The Mesh Class of GSS

Index:

Part1.   The mesh organization requirement of semiconductor simulation

For describing a simple two-dimensional PN junction diode, there is no need to setup a complex mesh structure. Unfortunately, we may meet CMOS transistor.
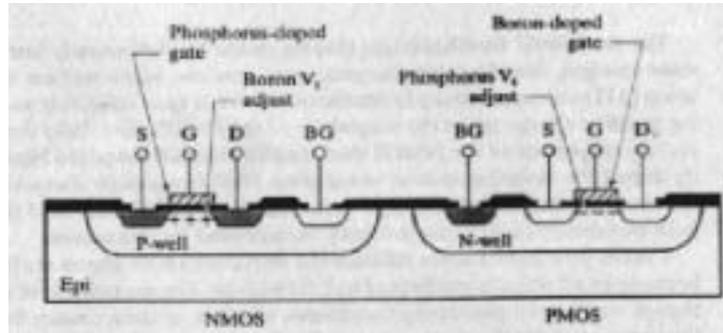

Fig 1.1 CMOS device

This is a mesh plotting extracted from floops. Beside silicon bulk, there are SiO2 layers and polysilicon gates. So, the device has 3 different kinds of materials: silicon, oxide and polysilicon. We must find a way to describe each of them.
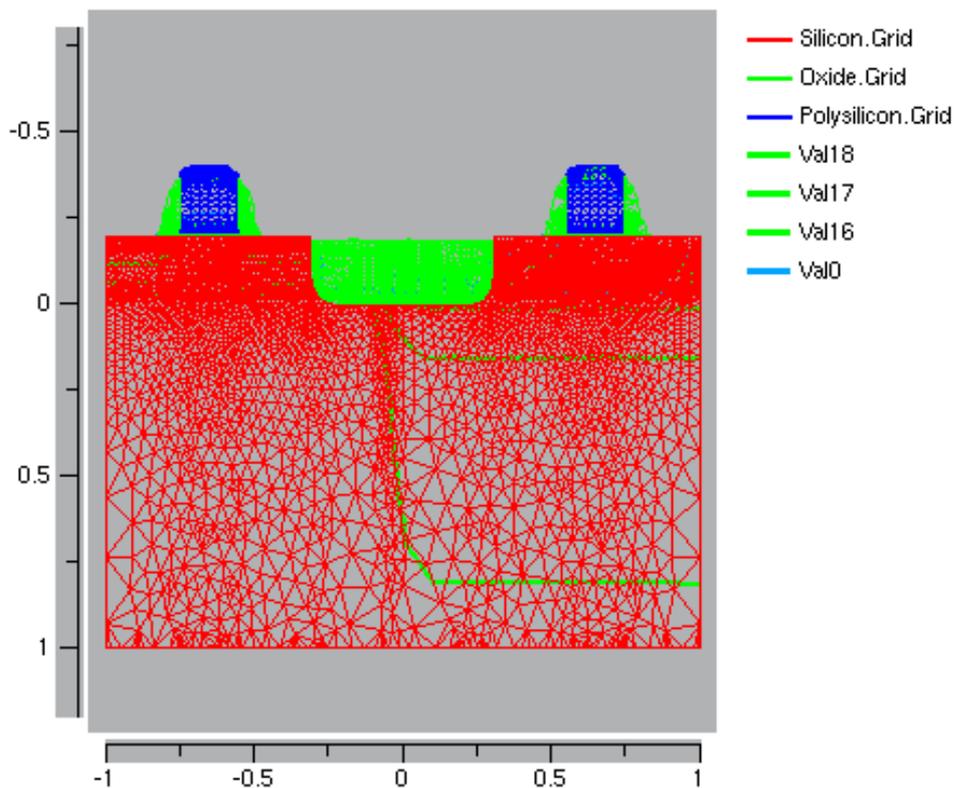

Fig 1.2 Mesh structure of CMOS transistor

There are two basic methods to support multi-type materials. First, the mesh is global and an extra label is assigned to each node to identify different materials. Second, we can group nodes to different regions and material label is assigned to each region. We choose second method at last, for it is more straightforward flexible and convenient for further use.

