Agent based data collecting in a forest fire monitoring system

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Abstract: **In forest fire protection systems 24 hour surveillance is of most importance. Real time data must be acquired to react fast enough to suppress fire occurrence or to minimize damage made by forest fires.**

In forest fire monitoring systems, usually a large area must be controlled. Real time data has to be collected and processed in time. When the amount of data reaches critical volume, modern software techniques have to be implemented in order to accomplish system goals.

In this work we have implemented agent technology on data retrieval and processing. A multi-agent system for real-time data collection and processing is described.

This work is a part of a more complex integral project of forest fire protection in Split-Dalmatia County. The integral forest fire protection system will be based on the information system for integration of all activities connected with early fire detection by 24 hours video and meteorological monitoring, management of forest-fire fighting and post-fire recuperation of burned landscape.

1. INTRODUCTION

Forest fire management is of large importance in the region of Split and Split-Dalmatia County in general, where tourism and agriculture are traditionally primary economic branches. Forest fire management could be done in three phases:

- before fire, focusing on the fire prevention,
- during fire, as a decision support system in fire fighting strategy and
- after fire, for planning the best recovery strategy.

The system input parameters could be grouped into four categories:

- fuel characteristics,
- terrain topology,
- meteorological data and
- images (video data).

The first two parameters are characteristics of the area of interest and are not changed frequently, so we store them as GIS (Geographic Information System) layers. Meteorological data and images are parameters that change over space and time with relatively high frequency. The change of meteorological data could be recognized in hour scale, and the change of image data, taking into account only information connected to forest fires, in minute scale. Also for the forest fire prediction system, meteorological data history (archive values) is quite important. In order to monitor meteorological parameters and collect images in real-time, the sensory network has to be established.

In our approach, which is now in development for the Split-Dalmatia County and is called the Integral Forest Fires Monitoring System [1], the system is a TCP/IP-based system conceived of:

- sensory networks and
- central server units for collecting, processing and storing all data.

Each sensory network has several sensory (monitoring) units, each of them including:

- pan/tilt/zoom-controlled video camera connected to the network-embedded video Web server,
- mini meteorological stations connected to network-embedded data web servers, and
- wireless (IEEE 802.11 b/g) communication unit.

The system overview is shown in Figure 1.

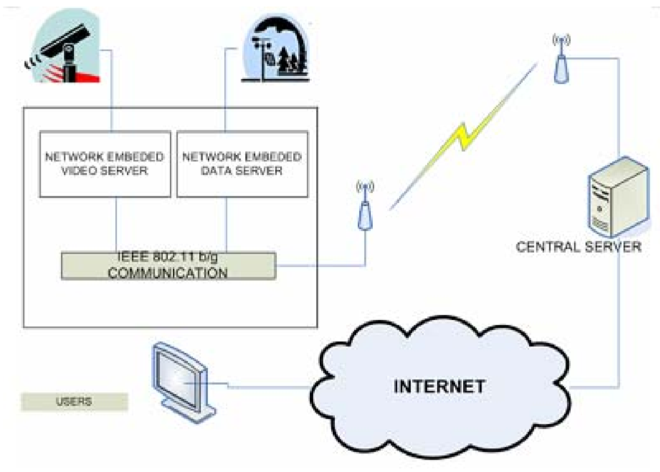

Figure 1 – The concept of Split-Dalmatia County Integral Forest Fire Monitoring System

Figure 2 shows the photo of one experimental monitoring unit which was in function during summer season 2005.

