Abstract Argumentation Scheme Frameworks

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Abstract. This paper presents an approach to modelling and reasoning about arguments that exploits and combines two of the most popular mechanisms used within computational modelling of argumentation: argumentation schemes and abstract argumentation frameworks. Our proposal combines the desirable properties of each by representing the components of argumentation schemes as argumentation frameworks. This allows us to make use of the structure provided by the schemes to guide dialogues and provide contextual elements of evaluation, whilst retaining the desirable properties of abstract frameworks to enable evaluation with respect to the logical relations between arguments. Our proposal takes account of dialogical aspects within a debate, such as burden of proof, and we illustrate our approach through a particular argumentation scheme, namely argument from expert opinion.

1 Introduction

Two of the most significant developments in the computational modelling of argumentation in recent years have been *abstract argumentation frameworks*, introduced by Dung in [9], which emerged from logic programming, and *argumentation schemes*, e.g. [18] which emerged from informal logic. Interestingly, these seem to pull in opposite directions: while abstract argumentation considers arguments as structureless atomic entities related only by a binary attack relation, argumentation schemes articulate the varied structures that can constitute arguments, thus adding enriching detail, rather than abstracting from this detail to give the clean semantic properties offered by argumentation frameworks. Both approaches have clear attractions: in this paper we will attempt to provide a means of capturing the variety of structures offered by argumentation schemes in a way in which the properties of abstract frameworks can still be exploited.

Abstract argumentation frameworks have been widely studied as a means of exploring issues relating to defeasible reasoning and non-monotonic logics. There have been various proposals for different semantics for these frameworks, and these have been investigated and compared (e.g. [6]). Complexity questions relating to decision problems regarding such frameworks have been resolved (e.g. [8]), and particular constrained frameworks explored (e.g. [10]). All in all, abstract argumentation frameworks give a clean and well understood basis for considering the status of a related collection of arguments.

Turning to argumentation schemes, these have been exploited in argument diagramming tools such as Arucaria [16]. There, however, they are no more than annotations on the diagram serving to group premises and conclusions, and require the user to employ them in a principled fashion. Argumentation schemes are also used in the Carneades framework [11]. There the nature of the scheme is used to distinguish between ordinary premises, which must be shown, assumptions, which must be shown on demand, and exceptions, which vitiate the argument if shown. These distinctions are made on the basis of the *critical questions* characteristic of the argumentation scheme being represented.

Central to the notion of argumentation schemes, as described in [18], is that the claim they support is merely presumptive. Associated with each scheme is a set of critical questions which if posed must be answered successfully, or else the claim withdrawn. As well as their use in Carneades noted above, critical questions have been used in [3] to identify the various ways in which arguments made by instantiating a particular scheme can be attacked. A formal characterisation of one particular argumentation scheme, for reasoning about action, and its associated critical questions allowing the identification of attacking arguments, is given in [2].

Argumentation frameworks and argumentation schemes have different strengths. Argumentation frameworks are at their best when we have completely identified the set of relevant arguments and the attack relations between them. Very often, however, this complete set is not available: in many applications the argumentation framework is created, often through a dialogue between participants advocating different points of view, e.g. [13]. Here argumentation schemes come to the fore: these schemes help to identify the ways in which arguments can be attacked and defended, and the dialogical burdens of production and proof [11] [14] which are proper to the various participants, and which may impact on the evaluation of the arguments. If a point cannot be decisively established, it is important to know which participant has the burden of proof with respect to that point. Essentially, argumentation schemes guide the generation of arguments, and supply contextual aspects for their evaluation. Once the contextual issues have been resolved, the arguments can be abstracted to an argumentation framework, and evaluated with respect to their logical relations.

In this paper we will draw upon several of the above approaches to provide a means of firmly integrating argumentation schemes with abstract argumentation frameworks. We first recapitulate the notions of abstract argumentation frameworks introduced in [9]. We then discuss the notions of argumentation schemes and critical questions, and the interpretation of them given in [11], illustrated by a particular example scheme, *Argument from Expert Opinion*, as formulated in that paper. We will pay particular attention to the way in which argumentation schemes identify the responsibilities of participants in a dialogue, and how this affects the status of the arguments within the scheme. We then provide definitions to represent argumentation schemes in a form reducible to argumentation frameworks, and to link them together to form *abstract argumentation scheme frameworks*. We again illustrate our approach by applying it to the scheme *Argument from Expert Opinion*. We conclude by identifying directions in which this work can be built upon: most especially how argumentation schemes can be used to drive dialogue and to confer properties on arguments that are required to differentiate arguments acceptable to different audiences.

