**Versioning of granulated data in hierarchically composed workspaces**

***Vladimir Jotov***

***e-mail: vjotov@acm.org***

*Abstract:*

*For the last 30 years there has been a lot of research of versioned software products, but nevertheless there still remain challenges. This article focuses on a model of versioned objects and hierarchically composed workspaces. The presented model of versioned object aims to solve the issue of granulation of versioned data. The model of hierarchically composed workspaces provides methods and rules for versioning, completing the first model.*

*Keywords: version control, data granulation, workspaces, models*

*ACM Computing Classification System (1998): F.4.1.*

**1. Introduction**

Classic version control systems allow the users to apply version control over files [2, 5, 6, 8, 9]. The domain of software development abstractions (classes, interfaces, objects, etc.) are distinguished from file abstraction domain. These systems are very fast and widely used. Nevertheless, the following disadvantages could be stated:

* The access to the objects (files) is vouched by file system. We have to notice that very few file systems support the required level of security when a user works with versioned objects.
* Files as versioned object have large data granulation level. They don’t allow the user to specify the relations between separate objects (files).

In order to solve these issues Nguyen [8] introduces object-oriented approach of versioning. In his models data is presented as table of slots made from attributes and nodes. As a disadvantage of the model it could be pointed out that many data slots could remain empty. Nevertheless the model follows the need of multilevel data granulation.

In software development industry the term workspace is comprehended as an isolated space (environment) where certain work is done. The first commercial solution with hierarchical structure of workspaces [12] was introduced in 1989. Nevertheless, Estublier [4 – page 406] emphasize that “**…a modern workspace is created “behind-the-scenes” to perform a particular user-selected task …** ”. The authors label the workspace as a system element that has to provide the following main features:

1. Sandbox – a save space where users have the opportunity to work without being affected from other users.
2. It allows building specific version/configuration of the software system.
3. Separation of changes, tests and other pursue activities without direct affect over the product or other users’ work.

Thus we can formulate the following problems in the current article:

* To present an object-oriented model of versioned object that allows specifying freely the level of data granularity.
* To provide a model of workspaces with hierarchical composition including set of rules for version control.

**2. Objectc Model**

Lead authors in version control domain [3, 10] determine the version object as two part entity - object states, and object versions' graph. Object version graph is a graph where the nodes represent object states, and arcs represent version transitions.

We can emphasize the main feature of a versioned object as the possibility to define data granulation in a free way. This feature needs to be supported by the model of versioned object. This leads us to the need of defining object compositions as part of the model. The formal definition of the composed object could be formulated as follows:

1. Composed object is an object that is built from other object using composition entity.
2. As composition we will comprise the entity that defines the relation between super-object and sub-object. One composed object could be super-object for one or more composition instances, i.e. to be built by one or more sub-objects.

The fact of adding the composed objects and sub-objects in the domain leads us to the need of redefinition of versioning process over versioned objects. On the following diagram is presented an example for change of version composition. Here arrows represent changes in objects’ content among different versions of end product.



Figure 1 An example for change in objects’ content

On versions binding of certain versioned object it is necessary to use relation of type foreign key. It follows from this pursue that **versioned object entity** has to consist only of unique and immutable number. It is useful to regard that number as primary key for the entity.

Object’s versions could be treated as its primitives (**versioned primitives**) with the following attributes:

* Versioned object id
* Version number – a serial number which specifies in unique way the version within the versioned object.
* Object’s name. Setting the name to be on primitive level allows the user to track among different versions even if the object is renamed. This model becomes more complete, excluding the weakness related with object (file) renaming in systems as Subversion (SVN), Git, and other. [2, 5, 6].
* Object content.

Versioned primitive is determined in unique way using the couple **versioned object id** and **version number**. In spite of the possibility to use that unique pair and compound key, good practices in ER model design [1] recommend that each entity should possess its own not compound key. In our case we will introduce an additional field as a primary key – global version number.

Versioning of composed object requires defining an additional entity – Versioned primitive composition (in short Composition). This entity is a relation entity that binds in a unique way version of a super-object with version of a sub-object. The following attributes of composition could be defined:

* Global number of super-object
* Global number of sub-object.

