Research Investigating Generation-Beyond-Next Computer Game Culture and Technology:

A Collaborative Research Partnership between the UCI Game Culture and Technology Laboratory and the Daegu Global R&D Collaboration Center

Progress Report

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Introduction

The report documents progress and results obtained from our research study that is investigating generation-beyond-next computer game culture and technology during the period of 1 January 2007 through 30 June 2007. This study is in support of a collaborative research partnership between the UCI Game Culture and Technology Laboratory and the Daegu Global R&D Collaboration Center, in Daegu, Korea. The initial scope and research areas for study was agreed to by both partners in December 2006, and that served as the basis for effort initiated during this project reporting period.

The process of completing all negotiations related to this study were completed at the end of March 2007. Later during Spring 2007, there were additional changes in the research scope and activities that were to be part of the study. Specifically, the research study agreement as of the end of March 2007 included a set of activities and corresponding budget line items that were focused on the organization and presentation of a series of multiple research workshops to be held each year during the 2007-2009 period. Early project effort during this reporting period focused on organizing these workshops. Thus, some of the results for this reporting period were produced in anticipation of these workshops. These will be identified later. However, as a result of research project renegotiation during Spring 2007, the proposed workshops were dropped from the study, and two courses were substituted in their place, and the previous budget for the workshops was reallocated to support production and delivery of these courses. These courses will be offered during the 2007-2008 project year (during the period from July 2007 through June 2008).

The first course will focus on the Computer Game Industry in the United States, which will be completed by the end of December 2007. Preparation of this first course in now in progress, and it will begin soon subject to a mutually agreed scheduled that will be presented separately. The second course will focus on Research Topics in Computer Game Culture and Technology and this course will start in early 2008 and be completed before the end of June 2008. Preparation and schedule for this course will

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be completed during the Summer/Fall 2007. Both courses will be taught over the Internet using both broadband audio-visual technologies and and also Web-based delivery of related course materials (e.g., course lecture notes). This will allow access of the course lectures and lecture materials over the Internet to our project partners at the Daegu Global R&D Collaboration Center.

With this project background in mind, we now turn to identify and describe the materials that are included in the remainder of this progress report for 1 January 2007 through 30 June 2007.

Project materials and results

There are research project materials and results in each of the following areas: (a) game research workshops; (b) the job requirements for the Project Manager to work at the Daegu Global R&D Colloboration Center; (c) scenarios for future computer games that require or assume multi-core processing capabilities, and (d) a revised project R&D agenda. Beyond this, there is also a report on the budget expenditures during this project reporting period. Each of these is described in turn.

Game Research Workshops

The first set of project materials relate to the initial project workshops that were conceived to support the project. The project workshops were envisioned to focus on bringing together executives from computer game companies in or near UCI in Irvine, CA (or Orange County more broadly) together with game company executives from Daegu affiliated with the Daegu Global R&D Collaboration Center supported by DIP in Daegu. Though these workshops were subsequently dropped from the project, there were two kinds of results that were produced. First, we did collect information that identifies and locates nearly 30 game companies operating within Orange County near Irvine, CA, using each companies Web site to establish where the company is located, or which people to contact at each company. The results are presented in a document identified as *Game Development Studios/Companies operating in Orange County, CA*. Second, we organized an event on the future of

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game culture and technology, including the future of persistent online virtual worlds (which are closely related to Massively Multiplayer Online Games (MMOGs)) under the title of "Web 3.0: The Game Web." It is further described and documented below.

Game Development Studios/Companies operating in Orange County, CA

This list of game companies in Orange County includes game industry leaders like Blizzard Entertainment and The Collective/Foundation 9 Entertainment (the largest independent game development studio in the U.S.).

It also includes game companies in early stage start-up or acquiring large capital investments such as Red 5 Studio (started from former lead developers of World of Warcraft, who has already raised $18M to develop a new MMOG), and Interplay Entertainment (seeking to raise $75M to develop a new MMOG for delivery in 2010).

Other notable game companies include GameSpy/IGN (operate one of the Web's largest fan sites for computer game players in the U.S.) and K2Network (which licenses MMOGs developed in Korea, translates the game from Korean to English, then distributes and offers game play services over the Web to these MMOGs throughout the U.S. and Europe).

This information on game companies operating in Orange County, CA therefore may be of interest to game companies in Daegu. However, no further effort will be directed to updating this list of game companies, since the focus on the game research workshops has been removed and replaced.

Web 3.0: The Game Web Symposium

As suggested above, we sought to create an interesting and thought-provoking workshop that would entice those involved in future-oriented computer game research and development both in the Irvine/Orange County area and with those from Daegu. Though the research workshops were canceled,

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we were nonetheless committed to going forward with this smaller event, which was held on 21 June 2007. The topic of the Web 3.0 is introduced and briefly explained in the document titled, *Notes on the Web 3.0: The Game Web*. This event was broadcast live to the Daegu Global R&D Collaboration Center over a broadband/HD videoconferencing system so that event participants here at UCI (more than 120 people attended) and in Daegu could see and hear one another during this 90 minute event. Organizing and producing this event would also serve to help us here at UCI to explore alternative videoconferencing and live video streaming over the Internet technologies, which are still part of the scope of the research effort. Thus, the results from this workshop in the form of four presentations is identified and included in this report

First, there is a presentation from Michael Guiliana, from the law firm of Knobbe Martens. This is the same law firm that employs Mincheol Kim, the lawyer who represented DIP and Daegu City in its negotiations with UCI regarding this project. Michael's presentation provided some visual examples of the differences between Web 1.0 (the original Web), Web 2.0 (the Web currently in development), and Web 3.0 (initial experiments now being started or researched). It also provides some documentation of the extreme growth in U.S. Patents focused on computer game technology.

Second, there is a presentation by Walt Scacchi (author of this report) that provides an overview of the future of game culture and technology 3-5 years forward (2010-2012) to help understand some of the new research directions and agenda topics that will be central to our research project.

Third, there is a presentation by David Perry, who is a leading figure in the computer game industry in the U.S. Perry had led the development of more than 30 top-selling computer games, including recently, The Matrix Online MMOG, which generated more than $300M in revenue and cost nearly $40M to develop and market. David has recently started two companies that focus on (a) bringing computer games and game culture from the Asian region to the U.S. (in particular, from Korea and China), and (b) to help independent game developers and prospective game investors to get together to

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form viable game production, marketing, and distribution projects. His two companies are called, GameConsultants.com and GameInvestors.com and both can be found on the Web.

Fourth, there is a presentation from Mats Johansson, CEO of EON Reality, which is headquartered in Irvine, CA. EON Reality is involved in research and development of advanced visual content management technologies (both software and hardware), as well as an integrator of emerging research technologies into commercially viable products and solutions. They are perhaps the largest firm in the world focusing on productizing and marketing of virtual reality and augmented reality products to well over 100 corporate and government clients. Their recent annual growth rate year-to-year is at 40%. Through a research partnership now being negotiated with UCI and the UCI GameLab, they seek to establish a new research and development center at UCI that will involve a consortium of companies (e.g., Microsoft, Hewlett-Packard, Christie Digital, Nvidia, and others) who seek to research, develop, and define the new industry standards for advanced 3D visualization technologies, including those for advanced computer games including MMOGs. We at UCI GameLab believe that such an R&D Center will further complement this research project, as well as provide possible additional partners who would be interested in working with the Daegu Global R&D Collaboration Center.

Job Requirements for the Project Manager

This task focus on the identification, interviewing, and recruitment of a Masters or Ph.D. level researcher who could located to work in the Daegu Global R&D Collaboration Center as interim or longer-term (two year) Project Manager. Much time and effort was focused on this task, leading to the selection of a top candidate who have a substantial track record in software research, as well as a history of sustained research collaboration with us here at UCI.

As part of this effort, it was necessary to develop and refine a set of requirements for what such a person qualifications would be, as well as to identify what arrangements and guarantees needed to be in

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place and/or explained to make sure the right person would be selected and invited to go to the Daegu Center. The results of effort are documented in the report, *Requirements for a Project Manager at the Daegu Global R&D Collaboration Center.*

As of June 2007, such a candidate was in place (Dr. John Noll, from Santa Clara University), but it has since become apparent that this person is no longer to be considered as a candidate for the interim or longer-term PM. The effort to again identify, interview, and recruit a new candidate is therefore an activity that will continue into the next project period starting in July 2007. We remain optimistic that the PM position will be filled during Summer or Fall 2007.

Multi-Core Game Technologies and Scenarios

The next area in which we have some initial results is focused on investigating the possible role of emerging multi-core processor technology in the development of online and mobile computer games in the 2010-2012 time frame. Effort in this area is also supported in part by Intel Research Laboratories (Santa Clara, CA) in partnership with Linden Labs (San Francisco, CA), developers of the persistent online virtual world, *Second Life*.

In late 2006, Intel Research publicly announced that it had successfully demonstrated its ability to manufacture an advanced generation microprocessor that contained 80 parallel processing cores. Intel also indicated that it believes that future applications such as computer games/MMOGs will require or exploit the massive processing power of such future microprocessors. Already the Microsoft XBOX 360 and Sony Playstation 3 are built using, respectively, 3 cores and 9 cores, though these game console technologies are expected to remain in production for five years or longer. But the game development industry was significantly challenged by the difficulty of migrating existing games or developing new games that could exploit the processing power of these multi-core game consoles. Game software development for multi-core processors is a daunting, difficult problem. This will be the

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dominant problem facing the game industry—how to develop next generation or generation-beyond-next games that truly exploit the available processing power offered by multi-core technologies.

It should be clear that Intel is not focused on computer game research or development. But it is particularly interested to learn what kinds of problems and challenges might arise as future games are investigated that envision the need for such "tera-scale" multi-core processing that will become available in the next 3-5 years. From our perspective, there is a great under-explored opportunity to investigate how future computer games might therefore require such advanced processing capability, as a way to potentially lead R&D efforts in that direction. Also, to be clear, Intel (as well as AMD, IBM, and SUN) has already begun to ship new microprocessor-based products that include multi-core technologies (currently offering 2-8 core microprocessor chipsets) that are expected to grow to 16-32 cores by the end of 2008, and thus into 16-128 cores by 2010-2012. Even low power devices like cell phones and ultra mobile personal computers (UMPCs) will transition to multi-core processors (2-8 cores) by 2010-2012. However, the computer game industry in the U.S. (and elsewhere) in general is not yet positioned to take advantage of this technology disruption. We believe this is an opportunity area for research and development breakthroughs and innovations.

To better help understand what role multi-core processing technology might play in the development of future computer games, we have developed some initial computer game and/or persistent online virtual work environment (i.e., Web 3.0 environments) scenarios. Four documents are included and described in turn.

First, the document, *Notes on scenarios that envision potential capabilities for multi-core processing support for computer games and persistent online virtual worlds in 2010-2012*, focuses on identifying about a dozen different scenarios for future computer games or game-like virtual worlds, where multi-core processing capabilities might be required. This list spans from simple scenarios that "turn up" the level of visual or physical realism that may be rendered or depicted in a game, to entirely new in-game

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capabilities that are beyond current game offering in either online or mobile games. The purpose of this list is to make clear that the number and diversity of possible future game processing scenarios is that future games may be quite different than game currently available. Once again, this points to an opportunity to establish a leadership position in future game research and development (as well as eventual commercialization and deployment in the 2010-2012+ time frame). It may be beneficial to Daegu Center/DIP partners to take this list of future game processing scenarios to see what other scenarios or processing capabilities might be envisioned or included in our game R&D agenda going forward.

Second, there are three closely related documents that develop a future, multi-core processing game/virtual world scenario in depth. The documents include (a) one page *Story Synopsis* for an online-mobile game play vignette, (b) the development and presentation of a *Storyboard and Script* for this game play vignette, and (c) an explanation of where and how for the *Technical Details for Multi-Core Processing Concepts in the Storyboard*, might be conceptualized, developed, or utilized along the way. These documents, as well as the multi-core scenarios document previously described, will be presented in more detail within the Video Lecture series in Summer/Fall 2007. As such, these documents serve at this time to help stimulate thinking at the Daegu Center and its game development partners.

Online-Mobile Game Research Agenda

The last area in which we have some initial results is in the development of an agenda that envisions technologies and capabilities that should be investigated by those who seek to engage in game research and development that is focused on producing commercially viable results in the 2010-2012 time frame. The document here can be identified as, *Developing a Research Agenda for Generation-Beyond-Next Computer Games: Online and Mobile Games*.

This agenda is a working document, rather than a fixed, rigid, and unchanging assertion of game R&D

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technology topics/areas. The agenda is however biased towards the science, engineering, and technology of future computer games (whether online or mobile), and thus direct less attention to game culture topics, which may be introduced and expanded in the next project period. The agenda also seeks to be responsive and expansive of topics and concerns that have been forwarded to us here at the UCI GameLab from game company partners and friends at the Daegu Center.

Last, the starting point for the Video Lecture series will be the presentation and discussion of this game research agenda. The purpose is to introduce and explain each concept identified in the research agenda, and why it is on the agenda. Thus, at this point, the agenda serves to help stimulate thing at the Daegu Center and its game development partners.

Final Remarks

The remainder of this report is far more voluminous that this overview. This is as it should be in our view, as what follows are the first round of results from our research project that has only been up and running (and funded) for three months. Whether the diversity and volumes of results that follows is indicative of what will be produced in the research period ahead is unclear. So please do not assume that what follows reflects what to expect in the near future. Instead, please view the remaining materials with an eye towards what research or directions might be investigated in the months or years ahead. We will of course have the opportunity to discuss and review these materials in the Video Courses during 2007-2008.

As such, we now present the detailed Project materials and results of our research efforts during 1 January 2007 through 30 June 2007, followed by the budget expenditure during this period.

Project materials and results

Game Development Studios/Companies operating in Orange County, CA

Game Development companies/studios in Orange County (listings in parentheses appear to no longer be in business)

1. Altus USA, Irvine – http://www.altus.com
2. Bandai Games/BandaiAmerica, Cypress -- http://www.bandaigames.com
3. Blizzard Entertainment, Irvine -- http://www.blizzard.com/
4. Codefire, Irvine -- http://www.codefire.com/
5. Coresoft, Laguna Hills -- http://www.coresoft.com/
6. Gamespy/IGN Entertainment, Costa Mesa – http://www.gamespy.com http://corp.ign.com/contact.html
7. InExile Entertainment, Newport Beach -- http://www.rpgcodex.com/phpBB/viewtopic.php?t=1925 (scroll down)
8. In-Fusio, Tustin -- http://corporate.in-fusio.com/corpweb/
9. Interplay, Irvine -- http://www.sec.gov/Archives/edgar/data/1057232/000117091806001092/presentation.pdf
10. Javaground USA – http://www.javaground.be/corporate_contact.html
11. K2 Network, Costa Mesa -- http://www.k2network.net/
12. Leadwerks, Newport Beach, -- http://www.leadwerks.com
13. Nexus Entertainment, Huntington Beach -- http://www.nexusent.com/
14. Obsidian Entertainment, Santa Ana -- http://www.obsidianent.com/
15. Papaya Studio, Irvine – http://www.papayastudio.com
16. Planetwide Games, Aliso Viejo -- http://www.planetwidegames.com/
17. Point of View, Tustin -- http://www.pointofview.com/
18. Ready at Dawn Studios, Santa Ana -- http://www.readyatdawn.com/news.asp
19. Red5 Studios, Aliso Viejo, CA -- http://red5studios.com
20. Shiny Entertainment, Newport Beach – http://www.shiny.com
21. SquareSoft USA/Square-Enix, Costa Mesa -- http://www.square-enix.com/
22. Superscape, San Clemente -- http://www.superscape.com/about/offices/usa.php
23. SuperVillain Studios, Costa Mesa/Santa Ana -- http://www.supervillainstudios.com/
24. (Taldren, Costa Mesa)
25. The Collective/Foundation 9 Entertainment, Newport Beach – http://www.colletivestudios.com
26. (Troika Games, Irvine)
27. VPI/Visual Perspectives Internet-- http://www.vpi.net/
28. Zeek Interactive, Huntington Beach -- http://www.zeek.com/

Web 3.0: The Game Web Symposium

Notes on the *Web 3.0: The Game Web*
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Institute for Software Research
Game Culture and Technology Laboratory
Calit2
University of California, Irvine
20 June 07

My objective in these notes is to outline some ideas that I believe lie behind the concept of the Web 3.0 as a Game-based Web.

First, by way of background, we are presently in the midst of activity surrounding the emergence of the Web 2.0, which some call the "semantic web" or the "social web". Both of these names seek to differentiate current activity from that which gave rise to the original Web (the "world-wide web" or the Web 1.0) that first appeared in the early 1990's. The first Web was founded on the practices and technologies for organizing networked (i.e., Internet-worked) access to remote documents, data objects, or other information resources using "hypertext" techniques such as non-linear documents, interactive or navigational document structures, hypermedia (i.e., hypertext style information resources that incorporated multiple types of media like text, graphics, animations, sound, etc.), and "hyperlink-based navigation" that originated in the 1970's and 1980's. Furthermore, on the original Web, data objects had ambiguous names/identifiers and file name extensions like "index.html" or "paper.doc" to convey something about the type of data in the file's content along with its location on the Web (i.e., it's uniform resource locator or "URL"), while Web-style hyperlinks usually had no semantic meaning other than "go to another Web object or data file by clicking on the highlighted text or tagged image". All of these are still in widespread use on the Web today. However, this all means that the original Web has little/no semantics, so its difficult to figure out what things are or where they are located.

