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# Multidimensional Context Dependent Information Delivery on the Web

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*Abstract*— **Multidimensional Semi structured Data MSSD are semi structured data that Present deferent facets under deferent contexts i.e. alternative worlds For the representation of MSSD various formalisms have been proposed by the authors both syntactic such as MSSD expressions and MXML as well as graphical such as Multidimensional OEM In this paper we present an infrastructure for handling MSSD This infrastructure provides appropriate tools for building MSSD applications and is independent from any particular application that uses it We also present a graphical interface called MSSDesigner that provides access to the infrastructure and we describe OEM History an MSSD application that supports keeping track of temporal changes in semi structured databases**

*Index Terms*— **SSD, OEM Graph, OEM History, MDSS Data, MOEM Graph..**

## I. INTRODUCTION

The nature of the Web poses a number of new problems While in traditional databases and information systems the number of users is more or less known and their background is to a great extent homogeneous Web users do not share the same background and do not apply the same conventions when interpreting data Such users can have deferent perspectives of the same entities a situation that should be taken into account by Web data models Those problems call for a way to represent information entities that manifest deferent facets whose contents can vary in structure and value Multidimensional Semistructured Data MSSD paired with an extension of OEM called multidimensional OEM have been proposed in MSSD and MOEM incorporate ideas from multidimensional programming languages and associate data with dimensions in order to tackle the aforementioned problems In MSSD variants of the same information entities each holding under a specific world have been consolidated to form multidimensional entities Syntactic expressions called context specifiers are associated to pieces of data facets of multidimensional entities and specify sets of worlds under which these data hold In this paper we present the overall architecture of an infrastructure that allows the management of multidimensional semistructured data This infrastructure can be used for the development of new applications and MSSD

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tools that will be placed on top of it by providing access to a number of operations on MSSD We focus mainly on MOEM graphs that can be used to represent MSSD and we present MSSDesigner a graphical interface for handling MOEM graphs which is also a part of the infrastructure A world represents an environment under which data obtain a substance In the following definition we specify the notion of world using a set of parameters called dimensions.

**Definition: 1** Let D be a set of dimension names and for each d € D let Vd be the domain of d, with Vd ≠0. A world w with respect to D is a set whose elements are pairs( d v), where d € D and v € Vd such that for every dimension name in D there is exactly one element in w.

The main difference between conventional and multidimensional semi structured data is the in introduction of context specifieres. Context specifieres are syntactic constructs, expressing constraints on dimension values that are used to qualify semi structured data expressions (SSD-expressions) and specify sets of worlds under which the corresponding SSD-expressions hold. In this way it is possible to have at the same time variants of the same information entity, each holding under a different set of worlds. An information entity that encompasses a number of variants is called multidimensional entity, and its variants are called facets of the entity. The facets of a multidimensional entity may differ in value and or structure, and can in turn be multidimensional entities or conventional information entities. Each facet is associated with a context that defines the conditions under which the facet becomes a holding facet of the multidimensional entity. If a facet **f** of a multidimensional entity **e** holds under a world W (Or under every world defined by a context specifier c ) then we say that **e** evaluates to **f** under **w** (under c, respectively).

Example1. The use of dimensions for representing worlds is shown with the following three context specifiers:

1. [time in {07:00..15:00}]
2. [language= English, detail in {low, medium}]
3. [Season in {fall, spring}, daytime= noon| season= summer]

In Example 1, context specifies (a) represents the worlds for which the dimension time can take any value between 07:00 and 15:00, while (b) represents the worlds for which language is English and detail is either low or medium. Context specifier (c) is more complex, and represents the worlds where season is either fall or spring and daytime is noon, together with the worlds where season is summer. Notice that according to Definition 1, for a set of (dimension, value) pairs to represent a world with respect to a set of dimensions **D** it must contain exactly one pair for each dimension in D Therefore if D f language detail g with V language f English g and V detail flow medium high g then f language English detail low g is one of the six possible worlds with respect to D This world is represented by context specifier b in Example together with the world f language English detail medium g . Notice that it is not necessary for a context specifier to contain values for every dimension in D Omitting a dimension implies that its value may range over the whole dimension domain. The context specifier is called universal context and represents the set of all possible worlds with respect to a set of dimensions D.

