Chapter 12. Basic Editing

Objectives

- Understanding topological errors
- Using snapping to ensure topological integrity of features
- Adding features to map layers using basic editing functions
- Using the sketching tools and context menus to precisely position features
- Entering and editing attribute data

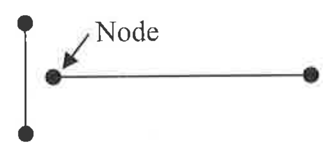
Mastering the Concepts

GIS Concepts

Editing can update existing feature classes or create new ones. If a housing subdivision is added to a city, the new roads must be added to the city's roads feature class. Likewise, new parcels, sewer lines, and other infrastructure need to be added to the city database to ensure that it is up to date. Entirely new feature classes can be created, for example, if the city planning department decides to create a map of garbage collection zones where none had existed before.

When editing, care must be taken to create and maintain topological integrity between features. If two parcels share a common boundary, then the boundaries should match exactly. Line features that connect in the real world, such as streets or water lines, should connect in the feature class. Lines that cross each other should intersect at a node. Lines and polygon boundaries should not cross over themselves. These basic rules must be observed to ensure the logical consistency of features so that they properly represent the relationships of their real-world counterparts.

Topological data models permit the user to test, locate, and fix topological errors. However, topology is even more important when editing spaghetti models because the user must manage it without help. Basic editing includes two capabilities that aid in maintaining topological integrity: snapping and coincident boundary editing.



A dangle—the two lines fail to connect.

Correct topology—the horizontal line intersects the vertical one, creating three lines.

Fig. 12.1. Topological relationships between lines

Snapping features

When creating line features that connect to each other, such as roads, one must take care that the features connect properly (Fig. 12.1). A line that fails to connect is called a **dangle**. Although you may not be able to see the gap between the lines, the gap will exist unless the endpoints of each line (nodes) have exactly the same coordinate values. Even though the map may look correct, certain functions, such as tracing networks or locating intersections, will not work properly. It is impossible to intersect lines properly by simple digitizing.

Snapping ensures that the nodes of lines and the vertices of polygons match. When snapping is turned on, it affects features being added or modified. If you place the cursor within a specified distance of an existing node or vertex, then the new feature is automatically snapped to the existing one—that is, the coordinates are matched at that one point (Fig. 12.2). This distance is called the **snap tolerance**.

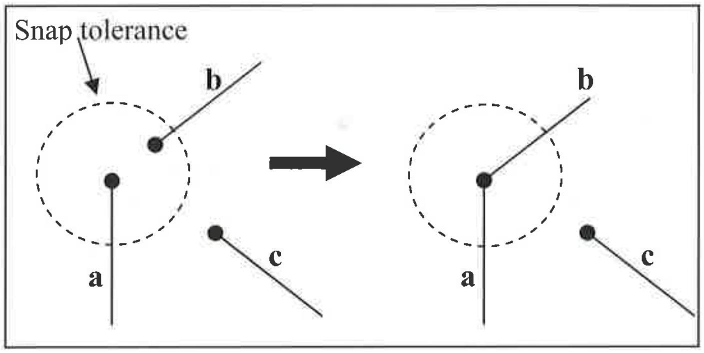


Fig. 12.2. Snapping. Line "b" snaps to "a" because it falls inside the snap tolerance. Line "c" remains unconnected.

Care must be taken in specifying the snap tolerance. If it is too small, then you will have difficulty making features snap. If it is too large, then you may find yourself constantly snapping to objects when it isn't needed. Snap tolerances are typically set either in pixels on the screen or meters in the map units. A snap tolerance of 10 pixels indicates that features will be snapped if the cursor moves within 10 screen pixels of an existing feature. When set in pixels, the snap tolerance remains the same as the user zooms in and out, and is the most convenient for most applications. A snap tolerance of 10 meters remains fixed, and will appear quite large if zoomed way in, and may become infinitesimal if zoomed way out. Setting the snap tolerance in map units is usually most useful when digitizing from a paper map when the screen is not being used, or if the user is trying to maintain a particular level of geometric accuracy independent of zoom scale. Four types of snapping can be used.

Point snapping is only used for point feature classes and snaps to an existing point.

End snapping only allows a new vertex to be snapped to the endpoints of an existing line. End snapping can ensure that new streams connect to the ends of existing streams, and only to their ends. End snapping only applies to line features.

Vertex snapping allows the endpoints of the new line to be snapped to any vertex in an existing line or polygon. It can ensure that adjacent parcels connect only at existing corners.

Edge snapping constrains the feature being added to meet the edge of an existing line or polygon feature. In this case, the vertex being added could be placed anywhere between vertices. Edge snapping can ensure that a street ends exactly on another street.

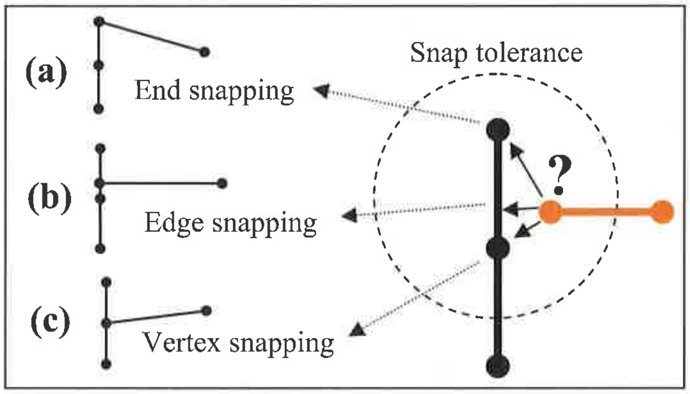


Fig. 12.3. Where will it snap? The snap type dictates where the new horizontal line will end.

Figure 12.3 illustrates how snapping changes depending on which type of snap is set. The vertical line already exists in the layer, and the horizontal line is being added. The dashed circle shows the snap tolerance. If end snapping is turned on, then the new line will snap to the endpoint of the existing line (Fig. 12.3a). If edge snapping is turned on, then the line can be snapped anywhere between the end and the vertex (Fig. 12.3b). If vertex snapping is set, then the new line will connect to the closest vertex or end (Fig. 12.3c).

If more than one kind of snapping is turned on, then the most inclusive one takes precedence. To ensure snapping only to ends, therefore, both edge and vertex snapping must be turned off.

Creating adjacent polygons

Two adjacent polygons should share the same boundary. In shapefiles and geodatabases the boundary gets stored twice, once for each polygon. However, the vertices should exactly match in both features. If this condition holds, the polygons are said to share a coincident boundary (Fig. 12.4). If they fail to match, gaps or overlaps are generated, which constitute topological errors and may cause problems during display or analysis.

