Development of an Interface for Ontology-based transformation between Features of different Types

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Affectionately Dedicated

To

My Beloved Parents, Sister

And

Teachers

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ABSTRACT

Implementation of the INSPIRE directive, the spatial data infrastructure for the Europe, has created a necessity for easy and convenient conversion between different models of geospatial data. Data model transformation across heterogeneous systems can be hampered by differences in terminology and conceptualization, particularly when multiple communities are involved. Requirement in current situation is an interface facilitating transformation of data to a desired format and immediate use of the data, which are collected from different formats and models. Ontology-aware software with shared understanding of concepts, enable users to interact with geospatial data models. Thus use of ontologies could make a friendly environment to the user in translating the data conveniently. Feature type ontologies, along with annotations are provided from an ongoing project at the Institute for Geoinformatics (IfGI, University of Münster, Germany), in order to reconcile differences in semantics. FME workbench provides a successful environment to execute set of rules for the data model transformation using a mapping file, which can be developed externally. The thesis work developed a user interface that includes operations to define rules for the translation of geospatial data, from one model to another. Annotated feature types are taken as input, and the results are encoded as FME Mapping files. The overall methodology involves three phases. Namely: development of the interface, test execution with sample data, usability test. In the development phase, the interface is designed with requirements identified in the literature survey. In the second phase the interface is verified for its proper functionality by executing the transformation on the trial data-set using two sample ontologies. The user-friendliness of the interface was evaluated by conducting a usability test. The GUI is named as Ontology Based Schema Mapper *(OBSM),* consisting four main components; Mapping Component, Ontology Repository, Rules Repository and Rule Generator. The functionality of the *OBSM* could be expressed as follows. The initial stage of the procedure imports the annotated feature types of the source data model to the system, while saving a copy in the Ontology Repository. Then two alternative options are given to the user; either to define new rules of transformation or to retrieve existing set of rules for transformation. If the user selects to define new rules, the target annotated feature type is also imported to the system. The user can generate *OBSM* mapper file, for the set of defined rules using the Rule Generator and save a copy in the Rules Repository or export to a desired location. The interface was tested with feature types used within the INSPIRE context. In the trial execution of the transformation, the source feature types are from the ATKIS data model and the translation rules are defined to translate into the INSPIRE data model for transport networks. The tool was evaluated for its usability, following principles for a heuristic evaluation. The evaluation was performed using a questionnaire and a prototype of the tool within a group of experts. Results proved that the users identify the tool as a convenient and easy to use in schema mapping.

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1 INTRODUCTION

The first chapter introduces the problem of Graphical User Interfaces (GUIs) for schema mapping, and the requirements that GUIs should fulfill in order to cater the existing problem. The chapter ends with a description of the structure of the thesis.

1.1 Motivation

Emergence and the implementation of the INSPIRE directive *(Directive, 2007),* the spatial data infrastructure for Europe, increased the necessity for easy and convenient communication between different structures of geospatial data. The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information on a wide range of sources, from the local level to the global level, in an interoperable way for a variety of uses.

Schemas express shared vocabularies and allow machines to carry out rules, which provide a means for defining the structure, contents of XML documents *(McQueen et al., 2008)*. XML is a concept used in web based data services, which stands for Extensible Markup Language and designed to transport and store data, with focus on what data is *(W3Schools, 2009)*. Data model transformation across heterogeneous systems can be hampered by differences in terminology and conceptualization, particularly when multiple communities are involved. Software tools have been developed in order to transform data from one data model to another, using graphical and command line interfaces *(Moore, 2007)*. The 'GO Publisher' *(Snowflake, 2008)*, 'Feature Manipulation Engine' *(Safe, 2009)* and 'GeoXSLT' *(Klausen, 2006)* are some of the software tools available for feature type *(ISO, 2005)* translation, in which translations are most often, based on a data-store, using abbreviated names of tables and attributes. Data models can be translated from one model to the other using conversion operations, which are referred to as schema mapping. These defined operations are called as rules of transformation *(Paolo et al., 2007)*. This enforces the users for a comprehensive understanding of large documentation on data models to a greater extent and complex programs that work on the data model mapping *(Florescu and Kossmann 1999)*.

"To be able to understand and reuse the components easily, some extra knowledge about the components is needed. This extra knowledge is called as the 'component meta-knowledge'. The component meta-knowledge for different domains is modeled by the domain ontologies" *(Erdur and Dikenelli 2002)*. "Semantic matchmaking can be hence described as the process of computing an ordered list of appealing resource taking into account also the semantics of resources annotation and request definition, given with reference to ontology" *(Agarwal and Lamparter 2005)*. Use of ontologies is one of the most successive approaches in semantic interoperability and semantic match making *(Moran et. al 2005, Melnik, 1999)*. Yet the domain ontologies are more significant to utilize in interoperability approaches. In most cases this fact is important when considering the semantic interoperability between different concepts in different application domains.

1.2 Problem Statement

Manually specifying schema mapping with abstracted attribute names is a time-consuming, error-prone and therefore an expensive process *(Lutz et al., 2006)*. Yet the most crucial factor is that these software tools must handle in a carefully tuned manner to get a reasonable result. Another limitation is that the users need a comprehensive knowledge about the semantics of geospatial data models under consideration *(Kuhn 2005)*. The time required in optimizing the use of the programs and the understanding of data models is hindrance for applications, where results need to be evolved with lesser effort. Moreover, there is a linear relation between the level of effort and the number of matches to be performed, which can be considered as a growing problem due to the rapidly increasing number of web data sources and e-businesses to integrate *(Volker et al., 2006)*. Thus the requirement for a faster and less labor-intensive integrative approach is justified. However, the restrictions in syntactical mapping process can be summarized as;

- An in-depth knowledge of both the source and target schemas is required in advance. Schemas need to be studied in detail before mapping. This is a very expensive step and cannot be avoided in actual project implementation.
- Mappings are often hard to understand and error-prone because humans normally think in terms of the semantics instead of the syntax – e.g. person is rather likely to map two pieces of information *(Line segment to road segment)* rather than two mapping elements *(EI 23434 to SG 56543)*.
- Mapping rules, typically cannot be reused, because they are tool dependent and must be created from scratch when a new schema mapping is defined.
- Concepts such as inheritance and logical constraints are not supported.

Therefore the main goal of the work can be summarized as : *the development of an interface which translates data from one model to another, with a set of predefined rules in translating the schema based on ontologies of the two data models in which the functionality will be tested in the INSPIRE data model context.*

1.3 Research Method

The work will develop a tool, which includes operations to define rules for the translation of geospatial data, from one feature type to another. The tool is named as 'Ontology Based Schema Mapper' *(OBSM)*, developed based on four key components including: *OBSM* Ontology Repository, *OBSM* Mapping component, *OBSM* Rule Repository and *OBSM* Rule Generator. Activity diagram, sequence diagram presents the operations arranged within these four components inside the tool architecture.

The overall methodology involves three phases. Namely; development of the tool, test execution with sample data and a usability test. In the development phase, the tool is designed with requirements identified in the literature survey. In the second phase the tool is verified for its proper functionality by executing the transformation on the trial data set using two sample ontologies. The study also includes a usability test to evaluate the tool for its user-friendliness by conducting a usability test.

The functionality of the tool can be expressed as follows. The initial stage of the procedure imports the annotated feature types of the source data model to the system. After the system checks the validity of the retrieved feature type name spaces, option is given to the user to define new rules of transformation or use of existing rules of transformation. If the user selects to define new rules, the target annotated feature types are also be imported to the system. In the next stage the user can save the used rules of transformation for future use and perform actual transformation on the data set.

The GUI is tested with feature types used within the INSPIRE context. In the trial execution of the transformation, the source feature types are from the ATKIS data model *(Grünreich 1992)* and the data are transformed into the INSPIRE data model for transport networks *(INSPIRE, 2008a)*. The ontologies used in the test run are developed using ontology developing language, Web Service Modelling Language [WSML] *(de Bruijn, Lausen et al. 2006)*.

1.4 Chapter arrangement

The arrangement of the dissertation chapters is as follows. The first chapter gives an introduction to the scenario and problem domain for the thesis work. The second chapter gives the background to the INSPIRE framework, annotation and WSML as ontology building language. The third chapter presents the design of the Translation *(OBSM)*. This explains the architecture of the translation tool along with activity diagram, sequence diagram as well the concept mapping algorithm used in rendering the ontologies. In addition the chapter describes the procedure of using the tool and the evaluation of the tool for its usability. The fourth chapter provides a brief overview of the test data models used in the evaluation of the GUI and results obtained in the test data run. The chapter five provides discussion on the possible work to improve the tool in future. Appendix contains a questionnaire used in the GUI evaluation.

2 BACKGROUND

This chapter introduce the INSPIRE directive, the spatial data infrastructure for Europe. As well the chapter gives an introduction to annotation of feature types and WSML as ontology building language.

2.1 INSPIRE directive on Spatial Data Infrastructure (SDI)

Normally data collected by various organizations are processed and stored locally within the organizations. When it comes to data sharing, it made the situation challenging due to the difficulties in data identification, access and manipulation of available data. This isolation of data causes gaps in availability, lack of harmonization between datasets at different geographical scales and duplication of information collection. Awareness is growing at national and at EU level about the need for quality geo-referenced information to support understanding of the complexity and interactions between human activities and environmental pressures and impacts. The INSPIRE initiative is therefore timely and relevant but also a major challenge given the general situation outlined above and the many stakeholder interests to be addressed *(Annoni, Friis-Christensen et al. 2008)*. According to the official web site, INSPIRE is an initiative developed with the intention of developing an European spatial information infrastructure delivering integrated information services that allow the users to identify and access spatial or geographical information in an interoperable manner. The target users of INSPIRE include policy-makers, planners and managers at European, national and local level and the citizens and their organizations, whereas possible services are identified the visualization of information layers, overlay of information from different sources, spatial and temporal analysis" *(Directive, 2007)*.

One of the concerns in INSPIRE directive is the road data infrastructure among the 34 themes defined for the European Spatial Data Infrastructure *(Markov 2008))*. The INSPIRE directive was created with the objectives of laying out the ground for the creation of a pan-European standardized, seamless, updated and quality assured digital road data infrastructure built on identified user requirements, simplifying the exchange of digital road data within and between different countries and harmonizing the specifications of road data in Europe *(Craglia and Nowak 2006)*. In developing a road data model for Europe several principles were followed in order to cater the identified requirements *(Directive, 2007):*

- Support collection and maintenance of data within the organizational level where it can be most effectively carried out
- Make use of existing data and create efficient GUIs to achieve seamless interoperability between existing data bases
- Involve all relevant stakeholders

- Use existing standards
- Set up efficient quality models
- Focus on core European road data

Accordingly European data model has been established for European data infrastructure. A detailed description of the European Road Data model is given in the section 4.1 of this thesis.

2.2 Semantic Web and Ontology Languages

World Wide Web (WWW) is not only a repository for static data, but furthermore offers interface to Web-accessible services, including spatial data infrastructures. These web services range from simple dynamically generated pages for pure information provision to more complex services for geo-spatial information provision like Web Mapping Services (WMS), Web Feature Services (WFS), Web Coverage Services (WCS), Web Terrain Services (WTS), Web Registry Services (WRS) and cartographic application related services as well as purchasing books, booking trips or trading with other internet-users over commercial or private marketplaces *(Feier et al.. 2005)*.

The goal of what is called Semantic Web Services (SWS) *(Sheila et. al 2001)* is the meaningful combination of Semantic Web technology and Web Services. Semantic Annotation refers to making the semantics of the service's underlying functionality or data explicit by establishing a link to domain ontologies. Therefore, the annotated feature type ontologies can be taken as semantic data model for Web Service technologies. So that Web Services can use these machine-processable annotations for processing services in addition to the static data on the web.

The Web Service Modeling Ontology (WSMO) *(Steinmetz and Toma 2008)* along with its related efforts in the WSML and WSMX working groups presents a complete framework for Semantic Web Services, combining Semantic Web and Web Service technologies *(Keller, Lara et al. 2004)*. Most common ontology building languages includes Resource Description Framework (RDF) *(W3C, 2008)*, Web Ontology Language (OWL) *(W3C, 2004)* and the Web Service Modeling Language (WSML) *(Lara, Roman et al. 2004)* in the family of languages.

WSMO framework is accompanied by a formal language, WSML that allows one to write annotations of Web services according to the conceptual model. Also an execution environment (WSMX) *(Steinmetz and Toma 2008)* for the dynamic discovery, selection, mediation, invocation, and inter-operation of Semantic Web services based on the WSMO specification is under development *(Steinmetz and Toma 2008)*. SWING project utilizes WSML for developing ontologies. This thesis work gives a major concern for the ontologies developed using WSML language, because at this stage it only focus on supporting the ontologies built using WSML language. In addition ontologies used for the pilot test are developed using WSML language, which is a product of schema mapping architecture for INSPIRE road data models [1].

2.3 Semantic annotation of feature types

In order to capture the semantics of a data model, feature types need to be annotated *(Klien, 2008)*. This can be done by mapping elements of the feature type schema to concepts in domain ontologies *(Andrei, Berre et al. 2008)*. It is assumed that all members of the geographic information community will interpret the terminology used in their domain ontology in the same way and, at the same time, people from outside the community are able to explore the intended meaning with the help of the concept definitions (Roman, Klien et al. 2006). *Figure 2.1* presents the concept of annotation between the domain ontology and the feature type ontology developed from the spatial information objects. The process initiates with the real world entities, which are represented as spatial information objects. These objects are encoded as features in the Geographic Markup Language (GML) *(Listings 2005)* and served via OGC (Open Geospatial Consortium) data services to GML ontology. Theses annotated feature type ontologies may contain one or more feature types in the same ontology.

This shall be achieved by annotating web content with consensual formalizations of the knowledge published, often referred to as *ontologies*. *(Feier etal.)*. Semantically enhanced information processing along with logical inference eventually shall allow the development of high quality techniques for automated discovery, composition, and execution of Services on the Web, stepping towards accurate integration of data on the Spatial Data Infrastructure *(Stollberg et. al, 2004)*.

