

Territorial Information System interoperability: a design improving interaction in an emergency

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Abstract

Risk analysis and emergency management use common instruments such as GIS (Geographic Information Systems) and TIS (Territorial Information Systems). They do not visualize maps alone, but they can be instruments of interaction among many components and actors (data, operators...). Interoperability represents the next fundamental step towards developing more efficient management systems. We can discriminate three levels: data interoperability, applications or software tools interoperability and finally systems interoperability. Software technological development is carried out in many frameworks such as CORBA (Common Object Request Broker Architecture) [8, 10], COM (Component Object Model) [2], JAVA [9, 11], .NET [2], etc. Each of them has resolved interoperability with different results. In any case, we built efficient architectures by using the present frameworks. Our paper aims to describe the interoperability aspects and to show some practical achievements. These allow effective monitoring in the presence of concurrent activities and detection. In particular, we will present two architectures adopted for defence risk (air-space control) and in the activities of the fire-brigade department.

Keywords: Geographic Information System, Territorial Information System, emergency management, risk analysis, interoperability.

1 Introduction

Many instruments of software managements and electronic equipment are designed and adopted to help operators in their risk analysis activities. Some of



these specialized instruments are used only to evaluate hazards. Others have transverse valence, such as GIS and TIS, extending their applicability into the field of environmental management. The emergency management is a special case of the last one.

Risk analysis must consider again the domino effects of catastrophic events during an emergency. Consequently, a system architecture oriented to emergency management includes more elements and parts of a risk analysis system, such as detection methods, evaluation algorithms and operators. However, some characteristics become of primary importance. In the case of an emergency, one stresses in particular: fast calculations, real time forecasts, effective shared data availability and interoperability.

The following aspects define the main and substantial differences: one adds different detection methods in an emergency activity; new software simulations are included to forecast dynamical evolution of events; one emphasizes coordination management among departments and operators; more and frequent refreshers of the environmental state should be used.

The structure of such a management system becomes complicated and frequently it needs more recent technological discoveries, in the software and hardware fields, to solve architectural problems.

2 Basic structure of a Territorial Information System

We restrict our analysis of the system to some aspects only, such as the more characteristic ones from the point of view of interoperability. We refer to our previous work, which is in the bibliography, for a more complete description of the system structure [3, 4, 5, 6, 7].

In synthesis, three levels or layers set up a TIS: data structures and management, modules of models inclusion and elaboration, interconnectivity and interoperability.

We manage data in a separated subsystem: orographic, cartographic, GIS, etc. In effect, we can assemble specific attributes, quality of information, resolution and data organization, by realizing a dedicated subsystem. We also arrange subsystems for general data, characterized by an internal structure like a matrix or vector.

In order to analyze, to intersect and to correlate data objects, a TIS must include efficient instruments. One prefers a graphical interaction that uses windows and sub-windows to insert different methods of analysis and mathematical operations. Special care for the graphical presentation of data must be used so as to create friendly instruments for visualization.

The core of our system is the interconnection module together with the database access subsystem. Technological innovation of software and the new architecture of our system allow more compatibility of different data structures and management of complex operations on the data.

Figure 1 shows the functional scheme of the system Terrapack32M, considering simulation tools such as external process. This scheme does not preclude internal simulation programs among default equipments, but the



integration of external processes should be executed normally in a greater and general activity: the interoperability.

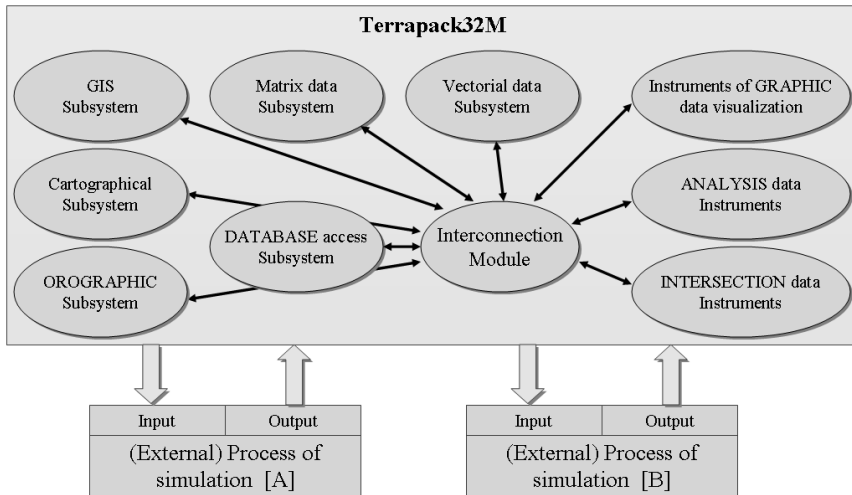


Figure 1: Functional scheme of TIS Terrapack32M.

