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ROTATOR Model: A Framework for Building Collaborative Virtual Workspaces

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1. Introduction

The impacts of virtual world technologies are beginning to resonate on a global scale. The recent developments and use of virtual world technologies in the form of virtual workspaces has demonstrated distinct characteristics and outcomes that can be used to plan and gauge levels of development and incorporation within a given business process framework. In supporting business processes, virtual workspaces can provide collaborative and immersive environments to better enable core business processes over a specified period of time. Virtual workspaces are particularly valuable today because they can provide workers with an online collaboration suite with varying levels of functionality that allow groups of workers to communicate in a highly interactive, self-contained collaborative workspace.

Recent uses of virtual workspaces have begun to identify some distinct characteristics and outcomes related to their integration in live working environments. Collectively, these characteristics and outcomes can be articulated through the identification of various functional stages that businesses realize to establish and maintain a distinct level of virtual world collaborative capability. However, to date there is no effective strategic model for evaluating and planning implementation of virtual workspaces in a business setting. To frame a discussion on implementation and planning processes for virtual workspaces the authors are proposing a new systematic model in this paper. This proposed model provides a staged breakdown outlining the characteristics and functionalities businesses can currently expect to encounter when implementing virtual workspaces. This proposed model is referred to herein as the ROTATOR Model.

In a broad sense, the concept of rotation involves having a clear central point that stays fixed, in this case that fixed point is the process of virtual workplace collaborations and like any palindrome it can be viewed from either end having movement from real to virtual with varying degrees of reality and virtualization processes and capabilities enmeshed in between.

This chapter presents the ROTATOR Model as a proposed framework for managing the development and implementation of virtual workspaces. The purpose of the ROTATOR model is to: (1) provide a pragmatic approach for describing various levels of virtual world application used for implementing virtual workspaces; (2) assist in identifying what level of

virtual world implementation is needed to achieve desired business outcomes; and (3) create a practical framework that represents the varying levels of both functionality and capability for establishing and maintaining virtual workspaces. In this chapter the authors propose the ROTATOR model to establish a series of incremental stages that form the foundation for a virtual workspace framework.

As a foundation for this analysis, the concepts, history and use of the terms virtual collaboration and virtual workspaces are also discussed in this article to clarify their import and use in industry. These discussions include a description of the recent evolution of virtual collaborative environments with a focus on the most important online global workforce drivers. The impact of other key technologies with respect to the ROTATOR Model within the virtual workspace arena including cloud computing, semantic web, and web 3-D are also discussed.

2. Defining the collaborative virtual workspace landscape

Over the past few decades, computing sciences has grappled with different approaches to presenting digitally generated content. In recent years the field of virtual reality (VR) has become one of the most intriguing technologies in the area of content presentation. Although most people tend to relate virtual reality to its use in more common entertainment arenas like gaming, the real impacts are in the broader areas of the, "arts, business, communication, design, education, engineering, medicine and many other fields" (Briggs, 1996). Over the last 15 years, John Brigg's prediction has proven to be correct--the biggest impacts of virtual reality technology use are now being felt especially in the business, communication and medical fields (Briggs, 1996). While the virtual world technology is still evolving and developing, it has finally matured to a level where we are routinely implementing it in whole or part in educational and business settings. The issue for businesses seems to be less one of will they implement VR technology in workspaces, but rather more one of how it will be done and in what sequence investment in the requisite technology will be made. This includes considering not just current VR technology but also requires understanding the likely evolution and trajectory of the technology development in the future. Additionally, savvy users should ask themselves now what other technologies are being or might be co-implemented to supplement the virtual environments along the way.

Appropriate planning and scaling of implementation of VR technologies based on knowing your industry goals, your company's historical and future growth patterns, your immediate real needs and your tolerance for risk are all crucial to planning implementation of VR platforms and workspaces. Poor planning for implementation of VR workspaces or any new technology may result in unnecessary risk exposure, cost overruns and simple ineffective use of costly infrastructure that is both unnecessary and/or inefficient. While there are many studies of the implementation of virtual, mixed and augmented reality spaces most or many of those have been focused on education and medical uses (Caudell & Mizell, 1992)(Steuer, 1992) (Barfield & Caudell, 2001) (van Krevelen & Poelman, 2010). Before considering the available studies and their place in the ROTATOR model though it's important to understand exactly what virtual reality is and how it is affected by other technologies like augmented reality. Additionally as cloud computing becomes more widely used in industry we will consider how that storage process along with some other most common storage processes may affect the implementation plan for VR workspaces in a

business setting. Often people mix up virtual reality and augmented reality so let's begin first with clear definitions of those concepts as used in this chapter and for purposes the ROTATOR model of virtual reality and augmented reality implementation.

