Discontinuity-Free Decision Support with Quantitative Argumentation Debates

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Cardiff Argumentation Forum

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Presentation Overview

1. Background
    - IBIS Charts and QuAD Frameworks
    - QuAD Algorithm/Semantics

2. Research Summary
    - Motivation for DF-QuAD
    - DF-QuAD Algorithm
    - Comparison of the DF-QuAD and QuAD Algorithms
    - Properties Not Held by QuAD
    - Properties Shared with QuAD
    - Relationship to Abstract Argumentation
    - Reverse Engineering Functionality
    - Applications of QuAD Frameworks

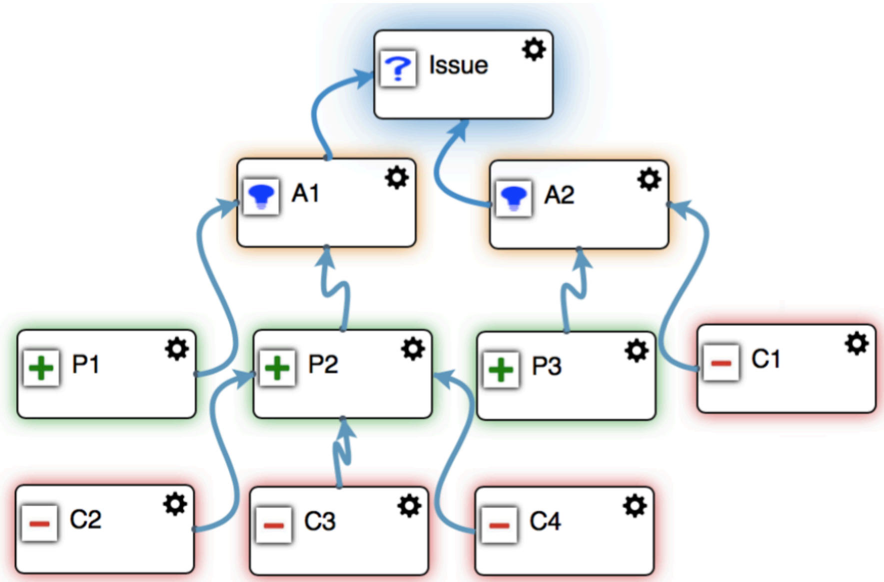
3. Future Work

4. Conclusions

Background – IBIS Charts & QuAD Frameworks

- IBIS (Issue Based Information System) charts [Kunz and Rittel, 1970].
- QuAD (Quantitative Argumentation Debate) frameworks [Baroni et al. 2015].
  - Special types of IBIS trees with base scores for nodes.

QuAD Framework [www.arganddec.com]



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- QuAD (Quantitative Argumentation Debate) frameworks [Baroni et al. 2015].
  - Special types of IBIS trees with base scores for nodes.
- Correspond to BAFs (Bipolar Argumentation Frameworks) [Cayrol and Lagasquie-Schiex, 2005].

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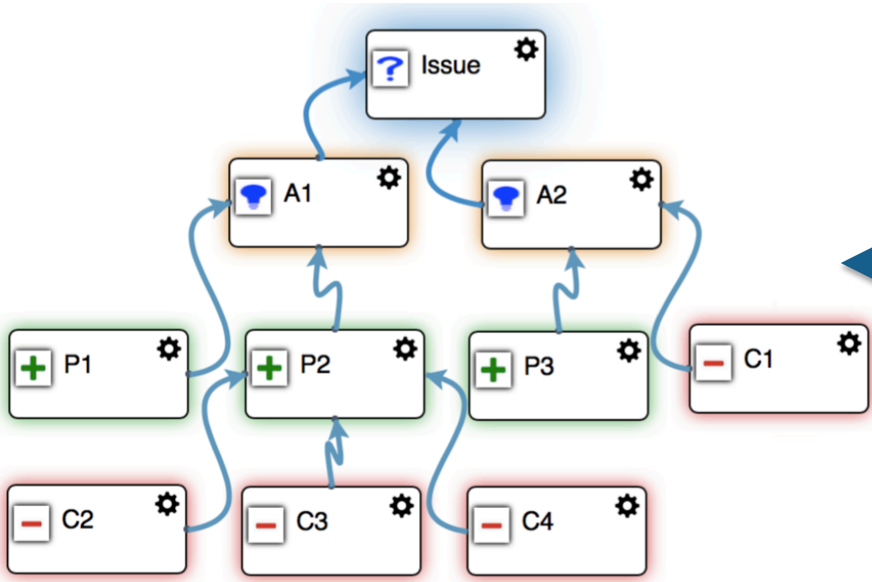
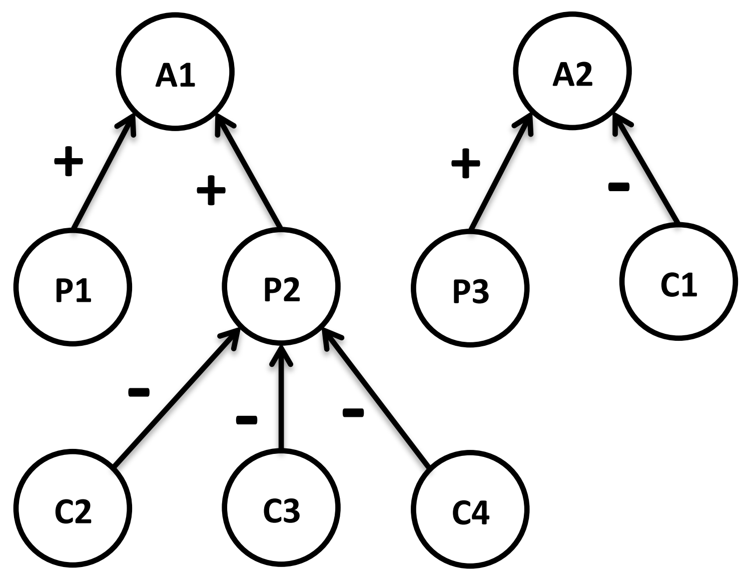


BAF Framework



Background – QuAD Algorithm/Semantics

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- Base scores and strengths are in [0,1].
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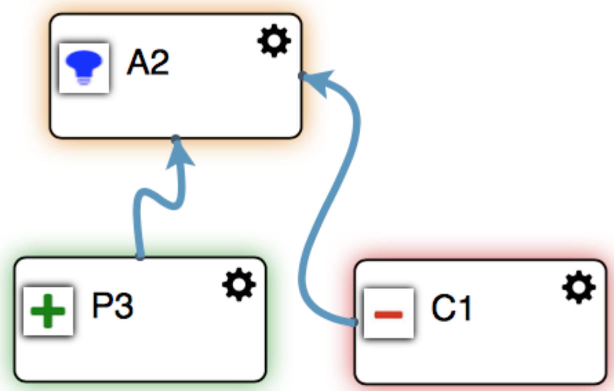

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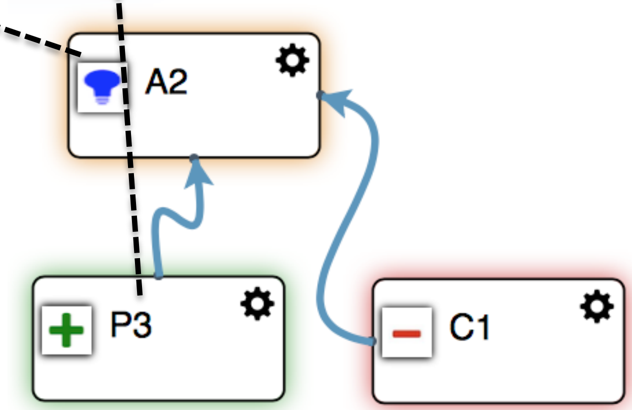

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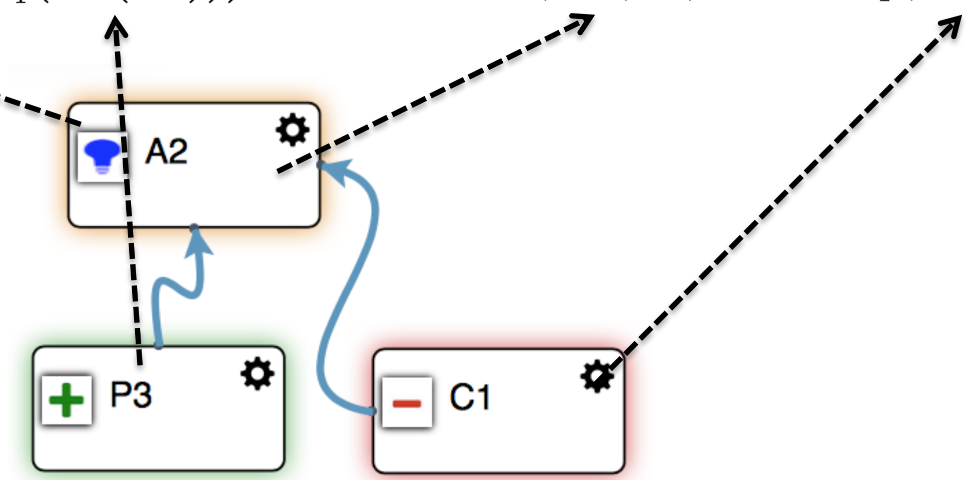

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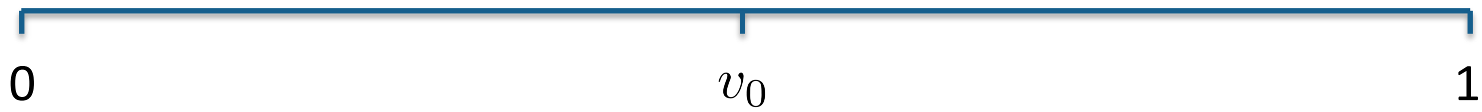

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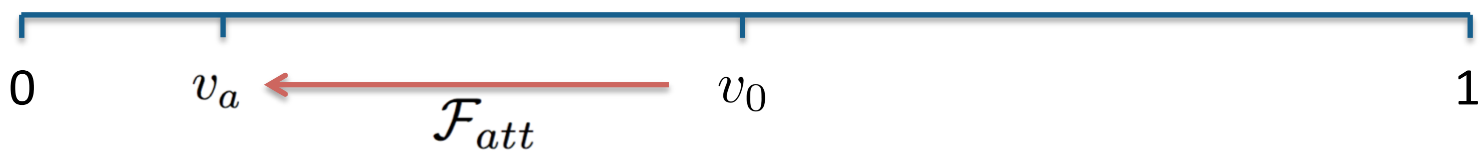

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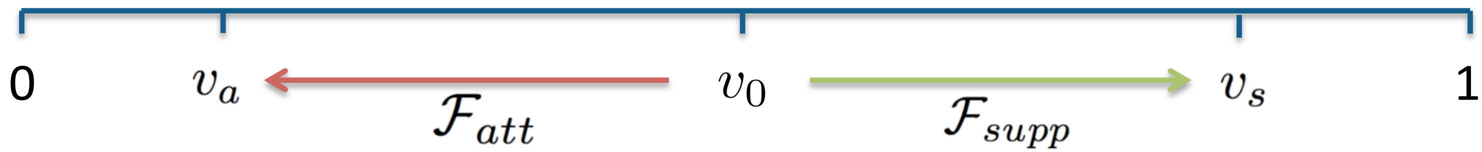

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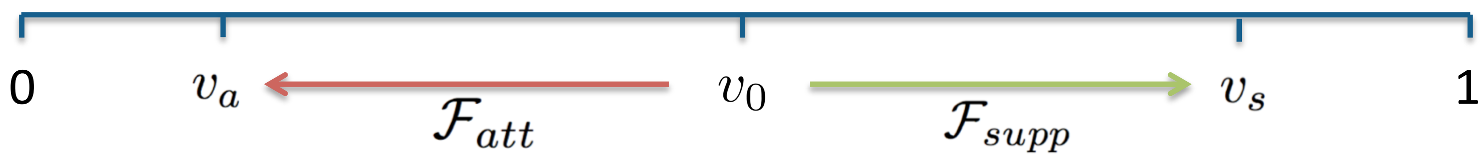

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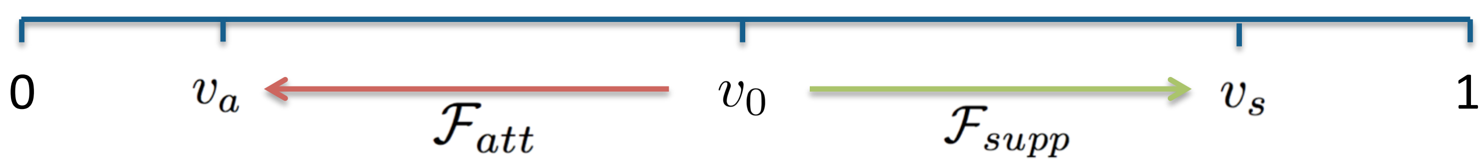


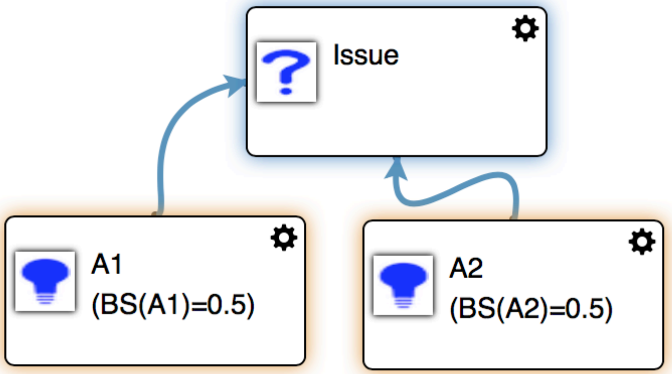
- If the set of attacker/supporter strengths is {} or a set of zeros it is considered **ineffective**.

