ACTIVE DSS FOR INDUSTRIAL EMERGENCY MANAGEMENT BASED ON GIS

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Giovanni Di Costanzo and Adam M.Gadomski

This paper presents some results in the area of the development of active decision support systems for territorial emergency management. Our project CIPRODS (Civil Italian Protection Overview and Decision-support System) is aimed at providing intelligent computer support during management of large industrial accidents that involves intervention of decision-makers from the Italian Civil Protection Operation Center. In order to improve real-time emergency interventions, we have used a system approach to integrate new AI technologies, especially the Case Based Reasoning method (CBR) , an intelligent agents approach and GIS The objectives of the CIPRODS prototype have been focused on the improvement of real-time interventions for the reduction of possible losses on population and on the environment. The system is composed of three main functional modules: Diagnostic, Predictive and Decision-making. All of them use a shared cartographic base as a reference representation of the domain of managerial interventions common for the system internal functions and its user interface and of the graphical interface.

KEYWORDS: Decision Support Systems, Emergency Management, Intelligent Agent, GIS, Case Base Reasoning, Artificial Intelligence, Risk Assessment.

INTRODUCTION

In the last years we have assisted to an enormous progress in the computer science technologies and the telecommunication. The possibilities to face a territorial emergency using various computer systems efficiently, are continuously improved. On the other hand the task to manage the emergencies has become more difficult for the complexity of the modern industrial systems, so that they are causes of the hypothetical risks as the sources of catastrophes produced by humans, and for that reason, the society, already subject to the natural catastrophes, is more vulnerable.

In these years we have also assisted to a crescent interest in the international collaborations among various actors engaged in researches in this field. For the activities carried out in the last years we can cite the project GEMINI (Global Emergency Management Information Network Initiative) [1], the conferences of the TIEMS (The International Emergency Management Society) [2], and others world-wide organisations, such the Society for Computer Simulation (SCS) International and the Society for Risk Assessment (SRA). The SCS conferences, among others, include also the "Mission Earth" session that pays particular attention to the management of emergencies [3]. All these initiatives testify a growing interest in the emergency management and represent a good opportunity for the experience exchange and for the presentation of new technological solutions and ideas related to the construction of territorial information and decision support systems and networks.

STATE OF ART

As a consequence of the increased complexity of present days industrial plants, the amount of information necessary for the management is so large, and its time density is so high, that the probability of human errors during emergency decision-making is not negligible. On the other hand the coping with unexpected situations requires from the mangers the remembering, mental elaboration and immediate application of complex professional knowledge, which if not properly used, causes fault decision. So uncorrected decisions taken by emergency managers can multiply human, economical, and cultural losses, instead of their mitigation. Therefore***, in disaster mitigation, the importance of the quality of the emergency managers is still increasing***. The current explosive growth of information technology methods and advanced software components lead not only to the increasing of data-bases but to the qualitative improvement of managerial decision-support.

The aim of the our work is to give a concrete contribution to the development of a system that integrating new software technologies, as Intelligent Agent, Case Base Reasoning and

GIS, and applying them to the design and implementation of an **active Decision Support Systems**, that will be usable for the emergency managers during large-scale industrial disasters. A central goal of our project is a definition of such facilities which allow an active decision support system for emergency management to be rapidly constructed and supported within the context of iterative development. In the next sections the three software tools (IA, CBR and GIS) will be presented before separately and then it will be shown how they can be put together in a system architecture in order to build an efficient and advanced DSS.

The GIS component is employed as a basic conceptual framework for the representation of the domain of territorial emergencies, and as the basic medium for sharing data between software agents, software functional modules and the system end-users.

ABTRACT INTELLIGENT AGENT ARCHITECTURE

The actual trend in the emerging software technology is to produce systems that are more **active** during the interactions with their users. Many approaches and strategies are currently used and tested in this research field, but probably the most fruitful technology worldwide experimented is **intelligent agent technology** to be based on, so called, **multi-agent approach**. Its main issue is to distribute heterogeneous problem knowledge and management strategies among autonomous agents assigned to the tasks defined into different knowledge domains and on various abstraction levels.

The design of Intelligent/Active Decision Support System for Emergency Management is closely related to our understanding and the capability of modeling of the concepts: decision making and intelligence. Both are closely related to the intelligent-agent technology currently being developed in software engineering and they will be explained in this paper in the framework of an abstract intelligent agent model. On the other hand, the emergency management decision-making is a real-world activity where inference processes are strongly based on experts' qualitative and distributed knowledge, on an assessment of incomplete and uncertain information, and on a reasoning among many abstraction levels. In such a context, Active Decision Support Systems (ADSS) based on recently developed software paradigms and technologies (various intelligent agent technologies) should, in the near future, not only provide data selected according to situation assessment procedures, but also to previously defined in emergency plans.

