Interaction and Expressivity in Collective Decision-Making

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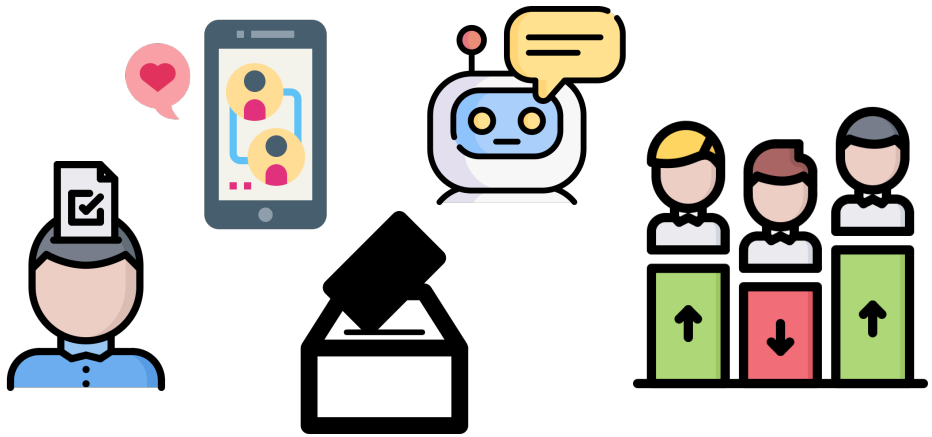
Early Career Spotlight @ IJCAI22

Classical social choice

...a set of autonomous agents need to take a collective decision...



Icons from Flaticon.com

Examples: voting and elections, measures of social welfare, matching, resource allocation, participatory budgeting...

- the final decision affects all the agents: a cooperative problem
- different and possibly conflicting individual preferences: the competitive dimension is dominant

First computational wave

There is no strategy-proof rule, but how hard is to know whether strategic voting can be profitable? Computational complexity argument:

Theorem [Bartholdi and Orlin, 1991]

Manipulating the single-transferable rule (used eg in Australia) is NP-hard.

We know everything about simple and independent alternative candidates, how about complex ones? Knowledge representation argument:

Theorem [List and Pettit, 2002 - Rephrased in Grandi and Endiss, 2013]

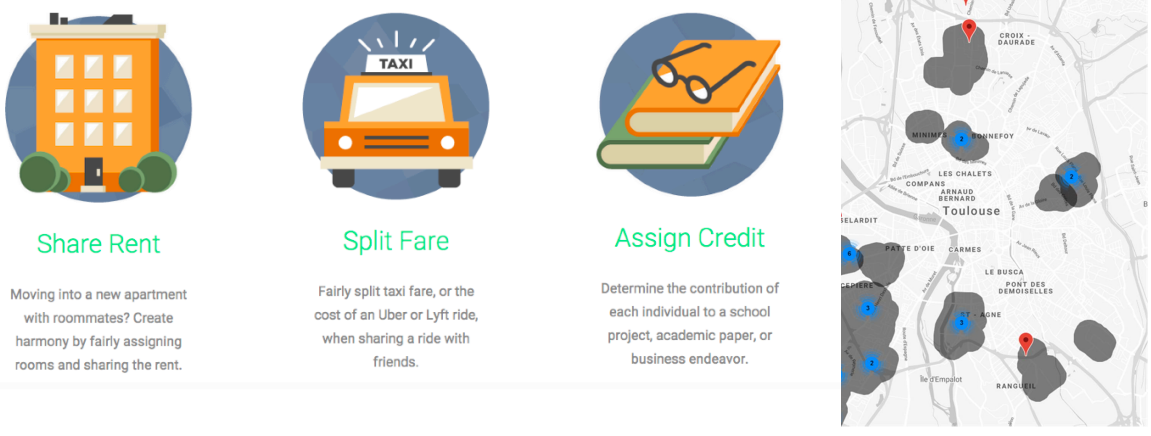
When voting on multiple interconnected binary issues, the majority rule is collectively rational iff the canonical CNF of the constraint is a 2-CNF.

The economic paradigm became mainstream in multiagent systems, and computational aspects of collective decisions well-recognised in economics.

Second computational wave?

