Towards Geo-spatial Application Provisioning: *Modeling Spatial data and Computation in Geo-Cloud*

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Contents


Overview of Geo-spatial Application
Modeling
Integration
Geo-spatial Cloud
Interoperability
Deployment in IIT Kharagpur Private Cloud

Geospatial Application

People

Decisions

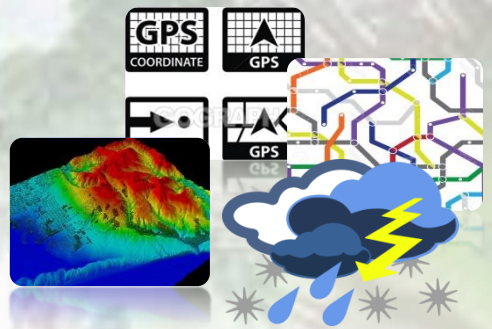
Data

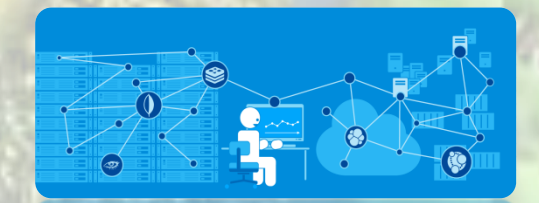
GIS

Analysis

Tools/ Methods

Visualization and Maps



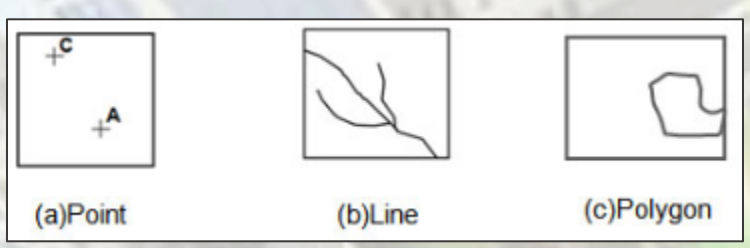


Identify → Analyze → Inference

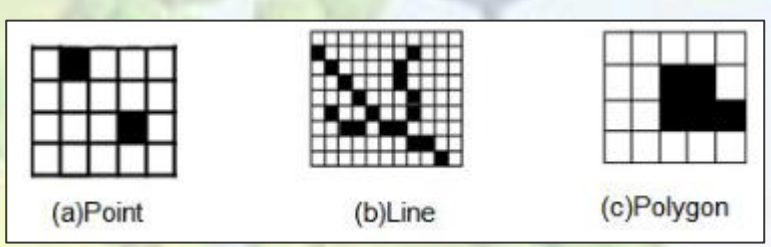
Spatial Data Modeling

- Spatial data is comprised of objects in multi-dimensional space

Vector Data Model



Raster Data Model



- Need a structural representation of spatial data sets – *easy to share, access and analyze!*

Spatial Data Modeling?

Logical Data Modeling

Logical Data Model to XMI and XSD

Logical Data Model to Database Schema

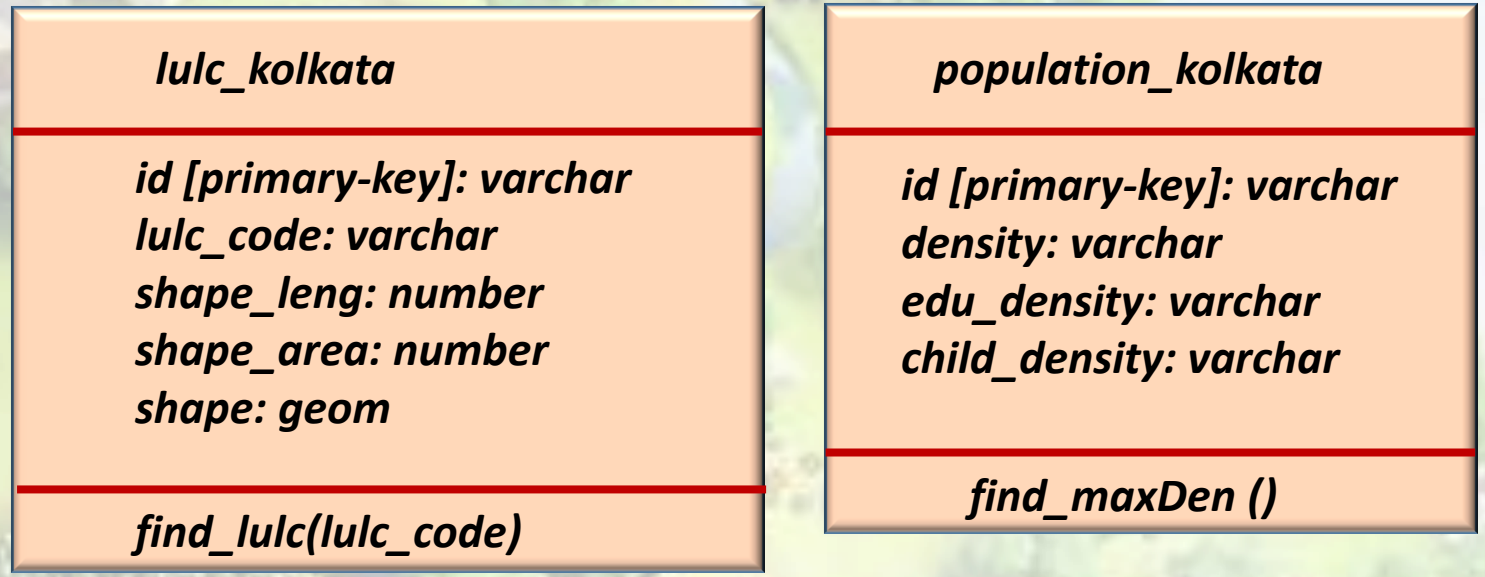
Logical Data Modeling

A ***logical data model*** or logical schema is a data model of a specific problem domain expressed independently of a particular database management product or storage technology (physical data model) but in terms of data structures such as relational tables and columns, object-oriented classes, or XML tags.

A logical data model (class diagram) includes

- **entities** (tables)
- **attributes** (columns/fields) and
- **relationships** (keys)

Logical data model of a ROI

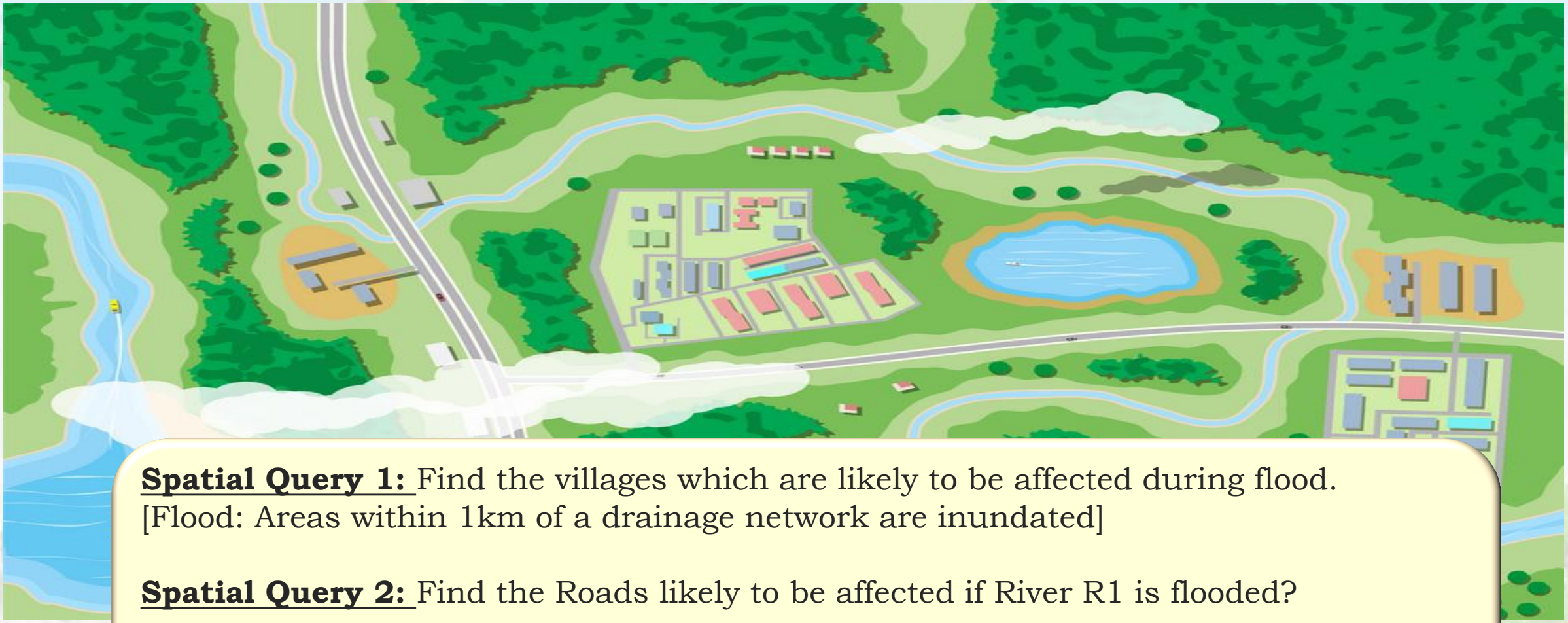


Logical Data Model (Class Diagram) of Spatial Data Repositories

DEMO

Example Scenario

Consider 4 independent repositories of a region **P**, namely, ***ROAD (R), DRAINAGE (D), VILLAGE (V)*** and ***ADMIN BLOCKS (A)***.
[Road: Polyline; Drainage: Polyline; Village: Point; Admin: Polygon]



Spatial Query 1: Find the villages which are likely to be affected during flood.
[Flood: Areas within 1km of a drainage network are inundated]

Spatial Query 2: Find the Roads likely to be affected if River R1 is flooded?

Spatial Query 3: To setup a new industry the requirement is: It should be in Admin Blocks A2 or A7, 2km from NH, no Drainage within 1km, within 5kmof villages with working population (20-50yrs) greater than 100

Consider 4 independent repositories of a region **P**, namely, ***ROAD (R), DRAINAGE (D), VILLAGE (V)*** and ***ADMIN BLOCKS (A)***. [Road: Polyline; Drainage: Polyline; Village: Point; Admin: Polygon]

Spatial Query 1: Find the villages which are likely to be affected during flood.
[Flood: Areas within 1km of a drainage network are inundated]

```
SELECT V.vill_id, V.vill_name FROM VILLAGE V, DRAINAGE D
    WHERE OVERLAP(V.shape, BUFFER(D.shape,1000))=1;
```

Spatial Query 2: Find the Roads likely to be affected if River R1 is flooded?

```
SELECT R.road_id, V.vill_name FROM VILLAGE V, DRAINAGE D
    WHERE OVERLAP(V.shape, BUFFER(D.shape,1000))=1
        AND D.dr_name="R1";
```

Consider 4 independent repositories of a region **P**, namely, ***ROAD (R), DRAINAGE (D), VILLAGE (V)*** and ***ADMIN BLOCKS (A)***. [Road: Polyline; Drainage: Polyline; Village: Point; Admin: Polygon]

Spatial Query 3: To setup a new industry the requirement is: It should be in Admin Blocks A2 or A7, 2km from NH, no Drainage within 1km, within 5kmof villages with working population (20-50yrs) greater than 100

```
Create VIEW REG AS(
SELECT INTERSECT(V.shape,A.shape) AS REG_SHAPE FROM ROAD R, DRAINAGE D, VILLAGE V,
CITIZEN C WHERE
OVERLAP(V.shape, BUFFER(D.shape,1000))=0 AND
OVERLAP(V.shape, BUFFER(R.shape,2000))=1 AND COUNT(C.citizen_id)>=100 WHERE
C.age>20 AND C.age<50 AND C.residential==V.vill_id)


SELECT INTERSECT (REG_SHAPE,A.shape) FROM REG, ADMIN_BLOCKS A
WHERE
A.block_name IN ("A2","A7") AND
OVERLAP(A.shape, BUFFER(REG_SHAPE,5000))==1
```

Logical Data Model to XMI and XSD

- **XML** is a ***markup language*** that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable

- Main purposes behind the proposal of XMI were as follows:
  - To help programmers, using the Unified Modeling Language (UML), with different languages and development tools to exchange their data models with each other
  - To facilitate in exchanging information about data warehouses

- **XSD** is an XML schema definition language which can be used to express a set of rules to which an XML document must conform in order to be considered 'valid' according to that schema
- It is designed with the intent that determination of a document's validity would produce a collection of information, adhering to specific data types

Exporting Logical Data Model to XMI

DEMO

Exporting Logical Data Model to XSD

DEMO

Logical Data Model to Database Schema

- A database schema of a database system is *its structure described in a formal language supported by the database management system* (DBMS)
- It refers to the organization of data as a blueprint of how a database is constructed (*divided into database tables in case of Relational Databases*)
- In the context of Oracle databases, a *schema object is a logical data storage structure*
- In general, the *language by which the database schema is described is called Data Definition language* (DDL)