- The aggregating function then determines the strength in the [0,1] range:

v_a	v_s	Strength
Effective	Ineffective	v_a
Ineffective	Effective	v_s
Ineffective	Ineffective	v_0
Effective	Effective	$(v_a + v_s) / 2$

Research Summary – Motivation for DF-QuAD

- Engineering Design setting:
  - Issue – Which is the best method for controlling the ventilation of a dining room?
  - Answer 1 – Building management control
  - Answer 2 – User control



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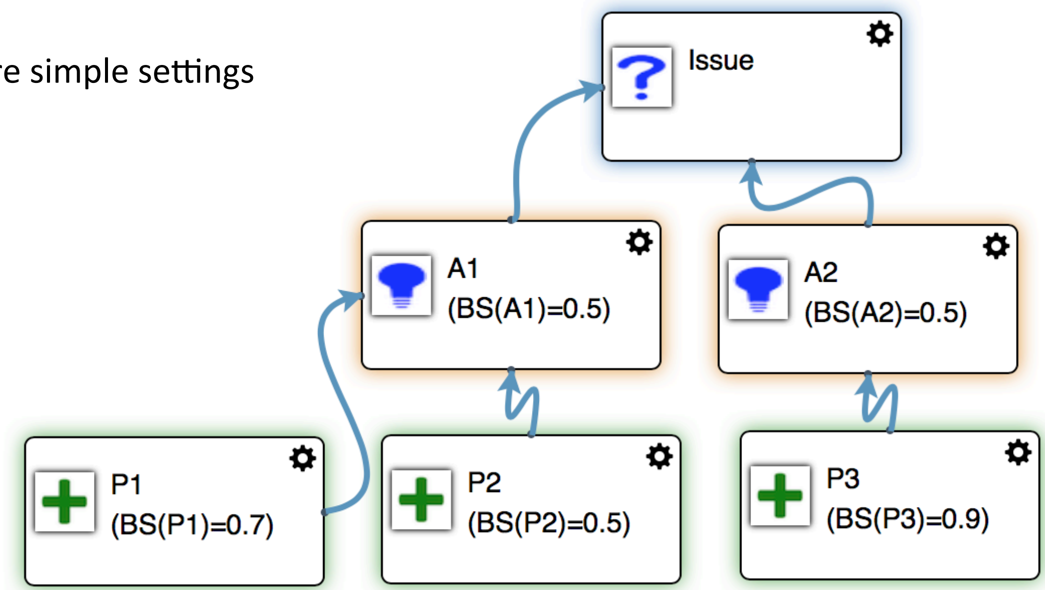

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Answer	Strength at Stage 1
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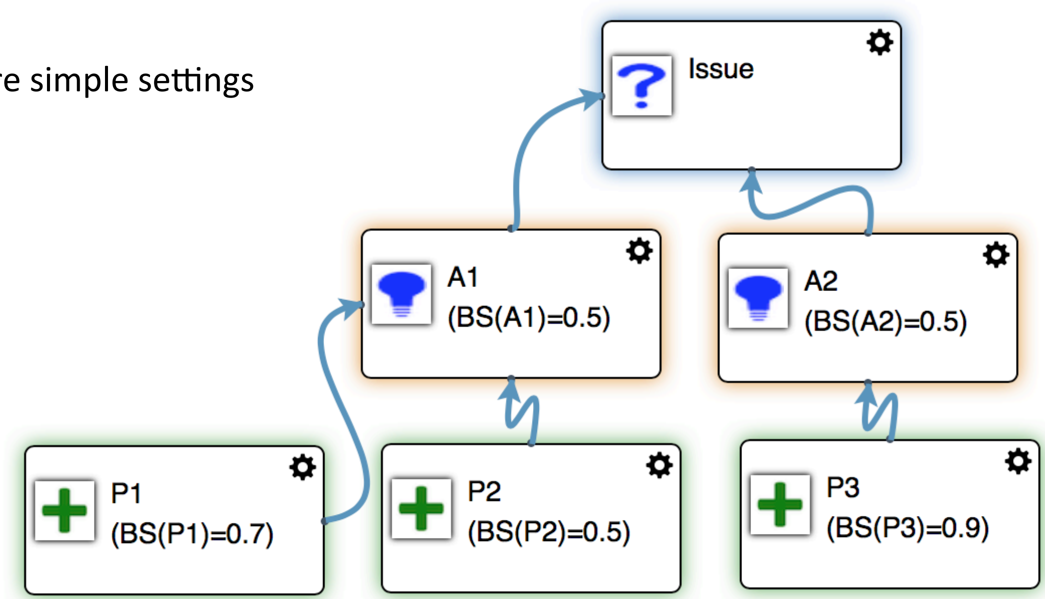

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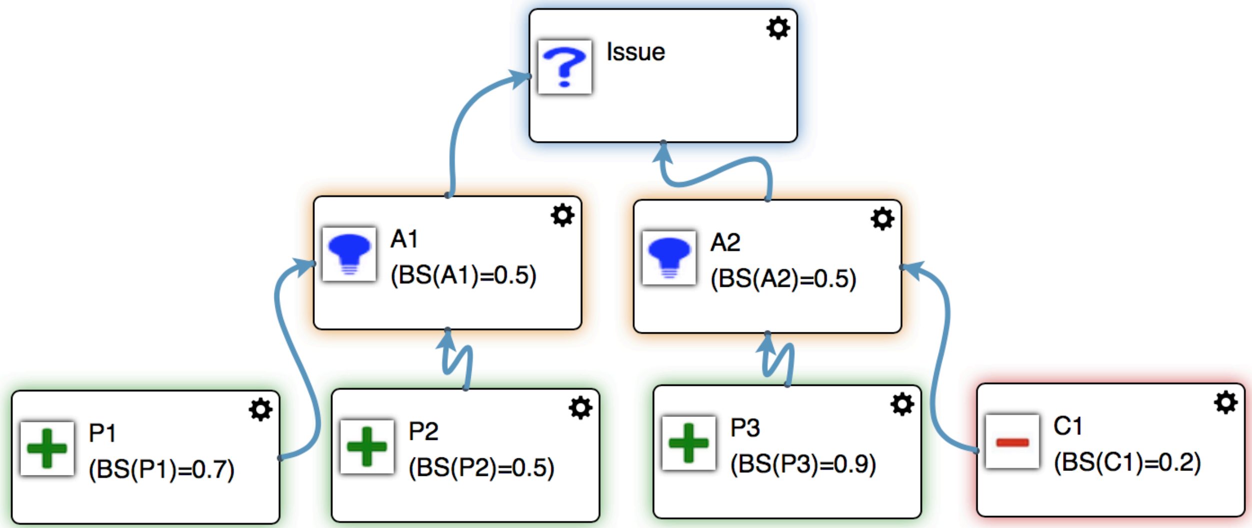

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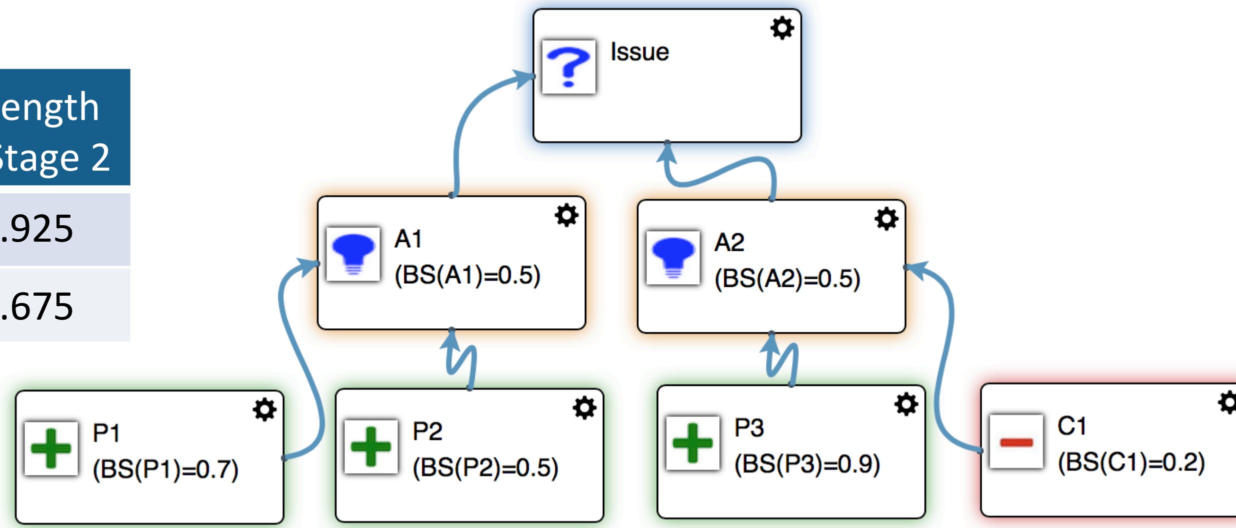

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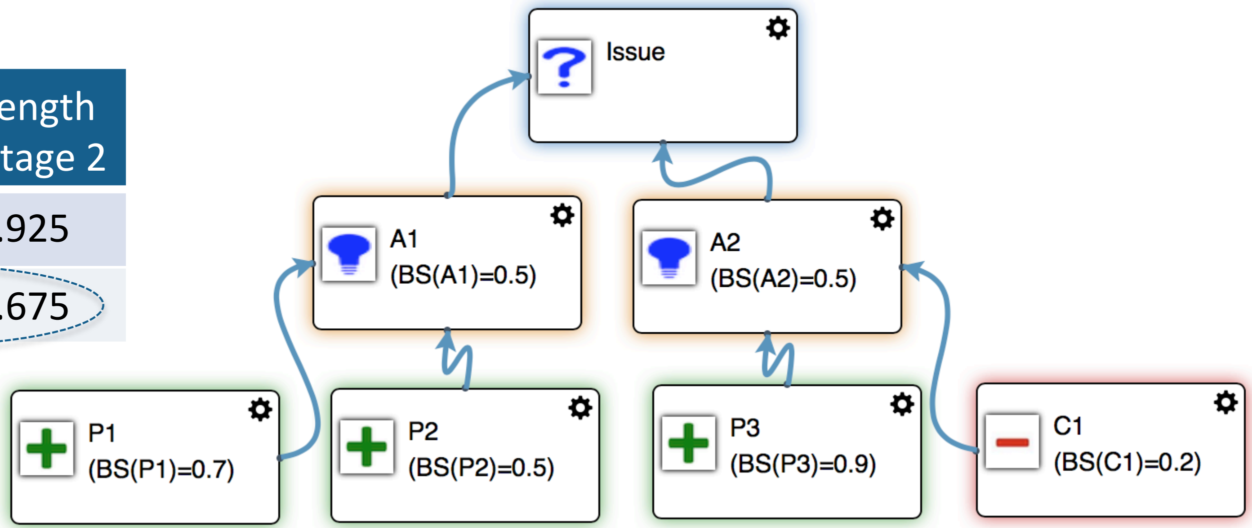

- Large drop in A2's strength between Stage 1 and 2 is disproportionate in some settings, e.g. Engineering Design.

- In other settings, e.g. E-Democracy, this may not be the case.