Also during the 1970's-1990's technologies associated with enriched representations of data as inter-related objects with attributes and values gave rise to practices that were designated as "semantic data representations", "object-relational systems", or "semantic networks" (from the field of Artificial Intelligence) to indicate that searching, locating, manipulating, or reasoning (i.e., deducing inferences) about objects was more easily supported through computational means when both the data objects and the relationships (associative "links") between them had explicit data types (or object classes) associated with them. Data objects and links could therefore have explicit semantics that could be remotely accessed or shared over a network. Capabilities such as these then gave rise to the notion of a *semantic web*, which both differs from the original Web, as well as offering new capabilities for accessing and processing information resources located through the Web. The late 1990's through present has also seen the emergence of new classes of information and commercial services not easily predicted from the original Web which embrace the current Web as an online milieu for socializing and communicating among friends, family, and/or distant others in ways not as easily accomplished with "traditional" media like telephone, print, video, cinema, radio, etc., as well as for experiencing hypermedia resources or synthetic worlds. This is now the world of the Web 2.0, today's Web. And there is much yet to be developed, commercialized, and exploited using Web 2.0 technologies, probably for another 10 years or longer. But the beginning of the Web 3.0 is now at hand.

Second, along with the development of the original Web was the rise of computer games and subsequently computer game technology as a pervasive popular culture. Computer games first appeared on large mainframe computers and soon migrated to small or personal computers when that technology began to appear in the 1970s-1980s. Networked computer games first appeared in the late

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1970s-1980s, which allowed for multiplayer game play, including player-vs-player and player-vs-multiple in-game characters. The appearance of the computer game, *DOOM*, in the early-mid 1990's heralded a breakthrough game-play experience for technically capable computer users and programmers. These people were already comfortable using network technologies like the Internet to remotely access data or programs, as well as to communicate information using email, use online discussion forums, and the like. Thus, by this time, corresponding to the emergence of the original Web, a growing base of computer and network savvy end-users and software developers began to embrace the potential of the Internet and later the Web as a platform for multiplayer game play in game-based synthetic or virtual environments. This potential was especially true for people familiar with then modern methods and techniques for producing interactive computer graphics and computer animations, both of which helped set the stage for the technology of immersive simulations or "virtual reality" (VR). VR represented the early marriage of computer graphics, computer-aided design (especially important to large corporate interests), and networked-based, persistent graphic "worlds" that offer the potential to support remote access over the Internet to distant users who could navigate, explore, or collaborate with one another in either a academic/corporate online space for R&D. Alternatively, the virtual landscapes of "cyberspace" and the "metaverse" appeared in the writings of science fiction authors like William Gibson (*Neuromancer, Burning Chrome*), Neil Stephenson (*Snow Crash*), Bruce Sterling, and others from the 1980s-1990s, where the notion of modifying or "hacking" the virtual world was a central storyline element. Internet-based games also introduced the concept and practice of "virtual worlds" (VW) that were primarily textual rather than graphic, such that the VW was experienced in the space between your ears as well as between your eyes and fingertips. These "multi-user dungeons" (MUDs, and later, multi-user dimensions and MOOs as object-oriented MUDs) helped reveal the potential for interactive fiction, online role-based socialization, and user-created virtual worlds as viable forms of immersive networked experience that did not necessarily require explicit or high quality graphic rendering. VW could become immersive not when they were simply high-resolution graphics environments, but when there was something interesting to do with other people who were also there with you, whether you could see them (or their avatars), or not. Games with MUD capabilities deployed over the Internet/Web with or without graphic interfaces thus helped realize the viability of shared, persistent virtual worlds. The pieces were at hand, but the available technology configuration and deployment for sustained, multi-mode VW and immersive social experiences over the Internet/Web were not yet acceptable during the 1990's. Advances in computer game technology, especially the migration to evermore powerful microprocessors and the use of hardware acceleration devices like "video graphics cards" helped enable more visually immersive computer game play and sustained experience in game-based virtual worlds.

Third, while the Web 3.0 might represent many things, it certainly can represent the marriage of the Web 2.0 with contemporary networked computer games, VR, and VW technologies and cultures. Early precursors to the Web 3.0 can be seen in the emerging metaverse in current activity in and around VW like *Second Life* (SL) on the one hand, and persistent massively multiplayer online games (MMOGs) or MMO role-playing games (MMORPGs) like *World of Warcraft*. Users or players in these VW are eager to hack or "mod" the worlds they start in if they can, or to collaborate and work together in order to have fun online. But what does this mean for the Web as we currently experience it? Well, for one, it might anticipate a future online environment where Web sites evolve or morph into immersive, game-based virtual worlds that can be sized to support the interests of an individual or provide a corporate entity with an large-scale VW as an alternate space for enterprise activities. Many currently available networked computer games like DOOM3, QUAKE4, Half Life2, NeverWinterNights, Civilization4, The Movies, and many more offer retail customers (game players) not only the packaged game (which may provide 5-80 hours of game play experience) but also a software development kit (SDK) whereby the customer is allowed to *mod*ify (or hack) the game to create a different game look, game play

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experience, or even to create entirely new games, all much like that encouraged in the world of free/o en source software development (W. Scacchi, Free/Open Source Software Development Practices in the Computer Game Community, *IEEE Software*, 21(1), 59-67, January/February 2004). Linden Labs, makers of SL, have also released source code for the SL client and server software under an open source software license, so that others outside of Linden Labs can begin to modify what can be or is possible in SL. Thus, the metaverse from science fiction is increasingly being treated not simply as a commentary on modern times, but instead as a specification or roadmap for the future, the Web 3.0 future.

Web 3.0 sites may be populated with AI-based autonomous game characters or non-player characters who help make a Web 3.0 site more habitable and sociable even when there are few real people on or at the site. Elsewhere, the Web 3.0 may provide new ways of blurring the boundaries between heterogeneous devices that are designed for autonomous or independent operation, with those that can be made to interoperate with one another across or mediated through a VW.

Similarly, the Web 3.0 may allow for the composition or juxtaposition of the physical world with elements from VW to realize mixed realities or alternative realities that enable users or players to experience the physical world through the lens of the VW.

The world of academic research and "big science" may be headed toward the adoption and assimilation of games and VW as the basis and platform for future simulation-based scientific research experimentation, demonstration, and conveyance to the public in a more accessible mode of expression or engagement. Imagine one or more VW were people can explore current models and theories of what is happening to our global/regional ecology, future access to water by growing populations of people with shrinking open spaces, the consequences of alternative policies for energy usage or carbon production/assimilation, and so forth. Your children "get" computer games and the Web 2.0 in ways you don't (yet) understand. You probably realize that the current educational system is profoundly inadequate and irrelevant to a world of young people who we expect to endure an agricultural/industrial age school system, even though they have been "post-industrial" since their birth. If you think that you or your children will primarily rely on today's mass media or politicians to guide your/their understanding of the science of our physical, chemical, biological, psychological, sociological, humanistic, artistic, or even cosmological worlds around us, I guess you are missing the point (so please get out of the way, but we will come back to get you on board or "beam you up" later).

The world of corporate operations and business transactions (whether business to consumer, or business to business) may begin to migrate to game-based VW whereby (a) employees that engage in immersive, contextualized on-the-job training experiences, when needed and where needed, as well as (b) corporate/enterprise "designers" can analyze existing workflows or business processes to determine how to redesign, streamline, or improve them through experiments with alternative enterprise designs or business operation prototypes that can be "played," played with, or stressed to the limit without substantial financial or organizational consequence in "organizational flight simulators". Government operations and transactions may subsequently follow. The corporate market for the Web 3.0 is mostly an unexplored frontier, and frontiers represent new venues or arenas for innovation, cultivation, acquisition, and economic development.

All of the preceding history and future of the Web 3.0 merely scratches the surface of what has been, what is, and what will be realized as computer games, virtual worlds, and the Web 2.0 come together. This is therefore merely a starting point for a discussion of what we can together make the Web 3.0 to be in ways that serve our individual and collective interests.

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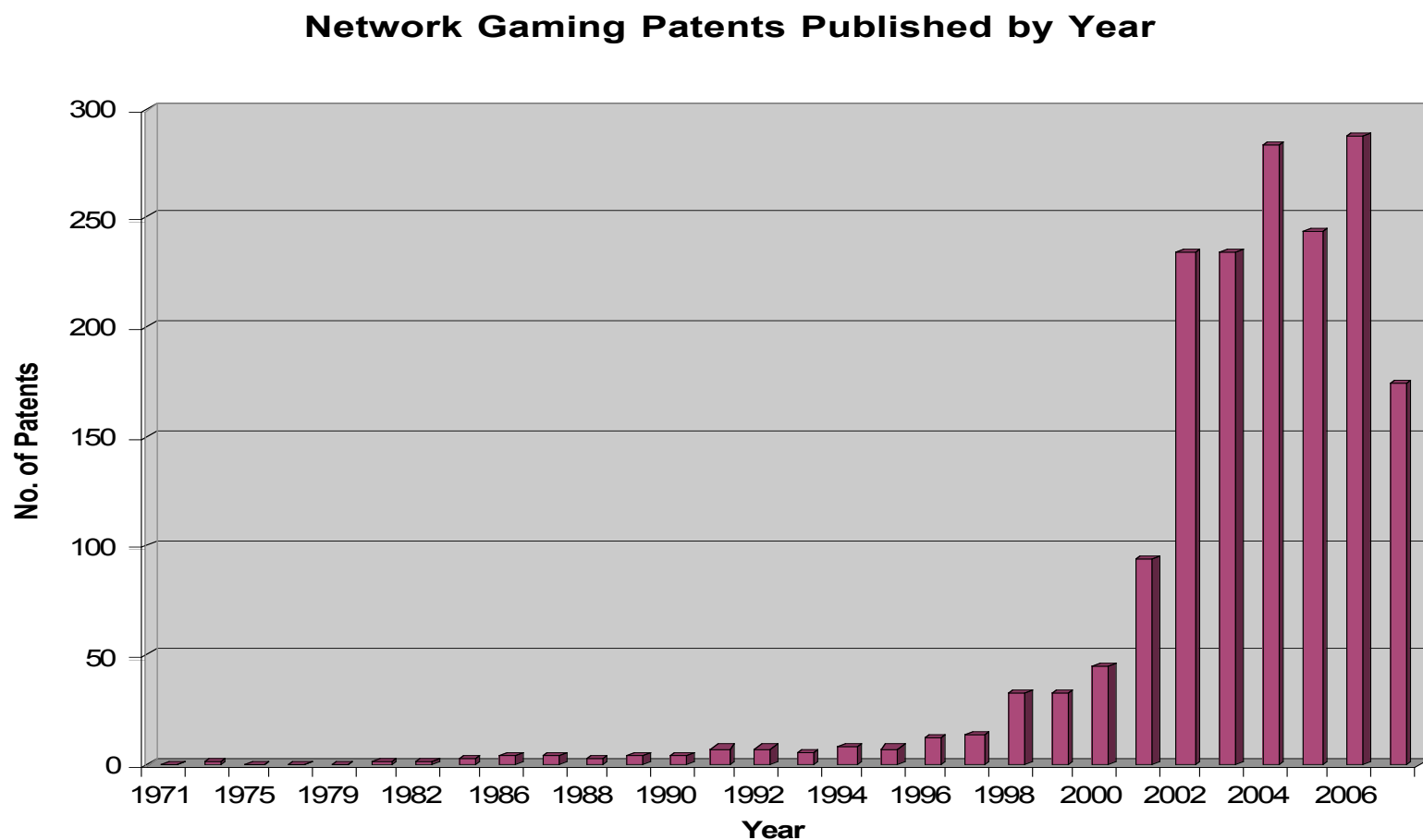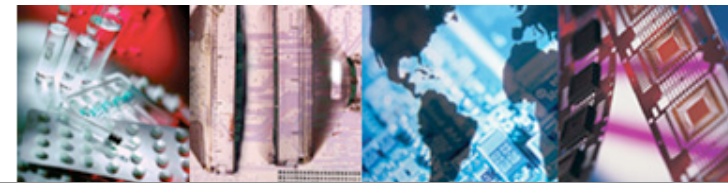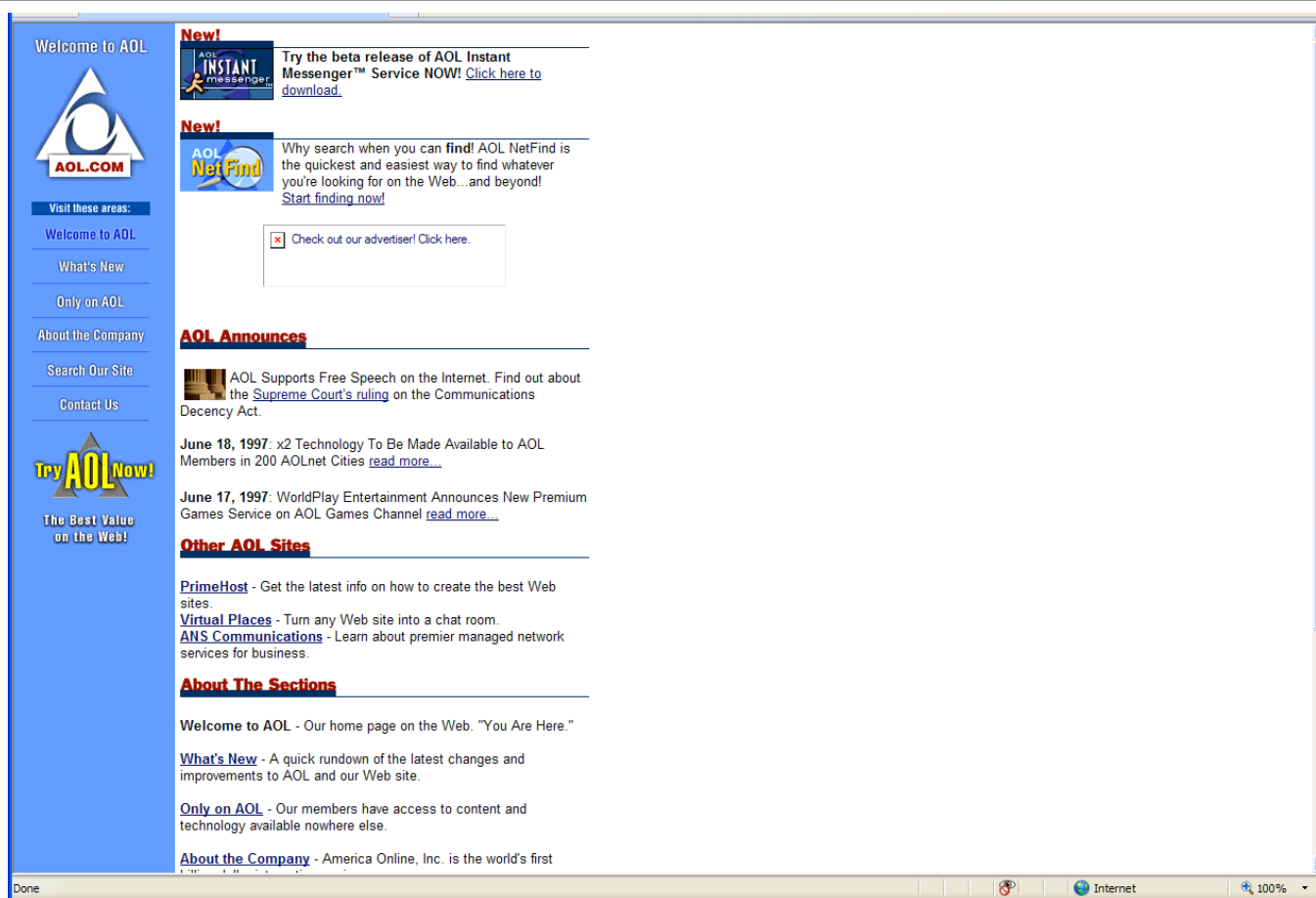
Intellectual Property Law
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Web 3.0

Network Gaming Patents

Network Gaming Patents Published by Year

Web 1.0

Web 2.0

Web 3.0

Web 3.0

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Game Web Research at the UCI Game Lab

Walt Scacchi

and

California Institute for
Telecommunications and Information
Technology (Calit2)

Game Web as Culture and Technology

- Games as immersive, experiential literary form -- *game play as emergent narrative*
- Gaming as rapidly growing *global industry*
- "Modding" and making games as practice-based *learning* and *career development*
- Game-based *virtual worlds as work spaces*
- Games as *new media* and cultural form
- Game culture as *social movement*

t3h S00p4rFr34k!
<Freakshow>
Level 30   Elite Boss

Actions
Options

All Pets
Call Genin
Keitaro
Seta
Taka
Call Jounin
Fujisawa
Chiba-san
Oni
Moshigosan

Pets
★Arachnie
Ms. Chievous

Kick Promote Find Quit

Team Friends Super Email Tab 1 2 3 4
Global Combat Rewards System
You gain 102 experience and 71 infamy.
t3h S00p4rFr34k!: d0 j0u d4r3 t0 ch4ll3ng3 t3h
    p0w4r 0f t3h S00p4rFr34k!?
You have defeated Slag Heap
You gain 102 experience and 71 infamy.
t3h S00p4rFr34k! has defeated Battle Drone

Team: 27

E | SE | S | SW | W | NW | N | NE
Destroy the SuperFreak
Defeat the Superfreak
Map Contact Mission Clues Badge
:17
:15 27
:43 27
t3h S00p4rFr34k!

