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Using virtual worlds as collaborative environments for innovation and design

Lessons learned and observations from case studies in architectural projects

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Abstract. In this paper we discuss observations and lessons learned in conducting architectural design projects in virtual worlds. By integrating a community of users in virtual worlds into a collaborative architectural design process, organisations can tap the community's creativity and intelligence through immersive technology. The paper provides an overview of the latest advances of information and communication technologies in immersive virtual environments and discusses some of the observations and lessons learned which should be taken into account in developing collaboration models for such activities. Here we propose four modes of collaboration, based on the choices for degree of openness and governance structure, which are illustrated by four case studies.

Keywords. Virtual worlds; open source collaboration; online communities; collaborative design; open innovation.

Introduction

The purpose of this paper is to discuss observations and lessons learned in conducting architectural design projects in virtual worlds and look at implications for improvement in such collaborative efforts.

With the network effects of the digital age, combined with the principles of open source movements, the world is starting to see the beginnings of more distributed and collaborative approaches to design and creation processes (Büyüközkan et al., 2007). Open source projects like Wikipedia and innovation crowdsourcing approaches such as those utilised by companies like InnoCentive, demonstrate how a loosely connected community of contributors based in different parts of the world can contribute to the design of a new product or resolving a problem in an emergent way.

Such approaches are not new in the business world: consumer goods and pharmaceutical companies such as Proctor & Gamble and Eli Lilly, as classic entrants, applied the concept to their innovation and product development process nearly a decade ago, and these models are now mainstream (Huston and Sakkab, 2006). Traditional mass-customisation approaches used by companies like Adidas and Benetton have also fueled such approaches, and the activities of companies like Threadless.com are based on taking advantage of consumer interest and involving them not only in component configuration, but also in the real design process.

Virtual worlds, which have become popular recently, offer new opportunities to take this open collaboration and design to the next level (Kohler et al., 2009): the combination of a 3D graphical modeling environment, document and file sharing capabilities and rich text, and voice and video communication help the contributors not only to connect better but also be able to create many-to-many relationships, conduct mass collaboration activities and perform real time simulations.

Therefore, linking the new possibilities which the emerging technology of virtual worlds provides with a community-centric perspective and open collaboration process allows distinctive opportunities to capitalise on users' innovative potential and knowledge. We believe that the concept of open design collaboration in virtual worlds is an emerging area where companies can systematically conduct innovative design projects across many sectors including architecture and construction, even though new models are required to make such efforts work.

Virtual worlds as platforms for collaboration and design

Continuous feedback from users is an essential issue in design; therefore companies normally run a series of test cycles during and after a product design phase. Typical strategies involve making physical prototypes of the product and evaluating them with relevant stakeholders. The use of virtual reality technologies and more recently online virtual worlds, however, have enhanced testing and feedback processes significantly, and in many industries have been used in place of physical prototyping for products which are complex or very expensive to build. For example, Caterpillar® collaborated in the mid 1990s with the company Fakespace® to create virtual prototypes of products which would have been too expensive to physically prototype.

The emergence of online virtual worlds has taken the virtual reality movement to the next level and reduced the cost and required time to build prototypes. The use of avatars (Galanxhi and Nah, 2007), the graphic representation of the self in a 3D virtual environment, differentiates the experience of virtual worlds from traditional virtual reality environments and makes it more engaging and easier for communication as well as collaboration (Kohler et al., 2009). Specifically, the use of avatars makes the interaction experience closer to a real world environment, provides the opportunity to interact not only with the prototype but among users and, for some environments like Second Life, combines voice, video and application sharing with 3D activities. Even though there are currently fewer examples of prototyping in Second Life (Kohler et al., 2009), using virtual worlds in order to create and test the new products and concepts in Second Life is becoming popular among companies in sectors such as consumer goods, automotive and construction.

Architectural collaboration in virtual worlds

Creating innovative outcomes in projects related to architectural or construction requires an element of collaboration as a key success factor (Blayse and Manley, 2004). The design team normally has to interact and collaborate amongst themselves to integrate each player's work into the final outcome. There is also a need to collaborate with externals such as customers and suppliers through each iteration to refine initial work and adapt the design to the externals' bottlenecks.

