ArcGIS® Schematics: Automatic Schematic Generation for ArcGIS

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ArcGIS Schematics: Automatic Schematic Generation for ArcGIS

An ESRI White Paper

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ArcGIS Schematics: Automatic Schematic Generation for ArcGIS

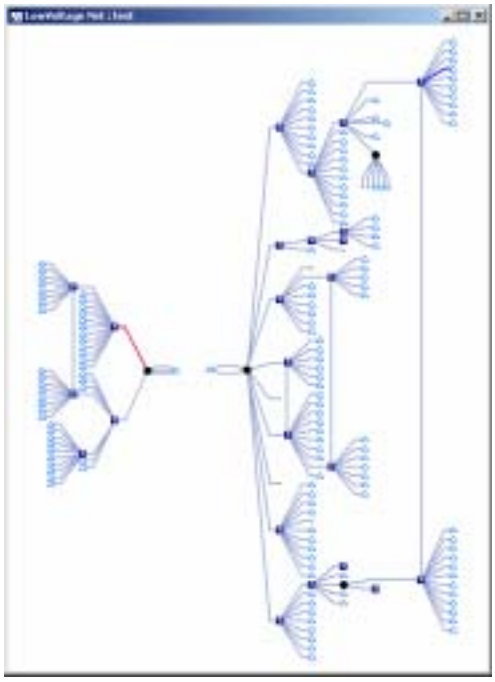
What Is Schematic?

The first definition of schematic is: a simplified representation of an object or a set of objects, intended to *explain* its structure and make the way it operates *understandable*. In our case, an object is a network, and a set of objects is the internal information related to network components.

A second definition of schematic is: a drawing or diagram representing a set of *relationships*. Relationships connect nodes in the model. This is called connectivity.

Another definition explains schematic as a way to represent any type of network within a symbolic system or a defined space without scaling constraints. For example, a defined space is a piece of paper where numerous pieces of information are displayed by optimizing the placement of the features. Within schematic, there are no scale constraints (cable length, distances, etc.).

Selection of a Part of a Network in ArcMap



Corresponding Schematic

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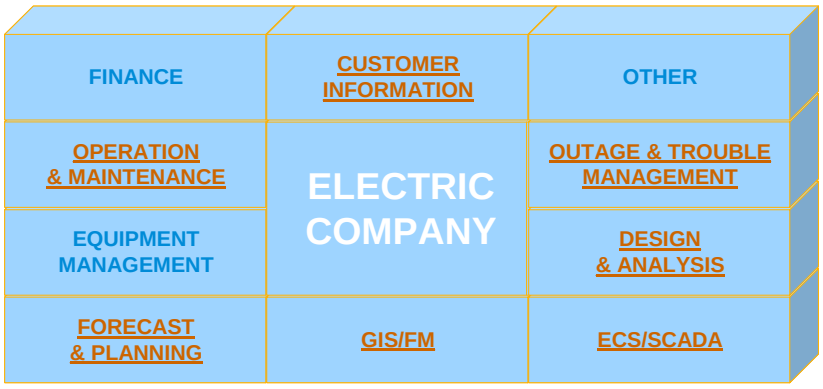
Who Uses Schematic?

Schematic representations are used by several industries such as telecommunications, energy, water and wastewater, transportation, and oil and gas. Other sectors, such as logistics, local government, homeland security, intelligence, epidemiology, criminology, and defense, are potential schematic users.



Above is the organization of a typical electric company. The departments producing and/or using schematics are underlined.

Schematic users can manage physical and logical networks, including social and economic networks, and may view and represent any kind of network such as electric power, traffic light, delivery route, computer, and so forth.

What Is ArcGIS Schematics?

ArcGIS® Schematics is an extension to the ArcGIS Desktop products (ArcView®, ArcEditor™, and ArcInfo®). It enables users to automatically generate, visualize, and manipulate diagrams from network data or data that has attributes for connectivity.

ArcGIS Schematics integrates with the ArcGIS environment to view, operate, and exploit any network in a geographic and schematic environment. Using ArcGIS Schematics, a user can obtain logical views of any linear network. ArcGIS Schematics allows a user to efficiently create multilevel representations and check the connectivity of any network. This powerful software provides many different layout algorithms allowing users to produce on-the-fly diagrams.

ArcGIS Schematics includes a set of tools that enables users to design and customize the type of diagrams they want to display. Any diagram generated with ArcGIS Schematics can easily be used in other ESRI® software such as ArcIMS® and ArcPad® by exporting the schematic to a shapefile.

