Compression Techniques for 3D SDI

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Outline

- Introduction
- Background of the problem
- The motivation
- Some compression techniques
- The methodology
- Concluding remarks

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Introduction - what is compression?

- Lossless compression
  - Identical result (compressed data is identical after decompression)
  - Without degrading data quality
  - Reversible process
  - Examples: gzip and winzip
  - Suitable for any text file e.g. XML file

Introduction - what is compression?

- Lossy compression
  - Degrading data quality
  - Compressed data quality is still acceptable
  - Compressed data normally not reversible (unless archiving is available)
  - Example: 24-bit bmp -> jpg
  - Commonly found in image compression, music compression, floating number compression (quantization), etc.

Introduction - why compression?

- Limitations
  - Limited bandwidth (large files and geometries)
  - Limited processing power (small device processor)
  - Limited resources (storage, graphic rendering)
- Advantages
  - Require lesser storage
  - Faster transmission / transferring
  - Low bandwidth consumption
  - Reduce redundancies

- Disadvantages
  - Lossy compression reduces quality of data
  - Lossless compression sometimes require lengthy decompression process
  - Require more processes (decompression when retrieving)
- Summary
  - Optimization is required to obtain the best in terms of compression rate and retrieval speed

Background of the problem

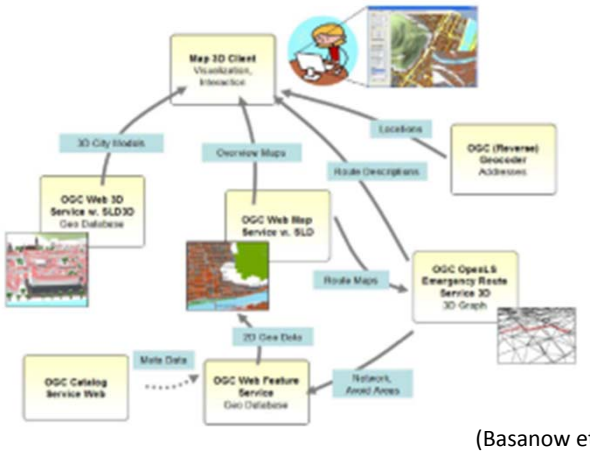
- Redundancies are found in meshes coordinate storage scheme (Deering, 1995)
- CityGML for a large city normally exceeds several Gigabytes (GB) (Mao, 2010)
- Bandwidth and resources limitations are common in mobile devices (Coors, 2007) & (Goetz, 2010)
- Specific compression algorithm may achieve 90% compression rate than a 60% - 70% common gzip compression (Goetz, 2010)

The motivation

- Various textual compressions library are available for general XML compression, but not specifically for GIS usage (e.g. Xmill, Xgrind, Xpress, XCQ).
- CityGML contents overhead generally > 60% for LOD3
- Better result is achievable by employing lossless compression on coordinates, leveraging the advantages of available textual compression library, e.g. LZMA or Gzip Algorithm / Fast Infoset (FI)

