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Web-based GIS for mapping voting patterns at the 2004 Australian federal election

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Abstract: This paper describes a Web-based geographical information system (GIS) for mapping voting patterns, at the 2004 Australian federal election, at the polling booth level. The locations of polling booths are geocoded and linked with national digital datasets, including the 2001 census. The Web-based GIS can generate maps displaying patterns of voting for political parties across polling booths with overlays of data showing the demographic and socio-economic characteristics of populations within the surrounding polling booth catchments. A classification functionality consisting of equal interval, quantile, median-based natural breaks and location quotient may be used in order to generate different map displays. The Web-based GIS has been developed as an information dissemination and analysis tool to not only benchmark voting outcomes but also to visualise relationships between voting patterns and local demographic and socio-economic data.

Key Words: Web-based GIS, Polling Booth, Voting Pattern, Classification

1. Introduction

In Australia there has been little explicitly spatial, disaggregated analysis of voting behaviour at federal or state elections, at least in terms of patterns and levels of voter support for political parties at the local level. The existing literature includes an analysis by Davis and Stimson (1998) of the socio-economic and demographic factors explaining variations in patterns of voting for Pauline Hanson's One Nation Party at the 1998 Queensland state election. It used step-wise multiple regression analysis of the characteristics of census collection districts (CCDs) around the state's polling booths. Also, there was an application by Davis and Stimson (2000) of a GIS-based model to evaluate policy impact and voter behaviour at the 1998 federal election, as well as a study by Forrest et al. (2001) of rural voter behaviour in the Farrer electoral division in southern New South Wales at the 1998 federal election. Moreover, Stimson, et al. (2006) spatially and statistically modelled voting

outcomes and socio-economic characteristics at the polling booth level after the 2001 Australian federal election.

Note that Singleton et al. (1998) conducted a post-electoral analysis to enquire into potential voter support for a political party at a federal election, and to evaluate whether the traditional supporters of Labor, the blue collar workers, voted for Labor at the 1996 federal election. These researchers analysed the vote for Labor at the disaggregated level of the polling booth, and they then assigned it *ad hoc* to suburbs. They used a one-variable linear regression model to eventually suggest that the Labor vote was highly affected by an erosion of blue collar support.

A model to facilitate spatial disaggregation was introduced by Taylor (2003) focusing on combining 2001 census and polling booth data into a single database within a spatial unit termed 'Sub Electorate'. This database was used to test whether the Australian Greens Party votes were positively correlated with the socio-economic and demographic characteristics. The correlation analysis suggested that the Greens Party votes were strongly correlated with tertiary education and secularity.

Geographical Information Systems (GIS) have great potential as a tool for analysing patterns of voter behaviour. GIS provides capabilities for presenting spatial data in a form that is understandable for most audiences. The development and increased use of GIS has intensified the demand for public access to digital spatial information.

Currently, there are a variety of Web-based GIS applications ranging from city guides, digital libraries, economic development, ecotourism, location services, traffic information, white pages directory, geographical analysis machine, local planning, safe city and crime analysis (Doyle et al., 1998; Kirkby & Pollitt, 1998; Openshaw et al., 1999; Peng, 1999; Peng and Tsou, 2003; Shyy et al., 2003; Shyy et al., 2005).

Peng & Tsou (2003) use the term Web-based GIS to refer to the use of the Web as a primary means to exchange data, perform GIS analysis, and present results. These applications provide interesting possibilities for the use of both the Web and GIS in terms of accessing different kinds of geographical information for a wider audience regardless of its physical location.

However, politicians, political party leaders and the general public who are interested in politics sometimes complain about the lack of information showing patterns and levels of voter support for a political party, including the dearth of maps to examine patterns of voting across polling booths with the capacity to match socioeconomic data from the census to polling booth catchments in their electoral division.

Yet often the information that they seek exists - such as the 2004 Election Results from the Australian Electoral Commission (AEC) *http://results.aec.gov.au/12246/default.htm* and 2001 census from Australian Bureau of Statistics (ABS, 2003). Nevertheless, the information is often not accessible in a form that potential users can easily assess or comprehend. We suggest, therefore, that there are better ways (e.g. the Internet and the Web) of delivering large volumes of voting and geographical information for public consumption.

Accordingly, this paper describes a Web-based GIS that allows citizens to access voting outcomes, and to use GIS technology, without the demand on users to learn a commercial GIS package. It shows how the authors developed a Web-based GIS which provides for the following:

a) depiction or mapping of patterns and levels of voter support (by classification) for political parties that was received either through the primary votes or through two party preferred votes for candidates standing for a party at the 2004 federal election,
b) classification of polling booth catchments' demographic and socio-economic data, and

c) visualisation of relationships between voting patterns and demographic and socio-economic data.

2. Building spatial databases

Building the necessary spatial databases has been achieved through the following processes:

- Every polling booth has been geocoded in *MapInfo Professional* GIS using the *MapInfo* StreetWorks and StreetPro databases of streets, localities, features and parks across Australia.
- The number of votes cast for each candidate standing for the House of Representatives at the 2004 federal election can be downloaded from the AEC website (*http://results.aec.gov.au/12246/default.htm)*. This is for every polling booth across Australia. That raw data of polling booths was rearranged to create a table which gives the number and the proportion of total votes cast for each political party for each electoral division in each state/territory. Those tables were then joined to the geocoded polling booths for all electoral divisions in Australia.
- The 150 electoral divisions for 2004 federal election (*MapInfo* MIF files) have been downloaded from AEC website (http://www.aec.gov.au/_content/who/profiles/index.htm) and converted to shape files.
- The 1:1 million scale main road layer is available for download from Geoscience Australia.
- CCDs were spatially allocated to a nearest polling booth location to form polling booth catchments in each of the 150 electoral divisions. The 150 booth catchments layers were then merged into one Australia booth catchments layer. The demographic and socio-economic characteristics of the population living within the polling booth catchments were measured using the 46 variables listed in Table 1.

Age and sex % population males % population age 0-17 years % population age 18-29 years % population age 30-39 years % population age 40-54 years % population age 55-69 years % population age 70+ years	**Ethnicity/race** % indigenous persons % born overseas % born in UK % born in Southern and Eastern Europe % born in Middle East % born in Asia
Family and household structure % single person households % couple without children households % one parent family households % couples with children households	**Religious affiliation** % Catholic % Anglican % Pentecostal % other Christian % Islamic % other non-Christian religion % with no religion
Housing tenure % households that are home owners % households that are home purchasers % households that are private renters % households that are public housing tenants	**Residential stability/Mobility** % of population not at the same address 5 years ago
Digital divide % population using computer	**Industry of work** % employed in Extractive Industries % employed in Transformative Industries % employed in Distributive Services % employed in Producer/Business Services % employed in Social Services % employed in Hospitality Industries
Engagement in work Labour force participation rate Unemployment rate	
Occupation (Robert Reich's categories) % employed as routine production workers % employed as in-person service workers % employed as symbolic analysts	
Human capital % persons age 15 years and over with a degree or higher qualification % persons age 15 and over with a certificate, diploma or advanced diploma	
Income % households with weekly income (less than $600) % households with weekly income ($600-$1,499) % households with weekly income ($1,500+)	

Table 1 - Variables derived from the 2001 census representing the demographic and socio-economic characteristics of polling booth catchments

3. Web-based GIS development

The Web-based GIS uses a *Dell* PowerEdge 2600 Server (Intel XEON, 68 GB hard disk, 1024 MB RAM) running *ESRI*'s MapObjects Internet Map Server (IMS) and the *Microsoft* Internet Information Server (IIS). MapObjects, which contains an ActiveX map control and a set of ActiveX objects such as data access and map display, are used in a Visual Basic programming environment running on a *Microsoft* Windows 2000 platform.

The mapping functionalities developed within the application include zoom, pan, area, classification, and label features. The maps and analyses provided by the application highlight magnitude and patterns of voting at the federal election. A client interface using a Java applet was also implemented for the Web-based GIS. A Java applet has the advantages of being versatile, platform neutral and secure (Peng, 1999; Peng & Tsou, 2003). This interface facilitates human-computer interaction in depicting or mapping inherent patterns and levels of voter support for a party.

The prototype Web-based GIS was developed for informing potential users of the voting outcomes at a federal election. The relationship between the IMS and Web browsers is displayed in Figure 1. The general public may access the developed Web-based GIS by visiting the Shared Research Resources component of the Australian Research Council

Research Network in Spatially Integrated Social Science (ARCRNSISS) website (http://www.siss.edu.au/shared_research_resources/national_spatial_data_sets) using a Web browser such as *Internet Explorer* or *Mozilla Firefox*.

