Argument Schemes and Critical Questions for deciding upon the Viability of a Human Organ for transplantation

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Abstract. In this document we present an extensive list of argument schemes and critical questions intended to enable agents to argue over the viability of a given human organ. These schemes can be regarded as a domain specific argumentation dialog game, in which the Critical Questions of a given scheme determine the possible dialog moves. In order to represent the wide list of Argument Schemes and Critical Questions in a comprehensible manner we propose in this report a novel formalization of the argument schemes interaction.

1 Introduction

In this document we present an extensive list of argument schemes and their associated critical questions to be used by agents to argue over the viability for transplantation of a given human organ. The aim is that, by capturing a sufficiently wide range of reasoning patterns, the schemes will enable and direct the agents in their collaborative decision making. The context of the agents’ deliberation is given in [7].

Argument schemes can be regarded as reasoning patterns, structures of inference, possibly nonmonotonic and nondeductive, that enable to identify and evaluate common types of arguments used in a particular domain. Associated to an argument scheme are critical questions that on the one hand identify valid lines of reasoning that can further support the argument instantiating the scheme and on the other hand identify the arguments that attack this argument.

In the construction of the argument scheme repository we introduced a novel formalization that enables to easily define the argument schemes interaction. In the following section we briefly describe the context in which this argument-based deliberation take place. In section 3 we give the basics of the argument schemes and we describe the notation to be used in writing the repository. In section 4 we provide the extensive list of the argument scheme and their associated critical questions. In section 5 we give our conclusions.
2 Arguing Over the Viability of a Human Organ for Transplantation

Within a hospital, when a patient becomes a potential donor, the Transplant Coordinator is responsible of determining which of the donor’s transplantable organs are viable for that purpose and offer for transplantation the organs deemed as viable. The organ offers are managed by the local Transplant Organization which intend to allocate the offered organs to a suitable potential recipient. The organ assignations are made via the Transplant Units responsible of the potential recipients. The Transplant Units are responsible of successfully transplanting the offered organs. In [7] we propose a human organ selection process in which the Transplant Coordinator (TC) offers not only the organs deemed as viable but also the ones considered non-viable, this time however, the offered organs will not be accompanied only by the donor’s and organ’s characteristics but also by the arguments that support TC’s belief to whether the organ is or is not viable. Also, prior to the allocation process, each Transplant Unit¹ (TU) will be able to contra-argue TC’s argument. In particular, a TU providing valid arguments would be able to label an organ as viable even though the TC deems it as non-viable. As a result, the organs labelled viable will be offered for allocation, via the Transplant Organization to all the TU who deemed the organ as viable. Namely this new process enables TUs to rescue organs that would have been discarded by the TC. In [7] besides providing a more in depth description of both, the current human organ selection process and the proposed one, we frame the proposed process in CARREL [8], an agent-based organization designed to improve the overall transplant process. Thus, the arguments of TC and TU, are managed by the agents Transplant Coordinator Agent (TCA) and Transplant Unit Agent (TUA) respectively. The Mediator Agent MA evaluates the agents’ arguments and gives the final decision, whether the organ should be labelled viable or non-viable to each TUA. The argumentation formalization are described in [7] and [3].

3 Argument Schemes an Critical Questions

Argument schemes capture reasoning patterns used in a particular domain. This reasoning patterns are in fact, structures of inference. Although argument schemes can capture monotonic deductive inference, such as modus ponens, their interest aspect is their suitability to encode nonmonotonic and nondeductive reasoning [6]. Argument schemes enable to identify and evaluate common types of arguments used in a particular domain. Associated to an argument scheme are critical questions that on the one hand identify valid lines of reasoning that can further support the argument instantiating the scheme and on the other hand identify the arguments that attack this argument.

¹ The information of the organ offer will only be sent to Transplant Units that are responsible of a potential recipient to whom the offered organ is suitable
Take the argument scheme *Appeal to Expert Opinion* that captures a sensible reasoning, or argumentation, pattern:

**AEOS** Appeal to Expert Opinion Scheme:
- $P$ is an expert in domain $D$ (1)
- And $P$ asserts $A$ to be true (2)
- And $A$ is in domain $D$ (3)
- Therefore $A$ is true. (4)

The critical questions associated to this scheme are:

(CQ1): Is $P$ an expert in domain $D$?
(CQ2): Did $P$ actually asserted $A$?
(CQ3): Is $A$ in domain $D$?
(CQ4): Is $P$ reliable?

Typically, Critical Questions (CQ) are regarded as defeaters of the argument instantiating the scheme ([10] [5] [9] [2]). Namely, if the scheme is instantiated by the argument $A_1$:

$john$ is an expert in domain $medicine$ (1)
And $john$ asserts $mary\_is\_healthy$ to be true (2)
And $mary\_is\_healthy$ is in domain $medicine$ (3)
Therefore $mary\_is\_healthy$ is true. (4)

The above CQs capture the possible attacks on $A_1$. Whereas -Is $john$ and expert in $medicine$?- challenges $A_1$, -$john$ is unreliable- attacks $A_1$ (in fact undercuts $A_1$ [4]). Note that there could be one or several schemes that conclude with the claim -Therefore $P$ is unreliable-², for example the [GAH] scheme:

**GAH** Generic Ad Hominem Argument:
- Person $P$ is bad (1)
- Therefore $P$ is unreliable (2)

which is an adaptation of a Walton’s *Generic Ad Hominem Argument* scheme [11]. Thus, the argument $A_2$ that instantiates this scheme with $P = john$, attacks $A_1$ (Pollock undercuts). In general, any argument instantiating [AE0], is attacked by argument instantiating [GAH] such that both instantiate the variable $P$ equally. Hence, all the schemes with the claim -$P$ is unreliable- can be regarded as associated to CQ4.

*Notation 1*: We will write as [AEO]([john, medicine, mary\_is\_healthy]) the argument instantiating scheme [AEO] with $P = john$, $D = medicine$ and $A = mary\_is\_healthy$. The order of the arguments of [S-name]$(X_1,...,X_n)$ is the order

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² The last line of an Argument Scheme is the scheme conclusion or claim, the other lines are the scheme premisses. E.g. in [AEO], lines (1), (2) and (3) are the premisses, and line (4) is the scheme claim
of their occurrence in the scheme [S-name]. Note that words starting with small
caps are constants, otherwise they are variable.

