Metadata Enrichment for Automatic Data Entry Based on Relational Data Models

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Abstract: *The idea of automatic generation of data entry forms based on relational data models is a common and known idea that has been discussed day by day more than before according to the popularity of agile methods as well as improvement of programming tools in software development. One of the requirements of automation methods, whether in commercial products or relevant research projects, could be the concept of metadata as a mediator between database and data entry forms. The metadata usually includes some schemas and constraints of target database, which could be used as a model for automatic generation of data entry forms. However, the most metadata models proposed in relevant researches have simple and undetailed structure. In other words, only the initial requirements of data entry are covered in the proposed metadata. In this study, the main objective is to emphasize the structure of metadata to discuss its enrichment methods to cover more data entry requirements. In this regard, some parts of a metadata model are also presented for objectification of the ideas.*

Keywords: *Data-Entry automation, Data-Entry requirements, Relational database metadata*

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I. INTRODUCTION

Over the years, automation of data entry user interfaces based on data models has been one of the methods of implementing data entry requirements in software programs. The main purpose of automation methods is to accelerate the implementation process through prevention of taking repetitive works. In practice, this is done through reuse of designs and logics leading to database data entry. The main requirements include UI design with the capability of CRUD operations on the entities, validation of input values and implementation of data transactions queries in consistence with a target database. In order to implement the logics, the usual solution is using metadata as a guideline model which some parts of it could be perceived through data dictionary resides in relational database management system. However, by considering metadata repository in a DBMS as the only source, the function of designed data entry forms would be very simple and rigidly depended on the physical model of the database. Hence, the possibility of defining lots of high level concepts or design details would be lost. On the contrary, through enrichment of the metadata, a wider range of data entry requirements could be covered.

In this study, has been tried to provide some ideas about the methods of formation, maintenance and enrichment of the metadata devoted to data entry requirements. This is done through classification of requirements and discussing methods and examples in response to these requirements. In this regard, it has also been tried to decline the dependence of metadata on implementation technologies of application level to develop the use of metadata to more applications and platforms.

II. RELATED WORKS

As this study has emphasized the content of metadata, to review the relevant works, those works are selected that have used metadata as a part of solution to implement data entry forms. In ref [1], the solution for generation of web data entry forms using extracted metadata from database is analyzed; although no specific structure and format is specified to maintain the metadata. In ref [2] with almost similar solution with [1], the idea of storage of metadata in XML format is discussed. The metadata used in these solutions is too simple to generate data entry forms and includes elementary data from independent structure of each table and its columns. For example, in the proposed metadata, the details of relationships, types of relationships and simple requirements as the possibility of defining value set for a column are not addressed. In a different work in ref [3], the same idea of generation of web forms using metadata is presented. Although this metadata is presented in form of an Entity-Relationship model, in addition to simplicity of concepts, it is significantly depended on technical requirements of application (in this case HTML pages).

In general, such applied attitude to metadata to discriminate the ideas and technologies could be observed in other works such as [4], [5] and [6]. In other words, in most researches, the content of metadata is not exclusively considered and emphasis has been on the applied role of metadata to discuss the solutions.

Clearly, with simple or application-depended metadata, there would be no chance to cover a broad range of data entry requirements. Therefore, it would be better to separate the concerns of metadata generation and the way of using it through separating the declarative independence of metadata from decision making processes consuming the metadata as much as possible.

III. A SAMPLE DATA MODEL FOR DATA ENTRY

In this section, for a better understanding of the ideas presented in this paper and also providing better examples, a sample ERD model is presented. This model represents the structure of a sample database which could be the target of data entry forms. It should be noted that this model is not necessarily a reality-based model, but simply covers various types of data entry requirements and concepts. This model keeps track of a company's employees, departments and projects. The model is divided into two parts presented in Fig.1 and Fig.2. In Fig.1, the main entities of *Employee* and *Department* and their relationships are presented. Each employee has a many-to-one relationship with the *Department* table to determine the related working department. Each department has also a one-to-one relationship with the *Employee* table that determines the manager of the department. Also, through an IS-A relationship, each employee can be specialized into Engineer and Technician entities. Finally in Fig.1, the *ParkingOwner* entity is shown. This entity represents the owners of parking lots in a company which has a union relationship with department and employee. In other words, each parking lot could be owned by either a department or an employee.

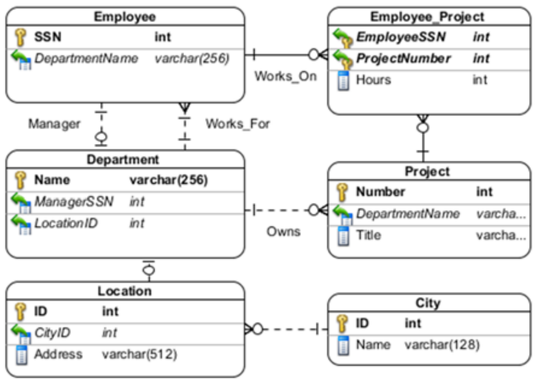


Fig.1 Sample database ERD model (First part)

In Fig.2, four new tables have been added to the previous model. First, the *Project* table that represents the projects of a department and has a many-to-one relationship with *Department* table.

Also, this table uses the *Employee_Project* table to establish a many-to-many relationship with the *Employee* table. In this way, for each department's project the employees involved in the project are identified. Finally, the *Location* table is presented which specifies the address of each department and also has a many-to-one relationship with the *City* table.

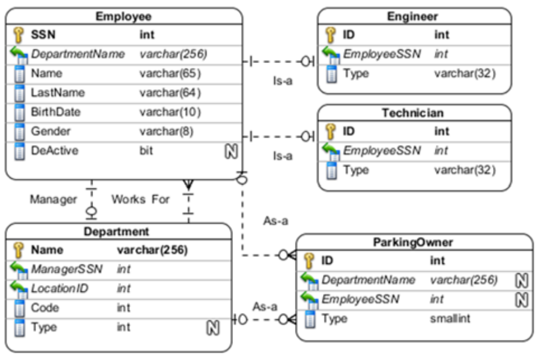


Fig.2 Sample database ERD model (Second part)

IV. EXTRACTION OF THE INITIAL ELEMENTS OF METADATA

In order to form the initial elements of metadata and as the beginning point, the data dictionary of target database residing in DBMS could be used. One way to extract the existing metadata is to query the data dictionary using the known standards. However, the ways of using these standards may be different in each RDBMS. For example, in relational databases of SQL Server and MySQL, the concept of information schema is supported; although different concepts are used in almost similar methods in Oracle database. In table 1, the way of extraction of tables, columns and the referential constraints in SQL Server and MySQL are presented. Similar queries of the same objects in Oracle are presented in table 2. In ref [6], [7] and [8], technical documents about the metadata management of mentioned relational databases are presented.

Table 1 Using the concept of information schema in fetching database objects

Extraction of	Instruction
Tables	Select * from Information_schema.tables
Columns	Select * Information_schema.columns
Referential Constraints	Select * from Information_schema.referential_constraints

Table 2 Fetching the same database objects in Oracle

Extraction of	Instruction
Tables	Select * from user_tables
Columns	select * from user_tab_columns
Referential Constraints	Select * from user_constraints

After extracting the desired data from the database, a structure is needed to maintain the metadata. In this solution, a relational model is proposed. The advantages of providing relational model for the metadata are as follows:

- It is in consistence with the target data entry relational database.
- It could be visualized through entity-relationship models.
- If needed it could be converted simply to other formats like XML using common available tools.
- Using today's ORM technologies, the metadata could be used effectively. In this way, in addition to separate the technical concerns of metadata manipulation, the key requirement of metadata survey (through entities and relationships) could be done with more facility.

Finally, the initial extracted objects like tables, columns and relationships could be illustrated in an ERD model as figure 3.

