An *e*-organization for *e*-Tools.

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This paper outlines the existing relationships between a set of *e*-Tools developed to support senior citizens and persons with disabilities and that are situated in a giving organization, as a Hospital, and the set of laws, norms and protocols that actually rule that organization. We present a virtual version of this organization and will consider the *e*-Tools, the patients, the healthcare providers as actors that interplay ruled by the actual mechanisms.

Keywords: Assistive Technologies, Institutions, Multi-Agent Systems

1. Introduction

There is a global trend of increasing longevity in our societies; more people live longer and, thanks to the progresses of medicine, many more persons survive acute diseases resulting affected by chronic conditions and some disabilities; as a result, the demographic shift is paralleled by an epidemiologic transition, raising the profile of frailty and disability within world's population [4]. When we refer to elderly and/or disabled people, we make reference to subjects affected by chronic diseases or outcomes of acute events, such as Parkinson disease, dementia, stroke, accidents, etc. They obviously represent a heterogeneous category of individuals: each patient may be affected by at least one of these symptoms: ambulatory impairment, memory loss, staggering gait, ataxia, visuo-spatial dysfunction, aphasia. In other terms, each and every one of these features can be differently combined in these patients in order to impair their self-dependency and to worsen their quality of life. The growing attention given to these citizens creates a need for deploying new types of services to sustain independence and preserve quality of life. Among others the Nursebot project [8] and the Bremen Autonomous Wheelchair [6] represent landmarks in the field cognitive robotics. Many other of those services need to have access to personal data, for example a patient's clinical data or the continuous tracking of that person in a given environment for example, inside a hospital or a house. Those services should not only be efficient but also comply with the actual laws, norms that apply in a country or a region and with the protocols that rule in a hospital.

In [3] we introduced an architecture to design *e*-Tools to support the activities of daily life of the target population in well-known environments. This architecture includes mobile robotic platforms for well-known environments (see fig 1), assistants for the caregivers caring for the patient in such settings, and other intelligent agents assisting the target population. In this work we extend our analysis of this architecture by studying the kind of interactions that exist in this environment and the laws that rule rational interactions between the actors. To do this we will use the HARMON*IA* methodology, introduced in [10], to model the organization. Basically, our aim is to show that by modelling those interactions it becomes easier to model the whole system and that this will help to better understand the complexity of the problem. For example, intelligent agents assisting the patient should allow her to change some non-critical activities, e.g., social engagements, but forbid modifying others as medicine-taking or entering into forbidden or dangerous areas. Our goal in this paper is to provide a picture of the overall system, and to give a sense of our vision of how agent technology can be used to help the senior citizens and persons with disabilities.

The rest of this paper is organized as follows. In §2 we give some details about the *e*-Tools architecture and recent developments. In §4 we illustrate the agent-mediated interactions between the *e*-Tools, the patients, the healthcare givers and the institution.

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In §5 we give our conclusions and talk about the future work.

2. The *e*-Tools Project

Many people facing some disability of all ages base their mobility in the use of a wheelchair. Some times this wheelchair is electric-powered, usually driven with the help of a mouse or joystick that allows the wheelchair to navigate. However, some disabled people experience considerable difficulties when driving a power wheelchair: common manoeuvres (e.g. exiting a room through a narrow door) are not easy; steering commands might not be sufficiently accurate (due to spasticity, paresis or tremor in the upper limbs) and collisions can result; and some users are unable to use their hands at all.

As previously introduced, our target population is characterized by different profiles of functional disability. That means that an electric-powered wheelchair should be flexible to the needs of different patients; at the same time, the wheelchair has to be flexible to the needs of the same patient in different times: patients go a pathway of changing (dys)functionality - possibly improving - during their illness. For this sector of population, a solution is to provide them with a *Robotic Platform* integrating some reasoning capabilities that allow the wheelchair to navigate in areas such as the patient's home, an assisted living facility or a hospital. Most of the time, navigation could be done autonomously under the guidance of the reasoning module.

