AN APPLICATION MODEL FOR VISUALIZATION OF NATURAL RESOURCES MANAGEMENT

Elizabeth Simão Carvalho *
José Carlos Teixeira **

* Department of Electrotechnic Engineering
University of Trás-os-Montes e Alto Douro
Quinta dos Prados, Apartado 202
5001 Vila Real Codex, Portugal
beth@utad.pt, http://www.utad.pt

** Department of Mathematics
University of Coimbra
Largo D. Dinis – Apartado 30085001
3001-454 Coimbra,Portugal
teixeira@mat.uc.pt, http://www.mat.uc.pt

ABSTRACT

Natural resources data is usually geo-referenced. It contains mostly 1-n dimension scalar or vector values, and can be associated with meteorology, geology, water, weather, etc. Scientists apply natural resources data in different models in order to predict or model the real world. Computer applications for this area have to be based on a powerful, adaptable and flexible architecture, besides using GIS and Scientific Visualization technologies for development. Other important feature is the correlation that has to be established between the data model and the visualization model. This paper introduces a conceptual model of a computer application to natural resources management. It uses visualization as the main key for information deliverance.
Keywords: scientific visualization, GIS, system analysis.

1. INTRODUCTION

Scientists use several different analytical tools to evaluate the behaviour of natural resources. These tools use mathematical models applied to natural resources data. They produce numerical outputs that are further used to interpret and extrapolate natural resource behaviours. These models can be also used to relate different kind of phenomena. On the other hand, the natural resources geographical aspects cannot be ignored. Its visualization is closely connected to a visualization of a map. A map is a valuable tool and can be used in several different ways in order to evaluate the natural resources behaviour. The management of natural resources is an important subject in our world and need task-oriented computer applications with well-designed visual output.

2. MODEL OBJECTIVES

The management of natural resources comprises many different aspects. From them two are especially important:

- The possibility of applying analytical tools
- The possibility of simulating non-natural and/or natural phenomena.

Besides these aspects, a model to support the management of natural resources should also allow:

- Interactive visualization of data (simulated, analysed with specific tools or original data) in both geographic and scientific aspects
- Import/Export of data and results, using different formats
- Time control (animation)
- Fast results and correctness
- Phenomena visualization recording

In our model, the final user can select an existing tool and apply it to the data. Then, he/she can, between others, observe the effects that are produced having the possibility of video production, annotation, snapshots, 3D virtual objects manipulation and connections with GIS [Cliff97] systems. This model is considered to be extensible, because of its modularity, and can easily integrate new tools that are not known by now. The crucial point is that higher-level abstractions allow the consideration of more visualization techniques into a unique conceptual framework.

Figure 1 shows the model use case view diagram. It shows what main actions the user wants to be able to perform with the application

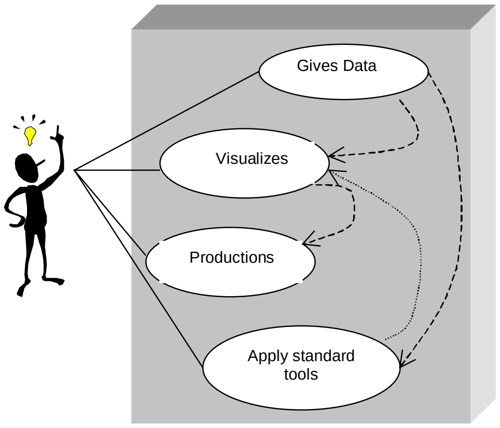

Figure 1: Model Use Case View Diagram

3. MODEL STATIC VIEW

Figures 2,3, and 4 show different levels of the model UML [James99] static view diagram. This view gives a structural and static description of the model. Because of the relationship that exists between natural resources and Earth environment, this view should express this interdependency.

The class *Map* models an empty space that is related to Earths surface in a certain instance of time. Its main attributes are *location* and *time*. The attribute l*ocation* holds 3D spatial coordinates that identify the limits of a rectangular area on Earth s surface, while the attribute *time* holds the date (day, month and year) when this area was modelled by the class *Map*. It is generalized into several classes *Quadrant.*

The class *Quadrant* models a rectangular space, somewhere on Earth. It can be generalized into other classes *Quadrant* or aggregated. Association of multiple *Information Layer* classes composes it.

