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OGC® Loosely Coupled Synchronization of Geographic Databases in the Canadian Geospatial Data Infrastructure Pilot

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Preface

This Discussion Paper documents results from the Interoperability Program CGDI Pilot and describes a suite of services that enable the sharing of geographic information across organizations for the purposes of: geographic database synchronization in support of a spatial data infrastructure; geographic database modification suggestions from trusted and un-trusted sources; and the transmission of geographic information in emergency notification events.

These services are called the Update Feed Service; Feedback Feed Service; and Emergency Alert Service respectively. Their information encodings are all based on the Atom Syndication Format, extended with GML and WFS Filter encodings to support geospatial requirements, and were implemented in the Canadian Geospatial Data Infrastructure Pilot.

Suggested additions, changes, and comments on this draft report are welcome and encouraged. Such suggestions may be submitted by email message or by making suggested changes in an edited copy of this document.

The changes made in this document version, relative to the previous version, are tracked by Microsoft Word, and can be viewed if desired. If you choose to submit suggested changes by editing this document, please first accept all the current changes, and then make your suggested changes with change tracking on.

Contents Page

Figures Page

OGC® Loosely Coupled Synchronization of Geographic Databases in the Canadian Geospatial Data Infrastructure Pilot

1   Introduction

1.1   Scope

This OGC™ Discussion Paper defines information encodings for specifying changes to geographic information sets. It does not define service interfaces for accessing these resources, as it is expected that the Atom Publishing Protocol, or in simple cases, HTTP GET alone, suffices for the service interface.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The OGC shall not be held responsible for identifying any or all such patent rights.

1.2   Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

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1.3   Revision history

Date	Release	Editor	Primary clauses modified	Description
28 Jan 08	1	Singh		1st public release

1.4   Future work

Improvements in this document are desirable to specify a distributed publication mechanism for these feed services, to refine the encoding of geospatial information in an Atom feed, and to validate the utility of using the Atom service architecture as a foundation for geographic information sharing.

2   References

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

The Atom Syndication Format, http://www.ietf.org/rfc/rfc4287.txt

The Atom Publishing Protocol, http://www.ietf.org/rfc/rfc5023.txt

GeoRSS: Geographically Encoded Objects for RSS feeds, http://georss.org

OGC 06-121r3, *OpenGIS$^®$ Web Services Common Specification*

OGC 04-094, *OpenGIS$^®$ Web Feature Service Implementation Specification*

3   Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Specification [OGC 06-121r3] shall apply. In addition, the following terms and definitions apply.

3.1
Atom
Atom Syndication Format
an XML-based document format that describes lists of related information known as "feeds", which are composed of a number of items, known as "entries", each with an extensible set of attached metadata

3.2
GeoRSS
GeoRSS describes a number of ways to encode location in RSS and Atom feeds. There are two encodings of GeoRSS: GeoRSS Simple and GeoRSS GML. Both encodings support the encoding of basic geometries (point, line, polygon, and box). GeoRSS Simple geometries may only support one coordinate reference system—WGS-84 latitude/longitude in decimal degrees. GeoRSS GML is a formal GML Application Profile, and allows the coordinate reference system to be specified as with any GML feature. Both formats are designed for use with Atom 1.0, RSS 2.0 and RSS 1.0, although it can be used just as easily in non-RSS XML encodings. The definition of GeoRSS is at <http://georss.org>.

3.3
Atom+GeoRSS
Atom+GeoRSS refers to an XML encoding using Atom version 1.0 with the GeoRSS extension.

4   Conventions

4.1   Abbreviated terms

APP   Atom Publishing Protocol

CGDI   GeoConnections Canada's Canadian Geospatial Infrastructure

IT   Information Technology

SDI   Spatial Data Infrastructure

SOA   Service Oriented Architecture

XML   eXtensible Markup Language

5   Overview

In today's environment where users and organizations are collaborating over the creation and on-going maintenance of geospatial data sets it is of critical importance for all Spatial Data Infrastructure (SDI) partnerships to be able to share geographic information in real time, and make the costs associated with sharing—in labor and IT resources—negligible. In this report the activity of enabling cross-jurisdiction updates to geographic data is termed *federated geo-synchronization*.

Some have approached this requirement from the database perspective, expecting collaborating organizations to use database replication technology for their geographic data sharing needs. This strategy cannot work in most cases because, most notably, every organization needs to work with a different information model. For example, a local jurisdiction often needs to maintain a large set of properties on their roads data, such as maintenance-related items like pavement quality and type. At the national level, however, that information is unnecessary. Another limitation of replication technology is that all parties must be using the same software. This is rarely the case in a multi-organization setting. Finally, replication involves reaching deep into another organization's IT infrastructure, requiring a level of trust between the parties which isn't always there.

The CGDI Pilot sought to minimize these barriers to participation by developing an interoperable solution to the geographic data synchronization problem that has none of these drawbacks. We also believe that this solution to the federated geo-synchronization issue is applicable to ongoing SDI initiatives across the globe.

5.1   Requirements

The geographic data sharing requirements of the CGDI Pilot were as follows:

1. Establish a mechanism for supporting feature synchronization and data currency in a distributed and collaborative SDI environment.

2. Support and promote close-to-source ownership of geospatial data for all data providers.

3. Ensure real-time access to current geographic features in Canada.

4. Establish a permanent collaborative environment for geospatial data as a key component for creating a sustainable and current spatial data infrastructure in Canada.