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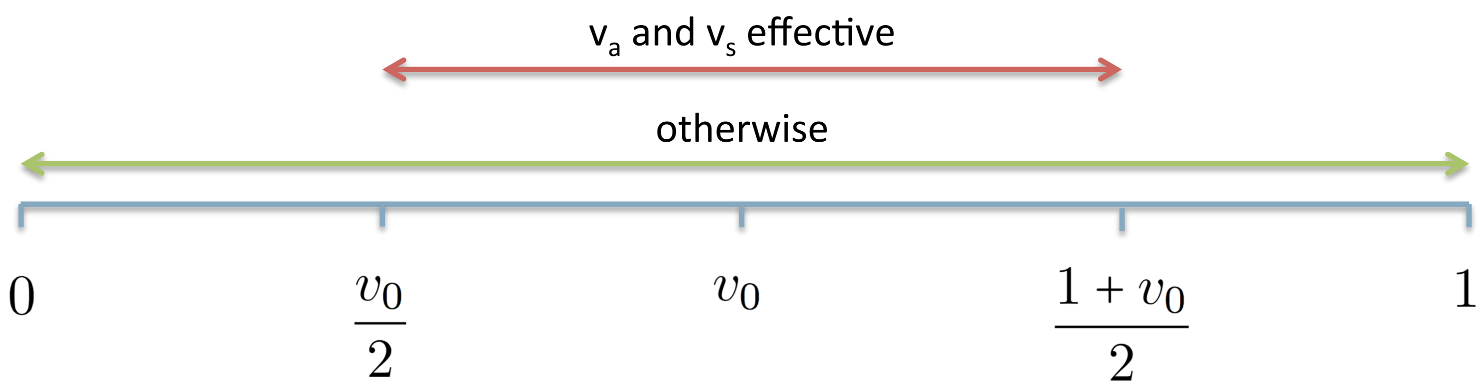
- The aggregating function's range in one case is a subset of [0,1]:



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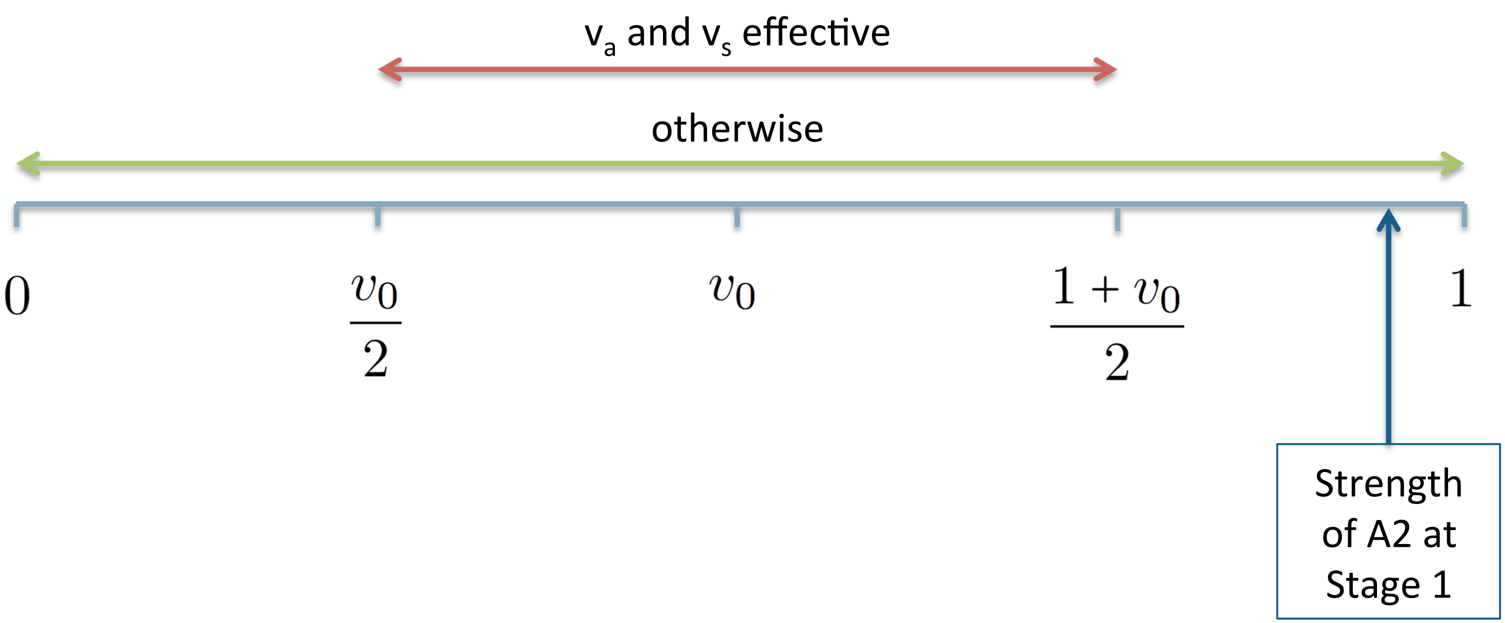

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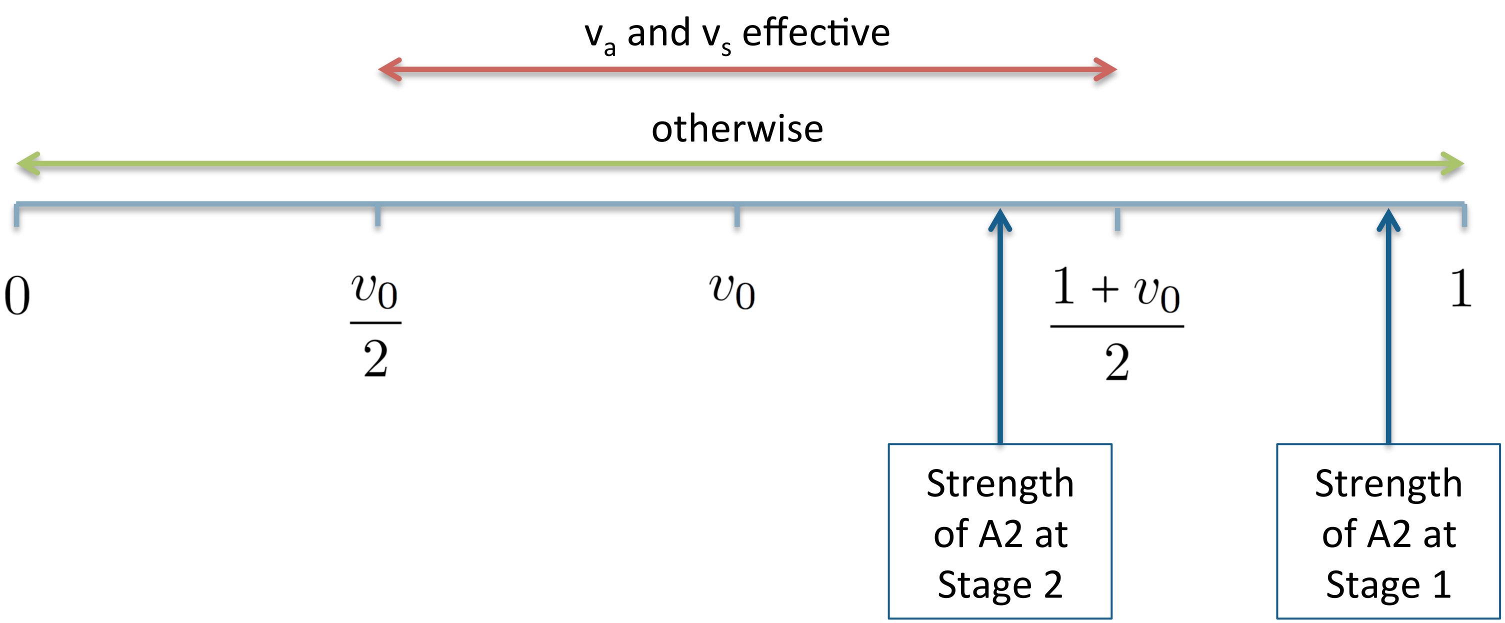
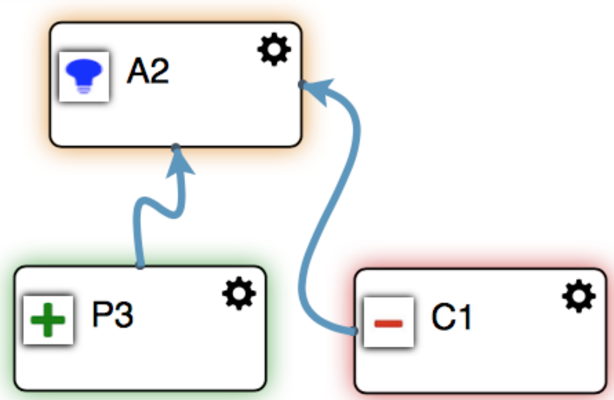


- Discontinuity, leading to counter-intuitive behaviour in some applications.

Research Summary – DF-QuAD Algorithm

- A new "discontinuity-free" algorithm for QuAD frameworks (DF-QuAD).
- Incorporates many of the same concepts as the QuAD algorithm.
  - Base score and strength in [0,1].



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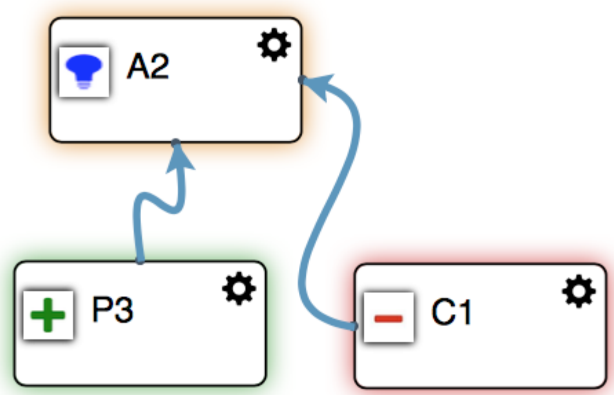

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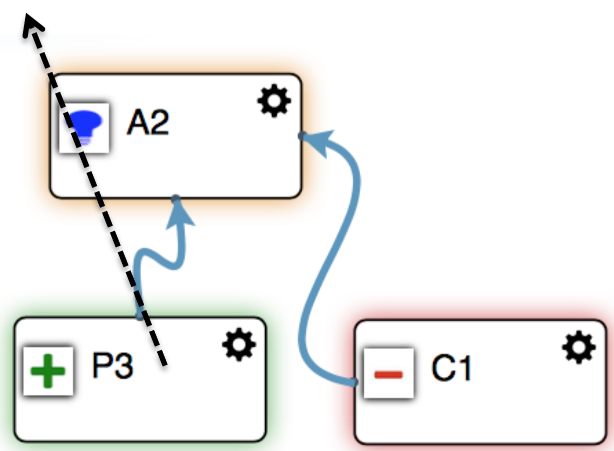

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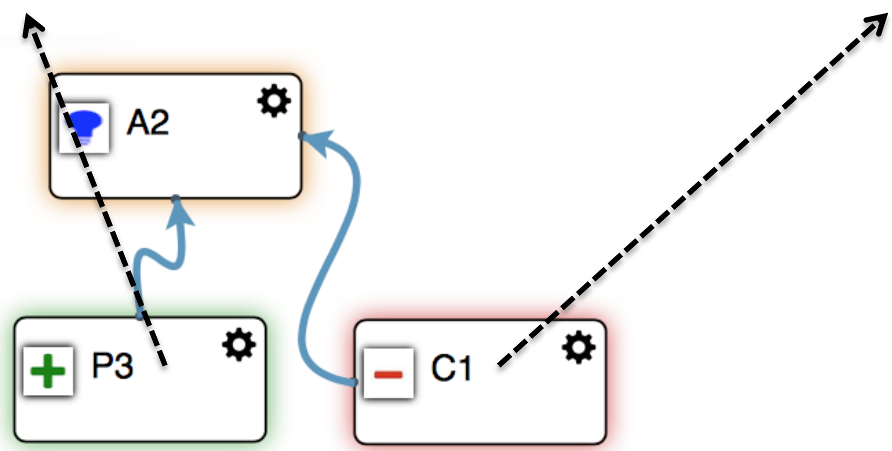

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0 1

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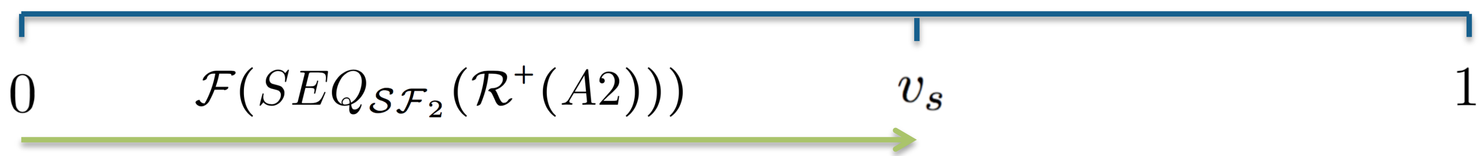

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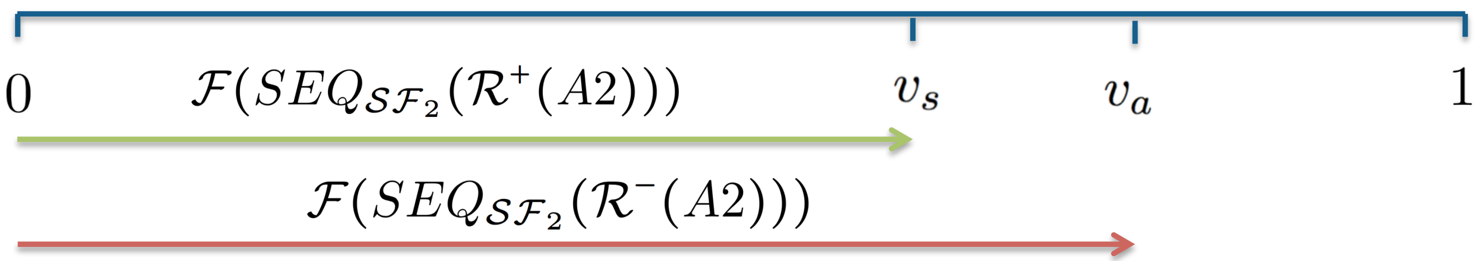

