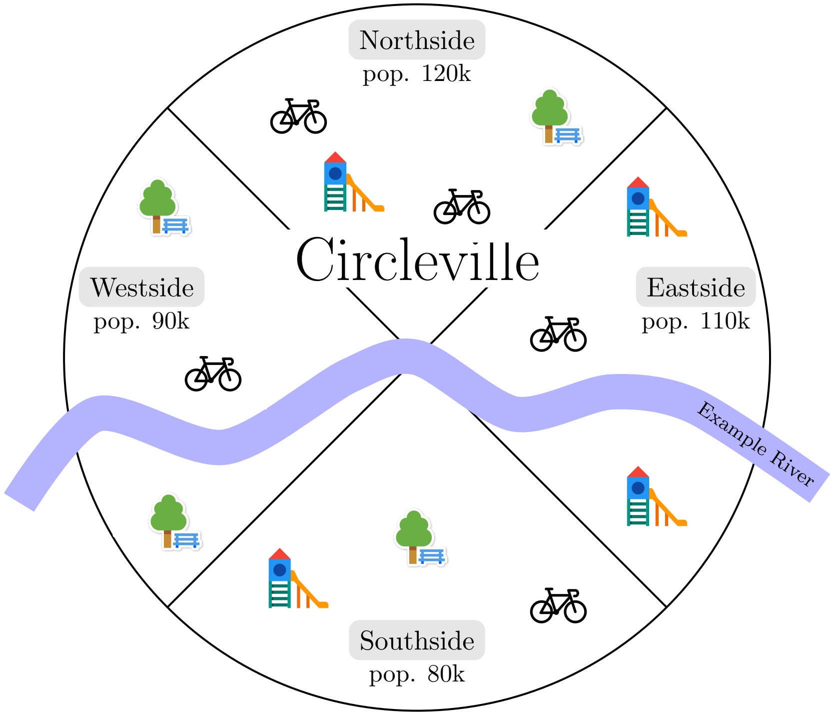
Computational Social Choice and Fair Participatory Budgeting

Piotr Skowron

University of Warsaw



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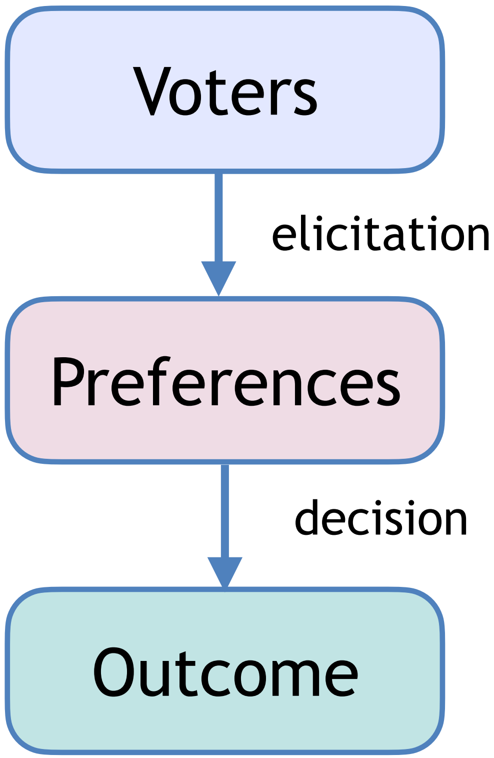

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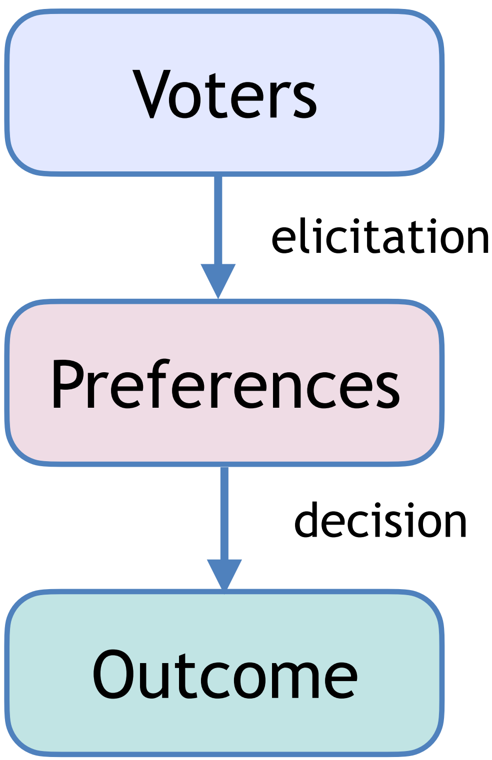

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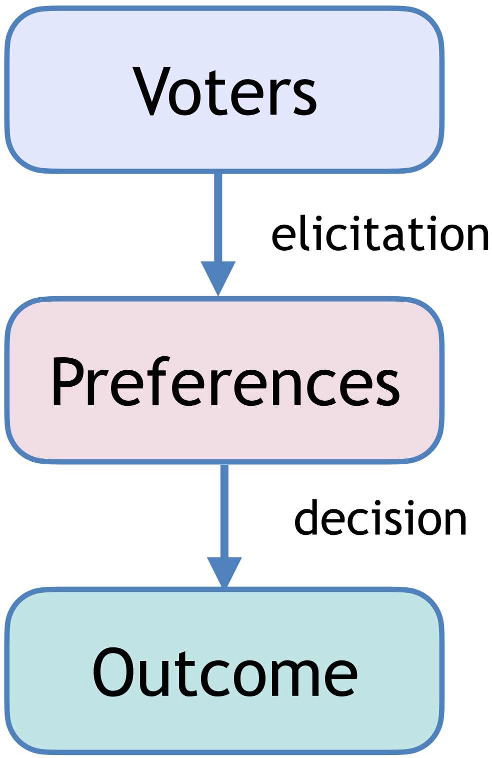

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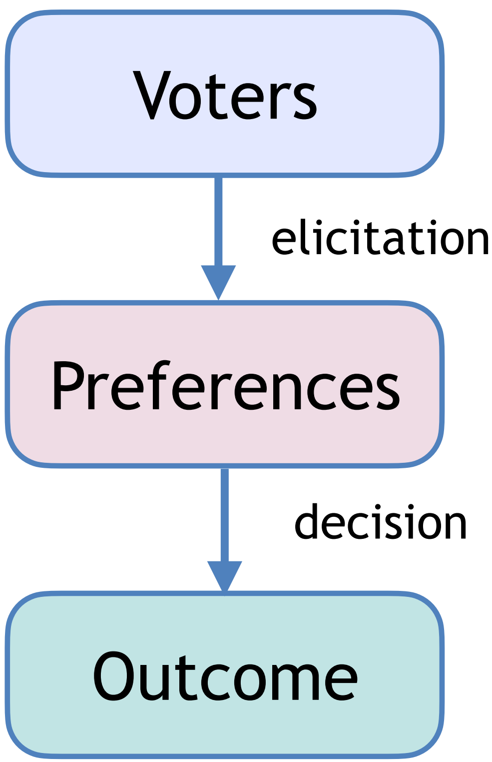

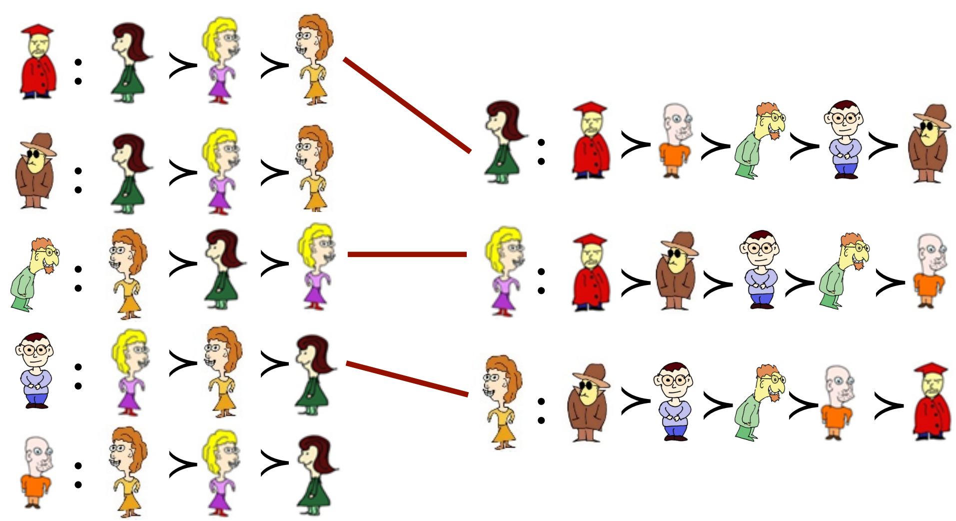

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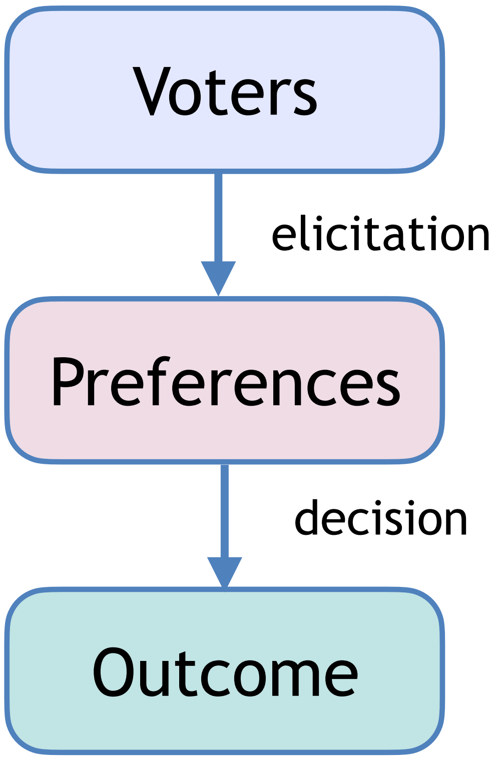

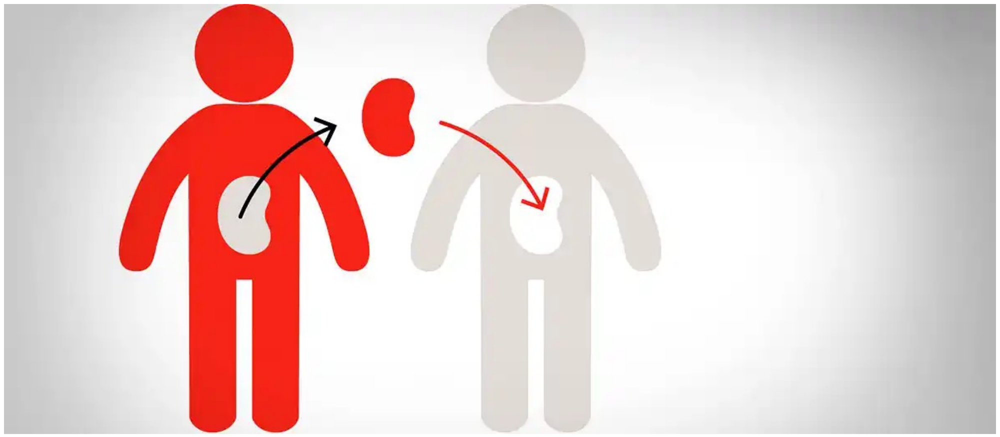

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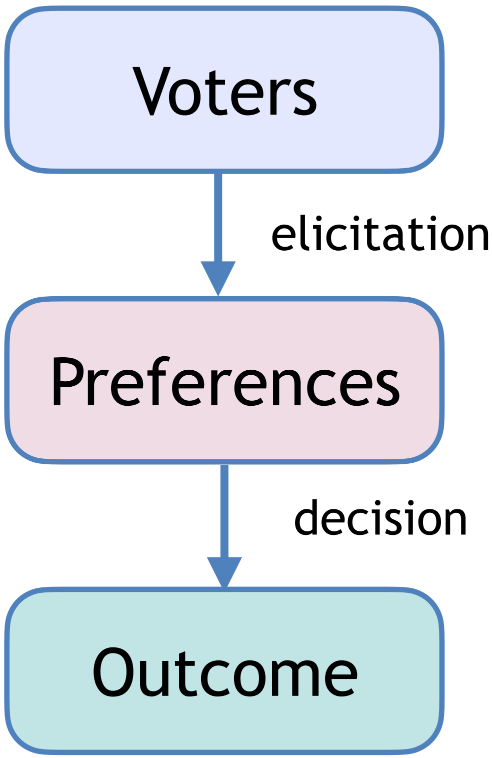

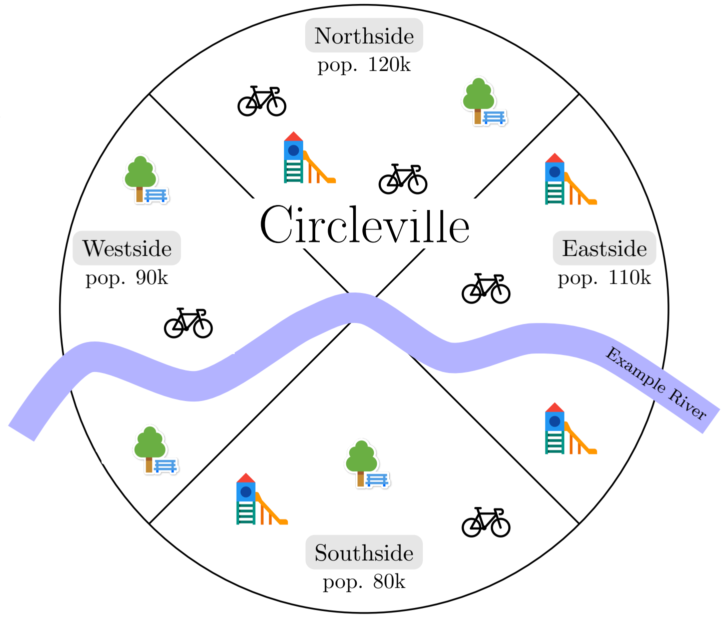

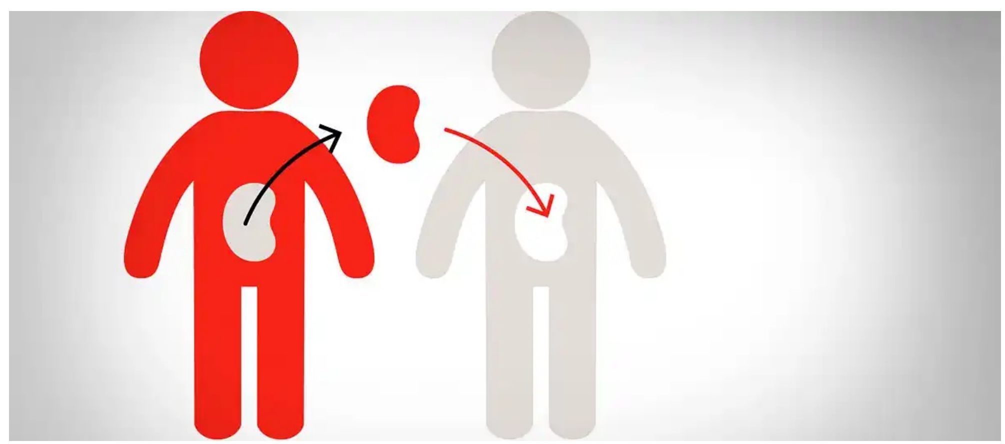

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Social Choice

Computer science
&
Discrete mathematics

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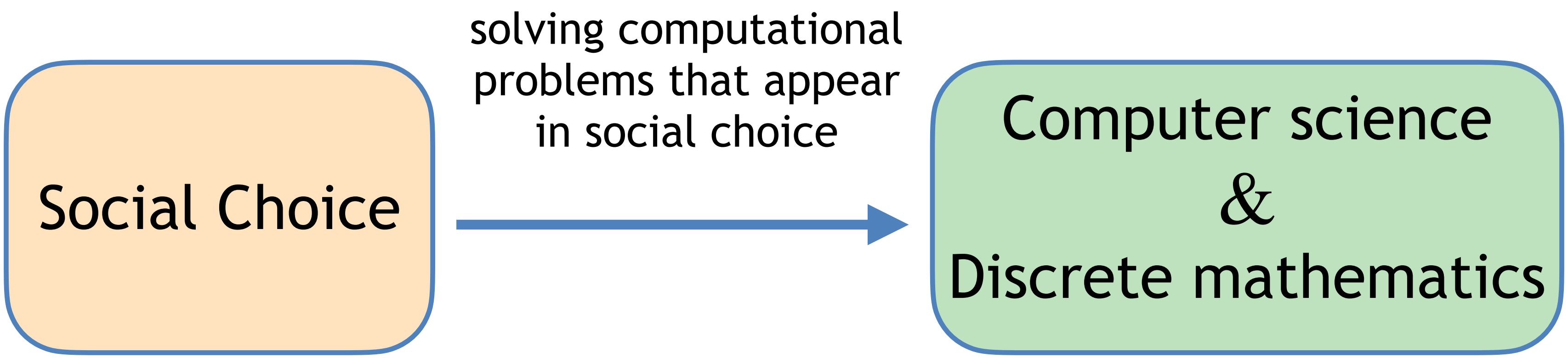