5. Consolidate the CGDI as the permanent spatial information infrastructure for accessing current geographic data content across government departments in Canada.

The CGDI Pilot project aims at establishing distributed geospatial data resources from data providers at regional, provincial and national levels in Canada and maintaining common and integrated data content at the national level using shared data models and open interfaces for supporting feature synchronization.

5.2   Geo-synchronization architecture

Geo-synchronization implies that a data provider may decide to keep his data store in synchronization with a portion or all of the content of one or more other geospatial data sources at a particular time. If the initial process involves also copying the content of the source to the target data store then the geo-synchronization service may also be used for data replication.

The proposed geo-synchronization service architecture described below allows SDI data provider participants to meet the following requirements:

- Keep data stores of SDI data provider participants in synchronization with a portion or all of the geospatial data content from one or more other data stores.

- Keep data stores of SDI data provider participants current by allowing external or internal users to submit feature change proposals via the GeoSynchronization service.

The proposed architecture follows the SOA model in a loosely coupled environment. The service allows data custodians to publicize changes to their geographic databases in a machine-readable manner, enabling geo-synchronization clients to automatically perform synchronization activities. Another feature of the architecture is that end users (internal or external to an organization) can create suggested feature change requests which are broadcast back to the data custodians, creating an efficient business process for accepting change requests, checking their validity, and applying the suggested change if deemed appropriate. To close the loop, those changes are then publicized in the same was as internal edits to the database.

The overall mechanism for implementing the architecture uses a message format known as Atom+GeoRSS feeds. The popular Atom specification for encoding timely event information had already been extended to support simple geographic features with GeoRSS (http://en.wikipedia.org/wiki/GeoRSS). The Atom+GeoRSS feed content has been popularized by Google News and can easily be overlaid on a map using Google Maps. The CGDI Pilot extends Atom+GeoRSS for geo-synchronization by adding GML features and/or WFS Filter requests that return GML features, to the format.

The geo-synchronization architecture presented in Figure 1 describes essential elements of a geo-synchronization service, including data currency and synchronization/replication of geospatial data. The section below indicates the role that each SDI participant may play when using the service.

User Role:

1. A user internal to a data provider organization or external to the organization such as a field worker, anonymous internet user, trusted user etc. connects to a WFS service at a data provider site.

2. He identifies an error in a geographic feature and wants to submit a "feature change" request. Using a client application he creates a GeoRSS feed entry of the "feature change" and posts his request to the GeoSynchronization service (change feed) of the data provider. The user subscribes to the update feed of the data provider GeoSynchronization service and awaits a response for his feature change request.

Data Provider Role:

3. A person responsible for the maintenance of geospatial data at a data provider site such as a Provincial Custodian representative has previously subscribed to the change feed of his geo-synchronization service and receives the "feature change" requests posted by users.

4. Using a client tool the Provincial Custodian representative validates the change request.

5. If accepted, the Provincial Custodian representative applies change request to his data store and the provincial WFS server posts an entry to the update feed of his GeoSynchronization service, indicating that the change request was accepted.

6. If rejected, the tool used by the Provincial Custodian representative posts an entry to the update feed of his GeoSynchronization service, indicating that the change request was rejected.

7. Following a response from the Provincial Custodian representative the user is notified of the result of his proposed "feature change" request.

Other Data Provider Role:

8. Another data provider wishing to keep his data store in synchronization with the Provincial Custodian data store subscribes to the update feed available from the GeoSynchronization service of the Provincial Custodian and using his own software tool applies accepted entries to his own data store.
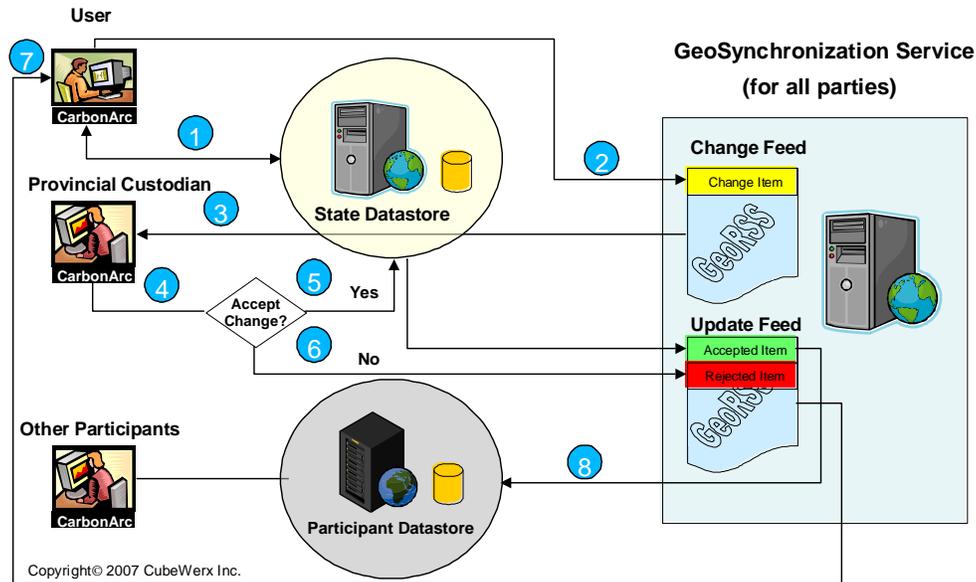
Figure 1 — Geo-Synchronization Architecture

6   Update Feed Service

The Update Feed service interface is extremely simple. There are two critical requirements for federated updates to work. First, federation partners must implement a common GML profile for the data being shared, and expose it through a WFS interface. Note that internally, each party may have a database model that is a superset of the shared model. Second, the geographic features in the shared data must have a globally unique identifier (GUID) property, so that no feature from any participant in the federation has a conflicting GUID.

