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Prior research studies and interests, and major findings
My prior research has concerned human culture in virtual worlds. I have conducted ethnographic research in the virtual world Second Life for a number of years, resulting in a number of articles as well as the book *Coming of Age in Second Life*. While my position (until September 2012) as Editor-in-Chief of *American Anthropologist* limits my time available for research and writing, I am currently writing the book *A Handbook of Ethnographic Methods for Virtual Worlds* with three colleagues (Bonnie Nardi, Celia Pearce, and T.L. Taylor), building upon our shared interests in methods and their relation to understandings of CGVWs.

Given limits of space I'll just speak about my major findings except to say that virtual worlds are legitimate places of human culture and can thus be studied using ethnographic methods. (Given these limits I also won't list any citations.)

Views on outstanding or emerging research problems going forward, and why
There are a range of important and fascinating emerging topics in relation to CGVW. Some examples (in no particular order): religion, identity, romance, embodiment, governance, design, community, commerce, localization, role of differing devices (smartphones, laptops, etc.). However, I think what is most crucial are some broader issues that will set the parameters for research, and that's what I will discuss for the rest of this paper.

1) *Moving beyond utopia or dystopia*. Many conversations around CGVW are shaped by a "hype cycle" that latches on to the "next big thing." I'm surprised, for instance, by how many people complain "World of Warcraft has been overstudied" right when we're beginning to get a robust research community on WoW (I can't imagine someone saying this about Indonesia!). We need more basic research that looks in-depth, over time, at a range of issues.

2) *Figuring out what's new and what's not*. Some aspects of human sociality in CGVWs are novel; some are not. It's important to research this because we don't always know ahead of time what is new and what isn't (for instance, not everything about avatars is new!). Connected to this is linking up CGVW to physical-world issues (without assuming that CGVW are always secondary or derivative of physical-world issues), and linking up CGVW to other online socialities (social network sites, blogs, etc.).

3) *Beyond "blurring."* There is a need to research ways in which CGVWs interlink and shape each other, other forms of online sociality, and myriad physical-world socialities. However, these forms of interconnection do not (with rare exceptions) result in a kind of "blurring": if two things "blur," they become a single object and the language of interconnection no longer applies. We need to find ways to argue for the relevance of CGVWs without leaning on an empirically inaccurate and conceptually impoverished language of "blurring."

4) We need typologies: distinguishing & linking CGVWs. Particularly at this stage of building a research community, we need typologies for conceptualizing similarities and differences between various kinds of online games and virtual worlds. This includes understanding virtual/actual interfaces, virtual/virtual interfaces, and CGVWs in their own terms.

5) Methods. We need to move beyond forms of methodological partisanship and build a robust toolbox of methods for researching CGVWs, keyed to the typologies discussed above. It is crucial to emphasize that given an appropriate research question, it is legitimate to conduct research in a CGVWs that does not include a physical-world component.

6) *Beyond "Trending."* There is a strong pressure to talk about trends and the future of CGVWs, driven in part by questions of design. The problem is that we can't research the future; we can only research the present and the past. Additionally, we have a horrible track record in predicting the future of online technologies, including CGVWs. In arguing for the relevance of research in this space, it's crucial that we argue for basic research with time frames long enough to permit in-depth methodological approaches and research questions that can link up to broader concerns in the social sciences and beyond.

Immersive Virtual Performance Assessments

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Immersive Virtual Environments (IVEs) have the potential to change the fundamental models we use to measure student learning. IVEs enable the automated and invisible collection of very rich and detailed event-logs on individual learners in real-time, during the very act of learning (Clarke, 2009; Ketelhut, Dede, Clarke, Nelson, & Bowman, 2008; Pellegrino, Chudowski, & Glaser, 2001). IVE based event-logs can provide details of students' actions and performances not possible in multiple-choice and paper and pencil tests. For example, higher order thinking skills related to sophisticated cognition (e.g., inquiry processes, formulating scientific explanations, communicating scientific understanding, approaches to novel situations) are difficult to measure with current assessment models (Bransford, Brown, & Cocking, 1999; National Research Council, 2006; Nichols, 1994; Nitko, 1989; Pellegrino, et al., 2001; Quellmalz & Haertel, 2004; Resnick & Resnick, 1992; Snow & Lohman, 1989; Huff & Goodman, 2007;). Using innovative technology and assessment design practices, IVEs can capture observations and learning not possible in current models of assessment.

IVEs enable us to create and measure authentic, situated performances that are characteristic of how students learn inquiry (Clarke-Midura, Dede, & Mayrath, 2010; Clarke-Midura & Dede, 2010; Hickey et al, 2009). For about a decade, in the *River City* project, my colleagues and I conducted federally-funded research on the feasibility and efficacy of using IVEs for teaching and assessing scientific inquiry (Clarke, Dede, Ketelhut, & Nelson, 2006; Dede, 2009; Ketelhut, Dede, Clarke, Nelson, & Bowman, 2008; Ketelhut, 2007; Nelson, 2007; Dieterle, 2009). For the past two years, with funding from the Institute of Education Sciences (IES), we are developing and studying the feasibility of immersive virtual performance assessments to assess scientific inquiry of middle school students as a standardized component of an accountability program.

The Virtual Performance Assessment Project

Using the Unity game development engine (Unity Technologies, 2010), we are developing summative assessments that measure students' science inquiry learning *in situ*. In one assessment, *A New Frog in Town*, students enter a fictional town and learn there is a mutated frog and must figure out what the cause of the mutation is. They take on the identity of a scientist and use an avatar to explore the virtual world. The student's avatar can interview with non-player characters (NPCs – computer agents); can collect data using virtual tools of scientists, and can observe tacit clues. The students must evaluate the credibility of the information provided by virtual world "residents."

Traditional assessments focus on items and rely on student affirmation as a response that indicates knowledge. In VPA, the assessment focuses on performances of students that are captured as interactions. These interactions allow us to diagnose what students know and do not know about science inquiry and problem solving. Embedded within the assessment are choices that students make. Rather than an ongoing narrative where there is a right answer, our assessments are similar to the "build your own adventure" chapter books where students construct their narrative through a series of choices such that they experience the outcomes of their choices. Since there is not a single right answer for the series of choices and interactions that students make, these rich observations enable us to make nuanced diagnoses of students' misconceptions.

The goal of VPA is for students to make choices based on sound science inquiry skills that advance the theory that they are attempting to build. A student's measure of science inquiry skills is based on their in-world actions. Their actions and choices are given a range of scores and weightings that contribute to an ongoing student model of science inquiry. They are temporally evaluated based on past, present, and future actions: A choice is evaluated in terms of the previous actions, their actual choice within the context of the available choices, and the outcome of their choice that sets the stage for the next set of actions. For example, if a character asks a student what they think the problem is and the student responds that they think the mutant frog is a result of pollution, the character will ask the student to provide evidence for their claim. The evidence that students give will be weighted and evaluated based on their prior actions (data that they have previously collected) and by what they choose to present as evidence.

Recommendations for Future Research

The role of virtual environments in learning is at the forefront of discussion. In the fall of 2009, The National Research Council held a workshop on games and simulations in science education (National Research Council, 2009). The White Papers from this research conference urge further studies to determine the full potential of collaborative, immersive simulations to support assessment (Quellmalz & Pellegrino, 2009), as well as virtual worlds that interweave assessment with engagement and learning (Clark, Nelson, Sengupta, & D'Angelo, 2009). The 2010 National Educational Technology Plan (NETP; US Department of Education, 2010) further echo this as they recommended research and development that explore how gaming technology, simulations, collaboration environments, and virtual worlds can be used in both learning and assessment. In order for video games and immersive environments to change k-12 education, I recommend we place emphasis in 3 areas:

Evidence

While numerous projects have been developing and studying video games and immersive virtual environments, there is not a lot of causal evidence for their effectiveness. Most studies focus on correlation data and don't really provide empirical evidence of learning. In order for these environments to really gain respect in the field, we need more evidence of their effectiveness for learning.

Design Frameworks

Design frameworks are extremely important in design of IVEs and videogames for learning. Good design starts with the learning outcomes, working back through embedded pedagogy/assessment/content, then thinking about performances and actions that involve those. Too often people build something cool, then ask what it teaches – and the answer too often is just game design and tech literacy.

Collaborative Assessment

Current state of assessment focuses on individual learners. New models of assessment with IVEs should focus on assessing collaboration or how individuals learn as part of a team.

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Prior research

- Cultural, historical and economic examination of cheating in single player, multiplayer, online and offline games, including MMOGs
- Women gamers: who they are; why they play; moderate and heavy gamer differences; social/casual gamers and their play styles
- Casual games: their culture, structures, differences and similarities to MMOs and social games
- Player culture
- Western players of Japanese videogames; localization; economics of the Japanese and global games industry

Current interests

- Refining methods for studying play and gamer attitudes towards play and wider play culture
- Ethical decision-making games and the good guy/bad guy dilemma
- Social games—their structures, their fictions, cultures
- Localization as a cultural practice

Major findings

- Play is contextual and dynamic
- Heavy players of social games and MMO games are not that dissimilar in play frequencies; dedication to games; spending $$ on games; interest in varied structures of the games
- Game spaces can lead to intercultural exchanges with positives as well as negative effects; interest in Japanese games can lead to further interests in learning about Japan, global issues, potentially development of cosmopolitan disposition

Outstanding/emerging research problems

- We need better methods for understanding play. The immediacy of play leaves little room for reflection; pausing too long to have players reflect means information can be lost

- Players still have a limited vocabulary for recounting and explaining their gameplay actions, preferences and understandings. We should be more creative in exploring alternative ways to capture such things
- Let’s take social games seriously
- Let’s get rid of the term ‘gamer’ as an identity marker

Serious Games, Dubious Aims:
Purposeful Use of Game Play

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The category of games known as serious games presents promising directions as well as formidable challenges to developers, designers, and researchers. The promise is in the potential "real-life" application of these games in areas such as education, healthcare, and training. The challenge is in maintaining the autonomy, entertainment, and derived gratification of the game, while delivering purposeful content; in other words, in respecting the boundaries of the magic circle and penetrating it at the same time.

The tension between these competing aspects of serious games drives much research and practice in game design. Interaction designers have traditionally dealt with this tension by making technical tradeoffs between "usability goals" (efficiency, effectiveness, safety, etc.) and user experience goals (engagement, entertainment, aesthetic appeal, etc.). Such an approach might somehow and sometimes work in the design of games with a primary focus on *content delivery* — that is, on the transfer of a specific topical or curricular content to a learner. However, it may not be as effective in the design of games that intend to cultivate or instigate behavior change — for example, drinking habits, sexual behavior, or stress-related activities of young adults. Designers cannot design experience, but *for* experience. Furthermore, while the mechanisms of (explicit) knowledge transfer across the "real" and virtual worlds might be partially understood, a similar understanding of how *experience* is transferred between these worlds is far from being available. Concepts such as "leakage," "interpenetration," and "immersion" invoked by game and virtual-world theorists to characterize this process are useful but too coarse-grained to be able to explain its rich, nuanced, and complex dynamics. Key questions still remain to be addressed:

- How does an experience in the game (e.g., acts of violence, submission, or affection) affect the player's behavior out of the game in real life?
- How does the performative experience of playing interact with the visual and aesthetic experience of the game?
- What types of social skills can be developed in the virtual environment of the game and leveraged in real life?
- What kinds of behavior changes are more effectively afforded in a game or virtual environment, and how can these be cultivated to encourage similar changes in real life?
- What kinds of designs lend themselves to this sort of cultivation?

Answers to these and other similar questions can inform and guide the design of games and virtual worlds, but they also have the potential to turn into effective interventions at the individual and social level. To attain the answers, parallel conceptual, empirical, and design work needs to be carried out by designers, players, and researchers. Crucially, it seems, we need to begin with a trichotomy, differentiating experiences *of*, *in*, and *outside* the game, rather than the simple dichotomy between online and offline experience; let alone the dismissive attitude of many philosophers and social scientists towards the experiential value of game play. I propose to call these, respectively, *designed*, *enacted*, and *real-life* experiences. Although these can be meaningfully understood as varieties of mediated experience, they manifest significant differences in terms the degree of performativity, materiality, and embeddedness to warrant the distinctions proposed here.

These distinctions have practical implications for the process of design, creation of content, division of labor, and so forth. In regards to division of labor, for instance, a clear separation of tasks and responsibilities arises between designers, subject matter experts, and those with a “thematic” understanding of the intended behavior. This latter role can be played by members of the target population with first-hand experience, by behavior scientists with expert understanding of the relevant behavior change, or ideally by both. The division of labor aligns well with partitioning of games into game mechanics, content, and themes.

At the workshop, I discuss these ideas on the basis of preliminary results from a project to develop games for health for college students — a project that intends to show that the aim of provoking behavior change through game play may, indeed, be less dubious than it seems on first encounter.

Securing On-line Games "On-line"

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***Abstract*—Over the last 20 years, highly immersive games have driven much of the research and development in computer graphics. We posit that in much the same way, securing on-line games can drive research and development in network security. Specifically, we argue that protecting games from being compromised presents unique security challenges that, when successfully met, can be used to secure a range of other networked applications. As an example, we describe our current efforts to harden software using on-line transformation.**

I. The Cheating Problem

On-line games have become increasingly profitable for both game publishers and game players. As a result, commercial-grade cheat software using advanced techniques found in malware has appeared. It is paramount for any on-line game to protect against cheating as many games quickly become unplayable in the face of widespread cheating.