Open collaboration in architectural or construction projects can be applied to different activities in the design process: from concept generation and evaluation to actual design or modification to final testing and refinement. Initiatives of companies like Starwood Hotels, one of our cases, link concepts of crowdsourcing and virtual worlds to facilitate concept testing and bring a new architectural project to fruition. Other efforts like the experiences of Implenia, another case, represent the opportunities to reduce the cost of the design testing and refinement process and create new services associated with construction facilities.

In order to get a better overview of the latest advances of information and communication technologies in immersive virtual environments and discusses some lessons learned about architectural collaboration, we selected four case studies of architectural design experiments using virtual worlds. The cases highlight practical

implications and reveal prerequisites and challenges of this new approach, and new models of collaborations to interactive and open design processes.

A brief summary of our four analyzed cases, Wikitecture (Chase et al., 2008), Starwood Hotels (Jana, 2006), PARC (Wadley, 2008) and Implenia (Driver and Jackson, 2008), has been provided using secondary data, participant observation within the virtual world and semi-structured interviews with both managers of such projects and the projects' stakeholders. Special attention has been given in each case to the nature and type of the project, the way interdependencies are managed internally and externally and also organisational issues such as participant motivation. We will show how governance issues and the way interaction occurs are affected by the nature of the problem and users.

Case study 1: Implenia collaborates for Second Life prototyping

Implenia is the largest construction company and building services provider in Switzerland and handles a variety of different projects in the construction sector, from large residential buildings to commercial towers, stadiums and subterranean civil engineering projects. The company often constructs physical foam models of the buildings or facilities in the design phase. These models can be used as an early prototype to show clients, get their input and build consensus. The company might spend up to €130,000 on such prototypes.

In 2007, in an attempt to reduce costs and extend the boundaries of working in a traditional mode, the company formed a think tank named EOLUS with companies including IBM and SAP to conduct experiments in Second Life (Graham-Rowe, 2008). In one of these experiments, the members were looking at the possibility of moving the design process to Second Life The idea was to create 3D models of the company's projects in Second Life instead of using CAD software or foam models (Driver and Jackson, 2008). By using Second Life, the client could become engaged in a more interactive experience, go inside the virtual building, see the surroundings, and attach comments to different parts of the building models, all of which can be done via remote connection.

Each member of the collaboration team had different motives for participation: Implenia was looking for new opportunities for design cost reduction and creation of new construction services; IBM wanted to experiment with virtual worlds technologies in real environments and enrich existing knowledge in its virtual worlds service practice; and SAP was curious to find out long term ways for integrating its core software products with new immersive capabilities. Even though these firms had different motives, they collaborated as the realisation of their goals was dependent on others.

The specification of the project, its scope, final outcomes and duration was not fully clear from the beginning. These eventually became clarified through the collaboration. The result, apart from initial goal of creating a 3D prototyping platform, included the development of new areas such offering construction services, where the team made a doll-house model in the physical world which was connected to a similar model in Second Life. Opening the doors or turning on the lights in the Second Life model triggers the same action in the doll-house model; a virtual thermostat also tells the real house what to do in terms of adjusting the temperature (Fig. 1). As Implenia already monitors 4,500 buildings in Switzerland using normal, physical presence, this new idea suggested a new service for facility monitoring.

Figure 1
EOLUS physical dollhouse with two way links to a Second Life counterpart

Case study 2: aloft hotels Introduced in Second Life

Starwood is one of the world's largest hotel and leisure companies, owning chains such as Sheraton, Westin and W. A new brand from Starwood is aloft hotels that opened in 2008, having previously been tested in Second Life. Starwood was thus the first hospitality company to seek feedback on architectural concepts in a virtual world (Jana, 2006). The reason for starting the Second Life project was to make a prototype of the hotel concept and to test it on the market. Potential customers and designers could log in to the Second Life environment, walk around the lobby and different rooms and comment on the layout, decorations, colours, etc. (Fig. 2).

