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INTELLIGENT MEDICAL ROBOT SOCIETY

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Abstract. Any treatment on long or short term duration and/or complexity begin to involve more and more complex hardware and software pieces of equipment. Most of them begin to have various degree of mobility. Although the medical staff has enough trouble in handling them some times. In this paper we propose a complex robot society to deserve a medical center. The evolution of human computer interface and of the complex expert systems with medical application drive us to idea that a dedicated medical society of intelligent agents can be created.
Key words: medical robot society, distributed framework.

INTRODUCTION

The technology became more complex. The computing and communication power are increased year by year. As result the human computer interaction systems begin to be affordable as the expert systems. The robot development has benefits from the spatial technologies that will drive to lower costs and increased performances.

Nowadays mobile telemedicine can provide telehealthcare to patients who can continue to live a normal active life instead of being stranded at the hospitals that are already facing an increased resource allocation problem including time unavailability, space limitation, and high on-site costs [2]. But this is only a post operation solve of the problems. Other approaches use remotely controlled surgical robots to operate a human by telepresence.

The development of communication techniques and standards rapidly evolving communications market to a new challenging problem named fixed–mobile convergence appears. This refers at the trend in convergence of services and networks. This term is used by the telecommunications industry to describe the integration of wire line and wireless access technologies in a common services world. In figure 1 the industry way of seeing convergence is presented [4].

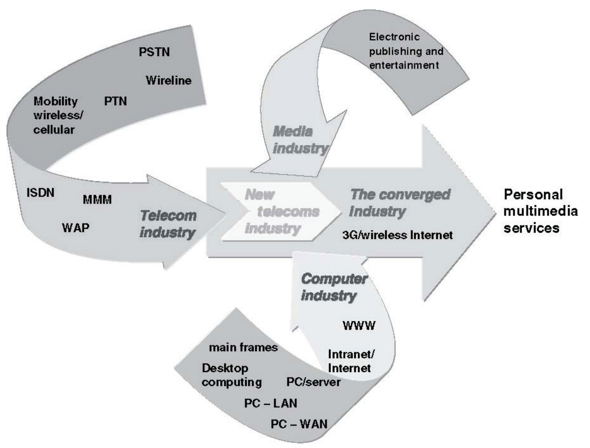

Fig. 1. Industry transformation and convergence

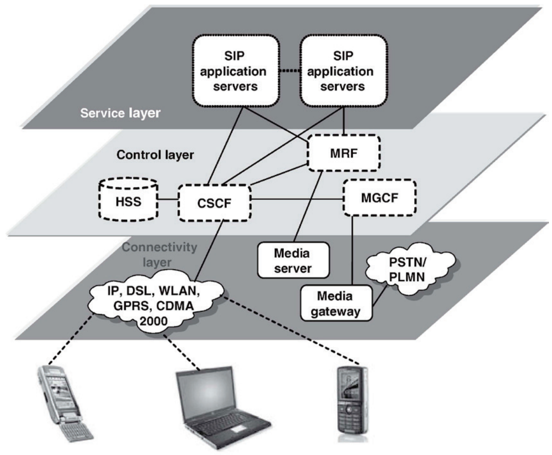

Fig. 2. Simplified view of the layered architecture in IMS

As can be seen from Figure 2, IP Multimedia Subsystem (IMS) provides an open, standardized way of using horizontal, layered network architecture. The application layer comprises application and content servers to execute value-added services for the user. The control layer comprises network control servers for managing call or session set-up, modification and release. The connectivity layer comprises routers and switches, both for the backbone and for the access network. The horizontal architecture in IMS also specifies interoperability and roaming, and provides bearer control, charging and security.

As result we con consider that is very easy to integrate in one great communication network all devices beginning with specialized devices and finishing with complex palmtops or notebooks.

How medicine can benefit from that? At first look seems not to be interesting due the fact that usually mobile devices are prohibited in medical centers. One example is the bad influence of a wireless communication enabled device over a peacemaker. First steps in these directions are already made by using sensor network to supervise the patient vital signs [2]. So the next step will be a integration into a large wireless network using the same model of emergence as previous mentioned one in order to obtain the needed medical center communication network,

THE SOCIETY

The main actors are a distributed framework of intelligent agents, expert systems with medical databases and medical mobile agents.

The translation for actual design of medical devices to the proposed one is simple because in fact an mobile platform computer controlled with wireless communication ability is need to be attached at the classical device. As result a mobile robot appears. The robot need also human computer interface devices for biometric analyze to be attached and a software with cognitive capability to be installed.

The need for autonomy of the entity will refer both mechanical and cognitive autonomy. Here the intelligent agents will be used. The use of agents is motivated because they are a solution for complex systems management. Also, the recent development of technology and especially the Internet requires the possibility that different applications communicate and interact. In general, for heterogeneous information environments, that are geographically distributed and complex in size, a centralized approach is practically impossible.

