Mobile Agent Paradigm Integration for New Service Models in Smart Ambulance

Sophia ALAMI-KAMOURI, Ghizlane ORHANOU, Said ELHAJJI

Abstract*: The Internet evolution has enabled the entire world to disseminate and access a large amount of unlimited information and data. The problem is that this wide distribution of data involves increased traffic on the network and implies a waste of time and bandwidth. The purpose of this work is to integrate the mobile agent paradigm into the connected ambulance to provide the patient with an efficient service throughout her way to the hospital by diagnosing the patient's condition and receiving recommendations. The mobile agent approach is proposed as an efficient model for processing and transferring data over the wireless network and addressing the needs of distributed and intelligent systems as opposed to the classic Client / Server model. We have already proposed a first service model for smart ambulance based on mobile agents. In this article, we detail this study and propose different service models for different use cases. In addition, we perform an implementation of our service model using JADE platform to show its feasibility.

Keywords*: heavy agent, jade, lightweight agent, local agent, mobile agent, smart ambulance.

I. INTRODUCTION

Today's technological trends such as intelligent systems, Internet of things, have led to the search for a model that allows sending and receiving data in real time. The mobile agent is an approach that has gained ground in the distributed system field due to its unique characteristics that meet the needs of new technologies and distributed applications. The agent model provides more benefits and flexibility than the traditional client/server model:

- A mobile agent can migrate autonomously between the different nodes of a network to perform calculations on its behalf.

- It's able to make decisions without the direct involvement of the user.

- The mobile agent allows secure Intra-net communications over public networks because they could be encrypted when they cross the network.

Several domains have benefited from the mobile agent approach like:

- Big data that processes data of large capacities and volumes. Thanks to the hadoop software, companies can store and process large data and duplicate this data on other machines in order to tolerate failures. Despite its advantages hadoop has several disadvantages, to face; the authors in [1] propose a new framework including the mobile agent model instead of the server client model.

- The Internet of Things is one of the hot topics. To process the data and to be able to communicate between different objects it is imperative to have a method that connects the intelligence of the objects, the cloud computing, the wireless sensors between them. This paper [2] is based on the integration of the mobile agent model to have this fusion. Add a sensor and intelligence to base objects for a system with unique identifiers that can transfer data over a network without the need for interaction between communicating entities.

- The health care field. The mobile agent paradigm is used in applications that treat remote patient tracking, applications that collect and process data and in smart healthcare [3].

The present paper aims to describe the principal concepts and advantages of smart ambulance and to present our proposed service model for smart ambulance using mobile agent model to enhance interaction and cooperation between different entities. The objective is to offer a quick and efficient service to patient during the period of his existence in the smart ambulance.

The paper is organized as follows: Section II presents the new concept of smart ambulance and defines how this ambulance can minimize and reduce unnecessary transport to hospital and respond quickly and efficiently to emergencies. Related work and existing projects are also presented in this section. Section III studies the use of mobile agent in telemedicine and presents some existing approaches that use them. In section IV, we propose our model of smart ambulance using mobile agent to look in a short period of time for the adequate hospital for the patient and the immediate care to administrate. Section V will focus on the implementation of our service model to prove its feasibility. Finally, the article is concluded in Section VI with conclusion and discussion

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about the proposed model and future work.

II. THE AMBULANCE OF THE FUTURE CONCEPT

A. The goal of smart ambulance

The ambulance of the future is a connected and intelligent ambulance, which has the ability to act quickly and arrive on time to the sick. Its role is to make an immediate diagnosis since the first minutes are crucial for the patient. With the smart ambulance, we are no longer required to bring people to the hospital if they do not really need it.

The particularity of this ambulance is its ability to respond quickly to emergencies, the ability to send and receive information about the patient by contacting hospital doctors for further diagnosis and even for more appropriate care service. For this, these smart ambulances should be equipped with several sensors and chips to be conform with a regulatory vision, transmission and dissemination of information.

When the patient is in the ambulance, the nurse will take his health parameters such as heart rate, body temperature, blood pressure, level of blood, etc., that will be sent to the hospital. These parameters will be displayed in the unit of the hospital on a computer that will be accessed by local nurses.

The most crucial aspect of the smart ambulance is its ability to send and receive data between concerned entities during a short period of time. From here, we had the idea of using the mobile agent model to propose an efficient communication model based on mobile agents.

