Distributed RFID Multi-Agent System for Healthcare Hospitals

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Abstract. Dependence is a permanent situation in which a person needs important assistance from others in order to perform basic daily life activities such as essential mobility, object and people recognition so there is growing need to supply constant care and support to the disabled and elderly patients.Cao et al. (2011a) Hospital today are under increasing pressure to increase the quality and efficiency of patient identification and monitoring procedures. Hospitals across the country face the same reoccurring problem: tracking and effectively managing high volumes of medical devices. Inevitably, the complexity of these issues often compromises efficiency, safety, and patient care and risk management Su and Shih (2011), Cao et al. (2009) It is necessary to develop intuitive systems with some degree of intelligence, with the ability to recognize and respond to the needs of individuals in a discrete and often invisible way. Intelligence proposing new ways of interaction between people and technology, adapting them to the needs of individuals and their environment offers a great potential to improve quality of life and simplify the use of technology by offering a wider range of personalized services and providing users with easier and more efficient ways to communicate and interact with other people and systems This paper proposes an RFID distributed based system that integrates RFID and multi-agent technologies in health care in order to make patient emergency care as efficient and risk-free as possible, by providing doctors with as much information about a patient as quickly as possible. It is aimed to enhance assistance for patients in healthcare environment by reducing risks.

1 Introduction

There is an alarming statistic from an international healthcare organization show that a huge number of people died in hospitals each year as a result of preventable medical errors. In addition, one third of personnel time is wasted in searching for medical equipment and patient files. Our distributed RFID multi-agent system is designed for the tracking, management and control patients in healthcare environment, improving patient' safety, eliminating or reducing

healthcare errors, improving the workflow of doctors and nurses , locating medical staff in real-time which are especially worthy, helping enabling patient tracking in hospital, bringing down health care costs but also facilitating automation and streamlining patient identification processes in hospitals, increase patient satisfaction, reduce patient complaints.Cao et al. (2011a), Cerlinca et al. (2010a).

Agent technology has proved to be a reliable tool with great potential for solving problems in large scale distributed systems. Multi- agent systems provide a solution for gathering heterogeneous information distributed in different healthcare specific systems and integrating it in order to build the complete medical history of a patient. Agents and multi-agent systems (MAS) have become increasingly relevant for developing distributed and dynamic open systems, as well as the use of context aware technologies that allow those systems to obtain information about the environment.

This paper presents an RFID-based multi-agent system in order to make patient emergency care as efficient and risk-free as possible. We use Distributed system principles to apply its features and characteristics to our system, then we used Multi agent and BDI agent approach to solve the complexity and build intelligent in our system. For the simulation part we use netlogo to simulate our model.

2 Related Work

Agents and multi-agent systems in dependency environments are becoming a reality, especially in health care. Most agents-based applications are related to the use of this technology in the monitoring of patients, treatment supervision and data mining.

Tapia et al. (2008a) Corchado present Ambient Intelligence based distributed architecture that uses intelligent agents with reasoning and plan- ning mechanisms. The agents have the ability to obtain automatic and real-time information.

about the context using a set of technologies, such as radio frequency identification, wireless networks and wireless control devices. The architecture presented by Tapia et al. (2008b) can be implemented on a wide diversity of dynamic environments to manage tasks and services. Lanzola et al. (1999) present a methodology that facilitates the development of interoperable intelligent software agents for medical applications and propose a generic computational model for implementing them. The model may be specialized in order to support all the different information and knowledge related requirements of a hospital information system. Kumar and Cohen (2000a). Cohen present using concepts from multi-agent systems literature for designing robust multi-agent systems and showed that teamwork and autonomy can be used to achieve this end. they introduced the Adaptive Agent Architecture (AAA) and discussed the design and performance of its fault-tolerance implementation.

3 System Model

There is an ever growing need to supply constant care and support to the disabled and elderly patients. The importance of developing new and more reliable ways to provide care and support to the elderly, and the creation of secure, unobtrusive and adaptable environments for monitoring and optimizing health care will become vital.

