Chapter 3
3D3C Real Virtual Worlds 2010: Definition and Visions for Researchers

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Dr. Grace Augustine: Is the avatar safe?
Jake Sully: Yeah it's safe. You are not gonna believe where I am!
From the movie Avatar (J. 2009)

3.1 Motivation: Preparing for a Long-Term Paradigm Shift

Around 1990, a disruptive technology—the Internet—emerged. New businesses like eBay, Amazon, and Google that embraced the Internet in innovative ways thrived. However, companies like Tower Records, Barnes & Noble, and Rand McNally, who failed to embrace the Internet early, were less fortunate (Tower folded, Barnes & Noble missed the online business that now belongs to Amazon, and Rand McNally failed to capture the online mapping business).

Circa 2008, another disruptive technology—smart phones—emerged. A new generation of mobile phones, led by the iPhone and Android brands, changed the communication and application markets. Apple, the leader of the field, and Motorola, leader in embracing the Android operating system, are winning. Nokia and Microsoft are losing. Thousands of application developers are harnessing the value of the new market of smart phones.

Every 10–20 years we witness a technology shift, comparable in magnitude to that of the Internet or smart phones. Such paradigmatic shifts can break older firms, reshape entire industries, and create enormous value and wealth. Missing such a shift, however, could be detrimental to businesses and IT suppliers alike. Consider the shift from mainframe computers to mini computers (which IBM missed and

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Digital captured), from mini-computers to PCs (which Digital missed, and Compaq captured), and from PCs to the network computer (which Microsoft missed and Google captured).

I maintain that Real Virtual Worlds will—in due course—offer such a paradigm shift. What we see now (2010), with Second Life, World of Warcraft (WOW), Club Penguin, and more than 100 other worlds, is just a beginning. In comparison to the Internet age, we are at the "Gopher" stage (Gopher was a pre-browser method to view hyperlinked materials).

I use the adjective "Real" to distance virtual worlds from the gaming worlds. "Real" hints at a much far-reaching potential. While clearly, today virtual worlds are used mostly for games and fun—Real Virtual Worlds (which I will formally define later) have the potential to alter our lives. (Note: for the sake of brevity, I will use virtual worlds or simply worlds.)

The timing of full impact of virtual worlds in not yet set. We observed a spike of interest in 2006–2007. 2008–2009 were more social in nature, with Facebook-like technologies catching our attention. The years 2009–2010 (now) seem to be more mobile in nature with smart phone technologies at the center of the public's focus. The release of the movie Avatar in 3D, the growth of 3D TVs, and the emergence of phone-based augmented reality seem to re-push the field of virtual reality. In any event, time is ripe for research to explore the field and suggest policies, technologies, and applications that can make use of the field and/or advance it.

3.2 Background: Second Life as a Case of a Real Virtual World

The young field of Real Virtual Worlds has its roots in two fields: virtual reality (Burdea and Coiffet 2003), for a review of augmented reality see Bimber and R. (2005) and for gaming worlds see Bartle (2004), Alexander (2003, 2005), and Taylor (2006). Other related fields are also affecting the virtual worlds ranging from economy (e.g., of virtual goods), sociology (nature of communities), and law (copyrights and ownership) to biology (new brain-based human–computer interfaces), computer science (performance, reliability, and scalability), and mathematics (algorithms for 3D rendering and animation).

Second Life (SL) is the first World that fully demonstrates the potential of Real Virtual Worlds. During the last 3 years, I have explored this world, visited places, made friends, reviewed technologies, and used it as a research ground. In short, I confess to being biased by my own experience [see, e.g.,Sivan (2008a)].