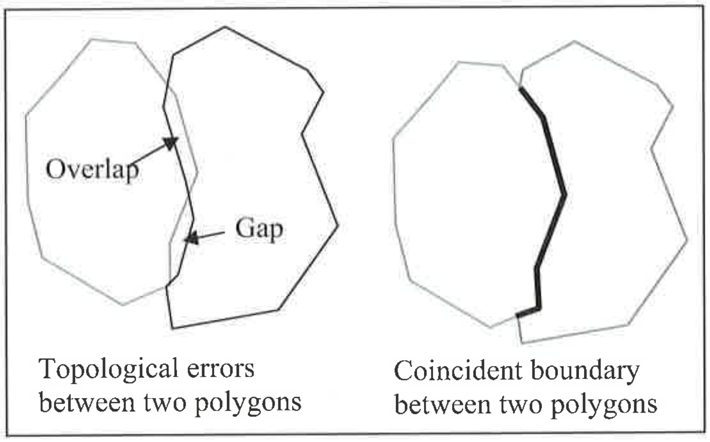


Fig. 12.4. Topological relationships between polygons

About ArcGIS

The editing process begins by opening the Editor toolbar, starting an edit session, and identifying which folder or geodatabase will be available for editing. Only one folder or geodatabase (called a workspace) can be edited at a time, but all the feature classes in the folder or geodatabase can be edited together.

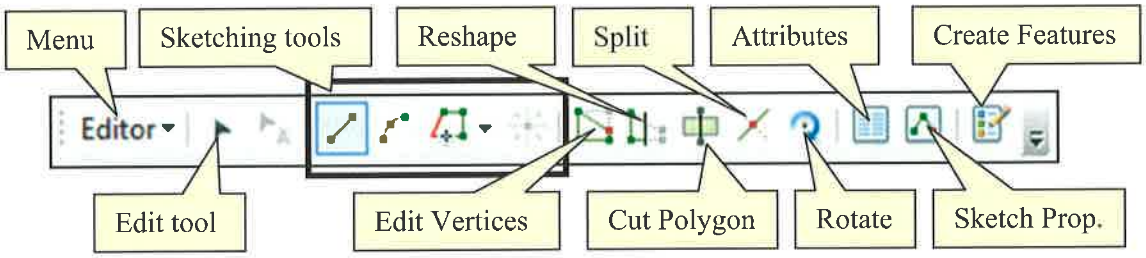


Fig. 12.5. The Editor toolbar contains many editing options and functions in one neat package.

The Editor toolbar

The Editor toolbar provides access and shortcuts to many editing functions (Fig. 12.5). The first button on the left opens the Editor menu, used for turning editing on and off, setting options, and performing certain editing tasks. The Edit tool selects one or more features for editing. It is similar to the Select Features tools on the Standard toolbar, but should always be used for editing.

Next come the Sketching tools, an assortment of methods to add vertices to a feature. The default is a straight line segment between vertices, but one can also create curves, right angles, midpoints, and other specialized vertices. The Sketching tools provide a lot of flexibility in creating features. The next four buttons provide access to common tasks, including editing the vertices of an existing feature to change its shape, splitting a line into two features, cutting a polygon in two, or rotating a feature.

The final three buttons launch editing windows. The Attributes window provides a convenient tool for editing feature attributes. The Sketch Properties window is used to examine, and if desired, edit, *x-y* coordinates of sketches. The Create Features window contains and manages editing templates, which are used to create new features.

What can you edit?

ArcGIS offers different levels of editing capability depending on the type of license. ArcView can edit shapefiles and personal or file geodatabases. ArcEditor and ArcInfo can also edit SDE databases, geometric networks, and planar topology. All of these levels are accessed through the same ArcMap interface.

ArcMap can edit several layers at once, as long as they are all in the same folder or geodatabase (workspace). This capability makes it easier to view and edit related layers simultaneously or to copy features from one layer to another.

TIP: Coverages cannot be edited in ArcMap. Use the ArcEdit program in Workstation ArcInfo instead, or convert the coverages to shapefiles or geodatabases for editing.

Editing and coordinate systems

ArcMap can edit layers with different coordinate systems from the data frame. The edits will automatically be converted to the coordinate system of the layer being edited. Consider editing a shapefile of roads stored in a GCS while displaying the roads with a digital orthophotoquad (DOQ) in a UTM projection. The roads coordinates will be converted into decimal degrees before they are put into the shapefile.

Performance and reliability

Although ArcMap has many useful capabilities, such as editing across coordinate systems and editing multiple files simultaneously, one must be somewhat cautious in taking advantage of these benefits. Editing coordinate features can be a complicated process, and software does not always work perfectly under arduous conditions. If an editing scenario is demanding extensive system resources by having many files open or by doing many projection transformations during an edit session, system performance and reliability may suffer. Moreover, because spatial data files are complex constructions, the price of an editing glitch may be the loss of data integrity; an ill-timed system glitch might not only lose recent changes but also corrupt the entire data set. Thus, you are encouraged to use the following procedures while editing:

- **Always have a backup copy of the file being edited,** stored elsewhere on the disk or on a different medium. This precaution is especially important when working on data sets that would be expensive or impossible to replace should something go wrong.
- Shapefiles are the simplest and most robust type of data file to edit and the hardest to damage during editing.
- Geodatabases offer special capabilities and tools for helping ensure that data are entered and maintained correctly.
- Limit the number of open files. A prolonged editing session should be conducted in its own map document and include only the layers that are needed.

- Avoid extensive editing in map documents whose primary purpose is cartography or analysis, and in which you have invested hours of effort. In Version 9, the author's students found that editing sometimes corrupted map documents such that tools would fail when they were run. The map documents needed to be re-created. We don't know if this problem will persist in Version 10, but better to be on the safe side.
- Save edits frequently in case of a system glitch. ArcMap does NOT automatically save edits at regular time intervals. However, remember that saving also clears the "Undo" memory of edits. After edits are saved, they can no longer be undone.

Feature templates

Editing utilizes sets of feature templates. A **feature template** stores all the information needed to edit a particular layer in the map document. It includes the feature class in which the edits will be stored, the attributes that are assigned to new features, and the default tool that is used to create them. The template shown in Figure 12.6 is named Commercial. It saves features into a polygon target layer called buildings. By default, the plain Polygon construction tool is used. The fields contain default values that are added to each feature, including its designation as a Commercial building.