The robotic platform we propose can be used to support the mobility of senior citizens or persons facing a disability that have a normal wheelchair, see figure 1. The typical environment we thought of is an hospital for the neuro-motor rehabilitation, referring to a real institution represented by IRCCS S. Lucia Foundation, located in Rome. Rehabilitation hospitals are in some way different from primary care hospitals; in this case the goal is represented by the patients recovering enough self-dependency in order to independently perform - at as a high level as possible - his basic activities of daily living. As a matter of fact, during their recovering, patients are trained to make progress in the necessary skill to make their discharge to home possible. Therefore the platform has to show complete autonomy in tasks such as path planning and location in the environment, and at the same time pay attention to the user's needs and requests.

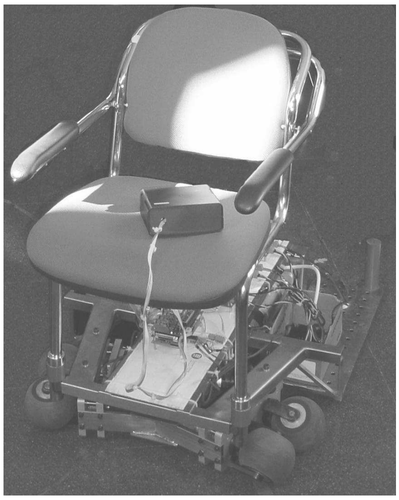

Fig. 1. The *e*-Tools platform

In our approach to the problem the wheelchairs will be driven by the robotic platform. Although we are thinking of a controlled situation in a quite well-known environment, structural elements like corridors, rooms, or halls may differ. Corridors and rooms in the same building may for example have a various width, length and illumination sources, as well as different distribution and uses. Therefore some of the main problems to solve are: (a) the interface with the user, and (b) the navigation problem.

In order to provide proper healthcare management (embedded monitoring and diagnosis functionalities) and to ease the relation of patients with other people and the environment we propose to build an integrated system in which the environment (a home, a hospital) and the people inside it (patients, carers) are connected. This approach integrates Ambient Intelligence (sensors, automatic diallers, automatic cooling and heating system) with solutions related to multiagent systems, machine learning and other AI techniques, affective computing, wireless devices and robotics.

Our proposal is to install, on top of the hardware of the robotic platform, a Multi-Agent System (`MAS`) that controls the behavior of the chair, monitors the state of the patient and interacts with him/her through a flexible interface that provides more or less assistance in navigation, depending on the patient's individual capabilities. Navigation should be autonomously controlled by the `MAS` most of the times, to relieve the user from tedious low-level decision-making tasks. To make this possible, the platform will be wirelessly connected to the environment, where an agent-based coordination layer will provide extra information to the robotic platform MAS. To support the agent-based coordination layer and to connect it with the robotic platform MAS, active landmarks will be installed. This active landmarks are small wireless machines installed in some strategic places of an area to transmit local information to the mobile entity. Similar initiatives and ideas can be found in the design of intelligent buildings for disabled and elderly people (see for example [2]) and in the last generation of road traffic support systems. In order to filter all the information received from the sensors and send only relevant information to a given platform, each room must be monitored and controlled by a MAS. This agent-based controller can proactively make decisions about room conditioning, or process sensor signals in order to extract meaningful information (e.g. to track a given person in the room).

Figure 2 depicts an example of this architecture as it was introduced in [3]. It consists of the following levels:

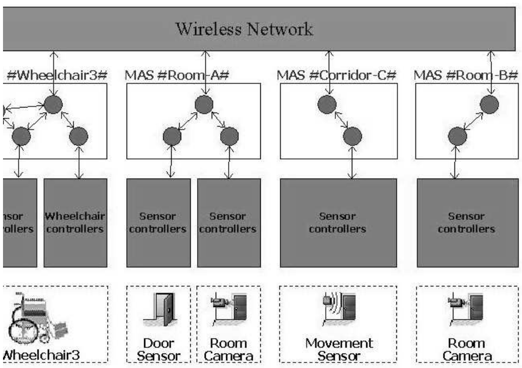

Fig. 2. The *e*-Tools proposed multi-level architecture.

