Distribution Management System
Open++ Opera v.3.3

System Description

Contents:

1. About This Manual

1.1. Notices

Notice 1

The information in this document is subject to change without notice and should not be construed as a commitment by ABB. ABB assumes no responsibility for any error that may occur in this document.

Notice 2

This document complies with the program revision 3.3D.

Notice 3

Additional information such as Release Notes and Last Minute Remarks can be found on the program distribution media.

1.2. Open++ Opera Documents

The following documents are associated with Open++ Opera:

Document Name	Number
User Manual	1MRS 751464-MUM
Administrator Manual	1MRS 751465-MUM
Installation Manual	1MRS 751466-MUM
System Description	1MRS 751467-MUM
MicroSCADA Integration Manual	1MRS 751468-MUM

1.3. Trademarks

2. Introduction

2.1. General about Open++ Software

Open++ Opera is a distribution network management system (DMS), which extends traditional MicroSCADA capabilities by providing geographically based network views. Opera LT package provides component data management and network modeling to provide network overview and topological coloring to see the network state. In addition, Opera has many optional modules with advanced functions. Open++ Opera can also be used without MicroSCADA or other SCADA systems. The software has been designed to assist the operation's personnel of electric companies in monitoring and operating their networks.

Both raster and vector based maps can be used as backgrounds for the network window. It is also possible to create and use schematic network views, instead of geographically based network presentations and maps.

The software runs on PCs using the MS Windows NT®, MS Windows 2000® or MS Windows XP® operating systems both in separate workstations or workstations connected to fileserver. Additional (regional) servers can be used to store network data to keep the start up time reasonable in low speed LAN/WAN networks. The saving of network and process data is made with MS Access 2000 ® or MS Access 2002 ® database management software. The graphics-based user interface of Open++ Opera is unambiguous and the standard Windows 'look and feel', together with online help, makes it easy to learn.

2.2. New Features and Functions in Open++ Opera version 3.3

- User management (replaces authority restrictions of Open++ Opera version 3.2)
- Region management
- Low voltage networks
- Inserting text to MV/LV substation
- New symbols
- Notices, event log and presentation of MicroSCADA alarms
- Improved protection analysis
- Load modeling using load curves
- Defining line type division and coloring
- Importing own features to menu
- Importing MS Access queries to menu

- Database reporting using MS Access
- Outage reporting
- Extended switching planning
- Defining own reports and forms
- New shortcut menu functions
- Changes in licenses
- New COM server application for free data forms

3. Operational Environment

3.1. System Requirements

The following table shows the minimum software and hardware requirements for the Open++ Opera -distribution management system. The proposed system configuration contains 1-3 PC's with possible Hot-Stand-By support.

All network adapter cards supported by the MS Windows NT, MS Windows 2000 or MS Windows XP operating system are supported by Open++ software. The device drivers are included in the MS Windows operating system package.

Open++ Opera can also be used without MicroSCADA or other SCADA systems.

Component	Requirement
Computer	Intel Pentium ® processor
Memory	64 MB
Disk space	One or more hard disks, with at least 5 MB free space on the hard disk(s) (minimum for full installation). 100 MB is recommended. After installing all software, there should be at least 50 MB available for the construction and operation of the program. However, the available space required depends to a large extent on the complexity of the program.
Monitor	VGA, 800x600 resolution, 256 colors, 70 Hz refresh frequency
Mouse	Any Windows compatible mouse
Optional components	One or more network adapter cards, when using Open++ software on a LAN with a TCP/IP protocol CD-ROM drive
Software	MS Windows NT version 4.0 with Service pack 4 or later, MS Windows 2000 with Service pack 3 or later recommended or MS Windows XP with Service pack 1 or later recommended. MS Access 2000 or MS Access 2002 relational database software (MS Access 95 or 97 during upgrading)
Optional software	MicroSCADA version 8.4.2, 8.4.3 or 8.4.4 with LIB 500 and LIB 510 version 4.0.2. 4.0.3 or 4.0.4 The Hummingbird ® Exceed version 5.1.3 or later. Paint Shop Pro ® is needed when converting other raster formats to bmp format, editing the color palette of the bmp formatted map material, cutting

	the bmp formatted map material into smaller pieces or changing them into different accuracy levels. CorelDraw ® or FontLab ® is needed, if new True Type symbol fonts need to be created.
Supported printers	Any printer type supported by the operating system. The following printers have been verified to work properly with Open++ software: HP ® DeskJet 690 Plus HP LaserJet 5/5M PostScript HP DeskJet 850C HP DesignJet 350C HP DesignJet 455CA Xerox ® Document Centre 220/230 PS2

In some PC workstations the full "Hardware acceleration" setting in display properties can cause several zoom window lines to be visible on screen. In that case lower the hardware acceleration setting.

3.2. Architecture

The Open++ Opera system consists of three programs from the user's point of view: Opera Network Editor (OperaNE), Opera Server Application (OperaSA), and Opera Workstation (OperaWS).

All programs (OperaNE, OperaSA, and OperaWS) can run on the same or different computers. Additionally, programs can run on the MicroSCADA system computer. OperaWS and OperaNE can be used in a multiscreen environment without 'dialog box-centering' or similar features in a multiscreen graphics adapter. Open++ Opera supports running several instances of OperaWS in the same workstation computer. In standard workstation only one OperaNE is allowed.

3.2.1. Opera Network Editor

The Opera Network Editor (OperaNE) is primarily used to model the distribution network onto the network database (network.mdb). It is also the administrator's tool for managing the whole DMS. The system can be used to manage both medium and low voltage distribution networks. The initialization of the background maps, defining of symbols and the management of the integration between MicroSCADA and Open++ Opera are the important tasks of this program. Many other descriptions and definitions are made by OperaNE.

OperaNE can be used while OperaSA and instances of OperaWS are running. Several OperaNE sessions can also be run at the same time. Number of the simultaneously allowed Open++ Opera workstations is defined by the license. The users have a responsibility, however, to check that they are not editing the same electrical components (same area) of the medium voltage network at the same time.

OperaNE updates the binary network file of the network database (network.dat) and the temporary network file (tempnet.dat) from the user input. This network model is used to speed up the operations of OperaSA and instances of OperaWS. A mechanism for informing instances of OperaNE and OperaWS from the new binary network file and temporary network file is included. The users receive information about new network data and can choose by the user input to load the new network model at once or later. The dimensions of network database are defined by the license.

3.2.2. Opera Workstation

Opera Workstation (OperaWS) is a program for the operative personnel of electric companies to monitor and operate their distribution networks.

The program contains the following functions:

- network topology management,
- network analysis including power flow and fault current calculations together with protection analysis
- operational simulations,
- fault location based on fault distance calculation and fault detector data,
- restoration,
- switching planning,
- field crew management,
- load estimation,
- database analysis,
- document archive and
- map printing.

The basis of OperaWS is a distribution network database managed by OperaNE and process data from MicroSCADA via OperaSA. Control actions occur mostly in the monitor window of MicroSCADA. The functionality of Open++ Opera is defined by the license. All instances of OperaWS are similar and can handle all cases, if the authorization level of the user does not restrict the functions.

3.2.3. Opera Server Application

Opera Server Application (OperaSA) is used for data exchange between MicroSCADA and instances of OperaWS by using the Support System Interface (SSI) to MicroSCADA. The connection between OperaSA and MicroSCADA is defined by the license.

The user interface of OperaSA is very simple and without network presentation. OperaSA provides real time information as well as station and control pictures from MicroSCADA for instances of OperaWS. Information is transferred via the Opera database (opera.mdb) and fault files (fau<xxx>.txt).

3.2.4. Hot Stand By

Hot Stand By (HSB) is a system to secure database connection with two servers which are capable to continue service alone, if connection to the other is lost.

HSB support is included in the Support System Interface (SSI), the dynamic Opera database, and the fault files, if defined so in license. In SSI, OperaSA must be ready to reconnect the SSI to the HSB SYS of MicroSCADA. Opera databases and fault files are redundant, so that the malfunction of an OperaSA computer does not stop operation of the system. OperaWS can be started using the redundant fileserver and OperaSA.

Open++ software have replication systems that constantly checks that information is same in both opera.mdb databases in both fileservers.

3.3. Slow Network Connections

Open++ Opera can be optimized for slow network connections. This feature is useful if there is a slow Wide Area Network (WAN) connection instead of a LAN between central and district offices. Additional regional servers can be used to store network data to keep the start-up time of the programs reasonable.

3.4. Terminal Services

Normally Open++ Opera is using client-server architecture, which means that e.g. OperaWS applications are run using the client computer processor and memory. The network model is loaded to the main memory of the client workstation.

However, Open++ Opera programs can be run in a terminal session using Windows NT 4.0 Terminal Server edition, or Windows 2000 Server (which includes Terminal Services). This is advantageous e.g. in case of slow network connections or when using dial-up networking with modems. This is often needed to use Opera in a home workstation. Additionally, it can be advantageous that occasional users from office workstations use terminal services since upgrading and maintenance of the software need to be done only on the server. Simultaneously in the same system the power users e.g. in control center can use standard workstations.

The NT Terminal Server can be expanded using Citrix Metaframe software. In this case Open++ Opera can be safely published as an application for remote use and makes the management easier. With MetaFrame Opera can even be run embedded in Internet Explorer. Using Internet Explorer requires also Web server e.g. MS Internet Information Server.

3.5. Communication

Open++ software programs uses TCP/IP protocols directly by Windows Sockets API and mailslot of MS Windows.

The system communication is illustrated in Figure 1.