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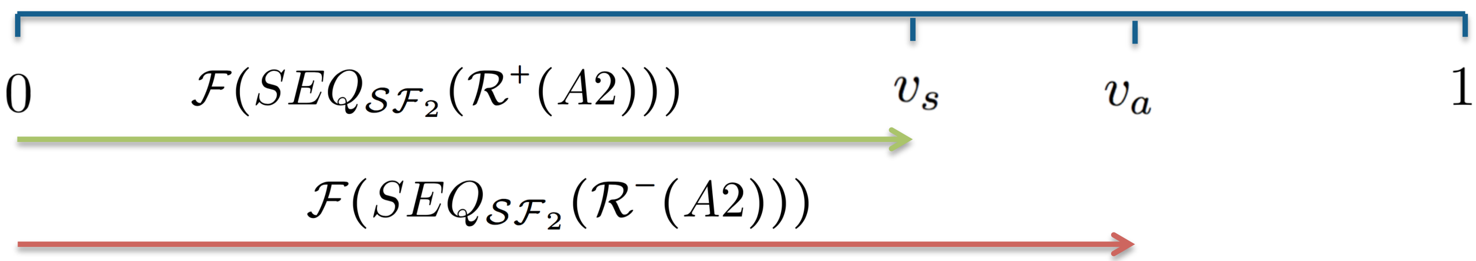

- The combination function then uses the base score and the **difference** between the attacking/supporting components to calculate the strength.

$$
\begin{aligned}
c(v_0, v_a, v_s) &= v_0 - v_0 \cdot |v_s - v_a| && \text{if } v_a \geq v_s \\
c(v_0, v_a, v_s) &= v_0 + (1 - v_0) \cdot |v_s - v_a| && \text{if } v_a < v_s
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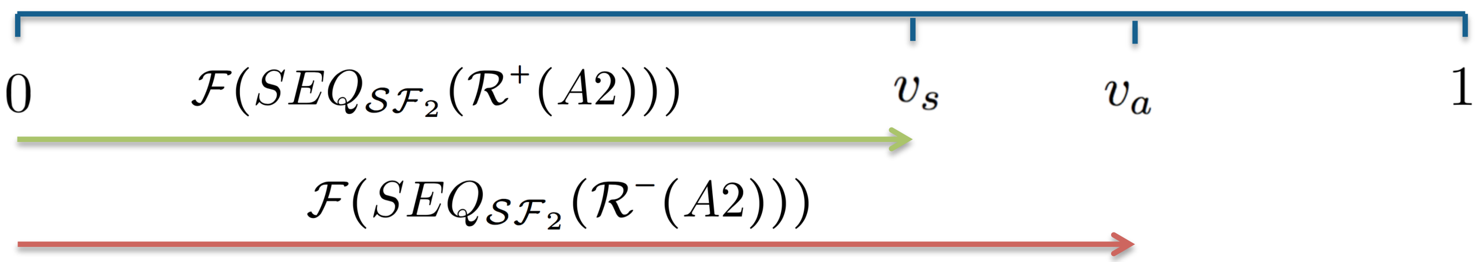

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- The strength is not restricted to a subset of [0,1] when attackers and supporters are effective.

- Identical results to the QuAD algorithm when attackers or supporters are ineffective.

Research Summary – Comparison of the DF-QuAD and QuAD Algorithms

- Engineering Design setting as used for QuAD.

QuAD Algorithm:

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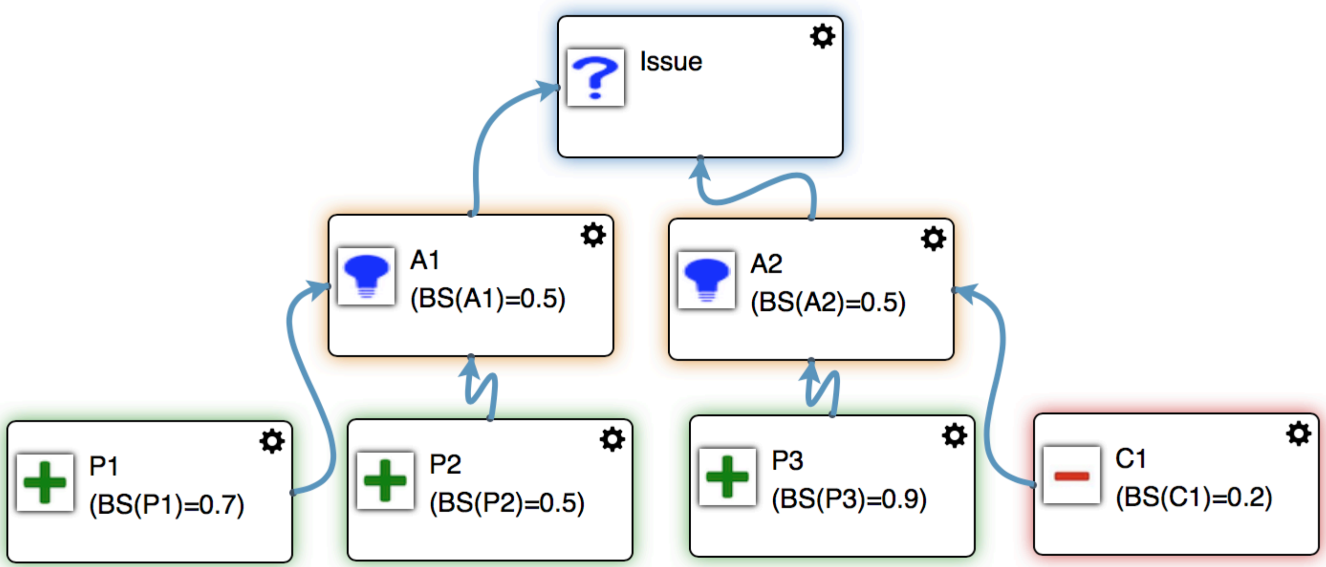

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DF-QuAD Algorithm:

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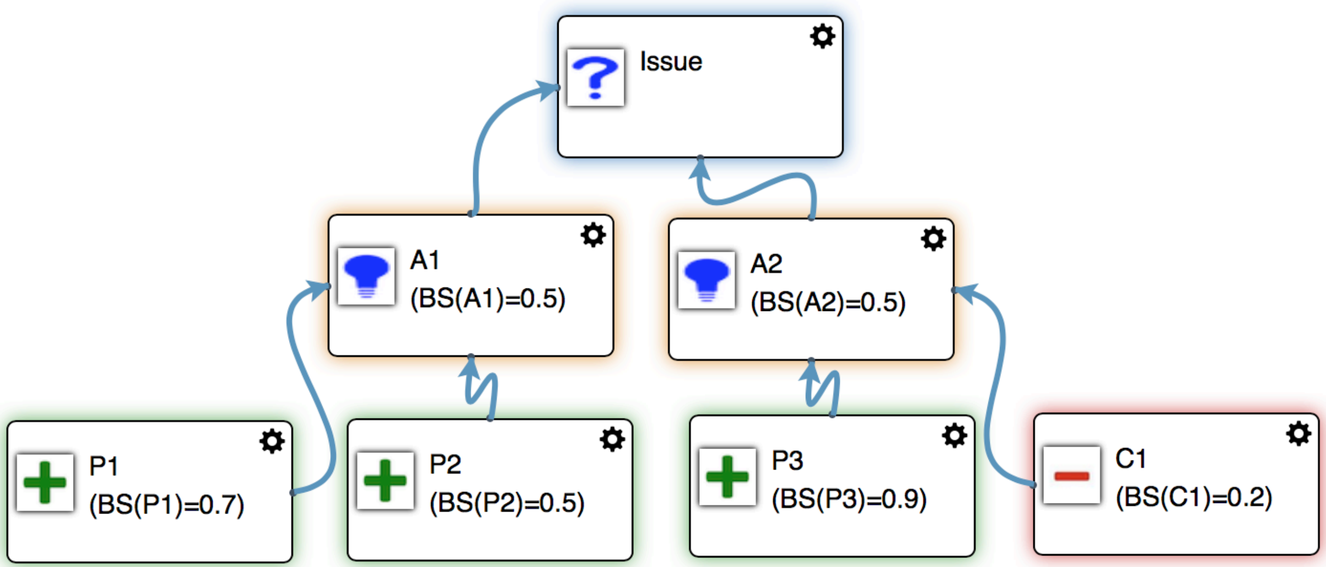

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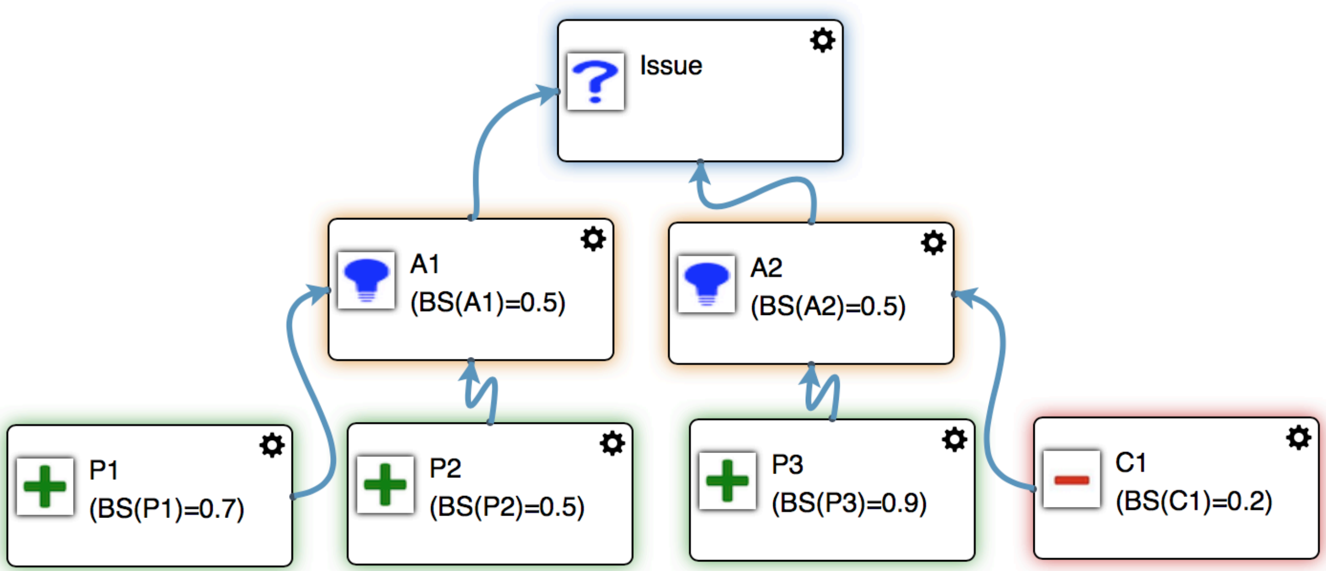