Multiple templates may be constructed for each feature class. As

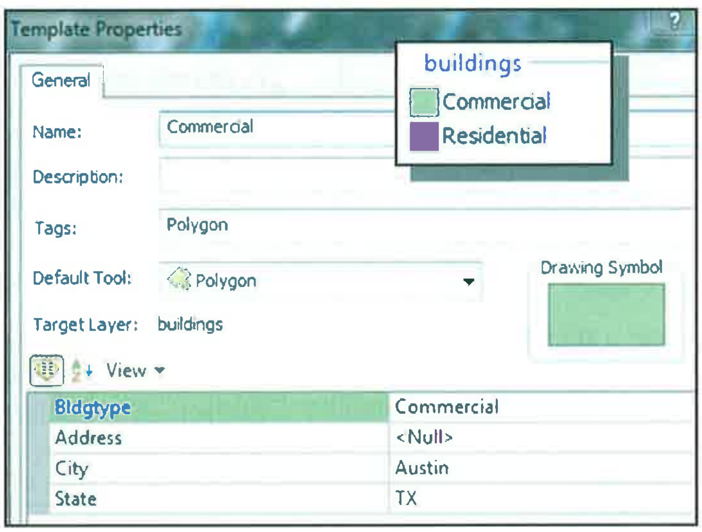


Fig. 12.6. Feature template properties

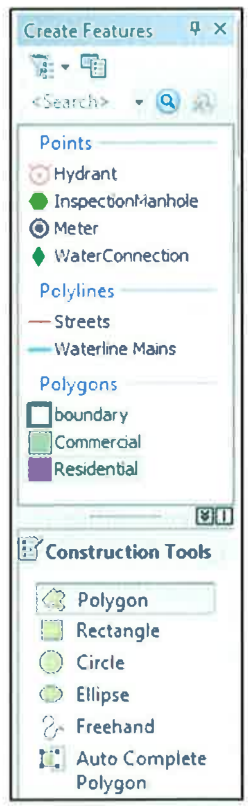


Fig. 12.7. Create Features window

shown in the inset to Figure 12.6, the buildings layer has another template called Residential. It is identical to the Commercial template except that the building type field, Bldgtype, contains "Residential". If the user is digitizing a new commercial building, she clicks on the Commercial template. When the building is added, the default attributes "Commercial", "Austin", and "TX" are automatically placed in the attribute fields. If she wishes to add a residential building, she clicks the Residential template, digitizes the building, and the attributes are automatically set. Using these templates can save a great deal of typing to enter attributes. Only the address field, which is unique to each feature, remains to be edited manually.

Templates are accessed and managed in the Create Features window (Fig. 12.7). The upper panel lists each available template, and the templates can be sorted and grouped various ways, such as by feature type, as shown in Figure 12.7, or by layer as shown in the inset to Figure 12.6. The user selects the desired template from this panel.

The lower panel shows all of the available construction tools for that feature type, with the default one defined by the template at the top. Each feature class type has its own set of construction tools used to create various shapes or perform special tasks, such as creating an ellipse or rectangle. The two buttons at the top of the Create Features window control the grouping and sorting of the templates (left) and the creation and management of templates (right).

Templates can be saved and reused, and so they also contain descriptions and tags that can help in searching for stored templates. The search toolbar provides access to stored templates.

Templates should be automatically created for each active layer in a feature class when editing is initiated. However, the user can also create and edit templates as needed.

How editing works

An editing session must be initiated before any changes to a file can be made. This requirement protects the user from accidentally making changes to a file without realizing it. Also, because ArcMap can only edit within one directory or one geodatabase at a time, opening the session establishes the workspace being edited.

Basic editing uses three main components: the Edit tool, the feature templates, and the construction tools. The Edit tool selects existing features when they need to be moved, rotated, deleted, etc. It is analogous to the Select Features tool on the Standard toolbar, but should always be used for editing. The templates control the features being added and where they are placed. The construction tools control the characteristics of the feature being created.

Creating sketches

The construction tools are used to create a **sketch**, a provisional feature that is being worked on, analogous to an artist sketching a figure lightly in pencil prior to inking in the final lines of the picture. This sketch is not actually added to the target layer until it is "finished," which is usually done by double-clicking the last vertex.

The green outline in Figure 12.8 shows a nearly completed polygon sketch, in which green vertices are separated by segments between them. The current or last vertex is shown in red. New vertices are added to a sketch by using one of the Sketching tools.

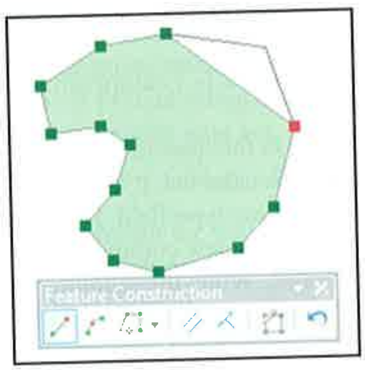


Fig. 12.8. Sketching a polygon

The Straight Segment sketching tool is the default. It appears as the first button on the left on the Editor toolbar as well. It merely creates a straight line segment between the last and the new vertex. It was used to create the polygon in Figure 12.8. Another tool that is commonly used and placed on the Editor toolbar is the End Point Arc Segment tool, used to create a smooth curve between two endpoints.

Additional Sketching tools are accessed by clicking the drop-down menu to the right of the Straight Segment and End Point Arc Segment tools (Fig. 12.9). The Right Angle tool, for example, forces the sketch corners to be square, making it much easier to create buildings. Other sketching tools can create curves, make parallel or perpendicular lines, trace along existing features, create midpoints or tangents, and do other specialized tasks. In this chapter we learn to use two of the most common sketching tools, the default Straight Segment tool and the Right Angle tool.

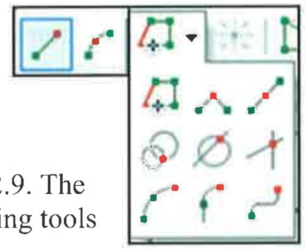


Fig. 12.9. The sketching tools

SKILL TIP: The functions and instructions for all of the Sketching tools may be found in the Skills Reference section (Editing).

While the user is sketching, a mini-toolbar known as the Feature Construction menu floats near the cursor on the screen. It provides quick access to different sketching tools and a choice of ways to add the next vertex. If you find the floating Feature Construction menu annoying, it can be turned off from the Editor toolbar using the Editor > Options menu.

Vertex and Sketch menus

During editing you can access two context menus to aid in certain tasks or change edit settings (Fig. 12.10). The **Vertex menu** appears when you right-click on the sketch (Fig. 12.10a). This menu provides functions for adding, deleting, or moving vertices. The **Sketch menu** appears when you right-click off the sketch (Fig. 12.10b). This menu provides functions for specifying exact angles, lengths, distances, and more.

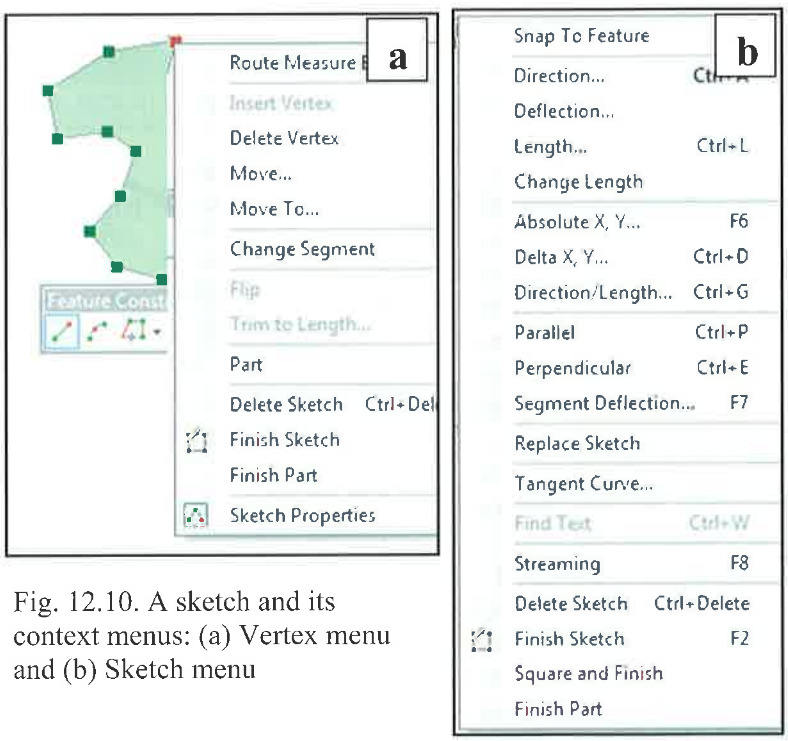


Fig. 12.10. A sketch and its context menus: (a) Vertex menu and (b) Sketch menu

The Snapping toolbar

A small toolbar to control snapping allows easy access to snapping tools in the middle of a sketch. The four basic kinds of snapping (point, end, vertex, and edge from left to right in Figure 12.11) are controlled with the click of a button. A menu extends the snapping types to intersection snapping (where two lines intersect at a common node), midpoint snapping at the midpoint of a line, and tangent snapping to a curve. The snap tolerance can also be controlled here.

