Multiagent System to Prevent Technological Risks

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Abstract

The presence of chemical industry in urban area represents a very high technological risk. That is the reson the installation of alert's sirens to prevent population from danger when an incident happens is became necessary. This installation should have some means which are sufficiently reliable in order to permit the detection of incident in an adequate time. The industrial site survey that permit the detection is nearly given back impossible in a reliable way without using a computer system that takes into account the complexity and the heterogeneity of information needed in this system. The system allowing to survey industrial sites is called Vigil System. It will have recourse to the questioning of information's systems and to the analysis of information that will be provided to him. Besides, a case based reasoning system allow to make a predictive analysis of the evolution of the situation. To represent and to follow the fast evolution of the situation, we needed a model which must be flexible, reactive and adaptable during execution. The agent paradigm seems to be the way to achieve this adaptive model. The system will permit to take into account the complexity and the adaptability of the Vigil System. The behavior of this system will be able to be self-adaptative in order to take into account the evolution of a situation in which occurs technics incidents. It is based on self-organisation of multiagent systems which allow the Vigil System to self-adaptate to the evolution of situation and to learn from its behavior.

1 Introduction

The presence of chemical industry in urban area represents a very high technological risk. That is why the installation of alert's sirens to prevent the population is necessary and must use a computer system to control it. Such systems must permit the detection of incident (leak of chemicals, fires, propagation of poisonous cloud, etc.) sufficiently reliable to permit an adequate answer before it becomes too late. It is necessary to survey industrial site where hight technological risks exist in order to detect incident earlier as possible.

In this situation, the conception of a Vigil System (VS) permits to manage the detection of incidents and their consequences on the evolution of the situation. These systems must give a precise diagnostic on the current situation thanks to the information they have to their disposition, and the way to manage it. These informations are available and accessible through different Information Systems (IS). The complexity of these systems gives back adequate the use of multi-agent systems. Multi-agents systems are adequate because they permit to take into account the diversity, the heterogeneity, the evolution and the complexity of information [3].

The Information Systems which are uses for the treatment of phenomena with a hight degree of gravity and emergency, like industrial crisis or climatic disasters, are the Information and Communication Systems (ICS). Works about the SIC of crisis management have already been done and have been presented notably in [4] and [2]. These works will be presented briefly in the section 2. We will demonstrate limits of the ICS for the design of systems that permit an intelligent survey of the industrial sites and the detection of incidents.

This paper presents the approach we used for the realization of a model of Vigil System based on an adaptive multi-agent system for the industrial site survey.

In the following of this paper, we start by describing Information and Communication Systems for the management of crisis (cf. section 2). Then, we present the general architecture of the Vigil System foreseen for the survey and the detection of incidents (cf. section 3). Then, we will propose a modelling by agents of the Vigil System (cf. section 4). We conclude this article on the necessity to specify the different organizations of agents.

2 ICS's: Domain and General Features

An ICS is a complex system with a dominant computing part. It provides civil or military institutions with the means necessary to manage emergency or crisis situations. Application fields of ICS's range from military strategic and operational management to handling of natural and industrial disasters or incidents.

An emergency situation is a situation which demands immediate intervention, without which it can quickly turn into disaster or crisis [8], for example, an incident causing environment pollution (oil slick, nuclear incident) which requires immediate actions to contain its impact.

The role of the ICS is to ensure co-operation between the decision-makers involved, posted in different fixed or moving geographical locations. In addition, they can use different local Information Systems (Geographical Information System, Knowledge Based System or Information Server). These actors come from all the bodies (firemen, policy, emergency doctors, ...) involved in handling the situation. They are able to co-operate by exchanging information such as messages and knowledge, which supposes perfect communication between the distant and heterogeneous sites of the ICS.

We are going to describe in the following of this section the general architecture of a ICS, then to present an industrial ICS of crisis management elaborated in precedent works of research. In last paragraph, we will underline limits of ICS in the setting of our present works of designing a Vigil System.

2.1 The ICS Functional Architecture

The ICS functional architecture [1] (cf. figure 1) can be divided into five major sections as follows:

1. *Collecting*, with sensors set above the system or with human observation transmitted by messages.

2. *Storing information*, the system must store the entire knowledge acquired from the external world and resituate it later to the user in a pertinent manner.

3. *Interpreting knowledge* linked to the situation. That supposes the systems is able to understand, analyse and synthetise the knowledge it contains.

