Computational Argumentation – Formal Models and Complexity Results

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Oct 14, 2020

TU WIEN Informatics

TECHNOLOGY

IBM's debating AI battles it out with human champion, wins

June 21, 2018 | 12:04 am

Font Size A A A

At an event held at IBM's Watson West site in San Francisco on June 18, champion debater Dan Zafrir (pictured) and IBM's AI system, Project Debater, began by preparing arguments for and against the statement: "We should subsidize space exploration." Both sides then delivered a four-minute opening statement, a four-minute rebuttal, and a two-minute summary. This video screenshot shows Zafrir as he listens to Project Debater's opening statement. -- IBM

SPOTLIGHT

Record-breaking €205M jackpot could be won from the Philippines

The Italian SuperEnalotto lottery is currently offering a €205.4 million jackpot prize, which is the biggest jackpot anywhere in the world at the moment...

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IBM's debating AI battles it out with human champion, wins - Mozilla Firefox

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BBC Radio 4 - Moral Maze,

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50 Years of the Abortion Act

Argument Analytics

Dig into the debate with tools from the Centre for Argument Technology at the University of Dundee.

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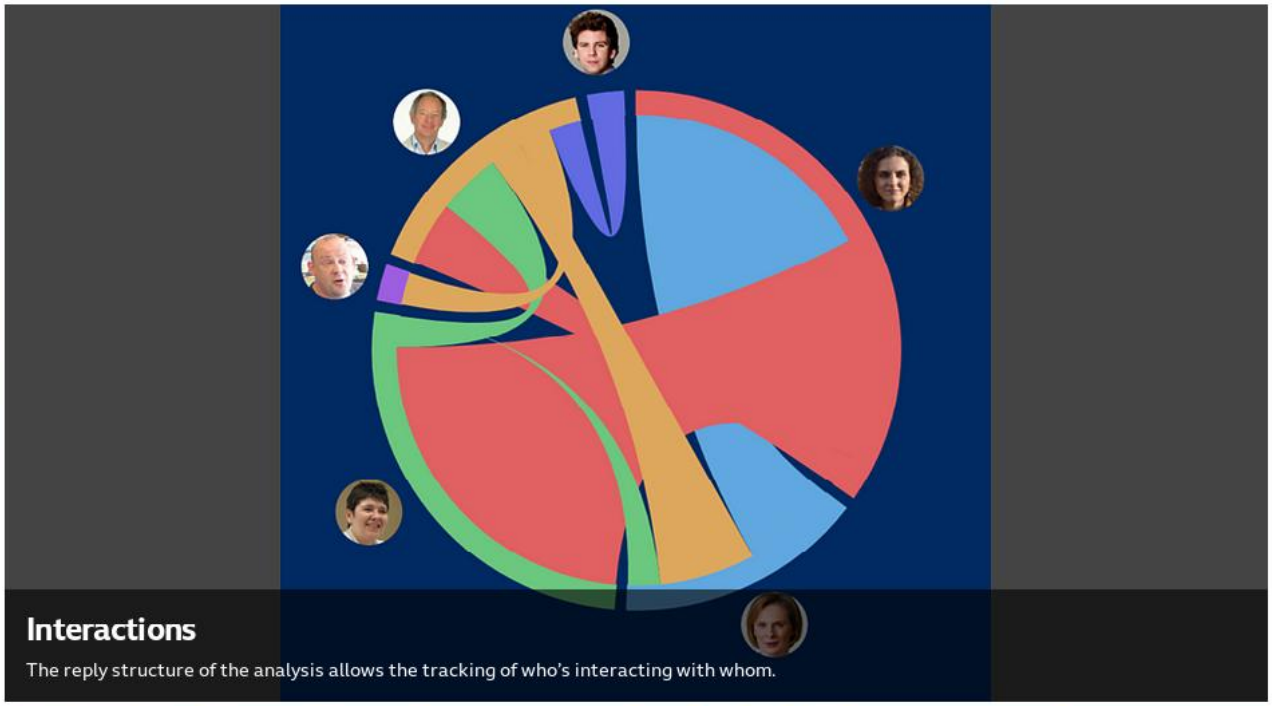
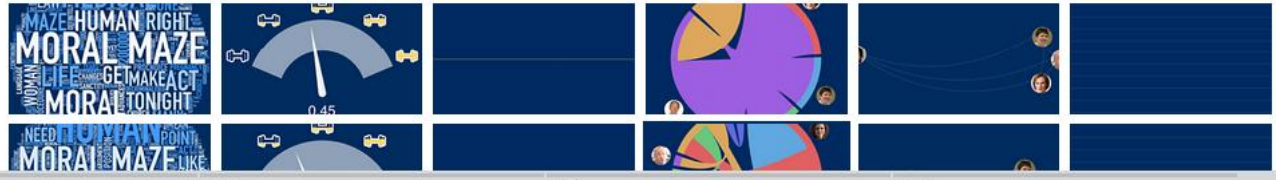


Interactions

The reply structure of the analysis allows the tracking of who's interacting with whom.



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Projects

Christian Biemann (Hamburg) Matthias Hagen (Halle)	ACQuA: Argumentation in Comparative Question Answering
Michael Kohlhase (Erlangen)	ALMANAC: Argumentation Logics Manager and Argument Context Graph
Torsten Zesch (Duisburg) Jürgen Ziegler (Duisburg)	Assure: Argument-Based Decision Support for Recommender Systems
Kristian Kersting (Dortmund) Matthias Thimm (Koblenz)	CALM: Argumentative Machine Learning
Anette Frank (Heidelberg) Heiner Stuckenschmidt (Mannheim)	ExpLAIN: Between the Lines - Knowledge-enhanced Argument Analysis in a Formal Argumentation Reasoning System
Elisabeth Andre (Augsburg) Wolfgang Minker (Ulm)	EVA: How to Win Arguments - Empowering Virtual Agents to Improve their Persuasiveness
Prof. Dr. Gerhard Heyer (Leipzig) Ringo Baumann (Leipzig) Gregor Wiedemann (Hamburg)	FAME: A Framework for Argument Mining and Evaluation
Sebastian Haunss (Bremen) Jonas Kuhn (Stuttgart) Sebastian Pado (Stuttgart)	MARDY: Modeling Argumentation Dynamics in Political Discourse
Iryna Gurevych (Darmstadt) Christian Stab (Darmstadt)	Open Argument Mining
Stefan Evert (Erlangen) Lutz Schröder (Erlangen)	RANT: Reconstructing Arguments from Noisy Text
Ralph Bergmann (Trier) Ralf Schenkel (Trier)	ReCAP: Information Retrieval and Case-Based Reasoning for Robust Deliberation and Synthesis of Arguments in the Political Discourse
Philipp Cimiano (Bielefeld)	RecomRatio: Rationalizing Recommendations

A First Definition

Argumentation is the study of processes "concerned with how assertions are proposed, discussed, and resolved in the context of issues upon which several diverging opinions may be held".
[Bench-Capon & Dunne: Argumentation in AI. Artif. Intell. 171:619-641, 2007]

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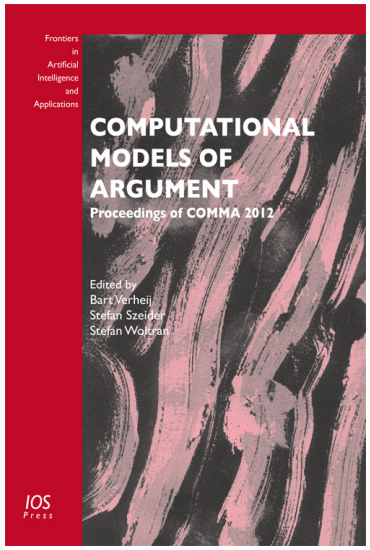

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[Bench-Capon & Dunne: Argumentation in AI. Artif. Intell. 171:619-641, 2007]

- Tasks: Decision Support/Making, Persuasion, Dialogues, Negotiation, Dialectical Reasoning, ..
- Challenges: inconsistency, inherently dynamic, empathy, strategic thinking, ...