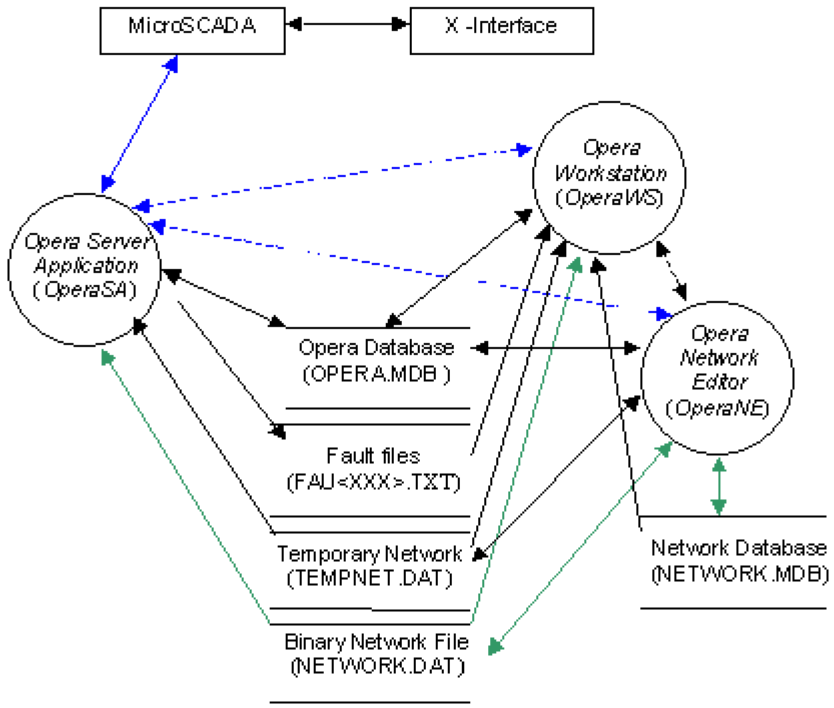

Figure 1. Open++ software communication

OperaSA is also used for data exchange between MicroSCADA and instances of Open++ software by using the Support System Interface (SSI) to MicroSCADA.

Open++ software uses direct messages from server to workstations and between workstations. The Opera Server Application (OperaSA) has a central role in Open++ software communications.

Real-time switch state change causes sending of an event-based data message from MicroSCADA to OperaSA. OperaSA then sends this data message directly to OperaWS workstations (dashed line in the figure). OperaWS does not read a server disk or database in this case.

When a new fault occurs, event-based data message is send to OperaSA from MicroSCADA. OperaSA saves fault data into a fault file, title of the fault into the Opera database and sends a message to OperaWS workstations. OperaWS workstations then reads additional data from fault files.

OperaNE updates network data changes direct to relational network database. Ready changes are then saved into the binary network file to achive fast upload to workstation memory. OperaWS uses network database only during opening of component data forms.

OperaNE uses temporary network file for temporary network data, which is read together with real network data into the memory of OperaWS workstations.

4. Licenses

4.1. General about Licenses

The functioning of the Open++ software depends on the licenses containing the information about main and optional functions together with information about connection between OperaSA and MicroSCADA.

The available commands in the user interface reflect the capabilities of the program in accordance with the installed licenses and installed selectable functions.

Open++ software v.3.3 requires licenses for the version 3.3 to function correctly. If previous license (version 3.2 license) is used with Open++ software v.3.3, a warning message "License version number is incorrect! ABB assumes no responsibility for any error that may occur while using this program!" is displayed. Open++ software v.3.3 licenses are delivered with Open++ software v.3.3 program update.

4.2. Functionality of Open++ Opera

License/sublicense	Operational Functions	Selectable Functions
Open++ Opera LT (Light)	• network component database and distribution network topology management	• temporary network data • terminal server support • using only one instance in OperaWS
• *MicroSCADA connection*	• connection between OperaSA and MicroSCADA	• possibility to connect MicroSCADA without using the monitor
• *Hot-Stand-By*	• two server system to secure database connection	
• *Demo*	• demo to allow introducing of Open++ Opera software with limited MicroSCADA connection (6 hours without reopening) and network editing only to temporary networks	
Open++ Opera Standard	• field crew management • customer information • map printing • measurement presentation	• field crew management • customer information

• *Alarms presentation*	• alarm and warning presentation	• alarms
• *Low voltage networks*	• management of low voltage network	
Extended Data Management	• document archive • free database objects • free data forms • queries	• document archive • free database objects • free form • free form for OperaWS • queries
Network Analysis	• network and protection analysis • operational simulations,	
• *Extended Load Modelling*	• load estimation • load curves	• load estimation • use of Velanders factors or load curves
• *Operations Planning*	• switching planning	
• *Reconfiguration*	• reconfiguration	
Fault Location	• fault management • fault simulation	
• *Restoration Support*	• fault restoration	
• *Outage Reporting and Statistics*	• outage report	
• *Automatic Restoration*	• automatic fault isolation and restoration	

Open++ Opera LT license authorises the most limited functionality of the program. *Standard* license is always required for additional functionality licenses. *Network Analysis* license is strongly recommended for optimal performance of restoration support functionality. Other requires and recommendations of the licensees are presented in the following figure.

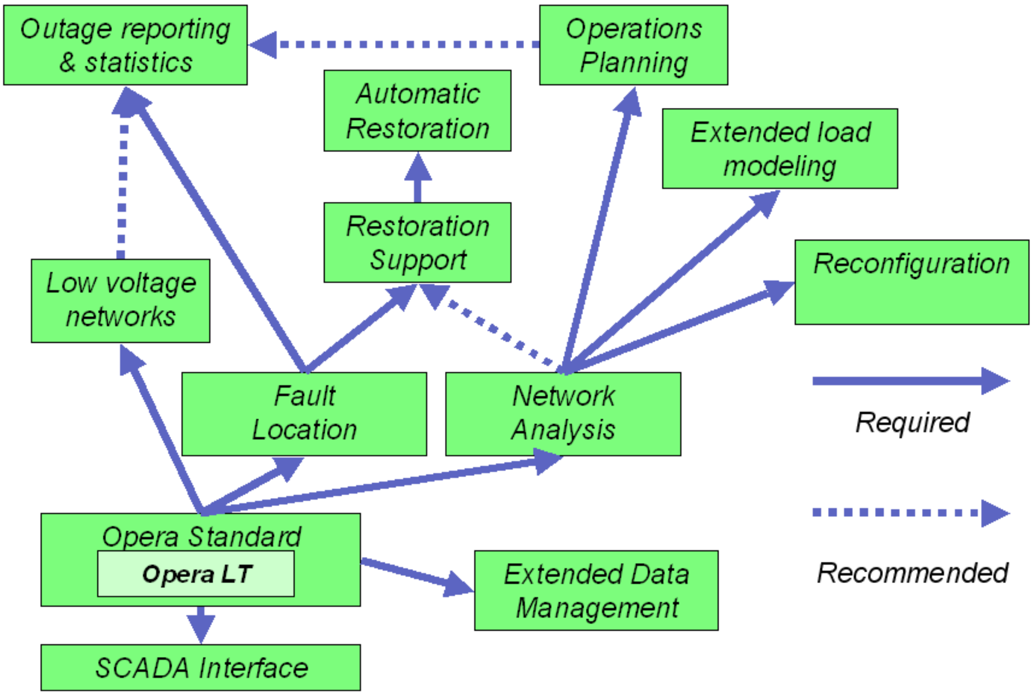

Figure 2. Functional dependencies of license modules.

4.3. Dimensions of the Network

License files defines not only the functionality of Open++ software but also the dimensions of the network database (number of primary substations having a primary transformer, transformers and disconnectors). Network size can be Small, Medium, Large or No Limit. The maximum numbers of components for different licenses are:

Network Size	Number of Components
Small	5 feeding HV/MV primary substations, 400 transformers and 800 disconnectors
Medium	15 feeding HV/MV primary substations, 1500 transformers and 3000 disconnectors
Large	30 feeding HV/MV primary substations, 4000 transformers and 8000 disconnectors
Extra Large- No Limit	unlimited number of feeding HV/MV primary substations, transformers and disconnectors

4.4. Number of Workstations

License files defines also the number of Open++ software workstations (OperaNE and OperaWS workstations used simultaneously). The number of workstations can be between 1…999.

5. User and Region Management

5.1. General about User and Region Management

User management enables login and logout functions with user identifiers without restarting the software. Region management enables dividing the network data into several regions according to feeding primary transformers and generators. The total amount of feeding primary transformers and generators defines the maximum number of regions. The user right level can be defined for each region separately.

After successful login, network windows show all parts of the medium voltage network that associates with regions that the user has rights to view. The program operates according to the rights given to the user logged in.

User management of Open++ software supports Hot-Stand-By (HSB). Login will succeed in HSB, if one fileserver is connected. However the user manager can be used only if the primary fileserver is connected.

5.2. User Levels

Open++ software contains four user levels with different rights:

Number	User Level	User Rights
1	Admin	administrator, all rights
2	Common User	control rights
3	Guest	view rights
4	No view rights	no view rights

5.3. Region Types

Open++ software uses three different types of regions:

The feeding primary transformer or generator region is called *dynamic region* and it contains all supplied network components in the current switching state. The region content changes dynamically according to the switching state. Unsupplied section of the network is not included into the region.

The user rights of an unsupplied network component is defined by the so called *normal region*. *Normal region* has defined to contain all network components during normal switching state.

The administrator can also define *extra regions* for freely chosen network components and nodes. This makes possible e.g. to control the same switching device from control rooms of several regions. Extra regions can be defined to only e.g. disconnectors and switching devices, or to all nodes in area selected by mouse.

The user needs control rights to only one type of regions (dynamic, normal or extra region) to carry out the switching operation.

6. User Interface

6.1. General about User Interface

The user interface of OperaNE and OperaWS consists of a title bar, menu, toolbar/ toolbox, status bar, together with main and auxiliary network windows, which show the distribution network. The user interface of OperaSA is very simple and without network presentation. The main network window of OperaNE and OperaWS (Figure 3) uses raster and vector based geographic maps as a background for the network presentation. It is also possible to create and use schematic network views, instead of geographically based network presentations and maps.

6.2. Network Windows

OperaNE and OperaWS represent the distribution network in two network windows. The auxiliary network window always shows the whole network. The main network window shows the area of the network in more detail. The area covered by the main network window is shown as a rectangle in the auxiliary network window. Normally the medium voltage network is visible in network windows. Low voltage networks are always separately read to the memory. After change to low voltage network, the medium voltage network is presented dimmed in network windows.

Network windows can be zoomed and panned. The size and location of network windows can be changed and the data is saved during shutting down of the program.