One of the serious difficulties in the design of DSSs is the necessity of acquisition, representation, and structuring of the problem knowledge in order to implement it in active autonomous software units. Our proposal is based on the results and products obtained during previous, emergency-management oriented European Union projects.

Independently of the numerous realizations of software agents by software industry, and research efforts, uniform theory of intelligent agents is not developed yet.

Various new approaches to the software agents modelling have been proposed. In this context we demonstrate a domain-independent conceptualisation of an intelligent agent architecture which is based on TOGA Top-down Object-based Goal-oriented Approach [4]. This approach is a generalisation of various concepts of the structural design methodology. Consequently, it assumes an ontology which is based on the model of an Abstract Intelligent Agent and on its goal-oriented point of view.

The choice of Intelligent Agent Technology results from our individual experiences and from a deep evaluation of the current trends in the market of software technology development. Intelligent agents represent the next generation beyond object-oriented software- objects which act autonomously in a certain domain, and perform tasks defined by the human user.

In computer science, the concept "agent" is put in many categories but, in general, an intelligent software agent is a class of software functional which can change its own intermediate goals and may learn. [5]

- Agent is " ... an autonomous, self-contained, reactive, pro-active computer system, typically with a central locus of control that is able to communicate with other agents via some ACL (Agent Communication Language). More specific usage means a computer system that is either conceptualized or implemented in terms of concepts more usually applied to humans (such as beliefs, desires, and intentions)."
- A software agent is a special software module assigned to predefined external tasks, having execution autonomy and reacting capability; the design of a multi-agent software system utilizes these primary software modules which cooperate together in different domains.
- Agent-Oriented Programming - is an approach to building agents, which proposes programming them in terms of mental notions such as beliefs, desires and intentions. These definitions are closely related to cognitive engineering and functional understanding of "intelligence".
- Intelligent agent (IA) is autonomous, task-driven, software component with capability of learning and reasoning about its own knowledge and preferences on different meta-reasoning levels.

In general, the integration of simple agents into one architecture enables to development of intelligent agents with learning capability, designated to cooperation with human users and with roles which have to be dependent on agent knowledge, preferences and ontologies.

In the presented TOGA approach, a general structural framework, called IPK (Information, Preferences, Knowledge) architecture, and basic reasoning mechanism of an abstract simple agent (ASA) is defined. The construction of this agent

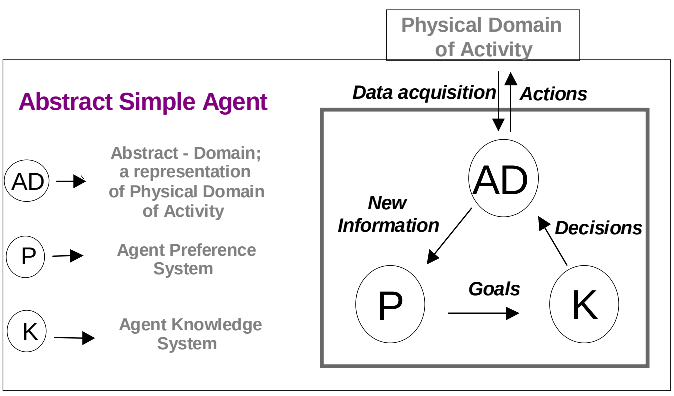


Figure 1 IPK (Infornation,Preferences,Knowledge) Architecture of an Abstract Simple Agent

is founded on the following main concepts:

- **information**, i, or inf : how situation looks (before, now, in the future)?
- **knowledge**, k : how situation may be classified and modelled, and what is possible to do ?
- **preferences**, p : what is more important ?
- **goal**, g : what should be achieved ?

More precisely, these relative concepts always refer to a predefined d-o-a (domain of activity) which is real or abstract and is a source of information. All of them have object-property, which can be aggregated and decomposed according to the abstract objects' framework.

One of the fundamental assumptions is that i , p, g, k are defined all together by three generic reasoning processes executed by (fig.1):

- the Activity-Domain system, ADS, consisting of a representation and a basic mechanism that every agent uses for the conceptualisation, decomposition and modification of the external reality from its own point of view.
- the Preferences system, PS, is a basic mechanism that every agent uses to generate the intervention goals. It is activated by new information coming from the Activity Domain.
- the Knowledge system, KS, is a basic mechanism that every agent uses to generate actions for the modification of the Activity Domain according to the current intervention goal.

