Poster Abstract: Collaborative Data Processing for Forest Fire Fighting

E. M. García, A. Bermúdez, R. Casado, and F. J. Quiles

***Abstract*—In this work, we propose a distributed system to provide to the firefighters with critical information in real time, in order to increment their safety and efficacy. The main element of the system is a wireless sensor network deployed over the field. Sensors obtain environmental information and collaborate among them to determine the current behavior of the fire fronts. Firefighters receive this information in a handheld device wirelessly connected to the sensor network.**

***Index Terms*—Environmental monitoring, localization algorithms, collaborative information processing, mobile devices, MicaZ, TinyOS.**

I. Introduction

The people involved in the extinction of forest fires is frequently exposed to many hazardous conditions due to the lack of critical information, such as field topography, fire evolution, and location of human and material resources and safety zones.

In the literature we can find several works which propose using a wireless sensor network (WSN) in forest fire fighting. In some cases, the only purpose of the network consists in acquiring environmental data. Then, these data are gathered and displayed in a base station, stored in a database, and/or sent to a remote location [1, 2]. Fig. 1 represents conceptually this behavior. Other cases, the WSN itself contains some intelligence to process the data obtained before sending them to the base station. Usually, the objective is to delimitate the fire perimeter [4].

Until our knowledge, previous works assume the existence of a central server that gathers the fire behavior and, occasionally, redistributes it to the firefighters by means of a different communication technology (GSM/GPRS, WiFi,…).

In this work we present EIDOS (*EquIpment Destined for Orientation and Security*). Its main contribution is that the network incorporates the fire model, which is built from the geographical information of the area (topography, combustible,…) and the data sensed by network nodes (temperature, humidity, wind direction and speed,…). Moreover, this model is directly sent to the firefighters, who carry handheld devices running a lightweight browser application. Fig. 2 shows this behavior.

The rest of this document is organized as follows. Section II presents the elements making up the EIDOS system, and the way they interact. After that, Section III outlines the methodology that we plan to apply to develop this proposal.

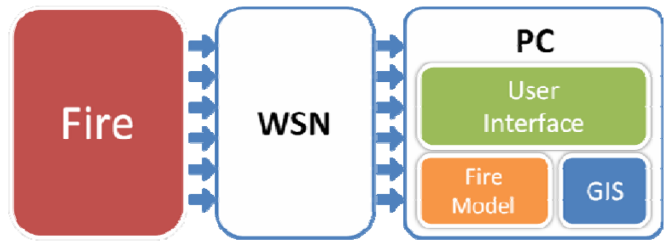

Fig. 1. Traditional proposals. The WSN captures physical data. This information is the input for a fire model at a local (or remote) server.

II. System Description

Fig. 3 shows the architecture of EIDOS system. The main component of the system is a network composed of thousands of sensor nodes, deployed in the field by means of an UAV (Unmanned Aerial Vehicle). Each sensor is an electronic device with wireless communication capability, encapsulated into a fireproof packaging.

Other key element in the system is the handheld device that the firefighters carry. It incorporates a lightweight GIS (Geographical Information System) engine to display the data proc-

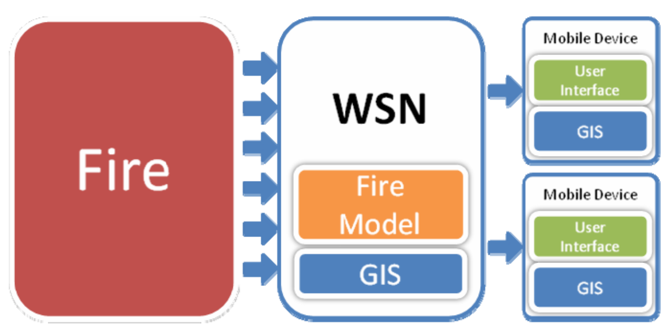

Fig. 2. EIDOS protocol stack. The WSN incorporates the fire model, processes physical data and delivers the result to the mobile devices carried by the firefighters.

The authors are with the Computing Systems Department, Research Institute of Informatics at Albacete, University of Castilla-La Mancha, 02071 Albacete, Spain. E-mail: {evamaria.garcia, aurelio.bermudez, rafael.casado, francisco.quiles}@uclm.es.

This work was partly supported by the following projects: CSD2006-46 and TIN2006-15516-C04-02 (Ministerio de Educación y Ciencia), PBC05-007-1 (Junta de Comunidades de Castilla-La Mancha), and PCTC0622 (Universidad de Castilla-La Mancha).