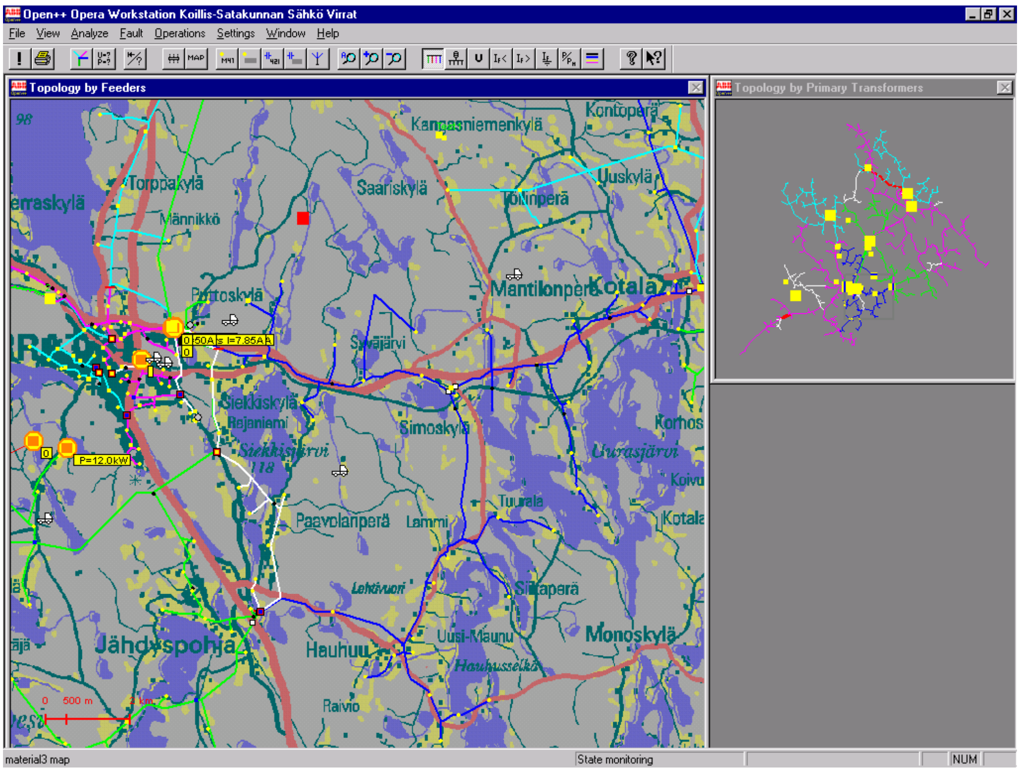

Figure 3. The basic OperaWS user interface

6.3. Network Diagrams

OperaNE and OperaWS can also present selected parts of the network as diagrams (Figure 4). The network diagram is generated automatically using the existing network data so that no special tasks are needed during network data entry. The network diagram window can be opened by selecting it from the menu opened when the user clicks the right mouse button on the place of the network in the main network window.

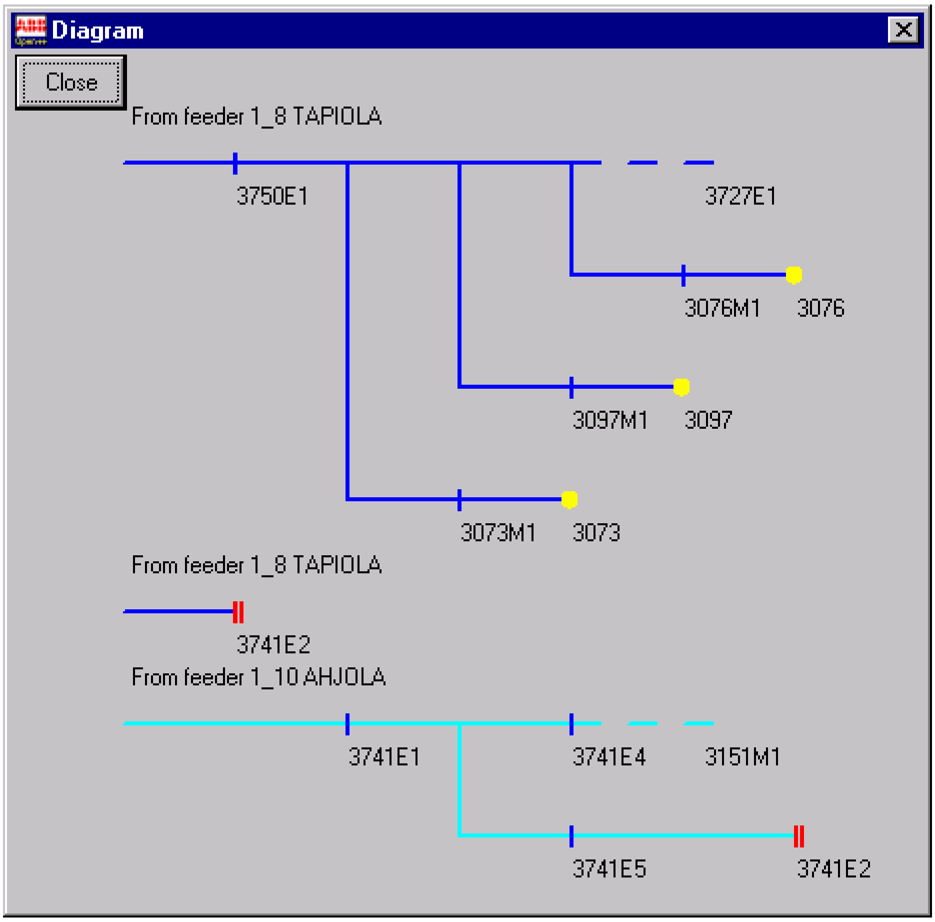

Figure 4. An example of a network diagram

6.4. Station Diagrams and Other Diagrams

Station diagrams are the way to handle station components in greater detail and to show the switching states of station components. OperaNE uses only internal station diagrams, contrary to OperaWS, which uses both station and control pictures from MicroSCADA and internal station diagrams. Normally internal station diagrams are converted from MicroSCADA. Station diagrams can also be created in OperaNE.

A particular symbol in the network window means that the object has a station diagram presentation. The internal station diagram (Figure 5) becomes visible after zooming in close enough. In OperaWS the MicroSCADA station or control picture and in OperaNE the internal station diagram is opened to a separate window when the symbol or station diagram in the network window is clicked with the right mouse button. The separate station window can also be opened with the menu command.

Other medium and low voltage network diagrams can also be created in OperaNE. These diagrams contain network objects, which would be shown more accurately in diagram mode (for example MV/LV stations and disconnector stations). This kind of connection between network objects is called a site node.

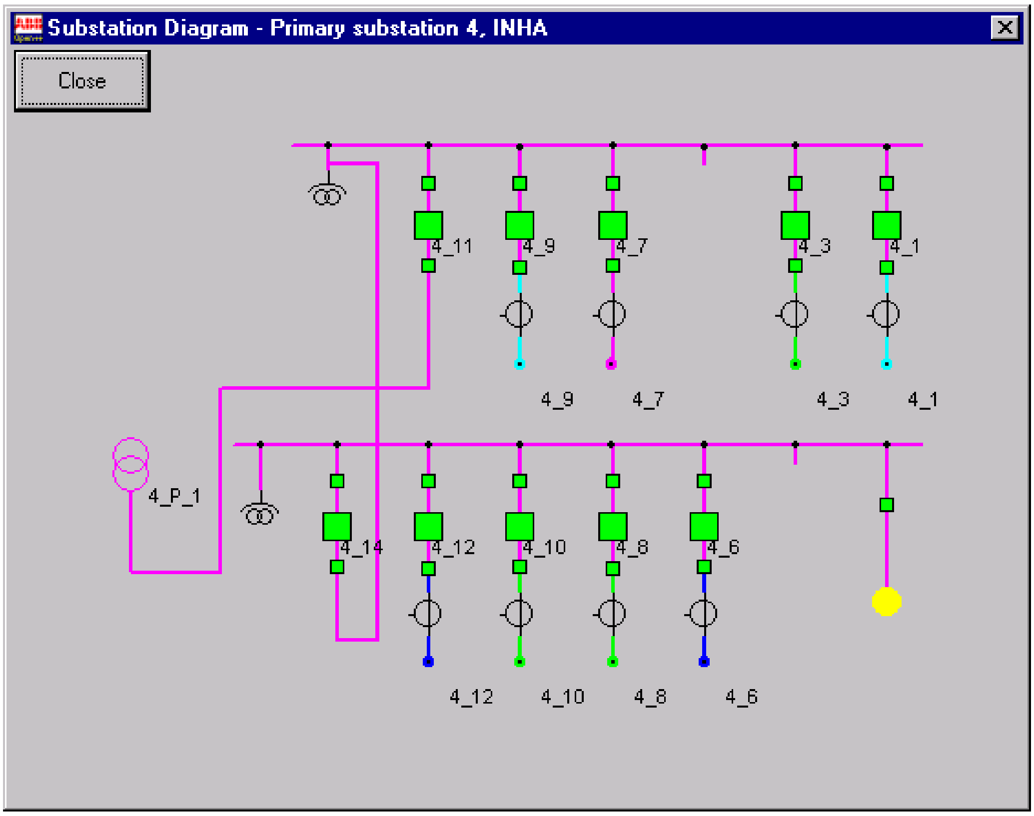

Figure 5. An example of an internal station diagram

6.5. Network Symbols and Coloring

OperaNE and OperaWS have default values for network symbols and coloring as well as other network view settings, but the user can easily change them if desired. Some object types can also be defined to show only in low voltage network view.

6.6. User Interface Controls

Network data and other data is presented using data forms and dialog boxes, together with colors in graphics-based network windows and diagrams. Functions are selected from mouse and keyboard-controlled menus and submenus or from toolbar/toolbox buttons. The main way to find the component data is by selecting from the basic user interface network window. The dialog boxes contain scrolling bars, list boxes, check boxes, option buttons, command buttons, and other elements from the MS Windows user interface.

6.7. Data Forms

In OperaNE, data for distribution network components can be entered and updated by using data forms or free data forms. Data forms are views into the Open++ Opera network database. OperaWS only uses free data forms for the browsing of component and free database object data (Figure 6). Free data forms can be used to define the layout of data forms. Data forms consist of boxes and buttons, which are used to insert and update component data. Data forms also contain buttons with different kinds of functions (for example calculation of line section length and maintaining the history of transformers).