Cheat software uses the same methods to modify the game application running on a client machine that advanced malware uses. Specifically, such software can replace critical files used by the game application, modify and inject code and data into the running game process, and attach itself as an external process to the game to hijack its execution [1], [2]. In addition, commercial cheat software also employs hardening techniques developed for malware. To thwart signature-based detection, cheats employ code polymorphism to generate uniquely different code with the same functionality. Examples of this include application packers and recompilation tools. Cheats employ code obfuscation for generating code that is difficult to reverse engineer. For example, cheats can strip out essential debugging information from their binaries [3] or perform just-in-time decryption and re-encryption of its instructions so that the entire cheat is never loaded in memory at any given point in time. Cheats use code metamorphism so that its functionality changes on a per-client or per-execution basis making it hard for game publishers to accurately determine everything the cheat software is capable of doing. Finally, cheats employ just-in-time cloaking and anti-debugging techniques to disable themselves when software runs to analyze or detect them [4].

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While cheats and malware share many similarities, there is one significant difference that makes the cheating problem more difficult: the adversary owns the machine the software is running on. As a result of this, cheats typically are run with administrator privileges and can completely avoid detection from user-space, anti-cheat software by hiding underneath the game within the kernel [5]. With this in mind, we argue that solving the cheating problem in on-line games will help us solve the general malware problem.

II. "On-line" Security for On-line Games via Transformation

In order to put an end to cheating, it is essential to make the development of cheat software more expensive than the potential financial gain in selling the cheat. One advantage cheat software and malware enjoy is that they target flawed application code which is static and does not change very often. As a result, developers of such software only need to reverse engineer and exploit a single instance of the application in order for them to to work across many machines. Diversity via randomization is one approach that is often used to make life more difficult for adversaries. For example, address space layout randomization is commonly employed to prevent adversaries from deterministically exploiting vulnerabilities [6]. The intuition is that it is much harder for adversaries to hit a moving target. Unfortunately, such an approach falls short when the adversary is the owner of the machine.

To overcome this, we are examining an approach for modifying networked applications that will force an adversary to continually expend resources in order to maintain control [7]. Our goal is to force cheat developers to reverse-engineer a new piece of software for every instance of the game a client invokes. Our approach is based on on-line, run-time transformation and entanglement. By allowing the server to alter the client dynamically at run-time, we aim to make cheat developers reverse and exploit a "new" application for each client or even each game process. By doing so, the profitability of developing cheats is significantly impacted.

Our approach encompasses several new techniques including:

Personal polymorphism and obfuscation: The idea of personal polymorphism and obfuscation is to dynamically transform a network application for each user. Personalized binaries that are generated dynamically on-demand can substantially increase the effort required from cheat developers and force them to perform reversing in an on-line manner while the code is executing. We are examining methods for partially transforming critical code of applications and tools that allow binaries to continually transform themselves each time they are invoked.

On-line integrity checks via entanglement: One way to ensure certain code is run untampered is to entangle it with a computation whose result must be returned to the server within a bounded time limit as with Pioneer [8]. Typically, this entanglement is done statically on an application beforehand. We are exploring mechanisms for injecting entangled integrity checks into games at run-time to ensure it is not tampered with. To ensure these checks are not disabled, they can either be timed or the entanglement result could be used to encrypt all data being delivered to the application.

Remotely triggered traps: Reversing an application is a significant cost to an adversary and is typically done in an off-line fashion. The idea of remotely triggered traps is to augment the application with code traps that can be dynamically enabled and disabled at run-time by the game server. Only when the proper subsets of traps are enabled and disabled, does the application work properly. Thus, an adversary is forced to either reverse the application on-line or figure out how to separate the "wheat" code from the "chaff" code in an off-line fashion.

Run-time relocation of code and data: Many compromises of applications such as on-line games occur because the adversary knows the exact location of code and data to attack. Load-time randomization of memory is one method for preventing cheats from deterministically attacking code and data. However, such a technique can be overcome at launch-time by scanning the memory image of the application. The goal of run-time relocation to continually move code and data in an on-line manner in order to break cheats. We are exploring mechanisms for rebasing libraries and relocating data at run-time and how such mechanisms impact the proper execution of cheat software.

On-line code canaries: The idea of on-line code canaries is to dynamically inject code into the running application to either ensure execution of particular code or to detect execution tampering. For example, to ensure execution of particular code, one could have the transformation engine dynamically inject a code canary that returns specific data back to the server at certain places of execution.

Application-level misdirection and entrapment: Cheat software often sits underneath an application in the operating system, making it difficult for an application provider to thwart [5]. The idea of application-level misdirection is to *change* the logic of an application at run-time to confuse an adversary and force them to reverse the new logic in order to effectively capture user data.

III. Conclusion

Securing on-line games presents significant challenges to game publishers due to the fact that the adversary owns the machine the game runs on and the fact that their games are static targets. We argue that solving the problem of cheating in on-line games will provide insights and technology that can be useful in the larger fight against malware. Towards this end, we are exploring mechanisms to dynamically modify and transform on-line games at run-time in order to force adversaries to continually expend reverse-engineering resources and to make cheat development more costly.

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Meru: Internet-scale Virtual Worlds

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We believe that one of the next major application platforms will be 3-dimensional, online virtual worlds. Virtual worlds are shared, interactive spaces. Objects inhabit the space, have programmable behaviors, and can discover and communicate with other objects. Users commonly experience the world through an avatar and can interact with objects in the world, much as they would in the real world. Many currently deployed applications are virtual worlds: multiplayer online games such as World of Warcraft and social environments such as Second Life are popular examples. Other examples include environments for virtual collaboration, distance learning applications, and augmented reality.

Unfortunately the early evolution of virtual worlds has been ad hoc. They have completely independent constructions, share few architectural aspects, and offer little or no interoperability. Because these systems are designed for very specific applications, each suffers from at least one of poor scalability, centralized control, and a lack of extensibility. Rather than support user applications and a seamless shared experience in enormous, rich worlds, systems like Second Life, EvE Online, and World of Warcraft partition their worlds into disjoint regions. Within these regions, they enforce harsh and disconcerting restrictions, imposing a “fog” past which an object cannot see or interact with the world. Skyscrapers are invisible until you stand beneath them; two spaceships cannot communicate until within a predefined range; a user cannot control something they own unless immediately next to it. Although frequently couched as a component of these worlds’ narratives, these restrictions are actually artifacts of the underlying design and implementation of their system architectures.

The Meru Project is designing and implementing an architecture for the virtual worlds of the future. By learning how to build applications and services before they are subject to the short-term necessities of commercial development, we hope to avoid many of the complexities other application platforms, such as the Web, have encountered.

We’re currently working on the following projects: (1) virtual world system components, (2) space architectures, (3) scripting, (4) content distribution for virtual worlds, and (5) graphics. The reminder of this project summary is organized around these five areas.

1 Virtual World Components

Meru addresses the issues of scalability and federation by carefully separating the components of a virtual world. The core components of any virtual world system are the simulation of the world, the simulation of individual object behaviors, and the storage and distribution of the content of the world. The Meru architecture separates these concerns:

- **Object Hosts** handle simulation of individual objects: receiving messages, handling events, and simulating behavior using user-created scripts.
- **Spaces** handle inter-object behavior: it gives objects names in the world, helps objects discover the names of other objects they might be interested in, enables communication between objects, and might provide physical simulation such as rigid body physics.
- **Persistence Services** handle storing and serving the large, read-mostly data a virtual world needs, such as textures and meshes.

2 Space Architecture

Currently we are focusing on the architecture of space servers. They provide four basic services:

- **Naming:** The space is a communication medium for objects, so it must give them names they can use to refer to each other. In this sense, the space can be though of as an address space. We use a simple flat namespace and assign these identifiers randomly.
- **Discovery:** In order to send messages, objects must have other objects' identifiers. The space must provide a way for objects to discover other object identifiers. Of course this mechanism should aim to return the identifiers of the most relevant objects to the querier.
- **Communication:** The space acts as a communication medium and mediates all inter-object messages. It must provide routing of messages and possibly apply rules to restrict communication.
- **Physical Simulation:** Much physical simulation depends on the state of multiple objects, and is simplified by having a single authoritative simulator. The space may provide some form of physical simulation, ranging from simple collision detection and response to a complex rigid body simulation, depending on what the particular world calls for.

We are designing our space service to handle all of these scalably. Some specific challenges we face in designing and implementing the components that provide these services are:

- **Efficient and Scalable Discovery:** Most existing systems use a simple distance cut-off approach to discovery, where all objects within some radius will be returned. While it is known how to efficiently implement this approach when the radius is relatively small, the nature of the query requires the radius to be large to find the majority of objects that are important. Further, these systems return many objects that could be quickly discarded as irrelevant. We're looking into different types of queries that more efficiently find important objects, but can still be implemented efficiently and scalably.
- **Scalable Communication:** Without restrictions on communication, object messaging can very quickly overload the system, leading to poor service for everyone. We are investigating how we can control message queuing to provide physically plausible quality of service under load while making the best use of resources when not under load.
- **Load Balancing:** Interests naturally collect: we know that interests often follow a Zipf distribution. This implies that as the world grows, the maximum load on a single space server using fixed size regions will increase. The resulting problems are already evident in most other systems that split their worlds into fixed sized regions: a few central hubs are overloaded or the number of participants is simply capped to avoid the problem. Instead, we are investigating ways to balance the load by dynamically segmenting the world, allowing loaded servers to split in order to double available bandwidth and compute power, and underloaded servers to merge so unused regions do not waste resources.

3 Scripting

In a seamless, scalable, and federated virtual world scripted objects are distributed across many hosts and users may generate and host scripts. Communication between objects via asynchronous messages is the norm, and objects may not trust each other. These challenges make popular scripting languages poorly suited to this domain. Most existing languages designed for virtual worlds are ad hoc and often lack even basic features for event-driven programming, code reuse, and interactive scripting.

We are developing Emerson, a scripting language based on JavaScript. Emerson addresses these challenges with three core design concepts: entity-based isolation and concurrency, an event driven model with concise and expressive pattern matching to find handlers for messages, and strong support for example-based programming within the live virtual environment.

4 Content Distribution for Virtual Worlds

Much of the content that makes up a virtual world is long-lived, static content: meshes, textures, scripts, and audio. Content distribution networks address the problem of efficiently serving these assets to millions of clients.

Virtual worlds have a few properties which suggest a different CDN design might be warranted. First, most content can be split into levels of detail and accessed incrementally. For instance, a texture can be displayed at lower resolution before the entire texture has been downloaded. Further, the client may not request all chunks: a higher resolution version of the texture might not improve the rendering because the mesh is too far away for it to be noticable.

Second, the relative importance of requests varies quickly over time. Unlike the resources on a web page, which are all required to display the page, the content required to display a virtual world may vary quickly. If the user turns, the relative importance of different meshes and textures in the scene change suddenly. Still, out-of-view elements should still have some priority since the user may turn back towards them soon.

Finally, virtual worlds have spatial locality that could be exploited by the CDN: resources that are geometrically nearby in the world are likely to be requested by the same client. For instance, the meshes for objects that are next to each other will likely be requested by all avatars in the region.

5 Graphics

A client displaying a virtual world must decide which assets to download and display, taking into account the effect that asset (or lack of the asset) will have on the fidelity of the world, the current and possible viewpoint of the user, the size of the content (both for download and as stored on the graphics card), and that the data must be streamed from the CDN.

We are building a flexible graphics asset manager which can account for these challenges and allows us to experiment with different algorithms for prioritizing and downloading assets and LODs of assets. Built on top of our CDN client library, it will be able to quickly update the priorities of assets. The algorithms could take into account resource constraints of the graphics hardware, perceptual metrics taking into account the objects the assets are associated with, the available levels of detail, and the time to transfer the data from the CDN.

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CGVW and Learning

Betty Hayes, Arizona State University

In the last decade, we have seen tremendous innovation and development in the technical sophistication of games and virtual worlds, and a parallel growth in their popularity for entertainment among an increasingly diverse population of players. Computer games and virtual worlds (albeit of different sorts) have proven their appeal for young and old, male and female players of all social classes and racial/cultural backgrounds. The potential and use of CGVW for learning, however, has lagged far behind in terms of sophistication, appeal, and impact. While there are a variety of reasons for this limited impact (in particular, the structures and constraints of formal schooling, such as the current focus on basic skills and content acquisition rather than problem-solving), here I argue that efforts to use CGVW for learning have been hampered by a narrow focus on what I will call the "game in the box," that is, the problem-solving space (for all CGVW are essentially problem-solving spaces) bounded by the game software. To understand how gaming supports learning, as well as to design and use CGVW for educational purposes, educators and scholars must think beyond elements of the game software to the social practices, or "meta-game," that take place within and around games. (While computer games and virtual worlds obviously have some different properties, the agenda I discuss below can apply to both.)

Thus, my first argument is that CGVW research needs to focus on what Jim Gee and I have called big G "Games" (Hayes & Gee, in press) [similar to distinction between discourse and Discourse made in Jim's earlier work (e.g., Gee, 1990]. By Games we mean both game play (that is, the play structured by the game as software) and the social practices going on in and around the game, as well as the interaction between the two. While we have growing evidence of the sophisticated forms of learning that stem from the combination of game play and social practices around entertainment-oriented CGVW, many questions remain about what configurations of game and social elements contribute the most to learning for different purposes and populations.

