Open source geospatial Business Intelligence (BI) in action!

OGRS 2009 – Nantes, France

Dr. Thierry Badard
Etienne Dubé
Belko Diallo
Jean Mathieu
Mamadou Ouattara

GeoSOA research group
Centre for Research in Geomatics
Laval University, Quebec City, Canada

http://geosoa.scg.ulaval.ca
1. BI for dummies or a short BI 101 course
   - With BI, you enter a different world … Please, forget what you know about classical databases! ;-) 
   - Focus on some open source BI tools

2. Merging BI and GIS (Geospatial)?

3. An open source software stack for Geospatial BI
   - GeoKettle
   - GeoMondrian
   - Spatialytics

4. Outlooks
   - Integration projects
What is BI (Business Intelligence)?

- Wikipedia states “Business intelligence (BI) is a business management term, which refers to applications and technologies that are used to gather, provide access to, and analyze data and information about company operations.”

- Something your boss or client is possibly interested into, and asked you to investigate ...

- Rely on an architecture with complex components and applications:
  - Data warehousing
  - On-line Analytical Processing (OLAP) servers and clients
  - Reporting tools
  - Dashboards
  - Data mining
Classical architecture of a BI infrastructure

ETL stands for Extract, Transform (integration, data cleansing, data structure, “updating”, …) and Load

Data sources (OLTP systems)
- Transactional databases
- Web resources
- XML, flat files, proprietary file formats (Excel spreadsheets, …)
- LDAP
- …

* ETL systems

Data loading → Data Warehouse

- Reporting tools
- OLAP
- Data mining

* ETL stands for Extract, Transform (integration, data cleansing, data structure, “updating”, …) and Load
The Data Warehouse: the crucial/central part!

- Repository of an organization’s historical data, for **analysis purposes**.
- Primarily destined to analysts and decision makers.
- Separate from operational (OLTP) systems (source data)
  - But often stored in relational DBMS: Oracle, MSSQL, PostgreSQL, MySQL, Ingres, ...
- Contents are often presented in a summarized form (e.g. key performance indicators, dashboards, OLAP client applications, reports).
  - Need to define some metrics/measures
The Data Warehouse: the crucial/central part!

- Optimized for:
  - Large volumes of data (up to terabytes);
  - Fast response (<10 s) to analytical queries (vs. update speed for transactional DB):
    - de-normalized data schemas (e.g. star or snowflake schemas),
      - Introduces some redundancy to avoid time consuming JOIN queries
    - all data are stored in the DW across time (no corrections),
    - summary (aggregate) data at different levels of details and/or time scales,
    - (multi)dimensional modeling (a dimension per analysis axis).
      - All data are interrelated according to the analysis axes (OLAP datacube paradigm)
  - Focus is thus more on the analysis / correlation of large amount of data than on retrieving/updating a precise set of data!
MDX query language

- MDX stands for MultiDimensional eXpressions
- Multidimensional query language
- *De facto* standard from Microsoft for SQL Server OLAP Services (now Analysis Services)
- Also implemented by other OLAP servers (Essbase, Mondrian) and clients (Proclarity, Excel PivotTables, Cognos, JPivot, …)
- MDX is for OLAP data cubes what SQL is for relational databases
- Looks like a SQL query but relies on a different model (close to the one used in spreadsheets)

```
SELECT
  { [Measures].[Store Sales] } ON COLUMNS,
  { [Date].[2002], [Date].[2003] } ON ROWS
FROM Sales
WHERE ( [Store].[USA].[CA] )
```
Results representation

- **Query:**
  ```sql
  SELECT
  { [Product].[All Products].[Drink],
    [Product].[All Products].[Food] } ON COLUMNS,
  { [Store].[All Stores].[USA].[WA].[Yakima].[Store 23],
    [Store].[All Stores].[USA].[CA].[Beverly Hills].[Store 6],
    [Store].[All Stores].[USA].[OR].[Portland].[Store 11] } ON ROWS
  FROM Warehouse
  WHERE ([Time].[1997], [Measures].[Units Shipped])
  ```

