“SIGEN: SIMULATION FOR TRAINING AND MANAGEMENT ON EMERGENCY SITUATIONS”

Civil-Military Endeavors

Luis F. Robledo, Eduardo Godoy

TACTICAL TRAINING SIMULATION CENTER

CHILEAN ARMY

Valenzuela Llanos 623, La Reina, 7860251, Santiago, Chile

56-2-290 7582

lfrobled@uc.cl
Abstract

SIGEN is a modern network simulation software designed by the Chilean Army Simulation Center, the Northern Catholic University, and sponsored by the National Emergency Office from the Ministry of Internal Affairs, which allows management training between the components of an organization, through the interaction of their different roles under a given initial situation, and monitoring their reactions from further specific missions, reports or given information. This tool is designed to work with organizations and institutions in emergency management, under strenuous situations, allowing real time and after-action reviews.

Keywords: Emergency, simulation, training, civil-military

Introduction

The Chilean Army Simulation Center (CEOTAC), a branch of the War College together with the Northern Catholic University (UCN), and sponsored by the National Emergency Office from the Ministry of Internal Affairs, during the year 2002 started the research and development of a major project called “Simulation for Training and Management on Emergency Situations (SIGEN)” under GRANT D02I1006.

This project considered the development of a specific software for training organizations and institutions in emergency management, under strenuous situations, allowing real time and after-action reviews.

SIGEN was implemented initially in the northern part of Chile. The results showed the need to have a computational tool available on line, oriented towards management and training, which would contribute to increase decision making skills in the prevention of disasters, mitigation and management of potentially catastrophic effects of natural, man-made, organizational or technological disasters, among others, which could show up in national or international environments, under a given Protection System.

Training through a computational simulation system allows management optimization in order to face emergency situations, making possible mitigation and prevention of catastrophic effects over the population.

SIGEN is a modern network simulation software designed by the Chilean Army, which allows management training among the components of an organization, through the interaction of their different roles under a given initial situation, and monitoring their reactions from further specific missions, reports or specific information.

The essential element of the system is the capability of evaluating the organizational behavior under critical and strenuous situations, in order to implement the lessons learned.
which would optimize the decision-making process of the key components of the organization.

SIGEN has been used in several training sessions with the participation of national and international organizations such as the Chilean National Emergency Office, the Chilean Armed Forces, city councils, fire departments, delegates from the national industrial sector and other foreign institutions, etc.

SIGEN facilitates training authorities and organizations - public or private ones - involved in a crisis or emergency situation, entering their decisions, actions and procedures into a database which captures the organizational conducts, establishing the concept of lessons learned, in order to quantify the levels of preparation and improvement in collaborative management in public or private organizations, during emergency situations.

SIGEN strengthens the economic sector through decreasing risk indicators associated with natural or man-made phenomena, by enabling the use of a modern preventive and executive technological tool for emergency and crisis situations.

SIGEN has been presented as a useful emergency management and training tool in the American Armies Conference (CEA) and in MERCOSUR, with a successful demonstration exercise during April 2008.

Components

SIGEN can be distinguished by its two main components: An instructional tutoring system and a collective training system, each one of them with a specific target in the training process

Instructional tutoring system

This system is oriented towards individual training over the concept of self preparation, without the need of counting with the presence of an instructor.

Collective training system

This system is the main component, and allows simulation and training through the following interfaces:

- **Player interface**: Net program connected with the main platform. It is used by the player during training. It involves the following concepts:
  - Situational awareness
    - Alarms for events (situations), orders, requirements, events occurring at subordinate levels, and communication requirements.
    - Geographic Information System (GIS)
  - Communications
    - Written
    - Oral
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- **Planning**
  - Decisions
  - Orders: definition and sending
  - Requirements: definition and sending
  - Accomplishment of orders received (percentage)
  - Unit control and supervision
  - Contextual and general information consulting.