Fig. 12.11. The Snapping toolbar

Adding adjacent polygons

A special construction tool is used for adding adjacent polygons. The Polygon construction tool is first used to enter a complete polygon with no neighbors. To add an adjacent polygon, you must switch to the Auto Complete Polygon tool and digitize only the new part of the polygon. The editor ensures that the polygons share a coincident boundary and are free from topological errors, including gaps and overlaps (Fig. 12.12).

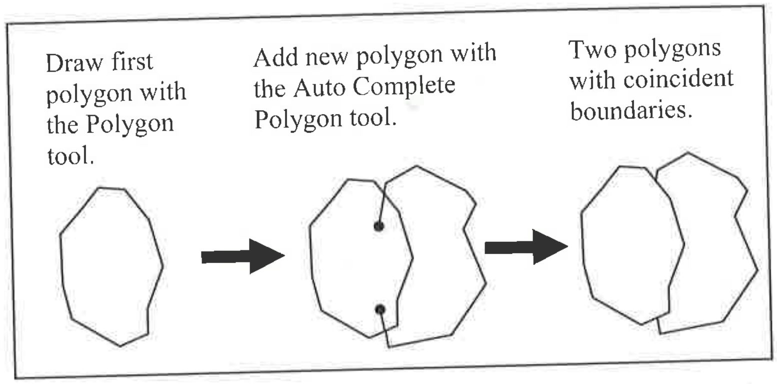


Fig. 12.12. Creating a coincident boundary between two adjacent polygons with the AutoComplete task

Another way to add adjacent polygons uses the Cut Polygons construction tool. With this method, an outer polygon is constructed around an area encompassing two or more polygons, and then the internal boundaries are added by cutting the polygons along the intended coincident boundary.

Editing attributes

Editing features often includes editing their attributes. The user can modify attributes in two ways. In the first way, edits are typed directly into an attribute table, as discussed in Chapter 4. The second method uses the Attributes window to edit the values of single or multiple features.

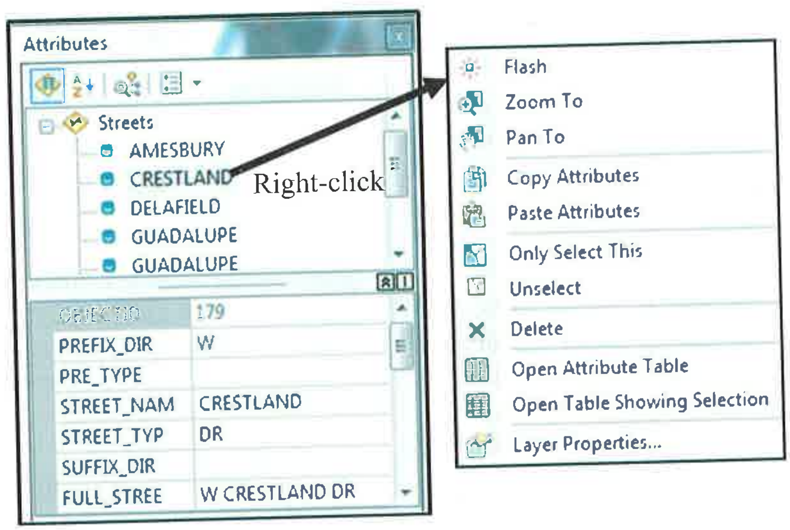


Fig. 12.13. The Attributes window can display and edit many records at once.

The Attributes window is accessed through a button on the Editor toolbar (Fig. 12.13). The upper panel shows the currently selected records; if no features or records are selected, then both areas will be blank. The lower panel shows the attributes of the highlighted feature in the upper panel. When the feature is clicked in the upper panel, the feature flashes on the screen to indicate which one it is, and the attributes in the lower panel may be edited.

The window also allows editing of attributes for multiple features. If the top row containing the feature class (Streets) is clicked, then the attribute values go blank. Further updates to the attributes are applied to all of the selected features.

Chapter 13. Editing and Topology

Objectives

- Understanding topology and learning to preserve topological rules during editing
- Learning techniques for digitizing complex groups of polygons
- Using additional editing tools to help create and preserve topological relationships: merge, union, intersect, clip, modify, and reshape
- Editing shared lines and polygon boundaries with map topology
- Creating and editing with planar topology

Mastering the Concepts

GIS Concepts

Chapter 12 presented some basic techniques for creating new features in a feature class. In this chapter, we examine additional ways to form and modify features with an emphasis on maintaining correct topology during editing.

Topology errors

Topology concerns how the features are spatially related to each other. The four types of spatial relationships introduced in Chapter 1 included adjacency, connectivity, overlap, and intersection. One major goal during editing, other than simply getting features into a feature class, involves ensuring the **logical consistency** of features, in other words, making sure that features are free of geometric errors and that their topological relationships are adequate for the purpose intended. Some of the topological errors to avoid during editing are shown in Figure 13.1.

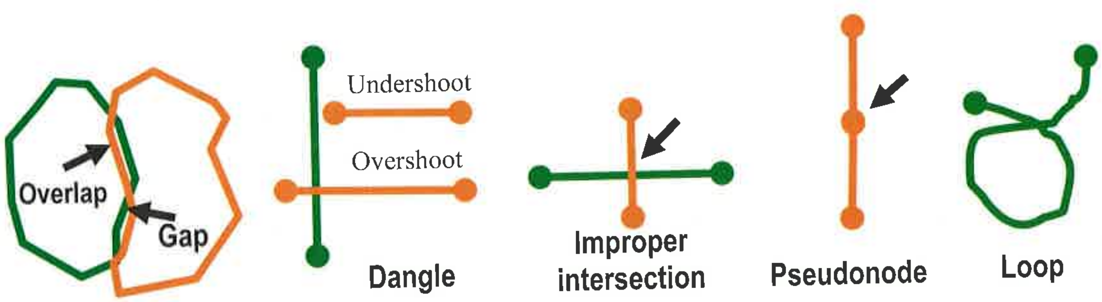


Fig. 13.1. Topological errors can occur when editing is not carefully performed.

Basic topology rules

(1) Adjacent polygons must share a coincident boundary that is exactly the same for both. There are no gaps or overlaps between adjacent polygons.

(2) Lines should always end on other lines. Failure of two lines to meet is called a **dangle**. Dangles can occur when one line is not quite long enough to meet the other (**undershoot**) or when one line crosses too far over the other (**overshoot**).

(3) Lines that intersect should each have a node (endpoint) at the intersection. Lines crossing without nodes are termed improper intersections.

(4) Nodes should exist only where three or more lines intersect. A node where only two lines meet is called a **pseudonode**.

(5) Lines or polygon boundaries should not cross over themselves and form loops.

