

MULTI-WINNER VOTING: REPRESENTATION, MANIPULATION, DELIBERATION

PhD Defense of **Oliviero Nardi**

DBAI, **TU Wien** – 16 October, 2026

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Multi-Winner Voting: Representation, Manipulation, Deliberation

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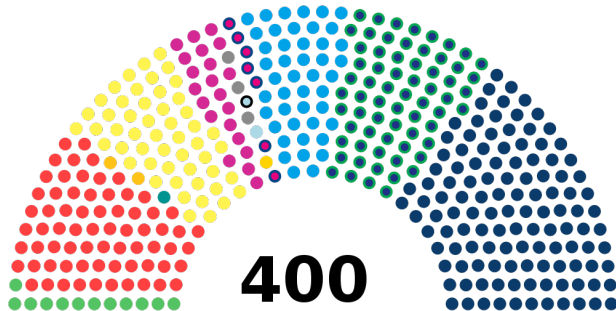


Multi-Winner Voting: Representation, Manipulation, Deliberation

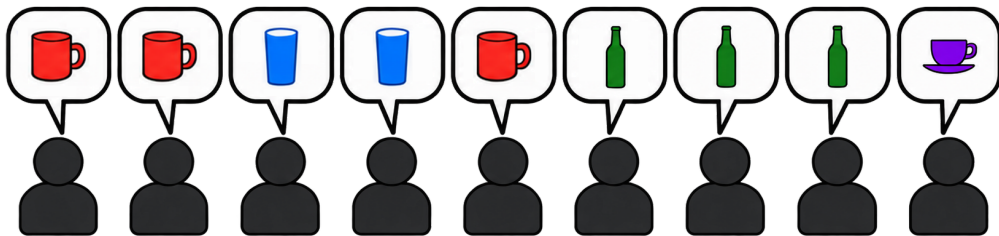
Multi-Winner Voting:

Representation, Manipulation, Deliberation









MajoritarianMango

In systems with PR, opinions are too strongly divided and nothing gets done.

ProportionalParrot

A party's share of seats in the House of Commons should reflect its share of the popular vote.

PastTheP

FPTP results

SingleTransfer

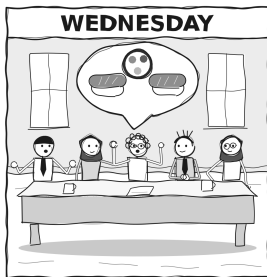
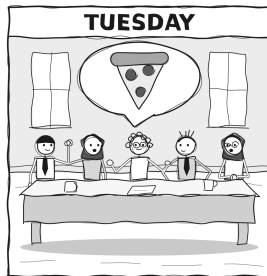
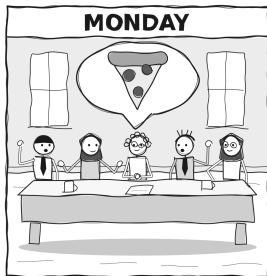
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JohnCitizen

PR will reduce wild policy swings and result in more long-lasting policies.

VDHondt41

PR will reduce hyper-partis promote cooperation between parties.





Multi-Winner Voting

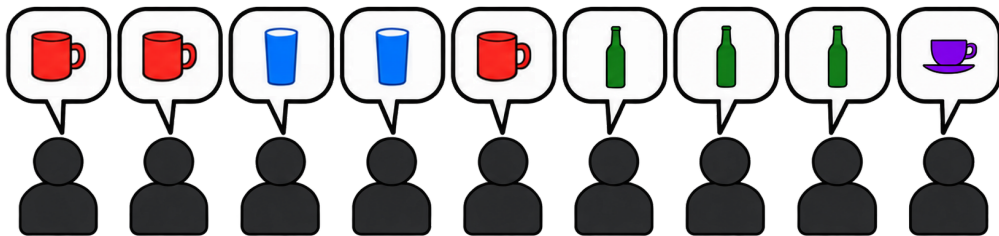
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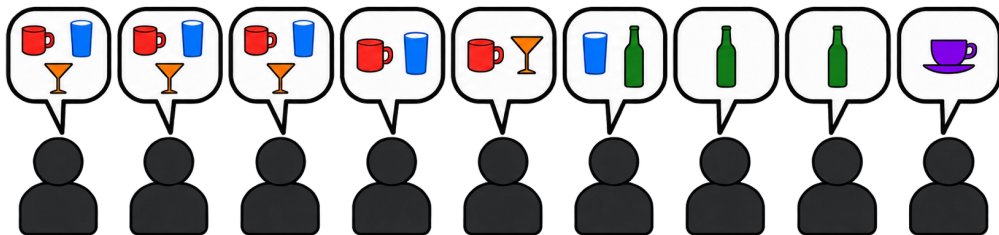
Representation, Manipulation, Deliberation

(Approval-Based)

Multi-Winner Voting:

Representation, Manipulation, Deliberation





**Vote for any number
of options.**

☐

Joe Smith

☒

John Citizen

☐

Jane Doe

☐

Fred Rubble

☒

Mary Hill



(Approval-Based)

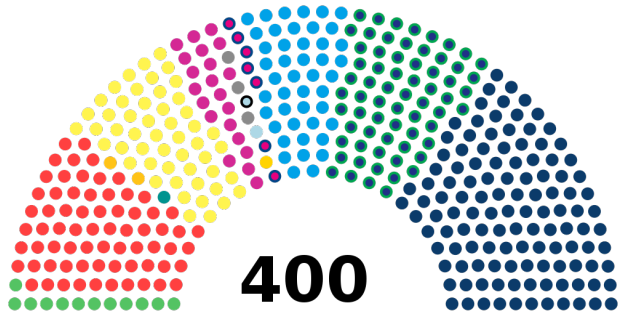
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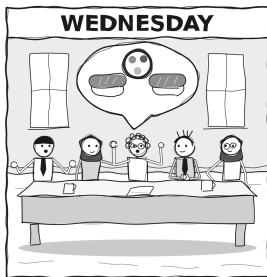
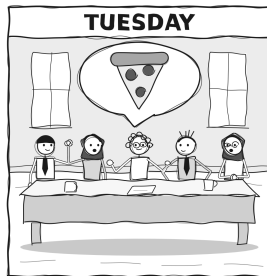
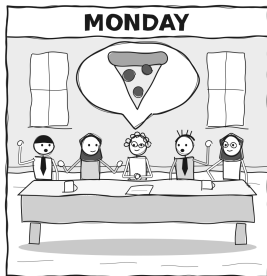
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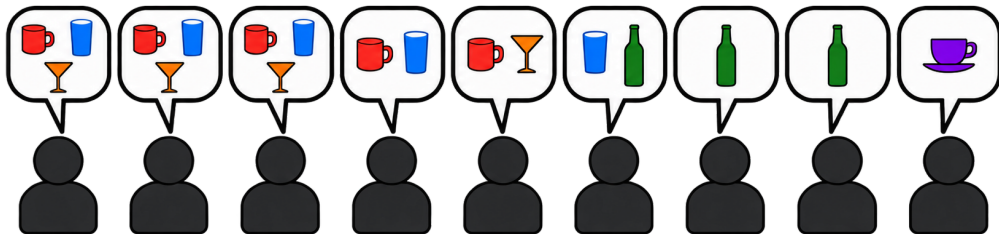
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(Approval-Based)
Multi-Winner Voting:
Representation, Manipulation, Deliberation

1. REPRESENTATION



COMMITTEE VOTING, INFORMALLY



COMMITTEE VOTING, FORMALLY

- Voters $N = \{1, 2, \dots, n\}$
- Alternatives $C = \{a, b, c, \dots\}$
- Target committee size $k \in \mathbb{N}$
- Each voter $i \in N$ submits an approval ballot $A_i \subseteq C$
- Collectively, we have a profile of preferences $\mathbf{A} = (A_1, A_2, \dots, A_n)$
- A voting rule F maps each profile $\mathbf{A}$ to a winning committee $W \subseteq C$ with $|W| = k$

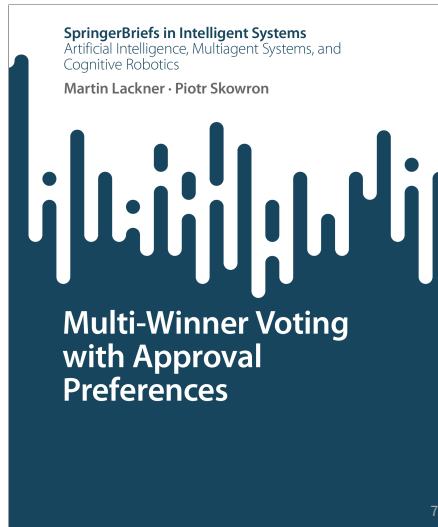
Additionally, we define $N(c) = \{i \in N : c \in A_i\}$.