– The *lowest level* contains all the physical devices that are connected to the environment. This level includes the cameras and sensors attached to the walls, patient monitoring systems, PDA's or other portable devices and intelligent wheelchairs.
– The *second level* comprises the hardware controllers that operate the physical devices and send information to the next level. In the case of complex devices such as wheelchairs or cameras, this level should also perform tasks that might need immediate actions to be taken: for example, in the case of the camera, a behavior to follow a person that is being tracked; or in the case of the robotic platform, effective obstacle detection and avoidance (*reactive navigation*) to ensure a high level of occupant safety [9].
– The *third level* is composed of agent-based controllers that receive information from the hardware controllers and combine it with the knowledge they have about the state of the system, to infer *what* information they need to improve their knowledge, *where* to obtain it, and *how* to obtain it. These MAS can also reason about the *relevance* of the information they receive, and distribute it to other agents or controllers that may need it. In order to integrate the information from the different agents in the environment and to coordinate activities and actors (patients, doctors, caregivers), the total population of agents composes the agent-based coordination layer (see §3). As part of this coordination, agents have to reason about the laws, norms and protocols that rule the environment where they interact.
– A *wireless network* provides connections among the previous layers. Since not only the patient's wheelchairs but also the environment and other people's portable devices have agent-based controllers connected to the network, interaction and coordination issues can be solved by the software agents.

3. The *e*-Tools agent-based coordination layer

The use of MAS in the healthcare domain is rapidly growing. These medical systems are designed to perform complex tasks and to gracefully adapt to unexpected events. Still, issues like privacy, security, safeness and trust are very sensitive as agents should have access to patient's medical records and maybe interchange that information with other agents to autonomously perform their assigned tasks.

Our MAS has the following basic agents. First, we have a *Patient Agent* (pa), for each client, that could be integrated into the platform or connected to it, for example, using a PDA. This agent should provide all the available and permitted services to the patient and it should take care of his/hers personal security. Each pa provides a personalized way of interaction with the patient and therefore patients could use it to ask for help or to ask the platform to drive her/him to a given place into the permitted space or to ask the system to show a possible path to the destination. It should ensure that the user is aware of the activities he (the user) is expected to perform, the pa should augment the likelihood that he will perform at least the compulsory activities (such as taking medicines). An important task is to avoid the user to be overly reliant on the system. Also, the pa takes under its responsibility the audit of the patient's biometric signals and it acts in consequence.

The *Medical Agents* (ma) will be situated in the PCs belonging to the medical and sanitary personnel as well as in their individual PDA. The ma will be in charge of managing all the patients' request messages and will allow to dispatch them all. Also, it will notify any anomaly in the patient's biometric signals and it will generate a request for help, if needed. A range of emergency situations can be avoided with the systematic data collection (e.g. catastrophic reactions). A special task to be performed is to initialize the daily activities for each user, as well as any constraints on, or preferences regarding, the time or manner of their performance. This schedule may then be modified in several ways: (a) the user or a caregiver may add new activities (e.g. add a new session at the gym), (b) the user or a caregiver may modify or delete activities already in the schedule, (c) the user performs one of the scheduled activities; or (d) as time goes the schedule is automatically up-dated (e.g. changes in priorities).

We also consider the need of having an agent that undertakes responsibility for the network of sensors. Its basic target is to distribute the information from all available sensors to all the agents that maybe interested. The list of actual sensors for this space include: movement, landmarks, cameras, presence, etc.

At last, we have a *Main Agent* (MAA) that represents the hospital entity. Among its objectives are to keep up-dated the monitorisation of all patients, to manage their (*ADLs*) and to provide them all with the mobility plans that may need to achieve them. Also, it should keep the coherence of all clients' schedules. MAA is responsible for the protection of all the clients' personal data, this fact is expressed as an Obligation, for example in equation 3.

3.1. Roles and agents

Following with the preliminary description of the agents that we made above, we will detail inhere some of the roles that each of the agents can assume. Entering in the detailed analysis of each agent, we start with the pa that we see portrayed in fig 4, where it interprets roles involved in a *Help Request Manager* to ask for help, with direct interaction or not of the patient. The role of *Plan Request Manager* to communicate with someone that it can provide him a route in the environment for travelling between two points. The role of *Monitoring Manager* keeps control of the patients vital constants and assures that they have acceptable readings. Finally, we have the *Navigator/Plan Executioner* that is in charge of managing the journey marked by a route in the environment. The ma executes roles of *Help Attend* that allows him to pay attention to those requests of help that the pa have processed and on the other hand develops the role of *Status Request* that allows him to make a follow-up of the detailed information regarding the patients, biometrical data that indicates the state of the patient as well as personal or geographical data, that lets the ma to have located the patient at all times.