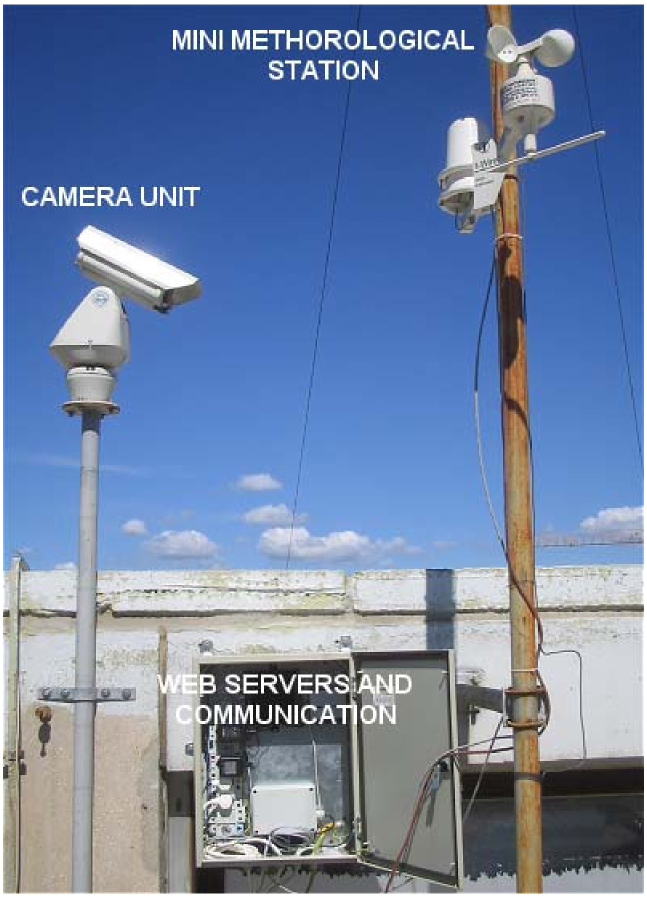

Figure 2 – Experimental sensory (monitoring) unit

In Intelligent Environment Systems, Information Technologies (IT) can be used for accomplishing two tasks: continuous surveillance and on-line decision-making [8].

When we are monitoring the environmental changes, we need to have real-time data readings from the sensors, as well as archive data trends and movements. That is why many sensor manufactures are offering Data Logging devices together with their sensors (National Instruments, Monitor Sensors, YSI, DeltaTrak and so on) with the task of collecting and logging the sensor data and displaying it when they receive a request, either via Internet or via RS-232 port [12,13,14,15]. Internet-enabled Data Loggers are preferred, mainly because of data accessibility.

Because of covering large area and spatial distribution, modern programming technologies must be applied in sensor data acquiring and logging systems.
There are several ongoing projects dealing with this problem. At UCSD (University of California at San Diego), real-time data grid called the Virtual Object Ring Buffer (VORB) was developed. The VORB is a multi-tiered architecture for accessing real-time data from distributed sensor networks [9]. Also, the InfoSleuth project – which took place at MCC (Microelectronics and Computer Technology Corporation) and with a goal of creating a unified system for data retrieval and processing – used agents for querying distributed environmental data-clusters in a transparent way [10]. At Lawrence Berkeley National Laboratory, Java Agents for Monitoring and Management (JAMM) agent-based system was implemented to automate the execution of monitoring sensors and the collection of event data [11].

Meteorological data and image collection could be done by two methodologies:

- by central server pull or
- by embedded server push

Classical approach to the first methodology would be an object-oriented application for cyclic collection of all data, while the second one is used for alarm triggering by sensors. In the Integral Forest Fire Monitoring System both methodologies have been applied, the first one for cyclic image collecting every 5 seconds and meteorological data collecting every 10 minutes and the second one for alarming if alarm values of certain meteorological or system parameters are reached.

The novelty of the approach described in this paper is in application of agent-based technologies for both tasks. The multi-agent based system was developed and implemented for meteorological and video data collecting (pulling) by a central server, but also for pushing data by the sensory unit if measured real-time data reaches the alarm values.

2. MULTI-AGENT SYSTEM FOR METEOROLOGICAL AND VIDEO DATA COLLECTING

Application of agent-oriented methodologies in process monitoring and control is a relatively new approach, particularly suitable for distributed and dislocated systems [2,3,4].

Formally, an agent could be defined as [5]:
"... an encapsulated computer system, situated in some environment, and capable of flexible autonomous action in that environment in order to meet its design objectives ..."

Agents designed for the forest fire monitoring system followed these guidelines strictly, because the system was conceived as a modular system where each module is **autonomous**, **aware of its environment** and **capable for active behavior** if alarmed.

Environment awareness is accomplished by connecting numerous meteorological sensors to a network-embedded microcontroller unit. Network-embedded microcontroller unit was responsible for collecting data from sensors, formatting and preprocessing it and giving it to the central server agent when asked for.

The fundamental system architecture is shown in Figure 3.

