previous major tasks outlined:

1. Spatial modelling of the location of activities, choices and events. Each component of the process model needs to have an X,Y,Z coordinate to embed it into the world.
2. Geometric Modelling of the process model components. Each process model component needs to be converted, even translated, into a 3D geometric model, with features that represent the modelling grammar either directly or indirectly.
3. Modelling of the physical surrounds of the model – buildings, business objects and people. The business model simulation requires a geometric model of the business components, and an appropriate animation to be displayed to indicate its correct usage.
4. Modelling tools for conceptual process models, and their importation and exportation to other systems. Along with the geometric model components, the user interface for model development must be intuitive and able to make the task of modelling easy for a business analyst.
5. Simulation of instances of process models being executed – via translation of avatars representing human resources. Analogs of 2D simulation methods need to be developed that enable the visualisation of running process model simulations.
6. Ability to annotate models with commentary from clients and from analysts, to assist in the validation process. the clients and analysts need to be able to

leave annotations within the environment that indicate problems with the model for later amendment.
7. Ability to represent statistical information alongside the process model, especially if performing Six Sigma or LEAN process improvement approaches. Similar to the text annotations, statistical annotation data should be incorporated into world for process validation, as examples of actual process executions. In addition, the ability to annotate process models with video and audio information from the analyst's analysis of the actual business in question. This allows the production of multi-media representations of interview and data collection information, opening up new possibilities for higher accuracy models due to the quality of feedback information.
8. Collaboration and remote interactions. The environment should support the ability to collaboratively generate a business process model by multiple analysts, and should allow remote access by the client and other stakeholders in order to communicate and analyse the model of the business for efficient feedback purposes.
9. The ability to treat such VE process models as a form of document. In a similar manner to other process model software systems, this framework should allow for creation of process models as living multimedia documents that can be annotated, shared and distributed by stakeholders in the business process.

An early proof of concept BPMN editor prototype has been developed as an implementation of many of the above items. We now describe its major components.

4 BPMN Open Simulator Implementation

BPMN (OMG, 2006) has been chosen as the grammar to implement in this prototype because of its common acceptance as a conceptual process modelling standard. Furthermore, extensions to previous research performed into 2D versions of BPMN modelling tools can thus be transferred and investigate via the development of a 3D BPMN modelling tool. It should be noted that this framework and implementation can be easily modified to suit another conceptual process modelling framework, as the grammar used for the process model is able to be changed relatively easily. This grammar is purely conceptual in nature, however, there are research efforts focussed on developing executable forms of BPMN. We do not address any executable concerns here (including related data structures and functionality), and so the modelling is restricted to high-level conceptual visualisation and communication.

The intention in this prototype is to show how easy it is to develop such environments using the latest VE technology. However, while a system may provide insight and capacity for modelling of new aspects of business systems, there is a need to consider the user base, which will typically be business analysts that do not have high levels of technical skills.

An example of the uptake of such environments by non-technical personnel is found with the Second Life user population. Of the approximately 80,000 users that may be on the world at any time, a large number are non-technical laity, that have taught themselves to use the environment (Linden, 2009). We argue therefore, that a well designed VE Conceptual Modelling tool is well within the reach of a typical business analyst with a modicum of computer skills.

A short introduction to VEs is now shown, to indicate their capacity for such modelling tasks.

4.1 3D Virtual Environment Technology Introduction

Virtual Environments have emerged as a powerful software technology for supporting collaborative 3D work and entertainment environments (Burdea and Coiffet, 2003). These environments are typically client server systems that support the creation of, and full interaction with, shared and collaborative 3D dimensional spaces.

These 3D spaces allow the creation of geometry representing many things experienced in reality, including buildings, terrain, forms of transportation, weather models, amongst other things. These objects are represented using data structures known as geometric meshes, which have images laid over them known as textures to give the objects visual appearances approximating real object properties (eg. stone, wood, glass). Human modellers can use VEs to model such objects very easily (refer to Figure 3).

