Argumentation and V&V

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ABSTRACT

The aim of this article is to enlighten links between argumentation and VV&A. Argumentation theory focuses on the links between assumptions and conclusions i.e. on structuring reasoning. Today, argumentation is studied by a variety of disciplines such as computer science (through artificial intelligence), linguistics, epistemology and the legal sciences.

In the first part of this article, after introducing an argumentation scheme stemming from legal science, we explain how evidence such as tests, expert's testimonials, articles, formal methods, simulations, etc. may be acceptable as justification for establishing a property and how to structure an argument of this property in an auditable format. In the second part, we present a framework to support group decision, such as a trade-off or a design choice, and to record it.

1.0 INTRODUCTION

In classical Modeling and Simulation (M&S), the aim of Verification and Validation (V&V) activities is to provide justification that establishes why a simulation may be considered compliant with its requirements. About the definition of V&V, in [1] we find the idea that for mathematical models, validation amounts to make sure "*we solve the right equations*", whereas verification is checking that we "*solve the equations right*"". If V&V relates to the origins of engineering simulation, they are no longer sufficient for complex systems. Indeed, given the volume of V&V documents, we need to organise them. For that, M&S standards, like GM-VV, ISO 15026-1.2, IEC 61508, MIL-STD-882D, suggest to organise V&V documents in an argumentation. Stevenson [2] defined the global V&V document like a set of justifications: "*Knowledge requires justification; quality assurance is basically knowledge justification*". But, because this documentation is not formal (or at least not completely), it seems vain to try to establish its formal validity.

In fact, we replace the notion of the validity by the notion of acceptability. There is no question here of the truth of a model (or a simulation) but whether a model is acceptable or not. Here, we will attempt to model statements (the V&V documentation) that logicians consider unscientific. Moreover, Carnap [3] describes such statements pre-scientific, he considers vague and incorrect. In this sense, we can here make a comparison with the work of Charles Hamblin [4] that questions the use of formal logic to deal with the study of argumentation. His goal is to understand what makes an argument acceptable, he gives a new model of the validity of an argument – that the validity does not depend on logical criteria but on dialectical criteria. For him, the relationship between the premises and the conclusion is no longer a logical implication but a dialectic that allows or prohibits discursive behaviour. Note that this approach coincides with the work of Perelman and Olbrechts-Tyteca [5]. They define a new theory of argumentation based on a dialectical approach that complements the formal logic. For them, in a Cartesian ideal, logicians admit that rationality as logical demonstration. Therefore, it becomes impossible to establish the reasoning other than formal which is "*a wholly unjustified and unwarranted limitation of the domain of our reasoning and proving faculty*".

Argumentation theory focuses on the links between assumptions and conclusions i.e. on structuring reasoning. The notion of argument obviously refers to the concept of evidence largely evolved in the history of science and does not have the same meaning depending on whether it is in the formal disciplines, experimental sciences or Humanities. Today, the study of the validity of an argument and its underlying mechanisms is studied by a variety of disciplines such as computer science (through artificial intelligence), linguistics, epistemology and the legal sciences.

The aim of this paper is to show how to use argumentation theory in V&V context. More precisely, we focus on two capabilities:

1) Argumentation to support confidence in a product;

2) Argumentation to support a collaborative decision.

These two capabilities are used for instance in projects for embedded software certification and in a thermal simulation context in the TOICA European project (Thermal Overall Integrated Conception of Aircraft).

The paper is structured as follows. Section 2 gives some considerations about simulation argumentation and requirements. Section 3 focuses on argumentation to support confidence in a product. More precisely, Section 3 presents the Toulmin's argument model, describes the argument model we use to perform VV&A tasks and presents the GM-VV argumentation network. Section 4 focuses on argumentation to support a decision. Lastly, Section 5 reviews existing tools to visualise argumentation.

2.0 ARGUMENTATION AND PROCESS

A simulation validation process should structure justification to convince an authority that the simulation answers particular questions. In order to do that, we need a document that provides for specified claims (the goal of the simulation) a convincing and valid argument. But, this document, this argumentation, cannot be modelled ex nihilo. It must be part of a process that accompanies the various stages of V&V and where, for each stage of V&V, argumentation is constructed by aggregating evidence, the documents produced at this stage.

