EVALUATING UNIVERSAL SUFFICIENCY OF A SINGLE LOGICAL FORM FOR INFERENCE IN COURT

AI & Evidential Inference Workshop, June 10, 2011

in conjunction with the 13th International Conference on Artificial Intelligence and Law

Joseph A. Laronge

Oregon Department of Justice, U.S.A.

joseph.laronge@gmail.com

http://inferenceincourt.com

ABSTRACT

Inference in court is subject to scrutiny for structural correctness (e.g., deductive or nonmonotonic validity) and probative weight in determinations such as logical relevancy and sufficiency of evidence. These determinations are made by judges or informally by jurors who typically have little, if any, training in formal or informal logical forms. This paper explores the universal sufficiency of a single intuitive categorical natural language logical form (i.e., *defeasible class-inclusion transitivity*, DCIT) for facilitating such determinations and explores its effectiveness for constructing any typical inferential network in court. This exploration includes a comparison of the functionality of hybrid branching tree-like argument structures with the homogenous linear path argument structure of DCIT. The practicality of customary dialectical argument semantics and conceptions of probative weight are also examined with alternatives proposed. The use of DCIT for depicting the reasoning of legal cases typically used in AI research is considered. Finally, the issues of intelligibility and acceptability by end-users in court of logical models are examined.

Keywords

defeasible class-inclusion transitivity, DCIT term logic, DCIT, argument schemes, legal reasoning, argument visualization, universal logic, IRAC, term functor logic, argument frameworks.

INTRODUCTION

There are various demands placed on inference in court that help shape the optimal standards for applicable logical models, forms, and argument frameworks. For example, the structural correctness (e.g., deductive or nonmonotonic validity) of logical arguments is a fundamental demand. While ever-present, this correctness standard becomes even more germane for certain judicial determinations. These include, for example, court determinations of logical relevancy[1], permissible inferences, or sufficiency of evidence. In these instances, there is an increased scrutiny of the logical reasoning processes.[2] So making readily apparent the logical connections along the entire line of reasoning to the trial judge or the appellate court in a manner that reveals structural correctness can be of critical importance to the advocate.

Argument structure flexibility in adding and subtracting premises is also important for inference in court. The process of legal argumentation is often dialogic between opposing counsels or between counsel and the court. The inference granularity of a line of reasoning must, therefore, adjust to accommodate these dialectical processes including changes in evidence, generalizations, and laws. And such changes need to maintain the structural correctness of the original inference line or tree-like structure.

Finally, the audience, whether judge or jury, is typically not trained in logic whether formal or informal. So the

[1] Determinations of logical relevancy are necessary for questions of admissibility (Fed. R. Evid. 401), as well as questions of hearsay (Fed. R. Evid. 801c), evidence of uncharged misconduct (Fed. R. Evid. 404(b), and the Best Evidence Rule (Fed. R. Evid. 1002) [28].

[2] Even if the ultimate probandum is largely supported through causal links (story-model) rather than evidential links (argumentative), a logical coherence is still important [9].

argument structures and logical forms that work best in court are those that are most closely related to common sense reasoning and intuition. And given that inferential networks in court can be extensive, the less unnecessarily complex the inferential structure the better.

This paper proposes that a particular logical form of nonmonotonic reasoning is well-suited and universally sufficient to meet these demands. An underlying reasoning expression of nonmonotonic reasoning is "Typically A hold." There have been numerous attempts to formalize this expression [46], [69], and [22]. Laronge was a recent attempt to derive a logical form of nonmonotonic reasoning based on a defeasible categorical logic [33]. It is called *defeasible class-inclusion transitivity* term logic (abbreviated as DCIT term logic or just DCIT—pronounced dee-kit).

As will be illustrated through various examples, this paper suggests that DCIT's generalizability and adaptability permit typical argument and inference schemes applicable to litigation to be reduced into its single uniform natural language logical form and argument framework. Consequently, only one logical form would be required to structure any typical logical argument in court. Such universal sufficiency would allow the actors in court to share a common, simple, and straightforward logical model of reasoning.

The resulting clarity of argument representation would also benefit AI applications to legal reasoning. The benefits are partially embodied in the concepts of isomorphism and transparency. A tight and clear correspondence between the AI representation and the source material improves the understanding, application, and maintenance of such AI system [55]. And, more fundamentally, these qualities may be a significant component in filling, as described by Reed, "[t]he gap between natural argumentation text and formal, machine processible argument structures. [11]" This gap "is in large part due to lack of a single, easily extractable formal structure that every argument would reveal. [11]" DCIT is an expression of one such formalism that attempts to achieve such universality and ease of extractability through its calculus of terms.

As an additional advantage, since DCIT relies upon a mode of inference (i.e, *class-inclusion transitivity*) that is typically developed in early childhood [33], it is likely to be readily familiar in application to judge or jury. There are even suggestions that categorical logic is cognitively veridical [52].

Further, DCIT is based on a rigorous and rigid logical natural language formalism that does not permit any enthymematic arguments (i.e., missing linked premises). This minimizes the risk of a judge or jury erroneously filling in the logical gaps in an effort to make the logical connections apparent. Such rigor also prevents the unintentional construction of structural fallacies since they cannot overcome the DCIT structural constraints.

The first section of this paper provides a short description of the fundamental features of DCIT and its historical connection to other categorical logics. The next section illustrates an argument framework (i.e., "a given set of arguments ordered by a defeat relation" [40]) and a metaphoric visual language for argument diagramming or mapping of inference in court as inferences are adjusted within a dialogical process that alters probative weight. Next, a comparison is made between the functionality of hybrid branching tree-like argument frameworks (e.g., Araucaria and Carneades) and a homogenous modular linear-path argument framework like DCIT. The next section illustrates the application of DCIT to two typical court decisions that have been used in AI literature to demonstrate validity of logical forms for AI (& Law) applications. Finally, the paper closes with a discussion of the importance of intelligibility and acceptability of logical models by end-users and the historical application of DCIT in court.

DESCRIPTION OF DCIT TERM LOGIC

Categorical logic (i.e., term logic) began with Aristotle. It was later developed by the Scholastics, Leibniz, and the algebraists (e.g., Boole, De Morgan, and Pierce) [14]. Despite this long history, in modern times term logic has typically been perceived as having limited applicability. It was not until the seminal work by Sommers and its further exposition by Englebretsen, however, that the "intrinsic, often hidden and dormant power of Aristotle's syllogistic" and the contention "that all assertions could be shown, somehow, to be categorical" were realized [13]. For example, Sommers' term logic (term-functor logic, Calculus of Terms, New Syllogistic) extended categorical logic to include compound statements and relational terms [14]. DCIT term logic follows in this

expanded categorical path blazed by Sommers and Englebretsen. (Laronge [33] provides theoretical support for DCIT and its comparison with term functor logic.)

Like term functor logic, DCIT term logic is based on the principle of *de omni et nullo*, namely, "whatever is true of all M is true of whatever 'M' is true of…Another, more general, way of the thinking of the dictum is as a rule of substitution. [15] p. 63]" Contrary to classical categorical logic, however, DCIT defines "M" more broadly than monadic terms (e.g. "Socrates," "man," and "mortal").

In classical categorical inference, these single word terms (i.e., "M") can be perceived as categories from a set-theoretic perspective that join by the use of a third expression (i.e., copula) between the Subject (that which is spoken about) and the Logic Predicate (that which is said about the Subject) of the premises supporting the claim or conclusion. While originally the copula was only a form of "to be", Aristotle later expanded this to four expressions meaning "belongs to every; belongs to no, belongs to some, does not belong to some. [14]" Such an approach has, however serious limitations.

To enhance the universal applicability of categorical inference, DCIT begins by (1) expanding the definition of term to include complex terms (i.e., the Subject and complex Predicate following a Grammarian parsing), rather than monadic terms, (2) eliminating the need for the copula expression, and (3) applying universal quantifiers (e.g., One who…, One that…; Any such who…, Any such that…) to characterize all the Subject terms that are matched to the previous complex Predicate in a transitive order. Existing universal and particular quantifiers, including generalized and other nonclassical quantifiers [14] that are an inherent part of a term remain intact within the premise. In this manner, DCIT can accommodate any quantifiers in its argument structure.

Figure 1 illustrates the typical transitivity of predication using monadic terms in a categorical structure in which "[F]or all we affirm of the predicate will also be affirmed of the subject" [4].

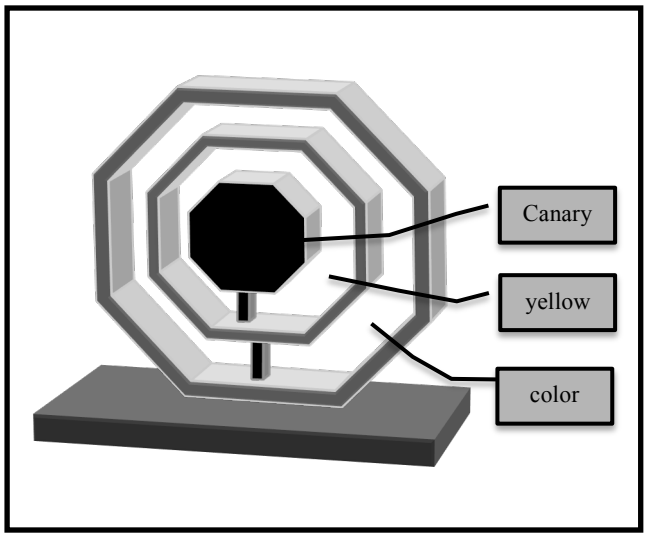

Figure 1. Monadic nested categories canary.

Premises: 1. The canary is yellow.

2. Yellow is a color.

Conclusion: The canary is a color.

Figure 1 depicts metaphorically the nested categorical relationship between the single terms. (It is not a Venn diagram.) This example illustrates one limitation of classical categorical inference structures. In this instance, despite appearing structurally correct, and assuming both premises are true, the conclusion is still false. This is because "yellow" is not essentially predicated of a "canary." "Yellow" is not fundamental to the nature of a canary as is, for example, the category "bird." Rather, it is nonessential or accidental. Angelelli [3] notes that transitivity of predication is restricted to essential predication, which occurs when the predication is as-of-a-subject.

DCIT resolves this issue and many other limitations of classical categorical reasoning. In this instance, the simple Predicate is expanded to the complex Grammarian Predicate as illustrated (see Figure 2).

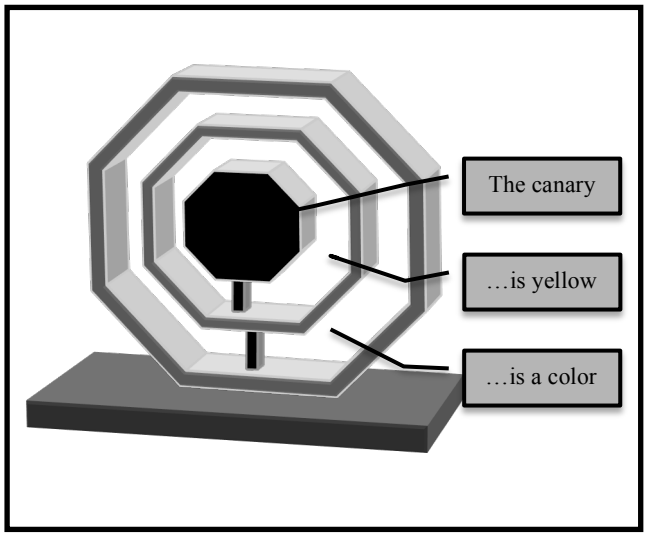

Figure 2. Predicate nested categories for canary argument.

Premises: 1. The canary…is yellow.

2. One that is yellow…is a color.

Conclusion: The canary…is a color.

A DICT structure template can also be used to depict this argument (see Figure 3).

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The canary…**	…is yellow.
2	One that…	…is yellow…	**... is a color.**
CONCLUSION			
		The canary…	**...is a color.**
ASSUMPTIONS TO LINKED PREMISES			
#	NOT INDICATED		

Figure 3. DCIT template canary argument.

While premise 2 in Figure 3 is not true, the scaffolding of the DCIT template ensures a structurally correct argument structure. This categorical structure can also accommodate, through the use of qualifiers, the concepts of proto-typicality [48] and fuzzy logic [72] [32] [36] where set membership is not necessarily a bivalent property, but rather a matter of degree. So, in this instance, if the premises had some degree of truth [35] then the conclusion would likewise have some degree of truth.

DCIT has some similarity with typical transitive arguments (e.g., "A is taller than B. B is taller than C. So A is taller than C.") in that both rely on the principle of transitivity. There are, however, significant differences. For example, typical transitive arguments depend on the transitive quality of the relationship unique to that argument (e.g., "taller"). DCIT depends, instead, solely on the transitivity of class-inclusion.

DCIT also has some similarity with the typical *modus ponens* logical form:

If A then B

A

Therefore B

The ubiquitous Tweety example follows this logical form [67]:

If Tweety is a bird, then Tweety flies.

Tweety is a bird.

Therefore, Tweety flies.

Like DCIT, *modus ponens* uses an internally consistent word order, sentence structure, and premise linkage which makes its structural correctness obvious. But while modus ponens relies upon non-distributive conditionals, DCIT relies upon distributive generalizations:

Tweety...is a bird.

One that is a bird...flies.

Therefore, Tweety...flies.

The distributive generalization of DCIT can, however, also be expressed as a distributive conditional:

Tweety is a bird.

If one is a bird, then one flies.

Therefore, Tweety flies.

And like defeasible *modus ponens* [67], DCIT can account for defeasibility as a nonmonotonic logic as later shown in this paper.

To fit any line of logical inference within a DCIT structure, five steps are followed:

1. Each premise (e.g., singular, compound, or relational) is regimented into a DCIT categorical form.

2. The Subject of the first premise must be the Subject of the main conclusion or ultimate probandum (e.g., "The canary").

3. The complex Predicate phrase of the last premise in the transitive string must be the complex Predicate phrase of the main conclusion or ultimate probandum (e.g., "is a color").

4. The remaining complex Predicate phrases of each premise must be the Subject of the following premise prefaced by a universal quantifier (e.g., One who…, One that…; Any such who…, Any such that…) creating a transitively-linked chain of premises in this distinct order.

5. For each transitively linked premise, any associated non-linking assumptions that provide some degree of support, necessary or ancillary, are appropriately added.

To apply the first four steps, regimentation of the linked premise wording is performed, where necessary, to fit the transitive categorical form without changing the meaning of the premises. Processes such as obversion, passive transformation [53, p. 97], reordering conjuncts [53, p. 97], and laws of identity [53, p.131] can be applied to conform the premises to this transitive canonical form.

The assumptions in the fifth step relate to Argument Scheme Critical Questions (see Figure 4).

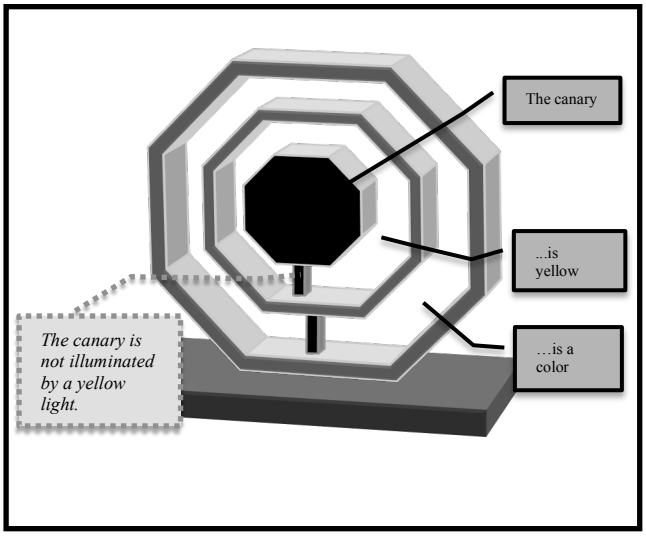

Figure 4. Predicate nested categories canary argument with supporting assumption.

In this "canary" argument, reminiscent of Pollack's red object example, the assumption that "the canary is not illuminated by a yellow light" provides ancillary support, rather than necessary support, for the transitively-linked premise 2 that "The canary is yellow."

The DCIT template also accommodates the distinction between ancillary and necessary assumptions in defeasible reasoning. In the following example, the second premise has a number of nontransitively-linked premise assumptions as shown in Figure 5. The supporting nature of assumptions, rather than a transitive-linking nature, is also depicted in a DCIT argument-bridge diagram that metaphorically reflects an inference step as a bodily movement (see Figure 6). This physical metaphor, aligning with Lakoff's concept of the embodied mind [17] helps make clear some of the terms related to inference (e.g., inference step or leap).

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The defendant...**	…fled from the crime scene according to Witness A.
2	One such who…	…fled from the crime scene according to Witness A...	... actually fled from the crime scene.
3	One such who…	... actually fled from the crime scene...	…was plausibly just fleeing for fear of police abuse.
4	One such who…	…was plausibly just fleeing for fear of police abuse...	**…was probably unlawfully arrested by the police fleeing the crime scene.**
CONCLUSION			
		The defendant...	**…was probably unlawfully arrested by the police fleeing the crime scene.**
ASSUMPTIONS TO LINKED PREMISES			
2	Witness A was testifying free from duress. (ANCILLARY) Witness A had the cognitive capacity to remember the incident. (NECESSARY)		
3	The defendant was a member of a minority class in a high-crime area. (ANCILLARY)		

Figure 5. DCIT template fleeing argument.