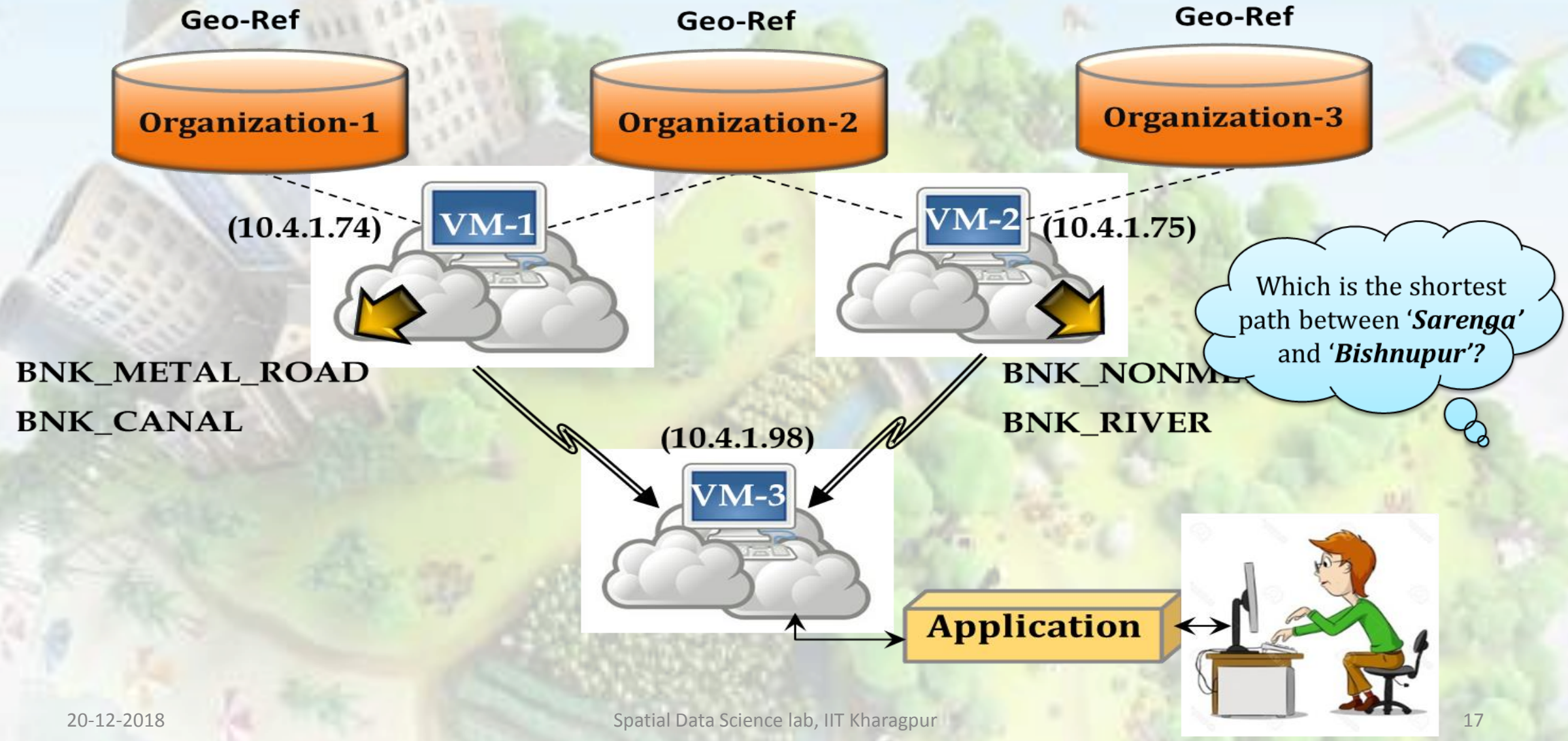
Exporting Logical Data Model to DDL

DEMO

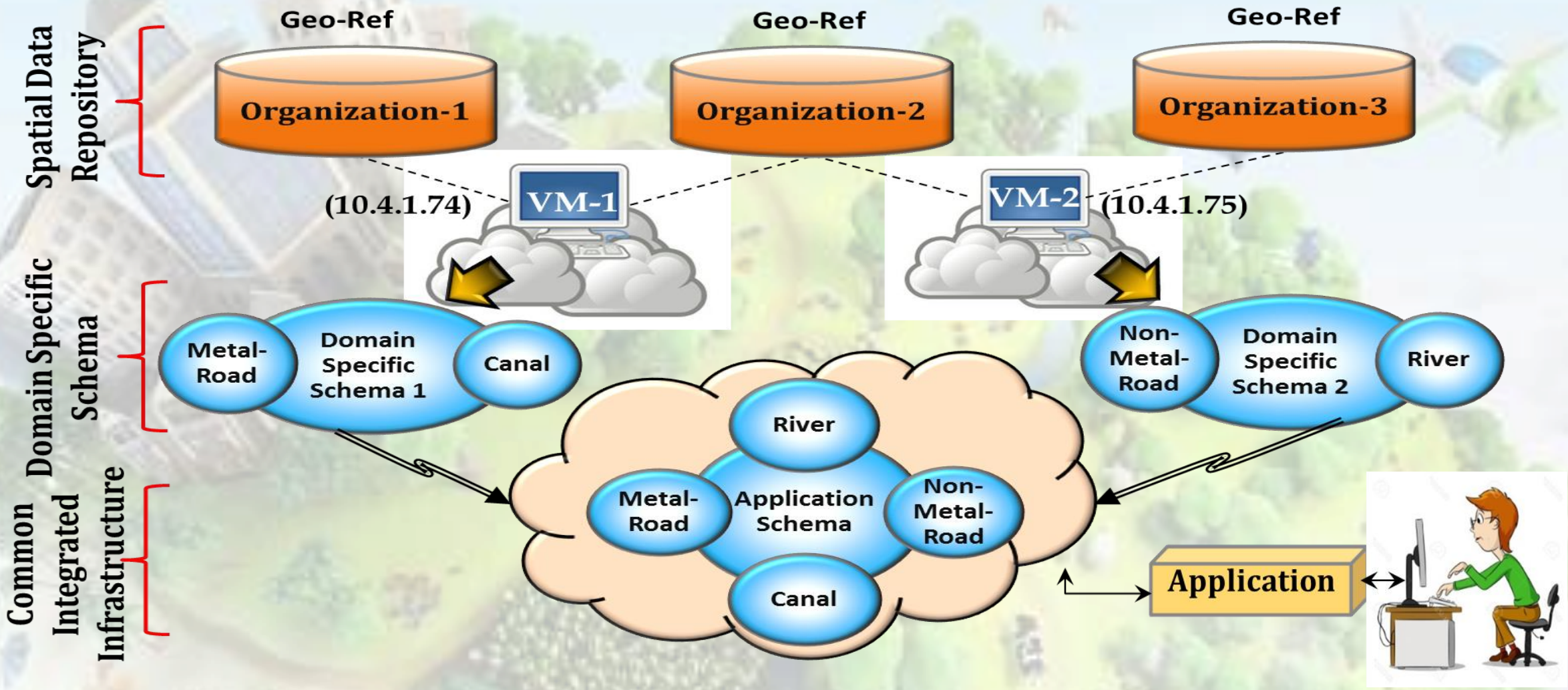
Integration of Data Models?

- Every organization has own data repository of geo-databases
- *Data repositories are isolated* because of no sharing mechanism
- The *formats of data in repositories are varying among organizations*
- Meaning of another organization's data difficult *to interpret*
- Sharing of data will be very *effective* if data repositories are integrated

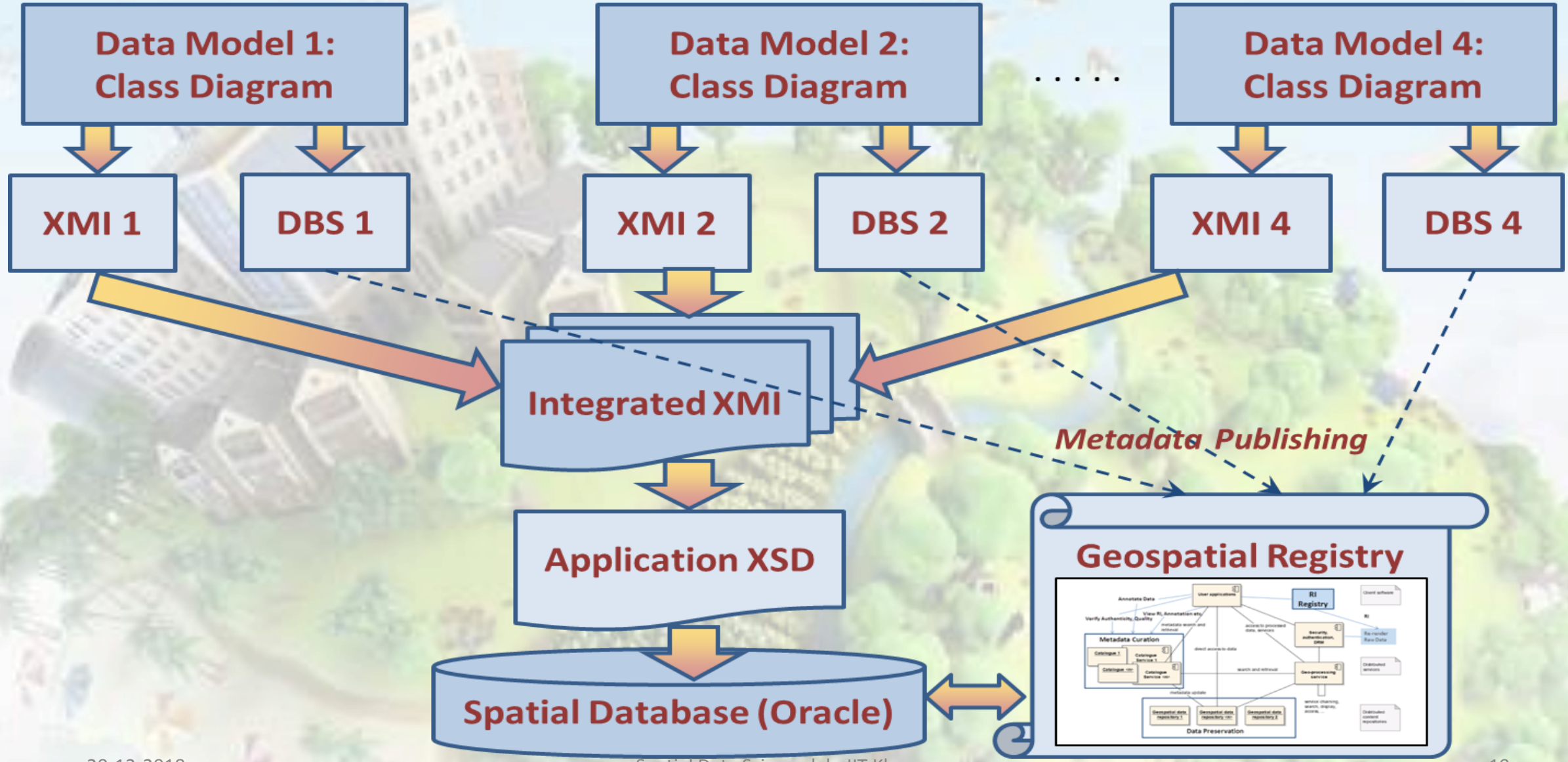
Integration of Data Models?



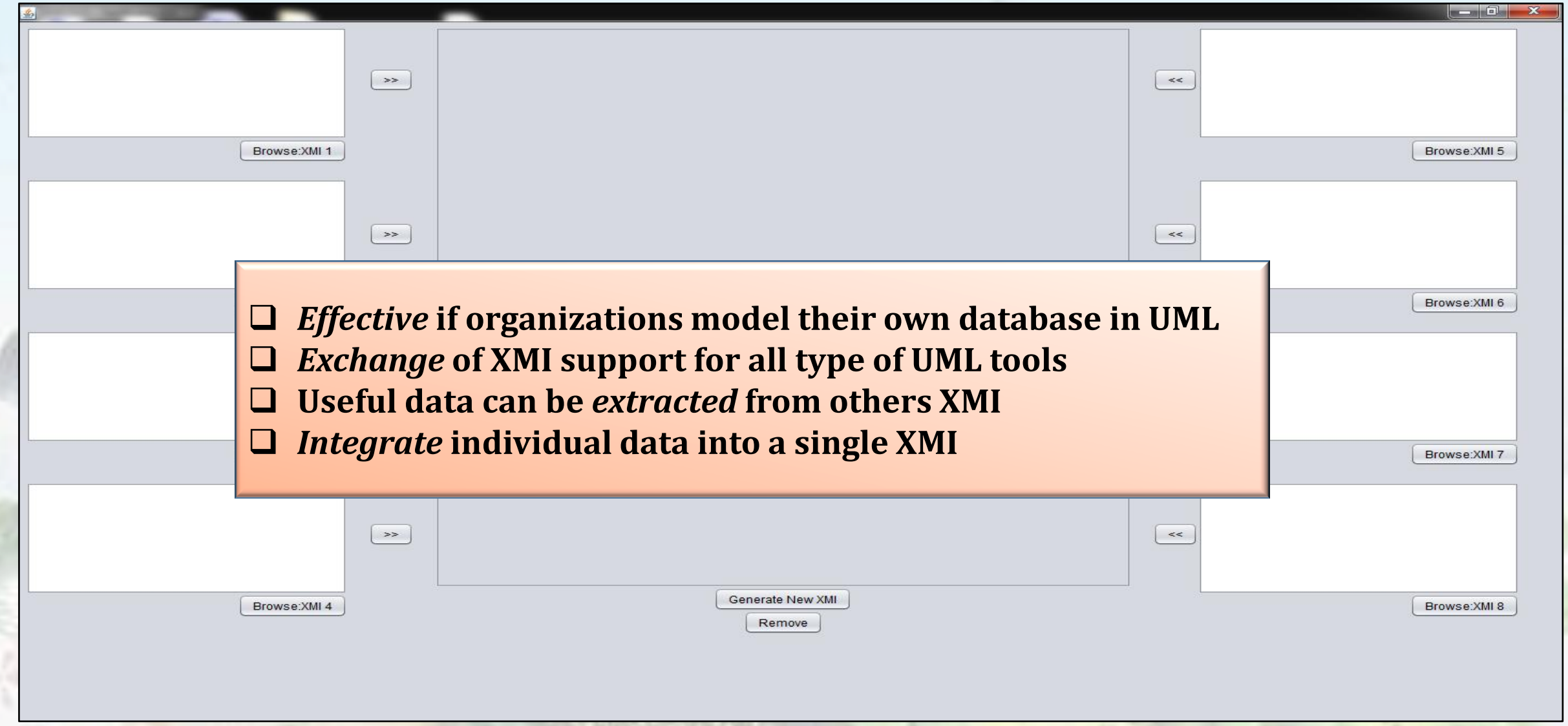
Integration of Data Models



Integration of Data Models



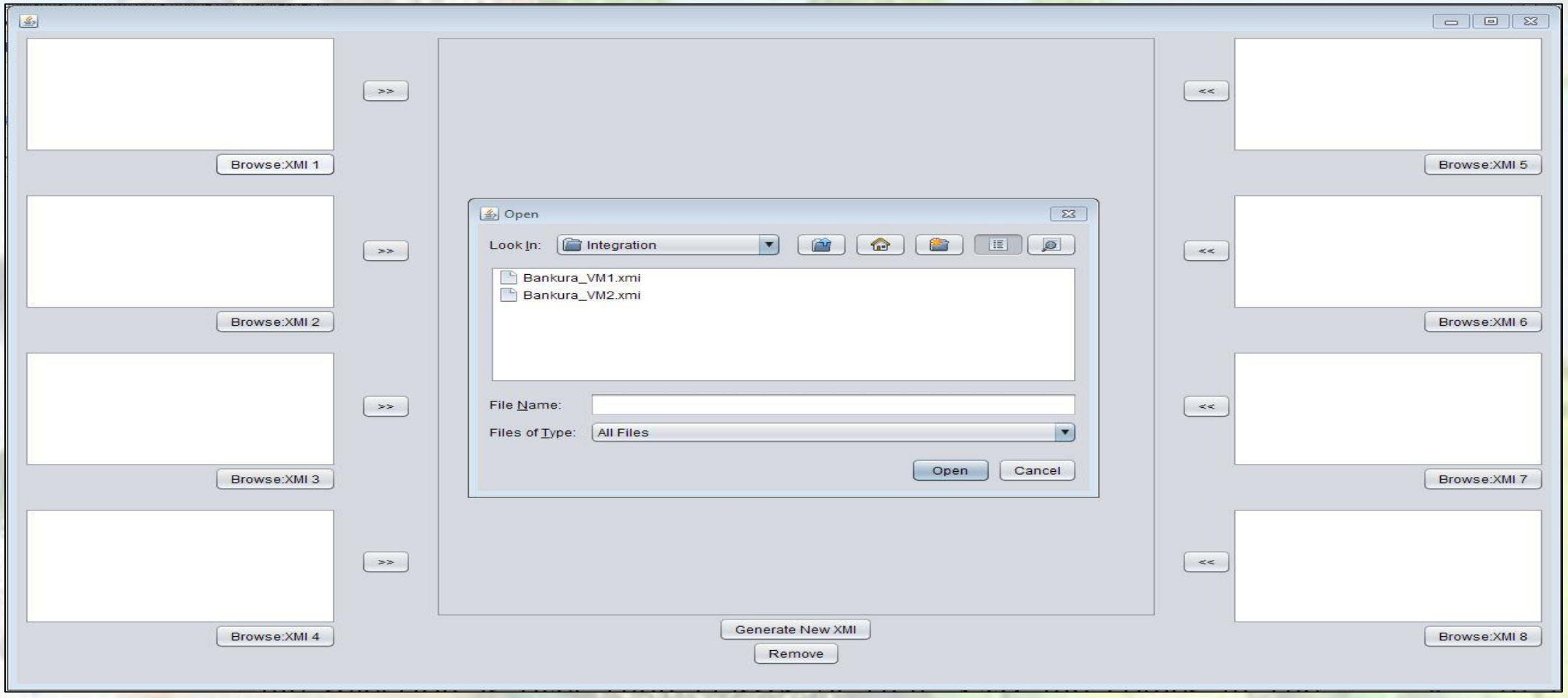
Integrated XMI Generation: GUI Design



- ***Effective*** **if organizations model their own database in UML**
- ***Exchange*** **of XMI support for all type of UML tools**
- **Useful data can be *extracted* from others XMI**
- ***Integrate*** **individual data into a single XMI**

