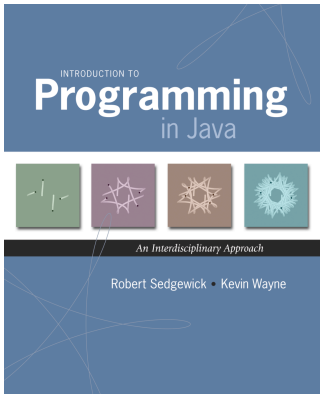
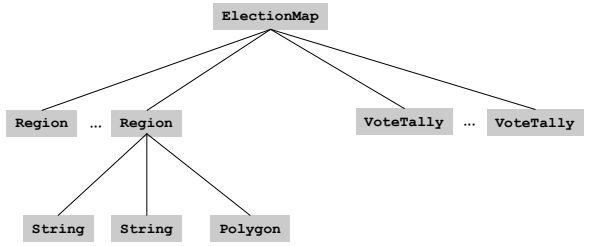
Case Study: Red States, Blue States



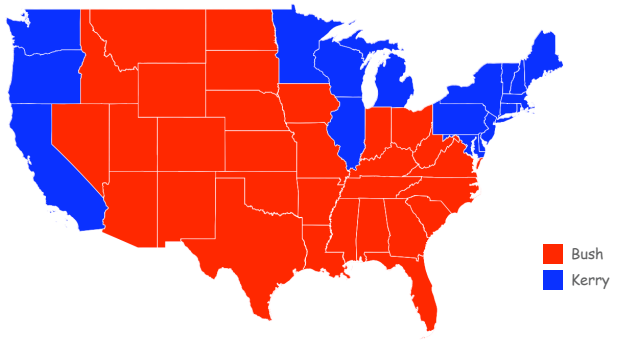
Modular Programming

Modular programming. Model problem by decomposing into components.

Polygon. Geometric primitive.
Region. Name, postal abbreviation, polygonal boundary.
Vote tally. Number of votes for each candidate.
Election map. Regions and corresponding vote tallies for a given election.



Case Study: Red States, Blue States



2004 Presidential election

Geographic Boundaries

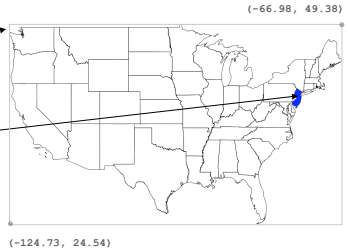
Boundary Data: States within the Continental US

USA data file. State names and boundary points.

Data source: US census bureau, www.census.gov/tiger/boundary.

```
% more USA.txt
-124.731216 24.544102 -66.980385 49.384365
104                          number of regions
Alabama                      bounding box
USA
498
 -88.200027   34.995548
 -88.202919   35.007942
…
New Jersey
USA
368
 -74.695305   41.357330
 -74.461754   41.250000
 -74.366302   41.202801
…
 -74.721313   41.347294
…
```

368 points (latitude, longitude)



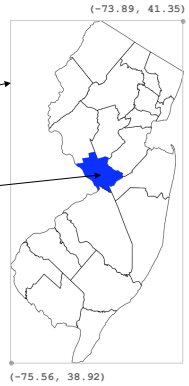
Boundary Data: Counties within a State

State data files. County names and boundary points.

Data source: US census bureau, www.census.gov/tiger/boundary.

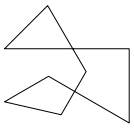
```
% more NJ.txt
-75.560143 38.928589 -73.894402 41.35733
21                           number of subregions
Atlantic                     bounding box
NJ
127
 -74.877563   39.608414
 -74.736694   39.729721
…
Mercer
NJ
88
 -74.748825   40.424248
 -74.722702   40.375301
 -74.674507   40.384399
…
 -74.808403   40.415401
…
```

88 points (latitude, longitude)

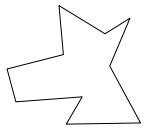


Polygon Data Type

Polygon. Closed, planar path with straight line segments.
Simple polygon. No crossing lines.



polygon (8 points)



simple polygon (10 points)

simple polygon (368 points)