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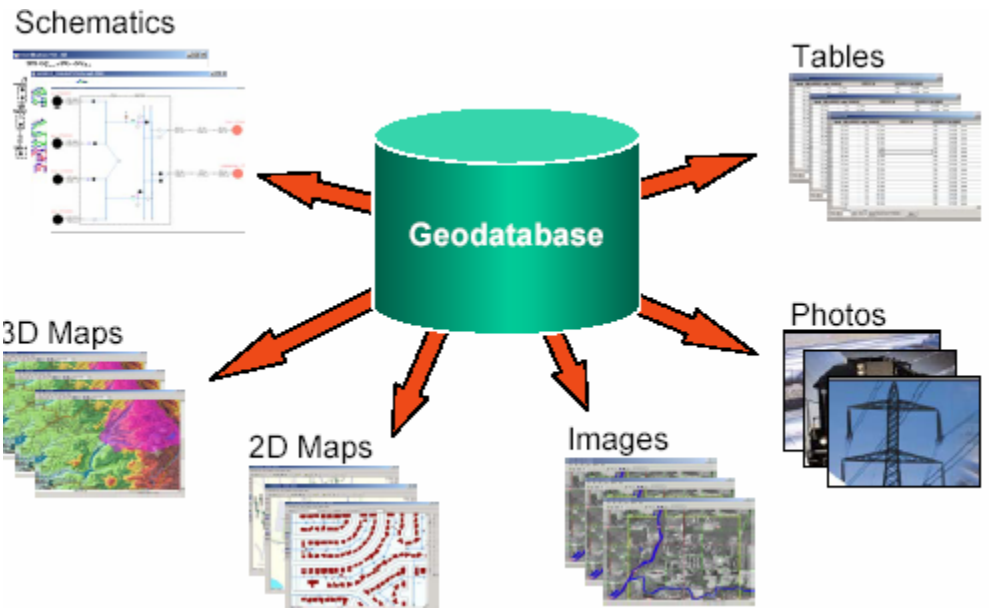


From generating a smart tree diagram of a distribution electrical network, viewing the orthogonal schematic of the transmission network then having an inside diagram of substations, ArcGIS Schematics helps engineers and technicians to drill down into the network information system.

Key Features

ArcGIS Schematics includes many innovative features. With features such as industry-standard customization environment and integration into the ArcGIS interface, users have a variety of powerful tools for schematic generation.

Automatic Diagram Generation

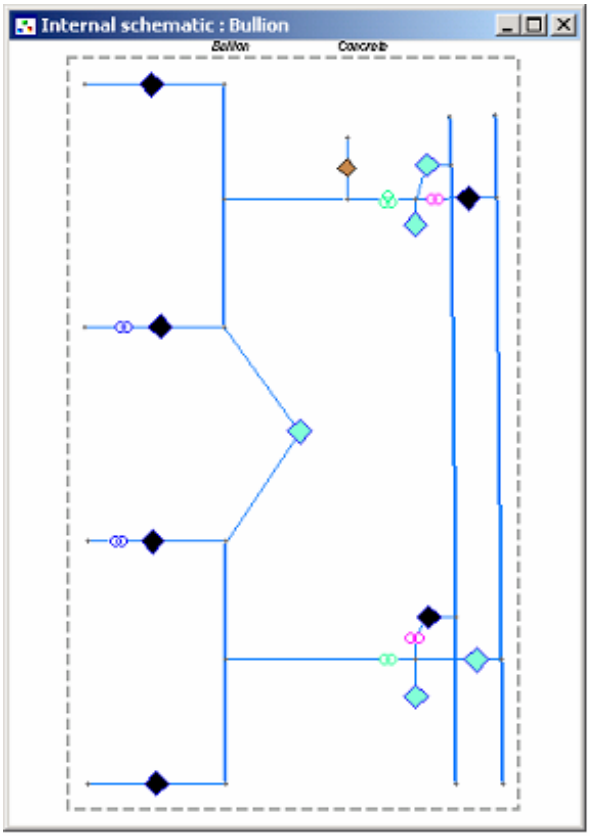
ArcGIS Schematics automatically generates geoschematic and pure schematic views from existing network data. This is the most effective way to limit the number of operations, avoid errors of manipulation, and decrease the number of tools. Compared to an interactive computer-aided drafting solution, ArcGIS Schematics speeds up the return on investment and facilitates network data updates.

