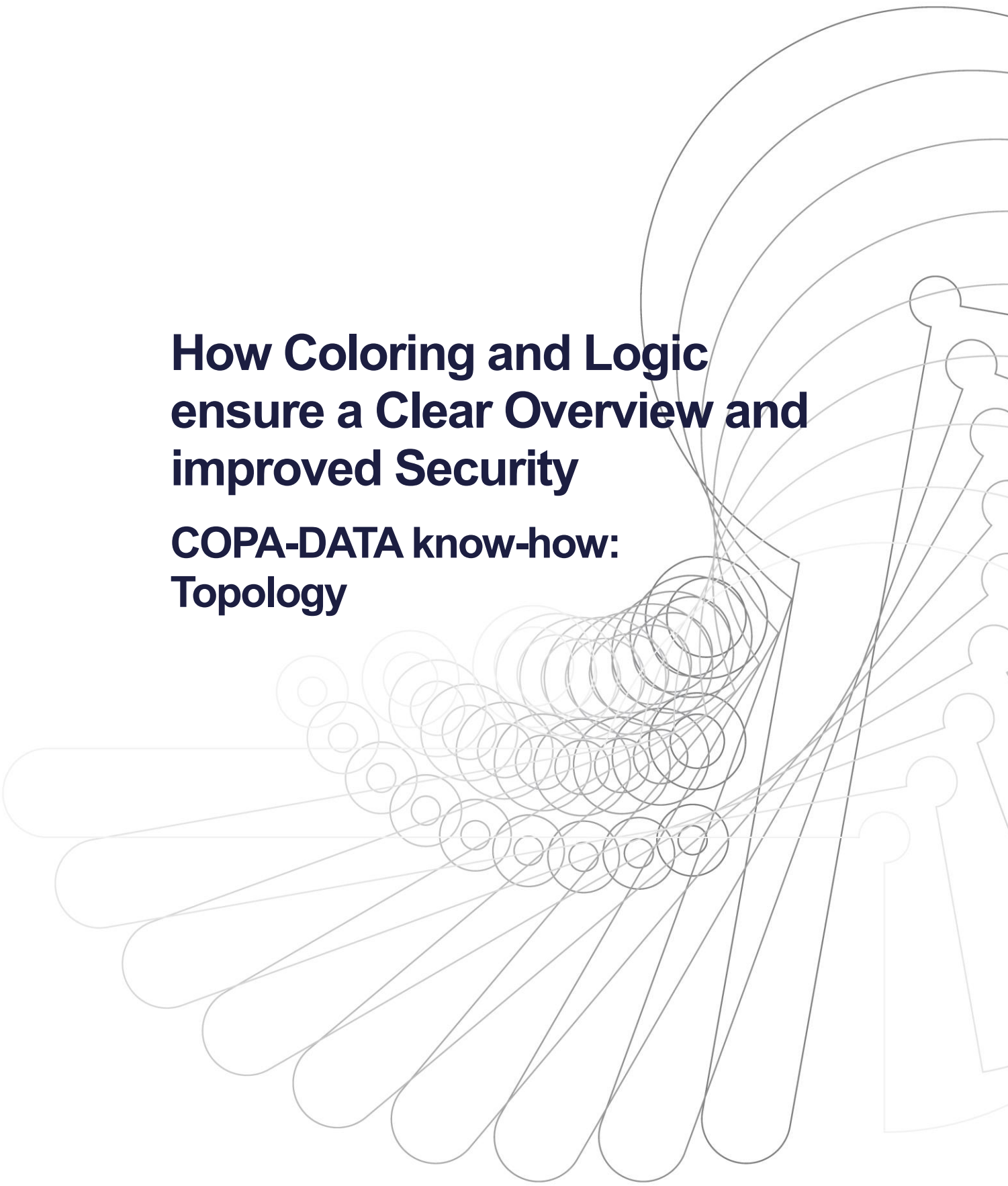
How Coloring and Logic ensure a Clear Overview and improved Security

COPA-DATA know-how: Topology



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Security rightly has uppermost priority in the energy sector. Misunderstandings, unauthorized actions or incorrect operations can be fatal in the direct vicinity of electrical current and can jeopardize supply. Therefore, it is all the more important to adopt systems that enable the user to have a clear overview of energy grids and the processes related to them. A graphical user interface is a basic requirement for working safely in this context. The better an overview and the more traceability this user interface provides, the

faster and more controlled any subsequent reactions can be. Topological coloring is an effective tool when creating the required overview within energy applications.