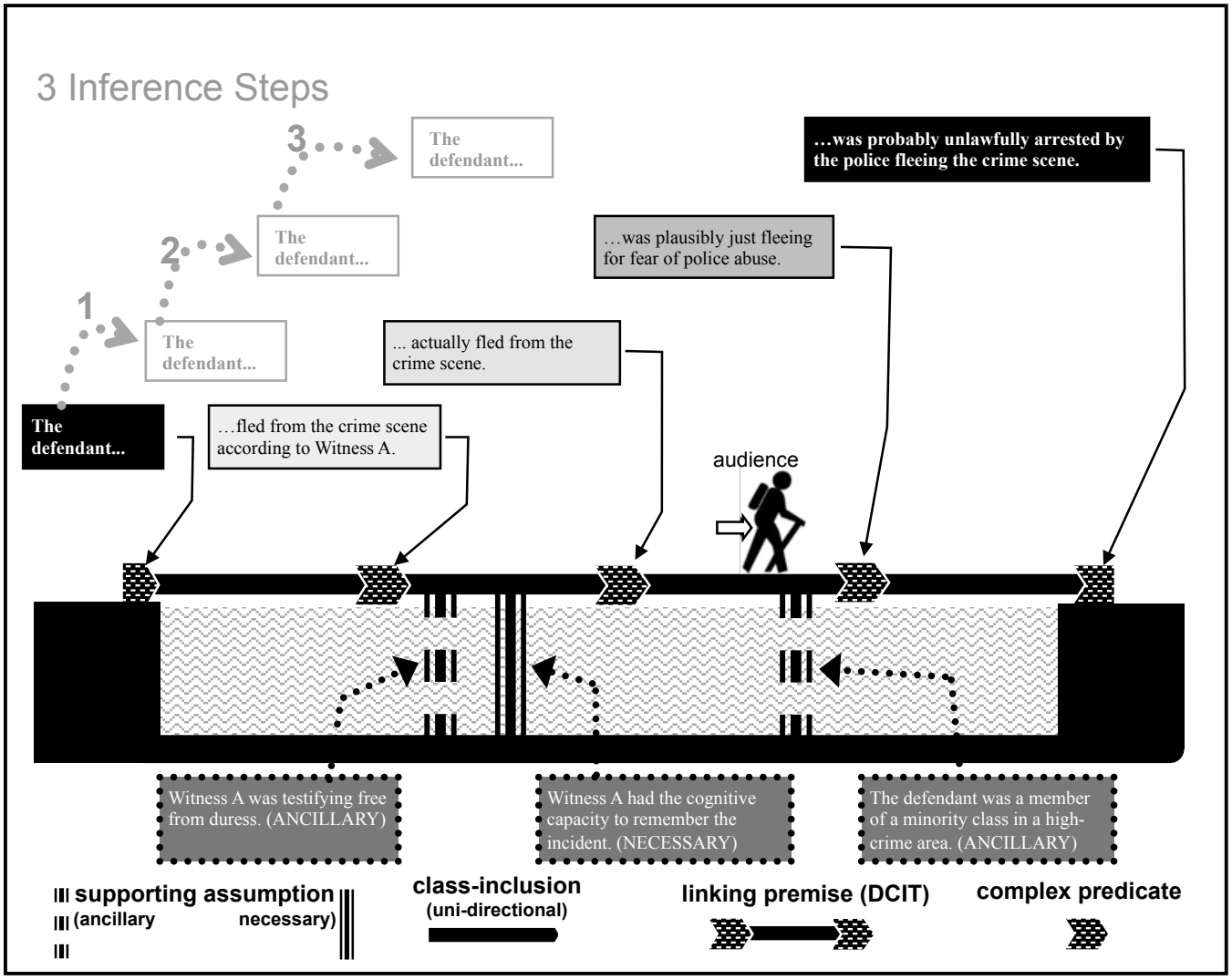

Figure 6. DCIT argument-bridge diagram fleeing argument.

Having had the "cognitive capacity to remember the incident" is a necessary assumption for premise 2 to have any level of acceptability. But, while being "free from duress" supports premise 2, it is not necessary for premise 2 to have some acceptability. Similarly, "The defendant was a member of a minority class in a high-crime area" is merely an ancillary assumption. This ancillary assumption for transitively-linked premise 3 aligns with a perception of reality existing for a portion of the population of Americans and acknowledged as reasonable by U.S. Supreme Court Justice Stevens in a dissenting opinion:

"Among some citizens, particularly minorities and those residing in high crime areas, there is also the possibility that the fleeing person is entirely innocent, but, with or without justification, believes that contact with the police can itself be dangerous, apart from any criminal activity associated with the officer's sudden presence." *Illinois v. Wardlow*, 528 U.S. 119 (2000).

Wardlow illustrates that the choice and degree of acceptability of generalizations, whether structured as transitively-linked premises, assumptions (ancillary or necessary), or implicit in Critical Questions attached to Argument Schemes can be dependent on the worldview of the audience [59]. This fact provides a cautionary note to uncritical reliance on a standardized list of Critical Questions or assumptions attached to any Argument Scheme. Such constructions of stereotypical reasoning must always account for the fact that one group's sound stereotypical reasoning may be unsound from another group's worldview [24]. And what is a Critical Question or assumption for one group may not be critical for another. Ascertaining these differences is one purpose of *voir*

dire. Jurors bring to court their own generalizations with ancillary or necessary assumptions that can operate for jurors as implicit "evidence" as they construct their inferential networks or stories.

Wardlow also illustrates that Argument Schemes can be found at different locations along the spectrum of generalized applicability. A "Position to Know" Argument Scheme such as associated with premise 2 will likely have more opportunities for application than the "Fleeing" Argument Scheme associated with premise 3. Even more generalizable might be an Argument Scheme such as "Argument from Analogy."

Without a rigorous scaffolding of transitively-linked premises separate from assumptions, the distinction between them can be obscured. For example, the issue in *State v. Bivens,* 191 Or App 460, 83 P 3d 379 (2004) was whether the evidence was legally sufficient to permit the jury to make a reasonable inference that the defendant's child "personally saw or through some other first-hand sense or sensation was conscious of and recognized" that the defendant slapped their mother (Payne) as this assault occurred. *Bivens* at 467.

The court describes the prosecutor's line of reasoning as follows:

> "To be sure, the record provides an ample basis for the first two steps in that line of logic. Payne's testimony provided the jury with a basis to conclude that the children were in their bedroom [away from the hallway where the fight took place] during most of the argument, and in particular were there toward the end of the argument when defendant slapped Payne in the face. Both Payne's testimony and that of the investigating officer's provide sufficient grounds to conclude that the argument and the fight could be easily heard in other areas of the house, and easily seen if doors were open." *Bivins* at 468. (see Figure 7)

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The children**…	…were in the house.
2	Any such who…	…were in the house…	…would have heard the arguing of the defendant and Payne.
3	Any such who…	…would have heard the arguing of the defendant and Payne…	...**heard the open-hand slap to Payne's face.**
CONCLUSION			
		The children…	**...heard the open-hand slap to Payne's face.**
ASSUMPTIONS TO LINKED PREMISES			
#	NOT INDICATED		

Figure 7. DCIT template *Bivins* argument with no supporting assumptions.

The court found the state's reasoning incomplete, however, noting that "the state's line of logic requires several additional intermediate inferences." *Bivens* at 470. These are as follows:

(a) "The open hand slap made a distinctive sound."

(b) "[T]he sound of the slap rose above the noise of the argument."

(c) "C, at age five, was sufficiently mature to distinguish the assaultive conduct from other aspects of the fight."

(d) "[T]he children and the five-year old in particular paid attention to the fight."

Bivens at 470.

While the court characterizes these propositions as "additional intermediate inferences," from a more rigorous logical perspective, these statements are not "intermediate inferences." There are no additional inference leaps that need to be made in the prosecution's line of reasoning since it follows a standard logical form. More accurately described, these four propositions are assumptions that provide support for premise number 3. This more complete argument structure is depicted in Figure 8.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The children…**	…were in the house.
2	Any such who…	…were in the house…	…would have heard the arguing of the defendant and Payne.
3	Any such who…	would have heard the arguing of the defendant and Payne…	**... heard the open-hand slap to Payne's face.**
CONCLUSION			
		The children…	**... heard the open-hand slap to Payne's face.**
ASSUMPTIONS TO LINKED PREMISES			
3	(a) "The open hand slap made a distinctive sound." (b) "[T]he sound of the slap rose above the noise of the argument." (c) Any such "was sufficiently mature to distinguish the assaultive conduct from other aspects of the fight." (d) Any such paid particular "attention to the fight."		

Figure 8. DCIT template *Bivins* argument with supporting assumptions.

By recognizing the logical form distinction between transitively-linked premises and premises as assumptions, the practitioner is less likely to fail to account for these assumptions as occurred in *Bivens*. But while a logical separation of form needs to be made between transitively-linked premises and assumptions, there can be a fluid exchange of the concepts that they carry between them. This could occur by altering the content of a transitively-linked premise to include within its sentence structure a modifier that represents an assumption.

DCIT's scaffolding also accommodates lines of reasoning when most of the generalizations contain statutory language (see Figure 9). Thus, there is no law-fact distinction [2] for DCIT analytical purposes.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The property tax complaint**...	...was filed more than 90 days after the Notice of Assessment.
2	Any such that…	...was filed more than 90 days after the Notice of Assessment...	...was not filed within the time allowed under ORS 305.280.
3	Any such that…	...was not filed within the time allowed under ORS 305.280...	...did not meet the ORS 305.560 requirements for a tax court appeal under ORS 305.275.
4	Any such that…	...did not meet the ORS 305.560 requirements for a tax court appeal under ORS 305.275...	...**should be dismissed.**
CONCLUSION			
		The property tax complaint...	...**should be dismissed.**
ASSUMPTIONS TO LINKED PREMISES			
4	Premise 4 necessarily assumes that the tax court does not have jurisdiction under another statute such as ORS 305.288.		

Figure 9. DCIT template property tax complaint dismissal argument with supporting assumption.

PROBATIVE WEIGHT OR FORCE

In addition to defining an argument structure, DCIT provides for a depiction of probative weight or force. Courtroom evidence has logically relevant probative weight if it has the capacity to increase or decrease the reasonably perceived level of probability of the truth of the ultimate probandum (Fed. R. Evid. 401). As new evidence is considered and counter-arguments are made in a dialogic process, the audience's (e.g., judge's or juror's) perception of the amount of probative weight can change. Pollack suggests that assessing these changing amounts of probative weight is a subdoxastic process [37]. But while the computation of these amounts or degrees of probative weight by the audience may be outside of conscious awareness, the resulting determination can be made visually explicit. The following section discusses how these changes to probative weight in a two-party dialogic process with an audience [41] can be reflected metaphorically in a DCIT visual argument framework.

For courtroom purposes, probative weight can be conceptualized visually as a discrete container of the audience's (e.g., judge's or juror's) perception of acceptability of each predication as that acceptability moves through the inferential network. It begins at the Subject of the ultimate probandum and moves toward its complex Predicate at the other end of the inference chain. The amount of this perception of acceptability can be altered as it moves along the line of reasoning. While this probative weight can always diminish at each nexus of predication (i.e., new categorical relationship or substitution), it can only be increased, up to its maximum starting level, by certain specified accrual configurations.

This DCIT conception of probative weight or force suggests that a piece of relevant evidence does not self-generate probative weight or force in and of itself. Rather, the premise associated with such evidence simply provides either (1) a transitively-enabled connection within the inferential network for the perception of acceptability of the audience to cross a nexus of predication; or, (2) support for such a link in the inferential network as an assumption. If the premise provides no constraint or resistance to the passage of the perception of acceptability, then such probative weight remains unaltered as it transits along the line of reasoning. However, if

the perception of acceptability is less than total for a particular premise, that premise creates resistance that decreases the probative force passing through it.

If an item of evidence was actually able to self-generate probative weight, then the probative weight that reaches the ultimate probandum would not be limited, as generally theorized, to the weakest link [38] in the chain of reasoning. And a transitively-linked premise along the line of reasoning would be able, contrary to current understanding, to increase probative weight beyond that which reaches it from up the same line of reasoning. Of course, a separate convergent line of reasoning (e.g., from corroborating evidence) can increase the amount of acceptability that reaches any complex predicate to which it connects, including that of the ultimate probandum, under certain circumstances.

So relevant evidence is, from a DCIT metaphorical perspective, simply one piece of a conductor within the inferential network that helps complete the circuit through which the probative force travels. The probative weight or force, like the signal strength from a generator, is provided by the audience (e.g., judge or juror). The starting level of such probative weight or force as it begins its path through the inferential network can, for illustrative purposes, be conceptualized as an amount of 100 indicating full acceptability.

To illustrate these changes in probative weight or force, an adaptation of the Toulmin canonical example that "Harry is a British subject." is used. In order to bring the Toulmin example into a current context, it has been modified to "Barack is a natural born citizen of the United States." (see Figure 10) To depict probative force and the addition of counter-arguments, the preceding DCIT metaphoric nested visual language has been adjusted.

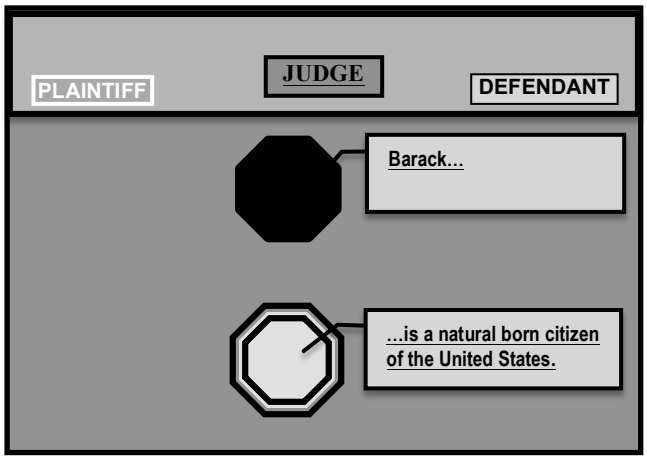

Figure 10. DCIT predicate dots argument map Barack 1.

Figure 10 shows the Subject and complex Predicate of the ultimate probandum. The solid black octagon represents the Subject of the ultimate probandum. It is the element whose membership (absolute or fuzzy) needs to be connected to the complex Predicate of the ultimate probandum in a categorical relationship by the defendant.

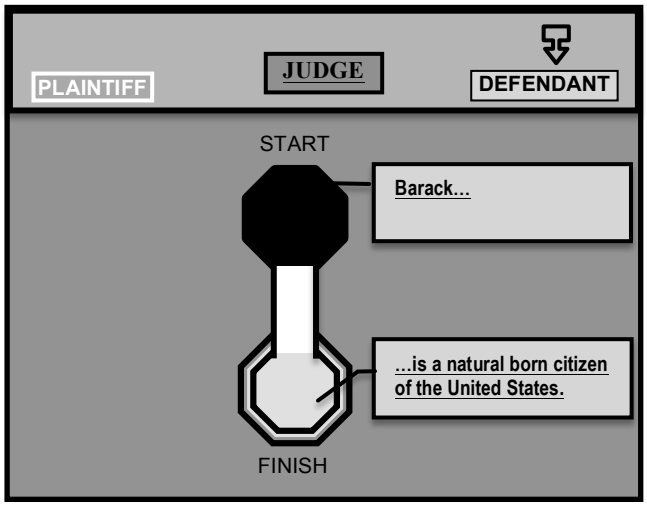

Figure 11. DCIT predicate dots argument map Barack 2.

Figure 11 represents the defendant's claim of the ultimate probandum, namely, that there is a class-inclusion relationship between the Subject of the ultimate probandum (i.e., "Barack") and the complex Predicate of the ultimate probandum (i.e., "is a natural born citizen of the United States."). Rather than visually depicting one dot nested within the other as done in the previous nested categories diagrams, this same categorical class-inclusion relationship is indicated by two parallel connecting lines which also represents a conduit for the movement of the audience's perception of acceptability (i.e., probative weight or force) to cross this nexus of predication.

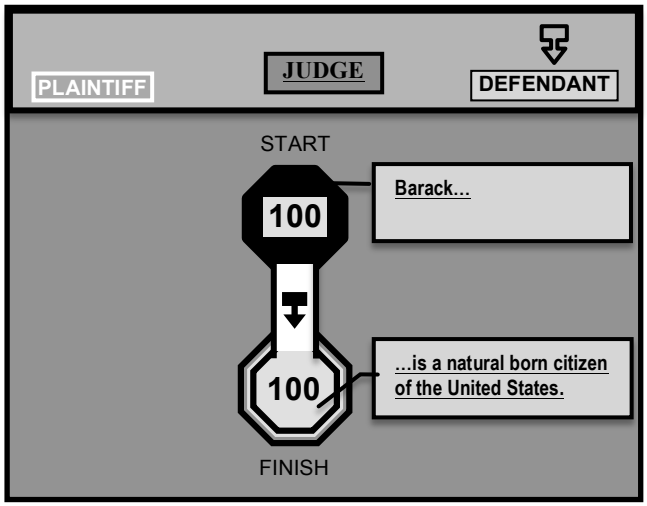

Figure 12. DCIT predicate dots argument map Barack 3.