Researchers in COMSOC are getting closer to real world collective decisions:

- *Preflib.org* contains a large number of datasets of preferences extracted from elections, sushi competitions, experiments...
- A number of voting platforms have been proposed for experiments and outreach: *Whale*, *Spliddit*, *Robovote*...
- Interactive democracy applications



spliddit.org, jeparticipe.toulouse.fr

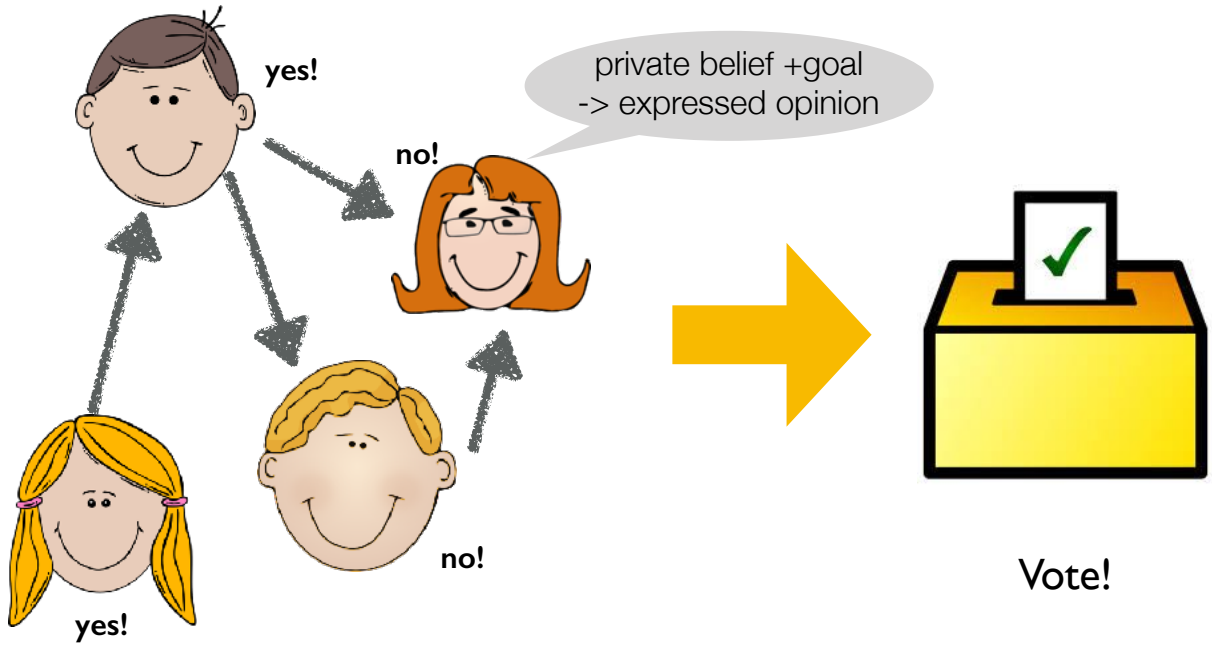
Better and more detailed introductions to computational social choice given by Jerome Lang and Edith Elkind in invited talks at IJCAI22 and 21

Outline

1. Interaction: social networks and iterative voting
2. Expressivity: combinatorial delegations
3. Conclusions and perspectives