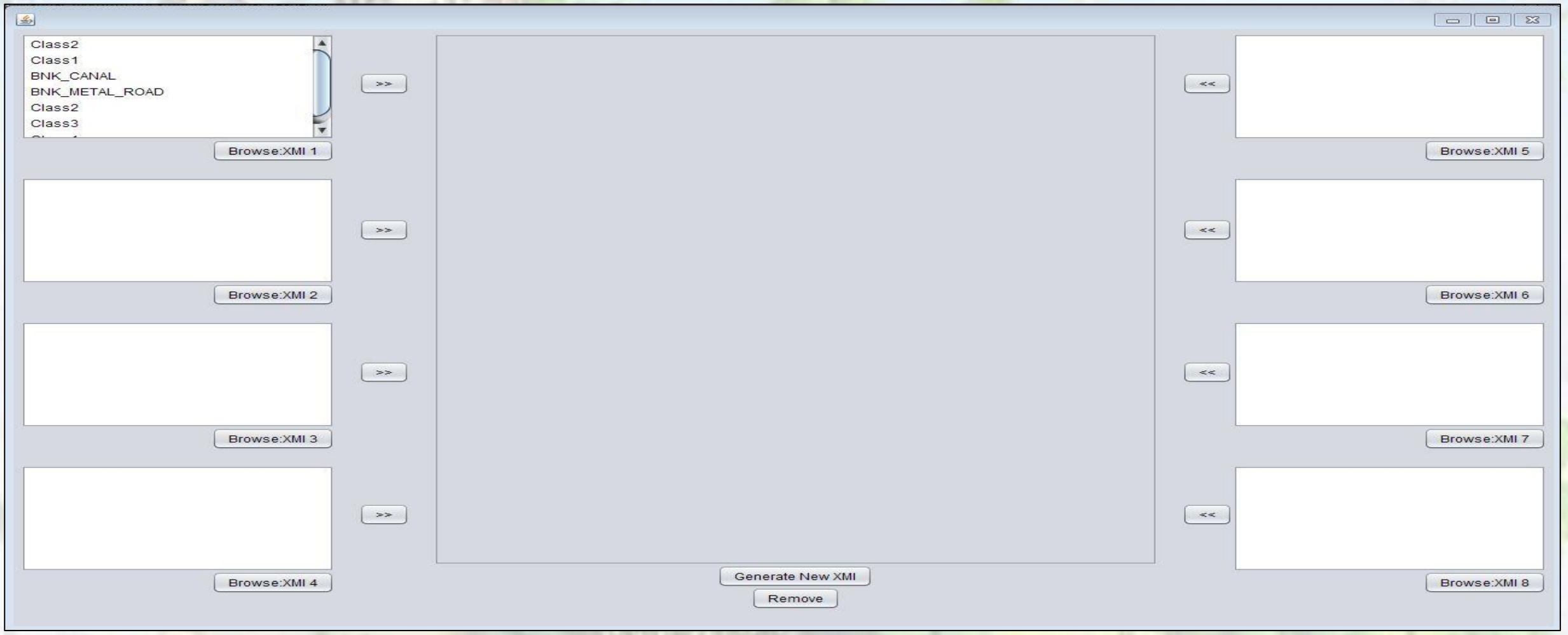
Integrated XMI Generation: GUI Design

Browse XMI Models



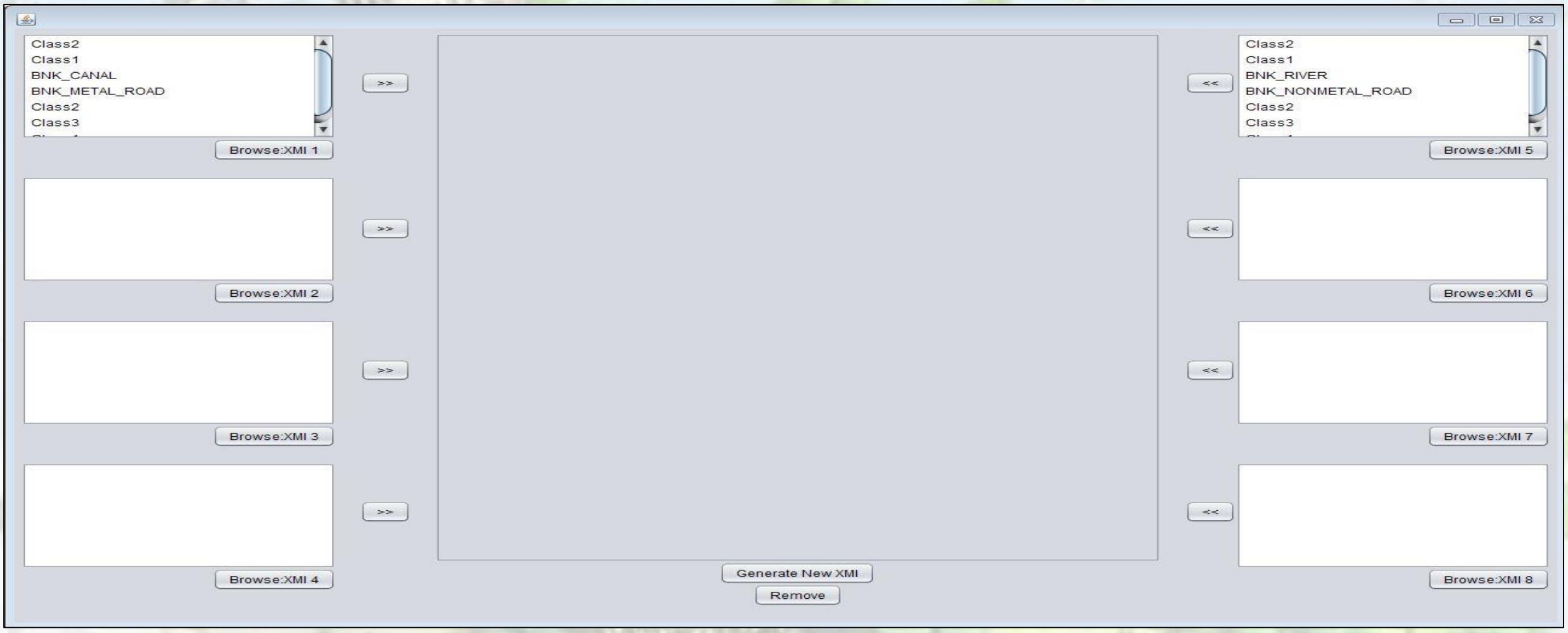
Integrated XMI Generation: GUI Design

Retrieve Classes



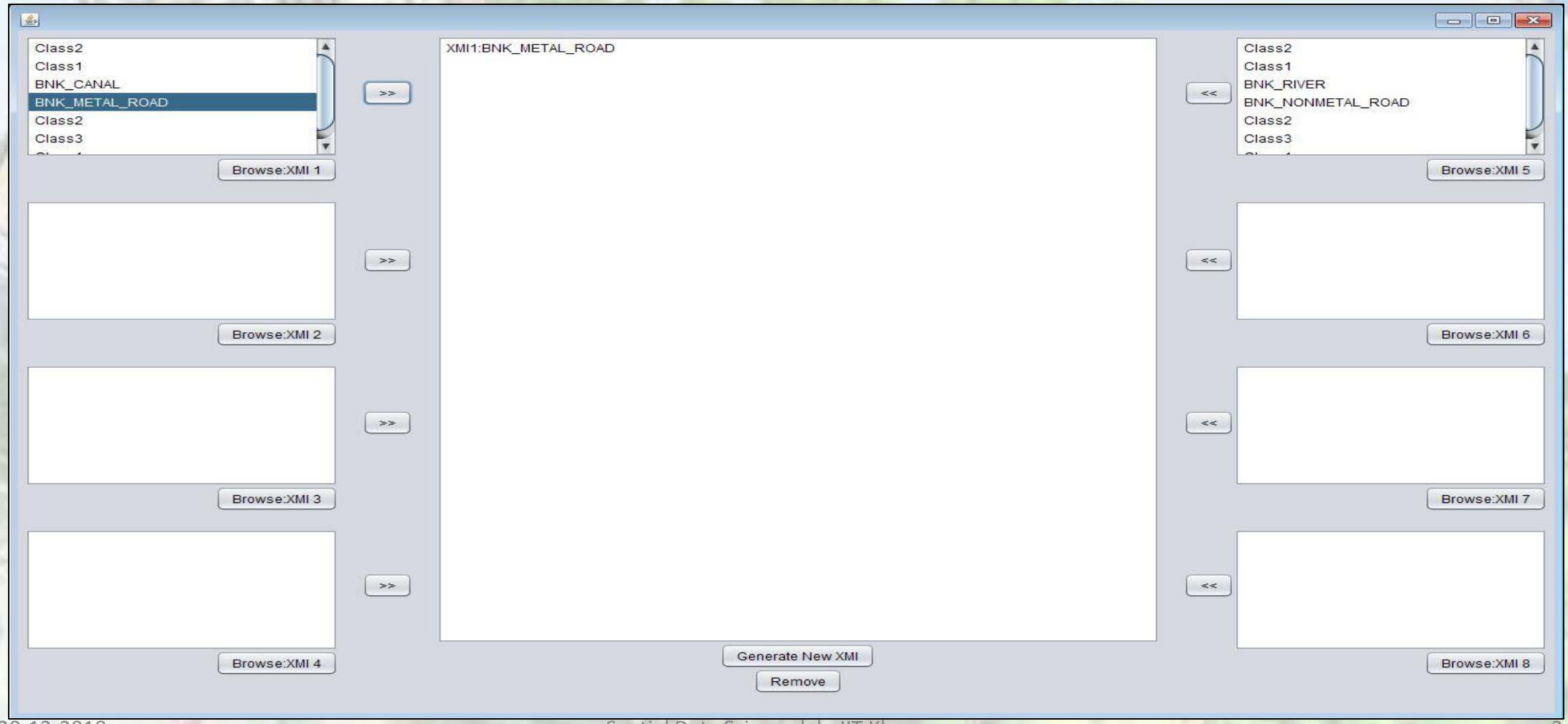
Integrated XMI Generation: GUI Design

Retrieve Classes



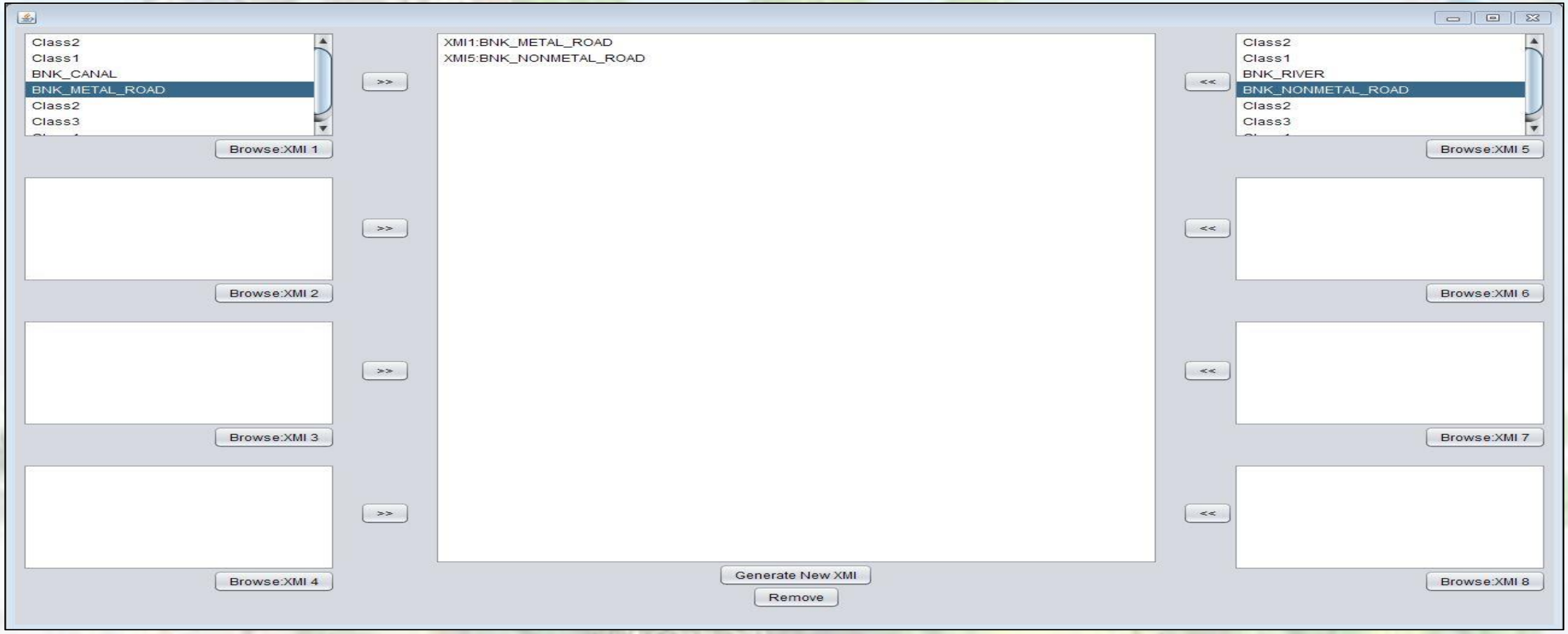
Integrated XMI Generation: GUI Design

Specific Class Selection

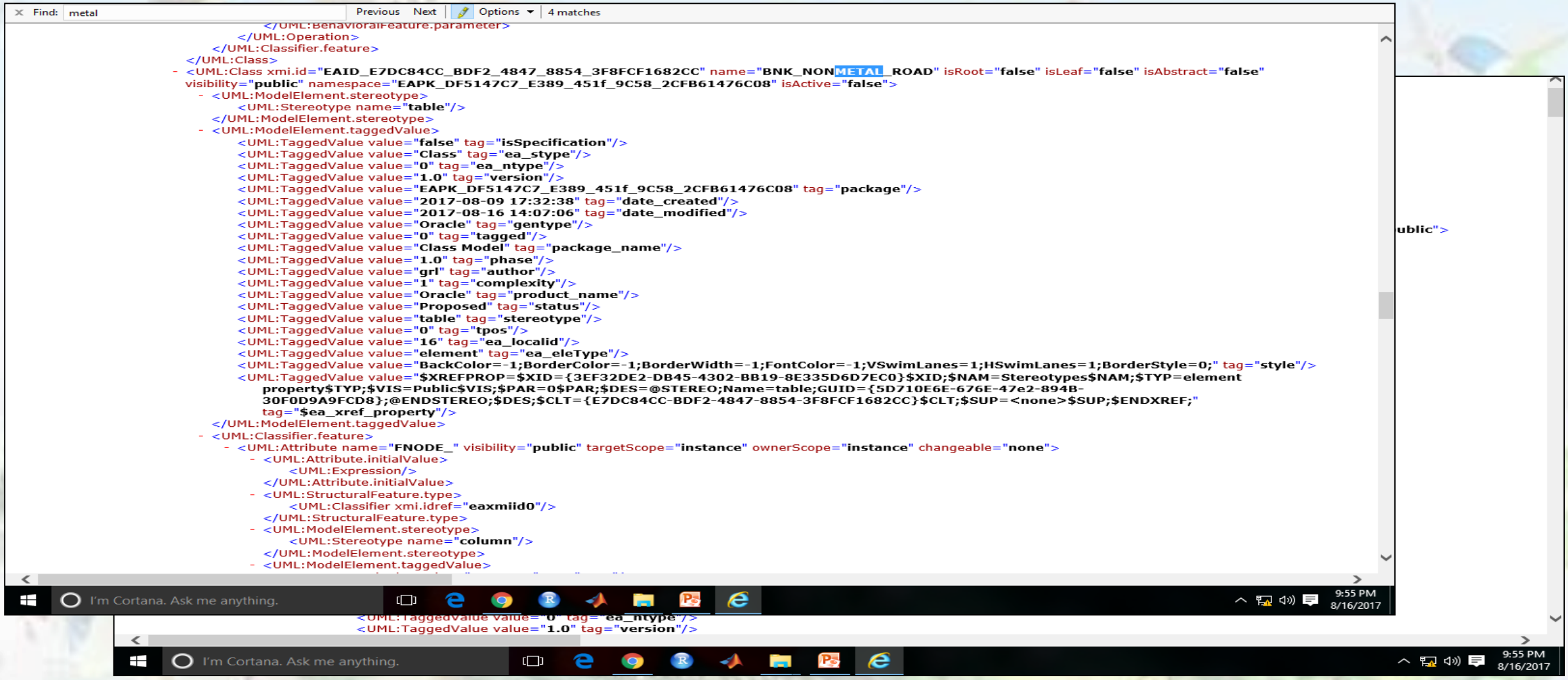


Integrated XMI Generation: GUI Design

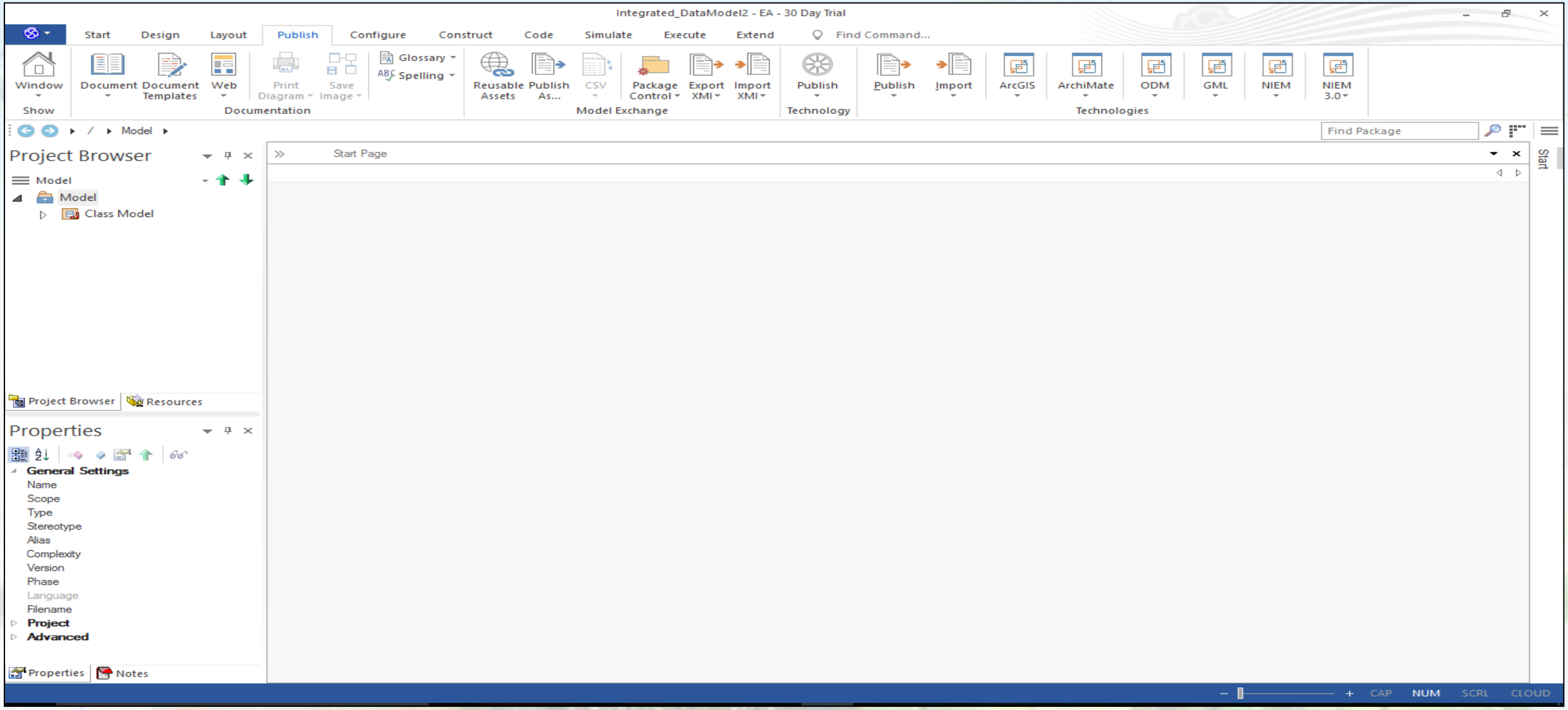