(6) There should not be duplicate copies of any points, lines, or polygons.

Perfectly legitimate exceptions can occur to topological rules. For example, a dead-end street by definition does not meet another road and must be a dangle. A highway overpass can cross over a street without intersecting it. Polygons showing areas sprayed with pesticide on different dates might have gaps or overlaps between them.

The effects of topological errors can vary. In some cases they are merely a visual nuisance. At times they can be a legal liability, such as an overlap between two parcels. In other cases they contribute to undesirable outcomes, like the slivers than can be formed during geoprocessing operations. In the worst case, they can cause a failure of the data set for its purpose—a street network containing improper intersections will not properly route traffic. Each user must evaluate the purpose of a data set and establish the topological rules needed. In some cases these rules will include more than the six listed previously. However, these six should be considered a basic level of integrity to which every data set should conform (not including unavoidable exceptions).

Topological integrity can be established at the outset by careful editing of features to minimize the occurrence of errors. Most GIS software includes tools for ensuring basic topological integrity during the editing process, such as snapping and the Auto Complete Polygon tool discussed in Chapter 12.

Topology rules and tools

Even careful editing cannot avoid all topological errors. Moreover, one does not always have control over the creation of a data set; one may be stuck with data that were poorly digitized without attention to topology. A GIS that is capable of storing topology will generally also possess tools that can be used to find errors and fix them.

Many topological errors are difficult to find by mere inspection; they require software algorithms to test and evaluate features at the *x-y* coordinate level. These tools are generally run on feature classes after editing is complete. The errors that are found are fixed by additional editing, which can create new errors. So the process is repeated until all errors have been found and fixed. These routines are extremely important in developing a logical consistency report for the feature class metadata. This report describes the procedures used and tests applied to a data set to ensure that it meets the topological rules we have listed.

Some GIS systems contain advanced capabilities for defining topological rules and ensuring that they are met. The ArcGIS geodatabase model is one of these. In Chapter 9 you were introduced to network topology and some of the solvers that evaluated connectivity. Feature datasets within geodatabases can also contain **planar topology**, which expands the use of rules to model a variety of topological relationships, not just within a single layer but between layers as well.

One class of rules applies to features within a single feature class. The types of rules available vary according to feature geometry. Each of the six topological rules cited above are represented by rules such as Must Not Have Gaps, Must Not Have Overlaps, Must Not Have Dangles, Must Not Have Pseudonodes, etc. Figure 13.2 shows a planar topology in ArcGIS that uses these rules to test the topology of geology and faults.

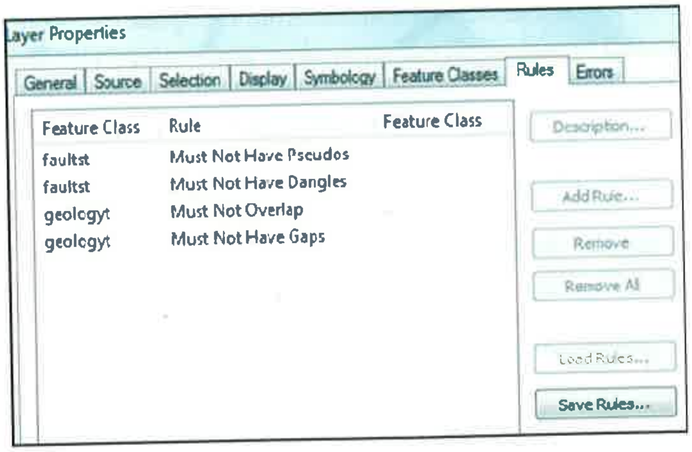


Fig. 13.2. Topology rules in a planar topology of geology units and faults

Other rules specify relationships *between* feature classes, such as the Must Cover Each Other rule that describes the relationship between counties and states in which every bit of the state area must belong to a county and no part of a county should lie outside the state.

Figure 13.3 shows typical topological errors occurring between layers. The boundary of the Pine Ridge Indian reservation (stippled area) should match the boundary between Shannon and Bennett counties, but it does not. Neither does it match the South Dakota–Nebraska boundary.

Creating planar topology makes it easier to locate and eliminate boundary errors by using special Topology tools while editing. This approach is helpful because many errors are too small to see at normal viewing scales—in Figure 13.3 the county boundaries appear to match the state boundaries but might not actually do so. Such errors typically occur because data come from different sources or because some people do not understand or use snapping effectively.

Using planar topology requires an ArcEditor or an ArcInfo license. The tutorial for this chapter includes a demonstration of using topology to test for pseudonodes, dangles, gaps, and overlaps, for users who have the appropriate license. However, it is nothing more than a brief introduction to an extensive and complex topic. Users interested in topology should read the appropriate ArcGIS Help files.

Users with an ArcView license have much more limited tools for working with topology and must take responsibility during editing to keep features as correct as possible.

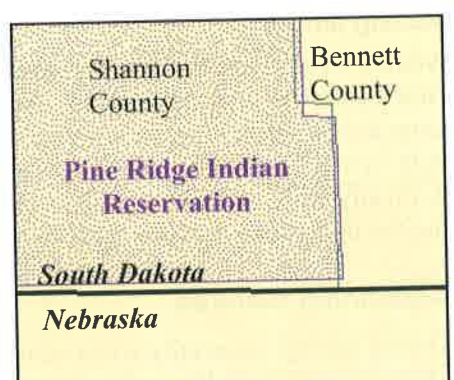


Fig. 13.3. Topological errors between layers

Editing complex polygon shapes

Some map types, such as geology and soils, have a complex interweaving of different units. It takes some forethought and planning to efficiently create polygons with correct topology. Experience digitizing such maps is the most effective way to learn appropriate techniques and avoid common mistakes. When planning, the key constraints to remember are:

- A line created with the Auto Complete Polygon tool must completely enclose a region.
- A line created with the Cut Polygons tool must start and end outside of an existing polygon selection.
- An island polygon requires creating a separate feature, which will then overlap the larger polygon underneath. The overlap must be corrected afterwards by clipping.

Consider the geology map shown in Figure 13.4. It would be easy to get "painted into a corner" and not be able to finish the sequence of polygons. For example, if one digitized polygons 2 and 5 first, polygon 3 would be a hole that would be a nuisance to fill. An island polygon, such as 13, cannot use the Auto Complete Polygon tool at all because it lies completely inside another polygon. It must be added after the polygons around it, which causes it to overlap the existing polygon underneath, violating a topology rule. Here are two ways to approach the editing. Both methods should help avoid gaps and overlaps and result in topologically correct polygons.

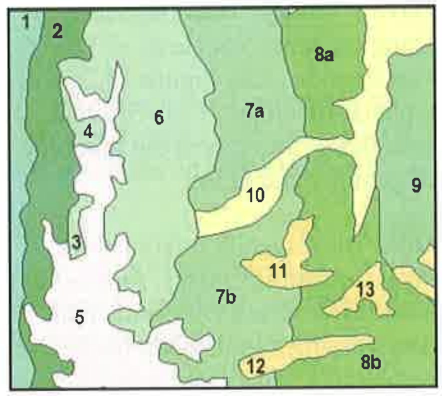


Fig. 13.4. Complex editing

Divide and conquer

Divide and conquer starts by digitizing the outline of a large area, such as the square outline of the map. The Cut Polygons tool is then used to carve out polygons from the larger region. One might start with polygons 1, 2, and 6 (creating a fake boundary between 6 and 7b that goes through 5). Then create 7 as a single unit, 8 as a single unit, and 9. Finally, use Create New Feature to create 5, 10, 11 to 13, and the remaining islands on top of the larger units. After creating each island, the Clip command (discussed in the next section) is used to eliminate the overlap with the larger polygon underneath. Occasionally with this method one is forced to create a superfluous boundary within a polygon, and then merge the two afterwards.