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COMMA 2020

8th International Conference on Computational Models of Argument

8th - 11th September 2020

Venue

The conference will hold in Perugia, an historical city located in the center of Italy. Perugia, considered to be one of the most famous cities of Italy due to its rich history and its artistic treasures, has preserved noble signs of beauty and charm from the beginning right through to modern times which are clear witness of the splendour of its past. It hosts one of the oldest Italian universities.

How to reach Perugia

Important Dates

13 July: registration deadline for full/short/demo papers

31 August: registration deadline with no proceedings paper

31 August: deadline for receiving payment and finalizing registration (be aware that bank transfer needs some days)

News

SEPTEMBER 11, 2020

Change in programme:

13:45-15:00: Abstract approaches (2)

15:00-15:20: closing session

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Outline

- Vision: Informed Citizens in a Web of Arguments
- The Gold Standard: Dung's Argumentation Frameworks
- Beyond Dung: Acceptance Problems from a Claim-Centric View

Vienna Manifesto on Digital Humanism

Vienna, May 2019

"The system is failing" – stated by the founder of the Web, Tim Berners-Lee – emphasizes that while digitalization opens unprecedented opportunities, it also raises serious concerns: the monopolization of the Web, the rise of extremist opinions and behavior orchestrated by social media, the formation of filter bubbles and echo chambers as islands of disjoint truths, the loss of privacy, and the spread of digital surveillance. Digital technologies are disrupting societies and questioning our understanding of what it means to be human. The stakes are high and the challenge of building a just and democratic society with humans at the center of technological progress needs to be addressed with determination as well as scientific ingenuity. Technological innovation demands social innovation, and social innovation requires broad societal engagement.

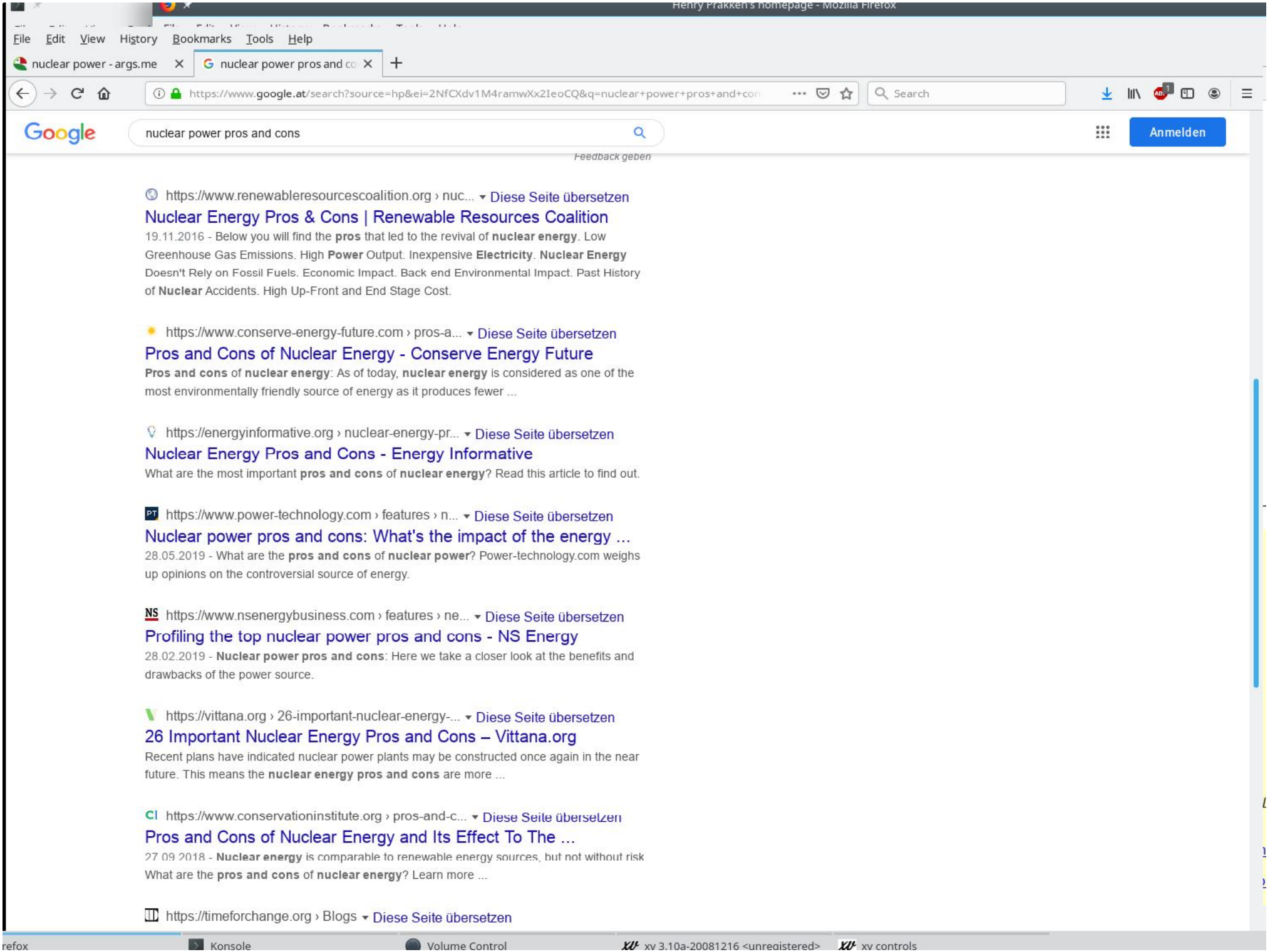
This manifesto is a call to deliberate and to act on current and future technological development. We encourage our academic communities, as well as industrial leaders, politicians, policy makers, and professional societies all around the globe, to actively participate in policy formation. Our demands are the result of an emerging process that unites scientists and practitioners across fields and topics, brought together by concerns and hopes for the future. We are aware of our joint responsibility for the current situation and the future – both as professionals and citizens.

Today, we experience the co-evolution of technology and humankind. The flood of data, algorithms, and computational power is disrupting the very fabric of society by changing human interactions, societal institutions, economies, and political structures. Science and the humanities are not exempt. This disruption simultaneously creates and threatens jobs, produces and destroys wealth, and improves and damages our ecology. It shifts power structures, thereby blurring the human and the machine.

The quest is for enlightenment and humanism. The capability to automate human cognitive activities is a revolutionary aspect of computer science / informatics. For many tasks, machines surpass already what humans can accomplish in speed, precision, and even analytic deduction. The time is right to bring together humanistic ideals with critical thoughts about technological progress. We therefore link this manifesto to the intellectual tradition of humanism and similar movements striving for an enlightened humanity.

Like all technologies, digital technologies do not emerge from nowhere. They are shaped by implicit and explicit choices and thus incorporate a set of values, norms, economic interests, and assumptions about how the world around us is or should be. Many of these choices remain hidden in software programs implementing algorithms that remain invisible. In line with the renowned Vienna Circle and its contributions to modern thinking, we want to espouse critical rational reasoning and the interdisciplinarity needed to shape the future.

