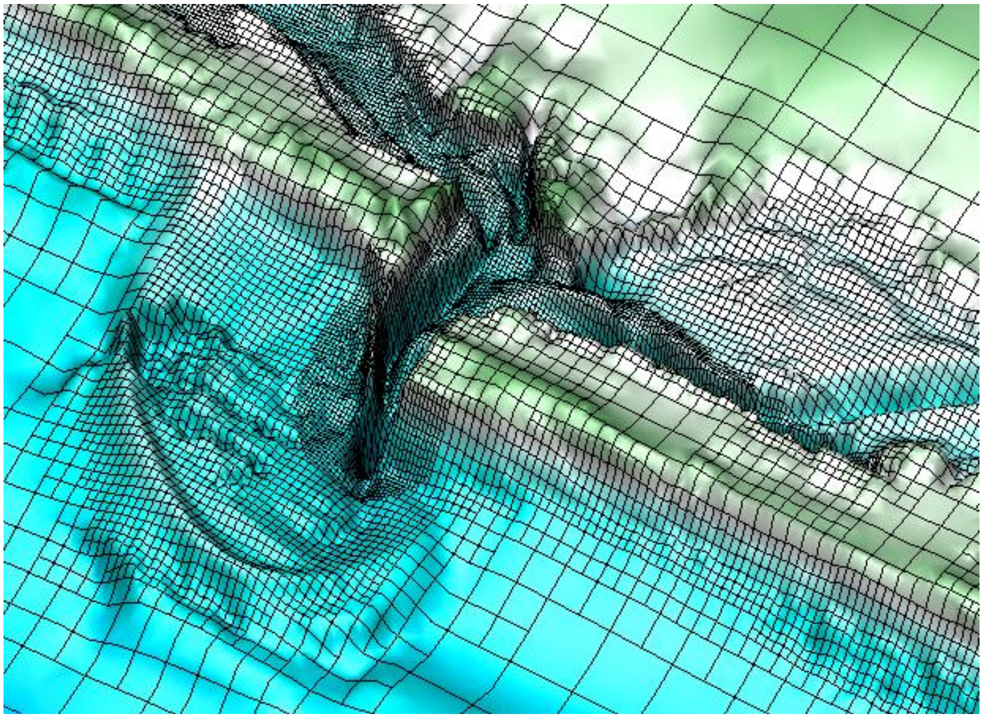
SMS 14.0 Tutorial

Quadtree Generation

Creating a Quadtree Unstructured Grid in SMS



Objectives

This tutorial demonstrates how to create a quadtree UGrid in SMS.

Prerequisite Tutorials

- Overview
- Map Module

Required Components

- SMS Core

Time

- 10–15 minutes

1 Introduction

This tutorial illustrates the process of generating a "quadtree constrained unstructured grid". A quadtree is hybrid mix of a Cartesian grid and an unstructured grid. It is different from a Cartesian grid in that each cell in the grid can be subdivided into four sub-cells, creating areas of increased resolution without decreasing cell sizes throughout the grid. In SMS, quadtrees can be used in several different simulation types. It is the principal geometric object for a CMS-Flow simulation and can be used for SRH-2D simulations.

For this example, bathymetry data (represented as a raster) and map module objects (coverages) from Ocean City inlet in the state of Maryland in the United States are provided in a project file which already includes a projection. From these, the quadtree grid generation process will be illustrated. Start by importing the project file:

1. In the SMS application, select *File* | **Open…** to bring up the *Open* dialog.
2. Select "Project Files (*.sms)" from the *Files of type* drop-down.
3. Browse to the *Quadtree_Generation\data files* folder and select "ocean_city.sms".
4. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1.

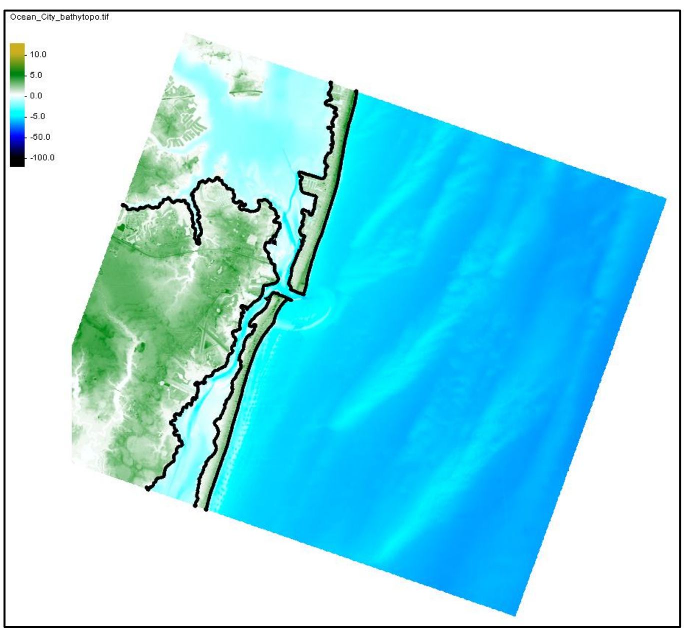


Figure 1 Ocean City inlet

As with any geometric grid in SMS, a quadtree is most efficiently generated from a Map module coverage of the associated type.