In this report we propose to consider critical questions not only as defeaters of
a scheme, but as both, "defeaters" and "supporters". In other words, to a CQ of
a scheme S1 we also associate the schemes that enable instantiation of arguments
which claims are assumptions of an argument instantiating S1. For instance we
associate to CQ1 of [AEO] any scheme that concludes with -Therefore, P is an
expert in domain D-. For instance, the scheme [EbT]:

EbT  Expert because of Title:
Person P has title T (1)
And people with title T are experts in domain D (2)
Therefore, P is expert in domain D (3)

In this occasion argument A3 = [EbT](john, degree_medicine, medicine),
supports premise (1) of the A1 argument.

Needless to say, that to [GAH] and [EbT] we can also associate the appro-
priate CQs. Hence, as pointed out in [9], CQ provides a dialectical nature to the
argument scheme. In particular, CQs can be viewed as the allowed moves in a
dialog game. Namely, given a proponent argument A that instantiates scheme
S, an opponent player could challenge A by instantiating one of S’s CQs, or
attack A if he is able to instantiate appropriately an attacking argument scheme
Sattacks−S associate to a CQ of S. The proponent, on the other hand, can in-
stantiate the supporting schemes of S associated to its CQ in order to either
answer to a challenge on A, or simply to further support A.

In order to represent the allowed moves of the dialog game, via argument
schemes and critical questions, in a readable fashion we propose a novel notation
which we found very useful in representing the argument-based deliberation of
our scenario.

3.1 A formalization for an Argument Scheme based Dialog Game

In constructing a repository of argument schemes an their associated critical
questions for the agents to argue over the viability of a human organ, we found
in the literature little help on how to represent a considerable amount of schemes
that were associated via CQ. Also, when developing the new notation we felt a
requirement from our working context to enrich the notation in order to repre-
sent aspects such as the agents’ roles or control flows, that we believe are useful
for other contexts as well.

Definition 1. An instantiation link of a critical question CQk associated to a
scheme S is a tuple I_{CQk} = (Attack, Support) where Attack is a possibly empty
set of schemes a1, a2..., an and control flows f1, ..., fm such that:

- For i = 1...n, there exist x1, x2, ..., xr and y1, ..., yt, constants, such that the
  argument a_i(x1, x2, ..., xr) attacks the argument S(y1, ..., yt).
- \( f_i \) is of the form \( \text{op}(F)\? A B \), where \( \text{op} \) is a boolean operator. If \( \text{op} \) validates formula \( F \), \( f_i \) is substituted by \( A \), otherwise, it is substituted by \( B \). Where \( A \) and \( B \) are, in turn, sets, possibly empty, of schemes and control flows. The schemes in both \( A \) and \( B \) have the same property of the \( a_i \) schemes. If \( \text{op}(F) \) evaluates positively \( F \) and the set \( A \) is empty, then the argument instantiating \( S \) is defeated.

Similarly, \( \text{Support} = \{s_1, s_2, \ldots, s_u, g_1, \ldots, g_v\} \), where \( s_i \) are argument schemes and \( g_i \) control flows, such that:

- For \( i = 1 \ldots u \), there exist \( x_1, x_2, \ldots, x_r \) and \( y_1, \ldots, y_t \), constants, such that the argument \( s_i(x_1, x_2, \ldots, x_r) \) claim is one of the premisses of \( S(y_1, \ldots, y_t) \).

- \( g_i, i = 1, \ldots, v \) are control flows. Where the schemes in both \( A \) and \( B \) have the same property of the \( s_i \) schemes. If \( \text{op}(F) \) evaluates positively \( F \) and the set \( A \) is empty, the challenge raised by \( \text{CQ}_k \) is answered. Namely, the argument instantiating \( S \) is not defeated by the challenge raised by \( \text{CQ}_k \).

The Instantiation Link of \( \text{CQ}_1 \) of \([\text{AEO}]\): - Is \( P \) an expert in domain \( D \)? - At this stage could be:
\[ I_{\text{CQ}_1} = (\emptyset, \{[\text{EbT}]\})^3. \]
The instantiation link of the \( \text{CQ}_3 \) of \([\text{AEO}]\): - Is \( A \) in domain \( D \)? - could be:
\[ I_{\text{CQ}_3} = (\{\text{KB}(A \in D)? \emptyset \emptyset\}, [\text{AEO}], \{\text{KB}(A \notin D)? \emptyset \emptyset\}, [\text{AEO}]) \]
Where \( \text{KB}(A \in D)? \) is a query to a Knowledge Base.
The instantiation link of \( \text{CQ}_4 \) of \([\text{AEO}]\): - Is \( P \) reliable? - could be:
\[ I_{\text{CQ}_4} = (\{[\text{GAH}]\}, \emptyset) \]

Therefore, in this context, a proponent can make his first move
\( A_1 = [\text{AEO}](\text{john, medicine, mary is healthy}) \). The opponent may then challenge \( A_1 \) via \( \text{CQ}_1 \): Is \( \text{john} \) an expert in domain \( \text{medicine} \)? to which the proponent may answer \( A_2 = [\text{EbT}](\text{john, degree medicine, medicine}) \). The opponent may then use the \( \text{CQ}_3 \)s associated to \([\text{EbT}]\) in order defeat or challenge \( A_2 \), or use a \( \text{CQ} \) associated to \([\text{AEO}]\) other than \( \text{CQ}_1 \).

Note that the supporting set of \( I_{\text{CQ}_4} \) is empty, therefore, given the challenge: - Is \( \text{john} \) reliable? - the proponent has no possible moves. Within the dialog game, if \( I_{\text{CQ}_4} = (\emptyset, \text{Support}) \) and \( \text{Support} \) is a non empty set, the burden of proof is on the proponent, i.e if the opponent raises a challenge via \( \text{CQ}_4 \), the proponent must answer to the challenge. Conversely, if \( I_{\text{CQ}_4} = (\text{Attack}, \emptyset) \) and \( \text{Attack} \) is non empty, the burden of proof is on the opponent, thus, in our example, the challenge - Is \( \text{john} \) reliable? - is not applicable, the only possible move of the opponent via \( \text{CQ}_4 \) is \( B_1 = [\text{GAH}](\text{john}) \).

