Fair and Efficient Social Decision-Making

CSCI 699

Fair Division 3: Sortition

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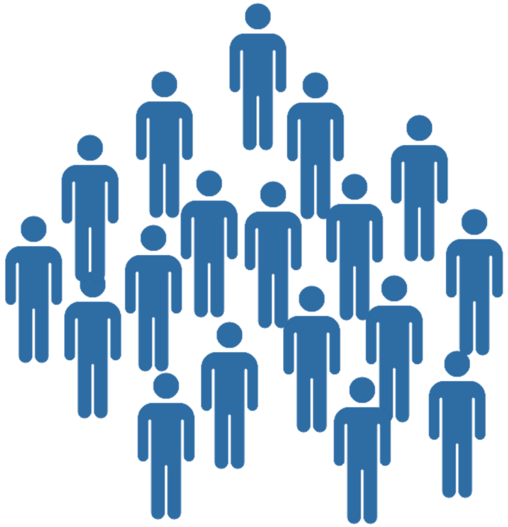
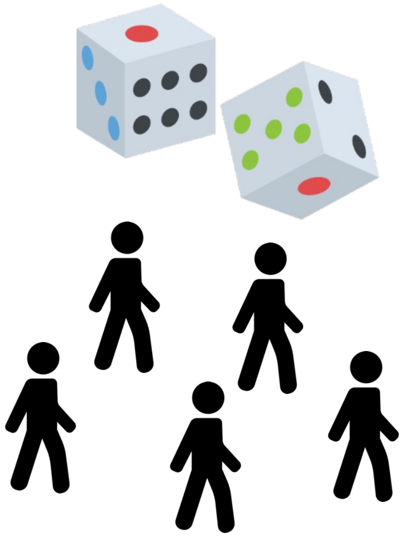
Citizens' Assemblies





