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Dedicated to Professor Iulian Coroian on the occasion of his 70^{th} *anniversary*

A multiagent based approach for national cancer registry management

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ABSTRACT. Cancer registry is an informational system for acquiring, managing and analyzing information about neoplazic disease persons. Its purpose is to provide accurate information about cancer occurrence in a particular geographical region. In this paper we present a proposal for the architecture of a multiagent system for national cancer registry.

1. INTRODUCTION

1.1. **Cancer Registry.** A cancer registry is a systematic collection of data about cancer and tumor diseases. The data is collected by Cancer Registrars. Cancer Registrars capture a complete summary of patient history, diagnosis, treatment, and status for every cancer patient in a geographical region. The purpose is to provide accurate, timely information on cancers occurring in the population of that region for research, planning and education.

Cancer registry management systems have been developed in many countries all over the world: USA[6], UK [5], Ireland [2]. Such a system is used to: collect, analyse and store accurate, timely and comprehensive data on cancer; uphold patient and carer confidentiality; facilitate planning of cancer services for prevention, diagnosis, cure and care, and provide appropriate information on cancer for ad hoc queries.

In Romania such a system does not exist. The goal of the CRONIS research project is to develop a registry management system that can be used not only for cancer, but for other nontransmissible chronic diseases. In this paper we present the architecture of such a system. The system is designed using a multiagent based approach.

The similar projects developed in other countries do not use multiagent approaches and do not fully automate the cancer registry management process.

1.2. **Agents.** An **agent** [4] is anything that can be viewed as **perceiving** its environment through *sensors* and **acting** upon that environment through *actions*. An *agent* is characterized by:

- the *architecture part*, or the agent's behavior - the action performed after any given sequence of percepts;

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- the *program part*, or the agent's built-in part - the internal functionality of the agent.

An *artificial intelligent* agent should be endowed with an *initial (built-in) knowledge* and with the capability of *learning*. The learning capability ensures the agent's *autonomy*, i.e., the capability of deducing his behavior from its own experience.

1.3. **Software Agents.** Intelligent **software agents** are a new class of software that act on behalf of the user to find and filter information, negotiate for services, easily automate complex tasks, or collaborate with other software agents to solve complex problems. Software agents [3] are a powerful abstraction for visualizing and structuring complex software. Procedures, functions, methods, and objects are familiar software abstractions that software developers use every day. Software agents, however, are a fundamentally new paradigm unfamiliar to many software developers. The central idea underlying software agents is that of delegation. The owner or user of a software agent delegates a task to the agent and the agent autonomously performs that task on behalf of the user. The agent must be able to communicate with the user to receive its instructions and provide the user with the results of its activities. Finally, an agent must be able to monitor the state of its own execution environment and make the decisions necessary for it to carry out its delegated tasks. There are two approaches to building agent-based systems: the developer can use a single stand-alone agent or implement a multi-agent system. A stand-alone agent communicates only with the user and provides all of the functionality required to implement an agent-based program. Multiagent systems are computational systems in which several agents cooperate to achieve some task that would otherwise be difficult or impossible for a single agent to achieve. Agents within a multiagent system communicate, cooperate, and negotiate with each other to find a solution to a particular problem.

1.4. **Agent-Based Systems.** An **agent-based system** is one in which the key abstraction used is that of an agent. An agent is a system that has the following properties [7]:

- *autonomy*: agents encapsulates some state and make decisions about what to do based on this state, without the direct intervention of human or others;
- *reactivity*: agents are situated in an environment (a physical world, a user via a graphical user interface, a collection of other agents, the internet), they are able to perceive this environment (through the use of potentially imperfect sensors), and they are able to respond in a timely fashion to changes that occur in it;
- *pro-activeness*: agents do not simply act in response to their environment, they are able to exhibit goal-directed behavior by taking the initiative;
- *social ability*: agents interact with other agents via some kind of agent-communication language [1].

The paper is structured as follows. The classes of agents identified are presented in Section 2. Some of the most important use case scenarios are described in Section 3. In Section 4 the agents roles are described. Some conclusions are given in Section 5.

