A Proposed Framework for Achieving High Level Automation in Cadastral Processing

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XXV FIG Congress
Kuala Lumpur, Malaysia
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Outline

- Context and Background
- 3D LandXML
  - reasoning and inference
- Proposed Framework using Web Ontology Language (OWL)
  - LADM in OWL
- Linking 3D LandXML and OWL with IRI
- Benefits
- Conclusions

XXV International Federation of Surveyors Congress, Kuala Lumpur, Malaysia, 16 – 21 June 2014

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"Smart" Nation

singapore

'Smart' Singapore will use technology to improve lives

Republic aims to be first smart nation as President notes rising demands on infrastructure

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BY XUE JIANYUE

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SINGAPORE — As cities around the world embark on ways to make themselves "smart" through the use of technology and data to improve the quality of life, Singapore will be aiming to go a step further by becoming the first smart nation.

President Tony Tan laid out the Government's plans for the second half of its term yesterday, noting the rising demands on amenities, infrastructure and resources as the Republic develops, and underlining its ambitions to improve the lives of citizens by making "full use of new technologies to develop sustainable and innovative solutions".

Related news

SINGAPORE
A Smart Singapore in the works
1 WEEK 3 DAYS AGO

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Inside Singapore

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The Most Singapore
READ COMMENTED

1. Singapore braces for worst

smart: *(of systems) operating as if by human intelligence by using automatic computer control*

(Collins English Dictionary)

http://www.todayonline.com/singapore/smart-singapore-will-use-technology-improve-lives

Context

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- How to be "smart" in Cadastral Processing?
- Propose a framework to complement the current automation technique based on LandXML with Semantic Web Technology using OWL (Web Ontology Language)
- OWL attempts to support human intelligence with reasoning and inference by computer systems

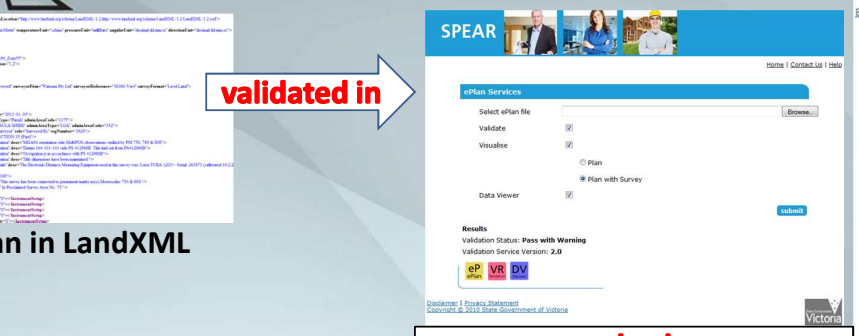
Background

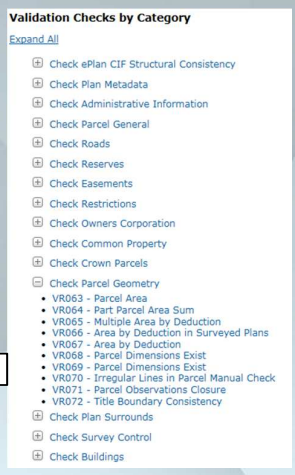
- automated cadastral processing is implemented using LandXML by ICSM's ePlan Working Group in Australia and New Zealand