Taka
Arachnie

Seta
Arachnie

Chiba-san
Arachnie
Keitaro
Arachnie

Fujisawa
Arachnie

Moshigosan
Arachnie

Ms. Chievous
Agent of Discord

Chat Tray Target Nav Menu

Powers Inspirations Enhancements Salvage

3 Att diss Beat SSR SSF
2 Go CSF FSF
1

F1 F2 F3 F4 F5

UCI Game Web Researchers

- *Studio Art*: Robert Nideffer (*Director*), Antoinette LaFarge
- *Informatics and Computer Science*: Dan Frost, Crista Lopes, Bonnie Nardi, Bill Tomlinson, Andre van der Hoek
- *Engineering*: Steve Jenks, Sung-Jin Kim, Joerg Meyer
- *Institute Software Research*: Walt Scacchi (*Research Director*),
- **Others**: Tom Boellstorf (Anthropology), Christopher Dobrian (Music), Peter Krappe (Humanities/Film Studies), Patricia Seed (History), Charlie Zender (Earth Systems Science)

UCI GameLab Research Partners and Sponsors

DIP
DAEGU DIGITAL INDUSTRY PROMOTION AGENCY

NSF

TACO BELL DISCOVERY SCIENCE CENTER

Sun microsystems

(intel)

the UC Discovery Grant
Success is a great investment

UCHRI

ISR

it²

abrc

bren:school
information and computer sciences

OCTANe@UCI

Claire Trevor School of the Arts

MASSIVE Research Symposium Corporate Sponsors

BLIZZARD ENTERTAINMENT

gamespy

K2 NETWORK
GAMERS FIRST

Linden Lab

Open Source Game Software Development

- The most successful OSSD projects obtain *sustained exponential growth* in their innovation frontier.

- Computer game software development is the #1 application area (and #2 overall) for Open Source Software development (OSSD) projects.

  – Growing number of commercial computer games now ship with tools for creating OSS game "mods"

- Future game and Web 3.0 development will increasingly depend on global OSSD practices and components.

Science Learning Games (SLG) for Informal Science Education

- Physical interaction quest game: *DinoQuest* at the Discovery Science Center (Santa Ana, CA)
  - Life-size dinosaurs (T. Rex, Argentinosaursus)
  - Family-based problem-solving and collective learning in physical environment
  - Game progress tracked via user-controlled IR wand that activates embedded sensor net

- Web-based SLG: *DinoQuest Online*
  - Addresses CA science education standards for K-6 grades
  - Interoperates with *DinoQuest*
  - Designed for internationalization
  - Developed by UCI GameLab

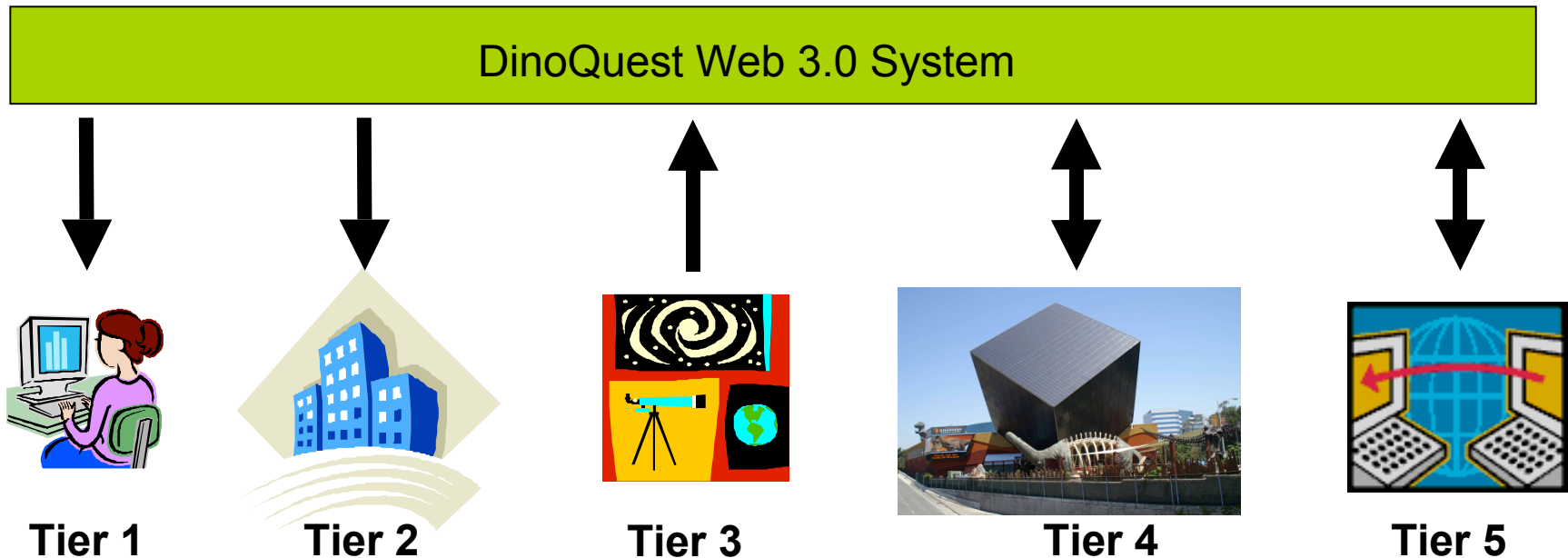- DSC planning new SLG exhibits through 2010
  - $60M investment planned

DinoQuest Online

DSC+UCI working to develop network of SLG-based science centers and exhibits

DinoQuest Web 3.0 System

Tier 1 **Tier 2** **Tier 3** **Tier 4** **Tier 5**

Tier 1: Individual player connection: your Internet connection at home.

Tier 2: Local institutional connection: library, science center, school.

Tier 3: Regional science center provides local exhibit content connected online.

Tier 4: "Gateway" science centers provide open interfaces and content.

Tier 5: Science Center Grid: **Massive Multiplayer Online Science Learning Games**
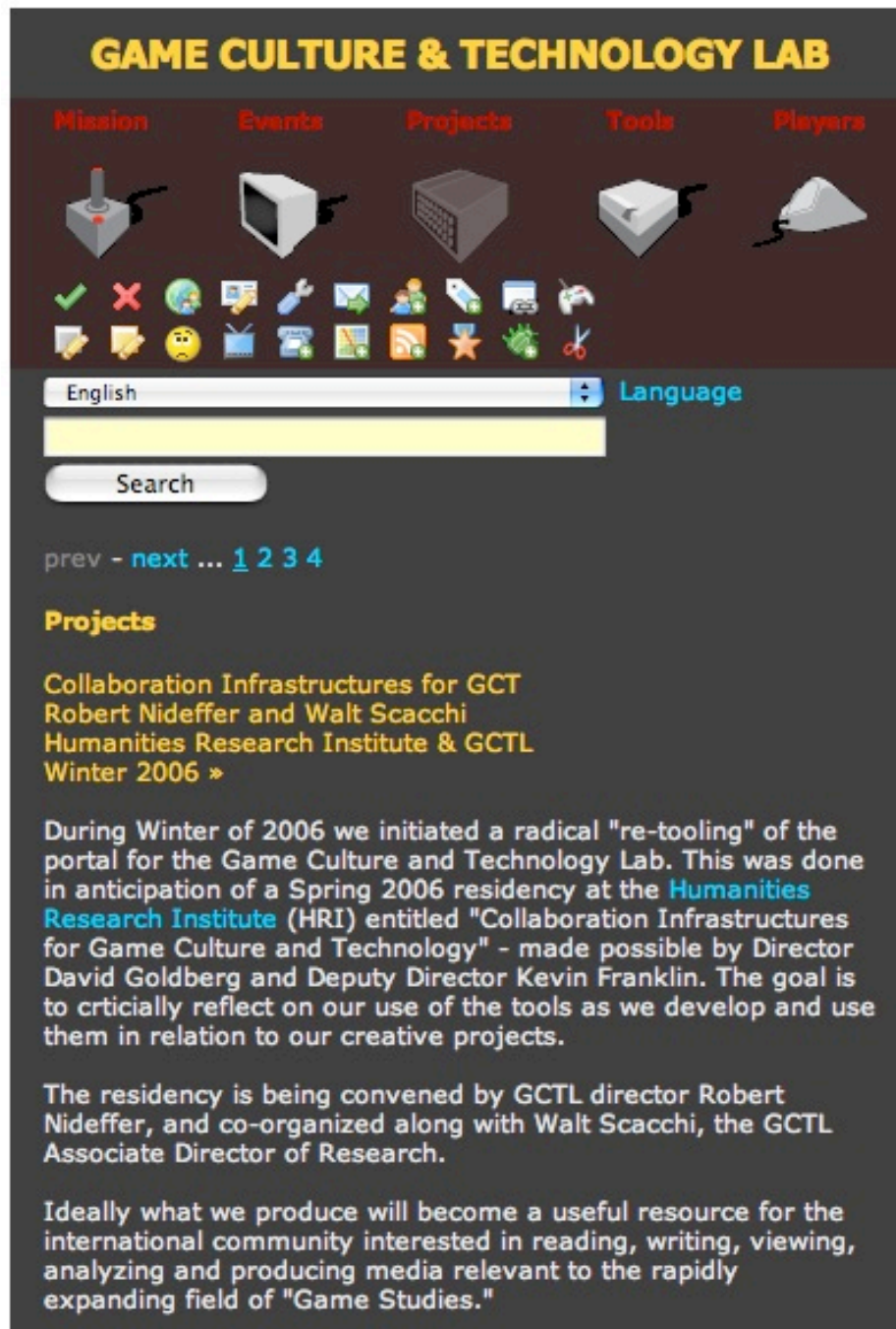
Persistent Collaborative Work in a Virtual World

- People meeting and working together through a persistent online information infrastructure
- Provide new ways of working together
- Provide new concepts, techniques, and tools for collective action/work spanning physical-virtual
- Confront uncertainties of sustained collaboration with limited/no face-to-face interaction
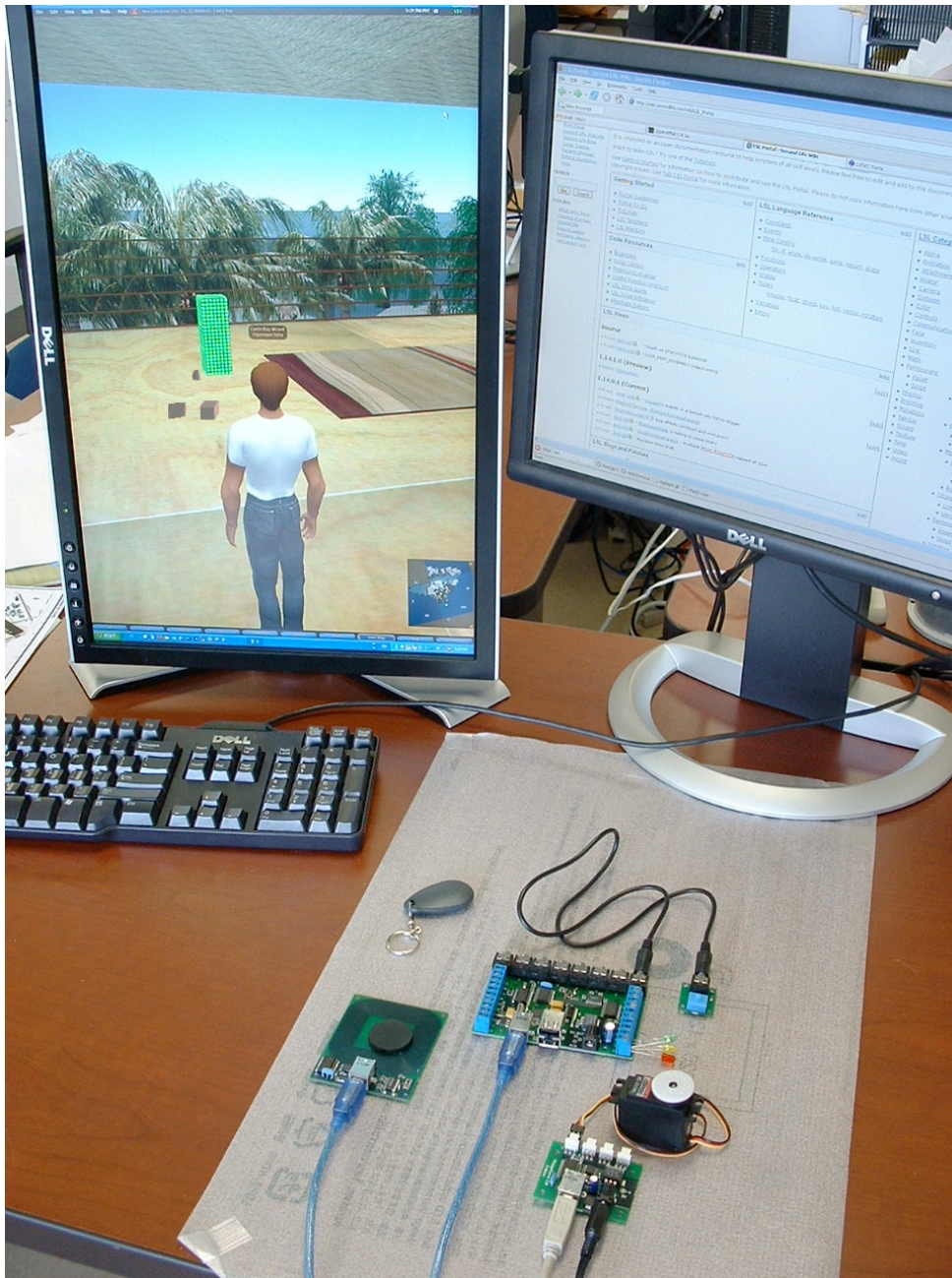- Develop or invent innovative solutions

The World View Map
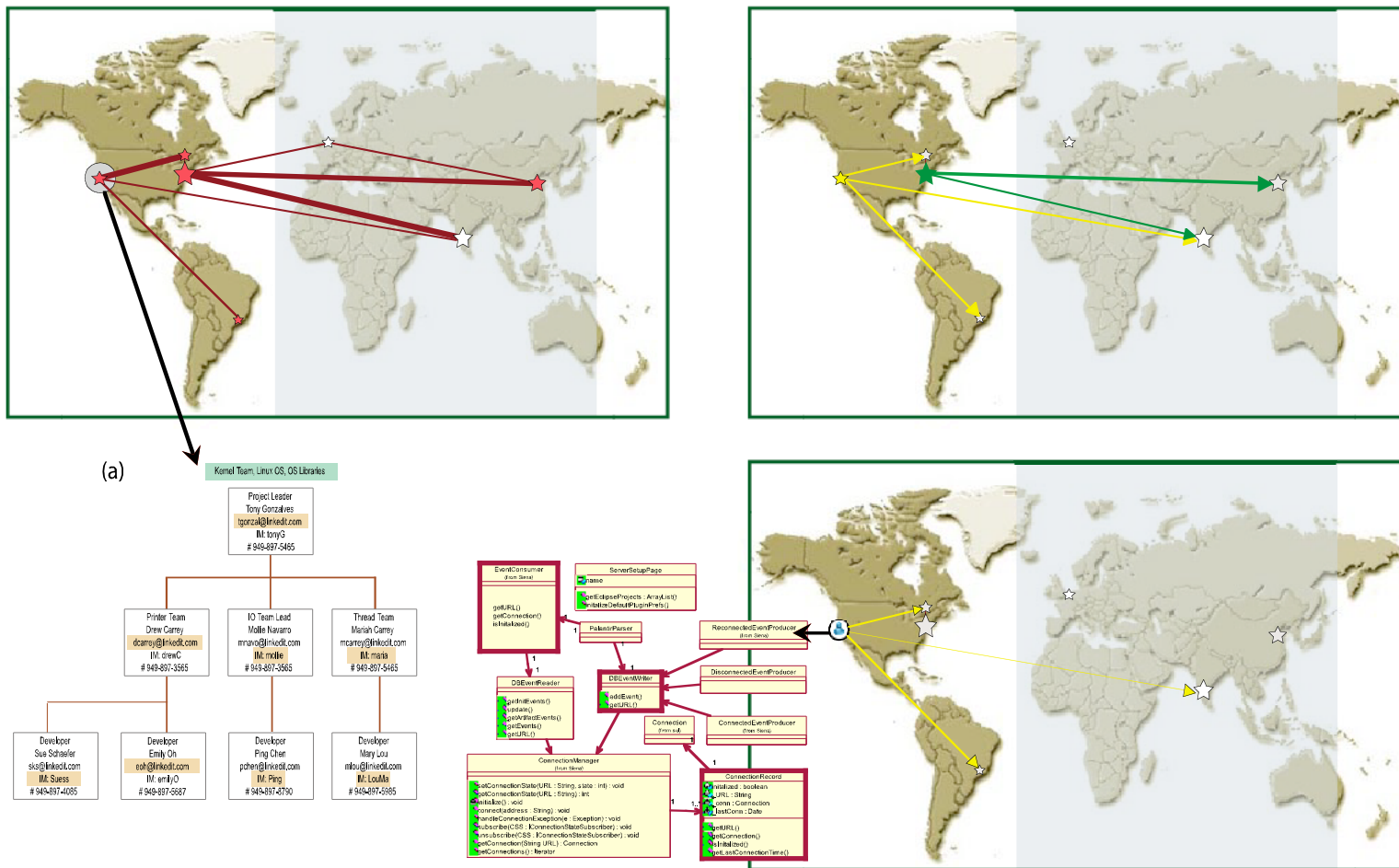
DICE: Domain Independent Collaboration Environment

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Bridging the physical-virtual world boundary

Game Web Collaborative Work Spaces

Transforming Science, Engineering, and Business via Web 3.0

- Games can employ advanced scientific models, simulations, visualizations
  - Global Climate Systems Science game engine
  - Nanotechnology-based "incredible machines"
  - Supply chain/infrastructure transformation quest
- Game Web environments can become platforms for experimentally interacting with emerging scientific models, business processes, and domains of expertise
- Will create new engine for innovation!

