Carrel: An Agent Mediated Institution for the Exchange of Human Tissues among Hospitals for Transplantation

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Abstract. In this work we present an application of Intelligent Agents Technology to mediate in the exchange of Human Tissues for transplantation. The impact of this activity is considered to be of first importance for health and also very important in economic terms. The creation of an Institution, called *Carrel*[1], will aid in finding intelligent means for a better assignation of organs, tissues and bones banked for transplantation in human beings. *Carrel* follows the approach of other well-known Agent Mediated Institutions such as Fishmarket [2], [6] and AuctionBot [16], [14] in order to assure a fair distribution of resources. *Carrel* is an Intelligent Resources Management Service.

Keywords: Agent Mediated Institutions, Negotiation, Tissues Bank.

1 Introduction

The importance for health of a single organ and tissue donor is of first magnitude, both from assistance and economic terms. A single organ donor can satisfy the transplantation of dozens of organ and tissue recipients [4]. For many of them, as observed by López-Navidad, transplantation represents the only therapeutic alternative and for some their only chance for survival. For example, in economic terms, for the Spanish case, the transplantation of one kidney compared with

[1] Upon Alexis Carrel [1873-1944], who received the 1912 Nobel Prize. He laid the groundwork for further studies of transplantation of blood vessels and organs.

dialysis would save the patient or the social security services between 186400 and 240530 Euros.

In the last 10 years there has been, in Spain, a growing number of donors and this situation leaded to the creation and implantation of *Tissues Bank* (TB). These are institutions specialized in the extraction and maintenance of tissues and bones from cadaveric donors for its ulterior use in transplantation. In Barcelona, for example, there are 3 of these institutions: Hospital de la Santa Creu i Sant Pau (HSP), Hospital Clínic de Barcelona (HCB) and, Hospital de la Vall d'Hebrón (HVH). Being Spain the first transplant organization in the world with 27 cadaveric organ donors per million population (pmp) in 1995 and arriving to 33 donors pmp in 1999. Catalonia, with a population of 6 millions inhabitants, has been the vanguard in Spain of transplantation and organ donors since transplantation were first performed in 1965. In 1999 there were 37 cadaveric organ donors per million population (pmp).

Our interest is to try to understand how organs, tissues and bones are assigned among recipients and to create an Institution to coordinate the assignation. Although the altruism of citizens, there exists a competence for a limited amount of resources and this fact allows us to think of the assignation problem as a special kind of *negotiation* among autonomous agents with antagonist interests. For example, two agents representing each a Hospital competing for a single piece of tissue.

Our proposal is to build an Agent Mediated Institution to regulate and speed the assignation of tissues and bones. The main objectives of this Institution[2] are: (1) to guarantee a fair and equitative distribution of tissues and bones, (2) to optimize the exploitation of the Tissues Bank and, (3) to improve the knowledge and methodologies associated with Transplants, for example in determining the relationship between donor tissue and recipient characteristics that influence graft survival. *Carrel* is in a sense an Intelligent Resources Management Service.

This Institution is designed to share among the Hospitals that are members all the information stored in the different Banks of Tissues and to assign the *best* piece to the recipient that shows the *best* match with the available pieces. The coordination among TBs could be done at regional level (eg. in Catalonia), national level (eg. in Spain) or trasnational (eg. in the European Union) taking profit of a single negotiation protocol, the information standardization and using the communication facilities provided by Internet. Internet is allowing many new ways of exchange and changing many conventions and procedures. Not only the actual organs and tissues exchanges have to be adapted to this new environment but new ways, services and practices of exchanges for these goods have to appear. Of course, these exchanges have to observe the local, national and European Union legislation. In this sense see the recommendations of the Transplant Experts Committee [5].

[2] Here we follow North's definition of an *Institution* as a collection of artificial constraints that shape human interaction [7].

