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INTEGRATED SIMULATION AND GAMING ARCHITECTURE FOR INCIDENT MANAGEMENT TRAINING

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ABSTRACT

The simulation-based training systems that are available or under development today for incident management are typically focused on macro level sequence of events. A few systems targeted at individual responders are under development using a gaming environment. Separate uses of such systems provide disparate experiences to decision makers and individual responders. There is a need to provide common training experiences to these groups for better effectiveness. This paper presents a novel approach integrating gaming and simulation systems for training of decision makers and responders on the same scenarios preparing them to work together as a team. An integrated systems architecture is proposed for this purpose. Major modules in gaming and simulation subsystems are defined and interaction mechanisms established. Research and standards issues for implementation of the proposed architecture are discussed.

1 INTRODUCTION

There is a growing need for preparedness for emergency response both for man-made and natural disaster events. The man-made disaster risk has increased due to a rise in possibility of terrorist attacks against the United States. Effective emergency response presents a number of challenges to the responsible agencies. One major challenge is the lack of opportunities to train the emergency responders and the decision makers in dealing with the emergencies. An on the job training approach is not useful given the thankfully infrequent occurrences of such events. The responsible agencies have tried to meet the need through organization of live exercises, but such events are hard to organize and expensive.

Modeling, simulation and visualization techniques can help address many of the challenges brought forth by the need for emergency response preparedness. A recent survey (Jain and McLean 2003a) indicates that a number of modeling and simulation applications for analyzing various disaster events exist. These need to be brought together for studying the impact of disaster events as a whole. Not only do we need to understand how a radioactive plume released by terrorists will disperse, we also need to plan what traffic routes people will use to evacuate the affected areas, what demands will be placed on the hospital resources in the area, etc. The individual simulation models such as those for studying the radiological release need to be integrated with those analyzing the traffic movement through the highways and arteries of the affected area, and with those analyzing the resource constraints of hospital systems, among others.

The integrated set of simulation tools should be used for training the emergency responders at all levels. It is important that the first responders and emergency managers go through training experiences on the same scenarios to effectively work as a team. Human beings can make good decisions under a stressful situation if they can recognize the pattern as similar to something they have experienced in the past (Klein 1989). If they have not experienced a similar situation in the past, their capability to make right decisions is impaired as there isn't enough time to evaluate all the possible options and select the right one. The understanding of human decision making from the Klein study suggests two important directions for emergency response training. First, simulation should be used to expose the emergency responders to a range of situations based on the potential scenarios that may occur in their jurisdiction. This will prepare them to select the right responses when faced with an emergency. Second, the responder teams across all levels should go through similar scenarios to have similar mental models. This will allow emergency managers to develop similar approaches and the emergency responders to fully support them, having experienced the success of the approaches in past simulations.

To provide the experience of the same scenarios across all levels of an emergency response team requires execution of large-scale live exercises such as those conducted under TOPOFF (Top Officials) program (Erickson and

Barratt 2004). These large-scale exercises are hard to organize since they require coordination across a large number of agencies across multiple levels of hierarchy. With the large number of resources devoted to such exercises, these exercises are very expensive. And, even with all the effort and expenses, they are able to expose the responders, emergency managers and government officials to only a limited set of scenarios. The creations of emergency events are limited in realism to avoid risk.

The limitations of live exercises can be overcome to a large extent through use of integrated gaming and simulation models that allow emergency response personnel across multiple levels in multiple agencies to get exposed to the same scenario. The Department of Defense (DoD) has found that use of simulations instead of live exercises for training can reduce the training costs to one-tenth (Robinson 2004). Use of integrated gaming and simulation over a distributed network can allow people to participate from different locations and thus provide some flexibility in scheduling the resources. Most importantly, use of simulation will allow providing the responders with experience of a wide range of response scenarios and thus significantly improve the emergency preparedness.

The development of integrated gaming and simulation for emergency response training is a challenging task that requires addressing technical, business, and social issues. This paper focuses on the technical aspect of developing an architecture for the integration. It proposes an architecture for integrated gaming and simulation for emergency response training. Relevant reported architectures for modeling and simulation are briefly reviewed. The proposed overall approach for integrated gaming and simulation tools for emergency response training is described. The proposed architecture itself is presented and its major components discussed. The paper concludes with discussion of further research for achieving the vision of the integrated gaming and simulation for incident management training.

2 BACKGROUND

The applicability of modeling and simulation to different phases of emergency response has been recognized for decades (see for example, Sullivan 1985). However, the idea of integrating the modeling and simulation tools for a more comprehensive modeling of the scenario is more recent. In this section, a few efforts for integration of simulation models are briefly reviewed.