- **Crosstab:**

- **OLAP client software propose:**
  - Alternate representation modes (pie charts, diagrams, etc.)
  - Different tools to refine queries/explore data
    - Drill down, roll up, pivot, …
    - Based on operators provided by MDX and on a complex logic implemented in the client part
Pentaho open source BI software stack

http://www.pentaho.org
Pentaho open source BI software stack

- Pentaho (http://www.pentaho.org)

**Diagram:**
- **Data sources (OLTP systems)**
- **Kettle** (ETL systems)
- **Data Warehouse**
- **Mondrian** (OLAP)
- **Weka** (Data mining)
- **Pentaho Reporting** (Reporting tools)

+ **CDF : Community Dashboard Framework**
+ **Other projects : olap4j, JPivot, Halogen, …**
Pentaho open source BI software stack
Why merge BI and GIS software?

Because …

“About eighty percent of all data stored in corporate databases has a spatial component” [Franklin 1992]

To support the geospatial component …

- You can use:
  - **GIS**
    - Implies the writing of very complex SQL queries
    - Sometimes, a long and hard job which requires dedicated human resources
    - Need to be done anew everytime data change or new analyses have to be achieved
  - **Classical BI tools (OLAP clients, reporting tools)**
    - Unable to handle the spatial dimension of data (or only a very basic support)
  - **Merging GIS and BI tools (e.g. Spatial OLAP)**
    - To fully exploit the spatial component
    - No need to write any SQL statements, just click away!
Components of a Spatial BI infrastructure

Components:
- Data sources (OLTP systems)
- GIS file formats, Web Feature Services, Spatial DBMS
- Data extraction
- ETL systems
- Data Warehouse
- Spatial ETL
- Spatial DBMS
- Reporting tools
- OLAP
- Data mining
- SOLAP, Spatial data mining, Map-driven dashboards, ...

Spatial Business Intelligence

Require to consistently integrate the geospatial component in all parts of the architecture!
Open source geospatial BI software stack

- Pentaho (http://www.pentaho.org)

+ CDF: Community Dashboard Framework
+ Other projects: olap4j, JPivot, Halogen, …
Open source geospatial BI software stack

- GeoSOA group ([http://geosoa.scg.ulaval.ca](http://geosoa.scg.ulaval.ca))

![Diagram showing the software stack with GeoKettle, GeoMondrian, Pentaho Reporting, Weka, and additional tools]

- Data sources (OLTP systems) → GeoKettle (ETL systems)
- Spatial ETL systems → Data Warehouse
  - Data Warehouse
    - PostGIS
    - Oracle Spatial
- Data Warehouse → GeoMondrian → Pentaho Reporting
- Weka (Spatial Data mining)

+ Spatialalytics: new open source project and ongoing experiments with CDF & Jasper Server
GeoKettle is a "spatially-enabled" version of Pentaho Data Integration (Kettle)

- True and consistent integration of the spatial component
  - All steps provided by Kettle are able to deal with geospatial data types
  - Some geospatial dedicated steps have been added

- Current stable version : 3.2.0-20090609
- Released under LGPL

http://www.geokettle.org
**GeoKettle**

Provides support for:

- Handling geometry data types (based on JTS)
- Accessing Geometry objects in JavaScript
- It allows the definition of custom transformation steps by the user (“Modified JavaScript Value” step)
- Topological predicates (Intersects, crosses, etc.)
- SRS definition and transformations
- Input / Output with some spatial DBMS
- Native support for Oracle, PostGIS and MySQL
- MS SQL Server 2008, Ingres and IBM DB2 can be used but it requires some tricks
- GIS file Input / Output : Shapefile (and GML soon)
GeoKettle