We must shape technologies in accordance with human values and needs, instead of allowing technologies to shape humans. Our task is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Nuclear Energy Pros & Cons | Renewable Resources Coalition
19.11.2016 - Below you will find the pros that led to the revival of nuclear energy. Low Greenhouse Gas Emissions. High Power Output. Inexpensive Electricity. Nuclear Energy Doesn't Rely on Fossil Fuels. Economic Impact. Back end Environmental Impact. Past History of Nuclear Accidents. High Up-Front and End Stage Cost.
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What are the most important pros and cons of nuclear energy? Read this article to find out.
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Profiling the top nuclear power pros and cons - NS Energy
28.02.2019 - Nuclear power pros and cons: Here we take a closer look at the benefits and drawbacks of the power source.
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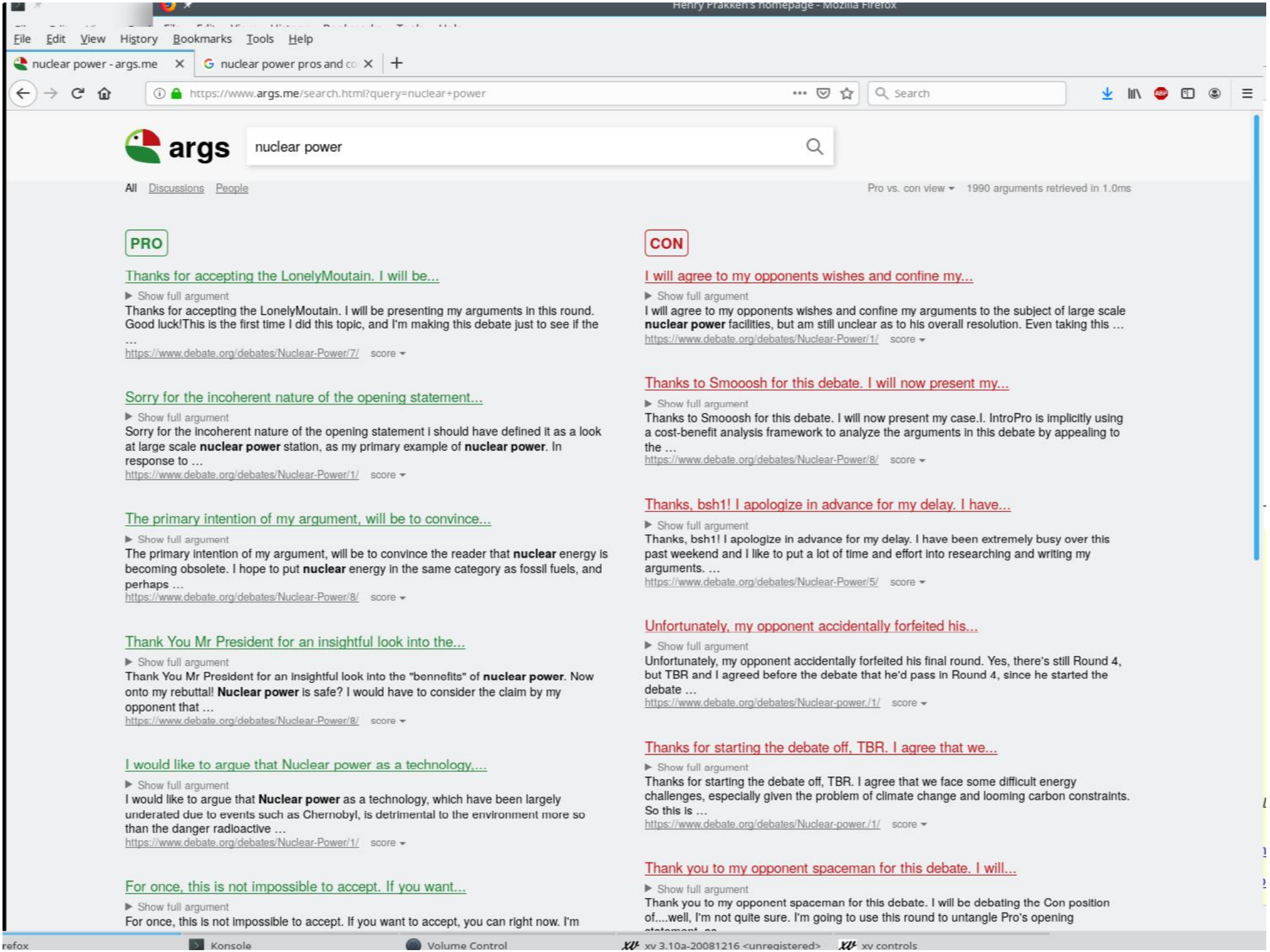
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All Discussions People
Pro vs. con view
1990 arguments retrieved in 1.0ms
PRO
Thanks for accepting the LonelyMoutain. I will be...
Show full argument
Thanks for accepting the LonelyMoutain. I will be presenting my arguments in this round. Good luck!This is the first time I did this topic, and I'm making this debate just to see if the ...
https://www.debate.org/debates/Nuclear-Power/7/ score
Sorry for the incoherent nature of the opening statement...
Show full argument
Sorry for the incoherent nature of the opening statement i should have defined it as a look at large scale nuclear power station, as my primary example of nuclear power. In response to ...
https://www.debate.org/debates/Nuclear-Power/1/ score
The primary intention of my argument, will be to convince...
Show full argument
The primary intention of my argument, will be to convince the reader that nuclear energy is becoming obsolete. I hope to put nuclear energy in the same category as fossil fuels, and perhaps ...
https://www.debate.org/debates/Nuclear-Power/8/ score
Thank You Mr President for an insightful look into the...
Show full argument
Thank You Mr President for an insightful look into the "bennefits" of nuclear power. Now onto my rebuttal! Nuclear power is safe? I would have to consider the claim by my opponent that ...
https://www.debate.org/debates/Nuclear-Power/8/ score
I would like to argue that Nuclear power as a technology,...
Show full argument
I would like to argue that Nuclear power as a technology, which have been largely underated due to events such as Chernobyl, is detrimental to the environment more so than the danger radioactive ...
https://www.debate.org/debates/Nuclear-Power/1/ score
For once, this is not impossible to accept. If you want...
Show full argument
For once, this is not impossible to accept. If you want to accept, you can right now. I'm
CON
I will agree to my opponents wishes and confine my...
Show full argument
I will agree to my opponents wishes and confine my arguments to the subject of large scale nuclear power facilities, but am still unclear as to his overall resolution. Even taking this ...
https://www.debate.org/debates/Nuclear-Power/1/ score
Thanks to Smooosh for this debate. I will now present my...
Show full argument
Thanks to Smooosh for this debate. I will now present my case.I. IntroPro is implicitly using a cost-benefit analysis framework to analyze the arguments in this debate by appealing to the ...
https://www.debate.org/debates/Nuclear-Power/8/ score
Thanks, bsh1! I apologize in advance for my delay. I have...
Show full argument
Thanks, bsh1! I apologize in advance for my delay. I have been extremely busy over this past weekend and I like to put a lot of time and effort into researching and writing my arguments. ...
https://www.debate.org/debates/Nuclear-Power/5/ score
Unfortunately, my opponent accidentally forfeited his...
Show full argument
Unfortunately, my opponent accidentally forfeited his final round. Yes, there's still Round 4, but TBR and I agreed before the debate that he'd pass in Round 4, since he started the debate ...
https://www.debate.org/debates/Nuclear-power./1/ score
Thanks for starting the debate off, TBR. I agree that we...
Show full argument
Thanks for starting the debate off, TBR. I agree that we face some difficult energy challenges, especially given the problem of climate change and looming carbon constraints. So this is ...
https://www.debate.org/debates/Nuclear-power./1/ score
Thank you to my opponent spaceman for this debate. I will...
Show full argument
Thank you to my opponent spaceman for this debate. I will be debating the Con position of....well, I'm not quite sure. I'm going to use this round to untangle Pro's opening
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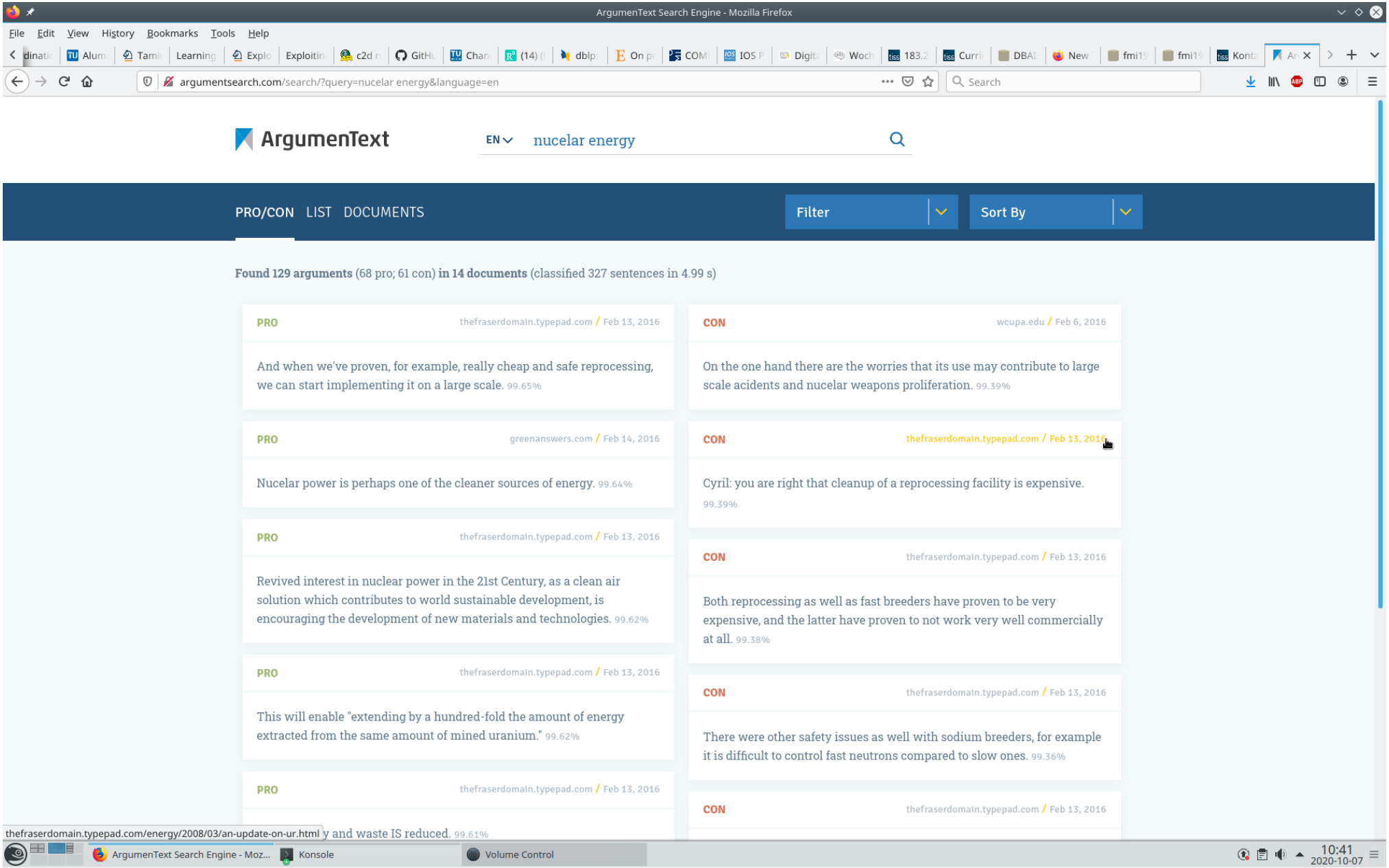
xv 3.10a-20081216 <unregistered>
xv controls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EN
nucelar energy
PRO/CON LIST DOCUMENTS
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Sort By
Found 129 arguments (68 pro; 61 con) in 14 documents (classified 327 sentences in 4.99 s)
PRO thefraserdomain.typepad.com / Feb 13, 2016
And when we've proven, for example, really cheap and safe reprocessing, we can start implementing it on a large scale. 99.65%
CON wcupa.edu / Feb 6, 2016
On the one hand there are the worries that its use may contribute to large scale acidents and nucelar weapons proliferation. 99.39%
PRO greenanswers.com / Feb 14, 2016
Nucelar power is perhaps one of the cleaner sources of energy. 99.64%
CON thefraserdomain.typepad.com / Feb 13, 2016
Cyril: you are right that cleanup of a reprocessing facility is expensive. 99.39%
PRO thefraserdomain.typepad.com / Feb 13, 2016
Revived interest in nuclear power in the 21st Century, as a clean air solution which contributes to world sustainable development, is encouraging the development of new materials and technologies. 99.62%
CON thefraserdomain.typepad.com / Feb 13, 2016
Both reprocessing as well as fast breeders have proven to be very expensive, and the latter have proven to not work very well commercially at all. 99.38%
PRO thefraserdomain.typepad.com / Feb 13, 2016
This will enable "extending by a hundred-fold the amount of energy extracted from the same amount of mined uranium." 99.62%
CON thefraserdomain.typepad.com / Feb 13, 2016
There were other safety issues as well with sodium breeders, for example it is difficult to control fast neutrons compared to slow ones. 99.36%
PRO thefraserdomain.typepad.com / Feb 13, 2016
CON thefraserdomain.typepad.com / Feb 13, 2016
thefraserdomain.typepad.com/energy/2008/03/an-update-on-ur.html
y and waste IS reduced. 99.61%
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Convincing? Not yet ...