Here despite the fact that attribute combination is always unique, we also will use additional attribute for primary key – composition id.



Figure 2 ER model of versioned object

Due to accounting and change traceability needs, our model will be extended in order to support the feature of versioned graph. In ER models graph structures could be presented using two entities – one entity for nodes and another for arcs [11]. Looking to versioned object definition, we could conclude that graph nodes correspond to versioned primitive entity. The missing part will be implemented as a new entity which will correspond to graph arcs – arc of version graph. The new entity requires the following attributes:

* Arc id – primary key.
* Global number of source version.
* Global number of target version.
* User that made the change.
* Date and time of change.

### Versioning of composed object

In the current paragraph we will represent the peculiarities in versioning of composed objects with rank one. Based on that, we will specify the versioning process of composed objects with rank N. The following definition specifies the term rank of composed object.

1. Composed object with rank zero, i.e. simple object is an object which is not associated with its own sub-objects. Composed object with rank N is an object for which the largest rank of associated sub-object is equal to N-1.



Granularity degree of an object is its rank.

It is important to note that the definition of composed object doesn't apply any restrictions on sub-objects. This leads to the following conclusion:

1. One sub-object itself can be part of composed object, therefore we can build a composition of composed objects.

One of core tasks ahead in the current article is to avoid unnecessary complication of the models. Having that as well as missing necessity, we can specify the following restriction rules during the building of composed objects:

1. In given composition of composed objects, certain object can be once at most.
2. One object can be part of at most one object composition.



Figure 3 A tree of objects

In change of composition between two objects, we should regard the objects’ versions as different (Figure 4). Let us examine a chair (super-object) with armrests (sub-objects). When we remove the armrests from a chair, we get a new version of the chair - a chair without armrests. We have to underline that sub-objects do not change its version. Therefore we get only change in compositions of super-object. We have similar situation in building super-object, i.e. when we have a simple object which is transformed to composed object. When we add armrests to a chair, we get a new version of that chair without changing the version of armrests.



Figure 4 Change in objects' composition through change of version

Another feature of composed objects is the case of sub-object change when we get an indirect change of the composed object (Figure 5). Let us look at the example: Let we have a change of a chair's upholstery from blue to red. In this case not only the version of the upholstery is changed but also the version of the chair. As a special case of sub-object change could be regarded as association of an object as a sub-object and removing of association with sub-object and its transformation to a simple object.



Figure 5 Indirect change of version of composed object in case of its sub-object change

The opposite case - when we have a change in super-object - does not mean that the version of its sub-objects is changed. So if you have a chair with three legs and red upholstery, the addition of the fourth leg of the chair does not change the version of red upholstery's sub-object. (Figure 6)



Figure 6 Change in super-object doesn't affect the version of sub-object

From the last two rules can be derived a consequence:

1. Changing the version of a sub-object for a super-object does not affect the versions of its sibling sub-objects ().

**3. Model of Hierarchical composed workspaces**

The first model that we are going to examine is the model of hierarchical composed workspaces. Within the model the following definitions will be used:

1. Product is called the subject of material or immaterial manufacturing, which after its creation can be reproduced and distributed to customers.
2. Product release is called a fixed version that has passed certain quantities of controls and meets the criteria of quality, safety and security. Only product releases are distributed to customers. Versions that are not released are called the practice working versions.
3. Workspace is a location where certain activities are carried out on the development of a version of a product.
4. A main workspace is a workspace which made ​​the final preparation of equipment and product release.

Arrangement (composition) of the workspace is taken to provide opportunity for each participant in product development process and its releases to carry out its activities both individually and cooperating with other participants. Namely the workspace provides the opportunity for independent work that does not affect nor is affected by the work of other participants. On the other hand, composing workspaces in a hierarchy is claimed to be a mechanism to ensure cooperative work. Diagram (Figure 8) presents a diagram of hierarchical composition of workspaces.