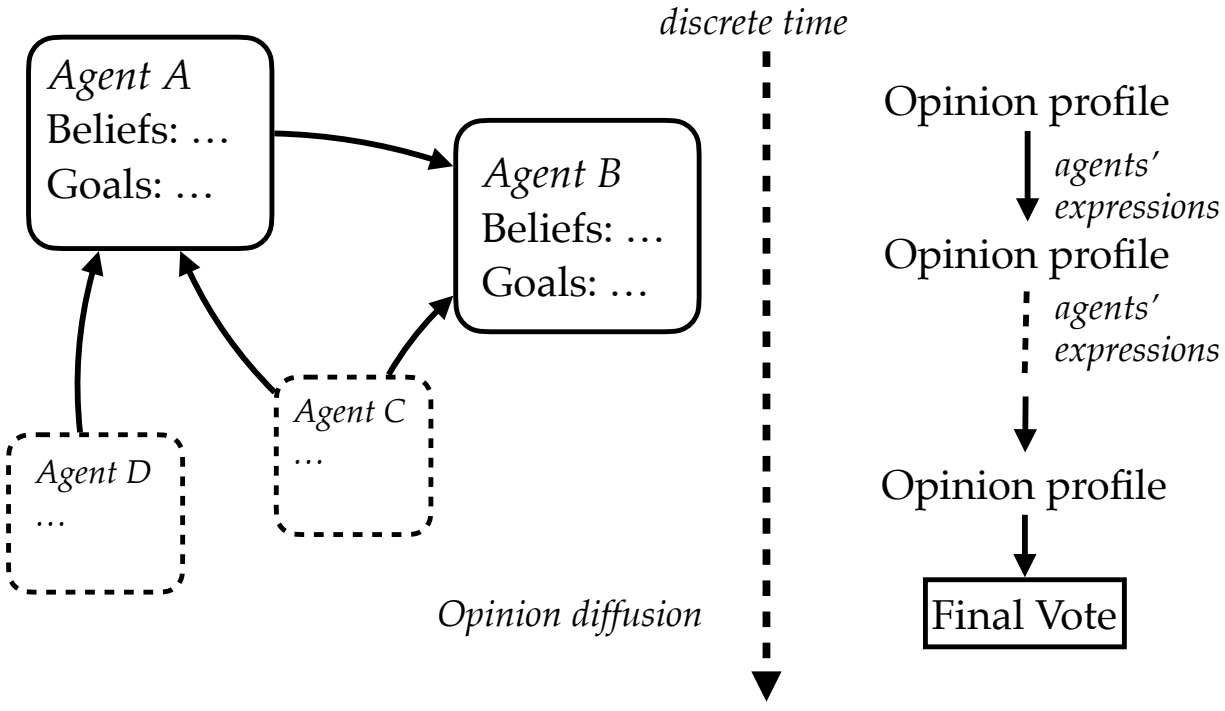
Social choice on social networks

Voters are typically considered in isolation. What happens when they are connected by a (influence or communication) network?



I wrote a survey chapter on "Social Choice on Social Networks" in 2017 (but research is moving fast, lots of recent papers missing)

Opinion diffusion as aggregation



- Agents linked by a network of trust or influence.
- Agents exert their influence by expressing opinions, entering a process of opinion diffusion which results in a final vote
- Each agent uses an aggregation function to update their opinion based on those communicated by influencers

Propositional opinion diffusion

Previous work on opinion diffusion focused on continuous or single binary issues. First task: adapt opinion diffusion models to voting-like situations.

General termination result on binary issues [AAMAS15]

If the influence update functions F_i satisfy ballot-monotonicity for all i, then synchronous propositional diffusion universally terminates on the class of DAG with loops in at most diam$(E) + 1$ steps.