\(^3\) Note that \( I_{\text{CQ}_1} = (\{[\text{AEO}]\}, \{[\text{EbT}], [\text{AEO}]\}) \) is also a possible instantiation link.
If both sets Attack and Support are empty, the argument acceptability is unresolved. In our context, the Mediator Agent, decides whether the argument is accepted or defeated.

**Definition 2.** A Critical Question can be regarded as: -if the formula $F$ is true then the scheme is defeated-. If the Conjunctive Normal Form of the formula $F$ associated to the critical question $CQ_k$ is $F = C_1 \land C_2 \land ... \land C_N$, the Arity of the $CQ_k$ is $N$. (Or, $CQ_k$ is a $N$-step critical question).

To attack a scheme through an $N$-step CQ, the opponent has to show $C_1$, $C_2$, ..., and $C_N$ to be true. To show that $C_j$ is true, the proponent can instantiate an argument scheme $S_{C_j}$ which claim is $C_j$ or challenge the proponent with -Is it the case that $\neg C_j$- to which the proponent is not able to answer. We assume that in order to show $C_k (k > 1)$ a player must first show $C_{k-1}$ ($C_{k-1}$ is a precondition to question $C_k$).

With a $N$-step CQ comes an Instantiation link of depth $N$, in which the the first layer of $I$ refers to $C_1$ and the $k$ layer refers to $C_k$. Thus we write the instantiation link $I$ of depth $N$ as:

$$I_1 = (\{a_{11}, a_{12}, ..., a_{1u}, f_{11}, ..., f_{1u}\}, \{s_{11}, s_{12}, ..., s_{1m}, g_{11}, ..., g_{1v}\})$$

$$I_2 = (\{a_{21}, a_{22}, ..., a_{2u}, f_{21}, ..., f_{2u}\}, \{s_{21}, s_{22}, ..., s_{2m}, g_{21}, ..., g_{2v}\})$$

...........

$$I_N = (\{a_{N1}, a_{N2}, ..., a_{Nn}, f_{N1}, ..., f_{Nu}\}, \{s_{N1}, s_{N2}, ..., s_{Nm}, g_{N1}, ..., g_{Nv}\})$$

Therefore, to answer effectively to a challenge raised by this critical question, the proponent must instantiate effectively one of the $s_{jk}$ argument schemes.

On the other hand, in order to defeat the argument instantiating the scheme via the N-step CQ, the opponent must instantiate effectively a sequence of argument schemes $a_{1k_1}, a_{2k_2}, ..., a_{Nk_N}$.

Let us Take the argument scheme for the viability of a human organ:

**VS Viability scheme:**
No absolute contraindications were found in donor $D$ (1)
And no absolute contraindications were found in Organ $O$ (2)
And there can be a matching recipient for $O$ (3)
And no logistical problems are expected (4)
And no wrong course of action $A$ is intended (5)
Therefore, organ $O$ is viable. (6)

To this scheme we associate the CQ:

(CQ1) *Does $D$ have Absolute Contraindication $C_1$ for donating $O$?*

4 Also, $C_j$ could be validated by an operator, for instance, $(KB(C_j)? \emptyset B)$.
5 If the burden of proof is on the opponent, the proponent does not have to answer.
6 If, for instance, on level $j$, the burden of proof is on the proponent, and the proponent is unable to show that $\neg C_j$, then $a_{jk_j} = \emptyset$. 
(CQ1) can be regarded as: \( \text{donor has}(D, C_1) \land \text{contraindication}(C_1) \)\?. Note that claiming that \( \text{donor has}(D, C_1) \) is not a reason to defeat an argument instantiating [VS], neither is claiming \( \text{contraindication}(C_1) \). Thus, the opponent has to first show that \( \text{donor has}(D, C_1) \) and then show that \( \text{contraindication}(C_1) \). Conversely, the proponent has to show that either \( \neg \text{donor has}(D, C_1) \) or that \( \neg \text{contraindication}(C_1) \).

Before presenting the argument schemes and critical questions repository, we must introduce a new notion into the instantiation link definition:

**Definition 3.** Given an instantiation link \( I_{\text{CQ}_k} = (\{a_1, \ldots, a_n, f_1, \ldots, f_u\}, \{s_1, \ldots, s_m, g_1, \ldots, g_v\}) \) as defined in definition 1. Then both, \( a_i \) and \( s_j \) have the form \([S-ID]_R\) where \( S-ID \) is the identifier of the scheme, and \( R \) is a set of roles. This denotes that, only agents that play roles that are in \( R \) can instantiate \([S-ID]\).

### 4 Argument scheme repository to argue over the viability of a human organ

In our context, we can identify three roles: the agent representing the Transplant Coordinator, TCA, the agent representing the Transplant Unit, TUA, and the agent mediating deliberation, MA. Normally, TCA will start putting forward an argument for viability (resp. non-viability) and TUA will attempt to defeat TCA’s claim. It is worth mentioning, that although we are presenting this scenario as **opponent vs. proponent**, it fact, it should be regarded as a collaborative decision making.

Provided that MA can make use of any instantiation of the schemes, we define the role sets: \( d = \{TCA, MA\} \) and \( r = \{TUA, MA\} \), such that \([S-ID]_d\) (resp. \([S-ID]_r\)) are schemes that can only be instantiated from the donor’s side (resp. Recipient). If all the agents can instantiate the scheme we will simply write \([S-ID]\).

