

An analysis of the Avetrana Murder Case through Abstract Argumentation

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Abstract. Argumentation is the activity by which one justifies his own position in a discussion. It plays a fundamental role in court trials, for faithfully reconstructing the course of the events from evidence and testimonies. So, the availability of automated techniques for carrying out argumentation would be extremely useful in that domain. Abstract argumentation focuses on the inter-relationships among the available arguments, neglecting their internal structure or specific interpretation. In this paper we report about the application of abstract argumentation techniques to a very famous criminal case happened in Italy. Our aim is, on one hand, showing a practical and relevant application of abstract argumentation, and, on the other, comparing the outcome of the automated approach to that of the judges in the real court.

Keywords: Machine Reasoning, Argumentation, Forensics

1 Introduction & Related works

Argumentation is ubiquitous in our everyday life, for trivial issues as well as for important ones. It is the activity by which one justifies his own position in a discussion. When such a position is not agreed upon by others, there is a need to settle the disagreement among different, contrasting positions. This is done by carrying out a debate in which each participant tries to support his own position with suitable arguments, also attacking the arguments put forward by others to support their position, and of course defending his position from the attacks of the others. More formally, argumentation is an inferential strategy for practical and uncertain reasoning able to cope with partial and inconsistent knowledge. Its goals are to identify, analyze and evaluate arguments.

One traditional application for argumentation is for settling legal disputes. In court trials, judges must make their decisions after considering both a body of evidence and a set of testimonies given by witnesses. While evidence, especially scientific one, is the main foundation for a decision, it is often insufficient, which calls for the evaluation of testimonies in order to obtain a reconstruction of the events of the case as faithful as possible. Sometimes the best available explanation is sufficient for the judge to take his decision, sometimes a proof beyond

any reasonable doubt is required. Identifying the truth among all testimonies is not easy for several reasons:

- there are often many different positions, and the relationships of the testimonies among each other, and among them and the positions, are often indirect and unclear;
- some testimonies are purposely deceptive in order to favor one of the positions;
- even when eye witnesses are truly committed to faithfully reporting what they saw, human memory tends to be inherently unreliable when recalling past events.

For these reasons, and given the relevance of taking the most faithful position, automated techniques for carrying out argumentation would be extremely useful both in general, and in court trials in particular.

Indeed, a lot of literature is available about application of argumentation to legal reasoning. Just to mention a few examples, [1] shows how it can be more appropriate than deduction for handling the need to support and justify some interpretations of a case against others, and review several systems aimed at implementing different aspects of argumentative reasoning. [2] presents a set of argument schemes that encapsulate preferences between social values revealed in past decisions to decide new cases. [3] proposes the use of abstract argumentation in case-based reasoning, resulting in a methodology to produce decision and explanations for new cases. [4] proposes a method to encapsulate the knowledge of bodies of case law using Abstract Dialectical Frameworks (ADFs), and for producing programs that decide the cases. [5] develops and discusses an Argumentation Framework to represent case law. [6] investigates natural-language argumentation in the case law domain, aimed at formalizing the structure of argumentation as a context-free grammar.

This paper reports about the application of abstract argumentation techniques to analyze a very famous criminal case happened in Italy. In the case, most of the available knowledge of the events was in the form of testimonies, in which deception and falsity were widespread. Everybody in Italy knows about this case, because it was emotionally enthralling since it concerned the murder of a young girl, and got wide coverage by the media. Actually, while the formal decision for the Italian law is definitive, many people are not fully convinced of the final outcome, nor about the reconstruction of the events that was considered as the most reliable to take that decision. Our aim is, on one hand, showing a practical and very relevant application of abstract argumentation, and, on the other, trying to explain on a formal basis the decision of the judges in the Court.

This paper is organized as follows. After recalling the basics of the formal approach to argumentation we will use, and some other works concerned with application of automated argumentation to real court cases, we will present the story, then we will formalize it in an abstract argumentation framework, and finally we will apply several different kinds of strategies to determine the winning arguments, discussing their features and outcomes.

2 Background

One of the most influential *computational models of argument*, developed by research in Artificial Intelligence (AI), is Dung’s Abstract Argumentation Framework [7], where the internal structure or specific interpretation of arguments is ignored, and only their inter-relationships are taken into account, representing the exchange of arguments and counter-arguments in a dispute.

Definition 1 An Argumentation Framework (AF) is a pair $F = \langle \mathcal{A}, \mathcal{R} \rangle$, where \mathcal{A} is a finite set of arguments and $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$ is the attack relation.

