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# Uniting Dissimilar Hex Meshes to Achieve a Many-to-Many Swept Topology

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**Abstract.** The pave and sweep approach for generating all-hex meshes continues to be the work-horse method for complex assembly models at Sandia. Model builders generally have to do significant amounts of often complex geometry decomposition to prepare the CAD model for sweeping. Being able to do many source to many target sweeping would significantly reduce the amount of decomposition required. Various attempts at a robust many-to-many sweeping algorithm have been made but a production-level capabilty still does not exist. One of the difficulties of the algorithm is generating clean imprints of projected source and target surfaces that result in high quality hexes and no slivers. This work describes a capability for uniting meshed volumes that don’t share a contiguous mesh at the interface. This capability will be used as a platform for further investigation into the source/target imprinting problem.

## Introduction

The pave and sweep approach for generating all-hex meshes continues to be the work-horse method for complex assembly models at Sandia. Due to the high quality that these meshes result in at the boundary of the domain, analysts are willing to put in large amounts of time decomposing their CAD models in order to get a swept mesh. The current production level sweeping technologies include single-source to single-target and many-source to single-target sweeping. Without the more complicated many-source to many-target (many-to-many) sweeping capability, model builders are often required to do large amounts of very sophisticated geometry decomposition. A robust many-to-many sweeping capability would significantly reduce the amount of decomposition required to generate swept meshes. Over time various efforts [1, 2, 3, 4] toward this goal have been made but to date a production level capability has not been developed. Most of these attempts try to automatically decompose the CAD model into many-to-one or one-to-one sweepable volumes. The difficulties associated with this are generally the 2D imprints of sources and targets and the decomposition of the interior of the volumes where there is no guiding geometry. This research attempts to gain further insights into the 2D imprinting of sources and targets by considering the scenario of uniting two meshed volumes that do not have a common mesh at their interface but which would result in a many-to-many swept mesh topology after a successful unite. We present a process for doing such a unite and a prototype capability within the CUBIT mesh generation software package.

## Approach

The high-level steps of the process we are describing for uniting meshed volumes are as follows.

1. Disassociate the original meshes from their CAD volumes
2. Unite the CAD volumes
3. Modify the meshes to be contiguous at the volume-volume interface
4. Reassociate the new mesh to the new CAD volume

Our research is focused on modifying the meshes to be contiguous at the interface (step 3). Figure 1 shows a sample problem that we will use to illustrate the approach. We determine all of the mesh loops that interact at the interface. These come from both loops that are on the interface itself but also mesh loops that can be propagated to the interface along hex columns from other features on the volume (Figure 2).

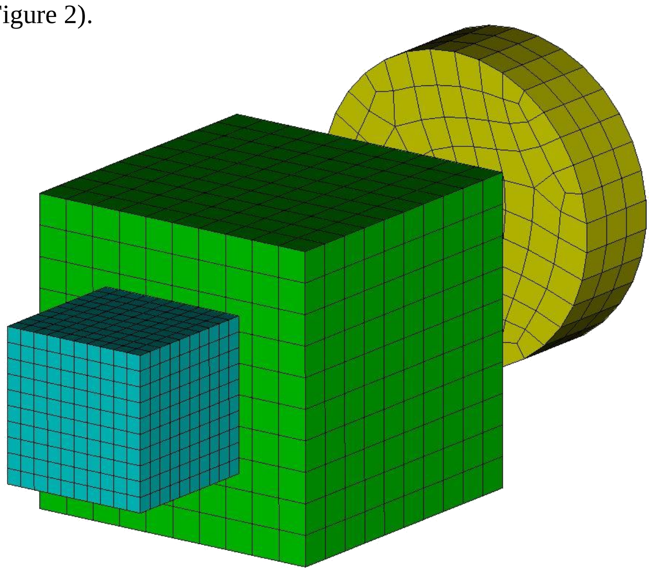


**Figure 1: Example problem.**

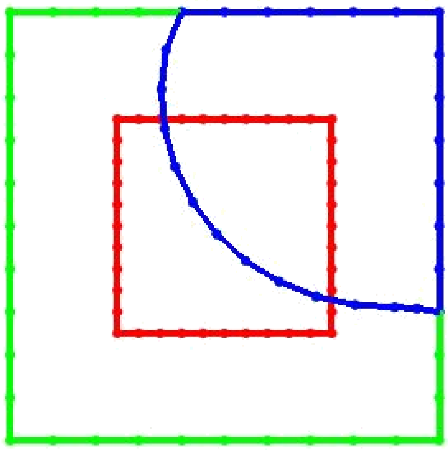


**Figure 2: Mesh loops.**

After propagating all mesh loops to the interface we intersect them to determine the new set of loops that must be paved and then swept away from the interface. Modifications to mesh loops that result from intersecting must be propagated back through the hex columns of the volume meshes so that the side walls later used for sweeping are consistent with the new mesh loops.

