

Topological Editing

(modified from R Briggs UT-Dallas, by P. Bolstad) 9/17/2007

For additional information, see

--ESRI White Paper, *Working with Geodatabase Topology*, March 2003 (*geodatabase-topology.pdf* in ESRI documents directory in the class directory in 35 Skok)

--ArcGIS>Help>Editing in ArcMap>Editing Topology

--ESRI *ArcGIS 9: Editing in ArcMap*, especially Chapter 4 *Editing topology* (35 Skok directory)

Topology: relationships between spatial features, and rules about these relationships

--the concepts of connectivity (linked), congruency (same as/on top of), and contiguity (adjacent)

--relationships are between parts of features (nodes, vertices and edges) rather than the entire feature.

Topology has been implemented in three ways:

--for *coverages*, as an integral part of the data,

--old technology which is being replaced

--implemented with CLEAN and BUILD commands

--CLEAN can move, create or remove geographic features

--BUILD modifies tables only

--requires ArcInfo (any versions since 1981) in order to be able to process coverages.

--for *shapefiles* (and feature classes in a gdb) as simple *Map Topologies* (ArcGIS 8.3 and later)

--imposed during an edit session for feature classes or shapefiles

--you simply define the shapefiles involved and set the tolerance

--all edges and vertices of features which are within the tolerance are considered shared

--there are no “rules,” no need to validate topology, no error reports, etc.

--available with ArcView level of ArcGIS from Version 8.3 inward

--for *feature classes*, the more sophisticated *Geodatabase (GDB) Topology* (ArcGIS 8.3 and later)

--stored as a relationship class within a geodatabase feature dataset

--separate from the data, which is not repositioned when topology is applied

--involves selecting rules, validating topology, etc..


--requires ArcEditor or ArcInfo level of ArcGIS

Simple Map Topology (if you only have the ArcView version of ArcGIS, as in the 1-year student edition)


To turn on Map Topology, 

Click **Editor** button and select *Start editing* (if not already started)

Click **Editor** button, click *More editing tools* and select *Topology*—topology toolbar opens

Click the *Map Topology* button , and select the feature classe(s)/shapefile(s) that will participate.

Optionally, set a *Cluster Tolerance* (e.g. 10 units)

Any vertices or edges which are within the *Cluster Tolerance* of each other are considered “shared” and all will be moved if edited with the Topology Edit tool 

Always use this when editing polygons or line networks.

Map topology exists only for the duration of the edit session. It is not stored (not even in the map document). Of course, any edits made based on the map topology will be saved if edits are saved. Topology is useful:

--when you want to edit shared components of features (e.g. the common boundary between two polygons)

--when you only have ArcView

--when you want to edit shared components of shapefiles

--when you want to edit shared components of two geodatabase feature classes which are in separate feature datasets or in two different existing geodatabase topologies

Geodatabase Topology Concepts

Available only with ArcEditor or ArcInfo levels of ArcGIS.

Topology may be defined:

--between feature classes (e.g. state boundaries must coincide with county boundaries)

--within a feature class (e.g. county boundaries cannot overlap)

--between subtypes (e.g. *residential* road type cannot connect to *interstate highway* road type)

Topologies have three components

--**rules**: about permissible spatial relationships (see above for examples)

--**cluster tolerances**: how close vertices must be to be considered coincident, and how far features can be moved

Rule of thumb is that this should be at least one order of magnitude ($1/10^{\text{th}}$) less than the accuracy of your data (if data accuracy is 2 meters, topology tolerance should be 0.2 meters or 20 cms)

--**ranks**: which features move (lower rank features move to match higher rank e.g counties (2) move to state (1))

Topology rules exist for:

--polygons: 10 rules --1 not yet implemented (for tessellations)


--lines: 12 rules


--points: 4 rules

Some rules apply to relationships between different files types e.g polygons relative to lines, etc..

