Computational Social Choice

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Rensselaer

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A.K.A.

- Preliminary research training for PhD in CS
- Doing research in computational social choice with Lirong
- A mini CS PhD in one semester

Today's schedule

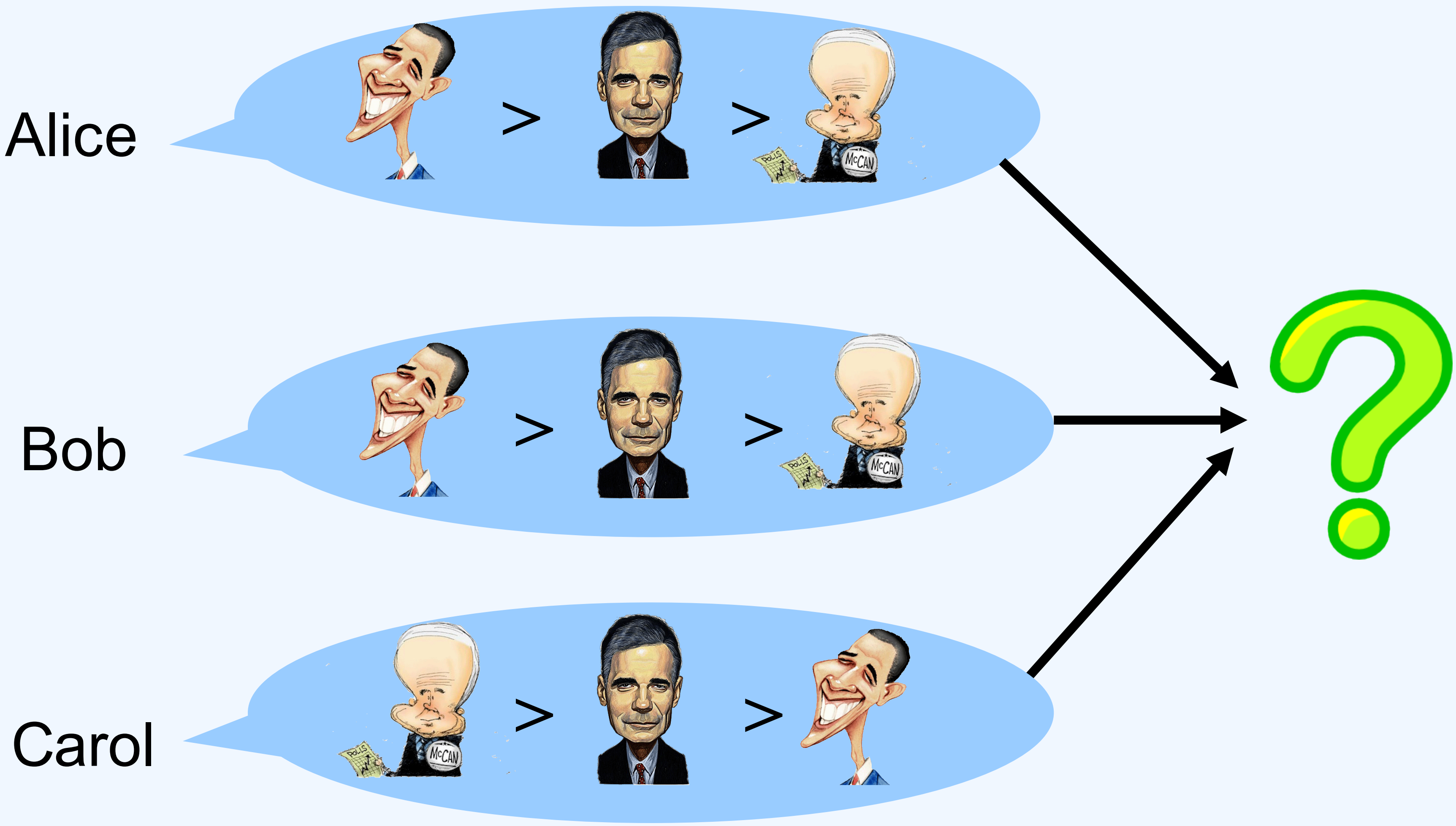
- Introduction to the course
  - the social choice problem
  - course schedule, grading
  - briefly introduce yourself
- Two goals of social choice mechanisms
  - democracy
  - truth
- Examples
  - elections
  - crowdsourcing
  - matching
  - resource allocation (we will use this to assign papers)
  - peer prediction (we will use this to grade your projects)

Social choice

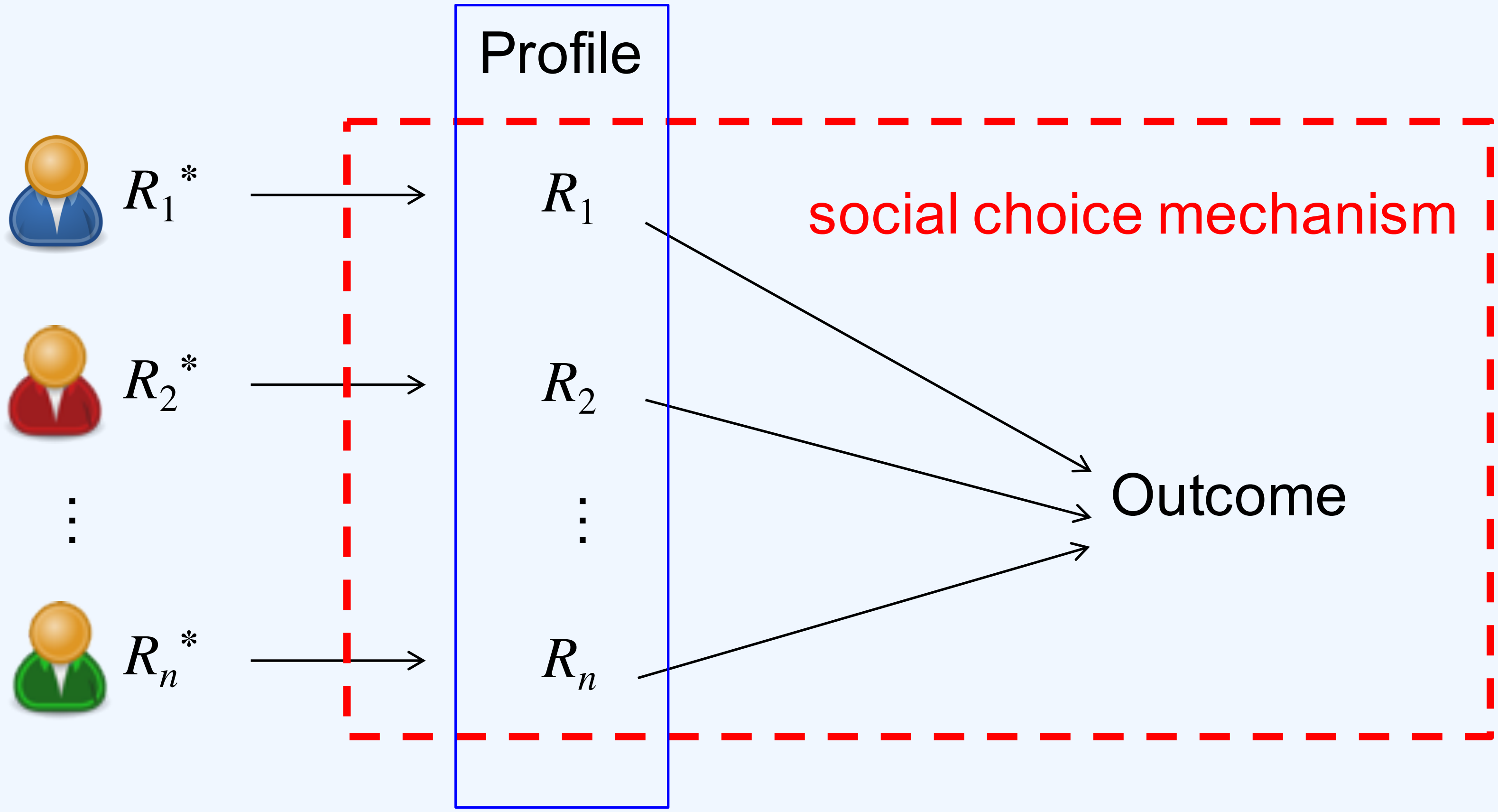
"*social choice is a theoretical framework for analysis of combining individual preferences, interests, or welfares to reach a collective decision or social welfare in some sense.*"