Specific Class Selection (contd.)



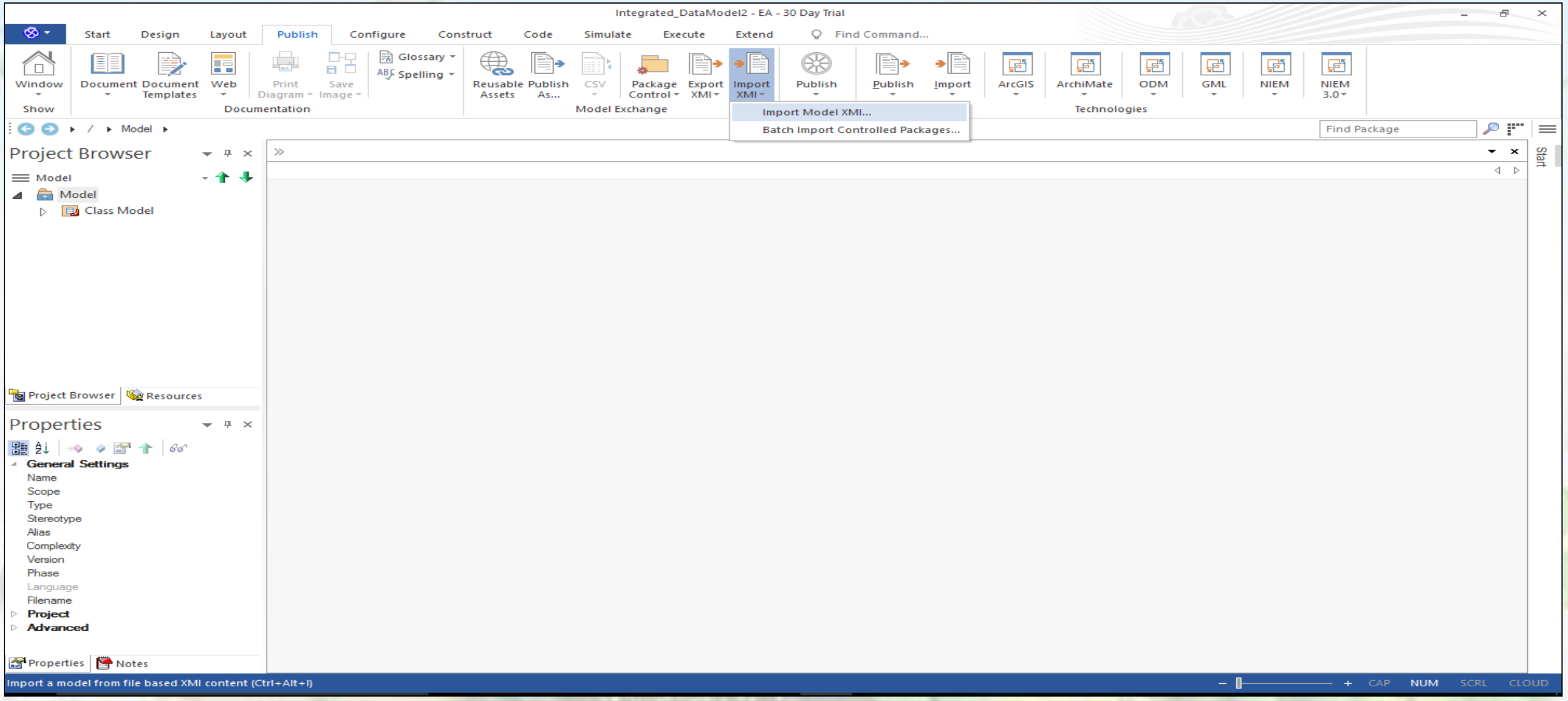
XMI of Integrated Classes



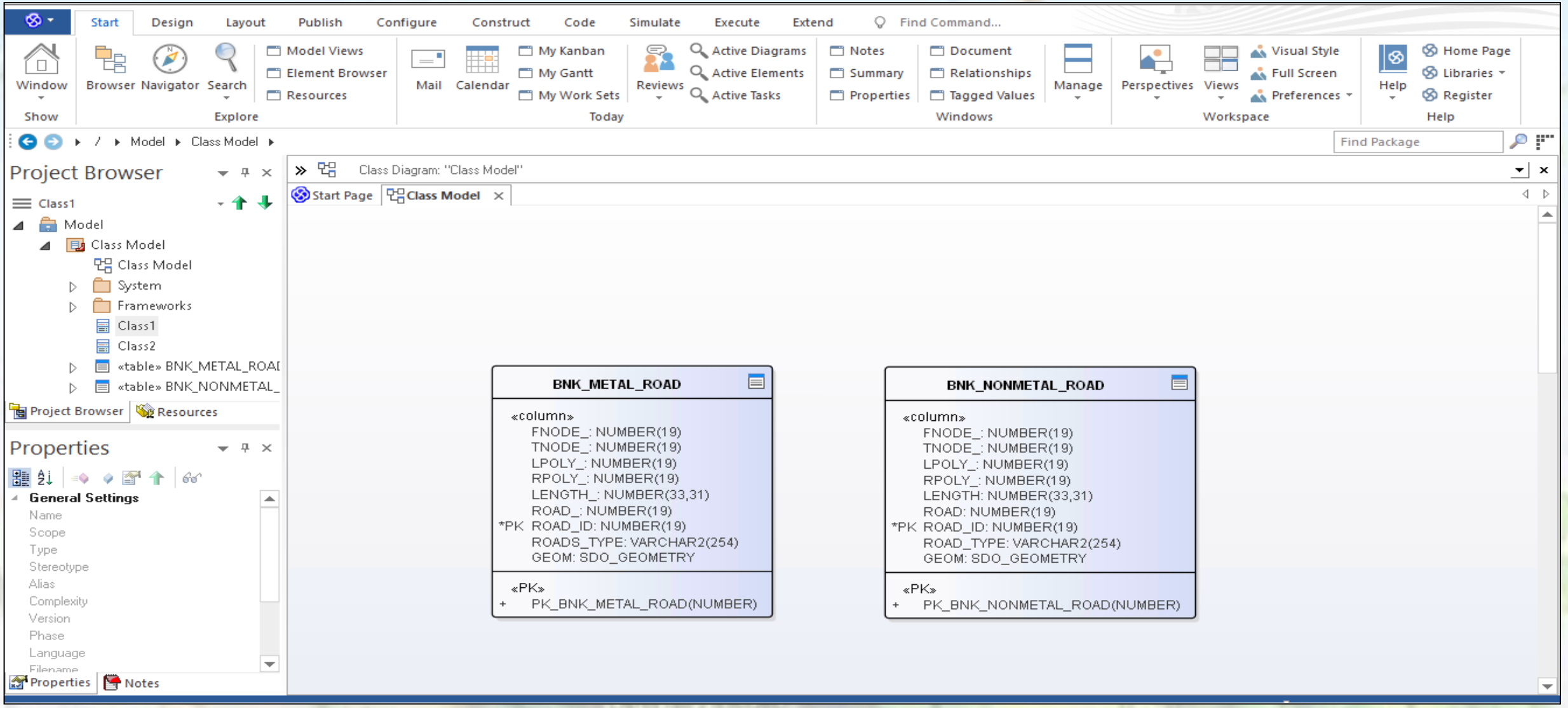
Generating Integrated UML



Importing Integrated XMI



Integrated UML Class Diagram



Geo-Cloud Application

amazon web services™ EC2

Google Compute Engine

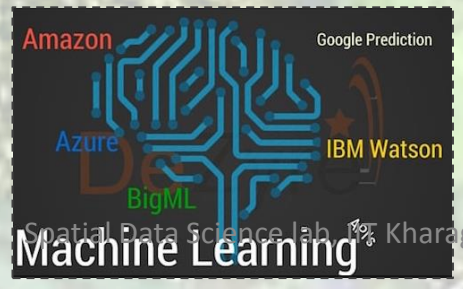
Google app engine

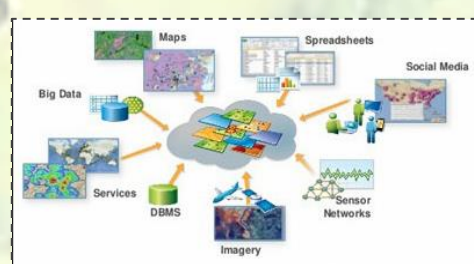
Gmail

Windows Azure

Windows Azure

Dropbox





Geo-Cloud Computing paradigm?