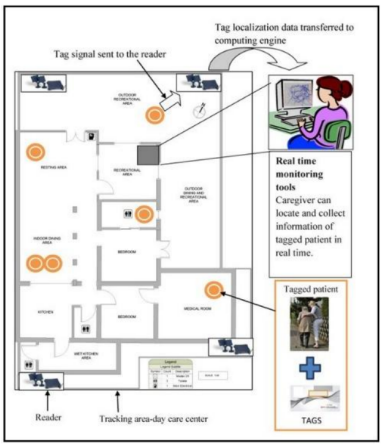

FIG. 1 – *System Architecture*

Our System is Distributed RFID Multi Agent System (DRMAS) having Intelligent capabilities interact with humans and take decision in risky cases, aims to increase quality of healthcare services provide by hospitals especially which designed for disabled and elderly patients.

DRMAS provides different services as monitoring and tracking patients doctors nurses and assets, managing high volumes of medical devices, improving patient's safety, eliminating healthcare errors, locating medical staffs this will increase patient satisfaction and reduce their complains. The below pictures show that all patients and objects inside the hospital will be tagged and monitoring screens and alerts will send if any vulnerability happened.

4 DRMAS As Distributed System

DRMAS consists of a set of human actors (patients, doctors, and nurses), devices such as (sensors, RFID tags and readers, computers and backend server) and adaptive mechanisms which work together in a distributed way. This collection of independent components that communicate with each other through a net- work and a distribution middleware is responsible for coordinating those component activities and sharing the resources of the system, so that users of the system think that they are dealing with a single system.

In our system we put tags on all pieces of medical equipment and on main actors (e.g., scalpels, thermometers, samples, beds, disabled and elderly patients, nurses, doctors.

...etc.) and drug products for inventory management. Each storage area or patient room is equipped with RFID readers that scan all tagged devices, actors, drug products, and their associated cases, such an RFID-based infrastructure offers a hospital a near real-time ability to track and monitor objects and detect anomalies (e.g., misplaced or mismatched objects) as they occur.

DRMAS consist of sub Modules each one has its own functionality and provide certain types of services. Virtualization in Distributed System build special environment for each

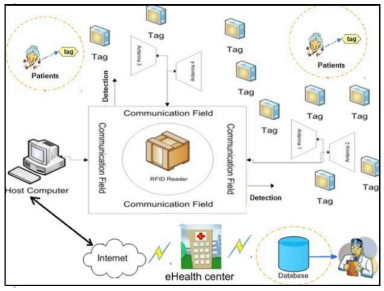

FIG. 2 – *A Distributed RFID System*

component, there is many APIS that used to make components talk together to achieve the final goals of our system. the below picture shows that all tags are spread in distributed way ,readers spread in the same way , all readers send the data to distributed database servers that interact with distributed applications servers. Because DRMAS is Distributed System, it has the following characteristics:

4.1 Scalability

A system is said to be scalable if it can handle the addition of users and/or resources to work efficiently without suffering a noticeable loss of performance or increase in administrative complexity.

Scalability of a system can be measured along at least three different dimensions. First, a system can be scalable with respect to its size, meaning that we can easily add more users and resources to the system. Second, a geo- graphically scalable system is one in which the users and resources may lie far apart. Third, a system can be administratively scalable, meaning that it can still be easy to manage even if it spans many independent administrative organizations. Lanzola et al. (1999)

Scalability is a desirable property in our distributed system through enabling it to handle growing amounts of work in a graceful manner. A scalable RFID system should be able to handle large numbers of tags without undue strain, and a scalable RFID protocol should therefore avoid any requirement for work proportional to the number of tags. An alternative means of improving the scalability of an RFID system is delegation. Tag delegation involves giving authorized entities the right to query and identify certain tags during a specified period. This clearly has the potential to reduce the back-end server's workload Kumar and Cohen (2000b).

To suit the increasing scale of RFID tracking and monitoring, we develop a distributed approach that performs inference and query processing locally at each location but transfers the state of inference and state of query processing as objects move across sites.