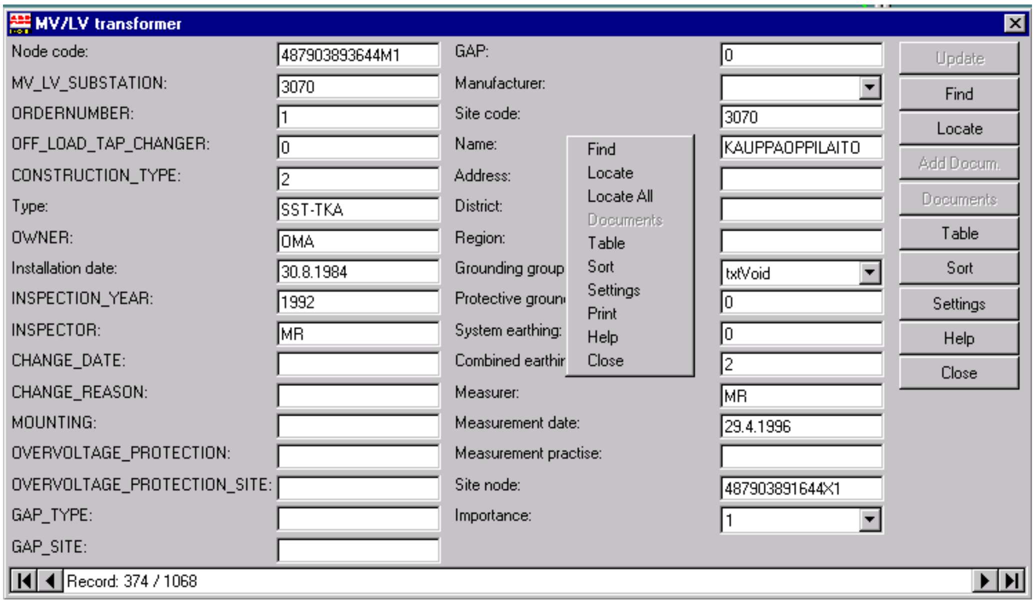

Figure 6. An example of free data form and the pop up menu

6.8. Online Help

OperaNE and OperaWS have an online help containing online manuals with contents, index and free text search features, together with context-sensitive resources.

7. Configuration of the Distribution Management System

7.1. Background Maps

The user interface of OperaNE and OperaWS uses raster and vector based geographic maps in the network window. Therefore, geographic map material has to be imported to the system. The system supports the following map formats:

- Raster maps in bmp (Windows bitmap format).
- Vector maps in AutoCAD ® dxf format.

All background maps used in Open++ Opera should be converted to these map formats and adjusted to a single orthogonal orientation, i.e. where the x-axis is horizontal (left to right) and the y-axis is vertical (down to up).

Raster material can be obtained either as computer data or scanned from paper maps. The conversion of raster formatted map materials to bmp is made by using an external tool, for example Paint Shop Pro. Raster formatted map material can also be modified by changing the color palette, cutting large bmp raster maps into smaller pieces and by changing them into different accuracy levels using, for example, Paint Shop Pro. This kind of modification can be used to view the background maps more quickly on the screen. The conversion of the supported vector formatted dxf map material to Open++ Opera internal vg2 format is made by OperaNE.

OperaNE can also be used to adjust the supported map materials. Dxf conversion function adjusts the vector maps automatically during the conversion. Vector maps in vg2 format can also be adjusted without conversion. The adjustment of raster maps can be done in two different ways: based on the coordinates of the map corners or on the coordinates of a free selection.

Map management by OperaWS makes the changing of the outlook and storing location of background maps possible.

7.2. Network Database

The network database is the basis of the Open++ Opera system. The dimensions of the network database are defined by the license. Network data entry is made in Opera Network Editor (OperaNE). Network data is stored by the MS Access 2000 or MS Access 2002 relational database software.

The database contains data on the lines and components of the distribution network. Load data and protection relay data for each protection unit - overcurrent, earth fault, and reclose - also has to be imported into the network database if the network analysis is included in OperaWS. Relay setting data can also be obtained from the relays via MicroSCADA. Network analysis uses load data to calculate the load flow of the electrical network. Protection relay data is used to check the acceptance of protection during network analysis. Additionally, the database can contain optional low voltage network data, free database objects (for example data of tenancies and measurements), documents connected to the components, temporary network data and customer data.

Open++ Opera uses two kinds of network databases: the network database (network.mdb) and the binary network file (network.dat). Updates of the network data in OperaNE go directly to the network database (network.mdb). OperaNE updates the binary network file from the database from the user input. After this command is given, a message is sent to all workstations (all instances of OperaWS and OperaNE) to inform them about the new network data. This data can be updated immediately by accepting the suggestion in the message window or later by using the command in instances of OperaWS. Because of this arrangement the medium voltage network data of the same area are not allowed to update same time in different workstations.

7.2.1. Network Data

Depending on the license the network database includes only medium voltage or both medium and low voltage networks.

Inserting and updating of network data is allowed in the *Data Edit Mode* of the system. The *Data View Mode* only allows the browsing of the existing network data. Browsing, updating and inserting temporary network data is made in the separate *Temporary Network Mode*.

Network data is managed by the graphics-based user interface of OperaNE with network windows and geographic background maps. The graphics-based data is inserted and edited using the mouse in the network windows, and the component data using data forms or optional free data forms. Internal station diagrams can be converted from MicroSCADA or created with OperaNE.

The basic data items are nodes and the line sections connecting them. Tables representing data from different components are linked to the nodes. A data model of the network is presented next in Figure 7.

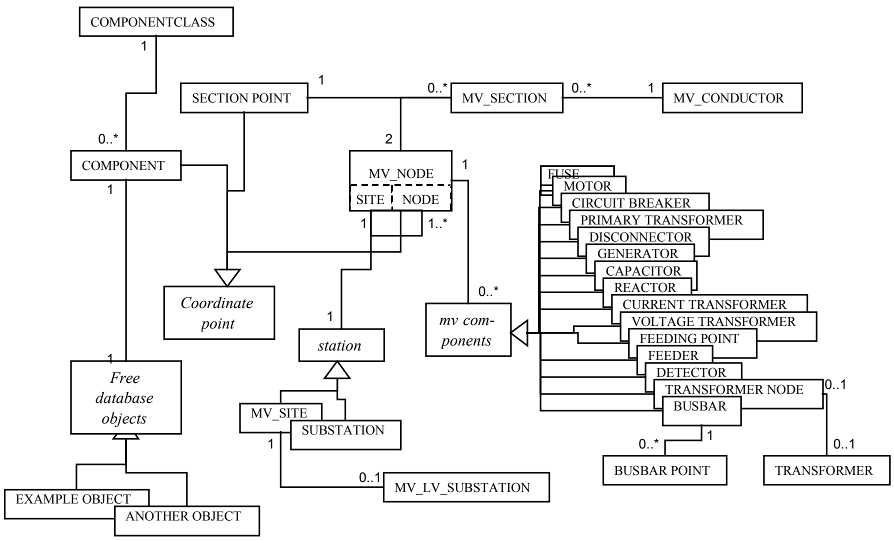

Figure 7. Network data model

7.2.2. MicroSCADA Integration Data

The optional integration of Open++ Opera and MicroSCADA requires that links between network components in different software is included in the database. The links between process objects, the virtual points and MicroSCADA measurements to the network components are updated in OperaNE and saved in the database. Cross-connections between MicroSCADA pictures and Open++ Opera stations are also saved in the database.

7.2.3. Customer Information

The customer data with customer loads can be imported to network database using MS Access import function (e.g. via ASCII text file). It is also possible to create a linked table to use an external customer database via ODBC. Open++ software does not include the customer data management.

7.2.4. Free Database

Depending on the license the free database can be used to add free database object types and data to the network database. The user can define the object types required by making changes within the database tables. The way of presenting the data of free database is the free data form. Free database also enables the adding of extra fields to the tables of existing node and line section types containing the initial fixed data content.

7.2.5. Documents

Documents are data (for example pictures or text documents), which are attached to the nodes of the network database if optional function is defined by the license.

Attaching documents to the nodes are managed in OperaNE. The attached documents can be browsed in OperaNE and OperaWS.

7.2.6. Temporary Network Data

The temporary network data can also be maintained using a separate temporary network file (tempnet.dat). The temporary network components cannot be integrated in process points of MicroSCADA. Integration needs the component to be inserted in the network database. Network coloring can be used to distinguish objects in a temporary network.

7.3. Integration to MicroSCADA

Integration of Open++ Opera and MicroSCADA offers:

- Conversion of station and control pictures from MicroSCADA to the network database in OperaNE.
- Utilization of all the position indication data from MicroSCADA to the topology management of OperaWS via OperaSA (cyclic and event based).
- Utilization of fault data from MicroSCADA to the fault location of OperaWS via OperaSA (event based).
- Utilization of relay settings from MicroSCADA to the network analysis of OperaWS via OperaSA.
- Control of switches by opening MicroSCADA monitor windows in OperaWS.
- Automatic fault isolation and restoration using the switching plan produced by OperaWS to control the MicroSCADA.
- Displaying MicroSCADA measurements in OperaWS.
- Load estimation using MicroSCADA measurements in OperaWS.
- The transfer of root point coloring and power flow direction from OperaWS to MicroSCADA station and control pictures via OperaSA.

7.3.1. Data Transfer and Databases

Open++ Opera contains an optional high-level interface to MicroSCADA, which provides real time and static data transfer to Open++ Opera (Figure 8). The data transfer from the MicroSCADA system is both static and dynamic. The transfer of the states of the switches and fault data is based on events in the MicroSCADA system and performed by OperaSA. This data is saved in the dynamic database (opera.mdb) used by OperaWS. The measurement data of MicroSCADA is transferred at regular intervals for network monitoring and analysis. Station diagrams are converted only occasionally using the conversion function supported by OperaNE and the data is static in the network database. Other pictures from MicroSCADA can also be defined to be displayed in OperaWS.

The full integration of MicroSCADA and Open++ Opera is supported in MicroSCADA version 8.4.2, 8.4.3 and 8.4.4 with LIB 500 and LIB 510 version 4.0.2, 4.0.3 or 4.0.4. With the older version of MicroSCADA, the interface is limited and requires special engineering.

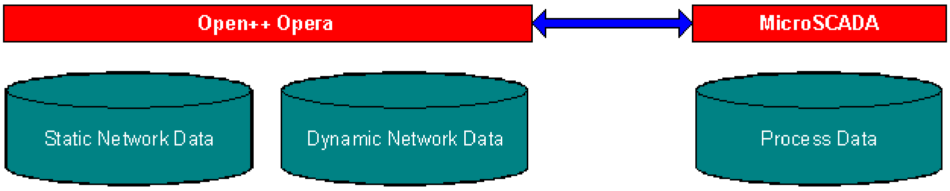

Figure 8. The integration of MicroSCADA and Open++ Opera

7.3.2. Cross Connections between Open++ Opera and MicroSCADA

All components, which relate to data transfer between MicroSCADA and Open++ Opera, should be cross connected by the process objects or virtual process points of MicroSCADA using the LIB 500 *Opera Interface Package* and OperaNE. These components include primary stations, feeders, circuit breakers, disconnectors, fault detectors and primary transformers. Also, the measurement data of MicroSCADA can be connected to the component of Open++ Opera. Virtual process points of MicroSCADA refer to manually operated switches in OperaNE. These virtual process points are defined as objects and used for storing the states of the switches and for getting the operation events in MicroSCADA.