In our context the control flows we use are:

- \((\text{KB}(F)? \ A \ B)\) where \( \text{KB} \) is MA’s knowledge base. (ACKB and CBRe, see [7])
- \((\text{Rep}(F)? \ A \ B)\) where \( \text{Rep}(F) \) is the reputation of the agent instantiating the CQ, and \( F \) is a dimension of the reputation, i.e. \( F \in \{\text{follow-up, transplant operation, logistics...}\} \). In general we will write \((\text{Rep}? \ A \ B)\).
- \((\text{commit}(F)? \ A \ B)\), if the agent commits to \( F \) then \( A \) otherwise, \( B \). In general, we use \((\text{commit}(F)? \ \emptyset \ \emptyset)\), thus, for simplicity we write \( \text{commit}(F)\)

A common sequence of control flow, when the CQ has the form -Is it the case that \( F\?- is:

\((\text{KB}(F)? \ \emptyset \ (\text{Rep}? \ \text{commit}(F) \ \emptyset))\)

Supposing this is an element of the \textit{Attack} set of an instantiation link, in our context, this means that if the MA’s knowledge base validates \( F \) the argument instantiating the scheme is defeated. Otherwise, if the agent instantiating this
control flow has good reputation with respect to \( F \) it can commit to \( F \) (or promise that \( F \) holds, or will hold). But if the agent does not commit to \( F \) or it does not have good reputation (w.r.t \( F \)) and the MA's knowledge base does not validates \( F \), the argument cannot be defeated through this Attack element.

In what follows we enumerate the argument schemes and critical questions of our repository following the proposed formalization.

**VS** Viability scheme:

No absolute contraindications were found in donor \( D \) (1)
And no absolute contraindications were found in Organ \( O \) (2)
And there can be a matching recipient for \( O \) (3)
And no logistical problems are expected (4)
And No wrong course of action \( A \) is intended (5)
Therefore, organ \( O \) is viable. (6)

CQ1: Does \( D \) have Absolute Contraindication \( C_1 \) for donating \( O \)?
   \( I_1: (\{PAS\}_d, \{PACRS\}_d), \{KB(common(C1)) ? \{PAS\}_d, \{PACRS\}_d \} \emptyset \}) \)
   \( I_2: (\{DGFS\}, \{DDTS\}, \{DRFS\}, \{DRFOS\}), \emptyset) \)

CQ2: Does \( O \) have Absolute Contraindication \( C_2 \) for being implanted?
   \( I_1: (\{OPAS\}_d), \{OPAS\}_d) \)
   \( I_2: (\{OGFS\}, \{ODTS\}), \{KB(common(C2)) ? \{OPAS\} \emptyset) \}

CQ3: Is there a matching recipient \( R \) for \( O \) of \( D \)?
   \( I: (\{NMS\}_r), \{commit(match)\} \)

CQ4: Are there expected Logistical Contraindications \( L \)?
   \( I: (\{LCS\}_r), \{Rep_r, ? \emptyset commit(\neg L)\} \)

CQ5: Is the wrong course of action \( A_1 \) intended on \( D \)?
   \( I: (\{DCACS\}_r), \{Rep_r, ? \emptyset commit(\neg intended(A_1, D))\} \)

CQ6: Is the wrong course of action \( A_2 \) intended on \( R \)?
   \( I: (\{RCACS1\}_r, \{RCACS2\}_r), \{Rep_r, ? \emptyset commit(\neg intended(A_2, R))\} \)

**NVS1** Non-Viability scheme (Donor Contra):

Donor \( D \) of organ \( O \) has \( C \) (1)
And \( C \) is an Absolute Contraindications for donating \( O \) (2)
Therefore, organ \( O \) is non-viable. (3)

CQ1: Does \( D \) have \( C \)?
   \( I: (\emptyset), \{PAS\}_r, \{PACRS\}_d) \)

CQ2: Is \( C \) an Absolute Contraindication for donating \( O \)?
   \( I: (\{RPDS\}, \{DCES\}_r), (\{DGFS\}, \{DDTS\}, \{DRFS\}, \{DRFOS\}) \)

The TCA has to show that the donor \( D \) does not have property \( C_1 \) only in the case where \( C_1 \) is a common contraindication.
Non-Viability scheme (Organ Contra):
Organ \( O \) has \( C \) (1)
And organ \( O \) with \( C \) cannot be transplanted (2)
Therefore, organ \( O \) is non-viable. (3)

CQ1: Does \( O \) have \( C \)?
I: \( (\emptyset), \{\text{OPAS}\} \)
CQ2: Can an organ with \( C \) be transplanted?
I: \( (\{\text{RPOS}\}, \{\text{O CES}\}, \{\text{OGFS}, \text{ODTS}\}) \)

Non-Viability scheme (Logistical Contra):
Organ \( O \) is expected to arrive to recipient \( R \) in time \( T_1 \). (1)
And Organ \( O \)’s cold ischemia time is \( T_2 \) (2)
\( T_1 \geq T_2 \) (3)
Therefore organ \( O \) is non-viable. (4)

CQ1: Is the expected time \( T_1 \)?
I: \( (\emptyset), \{\text{LCS}\} \)
CQ2: Is \( O \)’s cold ischemia time \( T_2 \)?
\( F = \text{coldIschemia}(O) \leq T_2 \)
I: \( (\{\text{KB}(F)\} \cup \{\text{Rep} \text{?: commit}[\neg F] \emptyset \emptyset\}, \{\text{KB}(\neg F)\} \cup \{\text{Rep} \text{?: commit}[F] \emptyset \emptyset\}) \)

Non-Viability scheme (Procedural Contra on Donor):
Donor \( D \) has organ \( O \) (1)
And carrying out course of action \( A \) on donor during \( D \)’s procurement phase
has as a consequence \( C \) on \( D \). (2)
And \( C \) is an absolute contraindication for donating \( O \) (3)
And \( A \) is carried out on \( D \) (4)
Therefore, organ \( O \) is non-viable. (5)

CQ1: Does \( A \) on \( D \) has as a consequence \( C \)?
\( F = [\text{course}_\text{act}(A, D) \to \text{result}_Dp(D, C)] \)
I: \( (\emptyset), \{\text{DGFS}, \text{DDTS}, \text{DRFS}, \text{DRFOS}\}) \)
CQ2: Is \( C \) on \( D \) an absolute contraindication?
I: \( (\emptyset), \{\text{DGFS}, \text{DDTS}, \text{DRFS}, \text{DRFOS}\}) \)
CQ3: Was \( A \) carried out on \( D \)?
I: \( (\emptyset), \{\text{DGFS}, \text{DDTS}, \text{DRFS}, \text{DRFOS}\}) \)

Non-Viability scheme (Procedural Contra on Organ):
Donor \( D \) has organ \( O \) (1)
And carrying out course of action \( A \) on donor during \( D \)’s procurement phase
has as a consequence \( C \) on \( O \). (2)
And \( C \) is an absolute contraindication for donating \( O \) (3)
And \( A \) is carried out on \( D \) (4)
Therefore, organ \( O \) is non-viable. (5)
CQ1: Does A on D has as a consequence C on O of D?

$$ F = [\text{course} \_\text{act}(A, D) \wedge d(D, O) \rightarrow \text{result} \_\text{a} \_\text{p}(O, C)] $$

I: ({{KB}(F)} ? (Rep? commit[¬F] {} {}),
{{KB}(¬F)} ? (Rep? commit[F] {} {}))

CQ2: Is C an absolute contraindication?

