Design and implementation of internet-based “Public Participation GIS” using a user-centred process and the open source model

Martin J. Bunch
Faculty of Environmental Studies
York University
Toronto Ontario Canada

Mike Maclennan
Malone, Given & Parsons Ltd.
Markham Ontario Canada

25 September, 2007
Presentation Outline

- The Context of the monitoring program
- web-GIS
- Public Participation GIS (PPGIS)
- Redeveloping the web-GIS
  - Methods
  - Results
- Conclusions
The Context

• Urban and periurban
• Earlier Cut backs in monitoring
• Now:
  – Source water protection
  – Green belt
  – Oak Ridges Moraine development freeze

Image Source: www.toronto.ca/ourcity/location01.htm
A two-tiered monitoring program

- TRCA’s Regional Water Monitoring Program
- Community-based Water Monitoring Program
What is “Juturna”?

• Web-based GIS application that supports environmental monitoring program in the Toronto region by

  – Facilitating collection and consolidation of water quality data
  – Providing tools for analysis of water quality data
  – Disseminating information on water quality within TRCA’s jurisdiction
Juturna Schematic

Internet

Web Clients

Streamed Spatial Data

Forms, Tables & Reports

Metadata services

DBMS

CA Assets

Monitoring Data

Spatial DBMS

Map Server

Web Server

SQL Geodatabase

Monitoring Data

Web Clients

Forms, Tables & Reports

Metadata services
Community-Based Monitoring

- **Map-based Data Entry**
  - users map their sampling areas
  - monitoring data tied to geographic data
  - visualization of all community sampling areas

- **Report Panel**
  - immediate reporting of publicly collected data
  - specify report parameters (e.g., dates)
  - multiple formats (e.g., PDF, HTML).
A Model of Communication for GIS

1. Selection of geographic models
2. Conception of Database Designer
3. GIS Analyst's Conception
4. GIS Output (maps, tables...)

PPGIS and PGIS

• Grounded in value and ethical frameworks that promote,
  – Social justice
  – Ecological sustainability
  – Improvement of quality of life
  – Nurturing civil society
  – Capacity building

• Applied in the context of partnerships among academe, civil society, government
## Traditional GIS vs. PPGIS

<table>
<thead>
<tr>
<th>GIS</th>
<th>Dimension</th>
<th>PPGIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Focus</td>
<td>People and technology</td>
</tr>
<tr>
<td>Facilitate official policy-making</td>
<td>Goal</td>
<td>Empower communities</td>
</tr>
<tr>
<td>Supply-driven; technological push</td>
<td>Adoption</td>
<td>Demand- and need-driven</td>
</tr>
<tr>
<td>Rigid, hierarchical &amp; bureaucratic</td>
<td>Org'l structure</td>
<td>Flexible and open</td>
</tr>
<tr>
<td>Because it is possible</td>
<td>Why use it?</td>
<td>Because it is needed</td>
</tr>
<tr>
<td>Specified by technologists</td>
<td>Details</td>
<td>Specified by users/focus groups</td>
</tr>
<tr>
<td>Led by independent specialists</td>
<td>Application</td>
<td>Led by facilitators/group leaders</td>
</tr>
<tr>
<td>General/multipurpose applications</td>
<td>Function</td>
<td>Specific, project-level activities</td>
</tr>
<tr>
<td>Top-down</td>
<td>Approach</td>
<td>Bottom-up</td>
</tr>
<tr>
<td>Capital-intensive</td>
<td>Cost</td>
<td>Low-cost</td>
</tr>
</tbody>
</table>

(Sieber 2003 as derived from Kyem 2000)
Problems w/ Original Prototype

- Top down approach to development
  - Design (functionality and its implementation) determined by technologists
  - Very limited stakeholder consultation
- Emphasis on functionality, not usability
  - Multipurpose
  - Multiple ways to go about doing things
  - Confusing interface
- Capital intensive (proprietary software)
- Code problems
  - Poor coding practices
    - E.g., no commenting, hard-coding hyperlinks
  - No documentation
Welcome to the Regional Watershed Monitoring and Reporting Service Pilot Project. The purpose of this pilot project is to provide increased accessibility to aquatic monitoring data, allow for rapid analysis and publishing of indicator information and support the overall goals of the Regional Watershed Monitoring Network. The current geographic scope of this project is limited to the Humber Watershed.