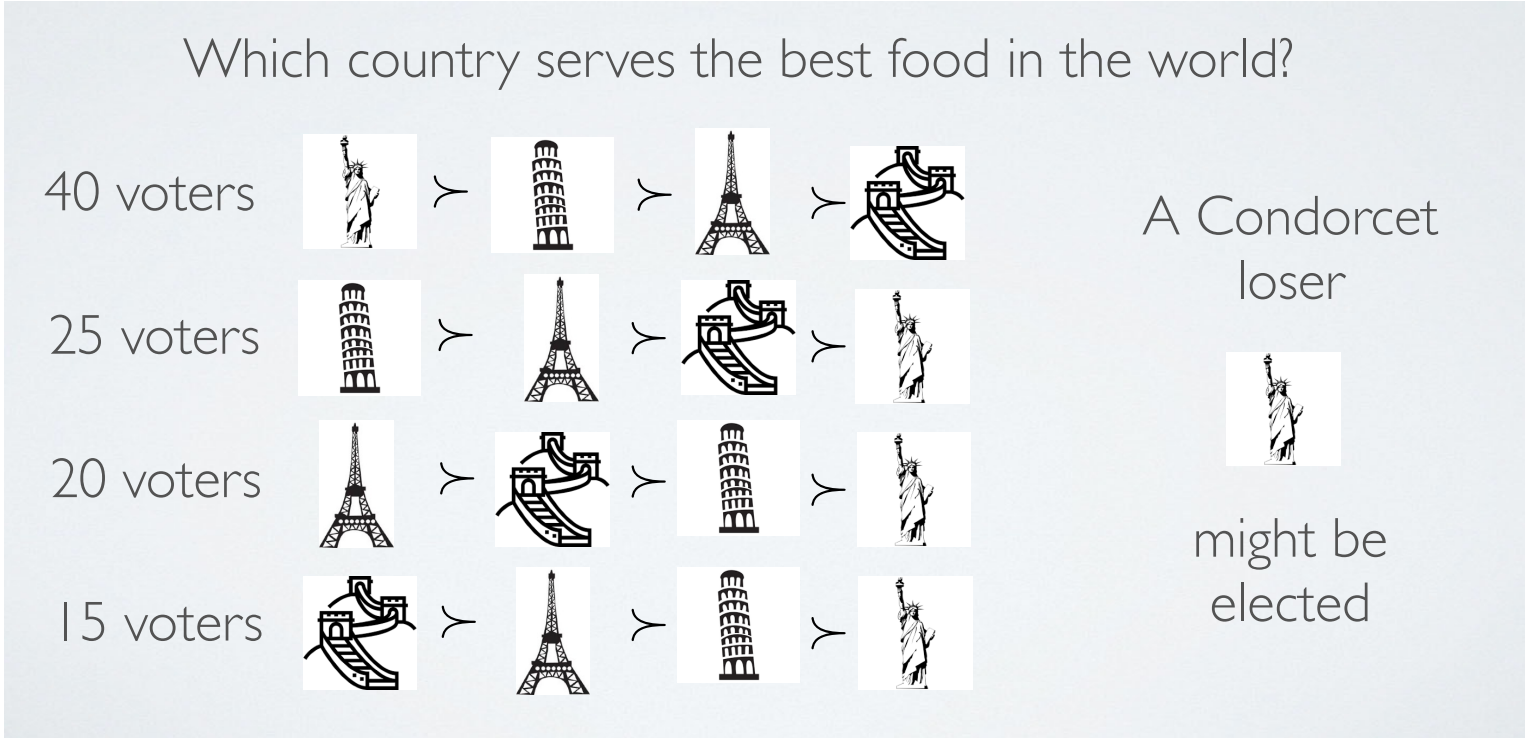
Convergence to aligned profiles of preferences [IJCAI16]

If the sources of a DAG are aligned preference orders (single-peaked, single-crossing, Sen's restriction) then under mild conditions termination profiles are also aligned.

Open problems: on termination, alignment, control...

Iterative voting

The plurality rule has low communication and computational complexity (and is arguably the most used rule). However:



Can we exploit strategic voting to design an interactive protocol to improve the results of plurality voting?

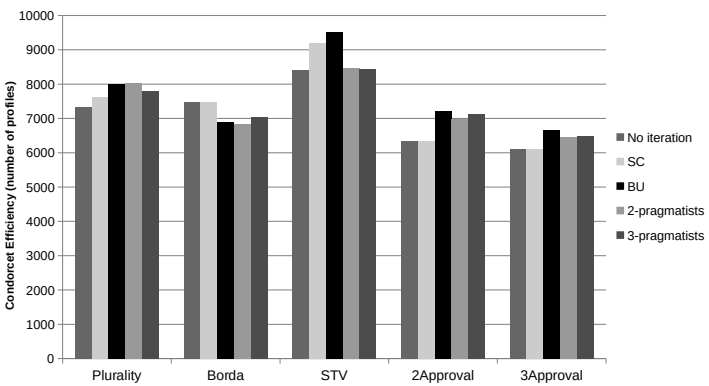
Multiple techniques to study iterative voting

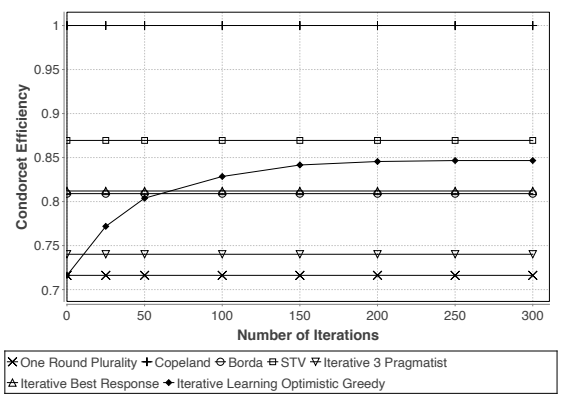
Mechanism design: find voter-response strategies that guarantee the convergence of the iterative process with any voting rule *[ADT13, collaboration between Padova, Tulane, and UNSW]*

Reinforcement learning: autonomous agents can be programmed to reach "good" collective decisions after iterating and with only the current winner as information *[ADT17: collaboration with Paris Dauphine]*

Behavioural economics: how do humans respond to polls in iterative voting (multiple referenda setting)? *[under submission, with Paris Dauphine]*

Outreach: Itero (https://itero.irit.fr) is an iterative voting platform developed to be used at outreach events. Come to our IJCAI22 demo presentation on Friday (poster tonight)!