2 Argumentation Frameworks and Argumentation Schemes

In this section we provide a brief overview of the two approaches to argumentation that we later combine within a single framework.

2.1 Abstract Argumentation Frameworks

Abstract argumentation frameworks (AFs) have proven to be an influential approach to non-monotonic reasoning over the past decade. The underlying idea of AFs is to model and evaluate arguments by considering how well they can be defended against other arguments that can attack and defeat them. The relationships between arguments can be modelled as directed graphs showing which arguments attack one another. No concern is given to the internal structure of the arguments, so the status of an argument can be evaluated by considering whether or not it is able to be defended from attack from other arguments with respect to a set of arguments. Essentially, an argument can be justified with respect to a set of arguments if it is not attacked by a member of that set, and all its attackers are attacked by a member of that set. AFs were first introduced by Dung in [9] but numerous subsequent works have extended the basic frameworks to incorporate properties such as preferences [1] and values [7], as well as extending the semantics associated with the frameworks, e.g. [6].

Here we recall the following basic concepts that were introduced by Dung in [9][1].

Definition 1. *An* argumentation framework (AF) *is a pair* $\mathcal{H} = \langle \mathcal{X}, \mathcal{A} \rangle$*, in which* $\mathcal{X}$ *is a finite set of* arguments *and* $\mathcal{A} \subset \mathcal{X} \times \mathcal{X}$ *is the* attack relationship *for* $\mathcal{H}$*. A pair* $\langle x, y \rangle \in \mathcal{A}$ *is referred to as '*y is attacked by x*' or '*x attacks y*'. For* R*,* S *subsets of arguments in the system* $\mathcal{H}(\langle \mathcal{X}, \mathcal{A} \rangle)$*, we say that*

a. $s \in S$ *is* attacked *by* R *if there is some* $r \in R$ *such that* $\langle r, s \rangle \in \mathcal{A}$*.*
b. $x \in \mathcal{X}$ *is* acceptable with respect to S *if for every* $y \in \mathcal{X}$ *that attacks* x *there is some* $z \in S$ *that attacks* y*.*
c. S *is* conflict-free *if no argument in* S *is attacked by any other argument in* S*.*
d. A conflict-free set S *is* admissible *if every argument in* S *is acceptable with respect to* S*.*
e. S *is a* preferred extension *if it is a maximal (with respect to* $\subseteq$*) admissible set.*

2.2 Argumentation Schemes and Critical Questions

Having recapitulated abstract argumentation frameworks, we now provide an overview of argumentation schemes.

In [18] Walton has provided a number of different argumentation schemes that capture particular patterns of reasoning. Although we note that different schemes have been proposed by others, we base our view of argumentation schemes on Walton. Argumentation schemes are stereotypical patterns of reasoning. Like deductive arguments they

[1] In this paper we use only preferred extensions and so do not define grounded and stable extensions.

have premises and a conclusion, but unlike deductive arguments they only provide reasons why the claim can be *presumed* to be true.

Such schemes follow a general pattern by which the arguments are presented as general inference rules whereby given a set of premises, a conclusion can be drawn. As noted above, however, the conclusions justified by an argumentation scheme are only presumptive, and open to question and defeat. In particular, an argument based on a particular scheme is subject to a set of critical questions characteristic of that scheme. The schemes allow arguments to be presented within a particular context but take into account that the conclusions drawn may be altered in the light of further considerations raised by the critical questions, such as new evidence or exceptional circumstances. We next illustrate the notion of argumentation schemes with an example: 'Argument from Expert Opinion'.

2.3 Argument from Expert Opinion

Several versions of this argumentation scheme have been presented. We use a recent version given in [11], which is stated as follows:

Major premise: Source E is an expert in the subject domain S containing proposition A.
Minor premise: E asserts that proposition A in domain S is true.
Conclusion: A may plausibly be taken as true.