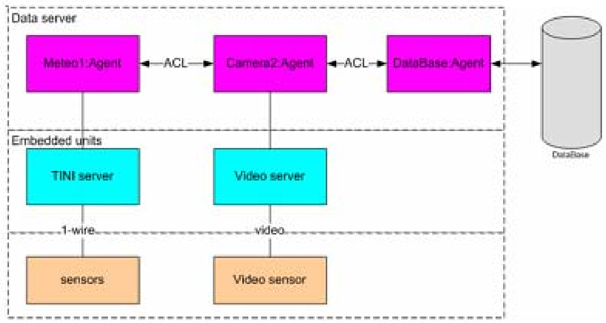

Figure 3 - The fundamental system architecture

The network-embedded microcontroller unit is Ethernet-enabled and runs a simple web server application so that agent communication is implemented by HTTP connections. First data preprocessing (digitalization) was done by the sensor itself. After that, microcontroller unit made further data processing, data averaging in 10-minute intervals and data formatting into a format understandable by the central server agent. At the beginning that was the XML format, but to minimize the activity of embedded microcontroller unit at the end direct agent communication and exchange of variable values was adopted. Agent deployed in the central server communicates with an embedded device over the network, asking for formatted data by HTTP request. It is important to emphasize that agents communicate using the standard FIPA ACL (Agent Communication Language). By using this approach time delay between data samples was minimized because each agent runs in its own thread and doesn't have to wait for another one to finish before activation.

The same procedure was used for image data collecting. The video part of the monitoring unit had pan/tilt/zoom-controlled heavy-duty video camera and an embedded video Web server. The embedded video Web server was responsible for image digitalization and compression in JPEG format. Each camera had a number of preset positions to cover the surroundings completely. The Camera Agent on the central server was responsible not only for image collecting but also for moving the camera to an appropriate preset position by adjusting camera's pan and tilt angles. Also in this case all communication between the Camera Agent and the video Web server was done by HTTP requests, but image transfer was realized by FTP requests.

Synchronization between Preset Agents is of critical importance because positioning the camera into the next position must be done after a picture from previous position was taken; this task is performed by the Camera Agent.

In Figure 3 there is a third type of agent called DataBase Agent too. His task was communication with the database – storing meteorological data and writing notes about collected images and alarms.

Two types of alarms could be encountered – the simple ones, meteorological data alarms and the complex ones, forest fires alarms. Meteorological alarms are generated by a simple expert system, and forest fires alarms are generated by a complex forest fires recognition algorithm. The algorithm was originally developed for our system and based on the recognition of smoke caused by a possible forest fire analyzing the images collected by Camera Agents. This algorithm will be subject of another paper. In this one we concentrate only on the agent-based data collecting system.

The user (operator) communicates with the system with the assistance of an User Agent and the User Agent retrieves data from the database with the assistance of DataBase Agent. A typical user screen is shown in Figure 4.

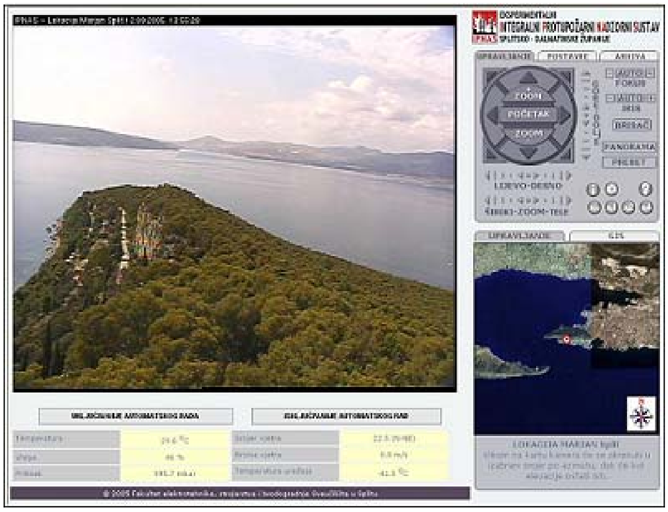

Figure 4. Typical user interface (location: Marjan, Split)

The main advantage of the agent-based approach for data collecting is in its simple extension for distributed systems. The forest fire monitoring system of the Split-Dalamtia County will be a sensory network system. According to our calculations, we need about 50 monitoring units to cover the entire County, and about 25 units will be needed to cover the most vulnerable areas. Because of that the system is designed as a distributed system, without one central unit. Each area, for example island Brac, will have its own central server, but all of them will be mutually connected through a TCP/IP network. Figure 5 shows the distributed system overview.