Another initiative of the company in Second Life was to create a competition where avatars were asked to provide ideas for improvement of the hotel design. The competition winner received the Virtual aloft island as a prize. The hotels that were subsequently built implemented most of the recommendations that had been received in Second Life. The company also used an indirect way to get feedback from the virtual world presence through monitoring the way that Second Life residents moved inside the hotel. For instance, it was possible to see to which areas of the hotel that avatars preferred to go to and which furniture they found attractive. Brian McGuinness, VP of Starwood Hotels, said during the period these experiments were conducted that one positive outcome of creating a virtual hotel is that money is saved by not having to build features in the real world that virtual visitors have disliked (Jana, 2006).

Figure 2
Avatar exploring virtual aloft hotel bathroom. Image courtesy Tao Taksahi under a Creative Commons by-nc-sa license

Case study 3: PARC experiments with building in second life

One good example of a collaborative building effort is a series of experiments conducted at Palo Alto Research Center (PARC), examining collaboration around building objects in 3D (Wadley, 2008). The experiments included extensive use of voice communication in the virtual world.

One experiment consisted of assembling a building from existing objects in Second Life. Each group member was shown a screenshot of the target "house" and how the house should look when complete. This was similar to a "jigsaw puzzle" task, though in an immersive environment. In a second effort ("garden" task), one group member was made leader and shown a picture of a house surrounded by extra objects such as garden furniture and a fence. The leader could only view the scene and not use the editing tools; instead (s)he was supposed to direct the other participants to build the scene (Fig. 3). The "house" experiment was intended to observe dynamics of open small-group collaboration, while the "garden" task forced more verbal interactions to build a facility through a slightly different governance mode.

Throughout the experience, the participants adopted organisational structures that precluded the need for fine-grained collaboration, possibly because the articulation work required for close collaboration represented too high a load. Most of the working groups decomposed the house into "base" and "roof" subassemblies, completed in a separate manner and joined later. The necessity to achieve a specific goal which was rather complex (building the house or garden) moved the working structure towards decomposing the project into sub-tasks that allow specialisation and independence from synchronicity. The need for coordination to integrate the final results also became clear in both experiments.

Figure 3
PARC 'garden' task. User1 verbally directs User2 to build within the virtual world

Case study 4: Wikitecture project

Wikitecture (Chase et al., 2008) is perhaps the best known project that has attempted to use an open approach to architectural design through a number of experiments (four to date). Collaborators are drawn from the Second Life community, with no restrictions to date on participation. The first experiment included a group effort at designing a small meeting kiosk. The activity was not a true wiki in the sense that contributors could not modify or delete the contributions of others, and thus, very little was learned from this first effort on the nature of totally open design work.

For the second experiment the group designed a courtyard building for group meetings in virtual world. Unlike the first one, members were able to modify or delete other contributors' designs. To facilitate communication, contributors could post information (text and images) about their designs on a photo-sharing website and leave

feedback on others' designs. A rudimentary archiving system was also introduced; this allowed rollback to previously saved design iterations.

The third and fourth experiments (2008–2009) introduced a 'wiki tree' as a more structured means of archiving, viewing and voting on design contributions (Fig. 4). The project brief for Wikitecture 3.0 was an international design competition for a medical clinic in Nepal (the Wikitecture entry won two awards); for Wikitecture 4.0 it was the design of a virtual classroom in Second Life, with the University of Alabama as client.

One important aspect of these experiments from an organisational point of view was the development of an assessment scheme to measure individual ownership in and contribution to the collaboratively authored design. In its current form contributors are asked to assess relative amounts of contribution of all team members. This provides a simple but generally reasonable judgment as to how much of the outcomes (e.g. compensation, ownership, IP rights) should be allocated to each contributor. It is also a mechanism for creating an intangible incentive for the participants as the level of contribution from each user is visible to the others. Future work will investigate enhancement of the current assessment scheme to make it more robust, e.g. to preclude 'gaming' the system for an individual's benefit.

As a very open community running a set of experiments, each Wikitecture project has been a learning experience, tending to raise more issues than it answers, e.g. assessment, project modularisation (how does one divide the work on a typical architectural project, which would be larger and more detailed than those attempted to date).

