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Leveraging Multi-Agent Systems with Cloud Computing to Enhance Foreign Assistance in Urban Environments

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Abstract
One of the most important tasks in the healthcare system is handling emergency circumstances that arise from major accidents or natural catastrophes. When a lot of people are involved and time is of the essence, we are all worried about the need for a coordinated response and organization. This study demonstrates how agent technology may successfully meet the aforementioned requirements and introduces a multi-agent system for managing territorial emergencies in large-scale disasters. In this study, we provide Ubimedic2, a multi-agent framework that may independently coordinate the operational units during rescue missions.
Keywords: Agent, Healthcare, Ubimedic2

1. Introduction
IT researchers are becoming increasingly aware of the need for technological assistance in the planning and execution of rescue operations as a result of recent catastrophic occurrences like earthquakes, tsunamis, and terrorist acts. Due to the scope and intricacy of these operations, a prompt and well-coordinated reaction is necessary to minimize the grave harm to people's health during disasters and to preserve the greatest number of lives. Numerous actors, including medical personnel, rescue volunteers, police officers, and firefighters, as well as resources, such as ambulances, medical cars, fire trucks, and hospitals, are what define this activity. To coordinate the operations and use the resources at hand to their fullest potential, all of these players need to cooperate and communicate with one another.
Decisions must be made quickly, precisely, and in real time because every situation is unique and unpredictable. Another peculiarity of these scenarios is the dynamic nature of the happenings. Actors' reactions must adapt quickly to the ever-changing scenario. Despite the challenges, cooperation and teamwork skills shouldn't be compromised. An increase in electronic medical equipment and the availability of infrastructural communication technologies like Wi-Fi and 3G have been two recent developments in the field of health care technology. Medical equipment in particular makes it possible to share data, and infrastructure communication makes it possible to employ a suitable network for communication.
We used software agent technology to meet the aforementioned objectives (Wooldridge, 2009; Weiss, 1999), and we offer a workable solution to these issues based on their unique qualities (Moreno & Garbay, 2003). In this article, we present a multi-agent architecture that can effectively manage the many tasks involved in rescue operations. We have created a multi-agent framework called Ubimedic2, which is based on this architecture and allows appropriate systems to be implemented for the management of the rescue operations.
The structure of the paper is as follows. We shall outline some relevant works in Section III and provide motivation for our work in the realm of emergency management in Section II. We will present the Ubimedic2 approach in Section IV, and in Section V we will go into great detail on the architecture. In Section VII, we shall present our future efforts and conclude in Section VI.

2. Motivation
The weakness of the centralized strategy now in use is what drives the need to implement a new, revolutionary methodology in rescue management. In the US model, all rescue actions pertaining to security or health issues are coordinated by a single Operative Centre, which may be reached by calling 911. Typically, the first aid, police, and fire departments are represented by three separate Operative Centres in European nations. Coordination and organization become increasingly challenging when all three departments must intervene.
The Operative Centre needs to gather as much data as it can from all of the operative units, including ambulances, medical cars, and helicopters, in order to improve the organization. Details include the patient's condition, the location of the unit, etc. An actual bottleneck is created by the Operational Centre's high volume of communications. Voice communication can only be used once at a time with wired or radio channel devices. Moreover, mistakes can happen when communicating via speech. Spelling words incorrectly is a frequent issue.
A small group of human operators makes up the Operative Centre. Their duties include gathering all relevant data, making appropriate decisions, and communicating with the operative units. All patient health data is gathered without the assistance of electronic gadgets. Copies of paper sheets are used to report data exchanged between the ambulance staff and the triage staff or between the ambulance personnel and the operating center. Due to calligraphy issues, these methods make data difficult to read and make it easy for bits of information to get lost.
These are a few of the main factors that, in our opinion, will cause the current rescue operation arranging approach to alter.

3. Related Work
The advancement of technology has consistently contributed to the healthcare industry, with particular emphasis on electronic gadgets that aid in diagnosis and treatment. System and data management are receiving more attention as the amount of digital data increases daily. The requirement for organizational assistance is growing more and more important given the complexity of how various activities within the healthcare system are organized.