Search for Aquatic Monitoring Information by:

Postal Code
Enter your postal code (e.g., M3J1P3)

Sub-Watershed
Select a sub-watershed

Station ID
Monitoring station number

Need a "How to Use" for this website? Click here
Public Participation and the WWW

- Usability criteria are widely applied in software engineering and computer interface design
- But there is a lack of such an approach for PPGIS

Steinman et al. (2004), adapted for web-GIS based on Arstien (1969)
Incorporating Stakeholder Participation into the GIS Production Process
Methodology for Redevelopment

• Iterative Development (ID)
  – Continual refinement via trial and error
  – Each cycle of development informs the next
• 3 stages within each iteration:
  – Examination (does the design suit the task?)
  – Definition (identifies solutions to problems)
  – Creation (solutions implemented)
• Also Informed by
  – Pervasive Usability Process
  – Discount Usability approach
Pervasive Usability

1. Requirements Analysis
2. Concept Design
3. Prototyping
4. Production
5. Launch

User Evaluation
(on the basis of: functionality, desirability, efficiency)

After: Brinck et al., (2000)
Discount Usability

• Performance of usability tests of small sets of users (e.g., five)
  – Captures more than 80% of all interface errors

• 3 Specific Techniques
  – Scenarios
  – ‘Simplified thinking aloud’
  – Heuristic evaluation
1\textsuperscript{st} Iteration: stakeholders

• Identify major stakeholders
  – Volunteer water quality monitors
  – Lay public
  – Outside consultants
  – Web-GIS system administrator
  – TRCA staff

• (representatives of each group became the user ‘testers’)

1\textsuperscript{st} Iteration: stakeholder interviews

- Scripted interviews and testing of the original website.
- E.g., a volunteer user would be asked respond to the following questions, while performing the operation using the web-GIS:
  - You would like to generate a report for the Humber watershed for the 2001 year. How would you generate a report for 2001?
  - You have recently compiled some data from a section of the Humber river. Given that you have to data to upload, how would you upload the data?
1st Iteration: design

• Use cases
  – Narratives: who does what with the system, for what purpose

• Functional requirements list
  – Describes functionality of the system

• Wireframes
  – Lays out the system architecture – can be converted to a minimally functional prototype (front end only, no content)
Use Cases: Lay User, Typical Scenario 1

Vincent is a new Canadian who heard about the TRCA community monitoring project from his friend. In curiosity he visits the site to learn more about the project and the methodology for collecting data. As a first Canadian, English isn’t his first language but he finds the information on the web site easy to understand and simple to follow. His background in as an engineer in his home country gives him a firm understanding of the basic principles of scientific methodology. He finds himself wanting to learn more about the program and become involved. He clicks a contact us link in the web site and sends an email out to the community monitoring coordinator to find out about the workshop sessions.

He also prints out a report of the subwatershed near his home to show his friends and family. The report summarizes assessments of fish, benthic and other stream health indicators for each water monitoring station, subwatershed, watershed or municipality covered in the system. The simple explanations and graphical features incorporated in these reports allow him to easily visualize the overall health of the subwatershed.
# Functional requirements list derived from use cases

## Juturna Web site Redevelopment
Prepared By: Martin Bunch and Michael MacLennan

<table>
<thead>
<tr>
<th>Site Map Code</th>
<th>#</th>
<th>Content / Tertiary / Functionality</th>
<th>Description/Purpose</th>
<th>Considerations and Notes</th>
<th>Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Global Elements (present on every page except Home page)</strong></td>
<td></td>
<td></td>
<td>P1P2</td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td>Link to home page</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td></td>
<td>Link to GTA watersheds</td>
<td>Humber, Rambroke, and Mimico Creeks, Don River, Duffins and Camlachie Creeks, Highland Creek, Rouge River, Petcoast creek</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td>Link to TRCA Monitoring Stations</td>
<td>Update-able with other watershed as they become integrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td></td>
<td>Watershed report Summaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td></td>
<td><strong>Home Page</strong></td>
<td></td>
<td></td>
<td>P1P2</td>
</tr>
<tr>
<td>1.0</td>
<td></td>
<td>User Log in and Registration</td>
<td>Promote new online services and direct volunteers to log in at site</td>
<td>Simple instructions</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td></td>
<td>Welcome and About information</td>
<td>Welcome information and a brief summary about the project and site</td>
<td>Concise information summary</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td>Toronto Watersheds health summary</td>
<td>Report summary of current Humber Watershed health</td>
<td>Dynamically derived real time Watershed Health Summary</td>
<td></td>
</tr>
<tr>
<td>1.2.1</td>
<td></td>
<td>Toronto Watersheds health summary</td>
<td>Report summary of current Humber Watershed health as separate frame in page</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.2</td>
<td></td>
<td>Links to Watersheds and Sub-watersheds</td>
<td></td>
<td>Only Humber watershed information is functional in this version. System will be immediately extensible to other watersheds as data for them becomes available.</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td></td>
<td>Link to other watershed Information</td>
<td>Links to report summaries of other watersheds (update-able)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td></td>
<td>Link to TRCA Monitoring Stations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td>Link to Watershed Report Summaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td><strong>Global Elements (Only at Home Page)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td>Link to TRCA site</td>
<td>Optimize overall design for implementation with existing TRCA site</td>
<td>Links to corresponding content on the TRCA site</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td></td>
<td>Site wide Search</td>
<td>Optimize overall design for implementation with existing TRCA site</td>
<td>Will search site pages as well as metadata</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
<td>Site Map</td>
<td>Optimize overall design for implementation with existing TRCA site</td>
<td>Link to complete site map</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td></td>
<td>Contact Information</td>
<td>Optimize overall design for implementation with existing TRCA site</td>
<td>Detailed information summarizing</td>
<td></td>
</tr>
</tbody>
</table>
User flows: community volunteer
2\textsuperscript{nd} and 3\textsuperscript{rd} Iterations

