THE NAVAL POSTGRADUATE SCHOOL MOVES PROGRAM – ENTERTAINMENT RESEARCH DIRECTIONS

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ABSTRACT

In 1997, the National Research Council issued a report that specified a joint research agenda for defense and entertainment modeling and simulation [NRC,97]. The NRC report provides a guide as to what research and development needs to be done to develop our future interactive entertainment and defense modeling and simulation systems. As a consequence of that report, a number of research laboratories have developed a joint entertainment/VR or entertainment/defense or entertainment/NASA focus. The Naval Postgraduate School MOVES Program, the largest modeling, virtual environments and simulation academic program, is one such organization following that report's research agenda with a number of active projects in defense and entertainment collaboration.

THE FUTURE OF NETWORKED ENTERTAINMENT

In the NRC report, we see that games and interactive entertainment (IE) have become the main technology drivers for networked virtual environments and not defense research expenditures. In order for the DoD to keep up with that evolving modeling, virtual environments and simulation technology, it then becomes important for DoD to examine the future of networked entertainment to see if there is the potential for a joint investment or collaboration. While we cannot say for certain what future networked entertainment looks like, we can hypothesize from what IE systems look like today. So we start out by looking at hypothetical versions of today's entertainment extrapolated into the future to identify perhaps what R&D we need to accomplish to get there. We need to look at what these IE systems will look like and how people will interact with such systems. We then examine how this can be aligned with DoD research desires for modeling, virtual environments and simulation.

To make our job a little bit easier, we make some assumptions on what we will have in the future:

- Infinite bandwidth to the home.
- Infinite 3D graphics capability and computing power in the home.
- Affordable for the home.

If these assumptions become true or nearly so, what will our games and IE systems be? Again, scenarios derived from today are the best we can do. We hypothesize a few such IE systems in order to motivate our research agenda.

Interactive TV

Probably the earliest vision of what Interactive TV will look like is captured in the 1966 motion picture "Fahrenheit 451," with Oskar Werner and Julie Christie. Interactive TV in that film shows Julie Christie participating in a television story with two on-screen characters. When it is time for Julie to respond, the characters look in her direction and a red light blinks on her wallscreen, appealing for a response. The message is that her response can possibly change story direction, that she can chat meaningfully with the on-screen characters and be "part of something". The technology necessary for such a system is networking to support two-way video/audio, entity streams (streams of state information for the involved characters) and sufficient resources that branching storylines based on user response can be "handled". Of course, the cynical tone of the film shows that no

matter what her response, the story just goes on as planned. In our future, we really do want the story to change! So the requirement for autonomous characters and an interactive storyline engine is critical to being able to actually do this. The user experience with this system is reflected in the film piece. Julie has both individual and group concerns. She needs to know from people in the room how did she do. She also needs to know how her interactions were perceived by her friends watching elsewhere.

3D Avatar Chat & RPG

Chat rooms and role playing games (RPGs) are popular now and will be more so as we move to 3D avatar (3D character body) display and synchronized audio. With respect to interactivity, we want to have a 3D avatar, with animated face. We want to chat with others or with autonomous characters over the Internet. Autonomous characters are players not being run by a human but rather by a computer program that is compelling enough for the human player to believe that he/she is actually playing against some sort of intelligence. Our graphics are going to have to be very good for future 3D avatar chat. Our autonomy will have to be more compelling than today's. We want to see the lips move on the character to whom we are speaking. This has to be synched with the sound. Our character's movements cannot lag. The Internet is going to have to let us chat/play with people who are located just about anywhere. We will have audio and entity streams transiting the net. We are going to be a knight fighting the giant, our body motions tracked. We are going to find ourselves talking to Lara Croft of TombRaider and she's going to answer back. We are going to feel as if we are interacting with Lara.

Quake 2007/Shooters 2013!

We are going to go into a dark, 3D world and fight monsters off the 'Net. We're going to hear them breathe and we're going to hear them die. Our 3D virtual environment (VE) will have fully articulated monsters, monsters steered by body-suited, armed opponents or computed autonomously. We are going to team with distant friends to accomplish our missions. We will have an audio stream and an entity stream. We will feel as if we are in the Quake-2007 VE. Our roommates will be able to smell the fear and us the blood.