- On-demand self service
- Ubiquitous Network Access
- Resource Pooling
- Location Independence
- Rapid Elasticity
- Measured Services
- Virtualization

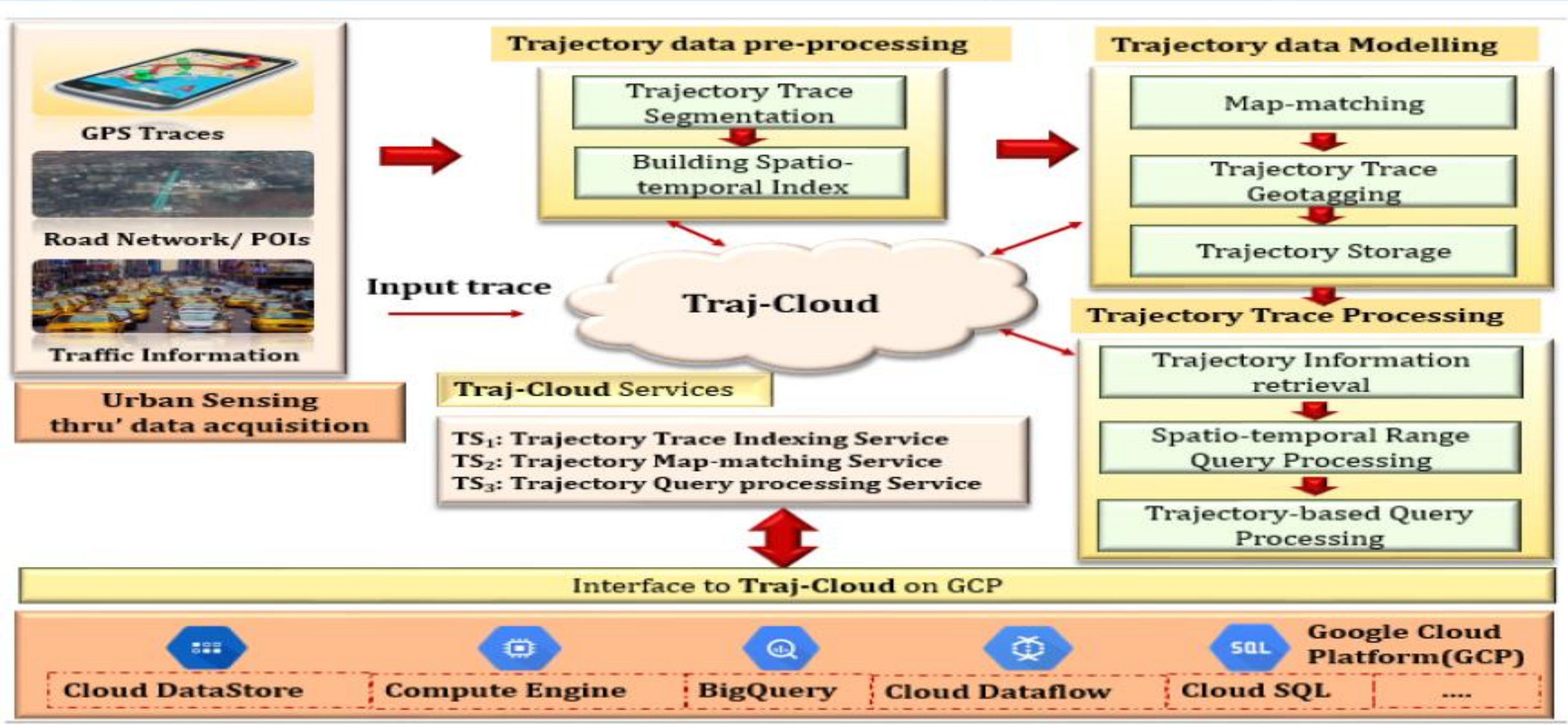
- Private and public organization wants to share their spatial data
- Provision of Geo-spatial services
- Geo spatial computations

Use Case 1: ***Traj-Cloud***

Traj-Cloud is a SaaS cloud which provides three major mobility services, namely,

- ***trajectory-indexing*** to efficiently handle huge real-time trajectory updates;
- ***geo-tagging, map-matching*** services in a distributed computing platform (i.e., Google Compute Engine) and
- ***trajectory-processing*** to resolve ***mobility based spatio-temporal queries*** to improve efficiency and reduce response time

Traj-Cloud



Traj-Cloud: A Trajectory Cloud for enabling Efficient Mobility Services, Shreya Ghosh, Soumya K Ghosh, ITS COMSNETS 2019 (to appear)

Traj-Cloud Service: Trajectory Query Processing

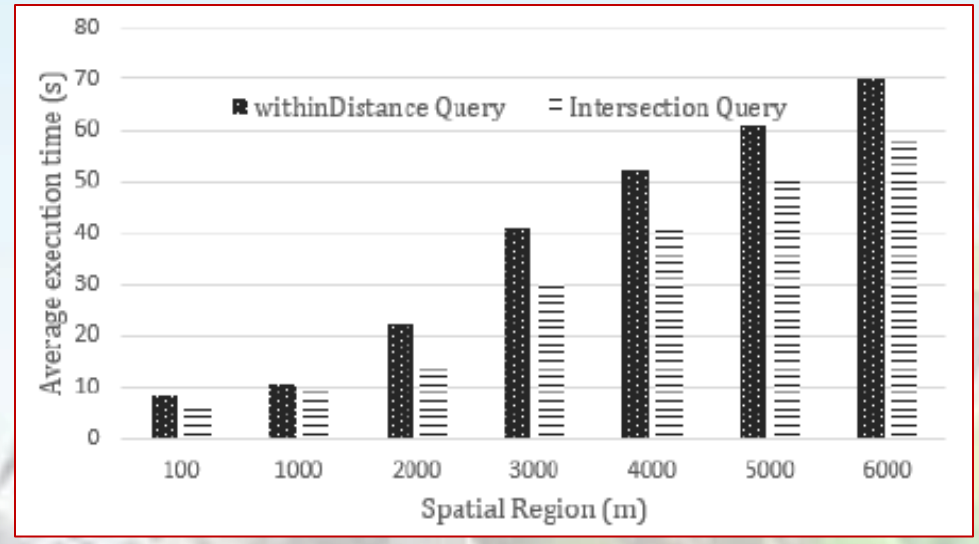
- Find all the petrol stations within 500m distance of a vehicle's trajectory

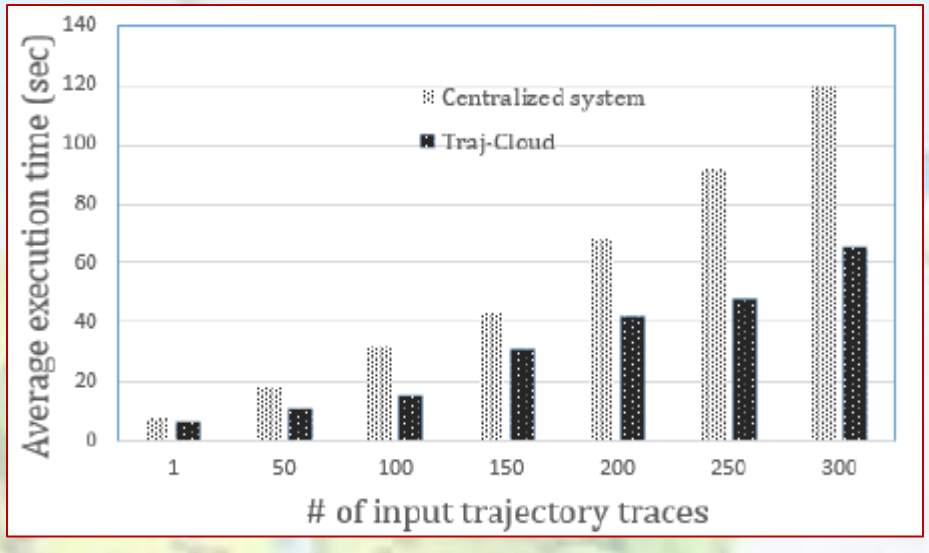
```
Select poi_Id from POI P, Traj T
where P.id="petrol_st" and
overlap(P.shape,Buffer(T.shape,500))=1 ;
```

- Find find trajectory segments passing through the residential area of a city

```
Select traj_Id from Traj T, Region R
where R.id="residential_zone" and
cross(T.shape,R.shape)=1 ;
```

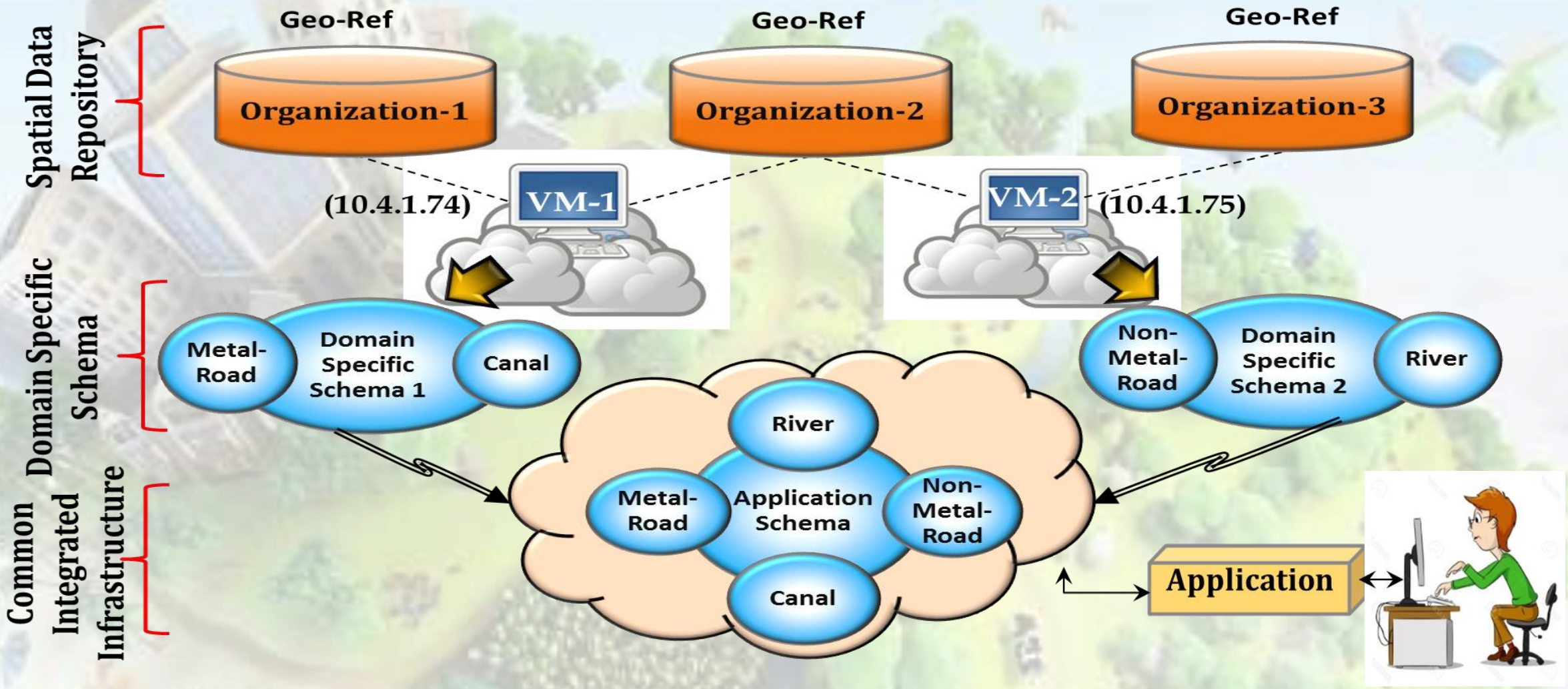
Efficiency of Traj-Cloud



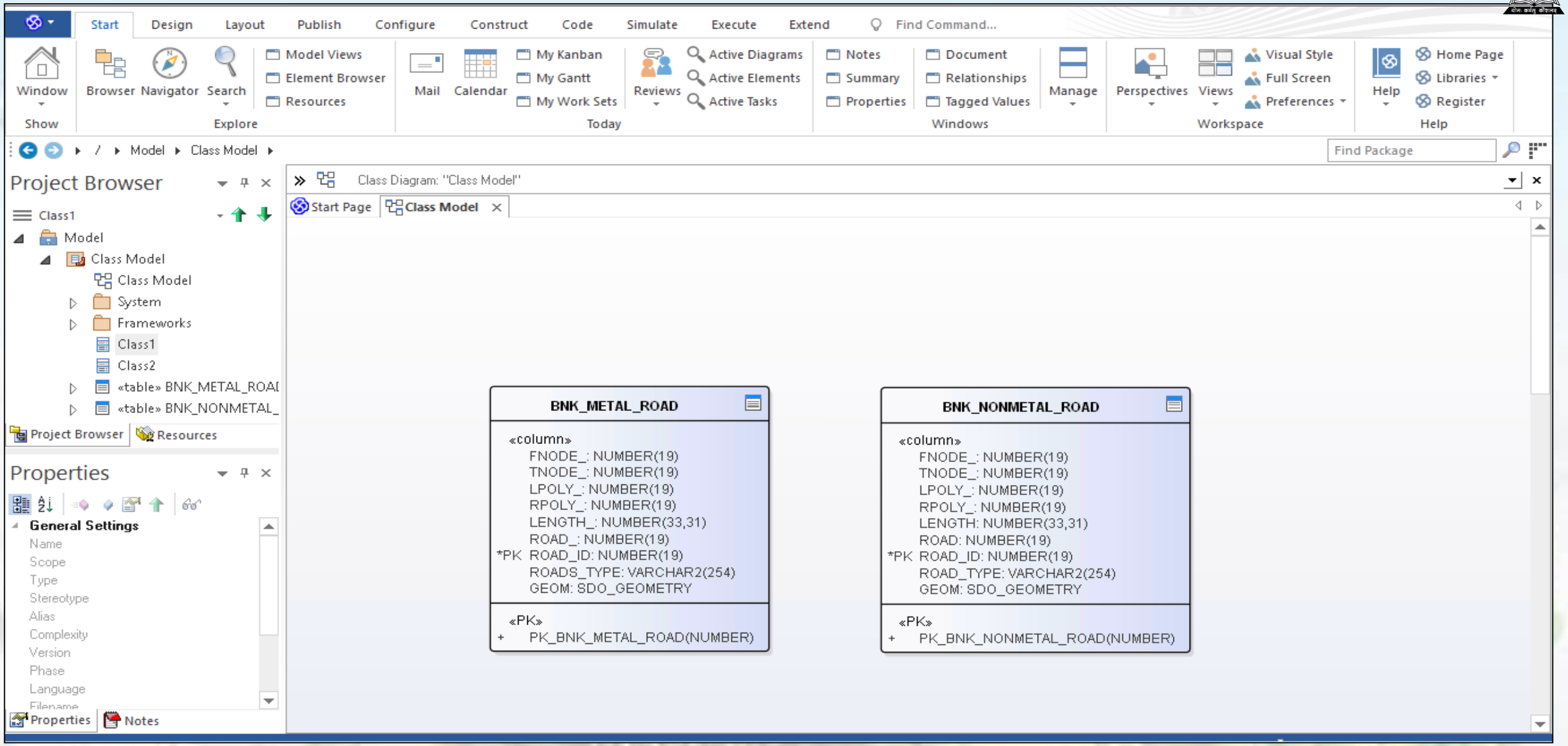


Type of Query	Linear Scan (Standalone)	Linear Scan (BigQuery)	Indexing (BigQuery)	Indexing + MapReduce (BigQuery + CloudSQL + Dataproc)
Point (10)	18.8 s	14.7 s	10.6s	6.2s
Range (10)	40.3 s	32.8s s	24.1s	13s
Point (100)	200.6 s	180s s	104s	85.8s
Range (100)	800.2s	450.1s	180s	142s
Point (500)	1780s	1000s	630.7s	432s
Range (500)	2540s	1860s	1020s	780s