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David Perry
GameConsultants.com

VIDEO GAMES

FROM PHYSICAL TO DIGITAL

- Console Games (Cartridges)
- Console Games (Ethernet + Media)
- Console Games (Online Only)
- Mobile Games (Cartridges – Nokia N-Gage)
- Mobile Games (Online WiFi / By Air Only)
- PC Games (Media)
- PC Games (Multiplayer – Various Methods)
- PC Games (Online Only – Digitally Distributed)

PHYSICALLY DISTRIBUTED

- Disc
- Packaging
- Advertising
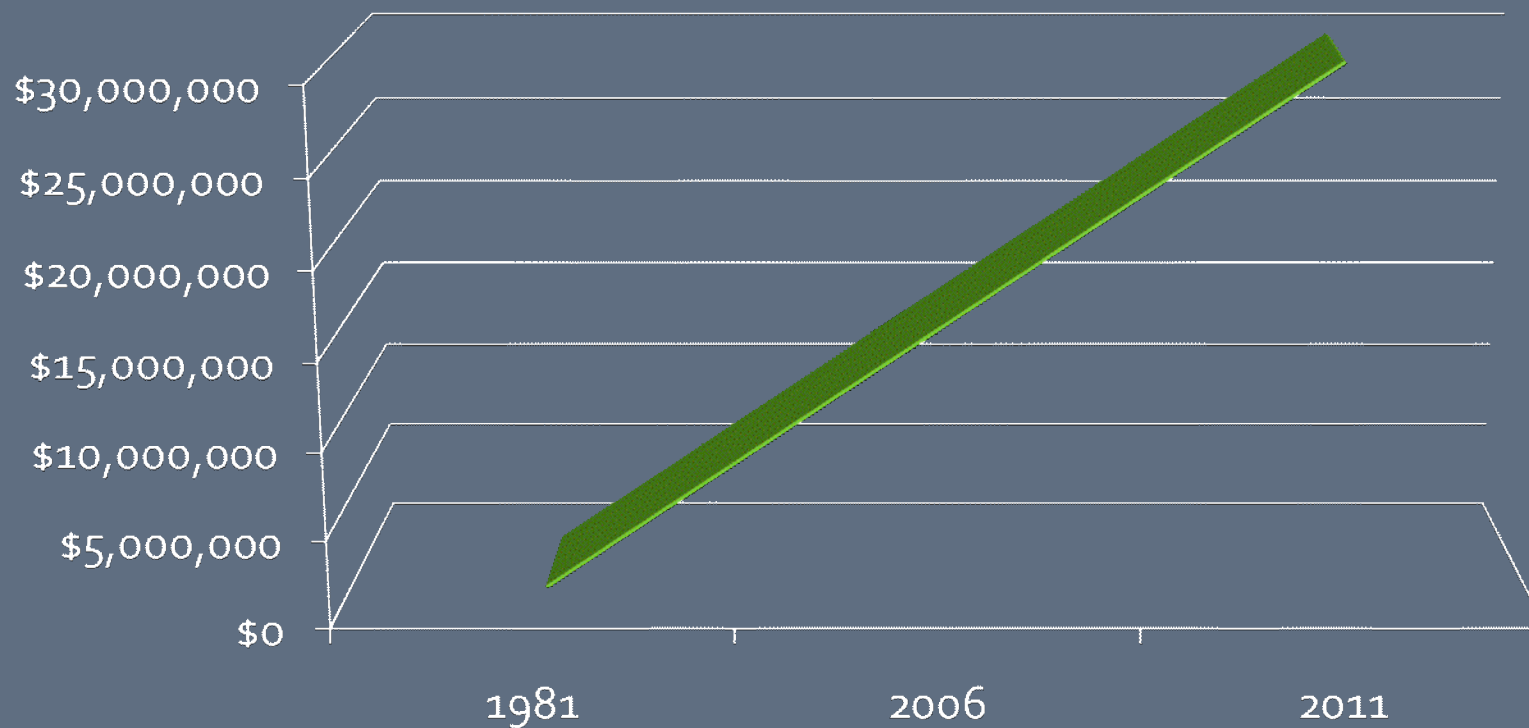- Marketing
- Return Reserves
- PR
- Customer Service

- Retail
- Co-op (with retailer)
- Sales Team
- Retailer Road Trips
- Distribution
- Insurance
- Shipping etc.

COST OF DEVELOPMENT

COST OF GAME DEVELOPMENT

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COST OF CONSOLES

DIGITALLY DISTRIBUTED

- ~~Disc~~
- ~~Packaging~~
- Advertising
- Marketing
- ~~Return Reserves~~
- PR
- Customer Service

- ~~Retail~~
- ~~Co-op (with retailer)~~
- ~~Sales Team~~
- ~~Retailer Road Trips~~
- Distribution (Reduced to Bandwidth)
- ~~Insurance~~
- ~~Shipping etc.~~

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LOVE?

Developer Friendly

- Full Price Game Sales
- Digital Distribution
- Other Revenue Streams

Retail Friendly

- Used Games
- Rental (Day and Date!)
- Used Rental Sales
- Live Used Rental Sales (Gamefly)

BRING ON ONLINE GAMES

- Games were $50, now $60? $70 next?
- Completely Remove the Price Barrier?
- How will movies / music compete then?
- Music will compete by piracy!

- Asian – "Free to Play, Lifetime to Master"
- Let the market pay what they want?
- Online can remove piracy concerns

Free? Not Really…

- **Micro-Transactions**
  - 1st Generation = Painting Cars / Vanity Items
  - 2nd Generation = Risk Based Objects / Collections etc.

- **In-Game Advertising**
  - 1st Generation = A Static Logo on a wall
  - 2nd Generation = Net Served, Targeted Advertising
  - 3nd Generation = User Adverts (Guilds etc.), Optional Advertising (higher profile), Interactive Advertising, Sponsorships of Players and Custom Clothing.

GETTING COSTS DOWN?

I'm inviting YOU to help me make a brand new massively multiplayer online PC game. I have a fully-funded development team ready now to start producing this game.

Here's the deal:

For one very lucky individual, whoever shines most during the game's development, I'm going to offer something nobody else would ever give away... I'm going to give them a major project to Direct, a fully funded, MMO guaranteed to be published by Acclaim.

The new Director will get royalties from their game, and I personally will be their Executive Producer.

Better still, EVERYONE that gets content (design/ideas/art/animation/audio)
into the finished game will get a verifiable major MMO credit on their resume + experience.

So please join me. It costs nothing, but the entry period will definitely be limited. Sign up now, become a team member, and take a step towards video game stardom.
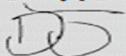
The project will remain TOP SECRET until we contact you. (Team members only.)

Thanks,

David Perry.
Director, PROJECT: TOP SECRET

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COMMUNITY CREATED CONTENT

- Community, Community, Community
- Small development team = 10 (or below)
- Average team = 30
- Big team = 60
- EA team = 150

TOP SECRET

- 38,000+
- 1% = 380 Developers
- First demo should spike 100,000+
- 1% = 1,000 Developers
- Mix Communities?
- 500,000 Artists
- 99% don't show= 5,000 Artists
- Not easy! But not impossible

A BIG GAME?

The Future?

- World of Warcraft
- Mass Market? Second Life?
- Second Life is at 4+M sign-ups
- Millions CCU? (Like TV)
- It will be online
- It will be community created
- It will be planned

Total signups

Total Signups

Jan 2006 to Mar 2007
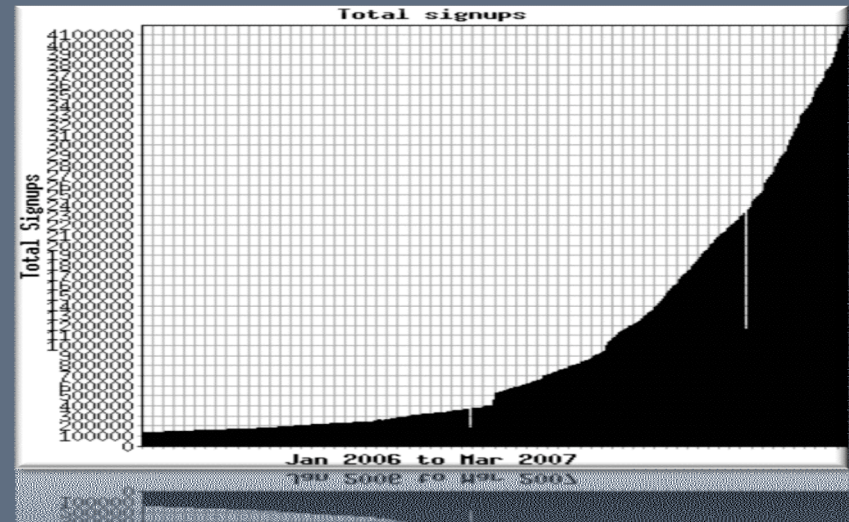
(LONG RANGE) FUTURE?

- Market will rebel against endlessly higher prices
- Consoles become Streaming Terminals / Play on Hardware you can't afford
- Concept of ownership goes away, Sony / Microsoft / Nintendo will be portals to all games
- A 'Killer-Ap' free game will get made & disrupt the industry
- Improved Immersion and control of key emotional drivers like "pride" make games highly addictive
- The Game industry will continue to attract talent and offer them new freedom - Warner Music. Peter Jackson. George Lucas. Steven Spielberg. James Cameron etc.
- Participating in TV shows from home. Gamers making money while playing. Free games. Shared experiences – like virtual live concerts & conferences.
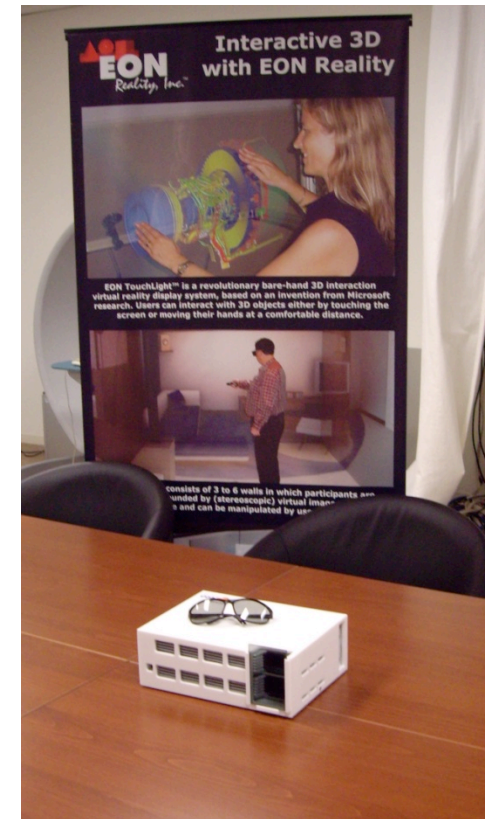- It's a pretty exciting future.

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Thank You

dp@gameconsultants.com

Current Uses – Mobile VR
EON ICATCHER Mini
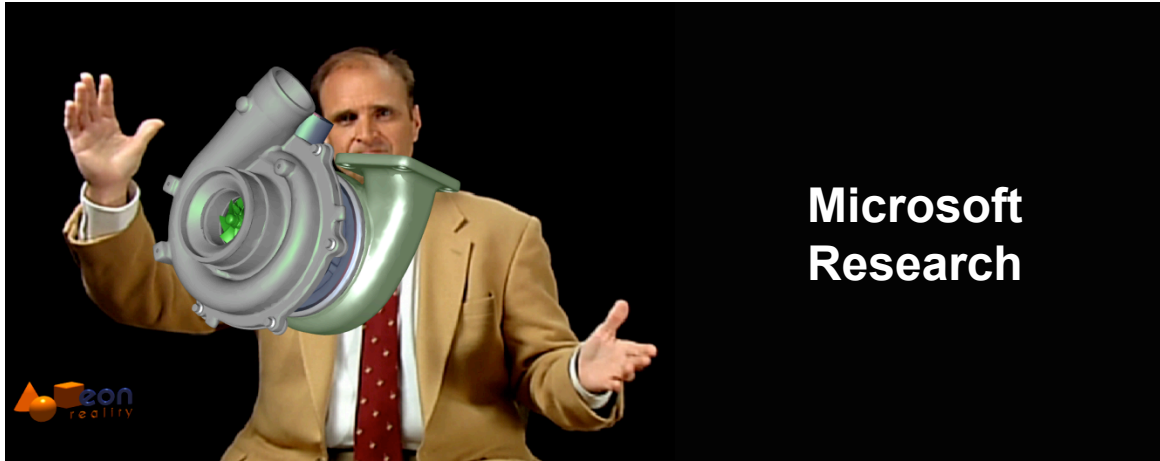
Microsoft Research
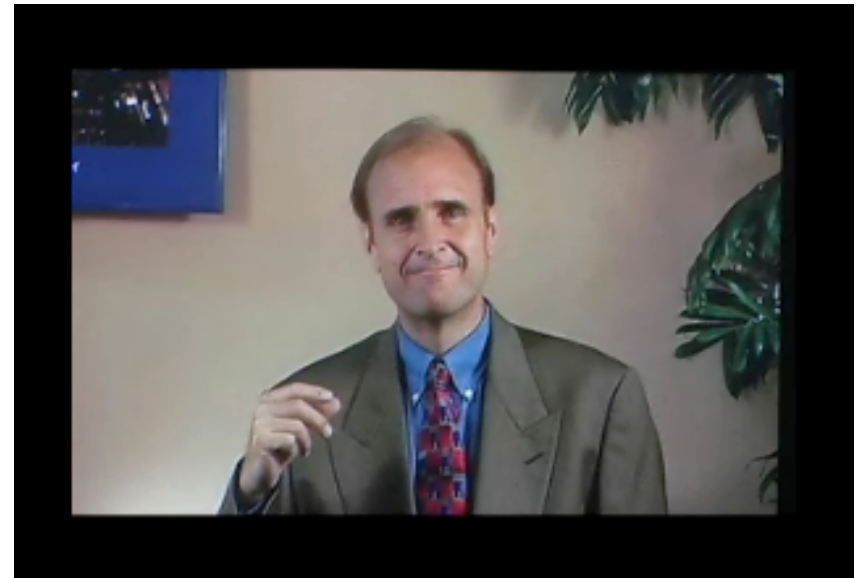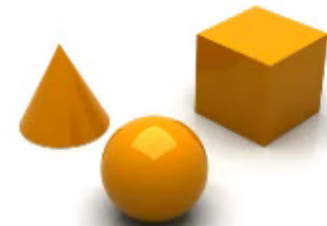
Virtual Conference Room
Immersive Telepresence

AR Pancho

AR Planets

Mobile AR

loading...
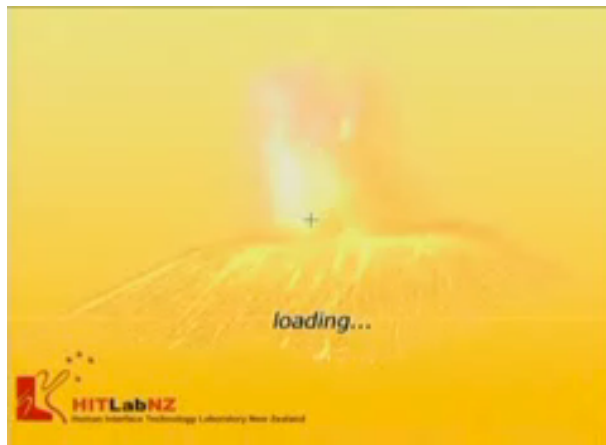
EON Human Creator: Automatic 3D Face Generator From a Single Picture

eon reality

Preserve your self for eternity in 3D on the Web, Improve your looks, Mingle with the VIPs & Bring past celebrities & Paintings to life

Learning from 3D Scans: Application to Images:
= smile. → + smile →
Input   3D Reconstruction   Rendering

What: Product Offering

• People are **fascinated with faces**, preserving or **improving their looks** and mingling with celebrities. EON Human combines all these aspects.
• EON **Human Face & Body 3D generator web service** allows **AUTOMATIC FREE user generated content creation** from **a single picture "Create your own face in 3D on line"**

Why: Scope

• Creates a **viral marketing traction** for **EonExperience** similar to "Skype/YouTube self propagation killer application that anyone with a web browser can use
• Provides **EDC's Experience & Discovery Centers** experience with **unique attraction** & content generator for **3D holographic screens**
• Increases **EON Viewers traction** (goal 100 million Viewers)
• Accelerate the establishment of the **EDC franchising of EON Virtual VIP Pass**
• Create the **worlds largest repositories of 3d faces**