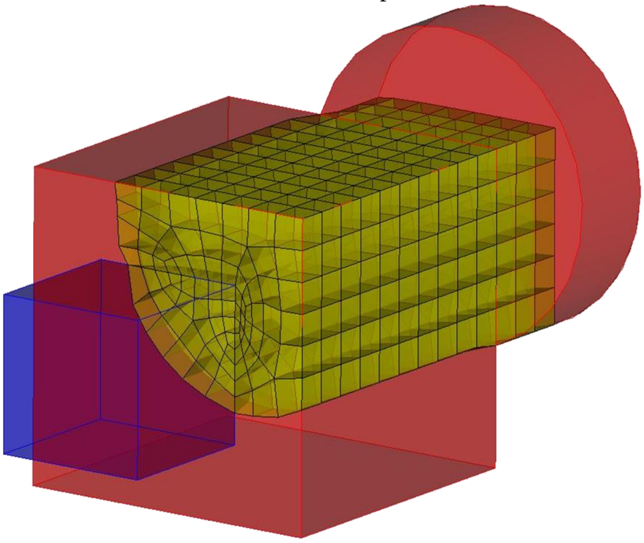


**Figure 3: New hexes generated by sweeping new mesh loops.**

Finally, the new mesh loops are swept back through the volume (Figure 3) and the new resulting hex columns are joined with neighboring mesh that was unmodified.

## Technical Challenges

The biggest technical challenge is coming up with the new loops to be paved and swept. In general, when the loops intersect nicely or are fully contained this is not a difficult problem. However, when loops come near to grazing one another there are cases when it would be better to snap loops to one another rather than creating slivers. The simple 2D example below (Figure 4) illustrates this concept.

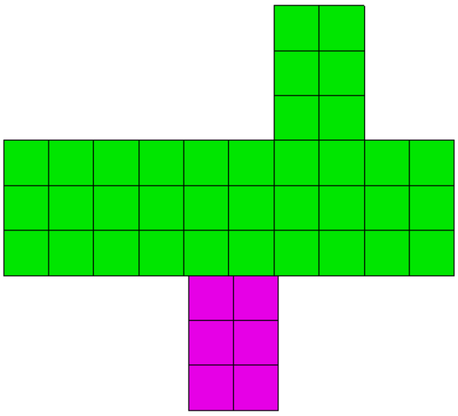


**Figure 4: Example of sliver generation.**

In Figure 4 the magenta surface mesh does not line up exactly with the green surface mesh.  If this is not taken into consideration the result of the unite will be that shown on the left below (Figure 5).  However, if proximity of interfacing meshes IS taken into account the result is that on the right below (Figure 5).

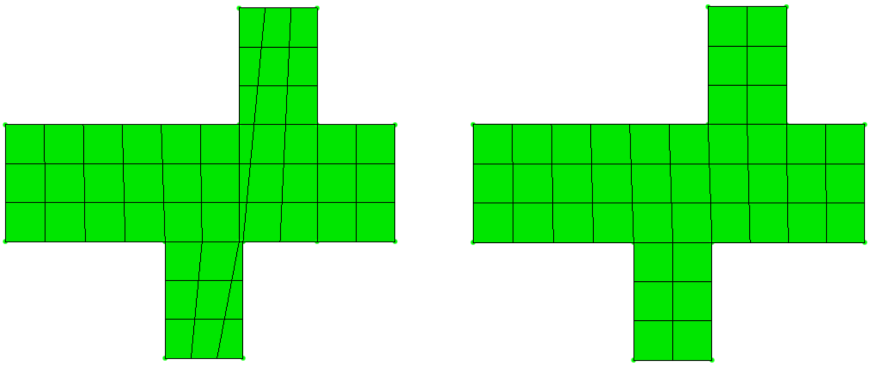
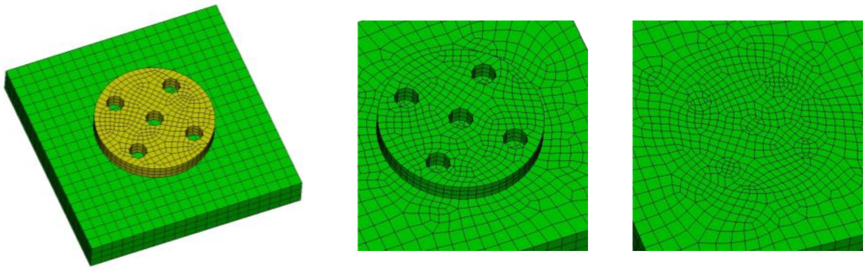