SL was conceived in 1999 by Linden Lab as an implementation of the Metaverse[1] (this term is often used in professional circles to denote Real Virtual Worlds). Any user may install the software and create a three-dimensional character for

[1] The term "Metaverse" first appeared in 1992 in a science-fiction book named Snow Crash by Neal Stephenson. The Metaverse was described as a three-dimensional world in which human characters spent their time, played, worked, and lived. In Stephenson's words, "the Metaverse [is] my invention, which I came up with when I decided that existing words (such as 'virtual reality') were simply too awkward to use" (Wikipedia 2007).

him/herself (aka "avatar"), adjusting features such as the shape of his body, skin, hair, and lips. (Note: "he" and "she" may both be used hereafter to denote both genders,) He may select to wear a hat, shirt, or skirt, and add rings, earrings or nose rings. After the body is constructed, the user may purchase a car, a plane or a yacht; he may build a room, an apartment, or a castle. He can meet people, robots, or dragons.

At first glance, many view SL as a game—a direct descendant of games such as Sims, WOW, and Doom. Veteran users will probably recall the worlds of Dungeons & Dragons and other paper-based fantasy games. Indeed, many of the action patterns and techniques of SL resemble these games. This is a good starting point. But the rest is far more profound and meaningful, exciting, and scary. The interaction of avatars, the believability of what you see, and the fact that everything is connected with real money all create a new level of experience, a kind of parallel world, a different world—a Real Virtual World. This is a world where anyone can choose his/her own life-style and actions: from a life of hedonistic leisure and entertainment to a life of lucrative work and creativity (in the real world).

Pepe is one of these avatars. She is a dancer at a nightclub. Her figure, her blonde hair, and her fluent speech (with a Spanish accent) make her very popular among visitors to the club where she works. Pepe hired a fashion consultant, who matched her looks and clothing to her career. Thus, her blonde hair was matched with her police shirt, which bears the letters "SLPD"—an internal joke that means Second Life Police Department.

Pepe is in the center of a human, social, and commercial enterprise, which also includes dancers of both sexes, DJs, club owners (who rent out private rooms to visitors), landowners, landscape designers, building contractors, architects, lighting experts, and musicians (Fig. 3.1).

What, in fact, makes SL a Real Virtual World? Let's consider Pepe's story (as an example):

- Pepe and the club she works in have a three-dimensional representation (**3D**). The users can zoom in and out, pan, and explore everything from the texture of her shirt to the coil in the lamp that is located 10 m above her. While Pepe moves herself, other users can roam around the room.
- Pepe can dance on the stage, because she belongs to a group of dancers of the club (**community**). Groups allow several users to act together in the Real Virtual Worlds, to buy land, to work, to get certain permissions, etc. While at work she uses the group of the club; when she shops at the Canimal fashion store, she uses the Canimal group ; while she studies English, she is part of a small group called English as a Second Language (ESL) for Spanish-speaking people.
- Pepe is both a creator and a beneficiary of other creations (**creation**). She creates by mixing and matching her outfit, the color of her skin and her hair, her jewelry, and her shoes–all of which were created by others. She can also buy furniture for her small county house and arrange it. With the right permissions, she can also create a garden for herself. With adequate programming skills, she can program the flowers in her garden to grow, or just buy the growing flowers from someone who has those skills (Table 3.1).

Fig. 3.1 Pepe—policewoman or dancer? (sample avatar)

Table 3.1 Different worlds viewed by the 3D3C Prism

	Sample worlds	3D	Community	Creation	Commerce
1.	ActiveWorlds	***	*	***	(per case)
2.	Club Penguin	*	*	*	*
3.	Google Earth	***	*?	*** (SketchUp)	?
4.	IMVU	***	***	**	***
5.	Second Life	***	*****	*****	*****
6.	Sony Home	*****	**?	**?	**?
7.	WOW	*****	***	*	*

Key: * = very low ** = Low *** = moderate **** = high ***** = very high

- All of her actions for work, fun, learning, or relations rely upon an economy that connects the virtual world to the real world (**commerce**). She can make money by working at the club, she can pay for her house, she can make money by selling flowers, and she can pay her English teacher.