Citizens' Assemblies

Athens

4^{th} century BC

Florence

14^{th} and 15^{th} century

Lombardy and Venice

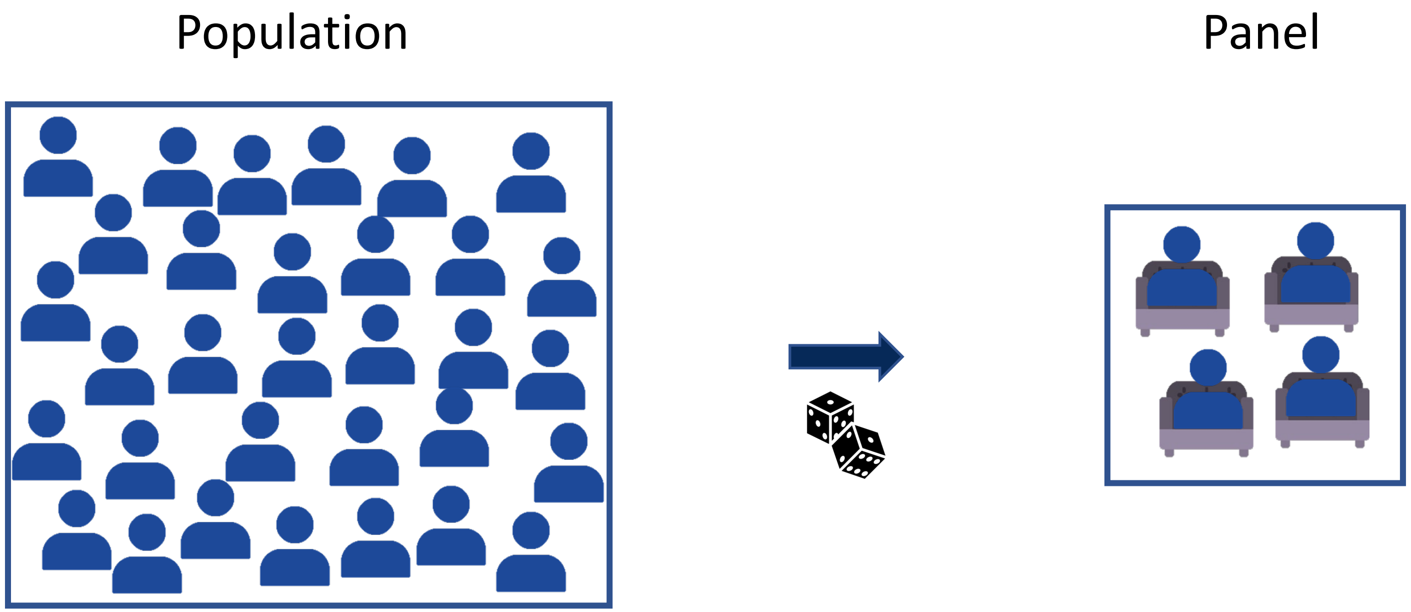
12^{th} to 18^{th} century

Citizens' Assemblies

Belgium

- Permanent Citizens Assemblies at a national level
- The recommendations *should* be followed up within nine months