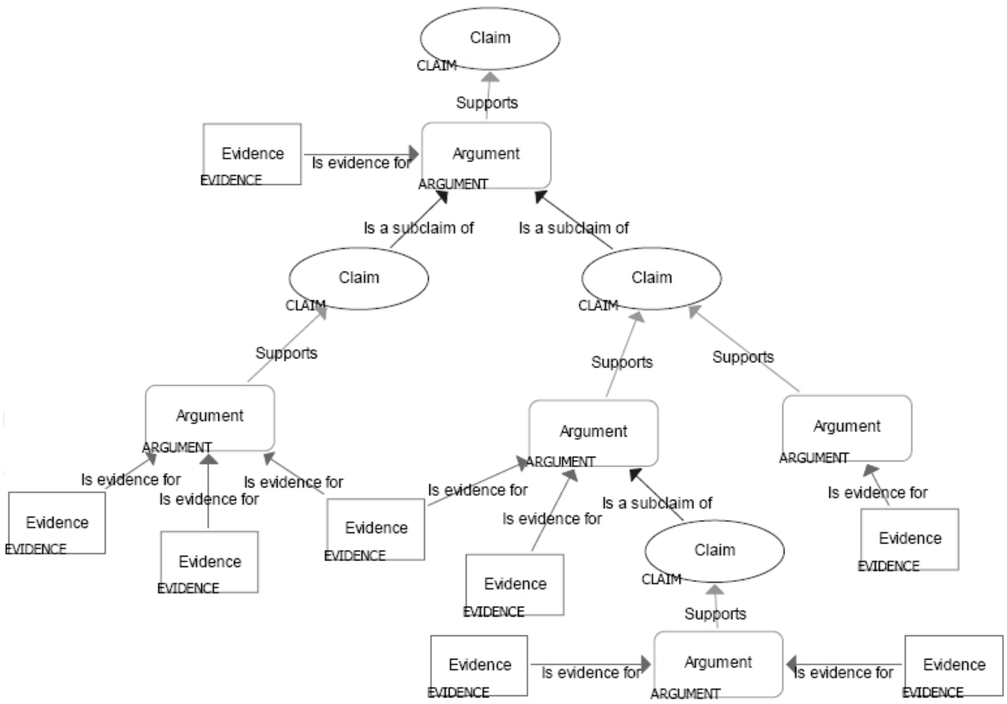

Figure 1: REVVA [9] Graphical argumentation.

There is a strong link between requirements engineering and argumentation. In the context of requirements, the problem is to break down a requirement to achieve a set of basic requirements. The result is a tree, which is rooted by the main requirement, has for final leaves basic requirements and where the nodes are intermediate requirements. In other hand, the argumentative approach tries to clearly express how evidence support a conclusion (this is a reasoning step). In practice, we want to establish complex conclusions, which involve several reasoning steps. The sequence of these steps -each step corresponds to our argumentation schema-, defines what we can call the argumentation tree or the structure of the argumentation. This tree allows us to read, share and analyse an argumentation. The interest of having an argumentation tree is to navigate in the argumentation, to communicate between experts, to locate missing parts or relationships, to detect contradictory assumptions, *etc*.