One expert defines virtual reality as a "three-dimensional, computer generated simulation in which one can navigate around, interact with and be immersed in another environment" (Briggs, 1996). While this definition has been expanded over time to include spaces that are less real in terms of mimicking the real world for business purposes, these business spaces almost always mirror closely in some way a real world setting. Virtual reality, (Milgram & Kishino, 1994) takes a computer-generated world and begins to immerse the user through varying levels of "real" content (Hampshire, Seichter, Grasset, & Billinghurst, 2006) (Haller, Billinghurst, & Thomas, 2007) (Ritsos, Ritsos, & Gougoulis, 2011).

As for augmented reality, various technologies have and continue to be developed that seek to enhance a user's current perception of real world reality in varying degrees. Where virtual reality attempts to replace the entire real world perception with a simulated one the concept of augmented reality takes the user's unmodified or actual reality and begins to infuse computer-generated elements into that real world reality (Alem & Huang, 2011). The computer-generated elements in this environment then in effect 'augment' what the user senses in their real world environment (Kroeker, 2010). So, for example someone working in a design environment and as a support the person might see computer-generated materials that are overlaid by computer projection into the client's landscape environment so the client can see what it would look like if there were palm trees in the west corner of the garden. The most common example of simple augmentation in fact is in TV sports casting where the viewer of an American football game might see lines and graphics depicting the ball placement or movement overlaid on the live TV feed from the game.

As computer graphics and generations become more sophisticated these augmentations are becoming more and more sophisticated as well and are drifting closer to merging with the virtual reality environment in a natural way. For example, as applications become mobile there are new and more challenging options for the use of augmented reality. Some recent examples of mobile applications that augment one's reality include Layar, a 'reality browser' that retrieves point-of-interest data on the basis of GPS, compass, and camera view (Alem & Huang, 2011). GraffittiGeo is another augmented reality application that lets users read and write virtual Twitter-style comments on the walls of restaurants, movies and cafes (Kroeker, 2010). There are additional advanced uses of augmented reality being employed in design and urban renewal work as well; allowing designers to literally sit together at a table and manipulate and overlay computer generated materials and design drawings on say a real world table in front of them using programs like ARUDesigner (Wang, 2009).

Additionally, the concepts of augmentation coincide with real-time presentation that is in semantic context with the real world. So if we had a sliding scale viewpoint of these concepts, we would see the real world reality on one end of the continuum—say to the left with full immersive virtual reality worlds (we have not yet reached the capability to use practically fully immersive virtual reality technologies) on the far other end of the scale—say to the far right. Augmented reality would of course fall on that scale somewhere in between but close to real world reality and relatively far away from the virtual reality side of the scale at the other end. However, as augmentation develops it trends closer and closer to the VR side of the equation. One challenge for planning implementation of VR worlds

and/or augmented reality use then is to better understand the characteristics between the two extremes of 3D virtual reality and real world reality with augmented reality spanning the spectrum in between.

2.1 Virtual verses real environments

Milgram's Reality-Virtuality Continuum defined in 1994 describes a continuum that spans space from the real environment into a pure virtual environment. In between those end points there are spaces of augmented reality that are closer to the real environment and /or augmented virtuality that are closer to the fully virtual environment (Milgram & Kishino, 1994). From the virtual reality perspective an environment is presented to the end user that can either contain totally virtual (computer-generated) content or be somewhere in between thereby containing relative levels of realism or actual existent artefacts not computer generated.

There is a natural merging (see Figure 1) of the two concepts where the purely virtual environment meets the natural or real environment. In essence, virtual reality evolves from systematically-generated environmental content that is presented to the end-user and gradually adds real world content while augmented reality (from an opposing perspective) evolves from the real world and gradually infuses digital content into the end-users presentation.

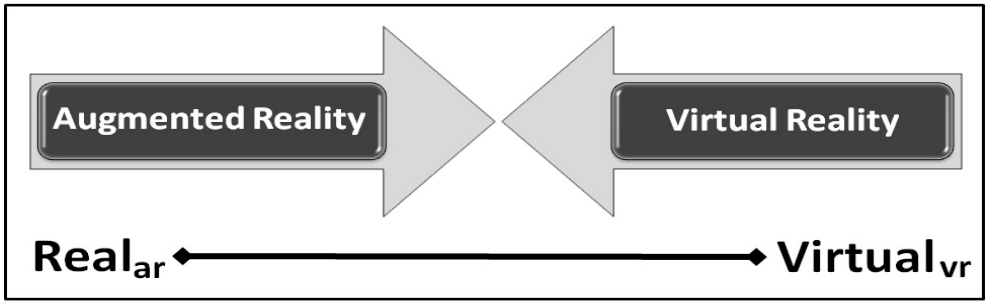

Fig. 1. Converging Realities: Real vs. Virtual

In a real environment we might have a live meeting with all the participants in the room in the same place at the same time to discuss or work on some kind of business problem. Of course this has become more and more impractical as people are geographically farther and farther apart because of workforce globalization and decentralization. To respond to the need to communicate across geographic boundaries we saw the introduction of technologies like Skype, live meetings online, instant message usage or even some kinds of social networking that involved either synchronous or asynchronous communications. The use of these tools has now become ubiquitous in the workplace as businesses find one or more combinations of these communications tools, which can be used to smooth and speed up communication and business processes.