- Further arguments might be needed to obtain a full picture
- Relation between arguments needs to be drawn on solid logical grounds
- Ultimately, this leads to a network of arguments instead of a simple list of pro and cons.

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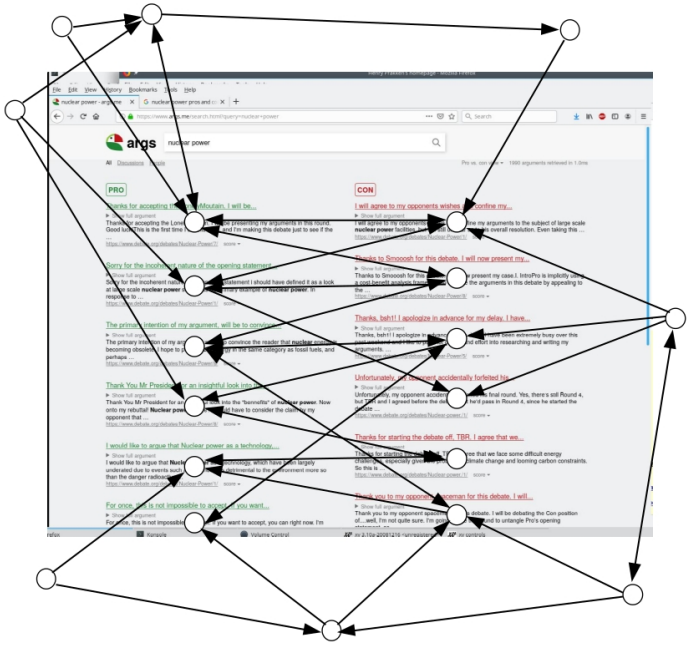
- Desiderata:



- Evaluation: which arguments are jointly acceptable?
- Short response times
- Good visualisation required (avoid bias)

Different AI Challenges

Computational Statistics

Computational Logic

Computational Complexity

Different AI Challenges

Computational Statistics

Computational Logic

Computational Complexity

Mine arguments from text

Different AI Challenges

Computational Statistics	Mine arguments from text
Computational Logic	Determine relations between arguments
Computational Complexity	

Different AI Challenges

Computational Statistics	Mine arguments from text
Computational Logic	Determine relations between arguments
Computational Complexity	Devise algorithms for acceptance problems

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On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games. Artif. Intell. 77(2):321–358, 1995.

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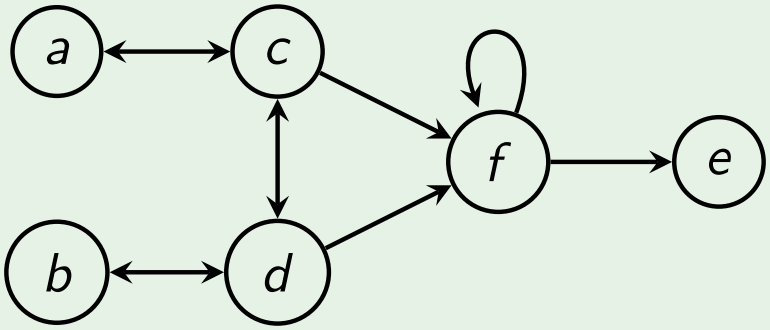
- "The purpose of this paper is to study the fundamental mechanism, humans use in argumentation, and to explore ways to implement this mechanism on computers."
- "The idea of argumentational reasoning is that a statement is believable if it can be argued successfully against attacking arguments."
- "[...] a formal, abstract but simple theory of argumentation is developed to capture the notion of acceptability of arguments."