ASA has fixed knowledge and preferences, but choice of its goal depends on current information.

In an emergency situation, an event modifies the Domain of Activity. This new information is processed by the Preference System that requires an assessment of the possible consequences of the emergency event. Then PS, using the criteria stored in its rule-base, generates an intervention-goal, represented as a desired state of the Domain.

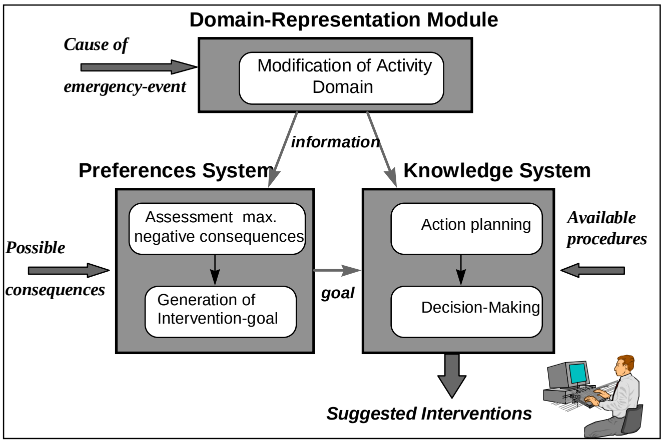


Fig.2 Decision-Making Module based on Abstract-Intelligent-Agent Architecture

The Knowledge System is activated by the intervention-goal; using information coming from the Domain and available procedures, it produces suggested interventions for Emergency Managers. These interventions can be realized as planned actions, i.e. as an ordered sequence of the available procedures. The overall system should act as an Artificial Intelligent Agent helping the human staff in management of the industrial emergency(Fig.2).

CASE BASE REASONING

The approaches world-wide used to build the so called Expert Systems or Knowledge Based Systems, try to solve the knowledge base building problems utilizing cognitive models of involved physical domains.

The methods that are utilized to build such types of models are essentially based on the exploitation of the production rules with an associated object oriented representation of the considered diagnostic domain. The real possibility to exploit this type of technology failed against many difficulties that raised during the phases of knowledge elicitation and formalization; in fact is often difficult to retrieve diagnostic knowledge from human experts especially in the environments where it results distributed inside different sources. So, the development of this type of models is difficult for these principal reasons:

- the knowledge acquisition process is difficult;
- the knowledge formalization process requires too much time;
- the developed Knowledge Bases are difficult to maintain and update;
- the verification and validation process of such Knowledge Base is a very difficult task;
- this type of models have low capacity of learning.

More recently new types of cognitive models was utilized in this fields: the new approach is no more based on the capacity of processing and analyzing the situations, but on the capability of memorization and retrieving similarities. This new approach aims to experiment the emulation of the capacity of the human brain to remember a certain scenario and to relate a new scenario with an old one in terms of similarities; in fact this mechanism is regarded as the basis of human learning capacity.

Presently the most promising technologies that could give a useful contribution in this field seem to be the so called Case Based Reasoning (CBR), that through a reasoning about a predefined Case Base built on the basis of experience, offers solutions to so called ill defined problems. That situation takes place when for lack of information available to the decision-maker, should be given possible solution even for condition not clearly defined. That's normally the situation in which people operate in real world, particularly for civil protection authorities. In that cases, even in situation not clear, but potentially very dangerous, it is necessary to do some choice early, in order not to be unprepared to have to cope with situation very dangerous and in which time factor play a key role.

The CBR approach is visualized inside fig. 3 and 4. As it is

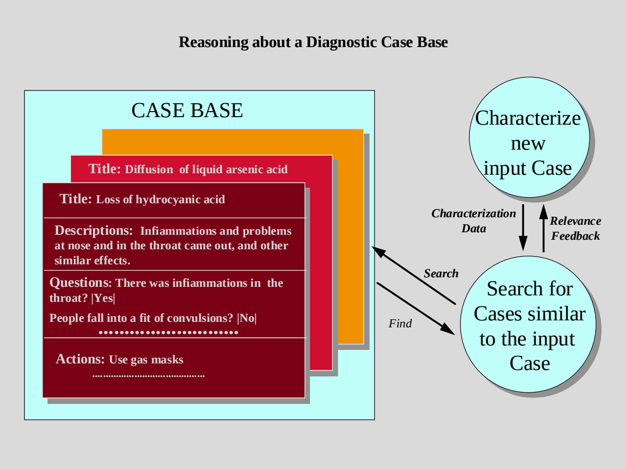


Figure 3 CBR Approach(1)

shown in fig. 3 the methods doesn't refer to a Knowledge Base but to a Case Base. The single case is represented with the following principal attributes:

1) The problem title that the case represent;
2) The problem description, using free language, that represent the principal characteristics of the case;
3) A set of attributes representing variables or parameters of the case itself. Such attributes can be associated to the case as a set of questions describing the attribute itself and whose answer furnish a value to the relevant attribute in relation with the problem described by the case. The attribute values could be numeric or symbolic.
4) A set of suggestions or actions to be executed to solve the case.

As it is visualized in fig 3, the solution method of the diagnostic problem, starts with the characterization process of a new case. The case is characterized introducing a general description (using natural language) of the problem and defining the attribute values (answering to questions) that are known to the system user.
Using these inputs data the system search into the case base, ordering the different cases in terms of more or less similarity with the configured case. The methods to find more or less similarity are:

1) textual comparison between cases descriptions, at level of word, set of characters and phrase, also with the help of a vocabulary of synonyms associated with the Case Base;
2) executing an attribute values analysis.

Regarding point 2, a certain attribute could be more or less important for the problem resolution. To the importance of the attribute may associated a relative weight. These weights represent the so called associative memory that arrive to a maximum when, on the basis of the past experience, a certain attribute value is considered determinant for the case.

Some aspects of such type of functionality have similarity with the neural processing. In fact also a neural network works uses an associative memory that is determined by the set of weights of the neural connections; it allows the discovering of similarities between different input patterns. The advantage of neural networks is that they have a completely automatic setting of the more suitable weights to recognize a certain input pattern: this automatic setting is executed during the learning phase and, for certain types of networks, it could be updated also during the pattern recognition phase. On the contrary in CBR the weight updating is a process that in many cases must be supervised by the expert of the problem. Anyway CBR has advantage of a more explicit learning process that is less dependent by mathematical algorithms that is more difficult to understand and control by the network designer.

As it is visualized in fig. 4, inside CBR process, after the searching of similar cases, using the relevance feedback data, the expert of the problem can evaluate the degree of goodness of the conclusion reached giving to the attributes a certain set of values. If the result doesn't fit the expectations of the expert, there are two possible alternatives:

1) the founded case doesn't fit the expectations for a not correct definition of the set of weights associated to the attribute values. The lack of a good conclusion is solved updating the set of weights associated with the relative attributes.
2) the founded case doesn't fit the expectations because inside the case base there is a lack of knowledge relative to the considered case. That is the situation in which the

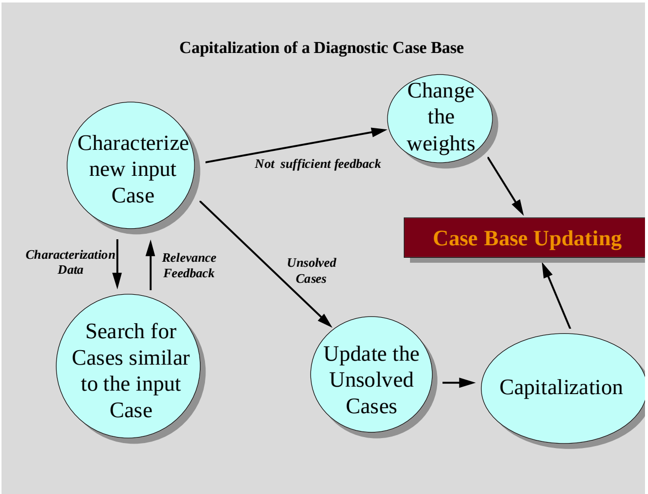


Figure 4 CBR Approach(2)

actual case may be considered an unresolved case.

It is necessary to consider that unresolved cases may be generated also if the input attribute's values (provided by the system user) contain errors and contradictions that could never be present in a real case.

The more powerful CBR tools use constraints (or rules) to avoid such input data inconsistencies. If the case is really an unresolved case, as shown in fig. 4, this implies the saving of the case itself. After that, by the capitalization process, the Case Base must be updated taking in account the founded unresolved case.

GIS IN EMERGENCY MANAGEMENT

In accident situations all activity is GIS-based and the use of a GIS System is a natural environment for implementing programs supporting the management of the catastrophe situation. Local authorities must be prepared to deal accidents. May be in real situations there is no time to use GIS. The simulation of possible accidents and GIS analysis functions are essential tools in training organisations to cope with disasters.