---Wikipedia Aug 26, 2013

Example: Political elections

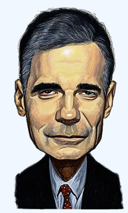
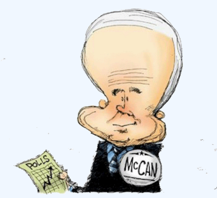


Social choice problems



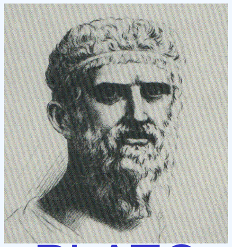
- Agents
- Alternatives
- Outcomes
- Preferences (true and reported)
- Social choice mechanism

Why this is social choice?

- Agents: {Alice, Bob, Carol}
- Alternatives: {  ,  ,  }
- Outcomes: winners (alternatives)
- Preferences (vote): rankings over alternatives
- Mechanisms: voting rules

A very brief history of social choice

Ancient Greece: 4^{th} C. B.C.



PLATO

13^{th}C.:

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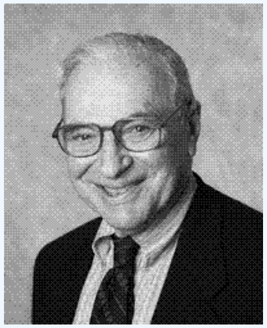
French revolution: 18^{th} C.

BORDA

CONDORCET

Modern: 20^{th} C.



ARROW

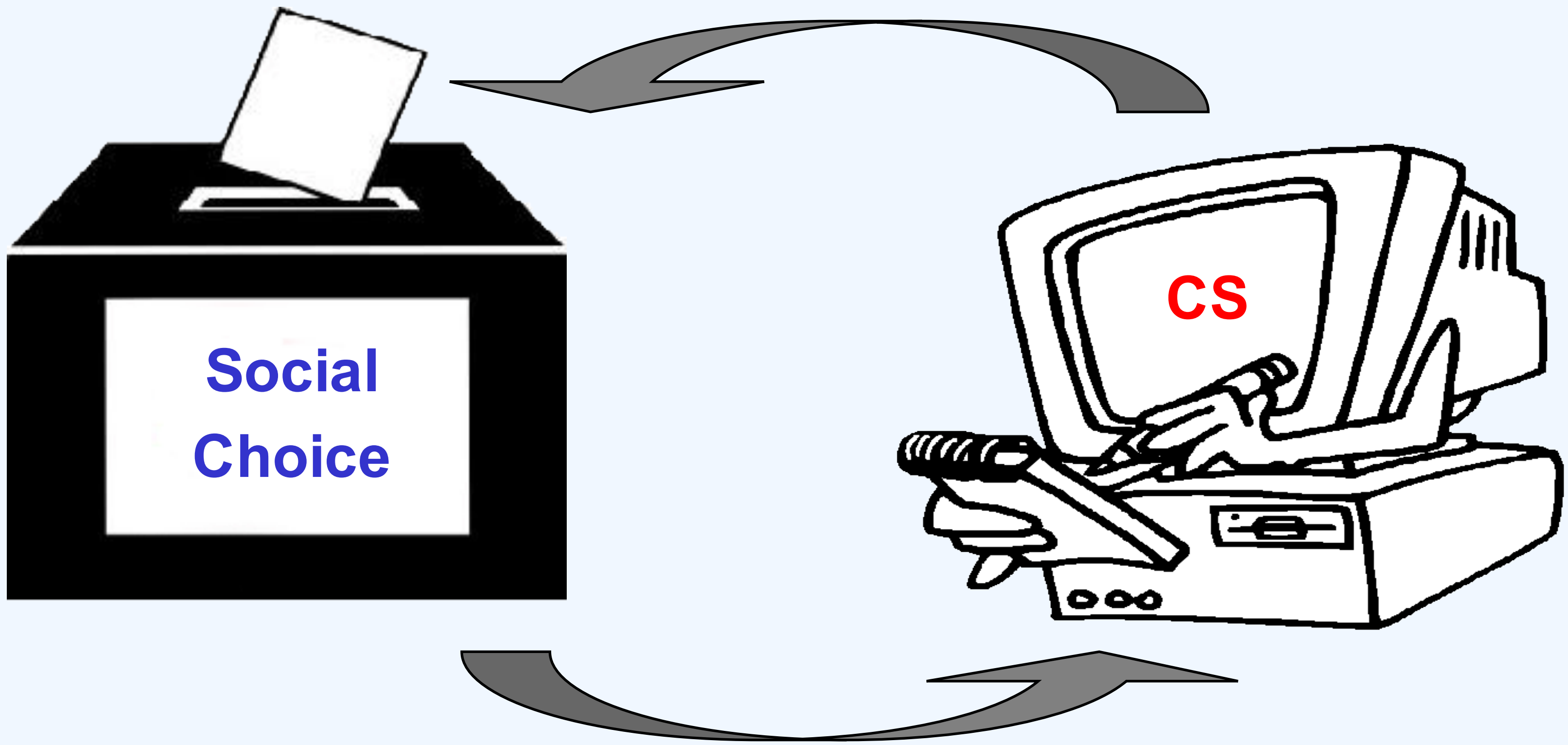
Computational social choice (COMSOC)

"*Computational social choice is an interdisciplinary field of study at the interface of social choice theory and computer science, promoting an exchange of ideas in both directions.*"