$\alpha \mathcal{R} \beta$ means that α attacks β , or β is attacked by α . A set $S \subseteq \mathcal{A}$ attacks $\beta \in \mathcal{A}$, denoted $S \mathcal{R} \beta$, if $\exists \alpha \in S : \alpha \mathcal{R} \beta$.

Basically, an AF is a directed graph where the nodes are abstract arguments and the directed edges correspond to attacks between them.

An argumentation *semantics* is a formal criterion that determines which subsets of arguments in an AF, called *extensions* in *extension-based semantics* [7], are ‘collectively acceptable’.

Definition 2 Let $F = \langle \mathcal{A}, \mathcal{R} \rangle$ be an AF, an extension-based semantics \mathcal{S} associates F with a subset of $2^{\mathcal{A}}$, denoted by $\mathcal{E}_{\mathcal{S}}(F)$.

So, many alternative extensions may exist for a given AF, as well as no extension at all (i.e., $\mathcal{E}_{\mathcal{S}}(F) = \emptyset$). $\mathcal{D}_{\mathcal{S}}$ denotes the set of AFs where an extension for semantics \mathcal{S} exists.

A central concept is *acceptability*, or *defense*: a (set of) argument(s) defends an argument if it attacks all of its attackers.

Definition 3 Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, $S \subseteq \mathcal{A}$ and $\alpha \in \mathcal{A}$, α is defended by S iff $\forall \beta \in \mathcal{A} : \beta \mathcal{R} \alpha \Rightarrow S \mathcal{R} \beta$.

The basic concept shared by all argumentation semantics in the literature is *conflict-freeness*: if an argument attacks another argument, then they cannot be both in the same extension.

Definition 4 Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, $S \subseteq \mathcal{A}$ is conflict-free iff $\nexists \alpha, \beta \in S$ s.t. $\alpha \mathcal{R} \beta$. The collection of all conflict-free sets for F is denoted by $\text{cf}(F)$.

\emptyset is conflict-free. A further requirement is *admissibility*: an extension should withstand the attacks it receives from other arguments by replying with other attacks.

Definition 5 Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, $S \subseteq \mathcal{A}$ is admissible if S is conflict-free and S is defended by itself, i.e. $\forall \beta \in \mathcal{A}$ s.t. $\beta \mathcal{R} \alpha : \exists \gamma \in S$ s.t. $\gamma \mathcal{R} \beta$. The collection of all admissible sets is denoted by $\text{adm}(F)$.

Note that \emptyset is not only conflict-free, but also defended by itself.

Definition 6 Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, a semantics \mathcal{S} satisfies the admissibility principle iff $\forall F \in \mathcal{D}_{\mathcal{S}} : \mathcal{E}_{\mathcal{S}}(F) \subseteq \text{adm}(F)$, namely

$$\forall E \in \mathcal{E}_{\mathcal{S}}(F) : \alpha \in E \Rightarrow (\forall \beta \in \mathcal{A} : \beta \mathcal{R} \alpha \Rightarrow E \mathcal{R} \beta).$$

Another essential property is reinstatement: if the attackers of an argument α are in turn attacked by an extension E , one may assume that they have no effect on α : then α should be, in a sense, reinstated, therefore it should belong to E .

Definition 7 A semantics \mathcal{S} satisfies the reinstatement principle iff

$$\forall F \in \mathcal{D}_{\mathcal{S}}, \forall E \in \mathcal{E}_{\mathcal{S}}(F) : (\forall \beta \in \mathcal{A} : \beta \mathcal{R} \alpha \Rightarrow E \mathcal{R} \beta) \Rightarrow \alpha \in E.$$

The justification state of an argument α can be conceived in terms of its extension membership. A basic classification [8] encompasses only two possible states for an argument (justified or not justified). In this respect, two alternative types of justification, skeptical or credulous, can be considered.

Definition 8 Given a semantics \mathcal{S} and an AF $F \in \mathcal{D}_{\mathcal{S}}$, an argument α is:

- skeptically justified iff $\forall E \in \mathcal{E}_{\mathcal{S}}(F) : \alpha \in E$;
- credulously justified iff $\exists E \in \mathcal{E}_{\mathcal{S}}(F) : \alpha \in E$.

Let us now introduce the four ‘traditional’ semantics, considered in Dung’s original paper [7], that we will use in this work. All of them are built on the concept of admissible sets.

Complete Semantics The notion of complete extension [7] is based on the principles of admissibility and reinstatement: a complete extension is a set which is able to defend itself and includes all arguments it defends.

