

Argument Schemes and Critical Questions for Heterogeneous Agents to Argue Over the Viability of a Human Organ for Transplantation

Pancho Tolchinsky¹, Sanjay Modgil² and Ulises Cortés¹

Knowledge Engineering & Machine Learning Group, Technical University of Catalonia¹
Advanced Computation Lab, Cancer Research UK²

Abstract

In this paper we present a framework in which heterogeneous agents can argue over the viability of a human organ for transplantation. This collaborative decision making process among human and/or software agents is mediated by a software agent that uses argument schemes and critical questions to direct the deliberation, and determines a final evaluation of the given arguments. The proposed model is framed in the CARREL System, an agent-based organization designed to improve the overall transplant process. In particular, we believe that the use of argumentation has the potential to increase the number of human organs that current selection processes make available for transplantation.

1. Introduction

Human organ transplantation constitutes the only effective therapy for many life-threatening diseases. However, while the increasing success of transplants has led to increase in demand, the lack of a concomitant increase in donor organ availability has led to a growing disparity between supply and demand. Hence, much research has focussed on definition and implementation of policies for increasing donor availability, identification of suitable recipients for organs, and procedures to increase the chances of successful transplantation. Furthermore, the scarcity of donors has led to the creation of national and international coalitions of transplant organizations. This has resulted in requirements for managing and processing vast and complex data, and accommodation of a complex set of, in some cases conflicting, national and international regulations and protocols governing exchange of organs and tissues. Hence, in (Vázquez-Salceda *et al.* 2003) an agent-based architecture - CARREL - is proposed for managing the data to be processed in carrying out recipient selection, organ and tissue allocation, ensuring adherence to legislation, and following approved protocols and preparing delivery plans. In this paper we focus on CARREL's support for donor organ (rather than tissue) transplantation. In particular we focus on how argument schemes and critical questions can enable heterogeneous agents to participate in collaborative decision making over the viability of a human organ intended for transplantation. We believe

that the use of argumentation in this way has the potential to increase the number of human organs that current selection processes make available for transplantation.

In §2 we briefly describe CARREL and the current organ selection and assignation process in which an agent representing the hospital in which the donor is located (the donor agent) initially identifies an organ as viable or non-viable for transplantation. If identified as non-viable, then the organ is discarded (not extracted from the potential donor) rather than being offered to agents representing potential recipients. However, this process does not account for the fact that doctors may disagree as to whether an organ is viable or non-viable, and that different policies in different hospitals and regions exist. For example, suppose a donor with a smoking history of more than 20-30 packs a year and no history of *chronic obstructive pulmonary disease* (COPD). Some would cite a donor's smoking history as sufficient reason for labelling a donor's lung as non-viable (OCATT). However, there are qualified physicians that reason that the donor's lung is viable given that there is no history of COPD (López-Navidad & Caballero 2003). In argumentation terms, a donor agent may begin with an argument *A1* that an organ is non-viable, followed by a recipient agent's attacking argument *A2* claiming the organ is viable. (On the other hand, a donor agent's argument for viability may be attacked by recipient agent's argument for non-viability). Note that the donor agent might now submit an argument *A3* attacking the recipient's *A2*. This process of argument and counter-argument may extend over a series of dialogical moves.

Hence, in §2 we describe an extension to the current CARREL architecture and a new organ selection and assignation process, so as to facilitate agent argumentation over the viability of organs. In this way, organs that ordinarily would be discarded having been deemed non-viable by the donor agent, may now be successfully transplanted to a recipient with a winning argument for viability. Organs that ordinarily would be discarded if deemed non-viable by all recipient agents, may now be successfully transplanted to a recipient whose argument for non-viable is defeated by the donor's argument for viability.