2. The Architecture of the Multiagent based System

After analyzing the requirements for a nontransmissible chronic disease registry management system, we have distinguished the following classes of agents:

- *Personal Agent (PA)*. It is an interface software agent responsible with the management of the interaction with user and the system interface interaction.
- *Collector Agent (CA)*. It is a mobile software agent responsible with the gathering of relevant (important) data from various sources (pharmacies, hospitals, laboratories, clinics, public authorities)/ chronic diseases registries.
- *Interpretive Agent (IA)*. It is a software agent designed for formatting and encoding the primary data sources, obtained from collector agent *CA*.
- *Regional Decisional Agent (RDA)*. It is an intelligent software agent having the following responsibilities:
  - It saves the data received from the interpretive agent *IA* into an historical database. Using this database, and its knowledge base $\mathcal{KB}$, the agent computes a score for each record. This score represents a measure for deciding which records should be saved in the Regional Registry of Nontransmissible Chronic Diseases (RRNCD).
  - Based on the above obtained score, it decides whether or not to update the RRNCD registry.
- *National Decisional Agent (NDA)*. It is an intelligent software agent responsible with updating the National Registry of Nontransmissible Chronic Diseases (NRNCD).
- *Knowledge Management Agent (KMA)*. It is a software agent that further analyzes the data from the national or regional registries in order to provide various types of reports.

3. Use case scenarios

For the nontransmissible chronic disease registry management system we have distinguished: a regional level (corresponding to local nodes) and a national level (corresponding to the central node). At each local node the following use cases were identified:

1. Updating the Regional Registry of Nontransmissible Chronic Diseases (RRNCD).
2. Using the RRNCD.

At the central node the following use cases were identified:

3. Updating the National Registry of Nontransmissible Chronic Diseases (NRNCD).
4. Using the NRNCD.

The flow for each scenario is presented in Figure 1.

In the following we describe the use cases identified above:

1. **Updating RRNCD**
   The interaction with the decision support system is initiated by the user

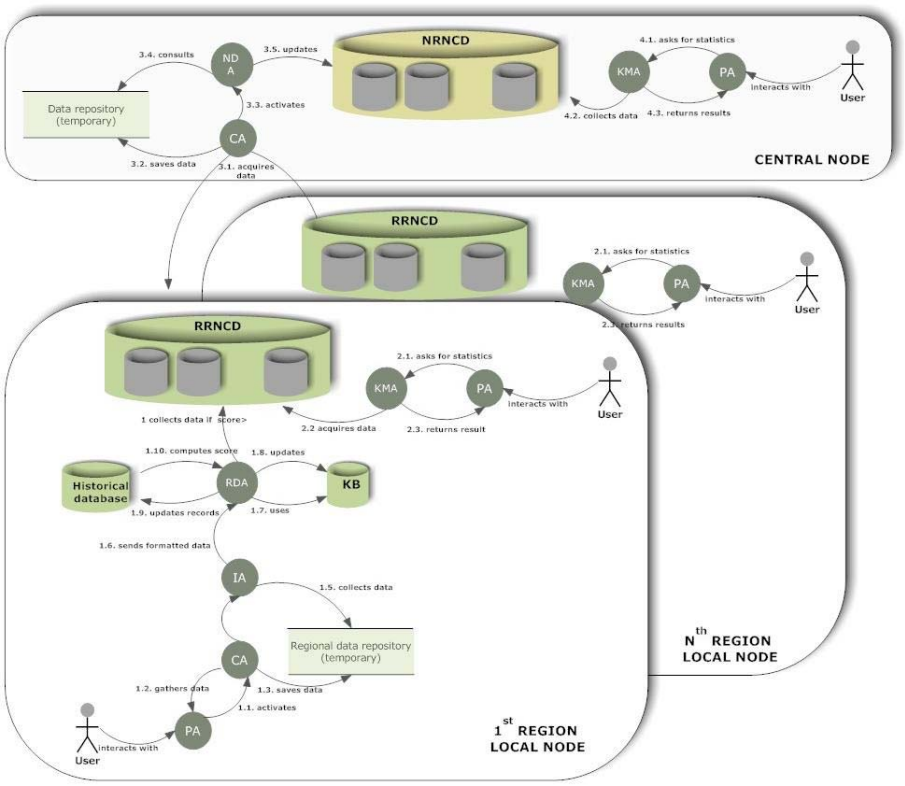

FIGURE 1. Architecture of the agents based system.