A number of simulation tools have to be integrated to address multiple aspects of a single disaster event as described in Section 1. Jain and McLean (2003b) proposed a framework to help define the scope of modeling and simulation tools for emergency response. The need for such integration in the incident management context has been recognized as evident by the urban security project at Los Alamos National Labs that integrates plume simulation and traffic simulation to compute exposures to the cars traveling through a toxic plume (LANL 2001). The Simulation Object Framework for Infrastructure Analysis (SOFIA) project at Los Alamos National Laboratory is developing a high-quality, flexible, and extensible actor-based software framework for the modeling, simulation, and analysis of interdependent infrastructures (LANL 2000).

A number of research efforts have been targeted at integration of simulation models outside the context of emergency response. In particular, Department of Defense has spent a large effort in developing war gaming capabilities that integrate a number of simulation models and humans-in-the-loop. DoD sponsored research in this area started in late 1980s with the development of SIMNET for real-time battlefield simulatons of tanks in a virtual training environment. Most recently one thread of the work is evolving into the Standard Simulation Architecture, designed as a combination of the High Level Architecture (HLA) and the Synchronous Parallel Environment for Emulation and Discrete-Event Simulation (SPEEDES) developed in the mid to late 1990s (Steinman and Wong 2003). Another group of researchers is proposing bringing HLA together with the Model-Driven Architecture (MDA), a concept developed by the Object Management Group (OMG). The MDA uses a language, vendor and platform independent meta-model as the core representation, with facilities defined to translate the representation for implementation. The combination of HLA and MDA offers benefits to both the developments and is recommended (Tolk 2002). Any proposed architecture based on HLA should weigh the alternate approaches and their support in the industry and accordingly plan the implementation. Overall, the focus of the DoD developments has been on war gaming involving a number of human decision-makers and actors. The associated research should prove to be very useful for integrated simulations for incident management, particularly for training applications.

Simulation applications for homeland security can get a jump start through adaptation of DoD integrated simulations, in particular, for larger jurisdictions with sufficient funding availability. United States Joint Forces Command is carrying out a leading effort in this direction. The Joint Theatre Level Simulation (JTLS) and JCATS (Joint Conflict and Tactical Simulation) have been integrated for multi-resolution modeling for training of incident management staff (Bowers and Prochnow 2003). The integrated system was used successfully for the Determined Promise 2004 homeland security exercise involving a large number of incident management personnel across multiple locations.

The integration of simulation models requires that the data is translated from one model to another model in the right context. Typically, human analysts have to spend some time ensuring that the translation of data is consistent based on the semantic understanding. Translation using syntactic grammar can be more efficient but not always possible. An agent-based architecture has been developed that uses object-oriented modeling techniques to encapsulate and organize the syntactic information while the semantic information of the objects is examined for data integration purposes (McDonald and Talbert 2000). The proposed architecture can provide value for interoperability of incident management simulations.

The Dynamic Information Architecture System (DIAS) has been developed at Argonne National Laboratory as an object-oriented simulation system that provides an integrating framework for new and legacy applications and can adapt to different contexts (Campbell and Hummel 2005). The system has been used both for U.S. Department of Defense applications and civilian applications. It is frame-based and uses the concept of entity objects as analogs to the real world entities being studied. It uses an extensive library of entity objects that can be used in modeling environmental, transportation, and command and control applications. The requirements for building the library of objects may require a large effort for implementation of the system in an incident management context.

HLA has been used for integrating distributed simulation models in the manufacturing domain. A neutral reference architecture was developed for integrating distributed manufacturing simulation systems with each other, with other manufacturing software applications, and with manufacturing data repositories (McLean, Leong and Riddick 2000). The need for standardization of interfaces was highlighted. Experience from this past research will be used in the development proposed here.

This brief review of related research indicates the feasibility of developing an architecture for modeling and simulation of incident management and at the same time indicates a need for standardization of interfaces and semantic and syntactic representations.

3 ARCHITECTURE

Simulation and gaming-based technologies can together provide a highly effective means for incident management training if integrated correctly using an appropriate architecture. What is simulation? In the "Handbook of Simulation", Jerry Banks (1998) defines simulation as: "…. the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history to draw inferences concerning the operational characteristics of the real-system that is represented. Simulation is an indispensable problem-solving methodology for the solution of many real-world problems. Simulation is used to describe and analyze the behavior of a system, ask what-if questions about the real system, and aid in the design of the real system. Both existing and conceptual systems can be modeled with simulation."