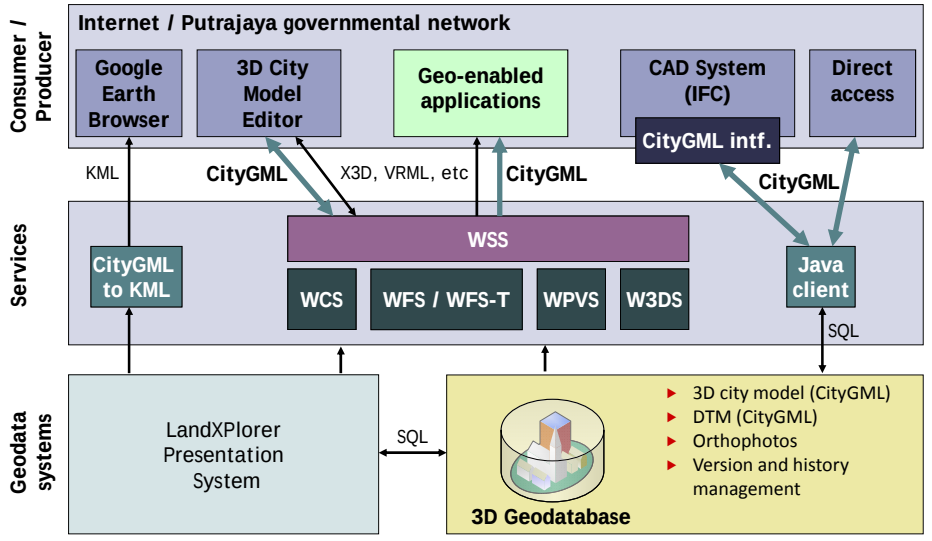
Example of 3D SDI

- Heidelberg 3D SDI



(Basanow et. al, 2007)

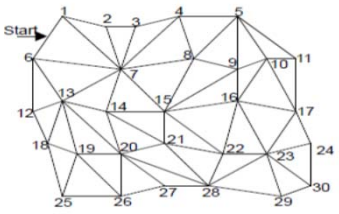
Putrajaya 3D SDI



T. Kolbe (2010)

Geometry / Connectivity Compression

Generalized Triangle Meshes



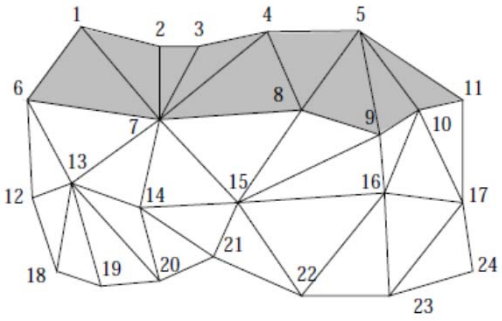
Generalized Triangle Strip:
R6, O1, O7, O2, O3, M4, M8, O5, O9, O10, M11,
M17, M16, M9, O15, O8, O7, M14, O13, M6,
O12, M18, M19, M20, M14, O21, O15, O22, O16,
O23, O17, O24, M30, M29, M28, M22, O21, M20,
M27, O26, M19, O25, O18

Generalized Triangle Mesh:
R6p, O1, O7p, O2, O3, M4, M8p, O5, O9p, O10, M11,
M17p, M16p, M-3, O15p, O-5, O6, M14p, O13p, M-9,
O12, M18p, M19p, M20p, M-5, O21p, O-7, O22p, O-9,
O23, O-10, O-7, M30, M29, M28, M-1, O-2, M-3,
M27, O26, M-4, O25, O-5

Legend:
First letter: R = Restart, O = Replace Oldest, M = Replace Mi
Trailing "p" = push into mesh buffer
Number is vertex number, -number is mesh buffer reference
where -1 is most recent pushed vertex.

(Deering, 1995)

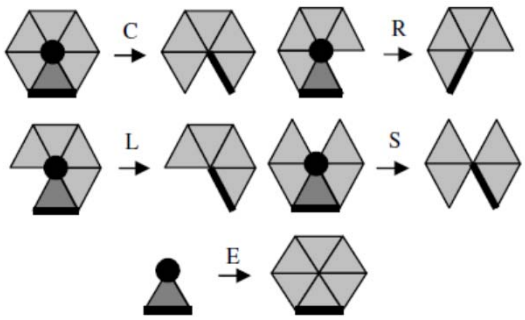
Triangle Strip Decomposition



vertex chain	vertex list	vertex degree
C^0	$< 1, 2, 3, 4, 5 >$	$< 0, 0, 0, 0, 0 >$
C^1	$< 6, 7, 8, 9, 10, 11 >$	$< 1, 4, 2, 1, 1, 1 >$
C^2	$< 12, 13, 14, 15, 16, 17 >$	$< 1, 2, 1, 3, 2, 2 >$
C^3	$< 18, 19, 20, 21, 22, 23, 24 >$	$< 2, 1, 2, 2, 2, 2, 1 >$