---http://www.illc.uva.nl/COMSOC/

Social Choice and Computer Science

Computational thinking + optimization algorithms



Strategic thinking + methods/principles of aggregation

Course at a glance

- Not a usual lecture course
  - lectures are like academic tutorials
  - expect a steep learning curve
- Try to
  - apply (computational) social choice to your research problems
  - improve computational social choice
- Participation is important
  - presentations, comments, grading, etc.
  - we will use piazza for discussions and announcements

Lifecycle of CS PhDs

- Learning
- Reading state-of-the-art papers
- Brainstorming for new ideas/topics
- Work it out
- Write papers
- Review others' work
- Dissertation

Schedule

	Topics	Your job
Part 1: Lectures (10-12 classes)	• Introduction to – social choice – game theory – mechanism design – computation • Computational social choice	• a few homeworks • prepare for paper presentation • work on the project START EARLY
Part 2: Students present papers (10-12 classes)	State-of-the-art research topics	Presenter • make slides • present the paper • lead the discussion Audience • ask/answer questions • participate in discussion
Part 3:presentations (2-3 classes)	Your own project	Presenter: give the talk Audience: enjoy the talk
Part 4: evaluation	Grade a classmate’s project	Quality of grading is part of your final grade

Paper presentation

- When you read the paper, think about the following questions
  - What is the problem?
  - Why we want to study this problem? How general it is?
  - How was problem addressed?
  - Appreciate the work: what makes the paper nontrivial?
  - Critical thinking: anything you are not very satisfied with?
- Prepare some “reading questions” for discussion

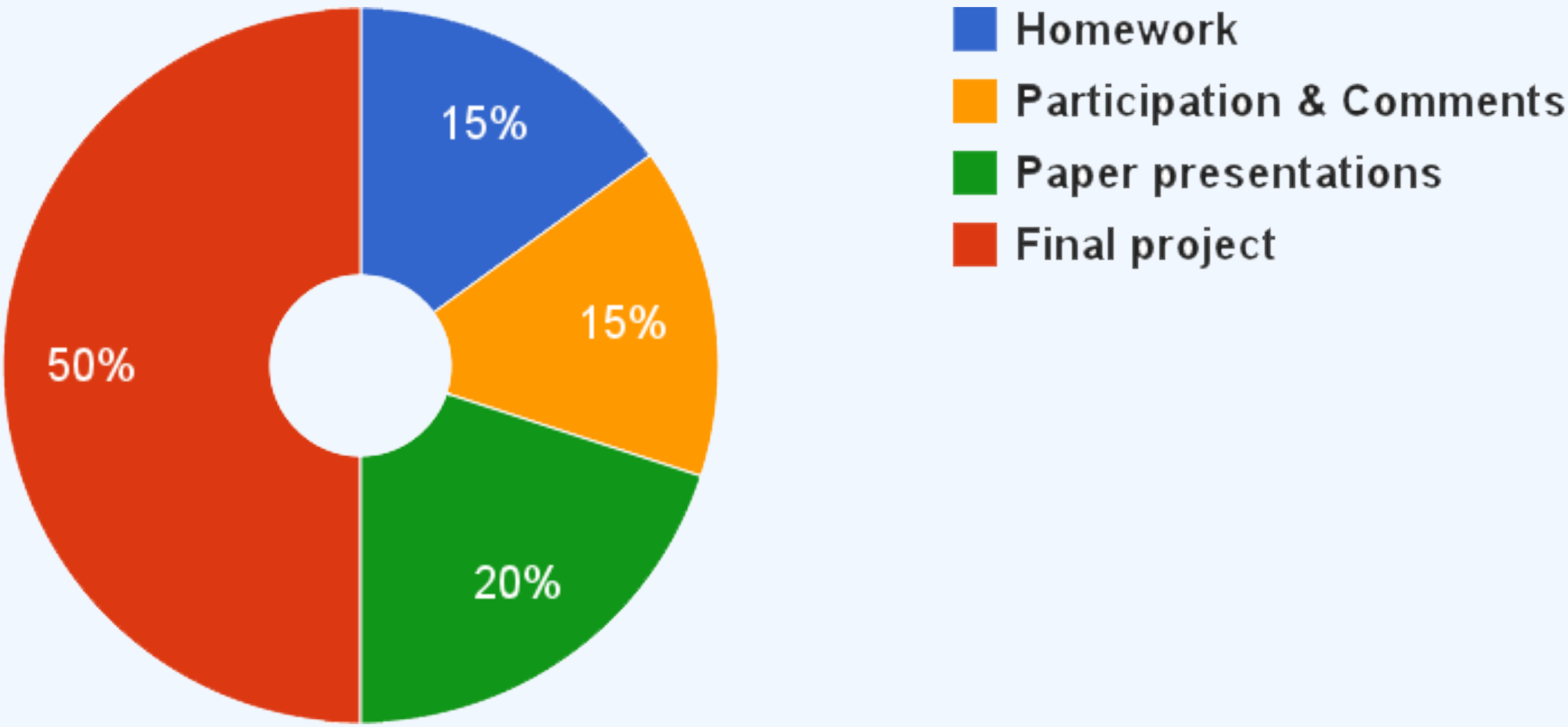
Project ideas

- Very encouraged to find your own topic
- Some quick ideas
  - Theory
    - design and analyze social choice mechanisms for topics of your own interest
  - Application
    - Online voting system for RPI student union elections
    - Matching and resource allocation (class slots, dorm slots, mentor application)
    - Mobile apps for preference handling

Awards

- A few possibility for awards
  - Best theory project
  - Best application project
  - Best presentation
  - Best participation
- NO bonus grade points

Your final grade



Objective: learning to **apply**

Expectation after the course

- This is a very technical and mathematical course
  - check out slides from last years
- After the course, you should
  - understand principles and methods in (computational) social choice
  - be able to apply what you learned to your own research
  - become an expert in Chinese accent
- More concretely
  - get some preliminary results for publication
  - develop a real-world preference-handling system
  - know what is Lirong talking about

Outcome of the previous year

- 2 published papers
  - AAMAS, UAI
- 3 in submission
- An online platform for sequential allocation (more to be done)
- An mobile app for voting

Some applications and social choice mechanisms

How to design a good social choice mechanism?

What is being "good"?

