SCHEMA MAPPING FOR RDBMS

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Abstract: Schema mapping is a specification that describes how data structured from one schema S the source schema is to be transformed into data structured under schema T, the target schema. Schemata S and T without triggers and/or stored procedures(functions and procedures) are statical. In this article, we propose a Schema Mapping Model specification that describes the conversion of a Schema Model from one Platform-Specific Model to other Platform-Specific Model according to Meta-Object Facility-Query/Verify/Transform in dynamical mode.

1 INTRODUCTION

Applications as database warehousing, global information systems and eletronic commerce need to take the existing schema with particular source S and use it in diferent form, but they need to start with understanding how will be the target schema T. Data exchange are used in many tasks in theoretical studies research and practical in software products. In early stage 1977, in (Shu et al., 1977) with their EXPRESS, data exchange system with main functionality conversion data between hierarchical schemata the data exchange was in the top research topics. In (Fagin et al., 2003) Ronald Fagin et al. underline that the data exchange problem meet the foundation and algorithmic issues; their theoretical work has been motivated by the development of Clio (Miller et al., 2000; Popa et al., 2002), a prototype for data exchange and schema mapping from source schema **S** to target schema **T**, the precursor of changes in SQL Assist from IBM DB2 family.

2 RELATED WORK

According to (Fagin et al., 2003) we have the *source* schema $\mathbf{S} = \langle S_1, S_2, \ldots, S_n \rangle$, where S_i's are the *source* relation symbols, the *target* schema $\mathbf{T} = \langle T_1, T_2, \ldots, T_m \rangle$, where T_i's are the *target* relation symbols and the schema $\langle S, T \rangle = \langle S_1, S_2, \ldots, S_n, T_1, T_2, \ldots, T_m \rangle$. All instances over the **S** represent *source instances* **I**, while instances over **T** **J** are *target instances*. If $\mathcal{I}$ is a named *source instance* in **S** and $\mathcal{J}$ is a named *target instance* the $\mathcal{K} = \langle \mathcal{I}, \mathcal{J} \rangle$ is the named instance over the schema $\langle \mathbf{S}, \mathbf{T} \rangle$. A dependency named *source-to-target* dependencies over $\langle \mathbf{S}, \mathbf{T} \rangle$ of the form

$$(\forall \mathbf{x})(\phi_{\mathbf{S}}(\mathbf{x}) \rightarrow \chi_{\mathbf{T}}(\mathbf{x}))$$

where $\phi_{\mathbf{S}}(\mathbf{x})$ is an expression(formula), with free variable $\mathbf{x} = (x_1, x_2, \ldots, x_k)$ of logical formalism over **S** and $\chi_{\mathbf{T}}(\mathbf{x})$ is an expression(formula) with free variable $\mathbf{x} = (x_1, x_2, \ldots, x_l)$ of logical formalism over **T**. A dependency named *target* dependencies over the target schema **T** (the *target* dependencies are different from those use for the *source-to-target* dependencies)

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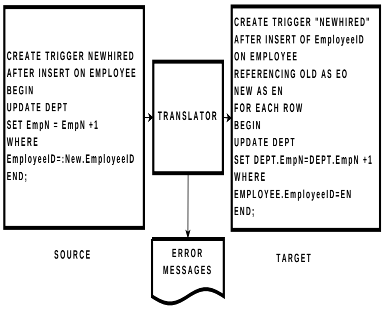

```
CREATE TRIGGER NEWHIRED
AFTER INSERT ON EMPLOYEE
BEGIN
UPDATE DEPT
SET EmpN = EmpN +1
WHERE
EmployeeID=:New.EmployeeID
END;
```

```
CREATE TRIGGER "NEWHIRED"
AFTER INSERT OF EmployeeID
ON EMPLOYEE
REFERENCING OLD AS EO
NEW AS EN
FOR EACH ROW
BEGIN
UPDATE DEPT
SET DEPT.EmpN=DEPT.EmpN +1
WHERE
EMPLOYEE.EmployeeID=EN
END;
```

Figure 1: A translator.