One of the most powerful components of such worlds, exploited by the new framework, is the ability to attach programs to the objects, known as scripts, to imbue objects with extra functionality. A major component of the functionality in the new BPMN editor is implemented using such a scripting process (refer to Figure 5).

In addition, one of the most useful facilities available within a Virtual Environment is the representation of the user as an Avatar, the user ego centre so to speak, that allows the humans to have a spatial presence in the Virtual Environment.

This paper shows that this 3D modelling approach is not too large an extension to present toolsets, and thus enables business analysts to utilise such tools with minimal training.

4.2 BPMN Modelling System Components

A lot of Virtual Environment systems may be used for this project. With reference to the functional requirements, the Open Simulator (OpenSimulator, 2008) and Second Life Client (Linden, 2008) were chosen to implement this prototype. The following details the major reasons:

1. Open Simulator is an open source virtual world server (BSD Licence) which works on many hardware platforms and is compatible with the Second Life virtual world viewer. This allows the implementation of such modelling systems on laptop systems that can be used in the field by analysts. In fact, the demonstrator in this paper was developed on a standard Apple MacBook.
2. Using the Second Life open source viewer provides a set of easy to use tools for content development, well suited to non-technical users who are a large

component of the Second Life community, thus facilitating its usage by business analysts (refer to Figure 3);

3. Open Simulator has a powerful scripting language, which can be extended by the use of C# language technology, thus enabling modelling environment interactions, such as process model linking (refer to Figure 5).
4. Open Simulator has been used in a successful executable process modelling system that uses the YAWL workflow package (Brown and Rasmussen, 2009). So Open Simulator had already proven its capabilities.

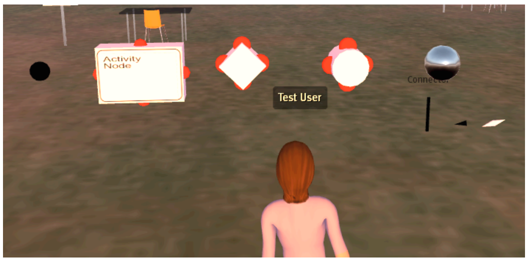

Figure 2 Showing the major 3D constructs present in the diagrams. From the left, they are, a flow link ball (for long bent flows), activity node, gateway node, event node and a control script embedded in a sphere. The other small items are the components of the BPMN graph flow connectors.

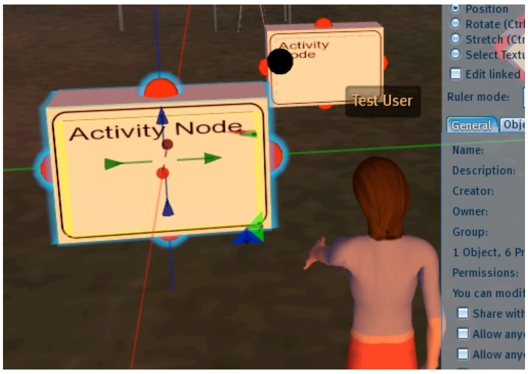

Figure 3 Illustration showing the tools used to position and edit BPMN model objects, in this case an activity node.

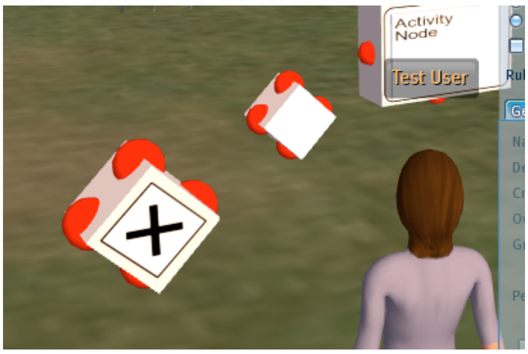

Figure 4 Illustration of using texture images to annotate BPMN objects, in this case to create a parallel gateway from a generic gateway.