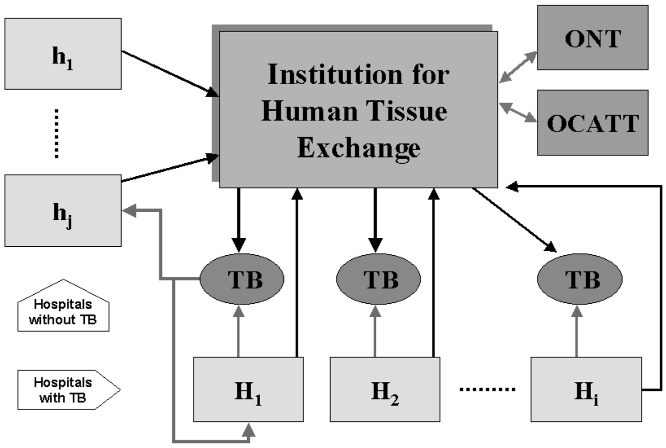

Fig. 1. Carrel: An Agent Mediated Institution for Tissues Assignment

1.1 Organization

This article is organized as follows. First, in section 2 we will briefly describe *Carrel*, the explanation of the *Carrel*'s scenarios is made in §3 and the main norms enforcing negotiation are detailed in §4 and in section §4.1 we explain the characteristics of the kind of interactions that can take place inside *Carrel*. In section §5 we describe our proposal for data standardization in this field. Finally, in §6 we give some conclusions and explain the future lines of research.

2 Carrel: An Agent Mediated Institution

Carrel is an Agent Mediated Institution designed to allow the distribution of human organs, tissues and/or bones[3] for transplantation. It is an Intelligent Resources Management Service. The central idea is to bring all the information from the different TBs into *Carrel*, so Agents representing different Hospitals can access the Institution and negotiate for the pieces the Hospital needs for a given transplantation. Those Agents have to accept *Carrel*'s norms of negotiation (see §4). This fact determines the co-operative nature of the Institution. In figure 1 we show the *Carrel*'s global view.

From the point of view of multiagent interactions, organs and tissues exchanging is a very attractive issue. These transactions are the kind of situations where one can claim that agents are well suited as they require: reactivity, situatedness, social abilities and autonomy [15],[13].

Organs and tissues exchanging could be classified as Task Oriented Domain (TOD). In those domains agents's activity can be defined in terms of a set of tasks that it has to achieve [10].

[3] From now on we will use the word *pieces* to designate organs or tissues or bones.

Agents inside *Carrel* have to represent a Hospital that needs a single piece for transplantation (eg. a Cornea or a Heart Valve) and they have to present this petition to the Institution. This petition will be formulated as a message (see table 1). If there is a set of available pieces, those will be presented, following the Institution's norms (see §4), to the Agent to choose in terms of its internal *selection function.*

This matching function is not always easy to define as selection criteria for a given piece of tissue are continuously modified, and may range from very permissive and elastic to very selective and strict. Moreover, transplantation criteria vary ostensively even between transplantation teams from the same geographical area an substantially between more distant transplantation teams [4]. This observation allows us to think in the creation of a trading agent representing each transplantation team and for each kind of organ, tissue and/or bone.

Although the exchange transaction of organs and tissues *only* requires from the Hospital's agents the application of a Selection Function when demanding a piece, and from Tissues Banks *only* to choose the moment when submit the information about their organs and tissues, these decisions -if rational- involve complex deliberative processes as observed by Noriega for the Auctions' case [6].

Complexity comes not only from the amount of information Hospital's agents have to access or need to take into account in the transaction, but also from the fact that the actual conditions of deliberation are constantly changing and are uncertain – new pieces are arriving to the system, the number of Hospital's agents is variable, the patient's conditions are dynamic, etc – and deliberation is time-bounded: the final assignment of a piece depends on the final acceptation given by the Hospital. So, the decision-making process in these conditions may be quite complex.

Let us now identify the actors of *Carrel* although we are talking for the general case most details correspond to the Catalonian case. The most important actors are the Tissues Banks, as they provide the pieces for transplantation, the Hospitals, the National Transplantation Organization[4] (ONT) [9] and the Organització Catalana de Transplantaments (OCATT)[8]. The precise role of OCATT and ONT for the Catalonian case is described in [3].

The participation of Hospitals in *Carrel* is based on the notion of membership. That is, Hospitals adhere to the Institution and respect the negotiation (assignation) rules and the agents that represent them inside *Carrel* are unable to break these conventions. In §3.1 we made a deeper explanation. Inside a Hospital an important actor in the transplantation process is the Hospital Transplant Coordinator (HTC), who takes the responsibility for the identification and screening of donors, organs and tissues extraction and its maintenance [4]. Also s/he participates on the distribution of organs[5], tissues and bones.

[4] The Organización Nacional de Transplantes is a technical organization within the Spanish Department of Health and Consumer Affairs, without attributes of direct management and whose fundamental mission is the promotion, facilitation and coordination of all types of organs, tissues and bone marrow.