Definition 2.1. A *data exchange* represent a 4-tuple $\mathbf{DE} = (\mathbf{S},\mathbf{T},\sum_{\mathbf{st}},\sum_{\mathbf{t}})$ with a *source* schema $\mathbf{S}$, a *target* schema $\mathbf{T}$, a set $\sum_{\mathbf{st}}$ of *source-to-target* dependencies and set $\sum_{\mathbf{t}}$ of *target* dependencies.
In (Berri and Vardi, 1984) Berri et al., proved that for practical purposes each*source-to-target* dependency $\sum_{\mathbf{st}}$ represents a *tuple-generating-dependency*(tgd) of the form

$$(\forall \mathbf{x})(\phi_{\mathbf{S}}(\mathbf{x}) \rightarrow \chi_{\mathbf{T}}(\mathbf{x,y}))$$

where $\phi_{\mathbf{S(x)}}$ represents a conjunction of atomic expression(formulas) over $\mathbf{S}$ and $\chi_{\mathbf{T}}(\mathbf{x,y})$ represents a conjunction of atomic expression(formulas) over $\mathbf{T}$.In (Fagin et al., 2005b) Fagin et al. identified a particular universal solution for data exchange and schema mappings, and argued that this is the best universal solution.
Definition 2.2. A **translator** represents a program that reads on *input* in one language the *source* language - source code program - and translate it into *output* in an equivalent program in other language the target language - source code - see Figure 1

A translator operates in the following *phases*: lexical analyzer, syntax analyzer, semantic analyzer, target code generator. In early stage 1950's Naom Chomsky (Chomsky, 1956) proposed the formal definition for context-free grammar, see Figure 2. Context-free are used in the design and description of *programming languages*, *compilers* and ***translators***. A context-free grammar is 4-tuple:

$$\mathbf{G} = (\mathbf{V},\sum,\mathbf{R},\mathbf{S})$$

where **V** - represents a finite set of non-terminal characters or variables; $\sum$ - represents set of terminals, disjoint with **V**; **R** - represents a finite set of **rules**; **S** - represents the start variable, used to represent the or program.
Definition 2.3. Let $\sum_1$ and $\sum_2$ be two alphabets, named source alphabet respective target alphabet and two languages $L_1 \subset \sum_1^*$, $L_2 \subset \sum_2^*$. A ***translator*** from the language L_1 to the language L_2 is a relation T from $\sum_1^*$ to $\sum_2^*$ when the domain of $\boldsymbol{T}$ is L_1 and the image of $\boldsymbol{T}$ is L_2.

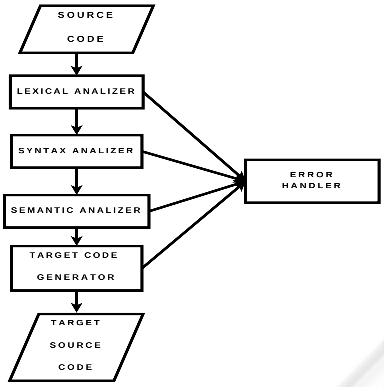

Figure 2: Phases of a translator.

$T : \sum_1^* \rightarrow \sum_2^*$
where dom(T)= L_1 and img(T)=L_2
In (Pranevicius, 2001) Pranevicius H. present an approach in idea to use **Z** specification language for development aggregate formal specifications, because the use of Z schemata in aggregate model permits mathematically strictly define **data structures** used in system description.

The formal specification approach using both aggregate approach an **Z** specification language are useful for specification the dynamichal behaviour of distributed information system and the large and global relational database systems.

In (Andreica et al., 2005) Andreica et al. they proposed a model who aims at proving the consistency of such transformations, which are often used in software applications that process databases; a symbolic model for the transformations between the relational database form and its XML representation.

3 OUR APPROACH

Our algebrical approach to data exchange and schema mapping is to include the stored procedures in *schema* mappings and to snapshot the dynamical of the schemata content in time extending (Fagin et al., 2003; Fagin et al., 2005b; Fagin et al., 2005a; Fagin, 2007; Fagin and Nash, ings), because they parse the ***statical schema mapping*** not a ***dynamical schema mapping***. We propose the *source* schema **S(t)** $=\langle S_1(t),S_2(t),\ldots,S_n(t)\rangle$, where $S_i(t)$'s are the *source* relation symbols, the *target* schema **T(t)** $=\langle T_1(t),T_2(t),\ldots,T_m(t)\rangle$, where $T_i(t)$'s are the *target* relation symbols and the schema $\langle S(t),T(t)\rangle = \langle S_1(t),S_2(t),\ldots,S_n(t),T_1(t),T_2(t),\ldots,T_m(t)\rangle$. All instances over the **S(t)** represent *source instances* **I(t)**, while instances over **T(t)** **J(t)** are *target instances*. If $\mathcal{I}$(t) is a named *source instance* in **S(t)** and $\mathcal{J}$(t) is a named *target instance* the $\mathcal{K} = \langle \mathcal{I}, \mathcal{J} \rangle$ is the named instance over the schema $\langle \mathbf{S}(t), \mathbf{T}(t) \rangle$. A dependency named *source-to-target* dependencies over $\langle \mathbf{S(t)}, \mathbf{T(t)} \rangle$ of the form