4. *Assisting the decision-making process*, by "intelligently" presenting the elements required to facilitate its preparation.

5. *Transporting the data* necessary for both action and information through the communication structures to which the system is connected (local network, special infrastructure network, radio network, ...).

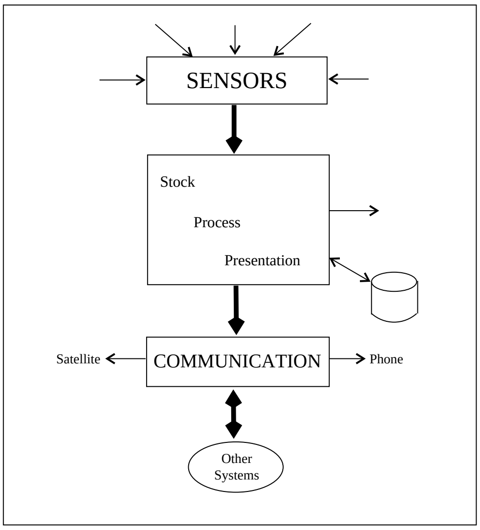

Figure 1. ICS Functional Architecture

2.2 ICS of crisis management

The architecture of the ICS described in the previous paragraph permits to express two categories of knowledge [4]. An architecture in classic network permits the access and the exchange of factuals data on the situation, by manipulating of Databases and Geographical Information Systems. Another architecture, enveloping the previous, permits to express the perception of the phenomenon by actors, that is their subjective appreciation of the situation as they discern it. This category of knowledge is generally represented graphically, and is given back available to all decision-makers. The system permits the simultaneous accesses which facilitate the decision-making of multilevel responsibility [11], and including the subjectivity of intentions of actors and groups of actors.

The decision-making in an ICS which is aiding to the management of an emergency situation must be cooperative, it must be the well negotiated results of objectives, projects, actions and points of view of the differents decision-makers. The main point of this decision-making is the good interpretation of communication for every actor between decision-makers, this is by it that the situation forms himself, brightens and become clearer. This communication must minimize incomprehensions and must put in evidence the local mistakes. In [12], it is proposed a model of system of interpretation of communication taking in account the objective facts describing the situation but also some subjective aspects of communications in order to construct a most complete representation in progress possible of the different points of view of decision-maker on the situation, in order to exhibit incoherences and dysfunctions in the intervention's organization.

2.3 Limits of the ICS of crisis management

In a general way, an ICS allow the users to arrange all the available informations as soon as they are making the ask. These informations are stocked in classics structures: files, databases, etc. In the setting of crisis management, we can notably use ICS for the exchange of informations between operators [4][2]. Henceforth, we stands temporally before the apparition of incidents and the management of crisis that ensues from it. We would like to be able to arrange a tool to supervise the complex industrial which is potentially dangerous and representing an important technological risk. This system should be capable to value a situation following an incident and to predict the short-term consequences of it. The classical ICS [1] of crisis management [4][5] don't actually permit to take into account these aspects, that is the reason we describe in this article the conception of a Vigil System. In the following section, we present the general architecture of our Vigil System.

3 A Vigil System to prevent technological risks

We present the general architecture of our system which has for objective to achieve a permanent survey of the current state of the industrials areas which presents technological risk.

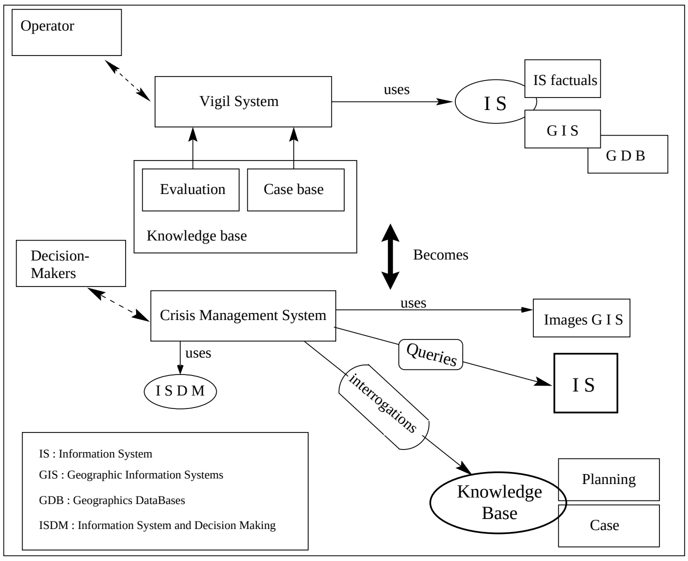

Figure 2. General architecture of Vigil System

3.1 Description of the Vigil System

The Vigil System receives facts and informations coming from different sources and warning him of an anomaly or an incident. It must:

1. validate this information,
2. situate information in its current context,
3. foresee the evolution while providing a state of the incident,
4. ask automatically for complements of information,
5. increase the relevance of the state of the situation.