My second argument is CGVW that stress the involvement of players as designers, by making game design a core game mechanic, facilitating modding, and encouraging robust design communities to develop around the game are particularly promising focal points for fostering skills with technology, design, system thinking, and socio-technical engineering (thinking about and creating beneficial interactions between people and technology). Examples of such CGVW from the entertainment sector that represent a true integration of play and design include *The Sims*, *Spore*, *Little Big Planet*, and *Second Life*. A growing number of programs funded by NSF and other agencies are investigating the use of game design as a starting point for the development of skills such as programming; however, often in such approaches game design is divorced from game play, the development of computing skills is divorced from other important learning such as design thinking and understanding complex systems, and social knowledge is divorced from technical knowledge. Earlier work has spelled out a number of learning principles that good games incorporate as part and parcel of their design (Gee, 2003). It would be useful also to identify a set of guiding principles for games that support players as designers, as well as to ascertain the relationship between these two sets of principles.

My third argument is that future research needs to more carefully examine how engagement in Games (game plus meta-game), including their affinity spaces, might lead people to other spaces and types of knowledge that are not specific to games. I would include here not simply how this engagement leads to discrete learning outcomes (i.e., the ability to use a graphic design tool), a decision to take a computer science course or a greater interest in engineering, but to actual participation in other interest-focused groups and to trajectories of expertise. For example, there are a great many opportunities now, thanks to technologies like the internet, social networking tools, and online research depositories, for people to engage in citizen science collectives and other ProAm communities that can have significant social and individual benefits. The research agenda in this area might investigate the similarities and differences between how these communities function, their requisite skills and knowledge, and tools, as well as how they relate to more traditional professional communities of practice. As one small example, modding communities engage participants in the acquisition of sophisticated technical language, language that may then prepare them to participate in other IT-related communities (Hayes & Lee, in progress).

Lastly, the significance of gender, racial, and economic diversity among players remains an important area of investigation. Work on CGVW and learning continues to be plagued by simplistic conceptions of sex differences, for example, or lack of any sustained attention to race or class in how players engage with CGVW. These factors have considerable importance not simply in the design of game play but perhaps even more importantly in the social interactions and identities that emerge as part of the Game.

My Background & Research

My work on CGVW grew out of my earlier interests in gender equity issues in education, informal, out-of-school learning, and literacy learning across the contexts of work, home and formal education. My research on CGVW games has focused on the following areas:

- The significance of gender in gaming and IT practices (Gee & Hayes, 2010; Hayes, 2005, 2007, 2008a, 2008b, in press)
- The design of informal learning experiences using CGVW to engage girls in STEM learning (Hayes & Gee, 2009; Hayes & King, 2009; Hayes, in progress; Scott & Hayes, in progress)
- Game design and learning (Gee & Hayes, 2009; Hayes & Games, 2008; Hayes & Gee, 2010)
- Learning in online affinity spaces associated with CGVW (Duncan & Hayes, in progress; Gee & Hayes, 2010; Hayes & Gee, in press; Hayes & Lee, in progress)

I have been a PI or co-PI on research projects funded by the MacArthur Foundation, the National Science Foundation, the National Institutes of Health, and the Annie E. Casey Foundation.

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Social, Cultural, and Political Economic Contexts of Gaming

A Position Paper for the Workshop on the Future of Research in Computer Games and Virtual Worlds

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My research has looked at the social, cultural, and political economic conditions that structure the play, circulation and production of electronic games. I've focused primarily on the learning dimensions of games, including games explicitly designed with a learning agenda, as well as more mainstream recreational forms of console gaming. My earlier work examined production, distribution, advertising, and play with CD-ROM based edutainment software in the mid nineties . I have also had an interest in understanding the unique social contexts afforded by Japanese media mixes such as Yu-Gi-Oh! and Pokemon, particularly the peer sociability surrounding portable game formats such as Gameboys and trading cards . Most recently, I have studied how gaming is part of a broader ecology of new media that young people navigate in their everyday lives, and can be part of a trajectory of learning for technical and creative interests .

The primary findings of my research center on how both the specific settings of play (in homes, afterschool centers, with peers, parents, mentors, etc.) as well as the broader cultural discourses and political economic contexts (media genres, market segmentation, etc.) determine the impacts of gaming. In other words, one can't simply look at the content and design of a game, or at particular instances of play, and expect to understand more generally what different people get out of a game or the broader societal impact. Conversely, if one wants to mobilize gaming for a social agenda, around learning for example, it is not sufficient to design a game with the appropriate learning principles. One also has to engage in outreach to particular player communities and settings, as well as creatively address distribution and marketing in order to push for any social change in the existing hardened set of gaming genres and player practices. In particular, the divide between entertainment-oriented and educational and serious games is extremely resilient, and it embedded in a longstanding set of social and cultural conventions as well as concrete market structures.

As far as research agendas, I can identify a few areas that seem to be crying out for more study, for the field of sociocultural studies of gaming and for the area of games and learning. More generally in sociocultural studies of gaming, I feel that there is a notable absence of research that looks at recreational gaming in everyday contexts, particularly among casual and recreational players. In contrast to the growing body of ethnographic literature on MMOs and more core gaming practices like modding and competitive gaming, we have almost no work that looks at play with casual games, mobile game platforms, or console gaming in the home among families and real life peer groups. These are the dominant contexts where gaming takes place, and though there are a handful of surveys in this area, we have virtually no practice based studies of these forms of gaming. In games and learning, in a related vein, I think we need to do much more work in understanding how gaming fits into the broader learning trajectories of kids as they navigate between different contexts of peer-group, family, and school. This kind of research could in turn tie into design and implementation work that looks more ecologically at games and learning, and the design of social contexts, paratexts, and the knowledge ecology surrounding games as much as the design of the game per se.

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Future Directions in Research on Computer Games and Virtual Worlds

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Perspective

Of all the attendees here, I probably have the least academic background. My academic training consists of a Bachelor's of Science in Computer Image Generation (a self-designed major in image synthesis technology) which I acquired in the mid '80s at the University of Wisconsin - Madison. Since then. however, my love of games in general and role play games in specific has led me into a career in multiplayer online game development. Beginning with my tenure at The Total Entertainment Network (TEN) where I led the game integration team and wrote WAN networking code for games such as Duke Nukem 3D, Total Annihilation and Dark Sun Online (one of the earliest virtual world products) and continuing to my current work as CTO of Blue Fang Games and NPHOS, I have accumulated over 25 years of practical on-line game experience. It is my hope that this perspective and deep knowledge of the real issues and concerns of on-line game developers will add a unique value to this conference.

Research

A too brief history of Project Darkstar

In the late 90s, coming out of my experiences at TEN on Dark Sun Online I realized that the on line role-play game industry needed a tool that didn't exist. Something that was as easy to program and as flexible as a MUD server but that could scale out to use the parallel processing power that was starting to become available. In addition, it had to be usable in a reliable fashion by game programmers who knew nothing about parallel programming.

In some ways, its a good thing I wasn't an academic because by then Dr. Jim Waldo had already published his 1994 paper [1] arguing that automated distribution of mono-threaded code was impossible. In my ignorance, I set about to solve the problem. The big difference being that, in Jim's case, he was discussing a general solution where as I was trying to solve a specific narrow domain. Out of that work grew the execution model that was eventually to became the Sun Labs Project Darkstar, somewhat ironically led at labs by Dr. Waldo himself.

Working on my own, I built a proof of concept of the execution model which was brought into Sun and dubbed the Sun Game Server. This was shown with much industry interest at the Computer Game Developer's Conference (DCGDC in 2006. Following that demonstration, Sun Labs picked up the project. It was then dubbed Project Dakrstar and a more finished version was shown at the 2007 CGDC. Following that showing, Jim Waldo and his team became interested in the project and took its lead.

When Oracle bought Sun, the project was ended, but the code has been released into the open source community where it continues to thrive and is under active development as the, renamed again, RedDwarf server. A number of commercial games [2] in past or current deployment have been based upon it and more projects are in the works this year.

What is Project Darkstar

Project Darkstar, now RedDwarf, is fundamentally an application server designed for near real-time event driven code. It provides transactionally consistent horizontal scalability without the need for any explicit threading, locking or any other parallel programming primitives. It is designed to scale out horizontally across thousands of processing nodes, each node being a multi-core system in of itself. It has all the properties of an enterprise system-- fault tolerance, disaster recovery, massive scalability and guaranteed referential integrity. It also provides nearly-orthogonal persistence and a game-oriented publish/subscribe communication channel system. It supports replaceable components for many of its key features including a transport and protocol stack that can be redefined through a plugin architecture. This allows it to communicate with just about any client capable of sending and receiving bytes of data.

Most importantly, it supports all of these features in an application transparent and very low latency model.[1]

Future Directions

Research and development on Project Darkstar, now RedDwarf, continues with many of the Sun researchers still involved. At NPHOS we have developed an HTML5 WebSockets transport and are exploring uses of the system in HTML5 based game content. The community continues to thrive and grow with known game projects in active development from the US to as far away as SIngapore. NPHOS is currently discussing possible RedDwarf service development deals with a number of national development boards and plans to complete the unfinished Sun Labs work to bring up the full multi-node deployment mode.

Directions for Other Research

All of this so far has been by way of establishing context. The focus of this conference is what sort of research and development we see as useful for the future of virtual worlds and the on-line games industry, Given my background, I am going to address this from the game industry side.

Technical Challenge: Daunting Scale

Distributed computing is still what we see at the core of our work. As Facebook has shown us, the potential demands of scale seem to be limited only by the number of people with access to a computer, and that too increases every year. As such providing those user with a seamless experience requires more and more processing power.

Distributed Computing Tools and techniques

To quote Jim Waldo in one of his famous under-statements, “Distributed computing is hard.” The tools we use to break down and manage the dynamic complexity of such large distributed system are inadequate. In many ways we are facing a second “software crisis” in this space and research on new and better ways of taking the burden of properly synchronizing this work is definitely needed.

Project Darkstar (RedDwarf) in its completed multi-node form will be a tool that will allow programmers to write massively horizontally scaled game applications as if they were operating on a single processor. It serves a convenient test-bed for many of the other research suggestions below. But as conceived and implemented it is only appropriate for applications that can be composed in an event-driven style. There are certainly improvements and refinements that could be made to its execution model in many areas, from queue management to distributed data storage and retrieval. As well, there may be other kinds of tools and techniques that can be developed that apply to other problem domains.

Distributed Physics Simulation

At the same time, the work required of a game server is continuing to grow. As game players are exposed more and more to advanced physical modeling in their desktop games (where they have what once would have been considered a

[1] It is estimated that the average event is handled in the low tens of milliseconds. The system has an execution time cap for the handling of any event, beyond which it terminates execution and informs the operator. The default setting for this cap is 100ms.

super-computer all to themselves) they grow to expect the same in their on-line environments. To meet the needs of physical modeling for so many players at once requires a horizontal scale-out. Scaling such near real-time physics in a distributed manner is a difficult and not yet solved problem ripe for further research.

One of the big issues in distributing physics simulation is latency of response. Each simulation node's idea of the positions of all objects in the simulated world is only approximately correlated to nay other node's notion due to the delay in propagating force change information. The Project Darkstar (RedDwarf) server dynamically shuffles users and data in affinity groups between processing nodes. A distributed physics system might use this affinity information and locality of reference to do local simulation of the world entities residing on its server and use the inter-node communication to communicate this to "puppet" entities being simulated in foreign nodes. In this way, the things that "matter most" to the user are all being controlled locally to that user, while the things that "matter less" are being controlled at their respective local nodes.

Technical Challenge: Artificial Intelligence and Emotional Simulation

As the physics of our virtual worlds become more and more true to the real-world, the limitations of the computer played characters in those worlds become more and more obvious. The virtual world provides a unique crucible for the exploration of artificial intelligence that adapts to both individual and group behavior of human beings. Human beings are remarkably good at learning the game and adapt their behavior to its patterns. To provide an interesting on-going challenge, the game should be made to adapt to the humans in return.

But humans do more than problem solve inside of on-line virtual worlds. In fact, it can be argued that the problem solving is at most the catalyst for the real interaction, which is social. Today, those social interactions are with other human beings because the computer is incapable of providing truly social responses. These responses are based as much in emotion as reason. A true computer-actor would be able to not just reason out logical decisions, or follow canned scripts, but form emotional reactions; love, hate, prejudice and so on. It would be capable of displaying these reactions in ways that were intuitively recognizable to humans. Although there have been some early research efforts in this space, nothing really practical has yet made its way out to the industry.

As an example of a natural place to insert such research into an online role-play game, consider the shopkeeper. In a virtual world today, a shop-keeper generally has one price that it charges all who wish to buy something. The settings modeled however are usually equivalent to a medieval or renaissance period. In these periods, pricing was done on a sale by sale basis and negotiated. A "smart shop-keeper" might have many factors it considers when determining whether or not to accept an offer. Some might be obvious, such as price offered. Others could be more subtle and include a level of "like" or "dislike" of the player, their other actions, their race or their sex. Attractiveness and charisma of the player could also factor in. Even a weight for what side of the bed the shop-keep got up on this morning could be a factor in the final decision.

Even more interestingly to my mind, the results of the transaction could be measured for a level of "successfulness". That measure could be fed into a learning pattern match where the pattern input was all sorts of perceivable traits of the player character-- height, weight, hair color, skin color, quality of clothing, and so on. This pattern matcher could then be applied to future "prospects' to determine the shop-keeps attitude toward the character and used as a weight in future transactions. In this way, the acquisition of prejudices might be modeled.