The service simply involves publishing to a Web location with a stable URI an "Update Feed" in Atom format with entries that contain either the actual changed features in the database, or a WFS query that returns the changed features. The feed can simply be an XML document located at a specific, fixed URL. Therefore, if desired, the feed can be secured and encrypted using any number of standard Web security technologies. Since the CGDI Pilot required geographic query on feeds, we implemented the architecture as a WFS. It may be useful to make this a generic requirement of an SDI federation, but it is not a specific requirement of the architecture.

To synchronize a data store with a source provider, a third party data provider must implement an Update Feed client and subscribe to an Update Feed from one or more

federation partners. Update Feed clients are software components that can parse and act on that feed. Once received, Update Feed entries are read and applied to a geodata store.

In the CGDI Pilot, the WFS Transaction interface was used to apply database changes, but this fact was opaque to the federation. The detailed characteristics of how the client performs the synchronization are of no concern to the interface. In theory, database maintainers could use native software to update their databases and still be in compliance with the interoperability requirements of the architecture. The only test of whether or not the synchronization client-service interaction is successful is to query both data services for the feature GUID and check that the content is identical in both locations.

6.1 Update Feed XML Encoding

Due to the simplicity of the interface, the only thing that must be detailed is the encoding of the XML document. The Atom Syndication Format was used for this purpose, along with the GeoRSS extension to Atom. This combination is generally called Atom+GeoRSS. The CGDI Pilot further extended this format to support the encoding of GML features and WFS queries to meet the project's needs.

The method of creating the feed is outside the scope of this interface. We recommend that services use the Atom Publishing Protocol to create the feed, but that decision has no bearing on the feed's use in a geo-synchronization setting.

```xml
Examining the example in <?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
xmlns:georss="http://www.georss.org"
xmlns:gb="http://www.geobase.ca/interop-pilot-2007"
xmlns:gml="http://www.opengis.net/gmlsf">
  <title>Geobase Feedback</title>
  <category term="update"/>
  <link href="http://www.geobase.ca/update"/>
  <updated>2003-12-13T18:30:02Z</updated>
  <author>
    <name>John Doe</name>
    <email>jdoe@geobase.ca</email>
  </author>
  <generator>Cubeserv</generator>
  <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af7</id>
  <entry>
    <title>Ontario updates</title>
    <author>
      <name>John Doe</name>
      <uri>http://www.example.com</uri>
      <email>jdoe@example.com</email>
    </author>
    <category
        scheme="http://www.geobase.ca/scheme/feedtype"
        term="feedback"/>
    <category
        scheme="http://www.geobase.ca/scheme/domain"
        term="Ontario updates"/>
```

```xml
<category
    scheme="http://www.geobase.ca/scheme/featuretype"
    term="Road Segment"/>
<category
    scheme="http://www.geobase.ca/scheme/action"
    term="insert"/>
<category
    scheme="http://www.geobase.ca/scheme/status"
    term="proposed"/>
<content>Ontario updates</content>
<id>urn:uuid:aca7bb43-2bd1-4c34-8d13-7b6b5644f2c0</id>
<updated>2007-11-06</updated>
<summary>
  Updates digitized with GeoBase WMS backdrop.
</summary>
<georss:where>
  <gml:Point srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
    <gml:pos>43.928958 -78.933283</gml:pos>
  </gml:Point>
</georss:where>
<georss:featureOfInterest>
  <gml:FeatureCollection
      xmlns:gb="http://www.geobase.ca/interop-pilot-2007">
    <gml:boundedBy>
      <gml:boundedBy>
        <gml:Envelope
          srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
          <gml:lowerCorner>43.92566 -78.93541</gml:lowerCorner>
          <gml:upperCorner>43.92895 -78.93328</gml:upperCorner>
        </gml:Envelope>
      </gml:boundedBy>
    </gml:boundedBy>
    <gml:featureMember>
      <gb:RoadSegment>
        <gb:cgdiId>urn:uuid:cebc5f9b-8bcb-47d6-a51c-
0753d5170475</gb:cgdiId>
        <gb:planimetricDataAccuracy>0
        </gb:planimetricDataAccuracy>
        <gb:acquisitionTechnique>n.a.
        </gb:acquisitionTechnique>
        <gb:acquisitionProvider>n.a.</gb:acquisitionProvider>
        <gb:acquisitionOrRevisionDate>2007-11-06-05:00
        </gb:acquisitionOrRevisionDate>
        <gb:nationalRoadClass>Arterial</gb:nationalRoadClass>
        <gb:numberOfLanes>0</gb:numberOfLanes>
        <gb:pavementStatus>n.a.</gb:pavementStatus>
        <gb:pavedRoadSurfaceType>n.a.</gb:pavedRoadSurfaceType>
        <gb:unpavedRoadSurfaceType>n.a.</gb:unpavedRoadSurfaceType>
        <gb:roadSegmentID>cebc5f9b-8bcb-47d6-a51c-0753d5170475
        </gb:roadSegmentID>
        <gb:segment>
          <gml:LineString
```

```
            srsName="urn:x-ogc:def:crs:EPSG:6.11.2:4326">
             <gml:posList>43.927222 -78.93475 43.928612 -78.935393
                      … etc …
                43.926257 -78.9333834 43.9259504 -78.9332889
             </gml:posList>
           </gml:LineString>
         </gb:segment>
       </gb:RoadSegment>
     </gml:featureMember>
       … etc …
       </gml:FeatureCollection>
   </georss:featureOfInterest>
 </entry>
</feed>
```