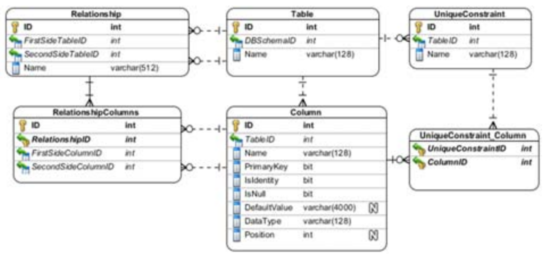
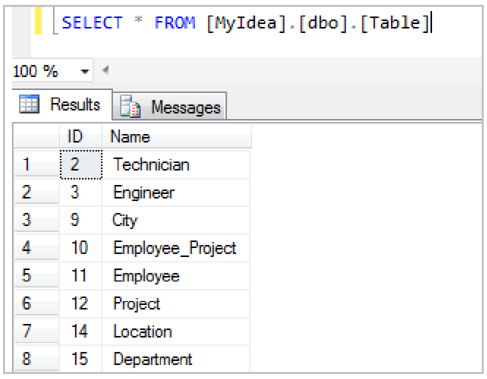


Fig.3 Core structure of the metadata

Obviously, this entity-relationship metadata model or the sample data entry model presented in previous section can be implemented in any commercial relational database. By implementation of these two models in SQL Server and using the commands like Table 1 to reproduce the sample database model in form of proposed metadata model, the data of three tables of Table, Column and Relationship would be similar to figures 4, 5, and 6.



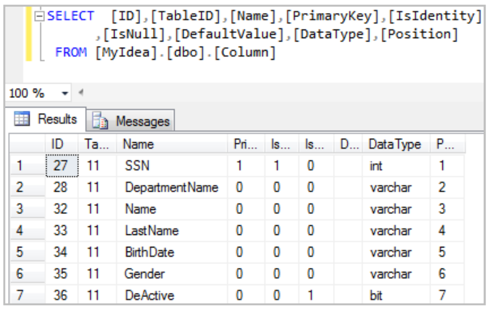
```
SELECT * FROM [MyIdea].[dbo].[Table]
```

100 %

Results | Messages

	ID	Name
1	2	Technician
2	3	Engineer
3	9	City
4	10	Employee_Project
5	11	Employee
6	12	Project
7	14	Location
8	15	Department

Fig.4 Data view of *Table* entity after converting the sample model to metadata



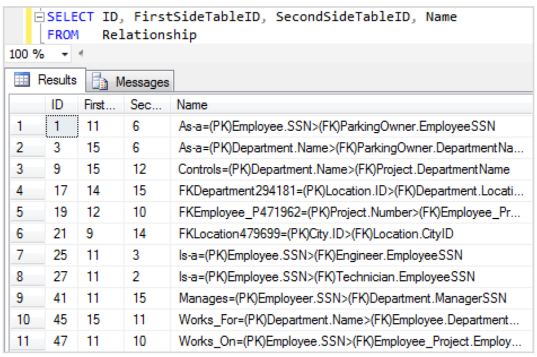
```
SELECT  [ID],[TableID],[Name],[PrimaryKey],[IsIdentity]
       ,[IsNull],[DefaultValue],[DataType],[Position]
  FROM [MyIdea].[dbo].[Column]
```

100 %

Results | Messages

	ID	Ta...	Name	Pri...	Is...	Is...	D...	DataType	P...
1	27	11	SSN	1	1	0		int	1
2	28	11	DepartmentName	0	0	0		varchar	2
3	32	11	Name	0	0	0		varchar	3
4	33	11	LastName	0	0	0		varchar	4
5	34	11	BirthDate	0	0	0		varchar	5
6	35	11	Gender	0	0	0		varchar	6
7	36	11	DeActive	0	0	1		bit	7

Fig.5 Data view of *Column* entity after converting the sample model to metadata



```
SELECT ID, FirstSideTableID, SecondSideTableID, Name
FROM   Relationship
```

100 %

Results | Messages

	ID	First...	Sec...	Name
1	1	11	6	As-a=(PK)Employee.SSN>(FK)ParkingOwner.EmployeeSSN
2	3	15	6	As-a=(PK)Department.Name>(FK)ParkingOwner.DepartmentNa...
3	9	15	12	Controls=(PK)Department.Name>(FK)Project.DepartmentName
4	17	14	15	FKDepartment294181=(PK)Location.ID>(FK)Department.Locati...
5	19	12	10	FKEmployee_P471962=(PK)Project.Number>(FK)Employee_Pr...
6	21	9	14	FKLocation479699=(PK)City.ID>(FK)Location.CityID
7	25	11	3	Is-a=(PK)Employee.SSN>(FK)Engineer.EmployeeSSN
8	27	11	2	Is-a=(PK)Employee.SSN>(FK)Technician.EmployeeSSN
9	41	11	15	Manages=(PK)Employeer.SSN>(FK)Department.ManagerSSN
10	45	15	11	Works_For=(PK)Department.Name>(FK)Employee.Department...
11	47	11	10	Works_On=(PK)Employee.SSN>(FK)Employee_Project.Employ...

Fig.6 Data view of *Relationship* entity after converting the sample model to metadata

V. METADATA ENRICHMENT

In this section, the methods of extending the core metadata are discussed. With more coverage of data entry requirements, a metadata could be enhanced from a repository of some physical or structural properties to a source containing higher level conceptual or behavioral concepts. The practical method used to enhance the structure of metadata is modifying its current structure (the structure extracted from the database in previous section) through adding entities, relations and attributes based on some requirement analysis and inferences. These changes could be the result of considering some general requirements of data entry or some specific strategy of data entry. Firstly, some general requirements (generalizable to other solutions) are discussed.

General and common requirements

When consuming the physical model of a relational database to design data entry forms and logics is discussed, recognized elements such as tables, columns and relationships come to mind. Assessing common requirements of these elements, which can be involved in the designs decision-makings of data entry forms (directly or indirectly), could be a good beginning point. Therefore, for the purpose of better separation of requirements, they could be divided into table requirements, column requirements and relationship requirements.

- Table requirements: for each table, the following types of general requirements could be applied in the metadata:

  Defining custom alias name for each table;

  Determining the table data entry mode in group or single form (one by one record);

  Determining whether a table is a reference table; For example, the *City* table in the sample model is a reference table.

  Determining whether a table is an associative table; For example, the *Employee_Project* table in the sample model is an associative table.

  Determining table independent data entry: this property specifies that whether a table can be the beginning point of a data entry scenario or not and it should be accessed just through relationship with other entities. For example, logically the *Location* table cannot be used as an independent data entry form and is considered as a piece of complementary information along with other entities.

- Column requirements: similarly, the following characteristics could be counted for each column:

Defining custom name for each column;
Determining the data entry ability of column;
Determining the search ability of column;
Determining the view ability of column in result of search operations.

- Relationship requirements: for each relationship, regardless of type of relationship, the following characteristics could be defined:

Defining custom name for the relationship;
Determining data entry ability of relationship;
Determining the searching ability of relationship;
Determining the view ability of relationship;
The mandatory constraint of relationship;
The transferability quality of relationship;
Determining the creation ability of other side of the relationship; For example, is it possible to create a new city when entering location information, or the city item is just selectable?
Capability of creating the other side of relationship directly in the current form or in a separate form.

The model after making these modification is shown in Fig.7.

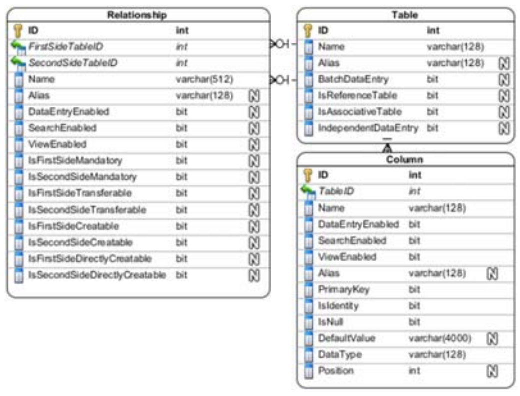


Fig. 7 Adding attributes to the model elements

Specialization of elements

In previous section, some simple general requirements were discussed which could be responded through adding some attributes to the initial metadata model. However, a desirable enrichment process of metadata is not limited to adding some properties. In other words, some advanced requirements should be covered through adding new entities and relationships to the model. The first proposed technique to cover more advanced requirements in the model is specialization of the existing elements. Using this technique, in addition to make the model developable to host more complicated requirements, the core model, derived from physical structure of relational databases, could be preserved. In order to specialize the concepts in the model, a few ISA-Relationship types on tables, relationships and columns could be added.