Figure 12 show the passage of defendant's perception of acceptability (i.e., probative weight). It is represented by a rectangular container attached to an arrow that moves down the predication path. In this illustration, since the starting amount of 100 is depicted as not changing in its transit across the nexus of predication, the ultimate probandum is fully acceptable by the defendant in this instance.

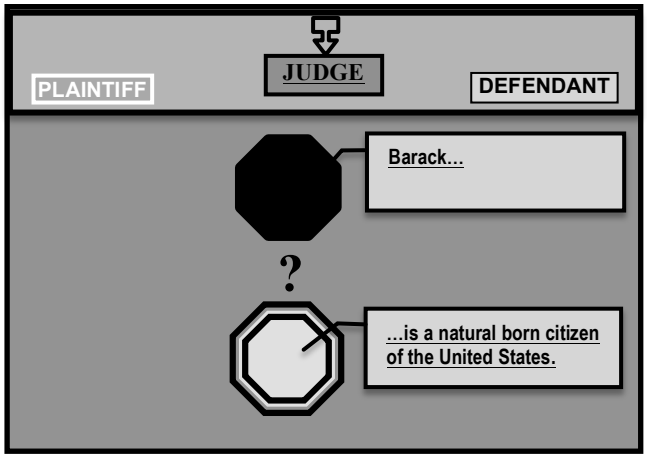

Figure 13. DCIT predicate dots argument map Barack 4.

Figure 13 indicates, with the question mark, a hypothetical response by the judge (i.e., audience) that the judge, contrary to the defendant, does not yet perceive any predication, namely, the judge does not yet perceive that the ultimate probandum has any truth to it.

In response, the defendant needs to find a less direct class-inclusion connection that might satisfy the court that there is some probability of truth to the ultimate probandum.

As illustrated in Figures 14 and 15, defendant has spliced into the path, in a modular fashion, an intervening complex Predicate to suggest to the judge two new categorical connections to replace the original one. Figure 14 and 15 begin to reveal that a line or path of reasoning can truly be represented as "connecting the dots." When an ultimate probandum is unzipped at the nexus of predication, complex predicate dots can be unpacked and ordered in a transitive categorical-linear path for the probative weight to travel.

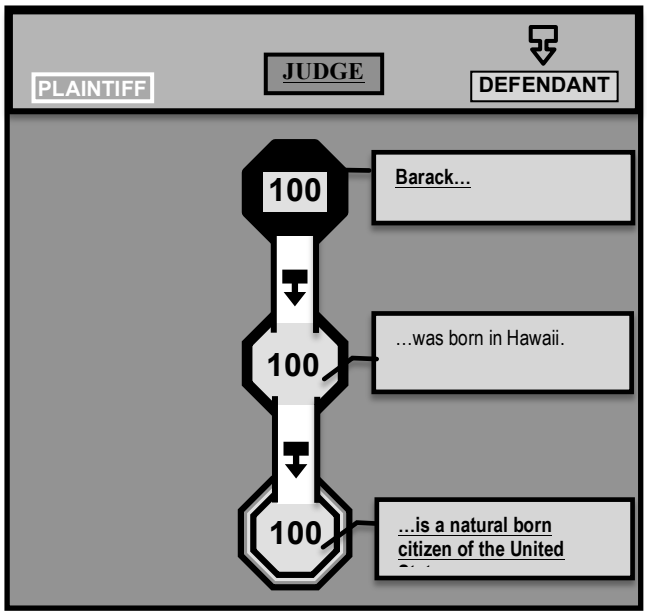

Figure 14. DCIT predicate dots argument map Barack 5.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**Barack…**	…was born in Hawaii.
2	One such who…	…was born in Hawaii…	**...is a natural born citizen of the United States.**
CONCLUSION			
		Barack…	**... is a natural born citizen of the United States.**
ASSUMPTIONS TO LINKED PREMISES			
#	Not Indicated		

Figure 15. DCIT argument template Barack argument 1.

In this hypothetical dialogue with the court, however, while the judge agrees with the second class-inclusion connection to some degree, the court in this example does not perceive the existence of the first connection (see Figures 16 and 17).

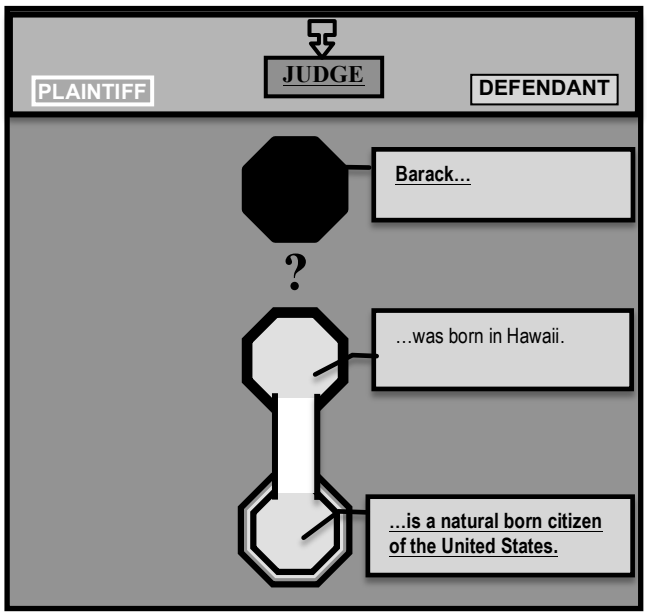

Figure 16. DCIT predicate dots argument map Barack 6.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**Barack…**	**…???**
2	One such who…	**…???...**	…was born in Hawaii.
3	One such who…	…was born in Hawaii…	**... is a natural born citizen of the United States.**
UNSUPPORTED CONCLUSION			
		Barack…	**...is a natural born citizen of the United States.**
ASSUMPTIONS TO LINKED PREMISES			
	Not Indicated		

Figure 17. DCIT argument template Barack argument 2.

Figures 18 and 19 reflect the increasing granularity of the linkage in defendant's effort to present predication connections that are perceived as capable of transferring the probative weight. This process illustrates that creating more inference steps does not necessarily mean more uncertainty.

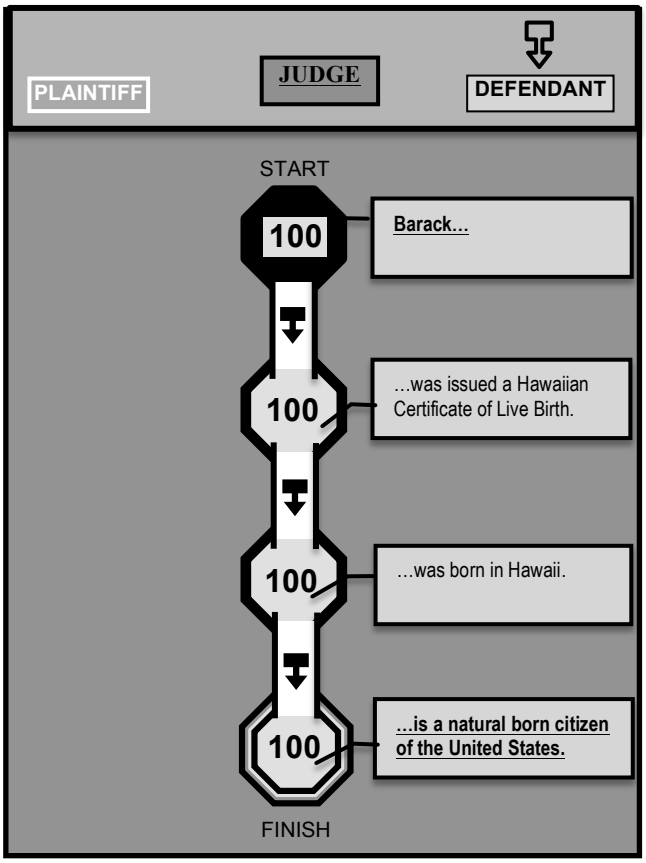

Figure 18. DCIT predicate dots argument map Barack 7.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**Barack**…	…was issued a Hawaiian Certificate of Live Birth.
3	One such who…	…was issued a Hawaiian Certificate of Live Birth...	…was born in Hawaii.
	One such who…	…was born in Hawaii…	... **is a natural born citizen of the United States.**
CONCLUSION			
		Barack…	...**is a natural born citizen of the United States.**
ASSUMPTIONS TO LINKED PREMISES			
	Not Indicated		

Figure 19. DCIT argument template Barack argument 3.

To counter this line of reasoning, the plaintiff could attempt to reduce the judge's perception of the amount of probative weight (i.e., the judge's perception of acceptability) that can reach the end of the defendant's line of reasoning. Plaintiff's attempt to divert or siphon off some of this probative force is, in this example, attached in-line with the defendant's reasoning pipeline (see Figure 20). This figure depicts the plaintiff's counter-argument and the judge's assessment of acceptability.

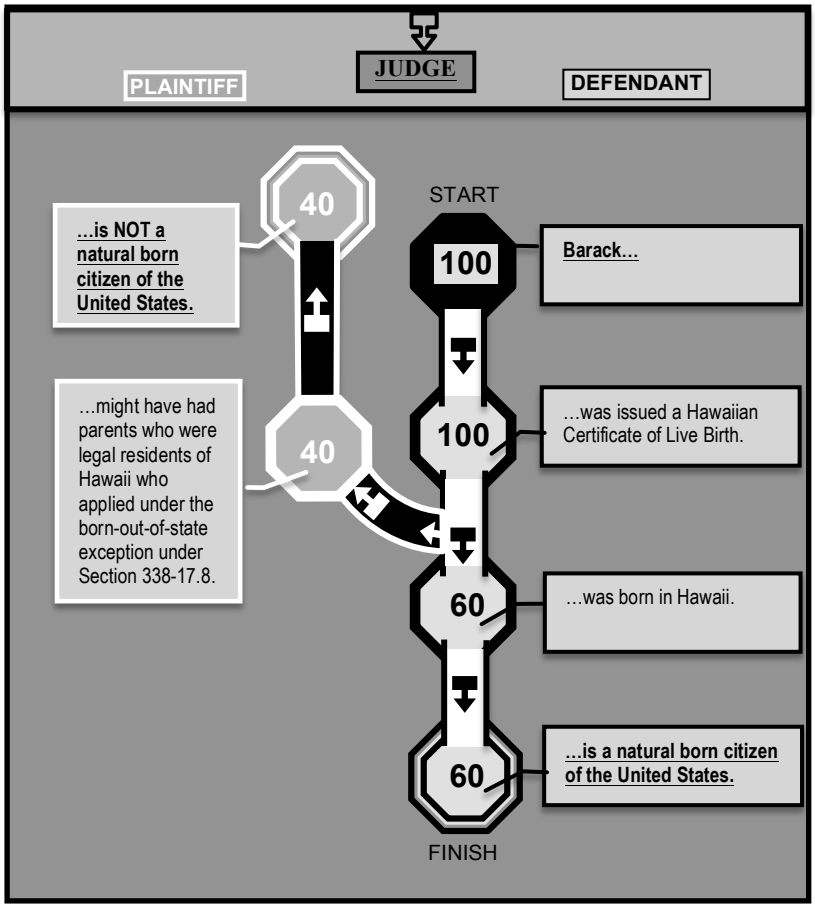

Figure 20. DCIT predicate dots argument map Barack 8.

The final determination of the judge "is not whether any given inference in a chain is too weak but is always whether, in view of all patterns of corroborating and contradicting evidence at all levels of all inferential chains, the final factum probandum has been shown to the degree of likelihood required by the applicable standard of persuasion, whatever that standard may be. [56]"

Based on plaintiff's counter-argument, Figure 20 represents a change in the judge's perception of acceptability or amount of probative weight that reaches the ultimate probandum. This calculus is not intended to represent a rigorous determination, but is only indication of one possible subjective result.

Rather than diverting or siphoning off some of the probative force by attaching in-line at a nexus of predication, plaintiff can also attach directly to a complex predicate when the objection is a characterization of one of defendant's premises such as a claim that the premise is, for example, inconsistent, ambiguous, or irrelevant (see Figure 21).

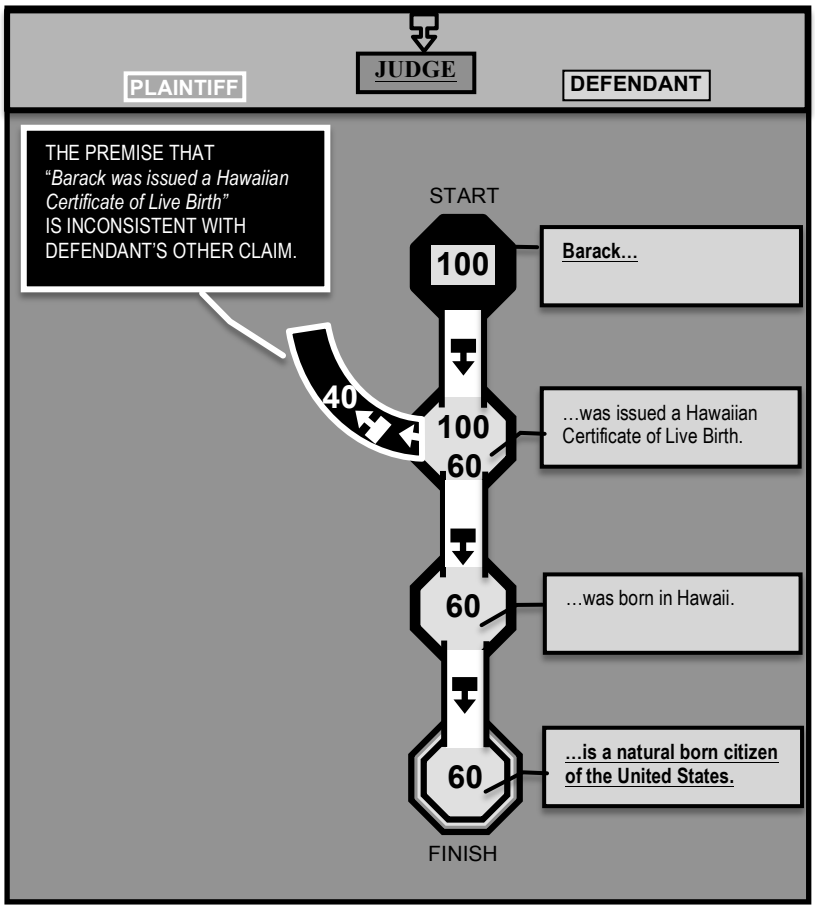

Figure 21. DCIT predicate dots argument map Barack 9.

Rather than attempting to divert the amount of acceptability from within the opposing party's line of reasoning, another counter-argument approach is to divert it by constructing an alternate competing line of reasoning. This is called an off-line objection. In AI (& Law) it is often called a rebuttal (see Figure 22) [44].

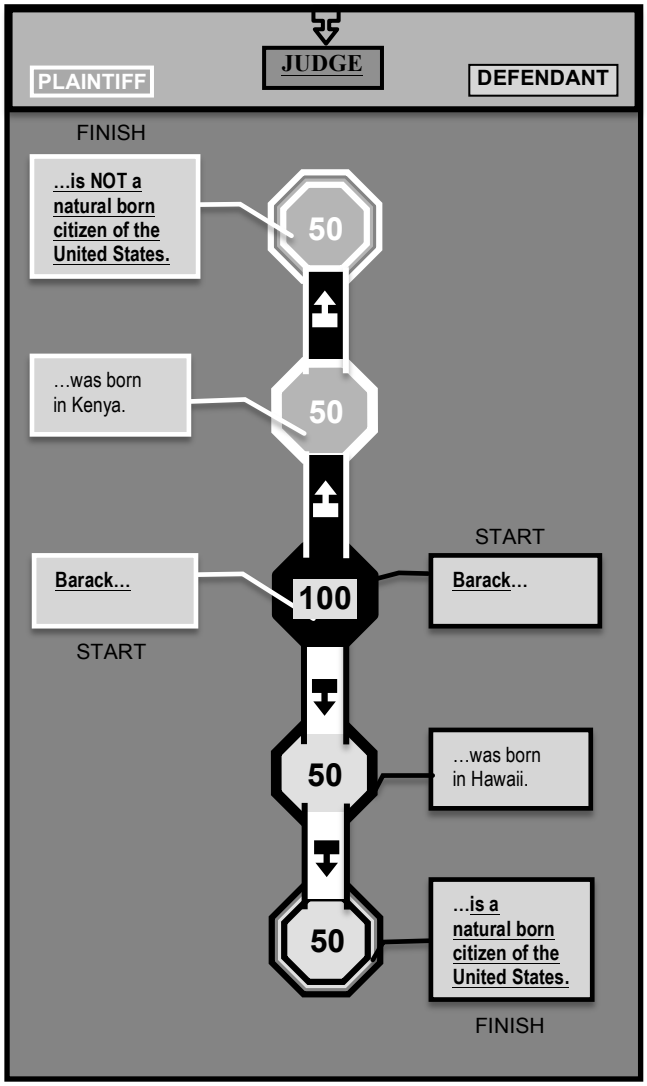

Figure 22. DCIT predicate dots argument map Barack 10.

Defendant has the option of attempting to increase the judge's perception of the degree of acceptability through a process of aggregation or accrual (see Figure 23) [43]. The actual amount of accrual is only hypothetical in this illustration. Such amount can be determined as a subjective process, based on probabilism [37], or based on another model. But, the process of accrual cannot increase the degree of acceptability beyond complete acceptance of the truth of the ultimate probandum.