THE STANDARD CONCEPTION: AVOIDING UNDERREPRESENTATION

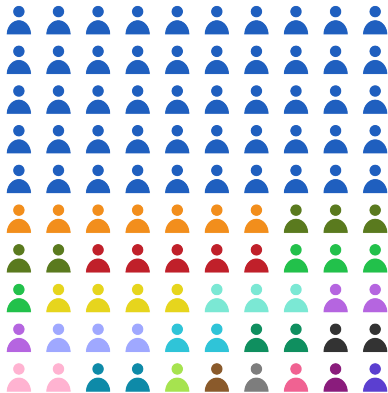
‘if a cohesive group of voters makes up $x\%$ of the population,
then it should get at least $x\%$ of the seats’

AVOIDING UNDERREPRESENTATION: STATE OF THE ART

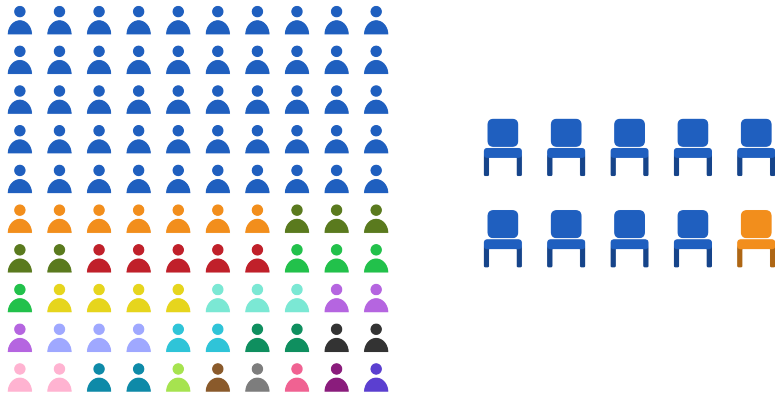
- Well-understood and formalised
 - Extended Justified Representation (EJR)
 - EJR+
 - Priceability
- Natural and appealing rules provably satisfy it
 - Proportional Approval Voting
 - Phragmén's Rule
 - Method of Equal Shares
- **We argue:** Not the last word on representation!



A PROBLEM WITH 'REPRESENTATIVE' RULES



A PROBLEM WITH ‘REPRESENTATIVE’ RULES



ANOTHER CONCEPTION: AVOIDING OVERREPRESENTATION

‘if a cohesive group of voters makes up $x\%$ of the population,
then it should **not** decide more than $x\%$ of the seats’

WHY AVOIDING OVERREPRESENTATION?

- Fairness:
 - Prevents groups from having ‘too much’ power
 - Avoids ‘envy’
- Might prevent strategic ‘bullet voting’
- Technical applications
 - Safety in blockchain technologies

N. Boehmer, M. Brill, A. Cevallos, J. Gehrlein, L. Sánchez-Fernández, and U. Schmidt-Kraepelin. Approval-Based Committee Voting in Practice: A Case Study of (Over-)Representation in the Polkadot Blockchain. In *Proceedings of the 38th AAAI Conference on Artificial Intelligence (AAAI-2024)*, pages 9519–9527. AAAI Press, 2024.

FORMALISING OVERREPRESENTATION

‘if a cohesive group of voters makes up $x\%$ of the population,
then it should not decide more than $x\%$ of the seats’

OVERREPRESENTATION: TENTATIVE DEFINITION

In a winning committee W , for every $c \in W$,
the group of voters $N(c)$ should not have
 $|A_i \cap W| > \left\lceil k \frac{|N(c)|}{n} \right\rceil$ for all $i \in N(c)$.

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$$|A_i \cap W| > \left\lceil k \frac{|N(c)|}{n} \right\rceil \text{ for all } i \in N(c).$$

THE DEFINITION HAS A BUG

Say we want to select $k = 6$ candidates. Consider the following profile:

- $A_1 = \{a, b, c\}$
- $A_2 = \{d, e, f\}$
- $A_3 = \{g\}$

Each voter can get at most $\lceil 6 \cdot \frac{1}{3} \rceil = 2$ candidates. Any committee overrepresents some voter:

- $\{a, b, c, d, e, f\}$ overrepresents voter 1 and voter 2
- $\{a, b, c, d, e, g\}$ overrepresents voter 1
- etc...

JUSTIFIED UPPER QUOTA (JUQ)

In a winning committee W , for every $c \in W$, if the group of voters $N(c)$ has

$$|A_i \cap W| > \left\lceil k \frac{|N(c)|}{n} \right\rceil \quad \text{for all } i \in N(c),$$

then there cannot be $d \in C \setminus W$ and $N' \subseteq N(d)$ such that

$$|A_i \cap W \setminus \{c\} \cup \{d\}| \leq \left\lceil k \frac{|N'|}{n} \right\rceil \quad \text{for all } i \in N'.$$

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then there cannot be $d \in C \setminus W$ and $N' \subseteq N(d)$ **such that**

$$|A_i \cap W \setminus \{c\} \cup \{d\}| \leq \left\lceil k \frac{|N'|}{n} \right\rceil \quad \text{for all } i \in N'.$$

JUQ FIXES THE BUG...

Let $k = 6$ and consider again:

- $A_1 = \{a, b, c\}$
- $A_2 = \{d, e, f\}$
- $A_3 = \{g\}$

Recall: each voter can get at most $\lceil 6 \cdot \frac{1}{3} \rceil = 2$ candidates.

Committee $\{a, b, c, d, e, g\}$ **satisfies** JUQ:

- **Voter 1** is overrepresented, must kick out c
- But: **voter 2** already at quota
- Thus, no need to swap c with f

...BUT NOT TRIVIALY SO!

Let $k = 6$ and consider again:

- $A_1 = \{a, b, c\}$
- $A_2 = \{d, e, f\}$
- $A_3 = \{g\}$

Recall: each voter can get at most $\lceil 6 \cdot \frac{1}{3} \rceil = 2$ candidates.

Committee $\{a, b, c, d, e, f\}$ **fails** JUQ:

- **Voter 1** is overrepresented, must kick out c
- **Voter 3** is underrepresented
- Thus, must swap c with g

WHICH RULES SATISFY JUQ?

Definition

Given a non-increasing $\omega: \mathbb{N} \rightarrow \mathbb{R}_{\geq 0}$, the ω -Thiele rule picks a committee maximising

$$\sum_{i \in N} \sum_{\ell=1}^{|A_i \cap W|} \omega(\ell)$$

Examples:

- **Approval Voting:** $\omega(\ell) = (1, 1, 1, \dots)$
- **Proportional Approval Voting:** $\omega(\ell) = (1, \frac{1}{2}, \frac{1}{3}, \dots)$
- **Chamberlin-Courant:** $\omega(\ell) = (1, 0, 0, \dots)$

TERRIFYING NEWS

Proposition

No Thiele rule satisfies JUQ.