The claim of this example is two staged: first, the combination of 3D, and 3C (community, creation, and commerce) defines a new medium. Second, as Real Virtual Worlds become more 3D and more 3C, we will fulfill the immense potential of the medium.

3.3 A Formal Definition: 3D + Community, Creation, and Commerce

Let's formally define Real Virtual Worlds as an aggregate of four factors: a **3D World**, **community**, **creation** and **commerce**. [For a longer review of 3D3C see Sivan (2008b)].

3D world: This is a dynamic world where viewers see objects like avatars, houses, and cars. The world has land, a sky, a sun (or maybe more than one sun), wind, gravity, water, and fire. Avatars move around freely (e.g., in SL you may fly up to a height of 200 m). The user can further examine the world from different points of view (roaming camera).

Community: Man is a social animal. Unfortunately, during the past century we gradually distanced ourselves from socializing—mainly through the advent of television. We sat alone in front of the screen, watching passively and without much interaction. We did not react, we didn't create and we couldn't see how others felt or reacted. The web actually enhanced this feeling of "isolation" (in a manner of speaking). Then emails emerged, followed by the "chat," the cellular phone, SMS,—and multiplayer worlds. So we are now actually returning to the community, to friends to people. Amazon began this trend by allowing readers to review and recommend books. Later, companies like YouTube allowed users to upload video contents. Moreover, of course, we have blogs (which include comments), social sites such as Facebook and MySpace—the ultimate in this genre where anyone may create a personal site to communicate with his friends. (Please note—all avatars in SL represent real users. There are no computerized avatars as in regular computer games such as WOW.)

Creation: Second Life's greatest invention and technological achievement was in giving users the capability to develop their own "things" (or in SL jargon: objects). In fact, the entire contents of SL (barring a few sample and demo objects) were created by users. Constructing objects may be done at several levels—first, by moving pre-constructed objects from one place to another (i.e., rearranging furniture in a home, or setting up a nightclub). Second, an object (i.e., a house) may be assembled from basic components such as walls and ceilings, followed by "painting" them with various textures. These basic components, called primitives, allow the construction of complex objects at a very high level of precision (see the SL example of Suzzane Vega's guitar, which is made out of more than a hundred primitives). Linden hit the nail on the head when they built a programming language (LSL—Linden Script Language) into the world. LSL allows users with programming abilities to endow their objects with behavioral attributes. As a result, we can see fish swimming in schools, a game of golf, pistols that shoot, and even Pepe's dancing. Largely, these are expansions of the capabilities found in worlds such as Sims, combined with industrial CAD software packages.

Commerce: Linden has created a new currency—the Linden dollar (or L$, for short). There is a defined exchange rate between the Linden dollar and the US dollar—in 2008 one US$ was worth about L$265. The entire economics of the SL world is based on this currency. The credibility of this economy is built on two levels—one conceptual and the other technical. At the conceptual level, Linden established and operates its own exchange. Within it, Linden guarantees the exchanging of L$ to US$ immediately and at any time. For instance, if Pepe earned L$2,600 from tips, she could access the Linden web site and exchange them for about US$10 which would be immediately transferred to her real account. Going the other way, if Pepe needed L$6,000 for a new hairdo, she could immediately buy them for about US$20. At the technical level, Linden has currency and commerce integrated into the game. For example, every object can have purchase ability and price.

Ultimately Real Virtual Worlds stem from the **integration** of the **3D**, **community**, **creation** and **commerce**. Second Life reveals the emergence of this integration. In SL you'll find a price for objects, permissions (i.e., an object may be restricted from being sold), and ownerships. The commerce is structured into the world itself. For example, let us assume that we enjoyed Pepe's dancing (and her Spanish accent) and wish to tip her. We point to her and transfer money to her by clicking a button. If Pepe wants to buy a new blouse, she goes to the shop, points to the blouse of her choice, and buys it for L$2,000. The blouse is defined as a unique object in this world, and Pepe will not be able to copy it. The shopkeeper will receive L$500 for the blouse, and the blouse manufacturer will receive L$1,500 (in accordance with a previously defined business agreement between them). At the end of the month, the shopkeeper will pay rent to the landowners, also based on a predetermined agreement.

