# Overcoming difficulties
# in building your
# Geometric Network?

**Robert D. Borchert**
**GIS Technician II**
**United Services Group**
**Great River Energy**

**ESRI International User Conference 2007**
**San Diego, California**
**June 19, 2007**
**8:30 am – 9:45 am**
**Room 31-A/B**

# Overcoming Difficulties in Building your Electric Geometric Network

- Having a Geometric Network for your electric or gas GIS can result in some money saving benefits. Some of the benefits include facilitating load management, staking, outage management and system analysis. On the other hand if you have never had a Geometric Network in place, the time and cost of building one can be expensive. This session will address the range of problems we have encountered while developing Geometric Networks and the procedures we have developed before and after the build to overcome those problems. We will share with you our problem solving method for building Geometric Networks The intent of this paper is to help you create a Geometric Network with 100 percent connectivity by helping you avoid some of the common mistakes and build errors.

# Qualifications

- BA in Geography with a minor in GIS.
- 10 Years progressive experience GIS.
- Working with GIS for Electric Systems for 6 of those years.
- EGUG member.

# Geometric Network: Topics

- What is a Geomeric Network?
- Why you may want a Geometric Network.
- Why you may not want a Geometric Network.
- What is required to create a Geometric Network?
- Quick overview on Creating a Geometric Network.

Today I am going to talk over a variety of topic on Geometric Networks.

I am going to start with a brief description of what a Geometric Network is.

I will also discuss why and why you may not want a geometric network.

I will give you a brief overview of what is required to make and work with a geometric network.

There will be a discussion on some of the problems you may encounter when creating or using your Geometric Network.

# Geometric Network: Topics

- Errors you may find after building your Geometric Network.
- Steps you can take before starting.
- Analyzing your Geometric Network after building it.
- Troubleshooting your Geometric Network.
- Advanced Geometric Network use.

I will cover some steps you can take before starting your Geometric Network that may help in making the creating of it a little easier and to help you avoid some of those problems.

I am going to discuss with you how to analyze your geometric network once you have it built and some of the errors you may find after you have built it.

I am going to talk about some steps and procedures you can work with to overcome those errors.

Everything I am going to talk about pertains only to out of the BOX ArcGIS and does not take into account any Developer tools that may be available.

And I will talk about an advanced step you can take to help maximize your Geometric Network.

# What is a Geometric Network?

- A geometric network is a set of connected edges and junctions, along with connectivity rules that are used to represent and model the behavior of a common network infrastructure in the real world.[1]
- Single dimension non-planar graph with features.
- Edge elements and junction elements connected by topology.

1. Defination taken from ArcGIS
Desktop Help. ESRI ArcMap 9.2

What is a Geometric Network?

A geometric network is a set of connected edges and junctions, along with connectivity rules that are used to represent and model the behavior of a common network infrastructure in the real world.

From a technical perspective it is a Single dimension non-planer graph with features.

Or rather Edge elements and junction elements connected by topology

# Or more simply…

- The GIS knows how things are connected from point "A" to point "B".
- Direction of flow.
  - Source to end
  - Path of electric current from Substation to Customer
- Dot to Dot puzzle.

Or more simply

Click

Your GIS builds a topology of  how things are connected from point A to point B

Or rather, as it pertains to electrical distribution, how electricity gets from the Substation to the customer
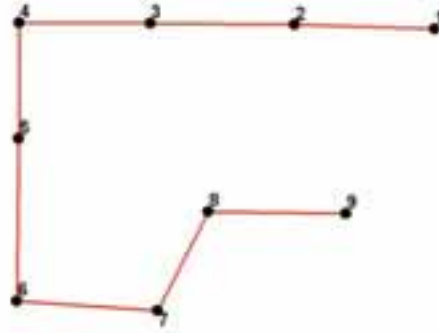
Click

The Geometric Network remembers the direction of flow.  How electricity travels from beginning to end

Click

The Geometric Network can be related to a Dot to Dot puzzle.

# Connecting the Dots

- Collection of numbered Dots
- Connected by lines



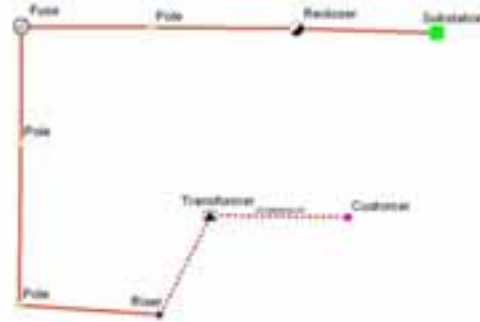Essentially a Geometric Network, is a collection of numbered dots, or points

Click

That are connected by lines

# Connecting the Dots

- **What are the Dots and Lines?**
  - Substations
  - Reclosers
  - Fuses
  - Transformers
  - Customers
  - Conductor