The Sensor Network Agent develops roles of *Monitoring*, since it picks up all the sensory information of our environment and it can control the changes that are produced on it, the locations of the patients and the staff, doors that open up and close up, . . . Using this information carries out the task of *Guard*, controlling that all these readings are correct and are not anomalies that can be considered risks or emergencies.

The MAA develops roles of coordination and control of the system. For example, it controls the actions of *Monitoring* and *Guard* in order to survey the patient's data and to control that they are correct, as well it keeps track of any reported incidence. It also carries out the *Planner* role, since it receives requests from the pa and calculates the *best* route in the environment. Finally, it will have the role of *Scheduler* or agenda, so it is in charge of carrying out the control of the activities that patients have to carry out along the day and of warning them when the time of their attending has arrived.

The agents that act in our architecture share an ontology that allow them to exchange information for carrying out their activities. This ontology contains the description of the elements of the physical environment as well as those of the conceptual world that the agents need to know. Also, it contains the actions and propositions that give support to the communicative acts that put them in contact.

3.2. Services

Now, we have already seen the agents that take part in our MAS platform, even though not all them have been implemented at this stage. Yet we have not developed those agents who have more dependence from physical resources, like the agents of the robotic platforms, in charge of the low level navigation, not even the agent of the sensor network. In [9] you find more details about the behavior of those agents .

The description of services can also be done using the AUML syntax. An example of this specification is shown in fig 4. In there a service can be seen as a class associated with the agent class which provides it, specifying a series of parameters that describe the composition of the service.

Once we have defined the agents of our system and their roles, we are able to see their participation in the services that *e*-tools-V1 offers. One of these services is related with the patient's needs for attention. The *Help Request* service allows the patient to ask for help whenever s/he needs it, propagating a notification to all the ma so the caregivers can choose to answer to this help request using the *Help Attend* service or leave the request in a queue. Also, this help request can be produced automatically, through the monitoring service that keeps control of the patient's vital constants in the p_i, that when it believes that these data readings are abnormal, it autonomously warns the ma about these irregularities.

Following the monitoring line we also find the *Emergency* service, that is provided by the agent of the sensors network. This services works taking continuous care of some sensors, controlling that situations of risk or emergency may not arise. Among the signals to be controlled we are considering electrical, fire, smoke, etc. If the detected situation, a combination of abnormal signals, is considered an emergency, the system would proceed to an automatic evacuation of the patients, bringing them to the closest safe location from their current positions.

The ma agents have the possibility to use the *Request Status* service to update all the patient's information. The data that is susceptible to change with time is the biometrical data and the one related with the location. Thanks to the biometrical data the sanitary staff can consult through their ma the status of their patient's vital constants and follow their evolution. Also when a request of help is produced by abnormal readings in these vital constants, the sanitary staff can consult *a priori* which are these readings and if it is necessary, they can collect the medical material that they may need before visit the patient. Also, making use of the location information that this service provides, the system can know at anytime where the patients can be found, if they are still or in movement and in the last case, the system knows where they are heading to, since probably it has planned the route.