Specialization of tables: each table in a database could be resulted by realization of several higher level entities. For example, in implementation of ISA-Relationships in form of accumulation of superclass and subclass in a single table, the table could encompass structure and data from several entities simultaneously. Through specialization of tables by making its columns, relations and even its data selective, chance of introducing new entities in the metadata is provided. For example, in Fig. 8 by adding a new entity called *TableDerivedEntity*, each previously detected table can be specialized. In other words, columns and relationships of each existing table can be selected and grouped in frame of a new entity. Moreover, using the *criteria* property in *TableDerivedEntity*, a distinctive range of data rows for each entity could be defined.

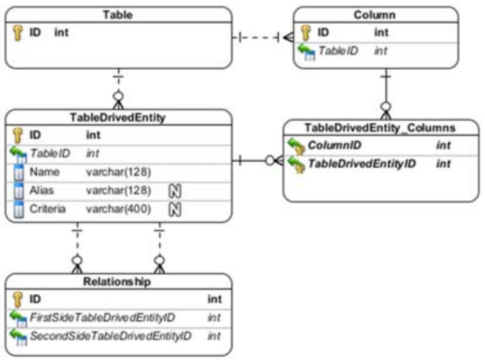
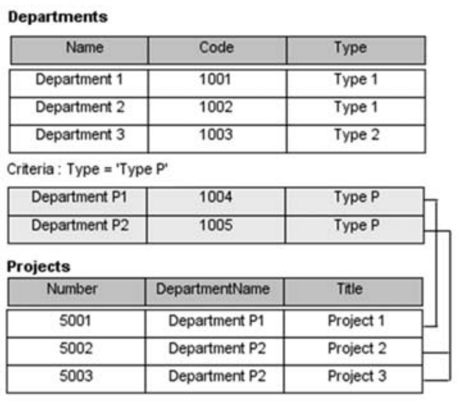


Fig. 8 Specialization of tables in the metadata

For example, using this method, the department records of *Department* table can be classified using the *Type* field. Then it is possible to allow just some specific types of departments to have projects.



Departments

Name	Code	Type
Department 1	1001	Type 1
Department 2	1002	Type 1
Department 3	1003	Type 2

Criteria : Type = 'Type P'

Department P1	1004	Type P
Department P2	1005	Type P

Projects

Number	DepartmentName	Title
5001	Department P1	Project 1
5002	Department P2	Project 2
5003	Department P2	Project 3

Fig. 9 Classification of departments based on type

Specialization of relationships: through separation of types of relationship in metadata, specific properties could be defined for each type of relationship. For example, in Fig. 10 one-to-many and one-to-one relationships have been specialized through adding new entities inheriting from the base *Relationship* entity.

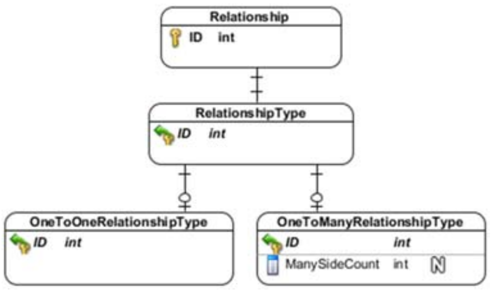


Fig.10 Specialization of relationships in the metadata

Specialization of columns: types of columns could be also specialized based on data type. Hence, not only separated specifications and structures are defined for each data type, but also it is possible to define structure for custom types of data in the metadata.

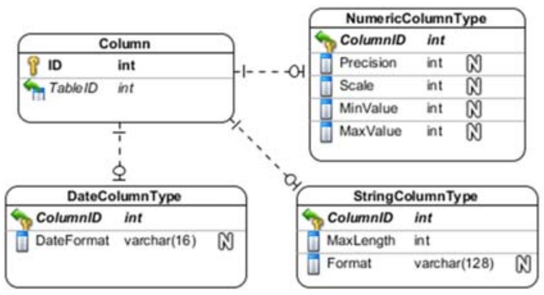


Fig. 11 Specialization of columns in metadata

Higher level relationships

One of the main capabilities of a desirable metadata could be possibility of defining conceptual and higher level relationships of target database like ISA relationships or Union relationships. Without prediction of these relationships in metadata, a big gap remains between metadata model and the object-oriented designs of entities behind the data entry forms. One technique to cover higher-level relationships is defining conceptual relationships in the metadata model and adjusting existing physical relationships with these conceptual relationships. Through classification of physical relationships in form of conceptual relationships, a bridge could be created between physical implementation of relationships and their underlying higher-level concepts. For example, as in Fig. 12, a set of physical relationships of superclass to subclass in database level (defined in *SupertoSubRelationshipType*) could be mapped to an *ISA-Relationship* entity in the metadata level. In this way, it is possible to define the known ISA-Relationship properties, such as total participation or disjoint quality of the relationship in the metadata.

In another example, many-to-many relationships could be defined in the metadata through the *ManyToManyRelationshipType* table. Since all the many-to-one relationships in physical level are converted to one-to-many relationships there would be a link between *ManyToManyRelationshipType* and *OneToManyRelationshipType* to detect all the implementing physical one-to-many relationships of each many-to-one relationship.

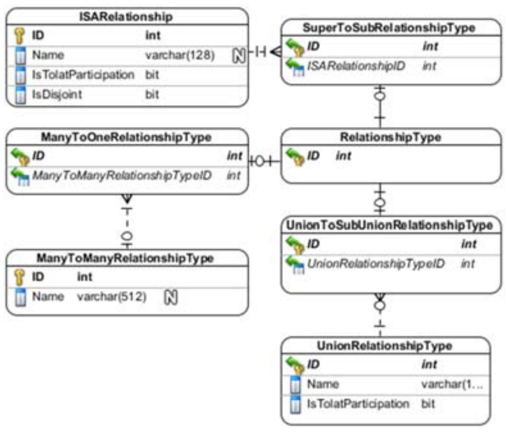


Fig. 12 Definition of conceptual relationships in the model

In this way, all the physical or conceptual relationships defined in the sample model can be defined in the metadata. In tables 3 and table 4 all the relationships of sample model and their definition class in the metadata are shown.

Table 3 Definition of sample model relationships in the metadata (Part 1)

Relationship	Type	Metadata Definition
Department-Employee (Works for)	One to Many / Physical	OneToManyRelationship
City-Location	One to Many / Physical	OneToManyRelationship
Department-Project	One to Many / Physical	OneToManyRelationship
Employee-Department (Manages)	One to One / Physical	OneToOneRelationship
Department-Location	One to One / Physical	OneToOneRelationship

Table 4 Definition of sample model relationships in the metadata (Part 2)

Relationship	Type	Metadata Definition
Employee-Project	Many to Many / Conceptual	ManyToManyRelationship
Employee-Employee_Project	One to Many / Physical	OneToManyRelationship
Project-Employee_Project	One to Many / Physical	OneToManyRelationship
Employee-Engineer/Technician	IS-A Relationship / Conceptual	ISARelationship
Employee-Engineer	Superclass to Subclass/ Physical	SuperToSub-RelationshipType
Employee-Technician	Superclass to Subclass/ Physical	SuperToSub-RelationshipType
ParkingOwner-Employee /Department	Union Relationship / Conceptual	UnionRelationshipType
ParkingOwner - Employee	Union Superclass to Union Subclass/ Physical	UnionToSubUnion-RelationshipType
ParkingOwner - Department	Union Superclass to Union Subclass/ Physica	UnionToSubUnion-RelationshipType

More complicated requirements

With emphasis on more complicated requirements and some creativity, more dynamic requirements and constraints of data entry could be predicted in metadata. Some of these requirements might be as follows:

- The value range of a column: the feature of defining valid range of values for a column;
- Arc relationships: selecting a single relationship from several specified relationships of an entity;
- Conditional relationship: the condition of making or not making of a relationship based on the entry value of an attribute of the entity;
- Conditional range of values: the dependence of value range of an attribute on the entered value of another attribute of the same entity;

- The condition of converting the values: dependence of values an attribute could be changed to on the current value of the attribute.

For example, through adding three simple entities to the model (figure 13), value range of a column, conditional relationship, conditional range of values and conditions of value conversion could be covered. Using the *ColumnValue* entity, the value range of a column is defined. Using the *ColumnValue_Relationships* entity, disabling or enabling of relationships based on column values is possible and with the *ColumnValue_Columns* entity, it is possible to determine the list of valid values for a column based on another column's value (or based on the same column' value in case).