The *Information Layer* class models each of the different information layers that can be associated to a specific Earth quadrant: fauna, flora, meteorology, economics, etc. An information layer contains the minimum necessary information to model some phenomena or analytical tool. Its main attribute is *layer* (figure 5*)*, which is of type *Ci*. This attribute holds all the information present in a certain information layer and all the necessary information to the model in order to manage itself. Because of its complexity, it is composed of other attributes: *ActualInstance*, *ActualRealization*, *FileList*, *SampleList*, *GeomList* and *ImageList*. These attributes hold different pieces of information related directly or not to the information layer being modelled by the *Information Layer* class. They identify, for example, the present instance of *Layer Identification* class, or what *Layer Management* class realization is occurring now, or track where

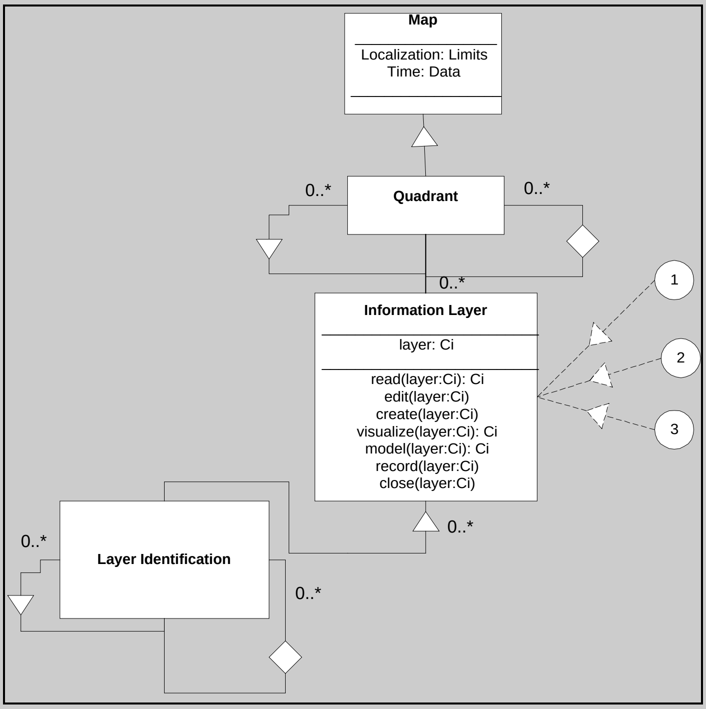

Figure 2: Classes Map, Quadrant and Information Layer Static View Diagram

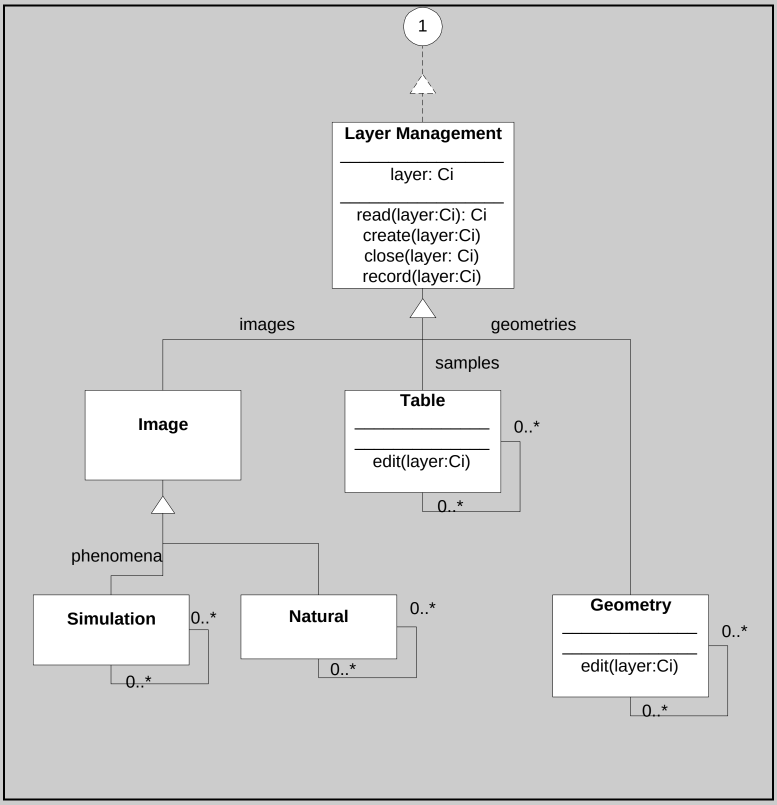

Figure 3: Class Layer Management Static View Diagram

data files are, or simply, hold layer information data. Its methods are *read*, *create*, *edit*, *close*, *visualize*, *model* and *record*. They permit different file operations, data modelling and visualization. It has three distinct realizations. It is generalized into several *Layer Identification* classes.

The class *Layer Identification* models the abstraction that class *Information Layer* implies. Several associations and specializations should be done in order to model a natural resource. For instance, considering a flood occurrence. In order to evaluate its impact, besides data related to water height, flow or terrain surface, it must be also known cities and roads positions. So, different specializations of the class *Information Layer* should be combined. Conceptually, the class *Layer Identification* represents all the instances that can appear from the *Layer Information* class specializations.

The class *Layers Management* is a realization of *Information Layer* class. It models the information layers management. This management is related to information and data keeping (in files). It is generalized into different classes: *Image*, *Table*, and *Geometry*. Each one is specialized in dealing with imagery, tabular and vectorial data. It heritages the attribute *layer* and the methods *read*, *create*, *close*, and *record*, from *Information Layer* class.