Information is communicated through coloring: Topological coloring

Topological coloring is based on the principle of communicating information by means of coloring - or communicating changes in the graphic display of the electrical network on screen. It primarily serves to give a quick overview of the switching status of a substation or an electrical grid in a single line circuit diagram. A situation can be significantly more rapidly evaluated using corresponding pre-defined colored lines than would ever be the case were the switches represented by lines that remain the same color.

Comprehension at first glance

The added value of topological coloring becomes particularly clear in the case of abnormal switching states. Lines that have been switched off or grounded are clearly recognizable due to their special coloring, which helps the user to evaluate any given network status shown.

There are many ways to create such displays: some solutions execute the coloring of lines using scripting or calculations in the PLC, which is usually done in zenon by VBA/.NET or straton. Using one of these methods, the variable value of the switching reports calculates whether a line is to be displayed as having a current passing through it, not having a current passing through it or as being grounded. The effort of such solutions increases or decreases with the complexity of the equipment to be displayed. In addition to the time-intensive configuration, putting such a solution into operation also demands a considerable amount of effort, because in addition to the switching elements, the individual line sections must be examined.

Reliable line coloring in seconds

A significantly more simple option to achieve topological coloring is to set parameters using zenon automatic line coloring (ALC). In the zenon Editor, the topological coloring is an add-on that has been implemented and which has also been configured as one of the working steps when single line circuit diagrams are drawn.

The zenon Editor enables you to achieve perfect topology in three steps:

1. Highlight all lines using multiple selection and mark the corresponding checkbox.
2. Set the corresponding ALC sources.
3. Define the switching elements as ALC switches.

zenon then calculates the topological model completely automatically derived from the graphics drawn. Beyond these three steps, there is no additional time or expense required when using this solution - a distinctive advantage over using a self-programmed topology logic.