Figure 7 Class diagram of Product-Release-Workspace model

### Versioned object visibility model in environment with hierarchical composition of workspaces

As in any hierarchical structure, here, too, will be considered a parent-child relation. We will focus on the versioned object visibility defined by the following principles of visibility.

1. *Local version of the versioned object* is the version that is associated with a specific workspace.
2. *Visible version* *of versioned object* for a given workspace means a version of the object with which the user can work.

Visibility principles:

1. *The local version of the versioned object for a given* workspace is the visible version of the object in the same workspace, despite other local versions in the parent workspaces.
2. The local version of object in a workspace can be seen recursively in all subspaces, unless another local version is defined therein.



Figure 8 Example of hierarchical composition of workspaces

From the above principles we can deduce some consequences:

1. In any workspace, where objects do not have a local version, they are presented with their version found in the nearest parent workspace
2. If for a given workspace the object has no version in either parent workspace, it is not visible in the selected workspace.

On Figure 9 we present the way the two principles of visibility influence object version distributions, for example hierarchical composition of workspaces.



Figure 9 Distribution of object versions according to the visibility principles

In order to achieve completeness and correctness of the model, the following constraint can be formulated: an object can present only one version in a workspace.

The composed object model and visibility principles lead us to the need to address the problem of composed object visibility.



Figure 10 Change in certain sub-object does not affect the version of its siblings

1. Certain composed object version is visible in certain workspace only and solely when all its sub-objects are visible in that workspace.

## 4. Transactions over versioned objects

We introduced transactions over versioned objects in [7]. Here we will make a short presentation and classification of them.

### Transaction within a single workspace

Creation is the first transaction for each versioned object. After completion of the transaction, the object has an initial (zero) version, in which it is "empty", i.e. contains no information.

The transaction of state marker creation by which we create a new version of a versioned object can be regarded as the basis of a mechanism for creating safe-points.

As a reverse transaction, to create a state may be classified for this waiver of marker status. Through the model was released, last state and current local version of the object is the version prior refusal.

The creation of long sequences of not branched versions, especially by the same user within the same workspace, leads us to the idea of the transaction of combining successive versions in order to save memory and follows faster and easier analyses of the work.

Updating versioned non-local object, i.e. an object that does not have any local version in the current workspace, can be defined as the most important of the current section. This transaction is not entirely limited only to a single workspace, since it is composed of the following steps:

* Retrieve the previous visible for workspace version of the site.
* Create a local version of the object in the current workspace.
* Creation of arc in version graph – linking the previous visible version with the new local version of the object.

Deleting an object is possible by creating a transaction called “tag for deleted object”. This tag is intended to "hide" the object in its workspace and respectively to make it invisible in its sub-workspaces. It should be noted that all transactions over the object described in this section can no longer available, except for transaction rejection of tag status.

### Transaction among two workspaces

Transactions between two workspaces can be divided into two groups - the publication of object’s version and giving up a local version. Before examining, it is necessary to introduce the terms "derivative" and "parallel" version of an object.

1. Let us look at one versioned object and two versions of its X and Y. If there is a road of the versioned graph of the object from version X to version Y, then Y version is called a derivative version of X, and version X is called previous version of Y.
2. Let us look at one versioned object and two versions of its X and Y. If there is no road of the versioned graph of the object from version X to version Y, then both versions are called *parallel* versions or *not-derived* versions.

Publishing an object’s version means the transformation of the local version of the object from the current workspace into a local version of its parent workspace.

The simple version publishing is in a situation where there is no local version of a published object in the parent workspace - Figure 11.



Figure 11 Simple publishing

Following the transaction which needs to be addressed, is that of updating publication (Figure 12). Typical for it is that it is possible when it simultaneously satisfies two conditions:

* In the parent workspace exists a local version of the object to be published.
* The version of the object to be published is a derivative of the version in the parent workspace.



Figure 12 Updating publication

When an updating publishing happens, merge of two versions is not needed as a derivative version of evolution up to the previous version.

When the object version to be published in the parent workspace is a parallel to the version in parent workspace (Figure 13), then it should merge both versions. As a result of the merger, a new version of the object is produced. We don’t aim to present a new method for merging versions of an object, so it can be used as handheld merge approach or algorithmic approach similar to the algorithm Westfechtel [13].