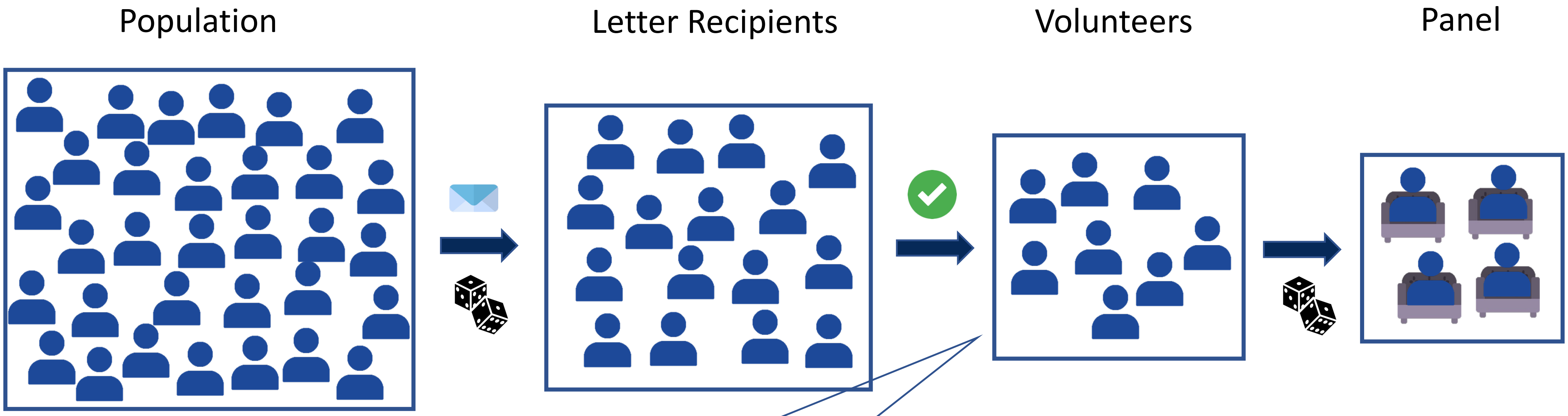
Ideal Sortition Execution



✓ **Fairness:** Everyone has equal chance of being on the panel

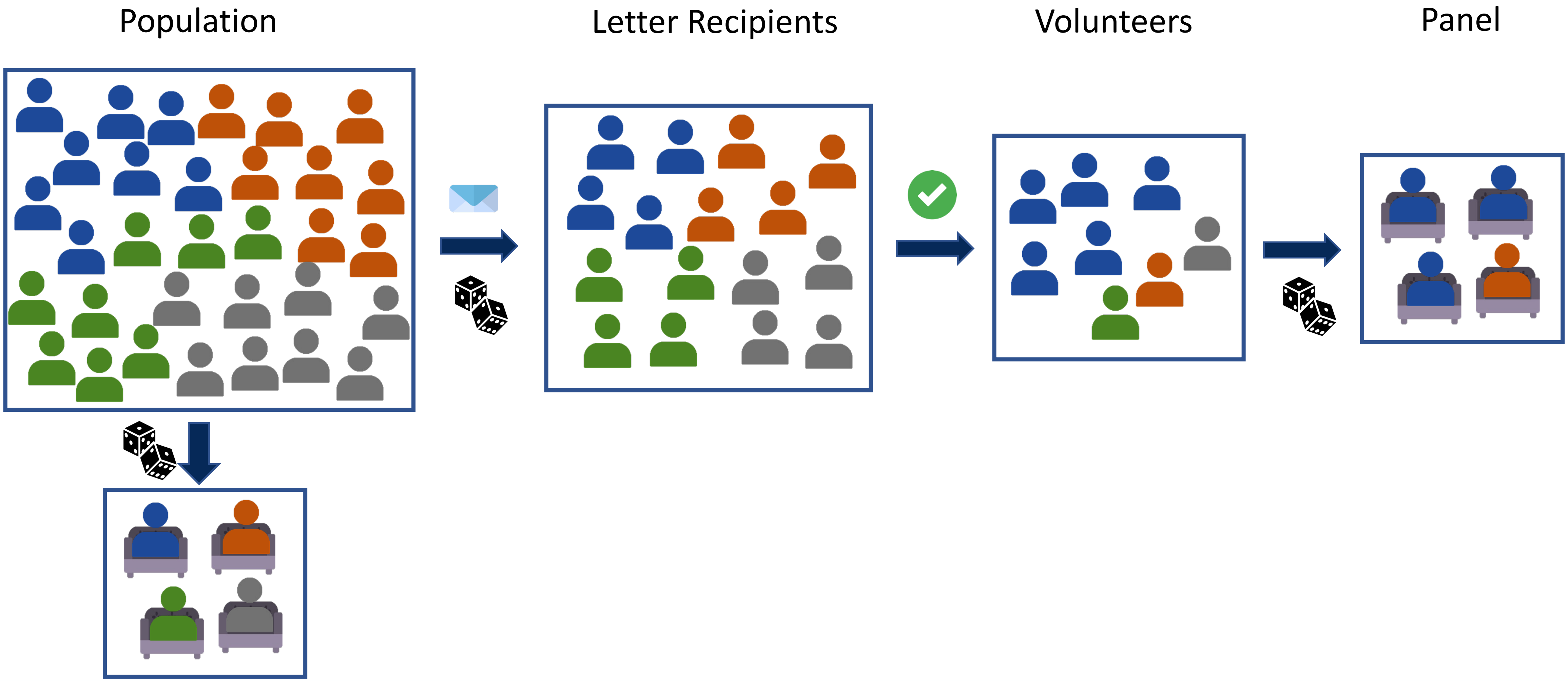
✓ **Proportional Representation:** A panel selected uniformly at random reflects the composition of the population, *in expectation*

Sortition in Practice



Climate Assembly UK 2020
Only 1,727 citizens accepted to participate out of the 30,000 recipients of the invitation!

Sortition in Practice



Features Quotas

- Gender
  - At least 47% of the representatives should females
  - At least 47% of the representatives should males
  - At least 3% of the representatives should self-identify non-binary
  -

- Age
  - At least 30% of the representatives ≤ 35
  - At least 25% of the representatives ≥ 65

- Geography
  - At least 35% of the representatives form the south
  - At least 30% of the representatives form the rural regions