I: ({{}},{[OGFS],[ODTS]})

CQ3: Was A carried out on D?

I: ({{Rep? {} commit[¬course\_act(A, D)]]},{})

NVS6  Non-Viability scheme (Procedural Contra 2):
Transplanting organ O from donor D to recipient R (1)
And performing A to R in the post-transplant has as a consequence C on R (2)
And C is harmful. (3)
And course of action A is intended on R (4)
Therefore, organ O is non-viable. (5)

CQ1: Does course of action A on R has as a consequence C on R?

$$ F = [\text{course} \_\text{act}(A, R) \rightarrow \text{result} \_\text{a} \_\text{p}(R, C)] $$

I: ({{KB}(F)} ? (Rep? commit[¬F] {} {}),
{{KB}(¬F)} ? (Rep? commit[F] {} {}))

CQ2: Is C harmful?

I: ({{DCES6],[OCES6],[DCES4],[OCES4]},{})

CQ3: Is A intended to be carried out on R?

I: ({{Rep? {} commit[¬course\_act(A, R)]]},{})

NVS7  Non-Viability scheme Match:
There is no matching recipient for organ O (1)
Therefore, organ O is non-viable. (2)

CQ1: Is there a matching recipient R for organ O?

I: ({{commit,match(O,R)}},{commit,¬match(O,R)})

DGFS  Donor Graft Failure Contraindication Scheme:
Organ O of donor D (1)
And organs O of donors with C usually have Graft Failure when transplanted. (2)
Therefore, C is an Absolute Contraindication. (3)

CQ1: Is it really the case of Graft Failure when donors have C?

$$ F = [d(D, O) \wedge d_p(D, C) \rightarrow \text{result} \_\text{g} \_\text{f}(O, R)] $$

I: ({{KB}(F)} ? (Rep? commit[¬F] {} {}),
{{KB}(¬F)} ? (Rep? commit[F] {} {}))

CQ2: Does condition C2 on recipient R prevent Graft Failure?
**OGFS** Organ Graft Failure Contraindication Scheme:
Organ $O$ of donor $D$ (1)
And organ $O$ with $C$ usually have Graft Failure when transplanted. (2)
Therefore, $C$ is an Absolute Contraindication. (3)

CQ1: Is it really the case of Graft Failure when the organ $O$ has $C$?
CQ2: Does condition $C2$ on recipient $R$ prevent Graft Failure?

**DDTS** Donor Disease Transfer Contraindication Scheme:
Donor $D$ of organ $O$ has $C1$ (1)
And when transplanting $O$ from donor with $C1$ to recipient $R$, $R$ may end up having $C2$ (2)
And $C2$ is harmful. (3)
Therefore, $C1$ is an Absolute Contraindication. (4)

CQ1: Is it really the case that $R$ will have $C2$?
$F = [d_p(D, C1) \rightarrow result_{r_p}(R, C2)]$

I: ($(\{KB(F)\}, (Rep? commit[¬F] 0) 0))$
I: ($(\{KB(¬F)\}, (Rep? commit[F] 0) 0))$

CQ2: Is $C2$ harmful considering $R$’s condition?
I: ($(\{RPCDS\}, \{RPCS\})), \{0\}$

CQ3: Is there a course of action $A$ that can prevent $R$ from having $C2$?
I: ($(\{DCAPS\})), \{0\}$

**ODTS** Organ Disease Transfer Contraindication Scheme:
Organ $O$ of donor $D$ with $C1$ (1)
And when transplanting $O$ with $C1$ to recipient $R$, $R$ will have $C2$ (2)
And $C2$ is harmful (3)
Therefore $C1$ is an Absolute Contraindication. (4)

CQ1: Is it really the case that $R$ will have $C2$?
CQ2: Is $C2$ harmful considering $R$’s condition?

The instantiation links are equivalent to the previous scheme

**DRFCS** Donor Risk Factor Contraindication Scheme:
Donor $D$ of Organ $O$ has $RF$ (1)
And donors having $RF$ are very likely to have $C$ (2)
And $C$ is an Absolute Contraindication for transplanting $O$(3)
Therefore $RF$ is an Absolute Contraindication. (4)

CQ1: Does $D$ have $RF$?
I: ($(\{0\}), \{\{PAS|d, PACRS|d\}\})$
CQ2: Do tests show that D does not have C?
   I: (\{\empty\}, \{\{\text{PAS}\}_d\})

CQ3: Is C on D an Absolute Contraindication for donating O?
   I: (\{\empty\}, \{\{\text{DGFS}, \text{DDTS}\}\})

**DRFCOS** Donor Risk Factor Contraindication on Organ Scheme:
Donor D of Organ O has RF (1)
And donors having RF are very likely to have C on O (2)
And C is an Absolute Contraindication for transplanting O (3)
Therefore RF is an Absolute Contraindication. (4)

CQ1: Does D have RF?
   I: (\{\empty\}, \{\{\text{PAS}_d, \text{PACRS}_d\}\})

CQ2: Do tests show that O does not have C?
   I: (\{\empty\}, \{\{\text{OPAS}\}_d\})

CQ3: Is C on O an Absolute Contraindication?
   I: (\{\empty\}, \{\{\text{OGFS}, \text{ODTS}\}\})

