THE APPLICATION OF CLOUD COMPUTING IN TRANSPORT PLANNING USING INTERACTIVE 3D VR SIMULATION TECHNOLOGY

Yuji Ito, Christophe Soulier & Yoann Pencreach
FORUM8 Co., Ltd., Nakameguro GT Tower 15F, 2-1-1 Kamimeguro Meguro-ku Tokyo, Japan

Brendan Hafferty & Patrick Hafferty
FORUM8 Western Regional Office, UK Fleet House, New Bridge Street, London, UK

ABSTRACT: *The design and planning of urban and transport infrastructure has undergone a tremendous transformation over the past few years. Not only has the available software technology changed considerably, so have the requirements and demands of the various stakeholders. As the democratic process becomes even more open, coupled with the advent of 24/7 information and news, so the demands of the general public to have a greater say in the actions that have a direct effect on their lives have increased. Local and National Government planning professionals are under increasing pressure to not only justify what they plan to do in words and pictures, but also to show the proposed new developments in a medium that is far more easily understandable to the ordinary 'man in the street'. In the recent past the only way to do this was by calling 'town hall meetings' and displaying large photographs, video clips or solid models. This paper describes a new and novel way to improve consensus building for contentious new infrastructure projects, by using Interactive 3D Visual Simulation computer models, delivered to the target stakeholder community via the Cloud.*

KEYWORDS: *3D, Visualization, VR, Cloud Computing, Urban Planning, 3D City Modeling, Consensus Building*

1. INTRODUCTION

According to the well-known computer analysts Gartner Inc., "…cloud computing heralds an evolution of business that is no less influential than e-business." Gartner maintains that "…the very confusion and contradiction that surrounds the term 'cloud computing' signifies its potential to change the status quo in the IT market."

The key point here being the use of the ubiquitous Internet to communicate and obtain on-line responses from and with multiple external people – in this particular case - stakeholders i.e. transport planners in different office locations, local & national government officials, the local business community & members of the general public.

The objective of this paper is to show how the use of the very latest interactive 3D software can be integrated into the very latest Cloud Computing technology and in so doing expand the consensus building process to anyone with access to the Internet (Conway G. 2011).

This objective will be achieved through the development of a new product called VR-Cloud, part of the family of Virtual Reality (VR) products produced by the Japanese company FORUM8. The aim is to complement the company's leading Interactive 3D Visual Simulation & Modeling software VR-Design Studio (formerly UC-win/Road), by enabling its 3D interactive environments to be accessed and manipulated over the Cloud.

The ultimate aim being that anyone with Internet access will be able to view new transport and infrastructure developments and even walk or fly through the proposed new 3D Space at will. No longer will they have to rely upon fixed views of new buildings, tunnels, bridges, highways etc., they will be able to experience what the new environment will actually be like within the virtual environment of their own PC or indeed Android.

One of the key benefits of using the Cloud to deliver these 3D VR environments is the fact that the stakeholder (member of the public or indeed any other interested party) does not require any special hardware. All they need is good Internet access.

Citation: Ito, Y., Soulier, C., Pencreach, Y., Hafferty, B. & Hafferty, P. (2013). The application of cloud computing in transport planning using interactive 3D VR simulation technology. In: N. Dawood and M. Kassem (Eds.), Proceedings of the 13th International Conference on Construction Applications of Virtual Reality, 30-31 October 2013, London, UK.

2. TRANSPORT PLANNING

2.1 Background

Transportation planning in the United States would appear to be changing with respect to its involvement with stakeholders. As in the UK and in many ways following the lead given by some European countries, the US urban planners seem to be moving away from the simplistic solution of simply moving traffic from A to B and towards a more holistic approach that takes into consideration the communities and environment through which the traffic has to pass. In addition this more enlightened approach would seem to place greater emphasis on rail and light rail (tram) networks, bicycle lanes and other forms of public transport as well as pedestrian movement (known in the UK as walking strategies).

These new ideas are in many ways not new. In 1998 there was a conference in the State of Maryland titled "Thinking Beyond the Pavement". The aim of this conference was to promote the concept that transport projects had to preserve and enhance the natural and built environments, as well as the economic and social assets of the neighborhoods they pass through.