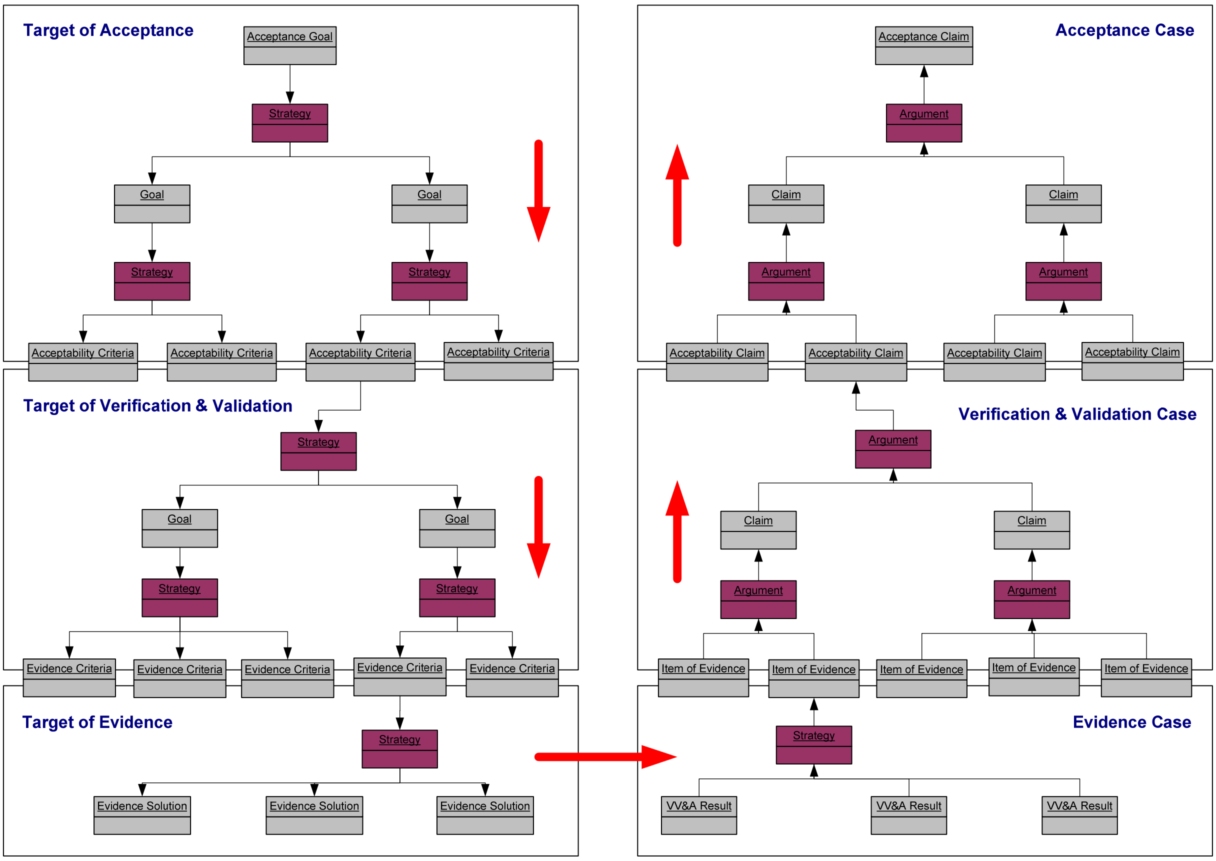

Figure 2: GM-VV Goal and Argumentation Mechanics.

In GM-VV, there is a goal derivation during the design and an evidence re-composition during the analysis and the reporting phase. Goal derivation is closely related with goal-oriented requirements engineering practices. Goal derivation is the decomposition of a top-level objective into a set of practical solutions to accomplish the objective. The evidence re-composition works in the opposite way. Evidence re-composition is an argumentation task. It consists in aggregate evidence collected into sub-claims into a single justified top-level claim.

Finally, in a process view, we can tell that argumentation activities start when requirements activities end and continues all along the process.

3.0 ARGUMENTATION TO SUPPORT CONFIDENCE IN A PRODUCT

3.1 Toulmin's Argument Model

It is in 1958 that Stephen Toulmin [6] presented its argument scheme. Today, this model is taught in many American universities to explain the mechanisms of the argument, for instance, it is used in teaching legal argumentation theory or "*critical thinking*".

Although we will not use the Toulmin's argument model strictly speaking, we will give a broad outline. This presentation will allow us to clarify the concepts related to the argument.

In the Toulmin model (Figure 3), any argument is composed of a *claim* or a *conclusion* "*conclusion whose merits we are seeking to establish*" and *facts* or *data*, noted (D), "*the facts we appeal to as a foundation for the claim*". In fact, well-argued is to state a conclusion by relying on data.

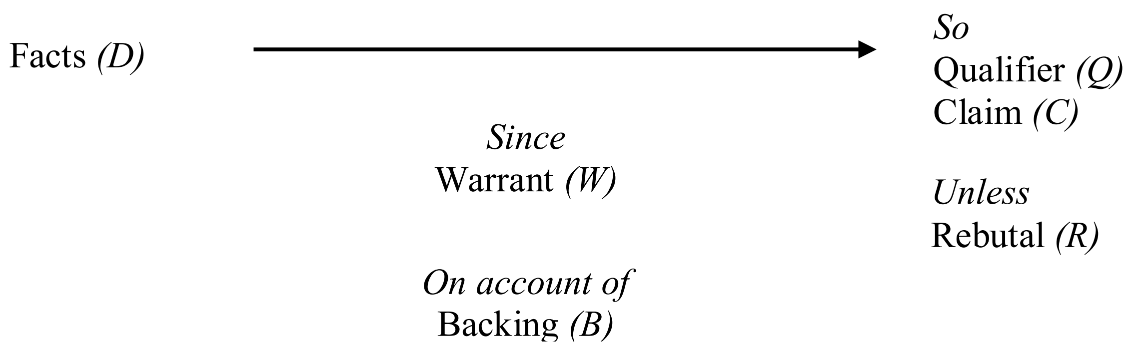

Figure 3: Toulmin's argument model.