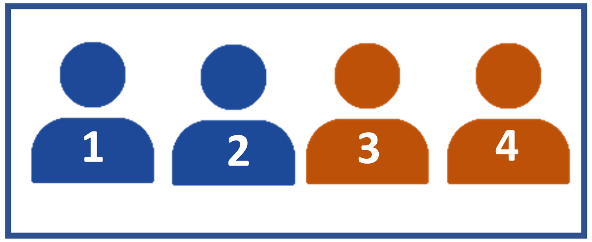
- …

Model

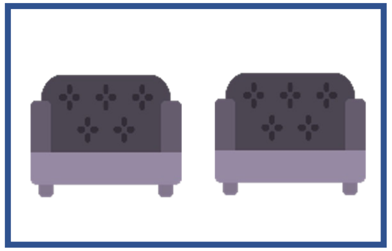
- A set of volunteers $N = \{1,2, \dots, n\}$
- A set of features F, where each $f \in F$ gets values in V_f
  - E.g. feature gender g gets values in $V_g = \{non - binary, female, male\}$
- Each volunteer i is characterized by the features
- A set of quotas such that for each $f \in F$ and $v_f \in V_f$, the number of representatives with feature f equal to v_f should be at least ℓ_{v_f} and at most u_{v_f}
- Goal: Find a lottery over panels of size k such that
  - Fairness: Each individual is selected with probability n/k (**ex-ante requirement**)
  - Representation: Each panel in the lottery satisfies the quotas (**ex-post requirement**)

Fairness and Representation

Volunteers



Panel



Quotas

- One representative should be blue
- One representative should be orange

Fair and Representative Lottery

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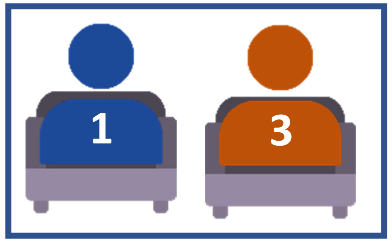

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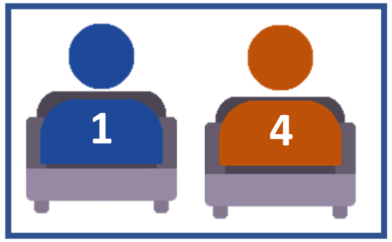

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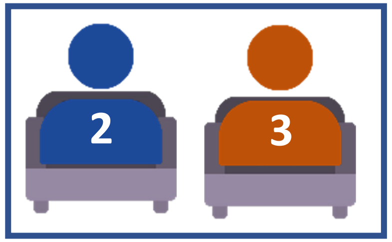

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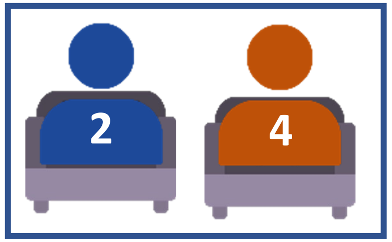
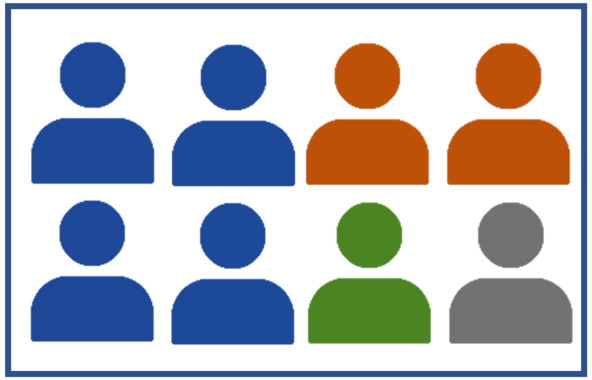


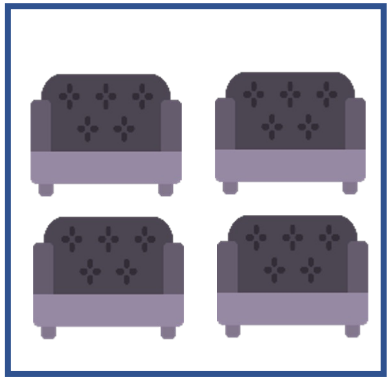
- Question: Can we always ensure fairness and representation?