Two goals for social choice mechanisms

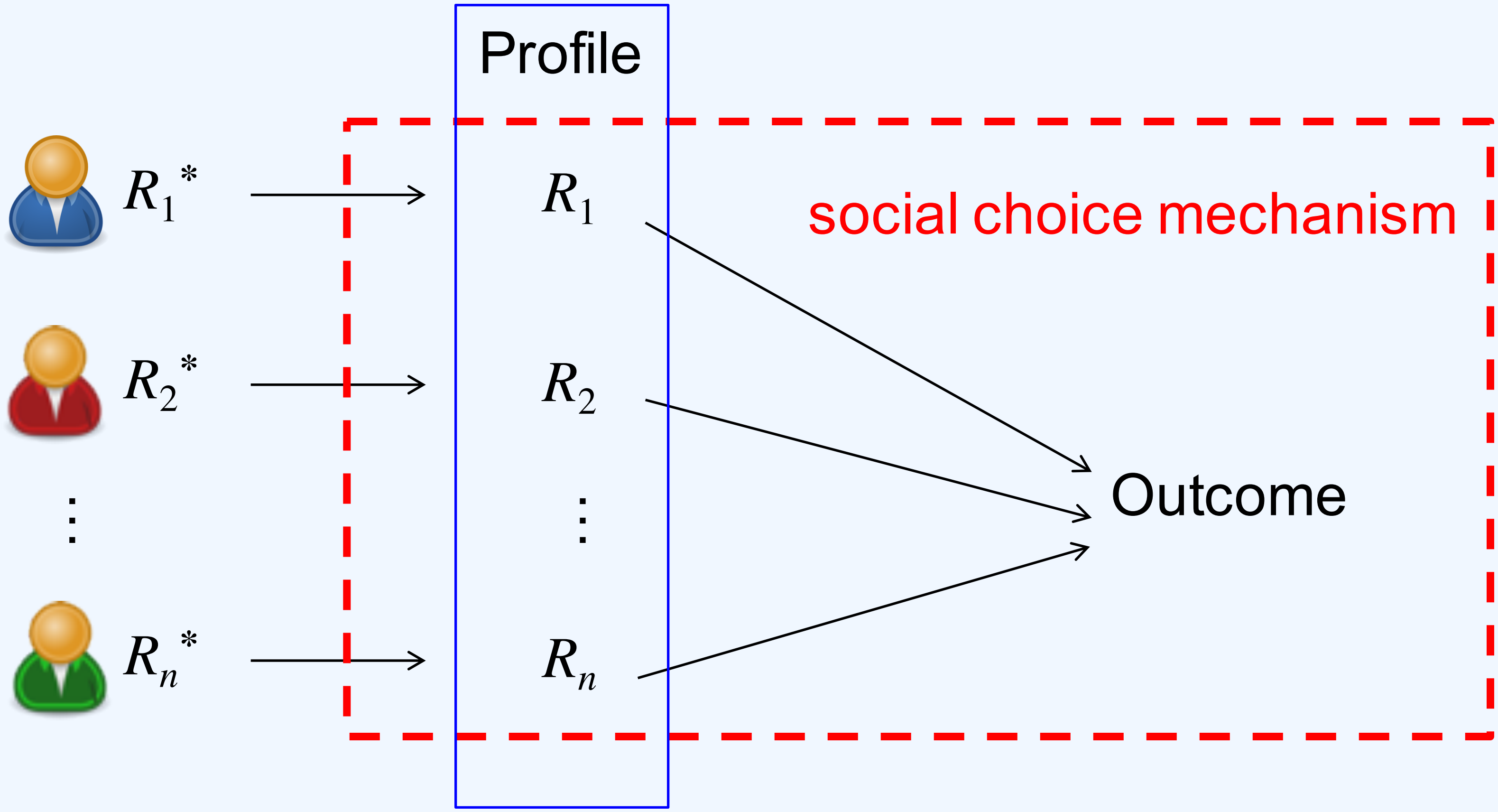
GOAL1: democracy

GOAL2: truth

Challenges

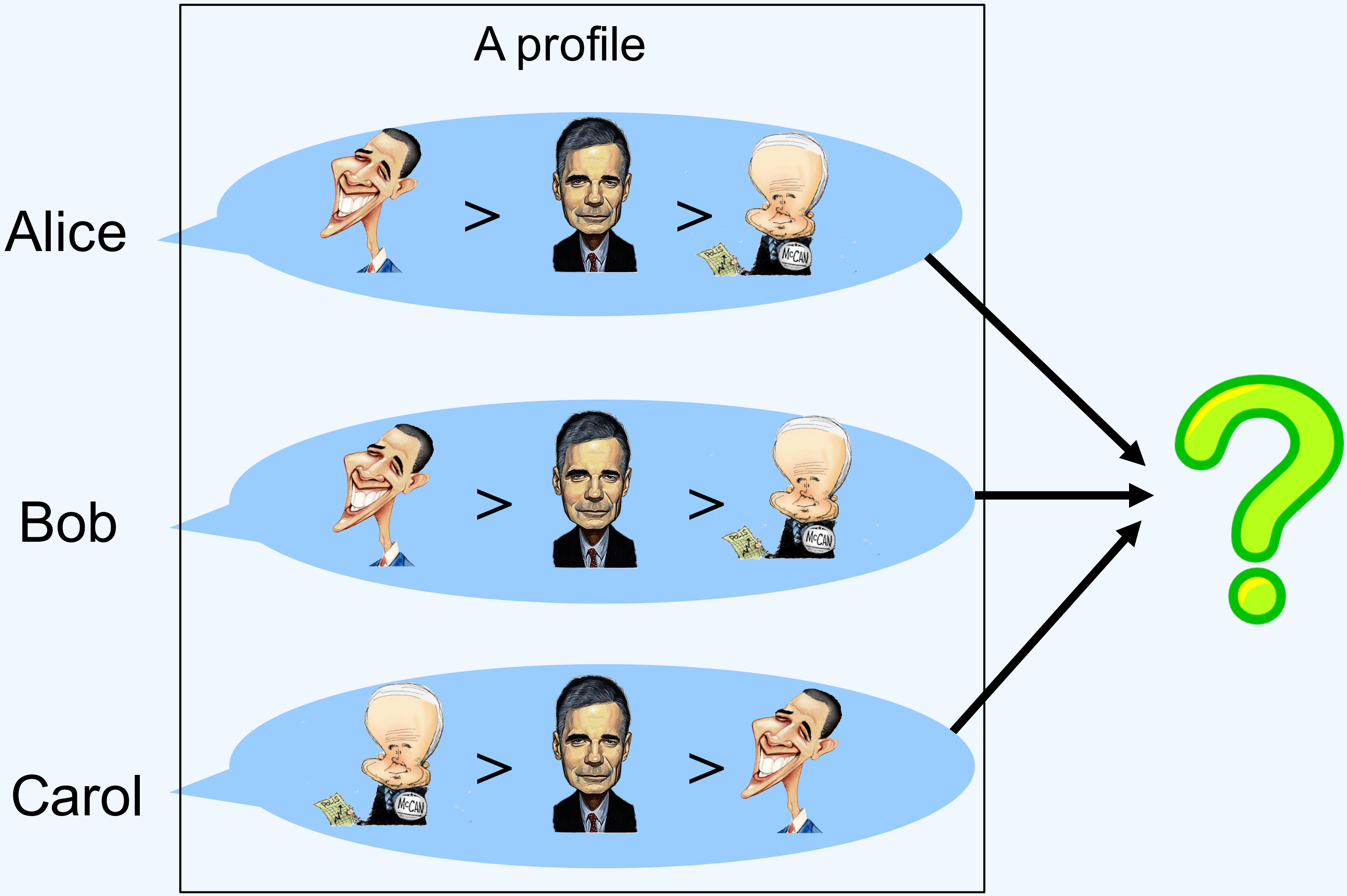
- Evaluation:
  - democracy: fairness, efficiency, etc.
  - truth: accuracy
- Computation: how can we compute the outcome as fast as possible
- Incentives: what if an agent does not report her true preferences?