- **Direction interface**: net program connected with the main platform, used by the Director of the exercise. It involves the following concepts:
  - **Control**: visualization and modification of the State and role of the overall training (exercise).
  - **Analysis**: visualization of the objectives generated by the players, chaining graphics, and general statistics.
  - **Direction**: activation of situations, outgoing messages to players, generation of situations, etc.

- **Design interface**: autonomous program used by the Director, in order to generate a definition file of the training. It involves the following concepts:
  - **Terrain and digital cartography definition.**
  - **Participants’ definition**: Structure, dependence, geographic position, etc.
  - **Definition of other participating roles.**
  - **Time.**
  - **Training objective and decomposition definition.**
  - **Definition of training situations according to the objectives with different activation methods.**
    - Manual
    - Automatic by the hour
    - Action dependent
  - **Incorporation of contextual and general information.**

- **Support interface**
  - File reading of training definitions.
  - Other technical functionalities like training activations, etc.

SIGEN Platform manages the interaction between all player interfaces, and the Director of the game, by returning information from different calls, and communicating all events produced during the training. It administers the game clock during the training phases, and manages the actualization of all simulation elements.

**Conceptual solution**

The model used in SIGEN is based on the answers to the following questions:

- What is the motivation of a role player leading to a course of action?
- What are the most important actions a role can play?
How do the actions of a role relate with other roles?

How is an executive order modeled and how does the environment influence it?

For the first question, we defined the elements that motivate a role in order to start an action: Incidents, Initiatives, and Objectives.

Next the objectives cover the following roles: decisions, received orders and suggested solutions.

The second question derives from the first one, where a role can generate objectives for itself (decisions) or objectives for the remaining roles. The most important actions a role can do are to resolve, to order and to request. We have to add to this the propagation and reporting of incidents in the organization. The relationship between the actions of a role and the remaining roles (and to itself) is given by the establishment of the objectives and the propagation or diffusion of incidents.

A more rigorous explanation of the above is given by:

Let \( R \) be a set of all participating roles in the training

Where \( R = \{r_1, r_2, \ldots, r_m\} \cup RPPN \), where \( RPPN = \{a_1, a_2, \ldots, a_n\} \) (first-order parallel roles)

and let the function \( f_i \) define the immediate lower level of a role:

\[
f_1: R \to \{R - RPPN\}
\]

\[
f_1(a_i) = \{a_j, \ldots, a_k\}
\]

\[
1 \leq i \leq |R|
\]

\[
1 \leq j < k \leq |R - RPPN|,
\]

\[
a_i \notin \{a_j, \ldots, a_k\}
\]

\[
f_1(a_i) = \{\}
\]

Let \( E \) be a set of the stimuli:

\[
E = \{I, \text{initiative}, OBJ\},
\]

where \( I \) is the set of all incidents:

\[
I = \{\text{incident}_1, \ldots, \text{incident}_n\},
\]

and \( OBJ \) is the set of objectives defined by:

\[
OBJ = \{\text{resolution}(r_i), \text{order}(r_i), \text{requirement}(r_i)\}
\]
The meaning of each element of this set is given by:

- **decision**: \( \text{resolution}(r_i) \) : Resolution of role \( r_i \)
- **order**: \( \text{order}(r_i) \) : Order of role \( r_i \)
- **requirement**: \( \text{requirement}(r_i) \) : Requirement of role \( r_i \)

Let \( A \) be a set of actions that a role can play:

\[
A = \{ \text{inform, resolve, order, require, execute} \}
\]

