An Introduction to Geo3DML

3D Geological Model Markup Language

Qu Honggang

Oct, 2014

D R Center of China Geological Survey
Outlines

- What & Why is Geo3DML?
- Design Principles
- Overview
- Module Components
- Applications
- Future Work
What & Why is Geo3DML?

- **3D Geologic** Model **M**arkup **L**anguage

- A wide range of techniques and software tools have been developed to meet various needs of modeling and information dissemination.

- It is impossible to envisage a standard piece of software which will fulfill all of the modeling needs.
What & Why is Geo3DML?

- In 2011, “From 2D to 3D” in CGS

- From 2012-2014, about $25 million per year in CGS for the 3D geological mapping and modeling.

- It is a big problem for the integration of such 3D geological models.
What & Why is Geo3DML?

● A common data format is a better way to support:
   joining up models produced by different tools into integrated models
   publishing models and increasing the interoperability of them between systems
   reducing data management cost by eliminating the complicates introduced by different data formats

● Geo3DML is designed to be an open 3D geological model data exchange format.
What & Why is Geo3DML?

3D Geological Modeling Tools
- GSIS / Creatar
- MapGIS-TDE
- 3D-Grid
- ……

3D Geological Spatial Database
- WVS
- WFS
- W3DS
- ……

Publication & Sharing Management System

Geological Survey Organizations

Institutes & Enterprises
Government Departments
Other Consumers

WVS: Web View Service
WFS: Web Feature Service
W3DS: Web 3D Service
What & Why is Geo3DML?

- Geometry Info
- Semantic Info
- Visualization Info

Geological object
What & Why is Geo3DML?

- Based on XML

- Data type supported in Geo3DML
  - Borehole
  - Geological Map
  - Cross section
  - Geological model
    - Boundary representation model
    - Cell tessellated model
Design Principles

- Clarity & Simple
- Practical
- Reuse existing standards
- Modeling tool independent
Geo3DML with Other Standards

- **Geo3DML**
  - Contributes geometry object model
  - Contributes coverage data encoding specification

- **GML* (v3.2.1)**
  - Contributes geometry object model

- **SWE* (v2.0.0)**
  - Contributes customized attributes definition
  - Metadata

- **SE* (v1.1.0)**
  - Contributes visualization parameter encoding specification
  - Aids in defining visualization parameter

- **Filter Encoding (v1.1.0)**
  - Aids in defining visualization parameter
# Geo3DML with Other Standards

<table>
<thead>
<tr>
<th>Standards</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>OpenGIS Filter Encoding Implementation Specification (v1.1.0)</td>
<td>Cited by Geo3DML to define visualization parameter.</td>
</tr>
<tr>
<td>OpenGIS Symbology Encoding Implementation Specification (v1.1.0)</td>
<td>Cited by Geo3DML as visualization parameter encoding specification.</td>
</tr>
<tr>
<td>OpenGIS SWE Common Data Model Encoding Standard</td>
<td>Cited by Geo3DML as the specification for encoding customized attributes of geologic features.</td>
</tr>
<tr>
<td>OpenGIS GML 3.2.1 Application Schema for Coverages</td>
<td>Cited by Geo3DML as the specification for encoding coverage data.</td>
</tr>
<tr>
<td>Standards</td>
<td>Relationship</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>GeoSciML</td>
<td>Help Geo3DML to model the relationship between geologic features.</td>
</tr>
<tr>
<td>CityGML</td>
<td>CityGML works for data exchange of digital city model, while Geo3DML works</td>
</tr>
<tr>
<td></td>
<td>for data exchange of 3D geological model. Besides, Geo3DML encodes model</td>
</tr>
<tr>
<td></td>
<td>data and its visualization parameter in a separate way, while CityGML dose</td>
</tr>
<tr>
<td></td>
<td>not.</td>
</tr>
<tr>
<td>WMS, W3DS, WVS</td>
<td>WMS, W3DS and WVS are protocols for web 2D/3D map service, while Geo3DML</td>
</tr>
<tr>
<td></td>
<td>is designed as a public common data format of 3D geological model, and it</td>
</tr>
<tr>
<td></td>
<td>can be utilized to exchange or store 3D geological model data.</td>
</tr>
<tr>
<td>GeoPDF</td>
<td>GeoPDF is designed for embedding 3D maps and coverage data in PDF, while</td>
</tr>
<tr>
<td></td>
<td>Geo3DML defines a way of organizing geologic features to form a geological</td>
</tr>
<tr>
<td></td>
<td>model.</td>
</tr>
<tr>
<td>3D PDF, U3D</td>
<td>3D PDF and U3D are working for rendering 3D CAD models in PDF, but CAD</td>
</tr>
<tr>
<td></td>
<td>models are not geological models.</td>
</tr>
<tr>
<td>DXF</td>
<td>DXF is designed to exchange CAD data between various software, but CAD</td>
</tr>
<tr>
<td></td>
<td>models are not geological models.</td>
</tr>
</tbody>
</table>
Overview