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Numerous researchers have been drawn to multi-agent technology, and its use in the healthcare industry is expanding daily. The capacity of multi-agent technology to self-organise and adapt to various circumstances has led to its exploitation. A thorough examination of the potential use of agents to address healthcare issues has been completed by Nealon and Moreno (2003) and Isern, Sánchez, and Moreno (2010).

Coordinated hospital patient scheduling (Decker & Li, 1998), remote patient monitoring (Larsson & Hayes-Roth, 1998; Laleci et al., 2004), decision support systems (Singh, Ismail, Haron, & Yong, 2004), healthcare knowledge-based systems (Hashmi, Abidi, & Cheah, 2002), and advanced health and catastrophe systems (Gao et al., 2007; Bessis, Asimakopoulou, & Xhafa, 2011) have all suggested using agents. A more thorough examination of similar works is available in Domnori, Cabri, and Leonardi (2011).

Since there was little comprehensive work on the subject of managing territorial emergencies in the literature, we chose to concentrate our study efforts in this area. We will provide a new architecture in the sections that follow, with the goal of providing invaluable assistance to the rescue effort. We expanded the Ubimedic framework (Cabri, D. Mola, & Quitadamo, 2006; D. Mola et al., 2006) by adding new intelligent components and adding more functionalities. The autonomy and support for decision-making of Ubimedic2 surpasses that of the last update. The reasons behind creating this design are thoroughly and in-depth disclosed in Domnori, Cabri, and Leonardi (2011).

4. The Ubimedic2 approach

Using a fully distributed method, Ubimedic2 allows all operational units to participate in the decision-making and coordination process. Using the JADE platform, which is supported by the majority of commercial digital communication devices, including desktops, thin clients, and smartphones, it was created in Java to be platform independent.

Agents use 3G and Wi-Fi to interact with one other. Wi-Fi technical communication is used for communication between devices and operating units (e.g., between an ambulance and an Ecg medical equipment) as well as between two nearby operative units (e.g., an ambulance and another ambulance). This indicates the greatest volume of data transmitted and the highest number of communications. Three-generation (3G) communication technology is used to communicate between operating units that are separated from one another. In this instance, less data is used because JADE only uses brief text messages for communication, which makes 3G technology ideal.

Electronic gadgets are used for the collection of all data. Data integrity and multicast communication are made possible by this. Handheld and electronic medical devices are used to gather personal and medical patient data. The operational units store all data and use it in the decision-making process.

The ability to assist medical professionals in making decisions is a crucial component of our architecture. We have many operational units responding to large-scale crises that are dispatched from other cities or even other nations. The personnel assigned to these units lack comprehensive knowledge on the hospital's location, the diseases in which they specialise, the resources at their disposal, and the greatest number of patients they are able to care for.

5. Architecture

This section will provide an introduction to Ubimedic2 architecture, along with a detailed description of each component's functions. In the scenario we are considering, a software agent represents each device in the operational unit. They function independently and converse with one another to exchange information or make decisions regarding the assignment and patient distribution. The behaviour of the agent depicts how the devices or units it represents behave in real life. The DBI paradigm has been used in the architecture's design. For the agent representing the operational unit, for instance, the beliefs are the details about the patient, the desire is to get the patient to the best hospital, and the intention is what the operator will do to become successfully

5.1. Agents

Agents in Ubimedic2 stand in for digital devices, medical staff operators, control centre operators, mobile units (like ambulances and medical cars), and stationary units (like a hospital or temporary first aid camp). The simplest agents in our system are those that stand in for medical equipment. They employ a client-server model. When a different agent requests information or assistance, they respond by providing it or refusing it if the agent making the request is dishonest or does not have the necessary authorization to access the information.

The other agents possess greater complexity and autonomy. They make decisions instead of human operators, therefore they need to be able to reason and gather the knowledge they need to choose the right course of action. The stringent procedures that have been established to arrange the activities make this feasible.

These protocols serve as the foundation for operations, and human operators gather the relevant data. In the actual world, procedures are required to prevent mistakes made by people and to assign blame when something goes wrong. These protocols can be converted into a series of instructions that provide agents with even a small margin of discretion in the event of unforeseen circumstances. All of the agents are categorised based on their functions in the following.