Agents work in open environments and need to be autonomous, heterogeneous and updated or modified dynamically. Agents are becoming a popular topic for research and development in applied functions, since they provide a natural means of performing the previously mentioned tasks in uncontrollable and dynamic environments. They can be constructed locally to the requirements of the user group.

The robot cooperation can be made as follows. On the supervised mode this is almost not required. The level of cooperation is low and will be resumed at the level of simple communication the trajectory of the robots can intersect in order to avoid unpleasant situations. The way of arranging them around the working place will be driven by AI commands. To do that the AI will use the medical knowledge database that will specify the correct place for any type of robot.

One situation can be if the targeted platform is overloaded but the transfer needs to be executed than this will be delayed. In order to communicate, the agents will use the KQML (Knowledge Query and Manipulation Language) [1]. The frameworks will exchange information by the use of some common XML like files that provide an asynchronous communication type which is necessary to avoid some temporary overloads.

We define a learning context as a set of semantically related schemata that are directly or indirectly linked to each other in the representation [6]:

$$LC = \left\{ s_i \in S \mid \forall s_j \in S, i \neq j, link(s_i, s_j) = 1 \right\}, \tag{1}$$

where $link: S^2 \rightarrow \{0,1\}$ is defined as follows:

$$link(s_i, s_j) = \begin{cases} 1, \exists directlink(s_i, s_j) \vee (\exists s_k \in S, link(s_i, s_k) \cdot link(s_k, s_j) = 1) \\ 0, otherwise \end{cases}, \tag{2}$$

The knowledge base of the agent contains a set of learning contexts:

$$KB = \left\{ LC_i \mid i = \overline{1,n} \right\}, \tag{3}$$

where n is the number of learning contexts in the knowledge base.

We define a concept as any element of the natural language that can have a meaning by itself. From a functional perspective, a concept can represent an object, an action or an attribute.

The knowledge base is represented as a localized neural network, in which nodes correspond to concepts. The same concept can appear in different learning contexts that can give it different interpretations. Therefore, we differentiate between two types of nodes: simple processing nodes and dictionary nodes. A dictionary node is a node that uniquely corresponds to a natural language concept. A processing node can be linked both to one dictionary node and to one or more processing node. Processing nodes are used for actual information processing, while dictionary nodes take over the internal computation results and act as an interface for external communication.

The self-organizing characteristic appears in critical situation like natural or artificial disasters. In crisis situation when unsupervised mode is active the robots will cooperate to maintain the global communication network active using ad-hoc networks techniques. This is crucial because the medical staff will launch calls for any type of robot that needs (e.g. a defibrillator needed in room c24-34). The self-organizing mode is off so the staff must control direct using commands the positioning of the robot (e.g. move to the right than to the left and finally go to corner of the room). So it will be situations when a robot can be declared unviable for use to maintain the inter cluster communication to avoid the typical phenomenon of cluster separation. This is unfortunate but is a low cost approach. To solve the problem the mobile repeaters robots can be used. In this situation communication network will automatically adapt to any required spatial configuration.

The need communication is critical for the society and some specific secured protocol will be used. The communication will have two main components. One is the natural language interface in order to interact with medical staff and the other is wireless based to fulfill the need for communications between the robots and from central AI and the robots [3].

In emergency situation a lot of precious time is spent to move the patient or the equipment in order to assembly a particular configuration specific to the required treatments need. Integration with the AI of the hospital, natural language recognition and mobile robots is needed to accelerate this process. We need also a self organization model of the robots to solve the situation when central Artificial Intelligence (AI) is not available due to any type of crisis conditions. So we use two types of models:

- Centralized using the AI control.
- Decentralized with low flexibility, but also with increased flexibility and adaptation caracteristiques than the classical approach. Here de ad-hoc problems and emergent capability of the agents can be analyzed.

At this hour there are already classic the approach using neural network in order to do simple phrases recognition. So after a period of training the central AI can set the weights to recognize the commands of known persons from local medical staff. The system is easy to integrate because the Bluetooth headsets are already used by anyone. So if a social behavior is well established it will be easy to replace those devices with a dedicated headset. Of course some special precautions must be taken in order to avoid interactions with the medical devices. The advantage is that vocal commands can be issued only by the one with enough credentials. Of course some emergency codes can be provided to permit to temporary associated staff to be recognized for crisis situation. After final biometric profile for a medical staff member is created by the central AI this is uploaded also to mobile robots. The reason is that they can react even when the AI is inactive due various conditions. As for the access to special commands that can generate injury a retina scan or fingerprint recognition it will be enough.