B. Related work

In this section, we will talk about various existing works and ideas on the intelligent ambulance:

SAEPP project: abbreviation of Smart Ambulance European Procurers Platform, a group of researchers in different areas of hospitals and health care with other organizations have set up a prototype ambulance equipped with new technologies that will help reduce the transport of patients to the hospital by treating them on the spot [4].

Intelligent Ambulance with Traffic Control: Nowadays, the number of cars in circulation has increased in addition to traffic jam problems, so that an ambulance cannot arrive in time in this case to provide first aid to the patient and bring him to the hospital in the shortest time. To overcome this situation, the paper in [5] describes a system that will control the traffic signal. The authors have developed an algorithm that will locate the ambulance and allow it to quickly reach the hospital by manipulating traffic signals.

Smart Pods: The objectives of Smarts Pods are to understand current models of emergency care and provide ECPs (Emergency Care Practitioner) with the vehicles, equipment and space they need to carry out more effective assessment and treatment on scene, thus minimizing the number of patients admitted to hospital. These would be achieved through the enhanced capabilities of emergency care practitioners, highly trained paramedics able to diagnose, treat, refer and discharge patients with complaints that can safely be treated without transporting it to the hospital [6].

Multi-agent system for coordinating ambulances for emergency medical services: The article [11] discusses the development of a multi-agent system that maintains the actual resources distributed organization in Gerona to respond to the challenge launched by the administration of large hospitals. Gerona is a city in northern Spain that has developed a computer system that facilitates the coordination between ambulances. This system selects an ambulance between several ambulances which will arrive first at the patient's place, give him the first care and transport him to the appropriate medical center by coordinating between several ambulances taking into account the tasks to be performed in addition to the estimated arrival time of the ambulance.

The next section focuses on works based on mobile agents in Telemedicine.

III. TELEMEDECINE BASED ON MOBILE AGENT MODEL

In distributed systems, client server model is the most used model. According to this model, when a customer needs a service, it typically sends a request to the server providing this service. If the customer needs a service that a particular server does not provide, they must send multiple requests to other servers to find the desired information. The problem is that this communication increases network traffic causing inefficient use of bandwidth.

To remedy to these problems, different types of enhancement were made to the communication model to support mobility at the system level. The mobile Agent model is the solution, thanks to its mobility, its ability to migrate from one host to another to find the information needed in a short period of time.

A. Types of mobile agent

There are many mobile agent types. In our proposed model [9], we focus on the following types:

- Lightweight agents: they are small agents able to move with a very short transmission time. Once their mission is over, they disappear.

- Heavy agents: unlike light agents, this type of agent is dedicated when a task requires long processing, its use is rare. They are called by this name because of the size of the executable code and that of the transported data which is much larger than that of the light agents.

In addition to the lightweight agent and heavy agent, we will use in our proposed model, an ambulance local agent.

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B. Related work

In this subsection, we will provide related work where mobile agents are used in telemedicine.

Multi-Agent Systems for E-Health and Telemedicine: the authors discuss in this article [7] the importance of using mobile agents to develop application in e-health for the patient's data exchange and remote monitoring. According to the authors, mobile agent technology is a promising technology with its flexible coordination and interaction capability that enables mobile agents to cooperate in achieving shared objectives of resources and tasks and to allow some degree of automation, which corresponds to the new environment in which health-care is provided.

Mobile multi-agent information system for ubiquitous foetal monitoring: this article [8] presents the design and development of a distributed information system based on a multi-agent mobile platform for automated foetal monitoring in real time. To overcome the problems of interoperability and opening in heterogeneous environments, the use of mobile agents and the deployment of a platform in the environment JADE is the solution used.

Context aware mobile agents for decision making support in health care: this paper [12] brings together Context Awareness, Software Mobile Agents and Decision Support Concepts by providing a real-time distributed system for the health-care emergency field.

In our approach we have used mobile agents for more interaction and cooperation between different entities in a short period of time.

IV. PROPOSITION OF MOBILE AGENT MODELS FOR SMART AMBULANCE

In our previous work [9] which will be extended in the present one, we propose a mobile agent service model able to diagnose the patient's conditions and find appropriate hospital using interaction and cooperation between ambulance and hospital.

The objective of our work is divided into 2 parts: immediate objective and objective once at the hospital.

We have two service models, the first one (Figure 1 and Figure 2) concerns the case where the patient has a medical history in particular hospital [9], the second case (Figure 3 and Figure 4) concerns a patient that is not attached to a particular hospital. This is the case that we will detail in this paper.