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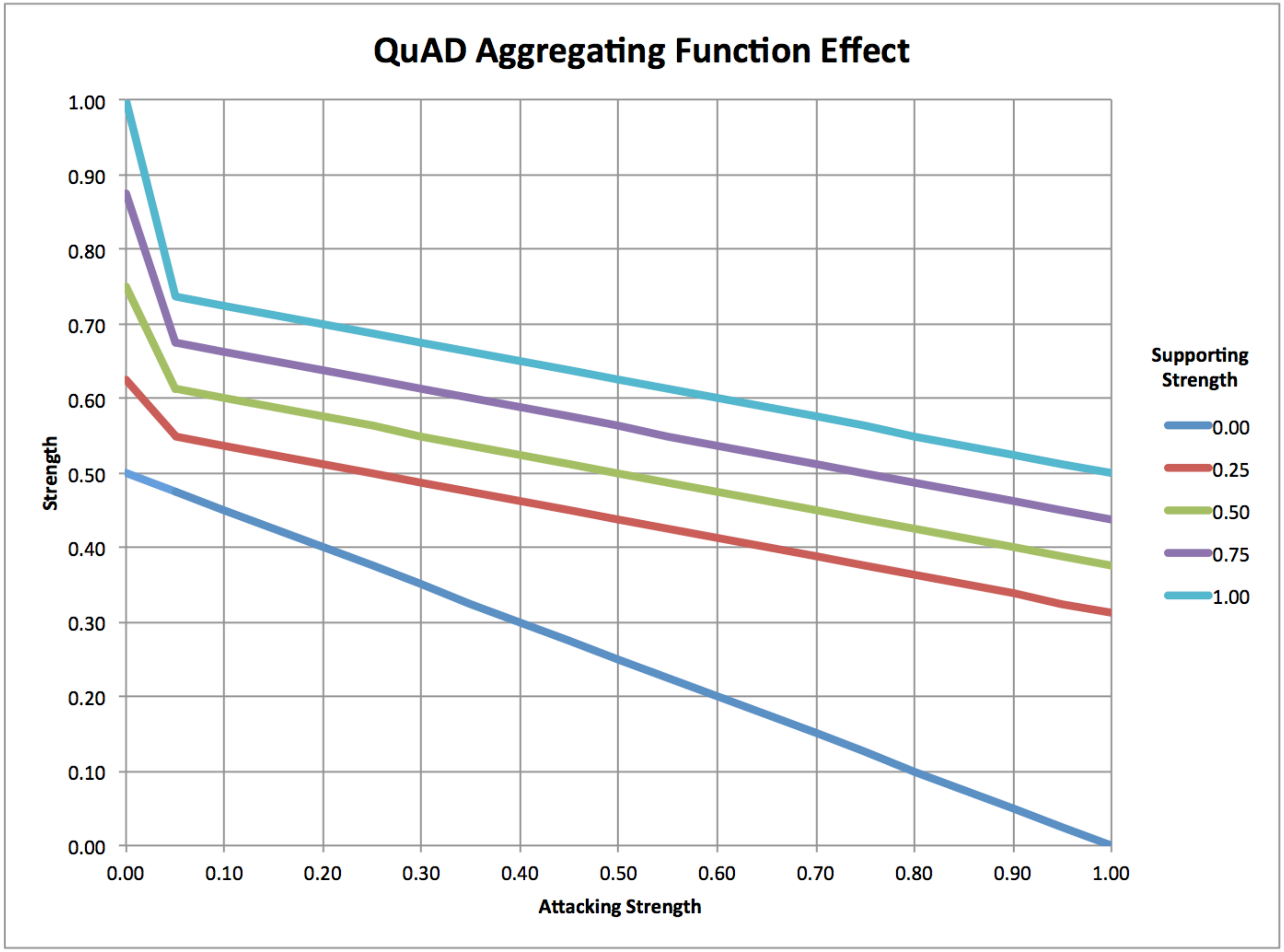

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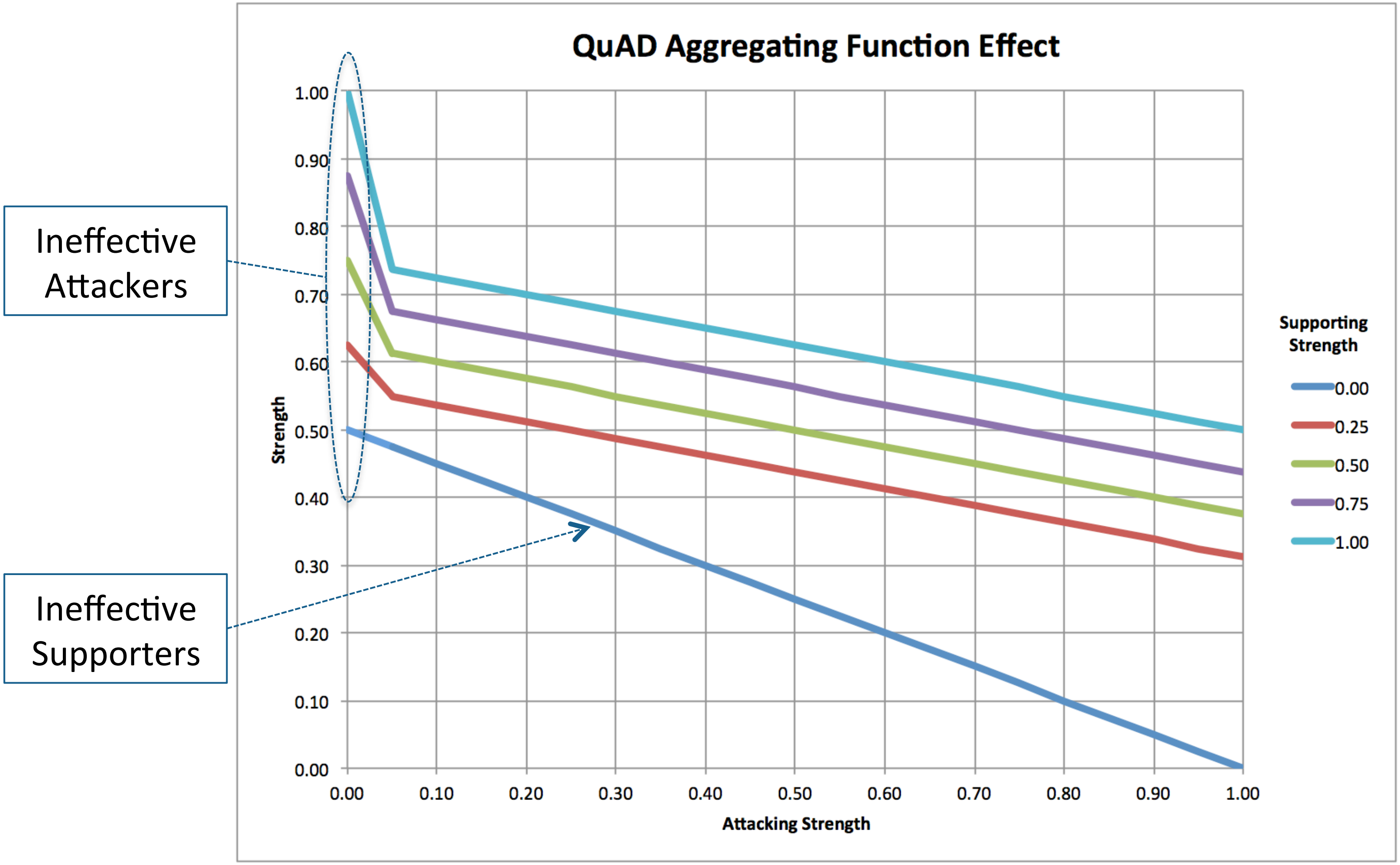

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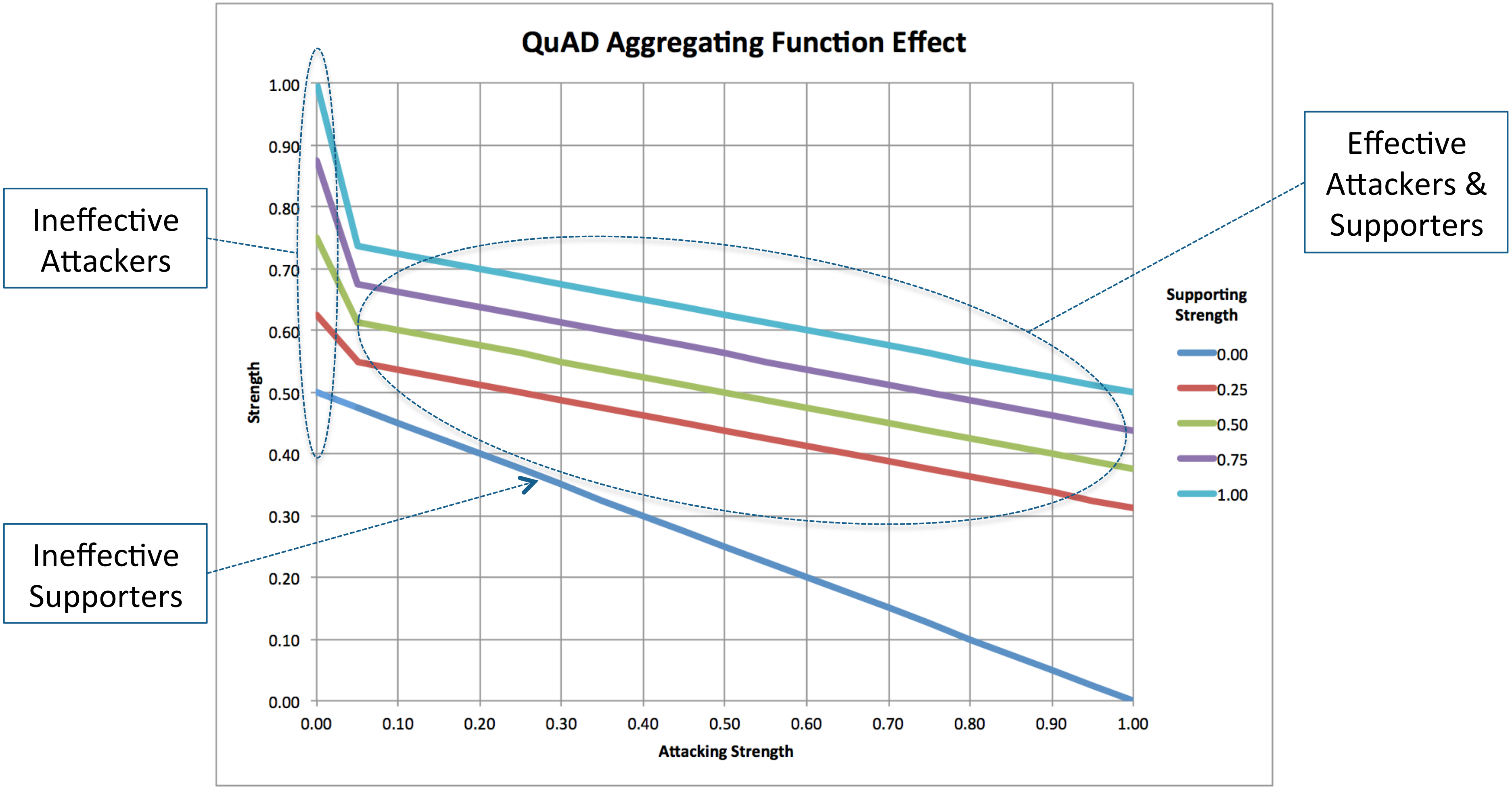

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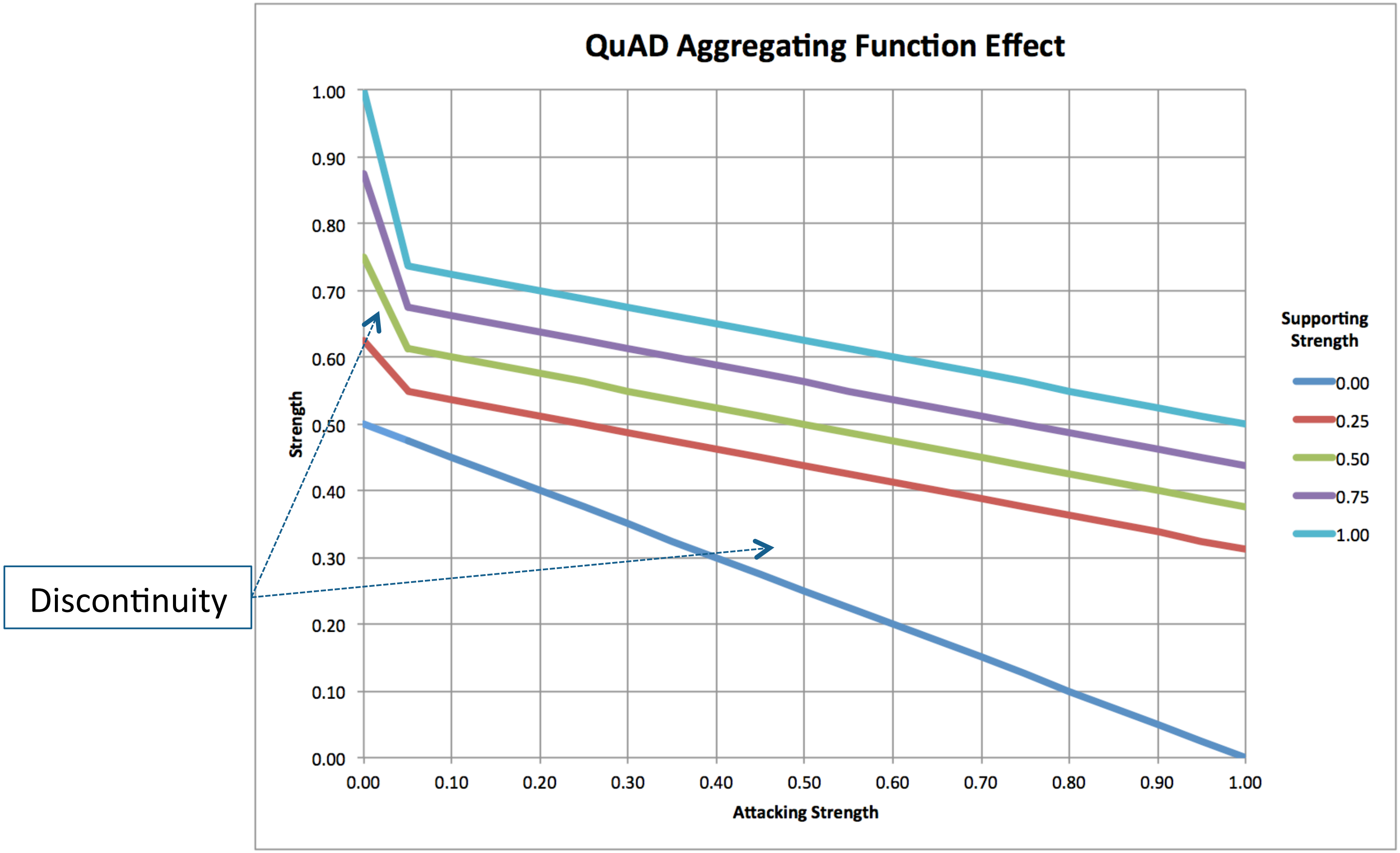