Figure 2, there are several novel uses of the Atom format that are worthy of notice:

- The `<entry>`'s `<id>` is the feature's GUID.

- The `<entry>`'s `<author>` is the data custodian

- `<category>` elements are used to communicate keywords from a formal dictionary. So the feed type is update, the domain is Tasmania, the feature type is placename, and so on.

- `<updated>` is the time the feature was created, updated or deleted

- `<summary>` and `<content>` allows for a narrative explanation of the update

- `<georss:where>` is used as a general "hint" as to where the feature is located, which may be the actual location in the case of a simple point, line or polygon, or the bounding box of a more complex feature.

- `<georss:featureOfInterest>` is the actual feature to be updated.

```
<?xml version="1.0" encoding="UTF-8"?>
<feed xmlns="http://www.w3.org/2005/Atom"
xmlns:georss="http://www.georss.org"
xmlns:gb="http://www.geobase.ca/interop-pilot-2007"
xmlns:gml="http://www.opengis.net/gmlsf">
  <title>Geobase Feedback</title>
  <category term="update"/>
  <link href="http://www.geobase.ca/update"/>
  <updated>2003-12-13T18:30:02Z</updated>
  <author>
```

```xml
    <name>John Doe</name>
    <email>jdoe@geobase.ca</email>
  </author>
  <generator>Cubeserv</generator>
  <id>urn:uuid:60a76c80-d399-11d9-b93C-0003939e0af7</id>
  <entry>
    <title>Ontario updates</title>
    <author>
      <name>John Doe</name>
      <uri>http://www.example.com</uri>
      <email>jdoe@example.com</email>
    </author>
    <category
        scheme="http://www.geobase.ca/scheme/feedtype"
        term="feedback"/>
    <category
        scheme="http://www.geobase.ca/scheme/domain"
        term="Ontario updates"/>
    <category
        scheme="http://www.geobase.ca/scheme/featuretype"
        term="Road Segment"/>
    <category
        scheme="http://www.geobase.ca/scheme/action"
        term="insert"/>
    <category
        scheme="http://www.geobase.ca/scheme/status"
        term="proposed"/>
    <content>Ontario updates</content>
    <id>urn:uuid:aca7bb43-2bd1-4c34-8d13-7b6b5644f2c0</id>
    <updated>2007-11-06</updated>
    <summary>
      Updates digitized with GeoBase WMS backdrop.
    </summary>
    <georss:where>
      <gml:Point srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
        <gml:pos>43.928958 -78.933283</gml:pos>
      </gml:Point>
    </georss:where>
    <georss:featureOfInterest>
      <gml:FeatureCollection
          xmlns:gb="http://www.geobase.ca/interop-pilot-2007">
        <gml:boundedBy>
          <gml:boundedBy>
            <gml:Envelope
              srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
              <gml:lowerCorner>43.92566 -78.93541</gml:lowerCorner>
              <gml:upperCorner>43.92895 -78.93328</gml:upperCorner>
            </gml:Envelope>
          </gml:boundedBy>
        </gml:boundedBy>
        <gml:featureMember>
          <gb:RoadSegment>
```

```
            <gb:cgdiId>urn:uuid:cebc5f9b-8bcb-47d6-a51c-
0753d5170475</gb:cgdiId>
            <gb:planimetricDataAccuracy>0
            </gb:planimetricDataAccuracy>
            <gb:acquisitionTechnique>n.a.
            </gb:acquisitionTechnique>
            <gb:acquisitionProvider>n.a.</gb:acquisitionProvider>
            <gb:acquisitionOrRevisionDate>2007-11-06-05:00
            </gb:acquisitionOrRevisionDate>
            <gb:nationalRoadClass>Arterial</gb:nationalRoadClass>
            <gb:numberOfLanes>0</gb:numberOfLanes>
            <gb:pavementStatus>n.a.</gb:pavementStatus>
            <gb:pavedRoadSurfaceType>n.a.</gb:pavedRoadSurfaceType>
            <gb:unpavedRoadSurfaceType>n.a.</gb:unpavedRoadSurfaceType>
            <gb:roadSegmentID>cebc5f9b-8bcb-47d6-a51c-0753d5170475
            </gb:roadSegmentID>
            <gb:segment>
              <gml:LineString
                srsName="urn:x-ogc:def:crs:EPSG:6.11.2:4326">
                 <gml:posList>43.927222 -78.93475 43.928612 -78.935393
                        … etc …
                     43.926257 -78.9333834 43.9259504 -78.9332889
                 </gml:posList>
              </gml:LineString>
            </gb:segment>
          </gb:RoadSegment>
        </gml:featureMember>
         … etc …
          </gml:FeatureCollection>
      </georss:featureOfInterest>
  </entry>
</feed>
```