A service agent (SA) is an agent that stands in for a device that a human operator uses to enter or read data. Examples of these devices include medical equipment, notebooks, and PDAs. These devices lack decision-making capabilities and have restricted functionality. The corresponding agents are separated into two groups according to how they are used:

• The agent that represents the medical device that the operators are using is called a Device Service Agent (DSA). This agent communicates with the other agents that are offering the specific information or service. It merely returns the requested data in response to a request.

• A client service agent (CSA) is an agent that stands in for an operator's client interface device, such as a smartphone, PDA, or laptop. In order to visualise the data, this agent obtains it from the client device and gathers it from additional DSAs.

The agent that represents an operating unit, such as an ambulance, medical vehicle, hospital, etc., is known as an operational agent (OA). Utilising devices through SA, this agent gathers patient data. It collaborates and communicates with other Operative Agents to make judgements regarding the distribution of patients across various hospitals. It was divided into two groups:
The agent who represents a mobile unit, such as an ambulance, medical car, helicopter, etc., is known as a mobile operational agent (MOA). In order to obtain the required information, this agent speaks with service agents (who are represented by devices installed on the car) and with other mobile and fixed agents in order to plan the activities.
The agent that represents a fixed unit, like a hospital or temporary first aid camp, is known as a fixed Operative Agent (SOA). Only mobile operative agents can communicate with this agent. It receives requests to provide accommodations for patients with specific pathologies and notifies them of the free resources that are available.
Special agent known as the Activator is in charge of deactivating the other agents when the operative units are no longer available and activating them when the operative units are ready to be employed. It forwards the requests for new operations that it gets from the operative centre to the MOA. When necessary, it requests that standby units be activated. It gets calls from ambulances to activate certain units, including medical helicopters, or to have the police or fire departments step in.
. In figure 1 here is the new protocol to represent a new model

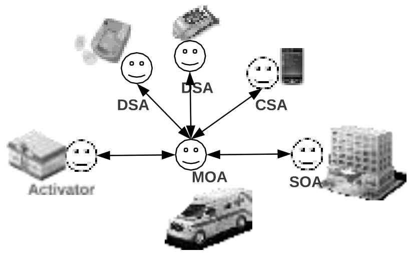


Figure 1: Agents and communication in Ubimedic2 architecture

5.2. Communication

Different technologies are used by the agents to communicate, as Figure 2 illustrates. One operational agent talks with a service agent, giving them the information they need. Their communication environment is confined to a small area. An ambulance uses its own devices that are installed inside. They can communicate with each other via Bluetooth or Wi-Fi. The operative agent connects to other operative agents via Wi-Fi and GSM technology. The technique employed is contingent upon the separation between the active agents. Wi-Fi technology allows ambulances operating in the same area to communicate more quickly. Nonetheless, the operational agents utilise GSM technology when they have to interact with distant units (like hospitals).
Due of its high mistake rate and sluggish data transfer speed, RF technology is not considered. It is not appropriate for data, but it can be utilised in any case for voice communication across long distances between human operators.

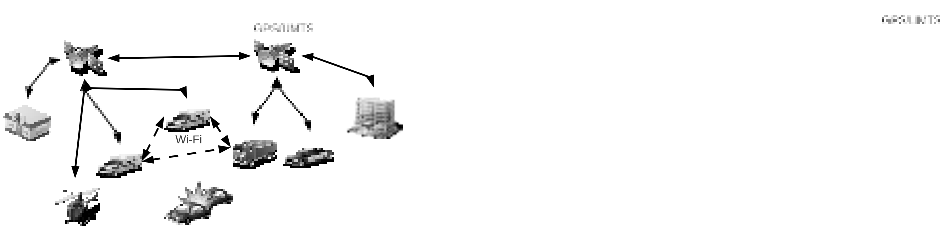


Figure 2: Communication model in Ubimedic2

The coordination process, we will go over the agent's coordination mechanism and the messages they exchange in the sections that follow.