- Upcoming features:
  - Cartographic preview (*work in progress*)
  - Implementation of data matching and conflation steps in order to allow geometric data cleansing and comparison of geospatial datasets
  - Read/write support for other DBMS & GIS file formats
    - MapInfo (.tab or MIF/MID), KML, GeoJSON, GeoRSS, ESRI Geodatabase, ArcSDE
    - Native support for MS SQL Server 2008 and Ingres
    - WFS, Sensor Web (TML, SensorML, SOS, ...)
  - Implementation of a “Spatial analysis” step with a GUI
GeoMondrian

- GeoMondrian is a "spatially-enabled" version of Pentaho Analysis Services (Mondrian)
- GeoMondrian brings to the Mondrian OLAP server what PostGIS brings to the PostgreSQL DBMS
  - i.e. a consistent and powerful support for geospatial data.
- Released under the EPL
- [http://www.geo-mondrian.org](http://www.geo-mondrian.org)
As far as we know, it is the first implementation of a true Spatial OLAP (SOLAP) Server
  - And it is an open source project! ;-)

Provides a consistent integration of spatial objects into the OLAP data cube structure
  - Instead of fetching them from an separate spatial DBMS, web service or a GIS file

Implements a native Geometry data type

Provides first spatial extensions to the MDX language
  - Add spatial analysis capabilities to the analytical queries

At present, it only supports PostGIS datawarehouses
  - But other DBMS should be supported soon ...
Spatially enabled MDX

- Goal: bring to Mondrian and MDX what SQL spatial extensions do for relational DBMS (i.e. Simple Features for SQL and implementations such as PostGIS).