When the relevance of the state of the situation requires it, the system topples then, by automatic transformation in a System of Crisis Management. It puts in the adapted communicational structure and deliver states of the situation automatically:

1. scheduling of intervention,
2. phasage of intervention,
3. increases state of intervention,
4. prevision,
5. balance.

The system (cf figure 2) is based on multiple knowledge coming from many domains on typical cases (Case Based Reasonning), constitute a Knowledge Based Systems (KBS) informs by distributed Information System. It has to centralize knowledge and current information to constitute the Vigil System. This Vigil System provides the current state of the situation in all domains concerning the risk's situation. This current state is presented to the user thanks to a Human Computer Interaction (HCI).

3.2 The HCI of the Vigil System

The Vigil System is charged to present the current situation. For this, different IS are requested for the representation of the current state thanks to an interactive HCI. This HCI has got several windows:

- a window containing the meteorological forecastings (sense of wind, humidity,...),
- a window traffic,
- a window with a view of the industrial area and the list of all factories and features of the site,

- a window that will provide the list of the rapid deployment force available. For each resources the following information: localistion, main function, available means.

The HCI will also contain:

- a display area that will give us the quality of the situation: synthesis of the situation with prediction of its evolution,
- a seizure area that allows the operator to bring in an information that will be situated and verified by the system.

3.2.1 Description of the knowledge base of the Vigil System

The design of such system starts by the definition of the ontology of the domain. That permits to describe the knowledge of the domain that will be manipulated. Then, this ontology is used in two different parts of the system:

- the part corresponding to the Human Computer Interaction,
- the part corresponding to the inventory of the Information Systems which are needed.

These two parts are integrated in the system in order to permit the interpretation of data from the different systems and the presentation of the assessment of this interpretation.

3.2.2 Ontology of the domain

We define, in this section, elements of the ontology of our system, that is the language of representation of the knowledge and the control of this one. The treatment of the domain of the technological vigil requires the construction of an ontology that will permit within our system to categorize knowledge inside the different Information Systems.

To function, the VS must have some informations provides by outsider servers on which it must be connected:

- general and local meteorology,
- state of roads and conditions of the traffic,
- information on the industrial sites,
- information on the strengths of security, institutions.

For each of these domains, it is necessary to arrange a specific ontology that defines terms used to describe the contextual knowledge. For example, to read a weather report, it is necessary to know what means the presence of an anticyclone.

The relative knowledge to the utilization of a computer system must permit to describe the user's interaction with the system. In our context of designing a Vigil System which permit the industrial area survey in presence of a high technological risk, these interactions will essentially limit to the visualization of representative elements of the current situation. Another type of interaction that should be present in the system is constituted by the possibility for the user to ask to the system for the verification of the relevance fact supposed.

The different elements of the ontology of the domain that have been described in this section permit to define organizations of agents.

4 A modelling by agents

The Vigil System that we presented previously in this article has for objective to provide to one or several operators the necessary elements to judge the gravity of a situation. These elements must permit him to fear the state of the situation quickly in order to react to the earliest. This understanding will make himself through the Human Computer Interaction (HCI). This graphic representation of the context of the industrial area survey takes place by means of a HCI piloted by an organization of agents called "Interface agents". These Interface agents have themselves recourse to an organization of agents called "Thematics agents". These thematic agents have to make the available knowledge synthesis on a particular domain in charge (example: the weather report, the situation of the road traffic, institutions). These various knowledge are available through different distributed Information Systems. They will be extracted by organization of agents that we will name "Query agents" that have to provide the result of their extraction to the thematic agents.