But we still build globe mesh structure for adaptive mesh refinement.

Part2. The mesh quality requirement of finite volume method

Our code uses classical FVM method, which means the control volume is surrounded by centers of circumcircle of nearby triangles. We hope no obtuse angle exist in these triangles. Or last least no obtuse angle towards the boundary segment.
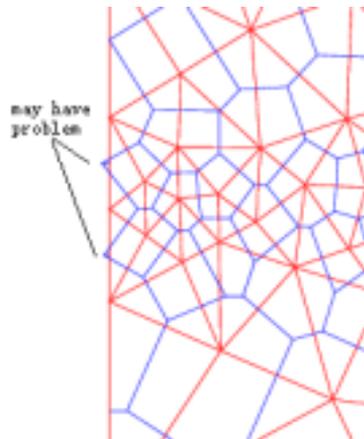
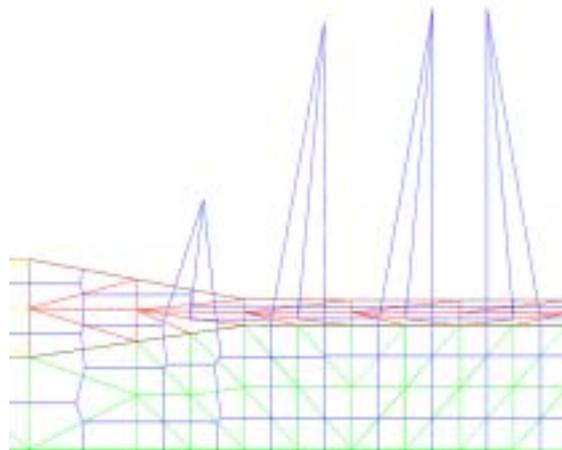We can bear figure 2.1 but no figure 2.2.

Fig 2.1 Good mesh   Fig 2.2 Bad mesh

Part3. The layered mesh structure

3.1 global layer and zone layer

The mesh class is separated into global (up) and zone (down) layer. When the mesh is imported from cgns file, it is stored in zone level. If multi zones exist, an zone interface object is built for zone-to-zone connectivity information. The discrete step of PDEs also depends on the mesh of zone level. The global level of mesh is built from zone level when adaptive mesh refinement is called. And after mesh refinement finished, new global mesh will be converted to zone level again.
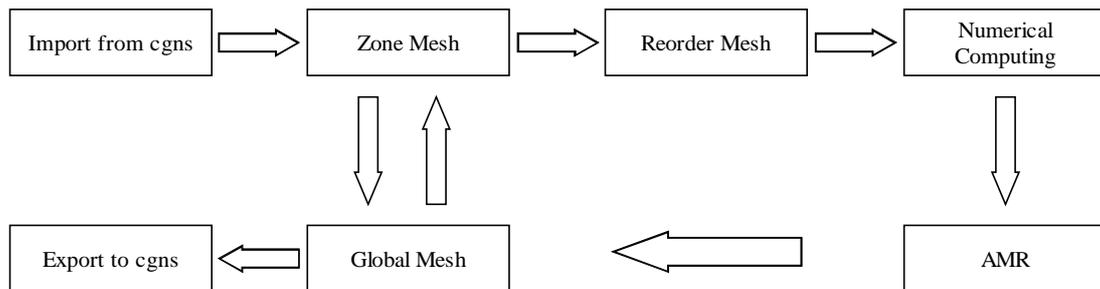