- Example query: filter spatial dimension members based on distance from a feature

```sql
SELECT
  {[Measures].[Population]} on columns,
  Filter(
    {[Unite geographique].[Region economique].members},
    ST_Distance([Unite geographique].CurrentMember.Properties("geom"),
    [Unite geographique].[Province].[Ontario].Properties("geom")) < 2.0
  ) on rows
FROM [Recensements]
Many more possibilities:

- in-line geometry constructors (from WKT)
- member filters based on topological predicates (intersects, contains, within, …)
- spatial calculated members and measures (e.g. aggregates of spatial features, buffers)
- calculations based on scalar attributes derived from spatial features (area, length, distance, …)
Spatialytics is a lightweight cartographic component which enables navigation in geospatial (Spatial OLAP or SOLAP) data cubes, such as those handled by GeoMondrian.

It aims to be integrated into existing dashboard frameworks in order to produce interactive geo-analytical dashboards.

Such dashboards support the decision making process by including the geospatial dimension in the analysis of enterprise data.

First version stems from a GSoC 2008 project performed under the umbrella of OSGeo.

Released under BSD (client part) and EPL (server part).

http://www.spatialytics.org
Spatialytics

- Is mainly based on OpenLayers and Dojo

- Allows:
  - the connection with a Spatial OLAP server such as GeoMondrian,
  - the navigation in geospatial data cubes,
  - and the cartographic representation of some measures as static or dynamic choropleth maps.

- More thematic capabilities will be added shortly!
  - A student currently funded by the Google Summer of Code 2009 program, under the umbrella of OSGeo, is currently working on this task.
GeoKettle, GeoMondrian and Spatialytics demos

- **GeoKettle**
  - A lab. has been held this week! ;-)
  - Contents will be available on the GeoSOA website shortly!

- **GeoMondrian/Spatialytics**
  - A basic online demo is available at:
    - [http://geosoa.scg.ulaval.ca/Spatialytics/](http://geosoa.scg.ulaval.ca/Spatialytics/)
  - It demonstrates the interaction with GeoMondrian and how the cartographic navigation in the geospatial datacube is performed.
  - Work in progress; more demos should be available soon …
Spatialytics – Outlooks

Features in development:

- More map-driven OLAP navigation operators (drill by position, by member, roll-up to parent, etc.)
- Dimension member selection / navigation controls
- Legend display
- New thematic mapping styles:
  - Choropleth: quantiles, other statistical distributions
  - Graphics: proportional symbols, histograms, pie charts, ...
  - Styles for other geometry types (lines and points)
  - Some styles or combination of styles allowing representation of multiple members/measures on a single map feature
  - Multi maps: Maps for different periods of time
  - ...

Spatialytics – Integration projects

First experiments with JasperServer + iReport

- iReport is a graphical report designer for JasperReports
- Will provide a framework to produce highly customizable reports or static dashboards
- Displays the information in different ways: maps, charts and tables
- Allows synchronisation between the different representations when the user drills down or rolls up on the map or the charts or …

Integration into Pentaho CDF + GeoReport (Inova)

- Another student funded by the GSoC 2009 program under the umbrella of OSGeo

Other integration projects to come …
Questions?

- Thanks for your attention!

Contact:

Dr. Thierry Badard
GeoSOA research group
Laval University, Quebec, Canada
Email: Thierry.Badard@scg.ulaval.ca
Web: http://geosoa.scg.ulaval.ca
Annexes
OLAP vocabulary

- Cube
- Dimension:
  - Temporal
  - Thematic
  - Geospatial
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
- Fact
OLAP vocabulary

- **Cube**
- **Dimension:**
  - Temporal
  - Thematic
  - Geospatial
- **Hierarchy**
- **Level**
- **Member**
- **Measure**
  - Descriptive
- **Fact**
OLAP vocabulary

- Cube
- **Dimension:**
  - Temporal
  - Thematic
  - **Geospatial**
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
- Fact
OLAP vocabulary

- Cube
- Dimension:
  - Temporal
  - Thematic
  - Geospatial
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
- Fact

Hierarchy:
- North America
  - USA
    - CA
    - NY
  - Canada
    - Quebec
    - Ontario
OLAP vocabulary

- Cube
- Dimension:
  - Temporal
  - Thematic
  - Geospatial
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
- Fact

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Time</td>
</tr>
<tr>
<td>Quebec City</td>
<td>2005-11</td>
</tr>
</tbody>
</table>
Cube translation in the DW - Star schema sample
### Fact table

<table>
<thead>
<tr>
<th>d_age_key</th>
<th>d_annee_key</th>
<th>d_sexe_key</th>
<th>d_statut_pop_key</th>
<th>d_unite_geo_key</th>
<th>population</th>
<th>nb_naissance</th>
<th>nb_deces</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>200</td>
<td>189</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>428</td>
<td>425</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>73</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>123</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>95</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>74</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>92</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>103</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>118</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>98</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>11</td>
<td>119</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>283</td>