We have rapidly developed beyond even these latest technologies now and are seeing rapidly evolving; newer ones emerge that include virtual reality and augmentation tools. While these new virtual reality and augmentation tools, allow for more depth and

expression in communication thereby facilitating increasingly effective communication processes like training programs and client communications, users are finding that they are often costly to implement and fraught with more risk factors than the earlier technologies like Skype and instant messaging (IM). For example, there is a steeper learning curve for use in VR technologies and there are risks associated with storage of information that may be considered meeting or business communications required by law to be housed and accessible. Additionally there may be significant upfront costs for software development or implementation that businesses don't anticipate. This does not mean that use of VR technologies should be avoided by businesses as effective implementation can have far more advantages then disadvantages when they are properly planned and implemented.

We are now beginning to see more extensive adoption by Universities, hospitals and medical companies as well as industry of these VR environments and augmented reality technologies. However, there seems to be little consideration given to the actual choice and implementation of the technologies with regard to their place on the continuum, their long-term viability and evolution, and the requisite return on investment (ROI) of implementation and use. By placing technologies on the proposed ROTATOR continuum and evaluating the goals and needs of an organization, companies can better plan and more efficiently use limited resources for implementation and adoption of VR and augmented technologies in business applications. Additionally, use of the ROTATOR model should aid in illuminating any potential risks associated with their implementation depending on the company and application. Use of the ROTATOR model can also shed light on possible risks associated with use and maintenance of VR and should help minimize risks based on planned and appropriate implementation policies and procedures.

2.2 Collaborative virtual workspaces: What they are and why we use them

Collaboration itself is a recursive process where two or more co-workers, groups or organizations bring their knowledge and experience together by interacting toward a common goal in the best interests of their customers and to improve their organization's success (Martinez-Moyano, 2006) (Wagner, 2005). A virtual synchronous collaboration involves interaction within a virtual space wherein all colleagues, without respect to time or geographic separation, are able to negotiate, discuss, brainstorm, share knowledge, and generally work together to carry out a given work task. These environments aim to provide technology-based solutions where participants can cooperatively work as a group to construct and share knowledge (Ghaoui, 2003).

Virtual collaborative workspaces provide a common working environment where employees can not only collaborate systematically with corporate computing resources but also communicate with other co-workers and customers. Many of the virtual collaborative environments are 3D virtual environments that allow for multiple users. Recent evolution of virtual collaborative environments has focused heavily on online digital solutions, with these solutions providing for:

1. **Shifts in training and instruction for business and academia**. Business organizations have begun to shift their training practices using distributed teams in blended approaches (Alavi & Gallupe, 2003) (Simeon, 2003) with the use of online and web-based networking contributing to a boost in what is often referred to as e-Learning. The

increase in distance programs at higher educational institutions has also been cause for the development of more group-oriented learning modalities for its remote participants (Harasim, 2000). Educational institutions are moving more agressively into 3-D virtual environments in order to create more social environments and to teach community involvment, creative thinking and social interaction skills (Ritzema & Harris, 2008) (Parsons, Stockdale, Bowles, & Kamble, 2008) (Bainbridge, 2007).

2. **Introduction of social context and peer influence into goal-setting**. Technology guides the movement from a "sense of belonging to a sense of purpose" helping to orchestrate "communities of knowledgeable" among peers (Gerben, 2009). This collaboration of peers is viewed as relevant in discourse, evaluation and community building and follows directly in line with a ripple-effect when circular organizational system values function (Watts, 2007) (Browning, Saetre, Stephens, & Sornes, 2008).
3. **Recognition of ownership and authority for decision-making**. Organizational structures tend to be flattened and decentralized in virtual collaborative settings such that all partners within a virtual team look to be included within the decision-making or else the technology can be perceived negatively (Cascio, August 2000). Ownership and trust need to be based on a shared understanding for effective decision-making to occur. It has also been noted that the flexibility and demands for more employee empowerment can place the owners of these types of collaborative toolsets as the enabler (Peters, 2007)(Fain, Kline, Vukasinovic, & Duhovnik, 2010).
4. **Method of Cost Containment**. Less overhead for companies to use teleworkers and a growing movement towards environmentally green ventures (less travel/gas consumption) has aided in the exponential growth in the use of virtual collaborative spaces. The advantages of this type of collaboration are more often clear offsets to such factors as maintenance and setup costs, trust and cultural differences, and the dynamic nature of virtual teams/organizations (Goel & Prokopec, March 2009) (Avats, 2010).
5. **Knowledge and Creativity Capitalization.** Increased interactions between departments and subunits otherwise unconnected could share information more freely in a virtual environment. A non-linear activity of information sharing across multiple departments , units and subunits sparks new ideas and initatives. This process will provide an heightening of overall knowledge access, management and organizational creativity (Bergiel, Bergiel, & Balsmeier, 2008)(Fain, Kline, Vukasinovic, & Duhovnik, 2010). Regardless of specialization, lateral unit activity increases knowledge and creativity which can optimize assessments with regard to user needs or customer satisfaction. Particularly in new product development (NPD), this capitalization serves to implement successfully innovative ideas going fromembeddedto embodied knowledge (Madhaven & Grover, 1998)(Badrinarayanan, 2008) as well as shifting that creativity to situated knowledge where dispersed teams share (Sole & Edmunson, 2002).