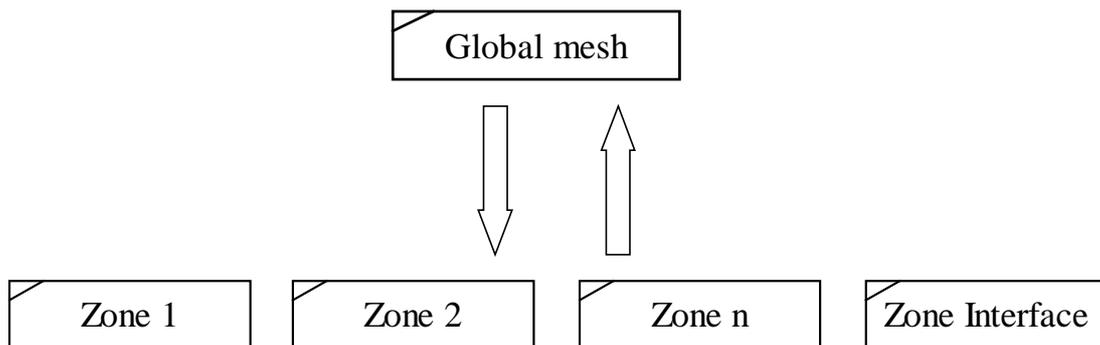Fig 3.1 The mesh functions of GSS

Fig 3.2 Mesh level

3.2 the mesh data structure of zone layer

In the zone level, mesh structure has 4 basic elements.

Class Node	Class Triangle
Attributes: The location (x,y) of the node. The boundary index of the node	Attributes: The index of the zone this triangle belongs to. The three of fore nodes belong to the triangle The area of the triangle.
Class Segment	**Class VoronoiCell**

Attributes:
 	
// segment is a collectioon of
// boundary edges with same lable
 	
The edge array.
The boundary index of these edges.
	Attributes:
	
	// this is the most complex data strcture.
	
	The location of the cell centre.
	The number of its neighbors.
	The position vectors to its neighbors.
	The edges of the cell.
	The area of the cell.
	If the cell is in boundary, the mirror site of its
	neighbors are stored for ghost cell technique.

Fig 3.2 Mesh class

The node and triangle object are mainly used for communicating with cgns file. The object segment will be converted to boundary condition during scientific computing. And last, the Voronoi cell contains the basic geometrical information for FVM method.
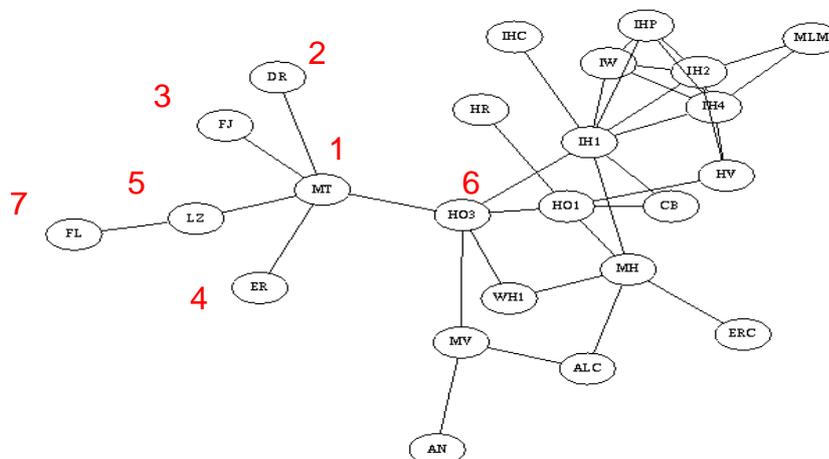
Part4. Reduce bandwidth of matrix

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Fig 4.1 Breadth-First search

A simple Breadth-First search can achieve our goals.

```
1.  Represent the mesh structure as a graph

2.  Choose a suitable starting node

3.  For each node reachable from the current node

    {

      Output the node

      Find all unvisited neighbors

      Order them based on increasing degree

      Visit them in that order

    }
```