[5] For organs procurement and exchange see [5]

The *Tissues Bank* (see §5) keeps information of all available pieces and participates in the negotiation process in three different steps: a) to provide *Carrel* with ALL the information it has about all available pieces, b) to deliver the pieces assigned by the Institution and, c) to keep track of the transplanted pieces.

In most of the cases, as shown in figure 1, the HCT does not take care of the Tissues Bank as most Hospitals do not have a TB. In other cases the Tissues Banks management is not assigned to the HCT. The HCT we are describing corresponds to the one described in [4] and [3].

Agents represent in *Carrel* each Hospital Transplant Coordinator acting in their name in the process of obtaining pieces for a transplantation. Each HTC is modeled as an Agency able to have different agents for each kind of piece and it is also able to specialize the Selection Function assigned to an Agent_i for a given Patient_k.

The negotiation in *Carrel* takes place in the Exchange Room (see figure2). There Agents deliver a sealed envelope with all the required information: the Hospital's Identification (provided by the Institution), the desired Piece's Identification, Recipient's relevant information, Hospital Transplant Coordinator's electronic signature, and it also contains the Selection Function which is private information. In *Carrel*, the OCATT and ONT do participate and their role is as observers of the whole process and maybe the ultimate referees in the case of conflicts.

In the next sections we will go into more detail in each of the components of *Carrel*.

3 Institution

The Institution is responsible of assuring the soundness and stability of the exchanges, and enforces these characteristics through the fair applications of the norms. *Carrel* assures:

1. The availability, presentation and delivery of organs, tissues and bones,
2. The eligibility requirements for Hospitals and Tissues Bank,
3. Acceptable behavior of participants within the site and,
4. The satisfaction of public commitments made by participants.

That is why *Carrel* could be seen as an Intelligent Resources Management Service. These resources are: Information, Organs and Tissues. The Institution has several scenarios, depicted in figure 2. There is, of course, a *Management Room* where the Institution takes care of the assignment of new memberships providing the identification number to each Hospital and is there where all the *norms* are designed and enforced. And in case of conflicts the solution is given there.

Agents have to communicate with the *Institution* and reason about the information it contains. This interaction among *Carrel* and the agents is based on

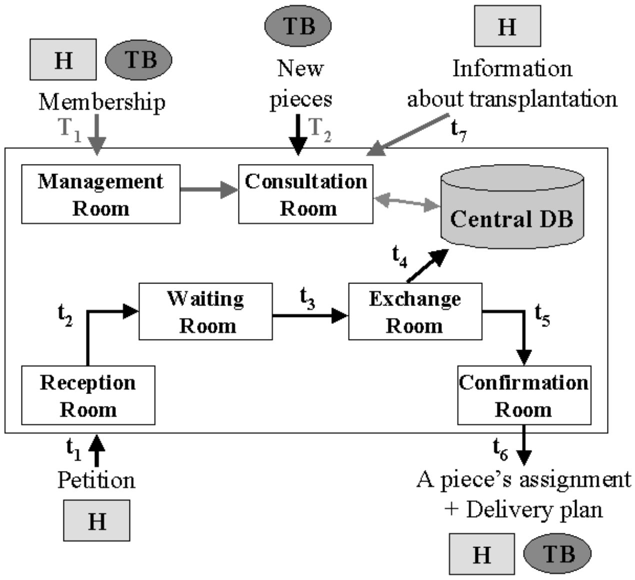

Fig. 2. The Scenarios in Carrel

a Language-Action Perspective [12],[11]. As the abilities of the agents to communicate and negotiate take an important role in our approach, we will devote the rest of this section to explain how these take place in every moment inside the *Institution*.

The most important scenario is the *Exchange Room*, where negotiation takes place. Agents arrive there after passing through the *Reception* and waiting in the *Waiting Room*.

The *Planning* scenario is the last step in the assignment process. Here the TB is communicated the assigned pieces that it has to deliver and it also communicates to the Hospital that was asking for the piece with its identification and the plan for its delivery. Also the TB receives this plan of delivery.