Recall: social choice

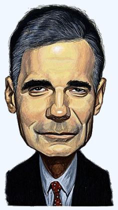
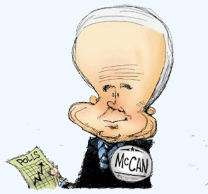


- Agents
- Alternatives
- Outcomes
- Preferences (true and reported)
- Social choice mechanism

Example1: Political elections



Why this is social choice?

- Agents: {Alice, Bob, Carol}
- Alternatives: {  ,  ,  }
- Outcomes: winners (alternatives)
- Preferences (vote): rankings over alternatives
- Mechanisms: voting rules
- Goal: democracy

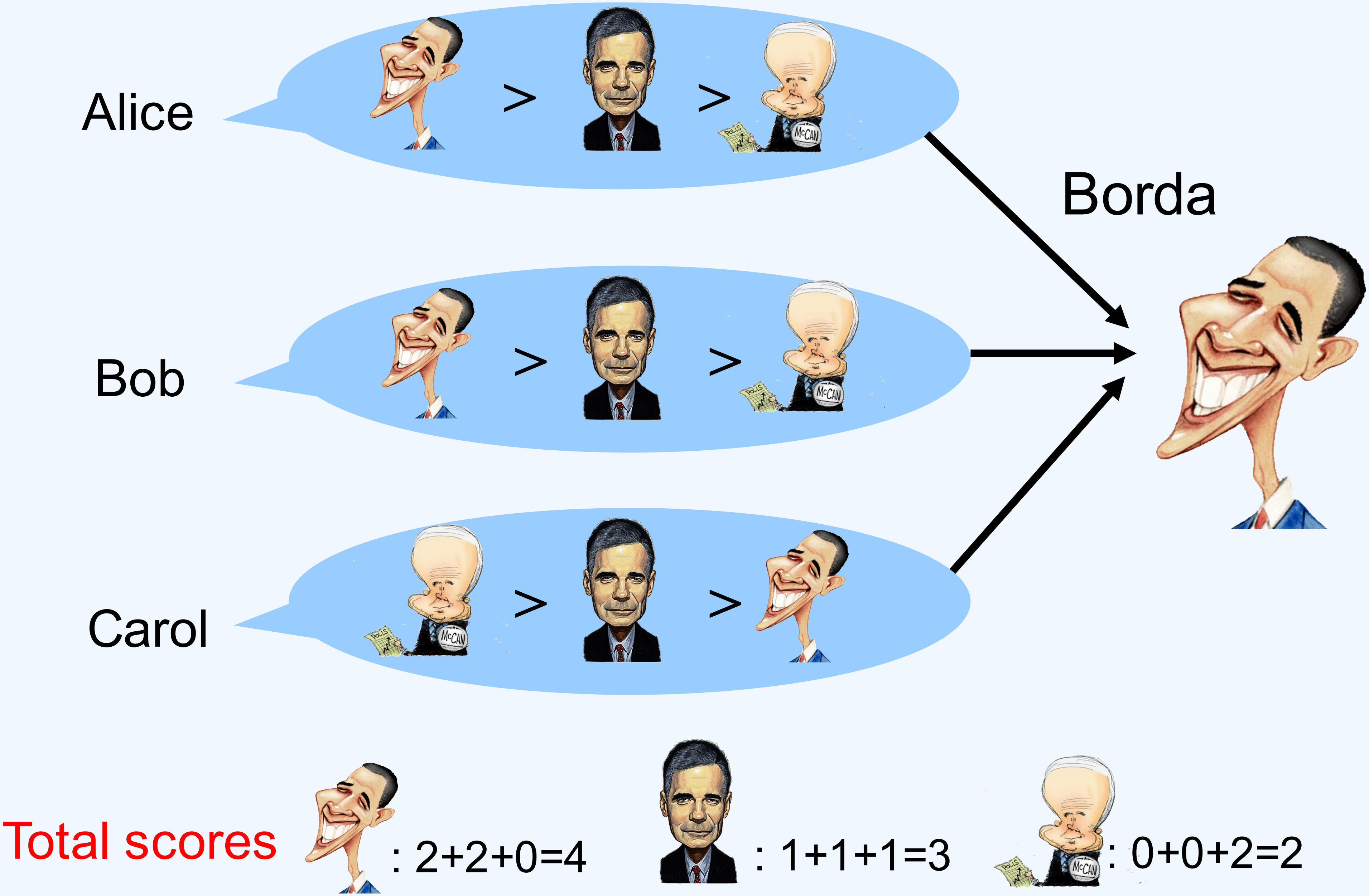
The Borda voting rule

BORDA

LULL

- Input: profile of rankings over alternatives
- Output: a single winner
  - For each vote R, the alternative ranked in the i-th position gets m-i points
  - The alternative with most total points is the winner
    - Use some tie-breaking mechanism whenever there is a tie