2 Defining the Quadtree Coverage

To create the quadtree coverage:

1. Turn off the “Pruned Coastline” coverage.
2. Right-click “Map Data” and select **New Coverage** to bring up the *New Coverage* dialog.
3. In the *Coverage Type* section, select **Quadtree Generator** under *Generic*.
4. For the *Coverage Name*, enter “Inlet Refinement”.
5. Click **OK** to close the *New Coverage* dialog and create the new “Inlet Refinement” coverage in the Project Explorer.
6. In the Project Explorer, drag “Inlet Refinement” coverage to be under the “Pre” folder.

3 Defining the Quadtree Grid Frame

A quadtree grid is based initially on a rectangular grid frame. To create the grid frame:

1. Using the **Create 2-D Grid Frame** tool, use three clicks to define the approximate extents of the computational domain using Figure 2 as a guide.

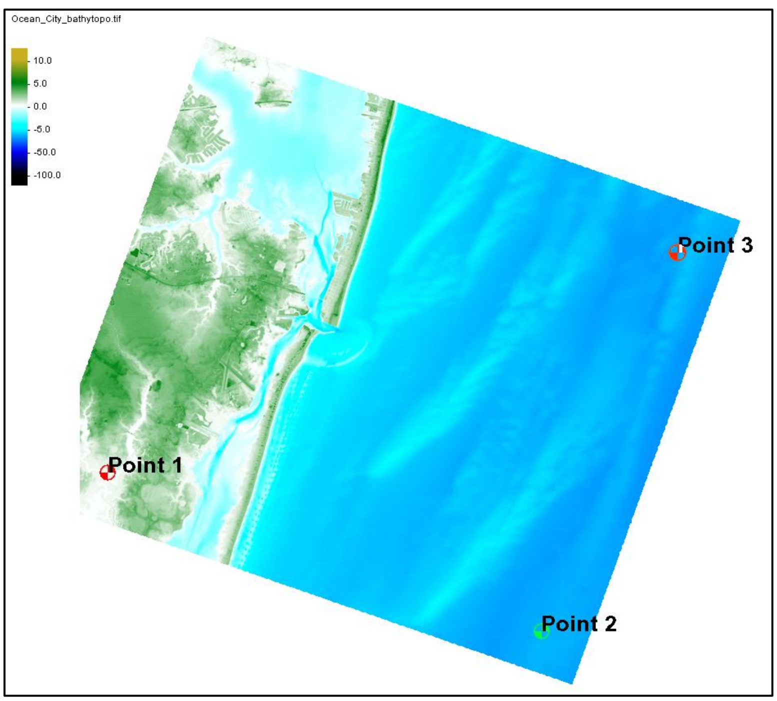


Figure 2 Grid frame generation points

   a. Click in the area labeled *Point 1* to define the lower left corner of the grid.
   b. Click in the area labeled *Point 2* to define the bottom edge of the grid.

c. Click at the area labeled *Point 3* to define the height of the grid.

Note: It is okay if the final grid frame does not appear exactly like the example. Exact dimensions are generally not known when setting up a grid. Guidelines for the grid frame include:

- The grid should include all areas of focus for the study.
- It is common for the grid to be aligned parallel to the shore or other geometric feature such as an inlet.

For this example, exact specifications will be specified later.

2. Using the **Select 2-D Grid Frame** tool, double-click on the selection handle in the center of the grid frame to bring up the *Grid Frame Properties* dialog.

   Note: This dialog allows explicit specification of the grid frame definition. The exact values do not generally matter in a real world simulation, but you may want to provide round numbers.

3. For consistency in this tutorial, enter the following in the *Origin, Orientation and Dimensions* section:
   - For *Origin X* enter “560000.0”.
   - For *Origin Y* enter “70000.0”.
   - For *Angle* enter “340.0”.
   - For *I size* enter “15000.0” (15 km).
   - For *J size* enter “13000.0” (13 km).

4. The *I Cell Options* section and the *J Cell Options* section, select the *Cell size* button and enter “160.0”.

   Note: This dimension is the maximum cell size for the quadtree and will be explained below.

5. Click **OK** to close the *Grid Frame Properties* dialog.

4 Defining a Refinement Region

As noted above, a quadtree grid is superior to a Cartesian grid because it can include refinement regions. This example will create a refinement region to refine the grid in the area of the inlet. A refinement region can be any shape. This example will use a polygon defined from the coastline.