- **Reception Room**
  In this room, the agents have to identify themselves showing the Hospital Transplant Coordinator's electronic signature and Hospital's membership identification. This event is represented in figure 2 as t_1 and it is here where the process starts. This room is always open to new Agents with a request (see table 1).
  This room also serves as fire-wall against possible intruders to assure data protection inside *Carrel*. We will not address in this paper the security problems but of course those are issues of a vital importance for the Institution in terms of performance and also to achieve trust among members.
- **Waiting Room**

When the Reception Room recognize the signature of a given Agent, it can go then to the Waiting Room. This event is represented in figure 2 as t_2. The agents have to wait here until a new negotiation is opened. This intermediate room serves to regulate traffic inside *Carrel* and to synchronize the Institution. In this room the format of the contents are revised to allow only well-formed messages to arrive to the Exchange Room. Rejected messages will cause an exit from the Institution (see table 1).

– **Exchange Room**
When a new negotiation is opened, in time t_3, the agents in the *Waiting Room* enter this room. The Exchange Room Manager Agent analyzes each agent's query and assigns a subset of the pieces offered in the Central Data Base that match its query. This is done this way due to two reasons: first, to lighten the agent's work during its reasoning, and second, to keep a control of how the tissues are offered and assigned. Each piece offered to an agent has an estimated procurement and a distribution costs associated, so the agent can use them when deliberating.
When an agent has received an offer list, it can start deliberating about them, qualifying each tissue according to the matching of its needs and the tissue's characteristics using its own selection function (see figure 4). The Agent is free to reject those pieces it dislikes.
Once the Agent has performed its deliberations, the assignment process takes place. This process uses a weighted graph that relates each Agent$_i$ with its pieces, with the qualification of each one provided by the Agent$_i$ as the weight of each arc. The goal of this process is to achieve a maximum satisfaction with a minimum cost for each agent.
After the assignment process is finished, the agents may have got a piece or not. In the case the Agent has not been assigned any piece, it will return to its Hospital to inform that there are no pieces matching its needs. If the agent succeeded in getting a piece, it will go to the *Confirmation Room*.

– **Central Data Base**
It contains *Carrel*'s central data base which gathers all the available information from all the BT members. That is BT inform the Institution about any new pieces acquisition.
After a transplant operation has been performed the transplantation center remains in contact with *Carrel* in order to provide information about the outcome. The Central Data Base gets the following information from the Hospital: (a) when receiving a piece, (b) when the transplantation takes place and, (c) after three weeks. *Carrel* also keeps track of incidences in any of those steps. Analysis of this information can help to identify factors that affect the long-term outcome of transplants.
The *Carrel*'s value increases with the growth of this Data Base. The proposed data structure for this Data Base is detailed in §5.1.

– **Consultation Room**
The purpose of this scenario is to allow the exploitation of all the available data stored in *Carrel*'s Central Data Base (see figure 5). The security in this room has to be extreme and therefore only authorized agents will have

access, as for example, in this version, only the HTC agents, OCATT and ONT agents are allowed.
In this scenario it is possible to get data to apply Knowledge Discovery, Data Mining and/or Machine Learning Tools to learn from data.

- **Confirmation Room**
  Although an Agent_i is assigned a piece during the assignment process, it is a *provisional* assignment. The Agent_i has to confirm that he accepts the assigned Piece_k. This event starts, in figure 2, in t_5.
  There exists a time window until it is considered *definitive*. This time window is also used to allow the arrival of an *Emergency "0"* request (see §4). These emergencies have the highest priority, and when an Agent_u arrives with such a query, the whole process is stopped to let Agent_u to search throughout the total current offer, including the provisionally assigned pieces.
  When the time windows expires, the agents can return to their Hospitals to inform that they got a piece and the delivering plan.
- **Planning**
  This task is performed within the *Confirmation Room.* For each organ or tissue a delivery plan is built. One has to remember that organs and tissues are free of charge but the procurement, conservation and transport cause an expense. In many cases plans are pre-calculated or can be re-used but sometimes a plan has to be created *ex profeso* for a given piece and a pair (TB_i, H_j).

3.1 Hospitals

A Hospital is represented in *Carrel* by the Hospital Transplant Coordinator agent (HCT). The role of the Hospital Transplant Coordinator is central as s/he directs and controls the entire organ and tissues generation and procurement process and guarantees the quality in the evaluation, maintenance and handling of donors has to be reflected in *Carrel*'s architecture.

But also the Hospital Transplant Coordinator serves also as interface between the surgeons and *Carrel.*

A special situation arises when the Hospital Transplant Coordinator from any center belonging to the National Health System detects the existence of a potential organ donor, s/he should communicate it to the central office of the ONT or to the OCATT if s/he is in the Catalan territory. In our case the HCT agent will communicate this to the OCATT agent in the Institution who in turn will distribute the information as appropriate.