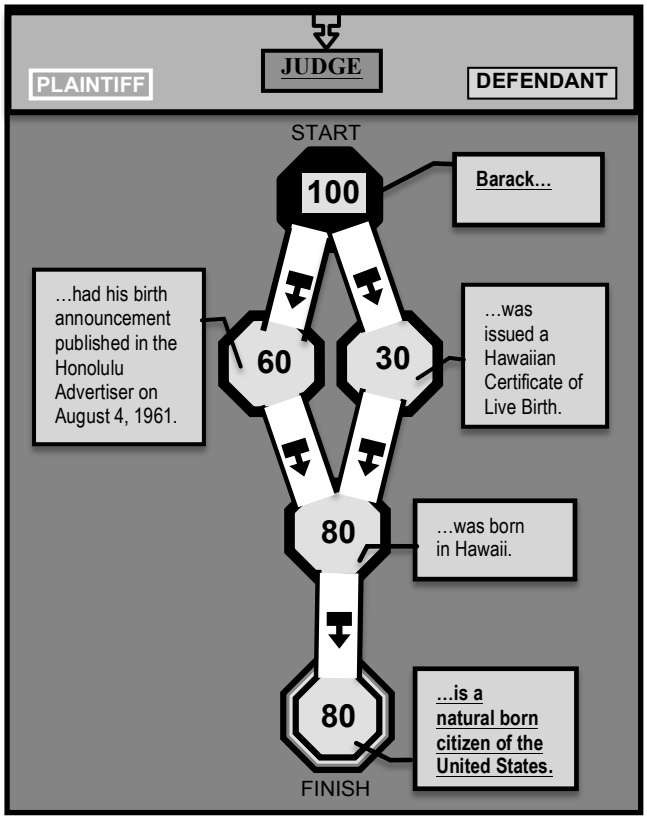

Figure 23. DCIT predicate dots argument map Barack 11.

As shown in Figure 24, the plaintiff can attempt as a response to divert the probative weight along each of the separate lines of defendant's convergent reasoning.

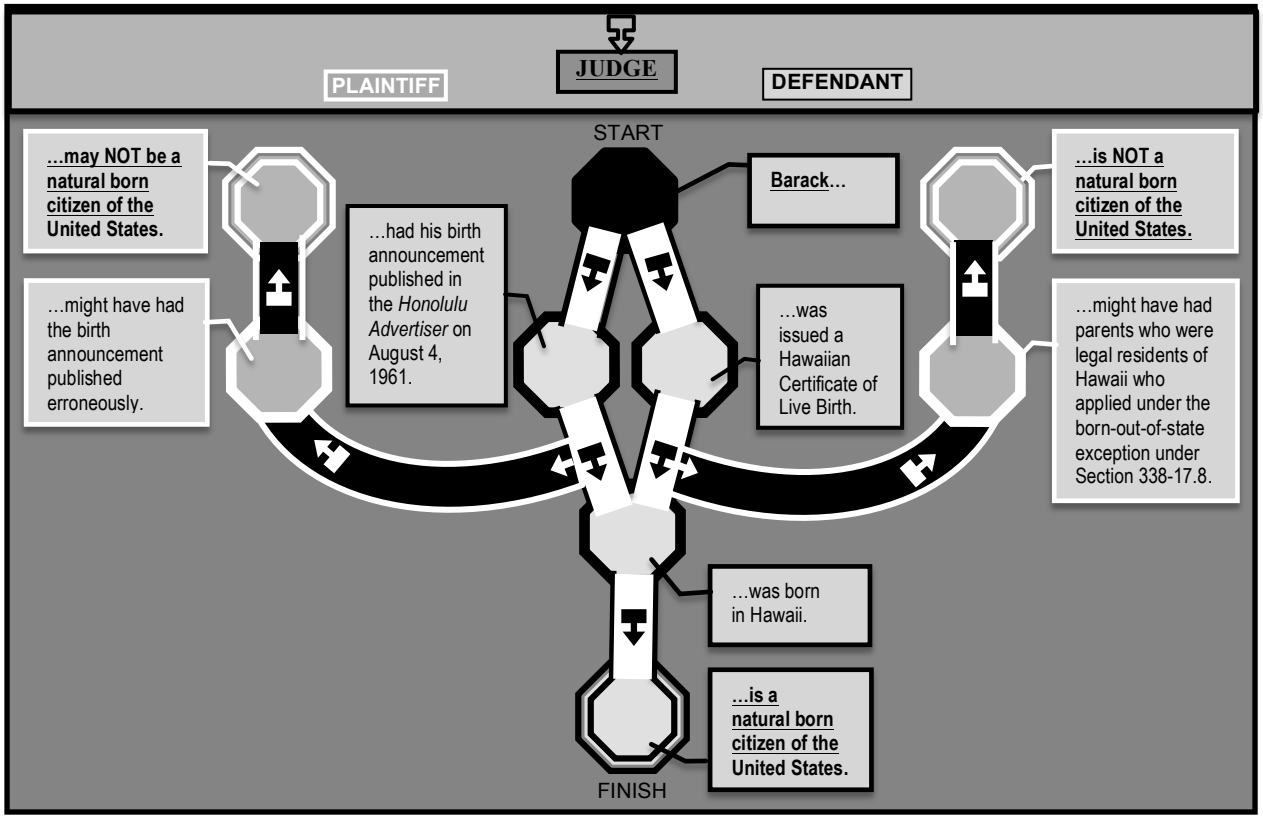

Figure 24. DCIT predicate dots argument map Barack 12.

This dialogic process, as illustrated in Figure 25, can continue *ad infinitum*

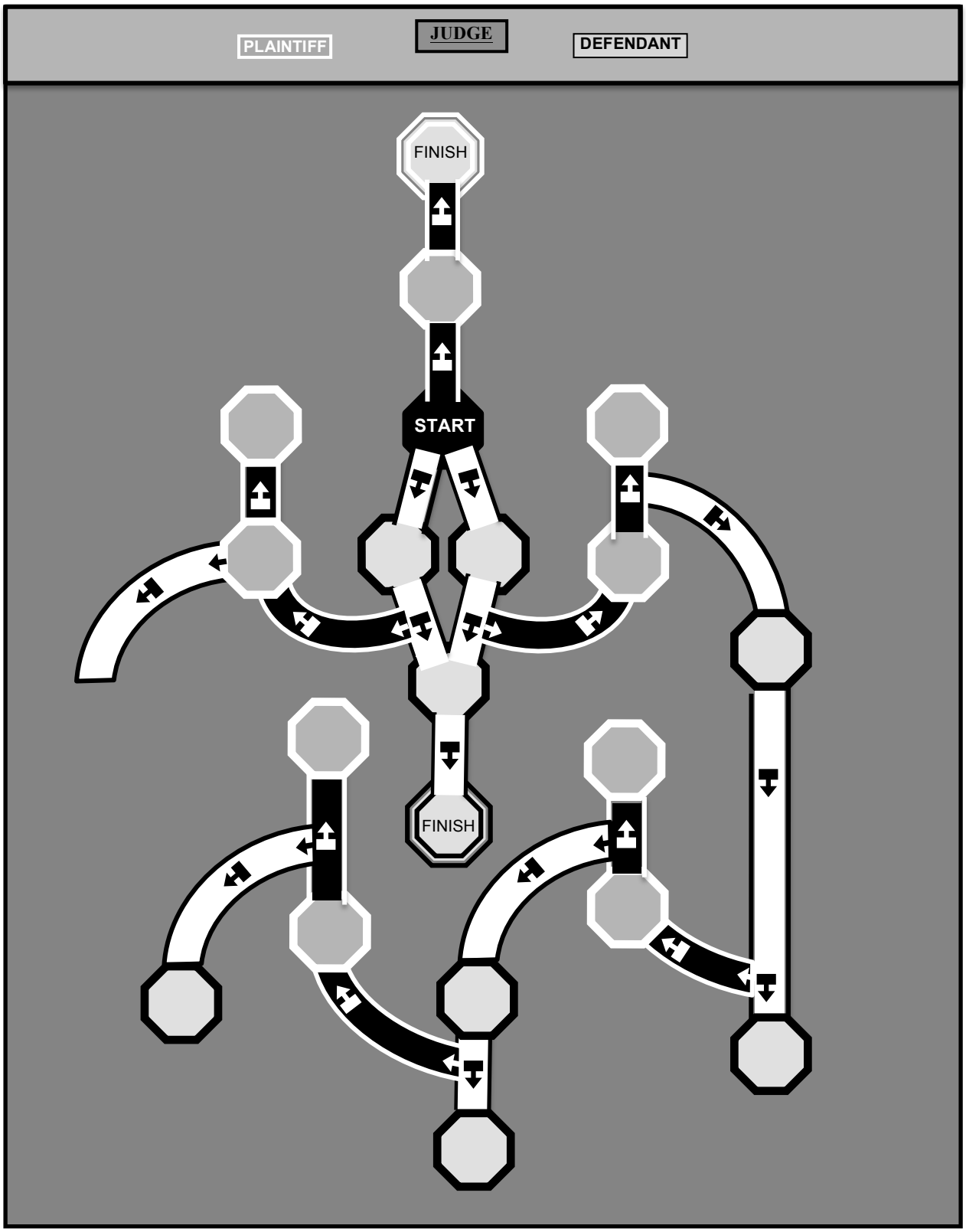

Figure 25. DCIT predicate dots argument map multiple attacks.

These attempts to divert the probative force must also account for the multi-leveled nature of inferential networks that is produced by assumptions, ancillary or necessary, that underlie and are integral to each transitively-linked premise. And at each sub-level, another underlying sub-level can exist with assumptions of assumptions *ad*

infinitum (see Figure 26). At each individual level, a complete network of arguments and counter-arguments can be present. The net result of the layered support from all the levels that attach to any transitively-linked premise at Level 1 impacts the amount of probative weight or force that can transit through that Level 1 premise.

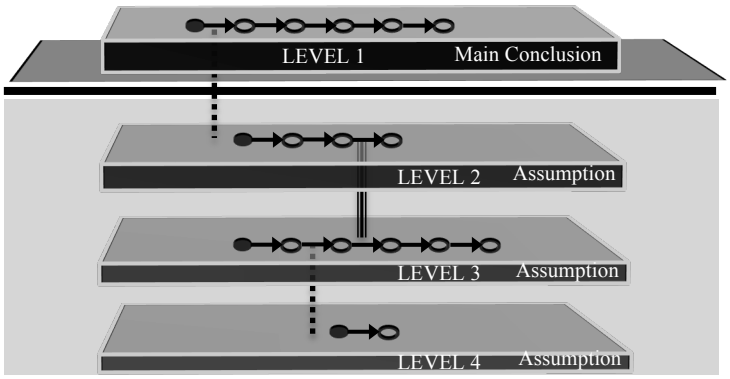

Figure 26. DCIT multi-level argument map1.

For example, Figure 27 depicts two assumptions that can support the premise that "One who was born in Hawaii according to witness Governor Ambercrombie was born in Hawaii."

1. The Witness was not biased in favor of citizenship. (Ancillary Assumption)
2. The Witness was in a position to know. (Necessary Assumption)

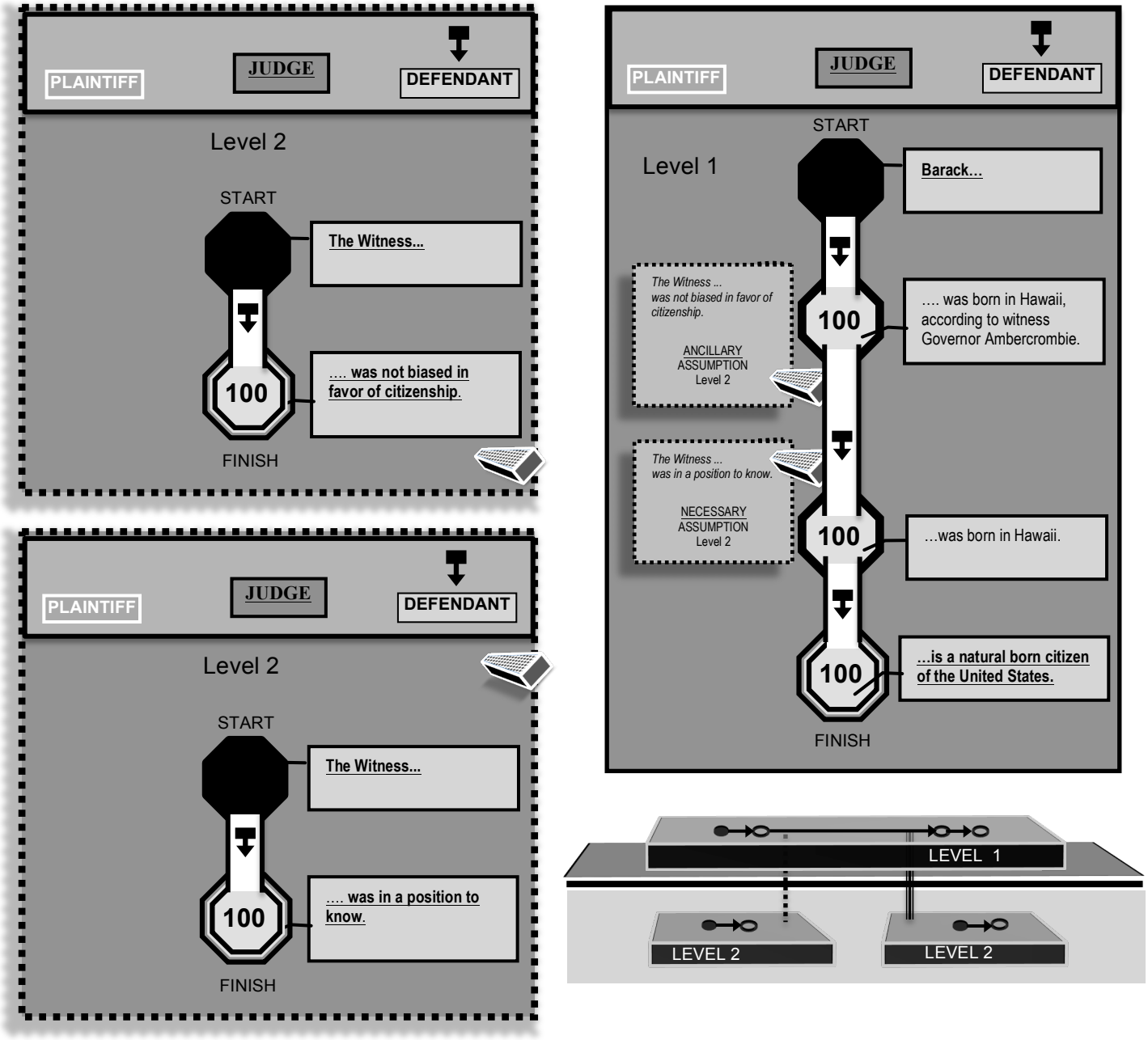

Figure 27. DCIT predicate dots argument map Barack multi-level 2.

In court, more than two levels of an argument are common. To account for such an increasing number of levels, the DCIT argument form is best represented with a DCIT Outline format (see Figures 28 and 29). Each hierarchy in the outline—depicted with an identical indent—represents a different level of the argument structure. The

pattern of support is consistent. The ultimate probandum (i.e., main conclusion) is located at the highest level (1.) of the outline. The next demoted level (i.e., 1.1) contains in order the three transitively-linked premises (TLP) directly supporting the main conclusion. And the following demoted level (i.e., 2.0) contains the supporting assumptions (necessary or ancillary) for the transitively-linked premise directly above each one. And then, again, the next demoted level (i.e., 2.1) contains the transitively-linked premises (TLP) directly supporting the adjoining assumption. This pattern continues down through any number of levels needed for purposes of analysis.

1. Barack...is a natural born citizen of the United States. (MAIN CONCLUSION)

- **1.1 Barack**...was born in Hawaii according to witness Governor Ambercrombie. (TLP)
- **1.1** One who was born in Hawaii according to witness Governor Ambercrombie ...was born in Hawaii. (TLP)
  - **2.0** *The witness...was in a position to know of the birth. (Assumption)*
    - **2.1** The witness...was in the hospital Waiting Room at the time of the birth according to the nurse on duty. (TLP)
    - **2.1** One who was in the hospital Waiting Room at the time of the birth according to the nurse on duty...was in the hospital Waiting Room at the time of the birth. (TLP)
      - **3.0** *The nurse on duty...remembered the incident correctly. (Assumption)*
        - **3.1** The nurse on duty...had contemporaneous notes that matched her statement of the incident according to her co-worker. (TLP)
        - **3.1** One who had contemporaneous notes that matched one's statement of the incident according to her co-worker...had contemporaneous notes that matched one's statement of the incident. (TLP)
          - **4.0** *The co-worker...had first-hand knowledge of the notes. (Assumption)*
            - **4.1** The co-worker saw the notes as they were written. (TLP)
            - **4.1** One who saw the notes as they were written...had first-hand knowledge of the notes. (TLP)
        - **3.1** One who had contemporaneous notes that matched one's statement of the incident...remembered the incident correctly.
    - **2.1** One who was in the hospital Waiting Room at the time of the birth...was in a position to know of the birth. (TLP)
  - **2.0** *The witness...was not biased in favor of Barack. (Assumption)*
    - **2.1** The witness...was the campaign manager for a Republican 2012 Presidential candidate. (TLP)
    - **2.1** One who was the campaign manager for a Republican 2012 Presidential candidate...was not biased in favor of Barack. (TLP)
  - **2.0** *The witness...was capable of perceiving the event correctly. (Assumption)*
- **1.1** One who was born in Hawaii...**is a natural born citizen of the United States**. (TLP)
  - **2.0** *Hawaii...was a U.S. territory or state at the time of the birth. (Assumption)*
    - **2.1** Hawaii...became a U.S. territory in 1898. (TLP)
    - **2.1** One such that became a U.S. territory in 1898...was a U.S. territory or state at the time of the birth. (TLP)

Figure 28. DCIT Outline template Barack.