Victoria's SPEAR

validated in

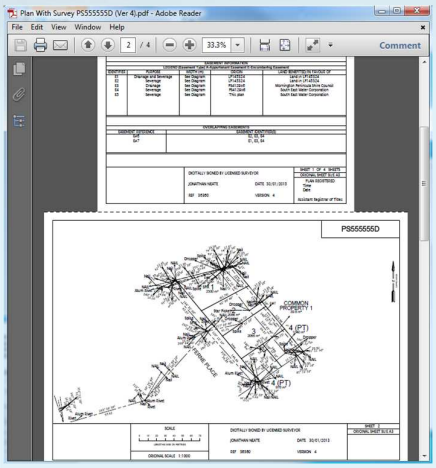
Survey Plan in LandXML

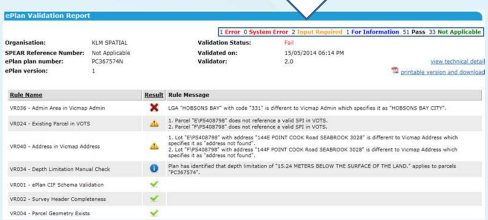




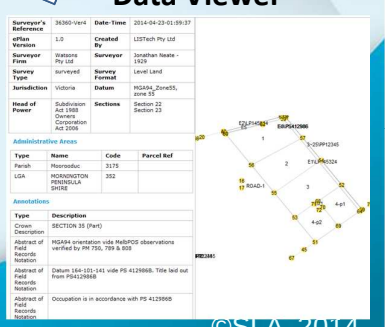
outputs

Plan in PDF





Data Viewer



https://www.spear.land.vic.gov.au/spear/eplanPublicServices/Prepare.do

Development in Singapore

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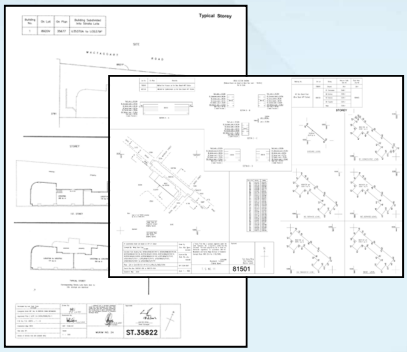
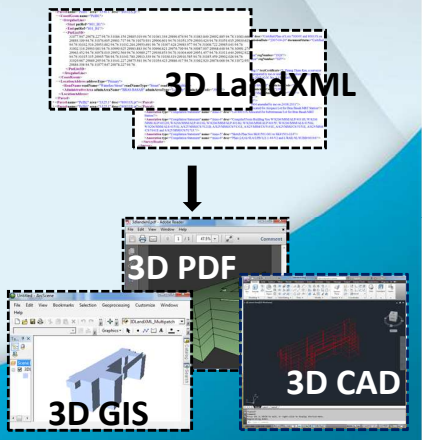
- The Land Survey Division of Singapore Land Authority (SLA) has embarked on 3D Cadastres and automated cadastral processing using LandXML

Paper Plan → **Image Plan** → **LandXML + 3D**





Enhanced LandXML to Store 3D

SINGAPORE

```
- <Parcels>
  - <Parcel name="70021N/1">
    - <CoordGeom>
      - <IrregularLine>
          <Start pntRef="433a"/>
          <End pntRef="433a"/>
          <PntList3D>29452.018 30232.133 123.280 29452.832 30216.800 123.280 29425.899 30215.278 123.280 29422.375 30281.345 123.280 29482.916
            30284.567 123.280 29484.221 30260.005 123.280 29451.876 30258.266 123.280 29452.008 30255.922 123.280 29452.207 30250.316 123.280
            29451.056 30250.256 123.280 29452.018 30232.133 123.280</PntList3D>
        </IrregularLine>
      </CoordGeom>
    </Parcel>
  + <Parcel name="70021N/2">
  + <Parcel name="70021N/3">
  + <Parcel name="70021N/4">
  + <Parcel name="70021N/5">
  + <Parcel name="70021N/6">
  + <Parcel name="70021N/7">
  + <Parcel name="70021N/8">
  + <Parcel name="70021N/9">
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  + <Parcel name="70021N/11">
  + <Parcel name="70021N/12">
  + <Parcel name="70020K/1">
  + <Parcel name="70020K/2">
  + <Parcel name="70020K/3">
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  + <Parcel name="70020K/24">
  + <Parcel name="70020K/25">
  + <Parcel name="70020K/26">
  + <Parcel name="70020K/27">
  - <Parcel name="70021N" parcelFormat="Volumetric" area="2621.4">
    - <Parcels>
        <Parcel name="Face1" pclRef="70021N/1"/>
        <Parcel name="Face2" pclRef="70021N/2"/>
        <Parcel name="Face3" pclRef="70021N/3"/>
        <Parcel name="Face4" pclRef="70021N/4"/>
        <Parcel name="Face5" pclRef="70021N/5"/>
        <Parcel name="Face6" pclRef="70021N/6"/>
        <Parcel name="Face7" pclRef="70021N/7"/>
```
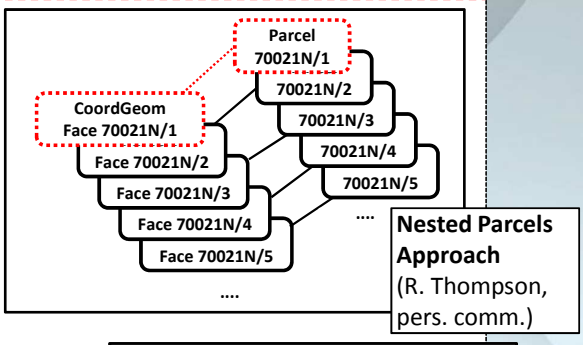
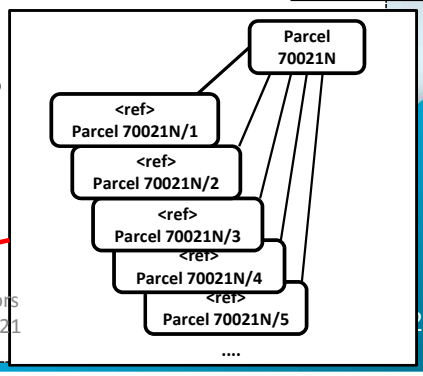

