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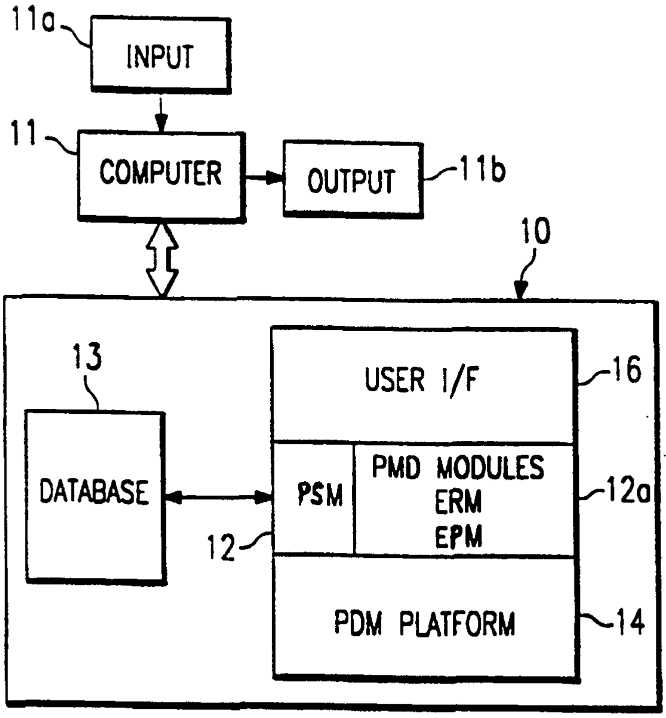
(54) Title: PRODUCT STRUCTURE MANAGEMENT

(57) Abstract

An object-oriented method of using a computer to store a model of an imprecise structure of a product. The product's components are modeled as items and item revisions. Each item and item revision has a view, which may have view revisions. Views and view revisions of an item or item revision are related to other with occurrences, as are views and view revisions of different items and item revisions. Context-specific view revisions are modeled as appearances. A user's request for a display of a product is received and used to invoke configuration rules that determine which view revision(s) are part of the product. The correct view revisions are assembled with their occurrences and appearances.



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PRODUCT STRUCTURE MANAGEMENT

TECHNICAL FIELD OF THE INVENTION

This invention relates to computer-aided product design, and more particularly to a method for managing the structure of a product during design and manufacturing processes.

BACKGROUND OF THE INVENTION

"Product data management" (PDM) is a term used to describe computer-based methods for managing product design and manufacture. A example of a PDM system is the Information Manager system, sold by Electronics Data Systems. The design of the Information Manager system is based on the objects it manipulates. A primary focus of the system is on representing the enterprise in terms of its objects and operations on them. Object classes are derived by modeling enterprise operations such as design, manufacture, administration, project management, and cost control.

Computer-aided design and computer-aided manufacturing (CAD/CAM) systems are another type of computer-based manufacturing aid. They are generally used by design engineers to model precise geometries of product designs and revisions.

Both PDM and CAD/CAM are helpful in today's product design and manufacturing environment. However, existing CAD/CAM systems and PDM systems do not effectively reconcile the needs of different types of potential users who are involved in product design and manufacture. A first type of user, such as a design engineer, is interested in precise configurations of a product, as well as accounting for revision alternatives. A second type of user, such as a manufacturing engineer, deals with imprecise configurations in general terms that may include different revisions of the same product. For example, a manufacturing engineer might wish to refer to a basic product whose components change according to certain dates or serial numbers.

A need exists for a computer-based manufacturing aid that will satisfy the needs of both types of users.

SUMMARY OF THE INVENTION

A computer-based product structure management (PSM) system stores data representing an imprecise structure of a product and presents data representing a precise structure of that product. The PSM stores a description of each component of the product as an object of a view data class. It also stores a description of a revision to a component as an object of a view revision data class. It links view objects and view revision objects with occurrence references to each other and to view objects and view revision objects of other components. During its run-time operation, it receives input from a user specifying a product to be presented. If the specification is imprecise, it applies configuration rules to determine which view revision of each component to use. For each component of the product, it retrieves an object of the view data class or an object of the view revision data class, and assembles a set of view objects and view revision objects, by using said occurrence references. The result is a structure list of items of the product.

An advantage of the PSM system is that it provides the ability to model a product's structure with a bill of materials, which represents the product beyond simply its geometry.

The PSM system stores data representing imprecise assemblies of a product, but can generate precise assemblies. This permits the creation of a "virtual assembly" from any combination of components or revisions to components. All revisions are interchangeable for use in a virtual assembly.

The ability to assemble more than one view for different versions of the same product permits concurrent development of different aspects of the same product. For example, the engineering and manufacturing departments of the same enterprise can concurrently contribute to product development.

The PSM system can incorporate the business rules of an enterprise to govern product assembly. This makes the PSM system better able to accommodate the needs of a particular user.

The PSM system maintains histories of revisions to individual components of the product. Thus, if a change is made to a product, and later considered incorrect, a user can restore a previous version.

The PSM system may be integrated with a CAD/CAM system to offer geometric models of a product. Bills of materials may be created by the PSM system and augmented with CAD/CAM geometries. Conversely, geometries can be created in the CAD/CAM modeling environment and used to create of bills of materials for use by the PSM system.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a computer-based PDM system, that incorporates a PSM system in accordance with the invention.

Figure 2 provides an overview of operation of the PSM.

Figure 3 illustrates a display of a portion of a bill of materials (BOM) for a particular product.

Figure 4 illustrates an expanded display of a bill of materials.

Figure 5 illustrates how PSM models different views of the same item revision.

Figure 6 illustrates the relationships between the data classes, item, and item revision.

Figure 7 illustrates the relationship between the data classes, view and view revision.

Figure 8 illustrates how a configuration object (CO) is created to manage relationships between item revisions.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 illustrates a computer system for implementing a product data manager (PDM) system 10, with which a product structure manager (PSM) 12 is integrated. PSM 12 is a type of PDM module, which deals with maintaining product revision histories and with assembling different configurations of a product from these revisions, in accordance with the invention described herein. As stated in the background section, an example of a PDM system 10, without PSM 12, is the Information Manager, a product of Electronic Data Systems.

PSM 12 is stored in memory of, and is executed by, a conventional computer system 11, such as a VAX/VMS pr a UNIX system. Typically, the computer system is part of a distributed network of workstations having a number of computers 11. In the example of this description, the operating system includes a windows type sub-system, which supports various graphical user interfaces, such as dialog boxes and selection buttons. Computer 11 is in communication with input and output devices, which for purposes of this description are a keyboard, pointing device, and graphics display.

PSM 11 may be integrated with other PDM modules 12a, which implement various PDM tasks. An advantage of implementing PSM 12 as a part of a more comprehensive set of PDM modules 12a is that it can then make use of data from other program modules and deliver data to them. For example, an enterprise process manager (EPM) module might model the process by which products are approved for manufacture, with data from that module being provided to PSM 12 to indicate that a particular configuration of a product has a "approved" status. An enterprise resource manager (ERM) module might model how resources such as materials and employees are allocated.

As explained below, PSM 12 stores a model of at least one product. The computer programming used to implement

PSM 12 is based on object-oriented design. Thus, data is associated with classes, which have hierarchies, and relationships. Classes specify what data they store and what operations can be performed on them. Instances of data classes are objects, and are derived by modeling the operations of various application domains. It is representations of these objects that are manipulated by the user interface 16.

The data model stored by PSM 12 is comprised of objects of the data classes, item and item revision, which refer to the data classes, view and view revision. In essence, an item and an item revision represent a component of a product. As will be explained below, the data classes, view and view revision, are attributes of the item and item revision data classes and permit each component to have more than one version.

PDM platform 14 provides a base upon which the rest of the system 10 is built. It has several modules, including a persistent object manager (POM). The POM provides the following services: mapping object representation to relational representation, messaging, and concurrent access control. In general, platform layer 14 isolates PSM 12 from the operating system and other sub-systems of computer 11.

User interface layer 16 is comprised of user application programming built on the underlying architecture. Because PSM 12 is designed for customization via user interface 16, it complies with the programming strategy often referred to as "toolkit" design.

Consistent with the "toolkit" approach, PSM 12 includes a stored set of "generic" functions. The Appendix lists various functions that can be performed on the objects of PSM 12. More specifically, these functions are provided within PSM 12 so that user interface 16 can pass messages to objects.

Figure 2 provides an overview of operation of PSM 12, together with an example of each step. In essence, PSM 12 is an interactive method of using a computer to model and manage the structure of a product and its revisions. It should be understood that many of the steps involve receiving data input from a user. For purposes of this description, the user is assumed to be a human user, but in some cases the input could be generated by other programming. Thus, the "user" referred to herein could be a human or a computer user.

As indicated in steps 21 and 22, product items and revisions to them are represented and stored as views and view revisions. In the example of Figure 2, Product 1 (which may also be an item) has three components. Each item is represented by a view, e.g., V-1-1, V-1-2, and V-1-3. One view, V-1-1, has three view revisions, VR-1-1-1, VR-1-1-2, and VR-1-1-3. As explained below in connection with Figure 4, views and view revisions are stored in terms of identifiers, descriptions, and any attached objects, such as drawings.

A feature of PSM 12 is the ability to store and to operate on data that represents imprecise configurations of the same product. Because any item of the product may have one or more revisions, the stored model is imprecise. As indicated in step 23, PSM 12 permits this imprecise product description by relating view and view revision objects with "occurrence" objects. In general, the occurrence relationship permits a product structure to be stored imprecisely by storing the information that one view uses another, without requiring references to specific view revisions.

As indicated in steps 24 and 25, if a user desires to view a precise product, he may either specify the product precisely or request the product imprecisely with some sort of description of what configuration is desired. An example of the latter might be a request such as, "Show me Product 1, as approved for production".

In step 26, the imprecise request results in the application of configuration rules to select a view revision so that the precise product can be assembled.

Regardless of whether the request is precise or imprecise, in step 27, PSM 12 retrieves the correct view revision. In the example, VR-1-1-2 is either part of a precise specification or has been selected by configuration rules.

In step 28, PSM 12 assembles a precise version of the product. In the example, a precise assembly of Product 1 is assembled from VR-1-1-2, V-1-2, and V-1-3. The product is displayed as a bill of materials, which lists components in terms of item or item revision identifiers. As explained below in connection with Figure 4, assembly may require PSM 12 to create "appearance" objects, which are paths to views that are context-specific.

The ability of PSM 12 to manage imprecise assemblies provides the user with the ability to view more than one version of the same product. Thus, step 24 could be repeated with a different request, resulting in application of different configuration rules, selection of a different view revision, and a different view of the product.

Figure 3 is an example of display generated by PSM 12, which presents a portion of a BOM list 30 for a particular product. Each item on a BOM may be a fundamental component, i.e., a piece part, or an intermediate sub-assembly. A product is also an item. In Figure 3, a bicycle has a number of items as components. As a better example, a carburetor can be a product in the sense that it can be sold as a unit, but could also be an item if sold as a component of a car.

A user can interact with the BOM 30 by selecting items with a pointing device. The user can control the level of abstraction displayed, such as by expanding or collapsing selected items to show or hide additional data associated with each item. Thus, although the BOM 30 represents a precise product structure, any of the items on the BOM 30 could be expanded to show its associated view or view revisions.

Figure 4 illustrates a product structure dialog 40, generated by PSM 12 that is an expansion of a BOM 30. The various columns of data available in displays such as those of Figure 3 and 4 are a matter of user choice and appropriate formatting by PSM 12.

Each item of dialog 40 is shown with whatever additional data is associated with it, i.e., an identifier of any item revisions, an identifier of its view, a view description, an occurrence description, whether it is an appearance, an appearance description, and its status. In general, this additional data may be entered by any user during any stage of product design. Thus, dialog 40 is a data input means as well as a means of presenting a final product structure.

In the example of Figure 4, an item, a chassis assembly, identified as EX-125, has two items, a front axle assembly and a rear axle assembly, which is a revision of the front axle assembly, identified as AX-025 and AX-025-1, respectively. Each axle assembly has two wheels, and all four wheels are the same item, WH-56-1, a tube-less version. However, in the context of the entire chassis, each wheel can be described in terms of whether it is left or right or front or rear. Thus, with respect to an axle assembly, a wheel has a direct parent-child relationship (an occurrence). In other words, the axle assembly has two occurrences of a wheel. The chassis has two occurrences of an axle assembly. However, with respect to the chassis, each wheel has a context-specific relationship, i.e., left front etc. (an appearance). Appearances permit PSM 12 to determine a path of views and view revisions when a produce has multiple components of the same view or view revision and when these components have an indirect relationship to other items.

Figure 5 illustrates how PSM 12 stores data entered via dialog 40 to model an imprecise structure and to assemble a precise one. The data classes used for this model are described in connection with Figures 6 - 8.

More specifically, Figure 5 represents a model of an item revision having more than one view. In this example, a specified item revision has two view revisions, and the items within each view revision are linked by occurrences to other view revisions. Instead of an item revision, the specified item revision could be an item having no revisions. In this sense, items and item revisions are used herein interchangeably.

Using concepts from graph theory, view and view revisions are modeled as nodes, occurrences as arcs, and appearances as paths. Data is attached to each of these objects. Because structure descriptions, i.e., views and view revisions, are used as nodes instead of item and item revisions, different views of the same item or item revision may be attached to that item or item revision. This permits multiple views of an item.

In the example of Figure 5, the item has two possible structures. One structure has four components, VR-2-1, VR-2-2-1, VR-2-3-1, and VR-2-4. The other structure has six components, VR-2-1, VR-2-2-2, VR-2-3-2, VR-2-4, VR-2-5, and VR-2-6. Several view revisions are common to either structure.

Although Figure 5 is a graph of two structures in two dimensions, the graph can be conceptualized as a three dimensional representation of imprecise structures. If the user's request is imprecise, the mechanism for determining which view revision of an object should be retrieved is by application of configuration rules. For example, a user may specify that he wants a display of the latest version of "Product A" having the status "Approved for manufacture by X".

Starting with any node on any plane, configuration rules permit PSM 12 to determine a precise assembly, by traveling up and down for different view revisions of an item, and on a plane for occurrences. A view revision of an item will cause a change of planes, and the correct view revision must be located to determine a precise structure.

It is possible that a user might request a product to be displayed that is entirely comprised of precise references. In that case, PSM 12 need only retrieve those objects for assembly without relying on configuration rules.

Figure 6 illustrates the relationship between the data classes, item and item revision. The objects of these data classes represent a product's components, thus corresponding to the items of a BOM. An item can be a component of another item. Some objects are attached directly to an item, whereas others are attached to an item revision.

An item revision is distinguishable from other item revisions, but satisfies the same form, fit and function requirements as all other revisions of the same item. Item revisions represent the iterative attempts by design engineers to satisfy the design goals of the product. For example, various revisions may reflect attempts to improve costs or eliminate bugs. In general, an item revision is considered interchangeable with other revisions of the same item. In the example of Figure 6, item AX-025 has two revisions, AX-025-A and AX-025-B.

An item or an item revision may have attributes, which include its specifications. Some attributes of an item specify it, while others are derived from specification attributes. As in any object-oriented system, attributes may themselves be objects. In fact, most attributes of an item are objects which can themselves be manipulated by application programming.

Figure 7 illustrates the relationship between the data classes, view and item. A view is an attribute of an item or item revision that is used to describe its structure. Each view knows what item it is a view of. View objects permit a user to specify an item that he desires to be displayed on a bill of materials. A view represents part of an imprecise structure in the sense that any view can have a number of view revisions.

Functions associated with views are set out in the Appendix. Attributes of the view class include an item folder (optional parent), a configuration object (explained below in connection with Figure 11), and a view type. View type is a data class whose objects represent enterprise specific classifications of views. For example, a view might be designated as a "design" view versus an "assembly" view. This classification can be used to differentiate between multiple views of the same product.

Figure 7 also illustrates the relationships between the data classes, view and view revision. A view can have one or more view revisions. Views maintain their own revision histories by making each view the "anchor" of its revisions. These view revisions are a data class, view-revision. In general, a view revision is a precise representation that can be associated with a BOM output. The user can specify a view revision, such that BOM 30 or dialog 40 will display the corresponding item.

Figure 7 further illustrates the relationship type, occurrence. A view or a view revision may have occurrences that refer to other view objects or view revision objects. In general, an occurrence is a relationship between two views that permits an assembly of components to be modeled. An occurrence is a parent-child relationship, used to store data about a referenced view in the context of the referencing view. View revisions may have occurrences, or reference occurrences or appearances.

The following is an example of how occurrence relationships are modeled:

{view revision } -> { view, item } .

When a view revision is entered, PSM 12 creates an item revision. Then, when a product structure is requested, it can be assembled from a user's reference to the associated item. Thus, view revisions are attributes of their item revision. There may be several view revisions per item revision.

The number of occurrences in a chain of items or item revision determines the depth of an assembly of those items. For example, the following item has a depth of four occurrences:

A -> B; B -> C; C -> D; D -> E .

The child of an occurrence may be a view (imprecise) or a view revision (precise). When assembly of an item is requested, if a precise specification is made, the associated view revision is retrieved. If an imprecise specification is made, the correct view revision is determined by applying configuration rules and then retrieved.

Figure 7 further illustrates the relationship of the data class, appearance, to occurrence and view revision data classes. Appearances provide PSM 12 with a means for identifying a context-specific occurrence. An appearance is an attribute of a view revision. Its attributes are a path and a parent.

Figure 8 illustrates how a configuration object (CO) is created when a view of an item is created, to manage the relationship between its revisions. The CO maintains two separate revision histories: one for working revisions and one for issued revisions. Working revisions are those that can be edited. Each time the user saves a working revision, he may choose whether to write over previous revisions. It the previous revision is not overwritten the latest revision is appended to the revision history. Issued revisions are those that may no longer be altered. Each revision history has a CO Root as its anchor. A history appears in only one CO and contains zero or more revisions.

When revisions are added to the CO, they are added to a history depending on whether they are working or issued revisions. Also, if a working revision becomes issued, a duplicate reference to that view revision object can be placed in the issue history object. The duplicate is kept in the working history until a subsequent working version is approved.

Figure 8 also illustrates how PSM 12 provides access to revisions. Revisions are stored as a "chain" with a pointer always pointing to the next revision in the chain.

Referring again to Figure 2, run-time operation of PSM 12 can begin with a user's imprecise request for a product. As an example, the user might request "product A as approved by management". As another example, a user might request "the last revision I worked on".

PSM 12 retrieves the correct view revision by applying configuration rules to determine which revision satisfies the user's request. More specifically, PSM 12 applies configuration rules to items to determine which item revision is in effect. Then, PSM 12 via the CO of that item revision, determines which view revision to retrieve.

As stated above in connection with Figure 1, PSM 12 serves a user interface layer 16, such that the user does not directly interact with PSM 12. However, PSM 12 includes a set of functions that serve interface layer 16. The Appendix sets out examples of such functions, including functions for dealing with configuration rules. From data provided as arguments to these functions, PSM 12 determines which items to consider and which revisions to return.

A precise configuration of a product or item may also be initiated by a request for a specific view revision. The view revision functions set out in the Appendix can be used to operate on specific view revisions.

For assembling a structure, PSM 12 first determines which occurrences of a view or view revision are in effect. Then, it finds the children of the occurrences, and applies configuration rules to decide which of that view's revisions should be loaded. The children of the occurrences of each of these view revisions are then found, a configuration rule applied, and so on, until the depth of the specified item is reached.

A feature of PSM 12 is that revisions may be assigned a status. Status is an object that defines the status type and approval date of a revision. In addition, revisions may be assigned effectivity data. In general, status is associated with approval for manufacture, and effectivity is associated with when to manufacture. For example, a revision might have the status "approved for production". This permits the user to access and work on a previous revision that has a specified status. Effectivity is defined in terms of a revision being effective between specified dates, before a specified date, after a specified date, between specified serial numbers, before a specified serial number, or after a specified serial number. The status object has the attribute status type, which are the particular status designations used by an enterprise, i.e., "released", "approved for manufacture", etc. The status and effectivity designations might result in a configuration which, in general, may not match a precise assembly created by a design engineer.

Another feature of PSM 12 is that users may work on "semi-precise" revisions. A substitute list is a data class, whose objects provide a means to specify a list of item revisions that should be substituted in place of other item revisions as determined by a configuration rule. View revisions may be placed on this list. The Appendix sets out functions for implementing the substitute list.

A "context" object permits the user to open multiple windows. Each window can have its own configuration rules. Functions associated with this object are set out in the Appendix.

A user may request appearances of different view revisions to be equivalent in different assemblies of the same product or in different products. To this end, an "equivalence" data class permits nodes that appear in separate assemblies to be declared equivalent. Functions associated with equivalence objects are set out in the Appendix.

Other Embodiments

Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments, will be apparent to persons skilled in the art. It is, therefore, contemplated that the appended claims will cover all modifications that fall within the true scope of the invention.

Module functions

initialize(PS)

Name: PS_init_module

Synopsis:

```
extern int  PS_init_module(
    void
);
```

Description: Initializes the PS module, creating an initial current context with default configuration rule, status, effectivity, substitute list and substitution rule.

The user must already have logged into POM. This function must be called before any other PS functions can be called.

Arguments:

none

Failures:

PS_pom_not_started	POM not initialized

Name: PS_exit_module

Synopsis:

```
extern int  PS_exit_module(
    void
);
```

Description: Called on exiting the PS module.

Arguments:

none

Failures:

PS_module_not_initialized	PS not initialized

PSObject functions

defineClientData(PSObject)

Name: PS_define_client_data

Synopsis:

```
extern int  PS_define_client_data(
    int       ps_class,                    /* <I> */
    char *    attr_name,                   /* <I> */
    tag_t     ref_class,                   /* <I> */
    int       property                     /* <I> */
);
```

Description:

Adds an extra attribute to a PS class. This extra attribute must be a reference to a POM object. The type of the reference is the specified class.

The attribute may have its property set to *PS_copyable*, in which case this attribute will be copied from one revision of the object to another. For BOMViewRevision, if property *PS_freezable* is set, when a BOMViewRevision is issued, the associated client data will be frozen too.

Client data attributes may be added to the classes *PS_bom_view*, *PS_bom_view_revision*, *PS_occurrence*, *PS_appearance* and *PS_view_type*. Property *PS_copyable* is only applicable to *PS_bom_view_revision* and *PS_occurrence*. Property *PS_freezable* is only applicable to *PS_bom_view_revision*.

Arguments:

ps_class	token identifying the class of PS object to which this attribute is to be attached
attr_name	name of the attribute
ref_class	identifier of POM class this attribute references
property	see description above

Failures:

no such class

class already has attribute of this name

attribute name too long

invalid property

askClientData(PSObject)

Name: PS_ask_client_data

Synopsis:

```
extern int  PS_ask_client_data(
    tag_t       instance,                                  /* <I> */
    char *      attr_name,                                 /* <I> */
    tag_t *     client_data                                /* <O> */
);
```

Description:

Returns the client data attributed to the supplied instance for the given attribute name. The client data will be a tag of a POM object.

Note this function is intended for enquiring client data of all PS classes except for occurrence. As occurrences are referenced using a parent,occurrence pairing a separate interface function *PS_ask_occurrence_client_data* is provided to enquire client data of an occurrence.

Arguments:

instance	tag of an instance
attr_name	name of the attribute to be retrieved
client_data	tag of a POM object

Failures:

no such instance

no such attribute name

no client data stored for this attribute

setClientData(PSObject)

Name: PS_set_client_data

Synopsis:

```
extern int  PS_set_client_data(
    tag_t       instance,                               /* <I> */
    char *      attr_name,                              /* <I> */
    tag_t       client_data                             /* <I> */
);
```

Description: Sets the client data attributed to the supplied instance for the given attribute name. The client data must be a tag of a POM object.

Note this function is intended for setting client data of all PS classes except for occurrence. As occurrences are referenced using a parent,occurrence pairing a separate interface function *PS_ask_occurrence_client_data* is provided to set client data of an occurrence.

Arguments:

instance	tag of an instance
attr_name	name of the attribute to be set
client_data	tag of a POM object

Failures:

no such instance

no such attribute name

no such POM object

View Type functions

create(ViewType)

Name: PS_create_view_type

Synopsis:

```
extern int  PS_create_view_type(
    char *      type_name,                      /* <I> */
    tag_t *     view_type                       /* <O> */
);
```

Description: Adds a new classification of views to the list of BOMView classifications valid for this site. A classification is a text string e.g. “DESIGN”, “Assembly”, etc.

Can only be used by the system administrator.

Arguments:

type_name	name of the new view type
view_type	returns the tag of the new view type

Failures:

PS_duplicate	duplicate type name
PS_invalid_string	type name too long
PS_invalid_string	null/empty string not allowed
	user not SA

delete(ViewType)

Name: PS_delete_view_type

Synopsis:

```
extern int  PS_delete_view_type(
    tag_t       view_type                                   /* <I> */
);
```

Description: Removes the specified view classification from the list of those valid for this site.

Can only be used by the system administrator.

Arguments:

view_type	classification to be removed from site list

Failures:

no such view type

user not SA

Name: PS_extent_view_type

Synopsis:

```
extern int  PS_extent_view_type(
    int *      n_types,                                    /* <O> */
    tag_t **   view_types                                  /* <OF> */
);
```

Description: Returns the list of BOMView classifications valid for this site.

Arguments:

n_types	number of view types on list
view_types	returned array of tags of view types

Failures:

Name: PS_find_view_type

Synopsis:

```
extern int  PS_find_view_type(
    char *      type_name,                     /* <I> */
    tag_t *     view_type                      /* <O> */
);
```

Description: Returns the tag of the view classification with the given name.

Arguments:

type_name	name of the view type
view_type	returns the tag of the view type

Failures:

no such view type

Name: PS_ask_view_type_name

Synopsis:

```
extern int  PS_ask_view_type_name(
    tag_t      view_type,                          /* <I> */
    char **    type_name                           /* <OF> */
);
```

Description: Returns the text string associated with a view classification.

Arguments:

view_type	tag of the view type
type_name	returns the name of the view type

Failures:

PS_invalid_tag	no such view type
PS_instance_not_initialized	instance not initialized

BOMView functions

create(BOMView)

Name: PS_create_bom_view

Synopsis:

```
extern int PS_create_bom_view(
    tag_t     view_type,                        /* <I> */
    char *    view_name,                        /* <I> */
    char *    view_desc,                        /* <I> */
    tag_t     parent_item_folder,               /* <I> */
    tag_t     target_folder,                    /* <I> */
    tag_t *   bom_view                          /* <O> */
);
```

Description: Creates a new BOMView. No BOMViewRevisions exist yet.

The BOMView may be attached to a specific Item(Folder) or it may be left floating.

Arguments:

view_type	site−specific identifier for the type of view, e.g. DESIGN, Assembly
view_name	
view_desc	
parent_item_folder	sets the parent ItemFolder of the BOMView. If null the BOMView has no parent and is left “floating”.
target_folder	the new BOMView is placed in this folder. If null the BOMView is placed in the parent ItemFolder
bom_view	tag of new BOMView

Failures:

PS_invalid_view_type	invalid view type
	view name too long
	description too long

delete(BOMView)

Name: PS_delete_bom_view

Synopsis:

```
extern int PS_delete_bom_view(
    tag_t       bom_view
);
```

Description: Deletes a BOMView, and all its BOMViewRevisions, provided none of them is referenced.

Arguments:

bom_view	tag of the view to be deleted

Failures:

PS_invalid_bom_view	no such view
PS_inst_referenced	a revision of the view is referenced

listWorkingBOMViewRevisions(BOMView)

Name: PS_list_working_bvrs

Synopsis:

```
extern int  PS_list_working_bvrs(
    tag_t       bom_view,                               /* <I> */
    int *       n_revisions,                            /* <O> */
    tag_t **    bvrs                                    /* <OF> */
);
```

Description: Lists all working revisions of the given BOMView.

Arguments:

bom_view	tag of the BOMView
n_revisions	number of revisions returned
bvrs	array of tags of BOMViewRevisions

Failures:

PS_invalid_bom_view	no such view

listIssuedBOMViewRevisions(BOMView)

Name: PS_list_issued_bvrs

Synopsis:

```
extern int  PS_list_issued_bvrs(
    tag_t       bom_view,                              /* <I> */
    int *       n_revisions,                           /* <O> */
    tag_t **    bvrs                                   /* <OF> */
);
```

Description: Lists all issued revisions of the given BOMView.

Arguments:

bom_view	tag of the BOMView
n_revisions	number of revisions returned
bvrs	array of tags of BOMViewRevisions

Failures:

PS_invalid_bom_view	no such view

askConfiguredRevision(BOMView)

Name:	PS_ask_configured_revision

Synopsis:

```
extern int  PS_ask_configured_revision(
    tag_t       bom_view,                          /* <I> */
    tag_t *     configured_bvr                     /* <O> */
);
```

Description: Given the tag of a BOMView, this function returns the tag of the revision of this view selected by the current configuration rule.

Arguments:

bom_view	tag of the BOMView
configured_bvr	tag of the BOMViewRevision (a revision of bom_view) selected by the current configuration rule

Failures:

PS_invalid_bom_view	no such view
PS_no_configured_revision	unable to configure revision

askItemFolder(BOMView)

Name: PS_ask_item_folder_of_bom_view

Synopsis:

```
extern int  PS_ask_item_folder_of_bom_view(
    tag_t      bom_view,                          /* <I> */
    tag_t *    item_folder                        /* <O> */
);
```

Description: Returns the tag of the item folder of which the BOMView is an attribute.

Arguments:

bom_view	tag of the view
item_folder	tag of the item folder of which the view is an attribute

Failures:

PS_invalid_bom_view	no such view

setItemFolder(BOMView)

Name: PS_set_item_folder_of_bom_view

Synopsis:

```
extern int  PS_set_item_folder_of_bom_view(
    tag_t       bom_view,                              /* <I> */
    tag_t       item_folder                            /* <I> */
);
```

Description: Records the item folder of which the BOMView is an attribute.

Functionality not currently implemented:
This function may only be used if the item folder attribute of this BOMView is currently null.

Arguments:

bom_view	tag of the view
item_folder	tag of the item folder of which the view is to be an attribute

Failures:

PS_invalid_bom_view	no such view

Name: PS_ask_bom_view_type

Synopsis:

```
extern int  PS_ask_bom_view_type(
    tag_t      bom_view,                              /* <I> */
    tag_t *    view_type                              /* <OF> */
);
```

Description: Enquire the value of the site–specific type of a BOMView, e.g. DESIGN, ASSEMBLY, BUCKET etc.

Arguments:

bom_view	tag of BOMView
view_type	site–specific identifier for the type of view, e.g. DESIGN, ASSEMBLY, BUCKET

Failures:

PS_invalid_bom_view	no such view

Name: PS_set_bom_view_type

Synopsis:

```
extern int  PS_set_bom_view_type(
    tag_t        bom_view,                              /* <I> */
    tag_t        view_type                              /* <I> */
);
```

Description: Set the value of the site–specific type of a BOMView, e.g. DESIGN, ASSEMBLY, BUCKET etc.

Arguments:

bom_view	tag of BOMView
view_type	site–specific identifier for the type of view, e.g. DESIGN, ASSEMBLY, BUCKET

Failures:

PS_invalid_bom_view	no such view
PS_invalid_view_type	invalid view type

BOMViewRevision functions

create(BOMViewRevision)

Name: PS_create_bvr

Synopsis:

```
extern int  PS_create_bvr(
    tag_t     bom_view,                          /* <I> */
    char *    revision_name,                     /* <I> */
    char *    revision_desc,                     /* <I> */
    tag_t     parent_irf,                        /* <I> */
    tag_t     target_folder,                     /* <I> */
    tag_t *   bvr                                /* <O> */
);
```

Description: Creates an initial working revision of this BOMView.

Arguments:

bom_view	tag of the view for which the first revision is to be created
revision_name	
revision_desc	
parent_irf	sets the parent ItemRevisionFolder of the BOMViewRevision. If null the BOMViewRevision has no parent and is left “floating”.
target_folder	the new BOMViewRevision is placed in this folder. If null the BOMViewRevision is placed in the parent ItemRevisionFolder
bvr	returns tag of the revision created

Failures:

PS_invalid_bom_view	no such view

revise(BOMViewRevision)

Name: PS_revise_bvr

Synopsis:

```
extern int  PS_revise_bvr(
    tag_t      source_bvr,                          /* <I> */
    tag_t      parent_ivf,                          /* <I> */
    tag_t *    new_bvr                              /* <O> */
);
```

Description: Produces a new working BOMViewRevision based on the source BOMViewRevision. This new revision is appended to the working history of the same BOMView as the source BOMViewRevision. The source BOMViewRevision may be a working or an issued revision.

Failures:

Arguments:

source_bvr	BOMViewRevision to copy from
parent_ivf	tag of the item revision folder of which this new BOMViewRevision is to be an attribute. If null the parent ivf of the source revision is used
new_bvr	tag of new BOMViewRevision

Failures:

PS_invalid_bvr	no such source bvr

copy(BOMViewRevision)

Name: PS_copy_bvr

Synopsis:

```
extern int  PS_copy_bvr(
    tag_t      source_bvr,                                   /* <I> */
    tag_t      bom_view,                                     /* <I> */
    tag_t      parent_ivf,                                   /* <I> */
    tag_t *    new_bvr                                       /* <O> */
);
```

Description: Produces a new working BOMViewRevision based on the source BOMViewRevision. This new revision is appended to the working history of a different BOMView from the root BOMView of the source BOMViewRevision. The source BOMViewRevision may be a working or an issued revision.

Arguments:

source_bvr	BOMViewRevision to copy from
bom_view	target BOMView
parent_ivf	tag of the item revision folder of which this new BOMViewRevision is to be an attribute
new_bvr	tag of new BOMViewRevision

Failures:

PS_invalid_bvr	no such view revision
PS_invalid_bom_view	no such view

delete(BOMViewRevision)

Name: PS_delete_bvr

Synopsis:

```
extern int  PS_delete_bvr(
    tag_t       bvr                                         /* <I> */
);
```

Description: Deletes the specified BOMViewRevision, provided it is not referenced.

If it is issued it may only be deleted by SA.

Arguments:

bvr	tag of the revision to be deleted

Failures:

no such revision

revision is issued *(if not SA)*

issue(BOMViewRevision)

Name: PS_issue_bvr

Synopsis:

```
extern int  PS_issue_bvr(
    tag_t        bvr                                   /* <I> */
);
```

Description: Freezes the given working revision and appends a reference to it to the issue history.

Arguments:

bvr	tag of the revision to be issued

Failures:

PS_invalid_bvr	no such revision
	revision already issued
PS_inst_modifiable	cannot issue if loaded for modify
PS_child_not_issued	cannot issue a bvr until its children are issued

remove(BOMViewRevision)

Name: PS_remove_bvr

Synopsis:

```
extern int  PS_remove_bvr(
    tag_t       bvr                                   /* <I> */
);
```

Description: When a BOMViewRevision is issued to the issue history, a reference to that BOMViewRevision remains on the working history from which it came. This reference can be removed using this function.

Arguments:

bvr	tag of the BOMViewRevision referenced

Failures:

PS_invalid_bvr	no such revision
PS_bvr_not_issued	revision is not issued
PS_not_on_working_history	revision not referenced by working history

askBOMView(BOMViewRevision)

Name: PS_ask_bom_view_of_bvr

Synopsis:

```
extern int  PS_ask_bom_view_of_bvr(
    tag_t      bvr,                                /* <I> */
    tag_t *    bom_view                            /* <O> */
);
```

Description: Returns the tag of the BOMView of which this is a revision.

Arguments:

bvr	tag of a BOMViewRevision
bom_view	returns tag of the root BOMView

Failures:

PS_invalid_bvr	no such BOMViewRevision

askItemRevisionFolder(BOMViewRevision)

Name: PS_ask_ivf_of_bvr

Synopsis:

```
extern int  PS_ask_ivf_of_bvr(
    tag_t       bvr,                                    /* <I> */
    tag_t *     ivf                                     /* <O> */
);
```

Description: Returns the tag of the item revision folder of which this BOMViewRevision is an attribute.

Arguments:

bvr	tag of the BOMViewRevision
ivf	tag of item revision folder of which this BOMViewRevision is an attribute

Failures:

PS_invalid_bvr	no such BOMViewRevision

setItemRevisionFolder(BOMViewRevision)

Name: PS_set_ivf_of_bvr

Synopsis:

```
extern int  PS_set_ivf_of_bvr(
    tag_t      bvr,                                  /* <I> */
    tag_t      ivf                                   /* <I> */
);
```

Description: Sets the tag of the item revision folder of which this BOMViewRevision is an attribute.

This functionality not currently implemented:
Only works if this BOMViewRevision was created with parent item revision folder null when its parent BOMView had parent item folder null. The parent item folder attribute of the parent BOMView must since have been set, and the item revision folder specified here must be a revision of that item folder.

Arguments:

bvr	tag of the BOMViewRevision
ivf	tag of item revision folder of which this BOMViewRevision is to be an attribute

Failures:

PS_invalid_bvr	no such BOMViewRevision

ask_is_issued(BOMViewRevision)

Name: PS_ask_is_issued_bvr

Synopsis:

```
extern int PS_ask_is_issued_bvr(
    tag_t       bvr,                                    /* <I> */
    logical *   is_issued                               /* <O> */
);
```

Description: Returns true if the BOMViewRevision is issued, i.e. if it is referenced from the issue history.

Arguments:

bvr	tag of the revision
is_issued	returns true if the revision is issued

Failures:

PS_invalid_bvr	no such BOMViewRevision

listOccurrences(BOMViewRevision)

Name: PS_list_occurrences_of_bvr

Synopsis:

```
extern int  PS_list_occurrences_of_bvr(
    tag_t       bvr,                                  /* <I> */
    int *       n_occurrences,                        /* <O>*/
    tag_t **    occurrences                           /* <OF> */
);
```

Description: List all the occurrences of the given BOMViewRevision.

Arguments:

bvr	tag of the parent BOMViewRevision
n_occurrences	number of occurrences returned
occurrences	returned array of the tags of the occurrences

Failures:

PS_invalid_bvr	no such revision

listAppearances(BOMViewRevision)

Name: PS_list_appearances_of_bvr

Synopsis:

```
extern int  PS_list_appearances_of_bvr(
    tag_t      bvr,                                  /* <I> */
    int *      n_appearances,                        /* <O>*/
    tag_t **   appearances                           /* <OF> */
);
```

Description: List all the appearances of the given BOMViewRevision.

Arguments:

bvr	tag of the parent BOMViewRevision
n_appearances	number of appearances returned
appearances	returned array of the tags of the appearances

Failures:

PS_invalid_bvr	no such revision

listStatus(BOMViewRevision)

Name: PS_list_status_of_bvr

Synopsis:

```
extern int  PS_list_status_of_bvr(
    tag_t       bvr,                                /* <I> */
    int *       n_statuses,                         /* <O> */
    tag_t **    statuses                            /* <OF> */
);
```

Description: Lists all the status objects attributed to the given BOMViewRevision.

Arguments:

bvr	tag of the BOMViewRevision whose statuses are to be listed
n_statuses	number of statuses found
statuses	returns an array of tags of statuses

Failures:

no such BOMViewRevision

Occurrence functions

create(Occurrence)

Name: PS_create_occurrences

Synopsis:

```
extern int  PS_create_occurrences(
    tag_t       parent,                          /* <I> */
    tag_t       child,                           /* <I> */
    int         n_occurrences                    /* <I> */
    tag_t **    occurrences                      /* <OF> */
);
```

Description: Creates a number of occurrences linking the specified parent and child BOMViewRevisions.

Arguments:

parent	tag of the parent BOMViewRevision
child	tag of the child BOMView
n_occurrences	number of occurrences to be created
occurrences	returns an array of the tags of the occurrences created

Failures:

PS_invalid_bvr	no such parent
PS_invalid_child	no such child
PS_invalid_bvr	cannot link revisions of same view
PS_invalid_value	n_occurrences < 1

Name: PS_delete_occurrence

Synopsis:

```
extern int  PS_delete_occurrence(
    tag_t       parent,                                 /* <I> */
    tag_t       occurrence                              /* <I> */
);
```

Description: Deletes the occurrence from its parent.

Parent must be loaded for modify.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence

Failures:

PS_invalid_bvr	no such parent BOMViewRevision
PS_invalid_occurrence	no such occurrence in this parent
PS_inst_locked	parent is locked

Implementation Note: This is actually deleting an instance of occurrence data. If that is the last occurrence data object of that occurrence delete the occurrence too.

ask_child(Occurrence)

Name: PS_ask_occurrence_child

Synopsis:

```
extern int  PS_ask_occurrence_child(
    tag_t       parent,                              /* <I> */
    tag_t       occurrence,                          /* <I> */
    tag_t *     child                                /* <O> */
);
```

Description: Enquires the child BOMViewRevision of an occurrence.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
child	returns tag of child BOMView

Failures:

PS_invalid_bvr	no such parent BOMViewRevision
PS_invalid_occurrence	no such occurrence in this parent

set_child(Occurrence)

Name: PS_set_occurrence_child

Synopsis:

```
extern int  PS_set_occurrence_child(
    tag_t       parent,                        /* <I> */
    tag_t       occurrence,                    /* <I> */
    tag_t       child                          /* <I> */
);
```

Description: Sets the child BOMViewRevision of an occurrence.

Parent must be loaded for modify. Child must be loaded for read or modify.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
child	tag of child BOMView

Failures:

PS_invalid_child	no such child
PS_inst_locked	parent locked

ask_seq_no(Occurrence)

Name: PS_ask_seq_no

Synopsis:

```
extern int  PS_ask_seq_no(
    tag_t       parent,                          /* <I> */
    tag_t       occurrence,                      /* <I> */
    int *       seq_no                           /* <O> */
);
```

Description: Enquires the sequence number of an occurrence, which determines the ordering of occurrences within their parent BOMViewRevision.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
seq_no	returns sequence number within parent

Failures:

PS_invalid_bvr	no such parent
PS_invalid_occurrence	no such occurrence in this parent

Name: PS_set_seq_no

Synopsis:

```
extern int  PS_set_seq_no(
    tag_t      parent,                    /* <I> */
    tag_t      occurrence,                /* <I> */
    int        seq_no                     /* <I> */
);
```

Description:

Sets the sequence number of an occurrence, which determines the ordering of occurrences within their parent BOMViewRevision.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
seq_no	sequence number within parent

Failures:

PS_invalid_bvr	no such parent
PS_invalid_occurrence	no such occurrence in this parent

Name: PS_ask_transform

Synopsis:

```
extern int  PS_ask_transform(
    tag_t       parent,                          /* <I> */
    tag_t       occurrence,                      /* <I> */
    double **   transform                        /* <OF> */
);
```

Description: Returns the transform of the given occurrence.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
transform	returns a pointer to some SM allocated space holding a 4x4 transform

Failures:

PS_invalid_bvr	no such parent
PS_invalid_occurrence	no such occurrence in this parent
PS_no_transform	no transform set

set_transform(Occurrence)

Name: PS_set_transform

Synopsis:

```
extern int PS_set_transform(
    tag_t      parent,                                  /* <I> */
    tag_t      occurrence,                              /* <I> */
    double *   transform                                /* <I> */
);
```

Description: Sets a transform for the given occurrence.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
transform	a pointer to 16 doubles – a 4x4 transform with no perspective and unit scale

Failures:

PS_invalid_bvr	no such parent
PS_invalid_occurrence	no such occurrence in this parent

askClientData(Occurrence)

Name: PS_ask_occurrence_client_data

Synopsis:

```
extern int  PS_ask_occurrence_client_data(
    tag_t       parent,                        /* <I> */
    tag_t       occurrence,                    /* <I> */
    char *      attr_name,                     /* <I> */
    tag_t *     client_data                    /* <O> */
);
```

Description: Returns the client data attributed to the supplied occurrence for the given attribute name. The client data will be a tag of a POM object.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
attr_name	name of the attribute to be retrieved
client_data	tag of a POM object

Failures:

no such BOMViewRevision

no such occurrence in parent BOMViewRevision

no such attribute name

no client data stored for this attribute setClientData(Occurrence)

Name: PS_set_occurrence_client_data

Synopsis:

```
extern int PS_set_occurrence_client_data(
    tag_t       parent,                            /* <I> */
    tag_t       occurrence,                        /* <I> */
    char *      attr_name,                         /* <I> */
    tag_t       client_data                        /* <I> */
);
```

Description: Sets the client data attributed to the supplied occurrence for the given attribute name. The client data must be a tag of a POM object.

Arguments:

parent	tag of the occurrence's parent BOMViewRevision
occurrence	tag of the occurrence
attr_name	name of the attribute to be set
client_data	tag of a POM object

Failures:

no such parent BOMViewRevision

no such occurrence in parent

no such attribute name

no such POM object

Appearance functions

create(Appearance)

Name: PS_create_appearance

Synopsis:

```
extern int  PS_create_appearance(
    tag_t     bvr,                           /* <I> */
    int       path_length,                   /* <I> */
    tag_t *   path,                          /* <I> */
    tag_t *   appearance                     /* <O> */
);
```

Description: Creates a new appearance. The appearance contains a path of occurrences starting with an occurrence of the BOMViewRevision which owns the appearance.

Note that the appearance stores a path of BOMViewRevision independent occurrence 'threads', so it is not necessary to qualify the occurrences on the path with parent BVRs.

Note that the parent BOMViewRevision is not itself modified by the addition of appearance data. This allows appearances to be created in the context of frozen issued revisions.

Arguments:

bvr	tag of the revision in whose context the appearance is being created
path_length	number of occurrences in the path
path	array of tags of occurrences forming a path through the structure below bvr
appearance	returns tag of the newly created appearance

Failures:

no such revision

revision is not loaded

invalid path

appearance of this path already exists

delete(Appearance)

Name: PS_delete_appearance

Synopsis:

```
extern int  PS_delete_appearance(
    tag_t      appearance,                          /* <I> */
    tag_t      bvr                                  /* <I> */
);
```

Description:

Removes the specified appearance from the context of a given BOMViewRevision. Only if this is the only place that this appearance is referenced will the appearance object itself be deleted. In that case if this appearance is referenced by any equivalence set then that reference will be removed.

Arguments:

appearance	tag of the appearance to be removed from the context of a BOMViewRevision
bvr	tag of the BOMViewRevision from whose context the appearance is to be removed

Failures:

no such appearance

askParent(Appearance)

Name: PS_ask_appearance_parent

Synopsis:

```
extern int  PS_ask_appearance_parent(
    tag_t       appearance,                          /* <I> */
    tag_t *     parent                               /* <O> */
);
```

Description: Returns the tag of the BOMViewRevision which 'owns' this appearance.

Arguments:

appearance	tag of the appearance
parent	returns tag of the parent BOMViewRevision

Failures:

no such appearance

Name: PS_ask_appearance_path

Synopsis:

```
extern int  PS_ask_appearance_path(
    tag_t      appearance,                          /* <I> */
    int *      path_length,                         /* <O> */
    tag_t **   path                                 /* <OF> */
);
```

Description: Returns the occurrence path of the given appearance.

Arguments:

appearance	tag of the appearance
path_length	returns number of occurrences in the path
path	returns an array of tags of occurrences forming the path

Failures:

no such appearance

Equivalence functions

create(Equivalence)

Name: PS_create_equivalence

Synopsis:

```
extern int  PS_create_equivalence(
    tag_t       appearancel,                          /* <I> */
    tag_t       appearance2                           /* <I> */
);
```

Description: Register the two appearances as equivalent.

If appearance2 and appearance3 have already been registered as equivalent, and we now say that appearancel and appearance2 are equivalent, this means that appearances 1,2 and 3 are all equivalent.

Restriction not presently implemented:
You cannot create an equivalence between two appearances of the same BOMViewRevision.

Arguments:

appearance1
appearance2

Failures:

PS_invalid_appearance	no such appearancel/2
PS_already_equivalent	the two appearances are already equivalent

Name: PS_delete_equivalence

Synopsis:

```
extern int  PS_delete_equivalence(
    tag_t        appearance                              /* <I> */
);
```

Description: Remove the specified appearance from an equivalence set. This means that this appearance is now deemed not to be equivalent to any other appearance.

Arguments:

appearance	tag of the appearance

Failures:

PS_invalid_appearance	no such appearance
PS_not_equivalent	appearance not in any equivalence set

ask(Equivalent)

Name: PS_ask_if_equivalent

Synopsis:

```
extern int  PS_ask_if_equivalent(
    tag_t       appearance1,                          /* <I> */
    tag_t       appearance2,                          /* <I> */
    logical *   equivalent                            /* <O> */
);
```

Description: Asks if the two appearances are equivalent.

Arguments:

appearance1	
appearance2	
equivalent	returns true if the two appearances are equivalent

Failures:

PS_invalid_appearance	no such appearance1/2

Name: PS_ask_equivalent_in_bvr

Synopsis:

```
extern int  PS_ask_equivalent_in_bvr(
    tag_t      appearance,                      /* <I> */
    tag_t      bvr,                             /* <I> */
    tag_t *    equivalent                       /* <O> */
);
```

Description: Returns the appearance of a given BOMViewRevision which is equivalent to a specified appearance of a different BOMViewRevision.

Arguments:

appearance	
bvr	tag of the revision in which an equivalent is sought
equivalent	equivalent appearance found

Failures:

PS_invalid_appearance	no such appearance
PS_invalid_bvr	no such revision
PS_not_equivalent	no equivalent found

Name: PS_list_equivalents_of_app

Synopsis:

```
extern int  PS_list_equivalents_of_app(
    tag_t       appearance,                          /* <I> */
    int *       n_equivalents,                       /* <O> */
    tag_t **    equivalents                          /* <OF> */
);
```

Description: List all those appearances deemed to be equivalent to the given appearance.

Arguments:

appearance	tag of the appearance
n_equivalents	returns number of equivalents found
equivalents	returns array of tags of equivalent appearances

Failures:

PS_invalid_appearance	no such appearance

Name: PS_list_equivalent

Synopsis:

```
extern int  PS_list_equivalent(
    tag_t       bvr1,                        /* <I> */
    tag_t       bvr2,                        /* <I> */
    int *       n_appearances,               /* <O> */
    tag_t **    appearances                  /* <OF> */
);
```

Description:

Compares bvr1 and bvr2, returning a list of all the appearances of bvr1 which have an equivalent in bvr2.

Restriction not currently implemented:
The two BOMViewRevisions must NOT be revisions of the same BOMView.

Arguments:

bvr1	
bvr2	
n_appearances	number of equivalent appearances found
appearances	array of tags of appearances of bvr1 with an equivalent in bvr2.

Failures:

PS_invalid_bvr	no such revision 1/2

Name: PS_list_not_equivalent

Synopsis:

```
extern int  PS_list_not_equivalent(
    tag_t      bvrl,                          /* <I> */
    tag_t      bvr2,                          /* <I> */
    int *      n_appearances,                 /* <O> */
    tag_t **   appearances                    /* <OF> */
);
```

Description: Compares bvrl and bvr2, returning a list of all the appearances of bvrl which DO NOT have an equivalent in bvr2.

Restriction not currently implemented:
The two BOMViewRevisions must NOT be revisions of the same BOMView.

Arguments:

bvrl	
bvr2	
n_appearances	number of non-equivalent appearances found
appearances	array of tags of appearances of bvrl with no equivalent in bvr2.

Failures:

PS_invalid_bvr	no such revision 1/2

Configuration functions

ask(Configuration)

Name: PS_ask_config_rule

Synopsis:

```
extern int  PS_ask_config_rule(
    int *       rule                                  /* <O> */
);
```

Description: Returns the current configuration rule for use in building configurations.

Arguments:

rule	configuration rule, which may be one of the following tokens:

PS_specific	finds the specified revision
PS_latest	finds the latest issued revision
PS_latest_status	finds the latest issued revision with the currently configured status
PS_latest_date_effective	finds the latest issued revision with the currently configured status which is effective for the specified date
PS_latest_num_effective	finds the latest issued revision with the currently configured status which is effective for the specified serial number
PS_substitute	if a revision of the view exists in the substitute list this will be substituted. This rule must be used in conjunction (bitwise OR) with one of the other rules

Some users may wish to load the major items of their structure by serial number, but select basic components like screws, washers etc. by effectivity dates. Therefore it is possible to OR the two effectivity rules together "*PS_latest_date_effective | PS_latest_num_effective*" to give the desired functionality. Any item whose range of serial numbers and range of effective dates spans those currently set with the configuration rule will be selectable. In practice, on any one item, one of the effectivity attributes (date or serial number) will have open–ended limits set, so selection will be done on the basis of one effectivity attribute only.

Name: PS_ask_config_status

Synopsis:

```
extern int  PS_ask_config_status(
    tag_t *      status_type                              /* <O> */
);
```

Description: Returns the status for use with the configuration rule.

The status is of the status types allowed for this site.

Arguments:

status_type	returns the tag of the status type

Failures:

no status configured

Name: PS_ask_config_date_effective

Synopsis:

```
extern int  PS_ask_config_date_effective(
    date_t *    date                                /* <O> */
);
```

Description: Returns the effectivity date associated with the current configuration rule.

Arguments:

date

Failures:

no effectivity date set

Name: PS_ask_config_num_effective

Synopsis:

```
extern int  PS_ask_config_num_effective(
    int *         effective_num                              /* <O> */
);
```

Description: Returns the effective serial number used with the current configuration rule.

Arguments:

effective_num

Failures:

no effective serial number set

Name: PS_set_config_rule

Synopsis:

```
extern int  PS_set_config_rule(
    int          rule                                        /* <I> */
);
```

Description: Sets the current configuration rule for use in building configurations.

Arguments:

rule	configuration rule, which may be taken from the following tokens:

PS_specific	finds the specified revision
PS_latest	finds the latest issued revision
PS_latest_status	finds the latest issued revision with the currently configured status
PS_latest_date_effective	finds the latest issued revision with the currently configured status which is effective for the specified date
PS_latest_num_effective	finds the latest issued revision with the currently configured status which is effective for the specified serial number
PS_substitute	if a revision of the view exists in the working substitute list this will be substituted. This rule must be used in conjunction (bitwise OR) with one of the other rules

Some users may wish to load the major items of their structure by serial number, but select basic components like screws, washers etc. by effectivity dates. Therefore it is possible to OR the two effectivity rules together "*PS_latest_date_effective | PS_latest_num_effective*" to give the desired functionality. Any item whose range of serial numbers and range of effective dates spans those currently set with the configuration rule will be selectable. In practice, on any one item, one of the effectivity attributes (date or serial number) will have open-ended limits set, so selection will be done on the basis of one effectivity attribute only.

Name: PS_set_config_status

Synopsis:

```
extern int  PS_set_config_status(
    tag_t        status_type                                   /* <I> */
);
```

Description: Sets the status for use with the configuration rule.

The status set is chosen from the status types allowed for this site.

Arguments:

status_type	tag of the status type to be set

Failures:

invalid status type

Name: PS_set_config_date_effective

Synopsis:

```
extern int  PS_set_config_date_effective(
    date_t      date                                    /* <I> */
);
```

Description: Sets the effectivity date associated with the current configuration rule.

Arguments:

date

Failures:

invalid date

Name: PS_set_config_num_effective

Synopsis:

```
extern int  PS_set_config_num_effective(
    int          effective_num                              /* <I> */
);
```

Description: Sets the effective serial number for use with the current configuration rule.

Arguments:

effective_num

Failures:

Substitute List functions

list(SubstituteList)

Name: PS_list_substitutes

Synopsis:

```
extern int  PS_list_substitutes(
    int *        n_substitutes,                     /* <O> */
    tag_t **     substitutes                        /* <OF> */
);
```

Description: Lists the BOMViewRevisions on the SubstituteList. It is these revisions which may be substituted into configurations if the configuration rule *PS_substitute* is set.

Arguments:

n_substitutes	number of BOMViewRevisions on the list
substitutes	array of tags of BOMViewRevisions on the list

Failures:

set(SubstituteList)

Name: PS_set_substitutes

Synopsis:

```
extern int  PS_set_substitutes(
    int         n_substitutes,                         /* <I> */
    tag_t *     substitutes                            /* <I> */
);
```

Description:

Sets the BOMViewRevisions on the SubstituteList. It is these revisions which may be substituted into configurations if the configuration rule *PS_substitute* is set.

If the current substitution rule is *PS_substitute_specific* then the exact revisions supplied are placed on the SubstituteList. If the current substitution rule is *PS_substitute_latest* the latest revision from the same ChangeHistory is put on the substitution list in place of each revision on the input list.

Arguments:

n_substitutes	number of BOMViewRevisions on the list
substitutes	array of tags of BOMViewRevisions on the list

Failures:

invalid tag of BOMViewRevision in substitutes array

Name: PS_ask_substitution_rule

Synopsis:

```
extern int  PS_ask_substitution_rule(
    int *        substitution_rule                          /* <O> */
);
```

Description: Returns the substitution rule currently set for use when setting the Substitution List.

Arguments:

substitution_rule	*PS_substitute_specific* or *PS_substitute_latest*

Failures:

set(SubstitutionRule)

Name: PS_set_substitution_rule

Synopsis:

```
extern int  PS_set_substitution_rule(
    int          substitution_rule                        /* <I> */
);
```

Description: Sets the substitution rule for use when setting the Substitution List.

Arguments:

substitution_rule	*PS_substitute_specific* or *PS_substitute_latest*

Failures:

no such substitution rule

Context functions

create(Context)

Name: PS_create_context

Synopsis:

```
extern int  PS_create_context(
    tag_t *     context                                  /* <O> */
);
```

Description: Creates a new context, making it the current context.

Its attributes are set to default values, with configuration rule *PS_latest*, no status or effectivity, an empty substitute list and substitution rule *PS_substitute_specific*.

Arguments:

context	returns tag of the new context

Failures:

Name: PS_copy_context

Synopsis:

```
extern int  PS_copy_context(
    tag_t       source_context,                 /* <I> */
    tag_t *     new_context                     /* <O> */
);
```

Description: Creates a new context, copying attributes from the given source context. The new context is made the current context.

Arguments:

source_context	tag of an existing context whose attributes are to be copied to the new context
new_context	tag of the newly created context

Failures:

no such source context

Name: PS_delete_context

Synopsis:

```
extern int  PS_delete_context(
    tag_t       context                                   /* <I> */
);
```

Description: Deletes the given context.

The current context cannot be deleted, another context must be made current first.

Arguments:

context	tag of the context to be deleted

Failures:

no such context

cannot delete current context

extent(Context)

Name: PS_extent_context

Synopsis:

```
extern int  PS_extent_context(
    int *        n_contexts,                        /* <O> */
    tag_t **     contexts                           /* <OF> */
);
```

Description: Returns a list of all contexts configured in this PS session.

Arguments:

n_contexts	number of contexts found
contexts	returns array of tags of contexts

askCurrent(Context)

Name: PS_ask_current_context

Synopsis:

```
extern int  PS_ask_current_context(
    tag_t *      current_context                              /* <O> */
);
```

Description: Returns the tag of the current context.

Arguments:

current_context	returns tag of the current context

Failures:

setCurrent(Context)

Name: PS_set_current_context

Synopsis:

```
extern int  PS_set_current_context(
    tag_t       context                                /* <I> */
);
```

Description: Makes the given context the current context.

The configuration rule, status, effectivity, substitute list and substitution rule of the given context become those used in loading configurations.

Arguments:

context	tag of the context to be made the current context

Failures:

no such context

WHAT IS CLAIMED IS:

1. A method of using a computer to store data representing an imprecise structure of a product and to present data representing a precise structure of that product, comprising the steps of:

storing a description of each component of a product as a view object of a view data class;

storing a description of each revision to a component of a product as a view revision object of a view revision data class;

linking view objects and view revision objects of different components with references to occurrence objects of an occurrence data class;

receiving input from a user precisely specifying a product to be viewed;

retrieving at least one view object or view revision object for each component of said product, by using said occurrence objects; and

associating each view object and view revision object with a component of said product to create a bill of materials.

2. The method of Claim 1, further comprising the step of linking view revision objects of the same component with references to a view object associated with that component.

3. The method of Claim 1, wherein said product has multiple components of the same type, further comprising the step of storing context-specific descriptions of such components as appearance objects.

4. The method of Claim 1, further comprising the step of using an object of a configuration object data class to store histories of view revisions.

5. The method of Claim 1, further comprising the step of using a configuration rule to determine which view revision object of a component is to be retrieved during said retrieving step.

6. The method of Claim 1, wherein said components are represented by item objects of item and item revision data classes, and wherein said view objects said view revision objects are attributes of corresponding item objects.

7. A method of using a computer to store data representing an imprecise structure of a product and to present data representing a precise structure of that product, comprising the steps of:

storing a description of each component of a product as a new object of a view data class;

storing a description of a revision to a component as a view revision object of a view revision data class;

linking view objects and view revision objects of different components with references to occurrence objects of an occurrence data class;

storing a set of configuration rules for determining how a precise version of said product is to be assembled;

receiving input from a user imprecisely specifying a product to be viewed and at least one condition associated with said product;

using at least one of said configuration rules to determine a view revision of a component of said product that satisfies said at least one condition;

retrieving a set of view objects and view revision objects, representing each component of said product, by using said occurrence references; and

associating each view object and each view revision object with a component of said product to create a bill of materials.

8. The method of Claim 7, further comprising the step of linking view revision objects of the same component with references to a view object associated with that component.

9. The method of Claim 7, wherein said step of receiving input is comprised of a receiving data representing a status condition and said step of using said configuration rules determines a view revision having said status.

10. The method of Claim 7, wherein said step of receiving input is comprised of receiving data representing an effectivity condition and said step of using said configuration rules determines a view revision having said effectivity.

11. The method of Claim 7, wherein said product has multiple components of the same type, further comprising the step of storing context-specific descriptions of such components as appearance objects.

12. The method of Claim 7, further comprising the step of using an object of a configuration object data class to store histories of view revisions.

13. The method of Claim 7, wherein said components are represented by item objects of item and item revision data classes, and wherein said view objects said view revision objects are attributes of corresponding item objects.

14. The method of Claim 7, further comprising the step of displaying said bill of materials, and receiving data from a user to add, modify, or delete data attached to said view objects.

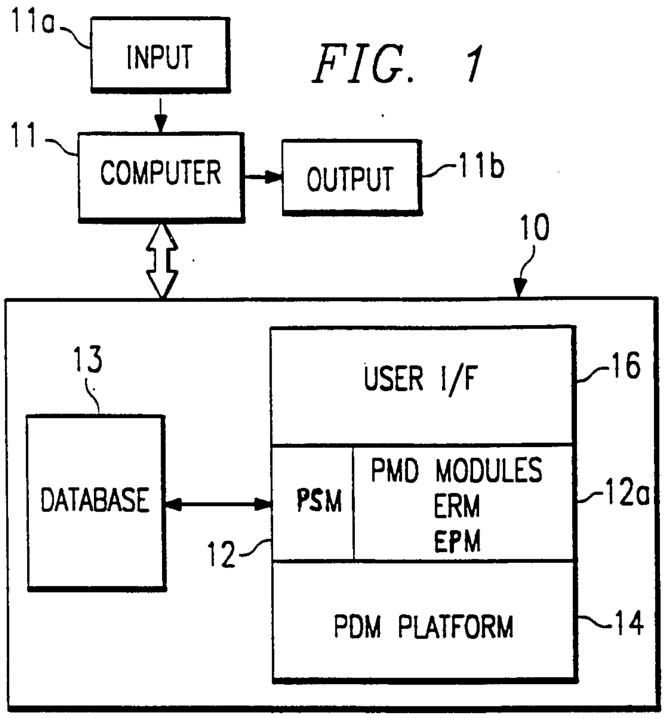

11a
INPUT
11
COMPUTER
OUTPUT
11b
10
13
DATABASE
USER I/F
16
PSM
PMD MODULES
ERM
EPM
12a
12
PDM PLATFORM
14

FIG. 1

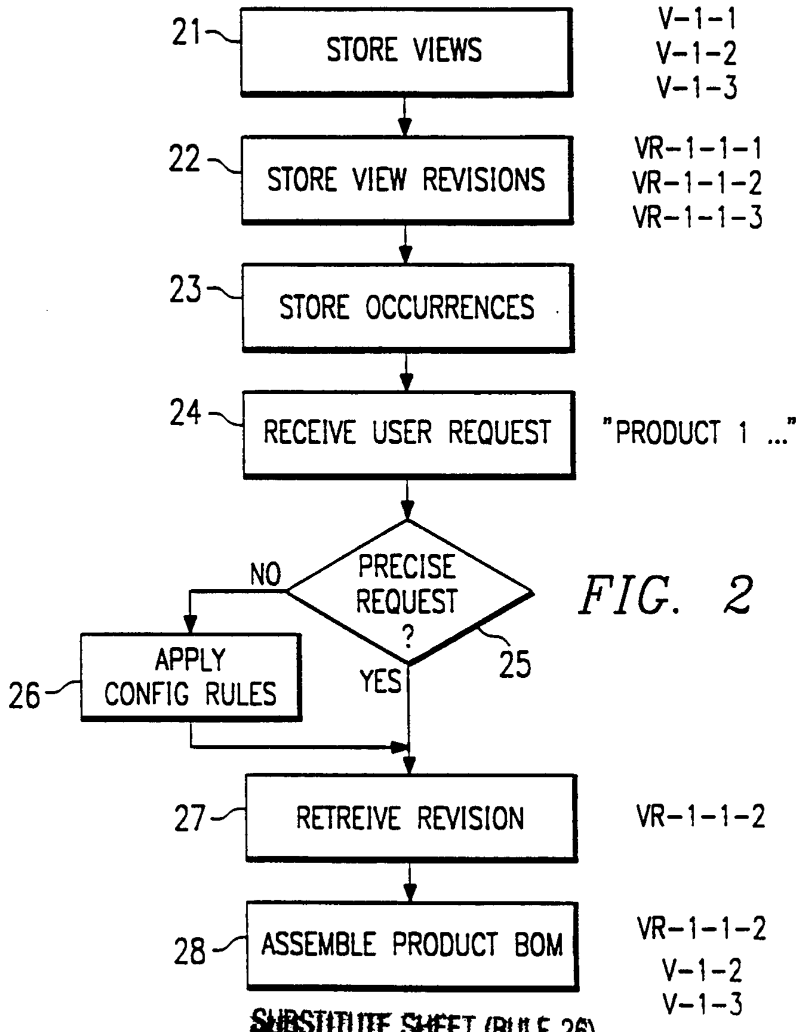
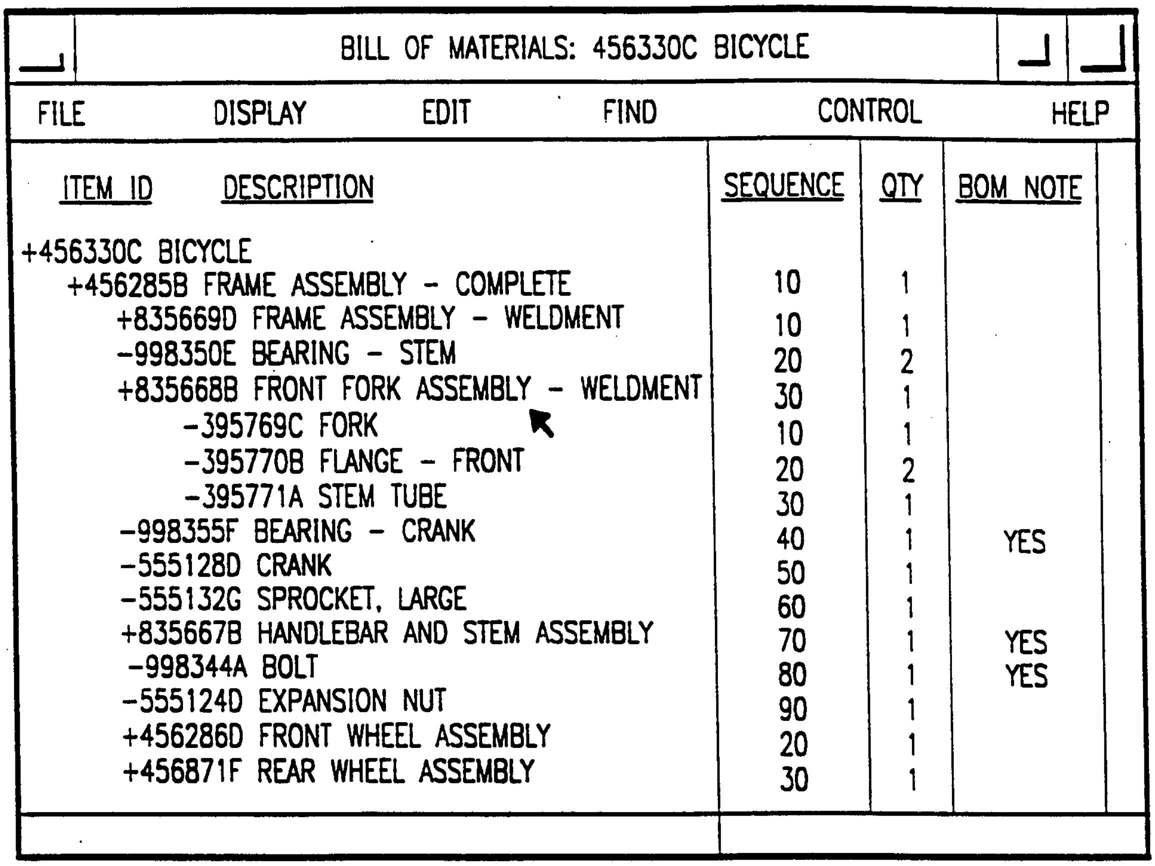

21
STORE VIEWS
V-1-1
V-1-2
V-1-3
22
STORE VIEW REVISIONS
VR-1-1-1
VR-1-1-2
VR-1-1-3
23
STORE OCCURRENCES
24
RECEIVE USER REQUEST
"PRODUCT 1 ..."
PRECISE REQUEST ?
25
NO
YES
26
APPLY CONFIG RULES
27
RETREIVE REVISION
VR-1-1-2
28
ASSEMBLE PRODUCT BOM
VR-1-1-2
V-1-2
V-1-3

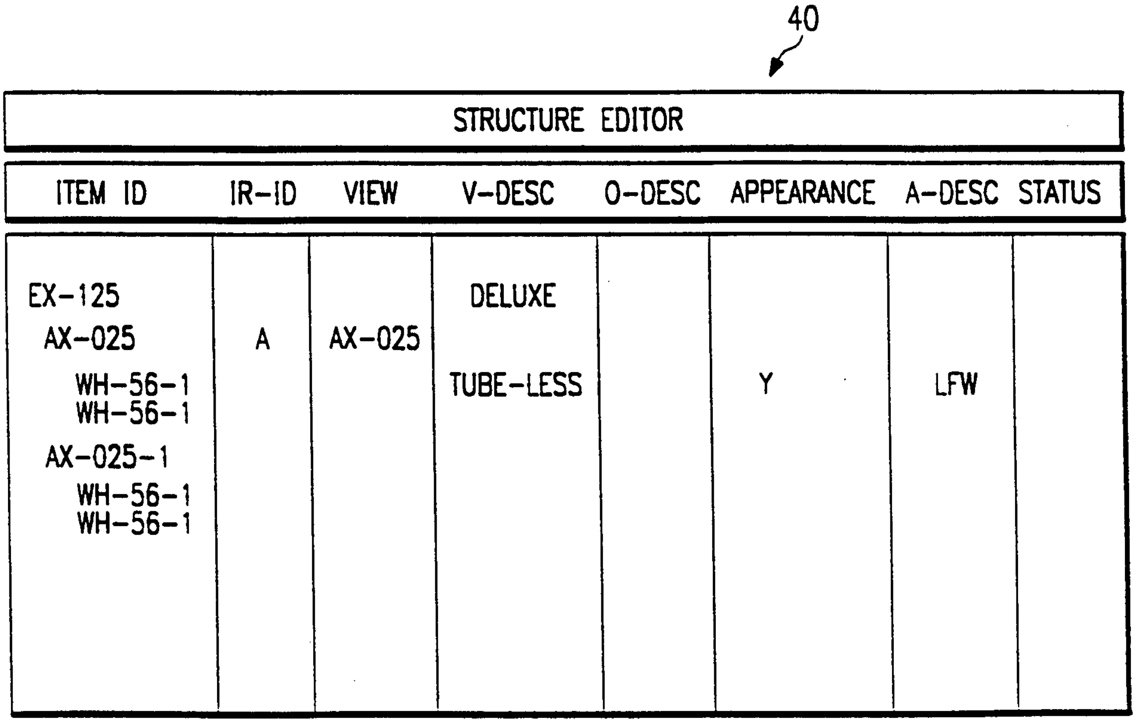
FIG. 2



BILL OF MATERIALS: 456330C BICYCLE

ITEM ID	DESCRIPTION	SEQUENCE	QTY	BOM NOTE
+456330C	BICYCLE			
+456285B	FRAME ASSEMBLY - COMPLETE	10	1	
+835669D	FRAME ASSEMBLY - WELDMENT	10	1	
-998350E	BEARING - STEM	20	2	
+835668B	FRONT FORK ASSEMBLY - WELDMENT	30	1	
-395769C	FORK	10	1	
-395770B	FLANGE - FRONT	20	2	
-395771A	STEM TUBE	30	1	
-998355F	BEARING - CRANK	40	1	YES
-555128D	CRANK	50	1	
-555132G	SPROCKET, LARGE	60	1	
+835667B	HANDLEBAR AND STEM ASSEMBLY	70	1	YES
-998344A	BOLT	80	1	YES
-555124D	EXPANSION NUT	90	1	
+456286D	FRONT WHEEL ASSEMBLY	20	1	
+456871F	REAR WHEEL ASSEMBLY	30	1	

FIG. 3



STRUCTURE EDITOR

ITEM ID	IR-ID	VIEW	V-DESC	O-DESC	APPEARANCE	A-DESC	STATUS
EX-125			DELUXE				
AX-025	A	AX-025					
WH-56-1			TUBE-LESS		Y	LFW	
WH-56-1							
AX-025-1							
WH-56-1							
WH-56-1							

FIG. 4

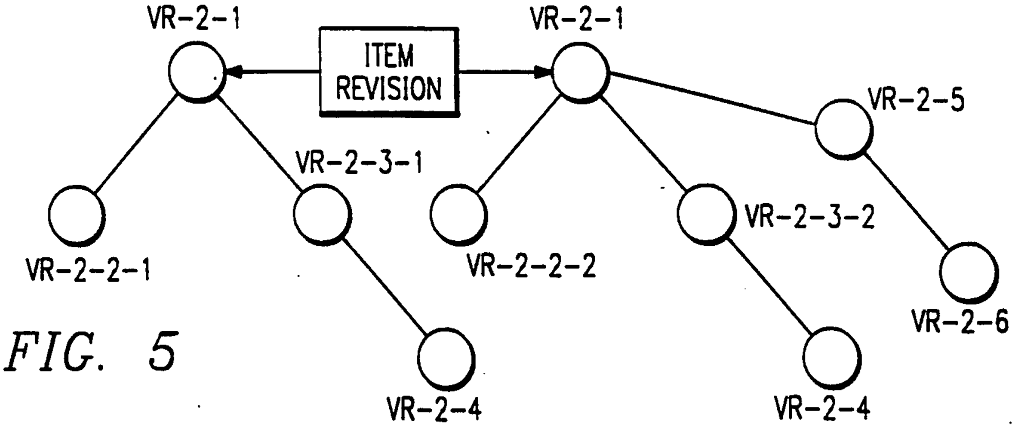


FIG. 5

FIG. 6

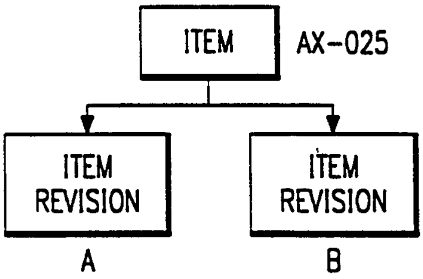
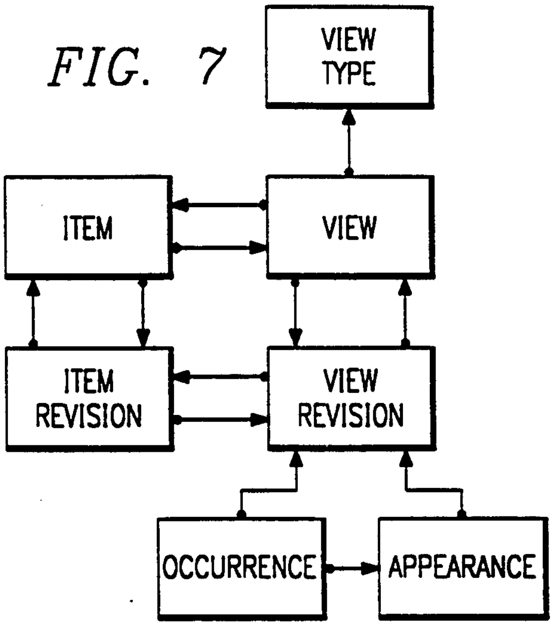


FIG. 7



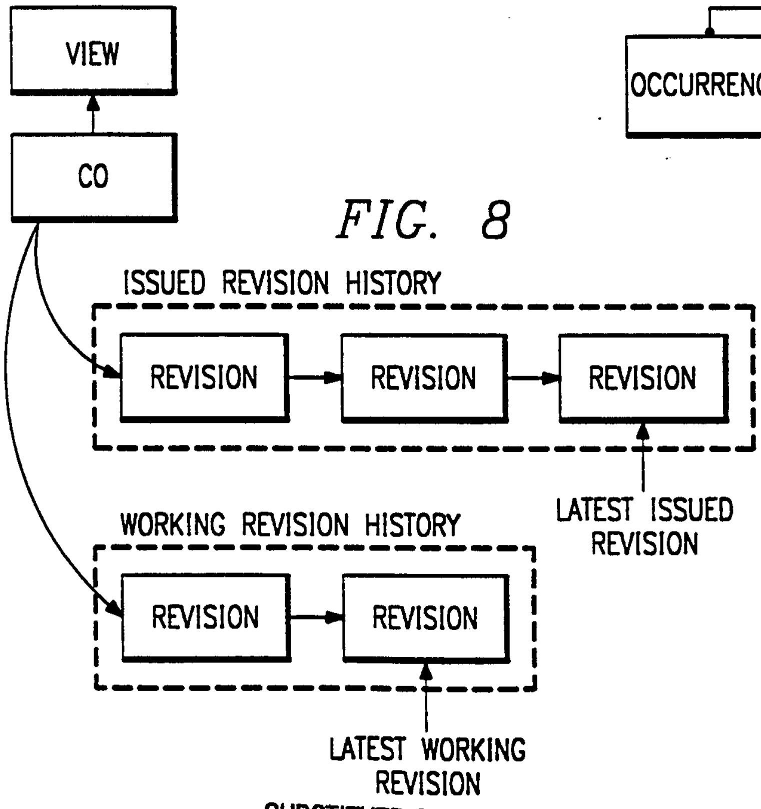


FIG. 8

INTERNATIONAL SEARCH REPORT

Inte: onal Application No
PCT/US 94/07170

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F17/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	COMPUTERS IN INDUSTRY, vol.19, no.3, June 1992, AMSTERDAM NL pages 257 - 270 CHUNG ET AL 'illustration of object-oriented databases for the structure of a bill of materials' see page 262, column 2, line 17 - page 268, column 2, line 3; figures 3-9 ---	1-3,6-8, 11,13,14
A	EP,A,0 483 039 (IBM CORP) 29 April 1992 see page 3, column 3, line 9 - line 54 see page 5, column 5, line 16 - line 43; figure 1 --- -/--	1,7

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search 6 October 1994	Date of mailing of the international search report 19.10.94
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Guingale, A

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 94/07170

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 520 923 (IBM CORP) 30 December 1992 see page 2, column 2, line 43 - page 3, column 3, line 3 see page 3, column 4, line 28 - line 41; figure 1 -----	1,7

1

INTERNATIONAL SEARCH REPORT

Int :onal Application No
PCT/US 94/07170

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0483039	29-04-92	US-A-	5317729	31-05-94
		JP-A-	4289920	14-10-92
EP-A-0520923	30-12-92	US-A-	5311424	10-05-94
		JP-A-	5189445	30-07-93