GE Energy

Smallworld* 4 Product Suite

Schematics: Making sense of a connected world

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Abstract

Enterprises such as electricity generators, water utilities and telecommunications providers pin much of their success on being able to efficiently operate their most important resource: their network. This efficiency depends, to a large part, on being able to easily understand the often complex interrelationships that exist between assets in a network. A better understanding of the network leads to better business decisions, which in turn leads to both a better service for an enterprise's customers and increased operating efficiency. One important tool that helps provide that understanding of the network is the schematic.

A schematic is not a map

Maps have been around for a very long time and are familiar tools for anyone considering a trip to an unfamiliar destination. So why are maps not used to help with understanding a network? There are a number of reasons for this and these are perhaps best explained by first looking at some of the characteristics of a map:

- In a road map, for example, the most important relationship between features is a geographic one. For example, an object that is north of another object in the real world is also north of it in the map[1].
- Maps have a constant scale. Two objects that are a great distance apart in the real world will be proportionally be the same distance apart in the map[2].
- Finally, a map has a lot of useful information to help the traveller get from point A to point B. For example, in a road map the most important geographic data will be in regards to the road network, but the map will also typically be embellished with additional features such as the location of restaurants or fuel stations that the motorist might also find useful.

These characteristics make it easier for someone unfamiliar with a geographic area to find the correct route. But for a network engineer the most important relationship is a topological one and not a geographic one. The engineer is most concerned about which asset is connected to which other asset. This is vital information that is often required to maintain safety in the network and guarantee service to customers. The complexities of the modern telecommunications network, for example, mean that an engineer needs to be able to see as many of these topological relationships as possible to make good decisions about a network's operation. Using a map makes the appreciation of these interrelationships more difficult, as connected assets that are great distances apart become difficult to squeeze onto a single piece of paper or a single computer screen (scaling the network down to fit often results in a representation that is too congested making parts of the network incomprehensible).

In addition, quite a lot of data that makes up a conventional map is not really of interest to the engineer: beautiful parks might be an idyllic setting for a field crew during their lunch break but for the operations engineer this kind of information results in a lot of unnecessary clutter that wastes space that could be better used for network data.

Helping the engineer to see clearly

To be the most useful to a network engineer a schematic needs to have at least the following characteristics:

[1] Strictly speaking maps use navigation lines called rhumb lines and so this rule might not hold true for all types of maps.

[2] Technically, depending on the co-ordinate system in use, a map might actually preserve distance (scale), area or direction.

- It needs to be correct. This might appear to be an obvious point: a schematic representation generated from a network should be topologically correct (A remains connected to B in the schematic). However, it is worth acknowledging that important, potentially life-threatening decisions will be made on the basis of the network relationships presented in a schematic and it is vitally important that the schematic be correct.
- It needs to be easy to keep up-to-date. For similar reasons as the previous point, a schematic needs to accurately reflect the current operational state of the network. Networks are not static entities: sections might expand to satisfy increased demand whilst other parts might be redesigned to improve service. The network is often continuously in a state of flux and so the schematics that are used to represent it need to be kept up to date.
- It needs to be as compact as possible. As mentioned before, the more interrelationships that the engineer can see in a schematic the more thorough the operating decisions will be. If part of electrical circuit is to be isolated, the engineer needs to know that this action will not overload another part of the network or accidentally energise assets that are currently being serviced by a field crew.
- It needs to be readable. Again this might be an obvious point but there is an inherent conflict between how much network information can be placed onto, say, a single piece of paper and how readable it is. It is quite easy to produce a schematic that has a lot of information but a side effect is that it is often too cluttered or confusing to be of any use.
- It needs to be fit for purpose. Unfortunately there is not one type of schematic that will cater to all types of networks or even all kinds of engineers. Some networks are inherently hierarchical in nature while others might have backbones. It is these specific schematic layouts that engineers find the most useful. Also symbology can play an important role allowing a schematic not only to be laid out in a helpful fashion but also presented using a symbology that is easily understood by the engineer.

Giotto need not apply

In the thirteenth century Pope Benedict IX, who was seeking the best artist to create five scenes from the life of Christ, decided to send a courtier to the artist Giotto to test his ability by asking for his best work. Giotto responded by drawing a perfect circle and got the job.

This might appear to be an unrelated story but before the widespread use of computers many of the schematics used by engineers were hand drawn. Most engineers took great pride in their drawings often generating works of art in their own right. Also, since the schematics were often drawn by those who ended up using them, their style dovetailed the very specific requirements of the user almost exactly thus making them very easy to use.

However, like many works of art, this perfection comes at a price:

- Engineers are some of the most qualified and most valued (and well paid) employees in an organization. It is simply not the most cost-effective use of their time to burden them with housekeeping tasks such as keeping a schematic drawing up-to-date.
- Manually drawing a schematic takes a long time. Even small network sections can take hours to draw and larger sections might take days or even weeks. This overhead makes the network less agile, making it more difficult to respond to customer needs or to deal with emergency situations.