3 Interoperability

One distinguishes different levels of interoperability: data, applications and systems. In the framework of public administration, one also adds a definition of interoperability based on a digital (electronic) signature.

At first, the data problem was resolved using converters. In order to give an efficient solution, open data or API (Application Programming Interface) was frequently used.

Later on, thanks to technological evolution, interoperability extended its operating area from homogeneous to heterogeneous technologies.

In recent years, the larger software companies have introduced new technologies improving the interoperability performance of their software framework. Different frameworks have been proposed: CORBA by OGM (Object Management Group), JAVA by Sun Microsystems, COM and the recent .NET by Microsoft, etc.

For example, software tools can be modulated in reused server and client components by means of COM, but client and server must reside on the same computer. Only the DCOM (Distributed COM) (by Microsoft) framework extends interoperability to a network (i.e. LAN). The .NET framework has been introduced to solve interoperability when an Internet network is adopted. It bases its functionality on binary, XML (eXtensible Mark-up Language) [1] and SOAP (Simple Object Access Protocol) [12] levels.

In any case, these modes allow one principally to write a program and to execute it on the supported platforms that are different and remote. This concept

should be extended to linked applications. A software program, which runs in a client or server system, controls (eventually it starts) applications on a remote system (different server). Each of them will resolve a specific problem, measure, algorithmic evaluation, depending on the control data, and they return elaborated information to the distributed network.

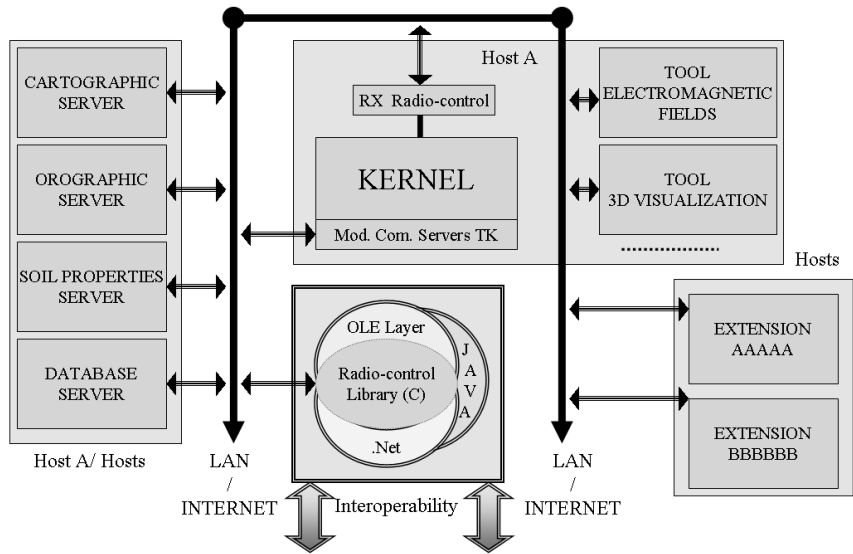


Figure 2: Structure of the distributed TIS. Terrapack32M manages databases as server components. All links are among hosts: the client, where resides the kernel and some special tools, many database servers and other remote systems.

Figure 2 shows the structure of Terrapack32M. Its network architecture is already evident by observing that data subsystems are effective servers. These can be included in the same computer, where the main software runs. However, they can be stored inside a remote hard disk. The kernel and some special tools are in the main host A. It uses a communication bus (networks LAN, Internet ...) to link database servers, internal tools and external processes. The basis of remote TIS management is the transmitting/receiving radio-control.

In order to put into practice the interoperability, we create a radio-control library using OLE (Object Linking and Embedding) layer, .NET and JAVA technologies. We introduce these different choices to resolve disparate implementations, adapting to the software structure of the pre-existing framework.

Normally, when new parts join themselves to an operative structure, the primary and main requirement is a more harmonic insertion, which exploits and preserves all potentialities of the used technology.