This integration of a 3D world–organized and managed communities, immediate creation capabilities of objects and services, and a virtual commerce which actually becomes real—is the basic allure of SL in particular and of Real Virtual Worlds in general.

Next, using the 3D3C framework, let's examine typical worlds. These worlds represent a spectrum of worlds; they were selected to highlight various aspects of the 3D3C definition and not because of their impact on the field. [An earlier version of this table was first presented in Metanomics, a virtual broadcast, hosted by Bloomfield in 2007 (Sivan 2007; Metanomics 2011).]

- WOW is the most popular multi-user game with more than 10 million users. WOW has relatively good 3D graphics. Since it is centrally created, the graphics delivery can be optimized. Creation, is relatively limited, (you can select your avatar and dress it, but you cannot change the environment). Real commerce is limited. I noted one star ("*") because while users cannot buy WOW gold for real money in the game, they can buy it on the Internet by paying another player to send them money in-world.
- IMVU is a chat world merged with MySpace-like personal pages (acronym can be read like Instant Message with a View). It does not allow your avatar to walk

around; you move from one scene to another. In many ways it is a limited world compared to WOW or SL. Still, it is 3D (only 3 stars)and has a strong community infrastructure (with groups, group chat, friends, and people who visited my page capacity albeit without permissions) and real money commerce—where you can buy and sell money; to buy and sell IMVU cash, see, for example, Anshex.com (2011).

- Club Penguin, now part of Disney (it was purchased for US$700m in 2007) is a kids' world. It does not have 3D representation, but rather employs a 2D approach. It has no ability to use currency. Club Penguin is included here to demonstrate that you do not have to be a 3D3C real world in order to be successful (Eldon 2007; Disney Corporate 2007).
- Second Life is a prime example of a full 3D3C world. It now has "full" (more than 3) stars in all the factors. Graphically it is less powerful than WOW, although the addition of reflective water and amazing skies in mid 2008 brings it a step closer to four stars. (Note: new Graphical Processor Units emerge from the likes of Nvidia and AMD-ATI, coupled with better 3D algorithms. We should expect the graphics to improve continuously. The number of stars should be adjusted to the relative market conditions.)
- ActiveWorlds is a platform for worlds and not a specific world. ActiveWorlds is used to build worlds, so the "rule" of each world is determined by its owner. It supports 3D and some of the features needed for community, creation, and commerce. It is really for the world owner to make a decision as to how to use the various factors in their world. ActiveWorlds is active since 1998 in this field (Active Worlds 2008).
- Sony Home for the Sony PlayStation 3 is a relatively new addition to the realm of virtual worlds. I am unsure about the ability to program objects and commerce. Note that if Sony Home turns into merely an arena for playing games (as some of the previews suggest) it will lose its ability to "play" in the area of virtual worlds.
- Google Earth is here because—in theory—it can become a virtual world or an infrastructure to build and run worlds. With SketchUp, Google's simple and free editing tool, one could easily create 3D objects. We are still missing structured community and commerce, but third party tools as well as Google tools like "Open Social" (for community) or Checkout (for commerce) may close that gap. (Google's latest foray into the field was Lively—an avatar-based 3D chat system that looked like IMVU. Lively was subsequently discontinued.)

In this initial and cursory analysis, I have outlined some of the intended qualities of the 3D3C factors. The factors are designed to be comparative (i.e., how the 3D of WOW is compared to the one of IMVU), *relative* (i.e., IMVU did not have many social features when it started; as it progressed it gained more stars), and explorative (i.e., Google SketchUp is an option for creation).