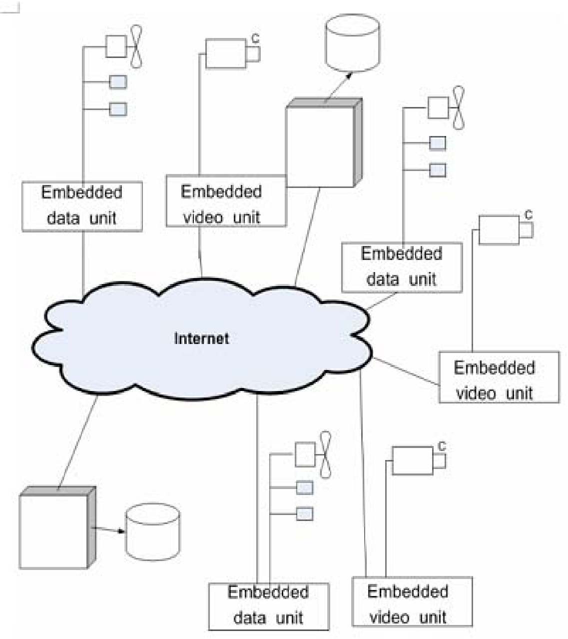

Figure 5 - Distributed system with a few monitoring stations and central units

Adding a new monitoring unit or a server unit could be easily realized by simply adding new agents. The distributed agent name server will be used to simplify agent communication. Experimental system which was in operation during the summer of 2005. had three monitoring units and one central processing unit. More details regarding this system are given in the next chapter.

3. EXPERIMENTAL SYSTEM DESCRIPTION

Although our tendency was to create a system that would not depend on hardware and software platform, we had to choose a test platform for our experimental system.

In variety of sensors available on the market, low cost iButton 1-wire sensors were chosen for meteorological data sensing. Together with the TINI embedded microcontroller [6], this network embedded meteorological station forms a reliable measurement unit.

Reasons for choosing TINI were its simplicity, low power consumption, open-source software support and particularly Java interface, because our multi-agent based system was developed using JADE (Java Agent Development Framework) [7] as a development framework.

To unify the approach, a video camera connected to the video Web server was considered to be a video sensor, the same way as a temperature measuring element connected to the data Web server was considered to be a temperature sensor. To cover the whole surrounding space each camera had 8 preset positions, and each preset position was considered to be its own video sensor responsible for monitoring certain part of the landscape. This means that each camera was treated as 8 independent fixed cameras mounted on the same place. Because of its behavior complexity, the data from this camera is taken in two steps. A supervisor agent for pan/tilt/zoom camera is taking care of positioning the camera in a sequentional queue and after the camera is still in place, taking the image from video input.

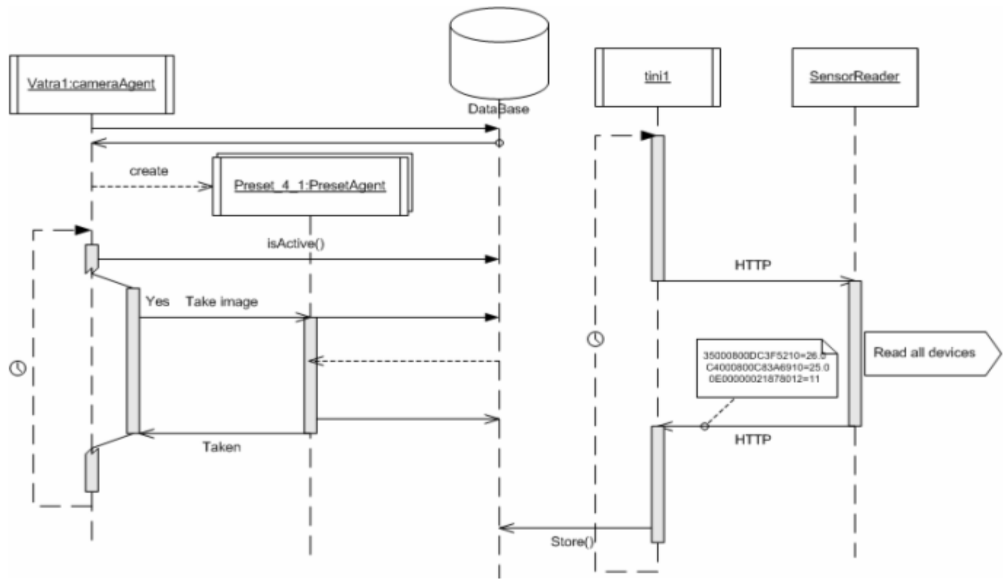

Figure 6 – The agent sequence diagram

The supervisor agent is called CameraAgent and agents he controls are called PresetAgent. The sequence diagram of a working system is given in Figure 6.