Those dots and lines have meaning in the GIS.  They can represent a variety of objects
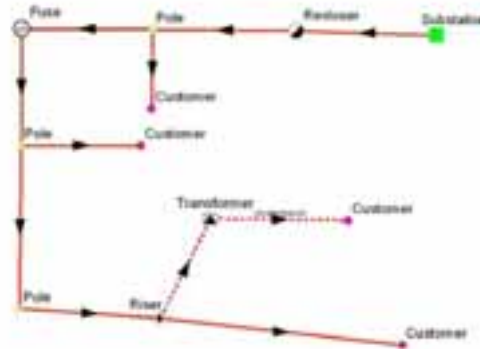

Click

Substations

Reclosers

Fuses

Transformers

Customers

And the lines can represent Underground and Overhead Conductors

# What is a Geometric Network

- **Direction of Flow**
  - Path of travel
  - From substation to customer
  - Multiple branches
  - Independent of polyline direction

Your Network will also establish and maintain a direction of flow.

Flow is the path of travel from beginning to end

Click

From your substation to your customer.

Click

Unlike your average Dot to Dot puzzle the Geometric Network can include multiple branches off of the initial line

Click

The direction of flow is independent of polyline direction

# Why you may want a Geometric Network?

- Quick analysis tool.
  - Find all "B" phase customers on Feeder 3.
  - Find which devices multiple customers share.
- Drawing errors.
  - Unconnected drawing elements.
  - Loops.
  - Missing drawing elements.
- More efficient editing.
  - Keeps elements connected.
- Outage management tool.

You may ask yourself, "Why would I want a Geometric Network"

Use a find all transformers on B phase of the North Feeder

Then you can generate a report using the Create Report or Crystal Report Wizard and generate your report based on selected features
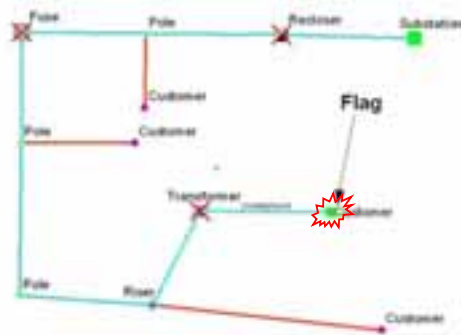
It can be used as an outage management tool.

It can help you locate drawing errors

Also it can allow for more efficient editing.

# Outage Management Tool

- Customer calls
  - Place Flag
  - Perform Trace Upstream
- Highlights possible problem spots
  - Transformer
  - Fuse
  - Recloser



You can also use the Utility Network Analyst as a tool in outage management. Say for instance you get a customer call about an outage.

Click

You place your flag at the customer

Click

And perform a Trace Upstream

Click

The trace has automatically found the path directly to the Substation.  You can change the display properties of the transformers, fuses, and reclosers to make them more noticeable.

This allows you to quickly spot a potential location for a device fault.

# Outage Management Tool

- Second Customer calls
- Place second flag on that customer
- Find Common Ancestors
- Highlights c̶ components
- Third Customer calls
- Fourth Customer calls
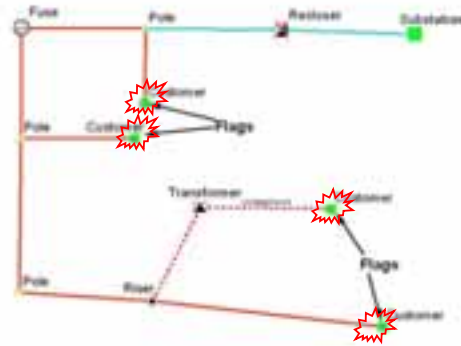
Well what if a second Customer calls

Click

Place a second flag on that customer

Click

 This time choose Find Common Ancestors from the Trace Task Toolbar and perform the trace

Click

The trace now selects only the components which the two customers share in common

Click

How about when the third customer calls

Click

When the fourth customer calls

The more calls you get the narrower your fault area gets.

# Why you may not want a Geometric Network

- Less efficient editing.
- Only one network element per location.
  - GPS Data
- Cannot LOAD new data in ArcCatalog.
- Can be more labor intensive.

On the reverse side, what are some reasons you may not want to have a Geometric Network

Click

The characteristic that can make it easier to edit can also make it more difficult to edit.

The network elements are all attached together.  When you move one element you move all attached elements.  This can make it easier or more difficult to edit, depending upon the situation.

It is not a problem to delete the Geometric Network and recreate it after performing your edits

Click

You can only have one Network Element per Location.

Click

You cannot load new data in ArcCatalog into your feature dataset while the Geometric Network is in place.  You need to first delete the Geometric Network. You can add new features during an edit session.

Click

Building a Geometric Network can be very Labor intensive and require a lot of time

## What is required to create a Geometric Network?

- ArcEditor or ArcInfo.
- ArcCatalog.
- Geodatabase or Filedatabase
  - SDE Database.
- Same Feature Dataset.
  - Standard Data Model
- Note on ArcView and ArcReader.
  - Cannot edit network elements
  - Will not publish for ArcReader

What is required to create a geometric Network?

Click

You cannot create a Geometric Network using ArcView, you must have either ArcEditor or ArcInfo

Click

You create the Geometric Network in ArcCatalog

Click

You need to have your system in a geodatabase.