This analysis also reveals some of the limits of the 3D3C factors, as they do not fully uncover the intricate nature of the field. We did not cover physics (the inherent ability of the world to support physics which, e.g., means that objects can fall to the floor—yes for SL, no for ActiveWorlds); voice communication/interface; and so much more. The 3D3C definition is designed to be a top-level starting point.

3.4 What Will Drive Virtual Worlds into the Future?

From the economical perspective, Real Virtual Worlds enjoy both a growing *supply* and a growing *demand*. The supply side stems from a more affordable and powerful technology. New advances in graphics processor units (GPUs) coupled with new interfaces like the Nintendo Wii, 3D engines like Havok Physics, and abundant high bandwidth, are bringing Real Virtual Worlds closer to the personal and enterprise user. At the same time, the demand is growing from both the young and the old. On one hand, we have younger, messenger-crazed users, who crave the interaction, and on the other hand—perhaps more importantly—we have the older folks who have more time, more money, and a need to express themselves.

The supply and demand forces will bring Real Virtual Worlds to the masses in terms of acceptance, cost, and value. At that point, the combination of 3D, community, creation and commerce will continue to boost the innovation within the industry. The immersion of the 3D world, the engagement of the community, the ability to express and innovate that stems from creation, and—most critically—the ability to gain from it economically (read: with real money) is what will propel Real Virtual Worlds ahead (Fig. 3.2).

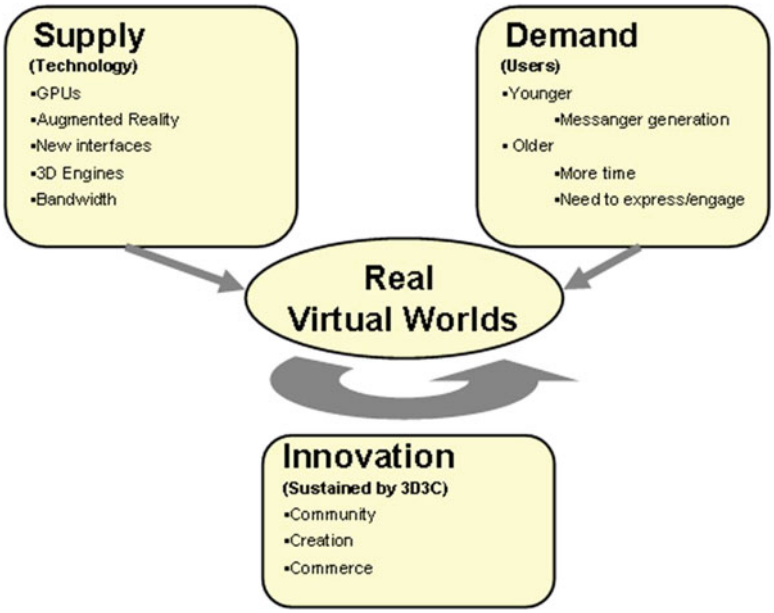

Fig. 3.2 Supply, demand, and sustained innovation for Real Virtual Worlds

With technology acceptance and advancement, we will enjoy a constant stream of innovations, creations, services, and products. Things like art, medicine, learning, and shopping will be enhanced by virtual galleries, home treatment clinics, learning kiosks, and family-owned stores.

However, there is one major roadblock to this vision: lack of standards. On the Internet, we were able to overcome this block with a well-oiled open system of standards that facilitates innovation and growth. We were unable to overcome this block in the gaming world where major game companies have their own systems. There are several open-source projects aimed at creating open virtual worlds (OpenSim, Croquet, Sun's virtual worlds). Linden, the maker of Second Life, is working with IBM and other firms to allow open worlds. I am personally involved with a Philips-led project to develop MPEG-V, a more formal approach to a standard for connecting real and virtual worlds (Gelissen 2008).

3.5 Visions

Let's examine a few examples and study the 3D3C factors in action, and highlight some of the IT dimensions of the scenario.