Behind the growth in the use of virtual collaborative environments are drivers such as the global distribution of both human and computing resources. Recent approaches to outsourcing, a distinct focus shift from time to results, and a mobile to global movement are all business forces that are fueling an increased interest in and use of these virtual workspaces.

1. **Approaches to outsourcing**. In this current era of outsourcing, the core ideology centers on "finding core competencies and outsource the rest" (known as the Bill Gates philosophy)(Crossman & Lee-Kelley, 2004)(Vashistha & Vashistha, 2006). Necessary

skills are not found in-house and local networks must tap external resources. Between the need for non-local resources and cost containment issues this causes organizations to go global where unique or specific skills are less costly (Crossman & Lee-Kelley, 2004)(Rowley & Jackson, 2009)(Howells, 1999) (Watkins, 1995).

2. **Focus Shift from Time to Results**. Managers are needing to focus more on results rather than time.This is aligned with themanagement by objective approach when time and competency matters little if results are not adequately evaluated and or determined as satisfactory (Shillabeer, Buss, & Rousseau, 2011). Further, managers need to be results-oriented instead of task or time-oriented (Amigoni & Gurvis, 2009).
3. **Mobile and Global**. As stakeholders and organizations become more mobile so too will the local and global networks. As these networks become more mobile so does the demand for more mobile technologies or those technologies that can eliminate natural and real barriers of geography, time zones and simultaneous communications (anytime/anywhere). These global and mobile teams or networks are viewed as complex for work and management (Ruohomaki, 2010). Once these elements or factors have the proper evaluation of tools and practices implemented the groundwork for accepting and cultivating virtual partnerships in virtual workspaces is laid (Vartiainen & Hyrkkänen, 2010)(Ruohomaki, 2010).

2.3 A virtual working space

Virtual world technologies provide computer-mediated three-dimensional (3D) interactive environments through which end users control one or more avatars (computer-generated proxies) in a persistent-state. Unlike other computer-mediated entertainment or simulation environments, virtual worlds typically retain a strongly temporal character where there is a persistent record of interaction from session to session. With respect to business processes, virtual workspaces utilize virtual world technologies to provide business users with a collaborative and immersion environment designed to better enable core business processes over a specified period of time (Cherbakov, Brunner, Lu, & Smart, 2009).

Virtual workspaces typically provide workers with, "a complete online communication/collaboration package that allows workgroups to share files and applications, use an online whiteboard, and communicate via chat or instant messaging"(Toolbox for IT, 2007). A virtual workspace is a workplace that is not located in any one physical space. That is, virtual workspaces consist of several workplaces that are technologically connected (typically via the Internet) without any regard for specific geographic boundaries. Workers are able to work and communicate interactively with one another in a collaborative environment regardless of their actual geographical location. There are a variety of advantages related tot he use of virtual workspaces for businesses and education.

For example, some advantages of implementing virtual workspaces are:

- Affecting a decrease in unnecessary costs by integrating technology processes, people processes, and online processes.
- Enabling employees to work from anyplace at any time supporting both the needs of the employees and an ever increasing global customer-base.
- Streamlining systems from multiple facets of work into a single unified unit easily accessible by both the consumer and the employee.

- Making it easier for employees because of business traveling, consolidates services, and assists in the communication processes.
- Increasing productivity because employees' are more focused with business related projects with only a single system to interact in.
- Making collaborations with team members easier with a singular virtual workplace.
- Allowing a company to reach more of its employees via meeting workspaces and virtual training sessions (Shafia, Ebrahim, Ahmed, & Taha, 2009)(Hertel, Geister, & Konradt, 2005) (Demster, 2005).

Some challenges to integrating virtual workspaces still exist. For example, some challenges of implementation of virtual workplaces are:

- Failure to leverage the technology that supports virtual workplaces resulting in decrease in productivity.
- Lack of human contact effecting team motivation, trust and productivity.
- Increased sensitivity to communication, interpersonal and cultural factors.
- Increased number and use of various formal and informal communications channels with the constantly-expanding use of social networking sites (Greenlee, 2003) (Powell, Piccoli, & Ives, 2004).