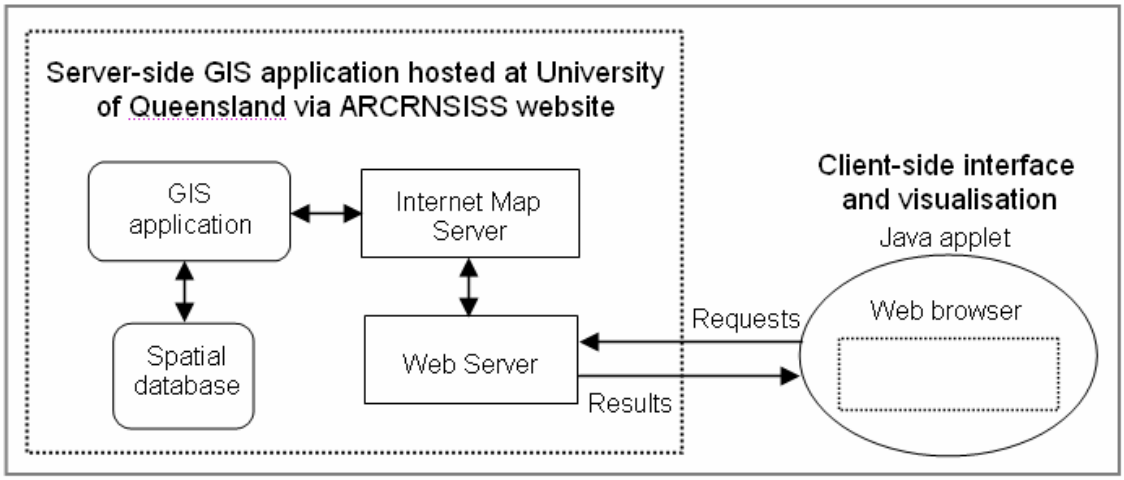

Figure 1 - Server-side GIS application and client-side Java applet interface

A Java applet serving as the client interface is loaded by the browser from the server, and subsequently executed on the client's computer (see Figure 1). Users may then select desired functionality from the interface and send their requests for information through the Internet to the Web server. The server interprets and distributes requests to the specified GIS application. The application performs its tasks and sends results back to the Web server. The Web server then returns results, such as maps in the Graphics Interchange Format (GIF) format, to the client's browser. Hence anyone who knows how to use a Web browser will be able to access our Web-based GIS interactively through a user-friendly interface from the Internet with minimal learning overhead.

Once a user makes a Uniform Resource Locator (URL) request to the Web-based GIS server, a map of Australia is displayed. Eleven options of functionality remain constant throughout the user's visit to the server. *Zoom In* and *Zoom Out* centre the map at the point where a user clicks with the mouse. *Pan* allows the user to move around the map by dragging the display in any direction using the mouse.

When a user selects *Label On* option, they are presented with one drop down menu from which they can choose to display the name of each poll place or the name of each electoral division. *Australia* displays the entire region being analysed. When a user selects the *Area* option, they are then presented with one drop down menu from which they elect to display Australia, one of seven states/territories, one of five metropolitan areas or one of the 150 electoral divisions. The system then zooms into the selected area. When the user selects the *Road On* option, the primary and secondary routes obtained from Geoscience Australia are displayed. *PollBooth On* displays polling booths in the mapped region. Finally, *Restart* takes the user back to the opening page.

The remaining option for this application is *Classification*. One of the major features of the Web-based GIS developed is the ability to generate thematic map displays of voting outcomes and the demographic and socio-economic characteristics of polling booth catchments. *Classification* is provided using either equal interval, quantile, median-based natural breaks or location quotient (LQ) approaches for thematic display.

The equal interval classifies the features into equally divided ranges of attributes values. In the quantile classification, each class contains approximately the same number of features.

The natural breaks approach is a median-based natural breaks classification that optimises attribute similarity.

Two statistical measures for comparing performances among equal interval, quantile and natural breaks approaches are presented. One is total within-group variance (TWGV) (referred to as group variation in Cromley 1996) associated with the grouping optimisation model of Fisher (1958) and Jenks (1963). The other is total within-group difference (TWGD) (referred to as absolute deviation in Cromley 1996), which is the measure structured in the median clustering objective (Murray & Shyy, 2000). Users of the Web-based GIS are able to choose whether or not they want to use TWGD and TWGV to statistically compare performances of these classification approaches.

The LQ is a nationally-benchmarked measure of the local polling booth vote for a political party relative to the national benchmark percentage for that political party. When users select the *Classification* option, they are then presented with one drop down menu. If they select LQ variables from this drop down menu, a benchmark classification map of polling booths for a specific political party will be shown. If they select percentage variables, they are presented with the second, third and fourth drop down menus from which they can select classification methods (equal interval, quantile or natural breaks) from the second drop down menu, choose whether or not to calculate TWGV and TWGD from the third drop menu and choose the number of classes from the fourth drop down menu. A classification map of polling booth voting outcomes, or a classification map of demographic or socio-economic characteristics of polling booth catchments, will then be presented. A user may click on the ***?*** option to display help information about these functionalities along with an example.

4. Web-based applications

The web-based GIS was developed to provide users with information, at a spatially disaggregated level, about patterns and levels of voter support for political parties and of relationships between voting patterns and demographic and socio-economic characteristics of surrounding polling booth catchments.

4.1 Types of display

Voting patterns at the 2004 federal election, and the patterns of distribution of demographic and socio-economic data from the 2001 census, may be accessed to produce the following types of display:

- voting patterns for polling booths using a dot distribution pattern in a two-dimensional space across Australia as a whole, or for different levels of spatial scale, including:
    a) across all of Australia
    b) within a State/Territory
    c) within a metropolitan city region, and
    d) within a federal electoral division.
- polling booths' percentages of the primary votes, and the percentages of the two party preferred votes for House of Representatives candidates representing the Coalition (Liberal-National-Country Liberal) Parties (Figures 2 and 3) and those representing the Labor Party (Figures 4 and 5). The Labor Party primary votes are shown to be strongest in the cores and some of the outer suburbs of the big cities and some of the larger regional centres and the remote regions, while support for the Coalition Parties is dominant in most rural and regional areas, as well as across the middle and some of the outer suburbs of the metropolitan cities. A distinct geographical electoral support divide is shown to exist.