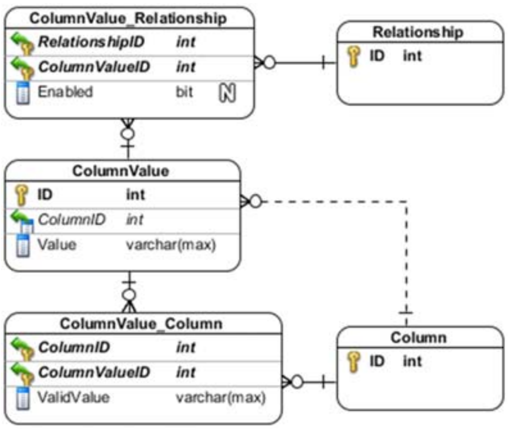


Fig. 13 Adding some complicated requirements of data entry to the model

For example, by placing the "male" and "female" values in the *ColumnValue* table for the *Gender* column of the *Employee* table, in the data entry process these values would be selectable rather than entered by user. Now presume we need another rule that do not allows male employees to involve in projects. This rule can be defined easily in the metadata by adding a record in the *ColumnValue_Relationship* table for previously defined "male" value and then setting the project relationship disabled.

Generic designs in metadata

Definitely, with more coverage of data entry requirements using the mentioned methods, the obtained model would be more efficient and applicable. However, such modifications in metadata model could also lead to some complications. Complexity of metadata structure or its non-general structure would bring some drawbacks such as less understandability and less generality of the model. In order to meet the problem, some generic designs could be used to define some of the requirements in the model if needed. Using these generic designs, there would be no need to define all required attributes of tables, relationships and columns explicitly in the metadata. Moreover, it might be necessary to define many application level attributes in the model. For example think of a requirement that needs to make emphasis on some columns in the UI by making the font of the column's label bold. This requirement is a trivial application level requirement and it is not wise to put it directly in the metadata model.

A general strategy to make such changes in the model might be using dynamic properties in form of tag/value. In Fig. 14, an example of the mentioned design technic is presented. As shown, the extra attributes of tables and columns could be defined in form of dynamic data rows rather than static physical attributes.

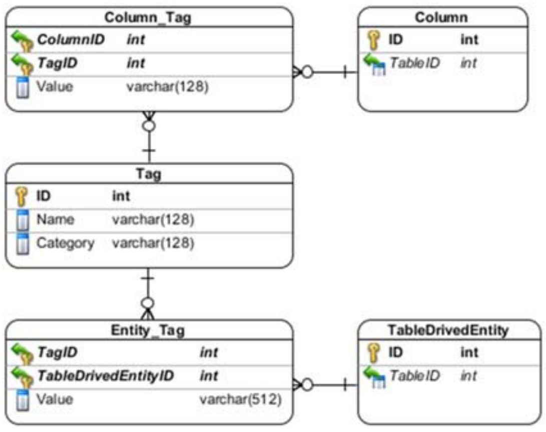


Fig. 14 Generic constructs to define attributes of tables and columns

Model customization

Using the techniques mentioned in the previous sections, an enriched metadata would be achieved that can be generalized to many common data entry solutions. The next supplementary step of metadata enrichment, could be customization of metadata to fit any specific data entry approach. These subjective customization could include adding optional types of attributes, entities or relationships to the metadata. For example, in Fig. 15, according to directed nature of data entry scenarios in applications, instead of one physical relationship between each pair of entities, two directed relationships could be defined in the metadata. This way, in addition to possibility of separating attributes of each direction, the process of navigation through entities and relationships in data entry forms are facilitated.

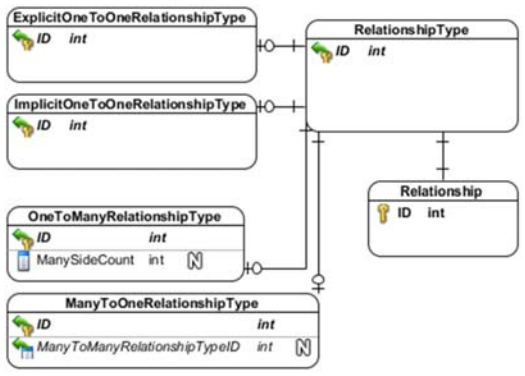

ExplicitOneToOneRelationshipType
ID int
RelationshipType
ID int
ImplicitOneToOneRelationshipType
ID int
Relationship
ID int
OneToManyRelationshipType
ID int
ManySideCount int
ManyToOneRelationshipType
ID int
ManyToManyRelationshipTypeID int

Fig. 15 Defining sample directed relationships in the metadata

For example, using the mentioned design, now it is possible in data entry forms to let the *Manages* relationship between employee and department be established only from the department side. As such, for each department, the manager employee is selectable while this relationship would be hidden in the employee form.

Regardless of reasons of customizations in metadata, the innovations applied to metadata could be also generalized to other solutions or just be limited to scope of a system.

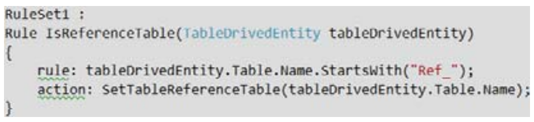
VI. INITIALIZATION OF CONSTRUCTS

A metadata with no data has no use and meaning in practice. As it was mentioned, data for core elements of metadata could be derived from the database. However, to initialize the extended parts of metadata what strategy could be considered? According to key role of metadata in automated data entry solutions and need to careful, quick and integrated management of all details, it is recommended to use a software program to manage metadata. With such an administrative program, in addition to apply control rules in metadata initialization, the involvement of user in lots of technical complexities (for example implementing metadata manipulation queries) could be avoided. In designing such a metadata management program, a combination of three methods of coding, rule engine and design expert intervention is generally proposed.

■Coding: for initialization of some constructs of metadata, fixed code snippets could be applied. Algorithms of these codes would not change a lot over the time. The examples could be the previously mentioned technics for extraction of initial structure of metadata from the database, extracting list of available values of a column in database (for example to fill the *ColumnValue* entity automatically) or converting types of relationships to each other in the metadata.

■Rule engine: experience have proved that there are semi-fixed rules and techniques in designing databases. These rules may be observed by a specific designer team or in a specific solution; although they may vary from a problem to another or from a designer team to another. For example, the rules of naming tables and columns are in this group. To extract some information of metadata due to these changeable designs, it is recommended to use rule engine environments. Hence, the way of implementation of these rules in extraction of information from the database is not depended on principal code of the program.

As an example, suppose a database that has 30 reference tables all starting with “Ref_” like “Ref_City”. Think of a metadata management program that has a module to detect reference tables. In facing such a situation the mentioned module can be implemented in two ways; hardcoded or dynamically programmable. Since a metadata management program is supposed to work with various database designs it would be better to use the dynamic rules.



```
RuleSet1 :
Rule IsReferenceTable(TableDrivedEntity tableDrivedEntity)
{
    rule: tableDrivedEntity.Table.Name.StartsWith("Ref_");
    action: SetTableReferenceTable(tableDrivedEntity.Table.Name);
}
```

Fig. 16 Sample dynamic rule for detecting reference tables

■Design expert intervention: a known challenge with the perception of concepts from the physical implementations of databases or literally reverse database engineering could be ambiguousness and mismatches in translating different design layers to each other (Conceptual, Logical and physical layers). In ref [10], the necessity of interpretations of user in validation of the concepts perceived from the database and in ref [11], the necessity of intervention of user in the process of conceptualization of database reverse engineering are emphasized. In general, the necessity of applying user's comment (as complementary part of mechanized methods) could be caused by lack of certain correspondence in mapping models from conceptual to physical level and vice versa. Moreover, it has been observed that in implementation of lots of concepts in the database, implicit structures (e.g. Triggers) are used. Regardless of these explanations and considering the defined metadata, there are some configurations in the metadata, which should be initialized in customized way due to user's decision. For example, the way of setting alias names for tables and columns or setting the display order of columns are in this group.

VII. SOLUTION IN PRACTICE

In this section, the proposed solution for the formation and enrichment of metadata and also its effectiveness in covering some of the fundamental data entry requirements are examined. For this purpose, the real database of AdventureWorks is used which is a well-known sample database used in many of the Microsoft's documentations. The version of the AdventureWorks database used is in this paper is 2012 and it is available on [12]. Also [13] helps to understand the database design as it describes all the tables in the AdventureWorks.