4.2 Openness

General agreement exists that the RFID network should be built on openness. Because RFID allows data to be collected inconspicuously, consumer organizations advocate clear no-

tice of purpose, limiting data collection, and acceptance of accountability by business and consumers. Personal data privacy is of paramount concern. Security and privacy must be balanced against the limits of technology. Those who implement RFID systems should make public their policies and practices involving the use and maintenance of RFID systems, and there should be no secret databases. Individuals have a right to know when items in the environment contain RFID tags or readers. They also have the right to know the technical specifications of those devices. Labeling must be clearly displayed and easily under- stood. Any tag reading that occurs must be transparent to all parties. There should be no tag reading in secret.

The ability of sub component of the system to talk with each other and to talk and integrate with other systems through different well defined APIS and procedures make it easy plug and play system and Openness one.

4.3 Fault Tolerance

The system can tolerate the temporary or permanent failure of individual lo- cation sensing components (location sensors, RFID readers). This model also has a fault tolerance approach to prevent any serious fault accrued in the system and make the system functional will under some fall Cerlinca et al. (2010b)

Clustering and Replication features in all servers in the system will protect it from any failure by this system and services will not be stopped if any crash happened, there is functionality in the system that continuously ping the services and switch to the passive node and restart the dead services and this will achieve the fault tolerance in the system Turcu et al. (2006).

4.4 Reliability

The reliability of an RFID system can be defined as the extent to which the system yields the same result in terms of tag identification and data exchange on successive trials. Furthermore, it depends on the quality of the logistic visibility of objects, which depends on the readability of the tags attached to those objects.

4.5 DRMAS as complex system

The term complexity has been widely used in different contexts by different people. In general, though, system complexity can be de- scribed as a measure of how understandable a system is and how difficult it is to perform tasks in the system. A system with high complexity requires great mental or cognitive effort to comprehend and use, while a system with low complexity is easily understood and used. In this section, we attempt to capture some of the aspects of systems that make them difficult to understand **?**.

Task-Structure Complexity: Task-Structure Complexity measures how difficult it is understanding how to perform a task in a distributed system. some tasks is complex in our system especially tasks related to take decision without human interaction these tasks need implementing intelligence in it.

Size Complexity: Another measure of system complexity is the size of the distributed system. Traditionally, the size of a distributed system is measured by the number of nodes, devices, services, applications or other components. In addition, a distributed system may have high cognitive complexity if users need to be aware of many concepts to use the system.

A concept is any logical item of knowledge defined or used by the system. A concept includes abstract notions like file-types, security policies, context information, device characteristics. Many concepts contribute to greater difficulty in understanding the system. Hence, the size of the body of knowledge required to develop applications for the system, manage the system or use the system to perform tasks is an important measure of complexity.

Complexity related to diversity: Diversity in the elements and components make it complex one. Therefore, increasing in the diversity will increase system complexity, so we have a lot of elements that can't talk to each other and can't communicate with each other. to solve this issue, we have to make tagging to the elements and then grouping them upon on their tags so them we have sub groups and sup modules each group have their own environment by using virtualization in distributed system, all groups interact with each other's upon some identified interfaces for each group.

DRMAS is complex one related to some complex task on it, nonlinearity for our system and diversity of its element and its size complexity, environment for the system continuously changed the ability of the system to adapt with such changes make it complex adaptive one.

Complex Adaptive System (CAS) is systems that have many components, often called agents that interact and adapt or learn Rattrout et al..

CAS is dynamic systems able to adapt in and evolve with a changing environment. It is important to realize that there is no separation between a system and its environment in the idea that a system always adapts to a changing, environment. Rather, the concept to be examined is that of a system closely linked with all other related systems making up an ecosystem. Within such a context, change needs to be seen in terms of co-evolution with all other related systems, rather than as adaptation to a separate and distinct environment.Cao et al. (2011b),Kumar and Cohen (2000a).

We can say our system is complex adaptive system based on the features like self-similarity, complexity, emergence and self-organization that emerge and produce a new behavior that not exist before them connections, and based on the properties (aggregation, non-linearity, diversity, flow) and the mechanism (tagging, building blocks, internal model) of the complex adaptive system. to solve this complexity we used agents and BDI agents as will described below in details Rattrout et al. (2010).