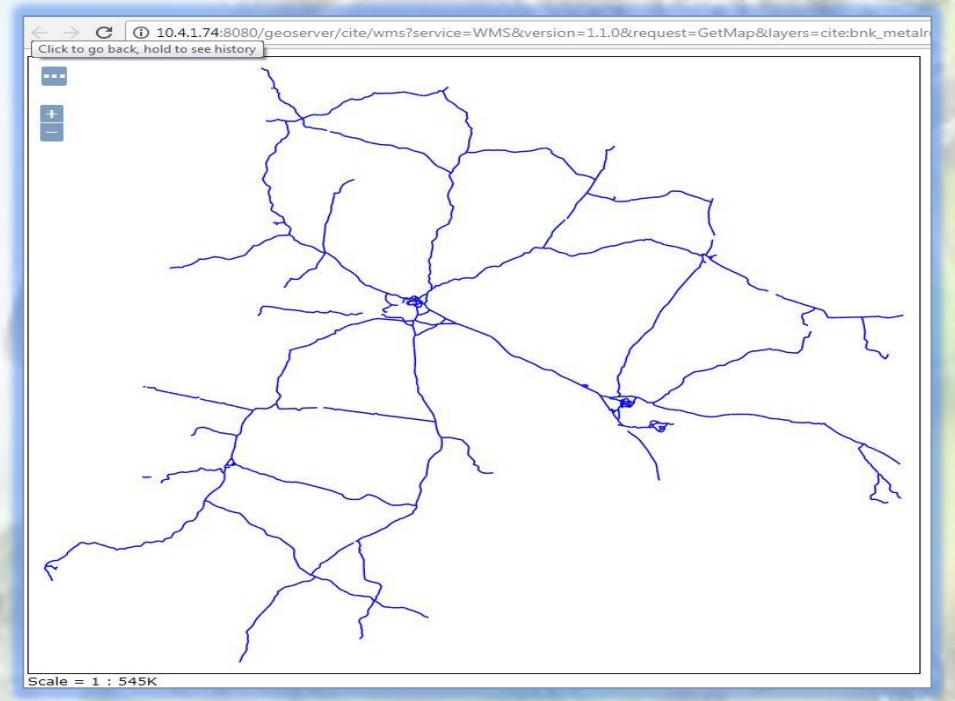
Use case 2: Integration of Data Models



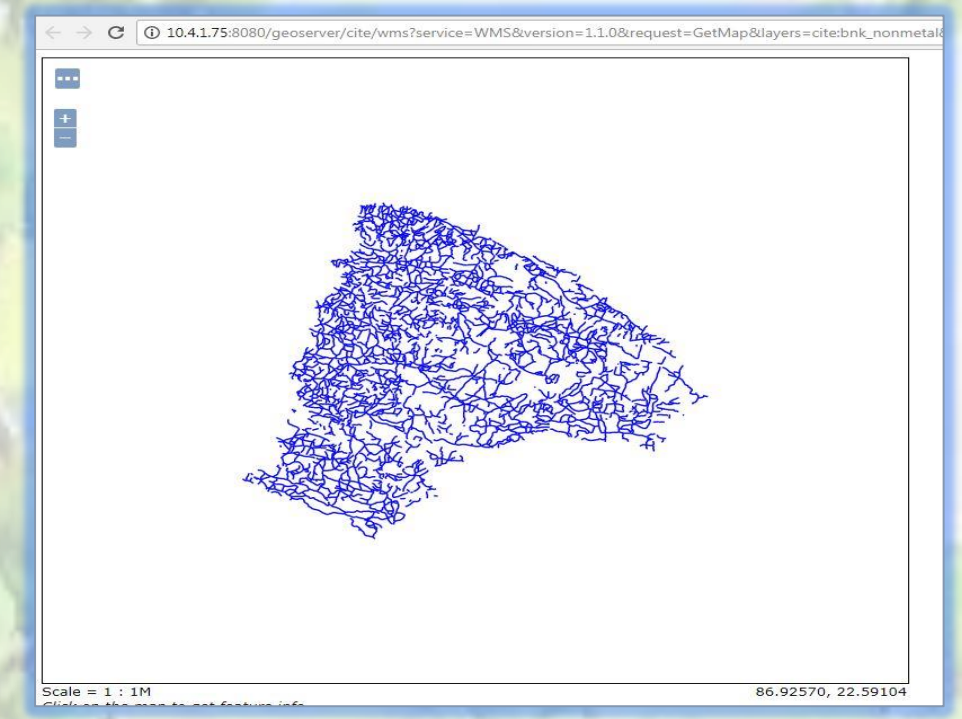
Integrated UML Class Diagram



Service Integration for Query in Cloud

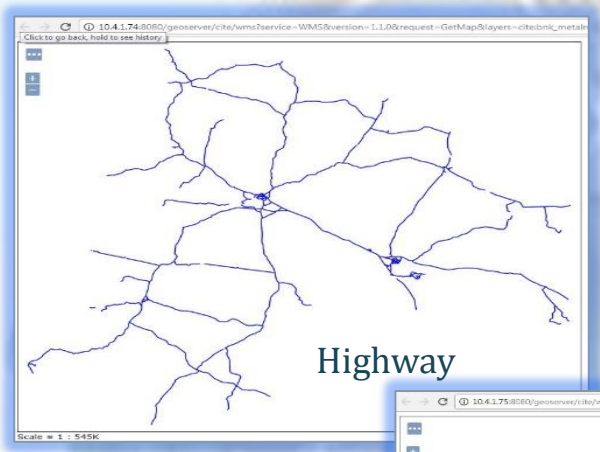


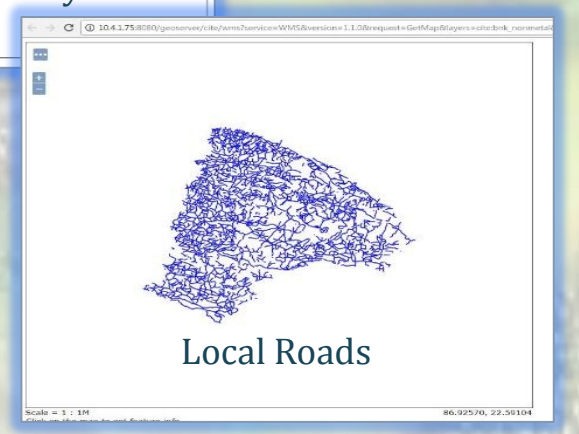
Highway

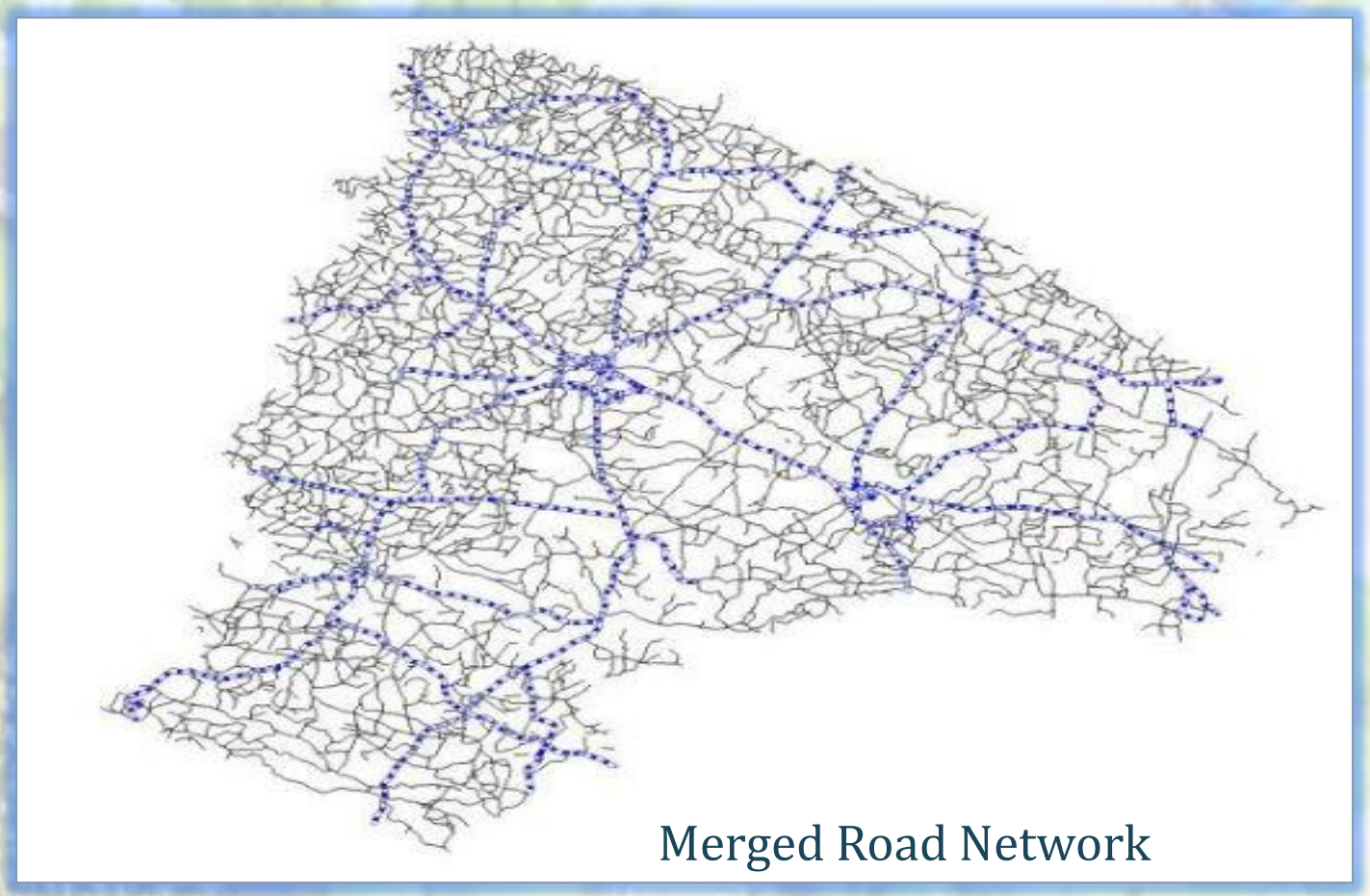


Local Roads

Service Integration for Query in Cloud







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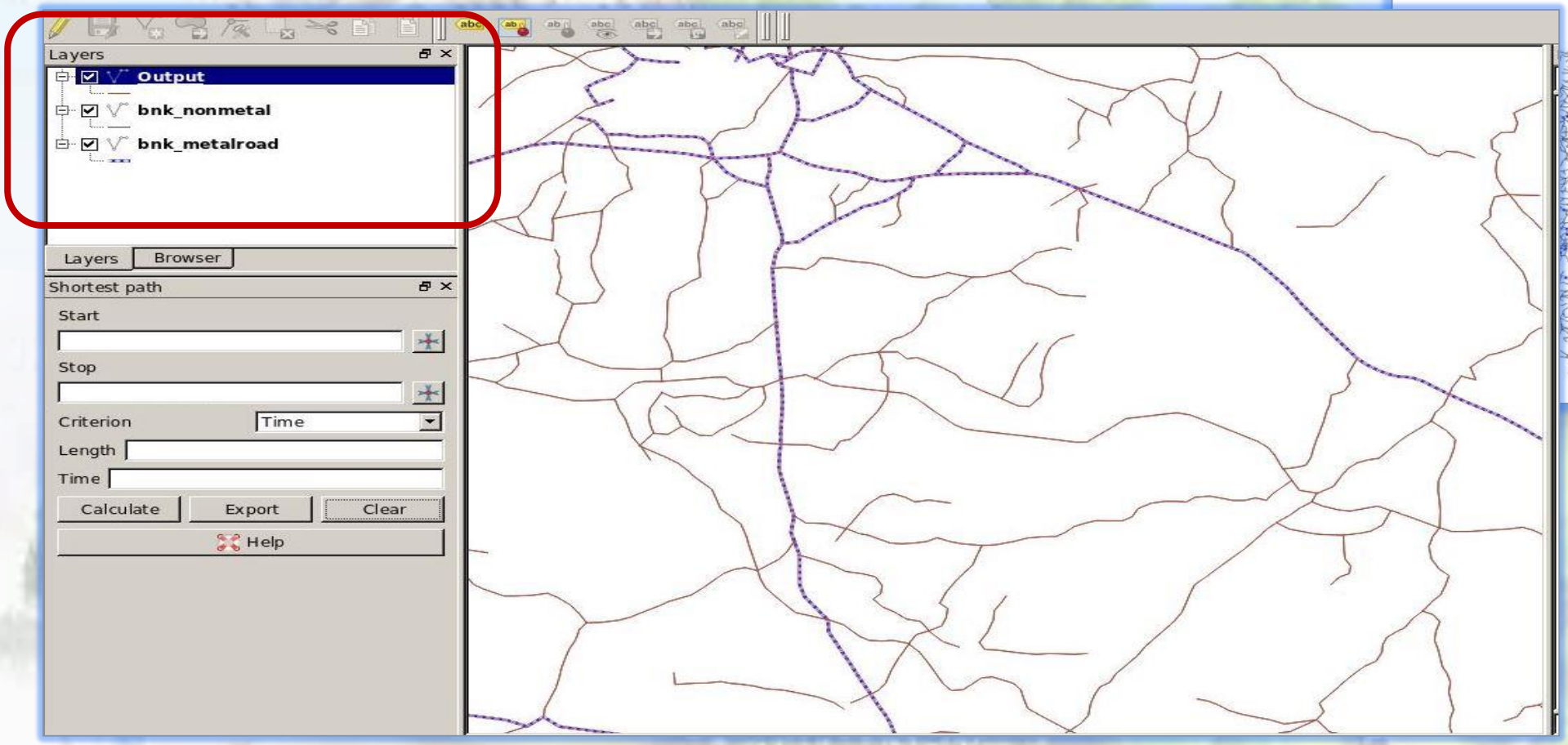
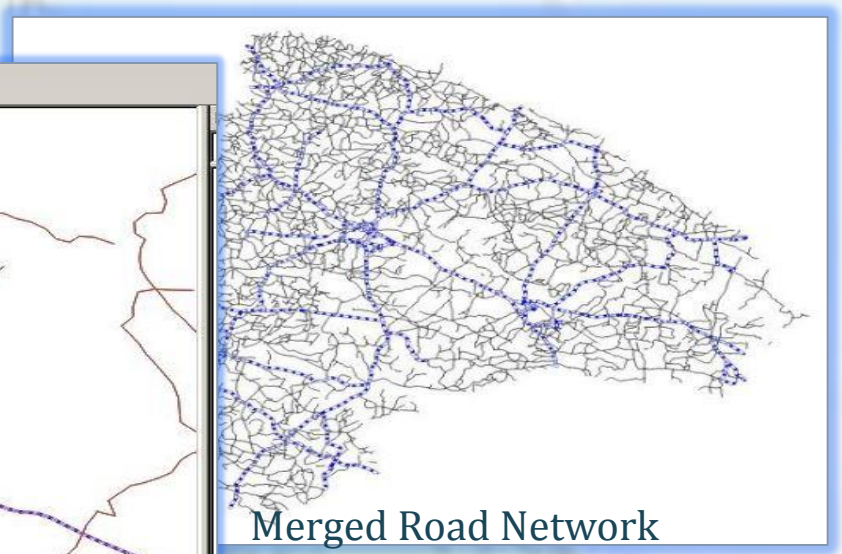
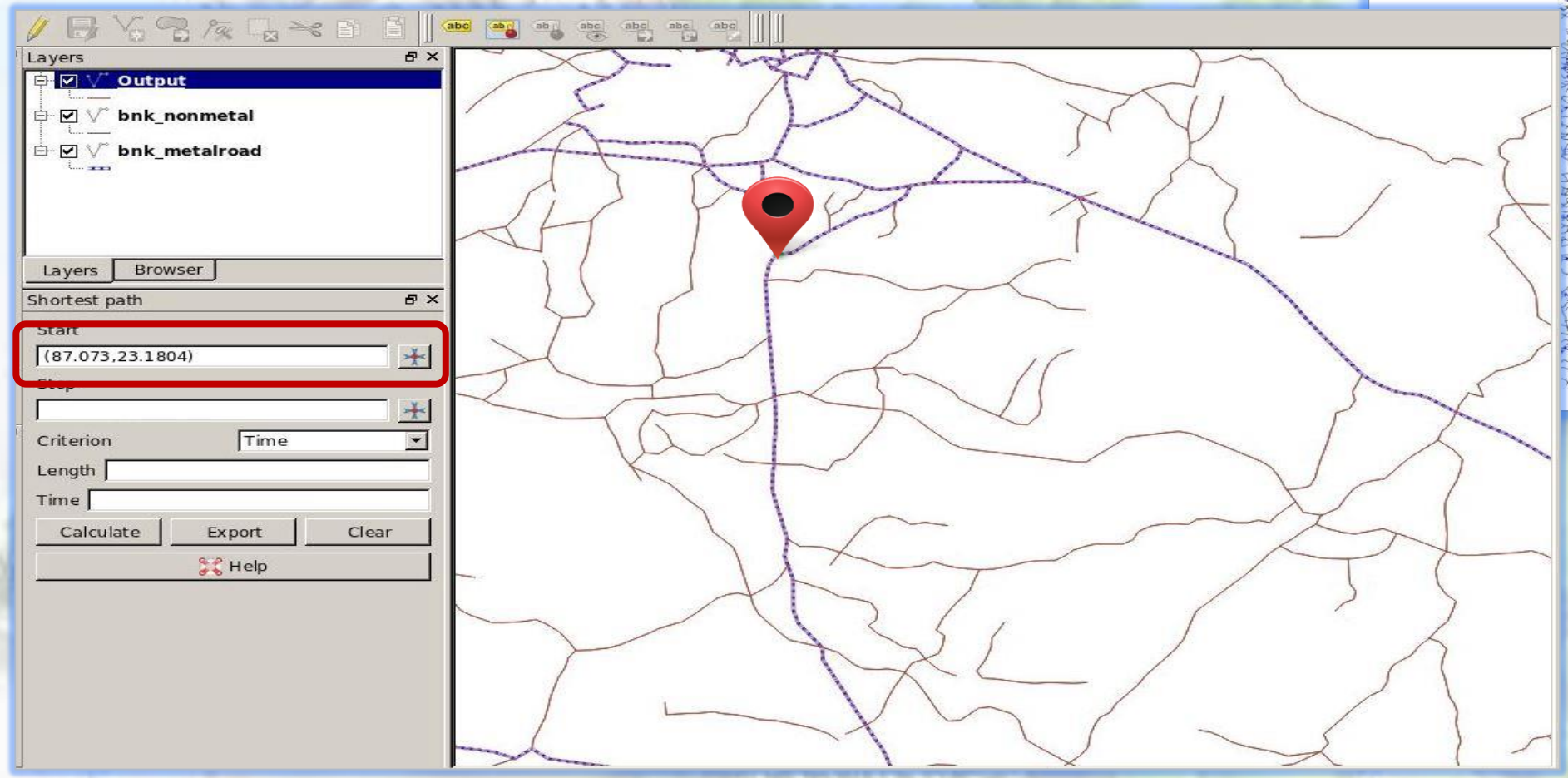