In order to manage the metadata model as well as its use in designing data entry forms, existence of two programs is presumed; one manages the information in the metadata, and the other uses this information in generating the data entry forms of the target database. It is necessary to mention that the examples provided of the features of these two programs are merely due to the visualization of the proposed concepts and the details of the design or implementation of the mentioned programs - due to irrelevance with the main theme of this research, which is the enrichment process of the metadata - will not be covered. Figure 17 shows how the four concept of metadata management program, data entry program, metadata database and target database interact with each other.

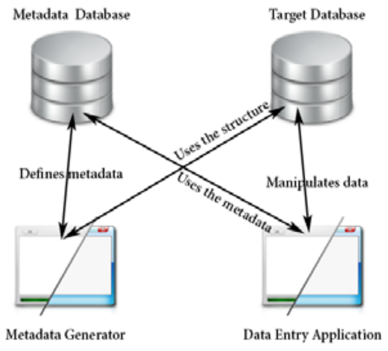
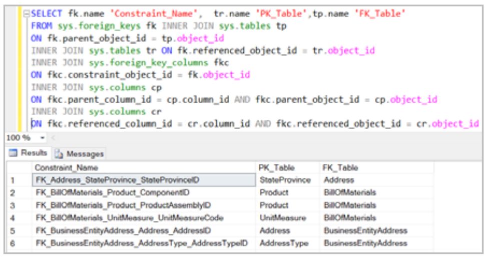


Fig. 17 Proposed applications and databases interaction pattern

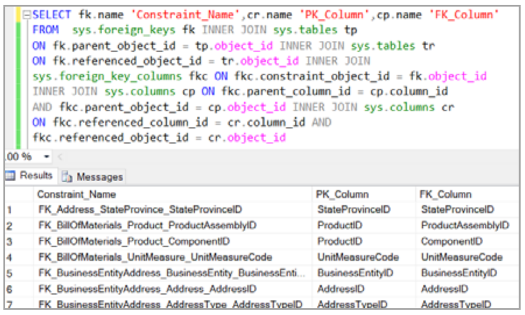
As previously mentioned, in order to extract the primary elements of the metadata, the data dictionary of target database could be used. For example, by running the queries shown in figures 18 and 19 in SQL Server, the details of all relationships in AdventureWorks are accessible, including relationship names and involving primary and foreign key tables and columns.



```
SELECT fk.name 'Constraint_Name',  tr.name 'PK_Table',tp.name 'FK_Table'
FROM sys.foreign_keys fk INNER JOIN sys.tables tp
ON fk.parent_object_id = tp.object_id
INNER JOIN sys.tables tr ON fk.referenced_object_id = tr.object_id
INNER JOIN sys.foreign_key_columns fkc
ON fkc.constraint_object_id = fk.object_id
INNER JOIN sys.columns cp
ON fkc.parent_column_id = cp.column_id AND fkc.parent_object_id = cp.object_id
INNER JOIN sys.columns cr
ON fkc.referenced_column_id = cr.column_id AND fkc.referenced_object_id = cr.object_id
```

	Constraint_Name	PK_Table	FK_Table
1	FK_Address_StateProvince_StateProvinceID	StateProvince	Address
2	FK_BillOfMaterials_Product_ComponentID	Product	BillOfMaterials
3	FK_BillOfMaterials_Product_ProductAssemblyID	Product	BillOfMaterials
4	FK_BillOfMaterials_UnitMeasure_UnitMeasureCode	UnitMeasure	BillOfMaterials
5	FK_BusinessEntityAddress_Address_AddressID	Address	BusinessEntityAddress
6	FK_BusinessEntityAddress_AddressType_AddressTypeID	AddressType	BusinessEntityAddress

Fig. 18 Fetching relationship names and tables in SQL Server

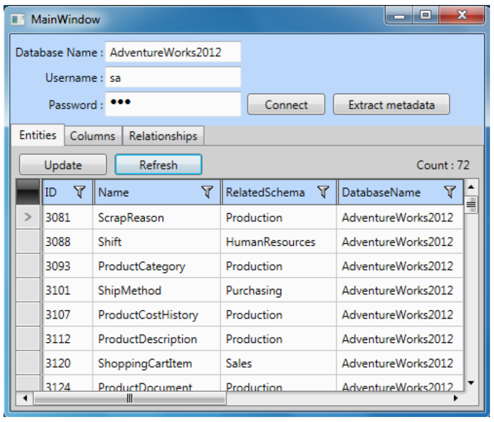


```
SELECT fk.name 'Constraint_Name',cr.name 'PK_Column',cp.name 'FK_Column'
FROM  sys.foreign_keys fk INNER JOIN sys.tables tp
ON fk.parent_object_id = tp.object_id INNER JOIN sys.tables tr
ON fk.referenced_object_id = tr.object_id INNER JOIN
sys.foreign_key_columns fkc ON fkc.constraint_object_id = fk.object_id
INNER JOIN sys.columns cp ON fkc.parent_column_id = cp.column_id
AND fkc.parent_object_id = cp.object_id INNER JOIN sys.columns cr
ON fkc.referenced_column_id = cr.column_id AND
fkc.referenced_object_id = cr.object_id
```

	Constraint_Name	PK_Column	FK_Column
1	FK_Address_StateProvince_StateProvinceID	StateProvinceID	StateProvinceID
2	FK_BillOfMaterials_Product_ProductAssemblyID	ProductID	ProductAssemblyID
3	FK_BillOfMaterials_Product_ComponentID	ProductID	ComponentID
4	FK_BillOfMaterials_UnitMeasure_UnitMeasureCode	UnitMeasureCode	UnitMeasureCode
5	FK_BusinessEntityAddress_BusinessEntity_BusinessEnti...	BusinessEntityID	BusinessEntityID
6	FK_BusinessEntityAddress_Address_AddressID	AddressID	AddressID
7	FK_BusinessEntityAddress_AddressType_AddressTypeID	AddressTypeID	AddressTypeID

Fig. 19 Fetching relationship columns in SQL Server

In this way, by adding a feature to a metadata management program, all 72 tables, 91 relationships, and 749 columns of the AdventureWorks database could be extracted and then transformed into the core metadata model. In Fig. 20, a view of a sample metadata management application and the entities extracted from the AdventureWorks database is displayed.



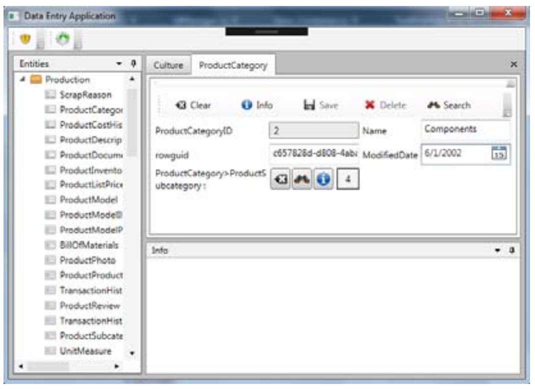
Database Name : AdventureWorks2012
Username : sa
Password : •••

Count : 72

ID	Name	RelatedSchema	DatabaseName
3081	ScrapReason	Production	AdventureWorks2012
3088	Shift	HumanResources	AdventureWorks2012
3093	ProductCategory	Production	AdventureWorks2012
3101	ShipMethod	Purchasing	AdventureWorks2012
3107	ProductCostHistory	Production	AdventureWorks2012
3112	ProductDescription	Production	AdventureWorks2012
3120	ShoppingCartItem	Sales	AdventureWorks2012
3124	ProductDocument	Production	AdventureWorks2012

Fig. 20 Extracted entities in a sample metadata management application

Interestingly, this basic information in the metadata can be used to design some data entry forms and the relationships between them. For example, in Fig. 21 the UI of the *ProductCategory* form in a data entry application is displayed.



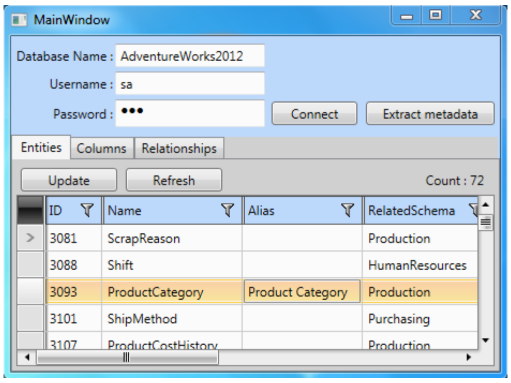
ProductCategoryID: 2
Name: Components
rowguid: c657828d-d808-4ab
ModifiedDate: 6/1/2002
ProductCategory>ProductSubcategory : 4

Fig. 21 The data entry form of *ProductCategory* table in a sample data entry application

Considering the role of metadata in explaining automation solutions, related works like [1], [2], [5] and [6] have optimistically defined the metadata structure at the current depth, in other words, a repository of elementary information about tables, columns and relationships. But, as mentioned earlier, this paper attempts to focus on the metadata and its capabilities in more depth.