Definition 9 Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, $S \subseteq \mathcal{A}$ is a complete extension iff S is admissible and every argument of \mathcal{A} which is defended by S belongs to S . The collection of all complete extensions is denoted by $\text{comp}(F)$.

Note that the empty set is admissible and initial arguments are acceptable with respect to the empty set. Due to reinstatement, any complete extension includes not only the initial arguments, but also the arguments they defend, those which are in turn defended by them, and so on. By definition, any complete extension is admissible.

Grounded Semantics Considering each complete extension as a reasonable solution, the grounded extension is the set of arguments shared by all these reasonable solutions.

Definition 10 Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, a set $S \subseteq \mathcal{A}$ is a grounded extension iff $S \in \text{comp}(F) \wedge \nexists T \in \text{comp}(F) \text{ s.t. } T \subset S$. The set of grounded extension is denoted by $\text{grd}(F)$.

For each AF there is exactly one grounded extension. As the set of complete extensions is non-empty and the grounded extension is just the \subseteq -minimal complete extension, the grounded extension always exists. Also, any grounded extension is a complete extension.

Preferred Semantics Preferred semantics seek to maximize the accepted arguments, taking into account maximal admissible sets.

Definition 11 *Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, $S \subseteq \mathcal{A}$ is a preferred extension iff S is admissible and $\nexists T \in \text{adm}(F)$ s.t. $T \supset S$. The collection of all preferred extensions is denoted by $\text{pref}(F)$.*

Any preferred extension E is also a complete extension. Indeed, preferred extensions may be equivalently defined as maximal complete extensions. Note that $\text{grd}(F) = \bigcap_{E \in \text{comp}(F)} E$ for any AF F . However, the grounded extension does not coincide with the intersection of all preferred extensions in general.

Stable Semantics Stable semantics relies on the intuition that an extension should be able to attack all arguments not included in it and leave no argument “undecided”, i.e., an argument must either be in the extension or be attacked by an argument of the extensions.

Definition 12 *Given an AF $F = \langle \mathcal{A}, \mathcal{R} \rangle$, $S \subseteq \mathcal{A}$ is a stable extension iff S is conflict-free and $\forall \alpha \in \mathcal{A}: \alpha \notin S \Rightarrow S\mathcal{R}\alpha$. The collection of all stable extensions is denoted by $\text{stb}(F)$.*

Any stable extension E is also a complete extension and a maximal conflict-free set of F . It follows that any stable extension is also a preferred extension, but not vice-versa. There are argumentation frameworks where no stable extension exists.

The classical semantics proposed above suffer from significant limitations in expressive power, due to their being able to express only unweighted attacks between arguments. Among the extended frameworks proposed in the literature to overcome this limitation, we recall here:

- the *bipolar* one [9], allowing to express also a support relation between arguments, in addition to attacks;
- the *weighted* one [10], allowing to set weights on arcs, expressing the strength of the attack;
- the *value-based* one [11], allowing to set a precedence ordering on arguments depending on the values they express;
- the *bipolar weighted* one (BAAF) [12], allowing to express both attacks and supports between arguments, plus weights on them;
- the *trust-based* BAAF (T-BAAF) [13], which adds to BAAFs the possibility of expressing the strength of the single arguments, by placing weights also on the nodes of the argumentation graph.

3 The Avetrana Case and its Formalization

For the purposes of this paper, we chose to apply abstract argumentation to a very famous criminal case happened in Avetrana, a town in the province of Taranto, Italy, from which it drew its name. The case generated much ado in Italy, for several reasons: the peculiarities of the story, the quite confusing information available about the events, the wide coverage it received from the media, and, last but not least, the strong debate among common people about the responsibility of the crime.

In a nutshell, the case started on August 26th, 2010, when a young girl, Sarah Scazzi, was missing. At first, her parents and relatives were questioned, in order to collect as much information as possible, and devise an inquiry strategy to understand what happened and hopefully find her. Very early, Sarah’s mother, Concetta, suggested to focus on the Misseri family: uncle Michele, aunt Cosima (Concetta’s sister), and their daughter, Sabrina. Indeed, the phone logs indicated that Sarah was at their place before disappearing. Since the very beginning, their account of the events was strange, lacking details and full of inconsistencies, which added to the suspects about their being involved in the case. After several weeks of interrogatories, lies and deceptions, the corpse of Sarah was found in a well in the country nearby. Many debates, tests and counter evidence followed this tragic event, until, on February 21st, 2017, after 3 court levels, the case was definitely closed condemning Cosima and Sabrina for the murder, and Michele for concealing the corpse. The Court determined that the reason that triggered Sabrina to kill Sarah, aided by her mother, had to do with her jealousy for a guy named Ivano.