This is just one example of a player/computer interaction that could be interestingly augmented and made to feel "more real" through potential AI research. Other kinds of interaction include dialog decision points and combat. Applying learning techniques in all these areas could vastly increase their interest and gameplay value.

Sociological Challenge: Social Engineering

On line virtual worlds, as mentioned above, provide a conveniently limited and controlled crucible of human social interaction. The game industry is just starting to wake up to the fact that these games live or die on the social interactions of their players. Players who form good positive social bonds continue to return despite other obstacles. Those who don't, drift off even without any strong motivation to leave.

How you foster such social interactions is an area of potentially valuable research. How much group activity is optimal? How much individual activity? How big should groups be? How do social controls effect the micro-society of the game, good or ill? What sort of interaction vocabulary leads to the happiest interactions?

Another area of potentially useful (and I think fascinating) sociological research is in the flow of information. Most games of this sort have a money economy which has gotten a lot of attention in recent years. But they also have an information economy which is generally ignored by game developers. How do you shape that flow of information, like you do a market? How do you encourage or discourage the passing of bits of information between players. This is another place where I believe there is room for a good deal of research.

The appeal to the sociologist of such research is that the online-game affords a degree of control over the world and ability to unobtrusively track actions in that world that is not attainable in the real world. It is a petri-dish of human interaction where such interactions can be observed and influenced with scientific accuracy and without the knowledge of the experimental subjects. The EU is already engaged in a public policy study using such techniques. [4]

It is worth noting that companies like Zynga are already doing such data collection and research-- though in their case solely for the purpose of figuring out what makes their games attract and keep the most players who spend the most money and they keep their results as a business advantage. Purer research on more general topics that can be shared with the entire community, however, could assist game designers in building games that are genuinely more interesting and enjoyable for their consumers.

Conclusion:

A good friend of mine used to say "Games are the Space Program of Computer Science." The game industry is out there on the cutting edge of computer use. Games consume far more computer resources then any other consumer computer use and take on hard problems such as realistic real-time 3D modeling before the enterprise is even aware they exist. They also set people's expectations for computers and the use their off. Skills and ways of using the computer that are learned as a child playing games become the skill sets of computer literate adults.

Just like the space program, it is my belief that, in solving cutting edge game issues, we will also be solving technical and scientific issues for myriad other uses. Couple that with just how much of a segment of the economy computer games have become (by some estimates larger then the movie industry or theatrical film)[3] and there are a myriad of good reasons to invest in and research for the game technologies of the future.

Another friend of mine, Mr. Tom Kalil, a senior technology advisor to the Clinton White House, said to me years ago, "The killer app of the internet is each other." As Facebook has shown, he was absolutely right. And where these two forces of society meet, are in the virtual worlds of on-line games.

[1] A Note On Distributed Computing – Jim Waldo, Geoff Wyant, Ann Wollrath, Sam Kendall

[2] https://sourceforge.net/apps/trac/reddwarf/wiki/Deployments,
Other games include CampFU by Rebel Monkey and Call of the Kings by GAMALOCUS,

[3] http://www.telegraph.co.uk/technology/video-games/6852383/Video-games-bigger-than-film.html,
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[4] The +Spaces Project

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Center for Computer Games and Virtual Worlds, UC Irvine

NSF Workshop - Sept 23- 24, 2010 Position paper

For the past decade now (at UC Irvine and elsewhere), I have been teaching new media studies, including courses on machinima; on computer games as art, culture, and technology; and on the history of simulation. I supervised research projects on MMOs and real-money trade, and a range of machinima productions. My current interests related to Computer Games and Virtual Worlds (each drawing on a recent or forthcoming publication of mine) include the following concerns:

- GUI & Error: Whether one sees graphic user interfaces as Taylorist discipline teaching ergonomic interaction, or as yielding to reductions of interaction to resemble what users had already learned – the GUI is pivotal for digital culture. The discursive formation of computer games runs parallel to that of the GUI: interaction revolves around perception, hand-eye coordination, and discerning errors. But while a typical GUI will aim for visibility and patient acceptance (or even anticipation) of user error, games probe the twitchy limits of reaction times and punish user error with loss of symbolic energy. Audiovisual cues pull users into feedback loops that a game might exhibit proudly, while less playful interfaces tend to hide them. Computer games are an adaptive response to the omnipresence of computing devices – we notice that gadgets often come with a game pre-installed so as to teach us how to handle them. Games afford users significant room for error deviates from common assumptions about the strictures of human-computer interfaces.

- Machinima: Beyond archiving the performative, ludic dimension of game history, machinima harbors another critical approach. Instead of reducing it to fan culture or a contribution to the oral history of videogames, one ought to show how machinima's gestures grant access to gaming's historical conditions of possibility, linking to a comparative horizon that informs, changes, and fully participates in video game culture. Machinima is to computer gaming what Brechtian epic theater was to dramatic and cinematic conventions a century ago. Moments and sequences of computer game-play are interrupted and time-shifted, in adjustments that allow them to be recorded as significant, interesting, or entertaining independently of the immediate context of their production. This halting of technical as well as semiotic relations can make visible, what is at stake in the gestures of machinima, and in a wider sense in digital culture.
- Genre: we need a coherent framework for game studies. Instead of bemoaning "ambiguity and lack of consistency in genre labeling" we can establish basic concepts to prevent aimless proliferation of generic labels. Without denying that cross-fertilization remains a driver in creating new game titles, it appears evident that three modes suffice to understand what is at stake in game studies – on a technical level: graphic display, database, and object-oriented programming, which correspond to psychological modes of engagement of id, ego, and super-ego, or to rhetorical forms of metaphor, metonymy, or synecdoche – or in a nutshell to action, adventure, and planning.
- Boredom and aesthetics. Boredom is a serious challenge to gaming. If gaming is an art form for the 21st century, as critics and designers have been claiming for years, then what precisely are its aesthetic principles? When serious or persuasive games proclaim the right to be "boring" – as Ian Bogost and Edward Castronova for instance put it – does this violate aesthetic dignity? We regard works of art as invested with a kind of right that corresponds to an obligation: including not just freedom from harm or destruction, avoidance of mistreatment or injustice, but extending to an avoidance of cliché, kitsch, faulty badly rendered, sophomoric, cliché artwork and user interfaces.

Badly implemented controls cause an aesthetic distortion of the work in the performance. Game aesthetics would forbid dull and repetitive music, predictable or hackneyed or incomprehensible dialogue, and visual errors like skating characters, unrealistic physics, or a lack of collision detection. It would banish faulty game mechanics such as slow or too unpredictable reactions to input, awkward, counterintuitive, difficult menus and input methods, crashes, no way of saving progress; it would render trial-and-error or brute force approaches unnecessary. In short, one might argue the aesthetic rights of games are violated if boredom is better than play.

- Let it bleep: what happened to sound? A visitor's day at an MIT computer lab gave rise to three demonstrations, as system administrators and students got access to Whirlwind and TX-o computers from Lincoln Labs. Whirlwind, the first computer that operated in real time, displayed a bouncing ball to demonstrate the speed and graphic capability of the machine, while the TX-o made music: Peter Samson had started looping control tones to play with their redundancies; John McCarthy turned his IBM704 into a light organ by sequencing the order of control lights into patterns. While the US Army in 1965 defined a "computer game" as a game of computer versus computer, the hackers at MIT decided in favor of human-computer interaction, and the rest is gaming history. But what is the status of computer sound in HCI and gaming now? I am fascinated with the current retro-subculture of chip-tune or 8-bit music – but what does it mean that electronic music now recycles the sounds of early gaming?

OpenSimulator: An Open Source, Multi-User Scene Server for 3D Immersive Applications

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We present OpenSimulator (OpenSim for short), one of the very few open source multi-user scene servers that researchers can use for experimenting with virtual world systems. The OpenSimulator project started in early 2007 as an open source server to Linden Lab's Second Life client. Using reverse engineering techniques that included monitoring messages on the wire, as well as some documentation provided by Linden Lab, the developers of OpenSim were able to fully reconstruct the client-server protocols, therefore being able to focus on the server-side development while taking advantage of the existing client developed by Linden Lab and others.

An OpenSim simulator serves a variable amount of 3D virtual space. Simulators can be interconnected to form larger, continuous spaces. An OpenSim-based virtual world can be as small as one single simulator or as large as thousands of simulators. A standalone world contains one single server that includes both the simulator and all resource services, and it's meant to be a lightweight desktop virtual world. A "grid" is a world consisting of several simulator servers that share the same resource services.

The software architecture of OpenSim is such that all important aspects of the virtual world infrastructure, including the scene renderer – server protocols, are plugins. As such, OpenSim does not provide a single solution for a virtual world infrastructure; it provides support for a family of solutions. This is what makes it most valuable for research.

OpenSim is fully programmable at several levels, with powerful features for real-world systems simulation such as a variety of sensors (touch, motion, and presence) and actuators (e.g. for generating light and sound, moving and spinning objects), as well as support for communications between simulated objects.

As interest grows in the emergence of the 3D Web, and as the Web browser becomes closer to supporting rich immersive applications, OpenSim is a critical component in the development and deployment of open standards for on-line, multi-user, interactive 3D scene servers – a healthy alternative to closed source, proprietary, commercial servers.

Face, Facebook, and Social Surveillance

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Because games are often understood as recreation, they accommodate and even encourage behavior associated with a respite from cultural norms. In contrast, social network sites blend the worlds of work and play and thus may be said to blur the boundaries of the magic circle.   Despite the fact that social network sites are often thought of as "third spaces"—different from the restricting spheres of home and work—recent research indicates that the rules that govern conduct in face-to-face relationships seem to apply on Facebook as well. And so, making certain kinds of game moves can threaten existing social relationships, even after two friends have implicitly agreed to play a game with each other by adding the same application.

Conventionally, if the one player is a social superior, the consequences of misinterpretation of a game move can be particularly serious, since they might take what appears to be an illegitimate move or face-threatening act as a sign of disrespect or disregard. Worse yet, disputes about whether a rule has been broken cannot be easily arbitrated by neutral parties, since outcomes are largely determined by computer algorithms that are divorced from human intervention. Moreover, in online games that involve asynchronous communication it is possible for one party to offend the other by insisting that the other party make a game move promptly or at an inappropriate time. It's also possible that those who have unequal resources at their disposal—whether of available leisure time or of in-game power, through leveling-up—will resent being asked to make a particular type of move, even if the other player assures them that the results will be mutually beneficial.

This research looks at how social surveillance functions in Facebook games and how monitoring the daily routines of others and keeping track of their group memberships often allows players to optimize their own play experiences and to benefit from other players without direct collaboration. In some games, this optimization actually involves predicting the nonparticipation of others, such as having knowledge of typical times away from keyboard or knowingly enrolling friends who are only nominal members of the game cohort who will never level up or perhaps even make initial game moves. These friends who are recruited but do not need to be surveiled may also provide respite, allowing independent casual play.

In many ways it could be argued that some of these games actually make the underlying logics of Facebook more visible in rewarding victory to those who have formed more alliances with other players. Social scientists have argued that "real-world" social networks reward individuals who can take advantage of the "strength of weak ties" [1] by, using large social webs of acquaintances in order to advance individual reputations. Facebook games make this actual fact about social networks explicit. Also, because the these games often involve organizing assets, positive and negative point values, and the measurement of labor expended in completing multiple tasks, they also fit the "object-oriented" metaphysics of Bruno Latour, in which a loser is defined as "the one who failed to assemble enough human, natural, artificial, logical, and inanimate allies to stake a claim to victory."[2]

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[1] Mark S. Granovetter, "The Strength of Weak Ties," *The American Journal of Sociology* 78, no. 6 (December 21, 2007): pp. 1360-1380.

[2] Graham Harman, *Prince of Nnetworks : Bruno Latour and Metaphysics* (Prahran Vic.: re.press, 2009), p. 18.

EcoMUVE: Advancing Ecosystems Science Education via Situated Collaborative Learning in Multi-User Virtual Environments

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EcoMUVE is a Multi User Virtual Environment (MUVE)-based ecosystems science curriculum based on national middle grades life science standards. The project is its final year of a three-year IES Education Research Grant. The collaborative, inquiry-based curriculum focuses on ecosystems science and the complex causality inherent in ecosystems dynamics.

Prior research (Grotzer and Basca, 2003) has shown that students often have difficulty reasoning about the causal complexity inherent in ecosystems. Teachers are challenged to convey concepts involving time delays, spatial distance, non-obvious causes, and population effects in hands-on, engaging ways. We hypothesize that immersive collaborative virtual environments can help students understand the abstract ideas and causal relationships in ecosystems.

The affordances of virtual worlds allow students to interact with ecosystems in ways impossible in the real world – in EcoMUVE students can shrink to the microscopic level to see microbes and can travel in time to witness the cyclical patterns of predator-prey relationships (Metcalf, 2010). We see MUVEs as vehicles for situated learning - learning by being embedded in a rich context (Dede, 2009).

EcoMUVE includes two one-week virtual-world modules as part of a four-week curriculum. The first module represents a pond ecosystem. Students explore the pond and the surrounding area, see realistic organisms in their natural habitats, and collect water, weather, and population data. Students visit the pond over a number of virtual "days" and eventually make the surprising discovery that many fish in the pond have died. Students are challenged to figure out what happened – they work in teams to collect and analyze data, solve the mystery and learn about the complex causality of the pond ecosystem. The second module is a forest ecosystem in which students explore predator-prey dynamics and the long-term impacts on the environment.