In §3 we describe a framework for the required agent argumentation over the viability of organs. In particular, we focus on a mediator agent's use of argument schemes and

critical questions to mediate the protocol based exchange of arguments between donor and recipient agents. These agents may range from more or less fully autonomous agents constructing arguments in some underlying logical language to “gateway” agents that facilitate doctor access to the CARREL institution. Here we focus on the latter, more immediately realisable scenario in which doctors submit natural language arguments instantiating schemes and critical questions as directed by the mediator agent (from hereon, donor and recipient agents will be assumed to be human doctors). In §4 we describe the evaluative role of the mediator agent. As arguments are being submitted, the mediator agent assigns strengths to the arguments on the basis of the current human organ acceptability criteria, (donor and recipient) agent reputations, and case based reasoning (see fig. 6) to then evaluate the winning arguments by applying Dung’s “calculus of opposition” (Dung 1995). Finally, §5 concludes with a discussion and programme for future work.

2. The Carrel Institution and the Organ Selection and Assignment Process

CARREL is formalized as an electronic institution; a type of dialogical system where all the interactions are compositions of message exchanges, or **illocutions**, structured through agent group meetings called scenes or rooms. Figure 1 shows the CARREL institution and the hospitals $UCT_1 \dots UCT_n$ that are members of CARREL. Each UCT_x is modelled as an agency. Each agent can be associated with one or more roles (described more fully in (Cortés *et al.* 2000)), and these roles define the rooms the agent can enter and the protocols it should follow. Here we focus on donor (DA) and recipient agents (RA) associated with each UCT_x , and describe their roles in the organ selection and assignment process. In particular, figure 1 shows the donor and recipient agents DA_1 and RA_1 for UCT_1 , and only the recipient agents $RA_2 \dots RA_n$ for hospitals $UCT_2 \dots UCT_n$. Encoded in CARREL are sets of legislation and protocols governing the exchange of organs and tissues. These are based on two physical institutions representing examples of best practice: the OCATT (Organització Catalana de Trasplantaments) (OCATT) and ONT (Organización Nacional de Trasplantes) (ONT) organ transplantation organizations for Catalonia and Spain respectively. The current selection and assignment process begins when DA_1 detects a potential donor. DA_1 informs OCATT (assuming all UCT_i are in Catalonia) only if the donor’s organs are deemed viable for transplantation. Organs deemed as non-viable are discarded. OCATT then offers organs to potential recipients in a prioritised queue. CARREL agents are then deployed to coordinate extraction of the organ and delivery to the highest prioritised recipient that accepts the organ as viable. However, if no potential recipients are found, then OCATT offers the organ to the ONT, and a similar process takes place, this time embracing the whole of Spain. In case of refusal, the organ is then offered to transplant organizations in Europe. If every organization fails to allocate the organ, then the organ will be discarded. Currently, in Catalonia, between 15 and 20% of livers, 20% of kidneys, 60% of hearts, 85% of

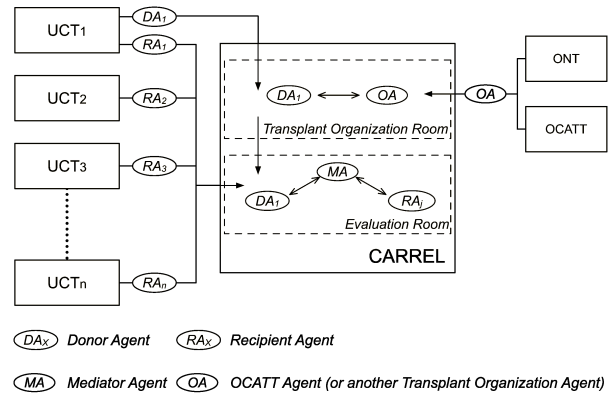


Figure 1: The Carrel Institution

lungs and 95% of pancreases are discarded (OCATT)

We now describe a new organ selection and assignment process (illustrated in fig.2) that aims to decrease the number of discards and therefore reduce the disparity between supply and demand of organs. To facilitate this process, the roles of the DA s and RA s have been extended to include submission of arguments. Having identified a potential donor, DA_1 enters the Transplant Organization Room (TOR) (see fig. 1) and communicates basic organ data (e.g., organ type) and donor data (e.g., the donor’s clinical history) to the OA agent representing the transplant organizations (e.g., OCATT or ONT). The OA agent contacts each RA_j identified as a potential recipient on the basis of basic organ and donor data. The MA in the Evaluation Room (ER) then mediates exchange of RA_j and DA_1 arguments for (non)viability (in the case that they disagree). Finally, the MA assigns strengths to, and determines the status of the submitted arguments in order to determine the *winning* argument, and so decide whether the organ is viable or not for RA_j . For a more in-depth description of this process see (Tolchinsky *et al.* 2005).