Fairness and Representation

Volunteers



Panel



Quotas

- One representative should be blue
- One representative should be orange
- One representative should be green
- One representative should be grey

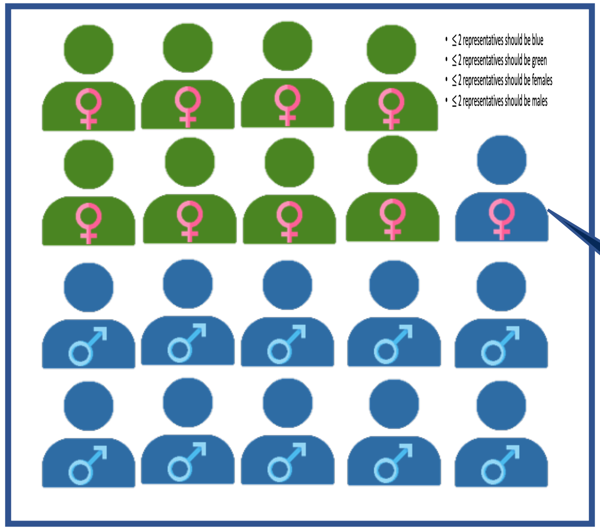
- Theorem [FGGHP, 2021]: For a given set of agents, panel size, and set of features with associated quotas, it is NP-hard to decide whether there exists a panel that satisfies the quotas

A Greedy Algorithm

- Start with an empty panel
- At each iteration for each $f \in F$ and $v_f \in V_f$ measure the need for v_f as following:
  - $need_{v_f} = \frac{\ell_{v_f} - (\#\, panel\, members\, with\, feature\, f\, equal\, to\, v_f)}{\#remaining\, pool\, memebers\, with\, feature\, f\, equal\, to\, v_f}$
- Choose v_f with the highest need
- Choose a representative at random among all the individuals in the pool with feature f equal to v_f
- If for some v_f, there are u_{v_f} members in the panel with feature f equal to v_f, then remove from the pool all the individuals with feature f equal to v_f
- If the final panel does not satisfy the quotas, restart

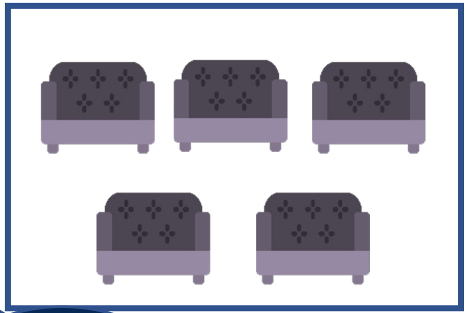
A Greedy Algorithm

Volunteers



$^{1}/_{16}$

Panel



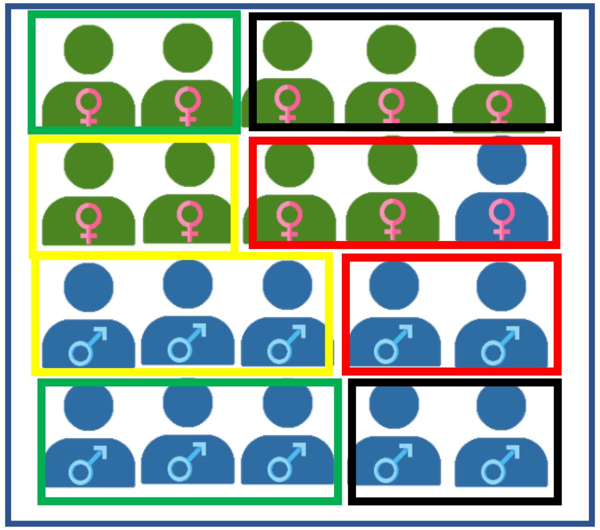
Quotas

- ≤ 2 representatives should be blue
- ≤ 2 representatives should be green
- ≤ 2 representatives should be females
- ≤ 2 representatives should be males