Pilot research data based on the first EcoMUVE module found gains in student understanding of ecosystem concepts including interactions between biotic and abiotic factors, and processes of photosynthesis, respiration, and decomposition. Initial findings on learning of complex causality in ecosystems showed significant increases in student understanding of effects over distance, and slight increases in understanding of effects over time and from non-obvious causes. Upcoming research on the full four-week curriculum will look at outcomes in student understanding of ecosystem content, understanding of the complex causal mechanisms in ecosystems, and affective measures such as student engagement, interest, and self-efficacy in science.

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Position Statement: ***Scale, context, and meaning in studies of computer games and virtual worlds***

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The goal of this position statement is to argue for creating linkages between methodologies based in digital data such as data mining and digital preservation, and ethnographic study. Of interest is any research that engages questions of human activity in computer games and virtual worlds, at analytic levels from the individual to the dense webs of places and activities that virtual worlds give rise to, both on- and offline.

The promise

In investigating computer games and virtual worlds, we encounter new, and radically different, sources of data abundantly available in digital form: keystroke- and chat logs, behavioral data generated from simple scripts, audio/video capture of instances of play, and data residing in commercial repositories. Repositories collect data on character and group statistics (e.g., guild and player rankings), character equipment and items, and history of play (e.g., achievements, gold earned, number of cooking recipes known). Commercially supported through advertising revenue, the repositories offer free data (although the data are not always designed to be used by researchers and must be reorganized). Repositories include, e.g., the World of Warcraft Armory, GuildOx: WoWGuildProgress, and World of Logs: Real Time Raid Analysis. World of Logs, for example, records, at a very fine-grained level, player actions in individual game contests, with a plethora of supporting statistics. An entire encounter can be reconstructed, not in its entirety, but in elaborate detail. Together these varied resources promise research at large scales, and the data, digitally native and fully searchable and analyzable with digital techniques, seem to avoid many of the problems of collection and management necessary for more traditional kinds of data that are not so intimately connected to the computer.

These data sources present many exciting methodological possibilities. Two of interest—data mining and digital preservation—are gaining ground, and seem open to positive interdisciplinary influences. Data mining seeks to identify behavioral patterns in large datasets through algorithmic and statistical analysis. Digital preservation, while an exercise in archiving, is, fundamentally a form of history; deliberations and judgments on the selection and organization of materials establish and maintain an archive.

The problems

Data mining and digital preservation promise scale and ease of analysis, but neither has worked out serious problems of interpretation, which relies on deep understandings of context and meaning. Ethnography excels at interpretation, and is responsive and accountable to the contextual nuances and meanings inherent in, and generated by human cultures and societies. Scale, context, and meaning should not be addressed separately, but engaged together, meeting strategically in a unified project of research. In discovering and inventing ways to integrate digital methodologies with ethnographic approaches, a more coherent and fruitful mode of investigation will be possible.

The research

The research question is how to design new forms of research that do not merely bring together "interdisciplinary teams," dragging along their well-known problems. A fundamental rethinking is necessary, a determined effort to establish procedures and policies to deepen understanding of the *nature of digital and non-digital data* useful for *investigating computer games and virtual worlds activities*.

The affordances and qualities of digital data are not well understood; we are just beginning to work with resources such as machinima, behavioral logs, character repositories, and the like. We do not yet understand these data on their own, nor how they will interact with traditional materials such as fieldnotes and interviews. Many questions arise. What kinds of analyses do the data lend themselves to? Are there principled ways to sample from, or aggregate across such data? Quantitative data, archived materials, and ethnographic data that represent only selected nations and cultures do not truly scale in any analysis. Half of all World of Warcraft players, for example, are Chinese, but the vast majority of studies, regardless of methodological approach, have been conducted in North America, and to a lesser extent Europe. How do we address this situation for artifacts that are global in scope and meaning?

The first step is examination of the data sources themselves as artifacts with their own particular affordances and properties. A second step will move toward devising ways to productively join digital methodologies and ethnographic approaches to better capitalize the strengths of each.

Position Paper: NSF Workshop on the Future of Research in Computer Games and Virtual Worlds

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The establishing point of my positionality in the field is that I am a rhetorician who finds reading speeches horribly boring. The tools of rhetorical analysis are quite interesting to me, but I cannot imagine making a career of engaging in the kind of analysis done by many of my colleagues in other Communication Studies departments. I differ in the texts I choose to study, because I am fascinated by the ways in which technologies work, leading to my focus on the rhetorical practices found in computer games and virtual worlds. A further illustration of my position within the field requires three moves: a discussion of my methodological approach, a short summary of my work, and a look at two issues I see as critical to the future of research on computer games and virtual worlds.

Trained as a rhetorician within a Communication Studies department, I am interested in the ways in which elements like words, technologies, and people structure how we conceptualize of computer games and how they are played. I think that much of the work originally designed for the analysis of speeches can be ported, with care, to analyze elements of computer games and virtual worlds. I am heavily influenced by scholars like Kenneth Burke, who holds “the whole overall ‘picture’ [of reality] is but a construct of our symbol systems” (1966, p. 5) and R.L. Scott who argues that rhetoric is epistemic, as rhetoric creates what we perceive of as truth (Scott, 1967). I believe in ‘big’ rhetoric, the contention that “everything, or virtually everything, can be described as ‘rhetorical’” (Schiappa, 2001, p. 260). Rhetoric is effectively “the study of what is persuasive” (Campbell & Huxman, 2009, p. 5) and has become “the study of the art of using symbols” (Campbell & Huxman, 2009, p. 14). In sum, “rhetoric offers another perspective, one that accounts for the production, circulation, reception, and interpretation of messages” (Zarefsky, 2008, p. 635). The primary issue I see with the application of rhetorical analysis to the study of new texts is that its tools were primarily designed for the study of speeches. This means that any rhetorical analysis of a computer game or virtual world must be approached with great care to account for the gap between methodological approach and chosen element for analysis (c.f. Paul, Forthcoming).

I primarily use rhetorical analysis to look at the interchanges between players, designers, and games. I used Kenneth Burke's concept of identification to analyze how raiding groups in *World of Warcraft* can come together and fall apart (Paul & Philpott, 2009). As the guild was increasingly defined by success in raiding, a lack of success threatened the stability of the group and, when adversity was faced, the low barriers to guild movement resulted in the quick demise of a long-standing guild. I analyzed how the term 'welfare epic' circulated through the discourse about reward structures in *World of Warcraft* and in doing so, indicated how the player base had shifted over the course of the game and how players, both those who praised and derided welfare epics, reified the premise that by performing 'work' in game they should be entitled to appropriate rewards (Paul, 2010). In addition to how designers shape games, I contend that players can have a fundamental impact on how a game is played, which can be clearly seen in the case of theorycraft, which has reshaped *World of Warcraft*'s design and planning (Paul, 2009b). In my most recent work, I am looking at how elements of the design of *Grand Theft Auto* function to warrant the violence in the game, which accounts for some of the divide in the commentaries between players and non-players of the series. Through careful construction of technically unnecessary flourishes, like humor, and a particular construction of the protagonist, those who actively engage in playing the games are immersed in a world where the violence that confounds critics recedes to status as a simple game mechanic.

I see two substantial research issues facing scholars seeking to analyze computer games and virtual worlds. The first issue is that much of the research in computer games and virtual worlds is limited to observations found in particular games or worlds, rather than examining how those observations apply across games or worlds (c.f. Paul, 2009a). The upside of taking a deep look at particular elements of a world is that the result is a rich understanding of those environments (Nardi, 2010; Taylor, 2006). However, the limitation is that the analysis is not necessarily as clearly generalizeable beyond those worlds or games. This is a particular problem in the case of journal articles, as limited space and time almost necessarily requires focusing on a limited research object. Though there have been projects that look at a phenomenon across texts, like Mia Consalvo's analysis of cheating (Consalvo, 2007) and Ian Bogost's analysis of how games can function persuasively (Bogost, 2007), this is an area where researchers can attempt to complement single-game or world analysis with additional games and worlds. This dynamic makes it especially important that scholars choose a variety of texts to analyze, from their favorite games to industry leaders, independent games and the myriad games in between.

The second issue is the relative youth of the field. Because video games are relatively new and because game studies is an emerging discipline, games researchers are often reliant on the good will of senior colleagues when it comes to assessing things like the quality of a research program or a grant proposal. This is not a problem exclusive to the study of games and virtual worlds, but the relative scarcity of norms, programs and senior faculty and researchers in game studies presents potential issues for graduate students and early stage faculty members who choose to pursue game studies. This is simultaneously an opportunity, as the relative lack of established norms and figureheads makes the field nimble and more able to adapt to change. I think it is crucially important for games scholars to coordinate on both research and how to best navigate colleagues who may be hostile to their research program.

Research in computer games and virtual worlds is in a fascinating place. The field is now established enough to have a community of active scholars, but still new enough to be flexible in response to change and innovation. As it grows, we stand to be in a position to help analyze, advance and understand a key element of contemporary culture.

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Prior research and related activities
I come to the virtual worlds space as a practitioner, designing multiplayer games and interactive media for museums and theme parks. In the late 1990s, my interest dovetailed into anthropological research in multiplayer games and virtual worlds, with a particular focus on how software design promotes emergent behavior. The findings of this work (my Ph.D. thesis project) were published in as *Communities of Play: Emergent Cultures in Multiplayer Games and Virtual Worlds* (2009, MIT Press), as well as a number of other publications. The focus of this research was on inter-game immigration and the emergent cultures of game refugees that become the casualty of multiplayer game closures. Some key findings include:

- Emergent behavior highly situated: It is the result of particular types of people coming into contact with specific software affordances and game mechanics.
- Because of their status as refugees, the play community developed "trans-ludic" group and individual identities that they carried with them across different games and virtual worlds, identities that were closely aligned with the virtual place they referred to as their "homeland."
- Different play communities develop different styles of play that impact the emergent behaviors they exhibit.
- A prevalent emergent behavior among this group was Productive Play, in which play activity transforms into creative practice.

This interest in Productive Play led to two NSF-funded projects. The first was a workshop co-produced in 2007 at UC Irvine with Bonnie Nardi and Jason Ellis (IBM) that expanded the term to include the use of play spaces in work contexts. This resulted in a special issue of the journal *Artifact* (Volume 2, Issue 2, 2008) exploring the many facets of productive play.

A subsequent NSF-funded study examined the University of There, a player-run university in *There.com*. This community exemplified emergent behavior, productive play, and the use of virtual worlds for peer-based learning and collaboration. One of the key findings was that players emergently developed "folk teaching" methods that paralleled many of the well-studied learning benefits of games, such as situated and constructionist learning.

Current Activities
I flew to this workshop directly from Washington DC where I was giving an interim presentation on my current research funded by the IARPA Reynard program. I am working with SAIC to conduct a cross-disciplinary study that combines psychometrics (quantitative) and ethnographic (qualitative) methods to gain insight into the relationship between real-world personality and observable avatar behavior in virtual worlds.

I am currently co-authoring a handbook on ethnographic methods for virtual worlds with Tom Boellstorff and Bonnie Nardi (UC Irvine), as well as T.L. Taylor (Copenhagen ITU). The idea for this book arose out of growing interest in ethnographic methods that we encountered at DiGRA, AOIR and other related conferences. The aim of this book is to offer a practical guide that provides readers with both a solid theoretical foundation and practical guidelines on how to conduct ethnographic research in online games and virtual worlds.

In addition to studying virtual worlds, my lab at Georgia Tech, the Emergent Game Group, also produces experimental multiplayer games in a variety of genres. I have also been consulting over the past two years with Sony PlayStation Home on the redesign of their public spaces.

Critical Research Topics

Research Myopia: I continue to be concerned that the vast majority of MMOW/G research seems to take place in one of two worlds: *Second Life* and *World of Warcraft*. I have described this as the real-world anthropology equivalent of only two islands being studied by the entirety of the discipline. I feel it's important for us to branch out because we are drawing generalizations about life online from a very narrow cross-section of cultures (especially MMOGs, which are predominately male). I have typically tried to avoid studying *Second Life*, but the current research project suffered a forced to migration due the closure of *There.com*, my previous research focus.

Latitudinal Studies: While much excellent foundational research has been done with in single-world studies, I would like to see more of what I term "latitudinal studies," that is, studies that take place across multiple worlds, and multiple genres of worlds. One of my students recently conducted a study (soon to be published in a co-authored paper) that looks at attitudes about avatar gender in *Second Life* and *Guild Wars*. This study has yielded interesting insights about the similarities and differences between virtual worlds and games, as well as generalizations we can make about both.

Mixed Methods Research: For some time, there has been a "methodological theology" debate, which has become quite contentious, between quantitative and qualitative researchers. I have used the metaphor, borrowed from Katherine Milton, of traveling by car or by plane: they both yield different data, but neither produces a complete picture: from the air, we may see patterns on the ground, but we cannot understand their meaning unless we can look at them up close. With my most recent project, I set out to prove a personal hypothesis: that the two can not only live in harmony, but work together to produce new insights and research findings. The current research, while still in-progress, is well on its way to bearing out this assertion.

Scholarly Rigor: One of the reasons I embarked on the methods book project is a growing concern I have about poor and sloppy scholarship. At the Virtual Cultures event here at UCI I was appalled to hear what passed as ethnography, a whole range of practices that clearly did not follow the established methods (or ethics) of ethnographic research. At this event, the expression was coined that "Leveling to 70 is not ethnography." I am very committed, both through the current book project, my research, the peer review process, and teaching (I've started an ethnographic and qualitative methods working group), to advancing the level of scholarship and rigor in online games and virtual world research.