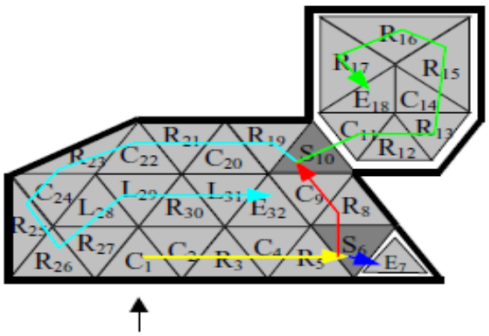
(Park et al, 1999)

EdgeBreaker



(Rossignac, 1999)

EdgeBreaker (cont.)

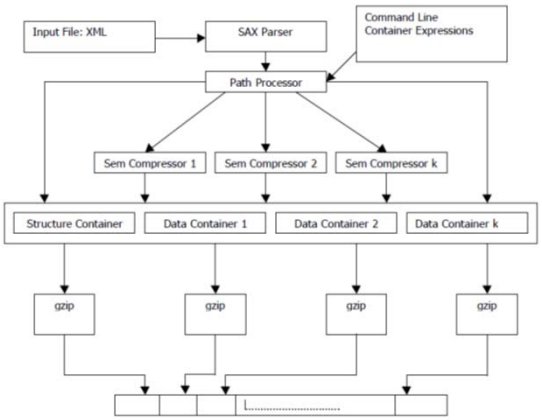


(Rossignac, 1999)

Output: CCRCRSERCSCRRCRRRERC RCRCRRRLLR L

XML / Textual Compression

XMill



(Liefke et al, 1999)

Description

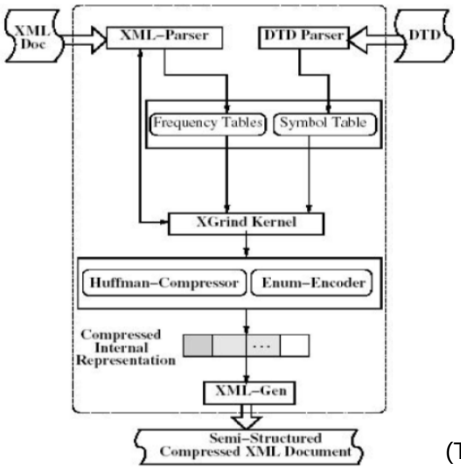
Advantages:

- Separate container for data and structure
- Path scanner

Limitations:

- No Coordinate Component
- No indexing for tag
- Gzip as the main compressor

XGrind



(Tolani et al, 2002)

Description

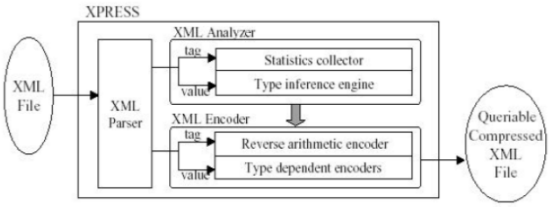
Advantages:

- DTD Parser
- Statistic collected

Limitations:

- No coordinate component
- No indexing for tag

Xpress



(Min et al, 2003)

Description

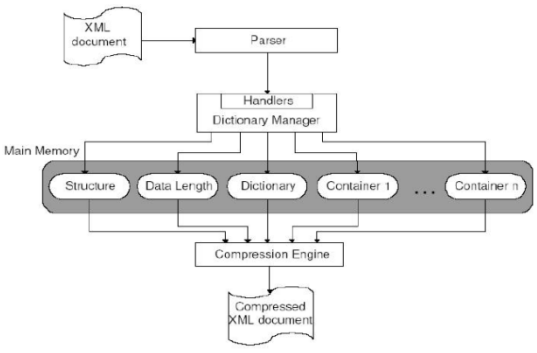
Advantages:

- Analyzer that provides type inference capability, statistic collector
- Encoding on type-dependent
- Query-able

Limitations:

- No Coordinate Component (Redundancy is expected)
- No indexing for tag

XComp



(Li et al, 2003)

Description

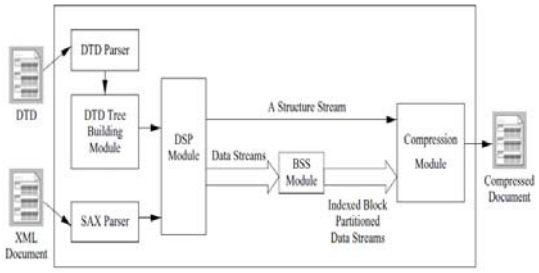
Advantages:

- DTD Parser
- Separate container for data and structure

Limitations:

- No Coordinate Component
- No indexing for tag
- Query-able: NO

XCQ



(Ng et al, 2006)

Description

Advantages:

- DTD Parser
- Indexing
- Blocks differentiating Structure Stream and Data Stream

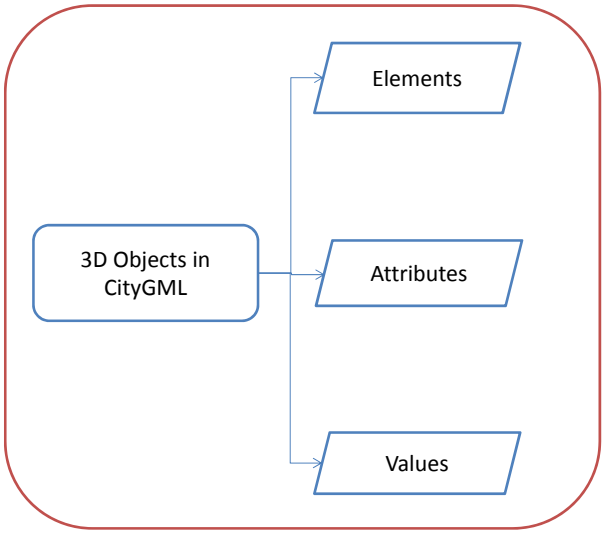
Summary:

- Effective
- Geometry and connectivity component could be embedded

The methodology

- Using XML compression technique to scan CityGML
- Detect redundancies and perform data mapping as well as data referencing
- URIs (unique resource identifier) are used to maintain connectivity (Xlink)
- Coordinates are scanned and quantized
- Gzip the scanned document at final stage