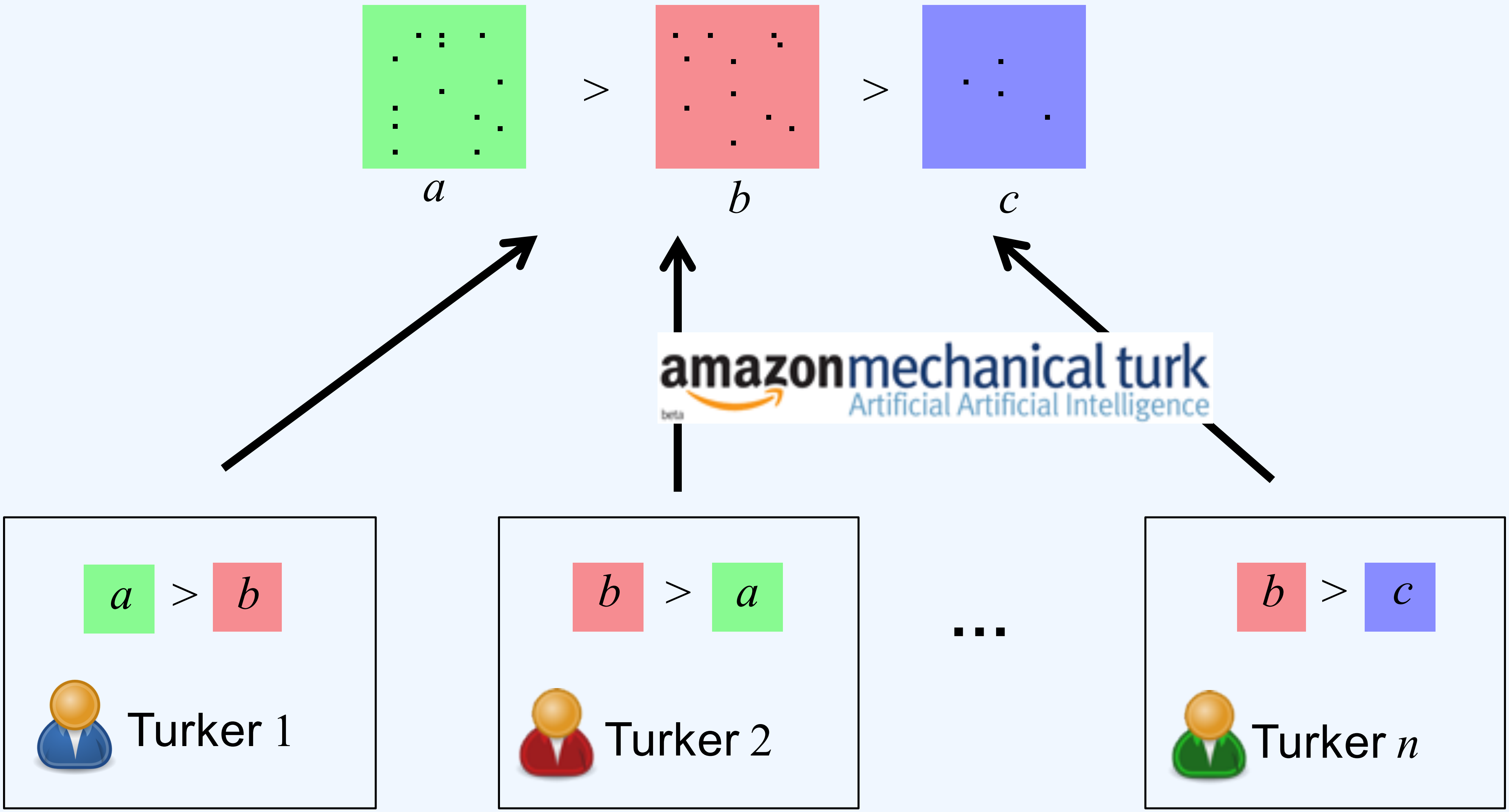
Example of Borda



Other voting rules?

- Many other voting rules beyond Borda will be discussed in the next class
- Which one is the best?
  - Hard to compare. Criteria will be discussed in the next class

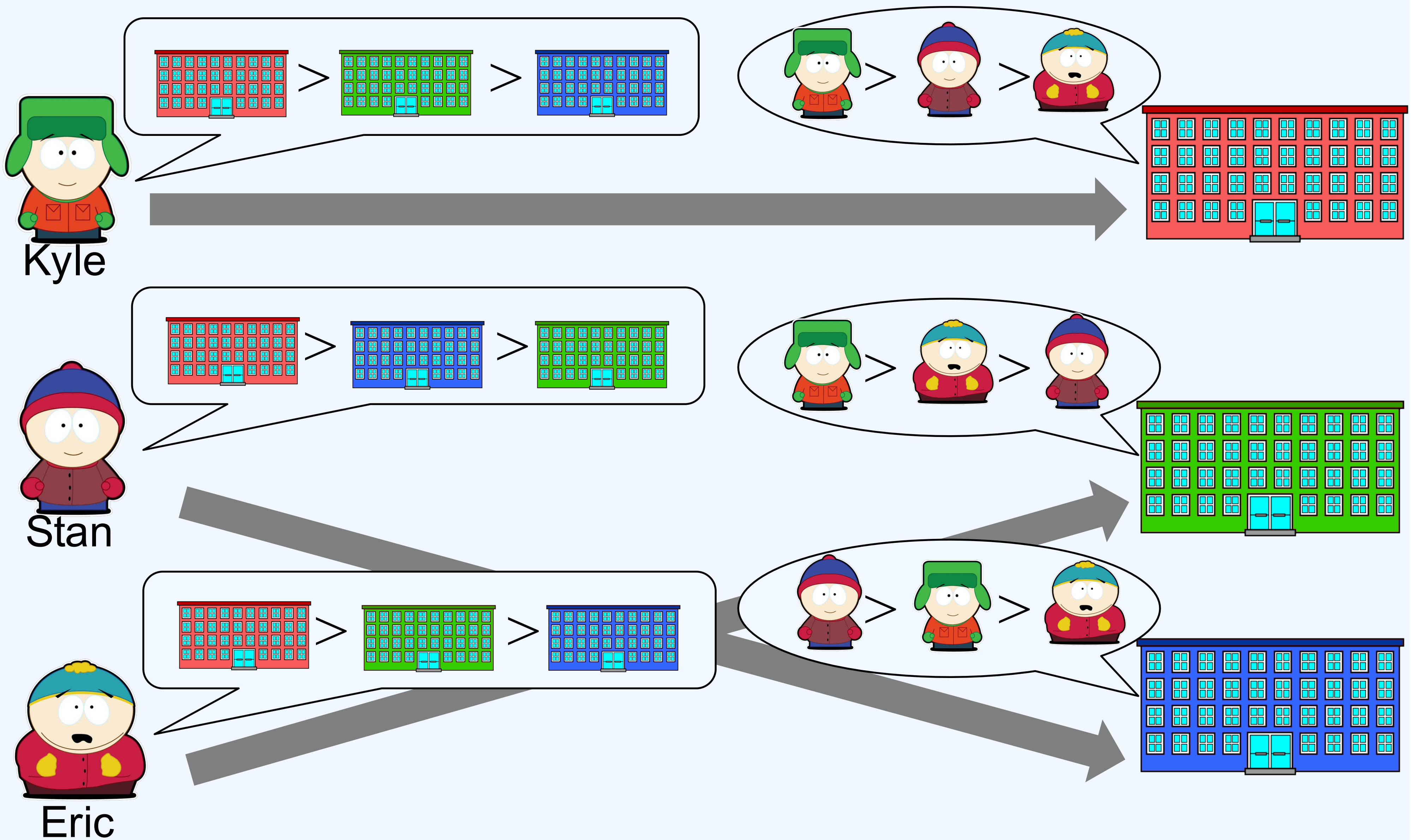
Example2: Crowdsourcing



Why this is social choice?