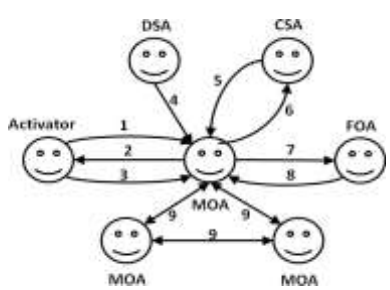


Figure 3: The coordination process

The Operative Centre human operator gives the Activator agent a new mission, which she allocates to one of the available ambulances. In order to negotiate the new job, the Activator first sends a request message (Figure 3-Step 1) to the MOA asking for its availability. The MOA replies to the request with an Accept message (Step 2) if the operative unit it represents is not handling another work. The Activator then delivers the required data (such as location, expected pathology, and seriousness) for the new task (Step 3). The MOA responds with a Refuse message if it is not prepared to take on a new task. In this instance, a different MOA is used to repeat steps 1 and 2.

After arriving, the MOA starts gathering health data from several DSAs (Step 4) that stand in for medical equipment like the oxygenator or ECG that is used in the operating room. Additional health data is gathered from the CSA (Step 5), which represents hand-held devices used by medical personnel, such as PDAs or smartphones.

Together with the patient's personal data, including name, surname, and age, all information gathered from the MOA is kept in a database. In order for the medical staff to view the data using the hand-hold device, the data gathered from the various medical equipment is transmitted from the MOA to the CSA (Step 6).

The MOA elaborates the gathered data at a predetermined frequency, determining which pathology is most pertinent to the patient and how bad it is. The most pertinent pathology will be considered if the patient has many diseases. An example of the order of priority the is the following: Heart and lungs, spine injuries, facial and head damage, etc.

Step 7 involves the MOA identifying the pathology, retrieving all the hospitals that treat it from the database, and requesting that the patient be hosted by the closest hospital by sending a request to the SOA representing that hospital. Step 8: The SOA has the option to approve or reject the request by sending an Accept message to the MOA based on the resources at their disposal. The MOA contacts the SOA of the next closest hospital if the SOA rejects the request.

The MOA will select a hospital regardless of whether a SAO representing a hospital in the territory responds. The hospital with the closest policy or one chosen at random may be the one used for selection.

The patient's health status may deteriorate over time or change as a more pertinent pathology appears. This implies that the MOA may decide once more which hospital to transfer the patient to, and that steps 7 and 8 will need to be performed in order to negotiate the hospital's acceptance of the patient. Regardless, once a pathology has been determined to be highly relevant, medical concerns will prevent the MOA from changing it to a less relevant pathology, even if health metrics turn out to be within range.

5.3. Interfaces

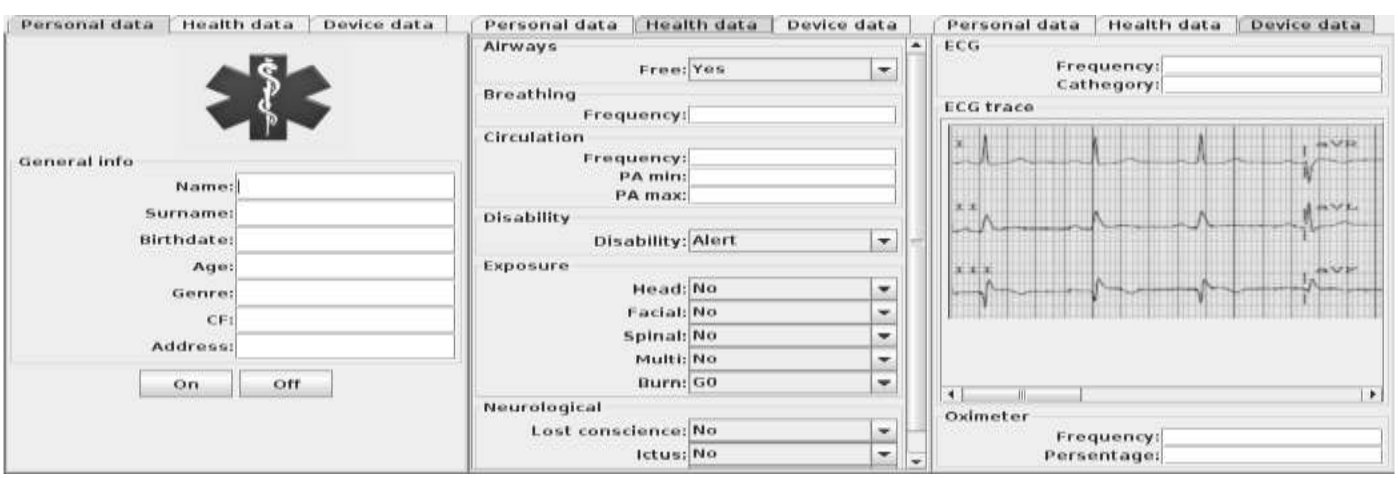
We have created a set of agents, such as Ambulance (inherited from MOA), Hospital (inherited from SOA), Ecg and Oximeter (inherited from DSA), and Pda (inherited from CSA), in order to verify the usability and feasibility of our system. We have created a unique user interface for every agent so that we can communicate with them, see how they behave, and give them the information they need.