3. The need for a virtual collaborative workspace framework

The exponential growth of the World Wide Web (WWW) over the past two decades has driven both technological innovation and increased senstivity to immediacy in communication and collaborative business functions. As the web has evolved so too has our desire to become more involved with the process of content-sharing and content-creation. Now new web-based semantic technologies are providing smarter, more meaningful content and virtual world technologies are presenting that content with a new level of depth and interactivity (Lesko & Hollingsworth, 2010). Additionally, we do this all faster and with less willingness to wait for the process to evolve. As an interface, today's virtual collaborative technologies provide users with some unique capabilities including:

- Shared Space: the world allows multiple users to participate at once.
- Graphical User Interface: the world depicts space visually.
- Immediacy: interaction takes place in real time.
- Interactivity: the world allows users to alter, develop, build, or submit customized content.
- Persistence: the world's existence continues regardless of whether individual users are logged in.
- Socialization/Community: the world allows and encourages the formation of in-world social groups (Book, 2008).

As a collaborative medium virtual workspace integration within any business requires some basic understanding of four key components. Those four key components are as follows:

1. Business Environment - this component recognizes both the internal and external factors that may impact the process of use of the collaborative medium. Factors such as geographical location, corporate policies and procedures, and collaborations with

external organizations can all influence the effectiveness of the virtual collaborative process (Duncan, 1972) (Mescon, Albert, & Khedouri, 1988).

2. Collaborative Tasks - this component highlights key activities in the collaborative process. Collaboration is a means of producing something joined and new, from the interactions of people or organizations, their knowledge and resources. These interactions are facilitated by relationships—the personal bonds or 'connections'—that are established and maintained by the people and organizations participating in the collaboration. Relationships give collaboration strength, allowing it to form and function effectively. The quality of those relationships is determined by three primary factors: trust, reciprocity and mutuality (Miller & Ahmad, 1981) (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009) (Schmeil & Eppler, 2010).
3. End-Users - this component focuses on modeling user needs, values, skills, perceived challenges and their capabilities in decision making. End users are those who directly interact with the virtual collaborative workspace. Other users or stakeholders may also require consideration including those who are not directly involved in the use but whose inputs and decisions may have influence on the features of use. Other stakeholders may include those involved in the development of the workspace and/or those whose participation and input are needed for the development of the workspace. (Geumacs, 2009) (Koehne, Redmiles, & Fischer, 2011).
4. Encompassing Technologies - this component outlines the collaborative media that are required to support virtual collaborative processes. The media consists of communication tools, shared business intelligence data, and shared virtual workspaces. These media allow the end-users to explore both synchronous and asynchronous collaborative experience across a common solution (Lim & Khalid, 2003) (Robidoux & Andersen, 2011) (Montoya, Massey, & Lockwood, 2011).

The characteristics of each of these components is unique to the level of virtual workspace integration within a given business scenerio. These four components can be used to more clearly understand the technological level of functionality experienced by businesses that integrate collaborative medium virtual workspaces with in their business processes.

4. Proposing a collaborative virtual workspace framework

The ROTATOR model describes seven stages of virtualization/augmentation that do or will characterize virtual workdspaces at varying different stages of development and capability. The model presumes fluidity and that actual business use may swing back and forth between different stages much the way a pendulum glides back and forth depending on the outside forces impacting the particular business need or use at any given time. The focus of the ROTATOR model is to provide businesses with a common framework for analyzing their needs for and processes related to implementing collaborative virtual workspaces. The purpose of the ROTATOR model is to:

- Provide a practical model for describing various levels of virtual verses real presentation end-users might have immersed in any given virtual workspace solution.
- Assist in identifying what level of virtual world/augmentation implementation is needed to achieve the business's described, desired business outcomes.
- Create a practical framework that represents the varying levels of both functionality and capability for planning, establishing and maintaining virtual workspaces.

The ROTATOR model has seven distinct stages that extend from a purely virtual world communicative environment to a real world presentation with no augmentation or virtual world presentation. The operative characterisitcs of each stage of this model are divided into four areas: 1) Business Environment, 2) collaborative tasks, 3) end-users, and 4) other encompassing technologies. These areas are designed and described because they are the ones most likely to affect and represent the business needs, uses, and outcomes available. The ROTATOR framework is specifically designed to be used as a situational, needs analysis based tool for business and other industries to use to guage the best investment of their time and money if they choose to begin using virtual reailty or augmented reality environments. The use of the term ROTATOR is indicative of the fact that business can approach the integration of virtual workspaces from either end of the model. In its broadest sense, the concept of rotation involves having a clear central point that stays fixed and in this context that fixed point is the process of virtual workplace collaborations and like any palindrome it can be approached from either end. In the case of virtual workspace collaborations that movement is between the two extremes of real and virtual environments, with varying degrees of reality and virtualized processes and capabilities enmeshed in between.

ROTATOR MODEL

STAGE		DESCRIPTION
I_{ar}	Reenforcing	Initial infusion of business content into real world presentation for individual user.
II_{ar}	Obverse	Integration of social content and sharing within visual presentation for multiple users.
III_{ar}	Transversal	Limited ability to build and manupulate environment with extensive use of user proxy.
IV	Attainment	Full 3D immersion and representation of business content with sense of personal presence for all collaborators.
III_{vr}	Transactional	Interaction between virtual workspaces and external content with multi-sensory input/output.
II_{vr}	Organization	In-world grouping, collaboration & social interaction.
I_{vr}	Rendering	Visually appealing, immersive, systematically-generated spaces.