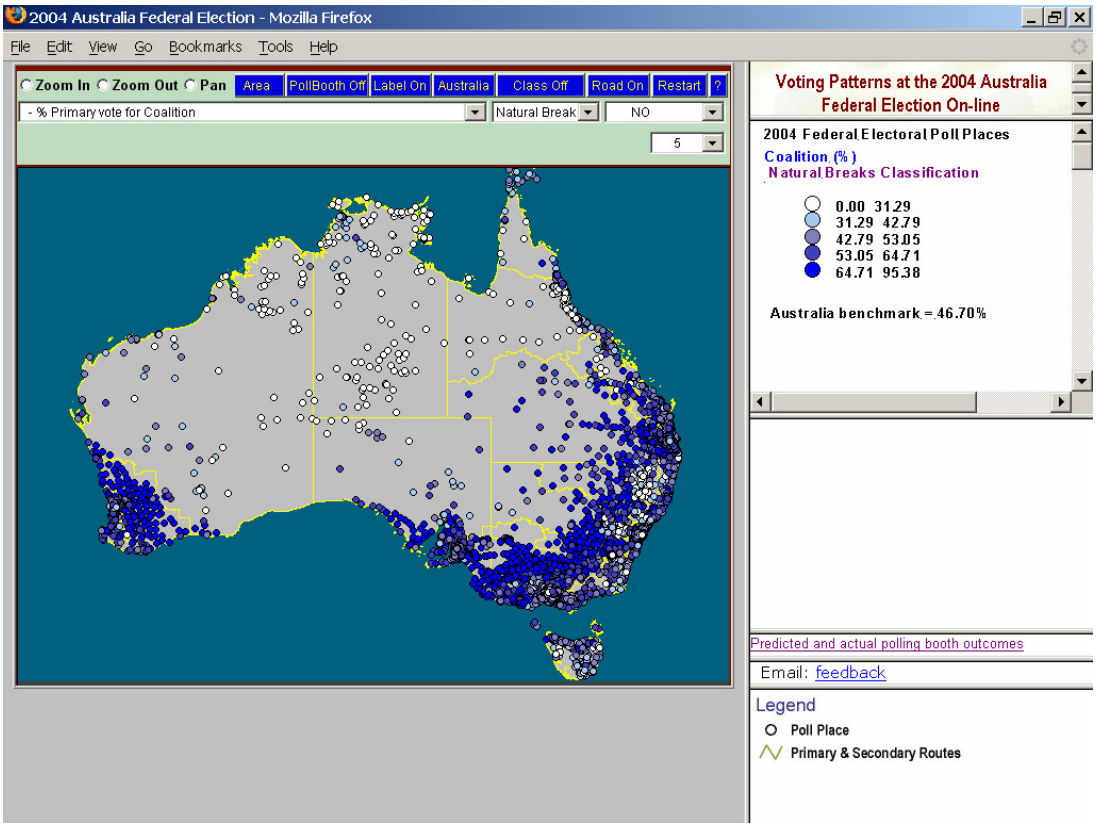

Figure 2 - Coalition % primary votes

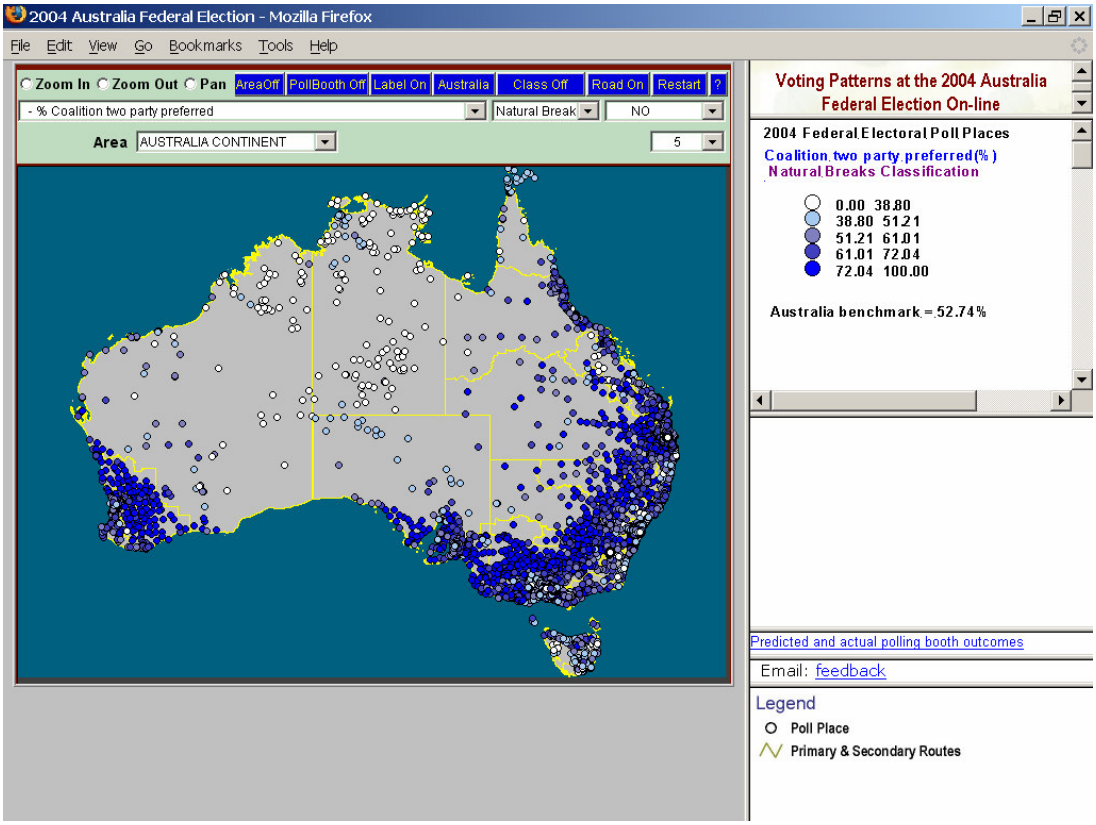

Figure 3 - Coalition % two party preferred votes

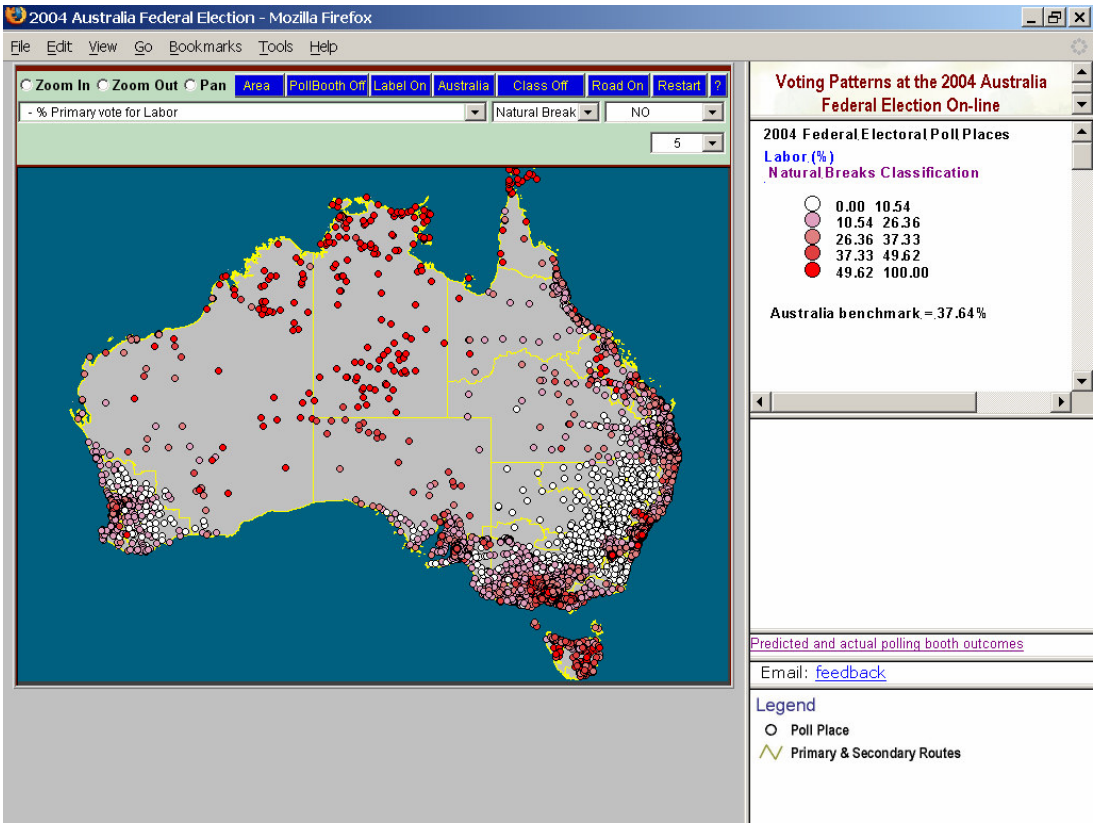

Figure 4 - Labor % primary votes

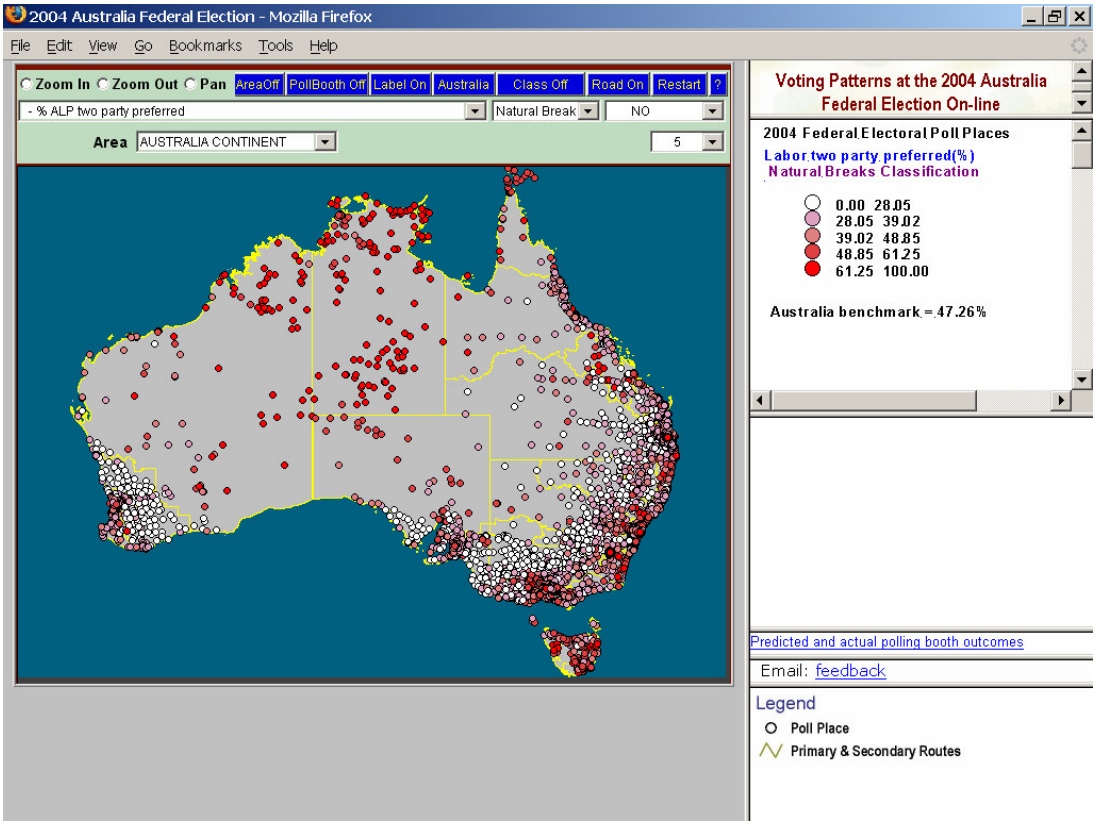

Figure 5 - Labor % two party preferred votes

- Polling booth LQs for the primary votes and two party preferred votes for a political party for House of Representatives candidates representing, for example, the Coalition Parties (Figures 6 and 7) and the Labor Party (Figures 8 and 9). The LQs here are calculated by comparing the percentage of the primary vote and the percentage of the two party preferred vote at each polling booth for the Coalition with the Coalition national benchmark percentages, and for the Labor with the Labor national benchmark percentages. At the 2004 federal election the national benchmark, or the percentage of national primary votes for each political party was:

    - Coalition Parties: 46.70%
    - Labor Party: 37.64%
    - Greens Party: 7.19%
    - Democrats Party: 1.24%
    - Family First Party: 2.01%

  and the percentage of national two party preferred votes for each political party was:

    - Coalition Parties: 52.74%
    - Labor Party: 47.26%

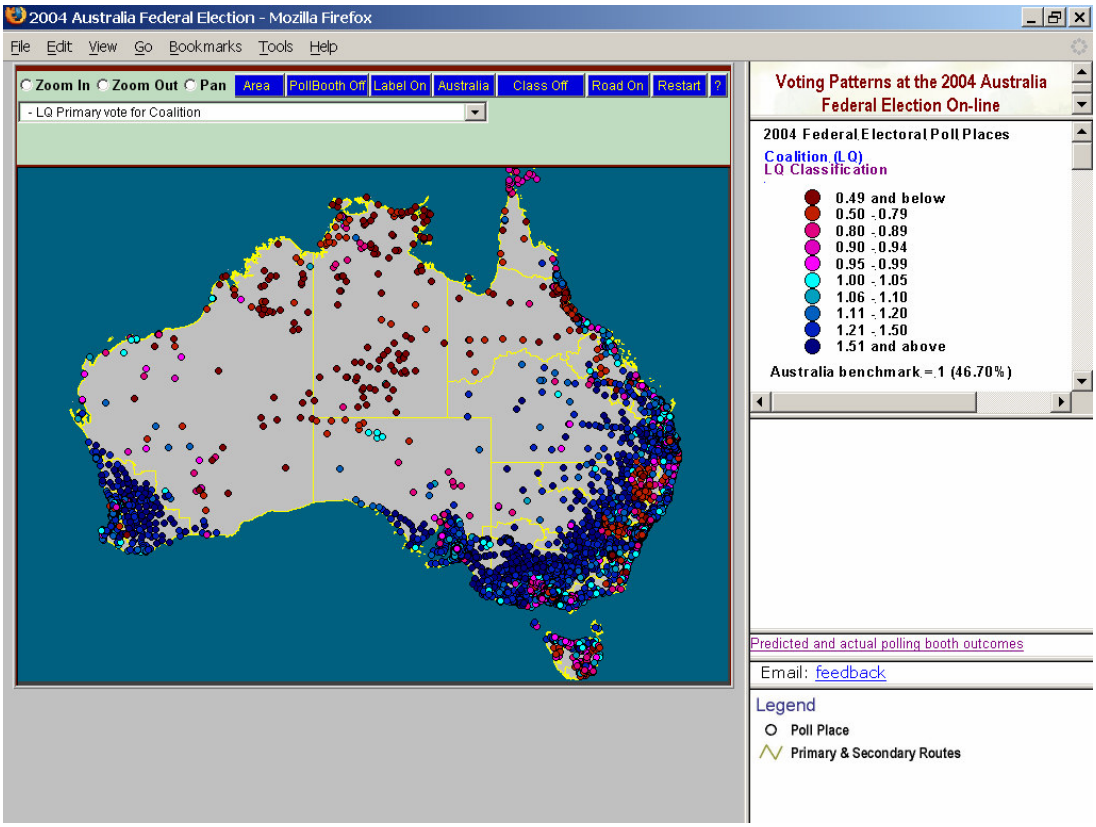

Figure 6 - Coalition LQ for Primary votes

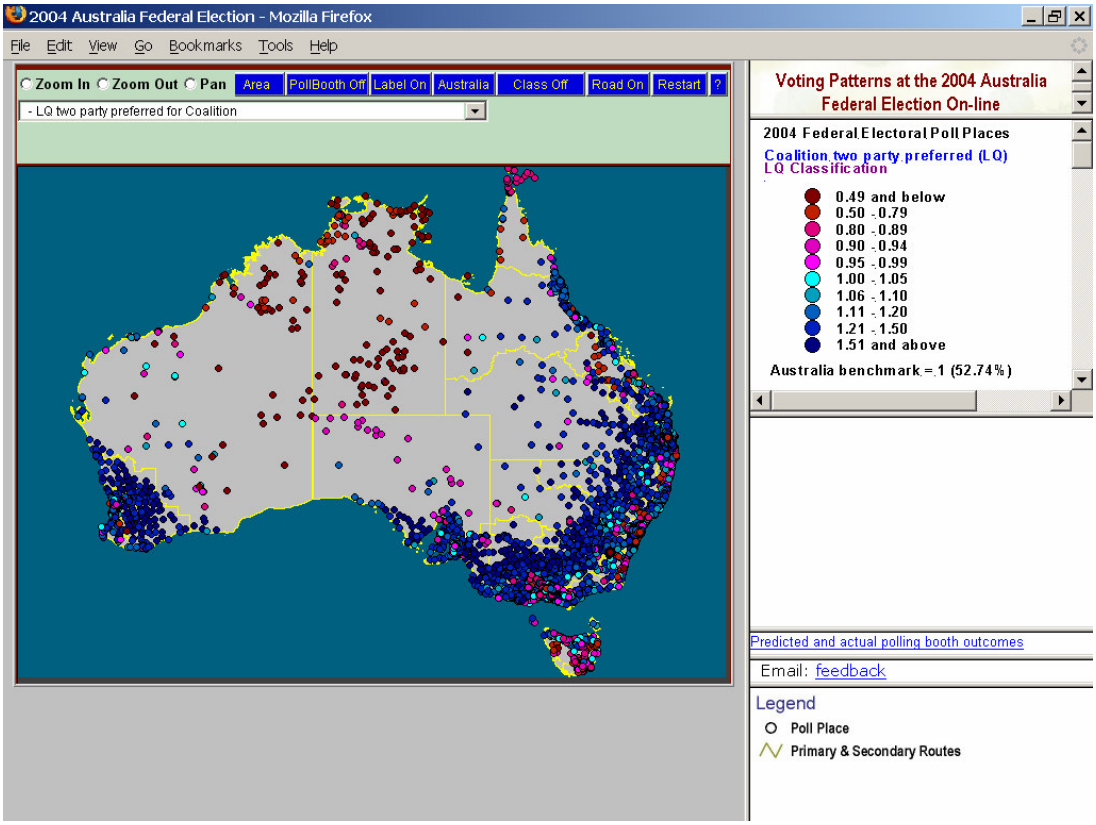

Figure 7 - Coalition LQ for two party preferred votes

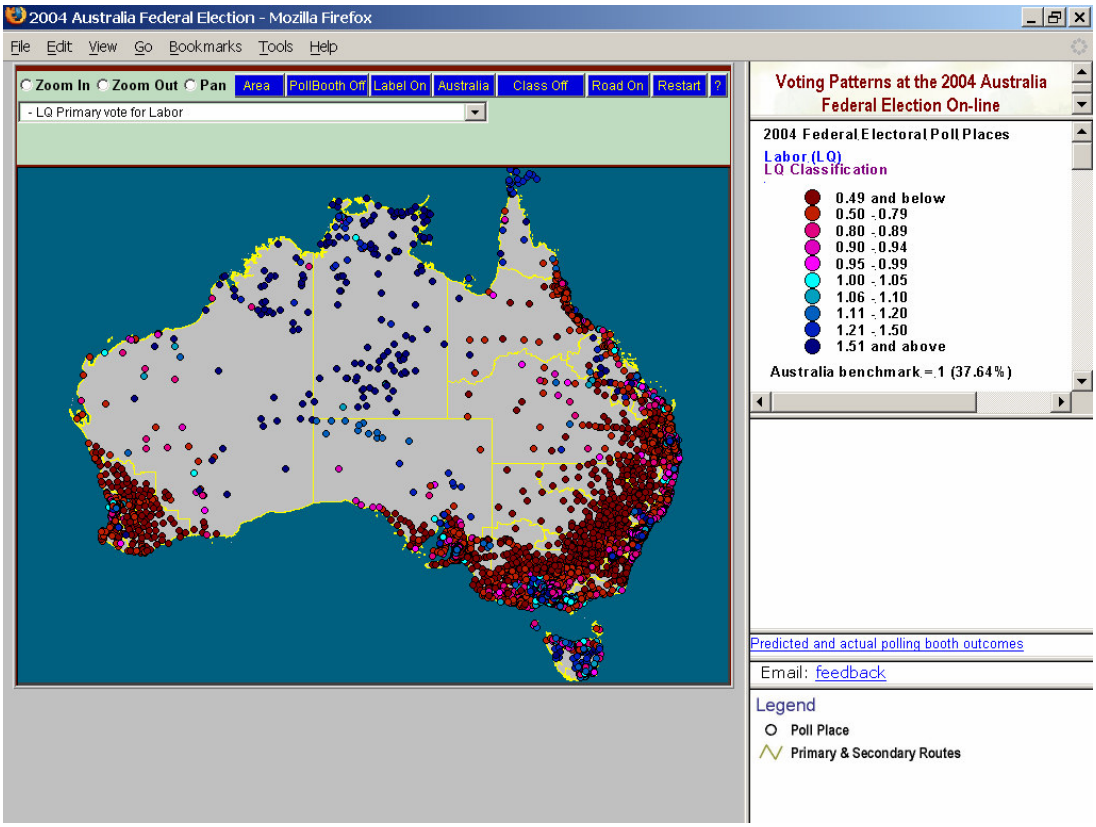

Figure 8 - Labor LQ for Primary votes

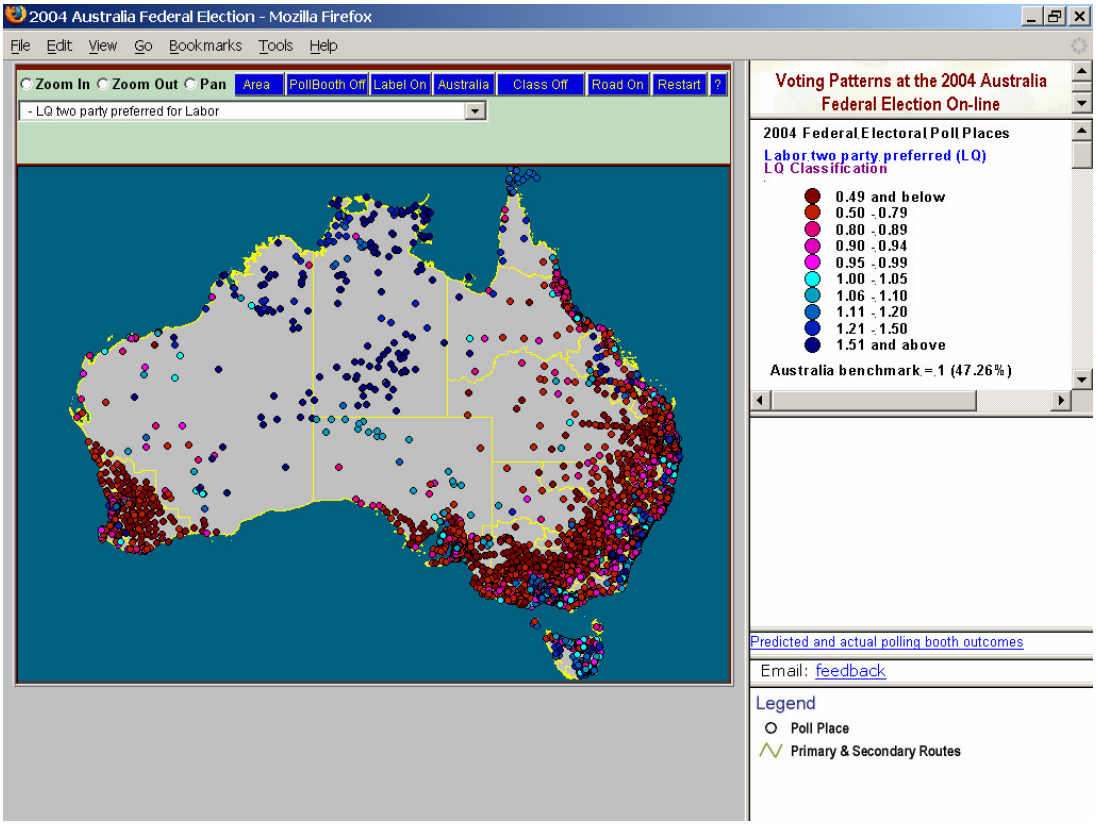

Figure 9 - Labor LQ for two party preferred votes

The LQ approach pre-determines the classes of LQ data into several classes such as: 0.49 and below (51% or more below the national benchmark vote), 0.50 - 0.79 (21 to 50% below the national benchmark vote), 0.80 - 0.89 (11 to 20% below the national benchmark vote), 0.90 - 0.94 (6 to 10% below the national benchmark vote), 0.95 - 0.99 (1 to 5% below the national benchmark vote), 1.00 - 1.05 (0 to 5% above the national benchmark vote), 1.06 - 1.10 (6 to 10% above the national benchmark vote), 1.11 - 1.20 (11 to 20% above the national benchmark vote), 1.21 - 1.50 (21 to 50% above the national benchmark vote), and 1.51 and above (51% or more above the national benchmark vote). The LQ approach is useful to show the pattern and benchmark of voting outcomes.

- Polling booths patterns of primary votes for minor parties, such as the Greens Party, the Democrats Party and the Family First Party (Figures 10, 11 and 12). These maps are generated using five classes in median-based natural breaks classification. Most supporters of the Greens live in the east and south east of Australia in particular in the inner areas of the large metropolitan cities. The supporters of the Democrats are found to be mostly in the east, south east and south of Australia, Northern Territory and in particular in parts of the metropolitan cities. And supporters for the Family First are found predominantly in some regional and rural areas and in some fringe areas around large urban centres.