Click

You need to have all the Feature Classes in the same Feature Dataset.

If you are already using a standard data model then you are probably set to go

Click

You can use the Geometric Network in ArcView, but you cannot edit any of the Network Elements.

When you publish to ArcReader you do not publish the Geometric Network.

# Basic procedure to create a Geometric Network

- Make a backup.
- Can corrupt your drawing.

If this is your first time creating a Geometric Network I would recommend making a backup of your Geodatabase

The creation of the Geometric Network can corrupt the integrity of your drawing. I will show you an example of this in a few minutes

# Basic procedure to create a Geometric Network

- Start ArcCatalog
- Right Click the Feature Dataset
- Select
  - ➤ New
    - ➤ Geometric Network…
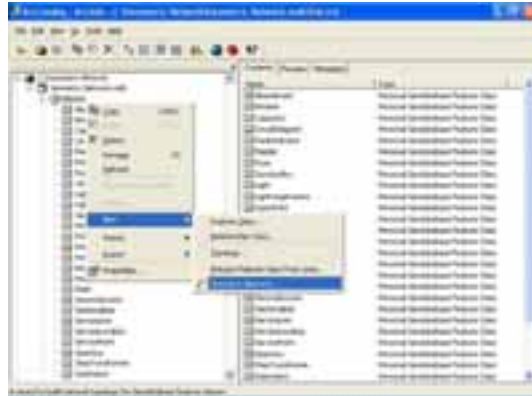


To create a new Geometric Network

Start ArcCatalog and navigate to your geodatabase.

Click

Right click on the Feature Dataset where you are going to create the geometric Network

Click

Select NEW

Click

Geometric Network

Click
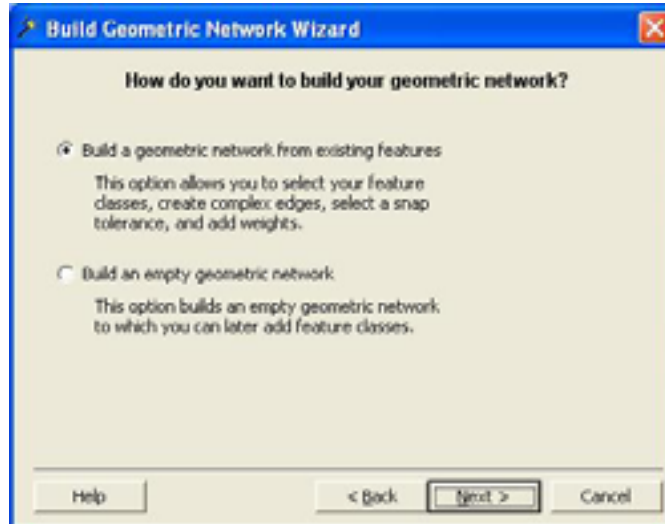
# Build Geometric Network Wizard

- Step by step wizard…
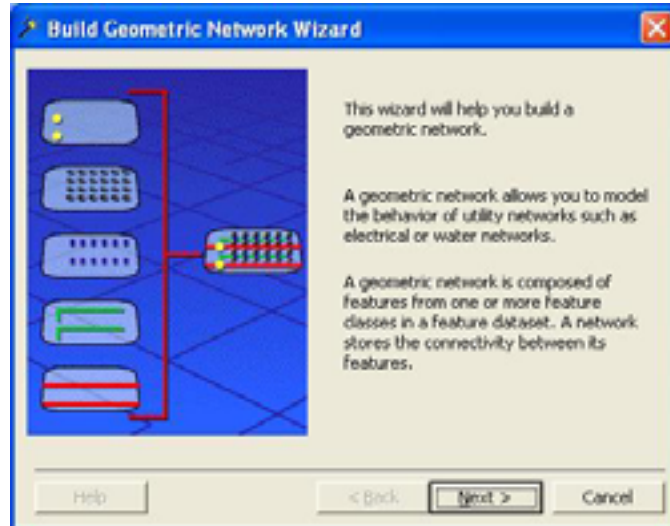


The Build Geometric Network Wizard will guide you step by step in creating the Geometric Network

Click Next to begin

# Build Geometric Network Wizard

- Build a geometric network from existing features



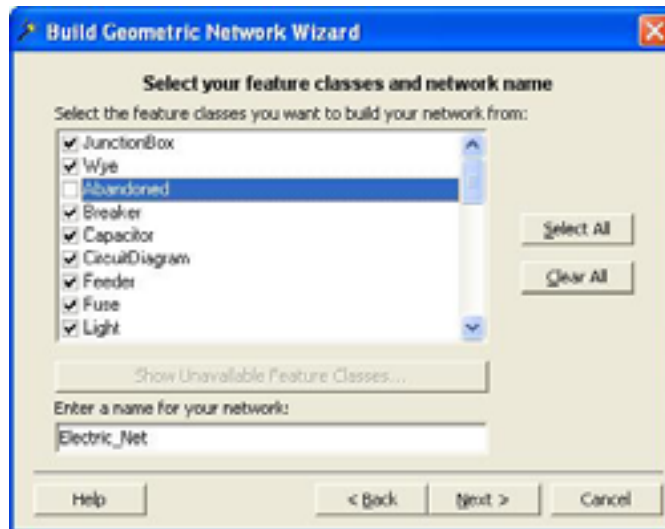Build a geometric network using existing features or build an empty geometric network.