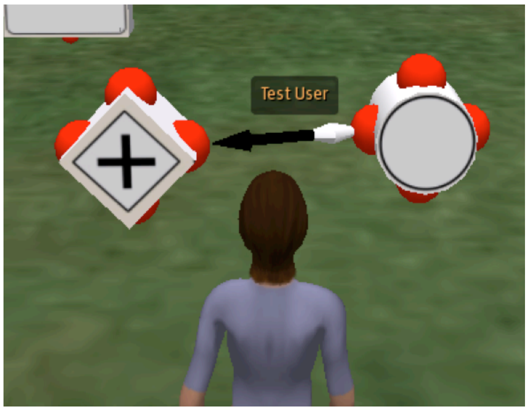

Figure 5 Illustration of linking BPMN process model components, in this case with a Conditional Flow between and event and a Gateway. Links are formed by clicking on pairs of red spheres.

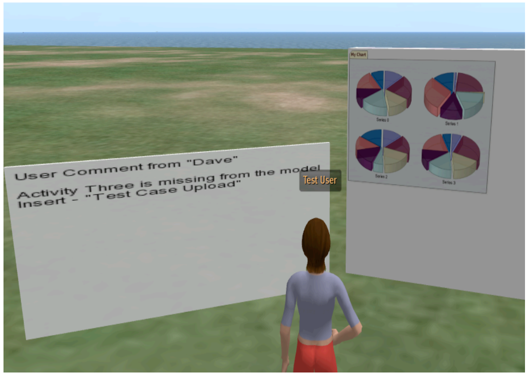

Figure 6 An illustration of the ability to insert textual annotations into the process model. Stakeholders may leave Comment Walls (left) or may use web services to show process statistics (right)

To meet the task and functional requirements, we have developed the following:

1. Object models for the 3D environment to represent the BPMN notation in world – these are Events, Activities, Gateways and Flows. Each have been given a simple 3D representation, and have been modelled with connection nodes for linking as a graph. Each can be dropped into the world from the inventory owned by the user in world, giving an easy to use modelling approach (refer to Figure 2 and Figure 3).
2. Textures for the different annotations – thus developed a complete image database for the annotation of the basic BPMN nodes with image information, as shown in Figure 4.
3. Flow Connection - as the modeller is in essence a graph drawing tool, there is a need to easily create the model flow connections, as per Figure 5.
4. Avatar instance animations. A human resource simulation model is required to show simulations of the processes being executed. This facilitates validation processes by providing an easy to use interface for running simple simulations of instances of processes being executed by an involved stakeholder, to support validation processes with the client (refer to Figure 9).