Finally, we define function \( f_2 \) that relates all previously defined elements \((r \in R, e \in E, a \in A, \text{ and } \text{pa} \text{ are all parameters of the action})\):

\[
f_2(r_i, e_j) = (r_i, e_j, a_k, \text{pa})
\]

\[
f_2(r_i, e_j, \text{inform}, \{ \text{incident}_m, \{r_k, \ldots, r_l\} \})
= (r_n, \text{incident}_m), \forall r_n \in \{r_k, \ldots, r_l\}, k \leq n \leq l
\]

\[
f_2(r_i, e_j, \text{resolve}, \{ \}) = (r_i, \text{resolution}(r_i))
\]

\[
f_2(r_i, e_j, \text{order}, \{r_k, \ldots, r_l\})
= (r_n, \text{order}(r_i)), \forall r_n \in \{r_k, \ldots, r_l\}, k \leq n \leq l
\]

\[
f_2(r_i, e_j, \text{require}, \{r_k, \ldots, r_l\})
= (r_n, \text{requirement}(r_i)), \forall r_n \in \{r_k, \ldots, r_l\}, k \leq n \leq l
\]

\[
f_2(r_i, \text{execute}, \text{pa}) = (r_i, e_j) \mid (\)
\]

In this way, we define the logic of the system.

**Architecture**

**Description of the three layer model**

In general terms, in order to have an implemented system, capable of having great cohesion and coupling, we have made use of the three layer concept. These layers allow the design of a system made up of component parts which have common functionalities. Each layer is defined as follows:

- **Presentation layer**: In charge of implementing the user’s interface. The user interacts with the system through events.
- **Logic layer**: All classes in charge of solving and responding users’ requirements. The objects of this layer are those which represent the domain of the problem.
- **Persistence layer**: The layer able to keep the state of the objects at the logic layer.

Visibility and communication between different layers cannot be completed in any direction. Figure 1 shows visibility between layers, represented by the directions of the arrows. As we can see, visibility goes from the upper to the lower layer only.

![Diagram of three-layer model](image)

Figure 1, General scheme of the three layer model.

*Presentation layer*

SIGEN system implements different kinds of interfaces, each one of them focused on different users, with different objectives. We define each interface as follows:

*SIGEN WEB*: This interface is used during games and training sessions, accessible by means of a browser.

*SIGEN Administrator*: It is also called Contents Administrator. This is the interface that configures and manages the games.

*SIGEN Simulation*: This corresponds to a simulator of different discrete events that model natural events that will be used later during the training phases of all the different roles involved in emergency management. It is made up of two main components: a discrete event editor that allows an emergency and catastrophe situation expert to create all possible events that may occur in a given scenario, and a second component which is
an event launcher that chooses, from previously created different scenarios, which one will be used in a particular game.

*SIGEN exploration:* This interface corresponds to the application of data-mining, in order to analyze the results of a previously played game. The objective is to search for behavioral patterns between the participants. This module is currently under research.

*Logic layer*

This layer has all program classes in charge of implementing the domain and logic of the system. The project that contains this layer is called SigenCore.

*Persistence layer*

As mentioned before, this layer is in charge of keeping all logic objects. It is implemented in SigenCore. The persistence of SIGEN utilizes Postgres database administrator.

It is important to mention that communications among layers are made through controllers. A controller is a specific class that behaves as the receptor of requirements of an upper layer where it belongs. This controller decides inside the layer, which class is capable of answering. Figure 2 shows SIGEN architecture.
Technological platform for training and management

The communication’s architecture of the system, where the geographic information is filed, has the management tools to develop real time collaborative management in order to have training on emergency and catastrophe situations. This result implies having adequate hardware (servers, network, routers, switches, ups, patch panels, etc.) and software (firewall, routers with differentiated packages, IP webphones, etc.).

Figure 3, User interface with main system functionalities and managing interface

Geographic Information System

As a training tool, SIGEN needed a module that would allow players to know the terrain, do their analysis, and create all required graphical orders. We built a GIS that would allow deployment of digital maps. Through this system, the user will be able to recognize the geographic space where the simulation is being held.

Figure 4, GIS interface

The geographic model is supported by a geographic database that allows queries, enabling the generation of new layers of information. These layers can be visualized and shared by different users. Inside the model, we can highlight the data model which allows the search of any known element inside the GIS, such as a street name.
This web based GIS supports the collaborative decision-making process. This geographic platform has digitalized images, aerial and satellite pictures for spatial visualization of the terrain, depending on urban or rural characteristics of the terrain.