Technical Approach

•.Create the **basic EON Human Face 3D Morphing Service (free),** On line VERY simple the User only NEEDS a JPEG picture and "Voila" automatically create his own 3d Image and upload it to the web "do it your self"
• The user can also **manipulate the 3D face**: Improved looks, weight loss, younger and animated morphable face, happy message, animate speech etc, which will **costs a fixed fee/session**
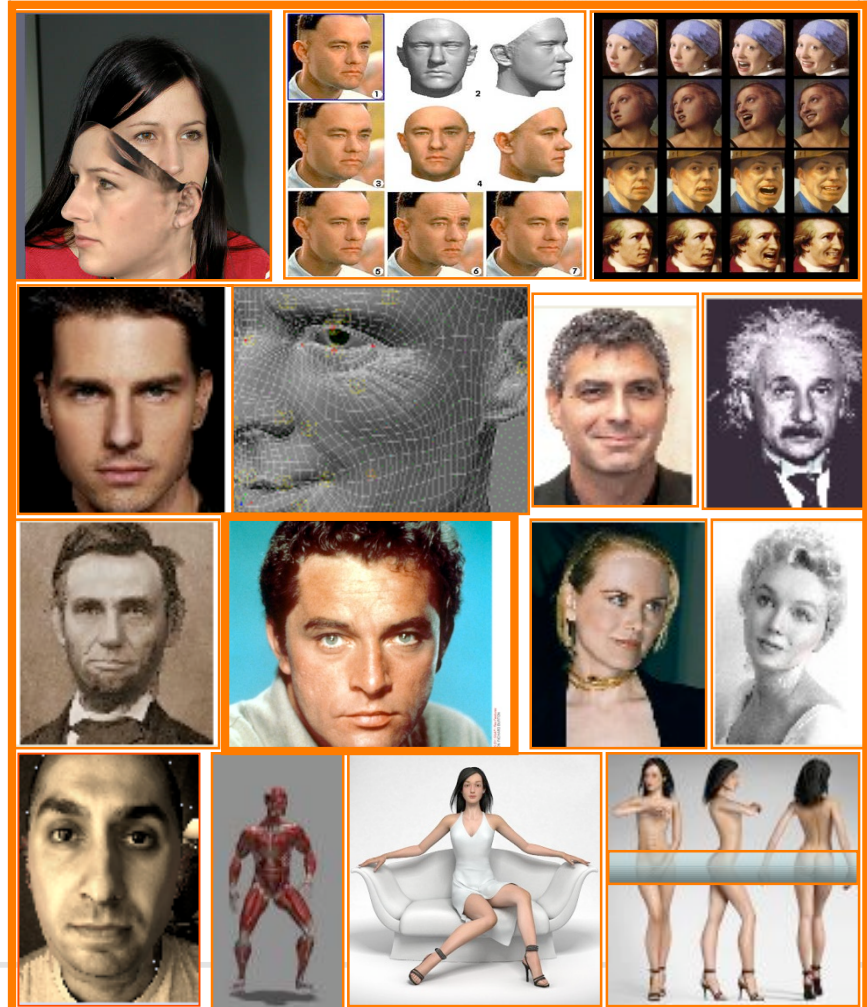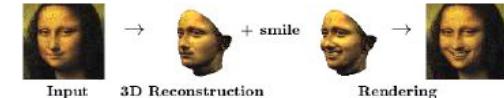• EON Human will also be released as an **Enterprise High End Tool and licenses**

Business Approach

• Create the initial **EonExperience VIP Pass** (face library, Virtual Madame Thousand of on line Interactive & morphable faces using pictures)
• Launch the weekly **Miss Virtual Universe** competitions (submission of "natural" face is FREE but "improved" face costs momey, weekly winner Wins a prize
•**License Technology to Madame Tussaud's & Ripley's believe it or not**
• **Create celebrity gallery** from Forbes The Celebrity 100,People's World's Most Beautiful People, The TIME 100 the most influential people of the 20th century
• **License Technology** to **Model agents**, **Fashion industry**, **Movie industry**, **Amusement parks** (Disney, Universal), **Cosmetic/Plastic surgery** application, **Dating service** companies (e-harmony), **Celebrity websites**, Night clubs
• **Game companies** where they can customize on line games with YOUR own face..
• **Arts & Museums** - Bring paintings and sculptures to life
• **Feature in EON coliseum** – on line avatars, this will have a significant advantage versus Second Life
• **Mobile phone** applications
• **Create the Virtual assistant** applications
• **Google 3d search by 3D face**
• Select Hollywood Partner –George Lucas

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2007		AR Head Mounted Display	1-3 Years		+5 Years
Tablet PC	Ultra Mobile PC	AR Head Mounted Display	3D Video Phone	3D Glasses	Mobile Online AR and RFID Tagged

Tablet PC	Ultra Mobile PC	AR Head Mounted Display	3D Video Phone	3D Glasses	Mobile Online AR and RFID Tagged
What: **Product Offering & Feature List)** EON I-Portal™ gets real-time input from position and orientation sensors, and update view-point position of 3D/2D data and orientation accordingly. Real-time data will conform to current industry standards for GPS, Differential GPS, or inertial tracking systems. Hardware will track the device's position and orientation in 3D physical space, independent of line-of-sight contact with a marker or source. A custom GPS Node acquires the position from the GPS and transfers the information to the Camera's World Position in EON Enhance reality Configuration examples: EON I-Portal™ software, Tablet PC Toshiba, Position system out doors AgGPS® 332 Receiver, Indoor GPS Product (Arc second) Indoor GPS Product , Tracker ~rostrain 3DM-GX1	Augmented reality with tablet PC or virtual glass displays overlaying and augmenting the real world to provide real time guidance and explanation. EON I-Portal™ can provide information as the user moves in a space such as: Product or environment information (what is it?, when?, where?, who?) Knowledge (how does it work?, a foundation for viable action), Decision base (why and how should I use it?, with implications of action Initially Tablet PC connected later versions with head mounted 3D glasses	Augmented reality with virtual head mounted displays Augmented reality with virtual glass displays overlaying and augmenting the real world to provide real time guidance and explanation.	Augmented reality with multi purpose 3D Video & Speech Phone Superimposed context relevant 3d data & Real-time position/orientation input The characteristics are portable, VR augmented reality and smart	Augmented reality with virtual glass displays overlaying and augmenting the real world Provides capability to enhance reality with context relevant data for example see through "Superman vision" by superimposing a video image with a 3d model of the same environment that contains additional hidden information	Augmented reality with virtual glass displays overlaying and augmenting the real world Combine Virtual reality, 3D Digital content, Artificial intelligence and advanced web and search Built into your eye glasses projected directly to our retinas Virtual personalities that overlay the real world will help with information Proactive assistance will step forward if they see that we are struggling to find a piece of information. High bandwidth, wireless communication to the internet at all times

Augmented Reality Displays & Tablet PC's

Overlaying and augmenting the real world to provide real time 3D guidance & explanation

What: Product Offering

- **Augmented reality** with tablet PC or **virtual glass displays overlaying** and augmenting the real world to **provide real time guidance and explanation**.
- **Superimposed context relevant 3d data** & **Real-time position/orientation** input
- **Initially Tablet PC** connected later versions with **head mounted 3D glasses**
- Provides capability to **enhance reality** with **context relevant data** for example see through "**Superman vision**" by superimposing a video image with a 3d model of the same environment that contains additional hidden information
- The characteristics are **portable, VR augmented reality and smart**

Who: Target Market

Target Use:
- **Construction & Infrastructure** - Interactive three-dimensional buildings/maps that could be collaboratively modified and analyzed (e.g., for prospecting)
- **Medical** -Visualization of hidden features (e.g., a doctor could "see" the fetus inside the mother's womb)
- **Industrial / Aerospace Installation & Support** Assisting difficult tasks (e.g., the system could "label" the parts of a system in order to facilitate the mechanic's work)
- **Tourism, location based Information & Cultural Heritage** Enhanced sightseeing : labels or any text related to the objects/places seen, rebuilt ruins, building or even landscape as seen in the past. Combined with a wireless network the amount of data displayed is limitless (encyclopedic articles, news, etc...).
- **Teleconferencing** with both real and virtual participants
- **Entertainment** (allowing computer-generated imagery to interact with live entertainers)
- **Games**

Overview

- EON I-Portal™ can provide **information** as the user moves in a space such as:
- **Product or environment** information (what is it?, when?, where?, who?)
- **Knowledge** (how does it work?, a foundation for viable action),
- **Decision** base (why and how should I use it?, with implications of action

Feature List

- **EON I-Portal™** gets **real-time input** from **position and orientation sensors**, and update **view-point position of 3D/2D data** and orientation accordingly.
- Real-time data will conform to current industry standards for **GPS, Differential GPS,** or **inertial tracking systems.**
- Hardware will **track the device's position** and orientation in **3D physical space**, independent of line-of-sight contact with a marker or source.
- A custom **GPS Node** acquires the position from the GPS and transfers the information to the Camera's World Position in **EON Enhance reality**
- **Configuration** examples: EON I-Portal™ software, Tablet PC Toshiba, Position system out doors AgGPS® 332 Receiver, Indoor GPS Product (Arc second) Indoor GPS Product , Tracker Microstrain 3DM-GX1
- **Future R&D Features**:
- Will Combine **Virtual reality, 3D Digital content, Artificial intelligence and advanced web and search**
- **Built into your eye glasses** projected directly to our retinas
- **Virtual personalities** that overlay the real world will help with information
- **Proactive assistance** will step forward if they see that we are struggling to find a piece of information.
- **High bandwidth**, wireless communication to the internet at all times
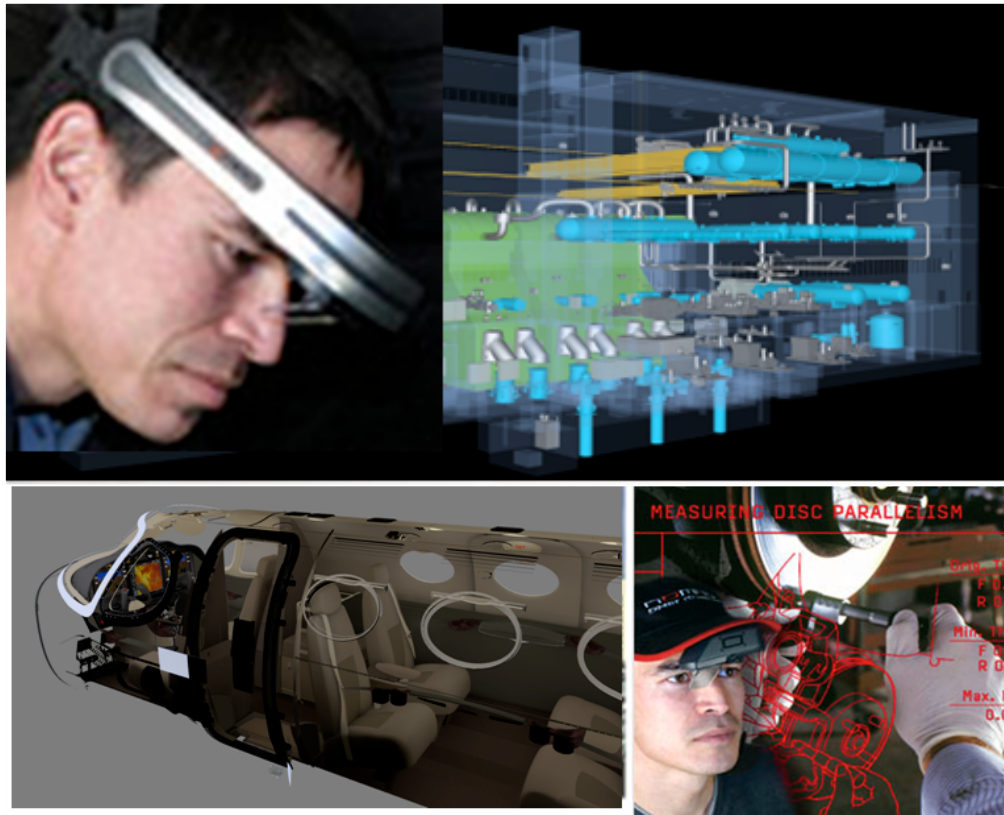
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EON I-Portal Hardware Devices:
Displays, 3D Eyewear, High precision GPS, 3D tracking Devices, tablet PC, UMPC
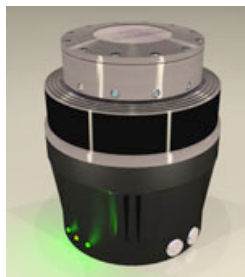
Convergence of technology

Virtual reality

web and search

Artificial intelligence

Digital content
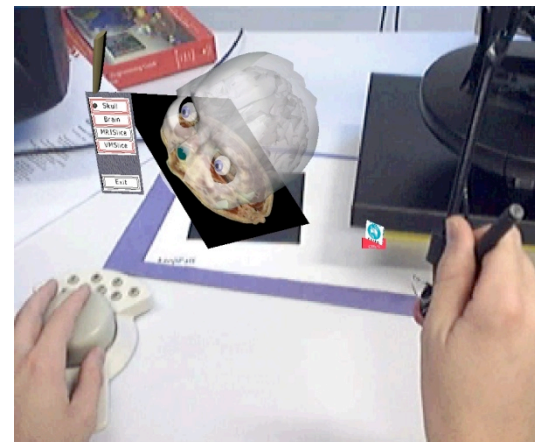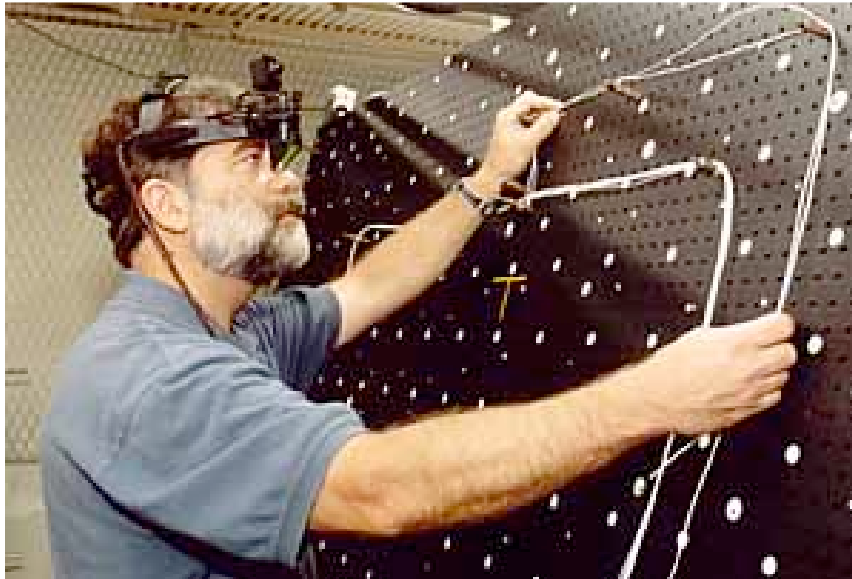
EON I-Portal Tablet PC	EON I-Portal Ultra Mobile PC	EON I-Portal Head Mounted Display	EON I-Portal 3D Video Phone	EON I-Portal 3D Glasses	EON I-Portal Mobile Online Mixed Reality RFID Tagged
Who: **Target Market, Customers & Partners**	Hardware suppliers (Intel, Samsung, Sony, Toshiba, Lenovo) Service providers (MTV, SK Telecom, Myspace) Gaming Companies Tourism, location based Information & Cultural Heritage Enhanced sightseeing : labels or any text related to the objects/places seen, rebuilt ruins, building or even landscape as seen in the past. Combined with a wireless network the amount of data displayed is limitless (encyclopedic articles, news, etc...).	IPCM Companies Construction & Infrastructure - Interactive three-dimensional buildings/maps that could be collaboratively modified and analyzed (e.g., for prospecting) Medical -Visualization of hidden features (e.g., a doctor could "see" the fetus inside the mother's womb) Industrial / Aerospace Installation & Support Assisting difficult tasks (e.g., the system could "label" the parts of a system in order to facilitate the mechanic's work Media & publications Entertainment on Line	Teleconferencing with both real and virtual participants Webex/ Cisco AOL Yahoo Skype Myspace MTV & music artists SBL	Entertainment (allowing computer-generated imagery to interact with live entertainers) Games	AOL Google Yahoo MySpace

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Job Requirements for the Project Manager

Requirements for a Project Manager at the Daegu Global R&D Collaboration Center

Walt Scacchi

Game Culture and Technology Laboratory

University of California, Irvine

Irvine, CA 92697-3455 USA

June 2007

Our objective is to set things up so that the person who serves the UCI-Daegu Global R&D Collaboration Center Project Manager can "hit the ground running" when he/she arrives in Daegu. Considering the short time frame, we don't what to be distracted by administrative issues, except those necessary to insure the ability to work and live comfortably in Daegu. We want the PM to be able to concentrate on the actual research project work.

Also, we need to have a firm foundation about decision-making boundaries and authority that may be required on some important project issue. The PM needs to be free to make technical or research project decisions, including resource allocations and staff assignment recommendations, without fear of that affecting the PM's personal situation.

Last, since the PM is not expected to speak or read Korean, then assistance will be provided to the PM to make sure there are no communications boundaries or limitations that might inhibit their work on this research project, or their living and traveling within or around Daegu.

The specifications of the Project Manager (PM) of Daegu Global R&D Collaboration Center at DIP (hereafter the DIP Center):

Duties

- Managing communications between DIP and UCI as a representative of UCI Game Lab
- Connecting UCI research topics which will be studied in Irvine to Company A's projects in Daegu

Competencies

- Communication: Strong communication (spoken and written) skills, including the ability to advice on collaborations people in different organizations
- Planning and Organizing: Ability to organize, plan and implement work assignments
- Professionalism: Research background and advanced degree (M.S./Ph.D.) in Computer Science, Game Design, or Software Engineering

In order to insure the person selected as the PM (or interim PM) can relocate to Daegu to enact the responsibilities and competencies identified above, the following are non-negotiable requirements for the PM position:

1. *Pre-paid transportation to Korea and back*, plus transportation to and from the airport in Daegu.
   1. Airline tickets for one round trip between California (or other US home base) and Daegu will be offered to PM or interim PM.
   2. Local transportation in Daegu to/from airport will be provided by the DIP Center.