This second option would be used for creating the system from scratch.

Since we are building from existing features we will choose the first option

Select Next

# Build Geometric Network Wizard

- Select the features classes and name for your Geometric Network



Select the Feature Classes that you want to have in your Geometric Network.

If you know you want all elements in the Geometric Network you can choose Select All

If there are some items that you need to remove just select them

This is also where you choose the name of the Geometric Network. The default name will be the name of the Feature Dataset Underscore Net

# Build Geometric Network Wizard

- Enabled values
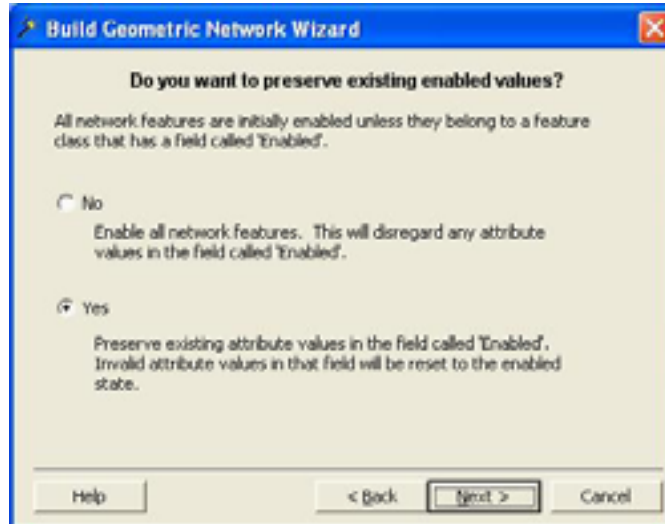


The Enabled value is a true/false designation.

True means that flow can go through that feature, false means that it cannot. The wizard will add this field if it does not already exist to all feature classes in the Geometric Network.

The Enabled field needs to be true for all network elements for which you want flow to pass through.

Such items as Normally open Switches would be enabled False

# Build Geometric Network Wizard
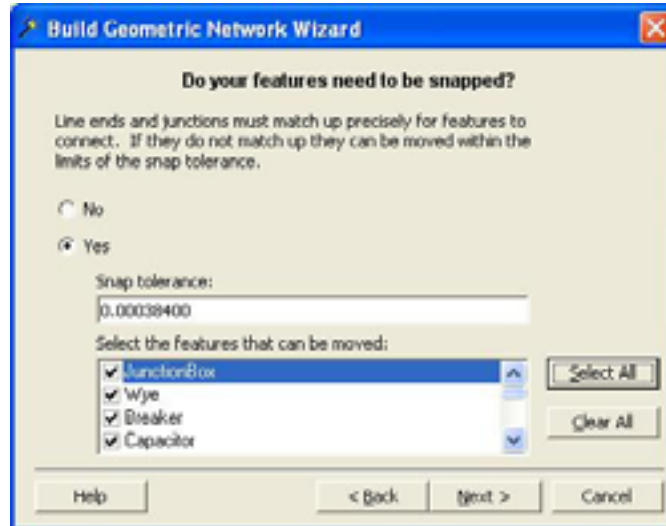
- Complex or Simple edges
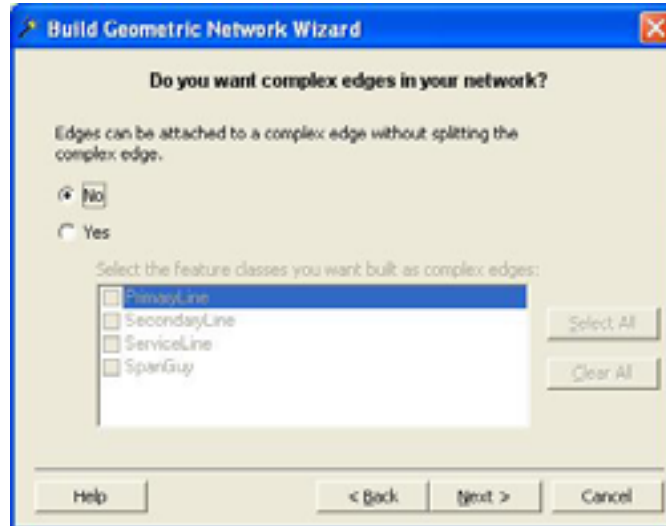


A complex edge allows features to connect without breaking a line.  As long as one of the features has a node

This is a personal preference.  However, use of complex edges can lead to conductors connected that should not be.

Click NO

# Build Geometric Network Wizard

- Snapping



Snapping is a critical part of the wizard. All features need to be connected for this to work. Even if the ends of two lines are only a centimeter apart you cannot establish flow.