Multirepresentation

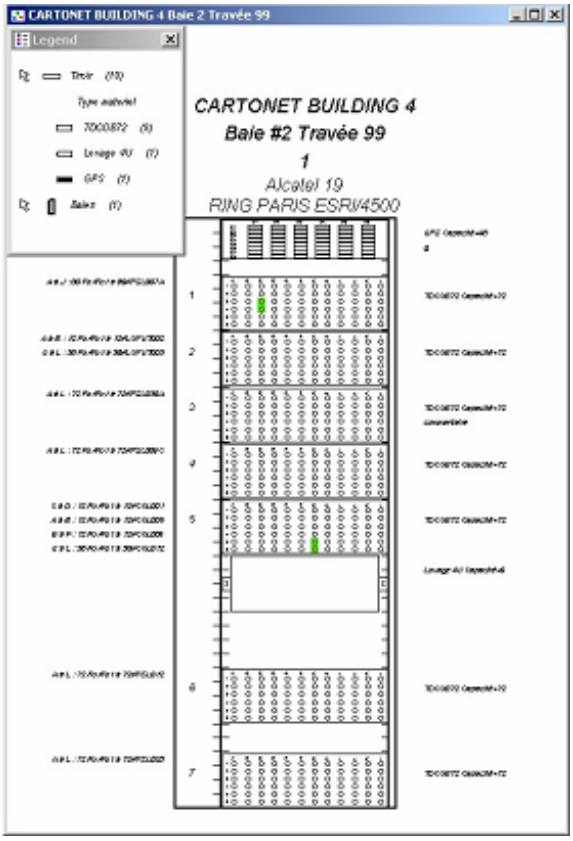
ArcGIS Schematics allows the viewing of the same set of network features through different representations: geographic, geoschematic, and pure schematic. Multiple representations give a better understanding of a network organization, thus speeding up any decision cycle.

Multirepresentation brings the following advantages:

- A synthetic display of the network architecture
- A quick evaluation of a network structure
- The ability to interact between inside plant schematics and equipment display
- The display of physical and logical network



Electrical Substation Inside Plant



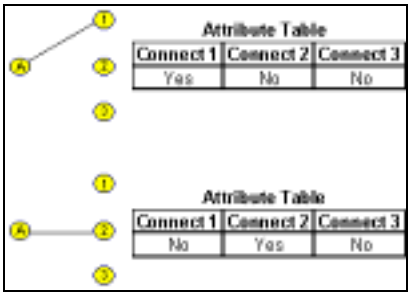
Telco Fiber Cabinet Inside Plant

Dynamic Interaction With GIS

In addition to being an extension to ArcGIS Desktop, ArcGIS Schematics works with ArcSDE®, thus allowing the use of versioning. This allows the user to retrieve information through selection from schematic to geography and vice versa. ArcGIS Schematics complements geographic information system (GIS) technology in the design, construction, and management of networks because it emphasizes the location in the geographical space.

Data-Driven Solution

ArcGIS Schematics is fully independent of the data model; it deals directly with the features in the geodatabase, avoiding duplication. The symbology is set by using connectivity attributes.



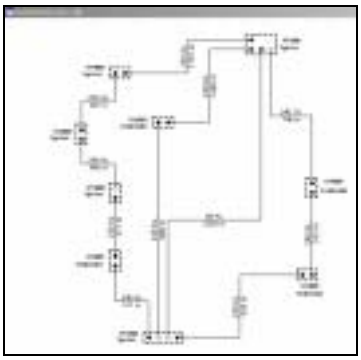
Different Positions of a Switch

Such a solution saves time and gives better quality and reliability. The schematic representation is always up-to-date. There are no discrepancies between the diagram and the database, making the solution a secured one. There is no need to have somebody update the paper maps by redrawing the symbols manually; all they need to do is open the diagram and print it again.

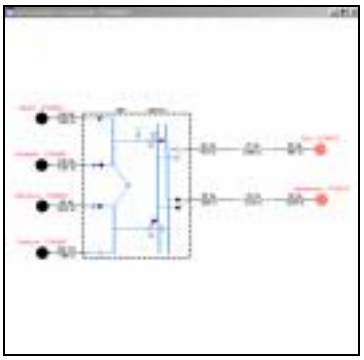
Customizable Algorithms

Different industries have different ways of representing their networks. Most companies have been generating schematics for a long time and want to use the same layout their teams are familiar with. ArcGIS Schematics offers easy to configure and easy to customize algorithms to fit all industry needs, standards of the companies, and specific needs of several departments within companies. Algorithms may also be created using a common object model (COM)-compliant programming language.

