Only *Hope* remains in the PANDORA's `.jar`

– Pervasive use of planning in a training environment –

G. Bernardi[†], **A. Cesta**[†], **L. Coraci**[†], **G. Cortellessa**[†], **R. De Benedictis**[†],
F. Mohier[‡], **J. Polutnik**[*] and **M. Vuk**[*]

[†] CNR, Consiglio Nazionale delle Ricerche, ISTC, Rome, Italy
[‡] BFC, Business Flow Consulting, Sceaux, France
[*] XLab Research, Ljubljana, Slovenia

Abstract

This paper shortly introduces features of a software system called PANDORA-BOX. [1] It shows a novel use of timeline-based planning as the core element in a dynamic training environment for crisis managers. A trainer is provided with a combination of planning and execution functionalities that allow him to maintain and adapt a "lesson plan" as the basis for the interaction between him and the involved trainees. The training session is based on the concept of *Scenario*, a set of events and connected possibilities that shape an abstract plan proposed to trainees through a timeline-based system. The PANDORA architecture provides a continuous reactive loop around trainees, and, additionally allows the trainer to directly intervene in the ongoing session giving him a complete, general and advanced view about the evolution of the *Scenario*.

Introduction

Goal of the PANDORA project[2] is to study how to support the training of crisis managers with innovative "ICT-like" technologies. In particular the project aims at creating a tool that corroborates with traditional training methods to generate the ability for trainees to react well to decision making under critical situations.

Why. When a catastrophic event occurs, it is often human behavior alone that determines the speed and efficacy of the crisis management efforts. Indeed, all too often, shortcomings in the response to the emergency do not stem from the ignorance of procedures but from difficulties resulting from the individual response to the challenge of operating in such a context, particularly when additional unexpected problems arise. Crisis management is of major importance in preventing emergency situations from turning into disasters. In recent years, poor management response to emergencies has often resulted in critical situations. In critical circumstances, there is a tremendous necessity of effective *leaders*. It is worth saying that the pressure of unexpected circumstances creates strong constraints on the abilities of leaders to take decisions. For example, given the severe time pressure imposed by the crisis, they have little time to acquire and process information effectively. As a consequence, they are required to assess information and making decisions under tremendous psychological stress and physical demands, often caused by the difficulty to operate in contexts where consistent losses as well as damages both to human lives and properties are occurring. Within this context training plays a crucial role in preparing crisis managers. Specifically, training for strategic decision making has to foster leaders' ability to anticipate possible consequences of bad decisions and to conceive creative solutions to problems. In this light experiential learning plays a crucial role.

What. The project is synthesizing a software environment able to support a lesson of few hours with a class of trainees that are exposed to a set of stimuli coming from an evolving crisis scenarios customized to the particular training needs. Key aspect in PANDORA is to create realistic responses to the decisions taken by trainees by reproducing believable situations, grounded realistic domain causality for those decisions to facilitate the development of a comprehensive range of decision making skills. Additionally, the idea underlying PANDORA is to take trainees behavioral features into account and plan training sessions tailored to individual differences and needs.

How. The starting idea for using planning within PANDORA was connected to the synthesis of a "Lesson plan", that is an organized set of lesson's items to be given to trainees over a time span according to a learning strategy. Additionally from the need of monitoring user status during lesson comes the idea of representing also the user's features as temporal items, hence inserting also these data in a uniform plan and using causal connections between different part of such plan to foster the continuous update of the plan. A natural technology for all this has been identified in the timeline-based planning, an approach to temporal planning which has been mostly applied to the solution of

[1] For those curious about the paper title we quote a short mythological description from the voice *Pandora's_box* on Wikipedia: "When Prometheus stole fire from heaven, Zeus took vengeance by presenting Pandora to Prometheus, Epimetheus' brother. With her, **Pandora had a box which she was not to open under any circumstance**. Impelled by her natural curiosity, Pandora opened the box-jar, and all evil contained escaped and spread over the earth. She hastened to close the lid, but **the whole contents of the jar had escaped, except for one thing** which lay at the bottom, **which was Hope**."

[2] http://www.pandoraproject.eu/

several space planning problems – e.g., (Muscettola 1994; Jonsson et al. 2000; Smith, Frank, and Jonsson 2000; Frank and Jonsson 2003; Cesta et al. 2011b; Chien et al. 2010). We have produced a first version of a comprehensive architecture, called the PANDORA-BOX, that fully demonstrates the feasibility of our approach. Central to the system is its original use of planning to model a quite rich domain. Specifically, planning is used (1) to compute diversified crisis scenarios corresponding to alternative training paths to foster creative decision-making, (2) to model and maintain trainees' behavioral patterns according to which training can be personalized, (3) to support mixed-initiative interaction between the trainer and the automated learning environment relying on a high level of abstraction for the internal representation. Here we describe PANDORA Year One Demo in a quite broad way. For a more detailed description the reader should refer to (Cesta et al. 2011a).