Now, using the metadata extension process described previously, more data entry requirements could be applied in the *ProductCategory* form.

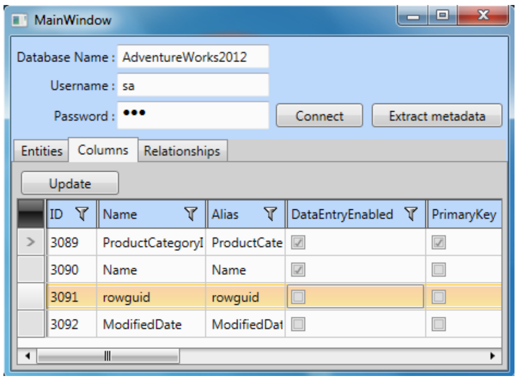
In the first step, metadata could be extended according to the "Common requirements" method discussed previously. Thus, it is possible to define some simple attributes for any concept in the metadata core and then managing them in the metadata management program. For example, suppose it is intended to apply three new requirements in the *ProductCategory* form. The first requirement is to change the form name from the "ProductCategory" term to the "Product Category", the second requirement is to set the columns of *rowguid* and *ModifiedDate* to read-only mode and the third requirements is to hide the relationship with the *ProductSubcategory* entity. All these requirements can be resolved by adding simple attributes to the current metadata elements and then setting them in the metadata application. The methods of setting the three mentioned requirements in the metadata management program are shown respectively in Figures 22, 23 and 24.



Database Name : AdventureWorks2012
Username : sa
Password : •••
Count : 72

ID	Name	Alias	RelatedSchema
3081	ScrapReason		Production
3088	Shift		HumanResources
3093	ProductCategory	Product Category	Production
3101	ShipMethod		Purchasing
3107	ProductCostHistory		Production

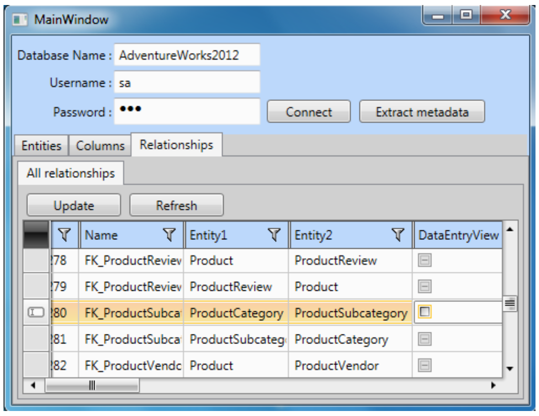
Fig. 22 Setting the *Alias* attribute for entities



Database Name : AdventureWorks2012
Username : sa
Password : •••

ID	Name	Alias	DataEntryEnabled	PrimaryKey
3089	ProductCategoryI	ProductCate	✓	✓
3090	Name	Name	✓	☐
3091	rowguid	rowguid	☐	☐
3092	ModifiedDate	ModifiedDat	☐	☐

Fig. 23 Making columns read-only in the metadata management application

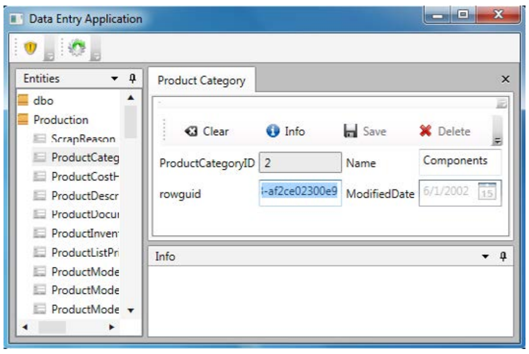


Database Name : AdventureWorks2012
Username : sa
Password : •••

	Name	Entity1	Entity2	DataEntryView
:78	FK_ProductReviev	Product	ProductReview	☐
:79	FK_ProductReviev	ProductReview	Product	☐
:80	FK_ProductSubca	ProductCategory	ProductSubcategory	☐
:81	FK_ProductSubca	ProductSubcateg	ProductCategory	☐
:82	FK_ProductVendc	Product	ProductVendor	☐

Fig. 24 Making relationships hidden in the metadata management application

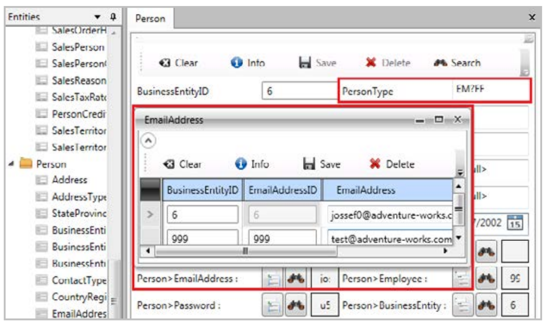
After applying these changes in the metadata, the *ProductCategory* form will be changed to Fig. 25.



ProductCategoryID: 2
Name: Components
rowguid: -af2ce02300e9
ModifiedDate: 6/1/2002

Fig. 25 The *ProductCategory* form after applying some basic requirements

In the next step of metadata enrichment, the concept of specialization of the core elements such as tables, relationships, and columns was discussed. For a better understanding of the capabilities added to the data entry forms by specializations in the metadata, data entry form of the *Person* table is considered. In this form, two requirements are defined; the first one is to apply a validation rule to the *PersonType* field and expresses that the field should only accept string values composed of 2 characters. The second requirement is the ability of defining only one email address for each person. In other words, to set the relationship between the *Person* entity and the *EmailAddress* as a one-to-one relationship and not one-to-many. As shown in Fig. 26, currently it is possible to set a PersonType value with a length of more than two characters. It is also possible to define multiple e-mail addresses through the link to the EmailAddress form.



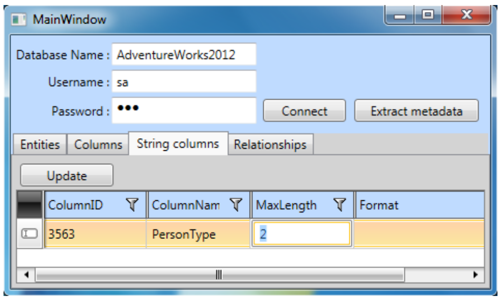
BusinessEntityID: 6
PersonType: EM?FF

BusinessEntityID	EmailAddressID	EmailAddress
6	6	jossef0@adventure-works.c
999	999	test@adventure-works.com

Person>EmailAddress : io:
Person>Employee : 95
Person>Password : u5
Person>BusinessEntity : 6

Fig. 26 The *Person* data entry form before applying requirements

In order to meet the requirements, the metadata can be extended according to the previously proposed specialization methods. For the first requirement, specialization of the string columns in a new entity is proposed (inherited from column entity as Fig.11). Hence, attributes such as the length and the format of a string column could be defined.

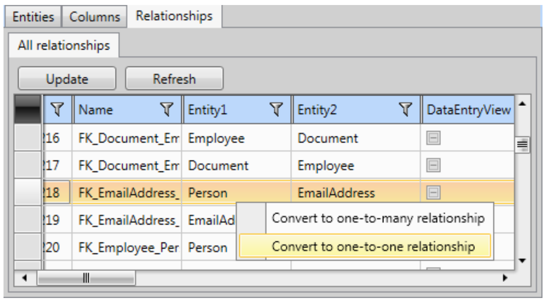

MainWindow

Database Name : AdventureWorks2012
Username : sa
Password : •••

ColumnID	ColumnNam	MaxLength	Format
3563	PersonType	2	

Fig. 27 Defining string columns' properties in the metadata management application

For the second requirement, the same way applies. More precisely, some specialized entities for relationship types should be added to the model and then assigned to existing relationships in the metadata application. Figure 28 shows how to specialize the relationship between *Person* and *EmailAddress* into a one-to-one relationship.

