WEB-BASED TRAINING SYSTEM FOR FOREST FIRE OFFICE STAFF

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Abstract: The objective of this paper is to present an approach for a web-based training system for Forest fire offices. The development of a modelling and simulation technology for systems with a network-like architecture is growing day by day. Forest fire offices represent an appropriate application such approach. It is based on an XML languages family defined in a research project and is applied to a number of systems that have been modelled and simulated. This paper introduces two different related issues: the system architecture; and the XML-based language and its use for simulation.

1 INTRODUCTION

Every summer forest fires ends up to being the centre of attention in press and media. In the period 1997-2001 more than 565.000 (Guardia Civil de España, 2003), (Ministerio de Medio Ambiente de España, 2003) (Instituto Nacional de Estadística de España, 2003) have taken place only in Spain. In most of the cases, these disasters are quite dangerous to populations. It is well known that available resources to extinguish fires are limited and demand large budget provisions: Therefore it is important to optimize their distribution and use.

There are many allies to fight together: fire: prevention, modern resources, new materials and simulators. All of them are useful and helpful tools to work as defence against forest fires. Usually, these technologies are associated to the strong development that has taken place in the last years in the field of the information and telecommunication technologies.

The logical introduction of these technologies in the fight against forest fires needs of modern operation stations where to process and store data (digital cartography and exchange of digital information need huge media storage) and run applications. The background provided by these technologies constitute an invaluable help for an improved decision taking. Some related technology-specific issues are:

- Technical Applications of GPS
- Localization and Tracking of ground and air resources
- Tracking down mobile platforms
- Image transmission in real time
- Infrared fire detection
- Fire simulation, as already different applications implement such as *CARDIN*, *FARSITE*, *FIREFOC*, and *FEOT* (Lymberopoulos,

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Papadopoulos, Stefanakis, Pantalos, Lockwood, 1996), (McGrattan, Baum, Rehm, Forney, Prasad, 2002), and (Molina, Castellnou, Plant, 2001).

– Fire prediction Behaviour as in *BEHAVE* (Andrews, 1998).

Most of the efforts mentioned above address fire simulation. However, it is important not to forget the training of engineers in charge of fire prevention (Bardaj, Molina, Castellnou, 1998), (Stolk, 2003) and (McGrattan, Baum, Rehm, Forney, Prasad, 2002). This is the main application topic of the research work described, that fills this important gap. The objectives of the investigation is to simulate fire extinguishing resources allocation under different conditions, to consider decision making procedure of a fire office engineer, to design the system front-end, and, finally, to process the simulation and obtain evaluation reports. The listed objectives consider the modelling to be the key for human knowledge accumulating as well as the basis for the knowledge use. The youngest time, the modelling technology profits a lot from advances in data acquisition and processing methods and from communication infrastructure as well.

The development of data modelling and behaviour simulation tools for a fire office was performed within the European research and development project XNETMOD (XNETMOD Consortium, 2003). Moreover, aspects of distributed architectures as well as web-based services were considered as well. Within the scope of this project, modelling technology focused technical systems with network structure in general. The application fields cover rather different application domains:

1. Oil/gas/water distribution networks;
2. Data capturing system, focussing on workflow simulation;
3. Forest fire office management.

Fire prevention and extinguishing tasks provide an appealing domain to test the technology and, on the other side, the application elaboration presents an intrinsic interest. Road network supervision for prevention and management of forest fire danger is only one relevant task. The other mentioned task is management of the fire extinguishing resources allocation. Simulation of system evolution, including the fire situation, resources dynamic, social aspects, is the further exciting task. The performed work was structured into four phases:

1. Problem Analysis intending to increase experience with respect to the subject and to elaborate use cases.
2. System architecture definition, with the main goal of proposing an Internet-based architecture.
3. Modelling aimed to define the Fire Office domain in terms of an XML language.
4. Simulation procedure design and implementation, with the objective to implement a model-based performing of tasks listed above.