Gaming is the use of computer-based interactive simulations to engage in games that use highly realistic scenes and allow the player to earn rewards through winning under defined rules. Game technology has primarily been used for entertainment rather than educational purposes in the past. A number of changes to gaming technology will be required to support incident management training needs. New functionality will need to be incorporated into game software to make it suitable for training applications. A common development strategy, a standard architecture, and neutral data interfaces will also be required to ensure that the game components are highly reusable.

Video game technology could be used to create virtual environments for the incident management trainee. These environments would contain realistic three-dimensional graphics and sound that could significantly enhance the learning experience. Learning applications might address theory and operation of incident management actions and equipment. They also might include various operational scenarios where strategies and tactics are covered. Training could be developed for all facets of the incident management including law enforcement, health care, fire department, and urban search and rescue. Decision makers and first responders alike could make effective use of these training capabilities.

Simulation involves defining the rules of operation and the probabilities of paths of action and time duration and letting the events unfold. Gaming relies on a trainee's actions to determine the course of events under defined rules and probabilities. In the context of incident management, simulations are suitable for training emergency managers and decision makers of involved agencies. Gaming is suitable for training first responders.

3.1 Requirements

The architecture for simulation and gaming for incident management training should provide the following major capabilities:

- Creation of a federation of simulation and gaming modules appropriate to represent the selected incident management scenario.
- Integration among heterogeneous simulation federates modeling interrelated aspects of the emergency event.
- Integration among heterogeneous gaming modules with trainees role-playing within the same locale in the emergency event simulation.
- Synchronization between the macro-level modeling of simulation and micro-level modeling of gaming modules.
- Control over execution of both simulation and gaming modules through a training manager console.

- Execution in Massively Multi-player Online Games (MMOG) mode to support a large multi-agency incident management exercise.
- Access to heterogeneous data servers for supporting simulation and gaming modules.
- Management of MMOG execution.
- Management of simulation federation execution.
- Reusability of simulation and gaming module components.

3.2 Concept

An architecture to meet the above requirements is conceptually presented in Figure 1. The architecture will have two major subsystems – one for simulation and the other for gaming. The simulation modules will each represent one of the major aspects of the emergency event or its response. The simulations will be based on defined behaviors of involved entities including the incident management organizations. The gaming modules will provide for role-playing by emergency responders in roles represented in the figure. Simulation and gaming subsystems will have their individual communication integration infrastructure. The two infrastructures will be linked through a data synchronization and transfer processor as shown in the figure.

The simulation subsystem will contain a number of modules within each of the groups as shown in Figure 2. The individual modules will model an aspect of the incident or response and will interact with other modules based on the scenario. The modules will also interact with the data servers and will be controlled by the simulation federation management. The data servers will include one for Geographical Information Systems (GIS) data. Such data will be used as input to simulation modules and for visualization of simulation outputs. All the interactions will go through the simulation communications integration infrastructure.

The gaming communications integration infrastructure may be based on the Massively Multi-player Online Gaming (MMOG) architecture. The MMOG architecture will be enhanced to meet the requirements of incident management training and the need to synchronize with the simulation subsystem modules.

The gaming subsystem will also contain a number of modules within each of the groups as shown in Figure 3. Trainees will immerse themselves into the scenario using the modules as game clients. They may interact with other trainees on other game clients and with entities that are controlled by simulation modules. The gaming modules will also interact with the data servers for the required data to execute the games. The information would include the detailed three dimensional (3-D) descriptions of the locales at and around the location of emergency incident. The locale 3-D geometry data will be accessed as warranted by the simulated movement of the trainees around the simulated area. The interactions will occur logically in the game environment and physically over the gaming communications integration infrastructure.

The proposed architecture will allow the training environment to be highly configurable. Simulation and gaming components can be selected and integrated based on a defined scenario. A scenario involving a terrorist attack using a dirty bomb can be modeled using components of the proposed system. The simulation modules employed for such a scenario may include crowd, traffic, explosion, plume, weather, fire, law enforcement, health care, transportation and communications. The gaming modules for the scenario may include victims, general public, terrorists, fire, police, emergency medical technicians (EMTs), hazardous material teams (HAZMAT), hospitals, shelters and public transportation. A natural emergency event such as a hurricane would require a different set of modules. The available modules in the proposed architecture can thus be