The scheme has associated with it the following six critical questions:

CQ1: How credible is E as an expert source?
CQ2: Is E an expert in the field that A is in?
CQ3: Does E's testimony imply A?
CQ4: Is E reliable?
CQ5: Is A consistent with the testimony of other experts?
CQ6: Is A supported by evidence?

If any of these critical questions are posed, in order for the presumptive conclusion to stand, its proponent must respond satisfactorily to that critical question. What counts as a satisfactory response, however, depends upon the specific role that the critical question plays. Following [11], we recognise the following three categories of critical questions:

- Those used to question whether a *premise* of a scheme holds (e.g. CQ2 and CQ3)
- Those used to recognise *exceptions* to the use of the scheme (e.g. CQ4 and CQ5)
- Those used to question the *assumptions* used in the scheme (e.g. CQ1 and CQ6)

These categories differ: the last two contend that the presumptive conclusion does not in fact hold, whereas the first denies that the argument can be proposed at all (since its premises are false), as argued in [17]. Moreover, for assumptions the *burden of proof* is on the proponent, whereas for exceptions the burden of proof is on the opponent.

3 Abstract Argumentation Scheme Frameworks

In this section we will articulate argumentation schemes in terms of argumentation frameworks. The idea is that, as the discussion above suggested, we should not see an argumentation scheme as an atomic whole, but rather as a *process* of argumentation. We therefore need to identify the elements of an argumentation scheme and the relations between them.

We can define a general argumentation scheme as:

GAS: A proposal that a set of premises provide a reason for a conclusion: *prop* = *conc*, *because premises*
A set of assumptions: $assump_1$ ... $assump_n$
A set of exceptions: $except_1$ ... $except_n$
A conclusion: *conc*

For simplicity we will, without loss of generality, discuss a scheme, GAS1, with a proposal, *prop1* (i.e. *conc1*, because *prem1*), one assumption, *assump1*, one exception, *except1*, and a conclusion *conc1*.

The proponent will put forward the argumentation scheme as *prop1*. In doing so the proponent asserts that *prem1* is true, and that *conc1* should be believed on the basis of *prem1*. These claims are distinct, and although elided in normal presentation, should be considered as two claims rather than one. Since *prem1* provides a reason for *conc1* only if the assumption is satisfied and the exception does not apply, putting the scheme forward implicitly commits the proponent to *assump1* and implicitly denies *except1*. Thus the proponent of the argumentation scheme can be seen as making four claims: *prem1* being true provides a reason for *conc1*; *conc1* should be believed; *assump1* is true; and, *except1* is not true. These claims are related in the following ways.

If either *assump1* is false or *except1* is true, although *prem1* does provide a reason to believe *conc1*, *conc1* should not be accepted. Thus both *not assump1* and *except1* attack *conc1*. By asserting that *prem1* is a reason for *conc1*, however, the proponent has attacked both *not assump1* and *except1*. This enables us to see the argumentation scheme GAS1 as an AF, GASAF1, with arguments *prop1*, *not assump1*, *except1*, *conc1* and attacks {(*prop1*, *not assump1*), (*prop1*, *except1*), (*except1*,*conc1*), (*not assump1*,*conc1*)}. A graphical representation of this AF is shown in Figure 1.

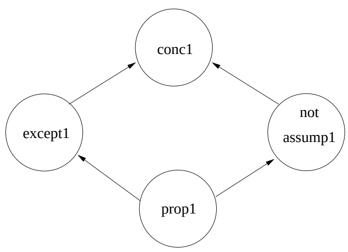

Figure 1: AF after proponent's arguments are put forward

Considered as a standard AF in which attacks are always successful, the acceptable arguments, representing the preferred extension for the framework, are {*prop1*, *conc1*}, and {*not assump1*, *except1*} are defeated, which corresponds to the claims attributed to the proponent above.

Now consider the role of the opponent. The opponent may simply accept GAS1. If the opponent is sincere, he will do so if he believes *prem1* and *assump1* and does not believe *except1*. The opponent, however, has the right to critique the argument. Suppose opponent does not accept *prem1*. An argument for *not prem1* constitutes an attack on the proposal, *prop1*, since *prop1* holds only if *prem1* is true. If, however, the opponent does not accept the assumption, this is an assertion of *not assump1*, which does not affect the proposal, but rather denies that the conclusion should be believed on the basis of the proposal. Similarly if the opponent believes that the exception holds, this requires the assertion of *except1*, which also denies that the conclusion should be believed, rather than that the original proposal is flawed.