This paper is structured into the following chapters: a brief description of the problem; the system architecture, presentation of modelling language, and technology application example for modelling the fire office resource management task. Finally, a description of how the system works is

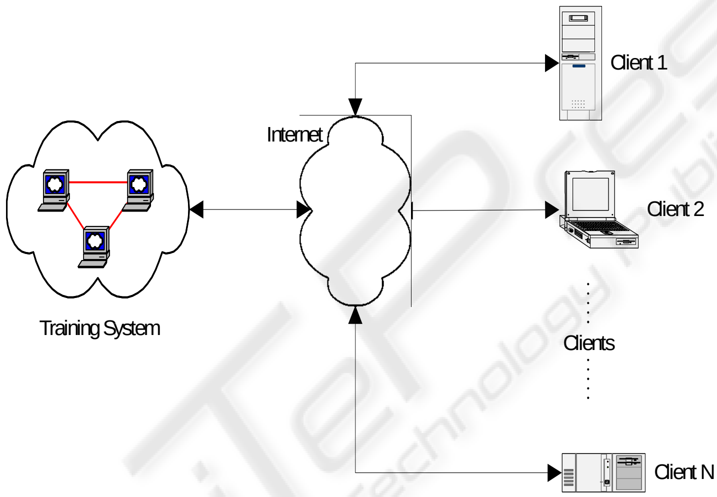

Figure 1: System Architecture Overview

introduced, and example of a training session is provided.

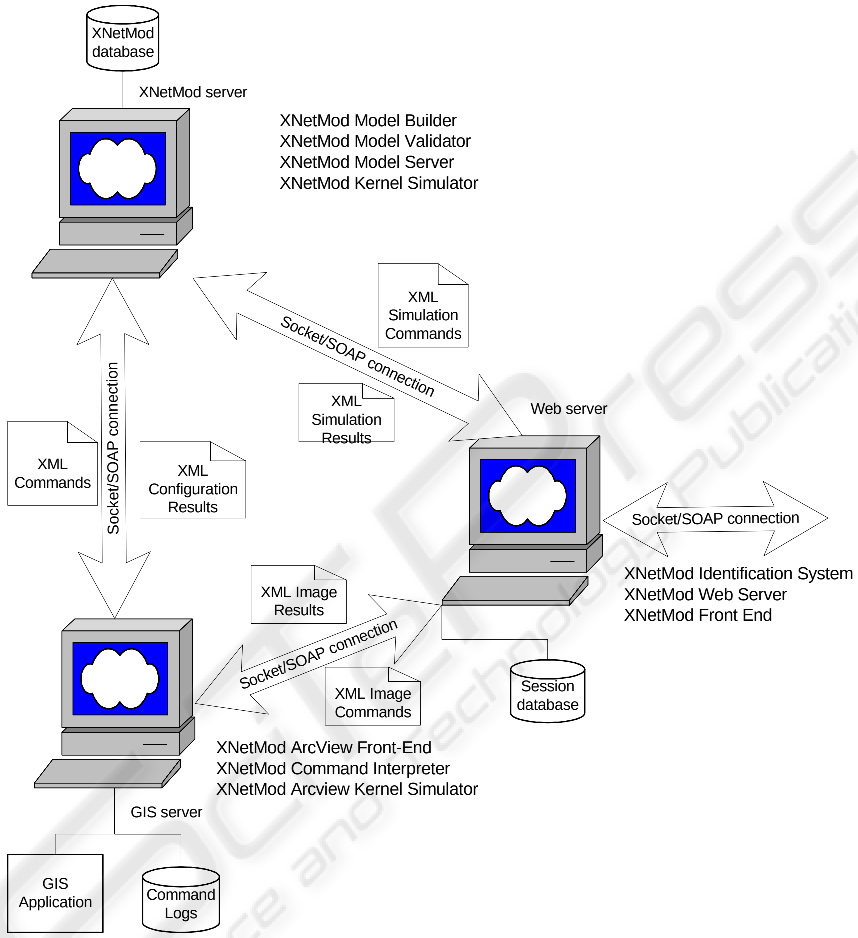

Figure 2. *Three server* architecture approach.