Adding territory

Adding territory relies mainly on the Auto Complete Polygon tool. One might start with Create New Feature to create polygon 1. Switch to Auto Complete Polygon and add 2 and 3. Add 4, temporarily closing the narrow neck between it and 6. Add 5 and 6. Go back and merge 4 and 6. Add 7a and 7b, leaving a hole where 10 is. Add 11 and 12 using Auto Complete. Add 8a, 8b, and 9. Finally close off 10. Go back to Create New Feature and create the islands, making sure to clip out the underlying polygon areas beneath each one.

Combining features

During editing, especially when editing complex shapes, creating a single feature at a time is often not sufficient. We mentioned that creating island polygons generates an overlap with the larger surrounding polygon. Occasionally it is easier to create a polygon in two or more pieces, after which they must be combined. During editing there are several useful techniques that can aid in maintaining correct topology. The editing functions are similar to the geoprocessing tools such as Clip and Intersect, but they operate on selected features, rather than on entire layers. Moreover, the attributes are treated differently. Instead of combining all the attribute fields from both inputs, the output feature simply has the same attribute fields as the layer being edited.

When using these combinations, the user should be sensitive to how attributes of the features are handled. In the case of a merge, union, or intersect, the resulting features will be given the attributes of one of the original features. In a geodatabase, the attributes of the feature selected FIRST will be copied to the output feature. For shapefiles and coverages, the feature with the lowest feature-id will be copied. If the feature attributes matter, then the user must pay attention to which attributes are being copied and must correct any attributes that were not copied as desired.

Merge

A merge takes one or more features and combines them into a single feature (Fig. 13.5). If the two features are adjacent, then the boundaries between them are removed. If the two features are separate, then a multipart feature will be created. This function might be used frequently to update a parcels map when an owner has purchased two adjacent parcels and combined them into one. It is also useful when one finds it easier to digitize a feature in two or more pieces and then combine them afterwards.

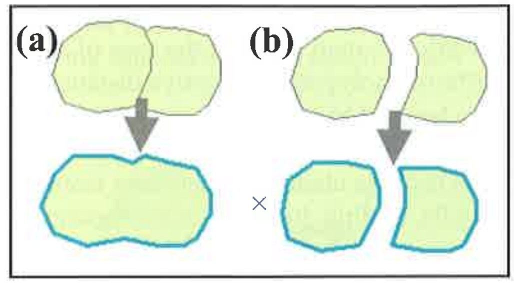


Fig. 13.5. (a) Merging adjacent polygons to create a new feature. (b) Merging separate polygons to form a multipart feature.

Union

A union performs the same operation as a merge, except that the original two features remain unchanged and a new feature is created in addition to the originals.

Intersect

An intersection creates a new feature from an area common to both original features (Fig. 13.6). A new feature is created, and the original ones are maintained. If two features are selected and an intersection is performed, the resulting new polygon will consist only of the areas shared by the original polygons. The new feature is created in addition to the original features, which are not changed or deleted. This function might be used to identify repeat infestations of pine bark beetle attacks. Two features representing infestations in two different years could be intersected to reveal the area attacked twice.

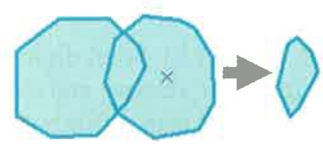


Fig. 13.6. Intersection of two polygons to create a third polygon

Clip

A clip behaves in a cookie-cutter fashion. If one feature lies over another, the underlying feature will be cut along the boundaries of the overlying feature (Fig. 13.7a). Two options may be specified, preserving the area common to both features (Fig. 13.7b) or discarding the area common to both features and retaining what is outside the clip polygon (Fig. 13.7c). In either case, the feature used for clipping is retained unchanged, and the feature underneath is modified. As shown in Figure 13.7c, clipping is one way to create a "donut" polygon. Clipping is useful anytime a polygon must have internal boundaries, such as a residential area with a park in the middle. It is also useful for creating an island polygon inside another. Clipping is crucial to enforcing the "must not overlap" rule by removing sections of a polygon that lie underneath another polygon.

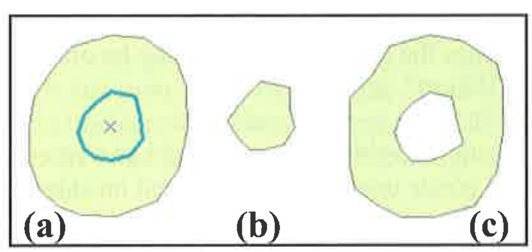


Fig. 13.7. Clipping. (a) Ready to clip the outer polygon with the selected polygon. (b) Option to preserve the common area. (c) Option to discard the common area.

Buffering features

A buffer delineates the area within a specified distance of a feature and can be created from points, lines, or polygons (Fig. 13.8a–c). The output may be lines or polygons. The buffer distance must be specified in map units. In the case of buffering polygons, a negative distance may be used to reduce the size of the feature (Fig. 13.8d). Buffers are useful for such tasks as identifying setbacks from parcels, finding drug-free zones around schools, or creating road widths from a set of centerlines.

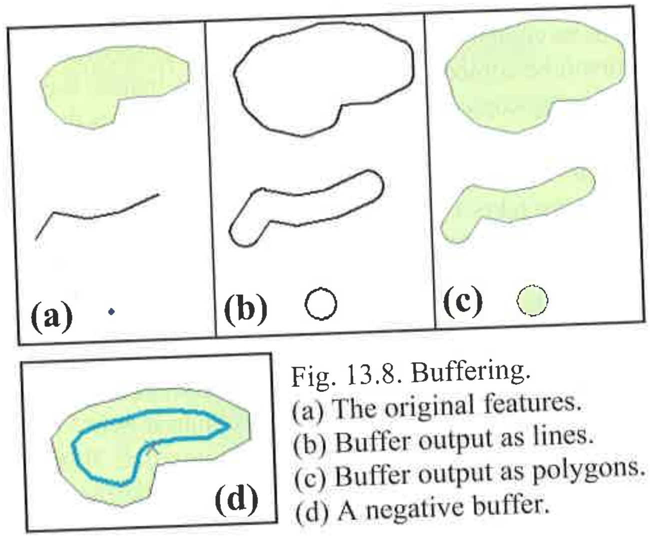


Fig. 13.8. Buffering.
(a) The original features.
(b) Buffer output as lines.
(c) Buffer output as polygons.
(d) A negative buffer.

Stream digitizing

Two methods can be used to place vertices for lines and polygons. So far you have used the point-by-point method in which each vertex is placed with a click (Fig. 13.9a). **Stream digitizing** offers another approach. The user chooses a tolerance that controls how far apart each vertex should fall. The first vertex is added with a click. Then the user smoothly moves the mouse pointer over the line to be digitized. Each time the tolerance distance is traversed, a new vertex is added automatically (Fig. 13.9b). Stream digitizing can be faster than point-by-point digitizing, but it does have some drawbacks.