Virtual Physical Therapy: John is a 75 year old male who had a stroke 5 years ago. Since then, he has been using his virtual home as a starting point for rehabilitation, fun, creation, and productive work. Initially, John was devastated. He could barely move his left arm and left leg. After 2 weeks of intense physical therapy, he continued his therapeutic regime at home. Using remote sensors and actuators (much like the Wii remote, and the Wii fit system), he was able to exercise his body. When he started visiting a local virtual club, treatment became fun—exercise turned into dancing to Trance music.

What We Need: To fulfill this vision we will need Nintendo Wii like sensors and actuators. We will also need better interfaces that do not involve a keyboard or a mouse. Something more direct that will be able to capture our input directly from our minds would greatly enhance the experience. We will also need recognition of the value embodied within the virtual healthcare community. A key factor is allowing people to think about virtual worlds as a place to be and not as a game.

Virtual Schools: A few months later, John met Jane. Together they developed the J&J English school. John and Jane designed an immersive virtual school for English language. Each object in the school can "talk" in English. They designed various student-student and teacher-student experiences. They have three regular classrooms where students can sit and watch their teacher on a video screen. They also have a special testing room for SAT (they had to buy that room). Each student who takes the SAT in the J&J school has to pay them (John in turn pays back the College Board, the owners of SAT). With full tuition, students get their own room that includes various items they have learned about. These rooms are often a place for conversation between students and alums of the school. In fact, there are more than 20 different J&J English schools. They all act the same, but are managed by different schoolmasters from all over the world. John has learned that hiring teachers is a key factor. Each teacher turns the school into his or her own. John and Jane focus on the infrastructure; the teachers focus on the actual teaching. They share the revenues from the students.

What We Need: Today learning is one of the top industries in Second Life. For the first time, educational institutions of all sizes can enjoy a common place of learning and allow synchronized learning. I have personally used SL to teach Executive MBA courses at Bar-Ilan University in Tel Aviv. Students use virtual worlds as a simulation to start small businesses, to work with technology developers and to feel almost real. Note that the commerce factor is critical for the J&J school system. The ability to run a franchise, where the firm maintains quality and standards and the local managers own the customers, is still missing. Classic ERP firms like SAP and Oracle will need to fill this gap.

Virtual Concerts: Once every 2–3 months John and Jane enjoy virtual concerts. In February, Live Nation Vcon hosted Madonna. John had to wait in line, for 2 h to get the ticket. Of course "wait" has a different meaning—"experience" is more like it. The line included meeting old friends and viewing clips of previous concerts. The unique thing about Live Nation Vcons is the fact that you get to experience the concerts with your friends. In essence, a Vcon allows up to a 100 people to "assemble" in the same place. The concert lasts 8 h. It starts with a couple of movies, a few earlier shows, and a simple get-together party. The concert itself is streamed to various virtual halls. Each visitor gets to pick one song (as part of the ticket). Together John and Jane have already accumulated 24 Madonna songs. John has traded old Bee Gees songs for some of Madonna's old songs that he missed. His collection is proudly exhibited in his summer home in Vir Italy, Toscana Island.

What We Need: This vision seems like the next step for Apple iTunes to take. We are still missing many technologies here. First the ability to have more than 20 people in one place today is a major problem in all worlds. This critical problem is a very difficult one because each attending avatar means that its data need to be streamed to all the other avatars. This causes exponential growth in bandwidth and, with growing attendance, becomes a major computation challenge. While there are some theoretical techniques to solve this (like turning crowds into flat backgrounds and calculating their look and feel once in the server) these are all theoretical solutions. Another set of challenges stem from linking mirror worlds (like virtual Italy) and fantasy worlds (the place with the school resides). Both Google and Microsoft's efforts in this direction are quite impressive.