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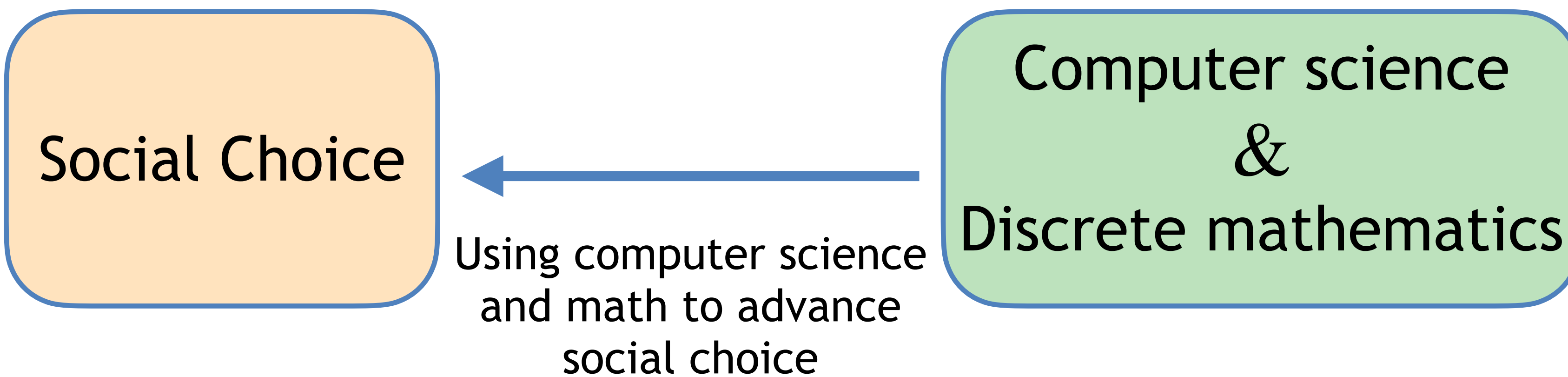

The model for participatory budgeting

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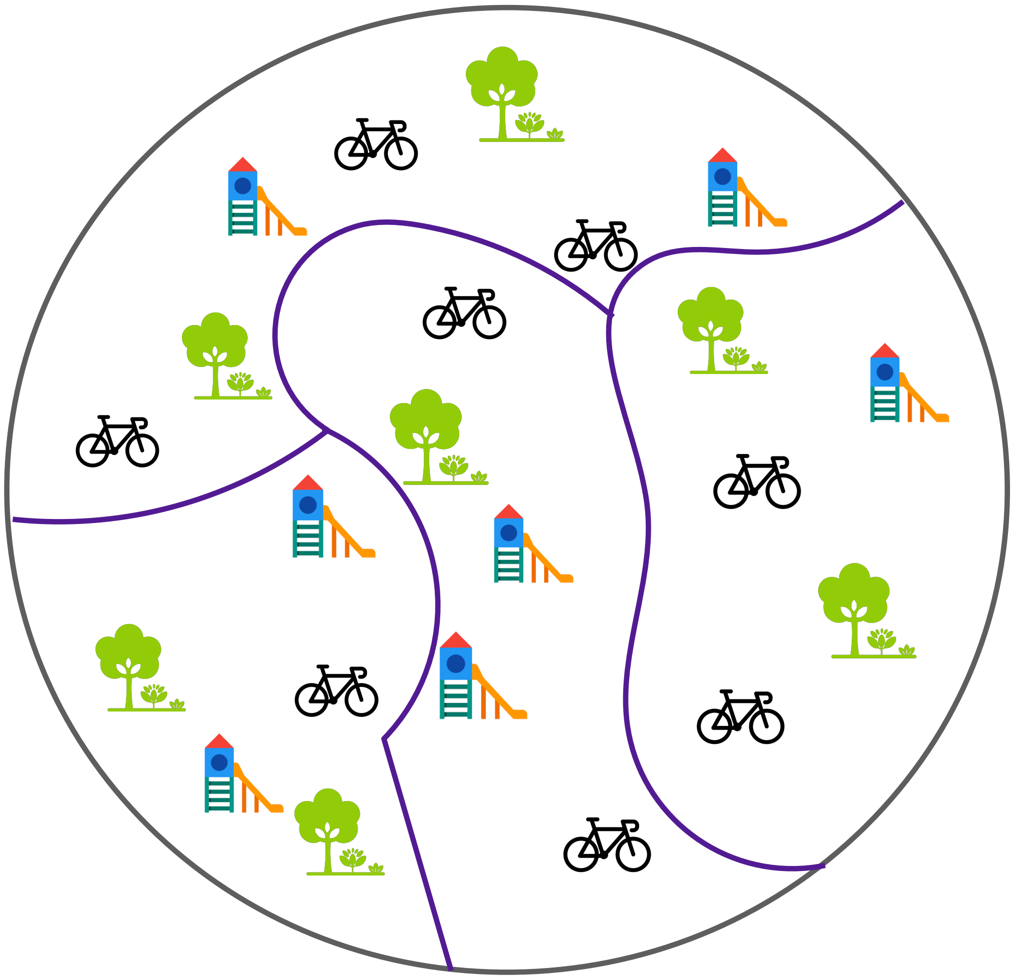
1. A set of *candidates* or *projects* $C = \{c_1, c_2, \ldots, c_m\}$.
   Each candidate c comes with a cost, $\mathrm{cost}(c)$.

2. There is a budget constraint b:
   We have to select a subset of projects W s.t. $\sum_{c \in W} \mathrm{cost}(c) \leq b$.

3. A set of voters $N = \{1, 2, \ldots, n\}$.
   Each voter has preferences over the projects.

How this is currently done



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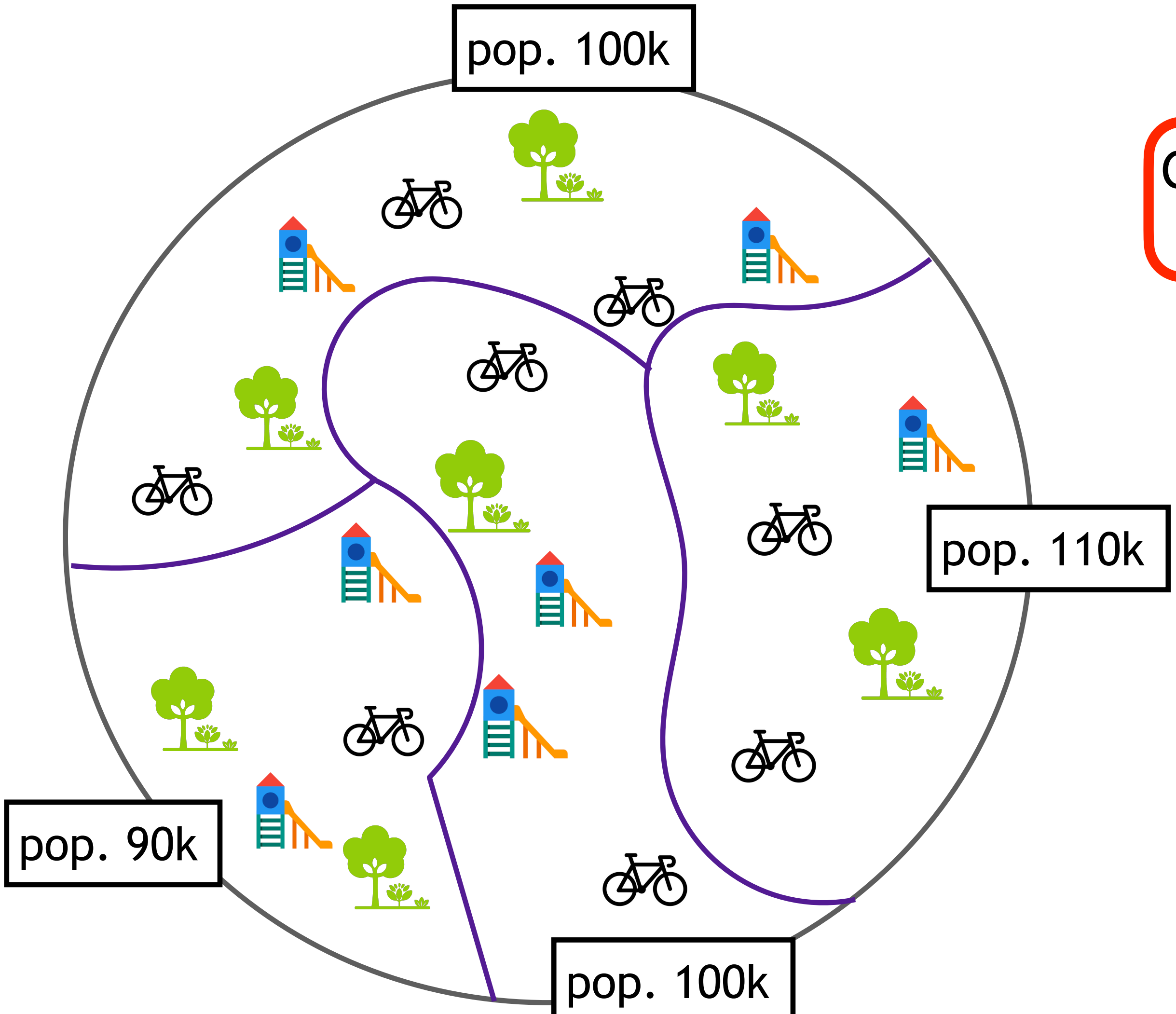

Choosing by the number of votes

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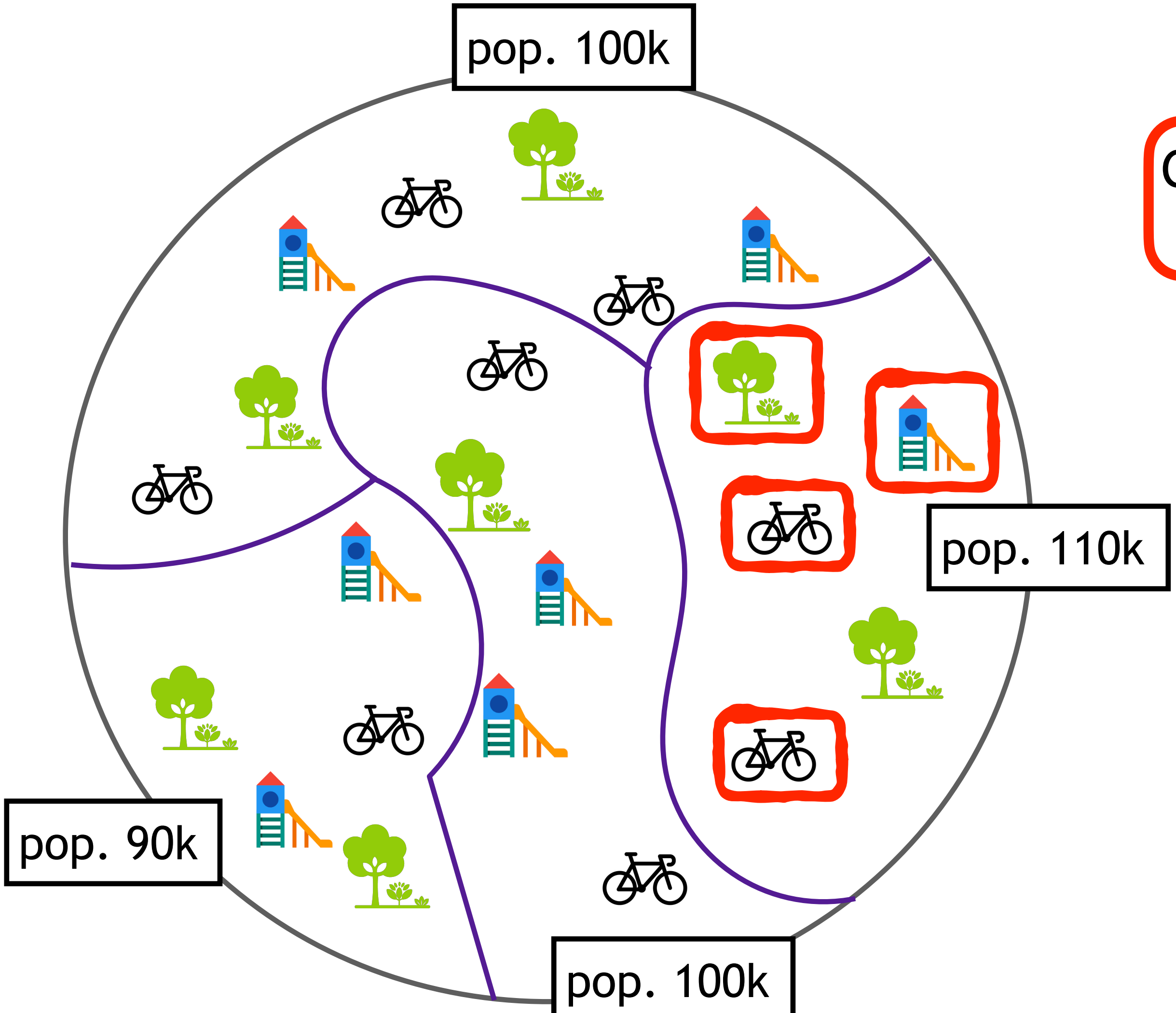
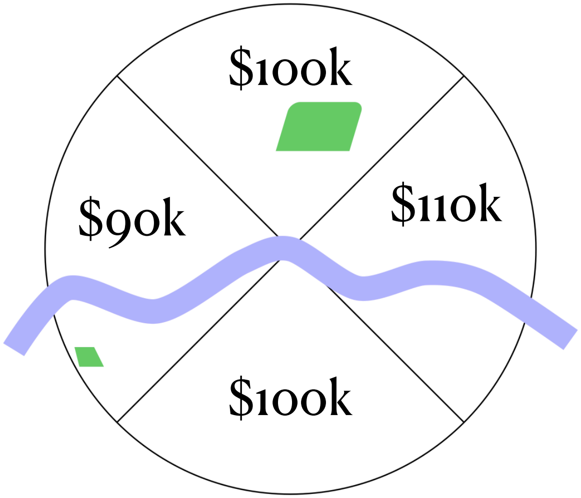


Choosing by the number of votes

How this is currently done

Solution: Divide the budget upfront between the districts!



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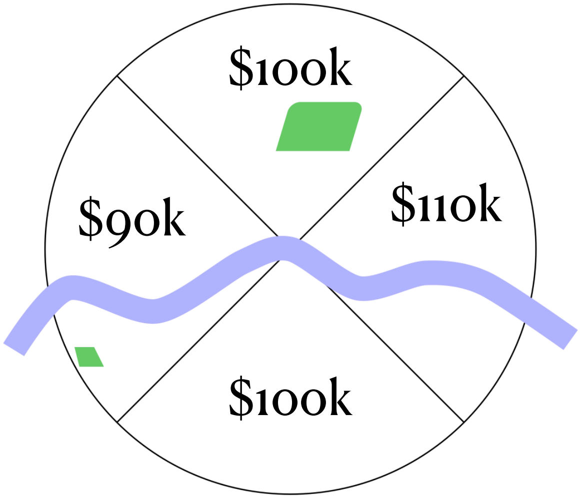

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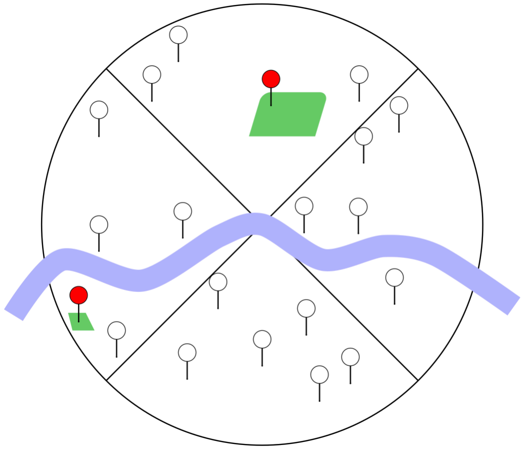

parents who want
a playground

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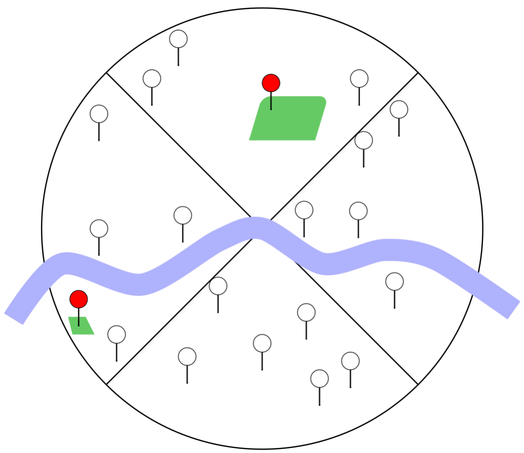

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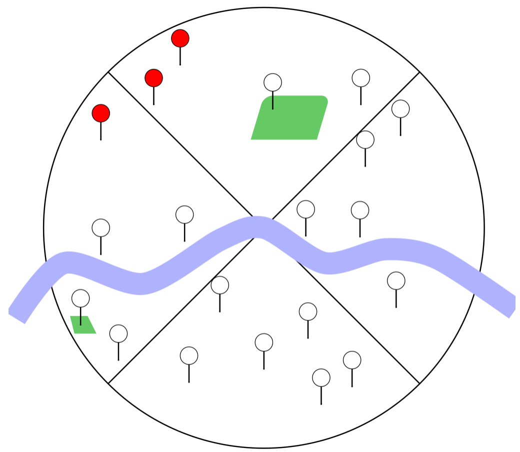

voters close to
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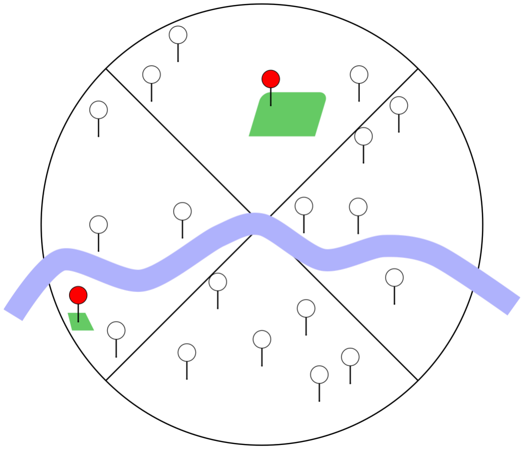