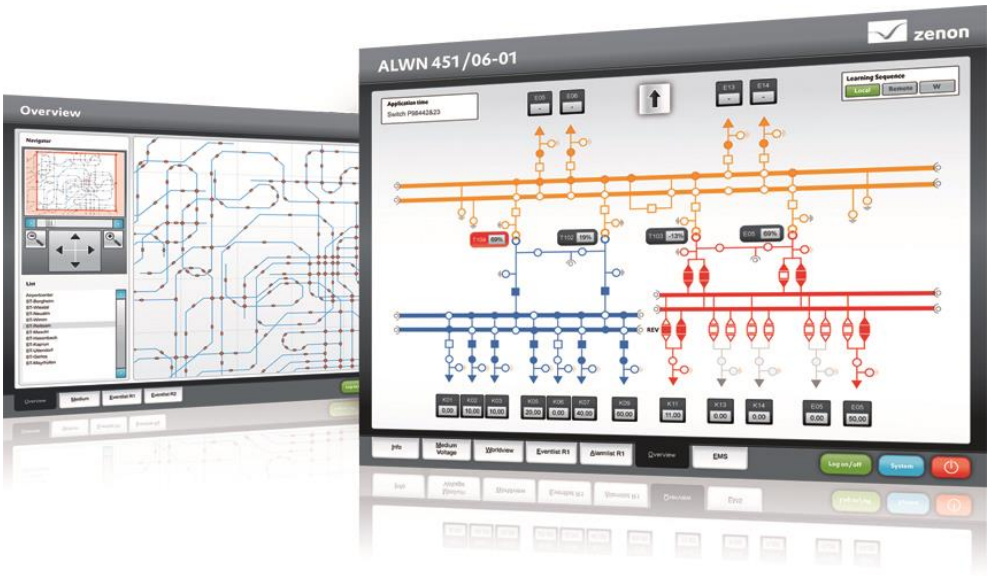

Figure 1: Topologically colored lines in a switching facility

Use in substations: Increased security as standard

Topological coloring is not often used in small substations. This is understandable when the low number of switching devices and switching fields means that users already have a good overview without it. Nevertheless, there are instances when smaller applications can benefit from topological coloring, particularly if they are expanded at a later point in time. Topological coloring is supplied as standard in the zenon Energy Edition, so no additional costs are incurred for the automatic line coloring function.

However, for larger substations it is essential to recognize the switching status in the colors of the lines shown in the single line diagram at a glance. Due to the circuit complexity, the probability that a displayed field may be wrongly interpreted or abnormal situations may be evaluated incorrectly is

too great in these cases. However, far too often, the topological information is calculated by self-written and difficult-to-maintain VBA programs or, in the case of zenon, zenon Logic programs. For zenon users, this state of affairs is completely incomprehensible when the available alternatives are considered: Amongst others the ALC element “transformer” has been included into the zenon Energy Edition license and supplied with it.
The ALC element “transformer” works with two topological colors: one for the primary voltage and one for the secondary voltage. With that a transformer return feed from the secondary side to the primary side ensures that the secondary energy source is displayed physically correct, which provides a significant safety aspect: the operator is made aware of a high-voltage (primary) side under power, although all high-voltage switches are in the “open” position. The operator therefore knows that he must disconnect the transformer on the secondary side in order to cut off the power on the high-voltage side.

Use in network control systems: Clearer overview, increased functionality

Topological coloring is an essential requirement in network control systems – regardless of size. The status of each line must be clearly recognizable at any given point in time in the power network, especially when dealing with different levels of voltage. A network control system must offer much more than representing the line status just by means of coloring. For one thing, it must make it possible to display a clear overview of a large electrical grid, whilst displaying the condensed switches and sum-reports. At the same time, there must be the capability to display all details of a specific branch if required. To deliver this, the various functions of a control system work together.

An overview and the detail in one: The world view

Larger electrical networks with all details shown can often not be displayed on a computer screen due to its size. To solve this problem the so called world view is used. In this case, the one-line diagram of the electrical network is drawn larger than the screen resolution. It is possible to pan both horizontally or vertically across the screen to change the section which is being displayed. This is somewhat comparable to the functionality in a PDF reader, where the document can be held with the hand symbol and moved. To get a complete overview, the zoom out function can be used. By zooming in (+), the section area being viewed reduces and the detail becomes larger and larger. By zooming out (-), more and more details on the screen come into sight until the whole network is ultimately shown on the screen. At this point, the switching and measurement values are usually only a few pixels in

size and can be difficult to recognize. This lack of clarity can cause problems for the operator. In this case, the decluttering function can be used to recreate a clearer overview. Decluttering restores “Order out of chaos”. In the context of the network control system, the decluttering function summarizes information as a clear element which is clearly visible at a zoom level where the whole network is being displayed. One example how the decluttering function might achieve this is by summarizing all switches in a line tree into one individual element. This element must display logical linking for several switches (for example, bus bar isolating switches, power switches and circuit breakers). In addition to the logical and correct display of these elements, their topological coloring must naturally also be correct. This is done by referencing the topological color from the detail on the overview symbol (or ‘alias’ as the COPA-DATA team term it). In the context of this terminology, an ALC alias from the detail shown on the overview element in this process is displayed.