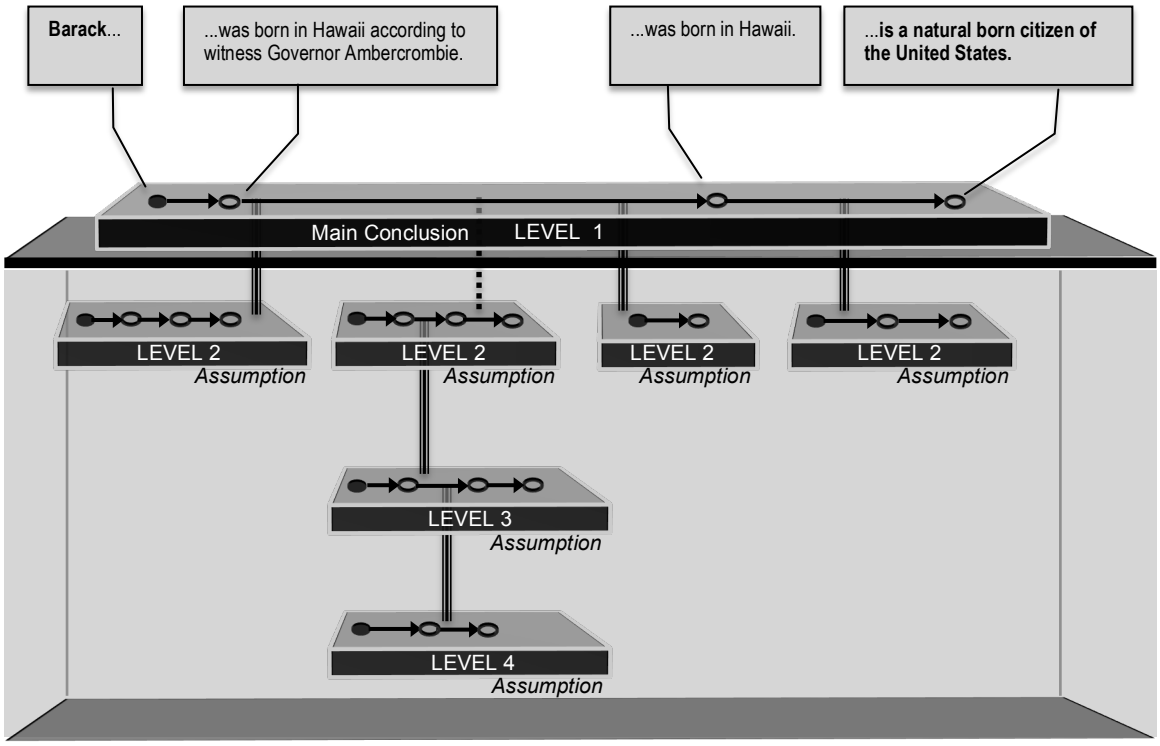

Figure 29. DCIT Multi-level argument map 3.

Each assumption presents the possibility of a different level of transitively-linked premises that support such assumption along with new assumptions that underlie this new lower level of transitively-linked premises. Within the DCIT Outline, counter-arguments can be inserted, with a different font color, as needed for the analysis.

In AI, counter-arguments at any of these levels are often conceptualized as attacks that can change the status of an argument. And such attacks have been differentiated by researchers based upon where the attack is attached, the nature of the attack, and its effect. These distinctions result in differing attack semantics [22] such as defeater, diminisher [37] [39], rebuttal, undercutting, undermining, refutation, and attack on an attack. Walton suggests that "such terms are fundamental to argumentation theory and to attempts recently made in artificial intelligence to build an argumentation technology [65, p. 1]." And Walton has attempted to make sense of the "confusion about these terms, and considerable ambiguity and variety of loose usage. [65 p. 1]" The DCIT argument framework provides another perspective on making sense of such terms.

Dung theorizes single attacks as part of an argumentation framework with a bivalent conflict-based attack relation [12]. Such an argumentation framework has been extended to included attacks on attacks with an *Extended Argumentation Framework* [49]. A DCIT argumentation framework, as shown in Figure 25, contemplates the possibility of a continuous attacking exchange. Status changes are not, however, measured on individual arguments. Rather, as in court, the DCIT argumentation framework determines the change in the status of the complete inferential network as measured by the perceived changes in probative force that finally reaches the predicate of the ultimate probandum.

Within the DCIT structure, there are four possible moves that can change the perception of the level of probative force that reaches the final predicate of the ultimate probandum. The **(1)** first move is an attack that diverts the level of probative force reaching the final predicate. This can be done in three ways: (a) connecting an alternative predicate at a nexus of predication (see Figure 20) that intersects to provide an alternative inference path; (b) connecting a complete objecting proposition to a predicate (see Figure 21); or, (c) connecting an alternative predicate directly into the Subject of the ultimate probandum at the start of the line of reasoning (see Figure 22).

Rather than attacking the opponent's line of reasoning, the remaining three moves that can shift probative force are attempts to maintain, restore, or increase the perceived level of probative force along one's own line of reasoning through enhancements. These moves include **(2)** adding supporting assumptions (see Figure 27), **(3)** bridging a perceived predication gap (see Figure 18), and **(4)** corroborating with a convergent line of reasoning (see Figure 23). Each of these moves can be triggered by a contention or inquiry about the lack of probative connection or decrease in probative force.

Hybrid Branching Tree-Like Argument Framework vs. DCIT Homogenous Modular Linear Path Argument Framework

The visualization of argument structures and frameworks is commonly presented as a branching tree-like structure [44]. For example, this format is typically used with argument visualization software tools such as Carneades, Arcauria, and Rationale. This tree-like structure is not, however, a recent innovation. Its use originates at least as early as Whately, the English Logician, in 1826 [68, p. 253], [64, p. 263] (see Figure 30).

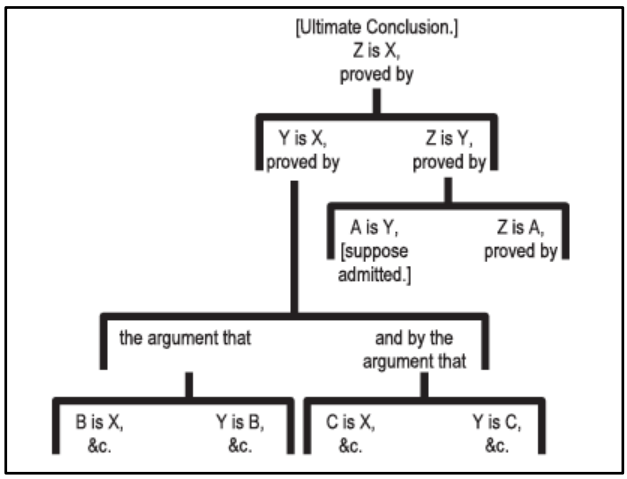

Figure 30. Whately tree-like argument map (current replication).

There are a number of problems, however, inherent with a tree-like argument structure. A fundamental one is that it obscures the order in which one premise depends on another premise in the logical chain of inference. For example, it is not readily apparent whether the premise "Z is A" or "Y is X" is first in line in the inference chain (see Figure 31).

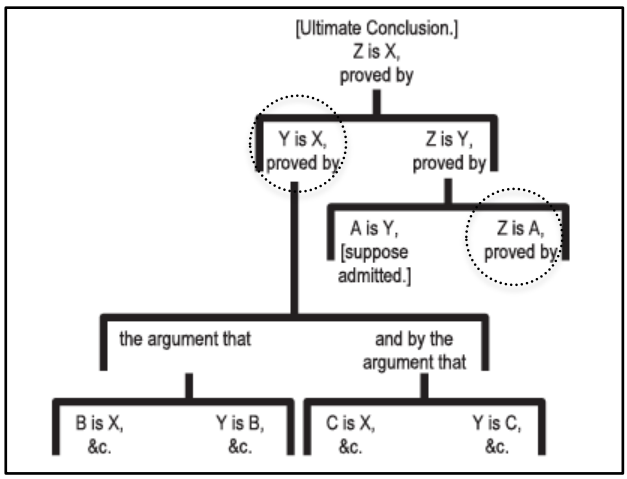

Figure 31. Whately tree-like argument map with Z is A comparison.

Similarly, the logical hierarchy between “Y is B” and “C is X” is not obvious with a tree-like structure (see Figure 32).

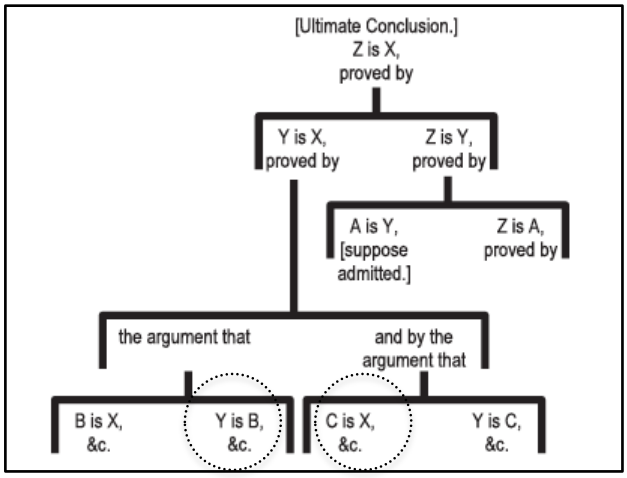

Figure 32. Whately tree-like argument map with Y is B comparison.

Such premise-order obscurity presents at least two difficulties. First, if a premise is judged as false, it would not be apparent which of the remaining premises that comprise the argument tree depend on that false premise. This determination is important since any such logical dependency would require that those dependent premises be pruned from the argument tree as well.

Second, an assessment of probative force at the juncture of a premise within an inferential network is dependent on the level of probative force that reaches that premise through earlier links in the chain of evidence. Without knowing the logical hierarchy of the linked premises, such evaluation of probative force is not possible. This assessment is important, for example, for balancing probative weight with undue prejudice (Fed. R. Evid. 403).

Figure 33 illustrates the implicit logical order contained within the Whately tree-like structure.

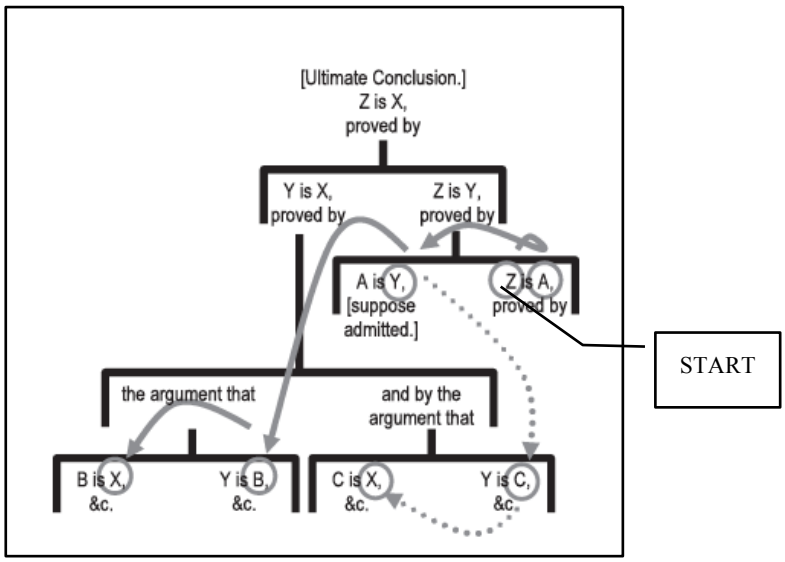

Figure 33. Whately tree-like argument map with logical order.

Another weakness of a tree-like argument structure is that it does not make readily apparent the precise number of inference steps that are contained within the argument structure. In practice, this number can be an important factor in determining whether there is an insufficiency of evidence because of a stacking or piling inference upon inference. “[A]t some point along a rational continuum, inferences may become so attenuated from underlying

evidence as to cast doubt on the trier of fact's ultimate conclusion. In other words, 'the chance of error or speculation increases in proportion to the width of the gap between underlying fact and ultimate conclusion where the gap is bridged by a succession of inferences, each based upon the preceding one.'" *United States v. Shahane*, 517 F.2d 1173, 1178 (8th Cir. 1975).

The U.S. Supreme Court has discussed the risks of reaching a conclusion based on piling inference upon inference. In *Lopez v. Gonzales*, 594 U.S. 47 (2006), the issue was whether the Gun-Free School Zone Act was within the scope of the Commerce Clause. Justice Rhenquist stated that "[t]o uphold the Government's contentions here, we have to pile inference upon inference in a manner that would bid fair to convert congressional authority under the Commerce Clause to a general police power of the sort retained by the States." Portions of the dissent of Justice Breyer, configured in a DCIT argument structure, illustrate the possible height of such a pile (see Figure 34).

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The Gun-Free School Zone Act** …	…forbids knowingly possessing a firearm knowingly in a school zone.
2	Any such that…	...forbids knowingly possessing a firearm knowingly in a school zone...	…will reduce the number of firearms carried to school by students.
3	Any such that…	…will reduce the number of firearms carried to school by students...	…will reduce the amount of gun-related violence in schools.
4	Any such that…	…will reduce the amount of gun-related violence in schools...	…will reduce the number of dropouts and victims of gun-related violence who typically have suffered academically.
5	Any such that…	…will reduce the number of dropouts and victims of gun-related violence who typically have suffered academically...	…will improve the quality of education in schools.
6	Any such that…	…will improve the quality of education in schools...	…will improve the functional and technological literacy of students.
7	Any such that…	…will improve the functional and technological literacy of students...	…will improve the functional and technological literacy of workers.
8	Any such that…	…will improve the functional and technological literacy of workers...	…will improve the business competitiveness of employers in interstate and foreign commerce.
9	Any such that…	…will improve the business competitiveness of employers in interstate and foreign commerce...	…**falls within the scope of the Commerce Clause.**
CONCLUSION			
		The Gun-Free School Zone Act …	…**falls within the scope of the Commerce Clause.**
ASSUMPTIONS TO LINKED PREMISES			
#	NOT INDICATED		

Figure 34. DCIT argument template *Lopez* dissent.

Figure 35 makes the number of inference steps apparent in the Whately argument (Figure 30) using DCIT. It also reveals that an inference step can be conceptualized as a process of substitution as the Subject of the ultimate probandum moves through transitive relationships to finally connect with the Complex Predicate of the ultimate probandum.

Based on this unraveling of the logical chain, a DCIT linear path alternative structure resolves the previously described difficulties as illustrated by the DCIT reconstruction of the Whately argument (see Figure 35).

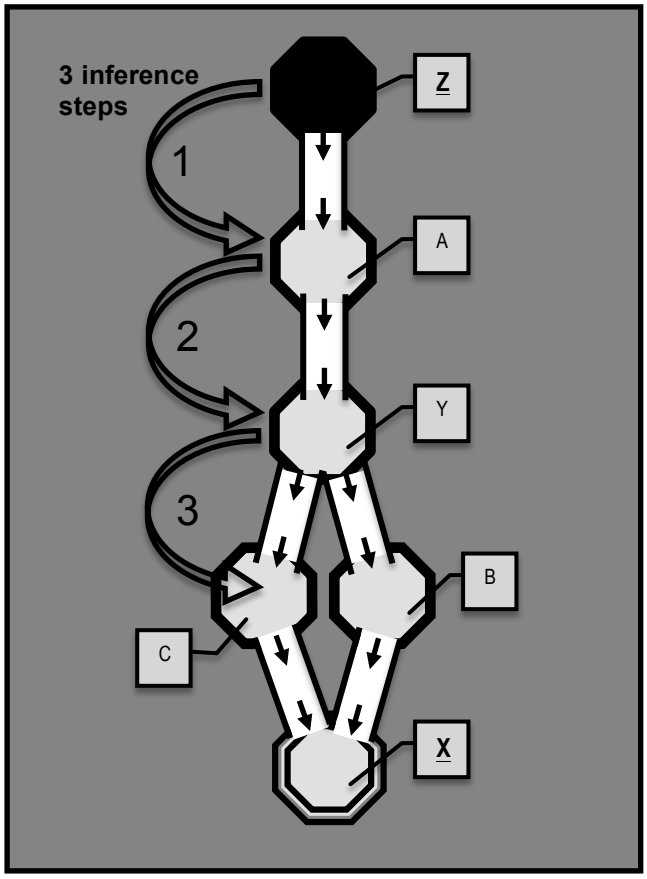

Figure 35. DCIT predicate dots argument map Whately.

Another fundamental challenge that can arise with a tree-like structure is that it is typically constructed with an "open architecture for integrating multiple forms of reasoning. [23]" This hybrid nature occurs from the grafting of different types of logical forms onto the same inferential tree-like network. For example, within Carneades, as a common argument structure, argument schemes are used as part of arguments "constructed from multiple, hybrid models. [20]" While logical connections at the juncture can easily be represented as a line intersecting with a new node within a visual argument graph, in practice such linkage clarity is more difficult to make apparent when translated into natural language.