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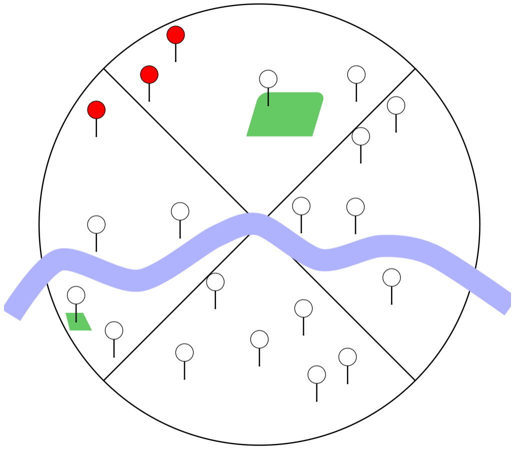

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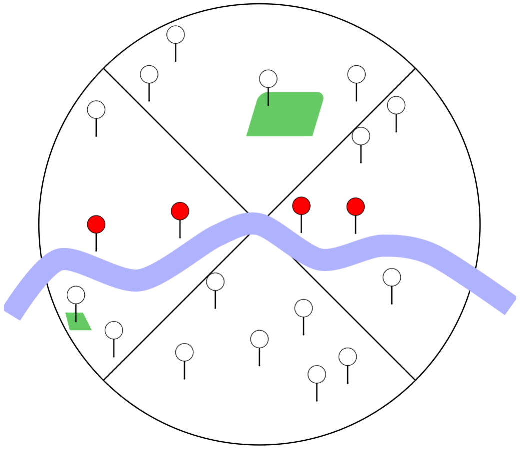
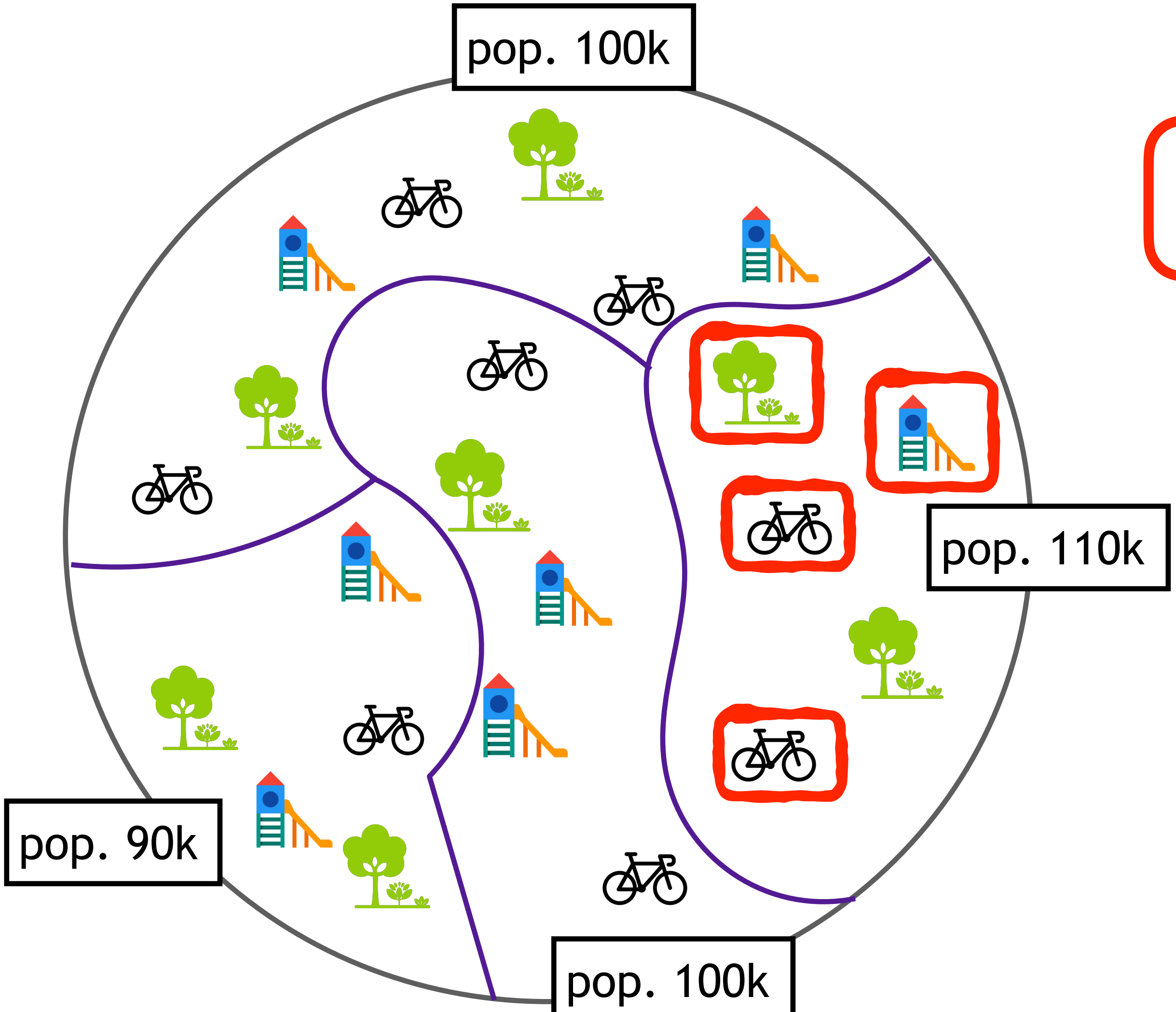


cyclists who want
a bike trail

How this is currently done



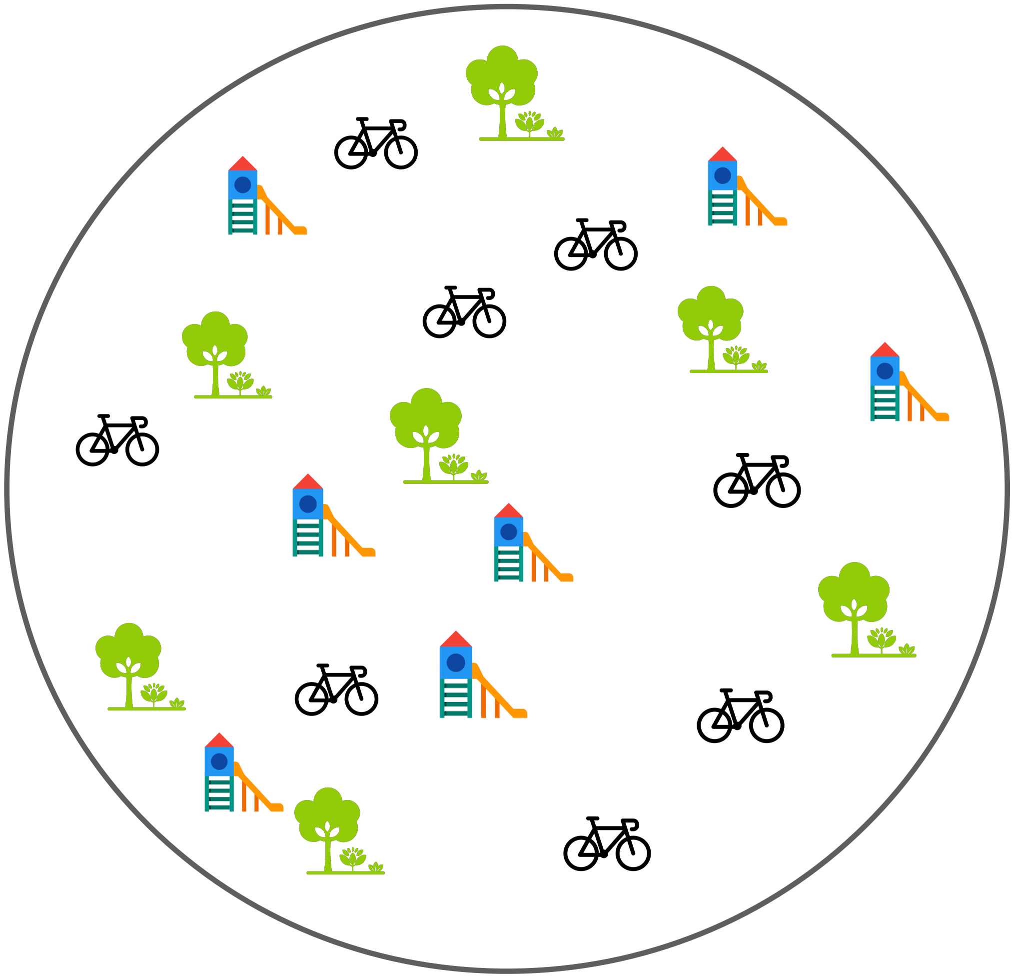
Districts are not the only division of voters

How this is currently done

 30% voters (green areas)

 30% voters (playgrounds)

 40% voters (bike infrastructure)



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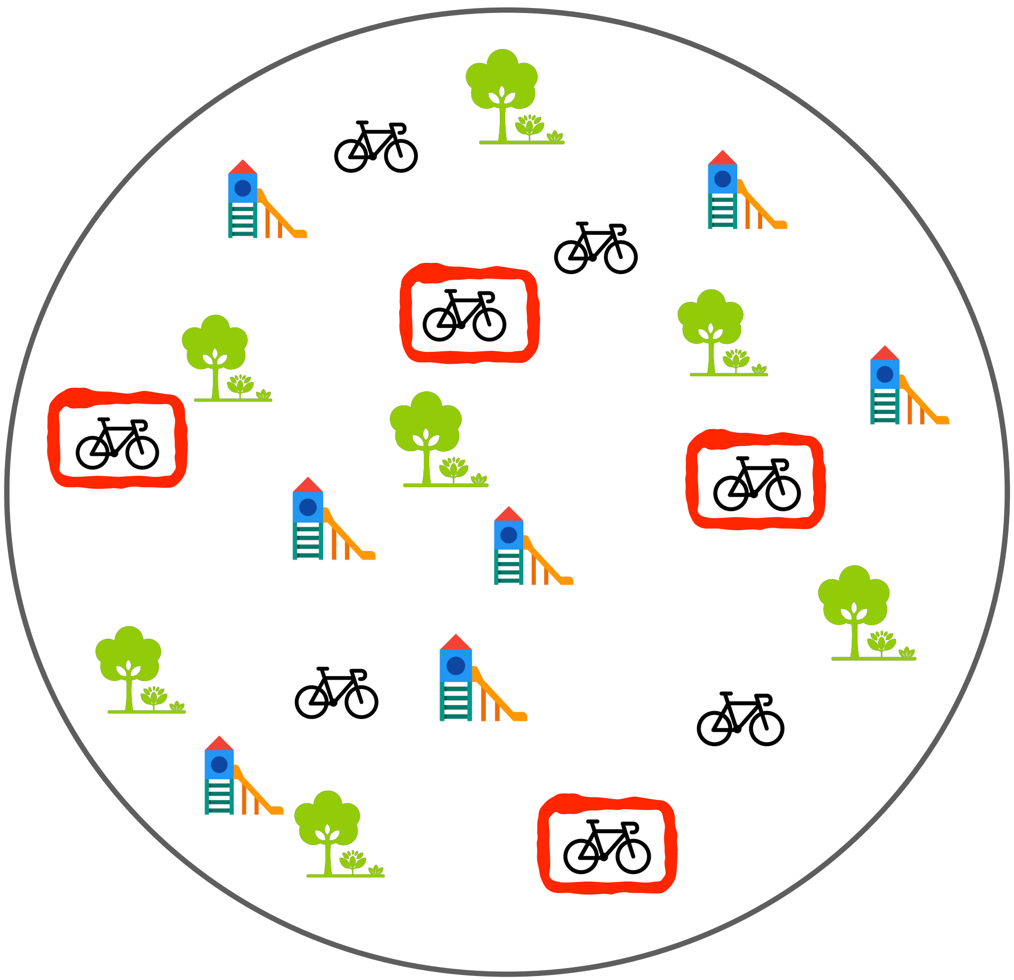

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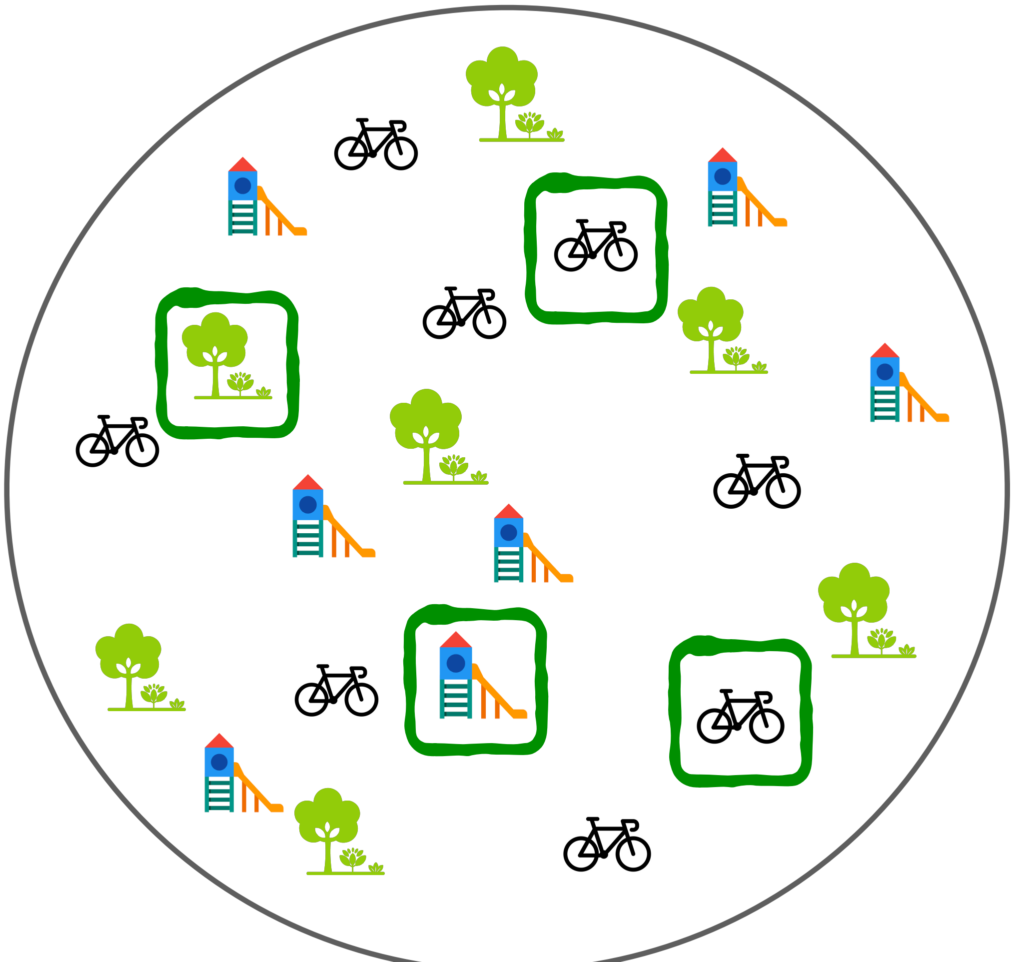


Choosing by the number of votes

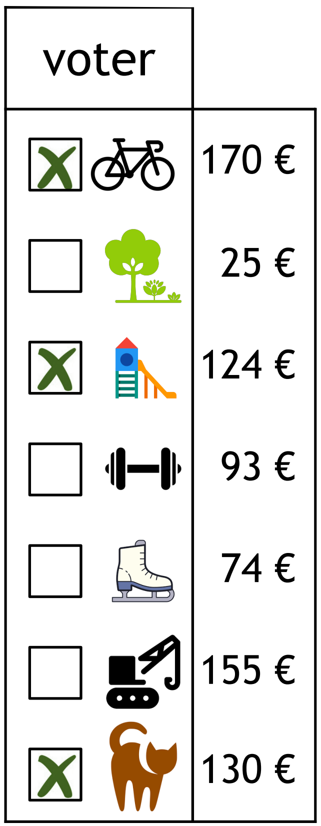
The rule should be fair to all groups of voters

Criterion of fairness.

voter	
X	170 €
	25 €
X	124 €
	93 €
	74 €
	155 €
X	130 €

$A(i)$: a subset of projects that voter i approves.

Criterion of fairness.