The PANDORA-BOX

Figure 1 describes the modules that currently compose the PANDORA-BOX system. At the more external level three are the main blocks of the current architecture:

1. the *Trainer Support Framework* which allows the trainer to keep control of the training session by biasing the learning content steps with an abstract plan called *Scenario*, dynamically adjusting the stimuli based on both his/her experience and observation of the different trainees' actions;
2. the *Trainee Clients* that according to a Client-Server communication allow distributed trainees to join a class and participate, also being able to receive both collective and individual stimuli during the class;
3. the *kernel* PANDORA *system*, identified by the dotted PANDORA-BOX in the figure, which is the main engine that generates the "lesson plan", animates it in an engaging way and adjusts it on a continuous bases to keep peace with both the evolution of the specific group of people under training and their individual performance.

In the rest of this paper we describe main aspects of these three blocks focusing in particular on the kernel because it is there that planning technology is more deeply used.

Planning the Training Class

The basic connection with planning relies on the idea of composing elements of the lesson through causal rules. In PANDORA-BOX lesson's content, e.g., different multi-media assets, are represented as elements of a temporal plan, hence the crisis plan is composed of different multi-media "messages" to trainees. Additionally, also all the background information, e.g., lesson strategy, trainee classification, evolution of crisis on-field resources, are represented as timelines to take advantage of both the uniform representation and the underlying technological functionalities. The combination of such information is useful to decide particular orchestration of messages.

One of the key points of our representation of the plan is the ability to adapt and update itself as a consequence of new information gathered from trainees during the ongoing lesson. Each action done by both the Trainer and the Trainees is figured as a trigger able to change the current running state of the backbone Scenario created by the trainer. As a consequence of this requirement, the system needs to activate a re-planning procedure in a continuous cycle in order to maintain the simulation consistent with taken decisions.

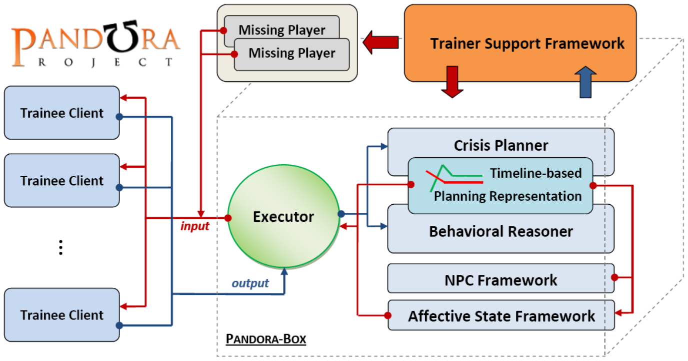


Figure 1: *The* PANDORA-BOX *general architecture*

Timelines-based modeling. As usual in timeline-based planning the basic indexing of domain knowledge is represented by timelines, that in generic terms, are functions of time over a finite domain (Muscettola 1994). A single timeline contains *a set of tokens* that we have called *"events"* here due to the association with visible effects on the whole played Scenario. Such events can have consequences in terms of casualties, injuries, involved resources, etc. or simply represent information sent to single trainees. From a technical point of view, an event is described through a predicate holding over a time interval and thus characterized by a start and an end time. According to this model, the domain of each timeline depends on the type of events that the same timeline is going to represent. Furthermore, events can be linked each other through "relations" in order to reduce allowed values for their constituting parameters and thus decreasing allowed system behaviors. Generally, relations can by represented by logical combination of linear constraints among event parameters and/or temporal points. We call the graph having events as nodes and relations as edges "Event Network" and we say that it is *consistent* iff it respects a set of consistency rules that we call "Causal Patterns". A causal pattern is a logic implication having a predicate signature as implicant and a logic combination of timeline values and relations as implicate. The semantic is that each node of the Event Network having the implicant pattern as signature requires the implicated pattern inside the Event Network.