Multi agent systems and intelligent devices-based architectures have been explored in DRMAS providing constant care in the daily life of dependent patients, predicting potentially dangerous situations and facilitating a cognitive and physical support for the dependent patient, facilitate decision-making process for medical staff, providing a larger volume of information about certain situations and reducing the number of operations performed by the human operator. Some agents in DRMAS are based on the deliberative Belief, Desire, Intention (BDI) model where the agents' internal structure and capabilities are based on mental aptitudes, using its internal data as beliefs and decide what job to so as desires and find the best execution plan to execute the job as intentions Fraile et al. (2009) EL OUAZZANI et al. (2018). DRMAS Agents consist of two types of agent Architectural agents and BDI agents Giza-Belciug et al. (2012).

There are predefined agents which provide the basic functionalities of the architecture:

Application/Service Agent: It is responsible for the communication between application, services and the platform; it manages the in- coming requests/response from application to services and vice versa. This agent always is in "listening mode".

Service List Agent: Manages the list of services that can be used by the system and contains the information of all trusted available services.

Messaging Agent: This agent analyzes the structure and syntax of all incoming and outgoing messages. If a message is not correct, this Agent informs the corresponding agent (Application/Service Agent) that the message cannot be delivered.

Team Leader Agent: This agent supervises the correct functioning of the agents in the system. This agent verifies periodically the status of all agents registered in the architecture by means of sending ping messages. Interactionof pre-defined agents The patient through an application has inserted the alert in the system. The Application/Service agent is responsible for registering this information into the system and notifies the Team Leader agent. The Messaging agent confirmed the credentials of the user who enters the information and validates the information entered. The Team Leader agent at the same time performs two tasks, requests the directory agent you select the service to run to launch the alert. The application/Service agent runs the service that launches the alert and finally the alert is sent through the reactive agents of the architecture Turcu et al. (2009).

Our system consists of five different agents based on the BDI model, each one with specific roles and capabilities:

Patient Agent: There is one agent for each patient registered in the system. This agent manages the users' personal data and behavior, maintains continuous communication with the rest of the system agents, especially with the NurseAgent, and with the Doctor Agent. The Patient Agent must ensure that all the actions indicated by the Doctor Agent are carried out and sends a copy of its memory base (goals and plans) to the Admin Agent to maintain backups.

DoctorAgent: There is one Doctor Agent for each doctor connected to the system. This agent runs on mobile devices inserts new tasks into the Admin Agent to be processed by a reasoning mechanism. This agent interacts with the Patient Agents to impose new tasks and receive periodic reports, and with the Nurse Agents to ascertain the evolution of each plan.

NurseAgent: There is one Nurse Agent for each nurse connected to the system. This agent schedules the users' daily activities and obtains dynamic plans depending on the tasks needed for each user. It manages scheduled users profiles (preferences, habits, holidays, etc.), tasks, available time and resources. Every agent generates personalized plans depending on scheduled-user profile.

Admin Agent: There is one Admin Agent running in the system performing two roles: the security role that monitors the users' location and physical building status (temperature, lights, alarms, etc.) through continuous communication with the Devices Agent; and the manager role that handles the sync in database between local servers and center one.

Devices Agent: There is one Devices Agent running in the system. This agent controls all the hardware devices. It continuously obtaining/updating data from sensors, interacts with sensors to receive information and control physical services (temperature, lights, door locks, alarms, etc.), gather all RFID tag read from all tagged objects, and also checks the status of the wireless devices connected to the system. This agent interacts with the Admin Agent to send the obtained information for processing.

Most of the work done in fault handling in multi-agent systems deals with detection and recovery from faults such as state- inconsistencies, relying on the traditional techniques for recovering from other distributed systems failure.