Every face is defined with coordinates thru PntList3D



Nested Parcels Approach (R. Thompson, pers. comm.)

all related faces are referenced to form a Volumetric 3D Parcel



High Level Automation

- Simply stores 3D data and be able to be parsed by computer systems are not enough
- Human intelligence by computer systems is required to achieve high level automation
- Human intelligence involves reasoning and inference, which generally refer to *understanding from what is defined (i.e. reasoning) to create new knowledge (inference)*

Scenario

- *LandXML A captures: Place X is located in Place Y*
- *LandXML B captures: Place Y is located in Place Z,*

if one is to ask "give me all LandXML files of Place Z", the result commonly does not include LandXML A as "Place X is located in Place Z" is not captured

reasoning: what does "located in" characterize? It is transitive: If A located in B, B located in C -> A located in C

inference: Place X is located in Place Z (new knowledge)

∴ Computer systems are able to return LandXML A even "Place X is located in Place Z" is not captured

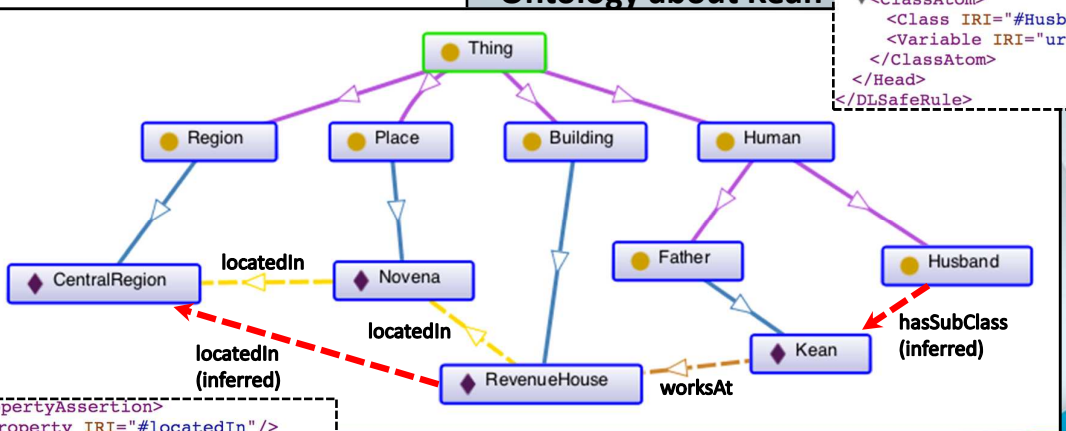
A Proposed Framework

- to support 3D LandXML with Web Ontology Language (OWL), which is a XML-variant language based on Description Logics
- OWL allows to construct ontology, which consists of common definitions used in the domain;
- OWL enables computer systems to do reasoning and make inference;