Figure 2 — Update Feed Example

6.2   Update Feed Query Interface

The only major problem with using Atom for the Update Feed requirement was the lack
of a query interface in the standard, which obviously includes the lack of a geographic
query interface. For expediency, participants used the WFS Filter query interface to get
around this problem, but more work needs to be done in this area before a generic
solution can be proposed. Figure 3 shows a simple time-based WFS query that returns all
entries on or after December, 12, 2003.

```
<wfs:GetFeature service="WFS" version="1.1.0" outputFormat="ATOM">
  <wfs:Query typeName="cw:FeedBackFeed">
    <ogc:Filter>
     <ogc:PropertyIsGreaterThan>
      <ogc:PropertyName>entry/updated</ogc:PropertyName>
      <ogc:Literal>2003-12-11T00:00:00</ogc:Literal>
     </ogc:PropertyIsGreaterThan>
    </ogc:Filter>
  </wfs:Query>
```

```
</wfs:GetFeature>
```

Figure 3 — Update Feed Query (WFS Filter)

7   Feedback Feed Service

7.1   Overview

Another project requirement was to demonstrate how the Update Feed architecture could support database updates from authoritative and anonymous sources. To fulfill this goal, the publish-subscribe methodology described above for update synchronization was used, and the Atom+GeoRSS format was also deemed appropriate for this use case. The only differences between the update feed and the feedback feed are that feedback feed entries must contain complete GML features (no WFS queries), and the entries may also contain an attribute stating whether the feature is an addition, modification, or deletion request.

In the CGDI Pilot a Web-based client was developed to demonstrate the ability for a national clearinghouse, like GeoConnections, to provide end users with a simple graphical interface for creating feedback—suggested changes, additions, deletions—on data accessible through the clearinghouse. While the feedback map resides on the federal system, the closest-to-source provincial data providers ultimately were the ones handling the feedback requests for their jurisdictions.
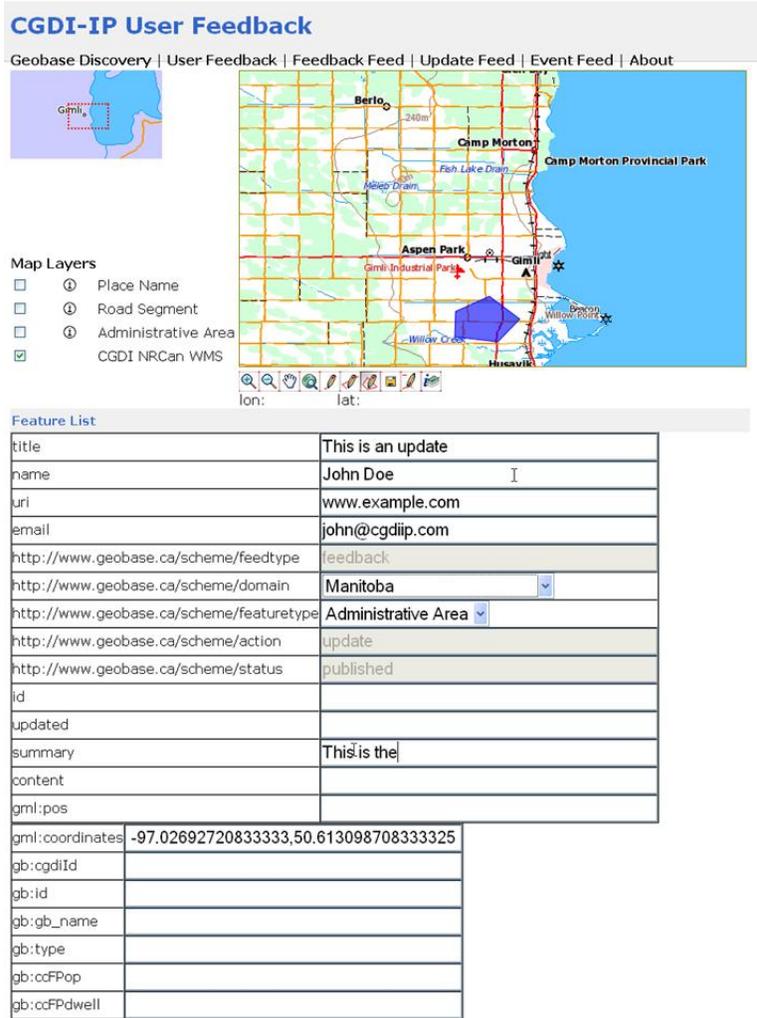
7.2   Workflow

The feedback workflow had the following steps:

1. User views data on a map using WMS and WFS services.

2. User enters editing mode.

3. User modifies geometry and attributes of an existing feature or creates a new one.

4. User saves the suggested change into a Feedback Feed.

5. The province receives notification of the feedback by querying the feedback feed for new entries in their area of custodianship.

6. Provincial data custodian reviews relevant entries from the Feedback feed, then copies or rejects update in the province database.

7. Province posts a new event to their Update Feed.

Figure 4 — User Feedback Web Client

7.3   Feedback Feed XML Encoding

The Feedback Feed uses the same Atom XML encoding as the Update Feed. The only difference is in the usage of the information model. Notice that the title of the example in **Error! Reference source not found.** refers to a *correction* instead of an *update*.