The class *Visual* is also related to the class *Information Layers* through a realization. It maps different visual graphic techniques according to the natural resource being analysed and the task being performed. It is specialized into several other classes, each one, related to a different graphic technique. It heritages also the attribute *layer* and the method *visualize* from *Information Layer* class.

The class *Calculator* models mathematically natural resources and its simulations, phenomena or related analytical tools. It heritages *layer* attribute, and *model* method from *Information Layer* class.

4. MODEL MANAGEMENT VIEW

Figure 6 shows the model UML management view diagram. This view shows the model internal organization using packages to hold different classes.

The subsystem *Realization* encapsulates several other modules. It is related to the *Information Layer* class realizations. Because of this, it contains modules directly associated to these realizations. Its behaviour depends on the input received from the *Interface* subsystem.

The subsystem *Visualization* contains the class *Visual* and its generalizations. Because the visualization issue in the natural resources field demands both cartographic and non cartographic visualization of data, a special approach might be used: divide it into two subsystems, one specialized in cartographic graphic techniques and other in scientific visualization [Grego97] techniques. The subsystem *Geographic* holds all the *Visual* class specializations related to cartographic techniques (those techniques usually available in a **GIS** system). The subsystem *Scientific Visualization*, on the other hand, holds all the *Visual* class specializations related to scientific visualization techniques (those techniques usually available in a Scientific Visualization system). The *Visualization* subsystem module can receive data both from the *Data* and *Modelling* subsystems. It can also send data to these modules.

The subsystem *Data* holds several databases, each one specific for different data format: imagery, geometry or tables, for instance. The model models this data. It contains the class *Layer Management* and its generalizations. It is responsible for data management.

The subsystem *Modelling* holds all mathematical models used to model a natural resource phenomena simulation and corresponding pliable analytical tool(s). It contains the class *Calculator* and all its specializations. The output data of this model is sent to the *Visualization* subsystem in order to be visualized and to the subsystem *Data* in order to be recorded.