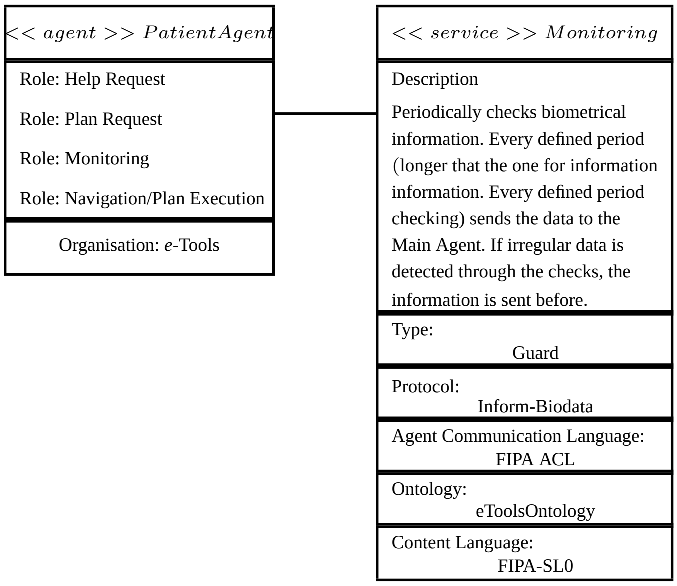

Fig. 4. Example of Agent and Service Specification

The *Scheduling* service is meant to palliate, in a certain degree, the afore mentioned patient's cognitive problems. Often patients suffering this impairment do forget which are their *ADLs*, as for example that they have to go to the dinner room to lunch, or to go to the gymnasium to make their exercises, etc. That is why *e*-tools-V1 offers them an agenda service that *knows* all their *ADLs*. When, in a given moment, the MAA detects that a patient has an activity programmed in a given room, it warns his p_i, that will be empowered to warn his owner and will offer him the possibility to drive him to the place where the appointment has to be produced. If the appointment is not compulsory and the patient refuses to attend in that moment, his p_i will remember him later that he still has a pending appointment.

Finally, we present the mobility service. The number of *ADLs* requiring navigation is large. Many persons in the target population move at extremely slow speeds or are affected from different degrees of ataxia. These conditions have different impact on self-dependency: in terms of timing (a very slow gait is useless to reach in time a toilette), distance (weakness can make too far even the nearest room), safety (such patients are at increased risk of falling). The task of helping people moving around could then become one of the most labor-intensive in assisted facilities. Using the *Planning* service the patient can ask to the system to drive

Fig. 3. Role Definition

him to a concrete zone of the hospital or can just ask to be reminded of how to reach to destination, in the case he has forgotten it. The patient can choose, through the interface that his p_i offers, to which room he wants to travel. We must say that the p_i will be only offering him as options, those rooms to which he can have access, and will avoid stairs, private rooms, offices, etc. Once the patient has selected his destination, his pa gets in touch with the MAA and requests him a route to go from the actual position to the chosen destination. When the MAA receives the request, it calculates the appropriate route in the way that we will portray later. Once it haves the resulting route sends it like a list of points to attain within a message back to the p_i that had made the request. When the p_i receives the route, it starts to execute it automatically, showing it to the patient through the interface. The patient will be able to actively interact with the controls of the chair, and if he prefers so, he can be the one who follows the points marked by the route manually.

To create plans (see §4.1), in first place the MAA needs a map of the environment to be able to design them. In our case we are using the real map of a floor of the IRCS Santa Lucia, we divided it into sections or stretches to convert it into a topological map (see fig 5). The topological map observes the geometric relations between the detected characteristics in the map with respect to an arbitrary axis of reference. This is represented as a graph where the nodes are the observed characteristics (rooms, room sections, etc) and the edges are the relations between them. These maps can be constructed without a reference to the actual position of the platform. Therefore the errors of representation are independent of the positioning errors of the platform. In our particular case we have divided the map into a grid and have drawn a graph that connects the stretches that can be safe or useful for the patients to travel. The edges will indicate the associated cost to the transition from a stretch to the next. Also, the nodes have an associated cost related to crossing the stretch associated. Places like corridors, narrow zones or doors suppose an added cost. Edges only connect stretches that are physically connected and that are transitable. Assigning a cost to nodes is also useful for the system when it has manage closed doors or blocked accesses, since it assigns a exaggerated cost to them, so they wont be chosen as part of a route by the MAA.

