

# **SIMFOR: TOWARDS A COLLABORATIVE SOFTWARE PLATFORM FOR URBAN CRISIS MANAGEMENT**

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## **ABSTRACT**

Risk and crisis management has become an important topic for public and private organizations. Nowadays, an important problem concerns the management of disasters (flooding, fire, nuclear explosion ...) in urban environments. To face such events, different actors like firefighters, mayors, or policemen have typically to deal with a wide amount of data, each at different decision levels. Aggregating various data from various sources to prepare the scenario is then crucial in order to create a credible realistic environment. The project SIMFOR has been initiated to develop a "serious game" oriented towards risk and crisis management in a complex urban context. This game will provide a 3D multi-actor training platform, which will help the players to improve both the prevention and the reaction to critical situations. Several actors can be managed by AI based on multi-agent. Phenomena like fire propagation or transportation net can be simulated by physical models. The first part of this communication will be devoted to the problematic of risk and crisis management. It notably situates the potentiality of "serious gaming" in such problem, which involves to aggregate data in an interoperable way using ISO standards. Part two concerns the SIMFOR serious game prototype. It presents the software architecture and a game session concerning a car fire scenario.

## **KEYWORDS**

Urban crisis management, serious gaming, data interoperability, ISO standards, OGC standards

## **1. . INTRODUCTION**

The study of risk and crisis management has become an important topic for most of public and private organization. Nowadays, a particularly important problem concerns the management of disasters (natural, chemical, or nuclear) as well as terrorist attacks in urban environments. While several strategies have been investigated, it remains difficult or impossible to organize most of such situations in real life; several risks are often coupled in a common crisis scenario which is complex to correctly simulate using computed environment. This paper addresses this problem in the framework of the SIMFOR project. Funded by the French government, SIMFOR aims at developing a "serious game" oriented towards risk and crisis management in a 3D urban context.

This document is composed of four parts. The first part (section 2) is devoted to the project context and the project goal. It notably proposes a list of needs like heterogeneous data management, physical simulations, artificial intelligence (AI), real-time multi-actor rendering involved in such project. The second part (section 3) is devoted to an overview of classical strategies used in the domain of risk and crisis management, and to a brief state of the art regarding the needs exposed in the first part. Part three (section 4) presents the actual architecture of SIMFOR, discusses the significant software parts of the game and the data flow involved. Part four (section 5) illustrates a game session in a car fire scenario.

## **2. CONTEXT AND GOAL**

Risk and crisis management is a topic concerning a wide range of structures such as primary school, nuclear power plant, or city halls. In dozens of countries, such structures have to develop risk and crisis emergency

plans which have to be regularly tested and updated. A common way to assess these plans is to repeat exercises in real life. Scenarios involved in the test plans usually bring together a large number of trades and actors which complicate the synchronization of actors. The example of a risk/crisis scenario in a school is a good illustration. Such a scenario will lead actors such as teachers, the mayor and his team, emergency service, and police to act together in a same issue. In practice, it is really difficult to gather all the actors and trades which take place in the scenario. Moreover, studying risk shows that it is often unrealistic to consider isolated risk at a time: a forest fire will involve cutting off electricity in some large areas which may entail critical problem in neighboring hospitals.

The SIMFOR project aims at handling all these aspects in a single software platform. The goal is to design a 3D multi-actor training platform which must help people to improve the prevention and the reaction to a wide set of urban critical situations (flooding, fire, buildings collapse, nuclear accident, etc.). This platform will not be devoted to a few numbers of experts belonging to a specific domain. It will be compatible with a wide set of scenarios coming from various trades. The relative software will allow real or AI-driven players to progress relatively to their ability, and should allow users to fit into different roles within the same scenario. To enhance realism, the platform will also be linked with a wide number of physical models (fire, water flooding, etc.). The multi-player aspect is crucial within the game because it conditions the exchanges between actors. Moreover, even if generic environments can be useful for basic training, the platform must allow designing new environments from a devoted editor which would be able to deal with realistic heterogeneous remote data. This editor, named *environment editor*, will allow aggregating a wide amount of data to prepare new simulations. The scope of SIMFOR is very large, and a single communication does not allow to give deep details about all the aspects involved in SIMFOR (multi-actors, physical simulations, IA, 3D rendering, heterogeneous data merging, etc.). In this way, mostly the overall architecture of the platform and the problem of data exchanged involved within the environment editor is aimed in this paper.