[1]The schema mapping project presents an analysis of existing schema mapping tools and propose architecture for flexible data provision with the implementation of the prototype. Results account for schema mapping requirements within the INSPIRE context *(Beckmann et al., 2009).*

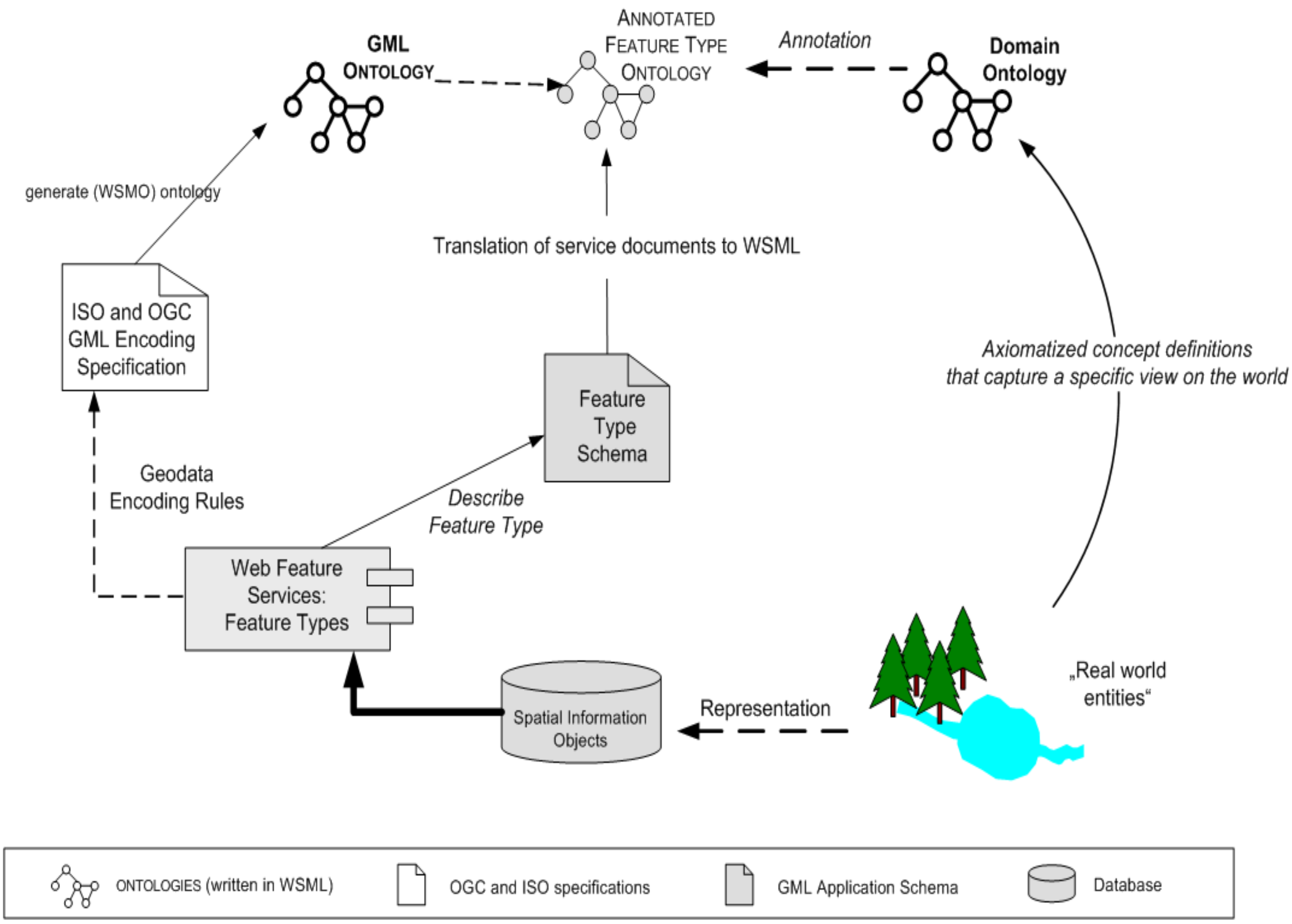

GML ONTOLOGY
ANNOTATED FEATURE TYPE ONTOLOGY
Annotation
Domain Ontology
generate (WSMO) ontology
Translation of service documents to WSML
ISO and OGC GML Encoding Specification
Axiomatized concept definitions that capture a specific view on the world
Feature Type Schema
Geodata Encoding Rules
Describe Feature Type
Web Feature Services: Feature Types
„Real world entities“
Representation
Spatial Information Objects
ONTOLOGIES (written in WSML)
OGC and ISO specifications
GML Application Schema
Database

Figure 2.1: Overview of items involved in the process of annotating ontologies in the context of WSMX *(Schade, 2008; modified)*

Mapping processes discussed earlier between schemas, focused on rather a syntactical approach. Tools such as FME or Spatial Data Integrator are used to successively map different attributes of two different schemas to each other. *Figure 2.2(a)* shows an example, mapping the syntactical elements of a source Schema to a Target schema, using line diagram, where as *Figure 2.2(b)* shows how the mapping is really done using, FME. Two data model schemas are presented along with its attributes. The boxes represent the different attributes while the design filled in the boxes represents different attribute types. As shown in the figures, in a schema mapping procedure, attributes of one schema is assigned to another with or without transformation operation.

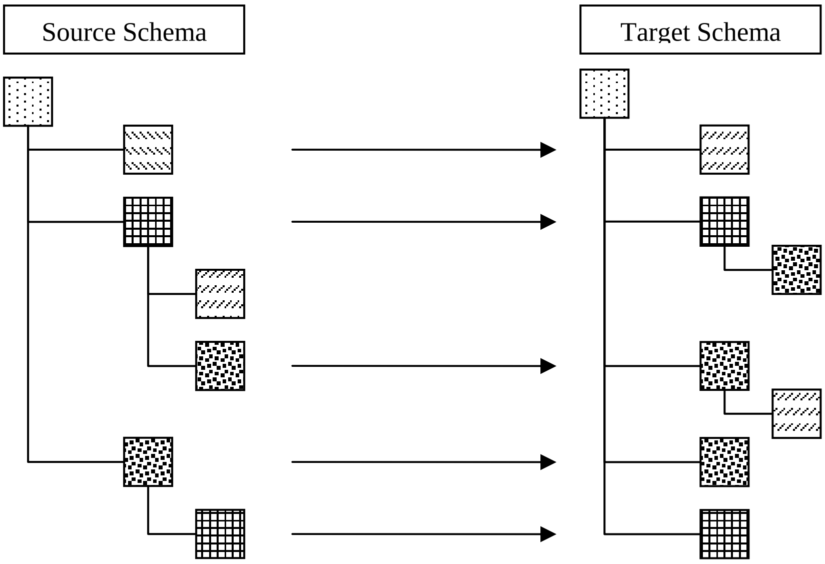
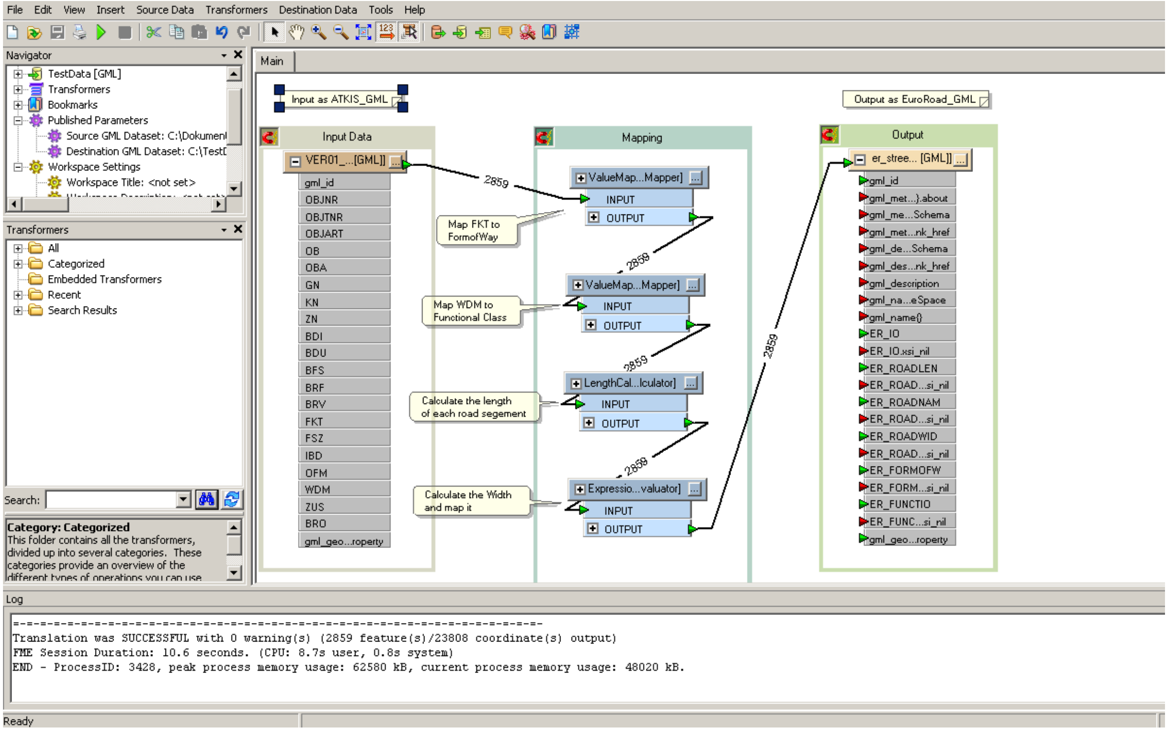


Figure 2.2(a): Syntactical Mapping using conventional schema mapping tools.



Category: Categorized
This folder contains all the transformers, divided up into several categories. These categories provide an overview of the different types of operations you can use

```
=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
Translation was SUCCESSFUL with 0 warning(s) (2859 feature(s)/23808 coordinate(s) output)
FME Session Duration: 10.6 seconds. (CPU: 8.7s user, 0.8s system)
END - ProcessID: 3428, peak process memory usage: 62580 kB, current process memory usage: 48020 kB.
```

Figure 2.2(b): Syntactical Mapping using conventional *Feature Manipulation Engine (FME)*.

3 INTRODUCTION TO THE OBSM tool

This section will describe the tool from the background of the tool to the internal functionality using the *OBSM* components, their arrangement within the tool and its functioning in greater detail.

3.1 Introduction to the General Scenario

The GUI is designed as a component in the Schema mapping architecture proposed for a project at the Institute for Geoinformatics (IFGI) in Münster, Germany *(Beckmann, et. al, 2009)*. The proposed architecture is presented in the *Figure 3.1.* Accordingly interaction between the components of the architecture can be described as follows; when the client *(Figure 3.1)* [1] has a requirement for a certain road data set, he request from the WFS [2], via a GetFeature(2) request. Then an OGC catalogue [3] is requested for available sources, then the central service checks for available rules, and then those are processed in a translation.

IF the data is already available GetFeature request is sent to the WFS and the successful response for the request is completed. If the required data is not available within the system, the GetCapabilites(3) request is sent to the WFS including the original street data, which will then send the URL of the feature to the WFS, in order to look for the corresponding rules for the transformation. If the required set of rules is available within the rules repository, WFS get the rules identified by the feature type name, which is the index for the database. If the rules are not available for the schema translation, rules will be defined accordingly within the rule generating component of the tool [5], using the feature type ontologies [6]. This will then be taken back to the WPS, on the specified file format of the Mapping file, which can really execute rules on the execution environment [4]. Once the set of rules are available within the WPS, it sends the Feature-URL along with the rules to the execution component. Execution component performs the actual transformation, on the data gained through the WFS, using the Mapping file. Server then uploads the data and sends the name identifying the feature type to WPS. Subsequently, WPS-Server sends Feature-Identifier to client where the client can download the data from the WFS.

(2). "GetFeature" is one of the most prominent OGC standards is the Web Feature Service (WFS) Implementation Specification (OGC, 2005b), an interface definition for the provision of vector data*(OGC, 2005*

(3). The service model is the overall model governing the structure of OGC Web Services. It is an architecture in which individual services have interfaces of known types. These interface types are described in service metadata and the service metadata are available to clients of the service via a "Get Capabilities" request.*(Doyle, Reed et al. 2001)*

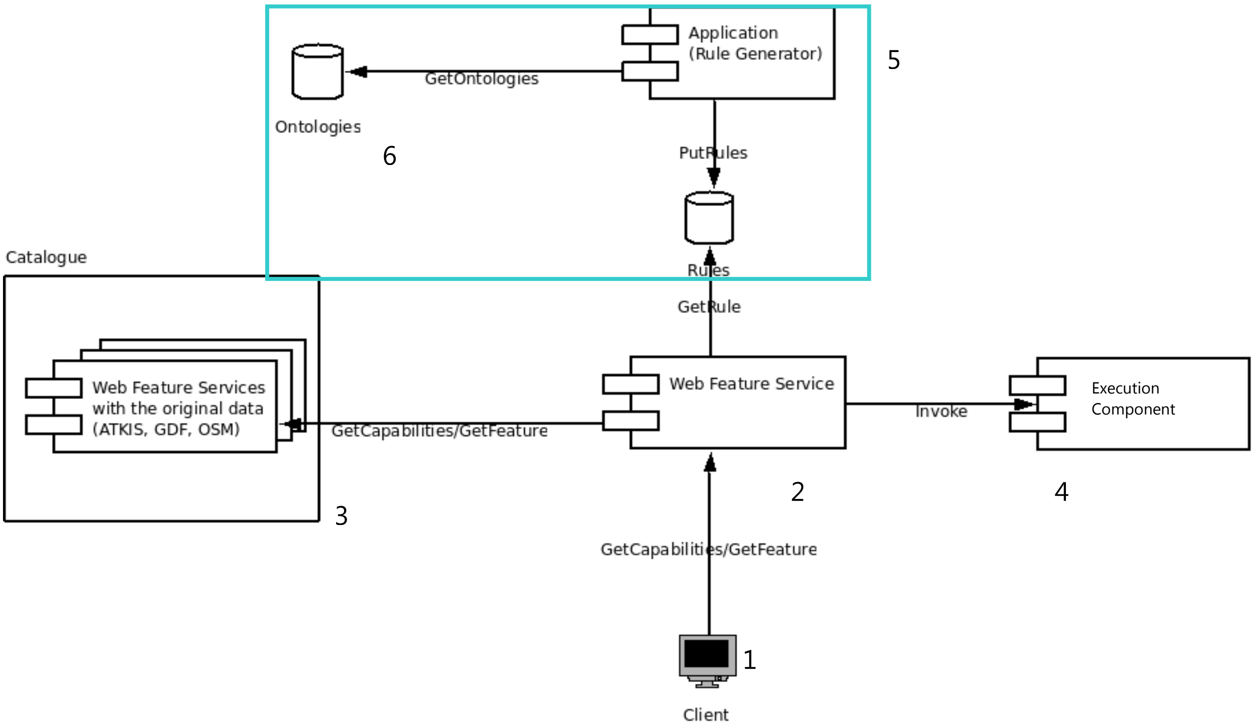


Figure 3.1: Components and the workflow of the architecture *(Beckmann, et. al, 2009)*.

3.2 Scope of the tool

The facts mentioned in the section 1.2 prove that faster and less labor-intensive approach is required for schema mapping. The most important applications for schema mapping GUIs are virtual data model integration and data model translation, which define mappings at concept level that can later be used at the data level when required.

The *Figure 3.2* is a detailed explanation of the component presented in the *Figure 3.1* by the highlighted blue box that exhibits the Communication of the GUI with external resource components. As mentioned in the sub-section 3.1, second case on the WFS (to get the rules when required set of rules are of available in the repository), is the main scope of the tool. As mentioned in the *Figure 2.1*, the GML ontology is directly developed from the feature type data model, which becomes the input for the *OBSM*. This is linked with the feature type ontology and annotated with the domain ontology. This annotated feature type ontology is the input for *OBSM*.