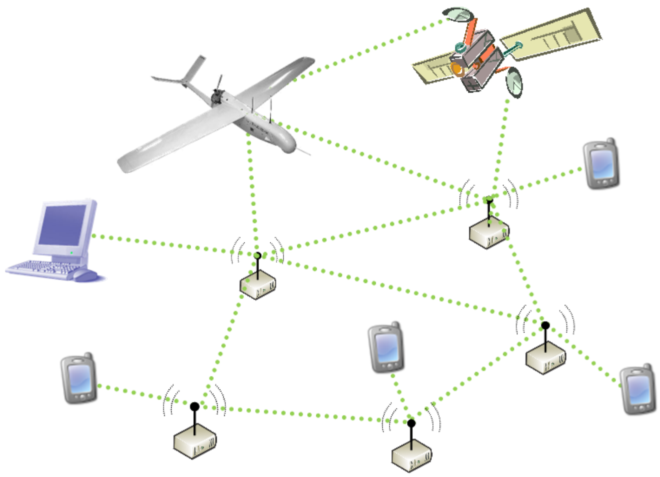

Fig. 3. EIDOS system architecture.

essed by the sensor nodes –as firefighter locations and fire behavior– over a map of the terrain. Additionally, the handheld device allows the firefighter to interact with the command, by sending reports and receiving instructions.

Besides the above elements, the system could optionally include a base station. It could be a laptop located in the command vehicle, wirelessly connected to the sensor network. This server can graphically show the data collected from the sensors, and run a more complex fire simulation [6], in order to predict the future behavior of the forest fire. All this information may be used by the command to decide the best strategy against the fire.

The position of each element in the system (sensor nodes and firefighters) must be known at any given time. With this aim, some of the sensor nodes –and possibly the UAV– are equipped with a GPS receiver. Then, the rest of nodes can calculate their exact position, by means of some ranging-based localization algorithm. A very simple approach is the Bounding Box algorithm [8].

Sensor nodes monitor their environment, by periodically measuring physical magnitudes, such as temperature and humidity. This information is shared with the rest of nodes in the network. Before transmit them, data can be filtered and/or compressed. In this way, the amount of necessary packets can be reduced –and consequently the energy consumption. Other techniques to extend network lifetime can be applied, as for example leaving to a sleep state some sensors when they are too close to others.

Finally, a collaborative algorithm processes all this physical information, in order to determine the current location and direction of the fire fronts. To do that, we plan to consider a widely accepted fire model, as [5]. The result of this distributed algorithm is sent to the firefighters' handheld devices and the base station.

III. Methodology

First, we plan to implement, analyze, and tune our proposals in a simulation environment. Then, we will develop a more realistic prototype, by using standard network devices. Finally, the prototype will evolve to a real system, in which all the hardware components will be designed specifically for the forest fire environment.

To simulate the wireless sensor network we are going to use TOSSIM [7], due to its ability to simulate TinyOS applications. TinyOS is a popular open source operating system for sensor nodes, developed by the University of California at Berkeley. The advantage of using TOSSIM is that, once the TinyOS code has been debugged, it can be directly downloaded to the sensor memory. We plan to adapt this tool to our scenario, by developing a customized GUI (Graphical User Interface), which will allow us to dynamically interact with the simulation.

Apart from the network simulator, we are going to make use of a specialized fire simulator [6], with the purpose of testing the behavior of our collaborative processing algorithm. In particular, TOSSIM will provide the location of the simulated sensors to the fire simulator, and the fire simulator will periodically give to TOSSIM the physical parameters (temperature and humidity) corresponding to each location. In this way, we will be capable of comparing the outputs of both simulators.

In the experimental deployment, we plan to use the Crossbow MicaZ mote [3]. It is a Zigbee compatible model, incorporating an Atmel Atmega128 microcontroller and a Chipcon CC2420 radio. As handheld device, we plan to use a standard PDA (personal digital assistant), equipped with Microsoft Windows Mobile or similar, and running a friendly Flash interface. Both the PDA and the base station will be integrated in the network by means of Zigbee adapters.

For the final system, we have to take into account that commodity-of-the-self sensors have not been designed for this extreme environment. So, final sensors must be designed and made to support high temperatures. They also need a fireproof and drop-resistant packaging.

References

[1] D. M. Doolin and N. Sitar, "Wireless sensors for wildfire monitoring," *SPIE Symposium on Smart Structures & Materials/NDE 2005*, San Diego, California, March 2005.

[2] Y. Li, Z. Wang, and Y. Song, "Wireless sensors network design for wildfire monitoring," *6th IEEE World Congress on Intelligent Control and Automation*, June 2006.

[3] Crossbow Technology, Inc., www.xbow.com.

[4] C.-L. Fok, G.-C. Roman, and C. Lu. "Mobile Agent Middleware for Sensor Networks: An Application Case Study," *4th International Conference on Information Processing in Sensor Networks (IPSN'05)*, Los Angeles, California, April 2005.

[5] G. Pruessner and H. J. Jensen, "A new, efficient algorithm for the Forest Fire Model," *Physical Review* E 70 066707, 2004.

[6] SEM (Systems for Environmental Management) corporation, www.fire.org.

[7] TinyOS, www.tinyos.net.

[8] K. Whitehouse and D. Culler, "A Robustness Analysis of Multihop Ranging-based Localization Approximations," *5th International Conference on Information Processing in Sensor Networks*, Nashville, TN, April 2006.