Figure 4
Wiki tree. Spheres represent archived designs, with colours indicating a design's popularity

Discussion

The examples presented in the previous section demonstrate that architectural collaboration in virtual worlds, at least in the specific case of Second Life, may significantly change the way distributed design teams work with each other and external stakeholders during the course of a development and/or design project. From this, we surmise that collaboration in virtual worlds has its impact on architectural collaboration primarily in three main areas:

- **Project Openness:** The collaborative nature of virtual worlds and the fact that it breaks the boundaries of the physical workplace makes it possible for a distributed group of people, possibly from different organisations, to work together in a more open way. However, the degree of openness differs from one project to anther; in cases like PARC experience, the participants might be a certain group of people and on other side of the spectrum, the interaction is open to externals (aloft hotel).
- **Governance model**: The definition of rules and working hierarchies for conducting activities within the virtual worlds might also change. In Wikitecture, where the

tendency is towards wikis or blogs, the group creates shared property or common ground where it is in everyone's interest to create a positive outcome (Lee and Lan, 2007). In such environments, a hierarchy (if one exists at all) is defined collectively by the group (e.g. Wikitecture). On the other hand, more traditional structures similar to those in the real world can also be utilised as in the case of aloft hotels, where the problem or facility as well as the feedback process and rules are defined by one entity.

- **Incentive processes**: Transparency over the activities conducted by others might be utilised to develop new incentive schemes for virtual world collaboration. One example is the assessment in the Wikitecture project which determines the contribution done by each participant and IP ownership in a collective way.

Considering the choices for degree of openness and governance structure, four modes of collaboration can be envisioned into which our case studies fall. These modes have been described in the context of general user contribution and collaboration (Pisano and Verganti, 2008); by our observation, they are extendable to collaboration in virtual environments. These modes of collaboration include:

- **Pure open design community:** A usually large, loosely connected group of contributors, where project owners and external contributors openly propose architectural project proposals, design sub-project components and solutions and decide which ones are more valuable. Early Wikitecture experiments fall in this collaboration mode.
- **Solver network:** Where a company utilises a social platform (e.g. Second Life) to share an architectural design with externals and many participants in order to receive feedback. Externals can propose solutions or provide feedback; the company chooses the ones it likes the best. The contribution of the participants is normally intangible and the rules of collaboration are defined by one entity. Projects like Virtual aloft by Starwood Hotels are examples of design collaboration in this mode.
- **VIP networks:** A selected group of partners work on a design project chosen by a project owner. The company defines the problem and chooses the solution. The collaborative building experience conducted by PARC fits within this category.
- **Consortium structures:** A private group of participants jointly select problems and design solutions. The relationship between the participants here is more or less horizontal. Implenia's experience is an example of this type of collaboration.

A graphic illustration of the collaboration modes is shown in Fig. 5.

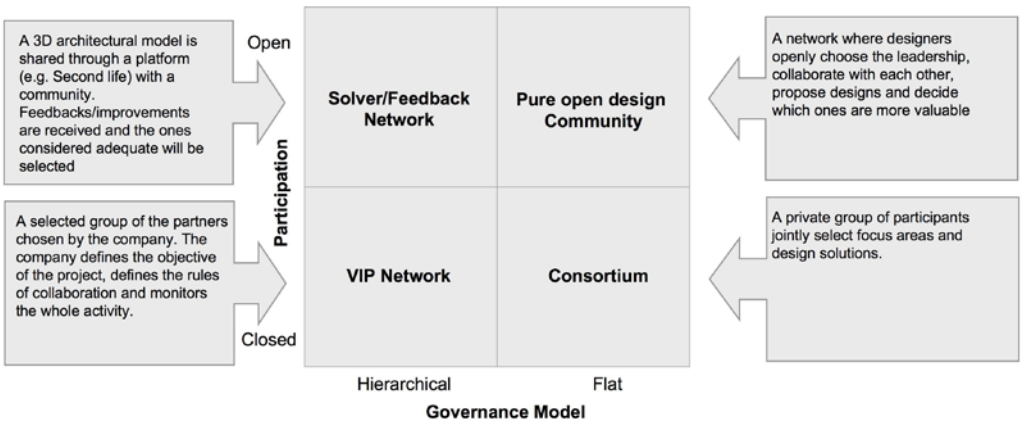

Figure 5
Different collaboration modes for architectural projects

The decision on the whether the structure for collaboration should be open or closed and the choice of the governance model depends on the nature of the architectural collaboration project: a certain mix of governance structure and organisation plus a

specific incentive scheme might be optimal for one effort and not as appropriate for another project type.

