Notes on the Mesh Handler and Mesh Data Conversion

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1. Introduction

At the outset of the development of the thermal-hydraulic code (THC) [1], efforts have been made to utilize the recent technology of the computational fluid dynamics. Among many of them, the unstructured mesh approach was adopted to alleviate the restriction of the grid handling system. As a natural consequence, a mesh handler (MH) has been developed to manipulate the complex mesh data from the mesh generator. The mesh generator, Gambit[2], was chosen at the beginning of the development of the code. But a new mesh generator, Pointwise[3], was introduced to get more flexible mesh generation capability. An open source code, Paraview[4], was chosen as a post processor, which can handle unstructured as well as structured mesh data. Overall data processing system for THC is shown in Figure-1.

There are various file formats to save the mesh data in the permanent storage media. A couple of dozen of file formats are found even in the above mentioned programs. A competent mesh handler should have the capability to import or export mesh data as many as possible formats. But, in reality, there are two aspects that make it difficult to achieve the competence. The first aspect to consider is the time and efforts to program the interface code. And the second aspect, which is even more difficult one, is the fact that many mesh data file formats are proprietary information.

In this paper, some experience of the development of the format conversion programs will be presented. File formats involved are Gambit neutral format, Ansys-CFX grid file format, VTK legacy file format [5], Nastran format [6], and CGNS[7].

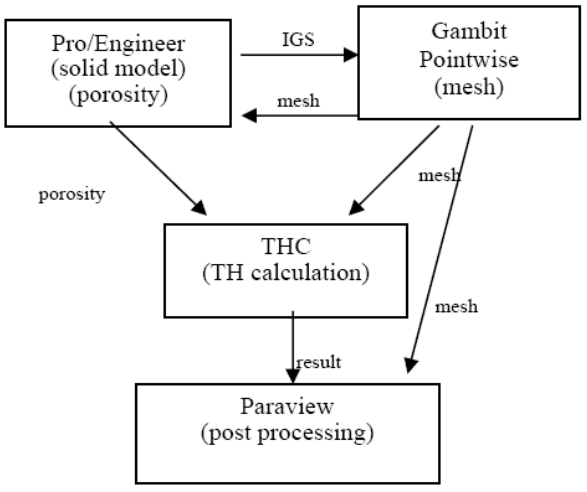
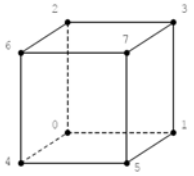


Figure-1. Data Processing Flow

2. Gambit File Format and Mesh Handler

Gambit neutral file format (GAM) which has extension ".neu" is well documented in its documentation system. This is the fact that makes the neutral file format as a reference the THC code. It defines not only the vertexes of a cell but also the edges and faces as well, as shown, for example, in Figure-2 for a hexahedron. This information is fully utilized in the mesh handler to find connectivity data around a cell.



Edge and Face Definitions

Edge	Nodes	Face	Nodes
1	0,4	1	0,1,5,4
2	0,1	2	1,3,7,5
3	1,5	3	3,2,6,7
4	4,5	4	2,0,4,6
5	1,3	5	1,0,2,3
6	3,7	6	4,5,7,6
7	5,7		
8	2,3		
9	2,6		
10	6,7		
11	0,2		
12	4,6		

Figure-2. Definition for hexahedron

Gambit puts out the ASCII data with double precision numbers. It mainly consists of four data parts, control, vertex, cell, block, and boundary (BD) condition. The control section tells us the numbers for vertexes, cells, blocks, and BD conditions. Vertex section lists the vertex serial numbers in parallel with their coordinates. Cell section defines individual cells with serial numbers in parallel with a series of vertex serial numbers. Block section lists the cell serial numbers in the block. BD section groups the cell faces that enjoy the same type of BD condition.

Mesh Handler is programmed with C++ language. MH heavily uses "vector" container in Standard Template Library [7]. Most of the data, such as vertexes, edges, faces, and cells, are stored in the respective vectors. MH can handle the most important cell types such as tetrahedron, hexahedron, prism, and pyramid. MH inputs data from Gambit file. MH has cell definition information, such as shown in Figure-2 for hexahedron cell, for example, as a static data. MH uses this information during the search for solving the cell connectivity issue.

Even though Pointwise has the capability to export mesh data with various types of file formats, it does not produce neutral file format. Therefore, it is necessary to choose a file format and to convert it to a neutral file format. Ansys-CFX grid file format (CFX) was chosen among many others because of the conciseness of the information.

3. File conversion and related issues

When one tries to convert a file format to another, firstly, the cell definition information should be correctly transformed. Considering the number of involved geometric entities one can imagine that the cell definition convention can be varied in many different ways. To make the comparison more feasible, right hand screw (RHS) cell definition system (CDS) is set up. It assumes; (1). base face sit on the floor. (2). base faces of tetra and hexahedron are arbitrary because of the isotropy of topology. (3). base face of pyramid is rectangular face. (4). base face of prism is one of triangular faces. (5). all of the geometric entities are assigned identification numbers in right hand screw direction consecutively from the base face.