2. *Direct billed or pre-paid housing*. The PM should not be responsible for finding housing. As such, housing should be pre-arranged and ready upon arrival (though some time to stay at a hotel may be appropriate, if needed).
   1. DIP will not cover housing cost of PM. However, DIP can introduce a fully furnished one-bedroom apartment.
   2. PM's administrative assistant will provide necessary support to insure arrangements for PM housing, and also assist in arranging monthly payment for housing by the PM or interim PM.
   3. Housing is desired in area where there are other English speakers or international visitors.

3. *Full-time English-speaking administrative assistant* who will assist the PM with administrative and organizational issues associated with our project tasks, and provide written or verbal translation services as necessary to work with others in Daegu, DIP, or Korean faculty and students who may be collaborators on the research project.

4. *English-speaking personal assistant to provide "concierge" services* for dealing with daily life in Daegu. This does not need to be full-time, but it does have to be frequent (several days a week for the duration). It may be part of the work responsibilities of the administrative assistant, unless someone else is specifically designated for this position.

5. *Annual salary* would be about 125 million won.
   1. Korean taxes and other required insurance fees would be around 15% of the salary.
   2. Monthly salary of 1/12 of 125 million won (approximately 10,416,667 won), and will be paid to the PM (or interim PM) on a monthly basis.

6. *Paid vacation* for the PM shall be *one month per 12 months worked*, or pro-rated for shorter periods.
   1. PM shall also benefit from and enjoy *paid time off for national holidays* celebrated in Korea.

7. PM will be expected to travel to and participate in international or domestic conferences related to his/her expertise in computer science, game design, or software engineering, as a representative of the DIP Center. Up to four conference trips per year may be expected, with travel/expenses to and from such conferences paid by the DIP Center.

8. PM will also be expected to travel to Irvine, CA for meeting with research project staff 2-4 times/year, with travel/expenses to and from Irvine paid by the DIP Center. PM should also be provided with routine access to videoconferencing facilities at the DIP Center.

9. *PM will be provided with a personal computer* of his/her choice and configuration connected to the Internet at the DIP Center. The interim PM will be expected to provide his/her own PC.

10. *Explicit, detailed assistance with Korean tax, health care benefits, and visa requirements:*
    1. It will approximately take little less than one month to get E7 Visa. The cost of the visa process will be paid to PM in won when he/she starts working in Daegu.

Other negotiable requirements:

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1. *English speaking tour guide*. The PM will be interested in learning about both local and national Korean culture and history, so having someone to show these off would be great.
2. Driver with car in support of business travel within Daegu, or to other destinations nearby, unless taxi service is provided, or municipal travel on buses, underground or surface rail is available when assisted by the PM's administrative assistant.
3. Housekeeper/cook, or equivalent who can provide regular assistance with food purchasing and preparation or similar.

This is a list of questions for the interview.

1. Why did you apply to the interim PM position in Daegu?

2. How do you think of Korea?

3. Do you know about Korea game industry?

4. How do you think you can give benefits to our game companies, using your specialty?

5. Why do you intend to quit your current job?

6. Can you speak any language besides English?

7. What is your philosophy of life?

I got his CV from his Web site. Please tell us if he has questions to us by email. Anyway, I'll try to call you 4pm on Monday in your time.

Thanks,

Lee, Hong-Hee
Deputy General Manager
Contents Business Department

Daegu Digital Industry Promotion Agency
H.Q. 2F, 2139 Daemyung-Dong, Nam-Gu,
Daegu, Korea 705 701
Telephone: (82-53) 655-0611
Fax: (82-53) 655-7052
Email: hlee@dip.or.kr

Multi-Core Game Technologies and Scenarios

Notes on scenarios that envision potential capabilities for multi-core processing support
for Computer Games and and Persistent Online Virtual Worlds in 2010-2012

Walt Scacchi
Game Culture and Technology Laboratory
University of California, Irvine
Irvine, CA 92697-3455
20 June 2007

The starting assumption we make is that computer games and virtual worlds like *Second Life* are currently limited to a conventional single processor-based computing architecture. In the future 3-5 years forward, we anticipate that an alternative computing architecture in the form of multi-core processors that may include 32-128 cores will become more widely available, and thus become the processing architecture of choice for computer games and virtual worlds like Second Life. This situation however will likely change both the ways how such games and worlds are developed, and also the kinds of processing capabilities and game-play mechanisms that may be supported.

With this in mind, we begin by identifying a number of possible scenarios for computer games and virtual worlds that assume, exploit, or otherwise require the existing of multi-core processing architectures, with the number of cores possible spanning 32-128. These scenarios are numbered for identification purposes only, and not to indicate a priority or preference.

1. Games or virtual worlds (GVWs) that provide higher resolution of visual realism than currently available—from flat shaded polygonal forms and textures to photo-realistic forms, surfaces, reflectances, shadows, etc. For example, this might entail the use of ray-tracing visualization pipelines or other rendering methods that are amenable massive or multi-core parallelism.
2. GVWs that provide higher resolution of object-centered physical realism than currently available—from simple physical forces and displacement/movement mechanics to complex physical behaviors and dynamic interactions between reactive/deformable objects. For example, this might entail the use of object-centered physical modeling that internalize externally observable (visual) behavior with some internal mechanism (e.g., game characters or avatars with "muscles" that compress or stretch in response to physical loads, and thus display deformable body/muscle contours). Such physical modeling techniques are amenable to massive or multi-core parallelism.
3. GVWs that provide higher resolution of complex multi-object behaviors than currently available—from simple or no "collision detection" when objects/avatars touch (or unintentionally "pass through" one another) to complex collisions between objects that may result in the object/avatars being fractured, deformed, or shattered into pieces in ways similar to real-world collisions among physical objects (e.g., dropping a glass of water should both spill/disperse the water in a fluid manner, as well as fracture the glass into pieces who flying shards may follow trajectories

determined by the glass's mass, velocity, angle of incidence with object/surface of collision, deformation/resilience (firmness) of the collision object surface, etc. Such physical collision modeling techniques are amenable to massive or multi-core parallelism.

4. GVWs where game characters/avatars are able to coordinate their gaze direction and visualize emotional states. Most game characters or avatars are unable to "look into the eyes" of others that can gaze back—they lack the ability to be able to look eye-to-eye. This in turn reduces or inhibits the conveyance of emotional expressions like attraction, interest, dis-interest, fear, etc. Instead, game characters/avatars act more like lifeless dolls whose visual expression or appearance is persistent, as well as un-reactive to presence of others. Game characters and avatars lack the ability to perform "gaze tracing" (like ray-tracing from the eyes outward into the surrounding world or towards others nearby) that can require eye movements, as well as head movement (e.g., head turns, nodding), and coordinated facial expressions (smiling, frowning, grimacing, etc.). Such visualization and coordination of visual gaze and emotional expression among multiple interacting game characters or avatars requires techniques amenable to multi-core, multi-tasking or multi-processing.

5. Same as 4, but with the gaze direction determined through computer vision techniques that employ digital cameras that monitor human player gaze direction, facial expression, head movement, etc. This also requires techniques amenable to multi-core, multi-tasking or multi-processing.

6. GVWs that support persistent (semi-) autonomous bots, avatars, or game characters with internal mental state, disposition, ability to act with discretion, self-identity, resources and game-play capabilities. In MMOGs like *World of Warcraft*, common game play entails groups of players acting as teams or clans engaging in shared quests or competitive battles against other teams/clans. Each quest/battle currently entails a multi-processing game play experience where each human's in-game character is guided, controlled, and monitored through a client-specific view port on a human players computer. If a battle entails two clans each with 16 human players, then there are 32 in-game characters, each associated with a human (client-side) computer (hence 32 processing cores) whose collective action (the articulated battle with emergent outcome) is coordinated and synchronized through a shared server. Here, we simply envision a scenario whereby the human player can experience a similar game-play experience with one or more teams/clans of (semi-) autonomous, artificially intelligent in-game character bots that are capable of believable role-based game play. Each in-game character/bot thus requires or benefits from at least one dedicated processing core to control and monitor the AI-based game-play behavior in a multi-bot (or mixed multi-bot, multi-human) game battle. Further, associated with each game character bot may be a persistent viewport that can record game-play experience from the perspective of an individual bot, thereby enable a kind of multi-channel concurrent "game camming", replay, or machinima capability.

7. Similar to 6, but where the bots now have "enterprise skills" or "business AI capabilities". In this regard, a game player can create, instantiate, or customize their own virtual enterprise as a collective of multiple bots (agents or actors) that can be collectively tasked to perform "administrative services" or similar, depending on the AI that the bots are programmed to perform. This would draw on known methods for

multi-agent process enactment, which has been used in computational studies of complex organizations. As before, each bot/agent requires a dedicated processing core for its AI, and perhaps zero or more additional cores for management of their visual appearance, physical behavior, etc.

8. GVWs that support or require interoperable multi-system commerce. For example, in a VW where a player can shop in-world for objects to acquire and purchase with a real-world payment instrument (e.g., credit card), payment processing may be performed in one or more systems that are external to the VW. The goal however is to maintain a seamless end-user/player experience. For instance, if a young person is shopping in a retail clothing store depicted in an online world like "Virtual Laguna Beach" and finds a object to acquire (e.g., "a nice shirt"), but requires a credit card (which they don't have, but their parent does), then the young person would like to be able to contact their parent from within the GVW, request and receive a credit card purchase authorization (perhaps after some negotiation via instant messaging), then take possession of the in-world object (put the new shirt on the young person's avatar). Such a capability requires multi-tasking, multi-system coordination, and network transactions that might best be enacted, managed, and tracked (e.g., for non-repudiation purposes) by multiple processors on the server side, or possibly on the client side.

9. GVWs that support multiple game engines for graphics, physics, AI, audio, networking, etc.

10. GVWs that support multiple physical game engines for physics, chemistry, biology, psychology, sociology, cosmology, etc. that span multiple levels of physical realism (from micro to macro).

11. Physically embodied user interfaces from heterogeneous devices to GVWs, such as SL to cell phones, computer-controlled musical instruments, scientific instruments (remote telescopes that capture images that are digitally pasted into a virtual sky on-demand).

Story Synopsis

Alex Szeto and Walt Scacchi
29 June 2007

Characters:

Alice – 17, female. Avatar has long hair, medium build, and has a preference to dress in themed clothing. Short tempered and flirtatious. In real life, she has short hair and dresses normally.

Roberto – 23, male. Avatar participates in role-playing and occasionally dresses in fantasy garbs, sometimes as monsters or monstrous humanoids. Is a builder in game and therefore knows how to create objects from scratch. In real life, he's a recent college graduate and has a regular office job.

Plot Summary:

The story mostly takes place inside a near future virtual world. Alice, who had previously set up a date with Roberto, shows up at the waiting spot. Her date is nowhere to be found. Frustrated, she immediately calls Robert on her cell phone in real life.

Instead of answering the call directly, Roberto's avatar flies to the island, surprising Alice. Roberto apologizes, stating that he is logging in through his cell phone and he is still on the drive home. Moments later, Roberto is sitting on his desktop and assumes full control of his avatar. The two exchanged a brief greeting before setting off again to prepare for the date.

Alice spends the time rummaging through her wardrobe for a space suit. Short on virtual cash, she gives a quick call to her mother, who authorizes her in-game purchase remotely.

At the same time, Roberto puts the finishing touch to his restaurant prototype, fine tuning the table arrangements through a natural language interface and imports recently published data from NASA to complete the virtual landscape.

Alice drops by on Roberto's restaurant and the two shares a virtual meal. The two muse over the computer controlled waiter, who contains the personality profile of one of Roberto's friends in his role playing club.

After dinner, the two prepares to head off and Alice gives Roberto a quick peck on the cheek. Roberto takes off, and Alice leaves her avatar to find her next date as she walks off in real life for a shower.

Storyboard and Dialog Script

Alex Szeto and Walt Scacchi
29 June 2007

{Fades in title}

{Fades into an outdoor scene with rolling mountains in the background and floating islands high in the sky over the horizon. A tree is sitting on top of one of the islands in the foreground. Several generic avatars fly by in the landscape in the background, and several more continues to do so as the scene progress}

{Alice flies over the island and lands under the tree. She raises her right hand and opens her palm, and a digital panel appears, clearly indicating the time as 8:07}

Frame 1: Alice waits for Roberto

Alice: *{clearly annoyed}* I can't believe he's late again. I swear…

{Cuts to a shot of Alice in real life behind the computer monitor. She picks up the cell phone on the desk and makes a call}

Frame 2: Alice makes a call to Roberto on the cell phone

Alice: *{speaking to the cell phone}* Rob, where in the world are you? You're late again. Log yourself in already!

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{Cuts back into the virtual world. Roberto, who appears as an ogre, flies down and lands behind the tree, and does a quick hand wave}

Frame 2: Roberto logs in through cell phone, surprises Alice

Roberto: Hey.

Alice: *{turns around}* It's about time.

Roberto: Sorry about that, traffic is really bad today and I'm still on my way home.

Alice: Never mind that this is the third time that you're showing up late. What's with the ogre model?

Roberto: *{looks down at his own avatar for a second}* Oh this? I've been botting for my role playing group lately. My bot must have switched my model. Kind of hard for me to swap models here, you know.

Alice: You're logged in from your cell phone right now?

{The Roberto avatar stands motionless for a short moment, and then becomes active again. Roberto's avatar is now more fluid, similar to how Alice's avatar acts}

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Roberto: Yeah. Hands free, of course. Give me a second; I'm pulling into the driveway right now. See you in a bit.

{The screen splits into two parts as a shot of Roberto in real life is panned in from the right. Robert's facial expression is clearly mapped to his avatar inside the virtual world}
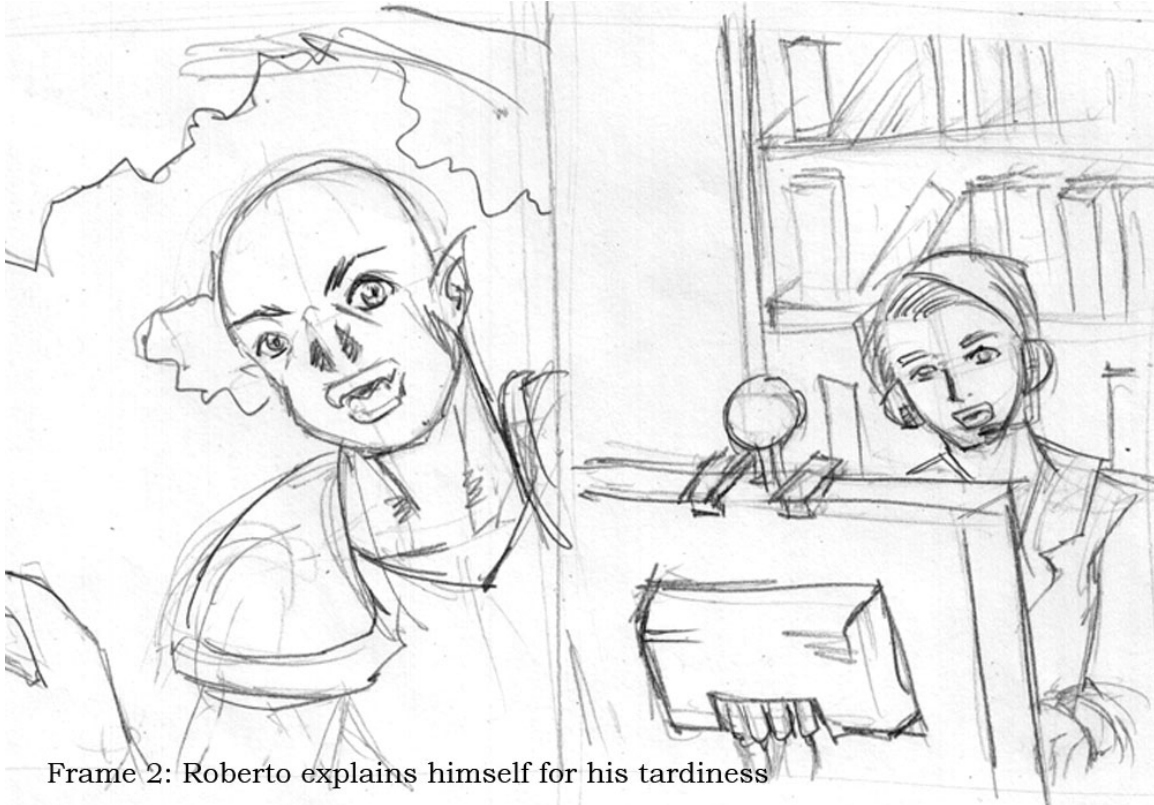
Frame 2: Roberto explains himself for his tardiness

Roberto: Alright, I'm on.

Alice: What's the plan for tonight?

Roberto: I was following on the NASA Website earlier today and they have just released the model data from their Mars exploration. I'll get my restaurant set up right away if you can give me a few minutes. When I'm done, I'll give you a quick call and you can come over. Sound good?

Alice: Sure! I've always wanted to see how the place looks like. I think I'll get myself a new suit just for the occasion.

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{Cuts to a shot of Alice's wardrobe, a space filled with mannequins that look like Alice's avatar, dressed in different outfits}

Frame 5: Alice buys a new outfit for dinner

Alice: Let's see if I can get something that fits the theme. Let's see, space uniforms…

{Alice's avatar flies through the wardrobe over multiple mannequins into the space suit section. She settles on one of the outfits and looks at the price tag}

Alice: Ouch. I can't afford that! Better call for help.