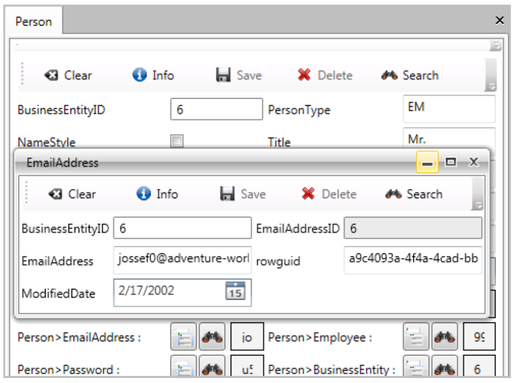


	Name	Entity1	Entity2	DataEntryView
!16	FK_Document_Em	Employee	Document	☐
!17	FK_Document_Em	Document	Employee	☐
!18	FK_EmailAddress_	Person	EmailAddress	☐
!19	FK_EmailAddress_	EmailAd		
!20	FK_Employee_Per	Person		

Entities
Columns
Relationships
All relationships
Update
Refresh
Convert to one-to-many relationship
Convert to one-to-one relationship

Fig. 28 Setting the relationship between Person and *EmailAddress* to one-to-one

After applying these changes in the structure and content of the metadata, the *Person* form will be changed to Figure 29. Firstly, the *PersonType* filed would not accept values with more than two characters; secondly, only one email address can be entered for each person.


Person

BusinessEntityID: 6
PersonType: EM
NameStyle: ☐
Title: Mr.

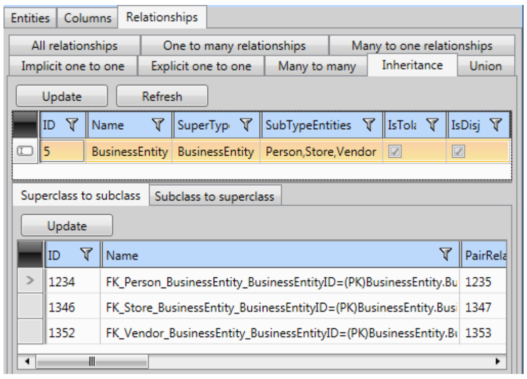
EmailAddress

BusinessEntityID: 6
EmailAddressID: 6
EmailAddress: jossef0@adventure-worl
rowguid: a9c4093a-4f4a-4cad-bb
ModifiedDate: 2/17/2002

Person>EmailAddress : io
Person>Employee : 99
Person>Password : u5
Person>BusinessEntity : 6

Fig. 29 The *Person* form after applying the requirements

In order to examine the higher-level relationships in the AdventureWorks database, we consider the most significant inheritance relationship which Introduces *BusinessEntity* table as the superclass and the tables of *Person*, *Vendor*, and *Store* as subclasses. In order to define this inheritance relationship in the metadata, we act as described previously in "Higher level relationships" section. In other words, we classify the physical relationships between the mentioned tables in the form of a higher-level conceptual relationship. Fig. 30 shows how to define these relationships in the metadata management program.

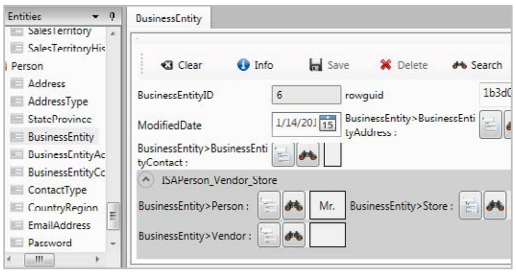


ID	Name	SuperTyp	SubTypeEntities	IsTot	IsDisj
5	BusinessEntity	BusinessEntity	Person,Store,Vendor	✓	✓

ID	Name	PairRela
1234	FK_Person_BusinessEntity_BusinessEntityID=(PK)BusinessEntity.Bu	1235
1346	FK_Store_BusinessEntity_BusinessEntityID=(PK)BusinessEntity.Busi	1347
1352	FK_Vendor_BusinessEntity_BusinessEntityID=(PK)BusinessEntity.Bu	1353

Fig. 30 Managing ISA relationships in metadata application

Now, the properties like *Disjoint* or *TotalParticipation* can also be defined for inheritance relationships. More important, when designing a data entry form containing ISA relationships (like the BusinessEntity data entry form), instead of visiting ISA relationships separately according to their physical level design, they can be implemented as a group of relationships realizing a higher level concept.



BusinessEntityID 6
rowguid 1b3d0
ModifiedDate 1/14/201
BusinessEntity>BusinessEntityAddress :
BusinessEntity>BusinessEntityContact :
ISAPerson_Vendor_Store
BusinessEntity>Person : Mr.
BusinessEntity>Store :
BusinessEntity>Vendor :

Fig. 31 ISA relationship between the *BusinessEntity* and the group of subclasses (*Person, Store* and *Vendor*)

However by considering a database with data like *AdventureWorks*, there is a more efficient way to identify and initialize the majority of relationships types rather than assessing them one by one by a system expert; through implementing a simple algorithm in the metadata management program, it is possible to identify most of the relationship types automatically. This algorithm is shown in figure 32.

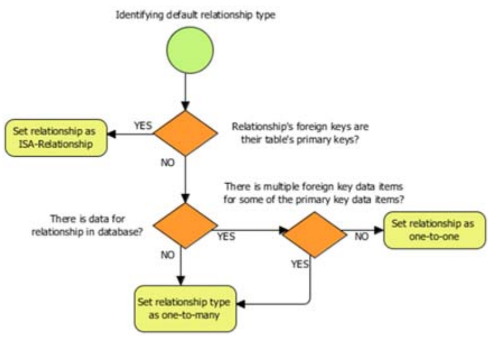

Identifying default relationship type
Relationship's foreign keys are their table's primary keys?
YES
Set relationship as ISA-Relationship
NO
There is data for relationship in database?
YES
There is multiple foreign key data items for some of the primary key data items?
NO
Set relationship as one-to-one
NO
YES
Set relationship type as one-to-many

Fig. 32 Algorithm of setting default relationship types

By running this algorithm on the AdventureWorks database, 73 relationships were identified as one-to-many, 11 relationships as one-to-one and 7 relationships as ISA relationships. The ISA relationships are shown in Table 5 and the one-to-one relationships are listed in Table 6. Rest of the relationships are one-to-many relationships.

Table 5 Detected ISA relationships in the AdventureWorks database

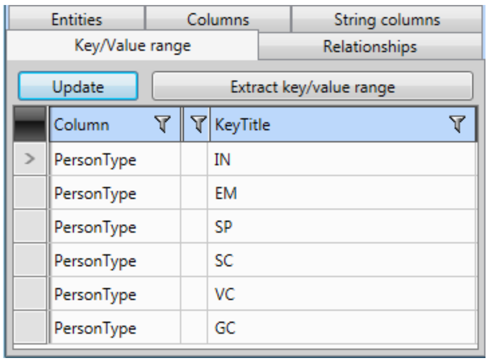
No	Superclass	Subclass
1	BusinessEntity	Person,Store,Vendor
2	Person	Employee,Password
3	Employee	SalesPerson

Table 6 Detected one-to-one relationships in the AdventureWorks database

No	Status	From	To
1		Address	BusinessEntityAddress
2		Person	BusinessEntityContact
3		Person	Customer
4		Person	EmailAddress
5		Employee	JobCandidate
6		CreditCard	PersonCreditCard
7	*	Person	PersonCreditCard
8	*	Person	PersonPhone
9		ProductDescription	ProductModelProduct-DescriptionCulture
10		Product	ProductProductPhoto
11	*	Product	ShoppingCartItem

By closer examination of these relationships, we find that the proposed method succeeds in identifying about 95% of the relationship types correctly, in other words, 86 relationships out of 90 relationships. More precisely, all of the one-to-many relationships are correctly detected and from the one-to-one relationships, only three of them (marked with * in the table) - in spite of their one-to-one data match in the database - require to change to one-to-many relationships. Also, among the detected inheritance relationship, it would be conceptually better to change the relationship between *Person* and *Password* tables to a one-to-one relationship. As mentioned earlier, these conversions can be easily done in the metadata managing program.