Also, the connection between primary substations and the MicroSCADA station and control pictures is created using the LIB 500 *Opera Interface Package* and OperaNE. The geographic selection of the MicroSCADA station and control pictures in OperaWS makes it possible to implement control actions on the same monitor screen as OperaWS.

7.3.3. Root Point Coloring and Power Flow Indication

Network topology coloring and power flow direction are transferred from OperaWS to MicroSCADA. Data defines the root point coloring and power flow indication in MicroSCADA station and control pictures.

7.3.4. Interfaces and Protocols

Open++ Opera and MicroSCADA are integrated by using an application program interface (API) based on socket and TCP/IP data transmission protocols. OperaSA performs the data exchange with MicroSCADA and instances of OperaWS by using the SSI to MicroSCADA. Switching, measurement, and event data can be transferred cyclically or event based from MicroSCADA to Open++ Opera. Control actions, root point coloring and power flow direction in Open++ Opera switches to MicroSCADA functions.

7.4. Network Symbols

Symbols represent the network components and objects of the free database in the network windows. Symbols also show locations of selected components and objects in network windows. You can define component or object type specific symbol for three different zoom ranges.

There are two types of component symbols that can be used in Open++ software

1. Default symbols are in use if nothing else has been defined..

2. TrueType symbols, which override default symbol types. Open++ software contains the standard TrueType symbol library (opera.ttf).

TrueType symbols are in fact TrueType fonts. Any existing TrueType symbol font can be used if it contains a suitable symbol. Fonts can also be created with any font editor or drawing program that supports saving as a TrueType file (ttf). The FontLab ® font editor program and CorelDRAW ® drawing program are examples of such programs.

Open++ Opera contains default symbols for all primary network components and all location symbols for all zoom ranges. The TrueType symbols can be defined for primary network components and various location symbols. Open++ Opera contains the standard True Type symbol library (opera.ttf).

The free database objects have no default symbols. The representation of free database object using the symbols requires the definition of symbols. Free database object types can also be represented with symbols in the auxiliary network window. The size and color of the symbols and the line width and color of the reference line are defined during symbol definition.

If the symbol is not defined and label properties are defined, only the label is seen in the network window. This is used to represent text object types.

7.5. Open++ Opera Settings

Settings are used to define, for example, the outlook of the network view and background maps. Also the functions of the systems can be customized using, for example, the fault location and network analysis settings.

The system settings are categorized in three groups:

- System specific.
- Workstation specific.
- OperaSA specific.

The system specific settings that affect all instances of the system are saved to the working directory of the fileserver. Examples of these settings are line color definitions and the zoom ranges of the symbols.

Workstation specific settings are used to modify separate workstations and they are saved to the working directory of the workstation. The outlook of background maps is an example of these settings.

OperaSA specific settings are defined by OperaSA. Examples of these settings include TCP/IP addresses.

Open++ Opera contains default values for all operational settings. However, the administrator can easily update the system and OperaSA specific settings and the users workstation specific settings. The language of the user interface and online help used in each workstation (OperaNE and OperaWS) is runtime changeable.

8. Operational Functions

8.1. General about Operational Functions

Open++ Opera has been designed to assist the operation's personnel of electric companies in monitoring and operating their networks. It extends the traditional MicroSCADA capabilities by providing geographic network views and advanced functions.

The main functions provided by OperaWS are:

- Network topology management.
- Expanded network data management
- Network analysis and operational planning.
- Fault location and restoration.
- Outage management

The functional content of the system depends on the licenses containing the information about main and optional functions together with information about connection between OperaSA and MicroSCADA.

The user right level of Open++ Opera software can be defined for each region separately.

8.2. Operational Modes

Different functional modes are used during the use of OperaNE and OperaWS.

OperaWS operates in three modes:

- *State Monitoring Mode*,
- *Simulation Mode* and
- *Switching Planning Mode*.

OperaNE also operates in three modes*:*

- *Data View Mode*,
- *Data Edit Mode* and
- *Temporary Network Mode*.

8.3. Network Topology Management

Network topology management is based on the integration of Open++ Opera and MicroSCADA. OperaWS contains information on the switching state of the distribution network, i.e. information on the state of all remote and manually operated switches and line sections.

The topology of the network is defined by the state of the switches. Every change in the state of the switches (both in MicroSCADA and in OperaWS) causes an update of the network topology on the screen. The new network topology is immediately displayed in the user interface. The topology of the network is displayed as feeders or as primary feeding stations using network coloring in the network window. The feeder topology color settings are used in the network diagrams, station diagrams, and in the root points of the MicroSCADA station and control pictures.

If looped connections or unsupplied lines are found, they are immediately shown to the operator with an alarm and with special colors in the network window. Indication of loop connections can also be removed by settings. Unsupplied MV/LV stations are drawn as white symbols with the special command. Uncertainty of the line state is colored with its own color. The color for earthed lines is used if the network is connected to earth, for example, by a temporary earthing or earthing switch. The state of the switches is shown with the defined symbols of the network.

Monitoring and topology management are made easier by using a functions called downstream and upstream traces. A downstream trace means the line sections fed via the selected line section. An upstream trace means the line sections feeding the selected line section. The trace is then colored with a warning color in the network and diagram windows.

8.3.1. State of the Switches and Line Sections

The switching state of all switches connected to MicroSCADA is updated using MicroSCADA station and control pictures. Updating can be done in MicroSCADA or by opening MicroSCADA station and control pictures in OperaWS by selecting the switch with the mouse. Switches can be remote operated real process objects or manually operated virtual process objects.

In the case of a failure in the MicroSCADA system or in data transfer between OperaWS and MicroSCADA the switching state of switches is updated using dialog boxes of OperaWS. In that case OperaWS proposes the change to the *Simulation Mode* and MicroSCADA station and control pictures are not useable. When data transfer capabilities return, the real time switch status is read from MicroSCADA and the network topology is updated accordingly.

The state of the switches, which are not connected to MicroSCADA (i.e. not defined as MicroSCADA real or virtual process objects), has to be updated using the dialog box of OperaWS by the user. The recommendation is that all switches should be connected to MicroSCADA.

The status of line sections is always updated in OperaWS. Close, open, and earthed are the possible line section states.

8.3.2. Checking of Switching Actions

The system provides checking of switching actions, which means that the checking of the connection to a loop or to an earthed network is made after selecting the switch in OperaWS. If the closing of the selected switch causes a loop connection or engaging to the earthed network, the alarm is given before opening the MicroSCADA station or control picture or the internal dialog box. Checking of switching actions can also be removed by settings.

8.3.3. Border Switch

The border switch can be modeled using a manually updateable measurement point. The border switch is handled in topology management as a normal switch if the state of the switch is open. The closed border switch supplies energy to or from the other network depending on the sign of the measurement value. The branch becomes energized or a loop connection is formed, if the electricity supply to the switch is also coming from another direction.

8.4. Network and Protection Analysis

Network and protection analysis functions require the Open++ Opera network analysis license.

Network and protection analysis is used to define the electrical state and protection functionality of the distribution network in a real time or simulated network topology using network calculations, load flow and fault current calculations together with the protection analysis of radially operated and meshed networks. Features of the calculations depend on the user-defined settings.

The generators and synchronous motors are taken into account as a short circuit current source. The big starting currents of asynchronous induction motors can be studied in load flow calculation. Additionally, the distributed generators and capacitors are taken into account in the load flow calculations. Calculations can also use measurement data provided by MicroSCADA.

The protection analysis function can analyze definite time-delay and inverse time type overcurrent relays. Data source for all relay settings can be changed between network model and active relay settings via MicroSCADA. Also the medium voltage fuses are taken into account during protection analysis. The solid earthed networks and networks earthed via resistor are supported in the protection analysis.

The network analysis has different kind of aims in network information system and distribution management system. Network analysis of network information system is made in peak load condition to enable the focusing of the improvements and additions to the network. Network analysis in Open++ Opera is used to analyze the real time network state for the most effective and safe use of the network. The load flow in Open++ Opera is calculated using the given or estimated load information.

8.4.1. Results of the Network and Protection Analysis

The network topology is automatically updated and network analysis executed after every switching state change, if the feature is not disabled by settings.

According to the results of the network analysis the network lines can be colored to show:

- Voltage drops in medium and low voltage networks
- Load levels in medium voltage networks
- Detection ability of short-circuit protection in medium and low voltage networks
- Three-phase short-circuit capacity in medium voltage networks
- Detection ability of earth fault protection in medium voltage networks
- Detection ability of the overcurrent protection in low voltage networks

The results are shown as selected in the viewing settings. Warning level and alarm level colors are used in presenting network analysis results when the calculated values exceed the corresponding settings for the limits. The representation of the calculation result depends on the user-defined settings.

8.4.2. Required Network Data

The following network data is needed for calculation purposes during network analysis in OperaWS:

- Distribution network data.
- Electrical properties of conductors.
- Switching state of the network.
- Load data for load flow calculation.
- Relay data for protection analysis.

The distribution network data is saved in the network database of Open++ Opera. The database is created by OperaNE. It contains node and line section data (for example the length of line sections, conductor types, and the electrical connections of components). Network data can be checked and changed by using data forms or by using the node and line section dialog boxes in the network window of OperaNE. OperaNE can also maintain separate temporary network data. OperaWS creates a distribution network topology from the distribution network data and temporary network data.

Load data is needed for the load flow calculation. Open++ Opera uses Velanders factors or defined load models (load curves) to change annual energy information to active and reactive power. Relay data is used in protection analysis. It can be changed via the circuit breaker data forms. Load and relay data is saved as a part of the network database. The electrical properties of conductors are also stored in the network database. The editing of all these values occurs in OperaNE.

The states of the switches are transferred from MicroSCADA and saved in the dynamic Opera database to be used by OperaWS.

8.4.3. Load Modeling

The MV/LV station and low voltage customer loads and the effect of the capacitors are taken into account in load modeling during network analysis. Load modeling uses single-line modeling capable to analyze balanced medium voltage networks (all medium voltage lines are 3-phased and the load in medium voltage side is nearly equally distributed to all three phases).