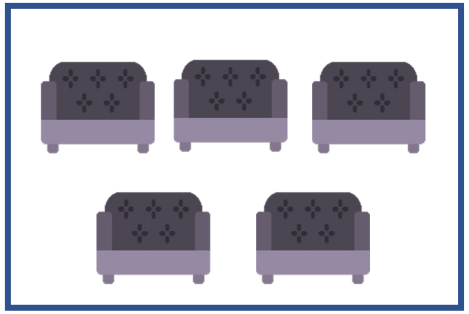
	Need of Green	Need of Blue	Need of Female	Need of Male
Round 1	$^{2}/_{9}$	$^{2}/_{11}$	$^{2}/_{10}$	$^{2}/_{10}$
Round 2	$^{1}/_{8}$	$^{2}/_{11}$	$^{1}/_{9}$	$^{2}/_{10}$
Round 3	$^{1}/_{8}$	$^{1}/_{10}$	$^{1}/_{9}$	$^{1}/_{9}$
Round 4	$^{0}/_{7}$	$^{1}/_{10}$	$^{0}/_{9}$	$^{1}/_{9}$
Round 5	$^{0}/_{7}$	$^{0}/_{9}$	$^{0}/_{9}$	$^{0}/_{8}$

Fair Lottery

Volunteers



Panel



Quotas

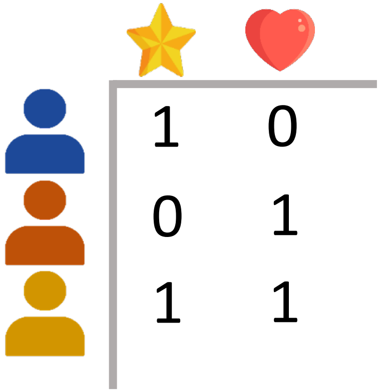
- ≤ 2 representatives should be blue
- ≤ 2 representatives should be green
- ≤ 2 representatives should be females
- ≤ 2 representatives should be males

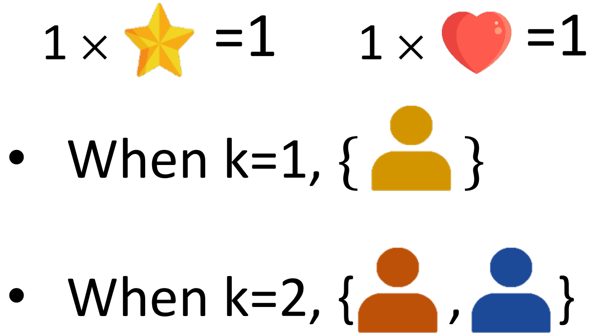
Fair Lottery

- Maximum Nash Social Welfare
  - Return a lottery over quota-feasible panels of size k such that $\max \prod_{i \in N} \Pr[i \text{ is selected}]$
- Leximin
  - Return a lottery over quota-feasible panels of size k such that $\max \min_{i \in N} \Pr[i \text{ is selected}]$ subject to that maximize the second minimum probability, etc.
- Theorem [FGGHP, 2021]: Maximum Nash Social Welfare and Leximin equalize volunteers' selection probabilities whenever the quotas make it feasible.
- Question: What about maximizing the utilitarian social welfare, i.e. sum of probabilities?

Axiomatic Properties

- Committee Monotonicity: When k increases, the selection probability of all volunteers weakly increases
- Theorem [FGGHP, 2021]: No selection algorithm can guarantee committee monotonicity
- Proof:





Axiomatic Properties

- Population Monotonicity: When more volunteers are added, the selection probability of all the existing volunteers weakly decreases
- Theorem [FGGHP, 2021]: No selection algorithm can guarantee committee monotonicity