EXTENDING THIELE RULES

We define **composite Thiele rules**, which work in stages of tiebreaking:

Definition

Given a **sequence** of non-increasing $\omega_1, \omega_2, \dots: \mathbb{N} \rightarrow \mathbb{R}_{\geq 0}$, the corresponding composite Thiele rule picks a committee as follows:

1. First, select **all** committees maximising the score of ω_1 ;
2. Among those, select all committees maximising the score of ω_2 ;
3. Repeat until you are left with a single committee (or without scoring functions).

Theorem

*There is a **unique** composite Thiele rule that satisfies JUQ: we called it **Adams Approval Voting**.*

ADAMS APPROVAL VOTING: DEFINITION

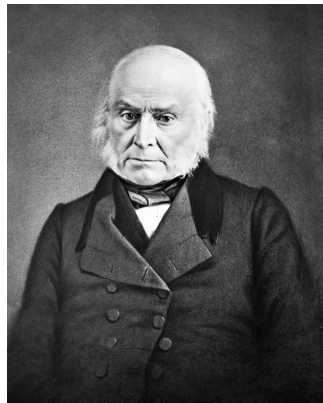
The rule is named after the sixth president of the United States, John Quincy Adams, and the electoral formula he proposed.

Definition

Adams Approval Voting is the composite Thiele rule defined by

1. $\omega_1(\ell) = (1, 0, 0, 0, 0, \dots)$ and
2. $\omega_2(\ell) = (1, 1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \dots)$.

We adapt it from parliamentary elections to committee voting.



ADAMS APPROVAL VOTING: EXPLANATION

Concretely, the rule proceeds as follows:

1. Select all committees W maximising the number of ‘covered’ voters, i.e., that maximise

$$|\{i \in N : A_i \cap W \neq \emptyset\}|$$

2. Among those, select all committees W' that maximise

$$\sum_{i \in N} \sum_{\ell=2}^{|A_i \cap W'|} \frac{1}{\ell - 1}$$

OTHER RESULTS: OVERREPRESENTATION

- We show that one can find a JUQ committee in polynomial time
- Another perspective on representation: balancing over- and underrepresentation
 - We introduce another axiom, **justified near quota**
 - Analogous results: Only Sainte-Laguë-AV satisfies it
- Relationship between our axioms and established underrepresentation axioms (e.g., EJR+)
 - We show that some natural avenues in proving compatibility fail

... And **many** other results!

2. MANIPULATION



SEQUENTIAL VOTING

- Voters $N = \{1, 2, \dots, n\}$ (fixed throughout)
- Pre-set number of rounds $k \in \mathbb{N}$:
 - Alternatives C_1
 - Alternatives C_2
 - ...
 - Alternatives C_k
- For each round r , every voter $i \in N$ submits an approval ballot $A_i^r \subseteq C_r$

SEQUENTIAL VOTING

- Voters $N = \{1, 2, \dots, n\}$ (fixed throughout)
- Pre-set number of rounds $k \in \mathbb{N}$:
 - Alternatives $C_1 = \{a, b, c, \dots\}$
 - Alternatives $C_2 = \{\blacktriangle, \blacksquare, \blacklozenge, \dots\}$
 - ...
 - Alternatives $C_k = \{\bullet, \bullet, \bullet, \dots\}$
- For each round r , every voter $i \in N$ submits an approval ballot $A_i^r \subseteq C_r$

SEQUENTIAL VOTING: MAJORITY RULE

Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice				
Rabbit				
Hatter				
Carroll				
Winner				

SEQUENTIAL VOTING: MAJORITY RULE

Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice	$\{a, b\}$			
Rabbit	$\{a, c\}$			
Hatter	$\{a\}$			
Carroll	$\{b\}$			
Winner				

SEQUENTIAL VOTING: MAJORITY RULE

Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice	$\{a, b\}$			
Rabbit	$\{a, c\}$			
Hatter	$\{a\}$			
Carroll	$\{b\}$			
Winner	a			

SEQUENTIAL VOTING: MAJORITY RULE

Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice	$\{a, b\}$	$\{b\}$		
Rabbit	$\{a, c\}$	$\{b, c\}$		
Hatter	$\{a\}$	$\{a, b\}$		
Carroll	$\{b\}$	$\{a, c\}$		
Winner	a			

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Alice	$\{a, b\}$	$\{b\}$		
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Hatter	$\{a\}$	$\{a, b\}$		
Carroll	$\{b\}$	$\{a, c\}$		
Winner	a	b		

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Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice	$\{a, b\}$	$\{b\}$	$\{a, c\}$	
Rabbit	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	
Hatter	$\{a\}$	$\{a, b\}$	$\{c\}$	
Carroll	$\{b\}$	$\{a, c\}$	$\{a, b\}$	
Winner	a	b		

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Carroll	$\{b\}$	$\{a, c\}$	$\{a, b\}$	
Winner	a	b	c	

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Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice	$\{a, b\}$	$\{b\}$	$\{a, c\}$	$\{a, b\}$
Rabbit	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	$\{a, c\}$
Hatter	$\{a\}$	$\{a, b\}$	$\{c\}$	$\{a\}$
Carroll	$\{b\}$	$\{a, c\}$	$\{a, b\}$	$\{b, c\}$
Winner	a	b	c	

SEQUENTIAL VOTING: MAJORITY RULE

Voters	Decision 1	Decision 2	Decision 3	Decision 4
Alice	$\{a, b\}$	$\{b\}$	$\{a, c\}$	$\{a, b\}$
Rabbit	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	$\{a, c\}$
Hatter	$\{a\}$	$\{a, b\}$	$\{c\}$	$\{a\}$
Carroll	$\{b\}$	$\{a, c\}$	$\{a, b\}$	$\{b, c\}$
Winner	a	b	c	a

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1				
Rabbit	1				
Hatter	1				
Carroll	1				
Winner					

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{a, b\}$			
Rabbit	1	$\{a, c\}$			
Hatter	1	$\{a\}$			
Carroll	1	$\{b\}$			
Winner					

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{a, b\}$			
Rabbit	0.5	$\{a, c\}$			
Hatter	0.5	$\{a\}$			
Carroll	1	$\{b\}$			
Winner		a			

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{a, b\}$	$\{b\}$		
Rabbit	0.5	$\{a, c\}$	$\{b, c\}$		
Hatter	0.5	$\{a\}$	$\{a, b\}$		
Carroll	1	$\{b\}$	$\{a, c\}$		
Winner		a			

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.33	$\{a, b\}$	$\{b\}$		
Rabbit	0.33	$\{a, c\}$	$\{b, c\}$		
Hatter	0.33	$\{a\}$	$\{a, b\}$		
Carroll	1	$\{b\}$	$\{a, c\}$		
Winner		a	b		

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.33	$\{a, b\}$	$\{b\}$	$\{a, c\}$	
Rabbit	0.33	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	
Hatter	0.33	$\{a\}$	$\{a, b\}$	$\{c\}$	
Carroll	1	$\{b\}$	$\{a, c\}$	$\{a, b\}$	
Winner		a	b		

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.25	$\{a, b\}$	$\{b\}$	$\{a, c\}$	
Rabbit	0.33	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	
Hatter	0.33	$\{a\}$	$\{a, b\}$	$\{c\}$	
Carroll	0.5	$\{b\}$	$\{a, c\}$	$\{a, b\}$	
Winner		a	b	a	

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.25	$\{a, b\}$	$\{b\}$	$\{a, c\}$	$\{a, b\}$
Rabbit	0.33	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	$\{a, c\}$
Hatter	0.33	$\{a\}$	$\{a, b\}$	$\{c\}$	$\{a\}$
Carroll	0.5	$\{b\}$	$\{a, c\}$	$\{a, b\}$	$\{b, c\}$
Winner		a	b	a	

SEQUENTIAL VOTING: 'REPRESENTATIVE' RULE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.2	$\{a, b\}$	$\{b\}$	$\{a, c\}$	$\{a, b\}$
Rabbit	0.25	$\{a, c\}$	$\{b, c\}$	$\{b, c\}$	$\{a, c\}$
Hatter	0.25	$\{a\}$	$\{a, b\}$	$\{c\}$	$\{a\}$
Carroll	0.5	$\{b\}$	$\{a, c\}$	$\{a, b\}$	$\{b, c\}$
Winner		<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>

OUR MAIN NEGATIVE POINT

Minimal forms of representative guarantees
already allow for **very simple** forms of manipulation:
FREE-RIDING!