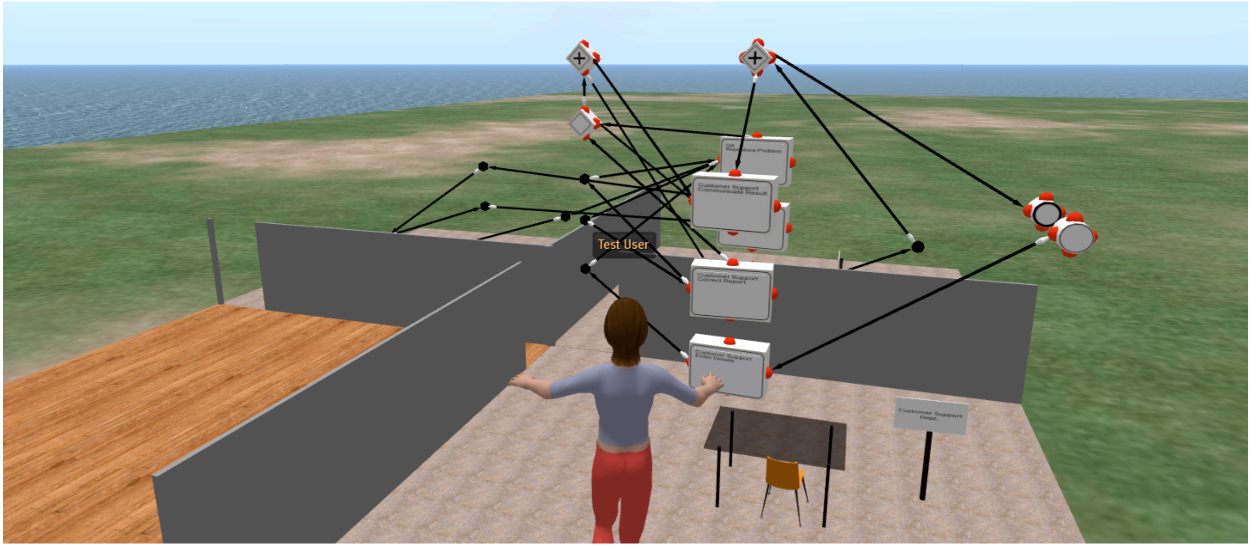

Figure 7 Illustration overview of the full 3D BPMN Software QA example in a Virtual Environment.

5. Annotations are implemented as signpost objects that can be left near the process, and have text inserted to show commentary by various clients who have viewed the model and wish to comment on the validity of the model. Video and audio interview data can be inserted into the world and embedded near the BPMN places of importance, for confirmation purposes, as per Figure 6. Such an approach enables the environment to become a 3D spatial database for the visual mnemonics of video, text and audio information.

5 Software Company Case Study

To illustrate the major features of this approach and prototype implementation, we have developed a 3D BPMN diagram for a Software Quality assurance process. The process involves a description of the interactions of three quality control departments within a software company – Customer Support, QA and Development – and how they interact to deal with software quality issues reported by users.

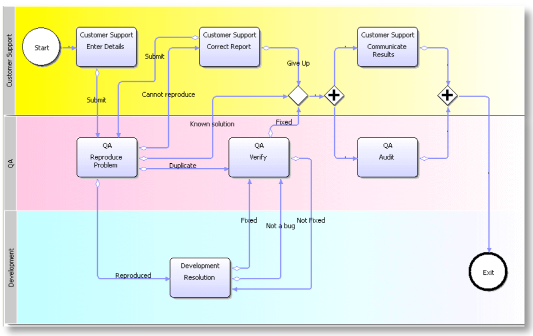

Figure 8 Example BPMN Model for a software quality process (Swenson, 2009). Each swim lane represents a department in the software organisation.

We use the case study to highlight a number of possibilities with visualisations:

- Spatial Locations;
- Representations of Human Resource Roles;
- Relationships between other aspects of the physical environment;

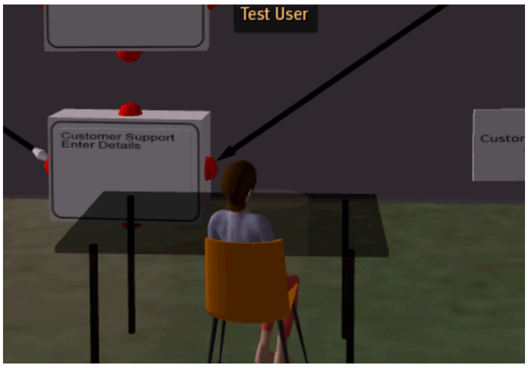

Figure 9 Showing the room with the Customer Support Activities. Note the sitting avatar, representing a Human Resource performing work.

Spatial locations for the processes being enacted are represented in this approach using 3D coordinates. BPMN and other forms of process modelling have a swim lane model of activity representation (OMG, 2006), here we extend that to an actual spatial locations and groupings with reference to the natural spatial structures used in the business, in a full 3D, rather than 2D manner (refer for an overview of the diagram to Figure 7).

We see in the following scenes (Figure 9 and Figure 10) that work is divided up into three departments in three different locations in the building. This is illustrated with a set of rooms aligned with a floor layout.

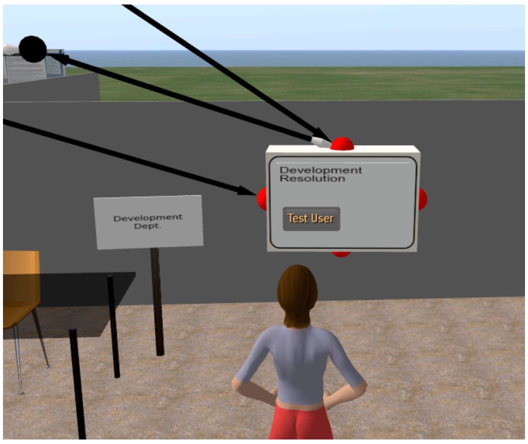

Figure 10 Activities in the Development Department for the example process model.