{Cuts to a shot of Alice behind the screen again. The avatar's action on the computer monitor is also clearly visible}

Alice: *{already on the phone}* Mom? It's me again. *{pauses}* It's not really that expensive… *{pauses}* Well, you did say that if I get an A on Chemistry… *{pauses}*

{The word "transaction authorized" appears in large print across the screen}

Alice: Thanks mom!

5

{Cuts to a shot of Roberto standing alone inside a restaurant. The restaurant appears to be floating in space, although the background is pitch black}

Roberto: *{In front of a dining table}* Probably can use some flowers.

{A bouquet of flowers appears}

Roberto: … flowers in a vase.

{The flowers are now neatly arranged in a porcelain vase}

Roberto: … umm, how about a clay vase? Earthy tones please.

{The vase looks as if it's made of clay and has a dull, natural looking brown color}

Roberto: and roses on top.

{The random assortment of flowers in the vase becomes a dozen roses}

Roberto: and finally, with a little help from NASA…

{Objects begin to load up in the background and appear one by one. When everything finishes loading, it appears that the restaurant is orbiting around Mars}

Roberto: *{Raises both of his hands and opens up a dialog panel. Alice's avatar appears in the panel}* Are you ready?

Alice: Sure. I'll be over in a minute.

{Roberto closes the dialog panel.}

{The empty restaurant begins to get populated with avatars, including staff and customers. Finally, Alice teleports into a spot near Roberto}

Alice: *{looks around}* bots?

Roberto: Yeah. They'll do for now. I think I'm going to convert half of the place into a night club in the end – I'll get more customers that way.

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{Roberto motions Alice to get seated. The both sit down. A waiter immediately walks over}

Frame 6: Roberto and Alice shares dinner in the newly created restaurant

Jason: Good evening. My name is Jason, and I will be your server today. What would you like to start with this evening? Something to drink?

Alice: Actually, nothing, thanks. I've spent my lot on my outfit today.

Roberto: Spaghetti and meatball, and a coke please. Just charge it straight to my debit dollars account.

Jason: Of course. Your meal should arrive in about 30 minutes. *{walks away}*

Alice: Don't you wish you can have the food poofed right in front of you when you order meals online? I swear, life is so much easier if you can really live in this world.

Roberto: I've always thought that it's the wait that makes the food tastes good, though. By the way, I saw how you are looking at the waiter – you're going to hook up with him later, aren't you?

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Alice: What, him? *{Takes a peek at Jason, who is now behind her}* Nah. Nice hair though.

Roberto: I thought you'd like him - he's from my role-playing group. He's half a world away so I've never been online with him, but I chatted with his bot every now and then. He had a pretty charming personality profile set up so I thought I'd bring him over. I think I've made a pretty good choice myself.

Alice: I think so too. Speaking of which… *{fades}*

{Fades to a street scene in a futuristic urban city. Neon shop signs decorate the shops and various other players are either walking around or flying overhead}

{Roberto and Alice flies down and lands on the street}

Frame 7: Roberto and Alice bids each other goodbye

Alice: Well, that was fun. I need to log off in a second though.

Roberto: *Okay. Come and check back any time you like. That restaurant should be open soon.*

{Close up of Roberto and Alice}

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Alice: Sure. Thanks for the great time.

{Alice's avatar leans forward and gives Roberto's avatar a peck on the cheek}

Frame 8: Alice leaves a parting gift

Roberto: Good night.

Alice: Good night.

{Roberto's and Alice's avatars teleport out of the scene}

{Alice teleports herself back under the tree between the floating islands. The background changed into that of a night sky}

Alice: That was tedious. Let's see if I can hook up with someone who wouldn't be late for once…

{A dozen or so panels appears and start rotating around Alice's avatar, a portrait of an avatar on each of the panels. The camera zooms out slowly to reveal the rest of the room. The Alice in the computer screen stands up, wraps her necks in a tower, and appears ready to go off and take a shower}
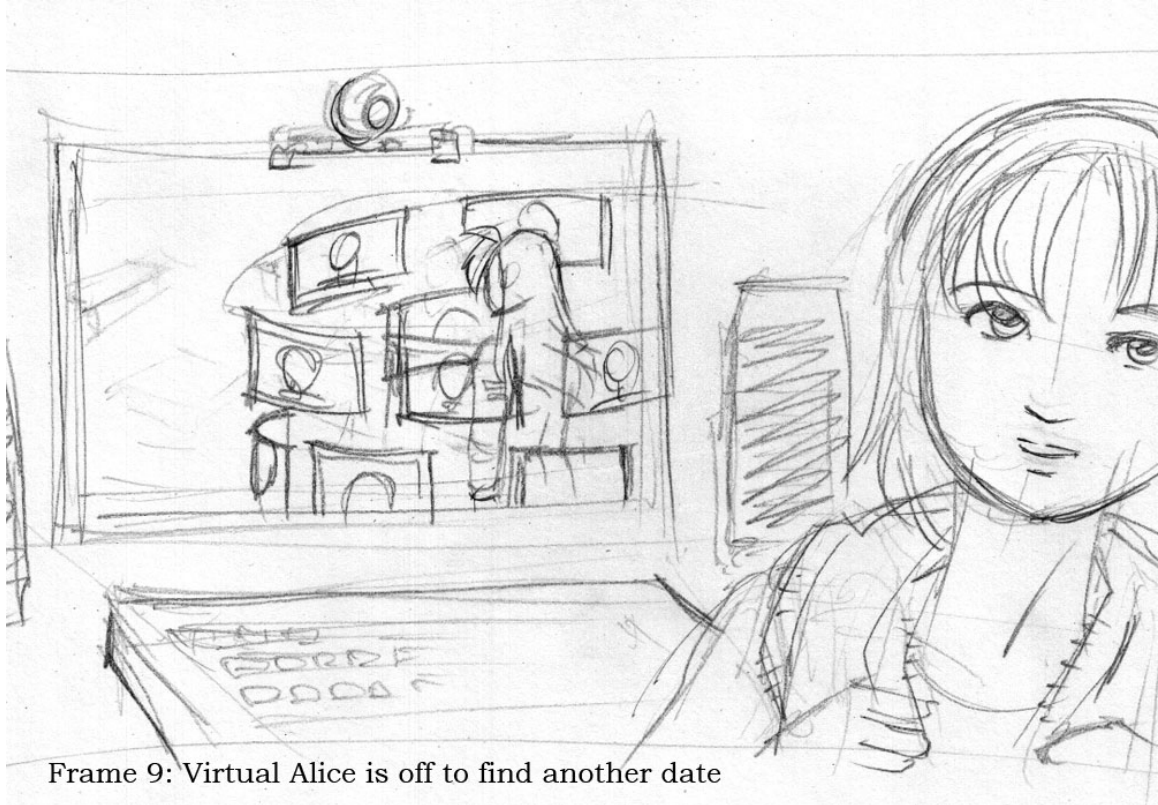
Frame 9: Virtual Alice is off to find another date

{Fades out. Roll credit}

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Technical Details for Multi-Core Processing Concepts in Storyboard

Alex Szeto and Walt Scacchi
29 June 2007

The following guide is a list of technical details associated with each section of the story, separated by the preliminary storyboard images. Each frame/scene has a brief explanation of the plot elements that are associated with the scene. It is followed by any technical details that are demonstrated up to that point.

Frame 1: Alice waits for Roberto

Scene 1: Alice (through her avatar) waits on the floating island for Roberto, then realizes that Roberto is late.

Virtual Worlds in 2010: Virtual worlds in 2010 will become a central hub for all forms of mediated communications. The virtual worlds become the primary means for users of the Internet to obtain news, meet friends, play games, etc. Virtual worlds in 2010 will look and feel much more realistic due to the widespread use of multi-core processors in home computer systems.

1

Projected Panels in Virtual Space: An extension of the traditional heads up display (HUD), projected panels allow virtual world users to display and share multimedia content such as videos, web pages, and other custom content effortlessly through the virtual world environment.

Frame 2: Alice makes a call to Roberto on the cell phone

Scene 2: Alice makes a call from the real world to contact Roberto.

Heterogeneous Connections to the Virtual World: In the virtual worlds of the future, mobile devices, especially smart phones, can easily connect to the data associated with the virtual world, or even the virtual world itself.

Frame 2: Roberto logs in through cell phone, surprises Alice

Scene 3: Roberto replies to Alice's phone call inside the virtual world through an avatar.

Behavior Engine: With the availability of multi-core processors to the average consumer, virtual worlds and other programs can now dedicate processing power to a special behavior engine, supported by special hardware. One of the primary functions of this special behavior engine is to collect user behavior over time while the user is online. This in turn creates a personal profile database that can be utilized in multiple ways.

Computer Assisted Avatar Control: With a functional personal profile database, a user can log on to a virtual world remotely through devices that provide limited control interfaces. For example, a user can log into the virtual world using a cellular phone, which limits his or her control to simple key inputs and voice based commands. The user can issue simple commands through this limited interface, which gets combined with matching action patterns from the personality profile database to produce more elaborate gestures with the user's avatar. This in turn facilitates better human interactions, even though a limited interface.

3
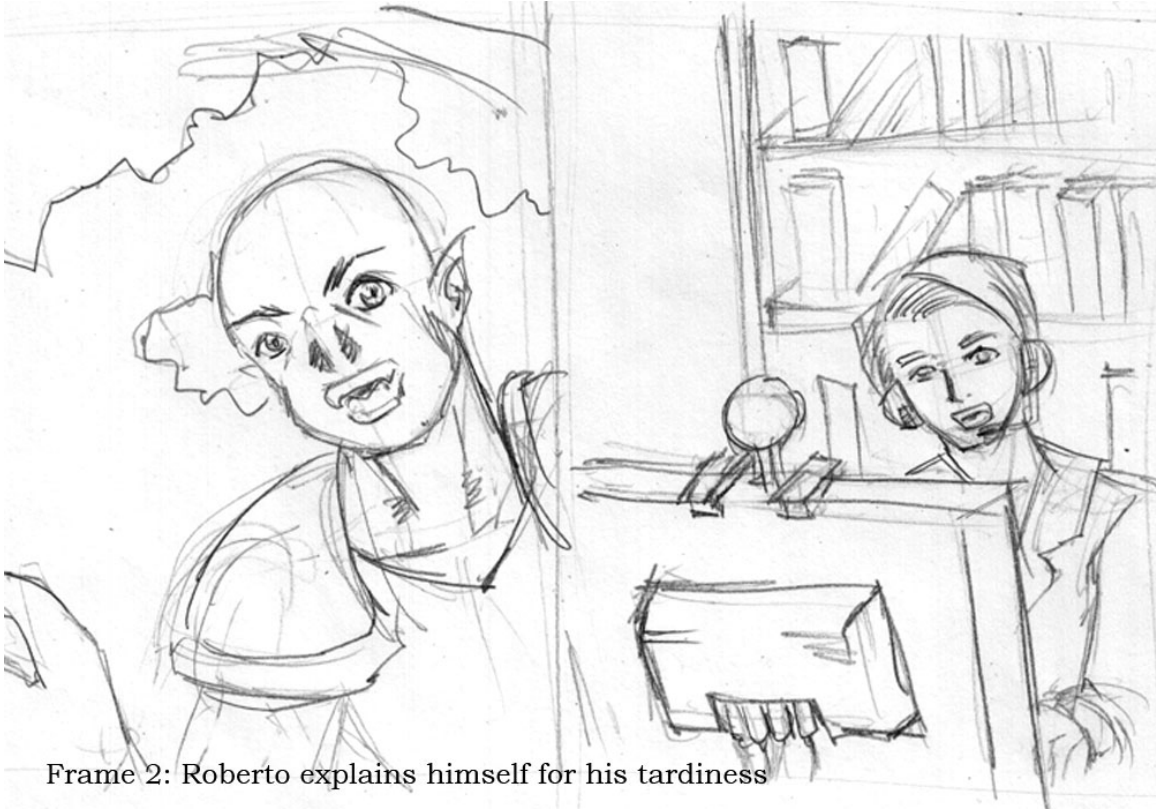
Frame 2: Roberto explains himself for his tardiness

Scene 4: Robert chats away as a Web-cam captures his facial expressions and map those emotions directly to his avatar.

Facial Expression Analysis: The processing power of a multi-core processor allows end users to run CPU intensive operations such as real time image analysis. This in turn generates a mapping of facial muscles that create the facial expression on the avatar as well as an accurate representation of the gaze direction of the eye, since direct eye contact is a key part of any face-to-face conversations.

4

Frame 5: Alice buys a new outfit for dinner

Scene 5: Alice attends to her wardrobe and asks for her mother's permission for a real-time online purchase authorization.

Algorithmically Generated One-Time Use Encryption Key: Transactions in the virtual worlds in 2010 are easier to make, more versatile, and more accessible because of better encryption schemes. Parents can now authorize purchases through single-use encryption keys, an encryption schematic that gets generated algorithmically and discarded when the transaction is finished. This allows parents to provide one-time authorization and access to a remote credit/debit card account, without directly exposing the card account number, while providing a brief time-to-live transaction authorization.

5

Frame 6: Roberto and Alice shares dinner in the newly created restaurant

Scene 6: Roberto customizes his restaurant using natural language and real world data, and shares a meal with Alice with a computer controlled waiter bot named Jason.

Natural Language Processing: Virtual world servers in the future can dedicate more processing power to the analysis of user created content. Eventually, the virtual world would have a database of word associated links to various models, textures, and positioning schemes that allows for faster content generation.

Real World Data Incorporation: In the near future, as more and more real world data becomes publicly available, one of the more interesting methods to visualize such data is to generate three dimensional graphical representations of the data. These visualization tools will be used extensively in strategic business planning as well as dynamic educational exploration.

Virtual Avatars (bots): In lieu of using Web pages to expose a user's presence on the Internet while the user is off-line, virtual avatars, or bots, are computer controlled avatars that serves as interactive profiles for other users to interact with in simple ways. While bots are not fully self-conscious entities, they are capable of adapting a scripted role base on another user's input. However, these virtual avatars are made unique by the

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application of their user's personality profile databases, which provides each bot with unique gestures and reaction patterns that differ from one another, even if the base script for the bots are identical. These bots in virtual worlds serve two obvious purposes: one, to allow complex avatars to serve otherwise mundane occupations in a virtual world that is uninteresting to most users, and to provide another natural conduit for interaction between users, even when a direct user to user connection is not available.

Real Life Merchandise Through Online Purchase: Expanding upon existing ideas, the virtual world provides a much better representation of most products, allowing the user to be better informed about the products and make wiser, more satisfactory purchases online. Beyond virtual goods, daily necessities such as food and groceries can also be purchases through virtual worlds.

Frame 7: Roberto and Alice bids each other goodbye

7

Frame 8: Alice leaves a parting gift

Scene 7: Alice's and Roberto's avatar decide to end their virtual date, and Alice's avatar give Roberto's a quick peck on the cheek before the two part ways.

Level of Details Scaling: While the idea of dynamic level of detail scaling is not a new concept, the future virtual worlds can take the basic idea to a whole new level by delegating specific amounts of processing to minute details based on proximity. With a multi-core based system, these levels of detail scaling can now apply to physics and behaviors on top of rendering graphics. It allows the processor to calculate the location and collision models of facial polygons while keeping other processors to manage less important details such as rendering the world around the avatars.

8

Frame 9: Virtual Alice is off to find another date
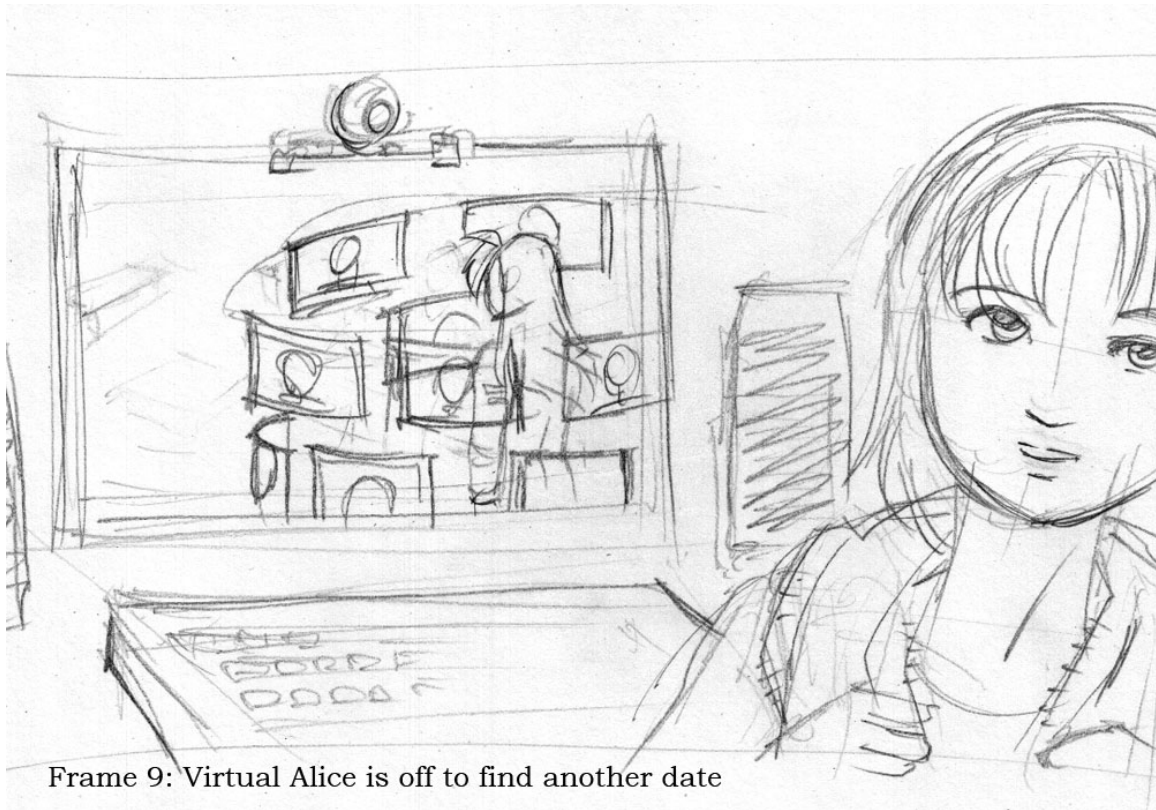
Scene 9: Alice returns to the point where she started, and logs off as she leaves her bot to look for another date.