This part is why you experiment on a backup of the geodatabase.

I would recommend using the default snap tolerance the first time. Increasing the snap tolerance can alter your drawing.
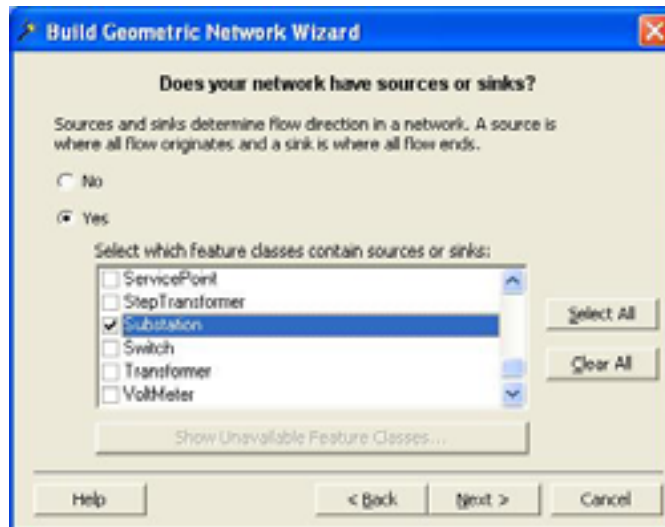
I will show you an example of this in a few minutes.

This is a permanent change and cannot be restored.

I will select all and use the default

# Build Geometric Network Wizard

- Sources and Sinks



Does your network have Sources or Sinks

A source is where the flow begins and goes outwards from there.

A Sink is the end point and flows goes backwards from there.

You only need sources or sinks in your network.

For electric systems a Source works best and is usually the Substation

choose yes

Click

And select your desired feature class or classes

The wizard will create a field called AncillaryRole in these layers.  The AncillaryRole will have a value of None, Source, or Sink which will need to be updated manually once the wizard finishes

# Build Geometric Network Wizard

- Weights



Weights are generally used for road, sewer, or water networks where resistance plays a factor.
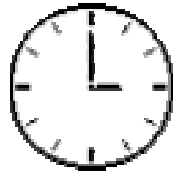
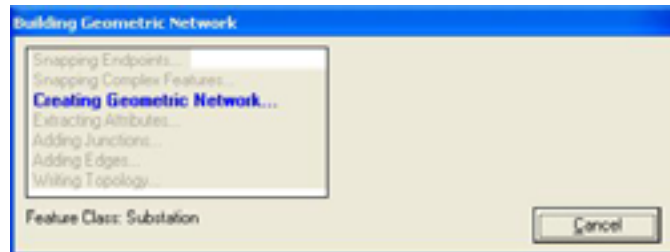# Build Geometric Network Wizard

- Summary



This is the final step in creating the Geometric Network.  This will be a summary of what the wizard is going to do.

After reviewing the steps to be performed click FINISH

# Build Geometric Network Wizard

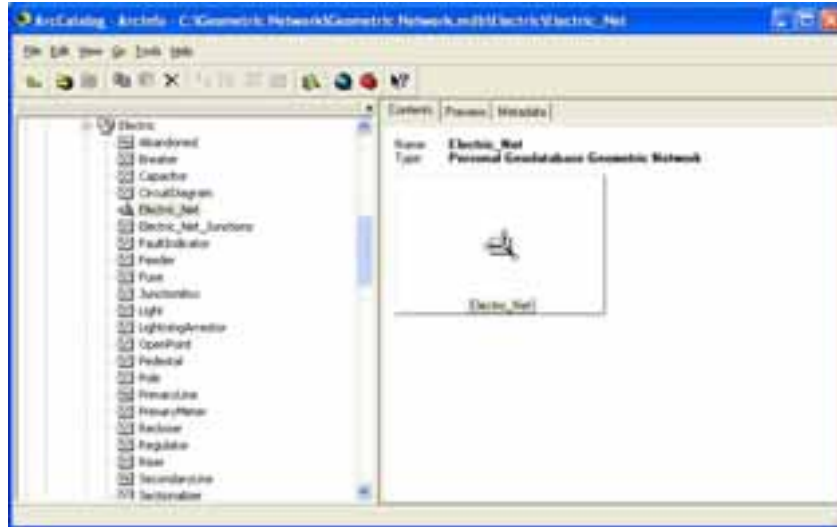- Building the Geometric Network



You will see this message window while the wizard is creating your network.

This step may take quite some time depending upon the size of your system.