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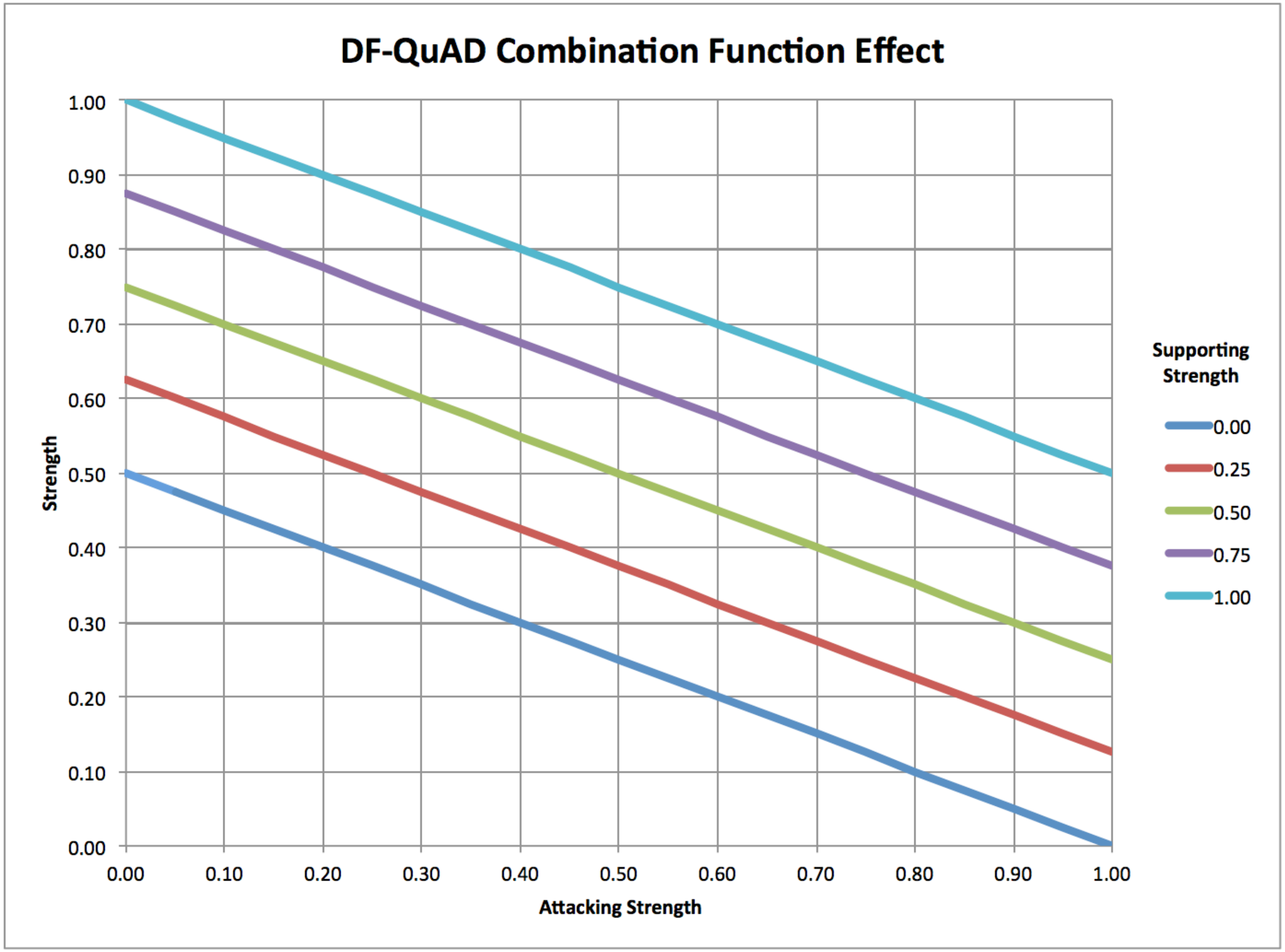
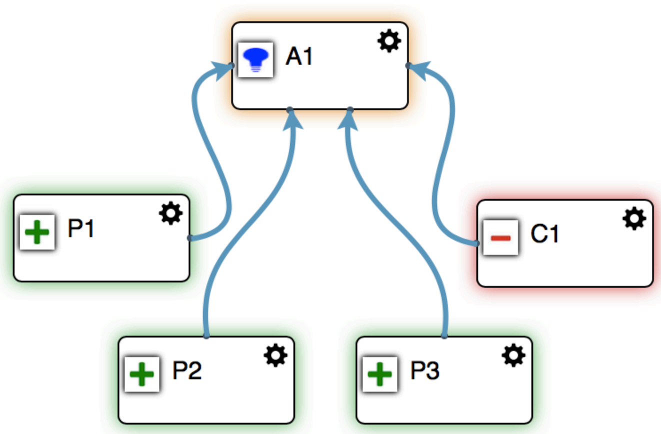
- DF-QuAD plotted for the same base score shows results without a discontinuity.



Research Summary – Properties Not Held by QuAD

- As an attacker's or a supporter's strength approaches 0, the framework becomes equivalent to a framework without that argument:
  - As the strength of the attacker C1 approaches 0:



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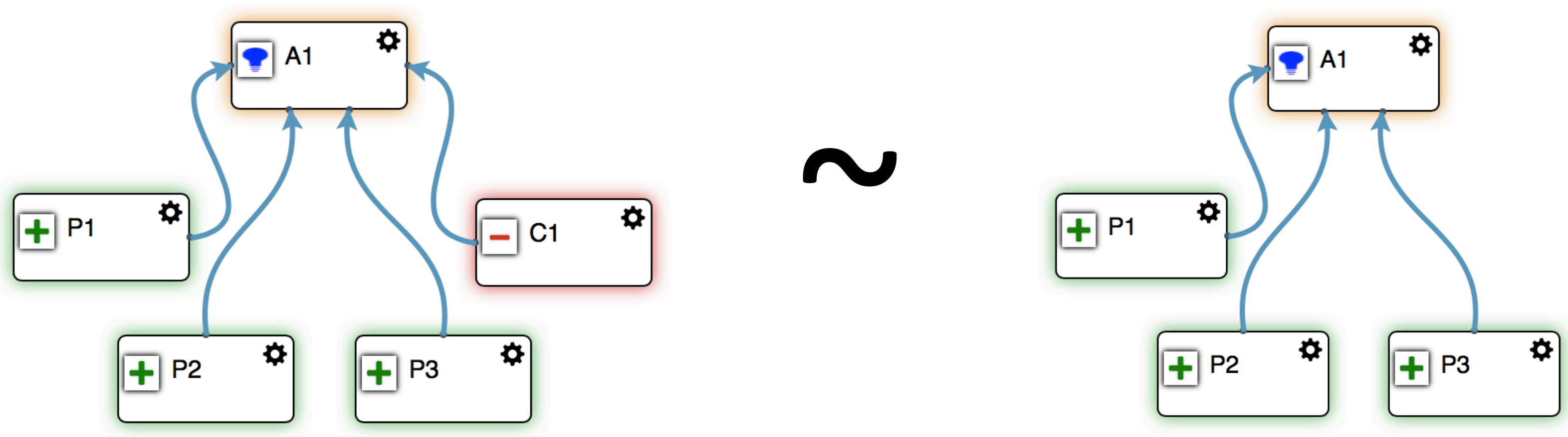
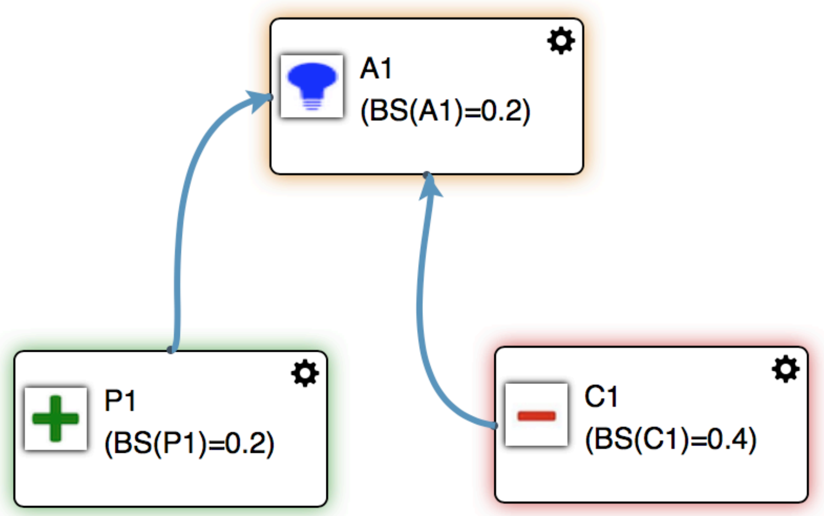


  - Similarly for supporters.
  - Gives DF-QuAD its discontinuity-free aspect.

Research Summary – Properties Not Held by QuAD

Condition	Strength
Argument's attacking component is larger than its supporting component	Less than or equal to the base score

- In DF-QuAD, the following results in a strength of A2 which is less than its base score:



Answer	QuAD Strength	DF-QuAD Strength
A1	0.24	0.16

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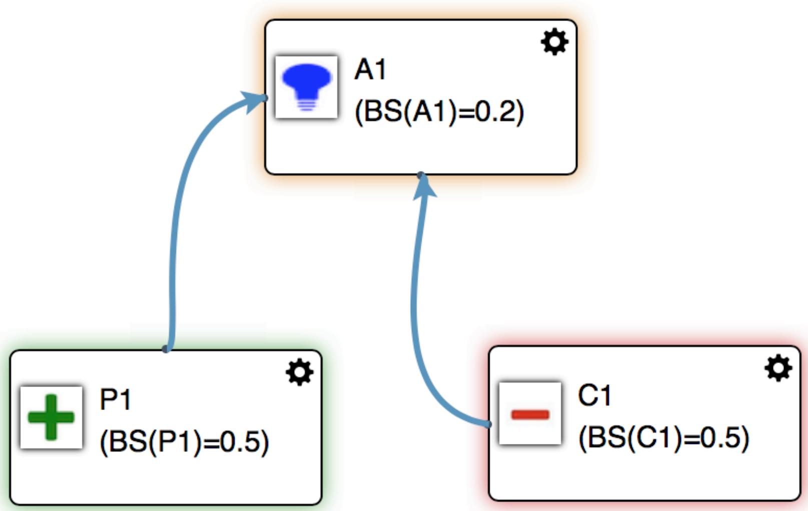

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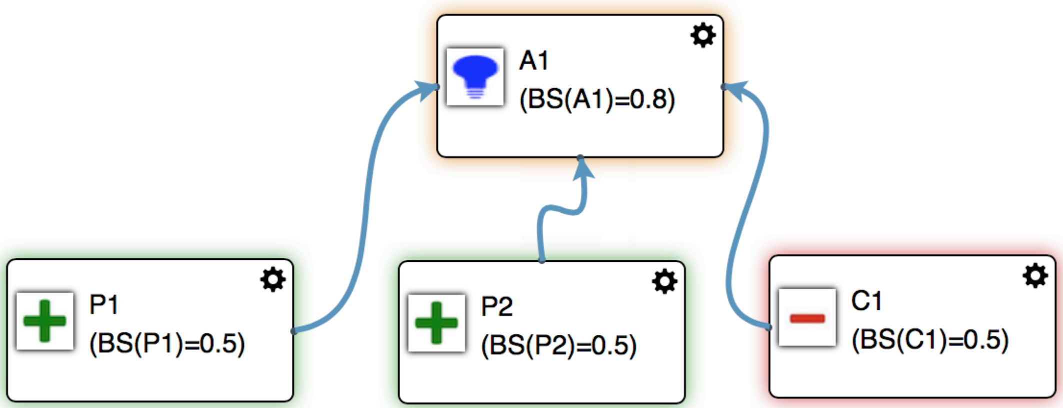
- In DF-QuAD, the following results in a strength of A2 which is greater than its base score:



Answer	QuAD Strength	DF-QuAD Strength
A1	0.675	0.85

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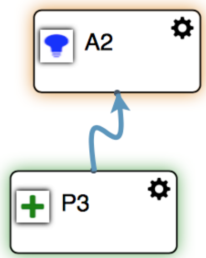
Research Summary – Properties Shared with QuAD