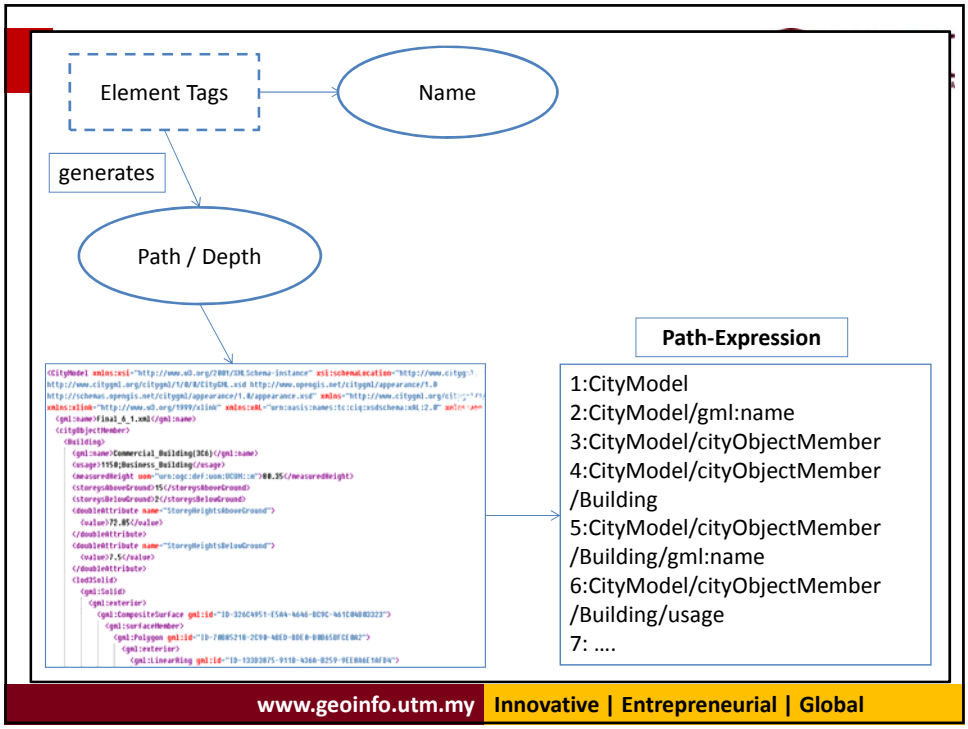
Components Break-down



The XML Component

CityGML Structure (Putrajaya 3D Building)

```
<CityModel xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.citygml.
http://www.citygml.org/citygml/1/0/0/CityGML.xsd http://www.opengis.net/citygml/appearance/1.0
http://schemas.opengis.net/citygml/appearance/1.0/appearance.xsd" xmlns="http://www.citygml.org/citygml/1/
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xAL="urn:oasis:names:tc:ciq:xsdschema:xAL:2.0" xmlns:app
  <gml:name>Final_6_1.xml</gml:name>
  <cityObjectMember>
    <Building>
      <gml:name>Commercial_Building(3C6)</gml:name>
      <usage>1150;Business_Building</usage>
      <measuredHeight uom="urn:ogc:def:uom:UCUM::m">80.35</measuredHeight>
      <storeysAboveGround>15</storeysAboveGround>
      <storeysBelowGround>2</storeysBelowGround>
      <doubleAttribute name="StoreyHeightsAboveGround">
        <value>72.85</value>
      </doubleAttribute>
      <doubleAttribute name="StoreyHeightsBelowGround">
        <value>7.5</value>
      </doubleAttribute>
      <lod3Solid>
        <gml:Solid>
          <gml:exterior>
            <gml:CompositeSurface gml:id="ID-326C4951-E5A4-4646-BC9C-461C04B03323">
              <gml:surfaceMember>
                <gml:Polygon gml:id="ID-70B85218-2C90-4BED-BDE0-B0B65BFCE0A2">
                  <gml:exterior>
                    <gml:LinearRing gml:id="ID-133D3875-911B-436A-B259-9EE8A6E1AFD4">
```