Perspective: lightweight deliberation

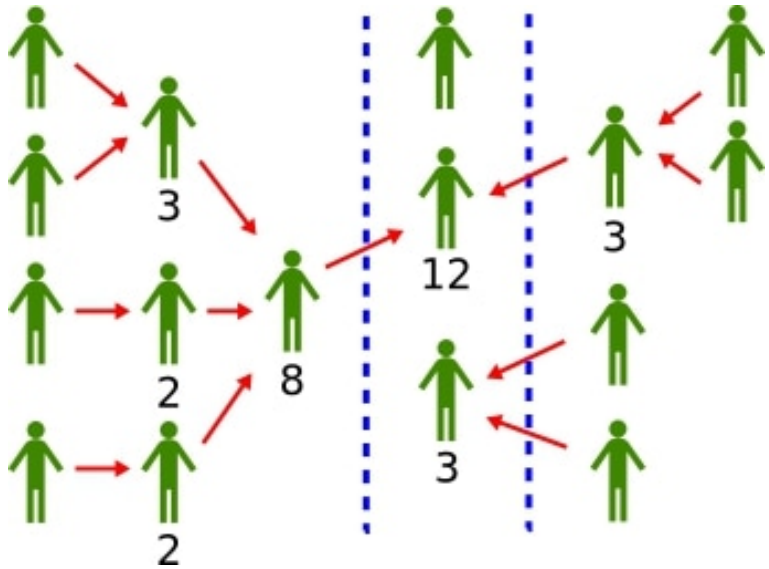
Iterative voting share aggregated information on preferences:
a weak form of deliberation?

Credit:Participedia,ScriptPro

- The outcome of iterative voting correspond to that of deliberation, e.g., single-peakedness increases?
- Consider not only strategic response but conformity or influence in individual votes. What is a good model?
- User experience can be tedious, online voting instead?

Liquid democracy

Liquid democracy allows a proxy to delegate her voting power and the delegated voting power received to another voter:

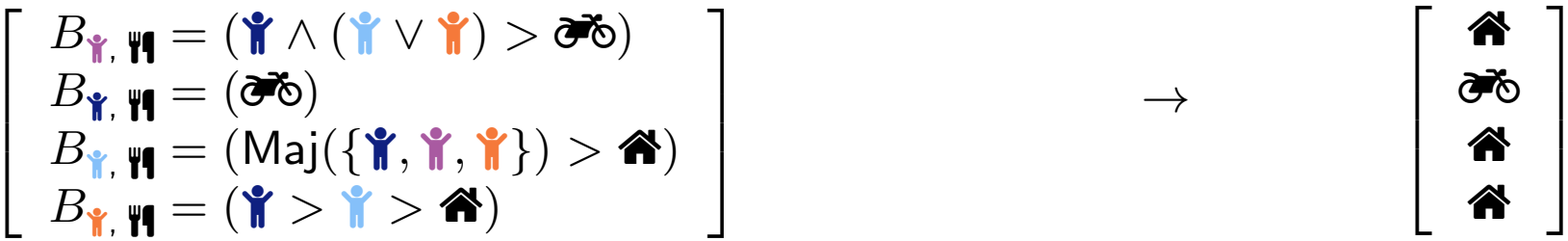


Motivational questions behind our work:

- [*Delegation* = *Influence*$^{-1}$] How to elicit the social influence structure?
- [*Classic problem in LD*] How to deal with cycles of delegations?
- [*Multi-issue delegations*] Pairwise preferences, projects in PB...

