

# Vote::Count

A Library for  
Counting  
Preferential Ballots

Background: Casting Ballots with Pebbles in Ancient Greece



## **We May Have Fancy Machines**

- **We're still using the same method as the Ancient Greeks to pick the winner.**
- **The Plurality Method: vote for one, choice with the most votes wins is only efficient when we are restricted to two choices.**



## **More than two choices?**

- **The 1912 Presidential Election with 3 Presidents Running (Taft, Roosevelt, Wilson) was won with less than 42% of the Vote.**
- **Lincoln had less than 40% with 4 major candidates in 1860.**
- **Clinton also had 42% in a three-way race.**
- **Primaries with more than two choices are frequently won by choices opposed by a majority of the participants.**

In the Presidential Elections:

Perot voters were nearly evenly split between Republican and Democrat Leaning, Clinton probably won.

Lincoln had a majority in enough states to win the Electoral College, but with preferential ballots and no electoral college, Douglas might have won it.

Without the Republican Taft acting as a spoiler the Independent Roosevelt would have defeated Wilson.

In Philadelphia's single party system, where it is common to have the party organization back a choice opposed by most of the voters, the opposition splitting to multiple alternatives usually results in the selection of the machine candidate.






This talk is about vote count and single member preferential ballot elections. There isn't time to talk about security issues which are completely outside the scope of Vote::Count. A library can't fix poor choice of voting equipment and poor procedure!

The Electoral College is a uniquely American issue. It will be impossible to amend the constitution to scap the system completely. It is more likely that we could amend the constitution to allocate electors proportionately within each state.





Proportional Representation and multi-member elections are interesting topics that we won't have time for today.

**What  
This Talk  
IS About**

-  **Preferential Ballots**
-  **How to find the  
winner of  
Preferential Ballots**
-  **Vote::Count  
Library**

Vote::Count is a programmer's library for resolving preferential elections.

## The Approval Ballot

-  The simplest alternative to the current system is the Approval Ballot.
-  Voters check as many or as few choices as they want.
-  If a voter strongly prefers one choice, then their best strategy is to vote for only that choice.
-  Bullet voting results in the election reverting to Plurality.

Supporters of Approval Voting for public elections are in denial of how people think and behave.

While Approval is simple, it only works a little bit better because the best strategy for voters is often to vote for only one choice, effectively reverting to plurality.

## Preferential Ballot Types

- Voters indicate multiple choices with a preference.
- **Ranked Choice Ballot:** voters rank choices.
- **Range (Score) Ballot:** voters assign scores.
- **Ranked Ballots are also referred to as Ordinal and Range Ballots as Cardinal.**

Rank any number of options in your order of preference.

Joe Smith

1 John Citizen

3 Jane Doe

Fred Rubble

2 Mary Hill

Range Voting is often referred to as Score voting by its proponents.

A third type the combines both, by restricting voters from scoring choices equally on a range ballot allowing the ballot to be interpreted as either an ordinal or cardinal ballot.



- A. To vote, fill in the OVAL ○ to the right of the candidate of your choice like this ● .
- B. If you wrongly mark, tear or spoil the ballot, return it and get another.

- Rank candidates in order of preference.
- Fill in the ① next to your first choice.  
Fill in the ② next to your second choice.  
Fill in the ③ next to your third choice.
- Do not fill in more than one oval per candidate. Do not fill in more than one oval per column.
- Ranking a 2nd, 3rd, etc. choice candidate will not hurt your first choice candidate.

	1st Choice	2nd Choice	3rd Choice
Candidate 1	①	②	③
Candidate 2	①	②	③
Candidate 3	①	②	③

Maine uses Ranked Choice Ballots, here is an example from the League of Women Voters.



**Range Ballots** With this type of Ballot voters assign scores. Voters may score choices equally.

Rate each candidate from 0 to 5	Zero Support 0	1	2	3	4	Max Support 5
Candidate A Party A	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Candidate B Party B	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Candidate C Party C	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Candidate D Party D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Candidate E Party E	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

An example of a standard Range Ballot, notice that the voter has scored A and D the same. The watermark is also a range ballot.

## **Ordinal Range Ballots**

- A variant of the Range Ballot that does not Permit Equal Scores.
- This variant may be evaluated as a Cardinal (Range) or Ordinal (Ranked) Ballot.
- Because it is in the form of a Range Ballot but is also Ordinal, Vote::Count refers to it as Ordinal Range.