The modular structure of our system and its architecture, oriented to distributed objects (data, tools and systems), allowed us to set up practical



services of environmental management. Some activities are in the risk analysis area, others resolve interaction among remote actors: operators, detection and monitoring stations. These can stay at a fixed location and they use physical links as modems. On the other hand, they can move inside the monitored area and they need to be linked by means of radio-communication.

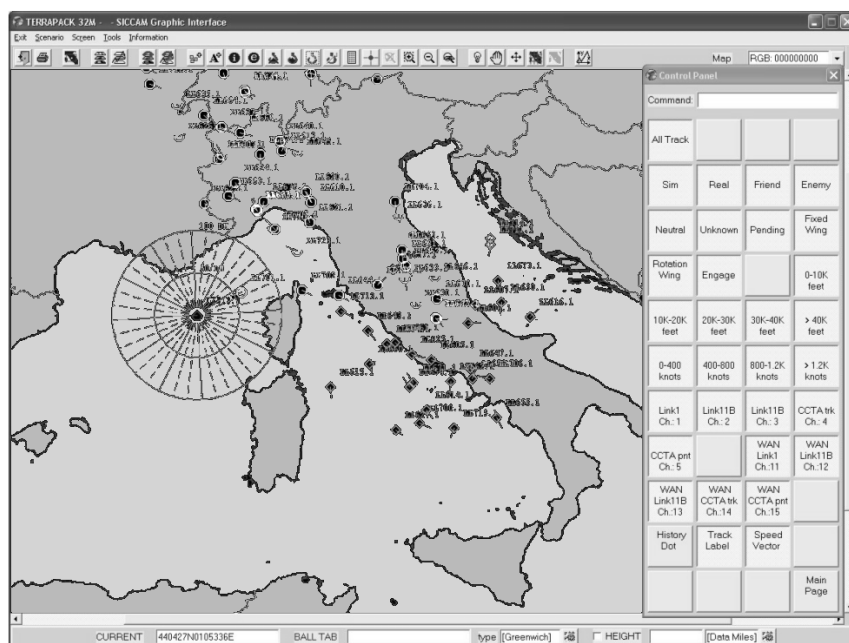


Figure 3: A monitoring station receives detections from a patrol and it transmits to other earth stations in broadcast mode by using of UDP/IP protocol. The figure shows an air-space map together with hypothetical detections.

4 Practical examples of TIS interoperability

In the following subsections, we will examine two examples exalting interoperability aspects. In the first case, we will linger over the broadcast method, whereas in the second example we will describe how data information are shared on line and how they are refreshed simultaneously to all monitoring stations.

4.1 Defence risk: air-space control

For defence activity, earth stations and air-patrol missions monitor national air space. Each patrol mission surveys a specific and limited zone. When it detects



objects by radar sensor, it should advise the earth control station (in particular the master control station) transmitting online the registered detection.

From moving jet-aircraft, detection data reach earth stations, distributed on the territory. All earth stations transmit data in broadcast mode by use of the User Datagram Protocol/Internet Protocol (UDP/IP). This is an alternative to the Transmission Control Protocol/Internet Protocol (TCP/IP). It warrants a smaller check system of errors, whereas it allows direct data exchange, so that one uses it normally for broadcast transmission. Redundancy of information must be managed from the master earth station that also resolves clashes of concurrent data.

Figure 3 shows a typical monitor of a control station. One can select specific tracks together with the list of their characteristics: engagement, altitude, speed-rate, links, history, etc.

Figure 4 defines the basic structure of the system. In this case, interoperability is between two heterogeneous systems: UNIX and WINDOWS. There are much data, which reside inside different servers. Dynamical data and communication data transmitted by means of UDP/IP (or eventually TCP/IP) protocols are channelled into the LAN.