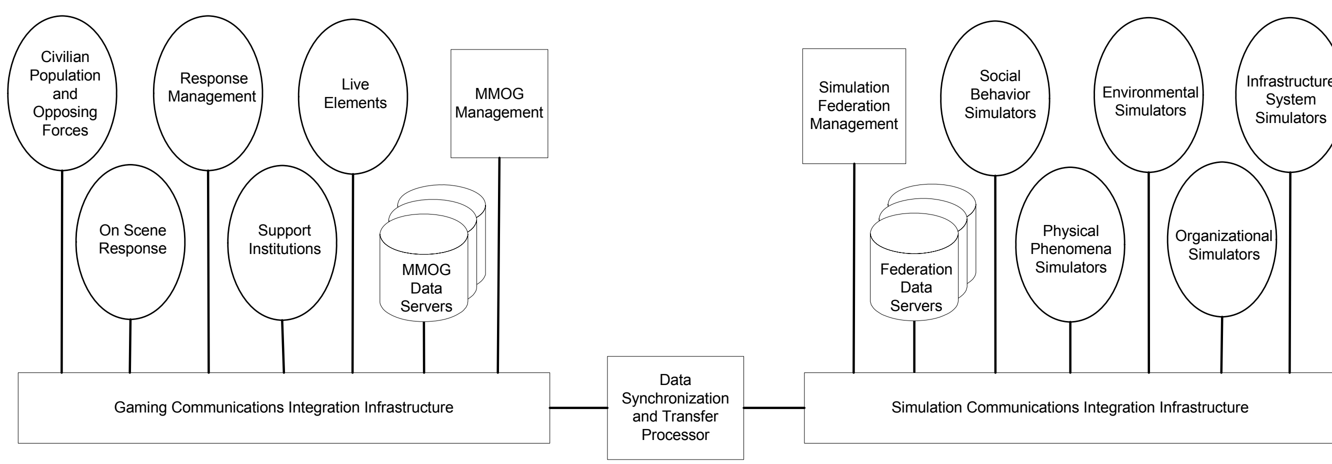

Figure 1: Architecture Concept for Simulation and Gaming Emergency Response Training System