Topologies are:

--**created** in ArcCatalog (by selecting appropriate rules)

--**validated** in ArcCatalog or ArcMap using the *Validate Topology* command 
(which identifies potential errors)

--**viewed** in ArcMap using the *Error Inspector* table 

--**fixed individually** in ArcMap using *topology editing tools*, or marked as *exceptions*

--**fixed in batch** (sometimes!) in ArcMap or ArcToolbox using geoprocessing tools
(See below for more information on fixing topological errors.)

Topology status may be:

--**Validated without errors.** *Validate Topology* has been run and no errors found
(or all have been fixed and *Validate Topology* run again to confirm this)

--**Validated with errors.** *Validate Topology* has been run, errors found, and they have been:
--left unresolved
--marked as exceptions (and thus will not be tagged again if *Validate Topology* is rerun)

--**not Validated.** These are known as *dirty areas*. They cover the entire layer if *Validate Topology* has never been run, or any area edited since the last time *Validate Topology* was run.

The Effects of Running Topology. When *Validate Topology* is run the following occurs in succession:

1. The first time *Validate Topology* is run, all feature vertices are aligned (moved!) to the integer grid of the spatial domain., The amount of movement is a function of the *precision* of the spatial domain of the feature dataset. This is generally small, so the potential movement is also small, but should be recognized especially if data has been created by entering precise coordinates, as may be the case for survey data.. This assures that features are coincident and remain so.
2. All vertices within the *Cluster tolerance* of each are combined; vertices in lower order feature classes are moved to the location of vertices in higher order classes. A vertex is added if two lines intersect without a vertex being present.
--it is possible for this to result in the ‘disappearance’ of lines or polygons
--a special topology rule (#26 in topo.ppt) is automatically applied to identify these cases.
Overall, this process assures that “shared geometries” (coincident segments), such as the common boundary between two polygons, are recognized and that “shared editing” will simultaneously adjust the boundary of both polygons..
3. The topology rules which have been defined are verified, and any violations are added to the error report.

Fixing Topological Errors and Creating Topological structures

There are various ways to fix topological errors, and/or create new topological structures, either individually or in batch.

For information, go to *Help>Editing in ArcMap>Editing Topology>Topology Error fixes*

1. To **fix errors individually**, you can right click on the error in the *Error Inspector* table and an appropriate tool is usually available. For example;

Subtract removes overlaying feature segments

Simplify removes self overlapping segments

Extend and **Snap** will fill gaps

Trim will remove dangles


Merge will combine feature segments from one feature with another


(some of these tools are also available directly on the Advanced Editing toolbar)


2. you can **run these same tools “in batch”** by using Shift or CTRL to select multiple errors simultaneously

3. you can use the **Topology Edit tool**  on the Topology toolbar and standard editing to fix individual errors

4. you can use one of the special **topology tools on the Topology toolbar**, which include:

 **Fix Topology Error** tool Don't be misled here. This is not a general purpose tool. It is used for errors involving sliver polygons which need to be merged with primary polygons.

 **Planarize Lines** tool, which is very powerful for "cleaning" lines. It will
--remove overlapping line segments (often needed)
--split lines where they intersect (which is often desired for GIS data)

 **Construct features** tool, another powerful capability which will construct polygons or lines from the geometry of other features.

Note: All these tools require that you first select the features to be processed.

For more info on these, go to *Help>Editing in ArcMap>Editing Topology>Making new features with topology tools*

5. Use the **Polygon Feature Class from Lines** capability to create polygons from lines
--This is in a strange place! You need to right click on a feature dataset and select New!
6. Use **geoprocessing tools**, such as those in:

ArcToolbox>Data Management Tools>Features

Check Geometry and Fix Geometry tools useful for cleaning data

ArcToolbox>Data Management Tools>Generalize

Eliminate tool very useful for removing sliver polygons

Be cautious when doing fixes in batch. There is the possibility you can introduce false data, even if you fix the topological errors.

See the examples below for the use of some of these.