- Concept framework
  (separation of data and visualization)

Model Data: Geologic Feature

Graphic Data: Visualization Scene

D&R Center of CGS
Module Components

- Consists of 7 Modules
A geological model consists of a couple of related geological features.
A map is the graphic representation of a couple of geological features.
Geologic Features in Model

Geologic Feature:
- Spatial property
- Non-spatial property
Geologic Features in Model

- Feature Relationship
  - Geologic History
    - Geologic events
    - Relative geologic age
  - Defining Structure
    - The role that a geologic feature plays in a geologic structure.
  - Aggregation Relation
    - Several geologic features can form a composite feature, i.e. a fault system.
  - Boundary Relation
    - i.e., a geologic feature may be enclosed by the surfaces of unconformity and fault.
Module: Geometry

- Spatial data structures defined by GML are compatible
  - Point
  - Line & Curve
  - Surface
  - Solid
  - Coverage

- Support:
  - Text data: WKT (Well Known Text)
  - Binary data: WKB (Well Known Binary) (encoded by Base64)

- Extensions to GML spatial data structures:
  - Customized TIN (Triangulated Irregular Network).
  - Customized Polyhedron: tetrahedron, cube.
  - Customized Corner Point Grid.
  - Grid bounded by a coordinate transformation matrix (4 rows * 4 columns).
    - Be easier to represent an irregular shape based on a regular grid.
Module: GeoProperty & Coverage

Geo3DML designs `<geo3dml:GeoDiscreteCoverage>` to hold coverage data related to general geometry objects by enumerating the topologic position that attribute relies on.
Module: Style

● Defines geological model’s visualization parameter.
● Based on OGC SE* specification;
● Referenced SLD**, CityGML, X3D, SE-3D…

*SE: Symbology Encoding
**SLD: Styled Layer Descriptor
Module: Metadata

- Based on GB/Z 24357-2009 & ISO/TS 19139: Geographic MetaData XML (GMD) encoding.
Test and Applications

- Geo3DML can describe 3D geological models from regional to site-specific investigations.
- We are working with four domestic popular 3D geological modeling software vendors on Geo3DML’s design and validation:
  - MapGIS
  - GSIS (Creatar)
  - 3D-Grid
  - Minexplorer
- Geo3DML has been fully supported by their productions:
  - exporting data into Geo3DML files
  - importing data from Geo3DML files
- Some kind of GoCAD text data can also be exported into and imported from Geo3DML.
<xml version="1.0" encoding="UTF-8"?>
    <Name>model</Name>
    <Type>Map3D</Type>
    <Metadata/>
    <FeatureClasses>
        <FeatureClass gml:id="769">
            <gml:name>Marks</gml:name>
            <Schema>
                <Field name="Front_Attribute">
                    <swe:Text/>
                </Field>
                <Field name="Back_Attribute">
                    <swe:Text/>
                </Field>
                <Field name="Shape">
                    <swe:Text/>
                </Field>
            </Schema>
        </FeatureClass>
    </FeatureClasses>
</GeoModel>
Geo3DML Viewer for parsing Geo3DML data
MapGIS(City)

Geo3DML

qhonggang@mail.cgs.gov.cn

D&R Center of CGS

www.cgs.gov.cn
1:200,000 Regional Geological Survey sheet in MapGIS Format (in Province)
City Geology Models in MapGIS Format (in City)

Geo3DML

D&R Center of CGS

www.cgs.gov.cn

qhonggang@mail.cgs.gov.cn
3D Hydrogeologic Model of City, China
(provided by MapGIS-TDE through Geo3DML)
3D Hydrogeologic Model of City, China
(provided by MapGIS-TDE through Geo3DML)
3D Bedrock Model of City, China
(provided by Creatar through Geo3DML)
3D Underground Geologic Model of City, China

(provided by Creatar through Geo3DML)
A part of the 3D Geologic Model of Faults & Sedimentation of One Oil Field
(provided by 3D-Grid through Geo3DML)
A part of the 3D Geologic Model of Faults & Sedimentation of One Oil Field

(provide by 3D-Grid through Geo3DML)
Future Work

- Geo3DML specification
  - Massive data exchange.
    - especially massive spatial data.
  - Geologic feature relation at semantic level.
  - Additional customized geometry data.
  - Proposal for publishing Geo3DML in CGS as a standard 3D geologic model data exchange format, in 2014.
    - We are doing a thorough test on Geo3DML as a 3D geological model data exchange specification within CGS:
      - Store data in spatial database which is conform with Geo3DML.
      - Online data service by XML/JSON document.
Future Work

● Applications of Geo3DML
  – Development of 3D geological model data publication and service web system based on Geo3DML
THANK YOU

qhonggang@mail.cgs.gov.cn