To create the refinement region:

1. In the Project Explorer, turn on the “ Inlet” coverage and select it to make it active.

2. Using the **Select Feature Arc** tool, drag a box to select all arcs in the coverage.

   Note: Refer to the “Map Module” and “Wavelength Based Mesh” tutorials to learn how to construct this polygon interactively or from the coastline arcs.

3. Right-click and select **Copy to Coverage…** to open the *Select Coverage* dialog.

4. Select the “ Inlet Refinement” coverage and click **OK** to close the *Select Coverage* dialog.

6. In the Project Explorer, select " Inlet Refinement" to make it active.
7. Click the **Build Polygons** macro to build polygons.

The polygon should appear similar to Figure 3.

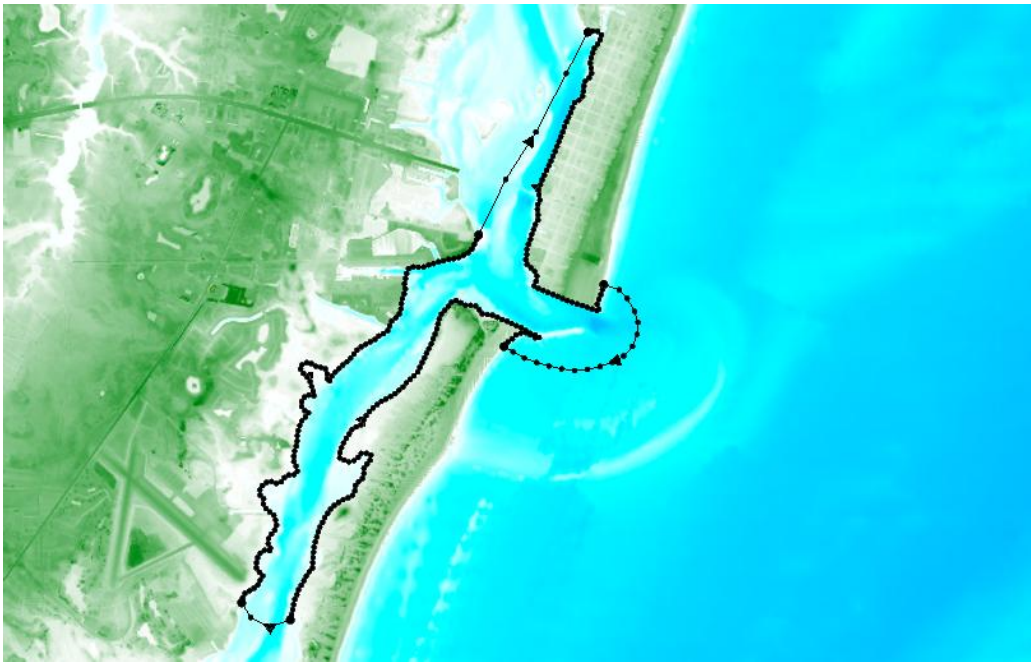


Figure 3 Refinement polygon over the inlet.

8. Using the **Measure** tool, measure the various distances across the inlet, the back bay, and the submerged jetty.

Note that the mouth of the inlet by the jetty is less than 200 meters wide, and the back bay at its narrowest point is about 300 meters wide. To represent flow through these openings, a minimum of 8–10 cells should exist across the opening. So, the maximum cell size for the inlet would be 25 meters (200 m/8 cells) and the maximum cell size for the inlet would be 37.5 meters (300 m/8 cells). This example will use a single refinement region, so the cell cannot be larger than 25 meters.

Next, note that the jetty is about 25 meters wide. This means that if a cell size larger than 25 meters is used, the jetty could be missed entirely. Ideally the cell size should be closer to half the width of the jetty. This could be done with multiple refinement regions, but a single cell size of 20 meters will be used for this example.

9. Using the **Select Feature Polygon** tool, double-click on this new refinement polygon to bring up the *Polygon Attributes* dialog.
10. Turn on the *Maximum grid cell size* option and enter "20.0" as the maximum cell size.
11. Click **OK** to close the *Polygon Attributes* dialog.

5 Generating the Quadtree

The quadtree is generated by converting the quadtree generator coverage to a quadtree grid. To do this:

1. Right-click on the " Inlet Refinement" coverage and select *Convert* | **Map → Quadtree UGrid** to open the *Map → Quadtree UGrid* dialog.

Note that the grid frame parameters as specified earlier. They can be edited here if desired.

Note: The *Target minimum cell size* is filled in as 20 meters from the polygon. The base cell sizes should be specified as a multiple of the minimum cell size to a power of 2 (20, 40, 80, 160, 320, etc.) This example has already specified it as 160 m.