- Agents: Turkers
- Alternatives: { a , b , c }
- Outcomes: rankings over the pictures
- Preferences: pairwise comparisons
- Mechanisms: Maximum likelihood estimator
- More in the "statistical approaches" class
- Goal: truth

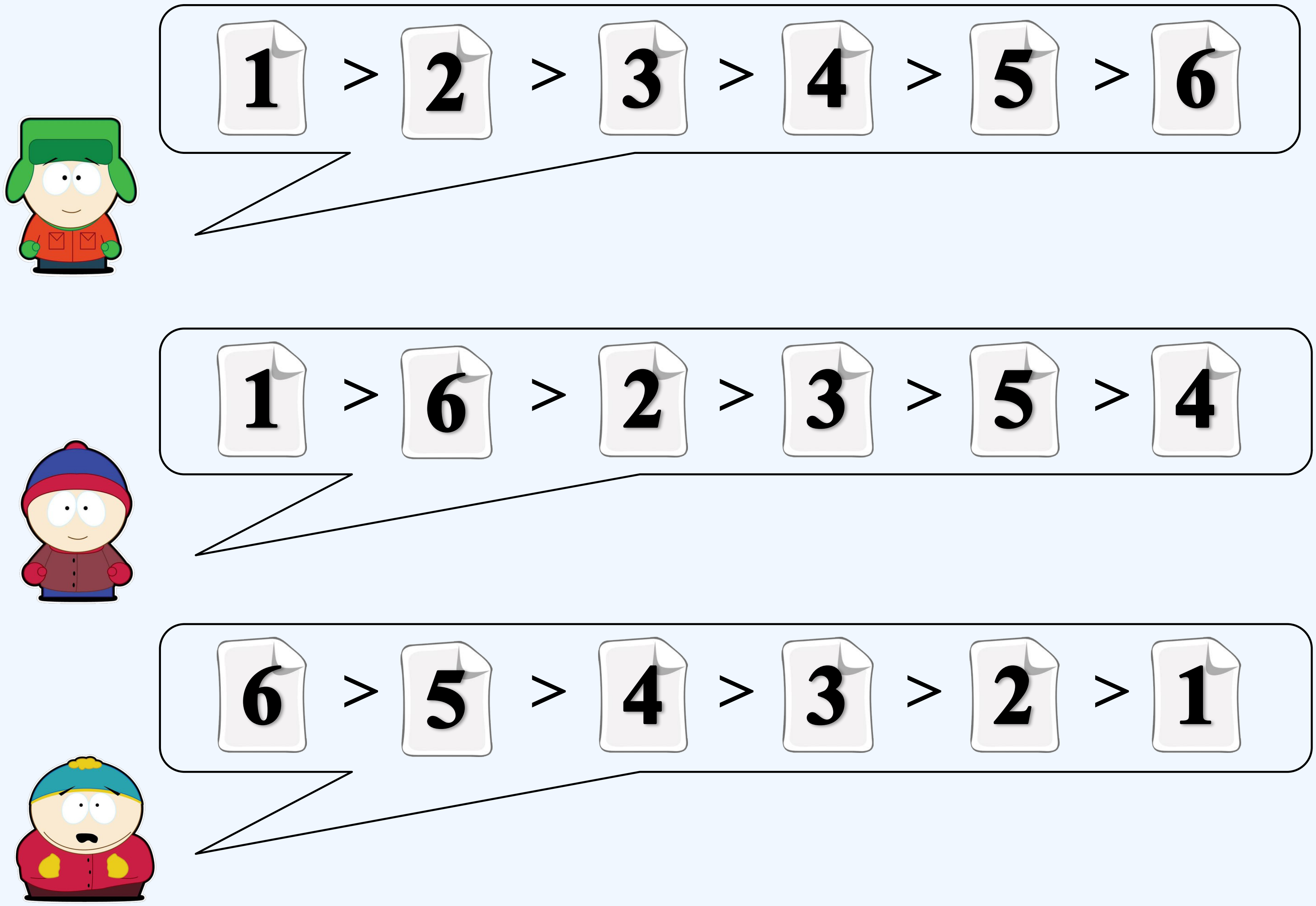
Example3: School choice



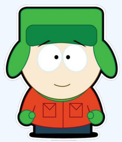
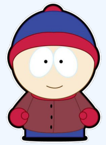
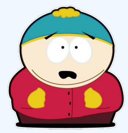
Why this is social choice?

- Agents: students and schools
- Alternatives: students and schools
- Outcomes: matchings between students and schools
- Preferences:
  - Students: rankings over schools
  - Schools: rankings over students
- Mechanisms: Stable matching (Nobel Prize 2012)
- More in the “matching” class
- Goal: democracy or truth?

Example4: Resource allocation



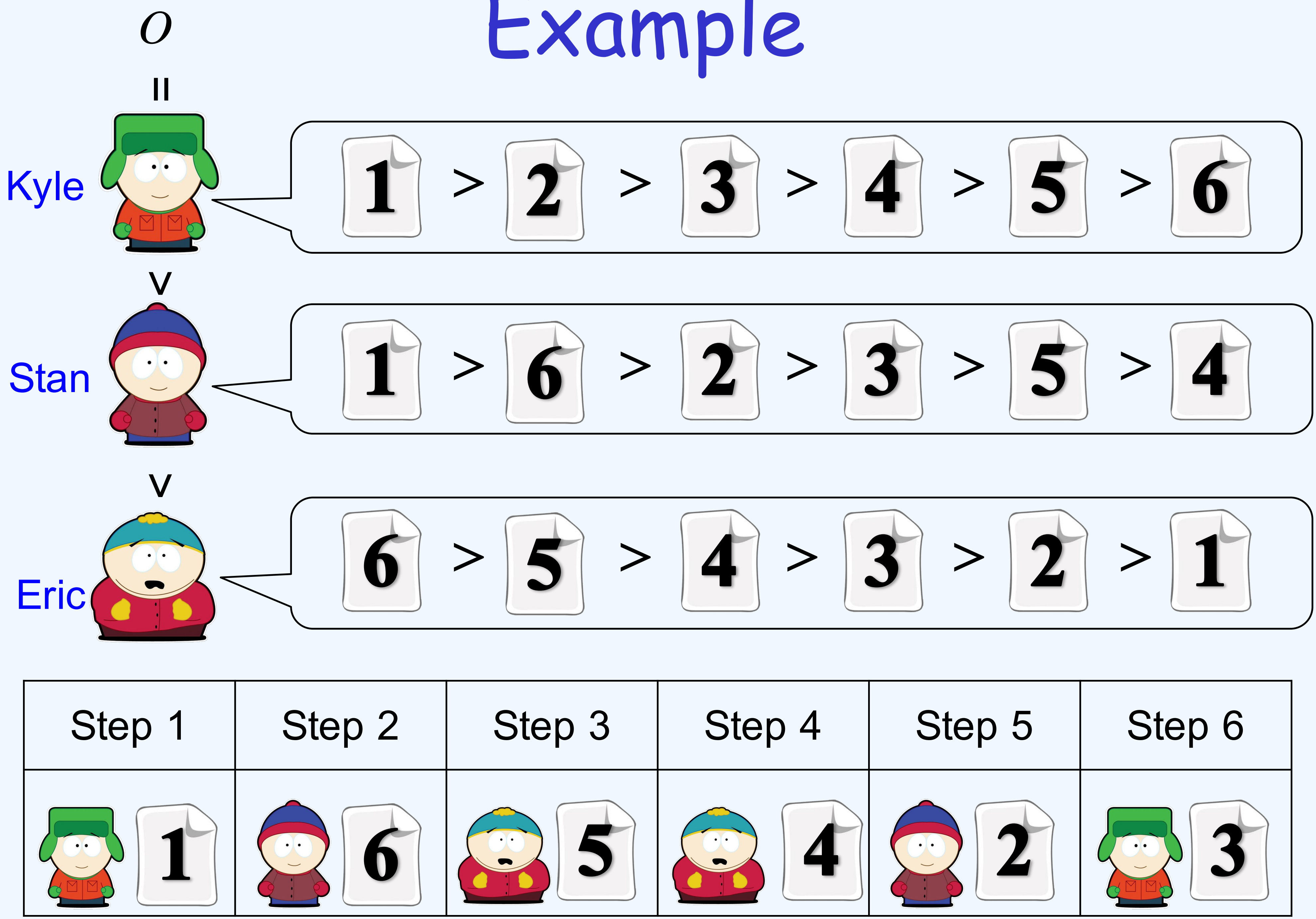
Why this is social choice?