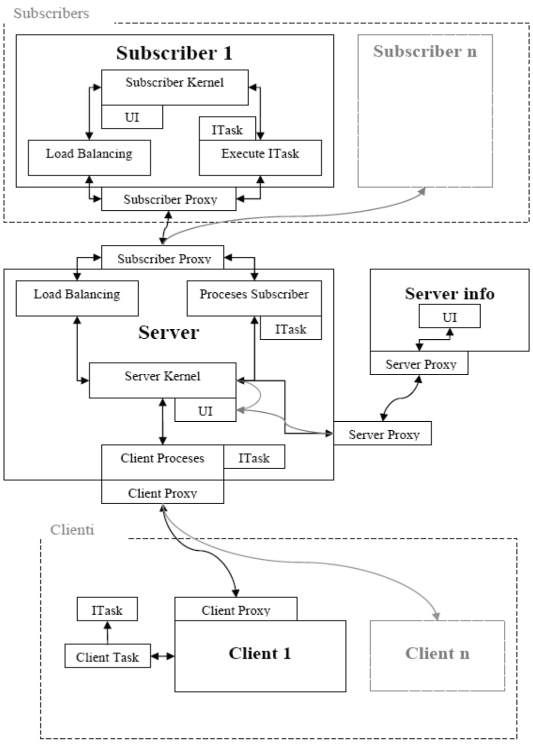

Fig. 3. System modules interactions

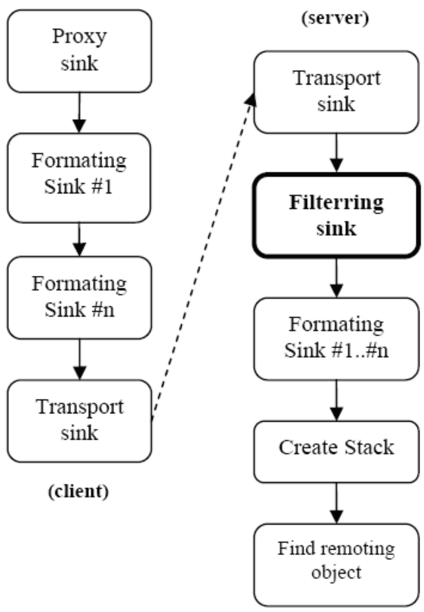

Fig. 4. Traffic filtering

Discover and learning of the environment will be made by the robots with the assistance of the central AI using the same technique like the voice recognition process. The robot will receive some basic knowledge about the environment like the 3D map of the hospital from central AI and also a supplementary set of rules given by the manufacturer concerning his mechanical limitation (e.g. the robot can not run if the angle of the road is over 30% and can not enter into a room that have a door with height lower that 2 meters). In time using a reinforcement learning approach the robot will begin to evolve into a natural manner in the desired building.

DISTRIBUTED FRAMEWORK

It consists from three entities as follows: *clients*, who will consume the resources, *subscribers* that will generate the resources and s*erver* that automatic connect the clients and the volunteers. The subscribers are the available robots at the moment. They are continuous exchanging because the system is dynamic.

The clients that are the personal staff interfaces used for translation. This are either on the AI mainframe or locally on the robot Clients and volunteers are created using a minimal web server core to communicate. To maintain compatibility the SOAP protocol is used over an XML stream [5]. The system modules interactions are presented in figure 3.

The server has a modular structure. The main component is server Kernel. We use .Net technology to implement it. It is enough to derive a class from MarshalByRefObject. The Server UI is registered at the events. An object ServerProxy is used to communicate with the kernel. Because the kernel also creates a ServerProxy we will have a proxy to proxy dialog.

To assure a good communications security a chain of sinks will be used. When a message is sent to a remoting object the proxy each method of the chain take the message modify him and then forward to the next method. The last method of chain is the one that make the transport of the message. In figure 4 the used sink chain is presented.

The referred client and server are no relation with the previous mentioned ones. When a special message filter is desired it is enough to design a custom sink that will implement what level of security is needed. If one custom sink it is not enough than a custom sub-chain can be created. This has another advantage all this chain is separately implemented in one .dll file. So when we implement the system for organizations with special security needs. They will only replace the sink that is provided with one created locally.

CONCLUSIONS

The proposed solution will present the following advantages:

- Self-organization in case of disasters: the leader which is the first called robot will designs dynamically organization structure according to the task goal. The robots in the some team can coordinate each other as to the needs of task.

- Dynamic comportment - this approach can form robots team dynamically according to the complicated task. Mathematical models are needed as in [7].

- Conciseness - the solution use unified frame to descript the individual robot, client and society leader in multi-robot organization.

- Robustness - there is no influence when a robot hardware failure or this is limited when the main control center is down but without loosing primary functionality.

- This society will probably quick replace a part of the medium qualified personnel from a medical center.

The implementation costs are not so high if is compared to the medium price of a medical piece of equipment.

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