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	1			
Rabbit	1			
Hatter	1			
Carroll	1			
Winner				

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	1	$\{a\}$		
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Hatter	1	$\{a\}$		
Carroll	1	$\{a\}$		
Winner				

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.5	$\{a\}$		
Rabbit	0.5	$\{a\}$		
Hatter	0.5	$\{a\}$		
Carroll	0.5	$\{a\}$		
Winner		a		

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.5	$\{a\}$	$\{a\}$	
Rabbit	0.5	$\{a\}$	$\{a\}$	
Hatter	0.5	$\{a\}$	$\{a\}$	
Carroll	0.5	$\{a\}$	$\{b\}$	
Winner		a		

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.33	$\{a\}$	$\{a\}$	
Rabbit	0.33	$\{a\}$	$\{a\}$	
Hatter	0.33	$\{a\}$	$\{a\}$	
Carroll	0.5	$\{a\}$	$\{b\}$	
Winner		a	a	

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.33	$\{a\}$	$\{a\}$	$\{a\}$
Rabbit	0.33	$\{a\}$	$\{a\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{a\}$	$\{b\}$
Carroll	0.5	$\{a\}$	$\{b\}$	$\{c\}$
Winner		a	a	

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.25	$\{a\}$	$\{a\}$	$\{a\}$
Rabbit	0.25	$\{a\}$	$\{a\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{a\}$	$\{b\}$
Carroll	0.5	$\{a\}$	$\{b\}$	$\{c\}$
Winner		a	a	a

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	1			
Rabbit	1			
Hatter	1			
Carroll	1			
Winner				

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	1	$\{a\}$		
Rabbit	1	$\{a\}$		
Hatter	1	$\{a\}$		
Carroll	1	$\{b\}$		
Winner				

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.5	$\{a\}$		
Rabbit	0.5	$\{a\}$		
Hatter	0.5	$\{a\}$		
Carroll	1	$\{b\}$		
Winner		a		

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.5	$\{a\}$	$\{a\}$	
Rabbit	0.5	$\{a\}$	$\{a\}$	
Hatter	0.5	$\{a\}$	$\{a\}$	
Carroll	1	$\{b\}$	$\{b\}$	
Winner		a		

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.33	$\{a\}$	$\{a\}$	
Rabbit	0.33	$\{a\}$	$\{a\}$	
Hatter	0.33	$\{a\}$	$\{a\}$	
Carroll	1	$\{b\}$	$\{b\}$	
Winner		a	a	

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.33	$\{a\}$	$\{a\}$	$\{a\}$
Rabbit	0.33	$\{a\}$	$\{a\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{a\}$	$\{b\}$
Carroll	1	$\{b\}$	$\{b\}$	$\{c\}$
Winner		a	a	

FREE-RIDING: EXAMPLE

Voters	Weight	Decision 1	Decision 2	Decision 3
Alice	0.25	$\{a\}$	$\{a\}$	$\{a\}$
Rabbit	0.25	$\{a\}$	$\{a\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{a\}$	$\{b\}$
Carroll	0.5	$\{b\}$	$\{b\}$	$\{c\}$
Winner		a	a	c

OUR MAIN POSITIVE POINT

FREE-RIDING can **backfire!**

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1				
Rabbit	1				
Hatter	1				
Carroll	1				
Winner					

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$			
Rabbit	1	$\{a\}$			
Hatter	1	$\{a\}$			
Carroll	1	$\{a\}$			
Winner					

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$			
Rabbit	0.5	$\{a\}$			
Hatter	0.5	$\{a\}$			
Carroll	0.5	$\{a\}$			
Winner		a			

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$	$\{a\}$		
Rabbit	0.5	$\{a\}$	$\{b\}$		
Hatter	0.5	$\{a\}$	$\{c\}$		
Carroll	0.5	$\{a\}$	$\{b\}$		
Winner		a			

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$		
Rabbit	0.5	$\{a\}$	$\{b\}$		
Hatter	0.5	$\{a\}$	$\{c\}$		
Carroll	0.5	$\{a\}$	$\{b\}$		
Winner		a	a		

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	
Rabbit	0.5	$\{a\}$	$\{b\}$	$\{b\}$	
Hatter	0.5	$\{a\}$	$\{c\}$	$\{a\}$	
Carroll	0.5	$\{a\}$	$\{b\}$	$\{a\}$	
Winner		a	a		

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	
Rabbit	0.5	$\{a\}$	$\{b\}$	$\{b\}$	
Hatter	0.33	$\{a\}$	$\{c\}$	$\{a\}$	
Carroll	0.33	$\{a\}$	$\{b\}$	$\{a\}$	
Winner		a	a	a	

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	$\{b\}$
Rabbit	0.5	$\{a\}$	$\{b\}$	$\{b\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{c\}$	$\{a\}$	$\{b\}$
Carroll	0.33	$\{a\}$	$\{b\}$	$\{a\}$	$\{a\}$
Winner		a	a	a	

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	$\{b\}$
Rabbit	0.33	$\{a\}$	$\{b\}$	$\{b\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{c\}$	$\{a\}$	$\{b\}$
Carroll	0.25	$\{a\}$	$\{b\}$	$\{a\}$	$\{a\}$
Winner		<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	$\{b\}$
Rabbit	0.33	$\{a\}$	$\{b\}$	$\{b\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{c\}$	$\{a\}$	$\{b\}$
Carroll	0.25	$\{a\}$	$\{b\}$	$\{a\}$	$\{a\}$
Winner		a	a	a	a

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1				
Rabbit	1				
Hatter	1				
Carroll	1				
Winner					

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$			
Rabbit	1	$\{a\}$			
Hatter	1	$\{a\}$			
Carroll	1	$\{c\}$			
Winner					

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$			
Rabbit	0.5	$\{a\}$			
Hatter	0.5	$\{a\}$			
Carroll	1	$\{c\}$			
Winner		a			

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$	$\{a\}$		
Rabbit	0.5	$\{a\}$	$\{b\}$		
Hatter	0.5	$\{a\}$	$\{c\}$		
Carroll	1	$\{c\}$	$\{b\}$		
Winner		a			

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$	$\{a\}$		
Rabbit	0.33	$\{a\}$	$\{b\}$		
Hatter	0.5	$\{a\}$	$\{c\}$		
Carroll	0.5	$\{c\}$	$\{b\}$		
Winner		a	b		

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	1	$\{b\}$	$\{a\}$	$\{b\}$	
Rabbit	0.33	$\{a\}$	$\{b\}$	$\{b\}$	
Hatter	0.5	$\{a\}$	$\{c\}$	$\{a\}$	
Carroll	0.5	$\{c\}$	$\{b\}$	$\{a\}$	
Winner		a	b		

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	
Rabbit	0.25	$\{a\}$	$\{b\}$	$\{b\}$	
Hatter	0.5	$\{a\}$	$\{c\}$	$\{a\}$	
Carroll	0.5	$\{c\}$	$\{b\}$	$\{a\}$	
Winner		a	b	b	

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.5	$\{b\}$	$\{a\}$	$\{b\}$	$\{b\}$
Rabbit	0.25	$\{a\}$	$\{b\}$	$\{b\}$	$\{a\}$
Hatter	0.5	$\{a\}$	$\{c\}$	$\{a\}$	$\{b\}$
Carroll	0.5	$\{c\}$	$\{b\}$	$\{a\}$	$\{a\}$
Winner		a	b	b	

FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.33	$\{b\}$	$\{a\}$	$\{b\}$	$\{b\}$
Rabbit	0.25	$\{a\}$	$\{b\}$	$\{b\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{c\}$	$\{a\}$	$\{b\}$
Carroll	0.5	$\{c\}$	$\{b\}$	$\{a\}$	$\{a\}$
Winner		<i>a</i>	<i>b</i>	<i>b</i>	<i>b</i>

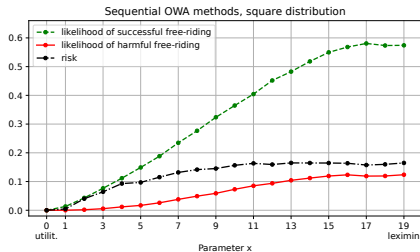
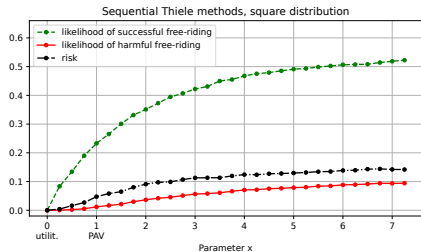
FREE-RIDING CAN BACKFIRE

Voters	Weight	Decision 1	Decision 2	Decision 3	Decision 4
Alice	0.33	$\{b\}$	$\{a\}$	$\{b\}$	$\{b\}$
Rabbit	0.25	$\{a\}$	$\{b\}$	$\{b\}$	$\{a\}$
Hatter	0.33	$\{a\}$	$\{c\}$	$\{a\}$	$\{b\}$
Carroll	0.5	$\{c\}$	$\{b\}$	$\{a\}$	$\{a\}$
Winner		a	b	b	b

SUMMARY: MANIPULATION

Using this fact, we show:

- For a large class of rules, it is **computationally hard** to decide if free-riding is beneficial
- That the **risk** of free-riding is **non-negligible** (via simulations)



MESSAGE

FREE-RIDING is unavoidable in 'fair' sequential voting,
but it is risky and its consequences hard to predict! ✓

3. DELIBERATION



SUMMARISING DISCUSSIONS

ProportionalParrot

A party's share of seats in the House of Commons should reflect its share of the popular vote.

111 

MajoritarianMango

In systems with PR, opinions are too strongly divided and nothing gets done.

11 

PastThePost

FPTP results in more stable governance.

39 

VDHondt41

PR will reduce hyper-partisanship and promote cooperation between parties.

88 

JohnCitizen

PR will reduce wild policy swings and result in more long-lasting policies.

89 

SingleTransferableLarry

I like the simplicity of stating my favorite candidate, as well as alternative choices.

8 

TommyHill

STV's advantage over MMP is that it doesn't explicitly enshrine political parties in our electoral system.

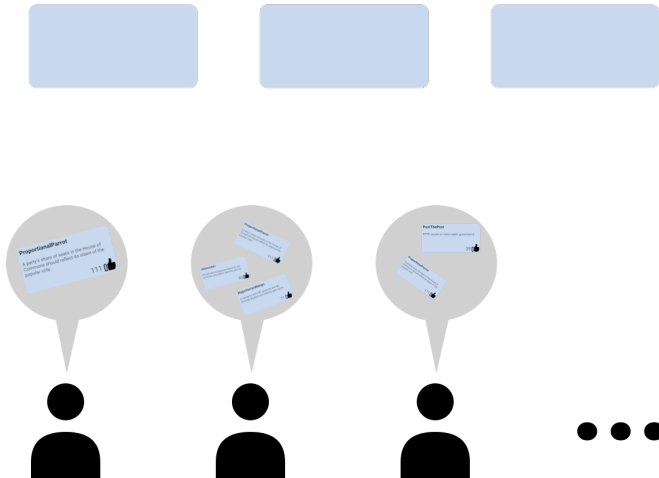
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PhanMinh_AF

MMP has a better chance of obtaining public support than STV due to its relative simplicity.

6 

SUMMARISING VIA APPROVAL VOTING



SUMMARISING VIA APPROVAL VOTING

ProportionalParrot

A party's share of seats in the House of Commons should reflect its share of the popular vote.

111 

PastThePost

FPTP results in more stable governance.

39 

PhanMinh_AF

MMP has a better chance of obtaining public support than STV due to its relative simplicity.

6 



SUMMARISING VIA APPROVAL VOTING

Ignores the broader argumentation!

SUMMARISING VIA ARGUMENTATIVE STRUCTURE

PastThePost

FPTP results in more stable governance.

39 

MajoritarianMango

In systems with PR, opinions are too strongly divided and nothing gets done.

11 

VDHondt41

PR will reduce hyper-partisanship and promote cooperation between parties.

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A party's share of seats in the House of Commons should reflect its share of the popular vote.

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STV's advantage over MMP is that it doesn't explicitly enshrine political parties in our electoral system.

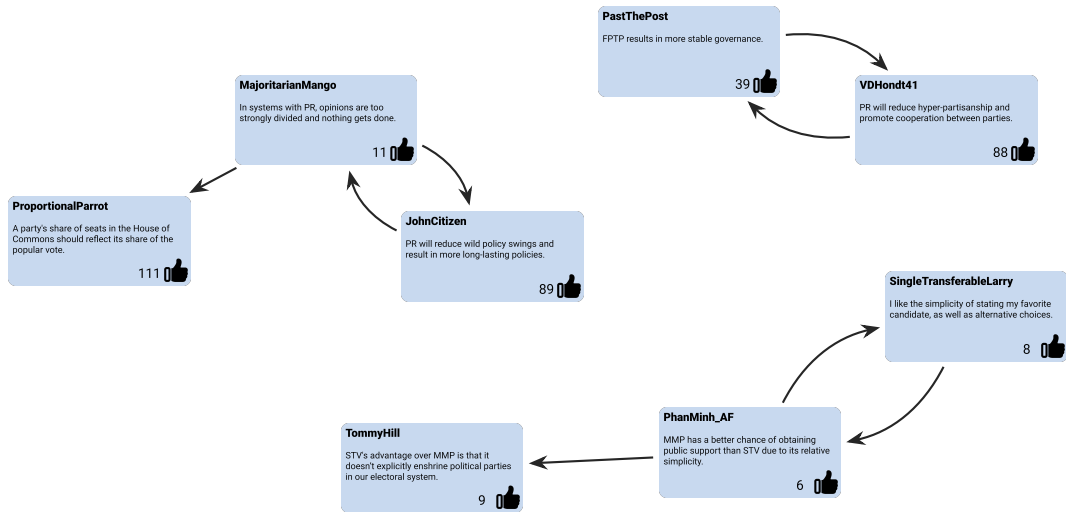
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PhanMinh_AF

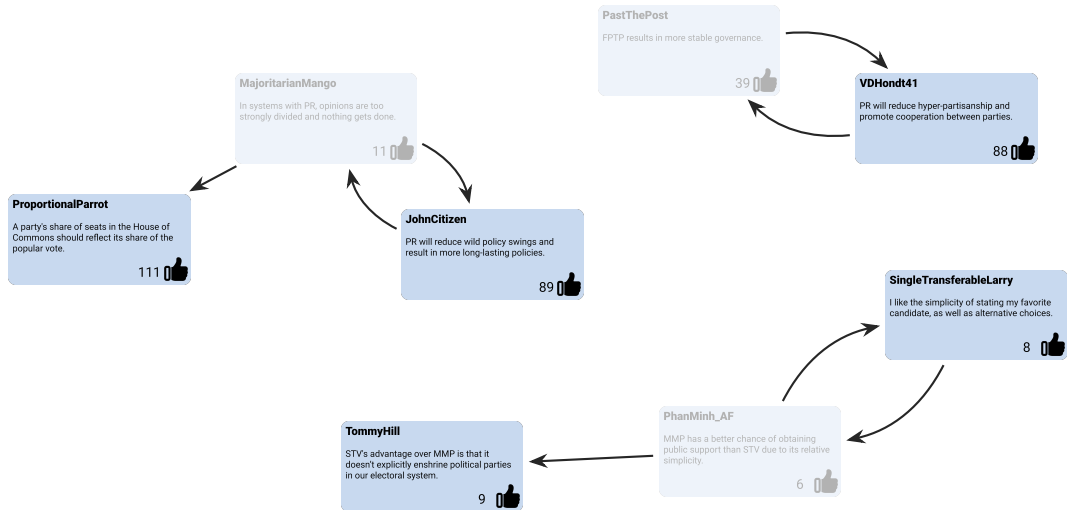
MMP has a better chance of obtaining public support than STV due to its relative simplicity.