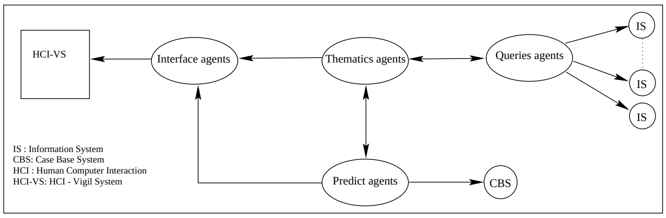

Figure 3. Relation between agents' organisations

In order to arrange a knowledge on the evolution of the situation, the Vigil System is endowed of an agent organization called "Predict agents". The whole agent organizations presents in the system are charged to make a merging analysis of information they have to their disposition and to get a synthetic representation of the current situation as well as the tendency of the evolution of this one.

Merging analysis of information expresses the capacity to put in relation of various nature information and from various sources in order to give a synthetic, coherent and sufficiently exhaustive representation of it so that an operator can have a global understanding of the current situation.

All these organizations of agents are based on a light agent architecture, as it is described by Wooldridge and Jennings in [13]. Indeed these organizations that require a big number of agents don't permit to use agent architecture as they are defined in [7].

We describe in the following of this section the different organizations of agents previously evoked.

4.1 Interface agents

The objective of this organization is to take into account in an intelligent way the HCI. Interface agents must try to present the applicable elements of the current situation as well as a synthesis of the evolution of the situation. For this, they must filter information provided by the thematic agents and overlook the secondary characters of the current situation.

To accomplish these different tasks, they have recourse to a graphic presentation by means of different definite components at the time of the conception of the system and that are representative of the state of the situation for the operator. The subjectivity of the graphic perception of this one brings us to conceive an adaptive interfacing that can alter to allow every operator to arrange the most meaningful representation for it. It is realized within the HCI by the means of components interchangeable components. Details concerning this design method of interface can be found in [10].

4.2 Thematic agents

Different aspects can characterize the current situation. It can be meteorological aspect (what time does it make?), geographical aspect (what density of population at a room?), temporal aspect (to what moment did the event take place?, institution (what are the available strengths?), material (what material we have to intervene if necessary). Each of these aspects will be taken into account by thematic agents. This thematic agents can be:

- Thematic agent “Weather report”: This agent has to supervise the meteorological situation in charge in order to have the applicable characters of this one. These characters then be provide to the organization of interface agents. It may be the same things for the other thematic agents.
- Thematic agent “Road Traffic”: This agent has the load of the survey of the road traffic.
- Thematic agent “Fireman”: This agent must acquire information concerning situations of the different organizations of fireman (availability, localization, material means). Some similar thematic agents exist for other institutions (police, urgency doctors...).
- etc.

The thematic agents must have an exhaustive knowledge of their domain and this knowledge is being bound to a contextual situation, so they must be able to put their knowledge in the context of the newly acquired information.

4.3 Query agents

Query agents are characterized by a knowledge about Information System (DBMS, ...) and capacities to extract the information in order to provide it to the thematic agents that ask for it. Information System may be able to be dynamic (to appear to either disappear to the son of the time), so query agents allow the thematic agents to be informed whatever are the circumstances. Query agent have the capacity to use the knowledge about the different queries they have made in the past.

4.4 Predict agents

These agents permit to have a synthesis on the probable evolution of the current situation from the contextual knowledge and the utilization of systems permitting a Case Based Reasoning. These agents will solicit agents thematics to do their prognostication on a particular domain but also on the evolution of the global situation. It is able to make hypotheses on events that can drag a meaningful change of the situation. To make these predictions, the predict agents use cased based reasoning.

All these agents organizations have to interact in order to extract information, to analyse it and to predict the evolution of the situation. If the system predict a bad evolution of the situation, it have to alarm the user who have to make decision as earlier as possible.

5 Conclusion and perspectives

We presented in this article, the modelling of a system permitting the industrial site survey that is judged to have a very high technological risk, and permitting the detection of incidents that can lead to an emergency situation. This system rests on a modelling by organizations of agents which are permitting to extract, to filter and to analyze the available information. This model is sufficiently generic to be used in different industrial contexts.

We develop a prototype, of a the Vigil System used for the major risk management within the city of Le Havre (Seine-maritime, France). This prototype is written in Java language, from a platform of system multi-agent development named MadKit [9] on which we endow a distributed architecture thanks to the Corba norm in order to answer to requirements of our system. This prototype has for objective the validation of the theoretical modelling and of the research works.

Some aspects have been let voluntarily outside: it is notably about the real time apsect. Indeed, to be efficient, this system must function under of the strong temporal constraints. This aspect is also study in our work [6] but not describe in this article.

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