- The obvious conclusion here is that it becomes progressively more difficult to keep paper-based schematics in step with the network.

The advent of software-based engineering drawing tools made this job somewhat easier. Engineers could now draw schematics electronically, which made editing quicker and offered a wider range of distribution channels. However, more often than not, the real challenge of drawing a good schematic is not the limitations of the drawing technology (be it pen and paper or a CAD tool) but the layout of the schematic itself. This is a difficult proposition for most humans and it becomes disproportionately harder as the network becomes more complex and business demands increase.

This semi-automatic approach to generating schematics has a number of drawbacks too:

- Some time and cost is saved but not as much as one would expect. Quite often an investment in a sophisticated CAD tool never generates the returns imagined (frequently because many of the CAD tools features are underused).
- The most common repository for network data is a GIS. A GIS is not a CAD tool and frequently two applications from two vendors are required to generate schematics. This leads to problems with keeping data in step and developing a practical work flow for users that can be followed day to day.

Recently, however, advances in mathematical graph theory have resulted in new computer algorithms which for the first time are now able to effectively address this historically manually intensive process.

These new software schematic engines offer the potential to quickly generate compact, readable schematic drawings from large amounts of network data. However, these new schematic engines are not human brains: they cannot (and unlikely ever will) generate schematics that are as beautiful as hand drawn schematics. They will never decorate their output with colloquial embellishments that are peculiar to one drawing office or another. Their proposition is a simply a business one: good schematics that are cheaper and easier to maintain.

A technologically advanced approach

The Smallworld Schematic Generator* product, from GE Energy, uses state-of-the-art technology based on several years of research and development to expose its functionality in a seamless and integrated way to the user.

The Smallworld Schematic Generator is an off the shelf module that integrates directly into the Smallworld Core product and is not two separate applications from two vendors that have to be coaxed into talking to each other.

This tight integration allows direct access to the most up-to-date network data, helping engineers make better decisions based on more recent information.

It also results in a much more efficient work flow for the engineer. Users can easily select sections of network to generate schematics from and quickly see the results before deciding to save the schematic or print it to a plotter. Obvious functionality such as being able to select an asset in the schematic and see its location in a geographic map (or vice versa) can be elegantly implemented as part of consistent user interface (engineers no longer have to struggle with the inconvenience of two user interfaces). Additionally, schematic data can be analyzed using same tools as other GIS data (for example it is possible to perform a trace analysis on the schematic as if it were geographic data).

A simple, intuitive user interface is a pleasant side effect of an integrated solution but it also offers the possibility of a highly task-focused work flow. The user experience can be focused for repetitive tasks in which the user does not need (or understand) the complexity of a CAD tool. For example, a dispatcher might only need to select an asset and then pick a schematic it belongs to before issuing it to a field crew to undertake maintenance.

A workflow that is so simple is ineffective if the schematics generated are unusable. The Smallworld Schematic Generator produces compact, well laid out schematics in a timely manner.

Some of the key features of GE Energy's Smallworld Schematic Generator are:

- Generation based on the latest, up-to-date network data reduces the potential for discrepancies between the schematic and the current state of the network.
- Ability to archive a schematic drawing for retrieval at a later date.
- Fast schematic generation with support for very large schematics (thousands of nodes) frees engineers to perform more important tasks that have a greater business benefit. Large schematics that might have taken a week to hand draw can now be generated by machine far faster, with obvious cost benefits.
- A number of built-in layout styles including orthogonal and hierarchical and the ability to mix layout styles allows a single engine to generate schematics for a wide variety of purposes within the organization.
- Support for adding geographic constraints that maintain the geographic relationships of assets in an orthogonal schematic help locate assets quickly for users such as field crews.
- Efficient white space management, the ability to manually pin assets and their labels, comb labeling and the automatic detection of overlapping text all contribute to a clean and effective presentation of network data.
- Incremental generation of schematics that preserves user edits allows a schematic to be fine-tuned by repositioning assets to further improve clarity. Large schematics can be generated more quickly by only processing changes.
- Tools for automatically detecting when a schematic becomes out of step with the network data that generated it helps to ensure schematics reflect an accurate view of the network.
- Schematic specific symbology and schematic templates can be used to specify commonly used schematics.
- The ability to import and export schematic data allows integration with other systems.
- A configurable, easy-to-use wizard-based user interface simplifies use and reduces training costs.
- An extensible architecture allows customers to embed specific functionality and tools.

Conclusion

A greater understanding of a network is becoming increasingly important to most enterprises as they attempt to optimize the performance of its operation. Being able to understand the complex interrelationships that exist is often an important part of many operational and planning activities.

Traditional paper-based and even semi-automatic solutions have proved to be increasingly cost ineffective and a hindrance to operating in a highly competitive marketplace.

The advanced Smallworld Schematic Generator provides an integrated solution that delivers timely, high quality schematic drawings that are up-to-date, with the flexibility and ease of use that results in real business benefits to the enterprise.