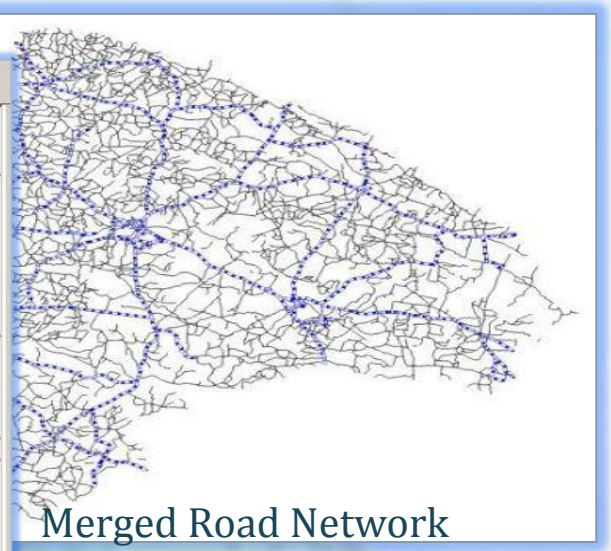


Shortest Path Calculation

Service Integration for Query in Cloud

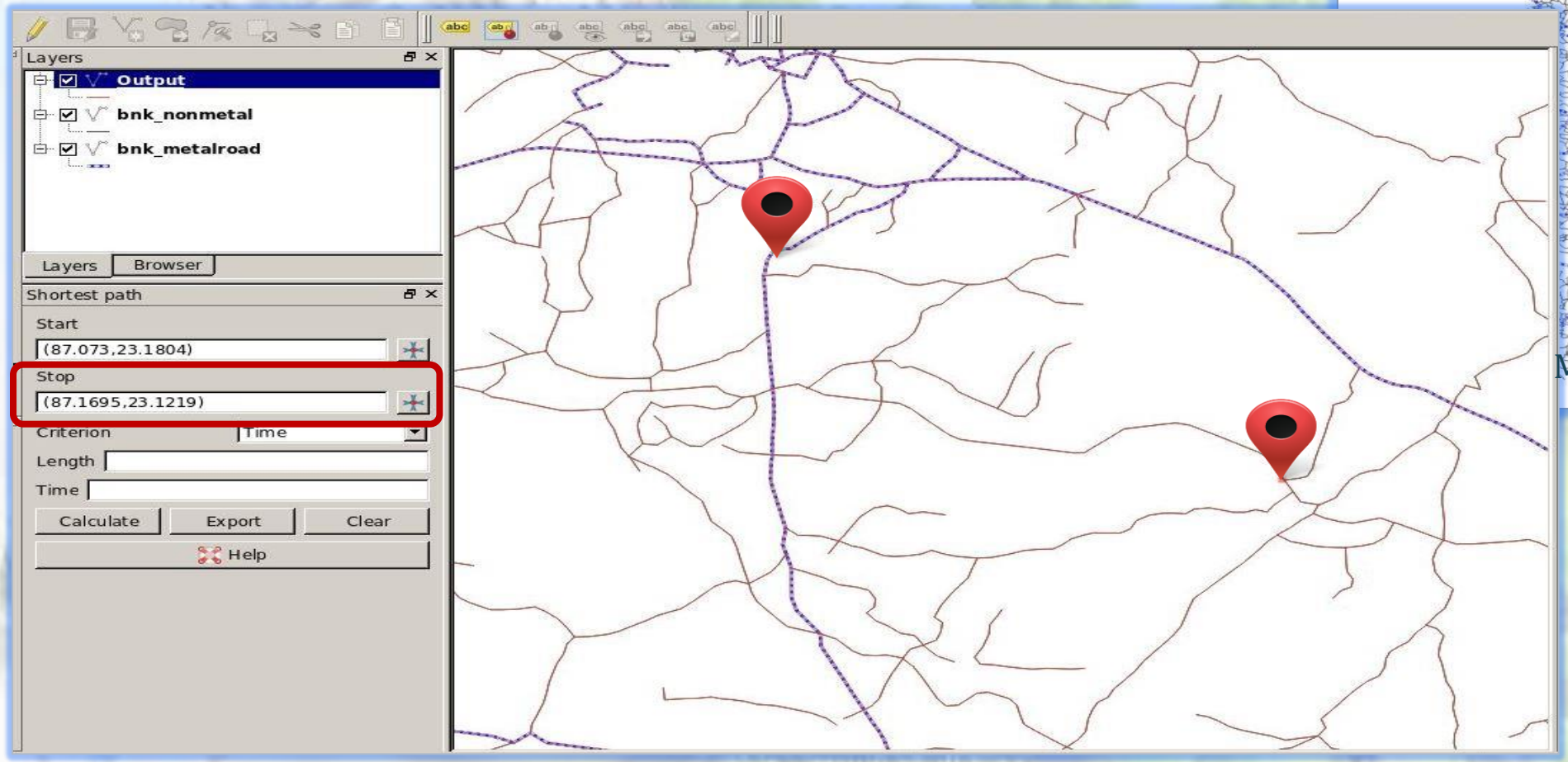


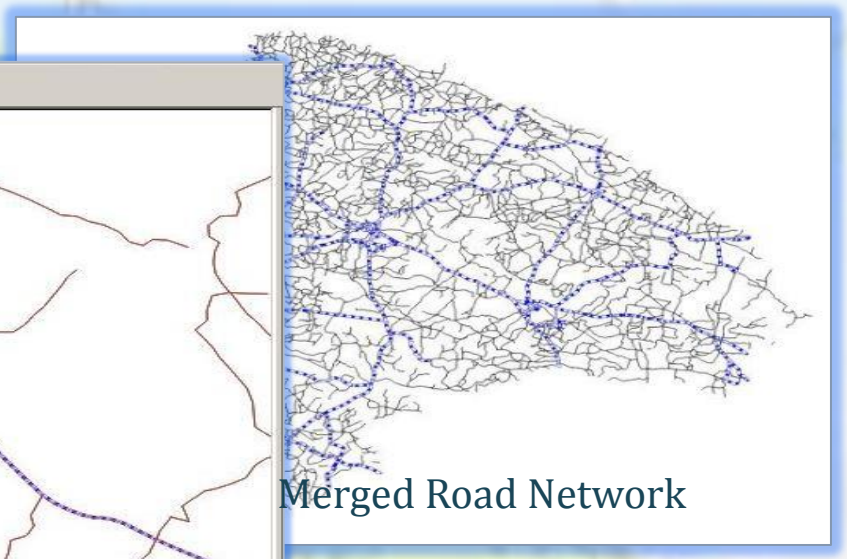
Shortest Path Calculation



Merged Road Network

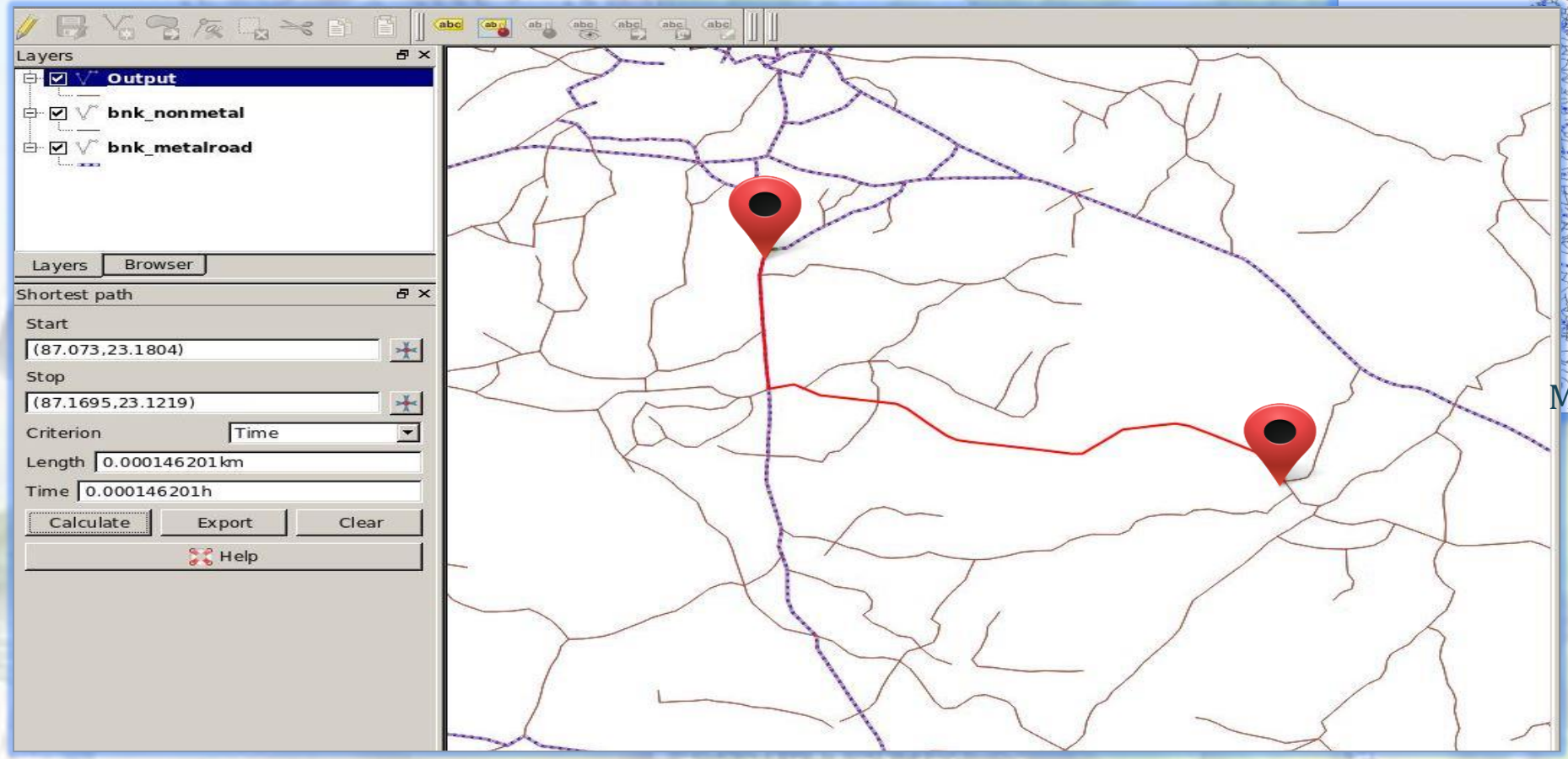
Service Integration for Query in Cloud



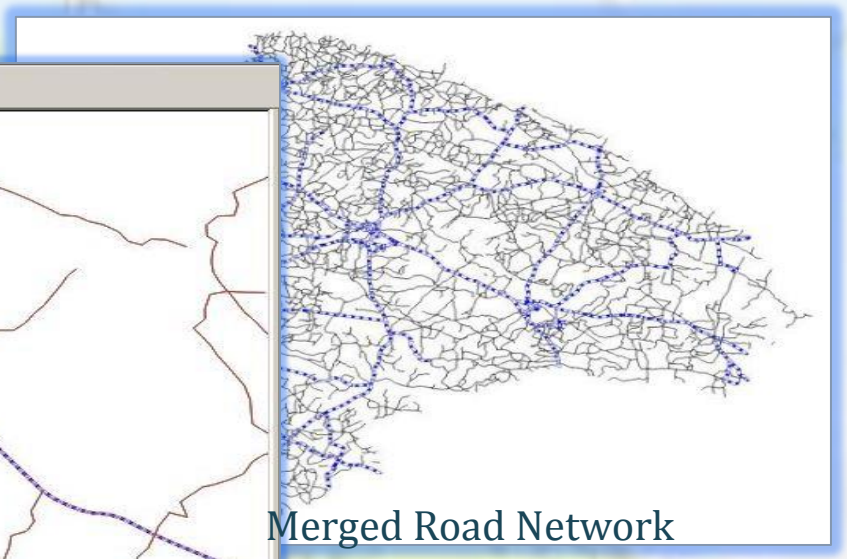


Shortest Path Calculation

Service Integration for Query in Cloud

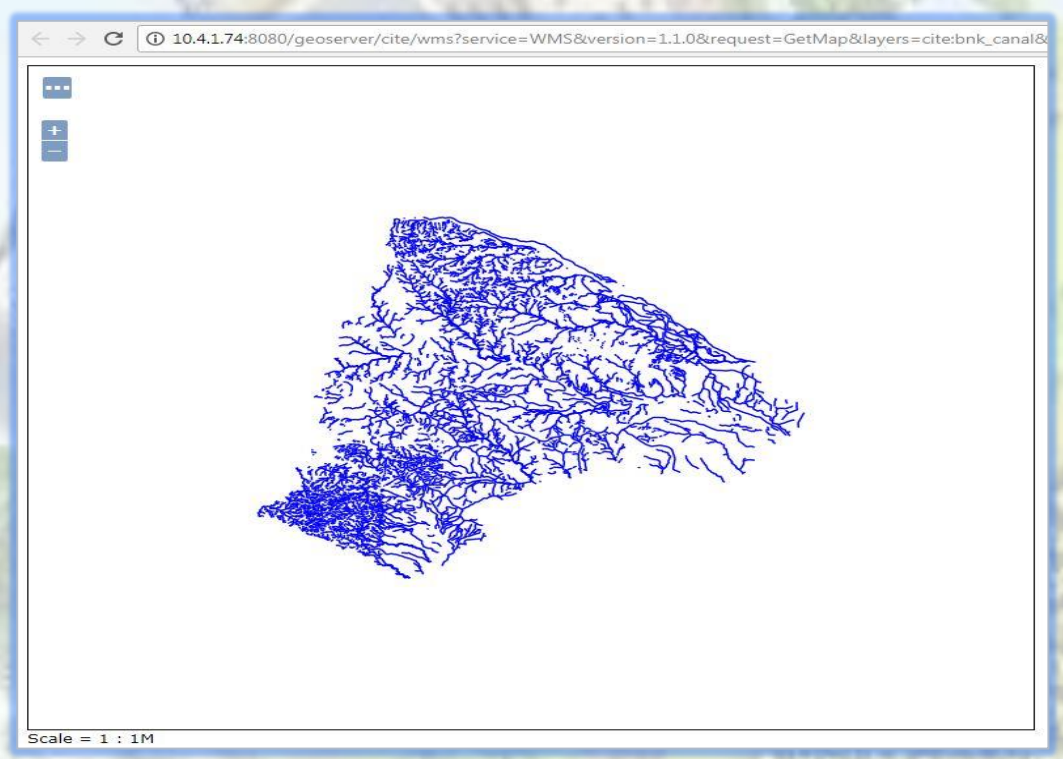


Shortest Path Calculation

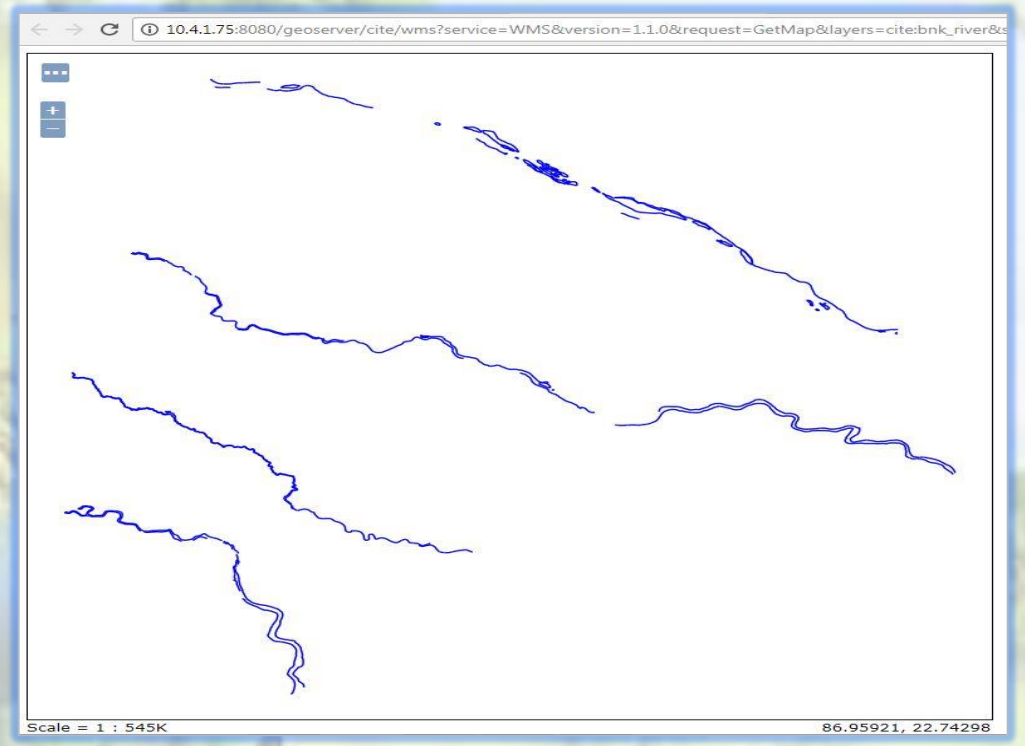


Merged Road Network