This potential obscurity can occur because many logical forms, such as typically applied to argument schemes, do not have a required premise order or intra-premise sentence structure. The lack of such a prescribed rigor can result in the linkage of the final premise of one grafted logical form not being readily apparent as it joins with the next premise in the following argument form that together comprise part of the inferential tree.

A DCIT argument structure provides an alternate solution. Rather than attempting to bind multiple logical forms into a single argument structure [20] (e.g., Carneades), DCIT provides the scaffolding to regiment each of the multiple logical forms into a single common logical form integrated into a homogenous, rather than a hybrid, reasoning structure.

For example, DCIT functions well with integrating Argument Schemes. Argument schemes can be classified as defeasible inference rules with associated assumptions [66]. They can also be viewed as generalized conditional premises [42]. "Argument schemes are not classified according to their logical form but according to their content. [7]" So they can be used in different forms [66].

An argument framework or structure using Argument Schemes without a rigorous logical form such as provided by DCIT, however, presents difficulties in actual litigation. For example, simply arguing that evidence is relevant because its premise statement is joined to the ultimate probandum (e.g., verdict) by premises that are self-described as "inference rules" or "warrants (Toulmin) can lack sufficient concreteness. And the use of nodes and edges, or boxes and lines is simply an unsubstantiated claim that a logical connection exists. In litigation, the court needs to actually perceive how the premises logically connect in natural language.

As one solution, hybrid approaches often rely on defeasible *modus ponens* [67] or bridging rules [10], [19] to connect different logical forms into a single argument framework. But the logical form of defeasible *modus ponens* can be unpersuasive to use in the courtroom.[3] The reason is that an argument in a defeasible *modus ponens* logical form relies upon a conditional, of whatever type [67], rather than a generalization. The conditional simply mechanically joins the factual premise and the conclusion by combining them as the antecedent and the consequent of the conditional. This implication requires acceptance with no new explicit or implicit evidence. And implicit in such a conditional is likely a generalization that needs to be made explicit. To the contrary, an inference step through the use of a categorically-related generalization permits probative weight to proceed based on explicit evidence or the factfinder's worldview and life experience.

The underlying DCIT argument construction process of attempting to "connect the predicate dots" is also fundamentally different than that used for a tree-like approach. The impact of this distinction is, perhaps, most pronounced when developing a factual argument such as whether the defendant is guilty. A DCIT approach begins with the visual depiction that the truth of the ultimate probandum is unknown at the start of the investigatory process. This is reflected in the physical separation of its subject and predicate at the opposite ends of the reasoning path. Then, like the construction of a temporal storyboard, the stepping stones (i.e., predicate dots) are placed between the two ends of the reasoning path until the gap between each stone can be crossed with, hopefully, reasonable inference steps such that no overly long leaps are required.

This DCIT structure also permits continual changes in the order of the stepping stones throughout the construction process. And it permits the placement of the stepping stones to proceed from either end or any place in the middle of the reasoning path. Further, this logical reasoning construction process and design may provide a natural linkage to the story-model approach. The temporal nature of a story is reflected in the ordering of the stepping stones or predicate dots. Figure 36 is a sample blank template used for building this stepping stone reasoning path.

[3] The O. J. Simpson MP argument is a noted exception: If the glove does not fit, then you must acquit. The glove does not fit. So you must acquit.

DCIT LINKED PREMISES			SUPPORTING ASSUMPTIONS
#	COMPLEX SUBJECT	COMPLEX PREDICATE	(necessary and ancillary)
1	→		a. b. c. d.
2	Any such (that)…	[REPETITION OF PREVIOUS PREDICATE...]	a. b. c. d.
3	Any such (that)…	[REPETITION OF PREVIOUS PREDICATE...]	a. b. c. d.
4	Any such (that)…	[REPETITION OF PREVIOUS PREDICATE...]	a. b. c. d.
5	Any such (that)…	[REPETITION OF PREVIOUS PREDICATE...]	a. b. c. d.
6	Any such (that)…	[REPETITION OF PREVIOUS PREDICATE...]	a. b. c. d.
CONCLUSION			

Figure 36. DCIT argument two-level template blank.

By comparison, a tree-like approach starts with the visual depiction that the ultimate probandum is a correct proposition. There is no gap or uncertainty depicted. And then, with a process and within a structure that provide no obvious temporal congruence, a search for supporting premises is made that can only branch out from a single root as the starting point with no clear depiction of where the branching may end. There is no Start and Finish. Such an approach lacks a connection with a story-model and provides no apparent embodied metaphoric engagement for the audience so that the meaning of its visual grammar is obvious for the uninitiated.

PIERSON v. POST

In AI (& Law), one means of demonstrating different argumentation frameworks and computational models is to illustrate them with legal cases. For example, *Pierson v. Post*, 3 Cai. R. 175 (N.Y. 1805) has been commonly used as a standard example [21], [5], [6], [8]. The issue in this case is "[w]hether a person who, with his own hounds, starts and hunts a fox on waste and uninhabited ground, and is on the point of seizing his prey, acquires such an interest in the animal as to have a right of action against another, who in view of the huntsman and his dogs in full pursuit, and with knowledge of the chase, shall kill and carry him away." (The text of the opinion can be found on the web at http://www.facstaff.bucknell.edu/kinnaman/Pierson%20v.htm.) The following DCIT templates illustrate one interpretation of a portion of the dissenting reasoning in *Post* that has been regimented into the DCIT canonical form. Implicit linking premises were added (see Figures 37 and 38).

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The fox**…	…is a noxious animal according to the admissions in the pleading
2	Any such that…	…is a noxious animal according to the admissions in the pleadings…	…is a noxious animal.
3	Any such that…	…is a noxious animal…	..should have the act of their being hunted encouraged to promote the important social value of protecting farmers.
4	Any such that…	..should have the act of their being hunted encouraged to promote the important social value of protecting farmers…	...should have the act of their being chased by large hounds encouraged to promote the important social value of protecting farmers.
5	Any such that…	...should have the act of their being chased by large hounds encouraged to promote the important social value of protecting farmers…	..**shall be deemed mortally wounded**.
CONCLUSION			
		The fox…	..**shall be deemed mortally wounded.**
ASSUMPTIONS TO LINKED PREMISES			
5	The noxious animal was actually being chased by hounds.		

Figure 37. DCIT argument template *Pierson v. Post* 1.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**The fox**…	…is a "wild and noxious beast," hostile to humans, that harms the work of farmers.
2	Any such that…	…is a "wild and noxious beast," hostile to humans, that harms the work of farmers...	…is a "wild and noxious beast," whose killing wherever found is meritorious and of public benefit.
3	Any such that…	…is a "wild and noxious beast," whose killing wherever found is meritorious and of public benefit...	… is a "wild and noxious beast:" that should have the act of destroying them encouraged.
4	Any such that…	… is a "wild and noxious beast:" that should have the act of destroying them encouraged...	…is a "wild and noxious beast" that pursuit like the present confers such a right to the object of it, as to make any one a wrong-doer who shall interfere and shoulder the spoil.
5	Any such that…	…is a "wild and noxious beast" that pursuit like the present confers such a right to the object of it, as to make any one a wrong-doer who shall interfere and shoulder the spoil...	…**shall be deemed to have been in the possession of Post who had a good claim of trespass.**
CONCLUSION			
		The fox…	…**shall be deemed to have been in the possession of Post who had a good claim of trespass.**
ASSUMPTIONS TO LINKED PREMISES			
	NOT INDICATED		

Figure 38. DCIT argument template *Pierson v. Post* 2.

POPOV v. HAYASHI

Popov v. Hayashi, 2002 WL 31833731 (Ca. Sup. Ct. 2002) is another case whose reasoning has been modeled to illustrate an argumentation framework [70], [71]. A portion of that reasoning is modeled here with a DCIT framework.

The main issue was whether Popov or Hayashi had an ownership interest in a baseball hit into the stands at the ballpark. While Popov momentarily touched the ball, it ended up in Hayashi's pocket (see Figures 39-41).

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**Hayashi**...	…discovered the loose baseball and put it in his pocket.
2	Any one that…	…discovered the loose baseball and put it in his pocket...	…acquired unequivocal dominion and control of the baseball.
3	Any one that…	…acquired unequivocal dominion and control of the baseball...	…assumed full possession of the baseball subject to the cloud of Papov's claim.
4	Any one that…	…assumed full possession of he baseball subject to the cloud of Papov's claim...	…had an equal undivided interest in the baseball with Papov.
5	Any one that…	…had an equal undivided interest in the baseball with Papov...	…**is entitled to share the proceeds of the sale equally with Papov.**
CONCLUSION			
		Hayashi...	…**is entitled to share the proceeds of the sale equally with Papov.**
ASSUMPTIONS TO LINKED PREMISES			
4	A1. That one was not a wrongdoer in acquiring possession of the ball. A2. Papov had a prior legitimate claim.		
5	A1. That one and Papov had a claim of equal dignity as to each other.		

Figure 39. DCIT argument template *Popvov v. Hayashi* 1.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**Popov**...	…had the hit ball momentarily touch his glove as he was falling before striking the ground as his attempted catch was interrupted by the unlawful acts of the crowd attacking him.
2	Any one that…	…had the hit ball momentarily touch his glove as he was falling before striking the ground as his attempted catch was interrupted by the unlawful acts of the crowd attacking him...	…undertook significant but incomplete steps to achieve possession of abandoned personal property that was interrupted by the unlawful acts of others.
3	Any one that…	…undertook significant but incomplete steps to achieve possession of abandoned personal property that was interrupted by the unlawful acts of others...	…has a legally cognizable pre-possessory interest in the property.
4	Any one that…	…has a legally cognizable pre-possessory interest in the property...	…**had a qualified right to possession which can support a cause of action for conversion.**
CONCLUSION			
		Popov...	…**had a qualified right to possession which can support a cause of action for conversion.**
ASSUMPTIONS TO LINKED PREMISES			
3	A1. That one is seeking an action in equity. (NECESSARY) A2. A court sitting in equity has the authority to fashion rules and remedies to achieve fundamental fairness. (NECESSARY)		

Figure 40. DCIT argument template *Popvov v. Hayashi* 2.

DCIT LINKED PREMISES			
#	COMPLEX SUBJECT		COMPLEX PREDICATE
1	→	**Popov**...	…had the hit ball momentarily touch his glove as he was falling before striking the ground as his attempted catch was interrupted by the unlawful acts of the crowd attacking him.
2	Any one that…	…had the hit ball momentarily touch his glove as he was falling before striking the ground as his attempted catch was interrupted by the unlawful acts of the crowd attacking him...	…did not acquire unequivocal dominion and control of an abandoned baseball hit into the stands of a stadium.
3	Any one that…	…did not acquire unequivocal dominion and control of an abandoned baseball hit into the stands of a stadium...	…did not acquire unequivocal dominion and control in a circumstance where it was physically possible and the custom and practice before claiming possession.
4	Any one that…	…did not acquire unequivocal dominion and control in a circumstance where it was physically possible and the custom and practice before claiming possession...	…did not acquire full possession according to the appropriate legal rule requiring such unequivocal domain and control.
5	Any one that…	…did not acquire full possession according to the appropriate legal rule requiring such unequivocal domain and control...	…did not acquire possession according to Gray's rule.
6	Any one that…	…did not acquire possession according to Gray's rule...	…did not establish by a preponderance of evidence that he would have retained control of the ball after all momentum ceased and after any incidental contact with people or objects.
7	Any one that…	…did not establish by a preponderance of evidence that he would have retained control of the ball after all momentum ceased and after any incidental contact with people or objects...	…**did not acquire full possession.**
CONCLUSION			
		Popov...	…**did not acquire full possession.**
ASSUMPTIONS TO LINKED PREMISES			
#	NOT INDICATED		

Figure 41. DCIT argument template *Popvov v. Hayashi* 3.

INTELLIGIBILITY & ACCEPTABILITY OF FORMAL ARGUMENT MODELS

The direction of AI & (Law) theoretical argument development appears to be one of increasing complexity in formal argument models, frameworks, and visual languages or conventions for argument diagramming. Yet, there can already be difficulty accepting the use of formalisms by users [50]. DCIT term logic, its argument framework, and visual language provide, it is suggested, an alternative path toward a more intelligible and acceptable model for end-users while maintaining the necessary level of rigor. Such a change in direction may be important.

Achieving a high degree of isomorphism between AI representation and legal decisions is already challenging. For one reason, logic and judicial reasoning are not always bedfellows. This has occurred for a number of reasons. For example, there has been a distrust of logic for judicial reasoning [25]. The formalist vs. instrumentalist (i.e, realist) debate is a reflection of some of that distrust [45]. Second, separating the *ratio decidendi* from the *dicta* can be enormously difficult [25]. And there is debate on even how to measure the quality of judicial reasoning [27].

Further, the practical use of increasingly complex formal models depends upon students, lawyers, and judges that are ready, able, and willing to embrace such constructions. Yet, law schools have been reluctant to embrace the science of proof as part of the curriculum [61]. And as Twining contends, "most literature of legal reasoning talks *about* it," rather than teaching how to master it [60].

This contention may have been one factor in the Carnegie Foundation Report, *Educating Lawyers,* advocating "that law professors should make explicit the analytical skills their students must learn. [54]" Perhaps, as a result of a lack of sufficient explicitness, some law students struggle [31], [16] with learning how to apply the ubiquitous IRAC (Issue, Rule, Application, Conclusion) method [51], and similar templates of legal reasoning and writing. And some "practitioners and judges continue to bewail the poor writing skills of new graduates and excoriate law schools for ineffective teaching. [1]"

The challenge in teaching logical reasoning is not tied to only law schools. In undergraduate schools, this challenge helped prompt increased development of informal logic in the 1970's [29], [30]. But the evidence of substantial improvement in critical thinking skills from such classes has been inconclusive [34]. This struggle may result from the student's lack of understanding of the underlying formal models of reasoning that support such tools. It is suggested that rough reasoning heuristics such as IRAC and the "Rabbit / Holding Hands principles [47]" are not sufficient replacements for such an understanding.

One possible exception has been argumentation classes using argument diagramming software (e.g., Reason!Able and Rationale). The visual language of the argument diagramming or mapping provides helpful scaffolding for constructing inferential networks [26], [63]. Yet, even with such scaffolding, students can struggle to properly fill in the boxes of premise and co-premises or differentiate between convergent and linked lines of reasoning [58].

A hypothetical court application of such argument visualization was examined by van Driel and Prakken [62]. The specific context was expert witness testimony. Their motivation was that "judges often find it hard to understand the expert reports and to ask the proper questions to the expert. [62]" (Such difficulty in understanding is indicative of the challenge in court of making reasoning clear even by expert witnesses.) So the authors conducted a case study. They interpreted the reasoning contained within an expert witness report and designed a Rationale software tree-like structure argument diagram. They then asked a legal expert with the Dutch Council of the Judiciary to speculate on its possible courtroom efficacy in advocating to a judge.

One conclusion of the legal expert was that Argument Visualization Software (AVS) "is likely more useful in training of judges and education of law students than in legal practice. [62]" Further, the legal expert stated that "[o]nce judges have become aware of the potential sources of doubt in argumentation, they can develop a critical attitude towards expert reports without the need to visualize them with an AVS. [62]" My own litigation experience with argument visualization suggests that the nature of underlying argument model(s) inherent in the visualization is a critical factor is determining the amount of help such visualization can provide to the court

As in the Dutch Council case study, increasing the clarity of expert witness reports was also my primary motivation to investigate the efficacy of argument diagramming in court. Since 1975, my litigation practice has almost entirely involved trials and appeals that required a court's analysis of expert witness reports. Over the

years, I noticed that I often needed to improve the clarity of my expert's reasoning in closing arguments at trial and in appellate briefs to optimize the effectiveness of their testimony and reports. While leaving some premises implicit occurs with adversarial arguments in court [3], judges can be reluctant, however, to allow attorneys to later fill in such gaps in reasoning left by an expert witness. *Chesterfield Assoc. v. Edison Township,* 13 N.J. Tax (1993).

In *Chesterfield*, a property tax case, the issue was the market value of residential townhouses. The real property appraisal method used was the Comparable Sales approach. This method relies upon Argument by Analogy in which the subject property is compared to sold properties that are sufficiently similar. Adjustments are made to the sales prices to account for relevant differences between the comparable properties and the subject property.

The comparable sales were 95 townhouses for which the appraisers for the taxpayer and the county stipulated to sales prices. Both appraisers then made adjustments to these sales prices to reflect differences between the comparable sold properties and the subject properties.

"The second adjustment which plaintiff's expert deemed appropriate was a 15% reduction in the stipulated sales comparison approach values to account for the occupancy of the townhouses by tenants. Plaintiff's expert did not explain the basis for this adjustment other than to state that '[t]he sales were adjusted downward because the subject units were occupied by tenants on the date of valuation.'" *Chesterfield* at 204. As the court observed, plaintiff's counsel, in an effort to fill this inference gap left by the expert's lack of explanation, sought "to support its expert's adjustment through its legal memorandum." *Chesterfield* at 204. But, the court found that "the alleged support [in the legal memorandum] is all supposition and speculation. There is nothing in the record to justify an adjustment for tenant occupancy much less one of the magnitude of 15%." *Chesterfield* at 204. An attorney's supposition and speculation in a brief can't close the gap in the reasoning left by an expert witness. Figure 42 depicts the reasoning of the plaintiff's expert with the addition of some of the necessary assumptions for Argument by Analogy.