- User testing using wireframes
  - This leads to a functional prototype

- User testing with an almost complete prototype
  - This leads to a version of the system that can be used to support the water quality monitoring program
Conversion to Free and Open Software (FOSS)

- Original web-GIS -$$$
  - MS Windows Server
  - ArcIMS
  - Crystal Reports
  - SDE
  - SQL, Java Script, Java Bean, Map Objects Java, VB Script, ASP, HTML
  - Some proprietary data (postal codes)

- New web-GIS-$
  - Linux (Fedora)
  - MapServer
  - Postgresql/PostGIS
  - FOSS Metadata catalogue
  - SQL, Ruby on Rails, HTML, AJAX
  - No proprietary data that is not already owned by stakeholders
Basic functionality

- Data upload
- Data download
- Data analysis
- On the fly report generation
- Biomonitoring and watershed education
- Administrator tasks
  - User account management
  - Data assessment
Improved system architecture and data flows
To search for specific monitoring stations use the map below. Or click on one of the following for watershed specific information:

[Humber] [Etobicoke and Mimico] [Don River] [Highland Creek] [Rouge River] [Duffins and Caruthers]

Screenshot from Juturna v 2:

“Discover Toronto's Watershed”
Community Based Environmental Monitoring

Community Based Environmental Monitoring (CBEM) is a process through which citizens can actively participate in monitoring their local environment. Environmental monitoring organizations seek to reconnect citizens and students with the natural environment and spark an interest in and commitment to environmental stewardship. Many of these groups can provide training and even equipment to help community groups collect reliable monitoring data that reflects some important aspects of environmental health or issues of concern.

Participants of community based monitoring programs may benefit from the experience in several ways:

- Data collected may be used to enhance or support scientific data collected by other scientists. Although data collected by community members may not have the same level of detail as that collected by professionals, with proper training and methods, community data can be a valuable
### Benthic Data Upload

#### Collection Method: Kick and Sweep

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acarina (Water Mite)</td>
<td></td>
<td>Isopoda (Aquatic Sowbug)</td>
<td></td>
</tr>
<tr>
<td>Amphipoda (Scud)</td>
<td></td>
<td>Megaloptera (Dobsonfly, Alderfly, Fishfly and Halkome)</td>
<td></td>
</tr>
<tr>
<td>Anisoptera (Dragonfly)</td>
<td></td>
<td>Oligochaeta (Nematode, Worm)</td>
<td></td>
</tr>
<tr>
<td>Chironomidae (Midge)</td>
<td></td>
<td>Coleoptera (Beetle)</td>
<td></td>
</tr>
<tr>
<td>Coleoptera (Beetle)</td>
<td></td>
<td>Dytiscidae (Water Scorpion)</td>
<td></td>
</tr>
<tr>
<td>Decapoda (Crayfish)</td>
<td></td>
<td>Ephemeroptera (Mayfly)</td>
<td></td>
</tr>
<tr>
<td>Ephemeroptera (Mayfly)</td>
<td></td>
<td>Gastropoda (Snail)</td>
<td></td>
</tr>
<tr>
<td>Hemiptera (True Bug)</td>
<td></td>
<td>Heteroptera (Stink Bug)</td>
<td></td>
</tr>
<tr>
<td>Hirudinea (Leech)</td>
<td></td>
<td>Trichoptera (Caddisfly)</td>
<td></td>
</tr>
<tr>
<td>Unidentified</td>
<td></td>
<td>Turbellaria (Flatworm)</td>
<td></td>
</tr>
</tbody>
</table>

[Save] [Submit]
Conclusions

• Involving users in the production process of PPGIS has resulted in an information sharing and monitoring facilitation tool that:
  – Has less functionality, but more usability (less “bling” more zing!)
  – Is more affordable to the host organization
  – Broadens the potential community of users
  – Can be maintained and extended!
Thanks!

Contact:
Martin J. Bunch
Faculty of Environmental Studies
York University

bunchmj@yorku.ca

This work was made possible by research grants from the Ontario Ministry of the Environment