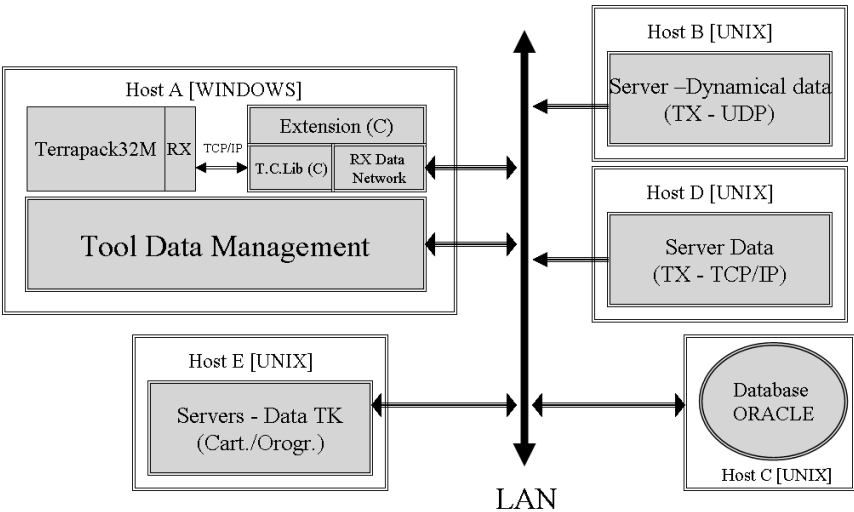


Figure 4: Architecture of air-space monitor for defence activity.

Again, the system uses same communication channel to receive cartographic, orographic and historical information. The ORACLE database is a transparent database and it shows its implicit properties of interoperability among different operative systems (e.g. MS Windows). In any case, C library in the Windows system, where the tool data management runs (host A), interfaces every database. In effect, all transmitted data are filtered by a special library, like IDL (Interface Description Language), when they are received.

23/02/2004 ore 13:03 Comando Provinciale Vigili del Fuoco di ROMA Turno "C"

Gestione Interventi Procedure di Supporto Servizi Stampe Configurazione Dati Amministrazione ?

Inserimento Chiamate VF102

Numero chiamata _____ Data chiamata 23/02/2004 Ora chiamata 13:03 Numero intervento _____ Data interven. _____ Ora 1° assegn. _____

Tipologia 01 Incendio normale (generico) Dettaglio Strada per incendio

Indirizzo Località Via delle Tre Cannelle Civ. _____ Km _____ Punti di Interesse [F4]

Comune Frascati Prov. RM Obiettivi rilevanti [F5]

Richiedente CARABINIERI 112 113 118 VV.UU. Tel. _____ dial

Note Operatore P.O.S. Note intervento _____

Chiamata _____ trasmessa a _____ ricevuta da _____

Comando _____

Scheda _____

Op. _____

Incendi	Aeroporti - porti	Incidenti stradali	Recuperi	Statica	Acqua	Vari
01: generico	05: incendio aeromob.	10: generico	14: veicoli e merci	18: valanghe e frane	22: danno generico	26: soccorso persone
02: dovuto a scoppio	06: inc. nave/traghetto	11: act. merci pericol.	15: sostanze radioatt.	19: sprofond. terreno	23: strapiamen. inond.	27: salvataggio pers.
03: da rilascio gas	07: emergenza carrello	12: Fabbatm. act. pericol.	16: parafulmini radioatt.	20: voragine stradale	24: rifornimento idrico	28: salvataggio animali
04: scoppio da incendi	08: recupero aeromob.	13: rimozione ostacoli	17: rilevatori vari	21: dissesto generico	25: proscioglimento	29: recupero salme
	09: ricerca aeromobile					30: recup. animali morti
						31: trasporto ammalati
						32: lavaggio strada
						33: cattura alienati
						34: altri tipi

Emergenza Protezione Civile

Annulla Abilita/Modifica Inizio partenza Utilizzo del piano di emergenza/soccorso In Attesa Chiusura chiamata Uscita

TERRAPACK 32M - TTP Elettronica - Comando Provinciale Vigili del Fuoco di

Uscita Scenario Schermo Script Tools Connessioni Informazioni

sfondo RM_new/RM_new - [1.030 m/pix]

Informazioni chiamata/intervento

INTERVENTO
Codice Tipologia: 1
Data: 18/02/2004
Progressivo: 1-76
Riferimento: Via della Croce

Squadra	Turno	Mezzo	Tipo-Mezzo
10/A	B	10/A	APS

Chiudi

Terrapack-32

Figure 5: In the fire-brigade department, operators bring up-to-date their monitors, adding informative cards and representative symbols on the map. These revisions spread in real time to all operators that work in the coordinating-room.



4.2 Coordinating-room of fire-brigade department

The fire-brigade department must monitor and manage much dynamical data during a fire event or emergency. Different operators observe phenomena evolution by using monitors connected with the services network. Each of them can transmit commands and receive the state of other remote operators, buildings, traffic situation, etc. Therefore, the system should bring up-to-date information for any operator that works at a different parallel station. It could insert new symbols on the map and data table. Then the system should permit a transparent operation that immediately changes all maps appearing on remote stations, so that all managers at control stations see the real time development of interventions so they can take better possible measures to avoid an increase of risk.