Extended justified representation (EJR):
We say that a group of voters S is T-cohesive for $T \subseteq C$ if

$$\frac{\mathrm{cost}(T)}{|S|} \leq \frac{b}{n} \text{ and } T \subseteq \bigcap_{i \in S} A(i).$$

A rule $\mathscr{R}$ satisfies extended justified representation if for each election instance E and each T-cohesive group S of voters there exists a voter $i \in S$ such that

$$|A(i) \cap \mathscr{R}(E)| \geq |T|.$$

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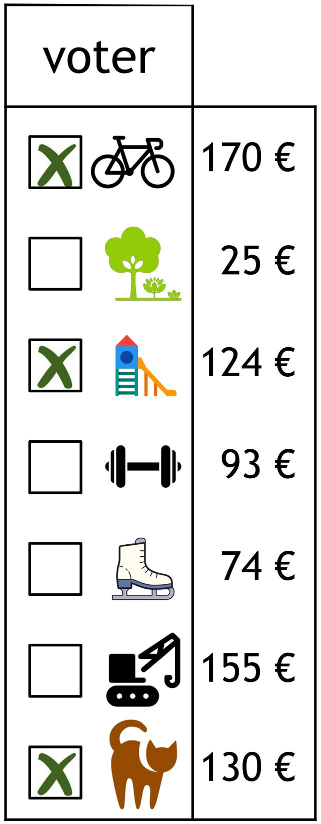

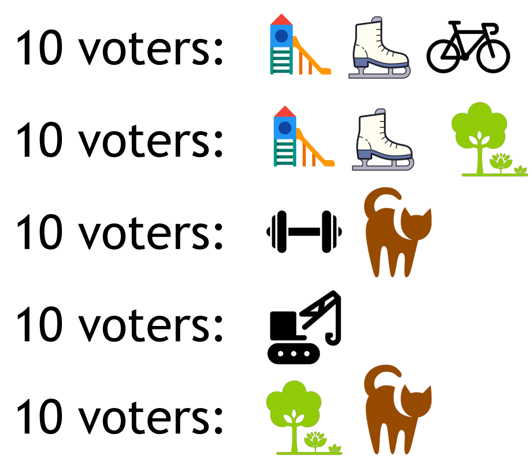

$b = 500$

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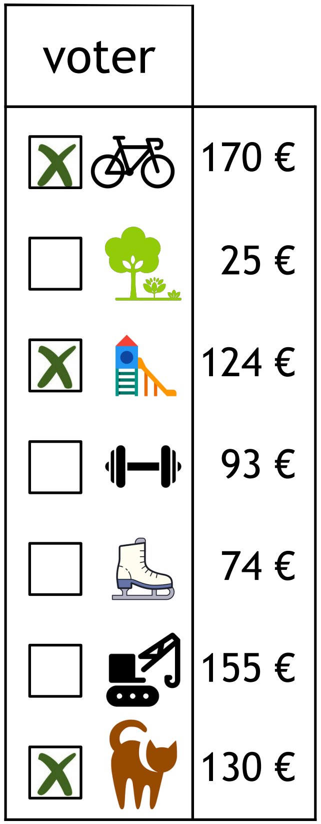

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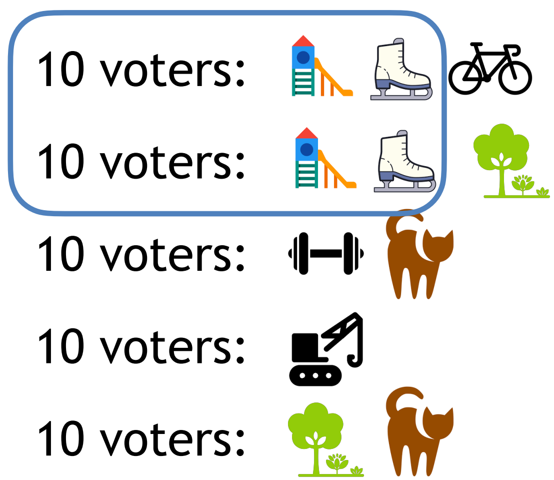

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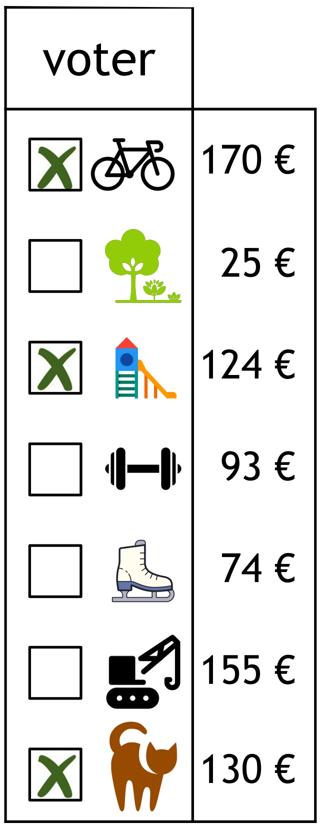

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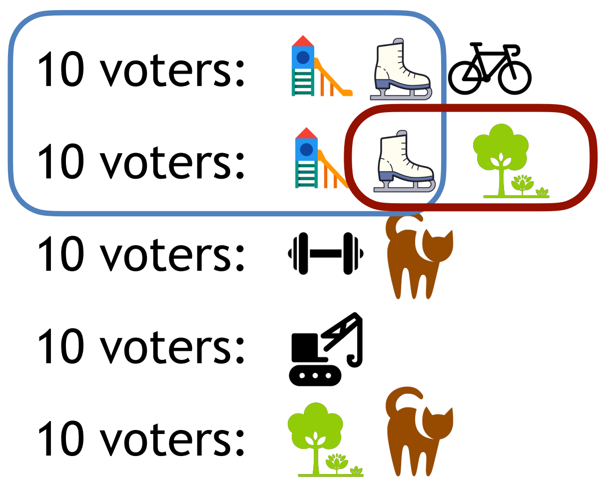

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open question!

Criterion of fairness.

1. K. Munagala, Y. Shen, K. Wang, Z. Wang. Approximate Core for Committee Selection via Multilinear Extension and Market Clearing. **SODA-2022**.

2. Z. Jiang, K. Munagala, and K. Wang. Approximately stable committee selection. **STOC-2020**.

3. D. Peters and P. Skowron. Proportionality and the limits of welfarism. **ACM-EC-2020**.

4. Y. Cheng, Z. Jiang, K. Munagala, and K. Wang. Group fairness in committee selection. **ACM-EC-2019**.

5. M. Brill, P. Golz, D. Peters, U. Schmidt-Kraepelin, and K. Wilker. Approval-based apportionment. **AAAI-2020**.

6. G. Pierczyński, P. Skowron, and D. Peters. Proportional participatory budgeting with additive utilities. **NeurIPS-2021**.

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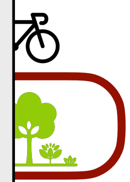

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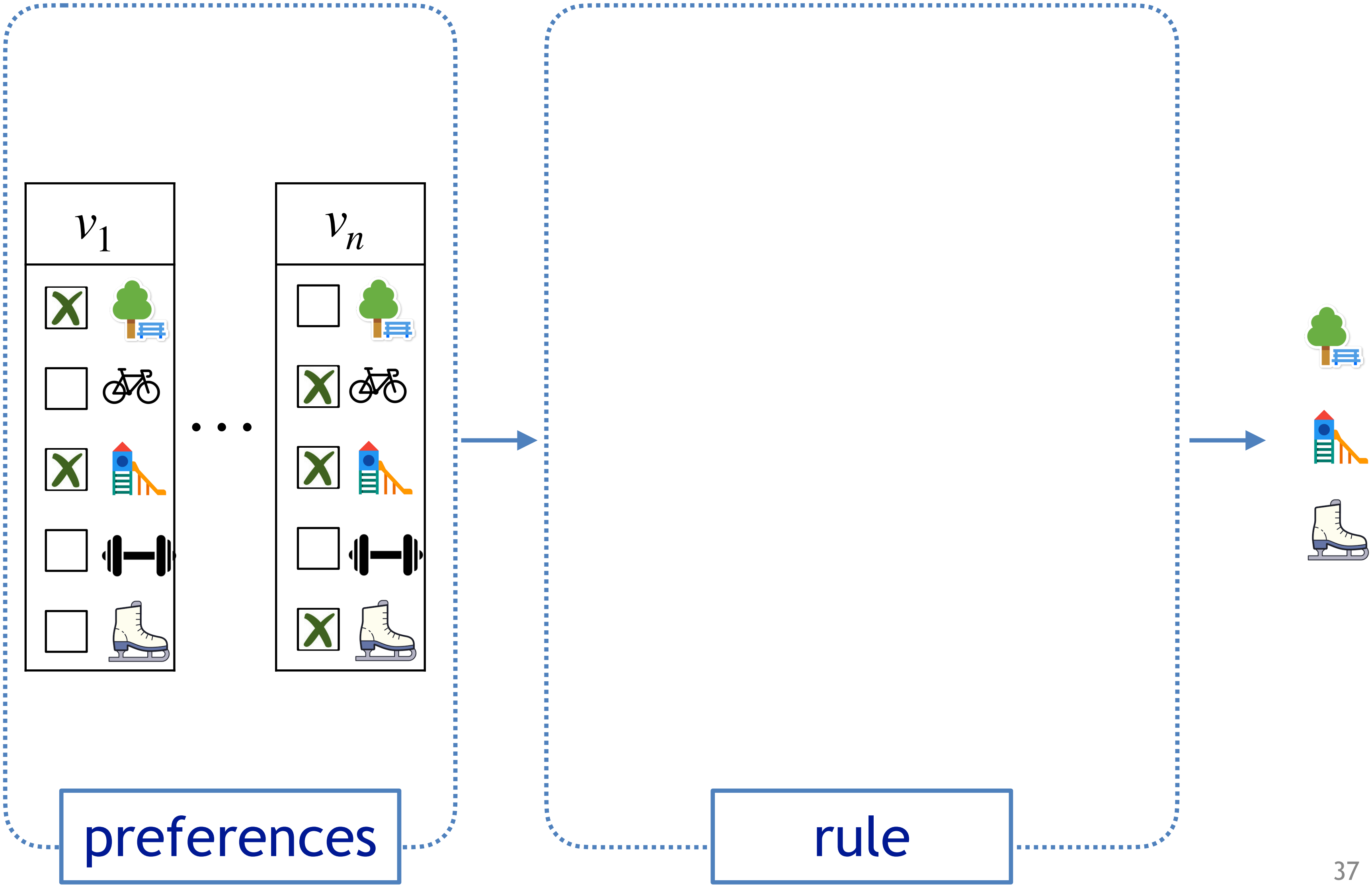
Method of Equal Shares: Idea



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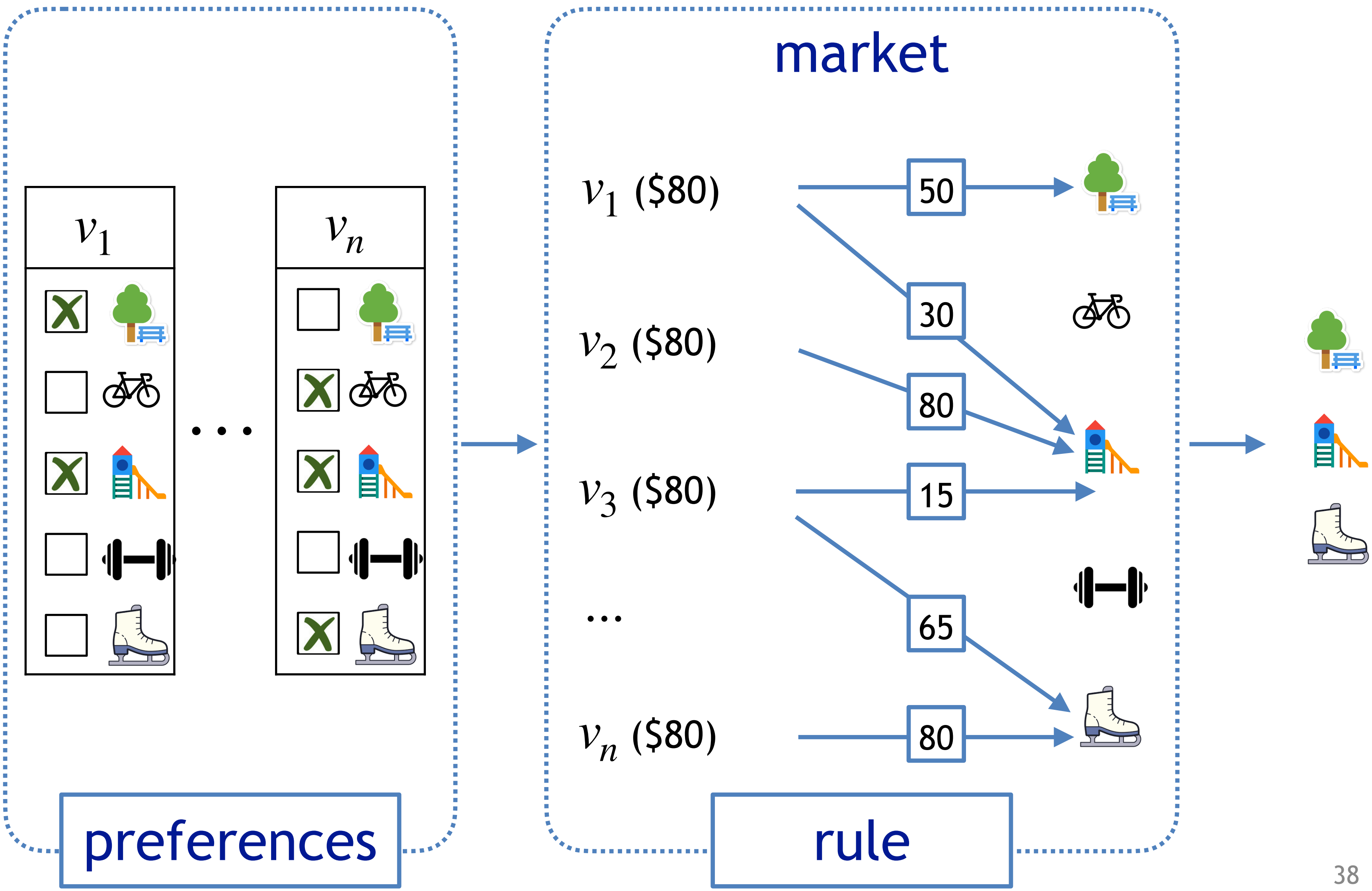

Method of Equal Shares for Approvals

1. The budget is evenly divided among the voters.
2. If a candidate $c \in C$ is selected its cost is divided among the voters who voted for c.
3. The rule selects the projects which can be paid this way, starting with those that minimise the voters' marginal costs per utility.

D. Peters, P. Skowron: Proportionality and the Limits of Welfarism. ACM-EC 2020.

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$b = \$1000$

	(20 votes)	(26 votes)	(11 votes)	(9 votes)	(20 votes)	(14 votes)
A (costs \$200)	✓	✓				✓
B (costs \$200)	✓	✓				
C (costs \$200)	✓	✓		✓		
D (costs \$200)	✓	✓	✓	✓		
E (costs \$200)	✓	✓				
F (costs \$200)	✓			✓		✓
G (costs \$200)			✓	✓		✓
H (costs \$200)					✓	

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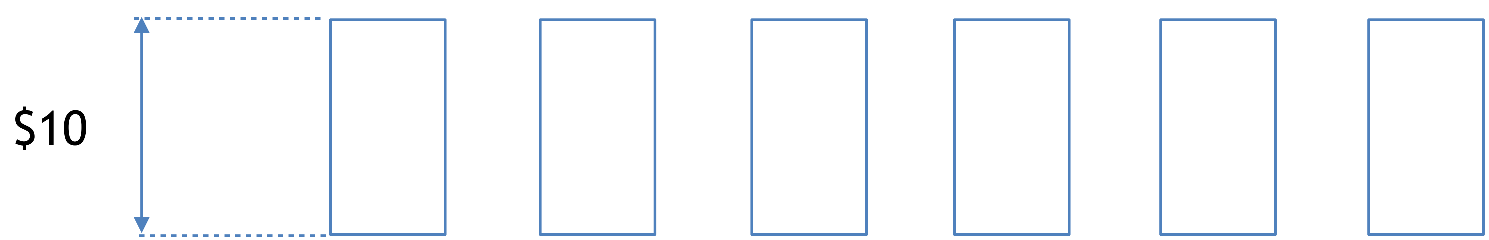
A (costs $200)	✓	✓				✓
B (costs $200)	✓	✓				
C (costs $200)	✓	✓		✓		
D (costs $200)	✓	✓	✓	✓		
E (costs $200)	✓	✓				
F (costs $200)	✓			✓		✓
G (costs $200)			✓	✓		✓
H (costs $200)					✓	

20 voters: 26 voters: 11 voters: 9 voters: 20 voters: 14 voters:



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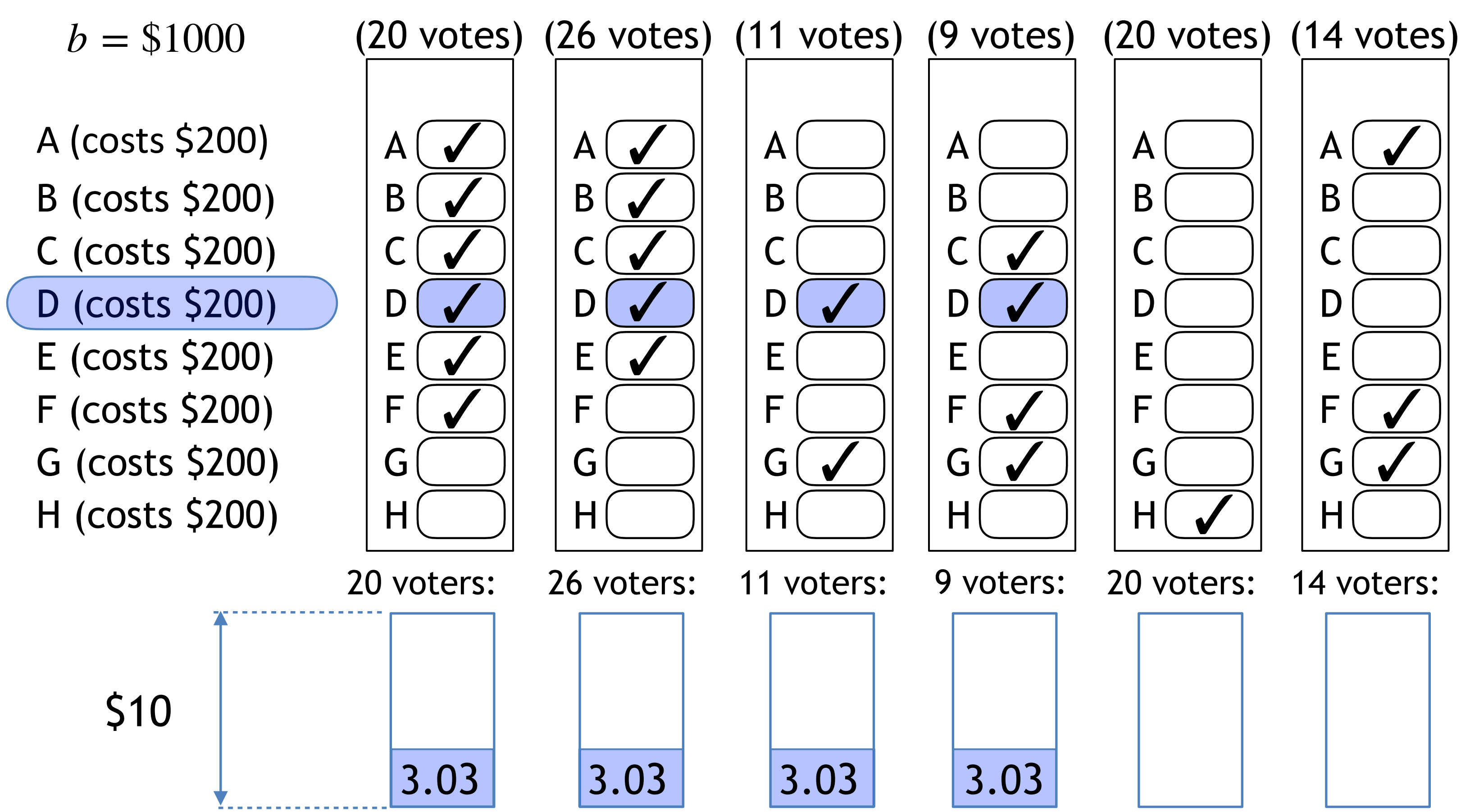

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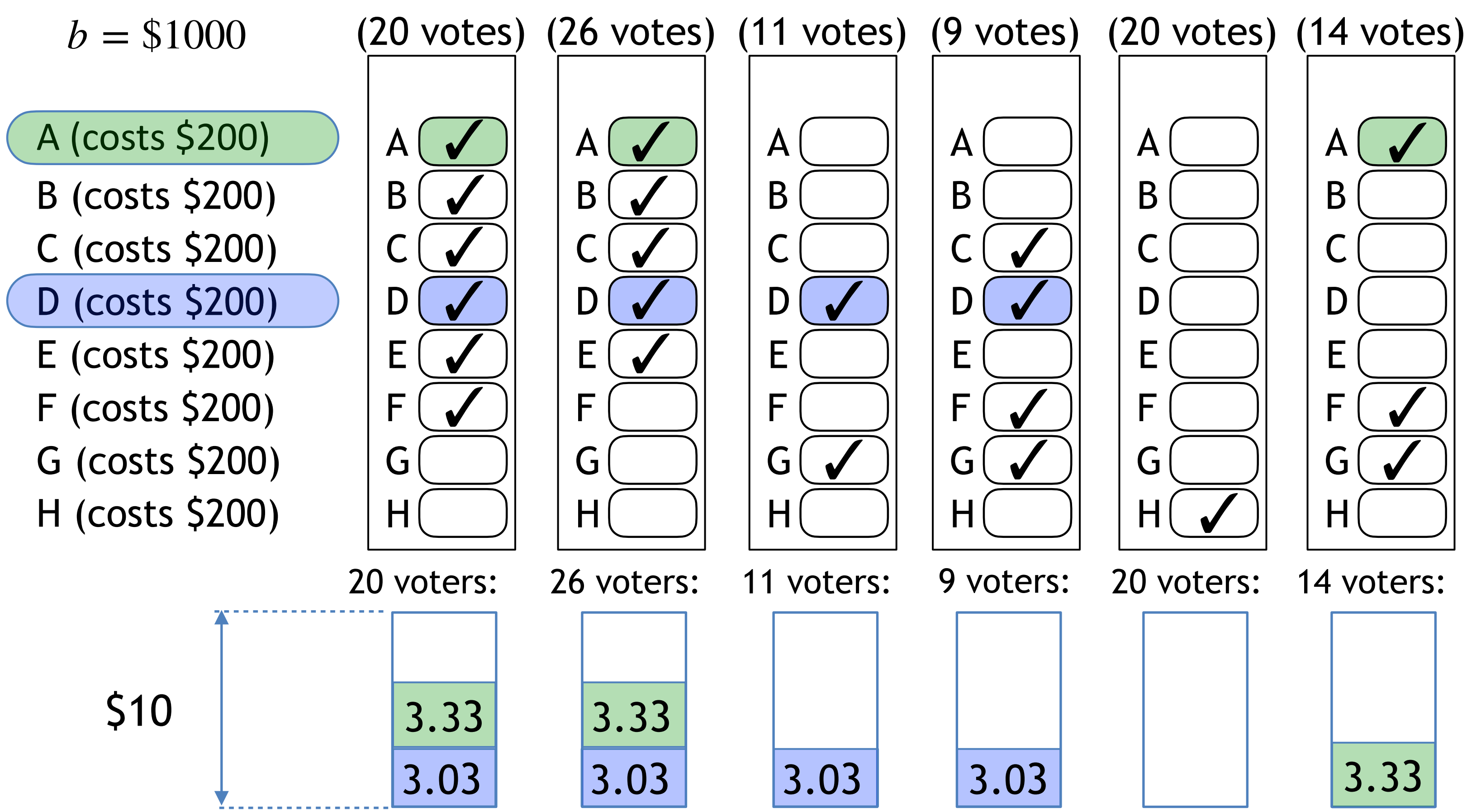

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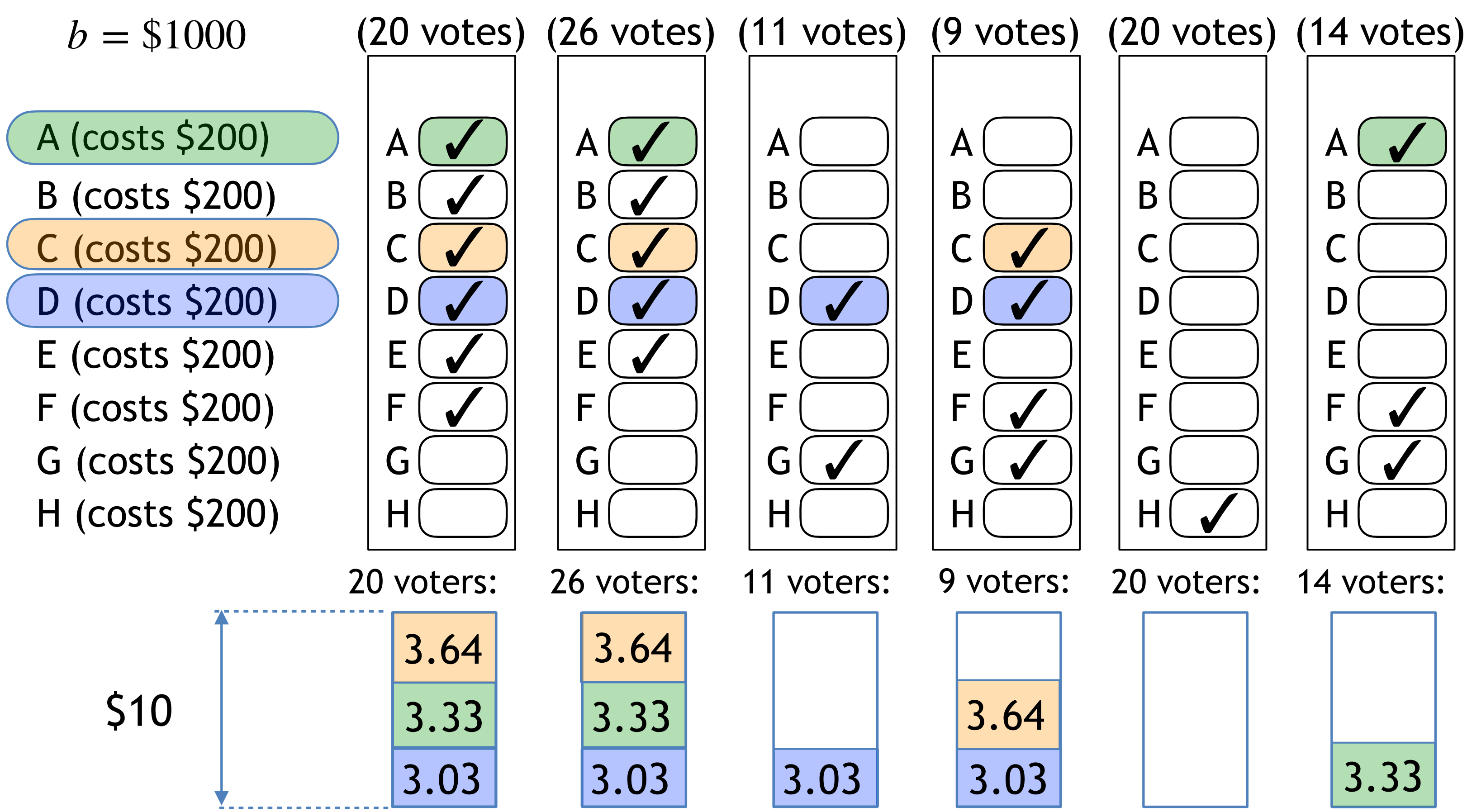

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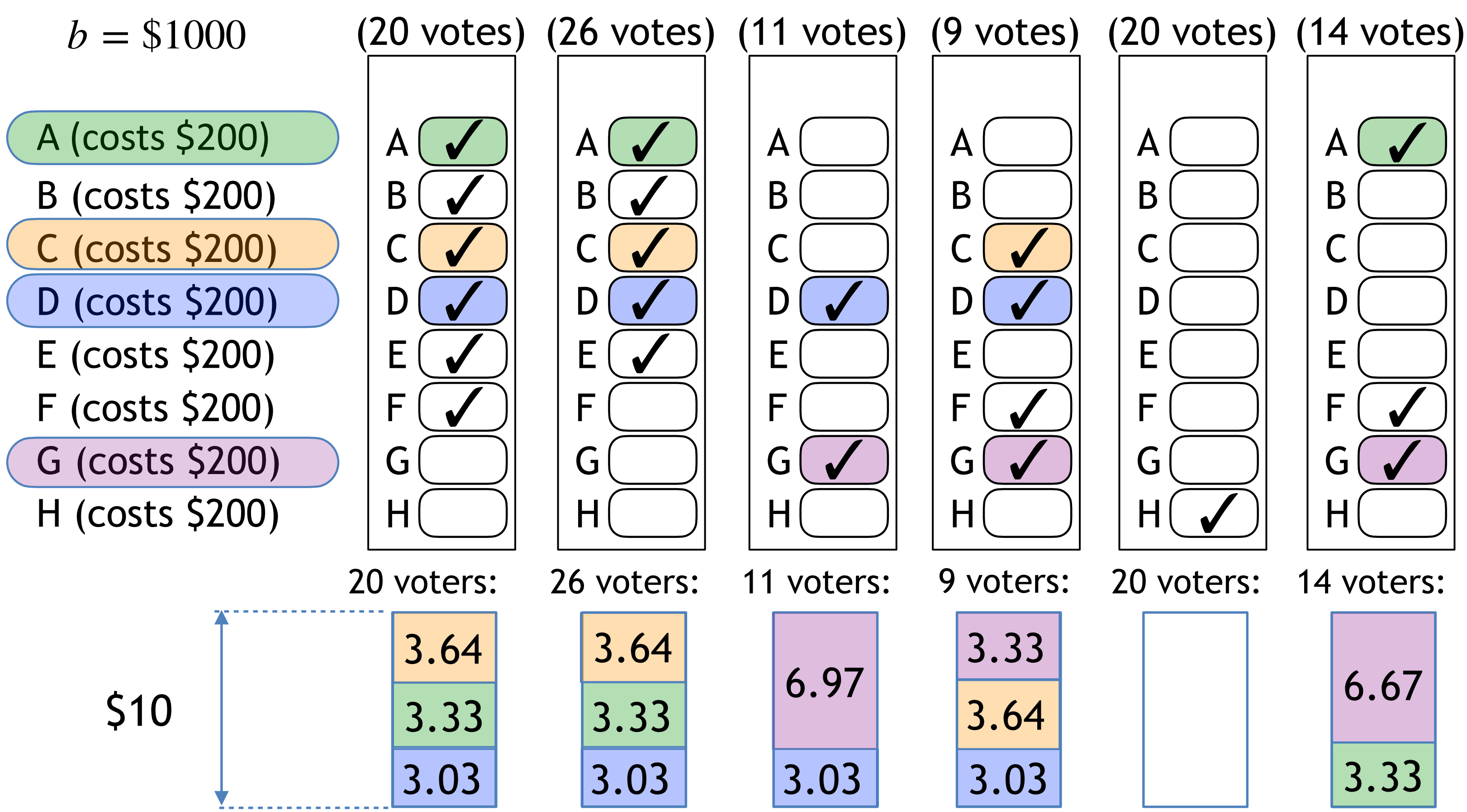

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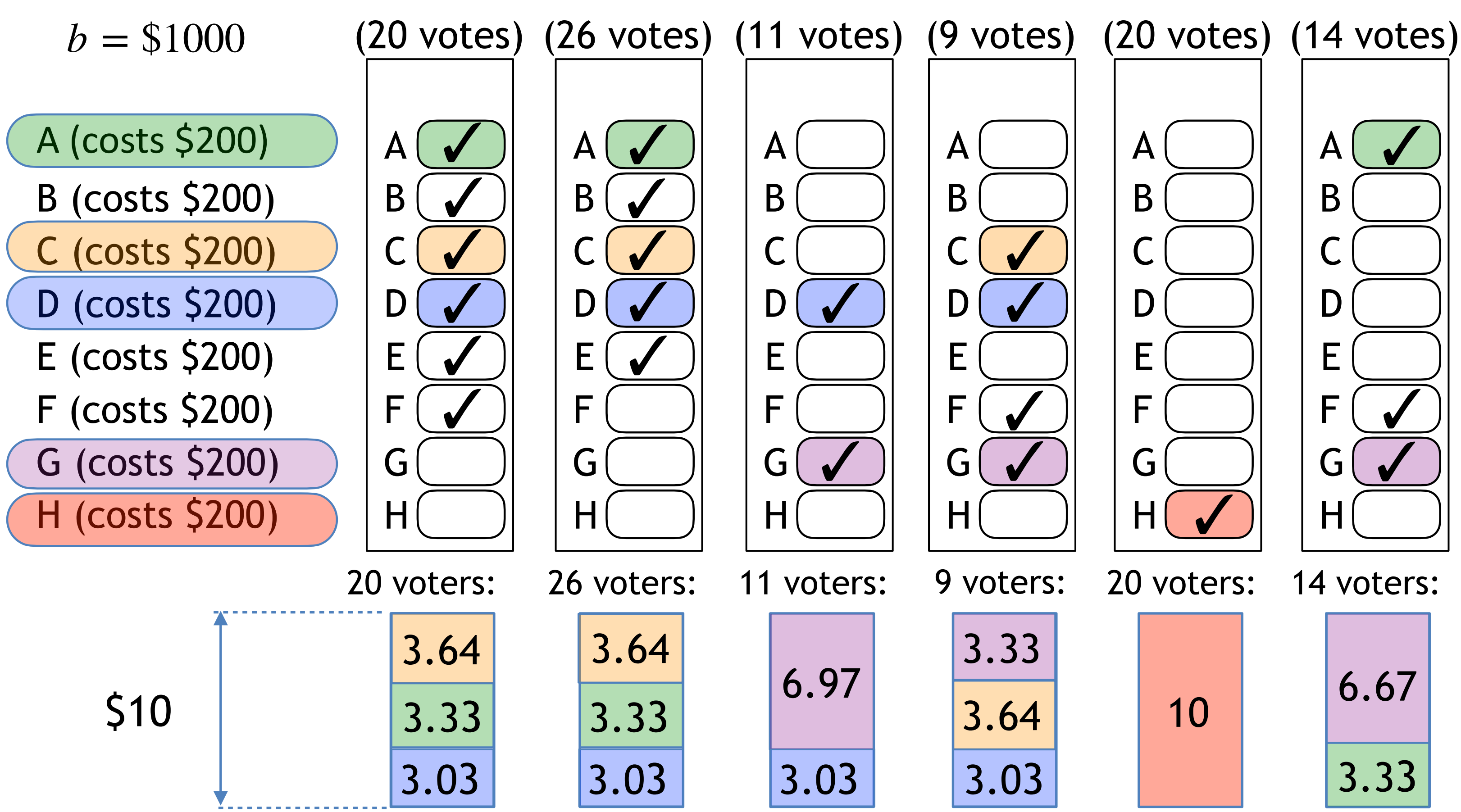

Method of Equal Shares for Approvals

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2. If a candidate $c \in C$ is selected its cost is divided among the voters who voted for c.
3. The rule selects the projects which can be paid this way, starting with those that minimise the voters' marginal costs per utility.