**Figure 5: Result with and without slivers.**

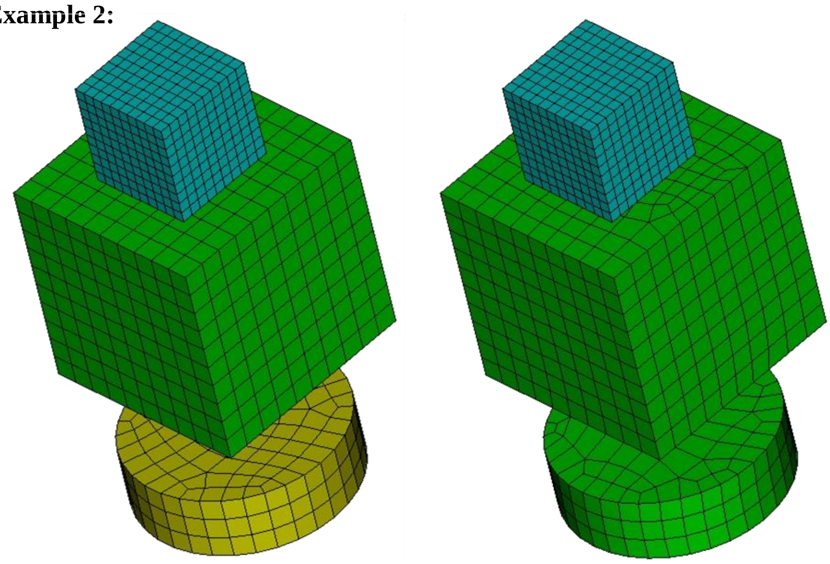
## Examples

**Example 1:**



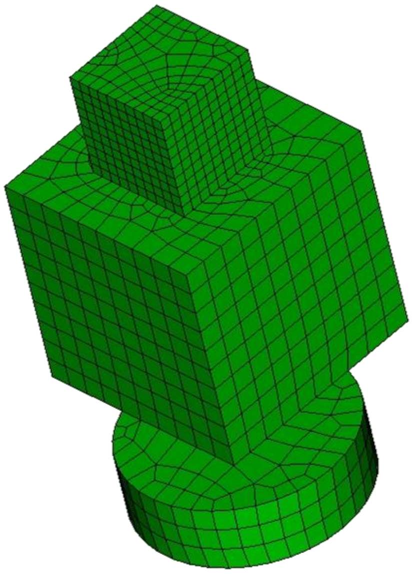
**Multiple contained loops** **Front after unite** **Back after unite**

**Example 2:**

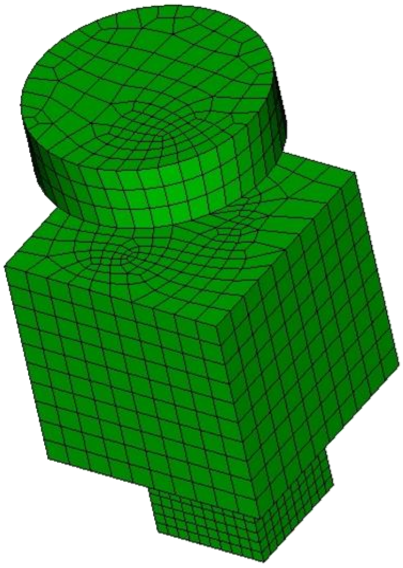


**Multiple volumes (intersections and contained loops)** **Front after first unite**

**Example 2 continued:**



**Front after second unite**



**Back after second unite**

## Future Directions

This work has been done to better understand the issues associated with imprinting source and target loops in a way that results in high quality swept meshes. The current capability provides a platform for further investigation into this problem. We plan to advance this 2D mesh loop imprinting capability to a robust level after which we will incorporate it into a new many-to-many sweeping algorithm.

## References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