Nothing special is required to handle a denial of *prem1*: this is an argument attacking *prop1* which must be defeated in the usual way to reinstate *prop1*. For the moment, therefore, we will take *prop1* as unattacked, since this debate is external to GAS1. We do, however, already have arguments for *not assump1* and *except1* in GASAF1, but these are attacked by *prop1*. Here, therefore, we must be able to distinguish between attack and defeat. To reflect the opponent's *burden of production*, which reflects that the presumptive conclusion holds until challenged, we allow the opponent to mark *not assump1* and *except1* as *produced*, and say that, *within an argumentation scheme*, an attack fails to defeat an argument marked as produced, unless the attacking argument is also produced. Figure 2 shows the AF for this scenario.

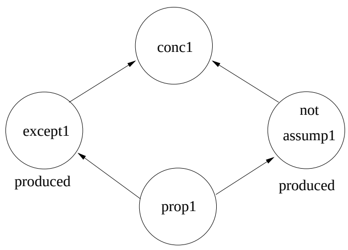

Figure 2: AF updated with CQs produced by opponent

Suppose the opponent marks *not assump1* as produced in GASAF1. Now *not assump1* will not be defeated by *prop1*, and so will defeat *conc1*. In order to reinstate *conc1*, proponent must therefore provide an argument external to the scheme to defeat *not assump1* (i.e. justify the assumption). Suppose, however, that the opponent marks *except1* as produced in GASAF1. This will mean that *except1* is no longer defeated by *prop1*, and so will defeat *conc1*. But in this case, since here the burden of proof is on opponent, proponent should not be required to show that *except1* is false in order to reinstate *conc1*. While a sincere proponent will simply accept *except1* when produced if he has reason to believe it, proponent has the right to challenge the opponent to provide an argument for *except1*. This can be reflected by introducing another element, which we will call *challenge*, which is initially implicit and so unmarked, but which the proponent can choose to mark as *produced* if he does not believe that the exception holds. Once produced, this will defeat the exception, and so reinstate the conclusion. Figure 3 shows this scenario and the effect of the *challenge* argument on the status of *except1*.

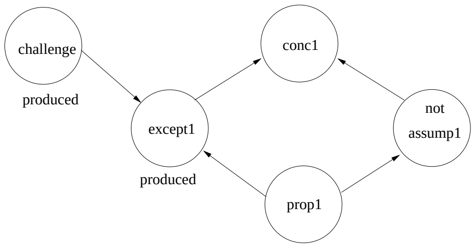

Figure 3: AF showing *produced* exception and challenge

Now, to discharge the burden of proof, the opponent must reinstate the exception with an argument for the exception, such that this new argument attacks the challenge.

One further addition is also required. If the proposal is defeated, the conclusion must also be defeated. But it is possible that all the assumptions, and none of the exceptions are satisfied, even though the premise is defeated. A person may be credible, unbiased and so forth, but we cannot use argument from expert opinion to justify a belief in an opinion if the proposal is defeated. We therefore need an additional argument, attacked by the proposal and attacking the conclusion, representing that the proposal is unacceptable. This need not be produced: it is always defeated if the proposal is acceptable. Let us term this additional argument *unacceptable*.

This enables us to see an argumentation scheme as an AF with a particular structure, illustrated in Figure 4.

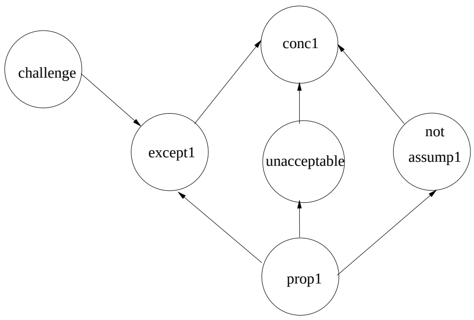

Figure 4: AF with *unacceptable* argument

We can now define this structure as follows:

Definition 2: *Arguments in an Argumentation Scheme Framework*: An argumentation scheme framework, ASF, is a tuple $<$*prop*, *Assumps*, *Excepts*, *Challenges*, *unaccept*, *conc*$>$ where *prop*, *unaccept* and *conc* are arguments, and *Assumps*, *Excepts* and *Challenges* are sets of arguments. All of *Assumps*, *Excepts* and *Challenges* contain zero or more arguments, and for every $except_i \in$ *Excepts* there is a corresponding $challenge_i \in$ *Challenges*. Let AS = $\{$*prop*$\} \cup$ *Assumps* $\cup$ *Excepts* $\cup$ *Challenges* $\cup$ $\{$*unaccept*$\} \cup \{$*conc*$\}$.

