DISTRIBUTED SENSOR NETWORKS: AN APPROACH

Polzonetti Alberto
School of Science and Technology
Camerino (ITALY)
alberto.polzonetti@unicam.it

I. Abstract - The emerging of global computing is changing the classical system model of computation - stand-alone and isolated - to an open, global and connected one, by showing the needs to suitably manage critical aspects of the concurrent and distributed computation in heterogeneous environment. In this paper, we present a regional project that aims to develop an open service platform in order to integrate heterogeneous sensing information in order to facilitate the administrative decision-making processes

Keywords-component; sensor network, distribuited systems

1. INTRODUCTION

During last years, several activities have taken place in order to monitor environmental changes with the aim of supporting the ordinary activities in the territory administration. This has brought the deployment of several sensing systems each one with own features and peculiarities. These systems work correctly in their specific application, but usually they are not reusable in different applications due to the lack of interoperability. Moreover, as sensor networks become more pervasive there emerges a need for interfacing applications to perform common operations and transformations on sensor data.
In this contribution, a regional project is showed, which aims to meet this issue. The project intends to study and experience a novel platform able to reorganize developed solutions (e.g. geographic information systems, sensor networks) in a new worldview that aims to improve and integrate the actual state of art in this sector.
The platform will employ monitoring systems and sensor networks to keep track of the status of the environment under a new point of view where all can be controlled and managed using a well defined access way that facilitates the management of heterogeneous data provided by different sensing systems: the main goal is to obtain a wide open system with an elevate degree of interoperability among monitoring services.

2. PROJECT OVERVIEW

Our project is attempting to analyze and deploy an open software platform able to support the realization, the maintenance and the evolution of a territorial control system: the interest is not only at research level, but it aims to apply this research in real case study involving civil protection organizations that will provide their already existing sensing systems.
The first phase of the project regards the study of this platform and its basic services, focusing on the possible problems and on the characterising aspects that can simplify the management and the accessibility of environmental information useful for administrative decision making. In order to increase the interoperability, standard interfaces for web applications and services must be defined. This study will provide the individuation of basic services for applicative fields, such as the geographic one, the workflow one, the sensors one, the knowledge one.
The second phase regards the case study and the deployment of a prototype for the security and the monitoring of the territory. The basic idea is to experiment the platform to integrate existing sensing devices and web technologies for the gathering of territorial data to detect critical events.

3. THE OPEN SERVICE PLATFORM

The purpose of the former phase is to study the available methodologies and technologies, that can be used to support this open platform. This study must relate the main platform features with the actual specifications defined by the standardization committees, in particular standards regarding web technologies (e.g. web services [2]), communication protocols (e.g. ZigBee communication protocol suite [10]) and the interaction patterns (e.g. service interaction patterns).

In this phase, we need to define a service platform that integrates primary services, in a homogenous way, for the following application fields:

Geographic services: the aim of this services is to allow the access to geographic archives in order to obtain a virtual spaces modeling, a geographic data querying and a geographic-based data interpretation;