These principles have since been adopted as guidelines for highway design in federal legislation. Since then the Federal Highway Administration set a target for all DOTs to adopt these new guidelines by 2007.

2.1.1 The Technical Process

Most regional transportation planners today employ what is called the rational model of planning. This process uses the analysis of quantitative data to decide how to best invest resources in new and existing transportation infrastructure.

Over the past 50 years both in the US and Europe there has developed a reliance of the use of travel modeling as a major element in the overall transport planning process. As the volume of vehicles on the roads and highways (motorways) increased, almost exponentially, so the reliance upon such modeling techniques increased accordingly.

The problem is that transport planning by its very nature is based on predicting the future and hence is not and cannot be 100% accurate.

As complex micro-simulation computer technology has become the norm in predicting traffic demand throughout the western planning community, so there is a great danger in assuming that the output of these simulations is an accurate reflection of what will actually happen if the proposed infrastructure changes take place.

This particular problem was highlighted by the study of Flyvbjerg, Skamris Holm and Buhl (Flyvbjerg B. 2005). In this study the authors found that many of the models that planners use to promote and secure large scale highway and rail projects are fundamentally flawed and often grossly inaccurate.

It is therefore particularly important that urban planners understand the concept of GiGo (garbage in – garbage out) and insure that their ‘models’ reflect all the available data and the various planning guidelines and the views of the customers i.e. the public – for whom they work.

A large part of transport and general urban planning involves this technical process that is designed to predict where future investment needs to be made. However it’s very important to understand the public involvement implications of this process.

As planners become to rely more and more on complex technical tools such as micro-simulation modeling software so it becomes more difficult for members of the public to understand all the technical issues and actually visualize what the proposed changes will look like and how they will affect their ‘way of life’ and home environment.

Indeed, it is not only the general public that find it hard to visualize new infrastructure projects, local and regional government politicians, who ultimately make the investment decisions on behalf of the public, often cannot understand all the features and benefits of such projects.

2.1.2 Stakeholder Consultation

This leads me to highlight the involvement of the public and the changes that have taken place in the way planners view the public and other stakeholders, particularly in Europe, and particularly since the 1960's.

Too often in the past there has been an attitude of 'we the professionals' know best. We know what's good for the community, we know how best to plan for the rise in population or the increased traffic congestion.

Far too often architects have been allowed to change the face of towns and cities without any level of consultation with the people who live and work within these built environments. Once again the 'professionals' know the best type of material, shapes and sizes that these new buildings should be constructed from etc.

As has been proven in many towns and cities throughout the west, especially in the industrial cities of the UK, this approach has led to urban decay. Whole communities have been demolished simply through the hubris of professionals, allowed by weak local officials and politicians to do precisely what they wanted without any thought to how it would actually affect the 'stakeholders'. In fact the term stakeholder is rather a new one as is the concept of consultation and consensus building.

2.1.3 Consensus Building

Stakeholder consultation and consensus building are really about initiating and sustaining constructive external relationships over time. Organizations that start the process early and take a long-term, strategic view are, in essence, developing their local "social license to operate." so said the International Finance Organization – part of the World Bank Group (IBMTech 2010).

For infrastructure projects that have an environmental and social impact, such consultation should not be a single conversation but a series of opportunities to create understanding about the project among those it will likely affect or interest, and to learn how these external parties view the project and its attendant risks, impacts and opportunities.

Listening to stakeholder concerns and feedback can be a valuable source of information that can improve project design and outcomes and help to identify and control external risks.

For stakeholders, the consultation process is an opportunity to obtain information, as well as to educate the professional planners about the local context in which the proposed project will take place, to raise issues and concerns, ask questions, and potentially help shape the project by making suggestions.

2.1.4 Sustainable development and sustainability

There has been a significant growth in the concept of sustainable development within the urban planning profession over the past 10 years.

However, sustainable development is a recent, controversial concept (Innes J. 2007). Wheeler, in his 2004 book, defines sustainable urban development as "development that improves the long-term social and ecological health of cities and towns." He sketches a 'sustainable' city's features: compact, efficient land use; less automobile use, yet better access; efficient resource use; less pollution and waste; the restoration of natural systems; good housing and living environments; a healthy social ecology; a sustainable economy; community participation and involvement; and preservation of local culture and wisdom (Levy J.M. 2011).