Definition 3: *Attacks in an Argumentation Scheme Framework*:

i) for all $assump_i \in Assumps$, attacks(*prop*, $assump_i$)
ii) for all $except_i \in Excepts$, attacks(*prop*, $except_i$)
iii) for all $assump_i \in Assumps$, attacks($assump_i$, *conc*)
iv) for all $except_i \in Excepts$, attacks($except_i$, *conc*)
v) for all $except_i \in Excepts$, $challenge_i \in Challenges$, attacks($challenge_i$, $except_i$)
vi) attacks(*prop*, *unaccept*)
vii) attacks(*unaccept*, *conc*).

Let ASatts be the set of all attacks in the ASF.

Definition 4: *Defeat in an Argumentation Scheme Framework*: Let *Produced* be the subset of AS such that an argument $ap \in Produced$ if and only if *ap* is marked as *produced*. Now for any *arg1*, $arg2 \in$ AS, attacks(*arg1*, *arg2*) succeeds if and only if attacks(*arg1*, *arg2*) $\in$ ASatts and $arg1 \in Produced$, or it is not the case that *arg2* $\in Produced$. Let ASdefs be the subset of ASatts such that $asdef \in$ ASdefs if and only if $asdef \in$ ASatts and *asdef* succeeds.

Definition 4 uses the dialogical status of arguments in AS to determine whether the attacks in ASatts are successful. Note that success is determined entirely by the dialogical status of the arguments concerned together with the burdens of production and proof imposed by the argumentation scheme. This is therefore entirely objective, and there is no need to consider different audiences in determining whether an attack succeeds. Once, however, we have made use of the dialogical status in this way, we can abstract away from it to return to an abstract argumentation framework, but with only the successful attacks included. An argumentation scheme framework can thus be abstracted to an abstract argumentation framework, in the sense of Definition 1, with X = AS and A = ASdef. We can then determine the acceptability of arguments in this framework using any of the standard semantics applied to Dung's AFs. Note also that a deductive argument can be viewed as a degenerate argumentation scheme in which all of *Assumps*, *Excepts* and *Challenges* are empty.

4 Linking Abstract Argumentation Scheme Frameworks

Thus far we have only considered a single argumentation scheme in isolation. We now need to embed the scheme within a larger framework. First note that only conclusions can be used to attack arguments external to the scheme: if it is not established that the conclusion should be believed, it cannot attack any other argument. All of assumptions, proposals and challenges, however, can be attacked from outside the scheme: assumptions by an argument that the assumption holds, proposals by an argument that the premise does not hold, and challenges by an argument that the corresponding exception does hold.

Suppose that we regard all arguments under consideration as representing arguments using some argumentation scheme. We will now have a set of instantiated argumentation schemes linked by the attack relation, with the conclusion of one argumentation scheme attacking the proposals, assumptions, challenges and conclusions of other argumentation schemes. We use the example of the scheme for argument from expert opinion to examine how instantiations of argumentation schemes and their associated critical questions form arguments that can be represented and evaluated in terms of the definitions just introduced.

The starting point in constructing the framework is an instantiation of an argumentation scheme. Figure 5 shows the complete ASF for an argument i and relevant fragments of ASFs for arguments j, k and m. Instantiating the scheme for argument i, an argument from Expert Opinion, creates an ASF with the following nodes: a *prop* node representing the proposal of the instantiated scheme, labelled in the graph with 'prop_i'; a *conc* node representing the conclusion of the scheme, labelled with 'conc_i'; an *assump* node representing a critical question of type assumption, labelled with 'CQ1'; and, an *except* node representing a critical question of type exception, labelled with CQ5, along with the *challenge* node on CQ5, labelled with the 'challenge_i'[2]. In accordance with our definitions, either of CQ1 and CQ5 may be answered by the conclusion of another ASF, which we indicate with the two nodes that attack the *assump* and *challenge* nodes in the framework. Furthermore, the conclusion of one ASF may attack the conclusion of another ASF, as shown in the graph by conc_i attacking conc_m. Finally, we also need to include a node in the graph for the claim that i is *unacceptable*, which is attacked by the proposal and which itself attacks the conclusion, as described previously.