Load data is inserted to MV/LV stations if only medium voltage network are used in Open++ software. If the low voltage network are used, the load data is entered to the low voltage consumer. The loads inside the primary substations are not modeled.

The load data of the MV/LV stations is entered into the network database in OperaNE. One or several load measurements or estimates can be given for each load point. In the case, where many transformers are located in the same MV/LV substation, the load is allocated to the first transformer. The measurements/estimates can be given as real power or annual energy. Additionally, the load factor (cosfii) can be given for each load measurement. If the load is given as annual energy, empirical factors (i.e. Velander's factors) are used to convert the annual energy to peak power. Velander's factors can be adjusted in OperaWS.

The settings of OperaWS determine if the power is to be analyzed as constant real power or if Velander's factors, together with annual energy, are used. Velander's factors take into account that the given real powers of load points are not likely to occur at the same time. This way the sum load (for example of a feeder) can not be as great as the direct sum of the load point real powers. It is also possible to use a constant factor setting, with which all loads in a network database are multiplied in network calculations. This is given as a system specific setting, but can be changed temporarily for each workstation during simulation. This can be used, for example, to make worst case analysis with larger loads.

Manually updateable, separate load points connected to any node of the distribution network can be used to model the separate load point, load of the border switch or backup feeder. The separate load points are taken into account during network calculation by adding the active power of the load point to the active power of the node. Manually updateable, separate load points connected to a disconnector, which is the ending point of a branch can be used to model an additional load or supply from neighboring network that is not included in the network database. If the state of this switch is 'open', the switch is handled normally in calculations. If the state is 'closed' and the value of the measurement is negative (<0), the switch node supplies the electricity to the network. This network is not calculated during load flow calculation. If the positive active power measurement is inserted into the switch, the amount of the active power is added to the power of the node as in the case of separate load points.

Open++ Opera can also use load models (load curves), when the real customer energy data can be imported from external customer database or inserted directly to network database table.

8.4.4. Load Forecasting and Load Estimation

The load forecasting starts automatically every hour. It creates dynamic load curves for feeders and provides also short-term (1 hour to 1 week) load forecasts for secondary substation loads. The calculation uses the latest MicroSCADA measurement data (busbar voltage, feeder current and other 1-phase current measurements).

Optional load estimation means the correction of the feeders and substations loads calculated using static load data such that the loads of the feeders approximates the current measurement of the feeder from MicroSCADA. The electrical state of the network can then be calculated as accurate as possible.

8.4.5. Using of MicroSCADA Measurement Data in Network Analysis

The definition of the connection between MicroSCADA measurements and the Open++ network database is made in OperaNE/Integra.

If the measurement data is connected to the nodes of the network, the measurement data serves as an input data for the network analysis of OperaWS in the following way:

- The current measurement connected to a node of the feeder or to the node limiting the MV/LV station and the feeder (node type feeder) is used during load estimation to make the load data of the feeder and MV/LV stations more accurate. The current measurements connected to a node belonging to a feeding HV/MV substation cannot be used in load estimation.

- The primary substation voltage measurement is used as a supplying voltage for feeders in load flow calculations. The voltage measurement is always used instead of primary transformer nominal voltage of setting of default busbar voltage always when it is available. The voltage measurement must be connected to a node belonging to a HV/MV substation to be used in calculation. A voltage measurement connected to a feeder node cannot be used in the calculation.

- Separate load points connected to any node of the medium voltage network can be used in network calculations. The separate load points are taken into account during network calculation by adding the active power of the measurement to the active power of the node.

- Separate load points connected to a disconnector, which is the ending point of a branch can be used to model additional loads or a supply from a neighboring network that is not included in network database.

8.4.6. Load Flow Calculation

The load flow for the whole MV network is calculated using modified Newton-Raphson algorithm.

The load data is applied to the network starting from the last node of the feeder. The calculation proceeds from the last node towards the supply point, calculating at the same time the maximum power, maximum load current, and power loss of each line section as well as the capacitive reactive power and the voltage drop.

Load flow calculations are the base for the presentation of the voltage drops and load levels.

8.4.7. Fault Current Calculation

The calculation of short-circuit currents needs a description of the distribution network and the relay settings used in overcurrent protection as well as the impedance of the primary transformer and the short-circuit impedance of the supplying network.

The short-circuit currents of symmetrical three-phase short-circuits are calculated using Thevenin's theorem by assuming the voltage of the fault point is the same as the voltage which has been given as a calculation setting.

The highest permitted three-phase short-circuit current of each conductor of a line section is calculated from the conductor's highest permissible short-circuit current (1 s) and by the duration of the short-circuit. The duration of a short-circuit is determined by the starting and operating time of the (constant time) relay and by the breaker operating time. Due to autoreclosure, attention should also be paid to the prolonged duration of the fault current. In the period of non-voltage between rapid and delayed autoreclosure, the cooling of the conductor is taken into account by calculating the so-called equivalent duration of short-circuit.

Unsymmetrical fault like two-phase short-circuit current is calculated using so called sequence networks. For this reason the negative sequence impedance is needed for feeding substations and generators.

In earth-fault calculation the earth isolated, neutral earthed and resonant-earthed networks can be analyzed. For the calculation of earth-fault currents, the program calculates the total earth capacitance of all feeders by using the earth capacitance of the conductors and the conductor lengths of feeders sections. On the basis of the total earth capacitance of the network and by Thevenin's theorem, the program calculates the earth-fault currents corresponding to the fault resistance defined, so that the internal impedance of Thevenin's source is assumed to be formed merely by the network's earth capacitance

8.4.8. Protection Analysis

During protection analysis the supported characteristic curves for the relays are:

- Constant time

- Normal inverse
- Very inverse
- Extremely inverse
- Long-time inverse
- User defined inverse
- RI-type for obtaining time grading with mechanical relays
- RD-type for earth fault protection

The detection ability of the short-circuit protection means that the operation of relays in two-phase short-circuits is checked in every end node of a section by comparing the two-phase short-circuit current and the operating value of the relay. Also line sections protected by medium voltage fuses are analysed.

The three-phase short-circuit capacity of each line section in medium voltage networks is checked by comparing the highest permissible short-circuit current with the calculated three-phase short-circuit current of the start node of that line section.

For SPACOM and RED 500 typed relays protection analysis can also be performed using relay settings obtained via MicroSCADA.

8.4.9. Network Analysis Used for Simulation

The switching state of a distribution network is changed periodically to keep the network near optimal state. Load changes, maintenance and service tasks together with fault situations also cause a need for changes in the switching state.

All switching actions can be checked beforehand by using the simulation of OperaWS. After changing the switching state, network analysis can be used to determine the electrical state of the distribution network with the changed network topology.

In order to analyze the settings of protection relays or the influence of the network analysis settings (for example by making the worst case analysis with larger loads), changes to this data are made and analysis executed again. The load forecasts can be used during simulation of the network state.

During simulations in OperaWS, the relay settings, load calculation methods, and network topology can be changed. This data is saved temporarily in the working directory of the workstation. No changes to the real network database or Opera database are made.

8.5. Meshed Network Analysis

Network analysis functions require the Open++ Opera network analysis license.

In meshed network analysis all the networks having a voltage level under the defined transmission voltage level are included in MV network and analyzed.

The primary transformers that have one nominal voltageabove transmission voltage level are used as feeding points having the defined busbar voltage as nominal voltage. The nodes of node type ‘Feeding point’ can be used in transmission network for topology analysis but the transmission network is not analyzed for load flow or fault currents. However, radial or meshed sub-transmission network can be included in network analysis. For example, one or several 400/220 kV primary transformers can be used as feeding points for 220 kV network when transmission voltage level is set to over 220 kV but less then 400 kV. Naturally, other primary transformers are used to transform the voltage to medium voltage levels.

8.5.1. Meshed Network Load Flow

The meshed network load flow for the whole MV network is calculated using modified Newton-Raphson algorithm. The meshed network load flow can not use voltage measurements at primary substations to set busbar voltages. The nominal voltages of network are directly used to transform the feeding busbar voltage to lower voltage levels. The load flow is calculated for the total network even if it consists of several isolated islands.

Big power plants have voltage regulating generators, where active power and voltage are known. In addition the load flow supports also smaller distributed generators where generators are producing active power and reactive power by regulating the reactive power produced. These generators can be connected to the network model using a ‘block transformer', which is modeled in the network model as a transformer, but getting the power from the generator.

As a result of the meshed network load flow analysis the node voltages and power flows of line sections are calculated and used in network voltage drops and load levels coloring.

8.5.2. Meshed Network Short Circuit Analysis

For meshed network short circuit calculation, the feeding network short circuit impedance is given for the primary substations where these feeding primary transformers are located.

During analysis the feeding network, synchronous motors and generators are used as current sources.

2- and 3-phase short circuit currents are calculated for all line sections with a given fault location. These values can be used to study the relay operations in specific fault situations.

8.5.3. Meshed Network Protection Analysis

During meshed network calculation the maximum short circuit currents are calculated for all line sections in the MV network. However, protection analysis is performed only for parts of network where the relay is feeding a radial branch.

8.6. Fault Management

Fault management functions require the Open++ Opera fault location license.

The fault location function of OperaWS deals with permanent feeder faults in medium voltage networks. In meshed networks the fault location works only if the faulted feeder or an opened circuit breaker is in a radial branch. Busbar faults (i. e. there isn’t a feeder for an opened circuit breaker) are located at the same way as radial feeder faults.The Open++ Opera system can manage several faults at the same time. Permanent faults in a distribution network are detected by relays connected to MicroSCADA. After permanent fault has occurred, the required fault data collected by MicroSCADA is automatically sent to OperaWS. The states of the remotely readable fault detectors are obtained from MicroSCADA and on-site readable detectors are managed by the user interface of OperaWS.

After that OperaWS automatically starts the fault location function and shows the present topology of the network. OperaWS analyzes the fault data and inferences the most likely fault locations. All the line sections, which are possible fault locations based on the fault distance calculation, are shown on the screen using the alarm color.

The general fault management of Open++ Opera is described in Figure 9.