To justify the transition from the data to the conclusion additional data are used, sometimes implicitly, called *warrant*. Warrant corresponds to the reasoning process, it establishes the logical connection between the data and the conclusion. Data and warrant are the support of the argument and distinguish between data and warrant is not always easy: warrants are general rules, they attest to the strength of the argument, while data are facts, evidence. Toulmin adds the concept of *backing* that bind justifications to the warrant. Backing support the warrant in argument, it is justification of why the warrant is a reason to accept the claim.

Finally, because the claim is not always necessary true, it is possible to express reservations with *modal qualifiers*. These qualifiers correspond to concepts such as "*possibly*" or "*probably*". In addition, adds to the conclusion the "*rebuttal*", which expresses exceptions, circumstances in which the conclusion is not true.

For instance, consider the following case: we know the fact that (D) "*data are encrypted with OpenSSL (AES) with a 128 bits key*" and we know that a 128-bit key is enough to protect data based on the Advanced Encryption Standard. We focus on the argument: if (D) is true then we can conclude that (C) "*Only authorized persons could read the data*". As we are not in a formal logic, we have not an axiomatic system that can give us the value of validity of the logical formula: D implies C. We are here in a rhetorical framework where we try to define if we are dealing with a "*good*" argument or not. In this example the conclusion is false. Indeed, the confidentiality of the data is not established in the absolute: an attacker can steal the key. We must therefore add a rebuttal (R) "*someone steals the key*", see Figure 4.

(D) Data are encrypted with OpenSSL (AES) with a 128 bits key

Since
(W) 128 key lengths of the Advanced Encryption Standard are sufficient to protect data
On account of
(B) The Advanced Encryption Standard published in 2001 uses a key size of 128 bits (FIPS PUB 197: the official AES standard)

So
(C) Only authorized persons could read the data
Unless
(R) someone steals the key

Figure 4: Toulmin's argument model example.

3.2 A Simple Argumentation Model

In the context of an argument aimed at structuring the proof elements, or evidence, to decide if a product, or a property of a product, is acceptable, we do not need all the subtleties developed by Toulmin. Therefore, we propose a simplified argumentation scheme structured around two key concepts: *evidence* and *strategy*.

3.2.1 Data, Fact, Evidence

Any demonstration, argument, is based on pre-established truths. For example, a mathematical proof still assumes that a set of axioms are true. These axioms are true by nature, there is no demonstration that proves them, and they are the basic element of all reasoning in this system. Similarly, any argument is based on a set of postulates, accepted by one that sets out the demonstration as well as its audience. In Toulmin's model this postulates are facts or data, but we will also call them sometimes: evidence.

In the context of legal argumentation theory, [10] defines *evidence* as: "*data (facts or opinions) presented as proof for an assertion*". The evidence has the particularity to be based on the trust, the credibility, of those who state them. The acceptance by the audience is not based on evidence itself, but on the trust given to the one who sets evidence out. Simple examples of evidence are: results in a scientific paper, piece of information given by an expert or a practice defined in a standard.

3.2.2 Strategy, Warrant

The warrant is the cornerstone of argument. This is the warrant that explains how, from evidence (or data), it is possible to infer a conclusion. The warrant in Toulmin's model corresponds exactly to what the ISO 15026 called Arguments and that the Goal Structured Notation (GSN) [7] called Strategy. In order to homogenize the different terms, we decided here to use the term strategy. To ISO 15026, the strategy is: "*Arguments are the glue that holds the assurance case together by relating its immediate underlying support – sub-claims, evidence, or assumptions – to the claim it supports. It yields the combined effect of the evidence, sub-claims, and assumptions that it utilizes into a conclusion and an associated uncertainty for its conclusion*". In the same way, for GSN "*strategies explain the inference between parent and children goals*".

Because we are in a context where the aim is to convince an authority (and the argumentation must be accepted by it), in addition to the strategy, we keep the Toulmin's concept of backing which is directly associated to the strategy. For us, backing are the justifications on why a strategy is acceptable. Take for instance the case of the use of a static analysis tool to analyse a computer code, the use of this tool must be justified. Backing could be: the use of this tool is acceptable in the context of this study (such acceptance may possibly be a certification), *etc.*

3.3 Examples

With evidence, strategy, backing and claim we can build auditable argumentation trees (or argumentation network in GM-VV). Of course, each element of the argumentation tree must be connected to a document (sometimes to many) and each reasoning step, from sub-claims to claim, needs to follow our simple argumentation model. Note that our argumentation model can be applied to justify any kind of claim: quality of a model, simulation result, *etc*. In Figure 5, we give a very naïve example of argumentation where the claim is the results of a simulation named S1, the backing is the use of S1 is acceptable for this study and there is only one evidence: the input data are correct.