4. CONCLUSION

Best fire fighting strategy is fire prevention; fire fighting starts before fire even occurs. The Integral forest fire monitoring system was designed to help in the prevention of forest fires occurrence in the Split-Dalmatia County. Similar systems have been developed, or are in development in other countries ([16],[17]) but there is no reference of a system as large and integral as this one, covering every aspect of fire protection. The system was conceived consisting of sensory units forming a sensory network and a number of server units for data analyzing, storing and presentation. Each sensory unit had two parts, video sensory device and meteorological parameters sensory device.

In this paper we have described the system responsible for data collecting, both image data used in automatic forest fire detection and meteorological data used in prediction of possible fires and fire fighting management. The novelty of our approach is in the application of unified agent-based methodologies for data collecting. The multi-agent system responsible for communication between server units and monitoring units was designed. The advantage of such approach is better control of overall system because of its modularity, easier system enlargement where adding new sensory units and new type of sensor units means just adding new agents into the system, and particularly the ability of data validation on different levels. The system conceived of three monitoring units and one server unit was in experimental work during summer 2005. The experimental system was recognized as very helpful by regional firefighting units.

REFERENCES

[1] D.Stipanicev, B.Hrastnik, Integral model for Forest Fires Protection in Split-Dalmatia County, FESB Report for Split-Dalmatia County, June 2003 (in Croatian)

[2] S.Bussmann, N.R.Jennings, M.J.Wooldridge, On the identification of agents in the design of production control systems, Agent-Oriented Software Engineering, Springer-verlag, pp.141-162, 2001.

[3] D.Stipaničev, M.Štula, Lj.Bodrožić, Multiagent Based Greenhouse Telecontrol System as a Tool for Distance Experimentation, IEEE Int.Symposium on Industrial Electronics, ISIE - 2005**,** Dubrovnik, 20-23.06.2005.

[4] M.Štula, D.Stipaničev, Agent Based Methodologies in Distributed Control, Proc.of Int. Conf. CEEPUS Summer School Intelligent Control Systems (ISBN 80-214-2976-3), Brno, Czech Rep. 29.08.-11.09.2005. pp. 222 – 228

[5] M.Woldridge, N.Jennings, Intelligent Agents:Theory and Practice, Knowledge Engineering Review, Vol.10, No.2, Cambridge University Press, 1995.

[6] TINI – Tiny Internet Interface - http://www.maxim-ic.com/TINIplatform.cfm

[7] JADE – Java Agent Development Framework - http://jade.tilab.com/

[8] Athanasiadis, Pericles A. Mitkas **,** Ioannis N. **,** An Agent-Based Intelligent Environmental Monitoring System, Management of Environmental Quality, An International Journal vol.15,no.3,pp.238-249, 2004. Emerald Publishers.

[9] Rajasekar, F. Vernon, T. Hansen, K. Linquist, J. Orcutt, Virtual Object Ring Buffer: A Framework for Real-time Data Grid", HDPC Conference 2004.

[10]Nodine, M., Fowler, J., Ksiezyk, T., Perry, B., Taylor, M. and Unruh, A. (2000), "Active information gathering in InfoSleuth", International Journal of Cooperative Information Systems 9(1-2), 3-28.

[11]Tierney, B., Crowley, B. et al. (2000), A monitoring sensor management system for grid environments, in "High Performance Distributed Computing (HPDC-9)", American Meteorological Society, Pittsburg, Pennsylvania.

[12] http://www.ni.com/dataloggers/

[13]http://www.monitorsensors.com/

[14]http://www.ysi.com/

[15]http://www.deltatrak.com/

[16]Alonso-Betanzos A et al., An intelligent system for forest fire risk prediction and fire fighting management in Galicia**,** Expert Systems with Applications 25, 2003, 545–554

[17]San-Miguel-Ayanz, et al., Towards the integration of spatial information on forest fires: The European Forest Fire Information System (EFFIS), New communication and information technologies in forest fire prevention and suppression, 2001, Kalamata, Greece.