Smart Tree



Orthogonal Schema



Internal Diagram

Multiple Data Source Access

The same session of ArcGIS Schematics can deal with a geodatabase and other databases, so it can manage spatial and nonspatial data. It gives access to the information system of the company and offers an integrated system managing all the assets.

Network Object Model

ArcGIS Schematics manages in memory a network object model allowing real-time management of connectivity and speeding up the process of layout display. This gives very good performance when applying algorithms.

Access to the Geodatabase

The objective of having a geodatabase is to get all information relative to the features to be represented and the geographic coordinates to display geoschematics and the connectivity between the features.

ArcGIS Schematics offers two ways to access the features in the geodatabase:

- The first one is to access the features through ArcMap™, read the geographic coordinates stored in the tables, then read the logical network to get the connectivity. ArcMap is an application within ArcGIS Desktop.

- The second way is to access the features through direct calls to the database and to get the connectivity through attributes. This method can be used when *to-* and *from-node* attributes, or any other attributes enabling the building of connectivity, are stored in the tables.

Data Selection and Diagram Generation

A user can select data to generate diagrams in ArcGIS Schematics by

- Attributes
- Location
- Tracing
- Manual selection

A specific function generates a schematic diagram by reading the selected features to get the object IDs then reads the geometric network to get the connectivity. Another function reads the features selected by the Utility Network Analyst tools then generates the corresponding schematic diagram.

ArcGIS Schematics can also generate diagrams by accessing the database directly and reading the connectivity stored as attributes in the tables (i.e., to- and from-nodes). Thus ArcGIS Schematics is also able to generate schemas from nonspatial data. A simple example of this could be an organizational chart for a company. If there is data in a table that says that Jay, the vice president, works for Pam, the president, and Larry, the manager, works for Jay, ArcGIS Schematics can create a diagram with this relationship. This is nonspatial data being displayed that only has a spatial context when looking at the location of the building in which they work on the map or perhaps the floor plan of the building, both of which might be part of another schematic diagram.

Through configuration, a diagram can be generated by mixing spatial and nonspatial data or allowing the ability to drill down between different diagrams as mentioned above.

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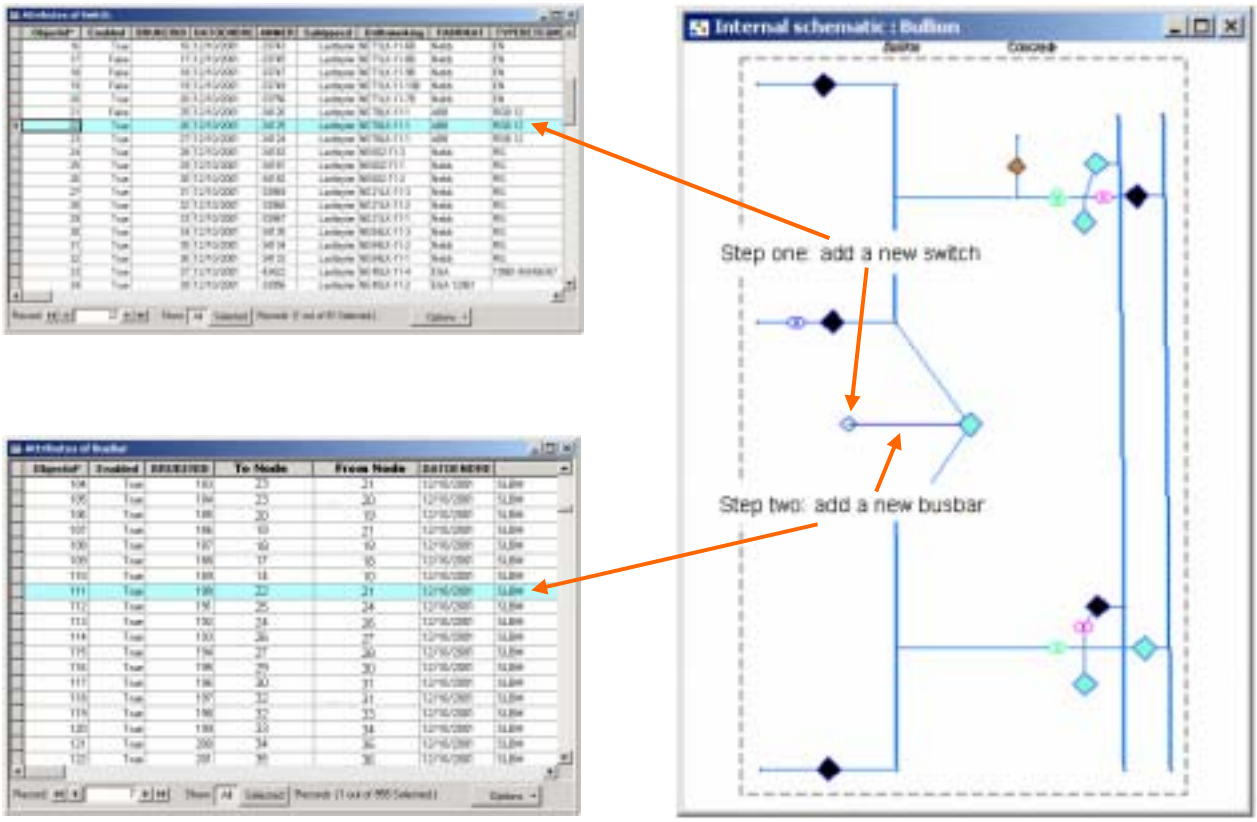