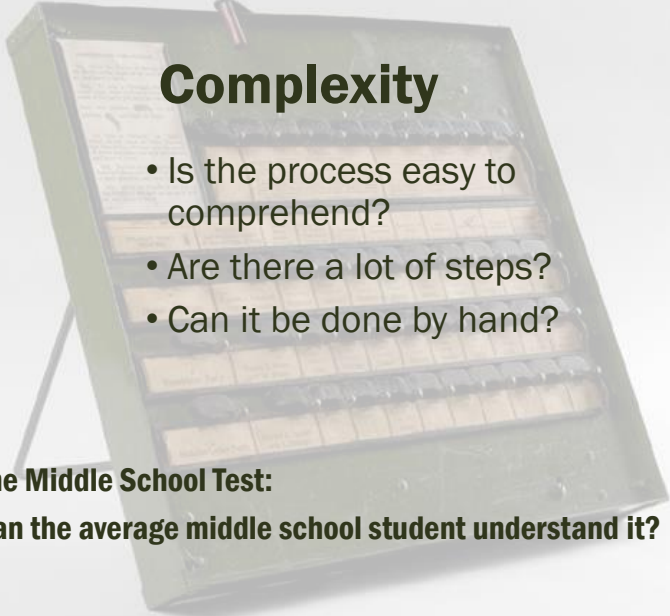
If the score depth is 10 or greater the loss of expression is minimal.

In voting terms Ordinal means ordered preferences, while Cardinal means assigned a value. So these terms are effectively synonyms for ranked and range. The Ordinal Range ballot takes the form of a range ballot but can be interpreted as an Ordinal Ballot.

## **Criteria**

- There are a lot of different ways to choose the winner of a preferential ballot
- There have been a lot of Criteria proposed for picking the best method.
- We need to look at the Criteria first.

Before I can talk about methods I need to talk about Criteria.



## Complexity

- Is the process easy to comprehend?
- Are there a lot of steps?
- Can it be done by hand?

**The Middle School Test:**  
**Can the average middle school student understand it?**

This criteria is subjective, and generally overlooked in discussions by Mathematicians. The middle school test is a policy test and somewhat hypothetical. The methods currently most favored by the Mathematicians, SSD and Kemeny-Young generally require being past introductory level college math to understand and considered a very hard fail on Complexity.



**The majority of criteria developed by mathematicians can be grouped together as Consistency.**

- Changes to non-winning choices should not change the outcome.
- A shift of support towards a choice should not harm them (and the reverse with a shift away).
- If choices are clones, if either would win without the presence of the other; both being present should not cause a non-clone to win.

There is a criteria that Mathematicians call consistency, which isn't very important from a policy perspective.

Imagine we hold the same election every day, and the same choice always wins. One morning the 4 people who always cast first preference for Rocky Road and second for Chocolate, simply vote for Chocolate, on that day for the first time Vanilla wins instead of Chocolate. This is both a shift of support towards the normal winner and the dropping of a weakly supported choice, neither of which should rationally change the winner.

The next slide is about clones.



## Clones

**The most widely used method of resolving preferential ballots is really bad at clones.**

- Definition: when supporters of each clone all give the next ranking to the other.
- French Vanilla and Vanilla Bean are likely to be clones in an Ice Cream Election.
- A cloning effect occurs when there are similar choices splitting a block of votes.
- Cloning effects are extremely common.

Democratic Voters tend to like both Elizabeth Warren and Bernie Sanders or not like them. The majority of their supporters would also rank the other one high on a preferential ballot. It is also possible to have a clone group of more than two, consider a hypothetical 2020 democratic primary featuring AOC, Bernie Sanders and Elizabeth Warren pitted against Joe Biden. The election would easily divide between voters who ranked all of the other 3 above Biden and those who preferred Biden.

## Condorcet's Criteria

- **Condorcet Winner**

A choice which defeats all others in Pairwise Comparison should always Win.

- **Condorcet Loser**

A choice defeated by all others should never win.



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## Marie Jean Antoine Nicolas de Caritat, Marquis de Condorcet

- Mathematician, Philosopher, Politician
- Friend of Benjamin Franklin
- Victim of the French Revolution
- Started the study of Choice Theory



## **Smith Criteria**

### **The third Condorcet Criteria**

- **Smith Set (Dominant Set)**

When there is no Condorcet Winner the smallest subset that defeats all others.

Named for the American Mathematician John Howard Smith.

- **Smith Criteria**

The winner should be a member of the Smith Set.