$$(\forall \mathbf{x(t)})(\phi_{\mathbf{S(t)}}(\mathbf{x(t)}) \rightarrow \chi_{\mathbf{T(t)}}(\mathbf{x(t)}))$$

where $\phi_{\mathbf{S(t)}}(\mathbf{x(t)})$ is an expression(formula), with free variable $\mathbf{x(t)} = (x_1(t), x_2(t), \ldots, x_k(t))$ of logical formalism over **S(t)** and $\chi_{\mathbf{T(t)}}(\mathbf{x(t)})$ is an expression(formula) with free variable $\mathbf{x(t)} = (x_1(t), x_2(t), \ldots, x_l(t))$ of logical formalism over **T(t)**. A dependency named *target* dependencies over the target schema **T(t)** (the *target* dependencies are different from those use for the *source-to-target* dependencies).

Definition 3.1. A *data exchange* represent a 4-tuple $\mathbf{DE(t)} = (\mathbf{S(t)}, \mathbf{T(t)}, \Sigma_{\mathbf{st}(t)}, \Sigma_{\mathbf{t}(t)})$ with a *source* schema **S(t)**, a *target* schema **T(t)**, a set $\Sigma_{\mathbf{st}(t)}$ of *source-to-target* dependencies and set $\Sigma_{\mathbf{t}(t)}$ of *target* dependencies.

For practical purposes each *source-to-target* dependency $\Sigma_{\mathbf{st}(t)}$ represents a *tuple-generating-dependency*(tgd) of the form

$$(\forall \mathbf{x(t)})(\phi_{\mathbf{S(t)}}(\mathbf{x(t)}) \rightarrow \chi_{\mathbf{T(t)}}(\mathbf{x(t),y(t)}))$$

where $\phi_{\mathbf{S(t)}(\mathbf{x(t)})}$ represents a conjunction of atomic expression(formulas) over **S(t)** and $\chi_{\mathbf{T(t)}}(\mathbf{x(t),y(t)})$ represents a conjunction of atomic expression(formulas) over **T(t)**. A stored procedure named *stored-procedure-s* over **S(t)**, of the form

$$(\forall \mathbf{x(t)})(\alpha_{\mathbf{S(t)}}(\mathbf{x(t)}) \rightarrow \alpha_{\mathbf{S(t)}}(\mathbf{x(t)}))$$

where $\alpha_{\mathbf{S(t)}}(\mathbf{x(t)})$ is a stored procedure over **S(t)** and a stored procedure named *stored-procedure-t* over **T(t)**, of the form

$$(\forall \mathbf{x(t)})(\beta_{\mathbf{S(t)}}(\mathbf{x(t)}) \rightarrow \beta_{\mathbf{S(t)}}(\mathbf{x(t)}))$$

where $\beta_{\mathbf{S(t)}}(\mathbf{x(t)})$ is a stored procedure over **T(t)**.

Definition 3.2. A *schema mapping model* represent a 6-tuple $\mathbf{DE(t)} = (\mathbf{S(t)}, \Sigma_{\alpha_{\mathbf{S(t)}}}, \mathbf{T(t)}, \Sigma_{\beta_{\mathbf{T(t)}}}, \Sigma_{\mathbf{st}(t)}, \Sigma_{\mathbf{t}(t)})$ with a *source* schema **S(t)**, all stored procedures over **S(t)** $\Sigma_{\alpha_{\mathbf{S(t)}}}$, a *target* schema **T(t)**, all stored procedures over **T(t)** $\Sigma_{\beta_{\mathbf{T(t)}}}$, a set $\Sigma_{\mathbf{st}(t)}$ of *source-to-target* dependencies and set $\Sigma_{\mathbf{t}(t)}$ of *target* dependencies.