Also our implementation has to reflect the infrastructure and personnel of a Transplant Coordination Unit (UCTx) which allows to successfully culminate any organ and tissue procurement and extraction process for transplantation [3].

Each UCTx is modeled as an Agency (see figure 3) that has different agents to deal with the request of each kind of piece, and it is also able to specialize the Selection Function for a given patient using the relevant information coming from the surgeon and the patient's data.

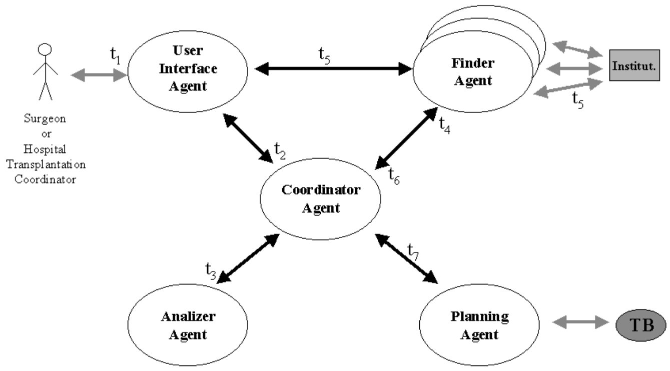

Fig. 3. The Transplant Coordination Unit's Agency

The Agency is composed by a *Coordinator* or HCT, and other agents, each one competent in a specific task. The *Coordinator* distributes tasks among the other agents in this Agency.

The *UI Agent* will be the responsible of communicating with the human users (the surgeons and/or Hospital Transplant Coordinator). The information given to this agent will be passed to the *Analyzer Agent*, specific for each piece, this agent will check if the information was properly introduced, that is, if all the characteristics were introduced, if all values are consistent following a given protocol. If there is some data missing, it informs the *UI Agent* who will ask the user to introduce it before validate it. When the *Analyzer* has all the information required, a new *Finder Agent* is created by the HCT. This agent will be the one going to the Institution to look for the desired piece. The *Finder Agent* is provided with a sealed envelope with all the information required (ie. hospital's information, patient's data, *etc*).

When a *Finder Agent* returns, it communicates the *Coordinator* the result of the negotiation. If a piece is found, the information is passed to the *Planning Agent* that will make up a logistic plan for the reception and transplantation. This information has to arrive to the surgeon that will perform the transplantation.

If no piece was found, it asks the *UI Agent* to inform the user (surgeon) of such failure. This will provoke an *impasse* that has to be solved by the Hospital Transplant Coordinator in person.

This Agency is also responsible to give feed-back, to *Carrel* , when the piece arrives, after transplantation and three weeks after the intervention or in the case of any casualty.

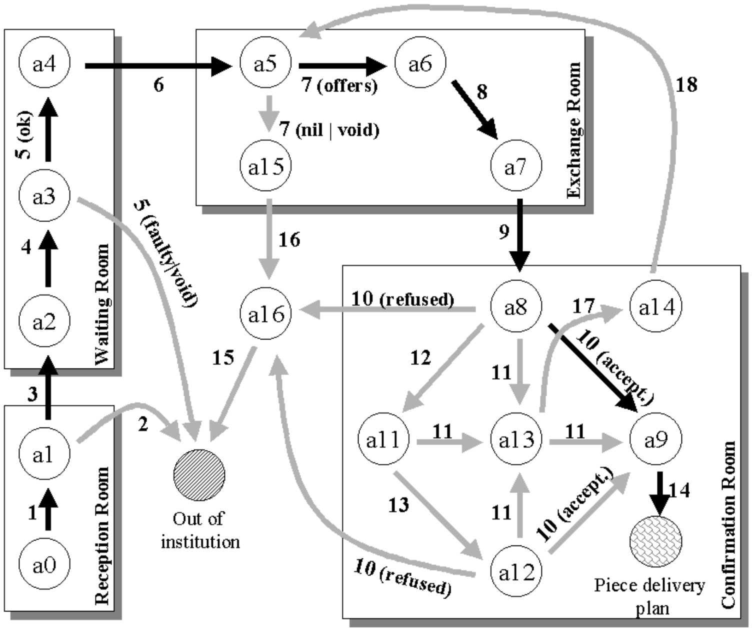

Fig. 4. Communication behavior of the Finder Agent for negotiation

4 Negotiation Norms

Carrel uses a set of norms that have to be accepted by all the members and these norms have to respect the actual legislation[6]. For example, inside *Carrel*, the following rules apply:

- The pieces assignment will follow a FIFO policy as this will prevent some of them to expire, that is, to be delivered as soon as possible to transplantation.
- The emergency "0" situations will always pass first.
- There is the obligation to inform to the Institution about each step that a piece follows (see §3).
- The TB have to commit to up-date *Carrel*'s Data Base and to follow the standard representation format for all pieces (see §5).