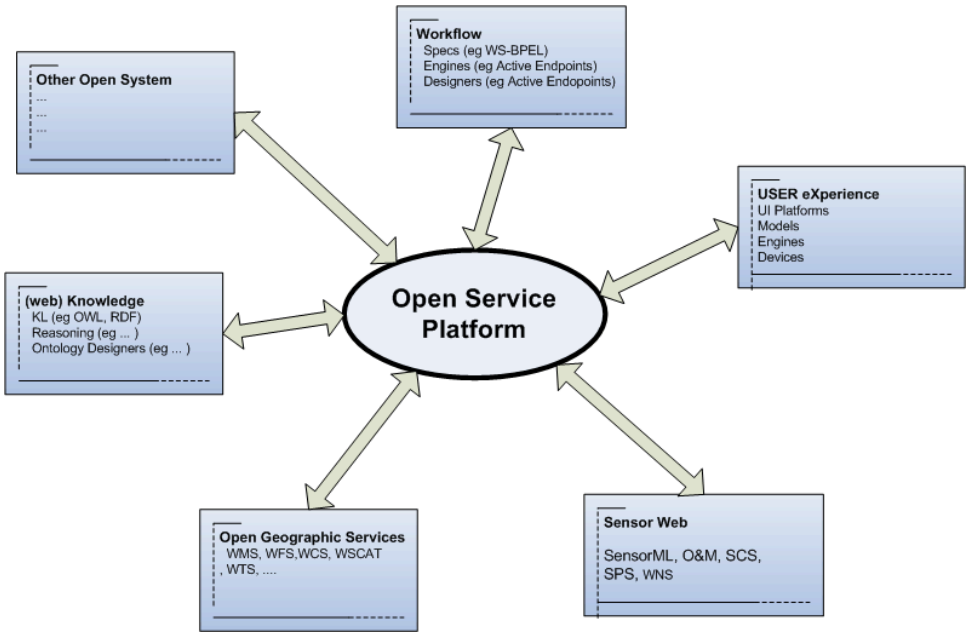

Figure 1 Open Service Platform

Services for the applicative cooperation based on synchronous and asynchronous collaboration profiles for the exchange of the informative flows between monitoring systems (e.g. workflow and Publish&Subscribe service)

Sensor services for the control sensor device and the management of distributed sensor information;

Knowledge services: that provide access to or operate over knowledge resources, like rule engines and automated reasoners;

Support services for the management of the technological infrastructure. These are centralized and demanded to specific operative points that also monitor the systems and the applications, control the security conditions and, in general, the operative and administrative applications needed for the correct operability of the informative system.

a. Geographic services

Nowadays national governments and international organizations are moving towards this direction and the growing adoption of infrastructures of standardized spatial data is a demonstration. INSPIRE European community aims to standardized territorial information and services simplifying the integration [3]:

"Art. 1 - … In order to bring about such integration, it is necessary to establish a measure of coordination between the users and providers of the information so that information and knowledge from different sectors can be combined"

"Art. 4 - The Infrastructure for Spatial Information in the European Community (Inspire) should assist policy-making in relation to policies and activities that may have a direct or indirect impact on the environment."

In this area, our interest is to simplify the representation of the territorial information, to share and to use them according to the specifications given by the Open Geospatial Consortium (OGC) [7].

What we have intention to do is a survey on the existing services to understand the current state of art and the needed improvements. Our approach aims to come to a point where the geographic information will not be anymore the object of the service, but they will be a "building block" for more "intelligent" systems.

b. Applicative cooperation

We define a workflow as "a block of activities correlated by different relationship typologies" and so we are interested in workflow management systems [4], that are able to describe the modelling, the definition, the execution and the monitoring of the business processes. The main aim is to identify a new methodology to integrate workflow with different cooperation paradigms, like Publish&Suscribe, Tuple Space-based and so on. This is due to the heterogeneity of the involved system that can have limited resources (e.g. memory, energy, CPU). For this reason a more light cooperation way is needed in order to preserve the lifetime of this system and monitoring of critical events.

c. Knowledge domain

The increasing attention on semantic technologies brings a novel and efficient approach to share data among several data sources in a distributed networked environment. In this way, different applications can be integrated dynamically using a shared Knowledge based on ontology.

However, the main problem regarding Geographical Information Systems (GIS) [1] is the lack of integration among heterogeneous systems. An efficient solution is represented by the ontology-based GISs, a schema that brings a dynamic and open integration for different systems. Ontology solves this issue with a mechanism to specific in an explicit way the concepts to use in the applications: this helps especially the information sharing, because otology can specify the nature of the involved entities. What we propose is to create ontology and meta data based GISs, that are able to associate, extract and elaborate information expressed in different languages. In particular, ontology is a key conceptual tool for gathering, specifying, storing, maintaining, managing and representing explicit and implicit knowledge contained in a complex domain like GIS.
The advantages that we want to obtain using this approach are:

Physic and logic independence among system entities;
System scalability;
Improvement of information management;
Better Interoperability among GISs;
System customize based on user profiles;

d. Sensor services

Last years have seen a growing interest in the sensor networks, that represent a mature technology for the development of low-cost and low-consume distributed applications which are used to exchange environmental information within wide geographical areas. A sensor network is an autonomous collection of mobile nodes that communicate over wireless links. In general, a sensor is an autonomous unit that is able to elaborate a set of operations, to sample/interact with the environment and to cooperate with other devices. But these networks usually suffer from significant robustness issues due to limited resources, such as battery, memory and CPU.
Sensor networks have been widely used in the development of decision support systems [6], in particular, for environmental monitoring applications. However, this increasing deployment has brought to the development of different information management and storage mechanisms causing an impracticable cooperation among sensor devices provided by different vendors. For this reason, several initiatives have taken place in order to develop an intuitive and expressive approach for representing and integrating data provided by different sensor typologies, for example:

SINA: Sensor Information Networking Architecture [9]; SenseWeb [8]; IrisNet: Internet-scale resource-intensive sensor network services [5].

The main aim of this section is to develop a global and heterogeneous sensor network that allows information sharing using interoperable and standardized interfaces. In this direction, we consider the Sensor Web Enablement initiative proposed by OGC a possible approach for our problem.

4. CASE STUDY: PROTEZIONE CIVILE

The second aim of our project is the deployment of a prototype for the security and the monitoring of the Le Marche region. Our experimentation will provide:

The classification and the specification of possible critical events and risk scenarios in order to identify a procedure to detect them;
The identification of the existing available monitoring systems;
The realization of prototypes for Sensor Web Services;
The verification of the prototype functionality;
The realization of a demonstrative application for the environmental monitoring.

The features that our system should have are: open-source code, tools to support a development community; interoperability with geographical standards and a customizable GUI.

e. The Scenario

The civil protection is a system that operates, in the regular scenario, to develop predictive analysis in order to monitor and prevent risks that can threaten the territory and, in the emergency scenario, to provide support for the emergency management. Civil protection system is a complex system, in which

cooperate several institutions, operative structures and public and private organization.

In Italy, the “Protezione Civile” is an organization that deals with prevention, management and resolution of