At each location, the activity is embedded for reference. With this example, the client is thus able to make a direct comparison of what is represented conceptually with a physical model of the environment, to assist the client in mapping conceptual constructs with their more physical understanding of the process. They can use the physical simulation as a mnemonic to help validate a business process model.

Representations of the roles of people doing their tasks can be shown to a client, thus adding insight into the reasons why things are performed in a certain manner, and why certain tasks are either performed badly, or are performed well. This is also useful with process improvement scenarios, where a process model can be labelled or colour coded "as-is" and "to-be", in order that the client can easily see the change, in a manner similar to 2D modelling systems.

Again, the client can verify whether the business analyst has correctly captured the tasks being performed, so along with the physical location, the client can give feedback on the business analyst on the validity of the process model, from an activity and role based approach using the annotation markers if necessary.

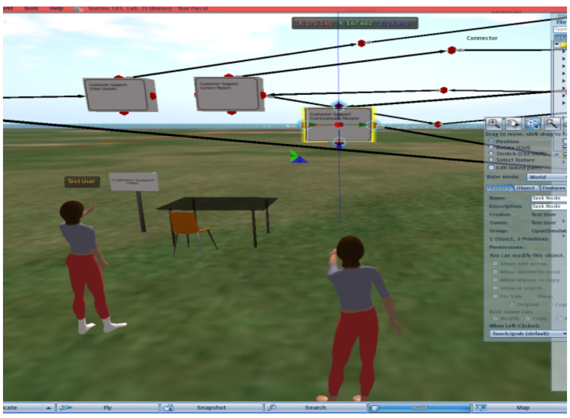

Figure 11 Illustration of collaborative capabilities of VEs, in particular, the ability to collocate avatars, and refer to objects in a natural spatially oriented manner. Both avatars here are discussing and manipulating the activity object (highlighted).

In summary, communication processes can be enhanced by the use of such tools due to their interactive nature. A model of the business can be shown to the client by an analyst, with the added advantage of it being interactive. Therefore, any number of potential scenarios in the business can be visualised and demonstrated with full control, facilitating dialog by allowing clients to ask questions and to step through the environment to examine particular details, to make them clearer.

The other major benefit of such 3D environments is the ease of network communication offered by the use of 3D Avatars. Compared to video collaboration, where the relative location of the client to what they are manipulating is not apparent, 3D VEs represent the person in the dialog, juxtaposed alongside the process model items being discussed. Coupled with a audio chatting capabilities, VEs offer powerful process communication capabilities, especially when dealing with spatially oriented conceptual process models. An example of collaborative modelling is presented in Figure 11.

6 Conclusions

In this paper we have outlined an approach to the use of 3D Virtual Environments as an annotation of process models for process model communication.

We have outlined the motivations and general requirements for the development of 3D Concept Model representations, and have developed a proof of concept BPMN Editor in Open Simulator, which provides most base functionality required to create usable BPMN diagrams in a 3D world.

As this is a first incursion into this research space, we see that there are many extensions to this research work that need to be explored in order to make the general approach and the software that much more usable.

The system successfully implements many of the ideas presented, but needs to be extended in a number of areas.

There needs to be a development of a message and event animation component, to clearly show the actions of the other event and timer constructs within the process model.

Suitable export and import tools need to be developed for integration with other BPMN tools. The 3D Environment can be used as part of a constellation of tools to support the development of 3D Process Model visualisations.

Finally, there needs to be an analysis of benefits via experimentation of insight into process systems. While there is a good argument for the use of visualisation systems in the communication of process models, qualitative and quantitative experiments need to be performed to establish the potential of such environments within the process modelling domain.

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