# Build Geometric Network Wizard

- Same Feature Set as Network Elements



When the wizard is finished, you will return to ArcCatalog
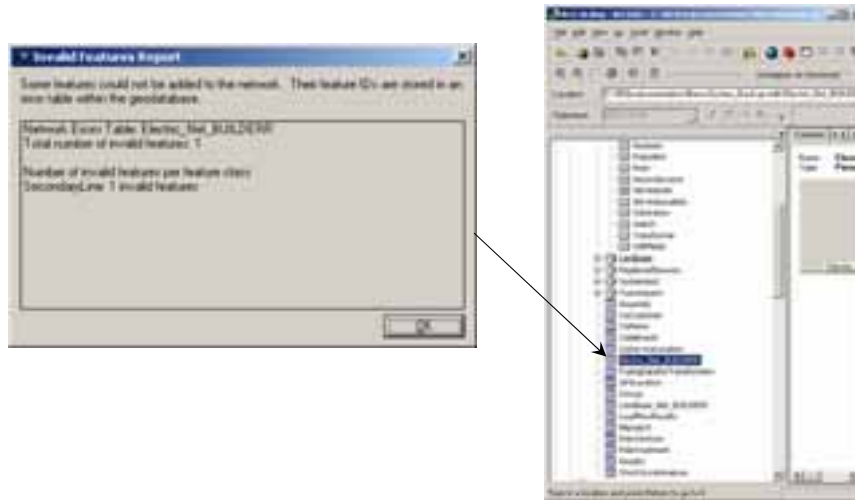
You will observe that there are two new files.

The first one is the topology of the network itself, the second is a collection of all the junctions in the Geometric Network

You do not need to load either of these they will automatically load when you use this feature dataset

# Errors you may find after building your Geometric Network
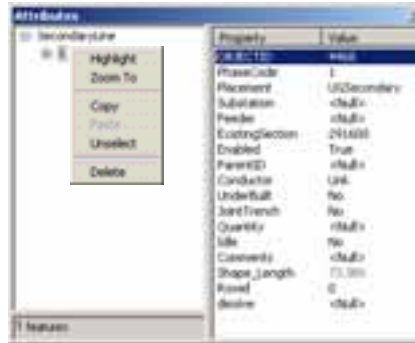
## INVALID FEATURES REPORT



There are a variety of problems you may encounter when you create your Geometric Network.

When you build your geometric network you may get this pop up box. Invalid Features Report. This is a list of specific errors in the Geometric network that cannot be resolved and you will need to address them before you can make your network function.

The list of errors will appear in your geodatabase as a table. That table if you look at in in ArcCatalog will have a listing of errors by object id

# Errors you may find after building your Geometric Network

- Fix errors in ArcInfo
- Add the Geometric Network Editing Toolbar.
- Start an edit session
- Open the Attributes window

If you have Invalid Features they can be found and corrected in ArcInfo or ArcEditor.

Start your ArcInfo session and add the Geometric Network Editing Toolbar

Add the toolbar for Geometric Network Editing.  The whole bar should be grayed out.

Start an edit session.  Part of the toolbar will highlight.  Now open your attributes window.

Click on the icon on the far right.  This is the Network Build Errors button.

A pop up window should appear telling you how many major errors you have and the attributes window should be populated with the errors.

You can zoom to each error and fix them.

# Errors you may find after building your Geometric Network

- Conductor connected to itself
- Different than a loop
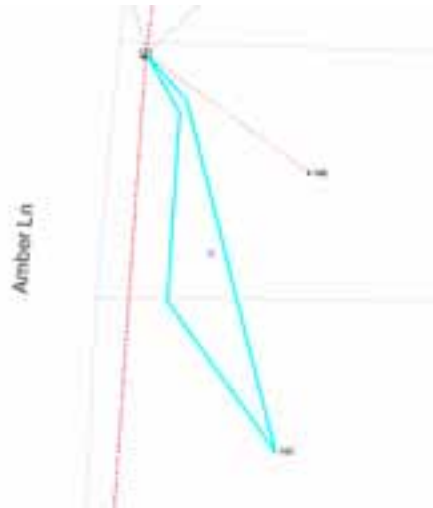


The most common error you will have when using this tool will be where the end points of the polyline match up.  This is different than a loop as I will show you shortly.

To fix this type of error you need to either move one of the end points or break the line physically delete  segment or add an open point/switch that is enabled FALSE

# Set Flow Direction

- Set Flow Arrow Button / Display Arrows Button
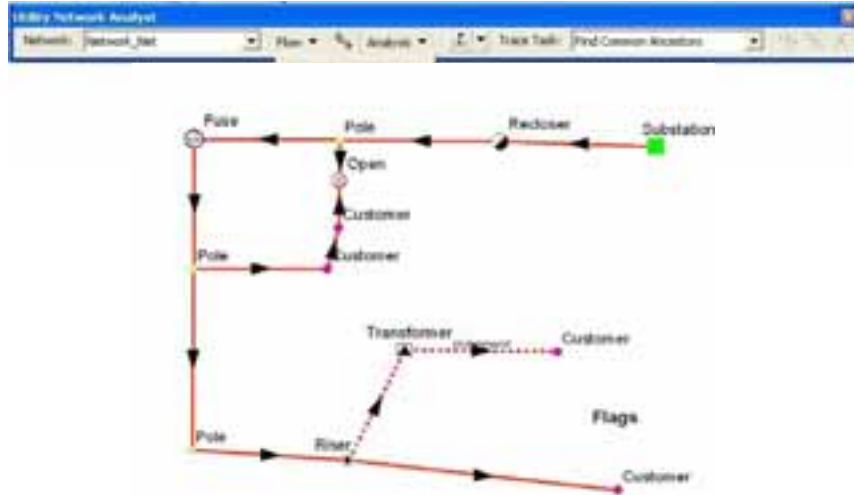


Here is what happens

Click

Click the flow drop down menu and click on Display Arrows. A series of black circles will appear in the center of each section of polyline. That is the symbol for uninitialized Flow.