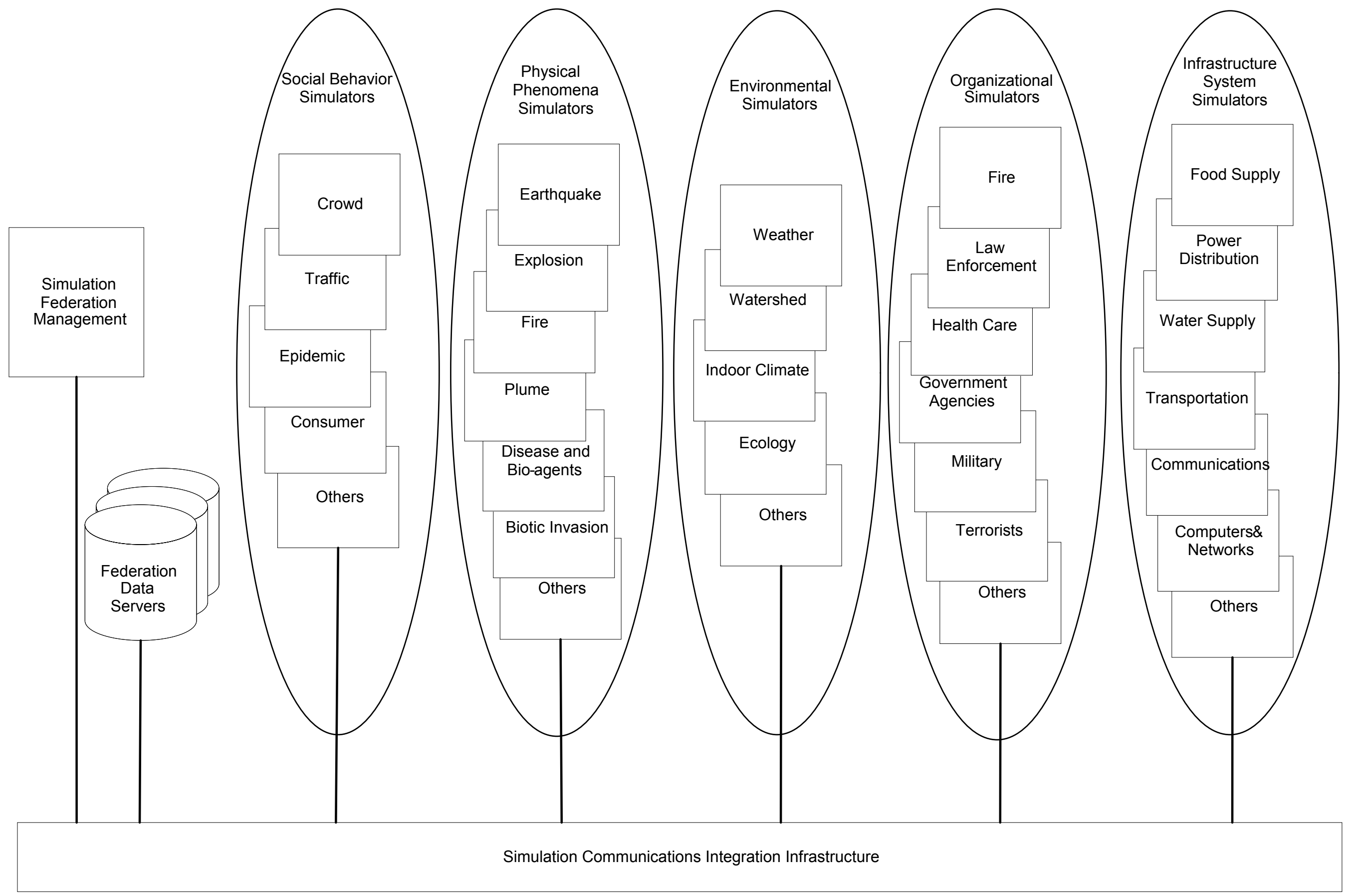

Figure 2: Simulation Subsystem and its Modules

configured to train incident management personnel across a range of scenarios.

The architecture concept will also allow flexibility in hardware systems for executing the training environment. The system modules will be distributed across a network of machines when training a large team. They may be set up as multiple processes executing on a multi-tasking operating system such as Microsoft Windows on a standalone machine for training an individual.

3.3 Issues

Realization of the proposed architecture presents some challenges. The primary challenge is the development of mechanisms for communications and time synchronization between and among simulation modules and game modules. Major issues associated with distributed multi-player games are how and when players receive information on fellow players actions. Time lags may occur between when a player initiates an action and when other players see the action. This latency causes problems in the execution of distributed games. The HLA Run Time Infrastructure (RTI) technology does not require the use of servers for centralized management of game data but uses time synchronization mechanisms that may be unacceptable in a game environment. In the HLA RTI world, simulators publish and subscribe to data objects to communicate. Simulations may be time-regulating or time-constrained.

An associated challenge is the management of the training of people from different levels of incident management hierarchy. The best mode for training the first responders using game client is to execute in real-time (i.e., time progress in game environment same as wall clock time). The best mode for training the incident management managers and other personnel operating in Emergency Operation Centers (EOCs) may be segments of real-time execution interspersed with accelerated time (i.e., time progress in simulation environment faster than wall clock time) and fast forwards (i.e., simulated time jumping to a few hours or a day later). This mode will allow the EOC team to train in decision making over few simulated days of an unfolding emergency event while spending only a day in wall clock time. Combined training of first responders and EOC teams would require careful orchestration of time segments and fast forwards.