Theorem: For approval ballots, when all costs are equal the method of equal shares satisfies extended justified representation.

Ideally it should work for cardinal utilities

voter		
4		170 €
2		25 €
9		124 €
7		93 €
2		74 €
1		155 €
3		130 €

Extended justified representation (EJR):

We say that a group of voters S is T-cohesive for $T \subseteq C$ if

$$\frac{\text{cost}(T)}{|S|} \leq \frac{b}{n} \text{ and } T \subseteq \bigcap_{i \in S} A(i).$$

A rule $\mathscr{R}$ satisfies extended justified representation if for each election instance E and each T-cohesive group S of voters there exists a voter $i \in S$ such that

$$|A(i) \cap \mathscr{R}(E)| \geq |T|.$$

$u_i(c)$: a utility that voter i assigns to c.

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We say that a group of voters S is (α, T)-cohesive for $\alpha \colon C \to \mathbb{R}$ and $T \subseteq C$ if:

$$\frac{\mathrm{cost}(T)}{|S|} \leq \frac{b}{n} \quad \text{and} \quad u_i(c) \geq \alpha(c) \text{ for all } i \in S, c \in T.$$

A rule $\mathscr{R}$ satisfies extended justified representation if for each election instance E and each (α, T)-cohesive group S of voters there exists a voter $i \in S$ such that

$$\sum_{c \in \mathscr{R}(E)} u_i(c) \geq \sum_{c \in T} \alpha(c).$$

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voter	
$\boxed{4}$	170 €
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A rule $\mathscr{R}$ satisfies extended justified representation **up-to-one** if for each election instance E and each (α, T)-cohesive group S of voters there exists a voter $i \in S$ and a candidate $d \in C$ such that

$$u_i(d) + \sum_{c \in \mathscr{R}(E)} u_i(c) \geq \sum_{c \in T} \alpha(c).$$

MES for Cardinal Utilities

1. Each voter is initially given an equal fraction of the budget, i.e., b/n dollars.

G. Pierczyński, P. Skowron, and D. Peters. Proportional participatory budgeting with additive utilities. NeurIPS-2021.

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MES for Cardinal Utilities

$b = \$2500$

	(65 votes)	(35 votes)	(35 votes)	(50 votes)	(10 votes)	(55 votes)
A (costs \$120)				1	2	
B (costs \$200)	30	30				
C (costs \$500)		30			5	10
D (costs \$600)				100		
E (costs \$500)	10		30			
F (costs \$180)			10	10		10
G (costs \$1000)	10	10	40	100	40	40
H (costs \$110)				2	1	1

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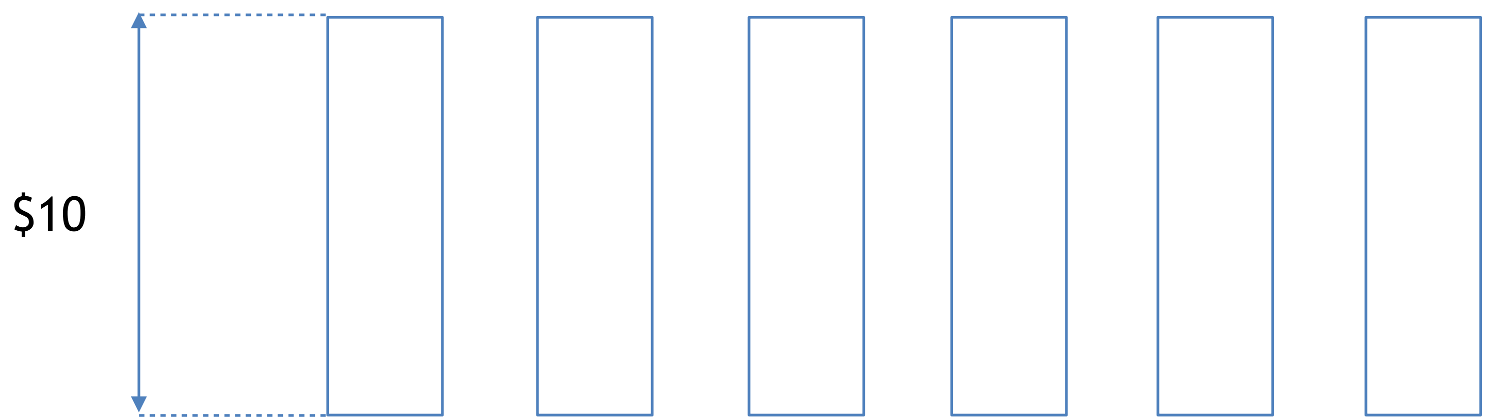
65 voters: 35 voters: 35 voters: 50 voters: 10 voters: 55 voters:



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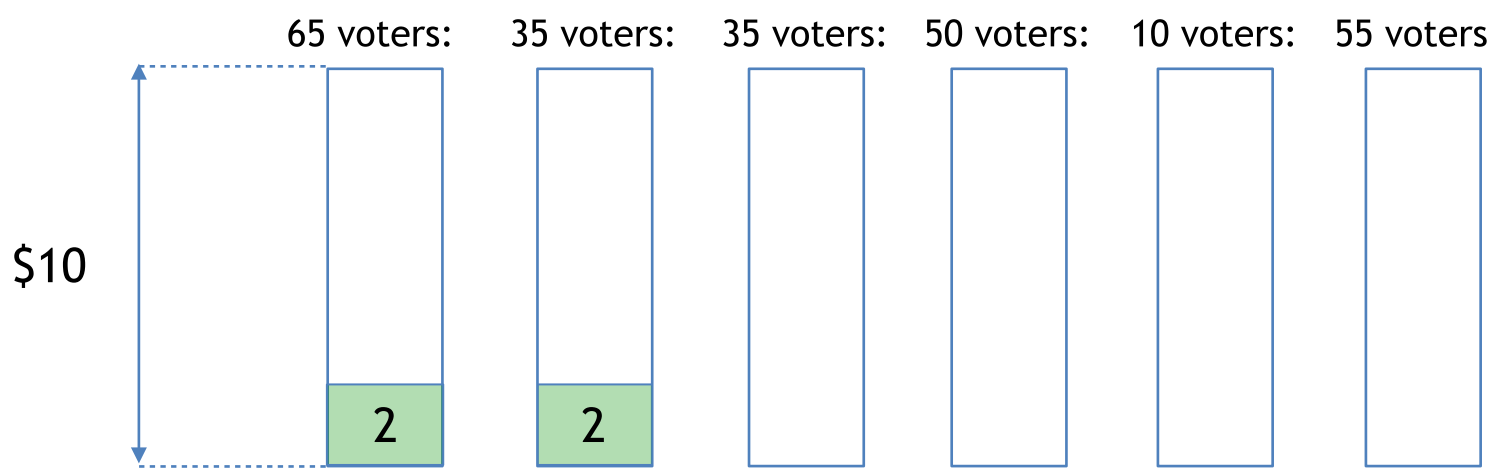

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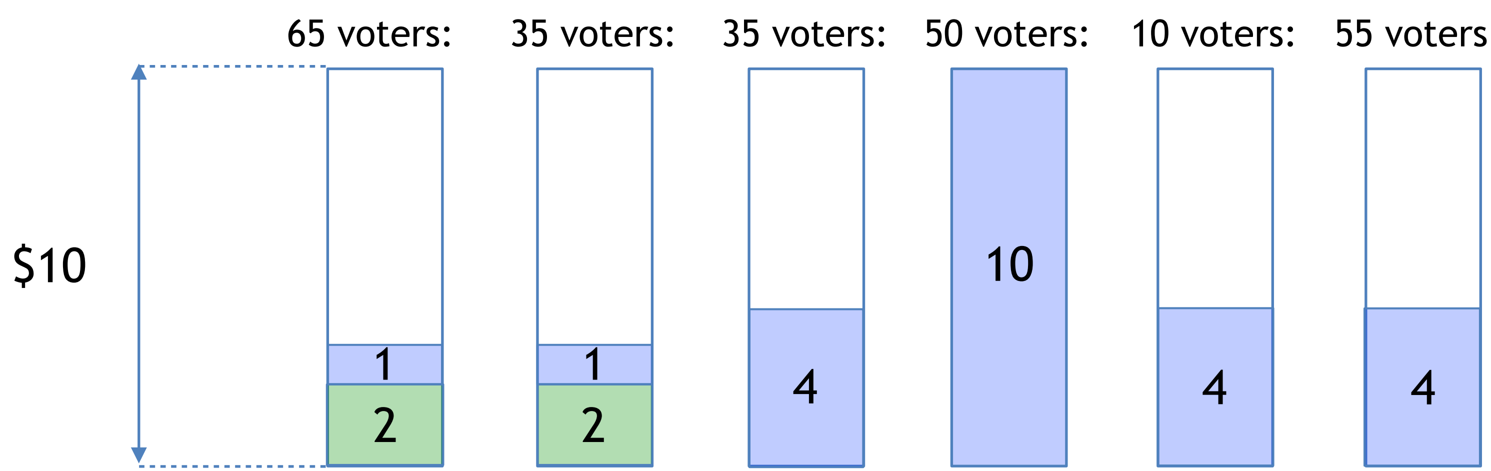

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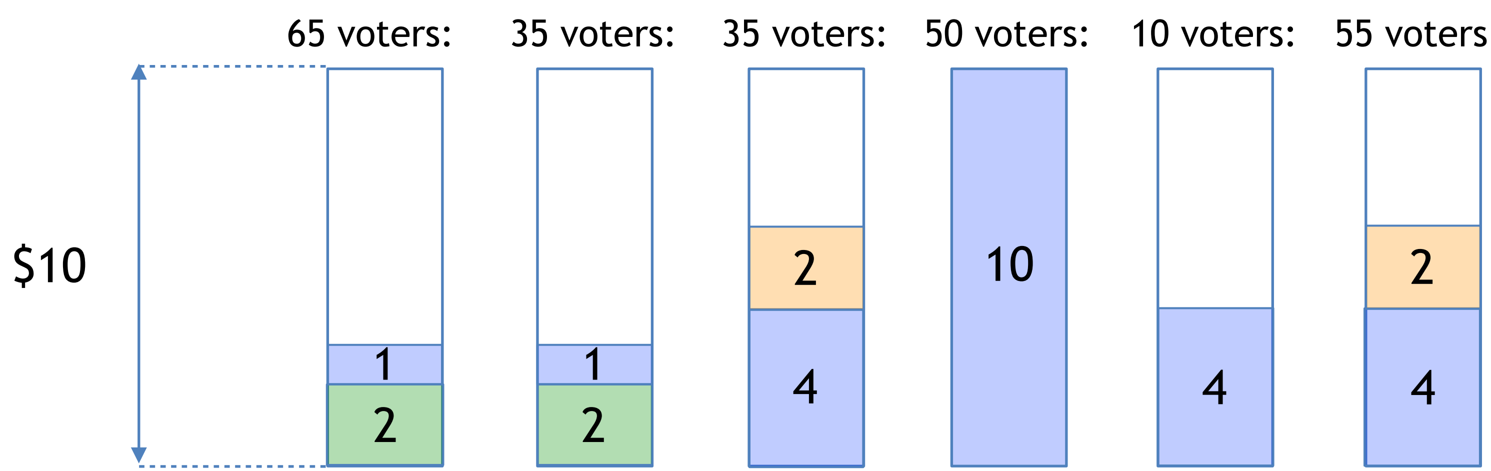

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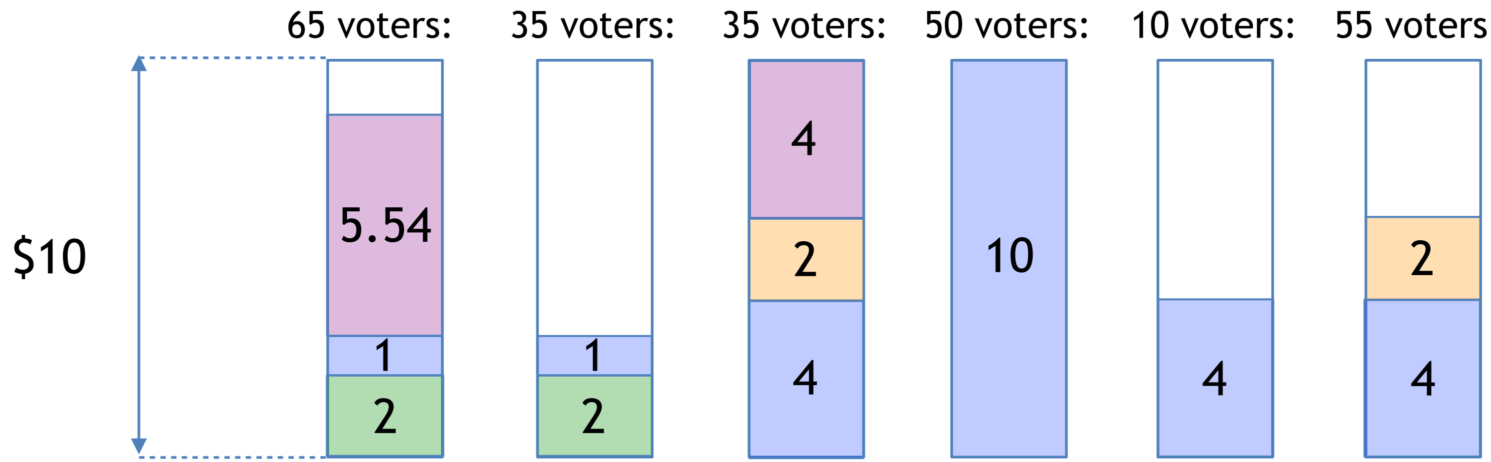

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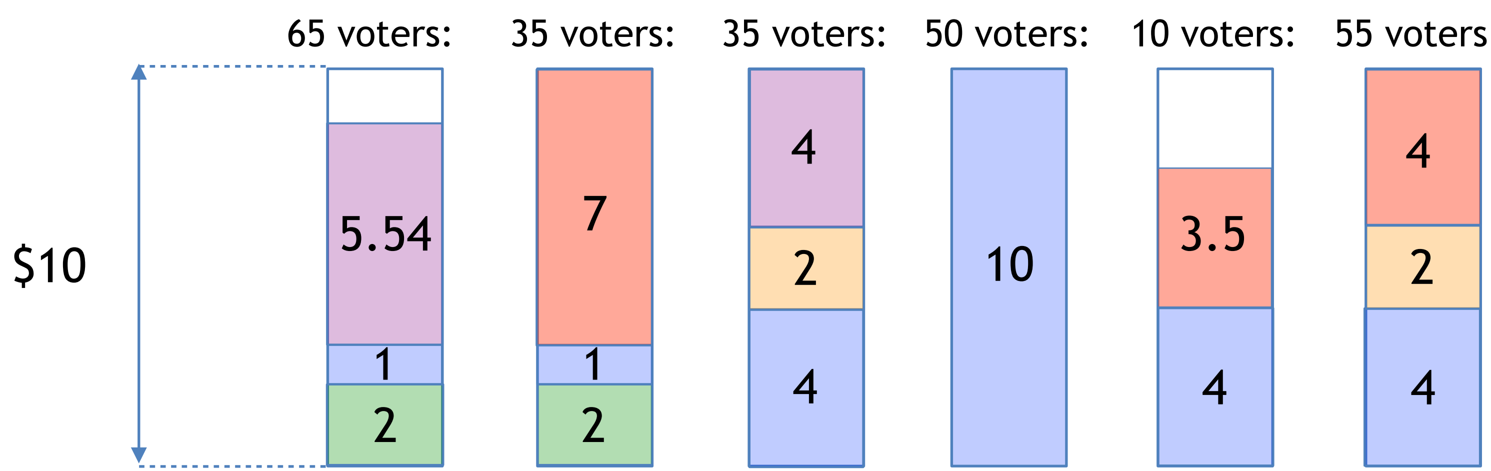

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Theorem: Method of equal shares satisfies extended justified representation up-to-one.

Can we get EJR (without up-to-one)?

Can we get EJR (without up-to-one)?

Theorem: There exists no polynomial-time algorithm that satisfies EJR.

Proof: For one voter this is simply the knapsack problem which is NP-hard.

Knapsack problem:
We are given a set of items, each with a weight and a value, and two integers: B, K.
Determine whether there exists a subset of items with total weight not exceeding B and with the total value at least equal to K.

How to use MES with approval ballots?

Given approval ballots we need to decide what is the utility?

There are two main choices:

1. The utility of a voter is the total amount of money spent on approved projects:

   $u_i(c) = \mathrm{cost}(c)$ if i approves c, and $u_i(c) = 0$, otherwise.

2. The utility of a voter is the number of approved projects:

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Greedy Algorithm:
Select candidates with the highest ratio of value to the weight.