Element Tags
Name
generates
Path / Depth
Path-Expression
1:CityModel
2:CityModel/gml:name
3:CityModel/cityObjectMember
4:CityModel/cityObjectMember
/Building
5:CityModel/cityObjectMember
/Building/gml:name
6:CityModel/cityObjectMember
/Building/usage
7: ....
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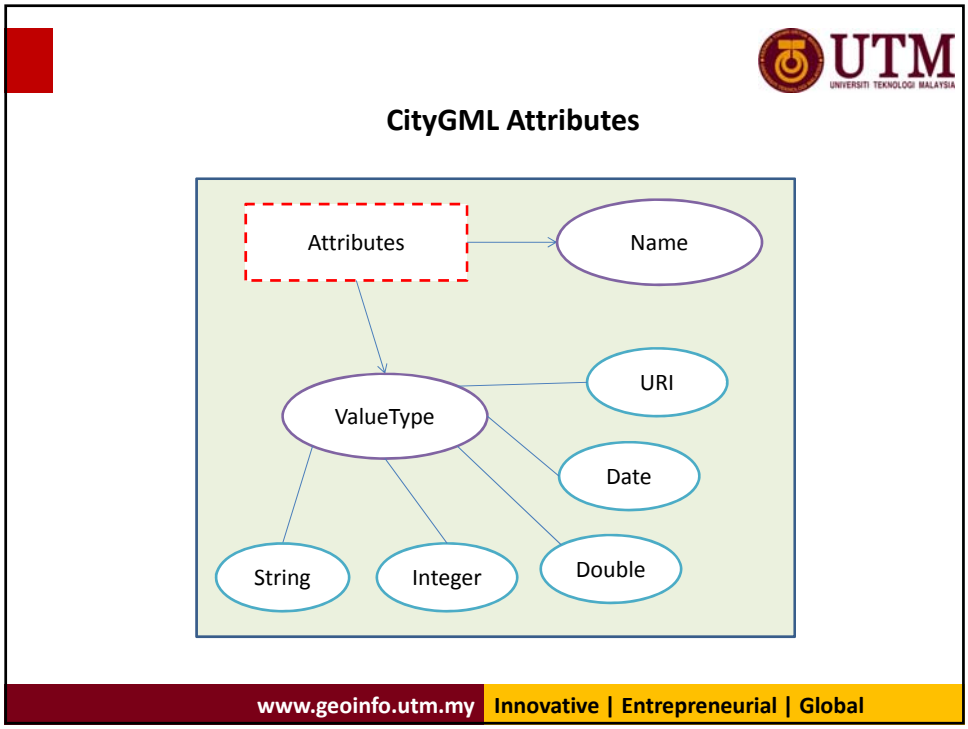
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CityGML Attributes
Attributes
Name
URI
ValueType
Date
String
Integer
Double
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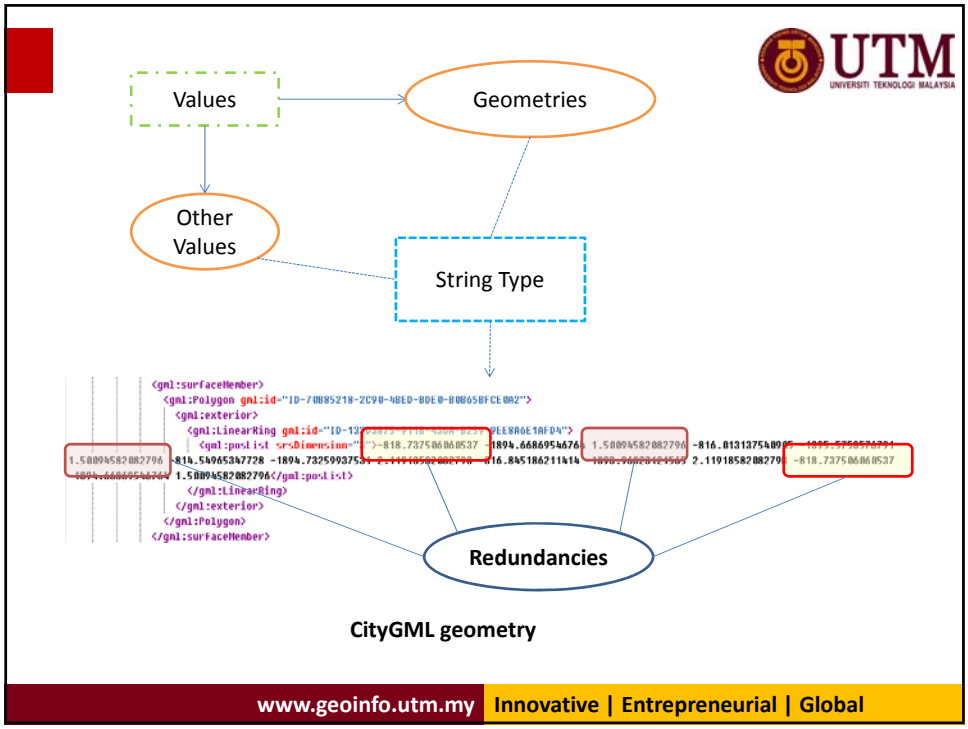
Values
Geometries