To improve the success of such exercises a number of specific project management techniques have been devised such as Collaborative Strategic Goal Oriented Programming (CoSGOP). This is a collaborative way of strategic planning, decision-making, implementation, and monitoring which is designed around achieving defined and specific goals.

CoSGOP is based on not only the detailed analysis of the available data it relies upon the maximum use of stakeholder consultation to build consensus and hence reduce contention within the project from its initial conception through to its completion.

2.1.5 Collaborative planning in the United States & the UK

Collaborative planning arose in the US and the UK in response to the inadequacy of traditional public participation techniques to provide real opportunities for the public to make decisions affecting their communities.

Collaborative planning is a method designed to empower stakeholders by elevating them to the level of decision-makers through direct engagement and dialogue between stakeholders and public agencies, to solicit ideas, active involvement, and participation in the community planning process. Active public involvement can help planners achieve better outcomes by making them aware of the public's needs and preferences and by using local knowledge to inform projects. When properly administered, collaboration can result in more meaningful participation and better, more creative outcomes to persistent problems than can traditional participation methods. It enables planners to make decisions that reflect community needs and values, it fosters faith in the wisdom and utility of the resulting project, and the community is given a personal stake in its success (LUDA 2010).

Experience shows that successful collaborative planning depends on a number of interrelated factors that involve all the stakeholders (Planners, Government & the Public):

- Inclusivity – all stakeholders must be invited to contribute
- Decision making - the stakeholders have the final decision-making authority
- Government commitment - both financial and technical must be present
- Clear Objectives – the non-technical stakeholders to be given clear objectives by planners
- Expert Opinion – planners provide guidance, consultancy, expert opinions and research
- Conflict – the meeting should be trained in conflict resolution and be in-tune with the needs and wants of all the stakeholders, especially the members of the public affected by the proposed development(s) (Northern Ireland 2006).

3. INTERACTIVE 3D SIMULATION TECHNOLOGY

VR-Design Studio is an example of the latest development in Interactive 3D Simulation and Modeling software technology from Japanese company FORUM8 (Smyth L. 2010).

The company has two development aims for VR-Design Studio: The first being to enable the user to reproduce all aspects of the real world within the software's interactive 3D space. The second is to enable the user to import data from 3rd party industry standard software applications and thereby add significant value to their projects.

VR-Design Studio is a modern solution for urban and transport planning and design projects, either applied on its own or coupled with third-party 3D design / engineering data and /or micro-simulation applications.

The software is also used extensively to plan for and visualize emergency scenarios within roads, buildings and tunnels either involving vehicles or pedestrians or indeed both.

Due to the high visual quality of the software and its high level of interactivity, VR-Design Studio powers a number of different Driving Simulators by many of the world's leading vehicle manufacturing companies and research institutions.

Users of VR-Design Studio can dynamically manipulate 3D space, import and edit 2D & 3D CAD data, build and texture block models, automatically build roads, tunnels & bridges, view multiple design alternatives in real-time, control the weather and overall environment, as well as being able to visualize and edit intelligent traffic in ways previously not possible & much more…

There are many software plug-ins available that enable third party products to benefit from VR-Design Studio's unique interactive visualization capabilities. These include industry standard engineering systems such as Allplan, InRoads & Civil3D as well as pedestrian and emergency evacuation simulation systems such as Legion and EXODUS and popular micro-simulation transport systems such as S-Paramics & Vissim.

CAD & GIS data can be imported in a number of industry standard file formats and there is a plug-in that enables LiDAR point cloud data to be imported directly into VR-Design Studio 3D environments.

A software development kit is also available as well as a 3D VR data creation service.

3.1 Interactive 3D Simulation & the Stakeholder Consultation Process

The traditional way to involve the local community in proposed new highway and other related transport developments was to produce a model of the development (often a physical model) and then invite the public to view it while it was displayed in the local town hall or library.

As time moved on and technology developed, these architectural models became digital. However, due to the complex nature of the 3D software, more often than not all the stakeholders could see were large photographic prints showing various views (architect's impressions), views that obviously showed the development is its 'best light'.

With the development of Interactive 3D Simulation & Modeling software (such as VR-Design Studio) it became possible for urban planners to engage with stakeholders in a totally new and interactive way. For the first time the planners could take their engineering drawings and convert them into highly photorealistic interactive 3D models of the proposed new development quickly and easily.