The GIS web based engine allows topological data management, and has the capacity of generating overlays, as mentioned before. This vector overlay corresponds to the sector where the training is being held.

**Lessons learned and decision-making support system**

This system corresponds to an internet management system that allows planning and conducting of simulated emergency situations. The module is supported over a organizational behavior data base, which contains a web mail able to capture individual behaviors, and has the simulated events models, the thread evaluating interface, load indicators, manager’s interface, and activity monitoring of the different nodes that are involved in the decision-making process. It has real time evaluating tools and will have data-mining tools in the near future.
This multipurpose system has the capacity of representing any structural organization through:

- Reconfigurable communication flows, so it allows flow modeling of an organization, keeping their organizational structure in order to define all required procedures.

- Resource administrator: This tool enables the system to have control over real time resources assigned to a player or a role, over a certain period of time. These resources may be materials (vehicle, ambulance, fire engine, etc.) or other resources like food, money, fuel, etc. All this will give more realism to a training session, therefore constituting a powerful tool for evaluating an organization during or after the session.

![Figure 7, “Resource administrator” interface.](image)

- Dynamic organizational web mail: It allows automatic recreation of all required formats previously established in the training planification of the organization.

- Lessons learned information generation: This capacity is held by an individual role evaluation system called “Instructional tutoring system”, and by a collective evaluating system which monitors real time organizational behavior of the organization. At this point, we consider real time graphical and statistic data generation, where the direction of the exercise and the thematic experts can monitor the training development. Graphic cluster generation of all communications can show all different organizational problems when running an exercise. These communication problems generally correspond to organizational or individual problems when making decisions, shown as bottle necks (or traffic jams). Real time statistics are used to study the emergency and catastrophe collaborative management held by the trained organization. All these tools are meant to be used with organizational and thematic expert judgment which accompanies the training and evaluating process.
Training experience

SIGEN has been used in decision-making emergency training for the last 6 years. This system has trained several city councils personnel and state-run service authorities in Floods, Tsunamis and Earthquake situation responses. At a national level, SIGEN has been used in training in conjunction with the Emergency Operations and Response Committee, and it has been used in postgraduate courses related with emergency response measures. This system is presently being requested by several enterprises for emergency response and planning, such as FORESTAL MININCO, SAG, etc.
During the 2003 national exercise at the II Region, with Antofagasta and Calama city councils, the system was used with 60 users at that place, in coordination with 40 users at Santiago city, 2,000 kms. distance, with observers in Concepcion (Chile), Central America and U.S.A., and a total of 105 users, all of this coordinated at a national level with the National Emergency Office.

At International Level, SIGEN has been used in training military units, from CHILE and ARGENTINA, in emergency situations response during 2002 and 2005, and with HONDURAS during the 2003 “MITCH” hurricane after action review.

A total amount of 1290, up to December 2007, has been trained in this system. During 2006, SIGEN was used to train people from EL SALVADOR and NICARAGUA. During 2007 up to this date, SIGEN is being considered as the training platform for “CONCORDIA”, an emergency training between PERUVIAN and CHILEAN armies.
This system was presented on 2007 to the American Armies conference in VENEZUELA, and to the Armies Chief of Staff meeting from MERCOSUR countries. This last presentation allowed for a multinational training in last March 2008 with delegates from all MERCOSUR countries, in order to define a common computational emergency training tool.

![Image of a conference setting](image)

Figure 13, American Armies Conference, Venezuela, 2007.

**Conclusion**

SIGEN is a system that, through the recreation of emergency situations, complements the different management levels of an organization, through on line reactions and collaborative decision-making, from all responsible authorities in emergency and catastrophe management. This system allows training of authorities and public enterprises that must participate in an emergency, trying to capture their organizational behavior through statistics and experts’ judgment.

**References**