2 PROBLEM DESCRIPTION

On fire extinguishing site, there are three main aspects to be considered:

1. Fire behaviour;
2. Resource allocation season plan;
3. Action against fire in a burning area.

The first one is out the scope of this research work as long as there are many projects oriented to analyse and simulate fire behaviour, as mentioned in the Introduction. One of the main tasks for forest engineers specialized on fire extinguishing is to plan resources for a summer season. One of the main and most difficult issues that the forest engineer faces is to choose place where resources to be allocated. Depending on personal background, available heuristics and statistics, the engineer must find the most appropriate places for each resource. With respect to this problem, tools for analysis and assistance by decision taking are welcome – a an improper resource allocation can lead to huge disasters.

One of the objectives for the seasonal planning is to obtain such resource allocation variant in a given region, which ensures access to fire accident within a predefined time interval, e.g. less than 30 minutes. Then engineers, considering different resources allocation variants and fire accident access times, associated to the allocation variants, must decide which of the resource will be moved from its base to the burning area, and which other resources must be reallocated to cover the rest of the region with the highest protection level. Forest engineers have to execute two tasks:

1. To establish a planning on resources allocation over the region. This task must be performed before the season has begun.
2. To perform resources management, and disposition in case of fire accident. This task must be carried out events dependent, during the season and considering actual forest fires and forest fire risks.

3 SYSTEM OVERVIEW

To support both main tasks mentioned above, Figure 1 shows a web-based architecture proposed where it is possible to identify two different components: web clients from remote places and the training system; they are linked together using the Internet connection. Any Internet browser available with Java-applet support facilities can be used for clients.

The Internet approach is appropriate to this simulation environment because forest engineers training process could be done remotely. As in case of Cuenca province (Spain), resources are limited, and sometimes it is not possible to find a convenient place both for instructors and trainees where to prepare the training/simulation sessions. In this sense, this solution makes it possible for engineers to take part in the training process from different parts of Cuenca.

The system architecture is refined in figure 2. At the server side, also a number of subcomponents, namely servers, were identified during the design phase. The design criteria applied was to achieve a system with the highest cohesion and lowest possible coupling. This was important because of the complexity of the architecture and thinking in terms of design robustness and maintenability. In this way each subcomponent (i.e. server) could work in a non-dependent way from others. At a first sight, three different servers form this system:

1. Web server, represents the front-end server to manage web client connections.
2. XNetMod server, represents the server where all the model information is stored.
3. GIS server, represents the main system source information.

This multi-server solution proposed allows implementing independent services to support each part of the system. XML language has been selected to exchange information because of its flexibility and its the standardization.

Each server sends XML files with commands requesting information to other servers; and XML files are sent back with results of the execution of those commands. A local protocol has been developed to control this information exchange process using either sockets or SOAP connections. This multi-server schema has proved as a solution with high flexibility, scalability and easy to extend.

4 XNETMOD MODELLING LANGUAGE

Once the architecture has been defined, the next step is to present how the system is modelled and the simulation performed. Roadmap networks is the base concept for define the model and to describe roadmap networks requires the following issues:

– To describe nodes of the network
– To describe relations between nodes

Each node represents some kind of information that networks could manage, like topological nodes or elements allocated to topological nodes. For example: in a roadmap network, topological nodes could be, for example populations, or crossroads (Molina, Castellnou, Plant, 2001). But in most of the cases, it is also interesting to describe all the elements that could be allocated to nodes like hospitals, hotels, or gas stations. The second type of elements are links. Each link represents network relations. On one hand links could be topological relations between nodes to describe the network topology. On the other hand, links could represent how some resources are allocated to nodes.