When the requested set of rules is not available in the rules repository the GUI request the source and target feature type ontologies. For both source and target, this annotated feature type ontology is required in order to render the ontology in the tool. Within the tool the user can either define new mapping rules in order to translate from source to target feature types or retrieve a set of rules available for translation of two feature types. Once the set of rules are defined, the tool develops the mapping file. The mapping file contains abstracted rules on its internal format. This will then be converted to the mapping file format, which is required by the execution component within the system architecture. It is then sent via WFS to the execution component, where the actual data transformation is performed.

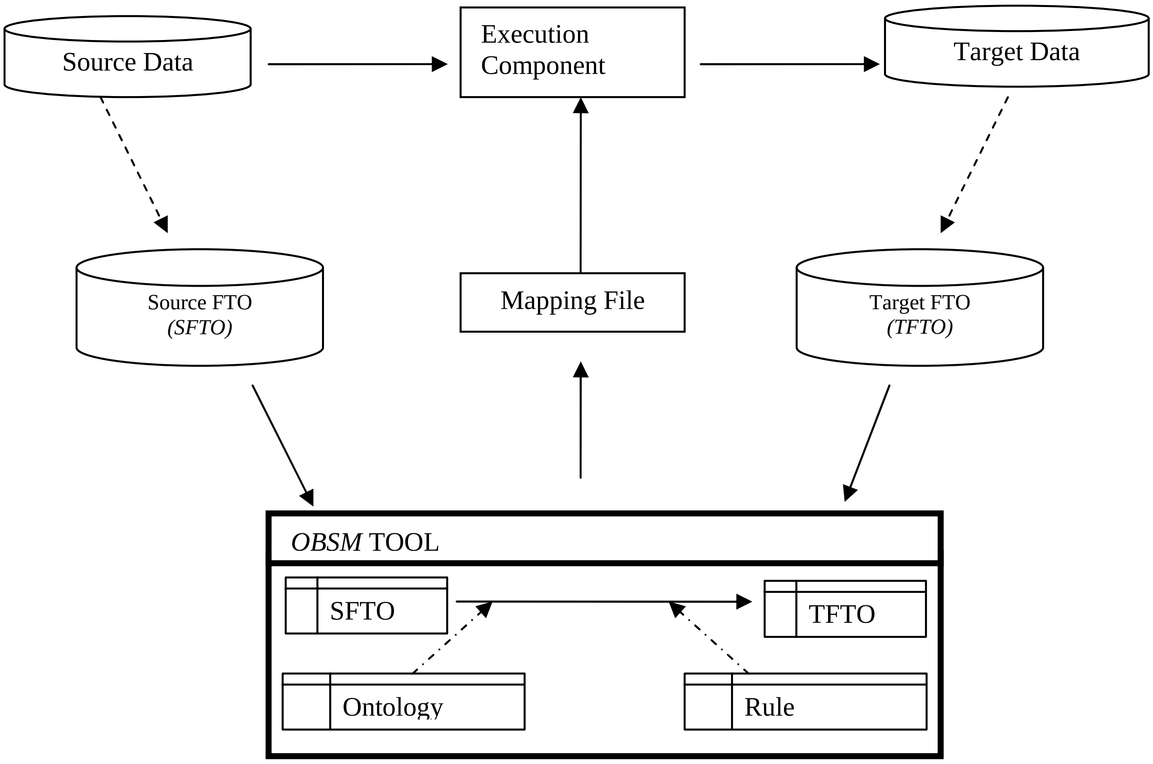


Figure 3.2: Communication of the tool with external resource components

3.3 Activity diagram

"An activity diagram represents the state of the method execution. i.e. the state of the object executing the method; the activities in the diagram represent activities of the object that performs the method" *(Rumbaugh, Jacobson et al. 1996)*. *Figure 3.3* presents the activity flow for the tool. The Activity diagram for the schema mapping use case depicts the steps involved in this workflow, which can be described as follows;

As first activity, the user needs to select the FTO according to his source data model. Concerning the steps present in the GUI, section of source feature type presents the step 01 while the left hand branch presents the step 02. Right hand branch presents the step 03 where as saving and exporting presents the step 04 of the GUI.

When the user selected the source feature type, user has two options:

Option 01(Left Branch): User can get a set of rules for the data model translation, which is already available from the tool. In this option the user first checks for available target feature types. If it is available he can select the desired target and import the rules for transformation and save them at a desired location as an *OBSM* mapper file. If it is not available he can go to the option 02, which means that the user defines new set of rules for data model transformation.

Option 02(Right Branch): User can define new set of rules at this option. User has to load the target feature type ontology. After source and target ontologies are rendered, the user can define new mapping rules. A defined mapping record is accepted after the inference check, on the concepts and the attribute of the concept. This process can be performed iteratively along with an inference check until all the rules are defined. These sets of defined rules are then converted into a set of abstracted rules by exporting to an *OBSM* mapper file, which can save into a desired location.

The activity diagram shows the steps where each action belongs, which makes easy to understand the processes described in section 3.4.

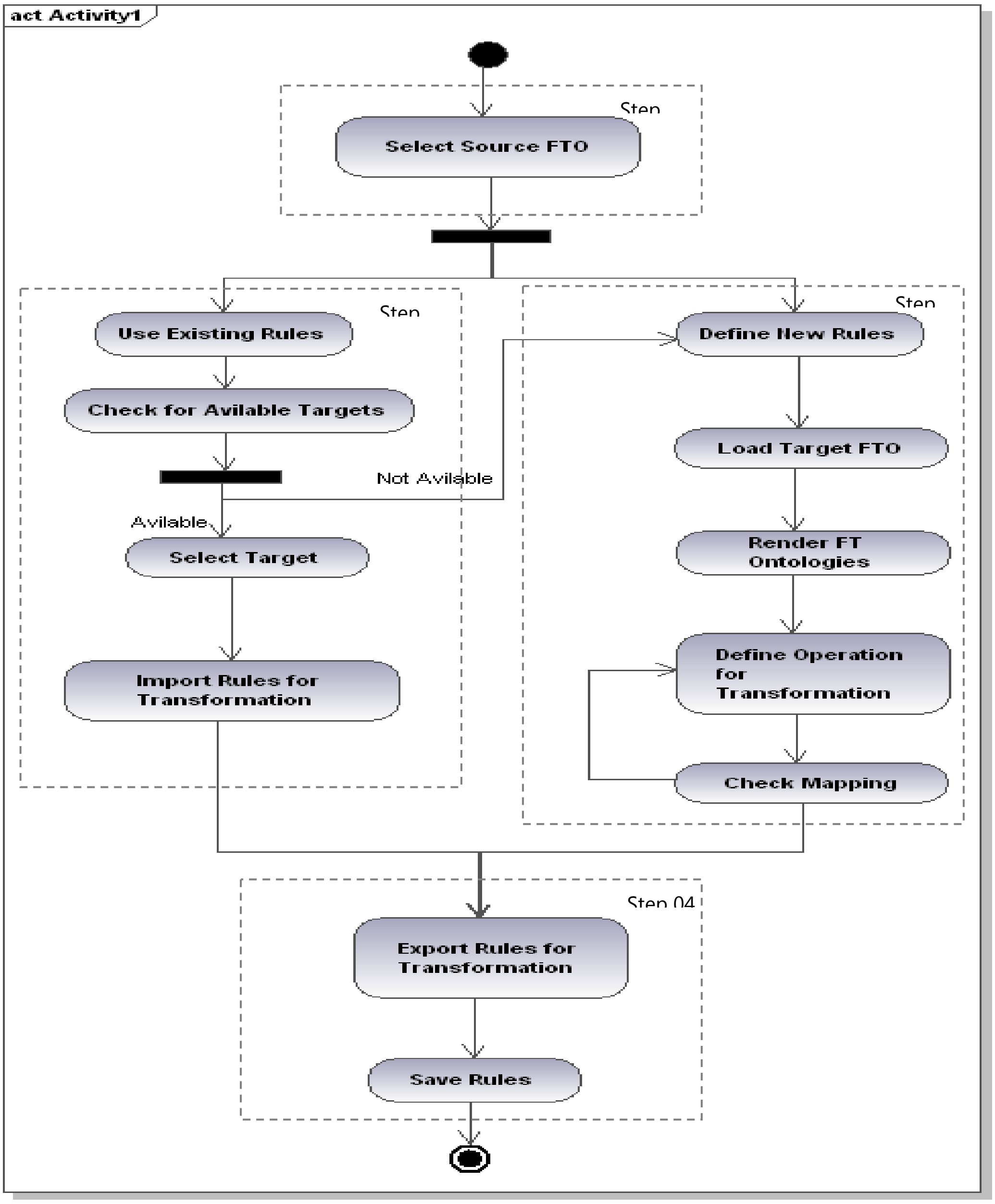


Figure 3.3: Activity Diagram of *OBSM*

3.4 Operation of the tool

The operation procedure of the tool is completed in four steps. The four tabs found in the GUI frame, indicate the steps that guides the user to complete a rule definition cycle. *Figure 3.4* presents the opening screen of the tool

OBSM

Ontology Based Schema Mapper

Version 1.0

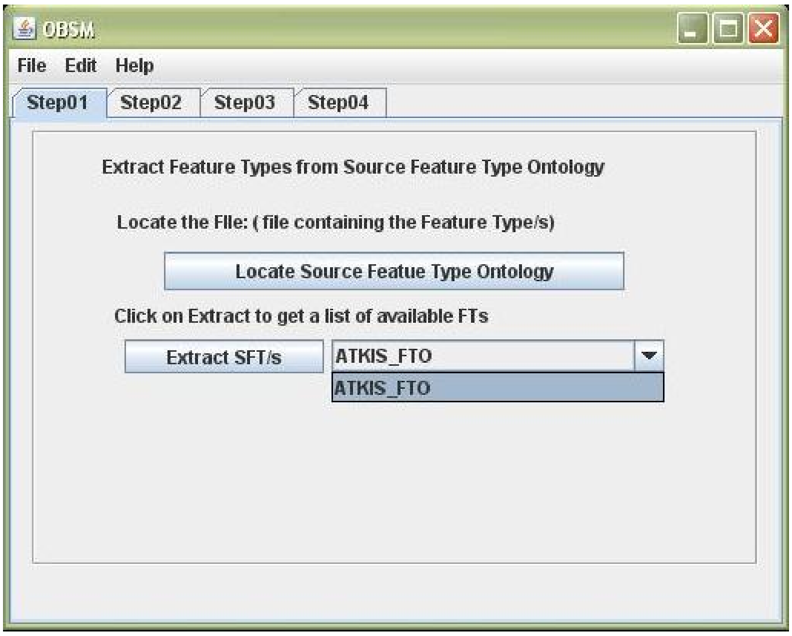
(2009)

Figure 3.4: Opening screen of the tool

Step 01

Figure 3.5 presents the first step of the process, which describes the source data model. In this step the user is asked to locate the file containing the source feature type ontology. Once the 'Locate Source FT' button is clicked, a file chooser appearing on a pop-up window will allow the user to locate the file.

Next operation in the step one is, to get a list of feature types. Once the 'Extract' button is clicked the GUI parse the selected file and read through to get a list of available feature types. For example, the GUI testing is performed with feature type ontologies built using WSML. The ontologies developed using WSML are available as *.wsml* files. Thus, it will provide a list of GML feature types available within the *.wsml* file read through. Once the user selects the name of the desired feature type, system gets the selected feature type from the file and register within the system.


OBSM
File Edit Help
Step01 Step02 Step03 Step04
Locate Source Featue Type Ontology
Extract SFT/s

Extract Feature Types from Source Feature Type Ontology

Locate the FIle: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

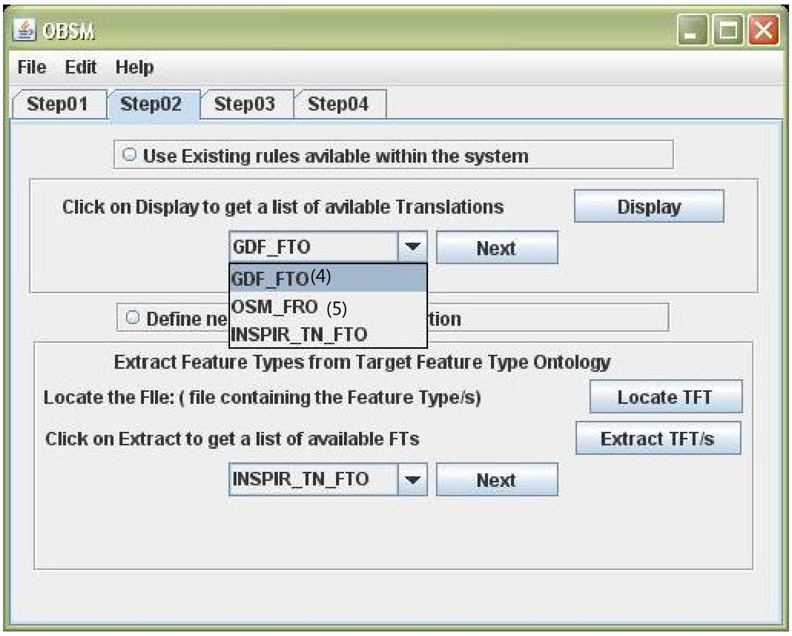
ATKIS_FTO

ATKIS_FTO

Figure 3.5: First step of the process

Step 02

The step 02 gives the next phase of the process which is presented by *Figure 3.6(a)* and *Figure 3.6(b)* respectively. In this phase the user is given opportunity to initiate the two alternative options; either user can decide to retrieve rules from the existing repository (Option 01) or define new rules for the translation (Option 02).