6 

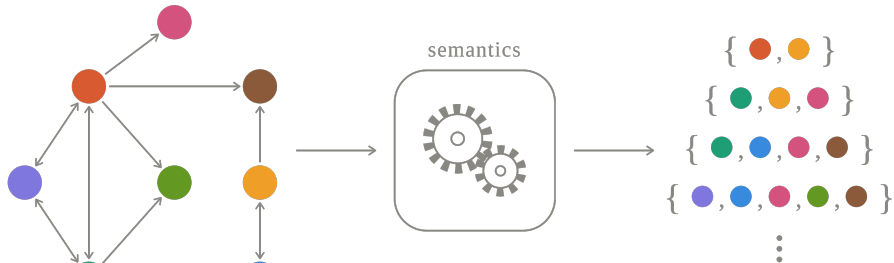
SUMMARISING VIA ARGUMENTATIVE STRUCTURE



SUMMARISING VIA ARGUMENTATIVE STRUCTURE

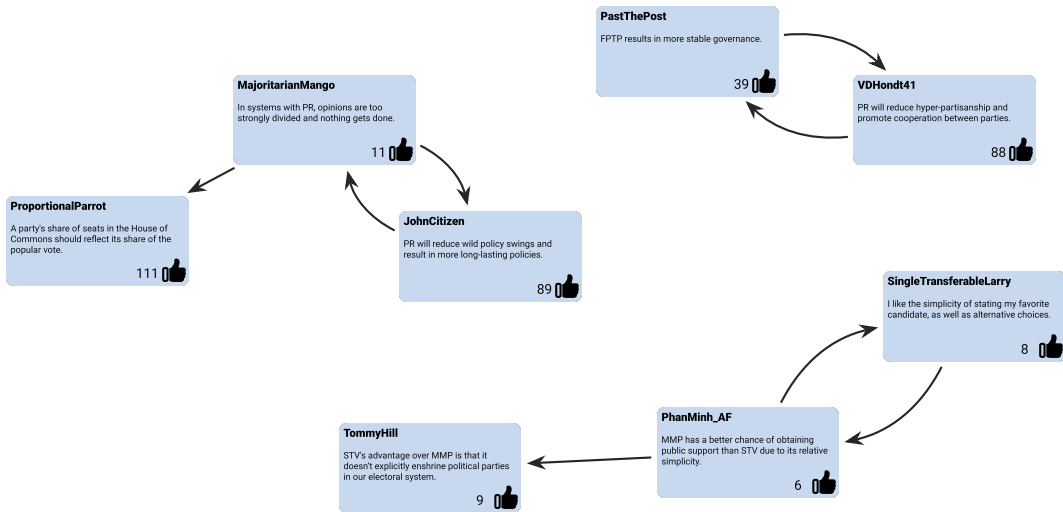


ABSTRACT ARGUMENTATION

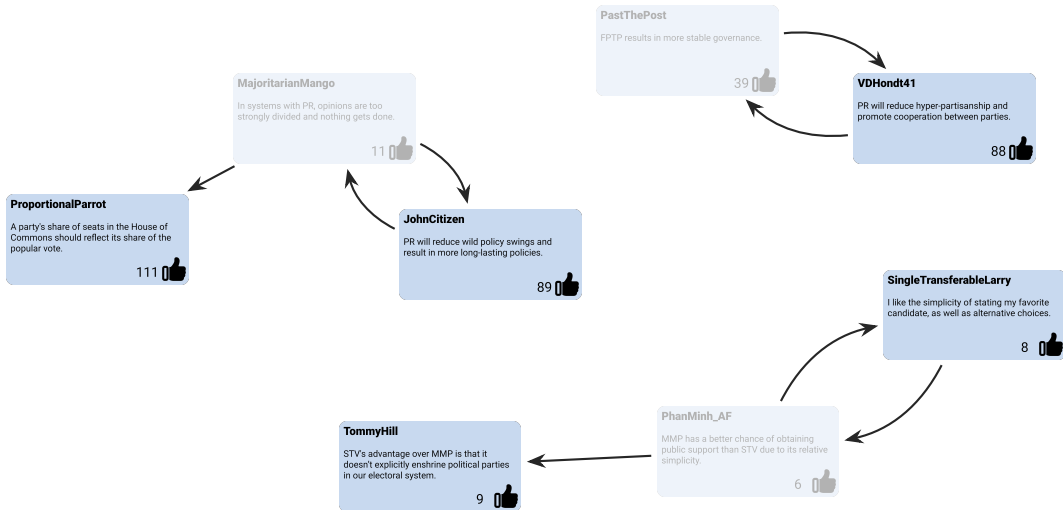


P. M. Dung. On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and n -Person Games. *Artificial Intelligence*, 77(2):321–358, 1995.