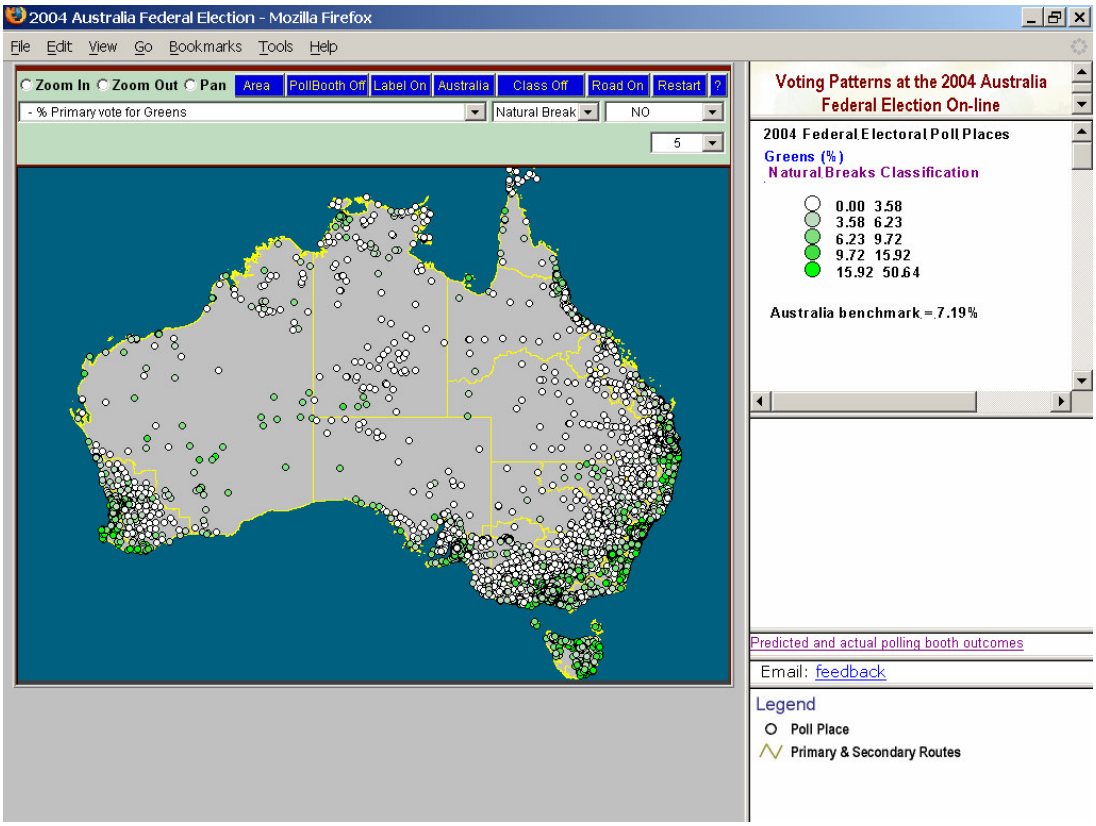

Figure 10 - Greens % primary votes

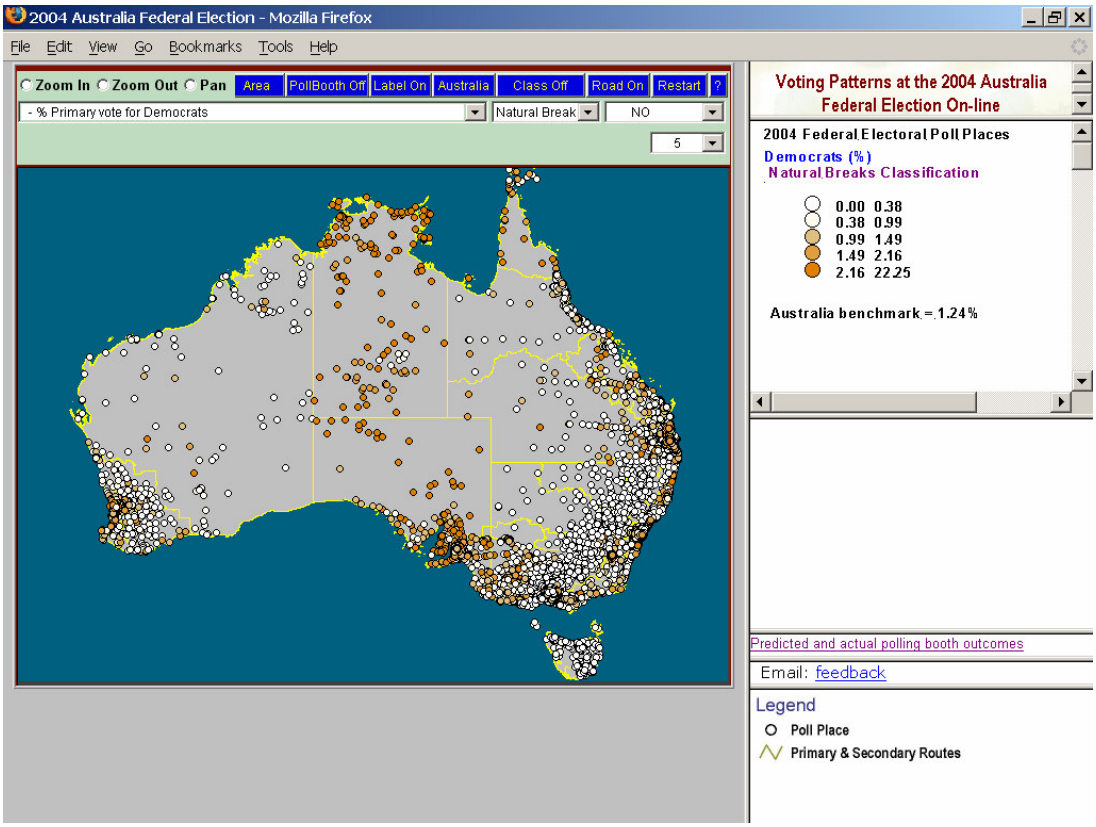

Figure 11 - Democrats % primary votes

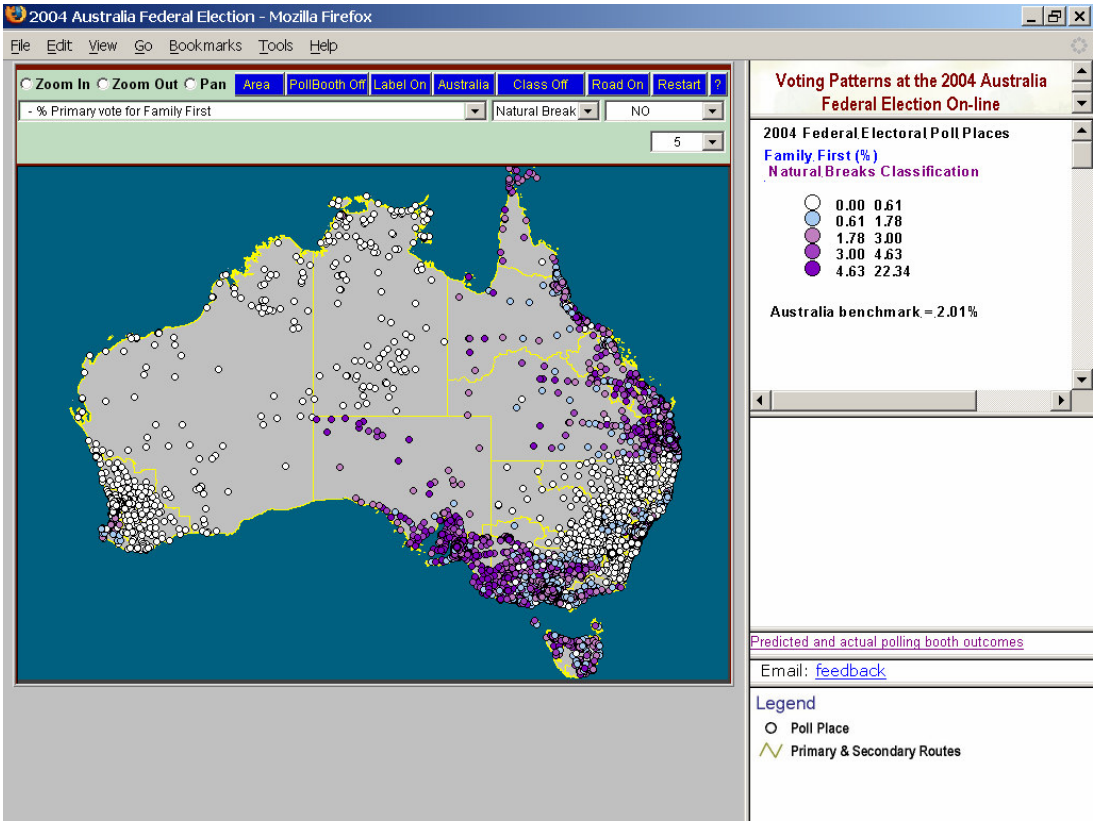

Figure 12 - Family First % primary votes

- Overlaid across those patterns of voting at polling booths are choropleth maps (that may be classified by natural breaks, equal interval or quantile) showing patterns of distribution for polling booth catchments of the 46 demographic and socio-economic variables.

  As examples, Figures 13 and 14 show support for the Coalition Parties at the polling booth level and support for the Coalition Parties the pattern of polling booth catchments with a high proportion of households with high incomes in the $1500+ category. The regional example shown in these Figures is for Melbourne.

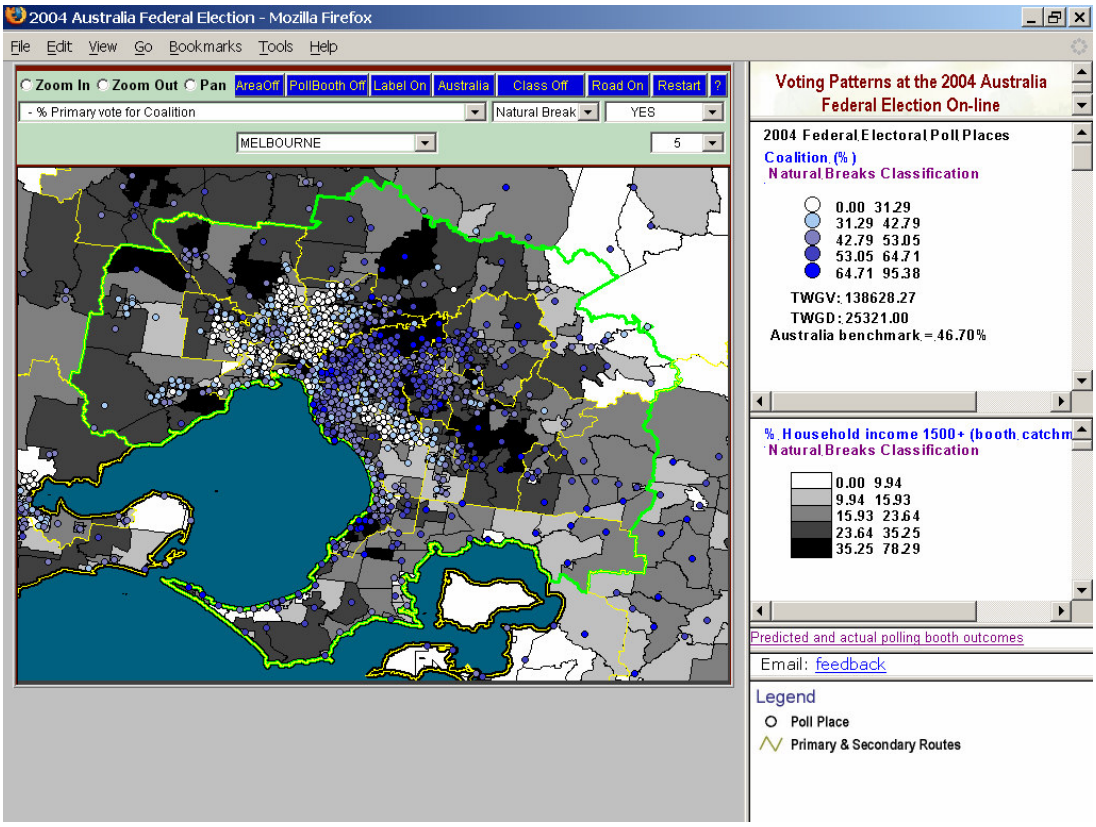

Figure 13 - Coalition % primary votes overlaid on household income $1500+ in Melbourne