Transaction give up of local version is the reverse transaction by publishing a version. The only step in transaction is the remove of the local version of the object on the workspace. It is important to note that if any of the parent workspaces has no version of the selected object, then the object becomes unavailable for subsequent use. This situation should be taken into account when the transaction takes place in the main workspace of the product's release.



Figure 13 Publication with merge

### Transactions over composed objects

Let us have the following situation: a local version of the object **B** in the parent workspace and its visible version in current workspace. Let us make in current workspace a sub-object in **A** of object **B**. (Figure 14). After publication of version of **A** sub-object may not lead to a change in the version of object **B** in the parent workspace. However, in a subsequent publication, version of the object **B** in conjunction with its compositions in the parent workspace will lead to automatic update of the compositional scheme of objects (on Figure 14 with green dotted arrow). This is dictated by the fact that information regarding the organization of the composite object should be considered as an inseparable part of it.



Figure 14 Newly created sub-object to a super-object

Publication of the new version of the composite object B, v3 leads to the requirement that this be done in a set with the version of the newly created sub-object (Figure 14 – arrows with number 2).

Let us consider the situation where we have a local version of the object in the parent workspace that is visible in the current workspace (Figure 15). In current workspace we change the sub-object A, which leads to a change of object B, i. e. the creation of a new local version of the sub-objects leads to the automatic creation of a new local version of the entire composite object. We should notice that separate publishing of the new version of sub-objects in the parent workspace should not be allowed. This restriction follows from the fact that a new version of sub-object assumes a new version of super-object (Figure 15 – red arrow with number 1). In addition, we introduced the restriction that an object may be present in only one version in a workspace. In conclusion to the situation we can define the following rule:

1. Publication of a version of local composite object should be made bundled with all local versions of its sub-objects that have a different version in the parent workspace   
   (Figure 15 – the green and yellow arrows with number 2).

Local versions of the sub-objects in the parent workspace can be either derivatives or parallel. In these cases it is necessary to execute the transactions that are covered above.

Let us examine the same situation, when we have a local version of the object **B** in the parent workspace that is visible in the current workspace (Figure 16). From the composition of the composed object, a sub-object is excluded. Reflecting this change in the parent workspace is achievable only by publishing the composed object. This publication only transfers the composition change in parent workspace without changing the version of sub-object. The former sub-object is no longer part of the new super-object version.



Figure 15 Indirect change inversion of super-object, caused by new version of sub-object



Figure 16 The absence of change in version of object A, i.e. there is no need of its publication

Let us have visible composed object **A** with sub-object **B**, object **A** and sub-object **B** are local versions in the parent space. We remove from the composition of object **A** its sub-object **B**, i.e. we create a new local version of object **A** (Figure 17). In this case a publication of any new version of object **B** would lead to the following conflict: version **v1** of **B** requires that in its workspace the object **A** should be with its version **v1** (visible or local version).

This fact could be regarded as a prerequisite for the following rule:

1. Let us have an object’s version that has previous version, and that is a sub-object of a composed object in the parent workspace. Publication of that object has to be performed simultaneously with publication of the composed object’s version.



Figure 17 Publication of former sub-object is not possible before publication of super-object’s new version

As we noted above, the reverse transaction of publication is the give-up of local version. Upon give-up of local version of the composite object we should be taken into consideration the fact that its version could largely dependent on the version of its sub-objects. This leads us to the following rule:

1. The give-up of local version of composed object has to be performed in conjunction with recursive give-up of all its sub-objects.

**5. Workspace environment configurations**

The model of workspace composition presented above allows us to specify its appearance in the form of workspace environment configuration. Under workspace environment configuration we will understand the process of determining the hierarchical architecture of workspaces. On (Figure 18 and Figure 19) we present two examples of workspace configurations. These diagrams display the freedom of workspace arrangement in a way that is the most appropriate manner according to company architecture, project specifics, methodology characteristics, or other needs.

Figure 18 presents workspace composition where all mainstreams are divided in separate sub-trees – requirements, architecture, development and QA. Only requirements that meet requestor’s business needs are supposed to be published to master workspace of the project. And only after that do they become visible to other project participants. The same scheme should be used for distribution of other artifacts – architecture, source code, test cases, etc. As a disadvantage of the examined architecture we can emphasize the large amount of information that users have to study. This is a very topical issue in large projects.



Figure 18 Model of organizational driven workspace configuration

In order to solve that issue on we present component-oriented architecture of workspaces. Here we have dedicated workspaces for each project participant and software components.



Figure 19 Model of component-driven workspace configuration

**6. Conclusion and future work**

Versioning of complicated objects in complex environments becomes necessary in complex prolonged software projects. Modern software life-cycle methodologies put more emphasis on linking artifacts between different stages – requirements, test plans, project plans, etc. Existing version control does not provide sufficient service level of change traceability among objects. We could formulate as a future research direction an investigation of traceability meta-data to support the accounting in versioning domain.

The issue of grant the respective data access level to versioned objects shapes the theme of data security in versioning domain. This theme is a challenge for further development of the presented models.

**Reference**

1. Ambler, S. W., Pr. J. Sadalage,Refactoring Databases: Evolutionary Database Design, Addison Wesley Professional, 2006.
2. Collins-Sussman B., Fitzpatrick, B. W., Pilato C. M., Version Control with Subversion, book compiled from Revision 10945, 2008, http://svnbook.red-bean.com/en/1.0/index.html (visited in march 2009).
3. Conradi, R. and Westfechtel, B. 1998. Version models for software configuration management. ACM Comput. Surv., Vol. 30, no. 2, pp. 232–282, June 1998, DOI= http://doi.acm.org/10.1145/280277.280280
4. Estublier, J., Leblang, D., Hoek, A., Conradi, R., Clemm, G., Tichy, W., and Wiborg-Weber, D. 2005. Impact of software engineering research on the practice of software configuration management. ACM Trans. Softw. Eng. Methodol. 14, 4 (Oct. 2005), 383-430. DOI= http://doi.acm.org/10.1145/1101815.1101817
5. Git - Fast Version Control System, http://git-scm.com/ (visited in January 2012).
6. Jones, M. T., Version control for Linux, 2006, http://www.ibm.com/ developerworks/linux/library/l-vercon/, (visited in February 2009).
7. Jotov, Vl., Transaction over Versioned Objects in Hierarchical Workspace Environment, ECAI09, 2009, Pitesti, Romania
8. Nguyen, T. N. 2006. Model-based version and configuration management for a web engineering lifecycle. In Proceedings of the 15th international Conference on World Wide Web (Edinburgh, Scotland, May 23 - 26, 2006). WWW '06. ACM Press, New York, NY, 437-446. DOI= http://doi.acm.org/10.1145/1135777.1135842
9. Price, Derek R., CVS—concurrent versions system v1.11.22, http://ximbiot.com/cvs/manual/cvs-1.11.22/cvs.html, 2006 (visited in April 2009).
10. Slein, J. A., Vitali, F., Whitehead, E. J., and Durand, D. G. 1997. Requirements for distributed authoring and versioning on the World Wide Web. StandardView, Vol. 5, no. 1, pp. 17-24, March 1997, DOI= http://doi.acm.org/10.1145/253452.253474.
11. Stephens, S. M. , Johan Rung , Xavier Lopez, X.: Graph data representation in oracle database 10g: Case studies in Life science, IEEE Data Eng. Bull, vol. 27, pages 61-67, 2004.
12. Sun Microsystem, Inc. The network software environment (NSE), Sun Tech. Rep. Sun Msicrosystems, Inc., Mountain View, CA, 104, 1989
13. Westfechtel, B., Structure-oriented merging of revisions of software documents. In Proceedings of the 3rd international Workshop on Software Configuration Management (Trondheim, Norway, June 12 - 14, 1991), pp. 68-79, P. H. Feiler, Ed. ACM, New York, NY, 1991, DOI= http://doi.acm.org/10.1145/111062.111071