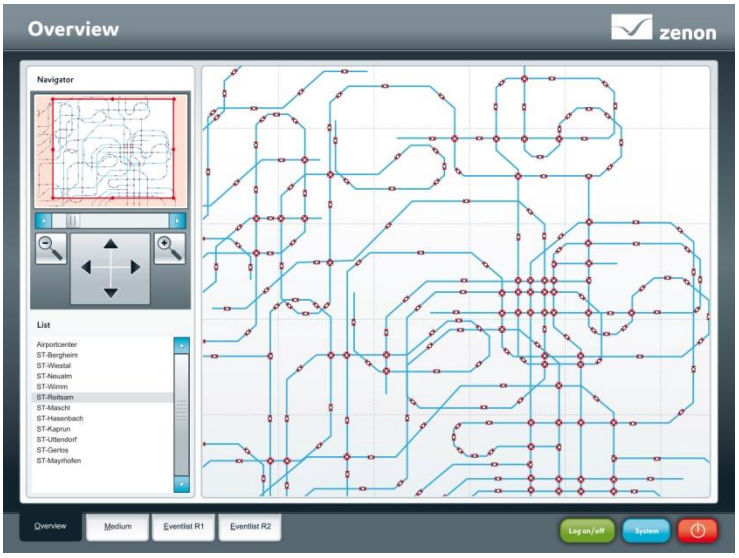

Figure 2: World view display in zenon

Simple fault location

In addition to world view and decluttering, there are other important functionalities that provide the operator with decisive advantages. Fault location is a significant aid for detecting ground faults and short circuits. Information from protective devices (distance protection, overcurrent (time) protection) are processed in the topological model and help the operator make the right decisions at the right time. The topological model is in a position to display the section of line where a short circuit or transient ground leakage has occurred in a different color. Furthermore, it is possible to provisionally insulate the topological model from new events in the event of

multiple ground fault stimuli (such as a storm). The operator can then subsequently establish if a displayed short circuit actually is a short circuit by means of test switches. Furthermore, they can better isolate the location of the error. As soon as this has been achieved and the required measures have been instigated, the model can again be released for monitoring and displaying new reports. Such a system acts similarly in relation to short circuits. Here too, a specific color is used to indicate that a protective device has a short circuit and has switched off the corresponding section.

Implemented logic: Switchgear Interlocking

Because the topological model illustrates the physics, i.e. the presence of electricity and voltage, switchgear interlocking can also be calculated. Because a network control system, in contrast to an on-site control system in the substation, does not have switchgear interlocking available, it must be in a position to logically register interlockings itself. Furthermore, interlockings throughout substations are not available in coded form and must be calculated by the control system itself. The topological model provides the possibility of having its findings influence the command centre. It has information on whether the switch activated is an isolating switch or a circuit breaker. If it is an isolating switch, the topological model recognizes if the isolating switch is under load or not, and passes this information to the command centre. According to the setting, this interlocking can be cancelled out by an additional action, which is also logged. The operator is therefore notified of the fact that his switching action may possibly destroy the switching device. This functionality has a particular advantage: it does not need to be configured additionally, but is automatically deployed if it is activated in the global settings.

Multiple supply and simulation

Network control systems also aid the operator when diagnosing whether network operation is ensured or not in the event that a source fails (for example, a generator, complete power station or feed-in from another network). With the functionality of the secured or multiple power supply, the topologically colored network can display its status. Using differently colored dashed lines or lighter lines, the user can quickly establish where in the network a bottleneck or failure could arise, as soon as a switch opens or a generator fails at a neuralgic point.

In addition to the special coloring and display of securely supplied lines, the operator also has the opportunity to test processes in advance, using a simulation mode. Using an exact display of the current network situation, they can – whilst disconnected from the live process – carry out a simulation of an existing switch setting. Because the topological model calculates in exactly the same way as with the real equipment, the operator immediately

has an exact picture of how the switching action will affect the real network. Incorrect operations can, therefore, be virtually eliminated. A further contribution to supply security is made in this way.

Summary

The advantages of topological coloring are particularly apparent in the context of the complexity of an electrical network. Shorter reaction times and safer switching actions means that the right control system can be a system with real added value for the operator and their customers.

Would you like to talk to an expert on the topic of topology? COPA-DATA Industry Manager Energy, Jürgen Resch, is happy to answer your questions: energy@copadata.com.