Position Paper: Advancing the Science of Computer Games and Virtual Worlds Across Science and Technology

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Introduction

My interest for this Workshop is to focus attention to the emergence of on Computer Games and Virtual Worlds (CGVW) within other scientific research and technology development communities. This includes attending to how such CGVW are or could be developed, along with what kinds of tools, techniques, and concepts are or could be employed to support the development and deployment of CGVW in such communities. My interest is directed at how CGVW can arise in areas like quantum physics, astronomy and astrophysics, chemistry, biology (including biochemistry, bioinformatics, genomics, proteonomics, and evolutionary biology), earth systems science, environmental and water sciences, and the social sciences, as well as in healthcare and advanced technology production operations. Such interest seeks to span from bleeding edge efforts most likely found in research laboratories whether physical and virtual, to informal educational venues where diverse publics, including children, adults, and families are interested in learning about science and technology in fun, playful and engaging ways.

Prior and Recent Research

My prior research in CGVW builds from my long-term comparative study of free/open source software (FOSS) development processes, work practices, and projects across different software application domains (or social worlds) such as computer games, astrophysics, bioinformatics, military computing, and Internet/Web infrastructure, as well as including game modding culture and practice [Scacchi 2002, 2010b]. In simple terms, my interest is in understanding how complex software-intensive systems come to be the way they are, as this may help inform our understanding for how CGVW can come into being in different R&D communities. More deeply, most of my recent research has focused on sustained empirical study of FOSS development projects, with particular attention devoted to understanding how work processes and practices are articulated through collaborative transactions in "software informalisms," that is, online artifacts like bulletin boards, Web pages, source code repositories, chat/instant message streams, bug reports, etc. that serve as venues for socio-technical interaction [Scacchi 2002]. Such studies when focused particularly on FOSS projects for CGVW, reveal new technical work practices like "virtual project management" and "role migration" that rely on meritocratic social hierarchies rather than administrative authority to govern the ongoing flow of software development work, along with the migration of contributors through such projects [Jensen and Scacchi 2007, Scacchi 2004]. Such intra-project migrations are different from the cross-world immigrations that Pearce [2009] has studied, though no systematic comparison has been started. When observed across social worlds, it is possible to observe how FOSS development practices in computer games, for example, crossover into Internet/Web infrastructure projects, but much less so scientific research projects, and vice-versa [Scacchi 2008]. But enough on this.

In conjunction with these field studies of FOSS projects, I also engage in producing different kinds of free or open source software systems, in particular, those enabling CGVW for R&D worlds. For example, in collaboration with Robert Nideffer, we led the development of a life science learning game environment targeted for children learners in the K-6 grades, for the Discovery Science Center, called *DinoQuest Online* [Scacchi, Nideffer, Adams, 2008]. This free to play, Web-based environment complements an on-site, interactive exhibit called *DinoQuest.* We helped design how these two environments would be integrated to provide an extensive learning experience in the life sciences using dinosaur-themed exhibit elements, paleontological field practices, and virtual scientific collaboratories for interacting with diverse scientific role-modeled video avatars. I have also led production on game-based virtual world for training semiconductor manufacturing technicians in diagnosing spills of benign or hazardous materials found in such manufacturing facilities [Scacchi 2010a].

Emerging Research Problem Areas of Interest

I believe there are an interesting set of research problems that are now beginning to emerge when we look at how CGVW may be employed or applied within other scientific or technological communities. Recently, I have become involved in prototyping new CGVW concepts for experimental use in rehabilitation and physical therapy involving assistive robotic techniques, for modeling and analyzing space debris fields in near-earth orbits, for astronomical visualization using spherical displays, for military command and control research, and for teaching cellular biology to undergraduate students. A recurring challenge that arises in all of these different adventures center around the need to start each time with an all-too-primitive CGVW development environment and supporting hardware/software infrastructure. Developing a new CGVW using general-purpose programming languages and methods, as in common in the computer game industry, is a very slow way to go. While you can implement (program) almost anything you want, the problem is too often you must program too much to get what you want, and you must often program around the provided capabilities and resource limitations that are at hand. In many ways, developing CGVW is more difficult that just developing a new FOSS application system. CGVW development has too few principles or practices that are geared to enable more rapid and simpler production of complex synthetic worlds for virtual interaction.

Modding and automated generation are much more interesting approaches to seek out, compared to programming, to more rapidly create new CGVW for research and experimentation. Yet the investment in tools and techniques to support these, as well as the scientific knowledge for how best and when to use such is lacking but needed.

Similarly, some CGVW prototypes need to be potentially of very-large scale, while others may need to be of small or micro-scale, in terms of number of in-world behavioral objects and avatars, the complexity and duration of their interactions, the number of underlying processor boundaries they must span, etc. Subsequently, we lack the scientific knowledge and engineering practices for how best to organize CGVW development efforts in general, and of different scales in particular. We also lack tools, techniques, and concepts for spanning such differentiated CGVW development efforts.

Research Infrastructure Requirements

One thing I have learned from study of complex system development efforts is that systematic empirical study of multiple projects really benefits from semi-automated data collection, modeling, analysis, and simulation (for reenactments, rehearsals, and scenario exploration) tools and techniques, as well as those that support data mining and knowledge discovery from online project repositories. Such tools and techniques are increasingly found to be of value in many diverse academic research disciplines, and they can scaled to support comparative studies across social worlds of varying size and complexity [Gasser and Scacchi 2008]. Much prior empirical study in CGVW has not employed nor exploited the potential of such tools or techniques, and this I think is an opportunity for both CGVW developers (to embed computational methods for streamlining in-world event sampling—conforming to informed consent and privacy preservation conditions), and behavioral researchers. CGVW in the scientific research and technology development venues represent a new kind of experimental and experiential world where processes and problems under study can be computationally and socially animated and transacted in new/old, interesting, and not-so-interesting ways.

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Self-organizing Massively Multiuser Virtual Environments

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I. Introduction

Current virtual worlds are still comparatively small. Even massively multiuser virtual worlds – also known as massively multiuser virtual environments (MMVEs) – usually contain between several thousand [Blizzard 2010] and sixty thousand [CCP Shadow 2010] concurrent users per copy of the world. This is due to restrictions in the amount of available content and the technical challenges to host more users at a time [Emilsson, 2009]. Future systems will have to cope with much larger virtual environments and user populations, ranging up to global scale virtual worlds with millions of concurrent users. To ensure a lively MMVE market with a large number of virtual world providers –both small and large – the necessary investment to operate such a large MMVE must be restricted, while ensuring that successful systems can grow very fast.

II. Self-Organizing MMVEs

To achieve these goals, future MMVEs must be *self-organizing systems* that are able to reconfigure themselves automatically at runtime and make full use of the resources of all devices that are currently available to them. This includes (a) transient devices of users that are logged into the system, e.g. mobile devices with high speed Internet access and standard PCs, (b) stable devices that are managed by the MMVE provider, e.g. a server cluster, and (c) devices that are provided by a third party, e.g. compute servers in the Cloud. Together, all these devices offer the MMVE system a very heterogeneous and dynamic resource pool, in which resources may become available or be lost at any time. Classical MMVE systems that are usually tailored towards relatively stable server infrastructures, cannot exploit this resource pool. Self-organizing MMVE systems can be far more responsive to dynamic changes in both system load and available resources, e.g. by redeploying system parts and responsibilities automatically. This allows them to achieve a very high level of scalability with respect to the size of the virtual environment and the number of concurrent users. At the same time, it allows the system provider to offer an MMVE very efficiently with a minimal amount of over-provisioning, thus reducing cost.

III. Prior and Current Work

My main research interest is the design and development of complex self-organizing distributed systems, specifically decentralized and highly interactive systems.

Since 2001 I'm investigating self-organization in peer to peer (P2P)-based Pervasive Computing environments. In Pervasive Computing systems, our daily environment is enriched with a large number of embedded and mobile devices that are connected together using wireless networking technology. Applications are executed on possibly large sets of such devices that must coordinate each other accordingly. Together with my colleagues I developed an adaptive system software [Becker, Schiele, et al., 2003] that identifies stable device groups in the mobile environment. Using these groups the system software dynamically forms a cluster hierarchy, establishes distributed application configurations (see, e.g., [Handte, Herrmann, et al., 2007]) and places system services dynamically (see, e.g., [Schiele, Becker, et al., 2004]). At the moment we are investigating how self-organization concepts can be applied to coordinate the physical context influences of pervasive applications that might otherwise conflict with each other (see, e.g., [Majuntke, Schiele, et al., 2010]).

In 2006 I extended my work to Internet-based global scale P2P systems – specifically for P2P-based MMVEs – and coordinate the peers@play project (see the project homepage at http://www.peers-at-play.org). The peers@play project is a research cooperation of three german universities, the Universitaet Mannheim, the Universitaet Duisburg-Essen and the Leibniz Universitaet Hannover. Our goal is to develop a prototypical framework for very large scale and highly interactive self-organizing MMVEs. We are specifically interested in scalable update propagation (see, e.g., [Sueselbeck, Schiele, et al., 2009a]), distributed data management and computation for MMVEs, consistency (see, e.g. [Itzel, Tuttlies, et al., 2010]) and security (see, e.g., [Wacker, Schiele, et al., 2009]).

While we originally restricted our system model to a pure P2P system that uses only end-user devices, we are now widening our focus to include hybrid systems with additional resource providers, namely server clusters operated by the MMVE provider and servers in the Cloud (see, e.g., [Sueselbeck, Schiele, et al., 2009]). On the one hand, this can help to solve many problems that we encountered in a pure P2P system, e.g. bootstrapping (see, e.g., [Knoll, Wacker, et al., 2008]) and system partitioning. On the other hand, new research challenges arise.

IV. Current and Future Research Challenges

To achieve truly self-organizing MMVEs, a number of research challenges must be addressed. I discuss the most interesting ones in the following.

How to develop self-organizing MMVE systems?

Foremost, we must develop a suitable programming model for self-organizing MMVEs. Key requirements are (a) separation of concerns, i.e., the application behavior must be separated from runtime adaptation behavior, (b) transparency, i.e., the distributed character of the system and possible runtime adaptations must be hidden from developers as much as possible, and (c) cross-layer knowledge, i.e., the developer must be enabled to specify requirements and dependencies, such that the system can adapt itself correctly later on. Starting points for this research can be found, e.g., in Grid computing, service oriented architectures (SOA) and Pervasive Computing.

How to adapt the system?

To adapt the MMVE dynamically, different adaptation mechanisms must be researched. As an example, service relocation can be used to change the system deployment at runtime. The implementation of a service can be exchanged dynamically, e.g., to switch between a centralized algorithm on a server and a distributed algorithm in a P2P system. To do so effectively, we must analyze, which functions are better suited for centralized server resources and which are better for decentralized peer resources? Using this knowledge, the system can aim to realize the best configuration at all times, while falling back to a less favorable one if needed. Finally, we must better understand, how to best react to specific situations, e.g., increasing system workload. Should the system, e.g., try to distribute the load on more peers? Should it move a system part from peers to a server or should it try to get additional resources in the Cloud?

How to allow the system to control its resource usage dynamically?

In many cases, the MMVE system may experience scarce resources at runtime, especially, if only peer resources are available. In such cases, the system must try to reduce its resource usage without reducing the provided service level unacceptably or even aborting. Note that disconnecting users from the system might not be a suitable strategy, as these users' peer resources become unavailable, too. Graceful degradation techniques must be developed, which, e.g., reduce how detailed a user is informed of other users' actions. This can lead to systems, where other users are switched to simple local bots if too many are nearby, to reduce network load. In addition, if only very few peers are available and no server can take over, simulating the whole world might overwhelm the peers. To counter this, simulation techniques and programming models could be developed that allow, to switch to a more coarse grained simulation of parts of the virtual world in which no user is currently active.

How to monitor and control the system at runtime?

A self-organizing MMVE is a very complex system. System providers must be able to monitor the current state of the system to detect potential choke points and problems early. In addition, they must be able to take corrective action, e.g., by overriding automated adaptation decisions. Finally, providers might want to set fixed rules for acceptable system configurations. As an example, a provider might want to define statically that the accounting service of an MMVE is always executed on his own server infrastructure instead of the Cloud or a peer.

How to efficiently test and evaluate the system?

Testing and evaluating a self-organizing system is a difficult task. If an error occurs, the system often adapts itself to cope with it, leading to suboptimal configurations that may mask the error and increase the complexity of finding its actual source. For massively multiuser systems, testing is even more difficult. Without many users and a large set of different available resources, tests cannot be done realistically and many errors will not be found. Possible solutions for this are MMVE simulation environments that allow testing an MMVE with virtual users and resources.

V. Conclusion

Self-organization concepts enable us to create highly complex distributed systems that have the potential to make full use of the computational resources of future computing infrastructures, e.g., the Cloud or P2P networks, to construct global scale MMVEs with millions of concurrent users. Work has already started and many concepts can be adapted from other areas, e.g., pervasive computing. Nevertheless, the unique requirements of MMVEs, their high interactivity and dependencies within the virtual world require us to rethink many of these concepts. A lot work is still to be done. Many problems must be solved.

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Background:

I have a Bachelors and Masters degree in Aerospace Engineering and a Ph.D. in Visualization Sciences. I currently teach game design, game development, graphics programming and 3D modeling & animation.