Smith's work is relatively recent, he was still teaching math in 2011. Unfortunately, I could not find an image of him.

## Later Harm

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Adding an additional choice should not harm the chances of a preferred choice.

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We've already seen that Approval fails as a viable method because Later Harm results in Bullet Voting.

Later Harm is a big driver in strategic voting. Voters casting insincere ballots breaks preferential resolution and in the worst case voters are effectively back to plurality.

# One More

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Resolvability

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Majority vote meets  
Condorcet, Later harm and  
Consistency.

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Unfortunately, Majority  
frequently fails to produce a  
winner, or even return a tie.

# One More

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## Majority Winner

Is an optional criteria.

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Adding an early step to check for Majority Winner makes any system meet this Criteria.

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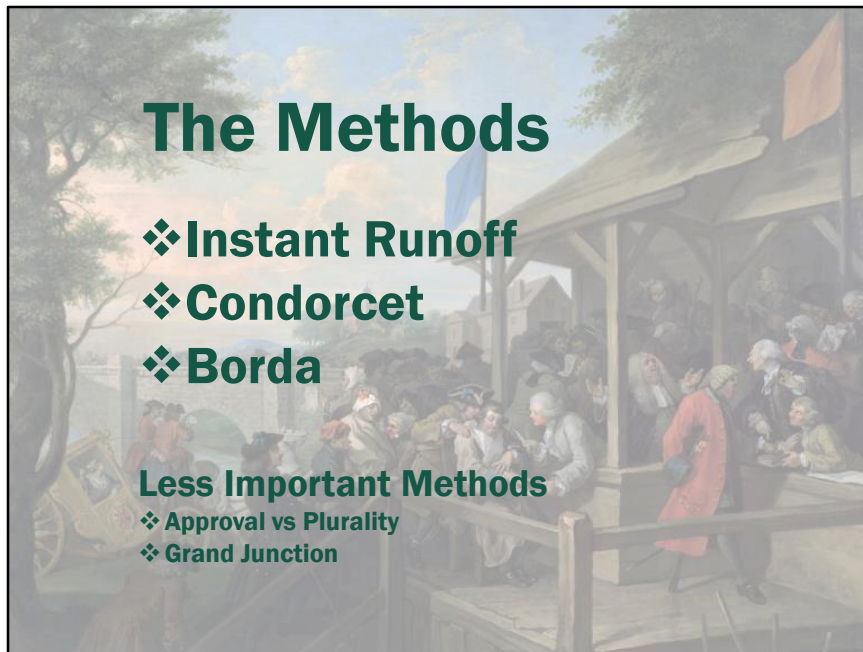
Systems that do meet it can shortcut by making extra checks for it.

Supporters of Score Systems will often argue against Majority Winner as a desirable criteria. If A defeats B 51% to 49%, but most A supporters ranked B second, B might have a much higher Borda Score

## Five Criteria

- **Resolvability**
  - **Complexity**
  - **Consistency**
  - **Condorcet**
  - **Later Harm**
- Arrow's Theorem states that it is impossible to meet both the Condorcet Winner Criteria and Later Harm.
  - It is seriously impossible to meet all five.

This is the fundamental Paradox of Preferential Voting. We are unable to meet all of the Criteria we've set. There is no perfect Method, only tradeoffs.



There are, for all of the criteria, and sub-criteria we've considered, only three basic methods that are widely used.

# Less Important Methods

## Approval vs Plurality

Hold a runoff between the Approval and Plurality winners.

## Grand Junction

- 1) Determine the majority threshold.
- 2) Count first choice votes.
- 3) If no majority, add the second choices.
- 4) Add levels until there is a winner or no more votes.

**These two methods are simple and resolvable.**

**Vote::Count implements a modified form of Grand Junction as a tie breaker because it is very resolvable.**

Grand Junction is also known as the Bucklin Method for its inventor. It was used in Grand Junction for a few elections. The modified variant for tie breakers is the most resolvable tie breaker, the only more resolvable tie breaker is random, which isn't repeatable.

## **Instant Runoff Voting**

- **Also known as Alternative Vote or Hare Method (after its inventor).**
- **Requires a Majority.**
- **When there is no majority the low choice is eliminated, and the votes recounted.**
- **The most widely used method of counting preferential ballots.**



## **Instant Runoff Voting**

- **Easy to Hand Count.**
- **Meets Later Harm.**
- **Meets Condorcet Loser, but not Condorcet Winner and Smith.**
- **Has a lot of consistency issues including:**
  - **The example many slides prior with the Rocky Road voters is possible with IRV**
  - **IRV handles cloning effects poorly.**

## The Borda Count (Scoring Methods)

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- **Count Borda a contemporary and rival of Condorcet popularized Vote Scoring.**
- **Vote Count groups all scoring methods as part of the Borda family.**



Like Condorcet, Count Borda made contributions in multiple fields.