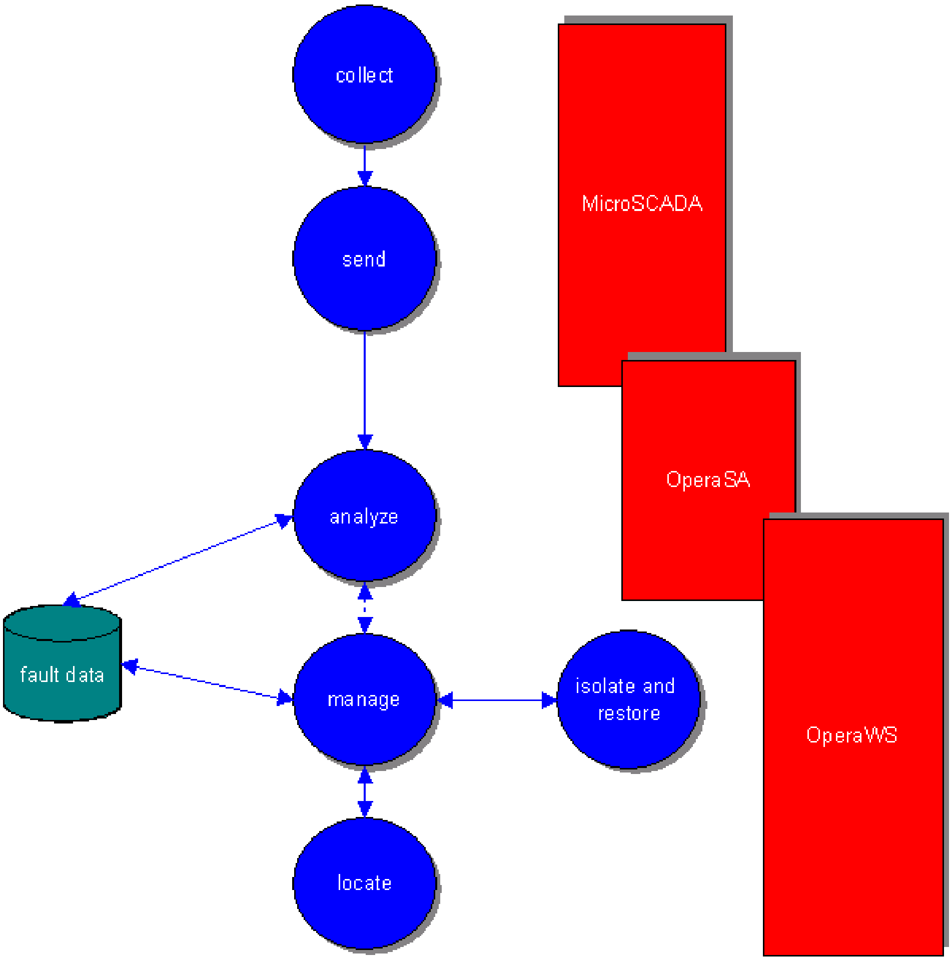

Figure 9. Fault management of Open++ Opera

8.6.1. Fault Location

The possible fault locations along a feeder in which a fault has been happened are determined based on:

- Fault distance calculation (based on sequence representation if necessary).
- Fault detector data.
- Type of line sections (underground cable/overhead line).
- Overload conditions for distribution transformer and cables.

The fault distance calculation function calculates the fault distance of two- or three-phase short-circuits and single or double phase to earth faults. The calculation requires fault current registration, for example at relays and data transfer from process via MicroSCADA. Fault location of short-circuits and earth-faults based on the transferred fault detector data can be run in any of the networks.

8.6.1.1. Fault Distance Calculation

The primary information for the fault distance calculation is:

- The measured short-circuit or earth -fault current (or measured or calculated reactance or impedance, if fault current is zero).
- The measured type of fault (two- or three-phase short-circuit or single or double phase earth fault).
- The measured loads just before a fault.
- The switching state of the network in the situation when the fault occurred.
- The network data of the feeder in which a fault has been happened.
- The short-circuit impedance of the supplying transmission network and the main transformer.

The fault distance is determined by comparing the measured short-circuit current and the type of fault with the calculated short-circuit currents along the feeder in which a fault has been occurred. The measured values can be obtained from MicroSCADA or given by the operator. The short-circuit current can be measured either on the protection terminal of the feeder in which a fault has occurred or on the busbar protection bay. The loading condition prior to the fault is used to eliminate the effect of the load current for better calculation accuracy.

The user of OperaWS can set the importance for the primary information using the factors. The value for the factors are in the range 0-1. A high value stresses the information and increases its importance in the inferencing. A value of 0 means that the information is not used in the inferencing. OperaWS contains recommended default values for factors.

8.6.1.2. Fault Detector Data

The states of the remotely readable fault detectors are obtained from MicroSCADA or updated by the operator and on-site readable detectors are managed by the user interface of OperaWS.

The fault location function inferences the fault detector zones, which the fault is in (i.e. an exact regions of the network bordered by fault detectors).The line sections of the detector zone, in which a fault has occurred, are the possible fault locations in the fault location inferencing.

The function analyses the consistency of the operation of several fault detectors by using the network topology (for example checking if some detector has not operated in series and if there are operations in two different branches). The function also analyses the direction of the earth fault current in case of a non-directional earth fault indication.

If there is some inconsistency, or two simultaneous faults along the feeder in which a fault has occurred, the factor of the fault detector data used for inferencing is set very low The user can update with the correct detector data and run the fault situation again.

8.6.1.3. Line Section Type

The type of line section has an effect on the possibility of fault location. The types are divided into three groups:

- Pure overhead lines.
- Covered overhead lines.
- Underground cables.

All the line sections of the feeder in which a fault has occurred are processed. Based on line type, the possibility of a fault being found in a line section is increased based on the maximum value of the factor and the length of the line section.

8.6.1.4. Overloading of Cables and Transformers

If OperaWS includes the load flow calculation of the network analysis, the overload conditions for cables and transformers before the fault can be checked. The calculated values of the loading conditions are compared to the technical limits of the conductors and transformers obtained from the network database.

If the overload exceeds the overload limit defined in the fault location parameters, the possibility of a fault being found in a line section object is increased based on user defined factors

8.6.2. Fault Isolation and Restoration Planning

Switching planning functions require the Open++ Opera network analysis license with optional switching planning function. The fault isolation and restoration planning made during the fault management also requires the Open++ Opera fault location license

The isolation and restoration planning function offers support for planning of operations needed after feeder faults. The function handles only the operations, which can be carried out by remote control. The initial state of the function is the result of the fault location. This means the faulted feeder and possible fault location based on fault distance calculation and fault detector data.

The isolation planning isolates the located fault as soon as possible and at the same time causes as few disadvantages to the customers as possible. The fault location can be based on the automatic fault location function, or the faulted zone can be defined manually. The restoration planning tries to restore the supply as soon as possible to as many customers as possible during repairing of the isolated fault. Switching sequence can then be executed manually or automatic using MicroSCADA.

The isolation and restoration planning can also be used in experimental switching planning.

8.6.3. Automatic Fault Isolation and Restoration

Isolation and restoration planning can be used to produce the switching sequence for automatic fault isolation and restoration. The function speed up the service restoration especially in the case of unmanned control center.

The administrator of the system have a possibility to set automatic fault isolation and restoration functionality on. If the functionality is not switched on, the fault isolation and restoration switching actions are done by operator.

If the automatic functionality is turned on and the fault can be definitely located, OperaWS generates the switching sequence and runs the automatic execution by MicroSCADA.

Only if the whole switching sequence is run successfully OperaWS can continue normally and may start another restoration sequence if a new fault appears. In case of error or stopped sequence the return value indicates this and OperaWS is blocked so that it cannot start another sequence before manual resetting.

8.6.4. Fault Location Simulation

The fault location simulation of OperaWS can be used to locate the real fault with modified MicroSCADA information (for example fault current) or fault location parameters (for example certainty factors).

The fault location simulation function can also be used to locate a new real fault if there is some problem with the MicroSCADA connection. The operator can enter the initial fault information and perform the fault location in the simulation mode. After reconnecting to MicroSCADA, the real time states of the switches are obtained by MicroSCADA.

Simulation can also be used to make a demonstration fault for purely simulation purposes (for example a fault cleared by the autoreclosing function of the protection relay can be studied afterward using the manually read measured values of the relay).

During simulation, OperaWS is not connected to process through MicroSCADA and the changes are saved temporarily for use at the workstation.

8.7. Operational Planning

Switching planning functions require the Open++ Opera network analysis license with optional switching planning function.

In the normal switching state the operational personnel plans the switching action during:

- Planning of maintenance outages.

- Optimization of the electrical state of the network in changing conditions (for example in changing load condition), i.e. reconfiguration.

The switching planning functions are based on the network data and the switching planning models. Automatic planning functions generate the switching sequence, which notices the technical constraints of the network and the protection demands. The switching sequence contains openings and closings of the switch devices and other actions needed during the outage.

In addition to the switching planning functions, the simulation of OperaWS can be used to examine the electrical state of the network and the functioning of the protection in any switching state. Simulation can be utilized in any switching planning situation. Also, the use of load estimation during network analysis to the existing network or to the simulated switching state supports the switching planning.

8.7.1. Outage Planning

In the normal switching state switching planning is needed to plan switching actions to disconnect the line sections for outages and restore the supply after outages. The maintenance outages can be planned in advance and there is no hurry during switching actions.

OperaWS contains the functions for planning the maintenance outages. The function starts by defining the point and location of the maintenance outage. Also, the required breaking capacity of the switches is defined. Then, the switching sequence containing both remote and manually controlled switches is generated using the switching planning models.

Beyond the automatic switching planning functions OperaWS can be used to manually create a switching sequence. A switching sequence created manually or by the maintenance outage planning function can be edited, simulated and executed supported.

8.7.2. Reconfiguration

The reconfiguration function helps to find an optimal switching state with minimal losses in existing load situation. The function is applicable for radial operated networks.

The reconfiguration function searches for pairs of an open switch to close and closed switch to open in order to achieve maximum reduction of losses. The function offers two modes; optimization with all switches and optimization with only remote controlled switches. There is also possibility to freeze open points to be included to optimization. The results can easily be studied with interactive tool provided by the system. The real switching actions are made by the operator.

From a practical point of view several different cases for applying the reconfiguration methods can be distinguished. Reconfiguration using all switches corrects any errors in the original selection of the open points. The procedure is repeated occasionally and especially using the maximum load situation of the network. It is also appropriate to implement the manual changes in conjunction with returning to normal state after restoration or scheduled outage. During the peak power even manual switching for loss reduction could be beneficial, because the marginal cost of energy is very high. In normal operation it is reasonable to make only remote-controlled switching changes.