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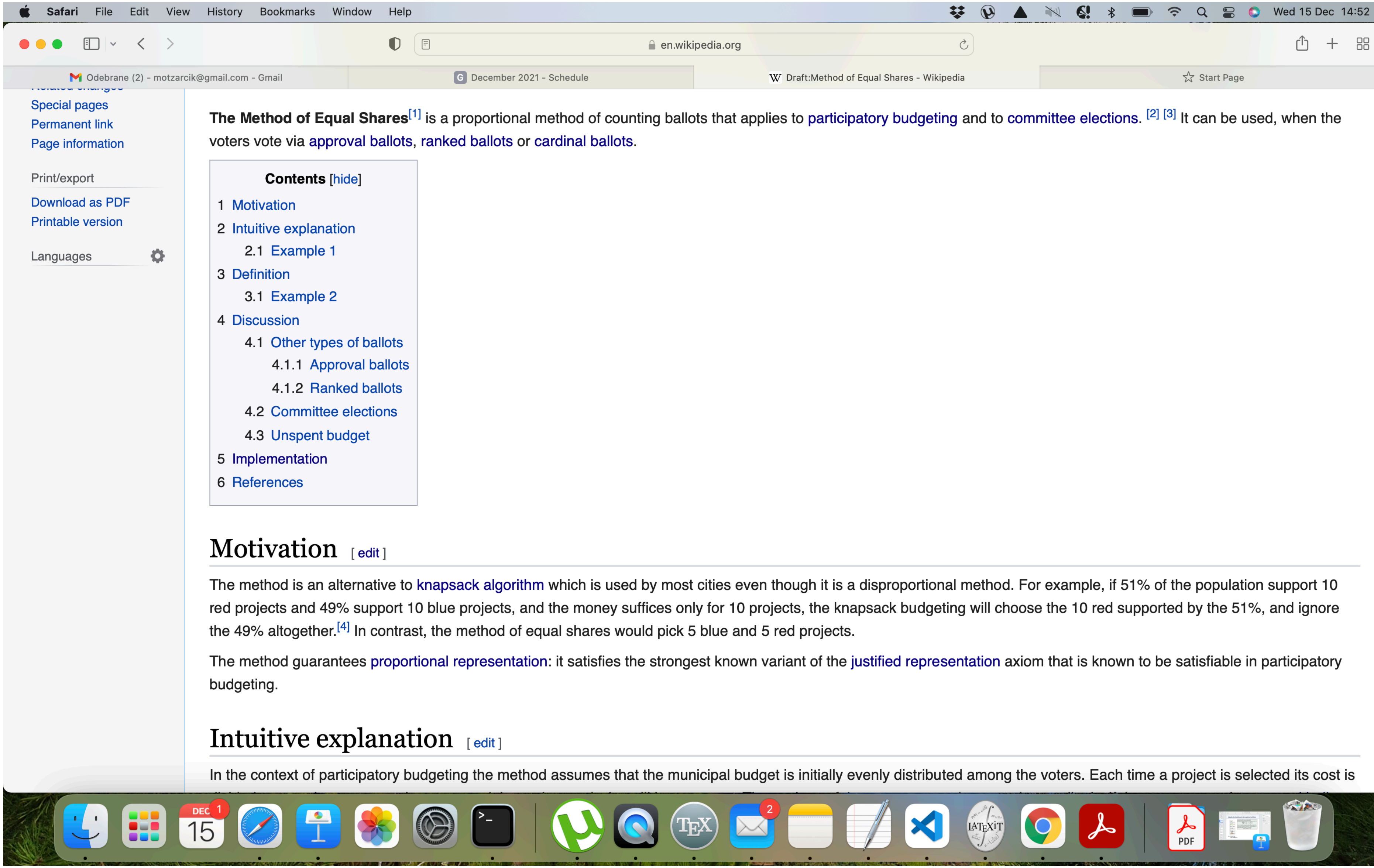
The current method selects the project with maximal numbers of approvals first.

Such project maximises the value divided by the cost, where the value is the sum of utilities that the voters enjoy from the project, assuming the utility is defined using approach 1.

Summary



The Method of Equal Shares[1] is a proportional method of counting ballots that applies to participatory budgeting and to committee elections. [2] [3] It can be used, when the voters vote via approval ballots, ranked ballots or cardinal ballots.

Contents [hide]

Motivation [edit]

The method is an alternative to knapsack algorithm which is used by most cities even though it is a disproportional method. For example, if 51% of the population support 10 red projects and 49% support 10 blue projects, and the money suffices only for 10 projects, the knapsack budgeting will choose the 10 red supported by the 51%, and ignore the 49% altogether.[4] In contrast, the method of equal shares would pick 5 blue and 5 red projects.

The method guarantees proportional representation: it satisfies the strongest known variant of the justified representation axiom that is known to be satisfiable in participatory budgeting.

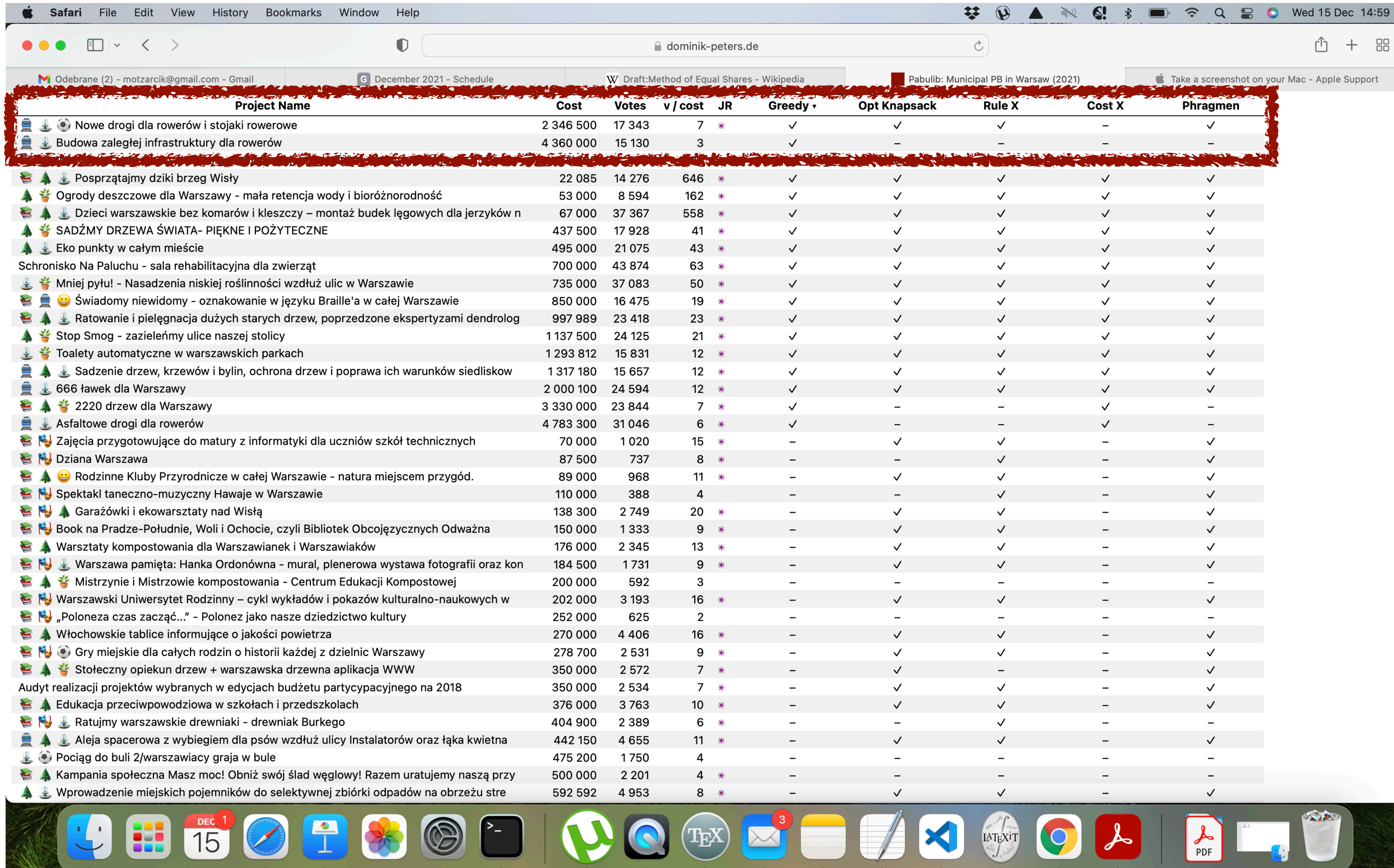
Intuitive explanation [edit]

In the context of participatory budgeting the method assumes that the municipal budget is initially evenly distributed among the voters. Each time a project is selected its cost is

Analysing data

Project Name	Cost	Votes	v / cost	JR	Greedy ▾	Opt Knapsack	Rule X	Cost X	Phragmen
Nowe drogi dla rowerów i stojaki rowerowe	2 346 500	17 343	7	*	✓	✓	✓	–	✓
Budowa zaległej infrastruktury dla rowerów	4 360 000	15 130	3		✓	–	–	–	–
Wycieczka rowerowa szlakiem poległych projektów budżetu partycypacyjnego	5 000	888	178	*	✓	✓	✓	✓	✓
Posprzątajmy dziki brzeg Wisły	22 085	14 276	646	*	✓	✓	✓	✓	✓
Ogrody deszczowe dla Warszawy - mała retencja wody i bioróżnorodność	53 000	8 594	162	*	✓	✓	✓	✓	✓
Dzieci warszawskie bez komarów i kleszczy – montaż budek lęgowych dla jerzyków n	67 000	37 367	558	*	✓	✓	✓	✓	✓
SADŹMY DRZEWA ŚWIATA- PIĘKNE I POŻYTECZNE	437 500	17 928	41	*	✓	✓	✓	✓	✓
Eko punkty w całym mieście	495 000	21 075	43	*	✓	✓	✓	✓	✓
Schronisko Na Paluchu - sala rehabilitacyjna dla zwierząt	700 000	43 874	63	*	✓	✓	✓	✓	✓
Mniej pyłu! - Nasadzenia niskiej roślinności wzdłuż ulic w Warszawie	735 000	37 083	50	*	✓	✓	✓	✓	✓
Świadomy niewidomy - oznakowanie w języku Braille'a w całej Warszawie	850 000	16 475	19	*	✓	✓	✓	✓	✓
Ratowanie i pielęgnacja dużych starych drzew, poprzedzone ekspertyzami dendrolog	997 989	23 418	23	*	✓	✓	✓	✓	✓
Stop Smog - zazieleńmy ulice naszej stolicy	1 137 500	24 125	21	*	✓	✓	✓	✓	✓
Toalety automatyczne w warszawskich parkach	1 293 812	15 831	12	*	✓	✓	✓	✓	✓
Sadzenie drzew, krzewów i bylin, ochrona drzew i poprawa ich warunków siedliskow	1 317 180	15 657	12	*	✓	✓	✓	✓	✓
666 ławek dla Warszawy	2 000 100	24 594	12	*	✓	✓	✓	✓	✓
2220 drzew dla Warszawy	3 330 000	23 844	7	*	✓	–	–	✓	–
Asfaltowe drogi dla rowerów	4 783 300	31 046	6	*	✓	–	–	✓	–
Zajęcia przygotowujące do matury z informatyki dla uczniów szkół technicznych	70 000	1 020	15	*	–	✓	✓	–	✓
Dziana Warszawa	87 500	737	8	*	–	–	✓	–	✓
Rodzinne Kluby Przyrodnicze w całej Warszawie - natura miejscem przygód.	89 000	968	11	*	–	✓	✓	–	✓
Spektakl taneczno-muzyczny Hawaje w Warszawie	110 000	388	4		–	–	✓	–	✓
Garażówki i ekowarsztaty nad Wisłą	138 300	2 749	20	*	–	✓	✓	–	✓
Book na Pradze-Południe, Woli i Ochocie, czyli Bibliotek Obcojęzycznych Odważna	150 000	1 333	9	*	–	✓	✓	–	✓
Warsztaty kompostowania dla Warszawianek i Warszawiaków	176 000	2 345	13	*	–	✓	✓	–	✓
Warszawa pamięta: Hanka Ordonówna - mural, plenerowa wystawa fotografii oraz kon	184 500	1 731	9	*	–	✓	✓	–	✓
Mistrzynie i Mistrzowie kompostowania - Centrum Edukacji Kompostowej	200 000	592	3		–	–	–	–	–
Warszawski Uniwersytet Rodzinny – cykl wykładów i pokazów kulturalno-naukowych w	202 000	3 193	16	*	–	✓	✓	–	✓
„Poloneza czas zacząć…" - Polonez jako nasze dziedzictwo kultury	252 000	625	2		–	–	–	–	–
Włochowskie tablice informujące o jakości powietrza	270 000	4 406	16	*	–	✓	✓	–	✓
Gry miejskie dla całych rodzin o historii każdej z dzielnic Warszawy	278 700	2 531	9	*	–	✓	✓	–	✓
Stołeczny opiekun drzew + warszawska drzewna aplikacja WWW	350 000	2 572	7	*	–	✓	–	–	✓
Audyt realizacji projektów wybranych w edycjach budżetu partycypacyjnego na 2018	350 000	2 534	7	*	–	✓	✓	–	✓
Edukacja przeciwpowodziowa w szkołach i przedszkolach	376 000	3 763	10	*	–	✓	✓	–	✓
Ratujmy warszawskie drewniaki - drewniak Burkego	404 900	2 389	6	*	–	–	✓	–	–
Aleja spacerowa z wybiegiem dla psów wzdłuż ulicy Instalatorów oraz łąka kwietna	442 150	4 655	11	*	–	✓	✓	–	✓
Pociąg do buli 2/warszawiacy graja w bule	475 200	1 750	4		–	–	–	–	–
Kampania społeczna Masz moc! Obniż swój ślad węglowy! Razem uratujemy naszą przy	500 000	2 201	4	*	–	–	–	–	–
Wprowadzenie miejskich pojemników do selektywnej zbiórki odpadów na obrzeżu stre	592 592	4 953	8	*	–	✓	✓	–	✓

Analysing data



Project Name	Cost	Votes	v / cost	JR	Greedy ▾	Opt Knapsack	Rule X	Cost X	Phragmen
Nowe drogi dla rowerów i stojaki rowerowe	2 346 500	17 343	7	*	✓	✓	✓	–	✓
Budowa zaległej infrastruktury dla rowerów	4 360 000	15 130	3		✓	–	–	–	–
Posprzątajmy dziki brzeg Wisły	22 085	14 276	646	*	✓	✓	✓	✓	✓
Ogrody deszczowe dla Warszawy - mała retencja wody i bioróżnorodność	53 000	8 594	162	*	✓	✓	✓	✓	✓
Dzieci warszawskie bez komarów i kleszczy – montaż budek lęgowych dla jerzyków n	67 000	37 367	558	*	✓	✓	✓	✓	✓
SADŹMY DRZEWA ŚWIATA- PIĘKNE I POŻYTECZNE	437 500	17 928	41	*	✓	✓	✓	✓	✓
Eko punkty w całym mieście	495 000	21 075	43	*	✓	✓	✓	✓	✓
Schronisko Na Paluchu - sala rehabilitacyjna dla zwierząt	700 000	43 874	63	*	✓	✓	✓	✓	✓
Mniej pyłu! - Nasadzenia niskiej roślinności wzdłuż ulic w Warszawie	735 000	37 083	50	*	✓	✓	✓	✓	✓
Świadomy niewidomy - oznakowanie w języku Braille'a w całej Warszawie	850 000	16 475	19	*	✓	✓	✓	✓	✓
Ratowanie i pielęgnacja dużych starych drzew, poprzedzone ekspertyzami dendrolog	997 989	23 418	23	*	✓	✓	✓	✓	✓
Stop Smog - zazieleńmy ulice naszej stolicy	1 137 500	24 125	21	*	✓	✓	✓	✓	✓
Toalety automatyczne w warszawskich parkach	1 293 812	15 831	12	*	✓	✓	✓	✓	✓
Sadzenie drzew, krzewów i bylin, ochrona drzew i poprawa ich warunków siedliskow	1 317 180	15 657	12	*	✓	✓	✓	✓	✓
666 ławek dla Warszawy	2 000 100	24 594	12	*	✓	✓	✓	✓	✓
2220 drzew dla Warszawy	3 330 000	23 844	7	*	✓	–	–	✓	–
Asfaltowe drogi dla rowerów	4 783 300	31 046	6	*	✓	–	–	✓	–
Zajęcia przygotowujące do matury z informatyki dla uczniów szkół technicznych	70 000	1 020	15	*	–	✓	✓	–	✓
Dziana Warszawa	87 500	737	8	*	–	–	✓	–	✓
Rodzinne Kluby Przyrodnicze w całej Warszawie - natura miejscem przygód.	89 000	968	11	*	–	✓	✓	–	✓
Spektakl taneczno-muzyczny Hawaje w Warszawie	110 000	388	4		–	–	✓	–	✓
Garażówki i ekowarsztaty nad Wisłą	138 300	2 749	20	*	–	✓	✓	–	✓
Book na Pradze-Południe, Woli i Ochocie, czyli Bibliotek Obcojęzycznych Odważna	150 000	1 333	9	*	–	✓	✓	–	✓
Warsztaty kompostowania dla Warszawianek i Warszawiaków	176 000	2 345	13	*	–	✓	✓	–	✓
Warszawa pamięta: Hanka Ordonówna - mural, plenerowa wystawa fotografii oraz kon	184 500	1 731	9	*	–	✓	✓	–	✓
Mistrzynie i Mistrzowie kompostowania - Centrum Edukacji Kompostowej	200 000	592	3		–	–	–	–	–
Warszawski Uniwersytet Rodzinny – cykl wykładów i pokazów kulturalno-naukowych w	202 000	3 193	16	*	–	✓	✓	–	✓
„Poloneza czas zacząć...” - Polonez jako nasze dziedzictwo kultury	252 000	625	2		–	–	–	–	–
Włochowskie tablice informujące o jakości powietrza	270 000	4 406	16	*	–	✓	✓	–	✓
Gry miejskie dla całych rodzin o historii każdej z dzielnic Warszawy	278 700	2 531	9	*	–	✓	✓	–	✓
Stołeczny opiekun drzew + warszawska drzewna aplikacja WWW	350 000	2 572	7	*	–	✓	–	–	✓
Audyt realizacji projektów wybranych w edycjach budżetu partycypacyjnego na 2018	350 000	2 534	7	*	–	✓	✓	–	✓
Edukacja przeciwpowodziowa w szkołach i przedszkolach	376 000	3 763	10	*	–	✓	✓	–	✓
Ratujmy warszawskie drewniaki - drewniak Burkego	404 900	2 389	6	*	–	–	✓	–	–
Aleja spacerowa z wybiegiem dla psów wzdłuż ulicy Instalatorów oraz łąka kwietna	442 150	4 655	11	*	–	✓	✓	–	✓
Pociąg do buli 2/warszawiacy graja w bule	475 200	1 750	4		–	–	–	–	–
Kampania społeczna Masz moc! Obniż swój ślad węglowy! Razem uratujemy naszą przy	500 000	2 201	4	*	–	–	–	–	–
Wprowadzenie miejskich pojemników do selektywnej zbiórki odpadów na obrzeżu stre	592 592	4 953	8	*	–	✓	✓	–	✓