Our body motions will be tracked in our game cell unit, our fist will clench our weapon, our avatar may be altogether different from our corporeal norm. Our articulated avatars will be detailed and well-modeled and the behaviors so realistic that it will be difficult to tell if they are live or if they autonomous characters . Our demand will be for premium quality of service in our networking and we will insist on minimal lag. We will have entity streams for large numbers of players and audio streams from nearby players. And maybe video streams for offline chat. Our experience will be one of fear, comradery, excitement, sweaty palms, the entire gamut.

ExtremeSports 2015!

Imagine the view from the wrestler we will have and the thuds against our body as we perform ExtremeSports from the safety of our VR room. Our worlds will be rich in surface detail and there will not be a missed mogul in its depiction. The lag on our 'Net will be so low that we will be able to perform the most delicate motion. We will be Pele.

MartialArts Forever!

The tracking of our body movements in the VR cell with allow us to practice moves against fearsome opponents. The human avatars will be incredibly detailed, with each articulation smooth and the skin textures real. 'Net lag will be near zero as our quality of service is set to premium. We will feel that fist from Washington, DC. We will be in touch with our inner soldier and those out there too.

So if we want to be able to do all this, what do we need?

We need hardware, a fast network, software, input devices, a whole lot of things that we have now and a whole lot more not yet started on. Compute power – we need as many cycles as we can get for under $500. We have 1 Ghz clock rates now and will move to 300 Ghz by 2015! Graphics - we see game machines that are claiming 66M textured polygons per second this year [EETIMES,99]. We will have 300M+ to 5B textured polygons per second in two to five years [Smith,2000].

Network - we are seeing high-speed nets to the home. Broadband access will be available to over 100 million US homes by the year 2003 and deployed in some 28 million homes [Forrester,2000]. DSL speeds of 1.5Mbps downstream and 384K bps back allow us to interact with 500 players in a game and have a video stream at the same time. Cable modems promise greater speeds and allows us interactions with even greater numbers of simultaneous participants.

Latency reduction and predictive modeling research are key to us making usable IE systems. [Singhal/Zyda,99] indicates that latency must be less than 100ms for high interactivity, maybe 200ms for some gaming apps. Today we are seeing people live with 350ms or greater for some gaming now, with truly awful playability!

NPS MOVES & THE NRC REPORT

The Naval Postgraduate School's Modeling, Virtual Environments & Simulation (MOVES) Academic Program and Research Center has developed a research focus aligned with the NRC report. The following areas are our focus:

- Networked Virtual Environments
- Standards for Interoperability
- Technologies for Immersion
- Computer Generated Characters
- Human Factors & Human-Computer Interaction
- New Educational Paradigms

We look at these areas and particular relevant NPS MOVES projects below.

Networked Virtual Environments - A Vision

Eventually, there will exist a persistent virtual environment simultaneously shared by millions. There can never be a global reboot. All modifications must happen on the fly. The development of participant programs (live and autonomous characters) for that VE must be as simple as writing a web page is today. In order to accomplish that vision, we must develop a network software architecture (NSA) that is extensible, composable, and interoperable. We need cross-platform, component frameworks and dynamic behavior protocols. We need the ability to suspend/resume state so that we can have a persistent universe. We need to be able to develop area of interest management techniques in order to support the large number of expected players in our VE.

The motivation behind cross-platform component frameworks is that we want to build systems that are changeable overtime, systems whose updates are downloadable over the Internet, systems that can work on multiple platforms, systems whose pieces are small-enough that they are understandable and reusable. This is more than just extending memory. Dynamically loaded modules require a consistent plug-in framework. The system must establish a convention such that modules can integrate into already running applications.

Our desire for dynamic behavior protocols is that each entity in the VE be able to define its own protocol modules, modules that are dynamically loadable from the web. Our desire for the architecture for such protocols is that it is easy to maintain, always fully implemented, always optimized per individual, that it never consumes unused system resources and is updateable in real-time.

For the NSA, a three-tier approach seems the way to go. The first tier is Global, with an environment registry that helps find a particular virtual environment, i.e. VR-DNS. The second tier is Environment, with an object registry that tells what objects are in a particular environment. The third tier is Object, with a module registry that points to the location of the code for our objects and their input/output channels.