A. First use case: Patient with medical history

For the first model, it is well detailed in our paper [9]. The figure1 shows the proposal scheme.

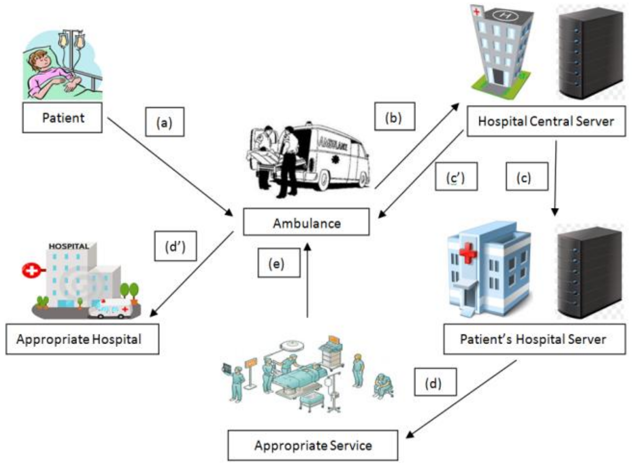

Figure 1. Proposed scheme for the first service model

In order to ensure these exchanges efficiently and in the short time, our proposition is the use of mobile agent model. As we have seen previously, we will use three types of mobile agents: local agent, heavy agent, lightweight agent.

- The heavy agent execute a task that involves lengthy periods of treatments, such as searching in patients database, which contains all needed information about them.

- The local agent, as his name indicates, will operate in the proposed ambulance.

- The lightweight agent will be the intermediary between the local agent and the heavy agent because of its low cost bandwidth.

The diagram in Figure 2 shows the role of the mobile agent model in data transmission to get a precise answer in a brief time, in the first case of the first service model (Figure 1).

For all diagrams, we will use the follow diagram key:

- This figure designates the Local Agent: 
- This figure designates the Lightweight (LW) Agent: 
- This figure designates the Heavy Agent: 

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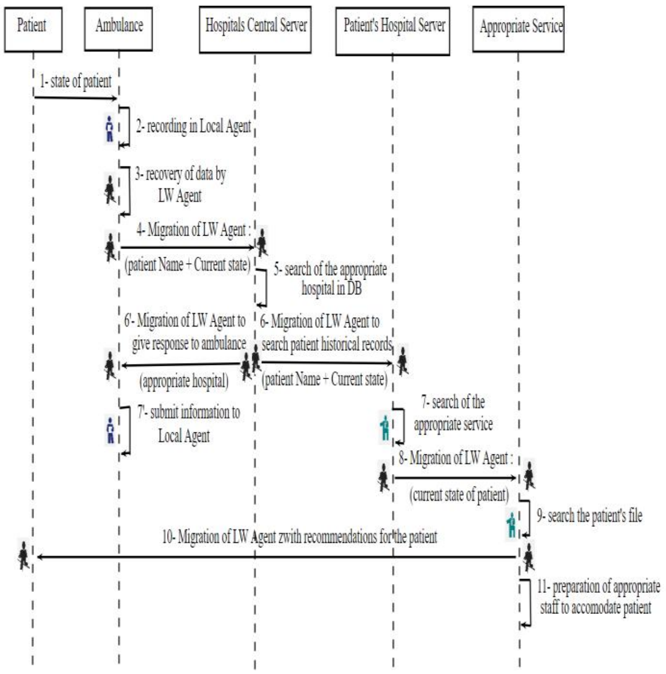

Figure 2. Diagram of data transmission for the first model

Model description:

Figure 2 above shows the position of each agent and its role when transmitting data. The explanation of this case is already published in [9].

B. Second use case: Patient without medical history

In the case where the patient has no medical history, the service model is as shown in Figure 3:

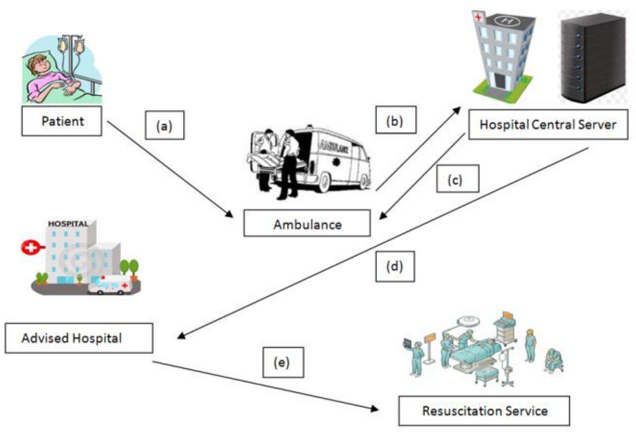

Figure 3. Proposed Architecture for the second service model

Below is explained the proposed architecture for the second service model:

(a) When the patient is in the ambulance, the nurse takes his healthcare parameters like: heart rate, blood pressure, temperature body and blood level.