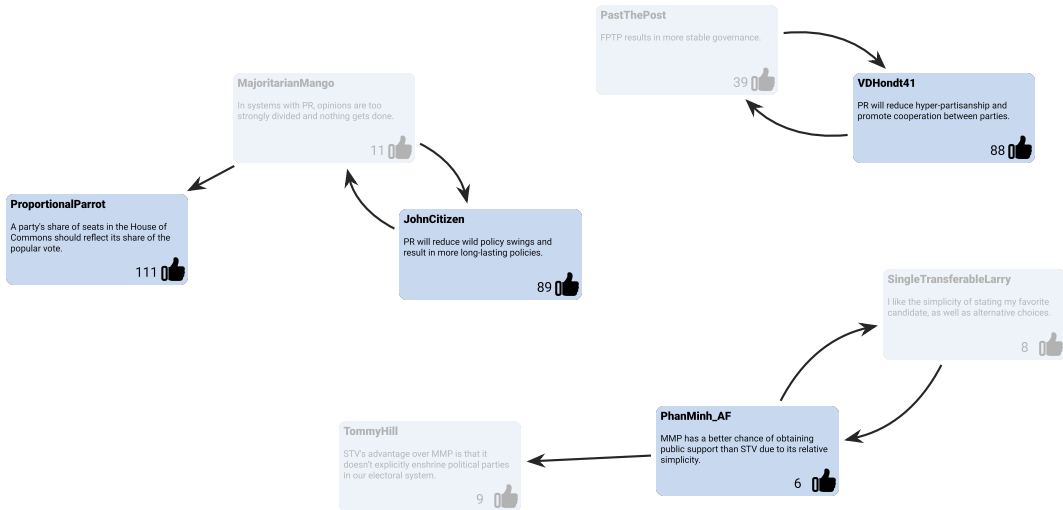
COUNTING THE EXTENSIONS



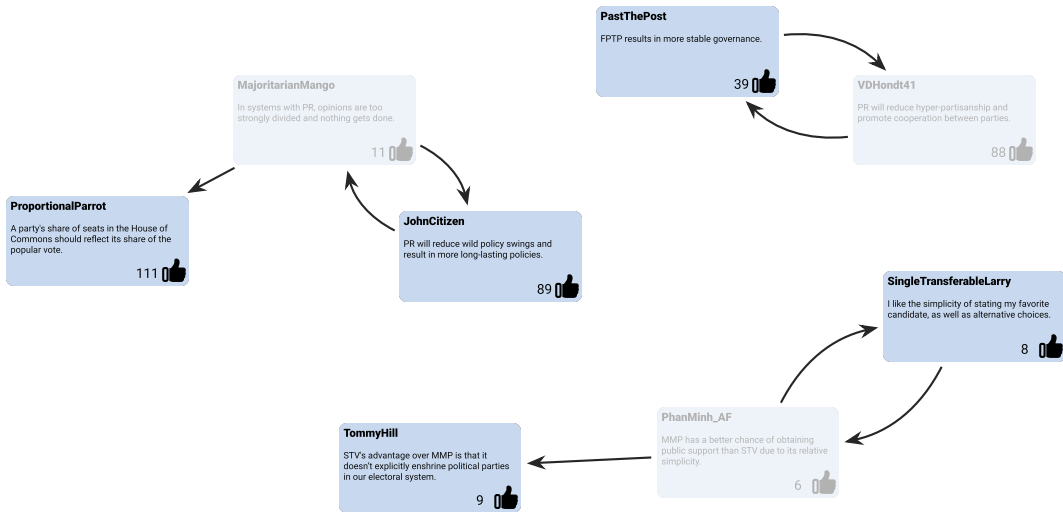
COUNTING THE EXTENSIONS



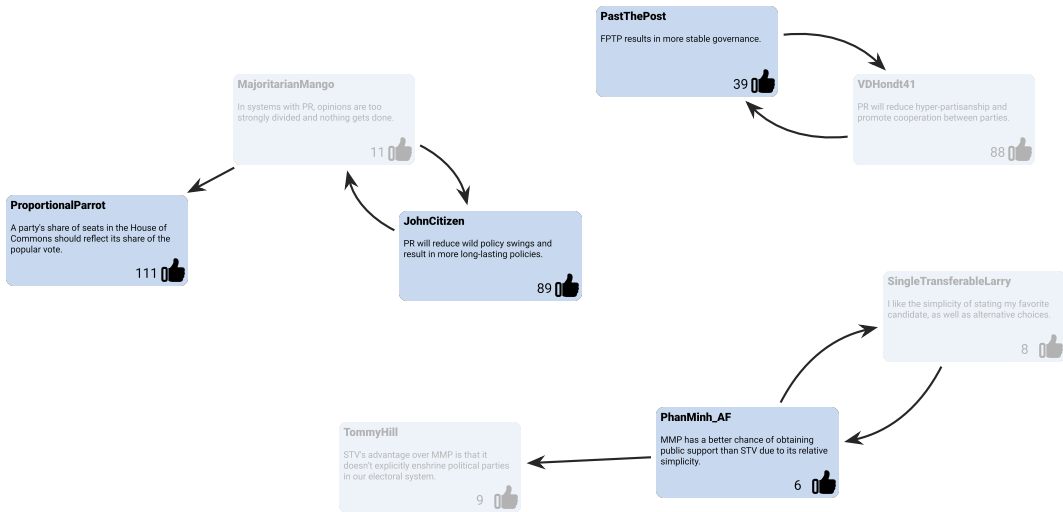
COUNTING THE EXTENSIONS



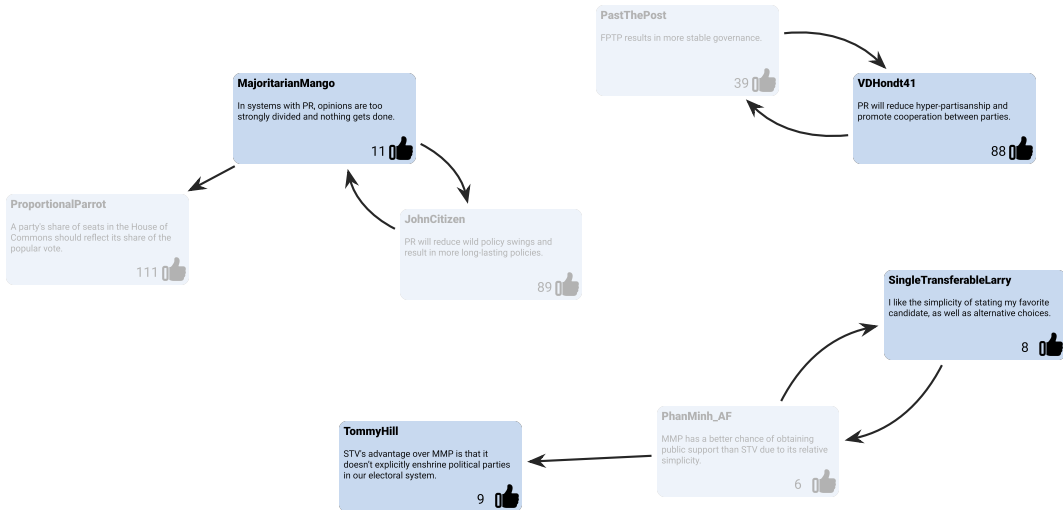
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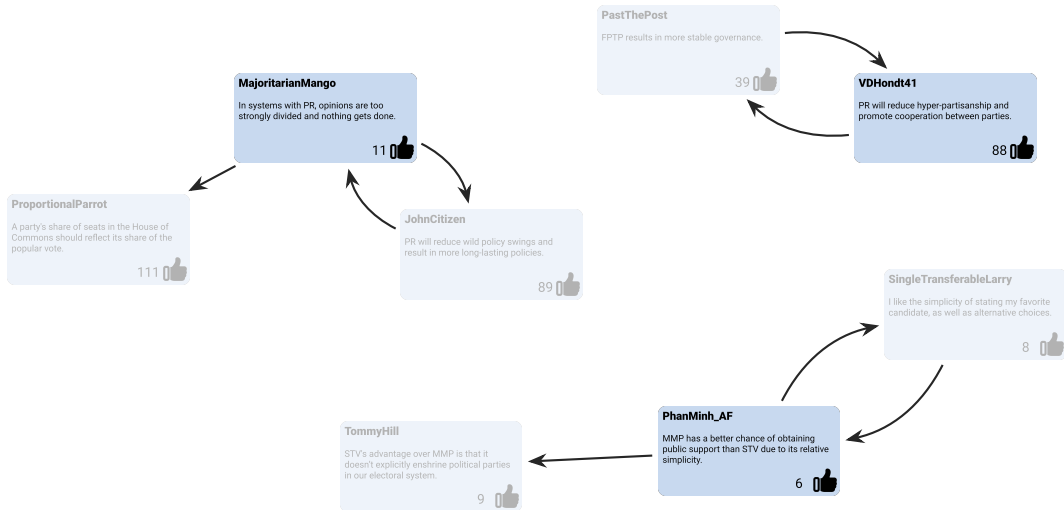
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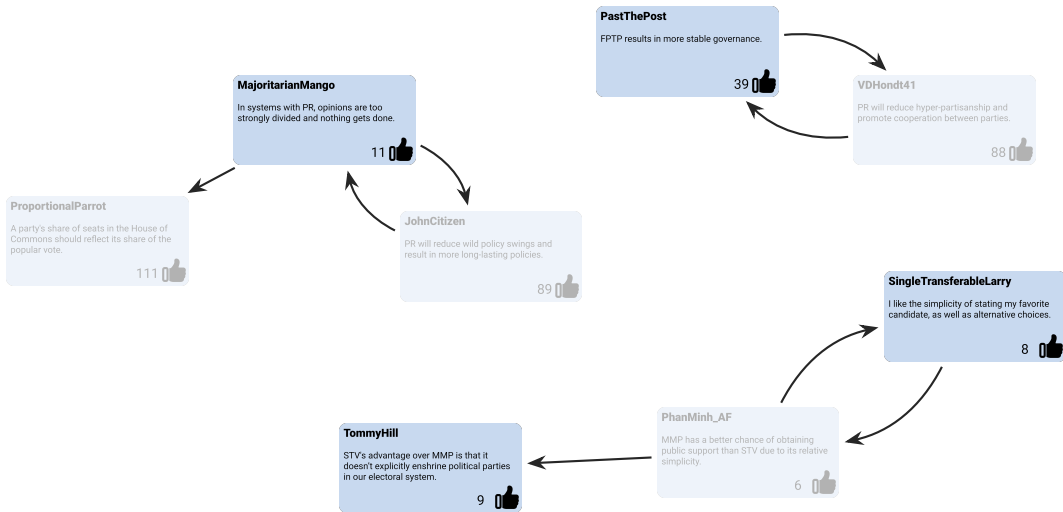
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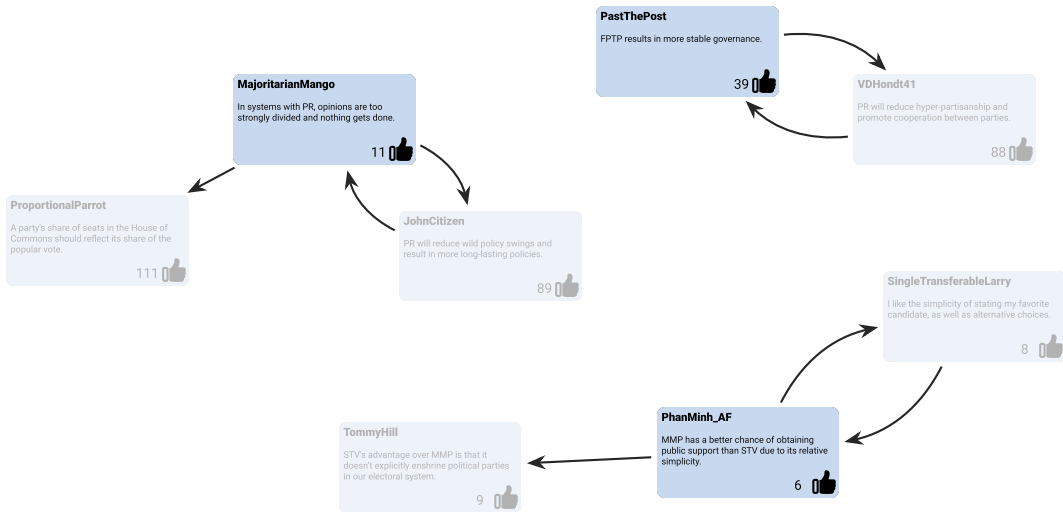
COUNTING THE EXTENSIONS