Other Values
String Type
Redundancies
CityGML geometry
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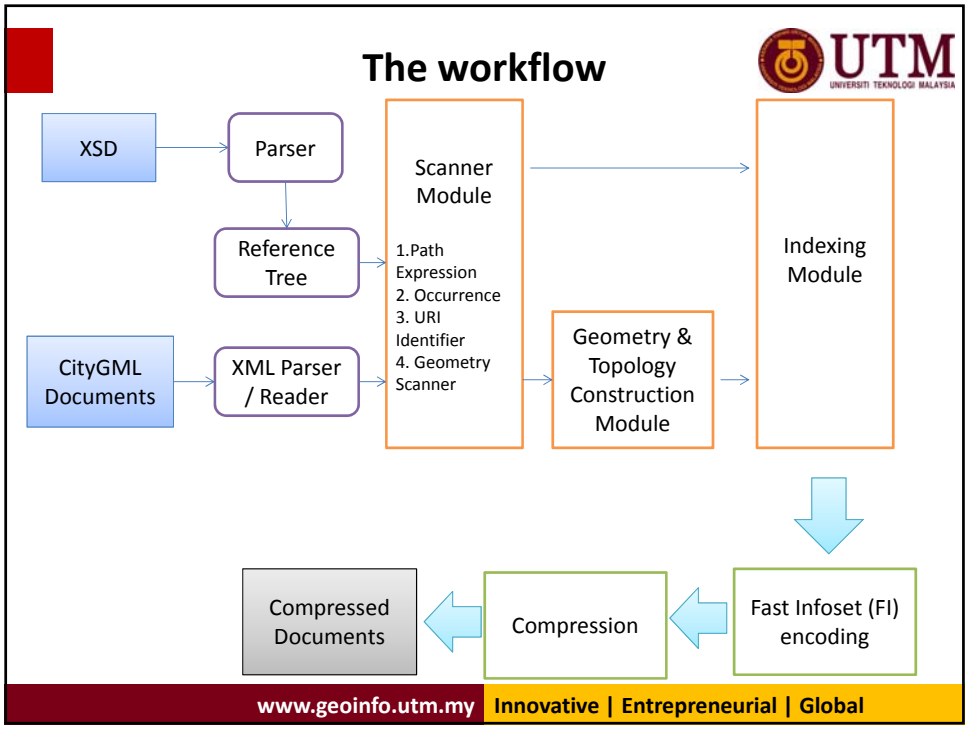
The workflow
XSD
Parser
Reference Tree
CityGML Documents
XML Parser / Reader
Scanner Module
1.Path Expression
2. Occurrence
3. URI Identifier
4. Geometry Scanner
Geometry & Topology Construction Module
Indexing Module
Fast Infoset (FI) encoding
Compression
Compressed Documents
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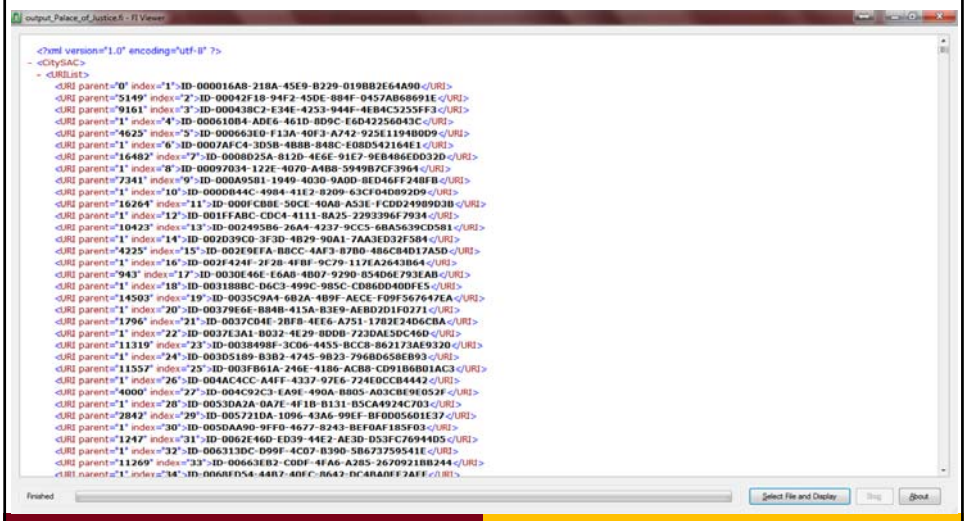
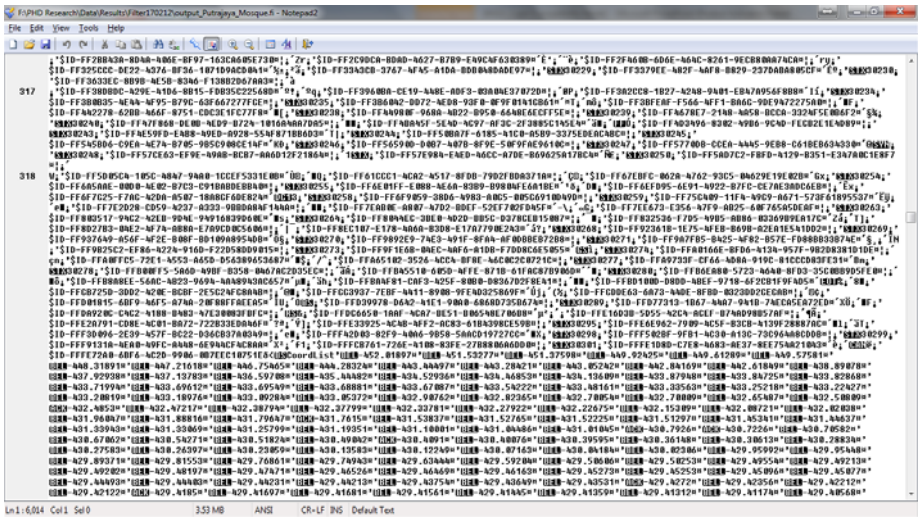
Advantages & applications