**DCAPS** Donor Course of Action Prevention Scheme:
Following course of action A1 on donor D and A2 on recipient R prevent C1 on D result in C2 on R (1)
And A1 and A2 are applied (2)
Therefore R will not result in having C2 as a consequence of D having C1.(3)

CQ1: Does A = (A1, A2) prevent R from having C2?
   F = course\_act(A1, D)∧course\_act(A2, R) → ¬[d\_p(D, C1) → result\_r\_p(R, C2)]
   I: (\{\{\text{KB}(\neg F)\}? (\text{Rep}\? \empty\ commit[\neg F]\) \empty\}),
       \{\{\text{KB}(F)\}? \empty\ (\text{Rep}\? commit[F]\) \empty\})

CQ2: Can A1 be performed on D?
   I: (\{\{\text{DCACS}\}_d\}, \{\empty\})

CQ3: Can A2 be performed on R?
   I: (\{\{\text{RCACS1}\}_r, \{\text{RCACS2}\}_r\}, \{\empty\})

**OCAPS** Organ Course of Action Prevention Scheme:

*The CQs and instantiation links are equivalent to the previous scheme*

**DCAPGFS** Donor Course of Action Prevention GF Scheme:
Following course of action A1 on donor D and A2 on recipient R prevent C on D result in R having a Graft Failure (2)
And A1 and A2 are applied (3)
Therefore R will not result in having a Graft Failure as a consequence of donor D of organ O having C.(3)
CQ1: Does \( A = (A_1, A_2) \) prevent \( R \) from having a Graft Failure?

\[ F = course\_act(A_1, D) \land course\_act(A_2, R) \rightarrow \neg[d_p(D, C) \rightarrow result\_r\_gf(R, O)] \]

I: \( \{\{\text{KB}(\neg F)? \ (\text{Rep}? \ 0 \ commit[\neg F]) \ 0\}\}, \{\{\text{KB}(F)? \ 0 \ (\text{Rep}? \ commit[F] \ 0)\}\} \)

CQ2: Can \( A_1 \) be performed on \( D \)?

I: \( \{\{\text{DCACS}\}_d, \{0\}\} \)

CQ3: Can \( A_2 \) be performed on \( R \)?

I: \( \{\{\text{RCACS1}\}_r, \{\text{RCACS2}\}_r, \{0\}\} \)

**OCA P GFS** Organ Course of Action Prevention GF Scheme:

The CQs and instantiation links are equivalent to the previous scheme

**RPCS** Recipient condition Prevention Contraindication Scheme:

Donor \( D \) of Organ \( O \) (1)

And Recipient \( R \) having \( C_1 \) prevents property resulting in having \( C_2 \) being a contraindication (2)

And Recipient \( R \) has \( C_1 \) (3)

Therefore, \( R \) resulting in having \( C_2 \) is not a contraindication. (4)

CQ1: Does \( R \) have \( C_2 \)?

I: \( \{0\}, \{\text{PAS}_r, \text{PACRS}_r\} \)

CQ2: Does \( C_1 \) on \( R \) prevent having \( C_2 \) being a contraindication.

\[ F = r_p(R, C_1) \land d(D, O) \rightarrow \neg[result\_r\_p(R, C_2) \rightarrow contra(D, O)] \]

I: \( \{\{\text{KB}(F)? \ (\text{Rep}? \ commit[\neg F]) \ 0\}\}, \{\{\text{KB}(\neg F)? \ (\text{Rep}? \ commit[F] \ 0)\}\} \)

**RPGFDS** Recipient condition Prevention GF on Donor Scheme:

Donor \( D \) of Organ \( O \) has \( C_1 \) (1)

And Recipient \( R \) has \( C_2 \) (2)

And \( C_2 \) on \( R \) prevents \( C_1 \) on \( D \) of resulting in a Graft Failure on \( R \) (3)

Therefore, \( R \) will not result in having a Graft Failure because of \( C_1 \) on \( D \) (4)

CQ1: Does \( R \) have \( C_2 \)?

I: \( \{0\}, \{\text{PAS}_r, \text{PACRS}_r\} \)

CQ2: Does \( C_2 \) on \( R \) prevent having a Graft Failure.

\[ F = r_p(R, C_2) \land d(D, O) \rightarrow \neg[d_p(D, C_1) \rightarrow result\_r\_gf(R, O)] \]

I: \( \{\{\text{KB}(F)? \ (\text{Rep}? \ commit[\neg F]) \ 0\}\}, \{\{\text{KB}(\neg F)? \ (\text{Rep}? \ commit[F] \ 0)\}\} \)

**RPGFOS** Recipient condition Prevention GF on Organ Scheme:

The CQs and instantiation links are equivalent to the previous scheme
RPDS  Recipient Precarious for Donor Property Scheme:
Donor $D$ of Organ $O$ has $C$ (1)
Recipient $R$ is in a precarious condition (2)
And organ $O$ of donor $D$ with $C$ can be transplanted on $R$ if $R$ is in a 
precarious condition. (3)
Therefore, $C$ is not an Absolute Contraindication for donating $O$ on $R$. (4)

CQ1: Is $C$ an Absolute Contraindication even if $R$’s condition precarious?

I:

F = precarious($R$) → ¬$\exists[dp(D, C) \rightarrow contra(D, O)]$

RPOS  Recipient Precarious for Organ Property Scheme:

The CQs and instantiation links are equivalent to the previous scheme

DCES  Donor Classification Exception Scheme:
Donor $D$ of Organ $O$ has $C1$ (1)
And $D$ has $C2$, a subclass of $C1$ ($C2$ more specific than $C1$) (2)
And $C2$ is not an absolute contraindication. (3)
Therefore, $C$ is not an Absolute Contraindication for donating $O$ in $D$. (4)

CQ1: Is $C2$ a subclass of $C1$?
I:

CQ2: Does $D$ have $C2$?
I:

CQ3: Does $D$ have $C3$ subclass of $C1$, and $C3$ is not $C2$?
F = subclass($C3, C1$) \wedge (set($C2$) \cap set($C3$) = $\emptyset$) 8
I:

OCES  Organ Classification Exception Scheme:

The CQs and instantiation links are equivalent to the previous scheme

RPCDS  Recipient Preferred Condition on Donor Scheme:
Donor $D$ of Organ $O$ has $C1$ (1)
And transplanting $O$ to $R$ may result in $R$ having $C2$
$R$ has $C3$. (2)
And transplanting $O$ to $R$ may result in $R$ not having $C3$ (3)
And having $C2$ is preferable to having $C3$ (4)
Therefore, $C1$ is not an Absolute Contraindication for transplanting $O$ to $R$. (5)

8 This could be addressed as a 2-Step Critical Question
CQ1: Does $R$ have $C^3$?
   I: ($\emptyset$, $\{\{PAS\}_r, [PACRS]_i\}$)

CQ2: Is $C^3$ preferable to $C^2$?
   \[ F = \text{pref}_\text{prop}(C^1, C^2) \]
   I: $\{(\text{KB}(-F)? \ (\text{Rep}? \ \text{commit}[F] | \emptyset) \ \emptyset)\}$,
   $\{(\text{KB}(F)? \ (\text{Rep}? \ \text{commit}[-F] | \emptyset) \ \emptyset)\}$

**RPCOS** Recipient Preferred Condition on Organ Scheme:

The CQs and instantiation links are equivalent to the previous scheme

**NMS** Non Matching Scheme:
Recipient $R$ has value $V_1$ on property $P_1$. (1)
And Organ $O$ has value $V_2$ on property $P_2$ (2)
And If $R$ has $V_1$ in $P_1$ and $O$ has $V_2$ in $P_2$ then, $O$ does not match $R$ (3)
Therefore, $R$ does not Match $O$ (4)

CQ1: Does $O$ has value $V_2$ in $P_2$
   I: ($\emptyset$, $\{\{PAS\}_d, [PACRS]_d\}$)

CQ2: Does $R$ has value $V_1$ in $P_1$
   I: ($\emptyset$, $\{\{PAS\}_r, [PACRS]_r\}$)

CQ3: Is it a reason for non matching?
   \[ F = \text{organHas}(O, P_2, V_2) \land \text{recipientHas}(R, P_1, V_1) \rightarrow \neg \text{Match}(O, R) \]
   I: $\{(\text{KB}(F)? \ (\text{Rep}? \ \text{commit}[F] | \emptyset) \ \emptyset)\}$,
   $\{(\text{KB}(-F)? \ (\text{Rep}? \ \text{commit}[-F] | \emptyset) \ \emptyset)\}$

**DCACS** Donor Course of Action Contraindication Scheme:
Action $A$ is intended on donor $D$ of organ $O$. (1)
And carrying out $A$ on $D$ may have as an effect $C$ on $D$ (2)
And $C$ is a contraindication for donating $O$ (3)
Therefore, $A$ is a wrong course of action on $D$ for donating $O$ (4)

CQ1: Is $A$ intended on $D$
   I: $\{(\text{Rep}? \ \text{commit}[\neg \text{course\_act}(A, D)] | \emptyset) \ \emptyset\}$

CQ2: Does $A$ entails $C$ on $D$?
   \[ F = [\text{course\_act}(A, D) \rightarrow dp(D, C)] \]
   I: $\{(\text{KB}(F)? \ (\text{Rep}? \ \text{commit}[-F] | \emptyset) \ \emptyset)\}$,
   $\{(\text{KB}(-F)? \ (\text{Rep}? \ \text{commit}[F] | \emptyset) \ \emptyset)\}$

CQ3: Is $C$ a Absolute Contraindication.
   I: $\emptyset$, $\{[DGFS], [DDTS], [DRFS], [DRFOS]\}$

**RCACS1** Recipient Course of Action Contraindication Scheme:
Action $A$ is intended on $R$ to be transplanted with $O$. (1)
And carrying out $A$ on $R$ may have as an effect $C$ on $R$ (2)
$C$ is harmful. (3)
Therefore, $A$ is a wrong course of action on $D$ for donating $O$ (4)
CQ1: Is A intended on R
   I: (\{\text{Rep}? \commit[\neg \text{course}\_\text{act}(A, R)] \emptyset\}, \emptyset)

CQ2: Does A entail C on R?
   F = [\text{course}\_\text{act}(A, R) \rightarrow \text{result}\_\text{r}(R, C)]
   I: (\{\text{KB}(F)? \text{Rep}? \commit[\neg F] \emptyset\}, \emptyset)
   (\{\text{KB}(\neg F)? \text{Rep}? \commit[F] \emptyset\})

CQ3: Is C harmful considering R's condition.
   I: (\{\text{DECS}6\}, \emptyset)

RCACS2 Recipient Course of Action Contraindication Scheme:
Action A is intended on R to be transplanted with O. (1)
   And R has C1 (2)
   And carrying out A on R having C1 may have as an effect C2 on R (3)
   And C2 is harmful. (4)
   Therefore, A is a wrong course of action on D for donating O (5)

CQ1: Is A intended on R
   I: (\{\text{Rep}? \emptyset \commit[\neg \text{course}\_\text{act}(A, R)]\}, \emptyset)

CQ2: Does A with C1 entail C2 on R?
   F = [\text{course}\_\text{act}(A, R) \land _\text{r}(R, C1) \rightarrow \text{result}\_\text{r}(R, C2)]
   I: (\{\text{KB}(F)? \text{Rep}? \commit[\neg F] \emptyset\}, \emptyset)
   (\{\text{KB}(\neg F)? \text{Rep}? \commit[F] \emptyset\})

CQ3: Is C2 harmful considering R's condition.
   I: (\{\text{DECS}6\}, \emptyset)

LCS Logistical Contraindication Scheme:
Problem P may occur during the transplant process of O. (1)
   And if P occurs, O's cold ischemia is expected to be T1 greater than allowed time T2. (2)
   Therefore, P is a Logistical Contraindication. (3)

CQ1: Will P occur?
   I: (\{\text{Rep}? \commit[\neg \text{logis}\_\text{expect}(P)]\}, \emptyset)

CQ2: Is there course of action A that can prevent P from happening in O's transplant process?
   F = \text{possible}\_\text{logis}\_\text{act}(A) \land (\text{logis}\_\text{course}\_\text{act}(A) \rightarrow \neg \text{logis}\_\text{expect}(P))
   I: (\{\text{KB}(\neg F)? \text{Rep}? \commit[F] \emptyset\}, \emptyset)