In the case of a proposed new highway development, not only could you now see the proposed new structure, you could actually simulate traffic and run as many different scenarios as you wish to test the feasibility of the design in virtual space (Ito Y. 2010).

This type of process was adopted by a number of Transportation Authorities, including the Contra Costa Transportation Authority in California. One particular project involved testing people's opinion to the proposed development of new overhead gantries and electronic signage on a 10 mile stretch of the I-80 highway.

This project involved the production of an accurate, photo-realistic 3D interactive model of the I-80 corridor travelling Westbound in Contra Costa County to the Bay Bridge, using Forum8's VR-Design Studio software.

An accurate virtual-reality model of the I-80 corridor was produced, including its street furniture, its existing signage, its surrounding infrastructure and the built environment. In addition the 12 new overhead signage gantries were produced and added to the virtual environment along with other infrastructure items as detailed in the engineering consultancy's preliminary design drawings.

Once built Forum8 activated the virtual 3D environment and populated it with appropriate vehicles. Scripts were set up so that users could drive in both directions on the I-80, either as driver or passengers (by means of low cost steering racks) and thereby assess the visual impact of the proposed signs along the highway. Furthermore, the signs included "live" changeable messages that could be programmed by the user of the Forum8 interactive 3D model.

Fig. 1: Testing Proposed Gantries in Various Weather Conditions

This type of interactive 3D simulation and modeling software can be used as a stakeholder consultation tool in a number of ways. Typically it has been used to produce movies that show before and after scenarios, as in the case of Utah DOT and a proposed flyover to relieve the congestion at an important junction.

This project was located just southwest of Brigham City, Utah, and involved the proposed construction of a new free-left-turn flyover designed to alleviate serious congestion by accommodating the eastbound 1100 South (US-91) traffic that wanted to travel south on I-15.

Though the State recognized that this investment would potentially improve the economic vitality of the community, the project team decided that they needed to open proactive dialogue with the community, land developers and other stakeholders, whilst at the same time exploring alternative lower cost options. They therefore decided to utilize the power of 3D digital visualization and simulation software in the form of VR-Design Studio.

Fig. 2: Utah DOT I-15 / 1100 South Congestion Project

However the software can have a much more powerful effect on the consultation process when its full interactive features are made available to the stakeholders.

For example, when you enable stakeholders, such as local politicians and members of the public to actually drive through the proposed new environment and experience for themselves the effect the proposed new highway development would have on the existing landscape and overall environment.

This new means of interactive stakeholder consultation has been used in many cases recently including by Wisconsin DOT to help members of the public understand more about roundabouts and how to deal with them.

Mark Lenters, the President of Ourston Roundabout Engineering, the company commissioned by Wisconsin DOT to manage the project commented; “In the US roundabouts are still rare and so the average driver often cannot understand how to navigate them or indeed understand the benefits to the transport planner. As anyone knows who has travelled in Europe, roundabouts are a common feature of most road networks and are seen as the ideal solution to relieving congestion at intersections, as well as dealing with intersections that have more than 4 entrances / exits.”

Ourston had previously utilized educational videos and pamphlets in attempt to convince the American public that roundabouts are nothing to be afraid of, but neither had been successful.

When Ourston landed the massive project for US41 in Wisconsin, which involved the design of 44 new roundabouts Mark Lenters approached Forum8 and its 3D Visual Interactive Simulation software VR-Design Studio.

Fig. 3: Learning to Drive the Roundabouts in 3D VR Space

VR-Design Studio was able to provide a practical solution whereby the public could drive through the planned roundabouts in 3D virtual space using a USB steering wheel. In this photo-realistic and spatially-accurate environment drivers could understand exactly what their journey to work would be like after these roundabouts were built. In addition the transport planners obtained valuable information regarding the effect these roundabouts would have as they could see them in 3D and in the context of the existing environment.

Mr. Lenters believes that "roadway designers need to take advantage of these new innovative technologies to present the public with the best possible visualization of their proposed projects".