The very short account we just provided for this case cannot express, let alone suggest, the intricacy of the case, due to inconsistency among different testimonies, sometimes even among testimonies given by the same person (especially uncle Michele), and between testimonies and evidence found during the inquiry. Indeed, especially the Misseris, tried to protect each other from being charged of the murder, but without devising a consistent, albeit fake, version of the events. So, they just tried to mess up the inquiry by declaring something, then retracting, or changing, or even contradicting their own declarations.

The following paragraphs describe how we took the most relevant excerpts from the documentation publicly available about the intermediate and final processes, decomposed it into a series of atomic claims, and identified attack relationships among these claims. Adopting a *divide et impera* approach, we partitioned the claims by topic, each of which we called a *panel*. The 5 resulting panels are:

1. the relationship between Sabrina and Ivano;
2. Sabrina’s jealousy for Ivano;
3. the morning of Sarah’s disappearance;
4. the days immediately following Sarah’s disappearance;
5. Michele’s claims.

Table 1 summarizes the extracted claims (column *Argument*), reporting for each a unique identifier (*#*), its source (*Source*), the element of the partition to which

it belongs (*Panel*), and the other arguments it attacks (*Attacks*). Figure 1 shows the corresponding argumentation graph Avetrana-case. Note the independence among panels.

#	Source	Panel	Argument	attacks
1	Sabrina	1	Ivano is just a friend of her	-
2	Sabrina's friends	1	Sabrina is in love with Ivano	1
3	Sabrina's friends	1	Sabrina was obsessed by Ivano so much that she spied him	1
4	Sabrina's friends	1	Sabrina and Ivano were close	1
5	Technical report	1	Sabrina and Ivano sent about 4500 SMS each other	-
6	Sabrina	2	The evening of August 25th (the day before Sarah disappearance) she didn't fight with Sarah	-
7	Sabrina's friends	2	The evening of August 25th Sabrina had a fight with Sarah because of Sabrina's jealousy for Ivano	6
8	Sarah's diary	2	Sabrina was angry with her due to Ivano's attentions for her	6
9	Sabrina	2	She admits that the relationship with Sarah was not relaxed.	6
10	Sabrina	3	On August 26th (Sarah's disappearance day) she had no appointment with Sarah to go to the beach	-
11	Technical report	3	The SMS log provides evidence that there was an appointment among Sabrina, Sarah and their friend Mariangela to go to the beach on August 26th	10
12	Sabrina	3	She claims that she was inside the home when Mariangela arrived at Sabrina's home to go to the beach	-
13	Mariangela	3	She claims that when arrived found Sabrina outside her home	12
14	Sabrina	3	In presence of Mariangela, because of Sarah's delay, she called Sarah's home, without success	-
15	Sabrina	3	During the call of argument 14, her father Michele is standing on the entrance of the garage	-
16	Mariangela	3	During the call of argument 14, Sabrina's father Michele was not present	15
17	Michele	3	He was into the garage with Sarah's corpse, and he heard Sarah's phone ringing because of Sabrina's calls	15
18	Michele	3	He saw Sabrina only after her return home from Sarah's home, where she went in search of Sarah	15
19	Concetta	3	Sabrina came to her home looking for Sarah, but Sarah had already left to go to Sabrina's home, hence she suggested to call her parents Michele and Cosima to stop there Sarah in case of arrival	-
20	Concetta	3	Sabrina claimed that nobody was at home	-
21	Cosima	3	During the facts reported by these arguments she was sleeping	20
22	Cosima	3	On August 26th she worked	21
23	Michele	3	He heard his wife and daughter fighting during the morning	22
24	Cosima's colleague	3	On August 26th Cosima and her were unable to go at work because the public transports were crowded	22
25	Cosima's neighbour	3	Cosima's car was not on the roadside	22
26	Cosima	3	After returning home from work, she went to sleep	23,24
27	Donato	3	Between 2:00 PM and 2:20 PM, he saw Cosima's car in the neighbourhood of via per Mare at high speed and followed by a blue van	26
28	Giovanni	3	He saw Cosima intimating Sarah to get in her car	26
29	Technical report	3	There is evidence that a call from Cosima's phone to Michele's phone is geolocalized in the Misseris' garage	-
30	Technical report	4	Phone calls happened between 10:26 AM and 10:40 AM on August 27th (Sarah's disappearance day) confirm that Cosima and Sabrina were in a zone compatible with the well in <i>Contrada Mosca</i> where the corpse has been found	31
31	Cosima	4	During the morning of August 27th she went to check the wine strength in a Misseri family's property, far away from <i>Contrada Mosca</i>	-
32	Concetta	4	In the morning of August 27th, at 11:00 AM, Cosima and Sabrina went to visit her	-
33	Michele	4	He found Sarah's phone in a farm several km away from Avetrana on September 29th	-
34	Michele	5	He killed Sarah, indicating exactly the place where he, alone, concealed the corpse (declared on October 6th)	35,36
35	Michele	5	Sabrina murdered Sarah after a joke that became a fight (declared on October 15th)	34,37
36	Michele	5	Sabrina murdered Sarah and called him to ask for help to conceal her corpse	34,37
37	Michele	5	He wrongly accused his daughter, he confesses to be the murderer taking the blame for the crime (declared on December 23th)	35,36