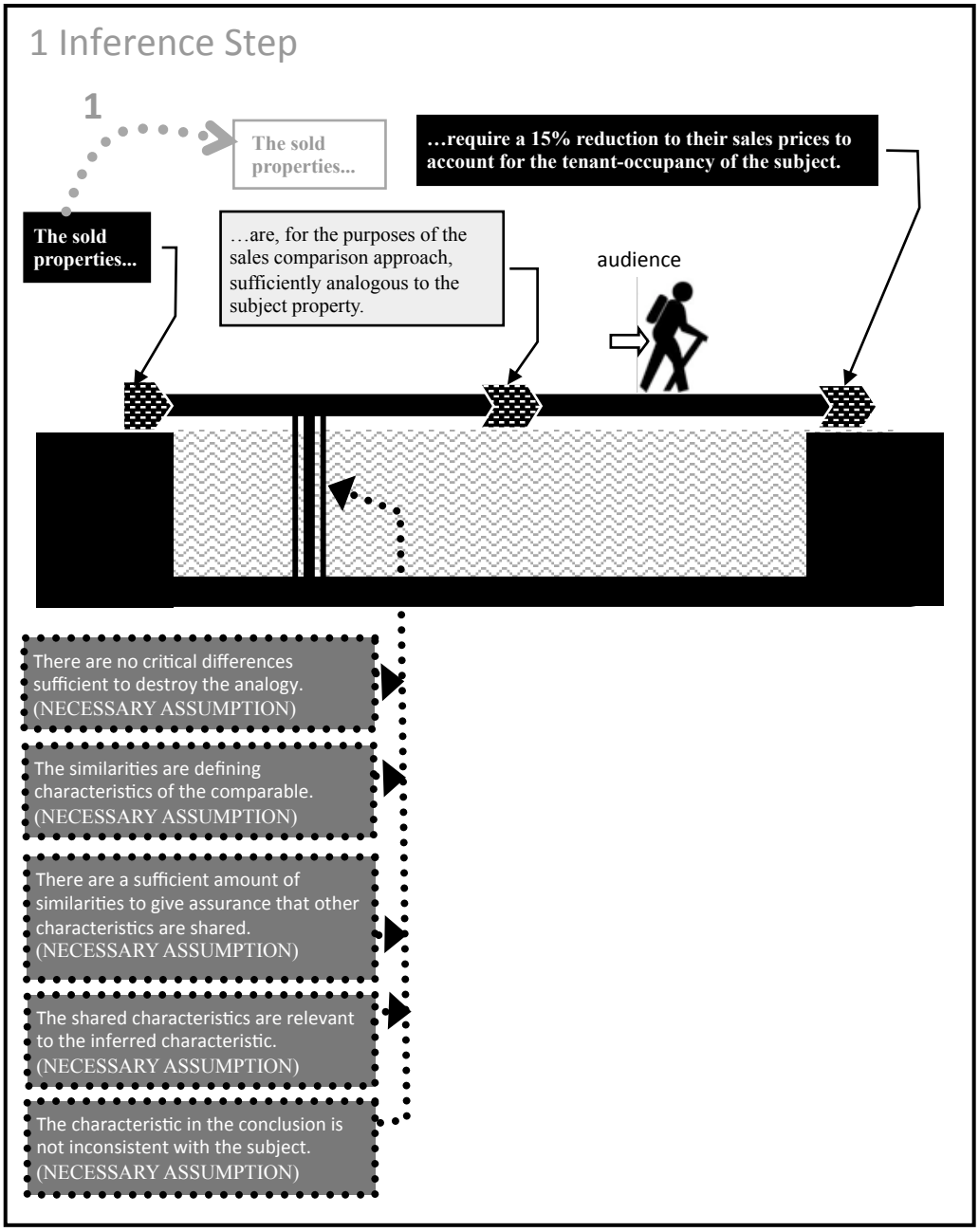

Figure 42. DCIT argument-bridge diagram *Chesterfield* expert witness testimony (added analogy assumptions).

And Figure 43 depicts the court's perspective of the expert's reasoning given the lack of evidence for one of the unspoken necessary assumptions.

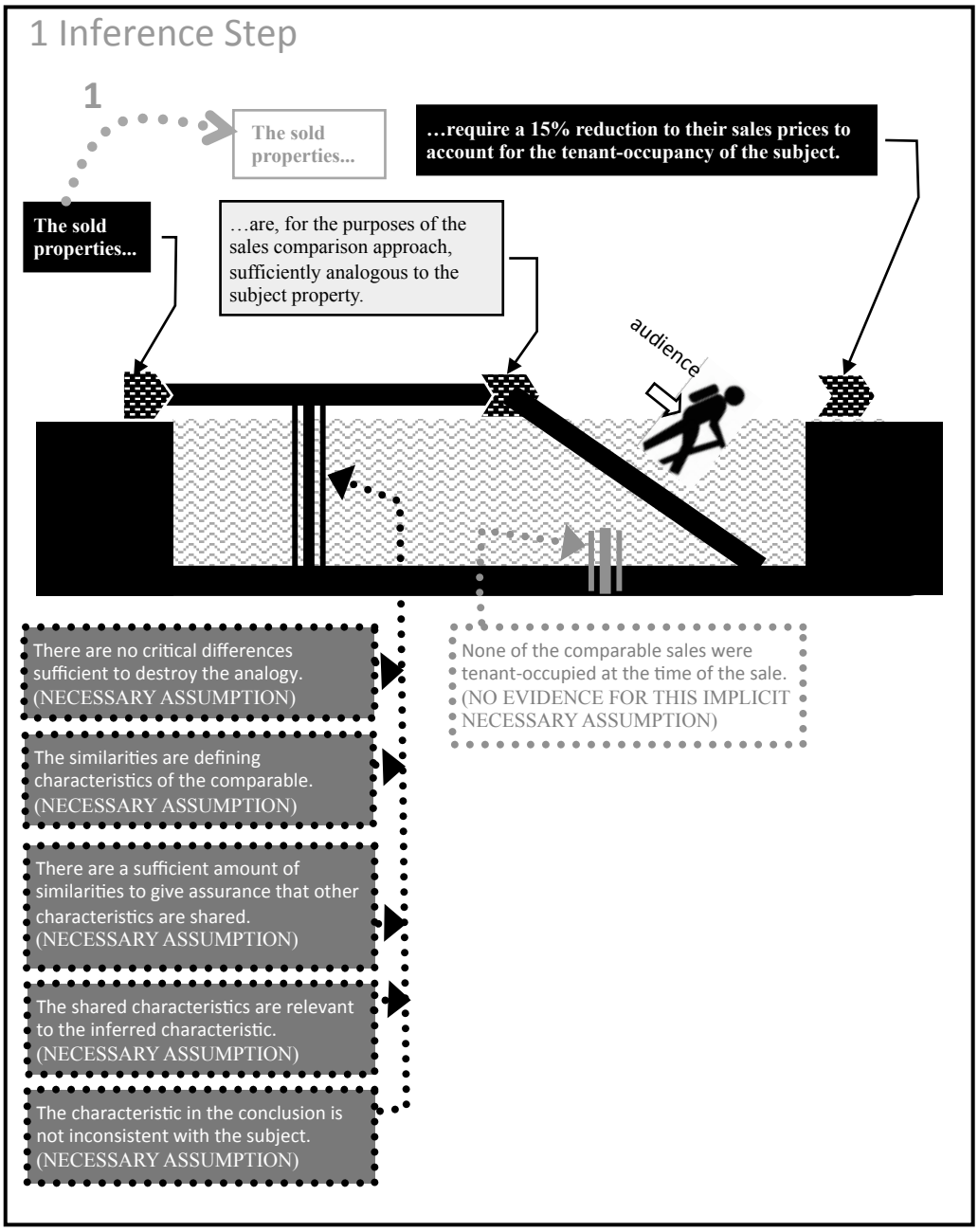

Figure 43. DCIT argument-bridge diagram *Chesterfield* court's perspective of expert's reasoning.

In an effort to get to the root of this expert witness reasoning clarity problem, starting in 2001 with the collegial support of Tim van Gelder, I began conducting ongoing argument visualization training seminars for Oregon expert witnesses using Reason!Able argument mapping software. In concert with this expert-witness training, I began using tree-like argument diagramming in trials and subsequent appeals for selected portions of the expert's reasoning and my own legal arguments. Finally, I further explored the efficacy of argument mapping by teaching "Advanced Argumentation" to law school students at Lewis & Clark Law School using Reason!Able as the chief pedagogical tool. I was then able to informally compare these students' argumentation comprehension with those I had previously observed in law students while teaching "Legal Research & Writing" at Willamette University Law School using only conventional methods.

The efficacy of typical argument visualization in teaching and litigating was apparent to me. But the concomitant demands were substantial. Fruitful typical argument visualization training required "lots of argument practice" (L.A.M.P) [47] by the expert witnesses and law students that was not always possible. And since clear mapping always depends upon clear reasoning, it was no substitute for a lack of understanding rigorous reasoning.

In court, while there were important instances when the judges found the typical argument mapping helpful, there were also severe limitations. It was necessary to explain the visual grammar on the spot. The visual distinction between premises and underlying assumptions was awkward. And the complex divergent branching and unnecessary sub-conclusions limited its applicability. I needed a better alternative to conventional hybrid tree-like argument visualization.

So while continuing to use traditional argument visualization in class and court during the next five years, I searched for a better solution. After constructing hundreds of arguments diagrams for class and court over these years, I slowly began to observe that a single logical argument pattern was uniformly extractable. This discovery process appears to have similarities to one experienced by Walton. He spent years finding and analyzing arguments in his classes. "Eventually the wealth of experience that came from studying these examples led to the formulation of argument schemes, forms used to represent the basic structure of each type of argument. [66]"

My own argument mapping experience lead me to the conclusion that each of those argument schemes can be structured within a single natural language intuitive logical form. Starting from this DCIT pattern, I was then able to reverse engineer it to eventually locate its roots in term logic and develop the necessary extensions to the term calculus for its theoretical justification. Finally, in 2006, I submitted my first-generation DCIT argument maps and templates as trial exhibits and illustrations in briefs (see Figures 44, 45, and 46).

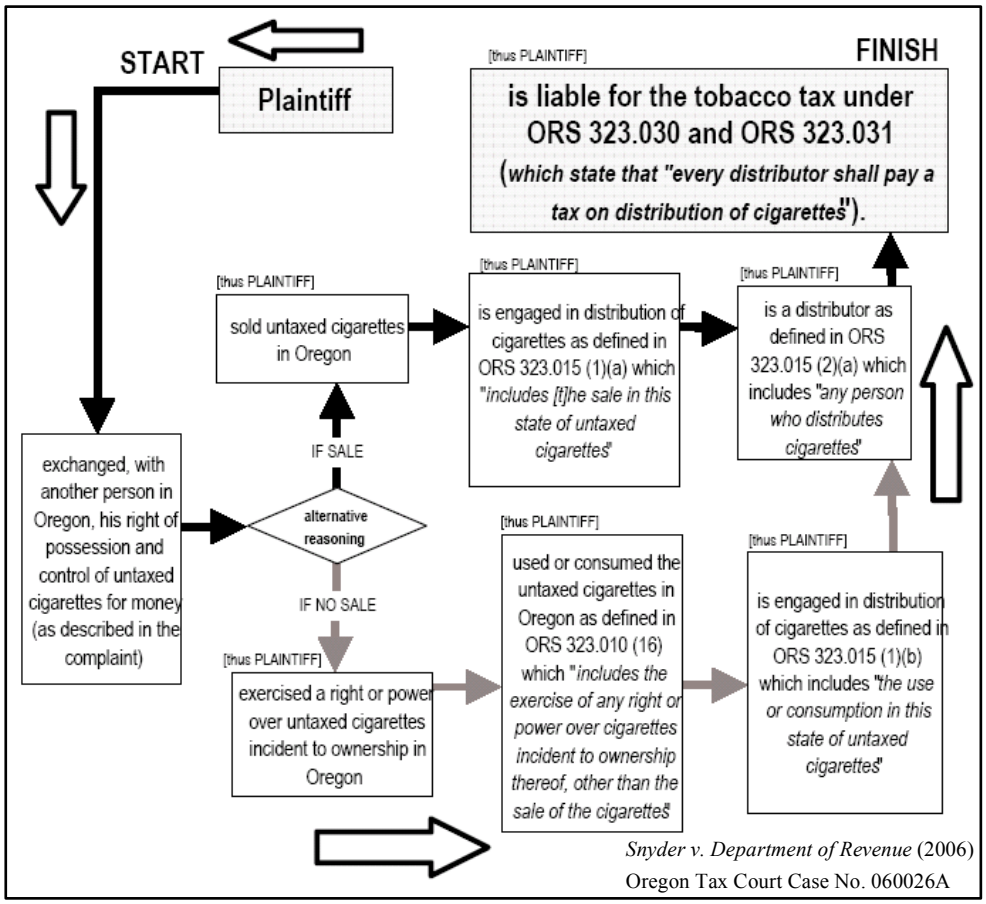

Figure 44. DCIT first-generation argument map *Snyder v. Department of Revenue.*

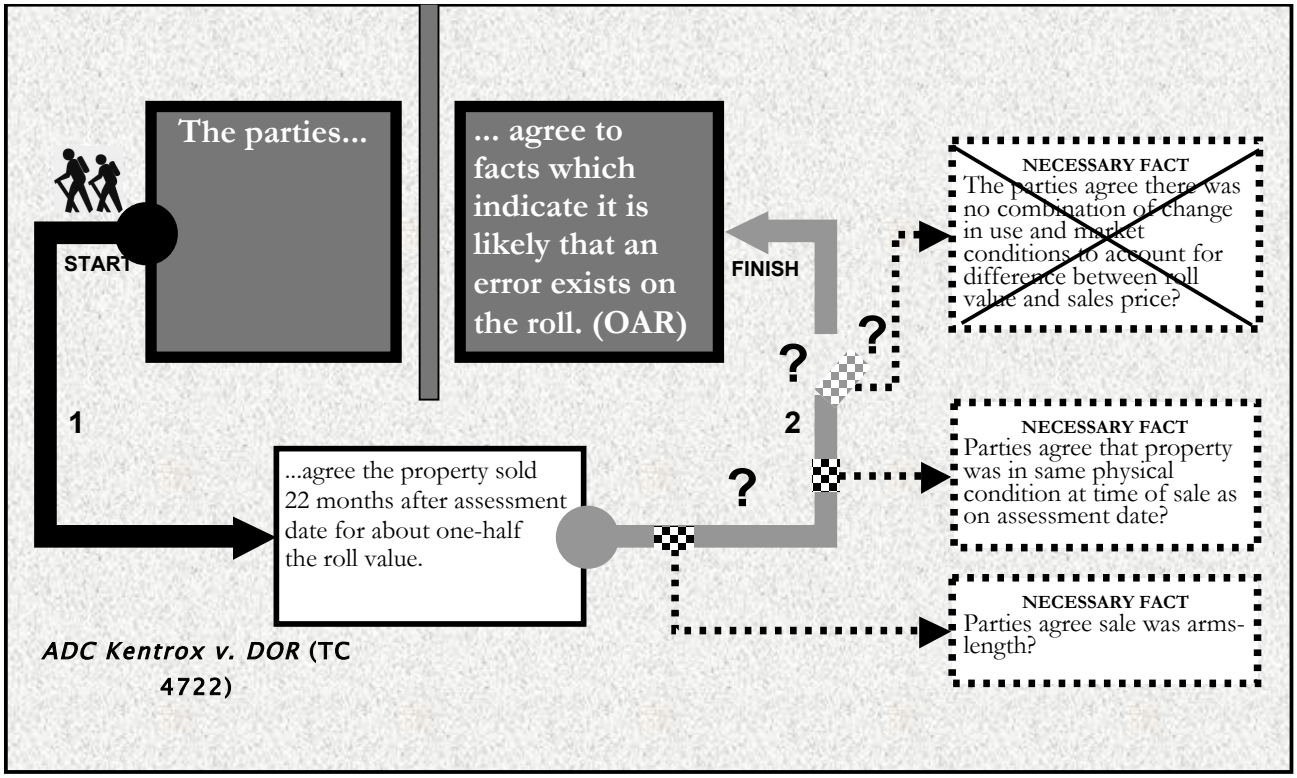

Figure 45. DCIT first-generation argument-bridge diagram *ADC Kentrox v. Department of Revenue.*

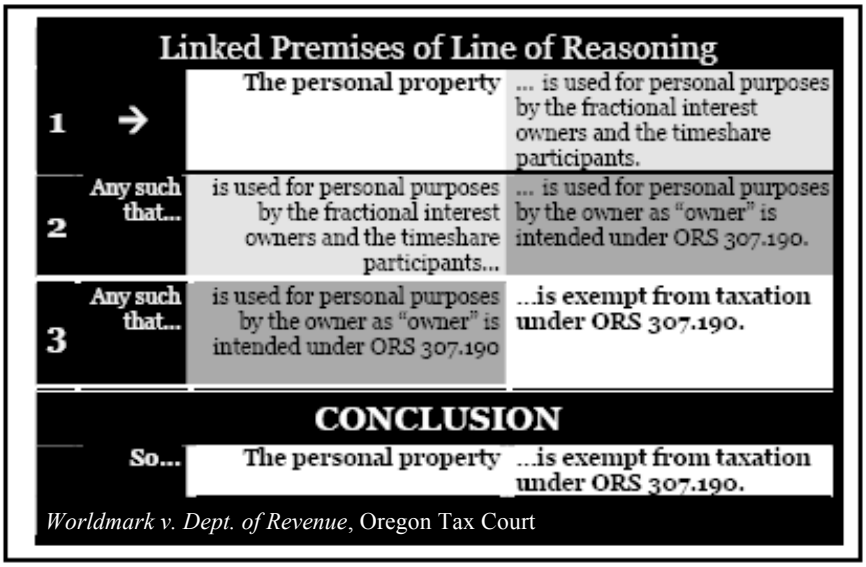

Figure 46. DCIT first-generation template *Worldmark v. Department of Revenue.*

Anecdotally, the advantages in class and court of DCIT became readily apparent. With a fail-safe generalizable template of structurally correct defeasible logical reasoning, clearer reasoning became more likely; was reached sooner; and, was easier to explain. The split attention and focus of the court between acceptability of the premises and acceptability of the reasoning pattern was replaced by a singular examination of the truth of the premises. For the last five years, I have continued expanding the use and applicability of DCIT argument structuring in litigation both in formulating lines of reasoning and portraying them as visual argument diagrams in court.