Click

Click on the Initiate flow button and watch them turn to Arrows.

You have successfully completed a Geometric Network. In some areas you may continue to see black circles that is in indication of some sort of error, such as a loop or sections that are not connected.

# Set Flow Direction

- Start an edit session
- Generate Flow Button



**Generate Flow**

Flags and Barriers

Solve Button

Trace Task
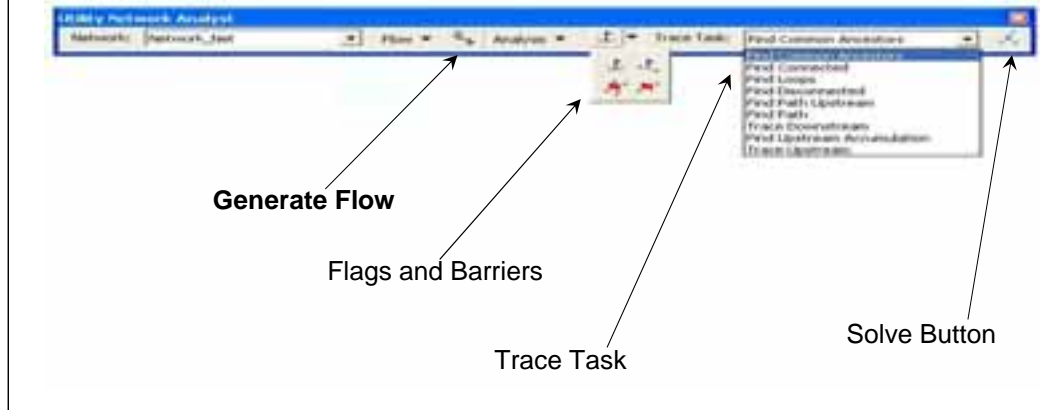
The final step to take before you can start to use your Geometric Network, or check for errors is to Set Flow Direction.

The Build Geometric Network Wizard has  wrote a set of instructions telling the system how to get from the Substation to the customer.

It just hasn't been activated yet.

Click

To set the Flow Direction you must first start an edit session with your Feature Dataset that contains the Geometric Network.

Then you just click on the Generate Flow button in the Utility Network Analyst Toolbar.

# Errors you may find after building your Geometric Network

Loops
- Missing drawing items. Or Enabled status not correct
  - Switches
  - Opens
- Multiple copies of an element.

There are a variety of problems you may encounter when you create your Geometric Network.

Click

You can only have one feature class per X,Y location. This is so that the system won't get confused as to which object flow goes though first. This is by design.
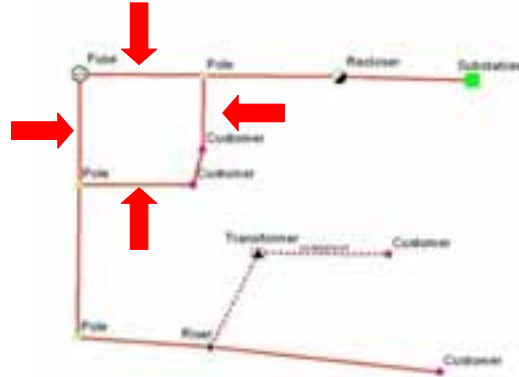
Click

You may have loops. As we covered before, they are usually a drawing error caused by missing drawing items or incorrectly placed polylines.

Click

Many of the features may not be connected. The Automatic Snapping in the Build Geometric Wizard can help with this if you re-run the Wizard and increase the tolerance.

# Find Loops

- Drawing error
- Circuit crosses back to itself
- i.e. short circuit
- Missing element
  - Switch
  - Open
  - Etc…
- Crossing Lines

You can locate loops

What is a loop?

Click

A loop is a drawing error

Click

Where the circuit crosses back to itself

Click

In other words a short circuit

Click

Usually the result of a missing element in the drawing, such as a Switch, an Open, or crossing lines.

# Fixing Loops

- Place Flag at Substation or on the conductor
- Find Loops
- ace
- M ctions
- P established



In order to find the loops in your drawing, place a flag at the substation or on the conductor

Click

Select the Find Loops option from the Trace Task Drop down menu

Your loop or loops will be the only things selected.

Click

Make your corrections and check to verify proper flow has been established

# Errors you may find after building your Geometric Network

- Many features may not be connected.
  - Automatic snapping in the Build Geometric Network Wizard.
  - Find Disconnected

There are a variety of problems you may encounter when you create your Geometric Network.