(b) These parameters are sent to the Hospital Central Server to know if the patient is attached to a particular hospital or not.

(c) Hospitals Central Server finds that the patient does not have a medical history, so, with the data received on the patient, he advises the ambulance to send him to an appropriate hospital.

(d) Hospitals Central Server sends the patient's data to the advised hospital according by the current state.

(e) Advised hospital declares the arrival of the patient and prepare the resuscitation service.

In the case where the patient has no medical history as seen in Figure 3, the diagram of data transmission becomes as shown in Figure 4.

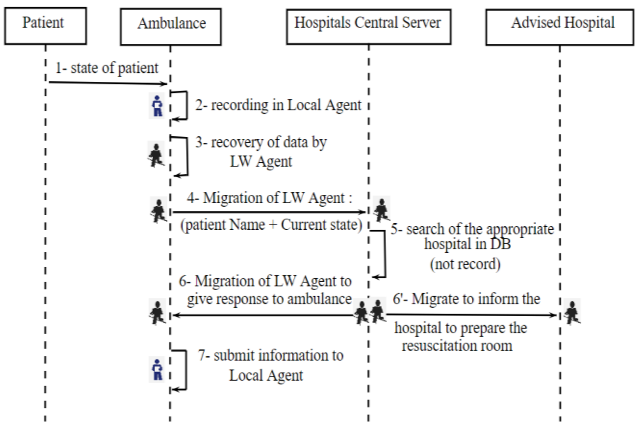

Figure 4. Data transmission diagram for the second model service

1. Once the patient is in the ambulance, the nurse takes the name and the current state of patient (current state means healthcare parameters).
2. These data (name of patient + current state) taken by the nurse are recorded in the local agent in the ambulance.
3. These data are retrieved by lightweight agent.
4. Lightweight agent move to the Hospital Central Server to search information about this patient.
5. When the lightweight agent looks in the database and doesn't find a history and information about the patient.
6. Then, the lightweight agent returns the response to the ambulance: the patient is not attached to a hospital and according to his case is advised the nearest hospital.

V. IMPLEMENTATION OF OUR MODEL

In this part, we look the implementation of our proposed approach to show

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the role and the functioning of the mobile agent in addition to the feasibility of the model.

A. The JADE platform

We developed our application with JADE (Java Agent Development framework) platform. JADE is a middleware allowing developers to build multi-agent systems. JADE is distributed by Telecom Italia and is free software [13].

JADE uses Java language and offers many Java packages, offers programmers applications at once: [10]

- ready-made features
- abstract interfaces for personal tasks depending on the application

B. Deployment mobile agents with JADE

An agent of JADE complies with FIPA standard, has a life cycle, has one or more behaviours (of behaviours type) which designates the operations to be executed, communicates with type ACL messages (Agent Communication Language) and provides services. The agent is globally identified by an AID (unique name).

The JADE agent platform is composed of agent containers that can be distributed over the network. Mobile agents live in containers that are Java processes that provide all the services needed for hosting and executing agents.

When creating our platform on JADE, systematically we have a Main-container that contains three agents, as shown in figure 5:

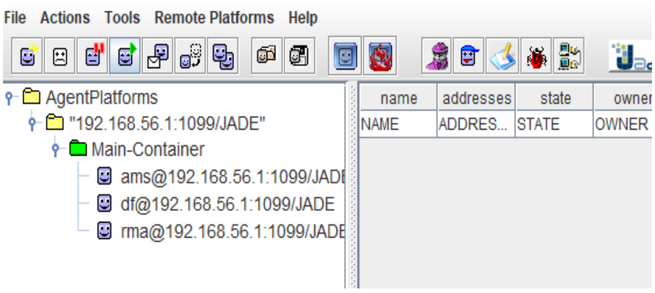

Figure 5. Main-container in JADE platform

- AMS (Agent Management System) agent: is an agent who performs supervisory control over the access and use of the agent platform, each agent must register with the AMS to obtain a valid AID. It is enabled by default once the main-container is started.
- RMA (Remote Management Agent) agent: agent implementing the JADE Management Console itself. All the actions done in the GUI, it's RMA who does these operations.
- DF agent: (Directory Facilitator) compared to the Yellow pages, agents wishing to advertise their services register with the DF. Visiting agents can then ask (search) the DF looking for agents which provide the services they desire. It is enabled by default once the main-container is started.