Relevant completed and ongoing research:

With funding from NSF, I recently organized a successful workshop that explored the use of games in engineering and computer science education. I am currently working with faculty from Electrical Engineering and Education on an NSF-funded project to develop a game to supplement the lab portion of introductory digital logic design courses. I am currently leading another USDA-funded project to develop a game to teach nutrition concepts to middle-school children in a school district with a high percentage of under-represented groups. In a previous project, I designed a suite of games to assess knowledge of design principles for assisted-living facilities. I also serve as a consultant on two other educational game projects, one to teach science to middle-school students and another for training teachers to deal with classroom situations.

Research Interests:

My primary research interest is in **applied gaming**, a term I coined to refer to the use of games and gaming-related tools and techniques in other domains. This expands on the popular notion of **serious games** that refers to the use of games for purposes other than entertainment to include activities like game engine-based simulation and visualization and the use of game design principles to improve curricular instruction.

Within applied gaming, my particular interest is in applications in education. I believe that applied gaming provides rich opportunities for advancing the field of games in particular and interactive media in general. I am particularly interested in exploring the use of **games to advance education** in various disciplines ranging from science and mathematics to engineering and architecture. Theoretical and design frameworks that form the basis for educational gaming also provide new models and ideas for developing games purely for entertainment. Another relatively untapped area of study is the use of multi-player games and virtual worlds as platforms for conducting research. This is particularly relevant to real-world applications that require the study of human behavior under various situations and contexts such as emergencies and natural disasters.

Other Previous Work:

My previous work was in **interactive 3d modeling**. For my Ph.D. research, I developed algorithms and tools for creating polygonal models with a large number of handles and holes (high-genus models). The result of my work was the development of **TopMod**, a topologically robust, 3D mesh modeling system that allows users to quickly and easily create aesthetically pleasing, unique shapes with complex geometry. Following my work on TopMod, I worked on an interactive design and simulation application (DConstruct) for use in a civil engineering dynamics course.

Games: Solutions in search of Problems?

One could argue that the field is no longer in its infancy. Is it even a "field" of study? But clearly "serious games" have not lived up to the initial expectation and hype. Otherwise, we would be seeing a lot more real-world examples. One problem is that developers of educational games are possibly approaching it from the wrong direction.

A lot of projects start out like this: "My students have problems learning or staying motivated. I've heard a lot about games and their potential to address these problems. Wouldn't it be great if I could make a game that would help my students learn and keep them motivated?"

Quite often this leads to "edutainment" which has clearly failed. What is needed is an examination of why the problems exist in the first place. Perhaps games are not the solution after all! Or perhaps, "gaming" can offer a solution. This is the whole thrust of my emphasis on "applied gaming". We don't necessarily need a game to make use of the learning principles embedded in good games. We just need to use those principles. A few people are experimenting with making their course into a game, incorporating a few motivating elements from games into their course structure. This approach probably provides a greater return on investment than investing in development of a full-fledged game. I am currently experimenting with this approach in two of my classes and in one of my research projects with middle-school kids.

A couple of other ideas on future directions for this field:

1. *Increasing re-use of educational games:* Every educational game project appears to be custom designed to meet a very specific (and narrow) set of objectives and for a limited audience. While this by itself is not an issue, this results in too much bloat. From a research stand point, this means that most results from effectiveness studies cannot be generalized. What we need are games or rather game frameworks that can be easily re-used or adapted to specific needs.
2. *Having low-cost, easy-to-use game development tools:* Related to the previous point is the need for low-cost development tools. Educators and scholars interested in making games cannot afford the multi-million dollar budgets of large game studios. However, we still need to have high-quality games in order to effectively compete with commercial games. In the extreme, I envision game development tools becoming commodity tools like Microsoft Office. Anyone would be able to whip up a small game with limited resources and in a matter of days rather than months. The tool would also allow the user to create much higher quality games with more effort and resources. A few tools that approach this ideal currently exist (e.g. GameMaker, Scratch) but a lot of work still needs to be done. The problem is that game development is a lot more complex than making PowerPoint slides.
3. *Using games for research:* Can we use games as research platforms? Can we study player behavior in the virtual world to make decisions in the real world? This looks at gaming from a different angle – the goal is not necessarily to educate or train the player, but to gain insights into how people might behave in the real world. Could we, for example, predict how people in the real world would react to an emergency by studying how they react to similar emergencies in a virtual world that has been designed similar to the real world? Essentially we treat the game as a simulation, with the players as test subjects. This is not really a new concept, but what would be new is taking it to the next stage of using MMOGs to do this kind of study.

Position Paper T.L. Taylor
NSF Games & Virtual Worlds Workshop, Sept 2010 IT University of Copenhagen

As a qualitative sociologist my work has primarily focused on ethnographic studies of multi-user experience within virtual worlds and computer gaming environments. Starting in the early 1990's with text-based MUDs and moving into graphical virtual worlds and then massively multi-player online games, I've been particularly interested in shared online spaces. I have broadened this recently and am wrapping up a book on e-sports which moves beyond a virtual environment context to explore an emerging community of (professional) play. Though the specificity of my various fieldsites is important to my findings and my training pushes me to tread carefully when it comes to generalizations, I would put forward the following as persistent themes evidenced in my work and mirrored in the research of others looking carefully at game culture:

- Users are active, engaged, meaning makers who construct through creative practice and norms systems of action and interpretation in virtual spaces (game and non) that often go well beyond designer intent. While users often create software products, mods, digital objects, etc. user production should not be limited to thinking about new bits of code but also include a serious consideration of practices and norms.

- Formal design, in its best moments, recognizes the "remix" nature of all game & world design. This can be seen both in the ways designers re-appropriate cultural conventions into the design of their spaces and moments where they integrate emergent community practices/developments into official releases of software. Making transparent of this mode of co-creative cultural production (indeed this is *the* mode by which culture is produced) is both critically and politically important.

- As in offline life, forms of stratification and hierarchy are persistent features of online life and communities. Debate (and struggle) regularly occurs within communities about appropriate behavior, notions of deviance, systems of inclusion and exclusion.

- Within a given virtual world or game there is often a fair amount of heterogeneity (which typically dovetails with discussions/debates/struggles around the previous point).

- There is no clear boundary between what is commonly called "real life" and "virtual life" and hard demarcations of game vs. non-game space do not hold up empirically.

- Experience in virtual spaces is embodied, both corporeally and through a complex relationship with an avatar. This is a non-trivial aspect and central to everything from identity to social experience to constructions of presence.

- Life in virtual and game worlds is never understood simply by looking at the game system, software, or boxed product. It is constituted through a complex assemblage that traverses everything from technology to culture to personal biography.

- Though we can never simply look at systems and software to understand experience, we also need to deal with the way technologies are actors in these spaces, often carrying with them powerful political, ethical, and social mechanisms.

Despite the growth in research over the past two decades in virtual worlds and game research, there remain a number of compelling areas for future research yet under-explored. Just a few are:

- More needs to be done understanding the complex relationship between formal design practices and the ongoing emergent production of user communities. Sometimes explicitly, sometimes not, game companies harness the productive activities of their user base. And at the same time we frequently witness an over-reach when it comes to companies trying to preserve a regressive notion of IP around their title.

Work by people like John Banks (2009) and Thomas Malaby (2009) provide some good footholds for future studies of the co-creative nature of the production of these spaces that integrates an inside-the-company orientation with a consideration of user activities. Situating this process within larger critical conversations about IP, cultural production, etc. is key.

- Much of the focus on virtual worlds and gaming has centered (without reflection) on the mediating device of the personal computer. Yet huge numbers of people use consoles (including old 2nd gen ones) to engage in gaming. Increasingly these boxes are also *network* devices, in which everything from traditional media consumption, the distribution of new content, and multiplayer experiences are flowing. This often involves complex negotiations between local and transnational domains. Understanding the role of networked consoles in our everyday play lives is a prime area for research not only in games but unpacking a more complex matrix of media practices.

- Slowly but surely we are moving beyond ideas that we can constrain time with computer games and virtual environments as "simply" play but more needs to be done to understand focused and passionate engagement with these spaces ala notions of "serious leisure", "professionalization", and intense commitment. This is counter to a rhetoric of "addiction."

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Scalable Content in Games and Virtual Worlds

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1. INTRODUCTION

Scalability is essential to creating rich and immersive interactive experiences. While one can define scalability as the ability to support a large number of concurrent users, we focus on scaling the number of complex virtual objects that can interact in a virtual world. These include user avatars and models, but they also include additional items, characters, and behaviors created by both users and centralized service providers. This type of content is essential to create rich extensible worlds, and it may vastly outnumber individual users. We believe that there are three major requirements for the development of scalable content.

Content must be data-driven. The development of quality content requires different skills than the development of complex software systems. Data-driven development separates the scripts for object behavior from the underlying software of the world. This approach is widely embraced by game studios, which bring together widely divergent talents, such as artists, musicians, designers, and software engineers [7]. Furthermore, this separation is crucial for virtual worlds that supports user-generated content, such as *Second Life*.

Content must be expressive. An easy way to support large amounts of content is to provide the user or developer with a small number of pregenerated objects that she can place as she sees fit. However, this is quite unsatisfying, particularly in the case of user-generated content. Individuals should be able to express themselves artistically with content beyond that specifically envisioned by the developers of the underlying software platform. This necessitates robust scripting languages like the one present in *Second Life*. In general, the virtual world should be architected so that all but the most radical changes do not require code modification.

Content must be optimizable. Allowing content to be both expressive and data-driven often comes at the cost of performance. Scripting languages do not benefit from the performance optimizations present in robust programming environments. In addition, novice developers do not always know the optimal way to implement a feature. The architecture for virtual worlds must be prepared for any kind of data-driven content, and optimize it the best that it can. This may include compilers that statically optimize scripts, or a runtime with dynamic script optimization.

1.1 Our Approach

In our work, we have applied database processing and optimization techniques to scripting languages for games and virtual worlds [2, 6, 8]. In order to leverage this technology, we make one important assumption: *the number of objects in the game is significantly larger than the number of scripts defining their behavior*. This allows us to combine objects that are executing the same behavior and process them in a set-at-a-time fashion (as in databases). In Section 2, we argue why this is a reasonable assumption for a large class of applications. In Section 3, we give a high-level overview of the advantages of this particular assumption.

2. APPLICATION AREAS

We believe that there are many applications that satisfy our requirement that the number of objects be much greater than the number of scripts defining their behavior. We present just a few illustrative examples.

Games. In most games, there are many objects of the same type. These objects all exhibit the same high-level behavior, and are differentiated by their data values. For example, behaviorally identical opponents in a role-playing game may have different visibility ranges, or do different amounts of damage. Modifying the parameters of an opponent, but not its behavior, is a very common tactic for adjusting player difficulty.

Furthermore, interesting gameplay often includes multiple copies of the exact same type of opponent. These opponents may be programmed to coordinate with others of their type, producing emergent behavior from a single script. For example, fighting an army of the undead is significantly more challenging than fighting a single ghoul.

In general, challenges and opponents are commonly built up by combining a small number of behaviors in different and interesting ways. These behaviors are modular, so that they can be combined freely. When combined, they can interact with one another to produce interesting emergent behavior, such as melee units providing cover for ranged units.

Scientific Research. Behavioral studies are an increasingly important area of scientific research. They are particularly important for understanding ecology and animal behavior. Virtual worlds present an enormous opportunity in this regard, as they are environments in which researchers can interact with the simulated animal populations in real time. A researcher might want to take direct control of a member of a herd, and see how the rest of the herd reacts to her actions. Or she may want to become a lone predator that threatens the safety of the herd.

Animal behavior simulations are are the most extreme example of our assumption; all of the animals (of the same type) have the same behavior scripts. In this case, emergent behavior comes entirely from the interactions with one another.

Education. The same factors that make virtual worlds appealing for science also make them fantastic for education. Virtual worlds can serve as ecological laboratories for students. For example, River City [1] is a world in which the inhabitants are mysteriously getting sick, and the students are tasked with finding out why. However, the number of inhabitants is relatively small and the environmental simulation is relatively simple. Again, since the project is simulating health effects, many of the inhabitants can be described by identical scripts. Increasing the number of inhabitants, as well as other parts of the ecosystem, can lead to more engaging and instructive experiences.

Policy Analysis. Behavioral simulations are also important for a large number of governmental policy decisions. For example, traffic policy is incredibly important to modern society. By modeling traffic in an interactive environment, we provide policy experts with the means to visualize and analyze the effects of their decisions.

3. TECHNOLOGY OVERVIEW

The cornerstone of our approach is a programming pattern which we call the *state-effect* pattern [8]. In this pattern, we assume that objects are processed together in discrete timesteps. For example, timesteps might correspond to animation frames or to some simulated unit of time (e.g. 1 second). However, there is no requirement that these timesteps occur at animation framerate or that every object be processed every timestep.

Each timstep is separated into a *query phase* and an *update phase*. Intuitively, the query phase reads object state from the previous animation frame; it cannot make any changes to an object. On the other hand, the update phase changes the state of an object, but cannot access other objects while doing so. The result of this separation is clearly delineated read-write phases that allow us to perform optimizations that are often used in databases, such as multi-query optimization on the scripts.