reasoning and inference with OWL

OWL Ontology

Ontology about Kean



Rule: Father (?x) -> Husband (?x)

```
<DLSafeRule>
 <Body>
  <ClassAtom>
   <Class IRI="#Father"/>
   <Variable IRI="urn:swrl#x"/>
  </ClassAtom>
 </Body>
 <Head>
  <ClassAtom>
   <Class IRI="#Husband"/>
   <Variable IRI="urn:swrl#x"/>
  </ClassAtom>
 </Head>
</DLSafeRule>
```

```
<ObjectPropertyAssertion>
  <ObjectProperty IRI="#locatedIn"/>
  <NamedIndividual IRI="#Novena"/>
  <NamedIndividual IRI="#CentralRegion"/>
</ObjectPropertyAssertion>
<ObjectPropertyAssertion>
  <ObjectProperty IRI="#locatedIn"/>
  <NamedIndividual IRI="#RevenueHouse"/>
  <NamedIndividual IRI="#Novena"/>
</ObjectPropertyAssertion>
```

"locatedIn" relation between classes

"locatedIn"'s characteristic: transitive

```
<TransitiveObjectProperty>
  <ObjectProperty IRI="#locatedIn"/>
</TransitiveObjectProperty>
```

Web Ontology Language (OWL)

- Supports formal semantics and rules, which enable to characterize:
  - Classes and Instances
  - Class Hierarchies
  - Class Disjointness
  - Object Properties
  - Property Hierarchies
  - Domain and Range Restrictions
  - Equality and Inequality of Individuals
  - Datatypes
  - Complex Classes
  - Property Restrictions
  - Property Cardinality Restrictions
  - Enumeration of Individuals
  - Property Characteristics
  - Property Chains

e.g.
```
<DisjointClasses>
    <Class IRI="LandLot"/>
    <Class IRI="StrataLot"/>
</DisjointClasses>
```
LandLot::= ¬ StrataLot

e.g.
```
<EquivalentClasses>
    <Class IRI="Father"/>
    <ObjectIntersectionOf>
        <Class IRI="Man"/>
        <Class IRI="Parent"/>
    </ObjectIntersectionOf>
</EquivalentClasses>
```
Father::= Parent ∩ Man

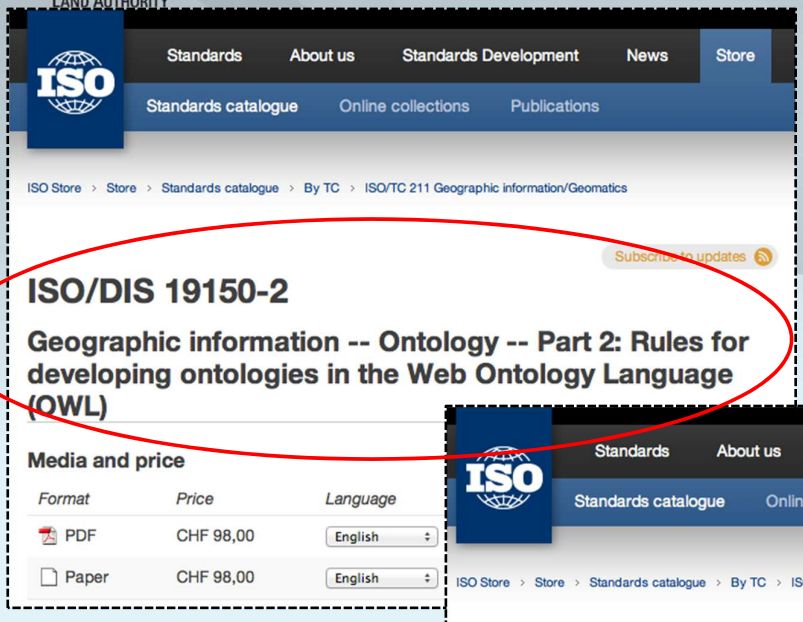
e.g.
```
<TransitiveObjectProperty>
    <ObjectProperty IRI="locatedIn"/>
</TransitiveObjectProperty>
```
locatedIn as transitive