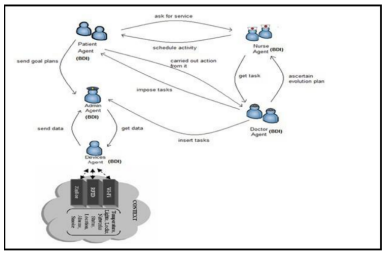

FIG. 3 – *Agents Workflow in the Distributed RFID Multi-Agent System*

If an agent needs to perform a task which involves another agent, it must communicate with that agent to request it. So, if the agent is down, all its functionalities will be unavailable to the rest of agents. The system depends on these mechanisms to generate all decisions, so it is essential that they have all processing power available to increase over-all performance. The problem is solved in a distributed way, so that if a component (agent) fails, the rest of the agents continue working. Moreover, the agents have certain responsibilities through which an agent looks for the over- all integrity within the system.

The agents in RFID system collaborate with context-aware agents that employ Radio Frequency Identification, wireless networks and automation devices providing automatic and real time information about the environment Rabhi et al. (2018). These technologies also allow the users interacting with their surroundings, controlling and managing physical services (i.e. heating, lights, switches, etc.).

All the information is processed by the agents, specially the Devices Agent which is a BDI agent that that runs on a Workstation. The Devices Agent monitors the users' location (continuously obtaining/updating data from RFID readers), interacts with the devices to receive information, control physical services, and also checks the status of the wireless devices connected to the system (e.g. PDA). The information obtained is sent to the Admin Agent to be processed.

All hardware is some way integrated to agents, providing automatic and real time information about the environment that is processed by the agents to automate tasks and manage multiple services. Next, these technologies are described.

To generate a new plan, a Nurse Agent sends a request to the Agents Platform. The re-quest is processed by the Manager Agent which decides creating a new plan. Then, the solution is sent to the platform which delivers the new plan to all Nurse Agents running. The planning mechanism creates optimal paths and scheduling to facilitate the completion of all activities defined for the nurses connected to the system.

4.6 Comprehensive view for DRMAS

DRMAS consists of sub models which include patient sub model that deal with the patient profile for each one consists of their habits, behavior and disease history, second sub model is the doctor sub model which consist of doctor's profile and time schedules, third sub model is nurse sub model to schedule patients' daily activities and obtain dynamic plans depending

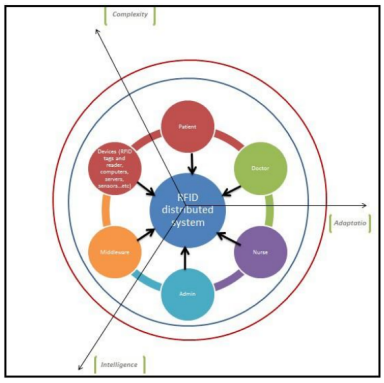

FIG. 4 – *Multi-Dimensional Model for Multi-agent Distributed RFID System*

on the tasks needed for each user and manage nurse profile, fourth sub model is the admin model, sixth sub model is device model. Note that each model as its own environment in our distributed system through virtualization and these sub models should interact with each other Nurse interact with the patients to build their profiles in the patient model, doctor should ha access on the data entered in this model to be able to see his patient profile, doctors interact with the nurse to arrange schedule for the patients and then inter- act with admin agent to insert the new tasks as reschedule timing or absent, then admin agent will send SMS to nurse model to reschedule the times or change all the times to the available doctors, device model interact with the hardware devices to collect information about the environment as temperature, lights, fire and read RFID tags and send information to the admin model, in case of fire happened, the intelligence in the admin model will send SMS to all doctors and nurses in the building to take all the patients away and evacuate the building.

If any patient tries to escape, directly de- vice agent read patient RFID tag and sends it to the admin agent which in turns will make an alarm and send SMS to the nurses available near to this patient to stop it. Through this mechanism it is appeared the intelligence in our distributed system.

If we look to the system from complex view we have to look at the diversity of elements in the system, incremental growth in system size, complex tasks in the system, nonlinearity and dynamic changes in system environment.

If we look to the system from adaptation view we must look at the ability of the system to adapt with dynamic changes on its environment this appear in reschedule all patients timing if one doctor is absent.

If we look to the system as intelligent one, we must see all tasks that needs human's decision and executed by the system without human interaction this appeared clearly if one patient try to escape in disables hospitals, so system will make alerts and send SMS to all available nurses to stop the patient.