Multiagent ranked delegations

We propose the use of multiagent ranked delegations with unravelling procedures associating a profile of direct votes:



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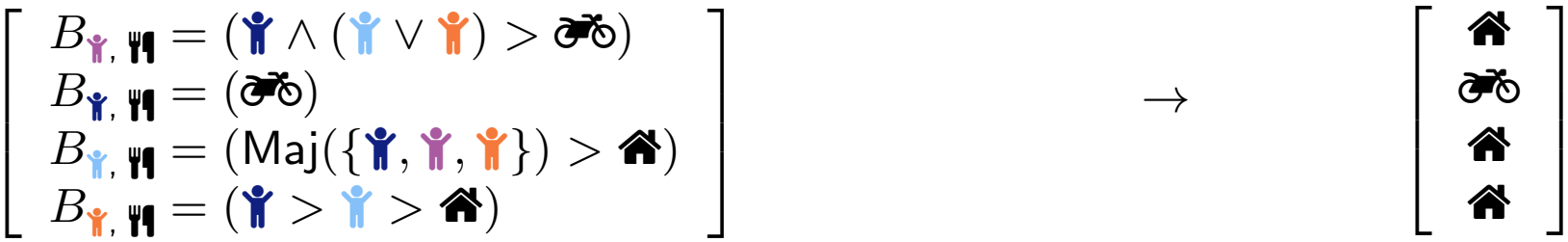


We propose two optimisation unravelling procedures and four greedy ones:

Theorem [Colley, Grandi, Novaro, JAAMAS22]

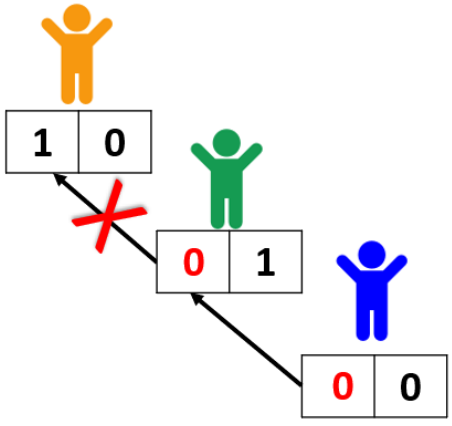
The two optimal procedures are NP-hard to compute, but are polynomial on ranked single-agent delegations (non-trivial algorithms).

Theorem [Colley, Grandi, Novaro, IJCAI20]

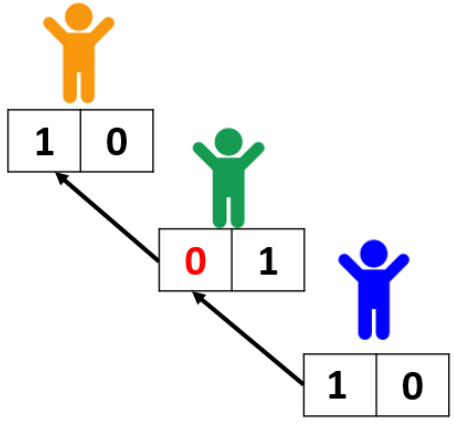
Unravelling a smart profile with any of the four greedy procedures takes polynomial time (assuming delegations in complete DNF).

Delegations and constraints

Two possible solutions to preserve consistency of delegations under constraints:



Minimising the number of changes to the **delegation profile** to result in a consistent profile of votes
(known from Brill&Talmon, Jain et al.)
Computing the result is NP-hard!



Minimising the number of changes to the **profile of final votes** to make it consistent (vaguely inspired from judgment aggregation)
Computing the result is NP-hard!

Our proposal: elicit voters' priorities over the issues and use poly algorithms to solve the delegation graph. Presentation on Friday (poster tonight)!

Perspective: large number of alternatives

Applications of interactive democracy involve very large numbers of alternatives

For example, computing a collective political program with 120 alternatives to be ranked (`Monprogramme2022.org/en`)

Challenges arise from using heavily incomplete data:

- optimal preference elicitation in real-time
- social choice with heavily incomplete data

Conclusions

Recent work on two aspects of computational social choice:

1. Interaction: social network relating the voters, iterate collective decisions
2. Expressivity: combinatorial vote with delegations

A number of perspectives for future research were presented:

- Implement and study iterative voting as lightweight deliberation
- Social choice with incomplete data on large number of alternatives

I presented joint work with Joseph Boudou, Rachael Colley, Arianna Novaro, Andrea Loreggia, Brent Venable, Dominique Longin, Edith Elkind, Sirin Botan, Emiliano Lorini, Francesca Rossi, Filipo Studzinski-Perotto, Jérôme Lang, Laurent Perrussel, Markus Brill, Stéphane Airiau, James Stewart, Toby Walsh, Paolo Turrini, Ulle Endriss

Thank you all for your attention!