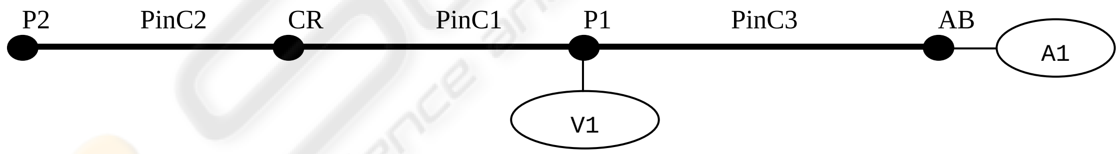

Figure 3. Network components sample

In figure 3 a simple scheme for a road representation is provided with the following elements:

– Four topological nodes: P1 (city of Cuenca) , P2 (village of Villalba de la Sierra), CR1 (a crossroad) and AB1 (airport at a crossroad).
– Two resource nodes: A1 (aircraft 1) and V1 (big truck 1)
– Two resource allocation links:
1. V1 to P1
2. A1 to AB1
– Three topological links:
1. PinC1: P1 to CR1 (highway 1)
2. PinC2: P2 to CR1 (local –path- 2)
3. PinC3: P1 to AB1 (local –path- 3)

In most of cases, each type of link has their own regularization rules. These rules describe all the constraints that each connection must check to be valid. That is the reason why links could be represented as a component with two elements:

a) Pin connections, to define the existing element-to-element relations within an application model.
b) Rules, to define regularization rules with respect to a connection type and within an instance of *Links*.

The instances of class *Rule* play an important role for the model structure verification (XNETMOD Consortium, 2003). From a formal point of view the rule based verification is founded on the work presented in (Stefanescu, 2000). The model is interpreted with respect to existing connections defined and considering these rules. Thus, when the model checker is running using the interpreter, the defined rules will be applied to the model structure.

Some topological rules could be:

1. Populations must be linked together with roads (Rule1)
1. Populations could be linked with crossroads (Rule 2)
2. Some resource allocation (allocation "pins") rules could be:

Hospitals must be allocated into populations

Gas stations could be allocated everywhere

A brief example of a model is:

```
<Model xmlns:xsi =
"http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation =
"http://www.w3.org/2001/XMLSchema/Model
Model.xsd" Name="Model">
<Node NodeId="A1" description="Aircraft
1" cost="3.14159" xsi:type="Node:Air">
<Node:speedAvg>500</Node:speedAvg>
</Node>
<Node NodeId="V1" description="Big
Truck 1" cost="1000"
xsi:type="Node:Vehicle">
     <Node:speedAvg>100</Node:speedAvg>
     <Node:costKM>10.3</Node:costKM>
</Node>
<Node NodeId="P1" description="Cuenca"
x1="200" y1="200"
xsi:type="Node:Population">
     <Node:habitNumber>50000
     </Node:habitNumber>
</Node>
<Node NodeId="P2" description="Villalba
Sierra" x1="125" y1="250"
xsi:type="Node:Population">
     <Node:habitNumber>5000
     </Node:habitNumber>
</Node>
<Node NodeId="CR1" description="String"
x1="100" y1="150"
xsi:type="Node:Crossroad">
     <Node:Risk>100</Node:Risk>
</Node>
<Node NodeId="AB1"
description="Airport" x1="200" y1="250"
xsi:type="Node:Crossroad">
     <Node:Risk>100</Node:Risk>
</Node>
<Link linkId="topology"
Name="topology">
<Pin PinId="PinC1" description="Highway
1" xsi:type="Pin:Highway" from="P1"
to="CR1">
          <Pin:limit>100 120</Pin:limit>

     <Pin:minSpeed>60</Pin:minSpeed>
          <Pin:lines>2</Pin:lines>
     </Pin>
<Pin PinId="PinC2" description="Local
2" xsi:type="Pin:Local" from="P2"
to="CR1">
          <Pin:limit>80 100</Pin:limit>
          <Pin:status>Good</Pin:status>
</Pin>
<Link:Pin PinId="PinC3"
description="Local 3"
xsi:type="Pin:Local" from="P1"
to="AB1">
          <Pin:limit>80 100</Pin:limit>
          <Pin:status>Good</Pin:status>
</Link:Pin>
<Link:Rule RuleId="Rul1"
description="Rule 1"
```

```
xsi:type="Rule:Instance"
from="Population" to="Population"/>
<Link:Rule RuleId="Rul2"
description="Rule 2"
xsi:type="Rule:Instance"
from="Population" to="Crossroad"/>
<Link:Rule RuleId="Rul3"
description="Rule 3"
xsi:type="Rule:Instance"
from="Crossroad" to="Crossroad"/>
</Link>
<Link linkId="Allocation"
Name="Allocation">
<Link:Pin PinId="All1"
description="A1toAB1"
xsi:type="Pin:Member" from="A1"
to="AB1"/>
<Link:Pin PinId="All8"
description="V1toP1"
xsi:type="Pin:Member" from="V1"
to="P1"/>
<Link:Rule RuleId="Rul11"
description="Rule 11"
xsi:type="Rule:Instance"
from="Resource" to="Base"/>
</Link>
</Model>
```