3. Arguing through Argument Schemes and Critical Questions

One influential informal logic based approach to argumentation is given by Walton (Walton 1996), in which arguments are viewed as instantiations of presumptive schema. Associated with a scheme is a set of critical questions. If $A1$ is an argument instantiating scheme $S1$, and $A2$ an argument ‘instantiating’ a critical question $CQ1$ associated with $S1$, then $A2$ is an argument that attacks $A1$. Strictly speaking, $A2$ is an argument instantiating a *scheme* $S2$ linked with $CQ1$. Hence, $A2$ can in turn be attacked by arguments instantiating critical questions associated with $S2$.

Conceptualising argumentation knowledge in terms of schemes and critical questions has provided a useful means for eliciting from doctors the required knowledge for arguing over the viability of organs for transplantation. (At present we have upwards of thirty schemes and associated critical questions). This conceptualisation has also served as a basis for a conservation based protocol that the medi-

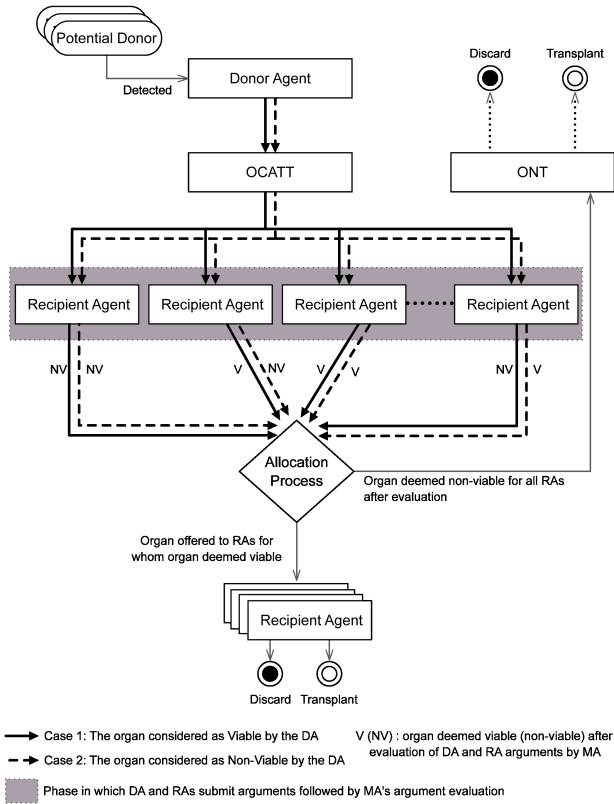


Figure 2: Human Organ Selection and Assignment Process

ator agent makes use of to direct submission of arguments by donor and recipient agents. To illustrate, consider the example in section 1, in which a donor agent - DA_1 - submits the following argument $A1$ for the non-viability of a donor's lung: *donor Mark of organ lung has a history of smoking, and a history of smoking is a contraindication for donating a lung, therefore the lung is non-viable*. This argument is an instantiation of the non-viability scheme:

NVS1 Non-Viability scheme 1:

Donor D of organ O had condition C
 And C is a contraindication for donating O
 Therefore, organ O is non-viable.

Associated with NVS1 are the following critical questions:

- NVS_CQ1: Is it the case that donor D had a history of C ?
- NVS_CQ2: Is it the case that a history of C is a contraindication for donating O ?

The mediator agent - MA - can thus direct the recipient agent - RA_j - to attack $A1$ by either of the following usages of a critical question:

1. posing the question as a challenge, in which case the burden of proof shifts to the donor agent to provide some justifying argument.

or

2. posing the question in terms of an attacking argument instantiating a scheme linked to the question.

An example of 1) is if RA_j poses NVS1_CQ2 as a challenge attacking $A1$. Then, DA_1 will be required to provide an argument $A2$ justifying that a history of smoking is a contraindication for donating a lung. $A2$ is required in order to attack the critical question, and thus 'reinstate' or 'defend'¹ $A1$.