The uses of plans. One aspect worth being observed in Figure 1 is how the PANDORA system creates loops around its human users. We can call the first one the *the-trainee-loop*: Trainees receive stimuli, their decisions are registered by the system and then reacted upon through plan adaptation, before loop continuation. The starting point for plan generation is the Trainer Support Framework because the trainer injects an initial Scenario (aka Abstract Plan) that acts as a connected set of goals when represented at the ground planning level. These set of goals triggers the basic planning activity of the Crisis Planner. The planner uses both the domain causal patterns and the timelines inputted by the Behavioral Reasoner with information on the single trainees to create a complete consistent plan at ground level that is ready for execution. The Behavioral Reasoner is the module responsible for both creating an initial user model of the trainees and maintaining it updated according to a continuous analysis of trainees decisions, and other data (Cortellessa et al. 2011). Two additional modules compose the PANDORA-BOX and are connected to an effective rendering of single events: the NPC Framework and the Affective State Framework. The first makes available additional virtual characters to be functionally used within the orchestrated events to influence trainees, the latter, at present, can be directly controlled by a timeline called `induced_stress` synthesized and updated by the Behavioral Reasoner to generate diversified multi-media effect to influence the engagement and the cognitive overload of the trainees. The Executor is the main responsible for the dispatching of events according to temporal order. It is also responsible for gathering decisions coming from trainees after selected stimuli and for forwarding them to the two modules that dynamically update the timeline plans (the Crisis Planner and the Behavioral Reasoner).

There is a second human-in-the-loop case that we can call *the-trainer-loop*: as shown in the figure this person observes what is happening in the class and can intervene on the trainees either *directly* through simulated characters (the Missing Players) and chat messages (not represented in figure), or *indirectly* by changing the Scenario and in so doing posting new goals at the ground planning level. In general the trainer has the possibility of just observing the lesson flow and annotate the abstract plan representation or more proactively taking part in the lesson or even interrupting it, giving direct explanations, and resuming the plan-based lesson. It is also worth saying that PANDORA provides another instrument that allows the Trainer *temporal navigation* through the lesson plan. A *Rewind* functionality allows to move the execution back in time providing two different behaviors:

– *default roll-back*, intended for debriefing purposes, that simply updates current simulation time t to desired target value keeping untouched actions taken by trainees;

– *heavy roll-back*, intended to revert to a crucial decision point at time t, removing each event representing trainees' choices at time $t' > t$, along with their consequences, in order to allow a different simulation course.

It is worth saying that the roll-back is a functionality of the Executor fully supported by the plan management machinery provided by the timelines. For the sake of space we have given a quite generic presentation of the PANDORA-BOX. One comment worth being done is that also in this experience we have noted, in agreement with (Pollack and Horty 1999), how in real applications as important as pure plan synthesis is the richness of services that can be developed around plan management.

The PANDORA interactive environment. We close this compact overview with a description of the functionalities realized to interface real users. Figure 2 depicts some of the interaction features in the current demonstrator. As direct consequence of the choices in the architecture, the system distinguishes between two types of interaction:

– *trainer-system interaction*, indicated as *Trainer View*, which is related to the functionalities available to the trainer to create a training session, monitor, edit it and interact dynamically with the class;

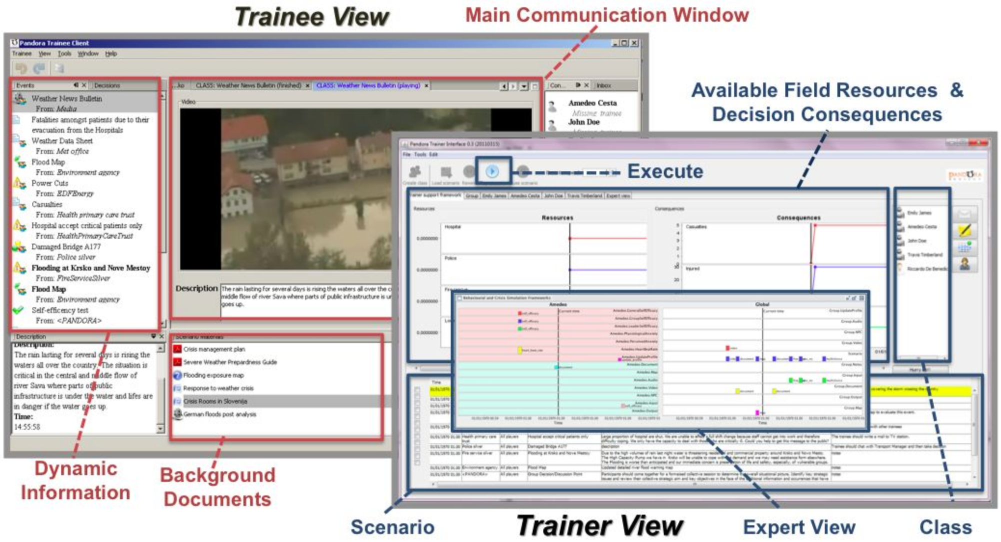
– *trainee-system interaction*, indicated as *Trainee View*, which is the interface through which the trainee can connect to the PANDORA-BOX, receive stimuli and make decisions about the critical situation.

Additionally we have a further view, called *Expert View*, which is an inspection capability over the timeline environment and its execution functionalities.