reference: http://www.w3.org/TR/owl2-primer/

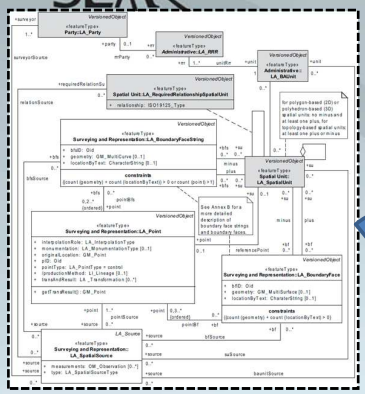
- Every class, instance, property (relationship) has a unique IRI (International Resource Identifier), e.g.

```
<owl:Class rdf:about="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl#BoundaryFace">
```


Draft ISO 19150



LADM in OWL



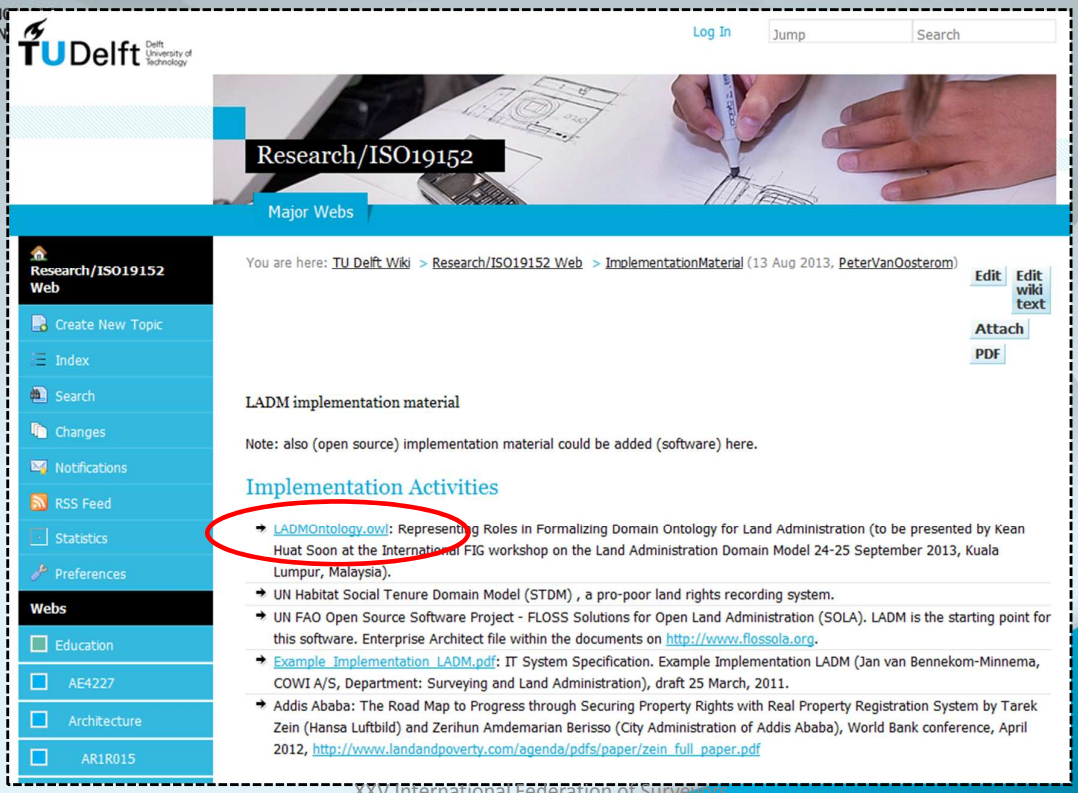
LADM in UML models

LADM (Land Administration Domain Model, ISO 19152), which is in UML models, is formalized in OWL