Data custodians have two methods of deciding on the authenticity of the feedback's author. The first is the information in the `<author>` element, which is not necessarily trustworthy as it's hard to know who created that information. More reliable is the URL of the feedback feed. If the feed is not coming from a trusted URL, it should be considered potentially hazardous and be validated manually by a human. However, if the feedback is coming from a trusted partner in the federation, a data custodian may decide to implement an automatic, machine-based method of applying feedback to their geographic data store. This would make sense, for example, in a scenario where a provincial data custodian was responsible for a regional transportation data store, and

allowed automated processing of feedback from trusted municipal partners who were updating road maintenance records.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<wfs:Transaction xmlns:gml="http://www.opengis.net/gml"
    xmlns:georss="http://www.georss.org/georss"
    xmlns:cw="http://www.cubewerx.com/cw"
    xmlns:wfs="http://www.opengis.net/wfs"
    service="WFS" version="1.1.0" outputFormat="ATOM">
  <wfs:Insert inputFormat="ATOM">
    <cw:FeedbackFeed xmlns="http://www.w3.org/2005/Atom"
     xmlns:ogc="http://www.opengis.net/ogc"
     xmlns:def="http://www.w3.org/2005/Atom">
    <entry>
     <title>Ontario updates</title>
     <author>
        <name>John Doe</name>
        <email>jdoe@nrcan.gc.ca</email>
     </author>
     <category    scheme="http://www.geobase.ca/scheme/feedtype"
                  term="feedback" />
     <category    scheme="http://www.geobase.ca/scheme/domain"
                  term="Ontario updates" />
     <category    scheme="http://www.geobase.ca/scheme/featuretype"
                  term="RoadSegment" />
     <category    scheme="http://www.geobase.ca/scheme/status"
                  term="published" />
     <content>no content applicable here</content>
     <id>5b9c07cc-2a18-4f95-80dc-7fcf02642636</id>
     <updated>2007-10-24</updated>
     <summary>Updates digitized in Google Earth with GeoBase NRN v1
     RoadSegment WMS backdrop.</summary>
     <georss:where>
        <gml:Point srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
           <gml:pos>43.92895886762516 -78.93328363202983</gml:pos>
        </gml:Point>
     </georss:where>
     <georss:featureOfInterest>
        <gml:FeatureCollection>
         <gml:boundedBy>
           <gml:Envelope srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
              <gml:lowerCorner>43.92566 -78.93541</gml:lowerCorner>
              <gml:upperCorner>43.92895 -78.93328</gml:upperCorner>
           </gml:Envelope>
         </gml:boundedBy>
         <gml:featureMember xmlns:gb="http://www.geobase.ca/interop-
    pilot-2007">
           <gb:RoadSegment>
              <gb:cgdiId>urn:uuid:551b3fb4-d930-4926-8ff9-
    f3cdf530588e</gb:cgdiId>
              <gb:planimetricDataAccuracy>0
              </gb:planimetricDataAccuracy>
              <gb:acquisitionTechnique>n.a.</gb:acquisitionTechnique>
              <gb:acquisitionProvider>n.a.</gb:acquisitionProvider>
              <gb:acquisitionOrRevisionDate>2007-10-24-04:00
              </gb:acquisitionOrRevisionDate>
              <gb:nationalRoadClass>Arterial</gb:nationalRoadClass>
```

```xml
                <gb:numberOfLanes>0</gb:numberOfLanes>
                <gb:pavementStatus>n.a.</gb:pavementStatus>
                <gb:pavedRoadSurfaceType>n.a.</gb:pavedRoadSurfaceType>
                <gb:unpavedRoadSurfaceType>n.a.
                </gb:unpavedRoadSurfaceType>
                <gb:roadSegmentID>551b3fb4-d930-4926-8ff9-f3cdf530588e
                </gb:roadSegmentID>
                <gb:segment>
                    <gml:LineString
    srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
                        <gml:posList>
                            43.92722 -78.9347 43.92861 -78.9353 43.92865
    -78.9354 43.92869 -78.9354 43.92871 -78.9354 43.92874 -78.9353
    43.92875 -78.9353 43.92877 -78.9352 43.92895 -78.9344 43.92895 -
    78.9343 43.92893 -78.9342 43.92891 -78.9342 43.92885 -78.9341
    43.92801 -78.9338 43.92746 -78.9336 43.92728 -78.9335 43.92703 -
    78.9335 43.92686 -78.9335 43.92664 -78.9335 43.92625 -78.9333
    43.92595 -78.9332 43.92566 -78.9332
                        </gml:posList>
                    </gml:LineString>
                </gb:segment>
            </gb:RoadSegment>
        </gml:featureMember>
        <gml:featureMember xmlns:gb="http://www.geobase.ca/interop-
    pilot-2007">
            <gb:RoadSegment>
                <gb:cgdiId>urn:uuid:3358f9af-7f1f-4d68-b637-
    86999061fdc8</gb:cgdiId>
                <gb:planimetricDataAccuracy>0
                </gb:planimetricDataAccuracy>
                <gb:acquisitionTechnique>n.a.</gb:acquisitionTechnique>
                <gb:acquisitionProvider>n.a.</gb:acquisitionProvider>
                <gb:acquisitionOrRevisionDate>2007-10-24-04:00
                </gb:acquisitionOrRevisionDate>
                <gb:nationalRoadClass>Arterial</gb:nationalRoadClass>
                <gb:numberOfLanes>0</gb:numberOfLanes>
                <gb:pavementStatus>n.a.</gb:pavementStatus>
                <gb:pavedRoadSurfaceType>n.a.</gb:pavedRoadSurfaceType>
                <gb:unpavedRoadSurfaceType>n.a.
                </gb:unpavedRoadSurfaceType>
                <gb:roadSegmentID>3358f9af-7f1f-4d68-b637-86999061fdc8
                </gb:roadSegmentID>
                <gb:segment>
                    <gml:LineString
    srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
                        <gml:posList>
                            43.92596 -78.9403 43.92635 -78.9386 43.92722
    -78.9347 43.92746 -78.9336
                        </gml:posList>
                    </gml:LineString>
                </gb:segment>
            </gb:RoadSegment>
        <gml:FeatureCollection>
      </georss:featureOfInterest>
    </entry>
   </cw:FeedbackFeed>
  </wfs:Insert>
</wfs:Transaction>
```