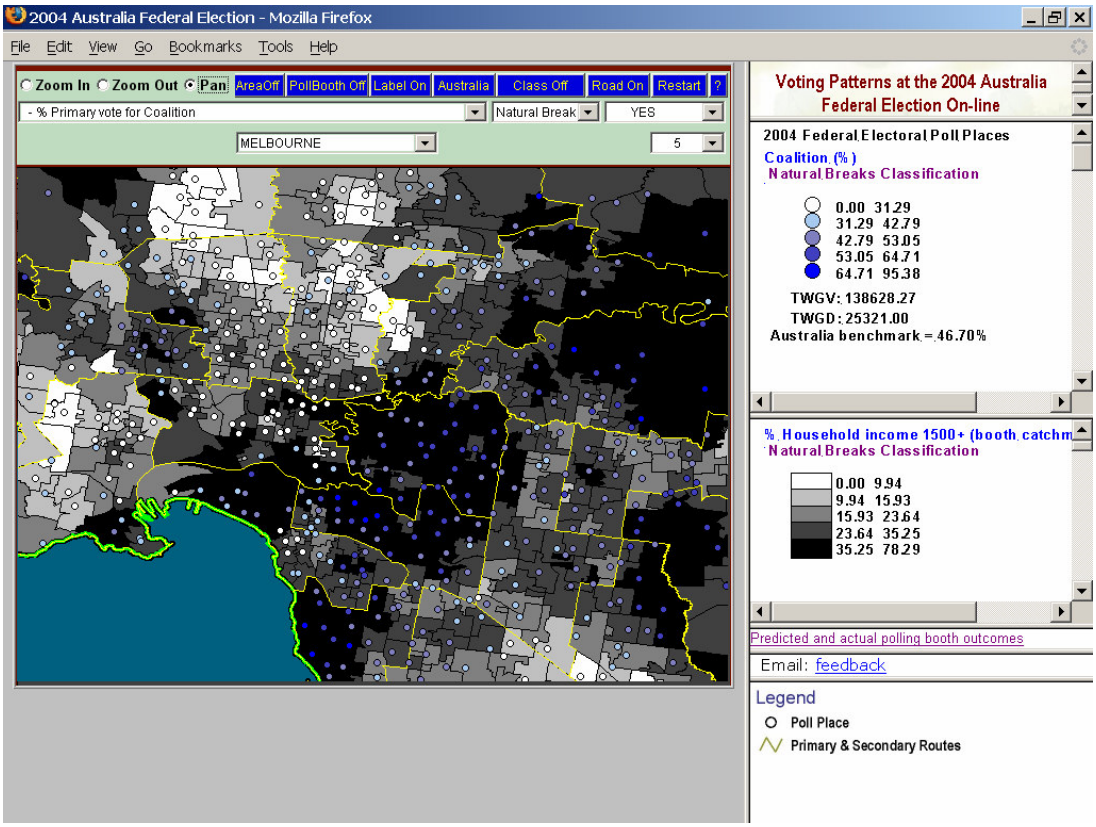

Figure 14 - Coalition % primary votes overlaid on household income $1500+ in Melbourne after zoom in

As another example, Figures 15 and 16 show for Melbourne how voter support for the Coalition Parties outnumbers that for the Labor Party at the polling booth level and how support for the Coalition Parties relates to the pattern across the polling booth catchments with high relative concentration of the 40 to 54 years old age group category (mainly the 'baby boomers' at the 2001 census).

These overlays shown in Figures 13-16 demonstrate how the Web-based GIS enables the viewer to perform exploratory analysis of many possible connections between polling booths voting outcomes and the demographic and socio-economic characteristics of the polling booth catchments across a region.

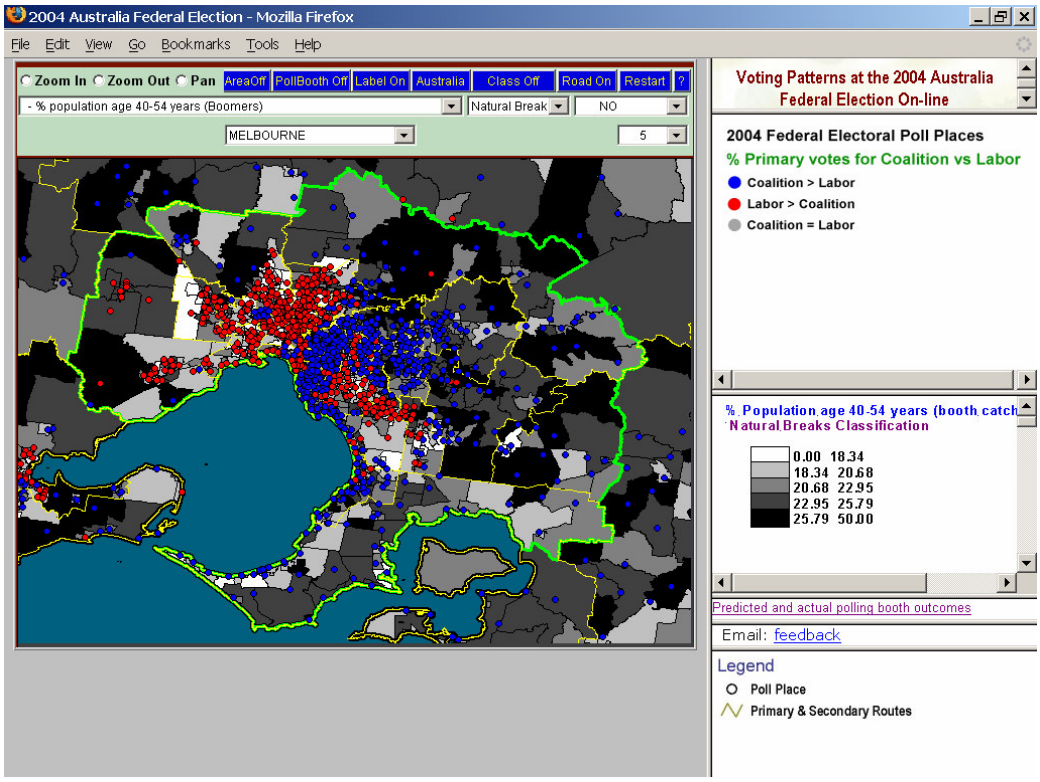

Figure 15 - % primary votes for the Coalition vs. Labor overlaid on % population age 40-54 years in Melbourne

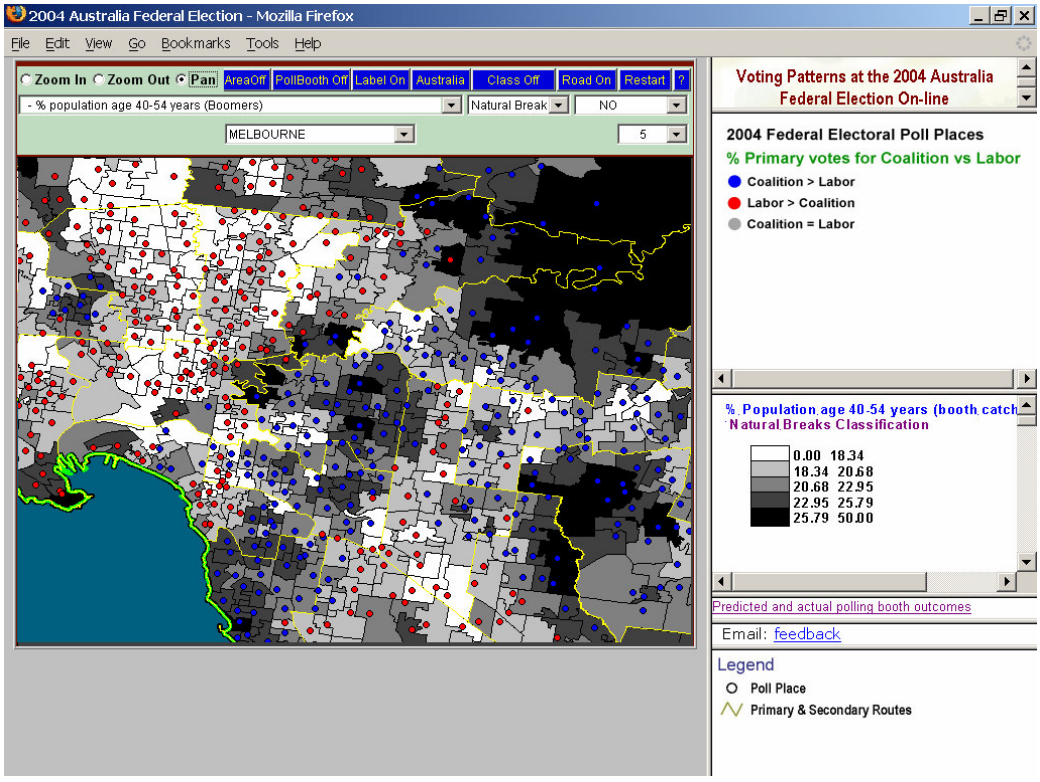

Figure 16 - % primary votes for the Coalition vs. Labor overlaid on % population age 40-54 years in Melbourne after zoom in