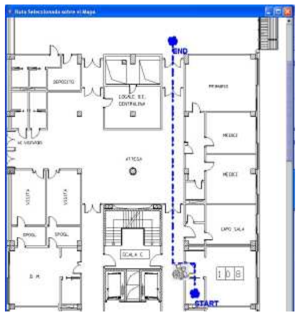

Fig. 5. Path planning for the Patient Agent

As a first safety measure, we must say that the map does not consider dangerous nor restricted areas as transitable zones. If these restricted zones are not included in our topological map, they will not be included to any route. All these stretches have been identified and evaluated in question of difficulty of crossing. The obtained results have been coded in `XML`, creating a *written* map that the MAA agents can easily read every time that they want to calculate a route. Once we have the topological map , from the start node and the destination node, we have to calculate the best route. To make it have the known algorithm of A^*, that gives us back the optimum route in cost an efficient time. We have also considered that maybe this method would be insufficient because there can be several robotic platforms moving around at the same time and that with a certain traffic, they can produce circulation problems. Even though this has to be solved at a lower level with navigation based in potential fields and other methods, with the high level route calculation we can help to avoid these situations.

The system will modify the topological map that we have loaded in memory. When it calculates a route and assigns it to a p_i, immediately, it will mark all sections of the map that he will use, increasing its cost, so that if any other p_j asks for a route, the system will try to search for an alternative path, in order to not use sections already assigned to p_i. Once p_i reaches her destination, the sections will modified again and leave them with their initial costs. This strategy is meant to diminish possible jams in the case that two pa ask for similar routes that could traverse coincident zones. To manage situations of heavy traffic, it should be developed an arbitration system that decides who can circulate in a crossing, similar to semaphores and settle down channels of circulation like the ones used in common highways.

3.3. *User Interface*

The *e*-Tools project will deliver different kinds of users interfaces depending on their category: doctors, nurses, client's family members and on the kind of terminal they have: PC, PAD, Cell Telephone, *etc*. The prototype's interface is primarily graphical, and it is currently on the screen of a computer. It is designed as a Web service that will adapt itself to the client's terminal.

The *e*-Tools client interface is still under development but in its definition there are some major concerns: a) It should give access at anytime to any available (and permitted service) b) It should allow the client to select a destination from a list and to change mind; c) It should keep the client informed about his actual position and direction; and d) It should help to avoid confusion modes.

Confusion modes could appear when the control is shared by the user and the deliberative control. Also, when the reactive mode takes control it should resume its action and try to avoid panic situations in the user.

In order to accommodate older adults with reduced eyesight other means as voice interfaces should be available.

4. Virtual Hospital

In our plan to deploy *e*-Tools in a real environment we will use the HARMON*IA* approach, introduced in [10], to define a *Virtual Hospital* that accomplishes with actual definition of the IRCCS Sta Lucia. The model of this organization should include references to different national laws and regulations as well as the medical protocols and internal regulations created by the IRCCS Sta Lucia.

The basic document for this task is its Regolamento Organico [1] that provides a high level description of the IRCCS Sta Lucia's Values, Objectives and Context. This document, for example, links the organization with Italian Healthcare system and, therefore with the Italian legal system and from it it inherits obligations, compromises, values, objectives and it defines also its context.

In figure 6 we show a simplified model of IRCCS Sta Lucia's actual organization and explain some of the scenes that occurs in a hospital to show HARMON*IA*'s power to model the agent-mediated interaction in an *e*-organization.

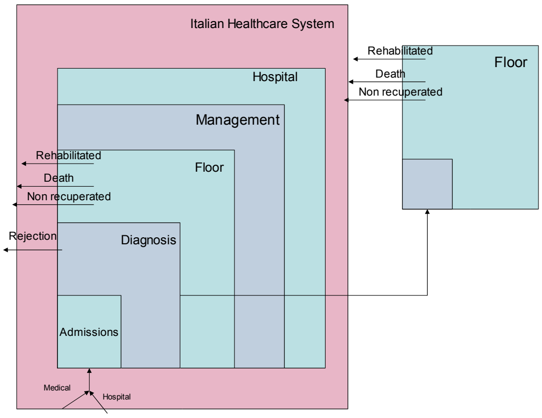

Fig. 6. IRCCS Sta Lucia organizational simplified model

Patient's are derived into the IRCCS Sta Lucia either by their doctor or from a Hospital to be rehabilitated – to rehabilitate patients from neurological accidents is one of the Sta Lucia's main objectives – there a diagnosticated and either sent to a floor or rejected. Once in a floor, each accepted patient is provided with a personal agent pa_i that allows her to use all the available and authorized agent-based services. Each pa_i is personalized to its owner so its identity is binded to her and makes it unique.