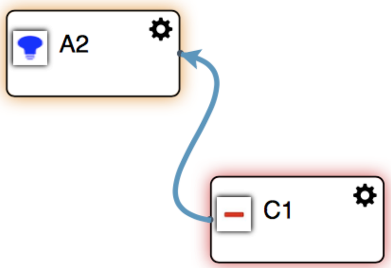
- The order of the sequence of attacking or supporting arguments does not affect the strength:

Pro before Con

Con before Pro

Stage 1





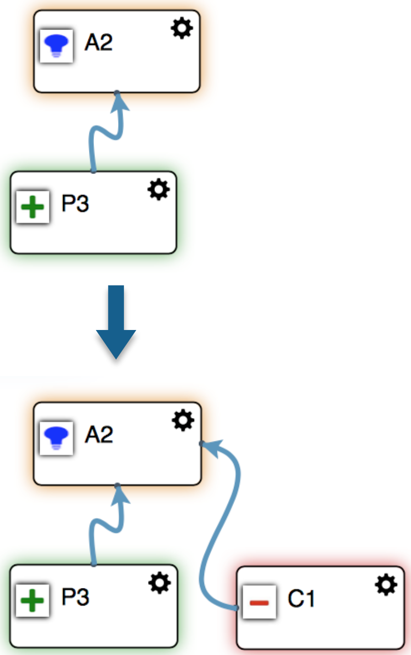
Research Summary – Properties Shared with QuAD

- The order of the sequence of attacking or supporting arguments does not affect the strength:

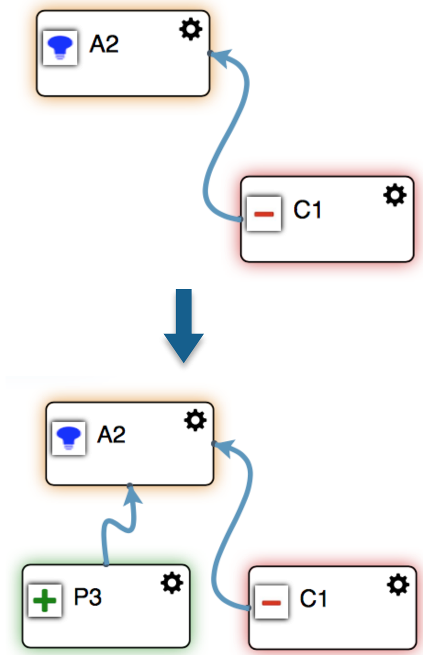
Stage 1

Stage 2

Pro before Con



Con before Pro



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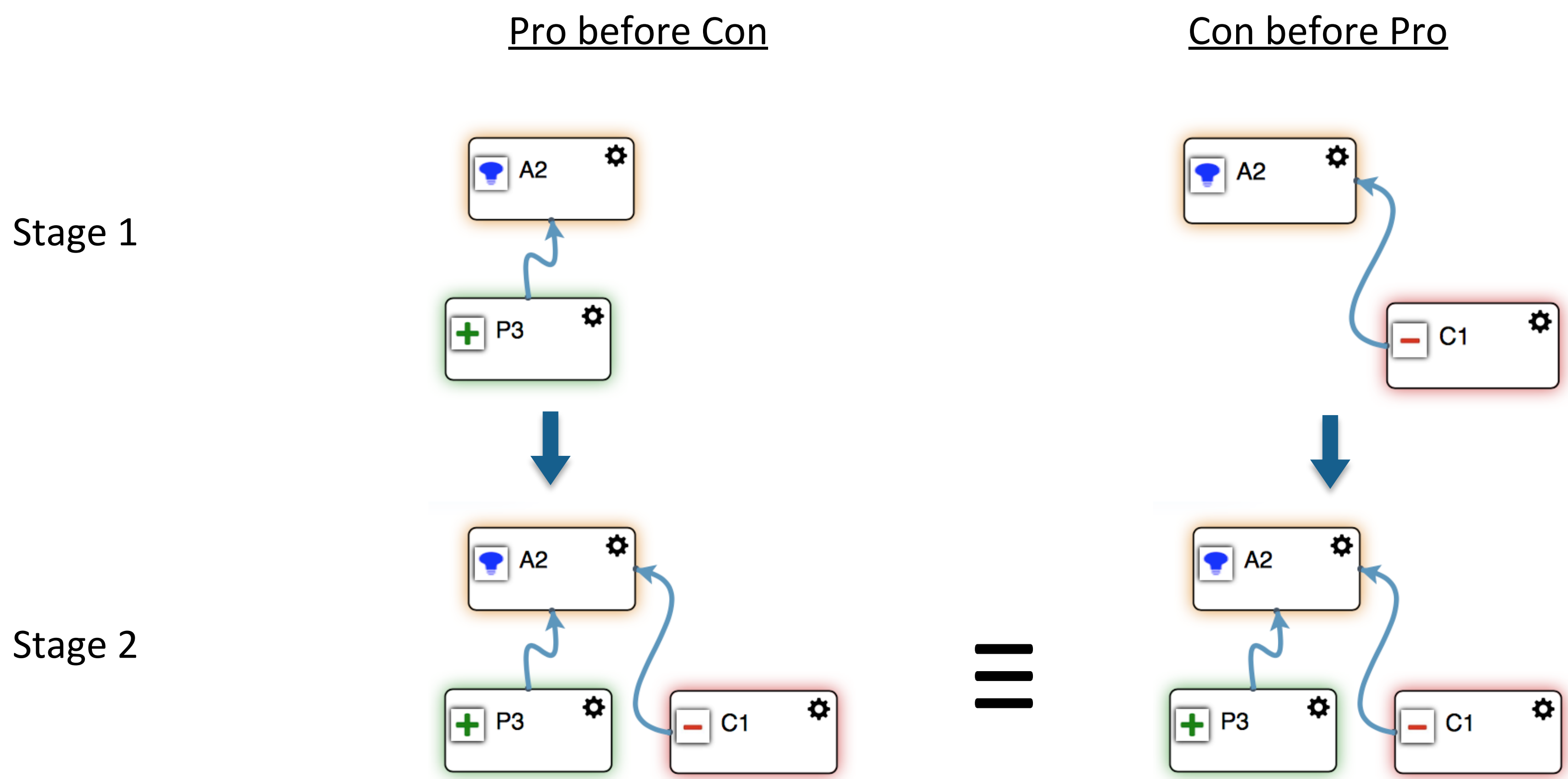

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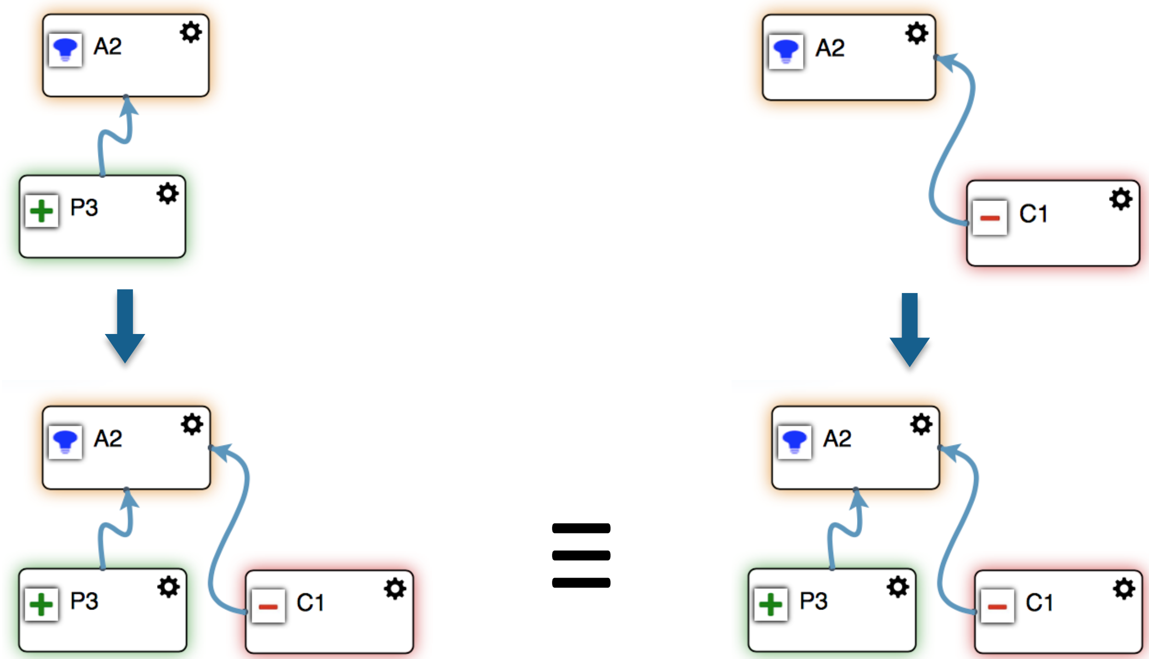

- More intuitive, comprehensive properties also hold, for example:
  - An attacker being added will not increase the strength
  - A supporter being added will not decrease the strength

Research Summary – Relationship to Abstract Argumentation

- QuAD and DF-QuAD yield the same results when attackers or supporters are ineffective.

- Abstract Argumentation frameworks [Dung, 1995] can be mapped to QuAD frameworks without supporters [Baroni et al. 2015].

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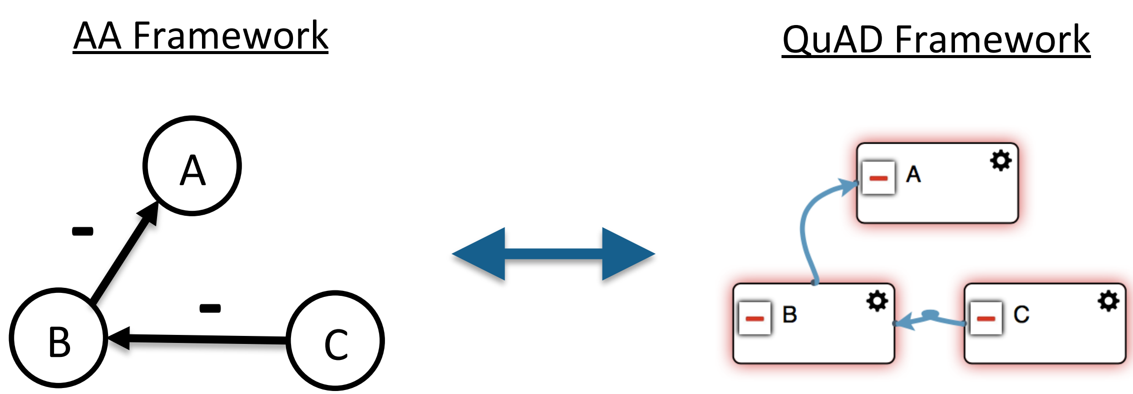

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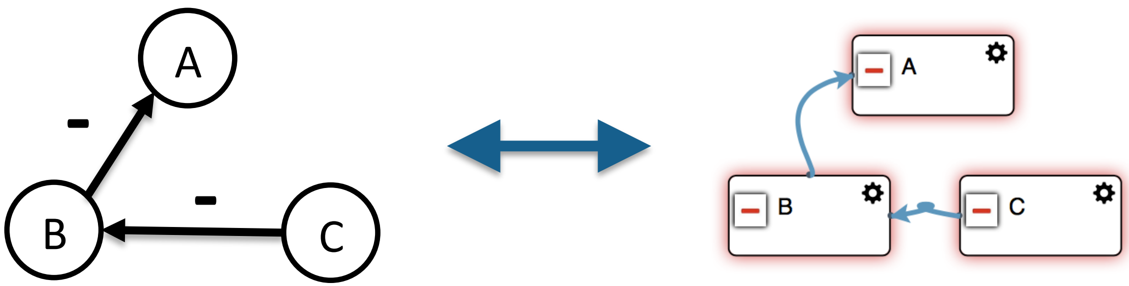
AA Framework

QuAD Framework



- If all base scores set to 1:
  - Arguments in grounded extension have strength of 1.
  - Other arguments have strength of 0.