○ Use Existing rules avilable within the system

Click on Display to get a list of avilable Translations

GDF_FTO

GDF_FTO(4)
OSM_FRO (5)
INSPIR_TN_FTO

○ Define ne tion

Extract Feature Types from Target Feature Type Ontology

Locate the FIle: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

INSPIR_TN_FTO

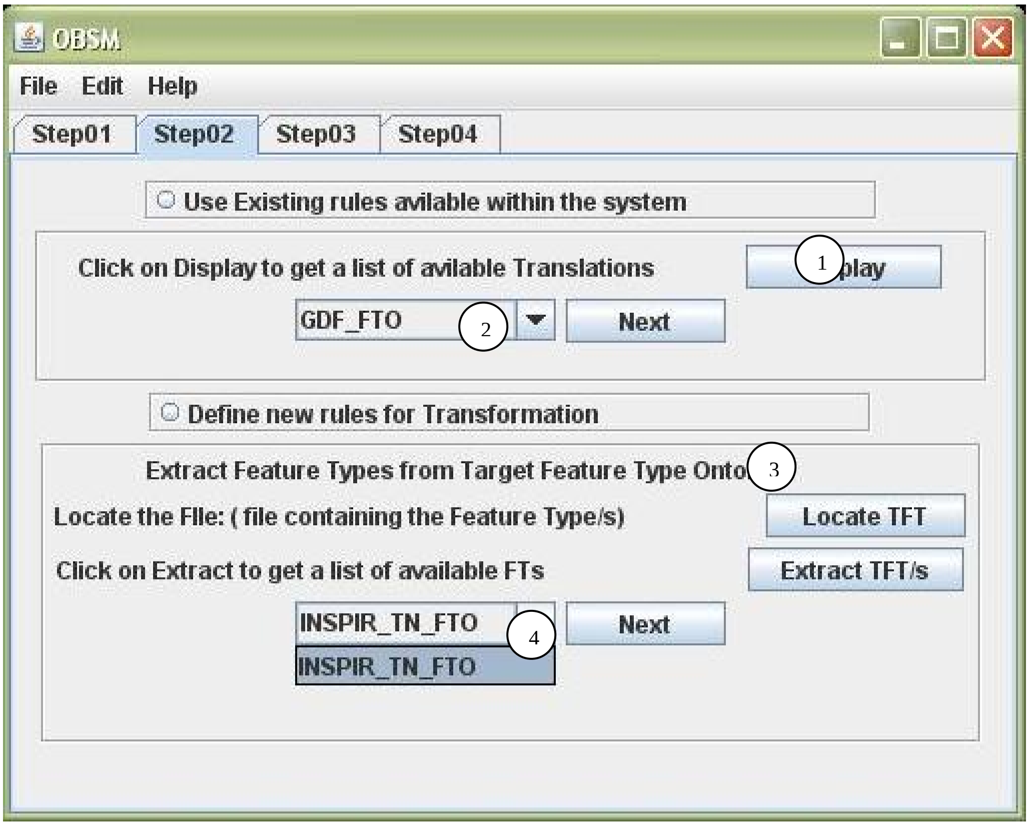
Figure 3.6(a): First option in the second step of the process

[4] Geographic Data Files (GDF) (ISO 2004)
[5] Open Street Map (OSM 2008)

Once the user selected the source feature type ontology (result of Step 01), the system searches through the table in the rule repository, which act as the registry index for the translations available in the local repository, to identify the mappings available and display the list accordingly,

Option 01: The user can browse through the rules repository and acquire a set of rules available within the system *(Figure 3.6(a))*. By clicking the "Display" button (1), user can get a list of target feature types, in the combo box (2).

Option 02 *(Figure 3.6(b))*: The user is given opportunity to proceed with defining the rules for schema translation. Thus to start with, the user needs to load the target FTO to the GUI. This is done similar to step 01, once the location of the feature type ontology file is entered by using the "Locate TFT" button (3), the system parse the file and read through, to a get list of GML Features available in the file. Once the user selects the desired target from a list (4) the system gets the desired GML feature type ontology and saves a copy of the file in the Ontology directory in the *OBSM* ontology repository.


OBSM

○ Use Existing rules avilable within the system

Click on Display to get a list of avilable Translations

GDF_FTO

○ Define new rules for Transformation

Extract Feature Types from Target Feature Type Onto

Locate the FIle: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

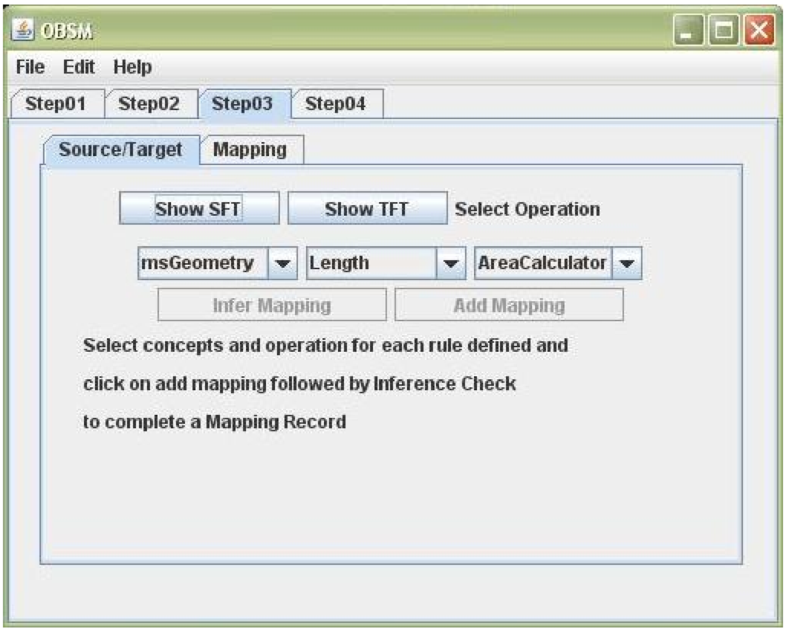
INSPIR_TN_FTO

INSPIR_TN_FTO

Figure 3.6(b): Second option in the second step of the process

Step 03

Step 03 represents the Mapping component of the tool. General arrangements of the graphical elements supporting this phase are presented in the *Figure 3.7(a)*.

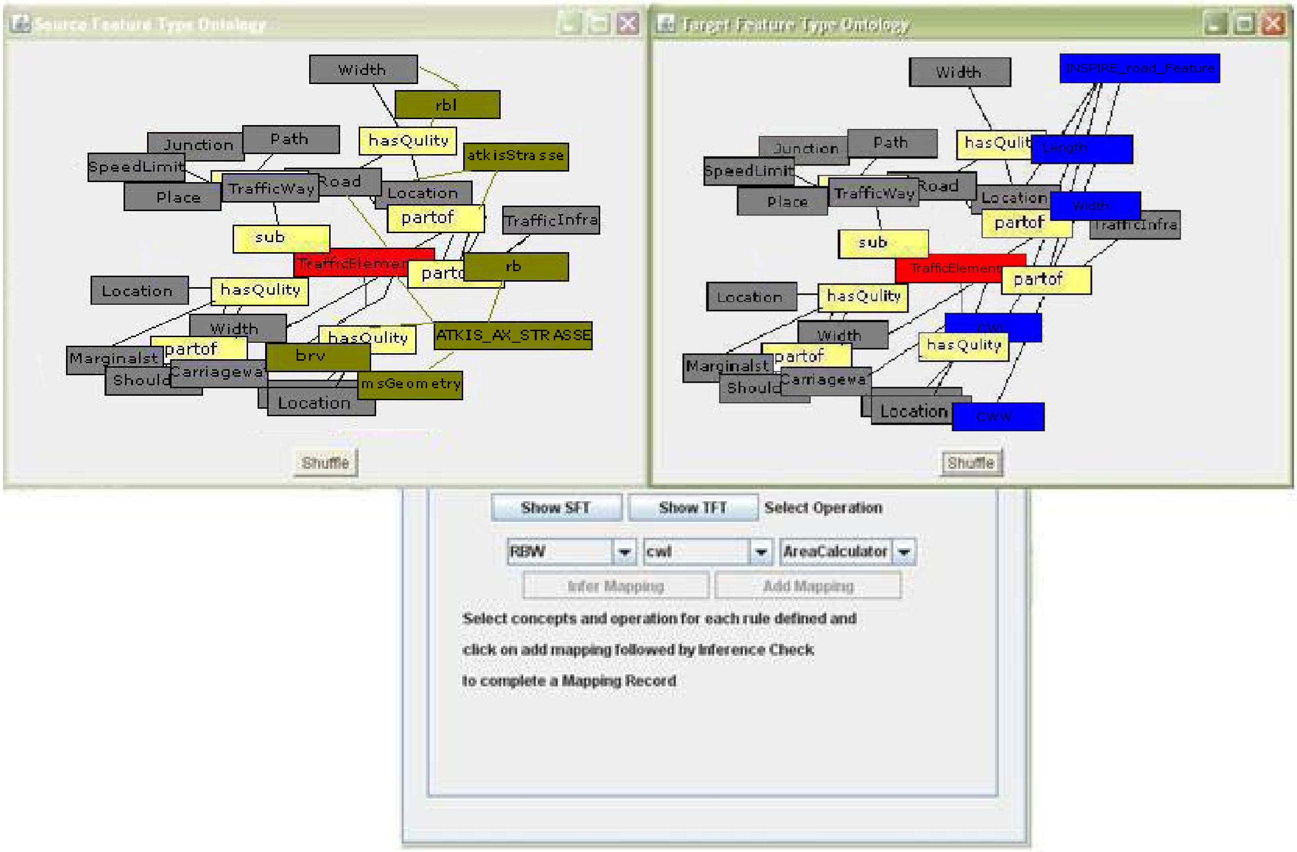


Select concepts and operation for each rule defined and
click on add mapping followed by Inference Check
to complete a Mapping Record

Figure 3.7(a): Arrangement of the objects in the third step of the process

This screen allows the user to visualize the ontologies graphically and define mapping rules. Clicking 'Show SFT' or 'Show TFT' buttons render the source and target feature type ontologies in separate pop up screens, as presented in *Figure 3.7(a)*. This allows the user to browse through the ontology concepts and relations. Two separate buttons assigned for the purpose of rendering source and target ontologies as it will provide the user, an easy observation panel for viewing the ontologies. The structure is accompanied with dynamical rotating effect, in order to give a representation closer to ontology development environment. Once a concept is selected, related concepts are highlighted in red color, in order to express the relation with other concepts within the ontology. This graphical representation of the concept maps is exhibited in the *Figure 3.7(b)*. 'Shuffle' button rearranges the concepts in the rendering environment to refresh the rendering view. The assignment of an individual concept to another is referred to as a "Mapping Record". The appropriateness of the mapping record could be assessed, using the "Infer Mapping" button.

By default "Infer mapping" and "Add mapping" buttons are disabled. First the user has to decide the source and target concepts for a mapping rule using the concept maps. Then these concepts need to be selected using the corresponding combo boxes present right below the rendering buttons. According to the source concept, a filtered list of operations (depending on the data type) is made available in the next combo box, where the user can define the mapping operation.

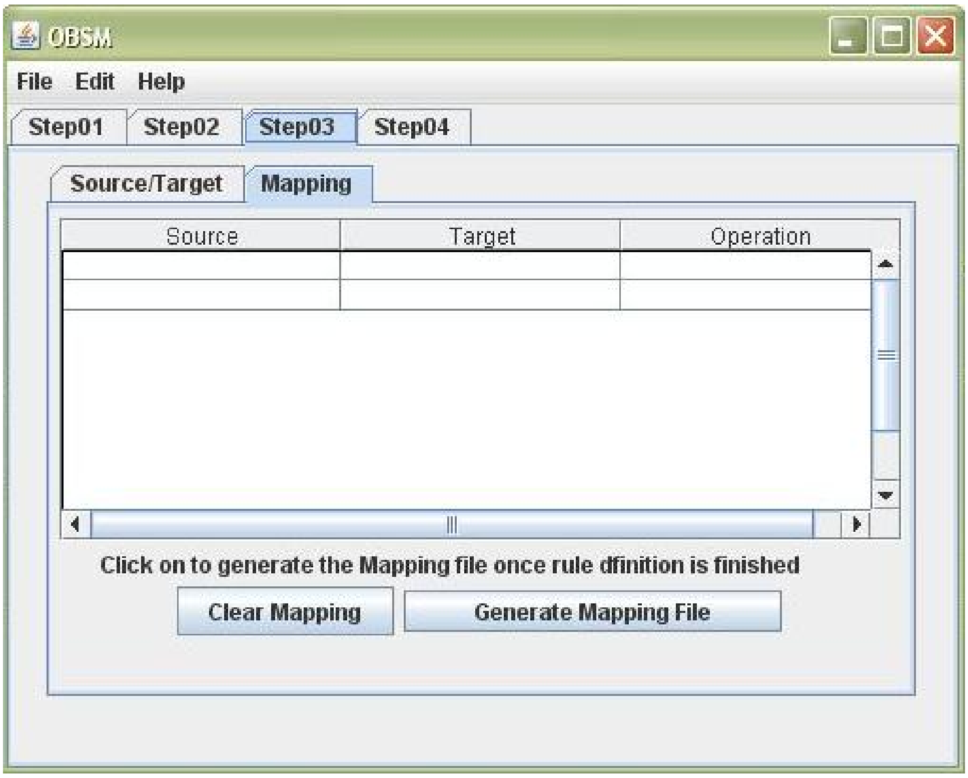


Select concepts and operation for each rule defined and click on add mapping followed by Inference Check to complete a Mapping Record

Figure 3.7(b): Rendering view of the ontology by the GUI

Once options are selected for all four combo boxes, “Infer Mapping” button gets activated allowing the user to check whether the mapping is acceptable. This will indicate that the operations defined are compatible and can be implemented on the data types identified. After checking the consistency, the mapping can be added to the table, using the ‘Add mapping’ Button, one record at a time. Definition of source and target concepts and the translation operation and checking the validity of the mapping using ‘Infer mapping’ will complete a single mapping record.

After the definition of a single record these three fields (source concept, target concept and operation) parse the parameter to a table, which is visualized within the ‘Mapping’ tab which will define the mapping records as mentioned in the section 3.4 in the text. User can regularly refer to the ‘Mapping’ tab and explore the previously defined mapping records. This is presented in the *Figure 3.7(c)*.



Click on to generate the Mapping file once rule dfinition is finished

Figure 3.7(c): Second phase in the third step of the process

If the user wants to remove a mapping record, which is already defined, he has to select the record in the table and has to click on 'Clear Mapping'.

Once definition of rules is completed, the user can generate the *OBSM* Mapping file by clicking on the 'Generate Mapping' button. After obtaining, the screen indicating the mapping file is generated successfully; user can proceed to the next step. At the current development stage the tool develops the mapping file, which is executable in the FME workbench.

The structure of the mapping record is given in Figure *3.7(d)*.

Explanation of the *OBSM* mapping file

The mapping record is an example of translating attribute of an ATKIS feature type to an INSPIRE feature type. It consists of the following:

Line 1-5: Defining the attributes of the ATKIS feature type. 'msGeometry', 'NAM', 'WDM', and 'BRV' are the attributes and 'gml_geometry', 'char(50)', and 'number(10, 2)' are corresponding types.

Line 11- 15: Assigning an operation to a source attribute, 'msGemetry' in this case. 'FACTORY_NAME' refers to the operation assigned to the source attribute. 'LengthCalculator' is the operation assigned to the source attribute in the example.

Line 17.22: Assigning the output of the transformation to the target attribute. In the example, the output of the transformation is assigned to the attribute 'LENGTH'.