### **3. PREVIOUS WORK**

#### **3.1 From a real life experience to a serious gaming based approach**

The study of risk and crisis management has become an important topic for most of public and private organizations. Risk and crisis generate an operation pipeline requiring the identification of the risk, the development of strategies to reduce it, the creation of directives to put these strategies into effect, and also some processes to handle crisis if preventive actions fail. Several specific methodologies have been proposed for modeling such operation pipelines ([Kara-Zaitri, 1996]), but there are basically three ways to assess their practical reliability: real-life experience, computer-aided simulation, and more recently, serious gaming based approach.

For most of small-scale crisis scenario (e.g. a fire in a building), real-life experiences ([Militello et al, 2004]) can be efficient, because they are a good way to validate plans and test preparations for a forthcoming emergency. However, the latter are in general very expensive, time consuming to organize and to execute, and also impossible to restart at an intermediate point, in order to try an alternate action or plan. Moreover, for large-scale crisis situations such as natural disaster (flooding, earthquake), real-life experiences are known to be very difficult or impossible to train because they require too much people with different responsibility level and critical resources to participate.

Computer-aided simulations (CAS) represent a significant improvement to real-life simulations ([Kleiboer, 97], [Simonovic and Ahmad, 2005], [Matejcek et al., 2006], [Fiedrich and Burghardt, 2007]). They are easier and less expensive to execute repeatedly, to test different approaches and decisions, and can be successfully applied to large-scale simulations including very complex rules to drive the actions and reactions covered by the simulation. However, if one set of rules can finely model a phenomenon, CAS are often limited to one kind of event and thus do not integrate the crucial multi-actor aspect.

In recent years, a new computer-based approach allowing handling real-life problems ([Stolk et al., 2001], [Haferkamp and Kraemer, 2011]) has emerged. This approach, called "Serious Gaming" (SG) has become popular in many fields such as education, business, safety, or tourism ([Kankaanranta and Neittaanmaki, 2009]). Basically, SG is founded on the union between simulation and video games technologies. This union is

not new for many big organizations (army has used them as a part of training and planning for decades), but the rise of SG-based planning and training is due to the recent breakthrough of computer games software and hardware. For less than ten years, SG has become a growing tool exploiting the advantages of both real-life and CAS to offer high level simulation capabilities such as real-time human interaction during the runtime and realistic environment. Nowadays, SG technologies allow combining the experience of a real-life simulation, the complexity and ease of reproduction of the CAS, while generally providing a 2D or 3D interactive graphics user interface. Another major contribution of SG is the potential multi-actor support that allows incorporating communication and cooperation of players inside the simulation. Most of all, SG brings a ludic way to handle problems with can be toilsome to approach with classical real-life or CAS. Largely inspired from entertainment games technologies (e.g. [www.pjb.co.uk/games-resources-examples.htm](http://www.pjb.co.uk/games-resources-examples.htm)), recent technologies for developing SG ([Iuppa and Borst, 2009], [Kankaanranta Neittaanmaki, 2009]) support 2D/3D geometries and textures, 3D sound, physical simulation, AI, network traffic, environment, and multi-players. Most of SG are based on so-called SG-engines which also integrate real-world constraints and contextual data. Some of them are able to track player behavior and assesses their ability, or to provide instant replay.

A lot of games have been developed for training, but a few of them are focusing on risk management. For instance, the serious game Moonshield by KTM is related to risk management. However, this game is only single player. The company EMI has developed a simulation package used for firefighters training but the solution is very focused on the forest fire prevention and requires the participation of specialists to prepare the scenario and the operating theater. The company Infoterra has developed a tool for risk management and crisis situations named RISKFRAME. This tool is based on a GIS covering the crisis cycle (prevention, during and after the crisis). However, it does not offer a 3D visualization module and is not coupled to a training system. This limits the disposal of the actors. Consequently, creating a SG-based training in risk management with a comprehensive tool integrating multi-actor, real personalized environments, scalable and realistic scenarios, and network gaming remains a challenging topic.

