How to calculate an election result in your bedroom

by Michael Sproul

Australia!

- Population: 24 million
- 8 states and territories
- Senate composition is decided *per state*

STV Preferential Voting

- Voters number candidates in order of preference
- Algorithm elects popular candidates, knocks out unpopular ones
- Lots of candidates, lots of ballots and complicated rules!

The AEC’s dirty secret

The Australian Electoral Commission keeps their code secret!

… but all the data is available as CSV!

… and the voting algorithm is defined in legislation!

Why Rust?

- Memory usage
  10^2 candidates × 10^7 voters × 4 bytes ≈ 1GB RAM
- Speed
  As fast as C/C++ without segfaults
- Types
  Easy refactoring, controlled mutability, ADTs (enums)

Naive Number Crunching

Example:

Candidate A has 100,000 votes

Quota = 80,000 votes

Elect Candidate A and transfer each vote to the next round with value 20,000/100,000 = 1/5

Logically, 4/5ths of each vote have been “used up”

Naive Number Crunching

What do we do with votes that are already fractional?

Naive Solution: Multiply their value by the new transfer value

E.g.

Candidate B has 80,000 ⅕ votes

Apply transfer value of (1/5)/80,000 = 1/400,000

Votes from previous round now have value 1/5 * 1/400,00 = 1/2,000,000

Naive Number Crunching

Uh oh!

- Irreducible fractional votes with **3000 digits in numerator and denominator**
- Standard `num` crate too slow, switched to `gmp` and `ramp`
- 20+ hours to run, 8+ gigabytes of memory used!

Reading the Legislation

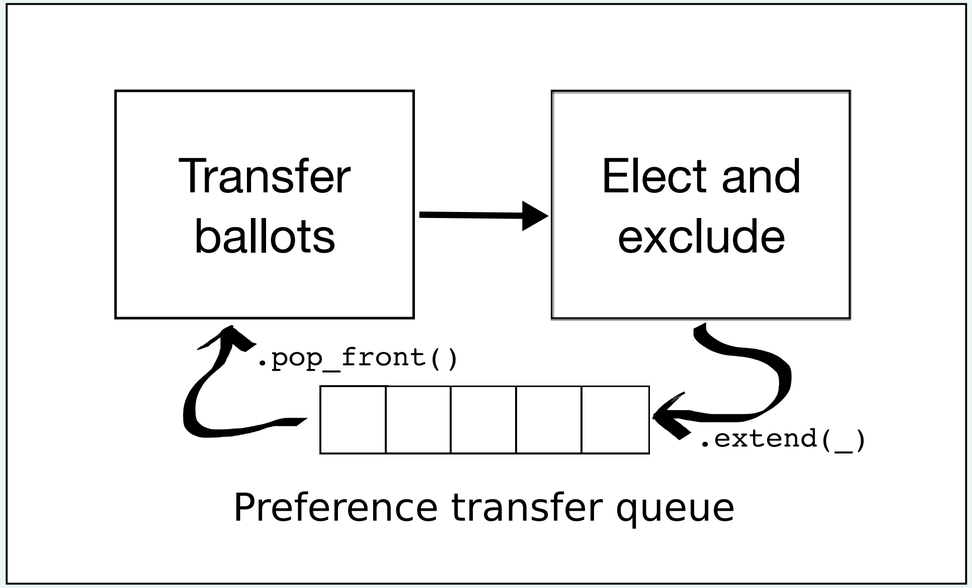
- Round vote counts to integers
- “Aggregate” transfer values to avoid multiplying them:

    t = (num_votes - quota) / (num_ballots)

- Downside: more complex, more sensitive to order of operations

System Architecture

Main algorithm, round i



Core Data Structures

```
pub struct VoteMap<'a> {
    info: HashMap<CandidateId, VoteInfo<'a>>,
    candidates: &'a CandidateMap
}
struct VoteInfo<'a> {
    votes: Int,
    ballots: TransferMap<'a>,
    eliminated: bool,
}
pub type TransferMap<'a> = BTreeMap<Frac, Vec<&'a mut Ballot>>;
```

Results

- Replicated the official result for all 8 states and territories
- For the largest state (NSW):
  - 4,705,270 votes
  - 20 seconds to run
  - ~1GB peak memory usage
- 1021 lines of code

Links

- My code: github.com/michaelsproul/aus_senate
- Another implementation: github.com/grahame/dividebatur

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Thank you!