8.8. Outage Data Management

The outage data management requires the Open++ Opera outage reporting and statistics license. The fault location, low voltage networks and operations planning licenses are needed for full operation of the function. The main functions in the outage data management are:

- LV outage data management
- MV fault reporting
- MV maintenance outage reporting
- LV network outage reporting
- Reclosing reporting
- Retrieval of customer and MV/LV station specific outage data

8.8.1. Management of the LV Network Outage

Information about low voltage network fault is normally notified by the customer. The information about the fault can be saved to OperaWS. LV outage maintenance data can also be saved using the LV network outage management.

The data about saved LV outages can be used to create the LV network outage report, which can be archived to an own archive.

8.8.2. Reporting Fault and Maintenance Outages

Outage reporting is used to report the basic data of the outage and actions during the fault clearance and maintenance outage.

OperaWS generates outage report template, where the most of the fields are filled-in beforehand based on executed sequence. The operator can define the exact fault location by pointing the location in the network window before reporting. The key values of the outage are calculated based on data of the outage. The operator completes the report and saves the data into the archives for the later use.

The fault reporting function is used after the fault has been repaired, supply is restored and fault is set to repair. The maintenance outage reporting function is used after the outage has been arranged and supply is restored.

Only the user, who has rights for the fault management and is responsible for the appropriate fault or maintenance outage can update the fault report data or report the appropriate outage.

8.8.3. Archiving Outage Data

The outage data of the repaired fault, performed maintenance outage and reclosings can be archived for continued consideration, for example reporting and collecting the customer and MV/LV substation outage data

9. General Features

9.1. Warnings and Alarms

Notices and warnings are generated in OperaWS based on network topology, network and protection analysis and fault location. Presentation of MicroSCADA alarms and warnings is in use if there is Open++ Opera license for alarm presentation and the functionality has been selected.

OperaWS notices and warnings are presented using colors in the network windows and inserting text to notices list and event list. MicroSCADA alarms and warnings are presented with user-defined symbols on network windows and changes in object alarm states presented by inserting text to event list.

The alarming of the following object types are transferred from MicroSCADA to OperaWS :

- Disconnector
- Primary substation
- Circuit breaker
- Measurement
- Fault detector

9.2. Field Crew Management

During fault clearing not only the remote controlled switches but also the manually operated switches need to be used. The control of manually operated switches needs the attendance of the field crew. The repairing of the fault requires the field crew to be able to move in the terrain.

The efficient organization of the field crew movements speeds the fault clearance by cutting the time needed for disconnection and repairing of the fault.

OperaWS supports the perceiving of field crew locations. The data content of the field crews in the database can be freely expanded. Additionally, a common document for field crews is available and can be used, for example, to handle working shifts and holidays of personnel.

9.3. Customer Service

In a fault situation customers call the control center to report that they have no supply. The customer service function provides fast search for the feeding transformer of a calling customer based on name, code or other information available. The result of the search is the secondary substation to which the customer is connected. The found substation is shown in the network.

The customer service function is based on customer data. The customer data with customer loads can be imported to network database using MS Access import function (e.g. via ASCII text file). It is also possible to create a linked table to use an external customer database via ODBC.

9.4. Database Analysis

Extended data management license contains database analysis.

A database analysis result summaries and the collection of data from the network database. Database analysis is based on queries. A query can be focused to an entire network data or to the object group selected beforehand. The rules of query can contain one or more constraints (for example the manufacture before year 70 and the last maintenance made before year 95), which are used to pick up data needed from the database.

The administrator can create queries using the MS Access capabilities or OperaNE query builder. The results can be seen in table format in MS Access. The queries containing coordinate or node code data can be seen in graphical form in OperaWS and OperaNE. Simple graphical queries can also be created using the functions of OperaWS or OperaNE.

Definitions of reports and forms enables the reporting of network database content using Open++ software menu command. The administrator of Open++ software defines the reports and forms into network database using MS Access.

9.5. Document Archive

Extended data management license contains document archive.

Documents are data files attached to the nodes of the network. Documents can be any files, which can be run with the program in a workstation (for example pictures or text documents). Connecting documents to the nodes is managed in OperaNE. The connected documents can be browsed in OperaNE and OperaWS.

9.6. Map Printing

OperaWS and OperaNE contain versatile graphical printing properties. Database data, together with geographical background maps, gives plenty of alternatives to print out network diagrams, site maps, substation diagrams and so on

Glossary of Terms

API

See Application Program Interface.

Application Program Interface

A set of routines that an applications program uses to request and carry out lower-level services performed by a computer operating system.

binary network model

Model of a relational network database used to speed up the operation of Open++ Opera. See also network.dat.

bmp

Windows bitmap format.

certainty factors

Certainty factors are used during inferencing to define the stress on individual inference rules.

control picture

A MicroSCADA picture.

DMS

Distribution Management System.

dxf

vector file format

experimental switching

During clearing of the fault the switching actions are made to locate the fault. The aim of the experimental switching is to locate the fault as soon as possible and at the same time to cause as few disadvantages to the customers as possible.

fau<xxx>.txt

File names of fault snapshot files (<xxx> is a running number). See also fault files.

fault distance

The fault distance is determined by comparing the measured short-circuit current and the type of fault with the calculated short-circuit currents along the feeder in which a fault has been occurred. The fault location of Open++ Opera is based on fault distance calculation and fault detector data.

fault files

Fault snapshot file created by OperaSA.

fault location license

The functional content of the Open++ Opera depends on the licenses and definition of optional functions during installation of the system. Fault location functions require the Open++ Opera fault location license (also requires the network analysis license).

free data form

Free data forms are the way to define the layout and content of data forms.

free database object

Free database objects are user defined object types, which can be added to the network database.

Hot-Stand-By

A system to secure database connection with two servers which are capable to continue service alone, if connection to the other is lost.

HSB

See Hot-Stand-By

internal station diagram

Station diagram of Open++ Opera.

Internet Protocol

The messenger protocol of TCP/IP, is responsible for addressing and sending TCP packets over the network. IP provides a best-effort, connectionless delivery system that does not guarantee that packets arrive at their destination or that they are received in the sequence in which they were sent. See also Transmission Control Protocol.

IP

See Internet Protocol and IP address.

IP address

Internet address (for example 127.0.0.1)

isolation

During clearing of the fault the switching actions are made to isolate the fault. The isolation isolates the located fault as soon as possible and at the same time to cause as few disadvantages to the customers as possible.

LAN

Local Area Network. A group of computers and other devices dispersed over a relatively limited area and connected by a communications link that enables any device to interact with any other device on the network. See also WAN.

LIB 500

MicroSCADA base tool.

LIB 510

MicroSCADA tool.

mailslot

An MS Windows communication method based on UDP/IP protocols. See also Internet Protocol.

MV

Medium Voltage.

network database

Relational MS Access based network database of Open++ Opera. See also network.mdb.

network.dat

Binary network file of Open++ Opera. See also binary network model.

network.mdb

File name of the Open++ Opera relational network database. See also network database.

Opera database

Dynamic MS Access based database of Open++ Opera, which contains for example the real time states of switches. See also opera.mdb.

Opera Interface Package

Opera Interface Package is a tool of LIB 500 used to cross-connect MicroSCADA and Open++ Opera.

Opera Network Editor

The Opera Network Editor (OperaNE) is a program primarily used to model the distribution network onto the network database. See also network database.

Opera Server Application

Opera Server Application (OperaSA) is used for data exchange between MicroSCADA and instances of OperaWS. See also Opera Workstation.

Opera Workstation

Opera Workstation (OperaWS) is a program for the operation's personnel of electric companies in monitoring and operating their networks.

opera.mdb

File name of the Open++ Opera dynamic database. See also Opera database.

opera.ttf

TrueType symbol font file of Open++ Opera.

OperaSA specific settings

Settings which define the functions of OperaSA. See also Opera Server Application.

process object

A MicroSCADA process object, which has a connection to a real process.

protocol

A set of semantic and syntactic rules that determine the behavior of functional units in archiving communication.

raster map

Map information consisting of dots. The number of dots depends on the resolution of the map. Each dot has some color information according to the number of colors used. See also vector map.

restoration

During clearing of the fault the switching actions are made to locate the fault (experimental switching), isolate the fault (isolation) and restore the connections during the fault (restoration). In the restoration, the outage areas are restored in order of importance, which is assumed to be proportional to the load.

SCADA

Supervisory Control And Data Acquisition.

service pack

Product update distribution system of MS Windows. Service packs keep the product current, and extend and update your computer's functionality. Service packs include updates, system administration tools, drivers, and additional components. All are conveniently bundled for easy downloading. Service packs are cumulative - each new service pack contains all the fixes in previous service packs, as well as any new fixes.

SSI

See Support System Interface.

station diagram

Diagram presentation mode of station components.

station picture

A MicroSCADA picture.

Support System Interface

A standardized method of transferring data between the applications.

system specific settings

The settings which define the functions of all instances of OperaNE and OperaWS.

TCP

See Transmission Control Protocol.

TCP/IP

See Transmission Control Protocol/Internet Protocol.

TCP-port

Service Access Point of a TCP-port. See also Transmission Control Protocol.

technical constraints

Technical constraints means limits for safe use of electrical networks and devices. For example voltage level, current capacities of lines and transformers and the proper operation of protection are technical constraints checked in Open++ Opera.

tempnet.dat

The file containing temporary network data.

Transmission Control Protocol

A software protocol developed by the Department of Defense for communications between computers. This is a connection-based Internet protocol responsible for breaking data into packets, which the IP protocol sends over the network. This protocol provides a reliable, sequenced communication stream for network communication. See also Internet Protocol.

Transmission Control Protocol/Internet Protocol

This is a set of networking protocols that provide communications across interconnected networks made up of computers with diverse hardware architectures and various operating systems. TCP/IP includes standards for how computers communicate and conventions for connecting networks and routing traffic. See also Transmission Control Protocol and Internet Protocol.

WAN

See Wide Area Network.

vector map

Map information, which consists of lines and curves. See also raster map.

vg2

Open++ Opera internal vector file format.

Wide Area Network

A communications network that connects geographically separated areas. See also LAN.

Windows socket

The Windows Sockets specification defines a network programming interface for MS Windows.

virtual process point

A MicroSCADA process point, which does not have a connection to a real process.

workstation specific settings

The settings which define the functions of a local workstation (OperaNE or OperaWS).

Index

G

H

I

L

M

N

W

ABB Oy

Substation Automation

P.O. Box 699
FIN-65101 VAASA
Finland
Tel. +358 10 22 11
Fax. +358 10 224 1094
www.abb.com/substationautomation

1MRS 751467-MUM