C. Description of our model's nodes

The main components of the proposed architecture are detailed below:

Ambulance node: it is the most important node in our architecture in the form of a terminal to provide a graphical interface to interact with the application. Here, the nurse will:

- Enter the patient's name and current status.

- Launch of the mobile agent to bring the necessary information.

- Wait in return for the name of the patient's hospital, in addition to the first aid to be administered according to his case.

Hospital Central node:

- The Lightweight mobile agent, once he recovered the data, he will migrate from the ambulance to HCS to search the database for the hospital.

- Once the name is found, this answer will be sent to the ambulance to take the path to the appropriate hospital and at the same time sent to the concerned hospital.

Patient's hospital node:

- Once the message is received, the heavy agent will search the patient's database for his medical records.

- Prepare for the patient's arrival and send the ambulance first aid.

Figure 6 shows the platform of the application with the different nodes that are defined in Jade as Containers, each container with the agents that are part of this node.

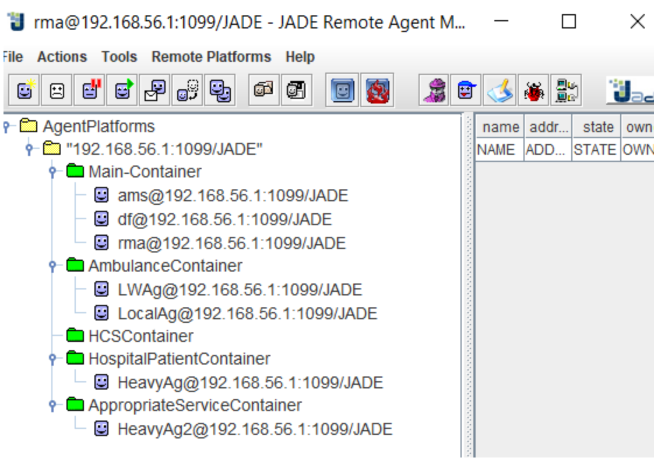

Figure 6. Application platform

When the data are entered by the nurse as an ACL message

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(figure 7), these data are stored in the local agent (figure 8) and are recovered by the lightweight agent.

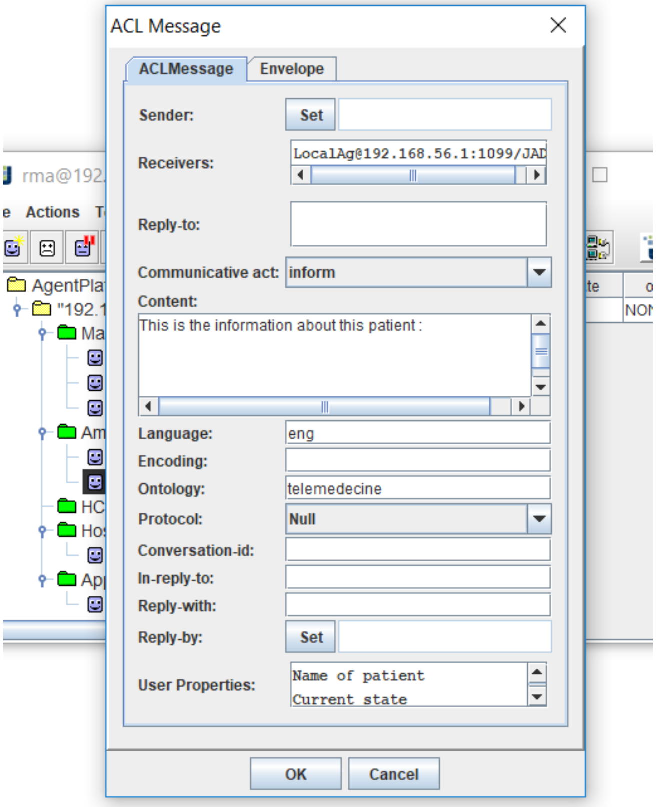

Figure 7. Data entered by the nurse

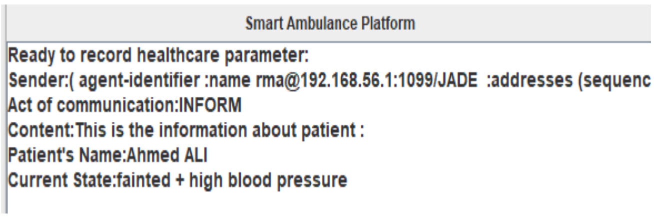

Figure 8. Recording data in local agent

The Lightweight agent migration from the ambulance node to the HCS (Hospitals Central Server) node is performed once the data are retrieved from local agent, as shown on figure 9.