<td>274</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>13</td>
<td>46</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>14</td>
<td>160</td>
<td>161</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>121</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>16</td>
<td>115</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>17</td>
<td>79</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>18</td>
<td>55</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>
**A dimension table**

- **Primary key (« surrogates key »):** Member identifier (natural key)
- **Member name**
- **Member attribute**

<table>
<thead>
<tr>
<th>d_unite_geo_key</th>
<th>division_code</th>
<th>division_nom</th>
<th>rg_econo_code</th>
<th>rg_econo_nom</th>
<th>province_code</th>
<th>province_nom</th>
<th>province_geom</th>
<th>region_code</th>
<th>region_nom</th>
<th>region_geom</th>
<th>pays_code</th>
<th>pays_nom</th>
<th>pays_geom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1314</td>
<td>Haute-Charlevoix</td>
<td>MULTIPOLYGON</td>
<td>11310</td>
<td>Campbelton</td>
<td>MULTIPOLYGON</td>
<td>13 Nouveau-Bréézil</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1315</td>
<td>Gloucester</td>
<td>MULTIPOLYGON</td>
<td>11310</td>
<td>Campbelton</td>
<td>MULTIPOLYGON</td>
<td>13 Nouveau-Bréézil</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2401</td>
<td>Les-îles-de-la-Madeleine</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Gaspé</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2402</td>
<td>Robbie</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Gaspé</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2403</td>
<td>La côte-de-Gaspé</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Gaspé</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2404</td>
<td>Gaspé-Rivière</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Gaspé</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2405</td>
<td>Bonaventure</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Gaspé</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2406</td>
<td>Kigogon</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Gaspé</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2407</td>
<td>La Malbaqués</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2408</td>
<td>Matane</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2409</td>
<td>La Mitis</td>
<td>MULTIPOLYGON</td>
<td>12410</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>2410</td>
<td>Rimouski-Neigette</td>
<td>MULTIPOLYGON</td>
<td>12415</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>2411</td>
<td>Les Basques</td>
<td>MULTIPOLYGON</td>
<td>12415</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>2412</td>
<td>Rivière-du-Loup</td>
<td>MULTIPOLYGON</td>
<td>12415</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2413</td>
<td>Rimouski-Neigette</td>
<td>MULTIPOLYGON</td>
<td>12415</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>2414</td>
<td>Kamouraska</td>
<td>MULTIPOLYGON</td>
<td>12415</td>
<td>Bas-Saint-Laurent</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>2415</td>
<td>Centre-du-Québec</td>
<td>MULTIPOLYGON</td>
<td>12420</td>
<td>Capitale-Nationale</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2416</td>
<td>Charlevoix</td>
<td>MULTIPOLYGON</td>
<td>12420</td>
<td>Capitale-Nationale</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>2417</td>
<td>Islet</td>
<td>MULTIPOLYGON</td>
<td>12420</td>
<td>Capitale-Nationale</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2418</td>
<td>Montmagny</td>
<td>MULTIPOLYGON</td>
<td>12420</td>
<td>Capitale-Nationale</td>
<td>MULTIPOLYGON</td>
<td>24 Québec</td>
<td>MULTIPOLYGON</td>
<td>0</td>
<td>Canada</td>
<td>MULTIPOLYGON</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Division level**

**Economic region level**

**Province level**

**Region level**

**Country level**
SOLAP vocabulary

- **Cube**
- **Dimension:**
  - Temporal
  - Thematic
  - Geospatial
- **Hierarchy**
- **Level**
- **Member**
- **Measure**
  - Descriptive
  - Geospatial
- **Fact**
- Cube
- **Dimension:**
  - Temporal
  - Thematic
  - Geospatial
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
  - Geospatial
- Fact
- Cube
- Dimension:
  - Temporal
  - Thematic
  - Geospatial
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
  - Geospatial
- Fact
SOLAP vocabulary

- Cube
- Dimension:
  - Temporal
  - Thematic
  - Geospatial
- Hierarchy
- Level
- Member
- Measure
  - Descriptive
  - Geospatial
- Fact

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Sales price</td>
</tr>
<tr>
<td>Quebec City 2005-11</td>
<td>$145,500</td>
</tr>
<tr>
<td>Place</td>
<td>Product</td>
</tr>
<tr>
<td>Quebec City 2005-11</td>
<td>XC skis</td>
</tr>
<tr>
<td>Place</td>
<td>Sold units</td>
</tr>
<tr>
<td>Quebec City 2005-11</td>
<td>582</td>
</tr>
</tbody>
</table>
Why merge BI and GIS software?

- Imagine you are a decision maker in public health policy…
- You will certainly have difficulties to answer to questions like:
  - Where are the urban spots that are more sensitive to heat waves, intense rain, flooding or droughts in a specific geographic area?
  - How many people with cardiovascular, respiratory, neurological and psychological diseases will there be in 2025 and 2050 in a specific geographic area?
  - How many people with low income live alone in a building requiring major repairs in a specific geographic area?
- And because some phenomena can only be observed and interpreted by representing them on a map!
  - Spatial distribution,
  - Spatiotemporal evolution, etc.