A practical tool is visualising the results of a GIS analysis functions in a thematic map.

The physical emergency domain is a domain of the goal of emergency management activities. A mental image of this domain is the direct domain of activity of the manager, there he expects to achieve particular intervention-goals. The suggested LRS conceptualisation framework is described in the paper [6]. This framework has been used in the decision support system.

It is composed of three layers :

- Layout layer, LL
- Resources Layer , RL
- Scenario Layer, SL.

The SL and RL layers are mapped into LL. All of them are represented by abstract objects-relations networks.

LL includes the most static knowledge of the considered territory and its information are represented by more or less schematic maps.

RL includes the set of all the equipment, the components and the human organizations that are active on the considered territory.

SL includes the set of all the factors and events that may be considered on the territory in relation with the emergency management activity.

Layout Layer

LL represents the configuration of the territory under consideration for the emergency management activity. The main type of information included can be regarded as a set of physical constraints. A boundary is normally present in the layout layer to divide an in-site portion of the layout from the off-site one. The in-site layout is the part of the territory under the responsibility of the in-site manager (the plant Authorities) normally not accessible to external people. The off-site layout is the external, public territory.

Resource Layer

With the term resource we refer to every equipment, system or component having some function or goal inside the LL. A resource may be a technical resource or a human resource. For reasons of conceptual clarity an object-oriented approach seems a quite natural choice. A resource has the following general attributes: *goal*, *location* on layout, *vulnerability* level, *destructiveness* level, *degree of protection*. The contents of some of these, like goal and location on the layout does not depend on the scenario. The vulnerability level and destructiveness level values may depends on the type of scenario. Using this type of formalisation the same physical resources (human or equipment) may be instantiated with different specific attributes depending on the situation and the scenario.

Scenario Layer

This layer contains all the information related to the different kinds of factors and/or events that may emerge inside the domain and which can have some impact during an emergency situation. These factors can be classified as: meteorological factors, population density factors, accessibility constraints to accident location, level of storage of hazardous materials and other particular events. In general this layer contains all the information about events which can be hardly predicted in advance and that may influence the emergency evolution.

SYSTEM ARCHITECTURE

The ADSS has been divided in 3 basic functional modulesdifferent module (fig.5) : Diagnostic, Predictive, and Decisional.

The Diagnostic module goal is a recognition of the cause of accident. It starts from emergency symptoms acquisitions and employees the CBR (Case Base Reasoning) method for the identification of the toxic substances and of the place of emergency source. Information about an emergency symptom are received from the different sources (police, health service, people) distributed on the national territory; operator introduces the symptom's description in natural language into computer. The Diagnostic system, through a reasoning about predefined cases on the base of the experience, suggests solutions to such ill defined problems.

The Predictive module goal is to indicate maximal and most probable negative consequences of the current recognized emergency state. On the user request and according the inserted data, it generates possible scenarios of the emergency which might be a consequence of the discovered accident.

The module of predictive simulation can be conceived like reasoning support for the generic agent who must manage the emergency. It supports the *what if* analysis, that an emergency manager has to carry out on the consequences that an intervention can produce, in reason of its localization in the application dominion and of its nature.

The Decision-making module by using a decision-making model, suggest the operator possible actions suitable in a

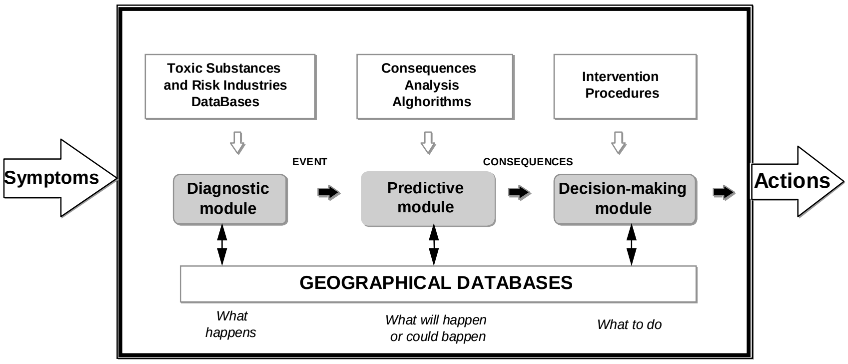


Fig. 5 DECISION SUPPORT SYSTEM ARCHITECTURE

particular situation. On the base of current emergency situation, the Decision-making System should assess the level and the type of possible risk, as well as should indicate adequate tasks, using emergency instructions/procedures. This module performs an automatic transformation of the information obtained from the Diagnostics and Prediction Modules into the form of suggested actions and other data useful for a decision-making manager. The output of the system will consist in actions or groups of actions that the system will suggest to carry out like answer to the incident events

DIAGNOSTIC MODULE

Diagnostic module concerns recognition of the accident, starting from symptoms and using CBR method. As first answer, the system present as possible cause of the symptoms, industries that are in the vicinity and treat substances that present that specific symptoms.