Table 1. Arguments and attacks in our formalization of the Avetrana case

Panel 1 While Sabrina always denied that she was close to Ivano (1), SMS logs reveal that they sent each other more than 4.500 messages (5), and indeed their friends declared that she was in love with him (2). Her obsession made her even occasionally spy him (3). Furthermore they had intercourse (4). So arguments 2, 3 and 4 attack argument 1. Argument 5 is not necessarily a proof of sentimental involvement between the two, anyway for some it could be. The choice has been to leave argument 5 without arcs.

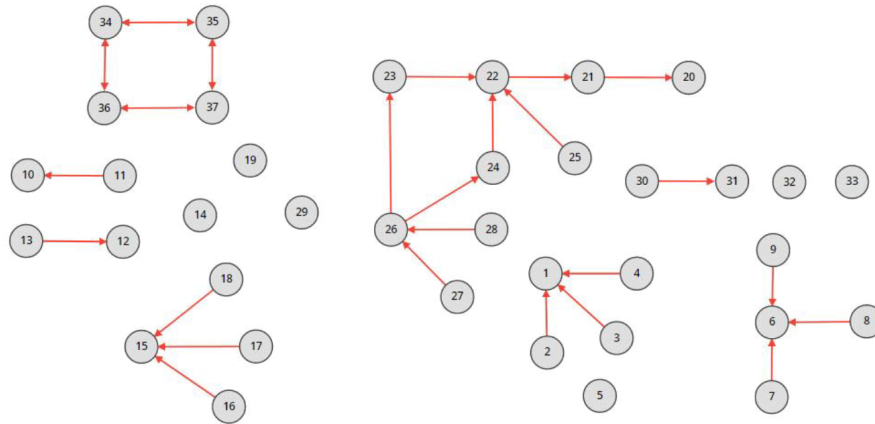


Fig. 1. Our Avetrana case argumentation graph

Panel 2 Sabrina initially denied that she argued with Sarah the evening before her disappearance (6), but her friend declared the opposite (7), and the morning she disappeared Sarah wrote in her diary: “[...] Yesterday evening I went out with Sabrina and Mariangela. We were in a brasserie for a fast Red Bull, then we came back home and Sabrina, as usual, got angry because, in her opinion, when Ivano is with us, I spend a lot of time with him. Obviously. At least he, unlike her, is gentle to me. I would love to have a boyfriend like him! Anyway, it doesn’t matter, I’m used to.” (8) Later, Sabrina will admit that she was not at peace with Sarah (9). So arguments 7, 8 and 9 attack argument 6.

Panel 3 Regarding the day Sarah disappeared, Sabrina declared that they had no appointment to go to the beach (10). Conversely, an appointment had been made the previous night with Mariangela (11), and further confirmed in the morning. Then, argument 11 attacks argument 10.

Sabrina always denied that, at the moment Mariangela arrived, she was already outside her home (12). Mariangela declared the opposite (13). Argument 13 attacks argument 12.

Sabrina declared that, after Mariangela arrived, she called Sarah’s home to check if whether she was there, given that she was late, but nobody answered to the phone (14). According to her declarations, during the calls her father Michele was near the garage entrance (15). Conversely, Mariangela declared that she never saw Michele there (16). Michele, in one of his inconsistent versions, declared that he was in the garage with the corpse, that he heard Sarah’s phone ringing several times, and that those were Sabrina’s calls (17). According to Michele’s declarations, he will see Sabrina only after she came back home from Sarah’s home, where she went to check the presence of Sarah (18). So, arguments 16, 17 and 18 attack argument 15, defeating Sabrina’s claims.