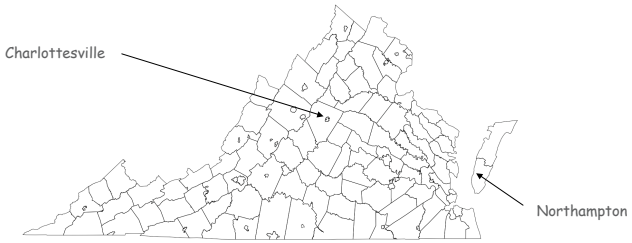
Polygon Data Type: Java Implementation

```
public class Polygon {
   private final int N;           // number of boundary points
   private final double[] x, y;   // the points (x[i], y[i])

   // read from input stream
   public Polygon(In in) {
       N = in.readInt();
       x = new double[N];
       y = new double[N];
       for (int i = 0; i < N; i++) {
          x[i] = in.readDouble();
          y[i] = in.readDouble();
       }
   }

   public void fill() { StdDraw.filledPolygon(x, y); }

   public double perimeter()                    { … }
   public boolean contains(double x0, double y0) { … }
   public String toString()                     { … }
}
```

Polygon: Pieces and Holes

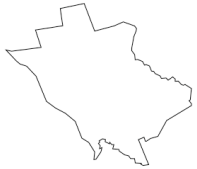
Pieces. A state can be comprised of several disjoint polygons.

Holes. A county can be entirely inside another county.



Region Data Type

Region. Represents a state or county.



Mercer, NJ
88 point polygon

New Jersey, USA
368 point polygon

Region Data Type: Java Implementation

```
public class Region {
   private final String  name;  // name of region
   private final String  usps;  // postal abbreviation
   private final Polygon poly;  // polygonal boundary

   public Region(String name, String usps, Polygon poly) {
      this.name = name;
      this.usps = usps;
      this.poly = poly;
   }

   public void draw() { poly.fill(); }

   public boolean contains(double x0, double y0) {
      return poly.contains(x0, y0);
   }

   public String toString() { … }

}
```

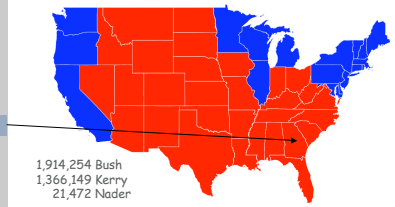

Election Returns

Election Returns: By State

Election returns. Number of votes for Bush, Kerry, Nader by region.

Data source: David Leip, www.uselectionatlas.org.

```
% more USA2004.txt
Alabama,1176394,693933,13122,
Alaska,190889,111025,10684,
Arizona,1104294,893524,14767,
Arkansas,572898,469953,12094,
California,5509826,6745485,164546,
Colorado,1101255,1001732,27343,
Connecticut,693826,857488,27455,
Delaware,171660,200152,3378,
District of Columbia,21256,202970,3360,
Florida,3964522,3583544,61744,
Georgia,1914254,1366149,21472,
Hawaii,194191,231708,3114,
Idaho,409235,181098,8114,
Kansas,736456,434993,16307,
Kentucky,1069439,712733,13688,
…
Virginia,1716959,1454742,26666,
Washington,1304894,1510201,43989,
West Virginia,423778,326541,5568,
Wisconsin,1478120,1489504,29383,
Wyoming,167629,70776,5023,
```

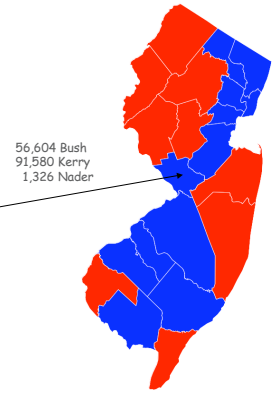


Election Returns: By County

Election returns. Number of votes for Bush, Kerry, Nader by region.

Data source: David Leip, www.uselectionatlas.org.

```
% more NJ2004.txt
Atlantic,49487,55746,864,
Bergen,189833,207666,2745,
Burlington,95936,110411,1609,
Camden,81427,137765,1741,
Cape May,28832,21475,455,
Cumberland,24362,27875,948,
Essex,83374,203681,2293,
Gloucester,60033,66835,1096,
Hudson,60646,127447,1353,
Hunterdon,39888,26050,742,
Mercer,56604,91580,1326,
Middlesex,126492,166628,2685,
Monmouth,163650,133773,2516,
Morris,135241,98066,1847,
Ocean,154204,99839,2263,
Passaic,75200,94962,1149,
Salem,15721,13749,311,
Somerset,72508,66476,1295,
Sussex,44506,23990,900,
Union,82517,119372,1498,
Warren,29542,18044,622,
```



Vote Tally Data Type

`VoteTally`. Represents the election returns for one region.