Virtual Shopping: Dan, John's older son, is about to turn 50. It is a good time to buy him a present. John is eager to buy his son something special: a car. John teleports to the nearest Toyota dealership (nearest to his son's residence). While all showrooms are similar, John wants to connect early with the service provider that will maintain the car he intends to buy for Dan. Using the virtual showroom, he builds an initial version of the car. He calls it "Dan's Eagle." He selects the various options. The initial design of "Dan's Eagle" is almost done. John can now view the virtual car. It is delivered to him seconds later. John invites Dan for a preview. Dan is excited; he reviews the design and modifies it a bit. The price changes according to the features he selects. When all is done, Dan approves the order. John and Dan both get a virtual copy of the car. The actual car will take a week to ship.

What we need: The ability to produce a joint design in 3D is already in place. An Israeli company allows you to post your picture on the web and design your own Yogurt cup. However, such efforts are sporadic and tend to be marketing-oriented. We need a full scalable system that involves many aspects—mostly human ones—to allow for this joint car design scenario.

Virtual Races: The monthly trip is about to start. John is ready. He has the maps set up, the goals, and the targets. John and Dan are ready for the game. Vrace, is a monthly competition that connects Dan (in the real world), and John (in his virtual home). Together they are given quests. They will win if they combine real and virtual know-how. Dan's Eagle is equipped with four cameras—one for each side. At any given moments, John can see exactly where Dan is. Using his GPS, John can tell Dan where to go. Jane helps with cracking the clues. She is using 3Dpedia.

What We Need: Vrace is a totally new product. A participatory sport that allows people to merge real and virtual worlds. This is not only a game but also an entire culture that will connect people of all ages. Today, most heavy users of Second Life are in for fun. They build, dance, and tour because it pleases them—this is a "lifestyle" trend that could use Real Virtual Worlds.

Conclusion: You will notice that many of the scenes presented here can be done today. In fact, some companies are already doing it. The challenge lies in the cost of integration. To accomplish the above scenes today, one would need heavy investments in infrastructure, servers, clients, user training, partner training, etc., all of which will probably make the effort a theoretical experiment.

However, assuming the infrastructure is already there: the 3D world, the community tools, the creation ability, and the built-in commerce—the cost vs. value equation starts to make sense. The key is the integration of 3D, community, creation and commerce—all under the same system. When we accomplish this standard level of integration, opening up businesses, setting up services, and enjoying the virtual worlds will be as easy as setting up a blog site today.

3.6 Conclusion for Research

Lastly, I want to point out five key challenges for research. These challenges, which I consider critical to the future of virtual worlds, stem from a preliminary analysis of the Metaverse (Metaverse 2010) ITEA2 EU project.

ITEA2 is an industry-driven, pre-competitive R&D program that brings together partners from industry, universities, and research institutes in strategic projects. The Metaverse1 project was designed to provide "a standardized global framework enabling the interoperability between Virtual worlds (as for example Second Life, WOW, IMVU, ActiveWorlds, Google Earth and many others) and the Real world (sensors, actuators, vision and rendering, social and welfare systems, banking, insurance, travel, real estate, and many others)." (Note: some of the outputs of this project were included in the MPEG-V standard mentioned earlier in the chapter.)

The 3-year project, which started in 2009, created the opportunity to look at virtual worlds from multiple perspectives. The following five research challenges, present my personal take. I believe these five challenges are critical and thus should be tackled by academic and industrial research. By sharing these challenges, I hope to instigate further research:

1. **The interface challenge**: One of the key innovations in personal computers was the invention of the mouse. Together with windows (be it the Xerox, X, Apple, or Microsoft versions), the mouse was the hardware side of the interface. Action like click, double click, and drag (and technically mouseup, mousedown, etc. on the software level) allowed new modes of operation. In a more modern example, iPhone commercialized the touch interface with actions like zoon, pinch, touch, touch, and zoom. Virtual worlds lack a standard method (with or without a device). Each world has a somewhat different combination of commands. Mastering these commands is often difficult and causes a relative long learning curve before the user feels the value. Even worse, moving from one world to another calls for yet another set of commands. The key question is what would be the combination of hardware and software needed for virtual worlds.
2. **The money challenge**: In 2007, I had an opportunity to discuss "money" in virtual worlds in an open-source meeting that took place in a virtual worlds conference. The participates were mostly technical people who develop various parts of the OpenSim project. When I raised the issue of money, I was answered in the following way: "money is a layer that should be added after the system is done." We already had this approach when the Internet was conceived. The combination of pure engineering focus, which does not value commerce, and the somewhat "protective" system of banking that enjoys hefty commissions did not allow—till this day—for a universal and common payment system. Starting a commence Internet site is still complicated. As noted in the 3D3C definition, I believe the full value of virtual worlds will be materialized, if it include commerce. We can clearly see the value of such built-in commerce in the relatively small economy of Second Life, where commerce in the form of products and services both within the virtual worlds and in the real worlds flourishes. Many people who use virtual worlds for educational goals (e.g., for teaching) artistic goals (making movies aka machinima), and therapeutic goals (e.g., for trauma treatments) use subcontractors in the virtual worlds. A true global 24 economy is occurring within Second Life. The money challenge also has to do with taxing issues that may differ from country to country as well as some checks and balances to deal with money laundry and other illegal activities. The key question is: what factors do we need to include and where to enable global the C in the 3D3C virtual world?
3. **The dependency challenge**: One of the key benefits of the Internet is the ability to trust it. As a user, I can go to both Google search and Bing search. I can get my news from CNN or Wall Street Journal; I can use email using outlook or using Gmail. We have choices. Furthermore, we can often "save" our work locally and move it from one supplier to another. We do not have that in virtual worlds. A virtual product or a service is often locked within one world. Often such worlds

simply end (see Google Lively, There.com, or Metaplace). Second Life's content creators are often lamenting the inability to move items from the official Second Life grid to the more open Open-Sim based grids. The key question is how can such a trusted, robust, Internet-like system can be develop that will sustain the 3D3C factors. (Note: there are several examples to closed trusted system including Microsoft XBox, WOW, and—of course—the more generic Apple's iPhone ecosystem. Weather the "ultimate" universal virtual world will be more like the Internet or more like Apple iPhone is yet to be seen.)

4. **The identity challenge**: In an earlier work (Sivan 2011), I have lumped together a set of related issues under the term identity. These issues include, for example, privacy, security, authentication, anonymity, adult content, rights, and copyrights. Examples includes how do we balance anonymity, a key value of virtual worlds, with the need to prevent grieving; how do we protect dressmakers from the theft of their textures; how do we allow software code (which is an integral of content) to run without taking too much energies from a particular server; what happens to an avatar when its own die. The gist of this challenge relates to the yet-to-be-solved interaction between these issues. The key question here is to take our real world—less than perfect—identity structures and bring them to the virtual world, then enhance them to match some of the new challenges. Note that such questions are not technical in nature; it has to do with what we value and what do we want to enable. Once we define that, the technical needed components could be developed.
5. **The many avatars challenge**: One of the key technical challenges to virtual worlds can be seen in Second Life "40-avatar-per-island" limit. Say you are a firm that organizes an event; once about 40 people have arrived to your virtual island, it is practically blocked and no other avatars can go in it. For example, a DJ organized a party and could *NOT* get into his own party because there were too many avatars already in his island. The key question here is how to allow for more people to participate in the same event. Contrast this with a web site that allows thousands of people to participate. You will note that in a real world we also have a limit to the number of people we can interact with at the same time, be it a party. In a large stadium, you interact with just a small percentage of the thousands of people you see. The main challenge is to develop the correct mental framework and supporting technology to solve this challenge.

Researchers like us, who tackle such challenges and other ones, are uniquely positioned to shape the future of virtual worlds. Good designs that include long-term considerations—both technical and social—will allow virtual worlds to better our lives. I look forward to much needed research work in this area.

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Biography

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