Argumentation Frameworks

. . . thus abstract away from everything but attacks

Example



Argumentation Frameworks

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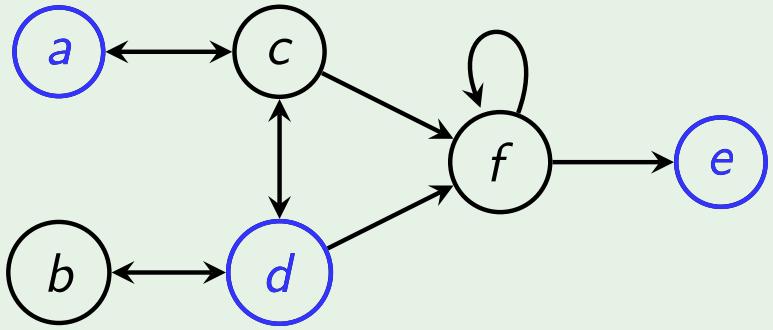

$stb(F) = \{\{a, d, e\},$

Argumentation Frameworks

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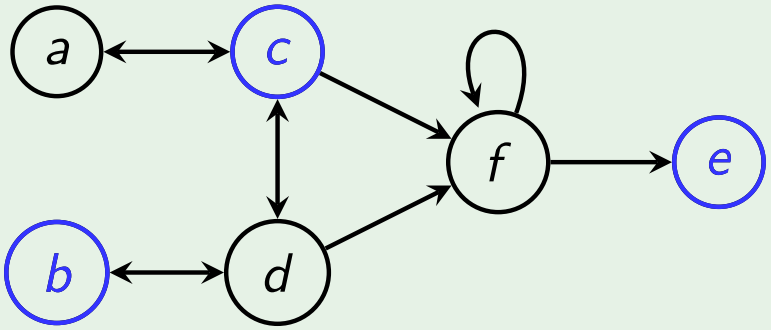
Example



$stb(F) = \{\{a, d, e\}, \{b, c, e\}\}$

Argumentation Frameworks

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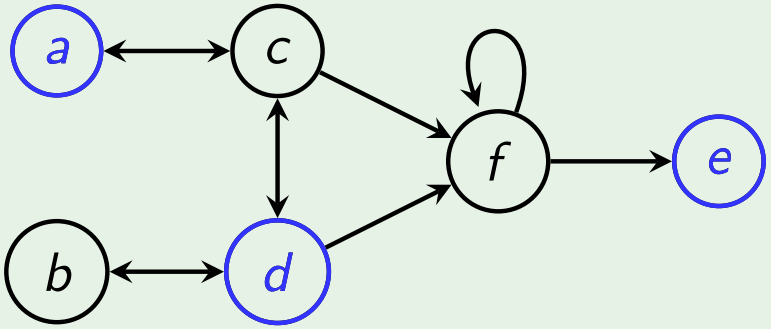
Example



$stb(F) = \{\{a, d, e\}, \{b, c, e\}\}$
$pref(F) = \{\{a, d, e\},$

Argumentation Frameworks

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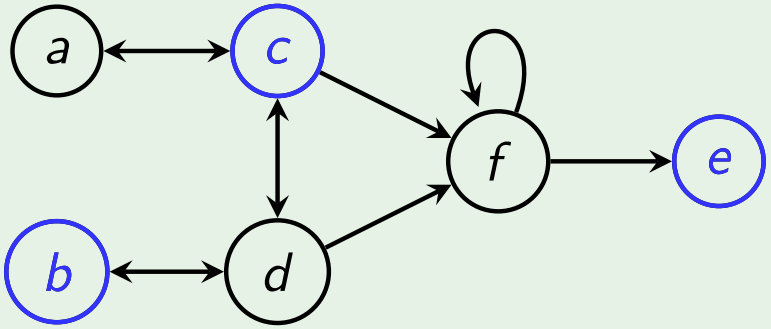
Example



$stb(F) = \{\{a, d, e\}, \{b, c, e\}\}$
$pref(F) = \{\{a, d, e\}, \{b, c, e\},$

Argumentation Frameworks

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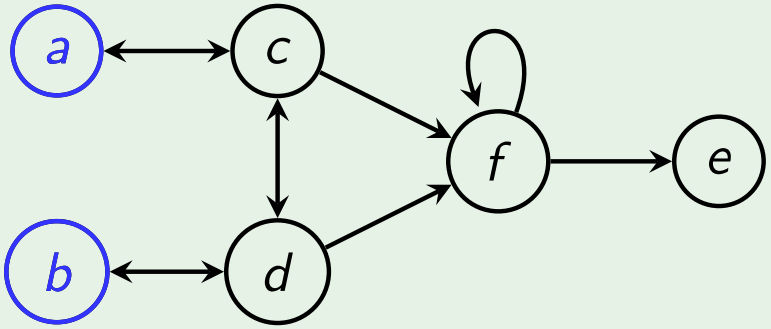
Example



$$stb(F) = \{\{a, d, e\}, \{b, c, e\}\}$$
$$pref(F) = \{\{a, d, e\}, \{b, c, e\}, \{a, b\}\}$$

Complexity Results – Dung AFs

Basic Decision Problems:

- $Cred_\sigma$: is an argument contained in some σ-extension?
- $Skept_\sigma$: is an argument contained in all σ-extensions?
- Ver_σ: is a set of arguments a σ-extension?

Complexity Results – Dung AFs

Basic Decision Problems:

- $Cred_\sigma$: is an argument contained in some σ-extension?
- $Skept_\sigma$: is an argument contained in all σ-extensions?
- Ver_σ: is a set of arguments a σ-extension?

σ	$Cred_\sigma$	$Skept_\sigma$	Ver_σ
cf	in P	trivial	in P
naive	in P	in P	in P
grd	P-c	P-c	P-c
stb	NP-c	coNP-c	in P
adm	NP-c	trivial	in P
comp	NP-c	P-c	in P
pref	NP-c	Π_2^P-c	coNP-c

We observe a certain gap:

- Due to the abstraction, reasoning is solely based on argument names, rather than on their claims
- in fact, several arguments might have the same claim
- thus, checking whether a claim is supported by every possible extension is a different problem compared to checking whether an argument is contained in every possible extension
- we propose a shift from an argument-centric view to a claim-centric view
- **how does this affect complexity of the basic decision problems?**[1]

[1] W. Dvořák and S. Woltran. Complexity of Abstract Argumentation under a Claim-Centric View. Artif. Intell. 285, 2020.

Argumentation Frameworks with Claims

Definition

A Claim-augmented Argumentation Framework (CAF) is a triple (A, R, γ) where (A, R) is an AF and $\gamma : A \to C$ maps arguments to claims.

Argumentation Frameworks with Claims

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A Claim-augmented Argumentation Framework (CAF) is a triple (A, R, γ) where (A, R) is an AF and $\gamma : A \to C$ maps arguments to claims.

Definition

For a semantics σ, we define its claim-based variant as follows:

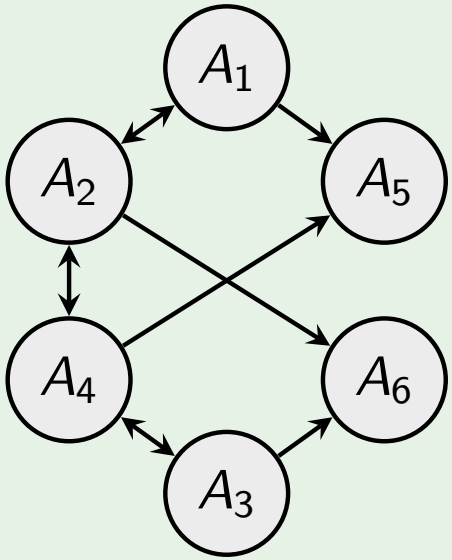
$$\sigma_c((A, R, \gamma)) = \{\gamma(S) \mid S \in \sigma((A, R))\}.$$

(Given a set $S \subseteq A$ of arguments and $\gamma : A \to C$, let $\gamma(S) = \{\gamma(a) \mid a \in S\}$.)