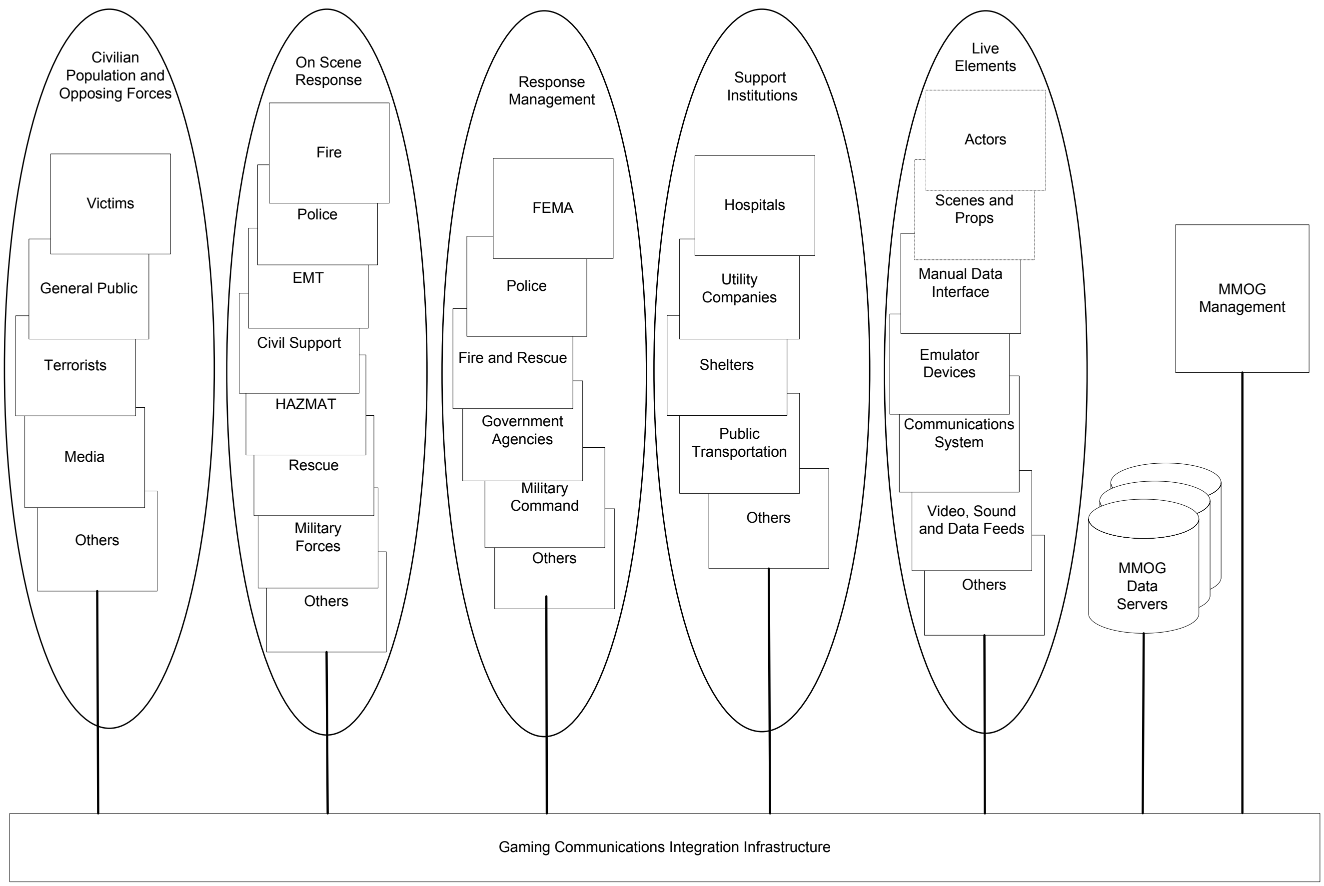

Figure 3: Gaming Subsystem and its Modules

Distributed simulation architectures have come a long way. HLA is the current standard architecture for the purpose. However, HLA has grown from the background of war games executed in real-time. While HLA has been used for accelerated time execution to some extent, it may be a challenge to achieve speedups of 10 and above with the large number of modules envisaged for a full scenario training.

MMOG architecture is still evolving. There is no standardization in this field as each game provider is using its own proprietary architecture. An open MMOG architecture will need to be developed that would allow plug compatibility of different gaming modules. The architecture should also allow plug compatibility of components of the core game engine also.

Massively Multi-Player (MMP) functionality involves the use of servers and is widely used in the gaming world. Due to its success as a commercial mechanism for distributed simulation and gaming, it should receive serious consideration for incident management applications. There have been security vulnerabilities associated with MMP games that have allowed players to cheat; therefore, appropriate safeguard must be enacted. For more information on MMP technology, see Alexander (2003).

Software licenses for game development systems and game distribution are often quite expensive. Pervasive use of this technology will require that many Department of Homeland Security (DHS) contractors get access to licenses to develop training applications. Perhaps hundreds of thousands of game-based training applications will ultimately be distributed. Game engine developers often collect royalties on each game sold. If commercial game engine software is used, the traditional business models of these software vendors may need to change.

4 SUBSYSTEMS

The architecture description in the previous section showed two major subsystems - simulation and gaming, each with a number of major groupings. This section provides descriptions of the two major subsystems and their major groups.

4.1 Simulation Subsystem

The simulation subsystem includes simulators that model the major capabilities and phenomena involved in emergency response. Together these simulators will create the incident with all its major aspects and the responses by all the major agencies involved. The modeling of all the major aspects will capture the interactions, planned and random, that will create unanticipated situations that occur in the real world during an emergency incident. Thus the simulation subsystem will create the emergency incidents in the virtual world. The ability to represent the incident in the virtual world together with the associated major aspects and the creation of unanticipated interactions will provide a valuable training environment.

The simulators in the simulation subsystem will need to operate at a level appropriate to the training audience. It will be appropriate to simulate the incident and the response at a macro level for training of emergency managers if they are being trained alone. If only the emergency responders are being trained, the incident needs to be simulated at micro level. To have both the emergency manager and responders experience the same incident a combination of simulations at macro and micro levels will be needed. For example, emergency managers would need to understand the time it takes for response vehicles to get to an incident site. However they may not need to get into the detail of the traffic congestion they had to go through along the route to get there. The vehicle travel times can be determined through a macro level simulation that may require determining the route from dispatch point to incident site and determine the travel time based on the distance and congestion factors based on the time of the day. On the other hand, for training a responder in the same scenario, the actual drive needs to be modeled. The responding unit needs to experience going through the traffic and facing the movement of individual cars. A micro level simulation will be needed in this case.