## Scoring Methods

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- **Scoring Methods do not meet Later Harm.**
- **Borda's original Method severely fails Later Harm.**
- **Scoring Methods do not meet Condorcet Winner or Smith.**



## **STAR. Score Then Automatic Runoff**

- **STAR demonstrates that scoring methods work better with Range Ballots than Ranked Ballots.**
- **STAR is simple.**
- **With the Range Ballot voters can communicate the importance of Later Harm by scoring secondary choices low or high.**
- **The voter trades off helping later choices more against the Later Harm effect.**

The name explains the process. Use the range ballot scores, take the top two choices and hold a runoff.

With range ballots the voter generates the scores.



## **STAR. Score Then Automatic Runoff**

- **Because the Voter has direct input to the later harm impact, Range Ballot scoring has considerably less later harm than classic Borda.**
- **When voters rank for later harm they also prevent their secondary choices from reaching the runoff.**
- **There hasn't been enough real world use of STAR yet to know how voters will really behave.**

Until recently almost all work and implementation of Preferential Ballots was with Ranked Ballots. It is only recently that there has been a lot of interest in Range Ballots, so STAR hasn't been around all that long.



## Condorcet Method

- Any Method that meets the Condorcet Criteria qualifies.
- Vote::Count uses Condorcet to refer to Pairwise Methods.
- Conduct all possible Pairings.
- Look for a Condorcet Winner.

For the final method type we are back to our old hero, Condorcet.



## Condorcet's Paradox

- Unfortunately, it is possible to have a preference Loop.
- $A > B, B > C, C > A$
- It is also possible to get a "knot" or find there isn't even a dominant set.
- Because of this Condorcet's Method fails resolvability.

Loops can actually occur at any odd number, but 5 is rare with real data and anything larger is limited in practice to sets of data designed to produce the effect.

Knot is a term Vote::Count uses to describe this, not an accepted math term.



## Solving the Paradox

- Condorcet and Borda argued about whose method was better.
- Early Condorcet implementations typically went to Borda Count to break the tie!
- Later IRV became a popular fallback.

Loops can actually occur at any odd number, but 5 is rare with real data and anything larger is limited in practice to sets of data designed to produce the effect.

Knot is a term Vote::Count uses to describe this, not an accepted math term.





## Criteria

- Pairwise methods almost always meet the Condorcet Winner and Loser Criteria.
- Most but not all meet Smith.
- As dictated by Arrow's Theorem all Condorcet Methods fail Later Harm.

There is actually a method that meets Condorcet Winner and fails Condorcet loser, so I can't say always.



## Consistency

- When there is a Condorcet Winner, Condorcet methods have excellent consistency.
- This consistency applies between the Smith Set and other choices in the absence of a Condorcet Winner.

Consistency has many sub components, some of which are contradictory. Condorcet in this case meets all of the major concerns. Even though not mathematically correct, when there is a Condorcet Winner, I consider Condorcet methods to be consistent.



## Complexity

- Benham Condorcet IRV is simple enough that it can be counted by hand.
- Smith Set IRV and other IRV and Borda Fallbacks are simple.
- The methods currently favored by Mathematicians: Kemmeny-Young and SSD require graduate level math.
- Other sub-methods also vary in complexity.



## Condorcet Methods

- Benham Condorcet IRV drops the choice with the lowest top count until there is a Condorcet Winner.
- Smith Set IRV runs IRV on the Smith Set. Simple and the best non-redacting Condorcet Method on Later Harm.
- Kemmeny-Young, SSD meet more consistency criteria.
- Various fallbacks.

There are a lot more methods in this family than I have space to list or brain cells to comprehend.



## Redacting Condorcet

- Redacting methods evaluate ballots that have been redacted to assess later harm effects.
- These methods have a lot of steps and may also require advanced math.
- These methods allow measurement of later harm and can set a later harm tolerance.
- With no later harm tolerance they almost always confirm IRV.