- Agents: {    }
- Alternatives: { 1 2 3 4 5 6 }
- Outcomes: allocations of papers to students
- Preferences: rankings over papers
- Mechanisms: sequential allocation
- More in the “fair division” class
- Goal: democracy or truth?

Sequential allocation

- Given
  - n students' preferences over $2n$ papers, and
  - an order O over the students
- SA_O has $2n$ rounds
  - In the first n rounds,
    - for each t =1 to n, the t-th student in O selects her most preferred paper that is available
  - In the next n rounds,
    - for each t =n to 1, the t-th student in O selects her most preferred paper that is available

Example



o
=
Kyle
1 > 2 > 3 > 4 > 5 > 6
>
Stan
1 > 6 > 2 > 3 > 5 > 4
>
Eric
6 > 5 > 4 > 3 > 2 > 1
Step 1
Step 2
Step 3
Step 4
Step 5
Step 6
1
6
5
4
2
3

Is it a good mechanism?

- Sounds good
  - Efficient: if we have different preferences, then we will all (almost) get what we want
  - Fair: (1^{st} pick, last pick), (2^{nd} pick, 2^{nd} to last pick)…
- How can we formalize these arguments?

Sequential allocation for you

- We will use sequential allocation to come up with an initial assignment of papers
  - Each team reports a full ranking over the papers
  - The earlier a team reports, the higher it will be ranked in O
    - You will have better chance to get your favorite paper

The second phase

- Each topic is assigned a date
- You can exchange the dates on piazza
  – e.g. using the top trading cycle mechanism
- More in the matching class

Project grading

- Step 1. Everyone is assigned 2 or 3 projects of your classmate's using sequential allocation
- Step 2. Your grading performance will be evaluated against other grades including mine
- Your final grade for project is p% of the aggregated grades and (100-p)% of your grading performance
- What is p? Let's vote after the drop deadline!

Wrap up

- Expectation: learn how to apply computational social choice to your own research area
- But be careful and keep in mind the two goals
  - democracy
  - truth

Before the next class

- Sign up at piazza (link on the course website)
- Say a few words about yourself
- Participate in discussions on piazza
  - Try to name some other applications of social choice
  - In your applications, will you design a mechanism to achieve democracy or truth?

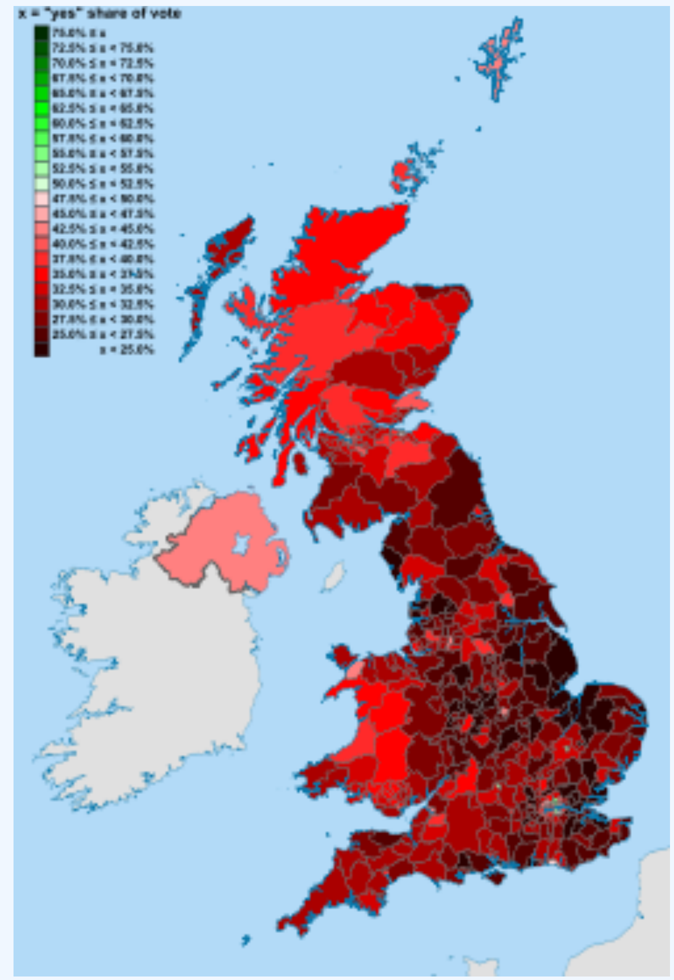
Why different from MOOC (e.g. coursera)

- Credits
- More interaction
  - Do feel free to interrupt with questions
- Hands-on research experience
- No similar course online
- I will be back to school eventually…

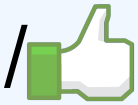
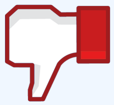
Change the world: 2011 UK Referendum

- The second nationwide referendum in UK history
  - The first was in 1975
- Member of Parliament election:

  Plurality rule ➔ Alternative vote rule
- 68% No vs. 32% Yes
- Why people want to change?
- Why it was not successful?
- Can we do better?

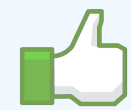
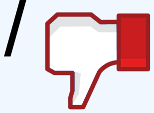


Example2: Multiple referenda

- In California, voters voted on 11 binary issues (/ ) 
  - 2^{11}=2048 combinations in total
  - $5/11$ are about budget and taxes

- Prop.30 Increase sales and some income tax for education
- Prop.38 Increase income tax on almost everyone for education

Why this is social choice?

- Agents: voters
- Alternatives: 2^{11}=2048 combinations of  / 
- Outcomes: combinations
- Preferences (vote): Top-ranked combination
- Mechanisms: issue-by-issue voting
- More in the "combinatorial voting" class
- Goal: democracy