Example

Consider an ASPIC$^+$ knowledge base with premises $\mathcal{K}_p = \{b, \overline{b}, c, \overline{c}\}$ and strict rules $\mathcal{K}_s = \{\overline{b} \to a, \overline{c} \to a\}$.
Pairs $(b, \overline{b})$, $(c, \overline{c})$, $(\overline{b}, \overline{c})$ are contradictory.

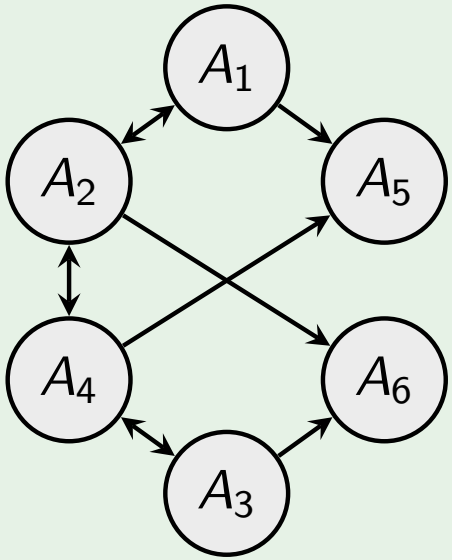
Arg.	support	claim
A_1	b	b
A_2	$\overline{b}$	$\overline{b}$
A_3	c	c
A_4	$\overline{c}$	$\overline{c}$
A_5	$\overline{b}$; $\overline{b} \to a$	a
A_6	$\overline{c}$; $\overline{c} \to a$	a



Example

Consider an ASPIC$^+$ knowledge base with premises $\mathcal{K}_p = \{b, \overline{b}, c, \overline{c}\}$ and strict rules $\mathcal{K}_s = \{\overline{b} \to a, \overline{c} \to a\}$.
Pairs $(b, \overline{b})$, $(c, \overline{c})$, $(\overline{b}, \overline{c})$ are contradictory.

Arg.	support	claim
A_1	b	b
A_2	$\overline{b}$	$\overline{b}$
A_3	c	c
A_4	$\overline{c}$	$\overline{c}$
A_5	$\overline{b}$; $\overline{b} \to a$	a
A_6	$\overline{c}$; $\overline{c} \to a$	a



Stable extensions of AF: $\{A_1, A_3\}$, $\{A_2, A_3, A_5\}$ and $\{A_1, A_4, A_6\}$.

Re-interpretation in terms of claims: $\{b, c\}$, $\{a, \overline{b}, c\}$ and $\{a, b, \overline{c}\}$.

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Pairs $(b, \overline{b})$, $(c, \overline{c})$, $(\overline{b}, \overline{c})$ are contradictory.

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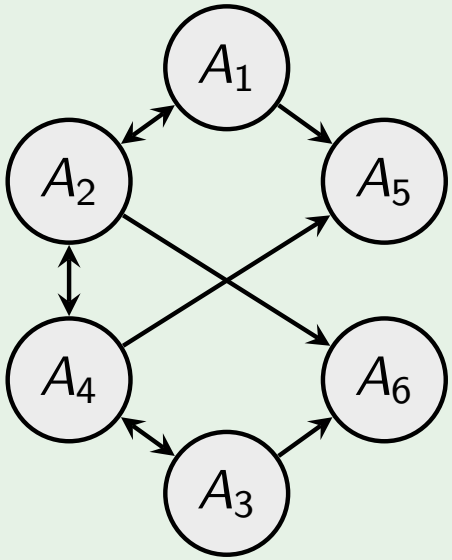
A_1	b	b
A_2	$\overline{b}$	$\overline{b}$
A_3	c	c
A_4	$\overline{c}$	$\overline{c}$
A_5	$\overline{b};\ \overline{b} \to a$	a
A_6	$\overline{c};\ \overline{c} \to a$	a



Stable extensions of AF: $\{A_1, A_3\}$, $\{A_2, A_3, A_5\}$ and $\{A_1, A_4, A_6\}$.

Re-interpretation in terms of claims: $\{b, c\}$, $\{a, \overline{b}, c\}$ and $\{a, b, \overline{c}\}$.

Observation: claim a appears in two extensions but different arguments are responsible for this.

Complexity Results – General CAFs

Decision Problems Reformulated:

- $Cred_\sigma$: is a claim contained in some σ-extension?
- $Skept_\sigma$: is a claim contained in all σ-extensions?
- Ver_σ: is a set of claims a σ-extension?

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σ	$Cred_\sigma$	$Skept_\sigma$	Ver_σ
cf	in P	trivial	**NP**-c
naive	in P	**coNP**-c	**NP**-c
grd	P-c	P-c	P-c
stb	NP-c	coNP-c	**NP**-c
adm	NP-c	trivial	**NP**-c
comp	NP-c	P-c	**NP**-c
pref	NP-c	Π_2^P-c	$\mathbf{\Sigma_2^P}$-c

Complexity Results

Theorem

Ver_{stb} is NP-complete.

Complexity Results

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Ver_{stb} is NP-complete.

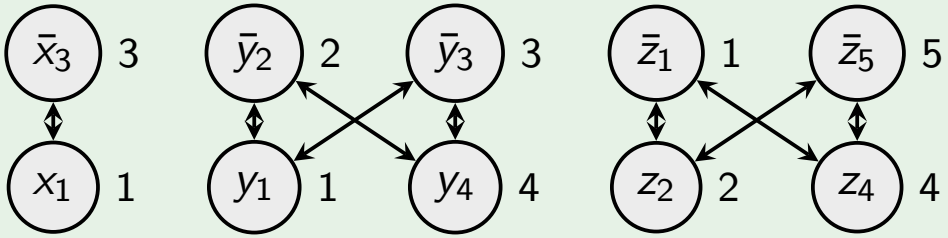
Proof Sketch (Hardness). We reduce from 3-SAT. Let φ be given as set $Cl = \{cl_1, \ldots, cl_m\}$ of clauses over atoms X. We construct a CAF $CAF = (A, R, \gamma)$ with the arguments given by the two sets $V = \{x_i \mid x \in X, x \in cl_i\}$ and $\bar{V} = \{\bar{x}_i \mid x \in X, \neg x \in cl_i\}$:

$$A = V \cup \bar{V} \quad R = \{(x_i, \bar{x}_j), (\bar{x}_j, x_i) \mid x_i \in V, \bar{x}_j \in \bar{V}\}$$

$$\gamma(x_i) = i \text{ for } x_i \in V \text{ and } \gamma(\bar{x}_i) = i \text{ for } \bar{x}_i \in \bar{V}.$$

It holds that φ is satisfiable iff $\{1, \ldots, m\}$ is stable.

Example: $\varphi = \{\{x, y, \neg z\}, \{\neg y, z\}, \{\neg x, \neg y\}, \{y, z\}, \{\neg z\}\}$.



Well-Formed Argumentation Frameworks with Claims

Definition

A CAF (A, R, γ) is called well-formed if, for any a, b with $\gamma(a) = \gamma(b)$, $\{c \mid (a, c) \in R\} = \{c \mid (b, c) \in R\}$.

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Instantiating ASPIC$^+$ knowledge bases always yields well-formed CAFs.

Example

Arg.	support	claim
A_1	b	b
A_2	$\overline{b}$	$\overline{b}$
A_3	c	c
A_4	$\overline{c}$	$\overline{c}$
A_5	$\overline{b}$; $\overline{b} \rightarrow a$	a
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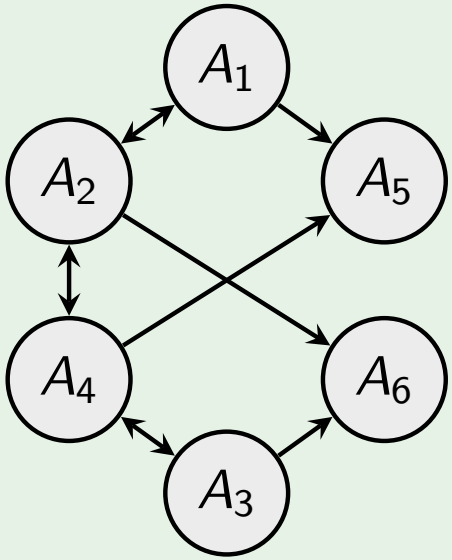

Complexity Results – Well-formed CAFs

Decision Problems Reformulated:

- $Cred_{\sigma}^{wf}$: is a claim contained in some σ-extension?
- $Skept_{\sigma}^{wf}$: is a claim contained in all σ-extensions?
- Ver_{σ}^{wf}: is a set of claims a σ-extension?