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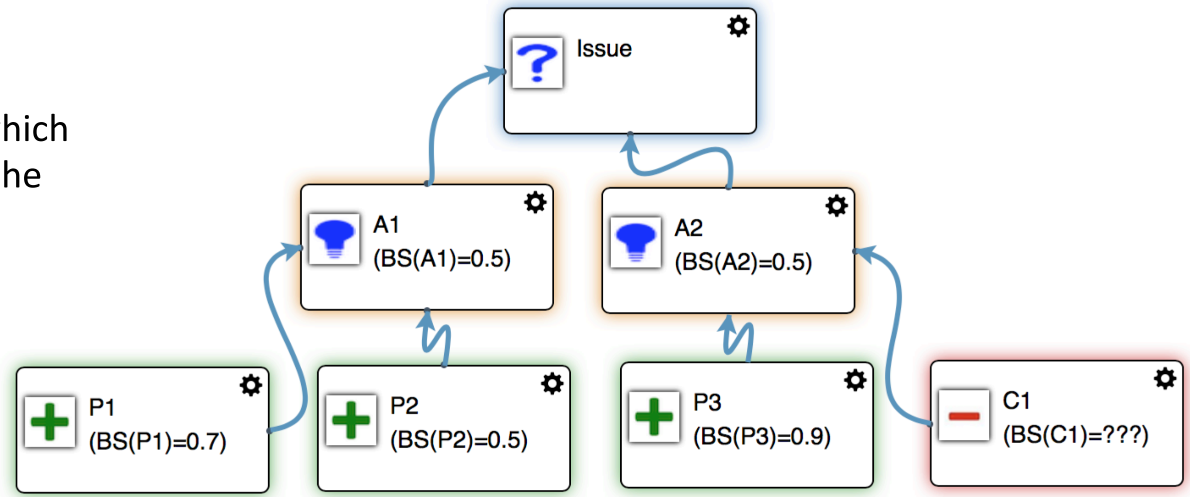

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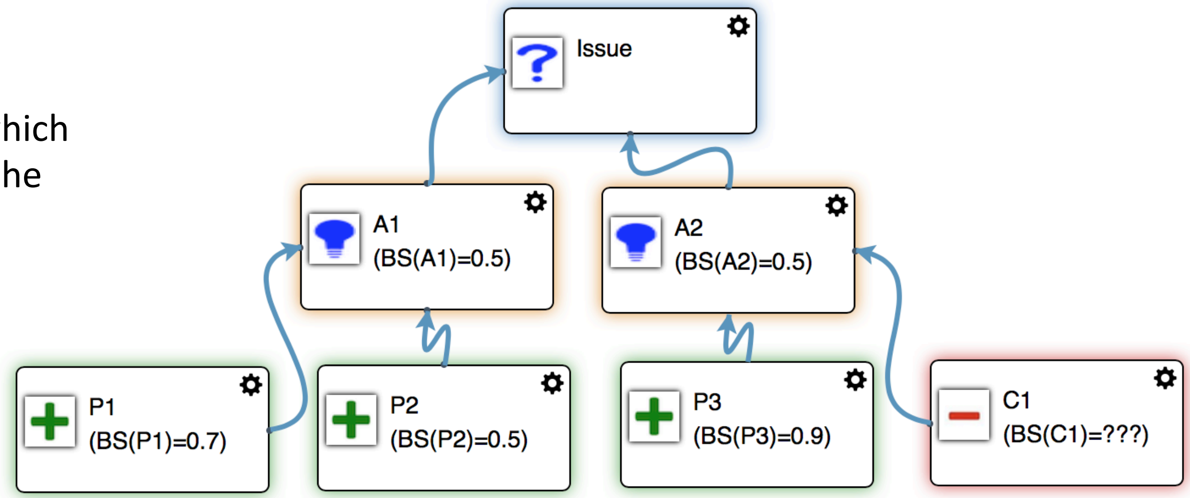

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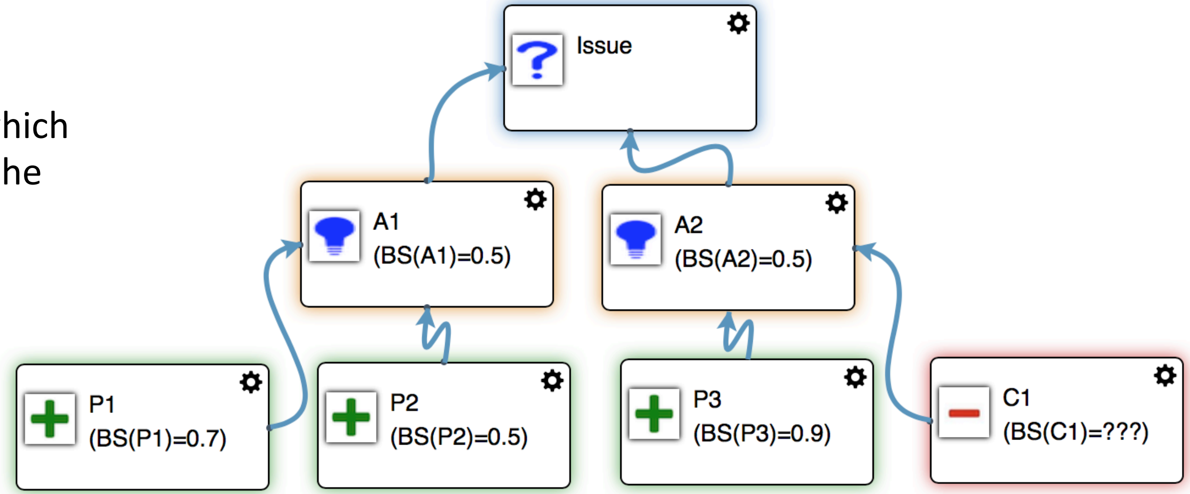
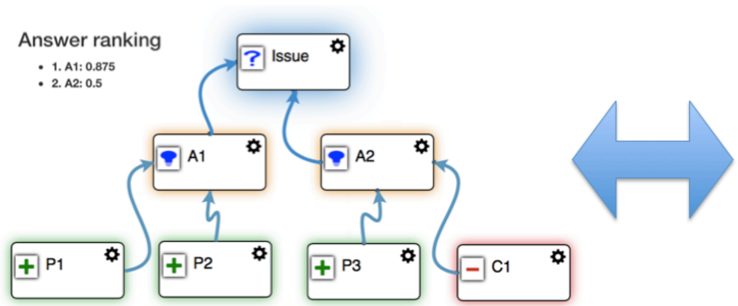


- Other alterations include:
  - Increasing the strength of arguments by increasing base scores, e.g. increasing BS(P3) or BS(A2).
  - Reducing the strength of arguments by adding attackers, e.g. to C1.
  - Increasing the strength of arguments by adding supporters, e.g. to P3 or A2.
- Not possible in QuAD.
- Not desirable in some applications, e.g. where manipulation could be a problem.

Research Summary – Applications of QuAD Frameworks

- Arg&Dec [www.arganddec.com]
  - QuAD framework
  - QuAD automatic evaluation
  - Unique translation from graph to matrix form



	Concept variant	
Selection criteria	A1 0.5	A2 0.5
P1 0.5	+	0
P3 0.5	0	+
P2 0.5	+	0
C1 0.5	0	-
Result	1.000000	0.000000
Ranks	1	2

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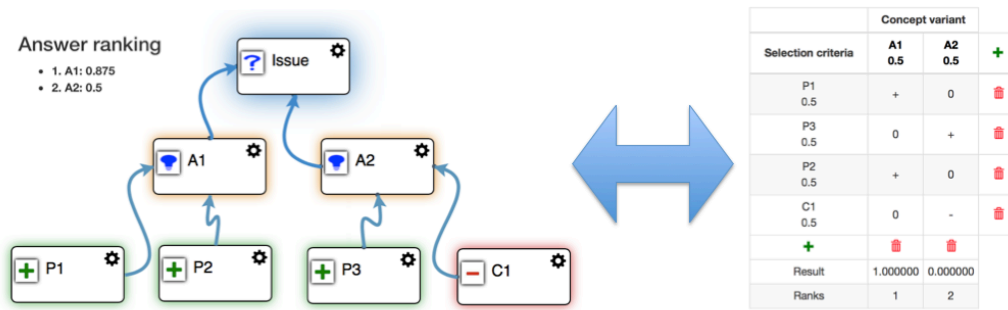
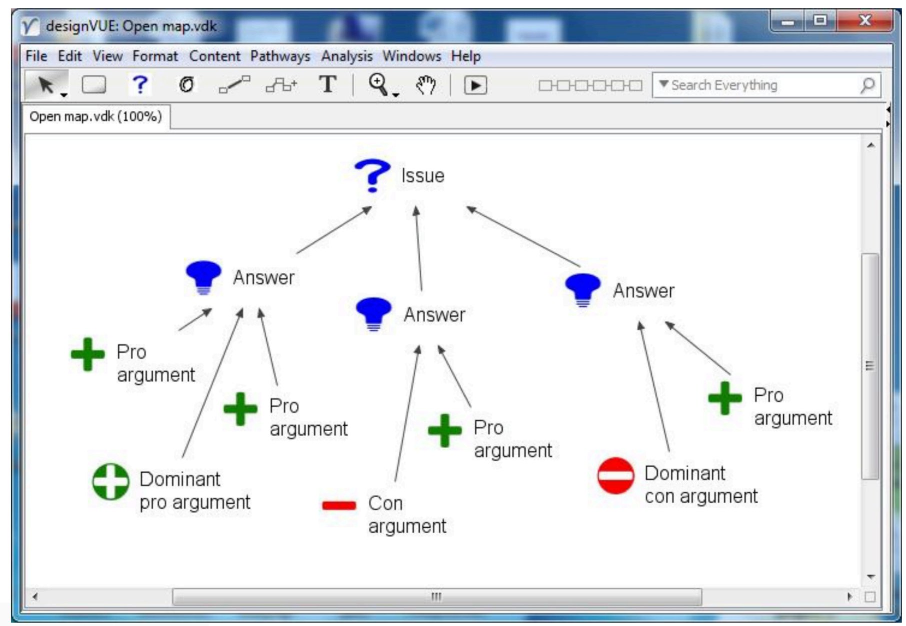


- designVUE [www3.imperial.ac.uk/designengineering/tools/designvue]
  - Debate mapping using IBIS graphs
  - Engineering design specific
  - Less limitations than Arg&Dec
  - Qualitative weighting measures



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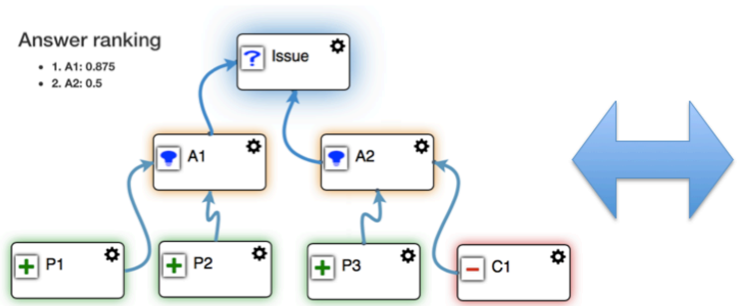

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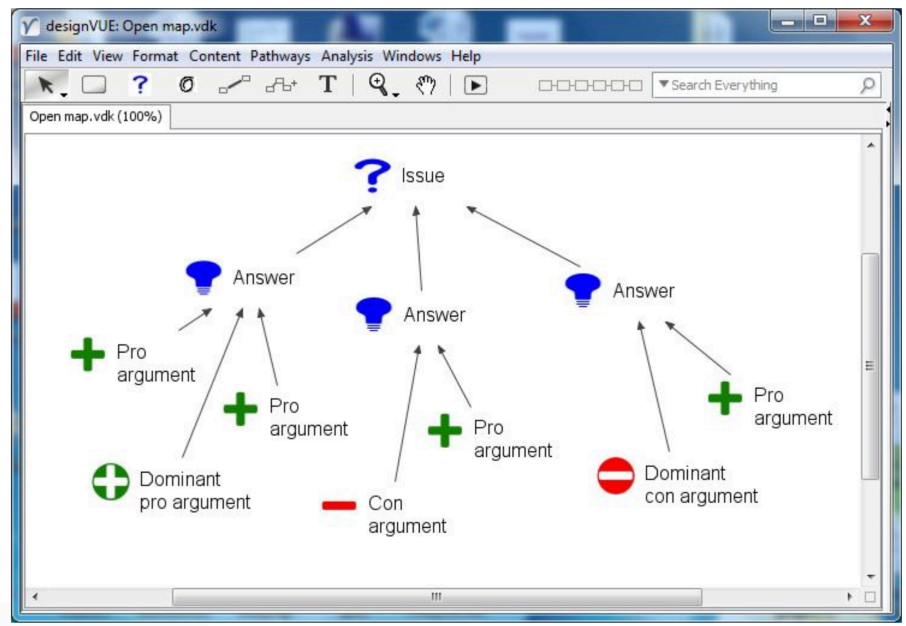

- Other Applications
  – E-Democracy
  – Argument Mining
  – Medical Decision Support
  – Legal Reasoning

Future Work

- Further development of the QuAD framework:
  - Voting
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- Relationships with other frameworks:
  - Matrix method [Aurisicchio et al. 2015]
  - Bipolar Argumentation Frameworks [Baroni et al. 2015; Amgoud et al. 2008]
  - Fuzzy Logic
  - Argumentation Labelling

Conclusions

- We have presented the DF-QuAD Algorithm:
  - Automatic evaluation within QuAD frameworks
  - Discontinuity-free algorithm
  - Shares many important properties with QuAD, and holds some new ones
  - Allows for reverse engineering

Thank You

Any Questions?