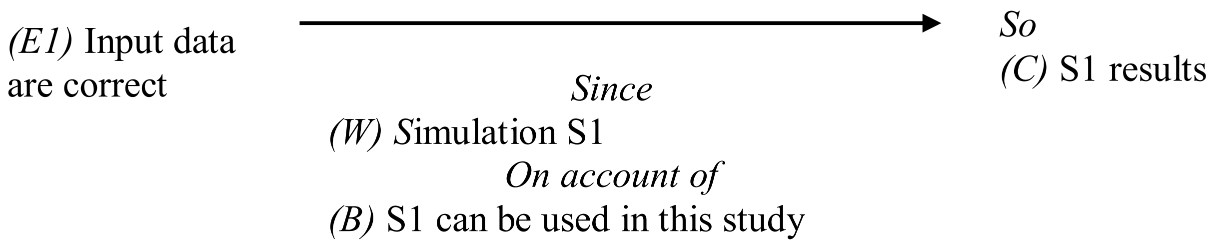

Figure 5: Simple argument model example.

3.4 Argumentation Network

In GM-VV, the "*Verification, Validation and Acceptance Claim Network*" or *Argumentation Network* consists of a structured argument that provides a compelling and comprehensible case that a simulation can be trusted. The aim is to ensure the quality and reliability of the simulation. Note that, in the standard proposal GM-VV "*the use of argumentation networks provides the verification and validation technical core of GM-VV*". This is a formal structured document, where all stakeholders could find all hypothesis and justifications. The concept of Argumentation Network is close to the concept of assurance cased defined for instance by the ISO/IEC 15026: "*The assurance case provides a structure of claims and sub-claims (or goals and sub-goals) with evidence (and assumptions) and connecting arguments that show the achievement of the top-level security goal(s) (or claim(s))*".

Technically, the argumentation network is a directed graph consisting of claims, arguments and supporting contextual information. This graph provides an auditable means to establish justified belief in a claim. The specification of GM-VV argumentation network is given Figure 6, it is based in on the Argumentation Interchange Format (AIF) [8]. In the GM-VV argumentation network, *S-Nodes* correspond to our strategy (or warrant) and *I-Nodes* correspond to our claims and our evidence.

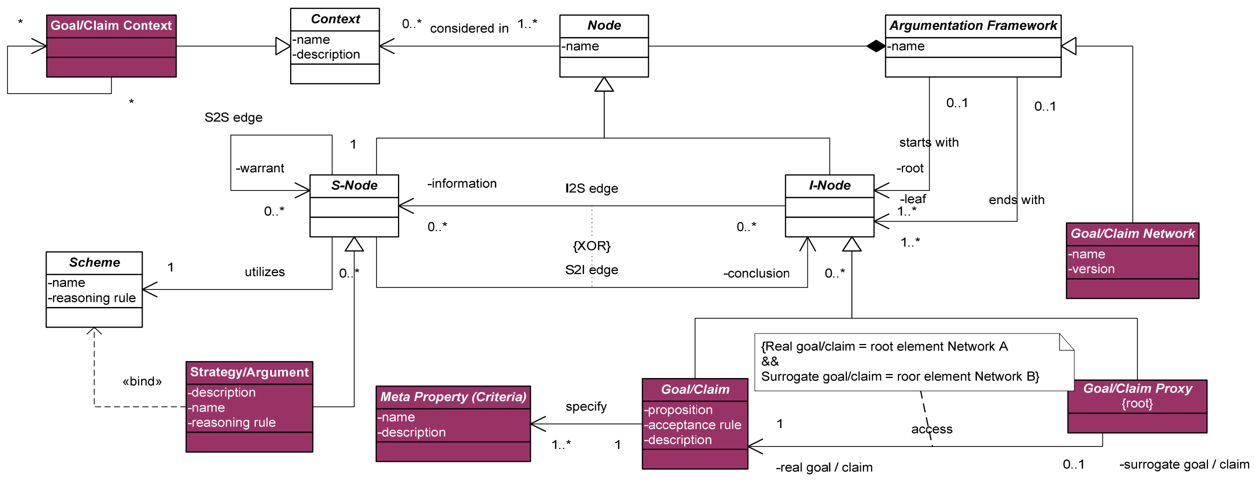

Figure 6: GM-VV Generic AIF-Based Claim Network Pattern.