σ	$Cred_{\sigma}^{wf}$	$Skept_{\sigma}^{wf}$	Ver_{σ}^{wf}
cf	in P	trivial	in P
naive	in P	**coNP**-c	in P
grd	P-c	P-c	P-c
stb	NP-c	coNP-c	in P
adm	NP-c	trivial	in P
comp	NP-c	P-c	in P
pref	NP-c	Π_2^P-c	coNP-c

Complexity Results – Well-formed CAFs

graph class	task	*naive*	*stb*	*adm*	*comp*	*pref*
acyclic	$Cred_\sigma^{wf}$	in P	P-c	P-c	P-c	P-c
	$Skept_\sigma^{wf}$	**coNP**-c	P-c	trivial	P-c	P-c
	Ver_σ^{wf}	in P	in P	in P	in P	in P
noeven	$Cred_\sigma^{wf}$	in P	P-c	P-c	P-c	P-c
	$Skept_\sigma^{wf}$	**coNP**-c	P-c	trivial	P-c	P-c
	Ver_σ^{wf}	in P	in P	in P	in P	in P
symmetric & irreflexive	$Cred_\sigma^{wf}$	in P	in P	in P	in P	in P
	$Skept_\sigma^{wf}$	in P	in P	trivial	in P	in P
	Ver_σ^{wf}	in P	in P	in P	in P	in P
symmetric	$Cred_\sigma^{wf}$	in P	NP-c	in P	in P	in P
	$Skept_\sigma^{wf}$	in P	**coNP**-c	trivial	in P	in P
	Ver_σ^{wf}	in P	in P	in P	in P	in P
bipartite	$Cred_\sigma^{wf}$	in P	P-c	P-c	P-c	P-c
	$Skept_\sigma^{wf}$	**coNP**-c	**coNP**-c	trivial	P-c	**coNP**-c
	Ver_σ^{wf}	in P	in P	in P	in P	in P

Parameterized Complexity Results (1)

Theorem

$Cred_\sigma$, $Skept_\sigma$, Ver_σ maintain their full complexity for CAFs with only two claims (exception Ver_{cf}).

Theorem

$Cred_\sigma^{wf}$, $Skept_\sigma^{wf}$, and Ver_σ^{wf} can be solved in time $O(2^{|k|} \cdot poly(n))$ and CAFs (A, R, γ) with $n = |A|$ and $|\gamma(A)| \leq k$.

Parameterized Complexity Results (2)

Theorem

$Cred_\sigma$, $Skept_\sigma$ and Ver_σ^{wf} are fixed-parameter tractable w.r.t. the tree-width of the CAF.

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Ver_σ is NP-hard for graphs of tree-width 1.

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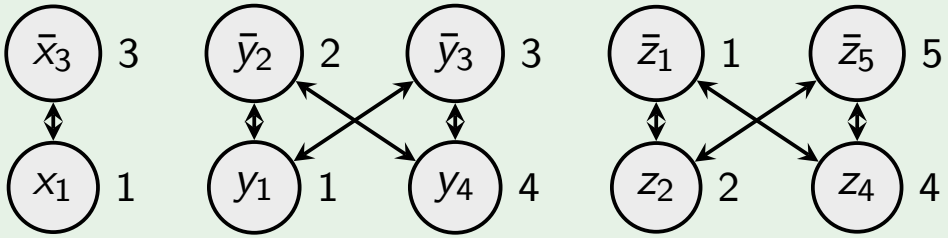
Theorem

Ver_σ is NP-hard for graphs of tree-width 1.

Proof Sketch: 3-SAT is NP-hard even for formulas where each variable occurs at most 3 times. Reusing our reduction yields trees. Recall:

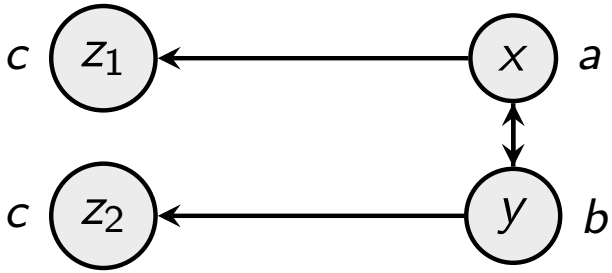
Example: $\varphi = \{\{x, y, \neg z\}, \{\neg y, z\}, \{\neg x, \neg y\}, \{y, z\}, \{\neg z\}\}$.



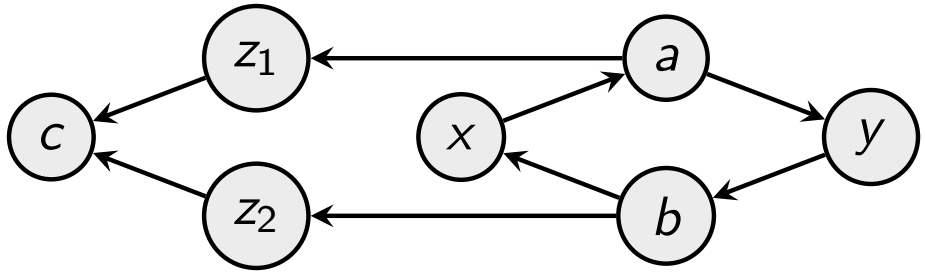
Parameterized Complexity Results (3)

Definition

For a well-formed $CAF = (A, R, \gamma)$ let $G_{CAF} = (V, E)$ with $V = A \cup \gamma(A)$ and $E = \{(a, \gamma(a)) \mid a \in A\} \cup \{(c, a) \mid (b, a) \in R, \gamma(b) = c\}$.



CAF $CAF = (A, R, \gamma)$



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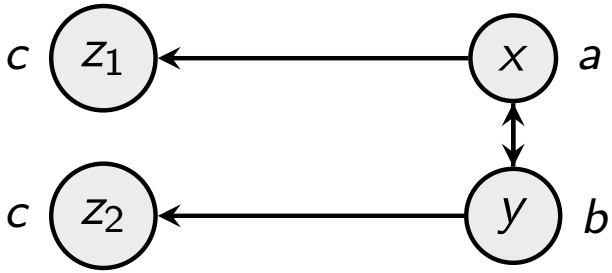

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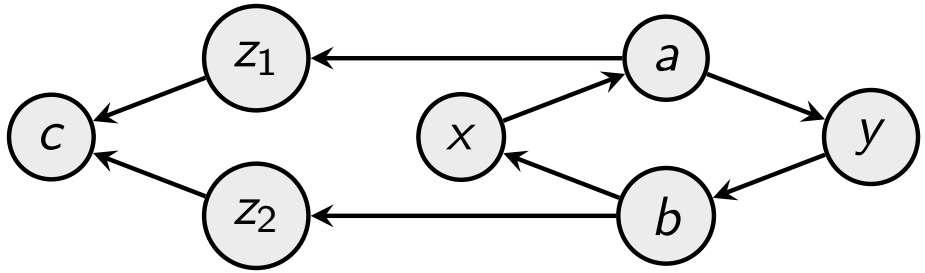

$G_{CAF} = (V, E)$

Theorem

$Cred^{wf}_{\sigma}$, $Skept^{wf}_{\sigma}$, and Ver^{wf}_{σ} are fixed-parameter tractable w.r.t. tree-width of G_{CAF} (i.e. incidence tree-width of CAF).

Parameterized Complexity Results (3) ctd.

The class of CAFs with bounded tree-width is incomparable with the class of CAFs with bounded incidence tree-width.

Parameterized Complexity Results (3) ctd.