Sarah's mother, Concetta, claimed that Sabrina went at her home looking for Sarah, and she informed Sabrina that Sarah had already left to her home, and that it could be a good idea to warn her parents that Sarah, maybe soon, should arrive, and that they should stop Sarah there (19). Sabrina answered that nobody was at home (20), but Cosima (Sabrina's mother) will declare that she was sleeping at home (21). Argument 21 attacks 20.

Anyway, Cosima, in other declarations, asserted that she went at work the morning Sarah disappeared (22). So, argument 22 attacks 21.

In a further version provided by Michele, Sabrina and Cosima had a fight that morning (23). In general, the presence at home of Cosima is supported by the declaration of a colleague of her, saying that public transportation was packed, so they were unable to go to work, and they went back home (24). However, a neighbor of Cosima declared that her car was missing from the place where it was used to be (25). Arguments 23, 24 and 25 attack argument 22.

Cosima declared that when she came back from work, she went to sleep (26), which is in contrast with 23 and 24. Anyway, this declaration has been refuted by Donato, who saw Cosima's car in *Via per Mare* street, between 2:00 PM and 2:20 PM, keeping a high speed and joined with a blue van (27).

The version of Cosima sleeping is contrasted from Giovanni the florist, who declared he saw Cosima following Sarah and ordering her to get on her car (28). However, a couple of day later he retracted this version, claiming that it was just a dream. Standing on such arguments, 27 and 28 attack 26.

A milestone is represented by the technical report of the *ROS* (the Special Operating Department of the *Carabinieri* corps, specialized in investigations), that localized a call from Cosima's phone to her husband at 3:25:04 PM (29).

Panel 4 There are other phone calls that have a central role in the case evaluation, happened the day after Sarah's disappearance, between 10:26 and 10:40 AM. These calls locate Sabrina and Cosima near the well in which Sarah's corpse was concealed (30). About that morning, Cosima declared that she went to check the strength of the wine that her family produces, in a completely different place than *Contrada Mosca*, where the well is located (31). Note that Cosima never mentioned what Sabrina was doing in the meanwhile. Argument 30 is a fact, so 30 attacks 31.

In the morning of the day after Sarah's disappearance, at 11:00 AM, both Cosima and Sabrina went to Concetta's home (32). No contradictions emerged about this.

Panel 5 Let us turn to Michele's declarations. He firstly claimed that he found Sarah's phone, three days after Sarah's disappearance, in a farm few kilometers away from *Avetrana* (33). This clumsy attempt to mislead investigations made the police insist on having a deeper understanding of the dynamics of the case. Under such a pressure, Michele admitted the murder, indicating exactly the location of the corpse, which was soon verified (34). The lack of precision and coherence of Michele's declarations always caused suspects about his honesty. The police questioned Michele several other times, until, nine days after Sarah's

Semantics	Extensions
stable	{2 3 4 5}
admissible	{}, {5}, {4}, {4 5}, {3}, {3 5}, {3 4}, {3 4 5}, {2}, {2 5}, {2 4}, {2 4 5}, {2 3}, {2 3 5}, {2 3 4}, {2 3 4 5}
preferred	{2 3 4 5}
complete	{2 3 4 5}
grounded	{2 3 4 5}

Table 2. Semantics for panel 1.

disappearance, he retracted the murder confession, accusing his daughter Sabrina, telling that the unfortunate event had been the consequence of a strong quarrel between them (35). Not even this version will turn out to be completely true, since Michele will add that he had been called by Sabrina after the murder to conceal the corpse (36). But he will retract again after several days, undertaking responsibility for the crime (37). Argument 34 attacks 35 and 36, argument 35 attacks 34 and 37, whereas 36 attacks 34 and 37, and finally 37 attacks 35 and 36.

4 Application of Abstract Argumentation to the Case

Exploiting standard available tools, we computed the extensions for several semantics for the Avetrana case argumentation framework.

4.1 Classical Semantics

Let us quickly recall that:

- admissible extensions are conflict-free subsets, containing arguments that defend each other;
- the preferred extension is the largest admissible extension;
- the stable extension is composed by the conflict-free subset that attack arguments outside the extension;
- the complete extension contains the admissible extensions leaving out the attacked or not defended arguments;
- the grounded extension is the minimal complete extension (so that it is unique);
- nodes without attacks (incoming or outgoing) are not relevant for extensions computation and semantically coherent with every extension considered to analyze the case.

While reporting the results of all these semantics in Tables 2-6, due to space constraints, in the following we will comment the grounded extension only, since it can be considered as a reliable core of arguments that is likely to be true.

Semantics	Extensions
stable	{7 8 9}
admissible	{ } {9} {8} {8 9} {7} {7 9} {7 8} {7 8 9}
preferred	{7 8 9}
complete	{7 8 9}
grounded	{7 8 9}

Table 3. Semantics for panel 2.