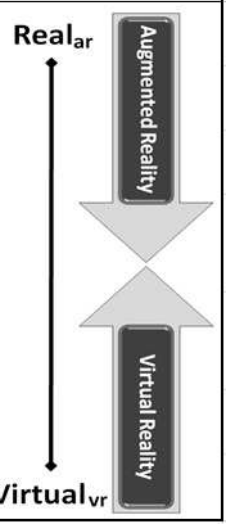

Fig. 2. Stages in the ROTATOR Model

Stage numbering begins at boths ends as well using roman numerals I through IV with Stage IV being at the center point. Beginning from the real end of the spectrum, the first three stages are designated Stage I_{ar}, Stage II_{ar}, and Stage III_{ar}. Beginning from the virtual end of the spectrum, the first three stages are designated Stage I_{vr}, Stage II_{vr}, and Stage III_{vr}. Note the the center has no subscript denoting a blend of both virtual reality and augmented reality at the center.

4.1 Stage I_{ar} – Reinforcing Stage

The Reinforcing Stage (Stage $I_{ar)}$ represents the initial infusion of digital content into a real world end-user presentation. The concept of augmenting reality involves superimposing digital graphics, audio and other sensory enhancements onto realtime environments. An evolving field in an of itself, augmented reality goes beyond the static graphics technology of television where the graphics imposed do not change with the perspective (Tech-Faq, 2011). At the Reinforcing Stage, the augmenting content is presented to a broad user base. For virtual workspaces at this stage the focus is on presenting business content to a broad audience with minimal end-user interaction. The following characteristics are anticipated from virtual workspaces at the Reinforcing Stage (Stage $I_{ar)}$ of the model:

1. *Business Environment* – The environment created by virtual workspaces at Reinforcing Stage of the model is characterized by its ease of use. There is minimal to no persistence and most content would be static or streamed in real-time. Management structured environment. Management may use environment for activity and time tracking. Document share and exposure a focus.
2. *Collaborative Tasks* – Basic collaborative tasks would include centralized distribution of preselected and relatively static content to a broad user base. Collaboration would be limited to central or corporate entity and end-user.
3. *End-users* – At this stage, end-users at looking for basic business content and minimal to no direct collaboration with other end users. As this stage, presentation is to singular end-users. Interaction with mostly non-verbal content such as email, circulars, team/corporate correspondence and documentation, and websites.
4. *Encompassing Technologies* – At this stage, technologies beyond the basic use of televised augmented content would include smart phone applications that combine the use of global positioning data with online data with video streams. Management structured and presented content for individual use.

4.2 Stage II_{ar} – Obverse

The Obverse Stage (Stage II_{ar}) infers a turning toward or facing to the end-user. At this stage, of the model virtual collaborative workspaces look to incorporate end-user input in the end-users presentation. Multiple end-users are expected at this level with an increasing degree of social interaction. The following characteristics are anticipated from virtual workspaces at the Obverse Stage (Stage II_{ar}) of the model:

1. *Business Environment* - The environment created by virtual workspaces at Obverse Stage of the model is characterized by an influx of end-user content and ability of end-user to manipulate pre-defined environment. Auto-environment construction based on systematically negotiated rules is expected.
2. *Collaborative Tasks* – Basic collaborative tasks would include group collaborations, presentation of multiple end-users in a singular presentation and interaction with presented business content are all a focus at this stage. Interactions include virtual meetings and various levels of digital socializing.
3. *End-users* – At this stage, end-users are looking for collaborative media to interact with others. Virtual teaming and the ability to create and manage specific groups and present content specific to that group is a focus here.

4. *Encompassing Technologies* – At this stage, technologies should include incorporation of various virtual meeting and presentation/demo capabilities. Although management structured and presented content is predominating, some end-user space definition and creation is included.

4.3 Stage III_{ar} – Transversal Stage

The Transversal Stage (Stage III_{ar}) involves a deliberate incorporation of business intelligence into presentation. It is at this level that we evaluate virtual working relationships, compare process needs and create virtual business communities. The following characteristics are anticipated from virtual workspaces at the Transversal Stage (Stage III_{ar}) of the model:

1. *Business Environment* - The environment created by virtual workspaces at Transversal Stage of the model is characterized by ability of end-users to interact and construct "intuitively" with the virtual environment. Automated workflow and content presentation are also anticipated.
2. *Collaborative Tasks* – Basic collaborative tasks include ability to team and structure flow if work from within the environment. Transversal Stage also infers activity across multiple virtual workspaces.
3. *End-users* – Although the focus would be on real world presentation of end-users, avatar/digital proxies are available.
4. *Encompassing Technologies* – At this stage, technologies would include automated workflow and content generation. A virtual work environment that allows for both auto-generated and end-user construction.