Line 28-31: Defining the attributes of the INSPIRE feature type. 'msGeometry', 'WIDTH', and 'LENGTH' are the attributes and 'gml_geometry', 'number(10, 2)', and 'number(10, 2)' are the corresponding types.

```
******************************
1.GML_ATKIS_1_DEF FeatureA\
2.msGeomerty                gml_geometry \
3.NAM                       char(50)  \
4.WDM                       char(50)  \
5.BRV                       number(10,2)  \
...

11.FACTORY_DEF * TeeFactory\
12.FACTORY_NAME LengthCalculator   \
13.INPUT  FEATURE_TYPE FeatureA_msGeometry \
14.OUTPUT FEATURE_TYPE LengthCalculator_OUTPUT   \
15.   _length @Length(10,2)   \
16.
17.FACTORY_DEF * TeeFactory \
18.  FACTORY_NAME "LengthCalculator_OUTPUT -> FeatureB Correlator" \
19.  INPUT FEATURE_TYPE LengthCalculator_OUTPUT \
20.OUTPUT FEATURE_TYPE __GO_TO_FINAL_OUTPUT_ROUTER__\
21.  @Transform(FME_GENERIC,SHAPE)   \
22.  @CopyAttributes(LENGTH,_length) \

...

28.GML_INSPIRE_1_DEF FeatureB \
29. msGeomerty                 gml_geometry \
30. WIDTH                      number(10,2)  \
31. LENGTH                     number(10,2)  \
```

Figure 3.7(d) presents the structure of the sample '*OBSM* Mapping file'

Step 04

This step gives the user the opportunity to save a copy of *OBSM* mapper file, which can then be executed in the FME workbench. By clicking on the 'Location' button, the location can be selected to save the file. 'Export Mapping' will export the file to the desired location, securing a copy in the rules repository *(Figure 4.8)*.

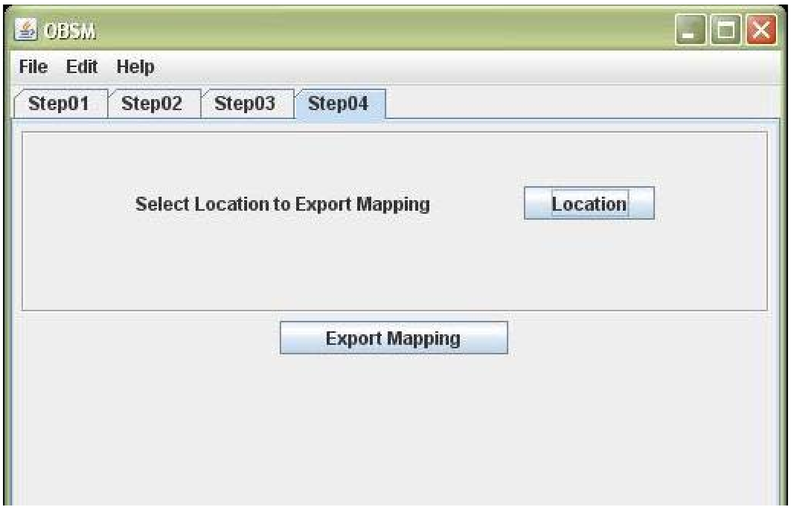


Figure 3.8: Forth step of the process

3.5 Components of the Tool

The GUI interaction comprises four components. These are introduced in the following.

OBSM Mapping Component

The mapping component is the main element of the GUI. Here, mappings are defined from source ontology to the target ontology, which is referred to as "A Rule Set". Feature type ontologies for the Mapping interface are retrieved from the internal repository, along with the annotations. One mapping will result a set of rules (intermediate mapping file) which will then delivered to the system architecture to covert to the format of the translator which performs actual transformation. For example; If the FME should be used for translation, an FME Mapping file is exported, if translation should be executed in GeoXSLT, a corresponding file is created. The mappings are defined manually between the concepts of the ontology. This step actually implements main idea of the thesis. The concepts of the domain ontology annotated with the actual data model, make use of the semantics in order to make the process of defining the mapping easier.

The definition of a mapping record is supported by a GUI, which allows;

- Searching and panning through source and target ontology concept maps allow understanding the concepts and their relations in the considered data models.
- Assignment of source ontology concepts to the target ontology using the combo boxes in the main window.
- Definition of the type of operator for the translation; The system identifies the type of the attribute corresponding to a concept and makes available only a selected set of operators for each mapping. For example;

Schema translation between data models ATKIS and INSPIRE:

Table 3.1 presents the Schematic representation of the rules definition table. Source and Target presents the source (ATKIS) and target (INSPIRE) concepts. The operator define the operation needs to be performed on the data translation.

Source	**Target**	**Operator**
msGeometry	LENGTH	LengthCalculator

Table 3.1: Schematic representation of the rules definition table

BRV attribute can be mapped to the LENGTH, because the type is same. Yet the operator LengthCalculator can only be assigned to the type 'num' but not to the type string.

OBSM Ontology Repository

This component serves as a database for the ontologies used within the tool. The tool comes along with a separate directory called "Ontology.dir". Once the user locate the file containing the source feature type ontology file in step 01-section 3.3, a copy of a file will be automatically copied to the repository, User can use these files any time for generating mapping files.

OBSM Rule Repository

The Rules Repository consists of a directory (RulesRepository.dir) and 'Rule Repository look-up table'. The Rules Repository look-up table consists of following parts;

- Feature type name of the GML feature type of Source feature type
- Feature type name of the GML feature type of Target feature type

The system has a directory which contains mapping files for standardized data models which are stable and not subject to frequent changes, schema mappings ("Rule sets") which are ready to use which comes along with the tool. In addition each time when a mapping file is exported, a copy is saved in the directory.

OBSM Mapping File Generator

The *OBSM* rule generator generates *OBSM* mapping files, out of the rules, which have been stored in the 'Mapping Table'.

The structure of a mapping rule consists, of:

-Attribute of the source data model

-Corresponding attribute of the target data model

-Type of the each attribute following the format declaration of execution environment

-Identifier for the transformation

(For example; In case of using the FME, an FME specific identifier is generated)

The translation operation can be selected using the combo box in the step 03 presented in the section 3.3. Once the parameters (i.e. Source and target concept considered in each mapping and the translation operation) are set these will be added to the rule table. The set of rules will be resulted in an *OBSM* mapping file (intermediate file), which can then be translated to the standard format of the FME mapping file before submitting to the WFS.

The user interface is developed using JDK6, development environment, along with the "wsmo4j" library for java. The order of occurrence of the operations described above is explained in the section 3.6 using the sequence diagram of the scenario.

3.6 Sequence diagram

Sequence diagrams *(Rumbaugh, Jacobson et al. 1996)* are one means for describing the internal workings of software components. The interplay of the tool components is shown in *Figure 3.9*. The sequence diagram for the schema mapping use case depicts the two options involved in this workflow, which can be described as follows. . *"alt"* presents the two different alternative paths present in the GUI operation, in obtaining an *OBSM* mapper file and *"seq"* presents the different components present within the tool.

Alternative 01: Request rules from Rules Repository

User can get a set of rules for the data model translation which is already available with in the rule repository, using [RequestRulesfromRapository]. In this option GUI send [GetOntology:OntoID] request to the 'OntologyRepository' to get the source Ontology as a WSML file [GetSOntology]. Next [GetSFTO] is send to the 'FeatureTypeOntology' and available feature types are taken using [GetSFTResponse:FTO]. Next, a list of targets is taken for the selected source feature type, using the [RequestList:FT_Name] from the 'RulesRepository' using the response [RequestListResponse]. Once the user decides the preferred target, the *OBSM* mapper file can be taken using the [GetMapperFile] request and save in a desired location.

Alternative 02: Define new Rules

User can define new set of rules at the option [Define New Set of Rules]. User sends the [GetSOntology: OntoID] request to the 'OntologyRepository' and loads the source and target Ontologies using [GetSOntology]. This request is sent to the 'OntologyRepository' when both source and target ontology is retrieved. The desired source feature type is loaded via [GetSFTO] request and [GetSFTResponse:FTO] response. The desired target feature type is loaded via [GetTFTO] request and [GetTFTResponse:FTO] response to the 'Feature Type Ontology'.

Then FTOs are requested to render into concept maps via [RenderSource] and [RenderTarget(wsml)] requests and [GetSConceptMap], [GetTConceptMap] responses respectively to the 'Mapping component'. Rules are defined for each attribute type using [DefineOperation(InpurAtt)] request and [GetOperation] response to the 'Operation Repository'. Next the set of defined rules is taken in to a *OBSM* mapper file by sending [GetListOfRules:MapperFile] request to the 'RuleGenerator' and [GetListOfRulesResponse:Mapper File] response; via the [GetMapperFile] request user can get the file, save in a desired location while [Save(MapperFile)] request secures a copy of the mapper file in the 'Rules Repository'.

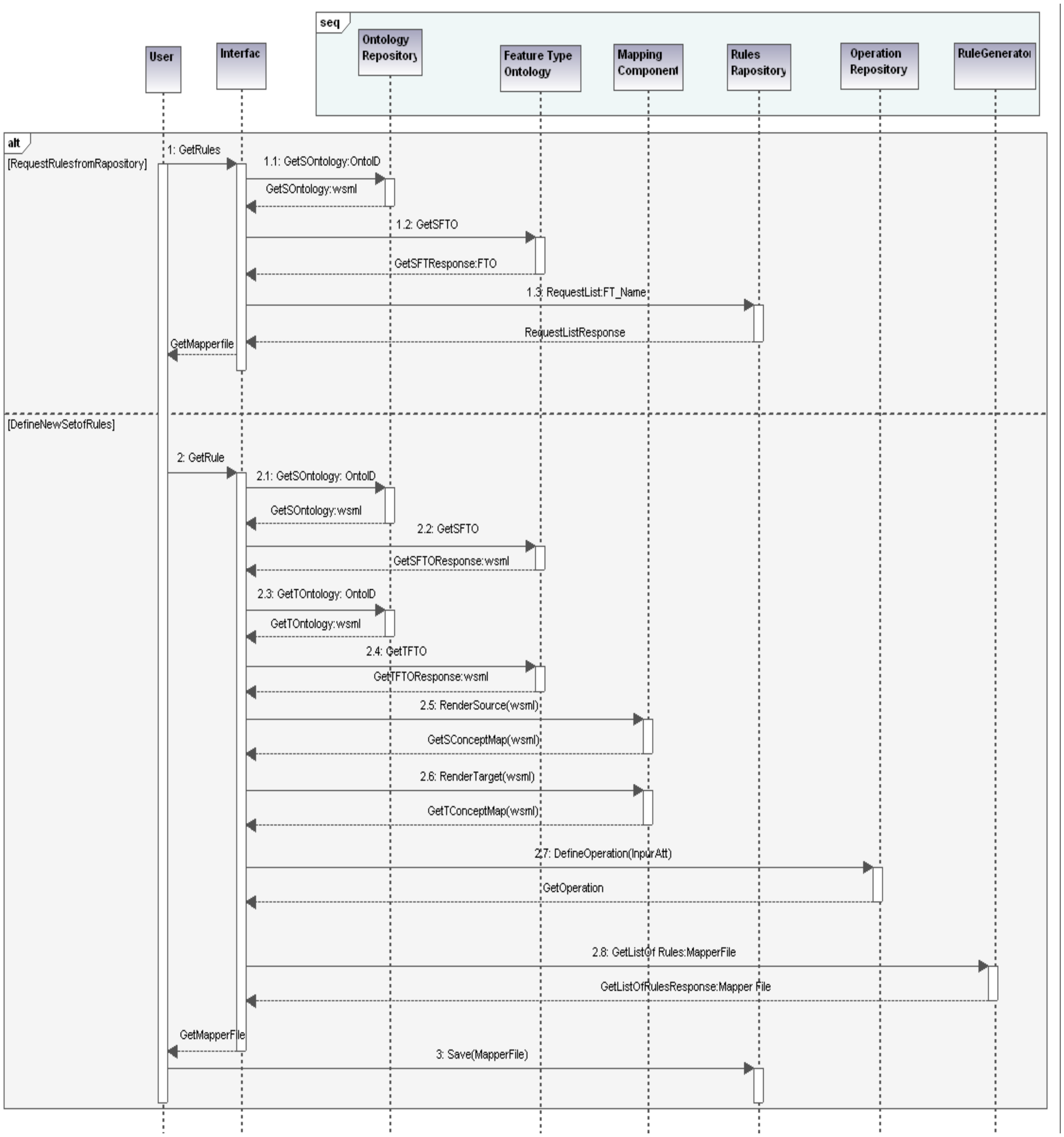


Figure 3.9: Sequence Diagram of *OBSM*

3.7 Evaluation of the tool

Usability of a product is a function of the particular user or class of users being studied, the task they perform, and environment in which they work *(Bevan, Kirakowski et al. 1991)*. Usability of an interface is one of the most important features that impacts on the performance of that system, when a software application is really used. Applications with a highly interactive nature, demands the application for the users' ability to navigate and access relevant information to a greater extent.

Systematic user acceptance testing with actual users is an important fact for the development of user-friendly interfaces. Usability testing approaches has gained a wider range of inputs from usability engineering studies *(Whiteside et at., 1988; Nielsen and Mack, 1994)* and the more general work on designing usable artifacts *(Norman, 1986; Landauer, 1995)*. The framework for the development of a user interface evaluation can be developed by adopting various procedures including the open process framework *(Firesmith and Henderson-Sellers, 2001)*, the user action framework *(Andre et al., 2000)* or the heuristic evaluation method *(Nielsen, 1994)*.

The evaluation performed on the GUI considered five main factors identified for usability evaluation *(Nielsen and Molich 1990)*:

Namely;

- User satisfaction;
- Ease of learning;
- Ease of use;
- Error prevention; and
- Efficiency of the interface.

Heuristic evaluation is an informal method of usability analysis where a number of evaluators are presented with an interface design and asked to comment on it.*(Nielsen and Molich 1990)*.

The questionnaire consists of two sections. Section 01 of the questionnaire dealt with users' preferences whereas the Section 02 dealt with the general performance of the system. The questions; 1.1-1.10 identifies the users attitude and perception on the tool where as questions 2.1 -2.5 identifies the strengths and weaknesses of the GUI. The open text question is designed on the objective of finding the recommendations for the improvement of the GUI. In addition, the users were also asked to comment on their overall impression of the tool such as the most and the least liked features, problems encountered, and some advanced useful features that could be incorporated into the tool. The reason for selecting the heuristic evaluation is that it can be implemented quickly and conveniently through experienced pool of evaluators.

The evaluation was performed while developing the tool, having three main objectives;

- To discover users' attitudes and perceptions on the tool
- To assess the strengths and weaknesses of the tool and
- To provide a set of recommendations for improvement.

The tool was evaluated using prototype model and questionnaire [as shown in the Appendix (a)] with the students in the schema mapping course (Sample size 10), who are a group of experienced users in schema mapping GUIs.

Results from the questionnaire

According to the results of the evaluation on the usability of the GUI, following justifications can be made on the general handling of the system. The number of responses for each acceptance level is converted to the fraction of the total population for the convenience of comparison.

Higher percentages of positive responses were obtained for questions 1.1, 1.3, 1.5, 1.7 and 1.9. This implies that the user is satisfied with the system's general capabilities and is in a position to employ the tool frequently in schema mapping procedures. The layout and the integration of the functionalities and the capabilities seem to be arranged in a coherent manner that the most of the users prefer the flow of work. In addition, users found the GUI as promising for easy understanding in its operation and confident on using the GUI. As the concepts and the logic of operation identified in the steps are rather familiar for the users in getting the desired output.