### **3.2 Preparing operation theater**

Even if generic environments can be useful for basic use, a serious game for training must allow designing new playgrounds from a devoted editor. This one would be able to deal with realistic heterogeneous remote data. Importing, representing, and exchanging heterogeneous data is then an important problem. In the platform described previously, three types of data are mainly involved: geospatial, BIM (Building Information Model) and CAD (Computer-Aided Design) data. Using these data to prepare the environment game implies to take into account interoperability to facilitate their access and agglomeration process. Interoperability may be defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged". In a world where software vendors have implemented various products tailored to the needs of specific communities and/or customers, standardization is the simplest and most efficient solution to interoperability problems ([Zhao, and Di, 2010]).

Many organizations, industry consortia and specific groups are involved in standards development activities related to urban matters: ISO/TC 211 - Geographic Information/Geomatics and the Open Geospatial Consortium (OGC) work on standards for geospatial information and services ([Sample et al., 2007], [François et al., 2010]); the building SMART consortium (formerly International Alliance for Interoperability, IAI) focuses on developing standards for the construction and facility management industries; The Web3D Consortium is concerned with standards for 3D data exchanged over the Internet. Taking advantage of standards that allow joint exploitation and combination of various geospatial and CAD data is a requirement for developing an interoperable platform, for which there is an increasing demand in many user communities. It will bring an easy way to prepare operation theaters and can be focused on particular virtual cities.

Some well-known standards in GIS, based on fully-described XML formats, are GML and CityGML ([Kolbe, 2009]) and WMS/WMS web services. GML (Geography Markup Language) is an XML grammar defined by OGC to express geographical features. It serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet. The ability to integrate all forms of geographic information is key to the utility of GML. CityGML is a common information model for

the representation of sets of 3D urban objects, implemented as an application schema for GML3. It defines the classes and relations for the most relevant topographic objects in cities and regional models with respect to their geometrical, topological, semantic and appearance properties. Generalization hierarchies between thematic classes, aggregations, relations between objects, and spatial properties are included. This thematic information goes beyond graphic exchange formats and makes it possible to employ virtual 3D city models for sophisticated analysis tasks in different application domains like simulations, urban data mining, facility management, and thematic inquiries ([Hagedorn and Dollner, 2007]). WMS (Web Map Service)/WFS (Web Feature Service) are standard protocols for serving georeferenced maps/entities over the Internet that are generated by a devoted server. Those standards have been considered as really interesting tool to ensure the game interoperability, because they allow managing most of the geographical, architectural, and semantic data needed for the game.

These standards are obvious to aggregate in an automatic way the heterogeneous data and to ensure the life of our application. Nevertheless, it is necessary to prepare the data to use them in a real-time environment. For instance, using cityGML file of several hundred of Mb based on XML is not realistic. This requires to prepare data in an automatic way to create a spatial data infrastructure (SDI) devoted to computer games. This SDI will bring an innovative way to prepare a new environment. The following part discusses this topic, which is one of the main components of SIMFOR.