The description of the simulators below provides a brief description of their capabilities. For brevity, the functionality at macro and micro levels is not discussed. An increase in the level of detail from macro to micro simulation similar to the traffic simulation example above can be envisaged. Also, only one of the simulators in each category is described as a sample.

4.1.1 Social Behavior Simulators

The social behavior simulators will simulate collective behavior phenomenon created through actions of multiple individuals. These include modeling of crowd, traffic, epidemic and consumer behavior. Other additional modules may be defined for social behaviors that are needed for specific situations.

The crowd simulation component, for example, should model crowd movement at locations of interest under different event scenarios, crowd behavior models and crowd management strategies. The locations of interest may include areas around modeled and potential emergency incident sites, major business, commercial and residential areas that may be affected by evacuation directives, and major public transportation points such as bus and train stations, local rail transport stations, and airports. Different event scenarios may include normal, rush hour, terrorist attack, accidental fire, and natural disaster. The model may predict crowd movement and crowd density variations along movement directions, predict occurrence of stampede and casualties, determine location of individuals (such as first responders) as a function of time, and predict individual movement times between selected points. Inputs may include street layouts including pedestrian areas, layouts within public buildings such as train stations and public parks, crowd volumes and density data, probabilities for stampede and casualties, weather conditions, location of emergency incidents, behavioral models of individuals, sensor data, and communications. Outputs may include location and status of specific individuals in the crowd, crowd volumes and density by city block and passages within public buildings and parks, crowd movement times between selected points, and crowd management systems data.

4.1.2 Physical Phenomena Simulators

These simulators will model the physical phenomena involved in the creation and growth of the emergency incident. These may include such physical phenomena as earthquakes, explosions, fires, chemical, biological or radiological plumes, etc. These simulators will provide the extent of the damage while other simulators may model the impact of the damage on the associated systems. For example, the earthquake simulators will predict the extent of damage to the road network; the transportation system simulator will model the impact on the system while the traffic simulator will simulate the impact on individual units resulting from the damaged road network.

The earthquake simulation module should model the occurrence of the earthquake, the resulting damage to physical structures and associated casualties. Inputs may include description of critical infrastructure elements in the region of interest, their vulnerability to earthquakes, the description of major buildings and facilities and their human occupancy profile for different times of the day, the probability of occurrence of earthquakes of different magnitudes, the location of other assets of interest (vehicles, etc.) inside and around the structures. Outputs may include the identification of the region affected by the earthquake, the damage to different elements of infrastructure (road network, power distribution, communications etc.), the damage to buildings and facilities, the number and kind of human casualties in the affected region, identification of damaged assets and the extent of damage.

4.1.3 Environmental Simulators

These simulators will model the environmental phenomena that may affect the growth or containment of the emergency incident, its impact on the population or on the efforts by responding agencies. Such environmental phenomena include weather, watershed, indoor climate, and ecology. These simulators will model these phenomena and provide the outputs to other simulators for modeling the impact. For example, the weather simulator will model the weather pattern over the duration of simulation; the fire simulator will model the growth or reduction in the fire due to weather conditions, while the fire department simulator will model the impact on fire fighting efforts due to weather conditions.

The weather simulation component should model weather conditions during the simulation horizon. Inputs may include the initial conditions and the probability of incoming weather systems of different types (clouds, storms, winds, etc.). Outputs may include the change in weather conditions over the simulated horizon.

4.1.4 Organizational Simulators

These simulators will model the actions of the organizations involved in any aspect associated with the incident. The organizations modeled may include the fire, law enforcement, health care, other government agencies and the terrorist organization. The simulator will model the flow of information within the organization, flow of authority and decisions and the resulting actions. It will utilize the relevant policies and procedures to model the behavior of the organization and its members.

The fire department simulation component should model the actions of the fire department in response to an emergency incident including the assignment of resources for response, the actions of the fire crew at the incident site, handling of any casualties among fire crew and any subsequent requests for additional resources. The model will determine the resources assigned based on the incident, and predict the time required to accomplish the rescue and/or subdue the fire. Inputs may include the description of the emergency incident (location, magnitude, etc.), the time profile of the incident (determined by other simulators such as growth of a fire by the fire simulator), the number of people trapped inside the affected structure, the number and profile of assets of interest within and around the affected structures, the information available from the associated 911 call, availability of fire department resources at responding locations, probability of fire crew casualty associated with incident magnitude and the affected structures, and directives from law enforcements (such as presence of terrorists at the site preventing the fire crew from entering the incident zone). Outputs may include the number of people rescued from the affected structure, the response time by the fire department, and the actions by the fire crew. Other simulators such as the fire simulator may model the impact of actions of the fire crew. For example, the fire department simulator will model the number of water hoses pointed at the fire, while the fire simulator will model the reduction in the spread of fire based on the water delivery rate and the magnitude of the fire. The two simulators will thus interact closely to model the unfolding events until the fire is put out completely.