Figure 5 shows a framework that includes two of the critical questions associated with the scheme from expert opinion: the remaining assumption and exception can be included similarly, whereas CQ2 and CQ3 require further ASFs with conclusions which attack the proposal.

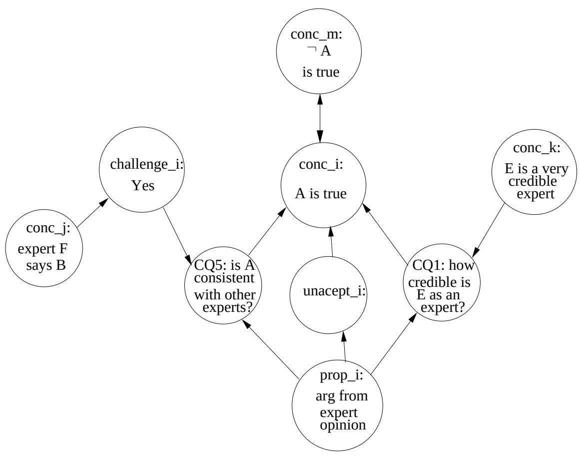

Figure 5: AF for Argument from Expert Opinion scheme

From Figure 5, we can see that CQ1 is an argument of type *Assumps*, questioning the assumption that *E* is credible as an expert. As shown in the framework, the way to respond to this question is to instantiate another argumentation scheme (argument

[2] Due to space restrictions we include only one of the assumptions and exceptions and omit attacks on the premise.

k) to provide an argument confirming that *E* is indeed credible as an expert, perhaps by listing *E*'s qualifications (as shown by the node conc_k attacking CQ1). CQ5, on the other hand, is of type *Excepts* and the response to this objection must be handled differently. The proponent of the initial argument may simply respond with a *challenge* to force the opponent to respond with some evidence to show that there are experts who disagree, best done by producing an argument from expert opinion based on a second expert.

5 Example

In this section we will make our discussion more concrete by presenting an example. The heart of the example will be two instantiations of Argument from Expert Opinion, the scheme discussed previously. We will, however, also make use of a number of other argumentation schemes for which we provide no description. We trust that the nature of these schemes will be clear from the context and the example. Identifying and classifying argumentation schemes, giving them a precise characterisation in terms of their premises and critical questions, is an area of active current investigation (e.g. [15]).

To begin the example, suppose Wilma and Bert are having breakfast and a discussion as to whether they should eat more grapefruit begins. Wilma is a grapefruit advocate, whereas Bert favours other kinds of fruit. Wilma presents her case using an argument from Expert Opinion:

W1: Jane is an expert on nutrition and she says that grapefruits are healthy.

Bert can now respond to this, and uses the critical questions characteristic of the scheme to choose his response. Suppose that he is willing to accept that Jane is indeed a credible expert on nutrition: this means that he will not question Wilma's assumption. But he recalls Jane saying something different, and so attacks the basic premise with an Argument from Testimony.

B1: Jane actually said "grapes are a healthy fruit", so she did not say that grapefruits are healthy.

Wilma needs to defeat this if she is to maintain W1, so she produces Jane's book *Eating for Life*, turns to page 69 and produces an Argument from Citation:

W2: Jane wrote *Eating for Life*, and on page 69 it says "Of all fruits, grapefruits are the most healthy." So Jane says grapefruits are healthy.

Confronted with this incontrovertible evidence, Bert must find another way to avoid grapefruit. Reviewing the critical questions, he realises he can use a dissenting expert.

B2: But other experts say different things.

Wilma is unaware of any dissenting experts and since Bert is using an exception, she can demand that he substantiate B2.

W3: Which other experts?

Bert has one, and so puts forward his own Argument from Expert Opinion:

B3: Carol is an expert on nutrition and she says that grapefruits are not good for you.