## **4. SIMFOR**

### **4.1 Towards an interoperable collaborative platform**

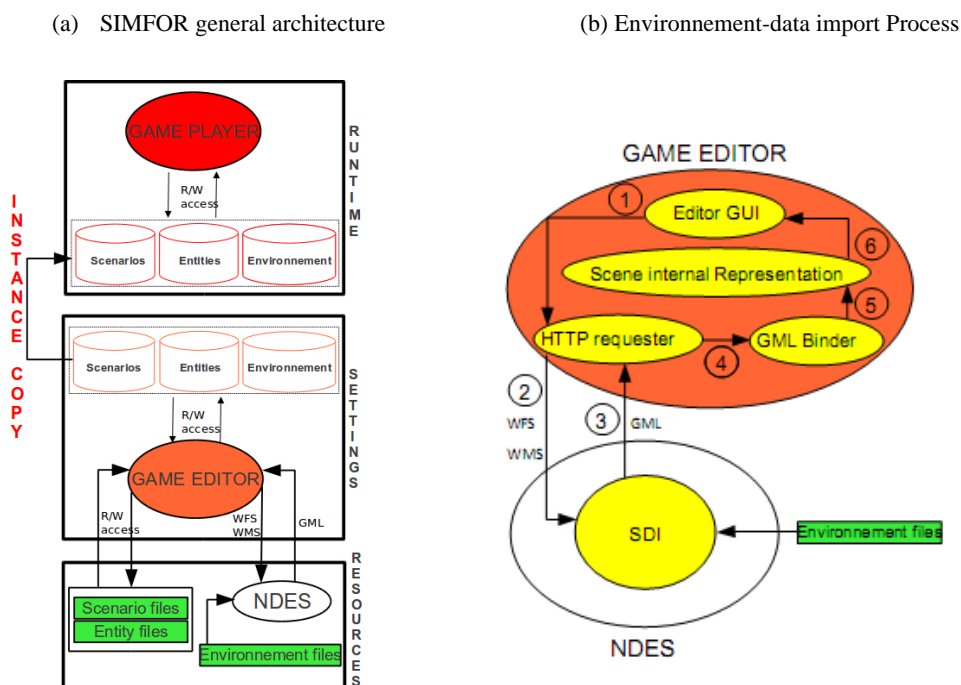
The goal of SIMFOR leads to a set of functional specifications which raise several research and technical points, conditioning the success of the project. The first one concerns the design of a 2D/3D urban environment from both quantitatively and qualitatively realistic data. This involves to manage the import, the representation, and the exchange of heterogeneous data such as geographical, architectural (BIM), and semantic data with well-suited technologies. The second point concerns the simulation of various crisis phenomena (e.g. fire, flood) and means integrating physical models into the game. The third point concerns the management of computer controlled agents and raises the problem of integrating AI processes into the scenarios. This part made by an other team of the SIMFOR project, will let to achieve cognition and agents communications. It will not be presented there. The last point in relation to the success of SIMFOR concerns the 3D interactive visualization of the game environment, and involves to be able to display a complex realistic 3D scene and to interact with some elements in real-time. This point is closely linked to the first one because it highly depends on the way the data are structured and communicated to the display environment. The state of the art exposed in section 3 allowed us to explore the panel of potential tools suitable for designing the SIMFOR platform. An overview of SG technologies has shown us that actual tools seem able to fulfill most of the technical points conditioning the success of the project. However, the huge amount of geographical, architectural, and semantic data required for the SIMFOR platform shows the lack in actual SG technologies, which are not directly compliant with geospatial and CAD standards. The SIMFOR platform has been designed to integrate this aspect through the general architecture illustrated on Figure 1.a. In its actual form, SIMFOR is composed of three logical parts: the resource, settings, and runtime parts.

The resource part encompasses all the data which are needed for the game. These data concern scenario files (files describing what type of crisis situation the players will have to face), entity files (describing real-life objects that will appear in the scenario), and environment files (describing the geographical and architectural environment of the scene). Scenario files and entity files are XML files structured with non-standard proprietary grammars. Environment data can be stored in various CAD and geospatial ISO or {it de facto} standards. The file formats supported are for example: MIF/MID, 3DS, shapefile, COLLADA, or CityGML.

The settings part relies on an editor which allows configuring a game session from a graphical user interface (GUI). This editor permits a direct import of a scenario and entities from their corresponding files. It also allows importing environment files from OGC WFS /WMS requests and GML answers through a Normalized Data Exchange Services (NDES) exposed on Figure 1.b. This service (described in the next part)

allows serving various files formats in GML files to the editor which is able to interpret the results and integrate the data in a 3D scene.

Figure 1 : SIMFOR main components



Once the scene is completed, an export of its components (scenario, entities, and environment data) to well-structured databases is achieved. The databases are duplicated in each actor world to ensure data coherence and avoid the modification of the initial structure of the simulation. The data transfer latency during the simulation is also excluded by duplication. These databases are then the support of the runtime part which relies on the game player. This last provides a GUI from which the user can join a game session. The runtime uses the information stored in the databases to make the game progress.