Mercer, NJ

New Jersey, USA

election returns

56,604 Bush
91,580 Kerry
1,326 Nader

1,670,003 Bush
1,911,430 Kerry
30,258 Nader

Vote Tally Data Type: Java Implementation

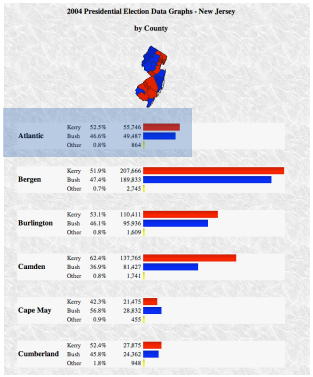
```
public class VoteTally {
   private final int rep, dem, ind;

   public VoteTally(String name, String usps, int year) {
      In in = new In(usps + year + ".txt");
      String input = in.readAll();
      int i0 = input.indexOf(name);
      int i1 = input.indexOf(",", i0+1);
      int i2 = input.indexOf(",", i1+1);
      int i3 = input.indexOf(",", i2+1);
      int i4 = input.indexOf(",", i3+1);
      rep = Integer.parseInt(input.substring(i1+1, i2));
      dem = Integer.parseInt(input.substring(i2+1, i3));
      ind = Integer.parseInt(input.substring(i3+1, i4));
   }

   public Color getColor() {
      if (rep > dem) return StdDraw.RED;
      if (dem > rep) return StdDraw.BLUE;
      return StdDraw.BLACK;
   }
}
```

```
% more NJ2004.txt
…
Mercer,56604,91580,1326,
…  i0  i1  i2  i3  i4
```

Screen Scraping the Election Returns

Screen scrape. Data available on Web; download html and parse.

http://uselectionatlas.org/RESULTS/datagraph.php?year=2004&fips=34




```
<div>
<br /><b>2004 Presidential Election Data Graphs - New
Jersey<br /><br />by County</b><br /><br /><img
src="img.php?year=2004&amp;st=NJ&amp;type=map&amp;off=0"
alt="Map" /><br /><br /><div class="info"><table
cellpadding="2"><tr><td style="width:100px"
rowspan="3"><b>Atlantic</b></td><td class="cnd">Kerry</
td><td class="per">52.5&#37;</td><td class="dat">55,746</
td><td class="bar"><div class="bardem" style="width:
26.8%"> </div></td></tr><tr><td>Bush</td><td
class="per">46.6&#37;</td><td class="dat">49,487</
td><td><div class="barrep" style="width:23.8%"> </
div></td></tr><tr><td>Other</td><td
class="per">0.8&#37;</td><td class="dat">864</td><td><div
class="baroth" style="width:1.0%"> </div></td></
tr></table><br /><br /><table cellpadding="2"><tr><td
style="width:100px" rowspan="3"><b>Bergen</b></td><td
class="cnd">Kerry</td><td class="per">51.9&#37;</td><td
class="dat">207,666</td><td class="bar"><div
class="bardem" style="width:100.0%"> </div></td></
tr><tr><td>Bush</td><td class="per">47.4&#37;</td><td
class="dat">189,833</td><td><div class="barrep"
style="width:91.4%"> </div></td></tr><tr><td>Other</
td><td class="per">0.7&#37;</td><td class="dat">2,745</
td><td><div class="baroth" style="width:1.3%"> </
div></td></tr></table><br /><br /><table …
```


Election Scraper (sketch)

```
int year    = 2004;  // election year
String usps = "NJ";  // United States postal code for New Jersey
int fips    = 34;    // FIPS code for New Jersey

String url   = "http://uselectionatlas.org/RESULTS/datagraph.php";
In in        = new In(url + "?year=" + year + "&fips=" fips);
Out file     = new Out(usps + year + ".txt");
String input = in.readAll();

while (true) {

  // screen scrape county name
  int p = input.indexOf("width:100px", p);
  if (p == -1) break;
  int from = input.indexOf("<b>", p);
  int to   = input.indexOf("</b>", from);
  String county = input.substring(from + 3, to);

  // screen scrape vote totals for each candidate


  // save results to file
  file.println(county + "," + bush + "," + kerry + "," + nader + ",");
}
```

extract text between and tags, that occurs after width:100px

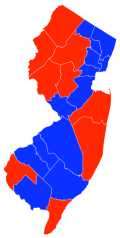
Election Map

Election Map Data Type

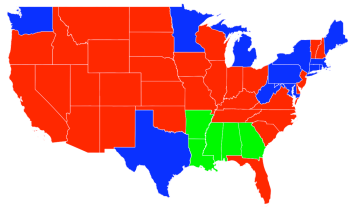
ElectionMap. Represents the election map for a given election.

```
public static void main(String[] args) {
   String name = args[0];
   int year = Integer.parseInt(args[1]);
   ElectionMap election = new ElectionMap(name, year);
   election.show();
}
```