In the actual case the CBR methodology has been employed for the diagnostic process of identification of the toxic substance as possible cause of reported symptomatology.

Symptoms Case Base

A symptoms case base is structured to allow the user to find all the toxic substances that can be the cause of some symptoms for the people, animals and environment. The user of such a case base system inserts the information he knows (one or more symptoms) and the system, on the basis of these information, is able to display a list of probable causes of that symptoms with a percent of probability. The main characteristic of such a case base is to allow the user to insert his information in natural language and these data can also be incomplete. The user inserts data through a set of predefined questions the system asks him.

For example suppose we have a signaling involving a set of people feeling ocular troubles (lachrymation, irritation etc.) (Fig.6). Now we are interested to know the probable cause of these troubles. For this purpose we insert the only information we know so we can type in natural language the following words: “eyes”, “lachrymation”, “irritation”. The system will search all the cases containing all the toxicants that cause the above symptoms and will display a list of these substances with a percent of probability. The first substance of the list has the higher percent of probability to be the cause of the symptoms. But after this first screening we surely have many toxicants in the list, all possible candidates for the above

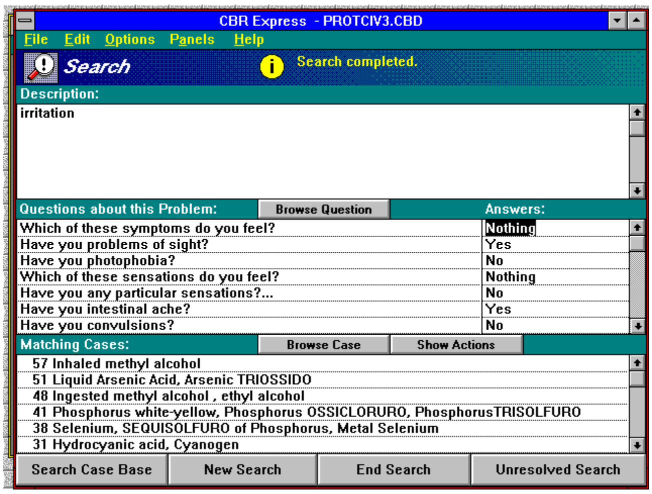


Figure 6 CBR Application window

symptoms. Further we also have a list of questions about the symptoms. For example we can have these type of questions: “Are there others type of troubles?”, “Are there people not able to see well?”, “Are there people with respiratory troubles?” and so on. These questions help the user to get more information and when the user answers these questions the systems will update the list of probable substances with a new percent of probability.

Some toxic substances will be added to the list and some others will be eliminated. Surely when we have inserted many information about the event we’ll have a small list of cause then we have a clear indication about the probable cause of the symptoms.

PREDICTIVE MODULE

Predictive Module, has the task to foreseen possible evolutionary scenarios for the assumed incident coming from the diagnostic module.

Simulation is the ability of a mathematical model, implemented in a computer, to generate a behavior of the system that is wanted to be simulated, most possible similar to that real one. Their use concurs of being able to perform situations assessment of the emergency and possible evolution before they are taken place, and therefore of being able to take the more opportune countermeasures in useful time. For that goal particularly useful are super-computers, as they are able to carrying out complex computations "faster than real time ".

Beyond to the numerical simulators it is possible to employ other qualitative methods of consequences analysis, as an example empirical methods for the fast assessment of critical elements in emergency.

Simulators can be very useful in the field of the emergency management, in particular if integrated in expert systems. In this case it is the same expert system that, on the basis of a particular situation of danger in action, which simulator decides to use, supplies the data of input (between those available ones), and to the end of the simulation it interprets the obtained result, in base to the scopes that are wanted to be reached. Making an example schematic, it can be thought next to the incident release of dangerous substances in air. The data of input are the time and the meteorological amount of released substance, data, etc.