5 INTEGRATED SYSTEM AT WORK

Our main goal in this sense is to obtain the most flexible and application independent system that is the reason why we decided to develop this GIS server. Most of GIS system has defined internal programming languages to develop scripts to automate some operations. Many scripts have been developed to deal main simulation operations over Arcview® (ESRI, 2003) and to export Arcview® information to the model in XML format.

So, if GIS system changes, it is only necessary write scripts in the language maintaining the same command files format. In our particular application, we used Arcview® and Avenue® (script language) as GIS application. The following program code is an example of an Avenue script to create a new Arcview theme to represent air resources (*aviones* in Spanish). Required fields are identification, maximum speed, water resources, staff, efficacy rate, node and node layer, that in the script are in Spanish.

```
'**************************************
**
'--- Script to build air resources theme
'**************************************
**
aView = av.FindDoc("MONTES Y VIAS
PECUARIAS")
theTheme=aView.FindTheme("Aviones.shp")
if (theTheme<>nil) then
  aView.DeleteTheme(theTheme)
end
aFile =
"C:\XNetMod\Acebo\Capas\Salida\Aviones"
.AsFileName
aNewFtab = FTab.MakeNew (aFile,
Polygon)
'--- add required fields ---'
aNewShapeField =
aNewFtab.FindField("Shape")
aNewField = Field.Make ("Id",
#FIELD_SHORT , 20, 0)
aNewField1 = Field.Make ("Vel_Max",
#FIELD_SHORT , 20, 1)
aNewField2 = Field.Make ("Cap_Agua",
#FIELD_SHORT , 20, 0)
aNewField3 = Field.Make ("Personal",
#FIELD_CHAR , 80, 0)
aNewField4 = Field.Make ("Coef_Efec",
#FIELD_SHORT ,20, 0)
aNewField5 = Field.Make ("Node",
#FIELD_LONG , 12, 0)
aNewField6 = Field.Make ("Capa_Node",
#FIELD_CHAR , 20, 0)
aNewFtab.AddFields({aNewField,aNewField
1,
aNewField2,aNewField3,aNewField4,aNewFi
eld5, aNewField6})
aNewFtab.Flush
aNewTheme = Theme.Make(
aNewFtab.GetSrcName)
aView.AddTheme(aNewTheme)
'--- turn on the theme ---'
aNewTheme.SetVisible(True)
'--- update the screen ---'
aView.GetDisplay.Flush
```