An example of 2) is RA_j submitting the argument $A2 =$ *donor Mark did not have chronic obstructive pulmonary disease and so it is not the case that Mark's history of smoking is a contraindication for donating organ lung*. $A2$ attacks $A1$ and is an instantiation of the following scheme linked with NVS1_CQ2:

NDAS No disease associated with history scheme:

If donor D did not have the disease E that is a manifestation of C
 Then it is not the case that: if Donor D of organ O had a history of C then C is a contraindication for donating O

Scheme NDAS itself has critical questions, instantiations of which may be challenges or arguments attacking $A2$. Note that $A1$ and $A2$ attack each other (the former is based on a claim that smoking history is a contraindication; the latter contradicts this claim). The mutually attacking arguments are depicted in figure 3, in which $S_name(x_1, \dots, x_n)$, with x_1, \dots, x_n grounded, stands for an argument instantiating scheme S_name . Hence, $A1 = NVS1(mark, lung, s_h)$ is the instantiation of scheme NVS1 with $D = john$, $O = lung$ and $C = s_h$. If the process of argumentation ceases here, then the MA determines the winning argument. This is discussed further in the following section.

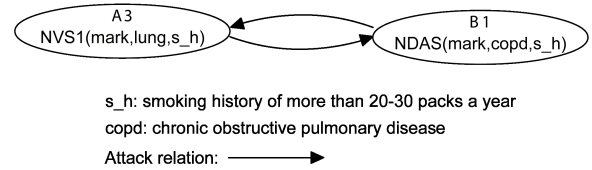


Figure 3: The Arguments used in the agents' deliberation over the viability of a donor's lung that had a smoking history and no COPD.

We now present a more involved example in which we reference the role of the MA in mediating exchange of arguments. The exchange is modelled as a turn taking dialogue in which the DA 's (RA 's) choice of illocution is guided by the MA on the basis of the schemes, associated critical questions, and schemes linked to these critical questions.

Suppose RA_j submits the following argument $A1$ for the viability of a liver organ available for transplantation: *donor john has organ liver, and no contraindications can be shown*

¹This terminology is borrowed from Dung's 'calculus of opposition' (Dung 1995), where if argument $A1$ is attacked by some argument A' , then $A1$ can be reinstated as an acceptable argument if its attacker A' is itself attacked; i.e., $A2$ 'defends' $A1$

for donating liver to recipient jane, and so organ liver is viable,
which is an instantiation of the viability scheme:

VS Viability scheme:

Donor D of organ O

And no contraindications are known for donating O to recipient R

Therefore, organ O is viable.

Suppose DA_1 submits the following argument A_2 for non-viability: *donor john of organ liver had streptococcus viridans endocarditis (sve), and sve is a contraindication for donating a liver, therefore the liver is non-viable*, which is an instantiation of the non-viability scheme NVS1. A_2 makes use of the claim that there is a contraindication, thus conflicting with A_1 's assumption that there are no contraindications. Hence, A_2 attacks A_1 , and now the onus is on RA_j to attack A_2 , and thus defend its argument A_1 for viability. The RA_j is directed by MA to pose one or both of the critical questions NVS_CQ1 and NVS_CQ2. Suppose RA_j poses NVS_CQ1 as a challenge attacking A_2 . Then DA_1 must defend A_2 with an argument justifying that donor *john* did indeed have *sve*. DA_1 can be directed by the MA to do so by submitting an argument A_3 instantiating:

PAS Patient Property Affirmation Scheme:

test S on Patient P gave result U

Therefore, P has C .

This argument can itself be subject to critical questioning by the recipient.