4.4 Stage IV – Attainment Stage

The Attainment Stage IV describes the intersection of real world spatial imagery ultimately forming a paraverse. From a more visual perspective, the ability to interact with data in-world and then present that data in 3-D is also a virtual workspace building consideration. Up to this point, most of the content has been presented via various 2D common formats found in our daily interactions with browsers, application sharing software, document viewers, videos, etc. To maximize the use of virtual workspace requires moving into the realm of 3D content presentation and interaction.

At this point it is important to incorporate the concepts of interreality physics and how they play a distinct role in the middle stages of this model. Interreality physics takes a systematic viewpoint of Milgrams virtuality continuum (Milgram & Kishino, 1994). An interreality system refers to the coupling of virtual reality systems with their real-world counterparts comprising a real physical pendulum coupled to a pendulum that only exists in virtual reality. According to Gintautas and Hübler (2007) an interreality system has two stable states of motion: a "Dual Reality" state where the motion of the two pendula are uncorrelated and a "Mixed Reality" state where the pendula exhibit stable phase-locked motion which is highly correlated (Gintautas & Hübler, 2007). The following characteristics are anticipated from of virtual workspaces at the Attainment Stage (Stage IV) of the model:

1. *Business Environment* - The environment created by virtual workspaces at Attainment Stage of the model is characterized by the fluidity of the environment and its ability to

intermesh and shift content and presentation between real and virtual. Both synchronous and asynchronous collaborations are available and the virtual workspace is able to support both persistence as well as well as streaming real-time flow of content and environment structure.

2. *Collaborative Tasks* – From a virtual collaborative perspective this tends to substantiate the movement notion of the ROTATOR model and a movement that flows between virtual and real. Automated teaming and workflow events are constructed to meet predetermined business requirements.
3. *End-users* – End-users are fully immersed within the environment with multiple sensory inputs and outputs. End-users are able to select and real or proxy presentation (avatar) within this virtual workspace.
4. *Encompassing Technologies* – At this stage, technologies would maximize the use and scalability of virtual machine and cloud technologies.

4.5 Stage III_{vr} – Transactional Stage

At the Transational State (Stage III_{vr}) of the model, where the user content comes from is a critical component to the business implementation and operation. There is an increasing demand for rich data resources found across the web so access to resouces external to the corporate environment capabilities with the virtual workspace is becoming critical. The following characteristics are anticipated from of virtual workspaces at stage III of the model:

1. *Business Environment* - At this stage the process of housing generated content and information becomes more critical and should be considered by the business attempting to integrate virtual world environmental collaborations at this level. Additionally, businesses may be more concerned than with security of auto-generated materials, risk involved with interactions with client, customers or professional clients for example for doctors or lawyers with professional requirements for protection of communications and data.
2. *Collaborative Tasks* – Building a virtual workspace capable of automating the content collection process and generating unique content for academic or business delivery is another way business manages these environments. An example of this might be similar to the way many online newspapers are being auto-generated today. Team projects or course assignments generate rules for collection and assignment bots perform the tasks of locating and presenting the content for users to manage and disseminate in the appropriate way or form.
3. *End-users* – Integration with team members, especially from outside the corporate infrastructure are expected. Sharing of corporate knowledge-based from within the virtual workspace becomes critical. Extensive use of digital proxy/avatar with infusion of real presentation of end-user.
4. *Encompassing Technologies* – At this stage, technologies focus on auto-generation of virtual workspace content and structure. There is a sense of both time and persistence within the environment.

4.6 Stage II_{vr} – Involvement Stage

The Involvement Stage (Stage II_{vr}) describes the basic collaborative functionalities utilized in virtual online sessions. Text chat, image depictions, including static slide presentations, document viewers, and whiteboards are common collaborative tools incorporated early in

virtual workspace developments. It should be noted here, that these tools are replications of 2-D tools used in real world (RL) applications. Additionally, the content from these tools is housed within the virtual world solution itself and is not generally pulled from external resources or over the Internet. Content for slide presentations and document viewings are often uploaded directly to the virtual world environment for viewing. The following characteristics are anticipated from of virtual workspaces at the Involvement Stage (Stage II_{vr}) of the model:

1. *Business Environment* - The environment created by virtual workspaces at Involvement Stage of the model is characterized by manually management established workflows and auto construction of the virtual workspace. Teaming is controlled at the management level as well. Management ability to track resource time and activity, and provide automated task assignment.
2. *Collaborative Tasks* – Basic collaborative tasks would include: enhanced communication from avatar including use of non-verbal cues such as avatar position, movement and gestures. The Involvement Stage also describes the inclusion of audio and video collaborative features incorporated beyond basic in-world collaboration functionalities. These may include use of voice chat, avatar body gesturing (i.e. pointing, raising hand, laughing, etc.) and use of video streams. As with basic in-world collaborations discussed previously, the content from background audio is housed within the virtual world solution itself and is not generally pulled from external resources. Content from voice chats and basic avatar action and gesturing is logged and maintained internally within the virtual world solution.
3. *End-users* – Although most of the virtual workspace is pre-created for the end-user, there is some capability for workspace definition by the end-users. End-users are involved in formal and informal socializing, virtual meetings, conference calls, and webinar type sessions.
4. *Encompassing Technologies* – At this stage, technologies would include built-in voice/text chat capabilities. Access to social sites and user interaction. Extensive use of digital proxy/avatar within the virtual workspace. Sharing of corporate/private correspondence, document collaboration, and virtual social gatherings are supported.