4.0 ARGUMENTATION TO SUPPORT DECISION

In this section, we want to address a particular problem: justification of a decision, like trade-off or collaborative design, by a committee of experts. We propose a two-step process to report meetings of experts and to support their understanding. Firstly, we will see how argumentation graphical representation (more precisely graph notation) could be used to support arguments capture of the experts during the debate as well as the relationships between the arguments. Secondly, after the experts have reached consensus, it is useful to structure it in a formal framework to record it [11]. If there are many works in argumentation representation, a lot of them, unfortunately, are interested in dialectic and defeasible evidence representation. Still, it is possible to use this legacy to define some properties and measures to help the managers understand the debate. The intended benefits of the method are to support deliberation, to rational the decision, to support a decision manager in the light of the experts' arguments and to record the motivations for the decisions in corporate memory.

Obviously, keeping a record of meetings that captures both the arguments and their relationships can help in the understanding of design rationales, design choices and trade-offs. Keeping a record of meetings is also very interesting for the constitution of a corporate memory. As [12] says: 90% of design activities are based on existing design. During the simulation's lifecycle, there is a danger that explanations of design decisions are forgotten. Very often, when a project is over, no one remembers why certain choices have been made, mainly because people have left the company or have forgotten, and the reasons for decisions have not been recorded. Keeping records of the arguments would avoid having the same discussion all over again, with the same arguments. In addition, recording the rational of a decision would allow the discussions to be resumed and experts could introduce new arguments if they feel the need to.

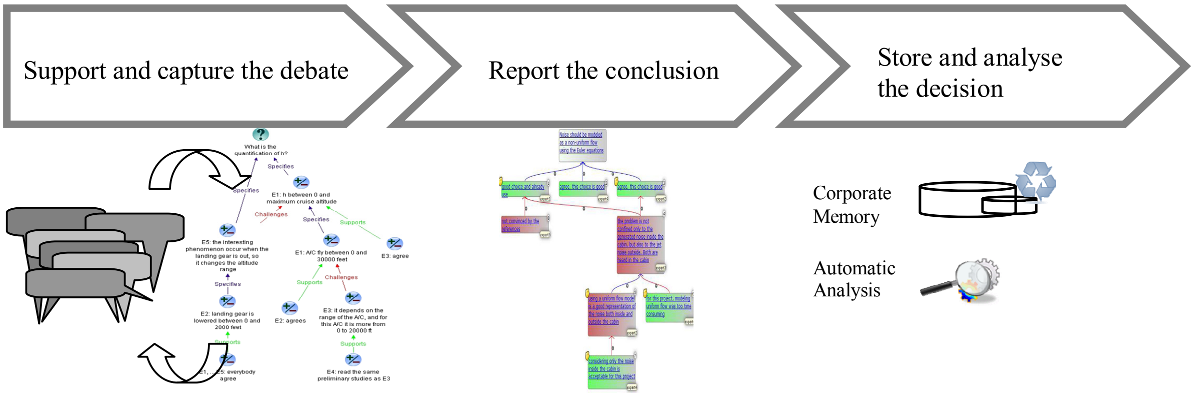

Figure 7: Support and report group decisions.

In a project like TOICA, we will use argumentation to support concept phase architecture trade-offs in an integrated multi-level, multi-disciplinary approach context and to support acceptability tasks in extended enterprise context.

4.1 Support and Capture a Collaborative Decision

We choose to represent the debate with a graph representation. Of course, we could use natural language in order to report a face-to-face debate or to record an expert's assertion in an online collaborative debate, but the natural language is poorly structured, it is very difficult to track information with it, and relations between experts' assertions are not clear. Using graphics to support reasoning is not new, but the progress of human-computer interaction played a critical role in this evolution. Today, an increasing number of visual representations have been developed to organize ideas, tasks and concepts (like mind maps, concept maps, fishbone diagrams, *etc.*). The use of graphical notations in engineer science, like the Unified Modeling Language (UML), is common now. More recently, graphical notations appeared in system safety. Languages like the GSN are used in this domain [13] to improve the comprehension of the safety arguments amongst stakeholders. In the domain of requirement acquisition, visual tools can also be used to represent requirements. Such requirement representation techniques provide more natural means of communication between users and developers, allowing to be more expressive in describing user's wishes and providing early feedback.

Argumentation graphical representation, called argumentation map, try to define a representation of argumentation map to improve usefulness. Theoretically, an argumentation map is able to represent all kinds of activities such as rhetorical reasoning, inference, debates, and trials. In fact, this is a "*boxes and arrows*" diagram with the boxes corresponding to arguments and arrows representing relationships [14]. The argument graph is similar to other activities of graphic representation, but focuses on the logical relationships, the evidence and inferences between propositions. Finally, we could define a simple representation of a debate, a deliberation. We have argument represented by boxes and relations represented by arrows.