LADM in OWL

```
<Ontology xmlns="http://www.w3.org/2002/07/owl#" xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#" xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xml:base="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl"
ontologyIRI="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl">
  <Prefix name="" IRI="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl#"/>
  <Prefix name="owl" IRI="http://www.w3.org/2002/07/owl#"/>
  <Prefix name="rdf" IRI="http://www.w3.org/1999/02/22-rdf-syntax-ns#"/>
  <Prefix name="xsd" IRI="http://www.w3.org/2001/XMLSchema#"/>
  <Prefix name="rdfs" IRI="http://www.w3.org/2000/01/rdf-schema#"/>
  <Prefix name="swrl" IRI="http://www.w3.org/2003/11/swrl#"/>
  <Prefix name="swrlb" IRI="http://www.w3.org/2003/11/swrlb#"/>
  <Prefix name="owl2xml" IRI="http://www.w3.org/2006/12/owl2-xml#"/>
  <Prefix name="LADMOntology" IRI="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl#"/>
▼<Declaration>
    <Class IRI="#AdminPublicServitude"/>
  </Declaration>
▼<Declaration>
    <Class IRI="#AdminSource"/>
  </Declaration>
▼<Declaration>
    <Class IRI="#AgriActivity"/>
  </Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▼<Declaration>
    <Class IRI="#BoundaryFaceString"/>
  </Declaration>
▼<Declaration>
    <Class IRI="#CertifiedSurveyor"/>
  </Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▼<Declaration>
    <Class IRI="#Conveyancer"/>
  </Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
▶<Declaration>...</Declaration>
```


available @ LADM Wiki



http://wiki.tudelft.nl/bin/view/Research/ISO19152/ImplementationMaterial

OWL + 3D LandXML

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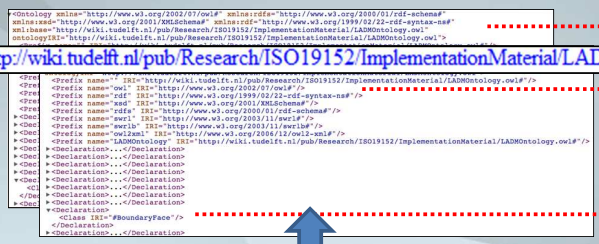
LADM OWL Ontology + Ontologies + Rules

Knowledge Tier

e.g.

<owl:Class rdf:about="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl#BoundaryFace">

Reasoning + Inference



Interlinking OWL and LandXML by populating DocFileRef of LandXML with IRI of related classes/relationships in OWL

the Framework will allow computer system to perform reasoning & inference in OWL ontology and parse 3D surveying data in LandXML

Data Tier

3D Data + Survey Details + Observations, etc

e.g.

<DocFileRef name="ParcelFace" location="http://wiki.tudelft.nl/pub/Research/ISO19152/ImplementationMaterial/LADMOntology.owl#BoundaryFace"/>

Benefits

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- computers are able to interpret semantics in LandXML;

e.g.

<Parcel class="**LandLot**" ...>
LandXML

reason and infer in

<**DisjointClasses**>
<Class IRI="**LandLot**"/>
<Class IRI="**StrataLot**"/>
</DisjointClasses>
OWL

computer interprets

"Land Lot is not Strata Lot"

- allow automated tools to share and process information;

e.g.

Looking for LandXMLs of "Land Lot"?

reason and infer in

<**SubClassOf**>
<Class IRI="**AirspaceLot**"/>
<Class IRI="**LandLot**"/>
</SubClassOf>
OWL

return with

<Parcel class="**AirspaceLot**" ...>
LandXML

- provide ways to discover, represent and give a context to information;
- allow information resources to be linked up, to be automatically understandable and reusable by computer applications

Conclusions

- proposed potential enhancement to existing validation tools by using semantic web technology
- discussed using OWL ontology, which describes declarative knowledge (facts) and procedural knowledge (rules) to support automation and integration
- demonstrated the linking of 3D LandXML and OWL with IRI to provide a semantic-aware framework for cadastral processing
- the same approach can also be applied to other XMLs like CityGML (e.g. thru *codeSpace*) without changing the schemas

Thank You!

(hopefully one day our computer systems will achieve wisdom)

soon_kean_huat@sla.gov.sg