COUNTING THE EXTENSIONS



COUNTING THE EXTENSIONS



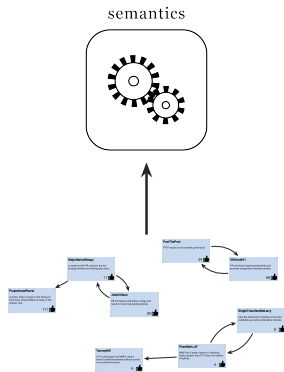
COUNTING THE EXTENSIONS

Abstract argumentation can be verbose!

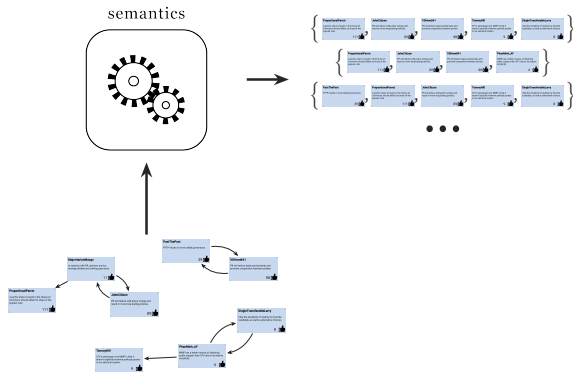
COMBINING ARGUMENTATION AND VOTING



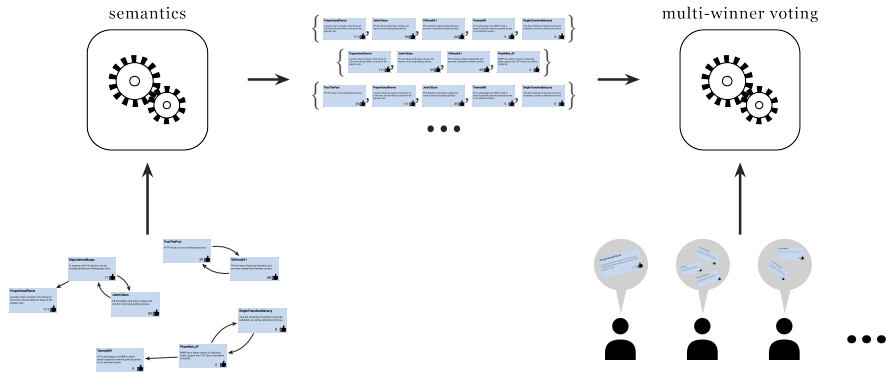
COMBINING ARGUMENTATION AND VOTING



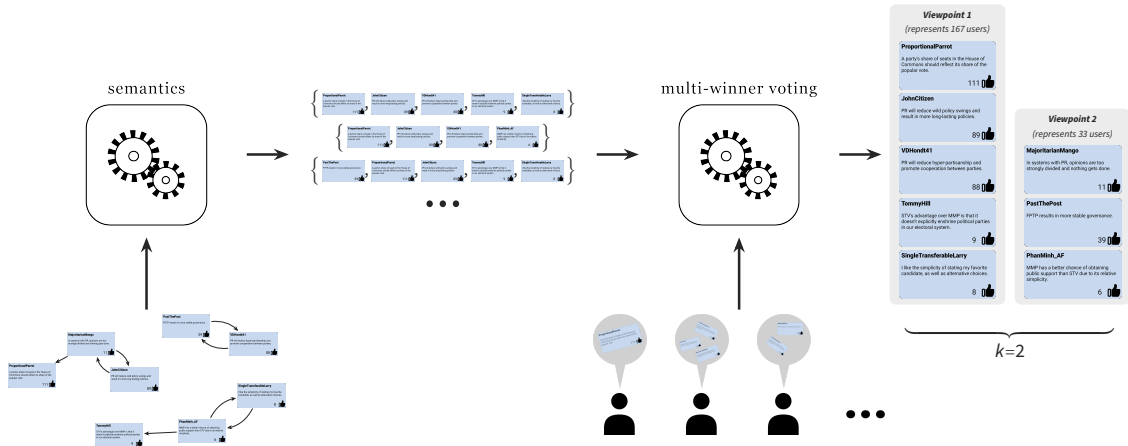
COMBINING ARGUMENTATION AND VOTING



COMBINING ARGUMENTATION AND VOTING



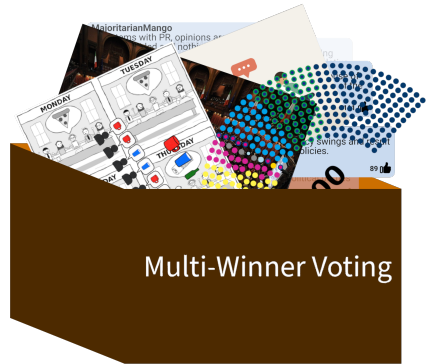
COMBINING ARGUMENTATION AND VOTING



SUMMARY: DELIBERATION

- We define a formal model of discussions (**argumentation framework** + **approvals**)
 - Outcomes are sets of extensions filtered using the preferences
- We quantify the representativeness of an outcome
- We introduce outcome-selection algorithms based on multi-winner voting ideas
- We study the rules **computationally**, **axiomatically** and **experimentally**

CONCLUSION



RECAP

- **Representation:**
 - We introduced formal definitions of overrepresentation in committee voting, along with rules to prevent it.
- **Manipulation:**
 - We studied free-riding in sequential voting, and show that it is not as appealing a strategy as one might think.
- **Deliberation:**
 - We introduce an approach for summarising online discussions, combining argumentation and voting theory.

FINAL SLIDE



First conference in Vienna



Today