On the other hand, suppose RA_j poses NVS_CQ2 as a challenge attacking A_2 . Then DA_1 is directed by MA to defend A_2 with an argument A_4 : *donor john had sve, and so transplanting liver to recipient jane may result in jane having streptococcus viridans infection (svi), and svi is harmful, therefore sve is a contraindication for transplanting liver*, which is an instance of the scheme:

DDTS Donor Disease Transfer Contraindication Scheme:

When transplanting organ O from donor D with condition C_1 to a recipient R , R may end up having C_2

And C_2 is harmful

Therefore, C_1 is a contraindication for transplanting O

A critical question associated with DDTS is:

DDTS_CQ1: *Is it the case that R ends up having C_2 ?*

RA_j can then attack A_4 and is directed to do so by submitting an argument instantiating a scheme linked with **DDTS_CQ1**:

DCAPS Donor Condition Course of Action Prevention Scheme:

Following course of action A on recipient R prevents D 's condition C_1 resulting in C_2 on R

And A is intended

And no harmful secondary effects are expected on R

Therefore R will not result in having C_2 as a consequence of D having C_1 .

For example, RA_j can submit A_5 : *administrating penicillin to the recipient Jane is intended to prevent John's condition sve from resulting in Jane having svi*.

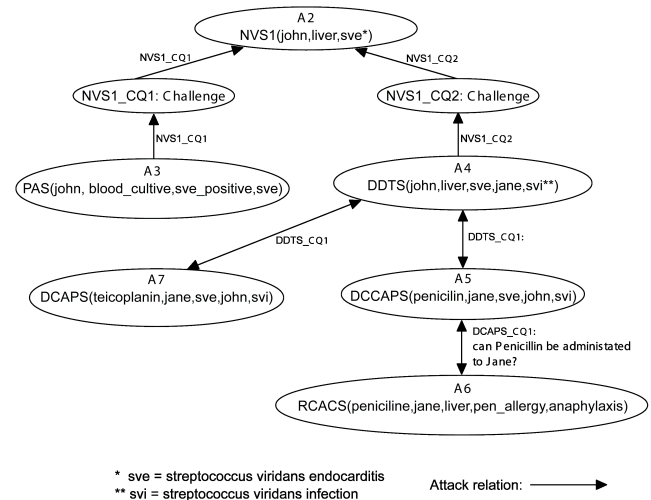


Figure 4: This graph captures the moves in a dialog over the viability of a donor's liver who had *sve*. Argument A_6 , not mentioned in the example, illustrates another possible dialog move that attacks the use of penicillin on a patient allergic to it. This may lead to submission of argument A_7 that proposes teicoplanin as an alternative treatment to penicillin.

Figure 4 depicts the agents' conversation graph, where the argument schemes instantiated and critical question posed as challenges are the nodes and the edges are the attacks. In the conversation graph more arguments can be found that illustrate other possible moves in the dialog. This process continues until the participants have submitted all their arguments (there is also a timeout trigger to ensure a stopping point). Note that this dialectical process as described here, allows for the *argument schemes and critical questions base* to be stored and managed by CARREL. Thus, changes to the schemes can be effected in a central CARREL repository, obviating the need for maintaining consistency amongst distributed repositories.

In (Modgil, Tolchinsky, & Cortés 2005) we proposed a logic programming based language and definition of argument interactions for formalising the argumentation exemplified above. This will enable the software agents that represent the medical doctors to take a more active part in the process, easing the task of the doctors by proposing instantiation to schemes. As stated earlier, we are currently viewing the agents as "gateway" agents via which doctors submit natural language arguments. The schemes and critical questions quite naturally conform to a protocol based exchange of arguments in which the CQ determine which are the possible dialectical moves. In order to capture this idea, consider an argument scheme AS and its associated set of critical questions $CQ_{AS_1}, \dots, CQ_{AS_n}$. Each CQ_{AS_i} is represented by a tuple $(Defend, Attack)$ where *Defend* and *Attack* are sets of argument schemes. Suppose A_1 is sub-