Finally, the subsystem *Interface* contains the *Information Layer* class and all its specialisations. It controls the behaviour of the subsystem Realization. On the other hand, according to the feedback received from the Realization subsystem, it also changes its behaviour. It can be divided into two interfaces: one external, responsible for the interface between the user and the model, other internal,

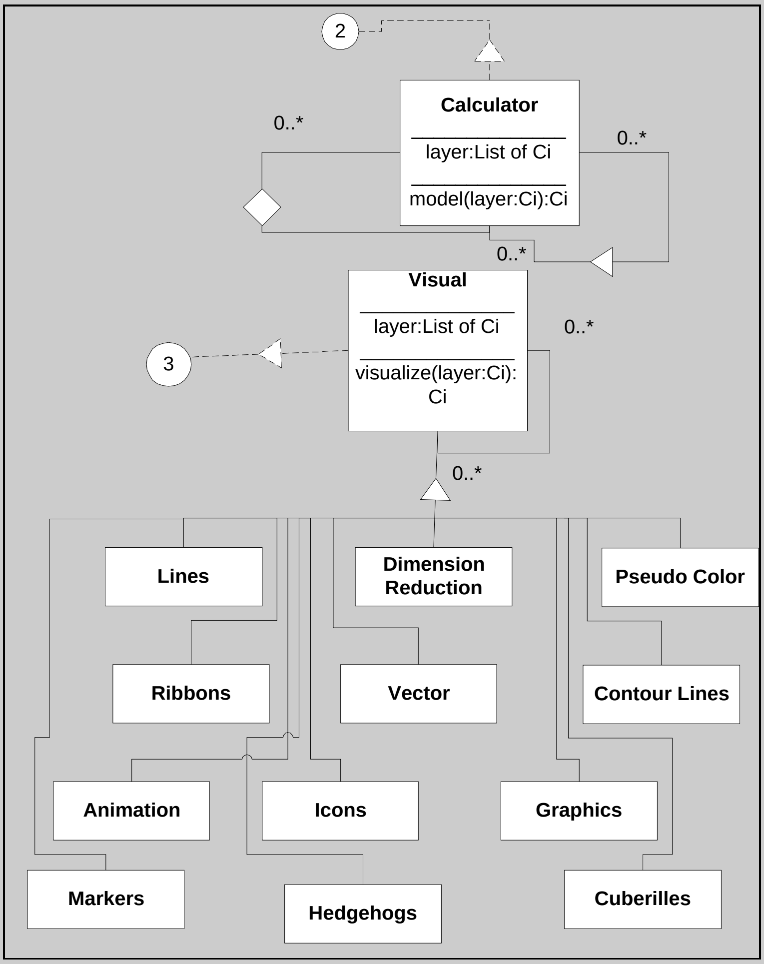

Figure 4: Classes Visual and Calculator Static View Diagram

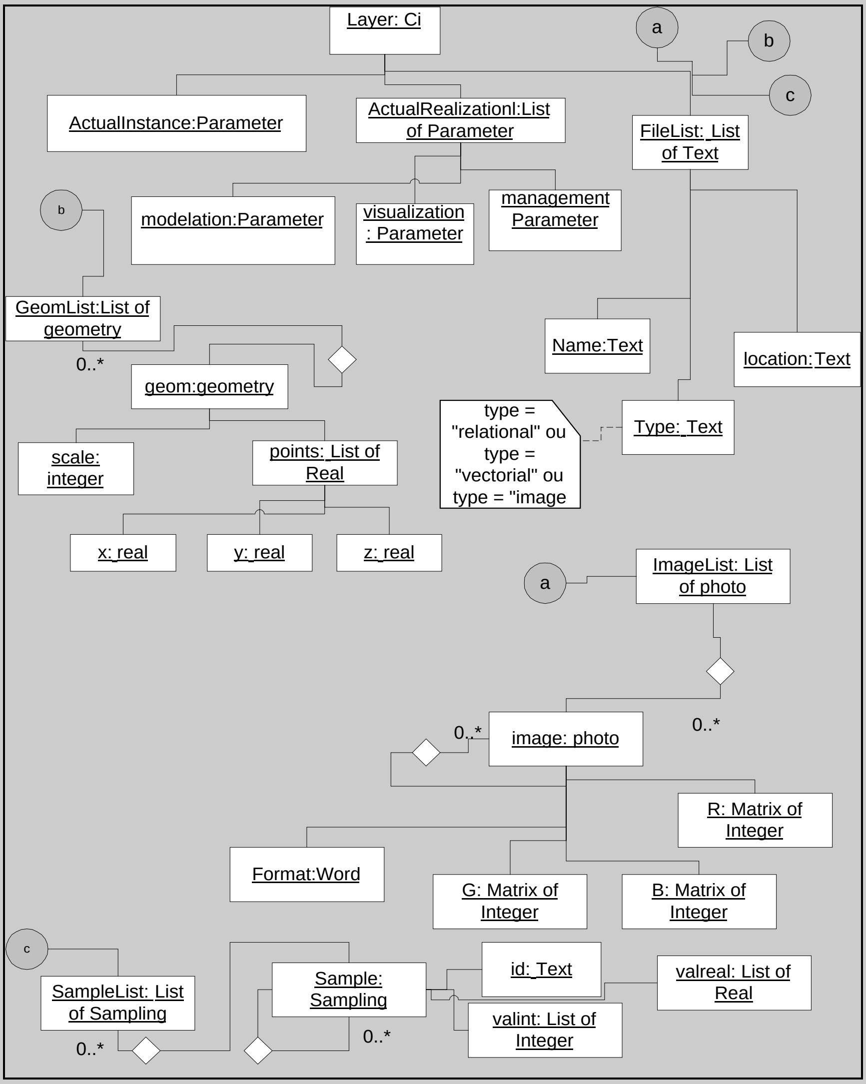

Figure 5: Static Attribute View Diagram

responsible for the intercommunication between model modules.

5. VISUALIZATION MAPPING

An important issue to the model is the visualization mapping. It should be enough expressive so that potential user can easily perceive what is being communicated through images. Many approaches can be used to define how the visualization mapping is done. For instance, the data model can be used as a basis. The question is what data model should be used and what techniques should be applied to map the visualization. There are several different visualization techniques that can be used. Each one can express better distinct data characteristics. One solution is to abstract the visualization mapping process from the natural resource itself and focus on the data characteristics.

The natural resources field data can be related to any natural element. There are basically four natural elements in our environment: air, earth, water and fire. Data can be also considered in three different physical states: gas, liquid and solid. Data used to describe the behaviour of natural resources and their phenomena can be mathematically modelled. They have continuity. Data is also generally geo-referenced and refers to a certain moment of time. Its origin can be from field measures or simulation processes. It can be a scalar, like temperature or humidity, or a vector, like speed or force. Its dimension varies, however rarely it is greater than three. They can be disorganized (0 dimension lattice), disposed in a line (1 dimension lattice) or in a grid (2 dimension lattice). It can be related to a volume, an area, or a simple point position in Earth space. Some metadata generally is associated to the data.

The visualization mapping is applied to the results produced by tasks such as phenomena simulation and analytical tool appliance. It is also used to graphically model the original data, which means, to simply visualize the input data without executing any special task on it.

Another interesting issue is what difference should exist when mapping a simulation task or just modelling the real world. Simulation is an attempt to visualize real world under certain special conditions. The visualization may be similar presenting only some indication (for instance, a label) showing that one is simulation and the other the real world. It will be straightforward to visually compare results.

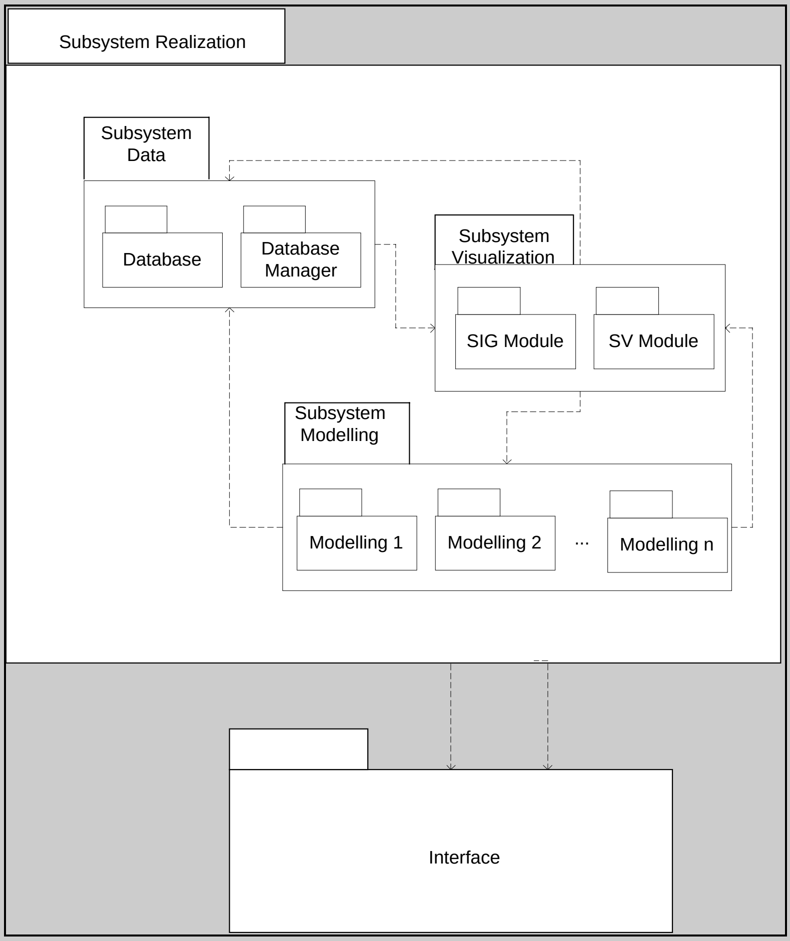

Figure 6: Model Management View Diagram

Physical nature and cognitive characteristics are also an important issue. Visualization of a solid data should express its compactness, while of a gas data its fluidity. Fire shines, while thin air is transparent. Water is blue and can be also transparent or translucent. Earth is brownish and opaque. Data disposal can be enhanced using grids, lines or simply, points. Scalar data represents a coefficient, an intensity of something. Vector data indicates direction, orientation or inclination.

Besides this, visual techniques should aloud 3D or higher dimension perceiving. Data geo-referenced characteristic implies the use of cartography (maps). Phenomena analysis demands [PuWL-97] techniques. Visual techniques for natural resources should match and merge both situations. They have to express correctly the cognitive message present in each one of these situations. It means that the model visual mapping should consider both the characteristics of the current data model and the task to be performed on it.

Figure 7 shows the relationships between visualization techniques and data characteristics that are proposed in the model. Different combinations and, consequently, instances can be achieved according data nature.

6. FURTHER WORK

Further work includes the implementation of more analytical tools and phenomena simulation, besides the connection to virtual reality [There97] and **GIS** environments. Another aim is to test the prototype with different kinds of natural resources data, like hydrologic basin data.

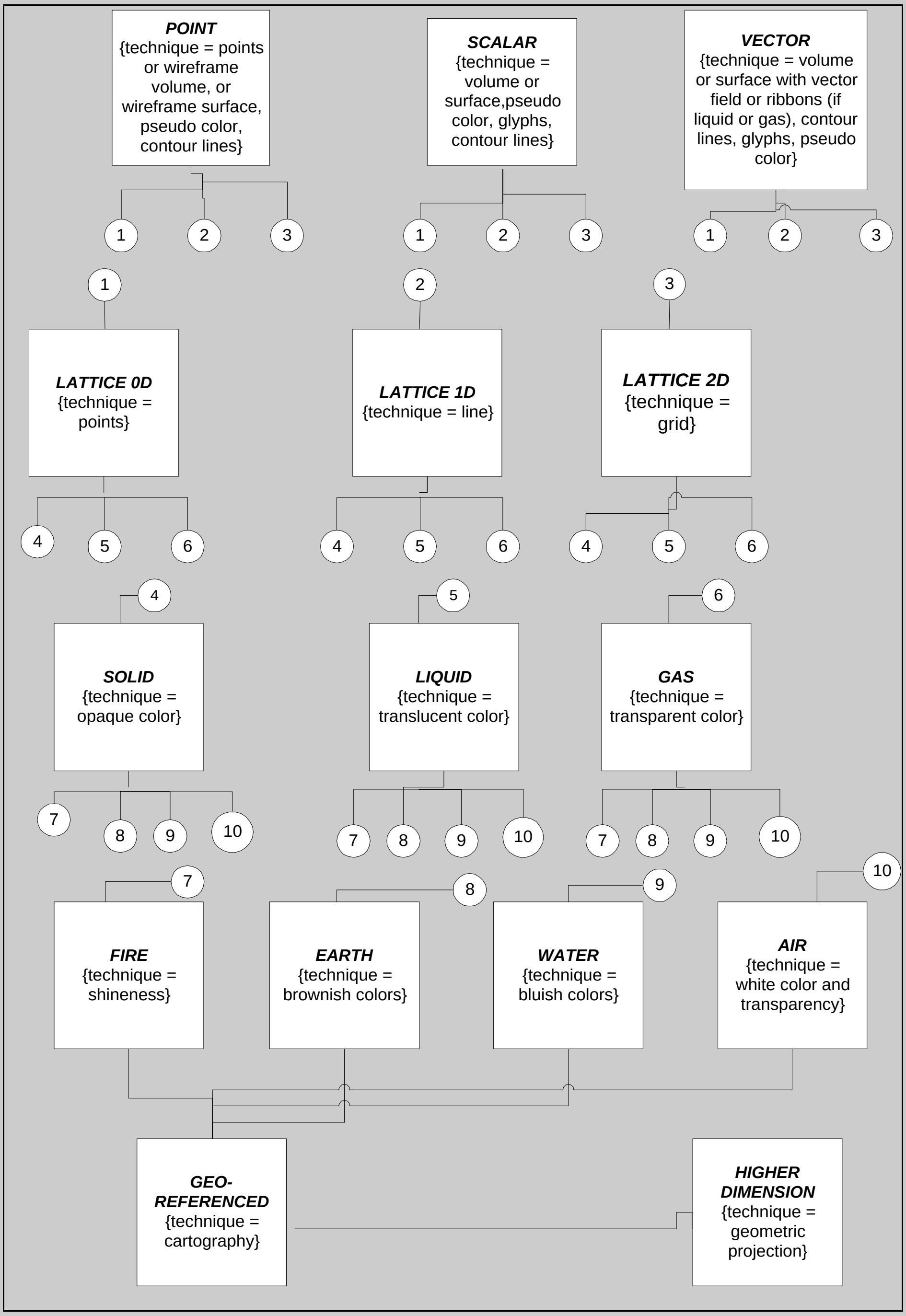

Figure 7: Visualisation Mapping Tagged Values

7. CONCLUSION

The model should be implemented in a modular way, enabling easily its update with a new analytical tool or phenomena simulation. The platform should be portable, flexible and extensible. These factors are necessary in the visualization area because constantly new technological inclusions might be done.

Virtual reality, collaborative [Brodi94] visualization and connection to **GIS** systems, are some areas of the extensiveness we are predicted in a application to natural resources management, that aims visualization as a key for information communication.

The area being analysed – natural resources – introduces a reasonable complexity. Its characterization is not easy. It implies different areas, such as dynamic fluids, earth sciences and terrain modelling. The combination of different visual techniques should be achieved in order to represent correctly different data characteristics. Because of this, a proper visualization must be achieved through the use of a well balance combination between data model, task to perform and visual technique. Another point is the relation between effectiveness and simplicity.

Because of the great amount of data and the complexity of simulations, in order to obtain a scientific visualization of quality, the use of potent equipments is still a real demand. The use of software specialized to the scientific visualization, is not any more a tendency but a real necessity. The complexity and variety of visualizations that are necessary demands a potent graphical library at least. Besides this, these kind of software introduce easy extensiveness to other systems – GIS, Virtual reality, etc. - and portability to other hardware.

The implementation of the prototype showed that the visual and cognitive model meets the visual expectation of the scientists in this area and validated the extensiveness, portability and flexibility of the model.

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