that authenticates himself / herself. The authentication activates the personal agent *PA*. The agent stores the data introduced by the user, and it sends an activation message to the collector agent *CA*. The collector agent can be configured to activate itself at user defined periods of time (using the personal agent *PA*). The collector agent *CA* collects the data, saves it in a temporary repository and sends an interpretation request to the interpretive agent *IA*. The interpretive agent *IA* receives the data gathered by the collector agent, formats / encodes them, and sends them further to the regional decisional agent *RDA*. The *RDA* agent saves the received data into an historical database, and then, using its knowledge base, computes the score S for each record from the current dataset sent by the collector agent. Depending on the value of the above computed score, the *RDA* agent decides whether or not to update the regional registry RRNCD associated with the corresponding chronic disease. The score S represents the measure to which a record from the historical database should be included among the records from the regional registry RRNCD. In order for a record to be added to the regional registry RRNCD, the value of

the score S must be greater than the value of a predefined threshold α. The value of the threshold is dependent on the nontransmissible chronic disease corresponding to the regional registry.

2. **Using RRNCD**
   In order to obtain different reports regarding the regional registries, the user interacts with the personal agent *PA*. The agent *PA* sends a message to the knowledge management agent *KMA*. The latter analyzes the data from RRNCD registry, constructs the requested report, and returns it to the personal agent *PA*. The *PA* agent presents the report to the user.
3. **Updating NRNCD**
   In order to gather the data from the local nodes, the collector agent *CA* from the central node gets the data from RRNCD registries, and stores them in an temporary repository from the central node. It then sends an activation message to the national decisional agent *NDA*. The latter consults the temporary repository and decides whether or not to update the national registry NRNCD.
4. **Using NRNCD**
   In order to obtain different reports regarding the national registry, the user interacts with the personal agent *PA*. The agent *PA* sends a message to the knowledge management agent *KMA*. The latter analyzes the data from NRNCD registry, constructs the requested report, and returns it to the personal agent *PA*. The *PA* agent presents the report to the user.

4. Agent Roles

Personal agent (*PA*) is a software interface agent responsible with managing the interaction between the user and the decision support system. It provides assistance to the user and adapts the user interface to the user preferences. As the Scenario 1 shows, it interacts with the Collector Agent (*CA*) at the regional level and corresponding to the Scenarios 2 and 4 it interacts with the knowledge management agent *KMA*.

Collector agent (*CA*) is a mobile software agent responsible for data gathering from various data sources (pharmacies, hospitals, population evidence officials, laboratories, clinics)/ chronic disease registries. At regional level, corresponding to Scenario 1, it communicates with the interpretive agent, sending a request for formatting and codification of the data received form the personal agent *PA*. At national level, corresponding to Scenario 3, the collector agent *CA* gather the data from the regional registries and activates the national decisional agent *NDA* in order to update the national registry of chronic nontransmissible diseases NRNCD.

The interpretive agent (*IA*) is a software agent having the role of formatting and encoding the primary data sources received from the collector agent (*CA*). *IA* takes the data from the temporary data repository from the regional level, formats and encodes it and send it to the regional decisional agent, as described in Scenario 1.

The regional decisional agent (*RDA*) is an intelligent software agent. It stores the data received from the interpretive agent (*IA*) in a historical database. Using the historical database and the knowledge base ($\mathcal{KB}$) it computes the score of a record similar to the records from the chronic disease registry. It predicts, using

learning techniques as neural networks, decision trees or clustering, the degree to which the current record is a possible candidate for saving in RRNCD. Based on the prediction result it decides if the RRNCD should be updated, as shows Scenario 1.

National decisional agent (*NDA*) is an intelligent software agent responsible with updating NRNBC. After being activated by the collector agent *CA*, corresponding to the central level, it consults the national temporary data repository and decides whether to update the NRNCD, or not, as Scenario 3 shows.

Knowledge management agent (*KMA*) is a software agent with the role of processing the data from RRNCD / NRNCD in order to create various reports. After receiving a request from the personal agent *PA* it consults RRNCD / NRNCD, processes the data conforming to user requirements and sends the results to the personal agent, as described in Scenarios 2 and 4.

5. Conclusions

We have presented in this paper the architecture of a cancer registry management systems based on agents. The architecture is general enough to be used for managing other nontransmissible chronic diseases, like diabetes. The proposed architecture will be used for the development of a software system for managing registries of nontransmissible chronic diseases (especially cancer) in Romania.

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