CONCLUSION

This paper has examined the extent of universal applicability in court of a single DCIT argument form. It has done this through demonstrating its application to case examples and dialogic processes common in litigation. The new possibility of such universal applicability points in a direction opposite to the increasing complexity of recent developments in evidential inference scholarship. And it touches on the ancient question of whether logic can be connected to the laws of thought as believed by the Scholastics [14]. Given the defeasible and subjective nature of much practical reasoning and the power of a story narrative to persuade, perhaps, the topics of psychologism or "cognitive logic" are worth re-exploring further [18].

For practical courtroom advocacy, however, the distinction between how we actually arrive at conclusions and how to lead the factfinder to our conclusion is important. This is the distinction, as described by Philipps and Sartor, "between the 'context of discovery' and the 'context of justification', i.e. between the way in which a legal solution is found, and the way in which it is supported by giving appropriate reasons. [67]" As Tillers suggests, "[e]ffective pretrial investigation requires not only imagination, but also careful marshaling of evidence and careful organization of thinking about evidence. It frequently requires the application of a variety of distinct marshaling and analytical methods... [57]" Like an explorer through a mountain range, in this early stage we must pursue many dead ends, make risky leaps, and endure the frustration of uncertainty in our quest. But, in the courtroom we are guides, not explorers.

Our job when advocating is to lead the factfinder to our conclusion along a subjectively perceived safe, clear, and measured reasoning path upon which the factfinder is ready, able, and willing to travel. How we first reached the destination of the ultimate probandum through our exploration is likely not the soundest path to comfortably escort the factfinder to that location.

The factfinder must weigh the likelihood of reaching our destination against a standard of proof and against the likelihood that the evidence leads to a different conclusion proposed by the opposing party. So the surer the footing and the easier the travel, the more likely the factfinder will stick with us to the end. This paper suggests that predicate stepping stones placed within a DCIT configuration and appropriately supported by ancillary and necessary assumptions provide an effective generalizable means for leading the factfinder to one's ultimate probandum.

ACKNOWLEDGMENTS

I gratefully acknowledge the years of collegial support in conventional tree-like argument mapping by Tim van Gelder during my association with Austhink. His passion and commitment to consider and pursue new argumentation pedagogy in a successful effort to produce substantial measurable gains in critical thinking skills has been inspirational to me for my own work in court with DCIT. I am also grateful for the years of encouragement of Peter Tillers. And while the merit of Peter Tillers' substantial academic publications is readily acknowledged, I have also greatly benefited from his years of blogging on evidentiary inference. I also want to express my appreciation for this workshop opportunity to my fellow AI & Evidential Inference panelists: Ronald J. Allen, Rainhard Bengez, Floris Bex, Scott Brewer, James Franklin, David Hamer, Bruce Hay, D. Michael Risinger, Michael Pardo, Federico Picinali, Henry Prakken, Boaz Sangero, Giovanni Sartor, Peter Tillers, Bart Verheij, and Douglas Walton. Finally, I wish to gratefully acknowledge Sharone Lee for our years of ongoing discussions on the placement and utility of fact-based inquiry within the dimensional structures of knowledge.

DISCLAIMER

Any views and opinions expressed herein reflect only the author's and do not necessarily reflect those of the Oregon Department of Justice or any other of the author's affiliations.

REFERENCES

[1] Abner, E. & Kierstead, S. A. (2010). Preliminary Exploration of the Elements of Expert Performance in Legal Writing, *16 Leg. Writing* 363.

[2] Allen R. J. & Pardo, M. S. (2003). The Myth of the Law-Fact Distinction, *97 NW. U. L. Rev.* 1769.

[3] Angelelli, I. (2004). Predication theory: classical vs modern. In *Relations and Predicates*, H. Hochberg and K. Mulligan, eds, 55–80. Ontos.

[4] Aristotle. Categoriae. In *Aristotelis Categoriae et liber de interpretatione*, L. Minio-Palueelo ed. 1949.

[5] Atkinson, K., Bench-Capon, T. and McBurney, P. (2005). Arguing about cases as practical reasoning. In Proceedings of the 10th International Conference on Artificial Intelligence and Law, 35–44, Bologna, Italy.

[6] Bench-Capon, T. (September 2002). The missing link revisited: The role of teleology in representing legal argument. 10 (1-3) *Artificial Intelligence and Law*, 79–94.

[7] Bench-Capon, T., Prakken, H. and Sartor, G. (2009). Argumentation in legal reasoning. In Argumentation in artificial intelligence, ed. Iyad Rahwan and Guillermo R. Simari, 363-382. Dordrecht: Springer.

[8] Bench-Capon, T.J.M. (2010). Representing Popov V. Hayashi with Dimensions and Factors. *Artificial Intelligence and Law*, to appear.

[9] Bex, F.J., van Koppen, P.J., Prakken, H. & Verheij, B. (2010). A Hybrid Formal Theory of Arguments, Stories and Criminal Evidence. 18 (2) *Artificial Intelligence and Law*, 123-152.

[10] Costantini, S. "Meta-reasoning: A survey," in *Computational Logic: Logic Programming and Beyond*, ser. Lecture Notes in Computer Science, A. Kakas and F. Sadri, Eds. Berlin, Heidelberg: Springer Berlin / Heidelberg, Jul. 2002, vol. 2408, ch. 11, 65.

[11] Debowska, K., Lozinski, P. & Reed, C. (2009). "Building Bridges between Everyday Argument and Formal Representations of Reasoning", 16 (29) *Studies in Logic, Grammar and Rhetoric*, 95-135.

[12] Dung, P. (1995). On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming, and n–person games, 77 *Artificial Intelligence,* 321–357.

[13] Englebretsen, G. (1981). *Three Logicians: Aristotle, Leibniz, and Sommers and The Syllogistic*. Van Gorcum & Company.

[14] Englebretsen, G. (1996). *Something to reckon with: The logic of terms.* University of Ottawa Press.

[15] Englebretsen, G. (1998). *Line Diagrams for Logic: Drawing Conclusions*. The Edwin Mellen Press.

[16] Felsenburg, Miriam E. and Graham, Laura P. (2010). Beginning legal writers in their own words: Why the first weeks of legal writing are so tough and what we can do about it. *16 J. Legal Writing Inst.* 223.

[17] G. Lakoff and Johnson, M. (1999). *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. Basic Books.

[18] Gabbay, D. M. and Woods, J. (2008). Resource origins of non-monotonicity. 88 (1) *Studia Logica*, 85–112.

[19] Gordon, T. F. and Walton, D. (2009). Legal reasoning and argument schemes. Thomas F. Gordon and Douglas Walton, Presentation at the Twelfth International Conference on AI and Law, Barcelona, Spain, June 10, 2009. Retrieved from http://www.dougwalton.ca/talks/09GordonWaltonICAIL.pdf.

[20] Gordon, T. F. and Walton, D. (2009). Legal Reasoning with Argumentation Schemes 12th International Conference on Artificial Intelligence and Law, ed. Carole D. Hafner, New York, Association for Computing Machinery, 2009, 137-146.

[21] Gordon, T. F. and Walton, D. (2006). Pierson vs. post revisited – a reconstruction using the carneades argumentation framework. In Paul E. Dunne and Trevor J. M. Bench-Capon, editors, *COMMA*, volume 144 of *Frontiers in Artificial Intelligence and Applications*, 208–219. IOS Press.

[22] Gordon, T. F. (2008). Constructing legal arguments with rules in the legal knowledge interchange format (lkif). In P. Casanovas, G. Sartor, N. Casellas, and R. Rubino, editors, Computable Models of the Law, Languages, Dialogues, Games, Ontologies, volume 4884 of Lecture Notes in Computer Science, 162–184. Springer.

[23] Gordon, T. F. (2008). Hybrid reasoning with argumentation schemes. In Proceedings of the 8th Workshop on Computational Models of Natural Argument (CMNA 08), 16–25, Patras, Greece. The 18th European Conference on Artificial Intelligence.

[24] Gordon, T., Prakken, H., and Walton, D. (2007). The Carneades model of argument and burden of proof, 171 *Artificial Intelligence* 875–896.

[25] Halper, T. (1968-1969). Logic in Judicial Reasoning. 44 *Ind. L.J.* 33.

[26] Harrell, M. (2005a). Using Argument Diagramming Software in the Classroom. 28 (2) *Teaching Philosophy,* 163-177.

[27] Henry, R. (2008-2009). Do Judges Think - Comments on Several Papers Presented at the Duke Law Journal's Conference on Measuring Judges and Justice; 58 *Duke L.J.* 1703.

[28] Imwinkelried, E. (2005-2006). The organization of the evidence course: The "preliminaries" to helping students develop the skill of identifying nonhearsay. 50 *St. Louis U. L.J.* 1047.

[29] J. A. Blair. (2007). The "logic" of informal logic. In H. Hansen, editor, Dissensus and the Search for Common Ground (Proceedings of the OSSA Conference).

[30] Johnson, R. H. (2009). Some reflections on the Informal Logic Initiative, 16 (29) *Studies in Logic, Grammar and Rhetoric*, 17–46.

[31] Kedia, S. (2009-2010). Re-directing the scope of first year writing courses: Toward a new paradigm of teaching legal writing. 87 *U. Det. Mercy L. Rev*. 147.

[32] Kosko, B. (1993). *Fuzzy Thinking, The New Science of Fuzzy Logic*. New York: Hyperion.

[33] Laronge, J. A. A Generalizable Argument Structure Using Defeasible Class-inclusion Transitivity for Evaluating Evidentiary Probative Relevancy in Litigation *J Logic Computation (2009) exp066 first published online December 2, 2009 doi:10.1093/logcom/exp066*

[34] Ortiz, Claudia María Álvarez. (2007). Does Philosophy Improve Reasoning Skills? MA Thesis, University of Melbourne.

[35] Paoli, F. (2006). Comparing two views of comparison: Pena and Casari on vagueness and comparatives. In 4 (1) *Logic & Philosophy of Science*.

[36] Philipps L. and Sartor G. (1999). Introduction: From legal theories to neural networks and fuzzy reasoning. 7 *Artificial Intelligence and Law*, 115–128.

[37] Pollock, J. (2010). Defeasible Reasoning and Degrees of Justification. 1 *Argument and Computation*, 7-22.

[38] Pollock, J. L. (1995). *Cognitive Carpentry: A Blueprint for How to Build a Person*. Cambridge, MA/London: MIT Press.

[39] Pollock, J. L. (December 2001). Defeasible reasoning with variable degrees of justification, 133 *Artificial Intelligence*, Issues 1-2, 233-282.

[40] Prakken, H. Argumentation without arguments. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.170.3067

[41] Prakken, H. (2008). Formalising ordinary legal disputes: a case study. 16 *Artificial Intelligence and Law,* 333-359.

[42] Prakken, H. (2010b). On the nature of argument schemes, in C. Reed and C. Tindale (eds), Dialectics, Dialogue and Argumentation. An Examination of Douglas Walton's Theories of Reasoning and Argument, College Publications, London, 167–185.

[43] Prakken, H. (2005). A study of accrual of arguments, with applications to evidential reasoning. In Proceedings of the Tenth International Conference on Artificial Intelligence and Law, 85–94. ACM Press.

[44] Prakken, H. (2010). An abstract framework for argumentation with structured arguments. 1 *Argument and Computation*, 93-124.

[45] Quevedo. S. M. (Jan., 1985). Formalist and Instrumentalist Legal Reasoning and Legal Theory. 73 (1) *California Law Review*. 119-157.

[46] Reiter, R. (1987). 'Nonmonotonic Reasoning', 2 *Annual Review of Computer Science*, 147-186.

[47] Rider, Y., & Thomason, N. (2008). *Cognitive and pedagogical benefits of argument mapping: L.A.M.P. guides the way to better thinking.* In T. Sherborne (Ed.), Knowledge Cartography - software tools and mapping techniques: Springer.

[48] Rosch, E. (1988a). Coherences and categorization: A historical view. In F. S. Kessel (Ed.), The development of language and language researchers: Essays in honor of Roger Brown (pp. 373-392). Hillsdale, NJ: Lawrence Erlbaum Associates.

[49] S. Modgil and T. Bench-Capon. (2009). 'Metalevel argumentation', Technical Report ULCS-09-018, Dept. of Comp. Sci., Univ. of Liverpool.

[50] Shipman, F and Marshall, C. (1999). Formality considered harmful: Experiences, emerging themes, and directions on the use of formal representations in interactive systems, 8 *Computer Supported Cooperative Work*, 333-352.

[51] Sinclair, M. (2003). "What is the R in 'IRAC'?" 87 *N.Y.L. Sch. L. Hum. Rts*. 87.

[52] Sommers, F. (2008). Rationcination: An empirical account. 21 *Ratio*, 115–133. doi: 10.1111/j.1467-9329.2008.00390.x.

[53] Sommers, F. and Englebretsen, G. (2000). *An Invitation to Formal Reasoning*. Ashgate Publishing Company.

[54] Sullivan, W. M. et al., (2007). Educating Lawyers: Preparation for the Profession of Law (Jossey-Bass).

[55] T. Bench-Capon and T. F. Gordon. (2009). Isomorphism and argumentation. In Proceedings of the 12th International Conference on Artificial Intelligence and Law

(ICAIL). ACM Press.

[56] Tillers, P. http://tillerstillers.blogspot.com/2010/03/my-1983-comments-on-direct-v.html.

[57] Tillers, P. http://tillerstillers.blogspot.com/search/label/evidence%20marshaling.

[58] Twardy. C. (2004). Argument maps improve critical thinking. 27 *Teaching Philosophy*, 95–116.

[59] Twining, W. (1999). Narrative and Generalizations in Argumentation About Questions of Fact, 40 *S. Tex. L. Rev.* 351, 355.

[60] Twining, W. (2005). Taking Facts Seriously—Again, 55 *J. Leg. Educ*. 360.

[61] Twining, W. (1984). Taking Facts Seriously, 34 *J. Leg. Educ*. 22.

[62] van Driel, S. and Prakken, H. Visualising the argumentation structure of an expert witness report with Rationale (extended abstract). In A. Wyner (ed.), *Proceedings of the Workshop on Modelling Legal Cases and Legal Rules*, in conjunction with JURIX-10, Liverpool 2010, pp. 1-8.

[63] van Gelder, T. (2003). Enhancing Deliberation through Computer Supported Visualization. *Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-making*, eds. P. A. Kirschner, S. J. Buckingham Shum, and C. S. Carr, 97-115. New York: Springer.

[64] Walton D. (2004). *Relevance in Argumentation*. Lawrence Erlbaum Associates, Inc..

[65] Walton, D. (2009). Objections, Rebuttals and Refutations. In: J. Ritola (Ed.), *Argument Cultures: Proceedings of OSSA 09*, CD-ROM (pp. 1-10), Windsor, ON: OSSA.

[66] Walton, D. (2011). Argument mining by applying argumentation schemes. 4 (1) *Studies in Logic*, 38-64.

[67] Walton, D. N. (2002). Are some *modus ponens* arguments deductively valid? 22 (1) *Informal Logic*, 19-46.

[68] Whately, Richard. (1836). *Elements of Logic*, New York, Jackson.

[69] Woods, J. Defeasible Reasoning. Chapter 18 In Chris Reed and Christopher Tindale, editors of a yet to be entitled collection of essays on the logic of argument. London: College Publications, to appear in 2010.

[70] Wyner, A. and Hoekstra, R. (2010). A legal case OWL ontology with an instantiation of Popov v. Hayashi. Knowledge Engineering Review, xx:xx. To appear.

[71] Wyner, A. Bench-Capon, T. and Atkinson, K. (2007).Arguments, values and baseballs: Representation of Popov v. Hayashi. In A. Lodder and L. Mommers, editors, Legal Knowledge and Information Systems. JURIX 2007: The Twentieth Annual Conference, 151–160. IOS Press, Amsterdam etc..

[72] Zadeh, L.A. (1973). Outline of a new approach to the analysis of complex systems and decision processes. 3 *IEEE Trans. Systems, Man and Cybernetics*, 28–44.