2. Under *Depth Options*, set the *Source* to be "Raster".

   Important: The values in the source must be elevations (positive values above sea level and negative values below). All geometry in SMS is now positive up. This is swapped for models/engines that utilize depth values.

3. Click **OK** to close the *Map → Quadtree UGrid* dialog.

SMS will create a quadtree UGrid within the defined grid frame and will add it to the Project Explorer as " Inlet Refinement Grid" under the " UGrid Data" folder. SMS has defined the cells, refined the cells as specified, and assigned elevation values to each cell.

6 Viewing the UGrid Properties

Because the quadtree generator was used, the generated UGrid is a constrained quadtree. To verify this, do the following:

1. Right-click on " Inlet Refinement Grid" and select **Properties** to open the *UGrid Properties* dialog.

Notice the *Constraint* field is set to "Quadtree 2D". Clicking on this field allows removing the constraint which should not be done in this tutorial.

2. When done, click **Cancel** to close the *UGrid Properties* dialog.

7 Generating a Quadtree from Multiple Refinements

To further illustrate the possibilities for refinement regions, another quadtree coverage has been set up for this region. To illustrate it:

1. In the Project Explorer, turn off the " Inlet Refinement" coverage and the " Ocean_City_bathytopo.tif" raster.
2. Turn on the " Refinement Zones" coverage and select it to make it active.

Note that there are multiple polygons with refinement regions specified. If desired, double-click on them to see the individual refinement values from 10 meters over the jetty to 80 meters in the back bays.

3. Right-click on the " Refinement Zones" coverage and select *Convert* | **Map → Quadtree UGrid** to open the *Map → Quadtree UGrid* dialog

Note that the base cell size has been increased to 320 meters.

4. Under *Depth Options*, set the *Source* to be “Raster”.
5. Click **OK** to close the *Map → Quadtree UGrid* dialog.

SMS creates a new quadtree and which is added to the Project Explorer as “ Refinement Zones Grid”. If desired, zoom in and use 3D viewing to review the quadtrees. Also, select cells or nodes to review the elevations.

Now to save the project, do this:

6. Select *File* **| Save Project** from the menu bar.

The project should appear similar to Figure 4.

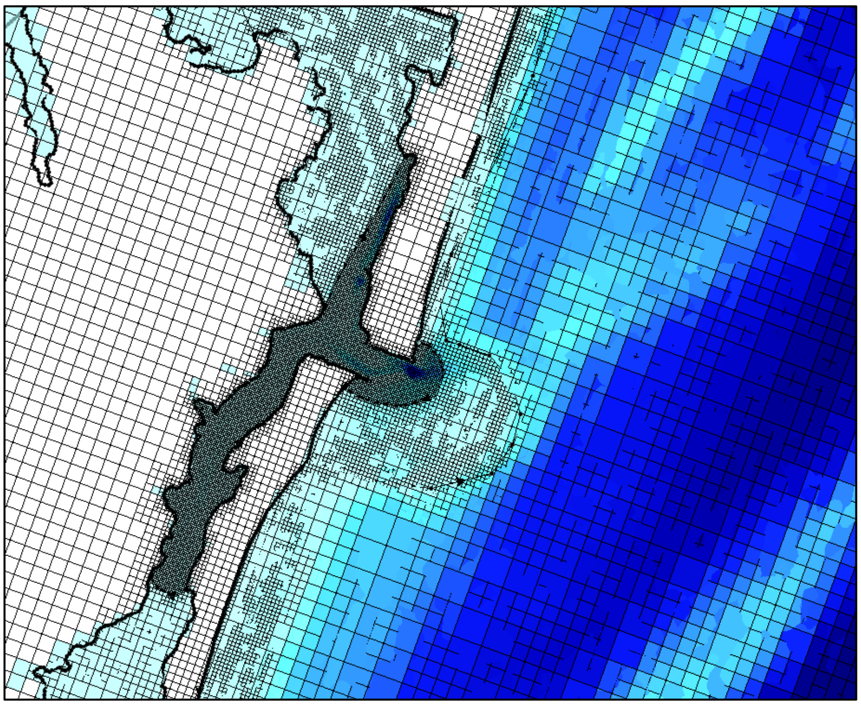


Figure 4 Quadtree with refined regions

8 Conclusion

This concludes the “Quadtree Grid Generation” tutorial. This tutorial has illustrated:

- Creation of a quadtree coverage.
- Definition of a grid frame defining the grid parameters.
- Assigning refinement attributes to regions inside the domain.
- Creation of a quadtree constrained UGrid from a grid frame.
- Evaluation of a quadtree.

The purpose of generating a quadtree is for inclusion in a specific numerical simulation. This example is applicable for the CMS-Flow engine. SRH-2D can also use quadtree geometries as the basis for calculations.

If desired, experiment with more the workflow demonstrated here. You may want to use more refinement polygons or experiment with different cell sizes.