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1.-Introduction:

The aim of this document is to determine the final UML modelling of the objects that constitute the PIVOT language.

The modelling of the PIVOT objects was part of task 3.1, Envelope of styles, and, in consequence, it had to be accomplished by the partners of WP3. However, as it affects other work packages, the final version contains the suggestions and contributions of all the other partners, too.

CLASIFICATION OF THE OBJECTS

One of the objectives of the conversion process is to enrich the geometrical description of the mock-up with the electrical data of the elements that constitute it. We may then consider the information divided in two categories. The first one will describe the geometry of the mock-up and the second one will determine the topology and the electrical behaviour of the components.

Likewise, we may then speak of geometric structures, if we refer to PIVOT objects used for containing the geometrical description of the mock-up, and of electrical structures, if we refer to those objects that describe the electrical model. Additionally, we will have a third category where we will include the auxiliary structures that complement the other structures used for this purpose.

2.-Auxiliary structures:

We begin with these basic objects, because they will appear recursively in the definition of the other objects.

The following two structures, Property and Coords, are auxiliary objects that complete the definition of the geometric and electrical structures. Property gives the possibility of adding a special attribute to a concrete object, while Coords is used for giving the coordinates of the points that describe a geometric element.

+ Property

The Property structure contains two attributes: the name and the value of the property and is used for describing those attributes that are not contained in the basic definition of an object.

+ Coords

The Coords structure contains the coordinates of a point of the space and it is used when describing geometric objects for completing their definition. This point may be the center of a sphere or one of the extremes of a line, or may be one of the points that define an arc. An object may contain several Coords objects as its attributes.

3.-Geometric structures:

These objects have been defined for containing the geometrical information stored in the paper designs and the AutoCAD and CATIA files. This includes the position and shape of the equipment elements as well as the routing and the connection points between wires and electrical devices. These PIVOT structures must be able of containing the description of geometrical objects in both 2D and 3D.

DESCRIPTION OF THE OBJECTS

Basic objects:

This group of structures would include those that are the parent structures from which derive all the others. They are not used directly, but through their child structures. Normally, they only have a few basic attributes for identifying them.

Two are the objects contained in this group, Geometry and GeometryContainer. Geometry is the parent structure of all the structures that describe the different elements that constitute a component of the mock-up and GeometryContainer is the parent structure for all the other structures that contain a collection of geometric structures.

+Geometry:

It is the base object from which derive all the other geometric elements. It contains two attributes: the name and the value of the property. This simplicity will make the elements more versatile.

+GeometryContainer:

It is the abstract object from which derive the other structures that contain a collection of geometric structures: Geometry2D for 2D objects and Geometry3D for 3D objects. This element is useful because the definition of some elements normally need other auxiliary geometric elements.

Objects only for 2D:

Initially, it was considered that, the same way there were structures used exclusively for describing geometrical elements in 3D, there will be structures for describing exclusively geometrical elements in 2D, too. Two examples of this case would be the circle and the arc, because they were not used in any 3D mock-ups that had been studied.

However, the initial definition of the arc object was considered a limitation of the model, because in future cases the circumstances could be different and it could be needed also for describing arc elements in 3D. Therefore, it was decided to extend its definition to 3D. As regards the circles, in order to avoid giving two definitions of the same structure, one for 2D and other for 3D, it was decided to use the arc object for describing the circles in 3D. The reasons for doing it this way are that the definition of the arc element is given by three points, what is

enough for defining a plane, and that any circle may be divided easily in three or more arcs. Taking this into account, the definition of the circle is redundant and it could be eliminated, but as it is an element so frequent in 2D and it has a definition so easy to show and convert, it was decided to keep it.

+Geometry2D:

This is the parent of all the structures that describe geometrical elements in 2D. This includes also the structures used for describing objects in both 2D and 3D. As it derives from GeometryContainer the child objects may contain other geometrical objects as its children.

+Circle:

It describes a circumference. Its properties are the center, given in 2D coordinates, and the radius. This structure is only used when describing 2D mock-ups and it should not be used for describing a circle or a sphere in 3D mock-ups.

Objects only for 3D:

In general, the mock-ups described in paper designs and AutoCAD files are in 2D, while 3D mock-ups will correspond to designs stored in CATIA files. The usual way of describing the parts of these mock-ups is using facets, i.e. polygons, because when exported to STL format each element is divided into a collection of triangles. These facets may be easily described using PolyLines. However, some other objects, such as cones and cylinders, have been considered for those cases in which the 3D mock-ups correspond to designs in AutoCAD or for those mock-ups which are contained in a format different from STL. Additionally, the sphere has been included also in this category.

+Geometry3D:

This is the parent of all the structures that describe geometrical elements in 3D. This includes also the structures used for describing objects in both 2D and 3D. As it derives from GeometryContainer the child objects may contain other geometrical objects as its children.

+Sphere:

It describes a sphere. Its properties are the center, described using 3D coordinates, and the radius of the sphere. This structure is only used when describing 3D mock-ups and it should not be used for describing a circumference in neither 2D nor 3D mock-ups.

+Cone:

It describes a cone. Its properties are the bottom and top points of the revolution axis, given in 3D coordinates, and the radius in the inferior part of the cone.

+Cylinder:

It describes a cylinder. Like the cone, it is described using the top and bottom points of the revolution axis, both given in 3D coordinates, and the radius of the cylinder.

Objects common to 2D and 3D:

Most of the geometric elements in 2D have its equivalent one in 3D. Bearing this in

mind, it was decided to use structures derived from both Geometry2D and Geometry3D, because, depending on the number of coordinates included in the description, they will be able to describe either 2D or 3D elements. These structures are the most common and practically all the elements of the mock-ups may be described with them.