Managing topologies in ArcCatalog

You can rename the topology without any negative effect

If you copy a topology, all associated feature data sets are also copied

You cannot rename a feature class that is participating in a topology

To delete a feature class that is participating in a topology, you must first remove it from the topology

--to remove a feature class, right click *topology name*, select **Properties** and click **Feature Classes** tab

Other properties of an existing topology (e.g. rules, ranks) can also be modified via Properties

Selected Topology Rules

Topology Rules for Lines in Networks (examples)

Must not overlap (one segment over another)

Must not intersect (except at end points e.g. lot lines should never cross themselves)

Must not have dangles (a good way to check for continuity; mark cul-de-sacs as exceptions)

Must not self overlap (the same segment must not overlap itself)

Other rules are available for relationship between two line segments

Topology rules for Points related to Lines

Must be covered by Line (all points must lie on a line)

Must be covered by endpoint of (line must have point on end--point has the error)

Endpoint must be covered by (same as above but line has the error—don't use both!)

See *Building a Geodatabase* in the class vault, under ESRI documents, for examples of all available topology rules

Example Topology Application: Buildings and Parcels

Create a geodatabase that contains buildings and roads shapefiles. You should work in directories on your local computer or flash drive (USB drive), by copying the data from the class directory, data\sample_data subdirectory.

To create a Geodatabase:

Copy the *buildings* and *parcel* shapefiles from the class directory to a subdirectory on your flash drive

On your flash drive, create a new personal geodatabase (start ArcCatalog, then File>New>Personal Geodatabase), named *fixbuild*. Note that will automatically be given the .mdb file extension. Note that you must specify a

coordinate system, this exercise is UTM NAD83 zone 15, or you may import it from the *buildings* shapefile.

Right click on the created *fixbuild.mdb* geodatabase, then select > New>Feature Dataset, name it something like *property*

Right click on the created feature dataset (*property*), and Import>Feature Class (single)

Select *buildings.shp* for the input, leave the output location for the *property* feature dataset, and name the output feature class something like *builds_I_edited*

Repeat the process to import the parcels, named something like *parcels*.

Create a topology in ArcCatalog

In ArcCatalog, right-click the feature dataset (*property*) that will contain the topology, point to *New* and click *Topology*.

Click **Next** to go past the introductory screen, and then Name the topology *build_topology*

Set *cluster tolerance* at 0.5 meters (remember, implies that vertices can move up to 0.5 meters). Click **Next**

Select layers to include in the topology: *builds_I_edited*, *parcels*. Click **Next**

Set rank for *builds_I_edited* as 1, *parcels* as 2 (lower ranks move more.) Click **Next**

Click Add rules and successively select, *must not overlap*, *must not have gaps*, *must not overlap with parcel*, and *area boundary must be covered by boundary of parcel*. Read about each rule as you enter, and click **Next** after each one.

Review summary. You should have 4 rules. Click **Finish**

Click, **Yes**, *would like to validate it now*. The topology is added to the feature dataset.

Right click on the topology name (*build_topology*), select **Properties**, click **Errors** tab, and then **Generate Summary**


There are 15 errors. 3--Must not have gaps

4--Must not overlap with builds, parcel

8—Area boundary must be covered by boundary...builds, parcel


The number of errors will depend on the cluster tolerance. Generally, as you increase tolerance, errors decrease, but that is not always the case.

View and Correct in ArcMap

Open ArcMap and use Add data , and navigate to the *fixbuild.mdb* and add the *property_topology* just created


When prompted, say *Yes* to add the feature classes also.


Start editing (**Editor/Start Editing**)

Set the digitizing editing properties, left click the editor menu dropdown triangle , select options and set the snap tolerance to something appropriate (1 meter in this example), then **OK**, then select Snapping from the editor menu dropdown triangle, and set vertex and edge snapping on for the two data layers.