Ecg is a symbol for the Electrocardiogram, a type of medical instrument. The interface is used to deliver the required information regarding the parameters of the patient's health.1. Heart hate and fibrillation kind are its two input fields (see Figure 4.A). Similar to how the Oximeter agent has been used in smart-phone device.

(see Figure 4.B).

Figure 4: ECG (A) and Oximeter (B) device interface

The medical staff uses the device to view the data gathered from the medical devices (tab Device data) and to provide personal (such as name, surname, and date of birth; see Figure 5 tab Personal data) and health (tab Health data) patient data.



We used this interface to simulate medical devices in our test actual medical devices can even be directly connected to the following: A) Service, which displays the task information sent from the Activator; B) Destination, which displays the hospital where the patient is being transported; and C) Seriousness of the main pathology.

First aid personnel input has been used to construct the business logic for applying the policy of pathology and seriousness detection as well as the hospital decision. It is however restricted because this is outside the purview of our study endeavour. Medical personnel can contribute to the re-implementation without altering our design in any way.

Figure 6: Ambulance GUI

6. Conclusion

One of the most criticised activities in the healthcare system is the rescue operation, which calls for intricate coordination and cooperation between several groups. The shortcomings of the existing strategy need the creation of new strategies that more effectively address these demands.

In this work, we presented a novel strategy and framework, named Ubimedic2, that is based on software agent technology and capable of managing and assisting human operators during rescue operations so they can concentrate on the organisational parts of the task rather than the medical ones. This framework provides decision-making support as well as real-time data collecting and communication. Our structure It is scalable, fully dispersed, and no longer has an operational hub acting as a bottleneck. Utilising digital gadgets and communication technology facilitates data integrity while saving time. The European Rescue Council's well defined standards, which provide stringent guidelines for classifying various disorders according to their severity codes, have made decision support possible. To achieve better usability, first aid operators affiliated with the Italian Red Cross assisted in the development of the user interfaces. We have created a series of user interfaces for interacting with the agent in usability simulations. This made it possible for us to watch the agents action and supply the information that is required in real-world scenarios that comes from genuine devices.

Device agents will gather data from the device itself, not from test interfaces. The test can be regarded as reliable because the agents' behaviour in the simulation we ran was identical to that of a real-world situation. We have tested data that is represented in ASCII format, such as text and numbers. However, JADE can handle messages with binary content, allowing device agents to communicate with one other through photos, movies, or other binary formats.

7. Future Work

We are taking different approaches to expand and enhance our foundation. The first is the incorporation of our framework's PIM (Process Integrated Mechanism) (Quitadamo et al., 2008) technology. The Institute for Human and Machine Cognition laboratory in Florida, USA, is the one using this technology. The concept that persists is the use of a single process (referred to as the Coordination Process) to coordinate a group of entities as it passes through the robots directing their actions. Our goal is to utilise it to coordinate the operational agents by integrating it with our system. The Coordination Process will perform two tasks as it moves through the Operative Agents and Activator. The initial step is to get the new tasks from the Activator and assign them to MOAs in accordance with their availability and location. The second involves the patient's dispatch to FOA based on the distance between the hospitals and the disorders they treat. In any case, since the MOA has all the information required regarding the patient's medical state, it will continue to decide the pathology and how bad it is. Performance should rise when a single process is used since less communications will occur between agents. The second path involves creating and evaluating user interfaces for smartphones, namely for those running iOS and Android. Specifically, the JADE tool for Android will be integrated with the Android-powered devices.

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