Simulator calculates absorbed doses from the surrounding populations, and the expert system, based on these result, generates of the recommendations to follow (to evacuate, to remain to close or the other remedies). The simulators that are possible to use in the field of the management of the industrial emergencies are many: simulator of the fire and its propagation, simulators of the dissemination of polluting in air and water, simulator of people evacuation, simulator of outbreaks. These or other simulators could be included in the decision support system also in following times, in how much the architecture will be of opened type, that is will let the possibility to insert others members, in particular other simulators at the moment they are made available.

DECISION MAKING MODULE

Decisional Module, through the implementation of a model of decision-making, make it possible to suggest to the operator the more opportune action respect to the particular situation of emergency. This module will have as input data about the consequences of the incident, identified in the previous phases, and the applicable procedures of intervention in all the emergency situations that can be, in some way, foreseen. The output of the system will consist in actions or groups of actions that the system will suggest as answer to the incident events.

Every possible action must preventively have been defined in correspondence of every assumed situation. A system of menu active (goal oriented) will guide the operator to select the more adapted operation, according to priority and criteria established previously and indicated explicitly to the system. Normally, in human the decisional processes these criteria are implicit, in the sense that we always operate having in mind one well known scale of personal preferences.

For being able to implement a decisional process on computer it is necessary to clearly define these criteria and the relative preferences to the agent of the emergency that must operate the choices. In the classic example of the polluting substance disseminated in air, the operator will have to decide if it is more important to inform the population advising of the remedies or to try to block the cause that produces the damage, or other. Once taken a decision, all the relative activities related to a situation will be held under control.

DEVELOPED PROTOTYPE

The targeted user group is the Emergency Operation Center at Italian Civil Protection (ICP) headquarters. Our aim is to analyze the domain of intervention of ICP and to use new tools in order to enhance the capability of ICP for fast recognition of industrial disaster. We have used a system approach to integrate the new AI technologies, such Intelligent Agents [2][3]and Case Base Reasoning (CBR)[7] integrated in a GIS to improve fast intervention reducing negative consequences on population and environment.

ICP activity mainly concerns continuos monitoring of normal condition, through the control room that receives information, news and requests. Its first task is to recognize a dangerous situation that could affect the safety of people and environment, and that needs some kind of intervention for recovery. In that situation it is necessary, as fast as possible, from one hand to arrange and to start the available appropriate emergency procedures to face the actual dangerous situation, and on the other hand to get more exact information about possible consequences and development of the accident.

We have recognized the following basic user requirements:

1. Manual activation of the system on the base of registered ***symptom*** obtained from the national territory by classical communication tools , such as telephone or fax.
2. Support in the ***recognition of toxic substances*** in the suspected zone.
3. Support in the ***identification of the industry*** which is a source of emergency, i.e. identification of place and character of incident which is a cause of emission of the toxic substances to atmosphere, to water, or to soul.
4. Support to the ***managerial intervention actions*** adequate to the recognized situation.

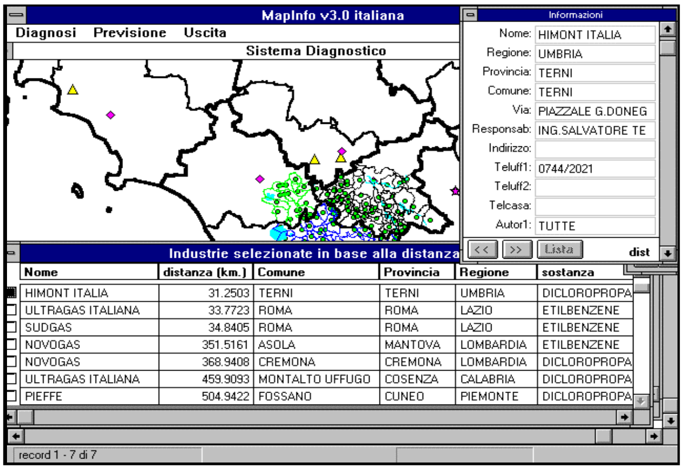
The ADSS will give a description, of the affected area, in terms of involved people, risk objects, etc. The user can see if nearby are present industries from which could be a toxic substance leakage.

For that goal the DSS will use two different Databases :

- risk industries databases with information such as geographical coordinates, surrounding population, networks and infrastructures, etc.
- toxic substance database, with associated symptoms.