```
</gml:featureMember>
```

Figure 5 — Feedback Feed Example

8   Emergency Alert Service

Emergency Alert Service feed items communicate the availability of new information and/or actions whose geography is a key component of the event. For the purpose of the CGDI Pilot, they include types and targets of events, links to new (feature) information, and links to OWS Context documents, which visualize those features on a map.

The CGDI Pilot once again re-used the above feed format for this purpose, modifying it to include Common Alerting Protocol (CAP) information. While some of the data, such as the location of the event, is duplicated within the event's entry, the inclusion of event information in conformance with multiple standards makes the transmission able to interoperate more easily with a broader array of client software and devices.
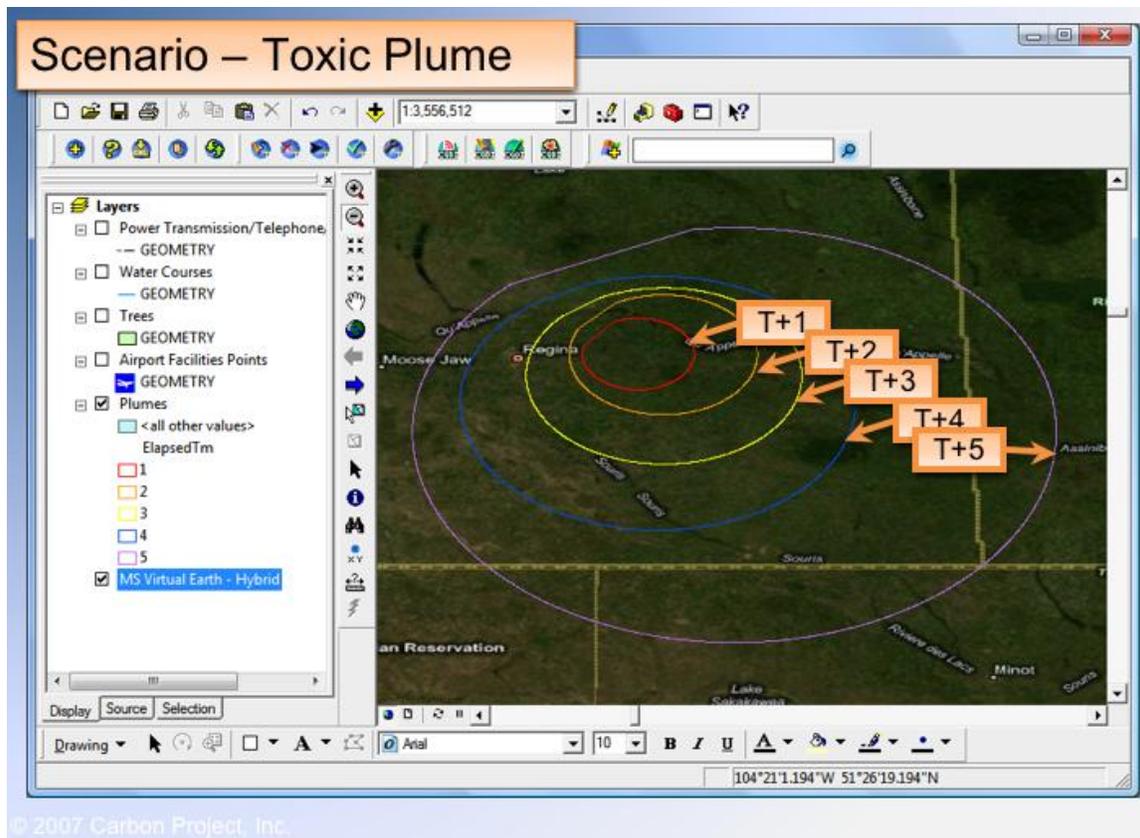
Figure 6 — Toxic Plume Emergency Event

Encapsulating the CAP alert in an Atom+GeoRSS feed allowed CGDI participants to use existing software tools to visualize the event. For example, Figure 6 shows a plume dispersing across an area. This type of emergency event has a geographic component that changes over time. The Atom information model allowed us to capture that event in five entries, and visualize it as individual space-time events or in a time series.