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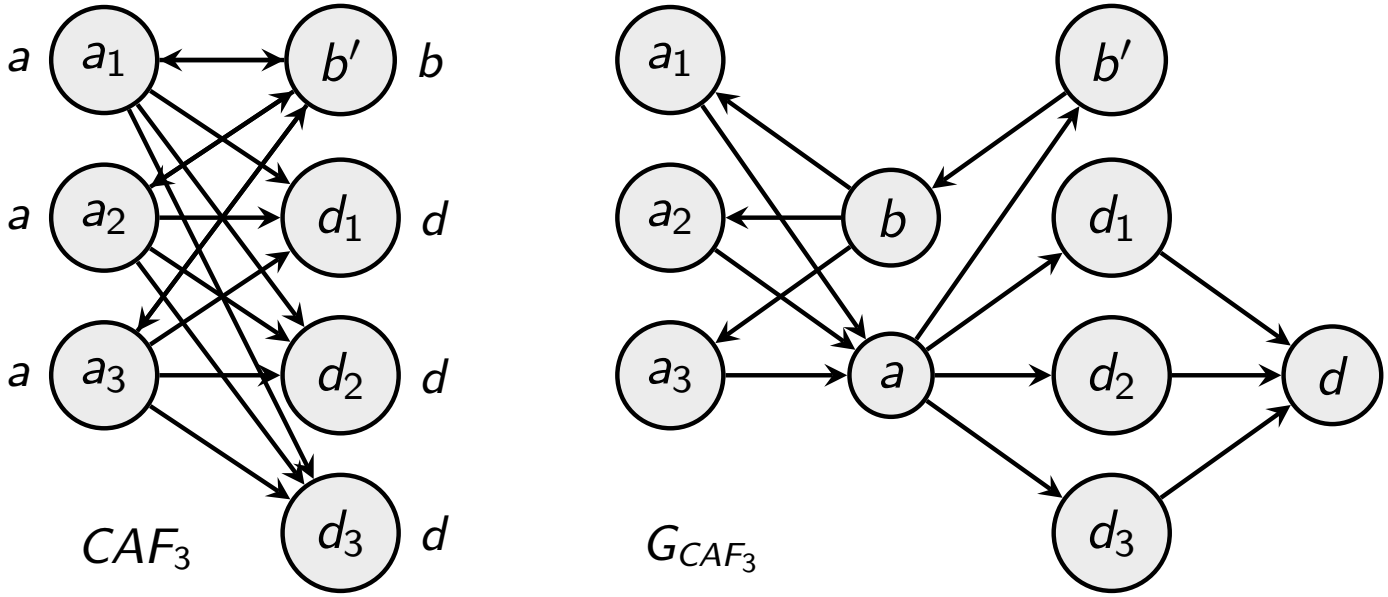
Consider bipartite well-formed CAFs $CAF_k = (A, R, \gamma)$ with $A = \{b'\} \cup \{a_i, d_i \mid 1 \leq i \leq k\}$, $R = \{(a_i, b'), (a_i, d_j), (b', a_i) \mid 1 \leq i, j \leq k\}$, and with $\gamma(a_i) = a$, $\gamma(b') = b$ and $\gamma(d_i) = d$. The tree-width of CAF_k increases with k, i.e. $tw((A, R)) \geq k - 1$, since we have a k-clique as graph minor. But as we only use 3 claims and deleting the claims leaves only isolated vertices in G_{CAF_k}, the incidence tree-width of CAF_k is ≤ 3.



Parameterized Complexity Results (3) ctd.

Consider the well-formed CAFs $CAF_k = (A, R, \gamma)$ with
$A = \{x_i, y_{i,j} \mid 1 \leq i, j \leq k, i \neq j\}$ and $R = \{(x_i, y_{i,j}) \mid 1 \leq i, j \leq k, i \neq j\}$.
We have $tw(CAF_k) = 1$. Let $\gamma(x_i) = c_i$ and $\gamma(y_{i,j}) = \gamma(y_{j,i}) = c_{\max(i,j),\min(i,j)}$.
Then, $tw(G_{CAF_k}) \geq k - 1$, as G_{CAF_k} has a k-clique as graph minor.

Parameterized Complexity Results (3) ctd.

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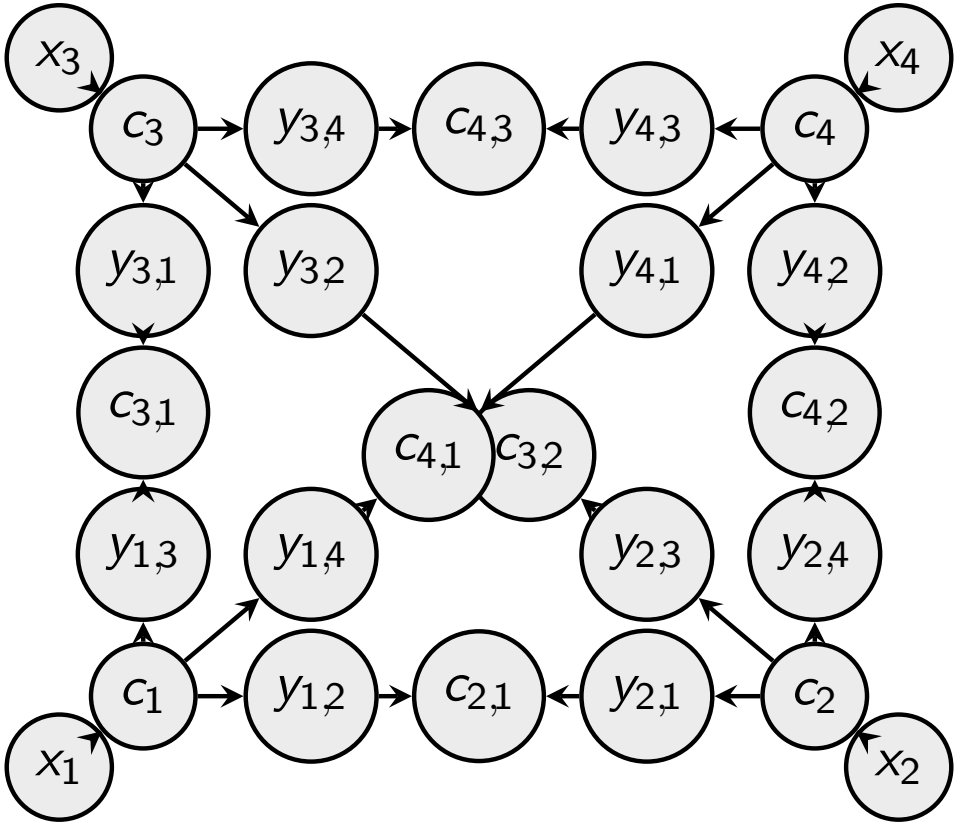


Ongoing Work

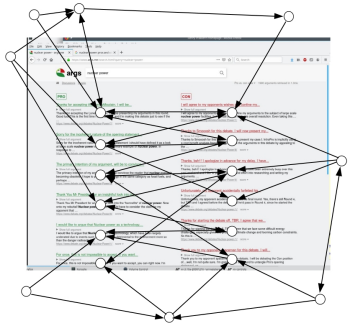
- Translation of CAFs to AFs with collective attacks (SETAFs)[2]
  - Note: there is increasing interest in SETAFs within the community
- Alternative semantics for CAFs[3]
  - For instance, doing maximization on the claim level instead of the argument level
- Further subclasses of CAFs
- Investigation of advanced reasoning problems on CAFs (enforcement, incomplete frameworks, ...)

[2] W. Dvořák, A. Rapberger and S. Woltran: On the Relation Between Claim-Augmented Argumentation Frameworks and Collective Attacks. ECAI 2020.

[3] W. Dvořák, A. Rapberger and S. Woltran: Argumentation Semantics under a Claim-centric View: Properties, Expressiveness and Relation to SETAFs. KR 2020.

Summary

- Formulated a vision towards a Web of Arguments



- Proposal for a core formalism to evaluate a network of arguments under a claim-centric view

- Thorough complexity analysis
  - Verification becomes harder for general CAFs
  - Well-formed CAFs show same complexity as Dung AFs (but there are deviations when subclasses are considered)
  - Parameterized complexity results