According to the CDS rules, one can understand the fact that the respective RHS columns of the Table-1, 2 and 3 are simply ordered, i.e. consecutive numbers compared to other file formats.

Table-1. Vertex identification of GAM & CFX

geometry	RHS	GAM	CFX
tetra	0-1-2-3	0-1-2-3	0-1-2-3
hexa	0-1-2-3- 4-5-6-7	0-1-3-2 4-5-7-6	0-1-3-2 4-5-7-6
pyramid	0-1-2-3-4	0-1-3-2	0-1-2-3
prism	0-1-2- 3-4-5	0-1-2- 3-4-5	0-1-2- 3-4-5

Table-2. Face identification of GAM & CFX

geometry	RHS	GAM	CFX
tetra	1-2-3-4	1-2-3-4	1-2-3-4
hexa	1-2-3-4-5-6	5-1-2-3-4-6	5-3-2-4-1-6
pyramid	1-2-3-4-5	1-2-3-4-5	5-1-2-3-4
prism	1-2-3-4-5	4-1-2-3-5	4-2-3-1-5

Table-3. Vertex identification of VTK & Nastran

geometry	CGNS	VTK	Nastran
tetra	0-1-2-3	0-1-2-3	0-1-2-3
hexa	0-1-2-3- 4-5-6-7	0-1-3-2 4-5-7-6	0-1-3-2 4-5-7-6
pyramid	0-1-2-3-4	0-1-3-2	0-1-2-3
prism	0-1-2- 3-4-5	0-1-2- 3-4-5	0-1-2- 3-4-5

Face numbering starts from one instead of zero for matching the convention shown in Figure-3. In that figure, the number in a circle and the bare number represent a face and a vertex respectively. Red numbers indicate the differences in definitions. As shown in tables, two file formats take the same definition for the tetrahedron. For hexahedron and prism, vertex definitions are the same but face definitions are different. For pyramid, from definitions of the vertex two file formats are different. Face information for VTK and Nastran has not been fixed because they are not available.

CFX file format was not available. Therefore, the information was extracted by Pointwise with the following procedure. Producing a single cell of any type, choosing the Ansys-CFX solver, specifying a distinct boundary identification to every face, and then (single cell) block data was exported to get the necessary information. This method was working for all cell types except pyramid cell because it is impossible to generate a pyramid cell separately with Pointwise. But base face of the pyramid can be identified because of the four vertexes. Rest of the faces of the pyramid is not of concern because they can not be boundary faces anyway.

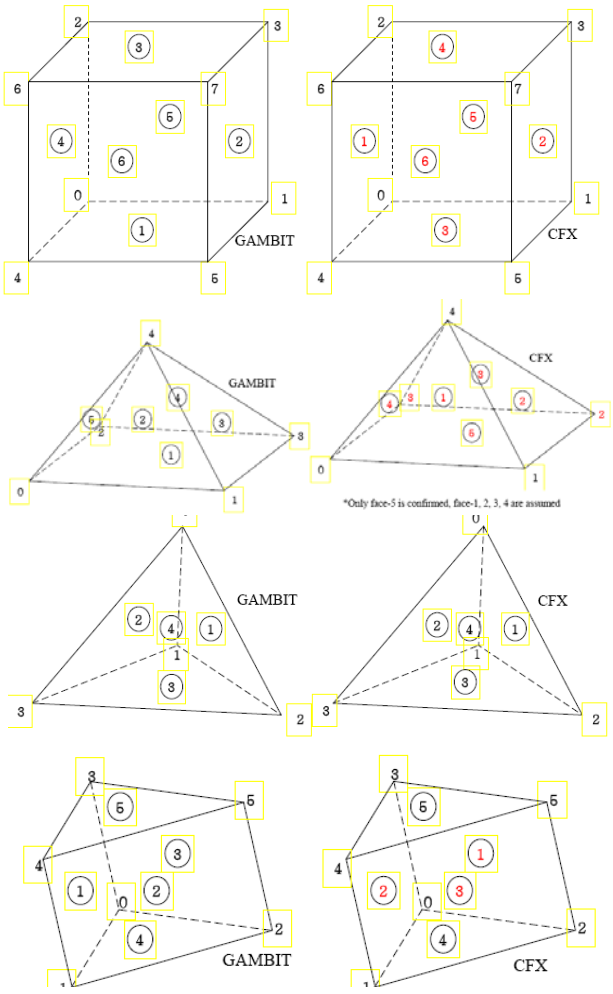


Figure-3. Cell Definition

4. Conclusion and Further Works

Mesh Handler for THC code has been extended to import the CFX file format. Several other mesh data formats are identified as well. The extension process will be continued to import more file formats, such as CGNS and Fluent[8] file formats.

REFERENCES

[1] Numerical solution methodology; kopec/ned/tr/07-10rev0
[2] Gambit 2 Users Guide; http://www.fluent.com/
[3] http://www.pointwise.com/
[4] http://www.paraview.org/
[5] The VTK Users Guide; http://www.kitware.com/
[6] MSC.Nastran; http://www. mscsoftware.com/.
[7] http://cgns.sourceforge.net/
[8] Tgrid 3.4 Users Guide; http://www.fluent.com/