4.7 Stage I_{vr} – Rendering Stage

The focus at the Rendering Stage (Stage I_{vr}) is on creation of a shared presence and experience with the user. The virtual workspace are designed with specific processes in mind that are temporal or lasting for a finite period of time. The physical laws of the real world are applicable aiding in familiarity and assimilation with spaces and business processessupported. At this beginning stage, businesses will have encorporated visually appealing, immersive and and systematically-generated virtual workspaces. The following characteristics are anticipated from virtual workspaces at the Rendering Stage (Stage I_{vr}) of the model:

1. *Business Environment* - The environment created by virtual workspaces at Rendering Stage of the model is characterized by displays and exhibits, architectural design and modeling, virtual tourism, and marketing. Predefined virtual workspaces. Most content is static and persistent with minimal fluidity to the content of the environment. Management has full control of virtual workspace design.

2. *Collaborative Tasks* – Basic collaborative tasks would include a limited exchange with system data internal to the virtual environments infrastructure. This stage is focused on the management collaborating with individual end-users.
3. *End-users* – Other than general interaction within the virtual environment itself, end-users would have minimal to no object creation or manipulation. There may or may not be an avatar proxy for end-user visualization and use. The emotional realism you might experience with your avatar or digital proxy would be limited to non-existent. It should be noted here that use of a digital proxy or avatar can have a certain degree of anonymity to it that can encourage more personal exploration; where shy users are more likely to participate (Lesko & Pickard, 2011).
4. *Encompassing Technologies* – At this stage, technologies would be limited to manual creation of virtual spaces. Spaces at this level have a degree of visual familiarity with layout and objects within the space for the end-users. When applicable, the liberation from the physical laws of the real world can make possible the creation of innovative and imaginative spaces, activities and experiences.

5. Conclusions

So the ROTATOR model is a proposed staged theoretical model that moves from reality and augmented reality towards collaborative virtualized environments or from purely virtual environments towards reality in four like steps. The model is set up to allow organizations to effectively understand and then evaluate their collaborative virtual workspace goals and objectives in order to create a long term plan for implementation and deployment of those workspaces. This model is just the first step in a larger framework the authors intend to develop based on case study analysis of past and projected implementations to help companies find the proper fit for their needs when using virtual spaces and like technology options for company communication and work.

The ROTATOR model is built on the premise that businesses may be starting from either a fully reality-based setting that does not yet use any virtualized communication mediums and move towards more aggressive forms of virtual medium use by adding augmented spaces to their systems. As the model moves towards the center space-labeled Section IV in the model—businesses can evaluate the delivery of each stage of the virtualized medium before reaching the fuller virtual reality space and/or plan for movement based on uses, needs and goals of the organization.

On the far right of the ROTATOR model a business might begin to see ways to continue it's movement into the more complex arenas of fully immersive virtual reality as these capabilities become more plausible for the organization to manage. It is anticipated that along with the more aggressive stages, nearer to the center Stage IV of the model, there will be greater risks for businesses to consider and a more difficult process of maintaining business content that may increase cost and some exposure for these businesses. However, this should not preclude some businesses from investing in the newest emergent options of virtual reality tools.

The impetus behind the ROTATOR model is to provide a structured first step in assisting businesses in evaluating and planning ahead for these kinds of implementations—be they aggressive use of newer immersion techniques for business collaborations or more stable

use of the mature, foundational collaborative toolsets. Further research will focus incorporated use of the ROTATOR Model and its ability to more clearly articulate the virtual workspace functionals needs and requirements.

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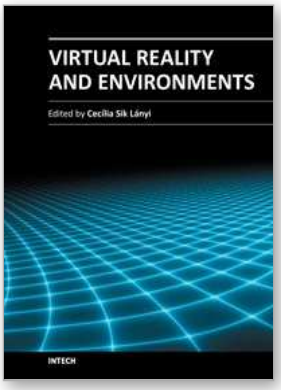

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Virtual Reality is clearly interdisciplinary research. It has, not only Information Technology importance but social, educational, economical importance too. It combines multiple disciplines for the development of virtual reality systems in which the user has the immersive feeling of being in the real world. Virtual reality has several applications in almost all fields of real life. The most typical fields for the application of virtual reality are health-care, engineering and game industry. This book may be a solid basis for the novice and advanced engineers who would like to develop user friendly Virtual Environments for education, rehabilitation and other applications of Virtual Reality. Our book provides a resource for wide variety of people including academicians, designers, developers, educators, engineers, practitioners, researchers, and graduate students.

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