4.7 Trust relation in DRMAS

Trust in our system is look like decision making when deciding whether or not to honor contracts, and as a mechanism to search trust- worthy exchange partners , trust appear clearly between RFID tags and reader , trust between them make tags to send its signal to the reader without authentication , and make reader to trust device agent to read its data and send the admin agent , trust make admin agent to accept data from the device agent without any doubt on it to make some decision regarding physical status of building and monitoring for the patients Zhao et al. (2006) Rhazlane et al. (2016).

Co-operation between agents is essential in our system. These agents have very limited knowledge. Agents should be designed to creating assessing and removing solutions. Consequently, some agents should interact to accomplish some tasks, interaction between nurse agent and doctor agent will help nurse agent to build daily activities and checks for the patients. Interaction between doctor agent and admin agent in case of doctor absent will reschedule all patient timing to that doctor to the available doctor. These interactions will build in term of trust between these agents, so agents should design and implement to support this trust Yahalom et al. (1993).

5 DRMAS Simulation

DRMAS focus on changing the quality of healthcare services provided by the hospitals specially which designed for elderly and dis- abled patients through using RFID technology and BDI agent (Rao et al. (1995)).

NetLogo 5.1.0 used to create this agent- based model. In this model, the physician team is treated as a single entity interacting with patients. Each team has the following key attributes which can be varied: attend- ing attitude, and sense making, RFID tagged or not Depending on the variations in these key attributes, patients will have differential likelihoods of improving tracking patients in healthcare environment. In this figure, the set-up parameters are in the top left. The center of the figure shows the team in the center, the color of each patient reflects that patient's status. The blue ones represent patients who are still inside healthcare environment while red one represents those who try to go out. The graphs on the right demonstrate the daily census and average length of stay for patients on the team as the month progresses.

Attribute contains check condition whether the staff to be tagged by RFID or not, chose on to make them tagged and off to make them not tagged. What can be noticeable that if we choose doctors to be tagged the stay for patient graph will show degradation than choosing to don't tagged the doctor this means that station period for the patient in hospital will decrease if the hospitals staff is tagged.

And about the daily census we can notice that this graph will increase if we choose to tagged the staff, this mean that number of patients comes and served by the hospital will increase and this will increase the overall outcomes of the hospital

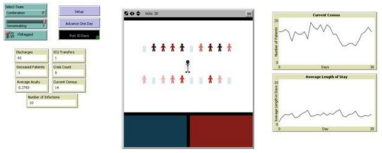

FIG. 5 – *DRMAS SIMULATION*

6 Conclusion

In this research we have proposed the DRMAS as multi agents paradigm for distributed RFID system, however agents are used for control, sensing and aggregating data. Complexity, scalability and adaptation in distributed RFID system are studied in this paper and a suitable solution using intelligent agent was proposed to address those aspects of such systems.

Our proposed distributed system used RFID technology to provide a solution for enabling the medical staff to access the patient medical history, by using an RFID tag that stores essential information about the patient and acts as a gateway to the complete electronic healthcare records of the patient, tracking and monitoring actors and devices, helping patient to complete their daily activities. Help to in- crease patient safety. The implemented multi-agent system allows the collecting and integrating heterogeneous information distributed in specific systems of various medical units, in order to retrieve the patient's electronic healthcare records as comprehensively as possible.

References

Cao, Z., Y. Diao, and P. Shenoy (2009). Architectural considerations for distributed rfid tracking and monitoring. In *5th ACM International Workshop on Networking Meets Databases*.

Cao, Z., C. Sutton, Y. Diao, and P. Shenoy (2011a). Distributed inference and query processing for rfid tracking and monitoring. *Proceedings of the VLDB Endowment 4*(5), 326–337.

Cao, Z., C. Sutton, Y. Diao, and P. Shenoy (2011b). Distributed inference and query processing for rfid tracking and monitoring. *Proceedings of the VLDB Endowment 4*(5), 326–337.