By using dynamic protocols, along with components of the existing Internet architecture, we can support the persistence of a large-scale distributed virtual environment. We hypothesize http Statelets, a platform independent file containing names of archived classes, URLs of the modules containing the classes, and the archived classes themselves.

Area of interest management through the use of multicasting for VEs has long been identified by NPS as being key to the scalability of networked virtual environments. The keys to success for such scalability are:

- Receive only what you need to process.
- Dynamic extensibility – the ability to dynamically add new protocols, environments.
- Must have the ability to handle "crowd" situations.
- Low overhead for interest management.

Issues in the mix of a successful solution to area of interest management include network latency, and available bandwidth, the long time to join a multicast group (0.5 seconds typical), multicast address space/allocation (think IPv6), the number of multicast groups supported by workstation/PC network interface cards, the number of multicast routes supported by network routers, and the current unreliable nature of large-scale multicast (need QoS support).

Standards for Interoperability - we must be designing standards for interoperability that are as simple to use as writing a web page. So once we have done all the net-VE research work above, we can then think about standardization.

Technologies for Immersion

The NPS focus on technologies for immersion is on the utilization of available, low-cost real-time graphics hardware such as the latest nVidia board sets and game machine development platforms like the Sony Playstation 2 and the Microsoft XBox. Trends from the game platform market are inspiring. The

Playstation 2 is listed as being capable of rasterizing 75M polygons/second and transforming 66M polygons/second and is being sold for $300. Plans for Playstation 3 six years from now are to be 1,000 times faster (66B polygons/second?) [EETIMES,99]! Silicon Graphics would do 20x increase in graphics in the same amount of time in previous generations. The Microsoft XBox is planned for 300M polygons per second. Where these numbers are taking us is closer to visual reality.

Ed Catmull defined visual reality as 80M polygons/picture [NRC,95, pg.252]. 80M polygons/picture at 60 pictures/second (fps) is 4.8B polygons/second. We are talking about machines that can visually display computer images indistinguishable from reality, speeds that game machines and PC boards are getting ever close to.

Tracking of human body motion in the networked VE is also a focus of NPS efforts. We are prototyping an inertial tracker that is capable of being deployed in a form factor the size of a wristwatch. We are going for sourceless, wireless, line-of-sight range tracking.

We are also looking at deployment of full sensory interfaces in order to include a wide range of sensory stimuli in our networked VEs including visual, auditory, olfactory, and haptic stimuli. We are looking at adopting location-based entertainment motion platforms like the LGM platform [LGM,2000].

Computer-Generated Characters

We want computer-characters in our net-VEs with whom we can interact in an intelligent fashion. We want autonomous behaviors for those characters. We want characters that can come in over the network and play with us, educate us, train us, characters that can learn and help guide the VE's story. We need software architectures that can provide:

- Adaptability - modify behavior automatically
- Learning - modify behavior over time, reinforcement learning.
- Agent-based - to allow for emergent behaviors.
- Behavior and Story Modeling
- High quality avatars

NPS MOVES Projects in Computer-Generated Autonomy

The NPS MOVES Research Center [MOVES,2000], in collaboration with the NPSNET Research Group [NPSNET,2000], has several projects in computer-generated autonomy. We are building a networked agent architecture in support of multiple game/defense development efforts. We are building videogames in support of various Army missions. We are building game-like simulations for training business managers in the operations of DoD clinics (SimClinic). We have constructed game-like simulations to explore the OPNAV management of the US Navy (SimNavy prototype).

The goal of the networked agent architecture project is to develop an NPS-owned agent-based simulation engine that operates in distributed fashion. We are developing tools for specifying the interiors and the interactions of the agents. Personnel in our research group have participated in the development of the engines underlying SimCity, SimAnt and SimFarm.

The motivation of our Army games project is to explore the development of web-based, instrumented, networked videogames. We are developing an integrated Career and Action game over a span of 48 months, fully instrumented, fully networked, developed for continual content refresh and update, using existing game development technology when possible, developing new technology when necessary. The Career game focuses on a simulated Army career, similar to an adventure game where experience through various schools and obtained objects moves the player forward in the action. The Action game is planned to be similar to Rainbow Six, with the focus on team play. The research focus in the development of these two games is to determine if games can be instrumented to be able to determine the aptitude, leadership abilities and psychological profile of the game player.