```xml
<?xml version="1.0" encoding="ISO-8859-1"?>
<feed xmlns="http://www.w3.org/2005/Atom"
      xmlns:georss="http://www.georss.org/georss"
      xmlns:gml="http://www.opengis.net/gml"
      xmlns:wfs="http://www.opengis.net/wfs"
      xmlns:gb="http://www.geobase.ca/interop-pilot-2007"
      xmlns:cw="http://www.cubewerx.com/cw">
  <title>GeoConnections CGDI Pilot Event Feed</title>
  <link rel="self"
      href="http://www.pvretano.com/cgdi/cwwfs.cgi?SERVICE=WFS&amp;VERS
      ION=1.0.0&amp;REQUEST=GetFeature&amp;TYPENAME=cw%3AEVENTFEED&amp;
      outputFormat=ATOM" />
  <updated>2008-02-08T05:07:20Z</updated>
  <subtitle>This ATOM feed is used to alert interested parties about
      emergency events. Feed entries are posted to feed to indicate
      that an emergency event has occurred and parties monitoring the
      feed will then be altered about that event.</subtitle>
  <id>urn:uuid:d24cd298-395b-4e48-9c20-013b3af9a4a5</id>
  <generator uri="http://www.pvretano.com/cgdi/cwwfs.cgi"
      version="4.7.3">CubeWerx Web Feature Service</generator>
  <entry cw:id="CWFID.EVENTFEED.0.6">
    <author>
      <name>John Doe</name>
      <uri>http://www.geofunctions.org</uri>
      <email>jdoe@nrcan.gc.ca</email>
    </author>
    <category term="event" scheme="http://www.geobase.ca/feedtype" />
    <category term="Manitoba" scheme="http://www.geobase.ca/domain" />
    <category term="area_alert"
     scheme="http://www.geobase.ca/featuretype" />
    <category term="alert" scheme="http://www.geobase.ca/action" />
    <category term="published" scheme="http://www.geobase.ca/status" />
    <content>Feature collection indicating time and place of alert
     action due to poisonos gas exposure</content>
    <id>urn:uuid:1225c695-cfb8-4ebb-aaaa-80da344efa6c</id>
    <link
     href="http://wolf.cits.rncan.gc.ca:8080/mapbuilder/demo/event/plu
     meContext.xml"
     rel="http://www.geobase.ca/linktype/ows_context" />
    <summary>Poison Gas Exposure notice for Southwestern Manitoba
     area</summary>
    <title>Manitoba sour gas plume alert</title>
    <updated>2007-11-07T00:00:00Z</updated>
    <georss:where>
     <gml:Point srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
      <gml:pos>50.74993437116105 -100.6120574479606</gml:pos>
     </gml:Point>
    </georss:where>
    <georss:featureOfInterest>
     <gml:FeatureCollection xmlns:wfs="http://www.opengis.net/wfs"
         xmlns="urn:oasis:names:tc:emergency:cap:1.1"
```

```
      xmlns:gml="http://www.opengis.net/gml">
   <gml:boundedBy>
     <gml:Envelope srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
         <gml:lowerCorner>50.06164 -101.18588</gml:lowerCorner>
         <gml:upperCorner>51.01049 -99.71660</gml:upperCorner>
     </gml:Envelope>
   </gml:boundedBy>
   <gml:featureMember>
     <PlumeAffectedArea fid="PT1">
     <id>1</id>
     <elapsedHours>1</elapsedHours>
     <areaAffected>
         <gml:Polygon srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
             <gml:exterior>
                 <gml:LinearRing>
                     <gml:posList>
50.73637 -100.796 50.79564 -100.726 50.80338 -100.656 50.79447 -
100.610 50.77536 -100.572 50.74900 -100.549 50.71873 -100.542
50.68659 -100.555 50.66018 -100.586 50.64414 -100.632 50.64092 -
100.683 50.65117 -100.733 50.67305 -100.772 50.70323 -100.794
50.73637 -100.796</gml:posList>
                 </gml:LinearRing>
             </gml:exterior>
         </gml:Polygon>
     </areaAffected>
     </PlumeAffectedArea>
   </gml:featureMember>
   <gml:featureMember>
     <PlumeAffectedArea fid="PT2">
     <id>2</id>
     <elapsedHours>2</elapsedHours>
     <areaAffected>
         <gml:Polygon srsName="urn:ogc:def:crs:EPSG:6.11.2:4326">
             <gml:exterior>
                 <gml:LinearRing>
                     <gml:posList>
50.78288 -100.803 50.84021 -100.716 50.84655 -100.696 50.85718 -
100.623 50.85131 -100.549 50.82967 -100.482 50.79489 -100.431
50.75121 -100.402 50.70389 -100.399 50.67471 -100.410 50.64772 -
100.430 50.62421 -100.459 50.60528 -100.495 50.59181 -100.537
50.58445 -100.582 50.58911 -100.674 50.60091 -100.717 50.61839 -
100.755 50.64072 -100.787 50.66686 -100.810 50.69557 -100.823
50.72549 -100.827 50.75518 -100.820 50.78288 -
100.803</gml:posList>
                 </gml:LinearRing>
             </gml:exterior>
         </gml:Polygon>
     </areaAffected>
     </PlumeAffectedArea>
   </gml:featureMember>
   </gml:FeatureCollection>
   </georss:featureOfInterest>
 </entry>
</feed>
```

Figure 7 — Emergency Alert Feed Example