To achieve an effective interaction with the GIS server has been a complex task. Each request containing an action is specified by two different messages in XML, the first goes from any other server to the GIS server and represents the action itself, and the second goes from the GIS server to the server from where the request was sent and contains the requested information. Some actions implemented are related to start and stop the GIS application, get actual system views, move resources from source to target. It includes ground vehicles (*coches terrestres* in Spanish), and intersections (*intersecciones*). A command example is:

```
<?xml version="1.0" encoding="iso-8859-
1"?>
<commands>
<command name="move"  mode="internal">
  <parameter name="resource"
type="coches terrestre.shp" value="3"/>
  <parameter name="from"
type="intersecciones.shp" value="269"/>
  <parameter name="to"
type="intersecciones.shp" value="273"/>
 </command>
</commands>
```

And finally, an example of some information exported from Arcview in XML format, including information on villages (*pueblos*), and the village of Albalate de Noguera:

```
…
<node nodeId="80"
xsi:type="Node:pueblos">
<pueblos_id>494</pueblos_id>
<area>150928</area>
<perimeter>1961.7</perimeter>
<pueblos_>490</pueblos_>
<nombre_pue>Albalate de
Nogueras</nombre_pue>
</node>
…
<link linkId="NodesTopology"
type="Topology">
<pin pinId="0"
xsi:type="pin:SimpleTopological">
<pin:description></pin:description>
<pin:bidirectional>true</pin:bidirectio
nal>
<pin:from>45</pin:from>
<pin:to>360</pin:to>
<pin:roadId>2622</pin:roadId>
<pin:length>8635.13</pin:length>
<pin:roadType>5</pin:roadType>
</pin>
…
</link>
```

6 TRAINING SESSION

Before the training session can be started, the system administrator must define the simulation framework. This framework is formed by a roadmap network and lists of available resources (one list for each resource type).

Once the system has been configured, the training session is ready. The first part of the simulation has the objective to prepare seasonal planning. In this part, forest engineers must decide where to allocate available resources in different nodes of the network. At the same time as the resources are being allocated; the system determines the fire accident access time limit for the resources depending on geographical situation. In parallel, an optimal resources distribution will be obtained by the system. Once the initial resources allocation process is finished, the forest engineer can compare this distribution with the optimal to check similarities and disparities.

After the planning phase, the system can simulate the appearance of a fire at random in some parts of the region. Then, the engineer has care on the resources movement towards the burning area, and reallocate free resources to cover unprotected areas. Finally, once the fire is controlled and extinguished the system generates a report archiving the actions provided by the engineer.

7 RELATED WORK

The project Gamma-EC (Dirk, 2003), is oriented towards developing computer-aided tools to improve the education and training disaster managers. This system focuses on crisis management in general terms, even when forest fire is one of the topics dealt. NIST Fire Dynamics Simulator and Smokeview, developed at NIST (NIST, 2003) is a computational fluid dynamics model of fire-driven fluid flow. Future of Fire Simulation, related to show different works about fire modelling and the nature of the fires in the Building and Fire Research Lab at NIST. The application of a GIS system for similar purposes that those described within this paper can be found in (Lymberopoulos, Papadopoulos, Stefanakis, Pantalos, Lockwood, 1996) and (Stefanakis, E., 2000). However the degree of integration with the rest of the application and functionalities achieved are higher in our approach.

Concerning implementation of the client server architecture, similar approaches can be found in (Alarcón, Garbajosa, Yagüe, Garcia, 2002), (Altendorf, Hohman, Zabicki, 2002) and (Milenkovic, Robinson et al., 2003).

8 CONCLUSION

The developed architecture was applied for the solution of an actual fire extinguishing problem in Cuenca province (Spain). This system will be included as powerful tool into Cuenca forest engineers training process.

The developed system has proved its flexibility, platform independency and scalability. Consequently, the developed XML-based language was applied for the modelling of road network, fire behaviour, and physical resources (human teams and vehicles) distribution related to the road network.

Herewith, the access of small and medium-sized enterprises (SMEs) to the advanced modelling technologies will sustain and strengthen their business fields as well as guarantee further diversification of intelligent IT-based services.

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