## 4.2 Resources

Scenario and entities are specified using XML grammars. Instance files are used to define the disaster type, actors, and means involved in the scenario. The environment files are served by the NDES. In its actual version, the NDES is based on an opensource spatial data infrastructure (SDI) as illustrated on Figure 1.b. This SDI contains a comprehensive geospatial software package with implementations of OGC Web Services like WMS and WFS, and various tools for geospatial data processing and management (analysis tools for example). It allows serving a wide range of file formats and notably CityGML files which is a major advantage for SIMFOR.

The NDES simply encapsulates this SDI and is considered has a remote entity which can be acceded by the game editor from standardized requests such as those provided for instance by WFS and WMS. In return, the NDES is able to provide geographical data to the editor in a standard GML form.

## 4.3 Settings

The import of data in the game editor is achieved from direct files reading for scenarios and entities, and from WFS/WMS requests coupled to GML answers for environmental data. For this purpose import procedures of massively used formats has been achieved as well as GML analyzing tools. To insure spatial data coherence, data has been expressed in WGS84 projection.

GML analyze has been based on a binder which allows mapping XML grammars to C++ classes. This technique is more suited for wide grammar than its homologue SAX or DOM approaches based on XML instance analyzing, and provides an easy way to read and write XML instances based on arbitrary grammar. The operation pipeline allowing the editor to import environment data is proposed on Figure 1.b. The simulation designer selects an entity he wants to integrate into the scene (1), the underlying WFS/WMS HTTP request is send to the NDES through a devoted requester (2), the NDES send back to the requester the GML corresponding to the selected entity (3), the GML flow is sent to the binder which produces a C++ object (4), the C++ object is linked to the internal representation of the scene (5), finally the entity is displayed in the editor GUI (6).

The scene editor has been developed as a plugin of Pxviewer, software from Pixxim partner, devoted to urban environment design. The scene edition is based on a layer system which allows gathering components of the scene by their functional aspects. More significant layers are Digital Elevation Model (DEM), building, and road layers which are the base of most of crisis scenarios. For each layer, the environmental components are automatically proposed to the game designer by requesting the NDES on its serving capabilities. The user can then choose objects he wants to integrate into the scene by activating devoted check boxes on the GUI. The designer has the possibility to move elements and enrich the semantic aspect of the scene objects with classical picking functions.

Once the setting part is achieved, the designer has to export the scene towards the game player to launch a game session. For this purpose, a set of export procedures has been implemented in the editor to transfer the C++ objects (DEM, buildings, roads, etc.) of the scene to spatial relational database tables. Spatial databases are optimized to store and query data that is related to objects in space, including points, lines, polygons or more complex entities. Tables are suitably structured to contain minimal geometric and semantic data.

Each relevant entity of the scene can be geometrically represented by its bounding box, its unique identifier and a point representing its location on the scene.

## 4.4 Game player

Last module of the project, the runtime is based on a GUI from which a user can launch or join a game session. In its actual version, the SIMFOR player GUI relies on the Delta3D (D3D) game engine ([www.delta3d.org/](http://www.delta3d.org/)). D3D is an open source engine which can be used for games, simulations, or other graphical applications. In addition to basic graphical components, D3D provides a variety of tools such as the "Simulation, Training, and Game Editor" (STAGE), a BSP Compiler, a particle editor, a stand-alone model viewer, and a "High Level Architecture" (HLA) Stealth Viewer. Furthermore, Delta3D has an extensive architectural suite that is integrated throughout the engine. This suite includes frameworks such a "Dynamic Actor Layer" (DAL) for actor proxies and properties, signal/slot support for direct method linking, a "Game Manager" (GM) for actor management, pluggable terrain tools for reading, rendering, and decorating terrain, and high-level messaging for actor communication.

In its actual form, the Game player GUI provides both a first and third person control of an avatar that the user choose at the beginning of the game. The GUI provides some communication functions (phone, fax, radio) which allow a player to communicate with other players during the game session and a 2D map of the simulation area to know where he is on the overall scene. The information used during the game session are dynamically updated from the spatial database. The spatial capabilities of the databases are used for answering to geometrical constraints involving the scene entities.