The goal of the SimNavy Prototype was to build an enterprise model of the US Navy in a fashion similar to Maxis' SimCity, with a dramatic computer-game interface, but with much higher resolution and Navy-relevant scenarios. The SimNavy concept was to simulate the OPNAV/N-code operation of the Navy, including resource allocation, the psychology of decision making, the zero sum economy, multilateral decisions and constraints, the conflict between political process and military requirements, and the dynamic nature of decision making. SimNavy's value was to provide an interactive experience through which Naval officers can learn how to make decisions at the various levels of the Navy's hierarchy. SimNavy was not a simulation for Navy war-fighting or tactics but rather a tool to examine the relationship between budget allocation and operational possibilities. A prototype of SimNavy was developed using commercial game artists for the Windows platform. The screens developed for that game are visible in the following online location [SimNavy,98].

NPS MOVES ACADEMIC PROGRAM

Besides providing a research agenda, the NRC report indicated that new educational paradigms were required to carry out that agenda, that Computer Science alone was not sufficient to build our future modeling and simulation systems. NPS has constructed a prototype educational program based on the NRC report - the MOVES (Modeling, Virtual Environments & Simulation) Academic Program [MOVES,2000]. The MOVES program is a blend of Computer Science and Operations Research, with the goal of producing graduates capable of understanding the mathematics behind modeling and simulation and the computer science required for the implementation of their models and simulations inside of a networked virtual environment. Both an M.S. and a Ph.D. in MOVES have been defined, with NPS having the only defined Ph.D. in M&S in the world (at the moment). The MOVES Program's Ph.D. specialization areas include physically-based modeling for virtual environments, networked virtual environments, human factors in virtual environments, adaptable software agents, modeling human and organizational behavior, discrete-event systems modeling, and data and model visualization.

CONCLUSION

Defense and entertainment collaboration are a natural considering the ability of the entertainment industry to outpace the DoD in many areas related to modeling, virtual environments and simulation. The Naval Postgraduate School MOVES Research Center, in conjunction with the NPSNET Research Group, is currently the largest funded effort aimed at developing DoD-relevant entertainment-derived, M&S systems. That research and development component, along with our strong MOVES Academic Program, are unmatched in focus and vision in this direction.

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BIOGRAPHY

Michael Zyda is a Professor in the Department of Computer Science at the Naval Postgraduate School, Monterey, California. Professor Zyda is also the Chair of the NPS Modeling, Virtual Environments and Simulation Academic Group. Since 1986, he has been the Director of the NPSNET Research Group. He has been at NPS since February of 1984. Professor Zyda's research interests include computer graphics, large-scale, networked 3D virtual environments, computer-generated characters, video production, entertainment/defense collaboration, and modeling and simulation. He is known for his work on software architectures for networked virtual environments.

Professor Zyda was a member of the National Research Council's Committee on "Virtual Reality Research and Development" and is one of the key authors of that report. Professor Zyda was the chair of the National Research Council's Computer Science and Telecommunications Board Committee on "Modeling and Simulation: Linking Entertainment & Defense". From that report, for the Deputy Assistant Secretary of the Army for Research and Technology, Professor Zyda drafted the operating plan and research agenda for the USC Institute for Creative Technologies (ICT).

Professor Zyda is a member of the National Research Council Committee on Advanced Engineering Environments. Professor Zyda is also a Senior Editor for Virtual Environments for the MIT Press quarterly PRESENCE, the journal of teleoperation and virtual environments. He is a member of the Editorial Advisory Board of the journal Computers & Graphics. Professor Zyda is also a member of the Technical Advisory Board of the Fraunhofer Center for Research in Computer Graphics, Providence, Rhode Island. He is a Member of the Board of Advisors for the Georgia Institute of Technology Modeling and Simulation Research and Education Center.

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Professor Zyda began his career in Computer Graphics in 1973 as part of an undergraduate research group, the Senses Bureau, at the University of California, San Diego. Professor Zyda received a BA in Bioengineering from the University of California, San Diego in La Jolla in 1976, an M.S. in Computer Science/Neurocybernetics from the University of Massachusetts, Amherst in 1978 and a D.Sc. in Computer Science from Washington University, St. Louis, Missouri in 1984.