Questions 1.2, 1.4, 1.6, 1.8 and 1.10 have obtained a lower percentage of acceptances, implying that complications and unnecessary confusions of operations within the system are minimized. In addition most of the users are satisfied with the consistency of the tool is up to the standard and is really aids the user by not requiring the user to read piles of documents before using the system.

The results of the section 01, is presented in the Table 3.2

Section 01:	*Strongly Disagree*	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
	%	%	%	%	%
1.1. I think that I would like to use this system frequently	11	0	11	44	33
1.2. I found the screens unnecessarily complex	22	78	0	0	0
1.3. I thought the layout was easy to use	0	0	56	22	22
1.4. I think that I would need the support of a technical person to be able to use this system	56	33	11	0	0
1.5. I found the various functions in this system were well integrated	0	11	33	44	0
1.6. I thought there was too much inconsistency in this system	44	33	22	0	0
1.7. I would imagine that most people would learn to use this system very quickly	0	0	0	44	56
1.8. I found the system very cumbersome to use	22	44	33	0	0
1.9. I felt very confident using the system	0	0	11	78	11
1.10. I needed to learn a lot of things before I could get going with this system	33	22	11	22	11

Table 3.2: Results obtained for the section 01 of the questionnaire (Percentage of votes from the total responses)

The results of the section 02, is presented in the Table 3.3

Section 02:	***Very Bad***	***Bad***	***Satisfactory***	***Good***	***Very Good***
	%	*%*	*%*	*%*	*%*
2.1. How do you rate the general handling of device – Ease of Operation	0	11	0	78	11
2.2. How do you rate the display – Visibility, Data display on the screen	0	0	22	67	11
2.3. How do you rate the logic of operation menu?	0	0	11	67	22
2.4. How do you rate the ease of information provision	0	0	56	33	11
2.5. How do you find display scale of diagrams	0	22	33	22	11

Table 3.3: Results obtained for the section 02 of the questionnaire (Percentage of votes from the total responses).

Questions 2.1, 2.2, 2.3 and 2.4 have obtained a higher level of acceptance implying that the user is satisfied with the general functioning and operation. In addition, the user is satisfied with general logic of operation. Only the question 2.5 seems to have obtained lower level of acceptance from the population compared to the other questions implying the, scale of display of the graphics need to be improved.

4 APPLICATION OF THE TRANSLATION TOOL

Two data models are used in the evaluation of the *OBSM* mapping tool's functionality.

1. ATKIS - "Authoritative Topographic - Cartographic Information System"
2. INSPIRE Data Specification on Transport Networks·

4.1 Data Models used in evaluation

4.1.1 ATKIS -"Authoritative Topographic Cartographic Information System"

ATKIS data model is the result of a multistage research and development project of the German State Survey Working Committee (AdV) in the fields of state survey, cartography and automation. The Survey Authorities will use ATKIS to provide for the changing demands being made on the state survey. A comprehensive summery of ATKIS is presented in a report, based on a translation *(Hesse and Leahy 1990)* of official AdV documents *(AdV 1988, "Gelbes Heft")*. Detailed descriptions are available in separate documents *(AdV Arbeitsgruppe ATKIS 1989)*. ATKIS comprises a nationwide standardized digital topographic database with a three dimensional structure. The database is built in the public interest and transferred to public and private users as a state service. The database is authentic and current. ATKIS is based on a modern cartographic model theory, as shown in *Figure 4.1*. The real world with its topographic objects and its thematic structure is presented as the original. The topographic survey creates the primary model, a topographic landscape model. This model is transformed through cartographic work into a secondary model, the cartographic landscape model. During both these stages generalization processes at various levels take place resulting in different degrees of detail. A tertiary model is built by adding user specific original data models or other derived models.

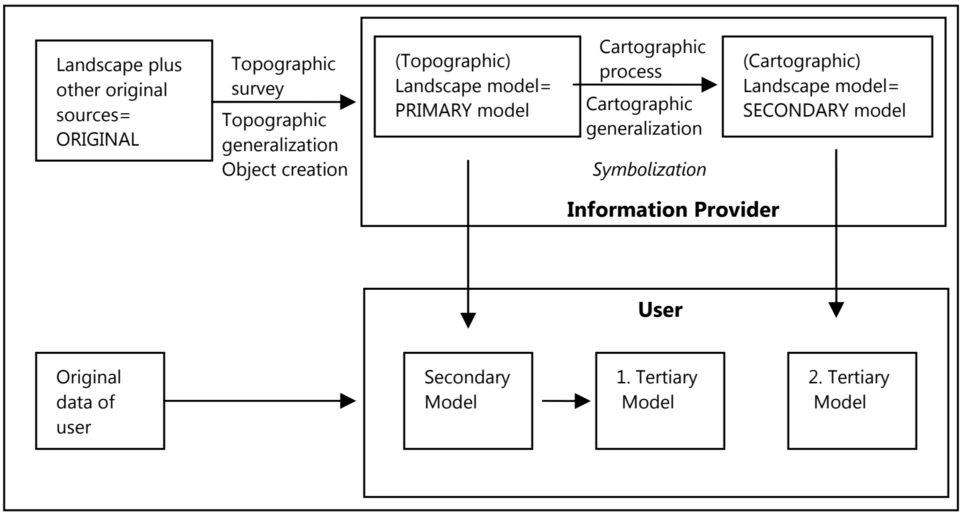

Landscape plus other original sources= ORIGINAL
Topographic survey
Topographic generalization Object creation
(Topographic) Landscape model= PRIMARY model
Cartographic process
Cartographic generalization
(Cartographic) Landscape model= SECONDARY model
Symbolization
Information Provider
User
Original data of user
Secondary Model
1. Tertiary Model
2. Tertiary Model

Figure 4.1: ATKIS data model architecture (*Source: Hesse, 1990*)

The creation of the primary model of the landscape takes place in the form of a three dimensional survey, based on topographic objects and object parts and their relationships. The objects are captured by shape, position and their topological relationship. Attributes are also assigned, coded and stored. Through this process of topographic modelling, a digital topographic landscape model is created in ATKIS terms, a Digital Landscape Model (DLM). Depending on the data capture accuracy and degree of structure, DLM will differ in degree of information density.

The creation of a secondary model is based on the DLM as the primary model. The stored topographic objects are assigned with symbology according to cartographic generalization rules. Through this process of cartographic modelling, a digital cartographic landscape model is created in ATKIS terms, a Digital Cartographic Model (DKM) according to the specifications of 'ATKIS3100' (Specification on road transport). Depending on the symbology catalogue and its degree of generalization chosen, a number of DKM versions for any map scale can be produced.

4.1.2 INSPIRE Data Specification on Transport Networks

INSPIRE data model specification *(2008b)*, includes four application schemas for *Road*, *Rail*, *Water* and *Air transport networks* based on the common transport network elements defined in the Common Transport Elements application schema. Includes links between different networks. Also includes the trans-European transport network as defined in Decision 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the Trans-European transport network and future revisions of that Decision", according to the D2.8.I.7 Data Specification on *Transport networks*. Transportation networks is one of the themes found in the INSPIRE directive *(2007/2/EC, 2007)* for spatial data Infrastructure themes. The Common Transport Elements covers elements that are shared by sub-themes *Road*, *Rail, Water and Air transport networks* and defines a number of common properties of transport network elements *(INSPIRE, 2008a)*.

Sub themes can be used in integration with other spatial data themes in an integrative approach of developing transportation networks. In addition these sub themes are important since they make the explicit background for topographic representations, link and node networks, inter-theme connectivity and capability to reference associated information. Thus this approach provides a framework for users to configure and associate their own information (from surface condition surveys, to journey planning, to Trans-European transport policy making etc.) using existing transport networks information in each Member State. *(INSPIRE, 2008c)*

The INSPIRE data model specification *(2008b),* defines, a liner network as the linear network is handled as a network of connected linear elements (links) with points (nodes) at the ends of the lines (at junctions, road ends, rail ends, ports, airports or airfields, etc.) and the aerial objects with a function in a network may be represented in the dataset. *(Figure 4.2)* describes the relationship of the data specification with supporting information architecture, which is explained in the sub chapter above.

In addition the data model schema *(2008a),* describes three fold primary aspects;

- Spatial (geometric representation as point, line and surface) are parts of the network;
- Temporal (temporal validity – description of when the network element exists in the real world and also optional information on when data was entered, modified or deleted in the dataset) and
- Thematic (related to the specialization of the sub-themes).

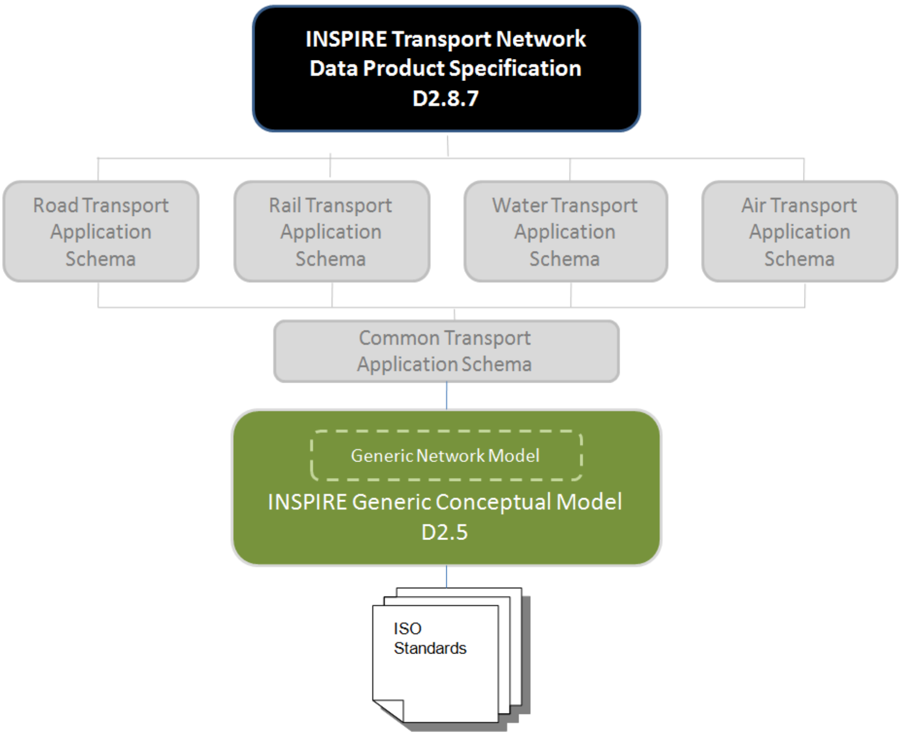

INSPIRE Transport Network
Data Product Specification
D2.8.7
Road Transport Application Schema
Rail Transport Application Schema
Water Transport Application Schema
Air Transport Application Schema
Common Transport Application Schema
Generic Network Model
INSPIRE Generic Conceptual Model
D2.5
ISO Standards

Figure 4.2: The relationship of the data specification with supporting information architecture *(Source:* D2.8.I.7 Data Specification on *Transport networks)*

All sub-themes (*Road, Rail, Water, Air*) employ a link and node structure to represent the content in the form of a linear network with the following sub-theme specific characteristics in relation to road transportation: *(INSPIRE, 2008a)*:

- A road system used for the transportation of vehicles in the *Road transport networks*;
- Ownership and traffic direction in the *Road transport networks*,

4.2 Annotation of the feature types to the domain ontology

Figure 4.3 presents a sample of test feature types of ATKIS and INSPIRE, annotated feature types with the domain ontology. The concepts of the domain ontology are represented in the ash color. The attributes of ATKIS data model and INSPIRE data model are represented in green and blue color respectively. In the process of annotation, data model attributes and domain ontology concepts are matched and linked. For example In the ATKIS data model 'BRV' is the attribute representing the width of the road. Therefore BRV is annotated with the domain ontology concept 'Road'.

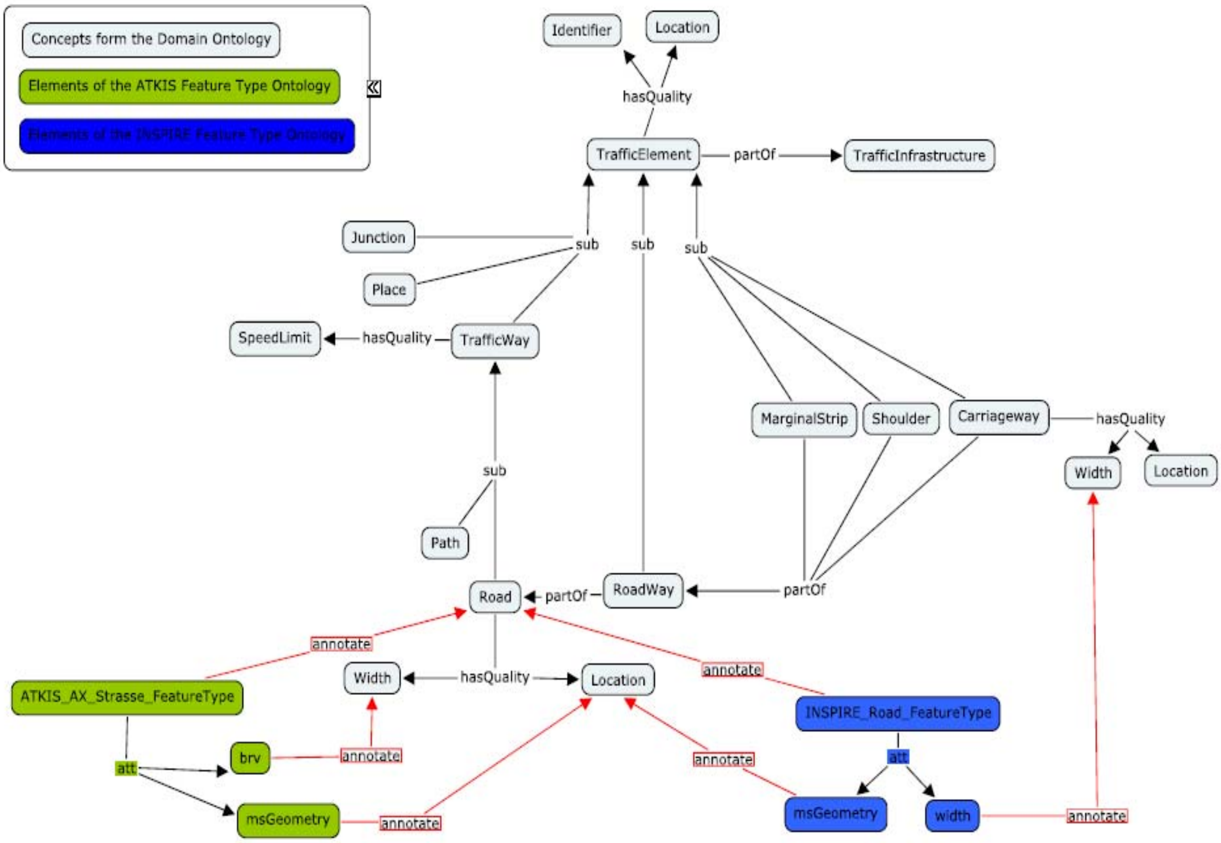


Figure 4.3: Annotated feature type ontology

The description of the Domain ontology

In the considered extraction from the ontology, Traffic elements are a part of the traffic infrastructure. Carriage ways and roads are part of the road way, which is a specific traffic element. Both, roads and carriage ways are attributed with width and location

4.3 Use of data in the tool and results obtained

Application of *OBSM*

This chapter explains the application of real data on the GUI. This stage of development, the tool is designed to use the FME workbench as a platform to execute the rules and WSML as the ontology developing language.