In the following, we will describe typical scenes where pa_i interacts with other agents to accomplish some generic tasks.

4.1. *Requesting a Plan*

Here we will illustrate the treatment given to the creation of a plan for a given agent pa_i willing to go from her actual position to a new one X. In our scenario there are two different ways to start this process. Either a patient p_i requests the system for a plan to go to X –using her pa_i– or the agent itself initiates the request. We assume that if the pa_i or a_i wants to go to X has the goal to go there $G_{a_i}\text{go}(a_i, x)$. This goal is state in expression 1.

$$G_{a_i}\text{go}(a_i, x) \;=\; D_{a_i}\;\text{go}(a_i, x) \wedge \neg B_{a_i} in(a_i, x) \\ \wedge \;\; B_{a_i}\text{achieve}(in(a_i, x)) \quad (1)$$

Once the request arrives into the system we find that the system (sl) has the obligation to find out if pa_i has the necessary permissions to go X before it creates and delivers a plan. Expression 2 depicts all this process.

$$O_{sl} \ (\ \text{check}(sl, P_{a_i}\text{go}(a_i, x)) \\ < \text{send}(sl, a_i, \text{Plan})) \quad (2)$$

In a hospital or an assisted living facility there are places to which access is forbidden for several reasons to different users. One special case are stairs and lifts. The system should assure that if pa_i is not allowed to change floor she will not use the chairs nor the lifts. Also, in the case of a platform they cannot be used to try to reach the stairs.

4.2. Requesting Status

A normal action in the daily activity of a healthcare giver is to collect information about a patient. In our context this can be achieved using the *e*-Tools facilities. For example, a caregiver could use his *Medical Agent* (ma) to ask for: *Tell me Patient*$_i$*'s (corporal) Temperature* or *Give me the Patient*$_i$*'s (actual) Status* or *Tell me where Patient*$_i$*'s is*? again, before to receive that information the system has the obligation to verify if the requesting ma_k has the appropriate permissions and it will write down the transaction in an special audit file, if finally it decides to deliver the data. This is expressed in expression 3.

$$O_{sl} \ (\text{register}(sl, log, \\ \text{personal\_data\_request}(\text{status}, ma_k, a_i))) \quad (3)$$

this is because the system should respect the Law on Personal Data Protection [5].

An exception occurs in the case of an emergency. If the system acknowledge that a pa_i is involved in an emergency and this patient's *clinical history* (HC) is requested by a caregiver's agent ma_k the system will deliver the information without creating an entrance to the audit files but it will create an obligation in ma_k such that after the end of the emergency it should create an entrance to the audit files as expressed in equation 5. Then, IF Context = Emergency the O_{sl} is created, see expression 4,..

$$O_{sl}(\text{inform}(sl, \text{access}(ma_k, \text{HC}(p_i)))) \quad (4)$$

$$O_{ma_k} \ (\ \text{declare\_access}(ma_k, \text{HC}(p_i)) \\ > \text{Emergency=NIL}) \quad (5)$$

4.3. Help Request Manager

When a `gethelp` request arrives into the system a new situation arises. The system starts to play as Help Request Manager. This request could be originated from two different sources: In the first the a_i decides that her owner is in *problematic* situation and it decides to send a request for help (see equation 6). In the second case is the patient himself who calls for help (see equation 7).

$$G_{a_i}\text{gethelp}(p_i, cg_j) \ = D_{a_i}\text{gethelp}(p_i, cg_j) \\ \wedge \neg B_{a_i}\text{helpattend}(cg_j, p_i) \\ \wedge B_{a_i}\text{needhelp}(p_i) \quad (6)$$

$$G_{p_i}\text{gethelp}(p_i, cg_j) \ = D_{p_i}\text{gethelp}(p_i, cg_j) \\ \wedge \neg B_{a_i}\text{helpattend}(cg_j, p_i) \\ \wedge B_{a_i}\text{needhelp}(p_i) \quad (7)$$

When the system sl gets a request as the ones depicted in equations 6 and 7 it should notify it to all the available ma_j and verify that this p_i has not pending requests. This behaviour is defined by equation 8

$$O_{sl} \ (\ \text{check}(\neg \ \text{wait\_attend}_{p_i})) \\ < \text{notify}(sl, ma_k, \text{request}_{p_i}) \\ \wedge \ \text{wait\_attend}_{p_i}) \quad (8)$$

5. Conclusions

Frail and senior citizens are at risk for hospitalization and premature institutionalization, due to complex interplay among age-related deficits, manifestations and treatment of disease, and behavioral, social and economic factors. For example mild cognitive impairment, including memory lapses and loss of executive functions, may conspire with visual impairment and poverty to interfere with taking medication as prescribed.