This last rule is not easy to enforce as many TB use very different codification procedures. Although, there exist some ongoing standardization process.

4.1 Negotiation

To describe the Negotiation process in *Carrel* we will follow Noriega's definition of a Dialogical Stance:

[6] In the Spanish case they are compiled in Royal Decree 20/70 of 1999 and, 4/11 of 1996

As all interactions can be tagged by illocutions (messages), and all observable commitments will be traceable to an illocution (message), agents can be thought of as entities who *engage in dialogue* and through dialogue *coordinate actions*(cif. § 4:90 [6]).

Message♯	Predicate	Parameters
1	Admission	id_agent, organ|tissue, {organ_parameters|tissue_parameters}*, info_recipient, selection_function
4	petition	id_agent, petition|consultation hospital_certificate, post stamp
8	weighted_list	id_agent {id_piece weight}$^+$
10	piece_eval	id_agent id_piece accepted|refused
15	exit	id_agent exit_reason
18	another_offer_list	id_agent

Table 1. Messages Finder Agent → Institution

In figure 4 we present the main flux of acceptable messages. We are assuming that an Agent$_i$ and *Carrel* engage a dialogue and not merely into a simple message-passing routine. We distinguish for this flux two dialogues that a Finder Agent could start: a) with *Carrel*; b) with the Hospital.

The first dialogue, between the Agent and *Carrel*, expresses the whole negotiation process. In figure 4 in black we depict a *standard* encounter between a Finder Agent and *Carrel* [10]. the first dialogue.

Message♯	Predicate	Parameters
2	deny	denied_certificate
3	accept	
5	petition_state	ok|faulty|void
6	init_exchange	
7	offer_list	{id_piece, info_piece}$^+$ |NIL|void
9	piece_offer	id_piece, cost_estimation
11	piece_reassigned_Exception	id_piece reassignment_reason
14	piece_delivery	{id_agent, id_hospital id_tissue_bank|id_hospital_donor delivery_plan}

Table 2. Messages Institution → Finder Agent

The second dialogue is between the Finder Agent and its Hospital more specifically with its HCT (see tables 3 and 4).

These messages include all the possible interactions we have identified until now. Of course, the interactions inside a Hospital are not covered (see 3.1).

Message♯	Predicate	Parameters
16	no_offer_Exception	void|nil
12	I_cannot_decide_ Exception	id_piece, info_piece
17	piece_offer_reassigned_Exception	reassignment_reason

Table 3. Messages Finder Agent → Hospital

Message♯	Predicate	Parameters
13	piece_offer_decision	accept|refuse

Table 4. Messages Hospital → Finder Agent

5 Tissues Bank

A Tissues Bank has several well-defined tasks. Among them, the most important are:

- Tissues procurement: all potential donors should be identified as early as possible.
- Tissues quality control: serological and other screening methods should be used to minimize the risk of transmission of of infectious diseases to the recipients.
- Tissues storage: tissues have to be keeped according to agreed criteria. And,
- Tissues distribution: a well-organized system for allocating and transporting donated tissues to the *most* appropriate recipient is important.

Most of them are related with those tasks realized by the UCTx (see §3.1). From our point of view the model of a BT becomes interesting when it is managed by the Hospital Transplant Coordinator.

In the *storage* task we include the classification of the available pieces for its further distribution. Information coming from different sources has to be attached to each piece of tissue or bone in the BT as for example, data from the several laboratories, data about quality controls, *etc.*

5.1 Data Standarization

The organization of all the information available in the Tissues Bank is crucial for the system. A first step is to create a standard for the identification of each piece and sub-pieces. This is due to a possible fragmentation of pieces for multiple transplants (eg. a bone).