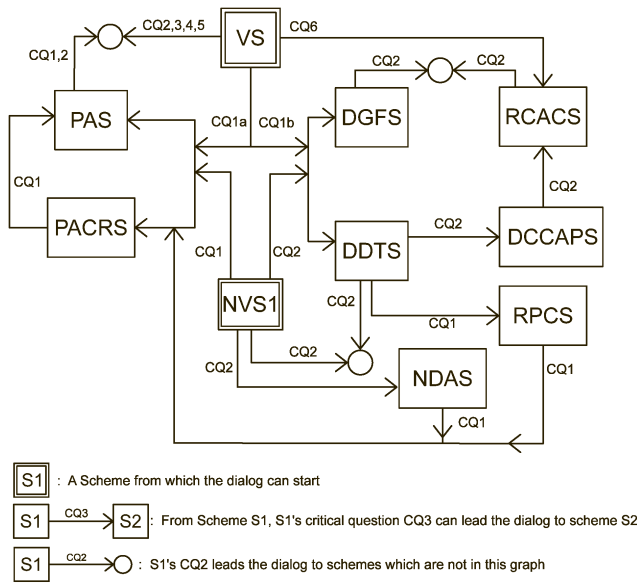


Figure 5: A fragment of the argument schemes and their relation via their associated critical questions. The schemes not introduced in the examples enable, for instance, to express that a condition in a patient appears in his clinical record (PACRS), that a donor’s condition is a contraindication because it may lead to a graft failure (DGFS), or they will enable to answer to the critical question: DDTS_CQ2 *Is C2 harmful considering R’s condition?* (RPCS).

mitted as an argument instantiating scheme AS . Then:

- CQ_{AS_i} can be expressed as a challenge location to $A1$, in which case some argument $A2$ instantiating an argument scheme in *Defend* must be submitted to defend $A1$ (in many cases the challenge is to some assumption C made by argument $A1$, in which case $A2$ is an argument justifying C)
- CQ_{AS_i} can be expressed as the location of an argument $A2$ instantiating a scheme $AS2 \in Attack$. $A2$ attacks $A1$ and $A2$ is then itself subject to critical questioning in the same way as $A1$.

Of course, if *Attack* is empty, CQ_{AS_i} can only be expressed as a challenge location. On the other hand, if *Defend* is empty CQ_{AS_i} can only be expressed as the location of an argument that attacks AS .

The MA implementation of this protocol is currently being prototyped in the COGENT (Cooper 2002) prototyping environment. This is a general purpose simulation tool grounded in Prolog, and which has been widely used for simulation in AI and other fields. This work is being undertaken as part of the ASPIC project (Argumentation Services Platform with Integrated Components), the aim of which is development of consensus theoretical models of argumentation and their implementation in software components for embedding in agent technologies. Currently, COGENT is being deployed as the prototyping environment for demonstrating usage of these components (including a dialogue

component) in scenarios such as the CARREL scenario.

In the next section we describe the MA ’s other role; in referencing knowledge sources to: a) determine whether arguments submitted are indeed valid; b) determine the strength of arguments. This role has not yet been prototyped.

4. Argument Evaluation

As arguments are submitted by the agents the MA constructs the conversation graph in which the nodes are the given arguments and the edges stand for the attack relation (See fig. 4). We now discuss how the MA references other knowledge sources to determine that an argument submitted is indeed a valid argument:

- A Knowledge Base of Acceptability Criteria (ACKB) encodes what are deemed valid arguments instantiating argument schemes. For example, an argument *donor Mary of organ kidney had black hair, and black hair is a contraindication for donating kidney, therefore, kidney is non-viable*, would obviously be an invalid instantiation of the non-viability scheme NVS1.
- Case Based Reasoning Engine (CBRe) may indicate that while an instantiation of a scheme is deemed non valid by the ACKB, there is an evidential basis (from recorded past cases) that the instantiation is a valid use of the scheme.
- If an argument is neither validated by the ACKB or the CBRe, it may well be that if the agent has a sufficiently high reputation (e.g., on all previous occasions the agent successfully transplanted organs it deemed viable) then it’s argument may be deemed valid