More Virtual Avatar Uses: One of the other uses for virtual avatars is to run it as a simple agent to perform time consuming tasks that requires data from the virtual world.

Matchmaking Via Personality Profile Database: One other use of the personality profile database is to use it as a baseline for searching users of similar interest in order to form groups of any size for events such as games, parties, or interpersonal relationships. A full personality profile database can provide the matchmaking service with much more usable data than current single point systems such as ladder ranking, and ensure that the end user experience is overall more positive than it currently is.

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Online-Mobile Game Research Agenda

Developing a Research Agenda for Generation-Beyond-Next Computer Games: Online and Mobile Games

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Version of 30 June 2007

Overview

This document seeks to initially capture and articulate a set of concepts that can serve as a foundation for developing a research agenda for multi-player computer games delivered on-line or to mobile devices anticipated for three-to-five years forward (2010-2012). Our understanding of what the computer game technology will be by 2012 is influenced in part by our research relationship and public information disclosures from our research partners such as at Intel's Microtechnology Research Laboratory, at Linden Labs (developers of the *Second Life* virtual world), our recent game development projects (with the Discovery Science Center, in Santa Ana, CA http://www.ics.uci.edu/~wscacchi/Papers/New/Calit2-Interface-DinoQuest-Fall06.pdf), and from research symposia we have held here at UC Irvine in the past year or so (see http://www.isr.uci.edu/events/massive/, http://www.calit2.net/events/ignitingtechnology/) with other game researchers in industry and academia. We are also influenced by the opportunities and needs that emerge from our partnership with the Digital Industry Promotion (DIP) agency and the Daegu Global R&D Collaboration Center, both in Daegu, Korea. Last, we are similarly influenced by our related research studies in areas like open source software development, sponsored by the U.S. National Science Foundation.

Overall, we believe that the future of computer game development will be influenced and constrained by a number of emerging trends. These trends include (a) the exponentially increasing cost of developing top-tier computer games (games with development budgets in the US$20M-$75M range, potentially growing beyond $40M-$100M by 2012); (b) the shrinking margins of profitability for games (especially console games) that are modestly successful, but not major successes, in the marketplace, due to high publication or distribution fees; (c) advances in microprocessor technology that anticipate the transition to multi-core processors with 8-128 parallel processing cores, within the next 3-5 years (along with PC memories growing to 4-64GB, and disk storage growing to 4-32 TB) as the basis for personal (desktop) computers for game play; (d) the growing demand for game developers (either in the technical or creative arts) such that there is a likelihood of a permanent shortage of game developers in the U.S. by 2012 (thereby further driving up the cost of game development); and (e) the growing economic value of games in national economies, as well as the growth of game-based economic systems with market valuations measured in billions of dollars, all giving rise to massive coordinated attacks on the (in)security of these game-based systems and economies. Thus, our research

efforts must be framed to in some way address these trends. Otherwise, to ignore these trends and to focus only on current game development, deployment, and support technologies likely to be in the market in 2008-2009 would be shortsighted and ultimately of limited value.

Our strategy at this point is to first articulate what we can call the "game technology stack", that is, the sequence of hardware and software technologies that should be included or addressed in some way in developing a research agenda for advanced generations of multi-player computer games. At a later time, we will address other research agenda topics including (a) advanced game development tools, (b) new game development processes (e.g., open source software development), (c) new application areas for multi-player computer games, such as "science learning games", business and new venture startup games, games for education (elementary, intermediate, secondary, college, and post-graduate levels), and game-based scientific research, as well as (d) concepts and techniques for advancing game culture, including (i) international game art festivals, exhibitions, and design competitions, (ii) regional, national, and international game play festivals, (iii) new venues for large-scale game play, such as "stadium-area games", all of which seek to expand broader public interest and markets for advanced computer games.

The game technology stack of interest addresses the following technologies:
- Hardware
- Operating systems
- Networking
- Objects and object/data base management services
- Game engines
- Game genre engines
- Meta-game technologies and development processes
- Device and venue specific games and game play experiences

Each of these technologies is briefly outlined below, and will be further developed and refined in a later version of this report.

Game technology stack (presented in order from bottom to top)
- Hardware platform
  - Processor cores
    - Single CPU
      - Multi-tasking (virtual processing cores)
    - Multi-core
      - Multi-processing
        - Thread/task per core
        - Multi-threads/tasks per core
  - Memory architecture and cache hierarchy
    - Single memory unit (e.g., multiple memory DIMMS) that realize a shared common memory across cores
    - Allocated partition of memory unit/core

- - Memory unit/core (e.g., Graphics card with GPU and on-board texture display memory, or graphic core with memory in the same chip)
  - Storage system
    - Permanent (installed) mass storage (disk drives)
    - Removable mass storage (e.g., flash memory drives)
    - Networked (remote) storage (typically, server-side only)
      - Storage area network
      - Network attached storage
      - JBOD—just a bunch of disk drives
  - Plug-in boards and device controllers
    - Graphics
    - Audio
    - Networking
    - Application-specific
      - Example: Game physics engine card
  - Support for Virtualization and Encapsulation of Operating System(s)
  - Other hardware peripherals (connected through external interfaces, connectors, or plugs/sockets)
    - Digital cameras (still frame, or continuous video streaming)
      - Computer vision system (camera plus image understanding software)
    - Cell phones (with media input sensors)
      - Cameraphones
      - Apple iPhone
      - User input streaming
        - Continuous text (or button click) inputs as game controller
        - Continuous media input as game control device
          - Audio streaming (sampling)
          - Video streaming
      - User streaming input servers (integrated with cell phone network service provider)
    - Gestural input devices
      - Wands (e.g., Ninetendo Wii)
        - InfraRed emitters (like television remote controls)
      - Other real-time position sensing devices or controllers
        - GPS-based positioning for wide-area sensing
        - Indoor GPS or other metrology sensors
    - Televisions and other media players
      - Home consumer devices or appliances that can be used in game play

- Operating system (Native vs. Game-based)
  - Capabilities (OS software capability architecture)

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- Security services (May need to be invoked/managed by installed Game)
  - Access control and Authentication
    - User identity management
      - Accounts and passwords
        - Persistent
        - On-demand (user-requested)
        - Automatically generated (virtual user-requested)
      - Password/Key management
    - User capabilities
      - Application invocation
      - (Remote) service invocation
  - Encryption/Decryption
    - Key management
      - Persistent keys
      - On-demand keys
      - Remotely administered keys
    - Ciphers (encryption algorithms)
      - User created
      - Automatically generated
      - Remote generation
  - Vulnerability/Exploit (including data corruption) management
    - Exploit Detection
      - Networked notification services
      - Exploit signature download
    - Isolation
      - Exploit location (pattern matching)
      - Exploit isolation
    - Exploit removal
    - Vulnerability patching
- Privacy management
  - See authentication and encryption/decryption
  - Spyware detection
  - Spyware removal
  - Spyware prevention
- Remote (server-side) administration
  - Access control and authentication regime
  - Remote client installation services
  - Remote client monitoring services
  - Remote client service deallocation or deauthorization
- Resource allocation
  - Memory management
  - Device/peripheral I/O coordination and scheduling
    - Query Manager

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- - - Query formation and optimization
  - - Response payload processing
  - o Networking services
    - Client-side
      - Request servicing
      - Response provisioning
    - (Remote) Server-side services
      - Request servicing
      - Response provisioning

- Networking
  - o Native hardware access control vs. virtualized machine
  - o Networking-based capabilities and security services

- Game objects and object database management service
  - o Games require and manage in-game objects
    - "Game objects" are software components for constructing and implementing games, game engines, or game services
    - Game objects are similar to "business objects" that may be realized using software technologies like "Enterprise Java Beans" rather than simple Java object/class constructs
  - o Common game object types
    - User-player characters
    - Non-player characters
    - Other game play objects
      - Player controlled
      - Non-player controlled
      - Game controlled (object not controlled by player)
      - Non-mutable game objects (established and fixed during game design or generated instantiation)
    - Game level or terrain map
  - o Game play object attributes
    - Location
      - Static
      - Bounded
      - Movable to selected in-game location(s)
    - Object appearance
      - Object skeleton (rigging armature(s))
        - o Composable/decomposable armatures required for objects that can be assembled or disassembled (fractured, destroyed, blown-up, etc.) during game play
        - o Transformable armatures required for objects that can be morphologically changed

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- o Skeletal movement determined by object behavior
  - Object geometric volume(s)
    - o Composable/decomposable (as above)
    - o Transformable
    - o Volume determined by object behavior with respect to object skeleton
  - Object volume surface textures or decals
    - o Support for layered/exchangeable visual appearance assets or asset kits (role-based or location-based object decorations)
    - o Surface textures may be transformed due to animated object behavior
- Object behavior
  - None
    - o Static or fixed objects, such as immutable level objects or game level
    - o Location, skeleton (if any), volume pre-determined
  - Procedural determination (pre-scripted)
    - o Script invocation via triggered event
      - Scripts may invoke other in-game services
      - Location bounded by script
  - Non-procedural
    - o User-guided
    - o Constrained by parameterized script(s))
  - Emergent
    - o Object self-identity (belief-based), role (skill-based), task (process-based) situated behavior reacting to or acting towards object-perceived situations (conditional events and anticipated outcomes)

- Game engines
  - o Single-vs. multi-core engine architecture
  - o Operating System
    - Interfaced to underlying (client-side) OS
    - Game-specific OS service architecture
      - Single core
      - Multi-core
        - o Master-slave
        - o Functionally specialized cores (graphics, AI, etc.)
        - o Distributed multi-agent
          - Single-function agent(s)/cores
          - Multi-function Agent(s)/core(s)
      - Hardware accelerator device control interfaces
        - o Graphics

- o Audio
- o Networking
- o Networking middleware
  - ▪ Data Communications
    - • Protocols
      - o http, smtp, ftp, rtsp, bittorent, etc.
      - o Game engine-specific protocols
    - • Database management system (DBMS)
    - • Software interconnection bus
  - ▪ Data and Meta-Data Representation
    - • Data description language (protocols)
    - • Database schemas (DBMS)
    - • Messages (interconnection bus)
- o Game play environment
  - ▪ End-user I/O services
    - • Keyboard/keypad (or other buttons)
    - • Mouse, mouse-wheel, joystick
    - • Audio (microphone, speakers)
    - • Video (camera, graphic display)
      - o Still images
      - o Video streaming
    - • Network (Internet/Web, LAN
  - ▪ User Interfaces
    - • (Mouse, etc.) Cursor controller
    - • End-user game system I/O configuration and service binding
    - • Game statistics dashboard and gauges
- o Game modification ("mods") capabilities
  - ▪ Object skeletons
  - ▪ Object volumes
  - ▪ Object appearance(s) or costumes
  - ▪ Object behaviors
    - • Script parameters
    - • Re-scripting
    - • Re-generation
  - ▪ Selected/grouped object transformations
  - ▪ Level redesign
  - ▪ Total conversion

- • Game engine genres
  - o Game genre as a family of common game types that form (or conform to) a product-line architecture (PLA)
  - o PLA is determined by a specification and configuration of the game play environment features and capabilities

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- o PLA serves as a coherent basis for managing and controlling the growth of alternative game software system versions (and platform-specific configurations)

- Meta-game technologies and development processes
  - o Game recording and replay mechanisms for creating game-based cinema and "machinima"
    - An important part of future game play will be the ability to either:
      - Record and document game play activities and play sequences so that they can be replayed with complete accuracy, but from different user viewports or viewing perspectives
      - Create hypothetical or prototypical game play scenarios or simulated experiences that can be used to communicate new game or virtual world concepts.
    - Game-based machinima appears to be well-suited for such applications
  - o Software development kits (SDKs) for modifying game objects, creating new objects or assets, or for developing total game conversions
    - Games increasingly provide SDKs that end-users can access and use (at no additional cost) who can then create new game assets, game scenarios, game play experiences, or entirely new games (total conversions) starting from a commercial game and its (proprietary) game engine
    - Games providing SDKs
      - Starcraft
      - Doom, Doom2, Doom3, Quake, QuakeII, QuakeIII, Quake Arena
      - Unreal Tournament (2001, 2004, 2007)
      - NeverWinter Nights
      - And *many others*
  - o Game development middleware
    - Commercial game engines (for action-oriented games)
      - Id Tech 4.0 (from Id Software)
      - Unreal Engine 3.0 (from Epic Megagames)
      - CryTek (from Crysis)
      - Gamebryo (from Emergent Game Technologies)
      - And *many others*
    - Other game middleware engines
      - Audio (e.g., Miles Sound)
      - Physics (e.g., Aegix)
      - Artificial Intelligence (e.g., AI Implant)
    - Virtual reality middleware
      - EON Studio 5.5 (for location or venue-specific games)
  - o Game content/asset servers (or services)
    - Procedural content generators (tools)

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- For generating in-game characters, game play objects, levels, maps or worlds by providing input values (or functional expressions) in pre-determined parameters
  - Non-procedural content generators
    - For generating in-game characters, game play objects, levels, maps or worlds by providing forward or backward chaining rule sets (e.g., "expert systems") that monitor and update objects (or object attributes) stored in an object/data base management system.
  - Remote asset services
    - Using services like Google Images, Flickr, YouTube (or other Web 2.0 content sharing sites) which host accessible and tagged media that may be uploaded or downloaded by end-users with few restrictions (copyrighted material may be excluded), where the accessed media (e.g., image, video sequence, audio file) may be imported into an SDK or game development environment for use within a game.
    - Commercial vendors may seek to offer
- Game-centered collaboration environments
  - Community development and support tools, services, and related information assets that seek to sustain and grow broader interest in the culture surrounding a game (and thus increasing its market value and revenue generating potential)
  - Every online/mobile game (or virtual world) benefits from a user participation community that can be realized via a domain-independent collaboration environment (DICE) that can be tailored to the game and its play settings.
- Persistent online Web 3.0 sites
  - Games can serve as personal virtual worlds that can be accessed via Game Web servers
    - Game Web servers are like current game servers combined with network interaction and navigation protocols
    - *Second Life* or *There* can serve as models for a Game Web server concept or prototype (though not as a target implementation platform)
    - Game Web servers can include all the capabilities of multiplayer online games, including all game players depicted as avatars, and include"non-player characters" (NPCs) who populate the Game Web site
    - NPCs may rely on AI capabilities to act on behalf of the GameWeb site owner, as well as engage in semi-autonomous behavioral interactions with GameWeb site visitors
      - NPCs who can welcome avatar-based visitors, provide guided tours, assist visitors in Website asset/content creation or modification, create simple

machinima of visitor experiences, contact human owners (or designees) who may be off-line (via phone and text-to-speech capabilities), and expel unwanted visitors or vandals who seek to disrupt or modify GameWeb site content in an unwanted or uninvited manner.

- o Meta-Game Development processes
    - ▪ Focused on creating new ways for large numbers of interested game developers and game content developers (e.g., undergraduate computer science/art students) to participate in a loosely-couple but highly parallel way to develop next-generation games using machinima, SDKs, game middleware environments, and domain-independent collaboration environments to create large-scale (or very-large-scale, or massive-scale) networked multiplayer computer games or game-based virtual worlds (including GameWeb 3.0 Web sites).
    - ▪ These processes are based on those invented and experimentally refined in the System Factory project (1981-1990) at the University of Southern California, and those practiced in the Google *Summer of Code*™ project that has run from 2005-2007
        - • USC System Factory project engaged approximately 2% of all Masters and Ph.D. computer science students in the U.S. from 1981-1988.
        - • Summer of Code engages from 400-900 students worldwide to participate in 40-90 open source software development projects during a twelve week long period (in the Summer each year).
            - o Each student has one mentor (a senior contributor or core developer) who supervises his or her software development work during this period.
            - o Students get paid by Google (e.g., $4,500-$5,000) if they complete their software development work, and satisfy their mentor.
            - o Mentors also get paid by Google ($1,500, a fraction of what the student gets paid).

- • Venue specific games and game play experiences
    - o Venues for networked computer games
        - ▪ Corporate training settings
            - • Health care
            - • Manufacturing
            - • Security services
            - • Merchandising and sales
            - • Others
        - ▪ Entertainment arenas (concert halls)
        - ▪ Cinemas

- Science centers and museums
- Libraries
- Sports stadiums (football stadium, motorsports park)
- Loosely-bounded metropolitan areas (e.g., retail shopping districts)
  - o Different venues may require special-purpose hardware devices for game play
    - Provides venue-branding of devices or venue-only device distribution and usage
    - Provides for venue-specific or unique game play experiences (you can't get this game play experience anywhere else)