% java ElectionMap NJ 2004



% java ElectionMap USA 1968

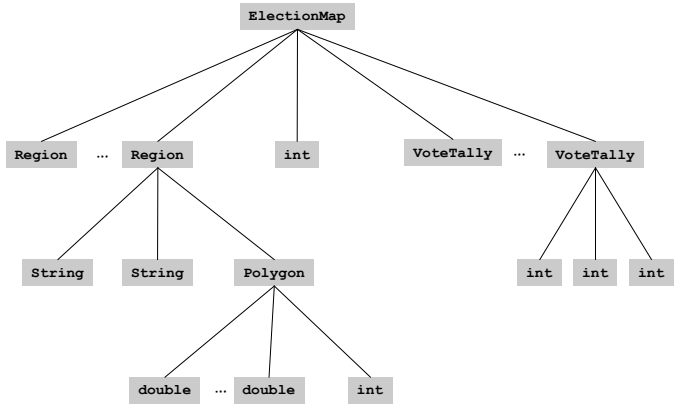


Election Map Data Type: Java Implementation

```
public class ElectionMap {
   private final int N;
   private final Region[] regions;
   private final VoteTally[] votes;

   public ElectionMap(String name, int year) {
      In in = new In(name + ".txt");

      // read in bounding box and rescale coordinates

      N       = in.readInt();
      regions = new Region[N];
      votes   = new VoteTally[N];
      for (int i = 0; i < N; i++) {
         String  name = in.readLine();
         String  usps = in.readLine();
         Polygon poly = new Polygon(in);
         regions[i]   = new Region(name, usps, poly);
         votes[i]     = new VoteTally(name, usps, year);
      }
   }

   public void show() {
      for (int i = 0; i < N; i++) {
         StdDraw.setPenColor(votes[i].getColor());
         regions[i].draw();
      }
   }
}
```


Modular Programming

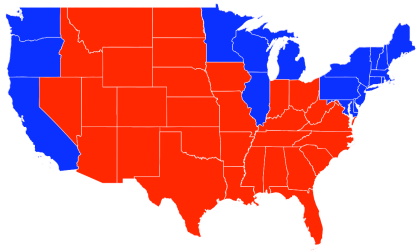
Relationships among data types.

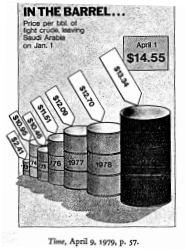


Data Visualization

Visual Display of Quantitative Information

Red states, blue states. Creates a misleading and polarizing picture.





Time, April 9, 1979, p. 57.

Edward Tufte. Create charts with high data density that tell the truth.

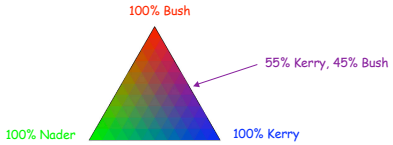
Purple America

Idea. [Robert J. Vanderbei] Assign color based on number of votes.

http://www.princeton.edu/~rvdb/JAVA/election2004

- a_1 = Bush votes.
- a_2 = Nader votes.
- a_3 = Kerry votes.

$$(R,\ G,\ B) = \left(\frac{a_1}{a_1 + a_2 + a_3},\ \frac{a_2}{a_1 + a_2 + a_3},\ \frac{a_3}{a_1 + a_2 + a_3} \right)$$

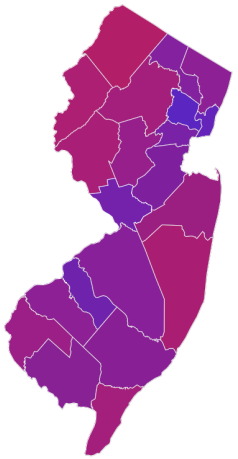


VoteTally.java

```
public Color getColor() {
   int tot = dem + rep + ind;
   return new Color((float) rep/tot, (float) ind/tot, (float) dem/tot);
}
```