Semantics	Extensions
stable	{11 13 14 16 17 18 19 21 23 24 25 27 28 29}
admissible	{ } {29} {25} {25 29} {19} {19 29} {19 25} {19 25 29} {18} {18 29} {18 25} {18 25 29} {18 19} {18 19 29} {18 19 25} ... {11 13 14 16 17 18 19 21 23 24 25 27 28} {11 13 14 16 17 18 19 21 23 24 25 27 28 29} There are totally 12288 admissible extensions
preferred	{11 13 14 16 17 18 19 21 23 24 25 27 28 29}
complete	{11 13 14 16 17 18 19 21 23 24 25 27 28 29}
grounded	{11 13 14 16 17 18 19 21 23 24 25 27 28 29}

Table 4. Semantics for panel 3.

Table 2 summarizes the relationship between Sabrina and Ivano. Translating the grounded extension we obtain: “Sabrina was in love with Ivano and obsessed by him, up to follow and control him. Sabrina and Ivano sent each other about 4500 SMS. They had an affair.” The grounded extension is also stable: its arguments attack the arguments not belonging to it.

Table 3 summarizes the jealousy of Sabrina for Ivano. The grounded extension says that: “The evening of August 25th, Sabrina was angry with Sarah because of the attentions of Ivano for her. Such an interest of Ivano for Sarah, and the fact that Sarah appreciated it, are confirmed by Sarah’s diary and by Sabrina’s interrogatories.” Just like in panel 1, the grounded extension is also stable.

Table 4 concerns the morning of Sarah’s disappearance. The grounded extension says: “There was an appointment among Sabrina, Sarah and Mariangela to go to the beach on August 26th. Mariangela went to Sabrina’s to go to the beach and found her on the street. Sabrina told her she could not find Sarah, and called Sarah’s home phone, getting no answer. At that moment, Mariangela did not see Michele (that was in the garage with the corpse). Sarah’s mobile phone could be heard ringing from the garage, given that both her corpse and her phone were there, and Sabrina was calling to cheat Mariangela. Michele and Sabrina met later, only after Sabrina came back from Sarah’s home. During the visit of Sabrina to Sarah’s home, Concetta told Sabrina that Sarah already left to reach Sabrina’s home, so Concetta suggested Sabrina to inform her parents that Sarah could arrive to them at any moment. Cosima declared that, in the

Semantics	Extensions
stable	{30 32 33}
admissible	{ } {33} {32} {32 33} {30} {30 33} {30 32} {30 32 33}
preferred	{30 32 33}
complete	{30 32 33}
grounded	{30 32 33}

Table 5. Semantics for panel 4.

Semantics	Extensions
stable	{35 36} {34 37}
admissible	{ } {36} {35} {35 36} {37} {34} {34 37}
preferred	{34 37} {35 36}
complete	{ } {35 36} {34 37}
grounded	{ }

Table 6. Semantics for panel 5.

meanwhile, she was sleeping since in the early morning she had been unable to go to work. Michele declared that he heard his wife and daughter having an argument. Cosima’s car was not parked outside her home. Between 14:00 and 14:20 Cosima’s car was seen near via per Mare, in Avetrana, going at high speed together with a blue van. Giovanni saw Cosima following Sarah and ordering her to get on the car. At 15:25 a call from Cosima’s phone to Michele started.” The extension is grounded and stable.

Table 5 regards the days after Sarah’s disappearance. The grounded extension says: “On August 27th, the day after Sarah’s disappearance, between 10:26 and 10:40, Cosima and Sabrina can be located near the well in Contrada Mosca, where the corpse will be found. Around 11:00, Cosima and Sabrina went to Concetta’s home for a visit. On September 29th, Michele will find Sarah’s phone in a farm a few kilometers away from Avetrana.” The extension is grounded and stable.

Table 6 regards Michele’s declarations. The grounded extension is empty, i.e., no subset of information is a candidate to be true. Anyway, there are two stable extensions. The former is: “Michele killed Sarah and knows the place where is the corpse. In fact, he claims that his initial accusation against his daughter is false. He undertakes all responsibilities.” The latter is: “Michele claims that the killer is his daughter, and that she called him only after the murder to ask for help to conceal the corpse.” Note that Michele’s contradictions make evident some limitations of the basic approach of Dung’s argumentation framework.

In order to understand which subset of information can be considered less likely than others, the need to weigh the attacks arises. So, we evaluated panel 5 exploiting the weighted argumentation framework.