Institutions are abstract patterns that are valid for all the environment W, while organizations are concrete instances of an institution defined inside a certain context C_a.

Norms are necessary in situations where the organizations are unable to totally control the actions of the agents that are acting in any given moment. In our case, for example, to try to rule the traffic in each floor of the Hospital needs of a norm like:

$$\text{Has\_norm}_{sl}(\text{you\_ought\_to\_drive\_on\_the\_right}) \quad (9)$$

that derives directly from the continental driving conventions. One of the main roles of institutions is to inspire trust into the parties that perform the transactions.

The completion and implementation of *e*-Tools –under this new approach– will be a step ahead in the improvement of the quality of life of senior citizens with the help of the new technologies. We must consider that there are 37 million citizens with disabilities of different types in Europe, therefore the beneficiary users of the system are many, and not only them, but also their families and the institutions.

The tools envisaged here are applicable to support a wide range of disability levels and needs, and can be used by a wide range of users – intact healthy people and those with mild cognitive limitations, elders with moderate impairment and disability, caregivers, etc. These agent-based systems are devised to support the execution of activities of daily life and of healthcare maintenance tasks – including standardized behavioral assessments useful in medical monitoring. In addition, they connect patients to the outside world, including entertainment and information, and facilitate communication with families and with the environment. Physical environments that are age-friendly can make the difference between independence and dependence for some senior people, as senior citizens who can safely go outside and *navigate* to a neighbor's house or to the park are less likely to suffer from isolation and depression. *e*-Tools provides a research scenario to test out a range of ideas for assisting senior citizens and persons with some disabilities.

To date, we have developed the mobile platform (see figure 1), along with the software to enable to install the agent layer but still we have to develop the second layer and to integrate the whole architecture at the IRCCS Santa Lucia in Rome.

Among the most important obstacles that new technologies –such as software agents– find in real applications in medical informatics we can mention: user expectations and acceptance, security and trust issues, lack of standards, and integration with pre-existing health-care systems. It can be expected that acceptance of such systems will increase in the future, as senior citizens will be more and more used to interacting with and relying on advanced technological devices. To overcome the other problems, we propose here a real integration of heterogeneous technologies to serve to disabled and senior citizen in a non-intrusive way and securing the personal information of the users, working towards an integral solution beyond existing efforts that try to solve subsets of problems. The *e*-Tools philosophy puts a lot attention in create tools to help useres to recover their autonomy in as much as possible. In this sense, our tools are meant not to override none of the personal capabilities of the user if s/he can solve a situation by his own.

Another beneficiary would be the software agents community. The number of conceived software applications, designed and implemented making use of the agent technology goes in growth in very different environments from the e-Commerce to the hospital and medical applications. The assistive technologies [7] open a new option to show the versatility and robustness of agent systems on a large scale, reducing the fragility of the conventional software bringing an infrastructure constructed with tolerance to the uncertainty, the inconsistency and different points of view.

Technology will never alleviate all problems that aged population and persons with disabilities face, in special those that require a human interplay. Beyond supplying an important aid to the disable patient in order to improve its quality of life, *e*-Tools alleviate caregivers from routinary tasks and could improve also their quality of life diminishing their degree of distress.

In fact, if caregivers stretch themselves too far in the care giving roles and ignore their own needs, both mental and physical distress may result. A mental status called *Burnout* would emerge if caregivers could not manage their stress properly.

At the end, it is important to emphasize as the interaction between technology and medicine in the a broader sense - pharmacotherapy, neuro-motor rehabilitation, cognitive rehabilitation - could guarantee positive fall-out on the society.

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