PAS Donor Property Affirmation Scheme:
Patient P gave result U on test S (1)
   And having result U on test S entails that patient P has C. (2)
   Therefore, P has C. (4)
CQ1: Is $U$ a conclusive result for test $S$?
\[
F = result(S, U) \rightarrow \neg [test(S) \rightarrow has(P, C)]
\]
I: \(((PNS2), (KB(\neg F)? (Rep? commit[\neg F] \emptyset \emptyset)), ((KB(F))? (Rep? commit[F] \emptyset \emptyset)))
CQ2: Is $S$ a reliable test to test $C$ on $P$?
\[
F = [positiveTest(S, C) \rightarrow has(P, C)]
\]
I: \(((PNS1), (KB(F)? (Rep? commit[F] \emptyset \emptyset)), ((KB(\neg F))? (Rep? commit[\neg F] \emptyset \emptyset)))

**OPAS**  
Organ Property Affirmation Scheme:

*The CQs and instantiation links are equivalent to the previous scheme*

**PACRS**  
Donor Property Affirmation based on Clinical Records Scheme:
Clinical records state that patient $P$ has property $C$. (1)
Therefore, $P$ has $C$. (2)

CQ1: Does test $T$ shows that $P$ does not have $C$?
\[
F = common(T) \wedge dataOf(T, C)
\]
I: \(((PAS)], (KB(F)? [PAS] \emptyset \emptyset))

**PNS1**  
Property Negation Scheme:
Patient $P$ gave result $U$ on test $S$. (1)
And result $U$ on test $S$ is not conclusive result to determine $C$ on $P$. (2)
Therefore $P$ may not have $C$. (3)

CQ1: Is there another test $S_2$ that concludes that $P$ has $C$?
I: \(((PAS)], \emptyset, )
CQ2: Is test $S$ unreliable?
\[
F = [positiveTest(S, C) \rightarrow has(P, C)]
\]
I: \(((KB(\neg F))? (Rep? commit[\neg F] \emptyset \emptyset)), ((KB(F))? (Rep? commit[F] \emptyset \emptyset)))

**OPNS1**  
Organ Property Negation Scheme:

*The CQs and instantiation links are equivalent to the previous scheme*

**PNS2**  
Property Negation Scheme:
Patient $P$ gave result $U$ on test $S$. (1)
Test $S$ is not a reliable test to determine $C$ on $P$. (2)
Therefore $D$ may not have $C$. (3)

CQ1: Is $S$ unreliable for determining $C$ on $D$?
\[
F = [positiveTest(S, C) \rightarrow has(P, C)]
\]
I: \( \{ (\text{KB}(\neg F) \land (\text{Rep}\land \text{commit}[F\lor\neg F]) \lor (\text{KB}(F) \land (\text{Rep}\land \text{commit}[\neg F] \lor \neg F))) \} \)

CQ2: Is there another test \( S^2 \) that concludes that \( D \) has \( C \)?

I: \( \{ [[PAS]]_d, \emptyset \} \)

**OPNS2 Organ Property Negation Scheme:**

*The CQs and instantiation links are equivalent to the previous scheme*

We know give two short dialog examples in which the agents make use of the argument schemes and critical questions:

![Diagram showing TCA and TUA arguments](image-url)

**Fig. 1.** A TCA offers the organ as non-viable, the TUA contra-argues claiming that kidney is viable because its patient also has hepatitis \( C \), and it does not believe that a kidney of an elderly person should be discarded, which is supported by the MA agent.

5 Conclusion

In this report we present a novel formalization of argument schemes and critical questions in order to enable agents to argue over the viability of a human organ. The most similar work we have found in the literature is the PARMA protocol [1], which is a multi-agent dialogue game protocol that enables argument over proposals for action. The argument schemes and the attack relations to an argument involved in this protocol have a rather high level reasoning representation (e.g. attack relations are formalized as sentences like *Disagree with the description of the current situation* or *Disagree that the desired value is worth promoting*). Our
In this dialog the TCA argues that the organ is viable if the recipient is administered with penicillin. The TUA contra-argues claiming that it cannot administrate penicillin to its patient given that she is allergic, thus it may cause her to have anaphylaxis. The MA then propose to administer teicoplanin.

Proposal is somewhat less general, but we believe it to be readily implementable. Moreover, we believe our formalization to be expressive enough as to capture a wide range of deliberative scenarios, as long as there is a reduced number of concrete reasoning patterns that can capture the overall deliberative process.

Within argumentation theory, argument schemes are a standard way with which to encode rules. We regarded argument schemes as being coherent with our previous work and formalization [7] and [3]. There are two other aspects that motivated our use of argument schemes and critical questions:

- "By explicitly handling argumentation schemes it becomes possible for agents to at once broaden the scope of the relevant information, and at the same time, narrow down selection on the basis of the argument schemes detected" [5]. In other words, agents are directed by the CQ in order to further support their arguments or to attack an argument that they disagree with. Note that not all disagreements are logically derivable (in a straight forward way), for example [DCAPS]CQ3-Can A2 be performed on R?-. Also not all the possible logical disagreements are applicable in certain contexts (e.g. in scheme [VS] there is no point in putting forward the challenge -Is O D’s organ?-, despite being a valid challenge from a logical point of view).

- Argument Schemes and Critical Questions provide us with a useful conceptual framework in which to elicit the required argumentation knowledge from physicians with experience in deciding the viability of human organs. The pseudo natural language used to represent this defeasible rules (argument schemes), and their defeaters (critical questions) enable to readily compre-
hend the content of these rules and propose new rules or changes in the existing ones.

In both, [7] and [3], we address the agents argument based deliberation as a three step process, in which a TCA provides its arguments, then TUA contra-argue and finally, MA evaluates the arguments, being able also to add its own arguments. This process does not conflict with the argument scheme formalization at hand, since, as we pointed out above, critical questions not only identify the defeaters of an argument, but also the lines of reasoning that enable to further support a given argument. Also in [3] we express our intention to address the agents’ deliberation from a dialogical perspective.

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References