Argumentation theory studies a lot of relations between arguments but a lot of works in argumentation theory studies in detail the notions of *supports* (or *corroborates*) and *challenges* (or *attacks*). To be simple, and a little bit naive, in a discussion, any argument supports or challenges one or several previously presented arguments. In addition, we add a particular relation named *specifies*. An argument specifies another when it gives precision or when it answers an open point. Of course, defining all relations between arguments with these three relations is restrictive and argumentation tools based on Kunz and Rittel IBIS model [15] propose a more complex model with more arguments objects and relations, but our aim is to define a framework as simple as possible. If our approach is too complex, it will never be used by engineers. That is why we choose to focus on three relations only, easily comprehensible.

4.2 Report and Record a Collaborative Decision

At this step, a decision has been taken by the group of experts. Arguments have been given by the experts and there were arguments for both sides, pro and con the final choice. To understand the final choice and to record the debate in a corporate memory, a decision maker, like a manager, would appreciate to have a formal representation framework mapping the deliberation of the experts in order to check if the arguments are evidence-based, if the decision is sufficiently well supported by the arguments, if some of the experts had changed their opinion during the debate, *etc*.

First, the debate ends because a decision has been taken by the group of experts. At this step, we do not have a claim anymore as it has turned into the conclusion of the debate. The conclusion of the debate is the hypothesis that has been chosen by the group of experts. In fact it is a sequence of arguments linked by the "*specifies*" relations. It represents a complex idea that has been decomposed into several assertions. In a debate, many hypotheses could be criticized. Experts promote ideas, but at the end there is only one conclusion of the debate. In this step, we do not want to track all experts' options, but only the final choice of the group. In this argumentation representation, we cut all branches of the argument diagram not linked to the final claim (the decision) and who is not a part of the debate conclusion. Note that, in some cases, this choice could be drastic.

Secondly, arguments have been exchanged between experts. More precisely, at each stage of the discussion, an expert utters an assertion and sometimes provides evidence to support it. Because we focus on justification of the conclusion, we choose to simplify relations between arguments in two relations: *corroborate* (support) and *attack* (challenge). We choose to collapse all argument linked by specifies relation in one argument.

Thirdly, the expertise of the experts is obviously relevant, otherwise we could assume they were not invited in the debate. But experts are not infallible. In such debates, there is a risk of an *argumentum ad verecundiam* (appeal to authority), which means considering an argument correct as made by a person commonly regarded as authoritative. To prevent that, experts could give evidences. Evidence is a link to resources such as articles, specifications, tests, books, *etc*. The obligation of giving evidence or not for each argument depends on the debate policy.

Because we have a formal representation of the debate, in [12] we propose an automatic analysis of an argumentation in order to understand the underlying debate and its conclusion as well. For that, we define a set of questions that can be automatically answered to understand a group decision. Notice that here we focus on the dialogue properties, not on the expert validity.