Analysing data

Project Name	Cost	Votes	v / cost	JR	Greedy ▾	Opt Knapsack	Rule X	Cost X	Phragmen
Nowe drogi dla rowerów i stojaki rowerowe	2 346 500	17 343	7	*	✓	✓	✓	–	✓
Budowa zaległej infrastruktury dla rowerów	4 360 000	15 130	3		✓	–	–	–	–
Posprzątajmy dziki brzeg Wisły	22 085	14 276	646	*	✓	✓	✓	✓	✓
Ogrody deszczowe dla Warszawy - mała retencja wody i bioróżnorodność	53 000	8 594	162	*	✓	✓	✓	✓	✓
Dzieci warszawskie bez komarów i kleszczy – montaż budek lęgowych dla jerzyków n	67 000	37 367	558	*	✓	✓	✓	✓	✓
SADŹMY DRZEWA ŚWIATA- PIĘKNE I POŻYTECZNE	437 500	17 928	41	*	✓	✓	✓	✓	✓
Eko punkty w całym mieście	495 000	21 075	43	*	✓	✓	✓	✓	✓
Schronisko Na Paluchu - sala rehabilitacyjna dla zwierząt	700 000	43 874	63	*	✓	✓	✓	✓	✓
Mniej pyłu! - Nasadzenia niskiej roślinności wzdłuż ulic w Warszawie	735 000	37 083	50	*	✓	✓	✓	✓	✓
Świadomy niewidomy - oznakowanie w języku Braille'a w całej Warszawie	850 000	16 475	19	*	✓	✓	✓	✓	✓
Ratowanie i pielęgnacja dużych starych drzew, poprzedzone ekspertyzami dendrolog	997 989	23 418	23	*	✓	✓	✓	✓	✓
Stop Smog - zazieleńmy ulice naszej stolicy	1 137 500	24 125	21	*	✓	✓	✓	✓	✓
Toalety automatyczne w warszawskich parkach	1 293 812	15 831	12	*	✓	✓	✓	✓	✓
Sadzenie drzew, krzewów i bylin, ochrona drzew i poprawa ich warunków siedliskow	1 317 180	15 657	12	*	✓	✓	✓	✓	✓
666 ławek dla Warszawy	2 000 100	24 594	12	*	✓	✓	✓	✓	✓
Asfaltowe drogi dla rowerów	4 783 300	31 046	6	*	✓	–	–	✓	–
Dziana Warszawa	87 500	737	8	*	–	–	✓	–	✓
Rodzinne Kluby Przyrodnicze w całej Warszawie - natura miejscem przygód.	89 000	968	11	*	–	✓	✓	–	✓
Spektakl taneczno-muzyczny Hawaje w Warszawie	110 000	388	4		–	–	✓	–	✓
Garażówki i ekowarsztaty nad Wisłą	138 300	2 749	20	*	–	✓	✓	–	✓
Book na Pradze-Południe, Woli i Ochocie, czyli Bibliotek Obcojęzycznych Odważna	150 000	1 333	9	*	–	✓	✓	–	✓
Warsztaty kompostowania dla Warszawianek i Warszawiaków	176 000	2 345	13	*	–	✓	✓	–	✓
Warszawa pamięta: Hanka Ordonówna - mural, plenerowa wystawa fotografii oraz kon	184 500	1 731	9	*	–	✓	✓	–	✓
Mistrzynie i Mistrzowie kompostowania - Centrum Edukacji Kompostowej	200 000	592	3		–	–	–	–	–
Warszawski Uniwersytet Rodzinny – cykl wykładów i pokazów kulturalno-naukowych w	202 000	3 193	16	*	–	✓	✓	–	✓
„Poloneza czas zacząć…" - Polonez jako nasze dziedzictwo kultury	252 000	625	2		–	–	–	–	–
Włochowskie tablice informujące o jakości powietrza	270 000	4 406	16	*	–	✓	✓	–	✓
Gry miejskie dla całych rodzin o historii każdej z dzielnic Warszawy	278 700	2 531	9	*	–	✓	✓	–	✓
Stołeczny opiekun drzew + warszawska drzewna aplikacja WWW	350 000	2 572	7	*	–	✓	–	–	✓
Audyt realizacji projektów wybranych w edycjach budżetu partycypacyjnego na 2018	350 000	2 534	7	*	–	✓	✓	–	✓
Edukacja przeciwpowodziowa w szkołach i przedszkolach	376 000	3 763	10	*	–	✓	✓	–	✓
Ratujmy warszawskie drewniaki - drewniak Burkego	404 900	2 389	6	*	–	–	✓	–	–
Aleja spacerowa z wybiegiem dla psów wzdłuż ulicy Instalatorów oraz łąka kwietna	442 150	4 655	11	*	–	✓	✓	–	✓
Pociąg do buli 2/warszawiacy graja w bule	475 200	1 750	4		–	–	–	–	–
Kampania społeczna Masz moc! Obniż swój ślad węglowy! Razem uratujemy naszą przy	500 000	2 201	4	*	–	–	–	–	–
Wprowadzenie miejskich pojemników do selektywnej zbiórki odpadów na obrzeżu stre	592 592	4 953	8	*	–	✓	✓	–	✓

Analysing data

Project Name	Cost	Votes	v / cost	JR	Greedy	Opt Knapsack	Rule X	Cost X	Phragmen
Parki Kieszonkowe dla Warszawy	1 621 800	12 787	8	*	–	✓	–	✓	✓
Toalety XXI wieku	647 956	11 051	17	*	–	✓	✓	✓	✓
Butelkomaty warszawskie - zintegrowany system informacyjny	457 000	9 985	22	*	–	✓	✓	✓	✓
Drzewa i krzewy na Modlińskiej oraz Jagiellońskiej	434 300	12 463	29	*	–	✓	✓	✓	✓
Kurs pierwszej pomocy w szkołach i przedszkolach	383 560	8 115	21	*	–	✓	✓	✓	✓
Bezpieczne parkowanie – zadaszone parkingi rowerowe w dzielnicach Ursynów, Mokot	301 000	6 417	21	*	–	✓	✓	✓	✓
1800 worków na wodę dla warszawskich drzew we wszystkich dzielnicach Warszawy	270 000	6 775	25	*	–	✓	✓	✓	✓
Warsztaty przeciwdziałania przemocy oraz treningi samoobrony dla dzieci i dorosł	218 000	6 166	28	*	–	✓	✓	✓	✓
,,Ogród zmysłów''	208 000	5 402	26	*	–	✓	✓	✓	✓
TUS - Trening Umiejętności Społecznych dla dzieci niepełnosprawnych	148 920	11 928	80	*	–	✓	✓	✓	✓
Chcę zobaczyć siebie bez nadwagi!	143 000	5 891	41	*	–	✓	✓	✓	✓
Tyci Lasy dla tyci ludzi - leśne kryjówki dla dzieci	126 400	6 923	55	*	–	✓	✓	✓	✓
Zatrzymajmy globalne ocieplenie - akcja edukacyjna	120 000	3 013	25	*	–	✓	✓	✓	✓
Ogrody deszczowe w warszawskich szkołach.	108 100	7 154	66	*	–	✓	✓	✓	✓
Inteligentne wiaty przystankowe	108 000	11 959	111	*	–	✓	✓	✓	✓
Dzień bez torby - ograniczenie użycia jednorazowych toreb foliowych na targowisk	105 000	3 228	31	*	–	✓	✓	✓	✓
Plac Wileński - Nowe nasadzenia i ławki	98 100	2 423	25	*	–	✓	✓	✓	✓
Naczynia eko na posiłki rozdawane dla osób bezdomnych na ulicy	96 000	5 953	62	*	–	✓	✓	✓	✓
Zmiana oznaczenia przystanków autobusowych NŻ komunikacji miejskiej	94 666	3 290	35	*	–	✓	✓	✓	✓
Tablica informująca o jakości powietrza – Fort Bema	90 000	1 776	20	*	–	✓	✓	✓	✓
Wspomaganie rozwoju ruchowego, sensorycznego i komunikacyjnego dla 390 dzieci 0-	87 450	1 777	20	*	–	✓	✓	✓	✓
Owoce miejskie	82 000	5 528	67	*	–	✓	✓	✓	✓
Praktyczny kurs pisania książek	75 500	1 823	24	*	–	✓	✓	✓	✓
Więcej warzyw, poproszę! Warsztaty kuchni roślinnej dla rodzin	75 000	1 937	26	*	–	✓	✓	✓	✓
Less waste - warsztaty w szkołach jak mniej marnować i być eko!	65 000	4 248	65	*	–	✓	✓	✓	✓
Szkoła w kuchni – kulinarne lekcje historii, matematyki i geografii.	62 400	4 531	73	*	–	✓	✓	✓	✓
Targi rękodzieła warszawskiego - hand made	59 340	6 126	103	*	–	✓	✓	✓	✓
Hałasen - instalacja artystyczna przekuwająca hałas w ciekawe doświadczenie	56 150	1 250	22	*	–	✓	✓	✓	✓
Jeże na warsztat. Jak pomagać kolczastym sąsiadom.	50 400	4 070	81	*	–	✓	✓	✓	✓
Przeciwdziałające samobójstwom tabliczki z numerami telefonów zaufania	49 000	5 165	105	*	–	✓	✓	✓	✓
Pasieka w Zespole Małych Form Opieki i Wychowania 'Chata'	37 350	8 247	221	*	–	✓	✓	✓	✓
Kulinarne wycieczki po Warszawie dla dzieci i młodzieży - wakacje 2021	33 750	4 988	148	*	–	✓	✓	✓	✓
Wspierajmy się nawzajem! - Spotkania dla osób w żałobie	33 080	1 738	53	*	–	✓	✓	✓	✓
Owocowa Warszawa - Owocowe Warszawskie Sady	28 500	4 651	163	*	–	✓	✓	✓	✓
Ukulele łagodzi obyczaje	26 500	990	37	*	–	✓	✓	✓	✓
Nauka tańca hawajskiego dla seniorów	19 900	1 693	85	*	–	✓	✓	✓	✓
Pszczele Rodziny Dla Dzieci - zajęcia i apiterapia w Domu Dziecka nr 15 im. Ks.G	18 800	2 733	145	*	–	✓	✓	✓	✓
Edukacja w zakresie szczepień	17 000	2 565	151	*	–	✓	✓	✓	✓
„Aktywna godzina – ruch dla każdego” – zajęcia sportowe dla wszystkich grup wiek	14 000	1 411	101	*	–	✓	✓	✓	✓

Analysing data

Project Name	Cost	Votes	v / cost	JR	Greedy	Opt Knapsack	Rule X	Cost X ▾	Phragmen
Parki Kieszonkowe dla Warszawy	1 621 800	12 787	8	*	–	✓	–	✓	✓
Toalety XXI wieku	647 956	11 051	17	*	–	✓	✓	✓	✓
Butelkomaty warszawskie - zintegrowany system informacyjny	457 000	9 985	22	*	–	✓	✓	✓	✓
Drzewa i krzewy na Modlińskiej oraz Jagiellońskiej	434 300	12 463	29	*	–	✓	✓	✓	✓
Kurs pierwszej pomocy w szkołach i przedszkolach	383 560	8 115	21	*	–	✓	✓	✓	✓
Bezpieczne parkowanie – zadaszone parkingi rowerowe w dzielnicach Ursynów, Mokot	301 000	6 417	21	*	–	✓	✓	✓	✓
1800 worków na wodę dla warszawskich drzew we wszystkich dzielnicach Warszawy	270 000	6 775	25	*	–	✓	✓	✓	✓
Warsztaty przeciwdziałania przemocy oraz treningi samoobrony dla dzieci i dorosł	218 000	6 166	28	*	–	✓	✓	✓	✓
,,Ogród zmysłów''	208 000	5 402	26	*	–	✓	✓	✓	✓
TUS - Trening Umiejętności Społecznych dla dzieci niepełnosprawnych	148 920	11 928	80	*	–	✓	✓	✓	✓
Chcę zobaczyć siebie bez nadwagi!	143 000	5 891	41	*	–	✓	✓	✓	✓
Tyci Lasy dla tyci ludzi - leśne kryjówki dla dzieci	126 400	6 923	55	*	–	✓	✓	✓	✓
Zatrzymajmy globalne ocieplenie - akcja edukacyjna	120 000	3 013	25	*	–	✓	✓	✓	✓
Ogrody deszczowe w warszawskich szkołach.	108 100	7 154	66	*	–	✓	✓	✓	✓
Inteligentne wiaty przystankowe	108 000	11 959	111	*	–	✓	✓	✓	✓
Dzień bez torby - ograniczenie użycia jednorazowych toreb foliowych na targowisk	105 000	3 228	31	*	–	✓	✓	✓	✓
Plac Wileński - Nowe nasadzenia i ławki	98 100	2 423	25	*	–	✓	✓	✓	✓
Naczynia eko na posiłki rozdawane dla osób bezdomnych na ulicy	96 000	5 953	62	*	–	✓	✓	✓	✓
Zmiana oznaczenia przystanków autobusowych NŻ komunikacji miejskiej	94 666	3 290	35	*	–	✓	✓	✓	✓
Tablica informująca o jakości powietrza – Fort Bema	90 000	1 776	20	*	–	✓	✓	✓	✓
Wspomaganie rozwoju ruchowego, sensorycznego i komunikacyjnego dla 390 dzieci 0-	87 450	1 777	20	*	–	✓	✓	✓	✓
Owoce miejskie	82 000	5 528	67	*	–	✓	✓	✓	✓
Praktyczny kurs pisania książek	75 500	1 823	24	*	–	✓	✓	✓	✓
Więcej warzyw, poproszę! Warsztaty kuchni roślinnej dla rodzin	75 000	1 937	26	*	–	✓	✓	✓	✓
Less waste - warsztaty w szkołach jak mniej marnować i być eko!	65 000	4 248	65	*	–	✓	✓	✓	✓
Szkoła w kuchni – kulinarne lekcje historii, matematyki i geografii.	62 400	4 531	73	*	–	✓	✓	✓	✓
Targi rękodzieła warszawskiego - hand made	59 340	6 126	103	*	–	✓	✓	✓	✓
Hałasen - instalacja artystyczna przekuwająca hałas w ciekawe doświadczenie	56 150	1 250	22	*	–	✓	✓	✓	✓
Jeże na warsztat. Jak pomagać kolczastym sąsiadom.	50 400	4 070	81	*	–	✓	✓	✓	✓
Przeciwdziałające samobójstwom tabliczki z numerami telefonów zaufania	49 000	5 165	105	*	–	✓	✓	✓	✓
Pasieka w Zespole Małych Form Opieki i Wychowania 'Chata'	37 350	8 247	221	*	–	✓	✓	✓	✓
Kulinarne wycieczki po Warszawie dla dzieci i młodzieży - wakacje 2021	33 750	4 988	148	*	–	✓	✓	✓	✓
Wspierajmy się nawzajem! - Spotkania dla osób w żałobie	33 080	1 738	53	*	–	✓	✓	✓	✓
Owocowa Warszawa - Owocowe Warszawskie Sady	28 500	4 651	163	*	–	✓	✓	✓	✓
Ukulele łagodzi obyczaje	26 500	990	37	*	–	✓	✓	✓	✓
Nauka tańca hawajskiego dla seniorów	19 900	1 693	85	*	–	✓	✓	✓	✓
Pszczele Rodziny Dla Dzieci - zajęcia i apiterapia w Domu Dziecka nr 15 im. Ks.G	18 800	2 733	145	*	–	✓	✓	✓	✓
Edukacja w zakresie szczepień	17 000	2 565	151	*	–	✓	✓	✓	✓
„Aktywna godzina – ruch dla każdego" – zajęcia sportowe dla wszystkich grup wiek	14 000	1 411	101	*	–	✓	✓	✓	✓