Example of an Internal Diagram of an Electrical Substation Generated From Table Data

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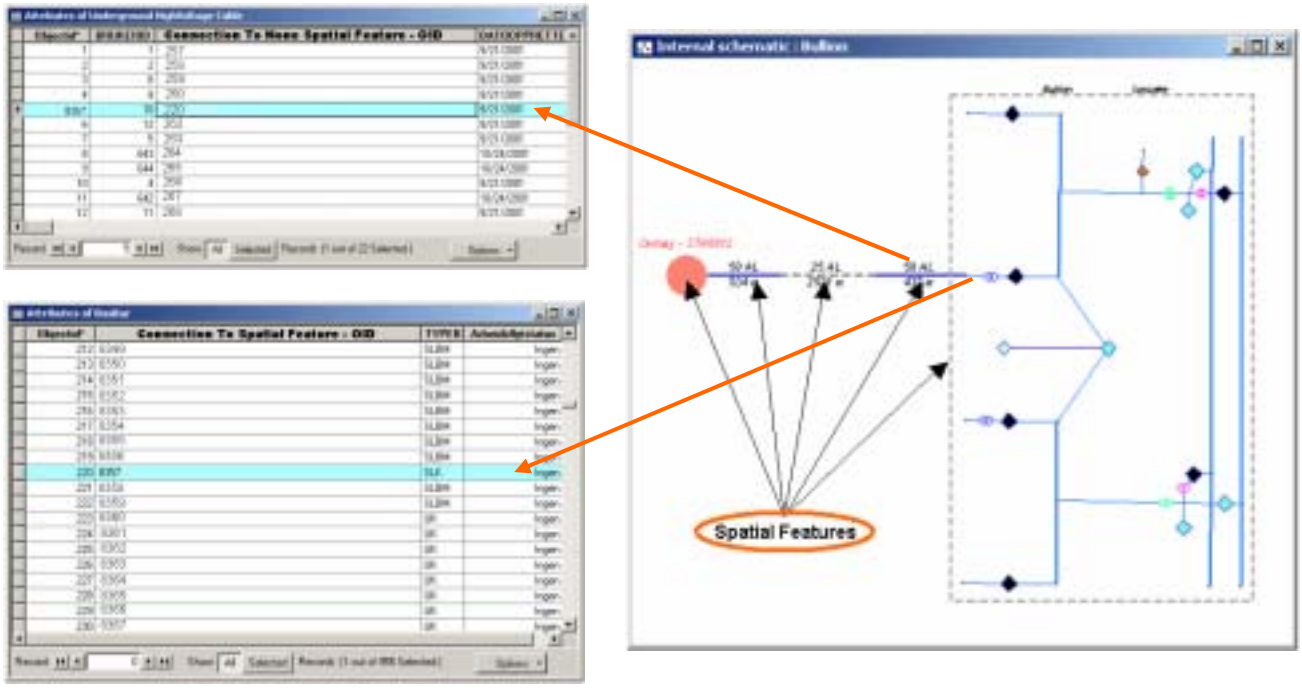
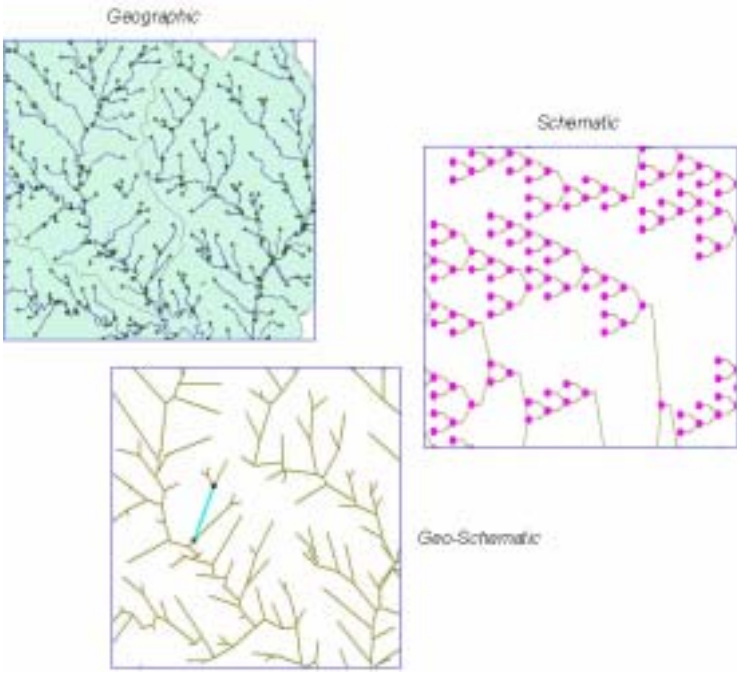