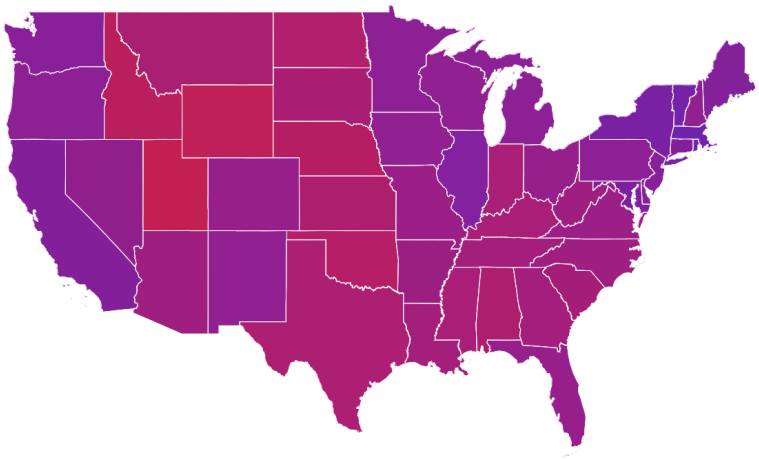

Purple New Jersey

```
% java ElectionMap NJ 2004
```



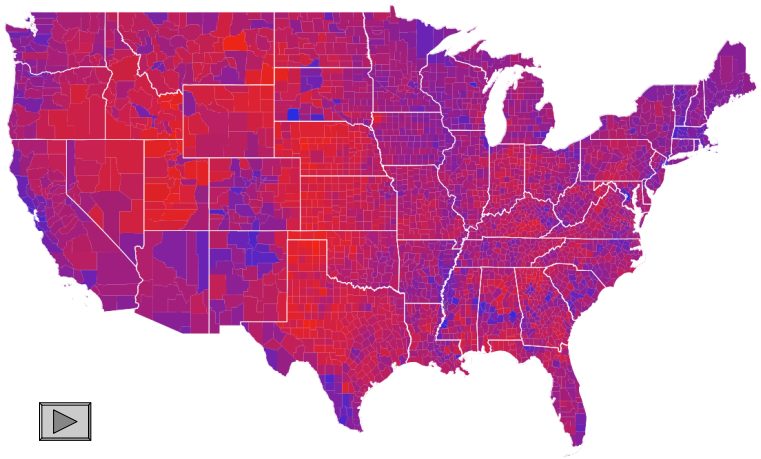
Purple America

```
% java ElectionMap USA 2004
```



Purple America

```
% java ElectionMap USA-county 2004
```

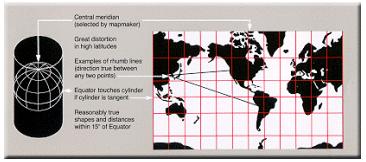


Data Visualization: Design Issues

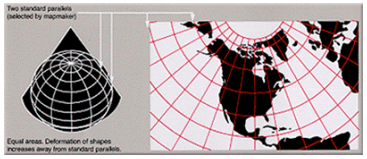
Remark. Humans perceive red more strongly than blue.

Remark. Amount of color should be proportional to number of votes, not geographic boundary.

Remark. Project latitude + longitude coordinates to 2d plane.



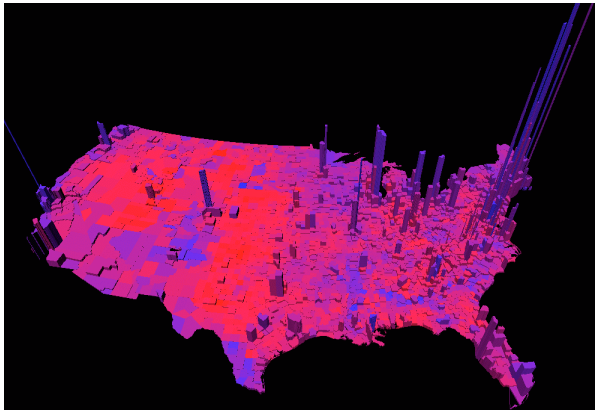
Mercator projection



Albers projection

3D Visualization

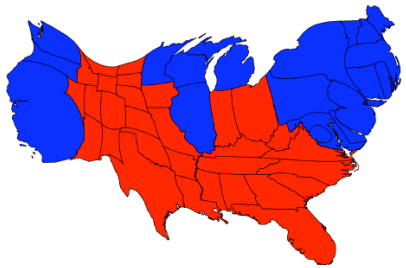
3D visualization. Volume proportional to votes; azimuthal projection.