Click

You can only have one feature class per X,Y location. This is so that the system won't get confused as to which object flow goes though first. This is by design.
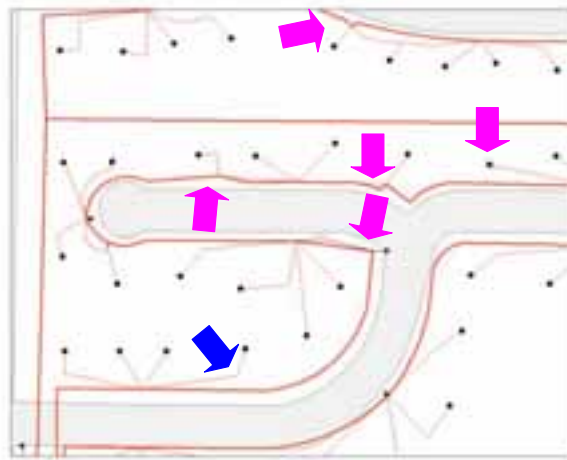
Click

You may have loops. As we covered before, they are usually a drawing error caused by missing drawing items or incorrectly placed polylines.

Click

Many of the features may not be connected. The Automatic Snapping in the Build Geometric Wizard can help with this if you re-run the Wizard and increase the tolerance.

Automatic snapping in the Build Geometric Network Wizard
Before Snapping / After Snapping — CAUTION

A note of Caution.  If you are experimenting with Geometric Networks it is advisable to make a backup first.  Let me show you why

Click

This is a representation of a real world electrical distribution system.

Click

If you look at the arrows to focus on areas of interest.

This is the system before increasing the snap tolerance.

Click

This is the system after using a snap tolerance of 2.0

Let me show you that again

Arrow Back

Before

Arrow Forward

After

REPEAT

# Errors you may find after building your Geometric Network

- Phantom nodes and polylines.
- Very small line segments.
- Incorrect options chosen at creation.
  - Enabled values
  - Ancillary role
  - Complex or Simple Junction

There are a variety of problems you may encounter when you create your Geometric Network.

Click

You can only have one feature class per X,Y location.  This is so that the system won't get confused as to which object flow goes though first.  This is by design.

Click

You may have loops.  As we covered before, they are usually a drawing error caused by missing drawing items or incorrectly placed polylines.

Click

Many of the features may not be connected.  The Automatic Snapping in the Build Geometric Wizard can help with this if you re-run the Wizard and increase the tolerance.

# Errors you may find after building your Geometric Network

- Cannot produce flow from the substation or source
- Check the AncillaryRole and Enabled fields
    - AncillaryRole – Substations are the **source**
        - 0 - None
        - 1 - Source
        - 2 - Sink
    - Enabled – A component is active or inactive in the network.
        - 0 - False
        - 1 - True



Some other problems you may encounter.

You cannot produce flow from the Substation or source

Click

Check the AncillaryRole and the Enabled fields which were created by the Build Geometric Network Wizard to ensure they are set to Source and True

Click

You will want to enter 1 for source

Click

And 1 for true

# Steps you can take before starting

- Point features are connected
  - Select all Service Points
  - Use Select By Location to unselect all Service Points that intersect a Secondary
- Connect Points
  - Bulk Snap Command
    - Developer Tool Kit

One of the basic steps you can take before creating your network is to ensure all your point features are attached to a polyline.  There are several ways you can do this.


Click

One method may be to create a temporary field and perform a Select by location operation.  Selecting all the points that intersect a conductor, use the attributes window to update that column with a value,  You can then symbolize based on the value in that field.

Click

You can then manually connect those points and find them easily based on that symbolization.  There are a variety of methods to do this and

# Steps you can take before starting

- Determine position of switches and status of areas where there can be an open
  - Update a column with that status
    - 0 = False = Open
    - 1 = True = Closed
  - Can then update the Enabled field after creating your network
  - If you delete your Geometric Network the Enabled field remains intact

Another step you can take before starting that will save you time afterwards is to determine the position of Switches and the status of areas where there can be an open.

Click

Update a column with that status. Use a 0 for false or Open and a 1 for true or closed. You may already have a device status field in your geodatabase.

Click

Once your network is built you can update the enabled field with that value.

Click

If you need to delete your geometric network and re-build it, that Enabled status will remain the same.

# Steps you can take before starting

- Find and correct very short polyline segments.
- Explode Multi-part Features.
- Find point features that intersect each other and move them apart.
  - GPS Data
  - Move Command

Another step you can take before starting that will save you time afterwards is to determine the position of Switches and the status of areas where there can be an open.

Click

Update a column with that status.  Use a 0 for false or Open and a 1 for true or closed.  You may already have a device status field in your geodatabase.

Click

Once your network is built you can update the enabled field with that value.

Click

If you need to delete your geometric network and re-build it, that Enabled status will remain the same.

# Loops

- Some other causes of Loops.
  - Duplicate lines.
  - Line not broken at switch or open.

# Questions?

Robert Borchert
GIS Technician II
United Services Group
Great River Energy
Elk River, MN 55330-0341
763-241-2211
rborchert@usgweb.com