Cerlinca, T., R. Prodan, C. Turcu, and M. Cerlinca (2010a). A distributed rfid based system for patients' identification and monitoring. In *10th International Conference on Development And Application Systems*, pp. 27–29.

Cerlinca, T. I., C. Turcu, C. Turcu, and M. Cerlinca (2010b). Rfid-based information system for patients and medical staff identification and tracking. In *Sustainable Radio Frequency Identification Solutions*. InTech.

EL OUAZZANI, A., S. OUEDERROU, S. I. EL AHRACHE, N. HARBI, and H. BADIR (2018). Preventive inference control between user profiles in data warehouse. *INTERNATIONAL JOURNAL OF NEXT-GENERATION COMPUTING 9*(2).

Fraile, J. A., D. I. Tapia, S. Rodríguez, and J. M. Corchado (2009). Agents in home care: A case study. In *International Conference on Hybrid Artificial Intelligence Systems*, pp. 1–8.

Springer.

Giza-Belciug, F., C. Turcu, and C. Turcu (2012). An rfid and multi-agent based system enabling access to patient medical history. *International Journal of Information Technology Convergence and Services 2*(5), 1.

Kumar, S. and P. R. Cohen (2000a). Towards a fault-tolerant multi-agent system architecture. In *Proceedings of the fourth international conference on Autonomous agents*, pp. 459–466. ACM.

Kumar, S. and P. R. Cohen (2000b). Towards a fault-tolerant multi-agent system architecture. In *Proceedings of the fourth international conference on Autonomous agents*, pp. 459–466. ACM.

Lanzola, G., L. Gatti, S. Falasconi, and M. Stefanelli (1999). A framework for building cooperative software agents in medical applications. *Artificial intelligence in medicine 16*(3), 223–249.

Rabhi, A., H. Badir, and A. Rattrout (2018). Towards an ontology-based data access system for aggregated search. *Conference on Advances of Decisional Systems*.

Rao, A. S., M. P. Georgeff, et al. (1995). Bdi agents: from theory to practice. In *ICMAS*, Volume 95, pp. 312–319.

Rattrout, A., R. Assaf, and A. Al-Dahoud (2010). Personalizing the dynamic information resources in a self organized web system using cas and mas. *Computer Science and Information Systems 7*(4), 883–905.

Rattrout, A., T. Issa, and H. Badir. Self-organized web resources using intelligent web agents.

Rhazlane, S., H. Badir, N. Harbi, and N. Kabachi (2016). Intelligent multi agent system based solution for data protection in the cloud. In *Computer Systems and Applications (AICCSA), 2016 IEEE/ACS 13th International Conference of*, pp. 1–7. IEEE.

Su, C.-J. and S. C. Shih (2011). Building distributed e-healthcare for elderly using rfid and multi-agent. *International Journal of Engineering Business Management 3*(1.), 16–26.

Tapia, D. I., J. Bajo, J. M. Sánchez, and J. M. Corchado (2008a). An ambient intelligence based multi-agent architecture. In *Developing Ambient Intelligence*, pp. 68–78. Springer.

Tapia, D. I., J. Bajo, J. M. Sánchez, and J. M. Corchado (2008b). An ambient intelligence based multi-agent architecture. In *Developing Ambient Intelligence*, pp. 68–78. Springer.

Turcu, C., T. Cerlinca, C. Turcu, M. Cerlinca, and R. Prodan (2009). An rfid and multi-agent based system for improving efficiency in patient identification and monitoring. *WSEAS Trans. Inf. Sci. Appl 6*(11), 1792–1801.

Turcu, C., C. TURCU, and V. POPA (2006). An rfid and agent technologies based system for the identification and monitoring of patients. In *8International Conference on Development and Application Systems, May 2006*, pp. 234–241.

Yahalom, R., B. Klein, and T. Beth (1993). Trust relationships in secure systems-a distributed authentication perspective. In *Research in Security and Privacy, 1993. Proceedings., 1993 IEEE Computer Society Symposium on*, pp. 150–164. IEEE.

Zhao, W., V. Varadharajan, and G. Bryan (2006). General methodology for analysis and modeling of trust relationships in distributed computing.