Wilma is aware that Carol is also an expert on nutrition, and now recalls that she did indeed say that. However, she can use W1 as an exception to B3. The situation is now as shown in Figure 6. Only W1 and B3 are shown in full: B1 and W2 are represented as single nodes, while B2 and W3 are included as parts of W1.

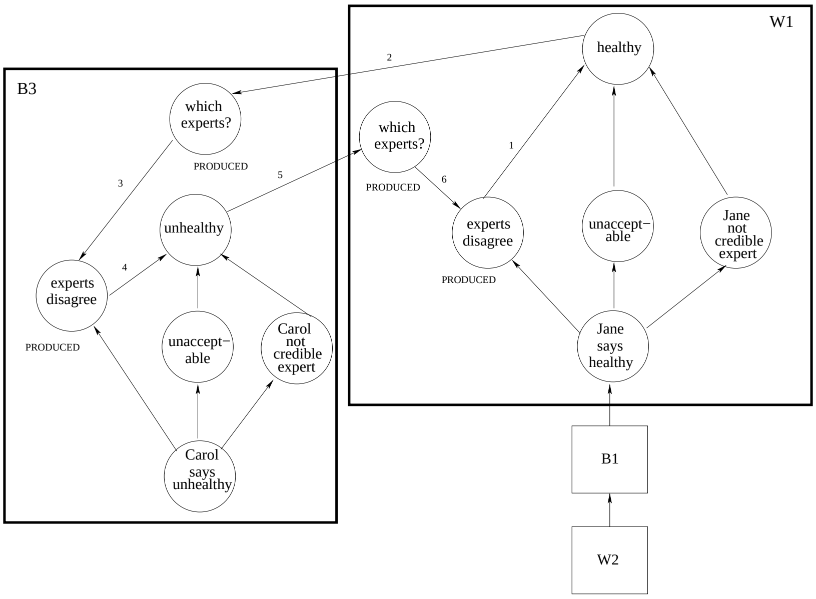

Figure 6: Arguments in the Bert and Wilma debate. The cycle of six arguments, where the attacks are numbered in the graph, gives rise to two preferred extensions for the framework. This conflict is resolved for a given audience by preferring one or other of the experts . If Jane is preferred attack 5 fails and is removed: if Carol is preferred attack 2 is removed.

At this point there is something of an impasse: the six cycle in the argumentation framework means that it has two preferred extensions[3], one containing the conclusion that grapefruits are healthy, and one that they are not. How do we resolve this dilemma? It is widely recognised that the acceptability of arguments does not only depend on their intrinsic merits, but on the audience to which they are addressed [12]. In approaches such as [7] properties are ascribed to arguments and different audiences are represented by different rankings of these properties. Arguments can now be compared with their attackers on the basis of these properties, and the ranking of the relevant audience used to determine which of these attacks will succeed. Unsuccessful attacks can then be removed to provide a Dung-style argumentation framework appropriate to that audience. The question now arises as to where these properties come from. Our answer is that they

[3] Only argumentation frameworks with even length cycles give rise to multiple preferred extensions [7].

come from the argumentation scheme used to generate the argument. For example, the values ascribed to arguments by [3] can be derived from their argumentation scheme for practical reasoning, and in our case the Argument from Expert Opinion confers the degree of authority associated with the particular expert. This provides another important reason for paying attention to argumentation schemes. In many applications we need to supply a principled way of choosing between mutually attacking arguments.

Returning to Bert and Wilma, the successful argument in our debate will depend on whether Jane or Carol is considered the better expert. At this point, if Bert and Wilma agree on which of Jane or Carol is to be relied on, the debate can conclude. They may, however, disagree, in which case neither will be persuaded: Wilma has failed to convince Bert, but equally Bert has not forced her to change her views. They may therefore agree to disagree. Suppose, however, Bert does some searching on the internet, and finds a paper reporting a study which shows that grapefruits have some bad effects. He can return to the fray the following morning and attack the conclusion of W1 directly with an Argument from Scientific Study:

B4: A study published in *Diet Today* showed that people who eat grapefruits are significantly more likely to suffer from indigestion. This shows that grapefruits are not healthy.

Wilma may accept this, or may continue the debate using the critical questions associated with Argument from Scientific Study: for example, that *Diet Today* is not a refereed journal. We leave the example here.