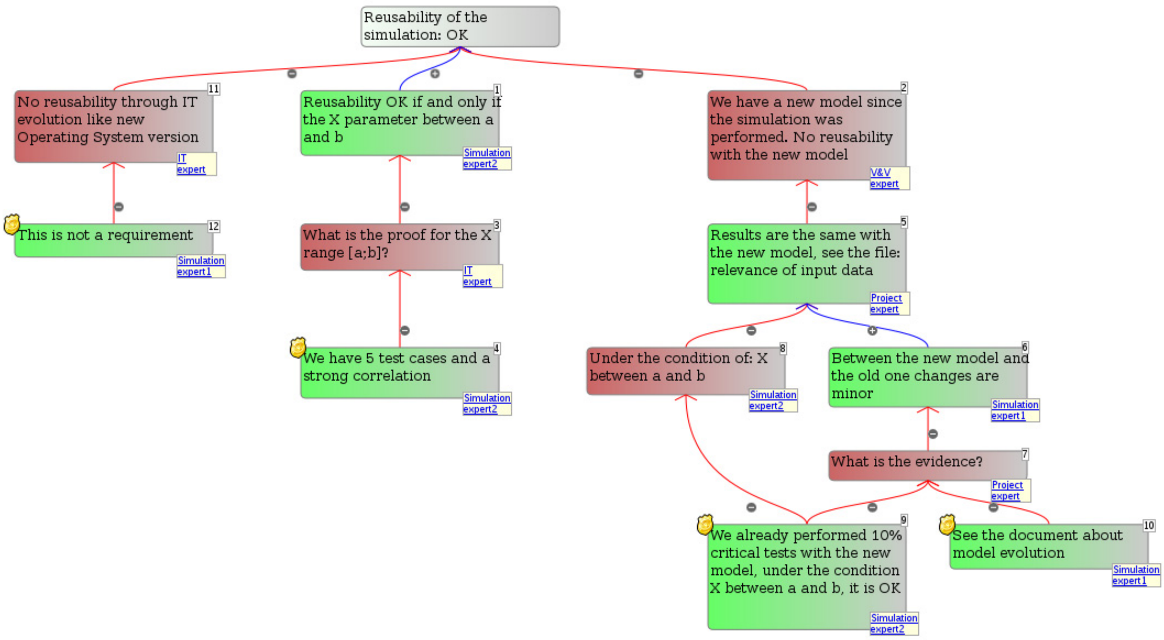

Figure 8: Report a collaborative decision example.

5.0 FEW WORDS ABOUT ARGUMENTATION VISUALISATION

During the last decade, an increasing number of visual software has been developed to organise, structure and visualise ideas, tasks and concepts (like mind maps, concept maps, fish-bone diagrams, *etc*.). Using graphics to support reasoning is not new, but the progress of human-computer interaction played a critical role in this evolution. The first example of diagrams used to illustrate an argumentation is provided by Richard Wately in his book "*Elements of Logic*" (1836, pp. 420-430). Whately said here that the diagram aspect is not useful per se for logical demonstrations but helps students to understand them. This is precisely what motivates our approach: giving a representation that helps non-experts, here the manager, to understand the outcome of a debate. In 1917, Wigmore defined a visual representation for structuring hypothesis to evidence in the legal framework as presented in [16]. For more information, [14] gives more information about the history of argument diagramming.

More recently, [17] shows how the use of graphical tools helps students to better understand the links between the arguments. In the same idea, [18] examines the undeniable contributions that visualisation tools could have to structure argumentation in legal field. We can also cite Bob Horn's work on information mapping and how a visual representation clarifies a debate [19]. He has proposed, for example, a clear graphical representation which summarises the positions of 380 philosophers, computer, cognitive and mathematical scientists on the question "*Can computers think?*". He proposes an "*Arguments Map*" which explains how 700 arguments are related to one another.

While the first diagrams were drawn with a pencil, graphical diagramming tools appeared with computers and advances in human computer interfaces. Nowadays, a lot of tools try to represent argumentation. In most of these tools, the argument map is a diagram, with boxes and arrows representing the structure of an argument.

For instance, Carneades[1] [23] is software based on a formal mathematical model for argumentation. Carneades provide argument evaluation in respect to various argumentation schemes. In the field of legal

[1] http://carneades.berlios.de.

argumentation, [20] describes a non-monotonic logic and an associated tool Argumed. The software Araucaria[2] [21] was tested in 2004 [22] by the Magistrate Court of Justice in Ontario, Canada. The results of this study were two-fold. In simple cases with few arguments involved, the software allowed the magistrate to quickly see what critical questions to answer. In complex cases, some judges found the software useful for clarifying all the aspects of the case and links between them. Araucaria supports text analysing and supports the user in building an argumentation diagram. The diagram is a tree structure and it is possible to translate them into Toulmin diagram or Wigmore diagram.

Today, there are a lot of graphical IBIS-type tools [15], they provide a visual environment for creating collaboration diagrams such as the argumentation map. They have a lot of fancy features and they clearly address problems like collaborative work, argumentation report and corporate memory.

6.0 CONCLUSION

In this article, we show how the question of validity of a V&V argument must be substituted by the acceptability question. We also present how argumentation theory could support V&V activities with two capabilities: argumentation to support confidence in a product and argumentation to support a collaborative decision.

Based on existing work, and more specifically on Toulmin's work, we laid the foundation for what should be a "good" argumentation, good in the sense of well-formed and auditable. The idea of structuring V&V elements in the form of an argumentation tree makes its way mainly through concepts such as Assurance Case, and there is an Object Management Group (OMG) group which defines an argumentation metamodel, but it is essential that argumentation trees are not limited to boxes and arrows and they should be built based on work conducted in linguistics and law.

Concerning argumentation to support a collaborative decision, we also built our work on state of the art of argumentation theory. We introduce a methodology in two steps: one step is the capture of the debate, the second one is the report of the conclusion of the debate. For capturing the debate, we use a graphical representation of arguments and relations between arguments. In the second step, we analyze the capture and simplify it.

And finally, such approaches cannot be useful without tools. Argumentation trees being potentially huge and use hypertextuality, so the question of visualization and navigation tools remains crucial for the use of argumentation on real cases.

7.0 ACKNOWLEDGMENT

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