First, in point-by-point digitizing the user only adds as many vertices as needed. Straight edges require fewer vertices and curved edges need more closely spaced vertices. In stream digitizing, one tolerance is used for both. Thus, straight lines often have more vertices than needed and may not be as straight, and curved sections may not have enough vertices. As a result, the features may be less accurately captured, and the file size is larger due to the extra vertices. The choice of stream tolerance is critical for good results.

Second, when creating a line point by point, the user can place a vertex exactly on the inflection points of the feature to capture the shape with greatest accuracy (Fig. 13.9a). In stream digitizing, the vertex falls when it reaches the set tolerance and may be offset from the actual inflection.

The third problem is that a slight movement off the line will create unwanted vertices that must be cleaned up later. A steady hand is required for stream digitizing. In Figure 13.9b, the sketch shows three places where the curve deviates from the feature being digitized (arrows).

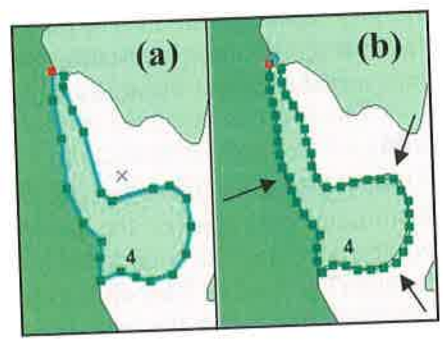


Fig. 13.9. A polygon captured with (a) point-by-point and (b) stream digitizing

Most users find that they develop a preference for one kind over the other. The style of the features being digitized affects the results as well. Feature classes with many long, straight lines will be much more efficiently digitized using the point-by-point method. Feature classes with many smooth curves can benefit from stream digitizing. It is also possible to switch back and forth between styles while digitizing a single feature, using stream for curved sections and point-by-point for straighter sections.

About ArcGIS

We now turn to a discussion of some additional tools and techniques for editing in ArcMap.

Changing existing features

Once a polygon or line has been created, it can be changed by eliminating unwanted vertices, adding vertices, or moving existing vertices. Other modifications include flipping lines, trimming them, extending them, and performing a variety of other editing functions. These functions are useful for cleaning up errors from stream digitizing.

Modifying features

The Editor toolbar contains an option for **modifying** existing features by adding, deleting, or moving vertices. The Edit Vertices tool causes the sketch of the feature to appear. When the edits are complete, the feature is updated to the current form of the sketch. Figure 13.10 shows how an original circular polygon is modified by moving vertices in the sketch.

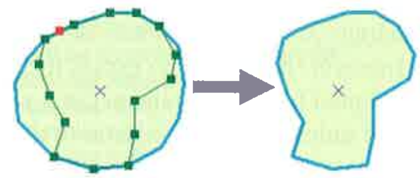


Fig. 13.10. Modifying a feature

Reshaping features

The Reshape Feature tool reenters a feature or a portion of a feature by using a new sketch to define the revised shape. The sketch must start and finish on the original feature, so it is helpful to have vertex or edge snapping on. When the sketch is finished, the original feature is modified to follow the sketch. Figure 13.11 shows the process of **reshaping** parts of lines and polygons.

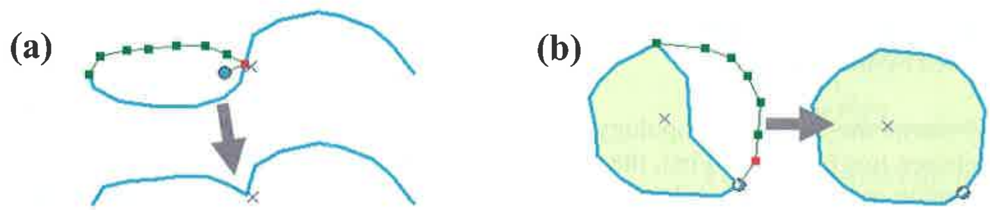


Fig. 13.11. Reshaping features. (a) Reshaping part of a line. (b) Reshaping a polygon.

Flipping lines

As we found in the chapter on geocoding, lines can have a direction. Lines begin at the "from" node and end at the "to" node. Normally the direction of a line generates little concern, and either direction works just as well. In some instances, however, the direction matters. In geocoding, it matters because it defines which way the addresses increase along the street. A streams feature class used for network analysis uses the line direction to encode the flow of water. A similar situation would hold for constructing a network of water pipes or sewers in which the direction of flow must be constrained and recorded.

The direction of lines may be determined by drawing them with arrow-ended symbols. Once drawn, you can see the direction of flow and flip the direction, if necessary (Fig. 13.12).

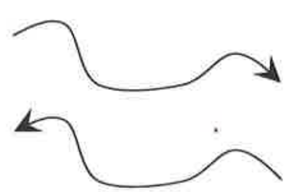


Fig. 13.12. A flipped line

Editing with map topology

Building planar topology with rules for a feature dataset and using it during editing requires an ArcEditor or an ArcInfo license. However, users with ArcView licenses or users who are editing shapefiles can use a function called **map topology** to edit features with shared edges or vertices. Map topology creates temporary relationships between features so that they can be edited together. Its purpose is to preserve existing coincident boundaries and nodes.

Topological editing uses a **cluster tolerance** to help enforce snapping and coincident boundaries. When two vertices of features being edited fall closer together than the cluster tolerance, the vertices are made coincident. Setting the cluster tolerance requires great care. If too large, it will change coordinates unnecessarily. If too small, it does not help prevent topological errors. However, it is better to err on the side of too small than too large. The default tolerance is designed to preserve the accuracy of features rather than do extensive corrections and should be used unless you have reason to do otherwise.

The user creates map topology by selecting which feature classes will participate in it. The topology is created on the fly for the set of features currently in the data view. The endpoints of lines are called **nodes**, and lines or polygon boundaries are called **edges**. The user selects the node or edge to be edited using the Topology Edit tool, which is similar to the regular Edit tool, except that it selects shared edges or nodes for editing. When using the Topology Edit tool to select a feature or part of a feature, all features sharing that boundary are also affected by the edits.

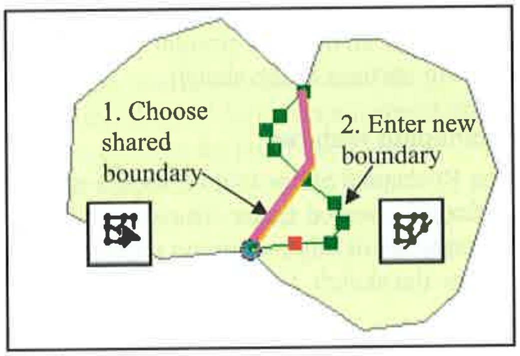


Fig. 13.13. Reshaping a polygon

Figure 13.13 shows the use of the Topology Edit tool and the Reshape Edge tool to change the boundary between two polygons. First, the shared boundary is selected using the Topology Edit tool. The selection color of the Topology Edit tool is purple to distinguish the selection from those made with the Edit tool. The Reshape Edge tool is then used to draw the new boundary between the polygons. When the sketch is finished, the new boundary replaces the old one, and the change is applied to both polygons.