Robert J. Vanderbei
www.princeton.edu/~rvdb/JAVA/election2004

Cartograms

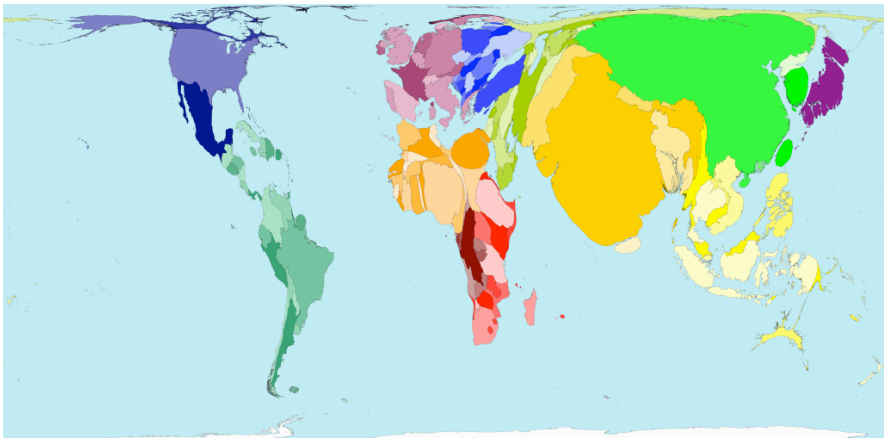
Cartogram. Area of state proportional to number of electoral votes.

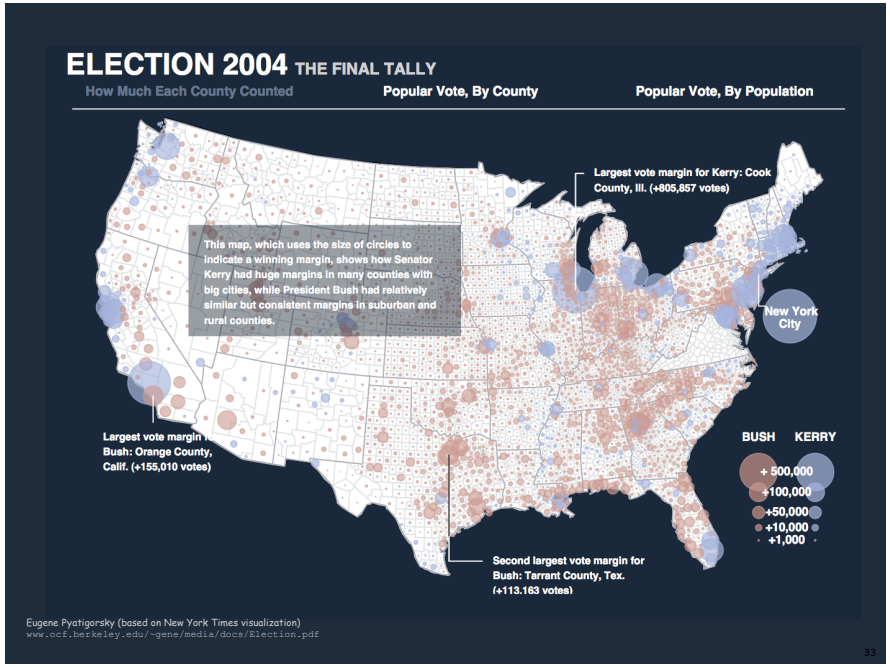


Michael Gastner, Cosma Shalizi, and Mark Newman
www-personal.umich.edu/~mejn/election

Cartograms

Cartogram. Area of country proportional to population.





Summary

Modular programming.

- Break a large program into smaller independent modules.
- Ex: `Polygon`, `Region`, `VoteTally`, `ElectionMap`, `In`, `Out`.

Ex 1. Build large software project.

- Software architect specifies API.
- Each programmer implements one module.
- Debug and test each piece independently. [unit testing]

Ex 2. Build reusable libraries.

- Language designer extends language with ADTs.
- Programmers share extensive libraries.
- Ex: `In`, `Out`, `Draw`, `Polygon`, ...