Example of a Diagram Mixing Spatial Data and Nonspatial Data

Types of Representation

ArcGIS Schematics is used to display geographic, geoschematic, and pure schematic diagrams. At the same time, the user can have different representations of the same set of features.



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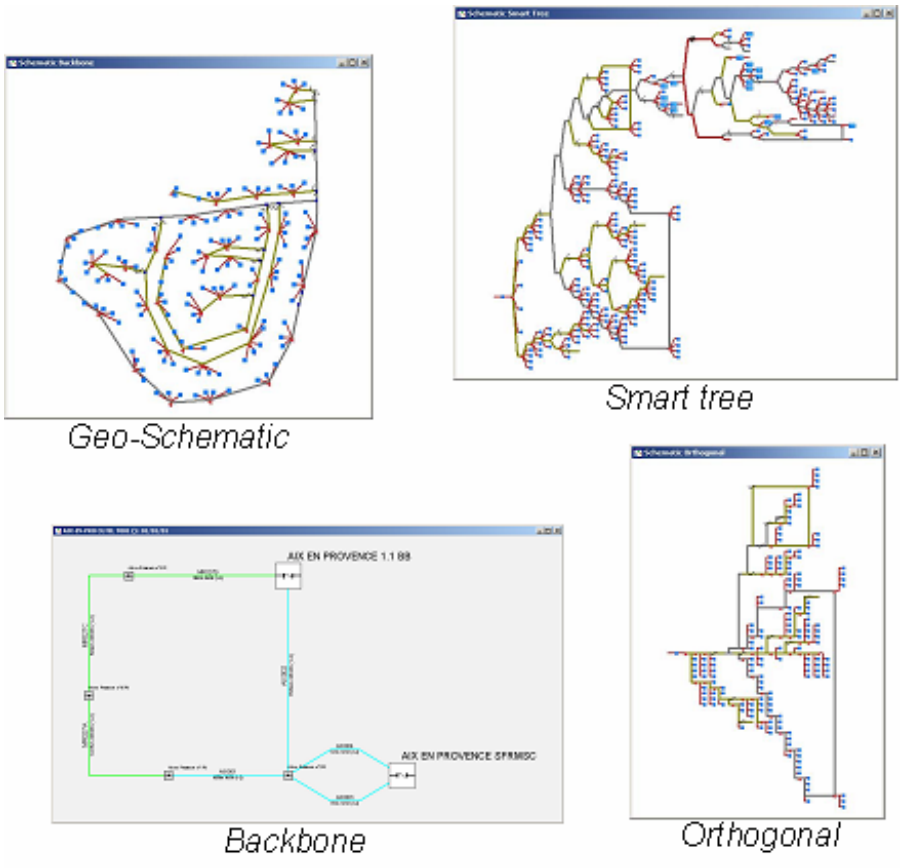
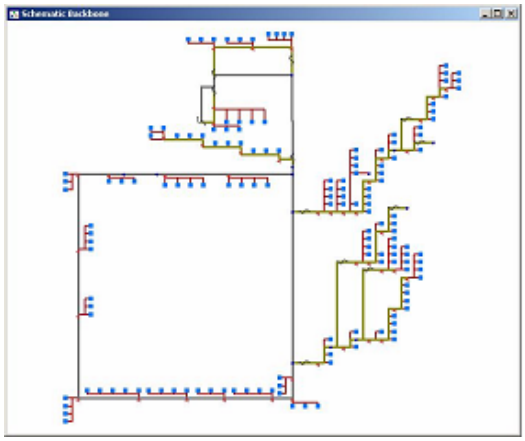
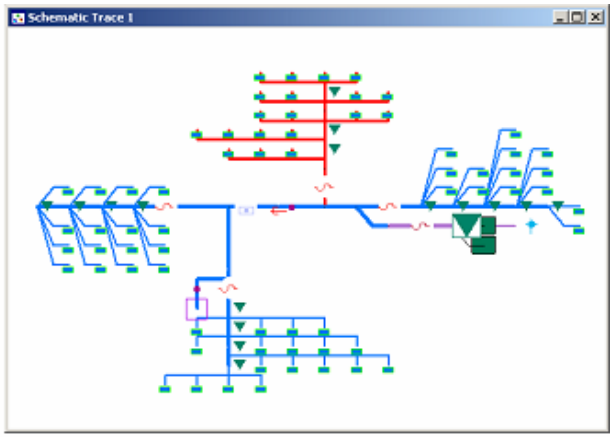
ArcGIS Schematics provides a set of algorithms to generate different types of layouts. For each algorithm, the user can change layout parameters to obtain the best data rendering.