4. THE LATEST DEVELOPMENTS IN INTERACTIVE 3D VR

Although the use of Interactive 3D Simulation & Modeling software like VR-Design Studio provides planners and politicians with an excellent new tool to employ in the stakeholder consultation process, there is still the issue of how do you enable the actual stakeholders to interact with the proposed new environments within the VR space.

As already mentioned the use of photographs and videos on web sites is a useful addition to the process, however if it was possible to enable stakeholders to actually interact with the proposed new development in the VR space and complete questionnaires on-line, wouldn't that improve the whole consultation process enormously.

The way that Forum8 has solved this problem is through the development of VR-Cloud®.

4.1 Cloud Computing

Cloud Computing is set to change the face of Enterprise IT "Cloud Computing is a pay-per-use model for enabling, available, convenient, on-demand network access to a shared pool of configurable computing resources (networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell P. 2009).

4.1.1 4.1.1 Public Cloud

Forum8's chosen utility cloud service is 'The Digital Planet Public Cloud'. Using this service customers are able to access exactly the cloud based capacity they need, when they need it. Servers and Storage can be scaled up and down by the customer via a customized and dedicated web portal. The customers are then billed monthly based on hourly usage of the selected resources. The Digital Planet Public Cloud is an excellent solution, especially for those customers looking for a way to cost effectively manage their own standard environment, with maximum flexibility and scalability.

VR-Cloud® is a cloud-based 3D Visual Interactive Simulation system that allows anybody to access and interact with a Forum8 3D VR environment via the internet – including via Android smart phones. The product is available in three packaged forms – VR-Cloud® Flash Version; Standard and Collaboration.

VR-Cloud® Flash - Users can host Forum8 3D VR environments on their websites using a Flash player and anybody can access and interact with the 3D environment without having to install any additional software. However, due to the Flash environment, it lacks some of the features available within VR-Design Studio.

VR-Cloud® Standard – This uses a special cloud system developed by FORUM8. It is faster than the Flash version and supports more concurrent users.

VR-Cloud® Collaboration – This is based on the same system as VR-Cloud® Standard, but includes user collaboration features such as 3D bulletin boards and annotations. These features allow the users to annotate within the 3D environment using words and shapes, helping users with their presentations and discussions. VR-Cloud (R) in conjunction with VR-Design Studio is a consensus building solution which uses 3D and VR on a cloud server. With only internet access being required, even a 'thin client' would be able to view and interact with the VR space via a web browser.

VR-Cloud® Flash - This version of the product was first known as SaaS and involves running VR-Design Studio on one or more servers with the remote control of the VR space achieved via Adobe Flash. Although somewhat limited in operation this version does expand public access to VR-Design Studio based Interactive 3D environments.

Potential data publication methods:

- Web free access - The data created in VR-Design Studio is open to the public for viewing and for comment and opinion
- Web seminar / show - It is possible to use the presentation and simulation function of VR-Design Studio to explain and demonstrate the 3D data to a large number of web seminar participants
- Cluster Option - By using the cluster option of VR-Design Studio, all users can share the same VR environment (traffic situation, time, the weather, etc.).

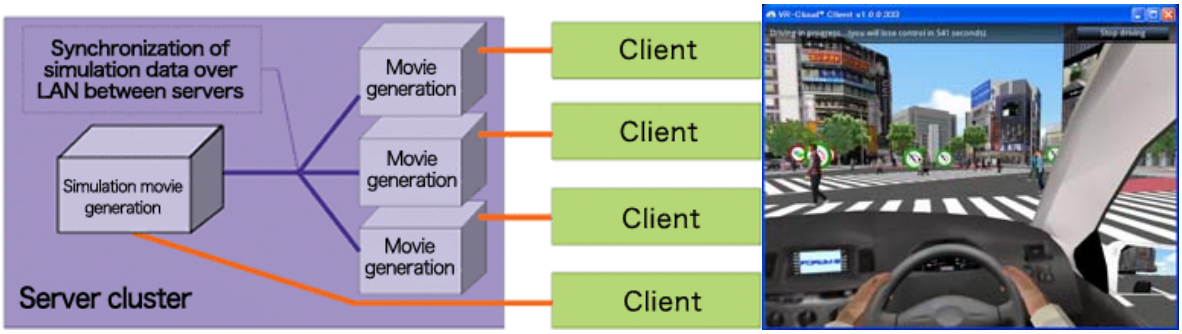

Fig. 4: The VR-Cloud Cluster Operation

As the number of clients that can be supported by one server is restricted, it's possible to combine two or more servers together. It is also possible to synchronize the VR environmental status of the servers by the use of the cluster option.