- Scanned data can be used for small devices for visualization
- Web service component
- Scanned document is a compact version, smaller in size after decoded / decompressed, and lossless type
- The framework enable implementation of different compression techniques
- Future development ensure external referenced files (texture images) are packaged within an archive

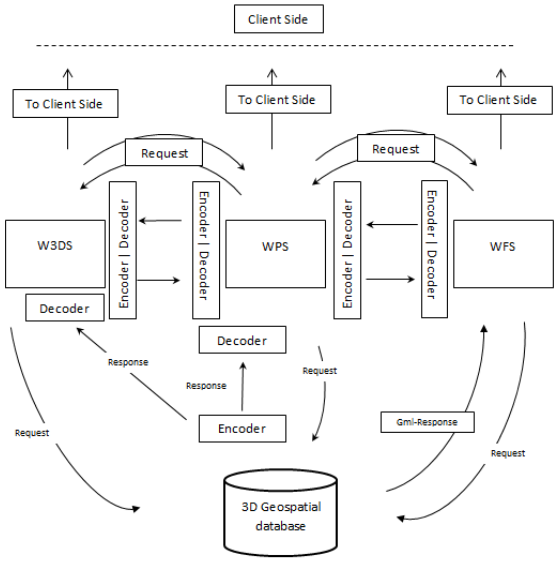
URI relationship (generated document)



Encoded Document



The Proposed Compression for Putrajaya 3D SDI



Concluding remarks

- We intend to make use of XMill compression technique for XML-based files within the Putrajaya 3DSDI case study
- Encoded document will be packaged as an archive for textures
- Javascript decoder for common browser / cross platform mobile
- Server side implementation for web service data transfer

That's all, thank you!

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