Add the *topology* toolbar if necessary via **Editor/More Editing tools/Topology**

Select *property_Topology* (or whatever you named it) in drop down window

If topology has not been validated, click the Validate Topology button 

Click Error Inspector icon  to open error report

To list all errors: in **Show** window, select <Errors from all rules>,

place check in **Errors** and **Exceptions** boxes, & remove check from **Visible Extent only** box.

Click **Search Now** button

In the rows of the table, right click on a row and select **Zoom to** or **Pan to** to see each error more clearly

--the error changes from red to black on the map

--choose a "must not overlap" error and zoom in

--if you select feature on either side with selection tool, the segments overlap

Click a column heading to sort by that column (e.g. Rule type)

--can use Shift and Control keys to select multiple errors simultaneously for evaluation.

To **fix errors individually**, you can right click on the error in the table and there is a tool available in the menu

--for example, right click on a "must not overlap error" row in error table and zoom to the error

--right click again and select *Subtract*—you will need to think carefully about which segment to subtract

For more information on fixes, go to *Help>Editing in ArcMap>Editing Topology>Topology Error fixes*

Example Topology Application ---Census Tract data

(Example uses census tract shapefile data, TR50_start, TR50LINEv9, etc., in the class vault data\sample_data directory),

Create and Validate in ArcCatalog

In ArcCatalog, create a new geodatabase, feature dataset, an import the shapefile that begin with TR50_start into feature classes.

Right-click the feature dataset that will contain the topology, point to *New* and click *Topology*.

Click **Next** to go past the introductory screen, and then Name the topology *tracts_topology*

Set *cluster tolerance* at 25 feet (remember, implies that vertices can move up to 25 feet). Click **Next**

Select layers to include in the topology: *tr50_start*


Set rank for *tr50_start* as 1 (only relevant if have >1 layer in topo. Lower ranks move more.) Click **Next**

Click Add rules and successively select *Must not overlap*, *Must not have gaps*. Click **Next**

Review summary. Be sure that you have 2 rules. Click **Finish**

Click, **Yes**, *would like to validate it now*. The topology is added to the feature dataset.
Right click on the topology name (tracts_topology), select **Properties**, click **Errors** tab, and then **Generate Summary**
For the *tr50_start* file there are 4 *Must not have gaps* errors


View and Correct in ArcMap


Open ArcMap and use Add data  to add the topology.

When prompted, say *Yes* to add the feature classes also.

Start editing (**Editor/Start Editing**)

Add the *topology* toolbar if necessary via **Editor/More Editing tools/Topology**

If topology has not been validated, click the Validate Topology button 

Click Error Inspector icon  to open error report

To list all errors: in **Show** window, select <Errors from all rules>,

place check in **Errors** and **Exceptions** boxes, & remove check from **Visible Extent only** box.

Click **Search Now** button

In the rows of the table, right click on a row and select **Zoom to** or **Pan to** to see each error more clearly

--you may then need to use fixed zoom buttons to understand error better 

--for example, last error is generated by a “multi-part polygon.”

Open Attribute table, select feature, and note it is one row (ObjectId=71).

To fix this, you can use the Explode icon  on the Advanced Editing toolbar

--this converts a multi-part polygon into separate polygons

--it creates two new rows in attribute table, and removes original polygon

--delete the smaller (based on area) of the two new polygons

Revalidate the topology by clicking the Revalidate button 

Click **Search Now** button again and you should only have 3 errors

Zoom to third error (now the last if you have fixed and revalidated 4th error as above)


--it's a gap polygon, which needs to be removed


--go to **Editor/Snapping** and be sure that snapping is set for

tr50_start Edge, in the upper window

and, Topology Elements Topology nodes in the lower window

--Under **Editor/Options** set tolerance to 50 feet

--Select *Topology Edit* tool  and double click on the lower left edge of the gap. Remove the gap by dragging the vertex in the lower left so it snaps to the upper right edge of the gap.

--Revalidate the topology by clicking the Revalidate button 

Click **Search Now** button again and you should only have 2 errors.