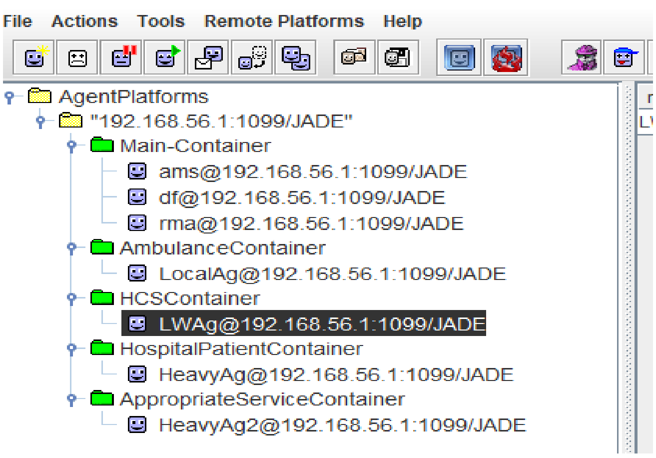

Figure 9. Migration of lightweight agent

Once the lightweight agent moves into the central hospital server, its looks in the database for the name of the appropriate patient hospital. When found, it sends the information to the hospital local agent and in the same time to the ambulance local agent. Figure 10 below shows the message received by this later.

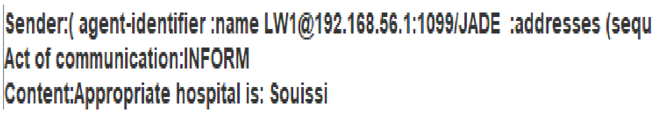

Figure 10. Data received by the ambulance local agent

Figure 11 illustrates the communication between agents in different locations.

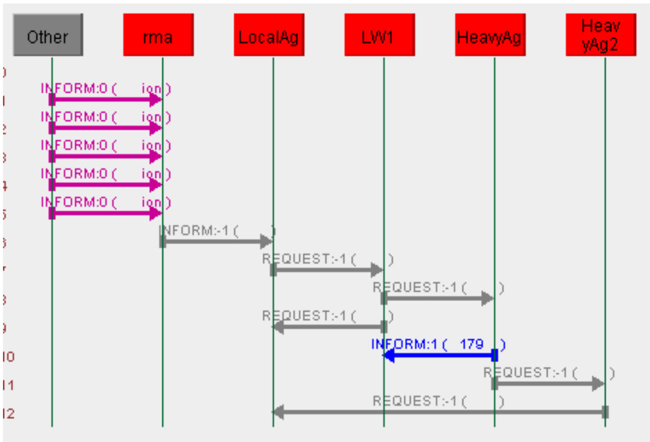

Figure 11. Traffic flow between agents

VI. CONCLUSION AND DISCUSSION

In this article, we have integrated mobile agent technology in the smart ambulance. This paradigm is very useful in smart environments because it meets the requirements of smart applications. Its major advantage is its ability to allow programs to move from one host to another to accomplish a certain task or only transfer the useful data. Our work focuses on the ambulance of the future and especially on its ability to diagnose and communicate the patient's state to the hospital to receive the doctor's recommendations quickly. Once the patient's condition is registered in the local agent, LW agent retrieves his data and migrates to the central hospital to look for the appropriate hospital. Two cases were studied: the case when the patient is attached to a hospital and the second when it is not. When getting the needed information, the LW agent is cloned. The original one continues his migration to the hospital and the cloned one return with the hospital address to the local agent in the smart ambulance.We have implemented our models in Jade framework to test the LW migration from one platform to another and its communications with local agents. Through the use of ACL messages and the traffic flow, we were able to give a clear idea of the operation of the whole mobile agents system used by our proposed models. In the future, we will be more interested in the security aspect of mobile agent's model services.

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