The example shows: how various critical questions can be used to drive the discussion, informing the moves of the participants; the role of producing arguments in determining the dynamic status of the arguments in the course of the debate; and how argumentation schemes can be used to confer properties on the arguments and so resolve conflicts in terms of the subjective audience to which the argument is presented.

6 Discussion

So far we have shown how the presumptive style of argument supported by argumentation schemes can be integrated with abstract argumentation frameworks. The various claims made explicitly and implicitly when advancing a scheme, and the possible means of questioning those claims, all appear as nodes in the framework, related in a particular way in order to produce a structured framework characteristic of the scheme. Evaluation of these arguments can then be effected by filtering the attacks to remove those that are unsuccessful by reason of their dialogical status, and then, having used this necessary contextual information, considering them as standard, purely abstract, frameworks.

A key motivation is the use of argumentation in dialogue: the schemes enable us to identify how an opponent can respond to an argument made using a particular instantiated scheme. Consideration of the example in Figure 6 gives further pointers to how further assistance can be provided for conducting dialogues. When various critical questions are produced they need to be met by arguments to justify the assumptions or substantiate the exceptions. But because the critical questions address particular issues, the arguments answering them must also be of particular types. In our example, the conclusion of B3, which establishes the exception by showing that there are dissenting experts, is itself the conclusion of an argument using the Expert Opinion scheme. Similarly there will typically be prescribed ways of establishing that someone is indeed an expert in order to justify the assumption that the expert is credible, perhaps by pointing to qualifications or a position held in a reputable university. Thus we can expect the arguments related to a given argumentation scheme to be themselves instantiations of a limited number of particular argumentation schemes characteristic of the concern they address. In this way, a given argumentation scheme can be seen as embedded in a conversation composed from a range of argumentation schemes in a well defined manner. This has analogies with general agent communication in which it is necessary to see individual speech acts as embedded in a conversation class to provide the context necessary to their interpretation and to guide the appropriate responses as the dialogue develops [4] [5].

Of course, modelling argumentation schemes and identifying characteristic responses to their critical questions does require significant analysis of particular domains in which debates take place. What the approach in this paper provides is a means of harnessing this analysis in a way which can be made compatible with abstract argumentation frameworks for evaluation. The domain analysis guides the dialogue and provides contextual input to the evaluation. The legal domain, in particular, often states quite explicitly that certain assumptions and exceptions can only be established in specified ways. An example analysis concerning reasoning from a precedent is given in [19]. Here the critical questions of the main scheme are responded to by further specific argumentation schemes, thus allowing the whole debate to be represented as a conversation made up of a cascade of particular argumentation schemes.

As well as providing contextual information which can be used to remove unsuccessful attacks and so provide a means of abstracting these features away to reach a standard AF, argumentation schemes can provide properties which can be used to resolve conflicts between arguments that depend on the subjective interests and opinions of the audience to which they are presented. Our example in section 5 illustrated this by requiring the audience to express a preference between competing experts. Once the preference has been expressed, the unsuccessful attack can be removed, again allowing abstraction to an abstract framework appropriate to that audience.

Note that the same technique is used both to handle burden of production and audience preferences. Argumentation schemes provide properties for their constituent arguments (objective dialogical status for critical questions and subjective audience-related preferences for conflicts) and these properties are used to identify attacks that are contextually unsuccessful. Once these properties have played their part in providing the contextual and audience-related elements of evaluation, they can be discarded and the resulting AF evaluated to provide the logic of the debate.

To conclude: in this paper we have shown how argumentation schemes can guide the identification of moves to challenge claims and make appropriate responses to particular challenges. Argumentation schemes also supply contextual elements of evaluation of the arguments in a way which allows abstraction to a standard Dung-style argumentation framework. This abstract framework allows arguments to be evaluated with respect to their logical relations. In this way, we provide a means of combining the distinctive advantages of both approaches. The proposal we have presented is intended to lay the foundations for a dialogical account of argumentation whereby dialogue interactions are guided by the particular moves, corresponding to the elements of the argumentation scheme, that can be put forward and subsequently evaluated through the use of argumentation frameworks. Articulating the machinery for this dialogical setting will be the focus of the next step with this work.

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