As an example, in the case of high openness degree and large number of participants, the cost of screening and selecting participants for an architectural project might be high: there is a need to find several candidates and each of the players might be assessed in terms of required skills, which can be time consuming and costly. Therefore, a project owner can work with a large group of participants if the evaluation of participants' background or expertise is simple or not required. Projects such as aloft hotel where the feedback concerning the colour and layout of the hotel is required from participants are example of such situations. In these cases, anonymous feedback is preferred as results would reflect the general public's opinion. Since the contribution of the participants in such projects is rather small in terms of required time and effort, elements such as virtual gifts or community recognition can be used as incentives. However, if the objective is to create a state of the art architectural outcome, as it was in with Implenia, the selection of participants should be conducted more carefully. The complexity of the task itself dictates lower numbers of participants so that the coordination would not be an issue. Incentive mechanisms in such efforts are also more complex as the financial and intangible takeaways should be clarified from the beginning.

The choice of governance structure to be hierarchical or horizontal, similar to degree of openness, depends on certain factors: Implenia's project was more horizontal in nature, as none of the participants had the knowledge necessary to define the project scope, activities and outcomes in detail. Conversely, in the PARC experiments, the owners were aware of the desired outcomes, required components and the number of participants needed, and therefore set a more hierarchical structure.

One important point to consider is the dynamic nature of the collaboration modes, as a given project might require more than one mode. In reality, an architectural project goes through different stages in its lifecycle: in the beginning a group of designers develop a concept, the concept is tested with a larger target group and then it goes through different stages of design and construction. As the project evolves through the mentioned lifecycle stages, its collaboration needs also change and there might be a need to shift from one mode to another. The aloft hotel model in Second Life was built in the early stage by a selected group of designers (VIP mode). As the project progressed and there was a need to test the architectural concept, the collaboration mode changed to "Solver Network", with different incentives. At the end the project returned to the VIP mode.

The optimum choice of collaboration mode and associated incentive is not restricted to the elements above. As virtual worlds are still in their infancy and knowledge of how to use them might be a challenge, an appropriate collaboration mode might involve a smaller selected group with a closed structure. Wikitecture is an example of such issues as in the second experiment, the mode of collaboration had a marginal transition towards a smaller selected group and the team was also supplied with a web interface in conjunction with the virtual world environment to overcome the difficulties related to technology literacy.

Conclusions

The results of our case studies and interviews suggest that "one size fits all" approaches to virtual collaboration in architectural design are probably not the optimal road to success. The choice of collaboration mode and the supporting organisation and processes, like any other strategic decision, depend on a number of factors: the purpose of the project, clarity and knowledge of the final desired outcome, mission-criticality of

the project and type of participants influence the governance model and the organisation which is normally adopted.

As the collaboration effort goes through different stages and the knowledge about other players' motives and the project itself increases, the governance model might change to adapt to new conditions. As an example for the purpose of general concept evaluation, a more open model in a "solver network" seems more suitable and a combination of virtual gifts and recreational events in the virtual world seems a good fit. However, as the project goes into the real design phase, an elite circle mode with different incentives and leadership mode may be adopted.

We also identified that, as virtual world platforms are still in their infancy and access to the immersive technology might be difficult for some contributors, other elements such as technology literacy should also be taken into account and in this specific case, combining virtual world collaboration with more traditional forms of community contributions (e.g. through a website) increases the quality and number of contributions. Significant improvements to the virtual world technology and changes to working methods for design and manufacturing are still to be made, but one can clearly see their potential to take the architectural collaboration performance to the next level.

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