4.2 Statistical measures for comparing classification performances

Two statistical measures for users to compare performances of equal interval, quantile and median-based natural breaks approaches for this research are TWGD and TWGV. Tables 2 and 3 indicate TWGD and TWGV associated with each classification approach for a range of class values. As the objective of the median-based natural breaks is to optimise attribute similarity, it is expected to produce the smallest difference value for the respective number classes.

As an example in Table 2, for five classes the natural breaks TWGD is 25321, which is much less than the differences found by the equal interval and quantile approaches of 164110 and 130977 respectively; and in Table 3, for five classes the natural breaks TWGV is 138628, which is also much less than the variance found by the equal interval and quantile approaches of 999861 and 840296 respectively. Figures 17 and 18 show the relative performances of equal interval, quantile and median-based natural breaks approaches using TWGD and TWGV measures. Similar comparative trends can also be found in Figures 19 to 24, which demonstrated the usefulness of the median-based natural breaks approach as an exploratory data analysis tool to help analyse voting outcomes.

classes	equal interval	quantile	natural breaks
3	242593	203188	39758
4	203092	158228	30916
5	164110	130977	25321

Table 2 - Coalition % primary votes (TWGD)

classes	equal interval	quantile	natural breaks
3	2308909	1813052	333723
4	1550013	1167289	204788
5	999861	840296	138628

Table 3 - Coalition % primary votes (TWGV)

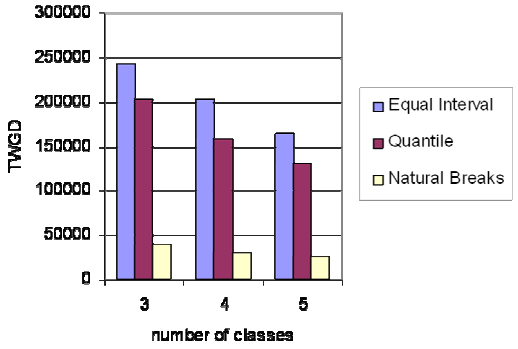

Figure 17 - Coalition % primary votes (TWGD)

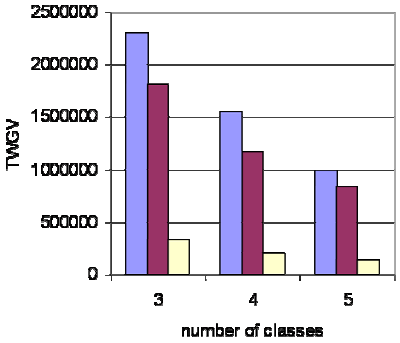

Figure 18 - Coalition % primary votes (TWGV)

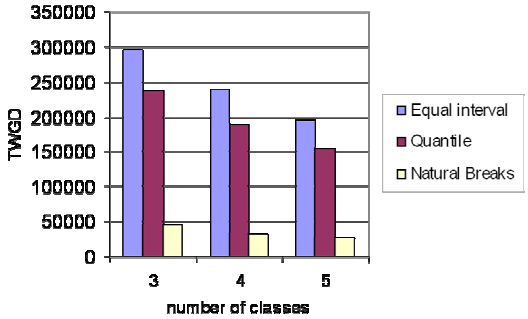

Figure 19 - Labor % primary votes (TWGD)

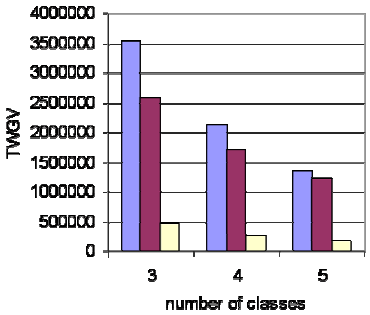

Figure 20 - Labor % primary votes (TWGV)

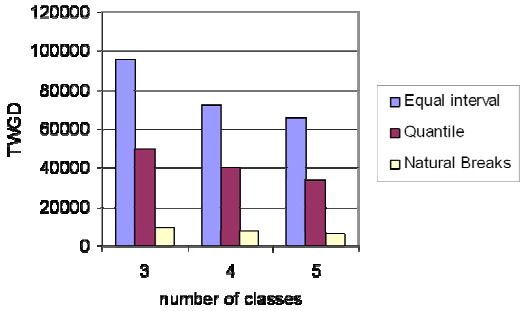

Figure 21 - % population age 40-54 years (TWGD)

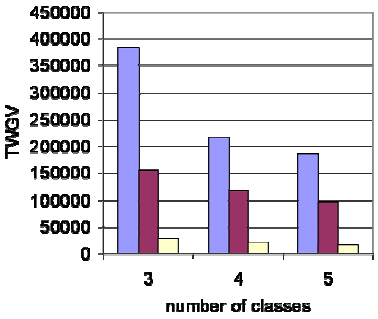

Figure 22 - % population age 40-54 years (TWGV)

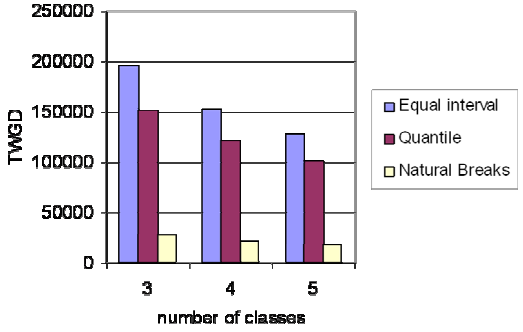

Figure 23 - % high income, $1500+ (TWGD)

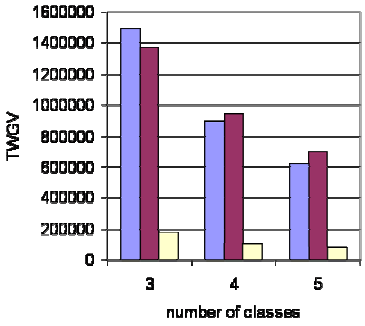

Figure 24 - % high income, $1500+ (TWGV)

5. Conclusions and further research

This paper has described a Web-based GIS which has considerable potential for promoting public awareness of patterns of voting outcomes at the local level. Anyone who knows how to use a Web browser will be able to access the Web-based GIS interactively from the Internet (broadband recommended) with minimal time spent learning how to use the application. The application described here is able to generate useful maps to examine patterns of voting across polling booths and present demographic and socio-economic data within polling booth catchments using various classification approaches including equal interval, quantile, median-based natural breaks and LQ. Users of the Web-based GIS can compare performances of equal interval, quantile and median-based natural breaks approaches using TWGD and TWGV statistical measures. As the objective of the median-

based natural breaks is to optimise attribute similarity, it produces the smallest difference value for the respective number classes.

The application examples shown in this paper demonstrated the usefulness and potential appeal of the Web-based GIS as an information dissemination and analysis tool to benchmark voting outcomes and to visualize the relationship between voting patterns and local demographic and socio-economic data. The spatial database can be updated as new voting data become available for future elections and as new demographic and socio-economic data become available from the 2006 census.

The further development of the Web-based GIS to analyse and explain spatial variations in the patterns of voter support for political parties in Australia might include: 1) the use of multiple regression analysis to model the determinants of variations in patterns of voter support for a political party at an election, and 2) the use of discriminant model to statistically distinguish between political parties by relating voting outcomes to demographic and socio-economic characteristics at the booth catchments level, as demonstrated in other papers (see Stimson et al., 2006; Stimson et al., 2007). Those results may then be used in a predictive context to model potential patterns in the level of voter support for a political party at a future election that might be expected in response to particular policies that are oriented towards specific demographic and socio-economic groups or to voters in particular regions. The on-line display of spatio-temporal voting patterns of change over time at federal elections at the local polling booth level of scale is to be explored.

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