+Point:

It gives the position of a point in the plane or in the space. The coordinates are two numbers in the first case and three in the second one. Apart from describing specific points, they may also be part of other structures such as PolyPoint or PolyLine.

+PolyPoint:

It contains a collection of two or more points

+Line:

It describes a rectilinear segment that connects two points. Its properties are the coordinates of the starting and ending point.

+PolyLine:

It contains a collection of two or more line segments, which may be defined using Line or Point structures. The Point structures are useful when the starting point of each bundle segments coincide with the ending point of the previous segment, while the Line structures are better when each line is independent from the others.

+Text:

It contains a string of characters. This text normally refers to another geometric element of the mock-up. Its function would be to show to the user in the graphical representation of the mock-up a datum of importance associated to that component.

+Arc:

The Arc was initially classified as a structure that described only elements in 2D. It was not considered for being used in 3D, because, at first, no elements of this type were found in 3D mock-ups. However, in order to not lose generality it was decided to extend the definition to both 2D and 3D.

The arc element is defined using three points, which describe the arc of a quadratic Bezier curve. The reason for choosing this type of curves is again that they are more general than the ones based in circumferences.

The arc structure is normally used for describing curves in 2D and 3D, but it could be used for describing circumferences, too. In this case, the circumference should be divided in three or more arcs and, then, each one of them will be described by an arc. The only significant limitation of this definition is that the arc described is always a curve contained in the plane defined by the three points used.

CLASS DIAGRAM

The geometry structures have been designed in order to describe all the elements in 2D and 3D that are needed for giving a complete geometrical description of the mock-ups

contained in the paper designs, the AutoCAD and the CATIA files.

First, the Geometry object has been defined as the parent of all the other structures. Geometry has the attributes needed for identifying and describing the properties of a generic object. From Geometry the structure GeometryContainer has been derived, so that the child structures may contain collections of objects.

Geometry and GeometryContainer structures are a-dimensional. They do not contain coordinates that make them refer to a concrete space. However, the mock-ups described by PIVOT are bi-dimensional and tri-dimensional, so it is required that the geometric structures that describe them are defined in these dimensions. In order to do this, the structures Geometry2D and Geometry3D are derived from GeometryContainer. They are the parent structures of the correspondent objects in 2D and 3D, and their children are the structures that describe specific geometric elements that are commonly used.

Finally, Point and Line are the parents of two other structures: PolyPoint and PolyLine, respectively. PolyPoint contains a collection of two or more points that hang from it as its children. Similarly, PolyLine is a group of Line objects.

4.-Electrical model structures

The objects of this section contain the electrical description of the mock-up. They define the type of each part, their connections and their electrical properties. Additionally, it is also necessary to establish a relationship between both the electrical properties and the geometrical model, so they also contain references to the associated geometric objects.

DESCRIPTION OF THE OBJECTS

+Model:

This is the generic element for storing the electrical description of an element. From it will derive the rest of the structures that will give a more precise description of each type of component.

+Part:

It is the object used for describing those parts of the mock-up that are not harness elements, i.e. electrical devices and equipment elements. It derives from Model, what allows it to contain a model object for describing the internal behaviour of the electrical device.

+Route:

This object contains the description of a harness element. Generally, it corresponds to a part of the mock-up that has been defined as a bundle segment. But a Route may contain other Route objects as children in order to reflect the possibility of the bundle segment containing in its interior different strands of wires.

+Wire:

The concept of wire must not be mistaken with that of bundle segment. A bundle segment may contain wires or strands of wires. It may have more than two connections and the connected parts may correspond to electrical devices or other bundle segments. In contrast to this, a wire always puts in contact two electrical devices, if necessary, crossing several bundle segments. It does not correspond to a physical element of the mock-up. The only geometrical reference it has is the routing of the wire: the path that it follows in order to put in contact its two connection points.

+Slot:

It describes a pin of an electrical device, this is, the point in which the device is connected to other components.

The electrical structures have been designed in order to describe the electrical characteristics of the different devices and harnessing elements that constitute the mock-up, define the topology and specify the routing of the wires.

The Model structure is the parent of all the objects that define the electrical behaviour of a component of the mock-up: Part, Route, Wire and Slot objects derive from it. The Model object gives a basic description of a generic element while the others give a more specific definition. It may also contain a collection of sub-Models for describing the internal behaviour of the element. This allows us to consider the whole mock-up as a single element represented by a Model object whose sub-Models will be the Part, Route, Wire and Slot structures that describe the internal components.

The Part object describes the electrical devices of the mock-up. As they derive from the Model object the Part structures may contain other sub-Model objects for describing its internal electrical behaviour. It is very common, for example, to use these sub-Models for describing the connections with other elements of the mock-up. These connections are defined by the slot structures, which, as derive from Model, may be stored also in the collection of sub-models. Additionally, another attribute of the Part structure will contain a reference to the Geometry2D or Geometry3D nodes that hang from the GeometryContainer object that describes its shape.

As regards the Route structures that represent the bundle segments they will contain a collection of references to the wires that cross through them and a collection of sub-Route structures in case that some of the wires are grouped in bundles.

The Wire objects will describe the wires that put in contact the different electrical devices of the mock-up and will contain two references to the Slot objects that describe the connections at their extremes. They will also have a reference to the geometry object of the GeometryContainer that describes their routing.

Finally, the Slot objects will contain a reference to the geometry object that gives the position of the connection point.