### 2.2 MULTIDIMENSIONAL OEM

Multidimensional Object Exchange Model (MOEM) is an extension of Object Exchange Model OEM suitable for representing multidimensional data. MOEM extends OEM with two new basic elements:

Multidimensional nodes represent multidimensional entities and are used to group together nodes that constitute facets p of such entities. Graphically multidimensional nodes have a rectangular shape to distinguish them from conventional circular nodes, which are called context nodes.

Context edges are directed labeled edges that connect multidimensional nodes to their facets. The label of a context edge pointing to a facet p is a context specifier defining the set of worlds under which p holds Context edges are drawn as thick lines to distinguish them from Conventional thin lined edges called entity edges. The definition of multidimensional data graph is given below

**Definition :2** Let C be a set of context specifiers, L be a set of labels and A be a set of atomic values. A multidimensional data graph is a finite directed edge-labeled multigraph G=( V, E, r, C,L,A, v) where:

**1.** The set of nodes V is partitioned into multidimensional nodes and context nodes V= Vmld U Vcxt. Context nodes are further divided into complex nodes and atomic nodes Vcxt = Vc U Va.

**2.** The set of edges E is partitioned into context edges and entity edges E= Ecxt U Eett, such that Ecxt Vmld C V and Eett Vc LV

**3.** r € V is the root, with the property that there exists a path from r to every other node in V.

**4.** v is a function that assigns values to nodes, such that v(x) = M if x € Vmld, v(x)= C if x € Vc and v(x)= $v^I$ (x) if x€ Va, where M and C are reserved values and $v^I$ is a value function $v^I$: Va → A which assigns values to atomic nodes

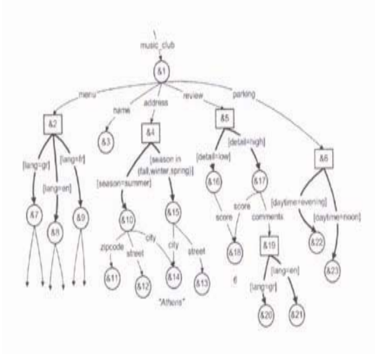

Fig. 1. A multidimensional music-club.

As an example consider the part of an MOEM graph in Figure which represents context dependent information about a music club. The graph is not fully developed and some of the atomic objects do not have values attached. The music club with oid &1 operates on a different address during the summer than the rest of the year in (Delhi it is not unusual for clubs to move south close to the sea in the summer period and north towards the city center during the rest of the year). Except from having a different value context objects can have a different structure as is the case of and which variants of the multidimensional object address with oid &4. The menu of the club is available in three languages namely English, French and Germen. In addition the club has a couple of alternative parking places, depending on the time of day as expressed by the dimension daytime. Two fundamental concepts related to multidimensional data graphs are the notions of explicit and inherited contexts. The explicit context of a context edge is the context specifier assigned to that edge, while the explicit context of an entity edge is the universal context specifier. The explicit context can be considered as the "true" context only within the boundaries of a single multidimensional entity .When entities are connected together in an MOEM graph, the explicit context of an edge is not the "true" context in the sense that it does not alone determine the worlds under which the destination node holds. The reason for this is that when an entity $\mathbf{e_2}$ is part of (pointed by through an edge) another entity $\mathbf{e_1}$ then $\mathbf{e_2}$ can have substance only under the worlds that $\mathbf{e_1}$ has substance. This can be conceived as if the context under which $_{\mathbf{e1}}$ holds is inherited to $\mathbf{e_2}$. The notion of validity of an MOEM graph ensures that edges pointing to multidimensional nodes do not exist in vain in particular, an edge h leading to a node q is invalid if the inherited context of h has no common world with the context union of the worlds represented by the explicit contexts of the edges that depart from q.

### 2.3 MULTIDIMENSIONAL XML

Besides MOEM which models MSSD as a graph a notation for expressing MSSD has been also proposed. The notation extends ssd-expression with context specifiers and is called mssd-expression. Another way to describe MSSD is Multidimensional XML (MXML) which is an extension of XML that incorporates context specifiers. In MXML elements and attributes may depend on a number of dimensions. A multidimensional element is denoted by preceding its name with the special symbol "**©"** and encloses one or more context elements that constitute facets of that multidimensional element, holding under the worlds specified by the corresponding context specifier. Context elements have the same form as conventional XML elements. MXML suggests a new way for designing Web pages which encode context dependent data. The multidimensional paradigm allows a single document to have a number of variants each holding under a specific world. Information in such a document is encoded in MXML. An MXML document may be associated with a Multidimensional XSL style sheet MXSL in short containing instructions on how to present information in XML documents An MXSL style sheet encodes a set of conventional XSL style sheets each being the facet of the MXSL under a specific world For each possible world the holding XSL is applied to the holding XML to give the view of the information under that world.