When IRV and Condorcet do not have the same winner there is almost always a Later Harm effect. Thus with no later harm tolerance the IRV winner should prevail. This fact has made these methods appear uninteresting. However, with them we can determine the number of votes the Condorcet Winner needed from the IRV winner and if that is less than their margin over the IRV Winner we can take the Condorcet Winner. Even with no tolerance allowed, in the 5% of elections where the Condorcet winner is confirmed over the IRV winner it is the better outcome, because the IRV outcome was an inconsistency effect.

## The Best Method?

- **Smith Set IRV: meets all 3 Condorcet Criteria, with less Later Harm.**
- **Borda: STAR is the best method in the Family, but it requires Range Ballots. STAR encourages voting strategies that can make STAR fail.**
- **IRV: Simple and Later Harm Protected**
- **Redacting Condorcet: Complex, better outcome than IRV.**

CPAN meta::cpan

**Vote::Count can be  
downloaded from CPAN.**

**Search [metacpan.org](http://metacpan.org) for  
documentation.**

## Vote::Count in Action

- The Distribution contains an examples folder.
- The tests are also useful as examples.
- The t/data folder contains a number of ballot sets.
- The Vote::Count::Start module will run and log several common methods.
- We're going to look at two example elections.

I've picked two interesting data sets for demonstration.

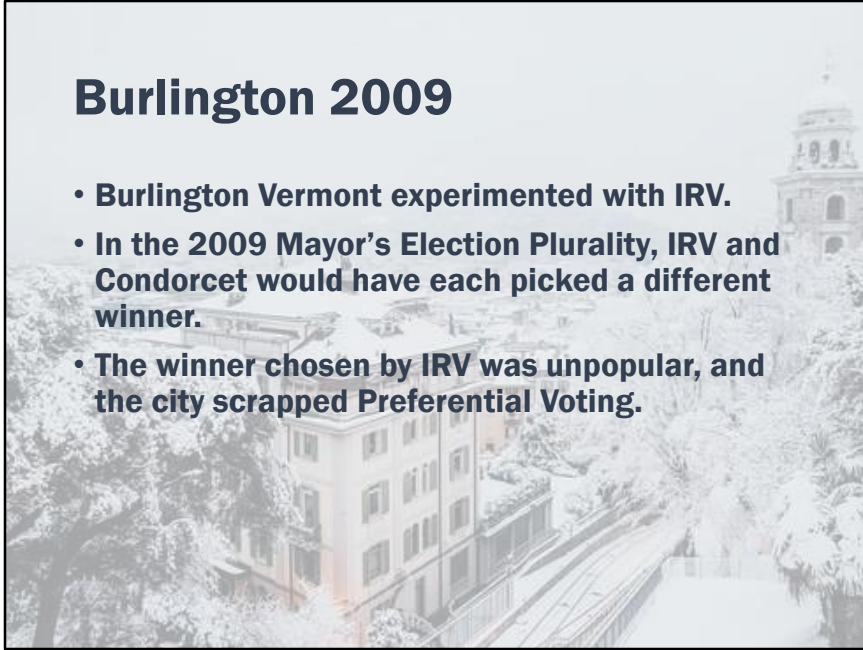




Tennessee is also a great cloning example. Memphis is located in the western part of the state far away from Nashville, Knoxville and Chattanooga In the Eastern Part of the State. Voters from the Eastern half of the state want any of the other choices than Memphis. There are more voters in the east than near Memphis, but Nashville is the closest eastern city. In this example voters also provided a ranking for all 4 choices.

## Burlington 2009

- Burlington Vermont experimented with IRV.
- In the 2009 Mayor's Election Plurality, IRV and Condorcet would have each picked a different winner.
- The winner chosen by IRV was unpopular, and the city scrapped Preferential Voting.



Since this was a Ranked Choice election we only have ranked data for this one.

## Vote::Count::Start

```
use 5.022; # or later
use feature qw /postderef signatures/;

use Vote::Count::Start;
my $Election = StartElection(
    BallotFile => $filename,
    FloorRule  => 'Approval',
    FloorValue => 5,
    LogPath   => $outfolder,
    LogBaseName => $name . "_basic",
);
$Election->WriteLog();
```

Vote::Count's Start Module will setup and run several popular methods. Here is most of a script using it.

5.022 is the minimum Perl version you can use, it will work with any later version as well.

# STAR

```
use 5.022;

use feature qw /postderef signatures/;
use Path::Tiny;

use Vote::Count::ReadBallots;
use Vote::Count::Method::STAR;
my $tennessee =
  Vote::Count::Method::STAR->new(
    LogTo => '/tmp/demo/tennessee_star',
    BallotSet => read_range_ballots('tennessee.range.json'),
  );
$tennessee->STAR();
say '='x60 ;
say "Running STAR for Tennessee";
say $tennessee->logv();

$tennessee->WriteLog();
```

Here is a short script to run STAR.