VR-Cloud(R) Standard - In this version of the software 'original transmission' technology has been implemented "a3S (Anything as a Service)", improving the performance by more than 4 times. Adobe Flash Player has not been used in this newer version. All user interfaces have been developed using OpenGL technology. Many simulation functions of VR-Design Studio are available in this version including manual driving via the keyboard.

As previously mentioned the performance and function of the VR-Cloud(R) Flash Version has been improved within the Standard version. The new transmission technology "a3S" (Anything as a Service) was developed and used to provide a versatile data communication technique between server and client and a management function.

VR-Cloud(R) Collaboration - In addition to the features of the Standard version, the application of advanced VR enabling consensus discussion and feedback on the cloud, such as the 3D bulletin board and annotation functions, etc., are now possible.

- 3D Bulletin Board: as well as the bulletin board and forum on the internet, it's also possible for users to write comments in VR space, create discussions, display items, browse the various discussions and replay other users' comments. The created discussion is displayed on the specified VR space position using a 3D icon. Synchronization between servers is also enabled.

- Annotation: using the simplified editor enables users to produce an annotation, such as a figure or text, etc, within the VR space directly, and then edit it. The created annotation is displayed on a specified position within the VR space and the other users can browse and respond accordingly.

5. CONCLUSION

As discussed in this paper the design and planning of urban and transport infrastructure has undergone a tremendous transformation over the past few years. The adoption by planners of 3D digital representations of proposed new developments, to the exclusion of 2D drawings and photographs, has revolutionized the whole planning process and in particular the way in which stakeholder consultation and consensus building can now take place.

As 3D software technology has developed, so have the requirements of planners, politicians and the general public. The advent of Cloud computing along with interactive 3D simulation and modeling software like VR-Design Studio means that planners can now broadcast their plans on the Cloud to be reviewed and commented on by any stakeholder irrespective of where they are – all they need is web access. This paper highlights these changes and how the latest in interactive 3D Cloud based technology adds a whole new dimension to the stakeholder consultation and consensus building process.

It describes how a new Cloud based product enables stakeholders to not only view the proposed new developments in 3D from their PC or Android, but they can also walk or drive through the 3D space as if they were actually there. In addition, they can also add their comments on-line or answer questionnaires. With the advent of this technology the whole stakeholder consultation process has suddenly moved into the 21st century. It is to be hoped that urban and transport planners around the world embrace it with open arms and thereby help to prevent some of the architectural and planning disasters of the past.

6. ACKNOWLEDGEMENTS

We acknowledge the invaluable contribution of a number of people to this project in particular our colleagues in the development team at FORUM8 and in particular Christophe Soulier and their leader Yoann Pencreach .

7. REFERENCES

Conway G. (2011). *Introduction to Cloud Computing: IVI White Paper*. IVI: Innovation Value Institute, National University of Ireland, Maynooth.

Flyvbjerg, B., Skamris Holm M. K., & Buhl, S. L. (2005). How (in) accurate are demand forecasts in public works projects? Journal of the american planning association, 71 (2), 131-144.

IBMTech Trends Survey. (October, 2010). Published electronically, www-03.ibm.com/press/us/en/pressrelease/32674.wss

Innes J. and Booher D. (2000). Public participation in planning, new strategies for the 21st century, *Working paper 2000-2007*, Institute of Urban and Regional Development, University of California, Berkeley.

Ito Y., Lorentzen T., Hafferty B., Tazawa S. and Goto H. (October 2010), The application of 3D visual interactive drive simulation technology to safer road design, *Presented at the ITS world congress, Busan, South Korea*.

Levy J. M. (2011). *Contemporary Urban Planning*. Boston, Longman.

LUDA project coordination team (2010), Improving the quality of life in large urban distressed areas, *LUDA E-compendium, Handbook E4Annex 1 & Annex,* http://www.ludaproject.net/compendium/pdf/hbe4_annex.pdf

Mell P. and Grance T. (October 2009). Published electronically, *The NIST Definition of Cloud Computing*, Version 15. http://www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf