Attributes Propagation on FEA Model

Ouarda Rachidiou
Laboratoire de Génie de la Construction et Architecture, Université de Bejaia, Route De Targa Ouzemmour, 06000, Bejaia, Algérie.
orachidiou@yahoo.com

Okba Hamri
Laboratoire de Génie de la Construction et Architecture, Université de Bejaia, Route De Targa Ouzemmour, 06000, Bejaia, Algérie.
okba.hamri@hmg.inpg.fr

Abstract – A way to manage the information needed during the FE simulation model preparation is by means of attributes linked to the adopted models. This paper presents the design and implementation of an attribute management system that supports the representation of all the information and data related to the simulation domain definition, needed to qualify an engineering analysis. The main objective of such a system is to be able to attach, maintain, reuse and check the attributes during the FE simulation model preparation. Among the applications of such an attribute system there is the ability to maintain all the HLT representations (BCs, material, B-Rep topology) in the same HLT data structure called the evaluated HLT and dedicated to express and describe specific concepts as they can be needed at a given stage of the preparation process.

Keywords – CAD models, simulation models, High Level Topology (HLT), attributes management system.

1. INTRODUCTION

Engineering design models are typically simulated and checked for safety against multiple loading and conditions. The simulation serves to confirm long before the product goes into service that the design would perform adequately and satisfy design requirements [1]. The simulation that predicts the physical behavior of an engineering component is commonly termed (engineering analysis). The analysis solution method used may be of different types, including finite element analysis (FEA) and formula based analysis. Further, discipline of analysis may be structural, thermal, vibration etc. Design models are usually analyzed across various analysis disciplines and analysis types. For a given design model, once the type and discipline of analysis is selected, many analysis models with varying levels of simplification may be defined.

This paper is organized as follows. Section 2 addresses attributes classification. Section 3 states persistent naming problem. Section 4 describes our proposed approach for then attributes management. Section 5 introduces the attributes attachments mechanism (application).

2. ATTRIBUTES CLASSIFICATION

2.1. Attribute concept

For our context, we defined an attribute as object with a specific meaning associated to a specific step of the FE simulation model preparation process. Its meaning depends on the simulation objectives that need to be characterized. For each analysis an unique set of attributes is associated. This later is composed of a set of topological and geometrical attributes in addition to the attributes expressing the concepts specific to this FE analysis, i.e. pressures, forces, temperatures,…

2.1.1. Topologic attributes:

The topological attributes are related to the definition of the High Level Topologic (HLT) entities. Because there are several HLT data structures that can be derived from the HLT schema.

2.1.2. Geometric attributes:

The geometric attributes related the definition of the geometric domain defining the model shape during the successive steps of the FE model preparation.

2.1.3. Analysis case:

Which are the attributes defining the physical problem being modelled such type of analysis (structural, thermal, vibration, or composition: structural + thermal ...), hypothesis type (displacement calculation, constraint calculation, idealisation forte, shear ...), each analysis case is composed by a set of models entity represented by a graph (relationships between the models). And each analysis is associated to the geometry of CAD model, when the geometry is modified a new analysis case is created.

2.1.4. Model entity:

According to the type of analysis we have a set of models entity (Material model, Mechanical model, Assembly model, Feature model, B-Rep model, polyhedral model) which associated to the set of hypothesis, and each model entity is represented by an unique topology graph which is associated to the geometric model.

2.1.5. Topology entity:

Topology refers to the spatial relationships between the various entities in a model. Topology describes how geometric entities are connected. Topology entity is associated to the geometric model.

2.2. Organization of attributes :

To support the effective specification of attributes for the complete set of related analyses, while at the same time making it efficient to collect the attributes required for each specific analysis, an organizational structure is needed for the purpose of describing sets of attributes. The organizational structure must, effectively, support a design process for scenarios where multiple physical behaviors must be evaluated. In many cases, the result of one analysis represents part of the problem definition of another.

3. PERSISTENT NAMING PROBLEM

The proposed HLT data structure [2] can handle the description of a form feature model, of a B-Rep topology of a CAD model, of BCs; of material distribution ... Therefore, all these concepts have their associated HLT data structures, which are instances of the same data structure. All these representations should be maintained and stay consistent during the FE simulation model preparation taking place over the polyhedral representation associated to the object. Maintaining all these HLT representations on the same polyhedral representation, raises many issues referred to as topological naming problem', which is in fact classically defined as persistent naming problem in the field of feature-based modeling [3], [4].

This problem consists in assigning persistent names to topological entities that may no longer exist at a given stage of the shape transformation process or that may be subdivided into several topological sub domains of the current instance during the same process.

This topological naming issue hides in fact two different problems: the entity naming problem (when and how it is possible to incorporate, generate and attach the attributes to the model) and the name matching problem (after evaluation of the topological changes due to an operator to maintain the consistency of the model) (see Figure 1). Indeed, the last one refers to the combination of different topological decompositions of the object boundary to meet user's needs and this combination of topological decompositions is also referred to as evaluated topology. The example of Figure 1 clearly shows such a configuration. The Figure 1(a) depicts the two HLT-Faces associated to two HLT-Bodies in contact before the evaluation and Figure 1(b) represents the three HLT-Faces derived from the original HLT-Faces after the contact evaluation and merging process between the two initial faces.

Indeed, distinguishing the HLT entities before and after this evaluation process, a specific naming mechanism is required.

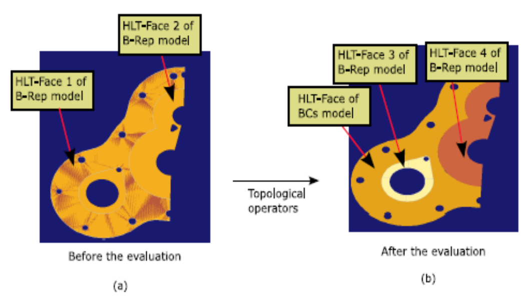

Figure 1: The evaluated topology concept: (a) The HLT of an initial B-Rep model with two HLT-Faces in contact (before the evaluation), (b) the evaluated topology after applying topological operators (after the evaluation).

The HLT data structure has been validated on a set of industrial components.
All the implemented data structures led to development of our software called"Impact", which is a software application based on Open Cascade library. "Impact" has been successfully integrated into"Simpoly".
Simpoly: is a specific industrial software dedicated mainly for the simplification of polyhedral models (see figure 2). It has been developed within the laboratory 3S.

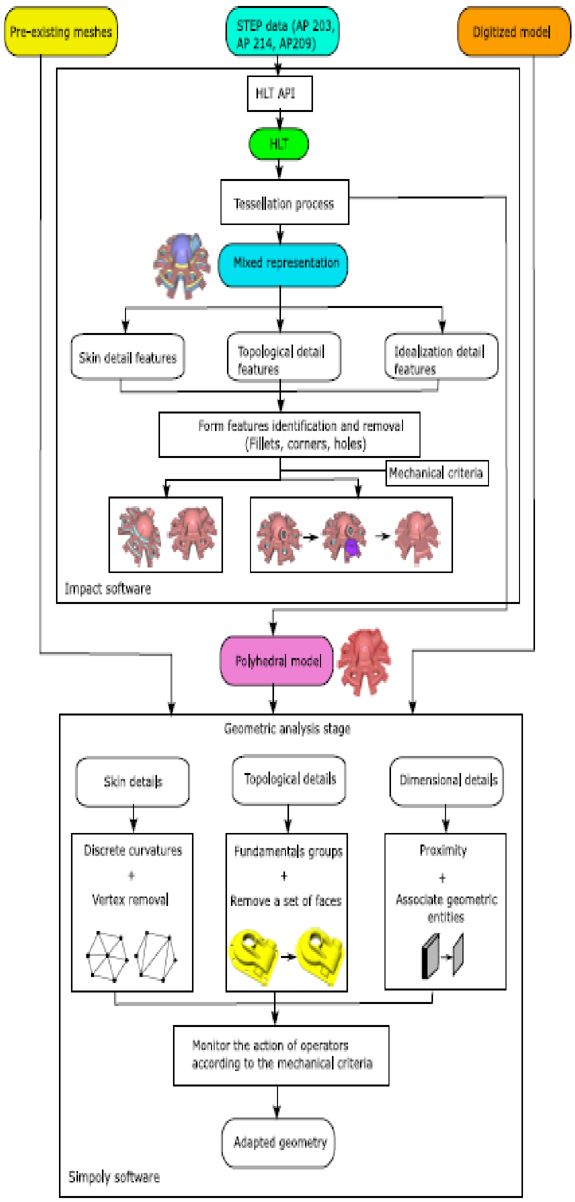

Figure 2: The integrated environnement for FE simulation model preparation.

4. ATTRIBUTES MECHANISM

4.1. The proposed approach

An alternative solution to the persistent naming problem is to set the attribute system as independent from the other data structures used in the software environment to ease the software maintenance and reduce the attachment process to a logical link between a geometric or topological entity and its attributes. The main categories of approaches related to the attribute attachment mechanism are:

.The "topology-driven" approach, which consists in attaching the attributes directly to the target entities (either topological or geometrical) (see Figure 3). This approach is used in most industrial software, its disadvantage is that it is not possible to maintain or reuse or check the attributes during the shape transformations up on the data structures of the geometric modeler, which are evolving during these transformations. Therefore, it becomes complex to propagate the attributes during such operations,
. The "reference key-driven" approach (see Figure 3). This approach is implemented in the form of labels. Application data are attached to these labels as attributes. By means of the labels and the graph structure they are organized in, the reference key aggregates all the user data, not just shapes and their geometry. These are attributes like any other; no one attribute is master of the others [5], which is an argument to ease the generation of the evaluated topologies with respect to all the other HLT data structures describing the individual concepts attached to a model. Effectively, the evaluated topologies should just be considered on the same level as any other instance of HLT data structure.

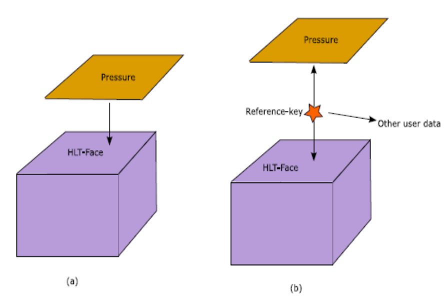

Figure 3: The main categories of approaches related to the attribute attachment mechanism: (a) topology driven approach, (b) reference-key approach.

The proposed approach lead to the development of the software, called Impact, which was been implemented into Open Cascade environment and then integrated into the Simpoly software provide the integrated software environment (see figure4), note that this last one is a commercial software dedicated to the polyhedral simplification.

4.2. The attributes mechanism

The attributes mechanism implemented in the proposed approach is based on the “reference key-driven” approach. On a single reference-key many attributes can be attached. For example, to associate the pressure to a topological face in a geometric model, both the face and pressure are attached to the same reference-key (see Figure 3). The geometry or topology becomes the values of shapes attributes, just as a number is the value of an integer attribute and a name that of a string attribute.

5. ATTRIBUTES PROPAGATION MECHANISM

One application of such a mechanism is to handle the evaluated topology as easily as possible (see Figure 5).
The label is associated to its attribute structure, which contains and maintains all the attributes attached to it.
Therefore, we can associate to each label a set of attributes. For example, in this case the HLT data structures an attribute attached to the label and similarly a tessellation can be an attribute attached to its corresponding label.
Additional attributes can be associated to the evaluated topology through this mechanism (tessellation ...).

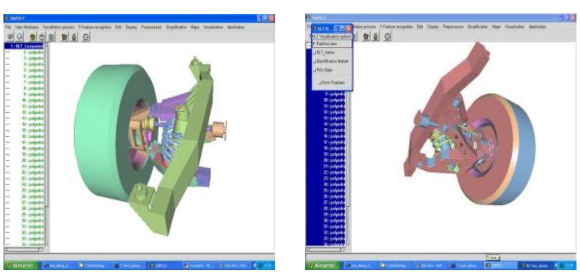

Figure 4: interface environment simpoly.

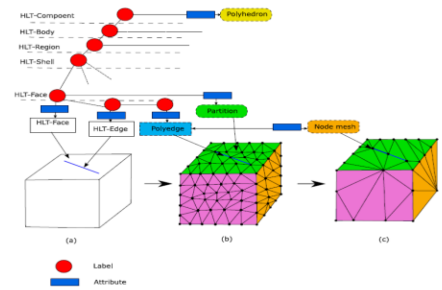

Figure 5: Example of attribute system application.

6. CONCLUSION

To efficiently support the creation process of FEA models from CAD data, several data and information describing both the object and the simulation case should be made available. In this paper, attribute management mechanisms are proposed. It represents a first step to set up a new attribute system for the representation and propagation of such data. A set of elements presented in this paper represent a key for transferring data between the model shapes generated throughout the model preparation process and characterizing the shape evolution process taking place during this preparation process. For time reasons, the attribute management mechanisms have been partially implemented and should be completed in the future to further validate the proposed approach. The important property of such a system is that it is independent of the set of data structures, and enables to follow their evolutions during the shape changes of the preparation process.

7. REFERENCES

[1] S.,D.C. Barton and N.K. Shaw (1993). "Steps Towards CAD-FEA Integration." Engineering with Computers 9(1): 17-26.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[2] Okba Hamri, J-Claude Léon, Franca Giannini, Bianca Falcidieno., Software environment for CAD/CAE integration, July 2010

[3] J. Kripac, A mechanism for persistently naming topological entities in history-based parametric solid models (Topological ID System) Proceedings of Solid Modeling ’95, Salt Lake City, Utha USA, 1995, pp 21-30.

[4] D. Agbodan, D. Marcheix, G. Pierra, A data model architecture for parametrics, Journal for Geometry and Graphics, 1999,Vol. 3, pp 17-38.

[5] Open CASCADE Application Framework.