## 15.EXPERIMENTAL RESULTS

This part illustrates a simple use-case of SIMFOR process: a car fire event taking place at Lunel (small size town). Basically, this scenario involves a car which starts to burn on a parking and a firefighters crew who have to stop the fire in the shortest delay. This simulation also includes a witness which contact the fire department and the mayor of Lunel. The disaster type, actors, and means involved in the scenario have been respectively specified by XML files similar to those given on Figure 2.

Figure 2 : XML files for disaster type,actors,and means involved in the scenario

```

<disasters>
  <disaster
    label="CarFire"
    type="fire"
    origin="natural"
    state="initial"
    location="parking1"
    ...
  />
  ...
</disasters>

<actors>
  <actor
    name="John.Smith"
    id="firefighter1"
    skill="good"
    function="firefighter"
    mesh="firefighter.xml">
    ...
  </actor>
  ...
</actors>

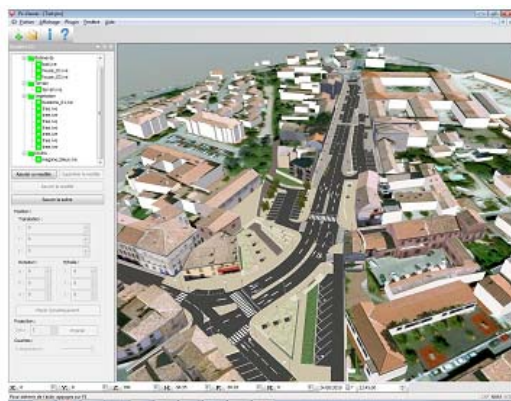
<means>
  <vehicle id="01"
    mesh="car.ive">
    ...
  </vehicle>
  ...
</means>

```

The listings define that in the Lunel car fire scenario, the fire is classified of "natural" origin and takes place on "parking1". The firefighter "John Smith" is involved (cause of his "good" skill) to stop the fire started on vehicle "01". The environment data of the Lunel town, gathered via the environment editor, are shown on Figure 3.a. The car which is burning appears on Figure 3.b. This image uses the "Firefighter" view of the simulation. Each granted person, via his own specific view, can act on the simulation, depending on its responsibility rank (city mayor, medical rescue, public organization head, etc.). Other risks, for instance explosion of inflammable material, can be added to this scenario.

Figure 3 : SIMFOR use case : car fire event in Lunel

(a) Scene editor



(b) Event scene



Several types of entities have been exported from the editor (cars, trees, buildings, streetlights, etc.) and structured in a spatial database table. Each entity is linked to a unique identifier and several geometric (e.g. absolute position, 2D hull, etc.) and semantic data. It also describes its state, which indicates through an integer value if this entity is safe, under fire, or completely burned. Those states are linked to specific Uniform Resource Locator (URL), pointing on precalculated IVE files ([www.openscenegraph.org/projects/osg](http://www.openscenegraph.org/projects/osg)) locally stored on the player machine. These IVE allow updating the graphical rendering of the scene entities according to their relative state in the database.

## 5. CONCLUSION

"Serious Games" seems to be particularly appropriate for training people to function in complex situations and as members of a team. SIMFOR has been initiated in this goal, as a multiplayer interactive game allowing to train individuals and teams in order to improve their skills. A promising prototype has been developed to allow players to train with basic environments and scenarios. Many aspects of the project remain under construction. One important part concerns the file formats which are not yet supported by the SDI used in the NDES such as CAD data, and thus which can't be served in GML files. Until now, these data

are loaded into the game editor via specific import methods, which should be replaced in a near future. This point involves investigating the possibility of transferring/converting various CAD data into the GML formalism.

An interesting way can be to use interoperable CAD formats, also based on XML, and perform a dictionary translation (U3D, 3DXML). This led up to geometric translations, as for example, parametric splines (usually Nurbs) to polylines. Despite the ISO19107 definitions (ISO19107, 2003) of geometric objects, there is some lacks in the usage of parametric curves and surfaces. A recurrent problem is also to express these geometries in different space representations (Euclidean, spherical, ellipsoidal, and geodetic). The communication loss, sometimes critical in such crisis situation have not been yet implemented. Standard HLA communication would permit spooling and dead-reconning of messages.

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