The Topology Edit tool is also convenient when working with connected line features, such as roads. If one road node is moved, the roads attached to the node move also. In Figure 13.14, the road node was selected with the Topology Edit tool and then moved downward. The attached vertices of the other lines are also moved when the sketch is finished.

The Topology Edit tool and other topology editing tools should always be used for editing a map topology. They can be applied to moving features, reshaping them, and modifying them. However, the map topology must be created prior to using the topology tools.

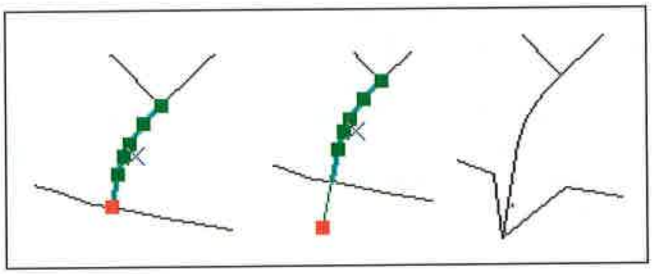


Fig. 13.14. When editing shared nodes, the node is moved, and the attached roads follow.

Editing with planar topology

With an ArcEditor or ArcInfo license, feature classes within a feature dataset may be assigned to participate in a planar topology. The topology is created in ArcCatalog, and specific rules are invoked concerning the desired topological relationships. Once the rules are defined, **validation** is performed to assess adherence to the rules. Errors are found and marked during the validation process. Afterwards, the user can view the errors and use specialized tools to fix them.

The available rules vary depending on what type of feature (points, lines, or polygons) they govern and whether they apply to a single feature class or to relationships between two feature classes. Figure 13.15 shows the rules that could be applied to lines (above) or polygons (below).

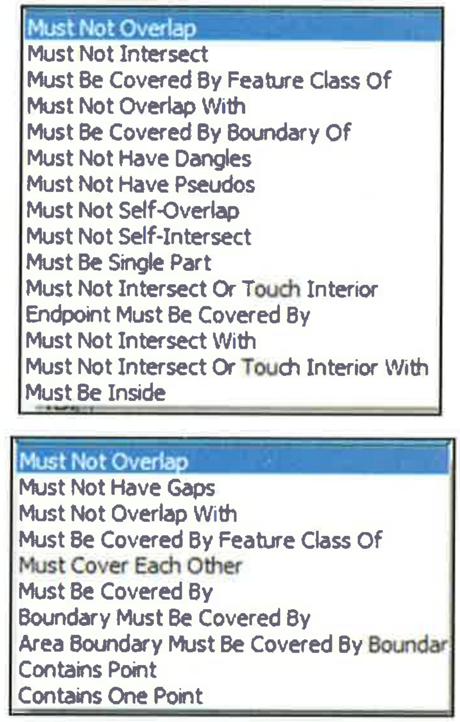


Fig. 13.15. Rules for lines (above) and polygons (below)

The topology is assigned a cluster tolerance when it is created. The cluster tolerance is the minimum distance allowed between vertices. During validation, if two or more vertices lie within the cluster tolerance, they will be snapped together.

By default, the cluster tolerance is the same as the feature class XY tolerance, or 0.001 meters. This value is designed to preserve coordinate accuracy. If the default is accepted, then virtually no vertices will be snapped together. Yet it is often desirable to set the cluster tolerance to a larger value, because then the topology can fix some errors automatically. The cluster tolerance should never be less than the XY tolerance.

Choosing the cluster tolerance can be tricky. Both the resolution of the data set and the size of the typical errors must be considered. If the tolerance is too small, then all edits must be manually done. If too large, it can degrade the data set accuracy. Imagine a road data set collected by GPS from a truck, with vertices collected every 25 meters. As lines are stopped and started at intersections, an offset of 3–5 meters typically occurs. These data are then placed in a topology. If the default cluster tolerance of 0.001 meters is employed, then none of the ends would be snapped, and each intersection must be edited manually. However, if the cluster tolerance is set to 6 meters, then most of the road intersections will be snapped automatically, leaving far fewer errors to edit. Since vertices average 25 meters apart, the cluster tolerance will not collapse actual measurements together.

During validation, several processes occur. First, cracking places an extra vertex on edges that fall within the cluster tolerance of another edge, vertex, or end, and then clustering collapses the vertices together. It is important to realize that the validation step can move the vertices of features from their original locations. Users can specify ranks for the different feature classes. Lower-ranked features will be moved to match higher-ranked features. If features have equal ranks, then both sets of vertices may be moved.

TIP: Because validation can change locations of features, it is vitally important that a backup copy of the data should be established before validating, in case of an error specifying the cluster tolerance or rules.

The validation produces a topology feature class that contains point, line, and polygon errors, which may be drawn and symbolized during an editing session. Figure 13.16 shows some topology errors for the Edwards aquifer geology and faults. The pink boxes indicate point errors, the pink line, a line error, and the red outline a polygon error.

The user examines and fixes the identified errors singly or in batches, as appropriate. Unavoidable errors, such as the dangles that occur where a fault ends, are marked as exceptions. Each type of error has different possible fixes that can be applied. Dangles may be snapped, extended, or trimmed. A gap must have a feature created to fill it. An overlap must have the overlap area removed.

TIP: There is an excellent summary of topology rules and error fixes in ArcGIS Help. Search for "topology error fixes" and select "Geodatabase topology rules and topology error fixes."

After all errors are found and fixed, the user must validate again. Often fixing one set of errors produces new ones. The process of validating, editing, and validating again must be followed until no new errors are found.

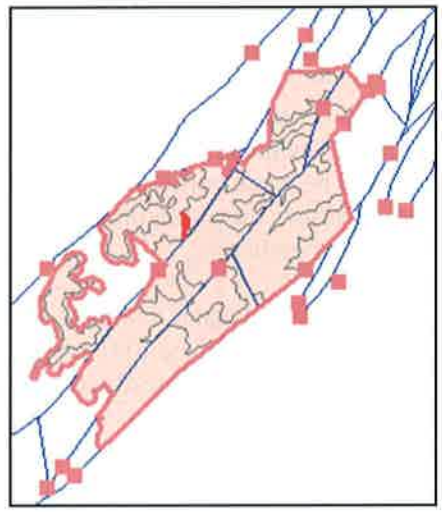


Fig. 13.16. Topology errors

Summary

- Careful editing helps create and maintain topological integrity between features. Topological rules establish requirements for feature adjacency, connectivity, overlap, and intersections.
- Planar topology establishes rules about the spatial relationships within and between layers, and can be used to help locate and eliminate errors.
- Strategic planning helps when digitizing complexly arranged polygon feature classes.
- Features may be combined to create new ones using merge, union, intersect, and clip. Care must be taken to ensure that attributes are correctly copied during these transactions.
- New features can be created by buffering points, lines, or polygons.
- Stream digitizing can help create smooth curved boundaries, but it has some drawbacks.
- Modifying and reshaping are two ways to change existing features.
- Temporary topological relationships, called map topology, may be used when editing with an ArcView license, allowing features that share vertices or boundaries to be edited simultaneously with the Topology Edit tool.