All algorithms can be applied on a subpart of a diagram. Thus, several algorithms can be used on the same diagram to get a better display.



Backbone + Orthogonal



Smart Tree + Orthogonal

Graphic Manipulation (Refinement Tools)

An automatically generated diagram can be refined at any time by using a set of refinement tools. These tools allow features to be translated, rotated, and scaled; colors changed; and so forth, independently or by group.

The main functions are listed below.

- Intelligent subnetwork movement
- Subnetwork collapse and expansion
- Size modification of symbol and text
- Node bypassing
- Parallelism
- Vertical and horizontal node alignment

Configuration/ Customization Tools

ArcGIS Schematics is delivered with a set of tools dedicated to the configuration and customization of applications called ArcGIS Schematics Designer. This user-friendly graphical user interface allows the administrator to define the working environment of an application: the *Project*. It acts as the central point where access is gained to other objects in the system. The project provides access to the schematic components that an application manages such as data sources, diagram types, element types, properties, behaviors, and so forth. A project and its associated characteristics can be created and defined through ArcGIS Schematics Designer or by programming with a COM-compliant programming language.

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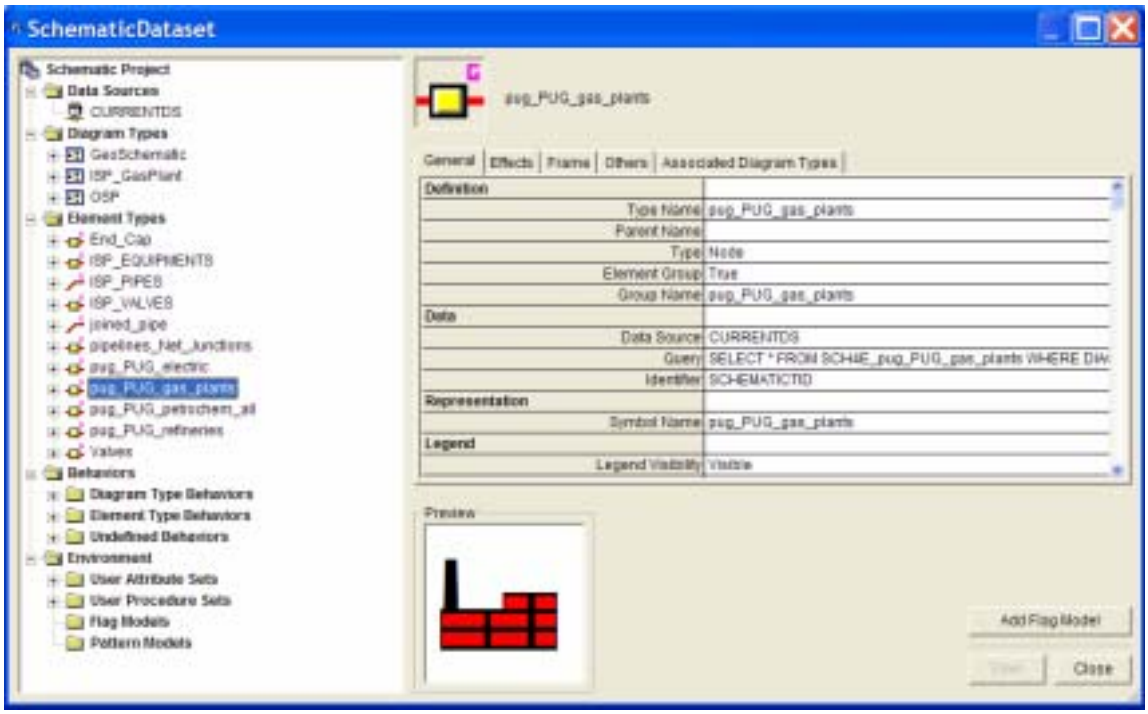