GIS FEATURES

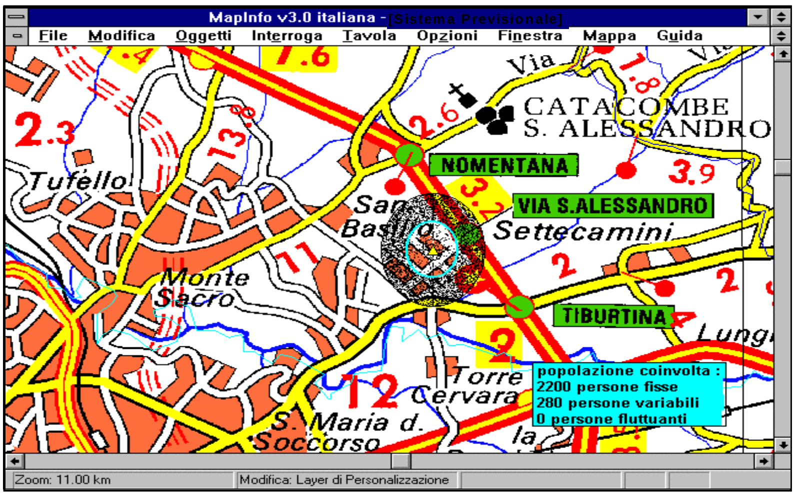
The three CIPRODS subsystems use a common base of cartographic data, that it concurs, through one fast localization, one precise identification of the incident scene on the competent territory, with the complete visualization of the context. In the given geographic data base is contained the



Map 1 Identifying and ordering of industries depending on location

layout of the Italian peninsula in terms of regions, provinces, communal borders, rivers and the lakes. On this layout it is possible to visualize approximately 200 present risk industries on the territory associated to all their characteristic information. Diagnostic module supplies in output the industries, ordered in base to the distances (map 1).

The distance of the industries from the point in which the symptoms have been taken place can give an idea of the probability that the incident has happened just in those industries nearer the hit zone. It is also possible to visualize



Map 2 Overlapping of impact area on territorial map

information regarding the single industry, like also the surrounding territory. With other verifications made in place or with telephone calls to the responsible of plant, it will be able to assess the situation of real incident in one of the selected industries. Using algorithms for analysis of cause-consequences it is then possible to graphically visualize the impact area for the type of identified incident. The extension and the shape of such area depend on the type and the amount of the involved substance, and on its storage condition. Moreover overlapping the impact area to the layer of the population, the number of involved people is obtained, that are those that fall back within the limits of the same area. Another possibility is to overlap one relative cartographic map to the zone. Such map must before be converted in digital shape (that is of type raster) and then introduced in the cartographic system Mapinfo (Map 2). In this way it is possible to visualize all the particular of the zone contained in the map same (road, nets, etc).

CONCLUSIONS

Summarizing, the application of the framework of Intelligent Agent, CBR and GIS platform seems to be a very promising for passing from the generally used data-driven paradigm and menu-driven paradigm to the goal-driven paradigm, namely, to an intelligent, personalised (role tailored) decision assistant of emergency managers. Our future research will be focused on the extension of geo-referenced data at global and local territorial level provided by GIS; value-added products (in digital or printed format) related to specific regions will be added in order to provide data to new agent functions such as regional industrial risk assessment and emergency intervention planning and modification.

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Giovanni Di Costanzo
dicostanzo_g@casaccia.enea.it

***Giovanni Di Costanzo**, graduated in Nuclear Engineering, is working at ENEA Casaccia as researcher. His job consist in design and development of new decision support systems. He has been author of several papers for international conferences especially in the field of emergency management, decision support system, intelligent agents. He is also contract professor of Information Technology at the post-graduated school of Sanitary Physics at the University of Rome.*

Enea, CR Casaccia
301 via Anguillarese
00060 Rome
Italy
Tel:+39.6.30484409
Fax:+39.6.30486511
URL:http://erg2217.casaccia.enea.it/personnel/dicostanzo/

Adam M. Gadomski
gadomski_a@casaccia.enea.it

***Adam M. Gadomski** works at ENEA, is author and co-author of more than 100 scientific papers. He received M.Sc. at the University of Warsaw in Nuclear Physics and the Doctor title at the University "La Sapienza", Rome. Before: Assistant Professor and head of Diagnostics Laboratory at the Institute of Atomic Energy (Poland). Involved in many international activities. Promoter and chairman of the International Round-tables on Abstract Intelligent Agent (AIA'93, AIA'94). Expert of the ISO/IEC for the terminology in AI and computer technology. The current research interest: MAS, intelligent agents, emergency management and IDSSs.*

Enea, CR Casaccia
301 via Anguillarese
00060 Rome
Italy
Tel: +39.6.30483404
Fax:: +39.6.30486511
URL: http://tisgi.casaccia.enea.it/personnel/gadomski/