Trainer View. This service allows to compose a *training class* completing it with "missing players" to have a coverage of institutional roles in crisis strategic decision making. Created a class the trainer can load a *Scenario*, and see it in tabular form with a series of important information such as the execution time of each goal event and who is the main recipient of information. It is worth highlighting how this representation is close to the current way of working of the trainers and has been instrumental in establishing a dialogue with them, before proposing any kind of completely new solutions. Along with the scenario, the interface also contains information about available resources to resolve the crisis and the consequences of trainees' decisions, both represented through resource timelines and dynamically updated during the training. The trainer is the one to have the basic commands from executing the plan, stopping execution, resuming it and rewinding. Furthermore, a specific requirement from user centered design has been a set of plan annotation functionalities plus a series of additional commands which allows the trainer to dynamically add new stimuli, in perfect line with the mixed initiative interaction style.

Trainee View. The Trainee interface contains three main blocks, plus a number of features related to communication of each trainee with the rest of the class and the trainer. The main building blocks are: (1) *Background Documents*, which represents a set of information delivered off-line to the class in the form of maps, documents, reports, in order to create awareness about the upcoming exercise; (2) *Dynamic information* that represents the information dynamically scheduled and sent to the trainee in the form of videos, maps, decision points etc.; (3) *Main Communication Window*, which is devoted to display stimuli (possibly customized) to individual trainees or to the class.

Expert View. In parallel with the traditional tabular view, the trainer can inspect the more advanced view of the PANDORA module, that is the internal representation for both the Crisis Planner and the Behavioral Reasoner. As already said, all type of information within PANDORA is


Trainee View
Main Communication Window
Available Field Resources & Decision Consequences
Execute
Dynamic Information
Background Documents
Scenario
Trainer View
Expert View
Class
Pandora Trainee Client
Trainee View Tools Window Help
Events
Decisions
CLASS: Weather News Bulletin (finished)
CLASS: Weather News Bulletin (playing)
Video
Inbox
Amedeo Cesta
John Doe
Scenario Materials
Pandora Trainer Interface 0.3 (20110315)
File Tools Edit
Resources
Consequences
Hospital
Police
Casualties
Injured
Behavioural and Crisis Simulation Frameworks
Amedeo
Global

Weather News Bulletin
From: *Media*
Fatalities amongst patients due to their evacuation from the Hospitals
Weather Data Sheet
From: *Met office*
Flood Map
From: *Environment agency*
Power Cuts
From: *EDFEnergy*
Casualties
From: *Health primary care trust*
Hospital accept critical patients only
From: *HealthPrimaryCareTrust*
Damaged Bridge A177
From: *Police silver*
Flooding at Krsko and Nove Mestoy
From: *FireServiceSilver*
Flood Map
From: *Environment agency*
Self-efficency test
From: *<PANDORA>*

Description: The rain lasting for several days is rising the waters all over the country. The situation is critical in the central and middle flow of river Sava where parts of public infrastructure is under the water and lifes are in danger if the water goes up.
Time:
14:55:58

Crisis management plan
Severe Weather Prepardness Guide
Flooding exposure map
Response to weather crisis
Crisis Rooms in Slovenija
German floods post analysis

Figure 2: *Screen shots of the current Trainer and Trainee Interfaces*

represented as a timeline and continually updated (see different colors for timelines related to the crisis and the user model in the Expert View). At this point, through the Execute button, the trainer can start the session.

The interaction environment has been critical in our dialogue with the end users and is going to further refined on the one hand to satisfy user requirements on interaction, on the other to make the advanced features more useful for the trainer. Our goal is to fill the gap between the internal representation and users' expectation, with the aim of promoting their active involvement in the management of training.

Conclusions

A first prototype of the complete system has been produced in early December 2010 while a first robust version of the PANDORA-BOX has been officially demoed on March 2011 to the EU project officers during the mid-term project review. This paper shortly introduces this year one demonstrator. It is worth underscoring the important role of planning technology in the PANDORA-BOX.[3] We have seen how the representation with timelines is the core component of the crisis simulation, and that a continuous loop of planning, execution, plan adaptation is created to support personalized training with Trainer in the loop.

Many improvements are scheduled in the remaining lifetime of the project. Just to give an idea, one of the next steps is to provide a tool for Knowledge and Scenario Authoring that allows incremental creation and/or editing of crisis Scenarios. Then, in order to achieve a high degree of realism, stress and pressure, the use of a 3D environment will be explored with the purpose to render a Crisis Room with all trainees together, even if for logistic reasons they are in different locations during the training.

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[3] Going back to the title of this short paper: internal to our PANDORA's BOX (**the** `.jar` **in the title**), there is mostly knowledge in terms of timelines and "simple" planning modules for planning and executing them. **Hence planning is our ... *Hope***!!!