ArcGIS Schematics Designer

Data Sources

Most of the time, organizations managing networks deal with sets of databases. ArcGIS Schematics allows connection to various data sources. Thus schematic can be generated not only from the geodatabase but also from any other data source providing information such as inside plant or logical connectivity.

Diagram Types

A network is made up of junctions and edges. These features are displayed in different generic structures called "diagrams." A diagram type is a template that brings together diagrams that have common characteristics. The diagram type defines what feature classes (element types) will be represented in diagrams of that type. For example, an electrical company managing several networks can define diagram types for its high-voltage, medium-voltage, and low-voltage networks and representation of their stations and substations. In the ArcGIS Schematics Designer picture above, there are three diagram types defined.

Element Types

An element type is equivalent to a feature type. It is defined by a name, its class, and a query returning all occurrences, attributes, and properties. Schematic manages two types of objects:

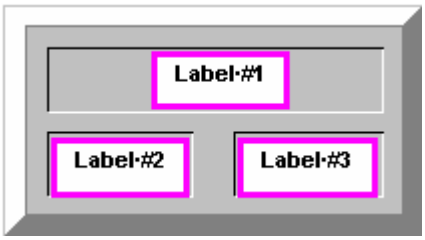
- Node (or junction)
- Link (or edge)

A node is a vertex in a network graph. It is represented by a symbol and may be assigned various attributes such as graphic (color, fill style, etc.), geometric (scaling, rotation, etc.), or visual (visibility, highlighting, etc.). Nodes can have geographic, geoschematic, or graph-based coordinates.

A link is an edge in a network graph. It is represented either by a direct single line segment or by several line segments passing through one or several link points. A link represents the connectivity between two nodes. It can represent physical or logical connections.

Properties

Properties are used to define the characteristics of a group of objects that have an impact on the graphic representation of a network. The overall state of a network is determined by the values of the existing set of properties at a given time. A label displayed either directly on the objects it applies to or inside a flag associated with these objects can represent any property.



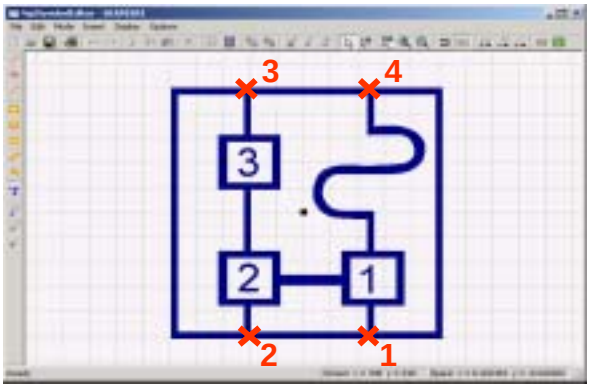
Flag Label Ports

Behaviors

When a behavior is defined, it specifies how the application will respond to end user actions on one of the application objects. Behavior is a way to assign commands or specific functions to objects. Behavior can be applied on the following objects: diagram types, element types, and legend (a legend is comparable to the table of contents in ArcMap).

Symbols

ArcGIS Schematics automatically utilizes existing ArcMap symbology. In some cases, the user needs to define specific symbols for schematic. This is generally the case when defining symbols that have multiple connection slots. ArcGIS Schematics provides a symbol editor to do this.



Example of a Symbol Created With ArcGIS Schematics Symbol Editor

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Conclusion

ArcGIS Schematics provides users with the ability to view their data, network or tabular, through various representations related to their specific industry. ArcGIS Schematics is integrated with the ArcGIS Desktop products (ArcInfo, ArcEditor, ArcView) for interoperability and advanced schematic capabilities. ArcGIS Schematics gives technicians and engineers the ability to generate diagrams from existing data through different types of queries. It provides all the tools needed to produce diagrams by drilling down the information system for outside and inside plants. All the algorithms and refinement tools provide the power to build the diagrams to fit users' requirements.