Semantics	Extensions
stable	{35 36}
admissible	{ } {36} {35} {35 36}
preferred	{35 36}
complete	{ } {35 36}
grounded	{ }

Table 7. Semantics for panel 5 using a weighted argumentation framework.

Extension	Sets
grounded	{2 3 4 5 7 8 9 11 13 14 16 17 18 19 21 23 24 25 27 28 29 30 32 33}
stable	{2 3 4 5 7 8 9 11 13 14 16 17 18 19 21 23 24 25 27 28 29 30 32 33 35 36} {2 3 4 5 7 8 9 11 13 14 16 17 18 19 21 23 24 25 27 28 29 30 32 33 34 37}

Table 8. Semantics for the entire graph using a value argumentation framework.

4.2 Weighted argumentation framework on panel 5

Argument 34 was initially taken by the detectives as a possible, but not very reliable, confession (he never appeared to be a reliable person). Arguments 35 and 36 are successive in time to 34. Given the results of other panels, confirming the jealousy of Sabrina for Ivano, and that Ivano had gentle attentions for Sarah, we decided to set weights of 0.3 for the attacks of argument 34 against arguments 35 and 36, and of 0.9 for attacks of 35 and 36 against argument 34. Later, Michele retracted again his version, going back to accuse his daughter, a version that is quite unreliable, so we set the weights of its attacks to 35 and 36 at 0.1, but the weights of the opposite attacks at 0.9. Weights are defined using a personal interpretation of arguments reliability on the base of its sense, and the state of the art of the case at the date of declaration, a set of information that, for lack of space and for scopes of the paper, is omitted here.

Table 7 reports the extensions that have been computed. Given the weights, the only stable extension is composed by arguments 35 and 36: “Sabrina killed Sarah and called Michele to ask for help to conceal the corpse”.

4.3 Value Argumentation Framework applied to the whole case

The value argumentation framework allows us to assign a type to each argument and to define an order of preference on the defined types. By doing so, we can make explicit if an argument refers to an evidence, that is: a document, a forensic report, a witness. So, knowing that typically the preference follows exactly such an order, we can insert it in the rules evaluated in the framework.

Table 8 reports the grounded and the stable extensions computed on the entire graph. The outcome is the union, respectively, of the grounded and stable

extensions computed using Dung’s argumentation framework. So, its interpretation can be obtained just appending the interpretations of the five panels.

However, we note that the two possible stable extensions have as difference just the two possible versions provided by Michele, which highlights the same weaknesses as Dung’s argumentation framework, and calls for a strategy to clarify such cases (e.g. the weighted argumentation framework).

5 Conclusions and Comments

Argumentation is the activity by which a position is defended in a discussion with other people. It is fundamental in court trials, in order to have a faithful reconstruction of the course of the events from evidence and testimonies. Among the automated techniques for carrying out argumentation developed by research in Artificial Intelligence developed, abstract argumentation considers the inter-relationships among the available arguments, neglecting their internal structure or specific interpretation.

In this paper, we considered a very famous criminal case happened in Italy, concerning the murder of a young girl. It was interesting for several reasons: it involved very ambiguous testimonies, and attracted much attention due to its story and to the wide media coverage it got. So, we extracted from the process deeds an abstract argumentation formalization which turned out to be consistent with the process outcomes, and computed a number of semantics on it. We specifically commented the grounded one, as a reliable core of arguments that is likely to be true. The automated outcomes confirmed most of the interpretations of facts made in the Courts, but also highlighted the limitations of traditional semantics when tackling cases with many contradictions. In any case, they confirm that abstract argumentation tools may represent a valid support for quickly highlighting consistent subsets of evidences and testimonies on which basing further investigations and final decisions.

Of course, the quantity and quality of the selected arguments, and of the attacks among them, determine the quality of the outcome. This points out another possible use of abstract argumentation: providing a formal explanation or justification of the reasoning carried out by the judges, allowing this way other people (e.g., the defendant’s lawyers) to understand, and possibly criticize, the formalization, by adding arguments or changing the attacks, in order to check whether other interpretations of the available information are possible.

For this reason, our future work on this case will be devoted to extract further useful claims concerning the case, and to identify different strategies for determining when and how to set the attacks among arguments. Also, we plan to apply more semantics, and complex abstract argumentation frameworks (e.g. the bipolar, bipolar-weighted, and trusted-bipolar-weighted ones), to the case, trying to overcome the limitations of classical approaches by introducing more information in the schema. If successful, we also plan to apply these approaches to other well-known, ambiguous or unsolved, criminal cases.

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