BURLINGTON MAYOR 2009

VoteCount\$ ./example/start.pl t/data/burlington2009.txt /tmp/demo

Running Basic RCV Methods for t/data/burlington2009.txt

Plurality Winner: WRIGHT

Approval Winner: MONTROLL

Applying Floor Rule of 5% Approval Count. vs Ballots Cast of 8976.

Floor Rule Eliminated:

WRITEIN

Remaining:

KISS, WRIGHT, MONTROLL, SIMPSON, SMITH

Borda Winner: MONTROLL

Instant Runoff Voting

Choices:

KISS, MONTROLL, SIMPSON, SMITH, WRIGHT

```
---
| Winner           | KISS |
| Votes in Final Round | 8374 |
| Votes Needed for Majority | 4188 |
| Winning Votes      | 4313 |
```

One of the choices Montroll wins Approval, Borda, and Condorcet, while two different choices win Plurality and IRV.

We're looking at the terse/brief logging option. Vote count logs at 3 levels, a summary level, a detail level, and a debug level.

=====  
Running Strict CondorcetVsIRV for t/data/burlington2009.txt

Condorcet Winner is MONTROLL  
Neither MONTROLL nor KISS were confirmed.

Redacted Ballots Winners:  
Condorcet = WRIGHT, IRV = WRIGHT

Elected: KISS

=====  
Running Relaxed CondorcetVsIRV for t/data/burlington2009.txt

Condorcet Winner is MONTROLL  
Neither MONTROLL nor KISS were confirmed.

Redacted Ballots Winners: Condorcet = WRIGHT, IRV = WRIGHT

The margin of the Condorcet over the IRV winner was: 587  
MONTROLL's greatest loss with redacted ballots was 1110.

Elected: KISS

Relaxed is just the term votecount is using, it will probably change in a future release.

```
VoteCount$ ./example/start.pl t/data/tennessee.txt /tmp/demo
```

```
=====
Running Basic RCV Methods for t/data/tennessee.txt
Plurality Winner: MEMPHIS
Approval Tie: CHATTANOOGA, KNOXVILLE, MEMPHIS, NASHVILLE
Applying Floor Rule of 5% Approval Count. vs Ballots Cast of 100.
Floor Rule Eliminated:
```

```
Remaining:
MEMPHIS, CHATTANOOGA, NASHVILLE, KNOXVILLE
Borda Tie: CHATTANOOGA, KNOXVILLE, MEMPHIS, NASHVILLE
```

```
Instant Runoff Voting
Choices:
CHATTANOOGA, KNOXVILLE, MEMPHIS, NASHVILLE
```

```
-----
| Winner                | KNOXVILLE |
| Votes in Final Round | 100        |
| Votes Needed for Majority | 51        |
| Winning Votes        | 58        |
```

```
=====  
Running Strict CondorcetVsIRV for t/data/tennessee.txt
```

```
Condorcet Winner is NASHVILLE  
Neither NASHVILLE nor KNOXVILLE were confirmed.  
Redacted Ballots Winners: Condorcet = NONE, IRV = MEMPHIS
```

```
Elected: KNOXVILLE
```

```
=====  
Running Relaxed CondorcetVsIRV for t/data/tennessee.txt
```

```
Condorcet Winner is NASHVILLE  
Neither NASHVILLE nor KNOXVILLE were confirmed.  
Redacted Ballots Winners: Condorcet = NONE, IRV = MEMPHIS
```

```
The margin of the Condorcet over the IRV winner was: 36  
NASHVILLE's greatest loss with redacted ballots was 16.
```

```
Elected: NASHVILLE
```



```
VoteCount$ ./example/star.pl
```

```
=====
```

```
Running STAR for Tennessee
```

```
Tue Oct 1 00:50:11 2019
```

Rank	Choice	Score
1	NASHVILLE	352
2	KNOXVILLE	307
3	CHATTANOOGA	289
4	MEMPHIS	268

```
Automatic Runoff Winner: NASHVILLE
```

```
[ NASHVILLE: 68 -- KNOXVILLE: 32 ]
```

CPAN meta::cpan

<https://metacpan.org/pod/Vote::Count>

<https://github.com/brainbuz/Vote-Count>

**John Karr**

<http://techinfo.brainbuz.org>

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