Our approach on symbolic modeling of data exchange and schema mapping are:

Definition 3.3.

$$DB(t) := \bigcup \{db(t) | is - database(db(t))\}$$

where *db(t)* is a database

Given a set of attributes *Attr(t)* and a set containing sets of attribute values *D(t)*, we define a column as a function mapping an attribute into the set containing its corresponding values:

$$ValColumn(t) : Attr(t) \rightarrow D(t),$$
$$ValColumn(a(t)) :=$$
$$\{d(t) | d(t) \in D(t)\}$$

where d is a value for attribute 'a(t)'

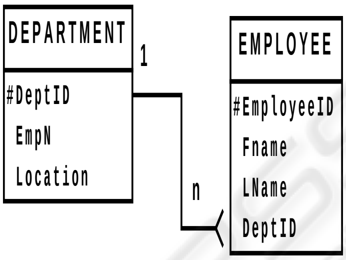

Figure 3: Database diagram for schema S.

Definition 3.4. Given a set of attributes $Attr_i(t)$, $i = \overline{1,...,n}$ the table **T(t)** from database is defined by:

$$is - Table(T_{n(t), Attr_i(t), i=\overline{1,...,n}, D_i(t), i=\overline{1,...,n}}) \Leftrightarrow$$

$$T(t) \in \bigcup_{i=1}^{n} \langle Attr(t), ValColumn(Attr_i(t)) \rangle$$

where $Card(ValColumn(Attr_i(t))) = nrw(t) = NoRows(T(t))$

the number of lines in table **T(t)**, $i = \overline{1,...,n}$, $n(t) = NoColT(t)$ the number of columns in the table **T(t)**.

In practice is posible to have S=T but $S(t) \neq T(t)$ that case is named by us **data exchange for copy schema mapping** because all stored procedures over **S(t)** $\Sigma_{\alpha_{\mathbf{S(t)}}}$, and all stored procedures over **T(t)** $\Sigma_{\beta_{\mathbf{T(t)}}}$ have the same semantic but diferent syntax in SQL and Procedural Languages / SQL flavors on different RDBMS.

We consider the folowing subdiagram with schema S=(EMPLOYEE, DEPARTMENT) with EMPLOYEE (#EmlpoyeeID, FName, LName, CompanyID), DEPT (#DeptID, EmpN, Location) see the Database Diagram for **schema S** 3. In our case S=T=(EMPLOYEE, DEPARTMENT). A trigger that increments the number of employees each time a new person is hired, that is, each time a new row is inserted into the table EMPLOYEE has the same **semantic** in **S** and **T** but different **syntax** in different **Procedural Language** over different SQL flavors.

Table 1: The triggers when a new person is hired.

RDBMS	**STORED PROCEDURES**
IBM DB2	CREATE TRIGGER NEWHIRED AFTER INSERT ON EMPLOYEE FOR EACH ROW MODE DB2SQL UPDATE DEPT SET EmpN = EmpN + 1

Oracle	CREATE TRIGGER NEWHIRED
	AFTER INSERT ON EMPLOYEE
	BEGIN
	UPDATE DEPT
	SET EmpN = EmpN + 1
	WHERE
	EmlpoyeeID=:New.EmlpoyeeID
	END;

Sybase	CREATE TRIGGER ”NEWHIRED” AFTER INSERT OF EmlpoyeeID ON EMPLOYEE REFERENCING OLD AS EO NEW AS EN FOR EACH ROW BEGIN UPDATE DEPT SET DEPT.EmpN = DEPT.EmpN + 1 WHERE EMPLOYEE.EmlpoyeeID=EN END
MySQL	CREATE TRIGGER NEWHIRED AFTER INSERT ON EMPLOYEE FOR EACH ROW UPDATE DEPT SET EmpN = EmpN + 1

Postgres	CREATE FUNCTION EmpA()
	BEGIN
	UPDATE FIRMA SET
	EmpN = EmpN + 1;
	END;
	LANGUAGE ’plpgsql’ VOLATILE
	CREATE TRIGGER NEWHIRED
	AFTER INSERT ON EMPLOYEE
	FOR EACH ROW
	EXECUTE PROCEDURE EmpA();

4 CONCLUSIONS

In this paper we proposed data exchange metamodel for copy schema mappings that describes the conversion of Schema Model from one Platform-Specific Model to other Platform-Specific Model according to Meta-Object Facility-Query/Verify/Transform in dynamical mode. A prototype application, named **ANCUTZA** (**AN**alyti**C**al **U**ser **T**ool **ZA**molxys)-universal SQL and Procedural Language/SQL **translator**-for data exchange metamodel is in project phase in idea to support a part of SQL flavors on different RDMBS.

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