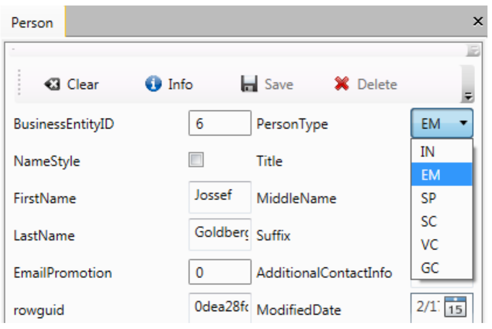
The next idea referred in enrichment methods was the possibility of including more complex requirements in the metadata. Using these definitions in metadata, it is possible to improve the raw data entry forms to forms containing more and more business rules. For example, remember the *PersonType* field in the Person form. In fact this field can only accept values from a certain range of two-character strings ('IN', 'EM', 'SP', 'SC', 'VC' and 'GC'). To cover this issue, a change in the metadata model and application can be done that allows to define a set of values for a column. In Figure 33, the feature of setting a set of values for a column is displayed. Note that these values can be directly extracted from the target database automatically.



Column	KeyTitle
PersonType	IN
PersonType	EM
PersonType	SP
PersonType	SC
PersonType	VC
PersonType	GC

Fig. 33 Defining a set of values for the *PersonType* field

Therefore, the user can only select the value of the *PersonType* field from a predefined set of values.

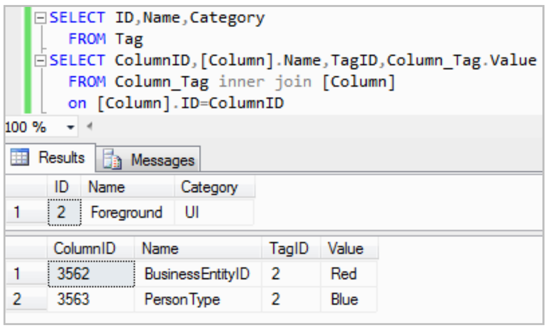


BusinessEntityID	6	PersonType	EM
NameStyle	☐	Title	
FirstName	Jossef	MiddleName	
LastName	Goldberg	Suffix	
EmailPromotion	0	AdditionalContactInfo	
rowguid	0dea28fc	ModifiedDate	2/1

IN
EM
SP
SC
VC
GC

Fig. 34 Selecting the value of the *PersonType* field

At the end of this section, the proposed idea of inserting some of the requirements in the metadata in form of general and dynamic construction would be considered. These categories of requirements can be either application level or technical requirements that are not directly related to the business rules of data entry forms. For example, setting a distinctive color for a column's header might be a requirement. In Figure 35, the proposed method of defining the color property as a tag and assigning it to columns through the ColumnTag table is presented. Also in Figure 36, the effect of these definitions in the metadata on the data entry form is shown.

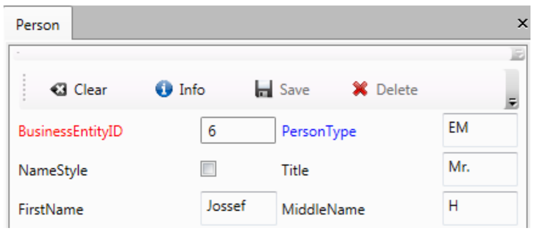


```
SELECT ID,Name,Category
  FROM Tag
SELECT ColumnID,[Column].Name,TagID,Column_Tag.Value
  FROM Column_Tag inner join [Column]
  on [Column].ID=ColumnID
```

	ID	Name	Category
1	2	Foreground	UI

	ColumnID	Name	TagID	Value
1	3562	BusinessEntityID	2	Red
2	3563	PersonType	2	Blue

Fig. 35 The concepts of Tag and *ColumnTag* in the metadata



BusinessEntityID	6	PersonType	EM
NameStyle	☐	Title	Mr.
FirstName	Jossef	MiddleName	H

Fig. 36 Different colors of fields based on the metadata definitions

VIII. CONCLUSION

In this study, the idea of generation and enrichment of metadata for automatic implementation of data entry forms based on database models is discussed. According to the mentioned, the structure of metadata could be systematically enhanced from a simple source of database schema depended on data dictionary to a more comprehensive model. A key point in discrimination of the solution is commitment to the known schema of relational databases and development of metadata based on the extracted initial elements.

The enrichment process begins from the extraction of common elements such as tables, columns and relationships and representing them in a relational model. Afterwards, through adding some properties to these elements, some common requirements of data entry would be covered. In the next step, for purpose of more structural development of model, some specialization techniques on the existing elements of the metadata are discussed. Then, the idea of considering some higher-level concepts of target database in the metadata design like ISA-relationships is proposed. The possibility of adding more complex rules and validation requirements in the metadata is the next discussed extension. However, there would be no need to apply all requirements and modifications explicitly in the metadata structure. To decrease the size of metadata, some attributes could be defined and initialized in form of tag/value using generalization techniques.

Moreover, for purpose of initialization of the proposed structures in metadata and generally metadata management, necessity of implementing a controlling software program is referred. According to this idea, by means of this program, the data in metadata could be initialized and managed through using a combination of three methods of coding, rule engine and direct intervention of user. In Fig. 37, the function of a metadata management program in a general automation approach of data entry is illustrated.

In the final section, in order to observe the functionality of the proposed solution, examples of initialization, extension and application of the appropriate metadata for data entry of a standard database is provided.

Considering the data nature of metadata, the enrichment of metadata is not limited to mentioned requirements and it is possible to extend it over other directions and applications. For example adding user profile concepts and related access controls for users or designing schemas for configuring a variety of reports in the metadata can be a supplementary goal.

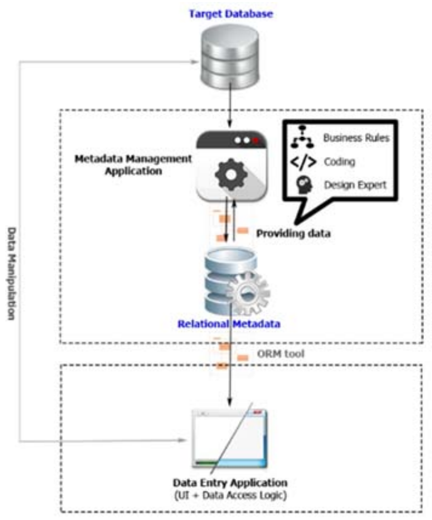


Fig. 37 Role of a metadata management program in an automated data entry approach

REFERENCES

1. A. Elbibas and M. J. Ridley, "Developing Web entry forms Based on METADATA.," in International Workshop on Web Quality in conjunction with ICWE 04-International Conference on Web Engineering., 2004.

2. M. M. Elsheh and M. J. Ridley, "Using database metadata and its semantics to generate automatic and dynamic web entry forms." in Proceedings of the World Congress on Engineering and Computer Science, 2007.

3. D. G. Saputra and F. N. Azizah, "A Metadata Approach for Building Web Application User Interface," in the 4th International Conference on Electrical Engineering and Informatics, 2013.

4. Kesler, John N. "Automated generation of dynamic data entry user interface for relational database management systems." U.S. Patent No. 7,401,094. 15 Jul. 2008.

5. Mgheder, Mohamed Ahmed. Database Metadata Requirements for Automated Web Development. A case study using PHP. Diss. University of Bradford, 2011.

6. Albhbah, Atia M., and Mick J. Ridley. "A Rule Framework for Automatic Generation of Web Forms." International Journal of Computer Theory and Engineering 4.4 (2012): 584.

7. Oracle, "Chapter 22 INFORMATION_SCHEMA Tables," [Online]. Available: http://dev.mysql.com/doc/refman/5.7/en/information-schema.html.

8. Microsoft, "Information Schema Views (Transact-SQL)," [Online]. Available: https://msdn.microsoft.com/en-us/library/ms186778.aspx.

9. Oracle, "Data Dictionary and Dynamic Performance Views," [Online]. Available: https://docs.oracle.com/cd/E11882_01/server.112/e40540/datadict.htm.

10. R. H. L. Chiang, T. M. Barron and¬ V. C. Storey, "Reverse engineering of relational databases: Extraction of an EER model from a relational database," Data & Knowledge Engineering, 1994.htm.

11. J.-L. Hainaut, J. Henrard, D. Roland, J.-M. Hick and V. Englebert, "Database Reverse Engineering," Encyclopedia of Database Systems, pp. 723-728, 2009.

12. Microsoft, "Microsoft SQL Server Product Samples: Database", [Online]. Available: https://msftdbprodsamples.codeplex.com/.

13. Microsoft, "AdventureWorks Data Dictionary," [Online]. Available: https://technet.microsoft.com/en-us/library/ms124438(v=sql.100).aspx.