## III. ARCHITECTURE OF AN MSSD INFRASTRUCTURE

An MSSD infrastructure is a set of tools and processes that create manipulate and query MSSD and are used directly or by applications that need the support of an MSSD framework. This section presents such an infrastructure for manipulating multidimensional semistructured data which can also be used for implementing additional tools and applications. The infrastructure consists of the following components described in Figure2.

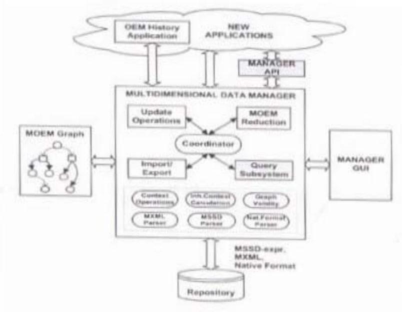


Fig. 2. Architecture of an MSSD infrastructure

**MOEM Graph** consists of the main memory data structures which actually hold graph representations of MSSD.
**Multidimensional Data Manager (MDM)** is responsible for managing MOEM graphs. It comprises a set of modules that allow the creation maintenance and querying of multidimensional semistructured data various modules of MDM can be accessed through graphical user interfaces offered by the Manager GUI.

**Manager GUI** comprises a number of user interfaces, which provide access to various functions of MDM, like MOEM graph creation and maintenance, and MOEM graph querying. MOEM graph creation and maintenance can be performed through MSSDesigner.

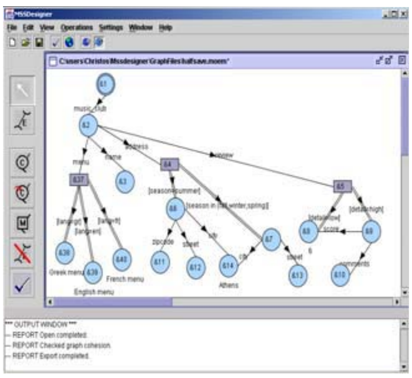

**Figure.3.A Sample Image of MSSDesigner**

**Repository** is the physical storage medium that supports the MDM needs for loading and saving MSSD and MOEM graph representations. Note that a number of formats able to represent semistructured data can be used when storing MOEM in files. At this moment, mssd-expressions, MXML and native format expressions are supported. **Manager API** aims at providing an application programming interface for new applications that will need to use the functionality of the system. This module enables applications to use the existing infrastructure by issuing commands in an especially made script like language. However an application can directly use the MDM as is the case of OEM History.
**Multidimensional Data Manager MDM** is the most important component It comprises a set of utility processes which appear inside a box placed at the bottom of MDM in Figure and are accessible to all other MDM modules Those utility processes are explained below
**MSSD-Expressions** The grammar of mssd-expressions is given in Extended Backus-Naur Form EBNF. Here we give as an example the mssd- expression that describes the address object with oid **&4** in Figure 1.
&4 ([ seasonsummer]:
&10{zipcode:&11,street:&2, city:&14 " Delhi"}, [season in {fall, winter, spring}]: &15 { city: &14,street: &13})
**MXML Representations** MXML has been defined in the following MXML extract describes the same address object as the above mssd- expressions example:

<@address>
[season= summer]
<address>
<zipcode>…</ zipcode>
<street>…</ street>
<city id="c1"> Delhi <city>
</address>

[season in {fall, winter, spring}]
<address>
<city idref="c1" /> Delhi <city>
<street>…</ street>
</address>
[/]
</@address>

### 4.4 MOEM REDUCTION MODULE

This module is responsible for two jobs:
(a) Reduction of a MOEM graph to a conventional OEM graph holding under a specific world, and
(b) Partial reduction of a MOEM graph to another MOEM graph holding under a set of worlds. Reduction to OEM Given a specific world it is always possible to reduce an MOEM graph to a conventional OEM graph holding under that world. By specifying different worlds, the same MOEM can be reduced to different OEMs. The graph to be reduced must be context deterministic i.e for every multidimensional entity in the graph the context specifiers of that entity must be mutually exclusive. This ensures that two different facets of a multidimensional entity cannot hold under the same world. A procedure which performs reduction to OEM is presented below, and it is based on the idea that inherited contexts identify the parts of the graph that do not hold under a world.