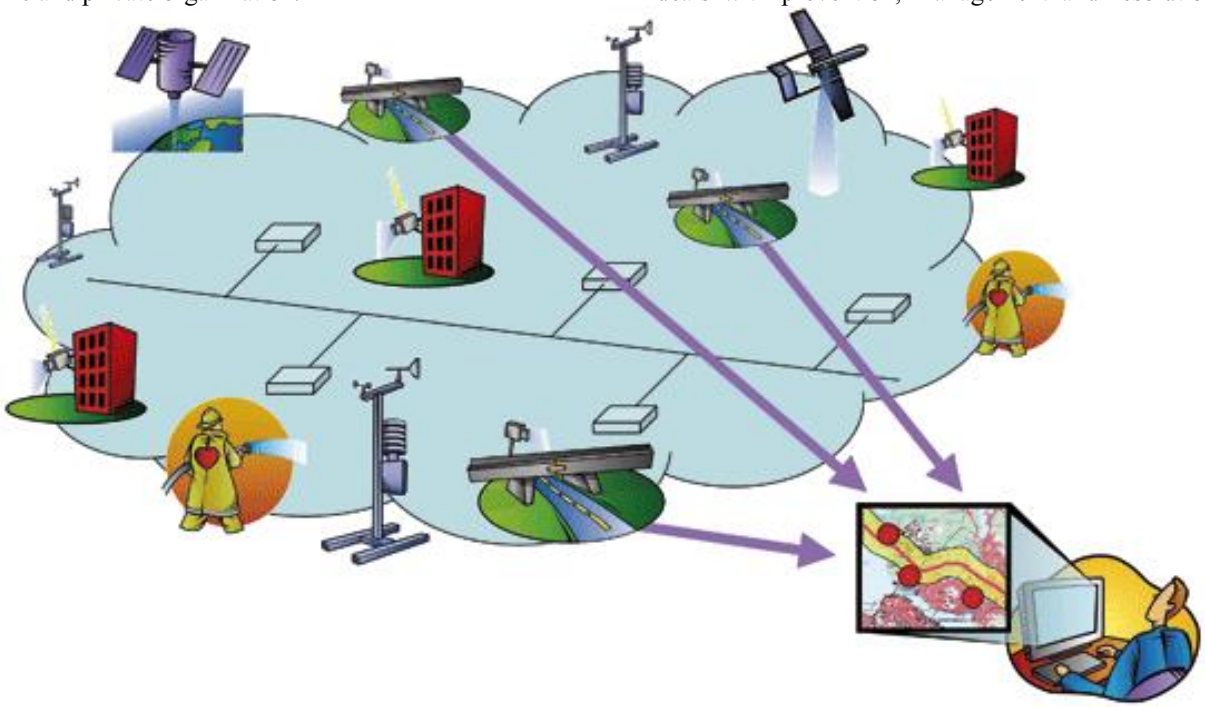

Figure 2 Example of Scenario

possible emergencies in a regional and national area. Its goal is to safeguard the lives, goods and buildings integrity from any calamities. In order to control the environment status, the Protezione Civile is supported by the RMIPR (Rete Metro Idro Pluviometrica), a regional network that monitors weather conditions: this net provides eleven typology of sensor distributed in the whole area, these sensors communicate each other by radio channels; our task is to extend this network with other private monitoring systems that are deployed in the region. This is the first step to realize an active monitoring system for the territory, that will adopt other than the use of the sensor networks and system already active, a new mobile system for video-acquisition, that should give the possibility to measure, recognize and rebuild in a 3D scenario, the environment according to the necessity.

5. Conclusion

This work shows the introduction of project that can significantly support the development of monitoring applications. The development of intra- and inter-organizational applications represents one of the most involved problems of monitoring systems.

The development of the open service platform can enable public administrations to manage environmental information that can be used to support territorial decision-making process and to monitor for example outsourcing services (e.g. rubbish administration).

Solutions like the proposed one are not available, and in general there are not standardized and consolidated platforms able to integrate data from sensors, workflows and ontology in an efficient way; the only thing in this direction is the presence of some proprietary software created ad hoc for particular application scenarios, and not accessible to everybody. Anyways these kinds of software present several problems: they are static, extremely expensive and not interoperable.

References

[1] BERNHARDSEN, T., Geographic information systems: an introduction, John Wiley & Sons, New York (Usa), 2002

[2] BLOOMBERG, J., Principles of SOA, Application Development Trends Magazine, March 2003

[3] EUROPEAN PARLIAMENT AND THE COUNCIL, establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Directive 2007/2/EC, March 2007

[4] Georgakopoulos, D., Hornick, M., Sheth, A., An overview of workflow management: From process modeling to workflow automation infrastructure, Springer Netherlands, April 1995

[5] GIBBONS, P.B., KARP, B., KE, Y., NATH, S., SESHAN, S., IrisNet: An Architecture for a World-Wide SensorWeb, IEEE Pervasive Computing, 2(4), October-December 2003

[6] JANKOWSKI, P., RICHARD, L., Integration of GIS-based suitability analysis and multi-criteria evaluation in a spatial decision support system for route selection, 1994

[7] REICHARDT, M., Sensor Web enablement, Open Geospatial Consortium (OGC) White Paper 05-063, 2005

[8] SANTANCHE, A., NATH, S., LIU, J., PRYANTHA, B., ZHAO, F., SenseWeb: Browsing the physical world in real time, IPSN 2006: Proceedings of the fifth international

conference on Information processing in sensor networks, New York, (Usa), 2006

[9] SHEN, C., SRISATHAPORNHAT, C., JAIKAEO, C., Sensor Information Networking Architecture and Applications, IEEE Personal Communications (pages. 52-59), August 2001

[10] ZIGBEE ALLIANCE, INC., ZigBee Specification, White paper, 2006