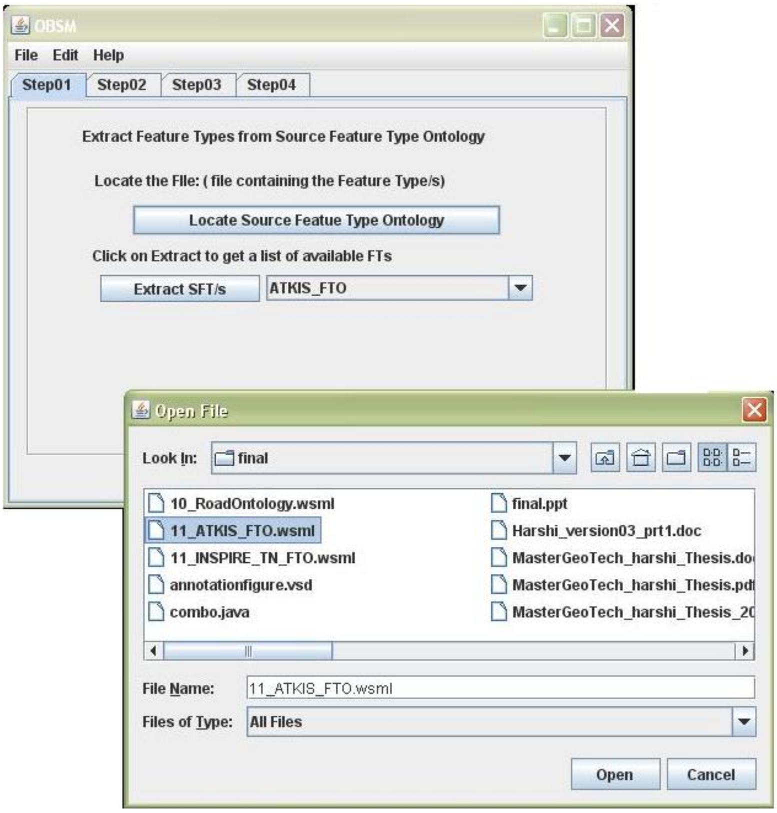
Step 01

In this step the source feature type is loaded to the system.

Procedure;

- ○ Click on the "Locate Source Feature Type Ontology" button. *(Figure 4.4(a))*
- ○ Locate the file using the file chooser window appearing

The file chooser allows only single file selection in this version of the tool. Once the file is selected it will be send through a passer and read in order to extract the feature type name. The file chooser only allows selecting *.wsml* files as the source ontology file.



Extract Feature Types from Source Feature Type Ontology

Locate the File: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

ATKIS_FTO

Look In: final

10_RoadOntology.wsml
11_ATKIS_FTO.wsml
11_INSPIRE_TN_FTO.wsml
annotationfigure.vsd
combo.java
final.ppt
Harshi_version03_prt1.doc
MasterGeoTech_harshi_Thesis.do
MasterGeoTech_harshi_Thesis.pd
MasterGeoTech_harshi_Thesis_20

File Name: 11_ATKIS_FTO.wsml

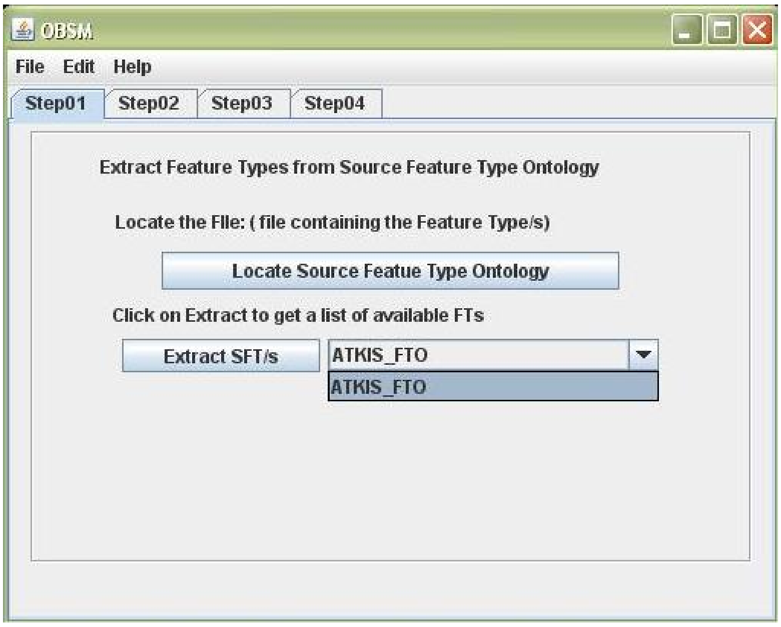
Files of Type: All Files

Figure 4.4(a): Selecting the source feature type ontology file

Procedure;

- ○ Click on the " Extract SFT/s" button *(Figure 4.4(b))*
- ○ Select the desired source feature type from the appearing list

Once the “Extract SFT/s” is pressed, a list of feature types available in the file is displayed as a list in the combo box. The user can select only one feature type for mapping at this stage of development.


OBSM
File Edit Help
Step01 Step02 Step03 Step04
Locate Source Featue Type Ontology
Extract SFT/s

Extract Feature Types from Source Feature Type Ontology

Locate the FIle: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

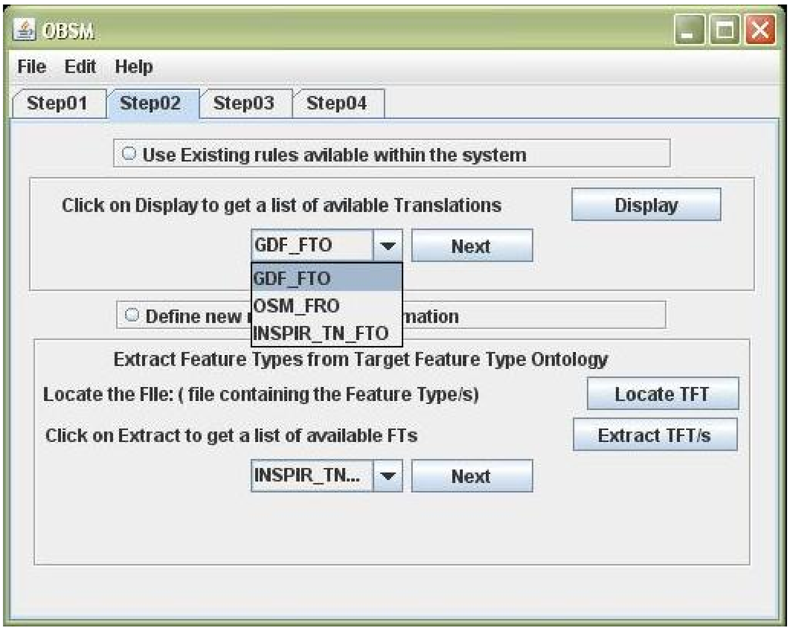
ATKIS_FTO

ATKIS_FTO

Figure 4.4(b): Extracting the source feature types

Step 02

In this step the user is given the opportunity to trigger the one of the alternatives present in the system in order to generate the rules file.



○ Use Existing rules avilable within the system

Click on Display to get a list of avilable Translations

GDF_FTO

GDF_FTO
OSM_FRO
INSPIR_TN_FTO

○ Define new mation

Extract Feature Types from Target Feature Type Ontology

Locate the FIle: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

INSPIR_TN...

Figure 4.5(a): Selecting the source feature types – alternative 01

Procedure;

Alternative 01: Radio button 01

User can check whether there is a set of rules already defined is available in the rules repository by clicking on the 'Display' button. *(Figure 4.5(a))*

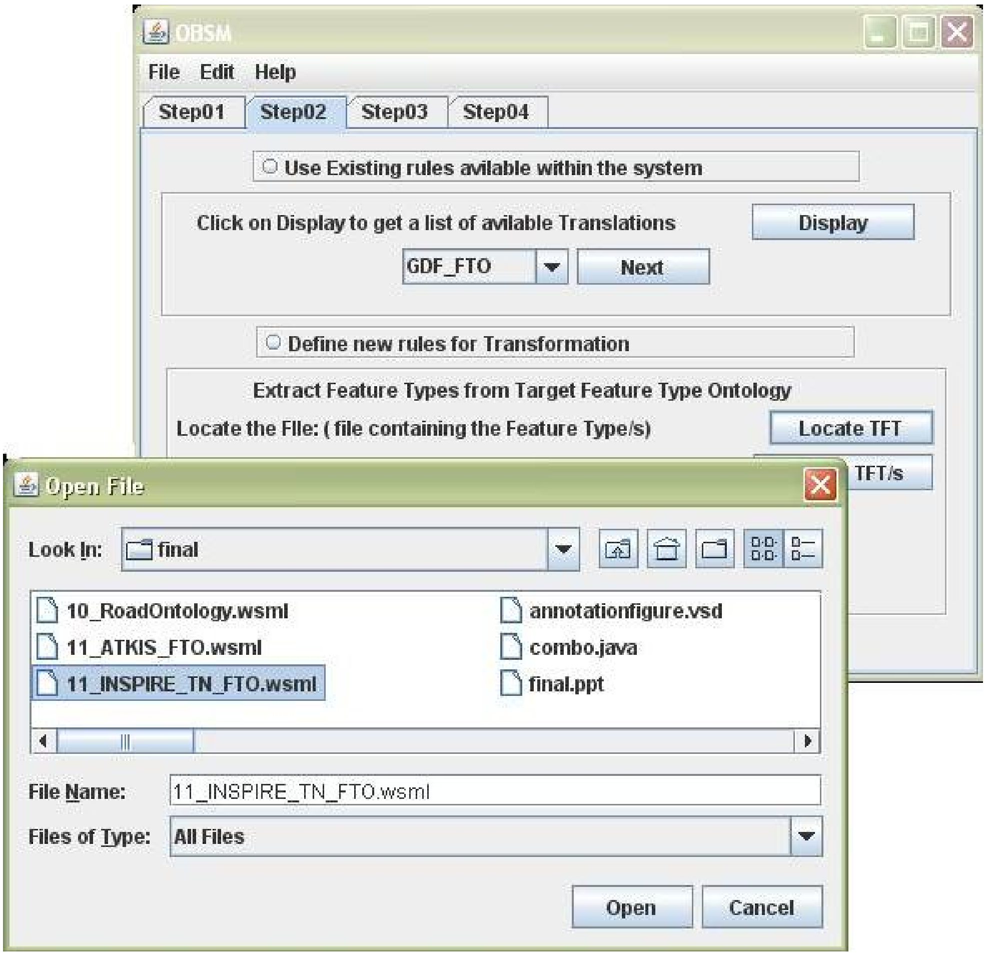
If this option is selected; the step 3 will not be activated. User can directly proceed to the step 04 by clicking on the ´Next´ Button.

Alternative 02: Radio button 02

User can define new set of rules for the schema translation.

- Click on the "Locate TFT" button. *(Figure 4.5(b))*
- Locate the file using the file chooser window appearing

The file chooser allows only single file selection in this version of the tool. *(Figure 4.5(b))*. Once the file is selected it will be send through a passer and read in order to extract the feature type name. The file chooser only allows selecting *.wsml* files as the source ontology file. Once click on the 'Extract TFT/s' the user can extract the target feature type *(Figure 4.2(c))*.



○ Use Existing rules avilable within the system

Click on Display to get a list of avilable Translations

○ Define new rules for Transformation

Extract Feature Types from Target Feature Type Ontology

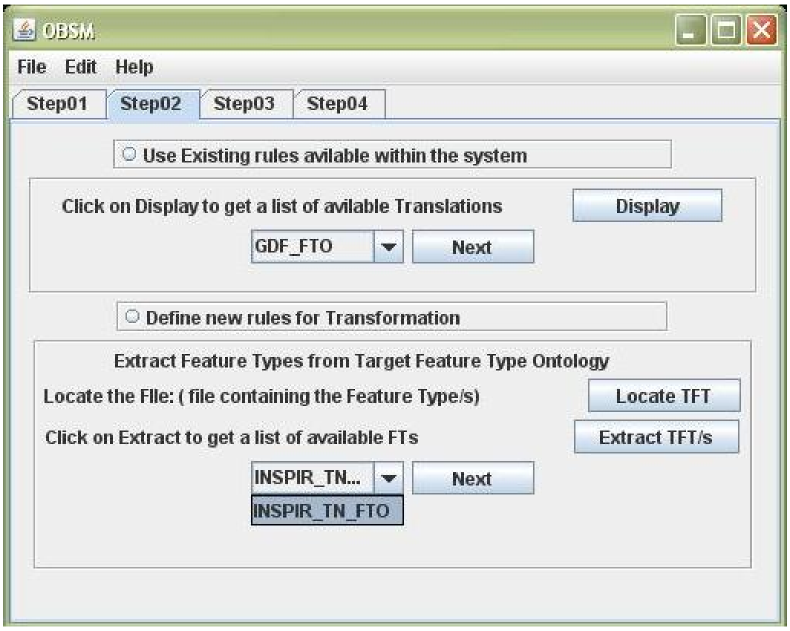
Locate the FIle: (file containing the Feature Type/s)

Look In: final

File Name: 11_INSPIRE_TN_FTO.wsml

Files of Type: All Files

Figure 4.5(b): Selecting the Target feature types - alternative 02



○ Use Existing rules avilable within the system

Click on Display to get a list of avilable Translations

GDF_FTO

○ Define new rules for Transformation

Extract Feature Types from Target Feature Type Ontology

Locate the File: (file containing the Feature Type/s)

Click on Extract to get a list of available FTs

INSPIR_TN...