To support these phases, object attributes are classified as either *states* or *effects*. These classifications obey the following rules:

- State attributes are read-only in the query phase.
- Effect attributes are write-only in the query phase.
- Multiple writes to an effect attribute in a query phase are *aggregated* via an associated aggregate function.
- Effect attributes are read-only in the update phase.
- In the update phase, each object updates its state attributes from its effect attributes and old state attribute values.

We have developed a scripting language for defining object behavior in games and virtual worlds. Our language is superficially similar to Java, except that it explicitly supports the state-effect pattern. Fields are specifically marked as state or effect, and have either an aggregator (if effect) or update rule (if state). Further details can be found in the language manual [3].

To take advantage of the state-effect pattern, we make use of our assumption that many objects execute the same script. This allows us to convert our scripts into database query plans and process them set-at-a-time [6]. We can process the objects in any order or even in parallel. This transformation allows us to take advantage of many database optimizations such as automatic indexing and code reordering. Furthermore, we can use properties of the scripts to distribute computation automatically across several machines, without having to use manual partitioning techniques such as geographic zoning.

Automatic Indexing

One of the difficulties with large numbers of scripts, is that that cost of processing them is often n^2 in the number of scripts [5]. For example, to simulate animal behavior like fish schools [], each fish has to interact with every other fish. One of the ways to improve this performance is through the use of aggregate indexing. Aggregate indices take advantage of the fact that all of these fish are computing the same script to reduce redundant computation. We have

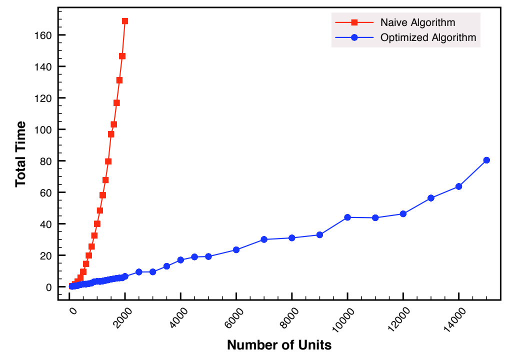

Figure 1: Naive Processing versus Indexing

been very successful in applying aggregate indeces to games; Figure 1 demonstrates the its improvement in processing a simulated real-time-strategy game [6].

Automatic Distribution

In order to scale to a large number of users, developers typically partition a virtual world across many physical computers. This is quite challenging, and many games and simulation platforms are forced to restrict the degree of interaction between objects on different servers in order to achieve scalability [4]. We can take advantage of the state-effect pattern and the structure of simulations to partition virtual worlds without limiting interactivity. Since the state-effect pattern limits readable updates to state updates at the end of each timestep, and effects can combined locally, we do not need to send a network message for every effect assignment. Instead, we can replicate objects at the beginning of each timestep and perform all other processing locally.

We further observe that interaction in many virtual worlds exhibits *spatial locality*. Objects only interact with other objects that are nearby according to some distance metric. This restriction is particularly common in games and behavioral simulations, where interaction frequently corresponds to physical contact. We can take advantage of this by only replicating objects on machines simulating "nearby" regions of space. This greatly reduces the amount of network communication that is necessary, and has allowed us to scale animal behavior simulations linearly with the number of machines in our initial tests.

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Position Paper :: Issues in Procedural Content Generation for Games

NSF Workshop on the Future of Research in Computer Games and Virtual Worlds

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Sept. 23-24, 2010 :: UC Irvine

One aspect of my recent work on computer games centers on the topic of procedurally generating levels and art assets found within computer games. This has specifically taken the form of two systems, Launchpad [FDG09] and Tanagra [FDG10] (work performed primarily in collaboration with my PhD student, Gillian Smith and Prof. Michael Mateas) that algorithmically generate playable levels for 2D platform games. These systems explore different points in the design space of interaction models between a human designer and a computational level generator. In Launchpad, the designer tweaks a set of generation parameters, and then is presented with a complete level, which they can accept or reject as a whole. No human interaction is necessary, beyond the initial setting of parameters. Tanagra, in contrast, explores a "mixed initiative" interaction style where the designer and computer take turns modifying and creating aspects of a level. With Launchpad, the designer is present at the very beginning and the end, while with Tanagra the designer is involved in crafting a level design throughout the entire design process.

As part of the 2010 Foundations of Digital Games conference, I helped to organize the Workshop on Procedural Content Generation in Games [PCG10], in cooperation with Rafael Bidarra (TU Delft), Ian Bogost (Georgia Tech.), Ian Parberry (Univ. of North Texas), Ken Stanley (Univ. of Central Florida), Julian Togelius (ITU Copenhagen), and R. Michael Young (North Carolina State Univ.). Parts of the call for papers for this workshop nicely express the broad goals of procedural content generation as a research area, and outline areas of work considered to fall underneath this community. Portions of this CFP are given below:

> As computer games increasingly take place inside large, complex worlds, the cost of manually creating these worlds increases substantially. Procedural content generation, where a computer algorithm produces computationally generated levels, art assets, quests, background history, stories, characters, and weapons, offers hope for substantially reducing the authoring burden in games. Procedural content generation has multiple benefits beyond reducing authoring cost. With rich procedural generation, a single person becomes capable of creating games that now require teams to create, thus making individual artistic expression easier to achieve. Automated content generation can take player history as one of its inputs, and thereby create games that adapt to individual players. Sufficiently rich content generation algorithms can create novel game elements, thereby discovering new game potentials. Finally, the procedural generation algorithm itself acts as an executable model of one aspect of the game, thereby improving our theoretical understanding of game design.

A listing of open research areas within procedural content generation include:

- Procedural level generation, for all game genres
- Procedural quest generation, for single and multiplayer games
- Procedural character generation
- Procedural weapon creation
- Procedural art asset generation, for a wide range of art assets
- Techniques for procedural surface generation
- Procedural creation of buildings, villages, towns, and cities
- Procedural generation of crowds in real time
- Techniques for procedural animation of procedurally, and non-procedurally created content
- Issues in the construction and use of mixed-mode systems with both human and procedurally generated content
- Procedural creation of background history and background stories for game worlds
- Adaptive games that create content based on prior player history
- Automatic game balancing through generated content
- Techniques for games that evolve and/or discover new game variants

- Procedural generation of computer and/or tabletop games
- Automatic generation of game rules
- Procedural generation of content for web-based and social networking games
- Player and/or designer experience with procedural content generation
- Models of player experience with procedurally generated content
- Theoretical implications of procedural content generation
- How to incorporate procedural generation meaningfully into game design
- Procedural generation during development (e.g. for prototyping, design, testing, tuning, etc.)

Procedural content generation in games can be seen to have some areas that are specializations of existing research areas (e.g., world, city, and building generation) to games. However, there are many areas that are novel and specific to games, such as procedural level generation, procedural generation of games and their rules, games that adapt their levels based on prior player performance, background stories for game worlds, etc. Focusing procedural content generation on the specific domain of games thus exposes a range of new and interesting research topics.

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Future Directions for CGVW Social Research

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For the purposes of this workshop I would first like to comment briefly on the methods used to examine CGVWs and then discuss briefly my own research, with and eye towards laying out possible future directions of research that would maintain a critical focus on issues of social justice, social exclusion, and social expression. After this I will briefly discuss five directions for such research.

Traditionally, qualitative methods of participant observation and ethnographic interviews have been used to supplement on-line survey data about virtual realm participants, their motivations and aspirations. The work of TL Taylor examined the complexity of social life within the game Everquest (Taylor 2006), and Tom Boellstorff applied ethnographic field observations combined with in-game interviews with participants of Second Life (Boellstorff, 2008) as has Bonnie Nardi (2010) and Nicholas Ducheaneut (2006; 2004) in World of Warcraft and Celia Pierce in looking at the migration of players across games (Pearce and Artemesia 2009). Bartle (2004), as a designer, examined how virtual realms actually work and the impacts they have on participants. Work by Dmitri Williams (2006) at the University of Southern California has used longitudinal studies, incorporating on-line surveys to assess the impacts of on-line multi player games on players off-line, Mia Consalvo (2007) has examined player perceptions about cheating in CGVWs.

Similarly, the history of studying the significance of play activity for understanding cultural meanings has a long history in cultural anthropology (for example the work of Clifford Geertz and Victor Turner (1982) and in sociology beginning with the work of Huizinga (1955). While Hendricks (2006) offers a more updated approach on understanding the significance of play, learning and social life, the early work of Gary Fine (1983) using ethnographic field observations demonstrated the utility of qualitative methods for capturing the significance of play and learning for Dungeons and Dragons players.

My own approach began with an in-depth analysis of chat files drawn from the early game of "Counter-Strike" a modification of the game engine designed by Value Software for their product, Half-Life. Using grounded theory, I spent over 70 hours playing on 39 different servers using a method of recording in-game public chats in real time (Wright, Breidenbach and Boria, 2002). 39 distinct patterns of talk were identified, which we were later able to distill into 5 major patterns. This textual analysis using grounded theory was supplemented by follow-up semi-structured interviews with over 25 players, based upon questions that emerged from the initial textual analysis of chat logs. The interviews allowed us to go into greater depth as to what gave the game play meaning for the participants and how it impacted other areas of their lives. A portion of that data will be published in a forthcoming book as a chapter (Wright, JT. forthcoming).

The current work I am engaged in involves looking at the types of conflicts and cooperative strategies used by game players in the *World of Warcraft* MMORPG. Since Spring of 2008 I have been recording in-game screen shots and field notes, while playing on 4 different servers with a variety of avatars (18 total avatars, 7 of which are at level 80 the highest in the game) in four different guilds, including several that do high level raiding for end game content. In addition, I am conducting in-game interviews using both screen shots recording chats and a ventrillo software program to audio record. Following the lead of Nardi, Taylor, Pearce and others I have worked to become a serious member of the different guilds I am in, establishing trust and looking carefully at player interactions around a variety of topics, from family to in-game issues. A preliminary look at this data revealed several areas of interest including gender conflicts, age conflicts, group entry and exit conflicts and supportive comments. While "trash talk" is frequent in the general and trade chat features of such games, especially in highly populated areas of the VW, social policing was also highly active with threats to report people who made racist or sexist comments overtly. What I will be publishing soon is an elaboration of these various forms of policing as well as the general areas of in-game chat which have emerged through interaction with players and observing player interactions with each other.

I propose that we should focus on five areas of research. *First*, we need to move beyond the play theories of Huizinga, Caillios and others who maintain the fiction of the "magic circle." It is clear that such a strict separation cannot be maintained for digital gaming as TL Taylor's work and others have pointed out. Henrick's has attempted to rescue Huizinga but with a caveat on these issues. Similarly, the psychological theories of play including Bateson, Wincott and Piaget are not sufficient to account for the social attractiveness of VW activities. Play activity has often been placed opposite work, and such a binary is also inadequate to explain how the imagination, pleasure and fantasy intersect to generate interest in CGVWs. *Second*, we need to conduct further investigations into the role of software in altering social interactions. Nardi (2010: 61-93) has done some excellent work in this area in her new book. The point is not to look merely at how software alters playing a game, but, also how people negotiate status and conflict between themselves while playing. *Third*, we need to more thoroughly investigate the everyday interactions of adults and children in CGVWs. The assumption that CGVWs are only for kids has been proven incorrect. However, it is interesting to notice how children and adults take on varying social roles within CGVWs especially when leading guilds or raids which require the exercise of authority. *Fourth*, we need to examine the social rules created to mediate both conflicts and cooperation between players in CGVWs. In my own work and the work of others how people leave and form groups in CGVWs produces emotional stress and also feelings of achievement. These need to be discussed and researched. Similarly, the use of various forms of "trash talk" as ways to exclude others and rank players, is also interesting in how it is regulated by groups of players. Finally, *fifth*, we need to develop social science theories which will explain how computer generated representations and play interactions in CGVWs transcend or reproduce existing social inequalities of race, class, gender, sexuality, age, and disability. This last component may also be the hardest since it means we need to adopt a critical stance towards the exercise of arbitrary social power with VWs, and ask how does our play, in fact, encourage or discourage ethical behavior in-game?

To embrace these five areas of research I would also like to emphasize four major areas of focus. The *first*, is on the development of critical theoretical models that can accommodate the fifth point mentioned above. This focus has been associated with Stuart Hall and the Birmingham School of Cultural Studies, and I would add the Sociology of Culture, ala Pierre Bourdieu. The key here is in acknowledging the role power plays in representation and social exclusion, in particular through the exercise of hegemony (the making normal given arrangements of racial, gender, age, class, sexual, disabled power). This focus couples well with the *second* focus which could encompass political economy. That is, how the intersection of game companies, financial and marketing institutions work to produce a commodity which reproduces dominant narratives about how power works in any given society. One of the best studies emerging in recent days is that of Dyer-Witheford and de Peuter, in their study of *Games* *of Empire: Global Capitalism and Video Games* (2009). Also the ethnographic work of Thomas Malaby (2009) (covering the business side of *Second Life*, via Linden Labs) is revealing in how entertainment software companies actually operate. The *third* focus, textual analysis is a lot more prevalent in studies which have been done of various computer games and their internal stories. This focus however, cannot be ignored since the narratives which computer games weave incorporate dominant themes that create naturalized hierarchies of who is considered powerful and who is considered weak in gender, race, class, and other social terms. Finally, the *fourth* focus should be on fans, or what has been called audience reception studies. This is an area which is rapidly developing and I suspect will lead in the future of much of our research. To conclude, rather than viewing the first five areas and the four areas of focus as completely separate I would like to see a move towards integrating these various strands to develop a more complete understanding of the role of CGVWs in our everyday environments.

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