4.1.5 Infrastructure System Simulators

These simulators will model the behavior of the infrastructure systems following the occurrence of an emergency incident. They will model the propagation of the impact of damage through out the infrastructure system based on the damage to one part due to the emergency incident. For example, the earthquake simulator may predict the destruction of food warehouses in the affected region. The food supply simulator will model food shortages, contamination, and the diversion of food shipments from other regions to the affected region.

The food supply simulation component should model the behavior of the food supply infrastructure including the movement, storage and distribution of food supply to the affected population. The model will be used to predict the time for supply of food shipments to affected areas, the deterioration of food supplies in storage, and the shortages. Inputs may include the damage to the food supply infrastructure, the availability of food supplies in the surrounding regions, probabilities of disruptions in food supply, probabilities of deterioration in food supplies, and the resources available for food supply distribution. Outputs may include the profile of food supply over time to the affected region. Crowd simulator, for example, may use the outputs from this simulator to model rioting situations caused by food shortages.

4.2 Game Subsystem

The game subsystem will include game client modules that allow a trainee to take any of the following roles: civilian population and opposing forces, on scene response, response management, support institutions and live elements. The functions of these modules can be established in parallel to the corresponding simulation sub-system modules.

Elements of the video game-based training systems would include, where appropriate, real-time computer generated graphics and audio. Objects represented would include the environment, the incident scene, various emergency response vehicles, affected population, equipment, emergency responders, etc. Emergency responders would include various characters that represent the fire department, urban search and rescue, health care, law enforcement and terrorists. Physics models and artificial intelligence would be used to give objects physically correct behaviors and movements, or enable them to act autonomously without human intervention.

5 OPERATIONAL CONSIDERATIONS

For individual training, the game environment should run on devices in the personal computer family including a workstation, desktop, laptop, hand held, and PDA. The computers used to run the software could be available hardware in offices of emergency responders or the trainee's personal computer at home. The software could also be used for classroom and team training at centralized training facilities. The software engine, simulations, and other course content would all be delivered over the Internet via a Web browser interface. The software would install and run automatically without requiring special computer support expertise on the part of the student. Updates to software and course materials could be routinely disseminated over the Internet without resorting to the distribution of physical media, such as CD-ROMs.

The game engine, associated simulation modules, and Re-usable Learning Objects would be tested for security and certified by appropriate testing facilities. The software would be secure and prevent the introduction of any security holes, viruses, worms, etc. onto the trainee's computer. The software also would not allow the student to achieve any unauthorized access to the host computer system areas or other networked systems as a result of the installation of the simulation-based training application.

The architecture described above can be used as the basis for development of a simulation-based incident management training system. The training system should support all the modes of operation defined in Table 1. The system should allow training of an individual or a team. The value of the system thus could be fully exploited for training teams involving both emergency management and responder level personnel representing multiple agencies.

Table 1: Mode of Operations for Training System

No. of Trainees	Agencies	Target audience		
		Re-sponder	Manage-ment	Multi-level
Individual	Single	✓	✓	
Team	Single	✓	✓	✓
	Multiple	✓	✓	✓

The training administrators should be able to configure the system to present the training scenarios selected by the users. The system may be configured using data and graphics files describing the identified locale, and the response resources and organizations to be modeled. It may utilize the modules and subsystems corresponding to the mode of operation and the scenario.

The system should be thus highly configurable to the composition and needs of the individual and/or groups that are being trained. The proposed architecture should provide the configurability and plug compatibility needed to support the concept of operations described in this section.

6 CONCLUSION

This paper presented the concept of integrated simulation and gaming capability for training emergency responders and commanders. A novel architecture that integrates simulation and gaming modules together was described. The capability to train responders and commanders together on a wide range of scenarios will enable development of effective emergency response teams. Realization of the capability requires research and development in several areas including: standard ontology for the incident management domain, standard data models, integration with standard data sources and systems used in the domain, standard interfaces for component modules, standardized training interfaces, communication and synchronization among and across the modules of the simulation and gaming subsystems, and achieving performance suitable for training with distributed execution.

DISCLAIMER

Software architectures and models are identified in the context in this paper. This does not imply a recommendation or endorsement of the associated commercial software products by the authors or NIST, nor does it imply that such software products are necessarily the best available for the purpose.

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