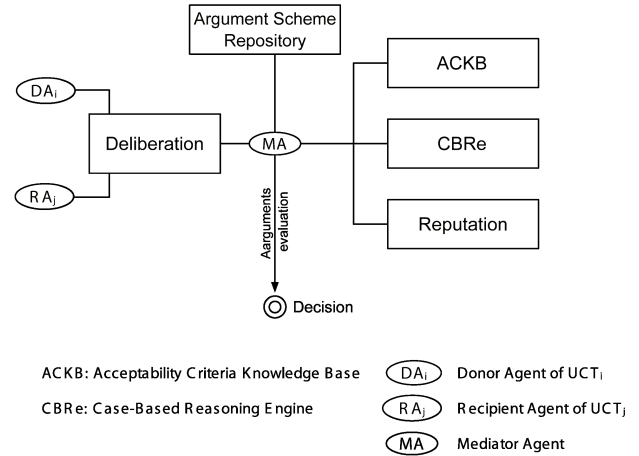


Figure 6: MA ’s argument evaluation process

Once the arguments have been accepted as valid and their attacks defined, the MA then applies Dung’s calculus of opposition (Dung 1995) to determine the acceptable arguments (that is the winning arguments) as described more fully in (Modgil, Tolchinsky, & Cortés 2005); in particular, to determine whether arguments for non-viability or viability are winning arguments. This requires assignation of strengths to arguments and possibly the posing of additional arguments.

This is due to the fact that conversation graphs (see fig. 4) may include mutually attacking arguments, e.g. $A1$ and $A2$, which result in an impasse for determining the winning arguments. The MA may resolve this impasse by either deeming one argument as stronger than the other, and so determining that, for example, $A1$ ‘wins out’ $A2$. Or, by the posing of a third argument $A3$ that asymmetrically attacks $A2$, and hence reinstating argument $A1$.

Once again, the MA references the above three knowledge sources in order to assign strengths to arguments and possibly pose additional arguments:

- The ACKB encodes a preference relation (partial ordering) among the criteria. This enables MA to assign relative strengths to the argument schemes instantiations.

This reflects the fact that not all the acceptability criteria are of the same nature. For example, while some criteria are suggestions (*lungs of donors with a smoking history of more than 30 packs a year should be discarded*) others are in fact legal obligations (*HIV is an absolute contraindication for being a donor*).

Also this knowledge resource is referenced by the MA in order to construct arguments. For example, if a condition $cond$ of a donor d is known to be a contraindication for donating an organ o (i.e. it is encoded in the ACKB as such) and neither the DA_i or the RA_j refer to this condition in their deliberation, the MA will then pose the argument $NVS1(d, o, cond)$.

- The arguments’ relative strengths are then readjusted by the MA to reflect the arguments’ evidential support derived from the **CBRe**. Supposing two symmetrically attacking arguments $A1$ and $A2$ are being evaluated, if there is sufficient evidence gathered from previous *similar* experiences that indicate that $A1$ wins out $A2$, $A1$ will be deemed stronger than $A2$. Also, referencing the **CBRe** the MA may pose additional arguments that were deemed relevant in previous similar situations.
- The agents’ reputations also influences the arguments’ relative strengths. MA may bias its decision favoring agents with good reputations. To illustrate with the endocarditis example, suppose the RA_j has a good reputation. Also suppose that *adminstrating penicillin to prevent sve from being a contraindication* is not a common procedure. Hence, it would not be addressed in ACKB, nor would there be evidential records in the **CBRe** in favour of or against treatment success. But, because of RA_j ’s good reputation, MA may prefer argument $A5$ over $A4$ (see fig. 4). This will enable $A5$ ’s attack on $A4$ to succeed.

5. Conclusions and Future Work

In this paper we address the use of argument schemes and critical questions as a means to direct exchange of arguments amongst human and non-human agents in the complex and sensitive domain of human organ transplantation. In particular we have focused on the schemes’ and questions’ dialectical nature encoded by a software agent in order to facilitate human agent submission of natural language arguments relating to the viability of human organs for transplantation.

We believe that this work has the potential to reduce the number of organs that are currently discarded and consequently, help to reduce the disparity between the demand for and the offer of human organs for transplantation.

The idea of defining an argumentation based dialogue protocol on the basis of schemes and critical questions, has been recognised by (Reed & Walton 2004) as having the potential to facilitate communication between fully autonomous agents and agents representing humans without the requirement for natural language understanding and generation. We believe that our work goes some way to illustrating this potential. The idea has also been concretely explored in (Atkinson, Bench-Capon, & McBurney 2004). In this work, arguments instantiating a presumptive schema for action are attacked by arguments linked to critical questions associated with this schema. Note that this work is limited to the second usage of critical questions described in section 3 here. They do not model usage 1, in which the posing of a critical question is an attack in its own right; one that shifts the burden of proof to an agent that who is then placed under an obligation to submit a defending argument.