Service Integration for Query in Cloud

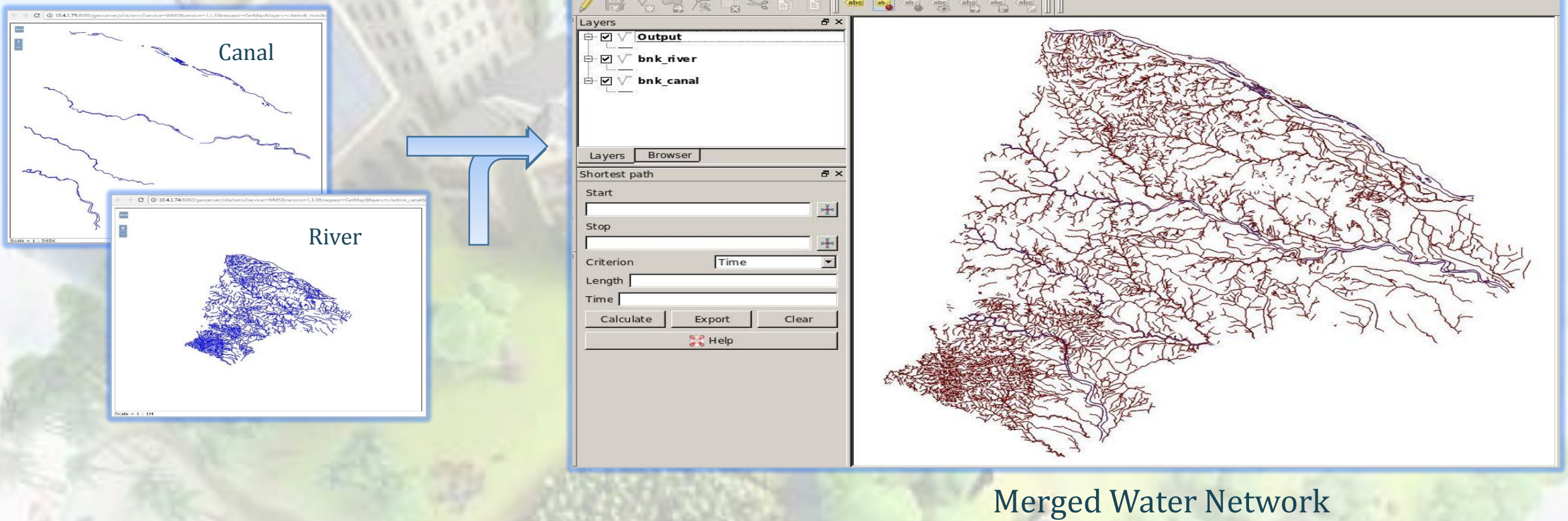


Canal



River

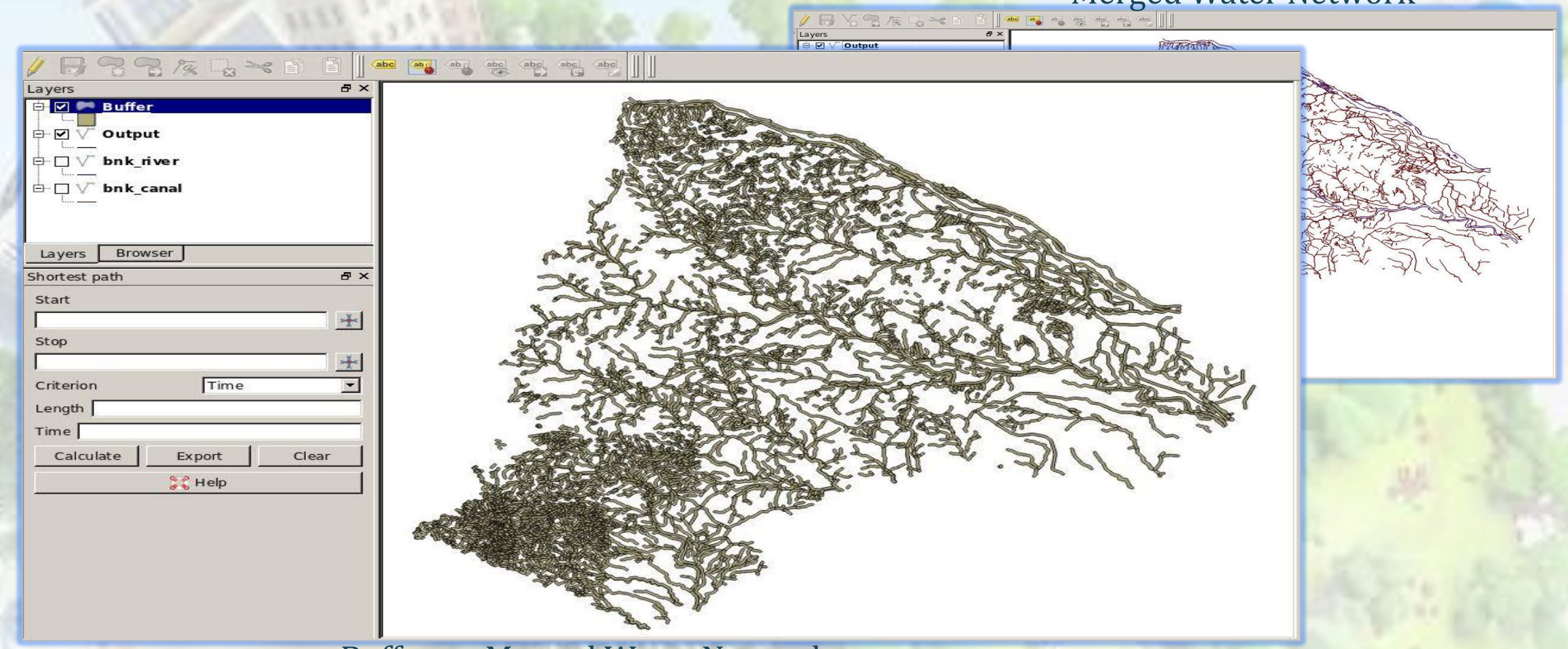
Service Integration for Query in Cloud



Merged Water Network

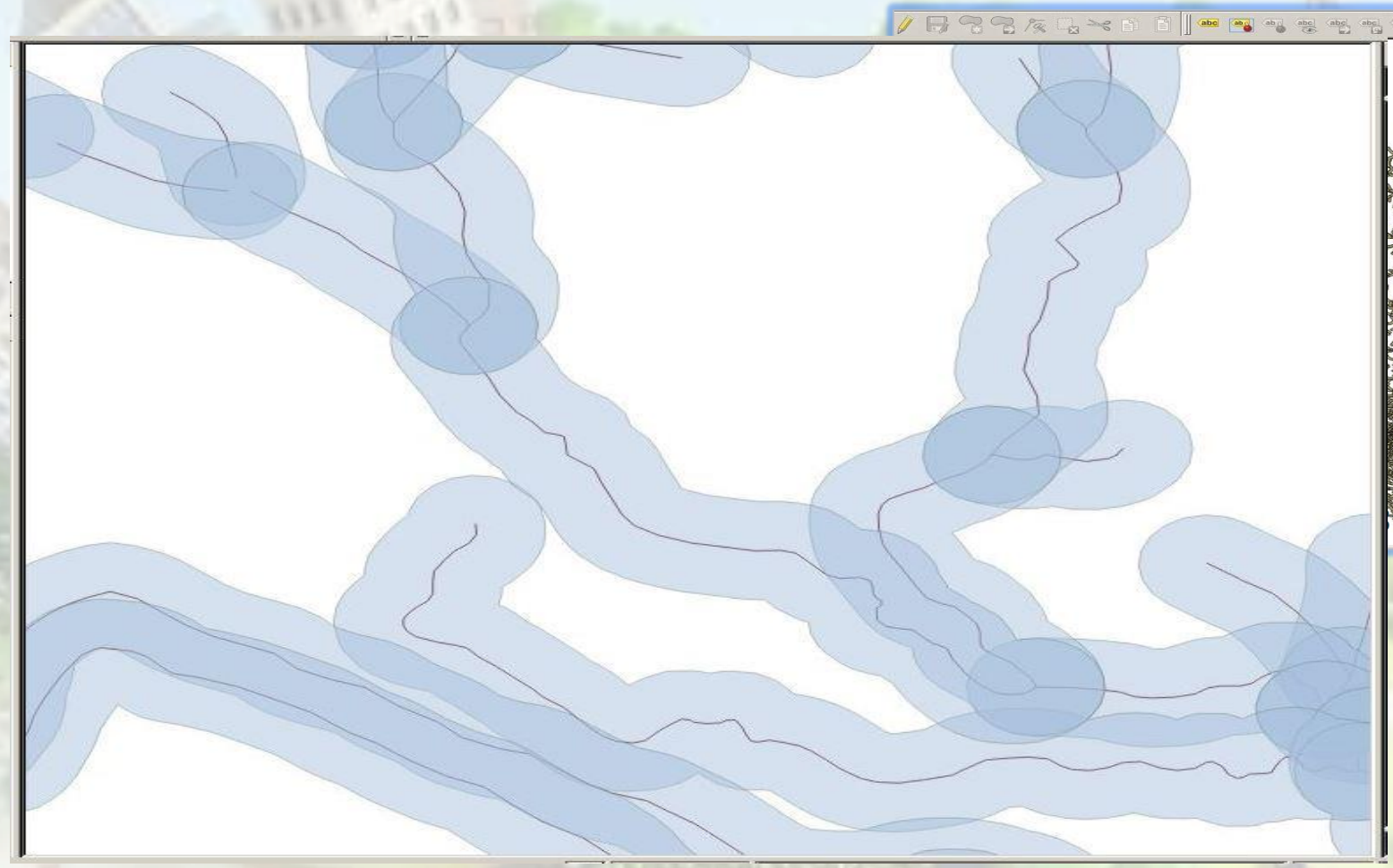
Service Integration for Query in Cloud

Merged Water Network

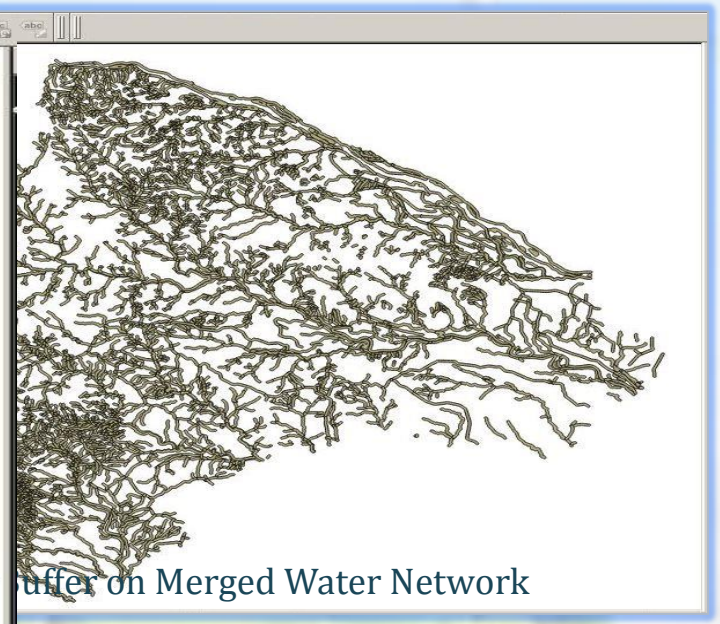


Buffer on Merged Water Network

Service Integration for Query in Cloud



Buffer on Merged Water Network (Zoomed)



uffer on Merged Water Network

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Thank You!!