Each piece is registered in the data base of a BT and in turn it has to communicate the arrival of new acquisitions to *Carrel*'s Central Data Base using a message that follows this format:

$$PP.HHH.DDDD.PPPPP.CCCC \tag{5.1}$$

`PP` stands for country identification code, `HHH` is Hospital's Identification code, `DDDD` is the Donor's Identification code, `PPPPP` is the piece's identification code

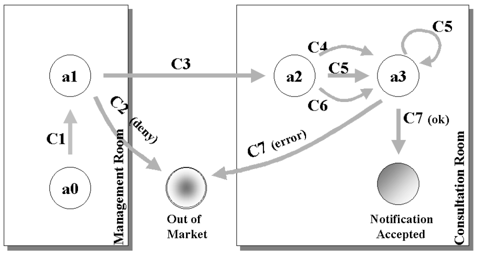

Fig. 5. Consultation Room

and, `CCCC` is the pieces's caducity identification code. In *Carrel* the registration identification is the same. The first three keys are the same for each piece coming from the same donor.

`DDDD` is an encrypted key that assures donor's anonymity. The `CCCC` code has to be elaborated and accepted by all actors. Although, in Catalonia, there exists a first approach for Cornea formulated by the *Cornea Transplant Consultancy Commission of the Catalan Health Service* [1].

5.2 Consultation Room

The Consultation Room deserves a special attention as it gives access to the information contained in *Carrel*'s Central Data Base. In figure 5 we depict the message interchange that describes what happens in this scenario. Messages coming from Agents accessing the Consultation Room are shown in table 5, the answers to those are in table 6. We distinguish those messages as Cx. As said before, the access to the Consultation Room is strongly limited.

Message♯	**Predicate**	**Parameters**
C1	admission	id_agent, query_function
C4	new_pieces	id_agent, $\{$id_piece info_piece$\}^+$
C5	query	id_agent
C6	transplantation_eval	id_agent id_piece id_patient

Table 5. Messages Consultation Agent → Institution

In figure 2, the access to the Institution is double: a) Reception Room and, b) Management Room. The second only allows the entrance of the agents representing the OCATT, the ONT and those representing the BTs and HCTs. That means that the certificates used to access *Carrel* from point are different to those used to access from the Reception Room. From this door it is impossible to access the Interchange Room.

The access to the Consultation Room grants the opportunity of tracing the life of a given Piece_k, using the data type described in equation 5.1, from its arrival into the system until three weeks after its transplantation. Also, the Consultation Room will allow, if agreed for all the members, to consult all the available data for all transactions.

Is in this scenario where Artificial Intelligence techniques could be applied to extract new knowledge from data. For example, to predict the delivery time for a given Piece_k, to argue why a Patient_i is not given with a Piece_k, etc.

Message♯	**Predicate**	**Parameters**
C2	deny	denied_certificate
C3	accept	
C7	ack	{ok|error}

Table 6. Messages Institution → Consultation Agent

6 Conclusions

Organ transplantation is the best available established technique for the treatment of end stage failure for most essential organs (liver, heart, lungs). Corneal transplantation is similarly well established and tissue transplantation, particularly bone but also skin, tendons, etc., is growing very rapidly. Over 1 millon people world-wide have benefited from successful transplants [5].

In view of increasing the potential success of transplantations we introduced a multi-agent based institution *Carrel* meant to mediate between Hospitals and Tissue Banks. This institution is responsible for the collection and management of data from donors and recipients, and also it is responsible to mediate in the organ or tissue allocation in a region or a country.

The implementation of such *Institution* aims to optimize organ and tissues distribution whilst ensuring the most clinically effective allocation, and to support donor organ procurement to increase the supply of donor organs and tissues. *Carrel* is a first attempt to model the process and attract the attention of the different actors as Hospitals, Tissues Banks, Organ and Tissues Sharing Offices, etc. towards the potentiality of these techniques in the promotion, support and co-ordination of organ and tissues transplantation in the broadest sense.

An important issue for the success of Agent Mediated Institutions like *Carrel* is Trust. Not only the actors like the Hospitals, the Tissues Banks, organizations as the OCATT and the ONT but also society has to *trust* on them. As observed by Noriega [6], if Agent Mediated Institutions are going to be trustworthy, it will depend largely on how effective they are in enforcing rules of behavior. In this case, the balance between an automatic mediation and the actual situation will be, in our opinion, the first step to gain trust. The other main issue is security. *Carrel* has to certify the security and integrity of all transactions performed on it.

Carrel aims to help in the improvement of transplantation results through scientific research.

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