Part5. Adaptive mesh refinement

Triangle, which has 16,000 lines of c code and designed by Jonathan Richard Shewchuk, is an excellent two-dimensional unstructured mesh toolkit. The author is an export in quality mesh generation and refinement. I just call triangle to refine the mesh and she never disappoints me.
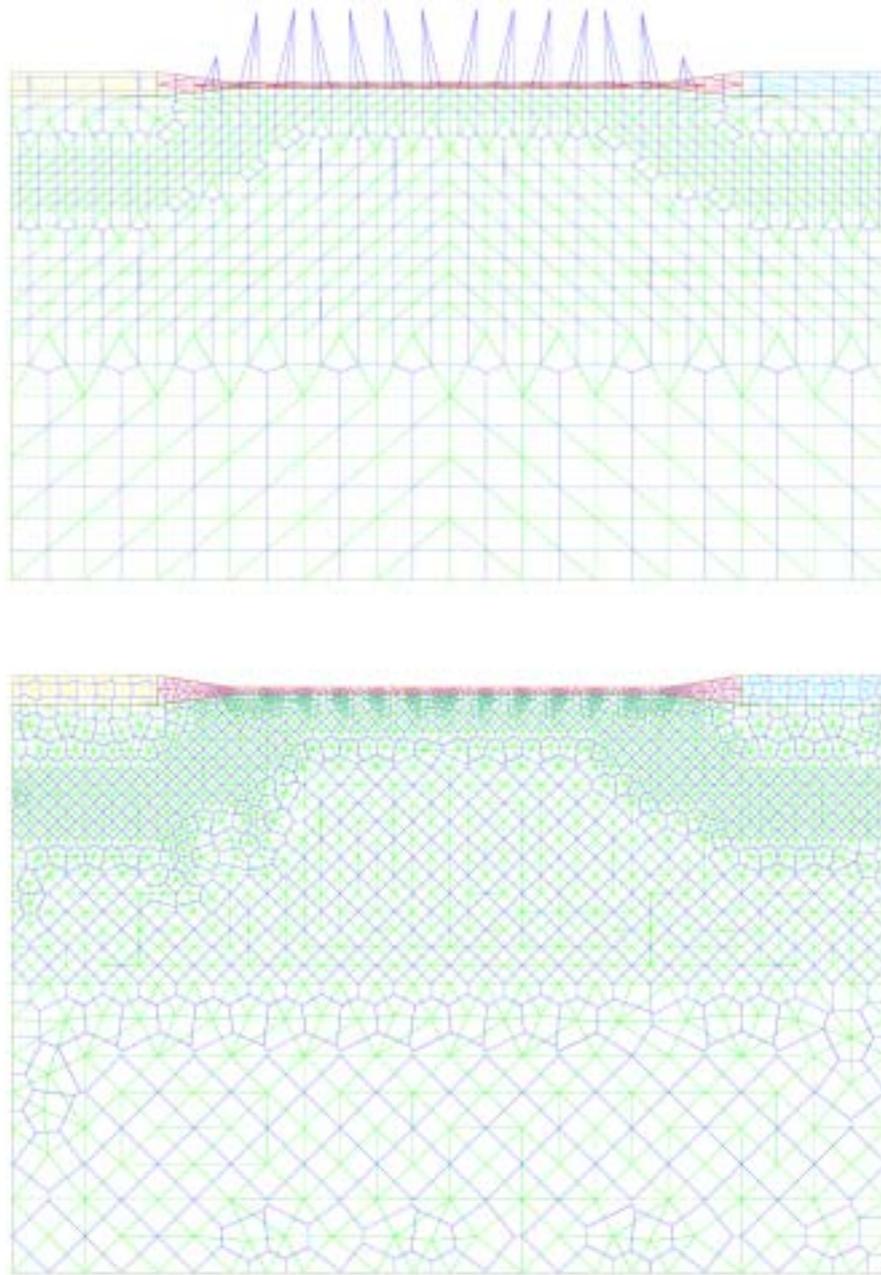
Fig 5.1 The result of mesh refinement.