The facet of an MOEM graph G under a world w, is an OEM graph $G_w$ that holds under w Given a world w expressed as a context specifier $c_w$, the graph $G_w$ can be obtained from G through the following process:
**Procedure reduce to OEM** (G, $c_w$ $G_{w)}$ is $G_w$
**Step1:** Remove every node and edge with $cw \cap i_c = 0c$, where $i_c$ gives the inherited context of the node or edge respectively.

**Step2:** For every entity edge ( p, l, $m_{1)}$ with $m_1$ a multidimensional node, follow the path of consecutive context edges ($m_{1,}$ c1,m2)…, ($m_{n,}$ cn, q), n ≥1, until no more context edges can be followed. Then if q is a context node add a new entity edge(p, l, q ) in the set of entity edges.

**Step3:** Remove all multidimensional nodes. Remove all edges departing from or leading to the removed nodes.

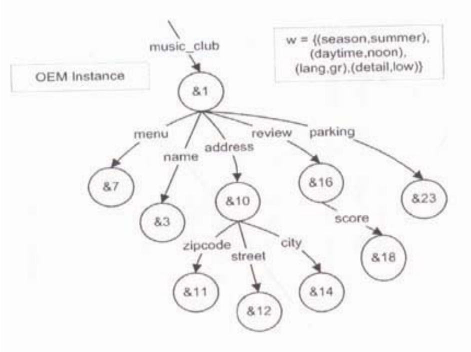


Figure.4 The OEM instance, holding under the world w, of the MOEM graph in Figure1.

**Partial Reduction** Partial reduction is in fact a generalization of the procedure reduce- to- OEM given above. In partial reduction a context specifier that represents a set of world's nearly more than one world is given. The MOEM graph is reduced to a new MOEM graph containing only the nodes and edges that hold under any of the specified worlds. In order to obtain the reduced MOEM graph the inherited context of nodes and edges is used, and a process similar to step1 of reduce- to- OEM is performed.

## 5.MSSDESIGNER

MSSDesigner is a graphical interface (part of the Manager GUI) that gives access to the functionality of MDM. A sample image of MSSDesigner Displaying a simple graph about a multidimensional music club is depicted in Figure4. MSSDesigner employs a multi document interface (MDI) where each document- frame corresponds to a data graph. All the operations performed by the various control buttons of the application, have effect to the currently focused frame. Through MSSDesigner it is possible to import a graph from an MSSD expression or MXML representation, and export a graph to one of those formats.

## CONCLUSION

In this paper we proposed an architecture for manipulating MSSD that can be used as an infrastructure for the development of new MSSD tools and applications We showed the capabilities of this infrastructure and we presented MSSDesigner a graphical user interface for designing MOEM graphs that is a part of the GUI of this infrastructure Furthermore we explained how a new application can exploit this functionality and aims at accommodating temporal changes in semi structured databases. We believe that MOEM has a lot of potential and can be used in a variety of edges among which in information integration for modeling objects whose value or structure vary according to sources in digital libraries for representing metadata that conform to similar formats in representing geographical information where possible dimensions could be scale and theme.

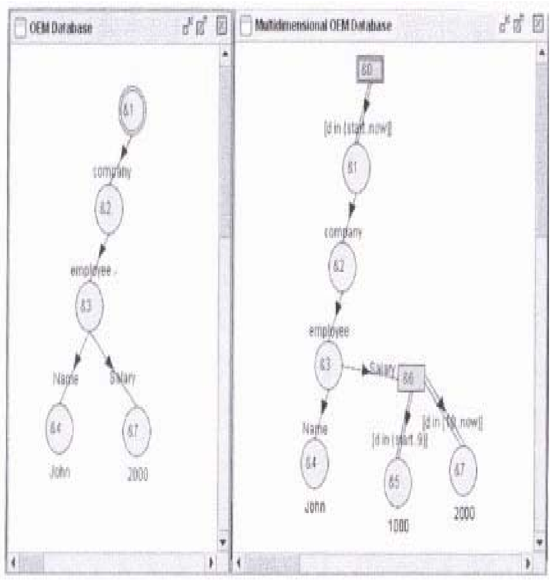


Figure.5 The Database after the insertion of new employee at d = 20

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