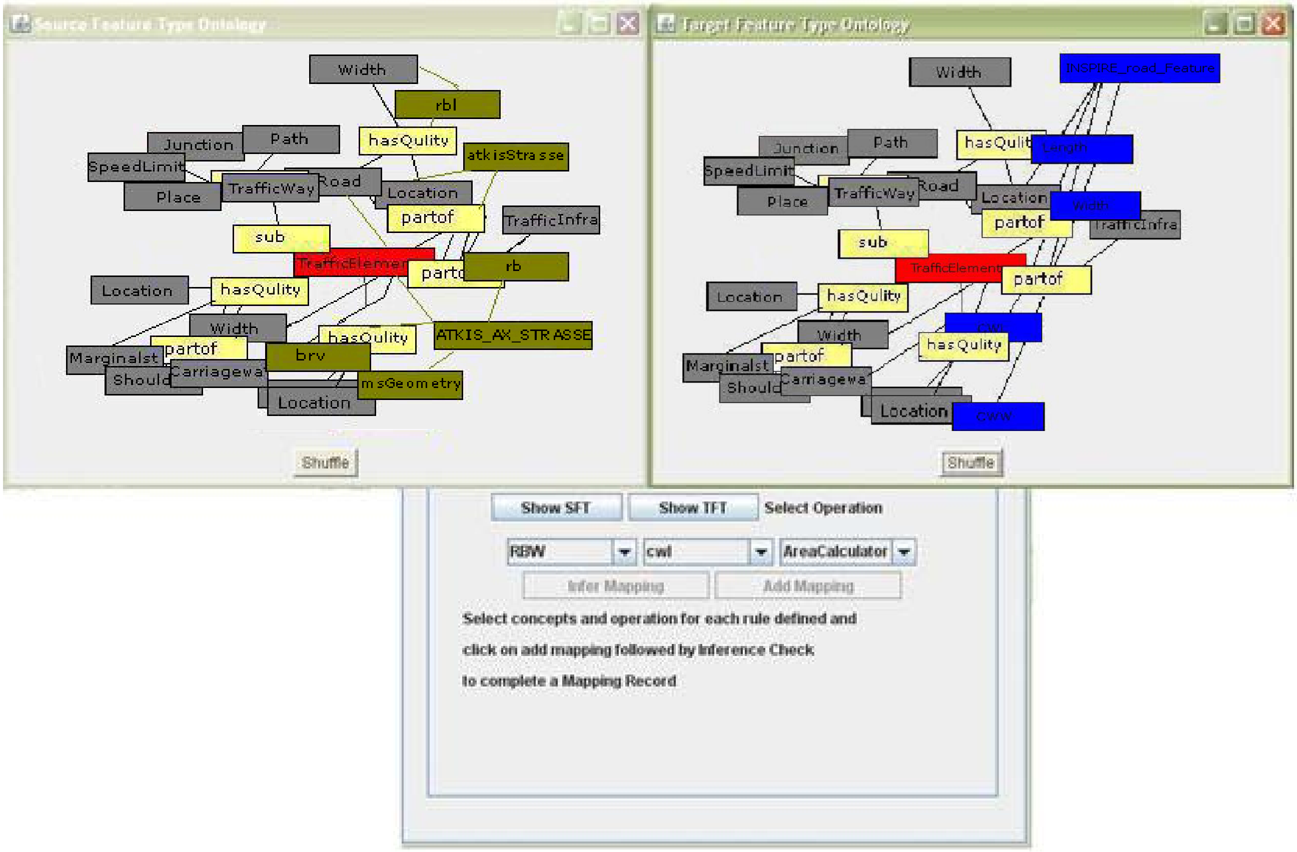
INSPIR_TN_FTO

Figure 4.5(c): Extracting the source feature types - alternative 02

Step 03

If the user decides to proceed with the second alternative; the step 03 tab will be activated. In the Source/Target tab user can click on the ‘Show SFT’ and ‘Show TFT’ to render the concept maps of source and target feature types *(Figure 4.6(a))*. Concurrent rendering of both target and source feature types will make the panning and navigating through the concepts easier. Selections of the source and target concepts will create the entries in the table, which can be viewed and manipulated using the table. Selected source and the Target concepts and the type will be displayed initially in the table. Once the three entries are selected, ‘Infer Mapping’ will be activated. If the mapping record is validated by the system, as correct, ‘Add Mapping’ will be activated. Then the record will be displayed in the table of the ‘Mapping’ tab. Records can be removed from the system, when needed using the ‘Clear Mapping’. User can select the operation to be manipulated on the attribute data, made available according to the type. *(Figure 4.6(b))*

The *OBSM* Rule Generator compiles a Mapping File for a *Rule Set* on request by the user. Once the definition of the rules is finished *(Figure 4.6(c))*, ‘Generate Mapping File’ will get the rules from the table to the tool and creates the ‘*OBSM* mapping’ file which can be executed in the execution environment.

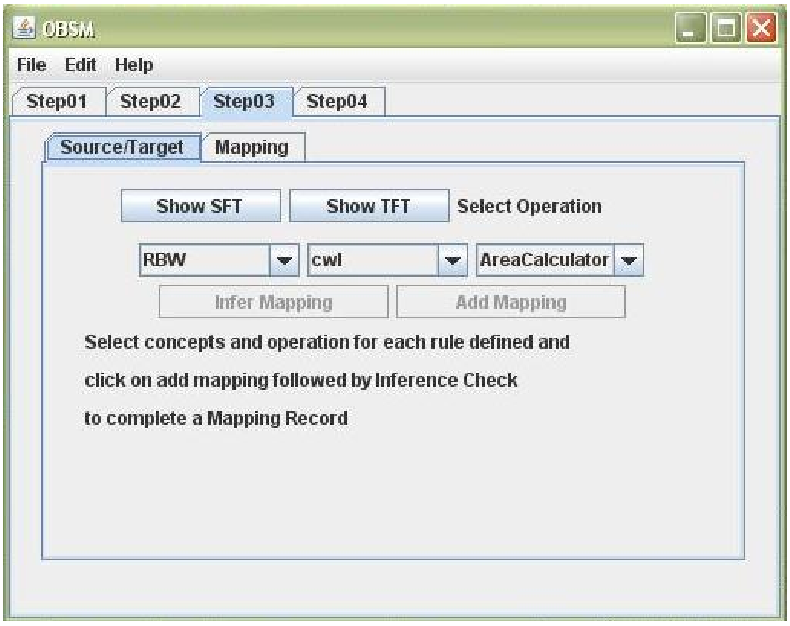


Select concepts and operation for each rule defined and

click on add mapping followed by Inference Check

to complete a Mapping Record

Figure 4.6(a): Rendering and navigation trough concept maps

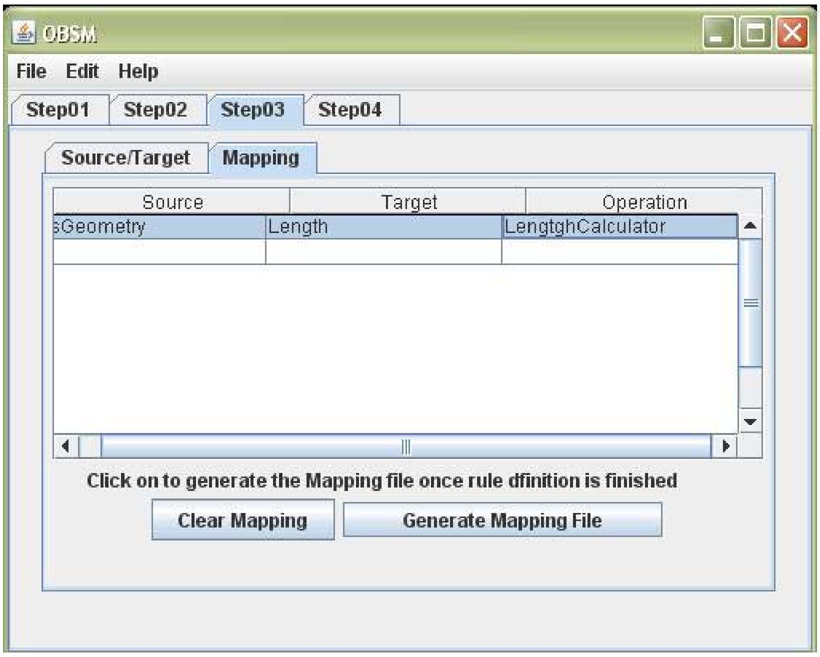


Select concepts and operation for each rule defined and

click on add mapping followed by Inference Check

to complete a Mapping Record

Figure 4.6(b): Definition of a mapping record



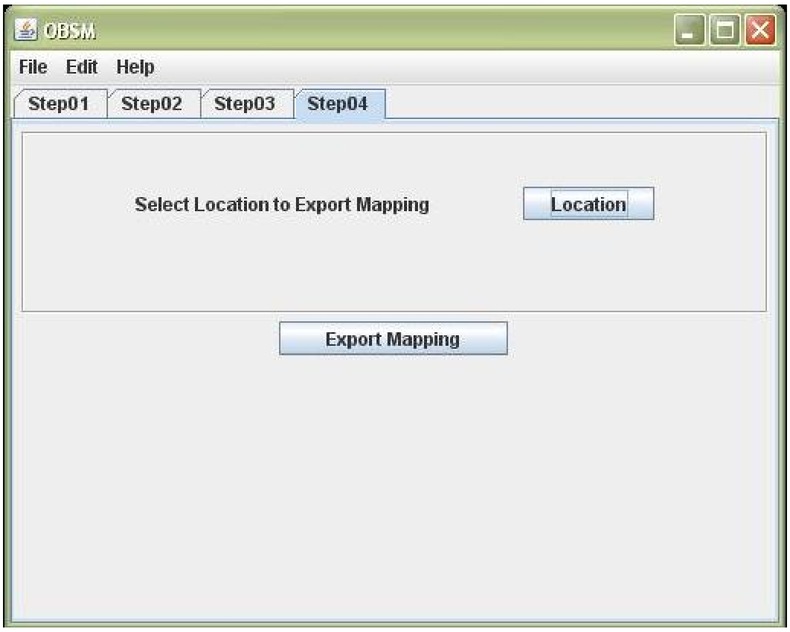
Source	Target	Operation
sGeometry	Length	LengtghCalculator

Click on to generate the Mapping file once rule dfinition is finished

Figure 4.6(c): Generation of the *OBSM* mapping file

Step 04

In this step the user can save a copy of *OBSM* mapper file, which can then be executed in the FME workbench. By clicking on the 'Location' button, the location can be selected to save the file. 'Export Mapping' will export the file to the desired location, securing a copy in the rules repository *(Figure 4.7)*.



Select Location to Export Mapping

Figure 4.7: Step 04 of the process

5 CONCLUSIONS AND FUTURE WORK

Key strengths of the tool are identified as the attractive user interface and the ability to interact in an easy to understand language compared to the factors that contribute to its overall user acceptance are its adoption of consistency in terms of conventions used, screen layouts, minimum use of colors, and use of graphics and icons.

It transpired from this study that users prefer an attractive graphical user interface in the process of schema mapping. In addition, the tool is attributed with simplified icons and visible screen instructions to enhance the overall performance. The system provides a feedback of an acceptable level and frequency though it is inadequate. Also the feedback emphasized on the necessity to include search tips, FAQ, and an online search guides to improve the user friendly features of the tool. The evaluation has resulted in bringing in to limelight several important developmental areas. The following could be addressed in the future upgraded versions of the tool:

- Provision of additional online help documentation along with examples.
- Ensuring that the content is kept relevant through regular content updates via Web Services with a public accessible repository for rules and ontologies.
- Improving error-handling messages through enhanced functionalities that provide suggestions and examples of problem resolutions.
- Addition of basic navigational buttons and functions (such as "next", "previous", "return" and "undo" buttons) to navigate within the 3rd tab (In the table).
- Provisions to be made in the system to access directly through the Internet in addition to the current local system.

OBSM only supports and confines to the transformation of single feature type at a time. But there may be instances where the user needs to combine several concepts from different feature types simultaneously. This opens up new vistas for future development and expansion of this study. In addition the mapping only allow 1:1 mappings, meaning the assignment of operations on a concept can generate rules to translate one concept to another but two or more concepts can not be considered in resulting a single concept. This requires attention because in reality, several concepts contribute to define another concept frequently. The set of rules defined earlier are stored in a single (local) repository. But if this could be stored in a shared environment like Web Services, sharing of the rules could be done more comprehensively. Since the tool is mainly built on the SWING project context, it only supports .wsml file format for ontology input and reading. But in reality ontologies are written in several different languages which support several different formats.

While developing the rules file, system recall the corresponding data model attribute in the format declared by FME which implies that the ontology needs to be declared the concept type in accordance with the FME specifications for data type declaration and available operations for transformations. The scope of functioning of the GUI can be enhanced by developing it to a state which support different input formats for ontologies like .owl and .rdf as well to utilize operations available with different schema translation GUIs like 'Go Publisher', 'SDI' or 'Geo XSLT'. Findings surfaced in this study could be identified as directions and subject areas that are needed to be attended in future research and in the enhancement of the functionality of this tool.

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APPENDIX

(A). Evaluation Questionnaire

The prototype was used to evaluate the usability of the schema mapping GUI *OBSM* using the following questionnaire.

System Usability Scale
Graphical User Interface for Ontology based Schema Translation

Date : 17.12.2008

Section 01:

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the screens unnecessarily ccomplex	1	2	3	4	5
3. I thought the layout was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Section 02:

	Very Bad				Very Good
1. How do you rate the general handling of device – Ease of Operation	1	2	3	4	5
2. How do you rate the display – Visibility, Data display on the screen	1	2	3	4	5
3. How do you rate the logic of operation menu?	1	2	3	4	5
4. How do you rate the ease of information provision?	1	2	3	4	5
5. How do you find display scale of disgrams	1	2	3	4	5

(B). Concept rendering algorithm

The key goal of the work is a graphical and ontology based aid for the user, which can be incorporated in mapping. In order to display the concepts in the feature type ontology, annotated with the domain ontology, a rendering algorithm is required. In the *OBSM* the mapping strategy used is 'The Spring Algorithm' *(Branke, Bucher et al. 1997)*. The positioning of all the nodes is done automatically with in the considered grid. The spring model assigns force between each pair of nodes. When two nodes are too close together, a repelling force comes into effect. When two nodes are too far apart, they are subject to an attractive force. This scenario can be illustrated by linking the vertices with springs, hence the name "spring model" (or "spring embedding method") *(Wolfram, 2009)*. The algorithm identifies the graph as a virtual physical system. Bodies included in the graph comprise dynamically changing force acting on or between them similar to magnetic repulsion and attraction. According to the literature, This algorithm works by adding springs to all edges and adding looser springs to all vertex pairs that are not adjacent *(Wolfram, 2009)*. Therefore the total energy of a system is expressed as in the *Equation 01*.

$$\sum_{i=1}^{|V|-1} \sum_{j=i+1}^{|V|} k_{ij} \left(\| x_i - x_j \|^2 - l_{ij} \right)^2$$ *(Equation 01)*

Where;

- x_i and x_j are Coordinate vectors of nodes
- i , j, $\| x_i - x_j \|$ is Euclidean distance between them.
- l_{ij} is Natural length of the spring between vertex i and vertex j, which can be chosen as the graph distance between $i$and j
- $k_{ij} = R/l_{ij}^2$ is Strength of the springs,
- *R* is Strength of the strings
- $| V |$ is Number of vertices

The dynamic placing of the vertices are identified by implementing a minimize function on equation 01 (Branke, Bucher et al. 1997). In adopting the vertices in the *OBSM* GUI, the minimize function is adopted by iteratively moving the along the direction of the spring force until an approximate equilibrium is reached. Multi-level techniques are used on different layers of the structure of the ontology. For the placement of the components (vertices and edges) a regular grid graph is used, where the physical distances between vertices are proportional to the graph distances in the graph layout.