An important aspect of our work is the specific, rather than abstract, nature of the schemes and critical questions:

1. The schemes and questions provide a better understanding of the agent’s deliberative context. This is because they not only serve to structure arguments, but also embed a great deal of the contextual knowledge.
2. it was easier to elicit the required knowledge from the medical doctors through very specific rather than abstract schemes of the type proposed (Atkinson, Bench-Capon, & McBurney 2004), e.g. *–In the Current Circumstances R we should perform Action A to achieve New Circumstances S which will realize some goal G which will promote some value V–*. We believe that this specificity will also be valuable for the end users when having to construct and retrieve arguments in a deliberation.
3. The schemes’s specificity not only facilitates the MA ’s evaluation task based on the ACKB, but also facilitates reference to previous experience in the process of evaluation. If defined in more abstract terms then graph comparison becomes more complex from a computational perspective. This is because the knowledge embedded in the more specific schemes reduces the degree of interpretation required in the argument graphs comparison.

As mentioned in section 3, we are currently prototyping the software agent mediation of the argumentation based dialogue. Future prototyping work will address the mediator agent’s role in the evaluative process described in section 4. This work is intended as a precursor to development of a robust large scale demonstrator with embedded argumentation components developed by the EU 6th framework project ASPIC (Argumentation Services Platform with Integrated Components).

Acknowledgments

This paper was supported in part by the Grant FP6-IST-002307 (ASPIC).

References

- Atkinson, K. M.; Bench-Capon, T. J. M.; and McBurney, P. 2004. A dialogue game protocol for multi-agent argument for proposals over action. In Rahwan, I.; Moraitis, P.; and Reed, C., eds., *Proc. First International Workshop on Argumentation in Multi-Agent Systems (ArgMAS 2004)*. Springer.
- Cooper, R. 2002. *Modelling High-Level Cognitive Processes*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Cortés, U.; Vázquez-Salceda, J.; López-Navidad, A.; and Caballero, F. 2000. UCTx: a multi-agent approach to model a transplant coordination unit. In *Proceedings of the 3rd. Congrés Català d'Intelligència Artificial*.
- Dung, P. M. 1995. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n -person games. *Artificial Intelligence* 77:321–357.
- López-Navidad, A., and Caballero, F. 2003. Extended criteria for organ acceptance: Strategies for achieving organ safety and for increasing organ pool. *Clin Transplant, Blackwell Munksgaard* 17:308–324.
- Modgil, S.; Tolchinsky, P.; and Cortés, U. 2005. Towards formalising agent argumentation over the viability of human organs for transplantation. In *MICAI 2005*.
- OCATT. Organització Catalana de Transplantaments (OCATT). <http://www10.gencat.net/catsalut/ocatt/en/htm/index.htm>.
- ONT. Organización Nacional de Transplantes. <http://www.msc.es/ont>.
- Reed, C., and Walton, D. 2004. Towards a formal and implemented model of argumentation schemes in agent communication. In Rahwan, I.; Moraitis, P.; and Reed, C., eds., *ArgMAS*, volume 3366 of *Lecture Notes in Computer Science*, 19–30. Springer.
- Tolchinsky, P.; Cortés, U.; Nieves, J.; Caballero, F.; and López-Navidad, A. 2005. Using arguing agents to increase the human organ pool for transplantation. In *3rd Workshop on Agents Applied in Health Care (IJCAI-05)*.
- Vázquez-Salceda, J.; Cortés, U.; Padget, J.; López-Navidad, A.; and Caballero, F. 2003. The organ allocation process: a natural extension of the CARREL Agent-Mediated Electronic Institution. *AiCommunications*.
- Walton, D. N. 1996. *Argumentation Schemes for Presumptive Reasoning*. Mahwah, NJ, USA: Lawrence Erlbaum Associates.