In spite of the number of hazard categories being indefinable, more frequent intervention activities have been inserted into the software window of disaster descriptions. The list includes the main categories: fires, airports and ports, car accident, salvage-services, statics, water and generic events. Each category branches out in specific disaster classes. For example, statics ramifies in the following subcategories: avalanches and landslides, chasms, generic trouble. The same window includes again the data of the applicant, location, description notes. A special button has been planned to activate civilian protection. In this case, interoperability among departments becomes an essential qualification confronting the emergency state.

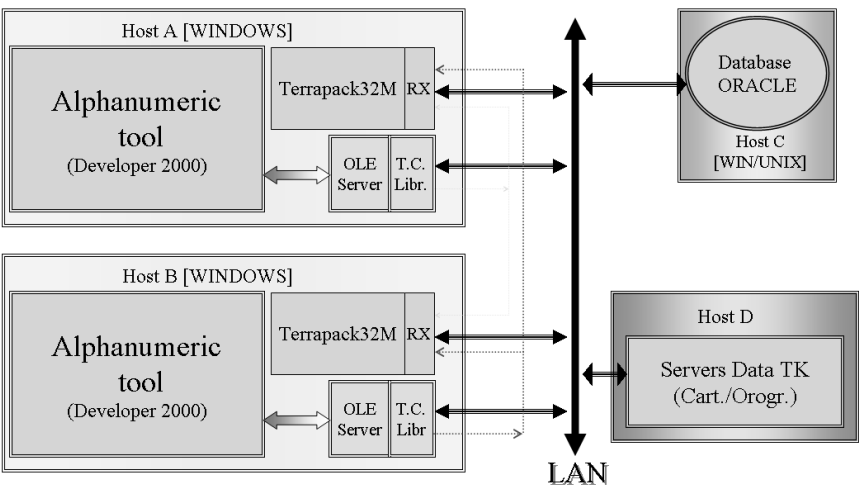


Figure 6: Basic architecture of system, oriented to real time insertion of shared data, when tools run inside remote MS Windows frameworks.

The architecture of the system uses as usual a LAN to connect hosts. Much data, by hierarchical structure, are contained in the ORACLE database, whereas we prefer to store cartographic and orographic data on different server optimizing hard disk space, data access speed-rate and a technique that superimposes data layers.

Figure 6 shows that we adopt systematically an OLE server layer to link different hosts. Each of the hosts runs inside remote MS Windows framework, so that OLE server technology is sufficient to realize interoperability among remote tools. Obviously, we have implemented a radio-control library to interface OLE servers.

5 Interoperability by web service

The Internet and web framework propose new challenges and interesting solutions that revolutionize interoperability methods.

In order to promote interoperability services among platforms, operative systems and programming languages, the Web Services Interoperability Organization (WS-I) is producing detailed lists that are based on SOAP.

On the same development line, the Geography Mark-up Language (GML) is the technology engine behind the geo-spatial Internet. This uses hyperlinks to manage geographical information and to realize a global information infrastructure.

The principal characteristic of the Internet is the huge amount of available data and news in the network. Management of these data, their inclusion inside the windows card, data correlation, data refreshment, etc. represent some aspects of data integration and data fusion development.

Different frameworks (JAVA, .NET, etc.) allow web service implementations [11] based on the SOAP protocol. This is not new technology but exploits existing protocols as such XML, HTTP (HyperText Transfer Protocol) and the RCP (Remote Procedure Call) model.

A modern and complex dashboard for a computer monitor can be built by using web service technology. This is an instrument panel where we visualize photos, web-camera images together with alphanumerical data, scenario maps, etc., where all components connect in the network.

Evidently, this mode increases transparency at every level: location, communication and language.

6 Conclusions

Frequently, risk analysis and especially emergency activity manage many shared resources. In the paper, we have emphasized the importance of interaction among all components. In particular, we have introduced a different point of view: the interoperability extended to application tools and among remote systems (servers). Two practical examples, implemented for the Air Force and fire brigade departments to carry out broadcast monitoring and shared management respectively, have been shown. Our next activity will exploit new



SOAP protocols (web services development) to improve the interoperability characteristics of the GIS/TIS environmental management system. We will examine different architectures, too. In particular, they will be based on open source systems.

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